Forming fabric selection for improved paper quality

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SUMMARY

Faster paper machine running speeds as well as the demand for improved economics in power and chemicals are placing new requirements on the performance of forming fabrics. As a result wire selection today has become an important tool with great impact on machine efficiency, paper quality and total cost.

The main factors to consider in wire selection :

FORMING FABRIC LIFE, STABILITY AND RUNABILITY, DRAINAGE AND RETENTION, FORMATION AND SURFACE PROPERTIES

are discussed in detail. Emphasis is being put on multilayer fabric constructions evidencing sound improvements in both paper quality and economy in the markets.

INTRODUCTION

The forming fabric manufacturer's challenge rests nearly exclusively with the need to satisfy increasing forming fabric reqirements (fig. 1).

Increasing paper machine speeds as well as the general demand to improve the properties of paper of all grades have granted the paper industry a wide range of synthetic forming fabrics. The key to success, however, is inevitably linked to understanding the papermaking and sheet forming processes.

Stability And Runability

The "stability" of a fabric has been considered as it's property NOT to shrink and/or stretch in it's dimensions under machine conditions. Today this "dimensional stability" has become a self-evident prerequisite to successful forming fabric operation.

Today's requirements, however, require adapting the properties of the elastic body "forming fabric" to a paper machine's dynamic stretching conditions. It is well known that the elastic body forming fabric suffers different machine direction (=MD) tensions while being turned around in a paper machine.

The fabric's reaction to varying tensions is as follows:

It elongates (shrinks in width) if tension increases and shortnes (widens) whenever tension decreases The important fact in this context is, that elongating always takes place faster than shortening and this "delay in shrinking back to it's original length when tension is being reduced is well known as "HYSTERESIS" (fig 2).

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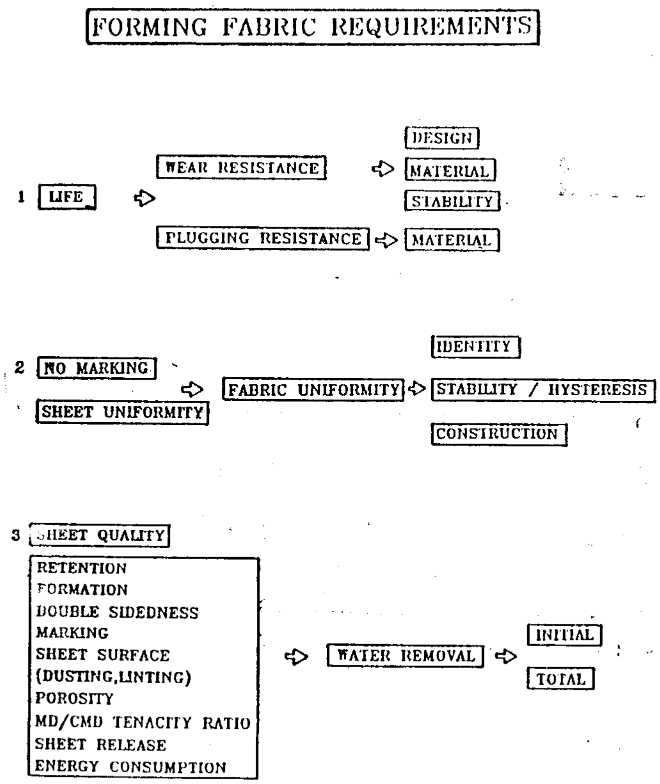


FIGURE 1

In accordance with this property of all elastic bodies it has to be accepted that LENGTH and APPLIED TENSION balance only after a well defined time after relaxation (fig 3).

The fabric in a paper machine reacts in according to it's elastic behaviour. It displays "waves" which can be observed in all paper machines from the point where the wire leaves the driven roll to a "point of equilibrium" in the return run. These "waves", resulting from the fabric's elasticity, are normal and insignificant, as long as equilibrium between wire length/tension is achieved in the return run of the wire with increasing speed and/or decreasing fabric length (as usual for TWIN WIRE FORMERS), however, the point of equilibrium starts shifting towards the headbox until it ultimately ends up in the forming zone. The resulting problems with streaky sheets are well known in the industry aud can only be sloved by changing the elasticity of the wire as demonstrated in fig. 2. It is, however necessary to understand that any change of one fabric property usually adversely affects others, and therefore COMPROMISING to optimize forming fabric application has become the art.

Synthetic Single Layer Forming Fabrics

Experienced paper makers once expressed a simple truth in a simple proverb :

THE FORMING FABRIC DETERMINES PAPER QUALITY

THE EFFICIENCY OF THE PRESS SECTION DETERMINES THE PROFIT YOU MAKE.

AND BY WASTING ENERGY IN THE DRYER SECTION YOU LOSSE THE MONEY YOU HAVE JUST EARNED

The truth of this saying may well be a subject for extended discussions. It has, however, been generally accepted that a forming fabric's influence on paper quality is significant as is evident in fig. 4.

HYSTERESIS

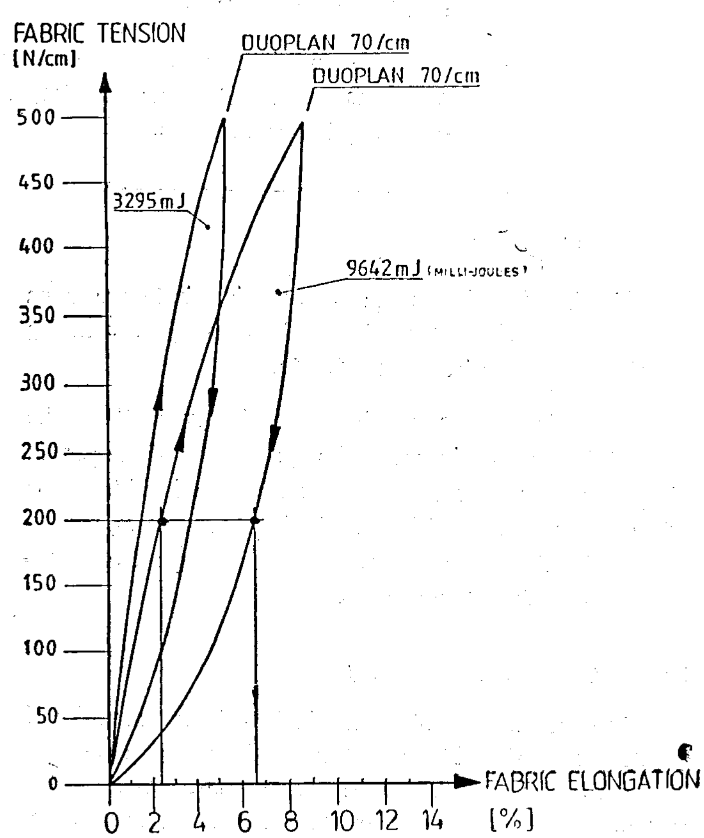


FIGURE 2

THE SIGNIFICANCE OF HYSTERESIS

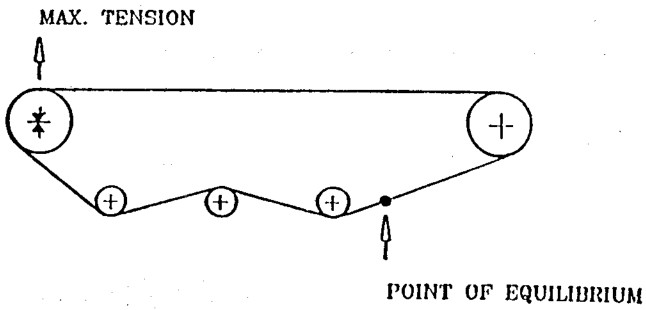


Figure-3

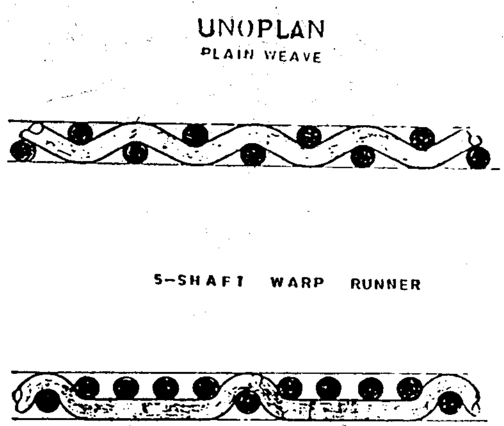


FIGURE 4

The 1:1 plain weave fabric construction represents the ideal wire with reference to quality. This is being traced back to the minimnm distance between paper fibre-supporting-points as well as the perfect monoplanity resulting in a reduced penetration of stock fibrics surface granting a markingfree, perfectly uniform paper sheet af excellent formation. This famous plain weave fabric, however, has an unacceptably low economy in terms of a fairly poor life potential deriving from it's running side characteristics. What had been the ultimate goal for a wire's sheet side, i.e. monoplanity, turns into a major disadvantage on the running side of the fabric is evident in the respective cross section, the MD-yarn is being expcsed to wear right from starting to turn the wire around thus weakening the construction's "tension carrying" element resulting in poor life.

A solution to improve a single layer fabric's lief potential was easily found. A change of weaving pattern gives the opportunity to protect the load carrying MD-yarn effectively.

Reviewing the result of the endeavours to improve life, however, evidences the real problem of single layer fabric constructions : The doubtless positive measure to improve life turns out to be a hazard to paper quality as it damages the wire's surface monoplanity and generates long MD slots prone to cause marking, sheet sealing and a different sheet release deriving from an increased paper fibre penetration into the fabric's surface (fig 4). The need to compromise or to select between

either "QUALITY" or "LIFE"

is evident and this finally enforced the development and introduction of double layer fabrics.

Synthetic Double Layer Forming Fabrics

The introduction of double layer forming fabrics gave the paper industry tremendous improvement in both paper quality and fabric life (figs 5 & 6).

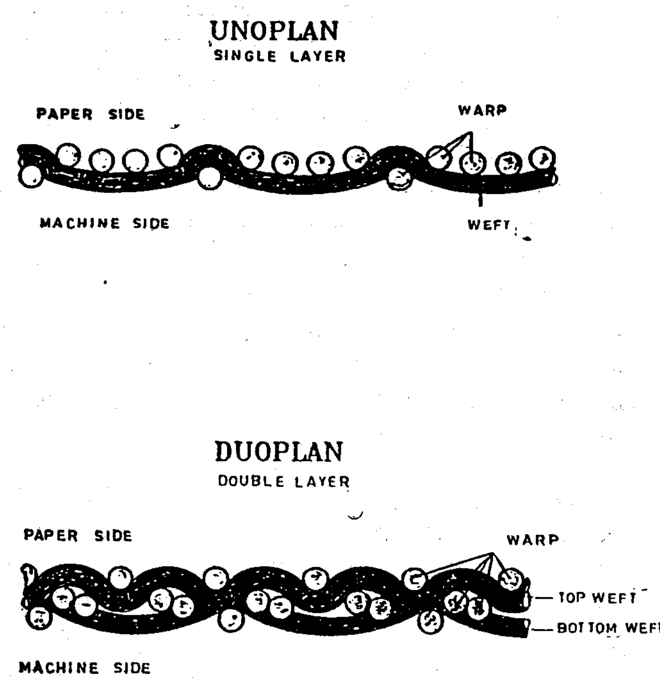


FIGURE 5

DUOPLAN
DOUBLE LAYER

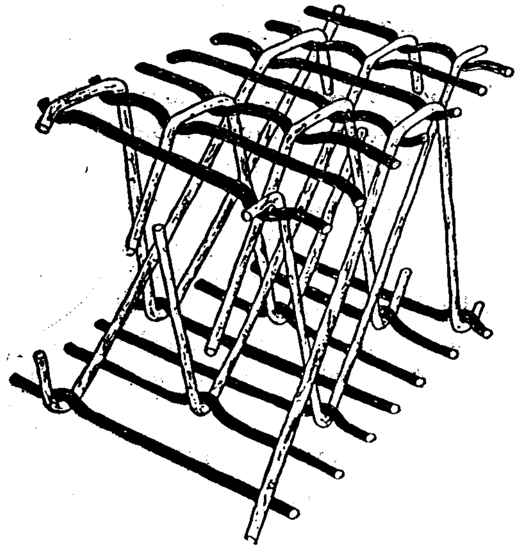


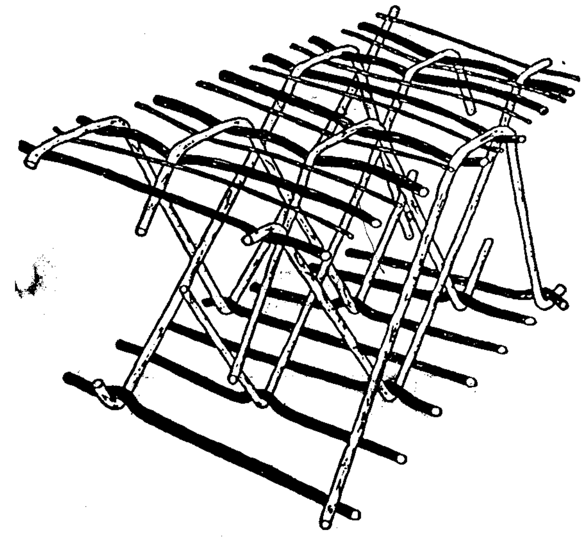
Figure-6

It effectively combined perfectly monoplane fabric surfaces with well protected backside MD yarns thus offering optimal characteristics for forming a paper sheet of high quality and at the same time providing a high life potential.

Further increasing paper machine speeds as well as a continuing demand to improve paper quality challenged the development of double layer forming fabrics with an improved surface uniformity. Higher yarn counts and extra CMD yarns in the construction of double layer surfaces flooded the market with a wide variety of designs, the most successful of which are shown in figs. 7 & 8. These "Extra Weft Added" constructions provided an increased number of fibre supporting points thus reducing the "gap" between each two points on the surface, resulting in less marking, improved formation and a more uniform sheet by effectively controlling initial water removal.

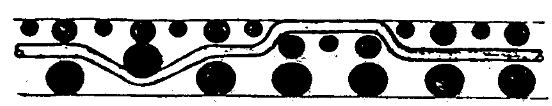
Today papermakers are left with the difficult decision to select the most suitable forming fabric construction for meeting their both productivity and quality objectives from a wide variety of designs. Besides modern means of assessing paper machine and paper forming processes (ultrasonic and Gamma-dewatering gauges) there are some considerations which may be of help. Field experience deriving from fabric performance evaluations on a wide variety of paper machines and paper grades have evidenced the importance of "fibre supporting points" i.e. the number of yarn knuckles in a wire's surface (fig 9).

DUOPLAN-E
DOUBLE LAYER-E



FIGURE

DUOPLAN-E
DOUBLE LAYER-E



DUOPLAN-T
DOUBLE LAYER-T

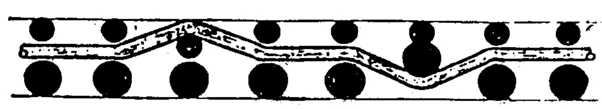


FIGURE 8

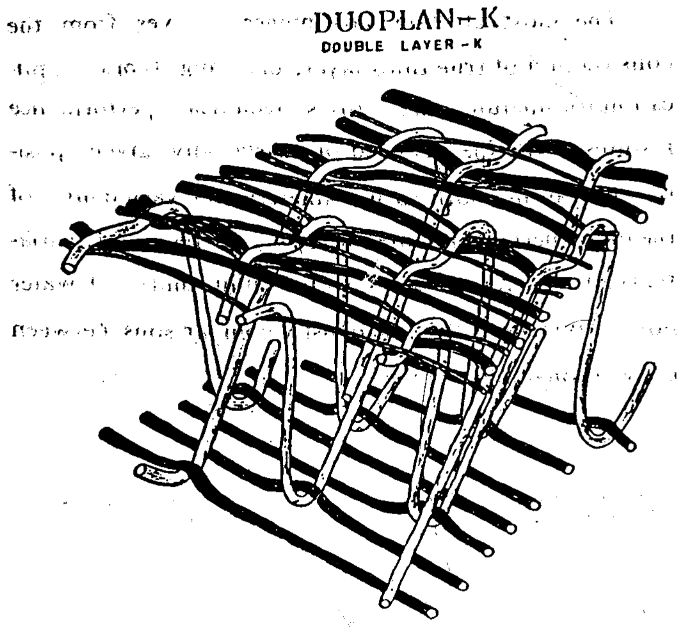


FIGURE 8

T-COUNT VS. FIBER SUPPORTING POINTS *

	SINGLE LAYER				DOUBLE LAYER		
	PLAIN	3 SHED	4 SHED	5 SHED	6 SHED	7 SHED	8 SHED
TC –	45	55	~63	~71	110	120	130
WARP+PICKS	25+20	30+25	~33+30	~39+32	60+25	70+25	80+25
PAPER SIDE					+25	+25	+25
	TP_x – 500/cm²						

TC – TOTAL COUNT OR T-COUNT
TP_x – FIBRE SUPPORTING POINTS

Figure-9

As a result it has been generally accepted that an increasing number of fibre supporting points improves formation of a sheet considerably. In this context it is, however, important to understand how this characteristics is being influenced by forming fabric construction.

Fig 10 shows the relationship between fibre supporting points and shed count. The requirement to employ minimum shed count numbers to maximize the numbers of fibre supporting points is evident. The truth is that the 7—shed construction has outperformed higher shed versions in the majority of existing fabric applications. Secondly the added disadvantages of high shed designs like their lower degree of constructional stability have contributed to the success of 7—shed designs.

Without downgrading the brilliant success of 7-shed forming fabrics in all markets and paper grades, it appears to be necessary to amend that double layer constructions in general are showing performance limitations as well. The success of increasing the number of fibre supporting points in double layer fabric surfaces is being traced back to the fabric designs ability to reduce initial drainage. As a result sealing of the wire by the initial sheet layer is retarded and the flow resistance is reduced. Consequently water removal is enhanced

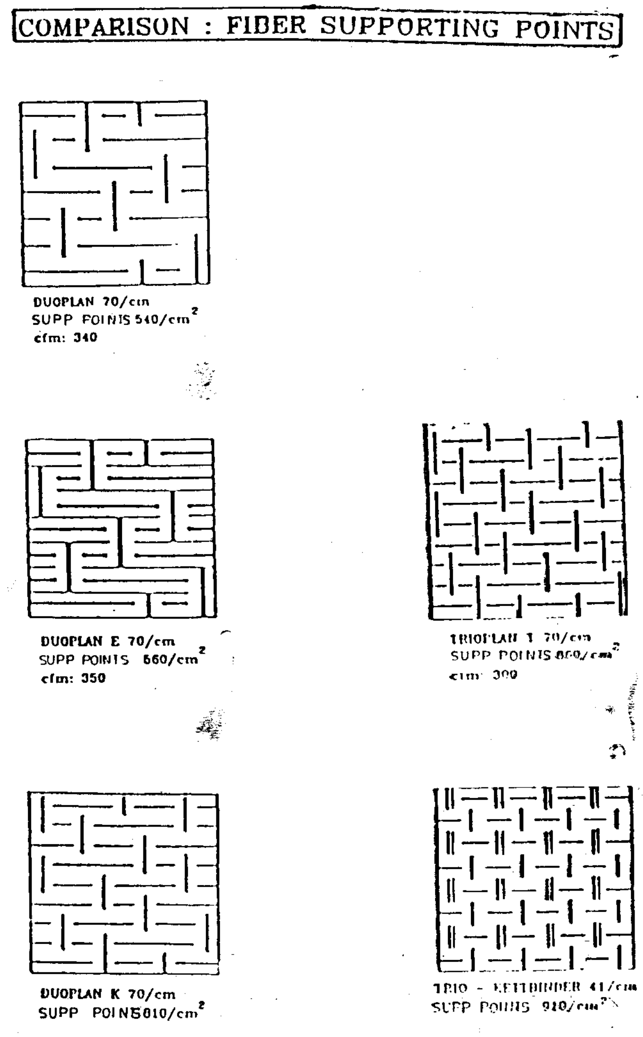


FIGURE 10

without damaging the initial sheet layer granting improved formation. This positive effect of a reduced flow resistance during the initial sheet layer on formation in return appears to be a hazard to retention as the more permeable initial sheet is a less effective "filter" for fines and fillers.

The need to compromise or to select between either "FORMATION" or "RETENTION"

is evident and finally enforced the development and introduction of triple layer forming fabrics.

Synthetic Triple Layer Forming Fabrics

When discussing single layer fabric constructions we had to accept that we could construct a fabric for either paper quality or life. Designing triple layer fabrics endeavours to combine two single layer fabrics, one for paper quality and one for fabric life in one compound.

First trials to link two single layer constructions together by employing CMD binder yarns was of limited success (Fig. 11). The vast difference in the stress and strain characteristics of the two different single layer constructions resulting in a "relative movement tendency" between the two layers frequently lead to layer separation and stability problems.

A second generation of triple layer constructions employed MD-binder yarns and successfully solved the problems of delamination and stability.

Both version's major disadvantages however, remained unsolved. Fabric caliper exceeded acceptable standards resulting in performance problems like water fibre carrying, problems with sheet transfer in twin wire formers culminating in a severe shadow marking tendency (fig. 8)

A new and third generation of triple layer forming fabrics has recently been developed which has proven itself successful in eliminating those problems (fig 11). In the new design with the elimination of binder yarns totally, the fabric caliper could be reduced to magnitudes of double layer designs.

The most striking advantages derives from the construction of true third layer, enabling fabric application to finetune the wire's technical performance features to the specific need of nearly any given position by varying both yarn diameters and yarn count of the construction's middle layer. The resulting variability of flow resistance as well as uniformity of water flow is evidenced in mass density comparisons between conventional and the new.

MASS, DENSITY COMPARISON

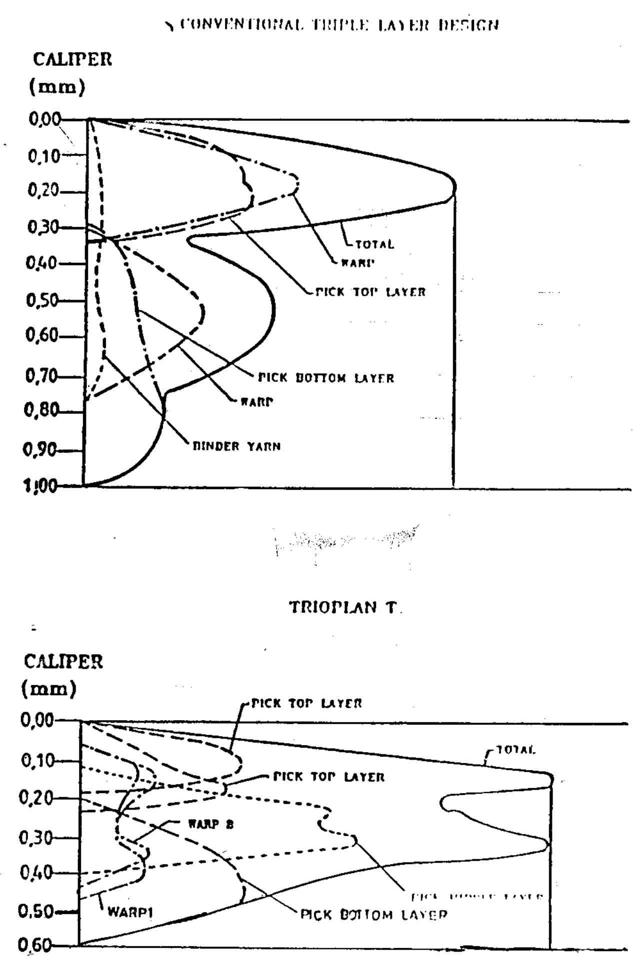


FIGURE 11

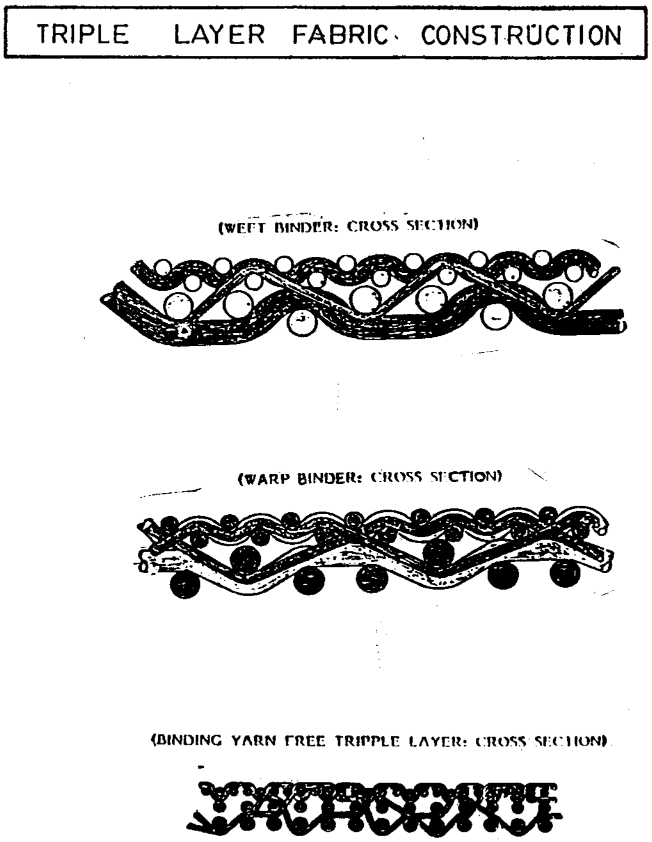


Figure-12

TRIOPLAN—T Triple layer designs (fig. 12).

An initial field evaluation of T R I O P L A N—T on selected applications has proven the designs capability to eliminate shadow marking and allowing an extra ordinary opportunity to improve on both formation and retention.

By comparing the number of achievable fibre supporting points of various constructions as well as considering TRIOPLAN — T's unique capability of adjusting it's flow resistance to the water removal requirements of the sheet it becomes explainable why TRIPOLAN — T is stressed to grant additional advantages to tomorrow's papermaking.