'PAPER, WORTH CARING ABOUT?'

Submitted to the Faculty of History of Art and Design
and Complementary Studies

In Candidacy For

BACHELOR OF DESIGN

DEGREE IN VISUAL COMMUNICATION

by

Jacqueline Carroll

March 1992

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INTRODUCTION

I propose to help people become more aware of the importance of paper. It is probably very much taken for granted, not realising its historical and social value. Its history was a long battle between people and the ages. We are now in the 20th century and I believe that the course of paper has completed its cycle as shown in the following diagram. Although it has travelled the full circle, it is now in a different society, a different set of attitudes and of course, a different environment. This keen interest in recycled paper reflects the fast living society in which we live. I want to discuss the processes of paper-making and its structure, which in turn will help one to understand the reasoning behind the importance of conservation and restoration. Such knowledge would quite possibly enable the general public to give paper the respect it is long overdue. I want to discover whether recycling is more important than restoration. Perhaps both methods are on a par?

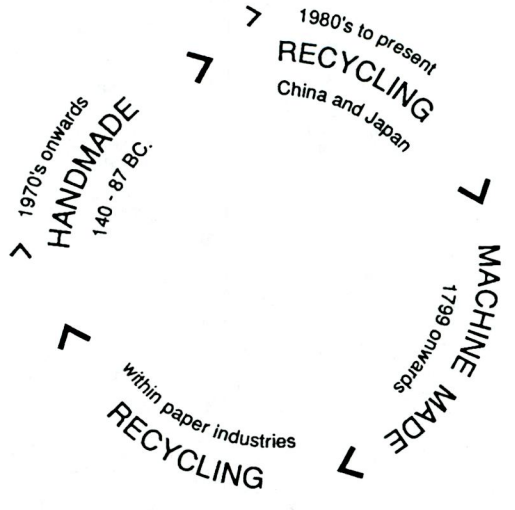


Figure 1-1 - Cycle of Paper-Making.

CHAPTER I

HISTORY

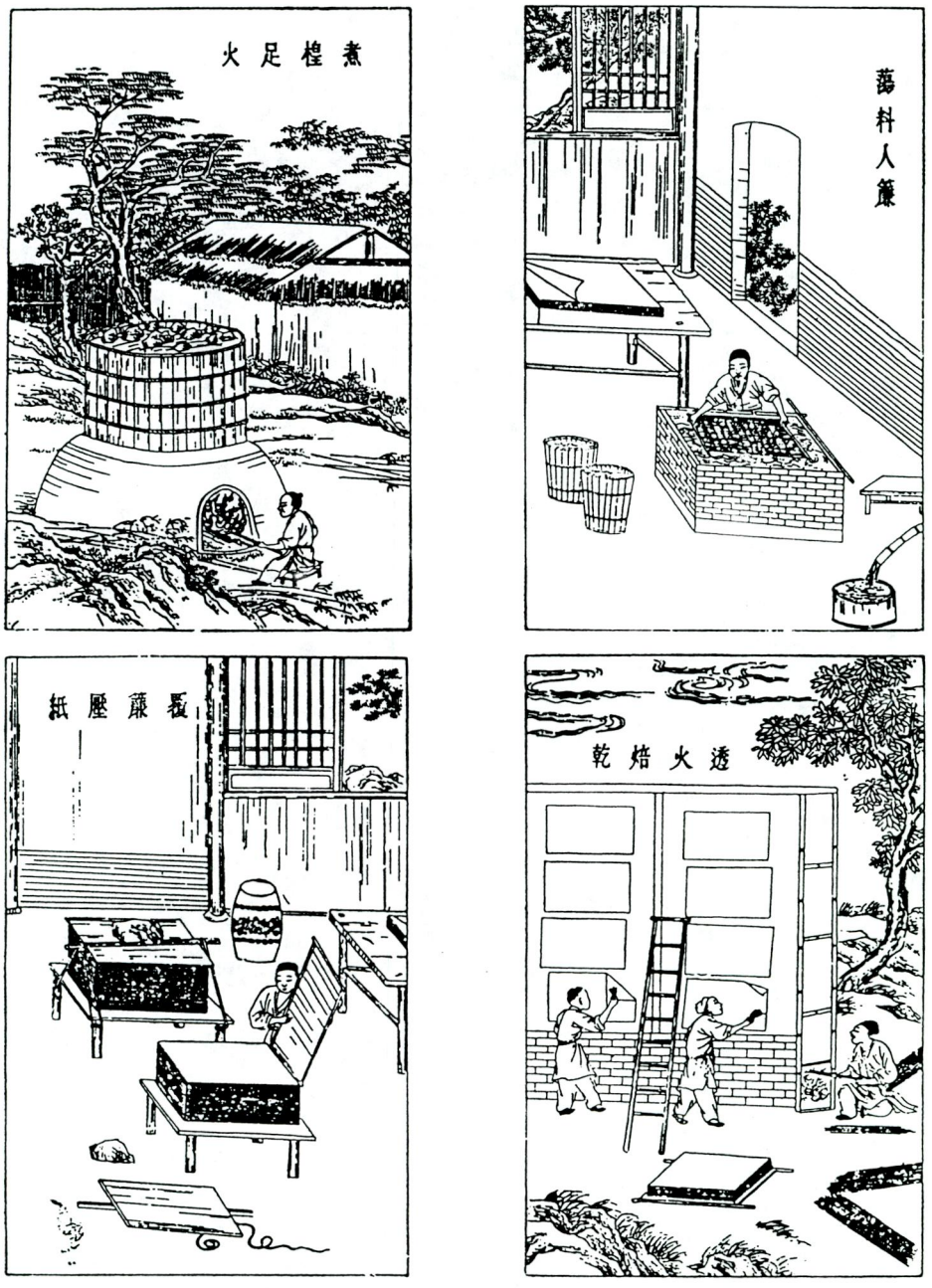
Although paper has been around for over two thousand years, material on which to write extends back as far as approximately five thousand years. The oldest known materials, parchment and papyrus are quite often confused with paper as they do serve the same purpose. The characteristics of paper and papyrus or parchment differ greatly in method of manufacture and also their use, as society both industrially and socially developed, which will be discussed in a later chapter.

We might know of dates relating to events, wars and inventions. However, no-one can put a precise date on the invention of paper but rather trace its development beginning as far back as possible. In 1901, a piece of paper was discovered by an explorer, Sven Hedin, which dated back to the year 250 A.D. Fifty six years later another sample of paper, found during excavations at Xian, dated back to 140-87 B.C. (1) Paper's development was no accident, but instead developed through necessity. The introduction of the 'brush' into China two thousand years ago resulted in people writing and drawing on silk. The soft and pliable characteristics of silk was entirely compatible with the nature of the brush. However, silk was very expensive and so the Chinese set out to discover a cheaper material on which to write but it also had to be soft and pliable. The result of their time, patience and experimentation was to develop and refine the fundamental steps to paper-making, which have remained with us, the world over.

By the last years of the 6th century, the Chines art of paper-making was spreading, reaching Korea and Japan. However it had already been in Japan, as Japanese writings of that time refer to its use and re-use. Indeed, this country and China make references to the first every recycled paper. As the paper being re-used had inks and dyes present, the new sheet would be greyish blue. The Japanese surpassed all other countries with their utilisation of paper. They used it for calligraphy, fans and garments. It was also used as part of the interior of their houses. Shoji or translucent paper was used in windows and fusuma or opaque made up the panels or partitions dividing rooms. (2)

China also had trade links with Jewish and Arab merchants. It was not through a peaceful means that the Arabs learned about paper-making. By the early 8th century the Chinese empire had reached the Turkish borders. At the same time in the East, the new-found power of the Islams was dominant. War broke out between China and Turkey, with the Arabs defending the latter, which resulted in China's defeat. As well as Chinese soldiers, civilians were taken prisoner. They taught their paper-making skills to the Arabs in return for their freedom. Technically, the skill did not advance in any way in the hands of the Arabs because they kept it a domestic industry. This marked the beginning of a four-hundred year journey for paper-making to reach across the Arab world, travelling from Samarkand to Spain and Morocco. (3)

Figure 1-2 - Early Paper-Making in China.



Chinese paper-making. From T'ien-kung k'aiwu, a dissertation on crafts by Sung Ying-hsing, 1634. Top left: Steaming bast. Top right: Paper formation. Bottom left: Pressing. Bottom right: Drying against a heated wall.

Figure 1-3 - Chinese Paper-Making.

Mid-11th century saw the coming of paper to Christian Europe from Spain, Sicily and Constantinople. Parchment was still important and used for official documents. By the 13th century the quality of paper-making was very high and was being exported to Italy, France and England. Soon, Italy was producing high-quality paper also, emerging mainly from Genoa, Milan and Venice. Paper-making reached France by means of the Jewish people, who had been paper-makers in Spain since the middle of the 11th century. They had to flee from Spain due to religious persecutions from Christians. Germany began to make paper during the last decade of the 14th century and Switzerland followed about twenty years later.

Paper-making reached Austria, Bohemia and Hungary from either Holland or Germany. Holland began making paper at the end of the 15th century and the following hundred years saw it become one of the leading manufacturing countries in Europe. England was using paper since the 13th century but only began making it in 1588. It was not until the 1820's that the first patented paper-making machine was established in England. About ten years later Ireland's first machine was up and running in Cork.

The art of paper-making arrived in America through the Spanish, when they built a paper mill in Mexico in 1680. It took two centuries for the skill to spread to America. It reached Canada in 1803 but it was another sixty-five years before it arrived in Australia.

The first paper-making machine was built and used in Scandanavia

in the last years of the 18th century. Invented by Louis Robert, it too came about through necessity. There was unrest among workers at his paper mill due to heavy workloads. Paper was in great demand and he knew the only solution to the problem of quantity was a mechanical one. He developed the machine with financial aid from the French Government. Another major financier was Henry and Seale Fourdrinier, who aided with the patent and also from whom the machine got its name.

The end of the 19th century witnessed rapid improvements to the Fourdrinier. Demand for paper escalated. Output was speeded up but the width of the machinery did not exceed three metres. By the beginning of the 20th century designs for bigger and better machines were being realised. The year 1915 saw the introduction of a machine five metres wide, with an output of two hundred metres per minute. This contrasted greatly with the previously accepted hundred metres per minute. An American-designed machine exceeded that amount five years later by producing three hundred metres within the minute. Ten years later witnessed machines eight metres wide, producing four hundred metres within the minute barrier. Beneath this mass development, speed and production, the fundamental design of the Fourdrinier remained unchanged. (4)

Mechanically-made paper produced a good quality that put hand-made paper under extreme pressure. This resulted in hand-made paper declining rapidly. Taking Japan for example, whom experienced the Industrial Revolution almost immediately after the Prusso-Japanese War in 1905. Hand-made paper could not compete with its

mechanical counterpart. The amount of Japanese households producing hand-made paper in 1901 was 68,562, falling to 13,577 by 1941. By 1973 the figure had plummeted to 697 - the development of mechanically-made imitation 'hand-made' paper would have, at the time, dashed any hopes of the survival of the genuine hand-made sheet.

One can see though this historical look at the development of paper, how even facts and figures changed so rapidly as time progressed. Earlier events, like the spreading of the skill itself, happened in blocks of one, two or even four hundred years. Finally developments relating to quality and quantity happened in leaps and bounds of five or ten years. However, it is now quite necessary to take a step back in time to discuss a very important reason why the process of producing paper speeded up. Louis Robert developed the Fourdrinier because of the demand on paper. One of the reasons for this demand could be summed up in a name, Guttenberg.

Johan Guttenberg has often been mistakenly called the inventor of printing. This is untrue as printing extends back to the Chinese in 594 A.D. When he died in 1458, Guttenberg left behind him two inventions which changed the art of printing, the demand on paper and thus the world of literature underwent an irreversible change. (5, 6)

Firstly, Guttenberg conceived and realised the idea of having movable type. With that resulted in a demand for letters for

printing, so he went on to make recasts of types by pouring molten lead into moulds. The result was that the spread of printing increased dramatically and so too did the demand on paper. His second invention was the development of a printing ink that would adhere to metal types in the printing press. Not only was the quality of paper required important but now the physical quality of the paper had to be considered. The paper had to withstand the pressures of the metal movable types, the process of actually passing through the press and also accept the ink Guttenberg developed. (7, 8)

One wonders how paper can withstand these various demands, being such a fragile material. It has come a long way from being at the receiving end of the gentle brushstroke, to what machines and society subject it to nowadays. However, it would not be fair to say that all paper is fragile. Indeed, it is perhaps stronger and more versatile than one might realise. The only way to know and understand its true strength is to have a knowledge of paper's actual ingredients.

CHAPTER II

CHEMISTRY

Chemistry is the science concerned with properties and their combinations and reactions. Paper too is a substance with properties and fortunately is not taken for granted as much as it used to be. With the growing importance of concern for our environment, properties of paper and their reaction with everything including storage, handling and environmental aspects, come under close scrutiny. Paper comes from pulp which is a mixture of water, fibres and adhesive additives. All fibres are cellular in structure and are called cellulose. However, do everyday users of paper actually understand the terms cellulose, fibres or pulp? Also, do we really understand man-made or synthetic fibres and their viability in paper-making?

Cellulose is a chain molecule. Every link in the chain molecule is a glucose molecule. This glucose molecule comprises of a sugar species and five carbon atoms. A sixth carbon atom is linked to the ring but it a carries a hydroxyl group. Every glucose molecule has three hydroxyl groups, the other two being linked directly to the carbon atoms. The links or glucose molecules are held together with an oxygen atom (Figure 2-1). Cellulose chains vary in length. Alpha chains of cellulose are extremely strong with possibly thousands of links or molecules. The shorter chains are not as strong and are called hydro-cellulose, which have a small content of sugar species. Cellulose chains lie in rows stacked together forming bundles, each bundle known as a fibril. (9)

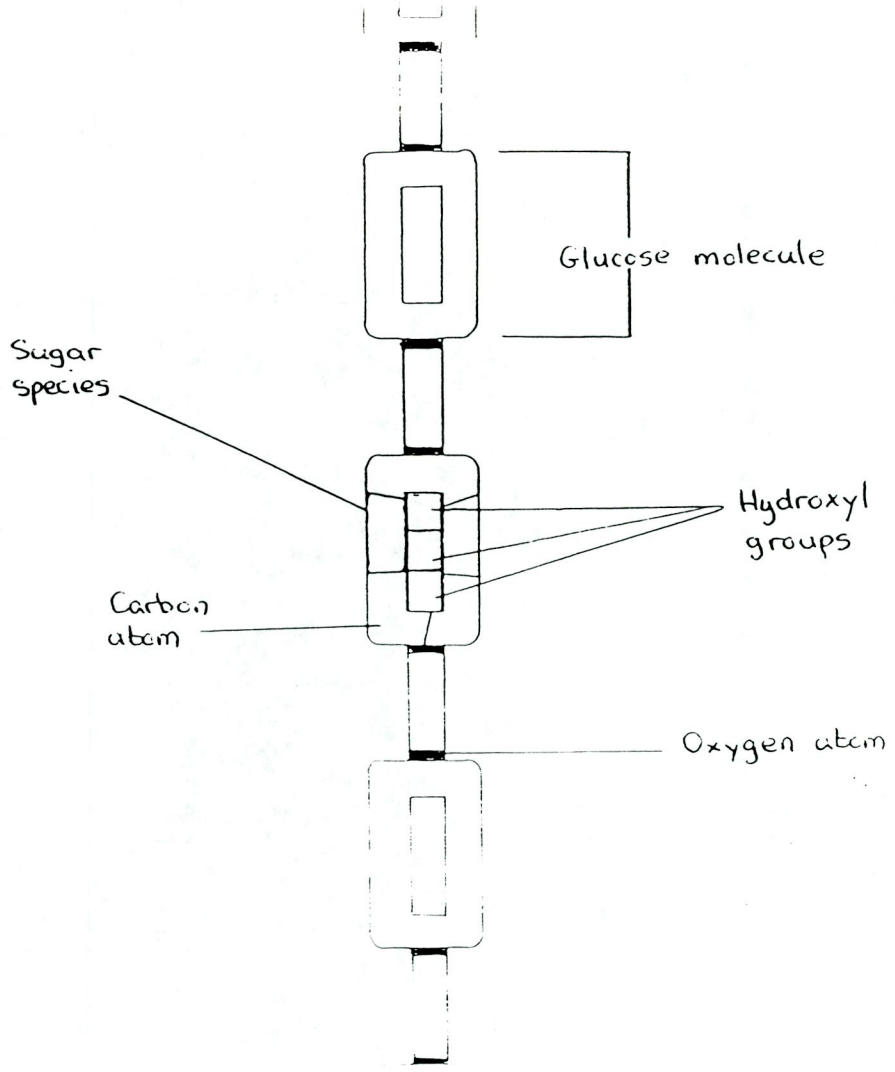


Figure 2-1 - Chain Molecule.

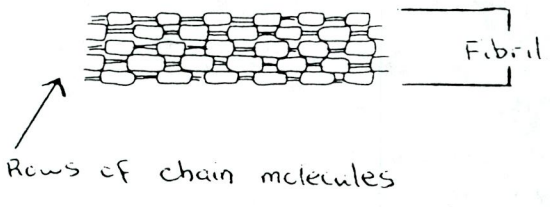


Figure 2-2 - Close-up of Fibril.

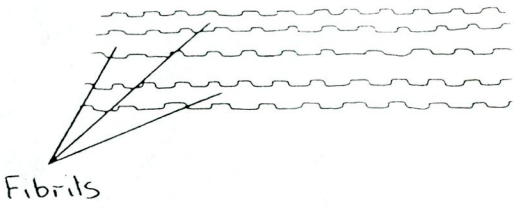


Figure 2-3 - Close-up of Fibre

A bundle of fibrils packed together form a fibre, which can be simple or compound in nature (Figures 2-2 and 2-3).

Simple cellulose fibres are taken from cotton, linen and hemp. They are normally used in hand-made paper due to their strength. Fibres with a simple cellulose make-up are not used for industrial paper-making because it would be too expensive. There would also be problems with printing if it was used in books. Paper made from simple cellulose have different characteristics depending on the raw material from which it came. Cotton-based paper gives a very white finish, linen gives a stiff paper, although still easily torn and finally paper made from hemp fibres is very strong. Papers manufactured for books require three fundamental characteristics. It must be light enough to turn over but not easily torn and also enduring to the ravages of time. The latter of these points refers to the finish which can be measured scientifically by using artificial ageing techniques. Indeed these aspects are relevant to paper in varying degrees, depending on its use. (10, 11)

Compound cellulose fibres come from Esparto grass and straw. These fibres are shorter and less resistant to the process of purification. Paper of this cellular content is not as strong or as durable as simple cellulose paper. Straw fibres are not as soft or bulky as Esparto grass fibres. Esparto-based paper can be manipulated into a soft 'fluffy' pulp and is suitable for off-set printing. Such paper is creamy in colour, clean and onto which ink will adhere to easily. This paper was used extensively in

Britain for a good many years but was eventually replaced by a wood fibre paper. However, it was discovered that the ideal paper came from a mixture of Esparto and wood fibres together. This results in a paper which allows easy running through the paper-making machine. During the 19th century wood became the most popular source of fibre as it was economical, accessible and plentiful. Wood fibres are also of a compound cellular nature. Sources are coniferous or softwood trees such as Spruce or Pine, and deciduous or hardwood trees like Eucalyptus, Poplar and Chestnut. The cellulose content of wood fibres is less than that of cotton (Fig. 2-4) (12, 13)

The fibres of a raw material are completely broken down prior to the pulp-making stage. This is called fibre processing. The extent to which fibres are disintegrated depends on the quality of paper desired. As the fibres are weakened during processing, they are forced to absorb more water. The cell wall of the fibre swells and fill up even further. The cellulose is now called hydro-cellulose. The more saturated the hydro-cellulose becomes, the slower it will be at releasing water at the drying stage. A slow drying rate will result in a better quality paper. (14)

Ninety-nine percent of the total weight of a pulp solution is water. The making of paper is all about extracting the water from the mixture of fibres and additives. The finished product normally has a water content of five percent but this can vary only slightly. The quality of water is very important, as has been noted in Scotland for example. The quality of paper here is

renowned all over the world due to the purity of the water.

Mechanical wood pulp is the result of a process which does not include chemicals. This process is inexpensive and only suitable for short-lived papers because certain impurities will filter through and weaken the structure of the paper. Mechanical pulp paper is usually strengthened with an addition of approximately fifteen percent of a stronger fibre. This gives a more opaque absorbent paper which can be bleached for a whiter finish.

The manufacture of paper with chemical pulp has longevity in mind and is more expensive. Chemical pulp and all other fibres, except mechanical wood, are put through the chemical process. The quality of pulp produced depends on the chemical alkaline which removes the ligneous and dissolves unwanted particles. It also dissolves the lignin which originally held the fibres together during its lifetime. The pulp is then bleached and washed.

Sulphite pulp is the result of using an acidic liquor called calcium bisulphate. Sulphate pulp is similar except that the chemical used here is called caustic soda. This chemical is suited particularly to Esparto and deciduous woods. Strong bleachable pulp is combined with cartridge paper. Easy bleachable pulp is mixed with Esparto and used for good quality paper. (15)

Certain chemicals are added to pulp for strengthening the paper. Addition of minerals or chemicals at the pulping stage is called loading or filling. In China the usual form of filling used is

clay. Different qualities of clay are used but the most common one used by the Chinese is Titanium dioxide, resulting in a very white opaque paper. An alkaline is added to the mixture to neutralise the effects of the acidic air. A loading of calcium carbonate can lower the risk of expansion and contraction of paper in a changing atmosphere, which will be discussed at a later stage. Overloading however will reduce the strength of the end product. With durability lessened there would be deterioration in damp conditions. (16)

Another mineral that can be added to the pulp stage is called engine size, which renders the paper oilproof. At the printing stage, for example, inks will not soak through the paper. Size is equivalent to and therefore replaces the lignin which had been dissolved, thus keeping the fibres intact. Alum and Rosin are two varieties of size that had been used since the 17th century. It was discovered however that they react, giving off sulphuric acid, leading to rapid deterioration. Nowadays, natural-based sizes are used, such as starch, casein and waterglass. (17, 18)

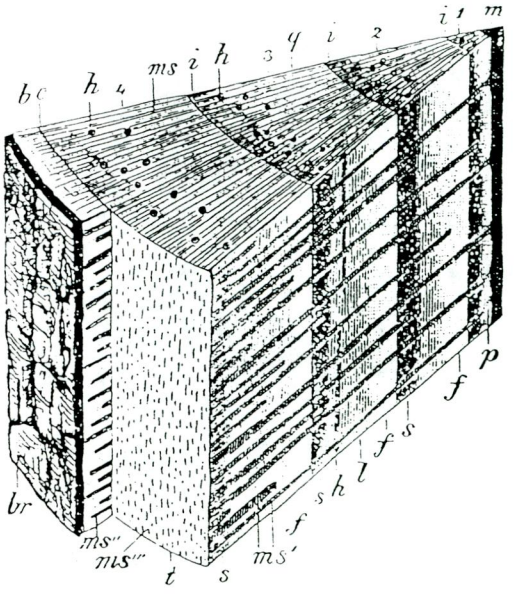
Paper is normally made from cellulosic material. However the chemistry make-up of paper has been experimented with, in relation to synthetic fibres. These man-made fibres are not hydrophilic. Instead, they are hydrophobic or averted to water. Nylon for example only has a water retention of four percent. Orlon, Terylene and Dacron are also hydrophobic fibres, only having a water retention of one percent. The preparation of pulp with synthetic fibres is difficult. The fibres are cut to the desired

length and added to water. However, synthetic fibres do not fibrillate but rather they decrease in length, causing difficulties in joining or even matting together.

The abilities of fibres bonding determines the strength of the paper. Cellulose fibres create no real difficulties. Synthetic fibres however cannot bond by beating or fibrillation. They can be either salt-bonded or bonded with synthetic polymer. Salt-bonding relies on concentrated salt reacting with the fibres. The salt solution causes the fibres to swell and become solvent. Different variations of salt are used on different synthetic fibres. A mixture of calcium and lithium bromide is used with Nylon. Calcium, and magnesium thiocyanates combined is added to Orlon and Dacron. The quantity used is usually five to ten percent of the entire solution. In bonding the water evaporates and the salt is lodged between the fibres. The bonding agent is the fibre itself as the high concentration of salt causes the fibres to gelatinise becoming sticky. As the binding agent is the fibre, the result is a homogeneous paper. (19)

Synthetic polymer bonding is similar to salt bonding except that a chemical called polymer is used instead of salt. The water evaporates from the mixture and the concentrated polymer lodges between fibres, reacts chemically giving a sticky consistency and joins the fibres. Different polymeric substances are suited to certain synthetic fibres. A synthetic latex called chemigum is used on Orlon and polyamide is used to join Nylon fibres. Preparation is similar to that of ordinary pulp. Fibres are

Straw cellulose, magnified 250 times. From Hassing.



Part of a four year-old spruce trunk at the boundary between two annual rings: 1, 2, 3, 4 four consecutive annual rings, in pith, f early wood, s late wood, c cambium, b inner bark, br outer bark; h resin canal, ms pith rays in the cross-sectional surface, ms' pith rays in the longitudinal section surface; ms'' pith rays in the inner bark, ms''' pith rays in cross-section

Figure 2-4 - Straw Cellulose magnified 250 times and Cross-Section of Tree.

chopped to required size, added to water and chemicals. The liquid is poured onto a screen, water drains off leaving what is called a 'waterleaf'. The waterleaf is the thin layer of paper still in its wet state. It is then hot-pressed at around one hundred and sixty degrees Celsius and put under a two hundred pound pressure for thirty seconds, resulting in a bone dry synthetic paper. (20, 21)

Properties of synthetic fibres vary according to the chemical used. For example, papers made from Nylon fibres and salt bonded are not suitable for extensive folding. When it is polymer bonded it would withstand folding. Fibrids are imitation wood pulp fibres. They have the same bonding properties as wood pulp and come in Nylon, Dacron and Orlon. The texture of Dacron is like parchment. It is similar to blotting paper to write on and would take about sixty thousand folds to break up a sheet of Dacron paper. Originally, it was considered that synthetic fibre paper be used for currency, maps and as filters for corrosive chemicals. Such paper has also been used to insulate electrical materials. (22)

CHAPTER III

INDUSTRIAL VERSUS HAND-MADE

Before looking at the differences between hand-made and industrial-made paper, one might consider how paper was made before machines were invented. Indeed as I have already said paper, papyrus and parchment have been around a long time. They were all used to write on but are all very different in the making.

The difference between paper and papyrus is that the raw material for paper is completely broken down into individual fibres but the latter is quite different. The name papyrus is derived from the plant called Cyperus Papyrus, which is a perennial flat leaf grass. It can grow up to six metres high and has a complicated root system and was originally found in Africa. When being harvested the most important part of the stalk is the first half-metre from the ground up. Its core is white and any damage would cause a brown stain in the end result. (23)

The bark is removed from the stems. They are laid on a flat piece of cotton, horizontally, each overlapping the previous one by a few milimetres. This continues until the sheet is around three centimetres thick. Another sheet of cotton is laid on top, holding the lengths in position. A felt layer is put on top of the cotton to absorb moisture during pressing. Weights were used originally but the screw-press was developed and proved more effective. Pressing took place at intervals until the sheet was

dry. However how does the sheet stay intact? One theory has been put forward by a Dr. Hassan Ragab who began studying papyrus in 1962. He believes that the core of the papyrus contains saccharids which glue the fibres together. (24)

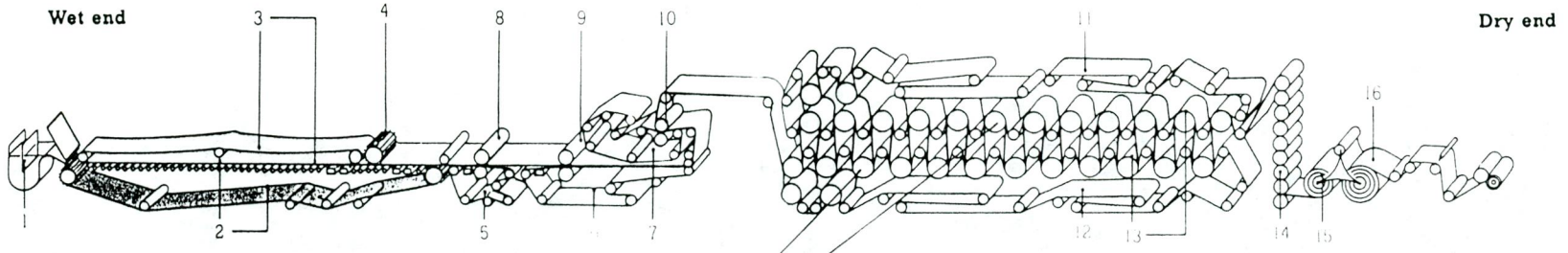
In those early times parchment was a very valuable material and is today still highly valued. It is very different to paper and papyrus in that it is made from a single piece of material, sheep's or goat's skin. The skin is scraped and dried on a frame, scraped again and polished. Parchment made from lamb's skin is velum.

These methods were used for centuries but the Industrial Revolution brought about many changes and improvements and the area of paper-making was no different. The paper-making came about at the beginning of the 19th century and between the years 1830 and 1910 a lot of hand-made paper businesses closed down. A minority of hand-makers persisted and eventually a revival for the business slowly began about twenty years ago, with historians, paper societies and conservators becoming involved. Paper can be either mould or machinery or hand-made. Nowadays all methods are important for both aesthetic and economic reasons. It is necessary to see how different those methods are and perhaps find out the advantages and disadvantages each might have. (25, 26)

With industrial-made paper, there may have been slight differences down through the years but the fundamental layout and design of the paper-making machine remains unchanged. The Fourdrinier,

invented in 1799, is today one of the biggest working machines in operation, as a single unit in its entirety. The largest one is nine metres wide and ninety metres long. It can run off up to two thousand metres of paper per minute, running speed is equivalent to seventy-five miles per hour. To build and install a Fourdrinier nowadays would cost within the region of £5,000,000. It probably wouldn't be economical to produce anything less than a tonne of paper in one go. The paper is a continuous web. A batch of paper that has been made to specific ingredients, relating to the combination of fibres and mineral and appropriate beating times is called a making. Its substance is the quality and weight of the sheet which is determined by the speed at which the pulp is poured onto the wire mesh of the machine. This wire is continuous and vibrates throughout the entire process. The vibration stops the fibres from setting in the same direction as the flow of the pulp, thus it determines the grain of the paper. It also prohibits the fibres from clumping together, which if happened would cause weak spots in the finished sheet. The wire side of the paper is always rougher than the upper side (Fig. 3-1). (27, 28)

The pulp does not flow off the sides of the wire mesh as it is fitted with a strap running along both sides, diagonally. Known as a deckle it can be adjusted to determine the size of the web of paper. The maximum width of paper a machine can manufacture is also called the deckle. As the pulp travels along the wire mesh, the drainage of water is aided by suction boxes underneath. Some machines are fitted with two layers of wire and therefore two webs of paper, running simultaneously. The papers join at the end



Paper making (above) In the Fourdrinier part of the machine the paper pulp is fed out of the flow box (**1**) on to the Fourdrinier wire screen belt (**2**). Deckle straps (**3**) ensure that the paper pulp does not slide off the wire screen belt. In the press part of the machine, the dandy roll (**4**) forms the web of paper. The paper, conveyed by belts (**5, 6** and **7**), is pressed between sets of rollers (**8, 9** and **10**) that extract excess moisture. The paper is then conveyed to the dryer where it is passed between the upper and lower felts (belts covered with felt) (**11** and **12**). The felts themselves are dried by passing over a number of felt driers (**13**). In the calender part of the machine the now dry paper is fed through a calender stack (**14**), which polishes the paper to give it a good finish, then on to a winding reel (**15**). When this reel is full, the machine feeds the paper onto another reel (**16**). The paper from the full reel is then unwound and fed by rollers on to a further winding reel. The pictures show the wet end (**right**) and the dry end (**below**).

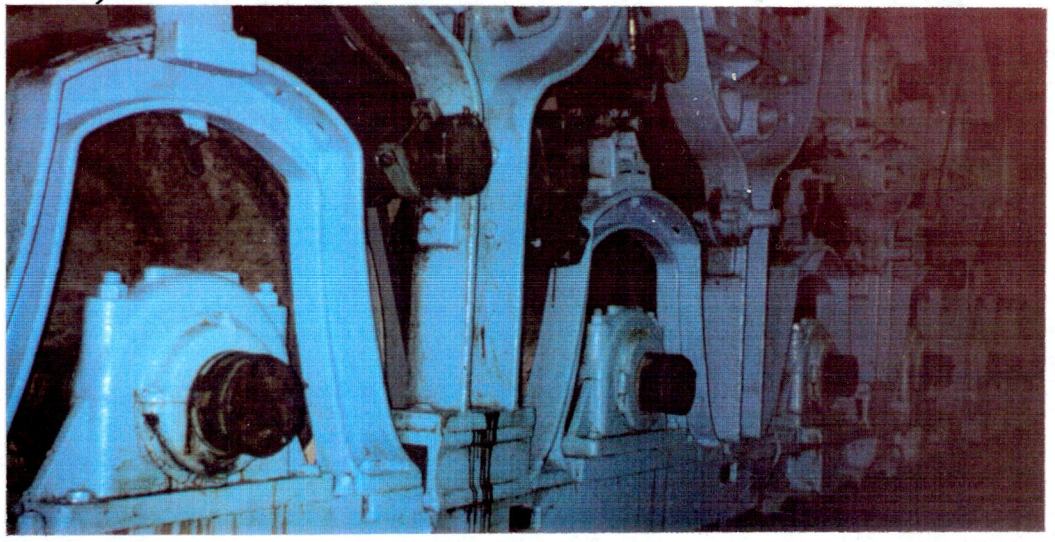


Figure 3-1 - Diagram of Fourdrinier Machine.

making one sheet. The advantage of the twin-wire process if that there is no rough side, as they have joined.

When the paper begins to form it passes under a wire-covered roll called a Dandy Roll. As well as squeezing excess water from the paper, it also administers the watermark. The design of the watermark is in relief on the roll and indents the paper leaving a transparent mark. The most commonly used Dandy Roll is covered diagonally with wire, resulting in a smooth finish called wove paper, with no visible wire marks. Another type of Dandy Roll has a wire covering travelling against the direction of the grain of the paper. These chain-wires are quite far apart and the type of paper produced is laid paper (Fig. 3-2). (29, 30)

At this stage the paper, still wet, cannot support itself. It is now leaving the wet end and proceeds through a mass of felt reels and pressure rollers. This part of the machine called the dry end will dry the paper almost completely. Here there are two options in treating the paper. It can be machine coated with China clay or given a coat of size. This surface sizing differs from the sizing at the pulp stage but will in fact complement each other. The paper is dried through steam-heated rollers and passed through machines calenders giving a finished surface. The friction between the rollers can be adjusted to determine the weight and surface of the paper. Paper passed lightly through will give an antique finish. Heavy calendering results in a glossy finish. Finally, the paper can if desired, be mechanically passed through a tank of size such as casein. Known as tub-sizing it can add up

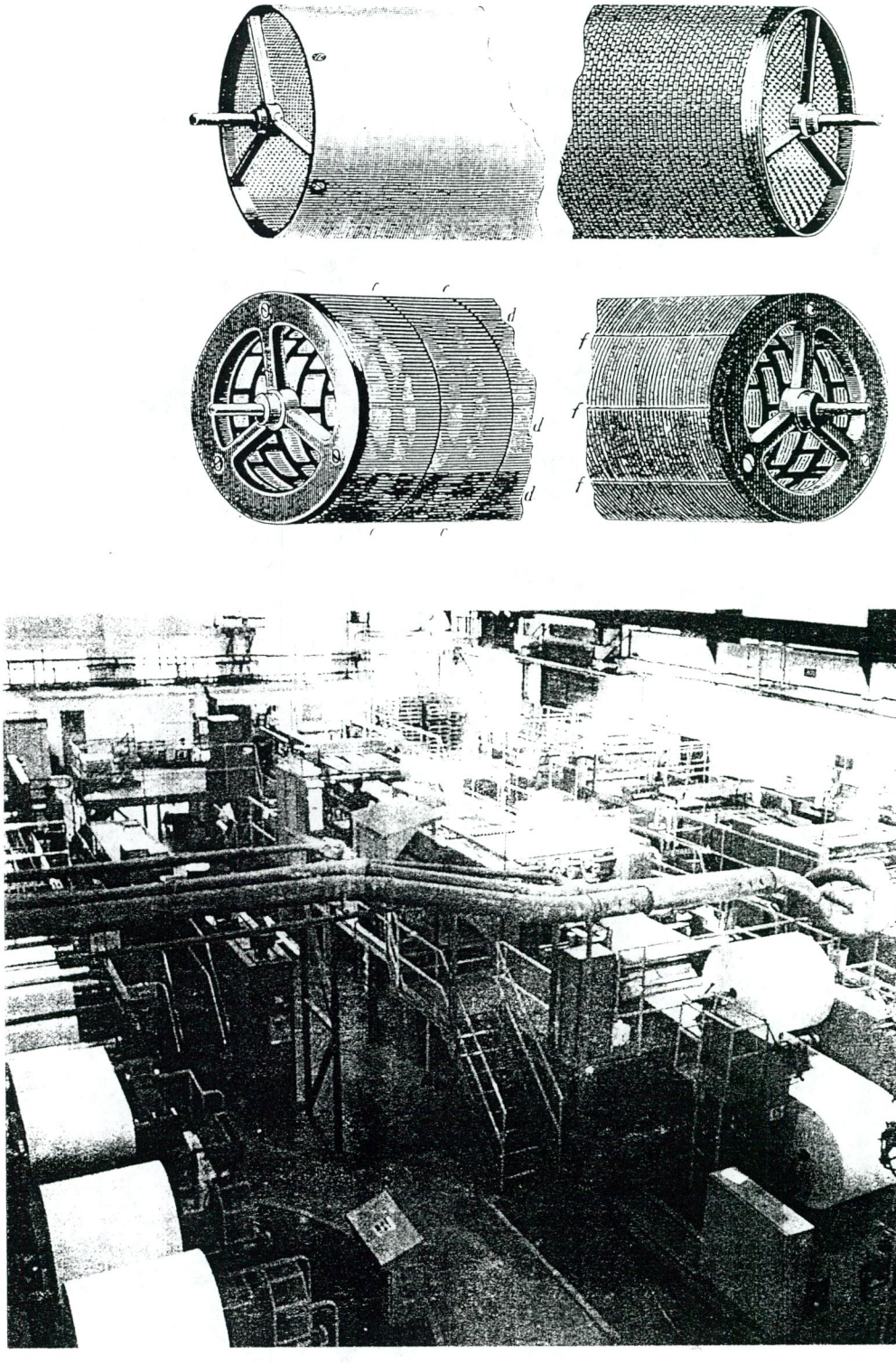


Figure 3-2 - Variety of Dandy Rolls and Interior of Paper-Making Plant.

to between five and forty percent of the paper's substance. There are four degrees of finish available - bright, bloom, semi-matt and matt. (31, 32)

The characteristics of a sheet are taken into account when selecting. The bulk of the paper is the ratio between its weight and calliper or thickness. Paper weighs in grams per metre squared or gsm. The grain of the paper is particularly important in book-binding. Direction of grain in pages, end pages and cover should coincide. It not, turning pages would break the grain and weaken the paper. The spine should also coincide. In relation to books, the opacity of paper is whether the word or image can be seen from the reverse side of the page. The colour of book pages are generally white or creamy. White pages project the type and colour images more decisively than cream pages. Stiffness and tear resistance does not always guarantee longevity of a book. (33)

If machines can turn out tonnes of paper in a short space of time, why use a slower process? Since the 1970's people have begun to see paper-making as a craft. One might say that this revival is a nostalgic longing for ways gone by, our heritage be achieving an individuality with paper. The best machine-made paper could never create the quality of individualism of a hand-made sheet.

Making hand-made paper is very much the same process used in the past. Following the breakdown of raw material into pulp, it is poured into a container or vat which is catered for by a vatman.

S/he dips the mould into the pulp and lifts out a covering on the wire. The water is drained off by constantly shaking from side to side. Known as couching this prevents the fibres from clumping together. The wet sheet is turned out onto a felt mat to drain. When a number of sheets are prepared, they are stacked on top of each other with a felt mat between each and put under a screw-press to drain off more water. Unlike the machine process, hand-made sheets are left to dry naturally. If necessary, hand-made sheets can be dipped in a natural-based size. Rosin which is soluble, coming from pine trees is added to the pulp for two reasons. It helps the fibres adhere and will also permit the addition of aluminium sulphate or alum. The alum must be carefully calculated when being mixed as it gives a harder but pliable surface and acts as a fixative for dyes. A miscalculated mixture would lead to deterioration (Fig. 3-3). (34)

Whether machine or hand-made the demand for white paper is ever increasing. Bleaching hand-made paper can destroy certain properties and therefore it is usually not used. However it is possible to have naturally white hand-made paper by using cotton cellulose. (35)

Down through the ages naturally grown berries and herbs were used for dying paper but permanence of colour was short-lived. Today the two basic ways of colouring are pigments and dyes. Pigments are colour particles suspended in the pulp and do not adhere to the fibres. They are usually used for pastel sheets. Dyes are chemical substances, soluble in water and actually change the

colour of the fibre. The results are more vibrant and longer lasting. Direct dyes have sodium salts which are compatible with cellulose fibres. (36)

As mentioned before the machine process is seen as a single unit but the hand-made process comprises of a number of units or tools. A well crafted sheet of hand-made paper requires four factors. A good mould, the correct pulp, a good vatman and an experienced coucher. The mould, normally made of cuba wood or mahogany houses the wire mesh. Mouldmaking is a well-established craft and good ones must be treated against warping due to constant use in water. The watermark is found on the screen and different screens create different finishes similar to the machine process. Phosphor bronze wires are used in wove screen. In the mould frame next to the screen is another frame called a deckle which controls the type of edge required on a sheet. Thick hand-made paper usually has two to three percent fibre in the pulp and thin paper requires no more than .5 to .7 percent fibre. Hand-made paper is available in three classes of finish. A 'rough' finish is when paper is dried only once and the impressions of the felt are visible. The term 'not rough' refers to when it has been repressed without felt mats. 'Hot pressed' is when the paper has been run through metal rollers. In the past anything from a piece of flint to a shell was used to give the final touch. (37)

People opt for either hand-made or machine-made papers for varied reasons depending on the job in hand. In today's society speed and time are of the essence. There is little comparison between taking twenty seconds to produce two thousand sheets of paper by

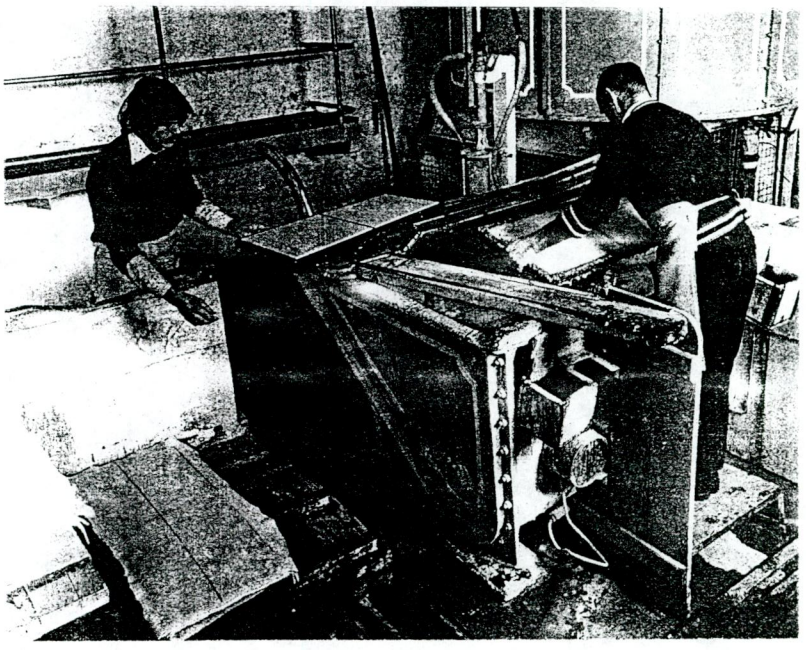


Figure 3-3 - Interior of Hand-Made Papermill.

machine and the same time is taken to produce one sheet of hand-made paper. It is the hand-made paper however that has character as it will probably last longer than machine paper. It is a shame to see these extraordinary speeds meeting society's demands, with poor quality especially with mass produced cheap books. However, attitudes are changing, as there is growing interest in replacing poorer quality paper with recycled paper.

CHAPTER IV

RECYCLING

Recycled paper has always been around, indeed as the Chinese and Japanese developed paper-making, they also recycled it. For years we have dumped our waste seeing it only as being a nuisance. However, recycling has been going on within industries all the time. It is only recently, through media and political attention, that the general public in Ireland have become aware of the fundamental necessity of recycling. Finally, we are catching up on our European counterparts.

A world-wide growth in population and a rising in the standard of living put an increased demand on natural resources. We live in what one might call a 'disposable' society not realising the potential value of our waste products. As a member of the European Economic Community, Ireland has obligations to adhere to certain regulations. This has resulted in the Environmental Action Programme being administered. There are four initiatives to this programme starting with the efforts of the local authorities. This I believe is the cornerstone of the whole operation, as the local authority researches the area to find out if a recycling scheme would be feasible. If so, they would then promote recycling and set up adequate facilities. To do this one requires financial aid provided by the government authority. The Industrial Development Authority would also undertake researching and possibly set up a new industry dealing entirely with recycled paper products. The final initiative relates to studying and

possibly adapting the tax system to promote recycling on a commercial level. It is all very fine having a scheme like this but its motives are economically based. I believe that a good recycling system in Ireland would eventually cut down on our import bills. However, we still have a long way to go before benefiting financially. This scheme will really only work if the public are motivated through their own conscience, which is why the majority are presently more concerned with the effects on the environment.

Any variety of papers are free of metals and plastics are suitable for recycling. There are different grades of paper and low grade such as newspapers are the easiest to recycle. Magazines are also low grade but are separated from newsprint because they will require more bleaching. Cardboard is low grade paper and in big demand, which is why recycling mills such as Smurfits in Clonskeagh, are a thriving success. Computer printout paper is high grade but still worth recycling due the quantity in circulation. There is an endless list of uncollected waste that could add to recycling. They vary such as telephone books, greeting cards, paper bags, calendars, comics, bills and even cigarette packets. All this waste is known collectively as post-consumer waste because it has completed the circle of manufacture, printing and consumer usage. Pre-consumer waste are printer's off-cuts, any printed pages that went wrong and even envelope trimmings. This is basically any printed paper that never reached its final destination, the consumer. However, every time paper is recycled the fibres are weakened. To strengthen the cycle, virgin

fibre is introduced to the pulp. Virgin fibre is essentially used in paper required for technical use such as printing machines, copiers and laser printers.

Packaging is very suitable for recycled paper and board. Smurfit's Papermill deals entirely with recycling, producing brown paper from which corrugated care is made. Recycled paper is made from secondary fibre which normally has a high content of foreign matter. At Smurfits, extra steps are undertaken to purify the fibres. Materials received are divided into two categories. Old card cartons or O.C.C. and kraft loose shavings or K.L.S, which comprises of shredded paper and magazines. At the early stage of pulp-making, the mixture passes through a series of purifiers. Known as turbo separators they first remove large metals, like staples. Next, any large plastic matter is discarded and finally passing into high and low consistency cleaners where very fine particles are removed (Fig. 4-1).

Now the purified pulp will follow the machine process and leave the mill as huge rolls of brown paper, a certain quality is still expected. As the mill is an ongoing twenty-four hour process, the efflux ratio must remain constant. This refers to the speed at which the pulp is poured onto the wire screen, from the breast machine, which houses the prepared pulp. At present there are no chemicals or added minerals in the process. However, the mill is considering plans to introduce bionic starch into the pulp which will strengthen the paper.

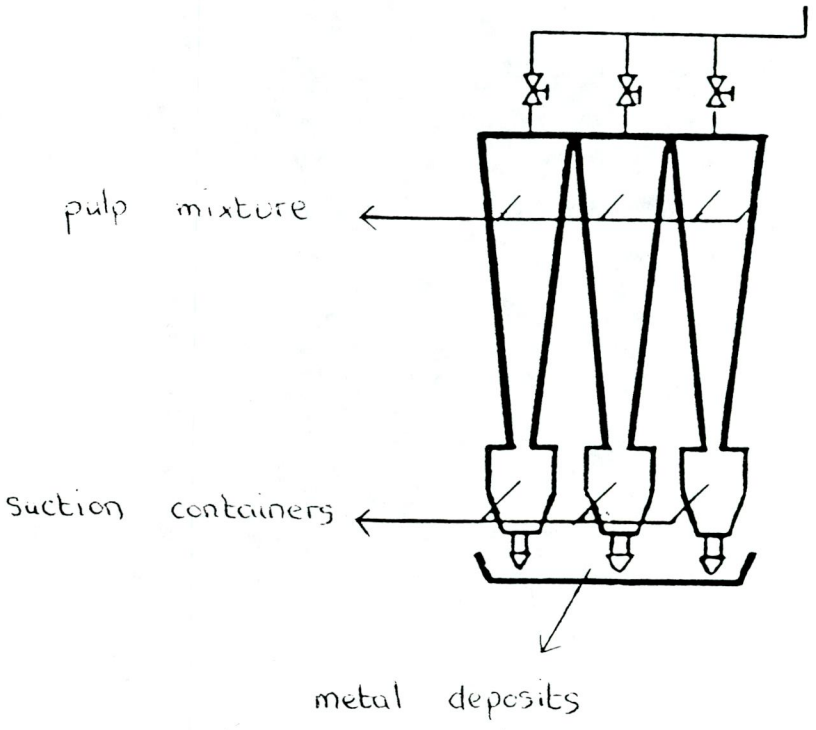


Figure 4-1 - Photograph and Diagram of Turbo Separators at Smurfits Papermill.

Recycling paper mills are essential but they need a constant supply of paper which is where the general public can help. Before gathering up waste to send to the mill, make sure it has been utilised to its full potential. Plain waste paper could be pulped in the home and using a special device to make fuel blocks or logs for the fire. Offices for example could do their rough work on the reverse of old reports. Envelopes could be manufactured with a see through area at the front. The address to be written on the paper inside the envelope and then resealed with a fresh peel-off sticking label attached to the envelope.

To get involved in a recycling scheme a waste paper merchant or buyer, needs to be contacted. Decide on what grade he wants, price to be paid and arrange the transport. Then find a location that is easily accessible to the public and sheltered from the weather. Collection points could be located alongside bottle banks. Finally, one could simply contact their nearest waste collection point and go directly there with waste paper. The force of the market dictates the price of any object. Therefore, if everyone bought products made from recycled paper and packaging, then market prices would drop, encouraging further purchases. Examples are stationery and home-manufactured goods in recycled packets. If companies using recycled packaging stated so, clearly on their products, then people would become more aware of its growing use (Fig. 4-2). This awareness might encourage others to participate in a scheme. Businesses and offices have an enormous network of communication. Recognising their stationery by printing it at the bottom of letterheads or compliment slips,

Figure 4-2 - Samples of Recycled Paper - Courtesy of Wiggens Teape.

would set an example for other businesses to follow.

Recycled paper uses the equivalent if not more energy and water needed to produce virgin paper. Recycled paper has to be purified extensively depending on what purpose the paper will serve. This de-inking and purification is expensive to produce good quality recycled paper, like stationery. All recycling schemes have a reasonably good infrastructure of collectors, buyers and recyclers. However, at the beginning of a recycling scheme there is normally an increased supply of paper collected, which results in a decrease in price for the waste. In return people do not want to collect any more because of no money incentive. Although I have talked about government and local financial aid, it unfortunately does not offer consistent back-up to small voluntary groups. Indeed the fundamental issue for very small businesses or organisations is a steady cash-flow. The length of time it takes to gather up a sufficient amount of waste paper to send for recycling causes major hindrance to a continued cash-flow. Financially speaking the use of recycling paper does face a challenge. However, if it takes three times more water to produce pulp from trees than from waste paper, then recycling paper has merit. Paper, whether machine-made, hand-made or recycled, is constantly under pressure. If not from the consumer or consumer demand, the pressure comes from the environment itself.

CHAPTER V

PAPER VERSUS ENVIRONMENT VERSUS PAPER

As I have already said, wood became the most popular source of fibre in the 19th century because it was economical, accessible and plentiful. However, attitudes have changed a lot in the last century. Is it economically viable to produce all paper from wood or is there an alternative? The trees are just as, if not more, accessible now but are they as plentiful? If not, does the entire responsibility lie with the paper manufacturers? Nowadays the most important aspect related to the paper and pulp industry is the environment. This was never even considered a hundred years ago because it has taken all this time for the problem to realise. Paper-making affects the environment in that the felling of trees interferes with the atmosphere. However the environment in turn affects paper causing it to deteriorate by means of light, air, temperature and pests. Knowing about the chemical make-up of paper helps one to understand how and why it is affected. Is the ecological cycle between trees and paper being hindered by man? If so, it is important to realise what is being done to rejuvenate our forests and discover what exactly are the long-term plans of paper manufacturing (Fig. 5-1).

Almost three and half billion cubic metres of wood is consumed per annum by the world. The paper industry accounts for 17% of this. Considering that it takes eighteen trees to make one tonne of paper, we are dealing with a phenomenal affect on the environment. Trees play an important role in maintaining a balance in the

Figure 5-1 - Photographs - Courtesy of Wiggens Teape.

atmosphere. Growing trees require sunlight, carbon dioxide, water and minerals and during the process, gives off oxygen. When it becomes obvious that the earth was falling victim to the 'greenhouse' effect, which is a rise above average in global temperature, scientists began to investigate. Gases emitted by industries certainly did to help but it was also discovered that loss of forestry due to paper-making resulted in a high percentage of carbon dioxide left in the atmosphere. The result was that the radiation from the sun became trapped within the atmosphere causing the greenhouse effect. Wood products of any nature including paper have a carbon dioxide content, as do decaying and undisturbed forests. Known as carbon locking, it too will eventually be released into the atmosphere and add to the greenhouse effect. Ground level also experienced the affects of loosing so many trees, leaving it exposed to the elements, thus increasing the rate of soil erosion considerably (Fig. 5-2). (38)

There are two alternatives which will counteract this problem. Firstly, recycled paper would help reduce the amount of trees being cut down. However, even though this would increase the storage time of carbon dioxide in the paper fibres, it would be eventually released into the atmosphere. The better solution lies in replantation of forests. Younger trees will absorb the carbon dioxide being emitted by utilised wood fibres, thus keeping an atmospheric balance. All paper companies have a vital part to play in replantation for both commercial and recreational use. The variety of trees grown and harvested are Spruce, Douglas Fir, Poplar, Aspen, Birch and Eucalyptus. Both softwoods and hardwoods

are grown, Pine being the most popular of the softwoods. Poplar and Birch which are hardwoods are used widely. The Eucalyptus is very popular but only in the right climate, as it has a growth rate to maturity of five to twenty years.

Commercial forests differ from natural ones in that they are grown for the purpose of harvesting. Usually planted on smaller tracts of land, compared to natural forests they are the long-term answer to the problem of deforestation. Commercial forestry takes the pressure of having to interfere with the natural ones. As well as harvesting full areas of forestry, the method of thinning is widely used. Thinning is really self-explanatory as it just refers to cutting down trees that are mature enough, leaving more growing room for the rest. Throughout Europe more and more farmers are being encouraged by the paper manufacturers to grow trees alongside crops and livestock. Inevitably resulting in financial prosperity and creating employment. Although the Eucalyptus tree cannot grow in Ireland, it is popular in warmer parts of Europe especially Spain and Portugal. Farmers in Iberia for example are having increased difficulties in agricultural economy and are willing to experiment with a fact growing species of tree, like the Eucalyptus. Indeed as time passes organisations such as the Common Agriculture Policy are realising the importance of cultivated forests. (39)

We are living in a scientific age and the growth of trees has not escaped investigation. Research in forestry is important both environmentally and economically. Through genetic research new

strains of trees have been developed which can give as much as 30% more pulp, compared to traditional species. Even by-products of trees whose potentials are being realised, range from resin, honey, medicines and oils.

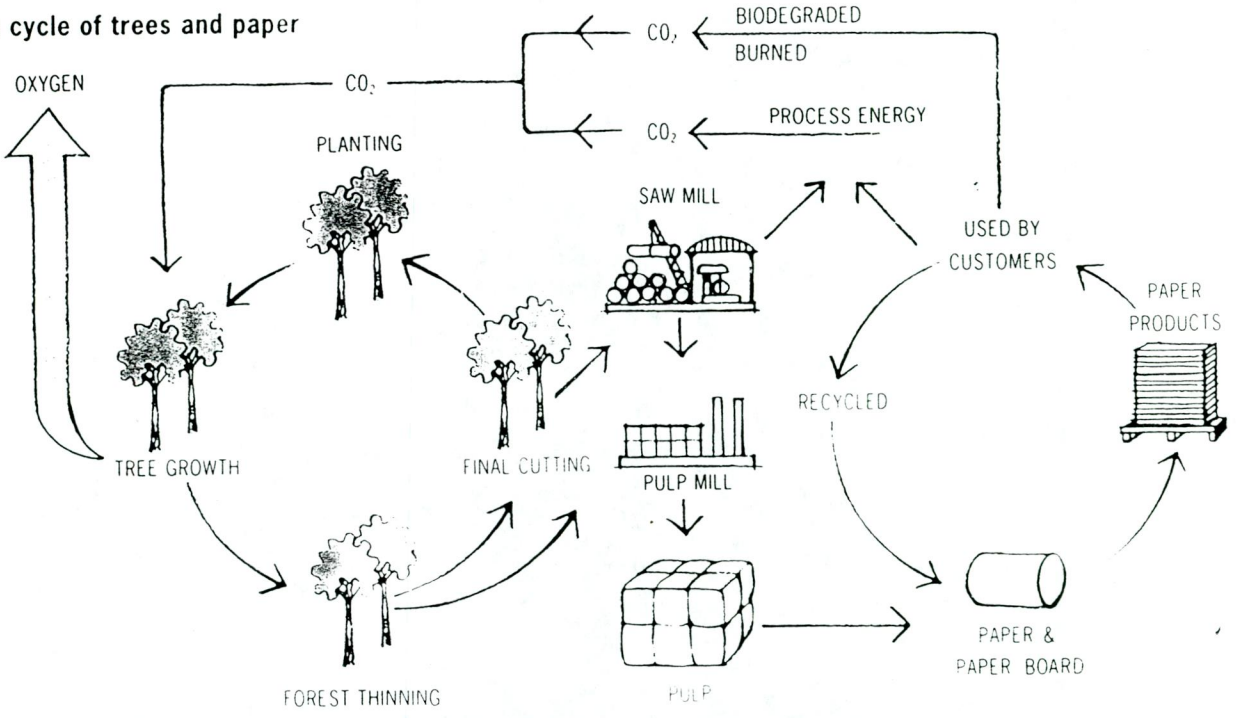
As soon as paper comes off the reels, or out from under the press, a new process begins. That of deterioration caused by the environment. The internal structure of paper coupled with external factors such as light, air, moisture and temperature will determine the rate of demise of paper.

All organic material is affected by light and thus damaged. Organic material is that which has been derived from plants or animals. Examples are cotton, linen, leather, parchment and paper. Any chemical reaction that takes place causes a weakening in fibre structure. This is the absorption of, followed by the releasing of, energy within the molecules, for example paper. The energy needed to set off such a reaction is called activation energy. Light energy is called photons which can be more destructive than the energy coming from normal room temperature. Light is made up of different wavelengths. This form of radiation is visible to the human eye. Light is a range of colours called the spectrum but it is the invisible wavelengths that cause most damage. The shortest wavelength is violet and the longest is red. Beyond these are the invisible wavelengths, those being ultra violet and ultra red. White light sources are daylight, tungsten light and fluorescent light, which can only show the spectrum when shone through a prism. (40)

Oxidation of sulphur dioxide can occur in the air or on a surface. All cellulosic materials will deteriorate at different rates depending on what the surface contains and thus acting as a catalyst. Sulphuric acid is the result of the oxidation. A high level of moisture in the air will speed up the destructive nature of sulphuric acid. Light and sulphur dioxide will cause more damage when they combine. One might wonder then, how come rag paper made from waste cotton lasted for centuries and modern books become brittle after ten years? It is possible that the presence of lignin in the paper allows easy absorption of acid pollution in the form of gas. Nowadays the lignin is dissolved during modern pulp making.

To control the moisture level in paper, one must have control over the humidity in the air. If paper, parchment or even leather is too dry, it is no longer flexible and the fibres will break and part. Dampness will also cause weakness and also promote the growth of mould and fungi. Once the relative humidity is constant, fibres will expand or contract. The level of humidity is read by a hydrometer. Biodeterioration occurs when the level falls below 70%. A change in the moisture level will cause a physical difference in size and shape of the paper. Machine-made paper will expand across the direction of the run of the machine. For example, a humidity change of 10% will cause an alteration of 30% in the width and 5% in the length. The same humidity change will cause hand-made paper to expend evenly but only about 5%. (41, 42)

The cycle of trees and paper



Eucalyptus trees are successfully grown as a managed crop and used by the paper industry

Figure 5-2 - Cycle of Trees and Paper and Photograph of Eucalyptus Trees.

Temperature has an adverse affect on light, air and particularly the moisture level. If there is a rise in temperature, the result is a rapid increase of biologically destructive activity. One slight advantage in a rise is that the drying slows down the rate of fading in dyes, provided light source is kept to a minimum. The most that the temperature of a cellulosic material is allowed to vary is five degrees celsius. More than five degrees change will cause a change in humidity level. (43)

It has taken approximately one hundred years for this environmental problem to surface. However, are we doing enough to counteract it? Scientists are researching the genetic field of tree growing, trying to develop suitable species that will mature faster, thus contributing to their replantation. Indeed some countries such as Sweden claim to be planting trees faster than they are cutting them down. The fact that the environment is fighting back creates an entirely new problem. The paper is made, now man must protect it from the effects of the light, air and moisture. The solutions to these problems, I believe, are to be found in studying how paper has reacted to a more structured environment, like a library. Learning how to preserve old books and documents would give us an insight to preserving modern day paper. It must be remembered however that paper differs now, in relation to chemical content.

CHAPTER VI

CONSERVATION AND RESTORATION

Very fragile paper is also very durable, provided that it has been cared for properly. Unfortunately, this is not always the case. Indeed man himself is to blame for damage to works of art, important documents and books, due to his own neglect or lack of respect for paper. Paper can crease or wrinkle, be dented, torn, burnt or stained. Care therefore should be exercised when handling it, particularly when curators and restorers are working on a book or a document.

Mass produced books of today will probably only have a ten to fifteen year lifetime, from examining older books, before becoming brittle and yellowed. However while such material is being produced, there are departments and laboratories restoring and conserving books and documents, some up to two hundred and fifty years old. Throughout Ireland conservation work is ongoing at University College Dublin, Trinity College, Chester Beatty Library, National Gallery and finally Marsh's Library, which I intend to refer to.

Archbishop Narcissus Marsh had the library built in 1701 beside St. Patrick's Cathedral which was designed by Sir William Robinson, Surveyor General of Ireland at the time. The exterior of the building is 19th century restoration style but the interior remains the originally 17th century layout. Archbishop Marsh, English born and educated at Oxford, became Provost of Trinity

College in 1679. While a Provost he promoted the study of the Irish language at the college and took part in the translation of the Old Testament into Irish for publication. He had plans drawn up to build the library, so the general public could have access to books. There are books in the library once owned by Jonathan Swift, Dean of St. Patrick's and once Governor of the library itself. The works of philosophers such as Aldus, Badius, Froben and Richard Pynson are kept there as is also the oldest book in the library which was printed in Milan in 1472. Indeed books such as these need care in both conserving their present condition and carrying out any necessary restoration work.

Repairs are carried out in Delmas Bindery located on the ground floor and basement of the library. The library itself was strategically placed on the top floor by Sir William Robinson. As the books are off ground, dampness has been kept at bay. The bindery is currently working on a three-year programme which involves examination of all the books. Their condition is recorded daily on a data sheet (Fig. 61). It is hoped in the future that reading back over recorded data will show a slowing down of the rate of deterioration, known as conservation. Restoration is the actual work carried out on the artifacts.

In Delmas Bindery, any damage that requires a more professional knowledge than the bindery itself can give, is applied with a protective covering of paste which I will describe later to deter further deterioration. Tears and creases or folded corners are repaired using a Japanese translucent tissue paper. This paper

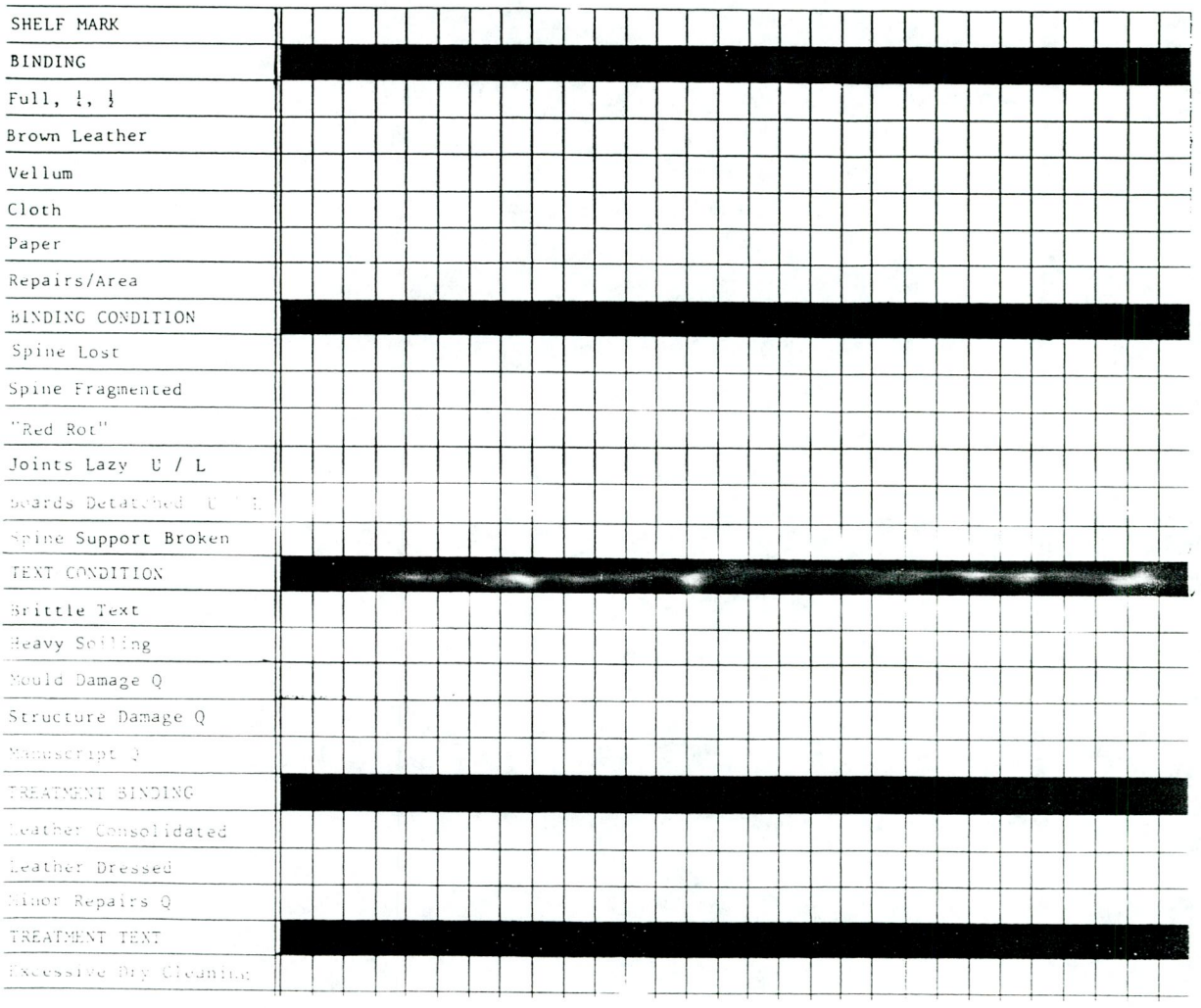


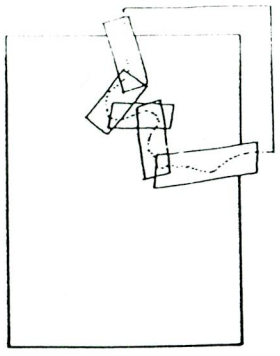
Figure 6-1 - Data Sheet used on a daily basis at Delmas Bindery.

has very long fibres which when damp will blend into the fibres of the damaged area. As well as rejoining a tear this method is also suited to actually replacing an entire area that has been torn away. It is sometimes necessary to dye the tissue paper with natural substances like tea or coffee but this method cannot be over-used as excess heat will eventually promote mould growth. Applying the tissue paper and paste is known as the wet method, the paste being called Klucel G. Also known as methyl cellulose which is an emulsion and cellofas is also used, scientifically termed as sodium carboxymethyl cellulose. The dry method involves the use of transparent paper that has a natural based adhesive side, with a neutral pH value. Kraft paper is used for stiffening and lining book covers. Acid-free white blotting paper is used to absorb excess liquid from a treated area. An eraser technically known as a silicone rubber is used for cleaning down grubby and dusty pages. (44)

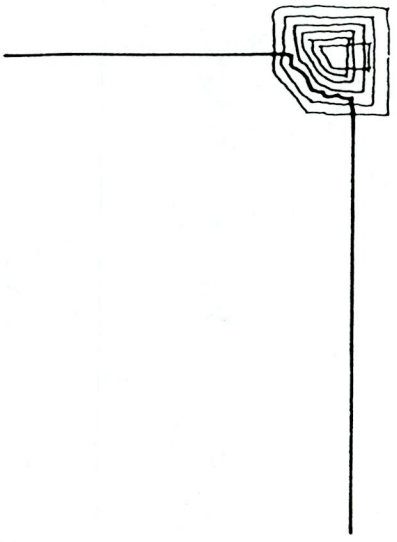
The protective layer applied to damages areas while awaiting further restoration, is a mixture of plain flour, cold water and thymol solution. It is mixed in proportion of 4 oz : 0.5 pint : 2 drops. The advantage of this mixture is that it is removable without causing further damage. Animal glues made from boiling hides, bones, hoofs and cattle horns are flexible, suited to repairing books spines. Cold water glue is made from milk protein and starch. Although it can be thinned out with water, it is still prone to bacteria and fungi growth and not used as much as it used to be. Mixtures of polyvinal acetate and polyvinal alcohol have also proved unsuitable. Solvents are used to

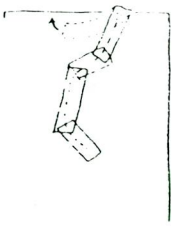
counteract mould growth. Areas treated with methyl cellulose which strengthen the surface of the page. Detached pages or documents are more likely to be dealt with by the Trinity Conservation Department. The laboratory there is supplied with dionised water. The sheet or document is immersed in calcium hydroxide which disperses any mould growth. Washing paper with water also helps strengthen hydrogen bonding of the fibres. Deacidification of paper is the process of soaking the page in calcium bicarbonate for about thirty minutes. When removed it is dried with blotting paper and placed between two boards with a neutral pH value. Similarly book pages can be sprayed with methyl magnesium carbonate which dries quickly and will not weaken the structure of the fibres. Delmas is not as technically comprehensive as Trinity, due to the expense it would entail. Setting up the most basic conservation department would cost within the region of IR£200,000 (Fig. 6-2). (45, 46)

The treatment of foxing is a major area dealt with in Delmas Bindery. Its causes are still not fully understood although it would seem to be a combination of factors. Mould, micro-organisms activated by dampness and tiny particles of iron, causing the surface to yellow. Traces of copper and zinc will result in brown stains, remembering of course that these particles are microscopic in size. Bleaching has proved ineffective as the stains generally re-appear a few months or years later. Through bleaching the print can easily fade, so there is a lot of research yet needed to treat the properties of ink, without causing damage to the page.



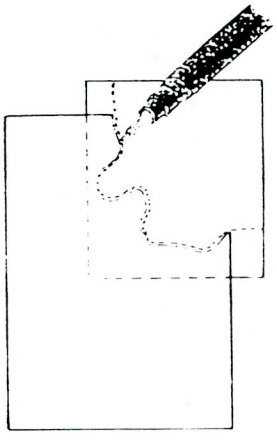
Mounting fragile and damaged leaves

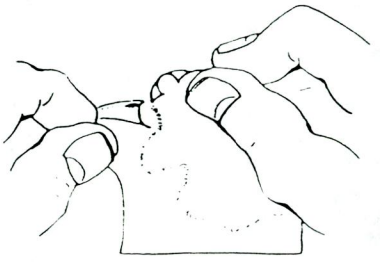


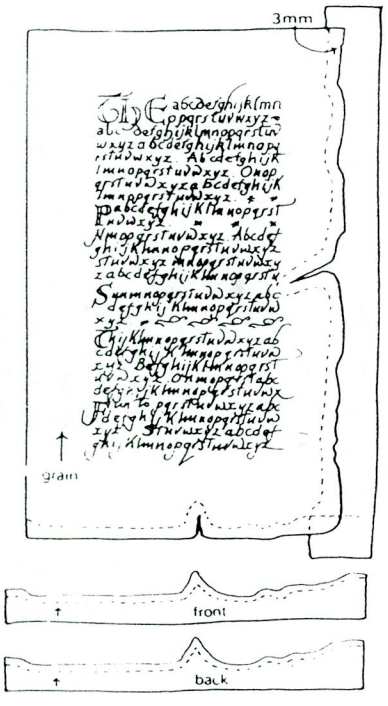


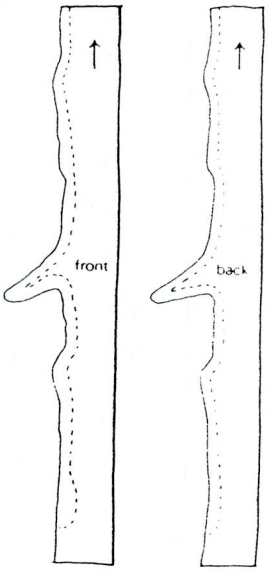
Paper repair: dry method

Filling worm holes









Repair of fragile leaves

Replacing a missing area of paper by overlapping

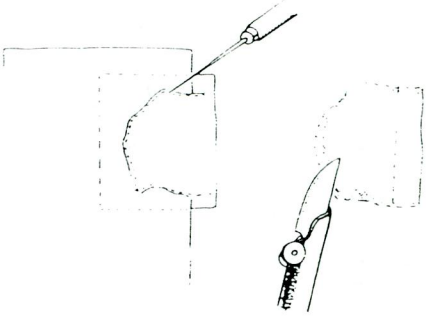
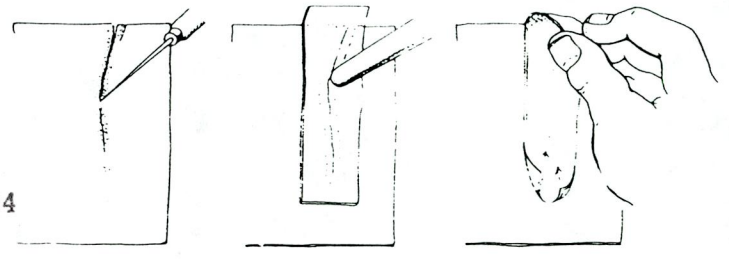


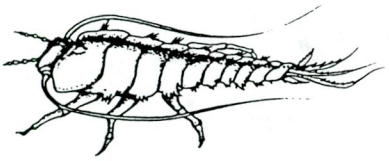
Figure 6-2 - Methods of Repair to Paper.



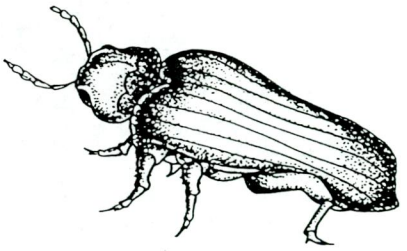
Paper repair: wet method

As well as dealing with microscopic damage such as mould growth or foxing, there is the problem of a larger nature, infestation. Insects and vermin thrive in a damp warm atmosphere and can cause widespread damage. A temperature of between 15 and 18 degrees celsius, along with a relative humidity of approximately 45 - 50% would deter their growth but this must be kept constant. Indeed the simple vacuum cleaner will remove insects and eggs from small corners otherwise unreachable. The most common insects are the silverfish, book-lice, moths, beetles and mites. The silverfish is easily recognised with its carrot-shaped, twelve milimetre silver body. They move very fast and are active in dark areas and at night. Main food source for silverfish is starch, animal size and cellulose. Book-lice are one milimetre in length and feed on mould, lichens, starch and organic glue. The other insects, although harmful, are not directly connected to books and paper damage, compared to the silverfish and book-lice (Fig. 6-3). (47, 48)

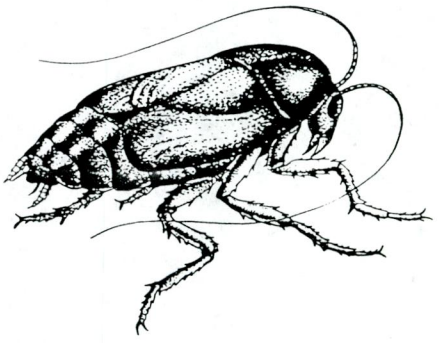
It would not be surprising if one were to think that the odds are stacked against the survival of paper. Therefore it is a question of letting the paper, in whatever form it may be, to deteriorate at the rate the elements dictate. Or do we try to preserve them beyond their natural time? Of course the natural life of paper depends entirely on its ingredients and place of storage. Unfortunately, not all storage places are suitable, referring in particular to the average home or office. Keeping old books or documents for posterity is admirable but also difficult as their physical condition deteriorates.



Silverfish

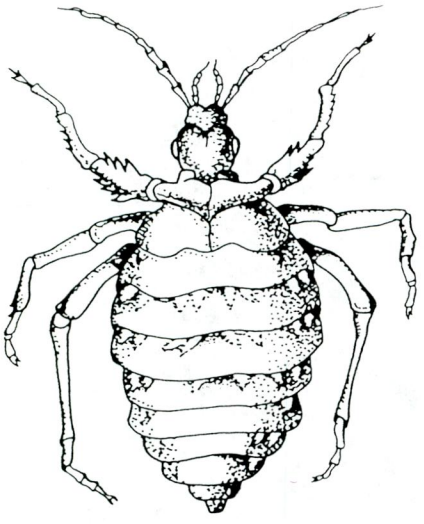


Wood-boring beetle



Cockroach

Book louse



Moth

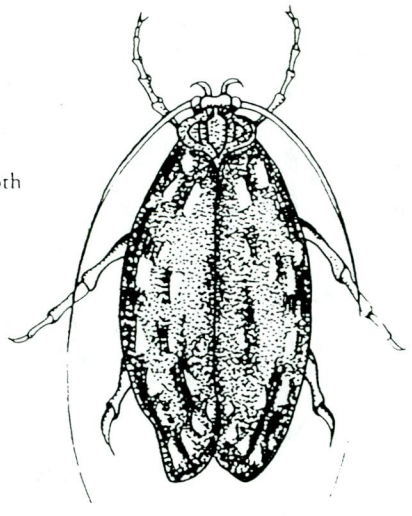


Figure 6-3 - Insects that can cause damage to Books and Documents in storage.

Conservation and restoration of paper is not just a question of knowledge in chemistry, it also relates to whether one believes in the principle of conservation or at least slowing down deterioration. Our history gives one a sense of place and one of the most influential means of recording our past has been on paper of different varieties. Restoration requires serious concentration and experienced restorers will undoubtedly follow a code of practice in relation to their work. An agreement should be reached between the owner of the artifact and the restorer referring to what exactly is to be carried out. The restorer should never do more than what was decided on. The procedure of work is to be planned in advance, using solvents and adhesives that have been tested and approved by the appropriate authority. Any extra parts with the books, like stickers, notes or bookmarks should not be discarded. Actual replacement of any part of the book, end pages or cover, for example, is a last resort. As the restorer is striving to preserve its original appearance. The deckle should not be trimmed but rather left in its original state. Any special treatment involving the use of synthetic fibres need to be noted and kept with the book's records for future restorers. It is important that restoration work does not obliterate or fade the text or image. Sometimes an owner might be advised to have a book conserved in a contemporary binding rather than trying to restore the present one which might be irreparably damaged. This is presently the case with a French edition of Samuel Beckett's "Waiting for Godot" which Trinity College paid IR£30,000 for. It is being treated by spraying the pages with methyl cellulose. A slow and expensive process which has already

cost the department IR£3,000 within the last three months. Some books or documents are so fragile that they cannot be even touched by the restorer. Any treatment in such a case would damage or reduce its value. (49)

It is possible to get archival paper which is not only acid free but also lignin and sulphur free. For conservators and archivists the pedigree of a suitable paper depends on how long it can last independently and as well as when in contact with other materials.

One mill that makes conservation and restoration papers to order, is the Moulin du Verger Mill founded in 1539 in France. They hand-make restoration papers only for conservation and restoration purposes. Mixtures of cotton, linen and manila fibres are used and the paper is made with 18th century style moulds. This method is used to give the paper a texture resembling old paper. Manufactured archival boxboard is used to make boxes in which to store material and for books without covers, thus needing the support. (50)

Papers made in the East are usually used for conservation and restoration purposes. The Japanese for example use fibres from the Mulberry bush to manufacture fine translucent paper. Some tissues they make even have a natural smell which acts as a repellent to insects. The quality of these papers have not been matched anywhere else in the world due to their translucent quality, porosity, high strength to weight and chemical purity. Paper originated from this part of the world and even after

paper's developments down through the ages, restorers still have reverted back to the country of origin. This should cause concern relating to paper made in the Western world. Paper is loosing its quality due to mass production and is technologically considered only in relation to how fast it can pass through photocopiers and printers.

CONCLUSION

Paper has character, substance, permanence, strength, history and most importantly a place in society. Awareness of paper's importance among the general public is taken for granted. People do not utilise the collection services that are available to aid the recycling industry. However this is mostly due to a lack of advertisement for collecting recyclable paper, the result of underfunding by the Government. An organisation like ENFO is doing a lot of work in circulating information about all recyclable materials, including paper, but they too are underfunded. The area of conservation and restoration is also lacking funding, particularly for trainees. The normal procedure for future conservators and restorers is to go abroad for training. Germany, England or Rome have particularly good reputations.

Being in Art and Design I have always been conscious of good and bad quality paper, whether it was too 'thin' or too thick. Through doing the thesis however I have learned some very important principles regarding paper. From its time of origin, right through the invention of printing, paper has and still is a source from which man communicates. Paper has been part of and recorded our history down through the ages and certainly should be preserved. I believe that a lot can be learned from studying old paper and books in relation to their chemistry, which would benefit paper-making today.

Before making a mark or design one's important decision is choice of paper. Choosing paper is now more relevant to me with the knowledge I have acquired through research, also in relation to the type of machinery which the paper will pass through. Hand-made paper is thankfully a reviving craft. Papers based entirely on natural ingredients will last longer than those with a chemical content. Longevity of recycled paper is questionable, as every time fibres are recycled they are weakened. Recycled paper is a reflection of society in that it is a material we can re-use, to a certain extent, while simultaneously being environmentally aware.

Ireland has a strong sense of history, most of which is recorded on papers, whether works of art, letters or printed books. Our National Library, the Dublin City Writer's Museum and Marsh's Library are among an endless list of place where such items are stored with conservation departments playing a major role in maintaining their cultural value. Society has not given paper its due respect because of a lack of understanding on how paper is actually made, what one can do with waste paper and also see the importance of its conservation. Indeed educating the public through advertisements and circulating more information would I believe benefit paper's survival.

FOOTNOTES

1] Rudin, Bo, Making Paper, Sweden: Rudins, 1990.

2] Ibid.

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13] Jennet, Sean, The Making of Books, London: Baynard Press, 1973.

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15] Williamson, Hugh, Methods of Book Design, London: Yale University Press, 1983.

16] Ibid.

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18] Jennett, Sean, The Making of Books.

19] Moncrieff, R. W., Manmade Fibres.

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21] Jennet, Sean, the Making of Books.

22] Moncrieff, R. W., Manmade Fibres.

23] Rudin, Bo, Making Paper.

24] Ibid.

25] Ibid.

26] Turner, Silvie, Which Paper, England: BAS Printers Ltd., 1991.

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28] Turner, Silvie, Which Paper.

29] Jennett, Sean, the Making of Books.

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32] Turner, Silvie, A Printer's Handbook, London: Westerham Press, 1989.

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36] Rudin, Bo, Making Paper.

37] Turner, Silvie, Handmade Paper Today, London: Lund Humphries Publishers Ltd., 1983.

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39] Ibid.

40] Thomson, Garry, The Museum Environment, London: Butterworths, 1986.

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42] Williamson, Hugh, Methods of Book Design.

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44] Johnson, Arthur, A Practical Guide to Book Repair and Conservation.

45] Ibid.

46] Thomson, Garry, The Museum Environment.

47] Johnson, Arthur, A Practical Guide to Book Repair and Conservation.

48] Turner, Silvie, Which Paper.

49] Johnson, Arthur, A Practical Guide to Book Repair and Conservation.

50] Rudin, Bo, Making Paper.

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