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PRACTICAL EXPERIENCES ON PULPING MIXED TROPICAL HARDWOODS 1/

by
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I N D E X

I. INTRODUCTION

Until 1944, Colombia depended completely on imported board and paper for all its printing and packaging needs. In 1950, Colombian domestic production of paper products was around 8,000 metric tons of container board which represented only 13 per cent of the total consumption of paper products in the country.

Last year's consumption of paper products was approximately 275,000 metric tons, of which a little over 200,000 metric tons was locally produced. Excluding newsprint, Colombia is approximately 95 per cent self-sufficient in its paper production.

Paper production has been increasing at a compounded annual rate of over 11 per cent during the last decade. This growth is second only to the metal mechanical industries and well above the 6 per cent average increase for the total industrial sector of the economy.

Deeply involved as one of the main contributors in the achievement of the remarkable growth of the Colombian Pulp and Paper Industry, is Cartón de Colombia.

Cartón de Colombia was organized by Mr. Walter Paepcke, the President of Container Corporation of America, together with a

group of important Colombian businessmen, in 1944, and the construction of the first plant to produce corrugated containers began in 1945.

In January 1947, the Cali Mill began production of paper board from waste paper and local fibres. As paper packaging commenced to develope, the Company began to produce its own pulp from raw materials available within the country. In 1948, Cartón de Colombia started producing pulp from rice straw and sugar cane bagasse, in an effort to reduce its dependence on imported pulp.

The expanding and rapidly increasing demand for board and paper products, along with the self-expansion of those industries served by Cartón de Colombia, forced the Company to face production pressures beyond its installed capacity. As a result, intensive modernization and enlargement of the existing machines, as well as additions of a new paper machine and several converting plants, took place during the decade of the fifties.

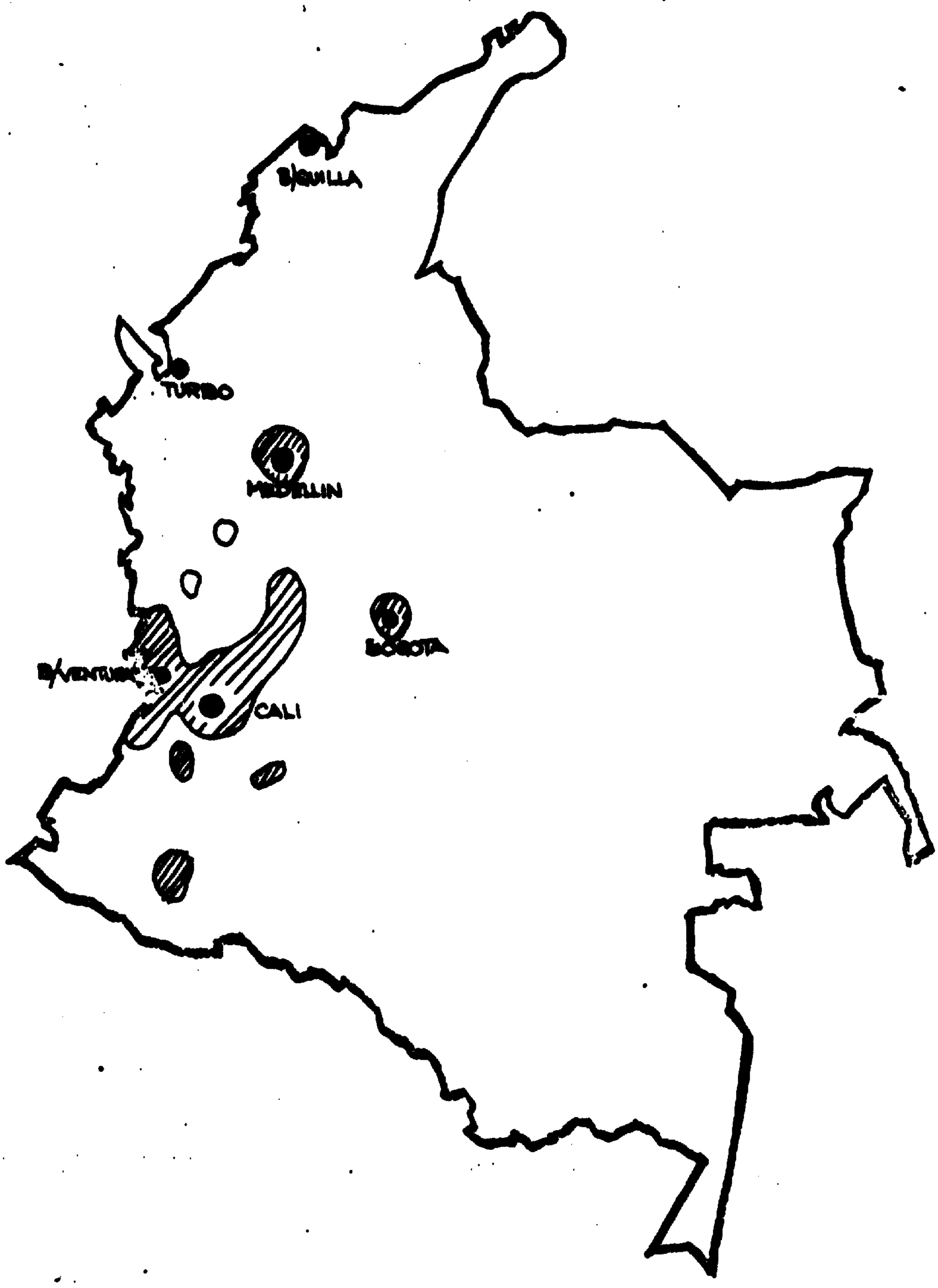
This growth, along with increasing import restrictions and the deficit in Colombia's Balance of Payment, made the need for self-sufficiency in raw materials for the manufacture of board and paper, more urgent than ever.

After several years of research and experimentations by the U. S. Forestry Laboratory, Container Corporation at its Circleville Plant, and Cartón de Colombia, a pulping process was initially developed which enabled Cartón de Colombia to produce pulp using mixed tropical hardwoods, available nearby, on a pilqt plant scale.

A new company, Celulosa y Papel de Colombia, "Pulpapel, S.A." was formed in 1959 to handle and develop on a commerical basis a process for pulping tropical hardwoods. Pulpapel was a joint venture of Cartón de Colombia, Container Corporation of America, and the Instituto de Fomento Industrial (The Colombian Institute for Basic Industrial Devdopment). Pulpapel initiated operations in the middle of 1963, and in 1965 Cartón de Colombia acquired the financial interests of its two original partners.

A recovery boiler, installed in 1968, initiated a chemical recovery plant to reduce pulping chemical costs. This system was completed and closed up with the installation of a lime kiln during 1971. In addition, semibleached pulp is produced in a single stage Kamyr bleach plant.

Today, Cartón de Colombia's operations in Cali have a 450 metric ton per day processing capacity in board and paper. The Mill



LOCATION OF CARTON DE COLOMBIA PLANTS AND CENTERS OF WOOD SUPPLY includes two paper and two board machines, two pulp plants, a corrugated plant, a folding carton plant, as well as processing facilities to manufacture multiwall sacks, fibre cans, drums and tubes. The Cali Plant has expanded through its 26 years of existence from an original 4 hectares to its present 25 hectares, and additional converting plants have been established in Bogotá, Medellín, Barranquilla and Turbo. Pulpapel has a pulp production capacity of approximately 220 metric tons per day (over 300 MTPD at the end of 1971) from native tropical mixed hardwoods of approximately 100 different species.

Cartón de Colombia through its affiliate, Pulpapel, has been the first plant in the world to use mixed tropical hardwoods for the production of pulp and paper on a commerical scale. Adequate quality products, as well as extensive personnel training programs and the conformation of an experienced professional and administrative group, have contributed towards integration of the pulp and paper industry in Colombia.

The experiences that Cartón de Colombia and Pulpapel have gained during the last decade concerning pulping mixed tropical hardwoods, are the subject of this report to the United Nations Industrial Development Organization.

II. FORESTRY OPERATION

The proximity of the woods to the Pacific Ocean region of Colombia, as well as the integration to the existing board and paper operation, and availability of power and water sources, had a great influence on the selection of the pulp plant near Cali, some 140 kilometers from Buenaventura, a port on the Pacific Coast. Pulpapel has in concession a forest area of approximately 58,000 hectares near Buenaventura, which was granted by the National Government for exploitation.

Pulpapol forests are located approximately 140 kilometers by road from the processing plant. The average transportation cost from the forest to the plant runs from US$5 to US$6 per metric ton.

Of the total wood consumption of Pulpapel, 35% to 45% originates from the Buenaventura own exploitations. The remaining wood requirements come from purchased wood from independent suppliers.

A. EXTRACTION

Since the Pacific Ocean region of Colombia is an area where annual rainfall is measured in meters (more than 7 meters of annual precipitation as average) extraction work becomes a rather cumbersome and complicated task, as the region is hilly with small to large slopes and ground which consists mainly of plastic clay, of low supporting pressure (0.2-0.5 $kgrs/cm^2$).

Tractos, unimogs, tractors with winches, stationary winches with 1 to 2 cable drums, combination of winches with aerial cables and roads built over corduroy logs as sub-base, have been tried in the wood extraction work. The latter system is the one presently in use. Exploitation is done on a clear cutting basis, taking advantage of all trees from a 10 cm. diameter on, except for a small number of species too hard to cut or too difficult to de-bark.

The felling and branch stripping of trees is done manually with axes. Tree cutting is done in the forest with chain saws. The de-barking and splitting of logs of an over-diameter (thickness of over 40 cm. diameter) is also done manually, using axes, metalic wedges and wooden hammers or cudgels. Stowing in the woods is done manually and the extraction is accomplished by air cables for distances up to 300 meters (single winch) and occasionally up to 600 meters (double winch). (See

Appendix No. 1). Winches are driven by $33\frac{1}{2}$ to $37\frac{1}{2}$ HP gasoline motors. 5/8" cables are utilized as guide cables and 3/8" as tractor cables. 300 and 600 meter cables with rope pulleys of 3/8" are used to carry the shipping cart and the wood load back and forth.

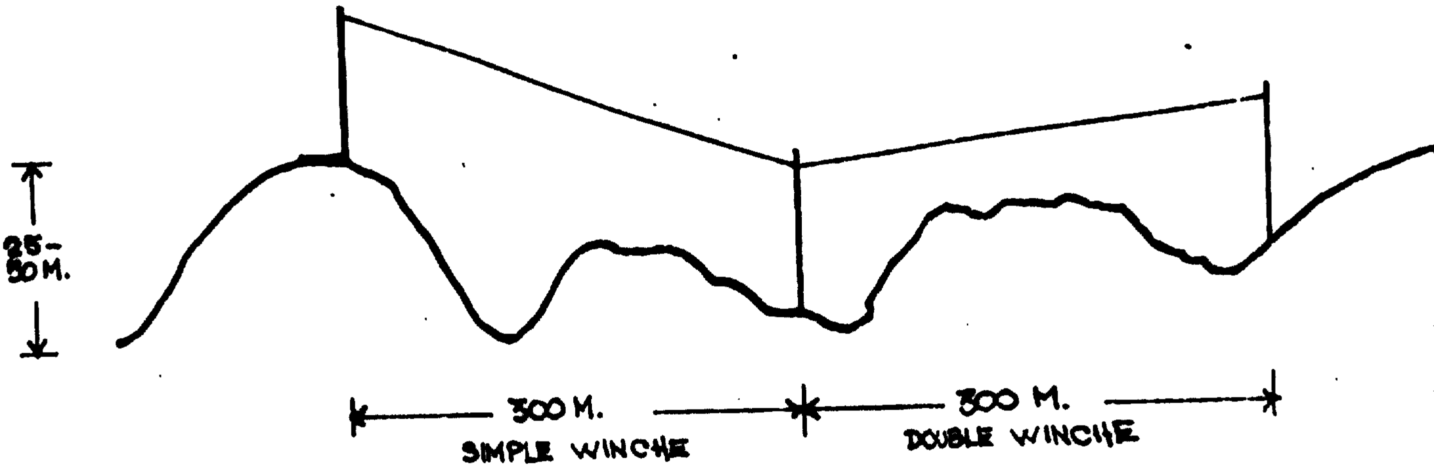
This sistem allows for the load to be picked up at any particular place of the line and on both sides of the road.

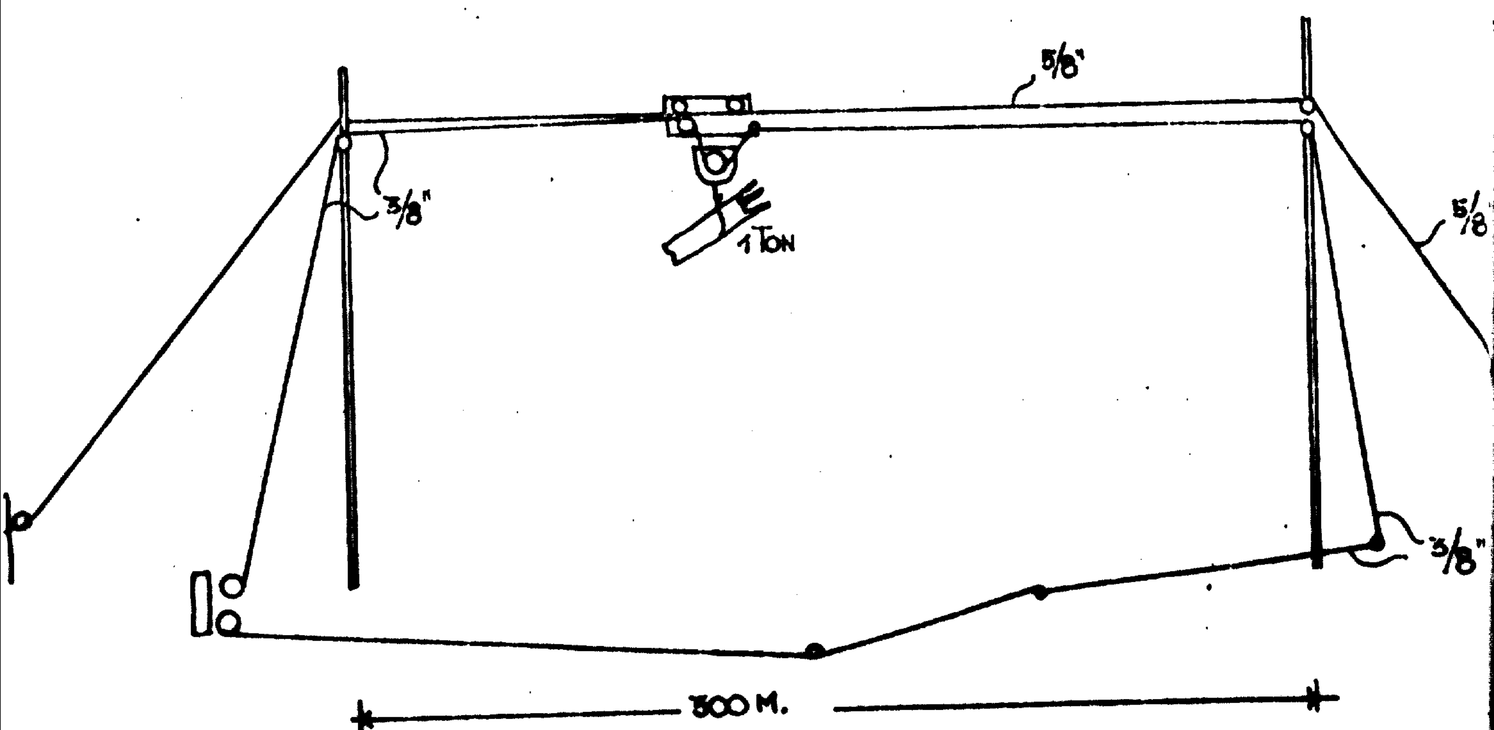
The winch load is usually one metric ton of logs from 1.50 m. in length and from 10 to 40 cm. in diameter.

The overall system from a determined point allows for the exploitation of approximately one hectare per line and up to 36 lines per point, depending upon the topography of the region and the characteristics of the road. (See Appendix No. 2). Extraction from each hectare can be from 60 to 70 tons of wood. The roads are 4 meters wide, and are built on the edge of the hills over which a ballast layer of 15 to 20 centimeter thickness is placed.

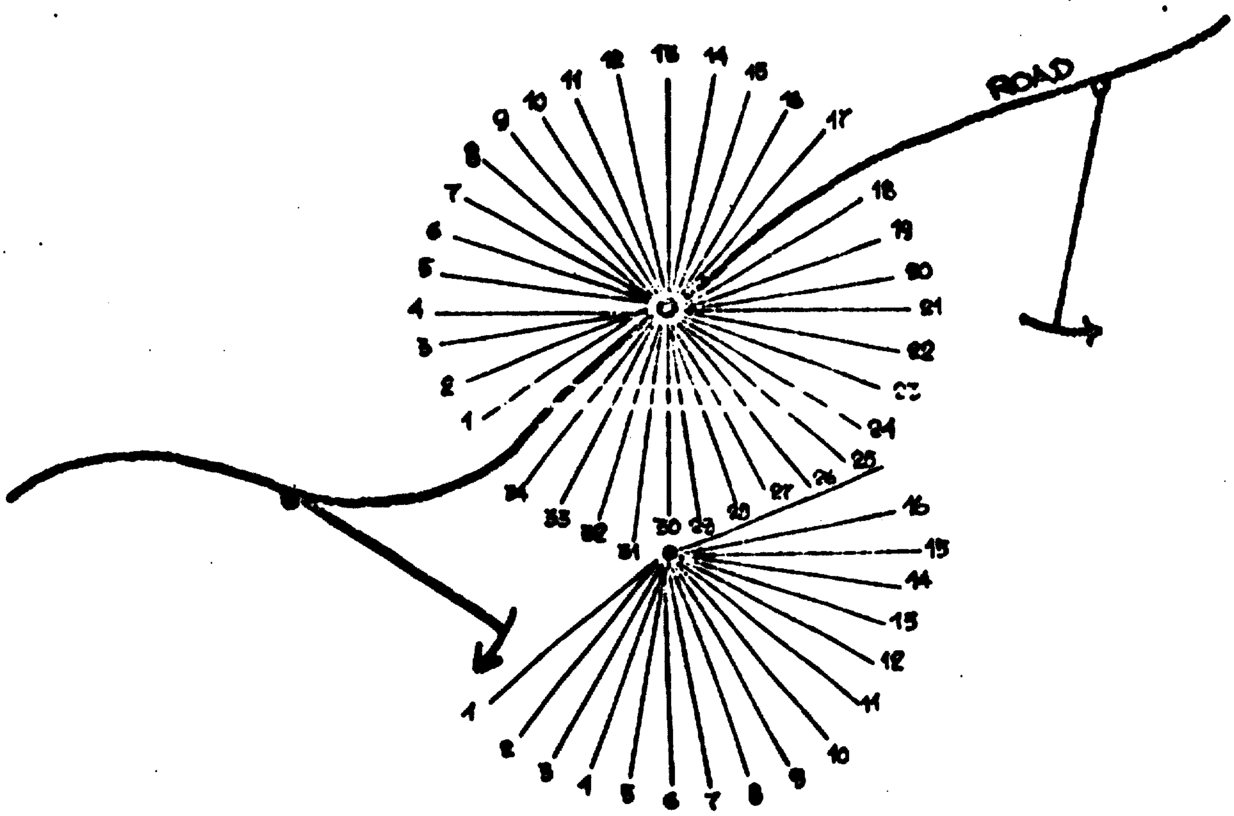
The roads are laid-out to follow the ridges to reduce earth removal work and to benefit from a more compact ground. This forces the extraction to be from bottom to top, thus

APPENDIX NO. 1





APPENDIX NO. 2



limiting the equipment and extraction systems. However, this has proven to be the best and most efficient system to obtain an economical yield per unit of area exploited.

B. YIELD

With a chain saw one man cuts, splits, de-barks, and piles manually the equivalent to 1.2 tons of round wood per work day.

Using one winch, 15 to 20 tons per work day can be extracted. There are 20 work days per month.

The system does not allow for intermediate towers, and, therefore, the length of the extraction cannot be enlarged.

C. ECOLOGY

The forest region of Pulpapel in Buenaventura corresponds to the ecological classification of very humid forests and tropical rain forests as defined by the system of L. R. Holdridge, which classifies the vegetation according to similar physical characteristics for separate zones with similar climates.

According to this system, very humid tropical forests are located in regions with temperatures of more than 24°C and annual precipitation of 4000-8000 mm. The vegetation is composed of native tropical species, the Evergreen Sylvas of the Pacific Coast Region.

In Appendix No. 3 we have listed of the mayor species that exhist in the zone with their common name, scientific name and family. The number in parenthesis indicates the abundance of the specie expressed in per cent of total stand per hectare.

Even though a great number of species form heterogeneous stands there are some species that form small pure stands where the prevailing species are:

Sande	(Brotium utile)
Chilco	(Rizophora mangle)
Nato	(Mora magistosperma)
Sajo	(Gammo sperma panamensis)
Mangle	(Rizophora mangle .)

Due to the great number of different species it is easy to suppose that many of them have different growing conditions, requirements of nutrients, space and light. Furthermore,

APPENDIX III

WOOD SPECIES USED FOR PULPING

	COMMON NAME	SCIENTIFIC NAME	FAMILY	% PER HA.
1.	Aceite María	Calophyllum Marie. Tr et. Pl	Guttiferae	0.68
2.	Ají	Capparis Odoratissima. Jacp	Capparidaceae	
3.	Araño	Matisia Cruceto K et Triana	Bombacaceae	
4.	Algarrobo	Hymenaea Courbaril (L)	Caesalpinaceae	0.07
5.	Amarillo	Nectandra Acutifolia. Miq	Lauraceae	
6.	Anime	Protium Nervosum (L) Marchal	Burseraceae	2.36
7.	Anime	Protium Colombianum. Cuatr.	Burseraceae	2.36
8.	Bagatá	Dussia Lehmanii. Harms.	Cesalpinaceae	
9.	Bacaito	Theobroma Bicolor H.B.K.	Burseraceae	
10.	Barbasco	Byrsonima Crassifolia, H.B.K.	Malpighiaceae	
11.	Biguare	Compomanesia Crassifolia	Myrtaceae	
12.	Caraño	Dacroydes Occidentalis Cuatr.	Burseraceae	
13.	Caraño	Protium Heptaphyllum (L) March	Burseraceae	
14.	Caimo Plátano	Himanthus Articulata. (Vahl) Woodson	Apocynaceae	
15.	Caimito Huevo Gato	Pouteria caimito (R. et P) Radlk	Sapotaceae	14.80
16.	Caimito Pumarejo	Lacmellea Speciosa (H.B.K.) D.C.	Apocynaceae	14.80
17.	Cascajero	Miconia Rudescens Benth	Melastomaceae	
18.	Candil	Maythenus. sp	Celastraceae	
19.	Cargadero	Guatteria Amplifolia Triana Et. Plan	Anonaceae	3.04
20.	Cauchillo	Sapium útile. Harms.	Sapindaceae	0.02
21.	Caratoso	Bursera Graniffera (L)	Burseraceae	0.49
22.	Carrá	Huberodendrum Patinoi Cuatr.	Bombacaceae	
23.	Castaño	Matisia Castaño Kars. etc. Triana	Bombacaceae	
24.	Cedro Macho	Hufelandia Péndula (Sw) Nees	Meliaceae	0.42
25.	Cedro Macho	Guarea-trichiliodes (L)	Meliaceae	0.42
26.	Cedro	Cedrela Odorata (L)	Meliaceae	
27.	Costillo Redondo	Aspidospermamegalucarpum. Muell-Arg	Apocynaceae	5.92
28.	Costillo Acanalado	Lacmellea floribunda. Benth. et Hook	Apocynaceae	
29.	Guángare	Iryanthera Jurucnsis Warb.	Myristicaceae	14.44
30.	Guángare	Dialyanthera Lehmanil	Myristicaceaa	14.44
31.	Guángare	Iryanthera ulet. Warb.	Myristicaceae	14.44
32.	Guángare	Dialyanthera otobo. Warb	Myristicaceae	14.44
33.	Chachaje	Aniba perutilis Helmsl.	Lauraceae	
34.	Chanú	Humiriastrum Colombianum. Cuatr.	Humiriaceae	3.52
35.	Chanul	Humiria procera	Humiriaceae	3.52
36.	Chilco	Sacoglotis Procera. (E. Little) Cuatr.	Humiriaceae	
37.	Chaquiro	Goupia Glabra. Aubl	Celastraceae	0.22
38.	Chocolate	Teobromo Stipulatim Cuatr.	Sterculiaceae	0.11
39.	Chucha	Miristica sp.	Myristicaceae	0.02
40.	Doblamarimbo	Macrolobium Schisocal Jacq.	Fabaceae	0.38
41.	Dormilón	Enterolobium Cyclocarpu. (Jacq) Grisob	Mimosaceae	0.41

	COMMON NAME	SCIENTIFIC NAME	FAMILY	% PER HA.
42.	Dormilón	Xylopia Aromática (Lam) Mart	Anonaceae	
43.	Embagatao	Glauca Multiflora	Fabaceae	
44.	Embagatal	Sloanea Multiflora	Fabaceae	
45.	Guabos	Inga. sp.	Mimosaceae	0.02
46.	Guabo Churimo	Inga Spuria. Willd	Mimosaceae	2.28
47.	Garza	Tabebuia Rosea (Bertol) D.C.	Bignoniaceae	
48.	Guaímaro	Helicostylis tomentosa Rusby	Moraceae	
49.	Guaímaro	Brosium sp.	Moraceae	
50.	Guayacán negro	Minquertia Punctata Sleumer	Olacaceae	1.85
51.	Guayacán amarillo	Centrolobium Paraense Tul	Fabaceae	1.85
52.	Guanábano	Guatteria Amplifolia Triana et Plan	Anonaceae	0.56
53.	Guasco Nato	Lecythis Minor. Jacq.	Lecythidaceae	7.87
54.	Guasco	Schweilera Scherophylla. Cuatr	Lecythidaceae	7.87
55.	Guácimo	Luchea seemanii Tr. et. Pl.	Tiliaceae	
56.	Guayabillo	Bellucia Grassularioides (L) Tr.	Melastomaceae	0.59
57.	Hueso	Swartzia Danariensis	Mimosaceae	
58.	Jigua Piedra	Genipa Americana (L)	Rubiaceae	5.19
59.	Jaboncillo	Isertia Pittieri. Standl	Rubiaceae	
60.	Juana Seva	Humiria sp.	Humiriaceae	1.13
61.	Lano	Pseudobombax Equanigerum	Bombacaceae	
62.	Lechero	Brosium Utile (HBK) Pittier	Moraceae	0.17
63.	Lana	Ochroma Tormentosa Wild	Bombacaceae	
64.	Lengua de Vaca	Herpetica Alata (L)	Caesalpinaceae	
65.	Laurel	Aniba sp.	Lauraceae	
66.	Madroño	Rhoeuia Chacoensis (H.BK)	Guttiferae	0.37
67.	Manteco	Gustavia Occidentalis Cuatr.	Lecythidaceae	0.44
68.	Marío	Calophyllum Longifolium Wild	Clusiaceae	
69.	Mangle Negro	Avicennia Nitida Jacq.	Verbenaceae	
70.	Mangle Blanco	Laguncularia Racemosa U Goerth	Combretaceae	
71.	Marequendo	Brosium Alicastrum Sw.	Moraceae	
72.	Machare	Symphonia Globulifera (L)	Guttiferae	
73.	Nato	Mora Magistsperma (P.B/et R.)	Caesalpinaceae	
74.	Orejero	Enterolobium Cyclocarpum Jacq.	Mimosaceae	
75.	Otobo	Dilyanthera Otoba Ward.	Myristicaceae	
76.	Pacó	Cespedesia Macrophylla Seemann	Ochnaceae	0.05
77.	Purga	Andira Inermis (sw) H.B.K.	Fabaceae	
78.	Piñuelo	Pelyciera Rixophorae Tr et Plan	Pelliceraceae	
79.	Pantano	Hieronyma Chocoensis Cuatr.	Euphorbiaceae	0.05
80.	Popa	Couma Macrocarpa. B. Rochr	Apocynaceae	
81.	Ruda	Zantoxylon. sp.	Rutaceae	
82.	Ruda Macho	Protim Glumeralosum	Buerseraceae	
83.	Sangre Gallo	Vismia Guianensis Seem	Guttiferae	
84.	Sangre Gallo	Vismia Rufa	Guttiferae	
85.	Sapotolongo	Pachira Aquatica Aubl.	Bombacaceae	
86.	Sebo	Compsoneura Trianae Ward.	Myristicaceae	0.07
87.	Sebillo	Virola Marcocarpa	Myristicaceae	
88.	Sorogá	Vochysia Ferruginea Mart.	Vochysiaceae	5.32
89.	Tachuelo	Lacmellea Floribunda D. et H.	Apocynaceae	
90.	Trapichero	Manilkara sp.	Sapotaceae	0.04
91.	Sajo	Campnosperma Panamensisi Stand	Anacardiaceae	0.02
92.	Tangare	Carapa Guianensis Aubl.	Meliaceae	

	COMMON NAME	SCIENTIFIC NAME	FAMILY	% PER HA.
93.	Teta de Vieja	Belotia Australis E.L. Little	Tiliaceae	1.28
94.	Tualve	Nectandre sp.	Lauraceae	
95.	Yaya	Trichilia Apendiculata	Meliaceae	
96.	Zanca de araña	Tovoumita guianensis	Gittiferae	3.82
97.	Zuela	Pterocarpus Officinalis	Mimosaceae	
98.	Manguillo	Ardisia Manglillo Cuatr.	Myrsinaceae	0.62
99.	Mangle	Rizophora Mangle (L)	Rizophoraceae	
100.	Jigua Negro	Nectandra sp.	Humiriaceae	

they have different physical and chemical characteristics of density, bark characteristics, and content of resins, oils, latex, etc. These characteristics affect the total use of the forest and many of the trees that are very resinous or densed are not harvested and are left standing.

As a first step to an understanding of the silvicultural management of the second growth tropical forests seven species, which show rapid height growth immediately after being cut, were selected:

1. Sangre Gallina (Visminia Rufa)
2. Jaboncillo (Isertia Pittieri)
3. Mora (Canostegia Multiflora)
4. Mora (Miconia Ruficalix)
5. Yarumo (Cecropia sp.)
6. Soroga (Vochysia Ferruginia)
7. Chaquiro (Goupia Glabra)

With these species the following different test plots were established:

a. Plots with one specie

b. Plots with two species

c. Plots with a mixture of the 7 species

d. Control plots with all species that occurred in the stand

The plots were established in 1959-1960 and, in the 10 years since establishment, no definite conclusions have been reached. Nevertheless, an evaluation has been started to determine the experiments that should be continued, changed or discontinued. This will permit us to discontinue or include other species offering good characteristics for lumbering or pulping. From what has been observed to date, we have reached the following conclusions:

1. Silvicultural management should not begin until 4-5 years after cut, because the species with seeds of slow germination require many frequent selective and release cuts to establish a plot with the desired specie or species.
2. The initial rate of thinning the stand must be low in order to keep the crown cover closed to prevent the rapid growth of undesirable seeds and species.

...

3. Thus far, we have seen a mayor increase in basal growth of trees in the treated plots.

4. In the control plots, it has been observed that excessive competition not only retarded diameter growth but height growth as well. In many places, seeds have overcome the spontaneous regeneration.

5. It is difficult to establish plots with a single specie and is more reasonable to have mixtures of more than four species. Causes for this behavior have not been established in a conclusive way. The lack of experience to handle homogenous lots of tropical hardwood species and mainly the strong possibilities of insects or diseases of difficult biological control make this a determining factor for the specie's behavior.

To clear up some of these and other questions, we are intensively studying the second growth with the goal of determining a rational plan for the management of these tropical forests, closely related to the behavior of species of fast growth and good fiber that will develop in the existing biological conditions of poor soil, clay type, high precipitation, high moisture, few hours of sun and high ambient temperature.

D. WOOD SUPPLY

During 1970 the pulp plant demanded approximately 200.000 metric tons of wood in logs for its yearly pulp production. By the end of 1975, 312.000 tons per year are predicted to be the wood requirements for the Cali Mill and by 1980, this figure would be 426.000 tons per year.

To satisfy these wood requirements we anticipate no difficulties as these needs will be supplied from areas with sufficient forest resources as the Pacific Coast, the use of waste from large saw mills now under proyect, the development of new concession areas and the increase of procurement of eucalyptus from the Cundinamarca State on the central part of the country, some 500 kilometers from the plant.

The long term supply will be supported by the reforestation programs that are presently under development through our direct technical assitance and direction. Government agency controlling natural wood resources is also undertaking long and strong range reforestation programs.

Coniferous species such as pinus patula, P. ellioltii , p. caribae, p. oocarpa and p. radiata as well as cupressus sp., have been the species planted with potential results in the Valle neighboring States, approximately 250 kilometers average distance from our Plant site.

There are also significant plantations of the eucalyptus specie established within the Valle State and the Cauca State, such as e. globulis, e. saligna, e. robusta and e. grandis.

Our Company also has two mayor nurseries of our own with with a present production capacity of 5 million seedlings to supply the reforestation programs within our zone of influence.

IV. PULPING

A. WOOD SPECIES RESEARCH

In order to determine the usefulness of tropical hardwoods in the manufacture of chemical pulps, a number of samples were sent to the Forest Products Laboratories in Madison, Wisconsin, U.S.A., in 1958. The samples consisted of 26 species of tropical hardwoods from the coastal region on the Pacific Ocean and from the Magdalena River region in the central northern part of the country.

The laboratory results confirmed the feasibility of production of board and paper using short-fibre pulps, in combination with the long-fibre pulps normally used.

Even though the 26 species investigated by the FPL were predominantly in existence, the Company was forced to include other unknown specis in its pulping operation, mainly due to the vast heterogeneity of the available local forests.

The use of these many unknown species created the need for further research in order to improve pulp quality, fiber strength, appearance and particularly yield. The research was carried out at the Pulpapel Laboratory, which has continuing responsibility for research and development. The investigation was oriented towards uniformity in the pulp manufacturing process, considering the large variety of fiber raw materials. Research information is transmitted to the Forestry Department of Cartón de Colombia in order to direct the reforestation program towards the species which will yield most favorable results.

1. Wood Transportation and Storage Facilities

The largest volume of wood is transported by road from the cutting areas to the plant, which has a storage capacity of 40,000 metric tons.

Upon receipt, the wood is weighed and sent to the chippers. The excess wood is stored in 500 ton log piles, separated 2 meters from one another and 6 meters from the fence, as a fire prevention measure. Inventory turnover is 4 to 6 months, in order to control aging. The yarding operation is done by independent contractors.

2. Equipment and Operation

The chipping facilities consist of two 90" MURCO chippers driven by 450 HP, 720 RPM motors and fed by chain conveyors. The chips are classified by means of two MURCO Double Deck vibrating chipscreens. Standard chip dimensions are 7/8" x 3/4" x 1/4".

Mixed tropical hardwoods are by themselves hard, uneven, diameter and sizes, difficult to de-bark and difficult to handle not only in the woods but also in the chipper room.

Through the experience developed in the Forest Product Laboratory, visits to the States and Canada and suggestions from the consulting firm for the project, (Sandwel of Canada) our tropical hardwoods were found to behave, as far as chipping was concerned, in a similar way to the Canadian frozen softwood. Therefore, chipper knives, of the laminated type, were recommended for use in our case. Canadian high speed laminated special treated knives made by Canada Illinois Tool Company (CITCO) were used in our chippers for some 6 years with good results and excellent efficiency, despite the higher cost of this type of knife when compared to regular solid knives. One set of laminated knives chipped 120-140 tons of wood before grinding was required. This, compared to 20-40 tons on a regular set of solid knives, represented substantial savings in knives as well as in down time for knife changing.

It was unfortunate that the Canadian knife manufacture had to discontinue this type of knife based on production costs and material availability, and the fact that we were, according to them, the only users of this type of knives in the world. As a result, we have tried to use German, British, Japanese and other European laminated knives, but only with chipping efficiencies running between 60-80 tons of wood per knife set before regrinding. We are still searching for a laminated knife similar to the Canadian type, and are expecting to try knives manufactured in Spain.

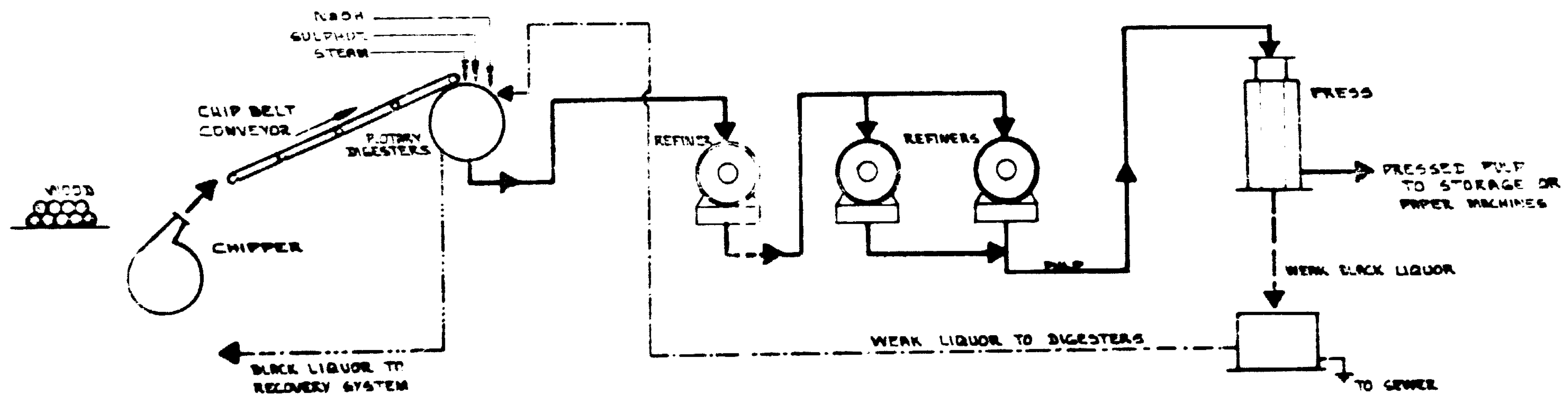
3. Chip Storage (OCS)

The 12,000 ton chip inventory is distributed in four 3,000 ton piles, in order to obtain a continuous rotation, inventory control, as well as a homogeneous mixture of random heterogeneous species, which is our basic contribution to the commercial pulping of mixed tropical hardwoods as opposed to tree selection.

B. SEMICHEMICAL PULP

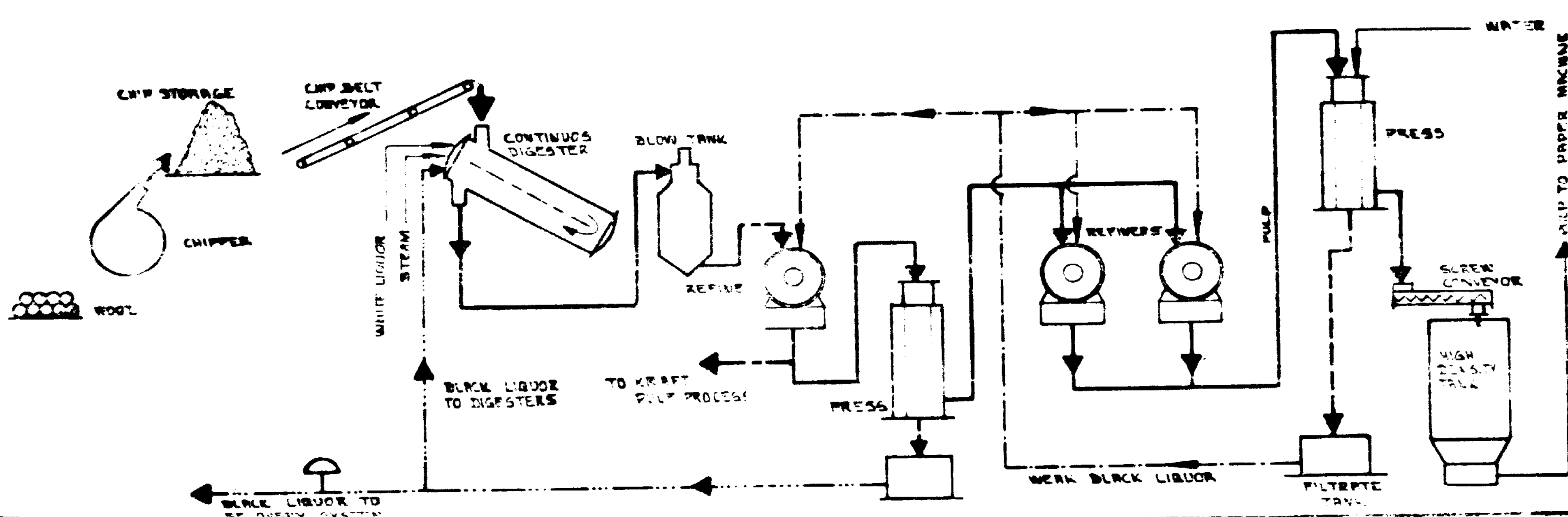
The production of semichemical pulp represented Cartón de Colombia's first efforts in the manufacture of short-fibre pulp from tropical hardwoods.

Prior to 1968, two different types of pulp were produced



SEMICHEMICAL PULP PROCESS (PRESENT)

SEMICHEMICAL PULP PROCESS WITH CONTINOUS DIGESTER



separately for the production of Corrugated Medium for the local market and for Corrugated Medium destined to export product markets. These processes have undergone several modifications in cooking cycles and chemical usage, which resulted in the production of a pulp that could be used in the manufacture of both types of Corrugated Medium with a quality that has proved superior to Medium made in the States and Europe.

1. Equipment

Three spherical rotating digesters with a 40 cubic meter capacity each and direct steam injection; chain conveyors, live bottom bin, 36" Sprout Waldron refiners, a P-300 Jones Press, and the necessary pumping equipment.

2. Process

Since 1968, a semichemical pulp is produced using liquid caustic soda and elemental sulphur with direct contact live steam of 80 lbs. pressure. Once the cooking cycle is finished, the cooking liquor goes to a blow tank where it is pumped to the chemical recovery system.

The black liquor used to complete the dry-wood/liquor ratio, is the weak liquor which results from the pulp washing process in a Jones Press.

After the black liquor is drained, the pulp is transferred by chain conveyors to the live bottom bin at 40% consistency. Then it is conveyed to the primary refiners where it is diluted to 7% consistency using white water from the paper machines.

The pulp is further diluted to a 5% consistency and is then refined to a 600cc freeness (CSF) at the secondary refining stage. It is then pressed to a final consistency of 30% and is transported to the storage areas by means of belt conveyors.

Pulp production is about 70 MTPD. Pulpapel is presently undertaking the installation of a Bauer M&D continuous digester which will replace the rotary globe digesters. This installation is expected to be in operation during the third quarter of 1971.

3. Pulp Characteristics

Kappa Number	120
Yield (B.D. pulp/B.D. wood)	65%
Total soluble residual solids (per ton of pulp)	50#

Other strength characteristics are shown on Graph #1.

C. HIGH YIELD KRAFT PULP

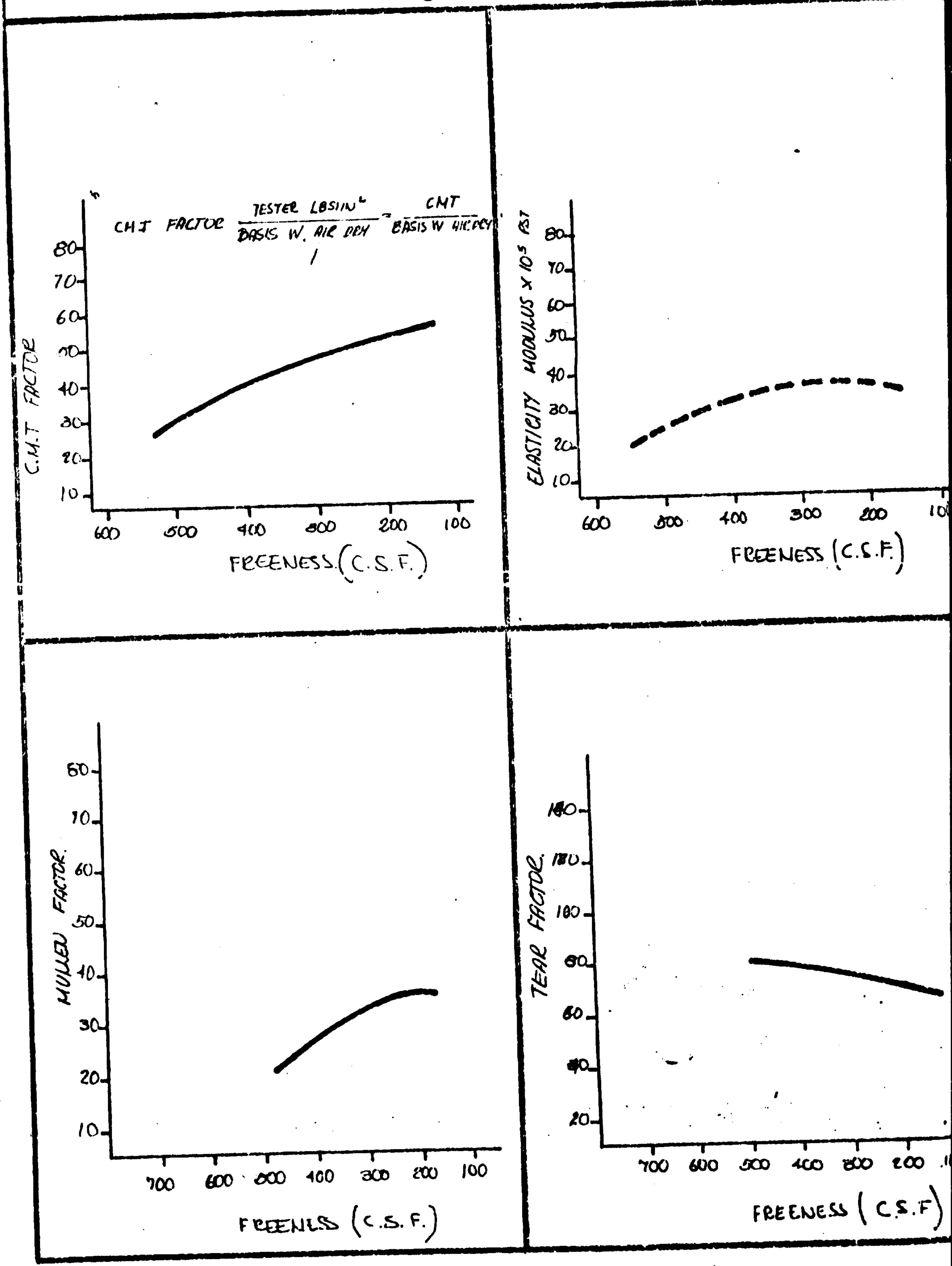
In 1963 the pulp plant started the production of "Modified Kraft Pulp", using a cooking liquor made from a mixture of sodium hydroxide and sulphur.

The purpose was to obtain a 56-58% yield pulp. Graph # 2 shows that the pulp thus obtained had low strength factors. This pulp had a high reject percentage which made refining and general pulp plant operation difficult. It also had a very dark color which caused appearance problems in the board and paper produced.

Based on these experiences, as well as laboratory results, the chemical formulas were changed, keeping cooking time and temperature constant. The results of the pulp obtained

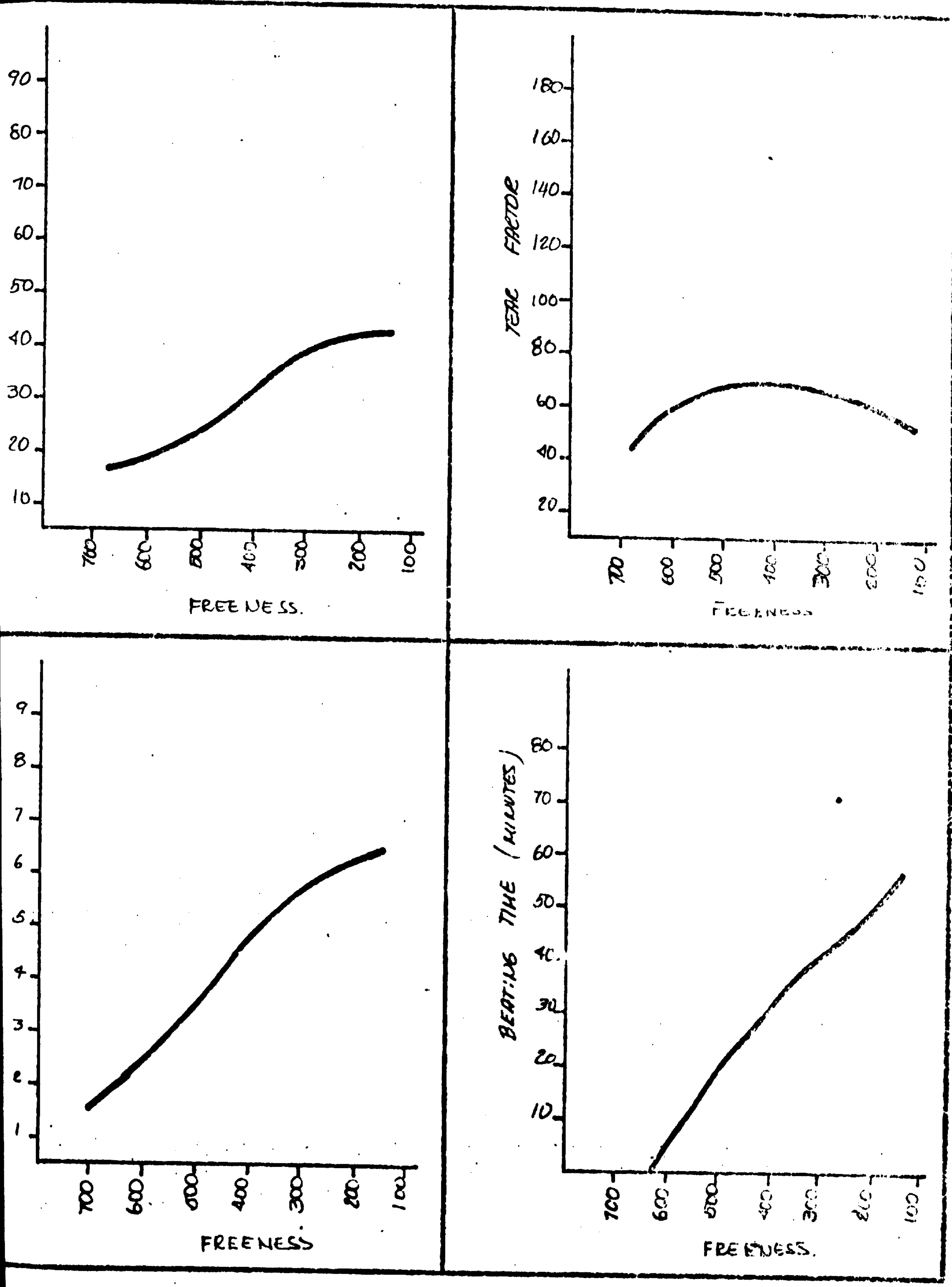
SEMICHEMICAL PULP

GRAPH No 1



PULPAPEL HIGH YIELD KRAFT PULP

GRAPH Nº 2



with a higher cooking liquor concentration are shown in Graph #3.

It was also observed that the darkening of the pulp was due to the extended time it remained in the blow tank, and that the aging of the wood in the chip piles considerably reduced its resistance factors. This led to a faster rotation of chips.

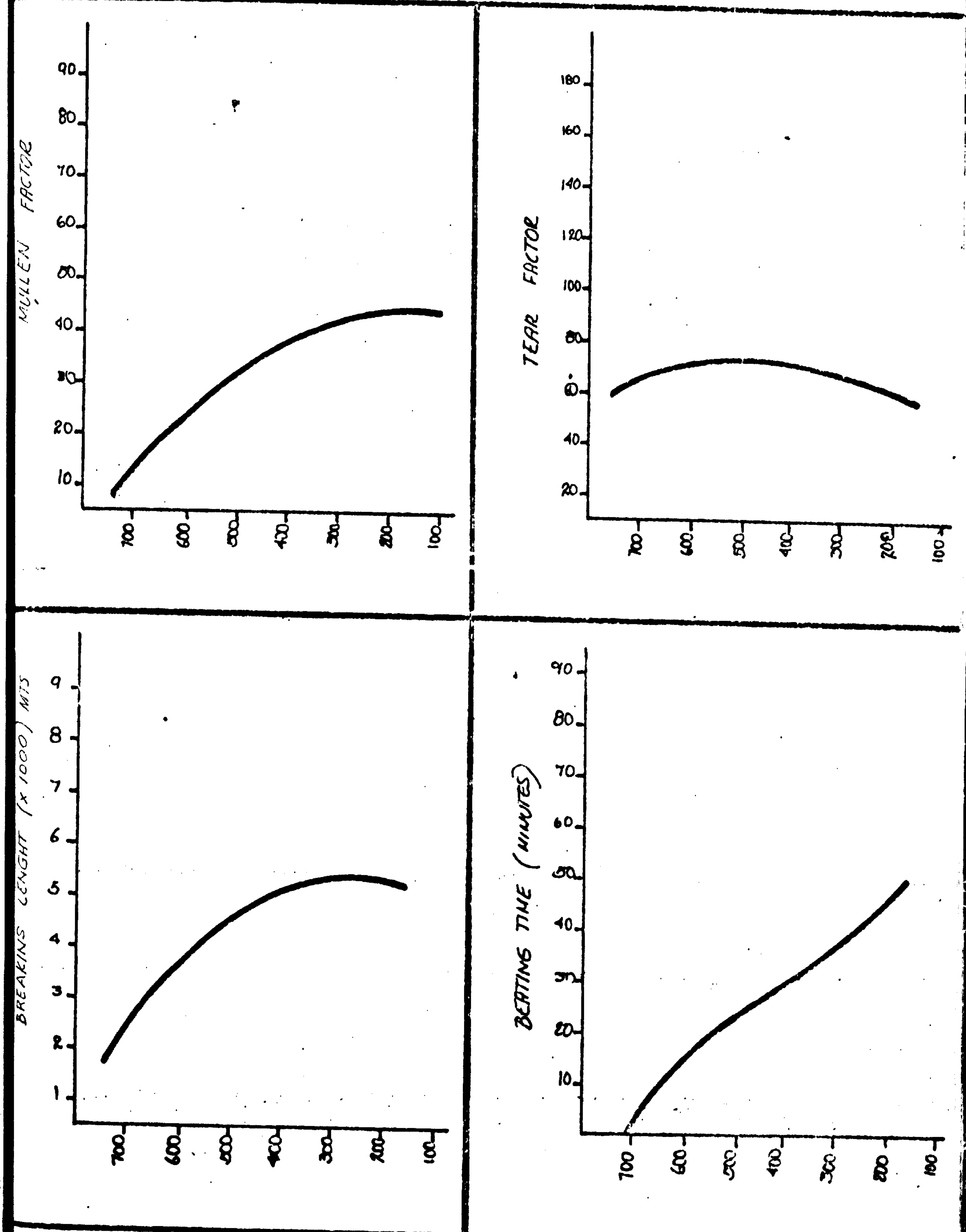
During this same period the utilization of residual black liquor to replace part of the water used to complete the liquor/wood ratio was undertaken. This was done with two objectives: to increase the concentration of chemicals in the digesters, and to develop the necessary cooking techniques to be applied after the recovery boiler installation.

In 1967, prior to the installation of the recovery boiler, the sulphidity of the cooking liquor was increased in order to obtain better physical properties.

As a result, higher and more uniform strength factors were obtained (See Graph #4), which permitted increased utilization of this type of pulp and also resulted in the production of higher quality board and paper.

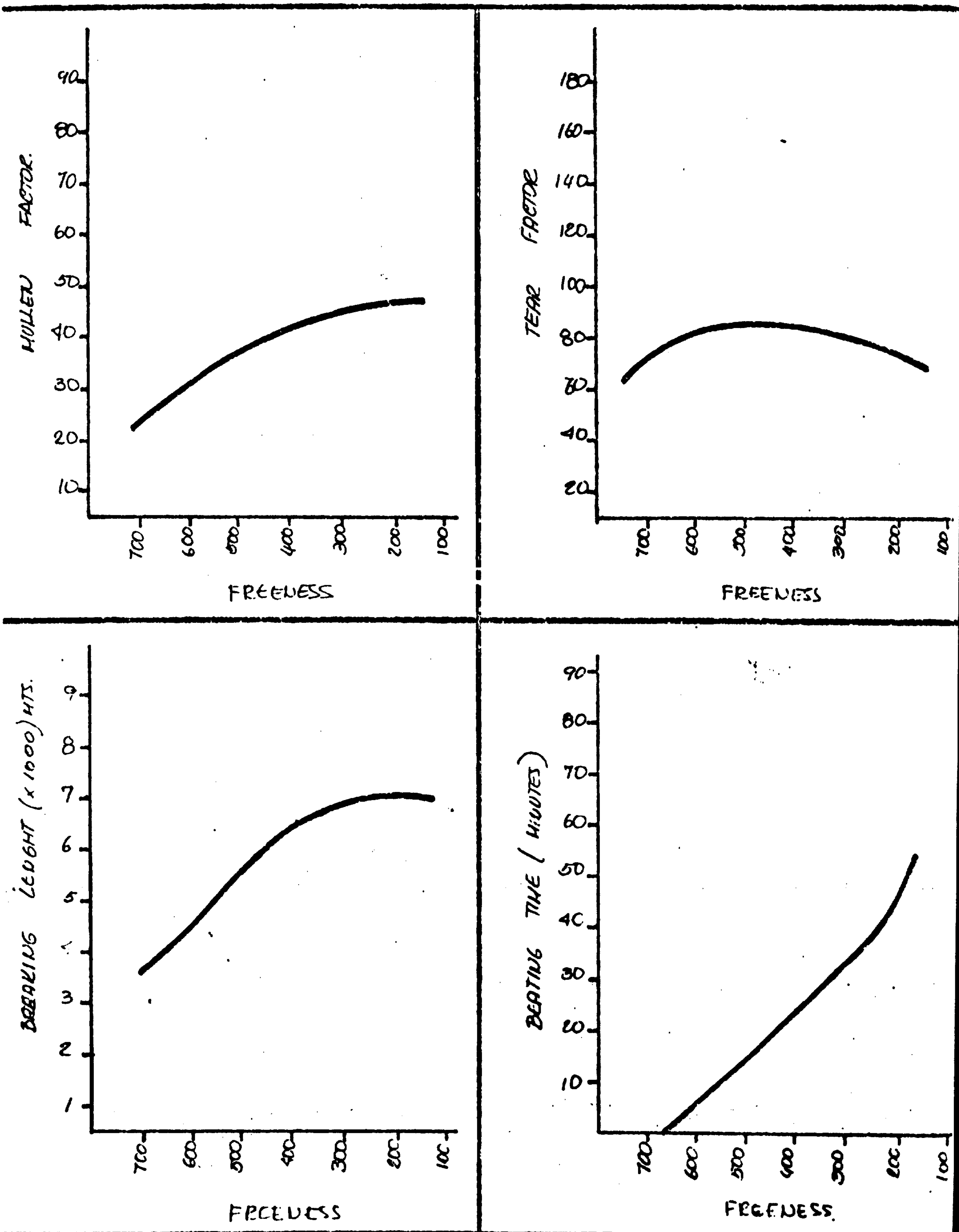
PULPAPER HIGH YIELD KRAFT PULP

GRAPH Nº 3



PULPAPEL - HIGH YIELD KRAFT PULP

GRAPH Nº 4



The next objectives were to increase the solids content in the black liquor (to make evaporation and subsequent chemicals recovery a profitable operation), to maintain an adequate free residual alkali, and to improve the quality of the pulp. This was achieved by totally replacing the water by liquor and increasing the NaOH/dry wood ratio. The pulp thus obtained was of acceptable quality (Graph #5) and very good appearance, which permitted the replacement of an even higher percentage of imported fibre for the manufacture of board and paper.

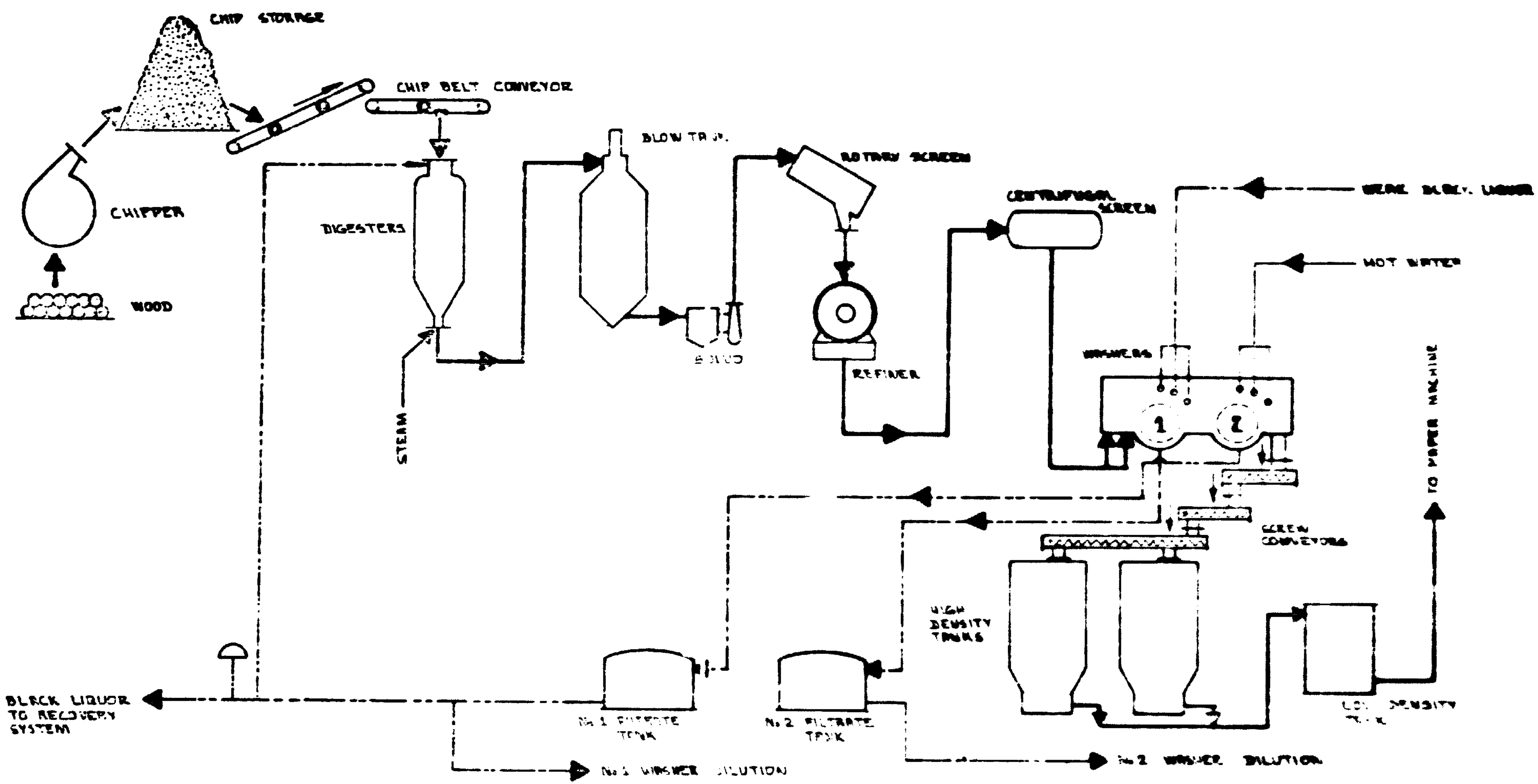
D. LOW YIELD KRAFT PULP

With the start of the recovery boiler in March 1968, the chemical pulping process suffered a substantial modification. The utilization of white cooking liquor resulted in the production of a kraft pulp from tropical hardwoods, with characteristics which differed considerably from those of the pulp obtained by means of the so-called "Modified Kraft Process".

1. Process

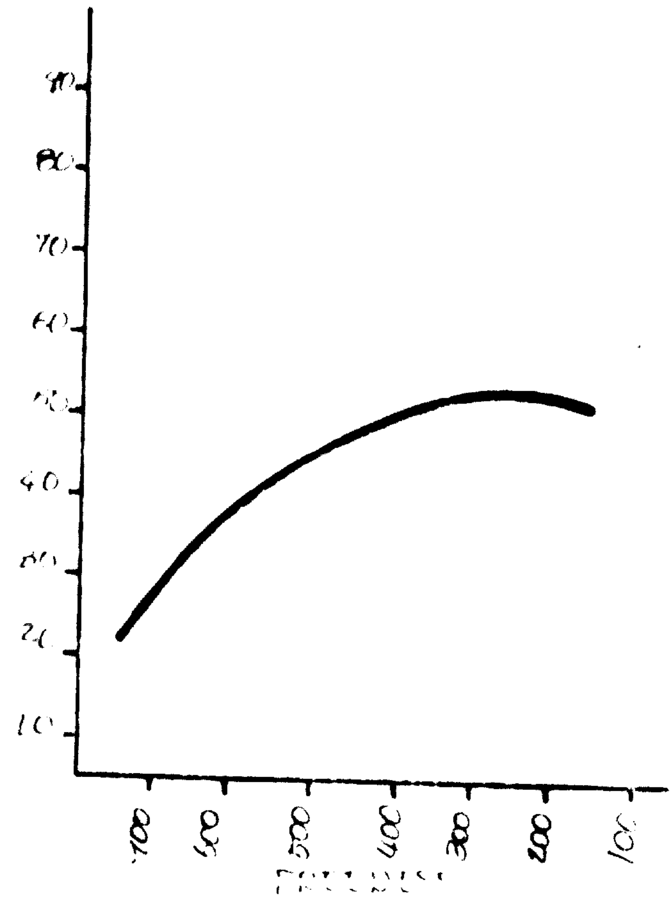
The cooking process for the production of low yield kraft pulp underwent several changes in order to obtain a pulp of a quality which would allow maximum replacement

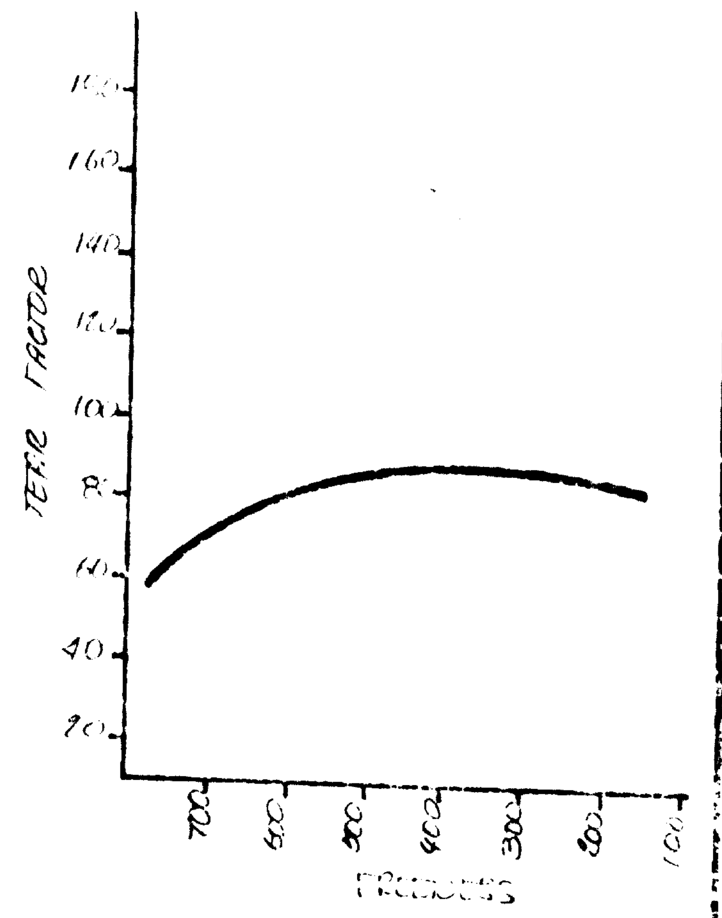
PRESENT PROCESS KRAFT CHEMICAL PULP

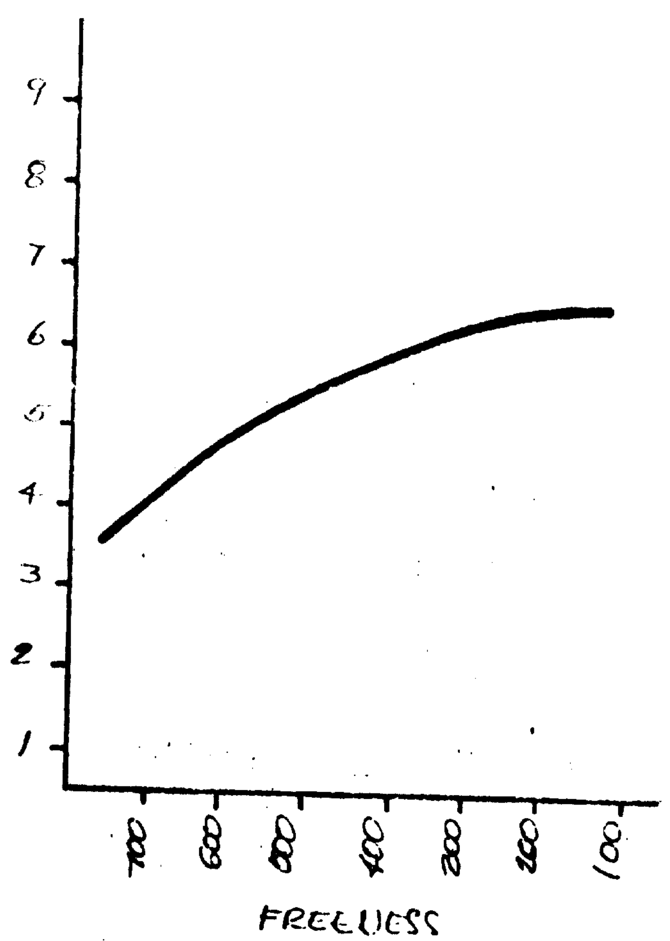


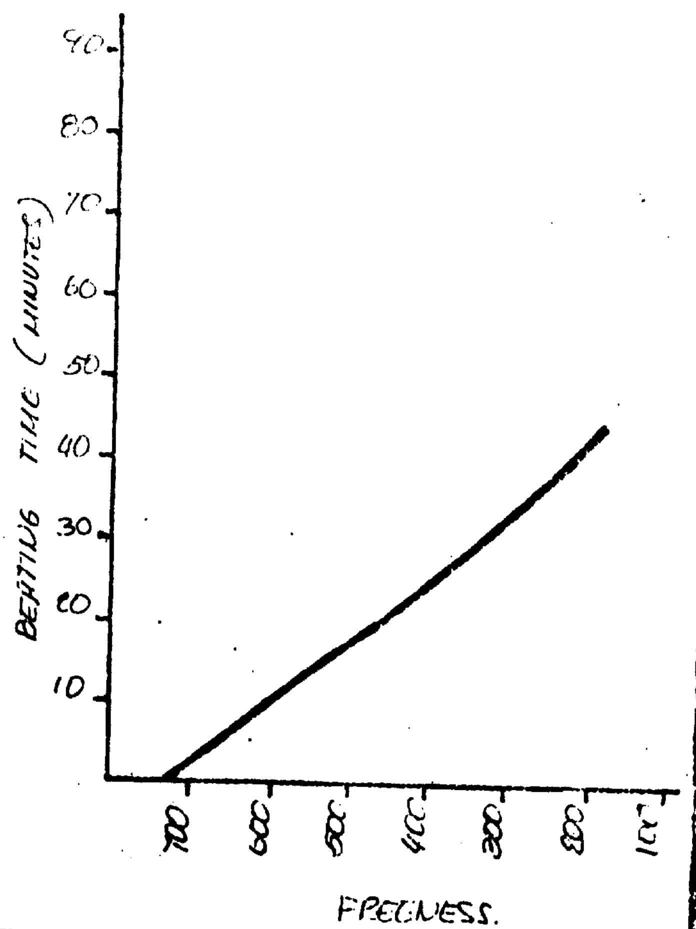
PULPAPEL – HIGH YIELD KRAFT PULP

GROUP No. 5









of long fibre pulps in our paper and board production. Research led to changes in the maximum temperatures, cooking, time, cooking liquor concentrations, liquor to wood ratio and steam injection rates. This process permitted total usage of black liquor, for the completion of the of the liquor/dry wood ratio.

2. Pulp Characteristics

$KMnO_4$ Number	16	21
Rejects (0.022" slot)	$<$0.5%	$<$3.0%
Yield (B.D. pulp/B.D. wood)	46%	52%
Consistency after cooking	15%	13%

See Graph No. 6.

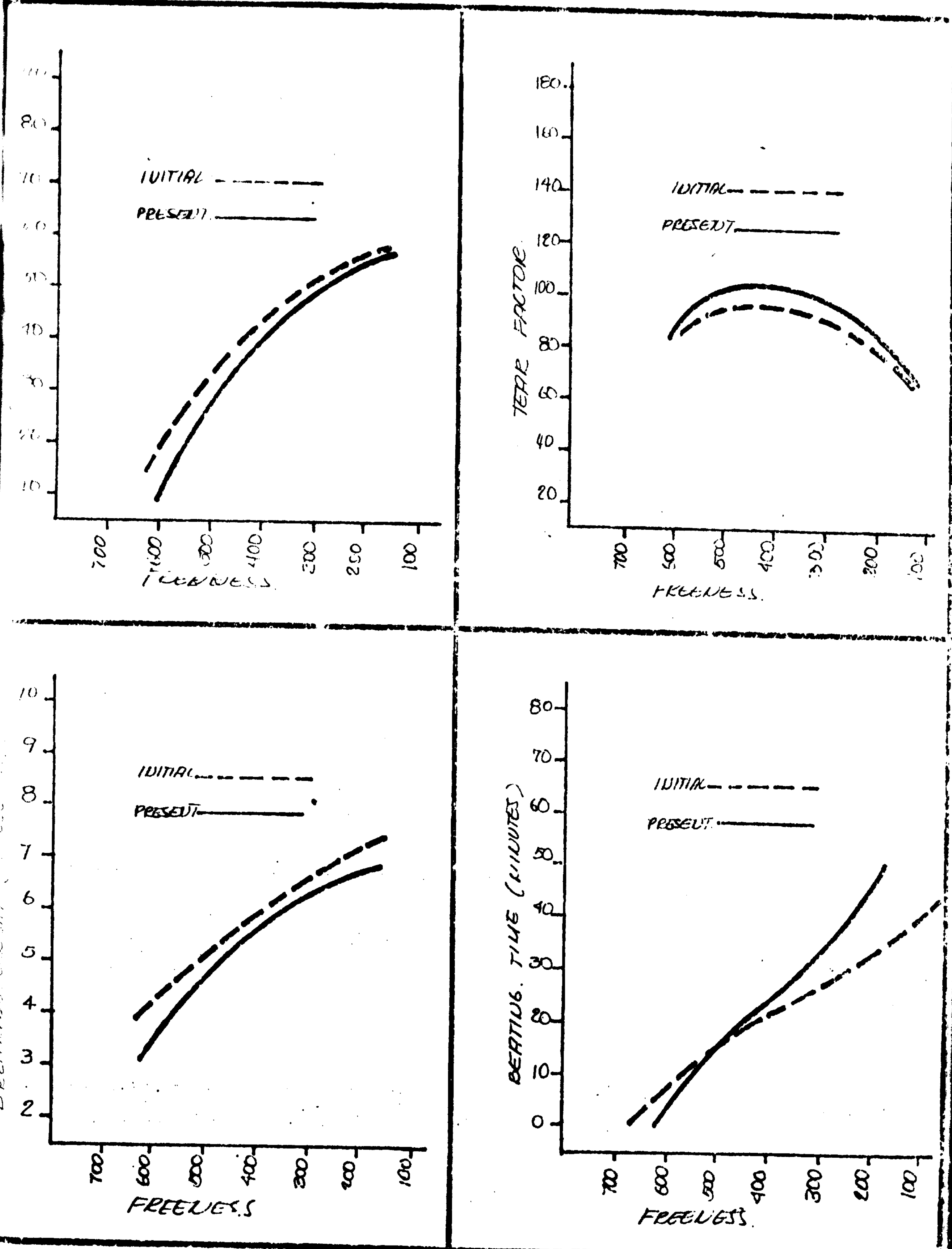
3. Equipment

The cooking equipment consists of vertical, stationary, cylindrical, $50M^3$ capacity digesters, with direct steam injection, and manual operation of the non-condensable gas relieving system. The chip loading of the digesters is controlled by means of a weightometer, and the white and black liquor supply is regulated by flow meters.

The laboratory controls the moisture content of the chips, as well as the composition of white and black liquors.

PULPAPEL LOW YIELD PULP KRAFT

GRAPH No 6



4. Pulp Refining, Washing and Storing

After the cooking process, the pulp goes to a $232M^3$ capacity Blow Tank flowing through an IMPCO 3-25 Solvo fibrilizer, to a 36-2 gravity Sprout Waldron Refiner, powered by a 600 HP, 900 RPM motor, at 7% consistency, 60°C temperature and 600cc freeness (CSF).

It is then circulated through an IMPCO A-25C Vaccum Screen to two counter-flow Wartsila Washers (3 meter diameter by 5 meter) discharging at 16% consistency into high density storage chests. With the installation of a third washing unit at the end of 1971, we expect to increase pulp washing capacity and obtain better pulp washing.

The IMPCO Screen rejects are returned to the Blow Tank. The dilution through the different stages of the process is done by the addition of black liquor.

Several equipment changes and modifications took place between the original pulping set up and the one existing today.

Pulp presses and Bauer cleaners originally installed were replaced with vacuum pulp washers and vacuum screen. Pulp drainers or thickeners originally used for double stage refining were kept to thickening pulp before the refiners to consistencies up to 6-8% to obtain a better pulp refining with better fiber strength development. These major equipment changes occurred on account of the recovery boiler installation, 5 years after the pulp plant commenced operations.

5. Pulp Uses

The fundamental and basic reason for the existence of our pulp plant was to reduce pulp being imported into the country. This, along with the development and utilization of the country's natural resources also contributed to supplement the waste paper market to furnish to the paper mill with the necessary raw fibreous materials to fully satisfy production requirements. Thus, the modified kraft pulp permitted us to replace imported Kraft pulp in the fabrication of paper for sacks and in Kraft Liners. Reasonable consumption figures were attained in the paper machines after some time in learning how to handle and develop the best use out of the domestically produced pulp. Limiting factors at this time were low tear and breaking length and of course, its rather dark appearance.

The unbleached kraft pulp presently produced allows us to manufacture kraft liners, special liners and extensible paper replacing imported long fiber pulp in the normal furnish. For the manufacturing of multiwall sack extensible paper and light weight papers, a significant replacement of long fiber has been obtained. Full replacement is still limited by the strength factors of the short-fiber which are inherent to it (approximately 20-25% under those generally obtained from softwoods and even hardwoods fibers from northern zones developed by the standard kraft pulping process).

Through the years, it has been necessary to develop and train good operators to process the short-fiber pulp towards its maximum usage. At the same time it has been necessary to condition the existing equipment for proper pulp treatment. Also, extensive investigation has been required to arrive at the present paper machine refining conditions.

E. SEMIBLEACHED PULP

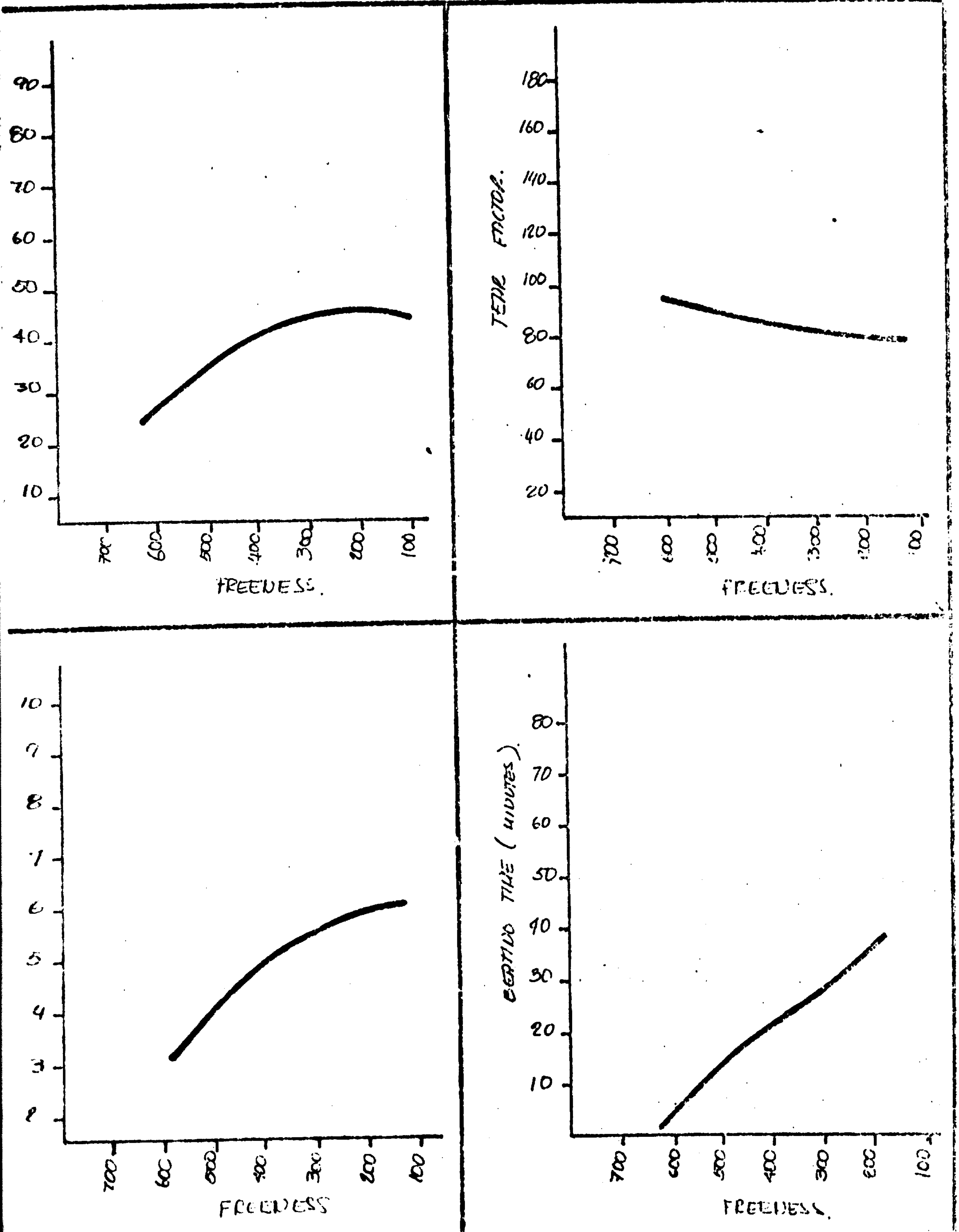
In order to achieve a higher utilization of short fibres in the different processes and products manufactured by Cartón de Colombia, additional research work was performed at the Pulpapel Laboratory to determine the feasability of producing semibleached pulp from tropical hardwoods. This type of pulp permitted a partial replacement of imported groundwood pulps necessary for the production of the different kinds of white grade boards.

The process utilizes the same equipment mentioned for the production of high and low yield kraft pulps. However, the wood is cooked to a lower permanganate number and the pulp is circulated through a bleaching tower and a Kamyr washer.

The pulp is pumped to the Kamyr bleaching tower at 4.7% consistency, where calcium hypochlorite is added, controlled by a flow regulator for a 90 minute period.

PULPAPEL SEMI-BLEACHED PULP

GRAPH Nº 7



This pulp is then recirculated in the bleaching tower, after which it is washed to remove the residual chlorine.

During the semibleaching process, the pH of the pulp ranges from 8 to 9, and its final brightness is 60 P.V. units. The total strength factor reduction is approximately 10%.

F. BLEACHED KRAFT PULP

1. Process

The chemical products used for the cooking of this type of pulp are approximately the same as those employed in the manufacture of "Low Yield Kraft Pulp". Cooking cycle is slightly longer and wood is then cooked to a lower permanganate number.

2. Pulp Characteristics

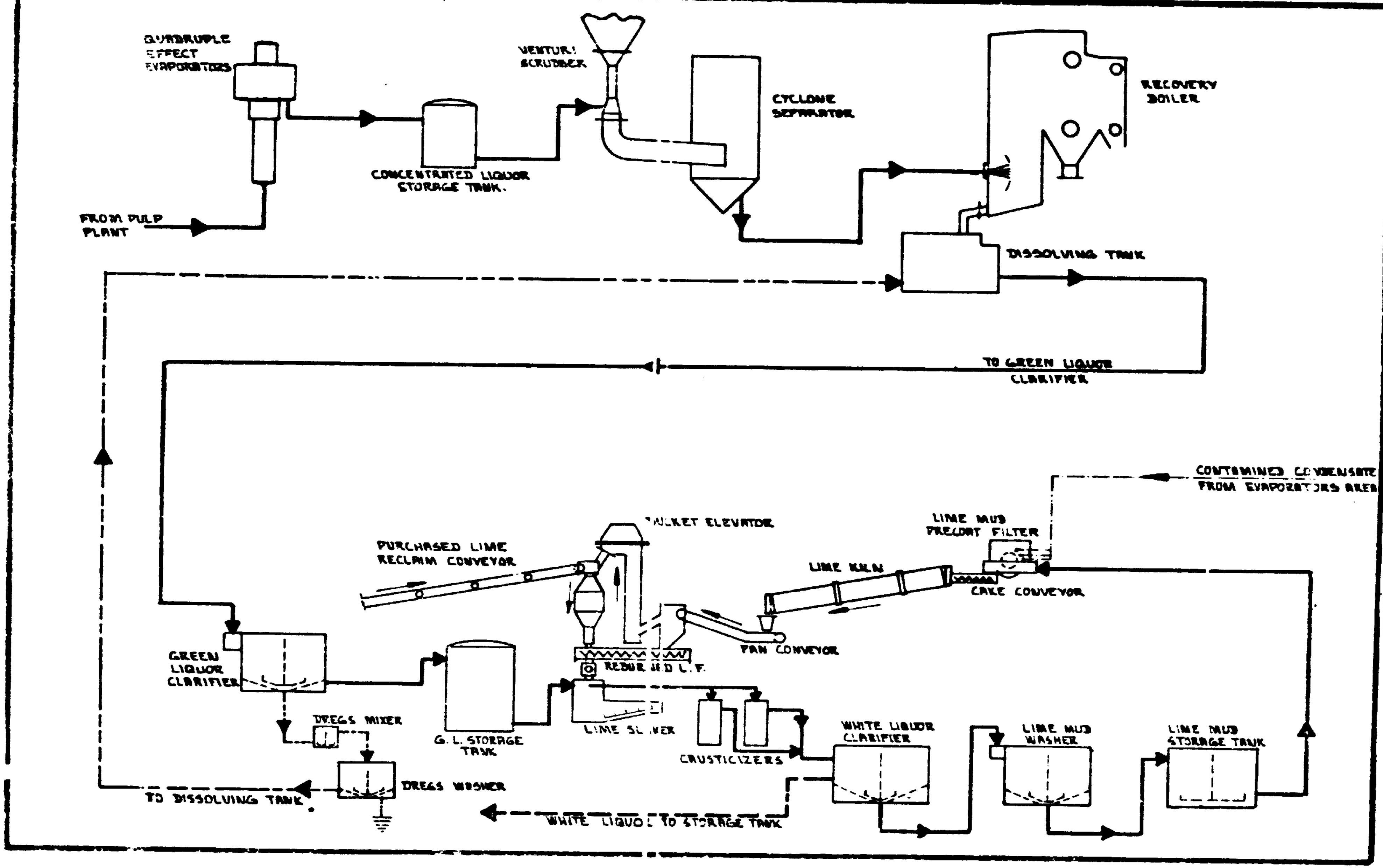
$KMnO_4$ Number	13
Rejects (0.022" slot)	$< 0.5\%$
Yield (B.D. pulp/B.D. wood)	46%
Consistency after cooking	10%

The refining and washing stages are carried out in the same equipment mentioned before. The pulp is then stored in a high density chest for bleachable pulp at 16% consistency and 600cc freeness (CSF).

G. BLACK LIQUOR RECOVERY EQUIPMENT

A four effect Swenson evaporation system, a Ventury-Cyclon, a B&W Recovery Boiler with a capacity of 390.000 lbs. of solids per day, and a Dorr Oliver Causticizing System completes the chemical recovery plant. A Lime Kiln is presently being installed which will permit closing the system when it enters into operation by the middle of 1971.

CHEMICAL RECOVERY PROCESS



1. White Liquor Characteristics

Na_2O Compounds	Grams/litre as Na_2O
NaOH	58.9
Na_2CO_3	10.5
Na_2S	19.8
Na_2SO_4	2.2
Total	91.4
Sulphidity	25%
Activity	88%
Causticity	84.5%

2. Black Liquor Composition

Total soluble solids	15%
Water	85%
Residual active Alkali	6.2% (Na_2O)
Specific gravity at 70°F	1.09

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