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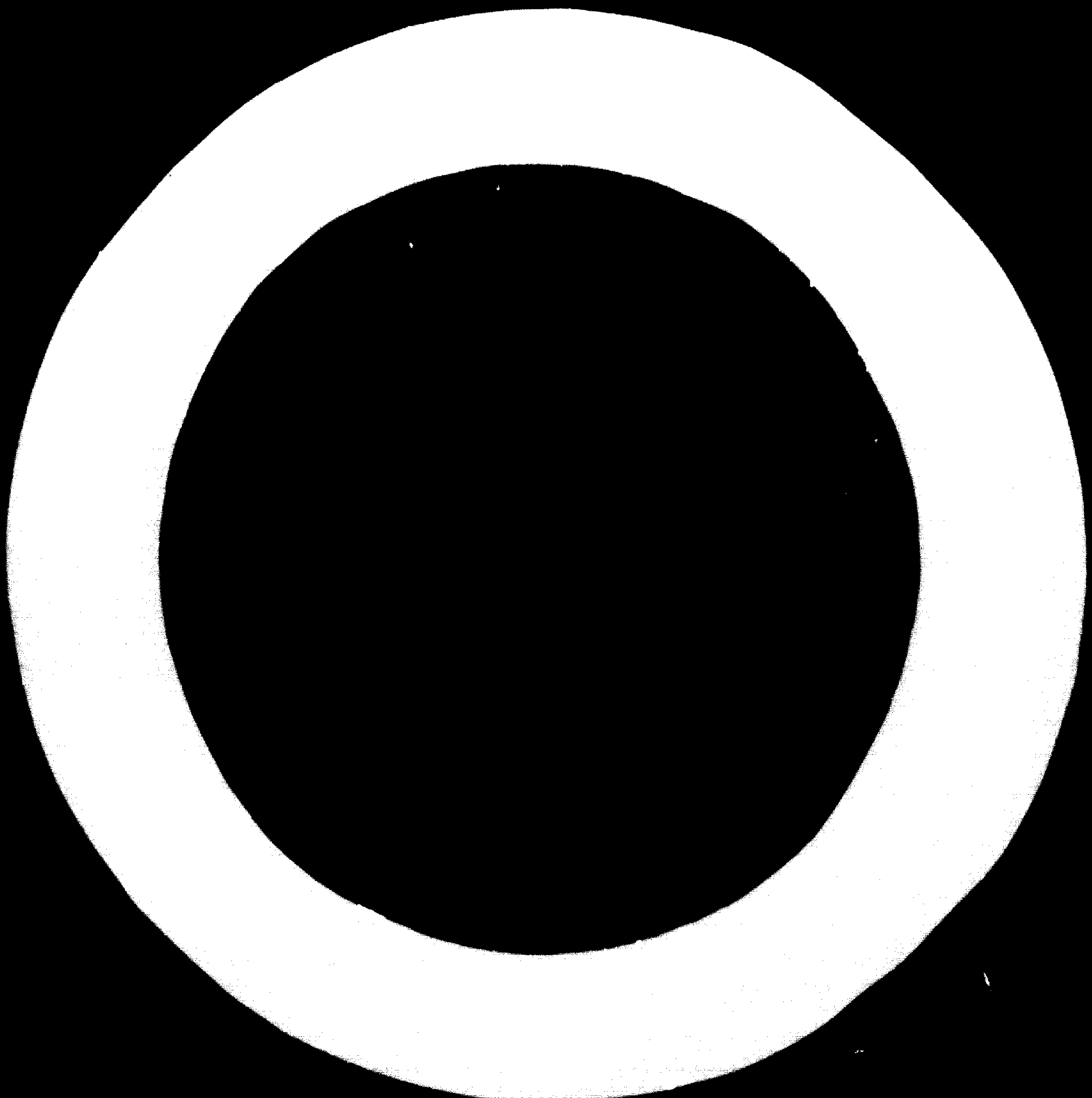
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PULP AND PAPER IN DEVELOPING COUNTRIES

Report of an Expert Group Meeting

Vienna

13 - 17 September 1971



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EXPLANATORY NOTES

Reference to "dollars" ($) indicates United States dollars.

Reference to "tons" indicates metric tons.

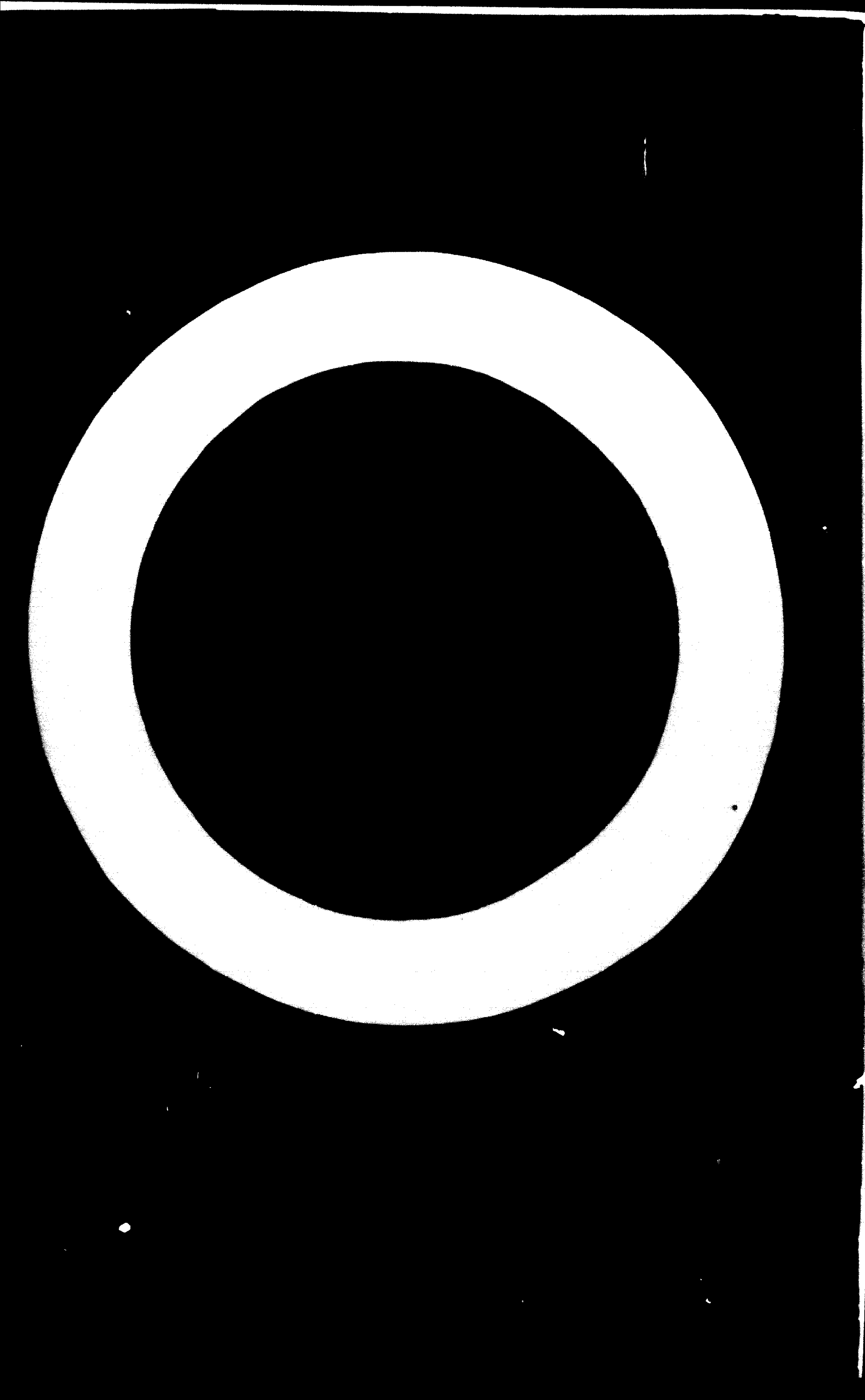
The following abbreviations have been used in this document:

M.G.	machine glazed
NSSC	neutral sulphite semi-chemical

INTRODUCTION

The Expert Group Meeting on Pulp and Paper in Developing Countries was held at Vienna from 13 to 17 September 1971. It was organized by the United Nations Industrial Development Organization (UNIDO).

The purpose of the Meeting was to focus attention on (a) the production of pulp and paper from indigenous fibres that were not commonly used owing to the lack of practical experience; and (b) methods for raising the efficiency of existing pulp- and paper-mills that often were the most effective steps to increase their output. The Meeting was also to study ways and means of helping developing countries with their pulp and paper production and to make relevant recommendations.



I. ORGANIZATION OF THE MEETING

The Meeting was attended by 25 experts from 13 countries, 20 observers from 11 countries, and representatives of the secretariats of the Economic Commission for Africa (ECA), UNIDO, and the Food and Agriculture Organization of the United Nations (FAO).

K. J. Bioernstad (UNIDO) was Director of the Meeting. The following persons served as members of the Expert Group:

Julius Grant (United Kingdom of Great Britain and Northern Ireland), Chairman

Joseph Atchison (United States of America), Vice-Chairman

Youssef A. Fouad (United Arab Republic),[1] Vice-Chairman

W. R. Jolley (United Kingdom of Great Britain and Northern Ireland), Vice-Chairman

Vishnu Prasad Poddar (India), Vice-Chairman

Donald L. Stacey (New Zealand), Vice-Chairman

Thamdoe Jeyasingam (Ceylon),[2] Rapporteur

Christopher Bray Tabb (United Kingdom of Great Britain and Northern Ireland), Rapporteur

A. Binder (Federal Republic of Germany)

Pablo R. Cardenas (Colombia)

P. Chaudhuri (Sweden)

Dante Cusi (Mexico)

Owen T. Dalley (Canada)

Foster P. Doane Jr. (United States of America)

Yehia Abdel-Latif Fahmy (United Arab Republic)[2]

S. R. D. Guha (India)

Roehjati Joedodibroto (Indonesia)

Tsutomu Kayama (Japan)

Bernhard K. Mayer (United States of America)

Edward J. Villavicencio (United States of America)

E. Norman Westerberg (Finland)

Zarl Zappert (United Kingdom of Great Britain and Northern Ireland)

1/ Now designated Egypt.

2/ Now designated Sri Lanka.

Papers were presented on the following subjects: newsprint from bagasse, paper and pulp production from rubberwood and mixed tropical hardwoods, low-cost pulp- and paper-mills, maintenance, efficiency, the manufacture of pulp from exotic raw materials, and the use of waste paper in pulp- and paper-mills. The papers were the basis for the Group's discussions.

The Group visited a paper-mill in Ortmann, Austria.

II. SUMMARY OF THE DISCUSSION

Newsprint from bagasse

Although many kinds of paper had been made from bagasse, the manufacture of newsprint from it had not yet been successful.

Only two bagasse newsprint projects had been attempted even though several countries with cane-sugar industries would enjoy large savings in foreign exchange for imported newsprint if bagasse were used in the manufacture of newsprint. It was stated that possible reasons for the lack of development included:

(a) Doubts as to whether a method of production which is both technically and economically sound has been developed;

(b) The output of a newsprint machine of viable size could exceed the domestic demand for newsprint, and the export of surplus production could have seemed unlikely;

(c) The estimated cost of producing newsprint from bagasse could exceed the cost of imported newsprint, especially when dumping had occurred;

(d) Sugar-mills could be too dispersed for a sufficient quantity of bagasse to be collected economically at one centre;

(e) Sugar-mills could be unwilling to sacrifice a reliable supply of fuel for their necessary steam power for an alternative fuel over which they would have no control of the supply;

(f) The price of the alternative fuel could be inflated by excise duties;

(g) The import of petroleum as fuel for sugar-mills could require scarce foreign exchange and thus decrease the appeal of bagasse as a raw material;

(h) There could have been anxiety about competition from wood.

The Group was informed of recent technical and economic developments. Some processes were reviewed and compared although it was felt that such comparisons were of limited value for the following reasons: data were incomplete or were not stated in basic units that could be costed out with different local unit prices; pulp was tested under different conditions; trials were made on different samples of bagasse (some fresh and some stored); the speeds of paper machines were not always stated. It was suggested that the advice of United Nations experts or independent consultants should be sought to permit a valid comparison and a determination of the feasibility of different methods.

Reference was made to investigations in the mid-1960s for the purpose of selecting the most appropriate process for conditions in the United Arab Republic. Tenders for a 100,000-ton per year bagasse newsprint and magazine paper-mill and a 50,000-ton per year bagasse chemical pulp-mill were compared, and the cost of production of bagasse newsprint by different processes was estimated. With the best process, the cost was about 7 per cent more than the cost of imported newsprint.

Most of the experts were opposed to raising the minimum level of properties for newsprint agreed upon at the Conference on Pulp and Paper Development in Africa and the Near East, held at Cairo in 1965. The acceptable level varied from country to country. It was agreed that in general the levels had increased since 1965 and brightness greater than 58° G.E. and opacity greater than 88 per cent were often now required. The minimal levels recommended in 1965 were brightness 50° G.E., opacity 86 per cent, tear 24 g cross machine direction.

For the kind of pulp required for newsprint, the colour of the bagasse at the time of pulping was of particular importance; the method and conditions of bagasse storage were therefore critically important. When evaluating data for different processes, it must be known whether fresh or stored bagasse was used.

Three procedures for making mechanical bagasse pulp were reviewed:

(a) Refiner ground pulp from depithed bagasse. The pulp was thought to have high opacity (95 per cent) but lower strength than mechanical pulp from wood;

(b) Refiner ground pulp from whole bagasse. After a preliminary refining stage, the pulp was fractionated into 2/3 fines, which was used as mechanical pulp, and 1/3 tough fibre, which was converted into chemical pulp;

(c) Hot refined pulp after steaming depithed bagasse for a maximum of 4 minutes to 130°C.

Bleaching could be required after all the processes unless fresh or well-preserved bagasse was used.

The main alternative was chemi-mechanical or high-yield, semi-chemical bagasse pulp. Depithed bagasse received a mild cook before refining. Subsequent bleaching was usually required. The pulp was expected to retain more unbroken fibres than straight mechanical pulp and was stronger so that a smaller quantity of long-fibred chemical pulp was required to reinforce the sheet. It was indicated that newsprint with sufficient dry strength could be made with little or no long-fibred chemical pulp. Very high-speed paper machines could be unsuitable for circumstances in some developing countries where lower speeds could be more practical. The necessary wet strength could then be lower and less chemical wood-pulp required. The use of chemicals for cooking and bleaching tended to impair opacity and ink absorbency. Mineral loadings had been used to counteract the undesirable effects of the chemicals. It was reported that 5-7 per cent of the mineral loadings was retained in the paper.

As the type and intensity of chemical treatment influenced properties and economies, the most recent developments in bagasse newsprint had been in the chemical treatment. Promising results were reported from a novel process under development in which the depithed bagasse was first subjected to water pre-hydrolysis at pH 4.5 for about 7 minutes at 175°C with losses of about 5 per cent. The unwashed pulp was then mildly treated with about 2 per cent of sodium sulphite and 1 per cent of sodium silicate on the depithed raw material at about pH 8 for about 10 minutes with the temperature constant at 175°C. The pulp was refined hot at 146°C and had a high consistency at the discharge of the digester. A brightness of 55° G.E. (maximum 58° G.E.) was reported without further bleaching when using fresh bagasse. A yield of approximately 85 per cent on depithed bagasse was reported, and losses in depithing calculated on the original bagasse were 30 per cent of pith and fines and 7 per cent of sugar, sand and other matter.

Another reported development was the determination of optimum conditions for cooking and refining. In the process, depithed bagasse was mildly cooked and then fractionated into a part, which was already sufficiently resolved by the cooking and part which required mechanical refining, preferably under pressure, to resolve it into fibres. Thus, account was taken of the relative toughness of the rind of sugar-cane compared with the flesh.

The process began with good but not excessive depithing in moist and wet state, with a loss of about 30 per cent on raw bagasse. The depithed bagasse was pre-impregnated with 7-[illegible] per cent of caustic soda and cooked in a [illegible] continuous rapid digester. The yield of digested pulp was about [illegible] per cent on depithed bagasse. Fractionation was effected by coarse screening, the coarse fraction exceeding 50 per cent. It was reported that the disc mill used to refine the fraction required normal maintenance. The refined and unrefined fractions were combined for washing, cleaning and bleaching to the required brightness with hypochlorite. In a trial at 6[illegible] G.E. the over-all calculated yield of bleached pulp from whole bagasse was about 46 per cent, and 65 per cent from depithed bagasse.

A furnish of 95 per cent of the pulp with 5 per cent of semi-bleached kraft softwood pulp with up to 6-7 per cent of retained clay was said to have given acceptable results. The inclusion of mechanical wood-pulp in the paper furnish was not considered justified by the results.

A predicted development was the production of fines that could improve the printing properties of the paper by heavily refining the rejects from the fine screening and vortex cleaners. Extensive trials on commercial newsprint machines were reported, including running at high speed on an experimental, twin-wire machine. The recovery of chemicals from the semi-chemical process was a predicted development.

Semi-chemical and chemi-mechanical pulp would cost more than mechanical pulp because of the lower yield, the cost of chemicals and extra capital cost. The disadvantages could be offset by savings in the required quantities of long-fibred chemical pulp, which would often be imported, and of the power for refining.

Although a bagasse newsprint project requires a large capital investment, it was considered vital to convince financing houses and Governments that excessively high risks would not be involved. This could be demonstrated by the operation of one or more pilot plants for a lengthy period with industrial-size machines. Alternative processes could be used and evaluated. The demonstration pulping-plants should be monitored by objective observers and be associated with a commercial paper-mill with a full-scale paper production. Pulp from the pilot pulp-plant could be stored to allow extended paper-machine runs. The representative of FAO indicated the interest of FAO in a demonstration plant. One expert suggested that the demonstration plant would help the makers of machinery to adapt their machines to the production of bagasse pulp. Several developing countries could collaborate in furthering the pilot-plant project, and companies interested in developing processes could pool their efforts.

Objections raised in the discussion included the difficulty of demonstrating chemical recovery on the pilot scale, the unrepresentative fines content of wet lap and the impracticability of depriving a plant of a paper machine for a lengthy period. Some participants objected to the expenditure of United Nations funds for the proposed demonstration plant. They doubted that objective conclusions would result from it and believed that it could hinder rather than help the development of a process for making newsprint from bagasse by deterring some companies, which had already invested heavily in the development, from further expenditure.

Some participants commented that Governments could help the development by imposing a tariff on newsprint imports, although tariffs on newsprint were unusual. A quota system which would prohibit imports when local production became sufficient could be preferable, but not if, at the same time, domestic prices were pegged at an unremuneratively low level.

Practical experience in the use of rubberwood for the production of pulp and paper

The Group appreciated the great value of the two papers on the use of rubberwood for pulp and paper, which presented much practical and scientific knowledge which had hitherto been inaccessible. Rubberwood was defined as originating from the species *Hevea brasiliensis*. Trees were usually felled and replaced when their yield of latex declined at an age of 25 or 30 years.

An attempt to make groundwood pulp from rubberwood in a mill-scale trial was unsuccessful. Rubberwood has not yet found acceptance as a major wood resource in newsprint manufacture.

Rubberwood is pulped commercially only in Japan and on a pilot-plant, experimental scale in Indonesia. An attempt to use rubberwood for paper in India was unsuccessful.

The Group noted that although annually hundreds of thousands of tons of rubberwood were successfully converted to chemical pulps for both paper and rayon, it had not yet proved possible to eliminate latex from the pulps. Therefore, it was not practical currently to incorporate more than 20 or 30 per cent of rubberwood pulp in paper or more than 20 per cent in dissolving pulp.

The chemical and morphological characteristics of rubberwood are generally typical of medium-density hardwoods. It is pulped conventionally by both the sulphate and the sulphite processes. The pulp is used in those papers for which chemical hardwood pulps are ordinarily used, such as writing, printing and duplicating papers, coating base papers and as a corrugating medium.

Relatively little information was presented concerning the physical characteristics of rubberwood pulp except from experimental work. The research suggested that the tearing strength would be above average for a hardwood, and the burst and tensile strengths well below the best strengths expected for hardwoods. The fibres were reported as fairly long for a hardwood (about 1.3 mm and sometimes longer) and of moderate width. The walls of the fibres were sufficiently thin that they would probably collapse when dried. Older rubberwood, say 50 years old, could give stronger pulp than 25- to 30-year old wood.

The total volume of standing rubber trees and the average rate at which they are replaced are poor guides to the quantity of rubberwood available for a pulp-mill or for the export of rubberwood as logs or chips. In calculating the availability, account must be taken of other factors such as:

(a) The type of land tenure, whether plantation or small holding. While collection from an area comprising a single or a few large plantations can be viable, collection from an area formed by numerous small holders might not be. In Malaysia and Indonesia, which are by far the largest rubber-producing countries, the proportions of the total areas devoted to rubber formed by small holdings are 55 and 73 per cent, respectively;

(b) Irregular availability. Although the average useful life of trees as producers of latex is 25 to 33 years, their replacement could be sporadic;

(c) New strains propagated by clonal grafting tend to produce more rubber from smaller trees down to 0.5 m-0.7 m diameter;

(d) Competitive uses. Rubberwood provides the domestic fuel required for drying and treating latex. Account must also be taken of the possible industrial uses of the wood or charcoal from it, such as for the manufacture of steel, which in Malaysia consumes more wood than is exported for pulping;

(e) It is uneconomical to use all the available rubberwood because twisted and small-diameter wood must be discarded.

The following advantages of rubber plantations as a source of pulp-wood were stated:

(a) The wood is a by-product of which there is normally a surplus;

(b) Plantations produce a uniform variety of wood with a rather uniform density (as compared with heterogeneous mixed tropical hardwoods);

(c) Plantations usually have a system of communications, housing and labour already available for extraction of the wood (which is often not the case when pulp-wood is extracted from virgin forests or when pulp-wood plantations are newly established).

The following disadvantages are connected with rubber plantations as a source of pulp-wood:

(a) Because the wood of the rubber tree is worth only a fraction of 1 per cent of the rubber it has produced, the plantation owner may not be interested in it unless he seeks a fractional increase in the profits;

(b) A plantation is not a secure source of pulp-wood. It could unexpectedly change to other crops;

(c) The branches of trees used for rubber production are permitted to grow only 3 or 4 m from the ground. The handling of these trees for pulp-wood is inconvenient;

(d) The impossibility of constructing heavy-duty roads could restrict the use of any heavy transport or mobile logging equipment, especially during the monsoon season. The inadequate roads and the labour-intensive handling of the trees could make logging a costly operation;

(e) Some rubberwood could be too remote from roads to be used in the production of pulp.

The group noted that the problem of latex in the pulp, which seriously restricts its application, has not been solved. There had been some success in reducing the latex content before the wood was pulped and also during pulping.

Although most of the latex is in the bark, some is found in the wood, even when there has been no damage by tapping operations, and even when wood immediately under the bark is removed. Under the tapping panels, hardened latex is often found embedded in the wood; that wood could be darkened and hard; it could also contain knots. It is rejected for the manufacture of dissolving pulp. The amount of later in rubberwood chips varied considerably, but an indicative figure of 0.3 per cent was suggested.

For paper-pulp, the bark is usually removed by hand immediately after felling the trees, when the bark separates most easily. The latex is fluid and some of it contaminates the wood. If the bark is left for some months, the latex hardens so that a smaller quantity would contaminate the wood during subsequent removal.

The amount of latex in the tree when felled can be minimized by so-called "murder tapping", in which the tree is virtually tapped to extinction during the six months before felling. Chemicals are being developed which could help to remove bark before felling.

In both the sulphate and soda pulping processes, latex remains emulsified while conditions remain strongly alkaline, but it tends to coagulate in the turbulent conditions during screening. Further coagulation could occur during bleaching. Advantage could be taken of the coagulation to separate latex and the rejects from screening operations. They could also be separated by fractionation or floatation. Agglomerations are not as sticky and are easier to screen out if the cooking liquor contained sulphur, which appears to have a vulcanizing effect.

Alum tends to aggravate coagulation of residual latex on the paper machine. The effects of latex in the pulp include:

(a) Blinding of pulp-mill screens and deposits in the system;
(b) Fouling of wires and felts on the paper machine;
(c) Fouling of drying cylinders and calender rolls.

These may lead to imperfections in the paper and loss of production by having to shut down and clean over frequently.

Rubberwood is particularly susceptible to fungal attack. Blue-stain fungus advances very rapidly and is followed by other fungi. Fungal attack reduces yield, increases the chemical demand in bleaching, though blue staining alone, which does not affect the cellulose itself, is objectionable mainly because of its effect on colour. Where it is found possible to use rubberwood directly for mechanical pulp, blue staining and other fungal attack could be an obstacle.

The blue-stain fungus requires moisture and oxygen. Although the storage of rubberwood logs under water deprives blue-stain fungus of oxygen and minimizes its spread, such a storage method is not used industrially. Rubber-wood pulping is almost exclusively confined to Japan where wood imported from Malaysia is used. The practice is generally either to debark the wood in the plantation immediately after felling, to chip the wood and to ship and use the chips as quickly as possible, or to transport the logs by lorry to the ship and use the wood as soon as possible after felling, preferably within three months.

Low-cost pulp- and paper-mills for developing countries

The Group shared the view that the capital cost of building a pulp- or paper-mill was higher in a developing country than for an identical mill in an industrialized country. The operating cost was also usually higher.

Some of the factors contributing to the high costs were: high transport costs, the use of foreign personnel, customs duties, and undue delays in completing projects. It was estimated that these costs could be as much as 50-100 per cent higher than for similar mills in Europe or North America.

Several participants expressed the view that some kind of protection was usually required to create conditions in which a new paper industry in a developing country could operate economically. More than nominal protection could, however, lead to the establishment of non-competitive industries which could harm the long-term economic growth of the country.

There was considerable discussion on the turn-key approach to new mill construction. A wide divergence of opinion was expressed regarding the advantages and disadvantages of the approach. A conclusion was drawn that different conditions would require different approaches.

It was stressed that for developing countries, wherever possible, the mills should be integrated pulp- and paper-mills to help make the projects viable.

The use of a small machine in a developing country was generally favoured as its output was suitable for the local market conditions. Furthermore, its operation was relatively simple and personnel could be trained on it. Giant paper machines were important in industrialized countries because labour was saved. Smaller machines that were still in good condition could become rebuilt. These machines could be useful in developing countries because a paper machine, if kept up to date by modifications, had a life of 50 or more years.

The services of consultants could be engaged for projects in which second-hand equipment would be used. Their responsibilities would include:

Ensuring the suitability of the equipment

Establishing the cost of other necessary equipment, the cost of dismantling, renovation, packing and shipment of the equipment and the cost of layout preparation

Determining the required quantities of steam, water and power

Preparing a total cost on an appropriate basis for comparison with new machinery

Supervising erection and start-up

The following design features for a low-cost pulp-mill were suggested by an expert:

(a) The use of simpler and more conventional equipment such as batch digesters with direct heating required low investment costs and were simpler to operate. Careful attention must be paid to improving their steam economy. Continuous digesters were, however, recommended for agricultural residues because of the low packing density in batch digesters;

(b) The use of the ammonium-based neutral sulphite semi-chemical (NSSC) process could be considered when the concentrated effluent could be sold profitably as a fertilizer. Such a process would be of value to developing countries which were largely agricultural;

(c) In developing countries where a very brightly bleached pulp was not essential, a simplified bleaching system in the following sequence was recommended: Chlorination - alkaline extraction - hypochlorite. In tropical climates, chlorination should take place in a short retention up-flow tower followed by down-flow tower. All the following stages should take place in down-flow towers. All filters should be installed at a high level for achieving gravity flow to the towers. Considerable savings could result from a batch system of bleaching. The recommended material for construction of the bleaching tower was rubber-lined carbon steel or tile-lined concrete. All major piping should be polyvinyl chloride or fibreglass;

(d) For the recovery section, the newly developed pyrolysis reactor could be considered for the NSSC, soda and sulphate processes. In the ammonium-based neutral sulphite process, the waste was converted to a marketable product by evaporating and drying.

Other participants advised the use of conventional, well-tried processes in developing countries.

The following design features for a low-cost paper-mill were proposed by some of the experts:

The knock-down type of Fourdrinier section

The use of table rolls

A manual lubrication system

A versatile type of paper machine

Minimum instrumentation to meet running requirements

The use of a roll grinder to grind roll journals so that costly lathes are unnecessary

A high degree of interchangeability of felts, felt rolls and press rolls

The standardization of equipment such as motors, pumps and agitators

The use of large chests between systems to carry out maintenance and repairs to certain units without completely stopping the entire plant

It was suggested that judicious thought should be given to securing used machinery. Although it was pointed out that substantial savings in capital investments could result, some experts felt that there were many risks connected with the purchase of used equipment.

In a subcontracting agreement, the following costs could be added to the basic cost of a machine before it was exported:

(a) The subcontractor's handling charge (and possibly commission if he was an agent for the manufacturer) for equipment he purchased and an engineering fee for assembling a subsection for sale to the main contractor that was based on the total cost of the subsection;

(b) The main contractor's handling charge (and possibly commission if he was an agent for the subcontractor) and an engineering fee for designing the whole plant that was based on its total cost;

(c) Contingency allowance and allowance for possible price increases;

(d) Financing charges;

(e) The premium for export credit guarantee;

(f) A margin if the guarantee does not give full cover;

(g) An allowance for claims if penalties for late delivery or performance were expected;

(h) The local agent's commission.

The need for an intensive personnel training programme was stressed in projects which were developed by groups without previous experience in the pulp and paper industry. Some experts stated that whereas training had been carried out mostly in European and North American mills, it was preferable for it to take place in countries where the environment and conditions were as similar as possible to those prevailing in the home country.

Systematic repair and maintenance in the pulp and paper industries of developing countries

The Group generally accepted the view that it was desirable to adopt a systematic approach to repair and maintenance in developing countries. It was agreed that the work load should be identified, evaluated, planned and executed at scheduled times. Many participants emphasized the need for technical training for both the maintenance and the operating staff. The view was expressed that some of the operating staff should possess mechanical and electrical skills. It was suggested that mills should operate permanent training programmes to improve the mechanical and electrical maintenance capability of the staff.

Several experts stressed the need for simple design of equipment because of limited foreign exchange for the import of spare parts. Moreover, there was a lack of the necessary technically skilled personnel to maintain highly complicated machinery.

It was suggested that planned maintenance should not be taken to extreme limits by dismantling items which were working satisfactorily and for which there was no reason to suppose any particular repair was necessary, but that as far as possible faults should be diagnosed by sound, vibration, temperature and leakage. It was stressed that the status of the maintenance staff should be upheld in various ways, including financial incentives.

Different views were expressed about the arrangements for planned long shut-down periods. Most participants preferred to shut down one department at a time to keep the mill in operation as long as possible.

Improving the efficiency of pulp- and paper-mills in developing countries

Efficiency should be fostered during the initial planning stage, in which the concept of the mill was crystallized regarding the site, process, product and capacity. The importance of neutral, competent consultants was stressed.

The training of personnel, both before start-up and on a continuing basis, was considered a vital factor in efficiency. The advantages and disadvantages of different types of training programmes were discussed.

Training in modern mills in industrialized countries was criticized because conditions were too different from those in developing countries, and sometimes because of language problems. Trainees could return untrained and dissatisfied. Such modern mills often manufacture a narrow range of papers, whereas a mill in a developing country was usually compelled to make many different papers.

Much was to be said for training in a mill pulping a similar raw material, especially when the raw material was a non-wood. Often this could mean training in a mill in another developing country, where circumstances could be similar; it could make a wide range of papers, or its mechanics could be accustomed to making spare parts locally instead of purchasing them. A common language was an advantage. If the mill was an efficient one, training could prove effective.

On-site training could be effective when the expatriates could speak the local language and respected the different culture and experience of the staff they were training. The expatriates must work together as a team. The participation in the whole project of an experienced paper-making group may be sought; it would be in its interest to send an efficient team for the start up and commissioning of the plant.

The cost of training before the start up of the mill was considerable and should be included in the budget. A delay in reaching satisfactory operation, which could result from inadequate training, was likely to be more costly.

When the mill was in operation, improved efficiency was most likely to be brought about by a change in the performance of the personnel. Training should, therefore, be continuous. The aptitude and performance of workers should be assessed at intervals; they could be assigned new tasks for which they were better suited, but for which retraining was likely to be required.

Continuous training also helped to sustain interest and invoked a sense of "production mindedness". The willingness to learn could be increased if the trainees participated in deciding what training was needed and in formulating the course. Such on-the-job training involved minimum interference with productivity.

Training was likely to require a training director and a staff of specialists. Management should encourage training programmes, preferably by participating in them. Management consultants could assess the performance of the mill's management at suitable intervals; they could recommend intensive training in management at a university or, if the demand was sufficient, arrange a course locally.

Skilled artisans such as mechanics and electricians often outnumbered operating personnel in a modern mill. Their training required the fullest attention in developing countries because their skills were usually in short supply. A form of apprenticeship was advised.

Effective management of production required knowledge and experience in industrial technology in addition to the expected knowledge of management techniques and ability to work effectively with others. The duty of management was to ensure high efficiency in terms of maximum profitability.

Management must ensure that a fair wage structure was determined on the basis of job evaluation. Any feeling of unfairness among the employees was liable to cause discontent and to reduce efficiency. Duties should be clearly defined to avoid confusion in operation. Wherever there was no tradition of factory work, absenteeism could become a major problem at harvest time or festival time. Management could possibly minimize absenteeism by scheduling the annual shut down during the harvest or festival period.

Management was advised to keep a continuous watch on costs. A method which had been found effective was to require costings of production weekly rather than monthly. The manager was then able to pinpoint adverse trends and correct them promptly. Weekly reports were more effective than daily reports of consumption and production, which tended to be disregarded. Costings, whether weekly or monthly, should be promptly prepared. A daily papermill "broke" report was advised. Management should discuss all costings and production reports directly with those responsible for production, maintenance and testing. Productivity was improved in two developing countries by means of incentive schemes.

In a paper-mill, efficiency is sometimes referred to as the proportion of the actual time the paper machine operates to the possible working time. Increasing the ratio is one main way of increasing the profitability of the paper-mill because of the importance of costs related to time compared with costs related to output. It was considered that such efficiency was often low in developing countries. Particular emphasis was placed on planned maintenance.

Efficiency so defined could be assisted materially by a sensibly arranged production programme, whereby different grades are made in a sequence which involves the least washing up or down time. A cycle could last two weeks to one month, depending on the number of grades and quantities. A properly equipped planning department must be set up to receive all the orders from the sales department, co-ordinate them into runs, plan the production dates and advise customers when they could expect delivery.

Similarly, improvements in efficiency are likely if customers would accept a limited number of sizes, tints and finishes to allow a rationalization of production; on the other hand, the advantage that a local mill possesses for supplying special sizes, substances and products could be used to attract customers.

The sales staff should be organized well before the start up so that contacts could be established with potential customers to discuss grades of paper and to mention a preliminary price structure. The negotiations must be completed and production planned well in advance of start-up because a customer currently depending on imports would need to taper off import orders up to six months in advance. The mill could have a difficult start if potential customers were committed to imported supplies for the first three or four months. Conversely, the customers would be dissatisfied if start-up was late and they ran out of imported supplies.

It was often not possible to dispose of surplus production by a new mill in a developing country except perhaps where special trading agreements applied, but a measure of efficiency was thought to be the way in which the mill progressed from first producing papers of only adequate quality to replace imports, to producing papers of competitive quality, and, finally, to producing papers sufficiently competitive for them to be exported.

The quality of the local product could be different from and possibly inferior to the imported product. A uniformity of quality was usually more important than the level of quality. It was important to reassure customers that the quality would be adequate for their purposes and uniform within the usual limits.

It would probably be difficult for the price of paper from a mill in a developing country to be lower than the price of imported paper (unless a high tariff was imposed), but it should be emphasized to the customer that the local mill could offer the advantages of reduced customer inventory, prompt delivery, and better credit terms. An efficient and conscientious staff that were highly trained or experienced before start-up would be an asset.

It had been found advantageous to maintain a 24-hour quality testing programme and to have a daily meeting between production supervisors and the head of quality control. Qualities such as cockle, which were not expressed in numbers, were better assessed by reference to a range of samples illustrating qualities from bad to good than by purely subjective evaluation.

Rejects for quality reasons must be made immediately. A uniform quality and minimum rejection were attained by good production control. The full range of monitor instrumentation could be impractical in developing countries. The most valuable items were: consistency regulation, flow measurement, substance and moisture control.

Often mills in developing countries wasted costly chemicals. Actual consumption must be compared with the proper requirements that could be established by ascertaining the consumption in mills known to be running efficiently.

The continuing training of operators and the development of management, including training or visits abroad, were essential to perpetuate enthusiasm and for rapid response to changing trends. New developments in technology applied judiciously could increase efficiency markedly for a relatively small outlay. Improved belting, wire cloths, felts and vacuum-box tops were cited as examples.

Assuming a paper-mill was properly operated and maintained, its efficiency could be most effectively increased by pushing up the paper-machine speed, by overcoming bottle-necks and making modifications or additions. If drying was the bottle-neck, improvements in de-watering at the couch and presses could substantially reduce the load on the dryers. Improved ventilation and high-velocity hoods could be considered before increasing the number of drying cylinders. Cylinders and framing of a size suitable for paper machines in developing countries were sometimes available from redundant paper machines in industrialized countries.

Improvements or modernization should be carefully costed in the planning stage to ensure a proper return on the investment involved. Modernization of existing mills could be as valid a way to increase a country's total paper output as the erection of new mills, yet it was much more difficult to finance. It was urged that Governments and bankers should look more sympathetically on such projects.

Most successful operators paid considerable attention to the future in order to keep abreast of progress in technology, not only in production but in end-uses. Modification or replacement of equipment to achieve this would cost annually about 3-5 per cent of the capital value of the plant.

Research and development effort was required to solve problems peculiar to the local situation, such as the finding of better fibrous raw material, the improvement of quality and the reduction of costs. Such research should be done in the particular country and deserved support.

Mixed tropical hardwoods

Mixed tropical hardwood was recognized as a potential raw material for developing countries. A survey conducted by one participant indicated that mills were operating in Brazil, Colombia, India, Japan and the Philippines. With the exception of Colombia, all the mills appeared to be using mixed tropical hardwood pulp in comparatively small proportions to the total furnish, and often, as a last resort.

It was the general opinion that Colombia had made headway in the use of mixed tropical hardwoods on a commercial scale for the manufacture of kraft paper for multiwall bags, linerboard, corrugating medium and bleached grade packaging papers. For most of those products, the pulp was mixed with considerable quantities of imported softwood pulp.

The main problem connected with tropical hardwoods is the multiplicity of species. A wide range of species could be used, except for those that were difficult to pulp (i.e. very hard woods, woods which were difficult to debark or susceptible to insect attack, decayed wood, and wood containing much silica, colouring matter, tannin, resin, etc.).

A transport system was discussed for conveying the wood from the forest in the absence of adequate road transport by tractors, tractors with winches, stationary winches and winches with aerial cables. In Colombia, winches with aeriel cables were used for extracting the wood from the valleys and placing the logs by the side of roads running along the hill tops. The average transportation cost was \$5-\$6 per ton of green wood from the forest to the mills, the average distance being about 140 km. The cost of the wood, including transport, ranged from \$8-\$15. For harvesting of trees, both chain saws and axes were used. In Colombia, the workmen favoured the use of axes. The output using axes was nearly double the output when chain saws were used.

In Colombia the forest operation averaged about 20 working days per month. The output per man was equivalent to 1.2 tons of round wood per work day. In Colombia, 6 of the more than 100 locally available species accounted for 88 per cent of the volume. The predominant species was the most difficult to cut. The tendency was for workmen to leave it, and the wood was, therefore, not extracted for the industry.

Some of the problems connected with wood storage were discussed. As the wood was subject to fungal and insect attack, the need for the development of a low-cost fungicide and insecticide was indicated. The wood was stored in a yard for about 40 to 45 days in Colombia. The stacking of mixed tropical hardwoods was a problem due to its crooked shapes and uneven diameters.

Debarking of tropical hardwood was diffiuclt because of its crooked shapes. Hand peeling appeared to be the practice in most of the mills. In Colombia, debarking was carried out in the forest, and no decay problem was experienced due to bark removal.

The life of a chipper knife was short, in view of the high wood density and silica. The Colombian expert stated that chipper knives of the laminated type were most suitable. One set of laminated knives chipped 120-140 tons of wood before grinding was necessary as compared to 20-40 tons when using a regular set of solid knives.

The Group discussed the merits of horizontal- and vertical-feed type of chippers. The mill in Colombia preferred a horizontal type of chipper, while an Indian mill did not favour the horizontal type of chipper. No conclusion was reached as to the most suitable type of chipper.

The question of moisture in respect of chipping was discussed. It was felt that moist wood was to be preferred for chipping. Poor chipping was experienced due to the uneven diameter of the wood. Logs of large diameter were split and fed into the chipper.

Much of the silica in the dirt on the wood could be removed by chip washing. Silica was, however, a constituent in some of the species of wood and, consequently, the lifetimes of the chipper knives were short. In Colombia, the evaporator tubes had only a thin crust of silica deposits after six months of operation.

In order to obtain a uniform mixture in the digester, the blending of species was recommended. The adverse effects that would result with regard to quality, on account of the non-uniformity of species, was emphasized. In the Philippines, the logs were segregated into three colour ranges; the darkest were used for liner board, the medium-coloured for bleaching, and the light-coloured for ground wood. The segregation and blending in predetermined proportions was considered impracticable in Colombia. The uniformity of the mixture was improved in the Colombian mill by stirring the chip pile with the use of a bulldozer.

The experience in New Zealand of cooking hardwoods and softwoods together was mentioned. The mixing of hardwoods and softwoods would depend on the type of mill and the type of equipment used.

Considerable interest was shown in the use of mixed tropical hardwoods for the manufacture of sack kraft. In Colombia, 80 per cent mixed tropical hardwood and 20 per cent long fibre was used in the fibrous furnish for sack kraft. A Clupak unit was used in the process.

The cost of producing pulp from mixed tropical hardwoods in Colombia was between $120-$140 per ton compared with $180-$200 for imported pulp, including duties and transport.

The Group shared the opinion that, on a long-term basis, the supply of pulp-wood with good paper-making properties would be grown on plantations. The Group discussed the very low annual growth rate of 0.5 m^3 per hectare by natural growth as against 10 m^3 per hectare for trees on plantations. The tendency, therefore, would be towards replanting of most suitable paper-making species after the areas were "clear cut". The growth cycle of some of the species planted in Colombia was as follows: eucalyptus 5 years; cypress 8-12 years; and pine 15 years. The reforestation of tropical hardwoods required about 20 to 25 years. It was stated that there could be difficulties in reforestation programmes on account of soil erosion.

The manufacture of dissolving pulp from exotic raw materials

In the discussion of exotic raw materials for dissolving pulp, eucalyptus, rubberwood and mangrove wood were considered and also indigenous non-wood materials such as bamboo, reed and bagasse.

It was generally possible to make dissolving pulps from bagasse, bamboo and reeds, which was technically satisfactory for viscose staple fibre, but the pulps would not be competitive economically or technically with wood-pulp. So far it had proved difficult, if not impossible, to attain the necessary quality for high-tenacity tire-cord filament viscose from non-woods. It was also very difficult to produce acetate grade pulp. Recent semi-industrial scale attempts at making acetate pulp from bagasse failed, although a pilot plant built in the 1930s had attained the objective. It should be emphasized that it would be possible and perhaps necessary to improve the properties of viscose obtained from non-woods by blending it with better viscose produced from wood dissolving pulp. Commercially successful plants in Brazil and Portugal export high-grade dissolving pulp made from plantation-grown exotic eucalyptus.

It was emphasized that conclusive results cannot be obtained from laboratory testing of cellulosic materials for dissolving pulp, although it could give preliminary data. Small-scale pilot plants, which simulated all the stages of industrial preparation and treatment, had proved more or less satisfactory. A pilot plant at Bandung, Indonesia, was generally available for such work. Its facilities included viscose spinning.

The following grades of dissolving pulp were mentioned:

Viscose grade. Alpha-cellulose above 88 per cent, ash less than 0.15 per cent, brightness above 85 per cent. A considerable percentage of hemicelluloses was permissible because they were largely removed during the mercerization process in the viscose factory;

Acetate grade. Alpha-cellulose usually above 97 per cent, hemicelluloses, ash and silica should be much less than could be tolerated in viscose pulp;

Nitrate grade. Similar to acetate pulp except that for explosive manufacture (but not for films or lacquers) more ash could be tolerated;

Ether grade. Similar to acetate pulp, except for the specific case of sodium carboxymethyl cellulose used in the form of aqueous solutions when ash and hemicelluloses could be less important.

The use of agricultural residues that are rich in ash and hemicelluloses for dissolving pulp is limited to rayon, explosives and sodium carboxymethyl cellulose.

Just as the density of woods affects the ease with which they are penetrated by cooking chemicals, so the microstructure of fibres and cells in pulps affects diffusion of reagents prior to solution of the cellulose. For example, during xanthation of alkali cellulose, if the pulp is insufficiently homogeneous, the most reactive cell types would consume more carbon disulphide and be over-xanthated, and the least reactive would be insufficiently xanthated to go into solution properly. The uniformity of cell type in the raw material, therefore, is important. Thus softwood pulps, which are composed almost entirely of tracheids, are more desirable than hardwoods, which contain more different types of cells. Before wood is pulped, leaves and bark are removed from the stem, but leaves, epidermis and bark when present with non-woods are usually more difficult or impossible to separate from the stem. The leaves, epidermis, bark, nodes, internodes and pith of non-woods give a much more heterogeneous anatomy than hardwoods, making them less suitable for dissolving pulp, particularly by impairing the filterability of the viscose.

Iron, manganese, calcium and silicon compounds are especially undesirable in dissolving pulp. Silica, which comprises sometimes half of the ash of non-woods, is present in different forms in different raw materials. An example was cited of pulps made by the same process - sulphite with alkaline refining - from reeds with a high silica content and from wheat straw and bagasse (both containing less silica). The silica content could be sufficiently reduced only in the pulp made from reeds.

After testing bagasse, rice, flax and wheat straw, cotton and maize stalks, palm leaves, reeds, and Arundo donax, one expert concluded that Arundo donax was one of the few non-woods that gave suitable viscose pulps by both the bisulphite and the prehydrolysis kraft methods. One method of removing ash during processing is mechanical separation by screening much of the silica rich epidermis as fines because they are loosened from the surface of the straw during prehydrolysis. The reduction of ash in mangrove wood-pulp by separation of the ash-rich fines content of the pulp is similar.

The partition of silica between liquor and pulp during cooking is determined by the rapidity with which dissolved silica is redeposited on the fibres while lignin is still being solubilized. Thus a rapid cook of a few minutes was found to give pulp containing the least silica. It was possible to produce (albeit in lower yields compared with woods) suitable viscose pulps from the most inferior non-wood materials by a rapid-cook intensive alkaline refining. But it would not necessarily be an economic production in practice.

The warning was given that non-wood pulps are sensitive to drying. A skin could be formed which hinders chemical reaction.

It was reported that sugar-cane bagasse could be made into suitable viscose pulp by the prehydrolysis kraft process, though not by the bisulphite process. The need for depithing bagasse was discussed and it was concluded that with clean hand-cut cane it might suffice to remove only the loose pith cells, which were contaminated with dirt and dust in a depithing stage, with a loss of about 5 per cent of the bagasse. Screening the bagasse after prehydrolysis to remove an additional 5 per cent of the pith cells was sufficient to reduce ash content, and further depithing did not improve pulp quality. Mechanical harvesting, however, introduced much more contamination, and full depithing was then required.

Furfural might be obtained from the hydrolysis liquor. But the hydrolysis of the bagasse itself to yield much furfural would degrade the bagasse too far for further pulping.

Prehydrolysis kraft pulp could be obtained from bagasse in a yield of about 31-36 per cent, with 96-98 per cent alpha-cellulose, 1.3-3 per cent hemicellulose and less than 0.1 per cent ash. Bagasse could be used for viscose pulp and for cellulose nitrates of fair stability.

A considerable amount of work on dissolving pulp from bagasse was carried out recently in Cuba, and 200 tons of pulp has been produced there. Pulp was made also in Romania and Italy from Cuban bagasse. The work was aimed at producing acetate pulp, but this objective was not realized; satisfactory rayon pulp was, however, produced. Investigations were carried out on the effect of age and the variety of cane, the nature of the soil, cultivation methods and the mechanization of harvesting. It was found that good depithing was essential to obtain maximum uniformity. Bagasse was not found to be a competitive raw material for dissolving pulp compared with wood, but in considering the economics of using bagasse, account must be taken of local conditions and other technological developments in a country.

Cotton stalks were not found to be a good raw material. They are very heterogeneous, with a bark content of 20 per cent and contain pith. Mechanical bark separation is unlikely to be complete, and residual bark is not pulped properly with the bisulphite process. Prehydrolysis sulphate pulping disintegrates the bark and dissolves much of its coloured matter. Natural cotton stalks might be pulped if it were possible to bleach the pulp satisfactorily.

Palm leaves only gave acceptable pulp if the leaflets were stripped off so that only the mid-ribs were pulped.

Maize cobs with about 1.2 per cent of ash contain less ash than most of the other non-woods discussed. With prehydrolysis kraft pulping and mild treatment, they produced acceptable pulp with good filterability. However, many difficulties were encountered as a result of the poor washing characteristics of the pulp, which is powdery rather than fibrous.

Straws contain leaves rich in silica. It would not be economical to separate the leaves, but the silica concentrated in the epidermis could be markedly reduced by screening after prehydrolysis. The partition of silica between liquor and pulp could be adjusted in cooking. Attempts were made to produce dissolving pulp from wheat straw on a commercial scale in Germany during the Second World War.

Bamboo is commercially pulped for rayon manufacture in India by the prehydrolysis kraft process. The yield of pulp is about 28 per cent. Dissolving pulp was produced commercially from reeds by the prehydrolysis kraft process in Romania with alpha-cellulose content 92-93 per cent, pentosan 2.5-3 per cent, ash 0.2-0.3 per cent and viscosity 15-20 centipoise. The decisive factors in changing to beechwood as the raw material were difficulties in the harvesting and handling of the reeds.

A mill for making rayon pulp from Arundo donax was established in Italy. The pulp was satisfactory. Difficulties in the culture of Arundo donax are, however, believed to have caused the mill to switch to beechwood.

Mangrove wood has been pulped since 1965 by the sulphite process in Japanese mills. Preliminary experiments were made on 20 samples from Malaysia, the Philippines, Sabah, Sarawak and Sumatra. It was found that the genus Rhizophoraceae including the genera Brugiera, Rhizophora and Ceriops were suitable for dissolving pulp, but several other genera were not.

It was stated that Japan imported 12,000 tons of mangrove wood monthly, mainly from Sarawak. The wood should be pulped as soon after felling as possible - within two or three months - to avoid deterioration by fungi. The mangrove wood-pulp is prepared separately from the mixed Japanese hardwood pulp with which it is blended.

The specific gravity of the varieties of mangrove wood used is between 0.65 and 0.9; these varieties are not well suited to paper-pulp. Despite its high density, mangrove cooks easily, and, in many ways, behaves better during pulping than Japanese mixed hardwoods.

The ash content of mangrove wood is higher than the ash content of most Japanese hardwoods with crystals of calcium oxalate in the ray cells, but only 2 per cent of the ash is SiO_2 and 3 per cent of it is Fe_2O_3 and Al_2O_3.

The yields of pulp from mangrove wood and from Japanese hardwoods are comparable. Mangrove wood-pulp has a relatively high alpha cellulose content. The only inferior property of mangrove pulp is compressibility, which limits the quantity of mangrove pulp to 50 per cent in the blend with mixed Japanese hardwood pulp.

Rubberwood, which is also used in large quantities in Japan for dissolving pulp, is not imported as chips. The latex content of the chips, which are used for paper-making, was found unacceptably high because liquid latex had contaminated the wood during the debarking of the freshly felled trees. For dissolving pulp manufacture, the logs are cut after the latex hardens and the debarked logs are shipped to the mill. The washing of the debarked logs in the drum barker further removes latex. The wood under the tapping panel [illegible]. Latex was not found in the wood rays. Rubberwood, like mangrove, is pulped by the sulphite process. Latex, which coagulates during pulping, is removed as far as possible by screening.

Up to 0.2 per cent of latex in the dissolving pulp was reported as tolerable, but a higher quantity impaired the quality of the pulp. The latex content limits the proportion of rubberwood in blends with Japanese hardwoods to 20 per cent. As rubberwood and Japanese hardwoods are about equally dense, the pulp produced from cooking them together has similar properties to pulp made from Japanese hardwoods alone.

Blue staining of rubberwood could present a problem. Pulp from blue-stained wood showed a relatively high permanganate number, low brightness and high extractive content and needed more chemicals for refining. However, blue staining, if controlled by pulping the wood as soon after felling as possible, does not appear a major problem if the proportion of rubberwood pulp is as low as 20 per cent.

The utilization of waste paper in the paper industries of developing countries

The Group agreed that the incorporation of some properly selected and prepared waste paper into the furnish of many papers could significantly reduce the production costs of a paper-mill, both when the remainder of the furnish was mainly locally made and when it was imported pulp. It was shown that waste paper could be collected economically in developing countries, and suggestions were given for adapting collection procedures to local conditions.

In industrialized countries, 20-40 per cent of the total paper and board consumption is recycled as waste paper for re-use. Although the United Arab Republic achieved such levels, it would generally take time to reach those levels in a developing country. The quantity available is often reduced because some paper, such as over-issue newspapers or used multiwall sacks, is re-used for packaging paper without being re-pulped. Boards and corrugating medium are usually the papers which contain most repulped waste, but examples were shown of duplicating papers made completely from de-inked waste.

Waste paper is often imported from industrialized countries for blending with local, short-fibred pulps such as those from straw or bagasse, in order to modify the characteristics of the paper and improve runnability on the paper machine in rather the same way as imported wood-pulps are used, but at lower cost. The costs of imported bleached or unbleached waste papers is about $100 per ton less than the cost of bleached or unbleached wood-pulps, though the difference is reduced by the extra cost of processing waste paper and the lower value of the pulp.

The collection of waste paper in bulk from large converting factories, printing works, envelope manufacturers and department stores is not complicated. It was recommended that collections be made daily, otherwise the firms might destroy the paper to prevent congestion and to reduce fire hazards. Such collections could be made by a paper-mill's own waste-paper unit.

Converting firms could have small, portable baling presses. In countries with small per capita consumption, converters could be the only practical source of waste paper. In the collection of small quantities from households, educational institutions and government offices, a middleman has to be employed to collect and supply the waste paper to a collecting centre for baling.

In an industrialized country, high labour rates could make sorting of waste paper unfeasible except at the point of generation. The dealer must be something of a diplomat so as to impose the requirements of the paper mills on the factories where the waste paper is generated. In developing countries, efficient sorting was often possible with lower wage rates. For the same reason, waste paper could be processed with less sophisticated and cheaper equipment. Dry cleaning of the waste could remove the heavy impurities and dust. The waste could be kollerganged to break glass. It was urged that designers of waste-paper treatment plants should take account of the large amount of foreign material in waste collected in poorer countries, which could quickly damage machinery.

Useful suggestions for stimulating waste-paper collection included:

(a) Offering schools a discount on new exercise books if used ones were returned;

(b) Offering small printers sacks made from old machine felts for collecting their waste and trimmings;

(c) Circulation of leaflets urging salvage of waste paper;

(d) Collection of old telphone directories when new ones were issued;

(e) Special arrangements for collecting waste confidential papers from government, which would otherwise be burned.

The fear lest the fibre length would be lowered by the repeated recirculation of waste, which could occur if recovery were intensive, was not thought to be confirmed in practice because the fibrous material was freshened by the loss of fines during repulping. Colour could deteriorate, however.

The problem of poor colour could be helped by the importation of bright waste papers. Another approach to the problem, which also arises when the bleached pulp is made locally with lower brightness than imported pulp, is to lower the level of brightness in paper specifications. The Indian Standards Institution is already working on revised paper specifications that would be more appropriate for production conditions in India.

Repulped over-issue newspaper is almost the only source of fibre in some newsprint mills in the United States of America. It was suggested that with such a furnish the cost of pulping equipment and the power consumption for pulping would be reduced for a newsprint mill. The cost would be smaller than the cost of a wood-pulping mill. It could be a viable solution to the problem of newsprint supply in developing countries.

Centralized waste-paper pulp-mills were discussed. Drying was not viable, and the pulps were sold as wet laps. In the United States of America, the centralized waste-paper mills are usually connected to paper companies because repulped waste is not always competitive with wood-pulp. Indeed, one mill producing telephone-directory paper with a high proportion of repulped obsolete directories abandoned the practice because it was cheaper to make semi-bleached, semi-chemical pulp from wood. Technically the repulped directories were satisfactory.

In Ceylon, the collection cost of waste paper for incorporation in white papers was reported to be about $9 per ton; the cost of baling and transport to the paper mill over more than 100 miles was $9; the cost of sorting was about $17 per ton. The total cost before the waste paper was de-inked was, therefore, $3[illegible] per ton. About 1.25 tons of waste paper was needed to produce one ton of de-inked pulp at a cost of about $43. The final cost of the de-inked pulp was about $[illegible] per ton after allowing for chemicals, services, depreciation etc. The cost of bleached straw pulp produced in the mill was about $225 per ton and the cost of imported bleached wood-pulp was about $250. Savings of foreign exchange resulted from reducing the proportion of imported wood-pulp in the furnish from about one third of the furnish to about one quarter by the use of de-inked waste paper.

Elsewhere, in a mill formerly using only imported virgin pulp, the differential between the purchase cost of virgin and waste unbleached fibre was $100 per ton. Substituting 40 per cent of the virgin fibre with waste gave an initial saving of about $40 per ton of paper. The net additional profit and the savings of foreign exchange was about $22 per ton of paper after deducting the cost of sorting, cleaning, the additional size press materials and amortisation, which amounted to $18 per ton of paper. But the savings vary greatly according to the prices paid for the waste, the percentage and type of waste used, and the equipment. It was suggested that, as a general rule, a saving of $[illegible] per ton of paper could be anticipated, which, if achieved, could justify the investment in a low-cost waste paper processing plant.

The prices of waste paper, according to grades, quoted for Ceylon exemplified a wide range; the cost of mixed unsorted papers was about one sixth of the cost of No. 1 white grade trimmings. The range in the United States of America was even greater. In Ceylon, better grades were stored under cover, but the unsorted waste was stored in the open under a thatch of palm leaves.

The collection of 40 tons of waste paper per day within a city of 25 square miles was found to requires a fleet of five 2-ton trucks. After rough sorting at the collection centre, the papers were packed into high-density bales of about 25 lb per cubic foot density. The staff included a storekeeper, a storeman, a weighbridge operator, a baler operator, 5 drivers and 15 unskilled workmen.

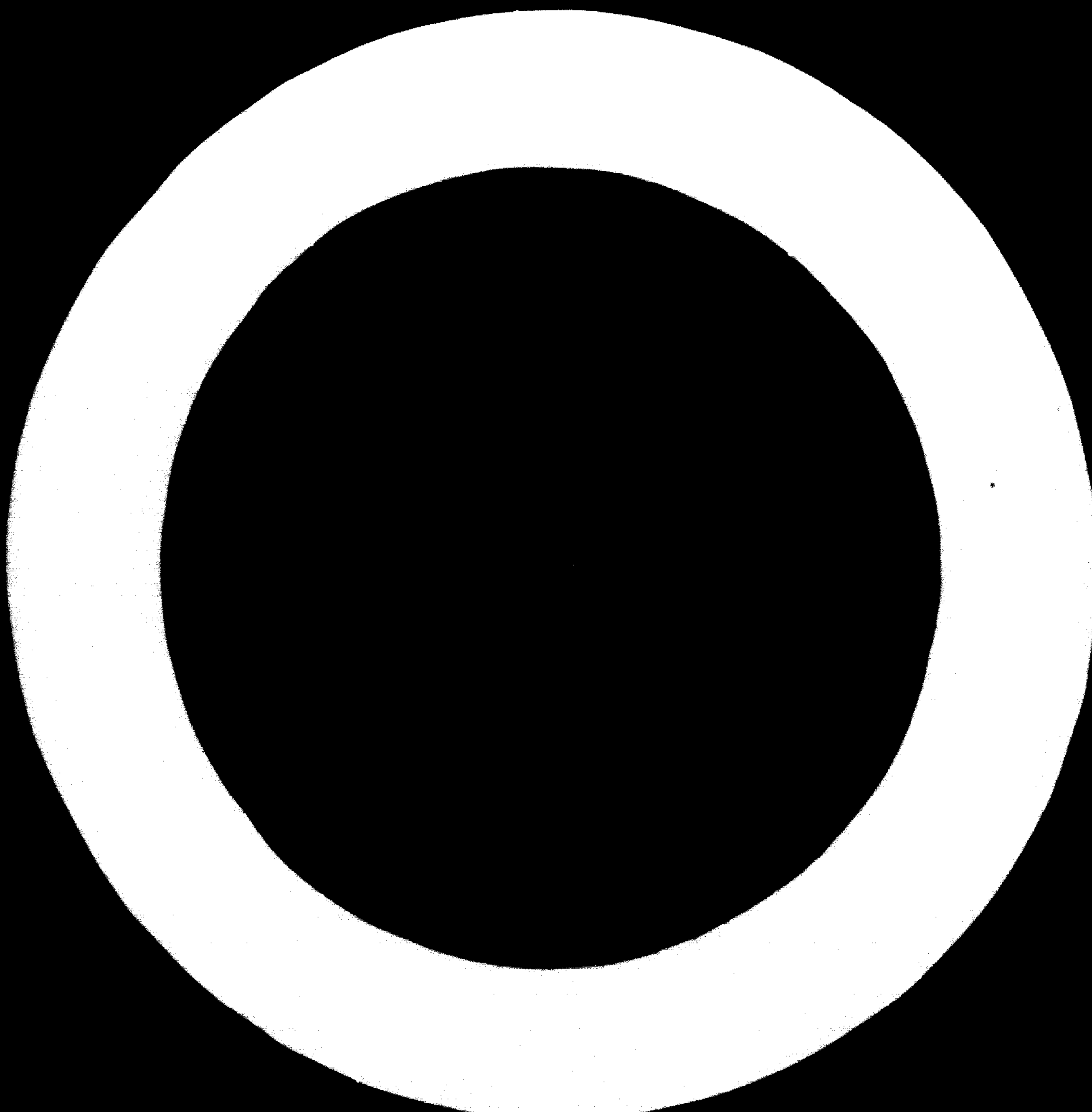
The investment for a simple but complete plant, including an asbestos-clad steel-frame building for repulping and cleaning 25-100 tons per day of waste paper would be $3,500-$4,000 per daily ton of capacity. In the plant, a fair degree of ink and bitumen dispersion could be done rather than de-inking. It would be an appropriate plant for a mill producing packaging papers and boards, though with carefully sorted unprinted white waste that was brightened by simple bleaching, white papers and boards could also be made. The equipment for an effective, low-cost plant was described in such a way that a mill could design and install a plant with the minimum of assistance.

Concerning partial replacement of imported virgin pulp with repulped waste, it was pointed out that repulped waste was normally weaker than virgin pulp, and, it could be necessary to compensate by the use of beater or size-press additives. Their cost must be taken into account.

While it was found possible in Ceylon to de-ink waste paper for inclusion in writing and printing papers by treating pulped sorted waste paper with de-inking chemicals and washing out the ink in washing hollanders followed by bleaching, the mill installed a floatation de-inking process for treating 25 tons per day of sorted waste paper. The chemicals used in the process for (A) mixed waste papers containing both groundwood and chemical pulp and (B) papers made from chemical pulp only, were:

	A (percentage)	B (percentage)
Sodium silicate	4	
Sodium peroxide	2	
Caustic soda	3	2
Soft soap	4	4
Calcium chloride	1.1	1.1

The mixture of sodium peroxide with sodium silicate reduces the yellowing of groundwood in the presence of caustic soda. Tinted papers are bleached with a zinc hydrosulphite. A de-inking plant using stock that contains coated and filled papers creates a serious effluent problem, however. The effluent was said to be a more serious pollutant than the effluent from a sulphite pulp-mill.



III. CONCLUSIONS

The following conclusions are based on the discussions of the Expert Group:

Newsprint from bagasse

It should not be assumed that newsprint can be produced mainly from bagasse at a cost below that of imported newsprint. The objective of investment in a bagasse newsprint mill is likely to be limited to import substitution rather than competition on the world market. The production of newsprint (or any other paper) should be pre-planned sufficiently in advance so that the mill is able to pulp the most suitable raw material and is not compelled to pulp a material because it is the only one available.

Before planning a paper industry, particularly a bagasse newsprint mill, the complete co-operation of the Government must be ensured because without it the project is unlikely to succeed. Only the Government can give the industry protection in the form of tariffs or restrictions on the import of newsprint (which was sometimes dumped at low prices) it would almost inevitably require to be viable.

As bagasse would be the prime source of fuel for power and steam in the sugar-mills, most of the bagasse diverted for newsprint production would have to be replaced by petroleum, natural gas or coal of equivalent thermal value. When bagasse has to be replaced by imported or costly fuel, partial depithing at the sugar-mill should be considered because the separated pith can be used in the sugar-mill boiler furnaces.

Considerable quantities of fuel are also required for process steam in the paper-mill; large quantities of electric power are used in mechanical or chemi-mechanical pulping and sometimes in the production of pulping chemicals. The prices of fuel and power that are very important costs in production are often controlled by Government; in the case of fuels, an excise duty is sometimes levied. Further, the annual production of sugar, on which the supply of bagasse depends, is controlled at the intergovernmental level.

As the viability of any plant depends considerably on an advantageous location, a site for a bagasse newsprint mill should be sought not only where there is an abundance of bagasse but where there are additional advantages such as proximity to a supply of natural gas or to a source of hydroelectric power.

Light coloured woods, particularly from conifers, are the most commonly accepted material for newsprint. They can be pulped by grinding, usually without chemicals. Fast-growing pines somewhat similar to those that have been used for newsprint in the southern states of the United States of America probably can grow in regions that grow sugar-cane. These pines and hardwoods (which are used for newsprint in Argentina, Australia and the Philippines) reach economic size in a relatively short time (usually 12 and 6 years, respectively). Saw-mill waste from suitable woods, which is usually cheap, merits particular consideration as part of a newsprint mill's raw materials now that refiner groundwood production has been developed.

In considering newsprint from bagasse, it should be remembered that the cost of attaining pulp of sufficient brightness depends on the colour of the bagasse at the time of processing. With fresh bagasse coming directly from the sugar-mill presses (which is available throughout the year in a few countries, of which Peru is one), an adequate brightness may be attained without bleaching. In most other countries, it is usual to store the bagasse for use between the cane harvests. The bagasse might deteriorate during storage and it might not be possible to obtain an adequate brightness without bleaching.

A study of the effect of alternative storage methods on the brightness of bagasse newsprint was suggested. Some of the newsprint trials in the early 1960s, which were mostly made on baled bagasse, might have been more successful had attention been given to the problem of bagasse storage. The effect of burning off leaves should also be considered.

When forecasting the production cost of newsprint from bagasse, the cost per ton of bagasse delivered to the mill must be calculated. Loose bagasse could be transported a short distance by conveyor, while long-distance transport by lorry would probably require baling and would be more costly.

Economy of size compelled competitive newsprint mills to be large. A newsprint mill in a developing country must suffer a disadvantage if it is not also fairly large. A mill could, however, be designed to make other kinds of paper, and there may be possibilities for regional trading arrangements.

In deciding with which process to pulp bagasse for newsprint, an important factor to bear in mind is the availability of long-fibred pulp to mix with the bagasse pulp. When long-fibred pulp is available locally, it may be economical to use a largely mechanical high-yield process for the bagasse pulp. The low strength and poor paper-machine performance of the pulp produced could be compensated for by using more chemical wood-pulp than is usual in newsprint. Conversely, when long-fibred pulp has to be imported or is costly or difficult to obtain, a chemi- (or semi-) mechanical process may be preferable if it produces a bagasse pulp which is stronger and performs better on the paper machine with less long-fibred chemical pulp.

When evaluating a bagasse pulp by means of a paper-machine trial or when using such a trial to obtain data for designing a future paper machine, the trial should be of sufficient duration at least to establish equilibrium in the recirculated water system and to permit observation of the effect of fines on the machine's performance.

Claims for economic recovery of chemicals from semi-chemical processes should be examined with considerable caution. Recovery plants are usually costly and unremunerative when handling the relatively small quantities of generally dilute chemicals from semi-chemical pulping.

The pulping of rubberwood

The Group suggested that the fibrous furnish of papers made from rubberwood should not include more than about 25 per cent of rubberwood pulp as the problem of latex had not been completely solved. When better raw materials for pulp are in short supply a proportion of rubberwood pulp in the furnish may be considered, for it was reported as being a usable hardwood pulp apart from the problem with latex.

No highly capitalized enterprise based on the use of rubberwood exclusively should be undertaken without some irrevocable arrangement which would secure an adequate, steady and continuous supply of rubberwood; otherwise rubber producers, who obtain relatively little of their income from wood, could endanger the enterprise by irregular felling (irregular replanting of their rubber trees) or by diversifying into production of other crops. Rubberwood as a source of pulpwood should be examined cautiously in countries where wage rates are increasing rapidly because its collection is labour intensive.

When considering using rubberwood for pulp, the possibility of chemical debarking should be investigated. Should this prove feasible, it should reduce the latex content of the wood (though the latex trapped in the wood under the tapping zone would not be reduced). Caution must be exercised to prevent the transfer of the debarking chemical's toxicity to the finished paper.

The Group noted the secrecy surrounding technical developments in rubberwood pulping, particularly with respect to the latex problem. It hoped for a freer flow of information to developing countries which may require the use of rubberwood to augment their raw materials for pulp.

Low-cost pulp- and paper-mills

A plant which is low in cost because it is inferior or incomplete must obviously be avoided. Expert advice must be obtained to examine tenders. The objective is not to choose the cheapest, but to buy a competitively offered plant of good quality which will operate efficiently, but which is not "over-engineered"; in other words, one that has been specifically designed to suit the requirements of a developing country where simplicity is important and not one designed for an industrialized country where complexity may be required for competition on a highly sophisticated paper market.

A pulp-mill should be integrated with a paper-mill (a) because there would be considerable savings in the cost of drying and baling the pulp (and the accompanying loss in pulp strength); and (b) because the services, facilities and overhead costs could be shared with little extra expense. The savings help to make locally made pulp competitive with imported pulp.

Nominal protection from the Government could be helpful in establishing a new pulp and paper industry. The protection could be in the form of tax exemptions on imported machinery, estate and initial income; tax relief during early years, and, as a transitional measure, protection by means of duties or restrictions on imports.

A pulp- or paper-mill that uses inferior raw materials is inefficient and becomes a high-cost installation. A successful mill must be pre-planned years in advance of its realisation so that it can be supplied with the best raw materials.

How the equipment may be bought and installed at the lowest cost consistent with efficiency should be considered. The use of second-hand equipment and local manufacture of equipment of good design should be reviewed. If the resulting savings are small in relation to the total costs and if the piece of machinery is a key one, it may be wiser to buy a new plant. The key to success with reconditioned, second-hand equipment is often the ability of the mechanics and operators and their desire to make it work properly.

The standardization of equipment should be practical as much as possible, otherwise an unduly large amount of capital would be devoted to the spare-part inventory. Interchangeable press and dryer felts, common bearings, instruments, motors, belts and pumps are items that can be standardized.

The costs of construction are likely to be increased if the site is not reasonably flat and if the ground does not have satisfactory load-bearing characteristics.

The cost of housing and of providing amenities may be reduced if the mill can be built within reasonable access of a town or village, but transport for the personnel for shift work must be considered.

Maximum advantage should be taken of a warm climate by keeping buildings to the minimum necessary, and by placing chests and tanks outdoors.

The mill must be assured of a sufficient supply of water which can be difficult to obtain in tropical countries or wherever prolonged periods of drought occur. The construction of a dam may be required. The water consumption is likely to range from 120 m^3 per ton of paper if paper only is made to 500 m^3 per ton of paper if bleached pulp and white papers are made. Ancilliary services would require additional water. It may be advantageous to combine a dam for water conservation with hydro-electric power generation.

The use of electricity from a public supply saves much of the large investment for a boiler and power plant. If the price of the electricity is excessive, it may be preferable to generate electricity in the mill and obtain the operating economies which can result from generating power from the steam required for pulping and paper-making, especially if a suitable used turbo-generator can be obtained. If power was to be generated thermally, a stand-by turbo-generator was not considered a justifiable precaution but a standby boiler was always desirable. Bagasse and wood that is unsuitable for chipping because it is crooked, undersized, rotten or otherwise inadequate for pulping often provide a lower-cost fuel for the boilers than traditional fuels, especially in remote areas.

A low-cost pulp-mill

Capital charges, comprising amortization (over about 17 years) and the interest on capital (including working capital) at 9 per cent per annum were stated to be about 50 per cent of the total pulp production costs.

The optimum output of a mill should be most carefully considered because the cost of producing one ton of pulp in a 50 ton per day mill might be 50-75 per cent higher than in a 200 ton per day mill largely because of capital charges and the costs of labour and administration. There can remain an advantage in size even for mills with capacities of up to 500 tons or more per day. It is usually not advisable to plan the export of the surplus production from an over-capacity mill on the international market except where a long-term captive market can be assured (most probably with a paper-mill in a neighbouring developing country).

Plantation-grown pulp-wood (usually both coniferous and broad-leaved) can be grown in an efficient low-cost way especially if suitable exotic fast-growing species are chosen. The subtropics are usually well adapted to conifers and the tropics to hardwoods and a limited range of conifers. It was reported that the production costs of 1 ton of bleached pulp from non-wood materials (e.g. bagasse and straw) are $6-$9 more than the production costs for 1 ton of pulp from pulp-wood. There are areas where the cost of bagasse is low and hence the pulp price differential is less.

Unconventional raw materials or unconventional processes should generally be avoided because they inherently involve the risk of unforeseen problems requiring modifications to machinery; such modifications can be slow and costly in a developing country and the delay in achieving break-even production or failure to do so can exhaust a mill's financial resources.

The higher investment costs common in a developing country can, to some extent, and sometimes to a large extent, be offset if the cost of raw material is substantially lower. The costs of wood as a percentage of the cost of long-fibred wood-pulp were reported as 42-48 per cent for sulphate pulp in Scandinavia and 20-24 per cent in Latin America (although the percentage may have been much too low if investment costs were high). The figure quoted for hardwood pulp in Latin America was 13-14 per cent.

The planning of pulp production for export on the world market requires cautious examination. The market is currently highly competitive and a developing country usually has no advantage except cheap raw materials, but it often has many disadvantages. Some disadvantages may be overcome when a local industry has been successfully established and can form a basis for expansion into export. A particular local advantage may be the deciding factor in competitiveness. An export mill is likely to require a market for 500, or probably even 1,000, tons of pulp per day.

When considering a larger output it should be taken into consideration that the unit cost of the raw materials often increases because of the higher transport costs. Two examples are bagasse that is supplied by more than one sugar-mill and bulky materials such as straw.

An over-sized chipping plant would be necessary for use on the following kinds of raw materials:

(a) Species of wood that quickly dull or damage the knives;

(b) Logs that are insufficiently straight and uniform in thickness for the chippers to operate efficiently.

The possibility of saving capital costs by adopting methods which employ less capital but more labour should be considered. This is likely to be more feasible in forestry, felling, extraction and possibly debarking, than in the pulp-mill itself. Mills in developing countries tend to employ so much low-wage labour that labour costs per ton of product exceed those in mills in North America. A considerable savings in investment may occur through manual debarking.

In order to minimize machinery costs, it is advisable to consider the effect of using conventional equipment such as batch digesters with direct heating. The cost is usually less than for modern continuous digesters. Their erratic steam demand, however, could require a higher capacity boiler plant with a resulting loss of some savings. Continuous digesters are recommended for agricultural residues, which do not pack well in batch digesters and often do not cook well in them either. Over-all steam economy may be better with indirect heating of batch digesters. But there could be scaling problems with indirect heating when the raw materials contain silica (e.g. bamboo).

Savings on construction materials can result from reducing the quantities of stainless steel and titanium used in sophisticated bleaching plants. The use of plastic piping and plastic coated fabrications may be considered as economical measures. The investment in plants for the manufacture of groundwood pulp and semi-chemical pulps is usually less than for chemical pulp plants, partly because chemical recovery is often unnecessary. Groundwood may be produced on a small scale, most easily from suitable conifers, but now also from suitable hardwoods. The pulp is used particularly in inexpensive printing and writing papers, and as a filler in paperboard. Semi-chemical pulp for inclusion in corrugating medium and to some extent in packaging papers and boards can be made from hardwoods (possibly mixed). High-yield bleached pulps can also be made from appropriate species. The uses of those pulps have been limited compared with chemical pulps, however.

A NSSC plant, for example is cheaper than a chemical pulp plant. The yield of pulp may be about 75 per cent for unbleached pulp compared with about 50 per cent for sulphate pulp and less wood, therefore, has to be processed. The relatively small amount of organic matter dissolved from the wood, especially if accompanied by a low chemical consumption, may make chemical recovery less necessary than for a chemical pulp plant. Recovery is frequently omitted unless cross recovery with the effluent from an adjacent sulphate mill is possible. The omission substantially reduces the capital cost. Provided alkalinity is maintained throughout the cook, cheaper construction in ordinary steel is often used, but stainless steel washers may be advisable.

The sulphate or kraft process (in which the make-up chemical is sodium sulphate but the active chemicals sodium hydroxide and sulphide) with its recovery of chemicals, is generally regarded as reliable and widely applicable, especially where the best strength of either unbleached or bleached pulp is required. This is usually true in the tropics where most raw materials are short fibred, and the available conifers generally give somewhat weaker pulps than conifers grown in temperate zones. The sulphate process is the most widely used chemical pulping process, although the pulp yield is not the highest. As some offensive odour could originate from the process, the mill should not be located near residential areas. The capital cost is likely to be lower than with acid processes, which require acidproof equipment. Digesters can be constructed economically of steel boiler plate with low silicon content provided there is an adequate allowance for corrosion (e.g. of 5-8 mm). Washers and screens can also be made of carbon steel. Chemical recovery is an integral part of the true sulphate process, and the minimum mill size may be governed by the smallest efficient recovery plant.

The soda process is basically similar to the sulphate process (both are alkaline processes), but the active chemical is sodium hydroxide only. It is little used for conifers because the strength of the pulp is inferior to sulphate pulp, but the difference is less in the case of broad-leaved (hard) woods and agricultural residues, for which it may be recommended. It was suggested that in the future it may prove industrially practical to combine soda pulping with oxygen bleaching to produce bleached pulp with very little effluent. There is usually less corrosion than in the sulphate process. Chemical recovery is not an inherent part of the process as it is with the sulphate process, but recovery is usually essential for economy. Prior to installing a recovery plant and adopting the sulphate process, some of the advantage of sulphate may be obtained by adding elemental sulphur to the soda.

The bisulphite process using calcium base has been largely displaced by the sulphate process, because chemical recovery is not practical with the process. Chemical recovery has been developed for the process if magnesium base is used. The unbleached pulp yield is 5-7 per cent higher than with the kraft process, and bleaching is less expensive. With short-fibred raw materials, however, the pulp strength is lower than with the kraft process. The use of steel digesters lined with acidproof bricks was suggested. The mill would be more costly than mills using alkaline processes because of the cost of equipment for handling acid pulp and liquors. It was stated that the chemical recovery system was less costly than for alkaline processes and the resulting savings could possibly balance the cost of equipment. The mill should be located on a suitable site that would prevent complaints about offensive odours from its neighbours.

The capital investment for a bleached pulp mill in a developing country includes the installation costs of a plant to produce chlorine and caustic soda from salt by electrolysis. (It can be economically advantageous if the plant could market surplus caustic soda at a reasonable price.) In developing countries, it is advisable to induce customers to accept a lower standard of paper brightness. A simplified bleaching system of only three or four stages would then be adequate. Oxygen bleaching was not applicable, as the process was under development and would be rather costly.

No economy should be made in the volume of buffer storage tanks for pulp and liquors, because the continued operation of the entire mill depends on them in the event of a breakdown in any section. Buffer storage between the pulp- and paper-mills is particularly important.

With the increasing concern about pollution, it is unwise to project a plant without the possibility of chemical recovery even if, because of small production, it does not appear economically attractive at the outset of production. As chemicals are a low-cost item in production costs of chemical pulp only if there is chemical recovery, it may be advisable to defer building a pulp-mill until the demand for pulp is sufficient for chemical recovery to be viable. It was reported that the cost of a plant for the recovery of chemicals and heat is slightly more than the cost of the associated unbleached wood-pulp mill including wood preparation, or about two thirds of the cost of a bleached pulp-mill with wood preparation. Plans for pulping materials, such as rice straw, most cereal straws and other non-wood materials containing sufficient silica to prevent efficient recovery, should be examined with caution.

The untreated part of the effluent from a pulp-mill can easily transform a river into which it is discharged, into a hazard to health when the river flow is low. The site for a pulp-mill must therefore be chosen where a treatment plant is least likely to be required, and this usually means where the effluent can be strongly diluted by a large river or possibly an inland sea or the ocean itself. The site must also be assured of an ample and constant fresh water supply. Both requirements may be met near the outlet of a river into the sea. The probable polluting effect of the mill's effluent should be determined in advance and compared with what is permissible (or likely to be permissible, assuming regulations have not yet been formulated).

A low-cost paper-mill

Capital charges are a large proportion of the costs of converting pulp to paper and must be kept to the minimum consistent with efficiency. Of the total cost of paper-making machinery, about 65 per cent is the cost of the paper machine, while 20 per cent and 15 per cent respectively are attributable to stock preparation and finishing. It was generally, but not unanimously, considered that the purchase of a reconditioned, small paper machine at a price well below that of a new machine afforded the best saving. The production of small quantities of many varieties of paper can be better accomplished on a small machine.

The prices of new paper machines of a given size span a very wide range depending on the degree of complexity. It is definitely advisable not to start with one of the sophisticated mass-production machines, which are designed for conditions in industrialized countries and can be a liability under conditions in developing countries.

To reduce costs in the stock preparation section, it may be possible to exclude deflakers and low-consistency vortex cleaners when only medium-quality papers are to be made. It is wise to include a high-density cleaner. A screen is essential to protect the paper machine wire-cloth.

The instrumentation for the section should be minimal because many commonly used devices such as magnetic flow meters require specialized maintenance. Relatively simple mechanical devices for proportioning stock and robust consistency controllers are available.

The cost of a high-density disc refining stage, which is often desirable with short-fibred pulps, may be reduced by positioning the disc refiner after the last pulp-mill filter, where the pulp, at about 10 per cent consistency, falls by gravity into the high-density storage tower. This would provide a stage of pre-refining to be followed by a final touch-up in the paper-mill with equipment such as conical refiners adapted to working at the lower consistencies found in a paper-mill.

For low cost, the wet end of a Fourdrinier paper machine with speeds of up to 200 m/minute and not exceeding 2.5 m width, maximum gross output 40-50 tons per day, should not have a pressurized head box or a cantilever wire frame. It would probably have instead table rolls and simple mechanically actuated float valves in fresh and recirculated (back-) water circuits.

The press section should be simple; it may comprise two straight-through presses with fabric on the first, smooth rolls on the second, and no smoothing press, except for special requirements. For speeds greater than about 250 m/minute, a pick-up transfer of the sheet from the wire to the press felt may increase operating efficiency, particularly with short-fibred pulps.

To lower the cost of the dryer section, open gearing, standard scoops in dryers of up to 1.5 m diameter for speeds up to 400 m/minute, simple felt tensioning and manual lubrication were advised, but felt dryers and automatic guides should be provided on all felts. The exclusion of a size press, with the extra drying section which it entails, markedly reduces the cost. However, the lay-out should permit subsequent extension of the dryer section and a size press (which might be necessary for the production of good offset lithography papers from some hardwood and non-wood pulps). Versatility may be increased without much loss of simplicity if a Yankee (large diameter) dryer is installed in place of some of the smaller dryers; this would permit the production of M.G. (single side glazed) and crêpe papers, as well as ordinary papers.

For controlling steam to the paper and felt dryers, a single pressure controller for the whole section may suffice. It is valuable to arrange such pressure controllers with two set points; one for normal operation could be changed manually to the other controller when production was interrupted by a break.

A line-shaft drive should be considered because of more straightforward maintenance, though thyristor-controlled drives were reported as reliable.

Elaborate paper-machine hoods and ventilation systems should normally be unnecessary in warm climates. No special ventilation of the pockets between drying cylinders is likely to be necessary for machines trimming less than about 3 m wide; a simple hood with an extraction fan of adequate capacity should suffice for the dryer section or for a Yankee dryer. Extraction fans should also be mounted on the walls of the machine house just below the ceiling with air inlets at floor level. Air and machine room heating is unnecessary unless the outdoor temperature falls below 10°C for long periods.

To simplify the calenders, a three- or four-roll stack without swimming rolls is suggested as adequate for many writing, printing, and packaging grades of paper.

Where there is a sufficient demand for tissues and they are costly to import, advantage may be taken of the relative simplicity of the tissue machine, which has only one drying cylinder. On it toilet paper may be made largely from waste paper; fruit wraps, bread wraps, coloured tissues can additionally be made (and, if necessary, M.G. papers at reduced efficiency). A tissue machine is one of the least costly machines available, but it has a small production (e.g. 10 tons/day).

Machinery to make solid boards in small quantities can be purchased for a fraction of the cost of a modern machine to produce boards in reels or sheets if a simple discontinuous board (wet-lap) machine is built with a hydraulic press and perhaps a tunnel dryer.

The lowest investment per ton of paper for a new paper machine is likely to be obtained when the trimmed width is 4.5-6 m, assuming a standard Fourdrinier with standard drying sections. A 3.5-4 m width is optimum for high-speed tissue machines. For writing and printing papers, the investment per ton of paper may be 70 per cent higher if the machine is designed to produce 30 tons per 24 hours, per metre width, than if it can produce 60 tons/24 hours/m width, or about 25 per cent higher if designed to produce 45 tons/24 hours/m width. However, those specific productions were considered too high for developing countries because they necessitate a high degree of automation, which may prove difficult to master without immediate service from suppliers and well-qualified operating and maintenance staff.

A steady electricity supply must be ensured to a paper-mill. If electricity is purchased from a public supply which is known to be subject to voltage variations, a voltage regulating transformer is required. The boiler plant can be purchased economically because usually 3 kg/cm^2 pressure is sufficient.

Improving the efficiency in pulp- and paper-mills of developing countries

Efficiency war tentatively defined in several ways, but the range of ways suggested for improving it was so wide as to make any one definition of little value. The suggestions for improving efficiency could be grouped in categories such as:

(a) Wise initial concept to ensure that every factor which could affect the efficiency and economy of the final project had been taken into consideration and correctly assessed;

(b) Careful planning and strict control during the stage of ordering and erection to ensure the minimum capital expenditure consistent with the building of a good mill;

(c) Improving the efficiency of the mill staff by training management, supervisors, operators and mechanics to get the best out of the plant;

(d) Astute management of all material and social aspects when the mill is operating;

(e) Auditing performance of operators and operations (the latter by comparison with performance of similar operations in other mills);

(f) The rationalization of the production and production programme, the systemization of maintenance and the standardization of spare parts;

(g) Constant attention to forward planning so that every advantage is taken of new developments in markets, technology and raw material supplies, and that changes in the end-uses are foreseen.

It was felt that efficiency in mills in developing countries tended to be low - sometimes very low. Means to improve the situation should be given urgent attention.

When the mill is the first mill to be established in a country, the lack of trade experience and expertise may lead to errors in initial concept, which may be a constant burden throughout the life of the mill or may lead to bankruptcy.

The minimum planning period must be five years before production is to begin. It is the minimum and assumes that an adequate supply of fibrous raw material would then be available. If the raw material is to be grown on plantations, planning must commence earlier.

One of the most difficult causes of inefficiency to remedy is the pulping of an unsatisfactory raw material, which may be expensive to pulp, which produces poor quality pulp that hinders the efficient operation of the paper machine, or which restricts the range of papers which can be made. Several non-woods display such disadvantages.

In order to plan the size of mill to be built, an expert forecast of the trends in demand must be made, especially to avoid the financial risks of completing a mill before an adequate market exists. Subsequent expansion must be foreseen and not be restricted by an inadequate raw-material supply at a reasonable price.

Expert advice is needed in selecting the optimum site, taking into consideration transport facilities, proximity to the market, infrastructure, the availability of personnel, water supply and effluent disposal.

When the fibrous raw material is an agricultural by-product such as straw or bagasse, the paper-mill may experience difficulty in establishing sufficient control over supplies. Unexpected problems of collection and misunderstandings with producers can deprive the mill of fibre. Discussions with mills in other countries that have faced these problems may help avert difficulties.

The high capital cost of pulp and paper equipment and its effect on production costs requires efficiency in operating the plant at or above nominal full capacity with the fewest interruptions. Sometimes complicated refinements in processes or machines intended to improve efficiency can reduce it, if the complexities are more than can be mastered by inexperienced operators or maintenance staff.

In planning plantations of fast-growing trees, it is important to remember that the pulping properties of trees of one variety grown in one country or site, may differ widely from the pulping properties of the same variety grown in another country or site. Age also has a profound effect on pulping properties. It is therefore necessary to perform pulping tests on representative samples from trial plots in order to choose the best varieties for propagation. It is also often possible for a developing country to have the costly pulping trials performed at little or no cost under certain bilateral aid programmes.

Pre-planning can to a great extent determine the efficiency of a mill. Wise pre-planning is required before any commitments have been made. The Expert Group welcomed the fact that the advice of United Nations experts and other competent advisers was increasingly being sought during the pre-planning stage.

Proper training of staff was vital for an efficient mill. Before start-up, the training programmes could be carried out:

(a) In modern mills in industrialized countries;

(b) In mills which pulped similar raw materials or produce a similar range of products;

(c) In mills in countries where language was not an obstacle in communicating with the trainees;

(d) On site in the mill itself by expatriate staff;

(e) On site by employees of a foreign paper company which had agreed to provide know-how, possibly in joint participation.

Training programmes of types (b) and (c) could be preferable to those of type (a). When a mill is supplied on a turn-key basis, the agreement should provide for the participation of local people in the design stage, as their participation itself gives valuable training.

Mixed tropical hardwoods

Mixed tropical hardwoods could be used as a basis for a pulp and paper industry in developing countries although they had limitations. The characteristics of the unbleached pulp will at best be equivalent to those of a moderate-quality hardwood pulp and therefore would be less suitable as the main constituent of strong papers for packaging; bleached pulp from mixed hardwoods could be more useful (but its use in India was stated to have seriously lowered the quality of the paper produced). Mixed hardwoods are unsuitable for groundwood pulp for newsprint except in special circumstances. However, as a source of pulp-wood they have two advantages: they provide an immediate supply of wood, which may be important when a paper-mill is to be built but no provision has been made in advance to grow good paper-making raw materials; the use of the wood helps to pay for clearing the forest for the plantation areas.

When planning a pulp- and paper-mill to supply the needs of a developing country, plantations of trees known to have good pulping and paper-making characteristics should be considered in preference to mixed hardwoods. In the tropics, fast-growing pines usually mature in 12 years and fast-growing hardwoods in 6 years. Trees in general and pines in particular can usually grow on poorer land than is desirable for agriculture.

When mixed wood can be obtained inexpensively as waste (offcuts and veneer cores from large saw-mills), their use should be carefully considered because the advantage of low cost may offset the economic disadvantages, and the number of species is likely to be fewer than occur in the forest.

Mixed tropical hardwoods might be used in the manufacture of:

(a) Bleached pulp for export. It would be unwise to assume that bleached pulps made from mixed tropical hardwoods could compete with the temperate hardwood pulps which have now reached a high standard of quality in the northern hemisphere. However, it has been shown that mixed woods in certain areas might be made into pulp acceptable for several purposes in industrialized countries. The pulp would be blended with stronger pulp. Under present market condition, the production of such pulp should be examined with caution as it could only be viable in exceptionally favourable circumstances. An export pulp mill must constantly market a very large output, usually more than 400 tons per day;

(b) Bleached pulp for the local market. It could be made where the combined demand from several existing paper-mills for pulp of the type produced would be sufficient to sustain a pulp-mill of viable size (which could be smaller than for an export pulp-mill). Each consumer would blend the pulp with some stronger pulp;

(c) Bleached pulp used in an integrated paper-mill for making standard papers. Such papers normally contain a proportion of hardwood pulp but in ordinary practice it is always blended with a longer-fibred pulp (usually from coniferous woods). If the proportion of longer-fibred pulp is insufficient, the paper may be low in quality and non-competitive except in a protected market. The longer-fibred pulp may be imported or made locally from pine or from bamboo, which is generally less satisfactory than pine;

(d) Unbleached pulp for strong packaging papers. The papers, which include sack kraft, are usually made from long-fibred coniferous wood pulp and it is impossible to make them of equal strength from hardwoods with their inherently short fibres. The quantity of hardwood pulp that can be added will depend on the strength of the mixed hardwood pulp and on the specification of the papers which is locally acceptable. The latter is determined partly by competition from imported paper. A higher quality of extensible paper was produced in one mill using mixed hardwoods by improving the sack kraft through the Clupak treatment;

(e) Unbleached pulp for common packaging papers. The papers, which include counter rolls and paper for small bags, vary considerably in quality. Hardwood pulp is unsuitable alone because of its short fibres, but a fair proportion of it may be used together with long-fibred pulp (or possibly waste from imported kraft papers) to make paper for many purposes. A proportion of hardwood pulp can be incorporated in liner board depending on the end-use and competition;

(f) Corrugating medium for corrugated cases. It is frequently made entirely from hardwood semi-chemical pulp. Mixed tropical hardwoods are being effectively used, but a cautious approach is recommended because there is evidence that the techniques which are used for temperate hardwoods may not suit mixed tropical hardwoods. Furthermore, some woods might not impart adequate rigidity to the paper;

(g) Groundwood pulp for newsprint and magazine papers. The wood should be uniform with medium- or low-density and preferably light-coloured and clean. Though mixed forests may contain a proportion of such wood, its selection from the other wood is unlikely to be economic for pulp-making, but if such selection has already been made by a saw-mill or plywood plant, their waste wood could prove suitable for refiner groundwood pulp.

The advice of forestry experts should be sought before clear felling forests because the consequences of badly managed clear felling such as soil erosion, the loss of fertility and other ecological disturbances can be very serious. Cleared forest land is often fertile and it should not be assumed that reforestation is the only or the best use of the cleared land; it may be better used for agriculture.

Natural regeneration after tropical forests had been clear cut was not recommended because the composition of the regrowth was usually unpredictable, and the rate of growth was feeble compared with the rate of selected fast-growing plantation species with good paper-making characteristics. Replanting

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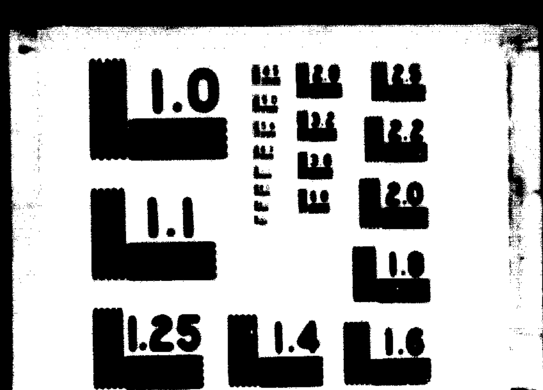

may prove much more difficult than expected. Large-scale field trials should therefore be made years in advance of clear felling to determine the programme of replanting the cleared land. Each team felling trees in a mixed forest should be accompanied by an expert in the local trees who can ensure that unacceptable species are not supplied to the mill.

It was most strongly recommended that steps be taken to balance the wide variations in the proportions of species in consignments arriving from the forests, because such variations cause grave problems in pulp and paper production. Some advisable methods are mixing the logs from consignments from different forest areas before they are chipped, mixing the chips in outdoor chip storage piles, or a combination of both methods. The alternative of grouping logs according to their pulping and paper-making characteristics as they arrive was considered uneconomic and was not recommended, except possibly when the wood is saw-mill waste or is derived from several sources each supplying different but single species. Rough selection can then be made, for example, selecting by colour and density the logs suitable for groundwood and those for chemical pulping. Some selection of mixed forest wood is recommended as it is always necessary to eliminate very undesirable species which would damage machinery or contaminate the pulp.

A chipper for mixed hardwoods should be selected on the basis of the dimensions of the logs, crookedness, hardness and silica content of the species. The mouth of the chipper may have to be larger than would be necessary for chipping the same quantity of uniformly grown straight trees in order to accept different sizes and shapes of logs. It may be necessary to use laminated chipper knives for hard logs which would unduly damage normal knives.

When projecting a chemical recovery plant, precautions should be taken against the effects of fines from hardwood pulps which may foul evaporators, of extractives which may influence viscosity and the possibility of silica, if there is a high proportion of silica-rich woods in the mixture.

When mixed hardwoods and longer-fibred materials such as pine or bamboo are pulped in the same mill, separate cooking of the two sorts was generally recommended, especially for the manufacture of strong papers. They may be processed together for cultural papers when strength is less important, but to do so is a disadvantage and is only recommended because the installation of a single processing line reduces capital expenditure.

The long duration of pre-impregnation and cooking helps to minimize the effect of the heterogeneity of mixed woods. Rapid cooking was not recommended. The Sloman counter - current process was suggested as a potentially beneficial process.

The manufacture of dissolving pulp from exotic raw materials

The Group concluded that dissolving pulp for rayon staple fibre could be made from non-wood raw materials. It was generally less satisfactory technically and economically than manufacture from woods. A country needing to give precedence to import substitution over competitiveness could, however, make dissolving pulp for a limited range of products from several non-woods.

The evident economic and technical success of manufacturing dissolving pulp from plantation-grown eucalyptus and other woods, including (with certain limitations) mangrove and rubberwood, contrasted with the economic disappointment experienced in using the non-woods Arundo donax and Phragmites communis reeds, which had been abandoned in two plants and replaced with beech wood.

The group urged that as much attention be given to the low consumption of textiles in developing countries as is given to the low consumption of paper and that more consideration should be given to the production of dissolving pulp for the manufacture of textiles.

The use of waste paper in the paper industry of developing countries

When purchasing waste-paper repulping equipment for a developing country from a supplier in an industrialized country, it is important to ensure that the design is appropriate. In some developing countries, waste contains much objectionable material liable to damage machinery, which is not sufficiently robust or appropriate to handle it.

The economy of waste-paper utilization must depend considerably on the capital charges per ton of product. In order to keep investment to the minimum for efficiency, it is important, therefore, to decide the extent of necessary improvement to the waste by screening and cleaning, ink dispersion or removal, bleaching, etc. The machinery installed should be as simple as possible to perform those tasks. For the main uses as boards and test liners, screening and cleaning may be sufficient with the help of chemicals in the slusher. To replace bleached wood-pulp, de-inking is likely to be required possibly with bleaching. A plant for the former task can possibly be designed and partly constructed locally, whereas for the latter task, a much more sophisticated plant is required.

The use of waste paper should be considered strictly on its technical and economic merits. Where virgin pulp is scarce, expensive or of inferior quality, waste paper assumes more importance than where good pulp is freely available at acceptable prices.

Waste paper may be considered for partial replacement of the virgin pulp used in paper made in developing countries, both when the mill otherwise used only imported pulp and when it uses imported pulp to reinforce locally made short-fibred pulp. Waste paper is probably most useful in grades which do not need to be free from specks such as boards, test liner, corrugating medium and toilet paper.

In developing countries where wages are low, it may be econimical to sort waste paper. Sorting may enable mixed grades to be used more profitably.

When it is planned to pulp waste paper, care should be taken to allow for effluent disposal because the effluent is likely to be highly polluting both because of its content of fine fibre and loadings and because of its biochemical oxygen demand (BOD).

The production and sale of de-inked waste paper from a repulping mill to a number of paper mills is not generally remunerative. It is difficult to recover the cost of drying the pulp, while the transport of moist pulp is uneconomical unless the paper-mills are located close to each other.

When waste paper is purchased from abroad, it should be specified that the bales should be of high density, but the gross weight of each bale should be limited to the size that can be conveniently handled locally, especially if the bales have to be man-handled, as is often the case. Arrangements should be specified in the contract for financial compensation if any part of a delivery cannot be used, but claims are difficult with imported waste, and it is best to have a reliable supplier or inspection before shipment.

The use of de-inked newsprint should be considered as a raw material for a small newsprint mill. Bundles of over-issue newspapers are desired rather than mixed waste.

IV. RECOMMENDATIONS TO UNIDO

The Expert Group made a number of general recommendations with regard to the pulp and paper industries in developing countries. It recommended that UNIDO should:

(1) Organize periodical conferences between developing countries in the same geographical region to discuss and exchange the results of research and information on pulp and paper manufacturing problems;

(2) Encourage the establishment of regional technical and management associations similar to those found in industrialized countries;

(3) Inform the pulp and paper industries of developing countries about recent advances and about publications which are of special concern to them;

(4) Explore the problems associated with the dissemination of technical information in the developing countries and identify means by which information can be made available;

(5) Contact countries which have few or no pulp and paper industries as yet and offer to assist with pre-planning at the earliest possible stage with a view to the ultimate establishment of a remunerative and efficient industry. The twofold aim would be to select the best raw material so that, if necessary, plantations could be commenced in time for the material to come to maturity before it is required and to ensure an unfailing supply of raw material to the industry, both initially and after foreseen expansion, by securing the allotment of sufficient land that is favourably located with regard to the pulp- and paper-mill;

(6) Give special consideration to the merits and problems of purchasing used machinery with a view to reducing the large investments required in pulp- and paper-mills;

(7) Make known the assistance it can give in checking feasibility studies before an order is placed for a pulp- and paper-mill or equipment. In view of the large investment involved, a second opinion may be an important safeguard.

With regard to newsprint from bagasse, the Expert Group recommended that UNIDO should:

(1) Consider whether the establishment of a demonstration plant should be encouraged;

(2) Seek to establish in government personnel a sympathetic awareness of the problems of potential investors or participants in newsprint projects and suggest the steps they might take to help to establish the confidence required to attract investment participation;

(3) Urge adherence to anti-dumping agreements concerning newsprint;

(4) Encourage regional participation because the output of a newsprint mill of viable size may exceed the demand in a developing country;

(5) Assist Governments in the formulation of procedures such as the imposition of tariffs or restrictions on imports which could protect an indigenous newsprint industry in its early years with the minimum of adverse consequences;

(6) Provide suitable informed and objective experts to assist a group planning a bagasse newsprint mill to choose the process most appropriate for the particular circumstances. This could help to overcome the doubts concerning technical and economic feasibility which deflect financing organizations from supporting bagasse newsprint projects.

With regard to rubberwood, the Expert Group recommended that UNIDO should:

(1) Continue the collection and dissemination of technical information concerning the special problem of rubberwood pulping;

(2) Negotiate arrangements with companies which use or have used rubberwood for pulp and paper, for making their experiences available to developing countries;

(3) Organize further discussion of the problems of using rubberwood, preferably as part of a regional meeting in South-East Asia on pulp and paper production;

(4) Consider how research in an appropriate existing laboratory to resolve problems, particularly those concerning latex, might be financed.

With regard to low-cost pulp and paper mills, the Expert Group recommended that UNIDO should:

(1) Assist in establishing an independent technical inspection service which will assist developing countries in the purchase of used machines with the ultimate object of obtaining finance and government approval;

(2) Issue a publication on methods for reducing costs in the construction of pulp and paper-making facilities in developing countries;

(3) Identify consultants, engineering companies or machinery suppliers who could participate in projects in which second-hand machinery is used to the satisfaction of the financing organizations and the purchaser;

(4) Maintain a register of used equipment such as paper-machines, complete mills and major items of pulping equipment currently available or about to become available, for the benefit of those who may be projecting installations in developing countries, and by putting the interested parties in touch with each other;

(5) Prepare a schedule of equipment that indicates which components are basically essential, which design features and materials of construction may minimize the price without sacrifice of efficiency under the conditions in a developing country, and also which features are sophistications which could be safely omitted or deferred until the mill's output is to be expanded;

(6) Advise on the best commercial approach to purchasing a mill comprising several sections in order to obtain the best value for money, bearing in mind that the cost of machinery can be increased in the course of a possible subcontracting;

(7) Consider means for encouraging the manufacture of certain appropriate equipment in developing countries. Countries with their own sugar industry may have considerable engineering facilities available which could manufacture some equipment.

With regard to maintenance and efficiency, the Expert Group recommended that UNIDO should:

(1) Provide advice on the preparation of maintenance schedules and on maintenance techniques;

(2) Promote a wider knowledge of its advisory services for improving efficiency;

(3) Conduct surveys of existing mills to identify the improvements that would be most beneficial for efficiency and carry out cost/benefit analyses, where more than small expenditure would be involved;

(4) Issue guidelines for efficient processing and techniques for lowering the consumption of raw materials and for the quality control of finished products in pulp- and paper-mills;

(5) Assist mills in developing countries with the rationalization of production by the reduction of the number of grades, sizes and finishes of paper produced;

(6) Facilitate the training of mill managers, maintenance, operating and technical control personnel from developing countries in pulp and paper mills of high technical efficiency in industrialized and developing countries where the same languages are spoken;

(7) Consider the possibilities for regional research and development laboratories or other means for assisting mills in small or poor countries unable to afford their own research and development facilities.

With regard to mixed tropical hardwoods, the Expert Group recommended that UNIDO should:

(1) Disseminate information on the commercial use of mixed tropical hardwoods for pulp and paper and on technical developments;

(2) Complete a survey of pulp- and paper-mills using mixed tropical hardwoods with as complete data as possible on the species being pulped, the species being rejected, pulping and chemical recovery, paper making and paper properties;

(3) Accelerate programmes for the development of certified sources of seed of accurately known provenance for plantations of fast-growing species and indicate to foresters sources of advice regarding which species to try in the local environment for specific end-uses;

(4) Co-operate with FAO in efforts to minimize the risk of ecological damage from clear felling or from unwise use of the cleared land;

(5) Provide information to help pulp-mills in the tropics minimize the deterioration of stored wood caused by fungi and insects;

(6) Assist Governments with the formulation of revised standards of quality in paper specifications to permit the use of poor-quality mixed hardwoods in countries that lack the foreign exchange to import pulp or paper.

With regard to the manufacture of dissolving pulp from exotic raw materials, the Expert Group recommended that UNIDO should:

(1) Extend its attention to the low consumption of textiles in developing countries and the role that man-made fibres from dissolving pulp could play in overcoming it;

(2) Encourage developing countries to use good cellulosic raw materials and proven processes for the production of dissolving pulp because they are generally unable to overcome the technical problems which almost inevitably arise;

(3) Facilitate pilot-scale trials to determine the suitability of a locally grown wood or other raw material for a projected dissolving pulp plant and experimental work to overcome problems with those materials;

(4) Assist with feasibility studies, not only of the production of dissolving pulp, but also where a filament or film plant exists, with studies of the effect on the plant's operation and on the quality of its products of the substitution of the imported pulp normally used with locally made pulp. The extent to which the local pulp could replace the imported pulp should also be considered;

(5) Advise on the storage of fibrous raw materials before pulping in tropical or subtropical countries where deterioration in storage tends to be more rapid than in temperate zones when the deterioration affects the quality of the dissolving pulp;

(6) Encourage the collaboration of experienced producers of dissolving pulp and cellulose derivatives with prospective producers in developing countries to help provide the latter with the highly specialized technical and commercial know-how of this industry and maintain a roster of consultants specializing in the industry.

With regard to the use of waste paper in the paper industry of developing countries, the Expert Group recommended that UNIDO should:

(1) Draw the attention of the developing countries to the possibilities which exist in exploiting the waste-paper resources in their respective countries;

(2) Advise mills in developing countries contemplating the use of waste paper as to the best first steps to take in this respect;

(3) Study of the use of waste paper imported from developed countries into developing countries, for example in the production of newsprint;

(4) Assist countries which are short of pulp and which must therefore use much waste paper to formulate reduced standard specifications for the physical properties of papers which would be adequate for the consumer, but which could be met when a substantial proportion of waste paper is incorporated in the paper furnish;

(5) Consider the formulation of guidelines and the preparation of indicative drawings which would enable a paper-mill in a developing country with adequate engineering facilities to build its own waste-paper slushing and screening plant using partly imported and partly locally made equipment;

(6) Prepare a selected bibliography covering all aspects of waste-paper utilization that are likely to be of interest to developing countries.

Annex

LIST OF DOCUMENTS PRESENTED TO THE MEETING[a]

ID/WG.102/1	Agenda
ID/WG.102/2	List of participants
ID/WG.102/3	How to build a low-cost paper mill in developing countries Karl Zappert, United Kingdom of Great Britain and Northern Ireland
ID/WG.102/4	Newsprint from bagasse: past and possible future action Eduardo J. Villavicencio, United States of America
ID/WG.102/5	A practical approach to waste paper utilization in developing countries Harvey B. Herman, Dominican Republic
ID/WG.102/6	Prospects for bagasse newsprint in India S.R.D. Guha, India
ID/WG.102/7	Use of mixed tropical hardwoods for production of pulp and paper in India D.K. Ganguly, India
ID/WG.102/8	How to raise the level of efficiency in the pulp and paper mills of developing countries T. Jeyasingam, Ceylon[b]
ID/WG.102/9	Collection and utilization of waste paper in Ceylon T. Jeyasingam, Ceylon[b]
ID/WG.102/10	Practical experiences in the use of mixed tropical hardwoods for production of pulp and paper A. Panda, India
ID/WG.102/11	Experiments on the Indonesian rubberwood as raw material for pulp and paper Alaudin, Soeprapti K, Moehji Rn, Sri Margono, Hendayani TA, Soetrisno and Kahar, Indonesia
ID/WG.102/12	Achieving a high level of efficiency in the pulp and paper mills of developing countries E. Crane, Australia
ID/WG.102/13	The special problems involved in developing, building and operating pulp and paper mills Joseph E. Atchison, United States of America
ID/WG.102/14	Trends in pulping of mixed tropical hardwoods Lars C. Bratt, United States of America

a/ A limited number of copies of the documents are available from UNIDO upon request.

b/ Now designated Sri Lanka.

ID/WG.102/15	Practical experiences in the use of rubberwood for the production of pulp and paper D.L. Stacey, New Zealand
ID/WG.102/16	How to build a low cost pulp and paper mill in developing countries P.B. Chaudhuri, Sweden
ID/WG.102/17	Practical experiences in the use of mixed tropical hardwoods for the production of pulp and paper Julius Grant, United Kingdom of Great Britain and Northern Ireland
ID/WG.102/18	Newsprint from bagasse Youssef A. Fouad, United Arab Republic[c]
ID/WG.102/19	How to raise the level of efficiency in pulp and paper mills in developing countries O.T. Dalley and A.W. Hooloway, Canada
ID/WG.102/20	Dissolving pulp from mangrove woods and para rubberwood T. Kayama, M. Nakamura and A. Nagoshi, Japan
ID/WG.102/21	Practical experiences on pulping mixed tropical hardwoods Pablo R. Cardenas, Colombia
ID/WG.102/22	The utilization of waste paper in the paper industries of developing countries Foster P. Doane Jr., United States of America
ID/WG.102/23	How to build a low cost paper mill in developing countries A. Binder, the Federal Republic of Germany
ID/WG.102/24	Manufacture of dissolving pulp from exotic raw materials Yehia Fâhmy, United Arab Republic[c]
ID/WG.102/25	Formulation of a set of rules for a systematic repair and maintenance service in the pulp and paper industries of developing countries Stanley J. McGilvray, Australia
ID/WG.102/26	Manufacture of dissolving pulps from exotic raw materials J. Nowakowski, Poland
ID/WG.102/27	Practical experiences in the use of mixed tropical hardwoods for the production of pulp and paper B.B. Gupta, India
ID/WG.102/28	Retrospects and prospects of newsprint from bagasse S.R. Krishnaswamy, Cuba
ID/WG.102/29	Bagasse newsprint P.W.R. Jolley and D.S. Cusi, United Kingdom of Great Britain and Northern Ireland
ID/WG.102/30	How to build a low-cost pulp mill in developing countries Erik J. Van den Ent, Ulf G. Roos and E. Norman Westerberg, Finland

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c/ Now designated Egypt.

ID/WG.102/31	How to raise the level of efficiency in the pulp and paper mills of developing countries V.P. Poddar, India
ID/WG.102/32	List of documents
ID/WG.102/33	Practical experiences in the use of mixed tropical hardwood for the manufacture of pulp and paper B.K. Mayer, United States of America

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