# PAPERMAKING

## AND MANUFACTURE OF PAPER PRODUCTS

## as a Small-Scale, Semi-Mechanized and Cottage Industry

MATERIALS--PROCESSES--EQUIPMENT
ORGANIZATION--ECONOMICS--MARKETING

JUNE 1958

TECHNICAL AIDS BRANCH, OFFICE OF INDUSTRIAL RESOURCES
INTERNATIONAL COOPERATION ADMINISTRATION
WASHINGTON 25, D. C.

Because this Manual represents a new kind of paper technology based on the synthesis of the time-honored techniques of handmade paper wit. the applicable know-how of mass production --

# YOU SHOULD PERHAPS CHECK AGAIN

even though you may have considered papermaking as a small-scale industry earlier and found it not feasible --

# IF YOUR PROBLEM WAS:

LACK OF SKILLED MANPOWER (this Manual has a device which may eliminate the need for special skill in your country)

LACK OF RAW MATERIALS (this Manual has a substantial list of possible new fiber sources to check for your country)

A LIMITED WATER SUPPLY (this Manual suggests how some kinds of paper can be made with very limited water)

A PAPER MILL ALREADY SUPPLIES STANDARD PAPERS (this Manual suggests many paper products and specialty papers that are useful and may provide continuing employment)

A PRIORITY NEED FOR OTHER INDUSTRIES (this Manual suggests how papermaking fits in closely as a part of other industries in a practical way and helps the entire economy)

A POLICY TO CONCENTRATE ON CENTRAL-FACILITIES INDUSTRY (this Manual suggests that papermaking use this approach)

A DESIRE TO STIMULATE ONLY PERMANENT INDUSTRIES (this Manual suggests the manufacture of a wide range of products of lasting importance to the economy)

SEE OTHER SIDE FOR SPECIAL GUIDE FOR SPECIAL PEOPLE

# THIS MANUAL HAS SPECIFIC INFORMATION FOR YOU IF YOU ARE A--

GOVERNMENT OFFICIAL interested in improving your country's paper supply. See:

Pages 1-23, 127-146, 161-212

GOVERNMENT OFFICIAL interested in advancing a broad industry program. See:

Pages 7-9, 127-158, 182-197, 204-205

INSTITUTE OFFICIAL considering papermaking as an Institute function. See:

Pages 1-10, 198-210

AGRICULTURAL LEADER looking for a way to use residues, or workers in off-season periods. See:

Pages 9-10, 27-57

CO-OPERATIVE LEADER studying the possibility of papermaking as a co-operative industry. See:

Pages 11-23, 198-210

FORESTRY INDUSTRY LEADER looking for ways to expand your activities. See:

Pages 7-8, 16-23, 58-64, 76-77, 161-181, 204-205

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## and Manufacture of Paper Products

a manual by

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for

TECHNICAL AIDS BRANCH, OFFICE OF INDUSTRIAL RESOURCES

INTERNATIONAL COOPERATION ADMINISTRATION

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Acknowledgment is also made of the considerable use made of the two standard and admirable English-language dictionaries of papermaking: the American Paper and Pulp Association's Dictionary of Paper and E. J. LaBarre, Dictionary and Encyclopedia of Paper and Paper-making (see Bibliography).

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PART ONE

# Understanding the Possibilities

CHAPTER 1

# The Impact of a Small-Scale Papermaking Industry

To make really high quality paper requires very great skill and trouble indeed. And to mass-produce paper takes millions of dollars and a substantial technical knowledge and resources.

Nevertheless, it is a lot easier--and a lot cheaper--to make some kind of usable paper than perhaps many people think. And of the 90 nations and territories in the world, 70 of them do produce paper or paper board of some kind in at least small amounts.

In the underdeveloped areas of the world, where both paper and money are scarce, it may be well worth exploring the various simplified ways in which paper may be made economically--especially because of recent technological advances which may change a previous decision not to undertake or expand a papermaking industry. Even if there should happen to be a local mechanized paper mill, a small-scale paper industry is also worth looking at. This is because of the special papers which may result and because of the way the making of such papers may be tied in with the making of many other products which the industry and the people of the area need. New chemicals and processes make more of these possible for an underdeveloped area, than may be imagined.

## COMBINATIONS OF TRADITIONAL AND NEW PRINCIPLES

This Manual suggests many applications of modern technology to small-scale pulp and papermaking, combining old and new principles for both hand and semi-mechanized operations. One particular example is the description of a new, very simple and inexpensive "paper box" that takes away the need for special skill in the forming of a sheet of paper by hand. With this device, the technical authorities in a country may work out the recommended fibers and treatment which are best under the circumstances, and the actual paper-making process may be introduced into the home for cottage industry with a minimum of training and with almost no capital outlay required. It is possible that in some areas the "paper box" can become as much a tradition in homes as the handloom. Similarly other new techniques of papermaking may become part of a country's skills.

And because this is an industry which can be based on waste materials or agricultural residues, using off-season labor, it offers a country almost "something for nothing." A multi-million-dollar paper mill may not be available to an area to produce the paper which the people need if they are to develop and progress toward their goal of self-improvement. But the people themselves, by the cumulative effect of cottage industry production, may accomplish at least some of the same result as the paper mill. They can do this if the government officials, the engineers and the other leaders involved will in fact take the leadership.

## SHORTAGE OF LOCALLY-PRODUCED PAPER DELAYS A COUNTRY'S PROGRESS

Paper is a civilized material which has resulted from the contributions of peoples around the world. It belongs to all of them jointly, with the great benefits of communication and convenience and service it makes possible--because it has been developed by joint efforts.

The Chinese invented paper. The Koreans and Japanese developed it to a fine hand art. The Arabs first used rag paper and introduced it to the West. The West developed the wood pulps and the highly-complex technology which made mass production of paper possible. And through all these combined efforts, the servant Paper is now available to help all the peoples of the world insure their freedom and improve their way of life. Where a shortage of paper hampers this effort, those in charge have the responsibility of developing an adequate supply.

The effect of a paper shortage has been described by the Food and Agricultural Organization (FAO):

> " . . . the effects may pass almost unnoticed; somewhat fewer books [are] printed and fewer newspapers read than might have been; schools economize more in their use of stationery; packaging standards [do] not achieve quite the same hygienic level. There [is] no crisis; but there [is] a steady, if hardly perceptible, brake on progress."

FAO concludes that:

> " . . . in any region or country, so long as a substantial proportion of pulp and paper supplies is imported, consumption is not likely to expand as rapidly as it would if there were ready access to domestically produced pulp and paper. The available historical data concerning production, consumption and trade in the less developed regions amply confirm this conclusion.
>
> " . . . In the longer term, unless efforts are made to encourage a more rapid expansion of domestic production, lack of adequate supplies of paper may hamper educational and cultural progress and economic advance."

The problem may be summarized by one set of figures: almost half of the 90 nations and territories in the world (41, to be exact) each consume less than 10 pounds of paper a year, per capita. The United States per capita consumption is 432 pounds a year.

Just how a particular country should go about increasing its domestic supply is a question beyond the scope of the Manual to answer in detail. What this Manual can and does do, in this connection, is to describe the various considerations which should be taken into account in answering the question, particularly in relation to the establishment or expansion of papermaking as a small-scale or cottage industry. The appearance of this Manual is no endorsement of the practicality of a paper industry in any given locality, nor the guarantee of its economic feasibility. It is intended simply to suggest and explain the various elements which should be investigated to determine whether local conditions do in fact make such an industry program locally advisable. Specifically, it introduces new evidence for an industry that may once have been studied and vetoed: it may be that a combination of indigenous and Western technologies may represent a new avenue of economic improvement.

## WHERE MASS PRODUCTION IS NOT EVERYTHING, PAPERMAKING CAN BE DONE MORE SIMPLY

The paper industry involves a major technology, of course. There are whole libraries of books and professional articles; many thousands of scientists and engineers are engaged in researching the field and experimenting with processes and equipment; new findings and new techniques are constantly being introduced; special chemicals and careful blends of fibers are the rule rather than the exception in many papermaking plants. Cheap, unlimited fresh water is essential. For good reason, papermaking is considered an intricate, heavily capitalized industry, with specialized requirements.

Yet this is not the important fact, in a country which may not be able to sustain a papermaking industry on the highly technical level. Paper can also be made simply and cheaply, for many purposes. Because airplanes, railroads and powerful automobiles can speed people from point to point, should it be said that it is no longer possible or useful to walk? Similarly, it need not be thought that a papermaking industry, on a cottage scale, is either impossible or not useful. It is certainly possible to develop papermaking as a small-scale or cottage industry; it may also prove quite worthwhile.

The reason that papermaking is such a highly-skilled, expensive and difficult production problem in America and Europe is that the industry there is intended to serve mass production of paper products (such as printing and packaging) which require high-speed handling through intricate machinery, and which must meet exacting standards, without causing any trouble in production. If a country's need for paper is not that demanding, then the problem becomes much simpler. For slower, simpler machinery or for hand use, it is possible to make adequate paper with much less trouble and expense, and with no more water than most other

industries. Such paper may serve well enough for writing or calligraphy, and for letterpress printing on small hand-operated equipment that takes cut sheets. It may do also for wrapping paper and for bags. And it may be the basis for other products, such as sandpaper or roofing paper, which need paper as a "raw material."

It is certainly true that some countries have natural resources which make them particularly able to have papermaking industries. For instance, the northern and northwestern parts of the United States, with an abundance of conifer forests and clear water in unpopulated areas, are ideal for mass-production of paper. Japan, with an especially suitable mulberry fiber, does exceedingly well by handmade paper.

But this is by no means the whole story. Just as important is the desire to have paper; and with enough interest and effort, all but a very few countries can have papermaking industries. This perhaps could not have been said a few years ago; but today, experiments have shown ways to make paper from a great range of fibers, from tropical hardwoods to residue straw. There is no fate that dooms any country to be without papermaking facilities, in most cases; almost any area may achieve this goal if only the leaders really want to go to work on it.

Actually, paper can be made at any level, from a school child without any skill at all making a simple sheet, through many intervening levels of hand skill and machinery, up to the multi-million dollar installations.

Also, as it happens, papermaking consists of several quite distinct steps very different from each other. These can be done at different levels of skill and technique (even though they usually are not).

In addition, because different raw materials and different processes can be used, a variety of papers and paper products can result. There is thus choice as to what should be done, based on the result desired.

There can be, therefore, any combination of (1) levels of operation, (2) types of fibers which may be available, and (3) suitable processes--all to be selected and combined to best meet the local situation. This Manual includes a guide to the various possibilities, although in any given area, technical people on the scene must determine what is possible and desirable in the local situation, and proceed on that basis.

While "small-scale" and "cottage" industry are not necessarily synonymous, and while "semi-mechanized industry" definitely involves a more mechanized level of activity than "cottage industry," the terms are used more or less interchangeably in this Manual (except where the specific meaning requires the particular level to be identified). This interchangeability is necessary because the Manual is actually discussing papermaking on all three levels simultaneously, leaving it to the

reader to decide the level appropriate to his own country. In the same way, there is no real way to distinguish between the starting of a new program in papermaking and the expansion or improvement of an existing industry; again, the range of possibilities is set forth, with the reader free to adapt any of the material which may serve his needs.

## MANY ADVANTAGES TO UNDERDEVELOPED AREAS IN SMALL-SCALE PAPERMAKING INDUSTRY

Paper can be made almost anywhere, but it sometimes may not be worth the cost. The problem, therefore, is to establish the purposes and advantages of papermaking as a small-scale or cottage industry, and determine whether they outweigh the costs.

These are some of the possible advantages:

1. In some particular cases where paper is in short supply and where almost any kind of paper will be better than nothing, the program can at least meet a direct need.

2. It requires no untrainable skills, power supply or large capitalization (at least in its simpler units). It is an industry which can put people to work full time, quickly and usefully, operating simple locally-made equipment.

3. Not only can it make use of surplus men--who are eating anyhow and whose productive contribution need not necessarily be figured on an absolute economic basis--but it does this on a relatively low per capita cost, on a production basis, per ton of output, versus machine-made paper. Also, this is probably a cheaper way to make jobs for them than in many other industries, figuring the total capital investment required to allow them to produce.

4. Where there is an abundance of skilled unemployed labor, this industry can improve their position by letting them develop the manufacture of paper products, art papers and converting papers that will mean a permanent place in the economy.

5. Where there are wastes and agricultural residues not being used, and where there are agricultural workers who need productive work during off-seasons, the program is especially useful.

6. Even where imported paper may be cheaper than can be made internally, there are often reasons why it is not imported--political questions, foreign exchange deficits, import restrictions. Rather than make the economy suffer from a shortage of paper, it might be worthwhile to make paper locally even if the cost does involve a temporary financial loss on the paper as such. The total economy might thus profit from paying a subsidy for paper.

7. Some kinds of crucially-needed paper, such as newsprint, probably cannot be made by small-scale or cottage industry on an economically-sound basis. However, if the industry can make other needed kinds of paper--such as writing paper and the paper for converting into other products--the result will be the release of more foreign exchange for the purchase of newsprint.

8. A small-scale or cottage industry may allow experimenting with new fibers and to some extent with new processes at a relatively small cost. Because most papermaking research in the technologically advanced areas is based on the needs of mass-produced paper, there may well be whole segments of potentiality that do not get adequate researching--and which may contain real advantages for local use in the underdeveloped areas.

9. It is altogether possible, with such devices as the "paper box," that remarkable technical advances might be made indigenously to meet local conditions and materials, once the industry is started.

10. Experience in handmade paper may be expected to lead to the interest and know-how in some entrepreneurs into moving up increasingly into machine papermaking--all the more because it is possible to increase mechanization, quantity and quality by stages and by levels, at least on the pulping and stock-preparation levels. This is, therefore, probably a good way to build the economic basis for a more substantial papermaking industry.

11. The development of a small-scale or cottage pulp and paper industry may, of course, be a substantial aid in developing the technological basis for a more substantial papermaking industry. It achieves a knowledge of fibers, of paper qualities, of equipment; it builds a tradition and trains a generation, upon which a succeeding generation may come into its own on a higher technological level. (Against this must be weighed the possible advantages of a higher subsidy and greater effort to achieve a higher level of paper technology at the outset, to leapfrog early steps along the way.)

12. Small-scale papermaking offers planners an industry which is material-saving oriented, but which can become labor-saving oriented as conditions change; it provides an opportunity to meet immediate objectives without a commitment that can be a handicap later.

13. Because paper is the raw material of industries making paper products, and because modern technology has made possible a remarkable assortment of paper products which can substitute simply and cheaply for more expensive materials, the development of a <u>paper product industry as a specialized form of papermaking</u> may have substantial advantages to the economy and to industrial development. Many of these products can be made by a small-scale or cottage industry.

14. While handmade paper may be judged and operated simply as a

utilitarian program, on economic considerations, it may also serve as an art program. Paper production can:

1. become an art form

2. be a medium for other arts

3. stimulate other arts

4. be the incentive for inventing new arts (such as puppets, mobiles, papier-mache', laminates)

It may also have religious uses, as in China and Japan.

15. Papermaking generally allows a "yes" answer to these questions on the establishment of a small-scale or cottage industry: Does it promise the economic well-being of independent craftsmen? Does it allow for private initiative? Does it require or permit or encourage individual creativeness?

16. In addition, there is an intangible which nevertheless ought to be considered by a leader who is sincerely interested in improving communication within his area. When people take pride in a thing, they use it more; they will use paper more for knowing it is their own manufacture. As a result, writing, reporting, reading, news dissemination, printing--all the factors which make people understand and work with each other to develop their society--will be advanced thereby.

17. Specifically, it may well spur the literacy program, by a two-part effect: (1) increasing the amount of paper available for the program, to develop the reading material needed by the new literates and (2) making the new literacy appreciated and valued all the more highly because of the local effort and pride that goes into making the magic paper on which the reading matter appears.

18. For all the reasons that literacy is desired and communication is developed, the papermaking industry can make a substantial contribution to a key element in economic improvement: an increase in productivity in industry as a whole.

## STIMULATION OF SMALL-SCALE PAPERMAKING INDUSTRY MAY BENEFIT OTHER INDUSTRIES

The possibility of introducing or expanding a small-scale paper industry might well reopen a number of other questions, or raise new ones, in connection with other industries as well. Among these are:

Timber industry -- It is possible that this industry is at a fringe level or perhaps uneconomic because of waste, high transportation costs for small volume of activity, etc. If a pulping operation could be tied to the timber industry--to use the present wastes, such as sawdust

or short pieces, or to share transportation costs and thus increase volume--it might make both the lumber and pulping operations feasible economically, whereas neither one might be so, separately. It should be particularly noted that increasingly there are new processes being developed for utilizing different trees for pulp. Earlier decisions on the value of forest resources--especially tropical hardwoods--should be re-examined.

Construction industry -- Paper is the basis for many items which the construction industry uses. In Japan, for instance, paper is a significant material in a variety of uses. If papermaking units could produce materials for construction purposes, and if the construction industry were tied in with both a lumbering and pulping industry, again the merger of interests might make each one stronger economically, by reducing unit costs and by making more and better materials available.

Papermaking industry -- Where there already may be a pulp or papermaking industry on a mechanized scale to produce newsprint and other printing and writing papers, the advent of a papermaking cottage industry for the making of special papers may nevertheless have advantages. Specifically, it will provide an additional market for its pulp. And it will increase the customary use of paper in the country, a development which ultimately and perhaps quickly creates a bigger market for the mill products themselves.

Printing and publishing industry -- Obviously paper is an important item here, and the industry can profit from the greater availability of one of its principal materials. Specifically, a paper industry should tend to reduce the cost of their paper. The stimulation of the printing and publishing industry normally leads directly to the improvement of an economy in general; therefore, stimulants to the progress of this industry are well worth considering by officials concerned.

Textile industries -- Paper manufacture uses many of the same fibers that are the raw materials of the textile industry. A coordination between the two industries may lead to encouragement of some crops over others; it may make certain crops economically feasible because the papermaker can use residues or wastes. There might even be a central facility for primary treatment of fibers for both textile and pulp processing, with the fibers then going separate ways afterwards, depending upon whether they are to be cloth or paper.

Specifically, there is generally a need for wool felts in the papermaking process (although in some instances, as in Japan with its tamo, felts can be eliminated). The manufacture of these felts might supplement the wool industry (as part of the textile industry).

In addition, textiles and paper are merging into one another in the types of products, with paper serving as a cloth substitute in many uses. This will be discussed also under paper products industry. The development

of "twisting paper" results in a material which can be spun or woven for various purposes--perhaps as part of the textile industry.

Chemical industries -- Pulp and paper making involves certain chemicals, such as starches and dyes, which may likewise become economically feasible for an industry if the papermaking market is added to other potential markets. If chemical industries already exist, papermaking adds to business.

Waste materials industry -- In countries where materials are scarce (and even in the United States) it is often economical to collect waste materials--such as old rags, rope and waste paper--for re-use. These particular wastes can convert to new paper fairly easily and economically. Cotton and linen rags in particular make excellent papers which can command premium prices.

Water industry -- In an area which requires special purification equipment to provide a healthful drinking supply or good water for industrial purposes, the additional needs of a papermaking industry may affect cost ratios and size requirements. Where the need for fresh water is otherwise not great enough to justify purification equipment, the additional factor of papermaking needs may finally justify the project. The same may be true of a dam or a reservoir, as part of a water-supply system.

Paper products industries -- The developments which may be possible in this field and in packaging are so extensive and so closely related to papermaking that they are discussed in detail in the next chapter.

## PAPERMAKING INDUSTRY MAY ALSO HELP AGRICULTURE

It should not be taken for granted that fibers now in use locally--if there is an existing papermaking tradition--are the only ones or even the best ones to use. There are recent innovations in processes which may make other available fibers much better, everything considered.

In the same way, it may even be that the country might study the question of introducing new crops in terms of their value for papermaking purposes. Between two crops which are equally suitable agriculturally and economically for food, the fact that the residue from one of them has extra advantages for papermaking might affect the choice of crop selected for planting, because it would mean extra revenue to the farmer. There could even be crops that do well, but have not been cultivated because they served no need; the demands of the papermaker might make the crop economically feasible and provide a necessary raw material. (For instance, the kozo bush thrives on the dry soil of the border of terraces in Japan; this plant provides a most excellent fiber for handmade paper, but it would otherwise perhaps be considered a nuisance.)

Papermaking as a cottage industry fits in well where there is an agricultural population which has off-season time, and where there are

crops or agricultural residues which can be used for the fibers. This obviously will help sustain the agricultural industry and those who depend upon it.

(However, papermaking can certainly be a full-time small-scale industry and in many countries there may be a way to tie the cottage industry worker to the industrial complex, through the industries mentioned here. As the mechanization of papermaking increases and the capital invested thus increases, the more important it becomes to keep the equipment busy full time, to amortize the costs. Full-time employment in the industry, therefore, should normally develop with mechanization.)

## MANY CONSIDERATIONS INVOLVED IN DECIDING ON PAPERMAKING INDUSTRY

While, as has just been shown, there are a great number of advantages to papermaking as a small-scale or cottage industry, and while it may have a beneficial effect on many other industries, it does not follow automatically that such an industry would be a good thing for every country. Local circumstances may make it uneconomic in that particular area.

Papermaking is considered to have more "independent variables" than any other industry. That is to say, there are so many different things to take into account, and so many different factors which affect each other, that a simple decision as to economic feasibility is not possible. For that reason, to get a clear understanding of considerations involved, reading of the entire Manual is highly recommended for all officials and other leaders who may be a party to making the decision. For instance, Part II deals in some detail with the processes involved in papermaking and thus may be considered of special interest to engineers or others wanting to learn how to make paper. Nevertheless, a careful reading of Part II by a government official will make him understand and appreciate far better why the problem is so complex, and why he must take special care to have all elements examined thoroughly before the decision is made.

Part III should be of direct interest to officials, other planners and entrepreneurs, since it is concerned with (a) the actual requirements of a small-scale papermaking industry; (b) the specific considerations, including the economic, to take into account in deciding whether to undertake the industry, and various ways to proceed with the programming.

CHAPTER 2

# Feasible Kinds of Paper and Paper Products

There are literally thousands of different kinds of paper and paper board, and paper products. Of these, there are probably hundreds which are feasible for small-scale or hand production in the underdeveloped areas.

Some of these products--useful to industry, business, research laboratories and ordinary people in their private lives--are listed in the section on colored paper in the middle of this Manual, as a convenient reference for planning purposes.

It is a central suggestion of this Manual that a small-scale papermaking industry can make these or other products as a distinctive contribution to the economy of a country, in addition to such usual grades of paper as the market may require.

The word "paper" in most languages refers to the simple product used for writing or printing, or perhaps also wrapping. As a world problem, paper has become generally identified with "newsprint," which is of course one very specialized kind of paper for a particular purpose. There is a growing understanding of the importance also of another product which is basically paper but which is often distinguished from paper because it is thicker and is used for purposes other than those originally associated with paper; this is paper "board" or "cardboard," used primarily for packaging.

Beyond these two general classifications, however, there are special papers which have been developed to meet almost every conceivable need which paper can be expected to serve (and because of inventive technology, many a need which paper could not be expected to serve!). Very often, all that is required to make the different product is (a) a different fiber to start with, or (b) different beating techniques, or (c) different chemicals added. From substantially the same papermaking process, quite different products are possible, from the most porous calligraphic writing paper to waterproof and greaseproof artificial parchment, or from facial cleansing tissue to roofing materials, from bulky opaque papers to thin transparent glassine. (Chapter 11 describes many of the techniques of processing.)

Certain kinds of paper cannot be made by small-scale papermaking as contemplated in this Manual, and there are a few others which perhaps

should not be so made in most circumstances. But the list of such papers is surprisingly small: enamel or coated printing papers needing machine perfection; newsprint and other continuous roll papers (such as adding machine tapes) which should be done in a true roll as distinct from a spliced roll and which must be made very cheaply; and cheap, standard writing, printing, wrapping and packaging papers or boards which are available competitively from mechanized mills.

Even the latter papers of the above list can be handmade, if the economics justify it. And in any case, the exclusion of all of these kinds of papers still leaves a tremendous range of papers and paper products which may well prove not only economic but most advantageous to be achieved through local production.

## FOUR CLASSES OF PAPER AND PAPER PRODUCTS

To simplify the picture of what is possible, it is perhaps well to distinguish four different classes of paper and paper products:

1. Finished paper and board, the usual papers and paper boards for varying purposes--writing, printing, wrapping.

2. Specialty papers, such as laboratory or industrial filter papers, for special and designated purposes, and which require certain kinds of fibers, chemicals or treatment in the original papermaking.

3. Converting papers and boards, the "raw material" for the making of such products as building paper for insulation, multiwall sacks, and laminates, which start out much like other papers but are treated later to add the properties needed (e. g., asphalt is coated on paper to make a roofing paper).

4. Paper products, an actual marketable or usable product, thought of in terms of its use rather than the fact that it has been manufactured from paper--such as sandpaper, boxes, envelopes. One group of products--packages--open such a large and important field for the benefit of the economy that it might well be treated as a separate industry, but much more feasible and able to function economically if it is supported by a local papermaking industry.

As has been noted, the papers and products in the last three of these four classes are listed in the colored section in the center of this Manual. These are generally products which (a) may now be costing foreign exchange; (b) may be more expensive because they are made in separate industries on the basis of imported paper stock; (c) may not be bought because of their expense or the use of foreign exchange; (d) may be produced out of some other more expensive material such as cloth or metal, and perhaps more laboriously made as a result; (e) may be not used because they are required in small, custom-made amounts and types and could not be produced locally, or (f) may not be even considered as a product it is possible to have.

The establishment of small-scale or cottage industries to make such products (i. e., specialty papers, converting papers and paper products) might serve, therefore, to help the economy in a variety of ways:

1. Saving of foreign exchange.

2. More productive use of men and materials because paper would substitute for more expensive items, would be more easily made, and could be produced under one roof instead of involving a variety of transactions between separate establishments producing at the separate levels.

3. Because of both availability and cheaper price, allow a broader use of materials in laboratories, industry and business--to assist those sectors in their own development. For instance, such producers may serve as sub-contractors of particular parts for big manufacturers.

4. Improve the standard of living by providing the increasing comforts and convenience that inexpensive and expendable paper products can provide.

5. Specifically, develop an industry which can be a permanent and increasingly useful part of the economy, without having to compete directly with the mechanized paper mills.

In general, the papers and products which are made by small-scale industry should be governed by these conditions:

1. The products have a small market, not justifying a major production unit.

2. The products may even be made according to particular specifications for various customers (e. g., a big manufacturer may sub-contract for a particular item to be used as part of a particular product it assembles or an individual may order his personal watermark in a paper).

3. Uniformity among the finished products is not too important (e. g., no two toys need be <u>exactly</u> alike, but two sheets of enameled printing paper do).

4. The products can use absorbent or unsized papers, or otherwise save time and materials in production (e. g., paper for adding asphalt for roofing purposes need not be bleached).

5. The quality of the product is not so demanding as to involve uneconomic use of time, equipment and chemicals to achieve the final small difference of perfection (e. g., ordinary paper vs. coated printing paper).

6. The product is one which logically results from the papermaking operation without undue handling, or where he ought to have control of the raw material, i. e., the paper. (For instance, a papermaker can easily go ahead and convert the paper into envelopes.)

7. Items which can profit from creativity and ingenuity in design and production ( e. g., decorative papers, toys).

8. Items which are clearly worth their cost, even though they are expendable (e. g., filter papers), as distinguished from "nice things to have" which may not be as readily bought in a material-saving economy.

## THE DIFFERENCES IN PAPERS

Papers differ from each other in a variety of ways, as has been noted above. Even within the general category of "finished paper and board," as listed, there are substantial differences. Some of them are obvious and easily noticeable--one paper is smoother than another, or whiter, or stiffer or tougher. Other differences are harder to see. Nevertheless, they are all important to the purposes which the different papers are intended to serve.

The important point from a planner's position is that these differences are not accidental or unimportant. They result from materials available and processes used. If the local conditions make one kind of paper much more feasible than another kind, the logical sourse to pursue is to determine first whether the readily-made kind of paper is marketable, or whether extra steps should be taken to develop other more-needed papers.

The key to understanding the possibly confusing array of different papers lies in the phrase used above, "the purposes which the papers are intended to serve."

If a paper is to be printed upon, it must be able to take printer's ink without smudging or soaking through; if it is going to be printed upon both sides, it must be relatively opaque, so that one side can be read without interference from the other. If a paper is to be used for calligraphic writing with a brush, it requires a more absorbent quality than a paper to be used for pen-and-ink writing. If a paper is to be used for wrappings, it must be stronger. So, it is possible to see the characteristics of paper as <u>specific properties</u> in such matters as appearance, strength, physical structure and protective qualities.

Through long usage, some of these characteristics have been combined into papers which serve certain general purposes. For instance, writing papers must have certain properties, including smoothness, opacity, ability to hold ink. Printing papers have a group of specific needs, including uniformity, ability to take special ink in a special way, and so on. Over the centuries, these different combinations have been more or less standardized and identified as <u>grades</u> of paper, so that to mention a particular grade is to refer thereby immediately to a particular set of specific properties.

A list of these grades and their key properties is included in

Part II, on technical aspects; see Page 104. In the same section of the Manual, there is a list also of the specific properties which papers may have, such as the kind of surface, ability to withstand bending, bursting strength, porosity and color.

Each of these characteristics affects the usefulness of the paper and the market--and with the exceptions noted, if the market requires or will support the effort, a small-scale papermaking industry can almost certainly be developed to achieve a reasonable and satisfactory version of the kind of product needed.

CHAPTER 3

# An Introduction to the Papermaking Techniques

This Manual explains both simply and in some detail the different ways paper can be made and the different steps and kinds of equipment involved. It is not intended as an instruction book by which a reader can learn enough about the craft to set up his plant and start producing. However, it goes into enough detail to present a realistic picture of the possibilities and problems to be taken into account in the evaluation of whether to undertake a cottage industry program in papermaking.

In addition, because most countries have present papermaking industries at some level of activity, the Manual is designed to suggest ways by which an existing technology can be improved--particularly in terms of quite recent advances in knowledge and technique which may make possible a level of papermaking which might have been out of the question previously. By a reading of the different methods and equipment now available, officials and technicians of a given country may take from the various alternatives whatever combination best meets their needs.

It cannot be overstressed that papermaking can be as simple an operation as desired, even though to get mass production and perfect uniformity of quality there are alternative processes and equipment available which can make papermaking as complicated as any which modern technology has devised.

## THE BASIC PROCESS FOR MAKING PAPER

The drawings on Pages 18 and 19, showing a child's way to make paper, offer a simplified introduction to papermaking. However, it will be clear that there is unfortunately a great deal more to the commercial production process than those simple steps. While the child will have paper, it will not be very good paper--and of course he will have started with a lot of his work already done for him, since he was using a raw material that already had the papermaking fiber in a semi-prepared state for him.

The chief substance in paper is cellulose, a chemical compound ($C_9H_{10}O_5$) which occurs almost always as a fiber in plants. Fortunately for the papermaking process, cellulose can be separated from the rest of the substances of the plant by mechanical or chemical means without being harmed as a fiber. The chief unwanted substance is lignin, the bonding

agent. The first problem, therefore, is to separate the cellulose from lignin and into distinct fibers. The second is to prepare the fibers in such a way that they will bond or "felt" back together into sheets of paper.

The one characteristic that distinguishes paper from other materials is that the individual cellulose fibers are "felted" back together to produce a sheet after being pulled apart in their natural state and frayed. For this reason, sheets of formed plastic are not paper--nor are such materials as papyrus, the Himalayan birch or the "rice paper" of China, which are really very thin slices of bark or pith used in their original formation.

Because different fibers require different treatments, especially for the making of different kinds of papers, there is no standard way of making paper. However, in general, the following steps apply:

1. Preliminary mechanical treatment of fiber -- Depending upon which fiber it is and its condition, it may require cutting, cleaning, washing, flaying, sorting or other processing to make it suitable for the next operation.

2. Chemical treatment of fiber -- The raw material is subjected to chemicals for a retting action or equivalent, to break the cellulose fibers away from their natural formation in the raw material, and sometimes to bleach the stock.

3. Rinsing -- The chemicals must be washed out of the fiber.

4. Mechanical pulping and beating -- Either by hand or by grinding equipment, the fibers are hammered and flayed until they are broken into separate fibers and, preferably, frayed. At this point the fibers become "pulp." Further mechanical action breaks the fibers still more and refines them; this is the "beating."

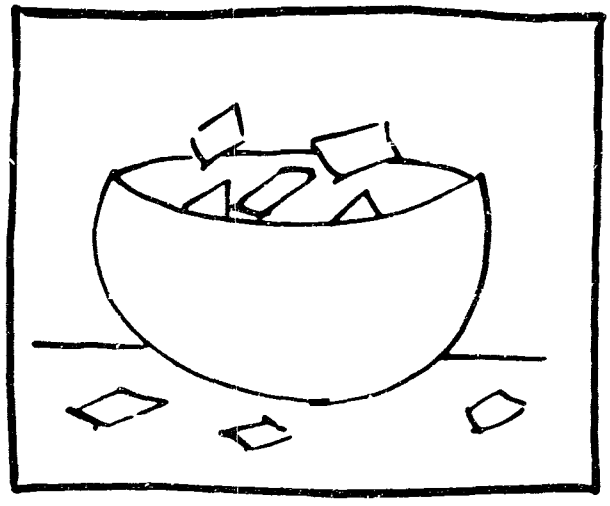
5. Chemicals added -- For some kinds of paper more than others, chemicals are added at the beating point to provide sizing (to make the paper less porous and thus better able to hold ink on the surface); to provide more opacity or other qualities (as by adding a clay filler); to provide color for the paper; or to otherwise affect the type of paper being made.

6. Formation of sheet -- By laying a solution of the pulp over a screen, and forcing the fibers to bond or mesh (felt is the technical term) while the excess water is drained away, a moist sheet of new paper remains on the screen.

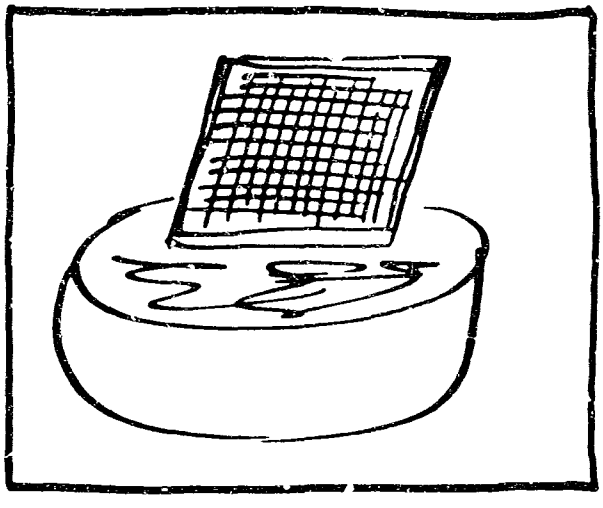
7. Drying -- The moist sheet is either dried on the screen or taken off by "couching" (pronounced "koo'ching"), after which the moisture is pressed out as much as possible and the sheet is dried.

# YOU Can Make Paper Yourself

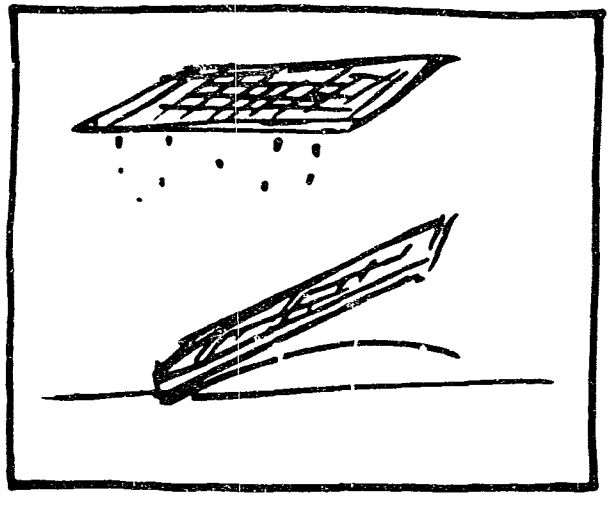
Anyone can make a sheet of paper by following the simple directions on these two pages. Even if you do not want to make paper yourself, you can get a general idea of the process in its simplest form by looking at these two pages. While production of paper in any quantity will require much more technology than shown here, a child in school can make paper this way--as a classroom project. (These pages may be reproduced as a booklet or film strip, or the drawings may be used with your own words to give other people some understanding of the factors involved in papermaking.)



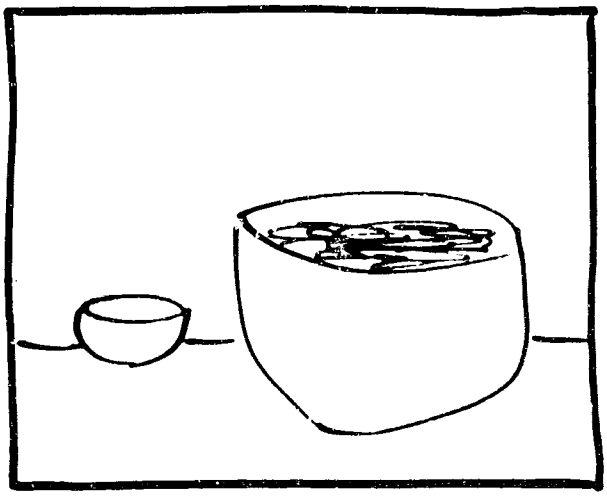
STEP 1 -- Cut old rags into pieces two or three inches square. Put them into a slightly rough-surfaced bowl with a little water, and beat the rags until they become separate, frayed fibers. To test, put a small amount of fibers in a glass of water. If there are no lumps when the pulp thins out, the beating is completed. Waste paper or any raw fiber (discussed in this Manual) can be used.



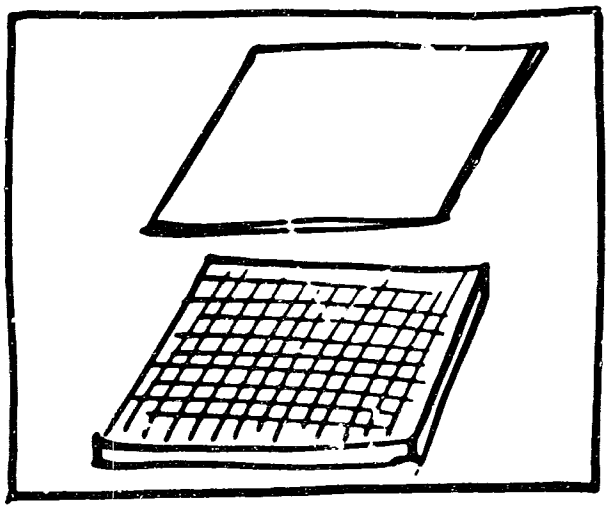
STEP 4 -- Stir the "slurry" in the tub enough to make sure that the fibers are well mixed. Then dip the mould into the tub, turning it under water so it is horizontal. Lift it out of the water, still horizontal, catching the "slorry" on the screen inside the deckle. Give it a small jerk while keeping the screen still level, and the fibers will "felt" better and make the paper stronger.



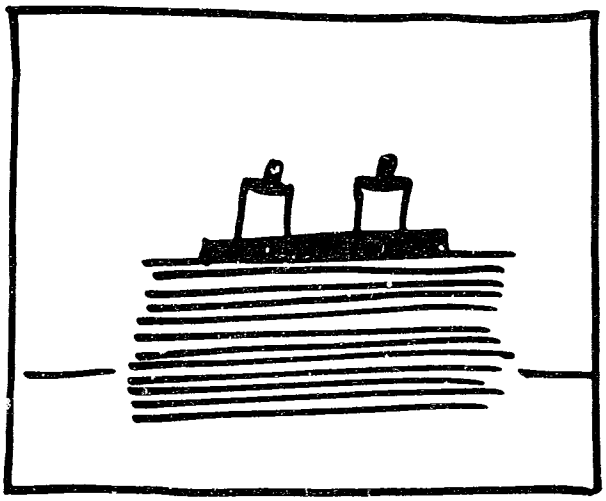
STEP 5 -- Hold the mould flat until the water drains, leaving a formed sheet on the screen. Then take off the deckle, and turn the mould upside down on a piece of cloth felt. With care, peel off or "couch" the sheet. You then have the mould free to make another piece of paper. If you wish, you may leave the sheet on the mould until it is completely dry. On most screens, it will peel off easily then.



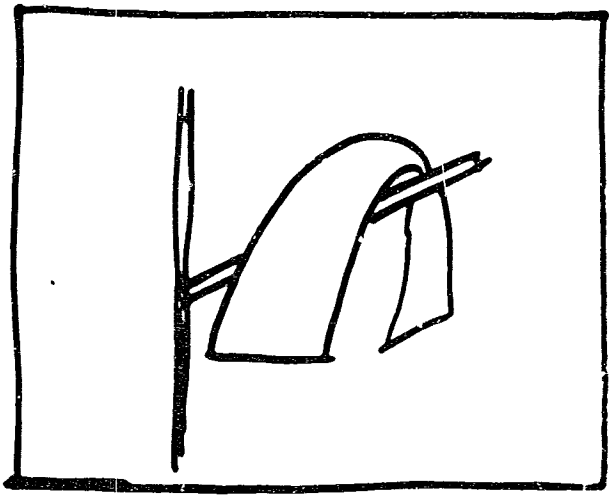
STEP 2 -- Put the pulp into a larger bowl or tub with enough water to make a "slurry" about as thick as cream. If you have chemicals to add--starch or other "size" to make the paper take ink better, or a dye to give the paper color--dump in the right amount (which you discover by research, or in other words, by trying). But you can make some kinds of paper without adding any chemicals.



STEP 3 -- Take your "mould" or screen to dip into the pulp. The mould is a wooden frame with a screen fastened on top of it; the screen is woven metal wire (but not iron), or woven fiber or even a coarse cloth. On top of the screen is another frame which can be lifted off; this frame is like a fence around the screen, about two inches high. This top frame is called a deckle.



STEP 6 -- If you peel off the sheet when wet, cover it with another felt, and then make and add new sheets the same way. After there are several sheets, the pile should be put under a press of some kind to squeeze out as much water as possible. If the sheets are then separated from the felts and pressed again (different sheets being put on top each time) the surfaces will get smoother.



STEP 7 -- After the sheets are pressed, they will be strong enough to be lifted up. They can be hung over a pole or line to dry, or they can be laid out flat. If three or four sheets are dried together, they will not curl as much. Then you will have paper--not as good as if you did a lot of special things to it, and had more skill--but it will be real handmade paper.

8. Sizing and coating -- The dried sheet may be dipped into a vat of size or otherwise treated to give its surface desirable qualities.

9. Finishing -- The sheet of paper may be polished or glazed by hand, or pressed through rollers (called a calender) to achieve a desired smoothness of surface.

10. Trimming -- The paper is finally cut into desired sizes of sheets.

There are hundreds, if not thousands, of refinements in the major steps described above--depending upon the particular fiber, the kind of paper desired, the volume of production involved, the kind of machinery, the chemicals available, the climate, and many other factors. As has been said, there are more independent variables in paper--more different materials, methods, qualities desired, and results obtainable--than in any other kind of manufacture. Even in the more narrowly-limited technology of hand-made paper, there still are as many varying techniques as there are kinds of fibers used and papers made.

In Part II, the 10 steps enumerated above will be discussed in more detail in terms of actual practice--not only in such countries as Japan and India, where paper is now being made by cottage industry, but also in the United States, in terms of processes which may be applicable to small-scale industry. It will be understood that by no means all of the different processes described under each step are actually undertaken by any one producer; quite the contrary, he may perform only one of the operations described under each step, depending (again) on his fiber, the paper desired, and the level of his technology.

## TECHNOLOGIES MAY BE COMBINED

In all of the apparent differences of the levels of technology, it is important to remember one very helpful fact about papermaking--the crudest processes in one step may be combined with the most advanced technique in another step. It is possible to have a pulping operation which is anywhere on a wide scale, from (a) being part of a cottage industry to (b) part of a mechanized industry to (c) no industry at all if the importing of pulp is a feasible matter. And yet, however the pulp is obtained, a cottage industry can exist for the actual making of the paper.

Thus, either fully-mechanized pulping operations or entirely hand methods may produce a slurry which may then be made into a sheet of paper by the simplest form of hand paper-lifting in the traditional vat. There are any number of combinations inbetween, and the practice in any one operation can be changed whenever it is determined to be easier or better.

Readers of Part II, therefore, should not be confused by the great variety of processes available. They need concern themselves only with the one or two types in each step of the operation which would seem to be

applicable to their conditions. So long as their total operation somehow performs each of the steps required to make and refine the pulp, form the sheet and dry it, they will have paper. There is no such thing as the one "right" way to do the job--and what is the best way in any one case will have to be determined by experiment and testing, as will be made clear in this Manual.

The descriptions of both hand and mechanized processes include those which are generally applicable. The variations in the processes become quite technical, depending upon the fibers used and the end-products desired; and research into equipment and the processes themselves is constantly changing the technical details and even establishing new processes.

For these reasons, the material should not be considered as definitive in any way, or even substantial enough to base a plan. For these reasons, also, no attempt is made to get really technical in detail. The descriptions do suggest the general scope of the problem, so that the processing element can be taken into account with the other factors in making a judgment as whether to proceed further with an investigation of the feasibility of mounting a handmade paper industry.

One conclusion may safely be drawn from the length and complexity of lists of fibers and the processes: there are processes already developed for making almost any cellulose fiber into pulp, and there is no need for research to discover radically different processes even though the raw material at hand may be unusual. A competent paper engineer, borrowing perhaps from experience in other underdeveloped areas, can almost certainly come up with an existing process which will serve adequately. (This is not to say that there cannot be improvements in processes to get better pulps and more fiber-per-pound from the raw material, or to increase efficiency. Nor is it at all impossible that a new process can be developed by experience. But this comes later, and should not get mixed up with the problem of selecting a process for the new small-scale papermaking industry.)

## PULP AND PAPER MAKING NOT THE SAME

The term "pulp" originally meant the cellulose fiber in its completely beaten state, ready to be made into paper. In the traditional making of paper by hand, no distinction is made between a "pulp" at an early stage of beating and a more completely beating "pulp" at a later stage of processing. In the advanced paper technologies, however, the distinction is being made increasingly. There is a growing practice of having "pulp mills" which specialize in preparing the fiber to a certain point only, with other mills--often even in different countries--buying the pulp and processing it further into the material from which they then make paper. Many investigations of papermaking in the underdeveloped countries, and especially those by the Food and Agricultural Organization (FAO), have concentrated on "pulp" and "paper" as two separate matters.

Because one of the suggestions of this Manual is that some cottage industries may find it economic to buy rather than make their pulp, it will perhaps be clearer in the Manual if the processes identified as "pulping" are limited to those meant by the more modern usage. Pulp, then, is defined as the cellulose fiber at the point when it is first reduced or broken down to its basic structure, with extraneous elements removed as much as possible.

When the pulp is further beaten and refined, and when chemicals are added to it for sizing, coloring, etc., the resulting substance (while still a pulp, in the true sense) will be referred to in this Manual as "stock." It is also one of the suggestions of this Manual that some areas may find it useful to prepare the stock at some central facility, so that a papermaker can buy a moist brick of stock, take it to his cottage, add the proper amount of water, and have the "slurry" which is put into the papermaking vat or poured into the paper box for the actual sheet making and final processing.

To summarize these distinctions as they will be used in this Manual, so that later confusion may be avoided:

PULP -- The result of the pulping process, with extraneous substances removed and with the fiber broken down and cleaned, but still needing further beating to be really suitable for papermaking. Pulp may be produced in one place and even dried into sheets for transporting to a papermaking operation.

STOCK -- The result of the beating and stock preparation processes, with the pulp beaten further and refined, and chemicals added as necessary, to the point of being ready for making paper.

SLURRY -- The stock with the necessary amount of water added to make a solution or suspension, into which the mould is dipped and lifted for forming the sheet of paper.

PAPER LIFTING -- The process which actually forms the sheet of paper from the slurry and deposits it (by couching) for final processing.

PAPER FINISHING -- The processes such as drying, sizing, calendering and trimming which complete the making of the ordinary grades of paper.

PAPER CONVERTING -- The processes such as adding special chemicals or laminating, which convert the ordinary type of paper into a special-purpose paper.

PAPERMAKING -- The term which covers all the processes listed above, including pulping for convenience. A pulping industry may also be referred to separately as may be useful.

While these distinctions may seem complicated or unnecessary at this point, they will serve a purpose throughout the rest of this Manual. It is suggested that the papermaking industry may want to standardize these distinctions as its processes become more a mixture of the traditional and new technologies.

One other term should be clarified as well: for purposes of this Manual at least, the product resulting from the paper lifting processes treated here is "handmade" paper, even though a mechanical pulper or beater might have been used, or the sheet formed in the "paper box." Inasmuch as the sheet will almost always be distinguishable from machine-made paper, this distinction may confidently be expected to hold.

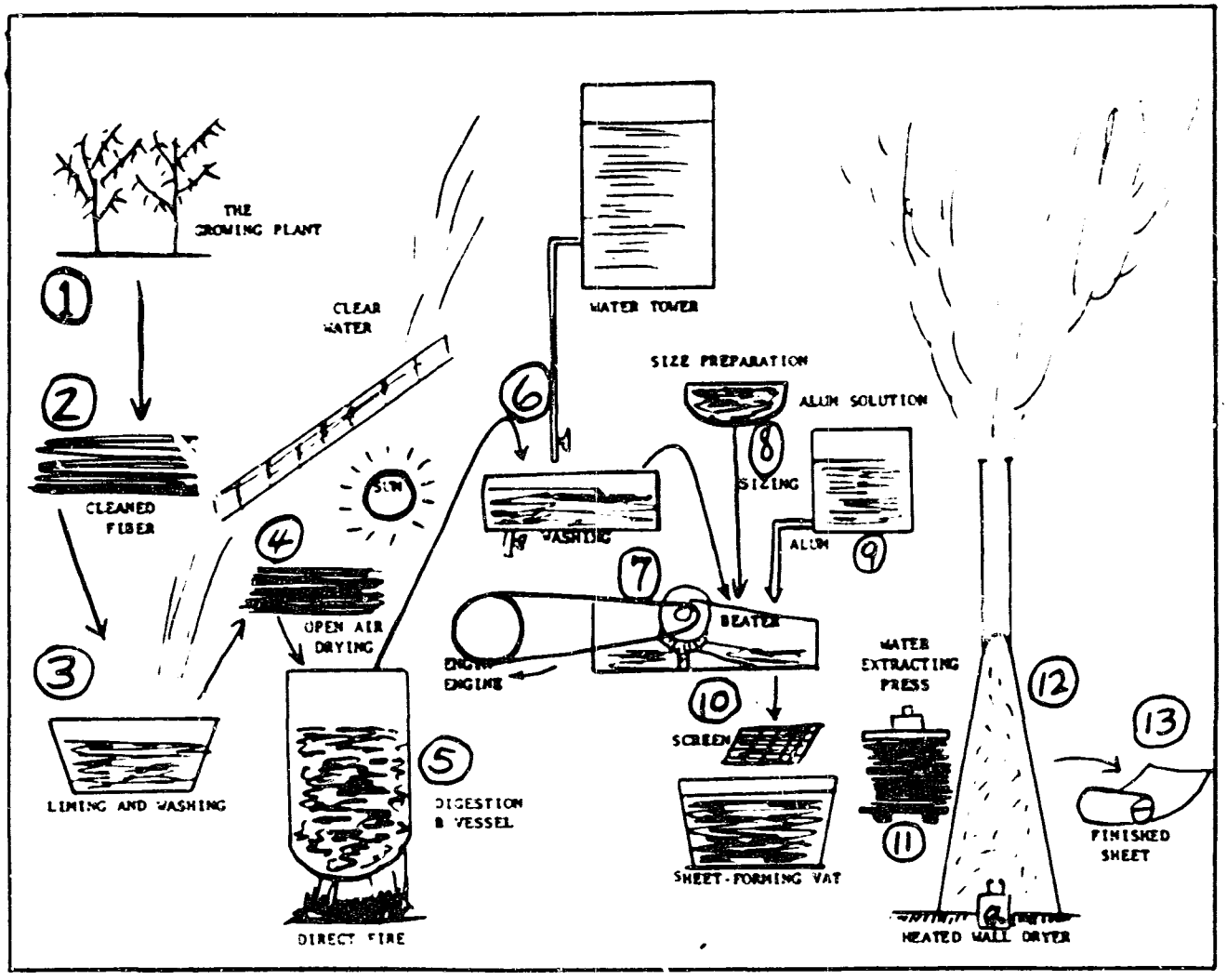



Fig. 8. SCHEMATIC FLOW DIAGRAM OF TRADITIONAL HAND-MAKING OF PAPER: (1) the fiber is grown; (2) usable part is gathered; (3) washed, sometimes retted; (4) dried in the sun; (5) "cooked" in digesting vessel over fire; (6) washed again; (7) pulp goes to beater; (8) size is added; (9) alum is added; (10) from beater, slurry goes to vat, is lifted onto screen as paper; (11) the sheet is pressed to get water out; (12) sheet is pasted against iron wall, heated by fire through flue system; (13) when dry, paper is completed.

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PART TWO

# Technical Aspects

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CHAPTER 4

# Papermaking Fibers

The chief raw material in the making of paper is the fiber. Fortunately for the communication and material convenience of the world, nearly any living plant can make some kind of paper, and there are enough plants which yield good papermaking fibers to make the assertion reasonably valid that almost every country has a source of raw materials for papermaking.

Without it being in any sense exhaustive, a list of some 377 different fibers is included in this Chapter as having been reportedly used for paper of some kind somewhere in the world.

What is of more importance than mere numbers, however, is the fact that recent technological advances in papermaking have opened the way to efficient usage of some of the most common of materials--and that among these materials are such wastes as straw and bagasse. In some instances, these advances have been in large-scale technology, but one of the major suggestions of this Manual is that the new findings may be so applicable to local adaptation that they warrant a new examination of the whole papermaking tradition and potentiality in most countries of the world.

Conifers (softwood trees) today are used for 85 to 90 per cent of the world's pulp production and cotton, waste rags and waste paper account for much of the remaining part--but this fact has tended to overshadow two very important developments:

1. Much work has been done to demonstrate that there are no real technological reasons why hardwoods and agricultural crops (or more especially their residues) cannot be used satisfactorily.

2. Around the world, pulp and paper mills are going up and operating with these fibers and processes, demonstrating the truth of the point above.

## PRINCIPAL POTENTIAL FIBERS

The principal fibers (besides the ones mentioned above) which seem to show the greatest promise today are the following:

1. Abaca' (manila), sisal, other leaf fibers -- Useful in papers which must possess high tear resistance, such as bulk goods bags.

2. Bagasse -- This sugarcane residue can be made into papers and boards of a variety of grades, including fine writing and printing papers. Practical methods of separating and using the pith have been found.

3. Bamboo -- High quality printing and writing papers and good wrapping papers can be made.

4. Broadleaf trees (including eucalyptus) -- Blended with other fibers, they are generally suitable for all papers except conventional kraft (very strong wrapping) papers.

5. Esparto -- This Mediterranean grass is used for fine papers.

6. Sabai grass -- Now comprising more than 20 per cent of the paper fibers used in India, this grass will make high quality papers.

7. Seed flax tow -- Excellent for fine papers (including cigarette paper) and specialty papers such as condenser papers.

8. Straw -- With suitable processing, this can make fine papers; yields low-quality wrapping paper and boards by cheap processes.

In addition, perhaps as important as the knowledge of the usefulness of these fibers separately, is the fact that these fibers seem to make even better papers, in many cases, when they are mixed with each other or with conifer pulps. For instance, bagasse or straw neutral sulphite pulps, added to kraft wood pulps produce better papers than kraft alone; straw processed by soda of sulphate improves quality papers. Abacá and flax pulps added to bagasse produce papers of extremely high tear resistance.

Since the new advances are mostly in this mixing of fibers and in the making of pulp, the techniques may be used for a small-scale industry making handmade paper, perhaps just as well as they are used by mechanized mills. The ways this may be done are discussed at length in the remainder of this Manual, and they suggest the possibility of a new kind of paper technology which would remain very much indigenous to the country which assimilated it into its existing papermaking tradition, but which would take advantage of the new findings of large-scale technology.

Particularly, it may be possible to improve both the yield from the fibers and the quality of the pulp on indigenous plants in a given country, so that what was once rejected as not feasible may now be quite worthwhile. A local research organization should be available to study the possibilities and to make tests (as explained later in this Manual) or expert assistance should be sought from other sources, once it is established that the potential for papermaking is enough to warrant such a step. (See Appendix IV for sources of additional information.)

Among the characteristics or properties which raw materials have in terms of their suitability as a fiber for papermaking are these (not in any necessary order of importance): (1) percentage of cellulose fibers which can be separated from the other substances of the plant in usable form for papermaking; (2) percentage of other substances in the raw material -- lignin, dirt, pith, nodes, ash, etc.--which affect the processing because of their varying degrees of difficulty of removal; (3) length of fiber; (5) drainage properties of the fiber after it is pulped; (6) color of fibers and susceptibility to bleaching or dyeing; (7) hardness, or ability to withstand pulping action, which affects the type of pulping process which must be used; (8) bonding or felting strength after beating; (9) wall thickness of the fiber, which affects the denseness, fineness and strength of sheets; (10) presence of hemicelluloses (polysaccarides other than cellulose) which affects ability to absorb water and thus affects beating process and strength characteristics of paper. From characteristics such as these, and from the different processes used to take advantage of them or overcome them as the case may be, the different kinds of paper result. (The paper properties involved are discussed in Chap. 9.)

TABLE 1: MAJOR CHARACTERISTICS OF FIBROUS MATERIALS

| Type of Fiber | Cellulose Percentage | Ease of Pulping* |
|---|---|---|
| Straws, esparto | 50-54 | 1 |
| Rice straw | 46-49 | 1 |
| Stalks, reeds | 52-58 | 2 |
| Bagasse | 59-62 | 2 |
| Woody-basts | | |
| a. woody stems | 40-48 | 4 |
| b. bast fibers | 70-80 | 3 |
| Leaf fibers | 70-80 | 3 |
| Bamboos | 60-63 | 4 |
| Conifer woods | 53-62 | 4 |
| Deciduous " | 54-61 | 4 |
| Rags | 70-80 | 2 |
| Waste paper | 75-90 | 1 |

* 1= easy; 4 = hard

The two principal qualities of raw materials from a general planning standpoint are (a) the cellulose content and (b) the relative ease of pulping, which is determined by many specific qualities in combination. TABLE 1, MAJOR CHARACTERISTICS OF FIBROUS MATERIALS, above, indicates the average variations for these two qualities. It should be borne in mind, however, that these are subject to considerable variation because of local conditions and techniques of processing.

# Check List of Fibers Suitable for Making Paper

Compiling a complete list of fibers suitable for papermaking apparently has never been attempted, presumably because (a) in one sense it could include nearly every kind of growing plant, (b) in practical terms, it is difficult to judge whether the reported use of an unusual fiber is meaningful, (c) new fibers are being tested constantly around the world, and (d) judgments of fibers previously rejected are subject to revision.

However, because it seems useful to present in this Manual as complete a list as possible of papermaking fibers which may have potential value to government officials and technicians in the underdeveloped areas of the world, a compromise is being attempted, starting on the next page.

All fibers which could be found to have been mentioned by reliable sources in connection with papermaking have been included, with abridged notes on the processes and products involved, as appear useful, from the original source. An authoritative recent article, "Papermaking Fibers," by Irving H. Isenberg, in Economic Botany, 1956, was used as the basic source; entries taken from this article are credited with a (1) at the end of each. This was supplemented by an extensive search through a variety of representative published material, both old and current. Those which had additional or different data are credited by the number in parentheses after the entry. (The bibliography of the materials used appears at the end of the list, with a key to the numbers.)

The result is a list which perhaps proves at least a comprehensive starting point for those who may want to check their own country's fiber resources against the world's experience. Where they find a fiber locally available which has a history of use elsewhere, they may write the appropriate officials for further information.

It should be noted that the kinds of paper reported as made from the fiber, and the processes used, are not necessarily limiting, especially in a small-scale papermaking operation. In addition, even minor differences in fibers (due to local growing conditions and variants of the plant), in climate, in water, in equipment, etc., may alter results. This table will give general clues as to what is possible and advisable, but research and experimentation under local conditions may find quite different purposes and results from those shown.

ABACÁ or MANILA FIBER (Musa textilis) -- used to make special grades. Japan, U. S. make lightweight sheet for stencil paper. Also used for tea bags; has gone into flour sacks and similar articles because it is flexible, strong and tough. Much of the fiber enters paper industry from old cordage and rough textile waste to make the so-called rope papers. One mill in Costa Rica produces abacá pulp and blends it with kraft waste paper to produce multiwall bag paper. May be in use in Philippines. (1) (2).

ABURA (Mitragyna macrophylla) -- soda process, makes pale brown paper of fair strength and quality; grown in Nigeria (5).

ACACIA (Acacia negra) -- planted in quantities in Rio Grande do Sul for tannin extracted from bark. Quality of wood is similar to eucalyptus, with more pentosans (12).

ACUREL (Trichilia oblanceolata) -- soda process, makes rather bulky pale brown, fairly soft opaque paper of good strength; grown in Trinidad (5).

AFARA (Terminalia superba) -- soda process, makes fairly strong, brown paper; grown in Nigeria (5).

AGIA, see MOTHI.

ALASI or JAVAS (Linum usitatissimum) -- used in India (6).

ALDER, EUROPEAN BLACK (Alnus glutinosa) -- probably pulped in Germany (1).

ALDER, RED (Alnus rubra) -- pulped in Pacific Northwestern U. S. (1) (2).

ALGAE, FRESH-WATER GREEN (Conferva) -- most familiar species known as Crow-silk. A book produced from this fiber in 1799 is still as good as when made, according to Dard Hunter. Also known as Hair-Weed and Water-wool (9).

ALMENDRO (Coumarouna oleifera) -- tropical wood found in Panama and Brazil (5).

ALOE, see HEMP, MAURITIUS.

ANDIROBA (Carapa guianensis and Carapa procera) -- tropical wood found in Brazil and Surinam (5).

ANGELINO ACEITUNO (Nectandra concinna) -- found in Venezuela (5).

ANGELIQUE (Dicorynia paraensis) -- tropical wood found in Surinam (5)

ARERE (Triplochiton nigericum) -- soda process, makes strong, light brown paper; Nigeria. (5).

ASH, ALPINE (Eucalyptus gigantea) -- pulped in Australia (1).

ASH, BLACK (Fraxinus nigra) -- small amounts enter mills with mixed hardwoods in U. S. (1).

ASH, EUROPEAN (Fraxinus excelsior) -- it is not known whether this is pulped (1).

ASH, MOUNTAIN (Eucalyptus regnans) -- pulped in Australia; used for newsprint; only old trees (about 300 years) are satisfactory (1) (4).

ASH, SILVERTOP (Eucalyptus sieberiana) -- (1).

ASH, WHITE (Fraxinus americana) -- small amounts used with other hardwoods in U. S. Also found in Canada (2) (16).

ASPEN (Populus alba) (Populus canadensis) (Populus italica) -- pulped in central and southern Europe (1).

(Populus nigra) -- pulped in central and southern Europe and in Italy with outstanding success (1) (6).

(Populus tremula) -- Finland, Norway and Sweden supply pulp from this (1).

ASPEN, QUAKING (Populus tremuloides) -- in North America, made into groundwood, sulfite, soda. kraft and neutral sulfite semi-chemical pulps. When bleached and mixed with longer fibered bleached stock, is well adapted for book, envelope and high grade printings (1) (16).

ASPEN, LARGETOOTH or BIGTOOTH (Populus grandidentata) -- in North America, made into groundwood, sulfite, soda, kraft and neutral sulfite semi-chemical pulps. Also called paper-poplar or soft poplar (1) (2) (9).

BABHAR GRASS, see SABAI.

BAGASSE, SUGAR CANE (Saccharum officinarum) -- used for bleached pulp by Pomilio method and for board and corrugated paper in Brazil. Bleached pulp being produced in Philippines. Has also been pulped in many other areas and by several processes. Among these

areas are Argentina, China, Colombia, Cuba, Hawaii, India, Mexico, Peru, Puerto Rico, South Africa, Taiwan and U. S. Is used for newsprint and fluting paper in South Africa (1) (2) (8) (16).

BAMBOO (Bambusa arundinacea) -- pulped in limited quantities in Thailand (1).

(Bambusa tulda) -- used in India (1).

(Cephalostachyum pergracile) -- (2).

(Dendrocalamus hamiltonii) (Dendrocalamus longispathes) -- pulped in India (1).

(Ochlandra travancorica) -- Indian bamboo having longest fibers. In India bamboos use sulfate process, although one mill uses sulfite process (4).

(Pseudostachyum polymorphum) -- pulped in India (1).

(Teinostachyum dulloa) -- pulped in India (1).

(Thyrostachys siamensis) -- pulped in limited quantities in Thailand (1).

BAMBOO, BALKI (Bambusa balcooa) -- (1).

BAMBOO, DABA or KANTA (Bambusa arundinacea) -- one of the most commonly-processed of bamboos (1).

BAMBOO, MULI or MITENGA (Melocanna bambusoides) -- pulped in India and Pakistan (1).

BAMBOO, SALLA (Dendrocalamus strictus) -- pulped in India (1).

BANANA (Musa sapientum) -- its fiber is not so long or strong as abaca (1).

BAOBAB TREE (Adansonia digitata) -- found in Tanganyika and other parts of Africa (1). (Also being grown increasingly in other warm climate

BAR or VAD or PIMPAL (Ficus varieties) -- inner barks of young branches used in India (8).

BARA-BARA (Diospyros guiannensis) -- soda process, gives brown paper of good strength; from British Guiana (5).

BARAMALLI (Tabebuia species) -- soda process, paper furnished is unbleached, fair strength with some shive; from British Guiana (5).

BARLEY (Hordeum sativum) -- straw from cultivated barley is pulped principally in Europe (1).

BASSWOOD (Tilia americana) -- soda pulp, found in Canada and U. S. (16).

(Tilia glabra) -- probably used in small amounts mixed with other hardwoods (1).

(Tilia michauxi) -- variety of white basswood, probably used in small amounts mixed with other hardwoods (1).

BASSWOOD, WHITE (Tilia heterophylla) -- probably used in small amounts mixed with other hardwoods (1).

BEARGRASS (Yucca elata) -- pulped in U. S. and used for specialty purposes (1).

BEECH (Fagus atropunicea) -- soda pulp, found in Canada and U. S. (2) (16).

BEECH, AMERICAN (Fagus grandifolia) -- small amount pulped in U. S. (1).

BEECH, EUROPEAN (Fagus silvatica) -- used considerably for pulp in central Europe, especially for dissolving pulp (1).

BHANG, see HEMP.

BHENDI (Hibiscus variety) -- bark of stem is used (8).

BHENDI, RAN TURAI (Abelmoschus esculentus) -- outer bark of stem is used; from India (8).

BIRCH (Betula alba) -- pulped in Scandanavian countries (1).

(Betula pubescens and verrucosa) -- Finland, Norway and Sweden supply pulp from this (1).

BIRCH, GRAY (Betula populifolia) -- perhaps pulped in Canada and U. S. (1).

BIRCH, PAPER or WHITE (Betula papyrifera) -- principal birch species pulped in U. S. and Canada; cooked with mixed solution of sodium sulfite and sodium sulfide (1) (15) (16).

BIRCH, RIVER (Betula nigra) -- perhaps pulped in U. S. and Canada (1).

BIRCH, SWEET (Betula lenta) -- sulphite and soda pulp, pulped in U. S. and Canada (1) (2) (16).

BIRCH, YELLOW (Betula lutea) -- sulphite and soda pulp, pulped in U. S. and Canada (1) (2) (16).

BLACKGUM or BLACK TUPELO (Nyssa sylvatica) -- one of principal species constituting major portion of pulp hardwoods in southern U. S. (1) (2).

BOIS MULATRE (Pentaclethra filamentosa) -- soda process, gives pale brown paper of good strength; found in Trinidad (5).

BOMBACACEAE (Bombax) -- small amount goes into chemical pulp in Thailand (1).

BRAZIL NUT (Bertholletia excelsa) -- tropical wood found in Brazil (5).

BRAZILIAN LOURO (Aniba cf. riparia) (Aniba duckei) (Ocotea sp.) -- tropical wood found in Brazil (5).

BUCKEYE, OHIO (Aesculus glabra) -- pulped in U. S. (1).

BUCKEYE, YELLOW (Aesculus octandra) -- pulped in U. S. (1) (2).

BULLETWOOD (Manikara bidentata) -- tropical wood found in Surinam, British Guiana and Puerto Rico (5).

BUL-RUSH or JUNGLI or PAN KANIS (Typha elephantina) -- whole plant except tops used; found in India (8).

BUTTERNUT (Juglans cinerea) -- small amounts are pulped in mixture with other central hardwoods in U. S. (1) (2).

CANDELERA (Cordia collococca) -- tropical wood, found in Venezuela (1).

CANTALA or MAGUEY (Agave cantala) -- enters paper industry as waste from cordage industry (1).

CARABALI (Albizzia caribaea) -- tropical wood found in Venezuela (5).

CAROA (Neoglaziovia variegata) -- one of chief sources of domestic pulps in Latin America. Fiber from leaf is pulped in Brazil and used in lightweight papers. (1).

CASTOR BEAN (Ricinus communis) -- has been suggested as fiber source but not yet in such service; wrapping paper from stem (1) (2).

CATALPA (Catalpa bignonoides) -- pulped with mixed hardwoods in U.S. (1) (2).

CATALPA, NORTHERN (Catalpa speciosa) -- pulped with mixed hardwoods in U. S. (1) (2).

CATIVO (Prioria copaifera) -- tropical wood found in Panama (5).

CATTAIL, COMMON (Typha latifolia) -- down of the fruit used for insulation purposes and may possibly enter the paper industry as a waste material; production of pulp in North Korea (1) (15).

CEDAR, ALASKA YELLOW (Chamaecyparis nootkatensis) -- (2).

CEDAR, INCENSE (Libocedrus decurrens) -- found on West Coast of U. S. and Mexico; sulphite and sulphate pulps (2) (16).

CEDAR, PORT ORFORD (Chamaecyparis lawsoniana) -- (2).

CEDAR, RED (Cedrela fissilis) -- found in forests of Brazil (2) (13).

CEDAR, WESTERN RED (Thuja plicata) -- (2).

CEDRO BRANCO (Cedrela huberi) -- tropical wood found in Brazil (5).

CEDRO ESPINO (Bombacopsis quinata) -- tropical wood found in Honduras (5).

CEDRO GRANADINO (Cedrela tonduzii) -- tropical wood found in Panama (5).

CENTURY PLANT or PITA (Agave americana)-- enters paper industry as waste from cordage industry; also used in India (1) (8).

CHAKRABHAND, MUDRA, TUTHINAR (Abutilon indica) -- outer bark of stems is used; found in India (8).

CHANDKUDA KARVAT, see VALKAL TREE.

CHAVAI, see PLANTAIN.

CHERRY, WILD BLACK (Prunus serotina) -- pulped occasionally by the alkaline process and perhaps by neutral sulfite semi-chemical (1) (2).

CHESTNUT (Castanea sativa) -- pulped especially in France and Italy (1) (2).

CHESTNUT, AMERICAN (Castanea dentata) -- both unextracted wood and chips which have been leached to remove tannins have been used. This was probably the first species in commerical semi-chemical pulps (1).

CHESTNUT, COMMON HORSE (Aesculus hippocastanum) -- perhaps used in southeastern Europe (1).

CHÚPON (Pouteria carabobensis) -- tropical wood found in Venezuela (5).

COCOANUT (Cocos nucifera) -- a fruit fiber (10).

CORN, AFRICAN (Sorghum vulgare) -- cane from this has been proposed for pulping (1).

CORN, MAIZE or INDIAN (Zea mais) -- has been pulped for board purposes in U. S. but apparently is no longer utilized. Corn stalks have been found suitable for paper and board, either alone or in blends, but economical methods must be found for collecting, storing, preserving and cleaning them (1) (2) (6).

COTTON, AMERICAN UPLAND (Gossypium hirsutum) -- the seed hair, both staple and linters, of several species and varieties of cotton has been used extensively in paper industry. Today the principal use of cotton fiber in paper industry is for rag content bond and similar grades, although some old rags get into roofing felts. Source of supply is old rags or cuttings, although linters are being used to some extent. Several countries, especially in Europe, make fine grades of paper from cotton fiber, including filter paper. The bast fiber can be used, and several investigators have experimented with pulping of the whole stalk. It is not known whether this bast fiber is presently being processed (1) (2) (8) (14).

COTTONWOOD, EASTERN (Populus deltoides) -- in North America, made into groundwood, sulfite, soda, kraft, and neutral sulfite semi-chemical pulps (1) (2).

COTTONWOOD, NORTHERN BLACK (Populus trichocarpa hastata) -- in North America, made into groundwood, sulfite, soda, kraft and neutral sulfite semi-chemical pulps (1) (2).

COTTONWOOD, SWAMP (Populus heterophylla) -- in North America, made into groundwood, sulfite, soda, kraft and neutral sulfite semi-chemical pulps (1).

COURBARIL (Himenaea courbaril) -- tropical wood found in Honduras, Surinam, Puerto Rico (5).

(Hymenaea davisii) -- tropical wood found in British Guiana (5).

CROW-SILK, see ALGAE

CUCUMBERTREE (Magnolia acuminata) -- pulped in mixture with other hardwoods in U. S. (1) (2).

CYPRESS, BALD (Taxodium distichum) -- sulphate and sulphite pulps; found in eastern U. S. (2) (16).

DAPHNE (Daphne cannabina) -- the bast fiber is used in Nepal in handmade papers; used there for postage stamps. Sometimes called Nepal paper, a very fine grade. Most of the paper used in Tibet is made from fibers of this plant and Edgeworthia gardneri (1) (5) (9) (11).

(Daphne involucra) -- the bast fiber is used in Nepal in handmade papers (1).

(Daphne pendula)-- used for Nepal handmade papers (1).

DETERMA (Ocotea rubra) -- tropical wood found in Surinam (5).

DHAK or PALAS (Butia frondosa) -- inner bark of young branches used; grown in India (8).

ELDER, BOX (Acer negundo) -- probably pulped occasionally in mixture with other hardwoods (1).

ELM, AMERICAN or WHITE (Ulmus americana) -- used especially as feltwood for manufacture of fiber roofing felt (1) (2).

ESPARTO (Lygeum spartum) -- pulped primarily in United Kingdom, but also in France, Italy, Spain, and Algeria. Used for fine printing papers in England (1) (5) (14).

(Stipa tenacissima) -- grows in southern Spain and in Algeria, Tunisia and Morocco (1) (9) (14).

ESPAVÉ (Anacardium excelsum) -- tropical wood found in Panama and Venezuela (5).

EUCALYPTUS (Eucalyptus rostrata) -- sulphate process; grown in Israel (15).

(Eucalyptus saligna) -- pulp produced in South Africa; soda process, light, buff-colored sheets, slightly harsh texture, weak; also used in Brazil (1) (5) (12).

EVERGREEN, see MAGNOLIA, SOUTHERN.

FIDDLEWOOD (Vitex gaumeri) -- tropical wood found in British Honduras (5).

FIR (Abies firma) (Abies homolepis) (Abies mariesii) (Abies mayriana) (Abies sachalinensis) (Abies veitchii) -- all are pulped in Japan; manufactured into groundwood, sulfate and sulfite pulps (1).

FIR, ALPINE (Abies lasiocarpa) -- manufactured into groundwood, sulfite and sulfate pulps; used in U. S. (1).

FIR, AMABILIS (Abies amabilis) -- manufactured into groundwood, sulfite and sulfate pulps; used in U. S. (1).

FIR, BALSAM (Abies balsamea) -- manufactured into groundwood, sulfite and sulfate pulps; finds considerable use in eastern North America (1) (2).

FIR, DOUGLAS (Pseudotsuga taxifolia) -- pulped by sulfate, sulfite processes in U. S. and Canada (1) (2) (16).

FIR, GRAND (Abies grandis) -- manufactured into groundwood, sulfite and sulfate pulps; used in U. S. (1).

FIR, NOBLE (Abies procera) -- manufactured into groundwood, sulfite and sulfate pulps; found in U. S. (1).

FIR, RED (Abies magnifica) -- manufactured into groundwood, sulfite and sulfate pulps; found in U. S. (1).

FIR, SACRED (Abies religiosa) -- manufactured into groundwood, sulfite and sulfate pulps; pulped in Mexico (1).

FIR, SILVER (Abies pectinata) -- manufactured into groundwood, sulfite and sulfate pulps; used in central Europe (1) (2).

FIR, WHITE (Abies concolor) -- manufactured into groundwood, sulfite and sulfate pulps; used in U. S. (1) (2).

FLAX -- tow of seed flax straw used to produce cigarette and fine book papers in U. S. and Canada (5).

FLAX, COMMON (Linum usitatissimum) --bast fiber has been in papermaking for centuries. This fiber in paper industry for many years only in form of old rags or textile waste, but recently the "straw" from linseed flax has been pulped after passing through breaker rolls. Resulting pulp contains not only bast fiber but shives or hurds (woody cells of stalk). The thin papers are used primarily for cigarette tissue but also for condenser tissue. The bast fiber alone goes into currency, rag content bond, and other fine papers; used in France, Germany, Italy, Netherlands, United Kingdom, U. S., Canada, and probably other countries (1) (2).

FLAX LILY or FLAX RUSH (Dianella tasmanica) -- has broad leaves; yields

good fiber for papermaking; found in Tasmania and Australia (9).

FLAX, NEW ZEALAND (Phormium tenax) -- called by misnomer "New Zealand flax" or "hamp"; used for textiles, rope and papermaking. The fibers are retted, teased, dried and exported unless made into ropes by local industries in New Zealand; also pulped in Australia. The name Phormium is in France applied to paper of the appearance and quality of that made from New Zealand flax, though merely consisting of jute fibers or sulphite pulp with waste paper (1) (9).

FLOR AZUL (Vitex kuylenii) -- tropical wood found in Honduras and Guatemala (5).

FOTUI (Jacaranda copaia) -- soda process; strong, pale brown paper, unbleached, fair strength but no shive; found in British Guiana (5).

FRIJOLILLO (Pseudosamanea guachapele) -- tropical wood found in Surinam (5).

GAMPI (Wikstroemia canascens) -- used by Japanese to make handmade sheets for nearly everything. The bast fiber is similar to that of mitsumata but is obtained only from wild plants (1).

GANJA, see HEMP.

GEHU, see WHEAT.

GHANAS PAN, see HEMP, BOWSTRING.

GINGER, or HALAD or HARDAR (Curcuma varieties) -- grown in India (8).

GONCALO ALVES (Astronium graveolens) -- tropical wood found in Venezuela (5).

GORAKH AMLI (Adansonia digitata) -- inner bark is used; grown in India (8).

GRASS, LEMON (Cymbopogon citratus) -- after oil extraction, lemon grass residue is pulped and formed into board in Guatemala (1).

GRASS, SABAI (Eulaliopsis binata) -- one of primary raw materials for paper industry in India; pulped by a soda process; makes high quality papers (1) (4).

GRASS, ULLA (Themeda gigantea) -- pulped for strawboards in India; also found in Australia (16).

GREENHEART (Ocotea rodieri) -- soda process, pale brown paper; found in British Guiana (5) (13).

GRONFOELOE (Qualea albiflora) -- tropical wood found in Surinam (5).

GUARUMO (Cecropia) -- tree found in Colombia. Because of its abundance and frequent occurrence in pure stands, it should be an important factor in any pulp and paper development in tropical America (4) (13).

GUAYABO DE MONTE (Terminalia guyanensis) -- tropical wood found in Venezuela (5).

GUAYACÁN (Tabebuia guayacan) -- tropical wood found in Honduras (5).

GUM, BLACK, see BLACKGUM

GUM, BLUE (Eucalyptus globulus) -- pulped in Portugal, Spain, Morocco and Chile. Also used in manufacture of roofing felts in southern California of U.S. (1).

(Eucalyptus globulus labillardiere) -- used in Brazil and Australia; mixed with imported chemical wood pulp in one factory in Sao Paulo; wrapping papers in India. Bleached soda pulps from eucalypts can be used to provide up to 100% of the furnish in the manufacture of high-grade writing and printing papers (Australia). Experience in Latin America has shown that bleached sulphate pulps from eucalypts can be similarly used. In Australia and Latin America up to 60% of unbleached eucalypt sulphate pulps are used for making wrapping and certain types of bag paper, and up to 30% in manufacture of multiwall bag paper. Up to 80% of eucalypt sulphate pulp has been used in the furnish for kraft liner boards and up to 50% in the liner furnish for lined board (3) (9) (15).

GUM, COTTON (Nyssa aquatica) -- sulphite and sulphate pulp; found in southeastern U. S. (16).

GUM, FOREST RED (Eucalyptus umbellata) -- used in Brazil (1).

GUM, MANNA (Eucalyptus viminales) -- perhaps pulped in Australia (1).

GUM, RED (Liquidambar styraciflua) -- sulphite and soda; found in U.S. (16).

GUM, RED RIVER (Eucalyptus camaldulensis) -- used in Italy (1).

GUM, SALIGNA, see EUCALYPTUS

HAIARI-BALLI (Diplotropis) -- soda process, moderately strong, rather speckled, grayish-brown paper; found in British Guiana (5).

HALAD, see GINGER.

HARDAR, see GINGER.

HEMLOCK (Tsuga diversifolia) (Tsuga sieboldii) -- pulped by Japanese (1)

HEMLOCK, EASTERN (Tsuga canadensis) -- sulphite, sulphate and mechanical pulps; pulped in U. S. and Canada (1) (2) (16).

HEMLOCK, MOUNTAIN (Tsuga mertensiana) -- undoubtedly mixed with western hemlock in the mill; found in U. S. and Canada (1).

HEMLOCK, WESTERN (Tsuga heterophylla) -- most important pulping species in Pacific Northwest region of U. S. and Canada; sulphite, sulphate, mechanical pulps (1) (16).

HEMP (Crotalaria juncea) -- used in India (7)

HEMP, AMBARI (Hibiscus cannabinus) -- bast fiber known also as kenaf; used in India. Also has been used in U. S. for rope paper manufacture and possibly in other countries, entering as old cordage or rough textile waste (1).

HEMP, BOWSTRING (Sansevieria zeylanica) -- may enter paper industry as cordage waste; leaf fiber is used in India (1) (8).

HEMP, COMMON (Cannabis sativa) -- bast fiber used for rope papers; most of fiber enters industry as textile or cordage waste (1).

HEMP or GANJA or BHANG (Cannabis indica) -- practically same as Cannabis sativa; grown in India (8).

HEMP, MANILA -- produced in Philippines; original source of class of papers known as Manilas which are very desirable for wrapping and other purposes, being very smooth, clean, soft and flexible, taking an excellent and characteristic finish and being quite strong. Many Manila papers today contain none of this fiber, being clever imitations (16).

HEMP, MAURITIUS or PITEIRA or ALOE (Furcraea gigantea) -- enters paper industry as old cordage or rough textile waste (1).

HENEQUEN (Agave fourcroydes) -- enters paper industry as waste from cordage industry (1).

HICKORY or PECAN (Carya sp.) -- undoubtedly enters American industry mixed with other central hardwoods (1).

HICKORY, SHAGBARK (Carya ovata) -- (2).

HOG PLUM (Spondias lutea) -- soda process, strong brown paper with few specks; from British Guiana (5).

(Spondias mombin) -- soda process, pale grayish-brown, tough opaque paper of good strength; Trinidad (5).

HOLLY (Ilex opaca) -- (2).

HOP VINE, COMMON (Humulus lupulus) -- bast fiber has appeared in paper in central Europe during war periods (1).

HORNBEAM (Carpinus betulinus) -- probably pulped in Germany and other countries of central Europe (1).

HUBUBALLI (Loxopterygium sagotii) -- tropical wood found in Surinam (5).

HUROWASSA (Pithecolobium trapezifolium) -- soda process, pale brown paper of fair strength; from British Guiana (5).

IMBAÚBA (Cecropia sp.) -- used in small amount for groundwood in Brazil; produces woodpulp with a length of fiber similar to that of poplar and chestnut but with higher yields than those of broad-leaved trees more commonly used in the industry (1) (13).

IMBUIA (Phoebe porosa) -- tree found in Brazil (13).

ITIKIBOUROBALLI -- soda process, bulky, pale brown paper of moderate strength; found in British Guiana (5).

JAVAS, see ALASI.

JIGGER (Bravaisia floribunda) -- soda process, pale brown, opaque paper of strength; found in Trinidad (5).

JUNGLI BAJRI, see BUL-RUSH.

JUTE (Corchorus capsularis) (Corchorus olitorius) -- Bast fibers of these two Indian species furnish the jute fiber of commerce. Jute fiber from jute butts, old sacks and bagging, and rough textile waste has been used in certain grades of paper for many years. One grade of board is still known as "jute" even though it no longer contains jute fiber. Jute fiber is weaker than flax and hemp and is easily rotted by water; it does not bleach but takes dyes readily; is not used for white paper. (1) (8) (14).

JUTE, BIMLIPATAN, see HEMP, AMBARI

KAKARALLI (Eschweilera laevifolia) -- soda process, soft brown paper of moderate strength; found in British Guiana (5).

KAPAS, see COTTON, AMERICAN UPLAND.

KAPOK (Ceiba pentandra) -- floss of kapok enters certain grades from waste sources (1) (2).

KARAHORA (Schefflera depressa) -- soda process, strong, pale brown paper; found in British Guiana (5).

KAURI, QUEENSLAND (Agathis palmerstoni and microstachya) -- is pulped by sulfite process in Brazil and northern Argentina, and for groundwood in Brazil (1).

KAUTABALLI (Licania venosa) -- soda process, pale brown paper, soft, rather bulky, and of poor strength; found in British Guiana (5).

KELA, see PLANTAIN.

KENAF, see HEMP, AMBERI.

KETKI, see KEVADA.

KEVADA or KETKI (Pandanus odoratissimus) -- leaf fibers are used; found in India (8).

KHAJATI, see MOTHI.

KHOI (Streblus asper) -- native bark used to make handmade papers of Thailand (7).

KORAI GANDULA, see MOTHA.

KOZO or PAPER MULBERRY (Broussonetia papyrifera) -- used by Japanese to make handmade sheets. Small amounts of handmade paper made in Vietnam, Cambodia and Laos. It is duplex, the layers being of similar composition, but lower layer is thicker and harder, both being sized with rosin, sodium silicate and alum. It is used in China in sericulture for the silkmoths to lay their eggs on. Dard Hunter said the finest oriental paper is made from paper mulberry (1) (9).

KUMHIA (Careyas arborea) -- inner bark of tree used; grown in India (8).

KURUKORURU (Diplotropis sp.) -- soda process, soft, pale brown paper of good strength; from British Guiana (5).

LARCH, EUROPEAN (Larix decidua) -- small amounts are pulped by sulfate process in central Europe (1) (2).

LARCH or TAMARACK (Larix laricina) -- small amounts pulped by sulfate process; used in U. S. and Canada (1).

LARCH, WESTERN (Larix occidentalis) -- small amounts pulped by sulfate process in U. S. and Canada (1) (2).

LAUAN WOODS -- there is talk of producing pulp from certain of the lauan woods in the Philippines (1).

LAUREL (Cordia) -- tree found in Brazil (13).

LAUREL BLANCO (Cordia alliodora) -- tropical wood found in Honduras, British Honduras and Nicaragua (5).

LICORICE ROOTS (Glycyrrhiza glabra) -- extracted roots have been used in board manufacture (1).

LINEN -- linen fiber like cotton is tubular, but has thicker walls which are jointed like a cane or rush. They are long, strong, and flexible and form compactly, making a strong, hard paper of great durability (14).

LOBLOLLY-BAY (Gordonia lasianthus) -- small amounts are probably used in mixture with other southern hardwoods (1).

LONG JOHN (Triplaris surinamensis) -- soda process, light pinish-brown paper of fair strength; from British Guiana (5).

MAGNOLIA, SOUTHERN, or EVERGREEN (Magnolia grandiflora) -- pulped in mixture with other hardwoods in U. S. (1) (2).

MAGUEY, see CANTALA.

MAHOE (Sterculia caribaea) -- soda process, opaque, pale brown paper of good strength but with some shive; found in Trinidad (5).

MAHOGANY (PLANTATION GROWN) (Swietenia macrophylla) -- tropical wood found in Honduras (5).

MALLOW, INDIAN (Abutilon theophrasti) -- bast fibers may enter the paper industry from cordage or textile industries (1).

MANILA FIBER, see ABACÁ.

MAPLE, BIGLEAF (Acer macrophyllum) -- probably pulped occasionally in mixture with other hardwoods (1).

MAPLE, BLACK (Acer nigrum) -- pulped in U. S. and probably Canada (1).

MAPLE, RED (Acer rubrum) -- pulped in U. S. and probably Canada (1) (2).

MAPLE, SILVER (Acer saccharinum) -- pulped in U. S. and probably Canada (1) (2).

MAPLE, SUGAR (Acer sacharum) -- wood of sugar maple pulped in U.S. and probably Canada (1) (2).

MAPLE, SYCAMORE (Acer pseudoplatanus) -- probably pulped occasionally in mixture with other hardwoods (1).

MARISHIBALI -- soda process, rather soft, pale brown paper of fair strength; found in British Guiana (5).

MARUL, see HEMP, BOWSTRING.

MARUPA (Simaruba amara) -- small amount for groundwood in Brazil (1).

MASA (Tetragastrix balsamifera) -- tropical wood found in Puerto Rico (5).

MESSMATE STRINGBARK (Eucalyptus obliqua) -- pulped in Australia (1).

MILK VETCH (Astragulus) -- used in Tibet (9).

MILKWEED, COMMON (Asclepias syriaca) -- floss has served as a kapok substitute and may enter paper industry as waste material. The bast fiber from stalks has been studied and perhaps could find use in specialties (1).

MILKWEED, SWAMP (Asclepias incarnata) -- floss has served as a kapok substitute and may enter paper industry as waste material. The bast fiber from stalks has been studied and perhaps could find use in specialties (1).

MILLET (Panicum miliaceum) -- may be pulped in China (1).

MITSUMATA (Edgeworthia papyrifera) -- shrub is cultivated to obtain bast fiber in Japan; Japanese use to make handmade sheets for everything; Dard Hunter said this is one of the most important fibers of the Orient (1).

MORA (Dimorphandra mora) -- soda process, strong, pale brown paper; found in British Guiana (5).

MORA AMARILLA (Chlorophora tinctoria) -- tropical wood found in Guatemala, Honduras, Venezuela (5).

MORABALLI (Peltogine) -- soda process, pale brown paper of fairly good strength; found in British Guiana (5).

MOROTOTO (Didymopanax morototoni) -- small amount used for groundwood in Brazil (1).

MOSS, SPANISH (Tillandsia usneoides) -- used for insulation and may find its way inadvertently as a waste into the paper industry (1).

MOTHA (Cyperus Rotundus) -- whole green grass is used in India (8).

MOTHI (Girardinia heterophylla) -- bast fiber used in India (8).

MOUJ, see PLANTAIN.

MUDRA, see CHAKRABHAND.

MUIRA-JUBA (Apuleia molaris) -- tropical wood from Brazil (5).

MULBERRY, PAPER, see KOZO.

MUNJ GRASS (Saccharum munj) -- from India (8).

MUTHA, see MOTHA.

MYLADY (Aspidosperma cruentum) -- tropical wood found in British Honduras (5).

NADDI -- discarded papers, used in India (7).

NAGPURI, see HEMP, BOWSTRING.

NARGUSTA (Terminalia amazonia) -- tropical wood found in British Guiana, British Honduras, Panama (5).

NEPAL PAPER, see DAPHNE.

NETTLE, COMMON STINGING (Urtica dioica) -- probably entered the rope paper industry as used cordage or fish nets, in Europe (1).

OAK (Quercus robur) -- pulped in France (1).

OAK, CHESTNUT or ROCK (Quercus montana) -- pulped in U. S. (1).

OAK, NORTHERN RED (Quercus borealis) -- (2).

OAK, WHITE (Quercus alba) -- difficult to pulp and bleach; found in Canada and U. S. (2) (16).

OAT (Avena sativa) -- straw is pulped from this, principally in Europe (1).

OGIA (Daniella ogea) -- soda process, light brown, opaque paper of good strength and quality; found in Nigeria (5).

OKRA (Hibiscus esculentus) -- perhaps used in small quantities (1).

OLIVE TREE (Olivillos) -- small type of olive tree in Chile; wood is used to make paper, chiefly newsprint (9).

ORO (Irvingia barteri) -- soda process, soft, rather weak, dark brown paper with some shive; found in Nigeria (5).

PALAS, see DHAK.

PALMS OF DIFFERENT VARIETIES (Palmae) -- leaves, stalks used (8).

PALM, TROPICAL (Raphia ruffia) -- raffia paper made from this; makers have named it "Madagascar" (country of its origin). Produces fine paper of warm, natural tone, suitable for etchings and engravings and is intended to serve same purposes as China and Japanese papers. Fibers are also used in cigarette paper. It is the same as bass, used for binding purposes in gardening (9)

PALMETTO, or CABBAGE PALM (Palmite guarany) -- reed-like plant of Brazil, used there for papermaking. Cooked with a little lime (without pressure) this plant produces fine white fibers of very excellent quality (9).

PAN KANIS, see BUL-RUSH.

PARAPARA (Jacaranda copaia) -- small amounts used for groundwood in Brazil (1).

PEAT -- peat paper is made from peat by C. E. Nelson's process; said to be better than ordinary wrapping. First factory to exploit this idea was opened in U. S. in 1906, but was liquidated in 1945 (9).

PECAN, see HICKORY.

PEPPERMINT (Eucalyptus salicifolia) -- (1).

PEROBA ROSA (Aslidosperma polyneuron) -- tree found in Brazil (13).

PIMPAL, see BAR.

PINE (Pinus insignis) -- from Chile. Only this and Paraná pine can

be considered as outstanding sources of the type of pulp required for certain grades of papers characterized by mechanical strength (13).

(Pinus montezumae) -- Mexican pine, a source, not major, of sulfate (kraft) pulp in North America (1).

(Pinus patula) -- spreading-leaved pine from which pulp is produced in South Africa. It is an "exotic introduced from Mexico" (1).

(Pinus pseudostrobus) -- Mexican pine sometimes used as a source, not major, of sulfate (kraft) pulp in North America (1).

(Pinus sylvestris) -- Finland, Norway and Sweden supply pulp from this (1).

PINE, AKAMATSU or JAPANESE RED (Pinus densiflora) -- probably pulped in Japan (1).

PINE, BUNYA (Araucaria bidwilli) -- pulped in small amounts in Australia (1).

PINE, CLUSTER, see PINE, MARITIME.

PINE, EASTERN WHITE (Pinus strobus) -- source, not major, of sulfate (kraft) pulp in North America (1) (2).

PINE, HOOP (Araucaria cunninghamii) -- pulped in small amounts in Australia (1).

PINE, JACK (Pinus banksiana) -- one of chief sources of sulfate (kraft) pulp in North America (1).

(Pinus divaricata) -- found in Canada and northern U. S.; sulfite pulp, also sulfate (2) (16).

PINE, LODGEPOLE (Pinus contorta latifolia) -- used in making sulfate (kraft) pulp in North America, not a principal source (1).

(Pinus murrayana) -- sulphite and sulphate pulps; found on Coast region of North America from Alaska to California (16).

PINE, LOBLOLLY (Pinus taeda) -- sulfate (kraft) pulp; one of chief sources of supply in North America (1) (2).

PINE, LONGLEAF (Pinus palustris) -- one of chief sources of sulfate (kraft) pulp in North America (1) (2).

PINE, MARITIME or CLUSTER (Pinus pinaster) -- made into kraft pulp in France, Portugal and Italy (1).

PINE, MONTEREY (Pinus radiata) -- pulped in Australia and New Zealand, commonly known there as radiata pine. Also pulped in Chile; can probably be acclimatized to various areas of Latin America. Not pulped in ts native California (1) (2) (13).

PINE, NORWAY or RED (Pinus resinosa) -- found in Canada and northeastern U. S.; sulfate pulp (2)(16).

PINE, OCOTE (Pinus oocarpa) -- tropical wood found in Honduras (5).

PINE, PARANA (Araucaria angustifolia) -- pulped by sulfite process in Brazil and northern Argentina and for groundwood in Brazil. Only this and Pinus insignis are outstanding sources of the type of pulp required for certain grades of papers characterized by mechanical strength (1) (2) (13).

PINE, PITCH (Pinus rigida) -- used in making sulfate (kraft) pulp in North America, not a principal source (1) (2).

PINE, POND (Pinus rigida serotina) -- source, not major, of sulfate (kraft) pulp in North America (1).

PINE, PONDEROSA or WESTERN YELLOW (Pinus ponderosa) -- used in making sulfate (kraft) pulp in North America, not a principal source (1) (2).

PINE, SAND (Pinus clausa) -- source, not major, of sulfate (kraft) pulp in North America (1).

PINE, SCOTCH -- (2).

PINE, SCRUB, see PINE, VIRGINIA.

PINE, SHORTLEAF (Pinus echinata) -- one of chief sources of sulfate (kraft) pulp in North America (1) (2).

PINE, SLASH (Pinus caribaea) -- one of chief sources of sulfate (kraft) pulp in North America (1) (2).

PINE, SPRUCE (Pinus glabra) -- source,not major, of sulfate (kraft) pulp in North America (1).

PINE, SUGAR (Pinus lambertiana) -- (2).

PINE, SWISS MOUNTAIN (Pinus montana) -- pulped in Italy (1).

PINE, VIRGINIA or SCRUB (Pinus virginiana) -- used in making sulfate (kraft) pulp in North America, not a principal source (1).

PINE, WESTERN WHITE (Pinus monticola) --a source, not major, of sulfate (kraft) pulp in North America (1) (2).

PINE, YELLOW WESTERN, see PINE, PONDEROSA.

PINEAPPLE PLANT (Ananas sativa) -- may enter industry as waste in various tropical countries which extract fiber from leaf of plant for textile purposes. The very narrow diameter of the ultimate fiber may be of intrinsic value in certain specialty grades (1) (2) (8).

PIQUIA (Caryocar villosum) -- tropical wood from Brazil (5).

PITA, see CENTURY PLANT.

PITA FLOJA (Aechemae magdalenae) -- (1).

PITEIRA, see HEMP, MAURITIUS.

PLANTAIN (Musa paradisiaca) -- fiber not so long or strong as that of abaca. Musa varieties such as kela, mouj, chavai are used in India (1) (8).

POLAK (Ochroma sp.) -- hard: soda process, light brown paper of good strength; soft: soda process, bleached pulp produced hard, tough white paper; from British Honduras (5).

POPLAR (Populus maximowiczii) -- probably pulped in Japan (1).

(Populus sieboldii) -- probably pulped in Japan (1).

POPLAR, BALSAM (Populus tacamahaca) -- in North America, made into groundwood, sulfite, soda, kraft and neutral sulfite semi-chemical pulps (1) (2).

POPLAR, BLACK, see ASPEN, POPULUS NIGRA.

POPLAR, PAPER or SOFT POPLAR, see ASPEN, LARGETOOTH.

POPLAR, YELLOW (Liriodendron tulipifera) -- pulped in U. S., chiefly with other hardwoods (1) (2).

POSSUMWOOD (Hura crepitans) -- found in Panama, Surinam, Venezuela (5).

POTATO PLANT, COMMON (Solanum tuberosum) -- bast fiber from stalk has been studied extensively and may have been used in central Europe during emergencies. Potato stalks or stems have been used in Germany to an increasing extent to provide vegetable fibers for the paper industry. As the cellulose from the stalks can be made into paper, several factories have been equipped to deal with this product on a large scale, though it has proved to be

more valuable in the cellu-wool or textile industry where price is not such an important factor (1) (9).

PRIMAVERA (Tabebuiadonnell smithii) -- tropical wood found in Honduras (5).

QUAM (Schizolobium sp.) -- soda process, rather soft, light brown paper of fair quality (5).

QUARUBA (Vochysia sp.) -- small amount in groundwood in Brazil (1).

(Vochysia guianensis) (Vochysia hondurensis) -- tropical woods found in Brazil, Surinam, Nicaragua (5).

RAGS -- cuttings from textile mills, "dust" on floor sweepings and from cuttings in clothing plants make good paper, beat more easily. Waste rags are used for fine, permanent papers.

RAJATE BIEN (Vitex cooperi) -- found in Honduras and Guatemala (5).

RAMETA (Lasiosiphon eriocephalus) -- inner bark of plant is used, in India (8).

RAMIE or RHEA (Boehmeria nivea) -- fibers used by early Chinese paper-makers believed to have included bast fibers of various species of this genus. To what extent used today is not known. Also known as grass-cloth plant. Possesses one of strongest known of fibers, but difficulty of removing gummy substance from the "ribbon" is considerable. In Europe is used normally only for textiles and paper to be used for bank notes, and in U. S. for cigarette papers (1) (6) (8) (9).

RAN TURAI, see BHENDI.

RANBHENDI (Malachra capitata) -- bast fibers are used, in India (8).

REDBAY (Persea borbonia) -- undoubtedly pulped in mixture with other hardwoods (1) (2).

REDGUM, see SWEETGUM.

REDWOOD (Sequoia sempervirens) -- some of this is reduced to fibrous material by the Masonite explosion process. The bast fiber has been formed into sheets for battery separators. Found on West Coast of U. S. (1) (2) (16).

REED (Arundo donax) -- source of pulp in Italy and Argentina, possibly other areas (1).

REED, DANUBE (Phragmites communis) -- pulped in Italy and Rumania, perhaps in other areas (1).

RHEA, see RAMIE.

RICE or RICE STRAW (Oryza sativa) -- straw from cultivated rice is pulped in China, Indonesia, Argentina, Italy, Brazil, U. S., Spain, Egypt, and possibly other regions. Is made into strawboard in India; whole straw, not tops, is used. Dard Hunter said this makes poor paper (1) (8).

ROBLE BLANCO (Tabebuia pentaphylla) -- tropical wood found in Honduras (5).

ROSELLE (Hibiscus sabdariffa)(Hibiscus altissima) -- perhaps used in small quantities (1).

RYE (Secale cereale) -- straw from cultivated rye is pulped, principally in central Europe (1).

SABAI or BABHAR GRASS (Ischoemum angustifolium) -- whole grass or leaves, rope is used, in India (8).

SALAI WOOD (Boswellia serrata) -- newsprint has been made from a mechanical pulp prepared by grinding salai wood and a bleached bamboo kraft pulp as the chemical fiber. In India (1).

SAL (Shorea robusta) -- wood of common Indian species is pulped in small amount (1).

SAMBABAIA -- a giant fern tree of Brazil, used to produce a good wrapping paper (9).

SANGRE (Pierocarpus vernalis) -- tropical wood found in Venezuela (5).

SASSAFRAS (Sassafras variifolium) -- may be pulped with other species (1) (2).

SIDA (Sida)-- bast fibers of certain species may enter paper industry from cordage or textile industries (1).

SIMARUBA (Simaruba amara) -- tropical wood found in Surinam (5).

SISAL (Agave sisalana) -- enters paper industry as waste from cordage industry (1) (2).

SPRUCE (Picea excelsa) -- Norway, Finland and Sweden supply pulp from this (1).

(Picea orientalis) -- pulp made from this in Turkey (1).

SPRUCE, AKAEZO (Picea glehni) -- Japanese make pulp from this (1).

SPRUCE, BLACK (Picea mariana) -- Picea genus is probably the most universally favored for pulping because the wood combines the desirable qualities of light color, relatively low pitch content and long fiber. It produces an excellent groundwood, sulfite or sulfate pulp. A favorite in Canada and U. S. (1) (2).

SPRUCE, BLUE (Picea parryana) -- sulphite and sulphate processes; found in U. S. and Canada (16).

SPRUCE, EZOMATSU (Picea jezoensis) -- Japanese make pulp from this (1).

SPRUCE, ENGELMANN (Picea engelmanni) -- sulfite, sulfate, mechanical pulp; used as much as possible in U. S. and Canada (1) (2) (16).

SPRUCE, HARIMOMI (Picea polita) -- Japanese make pulp from this (1).

SPRUCE, IRAMOMI (Picea bicolor) -- Japanese make pulp from this (1).

SPRUCE, NORWAY (Picea abies) (Picea excelsa) -- (2).

SPRUCE, RED (Picea rubens) -- a favorite in U. S. and Canada (1) (2).

SPRUCE, SITKA (Picea sitchensis) -- sulfite, sulfate, mechanical pulp; used as much as possible in U. S. and Canada (1) (2) (16).

SPRUCE, WHITE (Picea glauca) (Picea canadensis) -- sulfite, sulfate, mechanical pulp; good for practically every purpose where groundwood pulp is required; Canada and northern U. S.

SPRUCE, TOHI (Picea hondoensis) -- Japanese make pulp from this (1).

STRAW, see under name of plant.

SUGAR CANE, see BAGASSE.

SUNN (Crotalaria juncea) -- The bast fiber enters the industry for rope papers from used cordage and rough textile waste (1) (8).

SWAMP BLACKGUM, see SWAMP TUPELO.

SWAMP TUPELO or SWAMP BLACKGUM (Nyssa sylvatica biflora) -- used for pulp hardwood in southern U. S. (1).

SWAMPBAY (Persea palustris) -- undoubtedly pulped in mixture with other southern hardwoods (1).

SWEETBAY (Magnolia virginiana) -- pulped in mixture with other hardwoods in U. S. (1).

SWEETBAY, SOUTHERN VARIETY (Magnolia australis) -- pulped in mixture with other hardwoods in U. S. (1).

SWEETGUM or REDGUM (Liquidambar styraciflua) -- generally used as a pulpwood in southern U. S. (1) (2).

SYCAMORE (Platanus occidentalis) -- soda pulp; small amounts may find use with other central hardwoods (1) (2) (16).

TAIWANIA (Taiwania cryptomeroides) -- large tree used for pulp in Taiwan (1).

TAMARACK, see LARCH.

TATAJUBA (Bagassa gioamemsos) -- tropical wood found in Brazil (5).

TAUARI (Couratari pulchra) -- tropical wood found in British Guiana and Brazil (5).

TEAK (PLANTATION-GROWN) (Tectona grandis) -- tropical wood found in Honduras (5).

TEMANQUEIRA (Zanthoxylum rhoifolia) -- small amount in groundwood in Brazil (1).

TETRAMELES (Tetrameles) -- small amounts used for chemical pulp in Thailand (1).

TREE-OF-HEAVEN (Ailanthus glanduloso) -- used occasionally with other hardwoods in U. S. and is pulped in Japan also (1).

(Ailanthus altissima) -- (2).

TRYSIL (Pentaclethra filamentosa) -- soda process, strong, grayish-brown paper; found in British Guiana (5).

TUPELO, BLACK, see BLACKGUM.

TUPELO, SOUR, or OGECHE LIME (Nyssa ogeche) -- in Southern U. S. (1).

TUPELO, WATER (Nyssa aquatica) -- (2).

TUTHINAR, see CHAKRABHAND.

UTARNI (Doemia extensa)-- outer bark is used; from India (8).

VACO (Magnolia sororum) -- tropical wood found in Panama (5).

VAD, see BAR.

VALKAL TREE or CHANDKUDA KARVAT (Antiaris taxicaria) -- inner bark is used; grown in India (8).

WALLABA (Eperua falcata) -- soda process, soft grayish-brown paper of good strength; British Guiana (5).

WALNUT, BLACK (Juglans nigra) -- (2).

WANASORO (Cecropia juranyiana) -- soda process, brown paper of good strength (5).

WASTE PAPER -- most grades can be repulped to make a cheaper new grade of paper.

WATTLE (Acacia decurrens) -- this has a bark rich in tannins and is being pulped in South Africa (1).

(Acacia mollissima) -- used for bleached sulfate pulp manufacture in South Africa for printing, writing and envelope grades of paper (4).

WHEAT (Triticum vulgare) -- straw from common wheat is pulped in many countries, especially in Holland, Italy, Germany, United Kingdom, Argentina, Uruguay, Hungary, Algeria, Portugal, Spain, Turkey, possibly in others. About a half million tons of straw pulp are produced in U. S., but little, if any, is bleached and used for high-grade papers (1) (2).

WHEAT or GEHU (Triticum ativa) -- whole straw except tops is used in India. (8).

WHITE MOHO (Hibiscus sp.) -- soda process, pale brown paper of good strength and quality (5).

WIKSTROEMIA (Wikstroemia viridiflora) -- small amounts of handmade paper from this in Vietnam, Cambodia and Laos (1).

WILD CHATAIGNE (Pachira insignis) -- soda process, tough, fairly bulky opaque paper of good strength; Trinidad (5).

WILLOW, BLACK (Salix nigra) -- pulped in small amounts in U. S. Presumably some is pulped in Argentina and Turkey (1) (2).

WILLOW, WHITE (Salix alba) -- (2).

WISWISKWALIE (Qualea sp.) -- see Gronfoeloe.

YARURU (Aspidosperma excelsum) -- soda process, weak, soft, rather dark brown paper (5).

YELLOW MANGUE (Symphonia globulifera) -- soda process, soft, opaque, bulky, brown paper of fairly good strength; Trinidad (5).

YELLOW SANDERS (Buchenavia capitata) -- tropical wood found in Puerto Rico (5).

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CHAPTER 5

# Alternate Pulping Processes and Equipment

Particularly in terms of making better-quality and stronger papers, the basic theory of pulping and beating fibers is to draw them out as much as possible, shred them, and fray them, rather than cut them. This is a complex and (if by hand) a laborious operation to achieve good beating.

The dozens if not hundreds of different ways of producing pulp may be divided into two broad and obvious categories--traditional or hand, and modern or technological. While the traditional methods are given the most detail below, the modern techniques are also important because (a) they may in some cases be adaptable to smaller and simpler operations and (b) there may be many countries which should consider full-scale pulping operations, both for major papermaking products and for export (in which case, pulp would be readily available to cottage industry).

There are fundamentally three different processes which may be involved in making of pulp: (1) the natural processes such as retting, bleaching and decomposition which occur when the raw materials are left in the water, or perhaps in the air, or in a moist, warm place, as the case may be for different fibers; (2) mechanical processes, involving cutting, beating, hammering, flaying, rubbing and grinding to break the fibers away from extraneous materials and to shred or fray the individual fibers; (3) chemical processes, or digestion, by which various chemicals either in open vessels or under pressure and with or without heat, act upon the raw material to separate the cellulose fiber from other materials (without substantially affecting the cellulose, which is a singularly inert chemical compound). All three of these methods are often combined--in the ancient processes as in the modern ones--and the combinations are perhaps endless.

## TRADITIONAL HAND PULPING METHODS

In the traditional or hand methods of making pulp, no distinction is made between the pulping process and the beating process. By natural action (such as letting fibers soak in running water) or by chemical action (such as interlaying lime or lye with the fibers), or by mechanical action (such as hammering the fibers with stones), the purpose is to bring the cellulose fiber to the state which will best make the desired paper.

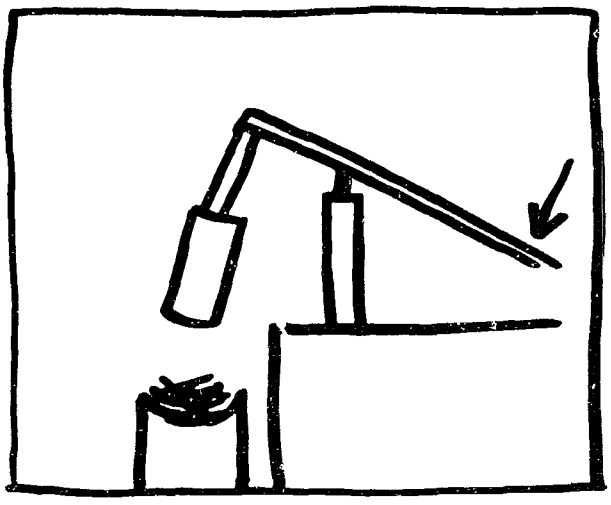

Fig. 9. STAMPER, HEAD UP

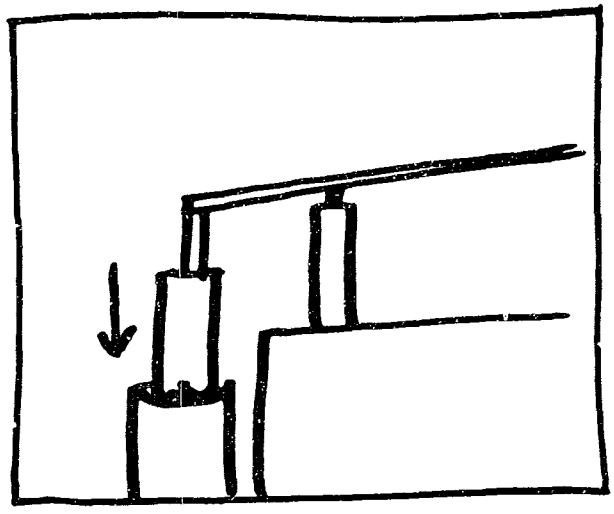

Fig. 10. STAMPER, HEAD DOWN

Over the course of many centuries, different techniques have been developed for handling specific fibers. The more important among these are described in simplified and general terms below, beginning on Page 65, and a reading of all of them will provide a cross-section of what is possible. How an area which has not had a papermaking tradition should best process the fibers it has available, or how a new fiber should be processed by a cottage industry which has already established its process for its present fibers, is arrived at by a combination of (a) common sense, (b) experience which may be learned from others, (c) trial and error and (d) research. If the new fiber is one which is now used elsewhere in small-scale industry an inquiry to the government concerned will provide information. As an indication of where these fibers are now being processed, the list starting on Page 31 lists as many countries as possible.

Also, it should be recognized that some of the more advanced mechical and chemical processes, described in the next section, may be adaptable to hand processing, as research may demonstrate.

Methods of beating -- The central part of the pulp-making process by hand is the beating, which, as noted earlier, covers both the pulping and beating processes which are considered separately in more advanced techniques. There are two distinct methods which may qualify as "hand processes" in beating, although one of them sometimes uses animal power. The simplest form consists of literally beating the fibers with sticks or stones or hammers of some sort, held in the hand, until the fibers break apart and are actually frayed. This is still the equipment for some of the best handmade paper produced in Japan. A very great amount of muscle power is required to pound the fiber to a satisfactory pulp for even a few sheets of paper.

The fibers may also be rubbed against rough stone. They should not be chopped, however. While the pieces may be cut to lengths of a few inches, the fibers should not be cut too small because the purpose is to

separate the fibers and fray their edges; usually, the longer the fiber, the better they "felt" or hold together in the sheet, and the stronger the paper.

The second form of beating involves the use of a semi-mechanized device, called a "stamper" in traditional European papermaking and a "dhenki" in Indian usage. If quantity production of pulp is desired, and power-driver beating equipment (discussed later) is not available as a central facility, it may be advisable to consider some sort of stamping equipment. In essence, as Figures 9 and 10 show, the device amounts to a huge "hammer" of stone or wood, which is lifted by leverage, and then dropped onto the fiber, over and over until it is pulverized. The principle is like a mortar and pestle. Manpower or some arrangement for mechanical or animal power lifts the hammer head and then lets it fall.

One variation of this is a huge wheel which keeps turning in a stone-lined trough--grinding and pulverizing the fibers underneath it. (See Figure 11.) An animal can keep the wheel moving around a central tethering post, as is sometimes done with oxen at water wells. (There is a mechanical version of this, called a Kollergang, which effectively pulps

Fig. 11. ANIMAL POWER TURNS A STONE TO PULP THE FIBER UNDERNEATH

a fiber by rolling granite stone wheels around a rounded bottom to set up a slewing motion; this improvement might be tested in a small-scale operation.)

Another device, recently developed, makes it possible to shred the fibers by means of spikes or claw-like points on a wheel which can be turned by a bicycle pedal. This may provide a relief from very heavy work if it is adaptable to local fibers.

Besides the felting action, the method and degree of beating affects the "freeness" of the pulp which results. A well-beaten pulp soaks up and retains more water than a poorly-beaten fiber, so that eventually the pulp looks like thick jelly and feels greasy like butter. This condition is called "hydration" and the pulp is called "wet." A "wet" pulp does not drain off its water easily on the paper-lifting screen, and it makes a stronger paper. A "free" pulp, on the other hand, drains its water quickly on the screen, and results in a paper that is soft, absorbent and weak. Where such paper is desired, there is no reason to beat the fibers unduly. For ordinary papers, there is a midpoint between "free" and "wet," and part of the knowledge of papermaking rests in knowing how much beating to do for the particular fiber to make the particular kind of paper desired.

## MODERN METHODS OF PULPING

There are increasing numbers of different processes being developed, and it is impossible to explain or even catalog them all in a Manual such as this. However, the principal processes are named and described briefly below, together with some indication of fibers for each, as an introduction to the reader who must have some understanding of the various alternatives available as he makes a decision on whether to undertake papermaking, and at what level and to what extent. More detailed information is available in two FAO publications, "World Pulp and Paper Resources and Prospects," 1954 (especially Appendix II), and Forestry and Forest Products Study No. 6, "Raw Materials for More Paper" (1953).

The modern pulp-making processes are of two basic types, mechanical and chemical; however, they are now combined so frequently in so many ways that there is a third middle type which is probably more significant than the two original types.

Mechanical processes: The process by which the major pulps in newsprint and other cheap papers are made (and thus the biggest-volume pulps in terms of world use) is called groundwood. It is literally a process by which logs of trees are pressed together against a revolving grinding stone and reduced to fibers. No chemicals or steam are required, but electric power consumption is considerable, and the process is thus most economic where there is cheap electricity. The equipment involved

is probably too large and expensive to consider as a central facility for a cottage industry alone; also, the timbering operations to obtain the logs would be too great for such a purpose, and the resultant paper too cheap a grade to be ideal for cottage industry. However, a full-scale pulping operation for other purposes, and tied in with a going or projected forest industry might be feasible, and cottage industry might use some of its pulp in a mixture. Other fibers, such as bamboo, may prove to be able to use the groundwood process.

Semi-chemical or steamed groundwood -- This is substantially the same as groundwood, except that the logs are steamed before being ground.

Disk and rod mills -- These are mechanical devices with revolving disks or bars of iron inside a boiler, grinding down and breaking up wood chips or other fibrous raw materials, sometimes with simultaneous steam. The action is not as coarse as the groundwood process, and better fibers result.

The mechanical processes yield a higher percentage of fiber for the material (75 to 95%) than the chemical processes (45 to 50%), but they are harder on the fiber, and thus generally make poorer paper. In addition, the lignin (the substance which binds the fibers together in nature) is not removed, and the color of the paper is poorer than in the chemical processes.

Chemical processes -- The method first used for cooking rags was the soda process, so called because it uses a solution of caustic soda in water; at high temperatures, this will dissolve all the other constituents of wood except the cellulose. To make it an economic operation, the soda must be recovered, and this makes the process a complicated one. The process is considered best today for pulping grass and straw, whereas wood pulping is better under the sulphate process. This process uses sulphur and sodium compounds (originally sodium sulphate, hence the name of the process) and gives higher yields and better strength characteristics, and can be used for a wider variety of papers. Also it is easier to recover chemicals used. It is an expensive installation--although apparently no serious attempt has been made to use a small and simplified version of the equipment for cottage-industry volume. The kraft process is a version of the sulphate, giving especially strong fibers. The sulphite process cooks with calcium bisulfite and sulphurous acid, and there are variations now which indicate that it may be useful for some of the fibers available in the underdeveloped areas--as for instance bamboo in India. However, it is not as versatile a process as the sulphate.

There is a continuous process which requires no pressure vessels and is suitable for making bleached pulp from annual plant fibers such as straws, bagasse and agricultural residues; called the caustic soda-chlorine process, it uses a weak caustic soda solution followed by chlorine, using them in about the same proportion as they are produced by electrolysis of

common salt. Mixed with other fibers, they may be used from newsprint through high-grade and glassine papers. The oldest chemical process is lime, still used as a retting process in a pit and also for cooking under pressure; while it is very adaptable to small operations, it is limited in the quality of pulps it can produce.

A commercial continuous process for pulping using caustic soda to produce a semi-pulp suitable for use in corrugating boards and then using wet gaseous chlorine to make fine pulps is called Celdecor; it is being used in a number of countries, particularly on straw, and is used also to pulp bagasse.

The only pulping process which can be recommended for processing as broad a range of fibers as eucalyptus wood, bamboo, bagasse and straws is a pressure process using either kraft or neutral sulfite chemicals for cooking, with the concentration of chemicals and pulping conditions being adjusted to the character of the raw materials.

Acid pulping processes are not good for agricultural residues because they leave the fibers relatively weak and brittle.

Combined processes -- These processes start with a mild chemical action which loosens the binding substances between the fibers, and then puts the fiber through a mechanical process to break the cellulose free. While they obviously require both chemical and mechanical equipment, and thus are more expensive to install on the face of it, they offer some interesting possibilities for the underdeveloped areas. The cold caustic soda process treats wood chips with cold caustic soda liquor and follows with refining in a disk mill. The Forest Products Laboratory, Madison, Wisconsin, U.S.A., reports that extensive experimentation has shown that the process can take hardwood chips and produce pulps with properties between groundwood and neutral sulphite semi-chemical pulps, and thus are suitable for printing papers and corrugating board. The chips are stepped in a solution of sodium hydroxide at atmospheric conditions for approximately two hours and then fiberized in a disk mill. The neutral sulphite semi-chemical process has been demonstrated to make pulps of good quality for bond papers, for news and printing papers, for linerboard and foodboard. The pulps are light in color when unbleached, and they gain strength upon bleaching. And the process lends itself to relatively small units and a minimum plant investment (although still most substantial by cottage industry standards). Besides hardwoods, the process will handle straw, bagasse, grasses and other agricultural residues.

A new and almost ideal process for the pulping of agricultural residues is the simple and relatively inexpensive mechano-chemical process, in which digestion is carried out in an open vessel at the same time a mechanical impeller "pumps" the chemical liquors into and out of the straw. The process is simple to operate, and uses different chemicals for different pulps. Straw cooked and circulated for 1 hour at about 98°C. in one case gave as good a pulp as a 5-hour cook at 140°C. by cooking alone. The process is especially suitable for the production of fine pulp from straw, bagasse and similar agricultural residues.

## IMPROVING THE QUALITY OF PULP

After the fibers are pulped, it is often necessary to subject them to a bleaching operation--adding chemicals, sometimes with heat, or by electrolytic processes. The bleach lightens the color of the pulp and thus the resultant paper; it is intended to make the paper as white as possible and keep it so indefinitely, without harming the strength of the fibers.

From an economic point of view, the bleaching agents do this at the cost of shrinking the pulp in weight, and of course the chemicals cost money themselves. However, they may properly be considered a second step in pulping--saving costs in the first chemical or mechanical operations. Thus, the question of whether the lignin should be entirely removed in the first pulping operation or partly in the bleaching is an economic question which can be answered only by the specific facts of the particular situation. Bleaching operations are generally faster and simpler than the added work which would have to be done by mechanical means, but they may cost more--and they may lower the quality of the pulp.

It should be noted that the bleaching elements--and indeed all of the chemicals used in the pulping process--create safety hazards. Chlorine is a poisonous gas; caustic soda can cause burns and blindness if splashed in the eye.

After the pulps are made and bleached as necessary, they are usually passed through a screen or sieve, to insure that all foreign substances and unpulped fibers are removed. This is also called a "knotter" in hand operations, to remove knotted fibers and foreign substances before the stock goes into the vat.

## REPULPING

If the pulp and paper operation are in a combined plant, the pulp simply moves over to the beaters, for the next phase of the process. However, it is perfectly feasible to dry out the pulp to transport it at a minimum cost (avoiding charges for the weight of the water which has been removed). When the paper producer receives the pulp, as will be explained in the next chapter, he "repulps" it and proceeds with his own operations. The repulping is done in the beater, although there is a specialized machine called a repulper.

Thus it is possible for a cottage industry to rely upon pulps produced elsewhere and shipped in. Whether it is better to do it that way, or to produce the pulps locally, will depend upon factors discussed in detail in Chapter 13.

## PROCESSES FOR PULPING SPECIFIC FIBERS

The methods described below include both traditional and modern technological processes. While they by no means cover all the fibers available or the only ways of reducing the particular fibers discussed, they do generally cover those which would be of the most interest to cottage industry in underdeveloped areas.

Rags -- Old rags have historically been a principal source of paper fibers; they are especially good because the using of the cloth and its repeated washing serve to break down the fibers substantially, so that much of the work of pulping is done beforehand, from the standpoint of the papermaker. However, because rags are likely to be dirty and oily or greasy, and to have buttons, pins and other materials attached to them, a great deal of effort is involved in sorting, dusting, cutting, and washing. For large-volume operations, there is mechanical equipment available to perform these steps. A traditional method is to take the cleaned and cut rags and, after moistening them, pile them together in a warm, damp place to decay. They may be left there three weeks or more, until the vegetable glutin which must be removed from cotton fibers has fermented enough to be easily washed away. Then the rags are boiled, washed clean and handbeated to a smooth pulp.

By more modern methods, the rags are boiled in digesters with a mixed solution of lime and soda, under a steam pressure of 40 pounds to the square inch, with the cooking continuing from 12 to 14 hours. This process loosens any coloring, grease, dirt and glutin, so that they may be washed away afterwards. After the washing, there is a bleaching operation, either with bleaching powder or an electrolytic bleach, and again there is a washing to remove the excess bleach. At this point, the pulp is called "half-stuff." It is ordinarily drained off, to become a white and compact mass of fibers; usually it is allowed to stand in the drainers for a week or more, to subdue the fibers. Then the pulp is put through a beating process.

Mulberry -- While the ancient methods have developed some variations, the process amounts substantially to this: (1) steaming the sticks or shoots to strip away the barks and separate the brown surface from the inside part of the bark; (2) the barks are then soaked for some hours or boiled again, often with caustic soda, soda ash, lime or other alkali, for two or three hours; (3) the barks are then left in clear (usually running) water to bleach for a day or two; sometimes chemical bleaches are used; (4) the material is then cleaned by hand, with the dark skin being scraped away, leaving the clean inner bark as the fiber; (5) the barks are then pounded by hand; (6) the bark is cooked in open vessels, for two or three hours with about 10% alkali, after an initial soaking period; the alkali may be caustic soda, soda ash, lime or hydroxide leached from wood ashes with hot water; (7) the cooked fiber is washed for several days in clear, cold running water--qualities believed important to insure good paper,

and to accomplish a bleach as well as remove the cooking chemicals; (8) impurities are picked away by hand; (9) the pulp is beaten, either by hand or mechanical beater; (10) an adhesive called "tamo," made from the roots of a plant similar to the hollyhock, is added, to insure later that the sheets of paper will pull apart in the drying process, even though no felts are used. In some of the variations, there are bleaching processes which require from seven to 11 weeks; in the old Chinese method, the inner bark was boiled in lye until separated into fibers, and when these were washed clean, the fibers were worked by hand into a pulp and then beaten fine with a mallet on a table.

Bamboo -- Although treated in various ancient ways to make paper, this fiber is also being pulped by modern processes.

In the traditional method, bamboo canes are stripped of their leaves and shoots, tied into bundles, and steeped in a pond until the green outer skin or bark can be removed. Then, split open by hammering, the bamboos are laid into a dugout trench or a pit lined with stones; layers of the cane are alternated with layers of lime. The pit is filled with water, and the bamboo soaks for several months, after which it is washed thoroughly in clear water to eliminate all of the lime. In a semi-disintegrated state from this processing, the bamboo is further beaten by hand or mechanical power to make it suitable for sheet-forming.

Cooking by the soda process is the newer method, with alternative amounts of soda and cooking times involved. One Indian process includes two cooks--one being with 5% caustic soda in an open boiler for four hours, and then (after thorough washing and crushing of hard portions) digestion in small quantities with 15% caustic soda at a 50-pound pressure per square inch for four hours--after which it is washed and lightly beaten to loosen the lumps, and bleached with 12% bleaching powder. This results in a grayish-white pulp with a yield of about 40%. This pulp may then be suitably beaten for sheet-forming in from three to four hours. An alternative cook is carried out at 60 pounds pressure for 10 hours, with 30 pounds of 76% caustic soda per 100 pounds of pulp. In Burma, the sulphite process has been used with a yield of more than 50% and with less bleach required than in the Indian process.

Waste paper -- First it must be sorted out into different types, since some trimmings of high-quality unused white paper can make a good repulped paper, while newsprint for instance can be used only for making paper boards. The point is that the fibers in waste paper were once pulped and beaten to what was presumably the best treatment for them; any new treatment now, a second time around, overdoes it and weakens the fibers. Waste paper is first generally screened or dusted and washed to remove dirt and impurities. Then it is digested by either (a) the cold process--2% caustic soda, allowed to soak at least 24 hours at room temperature, or (b) the hot process--5% lime of good quality, boiled 4 or 5 hours, and then washed to remove some of the lime. The pulp can

then be put in a beater or trampled under foot or pounded and rubbed. After washing, it is bleached with a light solution of bleaching powder. When printer's ink is present, stronger solutions of chemicals are needed. Lime and caustic soda can also be used, and there are special chemical disbursing agents which increase the amount of ink that can be washed away. Where the ink is not removed, the paper is grayish. With modern machinery, waste paper is simply put in a repulper or beater (see next section), being in effect treated as pulp.

Straws -- Such cereal straws as wheat, rice, oats, barley, and rye straws are relatively easy raw materials to pulp, either by traditional or modern chemical methods. In the old Chinese process, the rice straw first receives a preliminary pounding and is then buried in a trench after being saturated with lime. When the straw is disintegrated, the fibers are placed in porous cloth bags. These are held in a running stream to cleanse away all the lime. After that, they are beaten gently (brushed) and rubbed. Rice straw can be pulped simply by trampling and rubbing, without stampers. A more modern way is to boil the straw with 15% alkali for six hours, and then wash and bleach with 10% of bleaching powder. Straw can also be digested with caustic soda, lime or soda ash under pressure of about 50 pounds, at 150°F., for 2 to 5 hours. When treated this way and bleached, it yields a white paper pulp which is nearly pure cellulose, making a fine writing paper. It can be easily pulped in the beater (see next section). Under most processes, the nodes cause trouble, creating black spots like the point of a pin in the final paper; they must be washed and strained away as much as possible, and with modern equipment the problem can be completely overcome.

Bagasse -- There are different types of bagasse (the residue of sugar cane) and many current attempts to find the best way to process the fiber. It is easily reduced, washed and bleached to pulp, and has a good yield if the pith is removed; in addition, the paper improves with the removal of the pith. Although the acid sulphite process is not recommended, bagasse can be pulped by any of the usual commerical pulping methods. It requires approximately 7 tons of fresh bagasse (50 per cent moisture content) to make one ton of pulp. Normally a bulky and coarse pulp with poor strength, bagasse is one fiber which should be particularly studied in terms of mixing with other fibers. Writing papers can be made with up to 90% bagasse and the rest softer fibers; somewhat more is better for printing pppers. For wrapping paper, long fibers added to bagasse combine to give excellent results. Adding bagasse to wood pulp makes a firm sheet of paper and reduces the amount of beating required with wood pulp alone. Use of mineral fillers with bagasse produces good opaque paper, and harder paper, because the fine fibers of the bagasse pulp retain the fillers as well. (See Page 75 for discussion of fillers.)

Esparto and other grasses -- After cleaning and preliminary chopping, the grass is cooked in pressure boilers, from 2 to 5 hours under a pressure of approximately 50 pounds, with 15% caustic soda or with a

mixture of caustic and sodium sulphide. The boiler is usually the "vomiting" boiler or digester, which has a false bottom. The liquids bubble up through pipes and then spread through the fibers again and again as they fall to the bottom. The digested mass is then washed, pulped, bleached and screened. In modern plants, the final washing and bleaching are carried out in the beater (see next Chapter).

Jute -- The raw materials, usually in the form of old rope and gunny sacks, burlap, or as jute cuttings, are handled in the same way as old rags. The jute is then cooked in a cylinder rotary boiler, with lime or sometimes caustic soda being added. Afterwards, it is again treated as are rag pulps. Jute may also be retted by allowing to steep in lime. While some bleaching is required for the pulp in any case, the amount needed for making white paper is not only uneconomical but it so weakens the fiber that it is not practical for the purpose.

CHAPTER 6

# Alternate Stock Preparation Processes and Equipment

In modern pulp and papermaking, as has been explained, the fibers may have had considerable mechanical beating while being processed into pulp, but this should be distinguished from the beating process which follows the pulp-making process.

This perhaps may be made clearer by saying that pulp is not paper. Pulp is only one of the materials that goes into the making of paper. Beating--which is literally what the word says, a beating of the pulp by some mechanical means--is the first part of the process of making paper itself by combining pulp with all of the other materials.

The function of beating is not altogether understood, except that it improves the ability of the fibers to make good paper. The idea of the beating is to separate the fibers more thoroughly, split them, fray them, and otherwise pull them apart to the utmost while still keeping them connected, so that the thin, almost curled edges will "felt" or intertwine with one another and form the solid sheet of paper with strength to reisst tearing, creasing and crumpling, or whatever.

Among the various conditions and characteristics which result from beating these are the most important:

Felting power -- This is the ability of a fiber to entangle with other fibers; long and flexible fibers do this better than short and stiff ones, and thus make stronger and more elastic paper. The way a fiber is beaten may safeguard the natural qualities of the fiber or destroy them--as in the obvious instance of cutting long fibers into shorter pieces. Sometimes shorter fibers will "felt" better than longer fibers because they are made elastic and frayed to provide more interleaving surfaces, whereas the long fibers may not be properly treated. It is important to learn the best way to treat a given fiber to get the desired paper.

Flocculation -- This is in many ways the same thing as felting power, except that involves more than fibers themselves; it is the way fibers aggregate or come together to form a sheet--because of their felting power, or because of any mechanical assistance such as the vatman's shake, or chemical adhesives which may be added. Good flocculation makes

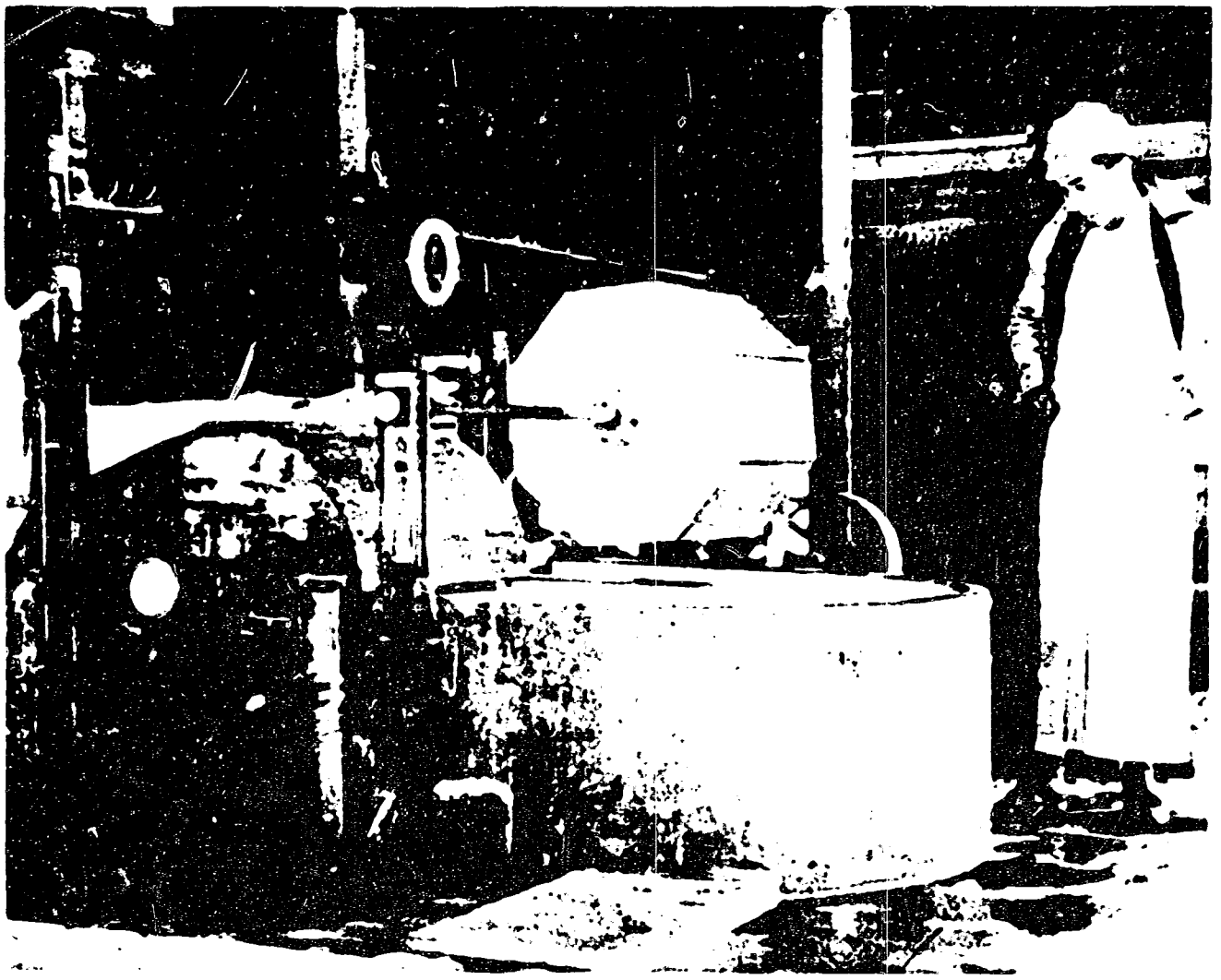

Fig. 12. A HOLLANDER BEATER WITH THE PULP-BEATING ROLL DISENGAGED

a denser, stronger sheet. Flocculation increases with increase in temperatures as well as with fiber strength and the amount of beating.

Hydration -- Some papers such as blotters should be "waterleaf," which is to say, soft and able to soak up liquids readily; in other papers, the opposite is the case. While chemicals can reduce or even eliminate the paper's ability to absorb, the way the fibers are processed is also important. Fibers beaten quickly and cut short, without frayed surfaces for felting, make absorbent paper; fibers beaten slowly and with dull surfaces to avoid cutting, work up into a harder sheet which is increasingly water-resistant and increasingly transparent. In the actual pulping and papermaking process, distinction is made between free or fast pulp (which drains water easily) and wet or slow or greasy pulp or stuff (which has had water beaten into it to such an extent that it will not drain it away, developing a feeling something like butter).

Fibrillation -- This is the actual process of reducing the fibers to their fibrillae; if there has not been enough beating, the fiber is called raw, and will not make a good sheet because it cannot felt.

Beating equipment -- The first really mechanized beater, called the Hollander because it was invented in Holland, succeeded the stamper about 200 years ago, and its principle is still basic to the beater or "beating engine" as it is sometimes called. The Hollander is shown in Fig. 12; a smaller Hollander is shown from a different angle in Fig. 13. The two important principles involved are (1) a partition is put into a tub to insure, with the motion of the beating equipment, that the pulp will keep flowing, so that all parts of the solution will have their turn at being beaten, and (2) the beating apparatus consists of rows of iron bars both on the turning wheel or roll and on the bed of the but, at angles to each other, so that the fiber caught between them as the roll turns is chewed and frayed. Fig. 12 shows the Hollander with the roll disengaged. The roll can be lifted or lowered to accomplish more or less chewing of fibers It is often said that "the paper is made in the beater"--the know-how as to the right kind and duration of chewing to provide is the secret of papermaking--because too little chewing will accomplish nothing on the fiber, whereas too much will destroy the fibers.

The length of time the pulp requires to be beaten, like the amount of chewing at any one time, depends upon the fiber and the kind of paper being made. It may continue with one batch for one hour or several hours, although with straw pulp it is sometimes said it is difficult not to overbeat the pulp in a beater. With handmade papers, this may be left to the judgment of the beaterman or the papermaker; in the more mechanized paper mills where uniformity is a necessity, the processes are worked out in detail and the beating is timed.

Usually, any other materials that are to go into the stock are added to the pulp in the beater, with the result that they become perfectly mixed with the pulp. For any one run of paper in a mill there is a formula, in effect, calling for the exact amount of each kind of pulp, the amount of the sizing, dye, "loading agent" or filler, and any other material which may be included to meet the specifications for the particular kind of paper to be produced. This may or may not be exact in cottage industry papermaking. (The substances added at this point are discussed in detail in the following section.) If the paper is to be made of a mixture of different fibers, they are usually combined in the beater at this point.

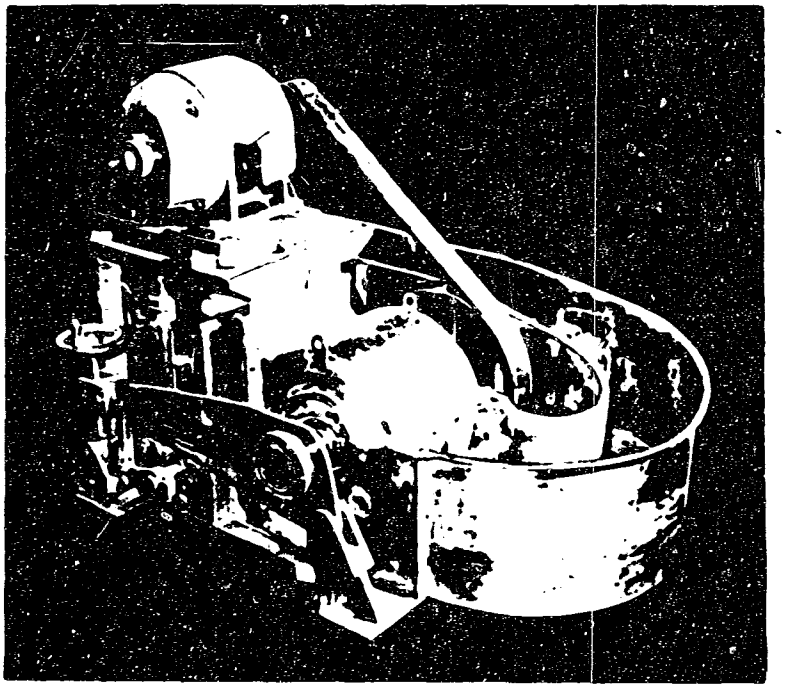

Fig. 13. A SMALL BEATER FROM ANOTHER ANGLE

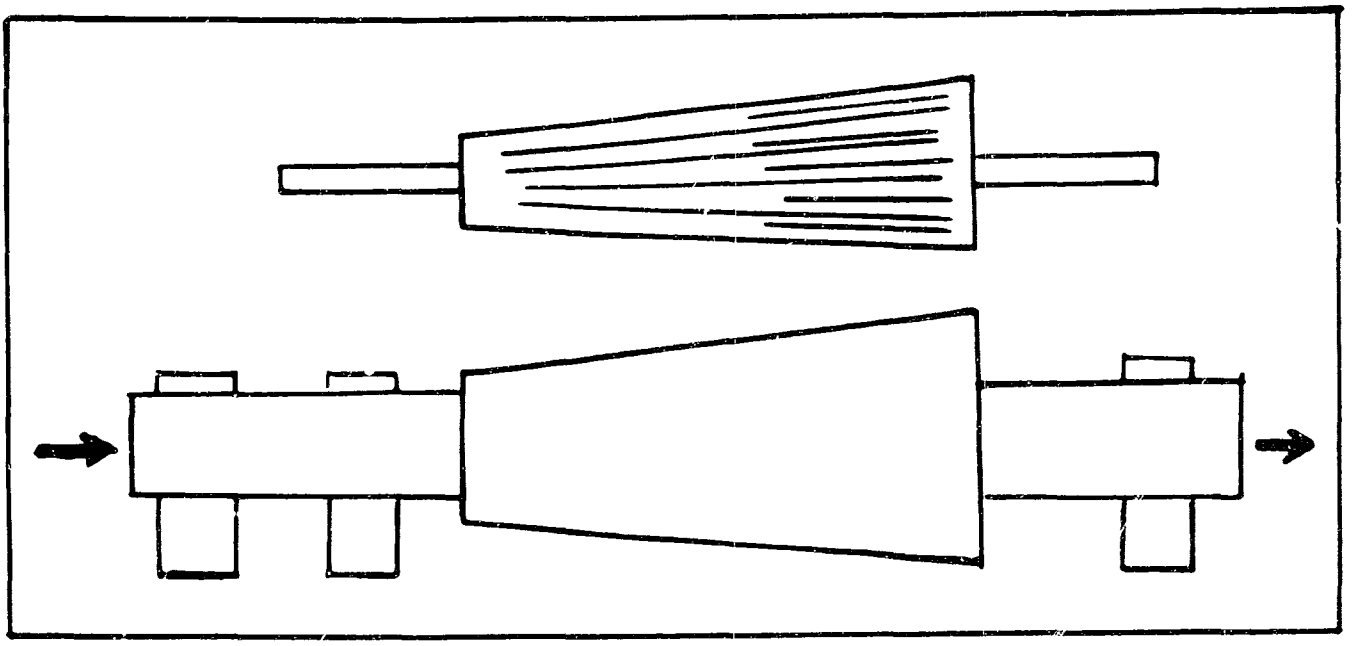

Fig. 14. DRAWING SHOWING THE JORDAN REFINER

For the better grades of paper, the stock goes from the beater to another kind of beater called a refiner--usually a "jordan," shown in Fig. 14. Inside the conical shell is another conical piece. There are long, thin steel bars something like the edge of an ice skate on the touching surfaces of these two cones, and as the stock is forced between them, every bundle of fiber is necessarily sheared or pulled apart--so that by the time the stock passes on through, it is thoroughly mixed and uniform. For some kinds of pulp, the jordan or refiner is supplanting the Hollander; this is especially true of grass fibers, so that it may be that under some circumstances, a modified jordan can serve as a central facility to do the pulping for a cottage industry.

In any event, when the stock leaves the jordan (or the Hollander, if no jordan is needed), it is ready to be made into paper. To insure the highest quality stock, sometimes a final screening is added at this point to eliminate all lumps, dirt or knotted fibers that could mar the finished sheet of paper.

## SUBSTANCES ADDED TO PULP TO MAKE PAPER

While the pulp is still in the beater or refiner, chemicals may be added to it and mixed thoroughly, to accomplish a variety of different purposes; (1) sizing, to make the paper less porous, so that writing ink will not soak up and blur; (2) adhesives, to make the paper stronger and otherwise improve its qualities; (3) loading agents or filler, to give a paper more substance and opacity, and sometimes to save the cost of the more expensive fiber; (4) dyes, to add color (or bluing, to increase whiteness); (5) insecticides and other preservatives, where necessary,

and (6) special chemicals to change the paper into special-purpose paper, as for instance "glassine." The first five of these types of chemicals are discussed here; the fifth is included in Chapter 11, dealing with special papers and paper products.

1. Size -- The adding of sizing chemicals is helpful in changing a pulp or stock from one which would otherwise make "waterleaf" or absorbent paper into a water-resistant paper, to the degree desired for the particular purpose. The opposite of waterleaf is "hard sized." Most printing papers need a little absorbency to help the printing inks dry or set; writing paper must resist the writing ink as much as possible. Size also improves the surface of papers and gives it stiffness and rattle, desirable in some papers. Size is of different types, based on different principles; some sizing materials work best when added to the stock in the beater, and some must be put on the surface of the paper after it has been made and dried. The size put into the beater is called "engine size;" the kinds put on the paper afterwards are called "tub size" or "surface size."

From the standpoint of a national economy or of the printing industry, size not only makes paper perform better; it actually saves money on the amount of ink needed for printing. One recent test showed that cellulose gums with good binding properties for paper may save up from 30 to 45 per cent of the amount of gloss ink needed on some papers. The extra cost of a properly sized paper may well be worth it to the printer if he can save having his ink soaked up in the paper.

A more direct question of economics arises for the papermaker himself. Engine sizing is cheaper to do than tub sizing, particularly on the cottage industry level, because tub sizing is a hand operation. However, sometimes there is no point in sizing the whole sheet, including inside fibers, when only the surface needs the treatment.

There are certain problems or considerations in terms of sizing which affect the operation: (a) emulsification, or keeping the size well mixed so it will be evenly distributed; (b) the use of fortified size, meaning synthetic resins which make less size do more; (c) the elimination of any acidity remaining in the stock as a result of the use of size; (d) the length of time the size should be in the beater, or, in other words, at what point it should be added, and (e) the effect of acidity on the retention of loading agents or fillers added later. Different answers to matters such as these affect the characteristics of the paper and the economics of the process.

The most common engine sizing chemical is rosin, which is a resin coming from pine trees in the manufacture of turpentine; there are different grades, varying in color. (Wax sizes are also used.) Rosin size is obtained by cooking rosin with alkali to make a soap--6 parts rosin to 1 part soda ash and 12 parts water being one formula. This size will not cause trouble in the vat, whereas animal sizes (discussed under sur-

face sizing, later) will stick to the mould, the vats and the felts. The rosin size, thinned in warm water, is added directly to the beater, usually after any coloring elements are introduced. After the size is thoroughly mixed, but not until then, alum is introduced to precipitate the size and bind it to the fibers. Some size should be kept on hand, because freshly-made size is not too good; moderately old size is better.

2. Adhesives -- These are chemicals added to make the paper stronger. Recently there has been great interest in this subject, and certain substances--notably Guar and locus bean gum--have been found to have particularly effective adhesive qualities. Not only do they help make the paper stronger, they simplify the effort of beating in some instances and help later in sheet formation. Guar is being talked about as the long-sought way to "pour hydration out of a barrel," i. e., achieve the effects of mechanical beating by simply adding a chemical.

Another substance used to strengthen the paper at this point is starch--which is also used as a size in surface sizing, as will be discussed later. In the beater, starch helps bolster the bursting strength of paper, reduces its surface fuzziness, and the tendency to dust when paper is converted to other products.

In the Far East, a sort of glue called tamo is extracted from the root of a plant similar to the hollyhock. Grown by the papermakers in their own gardens, tamo makes it possible to peel wet sheets from the pile, to dry, without tearing any, even after considerable pressure. Other vegetables produce adhesives which help the fiber in solution.

Alum, noted above in connection with the sizing process, not only "sets" the size but has an effect on colors which may have been added; it makes reds and blues generally stronger and brighter, but weakens colors such as yellows and greens.

Silicate of soda (water glass or soluble glass), made by fusing silica, such as sand or quartz, with carbonate of soda, can also be added to the stock in the beater to increase the strength of papers. It dries hard and white and gives an increased rattle and firmness to papers. Resistant to oils, it is especially useful in printing papers; in larger amounts it makes grease-resistant papers.

One recent development in additives is synthetic resins which impart a high degree of wet strength to paper--that is, the paper will not dissolve or pull apart even when wetted considerably. This has many applications, obviously. While these resins are often identified as sizing by the chemical firms which produce them, they are not true sizing in the sense that they resist actual water penetration; the water soaks in, but does not affect the strength of the paper beyond use.

Loading agents or fillers -- Paper made from stock which has no filler is somewhat transparent, depending upon the fiber and the thickness of the paper. To overcome this (especially for printing papers which must be opaque, that is, keep the printing on the other side from showing through) the stock is "loaded" with chemically-inert materials. The filler also makes the paper's surface smoother and has other advantages--including the fact that the filler usually costs less than the amount of fiber it saves. However, the cheapest fillers have a substantial disadvantage: they make the paper weaker and softer. The problem is to get the paper loaded correctly to achieve the right balance of the characteristics most desired.

China clay, or kaolin, is the commonly used agent, and one which weakens the paper. However, it is good for newsprint and book paper. Among agents which do not weaken the paper as much are gypsum; plaster; satin white, made of calcium sulphate and alumina agalite, pearl hardening and barium sulphate. Powdered talc is also used; however, it is much harder on cutter knives and on printing plates, when used in large proportions.

The qualities of a loading agent include the following: (a) it must not contain free acid or chlorine compounds; (b) it must be finely graded, of uniform consistency, and free from sand and grit; (c) it must not have a color which will adversely affect the color of the finished paper, and (d) it should have a high index of refraction, since this is what determines how opaque it will make the paper.

To add the filler to the beater, it is usually agitated with water in a separate tank to make it into a thin cream. Often it is mixed with the rosin size before either is put in the beater, since apparently this combination helps the fibers retain or hold onto the filler. It is not advised if the combined solution is conveyed to the beater by pipes, since it clogs. The best way is to have the mixing tank just above the beater.

4. Dyes -- Originally, paper was colored by dipping sheets into dye, as textiles are sometimes dyed. Where there is a beating process, it is almost always better to introduce the dye into the stock.

The kind of fiber makes a great difference here as in every other step of the papermaking process; some fibers soak up dye, some react to it in a way to change the color, some retain the dye and some do not; some use too much dye for the results obtained. It may be also a factor of the dye itself--and sometimes an expensive dye may be cheaper in the long run if it works better with the fiber than a cheaper one. In any event, it takes skill to use the right dye and to make it work evenly in the paper. (It should be noted that a dye in the beater usually is deeper in color than it will be in the finished paper.)

Most dyes used in papermaking today are anilines, even though many of them fade quickly when exposed to sunlight. Pigment dyes, used in the highest quality papers, are color fast; however, they tend to weaken the

sheet if used too much to obtain deeper colors. And because their covering power is low, they cannot be used satisfactorily with unbleached fibers. Formerly, they tended to be dull in their shades, but recent improvements have made some of them as bright as the anilines.

Some of the aniline dyes--especially the acid dyes--do not naturally soak up into the fibers and must be set by fixing agents such as size and alum. Also, they are soluble in any temperature and if accidentally wetted after finished, they will "bleed," that is, the color will rub off. Papers which are to be used for special purposes or made into particular products should avoid such dyes.

5. Preservatives -- Where there are special problems from insects and plant growths, it is possible to treat the stock so the paper will resist the ravages, although care must be taken not to unduly affect the color or other properties of the paper. Toxicity in the paper itself--the effect such chemicals might have on human use of the paper, including accidental chewing or swallowing--must be taken into due account. These are matters to be explored with technically-qualified persons in terms of the existing condition.

## AVOIDING WASTE IN PRODUCTION

While sometimes chemicals involved in the pulp and papermaking process are on the expensive side, there are ways of recapturing or recovering many of them, in sizable amounts. This is both an expense factor (in terms of equipment or labor necessary) and a savings factor (in terms of what may be salvaged) which should be taken into account when the determination is being made as to the process to be used in making the pulp. (See Chapter 13.)

The processes generally involve special filters. However, there is a simpler approach which will often avoid the problem: whenever possible, the waste waters should be reused in the same phase of the process. In other words, water squeezed out of pulp to dry it for shipment should be used to create the next batch of pulp, to take advantage of the chemicals it contains. If the materials are all reclaimed together at the end of the whole process, the sorting out of the various chemicals and fibers involved may not be worth it.

## TRANSPORTING PULP OR STOCK TO PAPER-PRODUCING UNIT

It will be suggested later in this Manual that the pulping and papermaking operations might well be separate. To achieve this, the pulp or stock must be prepared for transporting to the new location for paper-lifting.

It is possible, by forcing the stock through a relatively simple device, to eliminate most of the water and produce a lightweight moist

Fig. 15. WITH WATER ADDED, THE STOCK IS MIXED INTO A SLURRY

brick or slab of pulp which can be carried a considerable distance and be stored indefinitely without damage or deterioration (especially if bacterial control is included in the beating, as necessary). Some pulps make better bricks than others, because of their drainage characteristics. Care must be taken not to press the pulp too much, lest a felting action occur and a new pulping process be needed to loosen the fibers again.

The ultimate producer of the paper would obtain (perhaps buy) the moist brick, take it to his paper-lifting unit, simply add water as directed, and mix thoroughly to make the slurry for the final papermaking process. Fig. 15 shows the final process of mixing water into stock to make a slurry.

As noted earlier, if the pulp or stock were bought from another producer--perhaps even imported--it would come dried, often in a sheet resembling bulky paper. This would be put into a beater (sometimes specifically called a repulper) to reconstitute the pulp or stock. If a small portion of this stock were then to be transported by a cottage producer to his own unit, it would be made into a brick in the same way as described above.

## CHAPTER 7

# Alternate Paper Lifting Processes and Equipment

Once the stock is completely prepared, as described in the previous chapters, it is then ready to be made into paper. All the processes for making the sheet itself involve substantially the same principle: the fibers and other materials in the stock are kept uniformly suspended in water--i. e., made into a slurry--and then made to "felt" or bond together into a sheet when the water is removed. The different ways this is done affects the characteristics of the paper.

Against machine-made paper, true handmade paper has distinctive and highly valuable characteristics, if made with care and quality. A poor handmade sheet can be very poor indeed, not usable for its intended purpose--but a properly-made hand sheet brings premium prices and is used for the most exteting purposes, as for instance postage stamps and currency. It is difficult to explain in words the innate quality of the best handmade paper beyond its great strength and permanence. The technical terms are "wild" and "cloudy," meaning a non-uniformity of appearance that still has quality, of the same sort that makes the hand-tailored variations of clothing superior to the regularity of machine-made suits.

The making of the sheet of paper itself by machine is not included in this Manual because the size and complexity of the equipment involved are such that the operation could not be classified as a cottage industry by any definition. This is different from pulping and stock-preparation equipment, since in some sizes and processes, these pulping and stock-preparing operations might well be conducted as central facilities for cottage industry units.

Whatever degree of mechanization may be involved in obtaining pulp and stock, therefore, the basis of a cottage industry in papermaking will rest on the actual "paper lifting" or sheet forming process. Until the appearance of this Manual, this process consisted of a variety of ways by which a skilled papermaker brought a screen (usually called a mould, complete with its frame) into the stock suspension and induced the fibers to felt into a sheet. Now, however, the "paper box" offers an alternative process to this traditional method. Both of the processes are discussed in this Chapter.

In either process, the first requirement is the same--to keep the stock agitated, once it leaves the "beater room," until it is actually formed into sheets. Usually, in the larger operations, the stock goes to what is called a "stuff-chest," which is an enclosed vat partly filled with water. Inside the stuff-chest is an agitator--a pole or paddle or paddle-wheel of some sort--to keep the fibers moving about and continually evenly mixed. This particular operation might well be mechanized if possible, although by hard labor it can be done without power. Even when the stock is transferred to the actual tub, vat or other vessel in which the paper-lifting will take place, this mixing must continue, if a uniform paper is to result.

The stock must be transferred from the beater to the stuff-chest and to the vat (or perhaps directly to the vat, without going first to be stored temporarily in the stuff-chest). This transfer can be done mechanically--in the same way water is lifted from a river for irrigation--if it is not possible to have the beater operation at a higher level than the paper-lifting so that gravity flow may be used. It is reported, however, that even in the most efficient handmade-paper mills of Japan, the stock is placed in the vats without the help of mechanical means. It would seem that in this operation, the application of even simple "materials-handling" ideas and techniques would help reduce the labor cost of papermaking more than enough to warrant the change.

Better paper formation takes place when the stock is warm--from $80^{\circ}$ to $95^{\circ}$F. being ideal. A variation of more than 15 degrees from the minimum or maximum (in other words, lower than $65^{\circ}$ or above $110^{\circ}$ approximately) will cause serious difficulties. For this reason, the vat in which the stock is placed for the actual papermaking is often heated by a pipe along its side or inside it, or by a fire underneath it, in cold climates--and kept under the shade in hot climates.

How much water should be added to the stock will depend upon the kind of fibers involved and the kind of paper desired, as well as the techniques applied to the paper-lifting. However, a solution containing at least 75% water is probably the minimum. Where water is a consideration because of its scarcity, it may be re-used, as will be noted more fully later. In the modern Indian method of making paper by hand, some lime is added to the water at this point.

## THE HAND-LIFTING METHOD OF SHEET-FORMING

In some of the older techniques of paper lifting, the beaten pulp is floated on water (either in a dammed-up place or a running stream) and the mould is worked there, without any need for a vat to contain the stock solution. However, in most instances, a vat of some sort is involved. This can be a simple wooden tub of some sort or it can be metal, stone or cement. Cypress wood is considered best. Depending upon the exact technique, there are ledges of sorts along the edge or side of the vat, for support of arms and equipment. The size of the vat depends mostly upon the size of sheet made; it must be large enough for the mould to fit into.

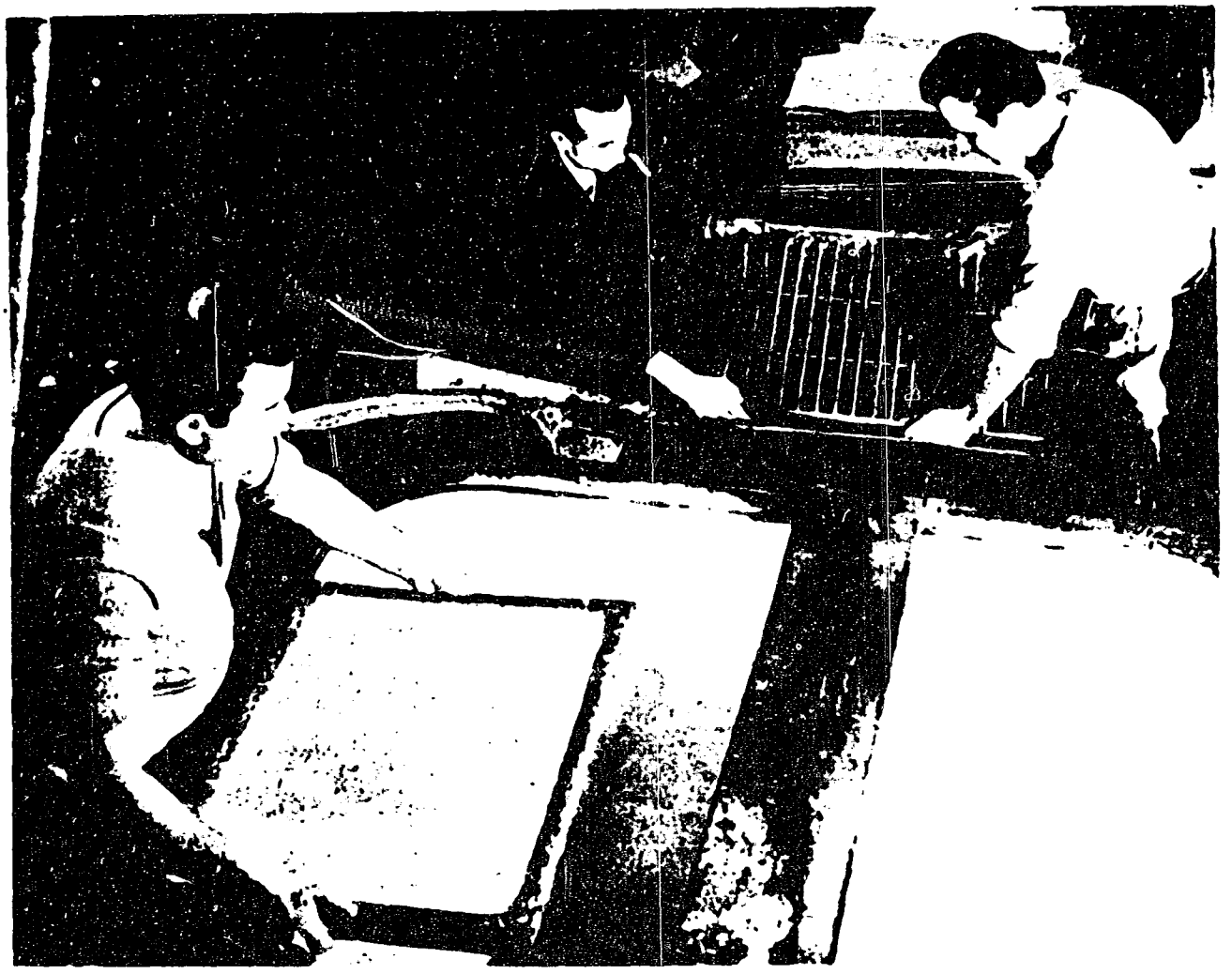

Fig. 16. VATMAN AT HIS VAT, COUCHER IN THE BACKGROUND

The vatman, as he is called in the papermaking tradition--or the paper lifter, to be more precise--usually stands rather than sitting or taking any other position; the work is hard, and the lifting action is enough to take the full strength of the body. It is simple to say generally what he does, but it takes a paper lifter from 5 to 10 years to really acquire the skill involved in making a strong, uniform sheet of paper day in and day out.

What he does is dip the mould into the vat, at an angle; then he straightens out the mould and brings it up to catch an amount of the solution on top of the screen, in the fence-like deckle. This is called the "vatman's stroke." (See Fig. 16; the man in the front, left corner, is the vatman, just completing his "stroke.") Depending upon his skill and the type and thickness of paper being madé, he gets enough stock the first time, or he throws some of it off, or he repeats the process more than once. As part of the process, he performs a series of "shakes," or twists of his arms or wrists, in all four horizontal directions (left, right, forward and back) to felt the fibers better. The whole operation takes only a few seconds. If he does not do it right, he has a sheet too thick or too thin, or wedge-shaped because the mould was tilted--and perhaps weakly-felted besides.

Since it takes from 5 to 10 years to master the vatman's stroke, this has meant that areas without a long tradition of papermaking and

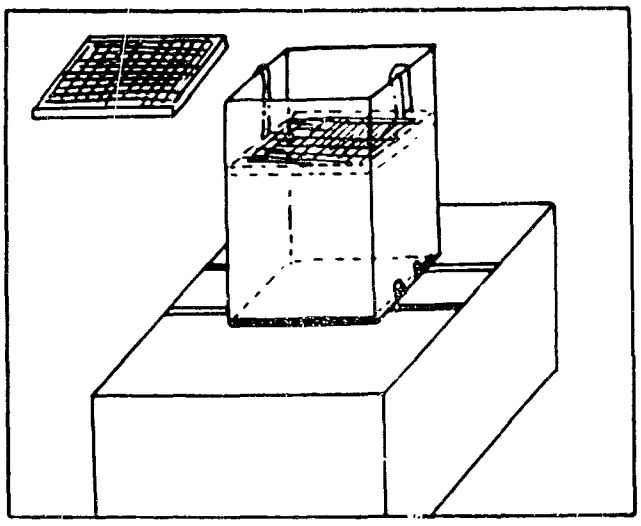

Fig. 17. THE PAPER BOX AND SCREEN

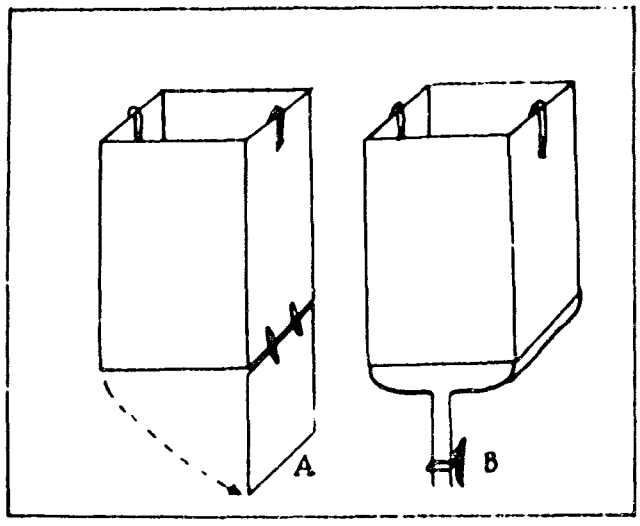


Fig. 18. (a) BOTTOM OPEN (b) VALVE-TYPE

thus without trained vatmen, have faced the necessity of instituting long-term training centers and a delay of several years before acceptable paper can be made.

## THE PRINCIPLE AND OPERATION OF THE "PAPER BOX"

This new device eliminated the need for the special skill in paper lifting and thus opens the way for small-scale paper production in any area willing to undertake the normal amount of research and technological development for a new industry using local materials. Besides making possible the manufacture of paper in areas that are presently handicapped by lack of skilled vatmen, it even makes possible satisfactory making of paper in schools for daily use.

The "box" is exactly what the name suggests, a box. The size of its sides will depend upon the size of sheet it is to make, because it is a few inches larger each way than the sheet size. The height of the box depends upon the fiber used and the method of making the pulp or stock, as well as the type of paper desired. On the average, it should be perhaps 12 inches.

On the inside of the box, near the top, a ridge of wood is fastened, to make a tight resting place for the mould; when the mould is in place, the screen should be about 3 inches from the top. The frame of the mould should be fairly watertight against the insides of the box. Fig. 17, above, shows the box, with dotted lines indicating where the mould rests across the inside.

The box has a bottom which is watertight, but which can be released to let the slurry out quickly. (There should be a tub or drain to catch the released slurry.) Fig. 18 shows the box with the bottom open.

These are the steps involved:

(1) With the bottom closed, fill the box with slurry until the slurry is just over the screen in the mould.

(2) Pour a measured amount of slurry into the top of the box, stirring it as necessary to make sure the mixture is evenly distributed.

(3) Then let loose the slurry in the bottom of the box. This must be done quickly, but without jerking the box itself. The bottom slurry, rushing out, creates a vacuum which sucks the water in the top slurry down hard through the screen, felting the fibers firmly on their way down. A formed sheet is left on the screen.

(4) Lift the mould out, and couch the sheet.

The development of this box is a demonstration of how the technologies of the East and West may combine to achieve a new useful tool. The box is actually a combination of the old Nepalese or Chinese principle of paper lifting and the mechanical test-paper maker used in American paper mills and laboratories.

In the old Oriental method, a mould was lowered into a vat of clear water until the screen was partially covered. Then the slurry was poured into the mould and evenly distributed. With great force, the mould was then lifted out of the water, creating vacuum and suction action. The American test-paper maker is a cylinder, with a valve at the bottom to release the water and thus make a vacuum. By adding this labor-saving action to the Oriental action, the box is able to achieve satisfactory results without the hard work and great skill involved in lifting the mould from the water.

These specific points should be noted to insure the best operation of the box:

1. It is important that the mould frame fit fairly tightly against the insides of the box, so that part of the slurry will not go around the outside of the mould frame and thus possibly affect the vacuum action. However, the mould should lift in and out of the box easily.

2. There should be handles of some sort on the mould to allow it to be lifted easily. When these are in the box, they should not fold over onto the screen. As one simple solution, rope pulls may be attached, long enough to drape over the outside of the box when the mould is in place, as shown in the accompanying sketch.

(3) When the slurry is poured in the bottom of the box, it should fill to a point just above the screen when the mould is in place. If there is too much vacuum created with this amount of slurry, the solution is to make the box smaller or move the mould-rests further down into the box, so that the screen will be lower and it will thus take less slurry to cover it. The box will not work, however, if the slurry does not cover the screen. Without slurry being that high, to form a closed top for the screen, the measured portion of the slurry would simply strain through the screen while it was being poured from the top.

4. The instructions above call for filling the bottom part of the box with slurry. While water could be used in the lower part of the box, perhaps more easily than the slurry, the result would be a loss of valuable chemicals and some small portion of the fibers as they escaped below the screen and mixed with the water as it drained away. However, if there are facilities for reclaiming these materials from the waste water, it will be perfectly feasible--and perhaps much easier--from the paper-forming point of view to use water in the box.

5. It is always a problem in paper lifting that the remaining slurry after each lifting becomes more dilute because most of the water drains back into the slurry after the portion of the pulp is removed. In the box process, it is possible to overcome this problem scientifically, in instances where the uniformity of the paper being made justifies. The measured amount poured in at the top of the box can be increased each time on a basis worked out to insure that the amount of poured slurry contains the same amount of fiber and filler as before.

6. The box, as shown, has the entire bottom drop out to release the slurry. Experimentation with certain fibers will show that less of a vacuum is required, and that a trap or valve of some kind, with a smaller opening, may work. This will be particularly true in the larger-size boxes for the bigger sheets.

7. In those uses where the bottom of the box drops, the box must of course be so held up above the vat or catch-all in such a way that the bottom is free to swing quickly open without jarring against anything which would shake the box itself.

8. Whether the slurry should be as thin as possible or as thick as possible to insure an even distribution above the screen when it is poured in, will depend upon the way the slurry is handled. The point is to insure a uniform sheet by having the slurry uniformly mixed above the screen.

9. Inasmuch as the box represents a new technique, any experiments and uses of the box will be helpful to others. Therefore, every effort should be made to report fully and carefully just what fibers in what solutions and with what strengths of vacuum prove to make the best paper.

## Local Research Needed on Box

It is quite certain the box can make an acceptable sheet of paper, one which is more uniform and perhaps stronger than that produced by hand by any but the highly-skilled vatmen.

However, it should be made very clear that the box has not yet been field tested on the same slurries as those used to form the best handmade papers. It may prove to be that the felting action of the box will produce a somewhat different paper than the hand-moulding operation

--perhaps worse, perhaps better. (Also, box production may be slower than the best that can be done by a skilled vatman.)

In any case, local research will be necessary to determine the best combination of three variables in making paper in the box:

1. The best local fibers, how best beaten (to what degree of fillibration, etc.) by locally-available processes.

2. The proportion of water in the slurry, and the total amount of slurry measured into the box to make the kind of paper desired.

3. The amount of slurry needed below the screen to create just the proper vacuum--not too weak or too strong--to felt the desired paper. A "wet" pulp generally requires more vacuum than a "free" pulp.

Once these variables are determined, it is relatively simple after that to maintain standards that will achieve uniform sheets. All boxes making certain-sized sheets (preferably with centrally-provided moulds and screens) will be of the same size, and thus filled with the same amount of specified slurry below the screen. All producers of a certain kind of sheet will be instructed to pour a specified measure of slurry into the top of the box. And the resultant sheet will be uniform with other sheets made in other boxes in other cottage units.

Different kinds of fibers, in different amounts in the slurry, and with different amounts of slurry to create the vacuum, will result in different kinds of paper. Since the increase in suction under older processes tends to make a paper "wild," it is likely that this particular variable can be controlled by the amount of vacuum created.

Some fibers which have been passed over because they cause certain troubles under existing processes may perhaps be re-examined profitably for the b x process. For instance, rice straw sometimes causes trouble on the large-scale, mechanized papermaking machine; it may prove to be fully satisfactory with the box, because of the different strength and action of the vacuum. On the other hand, the box may create certain difficulties if the vacuum is too great. For instance, mineral dyes tend to suck out of the bottom of a sheet if there is too much suction while the sheet is being formed.

## THE MOULD AND SCREEN

The mould or screen upon which the sheet of paper is actually formed is the same for either the hand lifting or box process, although actual operations may indicate that a certain kind of screen is better in the box for a particular fiber.

As already generally described, the mould is a frame on which is fastened a screen or mat of some sort to catch the fibers while the excess

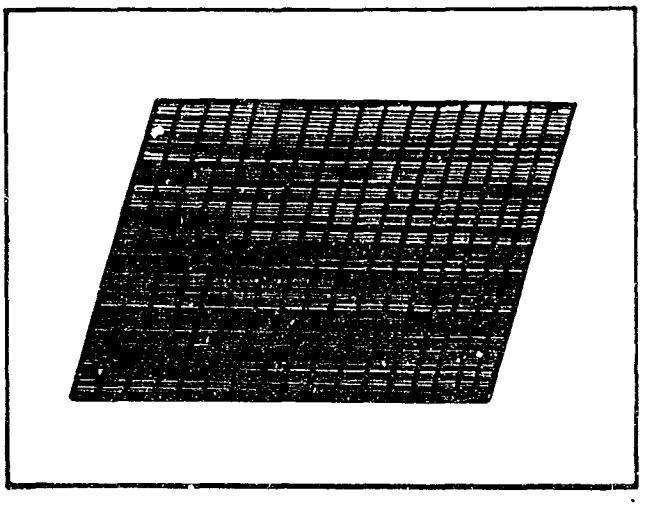

Fig. 19. THE LAID TYPE OF SCREEN

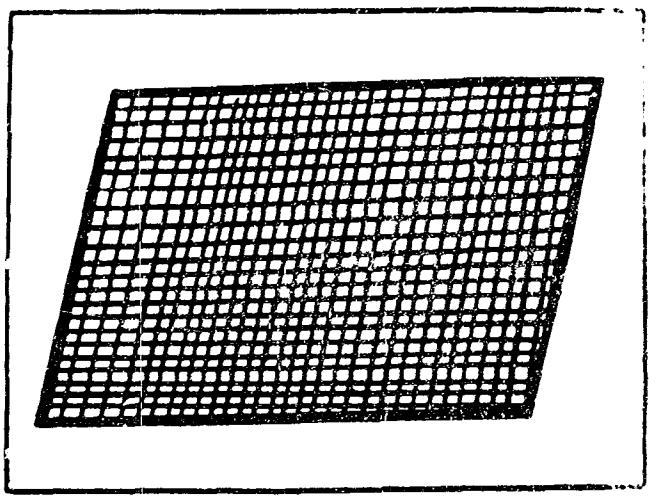

Fig. 20. THE WOVE TYPE OF SCREEN

water drains through. In the hand-lifting process, a "deckle" is used with the mould to hold the slurry on top of the screen until the water drains. The deckle is not needed in the box process, because the sides of the box serve the same purpose.

The frame is made of mahogany, white wood or oak, often reinforced at the bottom by harder woods or a non-ferrous metal such as brass; at the very least the corners are generally reinforced with metal. Depending upon the kind of screen the frame will carry, there are supporting ribs across the frame for the screen to rest upon.

The deckle is constructed of the same materials as the frame; it is removable, either altogether separate or hinged. The height of the deckle depends upon the amount of stock to be lifted. Its inside horizontal measurements are slightly larger than the desired sheet size because the paper will shrink somewhat upon drying. When the paper lifting is taking place, the deckle is held tightly against the frame, to hold the stock solution inside it; usually the sides of the deckle are wide enough to let the vatman have his thumbs there without overlapping the inside of the deckle and thus affecting the formation of the sheet. Because some of the solution gets under the edge of the deckle and thus "feathers out" the edge of the resulting sheet, handmade paper has a "deckled edge" on all four sides--at least until it is trimmed away, as it usually is. In Western countries where handmade paper is a luxury item, the deckled edge is prized as distinctive, and machine processes have been devised to make imitation (and generally poor imitation) deckled edges.

The screen itself is of various types and materials. Traditionally, and to some extent even today, in the Orient, the screens were fashioned of bamboo, grasses and reeds, tied together with animal hairs or fibers. This is called a "laid" mould or screen, with characteristic lines forming a pattern such as that shown in Fig. 19. The very first screens were probably a simple coarse cloth, however, and in some processes such as "wove" screens (Fig. 20) are still used--the Japanese to some extent using a woven horsehair mat resting on top of a laid mould. Except for this Japanese wove

mould, it is difficult or impossible to use the Oriental cloth woven mould in a vat operation, because it sags too much under the force needed to lift the stock solution. (Where used in the Orient, this type of mould is part of the process of paper lifting from pulp floated on water.) Modern wove screens are made of metal wire--stainless steel is best if it is fastened to the frame and need not be flexed. Aluminum, brass or other wires except common iron wires are also suitable, but iron wire is not because it will leave rust stains in the paper. Plastics may be used as the "wire," and it is possible to mould a whole screen in one piece of plastic, particularly where flexibility is needed. The reason some screens must be flexible while others need not be is explained in the next section on the "couching" process.

The moulds and screens are of two basic types, rigid and flexible. The rigid mould has the screen fastened to it, so that the two are really parts of one tool. The flexible mould simply has supports enough, as part of the frame, that the screen or mould cover can be laid across the top of the frame for taking off with the sheet of new paper and rolled up (as part of the couching process, to be explained next). Sometimes the deckle is hinged to the frame to allow the screen to be slipped in and out.

Especially in the woven screens, the numbers of wires to the inch--and thus the size of the openings for the water to drain through--depend upon the fiber and technique again. In American machine paper-forming, the following meshes to the lineal inch are used (i.e., to find the number of openings in a square inch, multiply the number by itself): pulp, 18-40; building board, 8-40; board, 40-60; roofing, insulating, wrapping papers, 18-70; newsprint, 60-65; book, 65-80; glassine, 65-75; sulphite bond, 65-75; rag paper, 60-75; tissues, 70-225. The thickness of the wire used varies considerably. It is obvious that the best mesh for a particular fiber and desired paper will have to be determined locally.

It is, in fact, perhaps worth considering whether the government, Pulp and Paper Institute, central facility or cooperative might not make such a determination on behalf of all papermakers working together, so that a uniformity in size and quality might be more closely realized. These screens could be metal or plastic and made in quantities; or, of course, they may provide a cottage industry in themselves, to produce screens in quantity and uniformity.

## PUTTING A WATERMARK IN PAPER

Watermarks are the thin patterns or words which can be seen in a sheet of paper when it is held to the light. They are made or caused simply by placing a raised surface on the moulding screen, so that less stock can settle at that point--with the result that the paper is thinner there, and thus more translucent.

All that is required to make a watermark on a sheet, therefore, is a metal (or plastic) device, raised in the pattern which is desired for

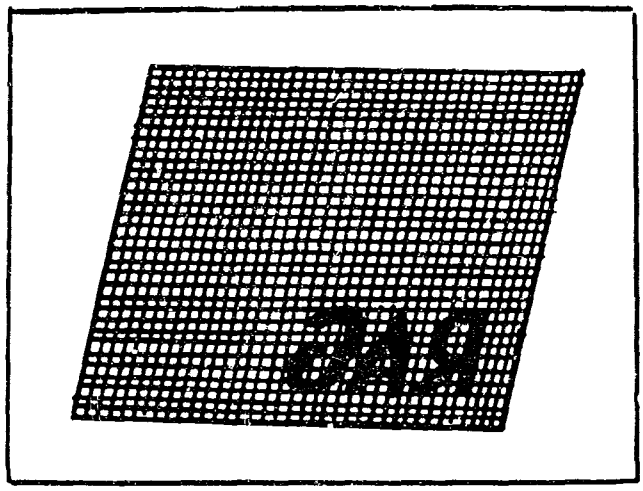

Fig. 21 WATERMARK DEVICE ON SCREEN

the watermark. In other words, if the word "RAG" is to appear as a watermark, the letters would be fashioned of bent wire in the size and style desired. These, then, would be fastened to the moulding screen, on the side which receives the stock suspension. Fig. 21 shows the mould screen with the device attached. Fine wire is used to hold the metal figure to the screen. While the device can be removed without too much trouble, to put on a new watermark for the next customer, probably a paper-maker should have a different screen for each watermark he uses with any frequency. If he has a complicated device he is likely to use again, probably he should not disturb it. The various purposes which a watermark can serve in a small-scale industry are discussed on Page 207.

## COUCHING THE SHEETS

After the fibers have felted on the mould or screen, to make the still-moist sheet of paper, the usual next step is to transfer the sheet to some other support, so that the mould can be used to make the next sheet. Some processes, it is true, leave the sheet on the particular screen until it is more or less dry--in which case, a number of screens are needed. However, in most processes, "couching" is a necessary operation, performed in one of two ways depending upon the type of mould. If the mould is rigid, the mould is deftly turned upside down so that the sheet will fall off without damage. Depending upon the kind of fiber and its treatment, it is put onto a piece of felted cloth or upon another fresh sheet of paper without cloth interleaving. If the mould is flexible, the sheet and screen both are taken off in this way, with the screen landing on top; the screen is then rolled up as a mat, leaving the new sheet of paper flat. Fig. 22 shows the flexible screen being lifted off. Sometimes the vatman does this operation himself, but it is more efficient to have a "coucher" do it, leaving the vatman

Fig. 22. COUCHER PEELING OFF SHEET

to use machine vector [illegible] the special skill required in the "stroke" or [illegible] letting. [illegible] 50 sheets, at the top, a coucher and [illegible] turning over a mold [illegible]) When there is a separate coucher, [illegible] felts are needed, the [illegible] the second felt with the coucher takes the sheet off the first, [illegible] felt [illegible] the sheet [illegible] the coucher [illegible] the [illegible].

<u>The felts</u> [illegible] Felts, [illegible] felts or blankets [illegible] the sheets [illegible] sheets [illegible] felts, especially [illegible] the last [illegible] felts are present. Only in the [illegible] East, where [illegible] and combined with the "[illegible]" [illegible] or other such chemicals, are the felts not needed.

Because the sheet of paper is to be pressed [illegible] felt, it is important that there be no defects in the felt [illegible]. [illegible] things [illegible] surfaces will impart the [illegible], [illegible] texture, [illegible] patterns or trademarks, [illegible] the felted surface, [illegible] from the paper sheet.

The felts are woven, and the [illegible] felts [illegible] the [illegible] felts [illegible] generally they must [illegible] through the [illegible] the manufacturer [illegible] without impartial [illegible] the sheet [illegible]. In addition, the felts should be strong, since they are subjected to constant swellings and contractions, and should [illegible] stand up for a long period of time to make their [illegible]. They must be firm enough to [illegible] easily, and supple enough to [illegible] easily [illegible] the coucher roll [illegible]. Moreover, they must be [illegible] and [illegible] character. The felts used on mechanical papermaking machines will not serve.

If there is [illegible] industry [illegible], there will probably have to be a skilled felt-making industry in a company [illegible].

The felts [illegible] several times longer than the [illegible] of the sheet [illegible]. Separate felts are needed [illegible] [illegible] of paper being made.

<u>The press</u> -- The [illegible] continues to lay the sheets and alternate felts one on top of another, until [illegible] has a considerable pile--usually called a "post." The exact number of sheets thus piled together depends upon the thickness of the sheet, the [illegible] fiber, and the pressure used in the next operation. This can vary from 100 to 300 sheets.

Best Available

CHAPTER 8

# Alternate Finishing Processes and Equipment

A sheet of paper can be dried and finished simply by letting it stay on the moulding screen in the air until dried, as has been noted, and as is shown in Fig. 23. However, it is possible to apply a variety of processes to the drying and finishing of the sheet, to achieve quite different "finishes" or surface characteristics, and even affect the internal structure and properties of the sheet. Some of these processes are quite rudimentary, and some are quite elaborate and involve complex

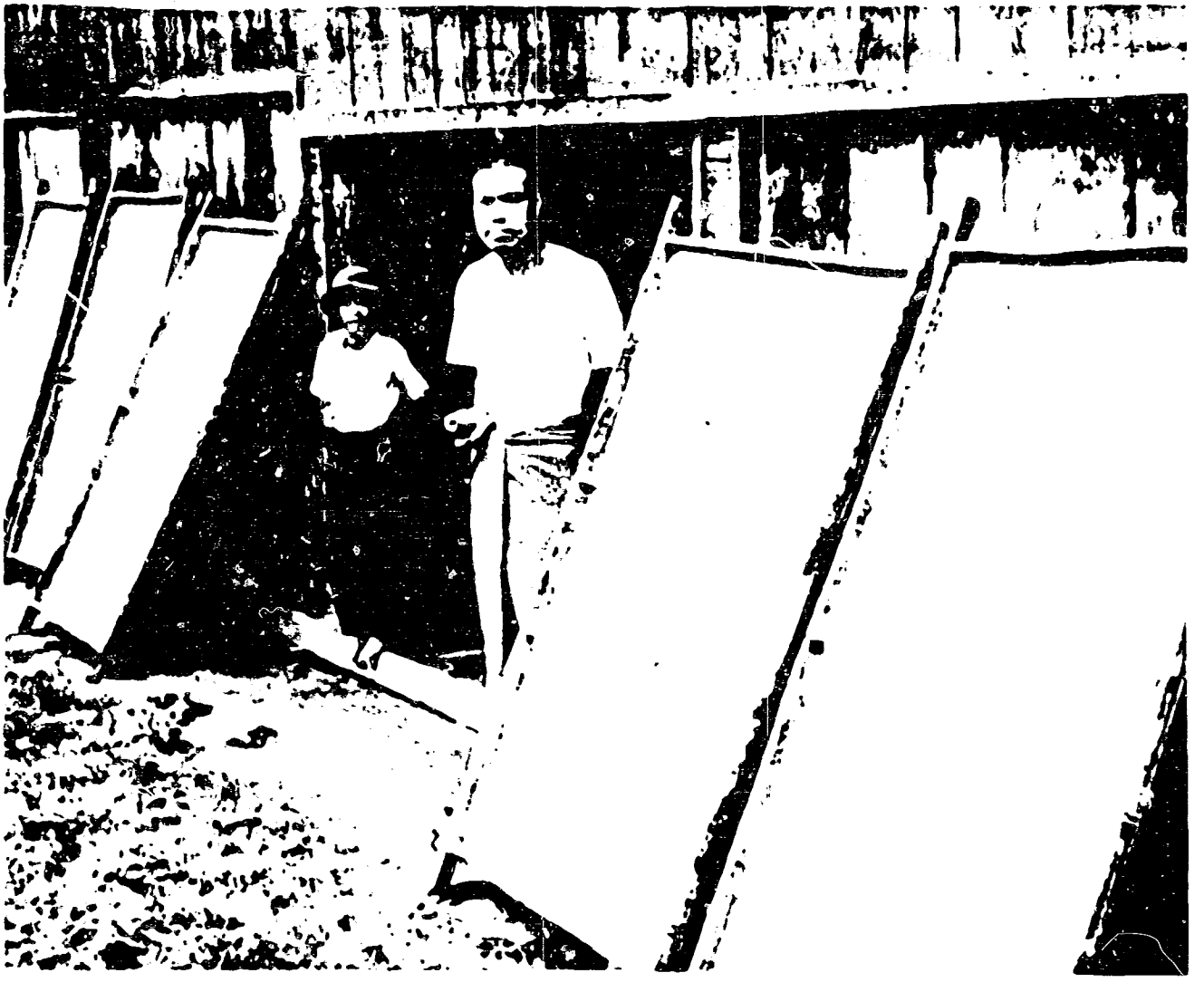

Fig. 23. SHEETS OF PAPER DRYING ON THEIR SCREENS WITHOUT COUCHING

machinery--depending upon the "finish" desired. Fortunately, for many uses, the finishes which require little or no machinery are even more desirable than the machine-precisioned finishes which require the heavy equipment.

## THE DRYING PROCESS

After the sheet is couched, there still is a good deal of water remaining in it, and in most cases also it is too fragile and weak to allow handling. A number of steps are required to eliminate these conditions:

The pressing -- First, the "post" of sheets is pressed to get out all the water that can be removed. This varies from such methods as putting heavy weights such as stones (or people) on a board on top of the post, to quite powerful hydraulic presses. One fairly simple press employing leverage is shown in Fig. 24, as is also the basic screw press, Fig. 25. The equipment required will vary with the kind of fiber and paper, the number of sheets in the post, the climate, the kind of drying equipment used in the later operation.

Ordinarily, pressure is applied slowly so that the sheets will not be crushed. Fibers requiring felts need more pressure than otherwise. Usually, also, the water is mechanically stroked away from the edges of the felts which stick out past the sheets--because this loose water would simply be soaked back once pressure is removed. The length of time the pressure is maintained depends upon the particular action of the sheets; in Japan, working with tamo, the load is held for about 24 hours to permit the mucilage to ferment and thus help the separation of the sheets (which do not have felts between them).

There is a difference in drying between soaked felts and fairly dry felts, because the wet felts involve pressure as such, whereas the dry ones

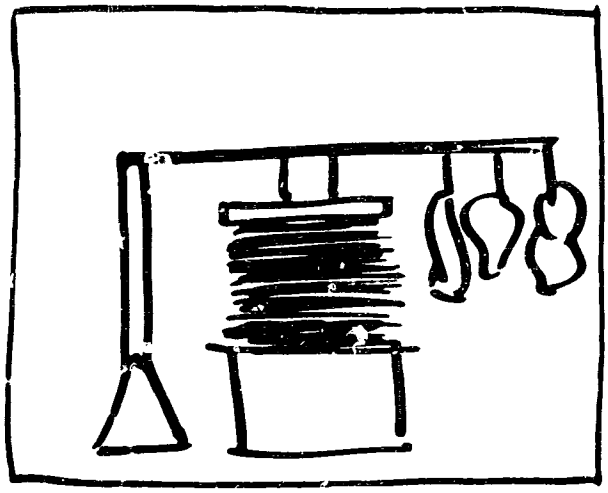

Fig. 24. PRESS USING LEVERAGE

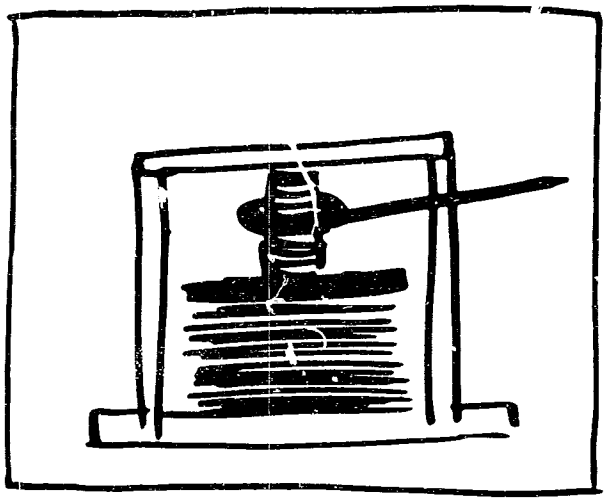

Fig. 25. PRESS USING SCREW PRESSURE

involve capillary action. There is also a difference between trying to do all the pressing in one long, heavy effort or doing a series of pressings. For one thing, a second "dry" pressing will make the paper smoother--and the longer the paper is under the press, the smoother the paper tends to become.

Repeated pressings, changing the order of the sheets in the post each time, will continue to improve the surface of the paper.

Loft-drying -- After the sheets are pressed as dry as possible, one way to complete the drying is to hang the sheets on lines or poles or on flat canvas trays in a house or other closed area, and then change the temperature humidity in the room to insure the proper amount and speed of drying. Ordinarily, this means that the drying starts in a cold room, with the temperature then being raised to 90° or 100°F.; there should be some louvres or other vents by which the moist air may escape. If the temperature drops or the moist air is not removed, the paper may stain and lose its value. This process sometimes continues for some days. Afterwards, with the temperature returned to normal, the paper remains some days longer to "mature." In countries with hot and humid climates, the drying conditions and times may be varied considerably. It may prove to be the case that other methods are preferable.

The sheets are usually dried in groups of 4 to 8 hung together on a line or over a pole. This prevents the wrinkling which occurs when they are dried separately. If the sheets should be wrinkled anyhow, they can be put back under the press to be smoothed down. Formerly, the sheets were dried over cow hair ropes in many instances; this made the paper flair out so now paper is often dried by holding its corners.

Paper which is loft-dried tends to have a rougher and harder surface, a more cockly appearance, and greater strength than machine-finished paper. This is because it has no tension when it is being dried and has not had the smoothing effect given by the paper machine.

Wall-drying -- A technique for drying which is quite common in the Orient involves spreading the paper flat against boards or brushing it against smooth masonry walls in the sun. Depending upon climate, this may take about two days. An improvement on this technique is the use of two parallel walls, with room between for a fire which heats the walls and thus speeds the paper-drying (Fig. 26). When the sheets are wall-dried, they are held rigid and flat, with the result that one side of the paper is unusually smooth, especially if the surface of the wall is polished. The other side is rough and bears brush marks if it has been brushed on; if a rubber roller is used, the difference between the two sides will be minimized.

Improved wall-drying -- An improvement in the wall technique, one which can be used indoors, is shown in the photograph, Fig. 28. It consists of two sheets of iron, making a narrow tent or inverted V at the end

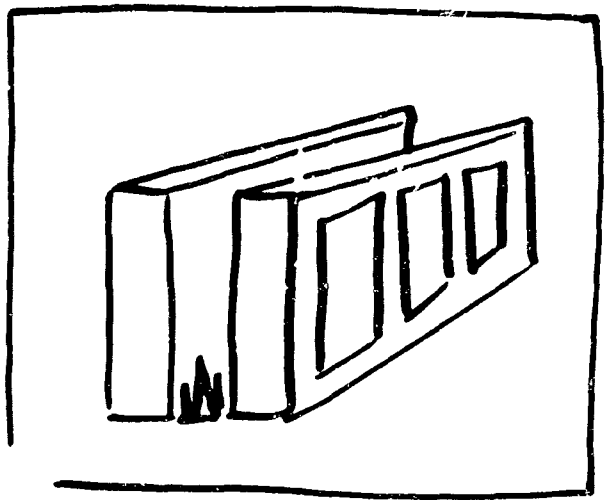

Fig. 26. DRYING WALLS, FIRE BETWEEN

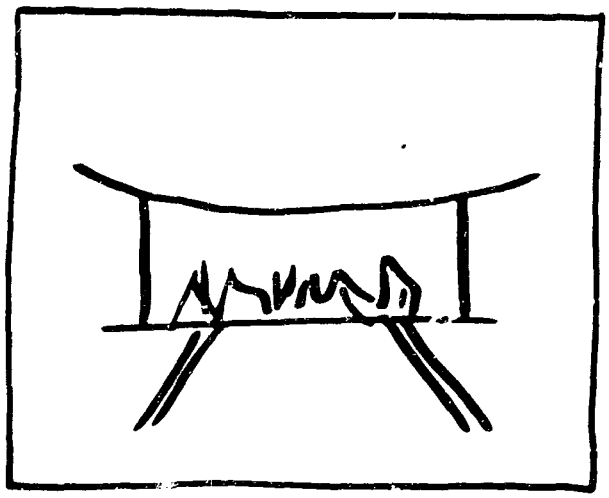

Fig. 27. IRON DRYER, FIRE BETWEEN

with the ends sealed; the fire is built at one end, and a flue takes the gases away at the other, with the warm circulating air inside heating the walls on which the paper is pasted. Steam can also be used. It is possible to make the dryer of inexpensive wood and plaster, or even mud mixed with oils (those that will not soak into the paper). The walls are polished to make their surface very smooth.

Iron dryers -- The Japanese and some few other papermakers now use iron dryers as well as the wall-dryers. One type consists of two sheets of iron lying horizontal about a foot apart, slightly curved, with coals burning between the two sheets, Fig. 27. After the paper is pressed, it is spread on top of the upper iron sheet with a large brush, and it dries almost instantly.

It is important that paper be properly dried--which means neither too much moisture retained nor removed. If too much is removed, the paper is brittle and unstable, since contact with moist air will enable it to soak up water and thus curl at the edges. Over-dried paper is also more likely to develop trouble from static electricity, particularly troublesome to a printer. Paper which is too moist will wrinkle.

## SURFACING OR FINISHING OF SHEET

Once the paper is thoroughly dried, the final operations are performed to make the surface of the sheets capable of serving their intended purpose. If, for instance, it is a writing paper, it must take ink, and therefore it is sized. Similarly, it must be smooth, so that must be achieved by chemical or mechanical means. There are three principal types of finishing: (1) sizing, (2) mechanical smoothing (or texturing) of the surface, and (3) coating with chemicals. (Except for specialty papers, this is not feasible for hand processing, and is not discussed here. See Chapter 9.)

Tub sizing -- Even though the paper may have been engine-sized (see Page 73) and especially if it has not, paper is "tub-sized" after it is dried. The word comes from the fact that the process was originally done in tubs or vats, although now it is often accomplished by a machine. Either starches or animal glue are used as the chemicals; the rosins of the engine sizing are not suitable. Glue, being more expensive, is generally limited to high quality writing papers. Starches may be derived from such grains and roots as corn, rice, wheat, potatoes, cassava, tapioca; special starches made by treating ordinary starches with acid and alkaline solutions, can be used for high-grade papers. Animal size is really a solution of gelatine, prepared by soaking animal hides in water, although commercial glues can be mixed in. The preparation of animal size is exacting, because it can appreciably affect the quality, color and strength of the paper.

The availability of sizing chemical and solutions is itself the basis for a cottage industry to support the papermaking industry, if the scale is large enough.

The result of tub sizing is to make the paper tougher, while making the fibers more flexible, so that the finishing operation can achieve a fine, smooth surface.

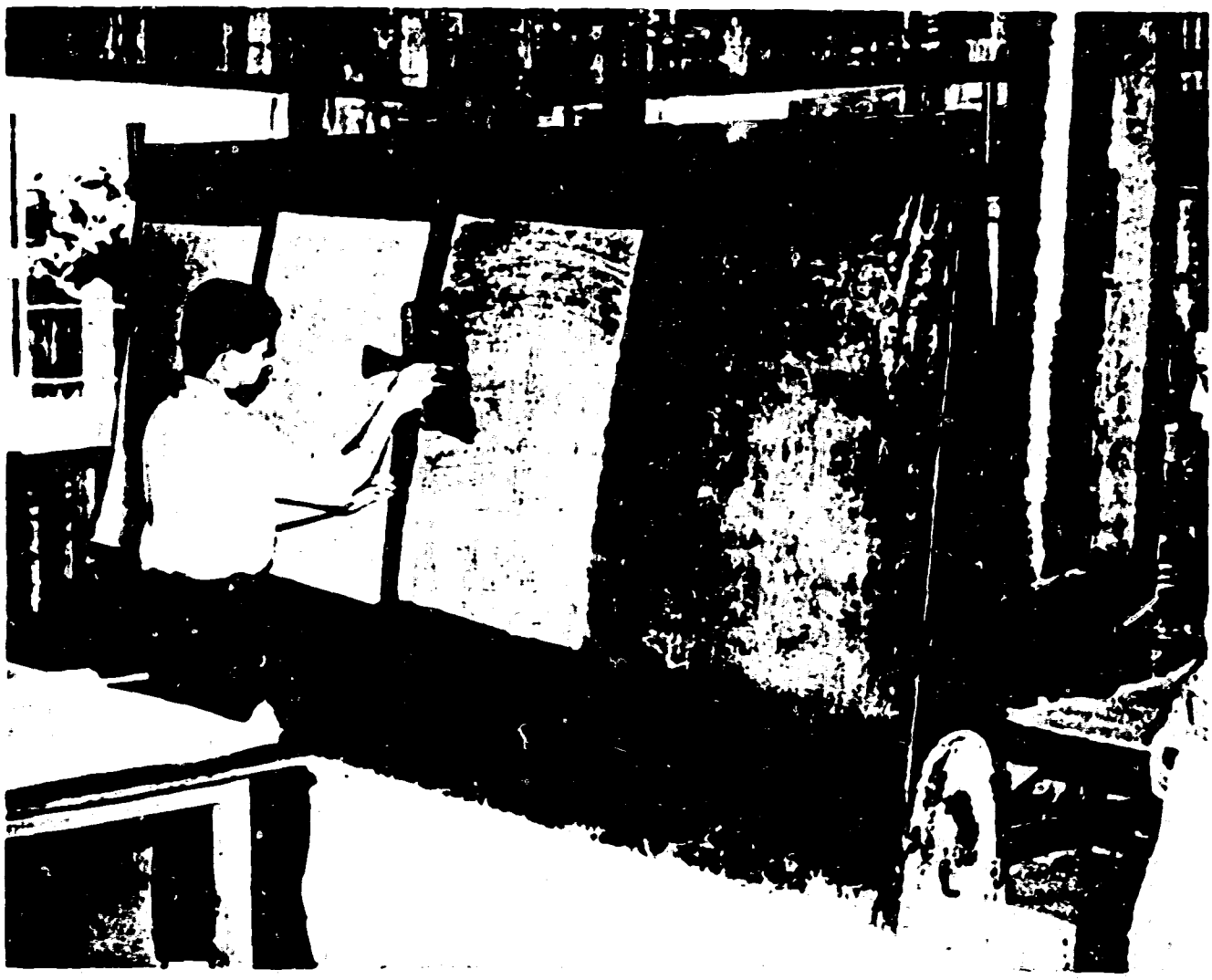

Fig. 28. MODERN VERSION OF DRYING WALLS: FIRE AT ONE END, VENT AT OTHER

Paper to be sized must be dried, but no too dry (about 85 to 90% bone dry, i. e., 10% moisture maximum). Either too dry or too moist, it will not absorb the size properly. The amount of tub sizing that the paper can absorb depends also upon the amount of engine sizing previously done. Generally, the more engine sizing, the less surface size is needed. While it is cheaper to do engine sizing, and while the rosin size will give the paper resistance to moisture and limit the spread of writing ink, rosin size does not help achieve fineness of surface or the ability to withstand repeated erasing, as does tub size.

Originally, the sizing was done simply by dipping a dried sheet of paper in a tub of warm or hot size and lifting it out to drain; then it was hung up to dry again. A good workman could spread a number of sheets at once and be certain that they all were in contact with the size, by dipping them into the size on sticks. After that, the sheets were piled together and put through a press, which salvaged some of the size for re-use. This practice, however, caused a great deal of damage to the sheets, so much so that the sizing room of the early Occidental paper mills was known as the "slaughter house."

Today, the sizing is done better on a machine composed of a flat trough or vat (in which the liquid size is contained) and an endless felt passing through it on rollers. Sheets put on this felt go into the size and come back up fully covered with the size.

The drying of animal-sized papers requires great care; loft drying is best at low temperatures. This brings out very fine qualities in the paper. If this is not possible, warm blasts of air can speed the drying.

Glazing -- A smooth stone such as an agate, or a big conch shell, has been used from early days to burnish a smooth surface on the paper, making it almost glass-like. This action also makes the sheet better able to take ink, by closing the fibers together on the surface. At the very least, it serves to rub away any obvious surface defects such as loose fibers.

A less arduous method of achieving the same purpose is the use of a glazing hammer, and it provides a more uniform surface. Usually powered by

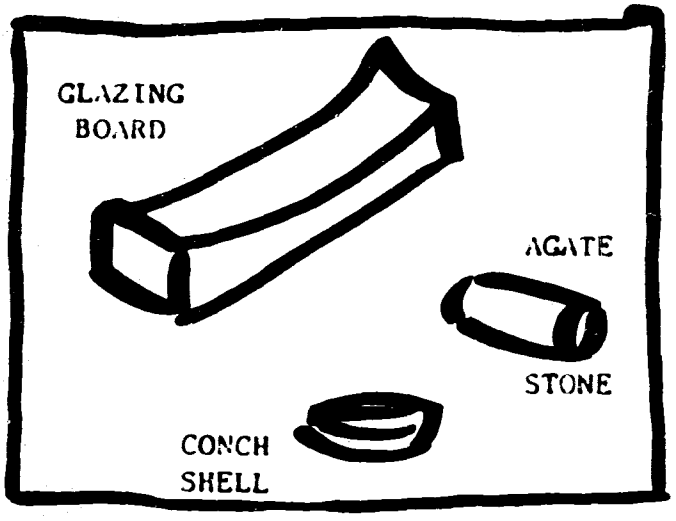


Fig. 29. GLAZING TOOLS

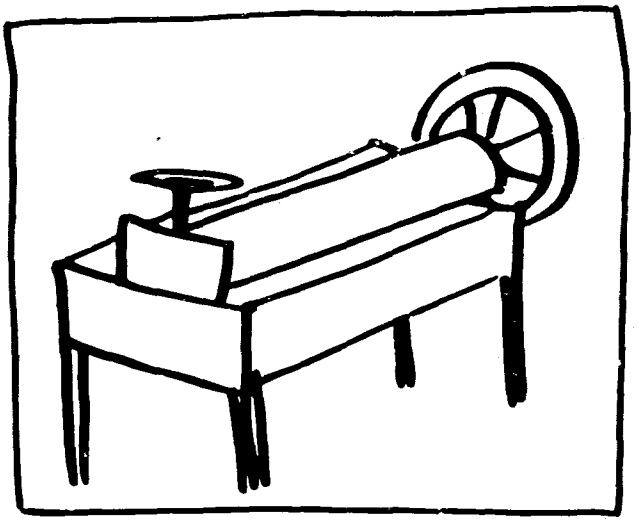

Fig. 30. A CALENDER

water, through leverage, this was a large hammer weighing at least 50 pounds which rose and fell on an iron plate or anvil, on which sheets of paper were placed.

The glazing tool--agate, flint, onyx--is ideally from 3 to 6 inches in length, about 2 1/2 inches in width and an inch thick, with the bottom cut at an angle to help it move over the paper (Fig. 29). In early days in Europe, women were said to be able to glaze up to 3,000 sheets a day this way. It was found that adding a little tallow or grease would make the stone slide more easily; and while this was true, not only did not smooth the paper but damaged it by rubbing in the greasy substance This is not, therefore, a labor-saving device which should be encouraged.

Calender -- The successor to hand glazing has been the calender--in its simplest form a pair of wooden rollers through which a sheet of paper passes under pressure and is thus smoothed (Fig. 30). Improvements have been made in the surfaces of the calenders, in the introduction of heat to the rollers (heat makes the fibers easier to affect and smooth down) and in the ability to adjust the top roller to take different thicknesses of paper.

## CUTTING AND PACKAGING

After the paper is completely processed, it should be trimmed to the required uniform size and then neatly packaged to prevent damage to the sheets (especially at the edges), as well as to make the product more attractive in the marketplace. However, in the early stages of a cottage industry, it may be that these operations can be dispensed with. Certainly there is still paper being made and sold in the world today which is simply rolled up and delivered to the printer, who does his own trimming.

If the paper is being handled by some centralized agency prepared to control quality, there should be a sorting and inspection operation, and a way of marking acceptable papers under a trade mark or other device. (See also watermarks, Page 207). The defects which occur in paper and which make the inspection necessary are discussed in the next chapter.

## CHAPTER 9

# Paper Properties

As a combined result of all the steps taken in the making of paper, the final product emerges with a very definite set of properties or characteristics.

It may give the reader a summary of the preceding technical descriptions to indicate those materials and operations which have the most effect on the ultimate character of the paper:

1. The choice of the fiber--its initial properties and the condition in which it was first received.

2. The type of pulping process used.

3. The kind of sizing, the quality and amounts used.

4. The type of bleaching, beating and refining.

5. The amounts and kinds of filler or loading, and how introduced.

6. The kinds and amounts of water used.

7. The kinds and amounts of coloring used.

8. The presence or elimination of extraneous substances.

9. The technique of paper lifting, and the thickness built up in the forming process.

10. The degree and length of pressing in the water removal.

11. The kinds and length of drying.

12. The techniques of finishing, including coatings, and the kinds of materials used.

13. The care in cutting and handling.

14. The care and suitability of packaging.

15. The care in transporting.

16. The care and conditions of storage.

From the differing combinations of the above come the different properties of the paper. While there are perhaps as many different properties as there are multiples of the processing variables, in general it is possible to group them under these four types of characteristics:

1. Surface characteristics (the texture, the color, the way the paper reflects light, etc.)

2. Physical characteristics (thickness, weight, opacity, length and width)

3. Mechanical properties (strength to withstand tearing or pressure, etc.)

4. Permeability properties (ability to withstand or accept fluids, temperature changes, etc.)

It is important to take such properties into account, both in the planning of papers to make and in the production. The market will usually be interested in papers of a certain kind; or at least if a paper is sold under a grade classification that indicates it has certain properties, there doubtless will be trouble if the claims do not prove true.

## PRINCIPAL PROPERTIES

The principal properties which handmade papers may possess are listed below. Not all papers will have even a majority of these properties, and some are mutually exclusive. In addition, some properties listed are primarily scientific distinctions set up for testing purposes (see Chapter 10). Where a term in the definition is underlined, that word too is defined in the list. To keep the definitions short, it should be understood that a sheet of paper is meant in each instance:

Abrasiveness -- scratching or cutting texture of the surface--good in sandpaper but bad in printing papers because it causes undue wear of type.

Absorbency -- ability to soak up liquids.

Air permeability -- ability to allow air to pass through sheet (so package can "breathe") or keep it from passing through (to retain odors, flavors).

Apparent density -- the weight of the sheet, figured by dividing the basis weight by the thickness or caliper.

Appearance -- the way the eye sees such properties as the color, finish, cleanliness and formation.

Basis weight -- the weight of the sheet, figured on a standard "basis," usually a certain size for one 500-sheet ream; see also introduction to list of paper grades on Page 105.

Bending strength -- ability to keep from breaking under an amount of bending.

Bonding strength -- ability of sheet to withstand "picking" tendency of a sticky printing ink to lift part of the surface away.

Brightness -- ability of the sheet to reflect light.

Brittleness -- ability to withstand breaking by bending; refers to easy breaking under little bending, as distinct from bending strength (e.g., an old piece of paper may be brittle).

Bursting strength -- ability to withstand breaking under pressure.

Caliper -- thickness of a sheet, usually measured in thousandths of an inch.

Color -- the different tones, hues, pigmentations of the sheet; also means "good" color when white and clean, or "poor" color when yellowish or dirty white.

Composition -- generally what the sheet is made of, and how it is formed.

Compressibility -- ability of a sheet to take or withstand pressure, as in printing.

Compression strength -- see compressibility.

Contraction -- ability of the sheet to shrink with dryness or cold, as distinct from expansion with moisture or heat.

Contrast ratio -- the amount of light which is reflected by a sheet when laid on a black surface, vs. the amount reflected when laid on a white surface.

Creasing strength -- ability to retain tensile strength after being creased.

Curl -- tendency of sheet to wave or warp in unusually moist atmosphere.

Deckle-edge -- the thin, feathered edge of a handmade sheet, caused by construction of paper lifting equipment.

Defects -- see list following, on Page 116.

Density -- see apparent density; not to be confused with porosity.

Dielectric -- ability to resist conducting electricity (generally a result of presence or absence of conductive foreign elements in the paper).

Dirt -- presence of foreign matter in sheet with a marked contrasting color.

Durability -- ability to keep its original properties under continual usage; not to be confused with permanence.

Elasticity -- ability to revert to original shape after deforming pressure is removed; not to be confused with stretch.

Electrical conductivity -- see dielectric.

Erasability -- ability of a sheet to withstand erasures in correcting writing or typewriting, i. e., to keep suitable appearance despite erasures.

Expansion -- see contraction.

Extensibility -- see stretch.

Feel -- the general reaction of a paper to the touch, in terms of its finish and general quality.

Finish -- the general term for the different textures or surface properties of a sheet. See list following, on Page 102.

Folding endurance -- see bending endurance; the difference is that folding is a harder punishment.

Formation -- the way the solid substances of the sheet have come together, whether uniformly or in "bunches" or "clouds," and affecting many qualities of uniformity.

Fuzz -- rough surface caused by fibers sticking out from the surface of sheet (this is generally a defect).

Gloss -- the ability of a surface to reflect light, especially in considerable degree due to a polished surface.

Grain -- the predominant direction in which the fibers lie; handmade papers seldom have it.

Greaseproofness -- ability to present the passage of greases and oils through the sheet.

Hardness -- ability to withstand markings by objects pressed against sheet; also, stiffness, hard to crumple in hand, or producing a strong rattle.

# PROPERTIES OF PAPER

Hygro-expansivity -- ability to expand or contract when its moisture content is changed (see contraction).

Initial tearing strength -- ability to resist the start of a tear at the edge of a sheet.

Ink absorption -- ability to "take" printer's ink, either to soak it up for quick drying, as in newsprint, or to keep it on the surface, for certain qualities of printing.

Loading -- the amount of mineral matter such as clay used as a filler in making the sheet.

Luster -- see gloss.

Meat juice resistance -- the ability of a sheet (usually wrapping paper) to keep the blood of butcher's meat from soaking through.

Moisture content -- the percentage of water in the sheet.

Moisture-proofness -- the ability to prevent moisture from soaking through a sheet.

Mold proofness -- ability of paper to withstand bacterial growth.

Odor-proofness -- ability of sheet to prevent odors from passing through.

Odor -- the "smell" which a sheet may have.

Oil absorption -- the ability of a sheet to soak up oil.

Oil content -- the percentage of oil which a sheet may have.

Pattern -- the design or formation or redecorative effect of some surfaces.

Permanence -- ability of paper to retain its properties over long period of time.

Permeability -- the resistance of a sheet to the spreading-out of a liquid or gas which soaks into the paper.

Pigmentation -- amount of color on the surface of a sheet; the amount of actual dyeing substance in the sheet.

Ply adhesion -- the bonding strength of two or more layers of sheets of paper laminated or glued together in some way.

Porosity -- the structure of the sheet in terms of the existence of connected air voids, and the size, shape and relationship of these voids.

Printing opacity -- the ability of a sheet to prevent the printing on one side to show through to the other.

Printing properties -- a collection of different properties which affect the ability of a printer to handle the sheet and get the desired printing results.

Printing smoothness -- the degree to which a sheet has no unevenness of surface to prevent the printing type from leaving a complete and even impression.

Protectivity -- the ability of a sheet to prevent alteration to printing or writing on the surface, or to reveal that such alteration has taken place (for bank checks, legal papers).

Rattle -- the degree of noise which a sheet makes when it is shaken--as evidence of stiffness, hardness, type of fiber, moisture content, etc.

Reflectance -- the ability of a sheet to reflect light.

Resilience -- ability of a sheet to recover from a distortion of its shape (see elasticity).

Resistance to penetration by a liquid -- ability to prevent a liquid from penetrating the surface of a sheet, or from soaking through.

Resistance to wear -- ability to withstand abrasion, or more generally any kind of use.

Scuff resistance -- ability to withstand the hard rubbing of an object at a specific point.

Shearing strength -- ability of sheet to resist cutting.

Size, sizing -- ability to resist penetration of liquids or vapors, especially water, because of sizing chemicals which are part of the paper (not put on the surface later).

Smoothness -- the degree of variation from an "absolutely" flat surface.

Specific volume -- the volume per unit mass of paper measured under standard conditions.

Standard sizes -- the width and length of a sheet, in terms of agreed-upon sizes.

Stiffness -- the ability to resist bending.

Strength -- see various kinds of strength: bending, bonding, etc.

Stretch -- the ability of a paper to increase its length under tensile stress or pulling; this is important in printing and wrapping.

Tearing strength -- ability to withstand tearing (see initial tearing strength.

Tensile strength -- ability to withstand pulling.

Texture -- the feel of the surface to the touch, or the appearance of patterns or irregulatities to the eye; generally, see list of finishes, below.

Thermal conductivity -- ability to conduct or resist conducting heat.

Translucency -- degree to which light may be transmitted through a sheet (as distinct from transparent).

Transparent -- degree to which objects can be seen and distinguished through a sheet.

Vapor permeability -- the ability of a sheet to allow or resist the passage of vapor.

Water absorption -- ability to soak up or resist soaking up water, specifically.

Waterproofness -- ability to resist penetration by water.

Wet tensile strength -- the ability of a sheet to withstand pulling after being wetted, either temporarily (as in towels) or permanently (as in vegetable parchment).

Wettability -- ability of a surface to absorb a particular liquid (as a desirable quality).

Weight -- see basis weight.

VARIOUS FINISHES OF PRINTING AND WRITING PAPERS

The "finish" of a sheet of paper is the texture or pattern of the surface, and aside from its aesthetics, it is important because of the effect it has on printing and writing.

The following list of finishes indicates in general the major types, together with some of the printing uses. (Although the printing terminology is too complex to be explained in this Manual, the data may be of use to persons involved in the printing processes. For the same reason, finishes which cannot be satisfactorily achieved by hand papermaking are nevertheless included; the producer or marketer of handmade paper will at least have some reference to the full range of finishes involved in printing.)

Antique -- surface relatively rough, usually on bulky stock. Excellent for oldstyle type and line engravings by letterpress, not suitable for

halftones letterpress. Some are suitable for offset halftones and sheet fed gravure. Good for books, folders, booklets.

Coated -- generally papers with a substance covering the basic stock, to make it smoother or glossier for improved printing quality.

Cockle -- a ripple-like and slightly-polished finish on fairly hard-surfaced writing papers.

Dull coated -- coated for good printing surface, for fine-screen halftones letterpress, but with a minimum of gloss.

Duplex -- the two sides are of different color or finish, as a blotter with a coated side for the message.

Eggshell -- finish that feels about like an eggshell, with same printing qualities as antique.

Embossed -- papers which have decorative designs or patterns of various kinds impressed in them (e.g., a basket weave).

Enamel -- a highly polished coated paper, usually on one side (although term is becoming used to mean any coated stock).

English finish (E. F.) -- smoother than machine finish, less than super-calendered, is low in gloss; takes letterpress halftones up to 120 line well, is used widely in magazines.

Glazed -- a highly-polished paper, in book, bond, cover, boards and some wrapping papers; generally they have a burnished appearance.

Gloss -- a paper that reflects light (i. e., from a shiny surface).

Laid -- a watermark effect in paper consisting of thin lines running 10 to 15 to the inch in one direction and a heavier line running approximately at one inch intervals across. Generally limited to better quality writing papers and text printing papers, in machine-made papers.

Leather finish -- simulates leather in feel and appearance, and to some extent in durability.

Machine coated -- a paper coated as part of the basic papermaking operation, and thus less expensive (and less coated) than regular coated stocks. Takes 120-line letterpress halftones.

Machine finished (M. F.) -- in smoothness, between eggshell land E. F., good for letterpress halftones up to 100 (or maybe 110) line screen.

Machine glazed (M. G.) -- glazed on the papermaking machine, and thus glazed only on one side.

Metallic coated -- coatings of a wide variety of metallic or metal-simulating surfaces.

Mosaic finish -- an embossed finish, like mosaic tiles.

Paneled -- a very smooth finish, technically produced by pressing against flat plates (as distinct from supercalenders), but with a wide range of surfaces from quite dull to quite glossy.

Parchment -- paper finished to simulate parchment in feel and appearance.

Ripple finish -- glossy but roughish, and with fairly definite indentations that cast a different shade of light.

Safety -- surfaces treated chemically to show up erasures, alterations, etc., in checks and other negotiable papers.

Satin finish -- finish with the smooth feel of satin; not too good for halftones in letterpress.

Smooth -- a paper which is without indentations that would affect its printability, particularly in letterpress halftones.

Supercalendered -- mechanical smoothing under pressured rolls, providing a finish varying from the highest E.F. to a highly-glazed surface.

Unglazed -- machine finish papers with a low degree of smoothness.

Vellum -- a very smooth and soft (calfskin) finish.

Walrus finish -- tough-looking grain, by embossing.

Wove -- a paper that does not show the wire marks which sometimes result from the papermaking process. Most paper is wove today.

## GRADES OF PAPER AND BOARD

As noted in Chapter 2, the various properties listed above, when combined to best meet specific purposes, have gradually been recognized as "grades" of paper. While the classifications keep changing with the development of new types of paper and new needs for special papers, and as demands change the relative importance of the various sub-grades, in general the following classification of grades will afford a general reference to the types of paper produced with more-or-less standard characteristics. While some grades of paper which cannot be made properly by hand methods have been omitted, it may well be that certain of the grades included in this list are not practical under the particular local conditions. Those which perhaps lend themselves best to small-scale manufacture under varying conditions are indicated by an asterisk (*) before the grade name.

Insofar as practical, the information below includes the U. S. practice or standards in "basic weights," as well as the other distinguishing properties of the different grades. The basic weight of a sheet of paper is the method of identifying the degree of weight of the paper - not the actual weight of a particular piece, which may be cut large or small and thus have an actual weight that would not be too meaningful for reference purposes. By the basis weight system, a "30 pound uncoated printing paper" means that 500 sheets of this particular kind of paper in the "basis size" (which happens to be 25 x 38 inches) will weigh 30 pounds. In the list below, this is indicated by 30# (25x38) with the ream of 500 sheets being understood. Where varying basis weights are usual, the range is indicated.

Separate lists are presented in this Manual for specialty and converting papers (defined below), and for paper products which may be made made for handmade paper. There is a good deal of overlapping among these distinctions, with some duplication being used to make each list reasonably complete in itself.

* ABSORBENT PAPER AND BOARDS -- general term for soft and loosely felted papers which have the property of absorbing water, solutions, or special chemicals. They are not sized with rosin, wax, or other water-repellent materials, but may be treated with synthetic resins or the like to enhance their wet strength. Among the papers included under this term are blotting, filter, matrix paper, toweling, and the base papers for manufacture of vegetable parchment, artificial leather, vulcanized fiber, and many other processed papers such as those used in the manufacture of various types of paper-base plastics.

* ACCOUNT BOOK PAPERS -- typical ledger papers used in account books, made of rag pulp, chemical wood pulp, or a mixture of the two, usually tub sized and supercalendered. Normally made 24 to 36# (17x22); essential characteristics: good tearing strength, erasability, good ruling qualities.

* ALBUM PAPER AND BOARD--BLACK, COLORED -- principally used for making photographic albums. Made in solid colors, particularly black and gray, 50, 65, 80# (20x26). A soft surface which takes paste without cockling essential. Also free of impurities which discolor the photographic print; the color should not rub off.

ANNOUNCEMENT -- fine stationery, paper or cards; panelled or plain, for matching envelopes.

ANTIQUE -- any paper with an antique finish.

* ART COVER --special decorative pover paper, used for announcements, greetings, holiday cards, and the like.

* ART PAPER -- fancy figured paper used by bookbinders for the end sheets and flyleaves in books. (Also highly coated stock unsuitable for handmade-paper industry.)

* ART PARCHMENT -- hard-sized, heavy sheet of rag or chemical wood pulp, with color, appearance, and surface reminiscent of the old vellums. Particularly adapted for diplomas and documents where heavy paper is desired.

BACKING PAPER AND BOARDS -- Thick paperboard placed in the backs of mirrors, pictures, etc., or used for partitions in furniture. Generally pasted or unpasted, rigid to prevent warping. May be lined or colored on one side to give the desired finish.

BAG LINERS -- (1) inner liners of bags used for packaging coffee, tea, etc. Glassine, greaseproof paper, waxed papers, or vegetable parchment frequently used for this purpose in order to retain oils and flavors in the packaged material and to exclude odors. Range from 25 to 35# (24x36). (2) liners of paper in bags of burlap or cotton to prevent leakage and exclude dampness and dust. Usually of creped kraft and are sometimes waterproofed with asphalt.

BAKERS WRAP -- lightweight wrapping paper used for wrapping baked goods. Usually made from bleached sulphite or sulphate pulp from 20 to 25# (24x36), usually glazed. Significant properties include a reasonable strength, a high finish, a good white color.

BALING PAPER -- general term applied to any heavy paper used for covering bales to protect the contents. May be reinforced with cloth fabric (cheesecloth) which is pasted to one side after it has been coated with asphalt, or it may be crinkled, corrugated, or treated with asphalt.

* BANK-NOTE PAPER -- bond paper to be converted into bank notes or currency. Made principally from good rag pulp, sometimes may be mixed with purified chemical wood pulps. Range from 20 to 24# (17x22). Excellent strength and resistance to wear the most important properties. Sometimes termed currency paper.

BEAVERBOARD -- originally a trade name for a laminated wood-pulp board; now a general term for any type of rigid wallboard.

BENDING CHIP -- paperboard used for manufacture of folding cartons. Made of waste papers and by definition must endure a single fold to 180° without breaking or separating the plies.

BIBLE -- high quality book paper in very light weights and thin sheets, with good opacity. Ordinarily for letterpress (and gravure), but can be made for offset. Smooth enough for 120 line screens. Basis 25x38.

BINDER'S BOARD -- single-ply, solid board used principally for the binding of books. Made from a base stock of mixed papers, ranges in thickness from 30 to 300 points (0.030-0.300 of an inch). Important properties: smoothness, uniformity, high density, flexibility, and strength.

BLANKS -- stiff, smooth, thick cardboards for window displays, backing for calendars, posters, etc. Basis weights from 120 to 775# (22x28) or 12 to 78 points.

* BLOTTINGS AND BLOTTING BOARDS -- unsized paper used generally to absorb excess ink from freshly written manuscripts, letters, and signatures. Also used for many other purposes where absorptivity is the required characteristic or where soft spongy paper is needed, even though the absorptivity is of secondary importance. Made from rag, cotton linters, chemical or mechanical wood pulp, or mixtures of these. Paper is porous, bulky, of low finish, and possesses little strength. Range from 60 to 140# (19x24). Some grades are made with a smooth machine finish, for printing with coarse screen halftones.

BOARDS -- these are the general type of paper which differ from "paper" as a product under 6 points (.006 of an inch) thickness. They are thus heavier than paper, usually starting at 12 points (6 to 12 is a no-man's land with some papers and some boards). They are also usually stiffer and heavier in bais.

BOARD AND BOX LINING -- grade of paper containing 65 to 75% of mechanical pulp with the balance usually unbleached pulp, though occasionally bleached chemical wood pulp is used. Principal use: covering chipboard before manufacture into various inexpensive setup boxes. Cleanliness and sufficient sizing for good pasting qualities are important properties. Principal basis weight: 32# (24x36).

* BODY PAPERS -- general term applied to all kinds of papers used by the paper converter for gumming, coating, finishing, and the like.

* BOGUS PAPERS AND BOARDS -- descriptive term applied to papers and boards made principally from old papers or poor-quality stock, to imitate grades using higher-quality raw materials.

* BOND -- writing paper with special strength and permanence, ease of erasure, good quality finish, cleanliness and freedom from fuzz. Used increasingly for printed letterheads and forms. Basis weight: 13 to 24# (17x22). Wood pulp or rag content.

BOOK PAPERS -- this is generally the grade for printing papers, with more emphasis on the softer finishes. Main characteristics are an even, uniformly closed sheet; a soft, strong, pliable sheet, and a high finish with an even bulk. Basis: 25x38.

BOXBOARD -- generally boards used for making boxes. U. S. standard size is 25x40 inches.

BOX LINERS -- papers used for the inside of boxes containing food or meat or crates containing celery, lettuce, or other vegetables, to keep the products fresh through the retention of moisture and to protect the contents from dirt or other contamination. Almost any grade and any weight of paper may be used, depending upon the product in question.

BUILDING PAPERS -- general term applied to a class of paper used in general construction work. Generally produced from strong fibers (rags, wood, screenings, and unbleached kraft pulp). Used in building construction for sheathing and under flooring and may be converted to such products as roofing, sheathing, and tarred or asphalt-coated vapor barrier.

BULKING BOARD -- general term indicating that the board is subjected to little or no calender pressure and is light as to weight per point of thickness.

BULKING BOOK PAPER -- paper used where maximum bulk per unit of ream weight is desired. Made from a variety of furnishes, selected and blended to give this property. Some grades are made of cotton-linters pulp, rag pulp, esparto, or chemical wood pulps; other grades contain a large percentage of mechanical pulp mixed with chemical wood pulps. There is little or no loading (fillers). This paper is usually made to specification as to finish and caliper.

BUFF PRINTINGS -- English term for buff-colored printing papers.

CARDBOARD -- general term for boards (i.e., paper) .0006 of an inch or more thick. Usual trade practice is to substitute a word more descriptive of the use, e.g., postcard.

CHART PAPERS -- hard, tough and pliable, able to take folding and much use; takes (pen) ink easily, erases well.

CHECK OR SAFETY -- used for negotiable papers; contain built-in precautions against counterfeiting (e.g., special watermarks) or alterations (e.g., inks or chemicals which show up erasures).

CHIPBOARD -- a somewhat-bulking paperboard of cheap quality and little strength, either "solid" chipboard with a poor surface or "combination" chipboard with a cover on one or both sides of a better stock and finish; thickness 6 points up.

CIGAR-BOX BOARD -- paperboard from which a box is made to hold cigars. It is a chipboard, usually pasted to form a sheet about 140 points in thickness and has a surface to which a cover paper can be readily adhered. Chief characteristic: stiffness.

CLEANSING TISSUE--see FACIAL TISSUE.

CONTAINER BOARD -- general term designating corrugated or solid fiber shipping container board or any board made for the use of corrugated or solid fiber container manufacturers. Large-scale, container boards are usually shipped in rolls and basis weight is expressed in pounds per thousand square feet.

CONTAINER LINER -- (1) general term for paperboard used for outerfacings in making corrugated or solid fiber container board; made from wood pulp, waste papers, or a combination of both. Significant properties: strength and good bending qualities. (2) a corrugated or solid fiberboard placed inside a container to give added protection along the sides of the box.

* CONVERTED PAPERS (CONVERTING PAPER) -- any paper which may be converted by a separate operation to produce a paper of different characteristics or to produce a product quite distinct from the original paper. Thus, kraft paper is made and sold to be converted into asphalt paper, waxed paper, gummed tape, or paper bags; writing paper is converted into envelopes,etc.

* CONSTRUCTION PAPER -- soft, cheap, bulking papers with a great range of colors for cut-outs and paste-ups, economical mountings. Basis weights 40 to 80# (24x36).

COPYING TISSUE -- a general term for tissue papers which are slack sized, soft in texture and of considerable strength, for use in printing or special many-copy purposes.

* COVER STOCK OR PAPER -- for covers, having qualities of good foldability, wearability, permanent color, and good printing surface. There is a wide range of finishes and weights, on a 20x26 basis, and often the covers have matching text stock.

CULTURAL PAPERS--see MECHANICAL PAPERS.

* DECORATIVE PAPER -- general term applied to any paper on which special designs have been printed or produced for decorative purposes.

DISPLAY BOARD -- generally thick paperboards, for use indicated.

* DRAWING PAPER -- the general name for a variety of papers used by artists, architects, layout men, etc., for pencil or ink drawings. Usually dull finish, good writing surface, erases well. Machine-made papers in basis weights of 80 and 100# (24x36); best drawing papers are handmade.

ERASABLE -- bond papers especially coated to allow typewriter erasure (until the ink sets).

FACIAL TISSUE -- used for the removal of creams, oils, etc. from skin, and other cleansing purposes. Made from bleached sulphite or sulphate pulp, sometimes with an admixture of bleached mechanical pulp, 8 to 13# (24x36) after creping. Desirable characteristics: softness, strength, and freedom from lint.

ETCHING -- high quality, smooth, strong drawing paper (also called steel plate). Erases well. Basis weight 120# (22x33).

FEATHERWEIGHT -- two somewhat opposing meanings: (1) very bulky for the weight (bulking papers) to make a booklet or book thicker; (2) very thin and light weight papers for writing, books, etc.

FIBERBOARD -- a hard board made of chemical wood pulp and waste materials; sometimes used to mean container boards in general, and sometimes a designation for vulcanized fiber.

FILLER BOARD -- general term designating: (1) inner layer of a combination board; (2) chipboard made for solid fiber container manufacture to be used as the inner layer(s) in container board (filler chip ranges from 0.012 to 0.051 of an inch in thickness and from 36 to 180# per 1000 square feet in weight); (3) inner layer for wallboard; (4) center or middle layer of other boards where this portion differs in any respect from the outside surfaces or liners.

FINE PAPERS AND BOARDS -- broad term including writing, and cover papers, as distinguished from wrapping papers and paper not generally used for printing purposes; the latter are generally referred to as "coarse papers."

FLAX BOARD -- fibrous insulation board manufactured largly from flax straw pulp.

* FOLDER STOCK -- board or bristol used for manufacture of folders for business filing, commonly made of wood pulp and waste paper, though can be made from rope or jute stock. Vary from 100 to 225# (24x36); common thicknesses are 0.008, 0.011, 0.014 of an inch. Significant characteristics include: tearing strength, stiffness, folding and noncurling properties, and uniform high finish without mottle.

GLASSINE -- transparent (but can be opaque) papers highly resistant or impervious to air, grease, moisture vapor. Usually calendered, in basis weights from 12 to 90# (with 15 to 40 being usual) 24x36. Used as protective wrappers, especially for foodstuffs; can take printing.

* GRASS PAPERS (ESPARTO) -- papers made with esparto as the fibrous material.

GRAY BULK BOARD -- paperboard used for the backs of pads or tablets of paper. Made of waste-paper stock, thick and but lightly calendered; stiff with a soft finish.

GROUNDWOOD PAPERS -- general term applied to a variety of papers made with substantial proportions of mechanical wood pulp together with chemical wood pulps, and used mainly for printing and converting purposes.

* HANDMADE -- paper made by hand molds in single sheets.

* HANGING PAPER -- the raw stock from which wallpaper is made. Sheet is made hard sized to resist moisture in coating and pasting; has a "toothy" surface to enable coating color to stick to sheet; is uniform in surface; soft and pliable for efficient operation in converting plant, and to lie flat when pasted. Variety of weights, 24x36 basis size, 480 sheets in ream.

HEAVY WRAPPER -- general term for a wrapping paper about 90 pounds per ream (24x36) and heavier.

HEMP PAPER (ROPE)--see ROPE PAPER.

FOOD PAPERS -- generally papers used to protect foods in regular packages must be able to protect against handling, contamination, insect infestation, gain or loss of moisture or volatile flavors; resistance to foreign odors; sometimes greaseproof.

INDEX -- thin, tough board finished and sized for pen and ink. Basis weights 90 to 220# (25.5x30.5).

INDIA -- approximately the same as Bible paper, but always "India" color, i.e., light buff.

* INDIA PROOF PAPER -- a paper of straw color, extremely soft and absorbent, unsized, which adapts itself to the surface of a steel plate or wood and soaks up ink without smearing afterwards; sometimes called India transfer paper.

* JAPANESE ART PAPER -- decorative papers, handmade, in various weights and textures.

* JAPANESE COPYING PAPER -- specially thin and strong handmade papers produced in Japan from long fibers, such as mitsumata and paper mulberry, and used for copying books.

* JAPANESE TISSUE -- a light weight paper made by hand from kozo fibers and commonly used for mimeograph stencils and lens papers.

* JAVA PAPER -- a packing paper made from waste papers.

JUTE PAPER AND BOARD -- any paper made with jute fiber or burlap wastes, basis 20 to 300# (24x36), a tough and durable sheet used for envelopes, folders, cover stock, pattern papers, cement bags, etc.

KRAFT PAPER AND BOARDS -- made of kraft pulp in various thicknesses. It may have a dry or water finish; chief characteristics are strength and bending qualities.

* LEDGER OR RECORD PAPER -- like bond paper, except even more strength and quality, with special emphasis on water and ink resistance and smoothness (papers are usually surface sized and supercalendered). Normal basis weights 24 to 36# (17x22).

LIGHTWEIGHT CHIP -- a paperboard used principally by the corrugated container manufacturers as a facing for single-faced corrugated rolls, for pads and partitions, and for other types of interior packing; made of chipboard, generally 0.006 to 0.012 of an inch in thickness and has a surface adapted to the adhesive used in corrugated board manufacture.

* LINEN PAPER -- a paper made wholly from linen rags, and generally linen finished (see list of finishes).

LINER BOARD -- paperboard used as an inner or outer facing in the manufacture of corrugated or solid fiberboard.

* LOAN PAPER -- tough, tub-sized, wove paper, made of the strongest materials and finished with a good writing surface, not highly glazed. The materials and treatment (hydration) are similar to those employed for bank and bond papers, but it is tougher and the basis weights are heavier. Used chiefly for bonds and shares, etc., which possibly gave rise to the name.

* LOFT DRIED -- any paper which is dried by hanging to dry in a drying loft, where the atmospheric conditions are regulated to give the desired rate of drying.

MANIFOLD -- a lightweight bond paper with porosity, sometimes with unglazed or cockle finish. Used for duplicate copies made by carbon paper. Basis weights usually 7 to 10# (17x22).

* MANILA -- originally strong papers made of manila hemp stock, now imitating papers with a similar color and finish (light straw colored, textured but smoothed-down and printable surface).

MANILA BAG PAPER -- a bag paper, made of a combination of chemical and mechanical pulps, which has a manila color.

MANILA BOARD -- a paperboard used largely for folding boxes and where packaging is required for foods. It is made from chemical wood pulp and is 0.016 to 0.035 of an inch in thickness; it has a manila color, is a good bender, clean in appearance, and has a surface suitable for printing in colored designs.

MANILA WRAPPING -- a term applied to a group of manila-colored wrapping papers, made of chemical, or a mixture of chemical and mechanical pulps. They are used for various wrapping and printing purposes and also for envelopes, filing folders, etc.

* MARKET PAPER -- a general class of wrapping papers for market use, such as dry-finish butchers wrap, delicatessen paper, etc.

MAT BOARD -- a paperboard, lined with a plain or decorated cover paper. It possesses rigidity and is used for mounting specimens or articles.

MECHANICAL PAPERS -- (1) a term applied to papers other than writing and printing papers, which are termed cultural papers. It includes such items as absorbent papers, tissue papers, wrapping papers, etc. (2) a term sometimes applied to papers made entirely or in part from mechanical wood pulp.

MIMEOGRAPH -- used for stencil duplicators. Qualities: opacity, lack of fuzz, absorbency. Nowadays, takes pen and ink well. Basis weights 6 to 24# (17x22).

* MUSIC -- paper to meet the special requirements of sheet music. Basis weights from 60 to 90# (25x38).

NEWS (NEWSPRINT) -- the general term for papers used primarily in newspapers; made largely of groundwood, slack sized and little or no mineral loading. Basis 30 to 35# (24x36).

NINEPOINT STRAWBOARD (.009) -- a paperboard made of straw and used by corrugated box manufacturers in making corrugated boxboard.

* NONTEST CHIP -- a paperboard used as a filler by makers of solid fiber container board and for general use where no minimum bursting strength is required. Made of waste papers and varies in caliper and finish according to requirements.

ONIONSKIN -- a manifold paper with some transparency and more permanence than most.

PACKING TISSUES -- a general term applied to tissues,for packing articles.

PARCHMENT TYPE PAPERS -- simulating genuine parchment (which is animal skin, not paper) in appearance, durability and velvety feel. Parchment bond basis weights 24 to 40# (17x22).

PASTEBOARD -- a general term applied to both paperboards and cardboards that are formed by pasting a liner on stock of a different grade; popularly used to denote any stiff board or cardboard of medium thickness.

PLATE -- (distinguished from plate-finished papers), soft, thick printing paper with smooth (non-glossy) surface, for use with true engravings and for woodcuts and lithography.

POSTCARD PAPER -- use obvious; surface smooth, for both printing and writing. Basis weight 94# (22 1/2 x 28 1/2).

POSTER -- two meanings: (1) specially for billboard posters. Basis weights from 32 to 45# (24x36); (2) inexpensive paper for throw-aways, flyers--with smooth printing surface, unsized, in standard colors. Basis weights 32 to 43# (24x36).

* PRINTING PAPERS -- general term for papers used primarily in printing. Printers require paper that will operate without interruption in presses, faithfully reproduce printed designs with freedom from strike-through and show-through, and accomplish this with low ink costs. Some of these requirements such as the necessity for strength with a smooth soft surface, cover more or less opposing qualities which have taxed the ingenuity of the paper manufacturer.

* RAG-CONTENT PAPER -- papers containing a minimum of 25 per cent rag fiber and generally made also with 50, 75, and 100% rag fiber content. These papers are used for bonds, currency, writings, ledgers, loose-leaf ledgers, manifold, papeteries and weddings, index, carbonizing tissues, blueprint, and other industrial specialties.

* **ROPE PAPER AND BOARDS** -- any paper made from manila hemp (commonly called rope). It may be composed entirely of rope fibers or it may contain some chemical pulp. Used as cable papers, shipping tags, saturating papers, and for other purposes where strength is an important property.

SEMI-CHEMICAL PAPERBOARD -- a paperboard made of straw or other fibrous material cooked with lime and other chemicals, or other chemicals without lime, in calipers ranging from 0.009 to 0.060 of an inch. It is generally unsized and has a rough finish. It is used as a corrugating material in shipping containers, tablet backs, separators, etc.

SOLID CARDBOARD -- a term applied to any cardboard that is made in one operation, as distinct from pasted together.

* SPECIALTY PAPERS -- (1) grades of paper and/or paperboard made with specific characteristics and properties to adapt them to particular uses. (2) grades of papers and/or paperboards made in a given mill which are not the primary products of that mill.

STRAWBOARD -- (1) a paperboard used for setup boxes, tablet tacks, etc. It is a rigid board but not susceptible to high finish and for the setup box trade is usually lined with paper. (2) a paperboard used for mailing tubes and cans, made about 0.020 of an inch in thickness for spiral winding and is resistant to crushing. (3) corrugating material in the manufacture of shipping containers, 0.009 of an inch in thickness and readily formed into flutes in the corrugating process. When it is pasted with a liner on one or both sides, it is rigid and resilient after compression. It is made from straw which is treated chemically and then passed through the customary papermaking process.

SULPHATE PAPER--see KRAFT PAPER.

SULPHITE PAPER -- any paper or board made with sulphite pulp.

SUPERFINE WRITING -- (1) highest type of writing paper such as loft-dried 100% rag fiber of best quality. (2) A writing paper with a fine smooth finish and a closed formation, made of sulphite, soda, and some rag pulp. It is not loft-dried. The better grades of flat writings and vellums would fall in the superfine group.

* TABLET WRITING PAPER -- hard-sized tablet paper for pen and ink writing.

TAG STOCK (and TAG BOARD) -- papers with durability in handling, water resistance, and able to take printing, writing or stamping. Used for tags, file folders, etc. Basis weight 80 to 300# (22 1/2 x 28 1/2).

* TEXT PAPERS -- generally better quality book papers, used also for booklets, announcements, annual reports. Finishes from antique to dull calendering, often laid. Basis weights usually 60 to 80# (25x38). Very often has deckle edge available.

THIN PAPERS -- any lightweight paper. The term is usually applied to such papers as Bible, cigarette, condenser, manifold, and like papers but not to facial or toilet tissue.

* TICKET STOCK AND BOARD -- a general term including thick china, various unclassified sulphite waste-paper boards, translucents, tough check, and good grades of writing or bond paper in the heavier weights. It is chiefly used for window tickets. Much of this board now has safety features.

TISSUE -- general term for lightweight papers; usually gauzy and often fairly transparent. Types range from printing papers to sanitary tissue. Basis weights under 18# (24x36).

* TOILET PAPER -- sheets with softness, strength, absorbency and cleanliness while usually in rolls, can also be in separate sheets, and made into pads.

TOUGH CHECK -- very strong cardboard used for tickets, shipping tags, etc. May be coated one or two sides, in many colors, in 3-, 4-, 6- and 8-ply or 12, 18, 24 and 30 points. Basis 22x28.

* TOWELING -- a creped absorbent paper made primarily from either bleached or unbleached sulphite pulp, with or without the addition of mechanical pulp. It should have sufficient strength to withstand use without disintegration or tear; fast absorbency and water capacity; softness in use, and freedom from lint and from unpleasant odors.

UNCOATED PRINTED PAPER--see BOOK PAPER.

* VAT PAPERS -- a term for handmade papers.

VELLUM -- (1) a paper imitating fine calfskin parchment; (2) tracing papers. (Vellum is also a finish).

WALLPAPER STOCK--see HANGING PAPER.

* WATER COLOR PAPER -- a paper for use with water colors--a typical drawing paper, tub sized, machine, air or loft dried; chief characteristics: hard sized surface, texture suitable to absorb the water colors so that they will not run and yet not penetrate too deeply. The surface should simulate the surface of canvas for oil painting.

* WATERLEAF -- papers which have no size (chemical) and which therefore are highly absorbent.

WET-STRENGTH PAPERS -- papers which do not lose their strength when they are wetted; chemical treatment of the fibers or paper makes this possible. In U. S. practice, the standard for a wet-strength paper is that it retain more than 15% of its dry strength when completely wetted with water.

* WRAPPING PAPER -- a general term applied to papers used for wrapping purposes, strength and toughness are predominant qualities. Basis 24x36.

* WRAPPING TISSUE -- a tissue manufactured from various types of furnishes, including bleached and unbleached chemical wood pulps, mechanical pulp, or screenings, in basis weights of 9 to 17# (24x36) using 480-sheet ream, and used in wrapping and packaging of merchandise. The chief characteristic is toughness, and in some cases, freedom from chemical residues which would produce tranishing of the wrapped products.

* WRITING PAPERS -- a general term for papers suitable for pen and ink, pencil, typewriter, or printing. Made in a wide range of qualities from chemical and mechanical wood and rag pulp, or mixtures of rag and chemical pulp or chemical and mechanical pulp. The most significant property is good writing and ruling surface. For some uses, good strength and creasability are also necessary.

## DEFECTS IN PAPER SHEETS

During the manufacture of paper, a great many things can go wrong to reduce the quality of the eventual sheet or at least change it from the properties it was intended to have. In a mass-production technology, where paper is used for printing and packaging on high-speed equipment, and where highest standards of quality at a minimum price can be insisted upon because of the competition, even minor defects are not tolerated. This may or may not be the case in an underdeveloped area, and it is certainly true that some defects which can be avoided only by great expenditure of time and money are not necessarily worth the cost of avoiding, for many of the end purposes of the paper.

In any event, on a practical basis, it should be noted that there is a considerable waste in hand papermaking--20 per cent being not unusual a figure for sheets discarded as unacceptable. This results from tears in the sheet, water drops, hairs from the felts embedded in the paper, knots, drops of sizing materials, bubbles, holes, blurred watermarks, imperfect laid lines, and pieces of rust from some part of the vat (and in particular the steam pipe). The best of these discarded sheets can be marketed as "seconds" or "retree," but the rest can only be repulped as "broke" into an inferior paper for wrapping the good sheets. Obviously, improved techniques and greater care about dropping water and sizing can reduce the waste and thus the price that must be charged for good sheets.

The following explanatory list of defects which may conceivably be encountered in handmade papers is included, therefore, both for its specific reference value, and for its use as a reminder that the technology of paper can be made very complex, and that a local producer will probably always have room for improvement.

Air bell -- a blister, froth or foam mark on the surface; from poor paper lifting or poor condition of drying felts.

Back mark -- the crease or mark left in a sheet of paper dried on a line or a pole instead of flat; sometimes has to be cut out, making two half sheets.

Baggy -- a sheet with a pushed-in center, as trousers are baggy when not flatly pressed.

Bark specks -- brown specks which are pieces of bark not removed from the pulp.

Bells -- see air bell.

Blackening -- dark area on sheet caused by too much pressure or moisture in paper as it goes through calender.

Bleach scale -- spot caused by undissolved bleach residue; usually shiny light brown, and brittle.

Bleeding -- color staining out of paper, or dissolved by a liquid; discoloring of surface from asphalt oils seeping through in converting papers.

Blister -- see air bell.

Blow -- see air bell.

Blue spots -- spots colored blue (or other colors) because of dye reaction with rosin; also a speckled effect caused by poorly prepared dyes.

Bristle marks -- scratches in surface of sheets that have been surface coated, made by bristles coming off coating brushes and sticking to calender roll.

Broke -- the general term for paper which has considerable defects (see ref...)

Brush marks -- see bristle marks.

Bronze specks -- a mineral formation known also as bronze fleck.

Bubblemarks -- see air bell.

Burning -- see blackening (also refers to flattening of calender rolls if left under pressure when not in use).

Burnt -- a sheet made brittle by over-drying; darkened sheet may be discolored by pulp burnt too long a chemical digestion.

Button specks -- powdered, light-colored specks caused by crushed pieces of buttons when waste rags are used as fiber.

Calender crushed -- see blackened.

Calender cuts -- creases, lines on sheet caused by wrinkles in paper passing through calender.

Calender marked -- sheets carrying marks made by markings on the calender roll.

# DEFECTS OF PAPER

Calender scales -- small bits of pigment that collect on the calender roll and are transferred to the paper.

Calender spots -- indentations or spots, sometimes transparent, caused by small pieces of paper sticking to the calender roll and then back onto another sheet; also spots or indentations caused by other particles or drops of oil.

Carbon specks -- black specks caused by coal dust in the pulp or on the sheet; usually called cinder specks.

Cinder specks -- bits of cinders or coal dust in the paper.

Clamp marks -- indentations in paper caused by clamps holding paper solid for trimming.

Clipped cuts -- sheets with edges broken by poor packing or handling.

Cloudy -- unevenness in the formation of a sheet; not necessarily a defect; also called wild.

Cockle -- wrinkles in small waves on sheet, because it is dryer or damper than the air; as a finish, it is not a defect (i.e., if cockling is uniform and in small waves).

Cockle cut -- a cockled paper pressed through a calender and cut as a result of a folding-up or wrinkling.

Contraries -- these are any materials unneeded or injurious to the paper; small bits can escape removal and be made part of the sheet.

Corner up -- a sheet bent at the corner, as dog-eared.

Cracking -- open breaks along creases when paper is folded; also, in coated paper, when the coating layer flakes away from the sheet.

Craters -- small pits in coated papers due to breaking of air bells.

Curl -- warping of an edge of a sheet or a curl across a sheet, due to uneven moisture in the sheet or internal stresses.

Cutter dust -- bits of fiber broken off during the trimming operation and settling between the sheets, causing trouble on the printing press.

Damp streaks -- crush marks or blackening of paper, caused by uneven pressing or drying of sheet.

Dead beaten -- paper made of stock over-treated in the beater, and thus brittle and weak.

Dead spots -- dull areas in high-gloss finished sheet.

Dirt -- anything in the paper that should not be there, making a mark or speck in the paper.

Dog-eared -- see corner up.

Drop marks -- blemishes caused by water dropping on a sheet while still being made.

Dusting -- a paper which may give off dust or lint and thus cause trouble to the printer.

Dye spots -- spots of stronger color than intended, caused by undissolved dye or a biological growth which collects the dye.

Feathered deckle -- a ragged and badly-finished deckle edge on the sheet, caused by deckle not fitting closely enough to the mould.

Fish eyes -- small, round, glazed or transparent spots caused by such materials as slime, undefibered portions of stock or foreign materials formed in the sheet and crushed when it goes through the calender.

Fluff -- the dust of some sheets (see dusting).

Foam marks -- see air bell.

Foul -- paper which has dirt, is not "clean."

Foxed or foxing -- spots, specks or stains in paper caused mostly by mildew or mold.

Fur -- bits of paper pulled from a sheet by a sticky felt and then transferred to another sheet.

Fuzz -- fibers sticking out from the surface of a sheet and tending to pull off in printing.

Grease spots -- spots in sheet formed by oil or grease, or a thin spot in a sheet because pulp would not stay over a greasy or oily area on the mould screen.

Grit -- abrasive specks formed in the sheet; they are very harmful in printing and in many other uses of printing where they may scratch.

Haircut -- a cut in a sheet of paper made by the calender because of a human hair or a long fiber caught in the calender (see calender marked).

Iron specks -- pieces of iron or iron rust in the finished sheet.

Knots -- splotches or lumps in sheet caused by incompletely defibered material forming in sheet.

Line -- see dusting.

Lumps -- see knots; also caused by slime or by partly-dried coating materials falling into fresh paper.

"M" -- paper which is not first quality but which has only very minor defects.

"N" -- paper which is inferior to "M," usually writing paper.

Overdried -- see burnt.

Peeling -- when the surface of a sheet scales or peels off (see also scuffing).

Phozy -- featherweight papers which are too fluffy or loosely made.

Pick -- the property of a paper which lets it release parts of its surface when attracted by a sticky in; caused by a poor adhesive on the surface (poor at least for the purpose intended).

Pinholes -- very small holes caused by hard (often metallic or stone) materials in the paper which fall out when the sheet is calendered; also may be caused by grit on calender punching holes in sheet.

Pitch spots -- caused by accumulations of resins in the stock.

Pole mark -- see back mark.

Retree -- slightly defective sheets of paper; not "good" but not broke; still generally usable, especially in printing.

Ring marks -- patterns or clouds of varying color in dyed papers, caused by bubbles in the paper lifting process.

Rosin specks -- amber-colored translucent specks caused by improper emulsification of size.

Sawdust spots -- in wood-fibered papers, sawdust specks sometimes remain untouched by the pulping process, and are crushed in a calender, causing large blemishes.

Seconds -- imperfect sheets (not to be confused with a kind of paper, "second sheets," for additional sheets in a letter).

Shiner -- a glossy spot due to fillers or other materials, either as shiny particles remaining or as holes or translucent spots pressed into the sheet by foreign specks.

Size stain -- see rosin specks; can be caused by any size, particularly discoloring kind, which is not fully mixed in.

Skipped coating -- brush marks on coated paper showing where brush was lifted in coating process.

Slime spots -- spots or hard and shiny blemishes caused by accumulation of slime in beaters or vat.

Specks -- small spots caused by a variety of foreign objects or materials in sheet.

Spongy -- paper without enough size, or too bulky and soft for the properties intended.

Spots -- different colors or degrees of transparency in a sheet due to water, oil, grease, size or other materials.

Stamps -- see fur.

Stickmark -- see back mark.

Two-sidedness -- two sides of a sheet being different either in texture or color.

Wavy edges -- see curl.

Wedgy -- a paper thicker or heavier at one end than another, due to the mould being titled in paper lifting; not noticeable in one sheet, but in a stack of sheets all formed the same way, the thickness different will become apparent.

Wild -- see cloudy.

SAMPLES OF PAPER

SHOWING VARIOUS GRADES AND FINISHES

APPEAR AS APPENDIX V IN THIS MANUAL

STARTING ON PAGE 244

## CHAPTER 10

# Testing for Paper Properties

While some properties of paper can be seen by the eye alone (and it is true that a practiced eye can see properties which escape the uninitiated!) many of the important properties do not show themselves until it is too late. That is to say, a paper which presumably had a good printing surface, but did not, will cause trouble on the printing press. Or a paper bag which presumably was strong, and proved not to be, would evidence that proof by dropping a half dozen eggs out the bottom while they were being taken home.

There are scientific ways to test for most paper properties, to insure that the desired properties actually are incorporated in the paper, and the undesirable ones are not present. While some people may begrudge the time and money required, it is only good business to make certain that the product being manufactured is actually what was intended. The business may well stand or fall, in the long run, on how well this is achieved, because papers which disappoint the customer when he uses them will keep the customer from returning for a second purchase.

In all, perhaps five different reasons can be stated for testing papers:

1. To insure that it meets the specifications set for it.

2. To insure uniformity.

3. To determine if it will do the job it is intended to do.

4. To provide a picture of the producer's improvement (or regression) so that planning and action can be taken.

5. To check the product against the competition.

In addition, testing of experimental papers can be usefully performed --probably by a regular research operation rather than a producer as such-- to determine which fibers and processes are best to make desired kinds of pulps and paper, or what kinds of pulp and paper can best be made from available resources. With a kind of revolution now going on in the paper technology of the non-softwood fibers, and with the potential for the discovery of efficient new processes for waste-material fibers, this is a possibility worth exploring.

## TYPES OF TESTS

A variety of standard tests have been developed, especially in the past 30 years, to serve both research purposes and product inspection. In addition, there are the simple, common-sense tests that will serve some purposes, e. g., to see how strong a sheet of paper is, pull it or tear it or crumple it; and where this is good enough for the immediate question, there is no point in going through a more or less expensive testing procedure for exact information that is not needed. On the other hand, where major decisions are being made between processes or fibers, the more careful the test, the more likely it is that the proper decision will be reached.

Most of the testing equipment is relatively simple and inexpensive, and a research or testing facility of a minimum sort could be part of a cooperative's marketing effort. A full-scale research facility would, of course, be necessary to the proper functioning of a Pulp and Paper Institute. And, in some countries at least, the government Bureau of Standards might incorporate pulp and paper testing as part of its operation.

The following are among the principal standard testing devices and techniques:

Analysis of specks -- Sometimes there are spots or specks in the paper (i.e., defects) which must be identified as to cause. Rubber specks can be recognized by the odor when burnt at the end of a pin. Woodspecks or bark specks due to chips or wood fibers not thoroughly pulped, can be identified by applying a drop of phloroglucinol, which will turn the specks red. Others may sometimes be identified by a characteristic color; see list of defects, Page 116.

Basis weight -- This means the standard weight of a ream (500 sheets, ordinarily) of paper of a standard size, measured in pounds. Thus, 60-pound uncoated printing paper means that 500 sheets of that kind of paper, each sheet being 25x38 inches (U.S. standard basis size for that type of paper), will weigh 60 pounds. Once "basis weights" are established as standards, it requires only a scale to insure that the standard is being met. Since it measures the amount of paper being bought and sold, it is an important test.

Bursting strength -- The "per cent Mullen" of a sheet of paper is one of the oldest and most-used standards, to indicate the ability of the paper to withstand punching through by solid objects. The sample sheet is clamped against a circular disk which has a one-inch hole in its center. A rubber diaphram is pressed against the hole from the other side, and fluid is added so that the diaphram expands against the sheet of paper until it breaks. The pressure required to break the sheet is registered in pounds-per-square inch, and this figure is the Mullen strength (or "Mullen points") of the sample. Dividing this figure by the basis weight of the paper, and multiplying by 100, results in the percent Mullen.

Coefficient of friction -- This is a measure of the smoothness of paper, by determining how much resistance a pack of weighted sheets shows to being slid across other sheets.

Color -- There are elaborate machines which test the exact degree of correspondence of color to a sample, but the simplest way is by visual comparison with a standard sample, making sure the light source is not a distoring kind.

Dirt -- While, again, there are standard methods for determining the amount of dirt a sheet may carry, the simplest way is by visual inspection.

Expansion or contraction -- Since many papers change their size (and thickness) as humidity changes in the room, it is important to know how a specific kind of paper will react. Under controlled conditions, the expansion and contraction are simply measured, before and after, as humidity is changed.

Folding endurance -- A small machine causes a piece of paper to be continually folded and opened, and counts the number of times the process occurs before the piece of paper breaks. This can be done by hand, but not as accurately because different pressures may be used in the different foldings.

Formation -- The simplest test is to visually examine the test sheet against a standard sample sheet; this requires a tester who is experienced in what to look for.

Gloss -- This measures the amount of light a sheet will reflect, as an indication of the type of surface of the sheet. Since light reflected from a very smooth surface are polarized (that is, they go only in one direction), a machine measures the degree of polarization of the reflected light from a sample sheet.

Ink absorption -- This is measured by the amount of a special testing ink which the paper will absorb.

Loading -- The amount of inert filler which has been put into the paper can be measured simply by burning the sheet after weighing it; the weight of the ash remaining is the index of the amount of loading.

Moisture content -- Mositure in paper affects the qualities of the paper, and of course the weight of it. To test, weigh the sample of paper both before and after heating--in a suitable device, such as an electrically-heated hot plate filled with a porous asbestos cover which serves both to hold the sample down on top of the heating surface and at the same time allows moisture vapor to escape easily. If a sample weighs 10% less after heating, the moisture content is calculated as 10%. The test is more meaningful if it is conducted in a room with a constant temperature and humidity, a standard in the U. S. being 73°F. and 50% humidity.

Moldproofness -- Paper is actually innoculated with molds under standard conditions, and the extent of mold growth which follows is then compared to a standard which has a known performance.

Opacity and transparency -- This is measured by a meter reading of the amount of light which can pass through a sheet of paper, hitting a photo-electric cell; while this is technically not measuring opacity, for practical purposes it provides a reliable index.

Picking -- Some surfaces of papers will be pulled away from the body of paper by a sticky ink on a printing press. A standard "bonding strength" can be determined, and any surface tested against this by the amount of force required to tear away a strip of paper which is pasted to the sheet being tested, under controlled conditions.

Porosity -- This tests the length of time required for a given amount of air to pass through a given area of paper, and thus indicates the density of the sheet formation and some of its absorption qualities. A "densometer," which consists of two metal cylinders, one of which fits into the other, is usually the test device. The larger cylinder, at the bottom, is filled with oil; the top one has nothing in it but an escape hold at the top. The air is blocked from escaping from it by a piece of the paper being tested; this paper fits inside to cover the hole. When the top cylinder settles down to float on the oil, the distance it sinks--being controlled by the amount of air which can escape through the paper--is a measure of the porosity.

Printing smoothness -- The surface of a paper--its topography, so to speak--can be measured by a brush which plots the profile of the sheet. Smoothness can also be tested by a device which measures the amount of air that will escape between two paper surfaces pressed together.

Rattle -- This is a test of the actual sound which a paper makes when it is shaken; the sound can be measured in decibels by a sensitive device which registers vibrations. Some papers should have good rattle as an evidence of their hydration; papers on which radio scripts are written should have as little as possible.

Resiliency -- This measures how much a folded sheet will spring back after release. The angle of return, measured with a simple protractor, is used as the index.

Scuff resistance -- This is a measure of the ability of paper to withstand rubbing or scuffing, and is especially important in wrapping papers, boxes and tapes. A recent machine has a wheel covered with an abrasive. After a certain number of turns of the wheel against the paper, the sheet can be measured with calipers to determine how much thinner the sheet is. The sheet can also be weighed before and after, with the loss of weight a measure of the scuff resistance.

Stiffness -- Some kinds of paper require more stiffness than others for the job to be done--shipping tags, for instance, or milk containers. The measure is the amount of force it takes to bend a sample piece of the paper to a given angle. A circular disk rotates to push the sample, which in turn pushes a pendulum away as it bends over. A scale indicates the amount of force required to move the pendulum, as a measure of stiffness.

Stretch -- The device is similar to the one used to test the tensile strength of paper, and measures the actual amount of stretch a given paper has, in inches.

Tearing strength -- A knife attached to a pendulum cuts through the paper on this test, as the pendulum swings on its arc. The greater the strength of the paper against tearing, the shorter the swing of the pendulum. This swing is read on a scale which denotes the force in grams to tear a sheet of paper.

Tensile strength -- This test simply measures the amount of pull required to break a piece of paper. A pendulum scale-assembly pulls the paper and is stopped from swinging back at the point the paper is broken. The scale gives the strength value of the paper directly in pounds.

Thickness or caliper -- Thickness is, of course, another of the characteristics of a paper which should be uniform and actually as stated. In letterpress printing, it is particularly important, since the type is adjusted to print correctly against a certain thickness of sheet, and any variations in succeeding sheets will make the type hit either too hard or not hard enough. Also, customers may well be suspicious of two bundles of different size when they are supposed to have the same number of sheets of the same thickness. To measure, there is an instrument called a caliper, which indicates the exact thickness of a single sheet of paper when it is slipped between two points.

Water absorption -- This is measured by the amount of time it takes for a sheet to absorb a given amount of water placed upon it.

Waterproofness -- Various tests can be used to determine the rate at which wafer will penetrate papers. One test involves a mixture of sugar and dye, sprinkled on a sheet of paper, which is then placed on the surface of a vessel of water. The length of time elapsed before the sugar--dye mixture changes color is a measure of the time required for the water to get through the sheet of paper to the dye. Another test is comparable, except that water is forced through the paper.

Wet strength -- Mullen or tensile strength tests are performed on a piece of paper which has been soaked in water.

INSERT 1

# Paper Products That Can Be Made by Hand

It is a mistake to look upon paper as simply a writing or printing or wrapping or shipping material. Hundreds or thousands of specific items necessary or useful in industry, commerce and the home, are basically paper. New industries can be built to make many of these products directly and in many cases, little or no extra equipment or skill is involved; what is mostly required are chemicals which much more than pay for themselves in the value they add to the basic paper.

Some of these products may now be costing foreign exchange, or may be more expensive than necessary because they are made as a separate operation based upon the purchase of paper as a product. A combined operation by which the producer of the paper continues the manufacture through to the processing of a paper product--will eliminate the middle marketing costs and thus allow a better price margin for competing and for profiting. In effect, it will also allow a paper-product manufacturer more control over his raw materials, often a problem in an underdeveloped area. Since some of these may be items not now used at all, their production and availability would open new markets and mean new standards of living.

Most importantly, if the papermaker concentrates on items such as these, he will be avoiding direct competition with mass-produced paper.

A comprehensive list of such paper products appears below; the asterisks (*) in front of certain items indicate they are especially suitable for hand manufacture, although in some instances this may be less true of the items marked and more true of other items not marked. By no means all of the possible paper products are listed, and local customs and needs undoubtedly will suggest other items which can be approached from this view. On the other hand, it is recognized that not all of the listed products are useful in every locality; the reader will realize that a Manual designed for world-wide use cannot avoid such a situation.

This list should be read in conjunction with Insert 2, SPECIALTY AND CONVERTING PAPERS THAT CAN BE MADE BY HAND, which follows this table, and also Chapter 11, which briefly explains the manufacturing processes involved.

# PAPER PRODUCTS

Abrasive papers (if not for use on machine)

* Accounting forms

Acoustic diaphrams

* Advertising specialties, materials for

  displays
  cut outs
  cocktail, lunch and dinner napkins
  art calendars
  blotters
  business greetings
  perfumed
  greeting cards
  folders
  posters
  booklets
  signs
  paper hats
  shopping bags
  stickers

Air mail

  envelopes
  paper
  tablets

* Albums

  wedding
  photograph
  scrap
  baby record
  bridal

Albumenized or light sensitive paper (sheets for quality portraits)

* Anti-tarnish bags and wrappers

Aprons

* Artificial flowers

Asphalt paper and board

Asphalt laminated paper

Asphalt sheathing paper

Attache case

Bags

  kraft
  coffee
  flour
  bakery
  bread
  cake
  cookie
  coal
  coke
  doughnut
  flour
  poultry
  wood
  charcoal
  candy
  tea
  vegetable parchment
  notion
  peanut
  popcorn
  inc cream carton liners
  cigarette carton
  sanitary napkin
  shoe
  grocery
  potato chips

Baking dishes and cups

Bank-deposit books

Banquet table covers

Barber cups

Barber's headrest paper

Barrel covers

Barrels, fiber

Baskets

corrugated
berry
picnic

Batik papers (decorative, fancy)

Beaming board and paper

Beer containers

Beer mats

Beverage packages

Bibs

Bill and currency straps

Binding cases

Bisque Tortoni cases

Black-line paper (similar to blueprint paper)

Blank-book paper

Blanket bags

Blotters

Blueprint paper

Bon bon cups and dishes

Book matches

Bottle bags

Bottle boxes

Bottles (paper)

Boxed writings

* Boxes

set-up
corrugated
gift
hosiery

Bags (Continued)

flower
ice cream
cigar
toy
jewelry

Bread labels

Bread shipping cases

Bread wrappers

Bronze crepe

Business forms

Butter chips

Butter dishes

Butter tub liners

Butter tubs (paper)

Button cards

Cake circles

Cake laces

Cake-pan liners

Calendars

Calico paper

Cambric

Candy bar wrappers

Candy-box dividers

Candy cups

Canisters

Card table specialties

Cardboard easels (for displays)

Carnival novelties

Carriers

bottles
cones

Carry-all bags

Carton labels

Cartons

Catalogue binders

Catalogue envelopes

* Ceremonial papers

Cement bags

Chocolate dividers and layer board

Cigar bands

Clasp envelopes

Closures for jam jars, etc.

Cloth substitutes

Cloth-winding boards

Cocktail napkins

Coffee bags

Coin cards

Coin envelopes

Collar specialties

Combs

Composition paper

Concrete form (board)

Conduits

Confectionery bags and specialties

Cones, paper

Confetti

Containers

Containers for liquid and moist food

Copybooks

Correspondence binders

Correspondence cards

Corrugated articles

* Corrugated boxes

* Corrugated fiber cases, shipping containers

Crib sheets

Crinkled (decorative-stained) papers

Cross-section paper

Cupboard shelf or lining

Cups, hot and cold

Cuspidors

* Cut cards

Cutouts

* Decorative papers

Dehydrated food packages

Dental headrest covers

Dental pinafores

Design paper (patterned)

Dials

Diapers and linings

* Diaphanie paper

Die cut specialties

* Diplomas

Discs -- fiber, parchment, waxed paper

Dishrag paper

Dispensers

* Display boards, containers, easels, novelties, paper racks

Disposable diapers

Dividers

Document envelopes, manila

Doilies

Door closure panels

Draining sheets or liners

Draperies

Dress covers, shields

Dresses

Drinking cups

Dry cleaner bags and special ties

Dusters

Dynamite paper

Eclair cups and dishes

Egg cartons and containers

Egg case fillers

Egg trays

Electrical insulation

Emery paper

* Envelopes
  lining
  stock
  manila

Excelsior
  tissue
  wrapper

Exercise-books

Export shipping bags

Facial tissue

Facing papers

Fertilizer bags

Festoons

Filing envelopes and supplies

Fillers (shredded paper)

Fillers (looseleaf)

Filter papers

Filters

Finger bowl liners

* Finishing paper

Fittings

Flats

Flock

Floor mats

Floor mops

Floor sheathing

Florists' board, paper, parchment, tissue

Flower pots--waterproof

Flypaper

Folded writing

Folders

Folding boxes

Food containers

* Food wrappers

Footwear components, shoe and boot board

Forks

Freezer paper supplies

Friction pulleys (laminated of friction paper or board)

Fumigating papers

Furniture polishing papers

Games

Garbage bags

Garlands

Garment bags
containers
hangers
protectors

Garnet paper

Gaskets

Gift wrappings

Glassine bags, envelopes, wraps

Graph paper

Graphite paper

Greeting cards

Grocery bags

Guide cards

Gummed labels, sealing tape, stay

Gummed paper

Hair curlers

Handkerchief tissues

Handles (paper core)

* Handmade papers

Hangers

Hanging papers: wallpaper

Hat stands

Hats

Heat-sealing bags, papers

Heliograph paper

Herbarium paper

* Holiday specialties

House sheathing

Hygienic paper specialties

Ice blankets

Ice cream bags, brick wrappers, containers, dishes, pails

Ice cups and paper

* Incense paper

Index cards

Indicator papers (litmus, turmeric)

Insecticide papers

Insulated bags

Insulating materials

* Jackets--report cards, press books, insurance policy cards

Jacquard cards and loom cards

* Japan art paper

* Japanese decorating paper

Jewelry tags and cards (anti-tarnish)

Jute envelopes

Kites

Kraft envelopes

Kraft specialties

Labels

Laboratory papers

Lace paper

Laminated board specialties

* Lamp shades

Lanterns

Laundry bags

Laundry blue paper

Laundry board

Laundry boxes

Laundry specialties

Lens tissue

Letter paper

Linear writing paper

Lined brief

Liner specialties

Liquor bottle bags

Liquid containers

Litmus paper

London boards

Loom cards

Loose-leaf filler

Loose-leaf ledger paper

Lunch boxes

Lunch sets

* Mailing cases

* Mailing envelopes

Mailing tubes

Manicure bowls

Manuscript binder

Manuscript cover

Marble paper

Masks

Mats

Medicated papers

Megaphones

* Memo covers

Memo pads

Menus

* Merchandise bags

Metallic (stylus) writing pads

Metrachromatype paper

Milk bottle caps

Milk bottles (paper)

Milk-can tops

Millinery bags

Mimeotype stencil paper

Moisture proof specialties

* Molded pulp specialties

Mops

Mothproof bags

Moulded pulp products

Moulded seamless containers

* Mounting cards

* Mounting boards

Mourning paper

Mulch paper

Multicolored crepe

Multiwall bags and sacks

Musical instrument cases

Napkins

* Nature papers (laminated with leaves, etc.)

Novelties

Onion bags

Order books

Oyster pails

Packages

Packers lard bags

Pads

Pails

Paint strainers

Pallets

Pamphlet cases, covers

Pan liners

Panel board

Paper boats

Papeterie paper

Papier-mache specialties

Papyroline paper (linen fabric pasted on)

* Partition screens

Patterns

Pay envelopes

Perfumed paper products

Permanent waving papers

Pharmaceutical paper

Phonograph record containers

Photo albums

Photo holders

Photo mount stock

Photostat paper

Picnic plates
Picnic sets
Pie plates
Pie tape
Place cards, mats
Plant covers
Plasterboard
Plates and dishes
Playing cards
Pocket sputum flasks
Postal card
Pouches
Poultry box liner
Profile paper (quadrille, etc.)
Rain clothes, cloaks
Reaction paper
Red wallets
Reflectors
* Release sheets
* Religious papers
Reptissue (embossed tissue paper)
Resin-impregnated papers
Ribbon blocks
Rope manila sandpaper
Rugs
Ruled paper
Sacks, paper shipping
Sandpaper
Sandals
Sandwich bags
Sanitary tissues
Sanitary towels
Satchel handles
Scale paper
Screens
Score cards and pads
Seaming cord
Sectional paper
Seed packets
Seed-germinating papers
Self-sealing wrapper
Self-sealing envelopes
Shelf paper
Shingles
Shipping cases
Shopping bags
Silver paper
* Silver polishing paper
Slates, paper
Slippers, paper

Soda cups, fountain supplies, straw

Souffle cups

* Soundproofing tiles

Spiral tubes

Stationery

Stationers' shelf boxes

Storage bags, cases

Straws, soda and drinking

Striped paper

Sundae dishes and cups

Table cloths and napkins

* Table decorations

Tablet

Tags

Tally cards

Tar paper

Tarpaulins

Tempered construction boards

Test papers

Thimbles

Tobacco bags

* Toilet paper

* Toilet seat covers

Towels

Toys

Transfer cases

Tray covers

Tub covers, liners

Tubes

Turmeric paper

Twines

Umbrella bags

Umbrellas

Vulcanized fiber paper and board

Wallpaper

Watermarked papers

Waterproof bags

* Waterproof liners

Water repellent bags

Wax paper specialties

Wet-strength bags

Wet wash bags

Windows

Window shade

* Wiping cloths

Yarns

INSERT 2

# Special Papers That Can Be Made by Hand

In addition to the paper products which can be made by hand, there are many kinds of specialty or so-called "converting" papers which may be made instead of the more-or-less standard grades of paper--again, in most cases, simply by adding certain chemicals or taking different steps in the finishing process. These are papers which are used as raw materials for further manufacture.

Not only does this take the papermaker out of direct competition with mass-produced paper as such, but it may provide a source of basic converting papers needed by other industries.

As with the paper products insert, preceding this one, the following list intends to be comprehensive, but it is by no means all-inclusive. It should also be noted that there is an overlap between converting papers and specialties on the one hand, and paper products on the other; and similarly at the other end, there is an overlap with grades of standard papers.

The asterisks (*) indicate papers which appear best-suited for small-scale or cottage production. Chapter 11 includes brief descriptions of the processes involved in many of the papers listed here.

* Acoustical products--insulating board; tiles

Acid-free paper

Acid-resistant paper

Album papers

* Analytical filter paper

* Anti-tarnish paper and tissue

Anti-acid manila (for insulation for cables)

Anti-rust paper (for metal packing)

Apple and pear wraps

Apricot paper

Armature paper (for insulation purposes)

* Art parchment

* Articulating paper (for dentists' use)

Artificial leather

Artificial parchment

Asphalt laminated paper

Asbestos paper

Asthma paper

Auto tire wrap

Bacon paper or wrapper

Balloon paper

Banana bags

Barrel liners

Basket liners

Battery board and paper

Beer filter paper

Berry-box board

Biscuit paper

Black album paper

Black needle paper

Black-out paper

Black pattern paper

* Black waterproof paper

Black wrapping paper

Blasting paper

Bloodproof butcher paper

Blotting paper

Blue rosin sheathing paper

Blue tracing paper

Book-binders' paper

Book-cover paper

Book end paper

Book-match board

Boot board

Bottle labeling paper

Bottle-packing boards

Box and barrel layer

Braille printing paper

Bread-bag paper

Brocade paper

Bronze paper

Buckskin board

Buffing paper

Building
  asphalt
  gypsum
  roof slabs
  artificial lumber
  sheathing papers and boards

Burlap-lined paper

Butchers paper

Butchers wrap

Butter bag paper

Butter box liner

Butter carton board

Butter and lard wraps

Button board

Cable-insulating paper

Cable marking paper

Cake boards

Cake wrappers

Calendar board and paper

Calender roll paper

Can board

Can liners

Candle board

Candy-bag paper

Candy-box liners

Candy-slab paper

Candy twisting tissue (for candy "kisses")

Canvas note paper

Cap board

Capacitor paper

Carbolic paper

Carriage panels

Carton liners

Carton sealing papers

Cartridge papers

Casket paper

Cedarized paper

Celery bleaching

Cellulose wadding

Cement paper and sacks

Chair seat board

Charcoal drawing

Check (or safety) paper (to prevent alterations)

Check book cover

Cheese manila

Cheese wrappers

Chemically treated paper and boards

# CONVERTING PAPERS

* China paper
Chocolate board
Chocolate wrapping
Chromatic paper
Cigar packs
Cigarette-mouthpiece paper
Citrus wrapping
Cloth-lined board and paper
* Cloth-substitute papers
Coaster board
Coin wrap
Colored specialties
Combustible papers
Concrete-curing paper or slabbing paper
Condenser foils and tissue
Conduit paper
Cookery parchment
Core stock
Cork paper
* Corrugated board
* Corrugated sheets
Cotton-batting paper
Cotton parchment
Cotton-yarn board
* Crate liners
Crepe paper
Crinkle-lined paper
Cup paper and board
Curing-box liner
Currency paper
Cutlery paper
Cyprus marble paper
Damask paper
Damp proof paper
Deadening felts
Decalcomania paper
* Decorative papers
Delicatessen paper
Design paper
Detail paper
Dial paper
Die-wiping paper
Dielectric paper
Disinfectant paper
Doily paper
Drug papers
Drum papers
Dry felt
* Egg case board
Elastic paper (crepe)

Electric cable paper

Electrical insulation

Electrical pressboard

* Fancy papers

* Filter paper and boards

Firecracker paper

Fireproof materials

Fish wrapper

Flameproof (flame-retardant)

Flint

Flour-sack paper

Form board

Freezer paper (frozen foods papers and board)

Friction papers and boards

Frisket paper

* Fruit paper and tissue

Fruit containers and wrappers

Furniture bogus paper

Furniture paper (paper hangings) boards

* Gasket board and paper

Gasoline-proof paper

Glassine paper

Glycerine paper

Gold announcement paper

Grained board and paper

Grass-bleached paper

Grease and oil resistant

Greaseproof board and paper

Gunpowder paper

Gun wadding

Gusset felt, stock

Hair-curling papers

Ham wrapper

Handkerchief tissue

* Handmade paper (fine)

Hard paper (for electrical insulating)

Holiday papers (decorative)

Hygroscopic papers (moist and flexible)

Imitation parchment

Impregnating papers

Indented board

Insect-resistant papers

Insulating board

Interleaving sheets

Iridescent paper

Jacquard board and paper

* Japanese vellum

Jeweler's Bristol, paper and boards, tissue (anti-tarnish)

Kite papers

* Kraft corrugating material

Lacquered paper

Laminated glassine

Laminated paper

Laminated strawboard

Lampshade Bristol

Lampshade papers and boards

Lard paper

Latex paper and boards

Laundry paper

Layer insulation paper

Leather and imitation leather paper and boards

Lincrusta paper

* Litmus paper

Locker paper

Loin paper

Lottery paper

Loud speaker (radio) cone paper

Luminous paper

Macaroni papermailing-tube board

Manila for oiling

Margarine wrapper

Match-box board

Match-stem stock

Matrix paper

Meat wrap

Metal protective

Metallic bronze paper

Metallic foil paper

Metallic (stylus) writing paper

Meter paper

Mica paper

Mildewproof board

Milk container board

Mist board

Model boards (for shoe making)

Moisture-proof specialties

* Molded pulp

Mold-resistant papers and boards

Money papers

Morocco paper

Mother-of-pearl paper

Mothproof paper

Mottled

* Mounting paper

Mulch paper

Multiwall bag (kraft paper)

Music paper

* Napkin tissues

Needle and pin paper

Neoprene-treated paper

Neutral gummed electrical papers

Noiseless paper

Noncombustible paper

Noncorrosive greaseproof wrapping

Noncurling gummed paper

Oatmeal paper

Obstetrical sheets

Odor-proof paper

Oiled board, papers

Oil-proof paper and boards

Orange-blank paper

Orange wrappers

Outdoor sign paper

Overlay paper

Oyster-pail board

Ozone paper

Pail board

Paper cloth

* Papier-mache' pulp

Papyrine

Paraffin and paraffined papers and boards

* Parchment, vegetable

Partition chipboard

* Pattern paper and board

Pear wraps

Phenolic sheets

Phosphorescent paper

* Photo album paper

Photographic mountand boards and papers

Photographic blotting

Pine tar paper

Plant drier

Plant-protector paper

Plaster-sack paper

Plaster board, base

Plastic coated papers

Plate wiping paper

Playing-card board

Pleating paper and tissue

* Polishing paper

Postage-stamp paper

Pottery paper

Pottery tissue

Pouncing paper

Powder paper

Preservative paper

* Protective paper

Pyroxylin-coated paper

Red rosin sheathing paper

Refrigator paper

Reinforced building paper

Reinforced paper

* Release paper

Resin board

Resin-impregnating paper

* Rocket paper

Rodent-resistant papers

Roofing felts

Roof-insulating board

Roofing paper

Rope armature paper

Rosin-sized sheathing paper

Rust-free paper

Rust-preventive paper

Sack paper
  flour
  cement
  charcoal
  sugar
  nail

* Safety paper

Sandwich paper

Sanitary napkin stock

Saturated felt

Saturating felts

Secondary corrugating material

Semi-crepe

Setup drinking-cup stock

Sheathing (building)

Sheathing--waterproof

Shirt board

Shoe board, covers, counter-stock

Silicated paper and board

Silk protection paper

* Silkworm-egg paper

Silo paper

Silver-coated paper and board

Silver nitrate paper

* Silver wrapping paper

Skips

Skaters paper

Slate paper

Soap wrapper

Socket paper

Soft plate paper (for engravings)

* Soundproofing materials

Spinning paper

Spool fiberboard

Stamp paper

Steak interleaving paper

Stencil boards and paper

Stereo paper and boards

Structural fiber insulation board

Suede paper

Suitcase board

Sulphurized board

Surgical dressing paper

Table-top paper

Tack Board

Tailors' papers

Tamale wrapper

Tar board

Tar binders board

* Tarnishproof paper and board

Tar paper

Tarred brown paper

Tarred felt

Tarred sheathing

Tarred slaters felt

Tea bag paper

Tea paper

Technical tissues

Tempered board

Templet board

* Test papers and boards (for laboratory use)

Textile board

Tile liner

Tile mounting paper

Touch paper (for fireworks)

* Towel tissue

Tracing paper

Transfer paper (such as decalcomania or pigment papers)

Translucent bond (masterpaper for direct printing processes)

Transparent paper

Tree-wrap paper

Tube board (for mailing tubes, etc.)

Twisting paper

Umbrella paper

Vapor proof paper and boards

Vegetable parchment

Velour papers

Vulcanizing paper

Wallboard, paper printers

Water proof papers

Water resistant papers

* Watermarked papers

Waterproof sheathing

Waxed paper

Waxed glassine

Waxing paper

Welding paper

* Wet-strength paper

* Window paper

Windshield wiping paper

* Wiping paper

* Yoshino

CHAPTER 11

# Converting Processes for Making Paper Products

The preceding pages in color -- Inserts 1 and 2 -- have listed a great number of special kinds of paper and paper products which may be made by a small-scale papermaking industry, or an industry based on such papermaking. The point was made that these items represent possible products which may be usefully made without competing directly with large-scale papermaking.

This Chapter describes briefly the processes and materials involved, although it is hardly possible to go into all of the possibilities, or to go deeply enough into any one of them to provide instructions on the actual process. From what follows, however, planners and entrepreneurs should learn enough about what is required to decided whether any of them appear likely to be fruitful enough to warrant investigating further.

In many instances, the descriptions below indicate generally the properties needed in the "body" sheet which is to be converted or used as the material for further manufacture. What these properties mean and how they may be produced in the paper sheet are discussed in Part II, and the descriptions below are limited to the additional (or in a few cases, different) processes which are involved.

Where a number appears at the end of a description, e. g. (IR 16267), this refers to a report on the subject which provides more details. These reports are listed in Appendix II, by alphabetical and chronological number, and with instructions for obtaining the materials.

Abrasive paper (sandpaper, emery paper) -- Using a backing paper which is strong and flexible (usually kraft or rope paper), abrasive papers are made by sprinkling abrasives onto a glue-coated sheet. Among abrasive materials are corundum, diamond, emery, garnet, pumice, quartz, flint, sandstone, diatomite, rouge (chiefly black magnetite or iron oxide) and such synthetics as silicon carbide, fused alumina, boron carbide, tungsten carbide, titanium carbide and metallic abrasives. Hide glue is used as the bond, except for waterproof papers, which requre resins.

It is necessary that the abrasive be sprinkled over the paper evenly, perhaps with a sieve as the paper moves evenly underneath. An ingenious machine can be made which first coats the paper with glue from a revolving

brush, which plays over the surface of melted glue in a steam gluing-pot below. Having accomplished this result, it softens the flue with a spray of steam, and sifts the sand upon the surface, all surplus sand dropping into a box below as the sanded or emery-surfaced paper passes over a roller. Other loose particles are blown off a fan, while the remaining ones are still more firmly fixed by a second jet of steam. Abrasive paper intended for use on a producing machine.

Acoustic diaphrams -- The papermaking stock is deposited on a concave form, in such a manner that it makes a tapering sheet with more thickness at the outer and wider edge than at the central portion (IR 9659).

Album papers -- The papers need strength for handling, folding and punching, and they must be able to take paste with the least possible wrinkling. They should have no impurities which might stain the photographs. Often they are colored black. A softness and bulk are helpful properties. Working toward these properties in combination, the papermaker develops his own process from his available fibers.

Anti-tarnish papers and tissue -- Used for wrapping silverware, aluminum goods, leaded glass, hardware, razor blades, needles and other tarnishable objects. Made of various papers, but must be relatively free from reducible sulphur compounds which yield sulphides, acids and alkalies (and thus tarnish). Copper salts or other inhibitors are sometimes used in treating paper used for wrapping silverware.

Asbestos paper -- Made by combining paper pulp and the mineral amianthus. Its fireproof and non-conducting qualities make it a staple commodity for many purposes, such as drop-curtains for theaters, insulation of electric wires, packing of steam-pipes, etc., as well as for general insulating purposes. Can be laminated. Can also be made waterproof by treating and thoroughly impregnating the finished article with a solution of aluminum palmitate in petroleum, tetrachlor carbonic gas or other volatile solvent.

Asphalt laminated paper -- Asphalt laminated paper has various end uses. Its primary purpose is to provide a water vapor barrier. Typical uses: as a ply in multiwall bags where content should be kept dry; as a body wrap on rolls or paper likely to absorb moisture from the air; as a sheathing paper on house floors and sidings, and as a water-resistant case liner. There are also some uncommon uses such as bulk popcorn carry bags and dried hop bags. Laminating is basically a coating operating with a second sheet being applied on top of the coating while the coating is still in a tacky semi-fluid state. The particular problems involved in laminating are control of amount of asphalt, maintenance of adhesion between the two plies, and control of asphalt spots.

Bags -- Paper bags can be fashioned entirely by hand by pasting two opposite edges of a piece of paper together to form a tube. The tube is then flattened, and about one inch of an end folded over. The folded flap is pasted down across one of the face surfaces. This is a flat-type bag. By somewhat more complicated folding and cutting out, it is possible to make also the square, self-opening and satchel bottom bags.

For a model, simply obtain the desired bag, take it apart carefully, and lay it out flat for a pattern for cutting and folding.

Beater-saturated papers -- Such papers can be made into gaskets, automobile oil-filter elements and embossed sheets. They are made by new processes with such materials as wool asbestos, certain ceramic fibers, rubber or resins available in water-dispersion form, ground cork, and phenolic resins when they can be made soluble in water. These materials are fully emulsified and put into the beater, where they are thoroughly integrated with the fibers in the pulp. (D-2917).

Barrels, pails -- Paper flour barrels, water-pails, and other like articles are made by cutting or stamping out their form from heavy paper possessing folding properties. They can be made waterproof or greaseproof or both (depending upon their use) by (a) treatment in the beater or (2) by coating with the proper chemicals later, as described below.

Blotters and blotting paper -- This is a highly absorbent paper, made with the minimum of beating and with usually no size, to keep the paper as waterleaf as possible; for cheaper blotters, an absorbent filler such as talc is added.

Boats -- Paper boats are made of especially prepared paper pulp, molded and pressed into shape.. They are then coated with a waterproof material.

Boxes, cartons, packages and containers -- These are made by cutting the paper sheet according to a pattern which will provide all the necessary sides and flaps when the paper is folded. (Usually, the folding lines are indicated, or even "scored" (that is, pressed down along the line, to make folding easier). Usually the sheets are delivered flat to the ultimate user, who does the folding and making of the packages as such. Special papers can be made to serve a variety of food and other packaging needs (D-4020).

Cloth substitutes -- Paper can be used as a substitute for cloth for many purposes. A heavy bamboo-fibered sheet makes a good lining for light coats. If a strong fiber is passed through a mangler to shred the fiber thoroughly, it will result in a paper with a feel something like chamois, which can be used even for dresses and which is practically impervious to air. Wiping cloths, towels, table cloths, drapes, aprons, hats, and many other cloth items can be made of paper. (See rugs, spinning paper.)

Cork paper -- This is made by coating one side of a thick, soft and flexible paper with a preparation of glue gelatine, and molasses, and covering it with finely ground cork lightly rolled in. This paper is used for packing bottles, glassware, etc.

Crepe paper -- This may be made by a calender which wrinkles instead of smooths.

Crinkle-lined paper -- Take tinted paper, put a white coating on it; after paper and pigment are dry, then crinkle it to make interesting patterns for decorative purposes.

Damask paper -- This linen-finish paper may be achieved by putting the sheet through a calender covered with a piece of coarse linen.

Decorative papers -- This is a general term for papers which either have patterns made in them or added later, and which are used for gift wraps, lampshade stock, fancy box packaging, screens, wallpaper and even mounting as a piece of art. They can be embellished in many ways by the kinds of materials put into the stock (e. g., mica specks) or added later ( e. g., "flock," a fine fuzz) by using an adhesive. Hand-painting or printing also may be used. Since such papers do not have to be uniform, and even gain from the handmade appearance, they are a natural product for small-scale industry.

Disposable diapers -- These must be made of clean, soft but strong and wet-strength paper, without irritating chemical impurities in the stock. They are then treated with some such substance as neoprene to make them safely waterproof.

Draining sheets or liners -- For cooking fish and processing other materials, it is necessary to hold the material in a way that will still allow it to drain. A wet-strength paper which has holes punched in it can be made by the usual process for wet-strength papers and by hand or machine hole-punching afterwards (D-1136).

Egg cartons -- The carton is made of pulp which is molded on a die or pattern. New pulp or reclaimed paper stock are used, sometimes in combination with resins or other binders, depending upon the particular shape required and the use of the product. (IR 9659).

Envelopes -- These are made in a variety of styles, sizes and colors, and can be made entirely by hand, as bags are made (see above). Special watermarked envelopes with matching watermarked paper (see below) make a luxury product.

Filter papers -- These are papers through which various liquid solutions are strained--in industry, in medicine, in research. For different purposes, different kinds of filters are involved, with different properties and standards. The key properties are great wet strength and maximum porousness; for many purposes, they must be absolutely pure of other chemicals. The usual finishing operations are not applied to filter papers; sometimes the paper stock is simply dried without sheet forming, and sold as "filter mass." They have no sizing. For a specific use, the customer can specify the degree of purity he requires (including distilled water).

A paper treated with neoprene rubber provides a satisfactory cheap substitute for the ordinary cloth filters used in processing many types

of chemical slurry. A heavy kraft paper is made with 5% neoprene latex as a binder in the stock solution. The latex imparts wet strength to the paper and is sufficiently resistant to water and chemicals to permit filtering of diluted acids and alkalis, most solvents and neutral salt solutions. (D-2260).

Fireproof papers -- These are papers treated with chemicals so they will not support combustion, i. e., will not carry a flame. They will burn, however. Such papers are used for lanterns, serpentines, artificial flowers, etc. They can be processed by air-spraying them with a fireproofing chemical, or by impregnation with a chemical such as an acetyl-cellulose soluble in acetone.

Floor mats -- Sheets of paper can be laminated by an adhesive, to make mats as much as 1/4 of an inch thick or more. Laminating a layer of tar in the middle of the mat will increase the warmth of the mat. A final step in the processing should be varnishing or other type of coating to protect against dirt, scuffing and moisture.

Food-industry papers -- Paper can be used in a variety of ways to protect food and to package it for marketing. The expense of such paper is more than made up by the damage and waste that are avoided, and by the "selling" that a good package can perform for itself. By selecting a particular food processor, it may be possible for a papermaker to develop a paper and package especially suited to the food products involved.

The chief requirements of a food package are: (1) Physical protection of contents. Protection against sifting, handling, contamination and insect infestation. (2) Protection against loss of quality. Resistance to gain or loss of moisture, loss of volatile flavors, and absorption of foreign odors. Resistance to grease penetration as in packaging of mayonnaise, butter, peanut butter, etc., and to penetration and staining of fruit juices. (3) Eye appeal--gloss, transparency, opacity, whiteness, and color design features. (4) Convenience--as to size and shape. (5) Shelf life consideration--fading of color, mechanical stability, ecc. (6) Processing and storage conditions--as, for example, in packaging foods for freezing and packaging of hot fruits.

In addition, paper can protect food in other ways: In the fresh fruit industry, oiled fruit wraps are used to control scale in packed apples. Paper is treated with a pure mineral oil substantially free from odor, taste, and color which absorbs the gaseous respiration products of the fruit. These gases, unless absorbed, would become concentrated and kill or scald the skin, making the affected areas susceptible to rapid decay when the fruit is brought out of cold storage. The oil is used at specific concentrations in the paper and the proper viscosity and specific gravity requirements have been carefully worked out. Later developments in this field are the applications of copper sulfate to paper to control

grey nest rot in pears, and the addition of diphenyl, which is a mycostat, to tissues for orange wrappers. These have greatly reduced the spoilage formerly common in packing these fruits.

Butchers can use blood-proof papers for wrapping. Bread and other foods that are handled a good deal before being eaten without further cooking should be protected by paper for sanitary reasons. Wrapping papers designed especially for customers may prove a profitable market, once the customers can be sold on the advantages to themselves in providing paper packaging of some sort.

Gasket paper -- Gaskets can be made of absorbent nine-point chipboard which has been impregnated with neoprene or some other such chemical. Bits of cork may be included in the stock before the paper is lifted. A gasket should be tough yet resilient, and fairly smooth and even, so that when it is put in place between two machine parts, it will provide a complete seal.

Glassine papers -- These are highly calendered, smooth, dense, transparent or semi-transparent papers, used for bags, envelopes, and printed wrappings. They can be made from chemical woodpulps, mechano-chemical bagasse and straw pulps, by full beating to achieve great hydration. A heated calender increases the properties.

Grass-bleached or silver tissue -- This is extensively used for wrapping silverware. See anti-tarnish papers, above.

Greaseproof papers -- These are usually made of pulps which have had a long beating to give them full hydration; a finished paper can be immersed in a bath of albumen and salt. (See also parchment.)

Gunpowder-paper -- Prepared by spreading an explosive substance on paper, with an adhesive as necessary. This is then dried and rolled up in the form of a cartridge.

Handmade papers -- While this entire Manual is dealing with handmade paper in a practical sense, a point should be made for fine writing and printing papers that have the special quality known as "handmade" and which are imported to the United States, for example, because of their particular charm, aesthetic qualities and permanence. These papers, which generally are shipped with the deckle edge not cut off, have an individuality and personality which are marketable and worth the effort if they can be achieved. In other words, all the papermaking effort should not go to making papers as much like machine-made papers as possible.

Impregnated papers -- These are papers dipped or soaked in solutions to make them transparent, waterproof, airtight, greaseproof, fireproof or odorproof. The result can also be achieve for some purposes by pouring on a molten material such as hot asphalt or war. Pressure may or may not be used. The particular chemicals used depends upon the end purpose of the product.

Indicator, test or reaction papers -- These are used to indicate the presence or absence of the specific chemical being tested for; usually the indication is by the way the paper changes color. Litmus paper is a

common example. These are usually unsized papers impregnated with the necessary chemical to turn color. Among the different chemicals which can be tested: hydric sulphide, chlorine, chlorine and ozone, arsenic, iron and copper salts, nitric and nitrous acid, iron salts, coal gas and sulphur dioxide.

Insulated bags -- See multiwall sacks and bags.

Insulating materials -- Paper can be used for four major types of insulating purposes (1) heat insulating, (2) structural insulating board, (3) electrical insulation, and (4) sound insulation. The properties required vary with the use; for instance an electrical cable insulation must have no extraneous materials which would make the paper a conductor, and high tensile strength and great tensile strength, because of the way it is bent after being wound tightly. Thus, a paper process must be devised to meet the specified requirements in each case. Beyond that, it is possible to impregnate with chemicals, or change the texture of the surface, as may be useful for the specific purpose. Sound insulation, which avoids smooth and hard surfaces, affords special opportunities for handmade papers.

Laminated papers -- These are simply sheets of paper (and of other materials used with paper) which are glued together. There are a variety of glues used, depending upon the sheets and the purposes of the final product. An introduction to the details of this process will be found in D-4120.

Metallic [stylus] papers -- Metallic paper is paper washed with a solution of whiting, lime, and zinc. Characters written on this paper with a pewter pencil are almost indelible. It may also be coated, for marking with a metal stylus of silver, aluminum, lead metal, brass copper, zinc, etc. The coating may be zinc-white or a mixture of clay, whiting, blanc fixe, lime and barytes, mixed with gelatine.

Metallic [foil] papers -- Paper can be coated with metallic substances such as bronze, aluminum or silver, to make a foil. The coating is a combination of the metal in flakes and casein or a lacquer.

Milk containers -- In the U. S., many distributors are handling a large volume of their business in paper milk containers. In addition to requirements for strength, stability, and leakproofness, paper for milk that must be sterile, and public health authorities are very insistent on this point. Control of bacteria depends mostly on a clean water supply and in keeping machine systems sterile and slime free. This involves a knowledge of organisms encountered and how to control them. To make the containers, see Boxes, above. Milk containers would be wax-coated and delivered flat.

Molded pulp -- This has been effectively used for many new functional and decorative packaging jobs in recent years. Traditionally used for protecting eggs and for bringing the baker's pies to market, it is now employed in packages for fluorescent light tubes and for standard electric

light bulbs. It is also used for the protective sleeves on liquor bottles. In more uncommon shapes, molded pulp, made by the blown method, is used widely for making decorative novelty containers for candy, lingerie, hosiery and many types of dry merchandise for which an individualized container provides striking counter display. Custom-made molds are often used for trademark identity.

New wood pulp or reclaimed paper stock, either of which may sometimes be combined with binders of plastic resins or other chemicals is used in the manufacture of these products. The pulp may be groundwood, sulfite or sulfate, used alone or in any desired combination, depending on the requirements for the particular shape to be produced.

Mother-of-pearl paper -- Glazed paper is first floated on a solution of silver, lead, or other metal, then, when dry, exposed to the vapors of sulphide of hydrogen, after which collodion is poured over the surface, producing rich and fascinating color effects.

Multiwall sacks and bags -- These are made of strong paper (usually kraft) laminated or impregnated with chemicals to serve the intended purpose. When several layers of paper are thus put together, they have great strength and can substitute for cloth, wood or metal in many uses. Even a two-layer bag with a tar lamination in the middle can serve as a heat-insulating bag for carrying hot or cold substances.

Papier-maché -- Used as the raw material for a variety of products, this can be a by-product of a pulp-making plant. It is an exceedingly strong, tough, durable substance, slightly elastic and not likely to warp or fracture. It is used to make ornamental boxes, trays, dolls' heads, toys, anatomical and botanical models, artists' lay-figures, picture frames, panels, mural ornaments, store window displays. For common uses, waste paper is repulped and mixed with a strong size of glue and paste, often with ground chalk, clay and lime added. In delicate work, dried pulp is ground into a powder and mixed with paste and potash until a very fine paste is formed, to be worked. Another method is to soak sheets of paper together in a strong size of paste and glue, after which the object is molded into the desired shape and dried in an oven.

Paraffin papers -- These are papers made waterproof by coating with liquid paraffin. (See waxed papers, below.)

Parchment paper -- More accurately vegetable parchment, it is so called because it somewhat resembles true animal parchment. It is made by putting a waterleaf sheet (of rag or other pure strong fibers) through a bath of sulphuric acid, and then washed thoroughly and dried. The sheet is odorless and tasteless, either greaseproof or grease-resistant depending upon fibers and treatment, and has a high wet strength. It can be used for food wrapping and as a printing specialty paper.

Pattern paper -- These are tough, foldable and durable sheets which can be cut up and used for tracing out patterns for clothing and other products. Since the surfaces of the sheets need not be uniform, so long as the sheet

itself is able to withstand moisture and other elements which might distort its shape, this is a good product for a small-scale industry.

Pottery tissues -- Used to mean both thin tissue paper to wrap pottery and the paper for printing transfers for pottery decoration. This latter paper is prepared by coating the base paper with a solution of gum arabic and starch in water. The base paper should be tough yet fairly soft and absorbent, should not expand too much when wet and should be fairly close and free of impurities and defects.

Rainbow surface tinting -- Wallpapers and many others are surface-tinted by being run through a color-vat. An iridescent or "rainbow" surface is given by treating the paper with a wash containing sulphates of iron and of indigo, and then exposing quickly to ammonical vapors.

Release papers -- These are sheets which are put next to tacky materials to keep them from sticking together or to other surfaces. A specific organic silicone has been found to present very unusual properties repellent to many tacky materials, and it is simply coated onto a sheet of paper with weight and other properties otherwise suitable for the intended use. Such papers may be used in the food industry for pan and cake liners and cookie bake papers; for candy, as drop papers (sheets may be reused repeatedly); for containers in the packaging of waxes, resins, rubbers, asphalt and adhesives; for rubber during production ot tacky sheets; for steel and other metals as a protection of highly-polished surfaces. (D-4024)

Resin-impregnated papers -- These papers are used for insulating and for building or manufacturing purposes, because they are hard, yet flexible and "workable" by a carpenter. Thin sheets of fairly strong yet absorbent paper are put through a bath in which the resins are dissolved in a solvent such as alcohol, and which contains chemicals to soften the resin and keep it from becoming brittle. After the sheets soak up the paper, they are pressed together, sometimes under heat.

Rugs -- Serviceable rugs can be woven of twisted paper, expecially papers treated with neoprene or similar chemicals. They may be washed with soap and can be hung to dry; they will retain their shape, and have excellent abrasion and wear resistance.

Safety-paper -- So treated or coated with chemicals that any ink-writing upon its surface cannot be erased, effaced, or removed without leaving indelible marks on the paper. As its name implies, it is used for safety in bank-checks or other commerical paper, to protect against alteration. Chemicals such as the metallic salts (iron, lead, zinc and manganese) can be added to the beater, or there can be a surface bath after the body paper is made. Many processes for insuring safety are kept secret. Sometimes little threads of silk and other material are included in the pulp to make duplication of the paper impossible. (Such papers are also called protective papers.)

Slate-paper -- This takes its name from the fact that it can be cleansed like a slate. It is prepared from paper of the required thickness and

consistency, by the use of benzine, followed by a preparation made of lead, zinc oxide, turpentine, seed-oil, copal, and sandarach. It may be then coated with a 10% solution of formalin to make it washable, and is then lightly calendered.

Soap papers -- These are used to wrap individual bars of soap. The paper must be clean, free from discoloration as a result of contact and dilute alkali, and resistance to the growth of molds; if colored papers, they must not bleed or change by contact with the alkali. Each paper is made according to the specifications of the user.

Solution-saturated papers -- These are made by passing dry, absorbent papers through a saturating bath. Such papers must be soft and porous to absorb the chemicals, and this tends to limit the properties of the finished material. (See beater-saturated papers.)

Soundproofing materials -- see insulating.

Spinning papers -- Strong papers which can be twined or twisted into threads or yarns (keeping their twist after wetting); the threads are then used to make coarse-wove bags for oranges, onions, etc., or for making fabric rugs. Sometimes called twisting papers.

Tar paper -- This is a coarse, thick paper coated or impregnated with a coal tar product, and used for covering roofs and lining walls, to secure warmth and dryness.

Tempered board -- A pressed wallboard (which see) is dipped into a drying oil and then baked in an oven for hardening of the oil film. Then it is put in a humidifying chamber to restore a controlled amount of moisture so that it will not warp in usage. (E-222).

Touch paper -- Used for fireworks, this is paper steeped in niter so as to burn slowly on being touched by a spark.

Toweling -- A creped absorbent paper with sufficient strength to be used without tearing or pulling apart, and with ability to absorb water. It should also be soft and free from lint and unpleasant odors. Thus "wetting agents" such as sulphonic acids and their derivatives, pine oil, and sulphates of the higher aliphatic alcohols are put in the stock. It is also useful, for some towels, to give them wet-strength (which see).

Transparent paper -- This is made by several different methods. The usual one employed is to apply a thin coating of a solution of Canada balsam in turpentine, or a solution of castor or linseed oil in absolute alcohol, the alcohol in the latter case being permitted to evaporate, thereby rendering the paper transparent. Such paper is largely used for tracing purposes, and may be restored to its original state of opacity, with the tracings left unchanged, by removing the oil with a fresh bath of alcohol. Glassines and parchments are transparent or at least translucent papers (see descriptions).

Twisting papers -- Used in wrapping candy, by twisting around it. Must be unsized to take paraffin coating, yet strong to withstand twist; calendering cuts down amount of paraffin needed. (See also spinning paper.)

Turmeric paper -- A yellow absorbent filter paper treated with extract of turmeric root, used in laboratories to detect presence of acid. (See indicator papers.)

Vegetable parchment -- see parchment.

Wallboard for construction use -- After a sheet of very thick paper is dried, it is put under a hardboard press. This is a very heavy piece of equipment (which could be a central facility) to deliver about 1,500 pounds per square inch of pressure on the board for about three minutes. The hot platen contains steam at 500 pounds per square inch as a heating medium. After the pressing, the boards are put in a humidifying chamber to restore a controlled amount of moisture, so it will not warp in use. It may then be made into a tempered board (see explanation). (E-222).

Wallpaper -- While this usually comes in rolls longer than can be handled by handmade-papermaking methods, it is possible to make decorative sheets which can be pieced together to cover walled surfaces. For this purpose, the base paper is given a ground coat of clay or of casein and clay, and then printed and perhaps embossed. The base stock must be able to take and hold ink, to resist bleeding of color, to stand wetting and scuffing, to return to its previous size and smoothness after pasting, and to stick to the paste.

Watermarked paper -- Any special paper, especially when handmade, can be without too much difficulty. (See Page 86 for description of the process.) This provides a custom paper for writing or negotiable or government use. Inasmuch as watermarks can be made either very simple in design or quite complex to the point of having a three-dimensional effect, art enters the process in whatever degree may be desired or warranted.

Waterproof papers -- These are made by coating paper or paperboard with such resins as phenolic, urea, melamine, nitro-cellulose, vinyl, and with such other materials as plastisols, organisols, waxes, rubber-waxes, asphalt, tar, gum and shellac. An older way is to soak the paper in shellac or borax. The Japanese use the juice of persimmon to waterproof such items as paper umbrellas. See greaseproof papers, which are also sometimes waterproof.

Waterproof liner -- A heavy protector against damage by rough surfaces or by water-seepage through cracks (in such usages as truckload shipping) can be made by using a water-creped kraft paper laminated with a layer of an asphalt which will not "bleed" in hot weather or become stiff or brittle at low temperatures. It can be reinforced with cords in a diamond pattern to eliminate cross tear. (D-3448).

Waxed papers -- Papers may be waxed in various ways. For food use, paraffin should be used--not ceresine (a mineral wax which has an odor) or a paraffin with an aniline dye. For other uses, it does not matter. Wax may be

applied by a cold process, being dissolved in alcohol, benzine or another solvent, and the paper immersed in a bath. Wax may be applied hot, through a bath of hot liquid which may also contain resins. The extra wax is taken off by a pair of hot squeezing rolls. A "wet waxing" process applies the wax while the paper is on chilled rolls, or by putting the waxed paper in cold water after application, so that the wax firms up on the surface instead of penetrating. Such waxed papers are also called "self-sealing" because a package with such paper will seal itself when heat is applied later.

Wet-strength papers -- Papers treated either during the making (in the stock preparation) or by coating afterward with synthetic resins such as urea-formaldehyde and melamine-formaldehyde. This makes the paper able to stand considerable usage even when soaked with water.

Window paper -- A tough paper treated with linseed oil to make it translucent, used instead of glass to let light into buildings.

PART THREE

# The Development Program

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CHAPTER 12

# Requirements for a Small-Scale Papermaking Industry

Part II of this Manual described the papermaking process in the range of applications to handmade paper as a cottage industry, including something of the range of paper products which are possible to manufacture This Chapter is designed to present the basic information--insofar as it can be done accurately and meaningfully--on what is required in the way of people, materials, supplies, services and financing to operate a small-scale or cottage industry producing handmade paper. At some points, the descriptions below summarize the material covered in detail in Part II, in the interest of clarity. However, it will often be helpful to refer back to the complete discussion.

Unfortunately, there are two very important reasons why it is meaningless (if not positively misleading and dangerous) to quote production figures, cost ratios and the other data that are needed to make a rational determination of the requirements involved. The two controlling reasons are these:

1. The variables in papermaking are too many and too great to bring together. One fiber is not clearly better than another; it is only better depending upon such conditions as the kind of paper desired, the costs of each fiber under the particular circumstances of where it is located and how it must be handled to reach the production point, the different processes that may be available and useful, the kinds of equipment and other problems involved in each of the processes, etc. As noted earlier, paper is considered to have the greatest number of independent variables of any manufacturing process. The kind of fiber, the climate, the kind of paper, the kinds of chemicals, the way they are put together, the time involved in putting them together, the size of the batch, the cleanliness of the material and the equipment, the skills of the people, the kinds of machinery, the different ways to do each operation, the thousands of variations in the product, and literally dozens or hundreds of other variables make it impossible to be too confident of any calculations based on generalities. Even the calculations based on definite facts which have been decided in a specific case are subject to great error, because small items omitted or mis-estimated may result in a very great difference in total result. Only an expert in such matters, working up the details of the particular operation, can hope to arrive at dependable data and conclusions.

2. There is no real experience in handmade paper that can be equated across national or regional lines. Even if figures can be developed into a pattern for a particular kind of papermaking in Japan, or in a particular state in India, the local conditions and the specific combination of variables of water, labor, fiber, customs, equipment, economic organization, etc., will be vastly different from the combination which will be necessary in another country. Any comparisons would be dangerous.

All that can be offered in the Chapter is the suggestion of enough of the requirements, within broad ranges of limits, to give a reader the general picture for making one highly-important decision: whether the needs for paper and/or cottage industry employment is great enough, and whether the chances of making papermaking as a cottage industry useful in his own country are great enough (from the general facts given) to warrant the trouble and expense of further investigation to get at the specific facts for the particular requirements of his country.

In simple terms, a reader of this Manual should be able to see in a very general way what the possibilities are for handmade paper in his country. If they look at all promising, he is then probably justified in spending the time and money to get expert help and go into the question more deeply and directly. If it is quite clear that such an industry would not be helpful or could not work out, then the subject should be dropped to save the trouble and expense. The most one can do--from just the reading of this Manual--is to decide that the matter ought to be investigated in more detail. An industry program should not be constructed on the basis of what is learned from this Manual, either in technology or in economics.

Because it may be of some assistance, readers are referred to the FAO Forestry and Forest Products Study No. 6, "Raw Materials for More Paper" (1953) for figures in some detail on large-scale pulping operations using different processes.

## RAW MATERIAL REQUIREMENTS

The principal raw materials are: (a) fibers; (b) chemicals for processing, sizing, filling, surfacing or coating and product converting, and (c) water. Each of these is discussed immediately below.

### Fibers

The fact has already been noted that there is a great variety of fibers useful for papermaking, and that these produce different products, (A comprehensive list of these fibers, the processes they require, and the different products they make starts on Page 30.)

It should also be noted that papermaking researchers are now finding ways of combining different fibers to make other and better papers, and the possibility that two seemingly inferior fibers may make a superior

paper should not be ruled out. Even more likely, a small amount of a special, expensive fiber may more than pay its way when it is added to a cheap, inferior fiber to improve the quality of the paper which it produces.

No fiber should be considered as available unless it can be brought to the processing point (1) dependably, when needed or before, (2) in sufficient quantities not only for present demand but for likely increased demand and (3) cheaply enough to let the resultant paper be sold at a price the market can or will pay.

The amount of fiber which goes into a certain amount of paper cannot be stated flatly to cover all cases. In some papers, it may be nearly 100% of the paper--in other words a ton of pulped fiber (plus the water needed for pulping) will make a ton of paper. But depending upon the amount of cellulose in the fiber, it may take even three tons of raw material to make the ton of pulped fiber. Some other papers require a good deal of chemical additions, such as sizes, and such fillers as clay to give the papers bo[illegible] and opacity. (There would naturally be a smaller percentage of fiber in such a paper.)

For any given fiber to be made into any given type and quality of paper, it should not be too difficult for an expert to determine with fair accuracy the amount of fiber actually required for a certain volume of production.

Considering that there will almost always be a waste factor as well, it may roughly be estimated that it will take a ton of pulped fiber for every ton of paper. And--for very rough calculations for the purpose of preliminary estimating only--it may be considered that for every ton of pulped fiber it will take two tons of raw fiber after all unusable materials have been cleaned away (that is, at the point of beginning the actual fiber-beating process.)

## CHEMICALS FOR PULPING

The amounts and costs here depend closely upon the specific process applied to the specific fiber for the intended paper, and upon the availability of local chemicals. Sometimes, local substitute chemicals are so much cheaper that their disadvantages are worth putting up with.

In some processes, chemicals are not an important part of the cost; and where chemicals do become costly, they sometimes make up for this by eliminating the need for heavy equipment or additional labor, or by making a valuable pulp out of what would otherwise be a useless waste or raw material. Sometimes, the availability of local chemicals can even sway the decision as to which process to use; a process which might normally be considered cheaper when chemicals are available at usual prices may become more expensive if the chemicals must be procured abroad and shipped long distances (especially if they are bulky or heavy and required in quantity). The availability of chemicals must be determined and costs established before the process can be determined, and only then can the costs be figured for chemicals actually to be used. It is

| TABLE 2 -- APPROXIMATE CONSUMPTION OF CHEMICALS TO MAKE BLEACHED PULP (shown as pounds per one ton of pulp) | | | | | | |
|---|---|---|---|---|---|---|
| CHEMICALS | Cold Caustic Soda | | Sulphate | | Sulphite | Caustic Soda Chlorine |
| | A* | B* | A* | B* | | |
| Sodium hydroxide | 200 | | 60 | | 20 | |
| Soda ash | | | | | | |
| Saltcake | | | 180 | | | |
| Salt | | 320 | | 260 | | 1,000 |
| Limestone | | | 100 | 100 | 330 | |
| Hydrated lime | 200 | 200 | | | 80 | 40 |
| Sulphur | | | | 60 | 260 | |
| Chlorine | 180 | | 120 | | 120 | |
| Sodium Silicate | 40 | 40 | | | | |
| TOTAL CHEMICALS | 620 | 560 | 460 | 420 | 810 | 1,040 |

*A and B refer to alternative methods of manufacture using different chemicals. Sulphate figures full recovery, including lime reburning

difficult, therefore, to suggest even a proportionate figure for chemical costs. However, as a rough guide based on large-scale production in the main pulp-producing countries, the TABLE above has been adapted from FAO materials.

## Chemicals for Sizing

What was said above about chemicals for pulping applies generally to sizing materials, except that it is seldom that the sizing agent will be an appreciable part of the cost.

## Chemicals for Filling

These depend very directly upon the qualities desired in the paper. They may be added in amounts that become an important part of the cost. However, when they do, they usually more than pay for themselves by the added price they help the paper bring. Contrariwise, some fillers amount to a cheap substitute for a portion of the fiber content, and can be considered a savings factor instead of a cost factor.

The availability of chemicals, it should be remembered, should be investigated as a principal requirement. This is particularly true of fillers, since their advantage may be offset if they are not locally available and require expensive transportation.

## Chemicals for Surfacing or Coating

What has been said above about chemicals applies in general here. It is not likely that coating chemicals will amount to an important part of the cost, in any papers made by cottage industry.

## Chemicals for Product Converting

Where special chemicals are required to make an ordinary paper waterproof or greaseproof or into an asphalt shingle, for instance, these will be special costs recoverable from the added value of the paper product. While such chemicals will of course have to be considered as a cost factor in determining whether to undertake the special product, these chemicals do not figure in ordinary paper processing. (See Chapter 11.)

## WATER

It is usually said that the pulp and paper industry not only needs more water than other industries, but needs it purer and softer. This circumstance may make some countries feel they cannot sustain any kind of a papermaking activity because of a short supply of water.

The truth of the general statement is subject to an explanation which may change the picture, in three regards:

1. The water need is primarily in the pulping operation. If the pulp is processed in an area which does have water, the papermaking operation can take place in areas which may not have very much.

2. The amounts of water presently used are based upon the fact that the operations generally take place where there is an unlimited supply of water, and where it becomes more expensive to save on water than to use it freely. In a materials-saving economy, such as the underdeveloped areas generally have, the water can be saved and used again, probably without seriously affecting the costs.

3. The great amount of water used is necessary to achieve the highest possible quality of pulp and paper. Where it might be acceptable to have a 25% reduction in quality of paper (a quality still acceptable for simple printing and writing, and ordinary uses, under less highly mechanized and fast-production conditions), it might be possible to reduce the use of water by that same 25% or more.

Minimum water needs -- While the usual figure is perhaps 40 to 50 gallons of water for each pound of paper produced, it is possible, even including the pulping operations, to make a useful grade of paper in a small-scale operation with a gallon of water to a pound of finished paper--particularly if care is used in hand-cleaning of raw materials and if no chemicals are used for pulping or bleaching (a good deal of water being needed to wash out residues of chemicals). The water used in the process would be captured and reused, until it eventually became slimy. A vat need be cleaned but once a week, unless there is a special bacterial slime problem. The greatest loss might be in the evaporation and other waste in the drying process. It has been estimated that there is a 2 or 3 pound loss of water for every pound of paper dried.

However, by centralizing pulping operations where water does exist, by careful use of water, and by timing operations perhaps to seasons which do have more rain or higher rivers than other seasons, it should be possible for almost any but a desert area to have water enough for papermaking. (The rainy season would normally coincide with the time the farmers could not be working the fields in any case.) And even in a desert area, where only a few pounds of paper are desired for a school, perhaps, it may still be possible to find the necessary water.

Kind of water needed -- Some authorities consider water as important a raw material as the fiber. Water should be soft if at all possible. (One way to test is to add some pure soap solution to the water; if it lathers easily, it is soft, but if it curds before giving lather, it is hard.) The water should be sweet, and it cannot be salt. It should also be free from debris, color, turbidity, organic matter (such as bacteria, algae and fungi), and excessive dissolved mineral matter, especially iron. A constant temperature, warm if possible, is desirable (water works fibers and chemicals well and rapidly at about 90°F.). However, these are all matters which can be dealt with; filters and screens can improve the original water supply surprisingly--and it may well be that a reasonably inexpensive water purification system installed for papermaking might make possible a better drinking supply; or vice versa, a better drinking supply might have the added advantage of making possible a better paper industry. Chemicals are available to control the bacterial growths which create slimes; these bacteria do not attack cellulose, so they are not too great a problem if the water is changed frequently and equipment can be cleaned regularly. The paper itself will not be substantially harmed in most cases. Iron present even in one part to 10,000,000 can create stains or spots, and must be carefully filtered out if present.

Power factor of water supply -- It is of course obvious that if the water supply comes to the location on high ground and drops to a lower level, this is a substantial advantage in making possible a power supply. This can be of three sorts: (1) mechanical power, by use of a waterwheel and a gear-and-shaft transmission system, (2) gravity flow of water itself through the equipment needing it, and (3) possibly the development of electric power. Because papermaking is in many ways a laborious business, any advantages of these kinds are substantial.

Waste waters -- The disposal of the used or waste water is important, particularly if the pulp or papermaking is on a large scale. A drainage system may be necessary to handle this water if the site for the operation is near inhabited places. Salvage of many of the materials in the water may be possible, often by filter systems again--and some of the wastes may actually be helpful in the cultivation of some agricultural crops such as plantain and papaya.

## PLANT REQUIREMENTS

The kind of plant and the equipment involved can be anything from a child's apparatus in school to large-scale mechanical devices. It is, therefore, again impossible to be very precise about requirements and costs, but the following may be helpful.

### Building

This depends upon the size and kind of operation--and upon the climate of the area. Fibers are beaten, and paper is made, much better in warm water, so that at the least some protection from cold is required. There should also be shelter to avoid rain and dust from doopping into the pulping solutions or the forming sheets. Storage of raw materials may or may not require shelter; chemicals almost certainly will. Drying activities may require a sheltered area, as noted below. The amount of space needed for all of these items will depend upon the size of operation, and the actual building requirement is therefore discussed in detail in connection with the specific factors below.

### Equipment

Equipment is available and to some extent needed for each of the various steps in the papermaking process, even in its simplest form. At its mechanized level, papermaking equipment is both bulky and delicate, but for cottage industry purposes, it will be rugged and requiring relatively little protection--except for a large-scale mechanical beating operation, if that is undertaken. Good machinery should always be well protected to keep it functioning smoothly for many more years.

Separation of fibers -- This can be done simply by retting, which may involve nothing more than digging a pit, into which the raw fiber is put with certain chemicals and allowed to steep. Or it can be done simply by hammering the fiber with a tool. It may be done also by mechanical equipment of a very simple type, moved either by musclepower (human or animal) or by simple mechanical devices such as a windmill or waterfall. This involves grinders and stampers--generally large stones made to rub against or pound down on the fiber to fray it and break it apart without too much cutting.

At these levels, which are described in detail in Chapter 5, this operation may be confined to a single cottage unit, each producer having his own pulp-making equipment. However, the mechanical grinders and stampers may be handled more efficiently as a central facility of some kind, whether privately owned or as a cooperative or government activity. In this case, they would be much larger, involving perhaps some covered area. This also would affect the size of the cottage unit by eliminating the need for heating equipment in each cottage.

If the pulping operation is to be truly mechanized, by the use of Hollanders or other equipment, again the equipment can be as large--or as small--as may be economically desirable.

At one extreme, there can be an operation using wood as the raw material on a large scale--not only for local cottage industry use but for an export market as well. This might also hold true for a pulping operation using esparto or bagasse or its raw material, and perhaps other fibers as their value is demonstrated. (These markets are likely to increase as more becomes known about the advantages of mixing various pulps to improve paper qualities.)

At the other extreme, it is possible to get a new 250-pound-per-day pulping machine from $5,000 to $8,000, plus freight and installation. (See Appendix IV for list of possible sources of information on pulping equipment.) Some used equipment is available, but may soon become scarce.

If the pulp were to be imported, a locally made repulper costing perhaps a few hundred dollars might do very well for a cottage industry program.

Each of these machines should be in a covered area, with some storage space for temporary holding of the pulp as produced.

Sheet-forming equipment -- For handmade paper, there are now two somewhat different processes and thus two types of equipment.

The traditional method involves a vat, which is a tub of some sort, in which the pulp is kept stirred at the proper consistency. The sheet is formed by dipping into it a mould, which is a screen or filter with a frame around the edge to contain a considerable amount of the slurry at the outset. Then the sheet must be "couched," or taken off the mould and laid in a stack or "post." The space required will depend upon the size of sheet to be made, since (1) the vat must be large enough to easily accommodate the mould, (2) there must be enough swinging room to do the couching, and (3) there should be room enough for the posting without danger of damage to the new sheets by such things as drops of water falling upon it from the vatman's hands. One papermaking unit may of course have many vats--20 being not an unusual number.

The second method involves a box (described in detail on Page 81) which is just the size of the desired size of mould to fit inside, with depth enough to hold a volume of slurry which will create suction upon release. This released slurry must be caught in a tub or vat of some sort. The couching and posting operations are the same as in the traditional method of forming sheets, and the total space required is approximately the same for either the vat or paper box method. Because the boxes can be simply and locally made, and because the process involves mostly filling the boxes with slurry and releasing it, consideration should be

given to having more than one box in a cottage unit. This way some boxes can be filling with slurry while others are being worked to make the sheet

In the case of either the vat or box process, it is also a question as to whether there should be more than one mould, or screen, for each vat or box. In some cases, as noted below, it may be better to leave the sheet on the screen for drying, rather than couching and pressing the sheet. The screens, however, need not be an expensive item. (See Page 84.)

Drying equipment -- There are various ways to dry the sheet, and they take quite different kinds of equipment and building space. The first step, however, is virtually the same in each. Water must be pressed out of the newly-formed sheets, and a press of some sort is contrived to achieve this. Depending upon the sort of press, this can involve either a small or large area (large if it requires a swinging handle to achieve leverage) Beyond that, the drying process may be simply hanging up the sheets separately to dry, preferably in a warm and walled place that will keep in a certain amount of the moisture to avoid too quick or uneven drying. However, some papers will dry well by laying on the grass in the open air, or by sticking against a wall facing the sun, or even (in some cases which by-pass the whole posting and pressing operations) standing up the original mould itself with the formed sheet of paper still upon it.

There are also techniques for drying the paper with heat, and these are more economical and effective in the long run. The Japanese now lay the sheet on a slightly warped sheet of metal which lies horizontally over a fire. Another technique is to build two brick or stone walls a few feet apart and parallel, so that a fire can be maintained between them. Then sheets may be pasted against the outer side of each wall and dried with the help of the heat coming through the wall. This latter is, of course, a sizable piece of equipment, depending upon the size and number of sheets dried at once, and is usually built without benefit of shelter. An inside version can be made of this wall. (See Page 91 for detailed discussion.)

Surfacing equipment -- Insofar as this is a separate operation (depending upon the kind and quality of paper being made) it may involve a piece of equipment called a calender, consisting of rollers under pressure, through which the sheet is pressed to smooth it down. These may be of local construction in most cases. Or it may involve a table for hand smoothing by rubbing the sheet with a special stone. Certain kinds of paper require dipping the dried sheet into a solution of chemicals; this again can be either a simple or elaborate operation; at its smallest, it involves a tub somewhat larger than the sheet being made.

Finishing and storage equipment -- Normally, sheets should be trimmed to a uniform size and packaged. This requires a suitable area, table or platform space, and trimming equipment--of which the simplest form is a very sharp knife. As for storage, this will depend upon mar-

keting circumstances. In some cases, even a few sheets may be taken away at once; in others, large amounts of paper may be stored against an infrequent collection. The space required will, of course, vary with the practice involved.

Research and testing equipment -- Slightly different growing conditions may affect fibers enough to change the quality of the paper, or at least to alter the process required to make the pulp and paper. Also, new fibers may come onto the market, at a price which warrants experimenting to find their usefulness. It would be helpful, therefore, for at least a central facility operation to have some testing equipment to judge the results of experiments. The types of equipment involved are discussed in Chapter 10. Their cost would vary from a few hundred dollars for a scale, caliper and perhaps one other key tester (depending upon the property of the paper which best identifies it) up to $5,000 or more for a versatile testing laboratory. A research laboratory could cost much, much more if it included equipment for making experimental paper.

## General Layout

The only considerations to take into account in how the plant should be set up and where the equipment should be placed are:

(1) those involving materials handling. Pulp and papermaking have a definite flow of operations, and if the intake of raw materials and the operations which follow one another are so arranged that the material needs no unusual handling to go from one point to the next, there will be a considerable savings of manpower costs. The possible exception to this comes from advantages which may be gained by a different arrangement to use mechanical power, as described below.

(2) precautions to insure that the pulp and paper are not damaged. As has been noted, drops of water from a vatman's hand can damage a sheet of paper they fall upon; the post (i. e., the pile) should either be a distance from the vatman, or screened from him. Also, as has been noted, dust can damage the quality of pulp if it falls into the solution, and can create trouble for the fresh paper as well; again, precautions must be taken.

## Facilities for Removal of Waste

Depending upon the process, there may well be a considerable amount of waste water carrying chemicals that should not go back into a common water supply for the community. Also, if the process involved is very complex, there may be problems in getting the water from one point to another in the plant. Pipes must be placed where they will not be damaged or tripped over, and where they will not prevent the moving of materials on wheeled equipment. The alternative of moving the water by hand, with the use of pails and buckets, is of course slow and costly in labor.

The exact solution to these problems must rest with an engineer familiar with the subject. Under some circumstances, the solution may be costly. However, in most cases involving special efforts to handle wastes, it is possible to recover the wasted fibers or chemicals as by-products, and the money savings here may offset the costs of handling the problem. Where there is not too much waste to recover, and where water pollution is not a problem to others downstream, the simplest solution is to simply provide a channel for the water to find its way back to the original water supply (but downstream). In some very small operations, particularly where water is being carefully controlled because of shortage conditions, there will not be enough waste water to worry about, and what little there is can be thrown into an area reserved for the purpose, to evaporate.

## ENERGY REQUIREMENTS

For the smallest and simplest operations, no energy outside man-power is required. In the sheet-making processes treated in this Manual, no power is required. However, in the pulping process, the use of some kind of power--from animal to electricity or water-power--is almost certainly an advantage, if not an economic necessity. The pulping operation is laborious, except insofar as chemical processes are involved. The amount of available power required for pulping depends upon the size of equipment, of course. A semi-mechanized beating system (stampers, for instance) can be powered by a domestic animal. However, for a central pulping facility, there probably would be more or less conventional machinery with conventional power requirements; obviously the figures will vary widely with the particular fiber being pulped, and perhaps with the volume and the operating conditions.

As noted above, for small-scale operations at least, there is a great savings in energy where it is possible to have the fresh water enter the mill at a high level and the waste water drained off at a low level, so that gravity may work through the system to eliminate the need for human handling of the water. Where there is no such natural advantage, it may be worthwhile considering a pump to put water into a high-level reservoir tank of some sort to accomplish the same purpose.

Various simple mechanical contrivances can be employed in various ways throughout production to minimize human labor. A manual on this subject, called "Power Transmissions for Cottage Industry," is available (see Appendix II).

## TRANSPORTATION FACILITIES

Transportation must, of course, be adequate to bring in the raw materials dependably on schedule and in the quantities required. A

failure in the transportation system at this point means that the workers depending upon this supply of materials are unable to work--at no fault of their own--and this not only reduces paper production but may cause extreme hardship on those workers and their families.

Transportation of the material which an individual unit will require or produce is almost always within the ordinary means of a person connected with that unit. If a cart of some sort is not available, the person can usually carry the material in his hands, on his back or on his head, as may be the customary method in the country--because a few pounds make an economic load of raw material or finished paper.

Except in some few special cases, there is no real problem of spoiling of raw materials or finished paper, so that this does not create any transportation problem in itself.

If a papermaking center is to be set up with many producing units, in a remote area, it is important to insure that there will be adequate and careful transportation facilities to take the finished paper to the market. Paper can be damaged by careless handling, and by being exposed to rain, as for instance on a railroad flat car or an open ox-cart.

## LABOR REQUIREMENTS

Paper can be made in almost any size of cottage unit--the larger the better, of course, for full efficiency and perhaps for quality as well. If a mechanical pulper is involved, it probably will be advantageous to have as many as 20 vats. However, there are units in Japan which consist of one vat, one bamboo screen (or mould), one wooden press and one steam dryer, using wood fuel, the whole operation being conducted by two women. One of the women brings the pulp from a cooperative common-facility center by hand cart.

It is difficult to make a flat statement about the smallest efficient unit possible--but it is true that work is speeded if one person does the stock mixing and sheet-making and another person does the couching and other operations. It is also well to have a third man to do the mixing and the other odd jobs. The capital required to do the mixing mechanically is probably a good investment in labor savings, at whatever wage scale is involved.

Because of the great differences in the various steps involved, it is possible to have specialists even in a relatively small operation--the pulp-maker, the vatman, the coucher, the dryer, the calenderer, etc. It is also a worthwhile practice to keep a skilled, higher-paid worker full time in the special operation, rather than have him spend much of his time doing other work that could be done by an untrained, lower-paid worker.

Either men or women can do the various operations; in Japan it is about half and half. In certain types of sheet-making, however, the weight of the mould or screen when it is dipped and lifted with the stock still in it, is quite heavy and is hard work for a strong man.

The amount of paper that can be produced by hand varies considerably, depending upon a number of factors--especially including the skill of the vatman or the handling of the paper box, the quality of paper being produced, the kind of slurry or stock, the size of the sheet, the arrangement of the vat and couching equipment, and the kind of mould. Also, when workers are cooperating together in a team and each specializing in part of the process more can be produced than the total that would result from the work of all of them separately.

However, with the warning that these production figures may be misleading outside of the local situation they reflect in India, there is presented herewith the data offered by the late Shri K. B. Joshi in the latest (fourth edition) of his official guide, "Paper Making," to paper makers who might be contracting with workers:

"Trampling and rubbing waste paper to pulp. An average man can prepare from 15 to 20 pounds of pulp by this process, [per 8-hour day, understood for all these figures] washing being separate.

"Paper lifting. An average vatman with fair speed can produce 400-480 well felted sheets of double fools-cap size [17" x 27"] or 600-700 sheets of blotting paper [per day], with the assistance of a coucher.

"Pressings and drying the sheets. Two adults are required to press and dry the sheets made by one vatman. [In most papermaking units, this would generally be reversed--two vatmen needed for one man to press and dry.]

"Polishing. A man with good practice will glaze 120-150 sheets per day by the old process. In case of calender two men can glaze 3 reams of paper quite easily in a day.

"Cleaning. One man can clean 400-480 sheets of paper per day.

"Paper Cutting. One man can cut 3 to 4 reams of paper per day with a sharp steel knife. With a cutting machine the number will be double or treble.

"Labour required. On an average about 10 men [10-man-days?] are required for the production of one ream of paper."

The number of sheets produced a day by one vatman--from 400 to 480--seems to correspond roughly with production in Japan and China.

The production that is possible with the paper box under ordinary working conditions has not yet been determined, since it has never been put into a cottage-industry operation. It seems likely that it will provide more useful paper than can be produced by any but the highly-skilled vatman under the traditional methods. A team of two workers should be able to produce perhaps a hundred sheets an hour. One person would control the valves to fill the boxes, the other would pour in the slurry and release it. The process would go even faster if the slurry could be fed in by a gravity flow. The coucher would remove the screens from the box and restore empty ones, although perhaps he would need an assistant for this.

It is most important to note that in the vat operation, considerable skill is required, whereas the very little technique which is involved in the box method can be learned quickly. Not only must vatmen be paid considerably higher wages than other workers, they do not exist in most parts of the world, and their training takes as much as five to 10 years on the job to turn out really uniform and high-quality sheets. The box method may require more workers for efficient production, but they can be developed out of an available labor supply, their wages can be at the prevailing rate for ordinary work, and they will produce uniform work of a regulated quality.

Most workers in a cottage unit would receive the pay of semi-skilled workers standard to the area.

It should be noted that in its simplest form of technology, pulp and papermaking is material-saving in its orientation--taking advantage of surplus labor to make a valuable product. As the value of workers increases (with the improvement of the economy) and the money value of paper decreases (in a high-technology economy, paper is cheap), this particular industry is in a position to take increasing advantage of labor-saving equipment--especially in the pulping and stock preparation operations.

## SAFETY AND HEALTH REQUIREMENTS

The safety factors to be taken into account in a handmade-paper cottage industry are generally these:

1. The chemicals used are sometimes harmful to eyes and skin if they splash about or are mishandled; however, under ordinary usage, they may be handled without any harm to those using them. Once they are in the pulp or paper, they are not harmful.

2. If a mechanized pulping operation is included, there are of course the usual dangers involved in handling electricity and getting hands or clothing caught in moving parts. Again, with ordinary precautions, there is no reason why the operation cannot be conducted in complete safety.

3. Some more advanced pulping processes involve steam and pressure, with danger of explosion or scalding. There are adequate precautions which can be taken to eliminate these dangers, if and when such processes are used.

4. Fire is used to heat water and to dry the sheets, in some processes. Here again, ordinary precautions can make the use of fire quite safe.

The health factors in papermaking are generally these:

1. If the raw material is waste rags or waste paper, there is the possibility of disease being transmitted through the waste. In addition, an excess of dust and lint in the handling of these wastes may be unhealthful. In general, this can be controlled by adequate ventilation and (in extreme cases) the wearing of masks and gloves.

2. Ventilation is also needed in some areas of operation where considerable evaporation of water is involved, and of course where certain chemicals may be used.

3. If the process which is used involves a worker putting his hands in and out of water hundreds of times a day--as in the vat-moulding of sheets of paper--there may be harmful effects, especially if the water is warm and the surrounding air is cold. Keeping the area warm will minimize this problem.

4. Care should be taken to prevent the drinking of water once it has entered the papermaking process, since it probably will have dirt or chemicals in it.

5. Waste waters should not be allowed to contaminate the regular drinking supply of a community.

## MARKETING FACILITIES REQUIREMENTS

These will depend upon local conditions and upon the volume of production (and thus the amount to be marketed). Requirements may range from none--for the individual cottage unit which brings his finished product to a cooperative center and is paid on the spot for his sheets--to a quite complex operation for the cooperative itself, especially if it is dealing in large volume and in different kinds of paper.

It probably will prove necessary for the marketing agency (e.g., the cooperative) to have a place where sheets may be inspected and sorted into different grades and types of paper, and accumulated until sufficient quantities are on hand to meet specific orders. Also, it probably will be necessary to package and label the sheets--perhaps in standard ream lots--for distribution purposes, and an area must be provided for such purposes. Tables and storage bins or shelves will prove useful. Scales

and other measuring equipment will be needed, and in the case of really important operations, there perhaps should be testing equipment to insure quality control. (This may be in conjunction with the research equipment noted above.)

### BUSINESS MANAGEMENT

Facilities should be provided for conducting the ordinary business of the industry. At one extreme, this would be virtually unnecessary--as in a single unit of one family, where the business amounts to buying pulp and selling finished sheets from a cooperative or entrepreneur right in the community. However, at the other extreme of a mechanized pulp-making operation or a cooperative production and marketing organization, there would have to be (1) correspondence and records concerning the purchase and delivery of raw materials, (2) records of dealings with the cottage units in their purchases of the pulp, and (3) full control of all financial activities. In addition, there would have to be office space of some sort for the person or staff involved in actually operating the central facility or organization.

### OTHER SERVICES AND SUPPLIES

Beyond the specific requirements described above, there are no particular needs which a small-scale papermaking industry would have--except, of course, the ordinary facilities and materials which people may need wherever and whatever they are doing. Here are such things as toilet facilities, drinking water, facilities for obtaining or preparing food and eating it, regular communication facilities such as mail and telephone (especially in the case of cooperatives or central facilities), and some type of recreation facilities--because papermaking can be a laborious and monotonous type of work.

# A CASE STUDY IN CHINA

Through the courtesy of Dr. J. E. Stepanek, Consultant to the United Nations Bureau of Economic Affairs, the following case study is offered as at least suggestive of the requirements and results of a small-scale papermaking activity, and should be read in connection with both this Chapter and the next. It is a report on a mill in Sinhua, in the mountains of Western Hunan, China, and assistance to it in 1948 by a UNRRA-financed agency, the Agricultural Industry Service.

Paper had long been made there of bamboo, by the traditional hand methods. As Dr. Stepanek reports (the rest of this Chapter being in his words):

By this [traditional] process, master craftsmen have been able to turn out an excellent paper for brush writing. However, it is expensive, is not physically strong, nor uniform in quality. A better quality paper is required for printing presses, for wrapping paper, and for other commercial uses.

Previous experience in China, at the Sinhua mill and elsewhere, had demonstrated the possibility of producing a greatly improved paper even in small plants. The requirements appeared to be better beating and quality control of the sizing materials, the filler, dyes, and bleach. The reconstruction of the Sinhua mill made possible a further technical development of the small scale paper industry.

The shortage of paper and the resulting very high, if not prohibitive price, for imported paper made such an investment fully justified. There appeared little likelihood at the time that capital would be available for the establishment of large modern mills within the near future.

While the equipment at Sinhua was under repair a testing project was carred out at the AIS laboratory to determine the technology and the economics of the various paper products that could be manufactured with the simple equipment available. Fifteen types of paper were produced experimentally including natural color, bleached and dyed papers for elementary school text books, for writing, posters, wrapping, match box covers, etc. Sample booklets were made up and used to test the market in nearby urban centers. It was found that at Hankow a ready market existed for writing and wrapping paper and that boat transport could be utilized. A number of the chemicals required including potash, resin, China clay, and rice starch were produced in Hunan. Others such as ferrous sulfate and sodium carbonate had to be imported and were expensive. Bleaching agents were not available at an economical price. Simple operating and control procedures were devised and workmen trained in their use.

Simultaneously with the laboratory and training work an improved beater was being built and the other equipment repaired. A new highway made possible easy transport of the equipment to the plant. Within the scheduled period the plant was ready for operation. The installation included:

Buildings. Open shed construction totalling 20,000 square feet on a 50,000 square feet plot of land. Plant was located on both river and truck road.

Water Supply. River water secured with 5" x 5" steam driven pump and stored in 2500 gallon stone reservoir plus 1000 gllon elevated steel tank.

Bamboo Washing. Eight pits each 11" x 11" x 2" of brick construction lined with concrete.

Digestion Vessels. Five wooden vessels with steel bottoms direct fired each five feet diameter by eight high.

Power Source. One eighteen horse power steam boiler operating at 100 pounds pressure driving one 10 1/4" x 9 1/2" steam engine belt connected to two Hollander beaters plus one 5" x 6" steam driving a 3.2 KW lighting generator.

Hollander Beaters. Two beaters with 30" deameter rolls 25" face rotating at 200 rpm set in tub of wooden construction. Each beater had a capacity of 70 pounds pulp dry weight, required approximately 5 horse power, and was mounted over two drain pits used for finished pulp storage.

Paper Making Vats. Twenty wooden vats averaging 90" x 48" by 30" depth. If used on one shift only each vat can produce 40 pounds paper per day. (Average output of entire plant taken as 500 pounds per day.)

Moulds. Each vat was provided with a mould, 40" x 50", and a screen, locally fabricated from fine bamboo strips held together with silk thread, on which the paper was formed.

Presses. Each vat was supplied with a locally manufactured lever press capable of extracting the water from a stack of 500 sheets.

Drying. The pressed sheets were dried by pasting on a plaster wall heated on the reverse side with flue gases. After removal and bailing into reams of 500 sheets, the paper was ready for the market.

## THE RESULTS

In late 1948 with no more than to-be-expected difficulties the plant went into operation. An economic analysis showed that under the conditions then prevailing the plant would show an excellent profit. An attempt has been made to translate the rapidly fluctuating currency of the time into [1958] U.S. dollars to show operating expenses and income for a typical month. While the costs prevailing in this very remote area are far too low to have an significance in any other country, they are believed to indicate the relative costs of the various factors for this one locality.

## OPERATING EXPENSES PER MONTH

I. Personnel: 1 works manager, 2 technicians, 3 office staff, 2 machinists plus 4 helpers, 20 skilled paper makers, 2 semi-skilled, and 14 unskilled workers; 48 individuals .....$ 390.00

II. Raw Materials and Supplies:

Green bamboo delivered to plant, 16 ton required for 12,000 pound finished paper.....$320.00
Potash, 2 ton..... 162.00
Alum, 740 pounds..... 15.00

| | |
|---|---|
| Resin, 660 pounds | $ 10.00 |
| Ferrous sulfate, 410 pounds | 4.00 |
| Sodium carbonate, 60 pounds | 4.00 |
| China clay, 400 pounds | 2.00 |
| Rice starch, 200 pounds | 3.00 |
| Coal, 30 ton | 150.00 |
| Miscellaneous | 60.00 |
| Total | 410.00 |

| | |
|---|---|
| III. Sales Promotion and Shipping Expense | 80.00 |
| IV. Maintenance and Repairs | 30.00 |

V. Fixed Charges:

| | |
|---|---|
| Land, buildings, and equipment value including rehabilitation costs | 4,000.00 |
| Operating capital | 3,000.00 |
| Interest on capital at local rate of 40% per year | 250.00 |
| Depreciation rate on fixed capital, 10% average | 30.00 |
| Total expenses per month | 1510.00 |

Income:

| | |
|---|---|
| 200 reams of 24" x 36" writing paper at $5.70 per ream of 500 sheets (40 pounds) | 1,140.00 |
| 100 reams of 24" x 36" wrapping paper at $5.70 per ream of 500 sheets (40 pounds) | 570.00 |
| Total income | 1,710.00 |
| Net profit per month | 200.00 |

The above assumes one shift operation, 24 days per month, 500 pounds per day paper.

## VALUE OF MECHANIZATION

The use of a power driven beater in this case could hardly be called the mechanization of a hand process since as is often the case the product was of such superior quality that it could reach entirely new markets. The combination of product design and process development along with mechanization had created a product new to the area. Even so it is interesting to compare the costs of the two techniques in an economy, at that time, charging 40% per year for capital but paid skilled workmen only $10 per month for a 48-hour week. The mechanized process would cost an estimated $124.00 per month for an estimated capital investment (two beaters plus power plant) of $2,500 amortized at a rate of 10% and carrying an interest charge of 40%. Two silled operators are included.

Twenty unskilled workmen would be required to beat out an equivalent weight of an inferior pulp. In the village possibly surplus labour would be used at a less than subsistence wage but hired labour would require $6

per month or $120 total. Obviously the value of mechanization lies in the possibility of two shift operation at little added cost as well as in quality improvement.

## TECHNICAL ASSISTANCE COSTS

A careful record was kept of all costs incurred by the AIS for this project. The direct machine shop expenses charged to the mill came to $220 equivalent including the fabrication of two beater rolls.

The services given by the AIS technical staff amounted to approximately two months' time of a senior engineer, six man months of junior engineer time, plus four man months' service of a laboratory technician. The total cost was $750 plus an additional $200 for subsistence and travel costs while at Sinhua. In addition three junior staff were kept at the mill for a period of three months to assist the engineer and to receive practical experience in paper mill operation. This cost an additional $150 including subsistence. The above expenses were incurred over an initial period of three and one half months plus an additional period of three months. The total cost comes to only five per cent of the gross value of a single years' product--again assuming shingle shift operation, or approximately 15% of the total investment. This latter figure compares favourably with development costs in a developed economy.

## FURTHER DEVELOPMENT

The first attempt at assisting the paper industry having proved successful thought was given to extending the work geographically to other areas and also to the further technical improvements at Sinhua. The next mechanization step was found to be the substitution of a steam heated calender roll for the heated plaster wall. The rolls would not only compress the paper but would apply a finish to both sides. One pair of rolls could replace the ten unskilled workmen required to apply and remove the paper from the old dryer.

The next step considered was that of using pressure rather than open vessel digestion. With the latter only young and more expensive bamboo can be utilized. The temperature is not sufficient to dissolve the gums binding the older fibers. An all-metal enclosed digester would make possible a temperature that would digest not only old bamboo but cellulose waste materials from the jute, ramie, and hemp industries.

Considerable attention was given to the economics of a machine-made paper on a very small scale--virtually the last step in the mechanization of a small plant. It was found that a half ton per eight hour day Yankee type two cylinder machine would be profitable under conditions prevailing at Sinhua. Such a machine could be manufactured at Shanghai at a cost approximating $20,000, including a 70 horse power motor. High capital charges in this case would force three shift operation.

Later such a machine was installed and operated near Chungking to provide paper for mass education publications.

## CONCLUSION

The Sinhua plant reconstruction showed that capital was available (at 40%!) for small industry development in spite of the political instability. (The Hunan government changed less than one year after the plant started to operate.) Even at this high rate of interest and with skilled workmen available at subsistence wages it was still profitable to make the first steps towards mechanization. However the value of mechanization alone was obscured by the paralleling product development work that resulted in a product new to the market. Further mechanization decreasing labour requirements and adding a little to the quality also appeared profitable. In all such analysis it was realized that comparison was being made between the Sinhua product and the cottage industry fully hand made paper. There was no competition with the large industry project, and it was thus not necessary to make a cost comparison. When an attempt was made some years later to introduce the same paper making process into an economy having access to machine made paper it was found to be most unsuccessful.

CHAPTER 13

# Factors Affecting a Decision to Undertake the Industry

Reading of Part II on the production processes and Chapter 12 on the technical requirements should help in understanding that must be taken into account in determining whether to go ahead with a small-scale papermaking industry, and on what level. The present Chapter will go into details of the various points to consider in deciding on the feasibility of such a program.

Unfortunately, no figures can be offered as to costs or revenue which would not be highly misleading outside of the particular area involved, or without full knowledge of all the factors involved. For example, transporting raw material 100 miles may cost little or much, depending upon condition of roads, season of year, type of vehicle, terrain, and luck. Labor costs may vary with efficiency, skill, interest and health--to say nothing of the help or handicap which a particular piece of equipment or type may be, or the particular ease or difficulty being caused by the fiber at the time, due to climate or other factors.

In a Manual such as this, however, it is possible to make these points:

1. Some countries, notably Japan and including India, find that handmade paper as a cottage industry can sustain itself and make a contribution, even where there are mechanized paper mills in operation. This would seem to warrant full investigation by other countries which have either (a) a serious need for paper and paper products, or else (b) an under-employment problem, especially in off-season work and especially if this is coupled with the availability of wastes and residues which can be made into paper.

2. The evidence suggests that pulp and papermaking as a small-scale industry has certain characteristics useful in the early technological development of a country: it is material-saving in orientation but can become labor-saving; it can start with the simplest of processes and equipment, and move to increasingly complex ones to improve production; it is flexible in its set-up, to take into account local conditions as they are and as they change; it can absorb additional capacity and develop higher-quality products as the market grows.

3. As to the specific economics of the situation in a given country, this must of course be determined locally. There are several specific cost and income factors which can be identified, and which can be explored locally by an Industrial Institute or other agency (see Page 198), working with a pilot operation, to get reasonable estimates of actual economic factors in the circumstances. These economic factors are listed and described below, and a suggested blank table is included to indicate how an agency might go about determining the answer for its own area.

4. It is possible to operate a papermaking industry at various levels of complexity, quality, quantity, variety, etc., from rudimentary cottage units through a semi-mechanized operation. What may be economic at one level may not be at all economic at another level, and it may well be that the simplest level is the best. Each of the different factors must be studied in relation to one another, to find the best combination And one of the important factors is how such an industry would tie in with other industries, again at different levels.

5. Specifically, the kinds and quantities of products which may be produced by small-scale or cottage industry in converting paper to other items (see list on colored paper in center of this Manual) may warrant considering the entire proposition from the standpoint of paper itself being produced as the "raw material" for the paper product industry.

6. No industry plan should be put into effect until a pilot operation is actually run off, to insure at least a reasonable hope of economic success (or else a guarantee of a subsidy, if the paper shortage is that critical).

## THE GENERAL PROBLEMS OF A SMALL-SCALE INDUSTRY

In most ways, papermaking as a small-scale industry is very much like any other small-scale industry. There are problems which are common to all of them--and although these problems are perhaps most serious in those ancient handicrafts which have continued relatively unchanged for a long period of time, it is at least important to be sure that a new or expanded industry would not soon develop the same troubles.

These are perhaps the chief problems:

1. Unwillingness to change to new methods and new designs or products.

2. Lack of modern, or at least efficient, tools and equipment.

3. Shortage of trained and skilled workers (as distinct from merely willing workers).

4. Inadequate training facilities to improve this situation.

5. Resistance to moving toward mass production techniques in even a part of the operation.

6. Inability (or even absence of desire) to standardize production or products, or even to achieve standards of quality.

7. Lack of efficient management.

8. Absence of coordination of effort within the producing area and perhaps unwillingness to work together.

9. Oppressive marketing practices (e. g., lecherous middlemen) and inability to achieve working agreements on beneficial marketing practices.

10. Absence of coordination or guidance from the central Government (or other planning body) to link the industry with other programs.

11. Lack of entrepreneural capital.

Unless there is some awareness of the importance of correcting (or in the case of a new industry, avoiding) such difficulties, there probably is no advantage in starting or expanding a papermaking program. If such a program is urgently desirable but these conditions are not right, then the first step in any effort would be to educate the people to the point of view necessary to achieve a successful small-scale or cottage industry. (This point is discussed in the next Chapter.)

## THE SPECIFIC PROBLEMS OF A PAPERMAKING SMALL-SCALE INDUSTRY

The specific problems of a papermaking industry are discussed under the various sections which follow in this Chapter. It is to be noted that the technical questions (of whether there is a usable fiber, for instance) and the economic questions (of whether such an industry can make a living for those in it, for instance) are not the only subjects to consider. And it is important to realize that ALL of the different factors involved must be taken into account and answered SATISFACTORILY before a decision should be made to go ahead with the industry. If, as an example, everything is possible and workable, except that the country has a water shortage and the available water might better be used for crops than papermaking, then ALL factors are not answered satisfactorily, and the industry should not be undertaken.

### Technological Factors

It has been said that almost any fibrous plant that grows can make some kind of paper. Therefore it will not often be a question for a country as to whether there is some kind of fiber r source available. How-

ever, as has been made clear, different fibers take different kinds of processing, and make different kinds of paper by different processes. The problem, therefore, is to decide what kinds of papers can be made in view of the available resources and processes involved, and then determine whether these particular papers would be useful or economical.

Reference to the LIST OF FIBERS, PROCESSES AND PRODUCTS (see Page 30) will give some idea of what a country's alternatives are, once it is known which fibers are grown or can be grown in the area.

Then, these questions must be answered in detail:

1. Which fibers do we have available:
   --in a sufficient supply (quantity at any one time)?
   --in dependable and continuous supply (over a period of years)?
   --accessible to collect and transport to the manufacturing point?

2. Which of these fibers are processable under our conditions:
   --do we have enough water?
   --can we achieve proper disposal of wastes?
   --do we have the technological skill, labor supply, materials and supporting services required for the process involved?

## Economic Factors

Even though it is technologically possible to support a papermaking industry, it may not be possible to do it at a cost (ALL costs included) which will make it self-supporting--even eventually if not from the start. Unless the paper products can be of a good enough quality to be bought, and unless they will be bought at a price that will meet all expenses, it is probably not wise to start a papermaking industry. A subsidy for a time may be necessary and sensible (this would include training and central research), but if the industry can never by expected to reach an economic point, then it will probably end up a block to progress by requiring the kind of protection that will prevent a healthy alternative solution to the problem of obtaining the paper needed for the country's growth. These economic factors divide into matters of COST and matters of MARKETS.

## Cost Factors to be Considered

In general, the cost factors are the same discussed in Chapter 12 on requirements. Each of the required elements shown there must be figured in detail for the process under consideration. However, beyond that, there are other specific factors to take into account, such as these:

Fibers and other raw materials -- Because fibers may be located in different places, some of which are closer and easier to reach and thus cost less to bring to the point of production, and because different processing methods involve different kinds of equipment and different amounts of labor, it is obvious that there is a difference in expense involved in

Best Available

should be a papermaking industry and where it should be located. Again, this should be done for each fiber and type of paper under consideration, because they do vary.

The factors which should be taken into account include:

1. Cost of delivery to the location of raw materials required, including fiber, chemicals.

2. Cost of locating the plant and people at the particular place (if, for instance, it was considered whether it might be well to move families from an overcrowded area to a less populated place where other advantages make a papermaking industry feasible).

3. Cost of building in one location versus costs in other places

4. Cost of water, waste disposal and power as needed (some locations may have the advantage of falling water, which would make much cheaper the handling of water throughout the process by gravity).

5. Cost of selling from the particular place.

6. Cost of delivering finished products to market from the location.

7. Availability of supplies and services (in terms of maintenance office management, communications, replacement equipment, transportation facilities, marketing services).

8. Availability of workers--enough people, enough skilled people enough dependable people, able to work at a pay scale that will make the product competitive.

## Marketing Factors to be Considered

The market for locally-produced handmade papers is something that can only be determined locally and at the time the question is being considered. This Manual, however, can perhaps be helpful in two ways:

1. It can make certain observations which may provide food for thought locally, and which can be tested out for their truth in the local situation.

2. It can suggest the various elements which should be taken into account in making a market analysis.

General considerations -- These are observations about the paper market which may be pertinent and helpful:

1. Experience shows that the rate of paper consumption is proportionate to the rate of industrial activity. The more industrial production, the more paper is used in the area, not only for industrial purposes but for advertising, for publications, for wrapping, for packaging, and for other printing and writing. Specifically, communication involving the written and printed word increases as industrialization increases; an underdeveloped area which is industrializing can expect that its need for printing and writing paper will be continually increasing as it progresses toward its goals. The social and economic level of a country can be measured quite accurately by its consumption of paper per capita, and the level of consumption would seem to be a cause as well as a result of the existing level.

2. In countries where paper is especially short and/or the price is very high, the present consumption of paper is no index of what the market might be with a more plentiful supply and reasonable price. There are so many uses for paper, that the market seems to grow with its availability. Furthermore, this market can grow in perhaps special ways--as for instance the way paper has become a vital necessity of daily life in Japan, for paper sliding doors, partitions, umbrellas, fans and other products.

3. There is always the possibility that the government should consider some sort of subsidy, if paper is made which directly serves other important purposes for the people. For instance, good paper packaging for foods might be important enough to sanitation to justify assistance. There is at least one instance in which packaging of small amounts of fertilizer made it convenient for small farmers to take some home on each trip to the marketplace, and this created a major improvement in crops. Such advantages are worth considering as part of the market picture.

4. A market is more than an expressed interest or need. Tremendous markets have been opened up for many products by imaginative and hard selling --to create needs and demands which were hardly considered possible at the outset. The paper industry might very well be able to find ways to <u>build</u> its market, even (or perhaps especially if) it is starting from scratch. But with paper, there almost certainly <u>is</u> a market, waiting only for costs to come down.

5. In average or inferior grades of paper, a handmade-paper industry cannot hope to compete with a mechanized facility. If such competition exists at the outset or is likely to arise in the foreseeable future, the only hope and function of the small-scale industry is to develop quality papers or different kinds of papers.

6. All of the unnecessary costs which go into the making and marketing of a product should be avoided as much as absolutely possible--because they too often raise the price out of the competitive market. As paper is a relatively low-cost item per sheet, in a small volume of pro-

duction on a handmade basis such extra costs will be particularly damagi to the sale of paper. In other words, if local customs or trade procedures will involve an elaborate or expensive or heavily-populated chain of middlemen and other handlers, if there are premiums to be paid, or excessive taxes, or other special cost factors, planners should take a long hard look before they commit themselves to a handmade paper program. Nor should this problem be maintained by assuming the solution is simply to cut certain necessary middleman or marketing functions. It is as fatal to fail to do the full marketing job as it is to come on the market with a price that takes one out of competition.

7. Obviously, one way to cut costs is to mechanize as much as possible. Ways to mechanize the most backbreaking and time-consuming part of the papermaking process are suggested in this Manual.

Market analysis -- It is difficult to determine what the market w be for a new product, especially if price cannot be determined. However in the case of paper, the initial market may be indicated in some instan by the purchases of the kind of paper under question from other sources. If, for instance, writing paper is to be made of a certain quality, then the controlling fact is that there is now writing paper of that quality being bought in such-and-such amounts at such-and-such a price. If the small-scale industry can make the same kind of paper at a cheaper price, there is economic justification (unless the going price is so inflated th the competition would cut it down to a price below what the cottage industry could in turn meet). Where the price at present is considerably higher than the new industry would have to charge, the present quantity bought m not mean too much. This is because the quantity bought might increase su stantially when the price goes down. It may also be that a lower price would mean a bigger market even for a product of lesser quality. If people cannot afford an expensive quality writing paper, they might neve theless buy second-grade writing sheets if the price is low.

The marketing factors which must generally be taken into account are listed below. A summary of techniques for finding the data is reprinted as Appendix I. Where more than one fiber and more than one kind of paper seems to show economic promise, the costs and markets must be worked out for each and a comparison made. These are the factors:

1. The present market (what quantities will be bought, at the di erent possible prices, which may in turn depend upon the volu bought--because increased production often reduces unit costs)

2. The trend of the future market (up or down, and to what extent)

3. The papers most desired, and the likely levels of acceptable prices.

4. The marketing facilities required (how expensive, at the outset and over the long term; the costs of promotion, advertising, selling and other marketing activities, including delivery).

5. The degree of likely effectiveness of advertising and promotion, in relation to the amounts expended.

6. The likely competition (both in terms of how it will affect the volume of the market, and what it will do to promotion and selling costs).

7. Standards of quality required (higher standards usually mean higher production costs).

8. Specifically, whether there is or will be soon a mechanized paper mill in completion (see the following for a discussion of the advantages and disadvantages of such competition).

9. The social desirability of the market (that is, whether the market for the particular kind of paper is one that ought to be encouraged or discouraged against other possible uses for the country's efforts and resources--a different kind of paper, perhaps, or a different kind of product).

Mechanized competition -- The experience of Japan indicates that the presence of a mechanized paper industry need not rule out a handmade-paper industry. The competition from the mill may well dictate that the handmade industry refrain from making printing, writing and wrapping papers--the cheap papers which are most logically mass-produced--and concentrate instead on:

(1) quality papers, such as fine printing and writing papers, bank-note paper, parchments, stencil papers, and other special-purpose papers

(2) papers that are basic to other paper products (see list in colored section in center of this Manual)

(3) novelty and fancy articles

As a matter of fact, the presence of a mechanized paper industry affords a handmade-paper industry a substantial advantage--a pulping operation from which it can get its own chief raw material, the pulp.

Possibility of U. S. market -- Although it is true that the United States imports handmade paper, the amounts are hardly in sufficient quantity to encourage any hopes that a new industry will find a U. S. market. The total for all grades of import is under $200,000. Obviously, a new producer would find very keen competition.

However, there is always the possibility of a "break," if the producer has something of really top quality or most unusual appearance, and if it cannot be copied in the U. S. While the graphic arts do not

offer a market, once in a great while an unusual paper will be taken up in the fine arts as an art technique. Among interior decorators, there are all kinds of possibilities--as witness a recent fad of "butterfly" paper from Japan, in which actual butterflies were laminated into the paper for lamp shades, screens, and comparable items. Special wrapping papers can find a market. Once in a while, also there is a special use in book binding, and especially box coverings. However, the big problem is in marketing--finding the right person who can recognize a particular paper and have a need for it at that particular time. It is definitely nothing to count upon; no handmade-paper industry should be started with this market in mind.

For the record, however, it can be noted that for an extremely high grade of handmade paper, aside from specialty items, the best price today is 91 cents a pound, including duty and freight to New York. A given importer might be interested in a supplier who could provide as little as $500 worth of the item a year.

**Organizational Factors**

By organizational factors, here is meant whether there will be a cooperative of producers, whether marketing will be handled separately, how a central mechanized pulping facility would be owned, etc.

The more different levels of organization that are involved in the making and marketing of the paper, the more costs there will be and the more people there will be entitled to a share of the profits--which means less for each. In addition, there is no doubt that the experience in some areas with middlemen who take advantage of the producers will make people hesitate before the middleman is accepted as a necessary level.

On the other hand, the more people who actually work, the more is produced and achieved, and the more there is to divide--IF there is proper efficiency and coordination. Especially as the volume gets larger, the different specialized functions may best be handled separately by different levels of organization. The people involved may be so efficient and far-seeing at their different functions that the handling costs will go down per unit and the market may be expanded to buy many more units, so that there will be a greater actual profit for each. This is what happens in an economy such as the United States, where there are very distinct specialties for such activities as manufacturing, packaging, wholesaling, retailing, advertising. These operations were not always large and distinct even in the United States, but they got that way from their small and simple beginnings by recognizing that there was an advantage in moving in that direction whenever alternative choices arose as to whether to continue to handle the whole operation at one level or divide into specialties.

In any case, at the outset, there should be some realistic calculating as to the economic and social advantages which would result from organizing in different ways. It should be recognized that the amount of

time a person or organization spends in one kind of activity, or has to divide up among a lot of different activities, has a very direct effect on such matters as these:

1. How easily and cheaply raw materials can be located and obtained. (If a hundred separate producers each must place an order for raw materials, the effort is almost exactly 100 times as great as if one representative placed an order for all of them--since the negotiations for any one order costs about the same whether it is for a large or small amount of material. Much of the same factor applies in transportation of many small orders versus one large one.)

2. Similarly, how efficiently financing, research, production, management, quality control, marketing and distribution can be achieved by the various types of organization, and what this would do to price and profits. Among the alternatives tried should be "mixed" types, as for instance a cooperative to do the pulping and an entrepreneurial system for papermaking and marketing.

The question of just what share of the selling price should go to the producer, and how much to middlemen, is of course a crucial one in determining whether a papermaking industry is an economic feasibility. There would seem to be no satisfactory guide, except to compute what it will actually cost a producer to make the paper and assume he must meet his expenses and have a fair profit. (Amortization costs should be included in these expenses.) If the additional costs of marketing can be added to that figure and allow middlemen profits, and still be at an attractive market price, then the industry is economically sound on the face of it. If these conditions cannot be met, even on a minimum basis, after careful efforts to reduce costs, then the project is not economically sound--at least with the type of organization being contemplated. (Some different organizational set-ups are discussed in Chapter 14.)

## Level of Operation

The volume of production possible or planned has a great effect on the price which must be charged. Usually, the greater the output, the less the cost for each unit. Also, the cheaper the price, the more that can be sold. This fortunate combination is the secret of an "abundance economy," where everyone profits from selling more goods at lower prices, making less profit on each item perhaps but much more in the long run--as distinct from the practice of making as great a profit as possible from each item today, even though it may prevent the market from growing tomorrow.

It is important, therefore, to try to figure the point which combines the most production at the cheapest cost with what the market will buy. The matter should be explored by developing costs, production volume,

prices and sales volume for each of the papers under consideration, on the following basis:

1. Completely hand operated, from first processing of raw material for fiber through papermaking, each cottage unit doing the entire operation, both in the traditional way of moulding and with the new paper box process.

2. Pulp produced centrally, and preferably mechanically, with cottage units taking the pulp and processing the paper separately. (This in turn should be considered against the cost of obtaining the pulp elsewhere--perhaps by import.)

3. The numbers of units combined into a producing and marketing group should be figured various ways (as for instance, one village or a cluster of villages around a central pulping facility) to see what happens to price and markets at different levels of volume.

## BROAD ECONOMIC CONSIDERATIONS

The encouragement and development of any cottage industry also involves broad policy considerations--whether the expenditure of time and effort and resources will serve the needs of the country better this way than the same expenditure in some other industry. The papermaking industry raises this problem in perhaps more important and direct a fashion than most other industries. For instance, if the need for paper is critical, ordinary economic considerations do not apply, because a country cannot grow and develop and progress toward its goals without an adequate supply of paper. On the other hand, papermaking may involve a considerable expenditure of effort for small results.

In terms of an integrated development of a country's economy, these are among the considerations to take into account:

1. The needs of the country for paper which can be produced by a small-scale industry.

2. The amount of capital required.

3. The protection the product has from competition from imports, the protection it is likely to continue to have, and the competition it should have--from a variety of points of view, including political considerations.

4. The level at which it should fit in (should it be cottage industry, or perhaps mechanized--depending upon capitalization problems, employment considerations, national pride, encouragement of handicrafts or industrialization, etc.).

5. Specifically, whether it is better to import pulp and/or paper, even if the local cost is competitive or less, to concentrate local energy on other industries--or, conversely, whether it is better to encourage a local pulp, paper and paper products industry, even if the activity must be subsidized against the price of imports. (Because of the different natures of the pulping and papermaking operations, it might turn out that a compromise of importing pulp and developing a papermaking industry might be a feasible first step in countries just starting out in the field.)

## EXPLORING ECONOMIC ALTERNATIVES BY USE OF MODELS

The decision to make paper or not, and at what level, and what kind, and how much, obviously is not only complicated in each separate question--it is all the more complicated by the fact that the answer to each question is changed by the way some other question is answered. Specifically, there is the varying factor of cost in relation to size--i. e., does an operation twice as large cost twice as much?

To keep track of the way all of these questions will affect each other, and keep making the changes every time a factor changes, is quite a hopeless matter. However, there is a fairly simple way to get the same result. This is called "model making."

By this method, a group of "models" is set up for comparison. Any one "model" is simply a statement or description of very specific circumstances and factors which will be taken as a fact, for the purpose. For instance, it can be decided that one "model" will be that 20 cottage industry units will go together in a cooperative to make paper, with the cooperative buying the raw materials, and the marketing but leaving all of the processing to the individual units separately to make and deliver to the central point. They will make a certain kind of paper from a certain kind of raw material. On the basis of this information, it is possible to figure out what the cost and profit factors will be. Now a second model can be "constructed," something like the first, except that it will have 50 units in the group. A third model might be like the first, except that a mechanical pulping device will be installed by the cooperative for the use of all. A fourth model might be like the third, except that it will have 50 units instead of 20. A fifth model might be like the fourth one, except that it uses a different fiber to make a different kind of paper. And so on, among all the different combinations that seem to be promising enough to justify the effort.

If there is presently a mechanized paper mill or one is likely within some years, one model should very definitely be included to take that into account.

The GENERAL CHECK LIST OF COSTS AND PROFITS, on the next page, gives in summary form the different considerations which should be figured in making a model; these will be recognized as the factors discussed in this chapter.

It must be recognized that these models cannot take into account all the factors to be considered, since some of them are not matters which can be reduced to cost and profit factors. (See below.) This is quite beyond the fact that it probably will prove impossible to get really accurate or dependable figures in many of the matters involved. It is simply that the development of models--intelligently and carefully done--is far better than nothing.

After each of the promising combinations is made into a model and figured out, it is then relatively simple to compare them with one another to decide--all things considered--which is the best model to follow. Or, in other words, which is the best way to proceed.

## Basic advantages of Pulp, Paper and Paper Products Industry

The intangible factors mentioned just above are included with economic and technological considerations in the list of advantages presented in Chapter 1. While it is advisable to review them in full before a final decision is made on undertaking a small-scale or cottage industry program, they may be summarized here briefly as follows:

1. Where need for paper is urgent, a supply can be provided.

2. People can be put to work simply, quickly, cheaply.

3. The industry is low-cost on a production basis.

4. Surplus skilled labor can be put into a permanent industry.

5. The industry lends itself well also to seasonal peasant work.

6. Locally-made paper avoids problem of holding back economy because of restrictions on importing of paper.

7. Locally-made paper of certain types frees foreign exchange to buy papers which cannot be made at home.

8. The small-scale industry may experiment with paper techniques as major technology cannot.

9. Local adaptations of new technology may lead small-scale industry to important place in the economy.

## BASIC CHECK-LIST OF COSTS AND PROFITS IN SMALL-SCALE PAPERMAKING

To figure, start with an estimated production for a normal month:
_____ pounds (or reams, tons, etc.) of _____ kind of paper
_____ pounds (or reams, tons, etc.) of _____ kind of paper, etc.

**MONTHLY COST OF MATERIALS** (to produce estimated amount, shown above)

Fibrous material _____ pounds (tons, etc.) @ _____ = _____
Chemicals _____ pounds (tons, etc.) @ _____ = _____
Filler (inert) _____ pounds (tons, etc.) @ _____ = _____

**MONTHLY COST OF DIRECT LABOR** (to produce estimated amount shown above)

_____ workers of _____ ccategory @ _____ per mo. = _____
_____ workers of _____ category, etc..... = _____

**MONTHLY INDIRECT LABOR** (other people in the organization)

_____ managers, with total monthly salaries of _____
_____ maintenance, clerical, etc., total payroll _____

**OTHER MONTHLY OPERATING COSTS AND OVERHEAD**

Power, light, other utility costs _____
Transportation costs to get raw materials in, paper out _____
Water (if bought by meter) _____
Office supplies, miscellaneous (mail, phones, etc.) _____
Taxes (other than on profits) _____
Insurance, rent, interest (if any) _____
Research, engineering services, other assistance _____

**MONTHLY SHARE OF CAPITAL EXPENDITURES**

| | Total costs | | Depreciated, amortized | | |
|---|---|---|---|---|---|
| Land cost | _____ | @ | _____ | months = | _____ |
| Buildings | _____ | @ | _____ | months = | _____ |
| Total equipment | _____ | @ | _____ | months = | _____ |
| Total tools | _____ | @ | _____ | months = | _____ |
| Total office equipment | _____ | @ | _____ | months = | _____ |

**MONTHLY MARKETING COSTS**

Warehousing, other expenses _____
Advertising, promotion _____
Commissions (not salaries if included in labor above) _____

TOTAL COSTS _____

INCOME FROM SALE OF MONTHLY PRODUCTION (as estimated above) _____

MONTHLY PROFIT (or LOSS) _____
TAXES ON PROFIT (if any) _____
NET PROFIT (or LOSS) _____

10. The small-scale industry will build interest and an economic basis for a more substantial papermaking industry.

11. Similarly it will build the technological basis for a more substantial papermaking industry.

12. It offers a material-oriented industry which can change to labor-saving.

13. A paper product industry as a specialized form of papermaking may bring important advantages to industry and the economy as a whole.

14. Handmade paper may serve as an art program.

15. The particular industry is good in serving the economic and political needs of the persons who would work in it.

16. Making their own paper will stimulate a country's people to pride and thus to greater use of communication techniques, to the benefit of the country politically and economically.

17. A tangible result will be assistance to literacy programs.

18. The industry will help improve productivity.

## CHAPTER 14

# How to Proceed

If your analysis of the deciding factors shows that a handmade paper industry is warranted in your particular situation, then you have the practical problem to face: how to proceed. This chapter is designed to help you.

First, you need expert help. As has been stressed, this Manual is intended to give you enough information to let one gain a general understanding of the opportunities and the problems. But before you invest sizable sums of money or stir up the interest of the people who will be starting the industry, you must:

1. Find the very best way you can to combine general techniques with your people's own established ways of doing things. There is no doubt at all that your present ways of operating and thinking have great value; rather than disrupt these assets and perhaps destroy them by introducing a conflicting way of operating, you must find some way of adapting the outside techniques to fit into your way of doing things. This almost always can be done when the value of the effort is understood, because most people are inventive and ingenious whenever they see that it will really help <u>them</u> to take advantage of the new techniques being suggested. <u>Your</u> big job as leader is to help them see that their own best interest lies in adapting these innovations to their needs.

2. Get a detailed market analysis of the future sales outlook for the paper industry.

3. Work out in detail all the mechanical, technical, administrative and other techniques, equipment and resources needed, to do the job you think needs doing and can be done in practical terms. At the very least, this involves expert assistance from a paper engineer or chemical engineer.

4. Test each point to be sure that it really will work as planned and described.

5. Arrange financing as needed.

6. Then put the plan into operation, through appointment of officials as may be necessary, budget allocations, and educational programs.

In many countries and in many other fields of industry, it has been found useful to establish an "Industrial Institute" to cover most of the steps involved in the fix points listed above.

An "Industrial Institute" (it may be known by another name, and is sometimes simple a part of a National Productivity Center or a Servicio) is usually a governmental agency devoted to:

1. Research on how best to adapt a particular industry or craft to the needs and present patterns of the country.

2. Planning and promotion of a development program.

3. Guidance to persons who will actually enter and operate in the particular industry--in such matters as technology, materials, training, financing, management, and marketing.

4. Preparation and circulation of information materials.

In case of papermaking, a Pulp and Paper Institute could perform the following functions and services, all of which are important in the development of a cottage industry:

1. Research on what papers are needed and what available fibers can produce them.

2. Technical assistance on making paper--fibers, how to process, etc.

3. Help to agriculture to produce useful fibers.

4. Encouragement to large industries (e. g., timber) to cooperate.

5. Develop standards of practice, terminology, quality, kind, and size.

6. Testing for quality control.

7. Research to improve techniques, develop new processes, etc., especially with local materials.

8. Develop screens and moulds best suited to local fibers and processes, and perhaps undertake manufacture.

9. Encouragement and assistance to individual entrepreneurs.

10. Help in organizing cooperatives.

11. Advise on purchase of central equipment.

12. Advise on styling and design in products, as necessary, through contact with other industries concerned and with handicraft associations.

13. Advise on marketing and distribution.

14. Advise on management practices and business procedures.

15. Advise on transportation.

16. Assist with financing.

17. Advise on legal matters, including taxes.

18. Advise on personnel and on training methods.

(Further information in Institutes, how to set them up and operate them may be found in the ICA Manual, "Activities and Institutions of the Industrial Technical Cooperation Program," available through United States Operations Missions. See Appendix II, Technical Information Materials Available.)

In any event, some agency would be required to undertake an action program, as follows, to get papermaking underway as a cottage industry:

1. Determine which fibers are available locally and which processes are best under local circumstances.

2. Plan an action program in detail, including such matters as raw materials needed, where they are coming from, how they will arrive, what equipment is needed and how it will be obtained or made, design and packaging, marketing, sales and distribution--including volume of sales and prices.

3. Test the program in a pilot study, and improve the program as necessary on the basis of these tests.

4. Establish a unit for pushing the program, and for education and training all concerned.

5. Prepare educational and promotional materials.

6. Set up a demonstration center or a traveling center to help train trainers--using models, simple laboratory equipment, drawings, and perhaps (since a small papermaking unit is not too bulky) a complete pilot operation.

7. Work out a capital expenditures program, help with financing and establishment of cooperative organizations and other agencies or individual activities as may be necessary to get production units started.

8. Arrange production of equipment and processing materials as needed, insofar as the cooperatives and other agencies may not be able to do it for themselves. In particular, this might involve the production of the moulding screens. (See Page 84.)

9. Undertake a training program--in such matters as production techniques, business management, marketing.

The importance of testing the plan, both from the technical and economic standpoints, cannot be overstressed. The investigation must be thorough--which is to say it must cover all of the points noted in this Manual, and cover them in detail. It must get down to cases, even to where the equipment will be located. Obviously, it must be impartial, and while it will have to be conducted by experts, they must be men who do not operate from preconceptions, however honest and honorable these men may be. One of the great dangers is that an expert who is accustomed to thinking in terms of one fiber and process, for instance, may be unduly influenced in his thinking and prove unable to understand the differences involved.

## ORGANIZATION OF THE INDUSTRY

The decision as to how to organize a small-scale or cottage industry is sometimes as a matter of national policy and sometimes as a de facto matter in view of the realities of the situation. Some may favor cooperatives, some may favor a private entrepreneurial system, and some may even see it as a government operation.

Assuming a governmental operation is undertaken only as a necessity to meet needs which cannot be met by the other approaches, the subject may be covered here in terms of non-governemntal methods.

### Cooperatives

In a papermaking cottage industry, cooperatives could be set up to obtain services and equipment on a shared basis, to operate certain central facilities on behalf of all, and to coordinate the individual efforts in such matters as are left to individual units. These activities might involve the following list (which includes some alternative methods):

1. Determination of the papers which should be produced by the members to best meet the market.

2. Technical assistance in making the paper--i. e., information as to the kind of fiber required, how to process it, etc.--and the training in improvement of techniques.

3. Central purchase of raw materials and perhaps equipment on behalf of each member, to provide an economical and assured supply; specifically, it could obtain the moulding screens.

4. Quality control on behalf of the membership, by inspections and by allowing use of watermark or trade mark on acceptable sheets of paper only.

5. Central ownership of certain mechanized equipment for joint use of all--particularly beating equipment.

6. A central marketing agency on behalf of all individual producers (or it could buy the papers from producers).

7. A central financial and credit agency on behalf of all to obtain capital equipment and materials.

8. A central legal and advisory service, and leadership for joint action in political matters such as taxes and labor laws.

9. Handling of transportation details in obtaining of materials and shipping of finished paper.

10. Central management of all business activities.

11. Providing services such as power, water and maintenance in each unit.

12. Providing the screens for moulds (especially if watermarks are involved).

Central Contractor

An alternative to cooperatives--one which may come about simply by the imaginative efforts of entrepreneurs--is the development of a private business arrangement, perhaps along the lines developed in Japan. There, workers operate under contracts with dealers at piece rates; often they use rented equipment. The dealer may serve any and all of the functions of the cooperative in relation to the individual producers with whom he contracts. He will be operating in his own business interest, of course, and this is subject to abuses which may require governmental control. But in the absence of other ways to organize and merchandise, he will be performing a considerable service by making an economic unit out of a scattering of separate small operations which cannot survive separately. He is particularly useful in a situation which involves part-time work in the homes--as would be the case where he might provide both pulp bricks and "paper boxes" (see Pages 79 and 81) plus

instructions, and would thus encourage the actual making of paper in spare time in the family unit. In Japan, for instance, the system allows the family to grow rice in the summer and work on the paper in the winter--and while the winter's work may amount to no more than a few dozen reams, it is needed employment and income, and it does add up (when all the families so engaged are added together) to a considerable production.

An entrepreneur of this sort, or even a cooperative, will hardly include "developmental" efforts in researching and improving techniques, because it will appear to be energy and money which are taken from profits In the long run, of course, such efforts will probably increase profits manyfold, and the private entrepreneur should be encouraged to undertake all the modern business practices possible, in the interest of his own firm's future growth and stability.

In any event, an entrepreneur who is considering investing his money in the facilities for a papermaking industry should be cautioned to study most carefully all of the factors noted in this Manual as affecting the economic feasibility of the project. Whether papermaking as a cottage industry offers the private entrepreneur a good possibility of fair return on his investment, and a secure business with growth over the long run, cannot be answered outside the particular circumstances of the proposed business. Entrepreneurs might well be encouraged to consider the possibility--but they must be advised also to investigate thoroughly before making a decision.

## Trade Associations and Federations

Where there are many different private companies or cooperatives, and where the industry may be located in many different centers, it may be useful to form a trade association or a federation of some sort. At its simplest level, the trade association may simply involve memberships and financial support to a central staff which does research on behalf of its members. For instance, how a trade association may assist with market research is described in Appendix I. It may pass along information of an economic or legal nature, and it may poll the members to find their opinion on a matter affecting their interests, and make this opinion known to the government or the agency concerned. The federation (using this word to indicate a type of organization which has closer ties to its constituent parts than merely financial support to a separate staff) can operate to provide financial support in turn for any of its constituents, and perhaps negotiate with large-scale industry on behalf of all of them. As an example, it might operate to keep prices of pulp low and uniform to all cooperatives or private producers, if the pulp were being produced and sold by a major pulping plant whose first line of business was serving large paper mills. Also it might be able to obtain government contracts unattainable by the units separately.

As demonstrated in other industries, notably textiles, regional or national associations can help bring the benefits of large-scale commercial organization and administration to the smaller units.

## Paper Products Industry as a Special Case

The development of a paper products industry might create special problems in technology and in marketing, because it would be even less uniform and in smaller volume than paper production. Very likely, only one unit might be making one special kind of paper product in the country--say for laboratory filter paper. There could well be enough of a total market in the country to keep the producer busy, and it would be useful and profitable. But how would the technology be developed to achieve satisfactory production of this special item in the first place? And how would the producer and his market get together?

There is probably enough at stake to warrant special attention to this problem--not for any one such paper product or any one producer, perhaps, but because of what they add up to in total, both in kinds of necessary products which may be locally made and the numbers of people usefully employed in the aggregate.

It may be that the Pulp and Paper Institute should have a special division concerned with the technological and marketing problems involved, or perhaps there should be a special national cooperative or trade association developed to look after the marketing problems at least. Conceivably, a governmental agency could be established to handle the problem on a clearing-house basis, in the interest of serving all industry with the special products which paper can produce, in small lots and probably at substantial savings of foreign exchange.

## CENTRAL FACILITIES

Whether the small-scale papermaking industry is organized as a governmental activity, as a cooperative or as an entrepreneurial system, it often proves most feasible economically when some of its processes are handled by a central facility.

In the steps toward mechanization of the paper industry--or even if the objective is only to improve the handmade paper industry, encourage it and make it competitive--the most logical part of the operation to mechanize is the making of pulp, or, even better, the stock-processing operations.

This is because the equipment and techniques involved are less complex and delicate than the paper lifting operation, because they are much cheaper to install and maintain than mechanical papermaking facilities (smaller units are available), and because hand preparation of fibers (pulping) involves much harder physical labor than the paper lifting and finishing operation.

In addition, a more uniform paper can be achieved by having one

central pulper or beater and hand sheet making than the other way around; or, at least, desired differences can be better controlled by starting from a uniform pulp supply than by dumping variable pulp types and qualities into one vat for the paper-lifting operation.

Other advantages are these:

1. It is a more economical way to obtain pulp, over a long period, at least.

2. It will simplify marketing of waste materials such as bagasse, and handling to the manufacturing point--if raw material is not directly available to each cottage industry unit out of its own field. Obviously, one purchaser dealing with suppliers and able to buy a relatively large amount at one time can achieve economies and simplify the operation.

3. Because sometimes very superior papers can be made by mixing fibers, a central beating operation can achieve this mixing more easily and more scientifically.

4. Higher quality pulp will result than from ordinary hand beating operations because of washing, bleaching, and screening facilities. (On the other hand, it should be recognized that one of the most important factors contributing to the high quality of some handmade papers is the great care and skill with which some producers beat their fibers.)

Therefore, centralizing the pulping or beating operation by obtaining power-driven pulping equipment, or otherwise mechanizing or using heavy equipment for chemical actions, should be considered from the outset as an alternative to undertaking the whole papermaking process in the separate units.

As explained in Chapter 6, the product of the mechanical pulper or beater could well be a moist brick or rolled sheets of pulp, which would be purchased by the separate cottage papermaking units. However, for shipping pulp a long distance, it might be more economical to remove all the water possible (to reduce weight) and repulp again at the point of use, as also explained in Chapter 6.

Obtaining a central pulping or processing facility can be achieved in a variety of ways, listed here in no particular order of advantage or likelihood (since this varies so much from one location to another):

1. The timber industry might add such an activity to its own operation, as an additional market for what otherwise is largely waste.

2. Any large agricultural producer might add such an activity to its own operation, for the same reason. This is particularly pertinent in the case of bagasse.

3. A cooperative might be established to purchase and operate such a pulper or beater.

4. The government might install the equipment and either operate it or lease it, as a subsidy to encourage the production of an important product.

5. An entrepreneur, or combination of entrepreneurs, might establish a pulping plant or beater operation as a separate business activity, or as part of a marketing operation handling handmade paper as well.

It is hardly likely that one paper-producing unit--short of a full-scale mechanized paper mill--could utilize even the minimum output of a pulping machine. For this reason, the possibility of a single cottage industry unit owning and operating a pulping machine is not listed above.

In countries which either have a going forest industry or which are developing one from marginal activities, there may be special advantages in attaching a pulp-making industry. (The later papermaking phases could be tied in, or could be a separate operation, based on purchase of the pulp.)

If such a tie-in were arranged, all the chippable low-grade timber--what would remain from the processing of high-quality lumber and other such products--would be pulped. This would obviously be an additional source of income to the forest industry, and would utilize wastes that the economy of a country might very well like to cut down.

Then, in addition, if chemical industries were tied into the same set-up, the residues from the pulping operation--including recoverable chemicals in the spent pulping liquors--could be utilized (along with the sawdust and wood shavings of the lumber mill) in the manufacture of chemicals.

Again, it should be noted that these operations could be separately located in different areas, if there was some reason for it, such as marketing, transportation, available labor supply, etc.

## STANDARDS AND QUALITY CONTROL

One of the reasons papermaking may be possible as a cottage industry is that there may be a market--perhaps even an urgent need--for paper which need not be up to the standards and uniformity achieved by mass-

production equipment. In other words, poor printing paper or writing paper may be better than no printing paper or writing paper.

Nevertheless, even in such a situation, there is still need for the product, and for a method of controlling quality to meet those standards. These standards can be at whatever level may be considered practical, being a balance of the skill involved, the water resources, the fiber available, the equipment, the effort, the time, the climate and other such factors--and the market. It may be for instance, that a standard might be deliberately set low to avoid undue use of meager water supplies to wash the fiber more and thus make it a cleaner paper.

But whatever the standards, they should be established by an appropriate organization--the Institute, the trade association, the cooperative, or the government agency--and insisted upon.

The watermark as a control device -- The fact that a watermark is simple to form in paper (see Page 86 for explanation of the method) and becomes a parmanent part of the product makes it a useful device for control of standards. A special watermark symbol can be furnished by the control agency to any papermaker who will make his sheets in accordance with the standards as set down. Inspection afterwards can eliminate such sheets as do not meet the standard. This could be a government operation or a private one, on a licensing basis; in the latter case it might well lead to the development of brand names with corresponding marketing advantages.

The watermark, of course, has a positive use as an incentive device. A papermaker should properly take pride in his product--if it is any good. If he must put his watermark on it, he will strive the harder to meet the standard, or to maintain it if he has already built his reputation. The watermark makes it easy to identify one producer's goods from another's, of course, and will simplify marketing payments, as well as avoid arguments in case wares get confused. (And, as was noted in the discussion of possible paper products, there might well be a market developed to provide special people--and perhaps government agencies--with their own watermarked papers.)

## Properties Which May Be Standardized

These are among the standards which should be set:

Standard sizes -- The sizes of sheets needed depend, of course, upon the intended use. Printing papers are now controlled, for practical purposes, by sizes of presses, or by customary sizes of paper for specific purposes. For instance, in the United States, ordinary business letters are put on 8 1/2 inch sheets. Because such printing does not need a "trim" to even up edges, as does a book, the printing sheet can be 17 x 22 inches, so that a printer can get four sheets of business stationery out of one large sheet. Where a standard correspondence size is already established in a country, paper production probably will have to conform. In the same way, there may be other controlling factors.

In any event, it would be well to make the sizes as standard and as few in number as possible. This avoids waste of raw materials (by making sizes that are awkward and therefore must be trimmed--and wasted--to result in the desired size). It also simplifies merchandising and stock in trade by workers and retailers, to say nothing of printers. The more different sizes also means the more different packages required to meet different demands--and every package involves a certain amount of waste under most circumstances. Most countries have standardization programs, connected usually with international programs of standardization, and paper sizes should be tied into those programs.

One way to control sizes will be to establish standard sizes for moulds--particularly if these are centrally made. Another way is by use of watermarks, as discussed above.

Paper Properties -- The qualities or characteristics which a particular kind of paper should have to be acceptable can be established. For instance, a "bond" paper suitable for writing, typewriting or printing, can be required to have a certain minimum strength, a certain degree of cleanness and color, etc. These properties are described in detail in Chapter 9, starting on Page 97.

Government standards can be imposed, of course, for goods sold as a certain type or grade of paper.

Probably it is sufficient, however, in a cottage industry, at least at the outset, to achieve control by inspection through producers' associations or cooperatives, etc.

Also, sorting and grading may be undertaken, after production, by the marketing agency, to insure high prices for really quality work. A practical decision has to be made as to the best way to get the most money return, in total, for the effort. Is it better to get a high price for a few sheets and a low price for all the others, or a standard medium price for many sheets and a low price for all the others, or a standard medium price for all? "Which way pays the most?" is the question.

In any event, to really achieve quality and standardization, it is very important that the producers understand exactly why they are being asked to meet certain standards.

Grades of paper -- It will probably prove advisable to encourage different units in the paper program to specialize on one or a relatively few kinds (called "grades") of paper -- those most suited to the raw materials available, the processes and the markets. In this way, they will best be able to ahhieve acceptable quality and the economy of operation that will mean profitable prices.

However, it is very important to note that this kind of standardization is not the same as the enforced type in connection with quality

and sizes. There should be freedom to experiment with different kinds of paper, to explore new markets with new paper products, and to otherwise let the industry grow. Limiting the kinds of paper produced for any but the soundest economic reasons will prove a mistake in the long run.

Techniques -- Standardization of techniques, insofar as possible, allows an exchange and interchange of people and equipment from one unit to another, and tends to make operations more efficient. However, here again, nothing should be done which will stifle the experimentation in method and design that will lead to improvements and advances. Encouragement of standardization--in a sensible, positive way by education and training, where the producer is first starting out--may achieve the advantages without doing the harm.

Terminology -- Standardization of terminology cannot be enforced, either, but in a new industry, it may be possible for the Pulp and Paper Institute, a national trade association, or other agency to decide upon a set of terms that will be used in all educational, promotional and training materials, and in demonstrations. As a result, the industry will have a uniform terminology--in its local language, if desirable, although there would be advantages to using the English terms--and will have no need to use varying and thus confusing words.

Settling on terminology sometimes means dividing on practices, too. For instance, will the word for "ream" mean 480 or 500 or 1,000 sheets? (All of these figures are now defined as a ream somewhere.)

## EDUCATIONAL, PROMOTIONAL AND TRAINING PROGRAMS

The needs for standardization and quality control, as noted in the section just preceding, point up a whole matter of great practical importance. While stress has been laid on the first step of starting by setting up a plan and testing it, the fact is that no plan can succeed if it is not properly communicated. This involves achieving an understanding by the people concerned of their own personal advantage in such a program, and then helping them with the technical know-how necessary for them to go about the work.

In practical terms, this means educational, promotional and training programs. A whole range of techniques and tools are available for the purpose; the most important consideration is to get clearly in mind just what the purpose is, and then get professional assistance in carrying it out. The exact form such communicative programs might take in any given country would depend upon local circumstances almost entirely.

It is possible, however, to suggest that these elements probably will be found useful to incorporate, in some way or another:

1. Why improving one's lot is important and how it is possible.

2. Why paper is important, and what it can do for knowledge, literacy, enjoyment, freedom and security.

3. How one's self-interest can be advanced through participation in this program (with specific ways suggested), by increased economic security.

4. How it is possible to go along with a changing technology and still keep one's culture and traditions.

5. How, in tangible fashion, people can act--what they can and should do as a first step, and where they will go from there.

6. Specifically, how they can get help to meet such problems as limited capital supply, small uncertain local markets, cheap but untrained labor, inadequate transport, difficulties of obtaining proper raw materials and making or buying equipment, lack of supporting services including training, and health and safety hazards.

7. How they can organize as a cooperative (if that is believed the best organizational approach) or how they can proceed as private entrepreneurs.

8. How they can protect themselves against unscrupulous adventurers--and conversely, if the country has a fear of middlemen, for instance, why they need not be feared.

9. Why risk is a good thing, when it is tied rationally into the line of progress of the country.

10. Why other industries should promote this industry, for their own advantage (for instance, the press stands to gain by encouragement of more use of paper and more reading, and specifically by having lower prices eventually for their own paper).

If it really is true in your country that there are advantages for people in becoming part of a small-scale papermaking industry, and if this fact is communicated to them along with assistance in doing something about it, it will almost certainly follow that the industry will start, grow and flourish.

CHAPTER 15

# Conclusions

The complexity of the details of papermaking in all of its various forms has made this quite a long Manual. To insure that the key facts come through, this short Chapter summarizes briefly the points made:

1. Locally-made paper may make an important contribution to a country's development.

2. Paper can be made simply, or at whatever level is desired, depending upon quality, quantity, and kind of paper.

3. Almost any country can find local fibers to make some sort of paper.

4. While paper can be made entirely by hand, it probably will be best in most cases to provide a mechanized central facility to make the pulp, and perhaps to complete the beating process.

5. By furnishing moist bricks or slabs of pulp to individual papermakers, the central facility can serve both large users and even the smallest cottage units.

6. The traditional method of hand-lifting a sheet of paper from a vat requires long skill, but the new "paper box" may well eliminate the need for this skill in most cases.

7. A central marketing agency, perhaps linked to the central pulping or beating facility, can be a workable agency, controlling quality and other standards through the control of moulding screens and watermarks.

8. Where there is already a mechanized paper mill, or a reasonably-affordable supply of imported papers, it is still possible that a local small-scale papermaking industry might find a permanent and useful role in making specialty and converting papers, and even paper products, which the economy needs.

THE ADVICE INTENDED: From the reading of this Manual, you have enough background information to study the problem in view of your own

local conditions, to see if papermaking as a cottage industry seems to have any promise at all. (Be sure to check the list of possible paper products and special papers which can be made, to see if any of them especially warrant the effort.)

If there IS promise enough, undertake a detailed investigation.

If the results look favorable, PROCEED.

# APPENDIX

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APPENDIX I

# Market Analysis Techniques for the Paper Industry

The article below is adapted from a report on American practice prepared by Howard N. Feist,Jr., for the U. S. Point Four program, identified as Report IR-10, 712, "Market Analysis in the Paper and Pulp Industry." It provides both a summary of the techniques involved and an indication of how a paper industry trade association might be able to be of service in this field.

Literature on market analysis is quite plentiful, consisting of chapters in books written on the general subject of market research and numerous articles in marketing magazines, such as JOURNAL OF MARKETING, PRINTER'S INK, and AMERICAN MARKETING JOURNAL. Two of the best general texts on market research which contain chapters covering market analysis rather thoroughly are MARKETING AND DISTRIBUTION RESEARCH by Lyndon O. Brown, New York: The Ronald Press Company, 1949, and MARKETING RESEARCH by David J. Luck and Hugh G. Wales, New York: Prentice-Hall, Inc., 1952. However, the main techniques as outlined in both of these texts and in various articles will be summarized in this section of the report with a slant as much as possible to the paper industry.

One must first realize that market analysis is only one phase of marketing research and that the paper industry in this country [U. S. A.] goes more deeply into marketing research than market analysis alone, although this phase of marketing research is one of the most important aspects of the job and an excellent beginning for a trade association. Marketing research can be divided into the following major fields of application:

Product studies -- Opportunities for new products, such as cardboard boxes to replace wooden containers or metal containers or for packaging in general. Our own paper industry has found a huge market for prepackaged food containers.

Consumer studies -- A study of the buying habits and preferences of users of paper so that the product can be modified or improved to better meet the needs and requirements of the buyers.

Evaluation of sales organization and operation -- Although

this is primarily an area for company research. an industry-wide survey enables the various members of the trade association to appraise their own organization and channels of distribution in contrast to statistics for the industry.

Advertising studies -- Determining advertising appeals for promoting the uses of paper and studying the effectiveness of advertising programs conducted by the association on behalf of all the members is an important phase of marketing research.

Market analysis -- Measuring current total sales potential, making market trend studies, and forecasting sales are the aspects of marketing research falling under this heading.

## Market Analysis

Market analysis may be divided into two broad categories--qualitative and quantitative analysis. Qualitative analysis has to do with the nature of the market and marketing methods. This would be a determination of the kind of people who constitute the market for paper, what their needs are in regard to grades and types of paper, how they buy paper, and rate of consumption. Quantitative analysis, on the other hand, has to do with the measurement of the size of the market to determine how much of various kinds of paper will be consumed in various parts of the market or during a future period. Quantitative market analyses are the main types of analyses conducted by trade associations and are the most rewarding to the members.

Current total sales potential is the sum total of the actual sales of various types of papers by all the companies that make and sell paper. The term "sales potential," when used in this sense, refers to realizable sales and is a measure of the active current demand for any specific type of paper. These figures enable the manufacturer to appraise his own achievement record of sales in terms of those for the industry. However, they do not include the unrealized potential demand for paper which may be obtained with proper promotional techniques.

Relative market potential is a measure of the relative importance of various markets either on a geographical or product basis. There are two considerations in dealing with this phase of market analysis--the relative level or current sales potential of each product or geographical market at the present time and their relative rates of growth. For instance, the market for wrapping paper might be a great deal larger than that for folding boxes, but the latter might be growing at a rapid rate, while the market for wrapping paper was somewhat static or possibly declining slightly. For a paper manufacturer contemplating expansion, the latter market would be the more promising.

Market trend studies is the branch of market analysis that deals with the trend of the market for a particular product. These are broad studies of past and projected performance in order to point up direction of growth, reasons therefore, and the approximate amount of increased consumption that can be expected over a period of time.

Sales forecasts is an estimate of the demand for a product over a specified period in the future. When done on an industry-wide basis the sales forecast becomes a market trend study. When done on a company basis, the sales forecast is based upon industry trends and past sales experience of the company.

On the basis of the information submitted above, market analysis, comprised of current total sales potential, relative market potential, market trend studies and sales forecasts, is the most promising field of endeavor for a trade association just commencing operation. The question which is next raised is how one goes about making a market analysis.

Methods of quantitative analysis

There are a number of methods of quantitative analysis employed in this country, but the most important in order of their probable applicability to the underdeveloped areas are as follows:

1. Direct data method. This is a measurement of current total sales potential by using the actual sales figures for various types of paper in selected geographical areas. This method necessitates the complete cooperation of the members of the trade association in supplying their own sales records by quantity and geographical area in which sold. To avoid revealing confidential data, the market is often divided into a number of subdivisions and then figures broken down by the company for these subdivisions. Similarly, the products are divided into general subdivisions and treated accordingly. The sum total of all of the reports from the companies gives the current total sales potential on both a product and area basis. By compiling these figures for a few years, it is then possible to make trend studies, relative market potential studies, and sales forecasts. However, such full support of an association by the members, although hoped for as the ultimate goal, is hardly feasible in actual practice, so that associations have to resort to other means.

2. Corollary data method. In the corollary data method, one determines the sales potential for his commodity on the basis of the sales data for another commodity. For instance, if we knew the average amount of paper used in a book and knew the sales of books for a given period of time, we could then determine the amount of paper used in books during this period. This method, of course, presupposes that data on closely related products is available.

3. Individual index. For some products it is possible to tailor an index to the product. To make such an index, one must: 1) isolate the important factors affecting demand for the product. These might include such things for wrapping paper as retail store sales figures, indicating the amount of wrapping that had to be done. 2) obtain data on these factors, suitably classified. This depends on whether or not such data is available. Much material is collected by the United States Department of Commerce and is available to U. S. industry free of charge. 3) convert figures in different units to a common denominator. On the wrapping paper, it might be found that only 60% was used by retail stores in their wrapping, while the remaining 40% was used in industrial consumption. Then it would be necessary to get a common denominator of 100 divided into 60 for wrapping paper sales in retail stores and 40 for industrial consumption. 4) combine these figures into one index, placing weights on the factors with the greatest influence. Thus, if the retail sales were down 10% for a given period while industrial activity was up 10%, one would expect a net decrease in sales for wrapping paper of 2%; a 6% decrease in retail sales index offset by a 4% increase in industrial sales index. This method, although quite good when it can be applied, is almost entirely dependent on availability of statistics from other products which often cannot be obtained.

## Specific Approach for Paper Market Analysis

Although it is not possible to determine the best approach to a problem unless one is actually in command of an understanding of what data is and is not available and of the industry in a particular region, the following specific approach is one which should yield the desired results for the trade association and which will not require full cooperation of all paper manufacturers.

Step 1 -- Divide the industry into basic divisions. These might be a) paperboard, b) wrapping paper, c) newsprint, d) fine papers, and e) book paper. In the United States, paper board is the most important of these subdivisions followed by wrapping paper, book paper, fine paper, and newsprint, in that order of importance.

Step 2 -- Classify the producers of paper into one of these categories. Compile a listing of the possible members for the trade association. On the basis of size of plant or number of employees, one should be able to estimate the production of a plant. By getting total sales figures from a number of the members of a division such as manufacturers of fine papers, it would then be possible to calculate the amount produced by firms who would not report. For instance, if the average production for firms reporting is 10,000 pounds per year per worker, it would then be possible to estimate the production of those firms not reporting their production figures on the basis of the number of employees working in those plants. Thus, if there were 28 producers of fine papers and 18 reported the figures desired, estimates could be made for the remaining members of the particular division.

Step 3 -- Divide the market to be analyzed into suitable geographic areas, provided the market is sufficiently large to warrant such subdivision.

Step 4 -- Where possible, classify users of the paper. For instance, in the fine paper division, offset printers or lithographers might represent a fair portion of the market. Make a listing of all lithographers in each geographical division. Based on the size of the lithographer, possibly as measured by the number of people employed and the amount of paper consumed per employee, it is then possible to estimate the total amount of paper consumed by lithographers in each geographic division and for the market as a whole. For instance, if sales records of a few cooperating companies showed that a lithographer would use 500 pounds of paper per employee on the average per year, by making a survey of lithographers, it would be possible to estimate the amount of paper which would be consumed in each geographic division by lithographers. A similar estimate could be made for other users such as greeting card manufacturers, novel and text book publishers, commerical printers and the like. Thus, even though the paper manufacturers who belong to the association do not give their full cooperation, the cooperation of a few manufacturers enables an association to compile market data, make a market analysis, and market trend studies.

Step 5 -- By presenting these studies to members of the association and potential members, the association is able to show the manufacturers the value of belonging to the association and of contributing the desired information. Once the first few studies have been made, the manufacturers realize their value and are usually more cooperative.

Thus, outlined above is a five-step procedure whereby an association might make a market analysis of the paper industry in a given geographic area.

## APPENDIX II

# Technical Information Materials Available

Thousands of different technical information items of interest and service to the development of industry in the underdeveloped areas have been prepared by U. S. agencies and are available through local Productivity Centers, Industrial Institutes, Servicios and United States Operations Missions.

Those listed below have been selected as being related to paper-making as a small-scale or cottage industry, or specifically referred to in the text of the Manual for general background. Some items are designed primarily for large-scale industry, but are included because they may be of some use for small-scale activities, particularly if a central pulping facility is involved, or because they may suggest ideas which can be adapted; these are indicated by "large-scale." Also included here are certain shorter items which cover subjects discussed in comparable detail in this Manual, and which therefore need not be ordered by those who have access to the Manual; they are indicated by "for the record," and are included simply to avoid unnecessary duplication in ordering.

The code symbols at the beginning of each entry and the full title as shown should be used to request these materials from the agencies listed above.

PAPER: BSB -- Pulp, Paper, and Paperboard

16-page pamphlet listing basic information sources, primarily in the U. S. A. Governmental, academic and commercial materials are included in fields of economics, trade, technology.

PAPER: CROR -- The Coarse Paper Industry

45-page report of basic data applicable to U. S. industry; use for small-scale paper industry in underdeveloped areas probably is limited to economists studying long-range possibilities of pulping industry.

PAPER: CROR -- The Paperboard Industry

47-page report of basic data applicable to U. S. industry; use for small-scale paper industry in underdeveloped areas is probably limited to economists studying long-range possibilities of pulping industry.

PAPER: D-649 -- Neoprene Is Now Being Used To Produce Stronger and Cheaper Paper Useful for Converting into Products

1-page report of new coating to make paper wear better, mixed in with stock.

PAPER: D-831 -- Pulp Mills Find Valuable Source of Material in Lumber Chips

2-page (plus illustrations) report on large-scale operations using lumber chips; may be applicable to smaller-scale pulping operations.

WASTE: D-898 -- Plywood Plant Converts Veneer Waste into Chips for Paper-making

1-page description of process on large scale, but may have adaptability to smaller-scale pulping operation.

PAPER: D-1134 -- New Protective Paper Wraps Provide Greater Safety for Fish in Transit or Storage

1-page report on two new products, which may be possible of small-scale production in underdeveloped areas.

PACKAGING: D-1136 -- Paper Liners Save Fish, Time, and Money for Canning Plants

1-page report on how wet-strength perforated papers can be used in fish-processing operations.

PAPER: D-1137 -- Use of Paper Fillers and Wrappings Makes Cheaper Products Available

1-page report of advantages of using paper instead of textiles as fillers and liners for many products; basically covered in this Manual.

PAPER: D-1520 -- High-Quality Paper Made from Wood Waste

1-page report of new process to blend waste wood fibers with kraft to retain the highest quality of each, under low pressure.

PAPER: D-1522 -- Neutral Sulfite Preparation of Pulp Paper May Simplify Salvage of Spent Liquor

2-page description of the new process, large scale.

WASTE: D-1703 -- Pulpwood Waste Furnishes Wide Range of Usable Chemicals

2-page report of development of chemical uses of lignin, normally a waste of pulp-making. Does not go into details of processes. Generally covered in this Manual.

**PAPER:** D-1735 -- Heat-Sealed Paper Packet for Packaging Individual Portions of Food and Drugs Is Efficient, Economical, Moisture-Proof

2-page (plus illustration) technical discussion, large scale.

**PAPER:** D-1737 -- Impregnating and Coating Paper Increases Its Usefulness

2-page discussion of methods of impregnating and coating papers to convert them into new and more useful paper products; basically covered in this Manual.

**PAPER:** D-1832 -- Brighter Paper at Lower Cost with New Bleaching Method

4-page digest (with illustrations) of cold steep bleaching system using a peroxide bleach liquor for high density pulp; large scale.

**CHEMICALS:** D-2162 -- Chemicals Make Paper Containers for Food Products Germicidal and Leak-Proof

2-page report on chemicals added to paper (in stock and by coating) to make them useful to food packaging. Large scale.

**CHEMICALS:** D-2260 -- Neoprene-Treated Paper Provides Cheap Substitute for Chemical Filter Cloth

2-page report on subject matter; large-scale but with application to underdeveloped areas to make possible another paper product.

**PAPER:** D-2426 -- Specialized Glues Improve Paper Products: Better Techniques Increase Production

1-page report on technical details of adding glues to stock to improve qualities of tissue papers, especially facial.

**PAPER:** D-2522 -- Specialty Paper Production Increased, at Lower Costs, with Specialized Glues

1-page report on special glues to increase speed of operation and give such qualities as grease, water and mold resistance to finished products; large scale.

**CHEMICALS:** D-2554 -- Chemical Stabilizers Reduce Fiberboard Warping

1-page description of chemical treatment to stabilize cellulose fibers in wallboard.

**PAPER:** D-2917 -- New Saturated Papers are Stronger, More Water-Resistant and Emboss Readily

3-page report on process to make papers suitable for such applications as gaskets, automobile oil-filter elements and embossed sheets; beater-saturated rather tub-surfaced. May have paper product applications in underdeveloped areas.

PACKAGING: D-3209 -- Tough, Vapor-Barrier Wrapping Paper Gives Complete Protection to Finish-Machined Parts

2-page report on a specialty paper for industrial uses.

PAPER: D-3448 -- Waterproof Paper Liner Protects Truck Cargo From Weather and Other Damage

1-page description of usefulness of waterproof paper liner, laminated with asphalt center; may suggest product in underdeveloped areas. Few production details.

PACKAGING: D-3713 -- Use of Double-Duty, Grease- and Water-proof Wrapping Papers Lowers Packaging Costs and Increases Product Sales

2-page report of various uses of special-property papers which can be produced by small-scale operations.

PACKAGING: D-4020 -- Knowledge of Physical and Protective Properties of Packaging Materials Aids in Preserving Frozen Foods

4-page summary of the subject; large scale.

PAPER: D-4024 -- Organic Silicone Treated Papers Offer Improved Release Properties When Used with Tacky Products

2-page technical description of process to make a paper product which may have industrial application in such fields as food, candy, containers, rubber and steel.

ADHESIVES: D-4120 -- Adhesives for Paper, Film and Foil Lamination

2-page discussion of available adhesives for laminating paper to paper, useful in making specialty papers and products.

PAPER: D-4191 -- Low-Cost, Easy-to-Make and Use Paper Honeycomb Cores Strengthen Aircraft Structures

2-page technical description of a paper product for a special use; large scale.

PAPER: D-4301 -- Advantages of Chlorine Dioxide Bleaching of Pulp

3-page technical report on subject, including economic aspects, process and installation, and problems; large scale.

PACKAGING: D-4482 -- A Knowledge of Paperboard Grades and Characteristics Will Aid Packers in Selecting Suitable Containers for Their Products

2-page summary of paperboard grades, with special reference to food packaging. Basically covered in this Manual.

PAPER: D-5028 -- Inexpensive Method of Chemically Debarking Trees for Pulpwood

1-page simple technical description of method to obtain peeled wood for pulping.

PAPER: D-7090 -- Manufacture of Hand-Made Paper

2-page digest from "Manufacture of Hand-Made Paper," published by the East African Substitutes Committee, Dar es Salaam. Concerned with making paper from waste paper; basically covered in this Manual, although original has additional details.

PAPER: E-163 -- The Manufacture of Paper from Hemp Hurds

3-page digest of general and technical information, from "Hemp Hurds as Paper-Making Material," by Lyster H. Dewey and Jason L. Merrill, Bulletin No. 404, U. S. Department of Agriculture.

PAPER: E-201 -- Use of Sugarcane Bagasse as a Raw Material for Paper and Board Manufacture

9-page digest of general and technical information, from "Economic Factors to be Considered in the Use of Sugarcane Bagasse as a Raw Material for Paper and Board Manufacture" (ARS-71-2), by Elbert C. Lathrop, published November 1954 by the U. S. Department of Agriculture, Agricultural Research Service.

PAPER: E-205 -- Manufacturing Methods of Pulp and Paper

7-page general description of processes and pulps used. Basically covered by this Manual.

PAPER: E-222 -- The Manufacture of Bagasse Board for Construction Use

2-page digested description of process; taken from "Bagasse Board for Construction Use,"by J. C. Huang, Industry of Free China, Vol. VI, No. 2; published August 1956 by Industrial Development Commission, ESB, Taiwan, China

PAPER: E-228 -- How Blotting Paper Is Made

For the record.

PAPER: E-239 -- Paper Making by Hand

For the record.

PAPER: IR 9072 -- Operating Statistics on the Paper and Pulp Industry

10-page report, on large-scale over-all industry basis of U. S. pulp and paper mills; covers financial aspects, investment quotas, production and productivity, and operating statistics.

ABRASIVES: IR 9590 -- Manufacture of Grindstones, Millstones, and Emery Paper

4-page summary of best raw materials for abrasives, including emery paper.

CASTING: IR 9659 -- Products of Molded Cellulose

4-page report of various references for making such products as acoustic diaphrams, egg cartons, hunter's decoys and paper base laminates from molded cellulose.

ABRASIVES: IR 10267 -- Abrasive Paper and Abrasive Cloth

11-page discussion of subject, including suppliers, storage problems equipment manufacturers, bibliography.

PAPER: IR 14334 -- Manufacture of Paper from Straw

3-page description of mechano-chemical process for pulping agricultural residues. Basically covered in this Manual.

PAPER: IR 15133 -- Paper from Wood, Straw, Bagasse and Bamboo

3-page report recommending processes suitable for pulping of eucalyptus wood, bamboo, bagasse, rice straw and similar straws in production of writing, printing, wrapping papers.

WASTE: IR-15891-EP -- Use of Waste Paper in Making Paperboard

1-page report, referring to detailed sources of information on use of diatomaceous earth to make possible the utilization, in paperboard manufacture, of waste paper impregnated with wax or asphaltic material.

PACKAGING: IR-16039-EP -- Paper Containers for Milk

4-page summary of advantages, disadvantages of use of paper milk containers.

ABRASIVES: IR 16267 -- Grindstones and Emery Paper

2-page summary of materials and procedures used in making abrasive products, including paper-based abrasives.

CHEMICALS: IR 16290 -- Recovery of Caustic Soda and Lime from Bamboo and Bagasse Paper Mills

2-page report on processes covering subject matter; large scale.

PAPER: IR 17122 -- Rag Washing and Bleaching

2-page description of common U. S. practice.

MISCELLANEOUS: MISC -- Activities and Institutions of the Industrial Technical Cooperation Program

218-page reference manual to assist in development of National Industrial Technical Centers and Technical Cooperation Programs. Describes centers around the world, in some detail; explains services available from ICA; suggests principles, action programs, methods of operating. (Being revised, 1958.)

FOOD PROCESSING: OD -- Starch

20-page summary of various types of starch, raw materials, production processes; useful information for small-scale operation, although data submitted is for large-scale plant.

PAPER: PR -- Coarse Wrapping Paper

34-page report on basic information for establishing and operating small mechanized plant; large scale compared with handmade-paper industry, but has much pertinent data.

PAPER: PR -- Corrugated Fibre Boxes

45-page report on basic information for establishing and operating small mechanized plant; large scale as compared with handmade-paper industry, but has much pertinent data.

COTTAGE INDUSTRIES: SRS -- Power Transmissions for Cottage Industry

37-page manual on equipment which may be improvised by rudimentary techniques from simple materials, to transmit power--pulleys, bicycle sprockets, lathes, etc.; very useful for converting available mechanical power to do specific tasks in the papermaking operation.

FIBERS: SRS-5 -- Vegetable Fibers and Their Uses

21-page U. N. report on processing and use of vegetable fibers, with emphasis on Asia and Far East; concerned with processing for textile industry use, but has some general data of interest to papermaking.

BUSINESS MANAGEMENT: SSS -- Increasing Productivity thru Simplification, Standardization, Specialization

109-page Manual for general guide and source of background material on U. S. experience in the subject. Includes principles, examples, methods, results to be expected.

APPENDIX III

# Printed Sources of Information (Bibliography)

Listed below are published sources of additional information, as described under the particular entry. This bibliography is by no means complete or even comprehensive, there being thousands upon thousands of books, monographs, articles and reports written about pulp and papermaking. However, the first section below, on bibliographies as such, should provide a key to much of this literature; in addition, the reader may seek more direct information from the sources shown in Appendix IV. The materials listed below do represent a conscientious collection of information likely to be of direct value to users of this Manual. Prices have not been included, because they change without notice. The materials are often available in major libraries; where individual copies are desired, they should be obtained from the publisher indicated in the particular entry. These items are not available through governmental sources, except in unusual circumstances.

## B I B L I O G R A P H I E S

The Bibliography of Papermaking and the annual Bibliography of Papermaking and U.S. Patents, produced by the Technical Association of the Pulp and Paper Industry (TAPPI), editor, Jack Weiner (previous editors, Clarence J. West and W.B. Weber).

This is a continuing series, in two parts: (1) an annual bibliography of all books and articles throughout the world dealing with pulp and papermaking, and including U.S. patents in the field for the year, and (2) a five-year condensation for the previous period, listing the most important materials. The volumes cover 1900-1928, 1928-1935, 1936-1945, 1946-1950, and 1951-1955, some of the older volumes still being available from TAPPI. This is the one clearing house of all material on the field of papermaking, being limited only to publication in the regular channels devoted to the subject. Distribution is generally limited to members of TAPPI, but this includes many libraries. Potential users in the underdeveloped areas are advised to contact TAPPI, at 155 East 44th Street, New York 17, New York, as to availability.

Forest Products Laboratory, U.S. Department of Agriculture, Madison, Wisconsin,

This organization lists publications by members of its staff on subjects of current interest and historical value on pulpwood, pulp, chemical constitution of wood and pulp, paper, paperboard, structural fiberboard and hardboard, plastics and molded pulp products, pulping process, pulping characteristics of wood, pulp processes and papermaking, pulp, paper and wood wastes.

Institute of Paper Chemistry, Appleton, Wisconsin.

This research and training institution has nearly 200 annotated bibliographical series on practically the whole range of pulp and papermaking, except for the mechanical considerations as such. For example, the subject of "Bleaching" includes 1,400 references in 441 pages, giving a reader a key to specific books, monographs and journal articles which should cover exact point being sought.

Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Peoria, Ill.

This organization, which has been doing pioneering work in the development of processes for pulping agricultural residues, maintains a list of its publications and patents on pulping, papers and related subjects. Usually these are materials which appear in the professional and trade journals, although the organization does produce special reports under its own imprint.

Basic Information Sources on Pulp, Paper, and Paperboard (BSB-190). Compiled by Pulp, Paper, and Paperboard Staff, Forest Products Division, Business and Defense Services Administration, U. S. Department of Commerce.

While developed primarily for U. S. users, this 16-page pamphlet constitutes a quite comprehensive bibliography of materials available, as well as other sources of technical information, including U. S. trade associations.

## BOOKS, ARTICLES, ETC.

American Paper and Pulp Association, 122 East 42d St., New York 17, N.Y.
World Per Capita Paper Consumption

By the Export Committee, American Paper and Pulp Association. Comparative statistical data 1932-1954 by geographical areas and country. Production, imports, exports, apparent consumption, population, and per capita paper use are shown as well as paper and board exports.

American Paper and Pulp Association, 122 East 42d St., New York 17, N. Y.
World Pulp and Paper News

Periodic summary reports on world trade in pulp, paper, paperboard and products presenting current information on production, consumption, and marketing trends in various foreign countries.

Carpenter, Chas. H., and Leney, Lawrence, 91 Paper Making Fibers. State University of New York, College of Forestry at Syracuse, 1952.

Includes basic characteristics of 91 of the more important fibers; 389 photomicrographs are shown.

Food and Agriculture Organization of the United Nations, Rome, Italy, September 1953, Forestry and Forest Products Study No. 9, Research in Forestry and Forest Products

This is a world directory of research institutions, with a summary of their objectives and activities, by country. While it covers all forest industry, it includes full information on pulp fibers. (See Appendix IV, following, in this Manual.)

Food and Agriculture Organization of the United Nations, Rome, Italy, April 1953, Raw Materials for More Paper

This book, representing the findings of an FAO pulp and Paper Consultation in Rome in December 1952, is perhaps the most comprehensive technical report available on the subject from the standpoint of the underdeveloped areas. It covers pulping processes for fibrous raw materials from new sources, going into the old ones as well, in applicable detail; suitability of fibrous raw materials for different paper products; process cost estimates for pulping fibrous raw materials; case histories; procedures recommended for the investigation of new fibrous raw materials for paper and for testing.

Food and Agriculture Organization of the United Nations, Rome, Italy, December 1952, FAO Forestry and Forest Product Studies No. 3), Tropical Woods and Agricultural Residues as Sources of Pulp

A symposium by experts in the fields concerned, covering tropical woods and agricultural residues as sources of pulp, in very useful detail from the standpoint of underdeveloped areas, from standpoint both of types of fibers and their characteristics and of pulping processes.

Food and Agriculture Organization of the United Nations, New York, 1954, World Pulp and Paper Resources and Prospects

This survey, prepared in cooperation with Unesco, ECE and ECLA, not only surveys the present situation and prospects by regions but includes comprehensive appendixes on resources and recent technical advances in processes. These appendixes include much technical data of direct practical use in the underdeveloped areas for planners considering papermaking on the scale treated in this Manual.

Hunter, Dard, Papermaking, 2nd edition, Alfred A. Knopf, New York, 1947.

A monumental one-volume work on the world history and practice of papermaking, emphasizing handmade papers and watermarks with many illustrations. While it is not a technical manual, it contains much of the author's great personal know-how in the field (Dr. Hunter once operated a hand paper mill).

Isenberg, Irving H., Papermaking Fibers, in Economic Botany, Vol. 10, No. 2, April-June 1956, pp. 176-193.

A comprehensive summary of the subject, with a historical introduction. (See Page 30 of this Manual.)

Joshi, K. B., Paper Making as a Cottage Industry, The All-India Village Industries Association [now the Research Institute for Village Industries] Maganvadi, Wardha, India, 1947.

A detailed and practical description of both traditional and modernized processes of making paper by hand, using Indian fibers and other resources. (See Page 173 of this Manual.)

Modern Packaging Encyclopedia, Packaging Catalog Cor. N. Y., 1950, Molded Pulp and Fabric Containers, p. 293.

A comprehensive treatment of the subject matter.

Mosher, Robert H., Specialty Papers--Their Properties and Applications, Remsen Press, N. Y., 1950.

A comprehensive listing and description of the kinds of specialty papers discussed from Pages 127 to 158 in this Manual.

National Association of Waste Material Dealers, 271 Madison Ave., New York 16, N. Y., Waste Paper Standards and Practices

Circular W.P.-54, approved by the Waste Paper Institute of the Association. An outline of standard grades and practices recommended for use in United States and Canada. Purchase agreement practices of seller and buyer, trade definitions, and a listing of prohibited or undesirable waste paper qualities.

Norris, F. H., Paper and Paper Making, Oxford, 1952.

A comprehensive 1-volume treatment of the subject, from the standpoint of high-level technology.

Riatt, William, Digestion of Grasses and Bamboos for Papermaking, Associated Booksellers, New York, 1931.

While this is now somewhat outdated by recent new process developments, it nevertheless provides a great deal of useful information.

Stephenson, J. N., Editor-in-Chief, Pulp and Paper Manufacture, McGraw-Hill, New York. Vol. 1--Preparation and Treatment of Wood Pulp, 1950; Vol. 2--Preparation of Stock for Paper Making, 1951; Vol. 3--Manufacturing and Testing of Paper and Board, 1953; Vol. 4--Auxiliary Paper Mill Equipment, 1955.

This series, a set of textbooks designed especially for home study purposes, was prepared under the direction of the Joint Executive Committee on Vocational Education Representing the Pulp and Paper Industry of the United States and Canada. It is in effect a second edition of "The Manufacture of Pulp and Paper, a 5-volume work published in the 1920's. A section by Dr. Dard Hunter on handmade paper appears in Volume III, which also discusses paper testing. Vol. II covers the pulping of rags and such annual crop fibers as straws, jute and bamboo, as well as waste papers. It has chapters also on beating and refining, fillers and loading, sizing of paper, paper coloring, and semichemical, high-yield chemical, and special groundwood pulping processes. The series as a whole represents probably the most complete single work on papermaking, although aimed at high-level technology.

TAPPI Data Sheets

A loose-leaf handbook of engineering, chemical and operating data for engineers, chemicst and superintendents, on the full] range of technical factors in pulp and papermaking. Largely large-scale. Distribution is generally limited to members, which include many libraries; potential users in the underdeveloped areas are advised to contact TAPPI, 155 East 44th Street, New York 17, N. Y., as to availability.

TAPPI Monograph Series

19 volumes to date; monographs on various special subjects of interest to pulp and papermakers, including water, starch, pulpwood, coating de-inking, bleaching, paper loading materials, microbiology, pigments, etc. (See TAPPI Data Sheets as to availability.)

TAPPI Standards and Suggested Methods

A loose-leaf manual of tentative, official and suggested testing methods, specifications and recommended practices in the pulp and papermaking industry. Largely large-scale. (See TAPPI Data Sheets as to availability.)

United Nations, Department of Economic Affairs, New York, 1954, Possibilities for the Development of the Pulp and Paper Industry in Latin-America

A joint study by the Economic Commission for Latin America and the Food and Agricultural Organization of the United Nations, discussing productive capacity and consumption; principal resources for pulp and paper production, and development possibilities, country by country in Latin America. (U. N. Sales No. 1953. II. G. 2)

United Nations and Food and Agriculture Organization of the United Nations, New York, 1955, Pulp and Paper Prospects in Latin America

This 465-page report of the Latin American Meeting of Experts on the Pulp and Paper Industry, held in Buenos Aires in 1954, includes both economic and technical data, principally of interest to Latin America and in terms of large-scale production, but nevertheless with much information for all areas of the world, and for papermaking on a small scale as well. (U. N. Publication Sales No. 1955. II. G. 4)

United States Department of Agriculture, Agricultural Research Service, Lathrop, Elbert C., Economic Factors to be Considered in the Use of Sugarcane Bagasse as a Raw Material for Paper and Board Manufacture

Basic data on subject matter, with U. S. usage in mind; however, contains much valuable data and ideas for underdeveloped areas. (November 1954)

United States Department of Agriculture, Agricultural Research Service, Lathrop, Elbert C., and Aronovsky, Samuel I., The Contribution that Sugarcane Bagasse can Make to the Paper and Board Industries

Comprehensive summary of data on bagasse in terms of pulping, and for use in corrugating, containers, fine papers, wrapping and bag papers, and newsprint; basically for U. S. use, but contains much information pertinent to underdeveloped areas. (November 1954)

United States Department of Agriculture, Agricultural Research Service, Lathrop, E.C., Aronovsky, S. I., et al, Fiber Shipping Containers from Sugarcane Bagasse

Comprehensive data on the subject matter, with U. S. usage in mind, but useful for data on general uses of bagasse as well. (November 1957)

West, Clarence J., The Utilization of Sugar Cane Bagasse for Paper, Board, Plastics and Chemicals, Sugar Research Foundation, Inc., New York, 1952, 2nd edition, 200 pp. (Technical Report Series No. 8)

This contains comprehensive technical data on the subject and an annotated bibliography comprising 437 references on pulp, paper and board from sugar cane bagasse.

Western Michigan College Lectures on Paper and Paperboard Converting, Lockwood Trade Journal Co., Inc., 15 West 47th St., New York 36, N.Y.

1954. Discussion of the everyday problems encountered in converting for packaging, single-service paperware, business and stationery products, personal and household products, products for industrial use, and testing for the paper converter. Large-scale, but of some value to the underdeveloped areas.

Witham's Modern Pulp and Papermaking, 3rd edition (Editor, John B. Calkin), Reinhold Publishing Corp., New York, 1957.

Perhaps as comprehensive a technical treatment of the subject as may be possible in one volume; intended for the reader interested in high-level paper technology.

## DICTIONARIES AND ENCYCLOPEDIAS

Dictionary and Encyclopedia of Paper and Paper-Making, by E. J. Labarre (2nd edition, 1952), Swets & Zeitlinger, Amsterdam.

Multi-lingual (English with French, German, Dutch, Italian Spanish and Swedish equivalents) one-volume dictionary with many special longer articles. Génerally English in its approach. Includes much material from the Dictionary of Paper, see below, but the two publications are by no means duplicating one another, and it is valuable to have both.

Dictionary of Applied Chemistry (called "Thorpe's Dictionary") 4th edition, 11 volumes. Longman's Green, New York.

Articles on pulp, paper, chemical additives, etc.

The Dictionary of Paper, 2nd edition, American Paper and Pulp Association, New York, 1951.

This dictionary is a concise but comprehensive compilation of American pulp and paper terminology and practice, produced as a cooperative industry effort. In addition to definitions of papers, boards and papermaking terms, it includes the classification and definitions of pulps, and of waste materials used in the paper and board industries.

Encyclopedia of Chemical Technology, 16 volumes, Interscience Publishing Co., New York, 1953.

Articles on pulp, paper, chemical additives, etc.

Van Nostrand's Scientific Encyclopedia, Van Nostrand, New York.

Articles on Pulp, paper, chemical additives, etc.

## DIRECTORIES AND CATALOGS

Names and addresses of concerns engaged in the pulp and paper industry are available in the directories listed below. Copies of these directories may be consulted at large libraries or purchased from the publishers.

Lockwood's Director of the Paper and Allied Trades

Annual. Regular edition and traveler's edition. Lockwood Trade Journal Company, Inc., 15 West 47th St., New York 19, N. Y. Includes manufacturers of equipment and supplies purchased by paper and pulp mills; manufacturers of paper specialties; paper dealers; watermarks and brands; pulp testing chemists; trade associations; statistical information.

The Paper Makers' and Merchants' Directory of All Nations.

Annual. Business Publications, Ltd., London. Primarily British, but includes overseas paper, pulp and board agents, and a classified list of merchants.

Post's Paper Mill Directory

Annual. L. D. Post, Inc., 1440 Broadway, New York 18, N. Y. Includes trade associations; buyers' guide to paper and pulp makers' machinery, equipment, supplies and services; statistical information.

Walden's A B C Guide

Annual, February. Walden, Sons and Mott, Inc., 41 Park Row, N. Y. Includes paper distributors of the United States and Canada with the personnel of each company and the kinds of paper handled by each house; manufacturers of paper and paper products, classified according to product.

Paper and Pulp Mill Catalogue

Annual. Fritz Publications, Inc., 431 South Dearborn St., Chicago 5, Ill. Selected distribution; manufacturers of equipment and supplies, chemicals and dyestuffs, for paper and pulp mills.

Paper Year Book

Annual. Davidson Publishing Company, 22 East Huron St., Chicago 11, Ill. Basic information on paper, paper products and related specialties, with listings of manufacturers and manufacturers' data; also alphabetical index of names and addresses of manufacturers.

Philips' Paper Trade Directory of the World

Annual. S. C. Philips & Co., Ltd. Graham House, 3 Tudor St., London E. C. 4, England. Pulp, paper, paperboard mills and converters of major producing countries of the world by name and address; production by type and grades and equipment. Commonwealth and foreign classification by product list, producing mills by country.

Modern Packaging Encyclopedia

Annual. Packaging Catalog Corp., 122 East 42nd St., New York 17, N. Y. Contains a section devoted to each major type of packaging product, such as cartons and boxes, bags and envelopes, seals and tags, labels, wrappings, cans and tubes, including a buyers' guide, a directory of trade names and a list of major trade associations in the field of packaging.

Thomas' Register of American Manufacturers

Annual, December. Thomas Publishing Co., 461 Eighth Ave., New York 1, N. Y. A general directory of manufacturers, classified by kind of product, including pulp and paper, and arranged geographically; also listed alphabetically. Includes trade name section, with registered trade names listed alphabetically.

## JOURNALS AND MAGAZINES

### Indian Pulp and Paper

Includes many articles on handmade paper as an industry; see specifically, "Conquest of the Cottage Industries--Modernization of the Village Papermaking Industry," Vol. 5, No. 12, June 1951, pp. 512-514, and "Manufacturing of Wrapping Paper from Sisal Fibre Waste as a Cottage Industry," Vol. 6, No. 5 (Nov. 1951) pp. 237-240.

### The Paper Maker

Published quarterly by the Hercules Powder Co., Wilmington 99, Delaware, U. S. A., James L. Anderson, Editor. This publication includes many articles on handmade paper, both from a historical and technical point of view.

### Tappi

A monthly technical journal, published by the Technical Association of the Pulp and Paper Industry, (TAPPI) 155 East 44th St., New York 17, N. Y. This publication provides the papers and leading discussions of the Technical Association, with technical data on the whole range of the industry--in matters of management, engineering, operations, science and other technical interest, on pulp, paper, paperboard and converted paper and board products. It is geared to high-level technology, but many reports are applicable or adaptable to small-scale operations. This magazine, like all TAPPI materials, is generally limited to members, which include many libraries. Potential users in the underdeveloped areas, where libraries may not have these materials, are advised to contact TAPPI, as to availability.

### Trade papers and magazines

These deal almost exclusively with large-scale operations. However, the following may have some articles of interest:

Paper Industry--Monthly. Fritz Publications, Inc., 1501 Washington Road, Mendota, Ill.

Paper Trade Journal--Weekly. Lockwood Trade Journal Co., Inc., 15 West 47th St., New York 36, N.Y.

Pulp and Paper--Monthly. Miller Freeman Publications, Bristol, Conn.

In addition, for a complete listing of trade papers and periodicals, the following guides, which are available in many large libraries, may be consulted: N. W. Ayer and Son's Directory of Newspapers and Periodicals, published by N. W. Ayer and Son, West Washington Square, Philadelphia, Pa.; Standard Rate and Data Service, Business Paper Section, published by Standard Rate and Data Service, Inc., 333 North Michigan Ave., Chicago 1, Ill., and Industrial Marketing, published by Advertising Publications, Inc., 480 Lexington Ave., New York, N.Y.

Much if not all of this material will appear in the TAPPI bibliography, also listed in this Appendix under the Bibliography heading.

APPENDIX IV

# Research and Consultant Sources of Information

Listed below are a number of possible sources of information and assistance in the various aspects of the pulp and papermaking industry. While the organizations listed are all interested in helping develop the industry, it may be that too many inquiries may interfere with their primary functions, and correspondence should therefore be entered into with discretion. In addition, many of them are geared to mass-production technology, and may have some difficulty adapting to the scale discussed in this Manual; inquiries, therefore, should be specific and detailed as possible. It should be noted also that there is no pretense that the following list is in any way comprehensive or complete, although it does try to be indicative of the variety of sources of information which may be available.

RESEARCH FACILITIES AVAILABLE THROUGHOUT THE WORLD in subjects related to forestry are listed in a publication by the Food and Agriculture Organization of the United Nations, the FAO Forestry and Forest Products Study No. 9, Research in Forestry and Forest Products, Rome, Italy, September 1953. In addition to research in the United States, this book indicates work on pulp and papermaking in Australia, Austria, Germany, India, Indonesia, Japan, Norway, Portugal and Surinam.

UNITED STATES SOURCES -- The United States Government maintains various laboratories and other facilities in connection with the pulp and paper industry (in some cases, insofar as they are part of the more basic industry involved, such as forestry). In addition, there are many non-profit, educational and private organizations which operate in this field in the United States, as listed below.

The facilities, types of research, and operational programs of the laboratories and organizations listed are varied in scope. Several conduct research ranging from the fibrous raw material (wood, straw, cotton, and waste paper) through all the processes and problems of manufacturing pulp, paper, paperboard, and converting basic material into finished products; others specialize. Fundamental and applied research in the fields of analytical, colloid, and organic chemistry, biology, chemical engineering, physics, and pulp and paper machinery are the broad overall

range of activities. Description and detailed literature outlining facilities and type of research may be obtained direct from the following laboratories.

U. S. Government Laboratories

Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wis.

National Bureau of Standards, U. S. Department of Commerce, Washington, D. C.

Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Peoria, Ill.

Foundations

Fibre Products Laboratory, Springfield, Ohio.

Herty Foundation Laboratory, Savannah, Ga.

Illinois Institute of Technology, Armour Research Foundation Technology Center, Chicago 16, Ill.

Lowell Technological Institute, Lowell, Mass.

Battelle Memorial Institute, 505 King Ave., Columbus, Ohio.

University Laboratories

Institute of Paper Chemistry, Appleton, Wis.

New York State College of Forestry, Syracuse, N. Y.

North Carolina State College, Raleigh, N. C.

University of Florida Engineering Experimental Station, Gainesville, Fla.

University of Maine, Department of Chemical Engineering, Orono, Maine.

Michigan College of Mining and Technology, Houghton, Mich.

University of Washington, Department of Chemistry, Seattle, Wash.

Western Michigan College of Education, Kalamazoo, Mich.

U. S. Forest Service Regional Field Offices

Juneau, Alaska; San Francisco, Calif.; Denver, Colo.; Atlanta, Ga.; Missoula, Mont.; Albuquerque, N. M.; Portland, Oreg.; Upper Darby, Pa.; Ogden, Utah; Milwaukee, Wis.

U. S. Forest Service Experiment Stations-Headquarters

Juneau Alaska; Berkeley, Calif.; Ft. Collins, Colo.; New Orleans, La.; St. Paul, Minn.; Asheville, N. C.; Columbus, Ohio; Portland, Oreg.; Upper Darby, Pa.; Rio Piedras, P. R.; Ogden, Utah.

Universities or Colleges Having Pulp and Paper Curriculum

Specialized college training in pulp, paper and paperboard production (including technical aspects of organic chemistry, engineering, etc.); domestic and international distribution and utilization; economics of the industry; forestry relative to timber and pulpwood resources; and related subjects are presented by a number of universities or colleges, including the following:

State University of New York College of Forestry, Syracuse, N.Y.

University of Maine, Orono, Maine.

Institute of Paper Chemistry, Appleton, Wis. (graduate program only).

Western Michigan College of Education, Kalamazoo, Mich.

Lowell Institute of Technology, Lowell, Mass.

North Carolina State College of Agriculture and Engineering, Raleigh, N. C.

University of Florida, Gainesville, Fla. (graduate program only).

University of Alabama, Tuscaloosa, Ala.

The Technical Association of the Pulp and Paper Industry, 155 East 44th Street, New York 17, N. Y., serves as a world central clearing house for research findings and technical data (see Appendix III, Bibliography, under TAPPI and under the journal Tappi), in all areas of interest to pulp and papermaking, although it maintains no research facilities of its own. While it is geared to mass-production methods, it may be of assistance in response to a direct inquiry.

Parsons & Whittemore-Lyddon Organization, 250 Park Avenue, New York 17, New York. This is a world-wide organization with its own firms in 16 countries on five continents, available for servicing the world-wide pulp and paper industry, with, as it says, "its own program patterned along the lines of the famed Point Four program."

Trade Associations -- A list of U. S. trade associations in pulp and papermaking appears on Pages 12-14 of "Basic Information Sources on Pulp, Paper and Paperboard" (see Appendix III, under "Bibliographies"). These may be able to offer specific advice or information in their specialties, although they are geared to mass-production methods and markets.

OTHER SOURCES -- The oldest continuous handmade-paper mill in the Western world is Cartiere Miliani-Fabriano, in Fabriano, Italy, dating back to 1276. (The photograph of the vatman and couchers, on Page 80 of this Manual, was taken at this mill.) It may be able to provide first-hand experience in answer to specific requests.

The Government of India operates a Research Institute on handmade paper at Maganwadi, Wardha, under the All-India Khadi and Village Industries Board. In addition, there is research in handmade paper in at least the following institutions in India: Handmade Paper Research Centre, Agricultural College Compound, Poona-5 (Bombay State), India; Handmade Paper Research & Production Centre, Director of Industries, West Bengal, P.O. Majhur Char, Kalyani (Nadia), India; Regional Research Laboratory, Hyderabad-Deccan-9, India.

Japan, of course, has the most advanced technology on handmade paper. Requests for information may be directed to a central clearing house, the Japan Paper and Pulp Association, Kami-Parupu Kaikan Building; 4, Ginza Higashi 3-Chome; Chuo-ku, Tokyo.

## M A N U F A C T U R E R S

The following manufacturers in the United States make equipment, as indicated under each listing, which may be useful for the scale of manufacture discussed in this Manual (see Page 168). It should be noted that the mention of any firm, product or process in this report is not to be construed as a recommendation or endorsement but merely as a citation that it is typical in its field. There are many other firms which may make comparable equipment, not only in the United States but also in other countries, as may be determined from listings in commercial directories. (See Appendix III for names of such directories.)

The Black-Clawson Company, Shartle Division, Middleton, Ohio.

Paper stock preparation equipment, including complete laboratory pilot plant equipment which may be comparable to the smallest-scale mechanized facility desired.

E. D. Jones & Sons Company, Pittsfield, Mass.

The Hi-Lo Pulper, and other pulping, beating and refining equipment, in small sizes as well as large.

Morden Machines Company, 3420 S. W. Macadam Avenue, Portland 1, Oregon.

The "Slush-Maker" and other pulping, beating and refining equipment, in small sizes as well as large.

Process Evaluation and Development Corporation, 205 East 42nd Street, New York 17, N. Y.

Developers of PEADCO Process for continuous pulping of bagasse.

Ronningen-Petter Company, Vicksburg, Michigan.

Filters, strainers for use in processing water.

The Sandy Hill Iron and Brass Works, Hudson Falls, N. Y.

Pulping, beating and refining equipment, in small sizes as well as large.

## CONSULTANTS

Government-supported consultant services may be available through local Productivity Centers, Industrial Institutes, Servicios, or United States Operations Missions.

Private consultant services may be obtained through advice of the government agencies listed above, and through private listings among the directories shown in Appendix III. The research and business organizations listed above may, in many cases, offer qualified consultant services on a contract-fee basis; or they may be able to suggest a qualified independent consultant for the specific problem at hand.

APPENDIX V

# Samples of Paper, Showing Grades and Finishes

Beginning on the facing page are sample sheets of various grades and finishes of paper, as discussed primarily in Chapter 9, beginning on Page 96.

Some of the differences in the sheets will be noticeable to the eye or to the touch; others are characteristics or "properties" which are "built into" the sheet to serve certain purposes, for instance ability to take printing ink, or absorb water, or withstand hard usage. Part II of the Manual, dealing with technical aspects, discusses the different processes and materials which make possible the variation in finished product to meet the particular requirements for the intended purpose.

It should be realized that the samples are taken from U. S. standard sheets for the grades as indicated and are machine made. The sheet made by hand may vary somewhat; however, it cannot vary substantially in the principal characteristics and still be identified as the same grade of paper. Even though a variation might make it a better sheet (as noted on Page 78), it becomes a paper of a different grade if it does not have the exact characteristics or properties needed to meet the particular purpose of the specified grade. (See Page 104.)

The notations on the sample sheets include also the "basis size" and the "basic weight" of the various papers shown, as explained at the top of Page 105. In addition, in the case of English Finish Book, three sample sheets are included to demonstrate the difference in thickness and opacity resulting from different "weights" of what would otherwise be exactly the same kind of paper--that is, the same type of paper is shown in 40, 50 and 60 weights.

# MORE INFORMATION AVAILABLE

To start a small-scale or cottage papermaking industry, you will be involved in a variety of special areas of knowledge and skill. While they are discussed briefly in this Manual, more detailed introductions and more technical information materials are available, in such related fields as:

ADVERTISING AND SALES PROMOTION
AGRICULTURE
BUSINESS MANAGEMENT
CHEMICALS
COST ACCOUNTING
COTTAGE INDUSTRIES
CREDIT
DISPLAY
DISTRIBUTION AND MARKETING
FIBERS
FOOD PROCESSING
GRAPHICS
INDUSTRIAL DEVELOPMENT
MACHINE OPERATIONS
MAINTENANCE
MATERIALS HANDLING
MERCHANDISING: WHOLESALE-RETAIL
MINERALS
PACKAGING
PAPER
PLASTICS
PRINTING
PRODUCTION METHODS AND CONTROL
QUALITY CONTROL
SAFETY
SERVICE TRADES
STANDARDIZATION
STYLING
TEXTILES
WASTE
WATER
WOOD

IN ADDITION, THERE IS A FULL RANGE OF MATERIALS ON OTHER INDUSTRIES

For further information and assistance, contact your local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

ANTIQUE BOOK

25 x 38 — 80/500

BIBLE PAPER

25 x 38 — 30/500

BOND 25% RAG

17 x 22 -- 20/500

BOND SULPHITE

17 x 22 — 16/500

COCKLE FINISH

17 x 22 — 20/500

COVER

20 x 26 — 65/500

EGGSHELL TEXT

25 x 38 — 60/500

**EMBOSSED FINISH**

**20 x 26 — 80/500**

ENGLISH FINISH BOOK

25 x 38 — 40/500

ENGLISH FINISH BOOK

25 x 38 — 50/500

DUPLEX BOOK (DULL COATED)

25 x 38 — 80/500

ENGLISH FINISH BOOK

25 x 38 — 60/500

GLOSS ENAMEL

25 x 38 — 70/500

**HI-BULK (GROUND WOOD)**

**25 x 38 — 60/500**

INDEX SULPHITE

25½ x 30½ — 110/500

LEDGER SULPHITE

17 x 22 — 24/500

OFFSET

25 x 38 — 60/500

OFFSET DULL COATED

25 x 38 — 60/500

NEWSPRINT

24 x 36 — 32/500

**OFFSET HOMESPUN (FANCY FINISH)**

**25 x 38 — 70/500**

PARCHMENT (TYPE) PAPER

17 x 22 — 20/500

ONION SKIN

17 x 22 — 9/500

TAG BOARD

24 x 36 — 125/500

VELLUM FINISH

25 x 38 — 70/500

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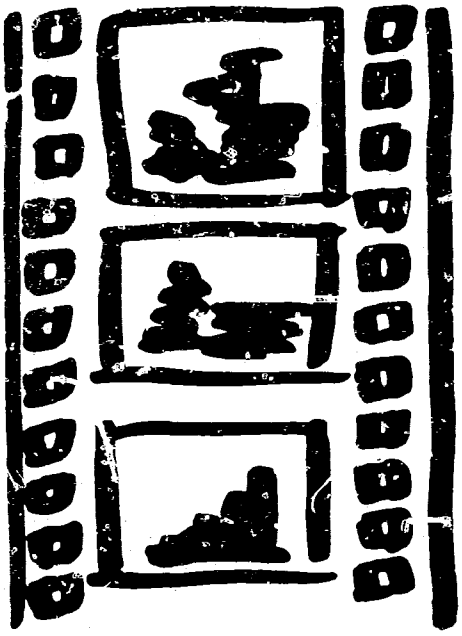
TERMS USED IN THIS MANUAL ARE DEFINED

ON THE PAGES UNDERLINED IN THIS INDEX



The drawings in this Manual have been prepared in the right proportion, and made to cover enough of the key subjects, to allow their use as a film strip or set of slides, for the purpose of illustrating a talk or meeting on the subject of papermaking. These drawings may be photographed or traced, and may be put in any order which will best illustrate the particular point the speaker wishes to make. (See especially Figs. 1 to 7, pages 18 and 19, which include also the basis for a script. For the most part, the photographs in the Manual are also in film strip proportions, and they may make adequate film strip material under some circumstances.