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FEASIBILITY STUDY AND PROJECT PROPOSAL FOR A KRAFT PULP AND PAPER MILL FOR THAI BOARD OF INVESTMENT

A.I.D. HISTORICAL AND
TECHNICAL REFERENCE
ROOM 1656 NS

FEASIBILITY STUDY AND PROJECT PROPOSAL FOR A KRAFT PULP AND PAPER MILL FOR THAI BOARD OF INVESTMENT

PRESENTED

BY

PARSONS & WHITTEMORE, INC.

PROJECT NY-773

DECEMBER, 1963

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FEASIBILITY STUDY AND PROJECT PROPOSAL FOR A KRAFT PULP AND PAPER MILL FOR THAILAND

SUMMARY OF RESULTS AND CONCLUSIONS

This report is the result of a technical and economic feasibility study (investment survey) made by the Parsons & Whittemore Organization, with the assistance of Kearns International, to determine the feasibility of installing a kraft pulp and paper mill in Thailand. A summary of this report is as follows:

	Section
1. It has been proposed that a mill to produce kraft papers and boards, including sack and wrapping papers and liner and corrugating boards, and multi-wall and grocery bags be built to supply an existing market in Thailand. This idea originated with the Thai Board of Investment and was brought to the attention of Kearns International, who had successfully established an industrial enterprise in Thailand. Then, at the request of the Government of Thailand, a detailed technical and economic survey was made by Parsons & Whittemore with the assistance of Kearns International to determine the feasibility of such a project.	I & II
2. A technical and economic feasibility study (investment survey) was financed jointly by the United States Agency for International Development (AID) and Parsons & Whittemore.	II
3. The interest of the Thai Government in promoting industrialization and the incentives extended are reviewed and the reasons for classifying a large kraft pulp and paper mill as a Group A industry are presented. Subsequent financial calculations are based on the assumption of granting a Group A license to this project for which application has been made.	III
4. A detailed analysis is made of the paper market in Thailand and the market at the time the mill will start operations is projected.	IV

Thailand consumes over 80,000 metric tons of paper per year, importing more than 80%; kraft paper consumption is 30,000 tons. FAO projections for Thailand indicate 200,000 tons total consumption by 1975; this Study shows a demand of 40-48,000 tons of kraft papers for 1966.

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Existing mills do not manufacture the strong kraft paper products required by the expanding cement, tapioca, beverage, fertilizer and soap industries.

5. The survey of the fibrous raw material situation showed that, although Thailand has a future potentiality for producing long-fibered coniferous wood (the most desirable papermaking material) it has an ample resource of sugar cane bagasse to support at the start of the overall project a pulp mill to meet 40% of the paper mills pulp requirements, and the cost of this material is developed in this Report. V

   Thailand also has a resource of bamboo, an important papermaking fiber now used in Thailand, and the survey shows that a pulp mill to be built later can be based on this material if proper Government protection and silvicultural management are given to the bamboo forests.

   Another small source of a highly desirable long-fibered material was found in kenaf cuttings.

   Other less promising fibrous materials in Thailand for the present were found to be tropical hardwoods, rice, straw, and overmature rubber trees.

6. The report points out that Thailand is not favored with domestic sources of many chemicals required for pulp and papermaking at an economic price and salt cake, alum, and rosin will need to be imported. However, limestone is available. The costs of these materials delivered to the mill are developed. VI

7. Wood, lignite, and imported fuel oil are the possibilities found for generating steam and power. A careful analysis indicated that imported fuel oil was the most economic from all considerations and the costs of steam and power are developed. VII

8. Detailed estimates are given in the report for the manpower requirements for the proposed mill and it is shown that rewarding employment will be created for a labor force of nearly 500 people. This labor force includes a 20-man foreign management staff which will be required for the initial stage of operation of the mill. However, a counterpart Thai staff will be trained to replace the foreign personnel. VIII

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9. A review is given of possible plant locations, taking into account all the technical and economic factors affecting site selection and recommendations are made for sites in the Mae Klong River within 100 km of Bangkok. A detailed description, including flow diagrams, is given of the operation of the proposed mill through the various stages of manufacture. This description takes into account that the mill will be built as two separate projects, first a partially integrated pulp and paper mill and second another pulp mill. A plant layout is also presented. IX & X XI

10. Costs of the complete equipment needed for the two projects by mill department are given, starting with processing of the bagasse at the sugar mills and ending with the shipment of the finished paper and converted products. XII & XIII

11. The services to be rendered to the Thai Paper Industries, Ltd., by the Parsons & Whittemore and Kearns Organizations are given in detail. XIV & XV

12. A time schedule for Project I covering a total period of 30 months is given for delivery of equipment, engineering services and construction of the mill. XVI

13. The estimated capital requirements for the two projects for equipment, construction and other requirements are given in detail and are summarized as follows: XVII & XVIII

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Project I

		US$	Baht
a.	Equipment including spare parts	13,870,000	
b.	Engineering and technical services	2,270,000	17,476,000
c.	Other expenditures, including site, buildings, freight, erection, overhead and interest during construction, development fee, contingencies including provision for escalation, etc.	3,299,000	112,304,000
	Total	19,439,000	129,780,000
d.	Working Capital		42,000,000
	Grand Total	US$ 19,439,000	Baht 171,780,000
	Equivalent Total in either US$ or Baht	US$ 27,619,000	Baht 579,999,000

Project II

		US$	Baht
a.	Equipment including spare parts	3,401,090	
b.	Technical services	553,910	3,630,000
c.	Other expenditures, including site, buildings, erection, overhead and interest during construction, development fee, contingencies including provision for escalation, etc.	1,052,600	27,030,000
	Total	5,007,600	30,660,000
d.	Working Capital		10,500,000
	Grand Total	US$ 5,007,600	Baht 41,160,000
	Equivalent Total in either US$ or Baht	US$ 6,967,600	Baht 146,319,600

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14. A financing plan for the $27,619,000 required for Project I is developed as follows: XIX

	Foreign US $	Local US $
a. Thai Investors		5,000,000
b. Parsons & Whittemore and Other U S. Investors	4,000,000	
c. Capitalized Services from Kearns Group		900,000
d. Loan from Foreign Lending Agency	14,000,000	
e. Convertible Debentures or Preferred Stocks		2,280,000
f. Capitalized Interest during Construction	1,439,000	
Totals	US$ 19,439,000	US$ 8,180,000
Grand Total	US$ 27,619,000	

The foreign currency expenditures above will cover equipment and technical services, and training of Thai personnel abroad. The local currency will cover living expenses for foreign personnel, inland freight and insurance, site purchase, buildings, labor and materials for equipment installation, overhead during construction, etc., and working capital. A similar financing plan is given for Project II.

15. Complete calculations are given for depreciation and interest and schedules are outlined for the drawdown of capital resources to meet capital requirements as well as for the amortization of the loan. XX

16. Detailed estimates are given for basic manufacturing costs for all final and intermediate products of the mill for both projects. XXI

17. Detailed estimates are given of sales, costs and profits over the period of the loans, and taking into account the projected expansion in production of the mill through the first eight years of operation when the maximum productive capacity will be reached. XXII & IV

It is pointed out that during this period the annual importation of pulp for the mill will have been reduced

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from 29,000 to 9,000 tons annually and at the same time the kraft paper demand which by this time has increased from approximately 45,000 to 54,000 tons will be manufactured entirely in Thailand. In addition there will be a very substantial sale of grocery bags, now imported, which is expected to increase with a rise in Thai economy.

As is shown in Section XXII of the report, the sales prices for the mill's products used in the Estimated Sales, Costs and Profits projection have been established to allow a reasonable dividend for the shareholders after the enterprise has met all of its financial obligations. While these prices are somewhat higher than the prices of paper imported into Thailand in March and April, 1963, when the market study was made, it is well known that, due to world market conditions, paper prices have for some time been abnormally depressed, and it must be expected that they will return to normal in forthcoming years.

In view of the great benefits to Thailand which the establishment of domestic manufacture of kraft paper will bring, the somewhat higher prices (average of 7%) are not unreasonable. In addition to the substantial savings in foreign exchange which will result from domestic production, the enterprise will create employment for and training of skilled workers; will benefit the transportation business and the local economy; provide an outlet for fuel oil from Thai refineries; release for other investment capital currently tied up in inventories and make more rational use of local fibrous raw materials, especially bagasse, which is presently being burned.

It can be seen from the projected profits (page 425) that in the later years of production, earnings in excess of those needed to provide acceptable dividends will be available. To the extent that these earnings are not required for reserves, the mill will be in a position to significantly reduce its sales prices for paper.

Certain domestically produced papers and many other products are protected by restrictions on imports through the Ministry of Economic Affairs' "Import Control List". It is expected that, if necessary, the present import restrictions on paper products will be extended to include the products of the proposed kraft pulp and paper mill.

18. Conclusions are drawn as to the feasibility of the proposed kraft pulp and paper mill for Thailand. XXIII

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I. INTRODUCTION

A. General

It is being contemplated that a pulp and paper mill be established in Thailand for the manufacture of unbleached kraft wrapping and sack papers and kraft liner and corrugating boards to supply the market in this country. All of these paper products are presently imported. It is also being considered that the proposed mill will include a converting plant for production of multi-wall bags for industrial use, and parcel-type bags for stores and shops. It is being planned, furthermore, that the papers and boards be made with the highest possible percentages of pulps made at the proposed mill from indigenous fibrous materials. Pursuant to a request of the Government of Thailand, a detailed technical and economic survey was made by Parsons and Whittemore with the assistance of Kearns International, to determine the feasibility of such a project. It is the purpose of this "Feasibility Study Report and Project Proposal" to present the results of the comprehensive field study and the extensive discussions and considerations of all of the technical and economic factors involved in establishing an integrated mill of this type in Thailand.

It is pointed out that this study and report were undertaken in cooperation with the United States Agency for International Development (AID) under an Investment Survey Participation Grant.

B. Outline of Survey and Report

The overall project is actually composed of two separate projects, based on the concept of a two-step implementation of the mill to arrive eventually at a completely independent domestic operation to the greatest extent possible, including use of the local fibrous raw materials. To this end, the first step would be a partially integrated pulp and paper mill using presently available fibers and imported pulp. The second step would be the completion of the mill's integration with full pulping facilities. These two separate undertakings will be referred to hereafter as Project I and Project II, respectively.

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The field study included comprehensive market studies of Thai and world markets, to determine the best grades of unbleached kraft-type pulp and paper and converted products to be produced and marketed in Thailand.

There was included a study of all raw materials for manufacture of pulp and paper known to be available in Thailand, and particularly those near areas of population concentration. The availability of fibrous raw materials was studied in particular detail. Taking into consideration the raw materials available or potentially available, a study was made of the most economic processes and of the grades of paper and board to be produced, so that the mill could be designed properly for producing those products offering the best market possibilities.

An important part of the field study was the location and evaluation of possible mill sites. For the preparation of the Project Proposal, a preliminary design was made to determine the equipment necessary for the complete operation of a mill to be built as two projects. Thus, Project I is to be installed as a partially integrated pulp and paper mill, based on the utilization of imported pulp and pulp made at the mill from domestic sugar cane bagasse. Project II will introduce further pulping facilities to utilize fibrous materials as may be supplied from developing resources in Thailand. Evaluation studies of various fibrous materials will be performed by means of a complete pilot plant to be included in the Project I installation. Thus, as soon as increased quantities of the most suitable local raw materials become economically available, which should be the case within five (5) years of start-up of Project I, the capacity of the initial pulp mill will be doubled through the addition of a second pulping line, in order to supply the paper mill with eighty per cent or more of its pulp requirements. Later development of Thailand's pine resources will enable the mill to supply one hundred per cent of its pulp requirements from domestic fibrous raw materials.

In addition to the basic pulp and papermaking equipment, which will be provided in the preliminary design given in the Project Proposal, there will also be included all of the auxiliary equipment, such as the complete steam generating plant, water treatment plant, waste

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effluent treatment plant, a complete maintenance and repair shop, and a complete chemical recovery system.

The annual production capacity of the mill will be up to 54,000 metric tons of paper and board, based on a working year of 320 days. However, during the first year of operation, the production will probably amount to only 30,000 metric tons, to allow for operating adjustments, and for paper dealers to exhaust their inventories of competing imported stocks.

Since it has been deemed necessary to build the pulp mill in two separate steps, it will be necessary to import over half of the pulp requirements during the first step, or first five (5) years of operation. However, the mill will be laid out so that the implementation of the second step pulping line can be carried out with a minimum amount of interference to the existing operation.

C. Scope of the Report

After thorough study of the information on conditions in Thailand, and taking into consideration all factors relating to a successful operation of a pulp and paper mill, the Feasibility Study Report including Project Proposal was prepared to include the following:

1. A summary of the background of the Project.

2. A detailed survey of the kraft paper market in Thailand.

3. A discussion of the world pulp and paper supply situation, details of the production and consumption of paper in Thailand, and projections for the future, especially with respect to the proposed Thai mill.

4. An analysis of the availability and cost of various fibrous raw materials available in Thailand and their suitability for pulping.

5. An analysis of the various non-fibrous raw materials necessary for the proposed pulp and paper operation, including their availability and cost in Thailand, or their estimated cost if imported.

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6. Discussion of the suitability of several potential mill sites.

7. An analysis of the steam and power requirements for both the partially and fully integrated pulp and paper mills, with a discussion of the relative economics of purchased power versus power produced at the mill.

8. A description of the proposed process and methods of operation, including flow diagrams and a proposed plant layout.

9. A complete list of all equipment to be supplied for the Project, both for processing and for the auxiliary facilities and services.

10. Estimates of the total capital requirements for the mill.

11. Estimates of the basic manufacturing costs for unbleached pulps and paper products.

12. Income and profit statement and financial plan.

In summary, this Report is intended to present a complete analysis of the feasibility of constructing a pulp and/or paper mill in Thailand, and to provide a basis for evaluation of such a project by Government officials, financial institutions and private investors.

D. Personnel Involved in Survey

In order to perform the field work required to fulfill the above objectives, a Team of four individuals was selected to conduct the Survey:

Dr. Julius Grant	Consultant and Director Hehner & Cox, Ltd. The Laboratories 107 Fenchurch Street London E.C. 3, England
Mr. Guy J. Monarque	Consultant Monarque and Morelli, Consulting Engineers 6333 Decarie Boulevard Montreal 29, Canada

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Mr. Ralph E. Phillips	Finance Expert Parsons & Whittemore, Inc. 200 Park Avenue New York 17, N. Y.
Dr. James E. Winkelman	Market Research Parsons & Whittemore, Inc. 200 Park Avenue New York 17, N. Y.

The itinerary and program followed by the Team is set out below:

Wednesday, March 6	Dr. Winkelman arrived Bangkok. Briefing and planning discussions with Kearns International (Thailand)
Thursday, March 7	Bangkok Industrial Service Division and Industrial Development Division of USOM (United States Operations Mission of the AID); Ministry of Industry; Bangkok-Swiss Trading Co., Ltd.
Friday, March 8	Bangkok ECAFE Committee on Industry and Natural Resources; Forestry Department, Ministry of Agriculture; United States Trade Center; Royal Thai Army Engineers Map Division
Saturday, March 9	Bangkok Berli, Jucker & Co.; Kian Gwan Motors; Thai Paper Trading Co., Ltd.
Sunday, March 10	Mr. Monarque arrived Bangkok; Conference with Kearns International (Thailand). Dr. Grant arrived Bangkok.

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Monday, March 11	Bangkok Briefing and Planning discussions, Kearns International (Thailand); Industrial Development Division of U.S. AID: Public Works and Engineering Division of U.S. AID: S. R. Tapioca Co., Ltd.
Tuesday, March 12	Bangkok ECAFE (Economic Commission for Asia and the Far East of the United Nations), Committee on Industry and Natural Resources; Siam Cement Co., Ltd.; Ministry of Industry; Boon Rawd Brewery Ltd.
Wednesday, March 13	Bangkok U.S. AID Mission; Board of Investment of Thailand; Berli, Jucker & Co.; Hiang Seng Box Factory Ltd.; United States Embassy; Export Promotion Board of Thailand.
Thursday, March 14	Bangpa-In Government pulp and paper mill; Bangkok Research Division of Forest Products, Royal Forestry Department, Ministry of Agriculture; Mr. Phillips arrived Bangkok.
Friday, March 15	Bangkok Thailand Tobacco Monopoly; Ministry of Industry; Royal State Railway Organization; Jalaprathan Cement Co.;

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	Lignite Authority Chemical Fertilizer Co., Ltd.; Royal Irrigation Department, Ministry of Agriculture; Government Lottery Bureau
Saturday, March 16	Site investigations in Chachoengsao area along Bang Pakong River.
Sunday, March 17	Site investigations, area west of Bangkok to Karnchanaburi; Tour of Government Pulp and Paper Mill at Karnchanaburi.
Monday, March 18	Investigation of bamboo forests northwest of Karnchanaburi
Tuesday, March 19	Packaging Manufacturing Co.; Forestry Department; Thai Paper Box Factory Ltd.; Rice Department, Ministry of Agriculture; Site investigation, Thesay area near Bangkok.
Wednesday, March 20	Bangkok Thai Pure Products Co.; Thai Sugar Organization; Municipal Fertilizer Plant; Thai Glass Factory.
Thursday, March 21	Ubon Visits to Kenaf growing areas, Kenaf baling plant, and experimental pine rosin distillery.
Friday, March 22	Srisaket Visits to Provincial Governor and to pine forests in Srisaket area.

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Saturday, March 23	Bangkok East Asiatic Co. Ltd.; Bangkok Package Factory Ltd.
Sunday, March 24	Pattaya Beach and return
Monday, March 25	Bangkok Thai Kong Industry and Commerce Ltd.; Express Transportation Organization; Customs Department; Dr. Grant departed Bangkok.
Tuesday, March 26	Bangkok Royal Army Engineers Map Division; The Bangkok-Swiss Trading Co., Ltd. Yankee Electrical Authority; FAO Forestry Division; The Shell Co. of Thailand, Ltd.
Wednesday, March 27	Bangkok Kit Karn Charoen Limited Partnership; Italthai-Industrial Co. Ltd.; Thai Revenue Department; Colgate-Palmolive (Thailand) Ltd.; The General Trading Co. of Siam Ltd.; Bara, Windsor & Co. Ltd.
Thursday, March 28	Bangkok Christiani & Nielsen Thai, Ltd.; Esso Standard Eastern Inc.; Guan Yau Huat Limited Partnership; Teck Heng Co. Ltd.
Friday, March 29	Bangkok Raylam Battery Company, Ltd.; Public Works and Engineering Division of the U.S. AID;

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	Construction Division and Hydraulic Section of the Royal Irrigation Department; Hamlet & Co. Ltd.
Saturday, March 30	Bangkok Discussions and review of Survey progress, Kearns International (Thailand).
Sunday, March 31	Site investigation, area west of Bangkok to Karnchanaburi.
Monday, April 1	Bangkok U. N. Technical Assistance Organization; East Asiatic Co. Ltd.; Thai Roong Ruang Sugar Mills, Ltd.; Tai Wah Trading Co. Ltd.
Tuesday, April 2	FAO Forestry Division; Several Divisions of the U.S. AID
	Mr. Monarque and Dr. Winkelman departed Bangkok.
Wednesday, April 3	Bangkok Industrial Development Division, U.S. AID Miooion; Thai Lottery Bureau.
Thursday, April 4	Bangkok Thai Farmers Bank; Siam Cement Co.; Esso Standard Eastern, Inc.; Bank of Thailand.
Friday, April 5	Mr. Phillips departed Bangkok.
Wednesday, April 10	Dr. Winkelman returned Bangkok, reviewed Survey progress with Kearns International (Thailand).

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Thursday, April 11	Bangkok U.N. Technical Assistance Organization; Ministry of Industry
Friday, April 12	Dr. Winkelman departed Bangkok.

All members of the Survey Team wish to express their great appreciation for the facilities placed at their disposal by the various Ministries and other Government organizations mentioned in this Study.

In particular, the transport and personnel placed at the Team's disposal by the Ministries of Industry and Agriculture during field investigations in the Karnchanaburi, Ubon and Srisaket areas greatly facilitated the speed and convenience with which the Team was able to carry out its work. Thanks are also due to the helpful advice and encouragement received from the United States Embassy and from the various officials of the U.S. AID in Thailand.

The Team would also like to express its gratitude for the cooperation, interest and assistance given by the following individuals in their respective capacities. The names are listed in the approximate chronological order in which they were met. It may be noted that discussions took place with and relevant information was obtained from at least eighty-six persons in all.

Mr. Henry Kearns President	Kearns International (Thailand)
Mr. Pisit Snidvongs Special Representative	Kearns International (Thailand)
Mr. Supan Jotikabukkana Manager	Kearns International (Thailand)
Mr. Bedford L. Seabrooke Chief of the Industrial Service Division	U.S. AID in Thailand
Mr. Donat	Industrial Development Division of U.S. AID in Bangkok.

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Mr. O. C. Sylwan Member	U. N. Technical Assistance Organization assigned to the Thai Ministry of Industry.
Mr. Gross	Bangkok-Swiss Trading Co.Ltd.
Mr. Chan	Committee on Industry and Natural Resources, ECAFE
Mr. Dusit Deputy Director General	Forestry Department Ministry of Agriculture
Mr. John O'Neil Commercial Attache	United States Embassy at United States Trade Center, Bangkok
Mr. Edgar Rodel Manager of Import Department	Berli, Jucker & Co.
Mr. Joseph D. Davis Deputy Director	Industrial Development Division, USOM
Mr. Don Price	Public Works and Engineering Division, USOM
Mr. Suriyon Raiwa Chairman of the Board	S. R. Tapioca Co., Ltd.
Mr. Soong Export Manager	S. R. Tapioca Co.,Ltd.
Mr. V. F. Hemmingsen General Manager	Siam Cement Co.
Dr. Patpoong Chief Chemist	Siam Cement Co.
Admiral Chalie Sindusopon Deputy Minister of Industry	Government of Thailand
Mr. Wang Teravut Production Manager	Government Paper Mills at Karnchanaburi and Bangpa-In
Mr. Wit Pirompakdi Managing Director	Boon Rawd Brewery Ltd.

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Mr. J. C. Ewer Director	U. S. AID Mission in Thailand
Mr. Tawee Bunjaketu Chairman of the Board	Board of Investment of Thailand
Mr. Bey Sales Department	Berli, Jucker & Co.
Mr. Suthas Tajavibulya Managing Director	Hiang Seng Box Factory Ltd.
Mr. A. Puhan Charge d'Affaires	United States Embassy Bangkok
Mr. R. Flucker Economic Counsellor	United States Embassy Bangkok
Mr. C. Thayer White First Secretary	United States Embassy
Mr. W. C. Rhodes Second Secretary	United States Embassy
Mr. Osot Kosin Secretary-General	Thai Export Promotion Board
Mr. Thanom Premrasmi Chief	Forest Products Research Division Ministry of Agriculture
Mr. Sukhum Phongsathorn Sales Department	Berli, Jucker & Co.
Mr. Yudh Poonpol Assistant Manager	Tobacco Plantation Department Thailand Tobacco Monopoly
Dr. Boon Chareonchai	Ministry of Industry
Mr. Fueng Chief	Goods and Land Division Royal State Railway Organization
Mr. Thavorntotab Secretary	Jalaprathan Cement Company of the Royal Irrigation Department

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Mr. Pandit Janakarnkit Secretary	"Lignite Authority Chemical Fertilizer Co. Ltd"
Mr. Sutep Tingsabhat	Royal Irrigation Department Ministry of Agriculture
Mr. Boonler Charoen-Bibhop Chief	Paper Section Lottery Bureau
Mr. Wichai Manager	Packaging Manufacturing Co. Ltd.
Mr. M. L. Dej Snidvongs Chairman	Executive Committee for the National Economic Development Board Privy Counselor to His Majesty, the King of Thailand,
Chairman	The Thai Firestone and Rubber Company
Mr. Samran Kalayanarooj	Thai Farmers Bank, Ltd.
Mr. M. L. Udom Snidvongs Deputy Manager	Siam Cement Co. Ltd.
Director	Siam Fibre-Cement Co. Ltd.
Mr. Phya Anuwat	Forestry Department Ministry of Agriculture
Dr. Sala Dasananda Director General	Rice Department Ministry of Agriculture
Mr. Roem Deputy Director of Agriculture	Ministry of Agriculture
Mr. Suvit Pantamanand Manager	Thai Paper Box Factory Ltd.
Miss M. L. Borasnyeramoj Manager	Thai Pure Products Co. Ltd.
Mr. Padech Nitayavardhana Deputy Managing Director	Thai Sugar Organization
Dr. Sang Sudthipong Director	Municipal Fertilizer Plant

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Mr. E. R. Burton Replacement Manager	Thai Glass Factory Australian Consolidated Industries
Mr. Uthai Jaiprasart Regional Forestry Chief	Forestry Department Ubon
Mr. Suriya Udomtwi	Provincial Forestry Section Srisaket
Mr. Chalor Governor	Srisaket Province
Mr. Arne Jensen Manager	Chemical Department The East Asiatic Co. Ltd.
Mr. J. Prins	Chemicals Department The East Asiatic Trading Co. Ltd.
Mr. J. E. Green	Chemical Department The East Asiatic Trading Co. Ltd.
Mr. Sang Brayoonhong	Bangkok Package Factory Limited Partnership
Mr. Cheong Hoi Manager	Thai Kong Industry and Commerce Ltd.
Mr. Chaleo Souvanna-Kitti Chief of Marketing Division	Express Transportation Organization
Mr. Voges	The Bangkok-Swiss Trading Co. Ltd.
Mr. Somvonk Pochyananda Assistant to General Manager	Yanhee Electrical Authority
Mr. Kasame Chatikavanij General Manager	Yanhee Electrical Authority
Mr. U. Aung Din	Food and Agriculture Organization of the United Nations

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Mr. Pochana Snidvongs	The Shell Co. of Thailand Ltd.
Mr. Manit Amoradhat	Shell International Petroleum Co. Ltd.
Mr. Jeremy T. P. Farrington	The Shell Co. of Thailand Ltd.
Mr. Prayad Sankhavanija	The Shell Co. of Thailand Ltd.
Mr. M. G. Forshaw Chemicals Manager	The Shell Co. of Thailand Ltd.
Mr. Sawat Pritsukasem	Kit Karn Charoen Limited Partnership
Mr. Giorgio Berlingieri Managing Director	Italthai Industrial Company Ltd.
Mr. Wanlop Arunyakasem	Colgate-Palmolive (Thailand) Ltd.
Mr. Vuthikrai Rungrangnaparajata	The General Trading Co. of Siam Ltd.
Mr. Otto G. Hager	Farbwerke Hoechst AG. Sales Department Chemicals Bara, Windsor & Co. Ltd.
Mr. C. Windahl Jorgensen	Christiani & Nielsen (Thai) Ltd.
Mr. Stanley Young General Sales Manager	Esso Standard Eastern Inc.
Mr. Guan Yau Yoo General Manager	Guan Yau Huat Limited Partnership
Mr. David Lim Assistant Managing Director	Teck Heng Co. Ltd.
Mr. Jason L. Vourvoulias Vice President and General Manager	Raylam Battery Company Ltd.

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Mr. G. S. Roache	Public Works and Engineering Division, USOM
Mr. Chung Chan Chief Engineer of Construction Division	Royal Irrigation Department Ministry of Agriculture
Mr. Boon Chob Chief of Hydraulics Section	Royal Irrigation Department Ministry of Agriculture
Mr. Benno Gimkiewicz	Hamlet and Co. Ltd.
Mr. Ananta Sudasna Na Ayudhya	East Asiatic Trading Co. Ltd.
Mr. Sanguan Chairoong Ruang Assistant Manager	Thai Roong Ruang Sugar Mills Ltd.
Mr. Antonio Yen Manager	Tai Wah Trading Co. Ltd.
Mr. Prayad Buranasiri Director of	Bank of Thailand
Mr. J. Turbang	Food and Agriculture Organization of the U. N.
Mr. Bancha Lamsan Vice President	Thai Farmers Bank
Miss Nash Deputy to Director	U. N. Technical Assistance Organization, Bangkok

E. Notes on the Present Study

1. All values are expressed in Thai Bahts on the basis of the following rate of exchange:

21 Baht = U. S. $1.00

59 Baht = £ 1 (Sterling)

2. All weights and measures are expressed in metric units unless otherwise specified. Quantities which are part of specifications given in English units, however, have not been converted into metric units (i.e., paper and reel sizes given in inches).

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3. The tables and figures normally occur in the portions of the text to which they refer. Certain documents and other illustrative matter of this nature could not be conveniently incorporated into the text in this way and are attached as Appendices.

4. Map No. 1 is a general map of Thailand on which all towns and localities mentioned in this Study are underlined. Significant features of the areas involved and referred to in this Study are also marked on this map. Maps relevant to Site Selection and Transport are inserted in the section covering these subjects.

5. Names of places, towns, areas, etc., often have two or more versions when transliterated into English. The differences are minor, however, and should not confuse the reader.

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II. GENERAL BACKGROUND OF THE PROJECT

A. History of Project

The Project for a kraft pulp and paper mill in Thailand had its inception early in 1962. At that time, Kearns International was apprised by its branch office in Bangkok that the Government of Thailand, more specifically, the Thai Economic Development Board, which is primarily responsible for the management of industrial expansion within the Thai economy, had a definite interest in the establishment of a kraft paper mill with an annual capacity of approximately 45,000 tons of kraft papers to serve the market in Thailand.

This interest was further strengthened by the recommendation made by the Chairman of the Board of Investment of Thailand to the Thai Economic Development Board, urging that a feasibility study be conducted for such a Project.

Following this, discussions took place during July and August 1962, between representatives of Kearns International, Pasadena, California, and Parsons & Whittemore, Inc., New York, concerning the possibility of erecting a kraft pulp and paper mill in Thailand. As a result, the two Organizations agreed to collaborate in furnishing the necessary assistance to the Thai Board of Investment in carrying forward the Project.

In August and September, representatives of Parsons & Whittemore, Inc., and Kearns International, met separately with officials of the Thai Board of Investment, the Thai Ministry of Industry, the Bank of Thailand, the Siam Cement Co., and the Jalapraphan Cement Co., and with the U.S. AID Mission and the United States Embassy in Bangkok. All of the participants in these preliminary discussions expressed interest in the development of a kraft paper project in Thailand, and all offered their cooperation.

It was pointed out, and agreed to by all interested parties, that the first step in the development of a sound project should be a comprehensive feasibility study and a specific project proposal, which would indicate the exact type and size mill to be constructed, and would pin-point the possible site locations as well as the raw materials to be used, and the specific products to be manufactured.

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The Thai Economic Development Board concurred in the recommendations of the Thai Board of Investment for a feasibility study, and made its request to the U.S. AID Mission in Bangkok, which in turn forwarded this request to the Department of State in Washington, D.C.

As a result of extensive discussions between Parsons & Whittemore, Inc., Kearns International and AID in Washington, and between the above and the United States Embassy in Bangkok, the U.S. AID Mission in Thailand, and the Thai Government, Parsons & Whittemore agreed to conduct the required feasibility study and prepare a complete report and project proposal.

It was recognized from the outset by the Kearns International and Parsons & Whittemore Organizations that, due to the increasing demand for paper and paper board and converted paper and paper board products in Thailand, it would be highly desirable for a mill to be established in this country to meet some, if not all, of the country's growing requirements in kraft papers and boards. Although the exact size and type of mill which might best be built would depend upon the findings of the feasibility study, it appeared that a mill with an annual production of 45,000 tons of paper might be warranted. The specific products indicated as promising for such a mill were unbleached kraft sack and wrapping papers and kraft paper corrugating and liner boards.

It was also believed at this time that there might also be integrated with the pulp and paper mill a corrugating box plant for the production of fiber board for packaging and a multi-ply sack plant for conversion of the sack paper into strong sacks for industrial use.

Initial impressions indicated that such a project might best be executed in two stages. The first would involve the installation of a paper mill for the production of kraft paper and paper board, and of the converting facilities for producing corrugated boxes and multi-wall bags. Imported unbleached kraft coniferous wood pulp would serve as the basic fibrous raw material. All auxiliary facilities, such as the steam and power plant, water treatment plant, waste effluent disposal facilities, maintenance shop, etc., would be included in this first stage so that the mill might be reasonably self-sufficient.

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The second stage would involve the construction of pulp producing facilities, using local fibrous raw materials, which would provide the major part of the pulp required. Raw materials to be considered were wood, bamboo, bagasse, straw, and other Thai agricultural products grown in large quantity.

Newsprint was to be considered as a possible third stage, or even as part of the second stage, depending upon the amount of bagasse found to be available.

Subsequently, it was realized that the two-stage approach as outlined above should be substantially modified, and, in view of the time interval of at least five (5) years between the two stages, should be considered as two separate projects. Project I would include a partially integrated pulp and paper mill, and Project II would entail a second pulping line.

On the basis of the above preliminary objectives, and in view of the broad scope and extent of the projected Study, Parsons & Whittemore, Inc., applied to the United States Agency for International Development (AID) for an Investment Survey Participation Grant under Title IV, Foreign Assistance Act 1961, on December 13, 1962.

Such a grant provides that, "If the Grantee, after making the survey, determines not to undertake directly or indirectly the investment opportunity,"(*) the United States Government will contribute up to 50% of the actual cost of the Survey and Report. Otherwise, Parsons & Whittemore, Inc., shall bear the entire cost by itself.

On February 14, 1963, the Parsons & Whittemore, Inc. application to AID for an Investment Survey Participation Grant covering the survey of an investment opportunity in Thailand for a kraft paper mill was approved. As agreed upon between all parties concerned, the Survey would include:

(*) General Condition No. 4, "Basis for Grant" of Attachment A, Investment Survey Participation Grant No. 64-3-0008 dated 2/14/63.

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1. A comprehensive market study which will determine the economics and profitability of the Project for the purpose of accurately estimating the necessary investment requirements. The market study will also indicate the present consumption of pulp and paper as well as converted products within Thailand. It will also evaluate the effect of the projected mill on the overall economy of Thailand.

2. A study of raw materials, including the availability, cost and suitability of raw materials prevalent in Thailand.

3. A study of plant site location, including a selection of the best available sites on the basis of their proximity to the sources of raw materials, availability of water and the supply of steam and electric power.

   The selection of the site will also depend on the distance from the centers of consumption and available means of transportation.

4. A study of building and equipment costs and production costs including preliminary layouts of plant facilities.

B. Background of Kearns International and Parsons & Whittemore, Inc. Organizations

1. Kearns International

   Kearns International is a service organization which specializes in discovering, evaluating and developing profitable business opportunities. It identifies markets and investment situations, brings together resources of management, capital and technical know-how, and is prepared to serve as the business vehicle for both private and public interests engaged in developing natural resources, manufacturing facilities and trade.

   Kearns International confines its activities largely to Asia. It has created an overseas network of joint relationships and offices in Tokyo, Japan; Rawalpindi, Pakistan; Manila, The Philippines; Bangkok, Thailand; and Hongkong. Its United States home office is in Pasadena, California, with branches in Washington, D.C., and New York City.

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This Organization, operating as both intermediary and negotiator in complex international business transactions, has contributed to the economic development of the countries in which it operates by utilizing sound business practices in performing the following tasks:

(a) gathering and analyzing economic intelligence covering a wide range of industries and business opportunities;

(b) representing prominent and respected business concerns throughout the Orient;

(c) gaining access to management skills, technical know-how, financial resources and marketing capabilities as they are needed in the development of selected undertakings.

Henry Kearns, the founder and President of Kearns International, has a comprehensive record of accomplishment. His experience in establishing and developing several successful businesses, his participation in the formulation of United States Government trade policy as Assistant Secretary of Commerce for International Affairs (1957-1960), and his broad scope of activities and travel throughout the world have enabled him to create and direct the type of service organization represented by Kearns International.

2. The Parsons and Whittemore-Lyddon Organization

(a) General

The basic objective of the Parsons & Whittemore-Lyddon Organization and its associated machinery companies is to further the growth of the pulp and paper industry by assisting investors and development organizations in all parts of the world to build mills designed to utilize local raw materials.

With the available local raw materials as a starting point, the Parsons & Whittemore-Lyddon Organization is prepared to carry out any pulp and paper mill project from the initial stages of the technical and economic survey

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through to completion, including design, supply of all equipment, engineering and construction, training of local personnel, operation, and marketing of the products.

These comprehensive services of the Parsons & Whittemore-Lyddon Organization have been often termed a "Private Technical Assistance Program". An outline of the overall activities of the Organization, which enable it to successfully provide such assistance, is given below.

(b) Pulp and Paper Project Divisions

Under the direction of pulping and papermaking experts of international prominence, an experienced staff of project engineers, technical experts and economists has been assembled in each of the principal Parsons & Whittemore-Lyddon Projecting Offices, which are located in New York, London, Paris, and Redenfelden, Germany.

The addresses of these Projecting Offices are as follows:

Parsons & Whittemore, Inc.
200 Park Avenue
New York 17, New York - U.S.A.

Lyddon & Co., Ltd.
20-26 Wellesley Road
Croydon, Surrey - England

Parsons & Whittemore (France) S.A.
5, Rue Jean Mermoz
Paris 8e - France

Parsons & Whittemore-Aschaffenburg G.m.b.H.
Redenfelden, Oberbayern - West Germany

The staff of each Projecting Office is prepared to advise and take action on all phases of the construction of pulp and paper mills of all types and sizes.

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C. Major Projects in Which the Parsons and Whittemore-Lyddon Organization has Participated or is Presently Participating

During the last few years, sixteen major mill projects completed by the Projecting Offices have started production in Cuba, Czechoslovakia, France, Hungary, India, Mexico, Poland, Portugal, Rumania, Tunisia, the USSR, and Vietnam. In various stages of completion at this time are ten new pulp and paper mill projects in a number of countries. In addition, contracts have been concluded for eight other complete projects, on which construction will be started within the next year.

The value of equipment orders for all thirty-three projects totals U.S. $263,000,000. The projects represent a total investment of more than $573,000,000 including local expenses, financing, working capital, etc.

A list of the major projects in which the Parsons & Whittemore-Lyddon Organization has participated or is presently participating is given below. It should be noted that twelve different raw materials are employed: wheat straw, rice straw, sugar cane bagasse, waste paper, rags, beech wood, pine wood, spruce wood, esparto grass, poplar wood, reeds and bamboo.

1. Projects Which Have Been Completed by the Organization During the Past Five Years (16 Projects)

(a) A bleached bagasse pulp and paper mill in Cuba

The Organization furnished the major items of equipment and technical services for this $14,000,000 project for production of 60 tons of bleached pulp and 100 tons of paper, using sugar cane bagasse as the primary raw material. This mill has already been in successful operation for four years, and the top technical personnel, who supervised the complete erection of this mill and operated it during the initial stages, are now in the New York Projecting Office.

(b) A bleached pulp mill in France

The Organization had the complete responsibility for all phases of designing, building and operating a bleached wood pulp mill in southern

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France utilizing beech wood as the primary raw material. This mill, using the prehydrolysis kraft process, was guaranteed to have a capacity for production of 100 metric tons daily of bleached paper grade pulp.

Within two years after the mill was completed, the average production rate was 200 metric tons daily of the highest quality bleached hardwood pulp being produced in France. This mill is still under the operational management of the Organization.

(c) A newsprint mill in Mexico

The Organization had the complete responsibility for furnishing all of the equipment and erecting a 100 ton newsprint mill in Mexico, utilizing Mexican pine as the basic raw material. This mill has also been in operation for about four years, furnishing almost half the newsprint requirements of Mexico.

(d) A straw pulp mill in Mexico

The Organization furnished all of the equipment and technical services, including supervision of erection, for a 60 ton unbleached straw pulp mill for production of corrugating quality pulp. This mill is located in Monterrey, Mexico, and has been in operation for more than two years.

(e) A straw pulp mill and corrugating mill in Portugal

The Organization had complete responsibility for furnishing all equipment and technical services for a 25 ton integrated straw pulp mill and corrugating board mill in Portugal. This mill has been in operation for several years, producing the highest quality corrugating board which is sold in a number of countries in Europe.

(f) A bleached straw pulp mill in Rumania

The Organization has furnished the complete equipment and technical services, including supervision of erection and supervision of start-up, for a 40 ton bleached straw pulp mill in Rumania. This mill has already been operating for more than two years.

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(g) A paper mill in Poland

A large, three-machine paper mill for production of a total of 200 tons of paper of various grades was completed by the Organization during 1960. In this mill, complete stock preparation equipment, paper machines and finishing room equipment were furnished, and supervisory services for erection were supplied, as well as complete engineering. This mill has been operating very successfully.

(h) An integrated unbleached kraft pulp and paper mill

A large integrated unbleached kraft pulp and paper mill was started up in July 1962. This mill is for production of approximately 185 tons of kraft paper daily and is integrated all the way from the wood yard to the multi-wall bag factory.

(i) An integrated bleached bagasse pulp and paper mill

A completely integrated bleached bagasse pulp and paper mill of 35 metric tons daily capacity was started up in India in April 1962. The Organization furnished the complete equipment and technical services, including supervision of erection and supervision of start-up for this mill.

(j,k) Two newsprint mills

The Organization has furnished the complete stock preparation equipment, newsprint machines, finishing equipment, etc., for two large newsprint mills, each of which produces more than 300 metric tons of newsprint daily.

(l) A bleached straw pulp mill

A 70 ton bleached straw pulp mill for pulping rye straw and wheat straw was completed and went into operation during 1962. The Organization furnished all of the equipment and technical services in connection with the building of this mill.

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(m) A combination bamboo and bagasse pulp and paper mill

An integrated 60 ton bleached pulp and paper mill in India, using a combination of bamboo and bagasse as the basic raw materials, has been completed and went into operation in early 1963. The Organization furnished all of the equipment and technical services for this mill, as well as construction supervision, erection supervision and start-up supervision.

(n) A bleached reed pulp mill

The Organization has recently completed a project, including technical services and all of the required equipment, for a bleached reed pulp mill which produces approximately 80 tons per day of bleached reed market pulp that is being sold to existing paper mills.

(o) A small groundwood pulp mill and paper mill for writing and printing papers in Vietnam

A complete paper mill and groundwood pulp mill has been constructed in Vietnam for production of 30 tons of writing and printing papers daily. The groundwood pulp is produced from local pine wood and the chemical pulp for blending with the groundwood is imported.

(p) A bleached esparto pulp mill

A bleached esparto pulp mill for the production of 80 tons of highest quality esparto pulp has been constructed in North Africa.

2. Mills Under Construction (10 Projects)

The Parsons & Whittemore-Lyddon Organization is in the process of executing a number of other complete contracts for various types of pulp and paper mills among which are the following:

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(a) An integrated straw pulp and paper mill

A project is underway for the construction of a large integrated bleached straw pulp and paper mill, involving production of 200 tons of straw pulp daily and 300 tons of bleached paper daily, utilizing bleached long-fibered wood pulp as a blend with the straw pulp.

(b) A bleached reed pulp mill

The Organization is in the process of executing a contract for a bleached reed pulp mill for production of approximately 80 tons daily of bleached reed market pulp, which will be sold to existing paper mills.

(c) A newsprint mill

A contract for complete stock preparation, newsprint machines, finishing equipment, etc., for a large newsprint mill is in the process of being executed. This mill will produce more than 300 metric tons of newsprint daily.

(d) A large sulfite dissolving pulp mill

The Organization has a contract for furnishing all of the equipment and technical services for a complete project for production of 320 tons daily of high quality, high-alpha dissolving pulp, using spruce and fir pulp as the primary raw materials. Engineering and construction have already started on this project.

(e) An unbleached bagasse pulp mill in Egypt

The Organization has a contract for a complete turnkey job for furnishing a 60 ton unbleached bagasse pulp mill now under construction in Upper Egypt. From the beginning, parts of this mill will be furnished with equipment capacity for 120 tons production daily, and the entire mill will be expanded to production of 120 tons daily as a second stage. This mill is expected to begin operations by mid-1963, and the bagasse pulp produced will be sold to existing paper mills in Egypt.

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(f) An integrated bleached bagasse pulp and paper mill in Argentina

The Organization has a contract for a complete project in Argentina for furnishing all of the equipment and technical services for a 100 ton integrated bleached bagasse pulp and paper mill, which is to be connected with the largest sugar mill in Argentina. Construction on this project has started, and it is expected that the mill will be completed by the end of 1963.

(g) A semi-chemical pulp mill

The Organization is furnishing the equipment and technical services for a semi-chemical pulp mill using oak wood as the basic raw material. This mill will produce 200 tons of pulp daily and is scheduled to be completed in 1963.

(h) A bleached hardwood market pulp mill in Belgium

The Organization has a complete package contract for construction of a 140 ton bleached hardwood market pulp mill in Belgium. This project is being handled by the Paris Projecting Office and is expected to be completed in 1964.

(i) An integrated bleached straw pulp and paper mill in Greece

The Organization has a contract for a 35 to 40 ton integrated bleached straw pulp and paper mill in Greece for production of writing and printing papers. Construction of this mill is well advanced and operations are scheduled to begin in 1964.

(j) A paper mill utilizing kraft pulp

The Organization is furnishing the equipment and technical services for a paper mill producing condenser tissue.

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3. Projects for Which the Parsons and Whittemore-Lyddon Organization Has Contracts, But on Which Construction Has Not Yet Begun (8 Projects)

(a,b) Two integrated bleached bagasse pulp and paper mills in India

The Organization has contracts for two integrated 60 to 70 ton bleached bagasse pulp and paper mills in India, using sugar cane bagasse as the primary raw material. These mills are to be built with sufficient flexibility so that bamboo and some long-fibered wood can be used as supplementary raw materials. Construction on these projects is expected to begin during 1963.

(c) A bleached hardwood market pulp mill in Argentina

The Organization has a contract for a complete turnkey job for construction of a 140 ton bleached hardwood market pulp mill in Argentina. It is expected that construction on this project will begin in 1963.

(d) An integrated unbleached pulp and paper mill in Argentina

The Organization has been awarded an order for the complete supply of equipment and technical services for a 110 ton integrated unbleached pulp and paper mill in the Province of Misiones in Argentina, for production of high strength paper and board, utilizing Parana pine and certain hardwoods as the basic raw materials.

(e) Expansion of unbleached bagasse pulp mill in the United Arab Republic

A contract has recently been concluded for expansion of the unbleached bagasse pulp mill now under construction in the United Arab Republic to fill ultimate capacity of 120 tons production daily. Preliminary engineering is underway and construction will begin during 1963 on the expansion of this project.

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(f) A folding box board mill in the United Arab Republic

A contract has recently been concluded for a complete folding box board mill in the United Arab Republic for production of 50 tons of high quality folding box board daily, utilizing rice straw, waste paper and some imported long-fibered pulp.

(g) An integrated bagasse pulp and paper mill in Ethiopia

A contract has recently been concluded for development of a completely integrated bleached bagasse pulp and paper mill in Ethiopia to be built in two phases. The first phase will involve construction of a 25 ton per day paper mill based on utilizing imported pulp, but including complete converting facilities with a corrugated box plant, a multi-wall bag plant, etc. The second phase will involve the construction of a bleached bagasse and/or bamboo pulp mill and gradual increase in the entire operation to production of 50 tons of pulp and paper daily.

(h) An integrated pulp and paper mill in the Malagasy Republic

A contract has recently been concluded with the Malagasy Government to build a pulp and paper mill utilizing local fibrous plants as the raw material for the pulp mill. Implementation of the project is expected by 1964, with start-up of the mill by the end of 1965.

4. Pulp and Paper Machinery and Manufacture

The Black-Clawson Company, associated with the Parsons & Whittemore-Lyddon Organization through common ownership, is a world leader in the manufacture of pulp, paper and converting machines, and has large pulp and paper equipment manufacturing facilities in the United States, Canada, England and Brazil. Black-Clawson equipment is also manufactured under license in Finland and Japan. Additional machinery factories are under construction in France and India

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for production of complete lines of Black-Clawson pulp and papermaking equipment.

Beyond such direct association with its affiliated pulp and paper machinery companies, Parsons & Whittemore-Lyddon has firmly established contacts with prominent construction engineering firms and leading manufacturers of equipment for the power, chemicals, and materials handling auxiliaries for a complete plant. In choosing the equipment processes, the Organization's engineers review the merits of products and systems supplied by all manufacturers in the field and select with complete freedom the most desirable combination for satisfying the requirements of the projects, keeping in mind the currencies in which the equipment must be purchased.

The group's project managers give consideration to the most advanced equipment, regardless of the source. At the same time it is the firm policy of the Project Divisions not to include processes and machinery that are experimental. Through cumulative experience and continuous study, engineers choose what has been thoroughly tried and is known to be successful.

5. Ownership and Operation of Pulp and Paper Mills

In addition to the projecting activities and machinery manufacturing activities of the Organization, it also participates in the ownership and operation of pulp and paper mills in many countries of the world. For example, the Organization participates in the ownership of ten mills in Germany, three in Austria, the largest pulp mill in France, two mills in India and one mill in Vietnam. It is also now building a large bleached pulp mill based on beech wood in Belgium, in which a majority participation is held, as well as an integrated bleached straw pulp and paper mill in Greece.

The experience in operating these mills, combined with the reservoir of trained operating personnel which they provide, has proved to be of paramount importance in supplying start-up personnel to live and work at newly built mills in all areas of the world for as long as required.

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For example, the technical management team from an affliliated company, Aschaffenburger Zellstoffwerke A.G., is now in its third year of residence at the large Egyptian rice straw and reed pulp and paper mill located at Alexandria.

Furthermore, the Organization's participation in the operation of these mills enables it to place local personnel in them for intensive training during the time that a mill is under construction.

6. Project Financing

The Parsons & Whittemore-Lyddon Organization has assisted the projects which it has contracted by collaborating with the client in submitting the technical and economic feasibility reports required by lending institutions. When necessary and when circumstances have made it possible, the firms of the Organization have participated in the financial arrangements.

The projects have in many cases been financed with the assistance of leading private and Government financial institutions in various countries. Above all, the collaboration of the export credit organizations in various industrial countries has been of utmost importance in arranging satisfactory financing of these projects.

7. Specific Services Performed by the Parsons & Whittemore-Lyddon Organization in Developing Pulp and Paper Mill Projects

Such direct and continuous activity at all levels of the world-wide pulp and paper industry as outlined above has enabled the Parsons & Whittemore-Lyddon Organization to evolve a project development, engineering, equipment supply and consulting capability for any new pulp and paper mill situation, or expansion of existing facilities. Specifically, the following services are rendered, as required:

(a) Conduct a thorough technical and economic field study and prepare a comprehensive feasibility report.

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(b) Supervise pilot plant work which may be necessary to prove the suitablility of a specific raw material with the processes which are available.

(c) Assist in the development of the necessary process which might be required to handle an unusual raw material.

(d) Assist the local group in arranging such credit facilities as may be required and as are obtainable in the country of supply. Under appropriate circumstances the Organization actually participates financially in a project.

(e) Furnish the complete engineering and technical services for the project in cooperation with the customer's engineers and with leading consulting engineers.

(f) Take the responsibility for the production and delivery of the pulp and papermaking machinery and all other equipment for the project. The equipment is furnished from industrial countries from which the procurement is advantageous to the customer.

(g) Supervise the erection of the equipment and the construction of the mill involved, and provide guaranties for production in regard to quality and quantity.

(h) Through the world-wide supply sources of the Parsons & Whittemore-Lyddon Organization, assist the mill in obtaining the necessary imported raw materials and chemicals which are not available locally.

(i) Provide training facilities for local personnel to be trained in foreign mills during the time that the mill is under construction, so that a trained cadre of local personnel will be available for start-up.

(j) Provide skilled operating personnel for starting up the mill and for continuing on-the-job training of local personnel. If necessary,

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provide expert technical management of the mill under a management contract by which the required trained personnel are provided to insure proper operation of the mill until local personnel can take over all operating positions. During this time, the training program is continued to insure assumption of responsibility by local personnel.

By providing any or all of these services, as desired by the client, the Organization insures that a new mill reaches full production in the shortest possible time, thus avoiding the excessive costs of long delayed start-up, which can endanger any new enterprise.

In this connection, the Parsons and Whittemore-Lyddon Organization is noted for its "package" or "turnkey" approach to pulp and paper mill projects. Under such an arrangement, the Organization assumes all of the responsibility for the success of a project, and performs all of the services listed above. The success of this approach, in both "developed" and new-developing countries, is perhaps best demonstrated by the degree to which the "package" concept is now being used in the establishment of many other types of basic industries.

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III. PROMOTION OF INDUSTRIAL INVESTMENT IN THAILAND

A. General

This Survey Report and Project Proposal has been based on two assumptions:

1. The Project for a kraft pulp and paper mill in Thailand will be classified as a Group A Industrial Activity.*

2. The Project for a kraft pulp and paper mill in Thailand will be granted the maximum concessions available to Group A Industries in accordance with the provisions of the "Promotion of Industrial Investment Act B.E. 2505 of 1962.*

Industrial activities falling under Group A are those which can be considered vital and necessary to the economy of the country. In general, those industries which have already been classified under Group A are those which can be described as basic heavy industries. Therefore, it is appropriate at this point to first explain why this project can be considered a Group A Industrial Activity, and then to review the intent and provisions of Thailand's Industrial Development Laws in order to justify the granting of maximum concessions to this Project.

B. Industrial Aspects of a Kraft Pulp and Paper Mill

A kraft pulp and paper project of the size under consideration for Thailand definitely falls into the category of basic heavy industry. It is basic because almost every industry and business is or becomes dependent on kraft paper and board to move its products to the ultimate consumer. This universal dependence upon kraft products is largely due to two outstanding qualities: its great strength and its versatility in use.

*See Appendix I for the complete text of "Promotion of Industrial Act B.E. 2505 (1962) and Announcement of the Board of Investment No. 1 and No. 2".

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Kraft paper or sulfate as it is sometimes called, is the strongest paper produced commercially. At its very coarest, it serves in fiber insulation board. In a fairly refined state, it is used widely in making liner and corrugating boards for the strongest fiber shipping cartons. Somewhat more refined, it provides strength for multi-wall bags for packaging and shipping cement, tapioca, fertilizer, sugar and other bulk commodities. In between the board and multi-wall bag qualities, it is made for multiple uses as grocery, shopping and garment bags, and wrapping paper and cartons. Other common applications of kraft paper are in electrical insulating paper, gummed paper, and, after being twisted, in twine and clothes rope. Finally, kraft paper can be impregnated with resin to make laminated plastic products for table tops, etc. In a semi-bleached form, kraft paper provides manila envelopes, higher grade wrappings, solid fiber boxes and shipping drums, and, most recently, food board. Full bleaching and refining produces book, printing and other fine papers.

The kraft paper is a "heavy" industry because it operates on a large scale in terms of total capital investment, project development time, and complexity of manufacture, and because it represents a high level of capital investment per worker as compared to other basic industries.

The initial stage or Project I of the overall kraft pulp and paper undertaking contemplated for Thailand will require approximately Twenty-eight Millon Dollars ($28,000,000) to complete.

The development time for the complete, integrated mill, measured from the proposed beginning of engineering of the Project I pulp and paper mill in 1964 through start-up of the partially integrated pulp and paper mill in 1967 and start-up of the Project II pulp mill in 1972, will cover a span of seven years. Continued development of local raw materials, especially of the pine forests, will extend several years beyond 1972.

Due to the complexity of the manufacturing process involved, as described in subsequent section of this Report, the establishment of a kraft industry requires great technological know-how and experience.

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Two aspects of the kraft process stand out in the above descriptions. First is the number of variables which must be closely regulated at every step of the process in order to produce the particular kinds of kraft paper or board required by the end user, without damaging the basic strength of the fibers. The second is the principle of chemical recovery in the kraft pulping process, which requires a large amount of additional heavy equipment and adds considerably to the time of installation and cost requirements of a kraft project in comparison with processes operating without chemical recovery. Owing to the large amounts of chemicals needed, however, (about a quarter ton of chemicals for every ton of paper manufactured), such a recovery system is economically indispensable for the relatively costly kraft products. This operation, incidentally, succeeds in recovering for re-use about 80% of the chemicals used in cooking the pulp. This is another reason why the kraft process is by far the most widely used pulping process today.

In addition to being a large scale, long-range and complex manufacturing enterprise, a kraft industry is also considered "heavy" industry in both literal terms: 4000 to 5000 tons of machinery and equipment for producing 45,000 tons of products per year; and in the more significant ratio of amount of capital investment required per worker.

In the United States, for example, with total assets of over 15 Billion Dollars invested in the pulp and paper industry, and a total of about 590,000 production workers employed, this ratio comes to approximately $25,000 of capital investment per worker.

Compared to twenty other basic industries in the same country, this ratio of $25,000 per worker ranks pulp, paper and board ahead of seventeen of them, including primary metals, ($23,000 per worker), motor vehicles ($21,100 per worker), instruments ($17,800 per worker), non-electrical machinery ($17,700 per worker), food and beverages ($17,200 per worker), rubber ($15,500 per worker), electrical machinery ($12,900 per worker), and others. It is exceeded only by the petroleum industry, tobacco and chemical industries.

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The United States paper and allied industry is the tenth largest manufacturing industry in this nation from the standpoint of value added by manufacture. In this very important United States industry, over half of the total wood pulp capacity of 32,245,000 tons, or 18,000,000 tons, is in kraft pulp production. In actual value, kraft bag, sack and wrapping paper, and corrugating and liner boards (the major products contemplated for Thailand) made up about 35% of total United States paper and board production in 1962.

It would be difficult to name an industry or business in the United States that does not require some type of kraft product in order to function properly. There is simply no comparably priced substitute for it.

C. A Kraft Pulp and Paper Industry for Thailand

The same situation as for the United States exists or will exist in Thailand. Even now, the marketing of key Thai industrial products such as cement, tapioca flour, glass products, fertilizer and some grains depend upon imported kraft packaging materials. It is also required for such important consumer products as soap, shoes, light bulbs, tires, batteries, beverages, appliances and packaged foods.

The manufacturing, packaging and shipping requirements of these industries have increased kraft imports from roughly 14,000 tons in 1959 to over 28,000 tons in 1962, over one-third of Thailand's total paper consumption. The present rate of industrial growth, plus expansion plans of various existing industries and requirements of new industries, will continue to require kraft products in increasing amounts as the per capita consumption of paper in Thailand (now about 3 kg/year), especially in areas outside Bangkok, follows the worldwide trend upwards to draw closer to that of Japan at 40 kg/yr or Italy at 24 kg/yr, not to mention the United States at 190 kg/yr.

As a supplier, a kraft industry is naturally interested in increasing the number and variety of its customers. The Thai packaging and shipping materials industry alone, (which, judging by other countries, will eventually represent nearly half of the entire country's consumption), will be greatly stimulated by the

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presence of its own source of supply. Color coating operations, printing and lithography, bag and box packaging of pharmaceuticals, food and textiles, and other sub-industries in the field of communications materials, home products and construction, will be established more readily with the urging and possible technological and financial support of a kraft industry.

But a kraft industry in Thailand will do much more than function as a large domestic supplier to other industries, and an obvious saver of foreign exchange. Its biggest impact may be the result of many indirect benefits to the Thai economy in its role as a consumer. It will directly employ and train hundreds of Thai workers, benefitting their families and creating skills useful to all industries. But perhaps of greatest importance will be the stimulus given to the development and conservation of domestic sources of raw materials. No extensive survey of Thailand's forest and agricultural materials suitable for pulping has ever been made. No controlled experiments have been run to select the most suitable species or determine plantation costs. Though some woodland areas have been declared reserve forests, poaching and burning are rampant, reforestation is directed almost exclusively toward lumbering woods, and even that is on too small a scale to replace cuttings.

Fortunately, plans are now being finalized for a three-year survey of Thailand's raw materials for the pulp and paper industry, sponsored by the United Nations Special Fund and the Thai Government. Based on preliminary findings, some of the long-term recommendations will include the following: the establishment of separate branches for research, pulp and paper technology, and fire and trespass protection in the Royal Forestry Department; establishment of more reserved forests in areas of most value to the expansion of the pulp and paper industry; employment of private foresters by both private and Government pulp and paper companies; and encouragement of the production of forest crops on private lands.

The presence of a growing domestic kraft industry interested in developing and utilizing local fibrous raw materials could supply the impetus required to bring Government and private interests together to implement such recommendations. The future of both lumber and paper sectors of the economy are at stake.

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A kraft industry will also require large quantities of chemicals, especially lime, caustic soda, soda ash, salt cake, sulfur, salt, aluminum sulfate, and rosin and size.

It is axiomatic that the prime prerequisites for the establishment of manufacturing facilities are sizeable markets for their products. For some chemicals, the paper industry has proved to be the most important market of all. In North America, for example, this industry uses 10% of all chemicals produced, including 90% of all salt cake, 75% of the alum, 60% of the clay, 20% of the rosin, and 16% of the chlorine.

In Thailand, only lime, salt and some rosin are presently available. But the caustic soda and soda ash industries have been assigned a high priority under Thailand's latest Promotion of Industrial Investment Act B.E. 2505, and the large amounts of each required yearly for a kraft operation will go a long way toward encouraging their manufacture locally.

As both a supplier and a consumer, therefore, a kraft industry will also further the development of such facilities as barge, truck and rail services. Heavier feeder lines from the Yanhee dam project may ultimately provide power to the areas around the mill. Fuel oil from Thailand's new refinery will be purchased in large amounts for both the pulp and paper mill, and for the several sugar mills which will substitute oil for the bagasse they now burn in order to sell the bagasse to the kraft mill.

In summary of the above points concerning a kraft pulp and paper industry for Thailand the following are emphasized:

1. A kraft pulp and paper mill of the size and scope contemplated for Thailand is a basic, heavy industry.

   (a) It is a large scale undertaking in terms of cost, development time and complexity of operation;

   (b) It has a high ratio of capital investment per worker;

   (c) It is a highly versatile and essential supplier to every economic sector.

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2. A kraft pulp and paper project coordinates with the overall development plans of the Thai economy.

   (a) As a manufacturing supplier, it saves foreign exchange, furnishes existing and new industries with essential materials, and encourages the growth of new sub-industries using its products.

   (b) As a manufacturing consumer, it employs and trains Thai workers, promotes the development of local raw materials, and encourages the establishment of sub-supplier industries.

   (c) As both supplier and consumer, it accelerates the growth of power, fuel and transport facilities, and in a broader economic growth sense, makes a significant contribution to the Thai economy by helping domestic industry to meet the rising demand of changing consumption patterns.

For the above reasons, a kraft pulp and paper mill is normally incorporated into the various country programs (Three or Five Year Plans) on an equal basis with other basic heavy industries such as metal smelting, chemical manufacturing, and power generation.

D. Background of Industrial Investment Act

It was for the purpose of encouraging the establishment of basic and essential industries that the First Industrial Investment Act, B.E. 2497, was promulgated in October 1954.

This Act was not as effective as intended, however, for in the four years and two months of its existence, only eleven companies were granted rights and benefits under provision of the law, resulting in a total investment of the equivalent of slightly over Eighteen Million Dollars.

In December 1958, therefore, this Act was repealed by the Revolutionary Party, and the Board of Investment was established. The need for this change was stated in the preamble of the Revolutionary Party's Thirty-third Announcement as follows:

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"Since the provisions of the Industrial Promotion Act of B.E. 2497 are not deemed adequate and may contribute an obstacle to the establishment of industrial enterprises because of delays in completing the required formalities and, furthermore, because the facilities offered are not sufficiently attractive to induce both domestic and foreign investment in industrial enterprises in Thailand, the Revolutionary Party, therefore, deems that the said Act should be revised once the Legislative Assembly is constituted. In the meantime, and pending the constitution of that Assembly, some measures must be taken with a view to promoting internal industrial development as promptly as possible, so that the country may receive benefits therefrom".*

As a result, the Industrial Investment Act B.E. 2503 was enacted in October 1960.

The effect of the interim Thirty-third Announcement and the new Act B.E. 2503 was much more perceptible than previous measures. There were 197 investment applications totalling the equivalent of $110,003,200 in a period of four years.

In order to accelerate the pace of capital investment still further by granting more privileges and benefits to investors and simplifying legal procedures, the Thai Government enacted Industrial Investment Act B.E. 2505 in February 1962, which is still in force.

E. Benefits to Investors Through Industrial Investment Act

This newest Act embodies the following benefits to Investors:**

1. Factories, Machinery, Component Parts and Accessories

The approved industry is exempted from import duty on imports of machinery component parts and accessories,

* Thailand's New Law to Promote Industrial Development, by Osot Kosin, Board of Investment, Bangkok, 2nd Edition, November 1962, Page 2.

** See Appendix I

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materials, tools and instruments and prefabricated frames and equipment for factory construction.

2. Business Taxes on Factories, Machinery and Accessories

The approved industry is exempted from business taxes on machinery, component parts and accessories, equipment to be used in the industrial activity, and other equipment and prefabricated frameworks which have been imported for construction of the factory.

3. Business Taxes on Exported Products

The Board of Investment is empowered to consider whether such exports shall be wholly or partially exempted from business taxes, and shall determine the period for which such exemptions are granted.

4. Duration of Income Tax Exemption

The approved industry shall be exempted on profits derived from industrial activity for five years, starting from the first year when business renders profits, or sales have commenced.

5. Remittance of Foreign Currency

An approved industry can remove or remit abroad in foreign currency all types of currency: repatriated investment, capital and profit derived therefrom, interest from loans abroad, currency committed to pay for the use of patent rights, for licensing agreements, or for other services of a third party.

6. Exemption from Import Duty on Raw Materials and other Necessary Materials Imported from Foreign Countries

Group A Industries shall be granted full exemption from import duty and business taxes on raw materials and necessary imported materials for the duration of five years.

7. Other Benefits to Investors

(a) The approved industry shall receive guarantees that the State will not initiate any similar

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industrial activity and that the State will not transfer any private industry.

(b) In cases where the approved industry is a company or partnership registered in Thailand, it shall be permitted to own land for carrying on the industrial activity to the extent deemed appropriate by the Board of Investment.

(c) The approved industry shall be permitted to bring alien skilled workers or experts into the country, together with their spouses and dependent children irrespective of immigration law quotas.

(d) Export of products shall be permitted.

8. Benefits to Investors to be Granted at the Discretion of the Board of Investment

(a) Prohibition or restriction of the import of competitive products.

(b) Increase of import duties on competitive import products.

(c) Exemption from or reduction of export duties on products.

F. Formal Application

Formal application has been made to the Board of Investment of Thailand, requesting that all phases of the proposed kraft pulp and paper project be officially classified as Class A Industrial Activity, and that this project be granted the maximum concessions available to such industries in accordance with the provisions of Act B.E. 2505 and the powers of the Board of Investment under this Act. The decision is still pending, awaiting the submission of this Final Report and Project Proposal.

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IV. MARKET SURVEY

This section on the potential market in Thailand on which the proposed mill will be based considers:

(a) the world background of pulp and paper as it has been found to affect the production and consumption in developing areas or countries.

(b) the kraft paper market in Thailand and its relation to the proposed mill, and

(c) the situation with respect to pulp supplies for the paper industry in Thailand.

A. World Background

1. General Comments

In considering the development of a cellulose pulp mill project in any country, it is advisable first to examine world trends in consumption of pulp and paper. In this connection, statistics on United States consumption and production have special significance because of the phenomenal growth of this industry in that country.

It is also advisable to consider the raw materials situation, and this subject is reviewed in the following pages. This review points out the great desirability of utilizing all types of raw materials, including hardwoods, agricultural fibers, bamboo and local grasses, as well as softwoods if world production of cellulose pulp is to keep pace with the consumption of pulp and paper products.

2. Consumption Trends in the United States

Consumption of paper in the United States has multiplied by nearly threefold since 1939, increasing from less than 16,000,000 short tons to more than 42,000,000 short tons in 1960. Per capita consumption increased in the same period from 111 to over 200 kg. At present, new uses are continually being found for paper, and there seems to be no end to its potential. It has been well stated that "Paper is a substitute for almost everything, but there is no economic substitute for paper."

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One of the principal reasons permitting the great increase in production and consumption of paper is the fact that new or modified methods of using new regional fibrous materials have been developed. The increase in pulp production and consumption has followed the same trend as that of paper. As a result, paper production has been able to expand to such high levels. This fact emphasizes the great advantage of developing domestic raw materials to the maximum extent possible, thus decreasing dependence upon the limited resources of the traditional pulp-producing regions.

3. World-Wide Paper Consumption Trends

Table I, showing paper consumption in a selection of areas of the world, and Table II, showing per capita consumption in various countries of the world, are given on the next four years. During the years since World War II, a number of factors have served to restrict the supply and consumption of paper in many countries. The most important of these factors have been the shortage of traditional pulpwoods and fuel on the one hand, and inadequate foreign exchange resulting in import restrictions on the other. As a result, some important paper-consuming countries have only recently attained their own pre-war per capita consumption figures. Had it not been for these shortages and restrictions, consumption of paper all over the world since the war would have increased to a much greater extent. Actually, there has been a steady increase in consumption in almost all countries of the world, year by year, especially during the last six years. As the economies of various countries of the world expand, the possibilities for world consumption of paper will continue to increase almost indefinitely.

It is evident that if the North American rate (which continues to rise) is to be even remotely approached elsewhere in the world, the requirements for fibrous raw material will be correspondingly great. To meet such a demand, all possible raw materials, wood and otherwise, will be needed.

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TABLE I

TOTAL PAPER EXCLUSIVE OF NEWSPRINT - GEOGRAPHIC AREAS AND WORLD TOTAL (PLUS WORLD NEWSPRINT AND PAPERBOARD TOTALS) '000'S METRIC TONS

Capacity, Production, Imports Exports and Apparent Consumption, 1958-1961; Projected 1962-1963

	1958					1959				
World Areas	Capacity	Production	Imports	Exports	Consumption	Capacity	Production	Imports	Exports	Consumption
United States	12,544.6	10,679.4	92.5	188.7	10,583.3	13,071.6	11,926.7	123.4	176.9	11,873.2
Canada	815.6	684.9	31.7	102.5	614.2	820.1	749.3	30.8	121.6	658.6
Mex., Cent.Am., Carib.	316.3	263.7	50.3	.09	313.9	338.0	281.7	45.3	--	327.0
South America	776.5	694.1	136.7	.6	830.1	829.4	748.1	115.6	.36	863.3
Free Europe	9,436.5	8,573.2	1,158.7	1,792.8	7,939.1	10,118.4	9,294.6	1,386.0	1,773.0	8,907.7
Africa	213.5	164.7	223.9	9.7	378.9	215.5	173.9	218.4	9.6	382.8
Near East	45.1	40.1	74.8	.09	114.8	48.6	43.9	87.7	.18	131.4
Far East	2,248.9	1,986.6	354.3	96.9	2,244.0	2,804.1	3,337.5	374.2	115.8	2,688.7
Communist Bloc	4,477.4	4,073.8	162.3	147.1	4,089.0	4,845.7	4,528.8	149.2	324.2	4,353.4
TOTAL	31,942.3	27,115.1	2,285.5	2,338.5	27,152.8	33,091.6	30,278.2	2,530.9	2,440.5	30,374.4
Newsprint	14,100.6	12,002.7	6,779.8	6,743.8	12,038.7	15,262.4	12,965.0	7,077.9	7,122.7	12,902.2
Paperboard	26,034.8	21,494.2	1,212.6	1,211.2	21,495.6	28,181.7	23,650.6	1,282.1	1,378.1	23,554.7
World Paper & Board	72,077.8	60,612.0	10,277.9	10,293.6	60,687.1	76,535.6	66,893.9	10,891.0	10,941.4	66,843.5

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TABLE I (Cont.)

TOTAL PAPER EXCLUSIVE OF NEWSPRINT - GEOGRAPHIC AREAS AND WORLD TOTAL (PLUS WORLD NEWSPRINT AND PAPERBOARD TOTALS) '000'S METRIC TONS

Capacity, Production, Imports Exports and Apparent Consumption, 1958-1961; Projected 1962-1963

	1960					1961				
World Areas	Capacity	Production	Imports	Exports	Consumption	Capacity	Production	Imports	Exports	Consumption
United States	13,704.8	12,150.8	112.4	192.3	12,071.0	14,256.4	12,417.5	107.9	187.8	12,337.7
Canada	876.3	769.3	29.0	136.1	662.2	997.0	814.7	29.0	106.1	733.0
Mex., Cent.Am., Carib.	379.2	315.8	54.9	.09	370.6	417.5	349.9	47.6	.27	397.3
South America	879.5	774.2	111.4	.18	885.5	935.6	898.9	136.7	.27	1,035.4
Free Europe	11,222.2	10,452.1	1,676.3	2,041.7	10,086.8	12,027.9	11,017.1	1,945.4	2,149.3	10,813.2
Africa	222.5	202.6	284.9	11.2	476.2	248.0	219.3	284.3	12.6	491.1
Near East	59.7	51.8	90.2	.36	141.7	78.2	64.7	91.6	1.5	154.8
Far East	3,140.4	2,835.2	404.6	166.7	3,073.1	3,625.7	3,306.7	508.1	214.3	3,600.5
Communist Bloc	5,585.1	5,190.7	177.4	350.9	5,017.2	5,884.4	4,469.4	260.8	626.1	4,104.1
TOTAL	36,069.9	32,742.5	2,941.4	2,890.6	32,793.2	38,470.8	33,553.8	3,411.6	3,298.3	33,667.0
Newsprint	15,752.2	13,828.3	7,529.8	7,495.6	13,862.5	16,479.2	14,311.9	7,688.8	7,632.9	14,367.9
Paperboard	29,552.4	25,099.4	1,492.6	1,594.5	24,997.6	31,305.7	26,980.9	1,629.7	1,876.9	26,733.7
World Paper & Board	81,374.6	71,670.3	11,963.9	11,980.7	71,653.3	86,255.7	74,846.7	12,730.1	12,808.2	74,768.6

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TABLE I (Cont.)

TOTAL PAPER EXCLUSIVE OF NEWSPRINT - GEOGRAPHIC AREAS AND WORLD TOTAL
(PLUS WORLD NEWSPRINT AND PAPERBOARD TOTALS) '000'S METRIC TONS

Capacity, Production, Imports Exports and Apparent Consumption, 1958-1961; Projected 1962-1963

	1 9 6 2					1 9 6 3				
World Areas	Capacity	Production	Imports	Exports	Consumption	Capacity	Production	Imports	Exports	Consumption
United States	14,895.1	13,036.2	127.0	201.4	12,961.8	15,447.5	12,945.5	127.0	204.1	13,276.7
Canada	942.6	843.7	29.0	149.7	723.0	962.5	860.9	29.0	149.7	740.3
Mex., Cent.Am., Carib.	439.1	374.6	49.1	1.9	421.8	499.0	431.8	50.7	6.4	476.1
South America	1,041.3	995.4	134.4	.45	1,129.3	1,138.2	1,074.8	126.7	2.0	1,199.6
Free Europe	12,603.7	11,495.0	1,994.7	2,254.1	11,235.7	13,288.2	12,240.5	2,085.3	2,403.9	11,922.0
Africa	282.2	269.7	229.2	10.3	488.6	389.4	308.4	211.3	13.5	506.2
Near East	94.2	78.6	106.0	2.0	182.5	109.5	93.1	118.9	3.0	209.0
Far East	4,154.9	3,581.7	539.9	226.8	3,926.8	4,566.5	3,997.2	576.1	237.1	4,336.2
Communist Bloc	6,714.5	4,913.7	193.0	466.3	4,640.4	7,638.1	5,741.9	197.6	422.7	5,516.8
TOTAL	41,167.7	35,621.3	3,402.4	3,333.8	35,689.9	44,038.9	38,102.5	3,522.7	3,442.5	38,182.7
Newsprint	17,309.2	14,524.3	7,640.5	7,565.9	14,598.9	18,035.7	15,106.0	7,842.7	7,847.2	15,101.5
Paperboard	33,040.9	28,989.5	N.A.	N.A.	1,356.3	34,961.5	31,211.3	N.A.	N.A.	30,654.3
World Paper & Board	91,517.7	79,135.2	N.A.	N.A.	78,860.7	97,036.1	84,419.8	N.A.	N.A.	83,938.6

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TABLE II

PER CAPITA PAPER CONSUMPTION IN VARIOUS COUNTRIES

	Per Capita Consumption in Kg. 1962		Per Capita Consumption in Kg. 1962
United States	205.5	Greece	13.0
Canada	133.8	Taiwan	10.9
Sweden	127.9	Lebanon	10.9
United Kingdom	105.7	Brazil	10.0
Netherlands	105.2	Malaya	10.0
Switzerland	105.2	Philippines	7.6
Denmark	99.8	U.A.R.	6.8
New Zealand	90.3	Algeria	5.0
Norway	88.9	Morocco	4.5
W. Germany	84.4	Turkey	4.0
Australia	82.1	Tunisia	3.7
Finland	78.0	Senegal	3.1
Belgium	68.9	Thailand	2.8
France	64.1	China (Mainland)	2.7
Japan	64.1	So.Vietnam	2.6
Italy	39.4	Malagasy	2.1
Hong Kong	33.3	Burma	1.4
Israel	30.4	Cambodia	1.2
Singapore	24.0	India	1.2
Poland	23.2	No. Korea	1.0
Cuba	21.7	Saudi Arabia	0.8
U.S.S.R.	16.1	Indonesia	0.5
Mexico	15.3	Ethiopia	0.3
Yugoslavia	15.0	Afghanistan	0.1
Spain	14.3		

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4. The World Fibrous Raw Material Situation

In the past, more than ninety per cent of the world's cellulose pulp production has been centered in five countries of North America and Northern Europe. As a result of this situation, the rest of the world found it necessary to depend upon these few countries for adequate supplies of coniferous (i.e. long-fibered) pulps.

It is being realized more and more that this dependence on a few countries for market woodpulp has tended to hold back the development of cellulose pulp production in other countries of the world. It is also being realized that the conifer forest resources of the Northern Hemisphere are by no means inexhaustible, and that they cannot be depended upon to supply the raw materials for the whole world in the more distant future.

Furthermore, it must be recognized that more of the easily accessible coniferous pulp wood will be required for mills now in existence or under construction. As new mills are built in the Northern Hemisphere in the future, it will become necessary for them to go to more inaccessible areas, establish complete communities and perhaps be confronted with high capital expenditure and operating costs due to the more remote situation. Naturally, this will result in greater difficulties for the countries which do not have their own resources of papermaking pulp.

A world-wide average increase of only 4.5 kg per capita would necessitate twenty million cords of wood or twenty million tons of some other fibrous raw materials, such as local grass or straw. Certainly the coniferous wood now available could not provide the raw material for increases of this order.

Confronted with this problem, world authorities in the pulp and paper field have concluded that the solution is to be found not in the continued use of the traditional coniferous woods but in the localized development of the use of hitherto undeveloped sources. As a result, world-wide research into the development of new raw material sources has received a great impetus, and a challenge to the dominance of the coniferous woods is well under way.

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World needs for wood pulp may be expected to grow merely on the simple basis of the continued growth of population and rise in living standards. Thus, if some countries now consuming small amounts of cellulose pulp begin to raise their per capita demand appreciably, then woodpulp is likely to be in short supply.

In Government circles, this problem is being examined extensively both nationally and internationally. It is being prompted by the Food and Agricultural Organization of the United Nations, the United States Agency for International Development, the United Nations Technical Assistance Administration, the Export-Import Bank of Washington, the World Bank, and the industrial development banks of the various countries, as well as by other organizations all over the world.

It will be appreciated that the Project which is the subject of this Study must be considered against this background of the world cellulose pulp situation as outlined above.

The foregoing figures for 1963, (Tables I and II), give the approximate total and per capita consumptions of paper and board for a number of relevant countries and regions. The data show that the North American Continent is far ahead of all the other regions in the latter respect, with the major European countries such as Sweden and the United Kingdom around rather less than half of the maximum figures. In relation to these, Thailand is far behind, but the significance of these figures is discussed fully below.

There is every reason to believe that the countries with low consumptions will gradually tend to move towards the maximum recorded (i.e. the figures for the United States), and that at the same time the consumption of the United States will itself increase progressively. There seems every indication, therefore, that there will be a progressive increase in paper and board consumption throughout the world for many years to come. This applies particularly to those countries which are already developing industrially and yet have at present a low paper and pulp consumption compared with the United States. Thailand is a notable example of a country in this category.

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The tables of Appendices Nos. II, III, and IV show the trends forecast by the Food and Agricultural Organization of the United Nations Organization for the next five and fifteen years. These data, which were published in 1960, are based partly on the national increase in population of the countries concerned and partly on the forecast rise in the standard of living which, experience has shown, runs parallel with paper and board consumption.

5. World Fibrous Material Supply for Pulp and Paper Manufacture

In the world as a whole there is an abundant supply of fiber suitable for the manufacture of some kind of paper. The statistics of supply would attain astronomical levels if they were known, for today practically every kind of vegetable growth can be a source of fiber for papermaking.

The problems which arise are mainly due to unequal geographical distribution of fibrous materials. This problem, though less acute today than it was a decade ago, is difficult principally because of disparities in the economies of the different countries of the world.

The principal source of papermaking fiber is, of course, wood. Until recently the coniferous species alone were considered suitable for most pulps. The sulfate process has relatively recently been adapted to hardwoods and, furthermore, other new and quite revolutionary methods and equipment have been discovered and developed for pulping hardwoods. Although hardwood pulps cannot be considered the equals of coniferous pulps for all purposes, they are, nevertheless, proving satisfactory substitutes for many purposes. They are destined for a much more exalted status in the future of pulp and papermaking.

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Technology has also opened the way to the use of other, non-woody vegetable materials such as bagasse, bamboo, straws, grasses, and even reeds. Some of these materials have been recognized as pulpable for well over a century, and some (particularly cereal straws) have at one time or another been used extensively for paper manufacture. Straw is now an important source of fiber in many countries, as in the Netherlands. Bagasse, esparto, the hemps, bamboo, and a long list of other materials have established their suitability for certain purposes in many countries.

Fears of world shortages of papermaking fiber as expressed several years ago were based on the availability of coniferous wood. Such fear is no longer justified on a world-wide basis because the great and growing use of intermediate length fiber from hardwoods, bagasse and bamboo is relieving the pressure on long fibered pulp. Also, recent appraisals of existing supplies of conifers in both Europe and North America show larger existing stands than were found in former surveys, and the increased integration of pulp and papermaking and manufacture of other wood products enable the wastes from other wood-using industries to go to the pulp mill. Added to this is the improvement in forestry husbandry which promises more cords of pulpwood per land unit, in shorter growth cycles and probably at lower cost.

To the extent that they are available the statistics indicate that the resources of materials for medium and short fibered pulp are very much greater than for long fibered pulp. Moreover, the geographical distribution of the short fibered material is wider.

The conifers, the principal source of long fibered stock, are located largely in the North Temperate Zone. The occurrence of conifers in South America, Africa, Asia and the Pacific Area is limited not only by nature but also by former uses for them. For instance, much of the original stand of Parana pine in Brazil has been cut over for lumber, and the availability of accessible stands for pulping is at the present time relatively minor. However, in New Zealand, Australia, Chile and South Africa, Insignis pine plantations are successfully supporting substantial pulp and paper operations; so substantial,

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in fact, that New Zealand and Chile are well on the road to self-sufficiency. Some 50,000 hectares of planted conifers in Indonesia indicate the possibilities of providing long fiber pulp woods even in the tropics.

Associated with the technological improvement and development of pulping processes for hardwoods and for bagasse, and other fibers, is a growing awareness on the part of paper makers that for many papers such as printing, writing and sanitary papers, medium length fibers used alone or with fortification with long-fiber pulp will produce satisfactory results.

6. Fiber Supplies in the World Regions

These developments are extending the supply of fibrous materials in the older papermaking regions of the world and are opening up possibilities of domestic manufacture in the many new regions. There are, in fact, few areas in the world today which do not possess some fiber which can be used economically to manufacture domestically a large part of home requirements. The position, by continents, is summarized below.

(a) North America

North America has a forest area of 720 million hectares according to the FAO, of which about half is considered accessible. On these lands, which comprise 32% of the total land area, a wide variety of conifers and the full complement of temperate zone hardwoods can be found. At the North, in Canada, parts of eastern United States and Alaska, are the spruces, firs and hemlocks which are suitable for all kinds of long-fiber pulp. On the western coast are hemlocks, firs and pines which support one of the World's largest concentrations of pulp and papermaking. In the Southeast, the Southern pines, pulpable by the sulfate and groundwood processes, support the world's largest production concentration of wrapping paper and strong boards and, more recently, of other grades of paper and board as well. In southern Canada and throughout

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eastern United States there are large stands of hardwoods. These range from the poplars, which grow up on the pine lands of the North after logging and subsequent burning, to predominantly beech, birch and maple forests of the North and the gum swamps and scrub oak uplands of the South. In all of these regions pulp and paper are now being made.

Canada can double its present production of newsprint paper and of market wood pulp, according to the findings of the Gordon Commission. Although part of this possible expansion would be for home use, the larger part would be available for export. Canada, in fact, may well become the world's largest supplier of long fiber.

The supply situation in the United States is now viewed with more optimism than it was a few years ago. A recent examination conducted by the United States Forest Service revealed that the United States has sufficient forest land to support any foreseeable home demand, that it has enough current available forest supply to support its present forest industries, and that its future wood requirements can be met if the forestry services are expanded accordingly.

In addition to virgin woodpulp, North America possesses a vast supply of waste paper, enough to supply up to a quarter of its paper production requirements. It also has other materials such as agricultural residues (cereal and flax straws and bagasse) and industrial wastes such as hemp, jute and textile cuttings.

The United States has hitherto not been self-sufficient in woodpulp and newsprint paper. Actually, it has been the world's largest importer of these products and will undoubtedly continue to be an importer but on a gradually declining scale. On the other hand, the United States exports a considerable tonnage of woodpulp and paper of various kinds. Its future role as an exporter is probably limited

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to sulfate woodpulps and to strong wrapping paper and container and similar boards for packaging purposes. It is unlikely that exports of other grades will become more important than they are at the present time.

(b) Europe

The total forest area of Europe, practially all of which is accessible, amounts to 108 million hectares. Of the 105 million hectares of accessible forest land, 63 million hectares are listed as conifers and 42 million hectares as hardwoods.

The European forests are similar in character to those of eastern North America. At the north and in the highlands of the continent are the softwoods: spruce, fir and Scotch pine. Fringing the conifers in the north and extending widely across central Europe are the hardwoods. Both types have been under increasingly intensive forest management for many generations, which in the case of softwoods has been directed more and more toward the production of pulp wood.

Recent surveys in Sweden and Finland have revealed substantially larger pulp wood supplies than were thought to exist. Announced plans indicate that a considerable part of new production will be converted into paper for domestic use and for export. However, the plans also call for large increases in exportable pulp, especially the strong chemical grades. The pulp countries of Europe producing surplus pulp have been Sweden, Finland, Norway, Austria and Czechoslovakia. Before the last war, Germany, Poland, Estonia, Austria, Latvia and Lithuania were able to meet their own wood requirements and provide enough to support some export trade in woodpulp, paper and other wood products. Of these countries, Austria alone exports at the present time. The statistics quoted earlier in this report indicated that Europe as a whole is approaching a balance in its woodpulp and paper production and consumption. To the extent that these new

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plans are put into effect, it appears possible that Europe can maintain its role as a world supplier of woodpulp, newsprint and other grades of paper for some time yet.

Most of the rest of the countries of Europe depend to varying degrees upon imports of wood and products of wood. Their forest supplies are not sufficient to meet domestic needs. Each country has, since the war, reexamined its wood situation with a view to reducing the necessity for imports. The Netherlands, in particular, has increased its use of cereal straw for paper and board, and is now exporting substantial tonnages to other European countries. France has gone extensively into pulping hardwoods and resinous pines. In Rumania, Hungary and Russia, reeds are being pulped in increasing quantities.

The use of waste paper to supplement other papermaking fibers is, of course, extensive in Europe. In some countries other fibers are used, especially esparto for the production of fine book papers in England and France. This grass is imported from Northern Africa.

The use of hardwoods is increasing in Europe as it is in North America. In the countries possessing existing pulp industries, expansion of hardwood pulping can be expected. In other countries the use of hardwoods may be difficult, except in small cold soda and semi-chemical mills which are economical in much smaller sizes than with the conventional chemical processes.

Although North American exports are increasing and yearly are claiming a greater share of the world market, Europe and in particular Scandinavia still remains the chief supplier of export woodpulp and paper. If, in the future, European consumption should begin to exceed its supply of woodpulp, Europe will find bridging the gap in supplies by use of other fibers difficult and it may become an importer of pulp. This could take the form of the development, by European capital, of

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pulp facilities in other parts of the world, in the tropics, for instance. An element of uncertainty is introduced into these forecasts by the implications of the European Common Market developments, and in particular the as yet unsolved problem of whether Great Britain will join this customs union. If this is not done, then it is highly probable that the Scandinavian countries will convert increasing quantities of their woodpulp production into paper which can be exported to Britain under more advantageous customs duties than apply to the six countries at present comprising the Common Market. This could mean less pulp available for export from Scandinavia, and the whole pattern of the pulp and paper industry (export and import) in Europe could thereby be modified considerably.

(c) The Soviet Union

In the Soviet Union, 34% of the land area is in forest. Much of this huge area is inaccessible at present. Of the 420 million hectares considered accessible, 297 million hectares of conifers and 50 million hectares of hardwoods are under exploitation at present.

For the time being the Soviets have little reason to consider hardwoods for pulp except for special papers. They have vast areas of conifers, mostly spruce and fir (with some pine in the south) which can be used for conventional chemical pulps. The potential is very large, but although the production and consumption of woodpulp and paper in the Soviet Union has grown very rapidly in recent years, little production purely for export has resulted. Whether the Soviets will enter seriously into world competition in pulp and paper is not yet known.

In a country so vast as Russia, with a large but scattered population, there is some possibility of the development of a paper use pattern similar to that of the United States, with the exception of advertising. Packaging for transportation of consumer goods could use

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large quantities of paper and paper board in the future. This is a possibility which can be expected as the standard of living rises.

Generally it has always been held that the problem of transporting woodpulp and paper products from far inland forest areas to tidewater for export would handicap the Soviet Union in developing a world trade. This may be the case in the North, but recent information indicates that there is a substantial development of paper and pulp manufacture in the South where there are tidewater ports. Some export trade may originate from this area.

(d) Africa and Asia

Africa and Asia are predominantly hardwood regions. Africa has a total forest area of 800 million hectares of which 282 million hectares are accessible and one 107 million hectares are under exploitation. All but 2 million hectares of the exploitable forest is hardwood. Free Asia has a total forest area of 420 million hectares, 264 million hectares of accessible forest, and 94 million hectares of forest under exploitation. Asia also has only 2 million hectares of coniferous forests. In the Asiatic countries in the Soviet Bloc there is an area of 36 million hectares of exploitable forest, of which 28 million hectares are of softwoods.

These forests are principally typical multi-species forests of widely ranging wood densities and other characteristics. They are also forests with occasional large trees in dense stands of small trees of little real value. Whether these natural forests will prove to be economic for any sort of operation is questionable. It is likely that in the future, and as demand occasions, they will be cleared and the land subsequently planted with single, fast-growing species or simple mixtures designated for specific purposes. Under such conditions much of the forest land in both Africa and Asia may well prove capable of

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producing fiber on very short rotations and at high yields per hectare.

The existing indigenous forests are not likely to support pulp and paper production for export. They may be used to a limited extent for domestic production. However, plantation forests in these regions may become important to provide export pulp and paper in the more distant future.

In Africa as well as in Southeast Asia, bagasse for medium length fiber, rice straw for short fiber, and bamboo for long fiber can easily become the sources of complete paper supply for many countries. It is even possible in some cases that other long fibers such as ramie, kenaf or sisal could be made available, and that no strong pulps from other parts of the world would be needed for domestic supplies. The prospect of such combinations for export appears doubtful within the foreseeable future, for they would be competing against combinations of like nature from South America, and with the plentiful supply of short and medium hardwood fiber in the northern countries.

(e) Central and South America

Over 40% of the total land area of 2 billion 22 million hectares in Latin America is classified as forest land; 310 million hectares are accessible and only 78 million hectares are under exploitation. Some 10 million hectares in the exploitable forests are coniferous, and the rest, 68 million hectares, are tropical hardwoods. The softwoods occur in the highlands of Central America, in southern South America and in the Parana pine plains of Brazil. The softwoods of Mexico are being pulped to an appreciable extent at the present time. The Parana pine of Brazil is suitable for strong pulps, but the merchantable supply within reasonable proximity to logical mill sites is not sufficient to support but a few operations of economic size.

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In Chile, plantation Insignis pine is being pulped in sufficient tonnage to supply domestic markets and to provide considerable excess for export. It is expected that the large stands of this plantation pine will form the basis of a major export industry for Chile in the future.

In Brazil, Argentina and Chile, various hardwood species have been planted and are now being used for pulp. In Brazil, eucalyptus grows well and is a dependable source for short-fiber pulps.

In Argentina, willows and poplars have been planted extensively and they are now being used for short-fiber pulps. In neither Brazil nor Argentina are there plantations of pine and other conifers ready yet for pulping, although in both countries plans have been proposed for relatively large scale planting of pine.

In Central America and parts of South America there are supplies of long-fiber plants of the hemp family, which are being used in one case to make paper. There are other plants also which under suitable circumstances could supply now a limited quantity of long-fiber pulp and much larger supplies after cultivation.

In much of Latin America the difficult technical problems of pulping local hardwoods of many species, and the equally difficult economic problem of clearing land and planting single fast-growing species, can be (and is being) avoided by pulping bagasse. Certainly in Cuba, the lowlands of Central America, in Peru, and in Northern Argentina where it is available, bagasse offers the quickest and by far the least expensive means of obtaining medium length fiber suitable for printing, writing and wrapping papers with little if any fortification with long fiber; for strong papers it is fortified with locally grown long fiber, such as sisal, and long fibered wood pulps, such as Parana pine in Brazil and Insignis pine in Chile, as well as with imported pulps from the Northern Hemisphere.

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7. General Conclusions

It is evident from the above brief survey of the world background of the pulp and paper industry, that the following main conclusions apply:

(a) There is a considerable potential for the development of pulp and paper production throughout the world. In the case of the developing countries this is almost without limit.

(b) There is abundant fibrous raw material for the above purpose for many years to come, probably in perpetuity.

(c) This fibrous raw material is not necessarily of the traditional long fibered coniferous type. New methods of processing have enabled a wide variety of alternative fibers to be used, despite the fact that these are medium or short in fiber length.

(d) In consequence, there will be an increasing trend for developing countries to become self-supporting in respect to their pulp and paper requirements.

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B. The Paper Industry and Market in Thailand

1. General Comments

The Market Study was primarily concerned with the four general grades of paper products used in the packaging industry in Thailand and which are to be manufactured by the proposed mill.

All four are types of "brown" or kraft paper, so-called because no bleaching is required of the pulp from which they can be made. These grades are described briefly as follows:

(a) Kraft Paper Used for Paper Bags and Paper Sacks

This grade includes the heavier grades of basis weight 70 to 100 g/sm used in the manufacture of multi-wall sacks for cement, fertilizer, tapioca and other similar products, and the lighter grades of basis weight 60 to 80 g/sm used in the manufacture of paper bags used commercially.

(b) Kraft Liner Board

This product is a heavy paper or light board of basis weight 120 to 135 g/sm, made from kraft pulp, and is used in the manufacture of corrugated boxes for shipping cartons. The box consists of a layer of corrugated material sandwiched between an inside and outside layer of kraft liner board. This type of fabrication gives a paper box board which is a very strong and resistant material ideally suited to carton manufacture.

(c) Corrugating Medium or Board

This material is a low-grade thick paper or thin board of basis weight 70 g/sm. It is the center portion of the three layers described above. Its purpose is to keep the liners separated to form the structural member. Therefore, its stiffness is of greatest importance.

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Corrugating medium, comprising twenty-five to thirty-five per cent by weight of ordinary carton fiber board, is not necessarily made from kraft pulp because stiffness can be obtained with lower quality pulps. Thus, short fibered raw materials may be used, such as mixtures of bagasse pulp and waste paper, or semi-chemical pulp.

(d) Miscellaneous Kraft Wrapping Papers

These grades are made in weights of 40 to 220 g/sm and include various brown wrappings which are used in commerce and industry. Some of them are made of kraft paper and others, the so-called "imitation kraft," use lower strength raw materials. The latter are cheaper products, often containing waste paper, but they are nevertheless important to the economy of a paper industry because they can comprise a large proportion of the wrappings used. The fact that they are weaker than kraft does not mean that they are not suitable for the purpose for which they are used. In many cases, their quality can be increased, such as by the inclusion of wet strength resins, which prevent a bag made from even relatively weak materials from breaking in use when wet.

The preceding four categories describe the basic types of paper to be produced by the kraft project being contemplated for Thailand. The following Market Analysis will, therefore, concern itself primarily with the present, past, and future consumption of these four types, so that the total capacity and future production schedule of the proposed kraft project can be reliably established.

In approaching a problem of this kind, the conventional method is to plot the consumptions of the various types of paper and board in use for some years prior to the date of the study, and then to extrapolate the resulting curve into future years. In this way, it is usually possible to obtain an approximate indication of the likely consumption of the different types of paper products under consideration by the time the proposed mill is likely to start-up and at intervals subsequently. Due

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allowance must, of course, be made for abnormal circumstances, such as the establishment of a new industry using large amounts of one or two paper types, but influences of this kind usually result in the forecast figures being lower than the actual figures so that the former provide a margin of safety.

In this way, it is possible to ascertain in advance, with a fair degree of reliability, the size and type of mill which should be built at a given time to best accommodate the qualitative and quantitative requirements of the country.

2. Sources of Market Information

Several basic sources of information have been used for the following market study.

(a) Thai import statistics, as published by the Department of Customs in monthly and annual Statements of Foreign Trade, 1962;

(b) FAO data, as published from the International Conference on Pulp and Paper Development in Asia and the Far East, Tokyo, Japan, October 17-31, 1960;

(c) Interviews with Thai manufacturers, importers, dealers and consumers of paper and board products, March-April 1963;

(d) Official publications and regulations of The Thai Revenue Department, the Ministry of Industry, The Department of Customs, and others.

3. Paper Production, Imports and Consumption in Thailand

(a) Domestic Production

Present domestic production in Thailand is approximately thirteen thousand tons (13,000) per year, broken down as follows:

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	Estimated Production 1963
(1) The Karnchanaburi Pulp and Paper Mill	3,000 tons
(2) Bangpa-In Mill	7,500 tons
(3) Three small mills	1,500 tons
Estimated Total Domestic Production	12,000-13,800 tons

A description of the above mills is as follows:

(1) The Karnchanaburi Pulp and Paper Mill

This mill is situated on the Mae Klong River, just below the junction of the two Kwai Rivers (see Map No. 1, and Section on Fibrous Raw Materials), and is approximately one hundred twenty kilometers (120 km) by road west of Bangkok.

This mill was started-up in 1936 under the auspices of the Thai Government and it was originally intended that the mill would run entirely on bamboo, drawn from the locality. For this purpose, some four thousand eight hundred square kilometers (4,800 sq km) of bamboo forest surrounding the mill site were set aside as a reserved area. For reasons explained in more detail in Section V, the mill has not been able to make use of this reserved forest to the maximum extent possible. This is due partly to the fact that the bamboo occurs in admixture with other plants, particularly trees, but mostly due to the depredations of the local villagers and farmers, who have cut and burned large areas of stands of usable bamboo.

Around 1955, paper was being produced at Karnchanaburi from a mixture of seventy-five per cent bamboo pulp and twenty-five per cent local hardwood pulp of the Bombax species, which was found to be quite suitable. This local hardwood was also subject to

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depredations of local farmers, and the required quantities were difficult to obtain. Two or three years ago, the mill reverted to one hundred per cent bamboo pulp and, according to the latest information, (July 1963), is still operating on this basis.

Current output of paper is approximately ten tons per day. Plans are being considered to double this capacity, subject to the availability of sufficient supplies of bamboo.

The types of papers made by this mill are chiefly the cheaper grades of bleached writings and printings. A small amount of wrapping paper is also produced, largely for the mill's own use. An analysis of this wrapping paper, which was apparently made when imported hardwood pulp was being used, is given in Appendix V (Sample C). The very low strength properties (in spite of the presence of thirty per cent chemical wood pulp) should be noted. Apart from the small quantity of wrapping paper produced, the products of this mill are bleached grades of papers. The present activities of this mill, therefore, do not conflict with those of the project kraft mill, which is the subject of this Report.

(2) Bangpa-In Mill

This mill, also Government owned, is located east of Bangkok, on the Chao Phraya River, (see Map No. 1), which subsequently flows southward through Bangkok to the sea. The mill was started-up in February 1961, and uses a furnish containing approximately seventy per cent bleached rice straw with twenty per cent of imported chemical wood pulp to make white papers. The remaining ten per cent of the furnish is usually made up of the "broke" from the mill production. The paper machine makes a trimmed reel of paper 3.3 m wide at a maximum speed of 200 m per min.

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The capacity of the pulp mill is forty tons per day, using an eight-hour cooking cycle, but it is estimated that this could be raised to sixty tons per day, or, if a second paper machine were installed, the total capacity of the mill could be raised to one hundred tons per day. The obstacles to increased production are the digestion operation and adequate supplies of raw materials, rather than the paper machine speed. Further details regarding the site and method of pulping used at this mill are given in Section V and IX of this Report. The important point to note here is that this mill, like the Karnchanaburi mill, produces white papers almost exclusively and therefore does not compete in any way with the proposed kraft mill.

It is common knowledge that the Bangpa-In Mill is working under difficulties, especially with regard to supply of raw materials. (Daily production is currently at the rate of twenty-five to thirty tons per day.) And there are rumors of its passing out of Government hands and of possible developments which would result in higher paper production. Such developments would affect the project kraft mill only if it were decided to make brown (i.e. unbleached) types of paper instead of white papers. This possibility seems unlikely at present in view of the already existing facilities for making bleached pulp, and the higher selling prices of writings and printings as compared to wrappings.

(3) Other Mills

Southeast Asia Paper Factory,
Thonburi Province

This is a small factory utilizing various types of waste paper to produce one to one and one-half tons per day of low-grade gray cardboard.

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Asia Cardboard Factory

Also in Thonburi, this equally small cardboard mill is very similar in capacity and production to the preceding one.

Luck-Si Paper Factory

This Bangkok mill is said to produce about three tons per day of low-grade cardboard from waste paper.

Samsen Paper Factory
Bangkok

Recently damaged by fire, this small mill was not yet back in operation in the spring of 1963. It was listed by FAO in 1960 as a paper mill producing one ton per day of duplicating paper from waste paper.

The combined total maximum potential production of these four mills is therefore approximately two thousand tons (2,000) per annum. This is not considerable and it is mostly cardboard.

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(b) Imports

According to the latest statistics published in the "Annual Statement of Foreign Trade in Thailand," released by the Customs Department in August 1963, the total paper imports for 1962 amounted to 66,078 metric tons (see Appendix VI for Customs data.) Of the above amount, the following categories could be considered as falling within the kraft and packaging papers classification:

Code	Description	Imports for 1962 Tons
6410302	Paper, kraft	6,881
6410399	Paper, common, etc.	1,309
6410401	Cardboard, common	309
6410402	Cardboard, corrugated	31
6410499	Cardboard, n.e.s.	14,218
6410701	Paper, wrapping, oiled	35
6410702	Paper, adhesive	112
6411904	Greaseproof paper and paperboard	174
6411905	Composite paper or board, etc.	53
6411906	Paper or paperboard, creped, etc.	100
6411999	Paper and paperboard in bulk, etc.	1,629
6420101	Paper bags	2,660
6420102	Cardboard boxes	403
6420190	Other containers, of paper and board, n.e.s.	469
6420914	Articles of pulp, of paper, of paperboard or of cellulose wadding, n.e.s.	117
	TOTAL	28,500

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As is common throughout the world, the generalized Customs descriptions, with only one exception, do not specify whether the above grades of paper are actually kraft, or mostly kraft, or what other kinds besides kraft. The one exception, Code 6410302, "Paper, kraft," is quite definite. The second description, "Paper, common for packing and wrapping," does not make clear the proportion of kraft papers and imitation kraft papers in this category. Similarly, it is not clear whether "Cardboard, common" and "Cardboard, n.e.s." (not elsewhere specified) include kraft liner board or finished cartons. The remaining categories are listed in general terms because Customs are guided by the descriptions given on shipping documents, which are commonly general in nature. As indicated by the grouping of papers and board in Customs categories, coarse papers and boards are interchangeable.

A proper analysis can be made however by taking those categories into which the products of the projected mill could be classified, and adding their totals for the purposes of this Report:

Description	Tons
Paper, kraft	6,881
Paper, common, for packing and wrapping, n.e.s.	1,309
Cardboard, common	309
Cardboard, corrugated	31
Cardboard, n.e.s.	14,218
Paper and paperboard, in bulk, rolls or sheets n.e.s.	1,629
Paper bags	2,660
Cardboard boxes	403
Paper or cardboard containers, n.e.s.	467
TOTAL	27,907=
	28,000

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The above figure of twenty-eight thousand tons (28,000) is believed to represent the amount of imported paper consumed in Thailand in 1962 of the types and grades which could be met by the proposed mill.

C. Consumption

Paper consumption in Thailand in 1962 is indicated as being 80,000 tons by adding estimated domestic production to import totals. This represents an increase of more than 8,000 tons over the previous year, and brings the average yearly increase since 1955 to approximately 6,000 tons per year. Allowing for the average yearly increase, estimated consumption for 1963 is a minimum of 86,000 tons. The following table gives paper consumption totals for the years 1955-1963.

Year	Total Tons
1955	38,440
1956	34,800
1957	47,790
1958	47,250
1959	55,280
1960	58,590
1961	71,765
1962	80,000
1963	86,000 (estimated)

Source: FAO, and "Pulp and Paper 1962 World Review"

Based on consumption data through 1959, projections into the future were made by FAO in 1960, which forecasted that paper consumption in Thailand would reach 90,000 tons per year by 1965 and 201,000 tons by 1975. These projections were formulated on the basis of the Log Normal Demand Function as described in the FAO report entitled, "World Demand for Paper to 1975" (FAO, Rome 1960). The base year for the projection was taken as the average apparent consumption for the years 1957 and 1958 (47,520 tons) which appeared to be the most normal consuming year and represented points close to the trend line for growth rate of consumption. At that time, the population in Thailand was estimated to be about 21.88 million, the population growth rate was calculated at two per cent per year, and an expected per capita income

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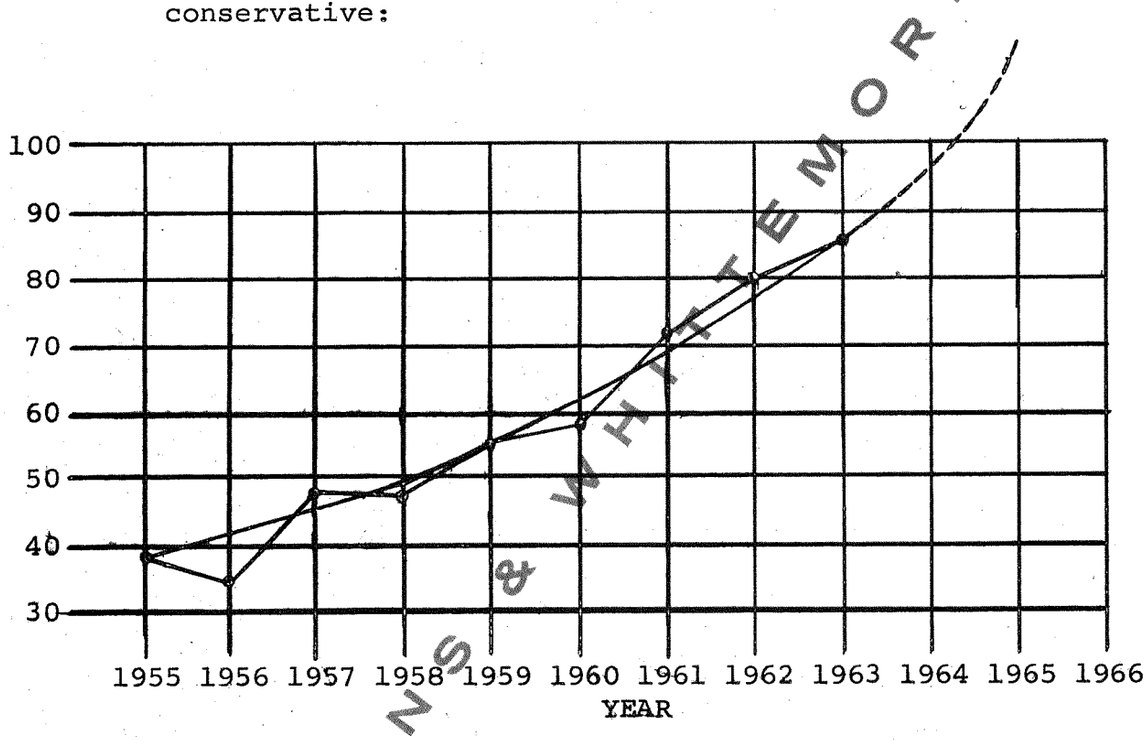
growth rate of three per cent per year was used, based on the World Bank Report on Thailand for real income growth per capita per year, 1952-1957.

Compared graphically with actual consumption totals, the FAO predictions of 1960 appear to have been too conservative:



Taking into account the consumption data for 1960-1962, the new line indicates a consumption in 1965 of about 110,000 tons. One factor explaining the higher figure is that previous estimates of the population were low. In 1962 a revised estimate gave the total population as 29,000,000 people. Another factor is that per capita income, increasing from B.1869 to B.2184 between 1960 and 1962, has risen faster than expected. A third reason is that many smaller industries have been established in Thailand since 1959 under an expanded economic development program. These firms, producing cosmetics, detergents and soaps, flashlight batteries, cigarettes, pharmaceuticals and dried foods, have greatly increased the need for paper, especially packaging materials. A fourth reason for the rapidly increasing rate of paper consumption in Thailand is the fact that consumption totals in all of Southeast Asia are very rapidly growing. Coefficients based on the conservative population and per capita income growth estimates previously mentioned foresaw consumption almost doubled

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by 1962 over the 1957 levels, and quadrupled by 1975 for the entire Southeast Asia area. Expressed in another way, whereas world consumption is increasing at a dramatic rate, from 66.8 million tons in 1958 to 93.1 million tons in 1963, Asia's share of this increase is also rising, from 9.5% of world demand in 1957 to an estimated 17.75% in 1975 and the sub-region of Southeast Asia is expected to maintain its present 2.4% share of the total Asia and Far East consumption. Thailand, a fortunate exception in Southeast Asia due to its political stability, hard currency, enlightened investment policies, steady growth rate of 4.5% per year, surplus of basic foodstuffs, and lack of a pressing population problem, is expected to also increase its share of the growing regional market, from 29.4% in 1958 to a considerably higher figure by 1975 if Thailand's relative prosperity continues.

D. Total Consumption of Papers for Packaging in Thailand

On the basis of imports of 28,000 tons in 1962 of the grades of papers proposed for the new mill as discussed previously, and the domestic production of "brown papers" and low-grade "cardboard" of 2,000 tons per year, there appears to have been a consumption of at least 30,000 tons of kraft or kraft-type paper products in Thailand in 1962. This represents 37.5% of the total paper consumption.

At this percentage and based on a conservatively projected total consumption of paper of over 100,000 tons by 1965, and over 200,000 tons by 1975, kraft or brown paper consumption will total over 37,500 tons by 1965 and over 75,000 tons by 1975. These estimates are all the more conservative if it is recalled that the proportion of paper board and brown wrappings tends to increase to over 50% of total paper production as industrialization and higher per capita income increase. In the United States, for example, approximately 18 million tons of the total woodpulp capacity of 32,245,000 tons is in kraft pulp production and over 16 million tons out of 34 million tons of production is in paper board (see Table III). It can therefore be expected that the consumption of kraft-type products in Thailand will be at least 45,000 tons per year by 1966, and climb to over 90,000 tons by 1975.

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TABLE III

UNITED STATES PAPER AND PAPER BOARD PRODUCTION

1962

GRADE OF PAPER	1,000 METRIC TONS	
Newsprint	1,884	
On machine-coated paper	1,842	
Groundwood, uncoated	831	
Book paper, uncoated	1,845	
Fine paper	1,811	
Special industrial paper including absorbent paper	824	
Sanitary paper	1,984	
Tissue paper except sanitary and thin	228	
Coarse wrapping and packaging papers	3,714	
Total	14,963	
PAPER BOARD		
Container board*	9,124	
Folding boxboard, except special food board	2,692	
Special food board	1,508	
Set-up boxboard	569	
Special paper board	2,151	
Wet machine board	121	
Total	16,165	
CONSTRUCTION PAPER AND BOARD		
Construction paper	1,330	
Construction board	1,542	
Total	2,872	
GRAND TOTAL		34,000

*Includes liners, corrugating and chipboard

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This conservative estimate of 45,000 tons by 1966 has largely determined the size of the projected mill.

E. Kraft Paper and Board Consumers in Thailand and Production Schedule of the Proposed Paper Mill

As previously explained, the rather vague classifications of imported paper make it difficult to determine the amount of each major type of kraft-type product to be produced by the projected mill. In order to determine the specific needs of the market in the years 1966-1967, and design the mill equipment accordingly, the major consumers of kraft-type products were interviewed. In addition, large importers and dealers were also contacted as a supplementary source of information, especially regarding prices, duties, grades and other marketing information. The results of these interviews are presented below:

1. S. R. Tapioca Co. Ltd. (Tapioca Flour and Milk)

This company is presently using 40,000 kraft sacks per month; 30,000, imported largely from Scandinavia, for export, and 10,000 for domestic shipment. The sacks for export are 40 in. x 22 in. x 4 in., 6-ply and weigh 0.6 kg each. The first ply is 85 g/sm, the other five plies are of 70 g/sm.

The domestically marketed bags are purchased locally, and are 37½ in. x 19½ in. x 4 in.; all plies are of 70 g/sm.

On the above basis, it is estimated that the amount of kraft paper presently used by this company is 500,000 bags x 0.6 kg = 300 tons per year.

S. R. Tapioca also uses 50 fiber board cartons per day, containing 24 milk bottles each, for a total of approximately 15 tons per year.

Total exports of tapioca flour were 110,000 tons in 1962, shipped largely to the United States. Of this total, at least 25,000 tons were exported by this company alone. It is expected that this level will be maintained in the future, with possibly an additional 30,000 tons going to Japan.

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2. Tai-Wah Trading Company (Tapioca Flour)

This company uses 100,000 to 150,000 imported kraft sacks per month measuring 39 in. x 19 in. x 4 in., six ply, 80 g/sm per ply, weighing approximately 0.5 kilo each, for a total of 600-900 tons per year. Tai-Wah expects its needs to increase 20% by 1966. This firm exports roughly 60,000 tons of tapioca flour to the United States (out of a total of 100,000 tons to that country) together with S. R. Tapioca. Therefore, these two firms account for 85% of the 100,000 tons exported per year in paper bags. Total present kraft sack needs for the tapioca industry then amount to:

	Tons
S. R. Tapioca Co. Ltd.	300
Tai-Wah Trading Co.	600-900
Other	106-140
TOTAL	1,006-1,340 yearly

3. Siam Cement Co. Ltd. (Cement and Cement Products)

This large company presently produces 700,000 tons of cement per year, and uses 3,600 to 4,000 tons per year of kraft sack paper. It operates two sack-making machines to satisfy all of its own requirements, importing the kraft paper directly from the United States, Scandinavia and Japan.

The basic weight of the sack paper is 70-75 g/sm and this is delivered in 450-500 kg rolls, 101 cm wide, with 7.5 cm diam cardboard cores.

This company is building a new plant in South Thailand, which will produce 1,000 tons of cement per day by 1966, increasing its kraft paper needs to 7,000-8,000 tons per year.

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4. The Jalaprathan Cement Co. (Cement)

This is a Government operated company at Nakhonsawan, producing 600 tons of cement per day. Most of this production has been delivered in bulk to the Yanhee dam project at Tak, but this dam is nearing completion. Beginning in the summer of 1963, the 600 tons will be sold on the market. The company plans to make its own sacks, beginning with 500 tons in 1963, and will eventually require 1,500 tons per year of kraft paper, basic weight 75 g/cu m, on rolls 103 cm wide and 120 cm in diameter (maximum), with a 7.5 mm core.

Together with the Siam Cement Co., therefore, the cement industry will require 8,500-9,500 tons per year of kraft sacks by 1966.

5. Chemical Fertilizer Co. (Fertilizer)

This new company, under the control of the Government Lignite Authority will initially produce 45,000-60,000 tons of artificial fertilizer by 1966, and eventually will produce 120,000 tons per year, comprising 90,000 tons ammonium sulfate and 30,000 tons of urea.

The fertilizer will be packed as follows:

50, 30 and 20 kg in paper sacks;
50 kg in three-ply sacks;
30 and 20 kg in two-ply sacks.
The urea sacks will also have a polyethylene liner.

Based on 30 kg sacks weighing an average of .3 kg apiece, the sack requirements for 1966 will total 450 tons, rising to 1,200 tons thereafter.

6. Organic Fertilizer Plant (Fertilizer)

This modern garbage-converting plant is operated by the Municipality of Bangkok. At present, though gunny, paper and plastic bags are used, much of the product is shipped in bulk, and it is planned to increase such shipments. Difficulties have been experienced with paper bags due to moisture in the contents, so that plastic bags are favored for packaging.

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Only 36,000 bags are used presently, or about 12 tons of paper per year, but use of a wet-strengthened paper could rectify the present shipping difficulties and result in an eventual sack paper requirement of 1,000 tons per year. This cannot be relied upon at present however.

At any rate, the fertilizer industry will require approximately 500 tons of sack kraft paper by 1966, and up to 1,200 to 2,200 tons some time later.

7. Thai Glass Manufacturers (Glass Products, chiefly Bottles and Tumblers)

This company ships only its tumblers in paper board cartons, using approximately 100,000 cartons per year. It would prefer shipping bottles in cartons also but customers prefer wooden crates so that they can be stored outdoors.

The cartons used for tumblers have inner and outer walls having bursting strengths of 38 and 26 psi respectively. They are purchased from different box manufacturers, in ten different sizes; each carton holds one gross of each size tumbler.

This glass company foresees an annual increase in carton usage of 5% to 10%.

The tonnage consumed is considered under the Box Manufacturers.

8. Bogna Glass Works (Glass Tumblers)

This company is associated with the Navy Department, and has recently begun the manufacture of glass tumblers, so that its needs cannot yet be accurately estimated. Its bottles are transported in wooden crates. This tonnage is also considered later.

9. Raylam Battery Co. Ltd. (Batteries)

The total consumption of paper used in making the batteries of this company is 15 tons per month or approximately 180 tons per year. This is all imported directly except for about 25 tons of cartons which will also be included under totals for Box Manufacturers. Since most of the other papers used

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in battery manufacturing are of a special kind, they should not be included in a production program at this time.

10. Other Manufacturing Consumers

The remaining manufacturers visited, such as soap and shoe companies, breweries, and the Thai Tobacco Monopoly, purchase their paper requirements through either importers, dealers, or box and bag manufacturers:

(a) Boon Rawd Brewery Ltd. (Beer and Soft Drinks)

This modern brewery and bottling plant uses 1,300,000 kraft cartons per year in three basic sizes for 500 cc and 650 cc bottles.

The average weight of the above cartons is 0.4 kg, giving a total annual tonnage of 520 tons, including the inner partitions. Soft drinks are shipped in wooden crates.

No increase in future consumption was predicted at this brewery due to the fact that a competing brewery has been established and is expected to take up the increased demand for the next few years.

(b) Thai Tobacco Monopoly (Tobacco Products)

The shipping carton consumption of this company is shown in the following table:

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TABLE IV

THAILAND TOBACCO MONOPOLY

Carton Consumption - 1962

Brand	Number of Cartons
Kled Thong	410,000
Moon	390,000
Samit	42,000
Chief of Rice	74,000
Gold City	100,000
Royal Standard	6,500
King Size Gold City	4,800
Crown Tip	2,400
TOTAL	1,029,700

An annual increase in requirements is estimated at 5-10% for the next five years.

This company also imports a certain amount of kraft papers through the Government Lottery Bureau. Some of these are as follows:

		Tons per Year
Bitumenised kraft	34 in. x 45 in. 48 g/sm	100
Bitumenised kraft	2,700 in., 280 cm wide	30
M.G. ribbed kraft	34 x 45 in., 49 lbs/ream	200
Kraft brown paper	34 x 47 in., 60 lbs/ream	1
	TOTAL	331

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(c) The General Trading Co. of Siam Ltd.

This manufacturer produces shoes, bicycle tires and uses 2,000 kraft cartons per month (18 in. x 18 in. x 12 in.). They also use 80,000 smaller board boxes (3½ in. x 5 in. x 2 in.) for tube packaging and 100,000 small bags of light imitation kraft for shoe packaging.

(d) Soap Companies

The consumption of cartons by the several vigorously competing soap and detergent companies in Thailand is a closely guarded secret. The cartons used weigh 0.6 kg each, and are all purchased from Thai box manufacturers. It would be safe to say that over 2,000,000 such cartons are used per year, for a total of at least 1,200 tons per year. An increase of 5-10% per year is indicated.

11. Converters

(a) Sack Manufacturers

Thai Pure Products Limited is the only independent kraft multi-wall sack manufacturer in Thailand. It utilizes one machine of Japanese origin and four stitching machines, with a capacity of 20,000 bags per eight-hour day, or a total of 3,600 tons per year. In 1962, however, only 800 tons were converted into sacks, most of it going to the tapioca and cement industries for domestic use, due to the fact that its sack size of 40 in. x 19½ in. x 4 in. is not acceptable to many export customers.

Their kraft paper is imported from the United States at basic weights of 72, 75 and 80 g/sm and roll dimensions of 40 in. and 48 in. width, 30 in. diameter (maximum) and 3 in. core centers. Future increases are not foreseen due to the decision of the cement industry to make its own sacks.

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12. Box Manufacturers

(a) Hiang Seng Box Works

This company has its own corrugating machine, with a capacity of 200 fpm, or 25 tons per day, or 40,000 boxes per ten-hour day. Present production is 15,000 boxes per day, or 2,700-3,000 tons per year. Most of the kraft liner board is imported directly from the United States. The corrugating medium is from Japan.

This box manufacturer expects to be running at full ten-hour per day capacity of 7,500 tons per year by 1966. Round-the-clock operation would naturally increase capacity to 17,500 tons per year with the same equipment, although box factories do not normally operate this way.

Results of a chemical analysis of liner board and corrugating medium used by this and other box manufacturers are shown in Appendix V, columns B1 and B2, D and E.

(b) Packaging Manufacturing Co.

The corrugating machine of this box manufacturer has a capacity of 80 fpm. Four box-making machines presently produce 600-800 tons of boxes per year. About half of their liner board is imported directly from the United States and Japan and half through an importer representing Finland. The corrugating medium of 122 g/sm is also from Finland; the liner board is 160 g/sm.

(c) Thai Paper Box Factory

This company uses 1,200 tons per year of liner board and corrugating medium from Japan, Finland and the United States; about one-quarter is purchased through an importer and the rest obtained directly. Reels are 48 and 50 inches wide. The machine speed is 120 fpm on a ten-hour day basis.

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(d) Bangkok Package Factory Ltd. Partnership

This company uses 1,200 tons per year of carton material; 800 tons are imported directly and 400 tons are received through an agent. Two machines are operated from 8 AM to 10 PM, producing 30,000 boxes per day. The liner board and corrugating medium are of United States, Japanese and Swedish origins.

(e) Thai Kong Industry and Commerce Ltd.

This company makes 10,000 cartons per day, running at 50 fpm from 8 AM to 9 PM, and can increase its production by 15%. It plans to install a new machine running at 200 fpm which will increase capacity four to five times. Present paper consumption is 80 tons of kraft liner board, 60 tons of corrugating medium and 50 tons of partition material per month, or a total of approximately 2,400 tons per year. Most or all is purchased through agents from the United States, Finland and Japan. This company is now testing a type of corrugating medium from Australia, which is much cheaper than the corresponding Finnish product (see Appendix V, Column E for analysis. The furnish and low strength merit attention).

It is believed that the above five box-making companies represent the major converters of kraft board and corrugating medium into boxes. All have their own corrugating machines; all will be running under total capacity shortly, and all appear to purchase raw materials from whatever source offers the best price. The total and projected productions of these four box makers should give a reliable indication of present and future needs for their types of paper and board.

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13. Wrapping Paper Consumption

The market for wrapping and smaller grocery-type bags made from kraft wrapping and imitation kraft is not as clear as for the previously discussed products. It was learned during the Survey that most grocery and other types of shopping bags are made in small shops or in the homes by hand. The required paper is purchased from many paper dealers, who import their needs either directly or through the Government Lottery Bureau.

The following interviews concern the Lottery Bureau and other importers and dealers who were willing and able to shed some light on the kraft paper market in general, and wrappings and bags in particular.

(a) Government Lottery Bureau

As mentioned previously, this Government agency purchases all of the Karnchanaburi mill's production of 3,000 tons per year for resale. In addition, it imports 300 to 400 tons of kraft paper per year, as well as large amounts of other types. About 70% of the Lottery Bureau's paper is sold to the larger wholesale paper dealers, and 30% to other Governmental Departments such as the Ministries of Defense and Interior.

The Lottery Bureau stated that 3,000-4,000 tons of kraft paper between the basic weights of 32 and 121 g/sm are imported into Thailand each year. This quantity is expected to increase to 6,000 tons by 1966.

The Bureau is not aware of the quantities of kraft papers above the basic weight of 121 g/sm which are imported directly by the larger wholesalers.

In this connection, it might be well to note that imports of certain types of paper are not entirely unrestricted. According to announcements by the Ministry of Economic Affairs in March 1962, import licenses are required for the following paper products related to this Study:

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Kraft paper weighing 32-121 g/sm.

Wrappings, except those used for cement bags.

All kinds of paper bags, except those for packing cement or tapioca flour exclusively.

The import licenses for the above papers, (as well as many other types of less concern to this Study), will "only be granted when the importers agree to buy one-third of the quantity imported from local paper mills."

Moreover, the Government Lottery Bureau has a monopoly on importing one large category of papers: glazed or unglazed wood-free or non-wood-free writing or printing paper weighing under 120 g/sm.

It is obvious from examining the full list of governmental restrictions on paper imports given in Appendix VII that the objective is two-fold: to keep out paper products which might compete with the production of the two Government pulp and paper mills, and to insure the sale of this production by means of linking the issuance of licenses for the import of papers in large demand to the purchase of certain quantities of the Government-produced paper.

(b) The Thai Paper Trading Co., Ltd.

This dealer imports largely newsprint, approximately 15,000 tons in 1962, and a small amount of wrappings. (Total imports of newsprint in 1962 are given as 15,458 in the Customs statistics.)

(c) Berli, Jucker & Co.

This large importing firm now imports only 1,500 tons of kraft liner board per year, all from Finland, and sells it to the box manufacturers described previously.

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(d) Hamlet & Co. Ltd.

This firm imports 1,500 tons of 70-80 g/sm kraft sack paper and 500 tons of kraft liner board per year from the United States. All is sold to large users rather than to wholesalers.

(e) Kit Karn Charoen Ltd.

This medium sized wholesaler and retailer stated that he sells a yearly volume of 1,000 tons of 40-50 g/sm of kraft paper, and 3,000 tons of 32-100 g/sm paper/year. He buys both from larger wholesalers and directly from abroad, and sells largely to printing firms and small shops using wrappings. He estimates there are approximately 30 other dealers like himself in Thailand.

(f) Guan Yau Huat

This large paper wholesaler deals in all types of paper. He imports an average of 100 tons of 121 g/sm paper per month directly from the United States and sells it for wrappings and shopping bags. He estimates there are four or five other large paper dealers with a comparable sales volume of kraft papers. (According to the Lottery Bureau the five largest paper dealers in Thailand are:

1. Guan Yau Huat
2. Hua Chieng
3. Hua Kee
4. Sang Far
5. Asia)

In estimating the size of the present and future markets for kraft-type miscellaneous wrappings and small bags, most or all of which is sold through wholesalers and dealers, certain assumptions must be made.

Since the Governmental Lottery Bureau is well informed regarding licensing, its estimate of 3,000 to 4,000 tons of imported kraft paper of basis weight 31 to 121 g/sm can be accepted.

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If the five largest Chinese paper wholesalers import a total of approximately 6,000 tons of kraft per year, it might be assumed that about half is within the licensed basis weights and is therefore accounted for by the Lottery Bureau's estimate. Stocks of heavier basis weights were found at all dealers visited, so that this figure of half is probably very conservative.

It is the practice of smaller dealers to group together in importing directly from abroad in order to enjoy quantity discounts. The total amounts of basis weight over 121 g thus imported, however, are not known, and must be deduced from the totals of the import statistics by subtracting the known quantities.

Therefore, if 30,000 tons is taken as the total of kraft-type papers and boards imported in 1962, minus approximately 8,000 tons of liner board and corrugating medium, minus approximately 7,000 tons of sack paper, the total of kraft-type wrappings is approximately 15,000 tons.

Compared to the following FAO table and very conservative predictions made in 1960, this figure of 15,000 tons is fairly accurate.

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TABLE V

WRAPPING PAPER CONSUMPTION IN THAILAND

Year	Wrappings and Other Papers* (excluding newsprint, printings, writings and paper boards)
1955	7,420
1956	4,900
1957	8,750
1958	9,870
1959	11,860
1962**	14,500
1965	17,500
1975	39,000

* "Other Papers" amounted to only 1,500 tons in 1962.

** Interpolated

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A total tabulation of the market for the products to be produced by the projected mill is as follows:

TABLE VI

Consumer	Kraft Sack Paper MT 1963	Kraft Sack Paper MT 1966	Kraft Liner Board and Corrugating Medium MT 1963	Kraft Liner Board and Corrugating Medium MT 1966	Wrappings and Small Bag Paper MT 1963	Wrappings and Small Bag Paper MT 1966
Tapioca Industry	1,006- 1,340	1,126- 1,520	- -	- -	- -	- -
Cement Industry	4,200- 4,600	8,500- 9,500	- -	- -	- -	- -
Fertilizer Industry	12	500	-	-	-	-
Thai Pure Products	800	800	-	-	-	-
Others	500	500	-	-	-	-
Hiang Seng Box Works	- -	- -	2,700- 3,000	7,500	- -	- -
Packaging Manufacturing	- -	- -	600 800	800 1,000	- -	- -
Thai Paper Box Factory	- -	- -	1,200	1,500	- -	- -
Bangkok Package Factory	-	-	1,200	1,500	-	-
Thai Kong Industry and Commerce	- -	- -	2,400	3,100- 5,000	- -	- -
Wrapping and Bag Paper - Importers, Dealers and Wholesalers	- - -	- - -	- - -	- - -	14,000	19,000
GRAND TOTALS	6,518- 7,252	11,426- 12,820	8,100- 8,600	14,400- 16,500	14,000 (based on FAO estimate)	19,000

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14. Summary of Paper and Board Consumption Interviews

The consumption of paper by present users as determined by the Survey is summarized in Table VI and comments are given in the following paragraphs.

(a) Sack Kraft

It has been assumed that the Thai cement companies will continue to prefer making their own sacks. Therefore, only 3,000 tons, chiefly for the tapioca industry, will be converted into sacks at the paper mill.

It should be noted that new uses for kraft sacks could increase very sharply in the next few years in Thailand. The fertilizer industry is just one example. Sugar, corn, rice, soya beans, castor beans, spices and salt are others.

(b) Kraft Liner Board

As pointed out earlier, paper board consumption in Thailand is increasing at a faster rate than the other types of papers and is expected to continue as more new industries are established. The maximum 1966 estimate of 16,500 tons for both corrugating medium and liner board in the above table is actually very conservative in that it reflects only part of the increased capacity presently being added to the five box manufacturers (new total capacity, 23,600 tons) and is based on only a one-shift working day. Also, no allowance is made for changes in consumption habits as weather-proofed cartons gradually replace wooden crates for many products.

The National Paper Board Association in its "Paper Board in World Markets 1958-1963," estimated in 1962 that total paper board consumption in Thailand would be 19,500 tons in 1963. Based on totals for the previous years, paper board consumption in Thailand should reach over 30,000 tons by 1966 and 40,000 tons or more by 1968. Considerably over half of this total will be kraft container board.

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(c) Corrugating Medium

The amount to provide for the inner layer required for 13,000 tons of liner board will be about 6,000 tons and this can be manufactured from 100% fibrous materials available in Thailand.

(d) Miscellaneous Wrappings

Because import totals are vague in classification, and the complexity of importer-wholesaler-dealer relationships and partial import restrictions preclude an exact knowledge of total demand for "brown" wrappings in any given year, a conservative quantity of wrappings will initially be produced. Of the 13,350 projected tons, 1,000 tons will be converted at the mill into shopping and grocery bags. It is planned to increase this amount by 500 tons per year for five years. The objective for the initial years is to attain market acceptance of better quality small bags without disturbing the home bag industry and the paper dealers which supply them.

It should be emphasized that the Market Analysis in Table V.I shows demand estimated in 1966. The projected mill is actually not scheduled to go into production until 1967 and will produce at 66-2/3% capacity, or about 30,000 tons during the first year of operation. It can thus be said that the 44,350 tons of full production will be really directed to the 1968 market levels rather than to the lower estimates for 1966 shown in the above table.

Determination of a future production schedule is essentially a compromise between the two extremes of too large and too small a capacity. Due to the high capital investment ratio per production worker as compared to other industries, (about $25,000 in the United States, the fourth highest of all industrial categories), it is economically advantageous to produce for as large a market as possible, and to install initially much of the equipment required for later expansion. On the other hand, the closer

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to capacity a paper mill can operate, the more profitable is the operation, so that the market must be large enough to guarantee the sale of all the paper produced. It is felt that the production schedule below is an accurate reflection of the market for the new mill's products three-four years hence with due allowances made for flexible market orientation and penetration, and for future expansion of production and conversion facilities.

The projected mill has been designed to produce the following quantities during the second year of operation:

	Annual Production MT/Year
Sack Paper	12,000
Kraft Liner Board	13,000
Corrugating Medium	6,000
Miscellaneous Wrappings	13,350
TOTAL	44,350

15. Prices of Paper

The prices paid by direct importers for the four basic types of paper discussed in this Study are composed of:

(a) CIF Bangkok Price

(b) Import Duty

(c) Business and Municipal Taxes

(d) Clearance, Handling and Transport Charges

These items are discussed below.

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(a) CIF Bangkok prices in Baht (U.S. $1.00=21 Baht)

	Bahts per Ton			Equivalent
	Maximum	Minimum	Average	U.S. Dollars
Kraft sacks (ready made)	5,040	4,662	4,851	231.00
Kraft sack paper	3,318	3,297	3,307	158.00
Kraft liner board	3,150	2,940	3,045	145.00
Corrugating medium	2,949	2,352	2,651	126.00
Miscellaneous wrappings	4,704	4,374	4,540	216.00
Miscellaneous bags (from import statistics-1962)			4,788	228.00

(b) Import Duties

Section X of the Customs Tariff Decree B.E. 2503 covering classifications and duties on pulp and paper imports, are reproduced as Appendix VIII.

The classifications relevant to the present Study are as follows:

48.01 Paper and Paper Board in rolls or sheets

(1) weighing 300 g/sm or more

(2) weighing less than 300 g/sm

48.04 Composite Paper or Paper Board

48.05 Paper and Paper Board, Corrugated, in rolls or sheets.

All of the above categories attract a duty of 10% ad valorem.

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48.16 Boxes, Bags and other packing containers, of Paper or Paper Board

(1) A kind not manufactured in Thailand and imported for re-export	B.[illegible].55 per kilo
(2) Cardboard	B.1.10 per kilo
(3) Other	B.6.60 per kilo

48.21 Other articles of Paper Pulp, Paper, Paper Board or cellulose wadding

(1) Joss Paper	60% ad valorem
(2) Other	10% ad valorem

(c) Business Tax and Municipal Taxes

All companies and individuals engaged in industry, commerce or services are subject to the business tax, unless exempted under the Industrial Investment Promotion Act. This tax is levied on importers at the time of import, and on producers at time of sale. Within the "sale of goods" category, there are nine sub-categories with rates ranging from 1.5% to 25%. The sub-categories pertinent to this chapter are "Type 1": "Goods and by-products not specified under types 2 through 9 or under any category" on which tax is to be paid by the importer or manufacturer at 5% of gross receipts; and "Type 9": "Goods not being finished goods or goods listed in Ministerial Regulations which are sold to a factory within the meaning of the law on factories for use as materials for production and sale," which are to be paid by the importer or manufacturer at the rate of 1.5% of gross receipts.

It is to be noted that a manufacturer therefore normally pays on imported raw materials, at 1.5% in this case, and then pays again on selling the finished product, this time at 5%.

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For example, in the case of the paper industry, a paper mill might import its pulp as a raw material at 1.5% business tax and then sell liner board or sack paper to a converter. According to the present law, the mill must then pay 5% tax. Actually, however, the sack paper or board is not a finished product at this stage. This double taxation "feature" of the business tax law has proved to be a problem of interpretation for both business and government, and it is reported that revisions are under consideration.

Gross receipts are defined as "The CIF price, plus import duties, plus landing charges, plus standard profit at the rate prescribed in the Standard Profit Schedule."

This schedule lists a standard profit of 3% of the CIF price plus import duties plus landing charges for paper and pulp products.

The municipal tax is a surcharge of 10% of the business tax, making the above total tax rates equal to 1.65% and 5.5% respectively.

(d) Clearance, Handling and Transport Charges

The amount of B.60 per ton has been used throughout this Study as the cost of landing goods to the dock.

(e) Discussion of Imported Paper, Board and Paper Products Prices

The following tabulation summarizes the cost of imported paper, board, multi-wall sacks and grocery bags in Thailand.

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TABLE VII

Average Prices of Imported Papers, Boards Sacks and Grocery Bags in Thailand - 1963

	Baht per Ton					
	Kraft Sack Paper	Kraft Liner Board	Corru-gating Board	Wrap-ping Papers (Avg.)	Kraft Multi-wall Sacks	Misc. Bags (Grocery Bags)
Price CIF Bangkok	3307	3045	2651	4540	4851	4788
Duty - 10% ad valorem	331	305	265	454	-	-
Duty - B.0.55 per kg.					550	
Duty - B.6.6 per kg.						6600
Standard Profit Allowance for Tax Calculation - 3% of CIF Value plus Duties	(109)	(101)	(87)	(150)	(162)	(342)
Landing and Handling Charges B.60 per ton	60	60	60	60	60	60
Business & Municipal Taxes -@1.5% of above items	57	53	46			
-@5.5% of above items				286	309	648
Delivery in Bangkok	42	42	42	42	42	42
Total Importers Delivered Cost (Less Std. Profit)	3797	3505	3064	5382	5812	12,138
Importers Business and Municipal Tax on Resale - @1.65%	64	59	52			
- @5.5%				304	329	686
Importers Upcharge - 10% Estimated	386	356	312	569	614	1,283
Cost to Consumer	4247	3920	3428	6255	6755	14,107

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The average current prices in Thailand shown in Table VII are low in comparison with current market prices in the United States and Europe. For example, by taking recent United States, Scandinavian and German domestic quotations on these products, adding US $40 for freight and insurance and 18% of the CIF value for Thai duties, taxes, etc., the prices, delivered in Bangkok, would be expected to be:

	U.S. Prices Baht/MT	Scandinavian Prices Baht/MT	German Prices Baht/MT
Kraft Sack Paper	5082	6022	7137
Liner Board	4452		
Corrugating Board	4263		
Wrapping Paper	5229	6839	7806
Multi-wall Bags	8623		
Grocery Bags	6938		

For the past four or five years, however, world pulp and paper market prices have been depressed because productive capacity in certain countries has considerably exceeded domestic demand. As is customary in a situation of this kind, the producers have held their domestic prices as high as possible, but in the keen competition for new markets for their excess capacity, export prices have become abnormally depressed.

This trend is now being reversed and prices are rising on the domestic market as evidenced by the price increases in the United States and elsewhere in 1963. As the domestic market becomes more profitable, and as the spread between productive capacity and the domestic sales market narrows, it is evident and indeed inevitable that export prices will rise to equal, if not exceed, the domestic prices.

On this basis, it is felt that by 1967, the sales prices established for the projected mill's products in Section XXII of this Report will be reasonably competitive with import prices at that time, and will also provide a rate of return high enough to attract prospective investors both in Thailand and abroad.

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F. Present and Future Pulp Supply and Prices in Thailand

In addition to the pulps manufactured by the Thai mills described in Section B of this Chapter, all of which are used by the existing paper mills, the following pulps and other paper making materials were imported into Thailand in 1962:

Material	Source	Amount Tons	Value CIF, Bangkok, Per Ton Bahts	Average Price Per Ton Bahts	U.S. $ Equiv. Per Ton
1. Pulps					
Groundwood Sulfite	Taiwan	209	562,567	2692	$128
	Japan Finland	1298	3,947,593	3041	$145
Other than Sulfite	Japan Taiwan	451	1,280,331	2839	$135
TOTAL		1958			
2. Waste Paper					
Old News-papers*	U.S.A.	.64	840	1300	$ 62
Paper waste and old papers n.e.s.	Hong Kong	50	2700	540	$ 26
TOTAL		50.64			

*Import licenses are required. This is due to the fact that if old newspapers could be imported without restriction, large quantities would be used for wrappings and small bags.

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Import dutues for "Papermaking Material" are as follows:

Pulp derived by mechanical or chemical means from any fibrous vegetable material: 10%.

Waste paper and paper board; scrap articles of paper or of paper board, fit only for use in papermaking:

Old Newspapers	B. 1 per kg
Other	27.5% ad valorem

Recent CIF Bangkok quotations for various grades of imported pulps are as follows:

Pulp Grade	Price Baht/ton	U.S.$ Equiv. U.S.$/ton
Unbleached kraft (Scand.)	2950	$141
Semichemical, unbleached (Scand.)	2320	$110
Unbleached strong sulfite coniferous unbleached (Scand.)	3030	$144
Unbleached sulfate, bagasse (Taiwan) approx.	2373	$113

Domestic prices for various grades of waste paper collected by small junk dealers and sold, according to quality, for either papermaking or conversion into small bags, are as follows:

	Baht/ton	Equiv. U.S.$/ton
White paper	1400	67
Proof paper	400	19
Mixture of white and proof paper	300	14
Used paper, writings and printings	100	5

As mentioned previously, the small "cardboard" mills use largely mixtures of white, proof and used paper, paying B.100 to 250 per ton. ($5-12). About 600 tons of their annual requirements are purchased from the five carton manufacturers at B.250-300 per ton.

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Inasmuch as the rice straw paper produced by the Bangpa-In Mill contains 60% of chemical pulp (See Appendix IX), it may be assumed that most of the imported pulps are used there. As this mill's production increases from the present 8,000 tons to its capacity of 12,000 tons, pulp imports will increase accordingly. To minimize such imports, plans are under discussion to send part of Karnchanaburi's bamboo pulp to Bangpa-In, provided the capacity of Karnchanaburi can be doubled.

As will be explained in detail in the following Section (Fibrous Raw Materials), the projected kraft mill will import between 17,000 and 29,000 tons, air-dry basis, of its pulp requirements in the form of 100% long-fibered unbleached kraft pulp from abroad during each year of the first phase (5 years) of operation. This will be reduced to 9,000 tons two years after start-up of the Project II pulp mill. In addition, 1,200 tons of mixed waste papers will be used in Project I, and an additional 1,200 tons in Project II. This latter quantity will be a higher grade of waste than that used in Project I.

G. Summary of Market Survey

Though shortages of pulpwood and fuel, as well as foreign exchange in certain countries, have restricted consumption increases to some extent, the world-wide trend has been a steady rise in consumption, which is expected to continue. Estimated world paper and board consumption totals for 1963 are 40% higher than those in 1958. Per capita consumption has increased from 21 to 27 kg during this period.

In the same 1958-1963 period, the Far East has increased its consumption by 100%. Per capta consumption now ranges from 1.1 kg (India) to 89 kg (Australia).

Thailand, a country enjoying unusually stable economic and political conditions, has increased its consumption from 38,440 metric tons in 1955 to an estimated 86,000 tons in 1963. Conservative FAO estimates predict that Thailand's future rate of increase will exceed that of the Far East in general, especially between 1965-1975, and project a consumption of over 200,000 tons by 1975. Per capita consumption is now approximately 3.0 kg.

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Over 80% of Thailand's present consumption of paper and board must be imported. Even if present domestic production is doubled, the ratio of imports to domestic production will become increasingly unfavorable.

The largest group of papers imported has been the "brown" or "coarse" kraft-type papers and boards, used primarily as packaging material. Imports of such products totaled 28,500 tons in 1962, approximately 37.5% of total consumption. This proportion of the total is expected to increase as industrial development is accelerated and new consumption patterns follow the trends of population growth and rising per capita income.

Based on import statistics, FAO projections and interviews with all segments of the Thai paper market, it is estimated that consumption of kraft-type products in Thailand in 1966 will equal 40,000-48,500 tons, broken down as follows:

	Amount-Tons
Kraft sack paper	11,500 - 13,000
Kraft liner board corrugating medium	14,500 - 16,500
Misc. wrappings	14,000 - 19,000
TOTAL	40,000 - 48,500

Approximately 9,000 tons of the 1966 kraft sack paper requirements will be converted by the consumers.

All of the liner board and almost all of the corrugating medium grades will be converted by the five existing carton manufacturers, who are in the process of more than doubling their present capacities.

Most of the wrappings will be sold by a large number of large and small wholesale and retail paper dealers, who resell it to shops, printers and home small-bag makers.

A large demand for cheap "brown" grocery and shopping bags is expected to develop. High import duties have restricted imports, and the inefficient nature of bags made by hand in homes has kept prices high and restricted what is normally a very large market.

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A limited number of small bags will be converted initially in order not to disturb the long-established market pattern of dealer to bag-maker to consumer. If this market develops as expected, without disturbing the present paper dealer structure, additional bag converting equipment can be installed in the mill at low cost.

Approximately 2,000 tons of pulps were imported into Thailand in 1962, and mixed with the locally produced pulps and waste paper at the existing paper mills. This amount will increase as the capacity of the existing mills is increased.

The projected kraft pulp and paper mill will import approximately 60% of its pulp requirements during the first five years of operation, beginning in late 1966, but only about 16% after start-up of Project II. This pulp will be 100% unbleached kraft sulfate, currently quoted at B. 2950 ($141) CIF Bangkok, without duty or taxes.

The current paper prices CIF Bangkok, as determined during the Field Survey, are presently below world market prices. An analysis of current domestic prices in the United States which reflect a rising price trend, however, indicates that by 1967 the world market prices for kraft paper and paper products will have risen substantially. This will undoubtedly raise the prices of paper CIF Bangkok to approximate the sales prices projected for the papers of the proposed kraft paper mill.

As outlined in par. 13 (a), Page 87 of this Report, certain locally (Thai) produced paper products are already protected by restrictions on imports through the Ministry of Economic Affair's "Import Control List." In this regard, it should be noted that these certain paper products are only one of seventy eight items currently on the "Import Control List" along with such other locally (Thai) produced products as rubber tires and tubes, matches, gunny bags, knitted and cotton fabrics, galvanized iron sheets, glass products, canvas shoes, shrimp products and others, all of which require import licenses in order to promote and protect locally (Thai) produced products. It is expected that, if necessary, the Ministry of Economic Affairs will extend the present import restrictions on paper products to include the paper products which will be manufactured by the proposed kraft paper mill.

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V. FIBROUS RAW MATERIALS

A. General Comments

In considering the fibrous raw material aspect of the Survey, consideration needs to be given to the fundamental characteristics of the raw materials used for the manufacture of pulp and paper and to the properties which determine their suitability for a particular purpose.

The substance of the fibers which gives paper and board its peculiar properties is known chemically as 'cellulose'. Cellulose occurs in all plant materials. Consequently, in theory, paper can be made from any plant material. However, in commercial practice the specific kinds of materials which can be used are relatively restricted. This is because the cellulose may be present in many plants in a small quantity, in a relatively degraded or unsuitable fibrous form, or in such a state as to involve a considerable expenditure of chemicals and steam in order to extract the cellulose in a condition suitable for pulp manufacture. Other technical and economic factors affecting the suitability of a particular plant material as a fibrous raw material for pulp and paper are as follows:

1. Availability of adequate quantities of fibrous raw materials at an economic cost.

2. Accessibility and ease of collection or harvesting.

3. Suitability of the particular fiber to give the required paper properties in an economic yield.

4. Suitability for processing by proven methods at an economic cost.

5. Ease of removing dirt, leaves, pith and other extraneous non-fibrous parts of non-woody fibrous materials.

6. Regularity of quality and supply of fibrous raw material.

7. Markets for the products at a profitable price.

It has been found that the coniferous woods, the so-called "softwoods", fulfill the above requirements to a greater

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extent than any other one plant material. The supplies are plentiful in many regions, especially industrialized areas; the coniferous woods can be replaced when exhausted; the fiber itself is highly adapted to impart optimum paper qualities; and a variety of processes have been evolved, enabling this wood to be converted into pulps suitable for present-day requirements of pulp, paper and paper board under scientific control.

However, many countries have insufficient coniferous woods to make possible a wood or pulp industry and in such cases it is necessary to consider what other fibrous materials from plant substances could be used. There are a fairly large number of possibilities, including agricultural fibers, such as sugar cane bagasse and cereal straws, bamboo, hardwoods (temperate and tropical) and reeds and grasses, which are being used in large and increasing amounts in the world pulp and paper industry.

When the above criteria are applied to the fibrous raw materials present in Thailand, a number of materials of greater or lesser potential are evident. These materials are discussed below in the order of their potential to satisfy the above requirements for a fibrous raw material.

B. Sugar Cane Bagasse

1. General

In considering the various fibrous raw materials available in Thailand, sugar cane bagasse meets the above requirements and is recommended as the primary raw material for the proposed 18,000 metric ton per year pulp mill for Project I.

Sugar cane bagasse is the fibrous material which is left as a residue after the sugar juice is pressed from the cane in the sugar mill. Although the physical properties of bagasse vary somewhat due to the variety of cane, the length of the growing season and the methods by which it is cut, shredded and crushed in each particular mill, it normally comes from the sugar mill with a moisture content of about fifty per cent, a residual sucrose content of about two to two and one-half per cent and a content of other water solubles of another two to two and one-half per cent. The remaining or non-water soluble content of the bagasse, which is of a fibrous nature, amounts to forty-five to forty-six

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per cent of the moist weight of the bagasse leaving the sugar mill.

The water insoluble portion of the bagasse above is actually composed of true fiber, pith, dirt and fines. The true fiber is the only part of the bagasse of real value for pulp and papermaking. On a moisture free basis, the average physical composition of the bagasse is approximately as follows:

Good quality fiber	60%
Pith, dirt, finely divided bagasse fibers, weeds, etc.	30%
Water solubles	10%

The fiber which remains after separation of the pith, dirt and fines is of short to medium length. The average fiber length may become decreased somewhat by high efficiency milling in the sugar mill, which results in damage to the fiber length due to excessive breaking of the individual fibers. Even under these conditions, however, the depithed bagasse yields a fiber of excellent papermaking characteristics.

The pith cells are non-fibrous and should be removed before pulping for most grades of paper.

The idea of utilizing bagasse for the manufacture of paper pulp in Thailand is not a new idea. A study was made for the Thai Sugar Organization by the Okawa Institute in Japan regarding newsprint. The report states that newsprint can be made from Thai bagasse, and the product compares favorably with standard newsprint made from groundwood. This conclusion was based on depithed bagasse from an integrated sugar and pulp mill, with a fifty-two per cent yield of pulp. The price for such depithed bagasse was calculated at U.S. $19.14 (B. 402) per metric ton, bone dry. The material suggested to replace the bagasse as fuel in this case was lignite, which is found in large quantities in Northern Thailand.

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It was felt by the sugar manufacturers, however, that the profit to be earned in the newsprint project under consideration would be too small to justify the capital expenditures required. Lack of sufficient water was also a problem.

2. General Application of Sugar Cane Bagasse for Pulp and Paper

During recent years, as a result of the tremendous increase in the consumption of pulp and paper and the resultant drain on the world's pulpwood resources, there has been a great amount of effort expended toward the development of new sources of fibrous raw materials. As the pulp and paper demand has risen in many areas of the world, where there are limited or no supplies of pulpwood, additional impetus has been given to investigation of agricultural fibers, especially bagasse.

Since about 1950, the efforts put forth in this direction have gone far toward bringing the level of technology related to pulping bagasse and the other fibers up to the level of technology of wood pulping. At this time, there are about thirty mills in the world producing bagasse pulps. As some of these are market pulp mills, selling to many paper mills, there are at least forty to fifty mills now using bagasse pulp in some proportion in their paper or paperboard products. In addition, there are at least eight or ten other bagasse pulp and paper mills under construction or in advanced development stages in various sugar producing areas.

At the present time, practically all types of pulp can be produced from bagasse. These range from a mechanical-type pulp all the way to high-quality bleached pulp of high brightness. Both bleached and unbleached bagasse pulps are finding expanded uses. Bagasse pulp, which, as mentioned above, has a short to medium length fiber, has, in the past, been thought of primarily as a blending pulp. However, in recent years it has been found that this pulp can be utilized in very high proportions in many grades of paper. In fact, some grades of high quality printing and writing papers can be produced with bagasse pulp contributing up to one hundred per cent of the fiber furnish. Although the bagasse fibers

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are not as long as the fibers of coniferous wood pulps, under proper refining and blending methods, they can contribute to paper certain qualities which cannot be obtained from the longer-fibered pulps.

Bagasse, being a by-product of the sugar industry, is normally burned to raise steam for the sugar mill. Thus, the value of the bagasse is related to its heating value. Where the cost of an alternate fuel such as oil, natural gas or coal is not excessive, the bagasse can be made available for pulping at a reasonable price.

Bagasse has the distinct advantage over other agricultural fibers in that it involves no problem of collection. The cost of collecting, crushing and washing are borne by the sugar extraction process and the bagasse , when delivered to the pulp mill, is in excellent condition for further processing. It has been found that properly baled and stored bagasse will keep in good condition for extended periods of time without deterioration. Storage is necessary because of the intermittent nature of the sugar grinding operation.

3. Properties of Bagasse Fiber

(a) Physical

In physical dimensions, the ultimate bagasse fiber has an average length of about 1.5 mm to 1.7 mm and a range 0.8 mm to 2.5 mm. It has an average width or diameter of about fifteen to twenty microns (0.015 mm to 0.020 mm). The average length of coniferous wood fiber is about 3.5 mm and its average width is about forty microns. On the other hand, the decidous or hardwood fibers have about the same length as bagasse fibers, but the same diameter as confierous wood fibers. Thus, the ratio of length-to-diameter of bagasse fibers is about one-third greater than that of coniferous wood fibers and two to three times as the ratio of deciduous wood fibers. The bagasse fibers have generally pointed ends and they are not readily fibrillated in beating or jordaning. Because of their high length-to-diameter ratio, and

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because they are not fibrillated, the bagasse fibers tend to produce a better formed, smoother and more compact sheet than that generally made from the larger and thicker fibrillated wood fibers. Therefore, it might be expected-and it has been shown in commercial practice-that the addition of bagasse fiber to wood pulp produces papers with smoother surface formation, which is especially important for printing papers.

(b) Chemical Properties

Chemically, bagasse fibers after pulping have the same principal constituents, that is, cellulose and hemicelluloses, as do the wood pulp fibers, but the proportion of these constituents in the two types of materials are quite different. While wood pulp generally contains eighty to ninety per cent of alpha cellulose and five to fifteen per cent hemicellulose, the bagasse pulps have only sixty-five to seventy per cent alpha cellulose and the hemicellulose content, consisting almost entirely of pentosans, varies from about twenty to thirty-three per cent. Because of the high hemicellulose content of the bagasse pulps, they tend to hydrate and swell more easily and quickly than is the case with wood pulps. Therefore, they require less power than is necessary with wood pulps to obtain the same degree of beating or refining. Fibers which can swell rapidly on wetting also tend to shrink rapidly on drying. This property of the bagasse fibers in addition to their high length-to-diameter ratio results in a large number of fiber-to-fiber bonds in a relatively small area of the paper web and this accounts for the high strength developed by the relatively short fibers.

(c) Yields of Bagasse Fiber

Modern methods of digestion and subsequent processing lead to the production of relatively high yields of fifty-five per cent for strong, unbleached pulp, fifty-three per cent for bleachable pulp, and forty-eight per cent for

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bleached pulp, based on completely depithed bagasse. In this connection it should be pointed out that for every one hundred tons of raw bagasse obtained from the sugar mill, approximately thirty-five tons to forty tons will be removed in the depithing operation in the form of pith, dirt and water solubles. Of the remaining sixty tons to sixty-five tons of clean bagasse fiber, it is possible to get a bleached yield amounting to about forty-eight per cent or about thirty tons, and an unbleached yield of up to fifty-five per cent or about thirty-three tons to thirty-six tons.

4. Types of Bagasse Pulp

(a) General

As has been stated above, practically all types of pulp can now be produced from bagasse. The process used, as well as the type and amount of chemical, depend on the end product desired. The different types of bagasse pulps are described below.

(b) Mechanical-Type Pulp

A mechanical-type pulp suitable for use in newsprint and other groundwood-type papers can be produced from depithed bagasse without the use of chemicals except for bleaching. By a process recently developed by the Hawaiian Sugar Planters' Association in cooperation with the Crown Zellerbach Corporation, a United States firm, the pulping action is a straight mechanical one using disc attrition mills.

(c) High-Yield Pulp for Corrugating Medium

High yield pulps for use in corrugating medium are most commonly made by the straight caustic soda or neutral sodium sulfite processes. Either of these chemical processes produces a high quality corrugating grade pulp from bagasse, and the choice depends on the relative cost of the chemicals and installation of a chemical recovery plant.

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(d) Chemical Pulp for Unbleached and Bleached Paper and Board

For production of fully cooked chemical pulps from bagasse, either unbleached or bleachable grades, the kraft, soda and neutral sodium sulfite methods are all applicable and give excellent pulps.

As will be shown later, it is recommended that the soda process be used for the mill proposed for Thailand.

5. Use of Bagasse Pulps in Various Paper and Board Grades

(a) Unbleached

Unbleached bagasse pulps have excellent use possibilities in many grades of unbleached paper and board. Some of the typical grades and proportions in which they have been used are as follows:

(1) Multi-wall bags - 30% easily, and up to 60%.

(2) Test liner boards - 50% and up to 80%.

(3) Corrugating medium - 100%.

(4) Ordinary "B" grade wrapping papers - up to 75%.

(5) Lightweight fruit wrap, etc. - varying percentages up to 100%.

(6) Glassine and greaseproof - up to 100%.

(b) Bleached

Bleached bagasse fiber pulps can be used in varying proportions in almost all grades of paper which require conventional bleached chemical pulps. It is especially suited for use in the following grades and percentages:

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(1) High grade writing and printing papers - up to 100% - and easily 75 to 85%.

(2) Liner furnish for white lined boards - up to 50% and perhaps higher.

(3) Toilet tissues, facial tissue and towelling - up to 100%, easily 75%.

(4) Solid bleached board - at least 50% and up to 100%.

(5) Glassine and greaseproof - up to 100%.

(c) Semibleached

A semibleached bagasse fiber pulp has been successfully used in a substitute newsprint sheet in up to ninety per cent to one hundred per cent or up to fifty per cent along with fifty per cent mechanical pulp from wood.

(d) Bagasse Mechanical Pulp

Bagasse mechanical pulp can be used in the following grades and proportions:

(1) Newsprint - up to 75% blended with 25% semibleached long fibered wood pulp.

(2) Book paper - up to 50% blended with bleached long fibered wood pulp.

6. World Production of Bagasse Pulp and Paper

As an indication of the suitability of bagasse for the manufacture of pulp and paper, it is pointed out that there are about thirty mills in the world using bagasse for the manufacture of pulp and forty to fifty mills using bagasse pulp for the manufacture of paper.

A partial list of the bagasse pulp and paper mills over the world now in operation or under construction is as follows:

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(a) CUBA

(1) One integrated bagasse pulp and paper mill designed for production of one hundred tons of newsprint from chemical pulp is now in operation, although it is understood that only about thirty tons to forty tons daily are being produced.

(2) One integrated bleached pulp and paper mill for production of one hundred tons daily of unbleached and bleached papers and paper boards. Latest reports indicate that this mill, now in operation, which uses the rapid continuous digestion system and complete depithing, is presently being operated successfully.

(3) One mill now under construction for production of forty tons of unbleached bagasse pulp and paper.

(b) PERU

(1) The W. R. Grace integrated bagasse pulp and paper mill with a daily production of more than one hundred tons of pulp daily and almost one hundred fifty tons of paper and board produces both bleached and unbleached grades of paper and board, including tissue and bag papers, with a high average percentage of bagasse fiber.

(2) A small mill in northern Peru for production of about 25 tons of unbleached pulp and bag paper daily. This bag paper is being converted to multi-wall bags and used for cement. The mill is owned by the cement plant.

(c) PUERTO RICO

A one hundred fifty ton per day unbleached bagasse pulp and paper mill for production of corrugating medium.

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(d) BRAZIL

(1) A forty ton per day bleached bagasse pulp and paper mill making good quality writing and printing papers.

(2) A pulp mill of forty tons per day capacity operated by West Virginia Pulp and Paper Company for production of high yield unbleached bagasse pulp for corrugating medium in an integrated operation.

(3) A seventy ton per day unbleached bagasse pulp and paper mill for supplying bagasse pulp to the Brazilian market.

(e) COLUMBIA

(1) An eighty ton bleached bagasse pulp and paper mill for printing and writing papers.

(2) A twenty-five ton per day mill making high yield unbleached bagasse pulp at Cali for corrugating medium.

(f) INDIA

(1) A bleached bagasse pulp and paper mill operated by Rohtas Industries for production of about twenty-five tons daily. This is part of a much larger pulp and paper mill and continuous digestion is used for the bagasse pulping.

(2) The Shree Gopal mill, using bagasse to supplement the bamboo supply for production of pulp and paper.

(3) A thirty-five ton bleached bagasse pulp and paper mill for printing and writing papers in southern India in the State of Mysore.

(4) A sixty ton bleached pulp and paper mill in the State of Madras, to use a fibrous furnish of approximately fifty per cent bamboo and fifty per cent bagasse.

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(5) A two hundred ton bagasse newsprint mill to be built by Rohtas Industries in cooperation with the Crown Zellerbach Corporation.

(6) Bagasse used along with a variety of other fibrous raw materials in the mill of the Bengal Paper Company for production of bleached grades of pulp and paper.

(g) PHILIPPINE ISLANDS

A twenty-five ton integrated bleached bagasse pulp and paper mill for bleached papers.

(h) ARGENTINA

(1) A small mill operating for many years for production of about twenty tons of low quality bagasse pulp and paper.

(2) A one hundred ton integrated bleached bagasse pulp and paper mill under construction.

(i) MEXICO

(1) An eighty ton per day mill with a major outlet in tissue papers.

(2) A bleached bagasse market pulp mill for production of about thirty-five tons daily, which is being expanded to eighty-five tons per day.

(3) A mill using bagasse to produce twenty-five tons of unbleached pulp per day.

(j) SOUTH AFRICA

A forty ton per day integrated unbleached bagasse pulp and paper mill for production of corrugating board has been in operation for several years.

(k) FORMOSA

An eighty ton per day bleached bagasse market pulp mill has been in operation furnishing pulp for most of the paper mills in Formosa.

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(l) UNITED STATES

A sixty ton daily bleached bagasse pulp and paper mill of the Valentine Pulp & Paper Company, Lockport, Louisiana, making writing and printing papers with ninety per cent to one hundred per cent bagasse fiber content which are competitive on the United States market.

(m) EGYPT

A sixty ton per day unbleached pulp mill under construction.

(n) VENEZUELA

A sixty ton per day unbleached bagasse pulp mill recently started up in an integrated operation with an existing unbleached paper mill for production of wrapping, sack, and multi-wall bag papers, and liner and corrugating boards.

(o) Other Bagasse Mills

In addition to the pulp and paper mills listed above, there are a number of wall board mills utilizing bagasse as the basic raw material, including the Celotex Corporation in Louisiana, which is the largest wall board mill in the world producing more than eight hundred tons of bagasse wall board daily.

7. Availability and Mill Requirements of Bagasse in Thailand

(a) General

Sugar production in Thailand has grown from seventy-four thousand tons per year in 1936 to over one hundred fifty thousand tons in 1963. Approximately thirty-six per cent of this total is produced in the central area of Thailand, in the provinces immediately southeast, west and northwest of Bangkok, and another forty per cent in a limited area southeast of the capital.

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The sugar is produced in fifteen sugar mills and, as will be shown later, seventy-six per cent of the total cane is crushed within two hundred kilometers shipping distance from the preferred sites of the projected pulp mill. (See Map No. 2 and sugar mill list on following pages.)

Because most of the fifteen sugar cane mills are quite small with grinding capacities of less than ninety thousand tons of raw cane per year, the quantity of bagasse economically available to any pulp mill is therefore considerably less than might be supposed from total production figures.

(b) Sugar Mills In Thailand

The largest grinding mills are located as follows:

(1) Karnchanaburi Province

There are now three mills between Karnchanaburi and Nakhon Pathon, a distance of forty kilometers along the Mae Klong river. The largest, Thai Rung Ruang, crushes a total of fifteen hundred tons of cane per day for an average season of ninety days, or a total of one hundred thirty-five thousand tons per year. The other two process a total of two thousand tons per day, or one hundred eighty thousand tons per year. These three sugar mills are an average distance of twenty kilometers from the general preferred mill site area.

(2) Suphanburi Province

This area, some one hundred seven kilometers northwest of Bangkok and approximately one hundred twenty kilometers from the proposed mill site, contains the NEDCOL Sugar Mill at Samchook with a grinding capacity of two thousand tons per day. This is the largest sugar mill in Thailand.

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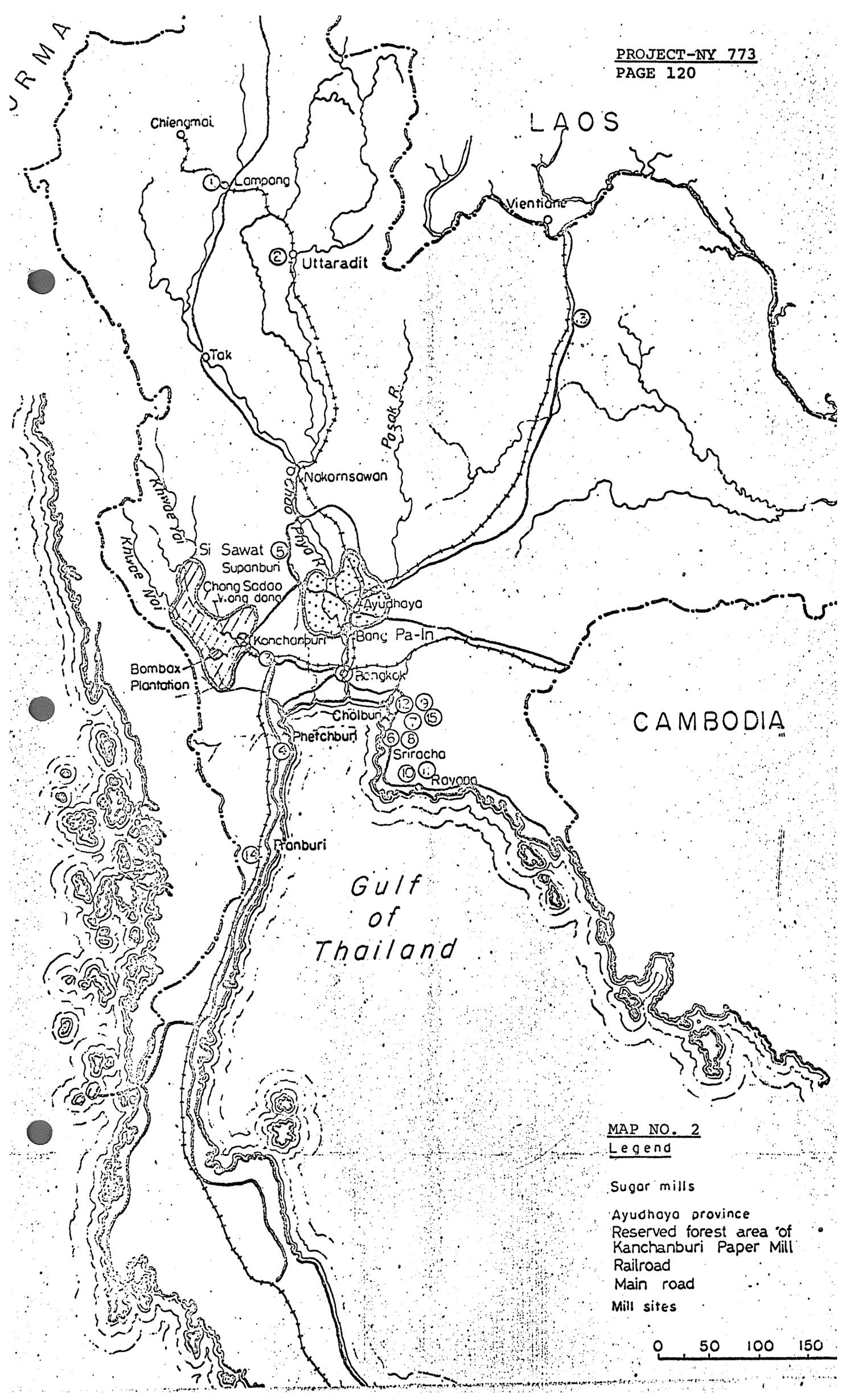
LAOS
CAMBODIA
Chiengmai
Lampang
Uttaradit
Vientiane
Tak
Pasak R.
Nakornsawan
Chao Phya R.
Khwae Yai
Khwae Noi
Si Sawat
Supanburi
Chong Sadao
Wong dong
Ayudhaya
Kanchanburi
Bang Pa-In
Bombax Plantation
Bangkok
Cholburi
Phetchburi
Sriracha
Rayong
Pranburi
Gulf of Thailand
MAP NO. 2
Legend
Sugar mills
Ayudhaya province
Reserved forest area of Kanchanburi Paper Mill
Railroad
Main road
Mill sites
0 50 100 150

LOCATION OF SUGAR CANE MILLS AND ANNUAL CANE-CRUSHING CAPACITY IN THAILAND

(Thousands of Tons)

Sugar Mill No. (Map No.2)	Sugar Mill	Annual Cane-Crushing Capacity
1	Lampang Thai	90
2	Uttaradit Thai	70
3	Thai Rung Ruang	140
4	Petchaburi (Thai-Seng)	60
5	Supanburi (NEDCOL)	175
6	Thai Kasikorn	43
7	Sa-ha Rungrang	60
8	Sriracha	86
9	Ang-Vein	60
10	Siam Kasikum	35
11	Industry Ban Kuy	43
12	Cholburi	145
13	Boon Gua Industry	57
14	Pranburi	12
15	Tawan Aug	12
		1,088

Source: FAO

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(3) Phetburi Province

One small mill, the Thai Seng in Phetburi, grinds eight hundred tons per day. Phetburi is one hundred sixty-nine kilometers southwest of Bangkok, and approximately one hundred twenty kilometers from the proposed mill site.

(4) Chonburi Province

Traditionally the "sugar-bowl" of Thailand, Chonburi has a grinding capacity of seven thousand one hundred fifty tons per day of sugar cane but only three of the mills have a capacity of over one thousand tons per day. This province, beginning some ninety kilometers southeast of Bangkok, is more distant from the preferred mill sites than the other three provinces discussed above.

(5) Other Provinces

The remaining larger cane grinding mills in Thailand, such as the Thai Sugar Organization's mills in Lampang and Utaritit, and the Thai-Seng mill in Rayon, are too far from the mill site under consideration and too scattered from each other to be seriously regarded as sources of bagasse for the proposed pulp mill.

(c) Bagasse Requirements for the Proposed Mill

Assuming that five thousand tons of this total will be high yield pulp for corrugating medium and based on a yield of eighty per cent of the completely wet depithed bagasse, the requirements for this grade will be six thousand two hundred fifty tons of wet depithed bagasse. The requirement for the remaining thirteen thousand tons of pulp for use in wrapping paper, sack paper and liner board, based on a yield of fifty-five per cent, will amount to twenty-three thousand six hundred tons of wet depithed bagasse. Therefore, the total requirement for wet depithed bagasse will amount to approximately thirty thousand tons (moisture free basis).

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Assuming twenty per cent lost during the wet depithing in the form of pith, dirt and water solubles, the total requirements of partially depithed bagasse delivered to the pulp mill will amount to thirty-seven thousand five hundred tons (moisture free basis).

Assuming a loss of five per cent in storage, the total requirement for partially depithed bagasse leaving the sugar mill will amount to thirty-nine thousand six hundred tons (moisture free basis).

Thus, assuming a loss of twenty per cent in the pith portion during the moist depithing stage, the total requirements for whole raw bagasse will amount to forty-nine thousand five hundred tons (moisture free basis).

The four sugar mills closest to the proposed pulp mill site, namely those in Karnchanaburi and Suphanburi Provinces, grind a total of five thousand five hundred twenty tons of cane per day for ninety days, for a total of four hundred ninety-five thousand tons of cane ground. Assuming a bagasse content (moisture free basis) of the cane amounting to about twenty per cent (based on eleven per cent fiber content), the bagasse output of these sugar mills conservatively amounts to approximately sixty thousand tons, which is more than adequate to support the pulp mill operation and to allow for some expansion.

The question of purchasing bagasse from Thai sugar mills was discussed with the General Manager of Thai Rung Ruang, the largest of the three sugar mills on the Mae Klong River, and closest to the preferred pulp mill sites. He was very much interested in selling bagasse, and said that the capacity of his mill could be increased to three thousand tons of unprocessed cane per day, or twice its present operation. However, no excess bagasse is presently available, since all of it is burned as fuel in the sugar mill's boilers. In fact, it is already being supplemented by imported fuel oil.

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The crushing season in this area is roughly from December 10 to March 10. Like most Thai sugar mills, this Company does not own cane growing lands, but buys cane from the local farmers.

It is assumed that the owners of the other sugar mills in question would also be willing to sell their bagasse to a pulp mill, especially in view of the fact that they will be provided all of the depithing, handling and conveying equipment, installed, as well as the substitute fuel oil and storage facilities. In addition, existing boilers will be fully converted to fuel oil use.

As the projected pulp mill expands its capacity in the future, additional sugar mills may be brought into the sphere of supply.

8. Importance of Depithing Bagasse and New Improved Methods Proposed

(a) General Comments

In view of the fact that thorough depithing is proposed for this bleached bagasse pulp and paper mill, the importance of depithing before digestion should perhaps be discussed fully. The Parsons & Whittemore technical staff, based on long experience in the bagasse pulping field, concluded some time ago that proper depithing of the bagasse before digestion is the key to production of high quality pulp and paper from this raw material. It is of great interest that the same view is now shared with practically all of the leading research workers and bagasse pulp mill operators in the world today.

Whether or not sugar cane bagasse should be depithed before pulping has been a subject of controversy ever since the prospect of using this raw material for production of pulp was first considered. There seem to be at least three schools of thought expressed in the literature on pith separation.

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The line taken by one group of workers is that they can use the whole bagasse without pith separation, thus obtaining a high yield of usable product, but disregarding to a large extent the quality of the product and the tremendous difficulties which result in paper mill operations when the pith is left in the pulp. This group consists predominantly, although not entirely, of men whose chief experience has been in the field of pulping wood. In many cases, after years of work with bagasse in which they have experienced many difficulties, these workers have finally come to the conclusion that separation of pith from the fiber is necessary after all, and have changed their ideas. However, many mills have been built on this basis over the course of years. In almost all cases, they have failed because of a tendency to arrive at definite conclusions before carrying out sufficient preliminary work.

The second school of thought recognizes the difficulties involved in handling pith and makes an attempt either to remove it in the cooking process or to carry out this operation in such a way as to change the character of the pith and render it usable as a filler in the final product. These processes are usually complicated and involve at least two stages of pulping which, of course, considerably increases the cost, thus rendering the process of doubtful economic value. Furthermore, in spite of the claims of both of these groups of workers that the pith goes through the process and is usable in the final product, in actual fact a large proportion of the pith is lost in the pulping process, in washing the pulp, in the refining process, and in all subsequent processes carried out in the paper mill. When the pith is left in the bagasse, a considerable portion of it is always dissolved out in the pulping operation because of its large surface area and ability to absorb the cooking chemicals even more readily than the fibers. When the cooking liquor is washed out of the pulp, if the washing is good, an additional part of the pith is eliminated with the wash liquor.

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When the pulp is subsequently run through pumps, over knotters, through centrifugal separators, over screens, over thickeners and into stock chests with agitators, every step of the way involves the mechanical action of one fiber against another. Later, when the pulp is broken up in the paper mill, it is again subjected to violent agitation, pumped in slush form through refiners and into more chests with more agitation. Inevitably, more pith is knocked loose from the fibers and into the water suspension and much of it, too, is thus eliminated from the system and lost completely.

Even so, the remaining pith always causes trouble throughout the paper mill operations and constant care must be exercised to prevent these ill effects. Thus, materials such as diatomaceous earth and other fillers of high absorption capacity must be added to prevent the pith from clogging up the wires, sticking to the presses, clogging up the felts and otherwise hindering the operation of the paper machine.

The Parsons & Whittemore Organization, therefore, believes that workers belonging to these two schools of thought are only deceiving themselves. In spite of their efforts, they obtain only a low yield of paper and experience many of the difficulties inherent in pulping bagasse with the pith present.

The third group of workers, with whom the Parsons & Whittemore Orgainzation entirely agrees, advocates that all pith separation be csrried out by mechanical means preliminary to the pulping operation. They further advocate that after this separation, both pith and fiber be given any further treatment separately and used for the purposes specifically suited to each.

Perhaps the most extensive work ever carried out on depithing bagasse has been by the Hawaiian Sugar Planters' Association. The results of this work were published in the August 1957 issue of the TAPPI magazine. The data presented in this report completely confirms Parsons

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& Whittemore's conclusion that it is essential to carry out a good depithing operation for the manufacture of higher grade papers from bagasse. All of the research workers in the Hawaiian group give unqualified endorsement to the idea of the third group of workers mentioned above.

This group has found, because of the nature and condition of the pith and the accompanying extraneous substances as it exists in the bagasse at the time of leaving the sugar mill, that pith is detrimental in every way to the production of high quality pulp.

If the pith is allowed to remain in the bagasse during the pulping or digestion process, it is only natural - because of its completely different physical structure to that of the fiber - that it would be attacked by the chemicals in a different manner. The pithy material is indeed attacked much more easily by the chemicals than is the fiber, therefore its digestion consumes much more chemical, yet yields little chemical pulp.

Furthermore, since the pith contains a high proportion of the residual sugars and other water soluble materials remaining with the bagasse, these materials also react with the chemicals, thus further increasing the chemical consumption. A considerable percentage of the pith is dissolved out during the digestion process and thus a low yield results in comparison with the total bagasse charged to the digester. In addition, when the bagasse is subjected to strong alkali or other chemicals in the digestion process while the pith is still present, some of this pith, along with the absorbed extraneous materials associated with it, tends to swell and become gelatinous in character, so that it causes great difficulties throughout the process of converting the pulp into paper or other allied products. This gelatinous material tends to clog up the wires on the paper machine, excessively decreases the drainage rate of the pulp on the paper machine, sticks to the press rolls, clogs up the felts and decreases the drying rate of the paper. It

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also makes the paper brittle, greatly decreases its strength properties and gives rise to dirty and shiny spots. In general, it renders the pulp unsuitable for conversion into high grade products.

Furthermore, because of the absorbed dirt and colloidal soil, the pith contains a high proportion of the ash content of the bagasse. Therefore, if the pith has not been separated before digestion, when an attempt is made to bleach the bagasse pulp, an excessive amount of bleaching chemical is required and even then it is almost impossible to obtain a high brightness without dirt spots.

It is obvious then, that for production of high quality pulp from bagasse, separation of the pith from the fiber is necessary before digestion. Over the past fifty years, many investigators have advocated separation of the pith from the fibrous elements of bagasse, but until recently only few have attempted to put such a process into commercial operation, because there was no economic use for the pith. As a result, many mills have failed in their attempts to produce a saleable paper from bagasse because they sought a high yield by leaving the pith cells with the fiber throughout the pulping, bleaching and papermaking operation. Not only did this result in inefficient and costly operations during every step of the process, but the final product was of poor quality and not acceptable on the market.

However, as a result of intensive efforts made over the past few years, excellent methods have now been developed for the separation of pith from bagasse fiber. A description of the best of these various new methods is given below.

(b) New Methods of Depithing

(1) General

Because of the recognized inadequacies of the previous methods of depithing, there have been intensive efforts over the past

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few years to improve the depithing process. These efforts have been concentrated on the moist methods of depithing at the sugar mill and the moist or wet methods of depithing at the pulp mill. In this respect, the important work of three particular institutions, each of which has made great contributions in this field, should be mentioned.

These institutions are the Chemical Engineering Department of Louisiana State University, Baton Rouge, Louisiana; the Northern Utilization Research Branch of the United States Department of Agriculture in Peoria, Illinois; and the Hawaiian Sugar Planters' Association in Honolulu, Hawaii. If the combined work of these three groups would be reviewed, it would undoubtedly be concluded that they have tried every conceivable method of depithing bagasse.

They have all made the results of their work available to the public and none of them involve any secret processes. The Parsons & Whittemore Organization has followed the work of all three groups with great interest and has participated to a certain extent in each of these developments.

A more detailed description of the developments of these institutions and other developments in the bagasse depithing field is given in the appendix to this report in an article entitled "Rapid Continuous Methods for Depithing and Pulping Bagasse".

After a thorough study of these various new depithing methods, including both technical and economic evaluation of the results obtained, the Parsons & Whittemore Organization has adopted the two methods which appeared to be best of those available. One of these is the moist method developed by Louisiana State University for use at the sugar mill and the other is the wet method for use at the pulp mill.

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(2) Continuous Moist Depithing at the Sugar Mill

In the work at Louisiana State University, which was directed by Dr. Arthur G. Keller and Dr. Paul M. Horton, emphasis was placed on finding an economical method of separating the pith from the bagasse fiber at the sugar mill while the bagasse was still in a moist condition. These efforts have been very successful, and as a result there is now available one of the best and one of the most economical methods ever developed for separation of the pith from the fiber at the sugar mill. When operating on moist, or humid bagasse coming from the sugar mill, it is possible by this method to separate about two-thirds of the pith from the fiber without any further addition of water. This separated pith can then be brought back to the sugar mill boilers, whereby its fuel value can be recovered.

The partially cleaned fiber can then be baled, which results in sizable savings in transportation costs, storage areas, etc. The economics of this type of moist depithing at the sugar mill are extremely favorable and complete details on the advantages of carrying out this operation are given in the Appendix in an article by Dr. Arthur G. Keller entitled, "The Parsons & Whittemore 'Horkel' Process for Mechanical Depithing of Sugar Cane Bagasse".

For this moist depithing process, Parsons & Whittemore proposes using the Horkel depithing machine developed by Dr. Keller and modified by Parsons & Whittemore engineers. The first commercial size units were put into operation at the new bleached bagasse pulp and paper mill of Papelera Pulpa-Cuba and have been used during three entire grinding seasons. The machines performed admirably and sufficient pith was removed from the raw bagasse so that an excellent grade of bleachable pulp was made in their Pandia continuous digester.

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An additional Horkel machine was installed for the 1960 grinding season to provide for additional bagasse requirements due to increased capacity of the pulp mill. Further details of this installation are provided in the Appendix in an article entitled, "Cuban Mill Operates Improved System for Cleaning and Depithing Bagasse". Other installations have been equally successful.

(3) Wet Depithing at Pulp Mill

In the normal method of operation at a bagasse pulp and paper mill, bagasse is first baled at the sugar mill in moist or humid form and is stored in specially constructed stacks for a period of several months before it is used at the pulp mill. The bales must then be broken up again after they arrive at the pulp mill. In order to bring about a complete separation of the pith from the bagasse in this form it is necessary to wet it up again thoroughly, break or rub the pith loose from the fiber and then separate the pith from the fiber.

What is believed to be one of the best of the continuous methods of depithing by the wet method involves the use of the Hydrapulper on a continuous basis, followed by passing the dilute wet bagasse suspension through a specially designed depithing machine. In the Parsons & Whittemore system for wet depithing a modification of the Horkel machine is also used for the wet depithing. In the Hydrapulper, the bagasse is thoroughly wetted, softened and broken up and then the pith, dirt, water and water soluble materials are thrown out in the depithing machine. This method results in a very uniform fiber fraction which is scoured clean and free of pith and dirt. The resulting fibrous raw material is superior for later digestion operations.

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(c) Two-Stage Depithing with Wet Handling at Pulp Mill

For the high quality unbleached and bleached pulps to be produced in the proposed bagasse mill in Thailand, especially for strong papers, a two-stage depithing operation is recommended. Based on work with the above depithing methods, it has been concluded by the Parsons & Whittemore Organization that the ultimate in pith separation appears to involve a partial separation at the sugar mill in the moist or humid condition, followed by a secondary wet depithing operation at the pulp mill to remove the remainder of the pith, to clean the fiber and prepare it in the best possible form for subsequent digestion.

This two-stage depithing operation is described in detail in other Sections of this Report and is shown in the appended flow diagrams. The reasons for adopting this two-stage depithing process are as follows:

(1) The moist or humid depithing method carried out at the sugar mill has one disadvantage in that it is more difficult to get a sharp separation of the pith from the fiber by this method than by the completely wet methods. Furthermore, the fiber obtained by the moist method is not quite as clean and free of dirt as the fiber obtained by the completely wet methods.

(2) Although the wet depithing at the pulp mill gives a superior quality fiber, this method has one serious drawback. The pith resulting from this type depithing operation is very dilute and if it is be used further, it must be dewatered and dried. This is true, even though the most valuable use is as fuel. On the other hand, by moist depithing at the sugar mill the pith is already fifty per cent dry and can be immediately returned to the sugar mill boilers in this condition so that the fuel value can easily be obtained. Because of these conflicting facts, it has been concluded that the ultimate in pith

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separation will involve a partial separation at the sugar mill in a moist or humid condition, followed by a secondary depithing operation at the pulp mill to remove the remainder of the pith and to clean the fiber and prepare it in the best possible form for subsequent digestion.

(3) For the moist depithing operation at the sugar mill the Parsons & Whittemore Organization has selected the method developed by Louisiana State University using the Horkel depithing machine. The economics of this type of operation are extremely favorable. The partially depithed fiber resulting from this operation at the sugar mill can then be baled and stored until required by the pulp mill. Approximately two-thirds of the pith can be separated at the sugar mill, thus leaving only one-third of the pith to be separated at the pulp mill. Therefore, the pith handling problem resulting from the wet depithing process at the pulp mill is not nearly as serious as if the entire depithing operation were to be carried out by the wet process at the pulp mill.

(4) For the final depithing operation at the pulp mill, the Parsons & Whittemore Organization uses the continuous Hydrapulper followed by the depithing machine. In this method, either the loose bagasse or the bales are broken up and wetted in the Hydrapulper on a continuous basis in the same manner which has been practiced by the Celotex Corporation for many years. This facilitates the bagasse handling problem at the pulp mill and results in reduction in handling costs. From the continuous Hydrapulper the bagasse suspension is pumped to a head box serving a drainer and a Horkel machine of special design operated wet where the residual pith, dirt and extraneous matter are thrown out. This method also removes the water soluble material in the bagasse as well as the dirt and pith.

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Naturally, having the two-stage depithing operation results in greater capital expenditure than when a single-stage depithing operation is carried out. For some grades of paper having moderate quality requirements it is not essential to have the secondary depithing operation at the pulp mill and for this reason an alternate system is sometimes proposed, involving merely the single-stage depithing operation at the sugar mill and only a dry bagasse handling method at the pulp mill. However, highest quality pulps for bleaching or highest unbleached strength uses such as to be produced by the Thailand mill require the most complete depithing possible.

(d) Comparison of Pulping Results When Using Whole Bagasse, Partially Depithed Bagasse (Single-Stage Depithing at Sugar Mill only) and Completely Depithed Bagasse (Second Stage Wet Depithing at Pulp Mill

During the past few years there has been a considerable amount of work carried out by a number of organizations, including Parsons & Whittemore, to determine the effect which the pith has upon the pulp produced from bagasse. In this work bagasse has been cooked by various methods, with emphasis on the kraft soda processes. Comparisons have been made of the results obtained when using whole bagasse, partially depithed bagasse in the moist condition at the sugar mill, and completely depithed bagasse with final wet depithing at the pulp mill.

Based on the various results obtained in these studies, a typical set of results is given is given as follows:

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COMPARISON OF TYPICAL PULPING RESULTS WHEN USING WHOLE BAGASSE, PARTIALLY DEPITHED BAGASSE (ONE-STAGE DEPITHING AT SUGAR MILL WITH 'HORKEL') AND COMPLETELY DEPITHED BAGASSE (HORKEL DEPITHING PLUS FINAL STAGE WET DEPITHING AT PULP MILL) USING A PANDIA CONTINUOUS DIGESTER

All Cooks using 12% Kraft Chemical (as Na_2O) and 10 minute Cooking at 180°C in Pandia Digester	Using Whole Bagasse with only Mild Dusting at the Sugar Mill	Using Partially Depithed Bagasse Fiber using Horkel machine for removal of 2/3 of the pith at Sugar Mill	Using Completely Depithed Bagasse Fiber (2-stage Depithing with final Wet Depithing at Pulp Mill)
1. Liquor ratio	6:1	3:1	3:1 or 4:1
2. Screened yield, %	45	50	55
3. Permanganate No.	16	14	12
4. Brightness (GE) %	28	32	37
5. Initial freeness (Schopper Riegler) ml	650	750	800
6. Burst factor at 500 ml SR	42	46	50
7. Tear factor at 500 ml SR	50	53	56
8. Breaking length, meters at 500 ml SR	6,000	7,000	8,000
9. Density g/cc at 500 ml SR	0.80	0.80	0.75
10. Folding endurance	400	500	700

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In analyzing the data in the preceding table it is apparent that both partial and complete depithing give very considerable advantages over the use of whole bagasse. It can be noted that the same order of improvement is obtained between raw and partially depithed bagasse. In other words, the wet depithing gives very substantial improvement in all pulp qualities. This fact is of great importance when the highest possible level of freeness, strength, and cleanliness are required.

The high freeness of the completely depithed bagasse pulp would be particularly important for running on high speed paper machines. Also, the higher bursting strength and tearing strength as well as tensile strength and folding endurance would be very important for high strength papers.

For this reason, it is recommended that the two-stage depithing procedure be installed in connection with this proposed bagasse mill for the production of high quality bleached grades.

(e) Pith Handling

As previously pointed out, two-thirds of the pith is separated from the bagasse by the moist depithing process at the sugar mill. This portion of the pith is returned to the sugar mill boilers where its full fuel value is obtained. This is the simplest method of using a major proportion of the pith.

The portion of the pith separated by the wet process at the pulp mill presents a different situation. This pith, after separation, is in a dilute suspension and, if it is to be used for other purposes, it is necessary to dewater it in some manner. This can be done by first filtering in on a vacuum filter, followed by pressing it out to approximately forty per cent dry in a press. This partially dewatered pith can then be dried, pressed into briquettes, and burned in a boiler at the sugar mill or used otherwise for fuel. This is proposed for the Thailand mill.

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The pith briquettes can also be used as household fuel.

If the pith is completely dried, it can also be used as a component of cattle feed after mixing with black strap molasses, as an example. This use has resulted in successful undertakings in a few places. Pith by-product utilization by this proposed mill would depend entirely upon economics.

There are also a number of possible other uses for the pith after it is dried. Consideration might also be given to the use of the wet pith (at about forty per cent dry) as a soil conditioner on the sugar cane fields. This utilization has been applied to a certain extent and the pith does serve as a useful soil conditioner, depending upon the nature of the soil.

9. Collecting, Handling and Storage of Bagasse

The collection of the bagasse will not be a problem, because the proposed pulp and paper mill will be located close to sugar mills which will have a sufficient amount of bagasse available to support the pulp mill.

The cost of collecting, crushing and washing the sugar cane is borne by the sugar extraction process and the resultant bagasse leaving the sugar mill is in an excellent condition for further processing. However, since the sugar mill operation extends over a period of only about three months, and since the pulp mill must operate over the entire year, it becomes necessary to store fairly large quantities of bagasse to insure a uniform year-round supply to the pulp mill. Therefore, any plan for use of bagasse for pulp manufacture must include provision for storage, during the sugar grinding season, of sufficient bagasse to last until the next season.

Fortunately, over the past thirty years, excellent equipment and techniques have been developed in the Louisiana, United States sugar industry for bagasse storage in connection with its use in production of insulating board and bleached pulp and paper.

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Similar techniques can be used for storage of bagasse in large quantities for use in this proposed pulp and paper mill in Thailand.

In considering the method for storing bagasse it must be remembered that it is a material with a very low bulk density of less than 10 pounds per cubic foot as produced. This low bulk density makes it necessary that the bagasse be baled in dense bales in order to facilitate storage and handling and to reduce the volume of storage space needed.

In Louisiana, the baling is carried out with a machine which is heavily reinforced, an enlarged version of the conventional hay baler. The bales are made to weigh about 115 kg on a wet basis (50% dry, as coming from the sugar mill) and measure 43 m x 54 m x 81 cm long. One of these single baling presses has a capacity of baling about 200 tons of wet bagasse per 24 hour day (100 tons on a bone dry basis).

The bales produced are moved by truck, railroad or by carts to a storage area located at a safe distance from the sugar factory for protection against fire. At the storage site, the bales are lifted from the cars with a portable conveyor and are stacked according to a definite pattern in piles which are about 20 m wide by 30 m long by 7.5 m high. The bales are arranged so that air can circulate freely through the stacks to remove the heat of fermentation and speed up the drying process.

The completed stacks are covered with corrugated iron sheeting to keep out rain. These sheets are re-used from year to year, being asphalt coated.

Once the bagasse is stored in bales, it looses moisture rapidly and, after several months storage, will dry out to less than 25% moisture content. The residual sugar content of the bagasse makes it an excellent medium for growth of numerous types of micro-organisms, which, under proper storage conditions, cause the material to heat sufficiently to drive off a large part of the moisture content. The end product of fermentation under such conditions is a mixture of acetic, butyric and related acids. Ordinarily, the bagasse is relatively sterile after this reaction and may be kept in outdoor storage

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areas for one or more years. In fact, when properly baled and stacked, the bagasse can be kept for several years without serious loss. Field losses, usually the lower tiers of bales in the stack, will ordinarily average about 5% of the original fiber stored.

The stored bagasse bales can be moved from the stacks to railroad cars or trucks with the same conveying equipment used for stacking and brought into the pulp mill as needed.

10. Estimated Cost of Bagasse at Pulp Mill

(a) General

Since bagasse is normally burned in the sugar mill boilers, it is customary to place a value on the bagasse to be released by the sugar mill of its equivalent fuel value plus a small sales premium to the sugar mill. Thus, the cost of the bagasse leaving the sugar mill will depend to a large extent on the cost of this replacement fuel. In Thailand this replacement fuel would be fuel oil and its delivered cost at the mill site is estimated to be B. 500 per ton.

Other items affecting the cost of bagasse at the pulp mill are those for the various operations necessary before the bagasse reaches the pulp mill, including the costs of moist depithing at the sugar mill, baling as may be required, transportation of loose and baled bagasse, handling and storage of the baled bagasse.

Indirectly involved in the cost of the bagasse are the costs associated with capital expenditures for conversion of existing boilers at the sugar mill to burn the replacement fuel or installation of a supplementary boiler. These capital expenditures are usually included in the total capital structure of the pulp mill and the indirect costs are included in the overhead for the pulp mill.

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(b) Calculation of the Cost of Bagasse at the Pulp Mill

From the standpoint of steam generation, one ton of fuel oil will replace approximately six tons of fresh bagasse at 50% moisture content, or three tons of bagasse calculated on a moisture-free basis. The calculations are as follows. The comparative heating values of fuel oil and bagasse are:

(1) One kilogram of fuel oil at 10,000 kcal/kg burned at 80% efficiency yields a net heating value of 8,000 kcal.

(2) One kilogram dry weight of bagasse at 4,600 kcal/kg burned at 58% efficiency yields a net heating value of 2,670 kcal.

(3) $\frac{8,000}{2,670}$ = 3 kg dry weight of bagasse.

(4) One tons of dry bagasse (burned wet) = 0.333 ton fuel oil.

Since the moisture content of fresh bagasse varies from 48 to 52% the weight is usually converted to the moisture-free basis for the purposes of accurate accounting of the tonnage taken from the sugar mill, and the value of the bagasse is determined on this basis.

It is proposed that the pulp mill will furnish the sugar mill with fuel oil in an amount equivalent to the heating value of the weight of the bagasse actually taken from the sugar mill. Since the pith removed in the moist depithing operation at the sugar mill will be returned for burning in the bagasse boilers, this does not enter into the accounting.

In addition to the fuel replacement, the cost of the partially-depithed bagasse delivered to the pulp mill will include the cost of moist depithing at the sugar mill; the cost of baling, handling, stacking, covering, unloading and conveying of the baled bagasse; transportation

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to the pulp mill of loose and baled bagasse; and the premium to be paid to the sugar company. The delivered cost to the pulp mill is summarized on the following page.

11. Bagasse Pulping Systems, including Pandia Rapid Continuous Pulping System and its Advantages

(a) General Comments

The history of bagasse pulping shows that a number of systems and chemical processes have had application. A description of the chemical processes used for the mill proposed for Thailand, are presented subsequent to the discussion immediately below on bagasse pulping systems. As to these systems, there has been a fairly wide range varying between the older batch pulping in rotary digesters to the modern rapid continuous pulping. The various major types of bagasse pulping systems are discussed in the following paragraphs.

(b) Batch Pulping in Pressure Digesters

The older type of conventional pulping in rotary globe or tumbling pressure digesters has been employed quite extensively in many parts of the world for agricultural fibers. The chemical process may be the soda, kraft or monosulfite.

The principle disadvantage of the conventional batch pressure digestion system is the high digester capacity required because of the bulky nature of the bagasse and the long, overall cooking time. The bulky bagasse, which is not subjected to compaction in these systems, is present in the digesters at a low density. Long charging and discharging times are needed for bagasse, and the heating time is long because a large volume of chemical is needed to obtain uniform pulping.

Because of the large volume of liquor required for uniform cooking, the low solids content of the spent liquor presents a serious difficulty in the chemical recovery process. Although the spent liquor can be discarded in some cases,

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TABLE VIII

ESTIMATED DELIVERED COST OF PARTIALLY-DEPITHED BAGASSE AT PULP MILL

Thai Baht per ton (Moisture-Free Basis)

		Baled and Stored Bagasse
1.	Fuel oil replacment, 0.333 tons @ B. 500 per ton	B. 166
2.	Moist depithing	B. 20.00
3.	Baling, handling, stacking, covering, unloading & conveying	B. 90
4.	Transport to pulp mill	B. 80
5.	Premium to sugar mill	B. 20
	Sub-Total	B. 376
6.	Storage loss at 5%	B. 19
7.	Delivered cost of partially-depithed bagasse at pulp mill	B. 395*

NOTE: * Cost increases to 435 in second stage (after five years) due to expiration of duty and tax concessions, resulting in increase in cost of fuel oil from B. 500 to B. 617 per ton.

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in kraft pulping recovery is economically necessary and the low solids content of the spent liquor represents a serious drawback.

(c) The Celdecor or Soda Chlorine Process

The Celdecor or Pomilio process is a patented process which is being used in several older installations for pulping agricultural fibers. This process is a modification of the soda process in which a mild soda cook at atmospheric pressure is followed by a drastic chlorination stage which continues the cooking process. The chlorination process is then followed by a caustic extraction process in which a comparatively high concentration of caustic soda is used. Finally, a hypochlorite stage completes the bleaching. Thus, this process is designed basically for producing bleached pulps.

When operated in this manner with a very high rate of chlorine application, the original Pomilio process was never very successful although it had the feature of utilizing the chlorine and caustic soda in the proporations made in an electrolytic plant using common salt as the raw chemical. The resulting pulp was found to be quite brittle and was not of a very high quality. Later developments have resulted in some improvements in the basic process. Thus, the idea of using the products of an electrolytic plant in the exact ratio in which they come from the cells has been modified, although the chemical requirements, especially the chlorine, are relatively greater than are used in the normal soda, sulfate or monosulfite processes for producing bleached pulp.

According to published information, the total chemical requirement is 40-45% of the weight of the pulp and this amount is proportioned into 70% alkali and 30% chlorine. This compares with 14-15% total chemical for conventional-type pulping with chemical recovery.

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This large difference is due to (a) the inherently high chemical requirement for the soda-chlorine process and (b) the technical impossibility of recovering the chemical values in the spent liquor from the soda-chlorine process.

Because of the high chemical requirement, especially since chemical recovery is not possible, an oversize electrolytic plant is necessary for a completely integrated mill using the soda-chlorine process. The power demand and, in turn, steam demand for power generation becomes excessively high, even for a mill with a low production.

The poor economics of this high chemical consumption is further accentuated by the fact that the spent liquor cannot be processed for chemical recovery. Thus, except for the unusual cases of very small mills of extremely low chemical costs, the generation of the large amounts of chemicals required necessitate expensive electrolytic and power plants.

The Pomilio-Celdecor process has the advantage of being a continuous pulping system and of operating at essentially atmospheric pressure. On the other hand, because of the bulk of bagasse, as discussed later, large treating towers are required. This results in high building costs.

Another disadvantage of the process is that both the system and certain of the equipment are operated under patents which add a premium to the cost of manufacture of the pulp.

(d) The mechano-chemical process using either soda or sulfate chemicals

The mechano-chemical process is a development of the last fifteen years in which agricultural fibers are pulped at atmospheric pressure at a temperature of 95-98°C for one hour in an agitated hydrapulper using soda or kraft liquors. This process was discovered in an attempt to arrive at an improved process for

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pulping agricultural fibers, including bagasse, and offers certain advantages which none of the conventional processes gave. It is possible to get both a high yield and a pulp with excellent strength characteristics, thus combining the good points of the conventional alkaline process with the good points of the neutral monosulfite process from a pulp standpoint.

There are several limitations of the mechano-chemical pulping process. Although bleachable pulps can be made from bagasse by this process, the chlorine requirement is uneconomically high. Another point is that for small installations, the equipment for the mechano-chemical process is economical but once medium-sized mills are reached, the capital requirements for the equipment increases unduly because of the relatively small capacity pulping units.

(e) Pandia Rapid Continuous Pulping System and its Advantages

(1) Pandia Rapid Continuous Pulping System

The many advantages of continuous operation have long been recognized by various chemical and mechanical industries, including the pulp and paper industry. From the early days, of course, paper has been manufactured continuously and in recent years the bleaching process and stock preparation process have also been converted from batch to continuous operation in many cases. However, the basic digestion process in the pulp mill has continued to be a batch operation with a few recent notable exceptions. Among these exceptions is the application of the continuous pressure digester to agricultural fibers, as mentioned above. As a result, the continuous pressure digester is now given first consideration when a pulp mill based on agricultural fibers is being planned.

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Problems in the mechanical design of equipment have been the major reason for the slow development of a completely acceptable continuous digester. It has been necessary in particular, to devise mechanical feeding and discharging devices to operate under pressure and also to develop means to obtain a positive flow of the cellulosic material and the cooking reagents through the cooking zone. All these mechanical obstacles have been overcome in the Pandia continuous digester proposed for the bagasse pulp in Thailand.

In addition to the mechanical problems, for production of high quality pulps a physico-chemical problem had to be overcome. This involved difficulties in connection with pulping cellulosic materials in extremely short times in comparison with conventional batch operations. The short cooking times are necessary so that the continuous pulping equipment would not become too bulky and expensive and would not become so large that it would be difficult to maintain control and obtain uniform pulping action. Therefore, in order to keep the size of the pulping equipment to a minimum it becomes necessary to conduct the pulping at relatively high temperatures and pressures thus speeding up the pulping action.

It has now been shown beyond question that the cooking of cellulosic materials can be carried out at high temperatures for short periods of time without degrading the pulp. In fact, pulping of agricultural fibers, particularly sugar cane bagasse, at high temperatures in 10 minutes or less has been found to give pulps in improved yields and quality with lowered bleaching chemical requirements. This is in itself a revolutionary development in the pulping field. This development has necessitated designs to allow for operating temperatures and pressures in much higher ranges than can be economically built into the conventional types of batch digesters.

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In practice, the Pandia horizontal tube-type digester has proven to be the natural development meeting the fundamental requirements above for continuous digestion and there are now a large number of successful installations, including over ten installations on agricultural fibers.

In addition to the suitability of the continuous digester as denoted above from the physico-chemical viewpoint, because of the physical structure of bagasse, the Pandia continuous digester is particularly applicable to this raw material. In the first place, bagasse is very bulky in contrast to the compact structure of wood. When conventional batch type digesters are used, the capacity per digester is small. Even when the raw material is compacted before entering this digester, it tends to spring back again into bulky form as soon as the compacting pressure is released. When using the Pandia continuous digester, this bulkiness is overcome and a rather high weight of material per cubic foot of digester space is obtained.

By means of the feeding screw a compact mass is forced into the digester. This feeding screw is the only known device for feeding bagasse into a pressure zone at an economical rate. Since this mass can expand again after entering the digester only to a relatively small extent, one of the greatest problems of using agricultural fibers, including bagasse, is overcome and a high digester capacity is obtained.

Another property of bagasse which renders a continuous digester particularly suitable involves the highly absorbent nature of bagasse fibers. Because of this absorbancy, liquor circulation systems commonly used in batch type pressure digesters are usually impracticable. While liquor ratios of 4 or 5 : 1 are common in wood pulp mills, in order to get good circulation when

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pulping bagasse, ratios of 10 : 1 or 12 : 1 must be used to insure satisfactory circulation and good heat transfer necessary for uniform cooking. Since such a high liquor ratio is impractical, digesters of the rotating type must be used for batch pressure digestion of bagasse in order to get good mixing at low liquor ratios. Unfortunately, rotating batch digesters are necessarily small and have low capacity so that the cost for an appreciable production is rather high.

The Pandia continuous digester solves this problem completely. Because of the constant motion of the mass through the tubes as it is propelled by the screws, there results an intimate and continuous mixing of chemicals and steam with the raw material. Thus highly uniform cooking can be obtained with liquor ratios of 4 : 1 or lower and no liquor circulation system is needed when pulping bagasse. As a result, the digesters are actually more simplified in construction when pulping bagasse than they are when pulping wood.

The open nature of the bagasse is still another characteristic which favours the use of the Pandia system. When pulping wood a considerable portion of the time in the digesters is consumed in allowing the liquor to penetrate the dense wood cells. The wood must be completely impregnated with liquor before the temperature can be raised to any appreciable degree. In the case of bagasse, because of the open nature of the fibers, the liquor penetration is almost instantaneous. In addition, these fibers are more susceptible to rapid chemical action.

Because of these two facts, when bagasse is subject to high pressures and temperatures obtainable in the Pandia digester, pulping action starts immediately and is extremely rapid. As a result, by using high temperatures,

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high strength unbleached pulps or fully bleachable pulps can be produced with cooking times of approximately 10 minutes or even less, depending on the steam pressure applied.

These continuous digesters have a high degree of flexibility in that any of the cooking liquors commonly used for pulping bagasse can be used. Thus, soda, kraft, or neutral monosulfite cooking liquor can all be used, and the concentration and consumption of chemical is approximately the same as when using these respective cooking liquors in rotating batch-type pressure digesters.

Another important advantage to this system is the quick response to the controls applied to it. The controls can be made fully automatic, practically all of the conditions can be recorded, and supervision is rendered remarkably simple because the human element is of less importance than in the case with batch-type digestion methods.

Still another advantage that applies in particular to the Pandia continuous digester is the small building space required, which makes for an extremely neat and compact installation and results in considerably reduced building costs for a given quantity of production capacity.

(7) Summary of Advantages of Pandia Continuous Pulping System

A summary of the advantages of the Pandia continuous digester system is as follows:

(a) Maximum processing flexibility, including the ability to employ any normal cooking liquor without change in the digester equipment.

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(b) Maximum uniformity of pulp quality due to thorough and continuous mixing of chemicals and steam with the fibrous raw material.

(c) Uniform raw material consumption, limiting the size of the "in process" material storage facilities.

(d) Uniform steam and power requirements which reduce peak load demand in the steam and power plant and allow operation at high load factors.

(e) Low steam requirements because of low liquor ratio and continuous heat recovery from blow tank cyclone.

(f) Uniform liquor demand, avoiding large storage facilities.

(g) Potentially higher yield for equivalent pulp quality.

(h) Small space requirements.

(i) High capacity per unit due to compacting the bulky raw material and operating at high pressure and temperature.

(j) Low labor cost because of greater productivity per man hour of labor.

(k) The possibility of increasing production, in steps, by relatively simple and economical additions to the unit itself without requiring any additional building space, and without increasing the number of operators required.

12. Choice of Chemical Process for Pulping Bagasse

(a) General Comments

During the past 100 yeras, various investigators all over the world have used almost every conceivable process for experimental production

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of pulp and paper from bagasse fiber. From a technical standpoint, it has been found that the soda process, the sulfate (kraft) process and the monosulfite process (neutral sulfite), or any modification of these well known processes can be used to produce satisfactory chemical pulps. By using a standard three-stage bleaching process, a good quality bleached pulp can also be produced following the use of any of the pulping processes mentioned above for a mill making white papers.

The acid pulping processes seem to be the only commonly used processes which are not adaptable to pulping bagasse. The pulps produced by the acid processes make relatively weak and brittle paper and paper board products. It is true that two-stage processes and processes involving a pre-hydrolysis procedure followed by an alkaline cook, have produced satisfactory pulps from bagasse, but the yields are invariably low and the costs are higher than when using a one-stage process. It is also possible that recently developed two-stage sulfite processes ending on the alkaline side would produce satisfactory pulps from bagasse. However, the practical value of such two-stage procedures is rather doubtful and their economic value seems definitely unfavorable at the present time for producing quality paper pulp. An exception is the possible production of rayon-grade pulp by the prehydrolysis sulfate process.

The alkaline process and the neutral sulfite process and various modifications of these processes are already in use in various geographically distributed mills in the world, to produce good quality pulps from bagasse and other agricultural residues. It has been found that alkaline processes give somewhat stronger pulps, whereas the monosulfite process gives a weaker pulp but of slightly higher yield and of somewhat lighter color before bleaching.

In this report, no attempt is made to describe all of the processes and modifications which have been proposed in the past for pulping

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bagasse. The three processes mentioned above, the soda, kraft and monosulfite process are by far the most important.

(b) The Monosulfite Process or Neutral Sulfite Process

The sodium monosulfite process, or neutral sulfite process as it is often called, has gained wide use in the United States for production of semichemical pulp from hardwoods. This process has also been used extensively for production of straw pulp in Italy and Germany and is at the present time being used for the production of bagasse pulp in Formosa. The pulping or delignifying agent is sodium sulfite (Na_2SO_3). Because acids are formed by hydrolysis of certain hemicelluloses in the fibrous material, the cooking liquor also contains a small quantity of a buffering or neutralizing agent in order to maintain the pulping reactions near the neutral point where this process gives the best results. The buffering agent can be sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), or sodium hydroxide (NaOH).

The neutral sulfite cooking liquor can be prepared directly from purchased sodium sulfite and sodium carbonate or bicarbonate. This is sometimes done by small mills in countries such as the United States where sodium sulfite is available as a byproduct of phenol manufacture. However, the cooking liquor is usually prepared by sulfiting sodium carbonate (soda ash) with sulfur dioxide gas. The latter reagent is made by burning sulfur. The reactions involved are as follows:

1. $S + O_2 = SO_2$

2. $Na_2CO_3 + SO_2 = Na_2SO_3 + CO_2$

3. $Na_2CO_3 + CO_2 + H_2O = 2\ NaHCO_3$

The relative amounts of sodium sulfite and sodium bicarbonate formed are controlled by the degree of completion of reaction 2 above, as determined by titration.

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In general, the unbleached pulp produced by this process is not as strong as the pulp produced by the conventional soda or kraft processes but the yield is somewhat higher and the pulp lighter in color than that produced by the alkaline processes. Thus, the process is more suitable for production of semi-bleached pulp or light-colored unbleached pulp where high strength qualities are not so important. For high strength unbleached or bleached pulp, the alkaline processes or modifications of the alkaline processes are usually more suitable than the monosulfite process.

In most existing installations, the monosulfite process is operated without a chemical recovery system so that its economic success depends very much upon the cost of basic raw materials, soda ash and sulfur, in the country where it is to be used. In the United States, where the costs of soda ash and sulfur are extremely low, the production cost when using this process renders it economically feasible even when used in small mills of 25 tons per day capacity.

Since soda ash and sulfur are expensive in Thailand, the cost of these basic chemicals for neutral sulfite cooking liquor would be extremely high. This fact, coupled with the circumstance that the newly developed processes for neutral sulfite recovery are complicated and involve high capital expenditures, would make the chemical costs completely prohibitive.

Another serious drawback to this process is the high equipment cost. The cooking chemicals are extremely corrosive to mild steel so that a great deal of the equipment and piping must be made of stainless steel.

Because of the economic limitations of the monosulfite pulping process as described above, it is recommended that this new mill for Thailand utilize one of the alkaline processes with an efficient, proven, chemical recovery system.

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(c) The Soda Process

The soda process is used very extensively all over the world for the pulping of bagasse and other agrifultural fibers to produce excellent grades of high-strength unbleached and bleached pulps.

The active cooking chemical is caustic soda (sodium hydroxide), but when a recovery system is incorporated in the process, soda ash is usually used as the make-up chemical. An exception is the case where caustic soda is available from an electrolytic plant producing chlorine for bleaching.

While most bagasse pulp mills using the soda process operate without chemical recovery systems, these mills are for 25 to 40 tons per day capacity and it has not been economical to date to install a recovery system for mills of this size, except in cases where the cost of market caustic soda is extremely high.

In the chemical recovery of the soda value in the black liquor this black liquor is first evaporated to bring it to a combustible state. The concentrated liquor is then injected into a furnace and the organic matter burned off from the sodium compounds to produce sodium carbonate, which is then reconverted as described below, into caustic soda.

The make-up chemical in a soda recovery system is soda ash or caustic soda, as mentioned above. The soda ash is added to the green liquor and the combined liquor causticized with hydrated lime to produce sodium hydroxide according to the following simple reaction:

1. Causticizing - $Na_2CO_3 + Ca\ (OH)_2 = 2\ NaOH + Ca\ CO_3$

The calcium carbonate can be recovered for reuse by calcining in a lime kiln and slaking to produce hydrated lime as below, although the capital expenditure is high and cannot be justified for small mills:

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2. Calcining - $CaCO_3 = CaO + CO_2$

3. Slaking - $CaI + H_2) = Ca\ (OH)_2$

Since there are losses in the lime recovery cycle, make-up limestone ($CaCO_3$) is added before calcining in the lime kiln.

If sodium hydroxide is used for make-up, it can be added to the white liquor after the causticizing step above, although the causticizing of the large parts of the recovered chemical is still necessary.

(d) The Sulfate or Kraft Process

The sulfate or kraft process has come into prominence in the past thirty years and has almost replaced the soda process for production of alkaline pulp from coniferous woods and hardwoods as well. This process is generally the preferred process since it makes the strongest and most versatile pulps of all the commercial processes as well as being applicable to all fibrous materials.

The operational details of the process are similar to those of the soda process above with the exception that the loss of chemicals in the system is made up by the addition of salt cake (sodium sulfate) instead of the soda ash or caustic soda. The actual sulfate cooking liquor contains caustic soda and sodium sulfide. In chemical terms, the kraft cooking liquor is made up of NaOH and Na_2S. There is also a small amount of Na_2CO_3 present.

The presence of the sodium sulfide results in a milder action which gives a slightly increased yield of pulp which is more easily bleachable and is stronger than that prepared by the soda process, in the case of wood and bamboo. The differences are with agricultural fibers. However, where less important different raw materials are to be used, as will eventually be the case in Thailand, the kraft process is more universally applicable than any other process.

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In general, the digestion is carried out under the same operating conditions as with the soda process, utilizing the same amount of active chemicals and obtaining approximately the same quality pulps. The active chemical or active alkali is based on the sodium oxide (Na_2O) content of the cooking liquor.

When using the kraft process, a chemical recovery system is absolutely essential in order to reduce the sodium sulfate or salt cake to sodium sulfide. In the normal sulfate process the recovery furnace serves as a reducing furnace and the make-up sulfate is reduced to sodium sulfide in the reducing atmosphere of this furnace. The chemical reaction involved in reducing the salt cake is as follows:

$$Na_2SO_4 + 2C = Na_2S + 2\ CO_2$$

The smelt from the kraft recovery cycle contains sodium carbonate and sodium sulfide. The sodium carbonate is causticized to sodium hydroxide in precisely the same manner as described above for the soda recovery cycle. The sodium sulfide is unaffacted by the causticizing step.

When the make-up chemical in a kraft recovery system is salt cake, then the sulfidity, which is the per cent of sodium sulfide in the cooking liquor (calculated by expressing all chemicals present at Na_2O), tends to level off in the range of 18 to 25%. This is an optimum range for most kraft pulping.

One disadvantage of full kraft pulping of wood is the penetrating disagreeable odor from the vapors entering the air. This condition is caused by the presence of certain organic sulfur compounds. However, these compoinds are present to much less extent in pulping bagasse and it is not considered a problem, especially when using rapid continuous digestion with such short cooking times that the mercaptans causing the odor do not form. It can be added that steps can be taken to alleviate or greatly reduce the odor in wood pulping.

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(e) Low Sulfidity Kraft Process

In order to take advantage of the benefits of the kraft process, some soda pulp mills add small amounts of elemental sulfur or sulfur compounds to the cooking liquor. Improved pulping over the straight soda process results. The odor problem is not created and the recovery operation is unchanged.

The operations in pulping with a cooking liquor of low sulfidity are the same as outlined above for kraft pulping. This same modified kraft process with low sulfidity is being used at the present time in some of the existing bagasse pulp mills.

(f) Summary of Choice of Chemical Process

The review of four potential pulping processes indicates that the soda and kraft processes are the most suitable for the pulping of bagasse. The monosulfite process is eliminated because of the lack of suitable recovery system and the high cost of chemicals.

Although the kraft processes and the soda process are similar in nature in the pulps produced and in the equipment required, as far as bagasse pulps are concerned, the universality of the kraft process, the operating economies with respect to yield and chemical make-up and the need for the highest strength pulps lead to the recommendation of the kraft process for the pulp mill for Thailand.

C. Forest Woods

1. General

The total area of Thailand is approximately 518,000 sq km. Of this area, approximately 320,000 sq km, or 62%, are covered with forests of one kind or another. Coverage, however, is not uniform since very little forest occurs in the central plain, where agriculture predominates. Of the forested

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land, 157,000 sq km, or approximately half, are accessible forests. Practically all the forest areas are State-owned.

It is estimated that forests of the coniferous trees, which are preferred for pulp and paper, constitute approximately only 1% of the country's forested area. Although the density of their growth is fairly high, there is no forest which can be regarded as purely coniferous, even in the pine forest area, where the occurrence of the pine in the surrounding forests is very patchy.

It is customary in Thailand to divide the forests into the evergreens, i.e., trees retaining their foliage the year round, (which include most conifers) and the deciduous forests, in which trees lose their leaves. The evergreens are sub-divided into tropical evergreens and hills evergreens.

It is pointed out that it is quite customary to classify trees as softwoods, which are mostly evergreens and have long fibers, and hardwoods, which are mostly deciduous in temperate zones and have short fibers. In addition, the mangroves form a separate category.

2. Tropical Evergreens (Hardwoods)

This type of forest is very prevalent in Thailand, especially in the southern and south-eastern regions. Most of the species are commercially important as lumber, and there is a large export trade, especially of *Dipterocarpus* species and rattans. Also, these trees yield many by-products, such as resins, rubber, wood oil and fruits, which also have export value. These trees are of limited interest in the initial stages of this Study. Naturally, wherever trees are of value as timber, their use in papermaking is not attractive on price grounds. In the present instance, the price would be high due to transportation costs over the long distances involved, and due to the high cost of extraction. Apart from this, the fiber lengths of tropical evergreens are short and this curtails their usefulness for making strong kraft pulp.

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3. Hill Evergreens (Hardwoods)

These woods occur chiefly in the mountainous regions of northern Thailand, and their extraction and transportation would be expensive. They are chiefly varieties of oaks and chestnuts and, as such, their use in papermaking is restricted to the type of pulp which can be made by a semi-chemical process, i.e., a type suitable for use in corrugating medium. However, here again the cost of extraction is high owing to the isolated locations and altitude at which the trees occur.

4. Mangrove Forests

The total area of this type of forest is estimated to be 1,620 sq km. Most of the area is along the shore of the Gulf of Thailand and along the West Coast of the Peninsula. Wood from the mangroves is used chiefly for fuel, charcoal, which is exported, and for boat construction. Mangrove is also a well-known source of tanning material. Tests carried out on the use of mangroves in paper manufacture have shown that the pulp is of the short-fibered type.

5. Deciduous Forests (Hardwoods)

These are very widespread, especially in the northern, central and north-eastern parts of Thailand, and it is estimated that they comprise about 70% of the forested area of the country. They are found on the plains as well as on the hills, although seldom at altitudes of over 1,000 meters.

They, like the tropical evergreens, are considered valuable commercial timbers (teak, for example), and are also sources of minor forest products, such as valuable oils and resins, fibers, crude drugs and foodstuffs. Less valuable species are used for fuel, posts, and heavy construction timbers. Though more easily accessible than the evergreens, they do not supply the long fibers required for the manufacture of true kraft pulp, and are not very cheap raw materials for the production of inexpensive wrappings and corrugating medium.

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6 Bombax Malibaricum

Bombax falls in the category of light-colored hardwoods and it yields a bleachable pulp with a fairly high degree of strength for its type.

There are other similar local species in addition to Bombax malabaricum, namely insignis, Spondius pennata and Tetramales mudiflora. They are all very similar in pulping properties and fiber length, the latter being 1.5 to 1.7 mm, or typical of short-fibered wood pulps. The rate of growth of bombax is relatively fast compared with most other local hardwoods, although some 10 to 15 years are required before a tree suitable for cutting for pulp wood is obtained. In this respect, therefore, bombax does not solve the problem of producing additional fibrous raw material for a large scale pulp mill between the time of originating the project and 5 years after the start-up of the mill.

In 1949, an area of nearly 800 hectares along the Kwai Noi River and some 30 m southwest of the town of Karncharnaburi was set aside as a bombax plantation. The object was to supply wood for the paper mill at Karnchanaburi, and planting began in earnest in 1955. It was intended that whatever area would be planted by 1965 should be exploitable on a nine-year rotation basis.

In 1955, the Karnchanaburi mill was using a mixture of bamboo with 25% of bombax. The plan to use bombax on the larger scale indicated above did not materialize, however, and at the present time, the Karnchanaburi mill is using a mixture of 60% bamboo and 40% hardwood for only a few of its papers. A yield of 38 to 40% is obtained. The failure of the bombax program was due largely to the depredations of local villagers and farmers, and in particular to their charcoal-burning activities and to their clearing of the ground for the cultivation of other agricultural products.

Plantation bombax is not a solution to the main problem, that of obtaining a strong, long-fibered pulp in a relatively short time, for use in papers which normally are made from imported kraft coniferous woods pulps.

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7. Coniferous Forests (softwoods)

These forests occur all over northern and northeastern Thailand at elevations of 700 to 1,000 m and higher, and they are particularly prevalent in the Dipterocarpus forests, as shown on Map No. 1. The coniferous forest is estimated at 2,000 sq km. Some of the best known stands are in the neighborhood of Srisaket and Ubon. However, they do not occur in any quantity in the southern peninsular or in southeastern Thailand in the region of Bangkok.

There are two main species, namely Pinus khasya and Pinus merkusii. These are large-sized trees which grow to 20 to 40 m in height and 200 to 300 cm in girth. P. khasya is found in the jungle, mountains and flat lands about 300 m above sea level. P. merkusii grows at lower altitudes, i.e., about 100 m. It is frequently associated with the local oak.

There are also exotic long-fibered species, such as Casuarina and Araucaria Cookii, which are indigenous to Australia and Indonesia. These species, however, are negligible in quantity.

Most of the pine forest areas are protected under the forest laws, and permission must be obtained for felling. This system has not worked very well, however, because there are considerable encroachments by local villagers who clear the forest for shifting cultivation and constitute a serious threat to the few natural pine areas which already exist.

It must be recognized that, in the past, the cultivation of pine forests has not aroused a great deal of interest in Thailand. Most of the forestry policies were concentrated on the more valuable timbers of the tropical hardwoods (see above). The pine forests have been regarded as a source of supply also of resin for distillation to provide turpentine and rosin. The whole of this output is consumed in local industries, and it is dealt with further in the Section on Non-Fibrous Raw Materials. Plans have also been made to develop the pine forests for use in plywood manufacture, but, as stated above, the principal interest in these forests has hitherto been in connection with the production of rosin and other by-products.

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A preliminary survey of the forest resources of Thailand was conducted by the F.A.O. in August and September, 1962, and a brief report, "Mission to Thailand to Review a Request for Special Fund Assistance for a Paper and Pulp Material Survey," was made, particularly from the point of view of supplies for a pulp and paper mill. As long term needs, this report recommended:

a. Establishment of a separate research branch in the Royal Forestry Department;

b. Establishment of a pulp and paper technology research unit, probably under the proposed "Applied Research Corporation of Thailand," or else under the Forest Products Research Division of the Royal Forestry Department;

c. Establishment of a Division of Forest Protection in the Royal Forestry Department, to include a modern fire protection organization and to work toward the solution of the difficult problem of forest trespass;

d. Vigorous progress in the land classification survey leading to the setting up of more reserved forests, particularly in the areas of most value for the expansion of the pulp and paper industry;

e. Willingness to grant leases to investors, particularly of forest lands nearest to the proposed plant sites. The Minister of Agriculture now has this authority for "reserved" and "protected" lands;

f. Employment of private foresters by pulp and paper companies, including those operated by Government agencies;

g. Encouragement of the production of forest crops on private lands, particularly by farmers on farm woodlands and by other owners of private land. This action could be stimulated by mill owners as well as by the Royal Forestry Department, particularly if the latter had a Division of Private Forestry Cooperation. The attractiveness of the short-rotation forest crops, such as bamboo and quick-growing trees, would favor their use in such a program.

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As a matter of interest, one of the two pine forest areas near Srisaket was visited during the Survey. The forests in question are about 30 km southeast of the town of Srisaket. The altitude is about 150 m. It was stated that approximately 40,000 trees exist in an area of 43 rai (approximately 6 hectares). The second forest area of a similar nature, 15 to 20 km to the southeast, is also a reserved forest.

The forest was viewed from the main road which crosses the belt of pine area, which is approximately 7 km wide by 17 km long, and by the team entering the forest from the road in places. The pine stands were noted to vary greatly in density; there were very few trees in one place and quite dense groups of trees in another. The trees were tall and straight having grown to approximately 20 m heighth and 45 cm in diameter in 40 years. It is believed that such trees will grow to a size of 10 cm in diamater, under the bark at breast height, in 10 to 14 years. It is understood that much denser stands exist at Phu kra-dung in Loei Province, but this is more distant from Bangkok.

It is unfortunate that there have been no systematic investigations of the conifers in Thailand, either in the form of a volume survey or with regard to pulping properties. P. khasya is currently being used to make newsprint in Vietnam, and there seems to be no reason why it should not prove excellent for the manufacture of kraft pulp. Unfortunately, the pine trees do not presently exist in sufficient quantity in one place to enable them to be exploited for paper manufacture. The only alternative is to plant pines on a large scale with the least possible delay. If trees suitable for pulp making can be obtained after about 10 years, and a rapid start is made, with proper planning, it should be possible to build up a regular supply of wood for the mill after this period. Forestry activity has been largely confined to those trees which are regarded as of more value economically. This favored treatment is demonstrated by the following figures, which show the planting program of the Forestry Department:

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Teak	5,000 rai annually
Other hardwoods	8,000 rai annually
Pinus species	500 rai annually

NOTE: 6.5 rai = 1 hectare (approximately)

An estimate of the potential area of pine in the southern parts of the privinces of Srisaket and Ubon (which are the nearest conveniently situated to Bangkok) is given in a paper written by Eberhardt Gaertner, FAO Forestry Division, as an Appendix to the report above. This is reproduced as Appendix No. XIII.

The report makes definite recommendations as to the type of soil on which the pine should be grown and also takes into account the high increase in the population of the northeastern part of Thailand, which in the past has caused a permanent encroachment on the forest by settlers. It is argued that pine plantations can be established only by conversion to other forest types, or by planting sufficient natural pine to regenerate itself on a sustained yield basis. The conclusion is reached that approximately 570 sq km in this district are suitable for pine forests.

However, not a great deal is known of the habits of the local Pinus species under plantation conditions, so that it is not possible to say in advance whether the above area is likely to be sufficient to sustain a mill of the size envisaged (see Part IV, Market Study) on a sustained yield basis. Unless plantation experiments are made, unexpected difficulties can be encountered in large-scale operations without previous experience.

For example, the pines now grow in admixture with hardwoods. The selective extraction of the pines could react unfavorably on any new seedlings of pine which might subsequently be planted, because of the lack of light. On the other hand, clear-cutting might also have unexpected results, in that it disturbs the overall equilibrium of the tree species of the locality. If, therefore, any steps are to be taken to deal with the raw material situation of a kraft pulp mill in the sense of

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providing long-fibered coniferous pulps, it is important that a start is made at once and on an adequate scale. Such work will involve plantation experiments with pine, first on a small-scale and subsequently on a larger scale to enable the mill's requirements to be met on a permanent basis. It is obvious that trials of this nature, quite apart from the production of the full amount of wood required, would take a considerable period of time. They would certainly also be expensive.

It is the stated policy of the Government with respect to forest land, to undertake forest conservation and reafforestation in order to produce a forest reserve equal to 50% of the total land area of the Kingdom. At the same time, there is a great demand for land for agricultural purposes, both among the traditional types of farmers, and also among the people of the many hill tribes who have no permanent homes and practice shifting cultivation from one place to another. If land for cultivation can be provided for those who need it, the forests need not be disturbed. Under present conditions, however, a strong policy is obviously required in order to keep intruders out of the forest reserves.

The general conclusion is that it would appear to be useless at this stage to count on the availability of any long-fibered coniferous wood suitable for kraft sack paper or liner board for at least 12 to 15 years. It could be made available by then only if the measures outlined above, i.e., plantation experiments and strict control of land, are put into operation without delay.

8. Rubber Wood

The rubber tree is grown widely in all the 14 southern provinces of Thailand, especially on the eastern side of the Gulf of Thailand. No accurate statistical data are available, but it is estimated that the area currently planted with rubber is approximately 400,000 hectares. Thailand ranks next to Malaya and Indonesia as a major producer of natural rubber. The output has risen over the last 10 years from about 100,000 to over 180,000 tons annually. There are some 250 rubber trees to the hectare but the density varies widely. At least

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80,000 hectares are over-age and therefore due for replanting, and it has been suggested that this wood might be a potential source of pulp wood. It has been estimated that by 1970, the total area of over-age trees may reach 200,000 hectares.

Most of the rubber estates are comparatively small and are privately owned. As a result, there has been little incentive for replanting, which is difficult on a small estate. The nature and type of the rubber tree holdings would also make extraction and collection difficult, unless special roadways could be built to those existing. This applies particularly in the rainy season, when road transport becomes very difficult. Preliminary experiments have shown that typical, short-fibered pulps can be obtained from rubber trees of the type grown in Thailand. However, the technology of pulping rubber trees has not been perfected, and a good deal of further experimental work is still required.

The question of the use of rubber wood from over-mature rubber trees for pulping was considered by the Stanford Research Institute in 1960 and the following conclusion was reached:

> "Considering the preponderance of small holdings in Thailand, it might perhaps be best to regard rubber wood only as a possible supplementary source of raw material for any pulp mill which happens to be located in or near one of the main rubber growing areas."

In view of this, together with the distance of the rubber estates from the main markets for pulp and paper and the nature and size of the estates, rubber trees as a source of pulp wood were not investigated further.

9. Summary of Wood Situation

(a) Thailand has fairly extensive supplies of wood, but most of the woods are either too valuable to be used other than as lumber or are short-fibered pulps and not suitable for sack kraft or kraft liner board. They are no more satisfactory for use in corrugating medium

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and low-grade wrappings than are agricultural fibers, which can be supplied to the mill at a much lower cost.

(b) There are two species of pine wood satisfactory for strong kraft pulps which are indigenous to Thailand, but their growth is limited and the existing stands are being jeopardized by indiscriminate cutting. Pine plantations are possible, but a minimum of 10 years would be required for usable wood.

(c) For the long-term future it is recommended that, in order to provide the strongest pulp for the kraft mill, immediate steps be taken to reserve and clear the forest areas sufficient to supply the requirements of the mill, and to institute a system of afforestation to provide pulp wood on a sustained yield basis.

D. Bamboo

1. Technology and Utilization of Bamboo for Pulp and Paper

Bamboo is a well-established papermaking fiber. It has been used in India for the last 50 years and is one of the mainstays of the paper industry of that country. The annual production of bamboo pulp in India is 250,000 tons. The methods of pulping it have undergone improvements over the years. The most suitable process is the kraft or sulfate process. A modern bamboo pulp mill is similar in practically all respects to a kraft mill based on wood. Bamboo is also successfully pulped by the new, rapid continuous method, such as that operating in the newest mill in India, which was built and started-up by Parsons & Whittemore in 1962. This method is proposed for the second-stage of the mill for Thailand. (See Section XI, Process Description.)

The properties of bamboo pulp are also well known. The fibers average 3 mm length, or the same as coniferous woods, although the pulp properties differ. The fiber diameter is 0.020-0.025 mm, or about half that of sofrwood fibers. The bamboo pulp has a desirably high tearing strength, but it gives a relatively low tensile strength due to poor bonding

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characteristics. When used in combination with the strongly-bonding bagasse pulp, the blend can be used to produce the full range of papers from bleached writing papers through the highest strength multi-wall bag papers. Thus, the need of long-fibered material for a pulp and paper industry in Thailand could be met with bamboo. The fiber dimensions of several Thailand bamboo species are given in Table IX. Several species are noted to be well above the previously stated normal lengths of 3 mm.

The silica contents of the skin and inner zones of several bamboos are also shown in Table IX. These figures point up a characteristic of bamboo, namely, the high silica in the skin zone. This skin tends to be disrupted in chipping and, if not removed, may cause difficulty in cooking and in recovery.

2. Availability in Thailand

Bamboo constitutes one of the most valuable forest products in Thailand. It occurs in abundance in the mixed deciduous-type of forest, which comprises about 15% of the total area of the country. There are some 34 common species comprising the Arundinaria, Bambusa, Cephalostachyum, Dencrocalamus, Oxytenanthera and Thyrsotachys families. One of the principal families is that known locally as Pai Pah (Bambusa Arundinacea, Wild). This grows to a diameter of 25 to 40 cm and is found throughout Thailand. Another important species is Pai Ruak, which is Thyrsotachys Siamensis Gamble; this grows to a diameter of 4 to 6 cm and is also found throughout Thailand.

Of secondary importance are Pai Bong (Bambusa Tulda, Roxb.), Pai Laolarm and Pai Hok, (Dendrocalamus Giganteus, Munro).

Bamboo also occurs in several other parts of Thailand in addition to the forests around Karnchanaburi. There are areas of it in Chiengmai Province, which are even larger than those at Karnchanaburi, and also in Lam Pang Province, and in the southwestern peninsula.

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TABLE IX

FIBER CHARACTERISTICS OF SEVERAL THAILAND BAMBOO SPECIES

Species	Fiber length mm	Lumen dia. micron	2 x wall thickness micron	SiO_2 in the "Skin Zone" %	SiO_2 in the "Inner Zone" %
Pai Bong (Bambusa tulda, Roxb.)	4.68	12	12	0.020	0.0020
Pai Kaolarm (Cephalostachyum pergracile. Munro.)	2.32	9	10	0.019	0.0015
Pai Rai (Oxytenanthera albociliata. Munro.)	2.59	12	12	0.020	0.0009
Pai Sang (Dendrocalamus membranaccus Munro.)	4.32	9	14	0.019	0.0031
Pai Hok (Dendrocalamus gigantens Munro.)	3.22	13	10	0.018	0.0027

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It was not possible to obtain details regarding bamboo forest surveys in Thailand. The bamboo occurs quite widely, but is scattered, and grows only in relatively small quantities in any one place. Also, the main stands are located in close association with mixed deciduous and evergreen forests. These occur principally in the western and northern Provinces of the country.

Bamboo is found in close proximity to the pulp and paper mill at Karnchanaburi, as described later.

Relatively little of this is systematically planted. There is a plantation at Prachin which cultivates bamboo shoots for food.

Bamboo also grows along the river near the Bangpa-In mill and also near Srisalut, where plantations exist for poles and shoots. These stalks are all relatively small and grow only 16 m in 5 to 6 years and are said to flower every 20 years.

3. Bamboo Experience at Thai Paper Mill

As already stated, the Thai Paper Mill at Karnchanaburi is at present using mainly bamboo in its production. However, at 10 tons per day, this is not very large. Some of the papers contain up to 30% of hardwood (Spondius pennata) with 70% of bamboo. A so-called "kraft" paper, used for wrapping and said to be made from bamboo is also produced by the Karnchanaburi mill. An evaluation of this is shown in Appendix No.V . The strength properties fall far short of those expected of a true kraft paper as shown also in Appendix XIV.

The bamboo species principally used by the Karnchanaburi mill is Thyrsostachys Siamensis. This is one of the predominant species of the locality. There is another and larger type of bamboo also found in the neighborhood, Bambus Arundinacea. This type is very thorny, however, and is not used for paper manufacture owing to harvesting and handling difficulties.

The Government has reserved approximately 4,800 sq km of land in the neighborhood of the Karnchanaburi

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mill for the mill's supply of pulping materials. This has been encroached upon very considerably by farmers, who clear the ground and plant kapok, castor plants, cotton, etc. The bamboo is cut down and used for fences, furniture, roofing, fishing poles, baskets, etc., or simply burned. Machines have even been devised for splitting bamboo and for peeling off thin strips which are used for weaving venetian-type blinds.

It is apparent that bamboo is a material of considerable economic importance in this locality and that its growth development is highly desirable. It is equally obvious that existing and future stands of bamboo will be pilfered for those more remunerative purposes (as compared with pulp manufacture), if they are not properly protected.

As a result of the conditions outlined above, the amount of bamboo in reasonable proximity to the Karnchanaburi mill has decreased. It must now be obtained from areas more distant from the mill, e.g., 50 to 80 km. In these areas, bordering the banks of both Kwai Rivers (Kwai Noi and Kwai Yai), the bamboo at or near the river edge is cut. The bamboo poles are trimmed by the villagers, made into rafts and floated down the river to the mill. The price delivered is B. 120 per metric ton calculated on a bone dry basis as determined from moisture tests made at the mill. The mill will accept only poles at least 7 m long and having a cross-sectional diameter of 1 cm at the narrow end. The yield of the pulp obtained is 38 to 40%.

The bamboo is chipped while wet because this reduces the wear on the cutting knives, which have to be changed every 3-4 hours. The present production of the mill is 10 tons of paper per day, but it is proposed to double this in the near future. The bamboo is cooked in rotary cylindrical digesters with a mixture of caustic soda and sulfur, so as to produce a mild kraft process.

The Karnchanaburi mill forest reserves, on which the villagers have encroached, are mainly to the northwest and west of the mill, and within easy reach of the two rivers which join near the mill, namely the Kwai Yai, which flows from the northeast, and the

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Kwai Noi, which flows almost parallel with it from a more southerly direction. These two join just above Karnchanaburi, and the river is then known as the Mae Klong River.

The potential yield of these reserves, as estimated by Mr. Wang Teravut, Manager of the Karnchanaburi Mill, assuming that the bamboo would be cultivated instead of allowed to grow wild, could be 4 to 8 tons per rai or 26 to 39 tons per hectare on a sustained yield basis; and it could be delivered to the mill at about B. 75 per metric ton, bone-dry basis, as opposed to the present price of B. 120.

The mixed bamboo forests between Karnchanaburi and Ban Tha Sao (Map No. 3) were visited. It was noticed that the large thorny type of bamboo (Bambusa arundinacea) grew nearer the mill than the type which is actually being used. Bambusa arundinacea is used largely for poles, especially for fishing purposes, because the stalks attain a length of up to 20 m in 6-10 months, although it takes an additional 2 years for the walls to thicken to maturity. Because of its size, this fast-growing species is of relatively great value, and therefore too costly for pulping purposes, even assuming it could easily be harvested on a large scale. (By way of contrast, the species pulped by the mill grow only 7 to 12 m in one year's time.)

Unfortunately, no helicopter service was available and it was therefore impossible to explore the bamboo situation along the banks of the Kwai Noi River. It is understood, however, that a good deal of bamboo exists in this area. It lies in mixed forests and within 5 km of the river bank. On the other hand, the river Kwai Noi appears to be a more difficult river for rafting purposes owing to the shallows and sand banks. This is not necessarily a drawback, because the bamboo could be stored on the river banks and rafted down in the wet weather when more water is available. Here again, however, it is reported that there have been inroads into the bamboo stands by local farmers and that the total amount of bamboo is tending to decrease rather than increase.

PROPRIETARY INFORMATION

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Not all the bamboo is floated to the mill. If the site from which it is cut is near the mill (and there are not many such sites now existing) the bamboo can be delivered very cheaply by road, e.g., for around B. 75 per ton, bone-dry basis.

Above the mill on the Kwai Yai River, at a distance of some 40 km, a hydro-electric dam will be built, and 6 km above the mill, a retaining dam (which will be smaller) will also be built. The latter will probably have a race in order to enable bamboo poles to be floated down past the dam.

It has been established that the local bamboo grows well after cutting and that it can be cut 3 to 5 years after the first planting. There is no special evidence that flowering difficulties occur as they do with some bamboos, but it should be made very clear that such knowledge as exists at the moment about these bamboos refers only to the wild plants and not to the cultivated bamboos.

It is unfortunate that steps have not been taken to ensure the preservation of bamboo in the forests around the Karnchanaburi mill. These could be a most valuable asset, not only to this mill, but also to any other mill which might be set up in the locality. As long as present poaching conditions exist, however, it appears that it will be impossible to rely on more than relatively small quantities of fairly inexpensive bamboo for paper manufacture.

4. Cost of Bamboo

It has been mentioned that bamboo costs B. 120 per ton dry at the Thai Paper Mill. Other prices of B. 75 per ton were reported. However, for the purpose of this report the conservative cost figure of B. 120 per ton has been used.

The delivered cost of B. 120 is equivalent to approximately US $6.00 per ton which is a very low figure in comparison with southern pine pulpwood in the United States, for example, at $14.00 - $16.00 per ton.

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5. Bamboo Procurement for Proposed Mill

It is envisaged that the second stage pulp mill will be based essentially on bamboo and that this pulp mill will start up in 1971. However, it is necessary to plan now for the bamboo for this mill.

As far as the method of procurement is concerned, the usual method as practiced by the Karnchanaburi mill will be used. In this method, the transport is by rafts which are formed of the bamboo poles. The rafts would be floated down the river, but they would have to pass over the race at the small retaining dam which will be built 6 km above the Karnchanaburi mill. This would mean that the rafts would have to be broken up, and the bamboo collected again after it had passed the rapids. With practice, this should not present any special difficulty, but it is more involved than floating the whole rafts directly to the mill, as is done presently.

The supply of bamboo itself is viewed as coming from plantations, rather than natural growth. As far as is known, there is no detailed information available on bamboo plantations anywhere in the world which have been established specifically to provide raw material for paper pulp. If bamboo plantations are considered for development in this part or any other part of Thailand, it would be a purely experimental project, especially in the beginning. It would therefore have to be approached as follows: small areas would have to be planted in order to learn the best planting conditions; then, larger areas could be planted based on this experience.

Although flowering does not appear to be characteristic of the indigenous bamboo in Thailand, it might well appear in plantation bamboo and must therefore be explored before full-scale development is under way.

Experiments of this kind, if initiated immediately, could well yield fruitful results by the time the mill has been in existence for 5 years. If the experiments are successful, the mill could use bamboo pulp in the production of its kraft paper in a proportion to be determined by the quality of the resulting pulp.

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Here again, therefore, there is an extremely strong case for conserving present bamboo forests and for developing them on a sustained-yield basis to provide material for paper pulp manufacture.

6. Summary of Utilization of Bamboo in Thailand

(a) Species of indigenous bamboo existing in Western Thailand are satisfactory pulping species, and they do not appear to present the problem of flowering frequently.

(b) Bamboo is obtainable at a reasonable price at B. 120 per ton delivered, dry basis.

(c) Although reliable information on the bamboo forests in Thailand is lacking, the opinion is that areas exist where adequate supplies can be grown under a rational system.

(d) Methods of handling and transporting bamboo have been developed and can be applied for the proposed mill.

E. Kenaf

Kenaf, a variety of the hibiscus plant, is a fast-growing plant resembling a hollyhock. The plant is known by over 120 names throughout the world, much as Ambary hemp, Deccan hemp, Bombay hemp, Java jute, Bimli jute, wild stockroos, mesta, bastard jute, sunn okro, and rosella.

The soft fibers from the stalks of Kenaf have been used by the native populations of Asia and Africa for several hundred years. At first, consumption of the fiber was restricted to the local area where it was grown, and the commercial value of the plant was not recognized until the middle of the nineteenth century. It was then recognized as an acceptable substitute for jute in the manufacture of burlap, sacking, rope, twine, and carpet backing, though not considered an important substitute for hard fibers such as sisal and Manila hemp.

This fiber is regarded as an economically promising fiber in Thailand. The Prime Minister has appointed a special committee to deal with the promotion of kenaf sales. At the present time, production is approximately

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200,000 tons per annum, and could be greatly increased to meet larger demand. Approximately 160,000 tons are exported as skeins of fiber to be made into sacks. A certain amount is also converted into sacks in Thailand for the home market. In the northeast region, the yield of dry fiber is 3% to 4% of the whole green plant or about 6% to 8% of the dry weight of the plant.

In the course of preparing the skeins of kenaf for the market, the dirty ends are cut off, leaving lengths of 20 to 30 cm. At present these waste ends are all exported, chiefly to Japan, for use in rugs and upholstery. The price depends on that of the kenaf skeins and is usually approximately 50% of the price of the skeins, or approximately B. 1,000 per ton at present. The price of the waste has gone as high as B. 2,500 per ton. Approximately 5,000 tons are available per annum. An analysis of a sample of this material from a factory near Ubon, is given in Appendix No. XV. The material was found to be a valuable papermaking raw material which can be processed at very little cost and without great loss of yield.

After being cut in the field, the kenaf stalks are retted for 10 to 15 days in shallow water-filled pits, and the fibrous residue is removed by beating the rest of the stalk to a pulp. The yield is only 6% to 8% of the whole stalks on a dry basis. It is believed that if the stalks could be stripped of their bark mechanically, instead of by the lengthy retting process, the ribbons might be used directly in the papermaking process without retting. In the present retting process, the inside of the stem is beaten to a pulp and therefore lost in releasing the long-fibered outside bark. If the bark were removed by a mechanical decorticator, the stalk could then be put back on the field so that the field would not lose the organic matter included in the stalk.

In the north and northeast, the main retting season is October to February. The separated and dried kenaf can be stored through the remainder of the year. The farmers receive the equivalent of B.60 per ton of stalk processed. They would probably welcome any proposition which involves selling the stalk for mechanical decorticating to produce a ribbon from the bark without having to ret it to remove the bark fiber. Samples of stalk from the 1962 harvest were taken from

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the Ubon region and the results of preliminary digestion experiments are shown in Appendix No. XVI.

The results of the chemical analysis indicate that it might be possible to make use of the whole stalks of the kenaf. However, it is more likely that onlh the bark ribbon would be used because of the high pith content in the inner stalk. This would eliminate the retting process and would allow the pulp mill to take the bark ribbons directly to the digester after cutting them to proper length without any further processing following the mechanical decorticating.

Kenaf fiber itself is extremely strong; stronger, in fact, in tearing strength than coniferous kraft wood pulp. However, the whole stalk of kenaf does not give a pulp as strong as kraft wood pulp and the presence of pithing material is detrimental to good operations. Certainly the long-fibered bark from the Kenaf stalks would undoubtedly contribute strength, but this yield is relatively small in relationship to the rest of the stalk, and the strengthening effect of these fibers would be lost if an attempt were made to use the whole stalk. Furthermore, the long distance of the projected pulp mill from the kenaf growing regions of the northeast, and the bulky nature of the stalks and consequent freight problems and expenses, tend to offset the possible advantage of utilizing the whole kenaf stalks rather than the waste cuttings or the bark ribbons.

Grade A kenaf in bales, currently selling at B. 2000 per metric ton exfactory in the northeast, is clearly too expensive a raw material for this project.

It is planned that a great deal of effort will be devoted to thoroughly investigate kenaf in the Project I mill's pilot plant before large quantities are accepted for pulping in the Project II pulp mill.

F. Rice Straw

Cereal straw, like bagasse, is a recognized papermaking raw material. It is widely used in Europe, and particularly in Holland, for a great variety of papers and its use has been studied in great detail. Several modern methods of pulping have been built around the use of straw and high yields of high-grade quality

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pulps are now readily obtainable. Straw, therefore, must be regarded as a highly desirable raw material; this applies in particular to wheat straws.

1. Economic Considerations

The principal varieties of papermaking interest included under this heading are straws from wheat, barley, rye and oats. Other straws (e.g. from rice and linseed) have also been used in localities in which they are plentiful, but they are less suitable for papermaking raw materials. The common cereal straws do not differ greatly in chemical composition. The only outstanding figure is the high ash content of rice straw, which consists largely of silica. Differences in pulping characteristics are small, and are due largely to physical structure. Wheat straw is generally accepted as being the best for pulp manufacture, but otherwise, opinions differ as to the order of merit of the others. Barley, being soft, does not pack so well into the digester, and, in any case, because of its softness, it is usually in demand by farmers for the bedding of cattle. It can, however, be successfully used for paper pulp making, and the same applies to oat straw which is little, if at all, inferior to wheat.

The economics of straw pulp production permit no generalization, and each country has to be considered on its own merits. Holland and Denmark are cases in point. Each is essentially a compact and intensively agriculturalized country. Straw is, therefore, abundant (yield, over 1.5 tons per acre), and being cheaply transported to the mills over the short distances, is itself comparatively cheap. The scientific farming methods used mean high yields, and, therefore, a surplus over the farmers' requirements for bedding, fertilization, etc. The enlightened use of chemical weed killers means, moreover, a clean straw, free from these sources of dirt and shive. Most important of all, the farming community has a direct financial interest in several of the largest mills, so that there are always available to the mills adequate supplies of straw at reasonable market prices.

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The highest proportion of the straw pulp made in Holland is an unbleached semi-pulp suitable for straw board manufacture, but a large tonnage of a good grade of bleached pulp is also produced. The position varies somewhat between these extremes in other countryes. Thus, Denmark is well placed to follow the example of Holland, and is doing so. Large mills have been erected in the wheatlands of South America, and there are medium-sized straw mills in various parts of Central and Southern Europe, and in Turkey and Portugal.

There is some difference of opinion as to whether straw is used to the best advantage on the farm, and indeed, whether it can be dispensed with. A number of farmers argue that return of straw to the land is an essential feature of good husbandry and cannot be substituted for in any way. Others argue with equal force that synthetic fertilizers and other forms of modern tillage can produce effects similar to those of straw, leaving the straw available for non-agricultural uses. Work carried out in the great cereal-growing areas of the Midwest in the United States have even indicated that straw left on the land is detrimental to subsequent growth of leguminous and forage crops.

The whole problem can probably be condensed into the simple statement that, if it is made worth while for the farmer to sell his straw to the paper maker, then he will manage without it on the farm. Should such an arrangement become possible, it can influence very materially the paper position of a country and build up what is virtually a new and valuable indigenous pulping industry. Successful cooperative schemes of this nature, in which the farmers have financial interest in the mills they supply, are in operation in Holland and Denmark.

Attention should be drawn to certain complications which may affect the main issue, as set out below.

The straw, however it is harvested, should be as free as possible from weeds and other foreign plants. The latter may arise from crops previously planted on the same ground. By the use of modern weedicides on the one hand, and care on the other, it is not difficult to produce an absolutely clean straw, and

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this is common practice in Europe. Where large quantities of straw are being purchased at a time, the moisture content becomes important, especially in wet weather. A figure not exceeding about 12% is a good target, but moisture contents of 17% should not be tolerated. The objection to wet straw is, however, not solely one of cost; such straw does not pass readily through the cutters and dusters.

The straw that must be held in the mill as stock can be stored out of doors in stacks. Since it is usually pressure-baled on the farms into bales about 25 kg or more in weight and secured by wire, the building of such stacks is not a difficult matter even where wholly mechanized handling is not available. About 800 to 1000 tons per stack is a convenient size, and the base bales should be kept clear of the ground on planks or concrete to avoid damage by damp. There should be adequate spaces between the stacks to act as fire-breaks and to provide easy access by truck, and the straw should be used in rotation, i.e., first in, first used.

Since the Bangpa-In mill, which is Government owned, was built to run on rice straw pulp, it is appropriate to give some further consideration to this particular fibrous raw material. Rice straw is not a widely used raw material for paper pulp manufacture, but under suitable circumstances, it has proved quite suitable for the purpose. Its utilization has been studied in Hungary, Egypt and Korea, and in all of these countries, rice straw is abundant and usually cheap.

2. Properties of Rice Straw Pulps

(a) A peculiarity of rice straw is its high silica content. This varies from one type of rice straw to another and from one type of rice straw to another and from one country to another, but is always considerably greater than the maximum figure for other straws.

Since the silica is partly dissolved in the digestion process, this chemical appears in the black liquor. When the ash content of the black liquor is high, difficulties in the black liquor recovery are encountered, more or less

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in direct proportion with the amount of silica present. The silica gives problems in evaporation, combustion and recausticizing. A certain ash content can be tolerated, but, in the case of rice straw, the problems become insurmountable for normal operating procedures and mills making rice straw pulp make no attempt to recover the black liquor. Considerable research has gone into developing methods to overcome the problem of high silica in the black liquors, but no practical method has been commercially successful up to the present time.

(b) Pulps made from straws tend to be slower draining (lower freeness values) than wood pulps and this is more so true in the case of rice straw. This tendency makes the pulp somewhat difficult to wash and also reduces the maximum speed at which the paper machine can be run, an important economic factor. Again this effect is greater with rice than with other straws.

This disadvantage, however, brings other small advantages in its association. For instance, the slow-draining condition of the pulp as it is produced means that less power is required to bring it to the stage of strength development at which it is ready for the paper machine.

(c) For the reason indicated above, as well as for the properties of the papers, no paper is normally made containing 100% straw pulp. Such a paper can be made, but in order to utilize the potential paper machine production to the best advantage and to produce papers with the highest possible quality, it is usual to add a proportion of long-fibered sulfite or kraft wood pulp. This has the dual effect of improving the drainage on the wire of the paper machine and therefore allowing greater speeds to be operated, and also of improving the tearing strength of the paper. The amount of such long-fibered pulp added depends on the straw pulp used and on the type of paper being made.

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(d) It is axiomatic in paper manufacture that the fibrous raw material needs to be low priced because paper is generally an inexpensive product. Thus, a fibrous raw material cannot be in a competitive position as to its utilization. In some countries, however, rice straw is a commodity inextricably bound up with the life of the farming community, and to some extent with that of urban life also.

It is widely used for a great variety of purposes such as roofing for houses, hedges, mats, baskets, footwear, packing and bagging material, and for protecting animals in the winter.

The important fact is that rice straw can have a market value quite apart from any potential use it may have as a papermaking material. Its market value as a papermaking fiber could conceivably become prohibitively high. Or, if the market price were held low, insufficient quantities of rice straw might be offered by the farmers, since they might prefer to use it for other purposes.

Considerable quantities of rice straw are available in Thailand. The production of rice in the country averaged approximately 7 million tons during the years 1956 to 1960, and more than 50% of this production came from the central flood plain region of the country, and in particular from the country adjacent to the banks of the Chao Phraya River.

Agriculture in Thailand provides a livelihood for approximately 85% of the population and produces about 80% of the country's export earnings (U.S. $130 million, in 1959). Most of this is derived from rice. Most of the land under agriculture is owned by the farmers, and, generally speaking, they form a reasonably prosperous community. Within recent years, high yield per hectare have been obtained owing to improved methods of agriculture. At the same time, the population has increased considerably since the war and the domestic

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rice consumption has increased proportionately. Production of rice has managed to keep pace with these increases, and exports have been well maintained.

Rice growing projects are assisted considerably by the large scale irrigation projects and this has had a bearing on the choice of the site of the projected mill (see Section IX). The low level Chainat Dam, which was partly financed by the World Bank and completed in 1956, provides irrigation for more than 800,000 hectares of crop land along the Chao Phraya River. An even more important dam, namely the Yanhee Dam, is under construction; this will be the largest of its kind in southeast Asia, and will be integrated with hydro-electric production. Table X shows the areas under cultivation, the production, the exports and the consumption between 1934 and 1962.

Detailed attention was given to the possibility of using rice straw for the manufacture of paper pulp in Thailand by the FAO Secretariat in a paper presented to the Converence on Pulp and Paper Development in Asia and the Far East, at Tokyo, in October, 1960. This was in the form of a Case Study based on the Bangpa-In mill, which at that time was a project in the course of development.

A system was worked out whereby the rice ready to be harvested (from October to January) would be cut by hand in the field. After threshing, any surplus straw would be made available by the farmers for collection by the paper mill. Some of the straw is utilized for cattle fodder, but there is usually a large excess. The plan was for the mill to collect the straw from the farmers, preferably by flat boat of about 25-tons capacity. About ten such boats would be hauled to certain central baling points by means of a motor boat. The straw was to be then baled at the sheds, by means of small portable baling machines. The baled straw was then to be stored in the sheds, and collected as required by the mill.

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TABLE X

RICE IN THAILAND

Averages	Area (1,000 acres)	Production (1,000 metric tons milled)	Exports* (1,000 metric tons milled)	Consumption (1,000 metric tons milled)
1934-38	8,327	2,832	1,388	1,444
1945-49	10,284	3,557	612	2,945
1950-54	13,153	4,505	1,321	3,184
1955-59	12,813	4,628	1,254	3,374
Annually				
1959/60	12,884	4,716	1,203	3,513
1960/61	14,174	5,012	1,563	3,449
1961/62 +	14,287	5,000	1,400	3,600

* Exports on calendar year basis

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This stage of transportation would usually be carried out by barges, and it was estimated that an average of six barges could be hauled to the mill by motor launch of 15-horsepower. At the mill, the baled straw was to be moved from the river by means of an automatic conveyor, either directly into the mill or into storage.

It will be seen that this method of utilization of rice straw depends very largely on water transport, as indeed does much of the rural transportation and economy of this part of Thailand. This, however, does not preclude the use of road truck or bullock cart transport where this is more convenient than river or klong.

Water transport by klong is sometimes subject to the limitation that the klong is usable only during a certain period of the year due to insufficient water during the dry season. This point is dealt with further in the Sections on Site Selection and Transport.

The paper mill at Bangpa-In was started up in February, 1961. It has a paper machine 3.3 m wide which runs a maximum speed of 200 m per minute. The straw is processed in rotary boilers having a capacity of 35 cu m, at a pressure of 7.73 kg per sq cm. Each of these operates on an 8-hour cycle, producing a 30% yield of bleached pulp. Under these circumstances, the mill has a capacity of 40 tons per day, which is hoped to be raised to 60 tons in the near future. A second machine would then be installed to increase the output to 100 tons per day. The average furnish of the paper made is said to be 70% rice straw with 20% chemical wood and 10% of the mill's repulped sub-standard papers. An analysis of a typical mill writing paper is shown is Appendix No. IX.

Thus far, the Bangpa-In mill has not run particularly smoothly. Apart from technical difficulties, there have been difficulties in obtaining rice straw supplies by the system

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envisaged. As a result, production has suffered and the capacity production of 40 tons per day has not yet been attained. (See Market Study.) The future of the mill appears to be uncertain, and there is some suggestion that it may be purchased from the Government by a private company.

The Bangpa-In mill is designed to make bleached pulp and white papers. Therefore, its functions are different from those of the proposed kraft pulp mill which is the subject of the present Study. On the other hand, rice straw can be used in its unbleached state and could undoubtedly be suitable for use in a corrugating medium for cartons. It would be unsuitable for use in cement sack paper or in kraft liner board because of its poor tearing strength.

Under present conditions of rice straw supply, it might be inadvisable for two mills to use the same basic raw material, especially if circumstances compelled them to be within close proximity of one another. Although a solution undoubtedly exists to this particular problem of supply, the overall position would not be improved if a competitor for rice straw entered the field. It would certainly tend to harden the price. For these reasons, it might well be regarded as bad policy for the proposed mill to utilize the fiber.

G. Miscellaneous

Other possibilities investigated in the Survey were sisal, cereal straws, ramie, jute, hemp, and manila. It was felt that none of these was available in the quantity, quality and price necessary to provide a suitable and economic pulp.

In concluding this Section, some notes on the activities of the Food and Agriculture Organization (FAO) of the United Nations should be noted. The Forestry Division has conducted a one-year study dealing with the stages of forest land management in Thailand. This report had not appeared at the time of the Survey. However, if

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among its recommendations are suggestions that a cultivation of pine for pulp manufacture should be promoted at a greater and more vigorous rate than at present, this would have a distinctly advantageous bearing on the present project.

It is also known that the FAO will soon be making a three-year study of all the papermaking raw materials in Thailand, including pine trees, other woods, bagasse, rice straw and bamboo. This again will be an interesting document in view of the period over which it is programmed. The present Survey is based on what is available now or in the relatively near future if the proposed mill is to start up reasonably soon. The results of the FAO Survey must therefore be regarded as having a long-term significance, which may well modify the Government's forest and agricultural policies of the future.

On the other hand, action by the Government in developing any particular species of tree or other agricultural product is not likely to be carried out on any scale involving great expense until the report of the three-year study is available, which will probably be about 1967. This means that it is unlikely that the Government will take any particular steps in planting pine forests or bamboo forest (although it is to be hoped that early steps will be taken to prevent the depredation of the existing forests) until the results of the three-year study are known.

It was learned that, although the Government does not intend to take immediate steps of this kind, it would permit an industrial enterprise to do so without waiting for the results of the three-year study, so long as it is satisfied that the project is an economic one. It was implicit in this statement that a private company taking these steps would have to meet the cost. The Government, however, might be prepared to clear-cut the existing forests so as to enable the private company to replace them by whatever raw material it felt to be most suitable for pulping purposes.

As pointed out earlier, it would be most unwise to commence large-scale planting without preliminary plantation experiments which will indicate the right species to be used and the best conditions under which to grow it.

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Given the types and magnitude of the mill's production, and the amounts of raw materials required, it would appear that long-range development work of this kind would be beyond the scope and resources of the present project.

H. Imported Wood Pulp

Until sources of domestic fibrous raw materials can be provided for the full production of paper, it will be necessary to import wood pulp for the proposed mill. The grade required for the kraft liner board and the sack paper will be unbleached kraft pulp, and the present price of this c.i.f. Bangkok, based on a London quotation (Scandinavian pulp) is equivalent to B. 2950, or US $140.50 per long ton. There is a duty of 10% for customs purposes, and a business tax of 1.5% on the c.i.f. Bangkok price plus duty. When made into paper and sold to users, the business tax becomes 5% of the selling price, and a municipal tax of 10% of the business tax is added.

Details regarding the imports of wood pulp and other fibrous raw materials are given in Section IV (Market Survey). It will be noted that the category "Chemical Wood Pulps, Other", is comprised largely of unbleached kraft pulp. If the price is calculated from the value c.i.f. Bangkok, and the weight imported, an average value of approximately B. 2950 is obtained. This confirms the figure given above.

Other London quotations (Scandinavian pulps) are (per long ton c.i.f. Bangkok):

Semi-chemical (unbleached) pulp	B. 2320
Strong sulfite (coniferous, unbleached pulp)	B. 3030
A current Taiwan quotation for unbleached sulfate bagasse pulp, C.I.F. Bangkok, is:	B. 2264
Waste paper is presently sold in Bangkok at:	B. 100 per ton

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The Customs Tariff Decree E. 2503 dated 1960 gives the following duties for papermaking materials:

Item 47.01	Pulp derived by mechanical or chemical means from any fibrous vegetable raw material	25.5% ad valorem (since reduced to 10%)
Item 47.02	Waste paper or paperboard; particles of paper or if paperboard, fit only for use in papermaking	
	(a) Old newspapers	B. 1.00 per kg
	(b) Other materials	27.5% ad valorem

As pointed out in Part IV (Market Study), industries which are suitably classified are exempted from duties and business taxes, so far as their raw materials are concerned, for five years. It is assumed that the present project will enjoy such concessions for the full five-year period. Furthermore, since the second stage pulp mill is, for all interests and purposes, a second project being implemented several years after completion of the Project I stage, it is expected that equipment, fuels, and raw materials imported for its construction and operation will also enjoy a full period of concessions.

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VI. NON-FIBROUS RAW MATERIALS

A. General

In this section, there are considered all the principal raw materials required by a pulp and paper mill other than those of a fibrous character. Included are the chemicals required directly for the pulping process as well as those for the paper mill. Less essential chemicals or those required only in small quantities (such as dye-stuffs) are not discussed, as they do not influence the general conclusions of this Study. Water and fuel are considered elsewhere in this Report.

Although it is envisaged that the mill will be initially only partially integrated with respect to pulp production, it is believed possible that the mill will eventually produce close to 100% of its pulp requirements. Therefore, for the purpose of this Section, it will be assumed that the mill will eventually operate with indigenous fibrous raw materials. Thus, based on 45,000 tons of pulp and paper per year in round figures, the approximate quantities of the various non-fibrous materials required by the pulp and paper mill, respectively, are given below.

B. Chemical Requirements for Pulp and Paper Manufacture

The chief non-fibrous materials required on an annual basis for a mill making 150 tons per day (45,000 tons per year) of unbleached kraft pulp and paper are as follows:

Chemical Requirements	Amount Tons per Year
1. Pulp Manufacture	
(a) Project I	
(1) Salt cake	1,800
(2) Lime (without lime recovery)	4,000
(b) Project I and II	
(1) Salt cake	4,200
(2) Lime (with recovery)	3,200

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2. Paper Manufacture	Amount Tons per Year
(a) Project I	
(1) Alum	1,600
(2) Rosin	750
(b) Project II	
(1) Alum	1,800
(2) Rosin	850

C. Chemicals for Pulp Manufacture

1. Salt Cake, Sodium Sulfate (Na_2SO_4)

Salt cake is used in kraft pulp manufacture to make up for losses of soda and sulfur carried away from the system in the pulp, wash water and recovery furnace stack. The procedure is to add the salt cake to the recovery furnace when the organic matter in the evaporated waste cooking liquors is being incinerated. The sodium sulfate is reduced to sodium sulfide by the organic matter. The sodium sulfide, together with sodium carbonate also formed in the combustion, then passes forward into the green liquor which is treated with lime, as discussed next, to form sodium hydroxide and sodium sulfide for use in the digestion. It is used in this way because, as a rule, it is a cheap and convenient procedure, since salt cake in many countries is an inexpensive chemical from natural sources or available as a by-product from other chemical operations. In fact, the kraft process is also known as the sulfate process for reason of using sodium sulfate as the make-up chemical.

Salt cake is not produced in Thailand, and it does not appear ever to have been imported, as there are no statistics. Local quotations were also not available.

There is, however, the possibility that this chemical might be produced locally in the future as a by-product from the manufacture of soda ash.

A quotation was obtained from the Salt Cake Association of London, which is concerned with the export of salt cake suitable for use in the kraft process. Salt cake packed in six-ply paper bags, net weight 100 lbs (1 cwt) is priced at £17.5.0.

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(B. 1018) per long ton, c.i.f., Bangkok. This is based on the current freight rate of £8.5.0. per long ton weight, usual Conference terms. By way of comparision, the price of salt cake in the United Kingdom is approximately (B. 500) per ton.

Salt cake is not specified in the Customs Tariff Decree B.C. 2503, 1960, but it is assumed from the duty on similar products that its duty would be 27.5% ad valorem. On the basis of a duty-free price of B. 1018 plus B. 123 freight, the delivered price of B. 1141 per ton is used in the subsequent manufacturing cost calculations.

2. Lime (CaO)

This chemical is second in importance only to salt cake in kraft pulp manufacture. It is used as hydrated lime ($Ca(OH)_2$ to causticize the sodium carbonate (Na_2CO_2) formed in the recovery furnace. This reaction produces caustic soda for re-use in pulping.

For this purpose, a high grade burnt lime is desirable, preferably with a free lime content exceeding 90% CaO. Lower grade limes can be used, but the value of the lime is then roughly proportional to the free lime content, with some deduction for the cost and inconvenience of removing the non-lime constituents and especially small stones.

Investigations in Thailand indicated that a large amount of lime is available and that the quality is, on the whole, fairly good. The lime contains approximately 75% of CaO and some unburnt limestone and 1% of magnesia (MgO). However, most of the lime suppliers are relatively small and a large supply might present some problems. A large user such as a pulp mill might find it advantageous to produce its own lime by either owning its own quarry or by purchasing limestone and burning it at the mill itself, although this step is not contemplated for the proposed mill.

The occurrence of limestone is fairly widespread in Thailand. The two existing pulp and paper mills in Bangpa-In and Karnchanaburi have limestone deposits of their own. In Bangpa-In, the kiln is only 35 km away.

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In Karnchanaburi, the mill has its own quarry and kiln and is in a position to produce all of its requirements.

The following local prices were obtained for lime and limestone:

Lime	B. 300 to B. 350 per ton
Limestone	B. 45 per ton

For the purpose of this Report, it has been assumed that suitable lime will be obtainable for use in the recovery system at a delivered price of B. 300 per ton.

3. Caustic Soda (NaOH)

Caustic soda is the main pulping reagent in alkaline digestion processes. It is used alone in the soda process and in conjunction with sodium sulfide in the kraft process. In the kraft recovery process the alkali lost in the recovery processes is made up with salt cake, as described above.

The amount of caustic soda required as make-up in the soda process with a chemical recovery system are comparatively small since this operation can usually recover about 80% of the caustic soda originally used, and only enough caustic is required to make up the losses from the operation. Where relatively cheap soda ash is available, however, the make-up caustic soda required at this stage can be produced chemically from it by the action of lime, the same reaction as used in causticizing the green pulping liquor.

The cost of caustic soda to the mill depends on the relative costs and availability of caustic soda, lime and soda ash on a quality basis.

Table XI shows the imports of caustic soda into Thailand for the year 1961. The countries of origin are given together with the quantities in kg, and the value c.i.f., Bangkok in Bahts. Division of the c.i.f. value by the number of tons imported gives an average price of B. 1,380 per ton. This price may be on the low side, because the price of caustic soda has risen recently.

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TABLE XI

IMPORTS

Commodity Code	Commodity Description	Country	Unit Code	Quantity	CIF Value Baht
5110300	Sodium Hydroxide	Hongkong	03	227	1292
		Penang	03	480	1440
		Singapore	03	340	504
		Japan	03	733500	1050335
		France	03	385500	562916
		W.Germany	03	356828	485433
		Italy	03	502200	617411
		Poland	03	50000	74351
		U.Kingdom	03	2031218	2797521
		U.States	03	5084	24352
		Australia	03	228	897
				4065605	5616452
5110400	Sodium Carbonate	Hongkong	03	480	6246
		Fed.Malay	03	12701	7692
		Penang	03	45539	44713
		Japan	03	2659935	2502570
		Taiwan	03	60	199
		Denmark	03	6	212
		France	03	250000	243086
		W.Germany	03	6460	14188
		Italy	03	200000	224086
		Poland	03	59000	55660
		U.Kingdom	03	910025	921362
		U.States	03	14109	47167
		B.W. Indies	03	11160	10222
		Kenya	03	3442269	3139148
		Un. S. Africa	03	304819	276082
				7916563	7492633

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Also, the method of packaging influences the price. For pulping purposes, solid caustic in non-returnable metal drums is used.

A local quotation for solid caustic soda from the United Kingdom in non-returnable metal drums, was ฿ 27 (B. 1593) per metric ton plus 22% duty ad valorem.

4. Soda Ash, Sodium Carbonate (Na_2CO_3)

As explained above, this chemical is required if caustic soda is to be produced by causticizing with lime in the soda recovery process.

Table XI also gives the imports of sodium carbonate into Thailand, with country of origin, quantities and values in kgs for 1961. The price, as calculated from the total, is approximately B. 940 per ton. The principal source of supply is from Lake Magadi, in Kenya. This is a heavy type soda ash, having a pouring density of 0.85 as against 0.5 for the commoner light soda ash used in pulping. Apart from the question of storage, these differences are insignificant from the pulping point of view. Typical chemical and sieve analyses of Magadi soda ash, as packed, are shown in Table XII . This is a good-grade soda ash, and suitable in every way for the purpose of causticizing lime to produce caustic soda.

The local quotation was ฿ 16 (B. 944) per metric ton c.i.f., Bangkok, in non-returnable 200-lb single-ply jute bags. There recently was an increase in price and, as a result, the price will likely remain stable for some time. The duty on imported soda ash is 27.5% ad valorem, plus an additional business and municipal tax of 1.65%.

In terms of material costs, there is little to choose between purchasing caustic soda or causticizing soda ash, although the latter is slightly the cheaper. The latter alternative, however, involves additional plant investment, and it is evident (by comparing the relative prices of caustic soda and lime and soda ash) that it would be more economic to buy the caustic soda and avoid the additional capital cost.

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TABLE XII

CHEMICAL ANALYSIS

A typical chemical analysis of Magadi Soda Ash as packed:

	%
Na_2CO_3	97.1
NaCl	0.29
NaF	1.8
Na_2SO_4	0.35
Insoluble	0.26
Loss on heating	0.20
Fe_2O_3	0.022

Note.-- The figure of 0.022% is the total Fe_2O_3 content. Most of it is present in the insoluble matter.

SIEVE ANALYSIS

A typical sieve analysis of Magadi Soda Ash as packed:

British Standard Sieve No.	Equivalent U.S. Bureau of Standards Sieve No.	Equivalent Tyler Sieve No.	Aperture Size (mm.)	%
+12	14	12	1.40	1.0
22	25	24	0.70	39.5
36	40	35	0.421	24.0
72	70	65	0.211	17.9
100	100	100	0.152	5.6
120	120	115	0.125	1.7
240	230	250	0.065	5.5
-240	230	250	0.065	4.8

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5. Sulfur (S)

Sulfur is used in pulp production to provide sulfidity when salt cake is not available. It is also burned to form sulfur dioxide for use in production of sodium sulfite and also sometimes for use in the bleaching process. There are two possible sources of sulfur for Thailand.

(a) Bagged, grade 99.8%, price c.i.f., Bangkok, U.S. $60 (B. 1,260) per metric ton. This is obtained from Canada.

(b) Lump-packed in 100 kg, non-returnable jute bags, at £ 20 (B. 1,180) per metric ton. This is of European origin.

The duty for lump sulfur is not specified, but sulfur sublimed or precipitated or colloidal, attracts a duty of 10% ad valorem. (The Customs Regulations state that where a particular commodity is not listed, it should be assumed that the duty is the same as the nearest like substance.)

6. Sodium Sulfite (Na_2SO_3)

This chemical is now frequently used in pulping processes, especially in the manufacture of semi-chemical pulps for use in corrugating board. In some cases, this chemical is obtained as a by-product from phenol manufacture, and under such circumstances, it is relatively cheap. Such sources, however, do not exist in Thailand nor are they likely to do so for some time to come.

The second source is by import of the sodium sulfite, but quotations obtained for commercial crystals were approximately £50 (B. 2,950) per metric ton plus 27.5% ad valorem duty. This is obviously a prohibitive price for the present purpose, even assuming that a lower grade than that covered by the above quotation could be used.

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A third source is to generate sodium sulfite from sulfur and caustic soda or soda ash. The sulfur is burned to produce sulfur dioxide. This gas is then passed into caustic soda or soda ash to form the sodium sulfite. This method could be adopted for a mill in Thailand, although the price of sulfur, an imported product, is also high. If native hardwoods were used to make semi-chemical pulp, however, it might prove worthwhile to manufacture sodium sulfite in this way, since the hardwood semi-chemical pulps are considered to be the best for corrugating board. It is pointed out that this generalization applies to hardwoods of the temperate zone, but there is reason to believe that many tropical hardwoods should give satisfactory semi-chemical pulps which certainly should be suitable for the corrugating medium required in the manufacture of kraft cartons.

7. Salt, Sodium Chloride (NaCl)

Sodium chloride is the basic chemical for production of sodium hydroxide and chlorine, which are formed by electrolysis of salt. This can only be done effectively in countries where salt and electrical power are cheap.

Sodium chloride is available in Thailand from solar evaporation of sea water in large salt pans on the coast, especially to the east of Bangkok, and on the northeast coast. Both the Bangpa-In and Karnchanaburi mills have electrolytic plants to make caustic soda and chlorine. These two plants are small, but consideration is being given at Karnchanaburi to enlarging electrolytic facilities and increasing production so that a surplus will be available for sale on the market.

Both of these mills make bleached pulps for white papers and, therefore, can use both the caustic soda and the chlorine. In the case of the projected mill, which will make unbleached pulp only, the caustic soda could possibly be used and the chlorine would therefore be surplus. There is a certain demand for chlorine in Thailand, but as Table XIII shows, this demand is comparatively small since no more than approximately 105 tons were imported in 1961. The value of this, c.i.f., Bangkok, was almost B.500,000, giving an average price per ton of approximately B. 4,680.

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TABLE XIII

IMPORTS

Commodity Code	Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
5110931	Chlorine, liquid or gas	India	03	3854	23555
		Japan	03	320	1910
		W.Germany	03	79998	344254
		U.Kingdom	03	20763	118282
		U.States	03	317	2802
				105252	490803

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This is a very high price by standards of chlorine used in the wood pulping industries. If chlorine could be sold at this price, it would easily pay for the cost of making caustic soda for mill use; this would be despite the rather poor quality of much of the local salt, which contains only 89% of sodium chloride.

The key to the problem is in the nation-wide demand for chlorine, which, at the present time, is quite small. Most of the chlorine imported is used for water sterilization, which requires very small quantities. Until there is a very big demand for chlorine, therefore, it seems impractical for a pulp mill producing only unbleached pulps to manufacture caustic soda by electrolysis and to sell the chlorine to help to pay for the caustic soda. It was learned during the survey that discussions are in progress to operate a plant at Bangkok, which will produce 10 tons per day of caustic soda. Even if realized, this would be far too little for the purposes of the present project.

D. Principal Chemicals for Paper and Board Manufacture

1. Aluminum Sulfate, Alum ($Al_2(SO_4)_3$)

Alum is used in the sizing of paper and to control the acidity of the papermaking operation. The delivered price for alum was taken at B. 1400 per ton for the purposes of this Report.

This chemical is produced locally at a Government factory near Bangkok, and is used by the Bangpa-In Mill. The price for a 17 to 18% Al_2O_3 grade, in slab form, is B.1,400 per ton delivered to the mill.

Processes exist for the preparation of aluminum sulfate from china clay by the action of sulfuric acid under pressure. In the regions where a suitable clay exists and its composition is satisfactory, this process is quire feasible. Experiments would first have to be made on local clays to ascertain their suitability, and, in any case, the sulfuric acid would largely have to be imported.

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The following quotation was obtained in London for aluminum sulfate 17 to 18% Al_2O_3, of German origin, in second-hand, non-returnable, single-ply jute bags holding 50 kg each: B. 1,500 per metric ton, c.i.f. Bangkok. This would attract a duty of 27.5% ad valorem.

2. Rosin, Colophony.

This chemical is used with alum for sizing in paper manufacture. Rosin is extracted from the pine trees in small local plants such as that inspected at Ubon. This processing plant utilizies the rosin removed from the Srisaket pine forests. An analysis of this rosin is shown in Appendix No.XVII. The analysis shows that the grade is quite satisfactory for use in the present project; in fact, the color is somewhat better than is required for kraft papers. But the supply is limited and, although domestic rosin has been bought by the Bangpa-In mill, the price, at B. 6000 per metric ton, is high. This price, incidentally, has recently been greatly increased from its previous level of approximately B, 3,000 per ton.

As an alternative, and in view of the inadequate supply, it may be preferable to import rosin from Portugal, at U.S. $229 (B. 4,810 per ton) c.i.f. Bangkok, plus 27.5% duty for the WW and and WG grades, (The KLM gum rosin is cheaper), or from France. The following quotation was obtained in London for rosin WG grade, in 800 cwt casks: B. 6,960 per ton, c.i.f. Bangkok.

A price of B. 4,937 per ton is used in this Report, based on the imported price of B. 4,810 plus B. 127 freight per ton.

E. General Comments and Conclusions on Chemicals

1. The prices of chemicals as imported into Thailand are relatively high, and it is, therefore, necessary to consider what can be done with indigenous chemicals.

2. Of the major chemicals required for pulp manufacture, salt cake will have to be imported and lime is available domestically. An alternate pulping chemical, sodium hydroxide could be made from salt available in Thailand.

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This, however, would not be practical at this time since there is practically no demand for chlorine. Also, though salt is relatively cheap, the grades available would require purification. In the future, with an increased demand for chlorine, it might be profitable to electrolyse the local solar salt in order to produce both caustic soda for use in the mill and chlorine to sell in place of the expensive imported chlorine. In this regard, much will depend upon steps taken by other parties interested in caustic soda and chlorine production.

3. The major chemicals for papermaking, alum and rosin, will need to be imported.

4. It must be appreciated that all the above data are tentative and the prices may change before the mill start-up in late 1966.

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VII. FUEL, STEAM AND POWER

A. General Comments

The cost of steam and electric power constitutes an appreciable portion of the production costs in a pulp and paper mill.

Power can usually be generated more economically by a fully integrated pulp and paper mill itself than it can be purchased; but in the case of a partially integrated mill, it may be cheaper to purchase the power required initially.

It has been established that this project will be built as two projects: 1. A partially integrated pulp and paper mill, and 2. a second pulp mill five years after the establishment of the first mill. An analysis of the cost of power has been made for the first project only, since, as mentioned above, if it should prove economical for the partially integrated mill to produce its own power it would be even more so for a fully integrated pulp and paper mill operation.

It is not possible to know the exact figures for power and steam requirements prior to the final engineering of the project. Based on experience, however, it is possible to make realistic estimates of the operating conditions and from these, arrive at power and steam requirements that are reliable.

As shown later in the calculations, it will be more economical to generate the necessary power at the mill rather than to purchase it, due to the high cost of public electricity in Thailand.

B. Fuels and Power

At the present time, there are three types of fuel being used in Thailand: wood, lignite and oil.

1. Wood

Wood supplies are running short, and there is a Government restriction on felling, thus eliminating wood as a possible fuel for this project.

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2. Lignite

Lignite is found in substantial deposits at Lampan Mamoh, in the North, where thermo-electric plants have been developed, one in particular in connection with the fertilizer industry. Surveys have indicated that the lignite deposits amount to at least 5,000,000 tons and possibly 100,000,000 tons. The output is 200,000 tons per annum, which could increase to 500,000 tons per annum. The price is B. 80 per ton f.o.b. site, plus B. 92 for delivery, or a total of B. 172 per ton. The calorific value is 3,700 cal per kg. Due to the relatively high cost of transportation of the lignite, however, its use does not prove to be as economical as that of fuel oil in this instance.

3. Fuel Oil

Fuel oil is marketed chiefly by the Shell Company of Thailand, Esso Standard Eastern and Caltex, and the price delivered to the mill site by truck as indicated by the suppliers, would be B. 500 per metric ton for the first five years. After this time, with duty and tax concessions no longer in force, the price would be B. 617 delivered to the mill.

There is at present in operation in Thailand a Shell refinery with an output of 4,000 barrels, and it is planned to establish another refinery with an output of 28,000 barrels/day. As these refineries produce primarily gasoline, it is reasonable to expect that they will have a surplus of fuel oil which may be available on a contract basis at lower prices that those currently quoted. The pulp and paper mill proposed in this Report will be a natural outlet for such surplus fuel oil.

It is cheaper to ship fuel oil by rail, but at the present time, due to the congestion of the railway system and shortage of rail tank wagons during the dry season, this is not always possible. Consequently, the price based on transportation by truck has been used. The grade of oil available is somewhat lighter than the Bunker "C" oil normally used in industrial furnaces. A typical analysis of the oils available is given at the end of this section. The calorific value of the fuel oil is 10,500 cal per kg.

These three fuels having been duly considered, it has been decided to use oil as the fuel for the proposed pulp and paper mill.

4. Electric Power

Due to the shortage and high cost of power in Thailand, industry has in the past had to generate its own power based mostly on imported fuels. The present investigation has shown

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that most industrial plants are still generating their own power. This problem of power shortage is now being met, to some extent, by the building of lignite-burning thermopower plants. It is hoped that long range development of the hydro-electric potential will be sufficient to meet the country's future estimated demands. For example, the first two giant generating units of the Yanhee dam project are scheduled to go into operation in 1964, thus increasing the electrical capacity of the country by 50%. Plans call for six additional turbo-generator units to be added later to give the dam a total rated capacity of 560,000 kilowatts. However, as a result of discussions with the electrical authorities, it must be assumed that, even with this high capacity, the price of electricity in Thailand for the initial ten years of operation of the new hydro-electric plants is going to be as expensive, if not more so, than the present rates.

Consequently, the average price as calculated from the existing schedule of rates provided by the "Yanhee Electricity Authority" has been used in comparing the cost of public versus mill generated power. Based on a demand of approximately 5000 kw, the cost of purchased power works out to an average of B. 0.405 per kw hr.

C. Estimated Power and Steam Requirements

1. Estimated Power Requirements

Departments:	Partially Integrated Mill HP	Partially Integrated Mill KW	Fully Integrated Mill HP	Fully Integrated Mill KW
a. Bagasse Preparation	699	520	699	520
b. Bamboo Handling	-	-	691	515
c. Digestion	800	597	1311	978
d. Washing & Screening	866	706	1577	1176
e. Wet Lap Machine and Waste Paper	370	275	380	285
f. Chemical Preparation	10	7	10	7
g. Stock Preparation	5905	4405	5905	4405
h. Paper and Board Machine	2415	1801	2415	1801
i. Roll Handling, Finishing and Converting	100	75	100	75
j. Evaporators	210	156	420	312

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Departments:	Partially Integrated Mill HP	Partially Integrated Mill KW	Fully Integrated Mill HP	Fully Integrated Mill KW
k. Chemical Recovery	350	261	660	492
l. Recausticizing	145	108	290	216
m. Steam and Power Plant	325	242	450	336
n. Mill Shops	235	175	255	190
o. Pilot Plant and Laboratory	25	19	25	19
p. Water and Effluent	550	410	910	679
q. Mill Lighting and Miscellaneous	-	200	-	300
Total Connected Load	13105	9957	16098	12306

The total estimated connected load for the partially integrated pulp and paper mill is 9,957 kw. Assuming a demand factor of 0.75, the maximum demand will be 7,450 kw.

If power is generated at the mill, a 7,500 kw turbogenerator will need to be installed.

2. Estimated Steam Requirements

	Partially Integrated Mill Tons/hour	Fully Integrated Mill Tons/hour
a. Digestion System	6.8	13.5
b. Pulp Washing (Recovered from Blow Heat System)	(4.7)	(4.7)
c. Paper and Board Making	25.0	25.0
d. Chemical Recovery System	5.6	11.2
e. Miscellaneous Steam	4.0	8.0
f. Steam Generated by Recovery Furnace	(8.5)	(18.6)
Net Process Steam Required	32.9 tons/hr	39.7 tons/hr

The steam required for the operation of the mill is estimated to be 35,000 kg/hr at 8 atm, saturated, if power is purchased; it will be 57,000 kg/hr at 41 atm and 385°C if power is generated.

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D. Comparison of Costs of Oil Versus Lignite Fuel (Steam Generation Only)

In the following comparison, the cost of the buildings for an oil-fired or a lignite-fired boiler has been assumed to be the same.

The cost of a fuel oil-fired boiler and auxiliary equipment installed would be B. 5,088,000.

The cost of a lignite-fired boiler and auxiliary equipment installed would be B. 9,360,000.

		Cost per Year Baht
1.	Oil - First Five Years	
(a)	Fuel - 57,000 kg/hr, 7200 hr/yr, oil at B. 500 per ton, 10,500 cal/kg, 80% efficiency	15,440,000
(b)	Labor - Operating	445,000
(c)	Labor - Maintenance	314,000
(d)	Supplies	594,000
(e)	Interest	410,000
(f)	Depreciation	470,000
(g)	Supervision, Control, Administration and Contingencies	575,000
	Total	B. 18,248,000/yr
2.	Lignite	
(a)	Fuel - 57,000 kg/hr, 7200 hr/yr, lignite at B. 172 per ton, 3,700 cal/kg of lignite, 75% efficiency	17,000,000
(b)	Labor - Operating	628,000
(c)	Labor - Maintenance	728,000
(d)	Supplies	990,000
(e)	Interest	749,000
(f)	Depreciation	867,000
(g)	Supervision, Control, Administration and Contingencies	975,000
	Total	B. 21,937,000

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The above figures show that it would be more economical to generate steam utilizing imported fuel oil rather than Thai lignite. Aside from price consideration, the use of oil would also be more practical in that it would give a neater, more efficient and compact plant and would be less subject to operating difficulties.

E. Comparison of Costs if Power is Generated at the Mill or Purchased

1. Generated Power

(a) Capital Cost

Installed cost of an oil-fired boiler for 57,000 kg. of steam per hr at 41 atm and an operating temperature of 385°C, including fuel oil pumping, boiler feed pumps, condensate receiver, deaerator, water treatment, chemical treatment, turbogenerator auxiliaries, piping, valves and fittings, instruments, etc. B. 23,646,000

(b) Operating Cost

	Cost per Year Baht
(1) Fuel - 57,000 kg/hr at 41 atm and 385°C	B. 15,440,000
(2) Labor - Operating	640,000
(3) Labor - Maintenance	450,000
(4) Supplies	890,000
(5) Interest	1,413,000
(6) Depreciation	1,641,000
(7) Supervision, Control, Administration and Contingencies	810,000
	B. 21,283,000

2. Purchased Power

(a) Capital Cost

Installed cost of oil-fired boiler for 35,000 kg of steam per hour at 8 atm saturated, including fuel oil pumping set, boiler feed pumps, condensate receiver, deaerator, water treatment, chemical treatment, piping, valves and fittings, instruments, etc. B. 4,327,000

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(b) Operating Costs	Cost per Year Baht
(1) Fuel - 35,000 kg/hr at 8 atm saturated	B. 8,395,000
(2) Labor - Operating	445,000
(3) Supplies	314,000
(4) Power - 7500 kva x B. 405 x 7200 hr	21,870,000
(5) Interest	260,000
(6) Depreciation	294,000
(7) Supervision, Control Administration and Contingencies	335,000
Total	B. 31,913,000

The calculations above definitely demonstrate that it will be more economical for the proposed paper mill to generate its own power.

The cost of generated power is B. 0.25 per kw hr, which is well below the price of B. 0.405 given in the schedule of rates from the Municipal Electrical Authority.

For the purpose of this Report, therefore, it has been assumed that the power required for mill operation will be generated by means of turbogenerators, and will be distributed at 3000 volts at a frequency of 50 cycles.

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TABLE XIV
INDUSTRIAL FUEL OIL

		Min.	Max.
Gravity	°API	12.0	
Flash, PM	°F	150	
Pour, Upper	°F		65
Viscosity:			
Redwood 1 @ 100°F		200	600
Sulfur, Bomb	%		0.5
Sed. by Extract	%		0.25
Water by Dist.	%		1.0
Sed. by Hot Filtr.	%		0.15
Explosivity	%		50
Distillation			-
Ash			0.10

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TABLE XV

SPECIFICATION

FUEL OIL

Specific Gravity at 60/60°C		max.	0.975
Viscosity Redwood I at 100°F	sec.	max.	450
Pour Point	°F	max.	70
Sulfur Content	% wt	max.	3.0
Water Content	% vol	max.	0.75
Sediment	% wt	max.	0.15
Flash Point P.M. cc	°F	min.	150

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VIII. PERSONNEL AND LABOR

A. General Comments

Labor is plentiful in Thailand and wages, by American or European standards, are relatively low. The Thai workers are industrious and possess considerable manual dexterity and intelligence, but their productivity (again by industrial standards in America and Europe) will be low until training increases their skill. This fact will make it necessary initially to employ more workers than a comparable mill of the same size would require in the more industrialized areas of the world.

Pulp and paper manufacture is a highly specialized industry. Since the pulp and paper mill proposed for Thailand will have to make high-grade products in order to be competitive and to meet the standards required of cartons and paper sacks, it will require a fairly large initial staff of experienced foreign personnel to start up the mill and to train the Thai operators.

A pulp and paper mill depends for economic operation very largely on full production, and shut-downs due to inexperienced supervision or maintenance can be extremely costly. Skilled supervision and workmen, therefore, although expensive, are cheapest in the long run. In order to reduce the foreign staff as rapidly as possible, it is proposed to set up a group of Thai understudies for key managerial and technical positions. After the start-up and the training period of perhaps one or two years, it will then doubtless be possible to reduce the foreign staff, but it is probable that a minimum number of key experienced personnel will be required for a number of years thereafter.

The question of labor availability and working conditions was discussed with the management of the two Government paper mills, Bangpa-In and Karnchanaburi. The questions of labor and rates of pay were also discussed with other industrial organizations in the country, and in particular with the cement works and the glass factory. It was found that, in general, Government rates of pay for paper and pulp mill workers are somewhat lower than the rates of pay for corresponding types of work in other industries. However, living quarters are

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often provided for workers in the Government factories, such as at the Bangpa-In Pulp and Paper Mill, due to its isolated location. Much of the housing is on the apartment house style, costing an estimated B. 10,000 per room. Free medical care is also available, and is compulsory if 120 or more employees are on the payroll. At the end of service, a pension is provided in the form of a lump sum equal to the monthly wage at retirement multiplied by the number of years of service. However, private firms have their own programs of a similar nature, some of which are contributory.

There appear to be no particular conditions imposed on industry, so far as labor is concerned, and although trade unions exist, their power is not great due to an overall surplus of labor. The cost of labor varies from one part of the country to another, but in general it is higher in Bangkok than in other regions. In general, a 42-hour week is worked; the two Government paper mills work three 8-hour shifts, but they are considering changing to the four-shift system.

As regards vacation, 10 working days with pay are given per annum. In addition, there are 12 to 15 legal holidays. This applies to all ranks of employees. In Government employment, wages continue during an illness of up to 30 days, but there appears to be no adequate check on whether absence for the whole of this time is really necessary in the event of a particular case of sickness. Overtime is paid at 1.5 times normal rate, and Sundays at twice normal rate.

Staff and management are employed on approximately the same basis as process workers, but it is usual for the former to receive a bonus of 5 to 10% of the net profits. Certain ranks of the staff obtain a free house, costing an average B.110,000. Services are usually provided, and in special cases a car.

B. Personnel Requirements

Since this Enterprise is to be implemented as two separate projects, the personnel requirements have been divided into the following categories:

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Project I - the partially integrated pulp and paper mill;

Project II - the additional pulp mill.

1. Partially Integrated Pulp and Paper Mill - Project I

(a) Operating Personnel

The operating personnel requirements for a combined pulp and paper mill capable of producing approximately 19,000 tons per year of its own pulp requirements from native fibrous raw materials and approximately 45,000 tons per year of kraft liner board, corrugating medium, paper sack material, miscellaneous wrappings, and assorted sack and bag products, have been estimated as follows:

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TABLE XVI

OPERATING PERSONNEL - PARTIALLY INTEGRATED MILL

PROJECT I

SO - Shift Operators
OH - Operator Helpers
GH - General Helpers

Department	Shift No.1			Shift No.2			Shift No.3			Shift No.4			Totals			Grand Total
	SO	OH	GH	SO	OH	GH	SO	OH	GH	SO	OH	GH	SO	OH	GH	
Bagasse Handling	2	2	10	2	2	10	2	2	10	2	2	10	8	8	40	56
Digestion System	1	2	1	1	2	1	1	2	1	1	2	1	4	8	4	16
Washing, Screening & Wet Machine	1	2	2	1	2	2	1	2	2	1	2	2	4	8	8	20
Chemical Recovery	3	3	3	3	3	3	3	3	3	3	3	3	12	12	12	36
Purchased Pulp Handling	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	12
Stock Preparation	1	2	1	1	2	1	1	2	1	1	2	1	4	8	4	16
Paper and Board Making	4	5	3	4	5	3	4	5	3	4	5	3	16	20	12	48
Finishing, Converting and Shipping																
*Male	7	9	9	7	9	9	2	2	2	2	2	2	18	22	22	62
Female	-	10**	3**	-	10	3	-	-	-	-	-	-	-	20	6	26
Steam & Power	2	1	1	2	1	1	2	1	1	2	1	1	8	4	4	16
Turbine, Boiler, Electric, Water & Effluent Treatment	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Mechanical Mill Service: Millwright	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Electrician	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Shops: Lathe, Shaper Milling Machine	2	2	-	-	-	-	-	-	-	-	-	-	2	2	-	4
Benchmen	2	1	-	-	-	-	-	-	-	-	-	-	2	1	-	3
Millwright	3	3	-	-	-	-	-	-	-	-	-	-	3	3	-	6
Pipe Fitter	2	2	-	-	-	-	-	-	-	-	-	-	2	2	-	4
Welder	2	2	-	-	-	-	-	-	-	-	-	-	2	2	-	4
Carpenter	2	2	-	-	-	-	-	-	-	-	-	-	2	2	-	4
Tinsmith	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-	2
Painter	1	2	-	-	-	-	-	-	-	-	-	-	1	2	-	3
Electrician	3	3	-	-	-	-	-	-	-	-	-	-	3	3	-	6
Guards: Gate House	-	2	-	-	2	-	-	2	-	-	2	-	-	8	-	8
Security	-	3	-	-	3	-	-	4	-	-	4	-	-	14	-	14
Yard Labor	-	3	10	-	1	3	-	-	-	-	-	-	-	4	13	17
TOTAL OPERATING PERSONNEL - PROJECT I:													108	170	129	407

* Includes 1 skilled Shipping Clerk, 4 shifts.
**Seven of these women are used in 2-shift converting plant, which will gradually increase from 1 to 2 shifts over a period of 5 years.

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(b) Clerical and Laboratory Personnel

(1) Office (days only)	Total Number Required
Office Manager-Accountant	1
Purchasing Clerk	1
Storekeepers	4
Personnel, Time and Payroll Clerk	1
Billing Clerks	5
Bookkeeper	1
Secretaries and File Clerks	3
Messenger	1
Total:	17

(2) Laboratory	
Paper Testers (shift)	4
Pulp Testers (shift)	4
Chemist (days only)	1
Assistant Chemist (days only)	1
Laboratory Assistants (days only)	2
Pilot Plant Operator (days only)	1
Helper (days only)	1
First Aid Orderlies (shift)	4
Total:	18

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(c) Supervisory Staff	Total Number Required
(1) Foreign Management (to be provided under Management Contract)	
General Manager	1
Accountant	1
Paper Mill Superintendent	1
Pulp Mill Superintendent	1
Converting Plant Superintendent	1
Steam & Power Plant Superintendent	1
Plant Engineer	1
Assistant Engineer	1
Technical Control Superintendent	1
Chief Electrician or Electrical Engineer	1
Instrument Engineer	1
Master Mechanic	1
Foremen -	
Bagasse Handling & Pulping	4
Paper Mill	4
Total:	20
(2) Thai Understudies to Foreign Management Personnel	
General Manager	1
Accountant	1
Paper Mill Superintendent	1
Pulp Mill Superintendent	1

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	Total Number Required
Converting Plant Superintendent	1
Steam & Power Plant Superintendent	1
Plant Engineer	1
Assistant Engineer	1
Technical Control Superintendent	1
Chief Electrician or Electrical Engineer	1
Instrument Engineer	1
Master Mechanic	1
Foremen -	
Bagasse Handling & Pulping	4
Paper Mill	4
Total:	20
Total Clerical, Laboratory and Supervisory Personnel:	75
Total Labor Force for Partially Integrated Pulp and Paper Mill - Project I:	482

2. Fully Integrated Pulp and Paper Mill - Project II

(a) Operating Personnel

When the mill is fully integrated, the new operating personnel requirements are estimated to be as follows:

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SO - Shift Operators
OH - Operator Helpers
GH - General Helpers

TABLE XVII

OPERATING PERSONNEL - FULLY INTEGRATED MILL
PROJECT II

Department	Shift No. 1			Shift No. 2			Shift No. 3			Shift No. 4			Totals			Grand Total
	SO	OH	GH	SO	OH	GH	SO	OH	GH	SO	OH	GH	SO	OH	GH	
Bagasse Handling	2	2	10	2	2	10	2	2	10	2	2	10	8	8	40	56
*Bamboo Handling	1	2	8	1	2	8	-	-	-	-	-	-	2	4	16	22
*Bamboo Chipping	1	2	3	1	2	3	-	1	3	-	2	3	2	6	12	20
Digestion System	1	2	1	1	2	1	1	2	1	1	2	1	4	8	4	16
Wash, Screen, Wet Machine	1	2	2	1	2	2	1	2	2	1	2	2	4	8	8	20
Chem. Recovery	3	3	3	3	3	3	3	3	3	3	3	3	12	12	12	36
**Purchased Pulp Handling	1	1	-	1	1	-	1	1	-	1	1	-	4	4	0	8
Stock Preparation	1	2	1	1	2	1	1	2	1	1	2	1	4	8	4	16
Paper & Board Making	4	5	3	4	5	3	4	5	3	4	5	3	16	20	12	48
Finishing, Converting, Shipping																
Male	7	9	9	7	9	9	2	5	2	2	2	2	18	22	22	62
Female		10***	3***		10	3								20	6	26
Steam & Power (Turbine, Boiler, Electric)	2	1	1	2	1	1	2	1	1	2	1	1	8	4	4	16
Water & Effluent Treatment	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Mech. Mill Service: Millwright	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Electrician	1	1	-	1	1	-	1	1	-	1	1	-	4	4	-	8
Shops: Lathe, Shaper, Mill, Mach.	2	2	-										2	2	-	4
Benchmen	2	1	-										2	1	-	3
Millwright	3	3	-										3	3	-	6
Pipe Fitter	2	2	-										2	2	-	4
Welder	2	2	-										2	2	-	4
Carpenter	2	2	-										2	2	-	4
Tinsmith	1	1	-										1	1	-	2
Painter	1	2											1	2	-	3
Electrician	3	3	-										3	3	-	6
Guards: Gate House		2			2			2			2			8		8
Security		3			3			4			4			14		14
Yard Labor		3	10		1	3								4	13	17
TOTAL OPERATING PERSONNEL - PROJECT II:													112	180	153	445

*Additions

**Purchased pulp is much less in Project II, and 4 unskilled men are moved to Bamboo Handling Dept.

***Includes women used in two-shift converting plant

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Additions	Shift Operators	Operator Helpers	General Helpers	Total
Department				
Bamboo Handling	2	4	16	22
Bamboo Chipping	2	6	12	20
Reductions				
Purchased Pulp Handling	—	—	-4	-4
Total Additions:	4	10	24	38
Net Additional Personnel:				38

(b) Clerical and Laboratory Personnel

No increase.

(c) Supervisory Staff

(1) Foreign Management

Reduced to approximately one-half of initial Project I level. It is estimated that the original roster of 20 foreign supervisors provided under the Management Contract can be reduced to one-half after the first two years of operation of Project I.

(2) Thai Understudies to Foreign Management Personnel

Remain unchanged in number.

(d) Total Personnel

The combined personnel for the fully integrated pulp and paper mill will then be as follows:

Production	445
Clerical	17

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Laboratory	18
Supervisory Staff (Thai)	20
Supervisory Staff (Foreign)	10
Total Labor Force for Integrated Operations - Project II:	510

The above lists are, of course, tentative and subject to revision later as the mill design is finalized, and after start-up, when the efficiency of the local labor can be determined.

C. Wage Rates

As a result of the various inquiries made, the following Thai rates of pay were established for use in the present Study. These figures are higher than those presently paid in Thai Government factories and, if anything, they are slightly on the high side when compared to the presently paid wages in other industries. However, they should be quite realistic by the time the paper mill starts operating.

1. Staff and Management (Thai)

General Manager or Managing Director	B.12,000 per month or as arranged
Works Manager	B. 9,000 per month
Chief Engineer	B. 8,500 per month
Chief Electrical Engineer	B. 7,000 per month
Works Doctor	B. 4,000 per month
Mill Superintendent	B. 4,000 per month
Chief Chemist	B. 3,000 per month

2. Office

Chief Accountant	B. 7,000 per month
Chief Clerk	B. 3,500 per month

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Clerks	B. 1,700 per month
Typists	B. 900 per month
Secretary	B. 3,000 per month
Messengers, etc.	B. 700 per month

3. Process Workers

Shift Operators	B.350 per 44-hour week
Operator Helpers	B.200 per 44-hour week
General Helpers	B.120 per 44-hour week
Women, Operator Helpers	B.160 per 44-hour week
Women, General Helpers	B.100 per 44-hour week

The above salaries are based on rates to be paid in Thailand and also on all Thai personnel. However, in the beginning the staff and management personnel will be composed mainly of foreign personnel, as it will be necessary that they be experienced men in their fields. As the Thais gradually develop the necessary knowledge and skill, they can gradually assume these duties at the foreman level.

Obviously, it will be necessary for the foreign personnel to receive remunerations attractive enough to secure capable people. In addition to their basic salaries, the foreign staff will have to be furnished with housing, school and recreational facilities and most of the other facilities they would normally expect to have at home. Such "extras" are described in the following section regarding fringe benefits.

It should also be pointed out that any change in social or labor legislation or practice will change the above labor cost calculations.

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4. Fringe Benefits

It is assumed that the workers will live in their own homes in the nearest town or village, but will be provided with transportation to and from work by the mill. On the other hand, certain members of the management and staff, particularly those who have to live at or near the mill, will be provided with houses, and the cost of maintaining such houses is included in the following fringe benefit figures. The capital cost of these houses will, of course, be included in the capital cost of the project. In the case of members of the foreign staff, allowance has also been made for home leave and for replacements during their absence.

(a) Fringe Benefits for Wage and Salaried Personnel (Thai)

Vacation	3 1/3%
Statutory Holidays	4 %
Yearly Bonus	4 %
Sick Pay - 15 Days	5 %
Transportation to Work	12 %
Medical	4 %
Welfare Fund	3 2/3%
Other	15 %
Total Benefits of Gross Payroll:	51 %

(b) Fringe Benefits for Foreign Technical and Administrative Personnel

Vacation - no replacement considered.

Statutory Holidays - included in monthly salary.

Sick pay - included in monthly salary.

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Medical	15%
Housing	12%
Travel	12%
Yearly Bonus - 2 Weeks per Year	4%
Other	7%
Total Benefits of Gross Payroll:	50%

D. Calculation of Personnel and Labor Costs - Project I

1. Pulp Mill

(a) Total Personnel Costs per Year

Operating Labor:

Shift Operat.	28x27,482 =	769,496	
Operat. Helpers	36x15,704 =	565,344	
General Helpers	64x 9,422 =	603,008	
		1,937,848	B.1,937,848

Service Labor:

Shift Operat.	17x27,482 =	467,194	
Operat. Helpers	27x15,704 =	424,008	
General Helpers	7x 9,422 =	65,954	
		957,156	B. 957,156

Control & Administration:

1,128,876x0.45 = B. 507,994

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Thai Understudies:

1,929,780x0.45 = B. 868,401

Total Pulp Mill/Year: B.4,271,399

(b) Man-days per Ton

$\frac{19,000 \text{ tons per year}}{320 \text{ working days}}$ = 59.4 tons per day

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations	28	36	64	128
Services	17	27	7	51
Total:	45	63	71	179

Operations personnel, man-days per ton:

$\frac{128}{59.4}$ = 2.15 man-days

Service personnel, man-days per ton:

$\frac{51}{59.4}$ = 0.86 man-days

(c) Cost per Ton

Operating $\frac{1,937,848}{19,000}$ = 101.99 per ton

Service $\frac{957,156}{19,000}$ = 50.38 per ton

Control $\frac{507,994}{19,000}$ = 26.74 per ton

Supervision (Thai) $\frac{868,401}{19,000}$ = 45.71 per ton

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2. Paper Mill

(a) Total Personnel Costs per Year

Operating Labor:

Shift Operat.	32x27,482 =	879,424	
Operat. Helpers	48x15,704 =	753,792	
General Helpers	36x 9,422 =	339,192	
Women, Operat. Helpers	12x12,563 =	150,756	
		2,123,164	B.2,123,164

Service Labor:

Shift Operat.	20x27,482 =	549,640	
Operat. Helpers	32x15,704 =	502,528	
General Helpers	9x 9,422 =	84,798	
		1,136,966	B.1,136,966

Control & Administration:	B. 507,994
Thai Understudies:	B. 868,401
Total Paper Mill/Year:	B.4,636,525

(b) Man-days per Ton

$$\frac{44,350 \text{ tons per year}}{320 \text{ working days}} = 138.6 \text{ tons per day}$$

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations				
Male	32	48	36	116
Female	-	12	-	12
Service	20	32	9	61
Total:	52	92	45	189

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Operations personnel, man-days per ton:

$\frac{128}{138.6}$ = 0.92 man-days

Service personnel, man-days per ton:

$\frac{61}{138.6}$ = 0.44 man-days

(c) Cost per Ton

Operating	$\frac{2,123,164}{44,350}$	=	47.87 per ton
Service	$\frac{1,136,966}{44,350}$	=	25.64 per ton
Control	$\frac{507,994}{44,350}$	=	11.45 per ton
Supervision (Thai)	$\frac{868,401}{44,350}$	=	19.58 per ton

3. Converting Plant

(a) Total Personnel Costs per Year

Operating Labor:

Shift Operat.	10x27,482 =	274,820	
Operat. Helpers	6x15,704 =	94,224	
General Helpers	6x 9,422 =	56,532	
Women, Operat. Helpers	8x12,563 =	100,504	
Women, General Helpers	6x 7,852 =	47,112	
		573,192	B.573,192

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Service Labor:

Shift Operat.	1x27,482 =	27,482	
Operat. Helpers	1x15,704 =	15,704	
General Helpers	1x 9,422 =	9,422	
		52,608	B.52,608

Control & Administration:

1,128,876x0.1 = B.112,888

Thai Understudies:

1,929,780x0.1 = B.192,978

Total Converting/Year: B.931,666

(b) Man-days per Ton

$\frac{4,000 \text{ tons per year}}{320 \text{ working days}}$ = 12.5 tons per day

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations				
Male	10	6	6	22
Female	-	8	6	14
Services	1	1	1	3
Total:	11	15	13	39

Operations personnel, man-days per ton:

$\frac{18}{12.5}$ = 1.44 man-days (first 3 years)*

Service personnel, man-days per ton:

$\frac{3}{12.5}$ = 0.24 man-days

* Note: One-half of the total converting operations personnel is used here due to the fact that only one of the planned two converting shifts will be

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utilized at the 12.5 tons per day production. The number, 18 workers, will be increased as daily production is increased, so that the number of man-days per ton will remain the same.

(c) Cost per Ton

Operating	$\frac{296,596^*}{4,000}$	=	71.65 per ton
Service	$\frac{52,608}{4,000}$	=	13.15 per ton
Control	$\frac{112,888}{4,000}$	=	28.22 per ton
Supervision (Thai)	$\frac{192,978}{4,000}$	=	48.24 per ton

* Note: Only one converting shift operating at 4,000 ton level

TOTAL PERSONNEL AND LABOR COSTS FOR PARTIALLY INTEGRATED PULP AND PAPER MILL - PROJECT I: B.9,839,590

E. Calculation of Personnel and Labor Costs - Project II

1. Pulp Mill

(a) Total Personnel Costs per Year

Operating Labor:

Shift Operat.	32x27,482 =	879,424	
Operat. Helpers	46x15,704 =	722,384	
General Helpers	92x 9,422 =	866,824	
		2,468,632	B.2,468,632

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Service Labor:

Shift Operat.	17x27,482 =	467,194	
Operat. Helpers	27x15,704 =	424,008	
General Helpers	7x 9,422 =	65,954	
		957,156	B. 957,156

Control & Administration:

1,128,876x0.45 = B. 507,944

Thai Supervision:

1,929,780x0.45 = B. 868,401

Total Pulp Mill/Year: B.4,802,133

(b) Man-days per ton

$\frac{43,480 \text{ tons per year}}{320 \text{ working days}}$ = 135.9 tons per day

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations	32	46	92	170
Services	17	27	7	51
Total:	49	73	99	221

Operations personnel, man-days per ton:

$\frac{170}{135.9}$ = 1.25 man-days

Service personnel, man-days per ton:

$\frac{51}{135.9}$ = 0.38 man-days

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(c) Cost per Ton

Operating	2,468,632 / 43,480	=	56.77 per ton
Service	957,156 / 43,480	=	22.01 per ton
Control	507,944 / 43,480	=	11.68 per ton
Supervision (Thai)	868,401 / 43,480	=	19.97 per ton

2. Paper Mill

(a) Total Personnel Costs per Year

Operating Labor:

Shift Operat.	32x27,482	= 879,424	
Operat. Helpers	48x15,704	= 753,792	
General Helpers	32x 9,422	= 301,504	
Women Operat. Helpers	12x12,563	= 150,756	
		2,085,476	B.2,085,476

Service Labor:

Shift Operat.	20x27,482	= 549,640	
Operat. Helpers	32x15,704	= 502,528	
General Helpers	9x 9,422	= 84,798	
		1,136,966	B.1,136,966

Control & Administration:

1,128,876x0.45 = B. 507,944

Thai Supervision:

1,929,780x0.45 = B. 868,401

Total Paper Mill/Year: B.4,598,787

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(b) Man-days per ton

$\frac{54,350 \text{ tons per year}}{320 \text{ working days}}$ = 169.8 tons per day

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations				
Male	32	48	32	112
Female	-	12	-	12
Services	20	32	9	61
Total:	52	92	41	185

Operations personnel, man-days per ton:

$\frac{124}{169.8}$ = 0.73 man-days

Service personnel, man days per ton:

$\frac{61}{169.8}$ = 0.36 man-days

(c) Cost per Ton

Operating $\frac{2,085,476}{54,350}$ = 38.37 per ton

Service $\frac{1,136,966}{54,350}$ = 20.92 per ton

Control $\frac{507,944}{54,350}$ = 9.35 per ton

Supervision (Thai) $\frac{868,401}{54,350}$ = 15.98 per ton

3. Converting Plant

(a) Total Personnel Costs per Year

Operating Labor:

Shift Oper. 10x27,482 = 274,820

Operat. Helpers 6x15,704 = 94,224

General Helpers 6x 9,422 = 56,532

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Women, Operat. Helpers	8x12,563 =	100,504	
Women, General Helpers	6x 7,852 =	47,112	
		573,192	B.573,192

Service Labor:

Shift Operat.	1x27,482 =	27,482	
Operat. Helpers	1x15,704 =	15,704	
General Helpers	1x 9,422 =	9,422	
		52,608	B. 52,608

Control & Administration:

1,128,876x0.1 = B.112,888

Thai Supervision:

1,929,780x0.1 B.192,978

Total Converting/Year: B.931,666

(b) Man-days per Ton

$\frac{7,625 \text{ tons per year}}{320 \text{ working days}}$ = 23.8 tons per day

Types of Labor	Shift Oper.	Operat. Helpers	General Helpers	Totals Man-Days
Operations				
Male	10	6	6	22
Female	-	8	6	14
Services	1	1	1	3
Total:	11	15	13	39

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Operations personnel, man-days per ton:

$$\frac{36}{23.8} = 1.51 \text{ man-days}$$

Service personnel, man-days per ton:

$$\frac{3}{23.8} = 0.13 \text{ man-days}$$

(c) Cost per Ton

Operating	$\frac{573,192}{7,625}$	=	75.17 per ton
Service	$\frac{52,608}{7,625}$	=	6.90 per ton
Control	$\frac{112,888}{7,625}$	=	14.80 per ton
Supervision (Thai)	$\frac{192,978}{7,625}$	=	25.30 per ton

TOTAL PERSONNEL AND LABOR COSTS FOR COMPLETELY INTEGRATED PULP AND PAPER MILL AND CONVERTING PLANT - PROJECTS I AND II: B.10,332,586

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IX SITE SELECTION

A. General Considerations

In approaching the subject of site selection it is desirable to indicate the criteria of a good site for a pulp and paper mill. The principal factors involved are given below in approximate order of importance.

1. Availability of Water of Adequate Quantity and Quality

This is by far the most important consideration and, if it cannot be satisfied completely, a site must be rejected on this basis alone. Both quality and quantity of water are important, but given modern methods of water treatment, quantity is perhaps of greater importance. Nowadays, natural waters can be purified both chemically and mechanically to give a supply of any desired purity. However, waters which are very impure to start with, especially with respect to finely-divided or colloidal matter or content of chemical impurities, require a great deal of treatment, which consumes relatively large quantities of chemicals. Consequently, the treatment cost of such water may become a significant factor in the production cost of paper or the other products.

A specification for water suitable for the manufacture of the papers and boards to be produced is given at the end of this section. (Table XVIII)

With respect to quantity, the following volumes are of water required by pulp and paper mills of the types proposed for Thailand:

Type of Mill	Quantity of Water Liters per Ton
Kraft paper	40,000
Kraft pulp and paper	130,000

These quantities must be available day and night throughout the year, even during the driest season. Also, these figures are for the water which will be used, which is less than the amount which must be available at all times because obviously water cannot be drawn from an almost empty river. Therefore, there must always be reserves of water present.

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Since the production in the proposed mill will be one hundred ~~seventy~~ tons per twenty four hours, the above quantities are equivalent to the following quantities which will have to be available at the site:

Manufacture of paper only	6.8 million liters/day or .08 cu m/sec
Manufacture of pulp and paper	22.1 million liters/day or 0.256 cu m/sec

In general, it is advisable to consider surface water, i.e. rivers and lakes. The salt content precludes the inclusion of sea water. Water below the ground can be a very uncertain factor where such large quantities are concerned although several prominent United States mills operate on well water. Such water involves sinking wells at considerable expense.

2. <u>Facilities for Effluent Disposal</u>

Most of the water taken from the river or other sources for process work will ultimately leave the mill. There will, however, be certain losses, for example through evaporation in the soda recovery plant and during drying of the paper on the paper machine. The water returned to the river will usually be less pure than when it was taken out and the impurities will contaminate the river water to a certain extent. It will be appreciated that during the digestion process, approximately fifty percent of the substance of fibrous material may be removed in order to produce the fifty percent yield of unbleached cellulose fiber commonly obtained. Most of this organic matter is destroyed later by burning in the chemical recovery process and the chemicals and heat obtained thereby are usefully employed. However, in order to wash the pulp after it has been digested, a considerable amount of water is needed, and, although very efficient methods of washing are now used, small amount of black liquor solids may be ejected into the mill effluent at this stage. These solids consist of a very small amount of spent cooking liquor, a certain amount of suspended fibrous matter of a very fine nature, and some dissolved organic matter usually in a colloidal state. These materials are very difficult to

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completely remove, but methods are available to purify the effluent to the extent of ninety five per cent pure or higher. The water used in papermaking also becomes contaminated by residual quantities of chemicals added to impart desired properties to the paper and which are not fully absorbed.

A means of partial purification of the effluent involves passing it through sedimentation tanks, where the maximum amount of suspended matter is first removed. The liquor can also be aerated in lagoons, artificially or otherwise, and a certain amount of organic matter can be removed by oxidation in this way. A further alternative is to segregate the worst portions of the effluent and to lagoon them separately, allowing only the least polluting portion to overflow directly into the river. Another method is to lagoon the objectionable effluent during the dry season and release it during periods of high river flow.

The most serious pollution takes the form of what is known as the biological oxygen demand (B.O.D.). The B.O.D. is a measure of the extent to which the effluent will remove the oxygen present in a river when these two waters are mixed together. If the dissolved oxygen is decreased to a low level, the fauna and flora of the river is affected adversely, and the natural plant life cannot grow and re-oxygenate the river. The river thus gradually becomes cumulatively worse in this respect.

It is apparent from what has been said that, after water supply, effluent disposal facilities represent an extremely important factor in selecting the mill site. If suitable facilities do not exist, a potential site must be rejected.

The above considerations apply mainly to pulp mills. The purification of paper mill effluents is much less difficult. However, the selection of a site for a paper mill usually has to be made with the possibility in mind of a pulp mill as a parallel or future development.

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3. Proximity to Raw Materials and Markets

It is usually necessary from an economic standpoint to locate the mill centrally with respect to fibrous material procurement. This location is sometimes relative - many mills transport their fibrous materials from fairly distant points; but the close proximity of the fibrous material is a great advantage.

The same considerations apply to other incoming materials, such as chemicals.

The proximity of the mill to the market is also of importance, although finished pulp and paper are transported great distances. Nevertheless, the lower the freight cost to the market, the more profitable the mill.

4. Transportation

Previous considerations have shown that transport is an important factor. It is a great advantage to locate the site so that it has available rail, road and possibly river transportation. This obviously affords considerable flexibility. Possession of a railway siding, for example, places the mill in a better bargaining position with respect to contracting for truck or water services.

B. Local Considerations Affecting the Choice of Site

It has been shown above that water is a most important consideration in selecting a mill site. There are many localities in Thailand with good water supplies, and if this were the only consideration, a wide choice of sites would be available. In the case of Thailand, however, other factors intervene to limit this choice considerably. These other factors are as follows:

1. Waterway System of Thailand

Most of the waterways of Thailand are part of a widely-ramified and complicated system of combined agricultural irrigation and transport. This system is of great importance to the economic life of the country and to the farming community, and it is subject to strict supervision. It was

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appreciated from discussions with Thai irrigation authorities that the linking up of the water supply and effluent disposal system of any proposed pulp mill with an irrigation scheme could present considerable difficulties. The places from which water can be taken are very restricted, they are controlled, and their adequacy cannot always be guaranteed.

Also, so far as effluent disposal is concerned, although there are no published regulations which determine the maximum limits of impurities which may be discharged into a water-course, the whole question of effluent disposal into the waterways is obviously of such importance that the matter or regulation is at present under consideration, and restrictions will undoubtedly be introduced. In any case, it is necessary to obtain permission either to take water from or to eject effluent into a water-course. It would therefore be much more convenient, if not absolutely necessary, to locate the mill on one of the five main rivers of the country, at a point where the river is always sufficiently large to render discharged effluent harmless by dilution.

2. Ocean Ports

Since there are not sufficient supplies of local fibrous raw materials to provide the pulp and paper mill with all of its fiber requirements initially, it is highly desirable that the mill site be near the ocean port at which imported pulp will arrive. This is inevitably Bangkok. Proximity to Bangkok for supply of imported chemicals is also of considerable importance.

3. Paper Market

The market survey revealed that about eighty percent to eight-five percent of the paper consumed in Thailand is consumed in or around Bangkok; and that in the case of the end products, which will be made by the proposed mill, this proportion is probably even higher. Reasonable proximity to Bangkok markets, therefore, is also a desirable site requirement.

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4. Water Transport

Water transport plays an important part in the economic life of Thailand. It is cheap, and, as presently operated, it is convenient. Therefore, location of the mill on a navigable river or waterway is desirable.

5. Fibrous Materials

As the proposed mill will eventually make all of its own pulp, reasonable proximity to the fibrous raw materials required for the manufacture of the pulp is essential. Since the mill is planned to start up using sugar cane bagasse and to expand into bamboo, it is natural to consider location of the plant within the two hundred kilometers radius of Bangkok where these fibrous materials occur. On the other hand, some consideration should also be given to the pine wood of northern Thailand 500 kilometers from Bangkok since this material is most preferred from a fiber standpoint. This consideration is somewhat weakened by recognition that these forests may not be productive before ten years to fifteen years. Therefore, it is more logical to place the mill in such a location that it is well situated to a port as well as to sources of fibrous materials. Anywhere within approximately one hundred fifty kilometers of Bangkok would be reasonable for the delivery of imported pulps, if such a site also enabled the mill to be located satisfactorily with regard to water supply, effluent disposal and native fibrous raw materials.

6. Quality of River Water

The five large rivers of the country all flow into the Gulf of Siam in an approximate north-to-south direction, and tend to form deltas at their estuaries. In the case of the Chao Phraya River, this delta feature near the estuary is very particularly marked, and together with the connected Nam Cha China River to the West, forms the fertile central agricultural plain on the landward side of Bangkok.

In common with most estuarial rivers of this type, the main rivers of Thailand contain sea water at

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quite long distances from the point at which they enter the sea. Salinity (salt content) records were found available only for the Chao Phraya River (see Map No. 4). Such data were not obtainable for the other four principal rivers, and the salinity aspect was assumed to be satisfactory, and the rivers were investigated for sites on this basis. However, at the time of these investigations, the samples of water were taken at or near the various sites, and these samples were subsequently analyzed for salinity and other relevant chemical properties. As will be shown below, the water at some of these sites, which were otherwise suitable, was too saline; and the sites were rejected.

Salinity in water is objectionable in pulp and paper manufacture for two reasons:

(a) If the water is highly saline, e.g. above about one thousand parts per million as sodium chloride, abnormal corrosion of the plant machinery occurs. The use of stainless steel to avoid this is costly and not always successful.

(b) A sodium chloride content in the process water of more than about one hundred twenty parts per million is regarded as objectionable in the manufacture of the type of sack and wrapping papers which the proposed mill will make. In the case of high grade writing papers the limit is even lower, namely, about forty parts per million as sodium chloride. The reason for this limitation is that in the course of time, the chlorides in paper develop acidity, which results in a deterioration of paper strength. This is obviously objectionable in the case of better quality papers such as are used for writing or printing. With regard to wrappings, however, this situation is much less serious, partly because wrappings have a high inherent strength, and partly because they are used and thrown away over a fairly short time period, i.e. before the acidity has time to develop and become effective. On the other hand, metal objects in contact with the paper may tarnish. For the present, mill sites were judged with respect to salinity on the basis of the kraft papers to be produced.

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C. Selection of Site

1. General

Based on the above considerations, each of the five main rivers of the country was considered as to practicability of location of the mill. These rivers are shown in Map No. 1. So far as salinity was concerned, a point was chosen which was believed to far enough away from the sea to be free from this handicap, although this choice was not always correct, (see below). As far as water flow was concerned, difficulty was experienced in obtaining the type of data required. Water level measurements of the Chao Phraya and Mae Klong Rivers were made available, but these could not be related to the actual amounts of water in the rivers at the sites investigated when the river is at its lowest. This is the information really required, but it does not exist. However, it is felt, from experience based on visual assessment, that all the eleven sites investigated should be satisfactory so far as the quantity of water available is concerned. Nevertheless, this point should be checked by long-range periodic measurements.

The main rivers of the country are discussed below in order from East to West (see Maps No. 1, 4 and 5):

(a) The Mekong River.

This river forms the eastern boundary of Thailand and Laos. Although it flows quite near the pine forest area at Ubon, sites along this river are either too remote from Bangkok or too remote from the potential raw materials of most immediate interest, namely bagasse and bamboo. Possible sites on this river were therefore not considered.

(b) The Bang Pakong River.

This river flows into the Gulf of Siam and is a comparatively small river. It enters from a northerly direction having previously turned south from the East, where it rises.

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(c) The Chao Phraya River

This river flows into the Gulf of Siam from a northerly direction. The city of Bangkok is near the mouth just north of the main estuary of the delta (see Map 4). This is the river for which recorded salinity data are available, and a study of these data (see Map No. 4) suggested that the place nearest the mouth where a satisfactory salinity figure could be counted upon throughout the year for the proposed mill would be above or near Thesay. This point is only twenty-five kilometers by river upstream from Bangkok.

(d) The Nam Tha China River

This river also runs into the Gulf of Siam from a northerly direction after it leaves the Chao Phraya River, and over a great deal of its southern stretch it is almost parallel with the Chao Phraya River (see Map No. 5). It is much smaller than the latter river, however, and it forms the western arm of the delta of which the Chao Phraya River is the eastern arm.

(e) The Mae Klong River

This river flows into the Gulf from a northwesterly direction, having risen in the northern hills and turned eastwards near Karnchanaburi. Above Karnchanaburi, it is split into the two Kwai rivers, the Kwai Yai to the north and the Kwai Noi to the south. It should be pointed out that all these rivers are connected by numerous canals (klongs) running in many directions but, generally speaking, from north to south of the country. Maps No. 4 and 5 show these waterways.

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2. Sites Investigated

On the basis of the considerations above, in the actual site selection operation, seven areas were investigated. The sites were lettered A to G inclusive as investigated and are dealt with below in this order and not necessarily in order of preference.

(a) Site A

This site is situated along the highway on the right bank of the Bang Pakong River south of the town of Chachoengsao. Ample building land is available and road communication with Bangkok is excellent.

An important advantage of this site is that it has direct communication with the sea. At the mouth of the river is an anchorage and a port at which ocean-going boats can be unloaded. Imported wood pulp and chemicals could be transported to the mill by road or via the river which is navigable for many miles. The distance from Bangkok by water is approximately sixty-five kilometers.

The disadvantages of the site are as follows:

(1) It is not near the bamboo growing areas, although a good deal of rice straw is grown in the locality.

(2) There is a possibility of flooding during the rainy season.

(3) There is no railway for siding facilities.

(4) A toll is charged on the Bangkok to Chachoengsao road (B.15 per truck, per single journey).

No sample of water was taken for analysis at this site. However, a sample taken at Site C higher up the same river was found subsequently to have an excessive salinity. It does not necessarily follow that because Site C has an objectionably high salinity, Site A will also have it, even though Site A is below Site C on the same river. It must be remembered that the

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klongs along the Bangkok to Chachoengsao road are not fed entirely by the saline water of the Nam Bang Pakong river. If, therefore, salinity tests on the klongs can be shown to be satisfactory, the potential site value of Site A would increase.

(b) Site B

Site B is situated to the north of the town of Chachoengsao. It is one kilometer from the main road from Bangkok, seventy-five one-hundredths kilometers from the railway which connects directly with Bangkok, and one kilometer from the Bang Pakong River. Chachoengsao is sixty-five kilometers from Bangkok by a new road, which runs in a north-easterly direction and joins the road north of Bangkok near the International Airport. The construction of this road is complete, but parts of it are still in bad condition.

There is adequate space for a factory of considerable size together with adequate storage facilities, but the actual terrain is composed of flat paddy fields, indicating a definite possibility of flooding.

The installation of a railway siding might be expensive owing to the built-up nature of some of the intervening land. It would also be necessary to build a special road to the site.

The river at this point is adequate for the water supply, although, since the site is above the town of Chachoengsao, effluent disposal might present difficulties in times of drought. However, this is not likely to be the case as a rule in view of the high diluting effect of the river at this point. Unfortunately, as shown under Site C, which is on the same river a little further downstream, the water at Site C is saline and therefore unsuitable for the mill.

(c) Site C

Site C is on the left bank of the Bang Pakong River opposite the town of Chachoengsao, and it

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is approached from the left hand side of the road leading out of the town towards the Southeast. The river is approximately one and five tenths kilometers distant, on the other side of the road. Railway facilities would not be available at this point because the line is on the other side of the river. A good bridge exists across the river at the town.

A sample was taken from the river at ten o'clock on March 16, 1963, at the point nearest to Site C, and an analysis is given in Appendix XVIIA. This shows a salinity of eight thousand six hundred fifty parts per million as sodium chloride. This figure is far too high to allow the water to be used for the proposed project. For this reason alone, Sites B and C must both be rejected.

(d) Sites D1, D2

At this point the road running due west from Bangkok crosses the river at the town of Ban Yai Cha. Two sites were investigated, namely D1 and D2. (See Map No. 5).

Site D1 is to the South of the town near a Bhuddist temple area. Beyond the road leading to the temple, there is a virtually unlimited terrain of flat rice paddy lands. Bangkok is thirty-four kilometers away, along a good road. The river to the site is navigable from the coast, but no railway is available here. However, at the other end of the space indicated, there is a school. Due to the educational and religious nature of the surrounding area, it was decided to investigate a different site located to the North of the main road from Bangkok. The conditions at Site D2 are similar to those of Site D1 (including the absence of railway facilities), but preferable in that there are no schools or temples. In both cases, the possibility of flooding exists.

It is likely that there are also good sites on the opposite sides of the river, corresponding with Sites D1 and D2. These, however, were not investigated, as the banks were lined with palms

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and other cultivated fields. There is obviously adequate water in the river at all times of the year, since it is always navigable, and the volume of water would suffice to dilute any effluent.

According to information received from the Royal Irrigation Department, Ministry of Agriculture, the salinity of the river is approximately one and five tenths (units not stated but presumably gallons) per liter or fifteen hundred parts per million at Ban Ang Thong, approximately thirty-five kilometers by river south of Ban Yai Cha (see Maps No. 1 and 5). This reading was taken early in March 1963. As a check, a sample of water was taken from the river at Site D1 at 13:45 on March 17, 1963. An analysis of this sample is shown in Appendix XVIIA, which shows a salinity of forty-five hundred parts per million as sodium chloride which is far too high to allow the water to be used for the proposed paper mill. Although there is a discrepancy between the test results on this sample and the results given by the Royal Irrigation Department, even the lower figure is much too high for the water to be used in the present project. Consequently, Sites D1 and D2 were also rejected.

(e) Site E (See Map No. 5)

This site is situated along the stretch of the Nan Tha China River, where the road, the railway and the river run close together approximately forty-five kilometers from Bangkok by road. A klong runs parallel with the railway, and the railway would therefore have to be brought across the klong. The land is mostly agricultural and the railway embankment is approximately three meters high.

This site is good in many ways, but would probably be liable to flooding. Some comments on the general question of flooding are given below. There is adequate water at this point, both for the supply of the mill and for dilution of the effluent. A salinity test was not taken here, because the information from the Royal Irrigation Department that the sea

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backs up to a point just south of Ban Yai Cha indicated that the salinity would meet the standards at Site E. However, the salinity of the river should be checked, and if satisfactory, Site E would be most promising. Of the sites previously described, this site is best placed to be provided with a railway siding.

(f) Sites F1-5

These five sites are situated along the left bank of the Mae Klong River as it flows in a southeasterly direction from Karnchanaburi to Ban Pong. Along this stretch of river, the road, railway and river run fairly closely together, and the contours of the river are such that, from time to time, areas of land occur between the river and the road or the railway so that all three are in close proximity.

The Mae Klong River is that from which the Government-owned Thai Paper Mill at Karnchanaburi draws its water supply and into which it discharges its effluent. Bamboo is floated down this river directly from the forests some fifty kilometers north of the mill. Along the river below Karnchanaburi are also several sugar mills processing sugar cane. At these points, the river flows between relatively deep banks. The left bank was ten to thirty meters above water level at the time of the survey, indicating that flooding would not occur under any circumstances. On the other hand, it would be necessary to pump the water this height out of the river, in order to service the mill.

The only official flow data obtainable for the Mae Klong River are contained in a Report entitled, "Hydrology of the Mae Klong River, etc.", issued by the Hydrology Section, Survey Division, Royal Thai Irrigation Department, in August, 1962. The relevant data are as follows: Normally at the beginning of May, the Mae Klong River just below Tha Muang starts rising slowly from its dry-season level, when a flow of about

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50 cm is maintained. The first major rise, varying from 400-600 cm begins in June or July. After that, a series of rises and falls continues through the Southwest Monsoon Season. August and September are the months in which flood peaks are to be expected. The frequencies of occurences of the isolated flood peaks above 1,000 cm as observed in the last twenty-three years (1939 to 1961) are as follows:

Months	Number of Occurences
June	3
July	10
August	17
September	15
October	11
November	2

Therefore, the total occurences in the last twenty-three years is fifty-eight times, with an average of about two to three times a year.

The river begins to recede following the withdrawal of the southwest monsoon during October or November, but it often happens that the last rise occurs in October or as late as November due to the Cyclonic Depression moving towards the Bay of Bengal. After the last rise in October, the river recedes gradually during the ensuing cold season and normally reaches its lowest point in April.

It is to be noted that during the hot season, February to April, the river also receives some additional runoff derived from the pre-monsoon showers. The additional flow of some 10 to 30 cm has been observed during the period. This helps stabilize the dry-season flow to a certain extent.

The average annual total runoff of the Mae Klong river near Ban Pong is about 13 million cu m or nearly 510 mm over its drainage area of 25,600 sqkms. Annual rainfall

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over the drainage area on the order of thirteen hundred mm is anticipated. The annual runoff coefficient of this basin would be about thirty-nine percent which is relatively high among the rivers of the country. This is due largely to the prevailing isolated intense rainfall over the head-water area.

In the period from 1939 to 1961, during which river rating has been in operation, the extreme lowest flow was observed at twenty-nine cms. It occurred on April 30, 1941, May 23, 1957 and May 1, 1960. The corresponding river stage was read at +12.64 m at Tha Nuang gauging station and at +14.66 m at Ban Tham gauging station, both at below sea level.

In years of early monsoon withdrawal followed by a late pre-monsoon of the coming year, the river may be fed only by runoff generated from ground-water until May. However, it has not been later than the first of May for the last twenty-three years. Nineteen fifty-four was a very dry year; complete withdrawal of the monsoon rain over the basin took place as early as the end of September, and the flow of the river was exclusively from ground-water from November 26th on, when one hundred forty cms was discharging. It gradually receded with the typical recession factor of 0.88. If the late pre-monsoon showers of the following year were like those of the year 1951, the probable lowest flow of sixteen cms would have occurred.

It will be seen from the above that under present conditions there is always likely to be adequate water in the Mae Klong River at Sites F for the purposes of the proposed pulp and paper mill. However, if their irrigation project materializes, some of the river water may be diverted to the irrigation system somewhere along this stretch of the river. The actual point of diversion is at present not clarified, but it may be above some of the possible sites. It is, therefore, desirable to discuss this possibility with the Royal Thai Irrigation Department as soon as the Department has reached a positive decision on

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the matter. It should be pointed out that so far as can be judged, inclusion of the mill effluent in the irrigation water will not be harmful.

A sample of water was taken at approximately eighty kilometers from Bangkok at 15:45 on March 17, 1963. The chemical analysis is shown in Appendix No. XVIIA . This reveals a satisfactorily low salinity of forty-nine parts per million calculated as sodium chloride. The hardness is correspondingly low, namely one hundred sixty-five total, and the total solids are only two hundred thirteen parts per million. The organic solids are also satisfactory. The sulfates are rather higher but not objectionably so, and the pH value shows a slight alkalinity as would be expected from the other data. A slight sediment, which settles slowly, was observed in the water. This would no doubt vary according to the time of the year and could be removed by simple means, giving a water quite suitable for the manufacture of kraft papers. That this should present no difficulty is apparent from the fact that the same water is used by the Karnchanaburi mill for white papers, although this mill is slightly higher upstream where the water is possibly somewhat purer.

All five sites on this stretch of the river are similar in character; they are on sandy soil and exceed forty hectares each. In some cases, a certain amount of clearing is required, but this would not be excessive. In others, the railway would have to be brought across the road. All are near enough to the river to enable it to be used as both a water supply and as a means of effluent disposal.

Sites F1 to F5 have the additional special advantage that they are well placed to receive any bamboo or hardwood from the forests to the Northwest of Karnchanaburi. Bamboo could be floated down the river in the same way as to the mill at Karnchanaburi, although as pointed out in Section V, it is intended to build a dam above the present mill. Facilities should

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be provided for a slip-way for the passage of floated raw materials. This should present no special difficulty if suitable provision is made beforehand. The exact proposed location of the dam is not known, but it is believed to be about six kilometers above the Karnchanaburi mill. Sites on this portion of the river are also well placed to receive any bagasse which might be made available from the three sugar mills in the area.

Communications with Bangkok for the transport of imported pulp and chemicals and for the disposal of the products of the mill are good, both by road and railway. Unfortunately, the river is not navigable from the sea up to Ban Pong. The navigability at all times of the year stops at about Ban Tha Rap just north of Rat Buri some twenty-five kilometers by road due south of Ban Pong (see Map No. 5). However, it might be possible to make some use of this facility by bringing imported pulp to Rat Buri from the sea by river, and then taking it to the mill by direct railway from this point.

(g) Site G (See Map No. 4)

This is situated at Thesay, approximately twenty-five kilometers by road due north of Bangkok on the left bank of the Chao Phraya River. It can be approached by a network of small roads which leads northward from the town of Bangkok in the direction of Non Buri. It is a little south of Pathum Than. The ground is agricultural in character, and there are paddy fields with indications of flooding. Some part of the ground would have to be cleared but the general terrain is flat. A salinity determination of the water at this point was not made, but the official data show approximately one hundred parts per million, (as NaCl presumably) which is admissible in the present instance. This would therefore have to be checked very carefully if this site is to be considered.

The great merit of this site is its proximity to Bangkok. If a paper mill without a pulp mill were to be built, this undoubtedly would be the best location.

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D. Comments on Flooding

At all the above sites, except those of F1 to F5, there are indications of the definite possibility of flooding. They are all in rice growing areas, at an altitude very little above sea level. This occurs to a more severe extent in some places than in others, where it might even render site development impossible. On the other hand, it must be remembered that because of the need for flooded land in order to cultivate rice, the flooding of this part of the country is encouraged rather than prevented. It may well be possible to avoid flooding of certain of the sites described above by arrangement with the local irrigation authorities.

Of more concern, however, is the flooding which arises, not from adjacent areas, but from the heavy rainfall which cannot drain away because of the flat land so characteristic of the countryside. Dikes which protect land from external inundations can create a "tray" effect from which water cannot escape naturally. This drainage problem can be solved by internal drainage and pumping of the water in wet weather. The drainage system must serve not only the area covered by the actual building area; but also the storage area containing the stacks of fibrous raw materials such as bagasse and bamboo.

The flooding problem has been encountered and met satisfactorily in the mill at Bangpa In, which is two meters below the flood level of the river. A coffer dam and dike around the whole site was built with a drainage canal which flows through a pumping station to the river.

E. Summary of Site Selection

The relative merits of the above eleven sites investigated may be summarized as follows:

(1) The most favorable choices for the proposed pulp and paper mill would be along the Mae Klong River. There are good road, railway and river connections. The entire area is free from flooding, is on good building ground and is reasonably near both raw materials and potential markets. The railway runs near all the different sites and, although a siding is not

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necessarily involved, it could easily be added later, if needed. Also, land is relatively cheap in this area, and building costs should compare favorably with those in the so-called delta areas represented by Sites A to E and G, where twenty to twenty-five meters of piling are required to reach bed-rock.

In addition, along the left bank of the Mae Klong River between Ban Pong and Karnchanaburi there are a number of towns and settlements from which the mill personnel could be brought to and from work by transportation provided by the mill. Consequently, housing for this personnel would not be required (see Section VIII, Personnel and Labor).

(2) It is mentioned incidentally that if it is intended to build a paper mill only, then Site G would be preferred due to its proximity to Bangkok. Housing facilities would not be required, and there would be the great advantage of cheap water transport from Bangkok or from the sea directly to the mill. The products of the mill could be shipped to Bangkok in the same way. Under these circumstances, the absence of a railway would not be a serious matter. Flooding appears to be the most serious objection to this site. This problem could be solved as discussed previously.

(3) If for any reason it is impossible to utilize any of the five sites, F1 to F5, a check should be made on the salinity at Site A if a paper mill only is to be built, and at Site E which is probably the best substitute for Sites F, if a satisfactory salinity figure is obtainable.

(4) It is strongly recommended that reliable salinity figures be obtained for any of the above sites which might eventually be used. Special attention should be paid to these measurements during the period of minimum flow and minimum tides. For the present purpose, the following maximum criteria can be adopted:

Total hardness	250 (max)
Total dissolved solids	600 (max)
Total chlorides (as NaCl)	200 (max)

The water at F1 complies with these requirements satisfactorily.

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TABLE XVIII

SPECIFICATIONS FOR WATER FOR PAPERMAKING
(Maximum permissible)

Suspended solids -	15 parts per million
Turbidity -	10 SiO_2 units
Color -	5 Pt-Co units
Total hardness ($CaCO_3$) -	100 parts per million
Calcium hardness ($CaCO_3$) -	50 parts per million
Alkalinity ($CaCO_3$) -	75 parts per million
Free chlorine -	2 parts per million
Iron (Fe) -	0.1 parts per million
Manganese (Mn) -	0.05 parts per million
Soluble silicon (SiO_2)	20 parts per million
Total dissolved solids	200 parts per million
Free carbon dioxide (CO_2) -	10 parts per million
Chlorides (NaCl) -	125 parts per million
pH value -	5 - 7.5

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TABLE XIX

ANALYSIS OF THREE SAMPLES OF WATER

By: Hehner & Cox, Ltd., London

Received on - 26 March, 1963

Marked - A, B and C

Place	Site C	Site D	Site F1
Date	16 March 1963	17 March 1963	17 March 1963
Time	10.00	13.45	15.45
Appearance:	Slight sediment; clear supernatant liquid	Small sediment settling slowly; cloudy liquid	Small sediment settling slowly; cloudy liquid
Total solids	10,880	4,940	213 pp million
Organic solids	1,663	180	45
Hardness- total	1,269	1,062	165
Temporary	65	180	20
Permanent	1,204	862	145
Chlorides (NaCl)	8,650	4,500	49
Sulphates (Na_2SO_4)	955	502	156
pH value	7.2	7.4	7.8

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X. TRANSPORT

A. General

Transport is obviously a vital factor in the economics of a pulp and paper mill operation. Large tonnages of both bulky raw materials and heavy rolls of finished products are involved. Like availability of water, transport is particularly important in the selection of a mill site, for remoteness means added costs. Also, construction of new transport facilities is to be avoided whenever possible.

The distances over which raw materials and finished products must be transported to and from the projected mill may be further classified into (1) distances from ocean ports for imported requirements, (2) distances from sources of domestic raw materials for chemicals, fibers and fuel, (3) distances from markets for finished goods. Also to be taken into consideration is transport of the equipment and materials of construction for the installation of the complete mill.

The above distances, separating industry from raw materials and markets in Thailand, are spanned by three widely used means of transport, namely railway, road and river. These methods of transport are discussed in this Section.

B. Railway Transport

The railway network, as shown at the end of this Section, is operated by the State Railway of Thailand. Its standard rates are considerably lower than those of trucking companies, and range both above and below water rates, depending upon the type of goods being shipped. However, discussions with industrial organizations indicated that, in general, railway transport is not preferred, especially over short distances. Seasonal traffic congestion, shortages of certain types of cars, and generally slower service were the disadvantages most often cited.

In certain cases, nevertheless, such as large shipments of very heavy or bulky materials, the railway has definite advantages. This applies particularly to a pulp mill which would bring in large quantities of fibrous raw materials and chemicals of various kinds from several sources.

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In any case, close proximity to a railway is always an advantage, if for no other purpose than to serve as a bargaining factor in arranging terms with other transport facilities. For this reason, and in order to have at least one alternate method of transport, the sites investigated were selected with railway facilities in mind.

The question of a siding was discussed with the railway authorities. Sidings are constructed and maintained by the railway at the cost of the user. Ordinarily, they are joined to a line only at existing stations, but exceptions can be made according to circumstances. The average cost of a simple siding is approximately B. 1,000,000 per km. Extra charges are made for the use of locomotives except in the case of short runs on the mill property.

Other data relevant to railway usage are as follows:

1. Maximum width allowable: 2.82 m

2. Maximum height allowable: 3.124 m (Heights are measured from the top of the rails, since wheel diameters vary.)

3. Maximum length: The length of Thai rolling stock varies from 16.5 m down to approximately 2.0 m, and as many as three cars can be linked to carry a maximum load length of approximately 20.5 m. Maximum loading length of the material, however, should not exceed approximately 16.6 m.

4. Maximum load allowable: Load capacities range from 8-28 tons per car. For purposes of this Study, the standard "covered goods wagon" of 12.5 ton capacity has been used. It is important that cars not be overloaded. The State Railway will concede an excess loading of up to 5%, but weight above this 5% concession is charged at five times the normal tariff rate.

5. Freight rates vary from 0.075 - 0.35 Baht/ton/km, as shown in the table on the following page. The distance of the preferred mill sites "F" from the port of Bangkok was averaged out to 100 m, so that the top line of the table indicates the freight rates used later.

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6. Freight classification: As indicated in the preceding table, there is nearly a 300% difference between Class 8 and those for Class 2 for distances up to 100 km. The rate differences are less for long distances.

The following list classifies most of the goods which might be shipped via railway in connection with this Project.

(a) Class 2

Insulating board
Electrical fittings
Furniture
Machinery
Motor spirits not otherwise classified
Motor vehicles
Oil and spirits not otherwise classified

(b) Class 3

Asbestos
Books of all kinds and newspapers
Brick, insulate or cellinsulate
Building materials not otherwise classified
Caustic soda
Cement and articles thereof except tiles
Construction material for construction and maintenance of telegraph lines such as wire insulators, screw, etc., but not including pole or posts
Corrugatediron
Fire bricks
Gasoline
Iron and steel, embracing all articles thereof
Lubricating oil
Nails
Paper, including all stationery
Plywood
Posts, wooden of all kinds, except wooden pegs not exceeding three meters in length and also excluding logs
Rosin
Soda ash
Stationery, including all papers and writing materials, except paper waste
Tile, including cement tile

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Certain kinds of timber
Wires, of all kinds, including telegraphic wires

(c) Class 4

Alum
Asbestos clay
Brick, common
Diesel oil
Fuel oil
Gypsum
Paper waste
Steel

(d) Class 5

Bag, gunny
Bamboo of all description
Barks of all kinds, (except of "Cutch")
Empty wooden barrels and casks and boxes
Foliage of all kinds, used for roofing wrapping purposes
Hemps
Lime
Plants of all kinds
Rattan
Sand
Stone
Stone mortar
Sugar cane
Tiles, burnt earthen tiles

(e) Class 6

Earth, natural
Straw

(f) Class 7

Salt

(g) Class 8

Construction materials for sections State Railway of Thailand or highways
Water, ordinary

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It was indicated at the time of the Survey that current rates are likely to be raised soon, probably by the transfer of certain commodities from a lower-priced to a higher-priced class.

Though paper is presently classified in Class 3, there is no mention of pulp. According to the Thai Railway authorities, some pulp has been carried previously by rail, and has been charged at the same rate as paper. Recognizing the unfinished nature of pulp, however, the authorities are in the process of lowering its classification. It will therefore be assumed for the purposes of this Study that pulp will be put into Class 5, at a rate of 21 Baht/ton/100 km. This assumption is supported by current practice in countries such as the United States and England, where railway rates for pulp are 60-75% of those for paper.

7. Demurrage and loading rates: (See following table) On the basis of an average loading and unloading total of B. 125 per 12.5 ton car, the average amount of 10 B. per ton is used for railway handling charges throughout this Report.

C. Road Transport

In general, road transport seems to be preferred in Thailand. At a standard rate of B. 70-80/ton/100 km, it is apparently much more expensive than both rail and water. However, contracts can be negotiated which considerably reduce this price, especially whenever return loads are involved. For example, the Karnachanaburi mill pays B. 300 for 4.5 ton truck to travel 130 km to Bangkok, or 67 B. per ton. The return, loaded, costs only B. 100 per trip, or B. 22 per ton, for an average over 260 km of B. 88, or B. 34 per 100 km. This compares very favorably with both railway and water rates and is much faster. It does not include the cost of loading and unloading, however.

Such low rates are usually obtained only from small truckers, who sometimes do not earn enough to cover the depreciation of their vehicles. The trucking agents, who do not own the trucks themselves, do not concern themselves with costs either.

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TABLE XXI

DEMURRAGE & LOADING RATES
(Thai State Railway Organization)

Charge	Bahts 24 hr/car 4-Wheel Car	8-Wheel Car
Load	10	20
Demurrage:		
Loading in excess of 6 hr	100**	200
Loading in excess of 4 hr	100**	200
Loading*	65	130
Unloading*	60	120

* Estimated average

** For first two days. The rate doubles from third day on.

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This situation may change due to the efforts of the Express Transport Organization, a large Government-owned shipping company operating on a commercial basis, to standardize rates and conditions to some extent. In April, 1963, maximum rates from Bangkok to the principal cities and towns in thirty-eight provinces were established and will be enforced by the Government.

There are actually two rate schedules: (a) full truck load (of 5000 kg) and (b) less-than truck load. Even if the load is bulky and does not weigh five tons, the full truck load rate will be charged.

For a destination between two towns listed on the schedule, the town farther from Bangkok is used to fix the rate. Rates between towns other than Bangkok are based on the rate from Bangkok to a town the same distance away.

One and a half hours for loading and the same time for unloading are included in the price. Express Transport also provides tarpaulins and insures the cargoes under the commercial laws of Thailand.

Taking the new standard rate of 80 Baht/ton/100 km as a base, and allowing for rebates, quantity discounts, return loads and competition from small single-truck owners, a rate of 67 Baht/ton/100 km has been used in this Study for the purpose of calculating delivered costs of certain raw materials.

D. Water Transport

Water transport plays an unusually big role in the economic life of Thailand. Maps No. 4 and 5 show the waterways which are navigable at all times of the year. Besides the five main river systems, there is a very extensive system of canals (klongs) of all sizes throughout the lower central part of the country.

Klongs connect Bangkok itself with the adjoining rivers, so that goods moving down toward the capital do not have to be transferred to coastal vessels. The many fine lines in Maps No. 4 and 5 show this maze of klongs, which largely take the place of secondary roads in the flat rice growing central plains. They are used very widely for both passengers and freight, and also serve the rural populations concentrated along their banks

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as a front yard, a water supply, a fish reservoir and a sewage disposal system.

The Bangpa-In rice straw mill, approximately 100 river km north of Bangkok, depends entirely on the Chao Phraya River. In fact, the first road to the mill area had not yet been completed in 1963. The Karnchanaburi paper mill receives all of its bamboo supply via the River Kwai. Likewise, many industries in and around the city of Bangkok obtain almost all of their imported needs via the klongs connecting with the port area. Some, such as the Siam Cement Co., even own their own fleet of barges.

Generally, however, barges are hired through such organizations as the previously mentioned Express Transport Organization, which in turn hires from small private contractors. Based on rates paid by the Bangpa-In Mill, water freight costs 30-35 Baht/100 km, including loading and unloading. No demurrage is charged, but there is usually no reduction for return loads.

Due to sand bars, goods coming in to the Bangkok ocean port must be unloaded from ship to lighter and then from lighter to river or klong barge for inland delivery. The cost of transferring from ship to lighter to Bangkok is 60-70 Baht/ton.

If loading into a warehouse is involved, the cost is approximately 100 Baht/ton. In calculating the cost of imported raw materials delivered to the area of the preferred mill sites F, an average of 60 Baht/ton has been added to either railway or truck rates from Bangkok to a point 100 km distant.

F. Conclusions

1. If the projected mill is located at one of the preferred F sites, road and railway will be used to ship raw materials to the mill. During Project II, bamboo will be floated down to the mill from the forests to the North. Finished products would be shipped to Bangkok most expeditiously by truck or rail.

2. From the transport standpoint alone, however, Site E appears to be the most favored because it is closest to Bangkok and can utilize all three means, water, road and rail, all year around.

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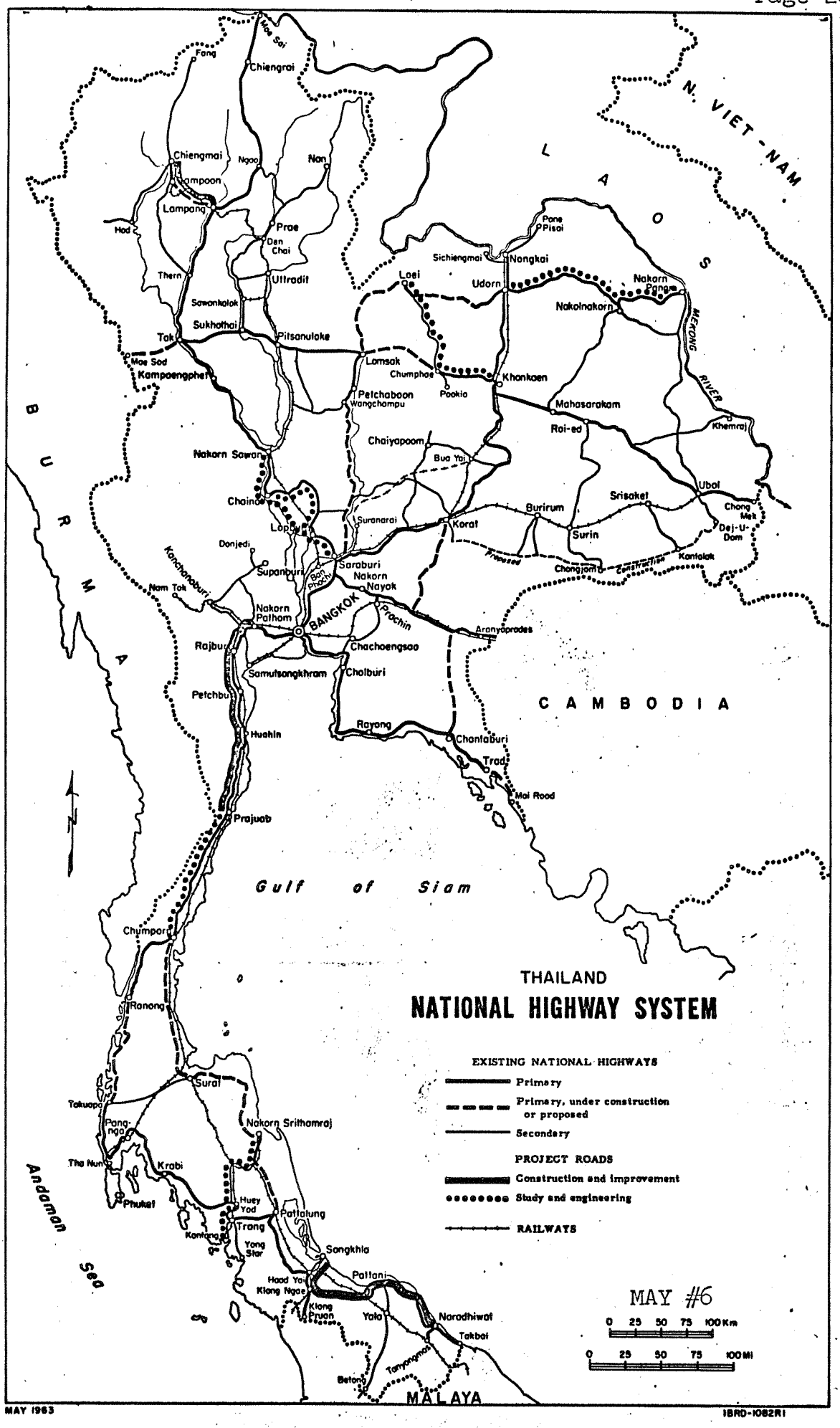

MAY 1963

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XI. PROCESS DESCRIPTION AND PLANT LAYOUT

A. General Comments

It was established previously in this Report that the mill for Thailand would be built in two separate stages as Two Projects:

Project I. Bagasse pulp mill and kraft paper mill.

Project II. Bamboo pulp mill (to be integrated with first stage).

The general description of processes in this section covers, therefore, the line of flow and equipment for a bagasse pulp mill of eighteen thousand - twenty thousand tons per year productive capacity and kraft paper mill for up to fifty-four thousand tons annually of paper and board in the first stage, followed by a pulp mill of twenty thousand - twenty-five thousand tons per year capacity using bamboo and other indigenous fibrous materials in the second stage.

The systems outlined in the following pages are completely flexible with respect to fibrous raw materials and grades of paper within the broad intent of production and are based on the latest advancements in pulp and paper technology.

Flow diagrams of the proposed processes are appended to this Report and can be used to supplement and clarify the operation in conjunction with the process descriptions.

B. Bagasse Depithing and Baling at the Sugar Mill and Mill Storage (Project I) Flow Diagram No. B-C/773/1040

Bagasse depithing and baling stations will be located at three sugar mills. The bagasse originating at the sugar mill grinders will be conveyed to the depithing and baling station at each sugar mill by drag conveyor, which passes under a tramp metal magnet. The conveyor will serve the necessary number of Horkel depithers (2 or 3) from whose pith outlets the pith drops into belt conveyor discharging into a blower for carrying the pith back to the boilers for burning.

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The depithed fiber from the Horkel machines will be collected on a belt conveyor which will discharge onto an inclined drag conveyor serving the baling station. This latter conveyor will discharge onto a drag feed conveyor feeding the balers. Any excess bagasse will be returned by conveyor to the inclined conveyor above.

The baling bagasse from the balers will be loaded onto trucks at the baling station and taken to the pulp and paper mill for direct use or storage. For storage, the bales will be stacked by a stacking type crane in an approved manner to permit drying. The same crane will reclaim the bales during the period when bales are not being received from the sugar mills and the bales will be transported to the pulp mill by suitable means.

C. Wet Bagasse Handling and Second-Stage Depithing at the Pulp Mill (Project I) Flow Diagram No. B-C/773/1040

During the grinding season, the baled, moist depithed bagasse from the sugar mill will be discharged from the trucks onto a conveyor feeding a continuous Hydrapulper for disintegration of the bales and slushing of the bagasse. During the off-grinding season, the bales from storage at the pulp mill will be reclaimed and introduced into the pulp mill system as above.

The wetted and disintegrated bagasse in the Hydrapulper will be extracted continuously through a screen overflowing the Hydrapulper and dumping into either of two chests from which the bagasse will be pumped to flow boxes serving two dewatering drums. Surplus bagasse will be returned to the Hydrapulper. The drained bagasse will drop onto a drag conveyor serving the second-stage or wet depithing machines. Surplus bagasse not taken by the depithers will return to the Hydrapulpers.

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The accepted, depithed bagasse will be collected on a belt conveyor which will discharge onto a storage pile on a concrete slab with drainage facilities. The pith removed in the depithers will flow to a horizontal filter discharging to a press which, in turn, will discharge into carts for transport to a pith boiler. The filtrate from the pith filter will drop into receivers under vacuum and the white water will discharge into pumps to a white water tank serving the Hydrapulper.

The bagasse from the storage pile will next be transferred by tractor shovel to an inclined conveyor discharging into a moving bottom storage bin. From this bin the bagasse will be taken by an inclined drag conveyor to the metering system in the pulp mill. Surplus bagasse not taken by the metering devices will return to the storage bin.

D. Pandia Continuous Digestion System (Project I)
Flow Diagram No. B-C/773/1041

The bagasse on the inclined conveyor above will drop into a drum-type metering feeder and the metered bagasse will next drop onto a horizontal conveyor equipped with a weightometer. The weighed bagasse will pass under a tramp metal magnet and drop into a mixer-impregnator where a small amount of cooking liquor will be introduced for preimpregnation.

The bagasse will then drop into a hopper over the Pandia screw feeder. The feeder, equipped with a variable speed drive, will introduce the bagasse into the digestion pressure zone. Liquor squeezed from the bagasse by the screw feeder will be collected in a tank and pumped into the digester, together with the main portion of the cooking liquor. The cooking liquor will be prepared from white liquor from the recovery plant and black liquor in a cooking liquor storage tank equipped with an agitator.

The Pandia digester itself will consist of two 42" diameter tubes, each with a time control screw conveyor and variable speed drive. The conveyor speeds will be controlled from a master control panel, as will be the feeder speed, the chemical feed and the steam supply. The first digester tube will have a special mixing conveyor to blend chemicals thoroughly with the bagasse. The second tube will discharge through an orifice-type discharge into a blow tank.

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The cooked bagasse will be blown through the discharger above to a cyclone separator mounted on the blow tank. A heat exchanger will be provided to recover the heat from the exhaust steam and used to heat water for the last-stage washer shower.

The bottom of the blow tank will have a motor driven vertical propeller agitator. Black liquor from the first washer filtrate tank will be admitted to the bottom of the blow tank for dilution and to the blow tank discharge to maintain the consistency of the pulp leaving the blow tank.

E. Defibering, Washing, and Screening of Bagasse Pulp (Project I)

The pulp will be pumped from the blow tank under agitation-controlled consistency through a magnetic trap to a prefiner for defibering of fiber bundles in the case of low yield and pulp and preliminary defibering for the high yield pulp. Following the Prefiner, the pulp will flow either directly to the washing system for the low yield pulp or through the defibering system for the high yield pulp. For the latter case, the pulp will first pass over a drainer conveyor before entering a Hydradisc refiner for complete fiberizing. The fiberized stock will drop into a stock chest and will then be pumped to the washing system at times this grade of pulp is being produced. Both high and low yield pulps will be under consistency and flow control going to the washing system.

Either grade of pulp will be diluted before entering the vat of the first of three vacuum washers in series. The dilution will be filtrate from the first washer and the shower water on this washer will be second-stage filtrate. The pulp will discharge from the first washer through a repulper and will be diluted with second-stage filtrate. The pulp will pass over the second washer and to the third washer in a similar way. Counter-flow filtration will be used throughout and the final shower water will be clear, hot water from the blow tank heat recovery system.

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The strong filtrate from the first washer will be used for dilution as above and also in the blow tank and for cooking liquor make-up with the surplus going to the recovery system. The filtrate tanks of the washers will be connected through a foam tank.

The washed pulp from the final washer will drop onto a belt conveyor equipped with a plow for diverting the pulp into either the high-yield or low-yield agitated stock chests.

Either grade of pulp will next be pumped under controlled consistency to the primary pressure centrifugal Selectifier screen; the stock will be diluted with white water before screening. The accepted pulp from the primary screen will sump and will be pumped to the first stage of the three-stage centrifugal cleaning system. The accepted, first-stage cleaned pulp will pass to a vacuum thickener discharging into the high-or low-yield high density stock chests. The rejects from the primary screen will go to a sump from which the stock will be pumped to a secondary pressure screen whose accepts will be returned to the primary screen line. The secondary screen rejects will be dewatered on a vibrating screen-thickener and then defibered in a disc refiner before dropping into an agitated refined rejects chest. This stock will be pumped to the high-yield stock chest described below.

The rejects from the primary cleaner will drop to a sump and be pumped to the second-stage cleaner whose accepts will return to the primary cleaner feed. The secondary rejects will drop to another sump and be pumped to the third-stage cleaner whose accepts return to the secondary cleaner feed. The tertiary rejects return to the rejects vibrating screen.

The thickened stock above will drop as mentioned, into either a high-yield or low-yield high density stock chests from which chests the stocks will be pumped to the stock preparation department or to the wet lap machine for pulp storage.

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F. Bamboo Handling and Chip Preparation (Project II)
Flow Diagram No. B-C/773/1043

Bamboo will probably be received mostly by rafts, and after dismantling the rafts, the poles will be taken from the river by a haul-up serving a conveyor taking the bamboo to the mill yard. This conveyor will discharge onto a conveyor serving the storage yard where the bamboo will be stacked by hand. The receiving conveyor above will also discharge onto a cross conveyor serving two feed conveyors in parallel equipped with showers and taking the cleaned bamboo to two special horizontal-feed bamboo chippers equipped with crushers. The bamboo will be reclaimed from storage by the storage conveyor operating in reverse and sending the bamboo to the chipper feed conveyors via the main receiving and cross conveyors above.

The bamboo chips will be collected on a belt conveyor discharging into the boot of a chip bucket elevator in turn discharging onto a belt conveyor serving a chip screen. The accepted chips from the screen will drop into a blower and will be blown to a cyclone emptying into a chip silo. The oversize chips will drop from the screen into a rechipper which will return the disintegrated chips by blowing to the chip screen. The fines from the screen will go to disposal. The separated air from the cyclone above, which contains dust, will go to another cyclone for separation of the dust by a water spray and the wetted dust will go to disposal.

The chip silo will discharge by a rotary discharger onto a belt conveyor serving an inclined digester feed conveyor equipped with a weightometer.

G. Bamboo Pulping, Washing & Screening (Project II)
Flow Diagram No. B-C/773/1044

The weighed chips above will drop into a chipbin over a hopper and the chips will then fall into a mixer-impregnator for pretreatment with cooking liquor.

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The pre-impregnated chips then will enter the screw feeder of the Pandia continuous digester and will be subjected to pulping according to the method described previously for bagasse. The pulp, as before, will discharge into a blow tank and will be pumped under controlled consistency and measured flow over a magnetic trap to a Prefiner and then to a vibrating knotter screen before passing, after dilution, to the vat of the first brown stock washer. The knotter rejects will drop into a tank and will be pumped to the mixer-impregnator for repulping.

The three-stage washer and liquor handling system will be operated the same as for the bagasse pulp above and the washed pulp will drop into an agitated washed stock chest.

The washed stock will next be pumped under controlled consistency to the primary Selectifier centrifugal screen and then to two parallel secondary screens with the final accepted pulp passing to a surge tank. From this tank the accepted pulp will be pumped to a vacuum thickener which will discharge into the screened stock chest for pumping under controlled consistency to the stock preparation department or to the wet lap machine.

The rejects from the primary and secondary screens will flow to a vibrating screen with the accepted pulp returning to the centrifugal screening system for re-screening. The rejects will go to a rejects tank and will be pumped back to the digester system for repulping.

H. Long-Fiber Preparation (Projects I and II)
Flow Diagram No. B-C/773/1042

Imported kraft pulp will be used to the extent of approximately one-half the pulp requirements in the first stage and to a considerably lesser amount in the second stage. Bales of dried imported kraft pulp will be charged into a batch-type Hydrapulper for slushing into pulp. The pulp will be periodically pumped, after passing through a magnetic trap, into an agitated slushed pulp chest. From this chest the pulp will be pumped under controlled consistency to the stock preparation system.

Wet lap bagasse or bamboo (Project II) pulp will be slushed in this Hydrapulper as well.

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I. Wet Lap Machine (Projects I and II)
Flow Diagram No. B-C/773/1041

Pulp from the screened stock chests will be pumped to a wet lap machine to provide pulp storage when the paper machine is running different grades of paper. The stock will be diluted to low consistency before entering the flow box of the wet machine. A sheet of pulp will be formed on the cylinder mould, passed through a single press, and will then be stripped from the press in laps and stored on pallets to be transported on hand trucks to storage. A pulp scale will be provided at this point. The wet lap pulp will be taken from storage as required to the stock preparation department for reslushing.

J. Waste Paper Preparation
Flow Diagram No. B-C/773/1042

Mixed waste paper will be received in bales which will be dumped into a Hydrapulper. The slushed pulp will be pumped to an agitated chest from which the stock will be pumped through a centrifugal separator for removal of coarse material such as grit, sand and metallic particles. The stock will then pass to a special rotary screen (classifier) for further removal of light and heavy foreign materials. The cleaned pulp will then be thickened on a couch-type thickener and dropped into a chest and then passed through a jordan before being dropped into the stock chest for subsequent pumping to the machine blending chest under controlled consistency and flow for use in corrugating board.

K. Stock Preparation and Broke and White Water Handling
Flow Diagram No. B-C/773/1042

The pulps from the bagasse and bamboo (Project II) and purchased pulp storage chests will flow to a refining system with pressure disc refiners for strength development. By employing a system of bypasses and flow meters, the refined stocks will be sent separately to either the primary machine chest or both it and the secondary head box blending chest, as required, with the desired proportions of pulp.

The stocks will next be pumped under controlled consistency to jordans for final refining and then will be metered to the two fan pumps serving the two headboxes. By-pass arrangements at the machine refiners will allow for variations in the final refining.

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The furnishes for the machine will be diluted at the suctions of the fan pumps with white water from the machine wire pit, alum added for pH control, and the stock pumped through the Selectifier screens to the headboxes.

Dry broke and trim from the machine will be reduced to pulp in a Sydrapulper and the pulp will be pumped to the wet broke storage chest. The wet broke from the couch pit will be pumped to a saveall and discharged to the wet broke storage chest. When a wet break occurs, water will be added automatically and the broke will be pumped from the couch pit to the disc-type saveall before being discharged to the wet broke storage chest.

The machine white water will be collected in clear white water and cloudy white water chests. The clear white water will be used at the showers of the machine and the cloudy white water will be used for dilution in the broke system and the rest of the mill.

L. Papermaking Chemical Preparation

The alum and size will be prepared in agitated tanks and pumped to the machine blending chest or, in the case of the alum, ahead of the fan pumps.

M. Paper and Board Machine and Finishing
Flow Diagram No. B-C/773/1042

It is proposed that the machine will be used alternately for the production of liner and corrugating boards, and bag and wrapping papers. A secondary headbox on the papermachine will give flexibility to the machine so that the grades of linerboard produced can be varied considerably to suit the market requirements. It will also help in using a maximum of the short-fiber pulp.

In the production of linerboard approximately eighty percent of the stock will be sent to the primary headbox and twenty percent to the secondary headbox. The secondary headbox will not be used when corrugating board and bag and wrapping papers are being run.

The headboxes will deliver the stock to a cantilevered fourdrinier section equipped with the necessary suction boxes and a suction couch. From the fourdrinier section the sheet will go to the press

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section consisting of two main suction-type presses and a smoothing press. From the press section the sheet will go to the dryer section which will be subdivided into three sections. Full specifications of the paper machine are given in the next section of this proposal.

Leaving the dryer section, the sheet will pass through an eight-roll calender stack before being wound into rolls on the reel. The rolls will then be slit and rewound on the slitter rewinder, the core shafts removed and transferred by slat conveyor. The linerboard rolls will be banded and weighed before delivery to storage. Bag paper is cut into sheets and taken to the converting department for making into printed multi-wall and grocery bags.

Rolls will be handled by means of hoists with trolleys and a monorail system.

N. Black Liquor Evaporation
Flow Diagram No. B-C/773/1045 and/1054

Complete chemical recovery systems will be provided for each phase of pulp mill installations. In general, the two lines will be the same. Thus, there will be two evaporation, recovery boiler and recausticizing lines, although allowance will be made for common equipment to the greatest extent possible. The descriptions below will, thus, have application for both phases.

The black liquor from the filtrate and foam tanks in the brown stock washing departments will be stored in a weak black liquor storage tank and then pumped through the black liquor oxidation system to reduce the objectionable odor conditions and to reduce chemical loss. Gases from the blow heat recovery system will also be sent to the oxidation system. From the oxidation system, the liquor will then be pumped to a five-body, quintuple effect, vertical, long-tube evaporator where the liquor concentration is increased to approximately fifty percent.

The evaporator system will be a conventional unit and will have the necessary interconnections so that any one effect can be by-passed.

From the second effect of the system, the concentrated liquor will be pumped to the thick or strong black liquor storage tank from whence it will be pumped to the recovery boiler.

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The heat necessary for evaporation will be supplied to the first effect by low pressure steam; and from this effect the vapor from each effect will flow counter-current to the liquor flow.

O. Recovery Furnace
Flow Diagram No. B-C/773/1045 and/1054

The concentrated black liquor from the strong black liquor storage tank will be pumped to the cyclone-type evaporator which utilizes waste heat in the gases from the recovery furnace to increase the total solids concentration of the liquor to approximately sixty percent. The concentrated black liquor will then be heated to the proper temperature and sprayed into the recovery furnace where it will be burned and the heat recovered. The volatile portions of the solids, which consist of complex compounds of soda and organic non-cellulose portions of the wood, will be driven off and burned. The residue, which consists chiefly of carbon and inorganic soda compounds, will settle to the special hearth on which the solids will be burned at a sufficiently high temperature to melt the ash. This molten ash, called "smelt", will be continuously discharged from the furnace hearth through a spout to the smelt dissolving tank from where it will be pumped to the recausticizing system.

The heat developed by the combustion of the black liquor solids will be first utilized in the furnace itself to complete the drying of the liquor. The waste flue gases from the combustion furnace will be passed through the recovery boiler where enough heat will be recovered to produce steam for general mill use.

The gases leaving the boiler will then be passed through the cyclone evaporator before being discharged to the atmosphere.

To make up for losses of soda and sulfur from the system, both contained in the pulp and lost in washing or carried out of the recovery stack, salt cake (sodium sulfate) will be added to the recovery furnace where it will be reduced to sodium sulfide. The salt cake itself will be received by rail car and will be charged to the salt cake system through a feeder to two cyclones by means of a fan. One cyclone will serve as a salt cake storage silo equipped at its

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bottom with a crusher and feeder and the other the day tank. The day tank will discharge through a feeder onto a screen whose accepts will drop into the salt cake dissolving tank for pumping to the recovery boiler. The salt cake rejects will be passed to the salt cake silo for disintegration in the crusher at the discharge of the silo. The latter's discharge will be handled by the blower serving the incoming salt cake.

P. Recausticizing and Lime Reburning
Flow Diagram No. B-C/773/1054

The green liquor from the smelt dissolving tank at the recovery furnace will be first pumped to a green liquor storage tank from which it will then be pumped to the slaker where lime will be added. From the slaker, the slurry will flow to the classifier, the grit going to waste and the liquor to a series of causticizing tanks where the reaction of quicklime on the green liquor will convert the sodium carbonate to caustic soda and precipitate calcium carbonate. The reacted liquor will flow to a clarifier, where the precipitated calcium carbonate will be separated from the liquor. The white liquor will then go to the liquor storage tank for future use in the digestion system.

The calcium carbonate precipitated from the liquor clarifier will be pumped to the lime mud washer to remove residual soda. The wash water from the lime mud washer will be stored in the weak liquor storage tank. This weak liquor will be continusouly pumped to the smelt dissolving tank in the recovery plant. The lime mud will be discharged to waste.

The make-up lime as received will be discharged through a grizzly into a hopper serving a crusher. The crushed quicklime will then be conveyed and elevated to storage by a bucket elevator after which it will be used in the causticizing of the green liquor.

The recausticizing equipment initially installed, will be of sufficient size to handle the liquor requirements of the completed mill (Project I and Project II). In Project II a green liquor clarification system will be added, and a lime kiln will be provided to reburn the lime mud, which will then pass over a filter washer and be discharged by screw conveyor into the kiln. Lime losses will be made up by the addition of limestone which will be crushed and added to the kiln feed screw conveyor.

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Q. Steam and Power Generation and Electrical Distribution and Lighting

The fuel-oil-fired steam generating units will supply the steam requirements of the mill with the steam that has first passed through an extracting and condensing turbo-generator.

Steam will be generated in the recovery boiler and in two 27,500 kg/hr auxiliary, fuel-oil-fired, package-type steam boilers for Project I of the mill. The steam will be generated at high pressure and then passed through an extracting and condensing turbo-generator of 7,500 kw capacity for generation of the power requirements of the mill. The power will be generated at 3,000 v. The extracted steam will be used for digestion, evaporation, recausticizing, paper drying, and general heating purposes.

Boiler feed water treating equipment will be provided to prevent scale and corrosion in the boilers.

Standby power for the mill will be provided by a diesel generator in the event of a shut-down of the turbo-generator unit.

All necessary power distribution equipment, substations, motor control centers, mill lighting, etc., will be provided for the independent operation of the entire mill.

For Project II, additional steam and power generating equipment as required will be provided.

R. Water and Effluent

All the sites considered for the proposed mill are relatively close to rivers of adequate size for the quantities of water required by the mill. The quality of the water in most cases would be satisfactory for the production of unbleached kraft papers and board without further treatment; however, water treatment will be provided for the boiler feed water, as mentioned previously.

The water requirements for the mill, based on a total production of forty-five thousand tons per year will be sixteen thousand liters per minute and the fresh water required for the process will be provided by a

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pumping station at the river. Booster pumps will be provided at the mill to give higher pressures where necessary.

Drinking water will be chlorinated for hygienic purposes.

A fire pump will provide protection with water from the river and the unit will be supplied with an auxiliary diesel engine for use during power failure. An elevated storage tank will provide water for emergency purposes.

Additional water pumps will be provided for Project II, although the pipe lines will be sized initially for the full water requirements.

There are at present no specific regulations restricting the return of mill effluent to the river. However, clarification and pollution reduction in a lagoon have been considered.

S. Mill Shops and Stores, Laboratory and General Services

Complete maintenance shops and general service equipment and a pilot plant and control laboratory will be provided according to the items listed in the next section.

T. Plant Layout

In order to provide a basis for determining the site and building requirements, a plant layout was prepared which represents a basic design for a mill of the type proposed for Thailand. The layout, which is given as Diagram No. B-L/773/1055 in the Appendix has been arranged to be applicable to any of the preferred sites discussed in Section IX. The layout is shown as providing an uninterrupted flow of raw materials into and finished products out of the mill.

The plant layout is made on the basis of providing for both phases of the planned mill. In addition, there is provision for expansion of the mill at a later date.

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In the layout, the transport of materials in and out of the mill is indicated as being by truck, inasmuch as this is the general case. However, with little modification, a siding for rail transportation could also be used together with the truck transport.

The bamboo is indicated as being received by river for the second phase of the mill's development. The water for the mill will also be taken from the river by means of the pump house shown in the layout.

It is to be understood that this layout is only indicative of one of many possibilities which could change to a considerable degree once the site is selected.

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XII. PROJECT I LIST OF EQUIPMENT PARTIALLY INTEGRATED PULP AND PAPER MILL

A. General Comments

The following list of equipment covers all of the process and services equipment necessary for the proposed partially integrated pulp and paper mill normally capable of producing 18,000-20,000 tons per year of its pulp requirements and 54,000 tons per year of kraft liner board, corrugating medium, bag paper, and miscellaneous wrapping papers. This equipment will be furnished by the Parsons & Whittemore Organization and will be of the latest proven design for use in a mill operating according to the most advanced established practices and technology.

In order to insure the production of highest quality sack paper, provisions have been made for the possible addition of extensible paper equipment to the paper machine should it be deemed necessary after start-up of the mill. Provisions have also been made for additions to the services in the event extensible paper is produced.

Although the equipment has been selected to meet the conditions as foreseen at this time, it should be appreciated that this is a preliminary design and modifications will undoubtedly be needed during the final engineering of the mill. Naturally, any changes will be made on the same basis of providing a mill designed and engineered to give a coordinated efficient operation.

With the above considerations in mind, the following complete list of equipment, by departments, has been prepared for the mill.

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B. Bagasse Depithing, Baling and Storage at Pulp Mill and Sugar Mill Replacement Boilers

1. Three (3) belt conveyors to transport whole bagasse from the sugar mills to the depithing plants, each complete with drive.

1a. Three (3) drag conveyors to feed depithing machines.

2. Three (3) tramp metal magnets to remove tramp iron from bagasse, thus protecting the Horkel depithing machines.

3. Seven (7) Horkel depithers, large size, each complete with feed screw and drive.

4. Three (3) fiber receiving belt conveyors, each complete with drive, to transport partially depithed bagasse to baling area.

5. Three (3) belt conveyors, each complete with drive, to transport pith from the Horkels to the blowers.

6. Three (3) blowers, to return pith to sugar mill boiler, each complete with drive, necessary ducts, etc.

7. Three (3) inclined drag conveyors to transfer depithed bagasse to baler feed conveyors.

8. Three (3) baler feed conveyors, drag type, each complete with chutes for regulating feed to balers.

9. Seven (7) semi-automatic balers, each complete with feed chute and V-belt drives.

10. Three (3) conveyors to return surplus bagasse to inclined conveyor, complete with drives.

11. Four (4) truck scales, steel platform printing and recording type (less locally constructed pit).

12. One (1) stacking crane, with grab.

13. Two (2) stacking conveyors.

14. Two (2) platform trailers for transporting bales from storage to pulp mill.

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15. One (1) tractor.

16. Motors and starters for all equipment listed above.

17. Walkways, platforms, etc.

C. Wet Bagasse Handling and Second-Stage Depithing at Pulp Mill, and Bagasse Drying and Briquetting

1. One (1) belt conveyor, complete with drive, to feed partially depithed bagasse in baled form to the Hydrapulper.

2. One (1) continuous Hydrapulper for slushing baled bagasse, 4.85 m (16 ft) diam, complete with rotor, special design wire grab, drive, overflow, junk box, V-belts, sheaves and motor base.

3. Four (4) agitators, two each for two-storage and settling chests, complete with drives.

4. Two (2) special discharge pumps for storage chests, cast iron, stainless steel fitted, with extended base for motor, and with coupling.

5. Two (2) head boxes to feed drainer drums.

6. Two (2) bagasse drainers, drum type, each complete with feed box and drive.

7. One (1) depither feed conveyor, complete with chutes to regulate feed to depithers.

8. Two (2) Horkel depithers, large size, each complete with drive.

9. One (1) belt conveyor to convey depithed bagasse to storage pile, complete with steel supporting structure and drive.

10. One (1) pith filter to de-water pith slurry from depithing machine, complete with drive and two filtrate receivers.

11. One (1) vacuum pump for above pith filter with base and coupling.

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12. Two (2) pumps for filtrate recirculation and transfer to filtrate tanks, with base and coupling.

13. One (1) pump for white water return to Hydrapulper and for dilution, complete with base and coupling.

14. One (1) screw press for de-watering pith from the pith filter, complete with vari-speed drive.

15. Two (2) tractor shovels, each with suitable bucket, to transport depithed bagasse from storage pile to the transfer conveyor feeding moving-bottom bagasse storage bin.

16. One (1) inclined drag conveyor to transport bagasse from storage pile to moving-bottom storage bin, complete with drive.

17. One (1) moving-bottom storage bin, special design, with variable speed drive. Steel for bin walls furnished for field fabrication.

18. One (1) inclined drag conveyor to transport the bagasse to the metering feeder.

19. One (1) tramp metal magnet to remove tramp iron from bagasse, thus protecting the metering feeder and Pandia digestion system.

20. One (1) return belt conveyor and chute to return excess bagasse not taken by the metering feeder back to the moving-bottom storage bin.

21. Motors and starters for all equipment listed above.

22. Pipes, valves and fittings, instruments and miscellaneous fixtures.

D. Pandia Continuous Digestion System

1. One (1) Pandia continuous digester to be complete with:

   (a) One (1) metering feeder, twin drum type, complete with fluffing roll, metering rolls, housing, and drive.

   (b) One (1) continuous weigher, indicating, recording, and controlling to be installed on

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the digester feed, complete with controller, and all accessories.

(c) One (1) mixer-impregnator, equipped with special chute, special design mixing conveyor and chute pipe, mild steel construction, including the constant speed drive.

(d) One (1) screw feeder, 40.5 cm (16 in.) diam screw size, feeder to be of carbon steel construction, and plug pipe and preheater of stainless steel, all parts in the pressure zone to be built in accordance with ASME Code for 170 psi working pressure.

(e) One (1) variable speed drive for screw feeder, complete with water cooled coupling, gear reducer, flexible coupling, chain, sprockets, chain case and base.

(f) One (1) digester tube assembly consisting of: two (2) stainless steel tubes, 1067 mm diam x 9450 mm long, each complete with removable heads, time control screw, and built in accordance with ASME Code for 170 psi working pressure; one (1) inlet chamber with stop valve assembly.

(g) One (1) T piece, 915 mm diam complete with 200 mm air-operated blow back valve.

(h) Two (2) variable speed drives for time control screws, each complete with reducer, coupling, chain and sprockets.

(i) One (1) discharger, 455 mm (18 in.) size, complete with impeller, housing with all parts in contact with stock in stainless steel, drive and remote control equipment; built in accordance with ASME Code for 170 psi working pressure.

2. One (1) blow tank to receive discharge from digester, capacity approximately 200 cu m, mild steel construction, designed to meet pressure, hydrostatic and structural requirements, complete with top cyclone, safety valves, and agitator of cast iron phenolic coated construction with torque arrangement

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for consistency control, reducer, base plate and coupling.

3. Two (2) tanks for measuring white and black liquor to cooking liquor tank, mild steel construction.

3a. One (1) cooking liquor tank, mild steel construction, complete with agitator and controls for proper blending of white and black liquors.

4. One (1) cooking liquor pump to feed liquor to the mixer-impregnator, cast iron stainless steel fitted construction, complete with base plate and coupling.

5. One (1) collecting tank for liquor drained from the screw feeder, mild steel construction, complete with fittings.

6. Two (2) squeeze liquor re-injection pumps, cast iron stainless steel fitted construction, each complete with base plate and coupling.

7. One (1) condenser, direct contact type, to condense flash steam from blow tank, complete with steam jet ejector and necessary controls.

8. One (1) hot water tank, capacity approximately 40 cu m, complete with steam sprayer, nozzles, overflow, vent, and fittings.

9. One (1) hot water pump for hot water tank, cast iron, bronze-fitted construction, complete with base plate and coupling.

10. One (1) magnetic trap, in-line type, to be installed ahead of blow tank pumps, complete with permanent magnet.

11. Two (2) stock pumps for blow tank, capacity approximately 1,000 liters/min, cast iron, stainless steel fitted construction, each complete with base plate and coupling.

12. One (1) Prefiner, 457 mm size, complete with cast iron body, stainless steel rotor and stator, base rails and drive.

13. One (1) drainer conveyor with drive.

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14. One (1) Hydradisc refiner, 1066 mm size, complete with main head, rotating element, refining disc, coupling, oiling system and pressure switch.

15. One (1) agitator for refined stock chest, cone type, cast iron phenolic coated construction, 900 mm diam, complete with propeller blades, shaft and drive.

16. One (1) stock pump for refined stock chest, capacity approximately 1200 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

17. One (1) consistency regulator, in-line pressure type, stainless steel construction, in line to washers.

18. One (1) magnetic flow meter for pulp to washer.

19. One (1) set of controls for the Pandia continuous digestion system comprising:

    (a) For metering feeder and mixer: start-up push buttons, indicating light, tachometer, and left-hand contacting ammeter.

    (b) For the screw feeder: start-up push button, indicating light for main motor, high-load contacting ammeter, tachometer, potentiometer, and manual/auto control switch.

    (c) For each digester tube drive: start-up push button, indicating light for main motor, increase/decrease push button for speed control, tachometer, and high-load contacting ammeter.

    (d) For the discharger: start/stop push button, indicating light for main motor, and high-load contacting ammeter.

    (e) For the liquor pumps: start/stop push buttons, indicating lights for motors.

    (f) For each stop valve: three (3) position selector switch labeled "Close - Open - Auto."

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(g) For the main control of the digester: three (3) position selector switch labeled "Auto/Manual."

(h) For each oil pump motor: start/stop push button and indicating light.

(i) For each re-injection pump motor: start/stop push button and indicating light.

(j) For the cooking liquor: one (1) flow recorder-controller for each digester.

(k) For the steam flow to the digester: one (1) pressure recorder-controller; one (1) steam flow recorder; and one (1) temperature recorder.

(l) For the warning system: necessary indicating lamps, horn acknowledgment button, reset button, and lamp test button.

(m) One (1) control panel.

20. Necessary instruments and controls other than those listed above for proper operation of equipment and process.

21. Special fixtures and insulation.

22. Tile linings and fittings for all chests and tanks in this department.

23. Necessary piping, valves and fittings.

24. Motors and controls for all equipment.

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E. Pulp Washing and Screening

1. One (1) brown stock washing system consisting of:

   (a) Three (3) washers, each approximately 2900 mm diam x 4300 mm face, mild steel construction, complete with mild steel vats, stainless steel wires and facing wires, stainless steel shower pipes and valves and mild steel feed box.

   (b) Two (2) intermediate shredder-repulpers, mild steel construction, each complete with shafts, intermediate chain drive and case between shredder and repulper shafts, dilution and drain connections.

   (c) One (1) final shredder-repulper, mild steel construction, complete with cut flight screw conveyor repulper.

   (d) One (1) press roll complete with air loading mechanism.

   (e) Three (3) drives for washers including shaft extension and speed reduction gear boxes.

   (f) Three (3) drives for intermediate and final repulpers including shaft extension and speed reduction gear boxes.

2. One (1) set of filtrate tanks for the brown stock washers comprising three (3) tanks each approximately 150 cu m capacity, mild steel construction, complete with fittings.

3. One (1) foam tank, capacity approximately 60 cu m mild steel construction, complete with fittings.

4. One (1) foam breaker for foam tank, mechanical type, mild steel construction, complete with housing, rotor, liquor launder and drive.

5. Three (3) filtrate pumps for dilution ahead of washers, capacity approximately 5000 liters/min each, cast iron stainless steel fitted construction, each complete with base plate and coupling (one spare).

PROPRIETARY WHITEMORE

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6. One (1) filtrate pump for cooking liquor dilution and to blow-tank in digestion department, capacity approximately 1000 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

7. One (1) filtrate pump to evaporator, capacity approximately 700 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

8. One (1) washer hood, structural steel and fiberglass construction, complete with three (3) ventilation fans, gear reducers, and couplings.

9. One (1) hot water heater for hot water to washer systems, steam injection type.

10. Two (2) agitators for washed high- and low-yield stock chests, horizontal type, cast iron phenolic coated construction, 1500 mm diam each, complete with propeller blades, shaft and drive.

11. Two (2) consistency regulators, in-line pressure type, in stock lines from washed stock chests.

12. Two (2) stock pumps for washed high- and low-yield stock chests, capacity approximately 4000 liters/min each, cast iron and bronze fitted construction, each complete with base plate and coupling.

13. One (1) primary screen, Selectifier 24 P, complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box and valve, base plate and coupling.

14. One (1) sump tank for primary screen rejects, stainless steel construction, capacity approximately 10 cu m.

15. One (1) stock pump for primary screen rejects, capacity approximately 1500 liters/min, cast iron and bronze fitted construction, complete with base plate and coupling.

16. One (1) secondary screen, Selectifier 12 P, complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box and valve, base plate and coupling.

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17. One (1) vibrating thickener, all parts in contact with stock of stainless steel construction, complete with inlet, screen plates, screen trough, and drive.

18. One (1) disc refiner for secondary rejects, complete with cast iron body, stainless steel plug and shell, bearings base plate and coupling.

19. One (1) agitator for refined rejects stock chest, horizontal type, cast iron phenolic coated construction, 1500 mm diam, complete with propeller blades, shaft and drive.

20. One (1) stock pump, cast iron and bronze fitted, for second-grade stock to cleaners, complete with base plate and coupling.

21. Three (3) sump tanks serving three-stage centrifugal cleaner system.

22. One (1) three-stage centrifugal cleaner system, complete with inter-connecting piping, valves, fittings and supports.

23. One (1) centrifugal stock pump, cast iron and bronze fitted, to primary centrifugal cleaner, complete with base plate and coupling.

24. One (1) centrifugal stock pump, cast iron and bronze fitted to secondary cleaner, complete with base plate and coupling.

25. One (1) centrifugal stock pump, cast iron and bronze fitted, to tertiary cleaner, complete with base plate and coupling.

26. One (1) vacuum decker, approximately 2900 mm diam x 4300 mm face, steel and stainless steel construction, complete with vat, cylinder mould, inlet box, showers, pulp discharger, breaker conveyor, main drive, and breaker conveyor drive.

26a One (1) belt conveyor for transporting pulp from vacuum decker to high density storage towers, complete with plow.

27. Two (2) sets of agitators and dilution nozzles for dilution in high density, high and low-yield stock chests, each agitator complete with propeller blades, shaft and drive.

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28. Two (2) stock pumps for high- and low-yield stock chests, capacity approximately 1200 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

29. One (1) white water pump, capacity approximately 9000 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

30. One (1) consistency regulator, in-line pressure type, in stock lines from secondary and first grade stock chests.

31. One (1) booster pump, capacity approximately 600 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

32. Tile lining and fittings for all chests and tanks in this department.

33. Necessary piping, valves and fittings.

34. Complete set of instrument and controls for proper operation of equipment and process.

35. Motors and controls for all equipment.

F. Wet Lapping

1. One (1) wet machine, complete with headbox forming roll, felt, and drive.

2. One (1) vacuum pump for wet machine, complete with silencer and drive.

3. Two (2) pulp trucks, manually operated.

4. One (1) white water pump, capacity approximately 750 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

5. One (1) pulp scale.

6. Special fixtures, tile lining and fittings.

7. Necessary piping, valves and fittings.

8. Motors and controls for above equipment.

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G. Waste Paper Preparation

1. One (1) lift truck for handling waste paper bales.

2. One (1) Hydrapulper, bath-type, 2150 mm (7 ft) HC, for slushing waste paper, complete with fabricated steel tub, dump valve, washout valve and V-belt drive.

3. One (1) Hydrapulper dump pump, cast iron construction, complete with base and coupling.

4. One (1) liquid cyclone, cast iron construction, with manual reject system.

5. One (1) classifier, complete with Meehanite casing, stainless screen plates, and scrapers and V-belt drive.

6. One (1) couch-type thickener with fabricated steel vat, phosphor bronze base cloth, complete with drive.

7. One (1) agitator, horizontal propeller type, complete with shaft and drive.

8. One (1) stock pump, cast iron and bronze construction, complete with base plate and coupling.

9. One (1) jordan, complete with plug, shell filling, base plate and coupling.

10. One (1) agitator for waste paper stock chest, horizontal propeller type, complete with shaft and drive.

11. One (1) stock pump, cast iron and bronze construction, complete with base plate and coupling.

12. Two (2) consistency regulator, in-line type, stainless construction.

13. One (1) magnetic flow meter.

14. One (1) agitator, horizontal-propeller type, complete with shaft and drive.

15. One (1) white water pump, cast iron and bronze construction, complete with base plate and coupling.

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16. One (1) stock pump, cast iron and bronze construction to liquid cyclone, complete with base plate and coupling.

H. Chemical Preparation for Paper Machine

1. Two (2) alum tanks, each complete with agitator and drive.

2. Two (2) alum solution pumps (one stand-by), each complete with base plate and coupling.

3. One (1) rosin size preparation tank, complete with agitator and drive.

4. One (1) rosin size storage tank, complete.

5. One (1) rosin size solution pump, complete with base plate and coupling.

6. Necessary piping, valves and fittings.

7. Motors and controls for pumps and agitators.

I. Stock Preparation, White Water System and Broke Recovery

1. One (1) belt conveyor to feed pulp bales to Hydrapulper, item (2), complete with belt, conveyor, structure and drive.

2. One (1) batch-type Hydrapulper, 5.45 m (18 ft) HLV, for slushing purchased pulp, complete with cast iron tub, mild steel extraction plates; rotor, supporting steelwork, dump valve, washout valve, heavy-duty drive with coupling, base plate and lubricating system; magnetic trap.

3. One (1) Hydrapulper dump pump, capacity approximately 18,000 liters/min, cast iron construction, complete with base plate and coupling.

4. One (1) agitator for the Hydrapulper dump chest, horizontal type, cast iron phenolic coated construction, 1500 mm diam, complete with propeller blades, shaft and drive.

4a. One (1) stock pump, cast iron and bronze construction, complete with base plate and coupling to pump to Hydradisc refiners.

5. One (1) consistency regulator, in-line pressure type, stainless steel construction, in stock line from Hydrapulper dump chest.

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6. Seven (7) 1066 mm single-disc Hydradiscs, each complete with main head, rotating element, coupling, refining disc, oiling system, and pressure switch.

7. One (1) agitator for the primary stock chest, cone type, 900 mm diam, cast iron phenolic coated construction, complete with propeller blades, shaft, and drive.

8. One (1) stock pump for primary headbox blending chest, capacity approximately 1100 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

9. One (1) agitator for the secondary headbox blending chest, cone type, 900 mm diam, cast iron phenolic coated construction, complete with propeller blades, shaft and drive.

10. One (1) stock pump for secondary stock chest, capacity approximately 800 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

11. Two (2) jordans for primary furnish, each complete with plug, shell filling, base plate and coupling.

12. Two (2) consistency regulators, in-line pressure type, stainless steel construction, in stock lines from primary and secondary stock chests.

13. One (1) jordan for secondary furnish to machine, complete with plug, shell filling, base and coupling.

14. One (1) fan pump for primary headbox, capacity approximately 50,000 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

15. Two (2) Selectifier screens for primary headbox, each complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box with valve, base plate and drive.

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16. One (1) fan pump for secondary headbox, capacity approximately 15,000 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

17. One (1) Selectifier screen for secondary headbox, complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box with valve, base plate and drive.

18. Two (2) white water pumps for wet end of paper and board machine, cast iron stainless steel fitted construction, each complete with base plate and coupling.

19. One (1) agitator for couch pit, cone type, 900 mm diam, cast iron phenolic coated construction, complete with propeller blades, shaft and drive.

20. One (1) save-all, disc type, of adequate capacity for designed machine production, complete with drive.

21. One (1) stock pump for trim at couch pit, capacity approximately 800 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

22. One (1) agitator for broke chest, horizontal type, 1500 mm diam, cast iron phenolic coated construction, complete with propeller blades, shaft and drive.

23. One (1) broke pump, capacity approximately 300 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

24. One (1) white water pump, cast iron and bronze construction, complete with motor base and coupling.

25. One (1) consistency regulator, in-line pressure type, stainless steel construction, in stock line from the broke chest.

26. Five (5) magnetic flow meters for metering pulp to primary and secondary headbox machine blending chest.

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27. One (1) Sydrapulper for dry broke, complete with two (2) 838 mm diam rotors, extraction plate and chambers in stainless steel, and drive.

28. One (1) broke pump from Sydrapulper, capacity approximately 2700 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

29. Tile linings and fittings for all chests in this department.

30. Necessary piping, valves and fittings.

31. Complete set of instruments and controls for proper operation of equipment and process.

32. Motors and controls for all equipment.

J. Paper and Board Machine

1. One (1) Fourdrinier paper machine for the manufacture of up to 54,000 air dry metric tons per year of liner board, cement bag paper, corrugating medium, and miscellaneous wrapping papers in general accordance with the following specifications:

(a) General

The machine will have a nominal capacity of up to 169 metric tons per day, based on the following approximate breakdown.

Grade	Days of Operation	MT/year
Liner board	92	15,500
Cement bag paper	71	12,000
Miscellaneous wrappings	113	19,000
Corrugating medium	44	7,500
TOTALS	320	54,000

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The machine will be designed and manufactured to operate at a maximum speed of 457 m/min and the hand of the machine will be in accordance with layout requirements.

(b) Primary Headbox

The stock will be fed to the machine by a totally enclosed headbox, designed for operating at all machine speeds. This inlet will be of the pressure/vacuum type with the required head in the inlet being maintained by regulated air pressure or vacuum above the stock level.

Stock will flow from the fan pump through a Stremtrol valve to a manifold header and thence through a series of feed pipes which discharge into the distribution chamber at the bottom of the headbox.

The flow through the feed pipes will be controlled by special pinch valves. These valves will be hand operated.

From the distribution chamber, the stock will flow up through a venturi section designed to even out any cross currents; in the passage above the slot, a motor driven perforated distributor roll will give a controlled agitation to the stock to prevent flocculation.

In the inlet chamber ahead of the slice, there will be a number of distributor rolls, so arranged as to obtain the best possible condition of stock flow.

All distributor rolls will be of stainless steel construction PVC covered with external bearings and removable journals to facilitate the removal of the rolls.

All distributor rolls will be driven by individually adjustable variable speed gear motor with flexible connections on any adjustable roll.

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The lower lip of the stock inlet nozzle or apron board will be very rigidly constructed so that it will remain straight and level. The top lip of the slice will be of the curve type slice design and will be adjustable both vertically and horizontally. The main vertical adjustment of the lip opening will be through a series of gear reducers, connected by a cross shaft which is motor operated. The edge of the lip will be flexible and will have approximately 15 cm centers to permit the leveling of the sheet. These adjusting screws are designed to obtain vernier adjustment.

The horizontal adjustment of the top slice will be through individual screw adjustments on the front and back side of the slice.

All parts of the headbox which come in contact with the stock will be made of stainless steel. There will be a transparent inspection window on the tending side and a window in the dome. These windows will swing open for wash-ups.

Adequate walkways and access ladders will be provided across the headbox and along the front side for each access to all adjustable parts and observation points without interfering with wire change, roll handling or operation. The crosswalk over the slice lip will be of stainless steel safety tread.

A main control valve and an air operated by-pass valve will be supplied for controlling the flow from the fan pump to the inlet headbox.

A complete pressure-vacuum control system will be supplied including the necessary liquid level controls as well as air pressure controls, complete with air compressor, switches and valving for maintaining the proper pressure or vacuum over the liquid in headbox.

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(c) Secondary Headbox

The secondary headbox will be designed with six (6) pinch valves for even distribution of stock flow.

The headbox will be constructed of carbon steel plate, structural shapes and stainless steel with all parts in contact with the stock of stainless steel.

The box will be built for mounting on the suction box rails and will have built-in screw jacks for adjustments. Eye bolts will be provided for lifting and removal during wire changes or when not in use.

A footwalk of stainless steel safety tread and aluminum handrails will be located near the slice lip.

One (1) holey roll will be located immediately upstream from the upper slice wall and will be adjustable both vertically and horizontally for close clearance with the adjacent slice wall and vat bottom.

This roll will be carried on anti-friction bearings and will be driven by a gearhead motor.

The curved upper lip will be adjustable vertically by means of a handwheel and enclosed gear units and will have individual warping rods on approximately 15 cm centers across the machine.

(d) Fourdrinier

The Fourdrinier will be of the latest, cantilevered, shaking, quick-wire changing type, having a wire width of 5385 mm by approximately 37.5 m long. The wire on the forming table will be level from the breast roll to the suction couch roll.

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The forming table equipment and the inside rolls are mounted on rigid, fabricated steel, box section sidebeams which are covered with stainless steel. These sidebeams are supported by fixed and pre-stressed cantilever beams.

Fourdrinier frames will be of welded steel, box section type, covered with stainless steel and arranged to carry table rails, suction boxes, save-alls, etc. Stainless steel is to be generally used throughout for all bolts and nuts.

Table rails will be constructed of a steel channel shape covered with stainless steel fitted with dovetailed strips on top for clamping the table roll bearing housings.

Deckles will be of the ruler type and will extend from breast roll towards the first suction box. They will have a flexible rubber lip against the wire. The deckle channel itself will be of stainless steel and will be mounted on hinged brackets, to be swung out of the way during wire change.

One (1) breast roll will be made from centrifugally cast steel tube rubber covered, with Meehanite cast iron heads, stainless steel journals and bronze head plates. The roll will be ground straight and accurately balanced.

The breast roll will be carried in anti-friction bearings encased in cast iron housings. Bearing holders will be mounted in phenolic resin springs, supported in cast-iron frames to permit frictionless shaking.

Breast roll doctor will be a stationary doctor with phenolic resin blade suitably supported for discharge to trays and integral movement with the breast roll during wire change. The doctor back to be mild steel, rubber dipped, and provided with a white water deflector to discharge water into the first save-all tray. A manual doctor release will be furnished.

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A primary forming board, immediately following the breast roll, will be constructed of stainless steel with beveled top strips of phenolic resin. The forming board supporting structure will be stainless steel mounted in brackets to permit vertical, horizontal and angular adjustment.

Table rolls will all be made of steel tube having a vulcanite covering 6 mm thick. These rolls will be made from steel tube fitted with Meehanite cast iron balancing heads, stainless steel journals and rubber covered head plates.

The rolls will be dynamically balanced and carried in anti-friction bearings which will be encased in housings of eccentric type design. This permits the operator to adjust the rolls vertically within limits, as well as to drop the rolls out of contact with the wire, if so desired. The table roll housings will be mounted on the dovetail rails which are secured to the top of the rails and arranged so that the spacing and position of the rolls may be varied in machine direction.

Deflectors fabricated of stainless steel will be located between the table rolls. These deflectors will be carried in adjustable brackets mounted on dovetail stationary rails which are carried from the main Fourdrinier beams.

The wire support deflectors will be provided with angular adjustment features.

Clamp brackets will allow the deflectors to slide on the rails so that they can be adjusted closely to the table rolls.

Shake Unit two point Simplex type, will be provided complete with connections to the breast roll. The shake unit will be driven by a PIV type variable speed drive.

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Wire carrying rolls will be provided, constructed of steel tube, covered with vulcanite. The finished roll will be fitted with Meehanite cast iron balancing heads, stainless steel journals, non-corrosive head plates and will be ground straight and dynamically balanced.

All wire rolls, including the guide roll, will be mounted in anti-friction bearings encased in cast iron housings. The bearing supporting brackets will be of cast iron. Inside wire rolls will be carried on pivoted arms equipped with hydraulic cylinders for raising and lowering for wire change. The first return wire roll will have its journal extended for driving purposes.

A wire guide, air operated type, will be located on the return of the wire. One (1) hand operated type guide will be located on the front side of the machine.

Wire stretchers will consist of a hydraulic controlled wire tension roll following the last driven roll and a wire take-up roll which is used for positioning the tension roll. In order for the tension control gauge to read true wire tension, an angular wrap of the wire at the tension roll will have to be maintained as a constant. This is accomplished by manual adjustment of the wire take-up roll.

The wire take-up will be carried in a pair of swinging arms carried on a cross shaft, the position of this being controlled through a segment gear and pinion and hand operated from a reduction gear unit located on the tending side of the machine. A cable and weight arrangement will be provided on the brackets for counterbalancing the roll.

Eight (8) suction boxes of fabricated stainless steel will be furnished. The boxes will have wide end of grain sycamore (or equivalent) wax impregnated covers. Five boxes will be located ahead of the dandy roll and three

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boxes after the dandy roll.

The boxes will be supplied with quick clamping hose connections and vacuum hose. One (1) roller type dolly will be furnished for removing the boxes.

An open-end dandy roll of the proper size will be provided. The roll will be equipped with No. 40 mesh bronze double-crimped spiral wire; one (1) oscillating internal shower and save-all will be included. This unit is not driven.

Save-alls of stainless steel will be located under the forming table from breast roll to and under the suction boxes. The troughs will be arranged to discharge white water to back side of the machine, then through the floor and into the side of the wire pit below water level.

These save-alls will be permanently mounted from the main Fourdrinier beams and do not have to be removed during wire change.

Steps and footwalks of grating will be located along the front and back side of the Fourdrinier, accessible by steps positioned at the ends of the walkways and in the center on front side only. One (1) cross machine walk will be supplied at the suction boxes.

Wire stringers or wire carriages for the couch and breast roll end of the Fourdrinier for stringing the wire will be complete with the necessary wire supporting poles, stands and air operated winch for pulling the carriages into the machine. Also included will be the tracks made of corrosion resistant material provided with drain connection for installing in the tending floor as well as across the machine pit. The carriage at the breast roll end will be adjustable for taking up the slack in the wire while stringing.

Showers constructed of stainless steel with flush-out valves and suitable for use with

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clarified white water, will be supplied for the inside wire rolls.

Water jets will be located both front and back side. They will be mounted so as to be adjustable either as assemblies or individual squirts. One (1) complete tail cutter assembly will be furnished, of the crank and pulley type. The jet water connection will be designed so that it does not have to be removed when changing wires.

Water piping consisting of a copper water header will be located along the frontside beam for supplying the wire roll, showers, suction box seal water and trim squirts. The inlet for this header will be carried to the back side of the Fourdrinier so that pipes do not have to be disconnected during wire change.

A drilled face suction couch roll with one suction box will be carried on spherical roller bearings of ample size which are enclosed in housings and with adequate seals to retain lubricants and prevent the entrance of water. The housings will be arranged so that they mount on the last cantilever beam of the Fourdrinier part.

The roll is designed for use in conjunction with the special quick-wire change type of Fourdrinier and has the following features:

(1) There are no loose pieces to be removed during wire change.

(2) The roll is built with a centrifugal cast bronze shell spirally drilled for quiet and efficient operation.

(3) The roll heads are of cast steel finished all over for balance.

(4) The suction box is of cast iron and is mounted on internal spherical roller bearings.

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(5) The box is counterweighted for easy movement and adjustment of the box is provided by means of worm and wormwheel on the front side of the roll.

(6) The suction connections of this roll are arranged so that no connections have to be broken during wire change.

(7) The seal strips are made of Micarta (or equivalent) supported in extruded brass channels by a pneumatic tube and have a continuous flow of water forced under the strips to keep all foreign matter out and to keep the packing free and lubricated.

(8) The deckle adjustment of 300 mm in each side is done from the front side of the roll and can be done while the roll is in operation.

(9) Grease fittings are provided on the front side of the roll and piped to all bearings inside of the roll so that all bearings can be kept lubricated from one point.

(10) The roll will be supplied with a stainless steel save-all pan.

An air roll to provide tension for the sheet leaving the couch roll will be provided, mounted from the press framing. Roll to be equipped with pneumatic lift device and driven.

(e) Press Section

The press section consists of two (2) suction presses operating straight through followed by a smoothing press.

The press rolls will be covered with 25 mm thick rubber. Bottom rolls will be approximately 1030 mm diam having a special spiral drilled face with bronze shells. They will be complete with suction box. Top rolls

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will be approximately 865 mm diam, self-skinning type. All press roll journals will have taper fits to suit bearings and will be grooved and drilled for removal of bearings by hydraulic pressure. The suction presses will be designed for 60 kg/lineal cm, nip pressure.

Press bearings will be carried in spherical roller bearings of adequate size and will be enclosed in housings designed for grease lubrication having adequate seals and flingers to exclude water.

Box-type frames and housings will be used and so designed that the top rolls may be located directly over the center of the bottom roll, and there will be provided the necessary adjustment to locate the roll in the proper direction.

Hydraulic controls will be of differential controlled loading type and double acting and will consist of two (2) cylinders, one on each side of the press, individually operated and controlled from the control console on the tending side of the machine. The top roll bearing housings are attached to pivot arms and actuated by hydraulic cylinders.

The dials will be calibrated to read kg/sq.cm hydraulic pressure. A loading chart showing nip pressure versus gauge pressure will be supplied for each press. The required pressure is maintained automatically under all operating conditions by a pressure control valve, with an auxiliary overload control valve. The third valve regulates the speed of travel when raising and lowering.

To raise the roll, the controller is moved to "LIFT" and the roll will remain in the "UP" position. Before lowering the roll, the indicator is set at the required pressure, and the controller is then moved to "LOWER." After the roll is lowered, the controller is set to "LOAD" and pre-set pressure is applied. For quick release of pressure, the controller is turned to "LIFT."

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Save-alls of stainless steel will be provided for the suction press bottom rolls and will be supported on the front side of the bearing housings for ease of changing felts. The save-all outlets will be at the back side of the machine.

The save-alls for the suction rolls will be designed so that the cleaning solution from a portable tank and pump can be circulated through the suction box and shell. Pipe connections with plugs shall be provided in the suction roll and a connection on the save-all pan. A blank flange will be supplied for use when cleaning the roll.

Footboards as necessary and walks with ladders will be provided across the machine and on the tending side of the press section.

Felt rolls will be constructed from steel pipe covered with vulcanite, fitted with Meehanite cast iron heads and steel journals. All the felt rolls will be carried in anti-friction bearings, encased in cast iron housings and mounted in cast iron brackets from which they will be easily removed for changing felts. One (1) roll for each of the felted presses will be wormed, and all rolls will be dynamically balanced.

One holding down roll will be made of steel pipe with rubber cover, with Meehanite cast iron heads and steel journals. The roll will be carried in anti-friction bearings encased in cast iron housings. The holding down roll will be arranged for helper drive.

Vertical stretchers of the screw type will be supplied for each press felt. These stretchers will have a cast iron frame which can be mounted on steel columns. Screws will be driven through worm gears from an air motor and a clutch is provided on front side screw so that the roll may be shifted to square up felt. The air motors will be furnished, arranged to be operable from machine room or basment.

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Guides will be provided to control the run of each of the felts and will be automatic air operated guides as well as hand operated guides, positioned on opposite ends of the automatic unit.

Felt conditioners will be provided for each felt. Each conditioner will be provided with three (3) vacuum shoes arranged for individual electric motor drive.

Showers of stainless steel, fan type showers for felt shrinking and washing will be supplied two (2) for each press. All showers will be for fresh water.

Oscillating press roll doctors complete with air loading will be supplied for the top rolls of the suction presses.

Smoothing press top roll will be approximately 865 mm diam. The bottom roll will be approximately 840 mm diam. Both rolls will have bodies of Meehanite cast iron, one having a rubber cover and the other a stonite cover.

The rolls will have pressed-in steel journals carried in anti-friction bearings and enclosed in Meehanite housings arranged for grease lubrication.

The top roll will be mounted on pivoted arms carried in needle roller bearing pivots and will be connected to hydraulic cylinders for lifting and loading the roll.

f. Dryer Section

The dryer section will consist of sixty-two (62) 1524 mm diam paper dryers and eight (8) 1524 mm diam felt dryers, all designed for operation at 5 kg/sq cm pressure.

The paper dryers will be arranged in double-deck fashion and divided into three sections.

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Dryers will have Meehanite cast iron bodies, bored on the inside, turned true and ground on the outside, balanced and tested for 10 kg/sq cm hydrostatic pressure permitting a working steam pressure of 5 kg/sq cm. The front head will have a manhole and will be equipped with a cast rope carrier ring. Official test certificates will be furnished for the dryers.

Dryer heads will have three tapped holes for jack bolts for use in removing the heads from the shell.

Dryer framing will be of box section design, jig finished for interchangeability, resulting in frames having rounded corners for cleanliness and harmonious appearance. Spacing of the top supports in the felt framework will be such as to provide the most efficient ventilation.

Fully machined surfaces for all bearings, frames, connections and brackets assure quick field assembly and reduce the possibility of becoming loose from vibration.

The dryers will be arranged in double-deck fashion with bottom row of dryers having their front bearings mounted on a raised concrete curb. The top dryer will be such that it will support the top felt frames and felt equipment.

The bottom felt equipment will be supported in the basement on structural steel framework which is to be supplied by the buyer as part of the mill structure. All felt equipment will be self-contained with mounting feet for ready assembly with the steel work.

Dryer bearings for the rotating drying cylinders will be anti-friction bearings enclosed in Meehanite cast iron housings. The front side bearings will be designed to allow for end thrust requirements caused by the expansion of the dryers.

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The bearing housings will be adequately sealed to prevent loss of oil and entrance of dirt and will be designed to use with a continuous oil circulating system.

Dryer gears will be of the open spur straight tooth type, of Meehanite cast iron. They will be accurately machined with generated teeth and will be braced and keyed on to the rear dryer journals.

Plate type guards will be provided over the meshing points of the gears.

Steam joints and siphons will be supplied for each dryer. The steam joints will be supported from the dryer bearing housings. Two (2) flexible steam hoses will be supplied for each dryer.

Footwalks will be provided for the drive side and the tending side of the dryer part.

The walks will be constructed of grating complete with a two-bar steel pipe handrail and supported on the drive side by steel pipe support posts.

Access ladders will be 610 mm wide and constructed of steel pipe handrails and cast Meehanite steps.

Felt rolls will be steel pipe, turned true and smooth, fitted with Meehanite cast iron heads, head plates and steel journals. All rolls will be mounted in suitable anti-friction bearings and encased in cast iron housings.

Automatic felt stretchers will be provided, one for each of the dryer felts with a squaring roll mounted on the stretcher framing.

Felt guides both automatic air-operated as well as hand guides will be provided for the top and bottom felts.

Automatic paper carrier equipment will be provided for carrying the sheet through the dryer section.

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Paper dryer sheaves will be of cast iron with a wide flange outside of groove and will be cast integral with the dryer head. Also included will be the necessary idler sheaves, rope stretchers, mounting brackets, etc. and a sufficient amount of cotton rope for the initial installation.

Spring rolls of steel pipe will be mounted in yielding type anti-friction bearings. The rolls will be located at the in-going side of the calender stack.

Circulating oiling system for the dryer bearings, gears and calender roll bearings and the inaccessible back felt roll bearings will be supplied. Provision will be made to air purge the lubricating areas. The system will contain the supply tank, filters, oil heater, oil cooler, indicators, pumps and motors, pressure-type sight feed oilers for dryer bearings, gears, felt rolls and pressure-type oilers for the calender roll bearings.

(g) Breaker Stack

One (1) breaker stack will be supplied to be located between the first and second dryer sections consisting of one (1) rubber-covered top roll and one (1) Microrok or equivalent covered bottom roll arranged for hydraulic loading.

(h) Size Press

One (1) horizontal size press will be supplied to be located between the second and third dryer sections. This size press will be complete with one (1) hard-faced fixed roll, 840 mm diam. The rolls will be mounted on cast iron box-type horizontal frames with swinging arms for the pivot roll. Pneumatic cylinder loading equipment with controls will be included.

One (1) Mount Hope fixed bow spreader roll complete with mounting brackets and rope sheaves will be supplied for mounting after the size press.

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One (1) paper roll with mounting brackets and sheaves to be located above and ahead of the size press rolls.

(i) Calender Stacks

Following the last dryer section will be one (1) eight roll, open side calender stacks with rolls facing outwards from frames.

Supporting frames will be of heavy-box type cast iron construction designed so that all rolls can be removed sideways. All rolls above the bottom roll will be carried on swinging arms pivoted in the main vertical frames.

Rolls for the calenders will be made of chilled alloy iron with face of rolls ground and polished.

Roll journals will be turned taper fit for anti-friction bearings, grooved and drilled for removing bearings by hydraulic means.

All intermediate rolls will be bored for steam.

Steam joints will be supplied for the bored intermediate rolls.

All rolls will be mounted in anti-friction bearings, enclosed in cast iron housings provided with adequate sealing to retain lubricants.

Roll diameters will be as follows:

Bottom rolls	865 mm x 5180 mm face
Queen rolls	560 mm x 5180 mm face
Intermediate rolls	406 mm x 5180 mm face

Spreader rolls of steel pipe, crowned, complete with anti-friction bearings in support brackets will be provided for leading the sheet into the calender. This roll will be vertically adjustable so as to service any of the in-going nips.

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Sheet treading will be assisted by a series of deflectors which will be supplied to direct the sheet from one calender nip to the next on the calender stack.

Footwalks and steps will be supplied.

Doctors will be provided for each roll, the bottom roll having an hydraulically oscillated doctor. All the doctors will be equipped with air operated lifting devices and will have steel blades.

(j) A Black-Clawson Auto-Flyte 36 constant speed, pneumatically operated reel of the latest horizontal arm design will be furnished. The reel will wind rolls up to 2130 mm diam.

The primary arms are rotated by a geared quadrant and pinion as the spool is winding. The pinion that drives the geared quadrant is driven by means of an electric motor and is controlled by a limit switch. A rotary switch is provided on the primary arms to stop the quadrant when rotated to a position to transfer the spool from the primary arms to the secondary arms. There is a fluid coupling included in the pinion drive unit. The fluid coupling prevents damage to the mechanism in case of binding. A brake on the drive motor prevents over-travel of the primary arms. These primary arms are also equipped with pneumatic cylinders to provide the application of pressure to the face of the reel drum during the initial winding operation.

The arrangement is such that the spool is allowed to lift when the paper is winding in the primary arms and when the spherical housings get seated in the secondary arms, the action is complete.

The secondary arms are of horizontal design incorporating an arrangement of pneumatic cylinders permitting varied pressure to be applied between the roll of paper and the reel drum. A pneumatically actuated brake is furnished to stop the full roll of paper after

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it has left secondary way bearing holders.

Reel drum of Meehanite cast iron will have the rope carrier ring on the front head. The front journal will be bored and provision made for water cooling of the drum.

Oscillating reel drum doctor with a double acting pneumatic cylinder is provided to move the doctor blade against or away from the reel drum face to prevent the sheet from wrapping the drum during the change of spools.

Reel spreader roll will be adjustable and heavily crowned and will be complete with supporters.

Rope carrier equipment will be provided for handling the sheet into the reel.

Spool starter speed-up drive is provided for bringing the spool up to the sheet speed before it comes into contact with the drum.

Three (3) reel spools will be made from steel pipe with Meehanite cast iron heads and cast integral journals mounted in anti-friction bearings. Both journals will be equipped with suitable type coupling arrangements to engage the winder tension control equipment on the unwinder stands.

Control will be provided by a Black-Clawson console unit which will mount the necessary controls for the operation of the reel and its components. This unit is to be located in the tending side aisle adjacent to the reel.

(k) Unwind Stand

The unwind stand will be of suitable design to receive the reel spools with the front stand provided with longitudinal and lateral adjustment. The unit will be equipped with an air operated brake.

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A sliding coupling and coupling shaft is used to engage the tension control equipment which will be supplied as part of the winder drive.

(1) Winder

One (1) Rollflyte Verti-shear slitter-winder Model 220 generally as described below; and with a maximum rewinding speed of 1525 m/min:

Main frames comprise heavy box section cast iron top and base frames, adequately proportioned for rigidity and vibration damping.

The top frames support replaceable slide ways of hardened and ground steel for the rider roll and rewind shaft bearing carriage slides.

Enclosed within the top frames are the power cylinders and roller chains for raising and lowering the rider roll and rewind shaft. Adequate access panels with covers are provided for adjusting and servicing the lift mechanisms.

A large tie beam across the top frame provides the necessary rugged stability to eliminate vibration and maintain this high-speed winder at top operating condition.

Winder drums are manufactured from centrifugally cast steel. The shells are bored for uniform wall thickness and balance. Wall thickness has been sized for minimum deflection of the drums.

The drum heads are of cast steel with suitably sized pressed-in steel journals.

Both front and rear drums are grooved with chevron-type grooves. The rear drum shall also contain spiral grooves to aid in roll separation. The grooving pattern also assists in obtaining hard starts on the core.

The drums are mounted in spherical roller bearings, the bearing housings are of cast iron and provided with seals and nipples for

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grease lubrication. The housings are bolted to the base frames.

The drums will be dynamically balanced for speeds in excess of the top operating speed.

Idler rolls will be furnished, one (1) to lead the web into the slitters; and one (1) to direct the web from the slitters towards the winder drums.

The rolls will be constructed of steel tube with cast iron heads and pressed-in steel journals mounted in anti-friction bearings with provision for grease lubrication and dynamically balanced above top-operating speed.

Both rolls will be provided with simple air actuated brakes which form an integral part of the bearing housings.

Rider roll assembly, single section, constructed of steel tube of proper wall thickness to provide rigidity, dynamically balanced above machine speed and mounted in anti-friction bearings will be provided.

The bearing housings are an integral part of the slide carriage which is guided for smooth operation when raised or lowered in the vertical machined ways provided on the top frames.

A synchronizing torque shaft connects the rider roll carriages. Gears, mounted on each end of the torque shaft mesh with racks mounted on the top frame to obtain level riding of the roll at all times.

Load and lift arrangements are through heavy roller chains connecting the rider roll assembly to the power lift cylinders within the frames. Rider roll pressure is under the control of the operator at all times by use of panel mounted control valves. There are no loose counterweights to be adjusted when changing paper grades.

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Two (2) rewind shafts, core type, will be provided. The shafts will be constructed of steel tube with steel journals designed to run in bronze bush bearings with an additional anti-friction thrust bearing on the rear journal which provides axial location in the bearing bracket and eliminates end play and insures straight side wound rolls.

The core locking device consists of a removable steel locking ring pressed against the paper core by a steel locking bar held in place by a bolt through one journal. A simple wrench is provided for tightening or loosening the bolt.

The shaft bearing brackets contain the bronze bush bearings with split caps provided with a positive lock in the "closed" position, and a hold-open latch and quick release device in the "open" position. The brackets are of high strength alloy and provided with upper and lower guides to insure lateral alignment and smooth vertical operation.

The raising and lowering of the brackets is done with power cylinders within the frames and directly connected to the brackets. A link chain circuit and a torque shaft assures level operation of the rewind shaft.

Slitters will be as follows: The rear slitter knives will be designed for mounting on a knife holder arranged to be fitted directly on the shaft extension.

The front slitter units contain built-in pneumatic cylinders for forward and axial loading of the knives. Each unit is self-contained and mounted on a crossbeam with machined guide ways to provide for lateral positioning.

The design of the slitter arrangement minimizes sheet threading problems and allows free access for servicing or positioning of the slitters.

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One (1) pair of trim guides is furnished with the slitter equipment.

An adjustable spreader bar will be provided, equipped with adjusting screws to vary the amount of bow in the spreader bar.

The adjusting screws can be positioned laterally across the web to provide variable profile to the spreader bar to suit off-caliper conditions of the web.

A roll ejector mechanism, power operated, to remove finished sets of paper rolls from the winder, is furnished. This consists of a bar spanning the machine, carried by arms at each end, which are bolted to gear sectors, pivoted on the bearing housing of the rear drum. This bar, when not in use, is out of the way, retracted behind the rear drum. In operation, it will push under the paper rolls and swing forward, actually lifting the paper roll out of the rear drum and rolling it out of the machine over the front drum.

As a safety feature, an electrical interlock is provided to insure all equipment is in proper position to eject and receive the roll before the ejector is operated.

A roll diameter scale is provided for the operating of the winder to indicate the rewinding roll diameter.

A rewind shaft core holder is supplied and will be located on the tending side of the machine, mounted on the roll out board. A V-shaped trough supports the fresh core so that the rewind shaft can be inserted from the tending side. Air cylinders at each end of the trough raise the prepared rewind shaft to the top of the roll out board. From this point, the shaft can be rolled on to the rewind shaft bearing bracket.

The control valve for the air cylinders is on the front tending side.

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A shaft puller is provided of simple design consisting of a rigid heavy construction welded steel framework which carries in its upper section sprockets and chain running the full length.

A special attaching clamp is fixed to the chain and is designed to engage with the reel shaft when it is desired to remove it from the split complete roll. The chain and clamp will pull the mandrel from the reel when it is located on the floor. Sturdy air cylinders connected to the welded steel framework, mounted on the floor, line the shaft puller up with the split rewound roll.

The reel lowering table will be a rigid mild steel fabricated structure mounted on two sturdy hydraulic rams.

The table structure will be skirted all round to prevent accidental obstruction when the table is in the raised position. A suitable electric link will not permit the roll ejector to operate unless the table is positioned to receive the roll.

Hydraulic cylinders also operate a retractable plate on the machine side of the table. This plate will bridge the gap between the table and roll out board. An electric link will also prevent the table from being lowered while the plate is in the out position.

A hydraulically operated hinge plate will prevent the roll from rolling off the table during the unloading operation.

A single unit hydraulic system will be provided comprising an electrically driven pump, oil storage tank, filters and control valves for actuating the reel lowering mechanism.

A drive mechanism and motor for the Rollflyte winder will be provided.

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(m) Foundation Plates

One (1) complete set of cast iron foundation plates planed on top will be furnished. These plates will be drilled and tapped for leveling screws. The leveling screws will be furnished.

The plates will be furnished continuously under the machine for the headbox section through the dryer section and then individually under the calender stacks, the reel, unwind stands and winder.

The plates will be of various widths and thickness as required by the various sections of the machine.

(n) Hydraulic System

A hydraulic system will be provided for operating the various hydraulic components of the machine, including the necessary oil tanks, pressure pumps with their motor in-drives, pressure reducing valves, gauges and operating control valves. Duplicate pumps will be furnished and so connected that in the event of failure of the operating pump, the second pump can be automatically cut in and maintain the pressure and sound an alarm.

Flexible hose connections will also be provided at the cylinders wherever required.

(o) Instrumentation and Control

Instrumentation for the proper operation and control of the paper machine will be furnished.

The operator's panels for the operation of the various sections of the machine will be supplied. These panels will include loading controls and necessary push buttons and valves for satisfactory machine operation.

Operation and loading of all press rolls will be accomplished hydraulically, the main presses will be differentially loaded to provide nip pressure less than roll weights. Wire change

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operation will be hydraulic with operator's controls mounted in headbox panel. Felt stretcher, calender pushouts and rider roll of winder will also be hydraulically controlled. The hydraulic master control panels will be for basement mounting.

(p) Steam and Condensate System

A complete steam and condensate system will be provided for the paper and felt dryers and calender rolls.

The equipment will comprise the main steam header along the machine and the condensate header, steam piping from the steam header to the dryers, condensate piping from the dryers to the condensate header, condensate vessels, necessary valves, controls and pumps.

Flexible hose connections will be provided at each dryer in both the steam and the condensate connections together with hand-operated shut-off valves and sight flow glasses.

2. Machine Hood and Exhaust System

One (1) totally enclosed machine hood and air system in general accordance with the following:

The machine hood will totally enclose the dryer section and the basement beneath.

The roof of the hood will be constructed from tongued and grooved easily demountable panels, fabricated from two flat sheets of aluminum between which would be inserted a 75 mm thickness of resin-bonded glass wool insulating materials.

An interval system of single sheet aluminum panels will be provided below the roof structure in order to insure uniform air extraction throughout the entire length of the hood.

The sides and ends of the hood between machine floor level and the underside of the roof will be constructed with an inner and outer sheet of aluminum between which would be inserted a suitable

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thickness of insulating board.

The lower panels along the front side of the hood for a height of approximately 2440 mm above the machine floor level will be capable of vertical movement obtained by means of suitable winches attached to a continuous layshaft driven by reduction gear boxes connected to 3 hp motors. These motors incorporate electro-magnetic braking features.

The whole of the operating gear would be mounted on the roof of the hood, and a suitable walkway will be provided alongside to facilitate the maintenance of the mechanical equipment.

The panel operating mechanism will be actuated by selenium cells between each section of the dryer part, and arranged to open the doors when a break occurs in the web. In addition, a number of push button stations would be provided for mounting in convenient positions external to the hood. A time interval of approximately ten seconds will be required to elevate the whole range of doors completely. Single-glazed observation windows will be provided in the moving panels located on the front side of the machine.

The upper panels on the front side of the hood will be of the bolted-on type, equipped where necessary with sliding doors, to provide access to the platforms attached to the machine frame.

Similarly constructed sliding doors approximately 2130 mm high will be provided in the lower half of the rear panels, while those forming the top section would be bolted in position.

The panels required to form the four sides of the basement enclosures will extend from floor to ceiling, and be constructed from a single sheet of aluminum, adequately reinforced.

The whole of the enclosure will be supported on a substantial rolled steel framework designed for attachment to the machine frames, or to the local building fabric.

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To permit the removal of "broke" from the machine pit, hinged doors will be provided in the basement panels.

Suitable insulating material will be provided between the joints of dissimilar metals, in order to prevent corrosion due to electrolysis.

Three (3) exhaust fans will be provided of mild steel construction, the impeller running in ball bearings and roller bearings and being of the high efficiency type with aerofoil section blades. The impeller shaft will be extended through the tail bearing to mount the V-belt drive pulley. An auxiliary cooling spinner would be provided for inboard bearing.

The fan casing will have an inspection door, and also a drain connection at the bottom of the scroll.

Heat exchangers will be provided for the exhaust fans described above and would be provided with single stage air-to-air heat exchangers.

The heat exchanger elements will be constructed from aluminum. These elements will be mounted in a galvanized sheet steel casing with mild steel angle flanges. The heat exchanger units will be complete with a mild steel base frame suitable for grouting into the plant house floor.

Water spray systems will be provided, consisting of stainless steel headers and nozzles for mounting immediately before the heat exchanger assemblies.

The spray system will be complete with centrifugal pump, galvanized mild steel pipework and isolating valves.

For mounting in this housing, internal fittings consisting of headers, spray nozzles and a bank of eliminator plates will be supplied. All items will be fabricated from stainless steel.

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3. Paper Machine Room Ventilation

One (1) air ventilating system complete, for the paper machine room including basement ventilation system, switchgear room ventilation system, operating aisle ventilation system, calender rectification system and roof heating system.

All systems are to include necessary supply and exhaust fans, heat exchangers, duct work, controls, piping and auxiliaries.

4. Vacuum System

One (1) complete vacuum system including necessary vacuum pump, extension shafts, couplings, valves, piping and controls, for the wire suction boxes, suction couch, suction presses and felt conditioners. Motors and drives will be supplied for this system.

5. Paper Machine Drives

All drives and motors for the operation of the paper machine will be provided as well as all necessary controls to set and regulate the overall machine speed.

6. Cranes

(a) One (1) paper machine room overhead, traveling, two hooks crane, electrically operated and cab controlled and of sufficient capacity to handle the heaviest piece of machinery.

(b) One (1) paper machine rolls overhead, traveling, two parallel hooks crane, electrically operated and floor controlled and of a sufficient capacity to handle the combined weight of the paper roll and spool shaft.

K. Roll Handling, Bag Conversion and Finishing

1. One (1) slat conveyor for handling of rolls, complete with steel chain and attachments, screw-type take-up, steel framing, reel braker, brake, reducer and coupling.

2. Two (2) shuttle conveyors with transfer cars, each complete with track, channel sides and cover plates.

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3. One (1) scale unit, complete with in-floor platform, stop and kicker.

4. One (1) lowerator, complete with steel chains and attachments suitable for both pallets and rolls, screw type take up, steel framing, carriers, brake, reducer and coupling.

5. One (1) roll bander, hand-operated.

6. One (1) up-ender to up-end rolls at the end of the inclined ramp from the lowerator, complete with double-acting hydraulic cylinder, gear pump, oil reservoir, filter, and piping.

7. One (1) back-stand unit, complete with steel frame, feed rolls, and idlers.

8. One (1) rotary cutter, complete with automatic layboy, sheet stops, controls and drives.

9. One (1) scale unit for sheets.

10. Two (2) tables, scissors-lift type, each complete with hydraulic mechanism.

11. One (1) multi-wall bag tuber to produce multi-wall bags for cement, tapioca, fertilizer, etc. complete with roll stands, feed rollers, perforating mechanism tube former, and variable speed drive.

12. One (1) bag sewing machine complete with sewing heads and drive.

13. One (1) printer for outside wall of multi-wall bags, complete with unwind stand, rewind stand, and drive.

14. Two (2) conveyors, each complete with belt, idlers, supporting structure and drive.

15. One (1) starch mixing and cooking unit, complete with jacketed heating and mixing tank, agitator with drive, heating elements, storage tank, and pump with base plate and coupling.

16. Three (3) grocery bag machines, each complete with printing attachments, back stand, tube former,

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link change gear for tuber operation, bottom pasting sector, scoring cylinder fingers, bottom forming cylinder fingers and slitter knives.

17. Three (3) lift trucks for roll and pallet handling.

18. Three (3) hoists with trolleys and monorail system for handling of rolls in finishing department.

19. Necessary piping, valves and fittings.

20. Motors and controls for all equipment listed above.

L. Black Liquor

1. One (1) weak black liquor storage tank of mild steel plate construction, capacity 500 cu m.

2. Two (2) weak black liquor pumps for pumping weak liquor to the evaporation system, capacity approximately 1200 liters/min each, ni-resist with stainless steel trim construction complete with base plates and couplings.

3. One (1) black liquor oxidation tower system to include:

   (a) One (1) foam breaker, mechanical type, steel construction, complete with housing, liquor launder and drive.

   (b) One (1) oxidation tower, capacity approximately 30 cu m, mild steel construction, complete with nozzles, and fittings.

   (c) One (1) blower, capacity approximately 50 cu m/min, complete with base plate and drive.

4. One (1) feed liquor pump, capacity approximately 1,000 liters/min, all cast iron construction, complete with base plate base and coupling.

5. One (1) quintuple-effect evaporator to concentrate the black liquor recovered from the pulp washing at approximately 15% solids to about 50% solids concentration, prior to burning. The evaporator equipment will consist essentially of:

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(a) Five (5) evaporator bodies of welded carbon steel construction with the exception of the first two effects where the tubes and tube sheets will be of stainless steel construction and the lower part of vapor body will be lined with stainless steel.

(b) Downcomer from first effect and piping from second effect to the flash tank are to be stainless steel construction.

(c) Integral liquor preheaters in effects No. 2 through No. 5.

(d) One (1) direct contact barometric condenser having all parts in contact with vapor in stainless steel.

(e) One (1) two-stage ejector system having stainless steel nozzles.

(f) Structural columns for evaporator bodies, platforms and stairways to provide access to the equipment.

(g) Flash tanks of steel construction as required for efficient operation.

(h) One (1) hot well of steel construction with lugs for concrete lining.

6. One (1) liquor pump for pumping from effect No. 5 to effect No. 3, capacity approximately 450 liters/min, all parts in contact with the liquor in stainless steel construction complete with base plate and coupling.

7. One (1) pump for combined condensate, capacity approximately 3,000 liters/min, all wetted parts in stainless steel construction, complete with base plate and coupling.

8. One (1) liquor pump for pumping from effect No. 4 to effect No. 3, capacity approximately 450 liters/min, all parts in contact with liquor in stainless steel construction, complete with base plate and coupling.

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9. One (1) liquor pump for pumping from effect No. 3 to effect No. 1, capacity approximately 600 liters/min, all parts in contact with liquor in stainless steel construction, complete with base plate and coupling.

10. One (1) liquor pump for pumping from effect No. 2 to strong black liquor tank, capacity approximately 200 liters/min, all parts in contact with liquid in stainless steel construction, complete with base plate and coupling.

11. One (1) pump for steam condensate, capacity approximately 300 liters/min, all wetted parts in stainless steel construction, complete with base plate and coupling.

12. One (1) strong black liquor storage tank of mild steel plate construction, capacity approximately 400 cu m.

13. Two (2) liquor pumps for pumping from the strong liquor storage tank to the recovery furnace, capacity approximately 250 liters/min, all parts in contact with liquor in stainless steel construction, complete with base plates and couplings.

14. Necessary piping, valves and fittings.

15. Complete set of instruments and controls for proper operation of equipment and process.

16. Motors and controls for all equipment.

M. Chemical Recovery

1. One (1) recovery furnace to burn the evaporated black liquor at a solids of 50%, designed for steam generation at 41 atm and steam temperature of 385° C. This unit is to be supplied complete with cyclone evaporator ; soot blowers; shot cleaning equipment; air heater; flues and ducts comprising: boiler outlet flue, economizer outlet flue and hopper, induced draft fan inlet and discharge flue, air ducts from forced draft fan to air heater, from air heater to air ports, air duct to cyclone evaporator; supporting steel;

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structures, galleries and ladders; pumps for direct contact evaporator; furnace feed tank; ash hopper; ash tank and pumps; salt cake feeder; smelt dissolving tank with green liquor pumps; black liquor heaters; burners; induced and forced draft fans; instruments and controls.

2. Two (2) recovery boiler feed pumps, each having an approximate capacity of 250 liters/min, cast steel construction with stainless trim complete with coupling and base plate.

3. One (1) crusher for salt cake, capacity approximately 2 tons/hr, complete with drive.

4. One (1) hopper for salt cake, complete with steel bars.

5. One (1) pneumatic conveying system for salt cake, capacity approximately 2 tons/hr, complete with blower, feeders, ducts, supports, valves, fittings, cyclones, and drives.

6. One (1) salt cake silo, capacity approximately 300 cu m, concrete construction.

7. One (1) salt cake service bin, capacity approximately 3.5 cu m, complete with necessary fittings.

8. One (1) feeder for salt cake service bin, screw feeder type, complete with housing, screw and drive.

9. One (1) salt cake screen.

10. One (1) salt cake mixing tank, complete with agitator and drive, connections, and heater.

11. One (1) recovery stack, complete with brick lining, cap and fittings.

12. Necessary insulation and special fixtures.

13. Necessary piping, valves and fittings.

14. Complete set of instruments and controls for proper operation of equipment and process.

15. Motors and controls for all equipment.

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N. Recausticizing

1. One (1) stationary primary lime grizzly screen, bar type, complete with frame and screen bars.

2. One (1) hopper with inclined secondary screen for lime.

3. One (1) crusher, capacity approximately 20 tons/24 hrs, to reduce quicklime to about 25 mm size, complete with flywheels and drive.

4. One (1) drag chain conveyor for lime, capacity approximately 20 tons/24 hrs, with gear reducer, coupling, steel roller chain drive and base plate.

5. One (1) bucket elevator for lime, capacity approximately 20 tons/24 hrs, heavy duty construction, complete with mild steel housing, chain, buckets, head and tail shafts, sprockets, access ladder and drive.

6. One (1) crushed lime bin, approximately 250 tons capacity, mild steel construction, complete with supporting legs.

7. One (1) feeder conveyor, screw type, to deliver the lime to the slaker-classifier.

8. One (1) slaker-classifier, complete with cast white iron liner, mixer, rake, overflow trough, deflector plates and roll chain drive.

9. Three (3) causticizers, complete with mild steel tanks, turbine impellers, driveheads, V-belt drives, guards, shafts, couplings, mechanism supporting structures, stuffing boxes, walkways and handrails.

10. One (1) white liquor sump tank, mild steel plate construction.

11. Two (2) causticizer sump tank pumps, capacity approximately 150 liters/min, stainless steel construction, each complete with base plate and coupling.

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12. One (1) white liquor clarifier, complete with mild steel tank, supports, vertical shaft, spider arms, blades, scraper, feed and overflow boxes, walkway and handrail, drive head, overflow alarm, lifting device and interconnection piping.

13. Two (2) white liquor sludge pumps, diaphragm type, cast iron body, rubber lined, complete with drive.

14. One (1) white liquor sludge sump tank, mild steel construction.

15. Two (2) white liquor slurry pumps, capacity approximately 750 liters/min each, stainless steel trim construction, complete with base plates and couplings.

16. One (1) white liquor storage tank, capacity approximately 200 cu m each, mild steel construction, each complete with immersion type steam heater.

17. Two (2) white liquor transfer pumps, pumping to cooking liquor tank, capacity approximately 150 liters/min, stainless steel construction.

18. One (1) lime mud washer having tank of mild steel construction and comprising: raking mechanism, drivehead with overload cut out, chain drive and case, manual lifting device, mechanism supporting structure with walkway and handrail, feed box and support, overflow boxes and supports, adjustable overflow pipes, handwheels and lifting devices, handrailing for tank, feed and overflow connecting piping.

19. Two (2) lime mud sludge pumps, diaphragm type, cast iron construction, rubber lined, complete with drive.

20. One (1) lime mud storage tank, capacity approximately 75 cu m, mild steel construction, complete with agitator, and drive.

21. Two (2) lime mud pumps (one a stand-by), stainless steel trim construction, complete with base plate and coupling.

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22. One (1) weak liquor storage tank, capacity approximately 150 cu m, mild steel construction.

23. Two (2) weak liquor pumps, capacity approximately 150 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

24. One (1) green liquor storage tank, capacity 200 cu m, mild steel plate construction.

25. Two (2) green liquor pumps (one as a stand-by), capacity approximately 125 liters/min, all iron construction, each complete with base plate and coupling.

26. One (1) green liquor heater, steam injection type.

27. One (1) fresh water booster pump, capacity approximately 200 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

28. Necessary insulation and special fixtures.

29. Necessary piping, valves and fittings.

30. Complete set of instruments and controls for proper operation of equipment and process.

31. Motors and controls for all equipment.

O. Steam and Power Plant

1. Two (2) package-type steam generating units having a capacity of 27,500 kg of steam/hr each when fired with fuel oil; discharge operating pressure to be 41 atm and operating temperature of 385° C. Furnaces are to be fully water cooled and boilers to be of the open-pass type. The boilers will be equipped with air heaters and superheaters of the radiant convection type and units are to be complete with steam temperature controls, forced draft fans, drives and motors. Stacks are to be of steel construction with short

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breeching connection to the boilers.

Also included are instruments and controls to regulate the boiler output by analyzing flue gas for oxygen content and correcting fuel and air flows to suit, to maintain and control boiler water level, to record and integrate steam flow, etc; the whole to be wired to a control panel. All safety and blow-off valves, feed and check valves, steam gauges, water columns, feedwater regulators, soot blowers, interconnecting piping and supports will be provided.

2. Feedwater heaters, condensate storage and aerator heater, having a capacity of 1,450 liters/min with 25,000 liters storage tank. Design pressure of unit is 2 kg/sq cm. Stainless steel nozzles and trim complete with relief valve; pressure and temperature gauges, high and low level controllers, etc. will be provided.

3. Two (2) boiler feed pumps capacity 725 liters/min each, centrifugal type, cast steel body with stainless steel trim complete with base plate and coupling.

4. A duplex fuel oil pumping and heating set mounted on a steel base; comprising heaters, pumps, gauges, valves, interconnecting piping, coupling, etc. Each pump is to have an approximate capacity of 70 liters/min. Oil storage tanks will be supplied and installed by the oil vendor.

5. One (1) blow down tank of steel construction, approximately 1,000 mm diam x 1200 mm high.

6. Water treatment equipment for the purpose of removing mineral solids from the water to produce an effluent comparable with distilled water including filters, demineralizer consisting of cation exchanger, anion exchanger, instruments and controls for semi-automatic operation, interconnecting piping, etc.

7. Chemical feed system consisting of tank, stainless steel positive displacement pump and agitator.

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8. One (1) turbo-generator single extraction-condensing type; inlet steam conditions, 41 atm and 385° C. with controlled extraction at 5 atm; generator to provide 7,500 kw, 3 phase, 50 cycle, 3,000 v, complete with ventilating air-cooler, oil cooler, throttle valve, controls, instruments and all auxiliaries.

9. Condenser for turbo-generator consisting of a single-pass surface condenser.

10. One (1) oil purification system complete with accessories.

11. Traveling crane for the turbo-generator erection and service having a capacity of 20 tons.

12. One (1) stand-by water cooled diesel electric generator, complete with fuel and lubrication oil pumps, filters and coolers, air cleaner, tachometer, gauges, cooling water and air piping, exhaust duct and muffler, etc. capacity 500 kw, to provide start-up power and emergency power in case of turbine failure.

13. One (1) mill air compressor having a capacity of 10 cu m/min at 7 kg/sq cm, complete with drive, filter, separator, cooler and air receiver.

14. Two (2) instrument air compressors of the non-lubricating type, having 2 cu m/min capacity of 7 kg/sq cm complete with drive after cooler, pressure reducing stations, air dryer and receiver.

15. Instruments and controls not specifically listed above but required for proper operation of equipment.

16. All steam, condensate, feedwater, chemical, blow down, compressed air and oil piping, valves and fittings necessary to provide a complete steam generating and power plant as outlined above.

17. Motors and starters for all equipment listed above of suitable type, enclosure and current characteristics for the service.

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P. Power Distribution and Mill Lighting

1. Main sub-station switchgear, indoor metal clad draw-out type, complete with air circuit breakers, main incoming and feeder breakers, current transformers, ammeter, ammeter switch, indicating lights, over-current relays, station battery and changer.

2. Necessary unit sub-stations consisting of primary interrupter switch transformer and low voltage feeder section. The transformers will be of the dry or non-inflammable liquid type; and the low voltage section of draw-out type air circuit breakers of interruption and load capacity as required.

3. Necessary primary and secondary power feeders.

4. Necessary motor control centers each complete with circuit breaker combination starters, push buttons and pilot lights with provision for padlocking, auxiliary contacts and control transformers, and reduced voltage starting equipment as required.

5. Low voltage wiring, lighting fixtures, panels, transformers, and necessary fittings.

Q. Water and Effluent

1. One (1) raw water pumping station having a capacity of 16,000 liters/min, consisting of intake piping, valves and pumps as well as the necessary instruments. Pumps will be provided with electric motors, drives and base plates and the discharge pressure shall be adequate to provide a supply at the mill of 4 atm. Distribution piping above and below ground shall be provided.

2. One (1) fire pump, 4,000 liters/min, with a discharge pressure of 11 atm, complete with drive, electric motor, auxiliary diesel engine and base plate.

3. One (1) elevated fire tank of approximately 380,000 liters capacity at 60 m height connected with a fire protection loop system complete with hydrant stations, shut-off valves, etc. as necessary and

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including instruments and controls as required.

4. One (1) sprinkler system for the paper machine room, finishing and shipping areas.

5. One (1) effluent discharge piping system from plant to river of cast iron and concrete pipe.

6. One (1) clarifier for effluent, to be complete with framework, scraper, skimmer, walkway, and drive.

7. One (1) sludge pump for clarifier, complete with base plate and coupling.

8. Motors and controls for all equipment above.

R. Mill Shops

Machine Shop

1. One (1) engine lathe, precision type, complete with drive, motor and accessories.

2. One (1) engine lathe, standard, complete with drive, motor and accessories.

3. One (1) toolmaker lathe, complete with drive, motor and accessories.

4. One (1) universal shaper, complete with drive, motor and accessories.

5. One (1) universal horizontal milling machine, complete with drive, motor and accessories.

6. One (1) radial drill, heavy duty, elevating arm type, complete with drive, motor and accessories.

7. One (1) universal hydraulic grinder, complete with drive, motors and accessories.

8. One (1) pedestal grinder (wet-dry) complete with motor, and accessories.

9. One (1) pedestal grinder (wet-dry) complete with motor, and accessories.

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10. One (1) roll grinder to handle all paper machine rolls, complete with drives, motors and accessories.

11. One (1) hacksaw, heavy duty, complete with drive, motor and accessories.

12. One (1) circular saw sharpener, complete with drive, motor and accessories.

13. One (1) circular knife grinder, complete with drive, motor and accessories.

14. One (1) tool grinder, complete with drive, motor and accessories.

15. One (1) combination belt and disc sanding machine complete with drive, motor and accessories.

16. One (1) hydraulic press, universal type, complete with drive, motor, and accessories.

17. One (1) arbor press, hydraulic, manually operated, bench type complete with accessories.

18. One (1) metallizing spray kit, complete.

19. One (1) pneumatic hand chipper with assorted chisels.

20. One (1) heavy jack hammer and drill steel set.

21. One (1) light jack hammer and drill steel set.

22. One (1) mobile compressor, heavy duty, gasoline powered, complete with accessories.

23. One (1) electrically operated and floor controlled overhead traveling crane, two 15 tons hooks.

24. Chain hoists and trolleys.

25. Hydraulic jacks.

26. Small tools and instruments including surface plates.

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Blacksmith Shop

1. One (1) forge, stationary type, heavy duty, complete with blower, drive, motor and accessories.

2. One (1) smoke exhauster complete with drive, motor and accessories.

3. One (1) anvil.

4. One (1) heat treating furnace, oil fired, complete with burners, drive, motor controls and accessories.

5. One (1) shears, bench type.

6. One (1) universal metal worker, complete with drive, motor and accessories.

7. Tools

Pipe Fitter Shop

1. One (1) pipe threading machine (stationary), complete with drive, motor and accessories.

2. One (1) pipe threading machine (portable), complete with drive, motor and accessories.

3. Tools

Tinsmith Shop

1. One (1) brake, hand operated, complete with moulding formers and accessories.

2. One (1) roll forming machine, complete with drive, motor and accessories.

3. One (1) beading and crimping machine, complete with drive, motor and accessories.

4. One (1) sheet metal squaring shears, complete with drive, motor and accessories.

5. One (1) funnel former.

6. Two (2) soldering kits

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7. Tools

Welding Shop

1. One (1) electric welding machine (stationary) complete with accessories.

2. One (1) electric welding machine (mobile) complete with accessories.

3. One (1) acetylene cutting-welding outfit (stationary) complete with accessories.

4. One (1) acetylene cutting-welding outfit (mobile) complete with accessories.

5. Two (2) welding positioners, universal, balanced, complete with accessories.

6. One (1) smoke exhauster complete with drive.

7. One (1) flexible shaft grinder, complete with drive and motor.

Carpentry Shop

1. One (1) circular saw complete with drive, motor and accessories.

2. One (1) band saw complete with drive, motor and accessories.

3. One (1) jig saw complete with drive, motor and accessories.

4. One (1) planer-jointer complete with drive, motor and accessories.

5. One (1) vertical borer complete with drive, motor and accessories.

6. One (1) wood lathe.

7. One (1) combination disc and belt sanding machine complete with drive, motor and accessories.

8. Tools.

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Paint Shop

1. One (1) spray painting outfit, portable, complete with compressor drive, motor and accessories.

2. One (1) vacuum cleaner.

3. Tools.

Electrical Shop

1. One (1) transformer oil filtering and testing outfit complete.

2. Portable ammeters, voltmeters and transformer.

3. Insulation and ground testers.

4. Tools.

Instrument Shop

1. Instrument testing equipment.

2. Tools.

S. General Mill Equipment

1. Two (2) lift trucks for mill shops, stores and general mill use.

2. Time clocks, time guard clocks.

3. Lockers and washroom equipment.

4. Hoist and trolleys for mill shops, stores and general mill use.

5. Mill stores equipment including bins, racks, pallets, ladders, hand trucks, filing system, calculators, typewriter and furniture.

6. Two (2) pick-up trucks.

7. One (1) complete internal telephone system complete with push button type switchboard and approximately twenty (20) lines to provide effective internal communication throughout the mill.

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8. Office furniture including typewriters, adding machines, calculating machines, desks, chairs, tables, filing cabinets and accessories and one (1) vault for record storage with combination lock.

T. Pilot Plant and Laboratory Equipment

1. One (1) cutter, to be used to reduce bamboo, bagasse or other fibrous raw materials to size suitable for pulping.

2. One (1) Hydrapulper, laboratory size, which will be capable of doing on a small scale everything done in the commercial Hydrapulper, to be used for the investigation of pulping processes, for cleaning and other treatments of fibrous materials, for blending in of pulps and any other use for which the Hydrapulper finds application.

3. One (1) vibratory screen for dry cleaning of fibrous materials.

4. One (1) rotary digester, small size of the tumbling type which will permit all kinds of pressure digestion.

5. One (1) disc mill, laboratory size, but capable of refining action similar to that of the commercial scale disc mills, for use in preparation of fibrous materials, fiberizing of digestion materials, and other processing.

6. One (1) pulp screen, small diaphragm, slotted screen plate type for removing from the pulp materials undigested and other unwanted particles.

7. One (1) hydraulic press, to be used to de-water pulps for the yield determination and other purposes.

8. Bleaching equipment, to consist of ceramic, stainless steel or polyethelene vessels of suitable size and equipped for agitation.

9. One (1) beater, laboratory size for processing the pulp in any batch operation before papermaking.

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10. One (1) jordan, of laboratory size, for continuous processing of the pulp before papermaking.

11. One (1) paper machine. This is a small Fourdrinier machine capable of producing a wide range of grades of paper.

12. One (1) fiber classifier for pulp evaluation.

13. One (1) complete set of sheet making and drying equipment.

14. One (1) set of pulp and paper testing instruments including:

    Freeness testers, Mullen testers, tearing tester, tensile tester, double fold tester, moisture tester, thickness gauge, basis weight scales, hP meters, sample cutters, sample dryers, scales, pH block comparator, and necessary accessories.

15. Liquor and stock tanks of ceramic, polyethelene or stainless steel, in suitable sizes.

16. One (1) set of platform scales.

17. Stirrers and agitators.

18. General laboratory equipment, including:

    Flash point tester, calorimeter, water still, fumes cabinet, microscope, calculating machine, electric timers, stop watches, vacuum pump, drying ovens, balances and scales, tachometer, pressure gauge, vacuum gauge, ammeter, voltmeter, glassware, chemicals and furniture.

19. Pipes, valves and fittings.

20. Motors and controls for all above equipment.

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U. First Aid Station

1. Two (2) folding stretchers.
2. One (1) examining table.
3. One (1) examining chair.
4. One (1) examining lamp, pedestal, goose-neck.
5. Examining lamps, forehead type.
6. One (1) oxygen apparatus (portable resuscitation unit).
7. One (1) sterilizing autoclave.
8. Linen, bedding, etc.
9. Laboratory ware and instruments.
10. Medical ware and instruments.
11. Medicine, drugs, bandages, etc.
12. Furniture.

V. Sugar Mill Boilers

1. Three (3) oil storage tanks.
2. Three (3) fuel oil heaters and associated equipment.
3. Three (3) duplex pumping, heating, and straining systems, complete with strainer, starter, heater and pumps.
4. Three (3) package-type boilers, complete with oil-firing equipment, windbox, air heater, fans, ducts, soot blower, brickwork, refractory, and structural steel.
5. Pipes, valves and fittings.
6. Motors and controls.

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XIII. PROJECT II LIST OF EQUIPMENT PULP MILL

A. General Comments

The following list of equipment covers all of the process and services equipment necessary for an addition of a 20,000-25,000 tons per year pulp mill to the existing partially integrated pulp and paper mill proposed for Project I. The stock preparation, papermaking, finishing and converting departments of Project I will remain unchanged according to the present planning.

This equipment will be of the latest proven design for use in a pulp mill operating according to the most advanced established practices and technology.

The equipment included has been selected basically for utilization of bamboo. However, since it is the intention of the Thai Government to develop sources of local fibrous raw materials through forestry and other agricultural programs, this same equipment with minor changes would also be suitable for pulping any other material available when the pulp mill is in operation.

Since conditions as foreseen at this time will undoubtedly have changed before the final engineering is done for this pulp mill, a number of changes will probably have to be made; all directed toward providing a mill which will use the latest equipment and technology in order to give an efficient and economic operation.

With the above consideration in mind, the following list of equipment covers the requirements for Project II.

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B. Bamboo Handling and Chip Preparation

1. One (1) two-strand chain bamboo haul-up of steel frame construction, with hinged section to allow for adjustment to water level and also for storing purposes during the monsoon season. The haul-up is to be complete with attachments, wearing strips, supporting structure, take-up, gear reducer, and chain.

2. One (1) slasher feed conveyor, complete with attachments, supporting structure, gear reducer and chain drive.

3. One (1) slasher to reduce bamboo to 3 m lengths, complete.

4. Fifteen (15) carts to transport bamboo.

5. Three (3) tractors.

6. One (1) boom-type stacker.

7. One (1) set of nozzles and fixtures for flume.

8. Two (2) haul-ups to transfer bamboo from flume to feed conveyors, complete.

9. Two (2) chipper feed belt conveyors to transfer bamboo from receiving conveyor to the chippers; each conveyor to be complete with belts, pulleys, idlers, take-ups, supporting structures, and drives.

10. Two (2) chippers, each 6 knife, 1830 mm diam disc, top discharge. Each unit is to be complete with a feedwork assembly, disc, shaft, bed plates, knives and anvils , speed roll, reducers and drives.

11. One (1) cyclone separator to receive chips from chipper and discharge to chip screen, mild steel construction with replacable wear plates.

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12. One (1) chip screen, complete with screening elements, vibrating mechanism, supporting structure, discharge chute for accepted chips, and drive.

13. One (1) rechipper for oversize chips, four knife, 250 mm diam disc, complete with knives and drive.

14. One (1) pneumatic conveying system to convey screened chips to storage silo, complete with blower, ducts, cyclones, and drive.

15. Two (2) concrete and tile chip storage silos, 5,000 mm diam x 9,000 mm high, complete with bin level indicators with alarm, and all appurtenances.

16. Two (2) rotary plate feeders to discharge chip storage silo, each complete with arch breaker arm, carrying rolls, scrapers, shafts, discharge chute, and drive.

17. One (1) chip belt conveyor to convey chips from silos to the digester chip bin, complete with rubber belt, idlers, pulleys, take-up, discharge chute, supporting structure and drive.

18. One (1) continuous conveyor weigher and recorder to be installed on the digester chip conveyor, complete with remote rate indicator, recorder and all accessories.

19. Motors and controls for all the above equipment.

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C. Digestion

1. One (1) Pandia continuous digestion system for bamboo pulping to be complete with:

(a) One (1) chip bin, conical, approximately 2,800 mm diam, mild steel plate construction.

(b) One (1) chip hopper to fit mixer, carbon steel construction, complete with cleanout door and vibrator.

(c) One (1) mixer, special design mixing conveyor and chute pipes, mild steel construction, including the constant speed drive.

(d) One (1) screw feeder, 265 mm (10½ mm) diam screw, feeder to be of carbon steel construction, and plug pipe and preheater of stainless steel, all parts in the pressure zone to be built in accordance with ASME Code for 170 psi working pressure.

(e) One (1) variable speed drive for above screw feeder, complete with water cooled coupling, gear reducer, flexible coupling, chain.

(f) One (1) inlet chamber with stop valve assembly.

(g) One (1) digester tube assembly consisting of:

Two (2) stainless steel tubes, 1,067 mm diam x 9,850 mm long, each complete with removable heads, time control screw, and built in accordance with ASME Code for 170 psi working pressure.

(h) Two (2) variable speed drives for time control screws, each complete with reducer, coupling, chain and sprockets.

(i) One (1) discharger, 455 mm (18 in) size, complete with impeller, housing with all parts in contact with stock in stainless steel, drive and remote control equipment. Built in accordance with ASME Code for 170 psi working pressure.

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2. One (1) blow tank, capacity approximately 200 cu m, mild steel construction, designed to meet pressure, hydrostatic and structural requirements, complete with top cyclone, safety valves, and agitator of cast iron phenolic coated construction, reducer, base plate and coupling.

3. One (1) cooking liquor tank, mild steel construction, complete with agitator and controls for proper blending of white and black liquors.

4. Two (2) white and black liquor measuring tanks.

5. One (1) cooking liquor pump to feed liquor to the mixer impregnator, cast iron stainless steel fitted construction, complete with base plate and coupling.

6. One (1) collecting tank for liquor drained from the screw feeder, mild steel construction, complete with fittings.

7. Two (2) squeeze liquor re-injection pumps, cast iron stainless steel fitted construction, each complete with base plate and coupling.

8. One (1) heat exchanger, direct contact type, to condense flash steam from blow tank, complete with steam jet ejector and necessary controls.

9. One (1) hot water tank, capacity approximately 50 cu m, mild steel construction, complete with steam sprayer, nozzles, overflow, vent, and fittings.

10. One (1) hot water pump for hot water tank, cast iron bronze fitted construction, complete with base plate and coupling.

11. One (1) magnetic trap, in-line type, to be installed ahead of blow tank pump, complete with permanent magnet.

12. Two (2) stock pumps for blow tank, capacity approximately 1,000 liters/min, cast iron stainless steel fitted construction, each complete with base plate and coupling.

13. One (1) consistency regulator, in-line pressure tank, stainless steel construction, in line from blow tank.

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14. One (1) set of controls for the Pandia continuous digestion system comprising:

(a) For mixer: start-up push button, indicating light, tachometer and high load contacting ammeters.

(b) For the screw feeder: start-stop push button, indicating light for main motor, high load contacting ammeter, tachometer, potentiometer, and manual/auto control switch.

(c) For each digester tube drive: start/stop push button, indicating light for main motor, increase/decrease push button for speed control, tachometer, and high load contacting ammeter.

(d) For the discharger: start/stop push button, indicating light for main motor, and high load contacting ammeter.

(e) For the liquor pumps: start-stop push buttons, indicating lights for motors.

(f) For each stop valve: three-position selector switch labeled "Close-Open-Auto."

(g) For the main control of the digester: three-position selector switch labeled "Auto/Manual."

(h) For each oil pump motor: start/stop push button and indicating light.

(i) For each re-injection pump motor: start/stop push button and indicating light.

(j) For the cooking liquor: one (1) flow recorder-controller for each digester.

(k) For the steam flow to the digester: one (1) pressure recorder-controller, one (1) steam flow recorder, and one (1) temperature recorder.

(l) For the warning system: necessary indicating lamps, horn acknowledgment button, reset button, and lamp test button.

(m) One (1) control panel.

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15. Necessary instruments and controls other than those listed above for proper operation of equipment and process.

16. Special fixtures and insulation.

17. Tile linings and fittings for all chests and tanks in this department.

18. Necessary piping, valves and fittings.

19. Motors and controls for all equipment.

D. Pulp Washing and Screening

1. One (1) magnetic type flow meter for measuring flow of stock from blow tank to brown stock washing system.

2. One (1) vibratory screen, each complete with inlet, showers, screen plates, screen trough, suspension devices, anti-friction bearings, and drive.

3. One (1) rejects pump, capacity approximately 750 liters/min, cast iron bronze fitted construction, complete with base plate and coupling; rejects tank.

4. One (1) brown stock washing system, consisting of:

   (a) Three (3) washers, each approximately 2,450 mm diam x 4,300 mm face, mild steel construction, complete with mild steel vats, stainless steel wires and facing wires, stainless steel shower pipes and valves and mild steel feed box.

   (b) Two (2) intermediate shredder-repulpers, mild steel construction, each complete with shafts, intermediate chain drive and case between shredder and repulper shafts, dilution and drain connections.

   (c) One (1) final shredder-repulper, mild steel construction, complete with cut flight screw conveyor repulper.

   (d) One (1) press roll, complete with air-loading mechanism.

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(e) Three (3) drives for washers, including shaft extension and speed reduction gear boxes.

(f) Three (3) drives for intermediate and final repulpers, including shaft extension and speed reduction gear boxes.

5. One (1) set of filtrate tanks for the brown stock washers comprising three (3) tanks each, approximately 150 cu m capacity, mild steel construction, complete with fittings.

6. One (1) foam tank, capacity approximately 60 cu m, mild steel construction, complete with fittings.

7. One (1) foam breaker for foam tank, mechanical type, mild steel construction, complete with housing, rotor, liquor launder and drive.

8. Three (3) filtrate pumps for dilution ahead of washers, capacity approximately 5,000 liters/min each, cast iron stainless steel fitted construction, each complete with base plate and coupling (one spare).

9. One (1) filtrate pump for cooking liquor dilution and to blow tank in digestion, capacity approximately 1,000 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

10. One (1) filtrate pump to evaporator, capacity approximately 700 liters/min, cast iron stainless steel fitted construction, complete with base plate and coupling.

11. One (1) washer hood, structural steel and fiberglass construction, complete with ventilation fans, gear reducers, and couplings.

12. One (1) hot water heater for hot water to washer systems, steam injection type.

13. One (1) agitator for washed stock chest, horizontal type, cast iron phenolic coated construction, 1,500 mm diam, complete with propeller blades, shaft and drive.

14. One (1) stock pump for washed stock chest, capacity

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approximately 2,500 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

15. One (1) consistency regulator, in-line pressure type, in stock line from washed stock chest.

16. One (1) primary screen, Selectifier 24 P, complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box and valve, base plate and coupling.

17. Two (2) secondary screens, Selectifier 24P, each complete with mild steel epoxy coated body, stainless steel rotor cage and cylinder, trash box and valve, baseplate and coupling.

18. One (1) rejects vibratory screen, complete with inlet, showers, screen plates, screen trough, suspension devices and drive.

19. One (1) accepted stock pump, capacity approximately 1,000 liters/min, cast iron bronze fitted construction, complete with base plate and coupling: stock chest, steel construction.

20. One (1) vacuum decker, approximately 2,900 mm diam x 4,300 mm face, steel and stainless steel construction, complete with vat, cylinder mould, inlet box, showers, pulp discharger, breaker conveyor, main drive, and breaker conveyor drive.

21. One (1) agitator and dilution mixing nozzles for high-density screened stock chest; agitator of horizontal type, cast iron phenolic coated construction, 1,500 mm diam, complete with propeller blades, shaft and drive.

22. One (1) surge tank pump, capacity approximately 9,000 liters/min, cast iron bronze fitted construction, complete with base plate and coupling: steel tank.

23. One (1) stock pump for high-density screened stock chest, capacity approximately 2,500 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

24. One (1) consistency regulator, in-line pressure type, in stock line from screened stock chest.

25. One (1) white water pump, capacity approximately 9,000 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

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26. One (1) booster pump, capacity approximately 600 liters/min, cast iron bronze fitted construction, complete with base plate and coupling.

27. Tile lining and fittings for all chests and tanks in this department.

28. Necessary piping, valves, and fittings.

29. Complete set of instruments and controls for proper operation of equipment and process.

30. Motors and controls for all equipment.

E. Black Liquor Evaporation

One (1) complete black liquor evaporation system, the same as for Project I.

F. Chemical Recovery

One (1) complete chemical recovery boiler and auxiliaries, the same as for Project I.

G. Recausticizing and Lime Reburning

(NOTES: 1. The green liquor clarification and lime reburning are to be engineered to tie in with the recausticizing system of Project I.

2. The key equipment for recausticizing in Project I will be sized for use in Project II and, in addition, the equipment below will include green liquor clarification and lime reburning for both Projects I and II. Furthermore, the lime preparation system of Project I will be employed with modifications for Projects I and II.)

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1. One (1) bucket elevator limestone, heavy duty construction, complete with mild steel housing, drain, buckets, head and oil shafts, sprockets, access ladders and drive.

2. One (1) limestone bin approximately 250 tons capacity, mild steel construction, complete with supporting legs.

3. One (1) feeder-conveyor, screw type, to deliver crushed limestone to the limestone hopper.

4. One (1) limestone hopper, mild steel construction to feed kiln feed conveyor.

5. One (1) lime kiln made of mild steel plate, complete with lime mud feeder, chain system with chains and supporting rollers; riding rings of cast steel; supporting rollers, with shaft bearings; drive, including main gear; reduction gear; transmission gear; coupling and brackets; auxiliary diesel engine drive; firing head; dust chamber; retractable feeding screw conveyor; bumping; heating and burning equipment for fuel oil; induced draft pen; ducting; primary and induced draft fans; lime dust scrubber, pump and stack; refractory; controls and control panel.

6. One (1) green liquor clarifier, open-type of mild steel and cast iron construction and comprising: tank, switch head, alarm panel, vertical shaft, scraper assembly with spiders, feed well, overflow urn and support.

7. One (1) green liquor sludge pump, cast iron, rubber lined construction, complete with base plate and drive.

8. One (1) dregs mixer tank with agitator, complete with impeller supports, shaft and drive.

9. One (1) dregs washer, complete with mild steel tank, impeller, supports, shaft and drive.

10. One (1) filter for lime mud, mild steel and cast iron construction, complete with vat, cylinder drum, wire cloth, vacuum connections, hood, variable speed drive and gear reducer.

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11. One (1) filtrate receiver of mild steel construction, complete with separator and fittings.

12. One (1) filtrate pump, cast iron and mild steel construction, complete with base plate and coupling.

13. One (1) vacuum pump, cast iron construction, complete with seal cocks, piping, vacuum gauge, guard and V-belt drive.

14. Piping, valves and fittings.

15. Motors and starters.

16. Instrumentation as required.

H. Steam and Power Plant

1. One (1) package-type steam generating unit having a capacity of 15,000 kg of steam/hr when fired with fuel oil; discharge operating pressure to be 41 atm and operating temperature of 385° C. Furnace is to be fully water cooled and boiler is to be of the open pass type. The boiler shall be equipped with a superheater of the radiant convection type and will be complete with motor. Stack is to be of steel construction with short breeching connection to the boiler.

   Instruments and controls to regulate the boiler output by analyzing flue gas for oxygen content and correcting fuel and air flows to suit; to maintain and control boiler water level; to record and integrate steam flow etc.; the whole to be wired to a control panel; all safety and blow off valves, feed and check valves, steam gauges water column, feedwater regulator, soot blowers, interconnecting piping and supports shall be provided.

2. One (1) boiler feed pump capacity 725 liters/min, centrifugal type, cast steel body with stainless steel trim, complete with base plate and coupling.

3. Additional water treatment equipment for the purpose of increasing the capacity of the existing water treatment plant by 300 liters/min.

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4. One (1) turbo-generator, back pressure type; inlet steam conditions 15,000 kg/hr, 41 atm and 385° C. exhaust at 5 atm pressure. The generator is to provide 2,000 kw, 3 phase, 50 cycle, 3,000 v, complete with ventilating air cooler, oil cooler and equipment throttle valve, controls instruments including all auxiliaries.

5. Instruments and controls not specifically listed above but required for proper operation of equipment.

6. All steam, condensate, feedwater, chemical, blow down, compressed air and oil piping, valves and fittings necessary to provide for the additional capacity required in the existing steam generating and power plant.

7. Motors and starters for all equipment listed above of suitable type, enclosure and current characteristics for the service.

I. Power Distribution and Mill Lighting

1. Additions to main sub-station switchgear for new power load.

2. Additional unit sub-stations consisting of primary interrupter switch transformer and low voltage feeder section. The transformers will be of the dry or non-inflammable liquid type, and the low voltage section of draw-out type air circuit breakers of interruption and load capacity as required.

3. Additional primary and secondary power feeders.

4. Additional motor control centers, each complete with circuit breaker combination starters, push buttons and pilot lights with provision for padlocking, auxiliary contacts and control transformers, and reduced voltage starting equipment as required.

5. Low voltage wiring, lighting fixtures, panels, transformers, and necessary fittings.

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J. Water and Effluent

1. Additional pumping station facilities to increase capacity to approximately 22,000 liters/min, including trash racks, piping, valves, pumps, and controls. Pumps shall be provided with electric motors, drives and base plates.

2. Additional water distribution piping above and below ground.

3. Additional fire protection equipment, including hydrant stations, shut off valves, piping, etc.

4. Additional sprinkler system for chip storage.

5. One (1) clarifier for effluent to be complete with framework, scraper, skimmer, walkway, and motor.

6. One (1) sludge pump for clarifier, complete with base plate, drive and motor.

7. Additional effluent discharge piping.

K. Mill Shops

1. One (1) chipper knife grinder, complete with drive, motor and accessories.

2. Additional chain hoists and trolleys.

3. Additional tools.

L. Control Laboratory

Additional pulp testing station equipment, including freeness tester sheet former, Mullen tester, scales, sample cutter, drying oven and accessories.

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XIV. ENGINEERING AND TECHNICAL SERVICES TO BE PERFORMED BY THE PARSONS & WHITTEMORE ORGANIZATION, INCLUDING OVERALL SUPERVISION OF CONSTRUCTION, ERECTION OF EQUIPMENT AND START-UP SERVICES

A. General Comments

In addition to the foreign currency requirements for equipment, there will also be foreign currency requirements for certain engineering and technical services, including design engineering, supervision of construction of the mill, supervision of erection of the equipment, and for providing a trained cadre for starting up and putting the mill into operation.

Parsons & Whittemore is prepared to furnish all of these engineering and technical services. In addition, Parsons & Whittemore is prepared to conclude an Operating Management Contract with the new pulp and paper company under which it will handle the operational management of the mill for an agreed upon period of time, including the supply of foreign field personnel required for the technical management.

The engineering and technical services to be supplied by Parsons & Whittemore are outlined below.

B. Design Engineering

The design engineering to be furnished by Parsons & Whittemore includes the following:

1. Complete equipment lists and complete balanced flow diagrams.

2. Complete preliminary and final layout drawings.

3. Complete mechanical layout drawings and necessary details of all loads for preparation of the foundation drawings and other structural drawings.

4. Complete piping drawings.

5. Complete electrical drawings.

6. Complete structural, civil and architectural drawings.

7. Complete specifications for all machinery, piping and electrical equipment.

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8. Bills of material, motor lists, pump lists, valves and fittings lists, and lists of erection material required for the equipment to be supplied by Parsons & Whittemore, as well as a complete list of spare parts.

9. Assembly drawings for individual machines and for parts which are subject to increased wear, or which require maintenance services.

10. Type and quantities of lubricating oils and greases for all machinery and equipment, and a complete lubricating schedule.

11. Preparation of "as built" drawings, lists and data.

C. Additional Technical Services, Including Assistance in Supervision of Construction

1. Assistance in comparison of bids and preparation of contracts for building construction.

2. Assistance in overall supervision of construction of buildings, foundations and preparation and development of mill site.

3. Assistance in scheduling construction so as to coordinate the construction with the installation of the equipment.

4. Assistance in checking work carried out by construction contractors to assure that these contractors follow the drawings and specifications.

5. Preparation of periodic progress reports on the project.

6. Preparation of organization chart for all stages of production and administration.

7. Assistance in establishing mill maintenance procedures, lubrication program and pulp and paper testing procedures to be used for product quality control and raw materials quality control.

8. Preparation of complete description of mill departments and operating manuals, outlining operating procedures of the various departments of the mill, including daily and monthly operating forms for the mill operations.

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9. Assistance in arranging for the training of the necessary mill operating personnel during the time of construction in leading pulp and paper mills abroad, to assure that the required cadre of trained personnel is available for the mill start-up.

10. Assistance in obtaining the necessary imported raw materials and chemicals which are not available locally.

D. Supervision of Erection and Installation of Equipment

Parsons & Whittemore is prepared to provide supervision for the erection and installation of the equipment supplied. In regard to the personnel for this work, experienced engineers and specialized erectors will be provided. The specialized erectors will include representatives of the machinery manufacturers from whom the major items of equipment will be purchased. A list of the erection personnel to be supplied is given in Appendix XVIII.

The new company will provide, at its own expense, all local foremen and all skilled and unskilled labor to perform their duties under the general supervision and direction of the Parsons & Whittemore erection staff. A list of the estimated number of local personnel required is shown in Appendix XIX.

The new company will also provide, at its own expense, all tools, equipment and materials for the erection and installation of the equipment.

E. Start-Up and Putting the Mill into Operation

Parsons & Whittemore is prepared to furnish a trained cadre for starting up the mill and putting it into operation. It is contemplated that this group of trained operators will be required for a period of approximately six (6) months. During that time, the group of trained operators will test the plant thoroughly and will assist in training the local personnel to gradually take over the operating positions. In addition, Parsons & Whittemore will make arrangements for training local personnel abroad in similar mills. The expense of this training is to be borne by the new company.

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A list of the start-up personnel to be furnished for this period of six months is detailed in Appendix XX. It should be pointed out that the start-up team is entirely separate from the field personnel to be furnished under the technical management contract and is in addition to this field personnel.

F. Operating Management Contract

Parsons & Whittemore is prepared to enter into an Operating Management Contract with the new company to provide management of the mill for an agreed upon period of time. A draft of this Operating Management Contract is included in Appendix XXI of this Report.

G. Estimated Cost of Engineering and Technical Services

	PROJECT I		PROJECT II	
	US$	Baht	US$	Baht
Design Engineering and Technical Services, incl. Supervision of Construction	$1,009,000	B. 5,296,000	$244,910	B.1,320,000
Supervision of Erection & Installation of Equipment	$ 757,000	B. 7,944,000	$185,000	B.1,270,000
Supervision of Mill Start-up	$ 504,000	B. 4,236,000	$124,000	B.1,040,000
Total Est. Cost for Engineering & Technical Services:	$2,270,000	B.17,476,000	$553,910	B.3,630,000
Operating Management Services to be included in separate Contract *	First two years: US$800,000 - 875,000		Three to ten years: US$500,000 - 600,000**	

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Notes: * One-half of the foreign management team will be gradually replaced by Thai Understudies. For estimating purposes, it has been assumed that one-half of the foreign personnel will be replaced after the first two years of operations.

** Decreasing to US$200,000 for continuing technical assistance.

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XV. SERVICES TO BE RENDERED TO THE THAI PAPER INDUSTRIES COMPANY, LTD. BY THE AMERICAN CAPITAL CORPORATION, AND HENRY KEARNS.

A. BACKGROUND: Services Already Performed by Henry Kearns and Associates, as the American Capital Corporation, in Respect to The Thai Paper Industries Company, Ltd.

The proposed Kraft Paper and Pulp Mill Project for Thailand is the direct result of efforts by Henry Kearns and his associates doing business as the American Capital Corporation.

Service with the ECAFE (Economic Conference on Asia and the Far East), and close working relations with The Thai Board of Investment enabled Henry Kearns to accumulate and examine convincing information which led to the now justified opinion that a Kraft Paper and Pulp Project would be feasible, profitable and useful to the economy of Thailand. American Capital Corporation, through Mr. Kearns, then undertook preliminary investigations and developed a proposal and recommendation which was presented to Parsons & Whittemore.

In negotiation with Parsons & Whittemore of New York, the Kearns group assisted in providing information and approvals leading to that company's undertaking a feasibility study of the project in cooperation with the AID Agency.

American Capital Corporation, assisted by its associate company, Kearns International, has worked diligently with Parsons & Whittemore during the course of the feasibility study and since its completion. The Kearns International office in Bangkok has devoted approximately 40% of its resources to the project. This service has included personal direction and assistance to the survey team in Thailand, personal advice and consultation of Henry Kearns in Thailand and in the United States, assistance and consultation in Washington, and three trips from the United States to Thailand in connection with the project.

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These actions absorbed approximately 20% of the Washington facilities of the company under the direction of Mr. Don Bostwick and approximately 25% of the Pasadena research facilities of the corporation. All of these services have added to the quality and reliability of the feasibility survey prepared by Parsons & Whittemore.

Kearns and the American Capital Corporation has assumed full responsibility for the corporate organization of the Thai Paper Industries Company, Ltd. This responsibility has included selection and acceptance of individuals of the highest standing in Thailand as Thai "promotion directors"; preparation and development of acceptable Articles of Incorporation, By-laws, etc.; and fulfilling the legal requirements of organization, such as the preparation of and required filing of corporate documents in Thailand, employment of competent counsel; and such other actions as required to establish corporate entity acceptable to Thai and American investors. All costs incurred in this organizational phase, including the payment of corporation fees, have been paid by the Kearns group.

B. Continuing and Future Services of the American Capital Corporation and Kearns International:

The American Capital Corporation, and its associate company, Kearns International, assumes as its further obligation in the development of the paper industries company the following:

1. Securing subscriptions from Thai investors for equity shares as outlined in the prospectus.

2. Securing subscriptions for debentures or preferred shares from Thailand as outlined in the prospectus.

3. Securing subscriptions of American or third country equity investment as required.

4. Securing subscription of American or third country sources of private capital, either in the form of debentures, bank loans, etc., or as otherwise required.

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5. Negotiation with Thai Government agencies, including the Thai Board of Investment and the Ministry of Industries, to assure the granting of the fullest possible range of investment privileges and concessions.

6. Negotiation and liaison with cognizant Thai Government agencies on necessary licenses, tax clearances, etc.

7. Continuing liaison with Thai Customs and Internal Revenue Agencies to achieve prompt and satisfactory handling of the new company's transactions.

8. Responsibility for the selection and assistance in acquisition of a site that will be acceptable to the directors of the company, upon the most economic basis.

9. Recruitment of capable Thai executive personnel, and the establishment of adequate training processes and programs to assure a continuing supply of competent indigenous employees.

10. Continuing advisory and liaison services by and between the American and the Thai participants.

C. Terms of Payment to the American Capital Corporation:

In normal practice, services such as those which have and will be performed by the Kearns group become a heavy financial burden in the formulative and early years of a corporation. It is with full realization that all available financial resources must contribute to the strength and early operation of the proposed company, that American Capital Corporation is willing to accept the same risks and delayed compensation as that experienced by other investors.

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Real compensation and reimbursement for expenses may be delayed for years, pending repayment of obligations and assurance of profitable operations. American Capital Corporation has made a sizable cash contribution, plus a major part of its time and facilities over a protracted period. However, it is willing to defer reward until the project is successful and the time when all investors will receive a return on their respective contribution.

In view of these factors, American Capital Corporation will receive a 10% equity participation as full payment for its services and advance expenses.

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XVI. TIME SCHEDULE FOR DELIVERY OF EQUIPMENT, ENGINEERING AND TECHNICAL SERVICES, AND ESTIMATED COMPLETION TIME OF PROJECT

A. General Comments

For purposes of clarifying the time schedule for implementation of the project, it is assumed that the Contract for furnishing the equipment and technical services will come into full force upon establishment of the necessary letters of credit by the Thai Paper Industries Company, Ltd. The date when the necessary letters of credit, or other acceptable financial documents, have been established is referred to in this Report as the "Confirmation Date".

B. Time Schedule for Delivery of Engineering

Parsons & Whittemore is prepared to render its engineering services on the following time schedule:

1. Complete equipment lists, balanced process flow sheets and preliminary layout drawings within six (6) months after the Confirmation Date.

2. Complete mechanical layout drawings, all final loads, foundation drawings of the buildings and final layout drawings within eight (8) months after the Confirmation Date.

3. Specifications and structural building drawings in sufficient detail for bids within ten (10) months after the Confirmation Date.

4. Piping, wiring and electrical drawings, complete specifications for all machinery, piping, electrical equipment and materials within twelve (12) months after the Confirmation Date.

5. All other engineering drawings, lists and specifications within fifteen (15) months after the Confirmation Date.

6. Description of mill departments, operating manuals, organization charts and other technical information within eighteen (18) months after the Confirmation Date.

7. "As built" drawings, lists and data within four (4) months after completion of the erection work.

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C. Time Schedule for Delivery of Equipment

It is estimated that delivery of the equipment to be furnished by Parsons & Whittemore will start within eight (8) months after the Confirmation Date, and that delivery will be completed at port of shipment within twenty-four (24) months from the same Confirmation Date.

D. Time Schedule for Erection of Equipment and Completion of Project

It is contemplated that erection will begin approximately twelve (12) to fourteen (14) months after Confirmation Date. Since the erection of the equipment will be dependent upon the civil works being completed, an erection schedule will be worked out jointly between Parsons & Whittemore and the Thai Paper Industries Company, Ltd. during the time of contract negotiations.

E. Start-Up

It is expected that within thirty (30) months after the Confirmation Date, i.e. six (6) months after delivery of the last shipment FAS U.S. Port, the pulp and paper mill should start operations, assuming normal shipping times for ocean and inland transportation.

F. Overall Schedule

A chart indicating a typical overall schedule for completion of a pulp and paper mill project is shown in Appendix XXII, as well as another chart giving an indication of the time schedule for this project (Appendix XXIII).

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XVII. ESTIMATED CAPITAL REQUIREMENTS FOR PARTIALLY INTEGRATED PULP AND PAPER MILL - PROJECT I.

A. General Comments

This section contains a tabulation of the estimated cost of all equipment, buildings, services and financial charges for completion of Project I.

The foreign currency requirements are expressed in terms of U.S. Dollars. The local currency requirements are in Bahts.

B. Estimated Capital Requirements

		Foreign Currency U.S. $	Local Currency Bahts
1.	Equipment by Mill Departments		
a.	Bagasse Preparation at Sugar Mills including fuel oil fired boilers	720,900	
b.	Bagasse Preparation at Pulp Mill	396,000	
c.	Digestion	390,400	
d.	Washing, Screening and Cleaning	530,000	
e.	Wet Lap Machine	55,500	
f.	Evaporators	280,000	
g.	Recovery	735,300	
h.	Recausticizing	160,000	
i.	Stock Preparation	1,040,000	
j.	Paper and Board Machine	4,857,900	
k.	Chemical Preparation for Paper Mill	26,800	
l.	Roll Handling, Finishing and Converting	433,000	
m.	Steam and Power Plant	1,040,000	
n.	Electrical Distribution	862,000	
o.	Mill Shops	372,200	
p.	Laboratory and Pilot Plant	233,300	
q.	Water and Waste	300,000	
r.	First Aid Station	10,000	
s.	General Mill Equipment	166,700	
	Sub-total for Equipment	$12,610,000	

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		Foreign Currency U. S. $	Local Currency Bahts
2.	Cost of Spare Parts for Three Years and Machine Clothing for Start-up	1,260,000	
	Sub-total for Equipment and Spare Parts	13,870,000	
3.	Design Engineering and Supervision of Construction	1,009,000	5,296,000
4.	Supervision of Erection, including Specialized Erection Foremen	757,000	7,944,000
5.	Supervision of Start-up	504,000	4,236,000
	Sub-total for Cost of Engineering, Supervision of Construction, Supervision of Erection, and Start-up	2,270,000	17,476,000
	TOTAL FOR ALL EQUIPMENT AND SERVICES TO BE SUPPLIED BY PARSONS & WHITTEMORE, INC.	$ 16,140,000	B. 17,476,000
6.	Freight and Insurance from Port of Shipment to Plant Site (Exclusive of Custom Duties)	441,000	9,267,000
7.	Training for Local Technical Personnel, Engineers and Operators abroad	130,000	900,000
8.	Cost of Site and Improvements, Buildings, Structures, Equipment Foundations, Water and Waste Lines to Mill Site, Fire Protection Reservoir, Personnel Facilities, Subcontractors Fees and Temporary Structures	310,000	39,290,000

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		Foreign Currency U. S. $	Local Currency Bahts
9.	Labor and Materials for Erection and Installation of Equipment including Erection Subcontractors Fees	113,000	21,448,000
10.	Administration and Overhead during Planning and Construction through Start-up	126,000	7,944,000
	Sub-total for Local Costs of Executing Project, exclusive of Costs of Foreign Contractors	1,120,000	78,849,000
	Sub-total, Investment Capital Requirements	17,260,000	96,325,000
11.	Allowance for Price Escalation and Contingencies	693,000	14,553,000
	TOTAL INVESTMENT CAPITAL REQUIREMENTS FOR COMPLETION OF PROJECT	$17,953,000	B.110,878,000
	Rounded Off	$18,000,000	B.110,880,000
12.	Development Fee (Capitalized services)		18,900,000
13.	Interest on borrowed capital and other financing charges during construction	1,439,000	
14.	Estimated working capital requirements, exclusive of spare parts furnished with equipment		42,000,000
	GRAND TOTAL FOR CAPITAL REQUIREMENTS FOR ENTIRE PROJECT I	$19,439,000	B.171,780,000
	EQUIVALENT TOTAL IN EITHER U.S. DOLLARS OR THAI BAHT	$27,619,000	B.579,999,000

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C. ESTIMATED BREAKDOWN OF WORKING CAPITAL REQUIREMENTS

PARSONS & WITTEMORE

ITEM	Unit Cost Delivered Baht/MT	Inventory Requirements Supply Months	Inventory Requirements MT	Working Capital Requirements '000 Bahts
1. Inventories of Raw Materials				
(a) Partially Depithed Bagasse	395	7	22000	8,690
(b) Salt Cake	1141	2	280	319
(c) Lime	300	2	645	193
(d) Imported Kraft Pulp	3345	2	4200	14,049
(e) Waste Paper	176	2	210	37
(f) Rosin Size	4937	2	105	518
(g) Alum	1400	2	225	315
(h) Fuel Oil	500	1½	5860	1,930
(i) Operating Materials for Bags and Finishing Room		2		22
(j) Miscellaneous Chemicals and Supplies		2		10
TOTAL CAPITAL REQUIREMENTS FOR INVENTORY OF RAW MATERIALS				26,083
2. Total Basic Production Cost for One Month's Inventory of Finished Products				4,036
3. Total Basic Production Cost for 30 Days Financing Terms				4,036
4. Estimated Labor Costs Before and During Start-up (3 Months)				2,460
5. Reserve for Pre-Payable Insurance Premimums and Miscellaneous Expense				5,385
			TOTAL	42,000

XVIII. ESTIMATED CAPITAL REQUIREMENTS FOR 2ND PULP MILL - PROJECT II.

A. General Comments

This section contains a tabulation of the estimated costs of all equipment, buildings, services and financial charges for installation of a second pulping line.

The foreign currency requirements are expressed in terms of U. S. Dollars. The local currency requirements are in Bahts.

B. Estimated Capital Requirements

	Foreign Currency U. S. $	Local Currency Bahts
1. Equipment by Mill Departments		
a. Bamboo Handling and Chip Preparation	301,500	
b. Digestion	335,800	
c. Pulp Washing and Screening	496,000	
d. Evaporators	280,000	
e. Recovery	699,800	
f. Recausticizing	160,000	
g. Steam and Power Plant	237,600	
h. Electrical Distribution	355,900	
i. Mill Shops	14,000	
j. Laboratory and Pilot Plant	3,300	
k. Water and Waste	208,000	
Sub-total for Equipment	$3,091,900	
2. Cost of Spare Parts for Three Years	309,190	
Sub-total for Equipment and Spare Parts	$3,401,090	

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		Foreign Currency U. S. $	Local Currency Bahts
3.	Design Engineering and Supervision of Construction	244,910	1,320,000
4.	Supervision of Erection, including Specialized Erection Foremen	185,000	1,270,000
5.	Supervision of Start-up	124,000	1,040,000
	Sub-total for Cost of Engineering, Supervision of Construction, Supervision of Erection, and Start-up	553,910	3,630,000
	TOTAL FOR ALL EQUIPMENT AND SERVICES TO BE SUPPLIED BY PARSONS & WHITTEMORE, INC.	$ 3,955,000	B. 3,630,000
6.	Freight and Insurance from Port of Shipment to Plant Site (exclusive of Customs Duties)	175,000	1,360,000
7.	Training for Local Technical Personnel, Engineers and Operators abroad	45,000	400,000
8.	Cost of Site and Improvements, Buildings, Structures, Equipment Foundations, Subcontractors Fees and Temporary Structures		10,200,000
9.	Labor and Materials for Erection and Installation of Equipment including Erection Subcontractors Fees		5,200,000
10.	Administration and Overhead during Planning and Construction	75,000	1,050,000
	Sub-total for Local Costs of Executing Project, Exclusive of Costs of Foreign Contractors	295,000	18,210,000

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		Foreign Currency U. S. $	Local Currency Bahts
11.	Allowance for Price Escalation and Contingencies	420,000	2,100,000
	TOTAL INVESTMENT CAPITAL REQUIREMENTS FOR COMPLETION OF PROJECT	$4,670,000	B.23,940,000
12.	Development Fee (Capitalized Services)		6,720,000
13.	Interest on Borrowed Capital and Other Financing Charges during Construction	337,600	
14.	Estimated Working Capital Requirements Exclusive of Spare Parts Furnished with Equipment		10,500,000
	GRAND TOTAL FOR CAPITAL REQUIREMENTS FOR ENTIRE PROJECT	$5,007,600	B.41,160,000
	EQUIVALENT TOTAL IN EITHER U.S. DOLLARS OR THAI BAHT	$6,967,600	B.146,319,600

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XIX. PROPOSED METHOD OF FINANCING

A. General

The grand total capital requirements for the proposed pulp and paper mill in Thailand are presented in Sections XVII and XVIII of this Report:

For Project I: Construction of a partially integrated pulp and paper mill and converting plant utilizing bagasse as the primary raw material.

For Project II: Construction of a second pulping line for utilization of bamboo as a primary raw material.

Of the total capital requirements, a major portion is required in foreign currency for financing the purchase of imported machines and equipment, technical services, supervision of construction, supervision of erection, mill start-up and training of Thai personnel in foreign mills.

The capital requirements in Thai currency are for financing the shipment of the machinery and equipment from the port to the mill site, the site purchase and development, buildings, and structures including local contractors fees, labor and materials for erection and installation of equipment, administration and overhead during planning through start-up, local expenses for foreign personnel while they are in Thailand, and working capital.

B. Ratio of Borrowed Capital to Equity

It is contemplated that the borrowed capital from foreign sources will represent approximately 55% of the total capital requirements, including interest during construction, and working capital. Due to the prohibitively high commercial rates of interest in Thailand, it is planned to obtain the necessary working capital from equity sources.

It is proposed that the interest on borrowed capital accruing during the period of construction and until the plant goes into operation (estimated at 30 months from the date the necessary funds become committed - confirmation date - CD) be capitalized at the end of

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the construction period and be repaid in accordance with the schedule for repayment of the principal. It is normal to capitalize interest during construction because it is at this time that demands on the new company are at a maximum.

If the interest during construction is excluded from the capital requirements, the ratio of borrowed capital to equity becomes approximately 53 to 47, based on the capital actually necessary to complete the project up to the time of start-up.

C. Proposed Schedule of Financing

The mill will be built as two Projects: the first, a partially integrated pulp and paper mill and converting plant, and the second, an additional pulp mill. It is therefore proposed that two loans be drawn down as the mills are engineered and constructed. The details of this draw-down are shown in Section XX.

The following tables will show the proposed method of financing each of the two projects, as well as the total financing for both.

D. Proposed Distribution of Total Capital Requirements and Currency Distribution for the Partially Integrated Pulp and Paper Mill and Converting Plant - Project I - Years 1 - 5

1. Proposed Distribution of Total Capital Requirements for Project I:

		Amount in U.S. $	Equiv. Amount in BAHTS
(a)	Share Capital Investment by Parsons & Whittemore and other U. S. Companies	4,000,000	84,000,000
(b)	Share Capital to be raised in Thailand	5,000,000	105,000,000
(c)	Capitalized Services	900,000	18,900,000
(d)	Convertible debentures or preferred stock	2,280,000	47,880,000

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	Amount in U.S. $	Equiv. Amount in BAHTS
(e) Loan from Ex-Im, AID and/or other foreign lending agencies	14,000,000	294,000,000
(f) Interest accrued during construction (to be capitalized at time of start-up)	1,439,000	30,219,000
GRAND TOTAL REQUIREMENTS, INCLUDING INTEREST DURING CONSTRUCTION, WORKING CAPITAL AND CAPITALIZED SERVICES	27,619,000	579,999,000

2. Proposed Distribution of Foreign and Thai Currency Requirements for Project I:

(a) Foreign Currency

(1) Parsons & Whittemore and other U.S. Companies Share Capital	4,000,000	
(2) Ex-Im or AID Loan, including capitalized interest during construction	15,439,000	
Total Foreign Currency Requirements	19,439,000	

(b) Thai Currency

(1) Thai Share Capital	5,000,000	105,000,000
(2) Capitalized Service	900,000	18,900,000
(3) Convertible debentures, or preferred stock	2,280,000	47,880,000
Total Thai Currency Requirements	7,280,000	171,780,000

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	Amount in U.S. $	Equiv. Amount in BAHTS
GRAND TOTAL CAPITAL REQUIREMENTS INCLUDING INTEREST DURING CONSTRUCTION, WORKING CAPITAL AND CAPITALIZED SERVICES, PROJECT I:		
Foreign Currency	19,439,000	
Thai Currency		171,780,000
EQUIVALENT TOTAL IN EITHER THAI BAHT OR U.S. DOLLARS	27,619,000	579,999,000

E. Proposed Distribution of Total Capital Requirements and Currency Distribution for Addition of the Pulp Mill for Project II - Years 6 - 10

1. Proposed Distribution of Total Capital Requirements for Addition of the Pulp Mill - Project II:

(a) Share Capital Investment by Parsons & Whittemore and other U.S. companies	1,300,000	27,300,000
(b) Share Capital to be raised in Thailand	1,640,000	34,440,000
(c) Capitalized Services	320,000	6,720,000
(d) Ex-Im or AID Loan	3,370,000	70,770,000
(e) Interest accrued during construction (to be capitalized at time of start-up)	337,600	7,089,600
GRAND TOTAL CAPITAL REQUIREMENTS INCLUDING INTEREST DURING CONSTRUCTION, WORKING CAPITAL AND CAPITALIZED SERVICES:	6,967,600	146,319,600

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	Amount in U.S. $	Equiv. Amount in BAHTS
2. Proposed Distribution of Foreign and Thai Currency Requirements for Addition of the Pulp Mill - Project II		
(a) Foreign Currency		
(1) Parsons & Whittemore and other U.S. Companies	1,300,000	
(2) Ex-Im or AID Loan, including Capitalized Interest during Construction	3,707,600	
Total Foreign Currency Requirements	5,007,600	
(b) Thai Currency		
(1) Thai Share Capital	1,640,000	34,440,000
(2) Capitalized Service	320,000	6,720,000
Total Thai Currency Requirements	1,960,000	41,160,000
GRAND TOTAL CAPITAL REQUIREMENTS INCLUDING INTEREST DURING CONSTRUCTION, WORKING CAPITAL, AND CAPITALIZED SERVICE - PROJECT II		
Foreign Currency	5,007,600	
Thai Currency		41,160,000
EQUIVALENT TOTAL IN EITHER THAI BAHT OR U.S. $	$6,967,600	146,319,600

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F. Proposed Distribution of Total Capital Requirements and Currency Distribution for Complete Pulp and Paper Mill and Converting Plant (Total of Project I and Project II):

1. Proposed Distribution of Total Capital Requirements for Complete Pulp and Paper Mill and Converting Plant (Total of Project I and Project II)

	Project	U.S. $	Equiv. in Bahts
(a) Share Capital Investment by Parsons & Whittemore and other U. S. Companies	I	4,000,000	84,000,000
	II	1,300,000	27,300,000
		5,300,000	111,300,000
(b) Share Capital to be raised in Thailand	I	5,000,000	105,000,000
	II	1,640,000	34,440,000
		6,640,000	139,440,000
(c) Capitalized Services	I	900,000	18,900,000
	II	320,000	6,720,000
		1,220,000	25,620,000
(d) Convertible Debentures or Preferred Stock	I	2,280,000	47,880,000
(e) Loan from Ex-Im, AID or Other Agencies	I	14,000,000	294,000,000
	II	3,370,000	70,770,000
		17,370,000	364,770,000
(f) Interest Accrued during Construction (to be Capitalized)	I	1,439,000	30,219,000
	II	337,600	7,089,600
		1,776,600	37,308,600
GRAND TOTAL CAPITAL REQUIREMENTS INCLUDING INTEREST DURING CONSTRUCTION AND WORKING CAPITAL	I	27,619,000	579,999,000
	II	6,967,600	146,319,600
		34,586,600	726,318,600

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2. Proposed Distribution of Foreign and Thai Currency Requirements for Complete Pulp and Paper Mill and Converting Plant (Total of Project I and Project II)

(a) Foreign Currency	Project	U.S. $	Equiv. in Bahts
(1) Parsons & Whittemore and other U.S. Companies, Share Capital	I	4,000,000	
	II	1,300,000	
		5,300,000	
(2) Ex-Im, AID or other Loans, including Capitalized Interest during construction	I	15,439,000	
		3,707,600	
		19,146,600	
Total Foreign Currency Requirements		24,446,600	
(b) Thai Currency			
(1) Thai Share Capital	I	5,000,000	105,000,000
	II	1,640,000	34,440,000
		6,640,000	139,440,000
(2) Capitalized Services	I	900,000	18,900,000
	II	320,000	6,720,000
		1,220,000	25,620,000
(3) Convertible Debentures or Preferred Stock	I	2,280,000	47,880,000
Total Thai Requirements		10,140,000	212,940,000
GRAND TOTAL CAPITAL REQUIREMENTS INCLUDING INTEREST DURING CONSTRUCTION AND WORKING CAPITAL (PROJECT I AND PROJECT II)			
Foreign Currency	I	19,439,000	
	II	5,007,600	
		24,446,600	
Thai Currency	I		171,780,000
	II		41,160,000
			212,940,000
EQUIVALENT TOTAL IN EITHER THAI BAHT OR U.S. DOLLARS	I	27,619,000	579,999,000
	II	6,967,600	146,319,600
		34,586,600	726,318,600

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XX. DEPRECIATION, WITHDRAWAL, INTEREST & AMORTIZATION SCHEDULES

A. Depreciation

1. General Comments

Depreciation on machinery and equipment has been calculated on the basis of 7-1/2% per year, as prescribed by the Royal Decree issued under the Revenue Code Governing Income Tax (No. 4) BE. 2494, (p. A.2, the Revenue Code as amended up to October 1961). The value of the equipment includes the price plus all delivery costs to the mill site, the cost of erection (including engineering and supervision of erection), interest on borrowed capital accruing during the construction period, and any locally purchased materials or equipment.

Depreciation on buildings and structures has been calculated on the basis of 2-1/2% of their value. (Same reference in Revenue Cost as above.) The value of the buildings and structures includes the cost of building materials, cost of construction, cost of staff housing, and cost of land improvements, but excludes the cost of the land itself.

Depreciation schedules are given for:

(a) Partially Integrated Pulp and Paper Mill and Converting Plant - Project I.

(b) Fully Integrated Pulp and Paper Mill and Converting Plant - Project II.

2. Depreciation Calculations for Partially Integrated Pulp and Paper Mill and Converting Plant (Project I)

	Pulp Mill		Paper Mill	
Baht Costs -	Equipment	Buildings	Equipment	Buildings
(a) Machinery and equipment (FAS port of shipment)	107,038,000	-	198,785,000	-
(b) Freight, handling and insurance charges	5,837,000	648,000	10,839,000	1,204,000

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Baht Costs -	Pulp Mill Equipment	Pulp Mill Buildings	Paper Mill Equipment	Paper Mill Buildings
(c) Engineering, construction and erection costs incl. supervision	17,100,000	5,700,000	31,760,000	10,586,000
(d) Site improvement, buildings, structures, staff housing, etc.	1,833,000	16,490,000	3,400,000	30,630,000
(e) Labor and materials for erection and installation of equipment	6,253,000	2,084,000	11,613,000	3,871,000
(f) Overhead during planning and construction	4,479,000	497,000	8,319,000	925,000
(g) Capitalized development services	5,954,000	662,000	11,056,000	1,228,000
(h) Interest on borrowed capital during construction	9,519,000	1,057,000	17,679,000	1,964,000
TOTAL COSTS EXCLUSIVE OF WORKING CAPITAL	158,013,000	27,138,000	293,451,000	50,408,000
Annual depreciation rate	7.5%	2.5%	7.5%	2.5%
Annual depreciation	11,850,000	2,035,000	22,009,000	1,260,000

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Total Annual Depreciation:	Pulp Mill	Paper Mill
Total - Thai Baht	B. 13,885,000	B. 23,269,000
Equiv. United States $	$ 661,190	$ 1,108,048

3. Depreciation Calculations for Second Stage Pulp Mill (Project II)

		Equipment	Buildings
(a)	Machinery and equipment (FAS port of shipment)	82,342,890	
(b)	Freight, handling and insurance charges	4,531,500	503,500
(c)	Engineering, construction and erection costs, including supervision	12,455,110	4,152,000
(d)	Site purchase and improvement, buildings, structures, staff housing, etc.	1,020,000	9,180,000
(e)	Labor and materials for erection and installation of equipment	3,900,000	1,300,000
(f)	Overhead during planning and construction	2,362,500	262,500
(g)	Capitalized development services	6,048,000	672,000
(h)	Interest on borrowed capital during construction	6,380,600	709,000
	TOTAL COSTS EXCLUSIVE OF WORKING CAPITAL	119,040,600	16,779,000

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	Equipment	Buildings
Annual depreciation rate	7.5%	2.5%
Annual depreciation	8,928,000	420,000

Total Annual Depreciation

Total - Thai Baht	9,348,000
Equiv. United States $	445,000

4. Total Annual Depreciation for Fully Integrated Pulp and Paper Mill and Converting Plant

	Equipment	Buildings
Total Proj. I and II	42,787,000	3,295,000
Total - Thai Baht	46,082,000	
Equiv. United States $	2,194,300	

B. Schedule of Expenditures and Withdrawals

Based on the Time Schedule and charts referenced in Section XVI, the charts in Appendices XXIV and XXV have been prepared to graphically show the schedule of the estimated expenditures involved in Project I. In terms of percentages, the expenditures of Project II would follow the same pattern. (The estimated Dollar and Baht expenditure schedules for Project I are given in Appendices XXVI and XXVII.)

In order to meet these requirements, the following estimated withdrawal schedules have been prepared which also indicate the currency and source of each withdrawal. (CD = Confirmation Date)

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Estimated Withdrawal Schedule
Project I

Date	Dollars (1,000) Equity	Loan	Total	Baht (1,000) Equity	Debentures (or preferred stock)	Total
CD + 1 mo.	1,000	3,200	4,200	25,000		25,000
CD + 6 mos.	1,000	3,200	4,200	25,000		25,000
CD + 9 mos.	750	1,100	1,850	20,000		20,000
CD + 12 mos.	750	3,200	3,950	20,000		20,000
CD + 15 mos.	500	1,300	1,800	15,000	21,000	36,000
CD + 18 mos.		1,000	1,000		26,880	26,880
CD + 24 mos.		1,000	1,000			
	4,000	14,000	18,000	105,000	47,880	152,880

Estimated Withdrawal Schedule
Project II

Date	Dollars (1,000) Equity	Loan	Total	Baht (1,000) Equity
CD + 61 mos.	300	700	1,000	7,000
CD + 66 mos.	300	700	1,000	7,000
CD + 69 mos.	300	200	500	7,000
CD + 72 mos.	200	800	1,000	5,500
CD + 75 mos.	100	400	500	4,500
CD + 78 mos.	100	400	500	2,440
CD + 84 mos.		170	170	
	1,300	3,370	4,670	33,440

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C. Interest During Construction (To be capitalized)

Interest accruing on the loans during the period of construction up to the time the plant goes into operation (estimated at 30 months from Confirmation Date - CD) will be capitalized at the end of this period and will be repaid in accordance with the schedule of repayment of the principal, with interest thereon corresponding to the rate of interest on the principal. Interest on the foreign currency loan(s) has been conservatively calculated at 6% per annum, although it is expected that the rate of interest on the Exim and/or AID loans will not exceed 5 3/4% per annum.

1. For Partially Integrated Pulp and Paper Mill and Converting Plant - Project I (Years 1-5)

It is assumed that the Project I foreign currency loan of U.S. $14,000,000 will be withdrawn and interest will accrue at 6% per annum as follows:

Interest During Construction
(6% per annum)

Withdrawal Date	Amount Withdrawn	Interest to end of Construction (CD + 30 mo.)
CD + 1 month	$ 3,200,000	$ 464,000
CD + 6 months	3,200,000	384,000
CD + 9 months	1,100,000	115,500
CD + 12 months	3,200,000	288,000
CD + 15 months	1,300,000	97,500
CD + 18 months	1,000,000	60,000
CD + 24 months	1,000,000	30,000
	$ 14,000,000	$ 1,439,000

Principal plus Capitalized Interest = $ 15,439,000

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2. For the Second Stage Pulp Mill Facilities - Project II To be Fully Started-up 5 Years after Start-up of Project I

It is assumed that the Project II (pulp mill) foreign currency loan will amount to U.S. $3,370,000 and will be withdrawn and interest will accrue at 6% per annum as follows: (CD = Confirmation Date of Project I Loan)

Interest During Construction
(6% per annum)

Withdrawal Date	Amount Withdrawn	Interest to end of Construction
CD + 61 months	$ 700,000	$ 101,500
CD + 66 months	700,000	84,000
CD + 69 months	200,000	21,000
CD + 72 months	800,000	72,000
CD + 75 months	400,000	30,000
CD + 78 months	400,000	24,000
CD + 84 months	170,000	5,100
	$ 3,370,000	$ 337,600

Principal plus Capitalized Interest = $3,707,600

D. Suggested Amortization Schedules

1. General Comments

Interest during construction is to be capitalized at the end of the construction period for each stage (mill start-up) and will be repaid in line with the principal repayment schedules and the interest rates applicable to the principal amounts.

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It is assumed that the principals will be repaid in equal semi-annual installments. On this basis, the amortization schedules are calculated for the various loans with the first payments on the Project I loans due 48 months after the confirmation date (CD + 48), which is 18 months after the start-up of the partially integrated pulp and paper mill and 12 months after efficient operation will have begun, and the first payment on the Project II loans is due 108 months after the original confirmation date (CD + 108). The Project I loan will be repaid over a period of 10 years. The Project II loan will be repaid over a period of 5 years.

2. Ten-year Amortization Schedules for Loan on Project I, Partially Integrated Pulp and Paper Mill

	U.S.$	Equiv. Thai Baht
Amount of Loan	14,000,000	294,000,000
Interest during Construction	1,439,000	30,219,000
Total amount to be repaid	15,439,000	324,219,000

For the following calculations of amortization of principal and interest, the rate of interest has been taken conservatively at 6%, although it is expected that it will not exceed 5 3/4% per annum.

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Amortization Schedule of Foreign Currency Loan
Project I

	Interest	Principal	Total
CD + 36 mos.	463,170		463,170
CD + 42 mos.	463,170		463,170
CD + 48 mos.	463,170	771,950	1,235,120
CD + 54 mos.	440,012	771,950	1,211,962
CD + 60 mos.	416,853	771,950	1,188,803
CD + 66 mos.	393,694	771,950	1,165,644
CD + 72 mos.	370,536	771,950	1,142,486
CD + 78 mos.	347,378	771,950	1,119,328
CD + 84 mos.	324,219	771,950	1,096,169
CD + 90 mos.	301,060	771,950	1,073,010
CD + 96 mos.	277,902	771,950	1,049,852
CD + 102 mos.	254,744	771,950	1,026,694
CD + 108 mos.	231,585	771,950	1,003,535
CD + 114 mos.	208,427	771,950	980,377
CD + 120 mos.	185,268	771,950	957,218
CD + 126 mos.	162,110	771,950	934,060
CD + 132 mos.	138,951	771,950	910,901
CD + 138 mos.	115,793	771,950	887,743
CD + 144 mos.	92,634	771,950	864,584
CD + 150 mos.	69,476	771,950	841,426
CD + 156 mos.	46,317	771,950	818,267
CD + 162 mos.	23,159	771,950	795,109
	5,789,628	15,439,000	21,228,628

3. Five-year Amortization Schedules for Loan on Project II Pulp Mill

	U.S.$	Equiv. Thai Baht
Amount of Loan	3,370,000	70,770,000
Interest during construction	337,600	7,089,600
Total amount to be repaid	3,707,600	77,859,600

At 6% interest per annum, the amortization of principal and interest on this loan will be scheduled for payment as follows:

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Amortization Schedule of Foreign Currency Loan
Project II

	Interest	Principal	Total
CD + 96 months	111,228		111,228
CD + 102 months	111,228		111,228
CD + 108 months	111,228	370,760	481,988
CD + 114 months	100,105	370,760	470,865
CD + 120 months	88,982	370,760	459,742
CD + 126 months	77,860	370,760	448,620
CD + 132 months	66,737	370,760	437,497
CD + 138 months	55,614	370,760	426,374
CD + 144 months	44,491	370,760	415,251
CD + 150 months	33,368	370,760	404,128
CD + 156 months	22,246	370,760	393,006
CD + 162 months	11,123	370,760	381,883
	834,210	3,707,600	4,541,810

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4. Consolidated Amortization Schedule, PROJECT I and PROJECT II.

Installment No. Project I	Installment No. Project II	Date Due	Payment of Principal $	Payment of Interest $	Total Payment $	Total Baht Equivalent
		CD + 36 mos.		463170	463170	9726570
		CD + 42 mos.		463170	463170	9726570
1		CD + 48 mos.	771950	463170	1235120	25937520
2		CD + 54 mos.	771950	440012	1211962	25451202
3		CD + 60 mos.	771950	416853	1188803	24964863
4		CD + 66 mos.	771950	393694	1165644	24478524
5		CD + 72 mos.	771950	370536	1142486	23992206
6		CD + 78 mos.	771950	347378	1119328	23505888
7		CD + 84 mos.	771950	324219	1096169	23019549
8		CD + 90 mos.	771950	301060	1073010	22533210
9		CD + 96 mos.	771950	389130	1161080	24382680
10		CD + 102 mos.	771950	365972	1137922	23896362
11	1	CD + 108 mos.	1142710	342813	1485523	31195983
12	2	CD + 114 mos.	1142710	308632	1451342	30478182
13	3	CD + 120 mos.	1142710	274250	1416960	29756160
14	4	CD + 126 mos.	1142710	239970	1382680	29036280
15	5	CD + 132 mos.	1142710	205688	1348398	28316358
16	6	CD + 138 mos.	1142710	171407	1314117	27596457
17	7	CD + 144 mos.	1142710	137125	1279835	26876535
18	8	CD + 150 mos.	1142710	102844	1245554	26156634
19	9	CD + 156 mos.	1142710	68563	1211273	25436733
20	10	CD + 162 mos.	1142710	34282	1176992	24716832
		TOTALS	19146600	6623838	25770438	541179198

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XXI. ESTIMATED BASIC COSTS OF MANUFACTURE

A. Basic Costs of Materials and Labor

Amounts shown below are the estimated costs of materials delivered to the mill site, based on prices prevailing at the time of the Survey, March-April 1963, except as noted. It has been assumed that all import duties and taxes will be waived for the partially integrated pulp and paper mill (Project I), and for the second pulp mill portion of the fully integrated mill (Project II).

	PROJECT I	PROJECT II
	Estimated Delivered Costs Bahts/ton	
1. Basic Fibrous Raw Materials		
(a) Bagasse, Partially Depithed (o.d.)	395.00	435.00
(b) Bamboo	-	120.00
(c) Kenaf	-	1,082.00
(d) Imported Pulp (o.d.)	3,345.10	3,731.20
(e) Waste Paper for Corrugating Board (o.d.)	175.70	175.70
(f) Waste Paper for Wrapping Paper (o.d.)	-	368.42
2. Chemicals		
(a) Salt Cake	1,141.00	1,387.00
(b) Lime	300.00	300.00
(c) Limestone	45.00	45.00
(d) Rosin	4,937.00	6,367.00
(e) Alum	1,400.00	1,400.00

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	PROJECT I	PROJECT II
	Estimated Delivered Costs/Bahts	
3. Utilities		
(a) Fuel Oil	500.00/ton	617.00/ton
(b) Power*	0.12/kwhr	0.15/kwhr
(c) Steam	34.98/ton	42.75/ton
(d) Water	0.15/cu m	0.15/cu m

*Generated at mill, not including capital investment cost, other financial charges and labor.

	PROJECT I		PROJECT II	
	Average Costs of Personnel Bahts/man/day			
	Operations	Services	Operations	Services
4. Labor				
(a) Pulp	47.44	58.58	45.41	57.92
(b) Paper	52.03	58.27	52.56	58.11
(c) Converting	49.76	54.79	49.78	53.08

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B. Estimated Costs of Manufacture of Pulps, Papers and Boards Project I

(The estimated cost for manufactured pulps and paper products which follow are based on the first full year of operation of Project I)

1. Estimated Cost of Manufacture of Strong Bagasse Pulp

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Bagasse Partially Depithed	2.370 tons	395.00/ton	936.15
(b) Salt Cake	100 kg	1,141.00/ton	114.10
(c) Lime	221 kg	300.00/ton	66.30
(d) Power	560 kwhr	0.12/kwhr	67.20
(e) Steam	3.0 tons	34.98/ton	104.94
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating and Pulp Handling	2.15 man-days	47.44/ man-day	101.99
(h) Labor-Repairs, Services and Maintenance	.86 man-day	58.58/ man-day	50.38
(i) Materials-Repairs and Maintenance	-	-	77.00
(j) Control and Administration	-	-	26.74
(k) Supervision, Thai Understudies	-	-	45.71
Estimated Basic Manufacturing Cost of Strong Bagasse Pulp (Excluding Interest, Overhead, Depreciation, Duties and Taxes)			B1,607.01/ O.D. Ton

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2. Estimated Cost of Manufacture of High-Yield Bagasse Pulp Project I

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Bagasse, Partially Depithed	1.560	395.00/ ton	616.20
(b) Salt Cake	80 kg	1,141.00/ ton	91.28
(c) Lime	200 kg	300.00/ ton	60.00
(d) Power	560 kwhr	0.12/kwhr	67.20
(e) Steam	3.0	34.98/ ton	104.94
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating	2.15 man-days	47.44/ man-day	101.99
(h) Labor-Repairs, Services and Maintenance	.86 man-day	58.58/ man-day	50.38
(i) Materials-Repairs and Maintenance	-	-	77.00
(j) Control and Administration	-	-	26.74
(k) Supervision, Thai Understudies	-	-	45.71
Estimated Basic Manufacturing Cost of High-Yield Bagasse Pulp (excluding Interest, Overhead, Depreciation, Duties and Taxes)			B1,257.94/ O.D. Ton

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3. Estimated Cost of Manufacture of Waste Paper Pulp for Corrugating Board, Project I

Item	Amount Required Ton	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Waste Paper	1.300	175.70/ton	228.41
(b) Power	150 kwhr	0.12/kwhr	18.00
(c) Water	20 cu m	0.15/cu m	3.00
(d) Labor-Operating and Maintenance	-	-	30.00
Estimated Basic Manufacturing Cost of Waste Paper Pulp (excluding Depreciation, Overhead, Duties and Taxes)			B279.41/ O.D. Ton

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4. Estimated Cost of Manufacture of Sack Paper
Project I

(Fiber Furnish: 80% Imported Kraft and
20% Bagasse Pulp)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Paper
(a) Imported Kraft Pulp	0.820 ton	3,345.10/ ton	2,742.98
(b) Unbleached Bagasse Pulp	0.210 ton	1,607.01/ ton	337.47
(c) Rosin	20 kg	4,937.00/ ton	98.74
(d) Alum	40 kg	1,400.00/ ton	56.00
(e) Power	750 kwhr	0.12/kwhr	90.00
(f) Steam	4.0 ton	34.98/ ton	139.92
(g) Water	75 cu m	0.15/cu m	11.25
(h) Labor-Operating	.92 man-day	52.03/ man-day	47.87
(i) Labor-Repair, Services and Maintenance	.44 man-day	58.27/ man-day	25.64
(j) Materials-Repair and Maintenance	-	-	61.00
(k) Control and Administration	-	-	11.45
(l) Supervision, Thai Understudies	-	-	19.58
Estimated Basic Manufacturing Cost of Sack Paper (excluding Depreciation, Overhead, Duties and Taxes)			B3,641.90/ O.D. Ton
Cost of Sack Paper at 5% Moisture			B3,459.81/ A.D. Ton

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5. Estimated Cost of Manufacture of Liner Board
Project I

(Fiber Furnish: 64.5% Imported Kraft and
35.5% Bagasse Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D.Board
(a) Imported Kraft Pulp	0.660 ton	3,345.10/ ton	2,207.77
(b) Unbleached Bagasse Pulp	0.370 ton	1,607.01/ ton	594.59
(c) Rosin	15 kg	4,937.00 ton	74.05
(d) Alum	30 kg	1,400.00/ ton	42.00
(e) Power	650 kwhr	0.12/kwhr	78.00
(f) Steam	4.0 ton	34.98/ ton	139.92
(g) Water	75 cu m	0.15/cu m	11.25
(h) Labor-Operating	.92 man-day	52.03/ man-day	47.87
(i) Labor-Repair, Services and Maintenance	.44 man-day	58.27/ man-day	25.64
(j) Materials-Repair and Maintenance	-	-	61.00
(k) Control and Administration	-	-	11.45
(l) Supervision, Thai Understudies	-	-	19.58
Estimated Basic Manufacturing Cost of Liner Board (excluding Depreciation, Overhead, Duties and Taxes)			B3,313.12/ O.D. Ton
Cost of Liner Board at 5% Moisture			B3,147.46/ A.D. Ton

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6. Estimated Cost of Manufacture of Corrugating Board Project I

(Pulp Furnish: 83.3% Bagasse and 16.7% Waste Paper Pulps

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Board
(a) Waste Paper	0.190 ton	279.41/ ton	53.09
(b) High-Yield Bagasse Pulp	0.86 ton	1,257.94/ ton	1,081.83
(c) Alum	20 kg	1,400.00/ ton	28.00
(d) Power	350 kwhr	0.12/kwhr	42.00
(e) Steam	4.0 ton	34.98/ ton	139.92
(f) Water	75 cu m	0.15/cu m	11.25
(g) Labor-Operating	.92 man-day	52.03/ man-day	47.87
(h) Labor-Repair, Services and Maintenance	.44 man-day	58.27/ man-day	25.64
(i) Materials-Repairs and Maintenance	-	-	61.00
(j) Control and Administration	-	-	11.45
(k) Supervision, Thai Understudies	-	-	19.58
Estimated Basic Manufacturing Cost of Corrugating Board (excluding Depreciation, Overhead, Duties and Taxes)			B1,521.63/ O.D. Ton
Cost of Corrugating Board at 5% Moisture			B1,445.55/ A.D. Ton

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7. Estimated Cost of Manufacture of Wrapping Paper
Project I

(Fiber Furnish: 56.5% Imported Kraft and
43.5% Bagasse Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Paper
(a) Imported Kraft Pulp	0.582 ton	3,345.10/ ton	1,946.85
(b) Unbleached Bagasse Pulp	0.448 ton	1,607.01/ ton	719.94
(c) Rosin	20 kg	4,937.00/ ton	98.74
(d) Alum	40 kg	1,400.00/ ton	56.00
(e) Power	600 kwhr	0.12/kwhr	72.00
(f) Steam	4.0 ton	34.98/ ton	139.92
(g) Water	75 cu m	0.15/cu m	11.25
(h) Labor-Operating	.92 man-day	52.03/ man-day	47.87
(i) Labor-Repair, Services and Maintenance	.44 man-day	58.27/ man-day	25.64
(j) Materials-Repair and Maintenance	-	-	61.00
(k) Control and Administration	-	-	11.45
(l) Supervision, Thai Understudies	-	-	19.58
Estimated Basic Manufacturing Cost of Wrapping Paper (excluding Overhead, Depreciation, Duties and Taxes)			B3,210.24/ O.D. Ton
Cost of Wrapping Paper at 5% Moisture			B3,049.73/ A.D. Ton

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8. Estimated Cost of Manufacture of Multi-wall Bags from Sack Paper Project I

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Bags
(a) Sack Paper	1.020 ton	3,459.81/ ton	3,529.01
(b) Power	25 kwhr	0.12/kwhr	3.00
(c) Labor-Operations	1.44 man-day	49.76/ man-day	71.65
(d) Labor-Repair and Maintenance	.24 man-day	54.79/ man-day	13.15
(e) Materials-Operating (thread, ink, crepe seals, etc.)	-	-	80.00
(f) Materials-Repair and Maintenance			10.00
(g) Control and Administration	-	-	28.22
(h) Supervision, Thai Understudies	-	-	48.24
Estimated Basic Manufacturing Cost of Multi-wall Bags from Sack Paper (excluding Depreciation, Overhead, Duties and Taxes)			B3,783.27/Ton

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9. Estimated Cost of Manufacture of Grocery Bags from Wrapping Paper Project I

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Bags
(a) Wrapping Paper	1.020 ton	3,049.73/ ton	3,110.72
(b) Power	45 kwhr	0.12/kwhr	5.40
(c) Labor-Operating	1.44 man-days	49.76/ man-day	71.65
(d) Labor-Repair and Maintenance	.24 man-day	54.79/ man-day	13.15
(e) Materials-Operating	-	-	25.00
(f) Materials-Repair and Maintenance	-	-	10.00
(g) Control and Administration	-	-	28.22
(h) Supervision, Thai Understudies	-	-	48.24
Estimated Basic Manufacturing Cost of Grocery Bags from Wrapping Paper (excluding Depreciation, Overhead, Duties and Taxes)			B3,312.38/ Ton

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C. Estimated Costs of Manufacture of Pulps, Papers and Boards Project II

(The estimated cost of manufactured pulp and paper products which follow are based upon the second year of operation (at full capacity) of Project II)

1. Estimated Cost of Manufacture of Strong Bagasse Pulp

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D.Pulp
(a) Bagasse, Partially Depithed	2.370 tons	435.00/ ton	1,030.95
(b) Salt Cake	100 kg	1,387.00/ ton	138.70
(c) Limestone	75 kg	45.00/ ton	3.38
(d) Power	560 kwhr	0.15/kwhr	84.00
(e) Steam	3.0 ton	42.75/ ton	128.25
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating	1.25 man-days	45.41/ man-day	56.77
(h) Labor-Repairs and Maintenance	.38 man-day	57.92/ man-day	22.01
(i) Materials-Repairs, Maintenance and Misc.	-	-	82.00
(j) Control and Administration	-	-	11.68
(k) Supervision, Thai Personnel	-	-	19.97
Estimated Basic Manufacturing Cost of Strong Bagasse Pulp (excluding Depreciation and Overhead)			Bl,594.21/ O.D. Ton

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2. Estimated Cost of Manufacture of High-Yield Bagasse Pulp Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Bagasse Partially Depithed	1.560 tons	435.00/ton	678.60
(b) Salt Cake	80 kg	1387 kg	110.96
(c) Limestone	70 kg	45.00/ton	3.15
(d) Power	560 kwhr	0.15/kwhr	84.00
(e) Steam (per metric ton)	3.0 tons	42.75/ton	128.25
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating	1.25 man-days	45.41/ man-day	56.77
(h) Labor-Repairs and Maintenance	.38 man-day	57.92/ man-day	22.01
(i) Materials-Repairs, Maintenance and Misc.	-	-	82.00
(j) Control and Administration	-	-	11.68
(k) Supervision, Thai Personnel	-	-	19.97
Estimated Basic Manufacturing Cost of High-Yield Bagasse Pulp (excluding Depreciation and Overhead)			B1,213.89/ O.D. Ton

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3. Estimated Cost of Manufacture of Bamboo Pulp Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Bamboo	2.000 tons	120.00/ ton	240.00
(b) Salt Cake	100 kg	1,141.00/ ton	114.10
(c) Limestone	75 kg	45.00/ ton	3.38
(d) Power	560 kwhr	0.12/kwhr	67.20
(e) Steam	3.0 tons	34.98/ ton	104.94
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating	1.25 man-days	45.41/ man-day	56.77
(h) Labor-Repair and Maintenance	.38 man-day	57.92/ man-day	22.01
(i) Materials-Repairs, Maintenance, and Misc.	-	-	82.00
(j) Control and Administration	-	-	11.68
(k) Supervision, Thai Personnel	-	-	19.97
Estimated Basic Manufacturing Cost of Bamboo Pulp (excluding Depreciation, Overhead, Duties and Taxes)			B738.55/ O.D. Ton

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4. Estimated Cost of Manufacture of Waste Paper Pulp for Wrapping Paper Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Waste Paper	1.300 tons	368.42/ ton	478.95
(b) Power	150 kwhr	0.12/kwhr	18.00
(c) Water	20 cu m	0.15/cu m	3.00
(d) Labor-Operating and Maintenance	-	-	30.00
Estimated Cost of Manufacture of Waste Paper Pulp (excluding Depreciation and Overhead)			B529.95/ O.D. Ton

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5. Estimated Cost of Manufacture of Waste Paper Pulp for Corrugating Board Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D.Pulp
(a) Waste Paper	1.3 tons	175.70/ton	228.41
(b) Power	150 kwhr	0.15/kwhr	22.50
(c) Water	20 cu m	0.15/cu m	3.00
(d) Labor-Operating and Maintenance	-	-	30.00
Estimated Basic Manufacturing Cost of Waste Paper Pulp (excluding Depreciation and Overhead)			B283.91/ O.D. Ton

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6. Estimated Cost of Manufacture of Kenaf Pulp from Kenaf Fiber Clippings Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Kenaf	1.540 ton	1,082.00/ ton	1,666.28
(b) Salt Cake	80 kg	1,141.00/ ton	91.28
(c) Limestone	75 kg	45.00/ ton	3.38
(d) Power	560 kwhr	0.15 kwhr	84.00
(e) Steam	2.3 ton	42.75/ ton	98.33
(f) Water	110 cu m	0.15/cu m	16.50
(g) Labor-Operating	1.25 man-day	45.41/ man-day	56.77
(h) Labor-Repairs and Maintenance	.38 man-day	57.92 man-day	22.01
(i) Materials-Repairs, Maintenance and Misc.	-	-	82.00
(j) Control and Administration	-	-	11.68
(k) Supervision, Thai Personnel	-	-	19.97
Estimated Basic Cost of Manufacture of Unbleached Kenaf Pulp (excluding Depreciation, Overhead, Duties and Taxes)			B2,152.20/ O.D. Ton

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7. Estimated Cost of Manufacture of Sack Paper Project II
(Fiber Furnish: 39% Imported Kraft, 16% Bagasse, 15% Kenaf, and 30% Bamboo Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton O.D. Pulp
(a) Imported Kraft Pulp	0.400 ton	3,731.20/ ton	1,492.48
(b) Bagasse Pulp	0.165 ton	1,594.21/ ton	263.04
(c) Kenaf Pulp	0.155 ton	2,152.20/ ton	333.42
(d) Bamboo Pulp	0.310 ton	738.55/ ton	228.95
(e) Rosin	20 kg	6,367.00/ ton	127.34
(f) Alum	40 kg	1,400.00/ ton	56.00
(g) Power	710 kwhr	0.15/kwhr	106.50
(h) Steam	4.2 ton	42.75/ton	179.55
(i) Water	75 cu m	0.15/cu m	11.25
(j) Labor-Operating	.73 man-day	52.56/ man-day	38.37
(k) Labor-Repairs and Maintenance	.36 man-day	58.11 man-day	20.92
(l) Materials-Repairs, Maintenance and Misc.	-	-	61.00
(m) Control and Administration	-	-	9.35
(n) Supervision, Thai Personnel	-	-	15.98
Estimated Basic Manufacturing Cost of Sack Paper (excluding Depreciation and Overhead)			B2,944.15/ O.D. Ton
Cost of Sack Paper at 5% Moisture			B2,796.94/ A.D. Ton

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8. Estimated Cost of Manufacture of Liner Board Project II

(Pulp Furnish: 14.0% Imported Kraft, 31.5% Bagasse, 7.0% Kenaf and 47.5% Bamboo Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Board
(a) Imported Kraft Pulp	0.145 ton	3,371.20/ ton	541.02
(b) Bagasse Pulp	0.325 ton	1,594.21/ ton	518.11
(c) Kenaf Pulp	0.070 ton	2,152.20/ ton	150.58
(d) Bamboo Pulp	0.490 ton	738.55/ ton	361.89
(e) Rosin	15 kg	6,367.00/ ton	95.50
(f) Alum	30 kg	1,400.00/ ton	42.00
(g) Power	710 kwhr	0.15/kwhr	106.50
(h) Steam	4.2 ton	42.75/ ton	179.55
(i) Water	75 cu m	0.15/cu m	11.25
(j) Labor-Operating	.73 man-day	52.56/ man-day	38.37
(k) Labor-Repairs and Maintenance	.36 man-day	58.11/ man-day	20.92
(l) Materials-Repairs and Maintenance	-	-	61.00
(m) Control and Administration	-	-	9.35
(n) Supervision, Thai Personnel	-	-	15.98
Estimated Basic Manufacturing Cost of Liner Board (excluding Depreciation and Overhead)			B2,152.02/ O.D. Ton
Cost of Liner Board at 5% Moisture			B2,044.42/ A.D. Ton

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9. Estimated Cost of Manufacture of Corrugating Board Project II
(Pulp Furnish: 83.3% Bagasse and 16.7 % Waste Paper Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Board
(a) Waste Paper Pulp	0.190 ton	283.91/ ton	53.94
(b) High-Yield Bagasse Pulp	0.860 ton	1,213.87/ ton	1,043.92
(c) Alum	20 kg	1,400.00/ ton	28.00
(d) Power	710 kwhr	0.15/kwhr	106.50
(e) Steam	4.2 ton	42.75/ton	179.55
(f) Water	75 cu m	0.15/cu m	11.25
(g) Labor-Operating	.73 man-day	52.56/ man-day	38.37
(h) Labor-Repairs and Maintenance	.36 man-day	58.11 man-day	20.92
(i) Materials-Repairs and Maintenance	-	-	61.00
(j) Control and Administration	-	-	9.35
(k) Supervision, Thai Personnel	-	-	15.98
Estimated Cost of Manufacture of Corrugating Board (excluding Depreciation and Overhead)			Bl,568.78/ O.D. Ton
Cost of Corrugating Board at 5% Moisture			Bl,490.34/ A.D. Ton

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10. Estimated Cost of Manufacture of Wrapping Paper Project II
(Pulp Furnish: 32.5% Bagasse, 59.5% Bamboo, and 8.0% Waste Paper Pulps)

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Paper
(a) Bagasse Pulp	0.338 ton	1,594.21/ ton	538.84
(b) Bamboo Pulp	0.620 ton	738.55/ ton	457.90
(c) Waste Paper	0.082 ton	529.95/ ton	43.46
(d) Rosin	20 kg	6,367.00/ ton	127.34
(e) Alum	40 kg	1,400.00/ ton	56.00
(f) Power	710 kwhr	0.15/kwhr	106.50
(g) Steam	4.2 ton	42.75/ton	179.55
(h) Water	75 cu m	0.15/cu m	11.25
(i) Labor-Operating	.73 man-day	52.56/ man-day	38.37
(j) Labor-Repairs and Maintenance	.36 man-day	58.11/ man-day	20.92
(k) Materials-Repairs and Maintenance	-	-	61.00
(l) Control and Administration	-	-	9.35
(m) Supervision, Thai Personnel	-	-	15.98
Estimated Basic Manufacturing Cost of Wrapping Paper (excluding Depreciation and Overhead)			B1,666.46/ O.D. Ton
Cost of Wrapping Paper at 5% Moisture			B1,583.14/ A.D. Ton

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11. Estimated Cost of Manufacture of Multi-wall Bags from Sack Paper Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Bags
(a) Sack Paper	1.020 ton	2,796.94 ton	2,852.88
(b) Power	25 kwhr	0.15/kwhr	3.75
(c) Labor-Operating	1.51 man-day	49.78/ man-day	75.17
(d) Labor-Repairs and Maintenance	.13 man-day	53.08/ man-day	6.90
(e) Materials-Operating	-	-	80.00
(f) Materials-Repairs and Maintenance	-	-	10.00
(g) Control and Administration	-	-	14.80
(h) Supervision, Thai Personnel	-	-	25.30
Estimated Basic Manufacturing Cost of Multi-Wall Bags from Sack Paper (excluding Depreciation and Overhead)			B3,058.80/ Ton

PROPRIETARY WHITEMORE

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12. Estimated Cost of Manufacture of Grocery Bags from Wrapping Paper Project II

Item	Amount Required	Unit Cost Bahts	Cost Bahts/Ton Bags
(a) Wrapping Paper	1.020 tons	1,583.14/ ton	1,614.80
(b) Power	45 kwhr	0.15/kwhr	6.75
(c) Labor-Operating	1.51 man-day	49.78/ man-day	73.48
(d) Labor-Repairs and Maintenance	.13 man-day	53.08/ man-day	6.90
(e) Materials-Operating	-	-	25.00
(f) Materials-Repairs and Maintenance	-	-	10.00
(g) Control and Administration	-	-	14.80
(h) Supervision, Thai Personnel	-	-	25.30
Estimated Basic Manufacturing Cost of Grocery Bags from Wrapping Paper (excluding Depreciation and Overhead)			B1,777.03/ ton

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XXII. ESTIMATED SALES, COSTS AND PROFITS

A. General

In this section the estimated sales, costs and profits for the proposed mill are projected for the first thirteen years of operation. In order to make these projections, certain guidelines have been established, and the assumptions on which these are based are set forth briefly in the following paragraphs.

B. Production Forecast

Based on the market survey given in Section IV of this report it is estimated that by 1968 (first year of full operation) the Thai paper and board market can easily absorb approximately 45,000 tons from the proposed mill. A conservative estimate has been made of the yearly increases in tonnage for each grade and the projected tonnages of each product to be sold are tabulated below:

Estimated Tonnage of Various Products

	Total	Sack Paper	Liner Board	Corrug. Board	Wrapping Paper	Multi-Wall Bags	Grocery Bags
1st Year	30,000	6,100	8,800	4,100	8,350	2,000	650
2nd Year	44,350	9,000	13,000	6,000	12,350	3,000	1,000
3rd Year	46,350	9,450	13,525	6,300	12,350	3,225	1,500
4th Year	48,350	9,900	14,050	6,600	12,350	3,450	2,000
5th Year	50,350	10,350	14,575	6,900	12,350	3,675	2,500
6th Year	52,350	10,800	15,100	7,200	12,350	3,900	3,000
7th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
8th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
9th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
10th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
11th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
12th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500
13th Year	54,350	11,250	15,625	7,500	12,350	4,125	3,500

It is to be noted in the Table above that, in the first year of operation, the total sales of products are estimated at 30,000 tons. This figure has been used on the assumption that the mill will require the normal "shake-down" period to reach full production and to allow a margin for development of markets.

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The following Table shows the estimated production of various pulps to be produced and to be imported:

Estimated Pulp Requirements

Proj.	Year	Bagasse	Waste	Bamboo	Kenaf	Imported Kraft
I	1st Year	12,000	600			17,400
I	2nd Year	18,000	1,000			25,350
I	3rd Year	18,800	1,050			26,500
I	4th Year	19,600	1,100			27,650
I	5th Year	20,100	1,200			29,250
I&II	6th Year	19,000	2,400	12,400	1,700	16,850
I&II	7th Year	18,000	2,400	20,700	3,350	10,000
I&II	8th Year	18,000	2,400	21,700	3,350	9,000
I&II	9th Year	18,000	2,400	21,700	3,350	9,000
I&II	10th Year	18,000	2,400	21,700	3,350	9,000
I&II	11th Year	18,000	2,400	21,700	3,350	9,000
I&II	12th Year	18,000	2,400	21,700	3,350	9,000
I&II	13th Year	18,000	2,400	21,700	3,350	9,000

C. Mill Facilities

The mill will be built as two projects. Project I will consist initially of an 20,000 ton per year pulp mill, based primarily on bagasse, a 54,000 ton per year paper mill and a multi-wall and grocery bag converting plant. The balance of the paper mill's pulp requirements will be supplied by imported unbleached kraft pulp. Included in Project I will be a complete pilot plant for investigations of various fibrous raw materials available in Thailand.

In the second Project, another pulp mill with a nominal capacity of 20,000-23,000 tons per year, based primarily on bamboo, is scheduled to begin operation five years after start-up of the first Project described above. This period of five years between Projects I and II is estimated to be the time required to investigate, experiment with, and develop adequate and continuous supplies of other types of fibrous raw materials potentially available in Thailand, such as bamboo, kenaf, and local hardwoods. It is assumed that the Thai Government will assist and support such local development efforts to the fullest extent, including reserving and protecting suitable land areas, training

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of forestry personnel, and providing labor and materials for reforestation and plantation programs.

D. Sales Prices of Products

The sales prices for products to be produced have been established as follows:

Sack Paper	-	Baht 5,080 per ton
Liner Board	-	Baht 4,700 per ton
Corrugating Board	-	Baht 4,100 per ton
Wrapping Paper	-	Baht 6,950 per ton
Multi-Wall Bags	-	Baht 7,480 per ton
Grocery Bags	-	Baht 8,250 per ton

These prices have been used throughout the thirteen year projection, although in the normal course of events world prices can be expected to rise considerably in this period of time. In a like manner, prices of the raw materials and labor have been assumed to be constant, although they too can be expected to rise roughly in the same proportion.

It will be noted that these prices are somewhat higher (average 7%) than the current prices of imported products. It must be emphasized that current import prices are unusually low and must be expected to increase in the forthcoming years, thus reducing the price differential between the imported product and the products to be imported in Thailand. This price differential should be readily acceptable bearing in mind the great benefits which the establishment of domestic manufacture will bring to Thailand.

In addition to the considerable savings in foreign exchange which will accrue to the Thai economy, the establishment of a local kraft pulp industry will:

1. Increase employment and training of skilled workmen.

2. Eliminate the need of carrying large inventories by the consumers and shorten greatly the delivery time of orders. In view of the rather high rates of interest current in Thailand, this will result in major savings to the consumers, who can thus avoid tieing up capital which might otherwise earn substantial returns.

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3. Furnish a local source of supply which will not be subject to extreme price fluctuations in the event of national emergency or in case of shortages in world supply.

4. Provide a more rational use of local fibrous raw materials, especially bagasse which is presently being burned.

5. Provide more and better packaging materials which will further rationalize distribution in Thailand and support Thailand's export promotion.

6. Provide a boost in the local economy in the area of the mill.

7. Support the expansion of transportation facilities, and other local service organizations.

8. Furnish an outlet for fuel oil from the Thai refineries.

It must further be noted (see page 425) that the proposed sales prices for the domestically produced paper yield, in the later years of production, earnings in excess of those needed for reasonable dividends. This means that, to the extent that these excess earnings are not required to be put into reserves, the mill will be in a position to significantly reduce its sales prices. In other words, it will be possible to strike a harmonious balance between the generation of sufficient capital resources for the mill and the benefit of lower prices to be passed on to the Thai consumer.

E. Cost of Operation

1. Manufacturing Costs

The estimated costs of manufacturing the various pulps to beproduced have been developed as shown

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in Section XXI. In order to separate the operations of Project I from Project II so that the effect of a second pulp mill utilizing local fibrous raw materials can be clearly demonstrated, and to show how the expected 5-year periods of investment concessions will affect each Project, the profit and loss projections have been calculated separately for the paper mill, the Project I pulp mill and the Project II pulp mill.

The prices used for transfer of pulp to the paper mill were developed as follows:

Bagasse pulps were priced the same as similar pulp from Taiwan delivered to the Thai mill.

Bamboo pulp was priced at mid-way between bagasse pulp and imported kraft pulp.

Kenaf pulp was priced the same as imported kraft pulp.

2. General Expense

General expenses were calculated for pulp and paper mills to include the estimated cost of general and technical management fees plus 1% of sales for the pulp mills (to cover insurance and miscellaneous expenses), and 3% of sales for the paper mill (to cover insurance, sales, advertising and miscellaneious expenses).

3. Freight on Products

Freight expenses were calculated at Baht 67 per ton of product.

4. Dividends on Preferred Stock

Dividends on prefered stock have been calculated at 7% of the stock value.

5. Taxes and Duties

It has been assumed for the purposes of this report that the enterprise will be exempt from sales and income taxes and import duties for five years on Project I and the profits on sales of pulp from Project II will be exempt for a further five years.

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6. Dividends

Proposed dividends are restricted to 70% of the available funds and to 15% of the equity share capital, whichever is lower, during the first 12 years (period of repayment of senior debt). The balance of funds available can thus be earmarked either for reserves (modernization, obsolescence, etc.) or can be passed on to the Thai consumer in the form of reduced selling prices of the mill's products. The following Corporate Cash Flow Sheet has been prepared to reflect these requirements.

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TABLE XXII

CONSOLIDATED CORPORATE CASH FLOW

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
1. NET PROFIT (LOSS)													
a. Paper Mill '000B.	12090	34958	44836	50867	56672	29444	32224	34196	36234	38209	39907	40856	41096
b. Pulp Mill-Proj.I '000B.	(12820)	(9442)	(5578)	(3978)	(2812)	3963	6098	6823	7442	8624	9135	9646	9773
c. Pulp Mill-Proj.II '000B						18367	38092	41839	43245	44737	33409	34109	34285
TOTAL '000B	(730)	25516	39258	46889	53860	51774	76414	82858	86921	91570	82451	84611	85154
2. DEPRECIATION ALLOWANCE													
a. Paper Mill '000B	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269
b. Pulp Mill-Proj.I '000B	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885
c. Pulp Mill-Proj.II '000B						9384	9384	9384	9384	9384	9384	9384	9384
TOTAL '000B	37154	37154	37154	37154	37154	46502	46502	46502	46502	46502	46502	46502	46502
3. TOTAL CASH FLOW '000B	36424	62670	76412	84043	91014	98276	122916	129360	133423	138072	128953	13113	131656

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TABLE XXII (Cont.)

CONSOLIDATED CORPORATE CASH FLOW

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
4. REPAYMENT OF PRINCIPAL ON LONG TERM DEBT '000B	0	16211	32422	32422	32422	32422	40207	47994	47994	47994	47994	23997	0
5. AVAILABLE FOR DIVIDENDS AND/OR RESERVE AND/OR '000B REDUCTION IN SALES PRICE	36424	46469	43990	51621	58592	65854	82709	81366	85429	90088	80959	107116	131656
6. PERCENT OF COMMON SHARE EQUITY	17.52%	22.35%	21.16%	24.83%	28.18%	23.83%	29.93%	29.44%	30.91%	32.60%	29.29%	38.76%	47.64%
7. PROPOSED DIVIDEND '000B*	25497	31185	31185	31185	31185	41454	41454	41454	41454	41454	41454	41454	69090**
8. PERCENT OF COMMON SHARE EQUITY	12.26%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	25.00%**
9. AVAILABLE FOR RESERVE OR PRICE REDUCTION	10927	15284	12805	20436	27407	24400	41255	39912	43975	48634	39505	65662	62566

*Limited to 70% of line 5 or maximum of 15% of equity during term of loan repayment by lenders requirements.
**70% and/or 15% restriction no longer applies.

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TABLE XXIII

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
REVENUE													
1. SALES													
a. Sack Paper-Tons	6100	9000	9450	9900	10350	10800	11250	11250	11250	11250	11250	11250	11250
Unit Sales Price - B.	5080	5080	5080	5080	5080	5080	5080	5080	5080	5080	5080	5080	5080
Gross Revenue- '000B.	30988	45720	48006	50292	52578	54864	57150	57150	57150	57150	57150	57150	57150
b. Liner Board-Tons	8800	13000	13525	14050	14575	15100	15625	15625	15625	15625	15625	15625	15625
Unit Sales Price - B.	4700	4700	4700	4700	4700	4700	4700	4700	4700	4700	4700	4700	4700
Gross Revenue- '000B.	41360	61100	63568	66035	68503	70970	73438	73438	73438	73438	73438	73438	73438
c. Corrugating Board - Tons	4100	6000	6300	6600	6900	7200	7500	7500	7500	7500	7500	7500	7500
Unit Sales Price - B.	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100
Gross Revenue- '000B.	16810	24600	25830	27060	28290	29520	30750	30750	30750	30750	30750	30750	30750

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
d. Wrapping Paper -Tons	8350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350
Unit Sales Price - B.	6950	6950	6950	6950	6950	6950	6950	6950	6950	6950	6950	6950	6950
Gross Revenue - '000B.	58033	85833	85833	85833	85833	85833	85833	85833	85833	85833	85833	85833	85833
e. Multi-Wall Bags - Tons	2000	3000	3225	3450	3675	3900	4125	4125	4125	4125	4125	4125	4125
Unit Sales Price - B.	7480	7480	7480	7480	7480	7480	7480	7480	7480	7480	7480	7480	7480
Gross Revenue- - '000B.	14960	22440	24123	25806	27489	29172	30855	30855	30855	30855	30855	30855	30855
f. Grocery Bags- Tons	650	1000	1500	2000	2500	3000	3500	3500	3500	3500	3500	3500	3500
Unit Sales Price - B.	8250	8250	8250	8250	8250	8250	8250	8250	8250	8250	8250	8250	8250
Gross Revenue- - '000B.	5363	8250	12375	16500	20625	24750	28875	28875	28875	28875	28875	28875	28875
g. Other Income- - '000B.	0	0	0	0	0	0	0	0	0	0	0	0	0
2. TOTAL INCOME	167514	247943	259735	271526	283318	295109	306901	306901	306901	306901	306901	306901	306901

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
COST OF OPERATION, NET INCOME AND PROFIT													
3. OPERATING EXPENSE													
a. Manufacturing Expense (incl. Control and Administration)													
(1) Sack Paper													
- Tons	6100	9000	9450	9900	10350	10800	11250	11250	11250	11250	11250	11250	11250
Unit Mfg. Cost - B.	3723	3676	3671	3667	3663	4040	4038	4038	4038	4038	4038	4038	4038
Gross Cost '000B.	22710	33084	34691	36303	37912	43632	45427	45427	45427	45427	45427	45427	45427
(2) Liner Board													
Tons	8800	13000	13525	14050	14575	15100	15625	15625	15625	15625	15625	15625	15625
Unit Mfg. Cost - B.	3576	3528	3524	3518	3516	3834	3831	3831	3831	3831	3831	3831	3831
Gross Cost '000B.	31469	45864	47602	49428	51246	57893	59859	59859	59859	59859	59859	59859	59859

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
(3) Corrugating Board - Tons	4100	6000	6300	6600	6900	7200	7500	7500	7500	7500	7500	7500	7500
Unit Mfg. Cost. B.	2195	2147	2142	2138	2135	2407	2404	2404	2404	2404	2404	2404	2404
Gross Cost '000B.	9000	12882	13495	14111	14732	17330	18030	18030	18030	18030	18030	18030	18030
(4) Wrapping Paper - Tons	8350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350	12350
Unit Mfg. Cost. B.	3558	3510	3506	3502	3498	3613	3610	3610	3610	3610	3610	3610	3610
Gross Cost '000B.	29709	43349	43299	43250	43200	44621	44584	44584	44584	44584	44584	44584	44584
(5) Multi-Wall Bags -Tons	2000	3000	3225	3450	3675	3900	4125	4125	4125	4125	4125	4125	4125
Unit Mfg. Cost. B.	4462	4076	4034	4005	3980	4350	4335	4335	4335	4335	4335	4335	4335
Gross Cost '000B.	8924	12228	13010	13817	14627	16965	17882	17882	17882	17882	17882	17882	17882

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
(6) Grocery Bags - Tons	650	1000	1500	2000	2500	3000	3500	3500	3500	3500	3500	3500	3500
Unit Mfg. Cost. B.	4022	3854	3814	3784	3759	3852	3846	3846	3846	3846	3846	3846	3846
Gross Cost '000B.	2614	3854	5721	7568	9398	11556	13461	13461	13461	13461	13461	13461	13461
TOTAL BASIC MANUFACTURING COST													
b. General Expense (incl. Advertising, Sales, General Management, Technical Management Fees, Insurance, etc.)	15945	19387	15289	15790	16270	16770	17124	15759	13974	11937	11937	11937	11937
c. Freight on Products (at average rate of B.67 per ton)	2010	2971	3105	3239	3373	3507	3641	3641	3641	3641	3641	3641	3641

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
4. DEPRECIATION ALLOWANCE													
a. Machinery and Equipment (7½%)	22009	22009	22009	22009	22009	22009	22009	22009	22009	22009	22009	22009	22009
b. Buildings and Structures (2½%)	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260
TOTAL DEPRECIATION	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269	23269
5. TOTAL COST OF OPERATIONS BEFORE INTEREST ON LONG TERM DEBT OR TAXES	145650	196999	199541	206775	214027	235543	243277	241912	240127	238090	238090	238090	238090
6. NET INCOME BEFORE INTEREST ON LONG TERM DEBT OR TAXES	21864	51055	60194	64751	69291	59566	63624	64489	66774	68811	68811	68811	68811

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TABLE XXIII (Cont.)

ESTIMATED SALES, COST AND PROFITS FOR PAPER MILL (Cont.)

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
7. INTEREST ON LONG TERM DEBT													
a. Dollar Loans	6322	12645	11906	10482	9167	7903	6638	5374	4109	2845	1581	316	0
b. Dividends on Pref. Stock	3452	3452	3452	3452	3452	3452	3452	3452	3452	3452	3452	3452	3452
TOTAL INTEREST	9774	16097	15358	31884	12619	11355	10090	8826	7561	6297	5033	3768	3452
8. NET PROFIT (LOSS) BEFORE TAXES	12090	34958	44836	50867	56672	48211	53534	56163	59213	61514	63778	65043	65359
9. TAXES													
a. Sales	0	0	0	0	0	9052	10668	10668	10668	10668	10668	10668	10668
b. Income	0	0	0	0	0	9715	10642	11299	12311	12637	13203	13519	13595
TOTAL TAXES						18767	21310	21967	22979	23305	23871	24187	24263
10. NET PROFIT (LOSS) AFTER TAXES	12090	34958	44836	50867	56672	29444	32224	34196	36234	38209	39907	40856	41096

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TABLE XXIV

ESTIMATED SALES COST & PROFIT FOR PULP MILL
PROJECT I

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
REVENUE													
1. SALES TO PAPER MILL													
a. Strong Bagasse													
Pulp - Tons	8600	13000	13600	14150	14350	14700	12000	12000	12000	12000	12000	12000	12000
Unit Sales Price - B.	2688	2688	2688	2688	2688	3045	3045	3045	3045	3045	3045	3045	3045
Gross Revenue '000 B.	23117	34944	36557	38035	38573	44762	36540	36540	36540	36540	36540	36540	36540
b. High Yield Bagasse													
Pulp - Tons	3400	5000	5200	5450	5750	6000	6000	6000	6000	6000	6000	6000	6000
Unit Sales Price - B.	2100	2100	2100	2100	2100	2317	2317	2317	2317	2317	2317	2317	2317
Gross Revenue '000 B.	7140	10500	10920	11445	12075	13902	13902	13902	13902	13902	13902	13902	13902
c. Kenaf Pulp - Tons							3250	3250	3250	3250	3250	3250	3250
Unit Sales Price - B.							3731	3731	3731	3731	3731	3731	3731
Gross Revenue '000 B.							12126	12126	12126	12126	12126	12126	12126

TABLE XXIV (Cont.)

ESTIMATED SALES COST & PROFT FOR PULP MILL
PROJECT I

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
REVENUE (cont.)													
d. Waste Paper Pulp - Tons	600	1000	1050	1100	1200	1200	1200	1200	1200	1200	1200	1200	1200
Unit Sales Price - B.	350	350	350	350	350	355	355	355	355	355	355	355	355
Gross Revenue '000 B.	210	350	368	385	420	426	426	426	426	426	426	426	426
e. Other Income													
2. TOTAL INCOME	30467	45794	47845	49865	51068	59090	62994	62994	62994	62994	62994	62994	62994
COST OF OPERATION, NET INCOME & PROFIT													
3. OPERATING EXPENSE													
a. Manufacturing Expense (incl. Control & Administration)													
1) Strong Bagasse Pulp - Tons	8600	1300	13600	14150	14350	14700	12000	12000	12000	12000	12000	12000	12000

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TABLE XXIV (Cont.)

ESTIMATED SALES COST & PROFIT FOR PULP MILL
PROJECT I

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
COST OF OPERATION, NET INCOME & PROFIT (Cont.)													
3. OPERATING EXPENSE (Cont.)													
a. Mfg. Expense (incl. Control & Administration (Continued)													
Unit Manufacturing Cost -B.	1736	1618	1608	1598	1593	1627	1597	1594	1594	1594	1594	1594	1594
Gross Cost '000 B.	14930	21034	21869	22612	22860	23917	19164	19128	19128	19128	19128	19128	19128
2) High Yield Bagasse Pulp - Tons	3400	5000	5200	5650	5750	6000	6000	6000	6000	6000	6000	6000	6000
Unit Manufacturing Cost - B.	1387	1269	1259	1249	1244	1246	1216	1213	1213	1213	1213	1213	1213
Gross Cost '000 B.	4716	6345	6547	6807	7153	7476	7296	7278	7278	7278	7278	7278	7278

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TABLE XXIV (Cont.)

ESTIMATED SALES COST & PROFIT FOR PULP MILL
PROJECT I

COST OF OPERATION, NET INCOME & PROFIT (Cont.)	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
3) Kenaf Pulp - Tons							3250	3250	3250	3250	3250	3250	3250
Unit Manufacturing Cost - B.							2185	2155	2152	2152	2152	2152	2152
Gross Cost '000 B.							7101	7004	6994	6994	6994	6994	6994
4) Waste Paper Pulp - Tons	600	1000	1050	1100	1200	1200	1200	1200	1200	1200	1200	1200	1200
Unit Manufacturing Cost - B	279	279	279	279	279	284	284	284	284	284	284	284	284
Gross Cost '000 B.	167	279	293	307	335	341	341	341	341	341	341	341	341
TOTAL BASIC MANUFACTURING COST	19813	27658	28709	29726	30348	31734	33902	33751	33741	33741	33741	33741	33741

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TABLE XXIV (Cont.)

ESTIMATED SALES COST & PROFIT FOR PULP MILL
PROJECT I

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
COST OF OPERATION, NET INCOME & PROFIT (Cont.)													
b. General Expenses '000 B. (including Gen. Management, Tech. Management Fees, Insurance, etc.)	6185	6884	4531	4615	4711	2723	2762	2394	1927	1365	1365	1365	1365
4. DEPRECIATION ALLOWANCES													
a. Machinery & Equipment	11850	11850	11850	11850	11850	11850	11850	11850	11580	11850	11580	11850	11850
b. Building & Structures	2035	2035	2035	2035	2035	2035	2035	2035	2035	2035	2035	2035	2035
TOTAL DEPRECIATION	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885	13885

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TABLE XXIV (Cont.)

ESTIMATED SALES COST & PROFIT FOR PULP MILL
PROJECT I

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
5. TOTAL COST OF OPERATIONS BEFORE INTEREST ON LONG TERM DEBT OR TAXES	39883	48427	47125	48226	48944	48342	50549	50030	49553	48991	48991	48991	48991
6. NET INCOME BEFORE INTEREST ON LONG TERM DEBT OR TAXES	(9416)	(2633)	720	1639	2124	10748	12445	12964	13441	14003	14003	14003	14003
7. INTEREST ON LONG TERM DEBT	3404	6809	6298	5617	4936	4255	3575	2894	2213	1532	851	170	0
8. NET PROFIT BEFORE TAXES	(12820)	(9442)	(5578)	(3978)	(2812)	6493	8870	10070	11228	12471	13152	13833	14003
9. TAXES													
a. Sales	0	0	0	0	0	975	1072	1072	1072	1072	1072	1072	1072
b. Income	0	0	0	0	0	1555	1700	2175	2714	2775	2945	3115	3158
TOTAL TAXES	0	0	0	0	0	2530	2772	3247	3786	3847	4017	4187	4230
10. NET PROFIT (OR LOSS) AFTER TAXES	(12820)	(9442)	(5578)	(3978)	(2812)	3963	6098	6823	7442	8624	9135	9646	9773

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TABLE XXV

ESTIMATED SALES COST & PROFITS FOR PULP MILL
PROJECT II

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
REVENUE													
1. SALES TO PAPER MILL													
a. Bamboo Pulp - Tons						12400	20700	21700	21700	21700	21700	21700	21700
Unit Sales Price - B.						3388	3388	3388	3388	3388	3388	3388	3388
Gross Revenue '000 B.						42011	70132	73520	73520	73520	73520	73520	73520
b. Waste Paper Pulp - Tons						1200	1200	1200	1200	1200	1200	1200	1200
Unit Sales Price - B.						663	663	663	663	663	663	663	663
Gross Revenue '000 B.						796	796	796	796	796	796	796	796
c. Other Income													
2. TOTAL INCOME						42807	70928	74316	74316	74316	74316	74316	74316

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TABLE XXV (Cont.)

ESTIMATED SALES COST & PROFITS FOR PULP MILL
PROJECT II

COST OF OPERATION, NET INCOME & PROFIT	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
3. OPERATING EXPENSE													
a. Manufacturing Expense (inc. Control & Administration)													
1) Bamboo Pulp - Tons						12400	20700	21700	21700	21700	21700	21700	21700
Unit Manufacturing Cost B.						771	741	738	738	738	738	738	738
Gross Cost '000 B.						9560	15339	16015	16015	16015	16015	16015	16015
2) Waste Paper Pulp - Tons						1200	1200	1200	1200	1200	1200	1200	1200
Unit Manufacturing Cost B.						530	530	530	530	530	530	530	530
Gross Cost '000 B.						636	636	636	636	636	636	636	636

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TABLE XXV (Cont.)

ESTIMATED SALES COST & PROFITS FOR PULP MILL
PROJECT II

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
COST OF OPERATION, NET INCOME & PROFIT (Cont.)													
TOTAL BASIC MANUFACTURING COST						10196	15975	16651	16651	16651	16651	16651	16651
b. General Expenses '000B. (inc. General Management, Tech. Management Fees, Insurance, etc.)						2560	2841	2507	2035	1478	1478	1478	1478
4. DEPRECIATION ALLOWANCES													
a. Machinery & Equipment						8928	8928	8928	8928	8928	8928	8928	8928
b. Building & Structures						420	420	420	420	420	420	420	420
TOTAL DEPRECIATION						9348	9348	9348	9348	9348	9348	9348	9348

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TABLE XXV (Cont.)

ESTIMATED SALES COST & PROFITS FOR PULP MILL
PROJECT II

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year
5. TOTAL COST OF OPERATIONS BEFORE INTEREST ON LONG TERM DEBT OR TAXES						22104	28164	28506	28034	27477	27477	27477	27477
6. NET INCOME BEFORE INTEREST ON LONG TERM DEBT OR TAXES						20703	42764	45810	46282	46839	46839	46839	46839
7. INTEREST ON LONG TERM DEBT						2336	4672	3971	3037	2102	1168	234	0
8. NET PROFIT BEFORE TAXES						18367	38092	41839	43245	44737	45671	46605	46839
9. TAXES*													
a. Sales						0	0	0	0	0	1226	1226	1226
b. Income						0	0	0		0	11036	11270	11328
TOTAL TAXES											12262	12496	12554
10. NET PROFIT (OR LOSS) AFTER TAXES						18367	38092	41839	43245	44737	33409	34109	34285

*Tax freedom of five years after first sales has been assumed.

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XXIII. CONCLUSIONS

The following conclusions are drawn on the basis of the Feasibility Study covered in this Report.

A. A market of approximately 45,000 tons per year of corrugating and liner boards and multi-wall and grocery bag paper was determined to be available by the time of mill start-up in 1967 and this market was indicated as having a potential to increase to 54,000 tons per year by the seventh year of operations.

B. The fibrous raw materials requirements were determined as being available in the form of sugar cane bagasse to the extent of 40% of the total requirements initially plus a small amount of waste paper together with bamboo, 38%, and kenaf, 6%, in Project II. The amount of imported kraft pulp would be a maximum of 20% after the first full year of operation of the complete mill.

C. The chemical requirements of salt cake, rosin, and alum were ascertained to be necessarily met by imports; lime or limestone, another important chemical was found to be available in Thailand.

D. Fuel for generating steam and power was determined as best being imported fuel oil.

E. A labor force of nearly 500 people was found to be necessary for operation of the mill. Included in the labor force would be a 20-man foreign management staff which would be gradually replaced by Thai personnel.

F. Several suitable sites are available on the Mae Klong River within 100 km of Bangkok.

G. An economically feasible kraft pulp and paper mill can be installed in Thailand provided that (1) the mill is classified as Group A by the Thai Board of Investment and (2) the mill is protected against abnormally low-priced imports by the existing import (license) control system.

H. A workable financing plan has been developed for the proposed mill.

I. The proposed mill will contribute greatly to the economy of Thailand as follows:

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1. It will provide a domestic supply for a major market of paper now imported and, therefore, will save importantly on foreign exchange.

2. It will permit the utilization and development of domestic raw materials.

3. It will create a new financially and socially rewarding employment for many men and women, both in the operation of the mill itself and the supply of the fibrous materials, as well as in other fields of transportation, material supply, and marketing of the products.

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It is the hope of the Parsons & Whittemore and Kearns International Organizations that this Feasibility Study and Project Proposal concerning a kraft pulp and paper mill for Thailand meets with the approval of the Thai Board of Investment, on whose behalf this study and proposal was prepared.

The Parsons & Whittemore Organization , which undertook the preparation of this study and proposal, assures the Thai Board of Investment that full cooperation will be given towards the success of the project.

Respectfully submitted,

PARSONS & WHITTEMORE, INC.

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APPENDIX I

PROMOTION
OF
INDUSTRIAL INVESTMENT ACT
B.E. 2505 (1962)

and

MINISTERIAL REGULATION
No. 1 and No. 2

ANNOUNCEMENT OF THE BOARD OF INVESTMENT
No. 1 and No. 2

Issued in accordance with the provisions of the Promotion of Industrial Investment Act B. E. 2505 (1962)

BOARD OF INVESTMENT
Mansion 2, Rajdamnern Avenue
Bangkok, Thailand

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PROMOTION
OF
INDUSTRIAL INVESTMENT ACT
B.E. 2505

In the name of

His Majesty King Bhumibol Adulyadej

Given on the 31st day of January, B.E. 2505
Being the 17th Year of the Present Reign

His Majesty King Bhumibol Adulyadej is graciously pleased to proclaim that:

Whereas it is expedient to revise the law on promotion of industrial investment so as to be more effective;

Be it, therefore, enacted by the King by and with the advice and consent of the Constituent Assembly acting as the National Assembly, as follows:

Section 1 This Act shall be called the " Promotion of Industrial Investment Act, B.E. 2505 ".

Section 2 This Act shall come into force as and from the day following the date of its publication in the Government Gazette.*

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* Volume 79, Part 12 (Special Issue), dated the 9th February, 2505 (1962).

Section 3 The Promotion of Industrial Investment Act, B.E. 2503 is hereby repealed.

All other laws, regulations and rules in so far as they relate to provisions of this Act or are contrary to or inconsistant with its provisions shall be replaced thereby.

Section 4 In this Act:

"Industrial activity" means industry, agriculture, animal husbandry, fishery, transportation, and provision of facilities for or promotion of tourism as defined by the ministerial regulations or by announcement of the Board issued under Section 5;

"Promoted person" means a natural or juristic person who undertakes an industrial activity and obtains a promotion certificate under this Act;

"Board" means the Board of Investment;

"Executive Committee" means the Executive Board of Investment;

"Member" means a member of the Board of Investment and includes the Chairman of the Board of Investment;

"Executive member" means a member of the Executive Board of Investment and includes the Chairman of the Executive Board of Investment.

Section 5 Industrial activities which may be promoted under this Act are classified into three groups, viz:

(1) Industrial activities under group A. are those which are vital and necessary to the economy of the country, as shall be designated by ministerial regulation defining the categories, sizes, or other conditions applicable to this classification;

(2) Industrial activities under group B. are those which are less vital and necessary to the economy of the country than those under group A., as shall be designated by ministerial regulation defining the categories, sizes, or other conditions applicable to this classification;

(3) Industrial activities under group C. are those other than the industries classified under groups A. and B., in respect to which the categories, sizes, and other conditions shall be defined by announcement of the Board with the approval of the Prime Minister.

Section 6 There shall be a Board of Investment which shall have the powers and duties relating to promotion of industrial investment as

defined herein. It shall consist of the chairman and other members, not exceeding fourteen in number, who shall be appointed by the Cabinet.

The Cabinet may appoint other persons, not exceeding seven in number, to be advisers of the Board.

The Board may appoint any person to be its secretary.

Section 7 A member or adviser of the Board shall hold office for a term of two years.

A retired member or adviser of the Board may be reappointed.

Section 8 Apart from retirement upon expiration of the term of office under Section 7 a member or adviser of the Board vacates his office upon:

(1) death;

(2) resignation;

(3) becoming bankrupt;

(4) being adjudged incompetent or quasi-incompetent;

(5) being convicted and sentenced, by a final judgment, to imprisonment, except for a petty offence or that committed by negligence.

Whenever a member or adviser of the Board vacates his office before the expiration of the term of office, the Cabinet may appoint any other person to fill the vacancy.

The member or adviser of the Board appointed under the foregoing paragraph shall hold office for the remaining term of the member or adviser of the Board he replaces.

Section 9 At any meeting of the Board, attendance of at least one half of the total membership shall be required to constitute a quorum. If the Chairman is absent from the meeting, the members present shall elect one among themselves to be Chairman. Any decision of the meeting shall be taken by a majority of votes.

Each member shall have one vote in casting votes. In case of a tie in voting the Chairman shall cast one extra vote to reach a decision.

Section 10 When the Chairman of the Board is unable to perform his functions, the Prime Minister shall appoint one of the members to act in this capacity.

Section 11 There shall be an Executive Committee of the Board of Investment, consisting of the Chairman of the Board of Investment

as Chairman and other members not to exceed six in number to be appointed by the Cabinet, which shall perform such duties as authorized by resolution of the Board and other administrative functions.

The Executive Board may appoint any person to be its secretary.

An executive member shall remain in office for a term of two years.

A retired executive member may be reappointed.

Section 12 Apart from retirement upon expiration of the term of office under Section 11, the provisions of Section 8 shall apply in the same manner to the executive member.

Section 13 The provisions of Section 9 shall apply in the same manner to a meeting of the Executive Board.

Section 14 The Board or the Executive Board may appoint a Subcommittee to consider or act upon any matter.

The provisions of Section 9 shall apply in the same manner to a meeting of the Subcommittee.

Section 15 Anyone desiring to be a promoted person under this Act shall file an application with the Board according to the form and procedures prescribed by the Board.

Section 16 Upon receipt of an application under Section 15 and determination by the Board that the applicant should be a promoted person under this Act, it shall issue a promotion certificate to the applicant.

In issuing a promotion certificate to an applicant who applies for expansion of an industrial activity, the rights and benefits granted to the applicant shall be limited to that part of the industrial activity so expanded.

The promotion certificate shall be in the form prescribed by ministerial regulation and signed by the Chairman of the Board.

Section 17 In issuing a promotion certificate to a promoted person granting the rights and benefits under this Act, the Board shall have the authority to impose such conditions as it may deem necessary governing the exercise of such rights and benefits.

Section 18 A promoted person shall receive the following guarantees:

(1) The State will not engage in any new industrial activity in competition with that of the promoted person;

(2) The State will not nationalize any private industrial activity.

Section 19 A promoted person shall receive the following rights and benefits:

(1) If the promoted person is a limited company or a partnership registered in Thailand, it shall be permitted to own land for carrying on the industrial activity to such extent as the Board deems fit even in excess of the limit permissible under other law;

(2) Exemption from import duties on the machinery, component parts and accessories which are required for the industrial activity. This shall include prefabricated factory structures to be installed for carrying on the industrial activity or such other materials and equipment for the construction thereof as may be approved by the Board under such conditions as it deems fit, provided that similar materials, approximately equal in price and quality, are not being produced within the country in sufficient quantity;

(3) Exemption from business tax on the machinery, component parts and accessories which are required for the industrial activity. This shall include prefabricated factory structures to be installed for the industrial activity and such other materials and equipment for the construction thereof as may be approved by the Board under such conditions as it deems fit, and irrespective of whether such tax-exempt person be a trader, producer or importer;

(4) In the case where a promoted person is a juristic person, it shall be exempted from taxes on income derived from the industrial activity for five fiscal periods under the Revenue Code beginning with the tax period in which such juristic person has either sold its products or gained an income.

The provisions of the foregoing paragraph shall not apply to a promoted person who receives promotion covering expansion of an industrial activity;

(5) Taking or remitting abroad of money in foreign currency will be permitted if it represents investment capital derived by the promoted person from a foreign country, foreign loan, profit derived from such investment capital, interest on foreign loan, or obligations assumed by

the promoted person under a contract relating to rights and services necessary to the industrial activity, provided however, that during any period when the balance of payment of foreign currency may be such as to require preservation of foreign currency reserved to a reasonable amount, the Bank of Thailand may for that purpose require that the taking or remitting abroad of such money be suspended or restricted temporarily;

(6) Subject to the immigration law, in so far as it is not otherwise provided herein, a promoted person shall be permitted to bring skilled workers or experts, who are aliens, into the country for the purpose of the industrial activity in such number and for such period as authorized by the Board, including their spouses and dependent children as approved by the Board to accompany them, irrespective of whether it is in excess of the quotas provided by the immigration law;

(7) Export of products which have been produced shall always be permitted except when otherwise required by national security or economic interest.

Section 20 Apart from the rights and benefits under Section 19 a promoted person for industrial activity under group A. shall be exempted from the import duty collectable under the law on customs tariffs and from the business tax on raw or necessary materials imported for use in the industrial activity in such quantity as is used or estimated to be used for production within the period of five years as fixed by the Board, provided that such materials approximately equal in price and quality, are not being produced or originated within the country in sufficient quantity.

Section 21 Apart from the rights and benefits under Section 19 a promoted person for industrial activity under group B. shall be granted a reduction of the import duty of one half of the amount collectable under the law on customs tariffs, and of one half of the business tax, on raw or necessary materials imported for the industrial activity in such quantity as is used or estimated to be used for production within the period of five years as fixed by the Board, provided that such materials, approximately equal in price and quality, are not being produced or originated within the country in sufficient quantity.

Section 22 Apart from the rights and benefits under Section 19 the Board with the approval of the Cabinet may grant to a promoted

person for industrial activity under group C. a reduction of import duty not exceeding one-third of the amount collectable under the law on customs tariffs and of not exceeding one-third of the business tax on raw or necessary materials imported for undertaking the industrial activity to such a quantity as is likely to be used for production within the period of five years as fixed by the Board, provided that such materials, approximately equal in price and quality, are not being produced or originated within the country in sufficient quantity.

Section 23 Apart from the rights and benefits under Section 19, Section 20, Section 21 and Section 22 if the Board deems it expedient for the national economic interest a promoted person may receive one or more special rights and benefits as follows:

(1) Prohibition, under the law on control of exports and imports of certain kinds of goods, of the import of products of the same kind as those produced by the promoted person for such period as the Board deems fit;

(2) Increase of import duty collectable under the law on customs tariffs for products of the same kind as those produced by the promoted person for such period as the Board deems fit;

(3) Exemption from, or reduction of export duty collectable under the law on customs tariffs for the products produced by the promoted person for such period as the Board deems fit;

(4) Exemption from, or reduction of business tax in case the promoted person exports his own products for such period as the Board deems fit.

Section 24 After five years from the date this Act takes effect, any promoted persons for industrial activities under groups A. and B. who thereafter begin operations of the industrial activities shall not receive the rights and benefits under Section 20 and Section 21, and such industrial activities shall be regarded as those under group C.

Section 25 In case the promoted person dies or transfers his activity to another person the promotion certificate shall be valid for a period not exceeding ninety days therefrom, and if the heir or transferee fails to apply to be a promoted person within the said period such promotion certificate shall expire.

In case the heir or transferee applies to be a promoted person within the said period, the provisions of Section 15 and Section 16 shall apply to him in the same manner, and such person shall receive only such rights and benefits and for such unexpired period as would remain to the former promoted person.

Section 26 In case a promoted person violates or fails to comply with the conditions imposed by the Board under Section 17, the Board shall be empowered to issue an order withdrawing wholly or partly the rights and benefits granted to the promoted person.

Section 27 After the Board has issued a promotion certificate to a promoted person under this Act, the Chairman of the Board shall without delay inform the Ministries, Dabuangs and Departments concerned of the issuance of the promotion certificate as well as the particulars of rights and benefits granted to the promoted person.

After the Board has issued an order withdrawing the rights and benefits granted to a promoted person under Section 26, the Chairman of the Board shall without delay inform the promoted person, Ministries, Dabuangs and Departments concerned of such order.

Section 28 Any industrial activity which may be prohibited or which can be undertaken only under certain conditions and for a specific period, shall be so designated by the ministerial regulations.

The ministerial regulations issued under the foregoing paragraph shall in no way affect industrial activities undertaken or permitted to be established or undertaken prior to the date of publication of the said ministerial regulation.

Section 29 The Board or the Executive may invite any person to give facts, explanations, opinions or technical advice.

Section 30 An executive member or competent official is empowered to enter the premises of the applicant and of the promoted person between sunrise and sunset for inquiry into facts or examination of documents or things in connection with the industrial activity from any person in such premises as is necessary. For this purpose the applicant and the promoted person must render appropriate facilities.

In case an executive member or competent official proposes to enter the premises as provided in the foregoing paragraph, the applicant

and the promoted person shall, except in case of emergency, be notified in writing at reasonable time in advance.

Section 31 In performing the functions under Section 30 the competent official shall show his identity card when requested by the person concerned.

The identity card of the competent official shall be in accordance with the form determined in the ministerial regulation.

Section 32 A sum of money shall be appropriated in the annual budget of expenditure as expenses for the work of the Board and of the Executive Board.

The with-drawal and disbursement of such funds shall be made in accordance with the rules laid down by the Board with the approval of the Cabinet.

Section 33 The members, executive members and advisers of the Board shall receive such remuneration as determined by the Cabinet.

Section 34 Applications for promotion which are pending consideration at the date of publication of this Act in the Government Gazette shall be regarded as having been filed under this Act.

Section 35 A person who has received promotion under the law on promotion of industrial investment at the date of publication of this Act in the Government Gazette shall be regarded as a promoted person under this Act, and the industrial activities already promoted shall be regarded as industrial activities under group A., B. or C. according to the ministerial regulations or orders issued under Section 5, as the case may be. Any industrial activities already promoted which do not fall under any of the aforesaid groups shall then be regarded as industrial activities under group C., provided however that the rights or benefits granted shall not be affected and will remain in effect under such obligation and timing conditions as theretofore imposed.

Section 36 Whoever obstructs or fails to render facilities to the executive member or competent official to perform the work authorized under Section 30 shall be liable to a fine not exceeding five hundred Baht.

Section 37 The Prime Minister shall have authority and responsibility for the execution of this Act, and shall have the power to appoint the competent officials and to issue the ministerial regulations for the execution of this Act.

Such ministerial regulations shall come into effect upon their publication in the Government Gazette.

Counter-signature:

Field Marshal S. Dhanarajata
The Prime Minister

MINISTERIAL REGULATION

No. 1 *

(B.E. 2505)

Issued in accordance with the provisions of
the Promotion of Industrial Investment Act B.E. 2505

By virtue of Section 5 and Section 37 of the Promotion of Industrial Investment Act B.E. 2505, the Prime Minister issues the following Ministerial Regulation:

The industrial activity of group A. and the industrial activity of group B. lying within the scope of being promoted in accordance with the Promotion of Industrial Investment Act B.E. 2505 shall have the categories, sizes and conditions as specified in the list attached to this Ministerial Regulation.

Given on the 10th February B.E. 2505

Field Marshal S. Dhanarajata
Prime Minister

* Published in the Government Gazette, Volume 79 Part 13 (Special Issue), dated the 10th February, B.E. 2505 (1962).

LIST ATTACHED TO
THE MINISTERIAL REGULATION
No. 1 (B.E. 2505)
Issued in accordance with the provisions of
THE PROMOTION OF INDUSTRIAL INVESTMENT ACT
B.E. 2505

The Industrial Activity of Group A.

Serial Number	Categories	Sizes	Conditions
1	Iron Smelting Industry (Smelting of iron ores into pig iron)	All sizes	Machinery and equipment approved by the Board must be used.
2	Steel Making Industry (Producing steel from pig iron or steel scraps)	All sizes	Machinery and equipment approved by the Board must be used.
3	Tin Smelting Industry	Daily producing capacity of not less than twenty thousand kilogrammes of tin metal	Machinery and equipment approved by the Board must be used and the metal produced must have a purity of not less than 99.5 per cent with smelting losses of not more than 2 per cent.
4	Lead Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and the metal produced must have a purity of not less than 99.8 per cent with smelting losses of not more than 5 per cent.

Serial Number	Categories	Sizes	Conditions
5	Zinc Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and the metal produced must have a purity of not less than 99.8 per cent with smelting losses of not more than 5 per cent.
6	Copper Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and the metal produced must have a purity of not less than 99.8 per cent with smelting losses of not more than 5 per cent.
7	Antimony Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and the metal produced must have a purity of not less than 99.8 per cent with smelting losses of not more than 5 per cent.
8	Tungsten Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and must be capable of smelting mixed tungsten or producing pure tungsten according to international standards.

Serial Number	Categories	Sizes	Conditions
9	Manganese Smelting Industry	All sizes	Machinery and equipment approved by the Board must be used and must be capable of smelting mixed manganese according to international standards.
10	Tractor Producing or Assembling Industry	Annual producing or assembling capacity of not less than one hundred tractors	Machinery and equipment approved by the Board must be used.
11	Motor Vehicle Spare Parts Industry	All sizes	Machinery and equipment approved by the Board must be used.
12	Bicycle or Tricycle With or Without Engine Industry	Sizes requiring capital investments of not less than five million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
13	Internal-Combustion or Electrical Prime-Moving Engine Industry	Sizes requiring capital investments of not less than three million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used and the quality of the products must be in accordance with international standards.
14	Agricultural Machinery Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
15	Water Pump Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used and the quality of the products must be in accordance with international standards.
16	Machine Tool Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used and the quality of the products must be in accordance with international standards.
17	Cast-Iron, Steel, Asbestos Cement or Plastic Pipe Industry	Sizes requiring capital investments of not less than ten million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
18	Motor Vehicle Tire or Inner Tube Industry	Annual producing capacity of not less than 50,000 of either tires or tubes	Machinery and equipment approved by the Board and mainly domestic raw rubber must be used.
19	Carbondioxide Industry	Daily producing capacity of not less than two thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material [illegible]hibited, if similar [illegible]rial of suitable [illegible]ty is available in [illegible]land. The quality of the products must be in accordance with international standards.

Serial Number	Categories	Sizes	Conditions
20	Caustic Soda Industry	Daily producing capacity of not less than five thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.
21	Sodium Carbonate or Soda Ash Industry	Daily producing capacity of not less than twenty five thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.
22	Ammonia Industry	Daily producing capacity of not less than ten thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.

Serial Number	Categories	Sizes	Conditions
23	Nitric Acid Industry	Daily Producing capacity of not less than five thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.
24	Hydrochloric Acid Industry	Daily producing capacity of not less than three thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.
25	Concentrated Latex Industry	Annual producing capacity of not less than four hundred thousand kilogrammes of 60 per cent concentrated latex	Machinery and equipment approved by the Board and domestic natural latex must be used.
26	Chemical Fertilizer Industry	Daily producing capacity of not less than fifty thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand. The quality of the products must be in accordance with international standards.

Serial Number	Categories	Sizes	Conditions
27	Plastic Powder Industry	Sizes requiring capital investments of not less than ten million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
28	Synthetic Fibre Industry	Daily producing capacity of not less than three thousand kilogrammes	Machinery and equipment approved by the Board must be used.
29	Lac Products Industry	Annual producing capacity of not less than five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.
30	Household Electrical Appliances Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
31	Fungicide or Insecticide Industry	Sizes requiring capital investments of not less than five million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.
32	Radio Parts Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
33	Television Parts Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
34	Electronic Products Industry Other Than Those in No. 32 and No. 33	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
35	Photographic Film, Cinematographic Film or X-ray Film Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
36	Sweet Condensed Milk Industry	Annual producing capacity of not less than one hundred and fifty thousand kilogrammes of sweet condensed milk	Machinery and equipment approved by the Board and the formula officially permitted must be used and must use refined sugar locally produced.
37	Vegetable Oil Industry	Daily producing capacity of not less than five hundred kilogrammes	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.

Serial Number	Categories	Sizes	Conditions
38	Cold Storage Industry	In Bangkok and Dhonburi must have the energy of refrigeration by absorbing heat not less than three hundred and two thousand kilogrammes calorie (refrigeration of one hundred tons); in other towns must have the energy of refrigeration by absorbing heat not less than sixty thousand kilogrammes calorie (refrigeration of twenty tons)	Machinery and equipment approved by the Board must be used.

for hours

The Industrial Activity of Group B.

Serial Number	Categories	Sizes	Conditions
1	Ship Building Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	The ships built must not be smaller than one hundred tons displacement and machinery and equipment approved by the Board must be used.
2	Passenger Car and Truck Producing or Assembling Industry	Annual producing or assembling capacity of not less than three hundred units	It must be capable of producing or assembling passenger cars and trucks and machinery and equipment approved by the Board must be used.
3	Internal - Combustion or Electrical Prime-Moving Engine Assembling Industry	Sizes requiring capital investments of not less than three million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.
4	Agricultural Machinery Assembling Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
5	Water Pump Assembling Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.

Serial Number	Categories	Sizes	Conditions
6	Machine Tool Assembling Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital).	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.
7	Carpenter or Black-Smith's Tools Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
8	Producing or Assembling Sewing Machine Industry	Sizes requiring capital investments of not less than five million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
9	Sewing Thread Industry	There must be not less than one thousand spindles of doubling frame	Machinery and equipment approved by the Board must be used.
10	Paper Industry	Annual producing capacity of not less than two million kilogrammes	Machinery and equipment approved by the Board must be used.
11	Wood-Pulp Industry	Annual producing capacity of not less than two million kilogrammes	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
12	Electric Wire or Cable Industry	Sizes requiring capital investments of not less than three million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The quality of the products must be in accordance with international standards.
13	Electric Accessories	Sizes requiring capital investments of not less than five hundred thousand Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The quality the products must be of in accordance with international standards.
14	Household Electrical Appliances Assembling Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
15	Spectacle Glass or Lens Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
16	Fountain-Pen Industry	Annual producing capacity of not less than one hundred thousand fountain-pen	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
17	Food Canning Industry (Using cans or other airtight containers)	Annual producing capacity of not less than five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used and must be capable of producing good quality food in cans or other airtight containers. Mainly domestic raw material must be used.
18	Concentrated Cream or Evaporated Milk Industry	Annual producing capacity of either kind or both of not less than fifty thousand kilogrammes	Machinery and equipment approved by the Board and the formula officially permitted must be used.

MINISTERIAL REGULATION
No. 2*
(B.E. 2505)

Issued in accordance with the provisions of
the Promotion of Industrial Investment Act B.E. 2505

By virtue of Section 16 and Section 17 of the Promotion of Industrial Investment Act B.E. 2505, the Prime Minister issues the following Ministerial Regulation:

The promotion certificate shall be according to the form attached to this Ministerial Regulation.

Given on the 10th February B.E. 2505

Field Marshal S. Dhanarajata
Prime Minister

* Published in the Government Gazette, Volume 79 Part 13 (Special Issue), dated the 10th February, B.E. 2505 (1962).

PROMOTION CERTIFICATE

No...../.....

The Board of Investment issues this Promotion Certificate to show that.....
whose office is situated at.....
and who has submitted an application to receive promotion to carry on the industrial activity.....
.....
activity of group.....is the Promoted Person in accordance with the Promotion of Industrial Investment Act B.E. 2505 and shall receive the rights and benefits and in exercising the rights and benefits observe the conditions as follows:

Rights and Benefits

.....
.....
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.....
.....

Conditions

The Board has laid down conditions for the Receiver of this Promotion Certificate, in exercising the rights and benefits to observe as follows:

.....
.....
.....
.....
.....

Given on.....B.E.....

Chairman of the Board

ANNOUNCEMENT
OF
THE BOARD OF INVESTMENT
No. 1 *
(B.E. 2505)

Issued in accordance with the provisions of
the Promotion of Industrial Investment Act B.E. 2505

By virtue of Section 4 and Section 5 of the Promotion of Industrial Investment Act B.E. 2505, the Chairman of the Board of Investment has issued this Announcement, as follows:

The industrial activities of group C. which are within the scope of being promoted in accordance with the Promotion of Industrial Investment Act B.E. 2505, shall have the categories, sizes and conditions as specified in the list attached to this Announcement.

Issued on the 27th February B.E. 2505

Tawee Bunyaketu

Chairman of the Board of Investment

* Published in the Government Gazette, Volume 79 Part 25, dated the 13th March B.E. 2505 (1962).

LIST ATTACHED TO

THE ANNOUNCEMENT OF THE BOARD OF INVESTMENT

NO. 1 (B.E. 2505)

Issued in accordance with the provisions of

THE PROMOTION OF INDUSTRIAL INVESTMENT ACT B.E. 2505

The Industrial Activity of Group C.

Serial Number	Categories	Sizes	Conditions
1	Mineral Oil Prospecting	All sizes	Machinery and equipment approved by the Board must be used.
2	Crude Oil Producing Industry	Daily producing capacity of not less than one hundred and fifty thousand litres	Machinery and equipment approved by the Board must be used.
3	Oil Refining and Distilling Industry	Use not less than one hundred and fifty thousand litres of crude oil daily	Machinery and equipment approved by the Board must be used.
4	Lead Ore Producing and/or Dressing Industry	Annual producing capacity of not less than one million kilogrammes of concentrate calculated on the basis of 70 per cent of lead metal	Machinery and equipment approved by the Board must be used.
5	Zinc Ore Producing and/or Dressing Industry	Annual producing capacity of not less than one million kilogrammes of concentrate calculated on the basis of 60 per cent of zinc metal	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
6	Copper Ore Producing and/or Dressing Industry	Annual producing capacity of not less than one million kilogrammes of concentrate	Machinery and equipment approved by the Board must be used.
7	Antimony Ore Producing and/or Dressing Industry	Annual producing capacity of not less than five hundred thousand kilogrammes of concentrate	Machinery and equipment approved by the Board must be used.
8	Tungsten Ore Producing and/or Dressing Industry	Annual producing capacity of not less than one hundred thousand kilogrammes of concentrate	Machinery and equipment approved by the Board must be used.
9	Manganese Ore Producing and/or Dressing Industry	Annual producing capacity of not less than five hundred thousand kilogrammes of concentrate	Machinery and equipment approved by the Board must be used.
10	Steel Working Industry (Fabricated steel products and castings)	All sizes	Machinery and equipment approved by the Board must be used.
11	Rolling Mill Industry	Annual producing capacity of not less than one million kilogrammes	Machinery and equipment approved by the Board must be used.
12	Tin Plate Industry	Annual producing capacity of not less than one million kilogrammes	Machinery and equipment approved by the Board must be used.
13	Galvanized Iron Wire Industry	Annual producing capacity of not less than one million kilogrammes	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
14	Galvanized Iron Pipe Industry	Annual producing capacity of not less than one million five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
15	Other Galvanized Iron Products Industry	Annual Producing capacity of not less than five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
16	Barbed-Wire Industry	Annual producing capacity of not less than five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
17	Bolt and Nut Industry	Annual producing capacity of not less than five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
18	Agricultural Tool and Implement Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
19	Electric Bulb Industry	All sizes	Machinery and equipment approved by the Board must be used.
20	Radio Receiving Set Manufacturing or Assembling Industry	Annual producing or assembling capacity of not less than one thousand sets	Machinery and equipment approved by the Board must be used.
21	Television Receiving Set Manufacturing or Assembling Industry	Annual producing or assembling capacity of not less than one thousand sets	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
22	Spinning From Cotton, Natural Fibre or Synthetic Fibre Industry	There must be not less than 3,000 spindles of spinning frame	Machinery and equipment approved by the Board must be used.
23	Weaving From Cotton, Natural Fibre or Synthetic Fibre Industry	There must be not less than 50 looms	Machinery and equipment approved by the Board must be used.
24	Cotton, Natural Fibre or Synthetic Fibre Products Industry	Daily producing capacity of not less than five hundred kilogrammes	Machinery and equipment approved by the Board must be used.
25	Bleaching, Dyeing, Printing or Finishing of Fabric or Yarn Industry	Total daily producing capacity of not less than five hundred kilogrammes by weight or three thousand square metres by area	Machinery and equipment approved by the Board must be used.
26	Rope or Mat Industry	Annual producing capacity of either kind or both of not less than one hundred and fifty thousand kilogrammes	Machinery and equipment approved by the Board must be used.
27	Cocoa-nut Fibre or Shell Products Industry	Annual producing capacity of either kind or both of not less than one hundred thousand kilogrammes	Machinery and equipment approved by by the Board must be used.
28	Bicycle Tire or Inner Tube Industry	Annual producing capacity of not less than (A) fifty thousand tires (B) one hundred thousand inner tubes (C) thirty-five thousand sets of tire and inner tube	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
29	Hard Rubber (Ebonite) Products Industry	Annual producing capacity of not less than thirty thousand kilogrammes	Machinery and equipment approved by the Board must be used.
30	Rubber Products (Other Than Those in No. 28 and No. 29) Industry	If rubber smoked sheet or rubber crepe is used as raw material, not less than thirty thousand kilogrammes must be used annually. If rubber latex is used as raw material, not less than ten thousand kilogrammes must be used annually.	Machinery and equipment approved by the Board and mainly domestic raw rubber must be used.
31	Reclaimed Rubber Industry	Annaul producing capacity of not less than three hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
32	Turpentine or Dammar Industry	Annual producing capacity of not less than twenty thousand kilogrammes of turpentine oil or not less than one hundred thousand kilogrammes of dammar	Machinery and equipment approved by the Board must be used.
33	Wood Shaving and Cement Board Industry	Annual producing capacity of not less than one thousand five hundred cubic metres	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited if similar material of suitable quality is available in Thailand.

Serial Number	Categories	Sizes	Conditions
34	Wood Parquet Flooring Industry	Daily producing capacity of not less than two cubic metres	Machinery and equipment approved by the Board must be used.
35	Wood Drying or Curing Industry	Curing capacity of not less than ten cubic metres	Machinery and equipment approved by the Board must be used.
36	Wood Preserving Industry	Annual preserving capacity of not less than seven thousand five hundred cubic metres	Machinery and equipment approved by the Board must be used.
37	Wood Distilation Industry	Daily use not less than one hundred cubic metres of wood	Machinery and equipment approved by the Board must be used.
38	Pressed Sawdust Industry (Briquettes)	Annual producing capacity of not less than two million and five hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
39	Glazed Ceramic Industry	Annual producing capacity of not less than one hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand.
40	Floor or Wall Ceramic Tile Industry	Annual producing capacity of not less than one hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used. The use of foreign raw material is prohibited, if similar material of suitable quality is available in Thailand.

Serial Number	Categories	Sizes	Conditions
41	Edible Flour Industry	Annual producing capacity of not less than three million kilogrammes	Machinery and equipment approved by the Board must be used.
42	Tea Industry	Annual producing capacity of not less than 20,000 kilogrammes of tea leaf or tea dust	Machinery and equipment approved by the Board must be used.
43	Rice-Bran Oil Industry	Use not less than fifty thousand kilogrammes of rice bran daily	Machinery and equipment approved by the Board must be used.
44	Agricultural Products Curing Industry	Hourly capacity of curing agricultural products of not less than five thousand kilogrammes	Machinery and equipment approved by the Board must be used.
45	Tannin Producing Industry	Daily producing capacity of not less than two thousand kilogrammes	Machinery and equipment approved by the Board must be used.
46	Artificial Leather Producing Industry	Sizes requiring capital investments of not less than five million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
47	Paint Industry	Daily producing capacity of not less than five thousand kilogrammes	Machinery and equipment approved by the Board must be used.
48	Printing Ink Industry	Annual producing capacity of not less than fifty thousand kilogrammes	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
49	Feather Selecting and Cleaning Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
50	Neutral Glass Industry	Sizes requiring capital investments of not less than three million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used, and mainly domestic raw material must be used.
51	Crystal Glass Ware Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
52	Modern Pharmaceutical Products Industry	Sizes requiring capital investments of not less than ten million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The pharmaceutical products produced must be manufactured from natural material or at least from intermediates or from domestic medicinal herbs or plants.
53	Electric Storage Battery Wet-type Industry	Annual producing capacity of not less than fifteen thousand wet-type electric batteries suitable for motor vehicle use	Machinery and equipment approved by the Board must be used.
54	Pencil Industry	Annual producing capacity of not less than one million pencils	Machinery and equipment approved by the Board must be used.

Serial Number	Categories	Sizes	Conditions
55	Button Industry	Sizes requiring capital investments of not less than five hundred thousand Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
56	Rattan and Bamboo Product Industry	Annual producing capacity of not less than three hundred thousand kilogrammes	Machinery and equipment approved by the Board must be used.
57	Deep Sea Fishing Industry	Engage fishing boat capacity of not less than thirty tons gross	Must fish in sea of not less than depth of thirty metres and must have a factory on shore in Thailand for processing fish and machinery and equipments approved by the Board must be used.
58	Fish Processing Industry	Daily capacity of processing raw fish of not less than five thousand kilogrammes	Machinery and equipment approved by the Board must be used.
59	Pearl Oyster Culture Industry	Sizes requiring capital investments of not less than two million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. The pearl oyster culture must begin with the rearing of oyster up to the production of pearls and other production from the mother-of-pearl.

Serial Number	Categories	Sizes	Conditions
60	Marble Industry	Sizes requiring capital investments of not less than ten million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used. Mainly the product must be produced for export abroad.
61	Mineral Water Bottling Industry	Sizes requiring capital investments of not less than one million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
62	Hotel Industry	In Bangkok and Dhonburi must have from one hundred rooms upwards; in other towns must have from 30 rooms upwards	Must be a first class hotel, the designed plan, accessories and equipment of which must be approved by the Board.
63	International Sea-transportation Industry	Engage sea-going vessel capacity of not less than eight thousand tons gross	Must carry on shipping between Thailand and foreign countries and must undertake to train Thai as students in navigation and marine engineering.

LIST OF MEMBERS
OF
THAILAND'S BOARD OF INVESTMENT*

The following is the list of Members and Advisers of Thailand's Board of Investment as appointed by the Council of Ministers after the announcement of the Promotion of Industrial Investment Act B.E. 2505 (1962):

1. Mr. Tawee Bunyaketu	Chairman
2. Dr. Chalong Harinsuta	Committee Member
3. Major-General Chalermchai Charuvastr	Committee Member
4. Mr. Chalong Puagtrakul	Committee Member
5. Rear Admiral Chalie Sindusopon	Committee Member
6. Mr. Panchert Cholavichea	Committee Member
7. Luang Yuktasevi Vivat	Committee Member
8. Mr. Leng Srisomwong	Committee Member
9. Lieutenant-General Vichai Phoags Ananta	Committee Member
10. Mr. Vicha Sethabutra	Committee Member
11. Mr. Sphrang Devahastin Na Ayuthya	Committee Member
12. Mr. Serm Viritchaikul	Committee Member
13. Luang Samriddhi Visavakam	Committee Member
14. Mr. Osot Kosin	Committee Member
15. Major-General Amporn Chintakanon	Committee Member
16. Minister for Finance	Adviser
17. Minister for Foreign Affairs	Adviser
18. Minister for Agriculture	Adviser
19. Minister for Interior	Adviser
20. Minister for Economics	Adviser
21. Minister for Industry	Adviser
22. Governor of the Bank of Thailand	Adviser

The Executive Members of the Board are:

1. Mr. Tawee Bunyaketu	Chairman
2. Rear Admiral Chalie Sindusopon	Executive Member
3. Luang Yuktasevi Vivat	Executive Member
4. Mr. Leng Srisomwong	Executive Member
5. Mr. Sphrang Devahastin Na Ayuthya	Executive Member
6. Luang Samriddhi Visavakam	Executive Member
7. Mr. Osot Kosin	Executive Member

* Published in the Government Gazette, Volume 79 Part 13 (Special Issue), dated the 16th February, B.E. 2505 (1962).

ANNOUNCEMENT
OF
THE BOARD OF INVESTMENT
No. 2*
(B.E. 2505)

Issued in accordance with the provisions of
the Promotion of Industrial Investment Act B.E. 2505

By virtue of Section 4 and Section 5 of the Promotion of Industrial Investment Act B.E. 2505, the Chairman of the Board of Investment, has, with the approval of the Prime Minister, issued additional announcement, as follows:

Additional industrial activities should be made to group C. which are within the scope of being promoted in accordance with the Promotion of Industrial Investment Act B.E. 2505, and they shall have the categories, sizes and conditions as specified in the list attached to this Announcement.

Issued on the 25th July B.E. 2505

Tawee Bunyaketu
Chairman of the Board of Investment

* Published in the Government Gazette, Volume 79 Part 69, dated the 31st July B.E. 2505 (1962).

LIST ATTACHED TO

THE ANNOUNCEMENT OF THE BOARD OF INVESTMENT

NO. 2 (B.E. 2505)

Issued in accordance with the provisions of

THE PROMOTION OF INDUSTRIAL INVESTMENT ACT B.E. 2503

The Industrial Activity of Group C.

Serial Number	Categories	Sizes	Conditions
64	Wire Net for Protection of Insects Industry	Sizes requiring capital investments of not less than four million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
65	Glass Sheet Industry	Sizes requiring capital investments of not less than ten million Baht (not including value of land and circulating capital)	Machinery and equipment approved by the Board must be used.
66	Galvanised Iron Sheet Industry	Annual producing capacity of not less than ten million kilogrammes	Machinery and equipment approved by the Board must be used.

APPENDIX NO. II

In the decade 1956-65 total world demand is estimated to grow at the annual rate of 4.8 percent. and in the following decade (1966-75) at the rate of 4.6 percent, reaching total tonnages of some 90 millions and 141 millions in 1965 and 1975, respectively. This means that the world's pulp and paper industry in the relatively short period of 20 years (1965-75) may grow to two and a half times its present size.

Consumption will, of course, grow at different rates in different regions of the world. Table 1 shows the expected evolution of demand for all categories of papers and paperboard and the annual growth rates implied.

Table 1

Region	Total Paper and Board Demand million metric tons 1955	1965	1975	Annual Growth Rate 1956-75 %
North America	31.5	42.8	58.6	3.2
Latin America	1.8	3.5	6.5	6.6
Western Europe	13.2	21.3	30.2	4.3
Eastern Europe	1.9	3.9	7.1	6.8
U.S.S.R.	2.5	6.1	12.3	8.4
Africa	.5	.9	1.6	6.2
Near and Middle East	.14	.28	.53	6.9
Far East	3.0	6.9	13.8	8.0
Mainland China	.9	3.1	8.8	12.3
Oceania	.8	1.3	1.8	4.5
World Total	56.1	90.0	141.4	4.7

Note: Figures may not add up because of rounding

FAO WASHINGTON MEMORANDUM

APPENDIX NO. III
(1,000 metric tons)

REGION	Economic growth rate per capita percent per year		Newsprint			Other paper and paperboard			Total paper and board		
	1955-65	1965-75	1955	1965	1975	1955	1965	1975	1955	1965	1975
1. North America	2.25	2.00	6,351	8,300	10,300	25,171	35,400	47,000	31,522	43,700	57,300
2. Latin America	2.50	2.00	495	1,000	1,800	1,327	2,500	4,700	1,822	3,500	6,500
3. Western Europe	2.50	2.00	2,648	4,200	6,000	10,505	15,500	21,200	13,153	19,700	27,200
4. Western Europe	... see text ...		222	450	900	1,668	3,200	5,700	1,890	3,700	6,600
5. U.SSR	... see text ...		307	850	1,800	2,168	5,300	10,600	2,475	6,100	12,400
6. Africa	2.00	2.00	102	190	350	384	700	1,300	486	900	1,600
7. Near and Middle East	2.00	2.00	31	65	120	108	210	400	139	280	520
8. Far East (excl.9-10)	2.00	2.00	221	430	850	609	1,160	2,300	830	1,600	3,100
9. Jap an	4.50	4.00	454	950	1,600	1,695	3,600	6,400	2,149	4,500	8,000
10. China Mainland	... see text ...		141	500	1,600	727	2,400	7,200	868	2,900	8,800
11. Oceania	2.50	2.00	310	450	600	450	800	1,200	760	1,300	1,800
WORL D TOTAL			11, 280	17,400	26,000	44,810	70,700	108,000	56,090	88,090	134,000

Note: Totals may not add up because of rounding of figures in the World Total

PAPERSONS WITHMORE

APPENDIX No. IV

ESTIMATED EXISTING CAPACITY AND CURRENT EXPANSION PLANS, BY REGIONS

	Rated Capacity 1958				Current Expansion Plans				Estimate of Future Rated Capacity				
	News print	Other paper and paper board	Total paper and paper board	Paper pulp	News print	Other paper and paper board	Total paper and paper board	Paper pulp	News prin	Other paper and paper board	Total paper and paper board	Paper pulp	Estimate Target Date
	1,000 metric tons												
North America	8,521	32,533	41,054	33,730	678	3,238	3,916	1,240	9,200	35,770	44,970	34,970	1961/62
Latin America	150	1,500	1,650	830	405	915	1,320	1,410	560	2,420	2,980	2,240	1964/65
Western Europe	3,910	14,750	18,660	14,750	740	2,965	3,705	4,950	4,520	17,720	22,240	19,690	1963/65
Africa	-	270	270	175	70	90	160	345	70	360	430	520	1964/65
Near and Middle East	15	65	80	50	40	285	325	110	60	360	420	160	"
Far East	700	3,685	4,385	2,700	480	1,140	1,620	960	1,180	4,830	6,010	3,660	"
Oceania	170	400	570	480	70	190	260	150	240	590	830	630	"
Rest of the World	980	6,150	7,130	6,565	945	5,215	6,160	5,435	1,930	11,370	13,300	12,090	1965
TOTAL	14,446	59,353	73,799	59,280	3,428	14,038	17,460	14,600	17,760	73,420	91,180	73,960	

APPENDIX NO. V

HEHNER & COX, LTD.

DIRECTORS
DR. JULIUS GRANT, M.Sc., F.R.I.C.
C. W. AYLEN.

ANALYTICAL & CONSULTING CHEMISTS.
PUBLIC ANALYSTS.

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The Laboratories,
107, Fenchurch Street,
London, E.C.3.

OUR REF. JG/DR 25102
YOUR REF.

16th April, 1963

ANALYSIS OF FIVE SAMPLES OF Paper (Thailand Project)

RECEIVED ON 27th March, 1963

MARKED A - E

SEALED -----

	A	B1
Substance (gm. per sq. m.)	123.7	126.7
Caliper (mm)	0.18	0.19
Bulk factor	1.44	1.48
Bursting strength (kg. per sq. cm.)	4.79	4.93
Burst factor	38.7	37.2
Ash (per cent)	1.0	0.7
Fibre furnish (approx. per cent)		
Chemical coniferous	35 (kraft)	20
Chemical deciduous	-	-
Semichemical coniferous	-	80
Semichemical deciduous	65	-
Bamboo	-	-
Groundwood	-	-

KEY

A - Corrugating Medium (Finland)
B1, B2 - Corrugating Medium (2 Samples ex Japan)
C - Wrapping (Kanchanaburi Mill)
D - Lined Board (U. S. A.)
E - Corrugating Medium (Australia)

Parsons & Whittemore Inc., New York.

B2	C	D	E
126.6	93.9	160.1	107.8
0.21	0.14	0.21	0.21
1.70	1.52	1.30	1.96
2.17	1.30	7.45	2.17
17.2	13.8	51.0	20.2
1.1	1.8	0.9	1.0
-	)	100 (unbleached	25
-	) 30	kraft)	75
-)	-	-	-
-) 85	-	-	-
-	70	-	-
15	-	-	-

p. p. HEHNER & COX LTD.

D. Grant.

APPENDIX VI

PAPER IMPORTS INTO THAILAND - 1962 (FROM NOVEMBER 1962 ISSUE OF THE IMPORTS AND EXPORTS OF THAILAND - DEPT. OF CUSTOMS)

IMPORTS

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6330998	Articles of natural cork, n.e.s.	PORTUGAL	03	859	39343
		U KINGDOM	03	158	17158
				1488	77701*
6330999	Articles of agglomerated cork, n.e.s.	PORTUGAL	03	10740	168828
		SPAIN	03	248	19893
		U KINGDOM	03	1	145
		U STATES	03	22	4541
				11011	193407*
6410100	Newsprint	PAKISTAN	03	101380	305691
		JAPAN	03	196393	670570
		TAIWAN	03	152649	639608
		ALBANIA	03	286824	777239
		AUSTRIA	03	716243	1983499
		CZECHO	03	343013	1017784
		FINLAND	03	4835998	13418220
		NORWAY	03	2282948	6654336
		POLAND	03	1893918	5797334
		SWEDEN	03	4571320	12013671
		U STATES	03	76841	284490
				15457527	43562442*
6410201	Printing paper, in rolls and sheets, not cut to size	JAPAN	03	6991343	38716087
		TAIWAN	03	837348	3918259
		AUSTRIA	03	67685	367382
		BELGIUM	03	3259	43682
		CZECHO	03	49294	400357
		FINLAND	03	417956	2180533
		W GERMANY	03	28330	281631
		ITALY	03	5080	47069
		NETHERLANDS	03	16091	168179
		NORWAY	03	1226153	6251181
		POLAND	03	50757	131321
		SWEDEN	03	394586	2389575
		U KINGDOM	03	2690	27683
		YUGOSLAVIA	03	5080	50872
		U STATES	03	41989	678769
				10137641	55652580*
6410202	Writing paper, in rolls and sheets, not cut to size	JAPAN	03	5030829	24745841
		TAIWAN	03	10160	68725
		AUSTRIA	03	21664	184044
		W GERMANY	03	4969	109715
		NORWAY	03	76319	502484
		U KINGDOM	03	382	4157
		YUGOSLAVIA	03	5080	50846
		U STATES	03	2162	40337
				5151565	25706150*
6410301	Paper, straw	HONGKONG	03	457792	1911001
		FED MALAY	03	12300	49200
		MACAO	03	375890	1607968
		JAPAN	03	55881	185461
		TAIWAN	03	72101	189347
				973964	3942977*
6410302	Paper, kraft	HONGKONG	03	6300	27354
		JAPAN	03	1334680	5830514
		TAIWAN	03	193072	953524
		AUSTRIA	03	30119	144478
		FINLAND	03	422866	1701191
		LUXEMBURG	03	29858	159581
		NETHERLANDS	03	72966	340618
		NORWAY	03	178147	853378
		POLAND	03	156113	684945
		SWEDEN	03	1239509	5171486
		U KINGDOM	03	4772	14911
		U STATES	03	3202476	11299817
		AUSTRALIA	03	10259	25966
				6881137	27207763*
6410390	Paper, common, for packing and wrapping, n.e.s.	HONGKONG	03	12344	271009
		JAPAN	03	85367	540013
		TAIWAN	03	28133	251048
		AUSTRIA	03	5010	25854
		CZECHO	03	4775	23264
		DENMARK	03	43	167
		FINLAND	03	17214	94171
		FRANCE	03	161	12817
		W GERMANY	03	32809	671160
		NETHERLANDS	03	249	7220
		NORWAY	03	354524	1016570
		POLAND	03	301150	986992
		SPAIN	03	4996	31882
		SWEDEN	03	294545	1561664
		U KINGDOM	03	49249	1208835
		U STATES	03	110007	425967
				1308576	7128633*
6410401	Cardboard, common	JAPAN	03	194636	474505
		TAIWAN	03	109227	223537
				303863	698042*
6410402	Cardboard, corrugated	FINLAND	03	28825	75290

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6410402	Cardboard, corrugated	NETHERLANDS	03	2196	44931
				31021	120221*
6410499	Cardboard, n.e.s.	SINGAPORE	03	516	10860
		JAPAN	03	9063775	26565784
		TAIWAN	03	617250	1254140
		AUSTRIA	03	13613	73354
		CZECHO	03	37202	157152
		FINLAND	03	1503979	4188118
		W GERMANY	03	62333	446057
		NETHERLANDS	03	106527	477207
		NORWAY	03	474656	1884718
		SWEDEN	03	228363	696649
		U KINGDOM	03	2419	22123
		YUGOSLAVIA	03	39359	169944
		U STATES	03	2019839	5158111
		AUSTRALIA	03	47478	117150
				14217309	41221367*
6410500	Building board of paper or of pulp, not impregnated	JAPAN	03	1134	26662
		AUSTRIA	03	773	16028
		NORWAY	03	109540	336562
		SWEDEN	03	72195	294707
		U KINGDOM	03	208	8859
				183850	682818*
6410600	Paper and paperboard, bituminized or asphalted, including reinforced and coated with graphite in imitation of slate	JAPAN	03	140625	492788
		AUSTRIA	03	7225	12727
		BELGIUM	03	9698	46029
		W GERMANY	03	14658	132745
		ITALY	03	2800	9025
		NETHERLANDS	03	18288	106396
		SWEDEN	03	18233	93862
		U KINGDOM	03	152652	355333
		U STATES	03	3585	39589
		AUSTRALIA	03	511	3975
				368275	1292469*
6410701	Paper, wrapping, oiled	HONGKONG	03	2511	59889
		JAPAN	03	2034	18238
		DENMARK	03	1700	18183
		W GERMANY	03	628	14596
		SWEDEN	03	8607	58427
		U KINGDOM	03	12737	195641
		U STATES	03	6882	118000
				35099	482974*
6410702	Paper, adhesive	JAPAN	03	7554	98766
		FINLAND	03	3900	36809
		FRANCE	03	764	13683
		W GERMANY	03	21011	264229
		NETHERLANDS	03	33436	323179
		NORWAY	03	1208	11711
		SWEDEN	03	22252	237726
		U KINGDOM	03	18031	256699
		CANADA	03	45	40780
		U STATES	03	3101	92944
		AUSTRALIA	03	164	12357
				111466	1388863*
6410703	Paper, enamelled	HONGKONG	03	6434	238634
		JAPAN	03	74308	513886
		AUSTRIA	03	33034	219866
		CZECHO	03	17142	104911
		FINLAND	03	26668	147672
		FRANCE	03	12	235
		E GERMANY	03	5822	58200
		W GERMANY	03	70542	705211
		ITALY	03	4929	43397
		NORWAY	03	172556	466388
		POLAND	03	458646	1318239
		SWEDEN	03	82771	456127
		U KINGDOM	03	218	2673
		U STATES	03	130976	1355285
				1084058	5630664*
6410704	Paper, stencil, in rolls	JAPAN	03	32	6082
		AUSTRIA	03	445	19507
		FINLAND	03	11786	62063
		U KINGDOM	03	72	4548
		U STATES	03	144	6263
				12479	98403*
6410706	Paper, tracing, in rolls	FRANCE	03	75	3652
		W GERMANY	03	9867	260545
		SWITZERLAND	03	8	240
		U KINGDOM	03	921	32854
		U STATES	03	289	22368
				11160	319659*
6410799	Paper and paperboard, coated, impregnated, vulcanized etc., n.e.s., other than bituminized or asphalted	HONGKONG	03	216	3788
		JAPAN	03	117695	1164660
		BELGIUM	03	1844	47747
		DENMARK	03	5	755

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6410799	Paper and paperboard, coated, impregnated, vulcanized etc., n.e.s., other than bituminized or asphalted	FRANCE	03	7	460
		F GERMANY	03	1430	17160
		W GERMANY	03	29005	303210
		NORWAY	03	13689	77703
		POLAND	03	50699	220571
		SWEDEN	03	65576	246059
		U KINGDOM	03	7492	194740
		CANADA	03	938	18540
		U STATES	03	20162	394300
				308758	2689701*
6410801	Wallpaper, including lincrusta	HONGKONG	03	3123	49509
		JAPAN	03	683	20150
		BELGIUM	03	3867	45953
		FINLAND	03	300	1056
		W GERMANY	03	1695	21059
		U KINGDOM	03	2645	34348
				12313	172075*
6411100	Cigarette paper, in bulk rolls or sheets	JAPAN	03	3674	51102
		FRANCE	03	133348	2194188
		U KINGDOM	03	1351	52269
		U STATES	03	334331	5725908
				472704	8023467*
6411201	Blotting paper, in bulk rolls or sheets	AUSTRIA	03	9898	55241
		W GERMANY	03	14510	99868
		NETHERLANDS	03	3000	20851
		U KINGDOM	03	2126	25665
				29534	201625*
6411202	Filter paper, in bulk rolls or sheets	JAPAN	03	972	23122
		DENMARK	03	14	1100
		W GERMANY	03	18114	758530
		SWEDEN	03	6	1218
		U KINGDOM	03	1990	89447
		U STATES	03	1899	88190
				22995	961607*
6411203	Filter blocks	W GERMANY	03	4	337
		U KINGDOM	03	3838	181722
		U STATES	03	36	4066
				3878	186125*
6411901	Drawing paper, bristol cardboard	JAPAN	03	188572	983470
		TAIWAN	03	189726	1038851
		AUSTRIA	03	10489	66856
		FRANCE	03	52	2090
		W GERMANY	03	1199	19155
		NORWAY	03	22170	153601
		U KINGDOM	03	593	43238
		U STATES	03	20	2075
				412821	2309336*
6411902	Paper glazed transparent	JAPAN	03	129652	1420582
		AUSTRIA	03	74476	718947
		FINLAND	03	447	8971
		FRANCE	03	16	1866
		W GERMANY	03	7180	131156
		ITALY	03	111219	1003737
		NETHERLANDS	03	390	11682
		NORWAY	03	4724	32960
		U KINGDOM	03	6292	115058
		U STATES	03	819	8401
		AUSTRALIA	03	24137	230266
				359352	3683626*
6411904	Greaseproof paper and paperboard	JAPAN	03	41246	228477
		AUSTRIA	03	12113	119912
		W GERMANY	03	1162	11711
		ITALY	03	3000	28256
		NETHERLANDS	03	23088	200440
		NORWAY	03	39665	282353
		SWEDEN	03	39929	264150
		U KINGDOM	03	12919	352587
		U STATES	03	1129	15199
				174251	1503085*
6411905	Composite paper or paperboard, not surface-coated or impregnated, whether or not internally reinforced	HONGKONG	03	1362	3913
		JAPAN	03	8885	56432
		FINLAND	03	7546	30122
		W GERMANY	03	1927	23248
		U KINGDOM	03	5252	105797
		U STATES	03	28362	989515
				53334	1209027*
6411906	Paper or paperboard, creped, crinkled, embossed or perforated	JAPAN	03	5419	22123
		AUSTRIA	03	63811	1089872
		FINLAND	03	2261	16830
		W GERMANY	03	4000	63104
		ITALY	03	1155	33721
		NETHERLANDS	03	17280	145135
		AUSTRALIA	03	5777	99025
				99703	1469810*

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6411907	Paper or paperboard, ruled, lined or squared, but not otherwise printed, in bulk rolls or sheets	JAPAN	03	8	484
		FRANCE	03	61	4977
		W GERMANY	03	1363	38415
		U KINGDOM	03	153	19373
		U STATES	03	1299	63260
				2884	126509*
6411908	Tissue paper, in bulk rolls or sheets	JAPAN	03	66341	520613
		TAIWAN	03	5080	58425
		AUSTRIA	03	13040	128906
		CZECHO	03	50571	457089
		W GERMANY	03	55	6898
		NORWAY	03	27284	260502
		SWEDEN	03	24353	272021
		U KINGDOM	03	39026	515575
		U STATES	03	8689	185676
				234441	2405705*
6411999	Paper and paperboard, in bulk rolls or sheets, n.e.s.	HONGKONG	03	23	6003
		JAPAN	03	355468	1587384
		TAIWAN	03	17841	199078
		AUSTRIA	03	1666	20352
		BELGIUM	03	1148	24588
		CZECHO	03	27358	104688
		FINLAND	03	15743	45356
		FRANCE	03	51	6754
		W GERMANY	03	60875	567523
		ITALY	03	5376	71916
		NETHERLANDS	03	18332	114523
		NORWAY	03	87936	3065406
		POLAND	03	171235	457588
		SWEDEN	03	10420	53411
		U KINGDOM	03	8236	101337
		U STATES	03	56295	253909
				1629426	6679810*
6420101	Paper bags	HONGKONG	03	6020	142612
		FED MALAY	03	140	820
		SINGAPORE	03	1270	10413
		JAPAN	03	971101	4980271
		FINLAND	03	880061	4280642
		W GERMANY	03	2026	8955
		NETHERLANDS	03	30	348
		NORWAY	03	85531	390802
		SWEDEN	03	501545	2011243
		SWITZERLAND	03	4	109
		U KINGDOM	03	3264	48952
		U STATES	03	208821	865851
				2659813	12741018*
6420102	Cardboard boxes	HONGKONG	03	68906	772950
		FED MALAY	03	53	544
		PAKISTAN	03	740	1642
		SINGAPORE	03	20482	291273
		JAPAN	03	99880	929840
		TAIWAN	03	389	2019
		AUSTRIA	03	11	825
		BELGIUM	03	76	448
		DENMARK	03	1353	21994
		FRANCE	03	2835	108057
		W GERMANY	03	13647	227434
		ITALY	03	2367	94024
		NETHERLANDS	03	14205	57365
		SWEDEN	03	365	1846
		SWITZERLAND	03	2270	55252
		U KINGDOM	03	80413	961172
		CANADA	03	823	14765
		U STATES	03	91696	1280898
		AUSTRALIA	03	2225	24674
				402736	4847022*
6420103	Box files, letter trays, storage boxes and similar articles, of paper or paperboard	U KINGDOM	03	20	739
		U STATES	03	70	1000
				90	1739*
6420199	Other containers, of paper or cardboard, n.e.s.	HONGKONG	03	25536	323774
		SINGAPORE	03	225	20007
		JAPAN	03	46993	267810
		TAIWAN	03	7	588
		BELGIUM	03	15	358
		CZECHO	03	99	220
		FINLAND	03	10761	107837
		FRANCE	03	76	1904
		W GERMANY	03	976	13990
		ITALY	03	678	47935
		NETHERLANDS	03	30284	274951
		NORWAY	03	42075	195451
		U KINGDOM	03	67549	769705
		CANADA	03	1028	20058
		U STATES	03	239142	2718275
		UN S AFRICA	03	778	8400
		AUSTRALIA	03	609	4955
				466825	4776218*

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6420201	Envelopes	HONGKONG	03	26566	318243
		FED MALAY	03	10	427
		JAPAN	03	16831	123881
		TAIWAN	03	13	521
		CZECHO	03	2	2000
		DENMARK	03	112	4276
		FRANCE	03	7	637
		W GERMANY	03	480	14424
		NETHERLANDS	03	290	1981
		NORWAY	03	14450	244042
		SWEDEN	03	7061	104002
		SWITZERLAND	03	295	5506
		U KINGDOM	03	29429	669380
		U STATES	03	2743	112185
		AUSTRALIA	03	40	1489
				98319	1602994*
6420202	Paper for typewriting, duplicating, writing, cut to size	FED MALAY	03	4	117
		JAPAN	03	526126	2576299
		AUSTRIA	03	58267	445116
		CZECHO	03	3218	32576
		DENMARK	03	3	260
		FRANCE	03	98	3599
		W GERMANY	03	258	7907
		NETHERLANDS	03	1585	5187
		SWEDEN	03	286	2251
		SWITZERLAND	03	7	183
		U KINGDOM	03	43828	691991
		YUGOSLAVIA	03	8944	20513
		U STATES	03	16098	671271
		AUSTRALIA	03	468	5058
				659184	4462327*
6420203	Paper, foolscap for correspondence	HONGKONG	03	1005	28030
		FED MALAY	03	3	136
		SINGAPORE	03	70	1836
		JAPAN	03	106	1867
		FRANCE	03	5	126
		U KINGDOM	03	242	5598
		U STATES	03	1	100
				1432	37693*
6420204	Writing blocks, letter cards	HONGKONG	03	139	4080
		FED MALAY	03	7	364
		JAPAN	03	7452	123416
		AUSTRIA	03	4060	46420
		DENMARK	03	14	415
		FRANCE	03	10	311
		W GERMANY	03	113	1713
		NORWAY	03	10088	66646
		POLAND	03	1120	10116
		SWEDEN	03	6045	69919
		U KINGDOM	03	12813	214690
		U STATES	03	47	3235
				41918	541325*
6420205	Plain postcards, correspondence cards	HONGKONG	03	7	400
		JAPAN	03	4037	26412
				4044	26812*
6420290	Paper stationery, n.e.s., packeted or boxed	HONGKONG	03	100	3669
		FED MALAY	03	1	177
		JAPAN	03	555	28537
		AUSTRIA	03	16	7588
		W GERMANY	03	829	16015
		U KINGDOM	03	926	29743
		U STATES	03	24	3196
				2451	88925*
6420301	Albums	HONGKONG	03	7908	80699
		JAPAN	03	52285	1387238
		TAIWAN	03	720	19217
		BELGIUM	03	32	6296
		W GERMANY	03	100	8529
		U KINGDOM	03	5	874
		U STATES	03	101	2144
				61151	1504987*
6420302	Diary books, note books, memorandum books	HONGKONG	03	3619	81599
		INDIA	03	106	1401
		FED MALAY	03	52	2038
		SINGAPORE	03	2	493
		JAPAN	03	44835	508246
		AUSTRIA	03	15	468
		BELGIUM	03	14	269
		CZECHO	03	9	146
		FRANCE	03	59	3677
		W GERMANY	03	306	8212
		HUNGARY	03	75	627
		ITALY	03	10	1012
		NETHERLANDS	03	408	7261
		SWITZERLAND	03	423	23986
		U KINGDOM	03	9656	277670

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6420302	Dairy books, note books, momorandum books	U STATES	03	548	57959
		AUSTRALIA	03	271	6170
				60408	981234*
6420303	Books, exercise	U KINGDOM	03	70	1986
				70	1986*
6420304	Account books, register books	HONGKONG	03	60	1154
		FED MALAY	03	520	33043
		U KINGDOM	03	225	18430
		U STATES	03	14	861
				819	53488*
6420305	Order books, receipt books	FED MALAY	03	17	529
		JAPAN	03	150	2905
		FRANCE	03	60	2874
		U KINGDOM	03	814	40000
				1041	46308*
6420307	Paper and paperboard files and binders	HONGKONG	03	1706	20139
		FED MALAY	03	7	610
		JAPAN	03	269	3007
		BELGIUM	03	5	174
		DENMARK	03	18	767
		FRANCE	03	153	4929
		W GERMANY	03	3071	22973
		SWEDEN	03	349	9462
		U KINGDOM	03	3777	127470
		U STATES	03	268	26107
				9623	215638*
6420308	Book covers, paper	FED MALAY	03	1	134
		JAPAN	03	527	12617
		AUSTRIA	03	1650	20555
		W GERMANY	03	13311	95109
		U KINGDOM	03	39	3830
		CANADA	03	60	706
		U STATES	03	193	7042
				15781	139993*
6420399	Other manufactures of writing paper, n.e.s.	HONGKONG	03	1388	10945
		FED MALAY	03	121	4732
		SINGAPORE	03	36	2769
		JAPAN	03	803	15346
		FRANCE	03	4	532
		W GERMANY	03	829	19184
		U KINGDOM	03	129	5444
		U STATES	03	2568	50997
				5878	109949*
6420901	Cigarette paper, cut to size	JAPAN	03	390	5227
				390	5227*
6420902	Carbon paper, cut to size	HONGKONG	03	46	6516
		ISRAEL	03	769	29279
		JAPAN	03	1078	22710
		TAIWAN	03	413	21129
		AUSTRIA	03	11394	644631
		DENMARK	03	286	11777
		FRANCE	03	394	25549
		W GERMANY	03	12642	772952
		ITALY	03	82	1851
		NETHERLANDS	03	716	35368
		POLAND	03	15481	114776
		SWEDEN	03	2	291
		U KINGDOM	03	11559	771133
		U STATES	03	6547	622627
		AUSTRALIA	03	747	37819
				62156	3118408*
6420903	Paper towels, napkins and tablecloth and similar articles	JAPAN	03	11864	156689
		AUSTRIA	03	5605	109857
		DENMARK	03	8	110
		FINLAND	03	1000	12847
		W GERMANY	03	2346	39012
		NETHERLANDS	03	2135	31334
		SWEDEN	03	342	8123
		U KINGDOM	03	65944	1048270
		U STATES	03	37362	719252
				126606	2125494*
6420904	Dress patterns	JAPAN	03	314	3699
		W GERMANY	03	15	284
				329	3983*
6420905	Blotting paper, cut to size	JAPAN	03	71	1627
		BELGIUM	03	23	143
		FRANCE	03	20	415
		W GERMANY	03	13208	91745
		NORWAY	03	3420	31443
		U KINGDOM	03	1902	29063
		U STATES	03	348	28429
		AUSTRALIA	03	37	2113
				19027	184978*

Commodity Code	Commodity Description	Country	Unit Code	Quantity	C.I.F. Value (Baht)
6420906	Toilet paper in sheets or in rolls	FED MALAY	03	33456	201047
		PENANG	03	247	1546
		JAPAN	03	178705	1438930
		TAIWAN	03	2911	18466
		AUSTRIA	03	44236	523441
		FRANCE	03	1950	13822
		W GERMANY	03	165	1020
		ITALY	03	9513	83579
		NETHERLANDS	03	12080	89335
		NORWAY	03	65480	614307
		SWEDEN	03	4577	29447
		U KINGDOM	03	228163	2291375
		U STATES	03	14986	174318
		AUSTRALIA	03	2607	28960
				599076	5509593*
6420907	Paper, plates, cups, spoons, forks and similar articles, including drinking straw	HONGKONG	03	232	7875
		SINGAPORE	03	1641	62500
		JAPAN	03	45	654
		DENMARK	03	1100	16129
		W GERMANY	03	3467	110533
		ITALY	03	56	934
		NETHERLANDS	03	17	904
		SWITZERLAND	03	72	1713
		U KINGDOM	03	5056	137347
		U STATES	03	16168	449619
		UN S AFRICA	03	11407	119079
		AUSTRALIA	03	8624	173020
				47885	1080307*
6420908	Paper, tapes, rolls, cards, discs for cash and other accounting registers and adding machines, clocks, index cards and the likes	FED MALAY	03	22	517
		PENANG	03	3	214
		JAPAN	03	30655	243044
		AUSTRIA	03	484	2199
		DENMARK	03	6	1681
		FINLAND	03	464	6135
		FRANCE	03	104	2486
		W GERMANY	03	10744	117084
		ITALY	03	510	8148
		NETHERLANDS	03	877	7738
		SWEDEN	03	14461	87518
		SWITZERLAND	03	724	53203
		U KINGDOM	03	7910	124074
		U STATES	03	88835	1312177
				155799	1966218*
6420909	Paper stencil and the likes, cut to size	ISRAEL	03	41	2054
		JAPAN	03	6136	260752
		AUSTRIA	03	3386	198822
		DENMARK	03	1644	67588
		FRANCE	03	8	417
		W GERMANY	03	10622	525142
		ITALY	03	5400	58161
		NETHERLANDS	03	161	7740
		SWEDEN	03	20	872
		U KINGDOM	03	29042	1615740
		U STATES	03	729	51924
		AUSTRALIA	03	3719	126130
				60908	2915342*
6420911	Transfer paper, such as used in lithographic work	HONGKONG	03	65	1617
		JAPAN	03	36	4400
				101	6017*
6420912	Sanitary towels	JAPAN	03	3306	33330
		TAIWAN	03	4588	24698
		W GERMANY	03	448	8560
		SWEDEN	03	380	2400
		U KINGDOM	03	303171	7810138
		AUSTRALIA	03	185	1150
				312078	7880276*
6420913	Bobbins, spools, cops and similar supports of paper sulp, paper or paperboard	JAPAN	03	196	2490
				196	2490*
6420914	Articles of pulp, of paper, of paperboard or of cellulose wadding, n.e.s.	HONGKONG	03	390	12056
		FED MALAY	03	9	1816
		SINGAPORE	03	3370	55140
		JAPAN	03	59961	507630
		AUSTRIA	03	45	7266
		BELGIUM	03	195	7219
		DENMARK	03	18	1111
		FRANCE	03	174	19946
		W GERMANY	03	7281	173757
		NORWAY	03	6333	69628
		POLAND	03	12800	60027
		SWEDEN	03	4957	35349
		U KINGDOM	03	6371	113533
		CANADA	03	16	14595
		U STATES	03	15296	545813
		AUSTRALIA	03	137	15000
				117343	1639886*
6510101	Silk yarn, other than yarn of noil or other waste silk, not put up for retail sale	JAPAN	03	76844	19711968

APPENDIX VII

The full list of known import restrictions on paper in Thailand are given below:

"The following qualities of paper are allowed free import into the Kingdom:

Newsprint, normally imported from 50/52 grs/sqm in substance.
Pitched Kraft Paper.
Green and Blue match paper.
Glassine and Cellophane paper.
Greaseproof paper.
Airmail paper.
Glazed two sides machine coated white art paper.

2. Import licenses are required for the following qualities of paper when importing into the Kingdom:

Glazed or Unglazed woodfree or non-woodfree writing or printing paper weighing from 120 grs/sqm upwards.
Cap paper weighing from 30 grs/sqm upwards (to 120 grs/sqm).
White linen faced paper weighing from 35 grs/sqm upwards (to 120 grs/sqm)
Poster paper weighing from 30-120 grs/sqm.
Kraft paper weighing from 32-121 grs/sqm.
Wrapping paper, except the following:

(a) Brown paper for packing cement imported by The Cement Factory for own use.
(b) Ribbed ocean paper.
(c) Wrapping paper with designs for wrapping presents.
(d) Green and Blue paper for wrapping match boxes and candles.
(e) Glassine and cellophane paper.
(f) Greaseproof paper.

It is essential that import licenses for the above mentioned papers will only be granted when the importers agree to buy one-third of the quantity ordered from abroad from local paper mills.

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3. Further import licenses are required for the following paper qualities/products.

   Exercise books (license will not normally be granted)
   All kinds of paper bags, except those for packing cement or tapioca flour exclusively, or those specially made with clear indications that they are for packing the goods imported and the importers' specific trade names appearing thereon:
   Joss paper.
   Used newspaper.
   Paper fans and umbrellas
   Paper used in Chinese prayers.

4. The Lottery Department has a monopoly of importing the following qualities of paper:

   Glazed or Unglazed woodfree or non-woodfree writing or printing paper weighing <u>under</u> 120 grs/sqm. Normally, however, they only import into the Kingdom one quality, viz. Glazed White Woodfree Hardsized Writing Paper in sheets of 31"x43" in the following substances - 50, 60, 70, 80 & 100 grs/sqm.

5. The following qualities of paper are prohibited to import into the Kingdom:

   Newsprint from 56 grs/sqm upwards (to 120 grs/sqm).
   Duplicating paper under 120 grs/sqm.
   Imitation art paper, weighing under 120 grs/sqm.

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Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	articles made up from goods falling within heading No. 46.01 or 46.02; articles of loofah.			
	Section X			
	PAPER-MAKING MATERIAL; PAPER AND PAPERBOARD AND ARTICLES THEREOF			
	Chapter 47			
	PAPER-MAKING MATERIAL.			
47.01	Pulp derived by mechanical or chemical means from any fibrous vegetable material.	27.5	-	-
47.02	Waste paper and paperboard; scrap articles of paper or of paperboard, fit only for use in paper-making.			
	(a) Old newspaper	-	Kg.	1.00
	(b) Other	27.5	-	-
	Chapter 48			
	PAPER AND PAPERBOARD; ARTICLES OF PAPER PULP, OF PAPER OR OF PAPERBOARD.			
	Notes.			
	1.- This Chapter does not cover : (a) Stamping foils of heading No. 32.09; (b) Perfume and cosmetic papers (heading No.33.06); (c) Soap papers (heading No.34.01), detergent coated papers (heading No.34.02) and cellulose wadding, impregnated with polishes, creams or similar preparations (heading No.34.05); (d) Paper or paperboard, sensitised (heading No.37.03); (e) Paper-reinforced stratified plastic sheeting (headings Nos.39.01 to 39.06), or vulcanised fibre (heading No.39.03), or articles of such materials (heading No. 39.07);			

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	(f) Goods falling within heading No. 42.02 (for example, travel goods); (g) Articles falling within any heading in Chapter 46 (manufactures of plaiting material); (h) Paper yarn or textile articles of paper yarn (Section XI); (ij) Abrasive paper (heading No. 68.06) or paper-backed mica splittings (heading No. 68.15) (paper coated with mica powder is, however, to be classified in heading No. 48.07); (k) Paper - backed metal foil (Section XV); (l) Perforated paper or paperboard for musical instruments (heading No. 92.10); or (m) Goods falling within any heading in Chapter 97 (for example, toys, games and sports requisites) or Chapter 98 (for example, buttons). 2.- Subject to the provisions of Note 3, headings Nos. 48.01 and 48.02 are to be taken to include paper and paperboard which have been subjected to calendering, super-calendering, glazing or similar finishing, including false water-marking, and also to paper and paperboard coloured or marbled throughout the mass by any method. They do not apply to paper or paperboard which has been further processed, for example, by coating or impregnation. 3.- Paper or paperboard answering to a description in two or more of the headings Nos.48.01 to 48.07 is to be classified under that one of such headings which occurs latest in the Customs Tariff. 4.- Headings Nos. 48.01 to 48.07 are to be taken not to apply to paper, paperboard or cellulose wadding : (a) In strips or rolls of a width not exceeding fifteen centimetres; or (b) In rectangular sheets (unfolded if			

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	necessary) of which no side exceeds thirty-six centimetres; or (c) Cut into shapes other than rectangular shapes. Except that hand-made paper in any size or shape as made directly and having all its edges deckled remains classified, subject to the provisions of Note 3, within heading No. 48.02. 5.- For the purposes of heading No. 48.11, "wallpaper and lincrusta" are to be taken to apply only to : (a) Paper in rolls, suitable for wall or ceiling decoration, being : (i) Paper with one or with two margins, with or without guide marks; or (ii) Paper without margins, surface-coloured or design-printed, coated or embossed, of a width not exceeding sixty centimetres; (b) Borders, friezes and corners of paper, of a kind used for wall or ceiling decoration. 6.- Heading No. 48.15 is to be taken to apply, inter alia, to paper wool, paper strip (whether or not folded or coated) of a kind used for plaiting, and to toilet paper in rolls or packets, but not to the articles mentioned in Note 7. 7.- Heading No. 48.21 is to be taken to apply, inter alia, to cards for statistical machines, perforated paper and paperboard cards for Jacquard and similar machines, paper lace, shelf edging, paper tablecloths, serviettes and handkerchiefs, paper gaskets, moulded or pressed goods of wood pulp, and dress patterns. 8.- Paper, paperboard and cellulose wadding, and articles thereof, printed with characters or pictures which are merely incidental to the primary use of the goods are included in this Chapter otherwise regarded as printed matter falling within Chapter 49.			

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	I. - PAPER AND PAPERBOARD, IN ROLLS OR IN SHEETS.			
48.01	Paper and paperboard (including cellulose wadding), machine-made, in rolls or sheets.			
	(a) Weighing three hundred grammes or more per square metre	10	-	-
	(b) Weighing less than three hundred grammes per square metre.			
	(1) Cigarette paper	-	Kg.	16.50
	(2) Newsprint paper	-	Kg.	0.33
	(3) Other	10	-	-
48.02	Hand-made paper and paperboard.	10	-	-
48.03	Parchment or greaseproof paper and paperboard, and imitations thereof, and glazed transparent paper, in rolls or sheets.	10	-	-
48.04	Composite paper or paperboard (made by sticking flat layers together with an adhesive), not surface - coated or impregnated, whether or not internally reinforced, in rolls or sheets.	10	-	-
48.05	Paper and paperboard, corrugated (with or without flat surface sheets), creped, crinkled, embossed or perforated, in rolls or sheets.	10	-	-
48.06	Paper and paperboard, ruled, lined or squared, but not otherwise printed, in rolls or sheets.	10	-	-
48.07	Paper and paperboard, impregnated, coated, surface-coloured, surface-decorated or printed (not being only ruled, lined or squared, falling within heading No.48.06 and not constituting printed matter within Chapter 49), in rolls or sheets.			
	(a) Weighing three hundred grammes or more per square metre	10	-	-
	(b) Weighing less than three hundred grammes per square metre			
	(1) Carbon paper and similar copying paper	-	Kg.	7.70
	(2) Other	10	-	-

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
48.08	Filter blocks of paper pulp.	10	-	-
48.09	Building board of wood pulp or of vegetable fibre, whether or not bonded with natural or artificial resins or with similar binders.	30	-	-
	II. - PAPER AND PAPERBOARD CUT TO SIZE OR SHAPE AND ARTICLES OF PAPER OR PAPERBOARD.			
48.10	Cigarette paper, cut to size, whether or not in the form of booklets or tubes.	-	Kg.	16.50
48.11	Wallpaper and lincrusta; window transparencies of paper.	10	-	-
48.12	Floor coverings prepared on a base of paper or of paperboard, whether or not cut to size, with or without a coating of linoleum compound.	30	Kg.	3.00
48.13	Carbon and other copying papers (including duplicator stencils) and transfer papers, cut to size, whether or not put up in boxes.			
	(a) Carbon paper and similar copying paper	-	Kg.	7.70
	(b) Other	-	Kg.	1.10
48.14	Writing blocks, envelopes, letter cards, plain postcards, correspondence cards; boxes, pouches, wallets and writing compendiums, of paper or paperboard, containing only an assortment of paper stationery.	-	Kg.	2.75
48.15	Other paper and paperboard, cut to size or shape.			
	(a) Foolscap paper	-	Kg.	0.66
	(b) Other	-	Kg.	1.10
48.16	Boxes, bags and other packing containers, of paper or paperboard.			
	(a) Being a kind could not have been satisfactorily manufactured in Thailand and imported for containing exported goods, as may be prescribed by the Director - General of Customs	-	Kg.	0.55
	(b) Cardboard box	-	Kg.	1.10
	(c) Other	-	Kg.	6.60

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Unit
48.17	Box files, letter trays, storage boxes and similar articles, of paper or paperboard, of a kind commonly used in offices, shops and the like.	-	Kg.	1.10
48.18	Registers, exercise books, note books, memorandum blocks, order books, receipt books, diaries, blotting-pads, binders (loose-leaf or other), file covers and other stationery of paper or paperboard; sample and other albums and book covers, of paper or paperboard.	-	Kg.	2.75
48.19	Paper or paperboard labels, whether or not printed or gummed.	10	-	-
48.20	Bobbins, spools, cops and similar supports of paper pulp, paper or paperboard (whether or not perforated or hardened).	10	-	-
48.21	Other articles of paper pulp, paper, paperboard or cellulose wadding.			
	(a) Joss paper	60	Kg.	30.00
	(b) Other	10	-	-

Chapter 49

PRINTED BOOKS, NEWSPAPERS, PICTURES AND OTHER PRODUCTS OF THE PRINTING INDUSTRY; MANUSCRIPTS, TYPESCRIPTS AND PLANS.

Notes.

1.- This Chapter does not cover :

(a) Paper, paperboard, or cellulose wadding, or articles thereof, in which printing is merely incidental to their primary use (Chapter 48);

(b) Playing cards or other goods falling within any heading in Chapter 97; or

(c) Original engravings, prints or lithographs (heading No. 99.02), postage, revenue or similar stamps falling within heading No. 99.04, antiques of an age exceeding one hundred years or other articles falling

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	within any heading in Chapter 99.			
	2.- Newspapers, journals and periodicals which are bound otherwise than in paper, and sets of newspapers, journals or periodicals comprising more than one number under a single cover are to be treated as falling within heading No.49.01 and not within heading No.49.02.			
	3.- Heading No.49.01 is to be extended to apply to: (a) A collection of printed reproductions of, for example, works of art or drawings, with a relative text, put up with numbered pages in a form suitable for binding into one or more volumes; (b) A pictorial supplement accompanying, and subsidiary to, a bound volume; and (c) Printed parts of books or booklets, in the form of assembled or separate sheets or signatures, constituting the whole or a part of a complete work and designed for binding. However, printed pictures or illustrations not bearing a text, whether in the form of signatures or separate sheets, fall in heading No.49.11.			
	4.- Headings Nos.49.01 and 49.02 are to be taken not to apply to publications issued for advertising purposes (including tourist propaganda). Such publications are to be taken as falling within heading No.49.11.			
	5.- For the purposes of heading No.49.03, the expression "children's picture books" means books for children in which the pictures form the principal interest and the text is subsidiary.			
	6.- For the purposes of heading No.49.06, the expression "manuscripts and typescripts" is to be taken to extend to carbon copies or copies on sensitised paper of manuscripts and typescripts. References in this Chapter to printed matter of any kind include references to any matter of that kind which is reproduced by means of a duplicating machine.			
	7.- For the purposes of heading No.49.09,			

Item No.	Classification	Rate of Duty		
		Ad valorem Per cent	Specific Duty	
			Unit	Rate per Unit Baht
	the expression "picture postcards" means cards consisting essentially of an illustration and bearing printed indications of their use.			
	———			
49.01	Printed books, booklets, brochures, pamphlets and leaflets.		Free	
49.02	Newspapers, journals and periodicals, whether or not illustrated.		Free	
49.03	Children's picture books and painting books.		Free	
49.04	Music, printed or in manuscript, whether or not bound or illustrated.		Free	
49.05	Maps and hydrographic and similar charts of all kinds, including atlases, wall maps and topographical plans, printed; printed globes (terrestrial or celestial).		Free	
49.06	Plans and drawings, for industrial, architectural, engineering, commercial or similar purposes, whether original or reproductions on sensitised paper; manuscripts and typescripts.		Free	
49.07	Unused postage, revenue and similar stamps of current or new issue of Thailand; stamp-impressed paper; banknotes, stock, share and bond certificates and similar documents of title; cheque books.			
	(a) Stock, share, bond and similar documents of title, and cheque books with space for writing or printing	-	Kg.	2.75
	(b) Other		Free	
49.08	Transfers (Decalcomanias).	27.5	-	-
49.09	Picture postcards, Christmas and other picture greeting cards, printed by any process, with or without trimmings.	15	-	-
49.10	Calendars of any kind, of paper or paperboard, including calendar blocks.	15	-	-
49.11	Other printed matter, including printed pictures and photographs.			
	(a) Printed advertising matter		Free	
	(b) Other	10	-	-

APPENDIX NO. IX

HEHNER & COX, LTD.

DIRECTORS:
DR. JULIUS GRANT, M.Sc., F.R.I.C.
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29th April, 1963

ANALYSIS OF A SAMPLE OF Paper (Thailand Project)

RECEIVED ON 16th April, 1963

"70 Rice Straw Pulp"
Writing paper from Bang Pa In Mill, Thailand.

MARKED

SEALED

Substance (gm. per sq. m.)	65.7
Caliper (mm)	0.10
Bulk factor	1.51
Bursting strength (k.g per sq. cm.)	0.85
Burst factor	12.5
Ash (per cent)	16.4
Fibre furnish (approx. per cent)	
Chemical wood pulp	60
Rice straw pulp	40

p.p. HEHNER & COX LTD.

J. Grant.

Parsons & Whittemore Inc., New York.

APPENDIX X

Rapid Continuous Methods For Depithing and Pulping Bagasse

Dr. Joseph E. Atchison
Vice President
Parsons & Whittemore, Inc.

Compliments of Parsons & Whittemore, Inc.
250 Park Ave., New York, N. Y.

Reprinted from **Paper Trade JOURNAL,** August 26, 1957

Rapid Continuous Methods For Depithing and Pulping Bagasse

This paper emphasizes the methods which have been developed in recent years for rapid continuous depithing and pulping bagasse. A review is given of older methods now in use for depithing bagasse and for continuous pulping of bagasse and a comparison is made of these older methods with the new improved methods which have been developed and which are now available for use.

The various methods of depithing are classified as "dry methods", "moist" methods and "wet" methods and the advantages and disadvantages of these methods are described. It is pointed out that the ideal depithing method may involve a partial depithing at the sugar mill in the moist condition, followed by a final wet depithing process at the pulp mill to remove the final portion of pith and dirt just before digestion.

In describing the various continuous pulping processes available, it is pointed out that the older methods of continuous bagasse pulping are slow cooking methods which require two to four hours cooking time and result in a comparatively raw pulp. In contrast, the new rapid continuous pulping methods, exemplified by the Pandia continuous digester involve a cooking time of only 10 to 15 minutes and result in a fully cooked easy bleaching pulp.

Dr. Joseph E. Atchison

Vice President
Parsons & Whittemore, Inc.

During the past two years the trend towards continuous pulping has gained tremendous impetus. We have seen announcements about use of the rapid continuous digester for production of bleachable pulp by the kraft process from wood. We have seen announcements of the production of bleached semi-chemical monosulphite pulp from hard woods, and we have seen announcements of the highly successful use of the Pandia continuous digester for production of bagasse pulp. Now, that the breakthrough has been made, there seems to be no doubt but that these methods of continuous pulping will find greater and greater use in the years to come.

In the case of pulping wood, the development of continuous digestion, for high quality grades, has been a long, slow process.

In the case of pulping bagasse, straw, and other agricultural fibers, however, methods of continuous pulping have already been used for many years, both in Europe and in South America. In fact, the largest bleached straw pulp mill in the world, that being operated by Celulosa Argentina in Argentina, uses a continuous process which has been used for some 20 years. Therefore, the idea of continuous pulping is not nearly as new to the agricultural fiber pulping industry as in the case of production of high-grade pulp from wood.

Even in the agricultural fiber field, however, the new methods of rapid continuous pulping seem to have tremendous advantages for pulping bagasse, straw, and the other agricultural residues. The traditional methods of continuous pulping of straw were principally carried out at atmospheric pressure or at temperatures of nearly those corresponding to atmospheric pressure. Therefore, the time of cooking varied from one to three or four hours or somewhat in the same range as in the case of the batch methods. In contrast, the newer methods of rapid cooking involve a cooking period of only 10 to 15 minutes when cooking bagasse or other materials of this type.

In the early continuous methods of cooking bagasse, it was realized that this material absorbs liquor almost instantaneously and therefore does not require drastic cooking conditions or long penetration times such as required for wood. This same factor is now being taken advantage of in the rapid continuous methods whereby bagasse can be cooked in these sensationally short times.

In this paper, the writer briefly describes some of the older methods of pulping bagasse and straw on a continuous basis and compare these methods to those resulting from more recent developments, such as the Pandia continuous digester involving a very short cooking time.

In addition, the writer would like to make some comments regarding the methods of bagasse depithing which have been used in the bagasse pulp and paper mills now in existence and compare these methods to some newer rapid continuous methods of bagasse depithing which promise much improved results in the future.

Importance of Bagasse Depithing Before Digestion

Many times the importance of depithing bagasse and properly preparing the bagasse or other agricultural residues before digestion, is overlooked to a great extent. The author has been emphasizing the great importance of this depithing step ever since he began work in the bagasse pulping field more than

18 years ago. Properly preparing the bagasse before digestion will have great effects on all other steps of the pulping process and will affect greatly the amount of chemicals required, the cleanliness of the pulp, the yield of the pulp and the general quality of the pulp.

Whether or not sugar cane bagasse should be depithed before pulping, has been a subject of controversy ever since the prospects of using this raw material for the production of pulp was first considered. There seem to be at least three schools of thought in the literature on pith separation.

The line taken by one group of workers is that they can use the whole bagasse without this separation, thus obtaining a high yield of usable product but disregarding somewhat the quality of the product and the tremendous difficulties which result in paper mill operations when the pith is left in the pulp. In many cases, after years of work with bagasse, in which they have experienced many difficulties, these workers have finally come to the conclusion that separation of pith from the fiber is necessary after all and have changed their ideas. However, many mills have been built on this basis over the course of years and in almost all cases have failed.

The second school of thought recognizes the difficulties involved in handling pith and makes an attempt either to remove it in the cooking process or to carry out this operation in such a way as to change the character of the pith and render it usable as a filler in the final product. These processes are usually complicated and involve at least two stages of pulping which, of course considerably increases the cost, thus rendering the processes of doubtful economic value.

The third group of workers, with whom the author entirely agrees, advocates that all pith separation be carried out by mechanical means preliminary to the pulping operation. They further advocate that after this separation both pith and fiber be given any further treatment separately and used for purposes specifically suited to each.

This group has found that, because of the nature and condition of the pith, and its accompanying extraneous substances as it exists in the bagasse at the time of leaving the sugar mill, the pith is detrimental in every way to the production of high quality pulp.

If the pith is allowed to remain in the bagasse during the pulping or digestion process, it is only natural—because of its completely different physical structure to that of the fiber—that it will be attacked by the chemicals in a different manner. Pithy material is indeed attacked much more easily by the chemicals than is the fiber, therefore its digestion consumes much more chemicals yet yields little chemical pulp.

Furthermore, since the pith contains a high proportion of the residual sugars and other water soluble materials remaining with the bagasse, these materials also react with the chemicals, thus further increasing the chemical consumption. A considerable proportion of the pith is dissolved during the digestion process and thus a low yield results, in comparison with the total weight charged to the digester. In addition, when the bagasse is subjected to strong alkali or other chemicals in the digestion process while the pith is still present, some of this pith along with the absorbed extraneous materials associated with it, tends to swell and become gelatinous in character so that it causes great difficulties throughout the process of converting the pulp into paper or other allied products. This gelatinous material tends to clog up the wires on the paper machine, excessively decreases the drainage rate of the pulp on the paper machine wire, sticks to the press rolls, slows up the felts and decreases the drying rate of the paper. It also makes the paper brittle, greatly decreases its strength properties and gives rise to dirty and shiny spots. In general, it renders the pulp unsuitable for conversion into high grade products. Furthermore, because of the absorbed dirt and colloidal soil, the pith contains a high proportion of the ash content of the bagasse. Therefore, if the pith has not been separated before digestion, when an attempt is made to bleach the bagasse pulp, an excessive amount of bleach is required and even then it is almost impossible to obtain a high brightness without dirt spots.

It is obvious then that for production of high quality pulp from bagasse fiber, separation of the pith from the fiber is necessary before digestion. Then what is the best method of carrying out this operation and how is it being carried out in the existing bagasse pulp and paper mills?

Classification of Depithing Methods

Over the last fifty years there has been a tremendous amount of effort devoted to working out proper methods of depithing bagasse, a great many articles have been written on the subject and a great many patents have been taken out on depithing methods. In fact, the United States patent literature is a very fertile source of information, regarding the work which has been carried out in the past on depithing. This work has been intensified during the past five years and the author is very happy to say that there are now a number of excellent depithing methods available.

In analyzing the many methods of depithing which have been proposed, they seem to fall in three categories. First, we have the dry depithing methods which involve separation of the pith from bagasse after it has been dried in storage or after it has been dried artificially to 80 or 90 per cent dry content. These methods, although considered inadequate, are in use at most of the bagasse pulp and paper mills operating in the world today.

The second group of depithing methods might be classified as "moist" depithing. By these methods the bagasse is depithed as it comes from the sugar mill in a moist condition, normally about 50 per cent dry. Naturally, they are particularly applicable when the bagasse is used directly after it leaves the sugar mill or if it is depithed at the sugar mill rather than at the pulp mill.

The third group of methods of depithing might be classified as the "wet" methods of depithing, whereby both the pith and dirt are very thoroughly separated from the fiber, leaving a very clean uniform fiber for the subsequent pulping operations. These methods are more applicable at the pulp mill for the final cleaning and depithing of the bagasse just before it goes to the digester.

As will be brought out later in this paper, the ideal solution to the depithing problem may involve a partial depithing in the moist state at the sugar mill with a final cleaning and depithing operation to be carried out at the pulp mill in the wet state.

Dry Methods Not Adequate

As mentioned previously, most of the bagasse pulp and paper mills in the world today use a dry method of depithing by means of which the dry bales of bagasse are depithed at the pulp mill. This method usually involves breaking up the bagasse bales in a hammer mill or some kind of bale breaker, followed by dusting and screening operations to remove as much of the dirt and pith as possible. This type operation usually results in removal of only about one half of the pith available in the bagasse. Fortunately, a good proportion of the dust and fine dirt is also removed in this type operation and some mills using it have been moderately successful. However, in order to bring about a more complete separation of the pith by the dry methods, it is necessary to break the fibrous portion up to such an extent that a large proportion of the fiber goes through with the pith fraction and is lost for pulp making. In addition, the dirt which is absorbed on the fiber is not removed by this method and this

dirt carries through into the pulping operation.

It has long been recognized by the existing mills that this dry method of depithing is not adequate but because of its simplicity and reasonably low cost, many of them have continued to use it but at the same time have been working on moist methods of depithing and wet methods of depithing. In fact, a number of the existing mills are now in the process of switching over to one of the newer and better methods of depithing.

Moist And Wet Methods of Depithing

Because of the recognized inadequacies of the dry methods of depithing, there have been intensive efforts over the past five years to improve the depithing process. These efforts have been concentrated on the moist method of depithing at the sugar mill and the wet methods of depithing at the pulp mill. The author would like specifically to mention the work of three institutions, each of which has made very great contributions in this field over the past five years. Each of these institutions is represented at this meeting and they will undoubtedly describe in more detail some of the important work which they have carried out.

These institutions are the Chemical Engineering Department of Louisiana State University of Baton Rouge, La., the Northern Utliization Research Branch of the Agricultural Research Service of the United States Department of Agriculture in Peoria, Ill., and the Hawaiian Sugar Planters Association in Honolulu, Hawaii. If the combined work of these three groups could be reviewed, it would undoubtedly be concluded that they have tried practically every conceivable method of depithing. They have all made the results of their work available to the public and I think that every one in the bagasse pulping field owes them a debt of gratitude. Our own organization has followed the work of all three groups with great interest and has participated to a very small extent in each of these departments.

Continuous Moist Methods of Depithing

In the work at the Louisiana State University, directed by Dr. Arthur G. Keller and Dr. Paul M. Horton, emphasis was placed on finding an economical method of separating the pith from the bagasse fiber at the sugar mill while the bagasse was still in a moist condition. These efforts have been very successful and as a result there is now available one of the most excellent and one of the most economical methods ever developed for separation of the pith from the fiber at the sugar mill. When operating on moist bagasse coming from the sugar mill, it is possible by this method to separate at least two thirds of the pith without any further addition of water. This pith can then be brought back to the sugar mill boilers whereby the fuel value can be obtained. The partially clean fiber can then be baled which results in sizable savings in transportation cost, storage areas and so forth. This method of partial separation at the sugar mill still leaves a sufficient amount of residual sugar in the pith remaining with the bagasse to cause fermentation, thus bringing about the necessary heat generation to dry the baled bagasse fiber in storage. In cases where the bagasse is taken directly from the sugar mill to the pulp mill and used without any baling or storage, it is possible by proper modification of this method to bring about more complete separation of the pith from the fiber without a secondary wet depithing operation at the pulp mill. However, the method is not designed for use at the pulp mill on bagasse which has been baled and stored.

By this method the pith is separated from the fiber in continuous manner and the separation is a very rapid one so that it can be classed as a rapid continuous method of depithing.

At the Northern Utilization Research Branch in Peoria, both moist and wet methods of pith separation have been developed. The moist methods developed at Peoria are also particularly applicable to the sugar mill. One of the best of these methods involves further dilution of the bagasse coming from the sugar mill down to 25 per cent dry, followed by running it through a disc refiner of the type which is in common use in the pulp and paper industry. From the disc refiner, the loosened pith and fiber mixture is run through an additional set of sugar mill rolls to bring the dry content back to 50 per cent. From this point the mixture is either run over screens at 50 per cent dry or is further dried in a rotary dryer down to 80 or 90 per cent dry and is then run over screens for separation of the pith. When carrying out the screening operation at 50 per cent dry, the screening area must be approximately twice the area necessary when the bagasse is dried down to 80 or 90 per cent dry. Both methods of operation have been carried out on a commercial scale with excellent results.

Other methods of depithing bagasse in the moist state have undoubtedly been worked out but full information on these methods have not been released to the public.

Continuous Wet Methods of Depithing

In the normal method of operation of a bagasse pulp and paper mill, the bagasse is baled at the sugar mill in moist form and is stored in specially constructed stacks for a period of several months before it is used at the pulp mill. During this time, the bagasse dries out to approximately 80 to 90 per cent dry and the bales must then be broken up again after they arrive at the pulp mill. In order to bring about a complete separation of the pith from the bagasse, in this form, it is necessary to wet it up again thoroughly, break or rub the pith loose from the fiber and then separate the pith from the fiber.

The author, in cooperation with the Northern Utilization Research Branch in Peoria, has carried out a considerable amount of work on a wet depithing method which involves the use of the well known Hydrapulper on a batch basis. By proper use of this method a very clean well broken up fiber fraction can be obtained. However, the equipment cost is rather substantial and it is still on a batch basis, contrary to the trend towards continuous processing for every step of the bagasse pulp mill operations.

One of the most interesting and undoubtedly one of the best rapid continuous methods of depithing has been worked out by the Hawaiian Sugar Planters Assn. This method involves the use of the Hydrapulper again, this time on a continuous basis, followed by passing the dilute wet bagasse suspension through a specifically designed depithing machine. In the Hydrapulper, the bagasse is thoroughly wetted and broken up and then the pith, dirt, water, and water soluble materials are thrown out in the depithing machine. This method results in a very uniform fiber fraction which is scoured clean and free of pith and dirt. The resulting fibrous raw material is superior for later digestion operations. The entire process requires only a few minutes so it can truly be called a rapid continuous depithing process.

Before leaving the subject of wet depithing methods and methods of handling bagasse in general, great credit should also be given to the Celotex Corp. This company has for many years used the continuous Hydrapulper for breaking up the bales of bagasse in huge quantities, followed by pumping the dilute suspension to a dewatering machine. Then, in this machine, a portion of the pith and a large quantity of dirt present in the bagasse are removed, it not being necessary to bring about a complete pith separation for production of good quality insulating board. By combining

the handling methods used at the Celotex Corp. with the refinement of the depithing operation developed at the Hawaiian Sugar Planters Assn., outstanding results are assured.

Summary of Depithing

Brief descriptions of several methods of depithing have been given and it has been brought out that the most promising methods for the future involve either a moist depithing at the sugar mill, or a wet depithing at the pulp mill. The wet depithing at the pulp mill does have one serious drawback. The pith resulting from this type depithing operation is very dilute and if it is to be used further, it must naturally be dewatered and dried. This is true even if the most valuable use is as fuel. On the other hand, by moist depithing at the sugar mill, the pith is already 50 per cent dry and can be immediately returned to the sugar mill boilers in this condition, so that the fuel value can easily be obtained. Moist depithing methods also have a disadvantage, in that it is more difficult to get a sharp separation of the pith from the fiber by the moist methods than by the wet methods and the fiber obtained by the moist methods is not nearly so clean and free of dirt as the fiber obtained by the completely wet methods.

Because of these facts it is believed that the ultimate in pith separation might involve a partial separation at the sugar mill in a moist condition, by a method such as that developed by Louisiana State University. The economics of this type of operation are extremely favorable. The partially depithed fiber resulting from this operation at the sugar mill can then be baled and stored until required by the pulp mill.

For best results it would then be desirable to have a secondary depithing operation at the pulp mill to remove the remainder of the pith and to clean the fiber and prepare it in the best possible form for subsequent digestion. If approximately two thirds of the pith were separated at the sugar mill, this would leave only one third of the pith to be separated at the pulp mill. Therefore the pith handling problem resulting from the wet depithing process would not be nearly so serious as if the entire depithing operation were carried out by the wet process at the pulp mill.

Perhaps the most promising methods of wet depithing for this final stage might involve the use of the continuous Hydrapulper as now used by the Celotex Corp., followed by the use of the special depithing and dewatering machine used by the Hawiian Sugar Planters Assn.

FIGURE 1—Typical bagasse feed in L. S. U. sugar mill depithing operation.

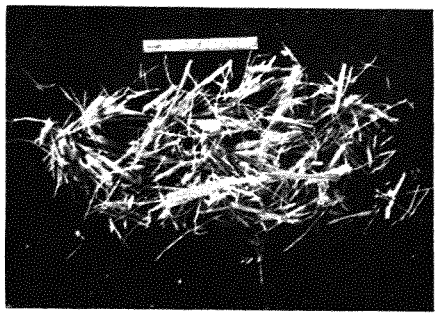


FIGURE 2—Fibrous product recovered by the L. S. U. method of depithing.

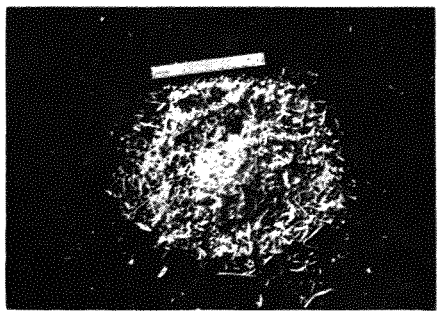


FIGURE 3—Pith fraction and extraneous material removed in the L. S. U. method.

Fortunately our own organization is in a position to supply the complete equipment for both of these excellent depithing methods. Both methods have been proved in large scale runs. There is no longer any doubt but that the problem of economically depithing bagasse has been solved. Thus the greatest obstacle in the way of large scale use of bagasse for manufacture of high quality pulp has been removed.

General Comments on Bagasse Pulping

As all of you know, during recent years a tremendous number of so-called new and "secret" processes have been proposed for pulping bagasse and other agricultural fibers. Many of these processes have been given newspaper publicity and great claims were made for them. However, it has always been the author's feelings that it was not necessary to have secret processes for pulping bagasse and that in most cases the methods are arrived at by a process of slow development based on information which is readily available to every one in the pulp and paper industry. The methods of rapid continuous pulping which are described in this paper are all well known and the equipment is readily available without payment of high royalties or special license fees.

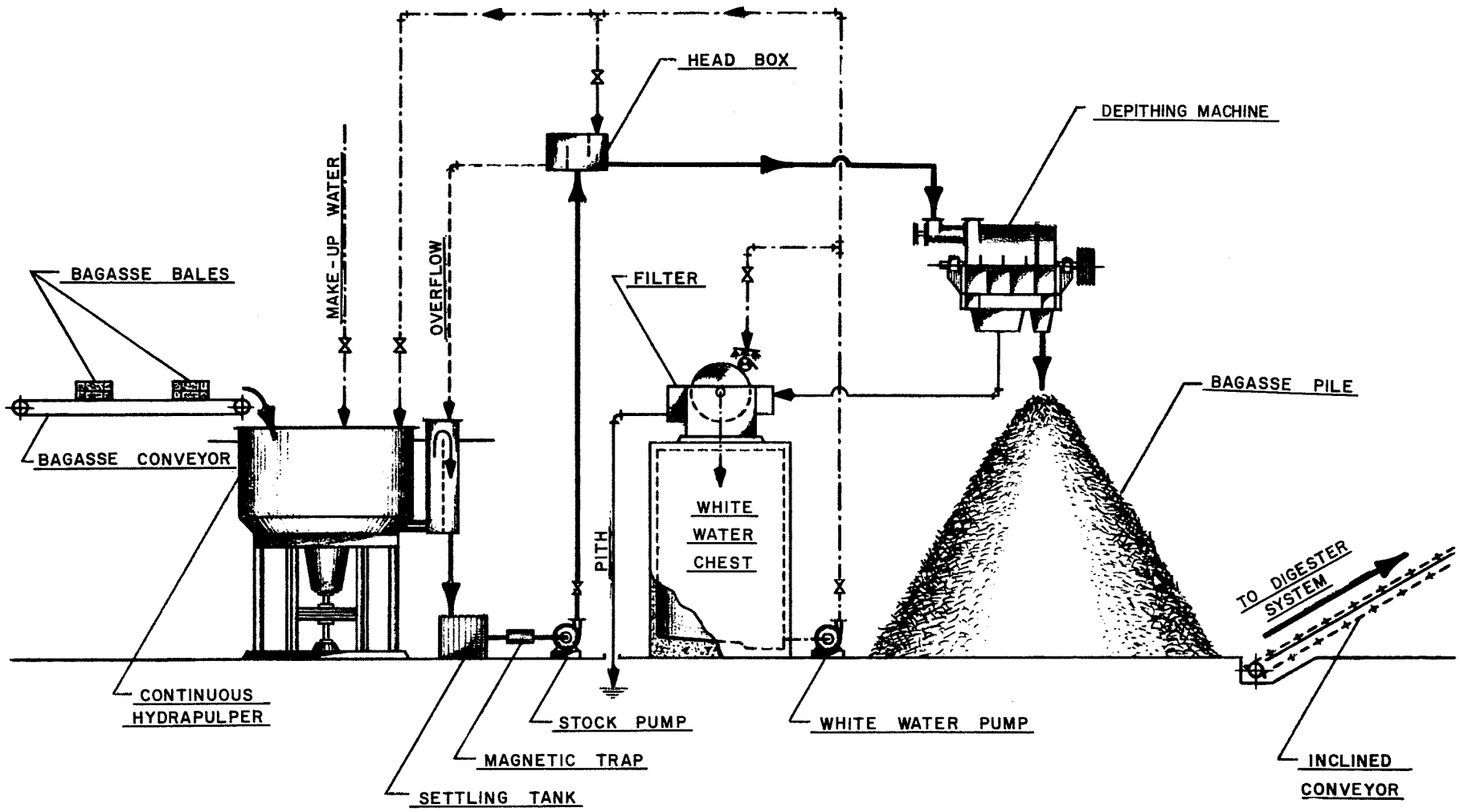
The author would like to emphasize again, however, although every one here is undoubtedly already familiar with the fact, that in choosing a process for pulping bagasse, one must always remember that it must be modified rather considerably from the way it is used when pulping wood. There are many properties of bagasse and other agricultural fibers which require special handling which is entirely different from the way wood is handled when using the same process. This fact naturally applies to continuous processes as well as to the traditional batch type processes.

However, since all of you are involved in bagasse pulping or are especially interested in it in some way or other, there is no need to go into the differences in properties and methods of handling bagasse as compared to wood. Suffice it to say that these differences do exist and any one attempting to use wood pulping methods without modification is usually in for some rather great surprises.

Continuous Methods of Pulping Bagasse

Over the past twenty years, considerable numbers of continuous processes have been proposed for production of pulp from agricultural fibers, such as bagasse. Many of these processes have been patented and some of them are in wide use in many parts of the world. As the author has mentioned previously, the continuous processes now in use lend themselves particularly well to pulping agricultural fibers. In fact, continuous methods have been used for this purpose for far longer than they have been used for pulping wood. In the agricultural fiber field, however, they found their greatest use in other countries of the world, and so far, have not been used on a commercial scale in the United States.

In contrast, in the United States, the rapid continuous methods have been used to a rather large extent on hardwoods for production of semi-chemical pulp for corrugating media and are now being used to an ever increasing



WET SECONDARY PITH SEPARATION SYSTEM AT PULP MILL

FIG. 4

extent for production of fully cooked chemical pulps including bleachable pulps from wood.

The continuous processes, which are already in use for pulping agricultural fiber, have been described very thoroughly in the literature *(1, 2, 3, 4)* and the author does not intend to go into detail in describing them here. However, some comments should be made regarding these processes in comparing them to the more recently developed rapid continuous processes.

Slow Cooking Continuous Processes

The continuous processes now in use for cooking bagasse and straw require a long cooking time and result in relatively raw pulp which is suitable in the unbleached state for production of corrugating media and rough grades of board. These processes usually use a vertical tower through which the raw material passes down through by gravity or they use a horizontal tube through which the raw material is propelled by means of a screw. The most commonly known of these processes are the Celdecor or Pomilio soda-chlorine process, the Ruguenot process and the Morley process.

All of these processes operate at or near atmospheric pressure and the cooking times are on the order of two to four hours. Because of the mild raw cook, if the pulp resulting from these processes is to be bleached, it requires a relatively high chlorine consumption. Therefore, for production of bleached pulp the total chemical requirements (adding the total caustic consumption to the total chlorine consumption) are much higher than when using pressure methods of digestion at higher temperatures.

The Kamyr continuous cooking system which has gained a certain amount of acceptance for cooking wood, has also been used for pulping straw on a continuous basis. This process also makes use of a tower through which the raw material passes by means of gravity. Although the process is operated under pressure, the cooking times are relatively long and the process cannot be classed with the rapid continuous methods which have been developed during the past two years.

Pandia Digester For Rapid Continuous Pulping

The continuous processes mentioned briefly up to this time have principally been processes operating at atmospheric or near atmospheric pressure. By operating in this manner, the mechanical problems and the physico-chemical problems associated with the pressure digestion processes have been avoided.

These same mechanical problems and physico-chemical problems have been the main reasons for the continued existence of the batch digestion processes for pulping wood.

In solving the mechanical problems in continuous pressure digestion, it has been necessary to develop mechanical feeding and discharging devices to operate under pressure and also to develop means to obtain a positive flow of the cellulosic material and cooking re-agents through the cooking zone.

In addition to the mechanical problems for production of high-quality pulps, the physico-chemical problems had to be overcome as well. This involved difficulties in connection with pulping cellulosic materials in extremely short times, in comparison with conventional batch operation. These short cooking times have been necessary so that the continuous pulping equipment would not become too bulky and expensive and would not become so large that it would be difficult to maintain control and obtain uniform pulping action. Therefore, in order to keep the size of the pulping equipment to a minimum, it became necessary to conduct the pulping at relatively high temperatures, thus speeding up the pulping action.

As a result of extensive experimental work, it has now been shown beyond doubt that the cooking of cellulosic materials can be carried out at high temperatures for short periods of time without degrading the pulp, provided these materials are in the proper condition before entering the reaction zone. This discovery in itself is a revolutionary development in the pulping field. It has allowed development of designs for operating temperatures and pressures of much higher ranges than can be economically built into the conventional batch type pressure digesters.

In practice, the horizontal tube digester, as exemplified by the Pandia digester, has proved to be the natural development meeting these fundamental requirements for rapid continuous pressure digestion.

As far as the application of the rapid continuous digester to the pulping of bagasse, straw and other agricultural fibers is concerned, extensive pilot plant and commercial scale runs during the past year have proved that a continuous digester of the Pandia type has great merit as a method of pulping these materials. It has been proven for bagasse specifically that high pressure and temperatures and very short cooking times, can be used for production of a high quality pulp.

Because of the physical structure of bagasse and straw, the Pandia digester is particularly applicable to these raw materials.

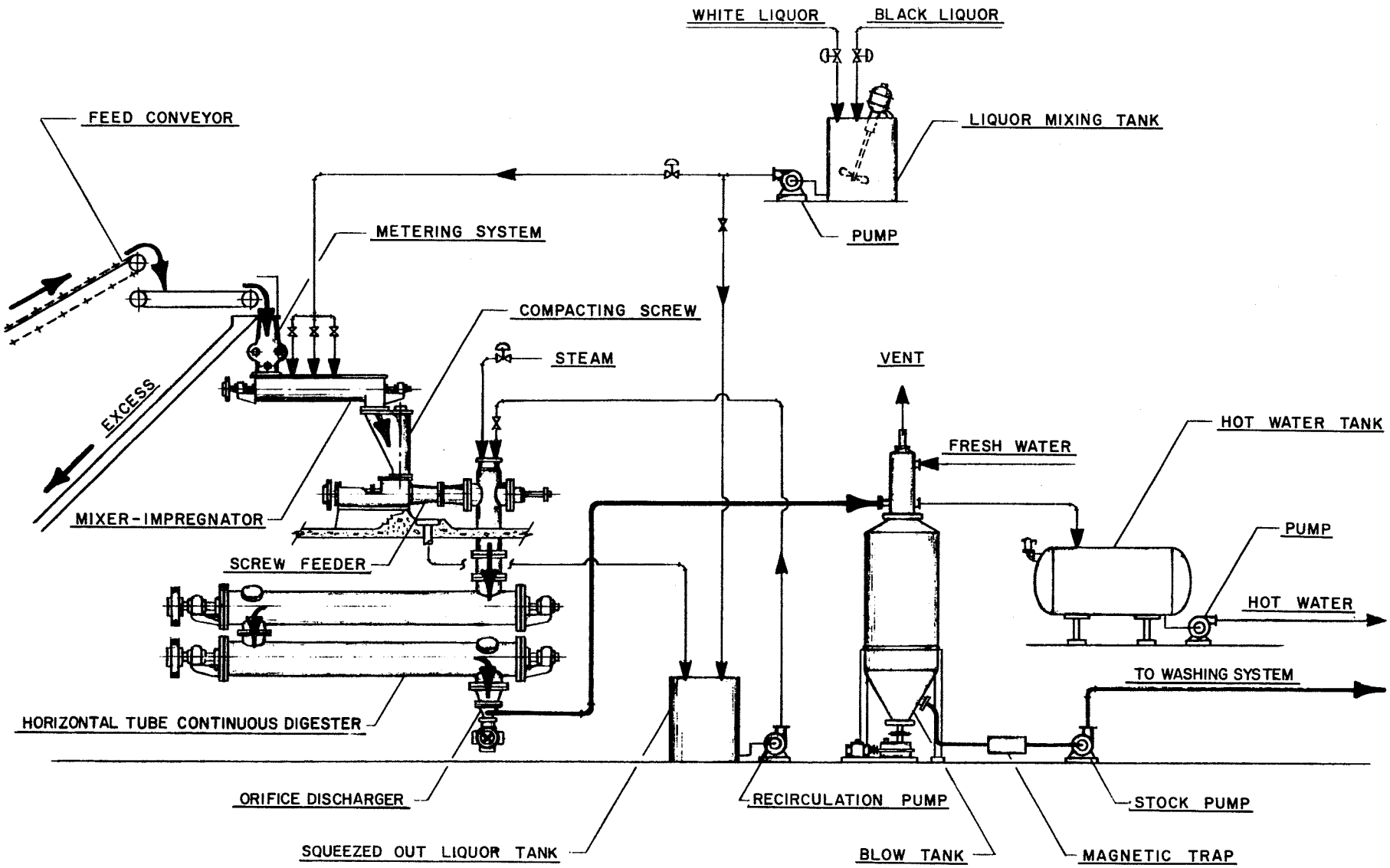
In the first place they are very bulky in contrast to the compact structure of wood. Therefore, when conventional batch type digesters are used, the capacity per digester is small. Even when the raw material is compacted before entering these digesters, it tends to spring back again into bulky form as soons as the compacting pressure is released.

When using the Pandia unit, this bulkiness is overcome and a rather high weight of material per cubic foot of digester space is obtained. By means of a special arrangement of a compacting screw and the feeding screw, the compact mass is forced into the digester tubes. This feeding screw is the only known device for feeding bagasse and straw into a pressure zone at an economical rate. Since this mass can expand again after entering the digester only to a relatively small extent to permit ready absorbtion of cooking chemicals, one of the greatest problems of using agricultural fibers, including bagasse, is overcome and a high digester capacity is obtained.

Another property of bagasse, which renders a rapid continuous digester particularly suitable, involves the high absorbent and open nature of the agricultural fibers. In the case of batch-type digesters, these properties are actually something of a disadvantage. Because of this absorbency, liquor circulation systems commonly used in batch type pressure digesters are usually impracticable. While liquor ratios of 4 to 5:1 are common in woodpulp mills with circulating systems, in order to get good circulation when pulping bagasse, ratios of 10:1 or 12:1 must be used to insure satisfactory circulation and good heat transfer necessary for uniform cooking. Since such a high liquor ratio is impractical, digesters of the rotating type must be used for batch pressure digestion of bagasse in order to get good mixing at low liquor ratios. Unfortunately, rotating batch digesters are necessarily small and have low capacity so that the original cost for an appreciable production is rather high.

In contrast, the horizontal tube digester takes full advantage of these absorbent properties. Because of the constant motion of the mass through the tubes as it is propelled by the screws, there results an intimate and continuous mixing of chemicals and steam with the raw material. This highly uniform cooking can be obtained with liquor ratios of 4.5:1 or lower and no liquor circulation systems are needed when pulping bagasse or straw.

The open nature of the bagasse fiber offers still another advantage, the mat-



RAPID CONTINUOUS DIGESTING SYSTEM FOR AGRICULTURAL FIBERS

FIG. 5

Advantages of Tube Continuous Digester

1. Greater processing flexibility, including the ability to employ any normal cooking liquor without change in the digester equipment.
2. Maximum uniformity of pulp quality due to thorough and continuous mixing of chemicals and steam with the fibrous raw materials.
3. Uniform raw material consumption, limiting the size of the "in process" material storage facilities.
4. Uniform steam and power requirements which reduce peak load demand in the steam and power plant and allow operation at high load factors.
5. Low steam requirements because of low liquor ratio and continuous heat recovery from blow tank cyclone.
6. Uniform liquor demand, avoiding large storage facilities.
7. Potentially higher yields or equivalent pulp quality.
8. Small space requirements.
9. High capacity per unit due to compacting the bulky raw material and operating at high pressure and temperature.
10. Low labor cost because of greater productivity per man hour of labor.
11. The possibility of increasing production, in steps, by relatively simple and economical additions to the unit itself without disturbing other equipment; without requiring any additional building space and without increasing the number of operators required.

ter of penetration time. When pulping wood, a considerable portion of the time in the digester is consumed in allowing the liquor to penetrate the compact wood cells. The wood must be completely impregnated with liquor before the temperature can be raised to any appreciable degree. In the case of bagasse, because of the open nature of the fibers, the liquor penetration is almost instantaneous. In addition, these fibers are more susceptible to rapid chemical action.

Then, because of the open nature and rapid absorbency of the bagasse and straw fibers, when these raw materials are subjected to the high pressures and temperatures obtainable in the Pandia digester, pulping action starts immediately and is extremely rapid. As a result, by using high temperatures, high strength unbleached pulps or fully bleachable pulps can be produced with cooking times of approximately 15 minutes or even less, depending on the steam pressure available.

These continuous digesters also have a high degree of flexibility in that any of the cooking liquors commonly used for pulping bagasse can be used. Thus, soda, kraft or neutral mono-sulphite cooking liquors can all be used and the concentration and consumption of chemical is approximately the same as when using the respective cooking liquors in rotating batch type pressure digesters. Thus, under changing conditions of chemical costs or of changing pulp requirements, different liquors might be readily used.

Another important advantage of this process is the quick responsiveness to the controls applied to it. Fortunately, the controls can be made fully automatic. Practically all of the conditions can be recorded and supervision is rendered remarkably simple because of this fact and because the human element is of less importance than is the case with batch type digestion methods.

Still another outstanding advantage that applies in particular to the Pandia continuous digester is the small building space required which makes for an extremely neat and compact installation and results in considerably reduced building costs for a given quantity of production capacity.

Advantages of Tube Continuous Digester

A summary of the advantages which seem to be associated with the continuous cooking of bagasse or straw by the Pandia process, as compared to standard process, appears in the box at the top of the page.

In way of proof of the above mentioned facts, there has been a considerable amount of work done with commercial size Pandia digesters on agricultural fibers. Unfortunately, most of this work has been carried out by private groups who do not want to divulge the results at the present time. However, the results obtained have been somewhat sensational and the author feels confident that this rapid continuous method for pulping agricultural fibers as exemplified by the Pandia digester, will prove far superior to other continuous pulping methods which have thus far come to light.

This type digester overcomes many of the draw-backs of other continuous digestion methods as well as the disadvantages of batch type methods of pulping bagasse. In fact, our organization is optimistic to the point that it believes that this type pulping method will give much greater impetus to use of these agricultural fibers than has ever been given previously.

In Figure 4 a diagram is shown of a wet method of depithing the bagasse at the pulp mill, and Figure 5 shows the subsequent cooking of the depithed bagasse in the Pandia Rapid Continuous Digester. It is not claimed that this is the ultimate in bagasse depithing and pulping, but it does represent a practical and economical method of producing a superior quality pulp from bagasse by means of a completely rapid continuous process.

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From a symposium on Utilization of Bagasse, at the Spring, 1957 (Miami, Florida) meeting of American Chemical Society.

APPENDIX XI

The Parsons and Whittemore "Horkel" Process For Mechanical Depithing of Sugar Cane Bagasse

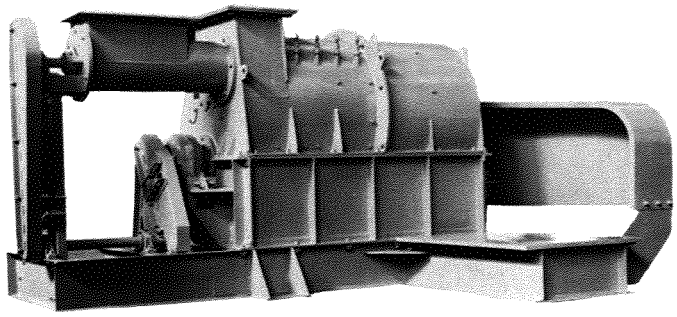
A Process Developed By
Dr. Paul M. Horton and Dr. Arthur G. Keller
at
Louisiana State University

Commercial Installation
Engineered By and Available Through
Parsons and Whittemore - Lyddon Organization
and Affiliated Companies

A Report By
Dr. Arthur G. Keller
Consultant Chemical Engineer

Reprinted from The Sugar Journal, December, 1957

Louisiana State University Develops Efficient Method For



Large sized Horkel for processing 100 tons daily of whole bagasse (BD basis)

THE MECHANICAL DEPITHING OF SUGARCANE BAGASSE

BY ARTHUR G. KELLER, PH. D.

Consultant Chemical Engineer

Bagasse, the fibrous residue from the milling of sugarcane, has attracted the attention of inventors and promoters for more than one hundred years as a possible source of raw material for the production of paper or wall board. West[1] has traced the history of bagasse as a material for paper production back as far as 1856. In another review[2] he lists United States patents as early as 1863 covering the use of bagasse as a raw material for paper production.

The large annual production of bagasse, estimated to exceed 50,000,000 tons, plus the fact that the material is concentrated at the sugar factories which are relatively few in number, would make it appear that this should be a cheap, renewable, and excellent material for any product requiring cellulose as its principal constituent. However, despite more than 100 years of effort, the use of bagasse, other than as fuel for the sugar factory, has not achieved any considerable industrial importance. An exception has been the sugar industry of Louisiana, where approximately one-third of the total annual production of some 1,500,000 tons is employed in the production of wall board, animal litter and more recently special grades of bleached paper.

The use of bagasse as a raw material for pulp production presents a great many problems, some technical, others economic. The technical problems arise because of the nature of the raw material. As produced at the sugar factory, bagasse varies widely in quality, appearance and composition. An average analysis of bagasse as made in Louisiana is about as follows:

Moisture	**49.0%**
Fiber	**45.0%**
Soluble Solids	**6.0%**

By definition, **fiber** is the water-insoluble portion of the bagasse and as commonly reported includes soil, foreign material and ash. Soluble solids include sucrose, glucose and fructose as major constituents plus small amounts of soluble organic compounds of indeterminate nature.

To consider further the term **fiber**, it should be noted that the stalk of sugarcane contains not one but several cellulosic constituents all of which are included in this term. The rind, and fibro-vascular bundles of the stalk are fibrous in nature. The juice cells, which occupy a major portion of the interior of the stalk, have walls of non-fibrous cellulose (parenchyma) called pith. This material has very little value in paper manufacture except as a filler.

Investigators[3, 4, 5] report that the presence in bagasse of pith, dirt, and leaves very adversely affect the yield and quality of the resulting pulp and paper. Since the pith is non-fibrous, finely divided, and quite reactive to the cooking chemicals, its presence results in excessive chemical consumption in cooking. Its ready absorption of soil and trash particles make their removal difficult. It reduces the "freeness" of the resulting pulp and makes high speed sheet formation impractical. The material hydrates very easily and this causes difficulties by increasing the stiffness and translucence of the resulting sheet. Dirt or soil in the bagasse must be removed if a high quality bleached product is desired.

Estimates of the amount of dirt, leaves and extraneous material vary but are in the range of 5 to 10 per cent by weight of the bagasse as produced. Lathrop[3] reports a typical bagasse (BD basis) as containing 21.6% pith, 68.4% fiber and 10.0% dirt and fines. The same authority also reports that losses on field storage of bagasse on a commercial scale are of the order of 10% of the weight of the "Fiber" put into storage. The presence of excessive amounts of leaves and cane tops as a result of mechanical harvesting further increases storage losses and costs.

Bagasse has been considered a relatively expensive form of cellulose as compared to other competitive materials such as pulp wood. This arises from the fact that cane sugar production is a seasonal operation, whereas pulp and paper mills must operate on a year-around basis. Since the bagasse supply is produced in a three to six month period, and the pulp mill must operate twelve months per year, purchase, preservation and storage of a sufficient amount of bagasse to permit continuous operation is essential. Transport from the sugar factory to the paper mill further increases the cost of bagasse as a raw material.

The final cost of bagasse to the pulp mill includes the following:

a. **Replacement value of bagasse to sugar mill.**
b. **Baling and storage costs.**
c. **Removal from storage for shipment.**
d. **Freight costs to pulp mill.**
e. **Insurance costs.**
f. **Depreciation charges on baling and storage facilities.**
g. **Interest charges on inventory.**
h. **Inventory losses in storage and handling.**

These items will be considered individually.

Since bagasse normally furnishes fuel for the operation of the sugar factory its value is essentially that of the fuel needed to replace it, plus an initial allowance to the factory to cover the cost of converting from bagasse as fuel to some other type of fuel. By agreement in Louisiana, one ton of bone dry bagasse fiber is considered as the fuel equivalent of twelve million BTU in fuel oil or natural gas. Using average values for these fuels: 1 Ton B.D. bagasse "fiber" = 2 barrels (84 gals.) fuel oil = 12 MCF (1,000 BTU) natural gas.

In addition, the sugar factory receives as a bonus, $0.50 per ton of B.D. fiber sold. Thus, with natural gas at $0.20 per 1000 cu. ft. of 1000 BTU gas, one ton of B. D. bagasse "fiber" is worth $2.90.

Bagasse is a bulky perishable material. Its preservation and storage for extended periods requires a heavy investment which can only be justified where the amount of fiber available annually is quite large, 15,000 tons or more. A recently constructed baling station, capable of handling 400 tons of B.D. fiber per day cost $300,000. Such a station includes the necessary system of conveyors for moving bagasse into and around the plant, at least four semi-automatic baling machines, and the structure to house them, plus a field storage area of about 20 acres. This area must be graded, drained and provided with roads or railroads for moving the bagasse into and out of the area. A 30 ton capacity Crawler-type crane is used to form and remove the stacks of bagasse which are about 100 ft. long by 60 ft. wide by 25 ft. high and which contain about 12,000 bales each. These stacks must be covered with a heavy galvanized iron roofing to keep out rain.

The baling operation, though highly mechanized, is costly in manpower and money. On the average, about 1.07 man hours of labor are required to bale and stack 1 ton of mill run bagasse or 0.45 tons of B.D. "fiber" from Louisiana sugar cane. The material must be carefully placed in the stacks to insure ventilation and removal of the heat of fermentation. Borax is used around the outside edges of the stacked material as a fungicide.

The bagasse dries out in storage to about 25% moisture by weight. To remove this material from storage and load it into trucks or railroad cars requires 0.36 man hours per ton of B.D. fiber. Rail freight costs in Louisiana are about $0.035 per ton mile with the average haul of about 60 miles. Since the original bagasse has dried out in storage the cost per ton of bone dry fiber is reduced by the weight of water lost.

Stored bagasse is rather easily fired and it is extremely difficult to extinguish a fire once started. For this reason a system of fire mains and hydrants is provided for field storage areas and the inventory is usually insured against damage from fire and windstorm.

Field and mill losses in handling bagasse amounts to about 25% of the dry weight of the fiber purchased. Some 10% by weight is lost by damage in storage and handling. Losses at the mill in dirt and pith washed out of the bagasse will amount to an additional 15% by weight of the original dry fiber. Much of this loss could be eliminated by depithing before storage at the sugar factory.

The total cost of bagasse delivered at the pulp or board mill under Louisiana conditions will be about as follows:

	1 ton B.D. "fiber"
Purchase Price	**$ 2.90**
Baling & Stacking	**$ 2.48**
Unstack and Loading	**$ 0.88**
Maintenance, Baling Station	**$ 0.21**
Depreciation, Baling Station	**$ 0.60**
Interest & Insurance	**$ 0.31**
Freight Costs	**$ 3.33**
Total cost at pulp mill	**$10.71**

With the loss of 25% of the weight of the "fiber" originally purchased it can be seen that the "fiber" actually entering the product must cost even more than the figure cited above or $13.39 per ton. Elimination of dirt and pith at the sugar factory could effect a savings of several dollars per ton of "fiber" purchased.

The need for separation of at least a part of the pith and dirt from bagasse to improve its paper-making qualities was recognized many years ago and a large number of patents have issued in the United States and elsewhere covering both machines and processes for effecting this separation. Separation machines and processes may be classified generally as "wet" or "dry". Most involve some form of screening to separate fine from coarse particles. A large number include treatment either "wet" or "dry" in rod mills, hammer mills, or disc refiners to rub the pith away from the fiber.

A novel development in this regard was the adaptation of Lathrop[6] et al of the Hydro-pulper to this purpose. Following beating or rubbing the pith (fine) particles are removed from the fiber "coarse" particles by screening. Separations are not complete and much difficulty is experienced with screening because the bagasse quickly blinds the screen. Wet screening is more satisfactory than dry in separation efficiency. Its great draw-back is the need to handle and store or transport the wet pith and fiber. Attrition mills and the Hydro-pulper consume very large amounts of power. To be satifactory, a process should be simple, continuous, require a relatively small investment, and be able to do a satisfactory job at a low total cost.

The machine and process developed at Louisiana State University by Paul M. Horton and the writer appears to answer the requirements for a successful operation. Both machine and processes are covered by United States and foreign patents (7) which are owned by the University. The machine is a modified swing-hammer mill which may be operated either dry or wet. The bagasse from the sugar mill is fed into one end of the machine and travels across the tips of the rotor hammers during which time it is subjected to a beating and combing action. The pith and dirt loosened by this action falls or is dragged around the hammer circle and forced through a perforated plate which closes the lower half of the rotor circle. The depithed fiber passes out the end of the machine to another similar unit for wet processing or to storage. The units presently installed in a pilot plant in the Audubon Sugar Factory, Department of Chemical Engineering of Louisiana State University, have rotors 17" diameter by 22" long. These units are operated in series using 3/16" perforations in the screens. The first mill, which is operated dry, normally removes about 20% by weight of the entering bagasse as a dry-pith-dirt fraction. "Fiber" from the first mill is fed to Mill No. 2 which is operated with water to soften and open the fiber bundles and to remove soluble solids from the "fiber". In this mill an additional 5% by weight of the original feed is removed as wet pith while a clean solubles free fiber is the final product. The installation has a capacity of 3000 lbs. of mill run bagasse (about 1000 lbs. of clean, bone dry fiber) per hour. Power requirements for the operation, including all auxiliaries, have averaged 24 KWH per ton of bone dry fiber processed. Estimates of the cost of operating a commercial size depithing plant under Louisiana conditions are $0.85 per ton of B.D. dry, depithed fiber. This cost includes power, labor, materials, maintenance, depreciation and license fees.

Depithed bagasse was subjected to digestion by the conventional Kraft process and the resulting sheets compared with sheets made from undepithed portions of the same lot of bagasse. Results of the comparison are shown in the table.

In the table the figures in Column 1 concern the fiber product from the wet separation of bagasse. The figures in Column 2 represent the results when processing the fiber product from dry separation of the same bagasse, while Column 3 includes the figures obtained when processing the

	1	2	3	4	5
% Active Na_2O, on B.D. Bagasse	11.0	11.0	11.0	11.0	11.0
Cooking pressure, p.s.i.	110.0	110.0	110.0	110.0	110.0
Time to pressure, hrs.	1.0	1.0	1.0	1.0	1.0
Time on pressure, hrs.	1.0	1.0	1.0	1.0	1.0
TAPPI Permanganate No.	6.10	7.10	7.25	20.0	14.0
% Screenings (.010" plate) on B.D. Pulp	1.10	1.75	0.31		
% Total Yield, on B.D. Bagasse	55.85	52.45	44.77	47.50	50.00
Canadian Standard Freeness	550.0	450.0	280.0	720.0	690.0
% Ash, on B.D. Pulp	0.5	1.0	3.5	0.1-0.2	0.1-0.2
% Pulp retained on:					
14 mesh	2.1	1.4	1.8		
30 mesh	30.5	22.6	17.8		
50 mesh	23.1	23.0	22.0		
100 mesh	29.9	34.2	36.1		
% Pulp through 100 mesh	14.4	18.8	22.3	6.0	16.0

Several hand samples made from the above screened pulps were tested by the Gaylord Container Corporation.

	Basis Wt. lbs.	Caliper in.	Mullen, Bursting %	Tear %
Pulp from wet separated fiber	44.5	.0045	89.0	110.0
Pulp from dry separated fiber	45.0	.0040	83.0	117.5
Pulp from Bagasse	44.5	.0050	88.4	104.5

original whole bagasse. Columns 4 and 5 include representative data for easy bleaching pine and gum pulps respectively.

It should be noted that the cooking conditions chosen do not necessarily represent optimum cooking conditions for sugarcane bagasse. They were arbitrarily selected by the group who did this work and are at least comparable insofar as the several materials considered are involved. Particularly noteworthy is the substantial increase in yield of pulp or bone dry bagasse when dealing with the wet separated fiber as compared to the whole bagasse. A substantial improvement is also to be noted in the case of the dry separated material. In both cases it will be observed that the yield on bone dry material is higher in the case of bagasse than was the case with pine or gum wood respectively.

A tabulation of the information employed in arriving at some of the cost figures which have been cited earlier in this paper will be found in the appendix. Table I presents data concerning the investment necessary in a bagasse baling station. Table II concerns the man-hour needs for the operation of a bagasse baling plant. Tables III, IV, and V provide further information on the cost of bagasse handling. All of this information was obtained from companies which are presently involved in the business of handling bagasse on a commercial scale.

Tables VI, VIIA and VIIB concern bagasse depithing costs. It will be noted that the investment in a depithing plant to handle 25,000 tons of fiber in a 70 day season totals $110,000.00. The total cost of operation of that plant for the 70 day season will approximate $17,000.00 or a cost of $0.85 per ton of depithed fiber.

Table IX shows the assumptions made in arriving at the savings which can be realized through depithing bagasse prior to storage. These have been stated elsewhere but will be repeated here for emphasis. First, it is assumed that depithing removes 20% by weight of the bone dry material charged. Second, it is assumed that depithing prior to storage will reduce field and processing losses to 5% of the bone dry weight of the bagasse purchased and stored. This compares to 25% for bagasse which is not depithed prior to purchase and storage. Third, it is assumed that the actual weight yield of pulp from one ton of mill run bagasse after 20% depithing will be identical with that from the same weight of mill run bagasse which has not been depithed.

Table X, which appears in the appendix, shows the comparative cost of bagasse delivered through the pulp mill. This comparison is between ordinary mill run bagasse and bagasse which has been depithed. All costs are on the basis of one ton of the bone dry material. We noted that savings are effected in the purchase price, the cost of baling and stacking, the cost of unstacking and loading the bagasse and in interest and insurance charges. There will be a sub-

TABLE I

Bagasse Baling Plant and Storage Site
Investment

Automatic Balers (4)	$ 64,000
Bagasse Scale	6,000
Conveyor System from Raw Sugar Mill to Baling Station	15,000
Conveyors and elevators in baling station	30,000
Baling Station Building	40,000
Installation Costs	45,000
Storage Site Grading	10,000
Fire Protection System	10,000
Mobile Crane Unit	55,000
Trucks and Trailers	25,000
Total	$300,000

Plant Capacity:—
Average, 250 lb. bales—104 per hour
—382 tons/24 hours
—25,000 tons fiber/crop

TABLE II

Man-Hour Needs Bagasse Baling
—Plant Operation—

Baling and Stacking—408 man-hours/24 hours
408 man-hours/382 tons bagasse/24 hours—1.07 man-hours/ton
—2.38 man-hours/ton B.D. "fiber"

Unstacking and shipping bagasse
40 man-hours/8 hour day—200 tons mill run bagasse
—0.20 man-hours/ton
—0.44 man-hours/ton B.D. "fiber"

TABLE III

BAGASSE BALING PLANT OPERATION AND MAINTENANCE COSTS

Basis: One ton mill run bagasse or 0.45 tons B.D. "fiber"

Bale and Stack	=	$1.12/ton mill run bagasse
	=	$2.48/ton B.D. "fiber"
Maintenance Cost	=	$5,325/year
	=	$0.213/ton B.D. "fiber"
Unstack and Load	=	$0.876/ton B.D. "fiber"

TABLE IV

Bagasse Baling Plant Operations
Fixed Charges

Depreciation, 5%/year on $300,000	=	$15,000/year
	=	$0.60/ton B.D. "fiber"
Interest and insurance on stored bagasse, 5.5% on value of product 5.5% x $5.59/ton B.D. "fiber"	=	$0.31/ton B.D. "fiber"

stantial reduction, too, in the cost of freight because of the 20% less weight of material which will have to be hauled from the sugar factory to the pulp mill. Maintenance and depreciation charges will increase because of the smaller tonnages of fiber handled from a given factory and the cost of depithing will be additional. This summary shows that the cost of a ton of bone dry mill run bagasse delivered to the pulp mill would be $10.707 compared to $9.78 for the depithed material.

Data from several sources indicate that yields of high grade bleached pulp from bagasse are of the order of 55% on the bone dry weight of the clean bagasse entering the digester. Losses from sugar mill to digester are of the order of 20% on the dry weight of the original bagasse and would be nil for clean depithed bagasse. On this basis, there would be required 2.27 tons of bone dry fiber with ordinary mill run bagasse and 1.82 tons of bone dry fiber with depithed bagasse to produce the same one ton of dry pulp. Bagasse costs per ton of pulp are thus:

Item	Bagasse Cost/ton Pulp
Mill run bagasse	**$24.30**
Depithed bagasse	**17.80**
Savings through depithing	**$ 6.50**

The savings of $6.95 represent the difference in the cost of raw material which would be required to produce the same quantity of dry pulp using mill run bagasse compared to cost for the amount of depithed bagasse required to do the same job. The obvious savings would be in the elimination of the very substantial loss of material because of the presence in bagasse of soil, leaves, and considerable amounts of pith which are lost in the preliminary and final screening of the bagasse either before or after digestion.

It is interesting to compare the above costs with those of pine pulp wood in the Gulf Coast area. The average cost of pine pulp wood delivered to a representative group of southern mills during the past year was $18.77 per cord. The average wood requirements per ton of bleached pulp for the same group of mills was 2.0 cords. The cost comparison below shows that bagasse under present conditions in the Gulf South enjoys a favorable cost position for the production of suitable grades of bleached pulp over pine wood.

TABLE V
Cost of Bagasse in Storage Piles

Item	Cost: Ton Mill Run Bagasse	Cost: Ton B.D. "fiber"
Purchase Price*	$ 1.305	$ 2.900
Baling and Stacking	1.120	2.480
Maintenance	0.096	0.213
Sub-total	$ 2.521	$ 5.593
Interest and insurance at 5.5% of sub-total	0.138	0.308
Depreciation charges	0.270	0.600
Total Cost	$ 2.929	$ 6.501

*Based on 1000 Btu natural gas at $0.20/MCF plus $0.50 bonus/ton B.D. "fiber"

TABLE VI
BAGASSE COST DELIVERED TO PULP OR —BOARD MILL—LOUISIANA CONDITIONS

Item	Cost: Per Ton Mill Run Bagasse	Cost: Per Ton B.D. "Fiber"
Total Cost of Stored Bagasse from Table V	$ 2.929	$ 6.501
Unstack and Load	0.395	0.876
Freight to Pulp or Board Mill	1.500	3.330
Total Cost, delivered	$ 4.819	$10.707

TABLE VII
Bagasse Depithing Costs

A. Investment

Depithing Units, including License Fees	$ 80,000.00
Auxiliary equipment, Drives, Motors, etc.	16,000.00
Installation costs	14,000.00
Total investment	$110,000.00
Capacity: 25,000 tons B.D. "fiber"/70 day season 360 tons B.D. "fiber" per operating day	

B. Operating and Overhead Costs

Power Costs, 24 KWH/ton B.D. fiber	$ 6,000.00
Labor, 24 man-hours/day, 70 days	2,100.00
Maintenance, per year	2,500.00
Depreciation, 5%	5,500.00
Overhead and Administration	900.00
Total Costs	$17,000.00
Cost/ton B.D. "fiber" (25,000 tons)	$ .68
Cost/ton B.D. depithed fiber (80% of "fiber"	.85

TABLE VIII
Bagasse Losses on Storage and Processing

		Source
1. Field Storage Losses	10%	(3)
2. Processing Losses	15%	(3)
3. Yield of pulp, whole bagasse*	39%	(8)
4. " " " " "	45%	(11)
5. " " " " "	45%	(12)
6. " " " , depithed bagasse	50%	(10)
7. " " " " "	54%	(11)
8. " " " " "	60%	(9)

*Based on B.D. weight of material charged to digester. Field storage and processing losses are based on B.D. weight of bagasse originally purchased and placed in storage.

TABLE IX
Savings through Depithing Bagasse Prior to Storage

Assumptions:

1. Depithing removes 20% by weight of B.D. material charged.
2. Depithing prior to storage will reduce field and processing losses to 5% of B.D. weight of bagasse purchased and stored.
3. Actual weight yield of pulp from one ton of mill run bagasse after 20% depithing will be identical with that from same weight of mill-run bagasse which has not been depithed.
4. Tons mill run Louisiana bagasse required per ton of finished pulp:
   - 1 ton mill-run bagasse = 396 lbs. finished pulp
   - 5.05 tons mill-run bagasse = 1 ton finished pulp
   - 2.27 tons mill-run B.D. "fiber" = 1 ton finished pulp
5. Tons depithed mill-run Louisiana bagasse required per ton of finished pulp:
   - 5.05 tons x 80% = 4.04 tons/ton pulp
   - 1.82 tons depithed B.D. fiber = 1 ton finished pulp

TABLE X
Comparative Costs of Bagasse Delivered to Pulp Mill

Item	Cost per ton B.D. Material: Mill Run Fiber	Cost per ton B.D. Material: Depithed Fiber
Purchase Price	$ 2.900	$ 2.320
Bale and Stack	2.480	1.980
Unstack and Load	0.876	0.761
Maintenance	0.213	0.266
Depreciation	0.600	0.750
Interest and insurance on stored bagasse	0.308	0.251
Freight to pulp mill	3.330	2.664
Depithing Costs	—	0.85
Total Costs	$10.707	$ 9.78

Figure 1—Typical bagasse feed to the HORKEL sugar mill depithing machine.

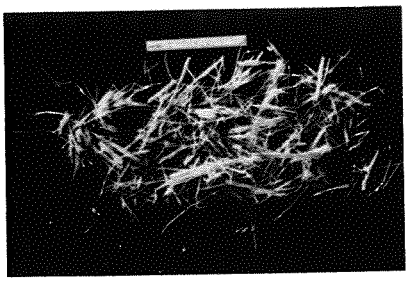


Figure 2—Fibrous product recovered by the HORKEL method of depithing.

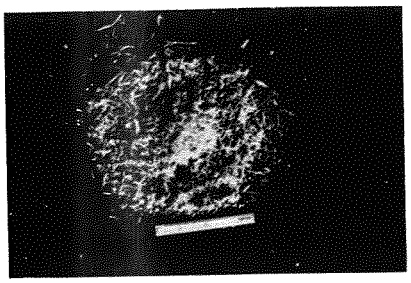


Figure 3—Pith fraction and extraneous material removed in the HORKEL method.

Item	Raw Material Costs Per ton Bleached Pulp
Pine	$37.40
Bagasse depithed	17.80
Cost advantage over pine	$19.60

The above figures do not take into account savings possible due to lower processing and bleaching cost with bagasse as compared to pine. Bagasse, basically, is a more delicate fiber with a considerably lower lignin content and consequently does not require so severe a cooking operation as would be the case with pine. It is recognized that industrial experience with bagasse as a raw material has not been so extensive as is the case with pine but at least one commercial plant is now in successful operation in this country and several smaller plants are operating in off-shore areas. It is also recognized that bagasse is not suitable for as many different grades of paper as is pine but, certainly with the cost advantage from the raw materials viewpoint which this study has indicated it merits consideration by the paper industry.

The very high proportion of the cost of bagasse chargeable to handling and storage (35%) points up the need for more study and the development of less expensive techniques for this operation. The very low bulk density and the perishable nature of fresh bagasse complicate the problem. Experimental work indicates that there may be some possibilities for bulk storage where the sugar factory and paper mill are contiguous. This would involve removal of a substantial portion of the moisture content of the bagasse prior to bulk storage. Depithed bagasse can be dried fairly simply with currents of warm air since the pressure drop through fairly high columns of the material is relatively small compared to the pressure drop through undepithed material.

The high freight costs (30% of the total cost) point up the extreme importance of a careful study of plant location with respect to the source of bagasse for most economic operation.

TABLE XI

Savings in Raw Material Cost —Depithed vs Whole Bagasse—

Basis:— 1 ton finished pulp		
B.D. whole bagasse "fiber"	=2.27 tons x $10.707	=$24.30
B.D. depithed fiber	=1.82 tons x $ 9.78	=$17.80
Savings in raw material cost		=$ 6.50

TABLE XII

Comparative Costs of Raw Materials for Pulp Production

Basis: 1 ton pulp Item	Cost/ton pulp
Pine Pulp Wood	$ 37.40
Depithed Bagasse	17.80
Cost Advantage over pine	$ 19.60

In conclusion, sugarcane bagasse offers many possibilities as a present and future source of raw material for the production of paper and pulp. Very large tonnages of the material are concentrated at sugar factories in many of the sugar producing areas of the world. The material, intrinsically, has little value other than as fuel. A major problem in connection with its use is the cost of handling bagasse from the time it is produced at the sugar factory until it enters the digester at the pulp mill.

Mechanical depithing methods have been developed which permit the removal of substantially all of the extraneous material present in bagasse plus a considerable amount of the undesirable pith and fines on a continuous and economic basis. Substantial savings in raw materials cost to the pulp mill can be effected by depithing of bagasse at the sugar mill prior to storage and handling.

The high percentage of the cost of bagasse incurred in handling and shipping indicates the need for further study of both these matters.

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APPENDIX XII

Cuban Mill Operates Improved System for Cleaning and Depithing Bagasse

The Parsons & Whittemore "HORKEL" Process

Developed By

Dr. Paul M. Horton and Dr. Arthur G. Keller

at

Louisiana State University

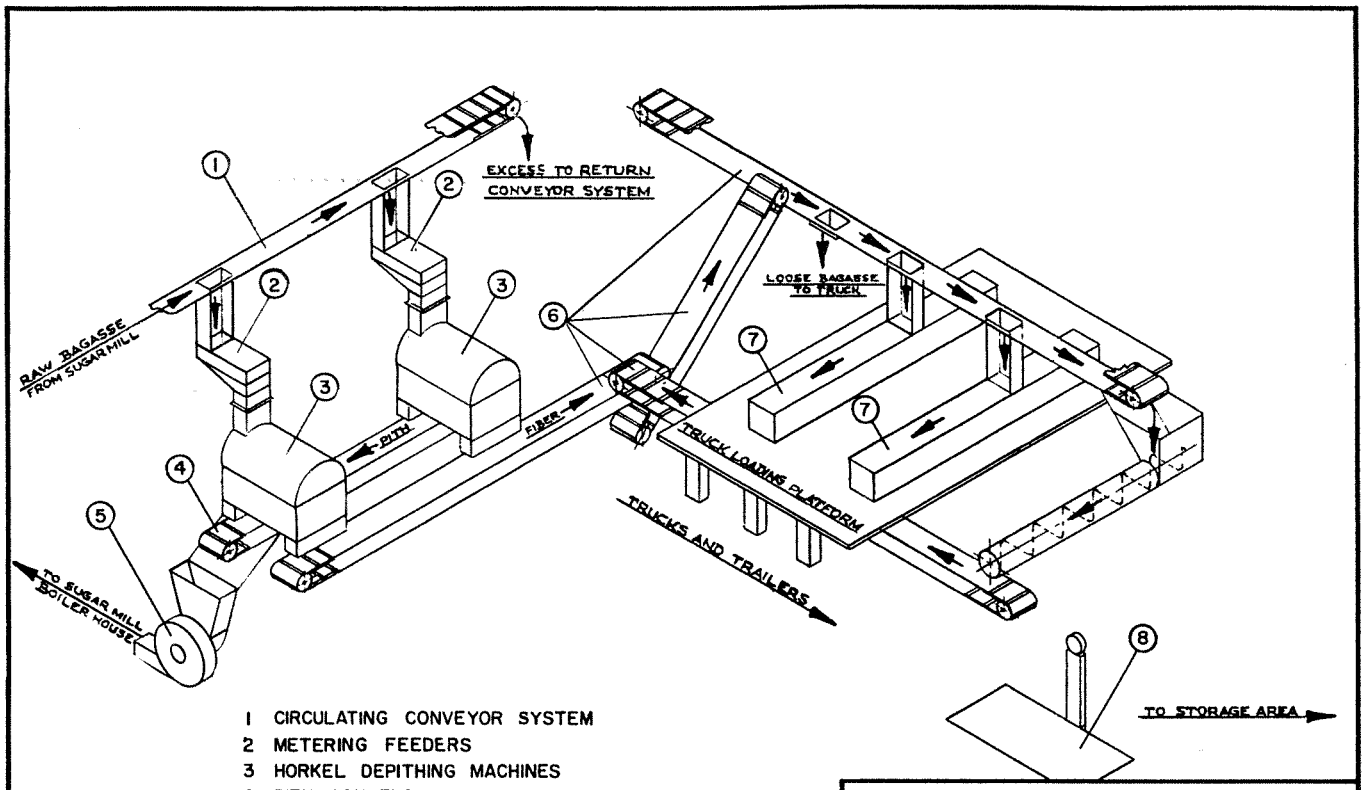
Commercial Installation

Engineered By and Available Through

The Parsons & Whittemore-Lyddon Organization

and Affiliated Companies

Reprinted from **Paper Trade JOURNAL**, June 30, 1958



BAGASSE DEPITHING AND BALING STATION USING PARSONS & WHITTEMORE "HORKEL" SYSTEM

Cuban Mill Operates Improved System for Cleaning and Depithing Bagasse

New machine efficiently separates pith from fiber at the sugar mill.

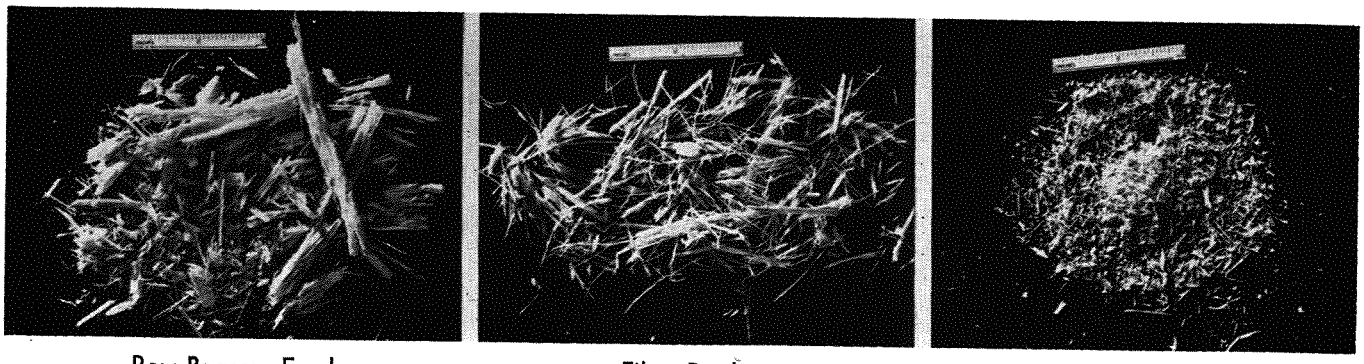
The first commercial Horkel mechanical system for removing pith and dirt from sugar cane bagasse at a sugar mill has just completed a full season of operation at the Central Trinidad sugar mill in Cuba. The resulting depithed, clean bagasse fiber has been baled and stored for utilization by Papelera Pulpa-Cuba, S. A.—a new, 100 daily-ton bleached bagasse pulp and paper mill now nearing completion near Central Trinidad.

New Machine

Key to the new system is the Horkel depither, a modified swing hammer mill developed at Louisiana State University and first proven in pilot operations at the Audubon sugar factory. The machine has been licensed for manufacture by the Parsons & Whittemore-Lyddon organization in New York and London. The Parsons & Whittemore-Lyddon organization and affiliated companies also have exclusive sales rights of the machine and the Horkel Depithing System throughout the world.

The two Horkel machines installed at Central Trinidad handled a total of 250 tons of bagasse (bone dry basis) daily on a sustained around-the-clock schedule, operating throughout the sugar cane grinding season.

What the Horkel system offers is said to be an economically sound solution to a problem in bagasse utilization that has limited the value of this fiber for many years. It is widely recognized that most of the pith and dirt particles in the crushed sugar cane must be removed before the cane is pulped for papermaking if the pulp is to compete with other commercial pulps for cleanliness, brightness, and runability on a paper machine. However, when the cost of removing the pith and dirt is high, as it has invariably been in the past, it often prices bagasse pulp out of the market. The Horkel system, it is reported, not only removes the pith ef-



Raw Bagasse Feed | Fiber Product | Pith Fraction

DEPITHING RESULTS: Dramatic improvement in the condition of bagasse fiber for papermaking made by removal of the pith by the Horkel process.

fectively but also produces new cost savings that lower the expense of making pulp from depithed bagasse below that of producing pulp from the whole bagasse.

Savings Made

The Parsons & Whittemore-Horkel system accomplishes savings in several ways:

1—By removing a high proportion of the pith at the sugar mill, the sugar factory can retain this part of the undepithed bagasse as fuel. The cost of replacement fuel is reduced accordingly and the pulp mill is not charged with the undesirable pith which it cannot use anyhow.

2—Baling costs per ton of useable fiber are reduced by the absence of the pith and dirt.

3—Handling costs drop, because more fiber is handled per man-hour when the bales are formed of depithed bagasse.

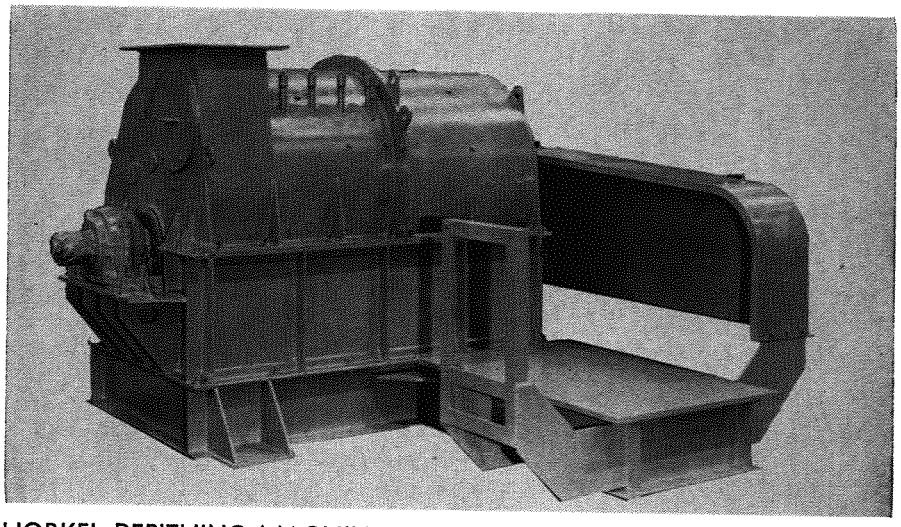
4—Freight charges go down if each ton of bagasse transported is more pure fiber and less pith and dirt.

5—A pulp mill digester charged with a ton of depithed bagasse will yield approximately 20 per cent more papermaking pulp than one charged with undepithed bagasse. Most of the pith in the whole bagasse merely dissolves out in the digester or forms undesirable products which must be removed later in the process.

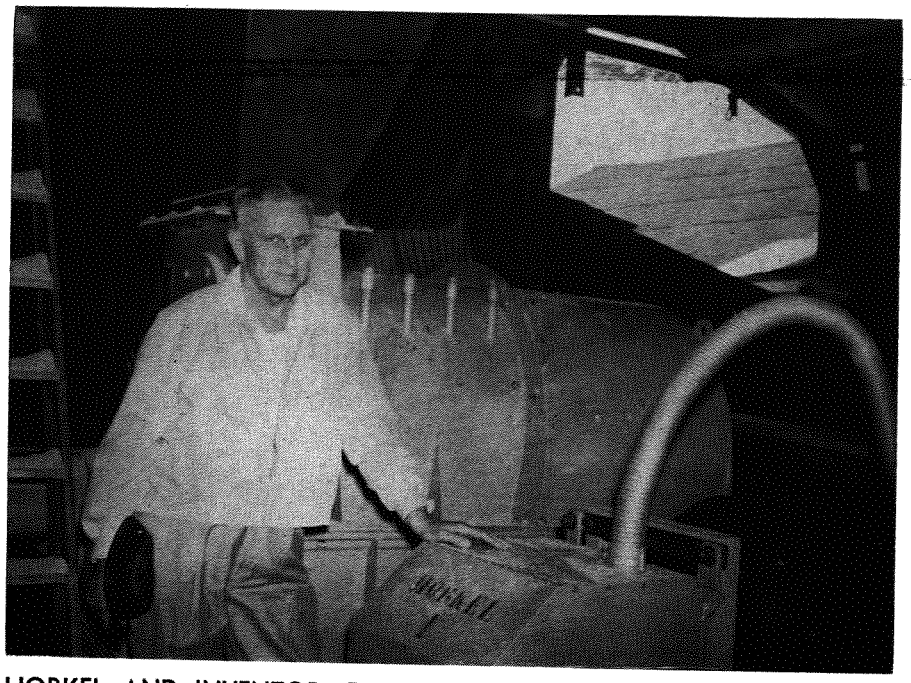
6—Direct cost saving in the value of cooking and bleaching chemicals *not* consumed by the absent pith, is considerable. The pith consumes more chemical than the fiber, yet yields very little useable pulp.

7—Noticeable savings will also accrue through reduction in the rejections of paper made with pulp manufactured from Horkel depithed bagasse. And there will be fewer shut-downs and less maintenance on paper machines and stock preparation equipment because of pith and dirt problems.

8—The paper machine can be run



HORKEL DEPITHING MACHINE: A modified swing hammer mill for removing pith and dirt from sugar cane bagasse, the machine will handle 125 tons per day (dry basis). Product of Parsons & Whittemore Inc.



HORKEL AND INVENTOR: Dr. A. G. Keller, co-inventor of the depithing machine, recently inspected one of the two commercial units in the Central Trinidad sugar mill, Cuba.

faster, and production can be increased after removal of the slow draining, slow drying, troublesome pith.

Comparative tests have shown that substantial savings are possible through Horkel depithing at the sugar mill. These savings stand against a low cost for depithing bagasse by the Horkel system. Substantial additional savings in the integrated bagasse pulp and paper mill are anticipated.

How It Works

The Horkel depither was named for its two inventors, Dr. P. M. Horton and Dr. A. G. Keller, both professors of chemical engineering at Louisiana State University. Their machine is designed to operate on moist bagasse as it comes from the sugar factory. It is a modified swing hammer mill with a housing designed so that bagasse may be fed into the mill at one end. The crushed cane residue travels the length of the rotor across the top of the revolving hammers. Passage of the material is assisted by the special design of the hammers, giving a screw effect.

The depithed fiber passes out through a space in the housing at the end of the rotor. The pith, which has been knocked free by the hammers, falls to the bottom of the housing, which is a perforated metal plate. The action of the hammers is especially designed to keep the surface of the perforated plate free of material and to drive the separated pith through the openings.

The commercial Horkel machine is said to be extremely versatile and is designed to be used under almost any conditions of sugar cane milling operations. Where circumstances are favorable, it can be used not only for moist depithing but for complete wet depithing of the bagasse and subsequent recovery of a high proportion of the residual sugar in the bagasse thus increasing the profits to the sugar mill and providing superior quality pith-free bagasse fiber for pulp mill use.

APPENDIX NO. XIII

(contributed by Eberhardt Gaertner, FAO Forestry Division)

Estimation of the potential pine area in the southern parts of the provinces of Srisaket and Ubon

1. According to Pendleton (Report to accompany the provisional map of the soils and surface rocks of the Kingdom of Siam; Bangkok, 1953) the prevailing soil types in the whole area between Surin in the west, the railway Surin-Ubon and eastwards the Mun-River in the north, and the mountain ridges along the national boundaries in the east and south are "Korat find sandy loams" and "Roi-et fine sandy loams".

The "Korat fine sandy loams" - soil group is one of the largest in area in Thailand and at the same time one of the most infertile. They are the weathering products of poor sandstons and the soils have often a pisolitic laterite layer in the subsoil. There were shale strata within the poor sandstones, which weathered to clayey soils. But these clays are found very seldom at the surface. The natural cover of the "Korat fine sandy loams' is a more or less open dry dipterocarp forest with Dipterocarpus tuberculatus, Dipt. ob'usifolius, Pentacme siamensis and Shorea obtusa as prevailing species. (Prevailing forest type along the road eastern of Ubon).

In large areas of the "Korat fine sandy loams" long sinuous bodies of so called "Kumpawapi sandy loams" are found on a little bit higher sandy ridges. These deep soils without characteristic horizon. They are naturally covered with moist mixed deciduous forests with Hopea odorata and Ditp. alatus. The visited area northern of Kantharalak was such a sandy ridge of "Kumpawapi sandy loams", where Pinus merkusii is mixed with Ditp. obtusifolius, Irvingia, malayana, Hopea odorata and even Dipt. alatus.

If "Korat find sandy loams' are deposited in shallow depressions, where they receive an additional supply of water from the surrounding higher slopes, paddy can be grown. These soils are called "Roi-et find sandy loams". They are now nearly entirely permanent agricultural land. Reforestation of these soils is therefore pretty unlikely.

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APPENDIX NO. XIII (Cont.)

The proposed pine plantations should be limited to the "Kumpawapi sandy loams", since on these soils a reasonable yield can be expected, where as the normal "Korat find sandy loams", are too poor for well growing pine plantations.

2. The general situation in the Northeastern Region of Thailand is characterized by a very high increase of the population, which caused in the past decades a permanent enchroachment of the forests by settlers. It seems to be very unlikely under these circumstances, that agricultural land can be reforestated. Therefore can pine plantations only be established by conversion of other forest types or completion of an unsufficient natural pine regeneration.

Although the area of the "Kumpawapi sandy loams" still covered with forests is unknown, it seems to be possible to get a very rough idea from the distribution of the forest types. The mentioned parts of the provinces of Srisaket and Ubon have without the forest on the ridges along the national boundaries an area of approximately 10 500 km^2. The distribution of forest types in this area is:

I.	18% Dry Dipterocarp forests	1890 km^2
II.	11% Mixed deciduous and semi-evergreen forests	1155 km^2
III.	71% Agricultural and non forested land	7455 km^2

Since these data are based on the results of a large scale inventory, which cannot provide figures for small areas, no pine forests were represented by the sampling units. The mentioned areas of the different land use types can also be considered only as a very rough estimate.

It can be supposed, that approximately 50% of the areas of group II are semi-evergreen and mixed deciduous forests, not suitable for pine plantations, since these are areas along river banks or in depressions. Thus it can be supposed that about 570 km^2 are suitable for pine forests.

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APPENDIX XIV

TYPICAL PROPERTIES OF SACK KRAFT PAPER

Basis weight	70	100 grams per sq m
Bursting strength	2.18	2.81 kg per sq cm
Tensile Strength		
Machine direction	8.6	10.5 kg
Cross direction	4.5	5.8 kg
Stretch		
Machine direction	2.0	2.0%
Cross direction	3.5	4.0%
Tearing resistance		
Machine direction	95	115 gm
Cross direction	105	135 gm
Air permeability	60	75 sec per 300 ml

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APPENDIX NO. XV

HEHNER & COX LTD.

DIRECTORS:
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C. W. AYLEN, F.I.A.C., F.I.D.

ANALYTICAL & CONSULTING CHEMISTS.
PUBLIC ANALYSTS.

Telephone:-Royal 3538.
Telegrams:-Hehner, Royal 3538.

The Laboratories,
107, Fenchurch Street,
London, E.C.3.

OUR REF. JG/DR 25097

YOUR REF.

6th May, 1963

ANALYSIS OF A SAMPLE OF Kenaf Waste Cuttings (Thailand Project)

RECEIVED ON 26th March, 1963

MARKED Ubon, Thailand

SEALED

Description.....	Bundles of strands of dark grey fibre with black incrustation; average length, 5 cm.
Moisture.....	9.3%
Preliminary digestion experiment:	
Caustic soda.....	4% on dry sample
Pressure.....	2.8 kg. per sq. cm.
Time on pressure.....	4 hours
Residual caustic alkalinity.....	Nil
Yield.....	74% dry basis
Pulp.....	Fairly dark brown in colour; very strong

Comments - This material is excellent for use in strong wrappings where colour is not of major importance. It is considerably stronger than kraft coniferous pulp. Its use in sack kraft or kraft liner board would permit the substitution of some of the kraft pulp by a weaker material. A fuller evaluation is required in order to ascertain the quantitative extent to which this can be done.

p. p. HEHNER & COX LTD.

D. Grant.

Parsons & Whittemore Inc., New York.

APPENDIX NO. XVI

HEHNER & COX, LTD.

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OUR REF. JG/DR 25096

YOUR REF.

6th May, 1963

ANALYSIS OF A SAMPLE OF Kenaf Stalks (Thailand Project)

RECEIVED ON 26th March, 1963

MARKED Ubon, Thailand.

SEALED ----

Description..... Light grey coloured pithy sticks, 1 to 3 cm. in diameter with a thin stringy bark with a narrow hollow centre.

Moisture..... 9.5%

Preliminary digestion experiment:

Caustic soda.....	15% on dry sample.
Pressure.....	2.8 kg. per sq. cm.
Time on pressure.....	6 hours
Residual caustic alkalinity.....	Nil
Yield.....	55% dry basis
Pulp.....	Light brown in colour; fairly strong.

Comments - This material would make a good semichemical pulp suitable for corrugating medium, and for cheap wrappings where appearance is not of major importance. The chemical consumption and digestion time in the above preliminary experiment are both high, but could be reduced by using a higher pressure and a conventional semichemical procedure. A fuller evaluation is required to ascertain the chemical consumption and yield under these conditions.

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APPENDIX NO. XVII

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OUR REF. JG/DR 25103
YOUR REF.

The Laboratories,
107, Fenchurch Street,
London, E.C.3.

2nd May, 1963

ANALYSIS OF A SAMPLE OF Rosin

RECEIVED ON 27th March, 1963

MARKED From Government Plant at Ubon

SEALED

		Lovibond Units
Colour ($\frac{7}{8}$ inch cube)	Red.....	14.0
	Yellow...	75.0

Equivalent to grade 'G'

Insoluble matter.....	0.17%
Ash.....	0.5%
Unsaponifiable matter.....	6.8%
Acid value.....	166.3
Saponification value.....	179.6

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D. Grant

Parsons & Whittemore Inc., New York.

APPENDIX NO.XVII A

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OUR REF. JG/DR 25098
YOUR REF.

9th April, 1963

ANALYSIS OF THREE SAMPLES OF Water (Thailand Project)

RECEIVED ON 26th March, 1963

MARKED A, B and C.

SEALED -----

Place	Site C	Site D	Site F1
Date	16th March 1963	17th March 1963	17th March 1963
Time	10.00	13.45	15.45
Appearance	Slight sediment; clear supernatant liquid.	Small sediment settling slowly; cloudy liquid.	Small sediment settling slowly; cloudy liquid.
Total solids	10,880	4,940	213 p.p. million
Organic solids	1,663	180	45
Hardness - total	1,269	1,062	165
Temporary	65	180	20
Permanent	1,204	862	145
Chlorides (NaCl)	8,650	4,500	49
Sulphates (Na_2SO_4)	955	502	156
pH value	7.2	7.4	7.8

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J. Grant

Parsons & Whittemore Inc., New York.

PROJECT NY-773

APPENDIX XVIII

ERECTION SUPERVISORY PERSONNEL TO BE FURNISHED BY CONTRACTOR

Description of Job	No. of Persons	Approx. Total Man Months at Mill Site
Overall Supervising Engineer	1	20
Mechanical Engineer	1	16
Electrical Engineer	1	14
Pandia Digester Specialist	1	3
Evaporator Specialist	1	3
Washer Specialist	1	3
Paper Machine Erection Engineer	1	10
Paper Machine Erection Superintendent	1	8
Instrument Specialist	1	6
Piping Superintendent	1	12
Welding Superintendent	1	12
Boiler Erection Superintendent	1	12
Turbine Erection Superintendent	1	6
Bag Machine Erection Superintendent	1	3
Tile Setting Specialist	1	4
Mechanical Superintendent	1	10
TOTALS	16	142

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PROJECT NY-773

APPENDIX XIX

ESTIMATED NUMBER OF LOCAL SKILLED AND UNSKILLED PERSONNEL TO BE FURNISHED BY PURCHASER

Job Description	No. of Persons
Foremen	14
Skilled Erection Fitters and Mechanics	20
Semi-skilled Erection Fitters and Mechanics	40
Skilled Welders	18
Semi-skilled Welders	18
Skilled Electricians	10
Semi-skilled Electricians	10
Skilled Bricklayers	10
Skilled Carpenters	3
Skilled Blacksmiths	2
Unskilled Laborers	185
TOTAL	330 *

* The total number of daily working personnel will vary throughout the different stages of the erection schedule. At the start of erection, there will be approximately 50 men. This number will gradually increase to a maximum of approximately 280 men some 12 to 14 months after the start of erection, and will then gradually decrease to approximately 100 men by the end of erection.

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APPENDIX XX

A TYPICAL ROSTER OF PERSONNEL TO BE FURNISHED BY CONTRACTOR FOR START-UP

Job Description	No. of Persons	Total Man-Months
Overall Technical Supervising Engineer	1	6
Paper Machine Specialists	3	18
Stock Preparation Specialist	1	6
Finishing Room Specialist	1	6
Instrument Specialist	1	6
Power Plant Specialist		6
Mechanical Engineer	1	6
Electrical Engineer	1	6
Totals	10	60

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APPENDIX XXI

OPERATING MANAGEMENT CONTRACT

This Contract, entered into this day of 1963, by and between the THAI PAPER INDUSTRIES COMPANY, LTD., (a share company), a company duly organized and existing under the Commercial Code of Thailand, (hereinafter called the "Enterprise"), and PARSONS & WHITTEMORE, INC., a New York corporation having its headquarters at 200 Park Avenue, New York 17, New York (hereinafter called the "Operating Contractor").

W I T N E S S E T H :

WHEREAS, the Enterprise desires to engage the Operating Contractor to supervise the executive, administrative, technical and operating personnel of the Enterprise and provide the overall management of the operations of the pulp and paper mill constructed in Thailand and for the training of local personnel therefor, and the Operating Contractor is willing and able to provide the desired services;

NOW, THEREFORE, the Enterprise and the Operating Contractor for and in consideration of the premises and the mutual covenants herein contained, do hereby agree as follows:

ARTICLE I

Definitions

A. As used herein the terms "Field Staff" or "Field Man" shall mean the personnel of the Operating Contractor who are assigned to work in Thailand to carry out the purposes of this Contract. It is contemplated by the parties that the personnel set forth in Appendix A hereto shall constitute the Field Staff. The functions of the Field Staff are separate and distinct from the functions of the Start-Up Personnel for whom provision is made in the Construction Contract to be arranged between the parties. It is further contemplated that such Field Staff will arrive pursuant to the schedule set forth in Appendix A and will remain in Thailand for the periods indicated therein. It is understood, however, that the number of personnel, their duration of stay and times of arrival may be altered as provided in this Contract or by mutual agreement of the parties hereto.

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B. As used herein the term "Mill" shall mean both the paper mill and the pulp mill to be constructed in Thailand, together with all the appurtenant installations and facilities.

C. As used herein the term "commencement of operations" shall mean the date on which the paper mill and/or the pulp mill, as the case may be, commences production.

ARTICLE II

Scope of Services to be Provided by the Operating Contractor

Subject to the overall policies established by the Board of Directors of the Enterprise, the responsibilities of the Operating Contractor shall be the following:

A. The Operating Contractor shall have full and exclusive authority for the management of the Mill and shall manage all services connected with the operation of the Mill including inter alia (1) production, (2) office management, (3) financial accounting, (4) cost accounting, (5) purchase or requisition of raw materials and other products, (6) inventory control of both raw materials and finished products, (7) hiring of personnel and payroll records, (8) sales, (9) engineering services relating to production, (10) maintenance, repair and replacement of plant equipment including utilities, and (11) supply of technical information.

B. The Operating Contractor shall arrange, for the account of the Enterprise, necessary training of local personnel both in Thailand and in foreign paper mills. Such personnel will be in addition to the personnel for whom training is provided in the Construction Contract between the parties. Any trainees sent abroad shall be compensated by the Enterprise and the Enterprise shall be responsible for all out-of-pocket and travel expenses by such trainees. The above expenses shall be paid by the Enterprise directly; but in the event that, for any reason, the Operating Contractor shall pay such expenses, the Enterprise shall reimburse the Operating Contractor within thirty (30) days after having been billed therefor by the Operating Contractor.

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C. The Operating Contractor shall train local personnel as rapidly as possible to the end that such local personnel will be able efficiently to operate, maintain and administer the mill. Such training of local personnel shall include on-the-job and in-service programs.

D. When, in the judgment of the Operating Contractor, a local employee has reached the required level of training and efficiency, such local employee shall replace the member of the Field Staff who is performing the function for which such local employee is trained. Upon such replacement, the service of such Field Man shall be terminated unless the Enterprise requests his retention for other duties. Any termination of a Field Man's services on account of replacement by a local employee shall be upon at least three (3) months' prior notice to the Field Man in question.

E. The Operating Contractor shall determine the types and quantities of products to be produced by the Mill. The Operating Contractor, however, will give full weight to the desires of the Enterprise with respect to the types and quantities of pulp and paper products to be produced as long as such desires of the Enterprise do not, in the judgment of the Operating Contractor, impair efficient and effective functioning of the Mill.

F. The Operating Contractor shall be responsible for the sale of the products of the Mill. The Operating Contractor, however, will give full weight to the desires of the Enterprise with respect to the organization of the sales program of the Mill.

G. All personnel of the Mill, including sales personnel, shall be subject to the direction and control of the Operating Contractor.

H. For the duration of this Management Contract the Operating Contractor shall, subject to the policy from time to time laid down by the Board of Directors of the Enterprise, use all its skill and knowledge to manage, administer and develop the Mill efficiently and to conduct the business of the Mill to the best of its abilities in the best interest of the Enterprise and its shareholders, and in a proper and business-like manner shall endeavor to maintain the Enterprise and carry it on in the ordinary course of business, provided nevertheless that the Operating Contractor shall not, without the express consent of the Board, borrow money on account of the Enterprise or acquire or dispose of any of the Enterprise's fixed assets.

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I. The Operating Contractor shall furnish all technical and other information for the time being in the possession of the Operating Contractor, which is or might be of use or benefit to the Enterprise and which relates in any way to the operation of such Enterprise.

J. The Operating Contractor shall supervise the conduct of the correspondence of the Enterprise and the preparation of all reports, returns, statistics, certificates and other documents required by the Government.

K. The Operating Contractor shall submit to the Board:

(1) not later than the thirtieth day of each successive calendar month, a report in a form approved by the Board on the conduct of the Enterprise during the preceding month,

(2) within 60 days after the last day of March, June, September and December in every year a statement in a form approved by the Board, of the revenue and expenditure during the preceding quarter together with such other documents as may be necessary or desirable to acquaint the Board with the state of the Enterprise,

(3) before or at least on the 60th day preceding the last day of each financial year of the Enterprise, estimates, in a form approved by the Board, of capital and revenue expenditure and estimated income of the Enterprise for the next ensuing financial year.

(4) on or as soon as reasonably may be after the 60th day following the last day of each financial year of the Enterprise, a report, in a form approved by the Board, on the conduct of the Enterprise together with a Balance Sheet and Profit and Loss Account of the Enterprise for the preceding financial year.

L. The Operating Contractor shall, when so requested by the Board, submit to the Board reports on world and local marketing conditions affecting the Enterprise's products.

M. The Operating Contractor shall ensure that the Enterprise effects all such insurances as are commercially reasonable and expedient for and in connection with the Enterprise and the Enterprise's products.

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N. The Operating Contractor shall produce for the Board or their duly authorized representative, whenever so requested, all correspondence and other documents relating to the Enterprise and to provide the Board with such copies or extracts thereof or therefrom, as the Board from time to time requires.

O. The Operating Contractor shall ensure that all of the obligations imposed on the Enterprise by the laws of Thailand are carried out.

P. The Operating Contractor shall attend, by their properly accredited representatives, all meetings of the Board for the purpose of giving such information and explanations as the Board may require or as may seem desirable to the Operating Contractor.

Q. The Operating Contractor shall maintain books of accounts and records of the Enterprise at the enterprise's principal place of business or at such other places as the Board may from time to time direct, adequate to give a true and fair view of the Enterprise's affairs and its profits.

R. The Operating Contractor shall not, either during the management period or at any time thereafter, disclose any information as to the state of the Enterprise's affairs which has come to the knowledge of the Operating Contractor by reason of its employment by the Enterprise under this agreement, except when such information as to the state of the Enterprise's affairs have been made public under the authority of the Board.

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ARTICLE III

Field Staff

A. The Operating Contractor shall directly employ the foreign personnel comprising the Field Staff, as set forth in Appendix A. The Field Staff, together with locally trained personnel on the payroll of the Enterprise, will comprise the minimum complement of personnel required to operate the Mill. In addition, management trainees, whether foreign or local, may be employed for training and ultimate replacement of the Field Staff.

B. The Field Staff, as listed in Appendix A, should be adequate to fulfill the obligations of the Operating Contractor hereunder; however, if, in the judgment of the Operating Contractor, efficiency of the operation of the Mill can be [illegible]

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improved by hiring foreign personnel in addition to those listed in Appendix A, it shall employ such additional personnel for the account of the Enterprise and so notify the Enterprise in writing, giving its reasons therefor.

C. The Field Staff shall serve for periods assigned by the Operating Contractor under written employment contracts.

D. The Enterprise shall appoint as General Manager of the Enterprise such member of the Field Staff as is nominated by the Operating Contractor for this position, such appointment to take place when requested by the Operating Contractor, but in any event not later than six months from the date of this Contract. As General Manager, such Field Man shall have full authority to manage the operations of the Mill, including such powers necessary for the efficient operation of the Mill as the right to hire and discharge, replace or discipline for cause all personnel on the payroll of the Enterprise.

The Board of Directors shall have the right to propose to the Operating Contractor that the General Manager shall be replaced in the event of dissatisfaction with his performance; in such event, the Operating Contractor shall nominate a replacement and the Enterprise shall appoint such nominee as General Manager of the Enterprise.

The Field Staff shall be assigned to the Mill by the Operating Contractor substantially in accordance with the schedule set forth in Appendix A. Certain of the field Staff shall be placed at the Mill during the construction of the Mill to familiarize themselves with the Mill and with the operating conditions prevailing in Thailand. During the later stages of construction, such Field Staff shall initiate a training program for local operating and administrative staffs and shall make all necessary arrangements to place the Mill on an operating basis. The Field Staff shall be increased as the Mill approaches completion so that the entire Field Staff shall be available for the commencement of operation.

E. In addition to the Field Staff, the Operating Contractor shall supply such services of its executive personnel in its home office or at the offices of affiliated companies, for the support of the Field Staff by way of liaison, consultation and such other aspects of the operations of the Mill as may be required to accomplish the objectives of this Contract.

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F. Members of the Field Staff, while engaged in services under this Contract, shall not engage, for profit or otherwise, in any other business or occupation without the written consent of the Enterprise and the Operating Contractor.

G. As set forth in Clause A, Article I, this Contract covers only the Field Staff, whose functions are to be performed in connection with the operation of the Mill. The Field Staff personnel are to be distinguished from the Start-up personnel, whose functions are to be included in the Construction Contract to be arranged between the parties.

ARTICLE IV

Management Fee and Reimbursement of Costs

A. The Enterprise shall pay the Operating Contractor a management fee based on the actual production of the Mill during the term of this Contract. Such fee shall be in the amount of one and one half percent (1.5%) of the gross sales value of the finished product provided, however, that in no event shall such fee be less than Two Hundred Ten Thousand Thai Bahts (B210,000) per month. The fee shall be computed on a monthly basis and shall be payable no later than fifteen (15) days after the end of each month of production.

B. Irrespective of whether any fee is paid or is payable under Clause A of this Article, the Enterprise shall also reimburse the Operating Contractor, in the currency in which expenses are incurred, for the following items:

1. Actual payroll, including for each Field Man provision for vacation, bonuses and fringe benefits such as Social Security, medical and hospitalization insurance programs. Each Field Man is to be entered on the payroll from the date such Field Man leaves his home or normal place of business for services under this Contract, until his return home or to his normal place of business upon completion of such services. The salary range for each Field Man shall be generally as set forth in Appendix A.

2. Sixty percent (60%) of the payroll of the Field Staff to cover Operating Contractor's supporting services and overhead charges.

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3. Transportation charges for the transportation of the Field Staff and their dependents (wives and unmarried children under twenty-one (21) years of age) from their homes or normal places of business to the Mill, except as may herinafter be provided. Transportation for seven (7) senior field men and their dependents shall be by first class regularly scheduled commercial airlines. Transportation of all other Field Personnel and their dependents shall be by tourist or economy class regularly scheduled airlines. If the Field Staff and their dependents travel by other means, then the total cost reimbursable by the Enterprise shall not exceed the cost of the most direct air route. For the purpose of this subparagraph, transportation shall be deemed to include:

   (i) Twenty-five (25) kilograms gross weight of excess accompanying air baggage for each Field Man and his dependent.

   (ii) Surface transportation of additional baggage and household effects (including the cost of packing, crating and forwarding) up to a maximum of two thousand five hundred (2,500) for each Field Man.

   (iii) One (1) privately owned automobile for each Field Man under contract for eighteen (18) months or longer.

4. Bona fide and reasonable travel expenses of the Field Staff and dependents as actually expended while in travel status, as authorized under this Contract.

5. Necessary passport and visa fees, work permits and other special charges incurred by the Operating Contractor or by the Field Staff and dependents in connection with their assignment under this Contract.

6. Cost of medical care and hospitalization, if any, of such of the Field Staff, their dependents, or the Operating Contractor's executive personnel who become ill or are injured while serving in Thailand under this Contract.

7. Charges for transportation as well as a travel allowance as set forth in Appendix B hereto, for travel undertaken by the Field Staff in the performance of services under this Contract. The parties will periodically review the

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amount of this allowance, and an adjustment will be made from time to time, by mutual agreement, to reflect the changes in the cost of living index.

8. Charges for transportation and travel expenses of the Operating Contractor's executive personnel, when required to perform services under this Contract away from their normal places of work, as well as, where such services are to be performed in Thailand, a subsistence allowance as set forth in Appendix C hereto. The parties will periodically review the amount of this allowance, and an adjustment will be made from time to time, by mutual agreement, to reflect the changes in the cost of living index.

9. Thailand federal and/or local taxes and duties, whether or not now in effect, which may be levied against the Operating Contractor and individual members of the Field Staff while in transit to the Mill or on duty at the Mill; provided, however, that if a Field Man brings into Thailand baggage, household effects and automobile free of duty or is reimbursed for import duties paid, and such baggage, household effects and automobile are not re-exported and are not resold, with the approval of the Enterprise, to persons or organizations holding similar exemptions, the field man shall pay the duties which would normally be imposed on such baggage, household effects or automobile or reimburse the Enterprise for such duties, as the case may be.

10. Charges for return transportation and travel expenses for the Field Staff, their dependents, baggage, household effects and automobiles, upon termination of their respective contracts.

11. Charges for the return transportation and travel expenses of any Field Man, his dependents, baggage, household effects and automobile prior to termination of his contract, if such field man is returned to his home or normal place of business for reasons of health as certified by a physician.

C. Upon termination of this Contract, the Enterprise shall pay the Operating Contractor an amount equal to fifty per cent (50%) of the average annual fee paid to the Operating Contractor during the term of this Contract. Such termination fee shall be paid in twelve (12) equal monthly installments, beginning one (1) month after termination. The provisions of this paragraph shall not apply, however, in the event of

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termination of the Contract prior to the termination date set forth in ARTICLE VIII hereof, if such earlier termination is due to force majeure.

D. The Enterprise shall not be required to reimburse the Operating Contractor for the following items:

1. Charges for the return transportation of any Field Man, his dependents, baggage, household effects and automobile, if such Field Man resigns or is discharged for cause prior to the termination of his contract. The Operating Contractor will furnish a replacement for any such Field Man and will bear the cost of transporting him to the Mill.

2. Return transportation for any dependent if such dependent does not remain at the Mill for a period of not less than half the required tour of duty of the respective Field Man and, in any event, for at least six (6) months, except for reasons of illness as provided in paragraph 12 above.

ARTICLE V

Provision for Payment of Fees And Reimbursement of Cost

A. Not less than thirty (30) days prior to the departure of the first Field Man for Thailand, the Enterprise shall establish an irrevocable, confirmed and divisible letter of credit in favor of the Operating Contractor at a United States bank satisfactory to the Operating Contractor, in the amount of Ond Hundred Thousand United States Dollars (U.S. $100,000), which shall be utilized for the payment to the Operating Contractor of the management fees and reimbursement of foreign exchange costs authorized under ARTICLE IV of this Contract. The Operating Contractor may obtain payment for such management fees and reimbursable costs upon presentation of an invoice of the Operating Contractor, certified by the General Manager, itemizing the fees and reimbursable costs due and payable for the preceding month or other mutually agreed upon period. The Enterprise shall replenish such letter of credit every three (3) months so that at the beginning of each quarter the letter of credit will be in the amount of One Hundred Thousand United States Dollars (U.S. $100,000). In the event that the Operating Contractor estimates this letter of credit will be insufficient to cover expenses during a current quarter, it will so notify the Enterprise and the Enterprise shall replenish the letter of credit by such amount as is required.

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B. Not less than thirty (30) days prior to the departure of the first Field Man for Thailand, the Enterprise shall make an advance deposit in the name of the Operating Contractor at the Bank of Thailand in Bangkok; in the amount of One Million Bahts (B. 1,000,000), which shall be utilized for the reimbursement to the Operating Contractor of local currency costs incurred as provided for in ARTICLE IV of this Contract. Each month the Operating Contractor will submit to the Enterprise an accounting of the expenditures made out of the deposit account during the preceding month. The Enterprise shall replenish this account every three (3) months so that at the beginning of each quarter the account will be in the amount of One Million Bahts. (B. 1,000,000). In the event that the Operating Contractor estimates this account will be insufficient to cover expenses during a current quarter, it will so notify the Enterprise and the Enterprise shall replenish the account by such amount as is required.

C. The payment procedures set forth in paragraphs A and B shall be repeated until termination of this Contract or payment of all amounts due under this Contract, whichever is later.

ARTICLE VI

General Obligations of the Enterprise

A. The Enterprise shall designate, and shall notify the Operating Contractor in writing thereof, a member of its Board of Directors who shall have authority to represent and act for the Enterprise in all matters relating to this Contract.

B. All necessary facilities and services required for the operations of the Mill, including all personnel required for such operations other than the Field Staff, shall be provided by the Enterprise, but shall be procured, arranged for or hired, as the case may be, by the Operating Contractor and paid by the Enterprise. Such personnel shall be hired in such numbers and classifications as the Operating Contractor may from time to time determine to be required for the efficient operation of the Mill.

C. The Operating Contractor shall be provided by the Enterprise with such financial resources, in the form of working capital as the Operating Contractor may determine will be required for the day-to-day operations of the Mill, based on an estimated operations budget which the Operating Contractor shall submit to the Board of Directors of the Enterprise within thirty (30) days of the commencement of each fiscal year.

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D. The Mill shall be provided, at the expense of the Enterprise, with all raw materials, power and water at such times and in such quantities as the Operating Contractor may from time to time determine to be required.

E. Arrangements for such security forces to safeguard personnel and property at the Mill shall be made, at the expense of the Enterprise, as the Operating Contractor determines to be required.

F. The Operating Contractor shall not be responsible for any and all damages, including consequential damages, to or arising from machinery, equipment, buildings and persons, and occurring in connection with the services provided for or by the Operating Contractor under this Contract and/or with other activities of the Field Staff and other personnel of the Operating Contractor at the Mill. Full insurance coverage shall be provided, at the expense of the Enterprise, against the above-mentioned risks and the Operating Contractor shall be held harmless against any and all claims arising from any such occurrence.

G. The Operating Contractor shall not be liable for any loss that may happen through the act, default or neglect of any agent, sub-agent, banker, broker, factor, or representative or which may arise otherwise than through willful neglect on the part of the Operating Contractor or any member of the Operating Contractor's Field Staff.

H. The Royal Thai Government shall be requested by the Enterprise to issue immigration and residence permits, and work permits to the extent required, for the Field Staff, their dependents and other personnel of the Operating Contractor, to permit them to enter and remain at the Mill for the duration of the assignments under their respective contracts. Such personnel shall be furnished assistance by the Enterprise in securing such permits.

I. Suitable living quarters at or in the vicinity of the Mill shall be provided, at the expense of the Enterprise, for the Field Staff and their dependents, as well as for the executive and other personnel of the Operating Contractor on temporary duty at the Mill. Such living quarters shall be equivalent to the standard of living quarters normally available to persons of the same standing in the pulp and paper industry.

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ARTICLE VII

Disputes

A. All disputes arising under or in connection with this Contract shall be settled by arbitration. The arbitration shall be held in Geneva, Switzerland, and shall be conducted in accordance with the Rules of Arbitration and Conciliation of the International Chamber of Commerce, Paris, France. Judgment upon the award rendered in any court having jurisdiction or application may be made to such court for the judicial acceptance of the award and an order of enforcement, as the case may be.

B. Minor complaints involving the Field staff shall be resolved by the General Manager, who shall have the ultimate authority on behalf of the Operating Contractor. The Field Staff shall be subordinate to and shall be responsible to the General Manager, and all complaints as to the performance of any individual Field Man shall be directed to the General Manager.

ARTICLE VIII

Duration and Termination of the Contract

A. This Contract shall become effective upon execution thereof and shall continue in effect for seventy-two (72) months from Start-up of the pulp mill. It shall continue thereafter from year to year unless notice of termination is given by either party in writing at least six (6) months prior to the specified termination date or any succeeding anniversary thereof.

B. If force majeure or other circumstances beyond the control of the Operating Contractor prevent performance of this Contract, the Operating Contractor may terminate this Contract by giving the Enterprise notice in writing thereof, such termination to take effect upon the expiration of thirty (30) days after such notice, unless the preventing circumstances cease to exist prior to the expiration of such thirty-day (30-day) period. In the event of such termination, the Enterprise shall pay the Operating Contractor the fees and reimbursable costs incurred, up to and including the date of cancellation. In the event that the force majeure or other circumstances beyond the control of the Operating Contractor shall only partially prevent the Operating Contractor from performing its obligations under this Contract, it shall notify the Enterprise of such preventing circumstances and shall thereupon be excused from performance to the extent so prevented.

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C. Upon termination of this Contract, the Enterprise shall take over all operations of the Mill, and the Operating Contractor shall be relieved of any responsibility under this Contract.

ARTICLE IX

General Provisions

A. All reports, notes, memoranda and other technical data furnished by the Operating Contractor pursuant to or developed in connection with the provisions of this Contract shall become and shall remain the property of the Enterprise, and the Enterprise shall have the right to use them for any purpose without paying any additional compensation to the Operating Contractor. All such data in the possession of the Operating Contractor shall be delivered to the Enterprise upon request.

B. The Operating Contractor agrees that it and its personnel, while in Thailand, will abide by all applicable laws and regulations of Thailand and the political subdivisions and municipalities thereof.

C. The Operating Contractor shall not assign, transfer, pledge or make other disposition of this Contract without obtaining the prior written consent of the Enterprise.

D. Except as authorized in writing by the Enterprise, the Operating Contractor shall not subcontract any part of the work under this Contract.

E. All notices and notifications required under this Contract shall be delivered to the parties at the following addresses, either by registered airmail, cable or telegram:

To the Operating Contractor: 200 Park Avenue
New York 17, New York, U.S.A.
Cable Address: PARSWHIT, NEW YORK

To the Enterprise: Thai Paper Industries Co., Ltd.
Bangkok, Thailand
Cable Address:

Notice by cable, telegram and registered mail shall be effective when sent.

F. No changes, modifications or amendments shall be made to this Contract except as may be mutually agreed upon in writing by authorized representatives of the parties thereto.

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G. The Operating Contractor shall have no liabilities arising out of or resulting from operation of this Contract other than those expressly provided in this Contract.

IN WITNESS WHEREOF, the parties hereto have executed this Contract on the day and year above written.

THAI PAPER INDUSTRIES COMPANY LTD.

By _____

PARSONS & WHITTEMORE, INC.

By _____

PARSONS & WHITTEMORE

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APPENDIX A

MINIMUM LIST OF CONTRACTORS FIELD MANAGEMENT STAFF NECESSARY FOR SUCCESSFUL OPERATION OF THE PULP AND PAPER MILL AND CONVERTING PLANT

No.	Position	To arrive at mill prior to initial mill start-up by:	Estimated Minimum Duration of Stay	Estimated Annual Basic Salary U.S.$
1	General Manager	30 months	102 months	18,000-24,000
1	Papel Mill Superintendent	2 months	74 months	12,000-15,000
1	Pulp Mill Superintendent	3 months	75 months	12,000-15,000
1	Converting Plant Supt.	2 months	74 months	12,000-15,000
1	Steam & Power Plant Supt.	6 months	74 months	12,000-15,000
1	Plant Engineer	6 months	74 months	12,000-15,000
1	Assistant Engineer	3 months	74 months	9,000-12,000
1	Electrical Engineer	3 months	75 months	10,000-12,000
1	Master Mechanic	3 months	75 months	9,000-12,000
1	Tech.Control Supt.	1 month	73 months	12,000-15,000
1	Instrument Engineer	3 months	75 months	12,000-15,000
1	Accountant	1 month	37 months	10,000-12,000
4	Paper Mill and Converting Plant Foremen	1 month	49 months	10,000-12,000
4	Bagasse Handling & Pulping Foremen	1 month	49 months	10,000-12,000
20				

This list of field staff and the estimated duration of their employment are based on the Operating Contractor's best estimate of the time required to train local replacements. In the event that it is not possible to secure and train competent personnel within these estimated times, the foreign personnel will have to be retained for longer periods.

PARSONS & WHITTEMORE

APPENDIX B

TRAVEL ALLOWANCE FOR MEMBERS OF THE FIELD STAFF

When a Field Man is required, in the performance of services under this Contract, to travel away from his regularly scheduled place of work, he shall receive, in addition to transportation charges as incurred, a per diem allowance for living expenses, of:

1. Within Thailand - B. 500 per day.

2. Outside Thailand- US $25 per day.

APPENDIX C

TRAVEL ALLOWANCE FOR OPERATING CONTRACTORS EXECUTIVE PERSONNEL

When the Operating Contractor's executive personnel are required, in the performance of services under this Contract, to travel away from their regularly scheduled places of work, each such executive shall receive, in addition to first class transportation charges, a per diem allowance for living expenses, of:

1. Within Thailand - B. 700 per day.

2. Outside Thailand- US $35 per day.

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APPENDIX XXII

presented in

F O R T U N E

PRINTED IN U.S.A.

Timetable for a

PHASE 1: FEASIBILITY REPORT AND PRELIMINARY ENGINEERING

MONTHS 1 2 3 4 5 6 7 8 9

Implementation Date

PHASE 2: BUILDING AND ERECTION

Start-up

MONTHS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

MILL SITE AND IMPROVEMENTS

RAIL SIDING—ROADS—SERVICE CONNECTIONS

PULP AND PAPER STORAGE AND GENERAL WAREHOUSING

SHOPS AND STORES

STEAM AND POWER GENERATION

CHEMICAL RECOVERY (PULP MILL)

ELECTRICAL-DISTRIBUTION, PIPING, INSTRUMENTATION

PULP MILL: DIGESTING, WASHING, SCREENING, BLEACHING

CHEMICAL PREPARATION AND STORAGE

STOCK PREPARATION

PAPERMAKING AND FINISHING

WATER SUPPLY AND EFFLUENT TREATMENT

RAW MATERIAL STORAGE AND PREPARATION

PAPER CONVERTING

FIRE PROTECTION AND YARD

ADMINISTRATION AND SERVICE BUILDINGS

SUMMARY

PHASE 3: EQUIPMENT TRIALS, START-UP AND ACCEPTANCE TESTS

MONTHS 1 2 3 4 5 6 7 8 9 10 11 12

MILL START-UP AND TRAINING RUNS

75% PRODUCTION

100% PRODUCTION

LEGEND

- Design and Engineering
- Building Construction
- Equipment Ordering
- Equipment Delivery
- Erection
- Equipment Trials and Personnel Training
- Other

An advertisement reprinted

Turnkey Pulp and Paper Mill

The building of an efficient, profitable pulp and paper mill in a developing country requires broad experience and the precise, three-phase planning whose principles are shown in the chart.

The first service required is the preparation of a feasibility report, during which market potentials, sources of fiber, water, power, availability of chemicals and transportation are evaluated, and the plant site is chosen. After feasibility is established, satisfactory financing has to be arranged, and the basic mill design created. Only then, can the project be implemented.

The building and erection of the mill demands exact scheduling of every detail and perfect coordination of effort to assure on-time completion of the project. This entails preparation of literally thousands of engineering drawings; construction supervision; the procurement and erection of all equipment—not only the mainline production machinery but all of the supporting equipment. While this is going on, apprentice workers have to be trained to become, later on, the permanent operating crew. At the right time, a team of pulp and paper making experts must be brought in to start up the mill. Some projects will also require subsequent management and product sales service.

The problems arising from such a complex industrial project can be frustrating, and minor mistakes can lead to major losses. The solution accepted by many countries has been to assign the whole responsibility of the entire project to one contractor. The Parsons & Whittemore-Lyddon Organization, in the many turnkey mills it has successfully completed, has demonstrated its ability to assume undivided responsibility for every phase of a pulp and paper mill project.

With a staff of more than 650 scientists and engineers, 12 pulp and paper machinery factories in five countries, and offices in 18 countries, the Parsons & Whittemore Organization and its affiliated companies form the world's largest group serving the pulp and paper industry exclusively.

Parsons & Whittemore can complete a "package" mill for the utilization of any one of a wide variety of trees, agricultural fibers, reeds and grasses, and guarantee that it will produce a specified quantity and quality of pulp or paper every 24 hours. The 16 mills now completed and running at full production provide evidence of success that speaks for itself.

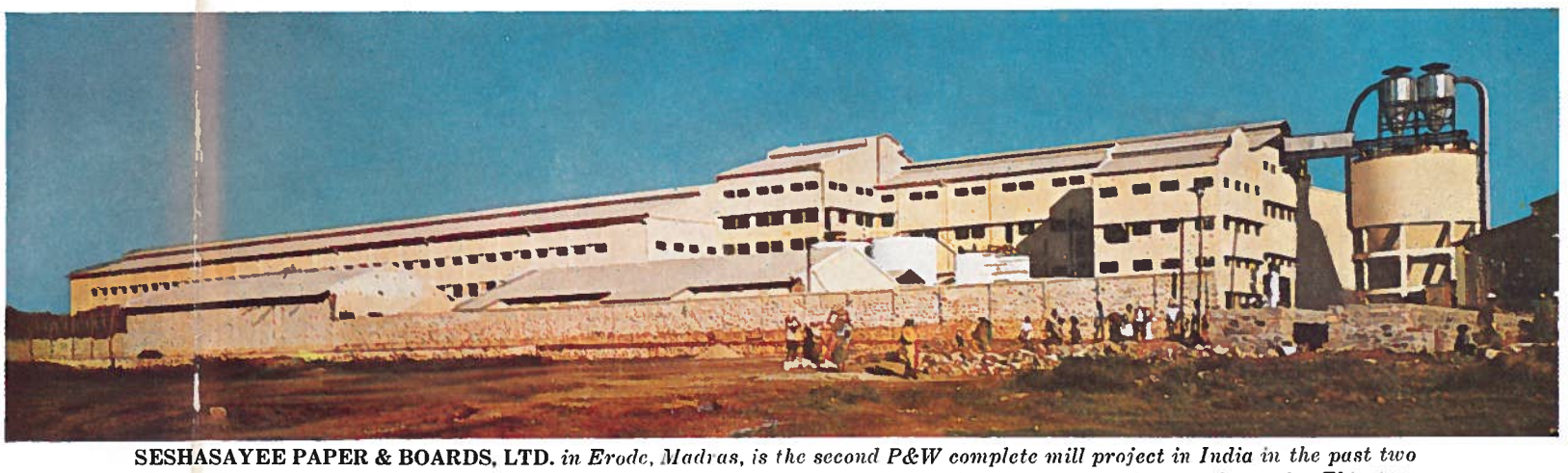
For the full story of the Parsons & Whittemore-Lyddon Organization—its facilities, services and projects—write for a copy of "Growing with the Paper Industry Since 1853."

PARSONS & WHITTEMORE PULP AND PAPER MILL PROJECTS

Here is the record of accomplishments during the past five years

	Turnkey Mill Projects		
	Completed	Under Construction	Recently Contracted
Mills	16	10	7
Countries	12	6	4
Contract Value	$ 99,500,000	$ 98,886,000	$ 64,300,000
Total Investment	253,000,000	218,000,000	101,600,000
Annual Production (short tons)	856,470	632,600	206,500

The projects listed above call for the utilization of fourteen different woods, grasses and agricultural fibers.



SESHASAYEE PAPER & BOARDS, LTD. *in Erode, Madras, is the second P&W complete mill project in India in the past two years. It is the world's first integrated pulp and paper mill to pulp sugar cane bagasse and bamboo continuously. This $12-million project was handled by the Parsons & Whittemore-Lyddon Organization on a global turnkey contract covering overall planning, financial assistance, design engineering, equipment supply, erection, start-up and personnel training.*

THE PARSONS & WHITTEMORE–LYDDON ORGANIZATION

World leaders in the development of pulp and paper mills for the use of local fibers

20-26 Wellesley Road, Croydon, Surrey (London), England / Redenfelden/Obb., Germany

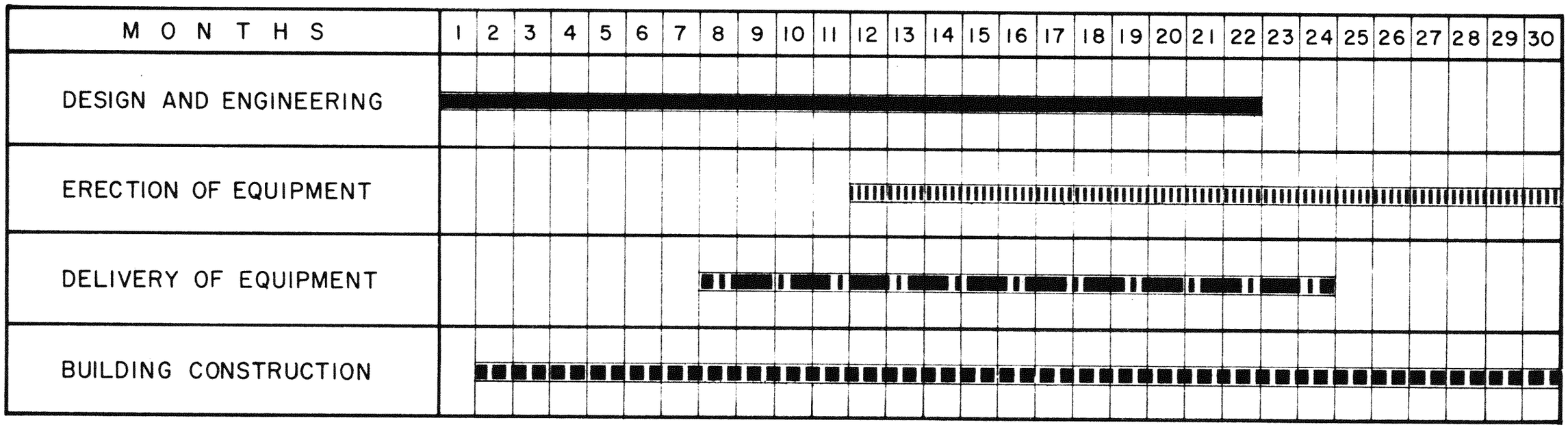
5 Rue Jean Mermoz, Paris 8° France / 150-A Mount Road, Madras 2, India

200 Park Avenue, New York 17, N.Y.

APPENDIX No. XXIII
PROJECT - I

PRELIMINARY TIME SCHEDULE

FOR PROJECT No. 773 - THAILAND

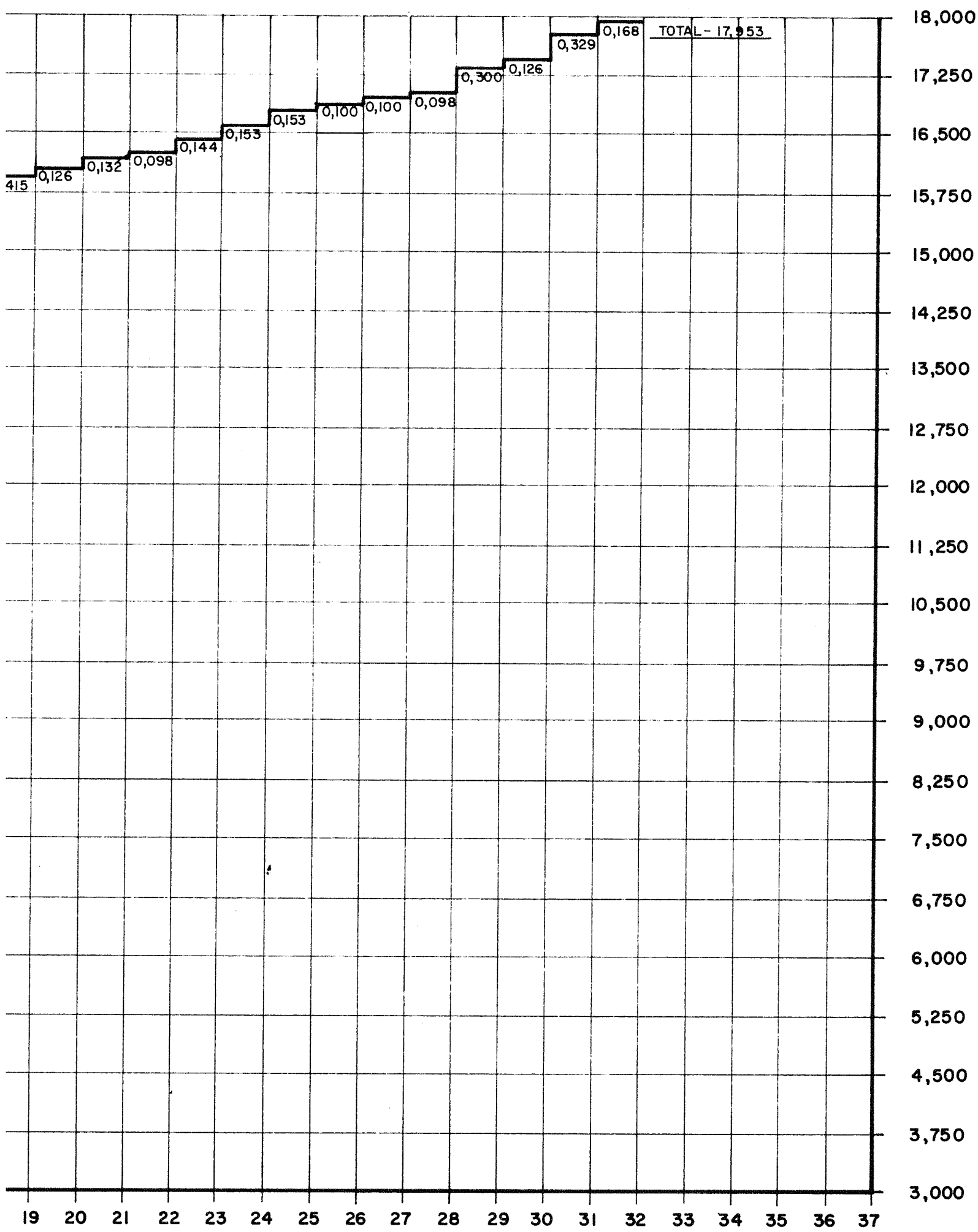


APPENDIX No. XXIV
PROJECT - I

773 – THAILAND

NDITURES REQUIREMENTS

DS OF DOLLARS

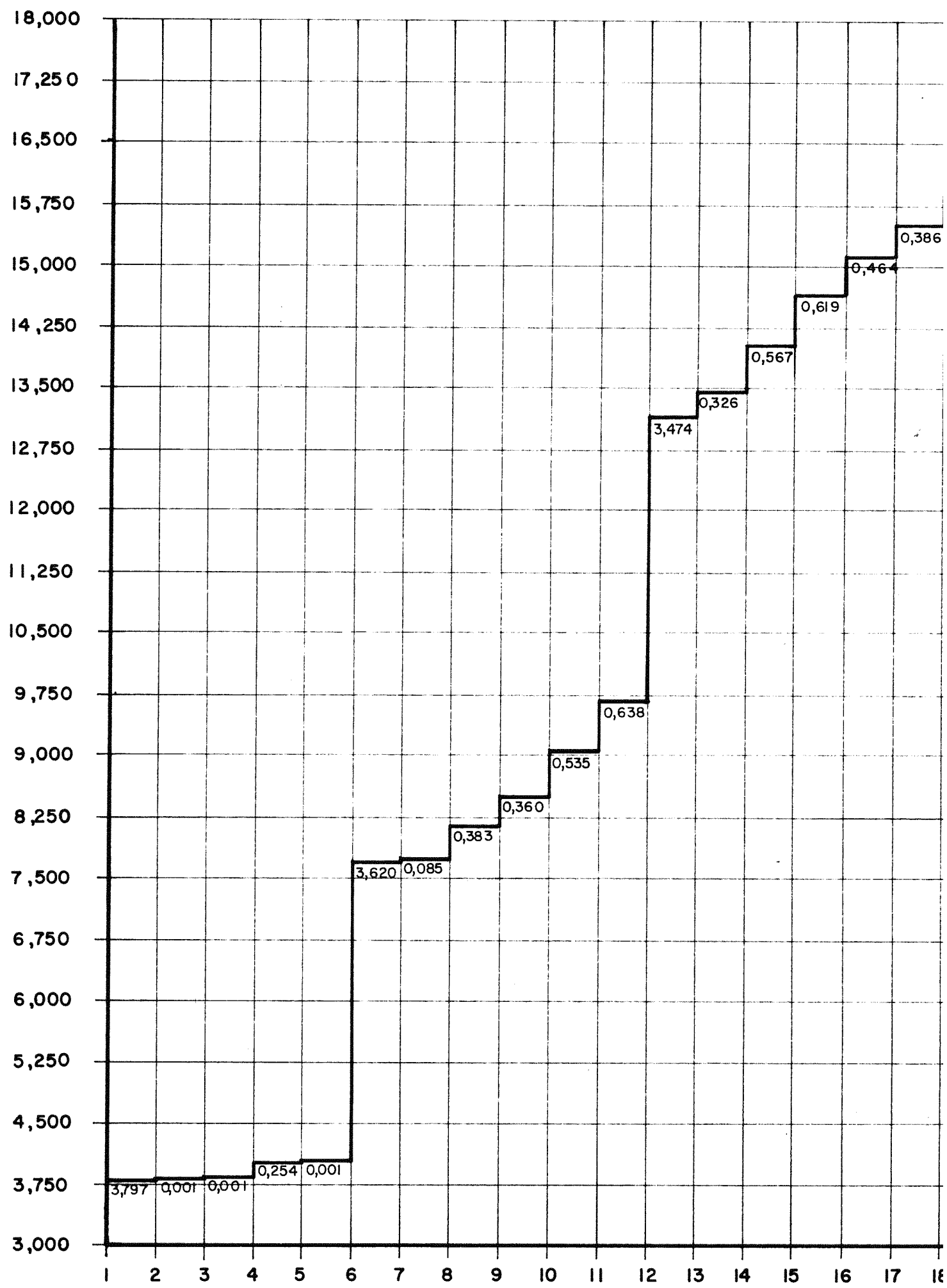


FIRMATION DATE

PROJECT N

EXECUTION AND EXPE

IN THOUSAN



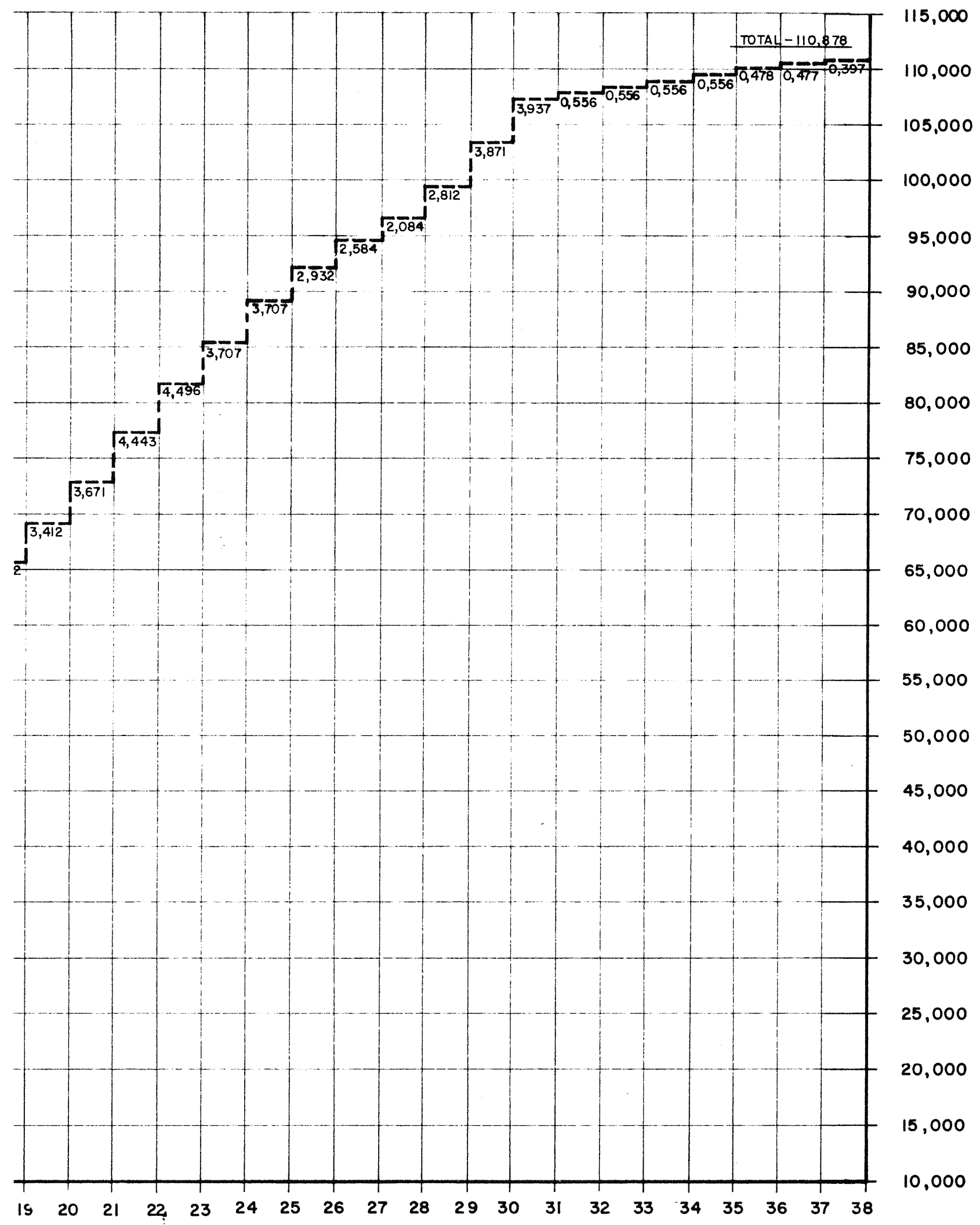
MONTHS AFTER C

APPENDIX No. XXV
PROJECT-I

773 — THAILAND

DITURES REQUIREMENTS

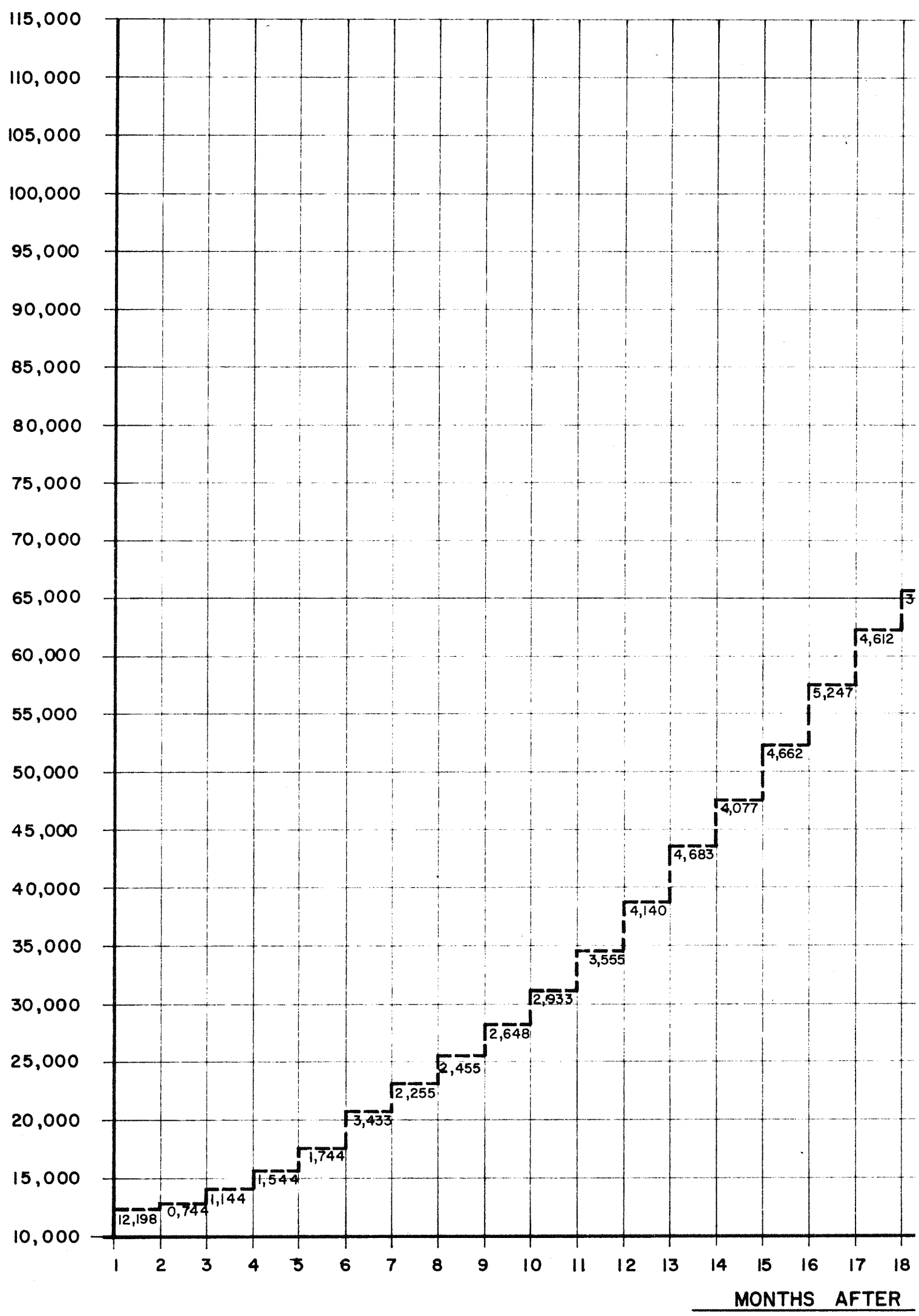
NDS OF BAHTS



PROJECT No

EXECUTION AND EXPE

IN THOUSA



APPENDIX XXVI

SCHEDULE OF EXECUTION AND EXPEDITURES

DOLLAR REQUIREMENTS

PROJECT I

	Equipment & Spares	Design & Supervision-Construction	Supervision of Erection	Start-Up	Freight & Insurance	Training of Local Personnel	Cost of Site & Improvements	Labor & Material Erection & Installation	Administrative & Overhead	Allowance Price Escallation & Contingencies	Total
CD + 1	3,467,500	252,250	75,700						1,260		3,796,710
2									1,260		1,260
3									1,260		1,260
4		252,250							1,260		253,510
5									1,260		1,260
6	3,467,500		151,400						1,260		3,620,160
7			22,080				62,000		1,260		85,340
8	69,350	201,800	22,080		4,410	21,000	62,000		2,520		383,160
9	208,050		22,080		13,230	21,000	93,000		2,520		359,880
10	277,400	100,900	22,080		17,640	21,000	93,000		2,520		534,540
11	554,800		22,080		35,280	21,000		2,260	2,520		637,940
12	3,363,475		22,080		57,330	21,000		3,390	6,300		3,473,575
13	242,725		22,080		30,870	21,000		3,390	6,300		326,365
14	381,425	100,900	22,080		48,510	4,000		3,390	6,300		566,605
15	520,125		22,080		66,150			4,520	6,300		619,175
16	381,425		22,080		48,510			5,650	6,300		463,965
17	312,075		22,080		39,690			5,650	6,300		385,795
18	242,725	100,900	22,080		30,870			5,650	6,300	6,930	415,455
19	69,350		22,080		8,820			5,650	6,300	13,860	126,060
20	69,350		22,080		8,820			11,300	6,300	13,860	131,710
21	34,675		22,080		4,410			16,950	6,300	13,860	98,275
22	69,350		22,080		8,820			16,950	6,300	20,790	144,290
23	69,350		22,080		8,820			11,300	6,300	34,650	152,500
24	69,350		22,080		8,820			11,300	6,300	34,650	152,500

PARSONS & WHITTEMORE

SCHEDULE OF EXECUTION AND EXPEDITURES

DOLLAR REQUIREMENTS

	Equipment & Spares	Design & Supervision-Construction	Supervision of Erection	Start-Up	Freight & Insurance	Training of Local Personnel	Cost of Site & Improvements	Labor & Material Erection & Installation	Administrative & Overhead	Allowance Price Escallation & Contingencies	Total
CD + 25			22,080					3,225	6,300	69,300	100,905
26			22,080					2,425	6,300	69,300	100,105
27			22 080						6,300	69,300	97,680
28			22,080	168,000					6,300	103,950	300,330
29			22,070							103,950	126,020
30			22,070	168,000						138,600	328,670
31				168,000							168,000
TOTALS	13,870,000	1,009,000	757,000	504,000	441,000	130,000	310,000	113,000	126,000	693,000	17,953,000

PARSONS & WHITTEMORE

APPENDIX XXVII

SCHEDULE OF EXECUTION AND EXPEDITURES

BAHT REQUIREMENTS

PROJECT I

	Equipment & Spares	Design & Supervision-Construction	Super-vision of Erect-ion	Start-Up	Freight & In-surance	Training of Local Personnel	Cost of Site & Improve-ments	Labor & Material Erection & Installa-tion	Adminis-trative & Overhead	Allowance Price Escallation & Contingencies	Total
CD + 1		1,324,000	794,400				10,000,000		79,440		12,197,840
2		264,800					400,000		79,440		744,240
3		264,800					800,000		79,440		1,144,240
4		264,800					1,200,000		79,440		1,544,240
5		264,800					1,400,000		79,440		1,744,240
6		264,800	1,588 800				1,500,000		79,440		3,433,040
7		264,800	231,700				1,600,000		158,880		2,255,380
8		264,800	231,700			100,000	1,700,000		158,880		2,455,380
9		264,800	231,700		92,670	100,000	1,800,000		158,880		2,648,050
10		264,800	231,700		278,010	100,000	1,900,000		158,880		2,933,390
11		264,800	231,700		370,680	100,000	2,000,000	428,960	158,880		3,555,020
12		264,800	231,700		741,600	100,000	2,000,000	643,440	158,880		4,140,180
13		264,800	231 700		1,204,710	100,000	2,000,000	643,440	238,320		4,682,970
14		264,800	231,700		648,690	50,000	2,000,000	643,440	238,320		4,076,950
15		264,800	231,700		1,019,370	50,000	2,000,000	857,920	238,320		4,662,110
16		264,800	231,700		1,390,050	50,000	2,000,000	1,072,400	238,320		5,247,270
17			231,700		1,019,370	50,000	2,000,000	1,072,400	238,320		4,611,790
18			231,700		834,030	50,000	1,000,000	1,072,400	238,320	145,530	3,571,980
19			231,700		648,690	50,000	800,000	1,072,400	317,760	291,060	3,411,610
20			231,700		185,340		500,000	2,144,800	317,760	291,060	3,670,660
21			231,700		185,340		200,000	3,217,200	317,760	291,060	4,443,060
22			231,700		92,670		200,000	3,217,200	317,760	436,590	4,495,920
23			231,700		185,340		100,000	2,144,800	317,760	727,650	3,707,250
24			231,700		185,340		100,000	2,144,800	317,760	727,650	3,707,250

DARSONS & WHITAKER

PROJECT NY-773

SCHEDULE OF EXECUTION AND EXPEDITURES

BAHT REQUIREMENTS

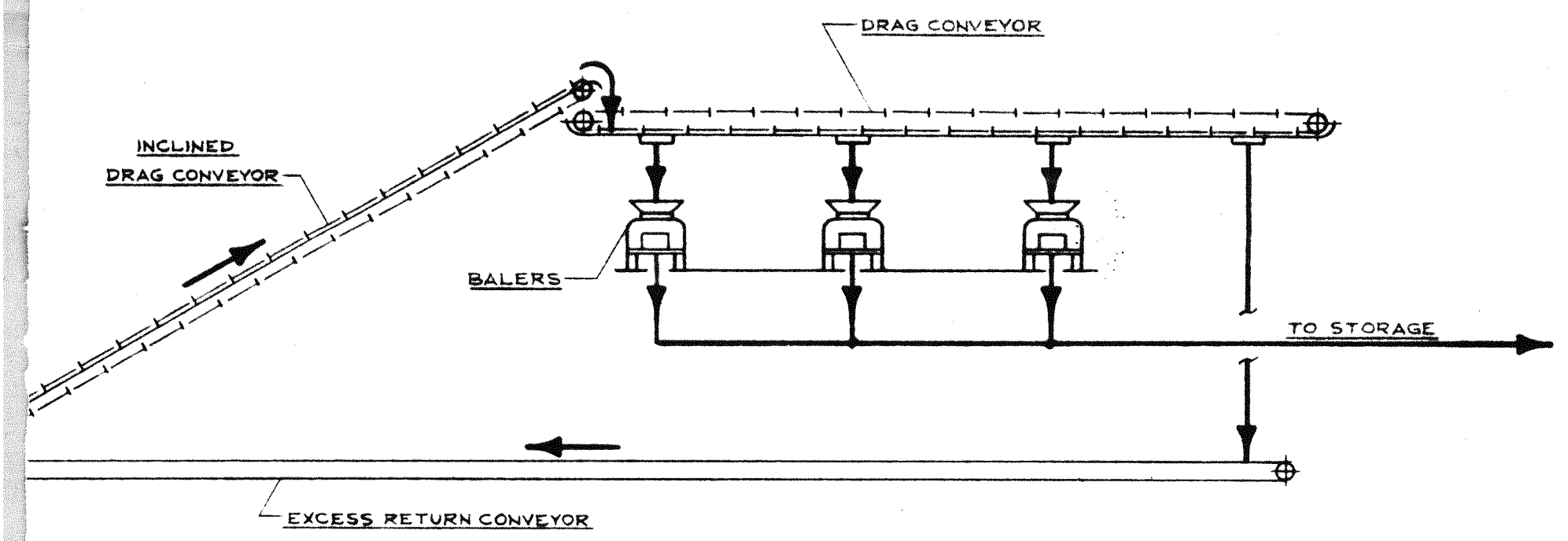
PARSONS & WHITTEMORE

	Equipment & Spares	Design & Supervision-Construction	Supervision of Erection	Start-Up	Freight & Insurance	Training of Local Personnel	Cost of Site & Improvements	Labor & Material Erection & Installation	Administrative & Overhead	Allowance Price Escallation & Contingencies	Total
CD + 25			231,700		185,340		50,000	612,800	397,200	1,455,300	2,932,340
26			231,700				40,000	459,600	397,200	1.455,300	2,583,800
27			231,700						397,200	1,455,300	2,084,200
28			231,700						397,200	2,182,950	2,811,850
29			231,700	1,059,000					397,200	2,182,950	3,870,850
30			231,700	397,125					397,200	2,910,600	3,936,625
31				397,125					158,880		556,005
32				397,125					158,880		556,005
33				397,125					158,880		556,005
34				397,125					158,880		556,005
35				397,125					79,440		476,565
36				397,125					79,440		476,565
37				397,125							397,125
		5,296,000	7,944,000	4,236,000	9,267,000	900,000	39,290,000	21,448,000	7,994,000	14,553,000	110,878,000

LIST OF DRAWINGS

BC/773/1040	Moist and Wet Depithing
BC/773/1041	Bagasse Digestion, Washing and Screening
BC/773/1042	Waste Paper Cleaning, Stock Prepatation and Paper and Board Machine
BC/773/1043	Bamboo Handling and Chip Preparation, Project II
BC/773/1044	Bamboo Continuous Digestion System, Defibering, Washing and Screening, Project II
BC/773/1045	Evaporation, Recovery and Recausticizing, Project I
BC/773/1054	Evaporation, Recovery and Recausticizing, Project II
BL/773/1055	Mill Layout

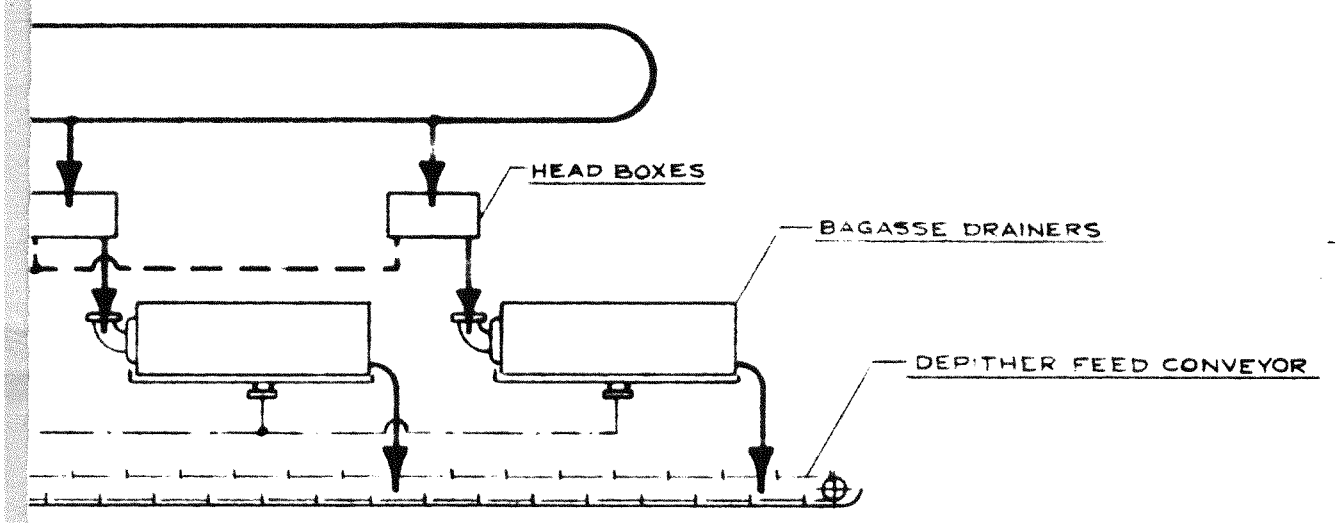
PARSONS & WHITEMORE

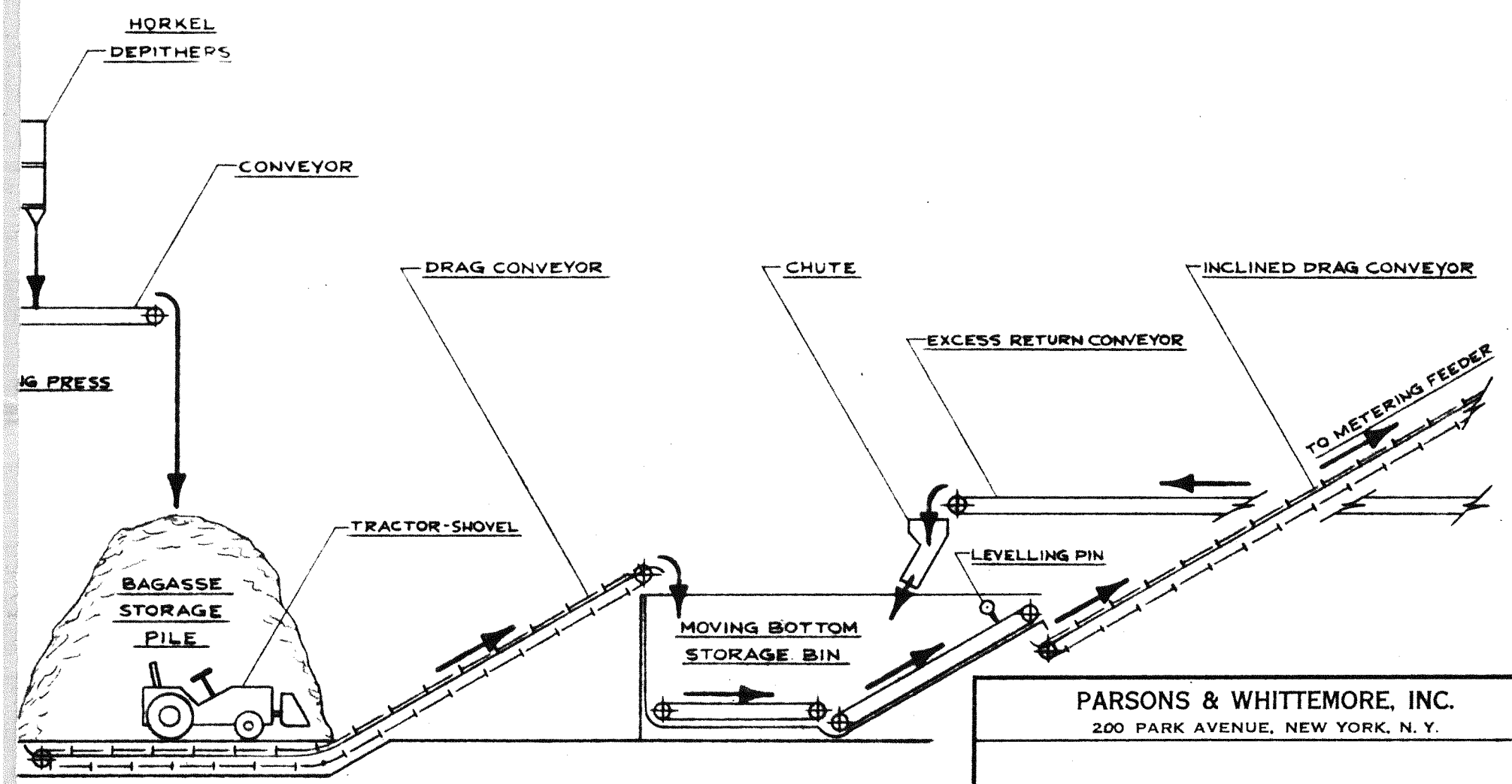


AND BALING STATION AT SUGAR MILLS

PITHERS AND 3 BALERS

" " 2 "





D HANDLING AT PULP MILL

PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

MOIST AND WET DEPITHING

THAILAND

DESIGNED BY: R.E.W.	PROJECT NO. 773
DRAWN BY: A.S.	DATE: OCT. - 63
CHECKED BY: G.J.V.	SCALE: NONE
APPROVED BY: JNM	DWG. NO. B-C/773/1040

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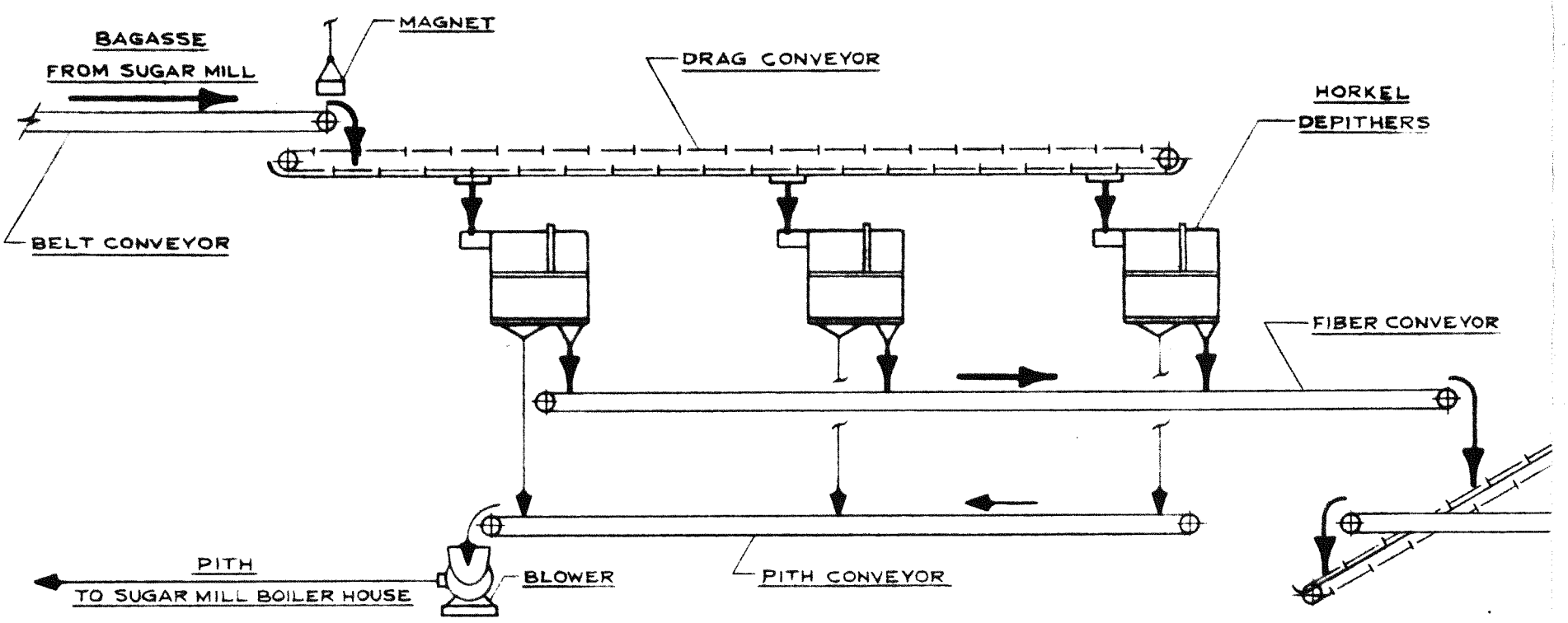
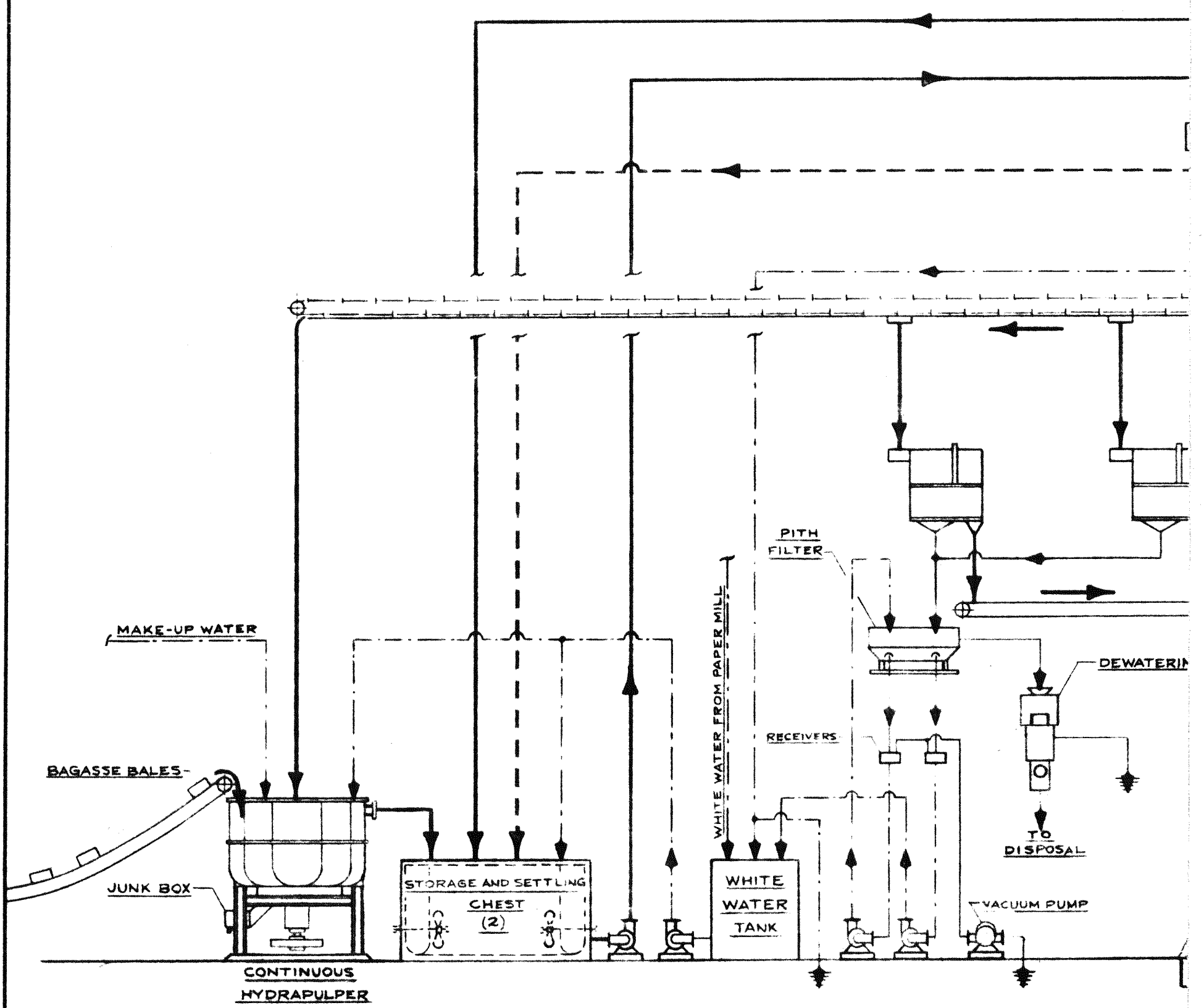
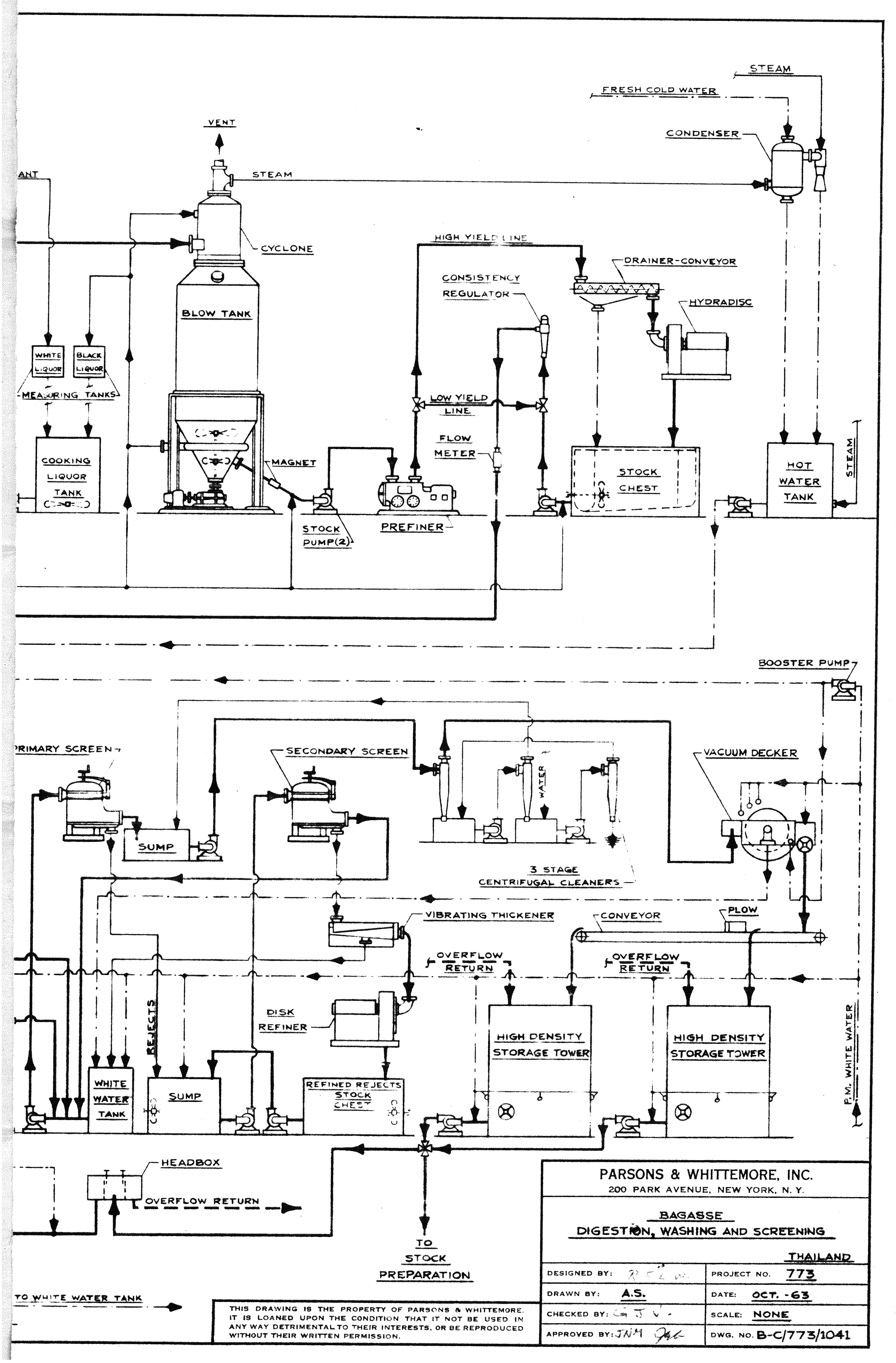


PRIMARY BAGASSE DEPITHING

NOTE: MILL A —— 3 DEP
MILLS B & C — 2 —



SECONDARY WET BAGASSE DEPITHING AN



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

BAGASSE
DIGESTION, WASHING AND SCREENING

THAILAND

DESIGNED BY: R.E.W.	PROJECT NO. 773
DRAWN BY: A.S.	DATE: OCT. -63
CHECKED BY: G.J.V.	SCALE: NONE
APPROVED BY: JNM	DWG. NO. B-C/773/1041

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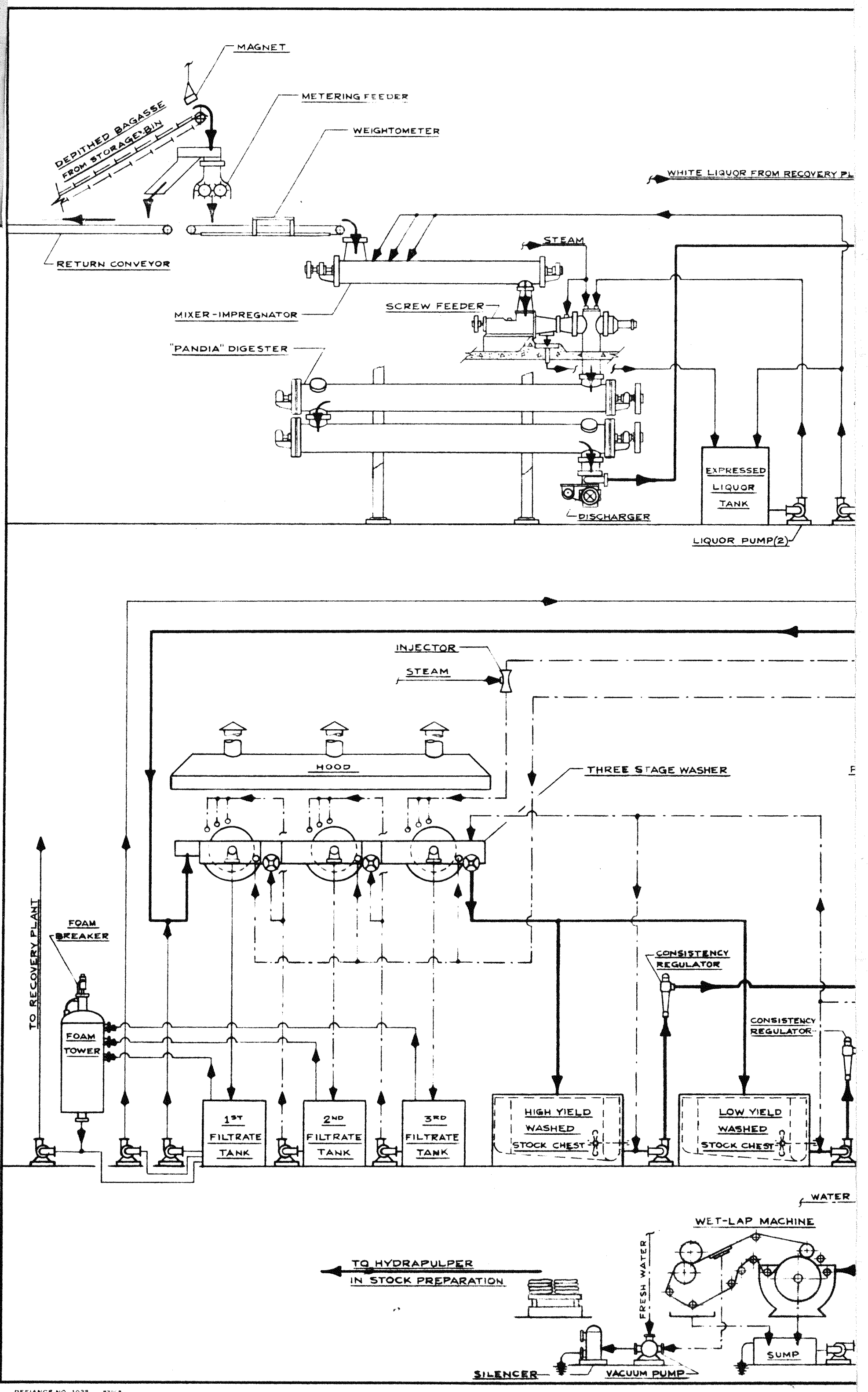
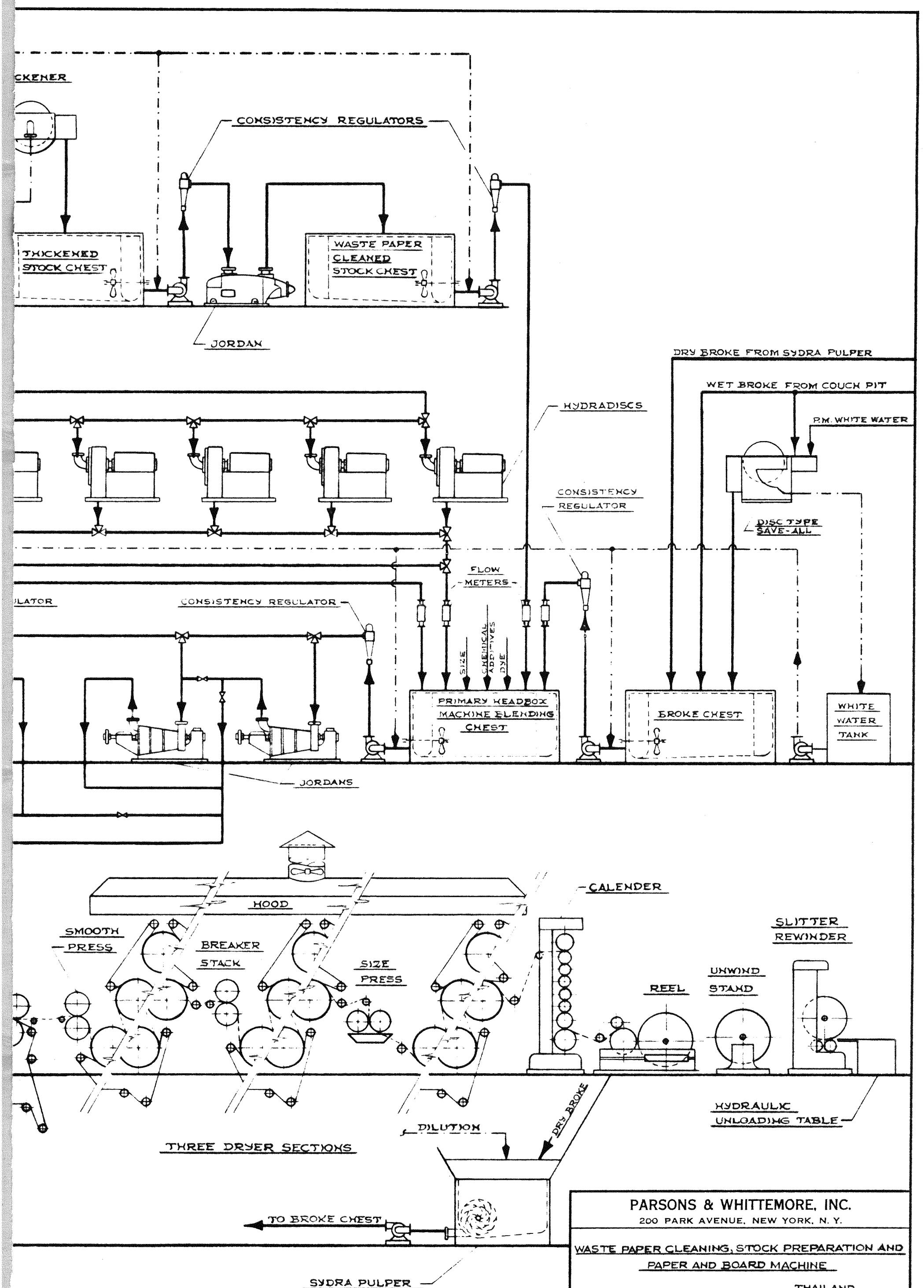


DEFIANCE NO. 1023 37202



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

WASTE PAPER CLEANING, STOCK PREPARATION AND PAPER AND BOARD MACHINE

THAILAND

DESIGNED BY:	PROJECT NO. 773
DRAWN BY: L. P.	DATE: OCT.-63
CHECKED BY:	SCALE: NONE
APPROVED BY:	DWG. NO. B-C/773/1042

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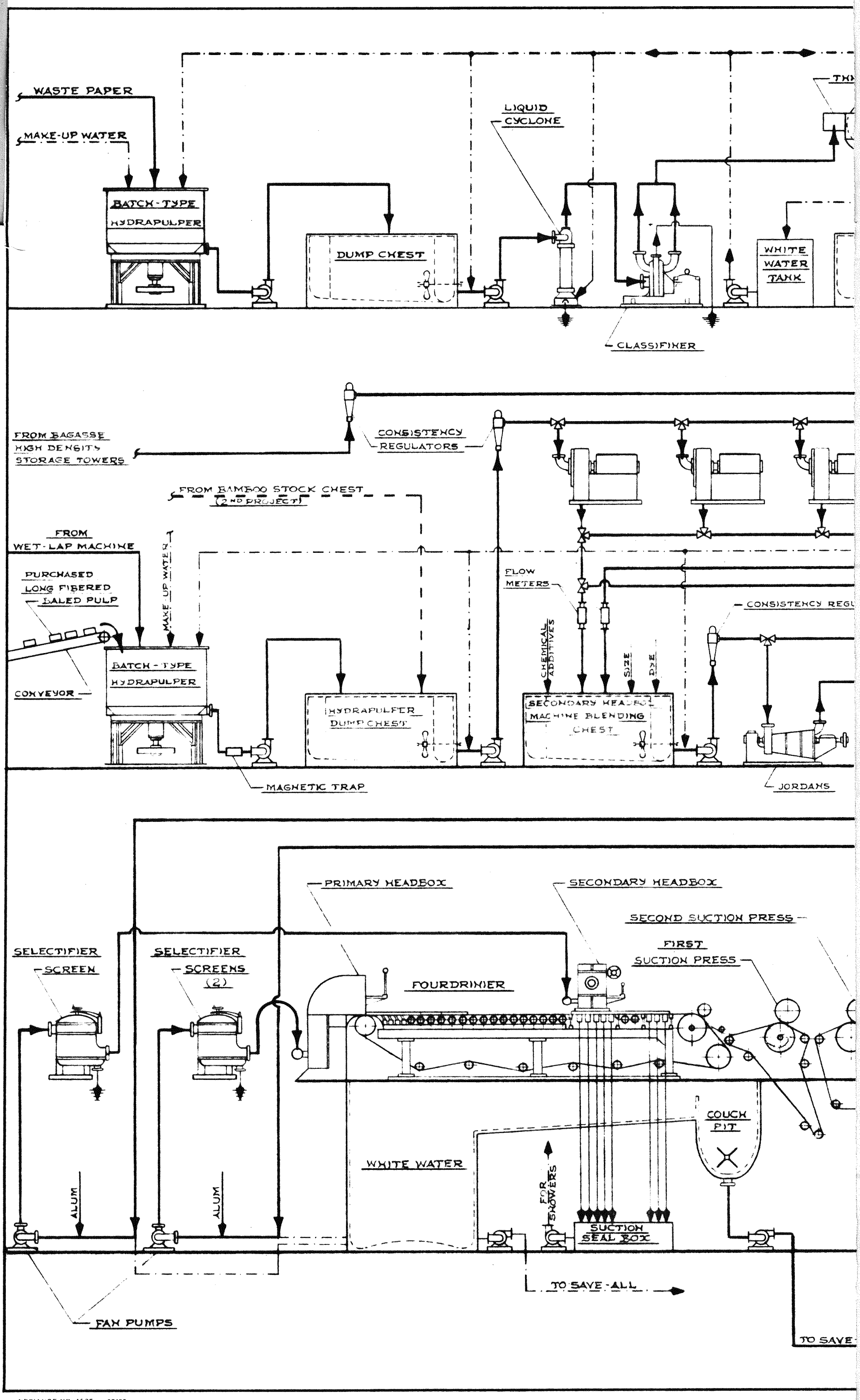
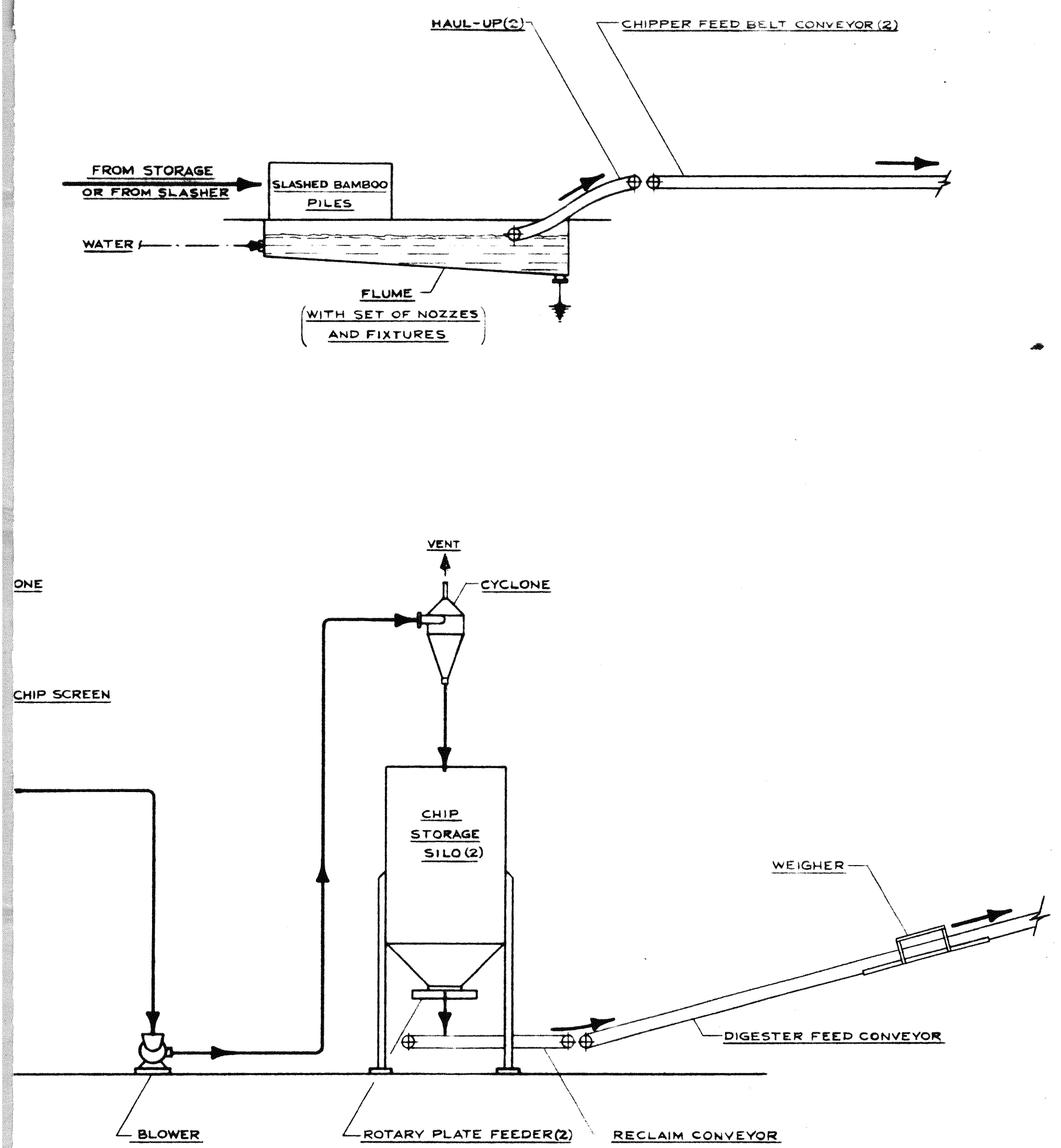


DEFIANCE NO. 1023 37282



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

BAMBOO HANDLING AND CHIP PREPARATION
(PROJECT 2)
THAILAND

DESIGNED BY:	PROJECT NO. 773
DRAWN BY: A.S.	DATE: OCT. - 63
CHECKED BY: G.J.U	SCALE: NONE
APPROVED BY: JNM	DWG. NO. B-C/773/1043

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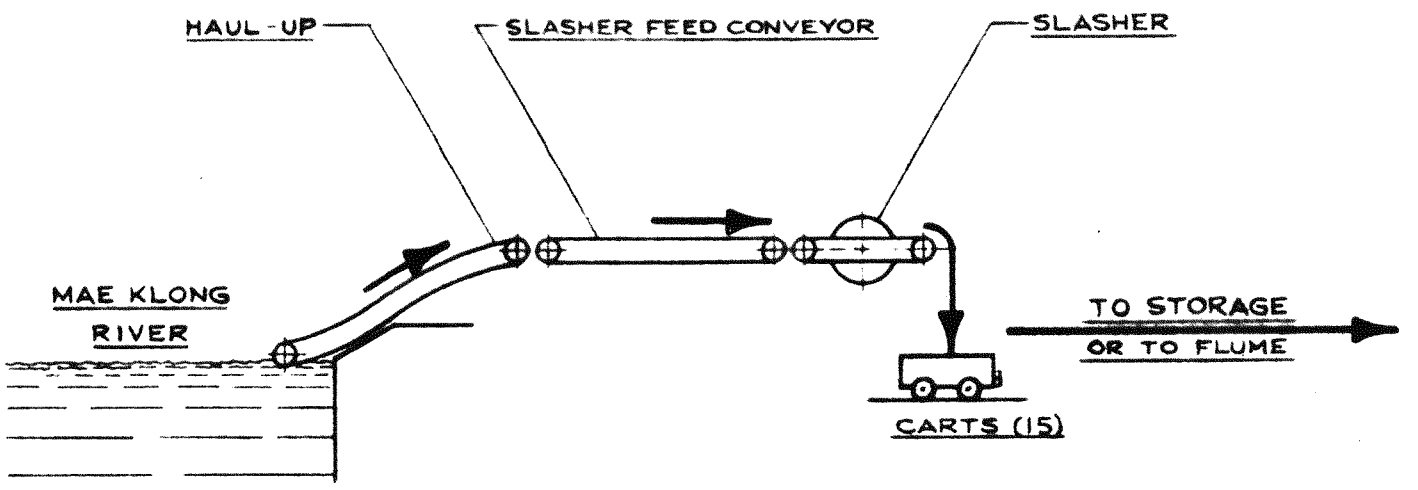
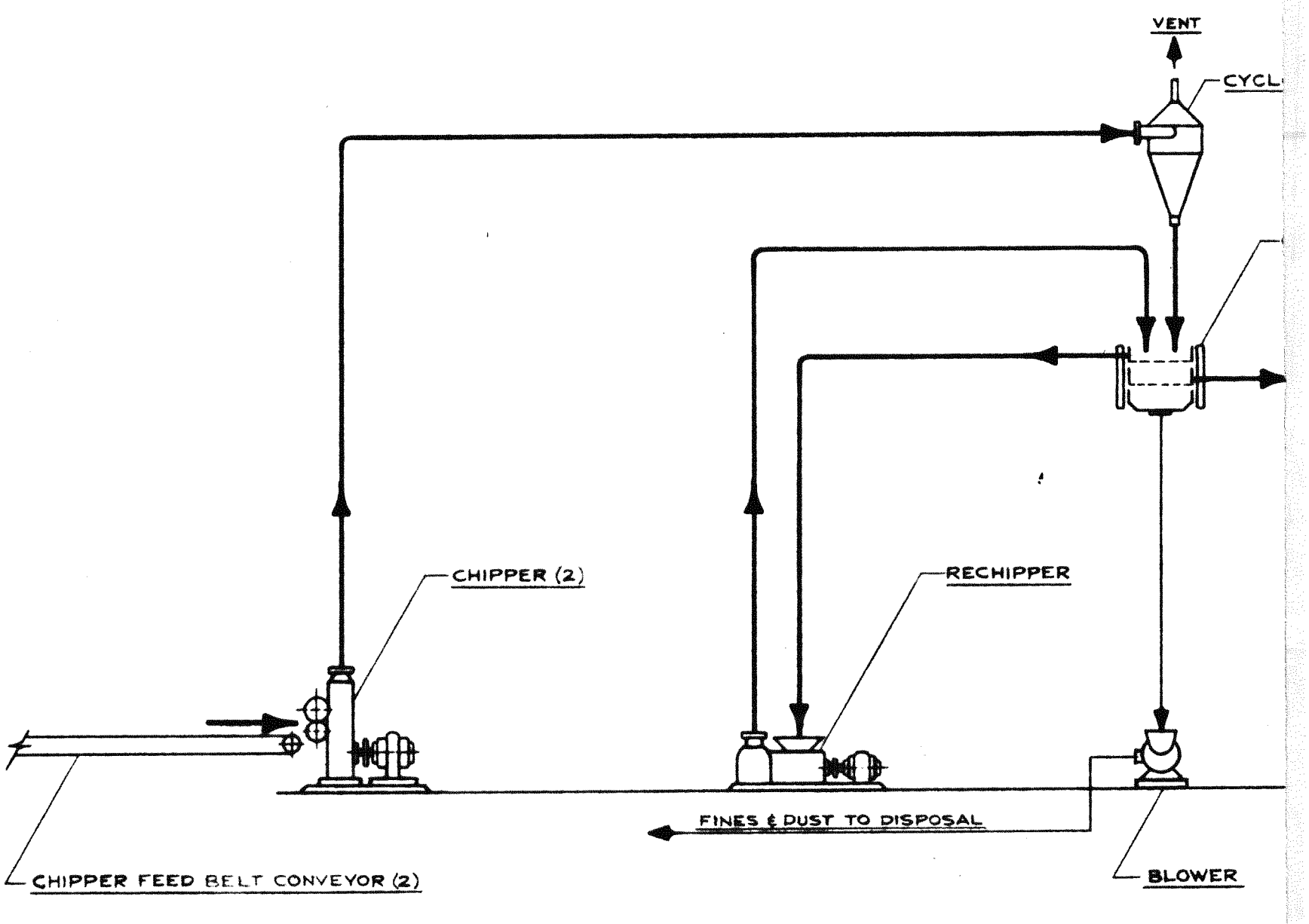
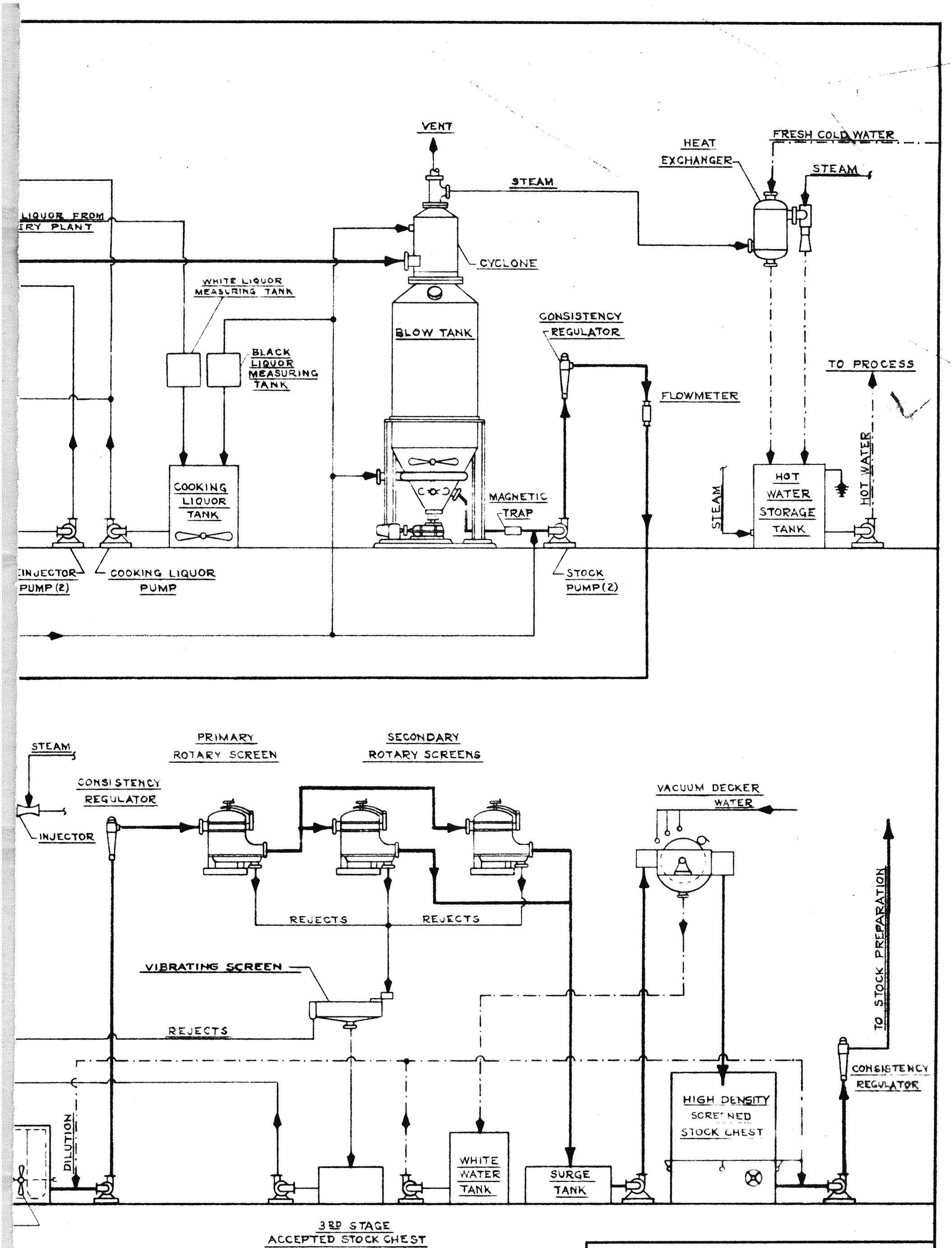

HAUL-UP
SLASHER FEED CONVEYOR
SLASHER
MAE KLONG
RIVER
TO STORAGE
OR TO FLUME
CARTS (15)


VENT
CYCL
CHIPPER (2)
RECHIPPER
FINES & DUST TO DISPOSAL
CHIPPER FEED BELT CONVEYOR (2)
BLOWER



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

BAMBOO CONTINUOUS DIGESTION SYSTEM, DEFIBERING, WASHING & SCREENING (PROJECT 2) THAILAND

DESIGNED BY: R. F. L. W.	PROJECT NO. 773
DRAWN BY: J. BD	DATE: OCT.-63
CHECKED BY: G. J. V.	SCALE: NONE
APPROVED BY: JMM	DWG. NO. B-C/773/1044

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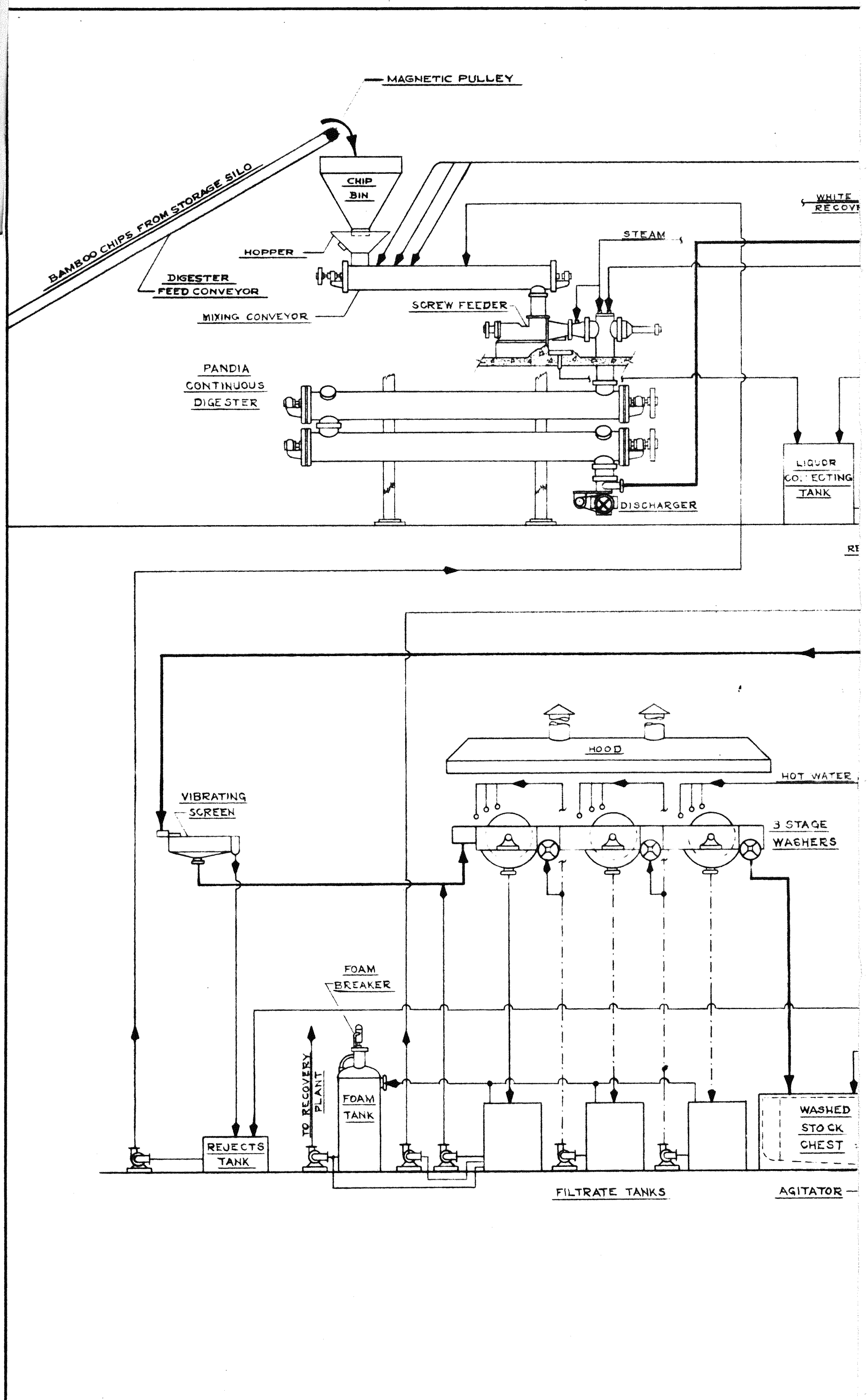
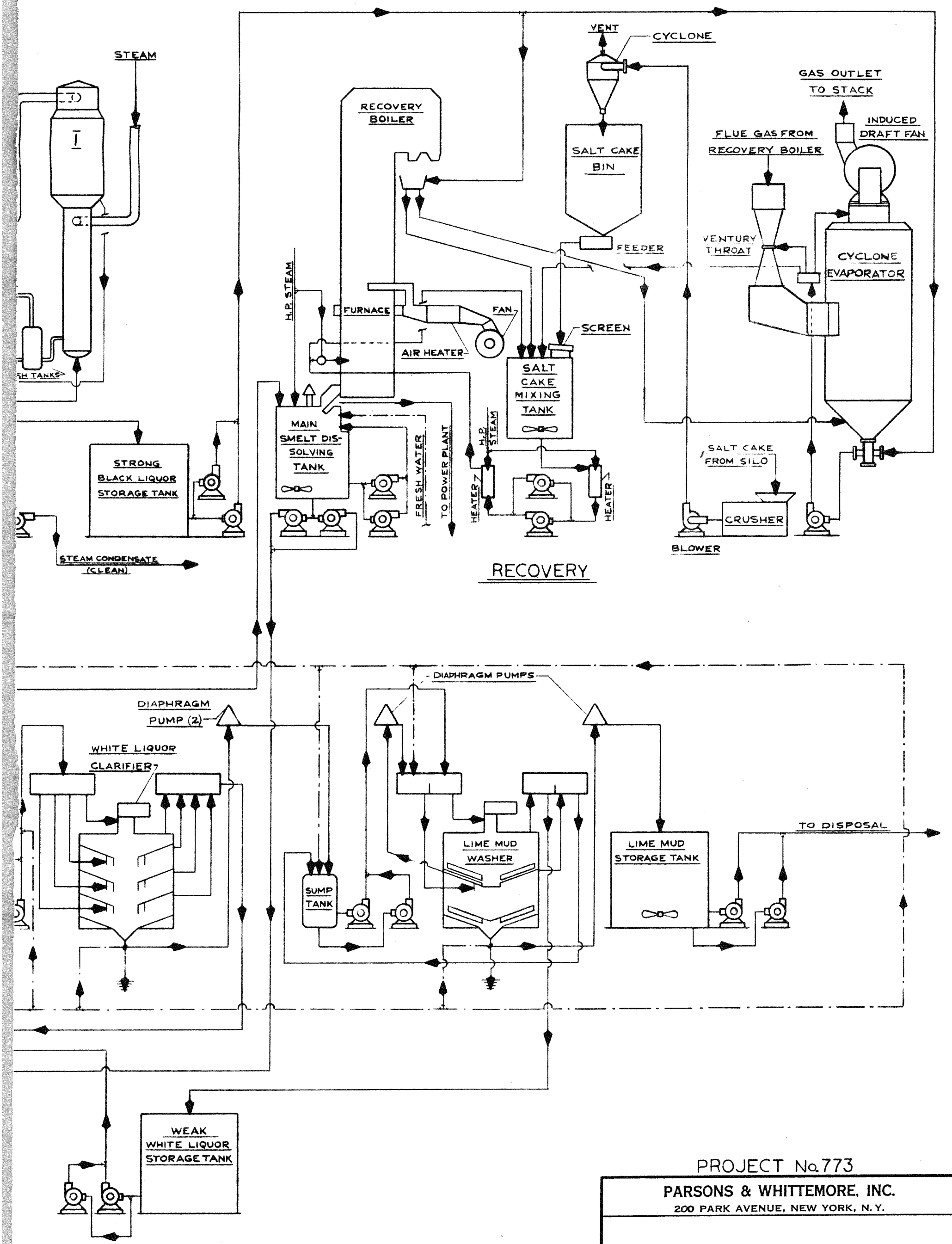

MAGNETIC PULLEY
BAMBOO CHIPS FROM STORAGE SILO
CHIP BIN
HOPPER
DIGESTER FEED CONVEYOR
MIXING CONVEYOR
SCREW FEEDER
STEAM
WHITE RECOVE
PANDIA CONTINUOUS DIGESTER
DISCHARGER
LIQUOR COLLECTING TANK
RE
HOOD
HOT WATER
VIBRATING SCREEN
3 STAGE WASHERS
FOAM BREAKER
TO RECOVERY PLANT
FOAM TANK
REJECTS TANK
WASHED STOCK CHEST
FILTRATE TANKS
AGITATOR



PROJECT No. 773

PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N.Y.

EVAPORATION, RECOVERY AND RECAUSTICIZING
(PROJECT 1)
THAILAND

DRAWN BY: A.S. OCT. 63	DESIGNED BY: R.E.L.W.
CHECKED BY: G.J.V.	APPROVED BY: J.N.M.
SCALE: NONE	DWG. NO. B-C/773/1045

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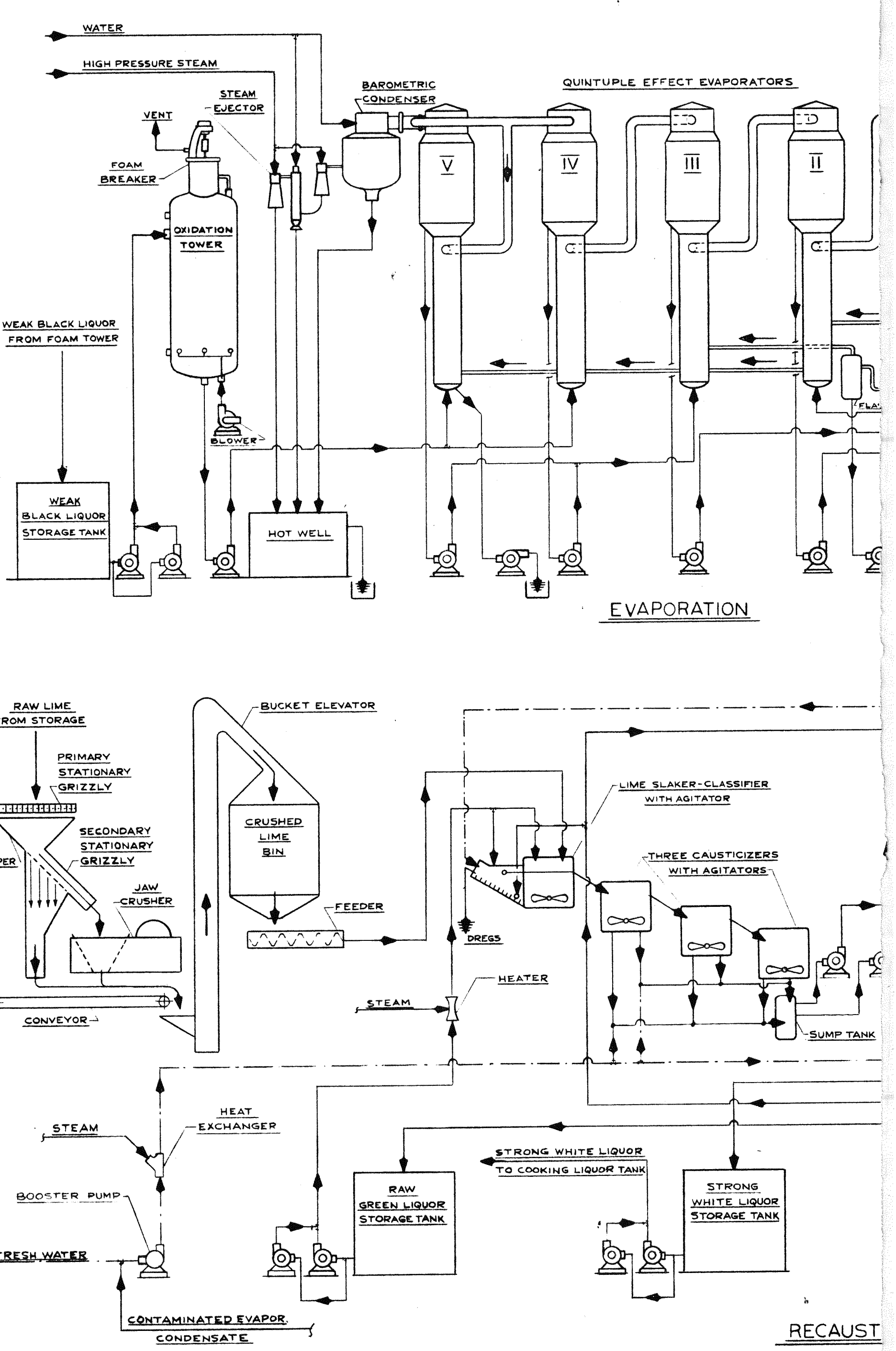
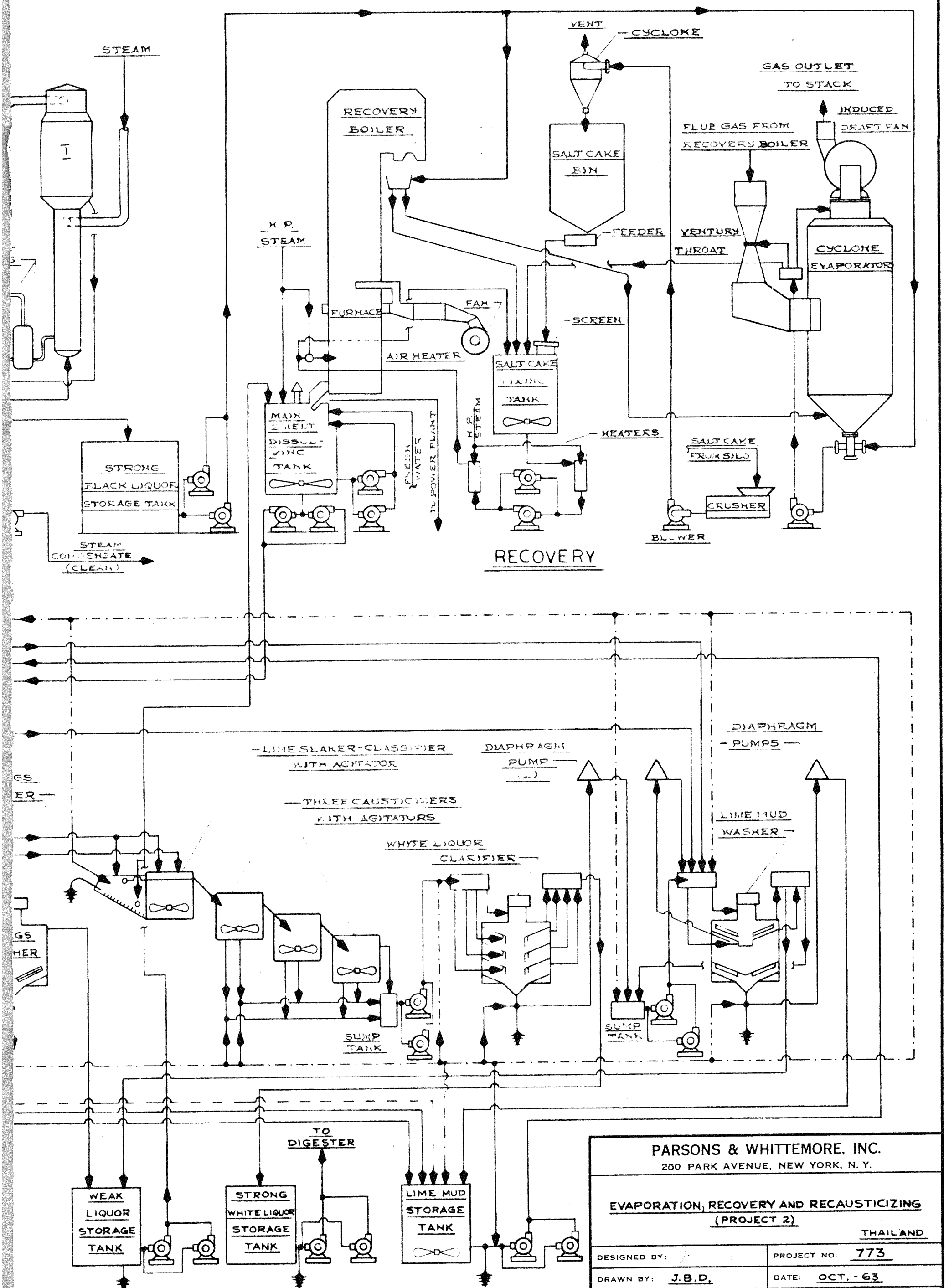

WATER
HIGH PRESSURE STEAM
STEAM EJECTOR
VENT
FOAM BREAKER
OXIDATION TOWER
BLOWER
BAROMETRIC CONDENSER
QUINTUPLE EFFECT EVAPORATORS
V
IV
III
II
I
WEAK BLACK LIQUOR FROM FOAM TOWER
WEAK BLACK LIQUOR STORAGE TANK
HOT WELL
EVAPORATION
RAW LIME FROM STORAGE
PRIMARY STATIONARY GRIZZLY
SECONDARY STATIONARY GRIZZLY
HOPPER
JAW CRUSHER
CONVEYOR
BUCKET ELEVATOR
CRUSHED LIME BIN
FEEDER
LIME SLAKER-CLASSIFIER WITH AGITATOR
THREE CAUSTICIZERS WITH AGITATORS
DREGS
HEATER
STEAM
SUMP TANK
HEAT EXCHANGER
STEAM
BOOSTER PUMP
FRESH WATER
CONTAMINATED EVAPOR. CONDENSATE
STRONG WHITE LIQUOR TO COOKING LIQUOR TANK
RAW GREEN LIQUOR STORAGE TANK
STRONG WHITE LIQUOR STORAGE TANK
RECAUST



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

EVAPORATION, RECOVERY AND RECAUSTICIZING
(PROJECT 2)

THAILAND

DESIGNED BY:	PROJECT NO. 773
DRAWN BY: J.B.D.	DATE: OCT.-63
CHECKED BY:	SCALE: NONE
APPROVED BY:	DWG. NO. B-C/773/1054

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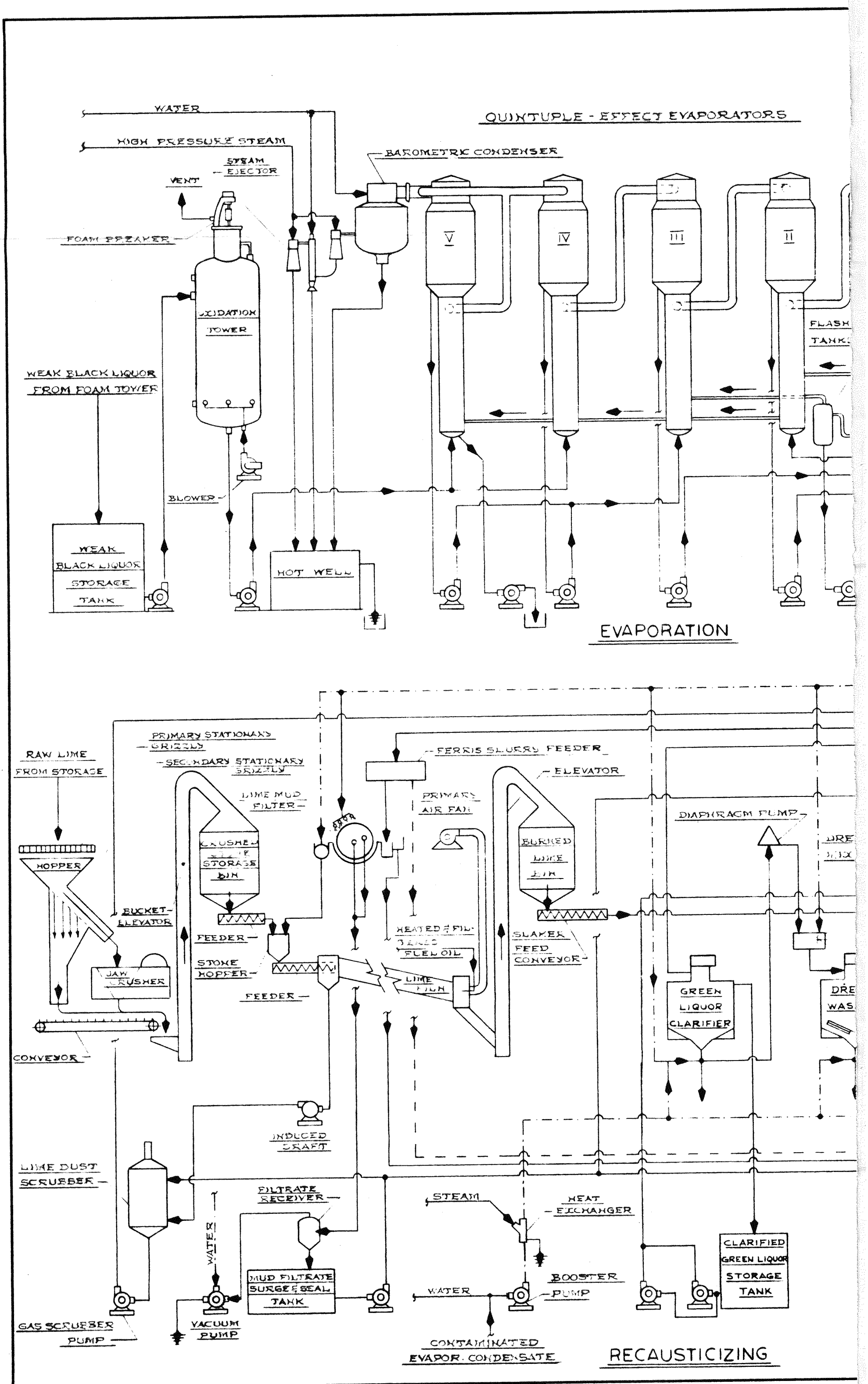
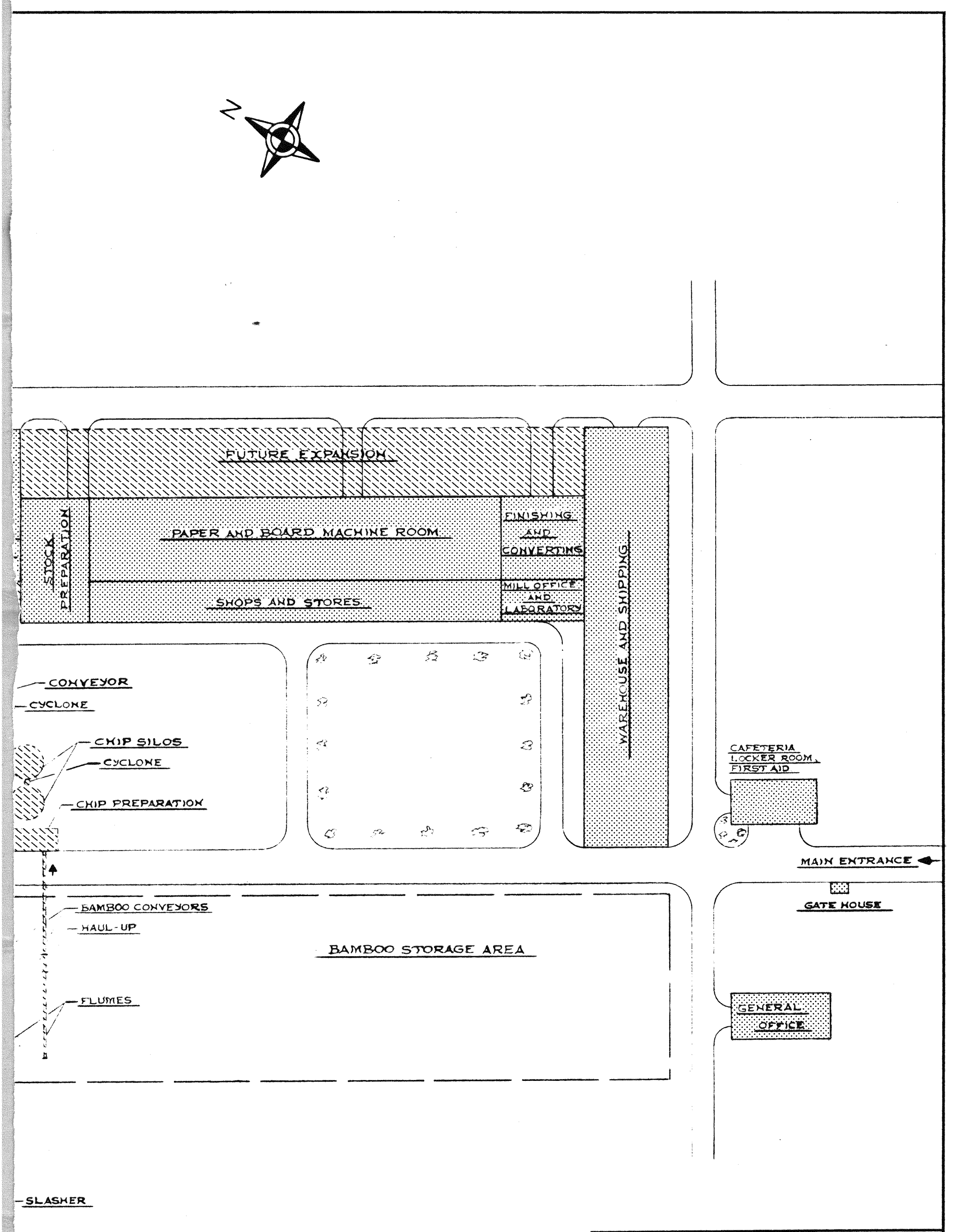


DEFIANCE NO. 1025 37282



PARSONS & WHITTEMORE, INC.
200 PARK AVENUE, NEW YORK, N. Y.

MILL LAYOUT

THAILAND

DESIGNED BY:	PROJECT NO. 773
DRAWN BY: L. P.	DATE: OCT. 1963
CHECKED BY:	SCALE: 1=1000
APPROVED BY:	DWG. NO. B-L/773/1055

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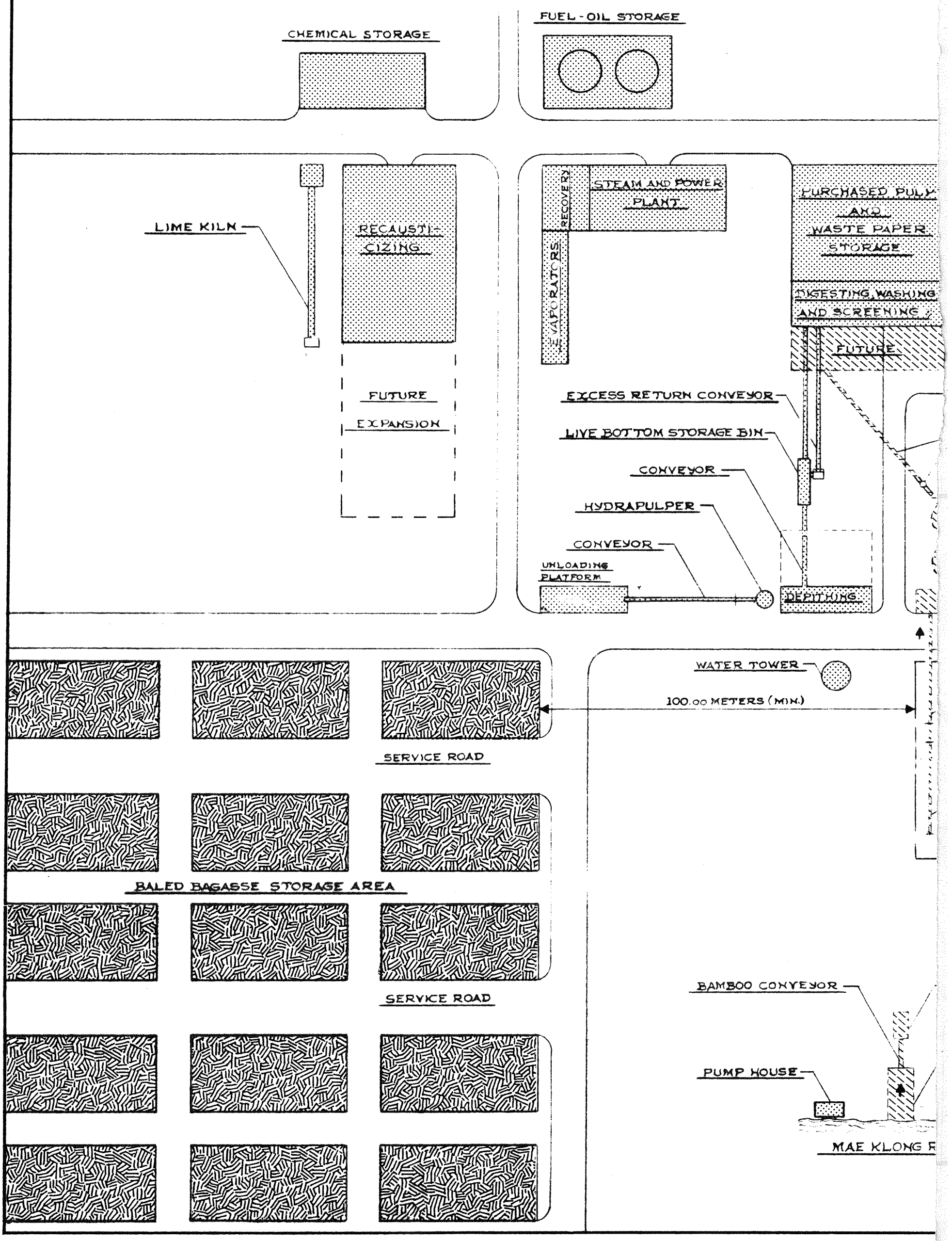


DEFIANCE NO. 1025 3/282

LIST OF MAPS

No. 1. Thailand, Showing Pine Forest Areas, Two Existing Government Pulp and Paper Mills, and Cities Discussed in Report
Source: Royal Forest Department, Ministry of Agriculture, Thailand

No. 2. Thailand, Showing Location of Sugar Mills, Reserved Forest Areas of Karnchanaburi Paper Mill, Railroad and Main Roads
Source: Report On FAO Pulp and Paper Resources in Asia, Tokyo, 1960

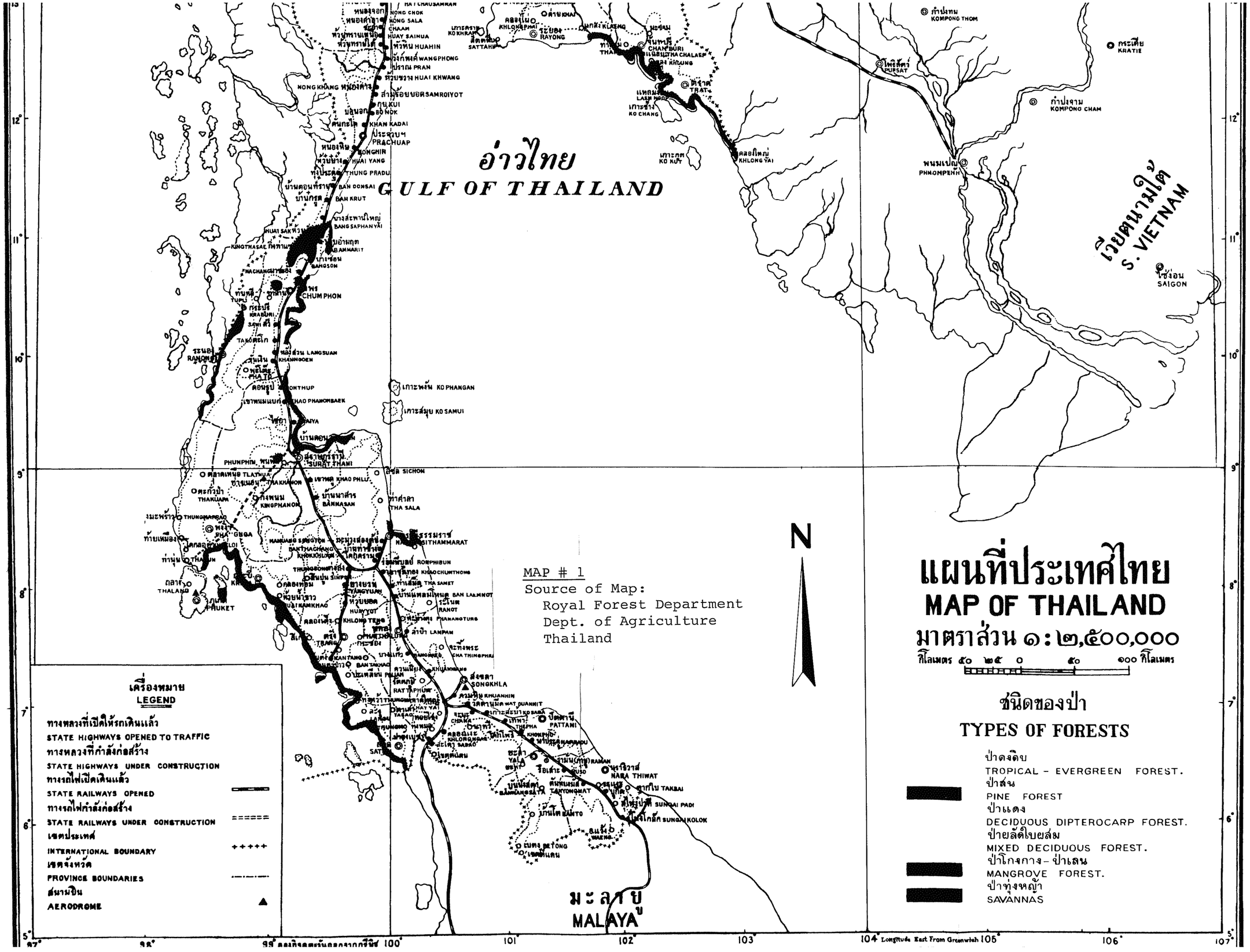
No. 3. Area to North and Northwest of Karnchanaburi

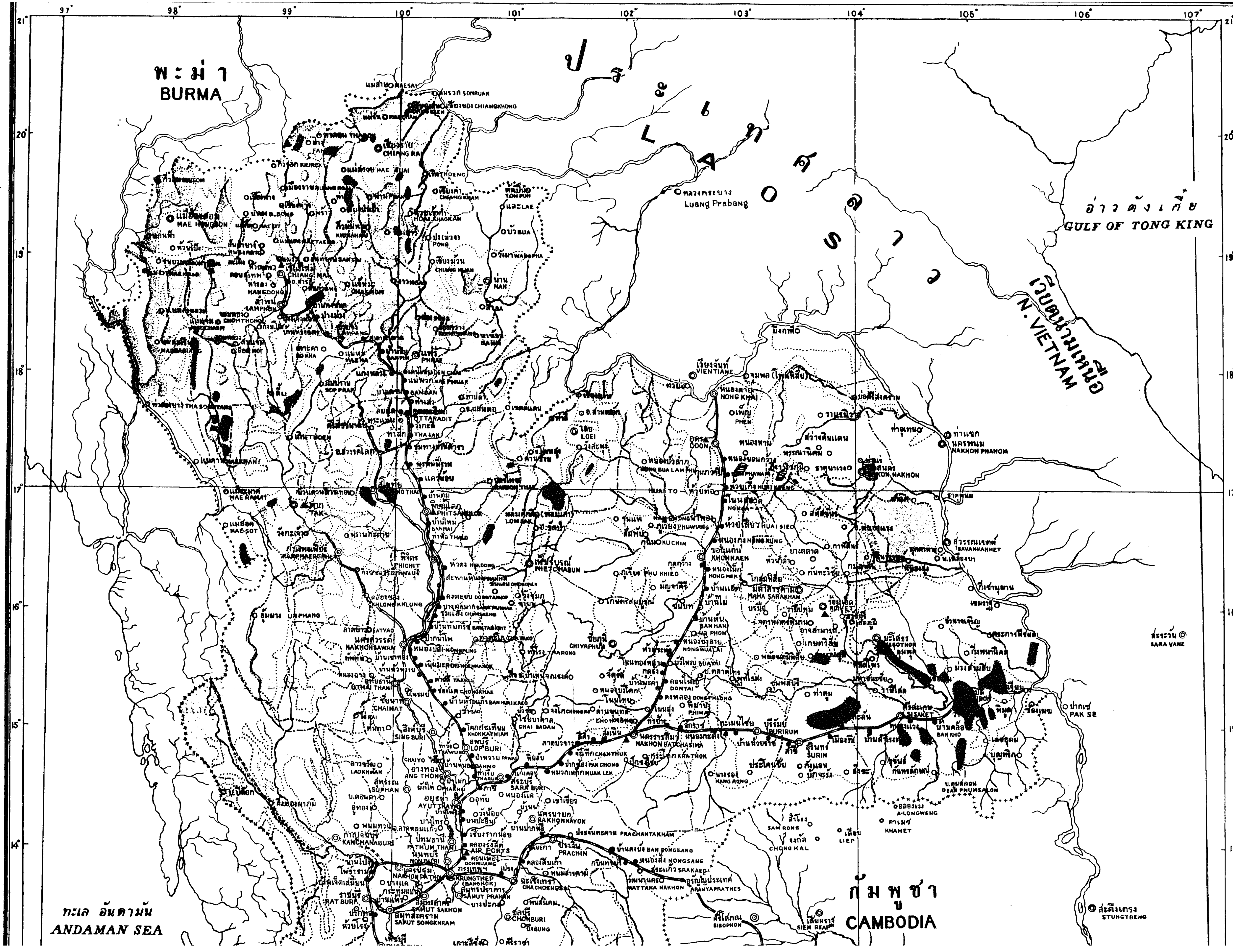
No. 4. Potential Mill Sites to North and East of Bangkok

No. 5. Potential Mill Sites to West of Bangkok

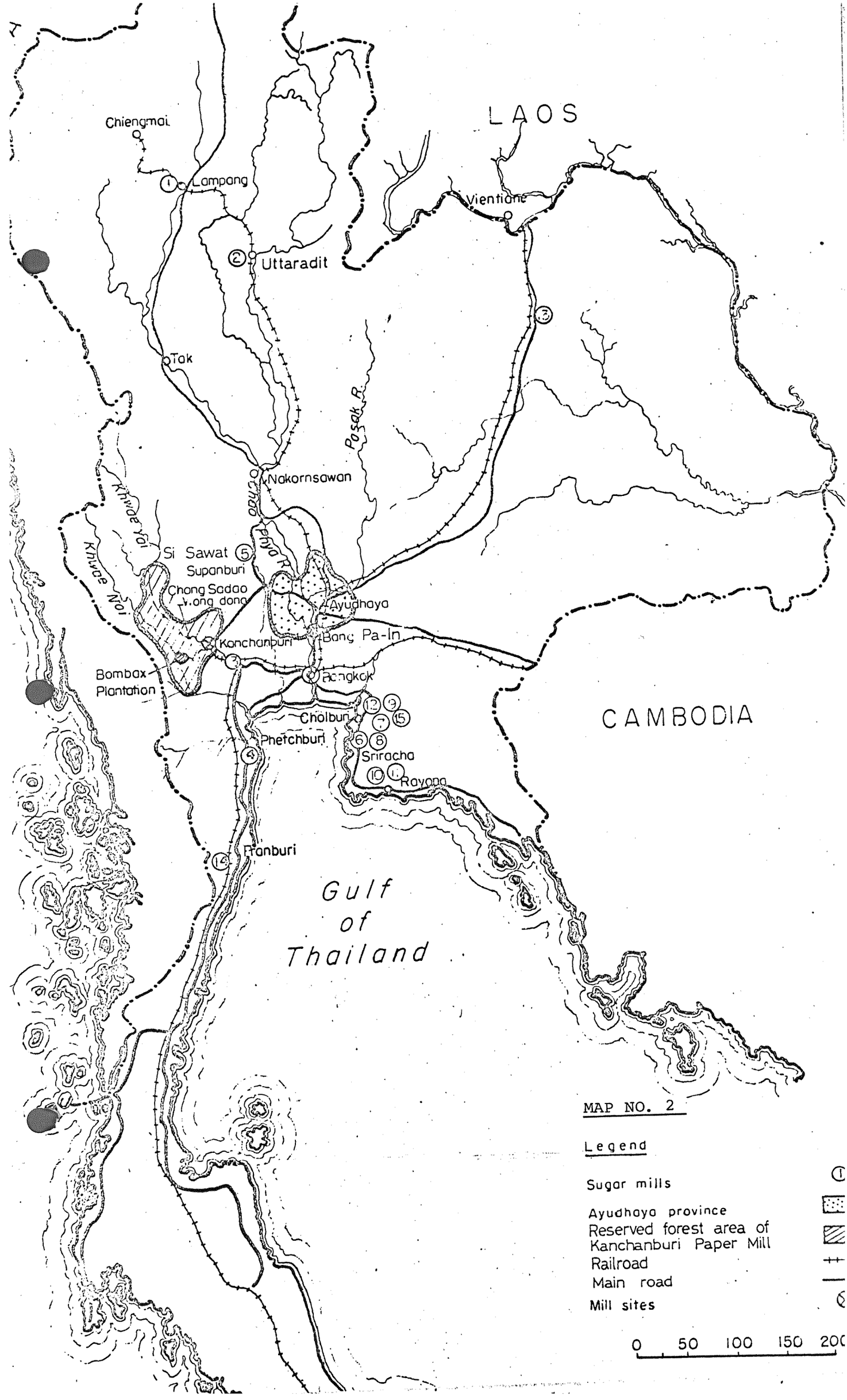
No. 6. Thailand National Highway System
See Page 266, Section X, Transport

PARSONS & WHITTEMORE


อ่าวไทย
GULF OF THAILAND
เวียดนามใต้
S. VIETNAM
มะลายู
MALAYA
N
MAP # 1
Source of Map:
Royal Forest Department
Dept. of Agriculture
Thailand
แผนที่ประเทศไทย
MAP OF THAILAND
มาตราส่วน ๑:๒,๕๐๐,๐๐๐
กิโลเมตร ๕๐ ๒๕ ๐ ๕๐ ๑๐๐ กิโลเมตร
ชนิดของป่า
TYPES OF FORESTS
ป่าดงดิบ
TROPICAL - EVERGREEN FOREST.
ป่าสน
PINE FOREST
ป่าแดง
DECIDUOUS DIPTEROCARP FOREST.
ป่าผลัดใบผสม
MIXED DECIDUOUS FOREST.
ป่าโกงกาง - ป่าเลน
MANGROVE FOREST.
ป่าทุ่งหญ้า
SAVANNAS
เครื่องหมาย
LEGEND
ทางหลวงที่เปิดให้รถเดินแล้ว
STATE HIGHWAYS OPENED TO TRAFFIC
ทางหลวงที่กำลังก่อสร้าง
STATE HIGHWAYS UNDER CONSTRUCTION
ทางรถไฟเปิดเดินแล้ว
STATE RAILWAYS OPENED
ทางรถไฟกำลังก่อสร้าง
STATE RAILWAYS UNDER CONSTRUCTION
เขตประเทศ
INTERNATIONAL BOUNDARY
เขตจังหวัด
PROVINCE BOUNDARIES
สนามบิน
AERODROME
กำปงทม KOMPONG THOM
กระเตีย KRATIE
กำปงจาม KOMPONG CHAM
พนมเปญ PHNOMPENH
ไซ่ง่อน SAIGON
ปัตตานี PATTANI
นราธิวาส NARA THIWAT
สงขลา SONGKHLA
สุราษฎร์ธานี SURAT THANI
นครศรีธรรมราช NAKHON SITHAMMARAT
ตรัง TRANG
ภูเก็ต PHUKET
ระนอง RANONG
ชุมพร CHUM PHON
ตาก TAK
ลำปาง LAMPANG
ลำพูน LAMPHUN
เชียงใหม่ CHIANG MAI
เชียงราย CHIANG RAI
พิษณุโลก PHITSANOKLOK
ตาก TAK
กาญจนบุรี KANCHANABURI
ราชบุรี RATCHABURI
เพชรบุรี PHETCHABURI
ประจวบคีรีขันธ์ PRACHUAP KHIRIKHAN
ชุมพร CHUMPHON
ระนอง RANONG
สุราษฎร์ธานี SURAT THANI
นครศรีธรรมราช NAKHON SITHAMMARAT
พัทลุง PHATTALUNG
สงขลา SONGKHLA
ปัตตานี PATTANI
นราธิวาส NARA THIWAT
เกาะพงัน KO PHANGAN
เกาะสมุย KO SAMUI
เกาะช้าง KO CHANG
เกาะกูด KO KUT
เกาะคราม KO KHRAM
สัตหีบ SATTAHIP
ระยอง RAYONG
จันทบุรี CHANTABURI
ตราด TRAT
ปัตตานี PATTANI
ยะลา YALA
สตูล SATUN
ตรัง TRANG
พัทลุง PHATTALUNG
ชุมพร CHUMPHON
ระนอง RANONG
ตาก TAK
ลำปาง LAMPANG
ลำพูน LAMPHUN
เชียงใหม่ CHIANG MAI
เชียงราย CHIANG RAI
พิษณุโลก PHITSANOKLOK
กาญจนบุรี KANCHANABURI
ราชบุรี RATCHABURI
เพชรบุรี PHETCHABURI
ประจวบคีรีขันธ์ PRACHUAP KHIRIKHAN
ชุมพร CHUMPHON
ระนอง RANONG
สุราษฎร์ธานี SURAT THANI
นครศรีธรรมราช NAKHON SITHAMMARAT
พัทลุง PHATTALUNG
สงขลา SONGKHLA
ปัตตานี PATTANI
นราธิวาส NARA THIWAT
ยะลา YALA
สตูล SATUN
ตรัง TRANG
ภูเก็ต PHUKET
ระนอง RANONG
ชุมพร CHUMPHON
สุราษฎร์ธานี SURAT THANI
นครศรีธรรมราช NAKHON SITHAMMARAT
พัทลุง PHATTALUNG
สงขลา SONGKHLA
ปัตตานี PATTANI
นราธิวาส NARA THIWAT
ยะลา YALA
สตูล SATUN
ตรัง TRANG
ภูเก็ต PHUKET
Longitude East From Greenwich
100
101
102
103
104
105
106
107
5°
6°
7°
8°
9°
10°
11°
12°
13°


พะม่า
BURMA
ประเทศลาว
LAOS
อ่าวตังเกี๋ย
GULF OF TONG KING
เวียตนามเหนือ
N. VIETNAM
กัมพูชา
CAMBODIA
ทะเล อันดามัน
ANDAMAN SEA
หลวงพระบาง
Luang Prabang
เวียงจันท์
VIENTIANE
CHIANG RAI
CHIANG MAI
NAN
LOEI
PHITSANULOK
NAKHON PHANOM
KHONKAEN
NAKHON RATCHASIMA
UBON
SISAKET
SURIN
BURIRUM
LOP BURI
AYUTTHAYA
KRUNGTHEP
(BANGKOK)
CHONBURI
KANCHANABURI
PAK SE
SARA VANE
STUNGTRENG
SIEM REAP
SISOPHON
ARANYAPRATHES

22

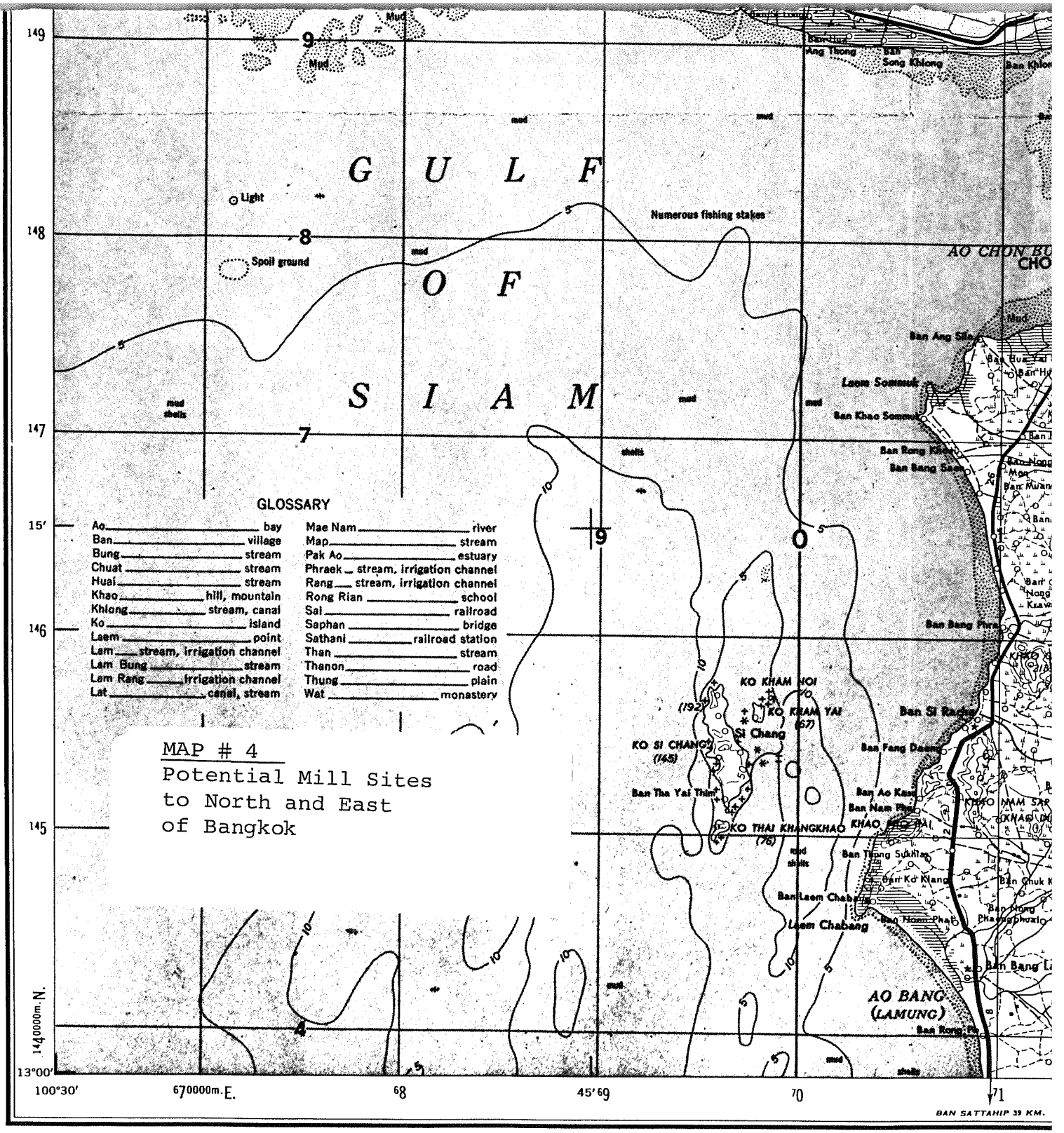

LAOS
CAMBODIA
Chiengmai
Lampang
Uttaradit
Vientiane
Tak
Pasak R.
Nakornsawan
Chao Phya R.
Khwae Yai
Khwae Noi
Si Sawat
Supanburi
Chong Sadao
Chong dong
Ayudhaya
Kanchanburi
Bang Pa-In
Bombax Plantation
Bangkok
Cholburi
Phetchburi
Sriracha
Rayong
Pranburi
Gulf of Thailand
MAP NO. 2
Legend
Sugar mills
Ayudhaya province
Reserved forest area of Kanchanburi Paper Mill
Railroad
Main road
Mill sites
0 50 100 150 200

MAP NO. 3

MAP OF AREA TO NORTH AND NORTHWEST OF KARNCHANABURI

LEGEND

MAP NO. 3
1:250,000

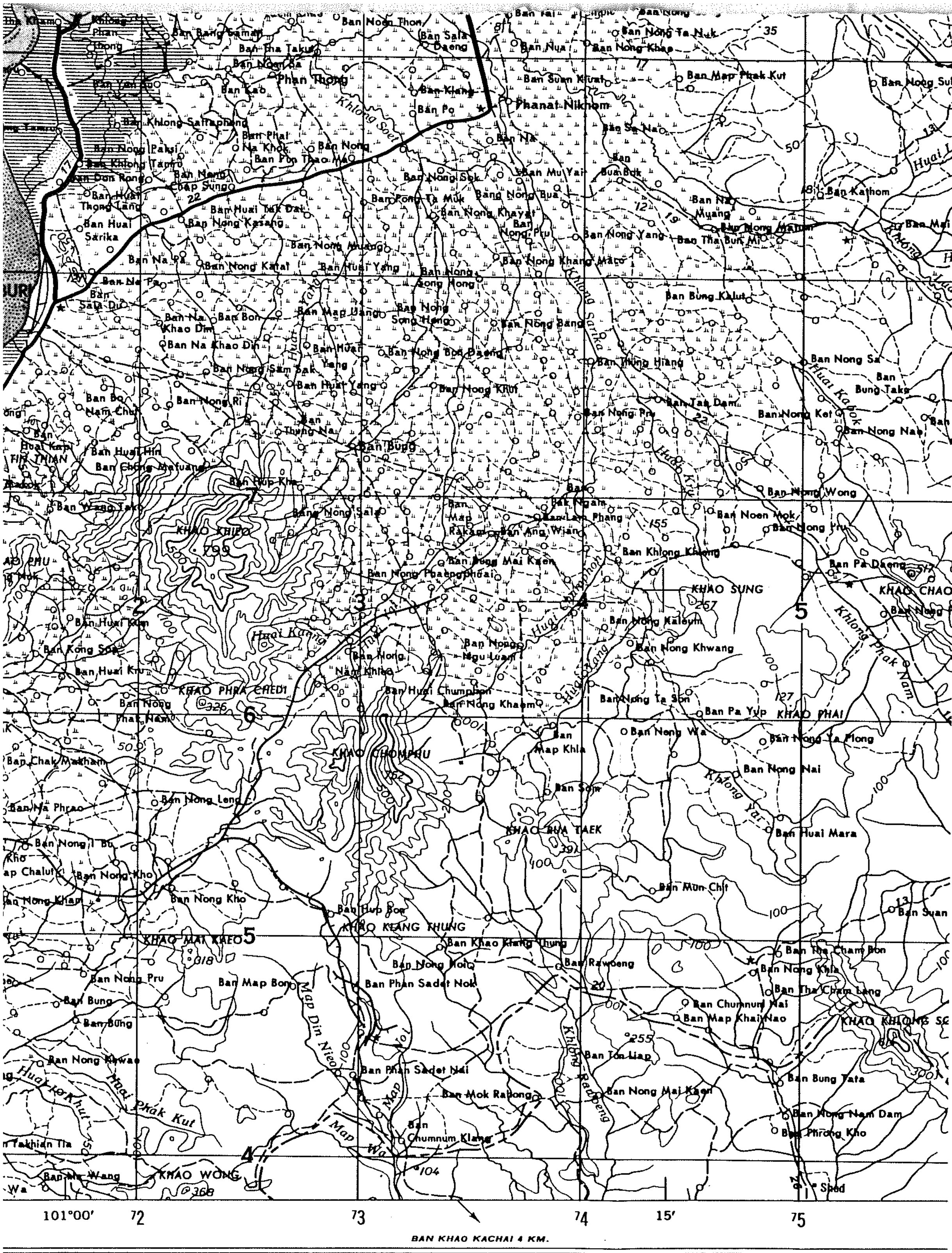


GLOSSARY

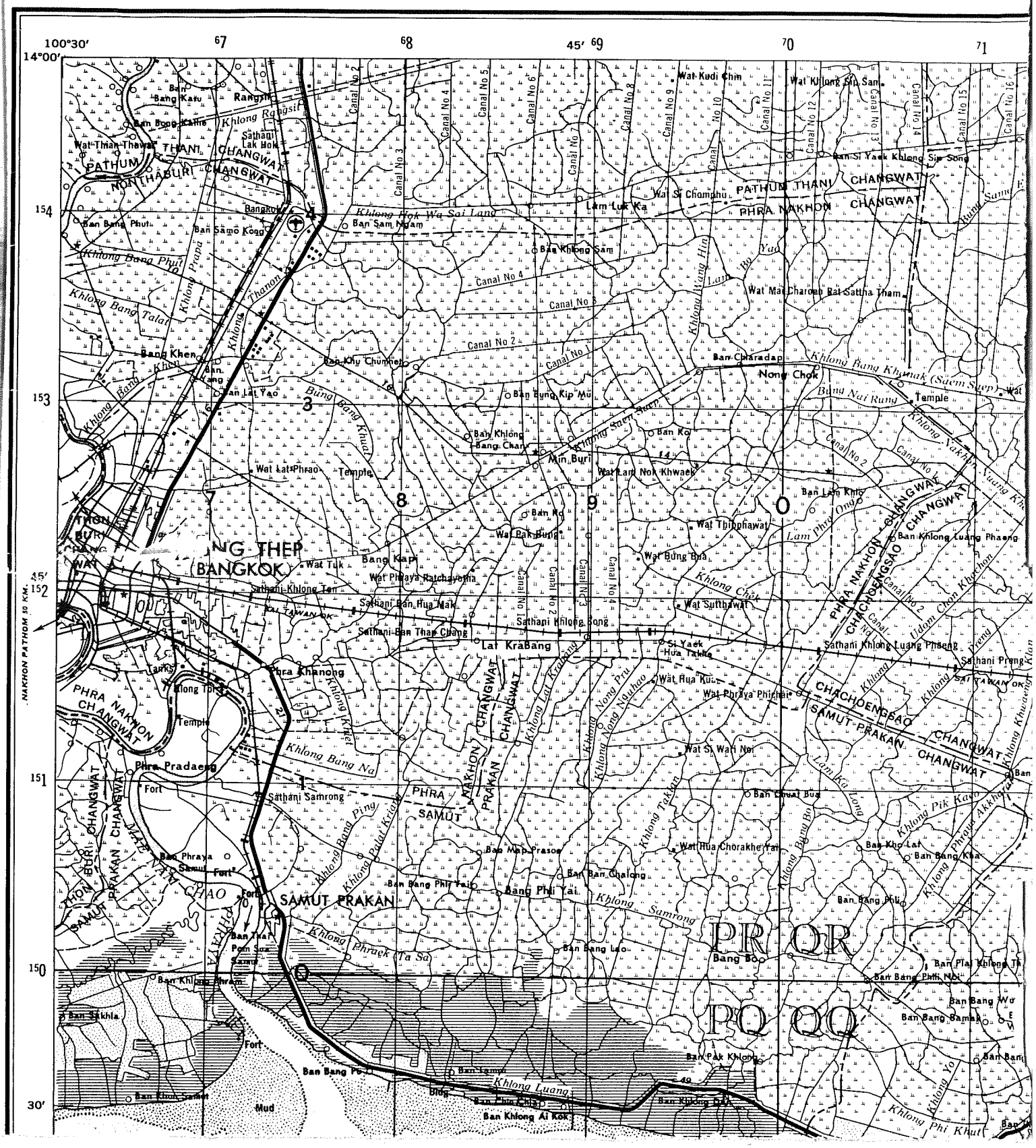
Ao	bay	Mae Nam	river
Ban	village	Map	stream
Bung	stream	Pak Ao	estuary
Chuat	stream	Phraek	stream, irrigation channel
Huai	stream	Rang	stream, irrigation channel
Khao	hill, mountain	Rong Rian	school
Khlong	stream, canal	Sai	railroad
Ko	island	Saphan	bridge
Laem	point	Sathani	railroad station
Lam	stream, irrigation channel	Than	stream
Lam Bung	stream	Thanon	road
Lam Rang	irrigation channel	Thung	plain
Lat	canal, stream	Wat	monastery

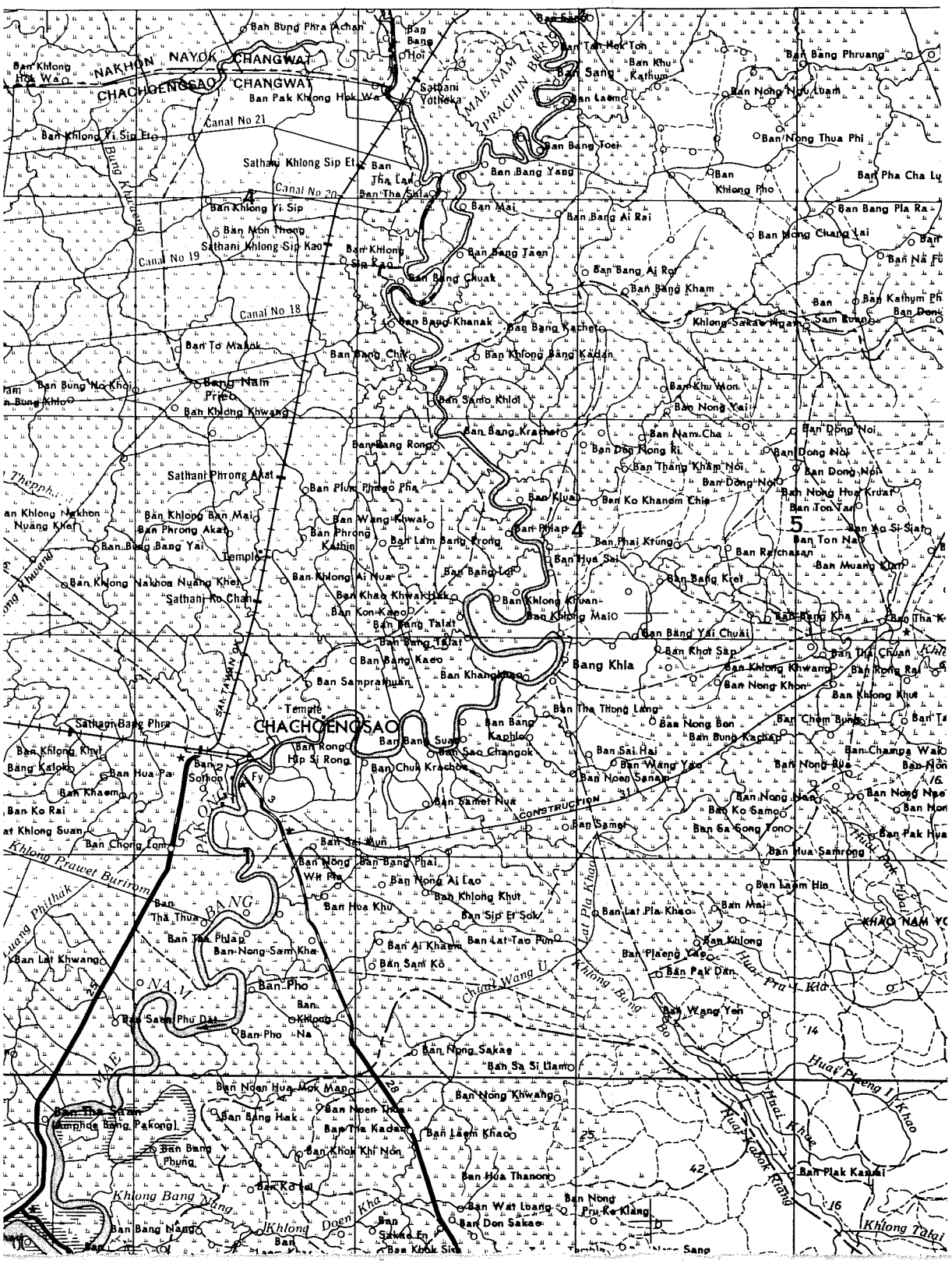
MAP # 4
Potential Mill Sites
to North and East
of Bangkok

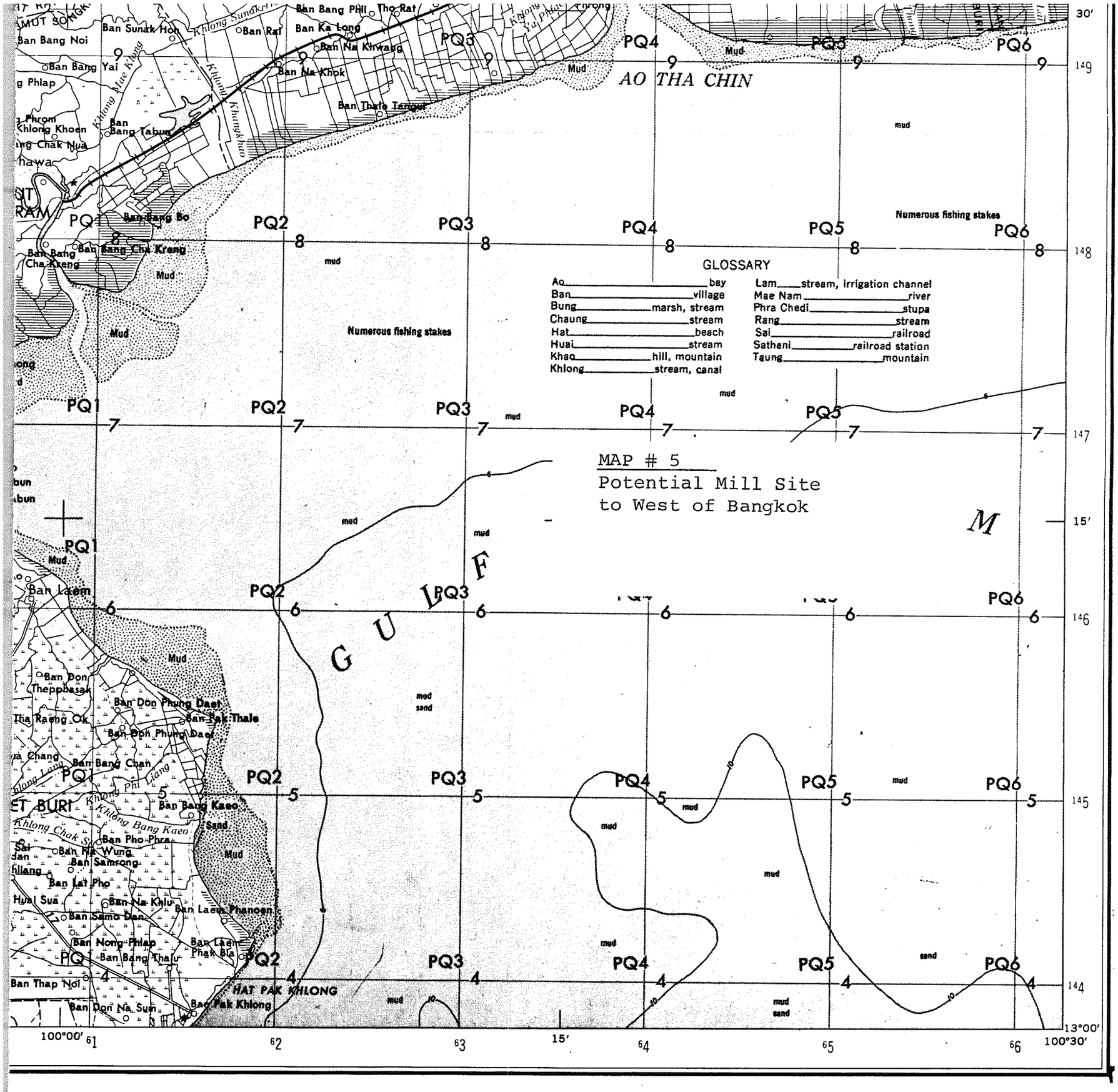
2nd importance _____ KANTHON KATCHAGIMA Fair weather, loose or light surface, one lane wide
MAHA SARAKHAM Fair or dry weather, loose surface

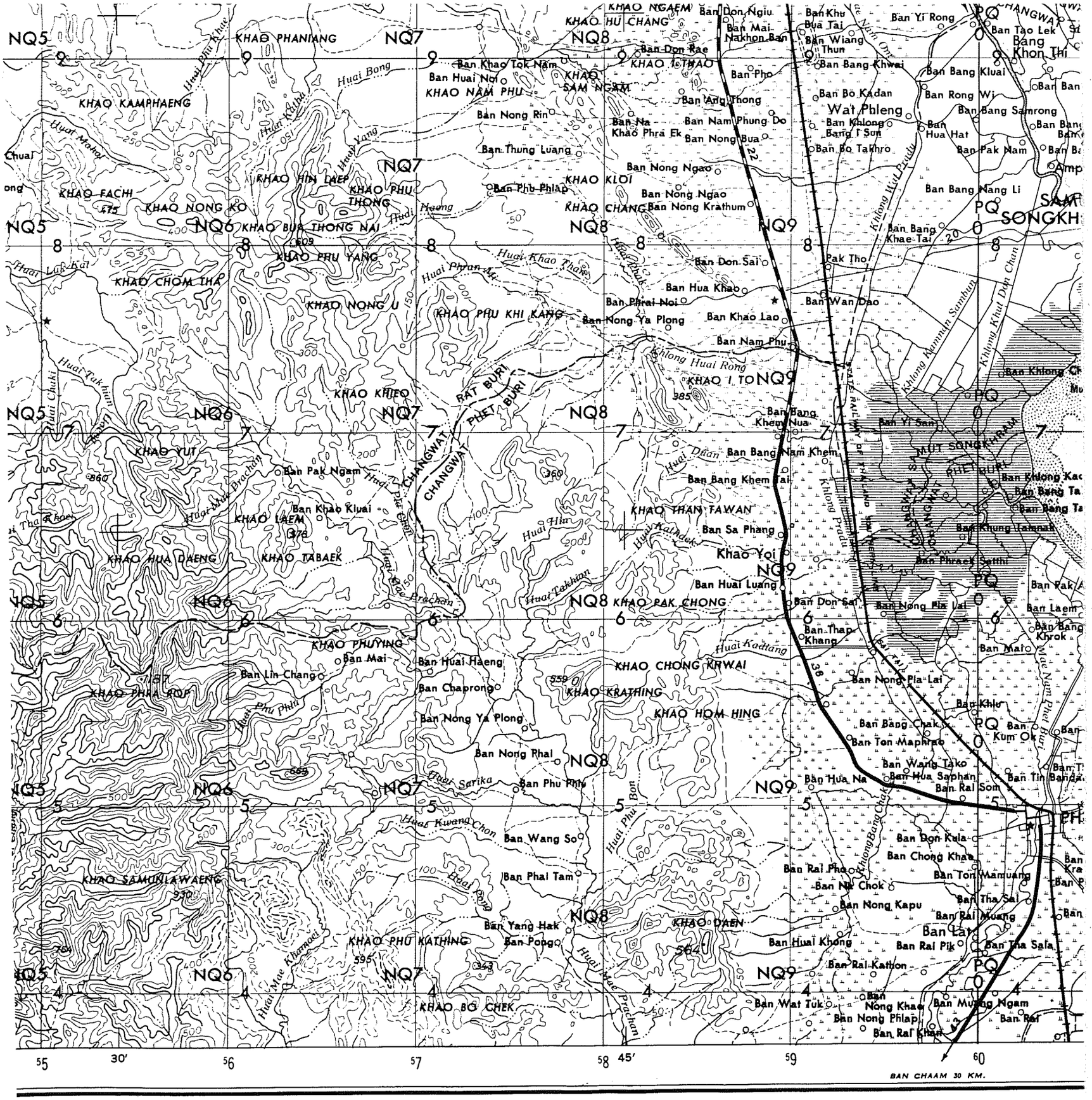


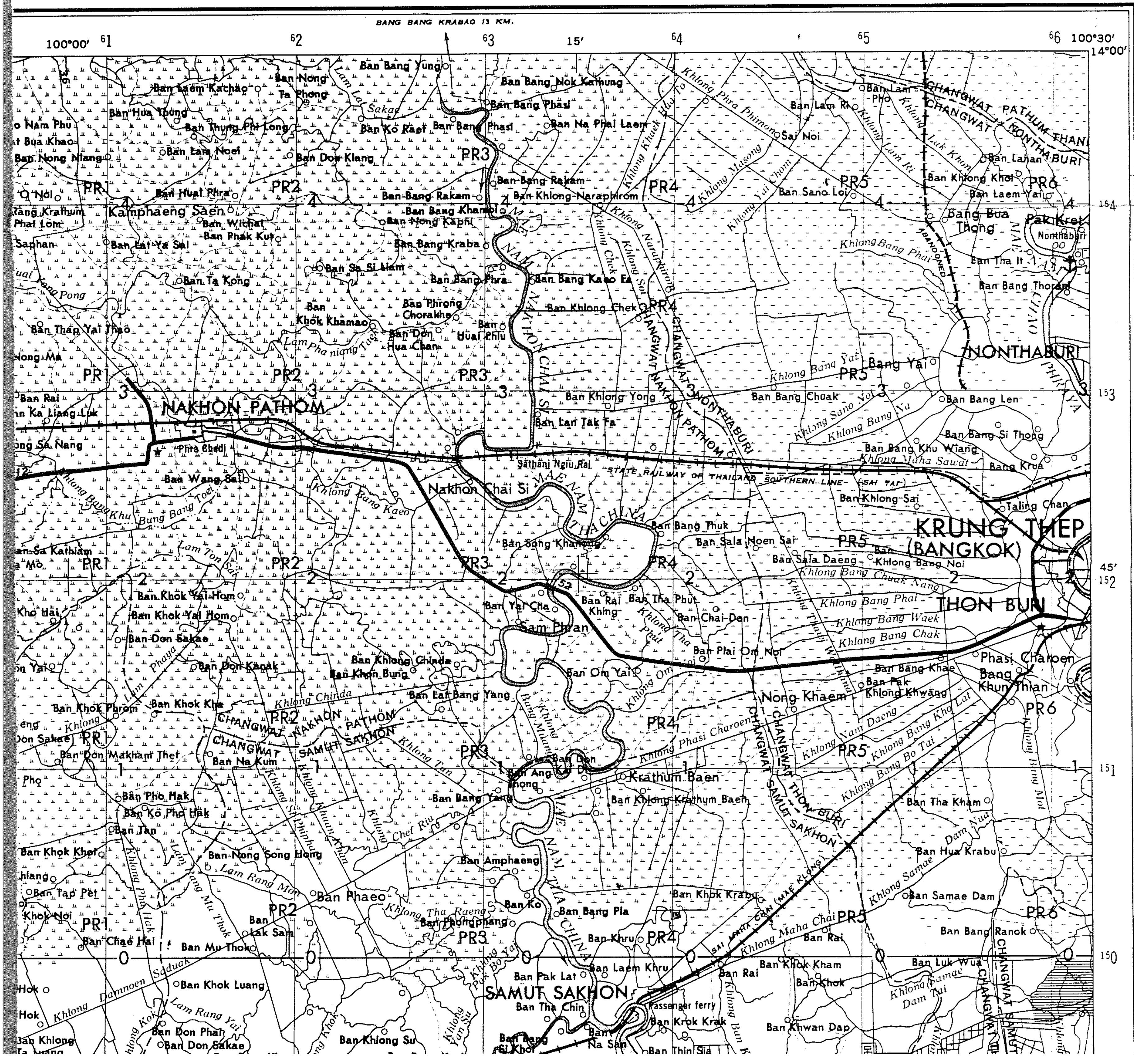
WITH SUPPLEMENTARY CONTOURS AT 50 METER INTERVALS

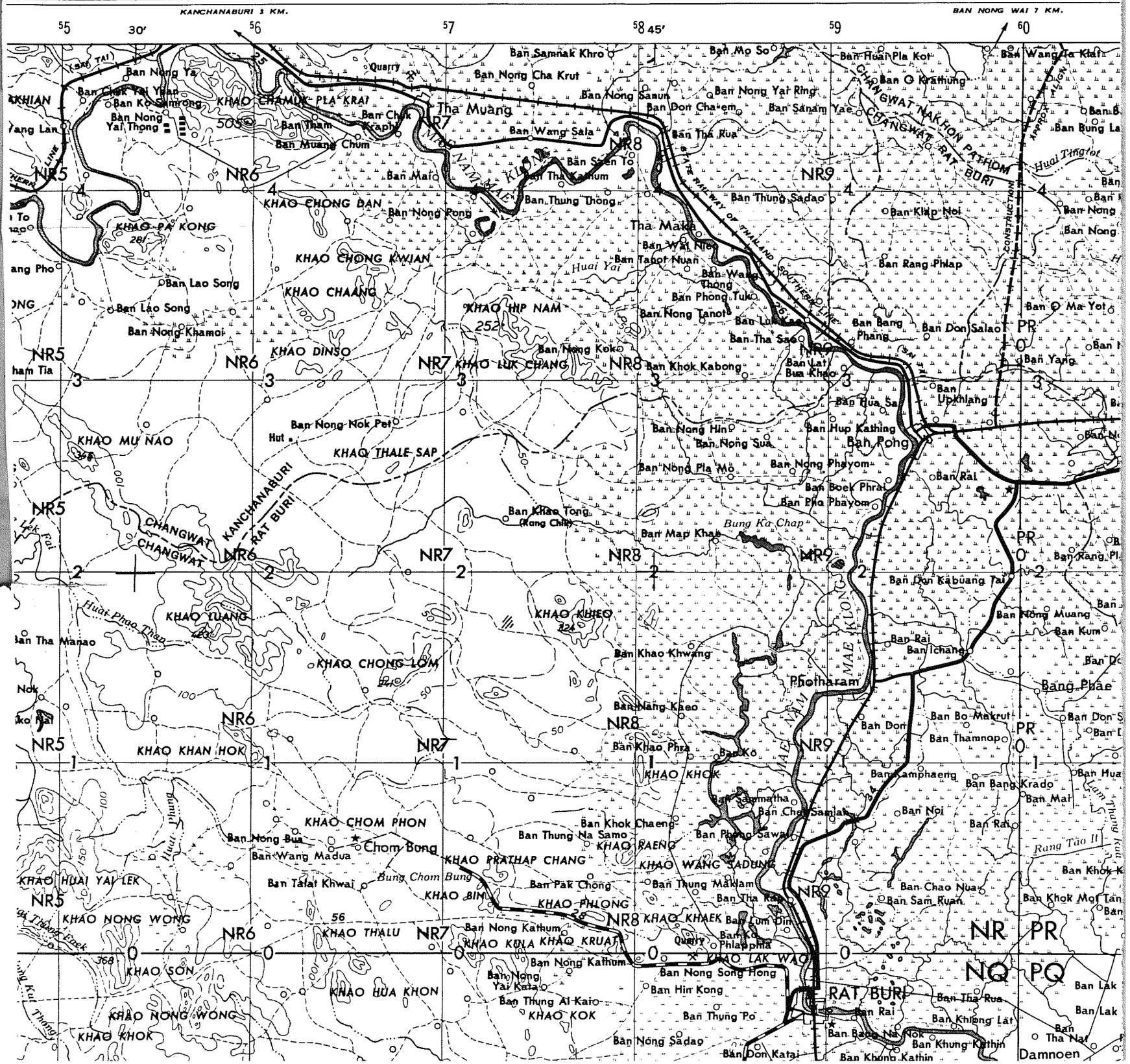

100°30′
14°00′
67
68
45′
69
70
71
154
153
45′
152
151
150
30′
NAKHON PATHOM 50 KM.
Bangkok
Ban Bang Phut
Ban Samo Kong
Khlong Bang Phut
Khlong Bang Talat
Khlong Prapa
Khlong Thanon
Bang Khen
Ban Khy Chumnien
Ban Lat Yao
Wat Lat Phrao
Temple
Ban Sam Nuam
Ban Khlong Sam
Canal No 1
Canal No 2
Canal No 3
Canal No 4
Canal No 5
Canal No 6
Canal No 7
Canal No 8
Canal No 9
Canal No 10
Canal No 11
Canal No 12
Canal No 13
Canal No 14
Canal No 15
Canal No 16
Wat Kudi Chin
Wat Khlong Bin Sam
Ban Si Yaek Khlong Sip Song
Wat Si Chomphu
Lam Luk Ka
PATHUM THANI CHANGWAT
PHRA NAKHON CHANGWAT
Khlong Hok Wa Sai Lang
Khlong Rangsit
Sathani Lak Hok
Wat Mai Charoen Rat Sattha Tham
Ban Charadap
Nong Chok
Khlong Bung Khwak (Saem Suep)
Bung Nai Rung
Temple
Ban Bung Kip Mu
Ban Khlong Bang Chan
Min Buri
Wat Lam Nok Khwaek
Ban Lam Khlo
Wat Thipphawat
Ban Khlong Luang Phaeng
Wat Bung Boa
Wat Sutthawat
Sathani Khlong Luang Phaeng
Sathani Prang
Lat Krabang
Sathani Khlong Song
Sathani Ban Thap Chang
Sathani Ban Hua Mak
Sathani Khlong Ten
Wat Phraya Ratchayonna
Wat Tuk
Bang Kapi
NG THEP
(BANGKOK)
Phra Khanong
Khlong Toei
Temple
Phra Pradaeng
Fort
Sathani Samrong
Khlong Bang Na
Khlong Bang Ping
Khlong Padat Krabang
Khlong Lat Krabang
Khlong Nong Pru
Khlong Nong Nguhao
Khlong Takan
Wat Si Wari Noi
Wat Hua Chorakhe Tai
Ban Chuat Bua
Ban Map Prasoet
Ban Ban Chalong
Ban Bang Phli Tai
Bang Phli Tai
Khlong Samrong
Ban Phraya Samut
Fort
SAMUT PRAKAN
Ban Thai Pom Sua Samut
Khlong Phrack Ta Sa
Ban Bang Lao
Bang Bo
Ban Khlong Phram
Ban Sakhla
Ban Bang Po
Ban Tampi
Ban Khlong Ai Kok
Khlong Luang
Ban Khlong Dan
Ban Pak Khlong
Ban Kho Lat
Ban Bang Kha
Ban Bang Phli
Ban Bang Phli Noi
Ban Bang Wu
Ban Bang Bamak
Ban Pla Khlong Ta
Khlong Phi Khut
Khlong Pik Kaew
Khlong Phraya Akkhorat
Khlong Yo
Lam Ka Long
Lam Phra Ong
Khlong Chek
Udom Chon Khlochon
Khlong Khuang
Khlong Bung Bo
Khlong Wang Hin
Lam Bo Yao
Bung Same
Canal No 2
Canal No 3
Canal No 4
Canal No 5
Canal No 6
Canal No 7
Canal No 8
Canal No 9
Canal No 10
Canal No 11
Canal No 12
Canal No 13
Canal No 14
Canal No 15
Canal No 16
Canal No 2
Canal No 3
Canal No 4
Canal No 5
Canal No 6
Canal No 7
Canal No 8
Canal No 9
Canal No 10
Canal No 11
Canal No 12
Canal No 13
Canal No 14
Canal No 15
Canal No 16
PHRA NAKHON CHANGWAT
CHACHOENGSAO CHANGWAT
SAMUT PRAKAN CHANGWAT
NAKHON PRAKAN CHANGWAT
THON BURI CHANGWAT
Mud
PR QR
PQ QQ


101°00′
72
73
74
15′
75
NAKHON NAYOK CHANGWAT
CHACHOENGSAO CHANGWAT
Ban Khlong Hok Wao
Ban Bung Phra Achan
Ban Bang Hoi
Ban Pak Khlong Hok Wa
Sathani Yothaka
MAE NAM BUE
PRACHIN BURI
Ban Sang
Ban Tan Hok Ton
Ban Khu Kathum
Ban Bang Phruang
Ban Nong Nju Lbam
Canal No 21
Ban Khlong Yi Sip Et
Sathani Khlong Sip Et
Ban Tha Lan
Ban Tha Sala
Ban Bang Toei
Ban Bang Yang
Ban Nong Thua Phi
Ban Khlong Pho
Ban Pha Cha Lu
Canal No 20
Ban Khlong Yi Sip
Ban Mai
Ban Bang Ai Rai
Ban Bang Pla Ra
Ban Mon Thong
Sathani Khlong Sip Kao
Canal No 19
Ban Khlong Sip Kao
Ban Bang Jaen
Ban Nong Chang Lai
Ban Bang Chuak
Ban Bang Ai Roi
Ban Bang Kham
Canal No 18
Ban Bang Khanak
Ban Bang Kachet
Khlong Sakae Ngan
Ban Kathum Ph
Ban To Mamak
Ban Bang Chik
Ban Khlong Bang Kadan
Ban Bung Nu Khoi
Bang Nam Priao
Ban Khlong Khwang
Ban Samo Khloi
Ban Khu Mon
Ban Nong Yai
Ban Bang Kracher
Ban Nam Cha
Ban Dong Noi
Ban Bang Rong
Ban Don Nong Ri
Ban Thang Kham Noi
Sathani Phrong Akat
Ban Plum Phaeo Pha
Ban Ko Khanom Chin
Ban Nong Hua Krwat
Ban Ton Tao
Ban Khlong Ban Mai
Ban Phrong Akat
Ban Wang Kuwak
Ban Phrong Kathin
Ban Lam Bang Prong
Ban Phai Krung
Ban Ton Nao
Ban Ko Si Siam
Ban Bung Bang Yai
Temple
Ban Hua Sai
Ban Raychasan
Ban Muang Klan
Ban Khlong Nakhon Nuang Khet
Ban Khlong Ai Mua
Ban Bang Lai
Ban Bang Kiel
Sathani Ko Chan
Ban Khao Khwak Hek
Ban Khlong Khuan
Ban Kon Kaeo
Ban Khlong Maio
Ban Bang Kha
Ban Bang Talat
Ban Bang Yai Chuai
Ban Bang Talat
Ban Khot Sap
Ban Thai Chuan
Ban Bang Kaeo
Bang Khla
Ban Khlong Khwang
Ban Nong Khon
Ban Sampranuan
Ban Khlong Khut
Temple
Ban Tha Thong Lang
Ban Chem Bung
Sathani Bang Phra
CHACHOENGSAO
Ban Bang Kaphlo
Ban Nong Bon
Ban Bung Kachap
Ban Khlong Khut
Ban Rong Hip Si Rong
Ban Bang Sua
Ban Sao Changok
Ban Sai Hai
Ban Wang Yao
Ban Nong Rua
Ban Hua Pai
Ban Chuk Krachot
Ban Noen Sanan
Ban Ko Rai
Ban Samet Nua
Ban Nong Sano
Ban Ko Samo
Ban Nong Nao
Ban Khaem
CONSTRUCTION
Ban Samet
Ban Sa Song Tong
Ban Pak Hua
Ban Chong Lom
Ban Tai Mun
Ban Hua Samrong
Khlong Prawet Buriram
Ban Bang Phai
Ban Nong Wit Pha
Ban Nong Ai Lao
Ban Lam Hin
Ban Tha Thua
Ban Hua Khu
Ban Khlong Khut
Ban Sip Et Sok
Ban Mai
Ban Lat Pla Khao
Ban Tha Pulap
Ban Nong Sam Kha
Ban Ai Khaem
Ban Lat Tao Pun
Ban Khlong
Ban Lat Khwang
Ban Sam Ko
Ban Plaeng Yao
Ban Pak Dan
Ban Pho
Ban Wang Yen
Ban Pho Na
Ban Nong Sakae
Ban Sa Si Liam
Ban Noen Hua Mok Mam
Ban Nong Khwang
Ban Bang Hak
Ban Noen Thon
Ban Tha Kachan
Ban Laem Khao
Ban Bang Phung
Ban Khok Khi Non
Ban Hua Thanon
Ban Plak Kamai
Ban Ko Lei
Ban Wat Luang
Ban Nong Pru Ke Klang
Ban Don Sakae
Ban Bang Nang
Ban Khok Sida
Khlong Bang Nang
Khlong Doen Kha
Khlong Bang Bo
Khlong Lat Pla Khao
Huai Pla Kad
Huai Pheng Ji Khao
Huai Khae
Huai Kabok Rang
Khlong Talai
KHAO NAM YO
PAKONG
BANG
NAM
MAE
Ban Tha Sadan
Amphoe Bang Pakong
Ban Bang Phung
Ban Bang Nang
Ban Sang


MAP # 5
Potential Mill Site
to West of Bangkok
GLOSSARY
Ao bay
Ban village
Bung marsh, stream
Chaung stream
Hat beach
Huai stream
Khao hill, mountain
Khlong stream, canal
Lam stream, irrigation channel
Mae Nam river
Phra Chedi stupa
Rang stream
Sai railroad
Sathani railroad station
Taung mountain
AO THA CHIN
GULF
Numerous fishing stakes
Ban Bang Phli
Tho Rat
Ban Sunak Hon
Ban Rat
Ban Ka Long
Ban Na Khwang
Ban Na Khok
Ban Thale Tanot
Ban Bang Noi
Ban Bang Yai
Ban Bang Tabun
Ban Bang Bo
Ban Bang Cha Kreng
Ban Laem
Ban Don Theppharak
Ban Don Phung Daet
Ban Pak Thale
Ban Bang Chan
Ban Bang Kaeo
Ban Pho Phra
Ban Na Wung
Ban Samrong
Ban Lat Pho
Ban Na Khlu
Ban Laem Phanoen
Ban Samo Dan
Ban Nong Phlap
Ban Laem Phak Bia
Ban Bang Thalu
Ban Thap Noi
Ban Don Na Sum
Ban Pak Khlong
HAT PAK KHLONG
Khlong Sunak Hon
Khlong Mae Klong
Khlong Khungkhao
Khlong Ya Phai
Khlong Phi Liang
Khlong Bang Kaeo
Khlong Chak Sai
Khlong Lang
Mud
Sand
mud
sand
PQ1
PQ2
PQ3
PQ4
PQ5
PQ6
30'
149
148
147
15'
146
145
144
13°00'
100°00'
100°30'


KHAO NGAEM
KHAO HU CHANG
KHAO PHANIANG
KHAO KAMPHAENG
KHAO NAM PHU
KHAO SAM NGAM
KHAO THAO
KHAO HIN LAEP
KHAO PHU THONG
KHAO FACHI
KHAO NONG KO
KHAO BUA THONG NAI
KHAO PHU YANG
KHAO CHOM THA
KHAO NONG U
KHAO PHU KHI KANG
KHAO KLOI
KHAO CHANG
KHAO I TO
KHAO KHEO
KHAO YUT
KHAO LAEM
KHAO HUA DAENG
KHAO TABAEK
KHAO THAN TAWAN
Khao Yoi
KHAO PAK CHONG
KHAO PHUYING
KHAO PHRA ROP
KHAO CHONG KRWAI
KHAO KRATHING
KHAO HOM HING
KHAO SAMUNLAWAENG
KHAO PHU KATHING
KHAO DAEN
KHAO BO CHEK
Wat Phleng
Bang Khon Thi
SAM SONGKH
RAT BURI
PHET BURI
CHANGWAT
STATE RAILWAY OF THAILAND
Khlong Huai Rong
Khlong Pradu
Khlong Kamnan Sunthon
Khlong Khut Don Chan
Huai Bong
Huai Phu Khae
Huai Kathu
Huai Yang
Huai Mahat
Huai Luk Kai
Huai Phran Ai
Huai Khao Thake
Huai Chaki
Huai Takhian
Huai Mae Prachan
Huai Pai Chan
Huai Hin
Huai Kahdek
Huai Dian
Huai Kadtang
Huai Phu Phlu
Huai Sarika
Huai Kwang Chon
Huai Phu Bon
Huai Mae Khamaei
Huai Mae Prachan
Khlong Bang Chak
Nam Phet Buri
Ban Don Ngiu
Ban Khu Bua Tai
Ban Yi Rong
Ban Tao Lek
Ban Mai Nakhon Ban
Ban Wiang Thun
Ban Don Rae
Ban Khao Tok Nam
Ban Huai Noi
Ban Pho
Ban Bang Khwai
Ban Bang Kluai
Ban Bo Kadan
Ban Rong Wi
Ban Ang Thong
Ban Bang Samrong
Ban Nong Rin
Ban Na Khao Phra Ek
Ban Nam Phung Do
Ban Khlong Bang I Sun
Ban Hua Hat
Ban Nong Bua
Ban Bo Takhro
Ban Pak Nam
Ban Thung Luang
Ban Nong Ngao
Ban Phu Phlap
Ban Nong Krathum
Ban Bang Nang Li
Ban Bang Khae Tai
Pak Tho
Ban Don Sai
Ban Hua Khao
Ban Wan Dao
Ban Phrai Noi
Ban Khao Lao
Ban Nong Ya Plong
Ban Nam Phu
Ban Bang Khem Nua
Ban Yi San
Ban Bang Nam Khem
Ban Bang Khem Tai
Ban Pak Ngam
Ban Khao Kluai
Ban Sa Phang
Ban Huai Luang
Ban Don Sai
Ban Nong Pla Lai
Ban Thap Khang
Ban Mai
Ban Huai Haeng
Ban Lin Chang
Ban Chaprong
Ban Nong Ya Plong
Ban Nong Phai
Ban Phu Phlu
Ban Wang So
Ban Phai Tam
Ban Yang Hak
Ban Poogo
Ban Nong Pla Lat
Ban Khlu
Ban Bang Chak
Ban Ton Maphrao
Ban Kum Ok
Ban Wang Tako
Ban Hua Saphan
Ban Hua Na
Ban Rai Som
Ban Don Kula
Ban Chong Khae
Ban Rai Pho
Ban Ton Mamuang
Ban Nik Chok
Ban Tha Sai
Ban Nong Kapu
Ban Rai Muang
Ban Lat
Ban Huai Khong
Ban Rai Pik
Ban Tha Sala
Ban Rai Kathon
Ban Wat Tuk
Ban Nong Khae
Ban Muang Ngam
Ban Nong Philap
Ban Rai Khan
Ban Rai
Ban Khlong Ch
Ban Khlong Kac
Ban Bang Ta
Ban Khung Tamnak
Ban Phraek Sathi
Ban Pak
Ban Laem
Ban Bang Khrok
Ban Mato
Ban Tin Banda
NQ5
NQ6
NQ7
NQ8
NQ9
PQ
55
30'
56
57
58
45'
59
60
BAN CHAAM 30 KM.


BANG BANG KRABAO 13 KM.
100°00′
15′
100°30′
14°00′
45′
NAKHON PATHOM
Phra Chedi
Nakhon Chai Si
Kamphaeng Saen
Sam Phran
Krathum Baen
Nong Khaem
SAMUT SAKHON
NONTHABURI
KRUNG THEP
(BANGKOK)
THON BURI
Bang Yai
Bang Bua Thong
Pak Kret
Taling Chan
Phasi Charoen
Bang Khun Thian
MAE NAM THA CHIN
MAE NAM NAKHON CHAI SI
MAE NAM CHAO PHRAYA
STATE RAILWAY OF THAILAND SOUTHERN LINE (SAI TAI)
CHANGWAT PATHUM THANI
CHANGWAT NONTHABURI
CHANGWAT NAKHON PATHOM
CHANGWAT SAMUT SAKHON
CHANGWAT THON BURI
Khlong Maha Sawat
Khlong Bang Kaeo
Khlong Phasi Charoen
Khlong Maha Chai
Khlong Damnoen Saduak
Khlong Chinda
Sathani Ngiu Rai
Ban Khlong Yong
Ban Lan Tak Fa
Ban Bang Len
Ban Wang Sai
Ban Song Khanong
Ban Yai Cha
Ban Om Yai
Ban Phaeo
Ban Amphaeng
Ban Bang Yang
Ban Bang Pla
Ban Khok Krabi
Ban Samae Dam
Ban Hua Krabu
Ban Tha Kham
Ban Pak Lat
Ban Tha Chin
Passenger ferry
PR1
PR2
PR3
PR4
PR5
PR6


KANCHANABURI 3 KM.
BAN NONG WAI 7 KM.
55 30′
56
57
58 45′
59
60
Ban Samnak Khro
Ban Mo So
Ban Huai Pla Kot
Ban Wang Ta Klan
Ban Nong Ya
Quarry
Ban Nong Cha Krut
Ban Nong Sanun
Ban Nong Yai Ring
Ban O Krathung
Ban Chak Yai Yuan
Ban Ko Samrong
Ban Nong Yai Thong
KHAO CHAMUK PLA KRAI
Ban Chak Kraphi
Tha Muang
Ban Don Cha-em
Ban Sanam Yae
Ban Tham
Ban Muang Chum
Ban Wang Sala
Ban Tha Rua
Ban Seen To
Ban Tha Kathum
Ban Maio
Ban Thung Thong
Ban Thung Sadao
Ban Klap Noi
KHAO CHONG DAN
Ban Nong Pong
KHAO PA KONG
Tha Makha
Ban Wai Nieo
Ban Tanot Nuan
Huai Yai
Ban Rang Phlap
KHAO CHONG KWIAN
Ban Lao Song
KHAO CHAANG
Ban Wang Thong
Ban Phong Tuko
Ban Nong Tanot
KHAO THP NAM
Ban Lu Kao
Ban Bang Phang
Ban Don Salao
Ban Nong Khamoi
KHAO DINSO
Ban Nong Koko
Ban Tha Sao
Ban Yang
KHAO LUK CHANG
Ban Khok Kabong
Ban Lat Bua Khao
Ban Upkhlang
Ban Bua Sa
Ban Nong Nok Pet
Hut
Ban Nong Hin
Ban Hup Kathing
KHAO MU NAO
KHAO THALE SAP
Ban Nong Sua
Bah Pong
Ban Nong Pla Mo
Ban Nong Phayom
Ban Rai
Ban Boek Phra
Ban Pha Phayom
Ban Khao Tong (Rong Chik)
Bung Ka Chap
Ban Map Khao
Ban Don Kabuang Tai
Ban Nong Muang
Ban Kum
Ban Rai
Ban Ichang
KHAO YUANG
KHAO KHIEO
Ban Tha Manao
Ban Khao Khwang
KHAO CHONG LOM
Photharam
Bang Phae
Ban Nang Kaeo
Ban Bo Makrut
Ban Don
Ban Thamnop
KHAO KHAN HOK
Ban Khao Phra
Ban Ko
KHAO KHOK
Ban Kamphaeng
Ban Bang Krado
Ban Mat
Ban Sammatha
Ban Chai Samlan
Ban Noi
Ban Rai
KHAO CHOM PHON
Ban Khok Chaeng
Ban Thung Na Samo
Ban Phong Sawan
Ban Nong Bua
Chom Bung
KHAO RAENG
Ban Wang Madua
KHAO PRATHAP CHANG
KHAO WANG SADUNG
Ban Talat Khwai
Bung Chom Bung
Ban Pak Chong
Ban Thung Makham
KHAO HUAI YAI LEK
KHAO BIN
KHAO PHLONG
Ban Tha Kae
Ban Chao Nua
Ban Sam Ruan
KHAO NONG WONG
KHAO THALU
KHAO KHAEK
Ban Lum Din
Ban Nong Kathum
KHAO KULA
KHAO KRUAT
Ban Ko Phlapphla
KHAO LAK WAO
Ban Nong Kathum
Ban Nong Song Hong
KHAO SON
KHAO HUA KHON
Ban Nong Yai Kalao
Ban Hin Kong
RAT BURI
Ban Tha Rua
Ban Thung Al Kaio
KHAO KOK
Ban Thung Po
Ban Rai
Ban Khlong Lat
KHAO NONG WONG
KHAO KHOK
Ban Nong Sadao
Ban Bang Na Nok
Ban Khung Kathin
Ban Don Katai
Ban Khung Kathin
Damnoen
Ban Lak
Ban Tha Nat
Ban Bung La
Huai Tingtot
Huai Phao Than
Rang Tao II
Lam Thang Kua
Lam Thang Kuai
Lek Fai
Huai Thong Kuai
Huai Bamphi
KANCHANABURI
CHANGWAT
CHANGWAT RAT BURI
CHANGWAT NAKHON PATHOM
MAE NAM KWAI
MAE NAM MAE KLONG
STATE RAILWAY OF THAILAND SOUTHERN LINE
CONSTRUCTION
APPROXIMATE ALIGN
NR5
NR6
NR7
NR8
NR9
PR
NQ
PQ