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Expert Group Meeting on New Techniques  
in Wet-Processing of Textiles

Manchester, United Kingdom, 13-17 June 1970

THE EASY-CARE FINISHING OF COTTON<sup>1/</sup>

AND OTHER

CELLULOSIC FABRICS

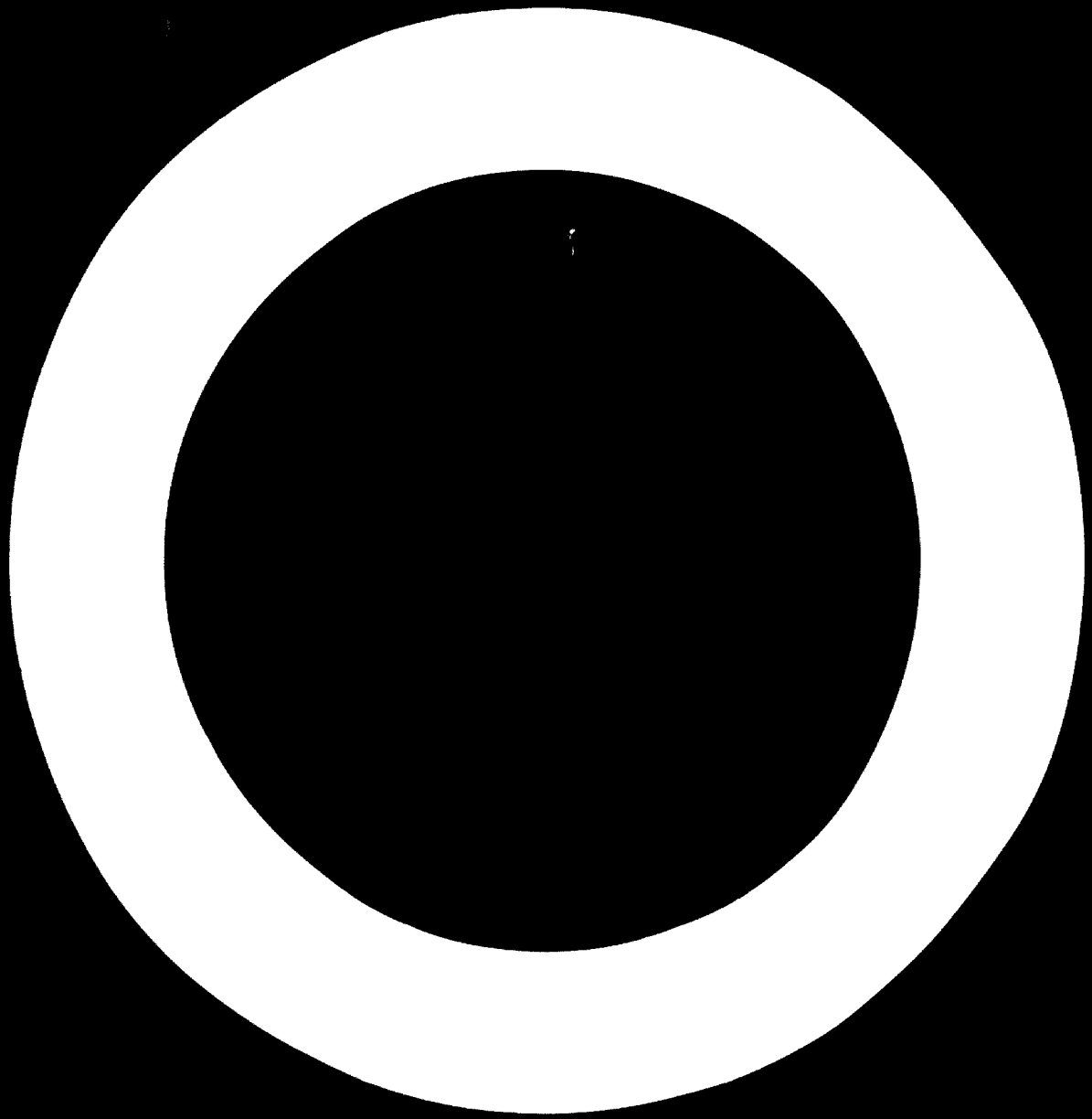
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## INTRODUCTION

Easy-care is a convenient term to describe garments which retain their appearance and shape after repeated laundering and wearing and which require a minimum of ironing. This concept involves a number of separate performance criteria which, although distinct, are recognised by the technical man as interdependent. They include:-

- Recovery from creasing when the garment is worn
- Recovery from creasing introduced during washing
- Absence of shrinkage during washing and subsequent drying
- Retention of shape during wear
- Quick drying
- Absence of seam puckering
- Recovery from stretch
- Absence of fibrillation

It is important to note that easy-care refers to the performance of the made-up article or garment and is not just a characteristic of the fabric.

Today, in Europe, Japan, the United States - and increasingly in other parts of the world - easy-care properties are demanded in a very wide range of products including shirts, dresses, sheets and pillowcases, workwear, curtains, slacks, blouses, etc., and hence the subject is of extreme importance to all manufacturers of fabrics and garments containing cotton or other cellulosic fibres.

In general, untreated cotton and rayon articles do not possess a sufficiently high level of easy-care performance to meet consumer demand, and it is this fact, probably more than any other, which has allowed the synthetic fibre interests to make incursions into markets which were previously dominated by cotton. It is some 50 years since this deficiency was first recognised, and all the work which has been carried out since that time has confirmed that the only practicable method of overcoming this disadvantage is some form of chemical treatment of the cellulosic material. This is still true today, and even cellulose/polyester blended fabrics containing up to 65% of polyester are normally given an easy-care finishing treatment in order to supplement the easy-care properties of the polyester component.

Much has been written about the theory of easy-care finishing - the relative importance of cross-linking versus resin formation, reactivity of cellulosic hydroxyl groups with the easy-care chemical, the relations between fibre and fabric properties, etc. - and a short bibliography is attached for the benefit of the interested reader.

However, in this paper, attention will be concentrated on the practical aspects of finishing, not only because of their more immediate value, but also because a great deal of the theoretical work which has been reported in the past is now seen to be irrelevant and/or misleading. Many of the theories were based on 'facts' or suppositions which are now known to be incorrect.

The problem is not to confer easy-care properties on cellulosic fabrics - this can be achieved quite easily; the essential difficulty is to obtain a satisfactory balance between these factors:-

- Easy-care performance (elastic properties)
- Wear life, tear and tensile strength (durability factors)
- Handle and other comfort properties

at an economic cost.

#### BASIC PROCESS

The easy-care finishing treatment which is in most common use today is called the 'pad-dry-cure' process. It comprises the following steps:-

- a. Impregnation of a well prepared fabric with a water solution of an easy-care chemical (often, though incorrectly, termed a 'resin') together with a catalyst and other additives.
- b. Removal of the surplus liquor (usually mangling).
- c. Drying of the fabric (usually on a stenter).
- d. Fixation of the easy-care chemical to the fabric by heat (curing).

- e. Washing to remove surplus chemicals.
- f. Drying.
- g. Making-up of the fabric into garments or other articles.

There are many versions of this process, but in almost all cases, the same basic sequence is followed. The variations lie in such factors as the choice of catalyst, the rate and extent of the first drying operation, the time and temperature of fixation, etc.

Considering each step of the basic process .....

#### Fabric

In this conference, much has already been said about the methods by which fabric can be satisfactorily prepared for dyeing, printing and finishing. In this paper it is therefore only necessary to state the properties which the prepared fabric should possess prior to easy-care finishing:-

- Excellent absorbency.
- Complete absence of size.
- Low fluidity, i.e. the fabric should not have been overbleached.
- A moisture content close to the normal regain.
- Absence of traces of alkali and buffering chemicals, i.e. the fabric should have been well washed.

It is very desirable that tests for all these properties are carried out before the fabric is passed for easy-care finishing.

Mercerisation is a very important pre-treatment and is discussed separately in two other conference papers.

#### Selection of Easy-Care Chemicals

There are many easy-care resins available (see Appendix A) from which a finisher can make his choice, and excellent descriptions of their properties and methods of application are given by the chemical suppliers.

In selecting a resin, the most important considerations are:-

- Properties required in the finished cloth. Chlorine resistance ? Durability to repeated laundering ? Low free formaldehyde ? Light fastness requirements for reactive dyestuffs ?
- Cost in relation to end-use performance.
- Equipment available, e.g. high temperature curing oven, ventilation.
- Degree of process control available in the mill.
- Guaranteed supply of consistent quality.

### Quantity

The quantity of easy-care chemical used depends almost entirely upon the degree of easy-care performance required. For shrinkage control, as little as 1% (solids) on the weight of the fabric may be adequate, while for good easy-care performance, between 4% and 6% on the weight of fabric is usually required for cotton fabrics. In the case of rayon, these quantities should be increased by about 50%. The most satisfactory way to determine the quantity of resin needed is to carry out a series of trials at several resin contents (see Diagram I.) .

### Catalysts

The rate of reaction between the easy-care finishing agent and the cellulose can be greatly increased by including a catalyst in the padding formulation. The great majority of resins in use today are di or polymethylol derivatives of organic amides, and these react with cellulose under acidic conditions. An ideal catalyst therefore is one which is not too acid in the padding solution, but which generates acidity during the curing stage. The selection of the most appropriate catalyst for a given finishing process is a complex matter since it depends upon:-

- The conditions of curing (time and temperature)
- The type of easy-care finishing agent
- The need or otherwise for some degree of curing during the drying stage
- The life of the padding solution



A list of the more important acid catalysts is given in Appendix B, together with comments on their suitability for particular finishing processes.

Some easy-care finishing agents will react with cellulose only under moist alkaline conditions. Almost all of these chemicals are relatively expensive and require careful manipulation not only to give the required fabric properties, but also to avoid toxicity problems. Used alone, they give only wet crease recovery properties, and hence they are usually employed in combination with a methylol amide resin in a two-stage process. Such treatments can give excellent results and are the basis of the 'Belfast', 'Teb-X-Cell' and 'Texoro' finishes.

#### Other Additives

It is a good policy to keep the formulation of the easy-care padding solution as simple as possible. Not only does this reduce the cost, since most additives are relatively expensive, but it also minimises the chance of precipitation or coagulation due to incompatibility. However, some additives do have a very beneficial effect and are almost always included. For example, it is desirable to add a wetting agent, a lubricant to improve the tear strength of the finished fabric and a stiffener or softener to give the required handle.

If special effects are required such as water repellency or resistance to burning, then the appropriate speciality chemicals can often be included in the easy-care formulation. However, great care has to be taken to ensure that the resulting solution is stable, not only when standing, but also when subjected to the shearing action of a pad-mangle.

#### Removal of Surplus Liquor

A pad-mangle is normally used to remove the surplus liquor and to leave the correct quantity of finishing agent on the fabric. This quantity is determined by the concentration of easy-care finishing agent in the solution and by the expression of the mangle. It is therefore important to measure the expression of the mangle regularly using a small sample of the fabric which is being treated and the appropriate padding solution.

In general it is better to aim for a low mangle expression (high squeeze) and a high concentration of easy-care finishing agent in the padding solution. With such a combination, residual inter-fibre liquor is reduced, migration is minimised, and the stenter can also be run faster because there is less water to be evaporated. It is essential that the fabric is thoroughly impregnated with the liquor before being passed through the mangle bowls, and probably the best system to use is a three-bowl mangle in which the fabric is subject to two 'dips' and two 'nips'.

### Drying

The most suitable form of drying equipment to use for easy-care finishing is a pin stenter fitted with overfeed. The air temperature in the stenter is normally in the range 140°C - 160°C, but the temperature of the drying fabric should not approach these temperatures unless of course the stenter is being used both to dry and cure the finishing agent.

For almost all purposes, the speed of throughput of the fabric should be such that its moisture content when leaving the stenter is within the range of 5% - 10%. The only exception to this rule is when the fabric is to be given some form of mechanical treatment (embossing, schreiner, etc.) prior to the final curing stage. In this case, residual moisture levels should be 10% - 15%.

After drying to the desired moisture content, the fabric should be cooled either by cold air jets or water cooled cylinders and then should be rolled into a batch. This prevents the fabric from being maintained at an unduly high temperature and also avoids the formation of accidental creases which may become permanent.

### Curing

In order to link the easy-care chemical to the cellulose, the dried fabric is usually heated to 130° - 160°C for a few minutes. This is normally achieved in a heated insulated box through which the fabric passes in open width on rollers.

It is important to note that the recommended times of curing always refer to the time for which the fabric is at the quoted curing temperature. This is always less than the time the fabric spends in the curing box due to the heating-up period.

The time and temperature of curing depend mainly on the resin/catalyst system, but the design of the curing oven often has a small additional influence. As a rough guide, a 10°C rise in temperature will halve the curing time.

The degree of fixation which has been achieved should be checked by measuring the loss of resin after a standard wash, e.g. 30 minutes at 60°C in a soap based detergent solution.

#### Washing

After curing it is very desirable to wash the fabric in order to remove unreacted resin and catalyst as well as by-products formed during the curing operation. The normal method is to use an open width washer in which the first tank contains hot (60°C) sodium carbonate solution to neutralise the acid fabric and release any amine odours. The later tanks should contain hot and cold water and additional lubricant can be added in a final wet-on-wet padding operation. Final drying is best carried out on a stenter.

#### Fabric Evaluation

The evaluation of the easy-care performance of the treated fabric is usually carried out by the methods described in the AATCC or BSI handbooks. Careful and regular testing of the finished fabric, coupled with systematic process control, is necessary for the successful and consistent production of easy-care fabrics.

With current technology, a balance must be struck between the elastic properties (wet and dry crease recovery, wash/wear retting) and durability factors (tear and tensile strength, wear life, etc.)

Specifications usually call for a minimum level of properties selected from these two groups. In order to achieve this required balance, it is common to treat the fabric in question with at least four levels of resin and plot the resultant properties on a diagram such as Diagram I.

#### Making-Up

In order to produce an easy-care garment from pieces of easy-care fabric, careful attention has to be paid to the selection of accessories and sewing conditions. The principle requirements are as follows:-

- a. All interlinings, pockets, zip fasteners, etc. should be made from stabilised fabrics in order to avoid differential shrinkage and puckering.
- b. Stabilised sewing threads should be used and thread tensions should be kept as low as possible.
- c. Sewing threads and needles of the minimum acceptable diameter should be used and the stitch spacing should be as large as possible consistent with seam strength and appearance.
- d. Wherever possible, the type of seam which gives least puckering should be used.

#### RECENT DEVELOPMENTS

In the previous section, the need to strike a balance between the easy-care properties and the durability factors was emphasized. For many years, it was assumed that such compromises were inevitable - that a 'price' had always to be paid for creating easy-care properties in cotton-containing textiles. Given the data available, this was not an unreasonable assumption.

The practical implications of the need to compromise were quite serious for the processor; he could not produce easy-care, light weight cotton shirtings or sheetings without an unacceptable loss of strength or wear life, and even with heavier weight fabrics, he could not always meet the high easy-care standards demanded in some markets, notably in the USA.

These limitations to cotton markets, coupled with the growing consumer demand for easy-care products, lead IIC to conclude that a solution to the easy-care/durability problem should be the chief aim of their research programme.

Since 1967, when these programmes started, major progress has been made. It has been shown, for example, that the strength and durability of an easy-care cotton fabric are strongly dependent, inter alia, on the efficiency with which two processes are carried out - mercerising and the application of the easy-care chemicals. Almost without exception, both processes are carried out in a very inefficient manner by finishing mills throughout the world.

Traditionally, mercerisation is used to impart lustre and to improve the apparent depth of shade of cotton fabrics. These are surface properties and be readily achieved by modification of the surface fibres only. However, to improve the mechanical performance of the fabric, most of the fibres must be modified. Such thorough treatment is difficult to achieve with the viscous caustic soda solutions which are normally used in mercerising.

The most effective way of achieving a uniform mercerising action is by use of liquid ammonia. However, although we are likely to see a growth in the number of liquid ammonia plants in the textile industry, it is essential to develop a process which can be utilised almost at once by the many mills with conventional caustic soda mercerisers.

These studies are under way, but they have not progressed to the point where detailed recommendations can be made.

Broadly speaking, improving the mercerisation process helps to maintain the tear and tensile strength of the easy-care cotton fabric. To maintain the durability, requires alterations to be made to the method of application of the easy-care chemicals.

In the conventional process described earlier, the resin is applied to the fabric with a large excess of water. This water, which after mangling weighs about 70% of the weight of the dry fabric, has to be evaporated, usually in a stenter. During drying, the resin migrates to the fabric surfaces and becomes fixed during the subsequent heat curing operation. The final resin distribution is thus very far from uniform, and it is believed that the excess surface resin is largely responsible for the loss in abrasion resistance of the treated fabric.

The obvious remedy is to reduce the quantity of water applied to the fabric with the resin to the point (about 35% of the weight of the fabric) at which

intended to help people to put these principles into practice. There are several alternatives:-

- a. Improved printing roller (Diagram II).  
Cheap and simple, but a range of rollers is needed for a variety of fabric weights.
- b. Rotary screen printing equipment (Diagram III).  
The low viscosity of the padding liquor causes lubrication problems and the add-on is difficult to control.
- c. Transfer printing systems in which a wet fabric, containing the easy-care padding solution, is brought into contact with a dry fabric. There are two variations: one in which the fabric to be treated is brought into contact with an endless carrier loop (Diagram IV) and one where, by an ingenious threading arrangement, the fabric to be treated forms both the 'wet' and 'dry' segments (Pfersee QS System).
- d. Lick rollers.  
This alternative has been developed into a fully commercial system in which the speed of rotation of the lick roller is varied to give a constant percentage add-on of liquor (Diagrams V and VI) .

All these systems can produce a more uniform distribution of easy-care chemicals in the treated fabric and hence give a better product. But they can also give process advantages which are of great value:-

1. The energy required to dry a fabric containing only 30% of water is much less than that required to dry a wet fabric. Thus, the stenter can be speeded up considerably or operated at a lower temperature.
2. Because the chemicals are distributed uniformly, the efficiency of their action is much higher and savings of 30% to 40% are possible for equivalent fabric performance.
3. Fabrics containing reduced levels of easy-care resins have a higher moisture uptake, better handle, greater attraction for optical whitening agents in washing powders and are less likely to give problems of smell.

This new approach offers such significant benefits in terms of product and process improvements and reduced consumption of chemicals and energy, that we are convinced that 'limited application' techniques will become widely accepted not only for easy-care finishing, but also for dyeing and possibly other finishing processes. When employed separately, both the improved mercerisation and the 'limited application' techniques will give significant improvements in product quality. If they are combined, it is possible to produce easy-care cotton fabrics which have the strength and durability close to that of the untreated material. More work is necessary before these developments can be said to be fully commercial, but they have demonstrated that a compromise between easy-care and durability is not inevitable and that these new processes can also result in major process economics.

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- 11 -  
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PROPERTIES OF EASY-CARE CHEMICALS

FINISHING AGENT	COST	CHLORINE RESISTANCE	DURABILITY	FREE CH <sub>2</sub> O	EFFECT ON DYES
Urea/Formaldehyde Dimethylol Urea - DMU	***	*	*	*	*
Glyoxal Dimethylol Glycol Urein - DMDHEU	**	*	***	***	***
Melamine / Formaldehyde Methylated Methylol Melamine	*	Variable	***	***	Possible
Ethylene Urea Dimethylol Ethylene Urea - DMEU	**	*	**	**	
Propylene Urea Dimethylol Propylene Urea - DMPU	*	***	**	**	**
Hydroxy Propylene Uree	*	***	**	**	...
Carbamate Alkoxyethyl Carbamates	**	***	***	*	...
Tetramethylol Acetylene Diurea	*	*	**	*	*
Triazone Dimethylol Ethyl Triazone	**	**	**	*	**

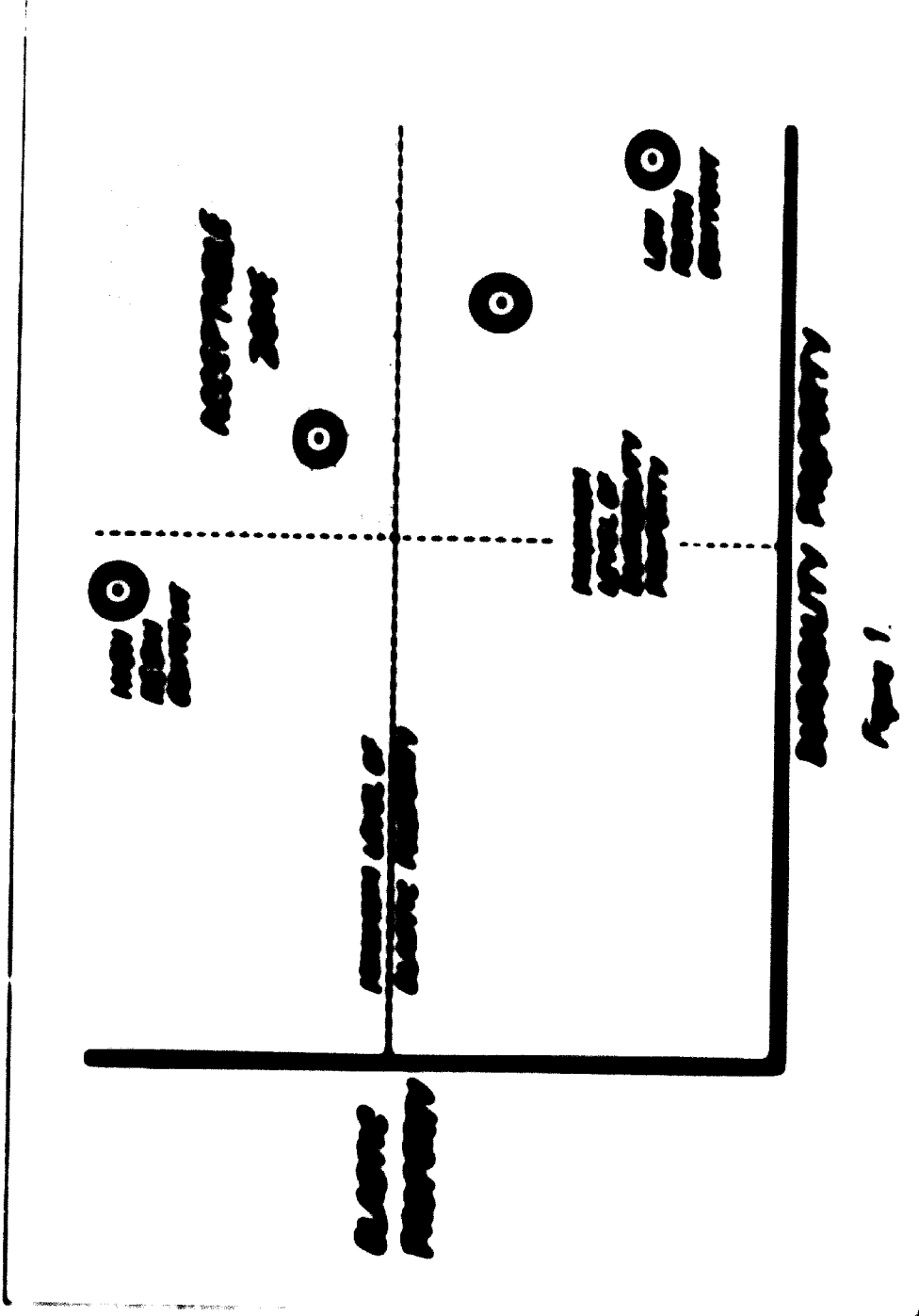
This list of properties assumes that the easy-care fabric has been adequately cured and given a process wash immediately after curing.

\* Worst  
\*\*\* Best

APPENDIX B

<p>1. AMINE HYDRO-CHLORIDE</p>	<p>71</p>
<p>2. AMINE HYDRO-CHLORIDE</p>	
<p>3. AMINE HYDRO-CHLORIDE</p>	
<p>4. AMINE HYDRO-CHLORIDE</p>	
<p>5. AMINE HYDRO-CHLORIDE</p>	

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PROPERTY

SOUTH SIDE

EAST SIDE

NORTH SIDE

SOUTH SIDE

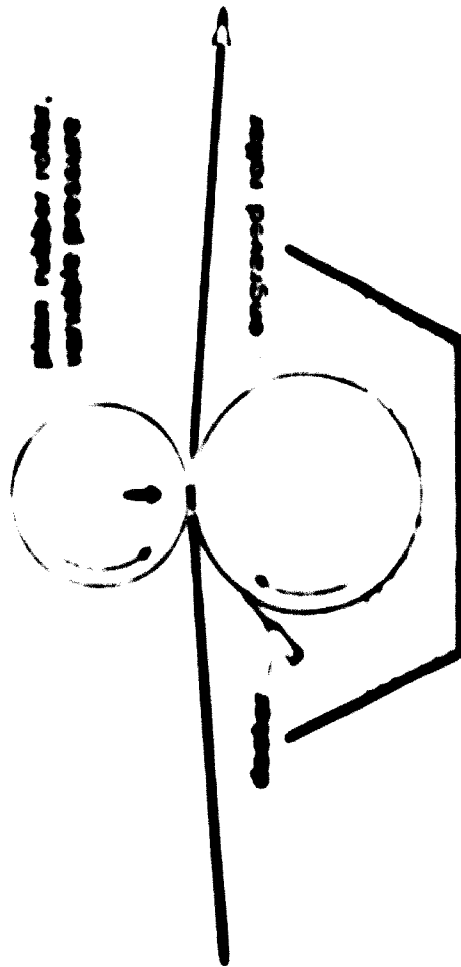
WEST SIDE

NORTH SIDE

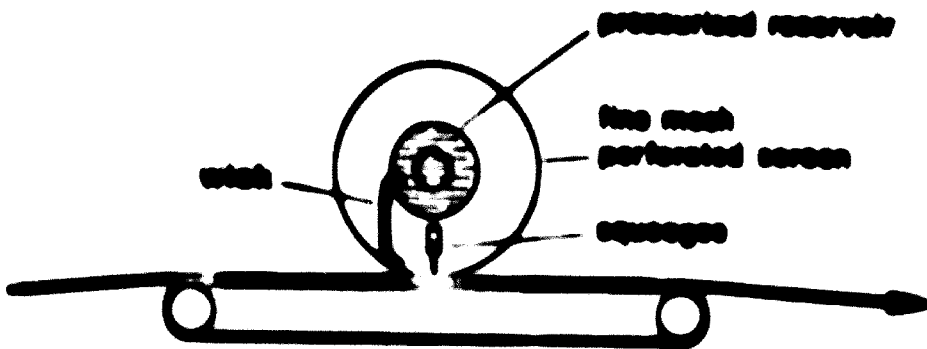
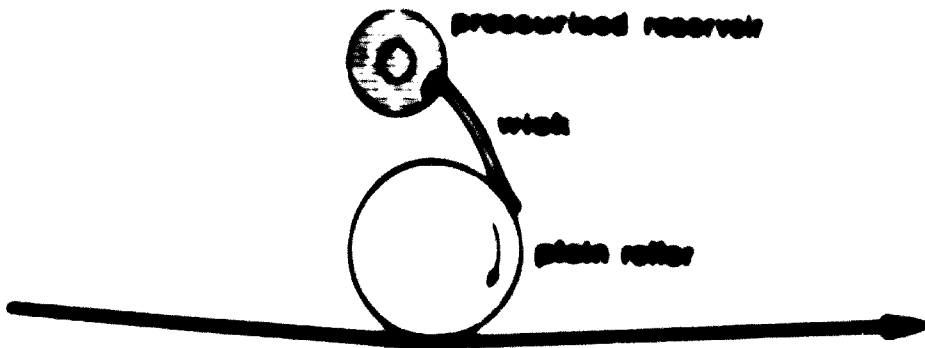
SOUTH SIDE

SOUTH SIDE

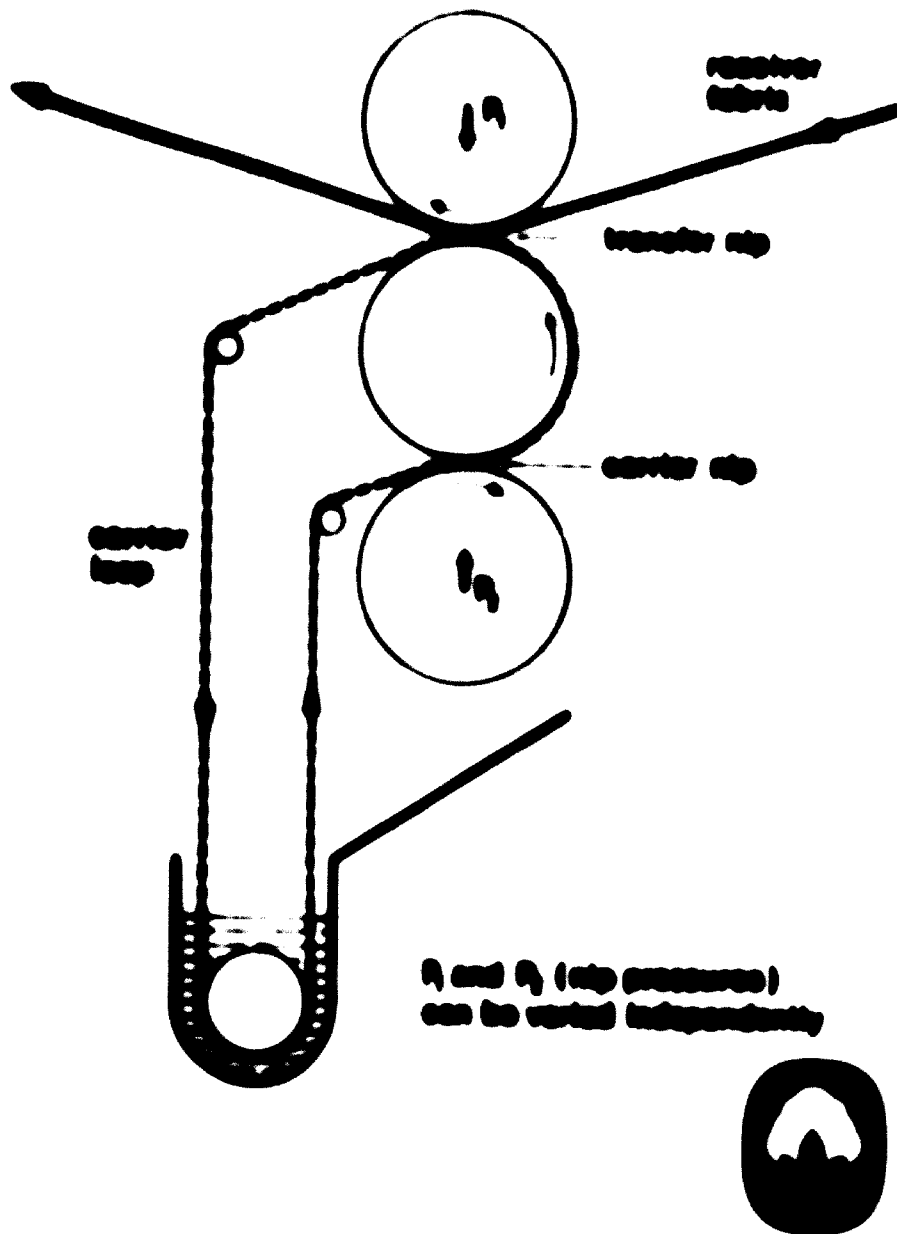
# LITHOGRAPH SPEC BY ENGRAVED ROLLER



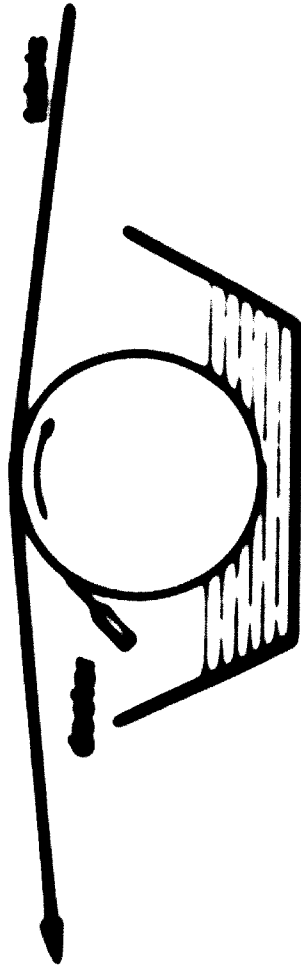
# LIQUOR TRANSFER BY WICKING SYSTEMS



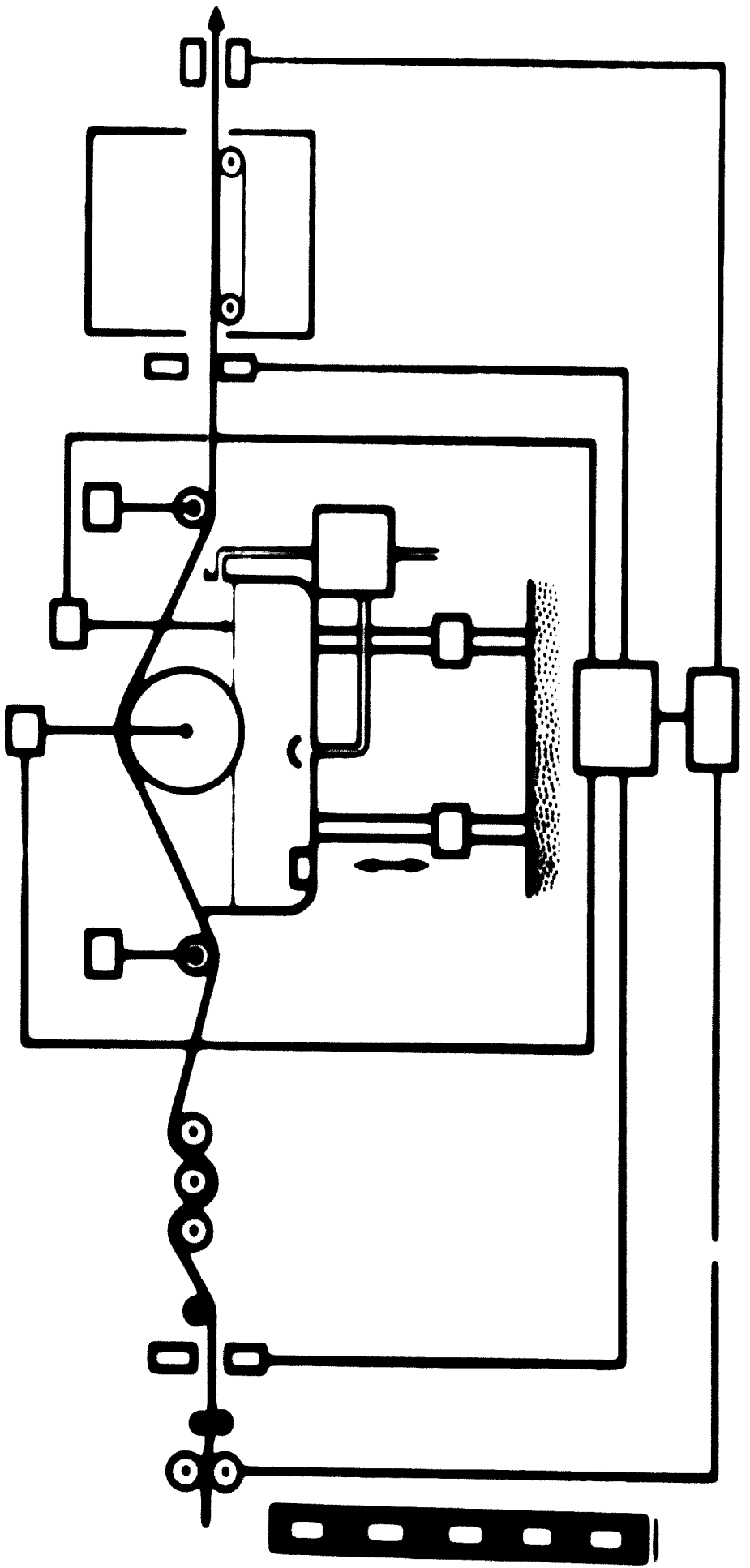
# PRINCIPLES OF TRANSFER PADDING



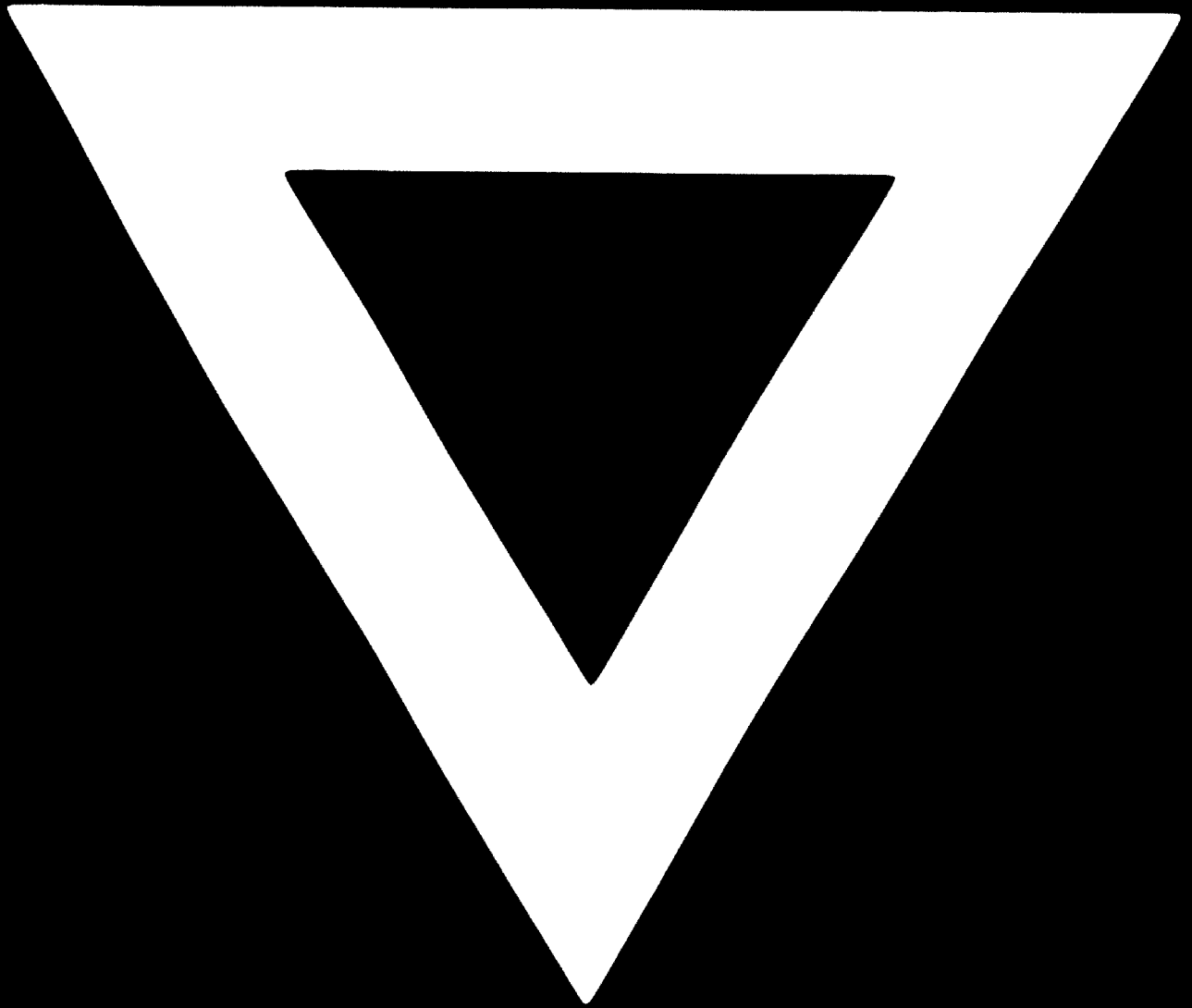
**LASER TRANSFER BY LICK-ROLL**



# TRIATEX MA SYSTEM







**76.01.15**