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RECENT DEVELOPMENTS IN WEAVING

by

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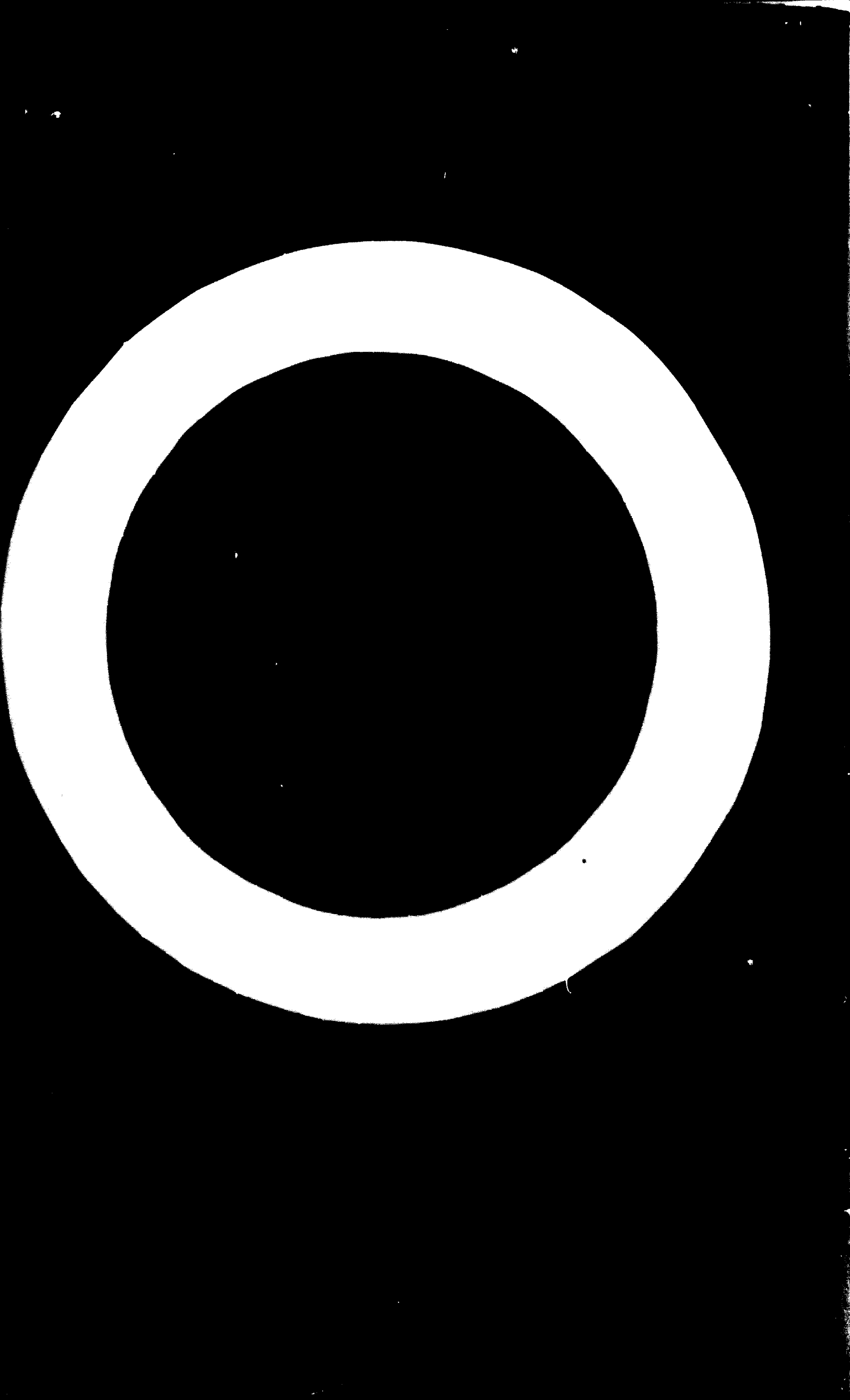

1. Introduction

Textile manufacturing methods - the making of yarn, the production of cloth, the dyeing and finishing of material - have undergone drastic changes during the past decade. For the textile industry these changes have had the following consequences:

1) increased productivity per manufacturing unit (through introduction of high speed machinery),
2) higher capital investment per labor force (more complex equipment),
3) less man hours required for a given output (through automation) and
4) diversification into special purpose techniques (with a partial loss of versatility).

While points 1, 2 and 3 can normally be converted into quantitative figures that enable an economic appraisal, it is often difficult for the potential buyer of the equipment to judge and evaluate the merits and chances of a newly developed technique that at least in the state of its introduction to industry may seem limited in versatility. The narrow range of application is in many cases typical for new types of machinery and it is in the interest of the machine manufacturer to modify such equpment as to widen the field of application in order to increase the market potential of the new product. On the other hand we realize that - speaking of weaving alone - the requirements as specified by the desired properties of the end products do indeed vary within rather wide limits. The state of today's technology, the knowledge of new materials and the vast experience in electronics and automation now enable the engineer and inventor to design machinery to perform a specific operation much better, faster and at lower cost than an allround-type equipment could possibly do. With this remark I only want to point out that in order to make meaningful comparison among equipment, mill management must have a clear concept of the product line it desires to manufacture (yarn type, cloth weight, yarn density, fabric width, color, pattern, quality etc.).

It appears appropriate at the beginning of this lecture to spend a few thoughts on the competitive situation that exists today between the weaving and knitting technique because, as you are probably aware, we are amidst a continuing shift from weaving to knitting, particularly in the apparel field. This situation is very pronounced in the United Kingdom, it is quite apparent also in other Western European countries and the United States. In 1970 81 % of all Cloth in the world was produced by weaving technique (fig. 1) and it is expected that this portion will decrease to about 77 % in 1975, while knitting is expected to grow from about 13 % to 16 % on world-wide basis. The corresponding figure for Western Europe and the United States combined indicate a trend from 73 % decreasing to 65 % for the weaving sector and an increase from 19 to 26 % for the knitting industry. Some

fig. 1

forecast has gone as far as to predict that by 1980 as much as two thirds of the cloth production in Great Britain will be supplied in knit-goods. Such predictions seem to be the outgrow of the initial enthusiasm that was placed into the entire knitting technology about four years ago. In the meantime I think practical experience has shown where the limitations of knitting are and it appears today very unlikely that knitting is on its way to replace fully the weaving technique. One fact, however, is plain; it is the availability of the smooth, low count, high-strength man-made filament yarn which made it possible for the circular and warp-knitting machine to be operated at ever increasing machine-speeds. Furthermore the consumer-demand for easy-care garments served as an additional promoting factor for the knitting technique. And yet, it is erroneous to believe that a knit structure will do the same as a woven structure - and vice versa. Let us look at some basic differences. One might say that the woven cloth always has the characteristics of a dimensionably stable sheet-like structure. The porosity and transparency is easily altered by changing the thread-count and/or the weft- and warp-thread density. Above all it is possible by weaving technique to produce a cloth of entirely closed structure with weft- and warp-yarn touching each other along their full length. On the other hand the knitted cloth is essentially a loose, porous structure with a high degree of flexibility or pliability. Since the thickness of a knitted material is very pronounced, due to the yarn folding into 3-dimension dimensional loops, considerably greater yarn-length must be worked into the knitted structure, in order to obtain a similar coverage as compared to a woven cloth. If one desires equivalent cloth weight, then knitting requires finer yarn count and herewith higher raw material cost. A simple example may illustrate this situation. A regular bed cloth can be woven with No 40 yarns and a weave density of 30 threads/cm. Under these conditions about 6600 m of yarn will go into 1 m2 of fabric, weighing 100 g / m2. A two-bar 20 gg (20 needles per inch) tricot warp knitting machine on the other hand will consume about 11'000 m total yarn length per m2 of cloth, necessitating a yarn count of No 67 if the same weight is required. We can say that in many cases, where knitting appears to be attractive by virtue of its higher production speed, the economic advantage may actually be rather small or nil due to higher material costs.

2. Survey of weaving techniques

After these general remarks let us have a look at the different principal weaving techniques that are in use today. Probably the most significant and distinguishing characteristic of a weaving machine is its method for weft yarn insertion, because this mechanism dictates essentially the design of the entire machine.

fig. 2

The typical feature of the conventional loom is the relatively large shuttle, usually a mass of approximately 0.5 kg, which is propelled by means of the picking rod. The initial velocity may reach about 17 m/sec. The acceleration and deceleration of this large mass is rather high, one reason for the very high noise level of conventional looms. The quill (spool containing weft yarn) which is transported by the shuttle is wound in the quill on the winding department, an operation that is entirely automatic today. The loom, or weaving automat as it is called, is capable to replenish the empty quill in the shuttle fully automatically at no loss of production time. Earlier models employ a rotary quill battery supply where labor is necessary for filling-up the quill magazine. In modern looms, quill boxes containing several kilograms of weft yarn are brought directly to the loom. No further labor is required because the removal of the quills from the container is carried out by the automatic box loader mechanisms. An important feature of

fig. 3

fig. 4

cloth woven on a conventional loom is the regular selvage as the result of the back and forth motion of the shuttle depositing the weft yarn.

The next step, which enables to operate the conventional loom with a stationary weft yarn supply is the loom winder

fig. 5 technique. First introduced in early 1950 the "UNIFIL" unit has been extremely successful and up to now this attachment is found on many new looms of various makes. The UNIFIL was, and still is, an answer to the threat of the so-called shuttleless looms. This apparatus can be attached to new or existing looms and in doing so the labor and machinery costs of the central quill winding department is eliminated. On the other hand an extra mechanic is needed to survey the UNIFIL winders. A further advantage lies in the fact that the total number of quills can be much reduced since each loom equipped with UNIFIL requires only eleven quills. The UNIFIL is offered with most major makes of conventional looms weaving synthetic filament or spun yarns.

The latest development in weaving technology also belongs to the machine types that require a winding station. In the multiphase or wave-shed weaving machine several small yarn carriers are travelling one behind the other across the weaving width, each depositing one length of weft yarn. The machine therefore is equipped with an ingenious winding device to provide each yarn carrier with an exact yarn length. This multiphase machine, which will be described in more detail later, was first shown to a greater public at the ITMA 1971 in Paris.

The largest and constantly growing group of non conventional machinery is usually put under the heading "shuttle-less looms". Common in these systems is the stationary weft-yarn supply from which without further winding process the yarn is directly inserted into the shed. The developments along this line were spurred no doubt by the successful introduction of the "gripper-shuttle" or projectile weaving machine introduced by SULZER already twenty years ago. In the early 60's other types of shuttleless looms began to appear - some remained on the market, others disappeared. Today it is estimated that of the total weaving capacity of new installations about one third is of the shuttleless type. This portion will probably grow to two thirds by the end of this century. The main distinction with respect to yarn insertion mechanism yields the following grouping:

a) projectile (gripper-shuttle) machine

b) gripper machine: - flexible or rigid rapier
- single or double rapier.

c) water jet (or hydraulic) machine

d) air jet (or pneumatic) machine.

The systems in use for cotton yarn weaving shall be described in more detail below.

3. Individual machinery

In this chapter we shall deal with specific weaving machinery, pointing out some of the recent developments. While it is not possible - nor necessary - to cover every make of machine, we
fig. 6 will concentrate on the most significant technical facts of the different machine types.

3.1 Conventional loom

Since 1963, the year of the ITMA Hannover where a surprisingly large number of shuttleless looms were exhibited for the first time, predictions have been made about the obsolescence of the conventional loom. At the present time the majority of looms in operation is still of the conventional type and it is probably correct to assume that it will take several years to replace them by new weaving technologies. As a matter of fact there are still certain product lines where weaving by conventional method is economically justified - this applies particularly to some sectors requiring only single shuttle looms.

The machine builders still found it worthwhile to put considerable engineering effort into improvements to make the conventional loom as perfect as possible. If such modifications can be realized with little change in machine costs, then they are justified - if not, the textile industry is not interested in it and a switch to shuttleless weaving is certain.

In general the following changes and improvements are noted

on conventional machinery:

a) enlarged weaving width, up to 450 cm, whereby two or three fabrics are woven simultaneously side by side,

b) electronic sensing mechanisms to control shuttle fligght, push-button control for early operation

c) improved shuttle-checking by means of hydraulic stop devices

d) better warp let-off systems offering more uniform yarn tensioning and a moderate tension level even at high machine speeds,

e) the factors above mentioned combined with materials of higher strength and durability have once more enabled to increase the production rate of the conventional loom.

Let us inspect the factor productivity somewhat closer. If we consider this characteristic in terms of weft insertion rate in m/min, then the number picks inserted per minute (machine speed) and the weaving width (not machine width) are the determining factors. At the ITMA 1971 one could see - and hear - conventional looms of small width running at speeds as high as 360 picks/min. This demonstrates indeed that it is technically possible to operate a modern loom at speeds unthinkable just a few years ago. However - and I think this is most serious - the wear and tear on the parts involved in this picking motion must be excessive and above all the noise reaches such a level that ear caps would become an indispensable protection item.

The solution - large weaving width at reduced machine speed - is a much better one not only in view of productivity but also with respect to the noise level which could possibly kept within the 85 dB limit. A large reed width on a conventional loom however should be fully utilized most of the time otherwise any

fig. 7 economic advantage is lost, because the shuttle irrespective of warp width always has to travel the same distance - from shuttle box to shuttle box. Thus, because the number picks / min cannot be adjusted in corrspondence to the actual cloth width - as is possible in shuttleless weaving - a considerable loss in weaving efficiency arises whenever the full width is not utilized. Here the conventional wide-width loom suffers a serious handicap that cannot be corrected technically.

3.2 Gripper shuttle machine

With over 25'000 machines in operation now, the gripper shuttle loom manufactured by Sulzer no doubt is the one with the greatest experience among non-conventional machinery. Originally designed as a high-production cotton weaving machine, the industrial success began in the wool industry, where the heavy multi shuttle looms were replaced. In this branch the advantages of weaving with a stationary weft supply yarn package offering multicolor pick-and-pick weaving at a considerably stepped-up production rate are quite obvious. Furthermore, due to the long knot-free weft-yarn length, less mending costs arise at the same time, improving the quality of the cloth which is a viable factor whenever high cost raw material is employed. The field of application could steadily bee enlarged and today the Sulzer machine is well introduced in the cotton and

fig. 8 synthetic sector. The working principle of this machine is well known today: A small projectile - only 40 g in mass as compared to 500 g of an ordinary shuttle - is picked from left to right across the shed by the energy released from a torsion bar. The weft yarn tip is gripped in the projectile (therefore "gripper shuttle"), thus pulling the yarn that is fed from large stationary supply spools. Due to the high initial velocity and the small resistance during the flight of the projectile this machine type is best suited for great weaving width. Today the SULZER machine is built in five different widths (85" = 216 cm, 110" = 279 cm, 130" = 330 cm, 153" = 389 cm, 213" = 541 cm). For light-weight cotton fabrics the 130" - or 153" - machine is usually the best choice.

fig. 9 The wide machines offer great flexibility as to cloth width at high production rates. If several cloths are woven side by side, their widths need not be the same. The application of new types of synthetic materials in the manufacture of the projectile is the latest improvement which enables to operate the gripper shuttles transport without the need for oil-mist lubrication. Finally we should point out that the cloths are woven with a smooth tuck-in selvage on both sides, sufficiently strong for the handling in any standard finishing operation.

3.3 The gripper weaving machines

In this weaving technique no flying shuttles or projectiles are employed. The weft insertion element, rigid or flexible rapiers, always remain mechanically coupled to the driving mechanism. Acceleration and deceleration therefore are considerably smaller; an advantage when compared to systems with a picking motion and free flying projectiles. On the other hand, by virtue of its working principle, the gripper weaving machine is not - and will never be - a truly high production machine. The gain in productivity over the conventional single shuttle loom, when equal weaving widths are compared, is of the order of 10 %. More significant is the advantage when multicolor weaving or pick-and-pick weaving is considered. The weft color change on the gripper machine is achieved essentially at no loss in production speed and pick-and-pick weaving in contrast to the conventional shuttle loom does not require any special mechanism. Of course the elimination of the quill winding operation ant the possibility to work with large packages and knot-free yarn-lengths is of advantage also in single-color weaving. Nevertheless it must be said that gripper looms today are installed in the first place where weft-mixing or multicolor weft is a necessity, for the production of outerwear cloth, decoration and upholstery materials.

For lighter weight fabrics, four or five makes are well established in the weaving mill today. Among these we have to distinguish between machines where the weft-yarn is being pulled
fig.10 by its tip ("Dewas" tip-to-tip weft transfer principle) and mechanisms where the weft yarn is gliding in loop-form through
fig.11 the gripper heads (Gabler-System). The former system has the advantage of a positive holding of the yarn, thus preventing any twist-loss, and it is applicable to a wide range of yarn-count and irregular specialty-yarns. The latter system provides simplicity in yarn handling and produces a regular selva[ge] on one side of the cloth. Typical representatives for tip-to-
fig.12 tip transfer are the weaving machines by Dornier and SACM,
fig.13

while the loop-transfer is being exercised on the machines
Fig.14 from Saurer-Diederichs and DSL-machine by Draper and +GF+/Rüti. A further distinction of these machine types concernes the rapier or gripper itself. It can be either a rigid or flexible structure. The flexibility is chosen in order to save in overall machine width, which otherwise will become quite considerable on large weaving widths. Another technical solution to this problem is the telescope rigid gripper as offered on the Saurer-Diederichs machine. With 2,4 meters, the
Fig.15 +GF+-Rüti gripper-loom represents the widest machine available for cotton weaving at the moment. It is operated with 220 picks per minute, therefore leading to the considerable weft-insertion rate of about 530 meters per minute.

3.4 Jet-weaving-machines

The jet-weaving-machines are relatively new on the industrial market. The water-jet-machine has gained already a significant place in the synthetic weaving sector. For obvious reason, water as carrying medium will remain restricted for rather hydrophobic fibers and yarns, although it must be pointed out that some experiments are being carried out to weave polyester-cotton blends with water-jet looms. The first airjet weaving machine built in Sweden was a loom with a working width of 60 cm. It was thought for quite some time that large weaving widths could not be obtained by this technique because of the diffusing air stream. It is interesting to note that a single airjet
Fig.16 machine has been designed in Czechoslovakia to work over a

weaving width of 230 meters at 380 picks per minute. The result is the astonishing weft insertion rate of 875 m/min. The working principle is as follows: A measuring drum pulls off the yarn from a stationary spool and delivers the yarn tip to the air-jet located near the selvage of the cloth. When the shed opens, a strong air current ejects the weft-yarn and carries it across. A confusor, consisting of many ring-shaped lamellas mounted on the lay, restricts the air-stream into a rather narrow channel. On the other side of the cloth the weft yarn is usually held by suction until it is woven in by the consecutive pick. Due to the very high weft yorn transport velocities (usually in the order of 30 to 40 m/sec) it is necessary to provide an intermediate yarn reserve on the measuring drum. It would not be possible to pull off any yarn at this speed directly from a cone. The setting of the yarn length measuring device can be varied within 30 cm, therefore allowing to weave cloths between 200 and 230 cm width. The
fig.17 machine is particularly suited to work with spun yarns in the count range of Ne 6 to Ne 50. It produces cloth up to 300 g/m2 weight.

One of the most interesting new developments in the field of shuttleless weaving machines is no doubt the multi-airjet-machine from te Strake. This machine was also shown in public for the first time during the ITMA 1971. With 180 cm working width and 400 picks/min, the machine reaches an extremely high weft insertion rate of 720 meters/min. The working principle
fig.18 is as follows: From the stationary spool the yarn is taken off

by means of a measuring drum, delivering a constant yarn length per pick. The main jet located near the selvage inserts the yarn into the groove of a specially formed reed. By this one obtains a channel which prevents the rapid diffusion of the air stream. To guarantee the transport over the entire width a series of small jets are mounted on the lay. In this manner the weft yarn is essentially carried from air jet to air jet (there are 25 jets on a working width of 180 cm). The jets on the far side are arranged in a closer spacing in order to increase the pulling action on the yarn. The shed motion can be kept rather small, which helps to operate at a low warp tension level. In case of a weft yarn break, the machine stops automatically, moves the shafts into open shed position, sucks the remaining weft yarn away and resumes its normal operation without any need for manual control. As yet there is little information about the indu trial experience of this machine which is in its introduction state.

In judging the air-jet looms for cotton weaving it can be said that these machines, once they have passed their prototype state, may well be qualified as high-speed equipment for simple mass production fabrics.

3.5 Multiphase weaving machine (wave-shed machine)

Probably the greatest attraction among the weaving machinery exhibited at the ITMA 1971 in Paris was the multiphase machine shown by the +GF+/Rüti machine works. Weaving techniques whereby a multiplicity of weft yarns can be inserted simultaneously, are theoretically best suited to obtain maximum productivity. This technique is now accomplished in the so-called "turbo-weaving machines TWR" in which a number of

fig.19 small weft carriers are propelled across the machine, one after the other, by means of individually activated reed bars. The warp is divided into individual narrow groups and the shedding motion follows immediately behind each shuttle. The heart of the machine is the winding apparatus which must pro-

fig.20 vide each weft-carrier with the necessary length of yarn. From a large yarn-package pre-determined weft-lengths are wound onto a stationary sword. The U-shaped weft carriers one after the other stripe off the necessary number yarn-windings from this sword. Thus the yarn is held inside this carrier from which it is laid into the shed when traveling acros With 230 cm working-width, there are 23 shuttles in operation simultaneously. If the traveling time for each shuttle is 3 seconds, then a weft-insertion rate of approximately 1000 m/

fig.21 min will result. So far the machine is limited to spun yarns and to light-weight structure, single-color cloths. From an engineering standpoint it appears possible however that the field of application may well be widened in the future. The machine operates at an extremely low-noise level and is practically free of vibration.

Several machines are being evaluated now under industrial conditions and it will depend upon the experience gained in these tests how fast the multiphase weaving machine can find acceptance on a larger scale.

4. Comparison

In view of the many solutions offered today to produce woven cloth it appears difficult to make the proper machine selection for a given product line. It is not necessary however to consider every possible make of loom because there exist some very distinct categories. It is useless for instance to compare large width single shuttle looms with narrow multicolor gripper machines. In order to arrive at a meaningful comparison between possible candidates of weaving machines a thorough economical appraisal considering the specific conditions of the particular case is a necessity. Such appraisals must also include factors for which there exists no quantitative measure, such as reliability and durability, the spare part and servicing situation. It is obvious that it is impossible to give concrete recommendation within the scope of this paper. Some more general statements we can make with respect to the productivity of different weaving principles. Let us look first at the yarn velocity and weft-insertion time for different systems. The total time necessary to insert the weft yarn depends on the maximum velocity possible for a given system as well as on the acceleration and deceleration behavior. Jet machines, projectile machines and shuttle looms operate with relatively high accelerations. The maximum velocities vary between 35 m/sec for airjet looms, 29 m/sec for gripper-shuttle insertion, 26 m/sec for gripper-type mechanisms and 17 m/sec on a conventional loom. With these data it is possible to calculate the total weft-inser-

ig.22

tion time to cover a weaving distance i.g. of 2.2 meters. The corresponding times can serve as a relative rating of the various weaving techniques. It is obvious that with a short weft-insertion time a high number of picks per minute can be attained. In this respect the rating lists in the following order: airjet, projectile, gripper and shuttle loom.

fig.23 To obtain a measure for the actual production expressed as weft length inserted per unit time, the number picks / min must be multiplied with the weaving width. Here we have the following situation: In the 3 to 5 m-range the projectile machine takes place number one with up to 900 m/min weft-yarn consumption.

Even the widest and fastest shuttle loom reaches "only" 600 m/min weft insertion. In the range of 180 cm to 250 cm weaving width, the multiphase machine is dominating with the impressive weft insertion rate of 1000 m/min. Next is the Czechoslovakian Jet-tiss machine with 880 m/min. The new enlarged version of the +GF+/Rüti gripper machine particularly suitable for cotton yarn is capable of inserting 530 m/min on a cloth width of 240 cm.

Productivity alone does not determine the suitability of a certain weaving technique for a given purpose. It must be remembered that the figures mentioned are the theoretical maximum weft insertion rates. The actual productivity is obtained through multiplication by the efficiency factor. Now when the number picks/min is increased, the probability for

weft yarn breaks also increases due to higher accelerations. Greater weaving width also will tend to raise the chances for machine stops due to warp yarn breaks. The weaving efficiency therefore is often smaller on wide machines - in spite of the slower picking sequence. The problem with the utilization of the full width on conventional looms has already been discussed above. Other questions enter when large width machinery is being considered: The warp preparation department must be able to handle large beams. Transport, although less frequent, may be cumbersome and the total down time of a machine for beam change is inevitably higher.

With these remarks we want to point out that large width weaving, besides higher productivity, will create certain problems. Nevertheless, there is no doubt in my mind that low price, mass production single-color cotton fabrics should, for reason of economics, be produced on machines of at least 230 cm weaving width.

Among shuttleless machinery there are a number of other alternatives - of more technical nature - that must be weighed against each other: (Fig.24)

a) weft yarn transport. When the yarn tip is gripped, twist cannot be lost and the system can deal with a larger variety of weft yarn types. The pulling of a weft loop on the other hand enables the formation of a regular selvage on one side.

b) guide system. There exists the danger of streakiness due to lubrication marks, particularly on delicate fabrics.

c) selvage. Both sides leno weave or tuck-in selvage; one side normal or separate selvage thread. In this respect, the finishing trade has learned to handle most selvage types satisfactorily.

Depending upon the method used to form the selvage, a certain yarn loss usually occurs which does effect the economics of the process.

In view of the undisputably growing importance of diverse shuttleless looms one may ask why the conventional looms still are considered at all. The following reasons can be given as answer:

1. Relatively low investment costs.
2. Productivity - with respect to investment - at a reasonable level.
3. Selvage without problems.
4. Possibility to eliminate quill winding department through use of UNIFIL.
5. Operating personnel is familiar with system.

On the negative side for the loom - and these are reasons why weaving machines are being introduced in industrial countries at a fast rate - we must note the problem of noise generation and above all the increased labor cost. In the western countries developments that enable a reduction in the num of personnel generally are quickly adopted in spite of h: er capital cost. In 1955 the labor costs to produce woven cloth amounted to about 60 %, while capital costs were only 20 %. Today, the investment portion amounts to approx. 50 % and labor costs have shrunk to 40 %.

The latest technical innovation in this direction is the computerized control system for weaving mills, enabling automatic supervision of product, machinery and operating personnel. It is expected that such systems, of which there are a few in operation already, will find rather fast acceptance as an indispensable tool for modern production planning.

5. Summary

For the manufacture of single color, simple cotton fabrics, large width weaving equipment - for productivity reason - should be considered. This might be either conventional shuttle looms, gripper shuttle - or gripper machines (and air-jet machines once these are industrially viable). In the multicolor and pick- and pick weaving sector the gripper- and gripper shuttle-machines must be given preference. In industrial countries with considerably higher labor wages, the replacement of conventional equipment with machinery of highest productivity (high capital investment) is mandatory. For developing countries the economic appraisal of different weaving systems may well lead to the conclusion that modern conventional looms can compete with shuttleless weaving machinery.

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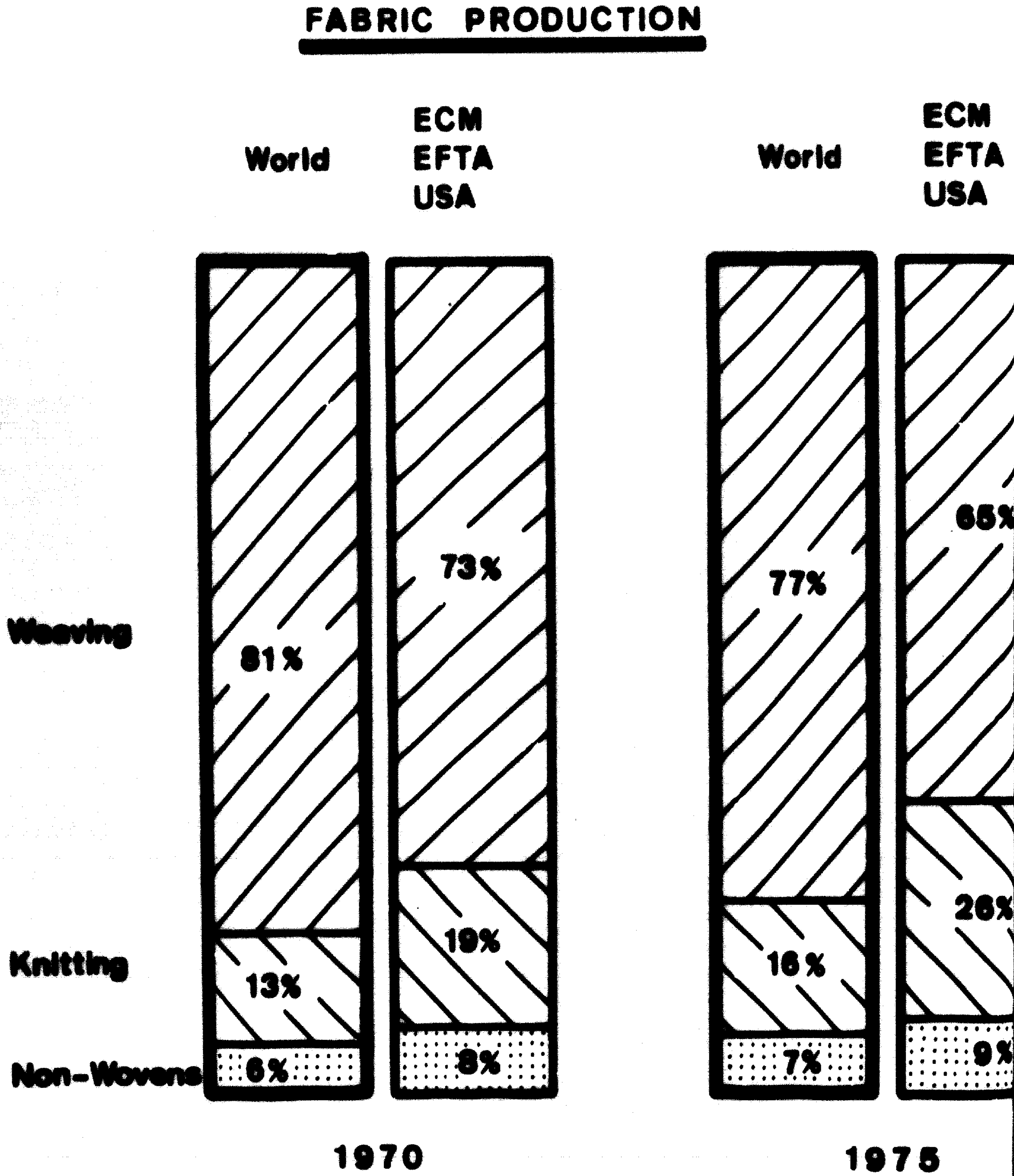


Fig. 1 Output of Fabrics (weight) by weaving, knitting and Non-Wovens

Fig. 2 Principle Weaving Techniques

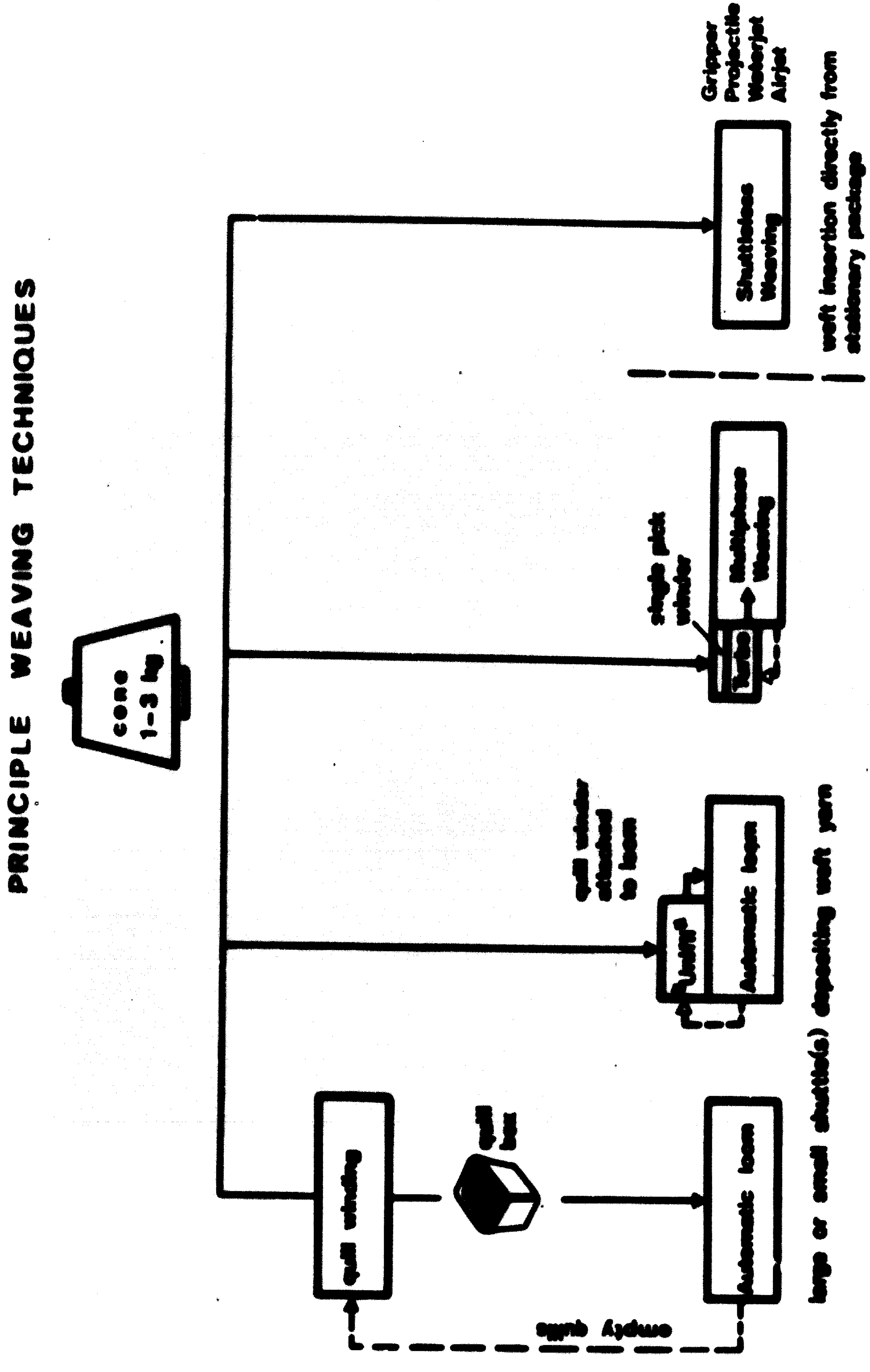
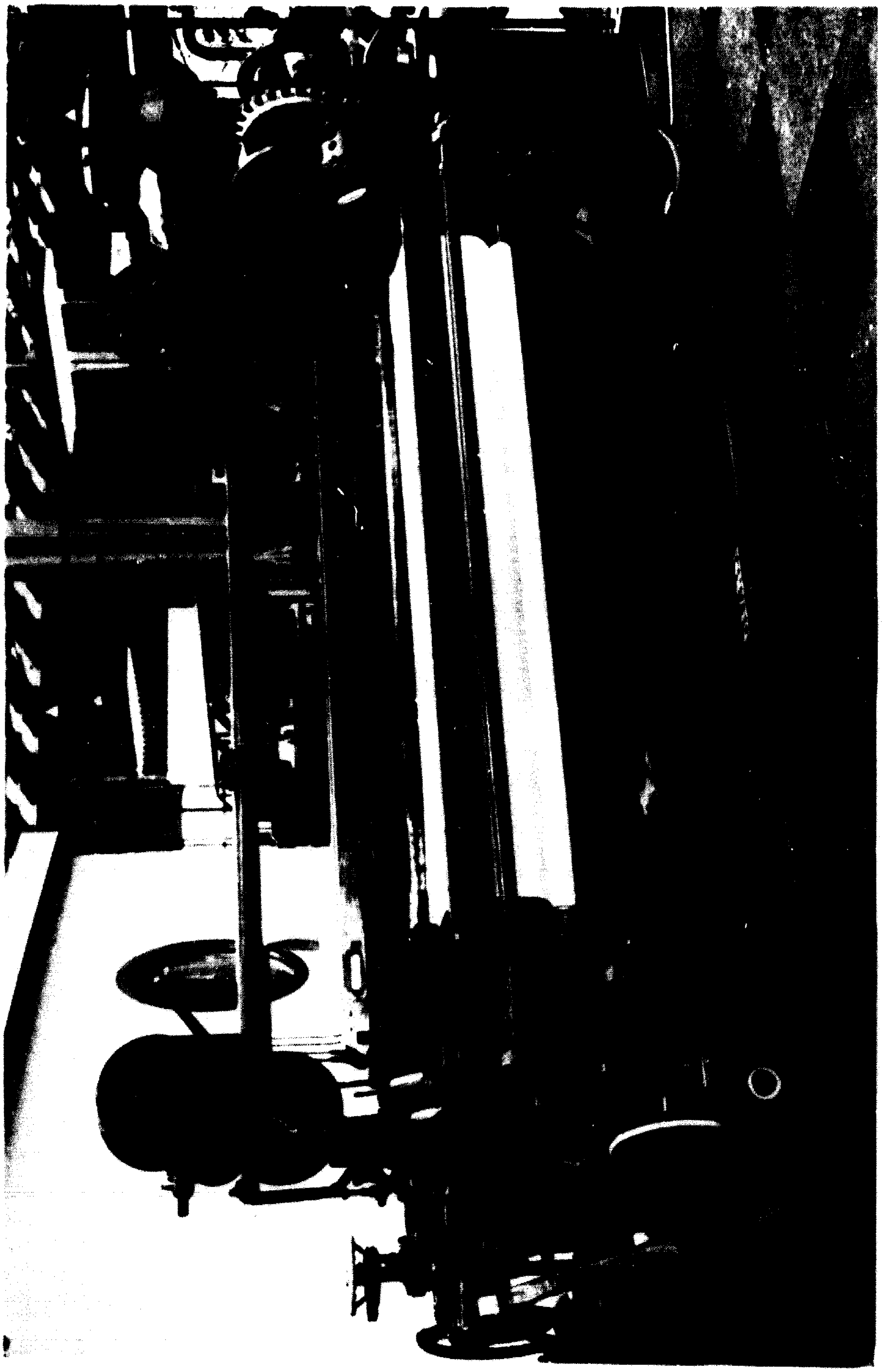


Fig. 3 Conventional Automatic Loom
with Battery - type Quill Changer



WEAVING ECONOMICS COMPARISON

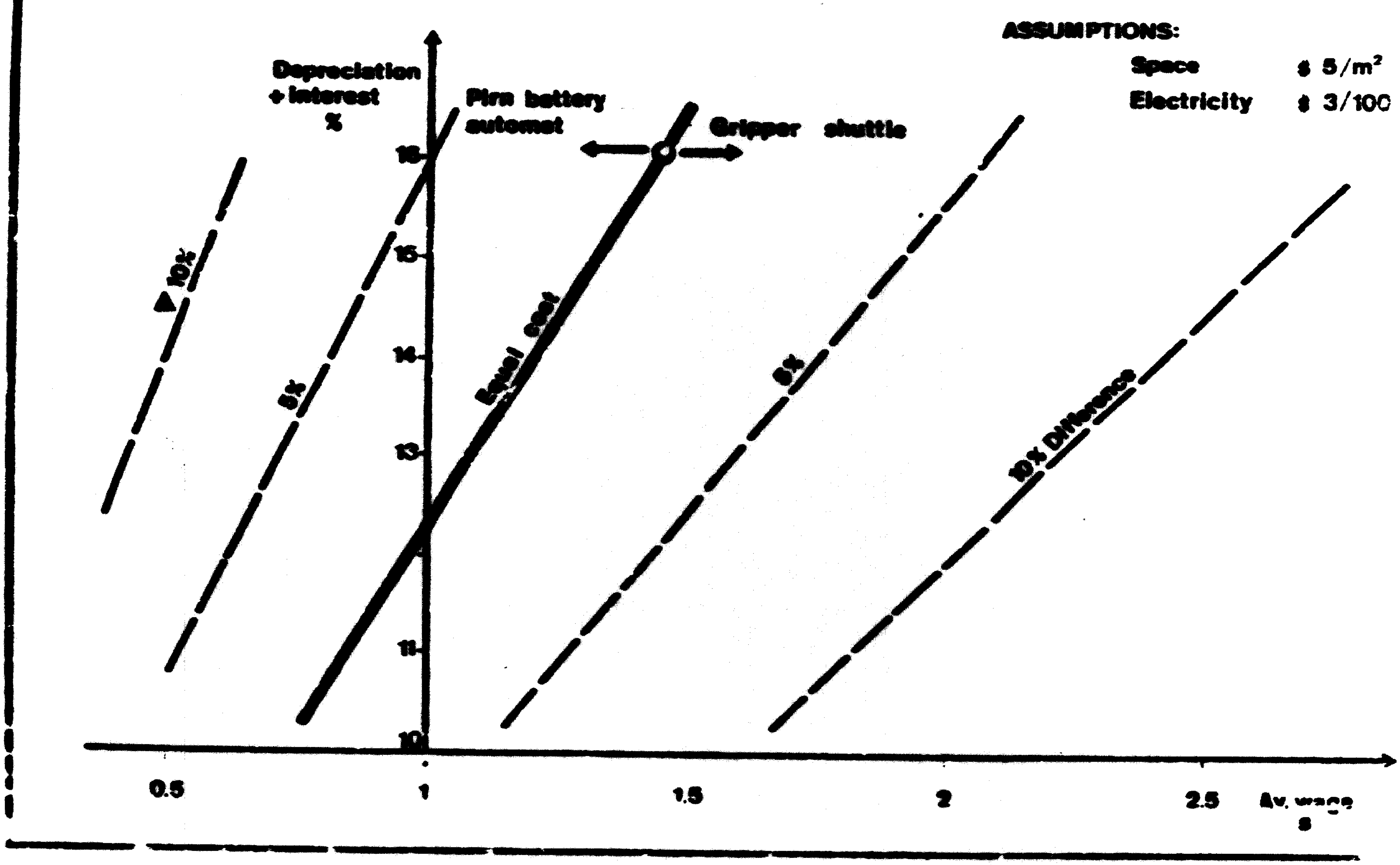


Fig. 4 Conventional Automatic Loom
with Box - loader - type quill changer

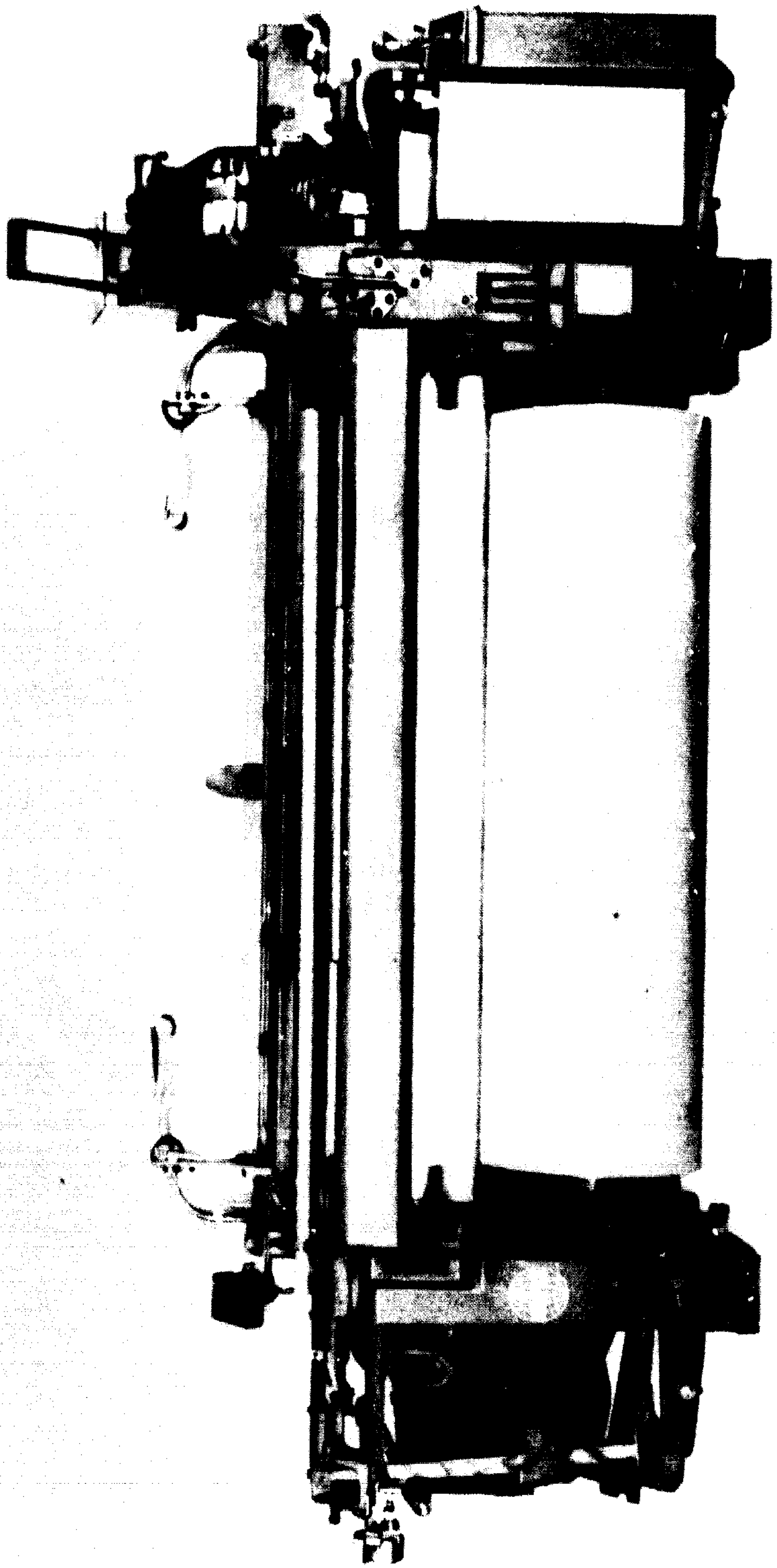


Fig. 5 Conventional Automatic Loom
with UNIFIL - quill winder

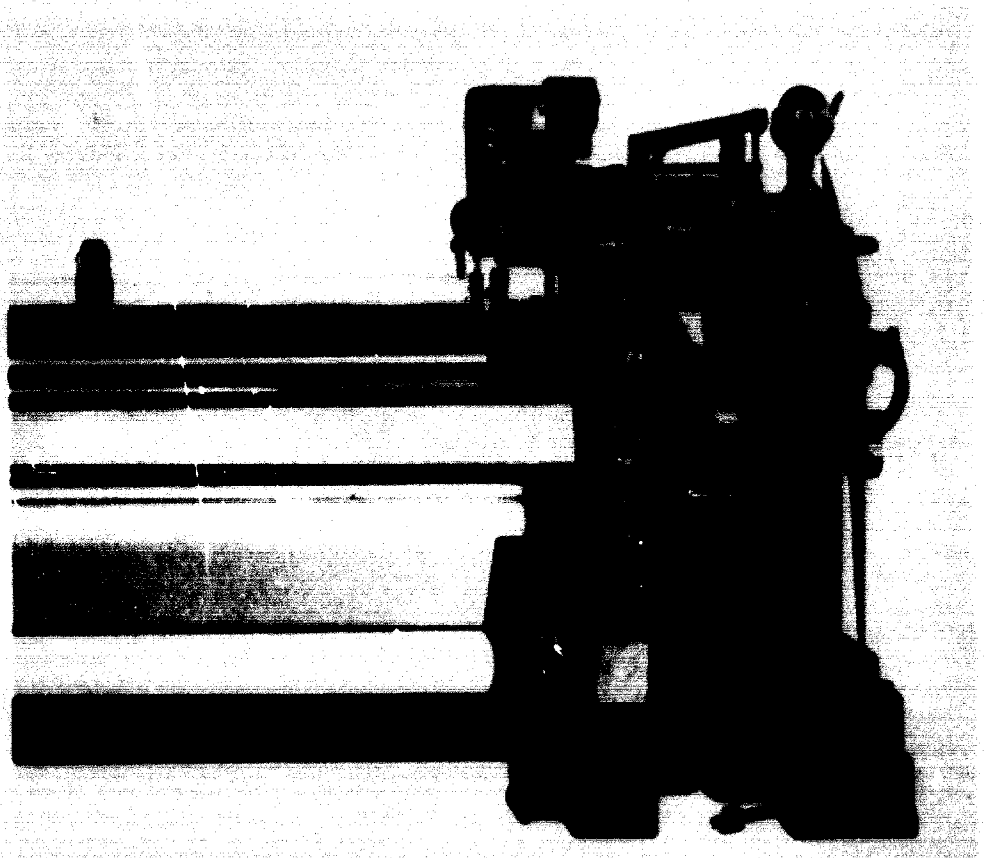


Fig. 6 Different Methods of Weft Insertion

WOVEN CLOTH PRODUCTION METHODS

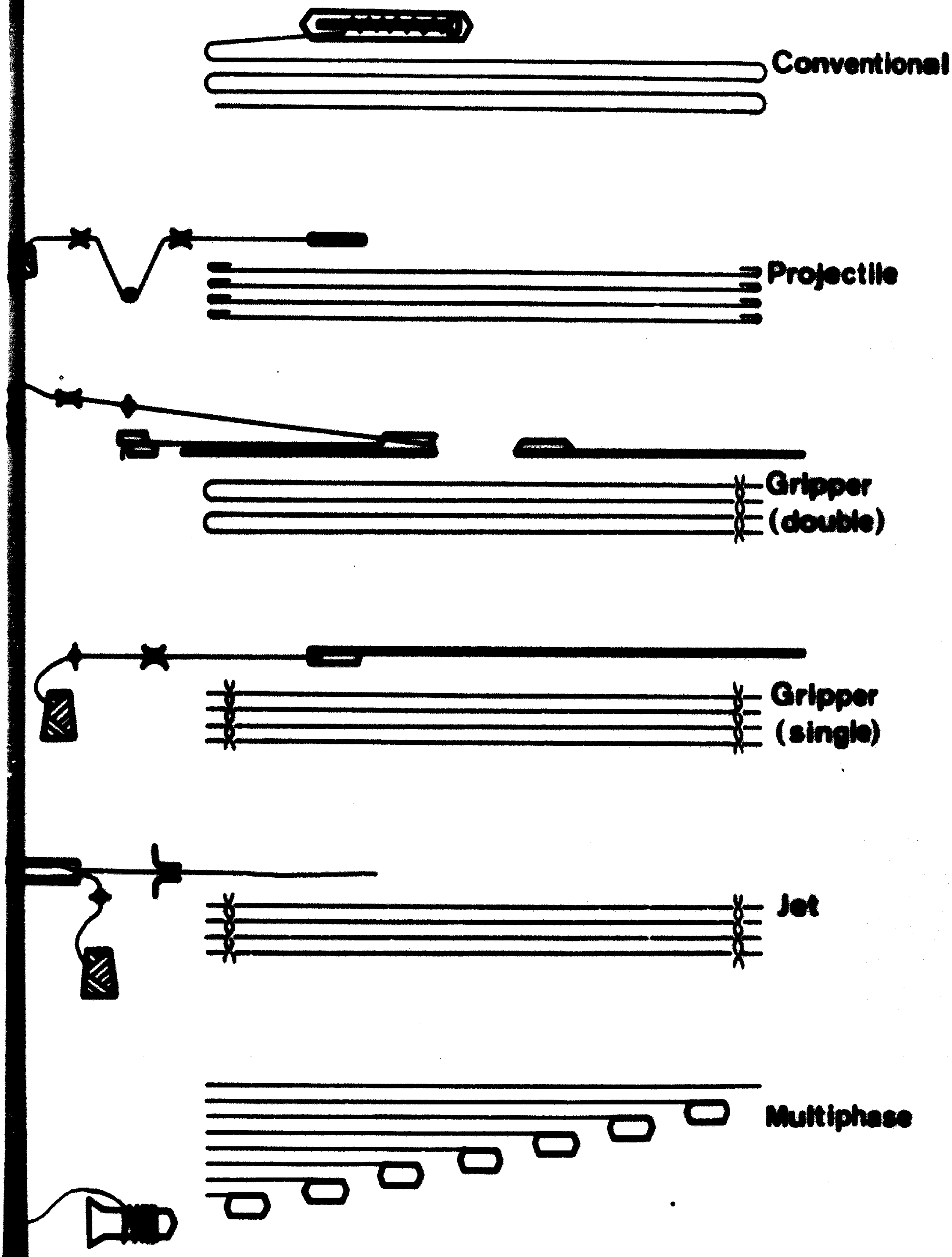


Fig. 6A Conventional Automatic Loom with push-botton control and hydraulic shuttle checking.

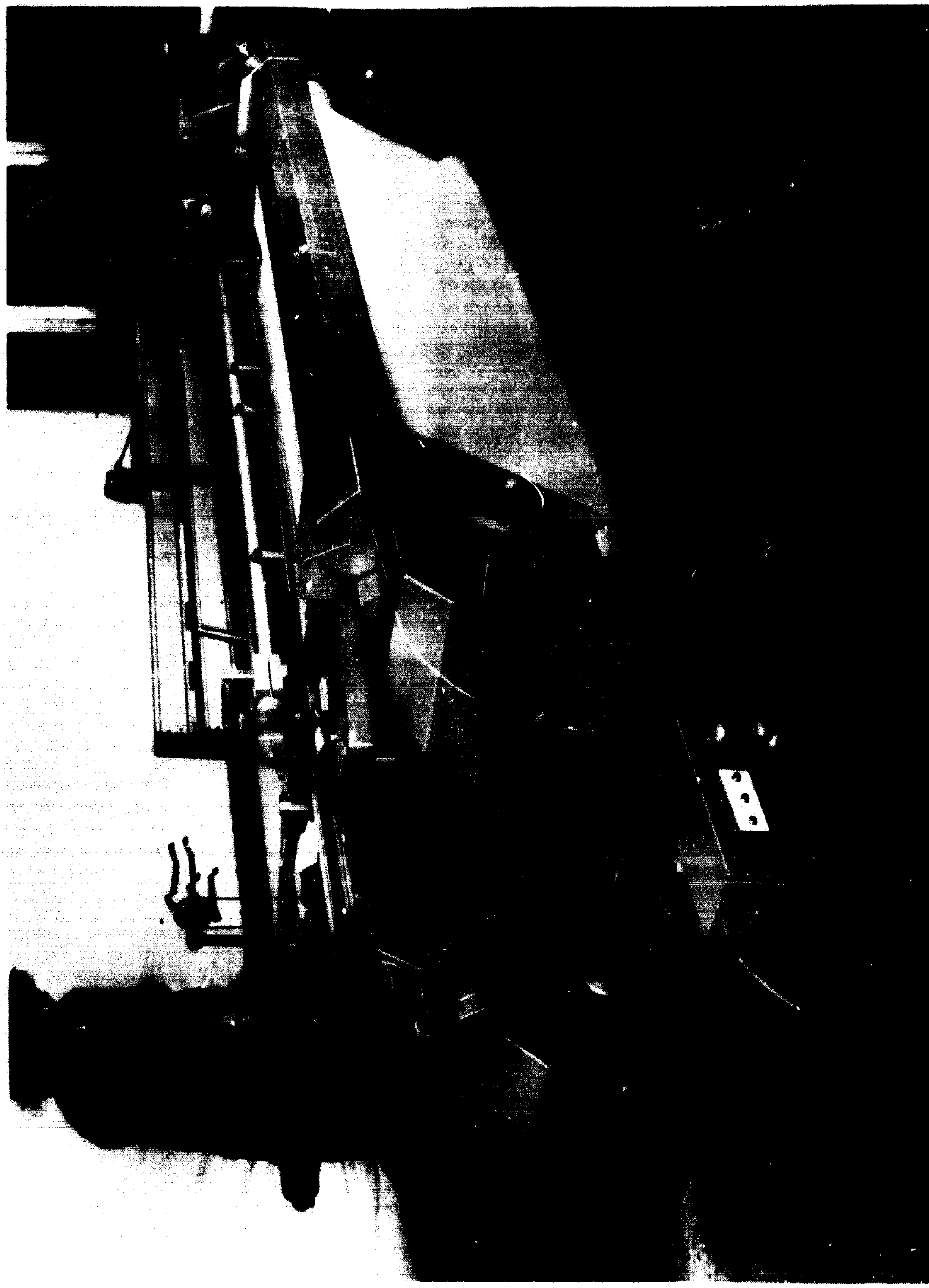


Fig. 7 The Utilisation of weaving with on conventional loom and gripper weaving machine

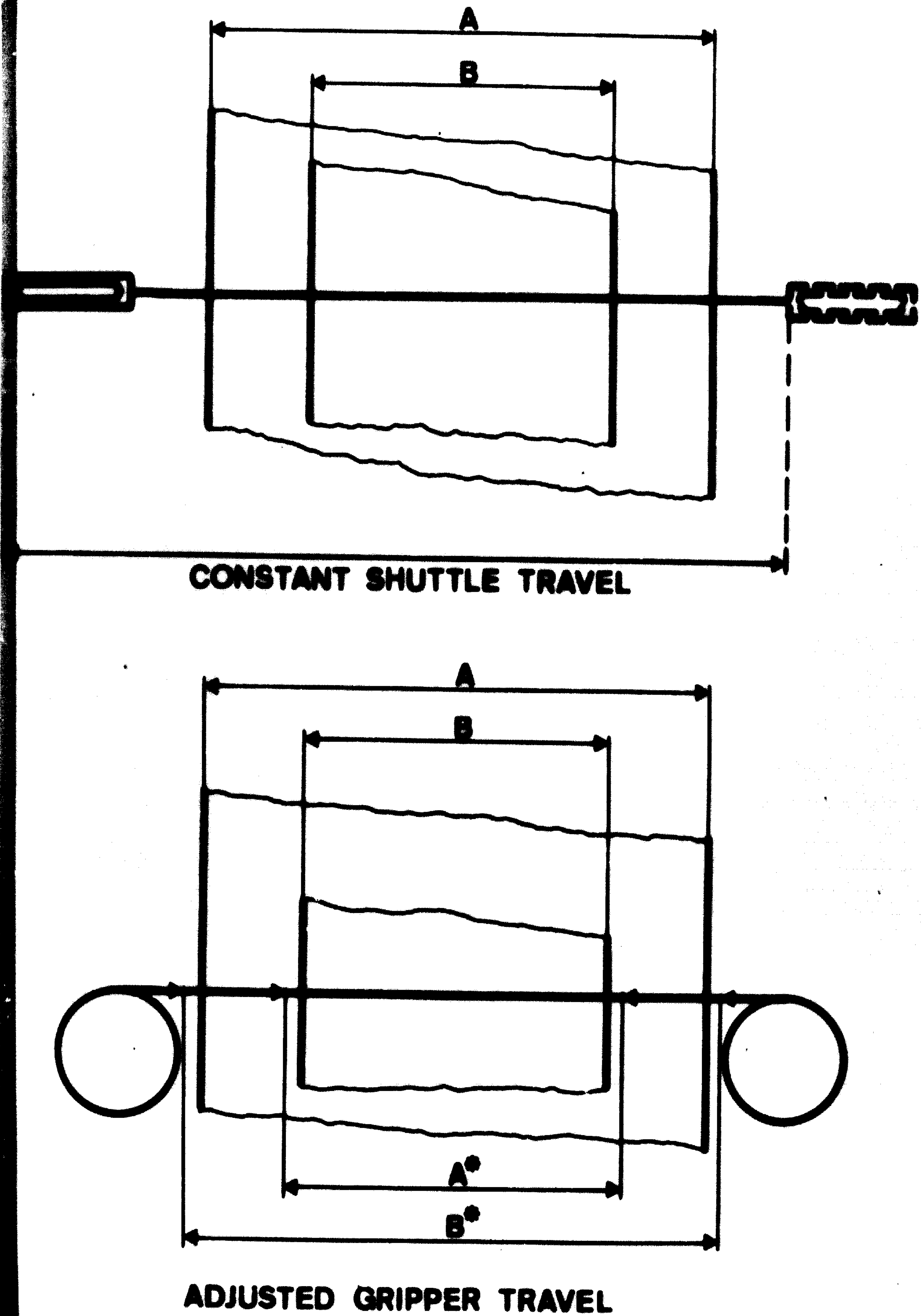


Fig. 8 Comparison of conventional shuttle and SULZER - projectile.

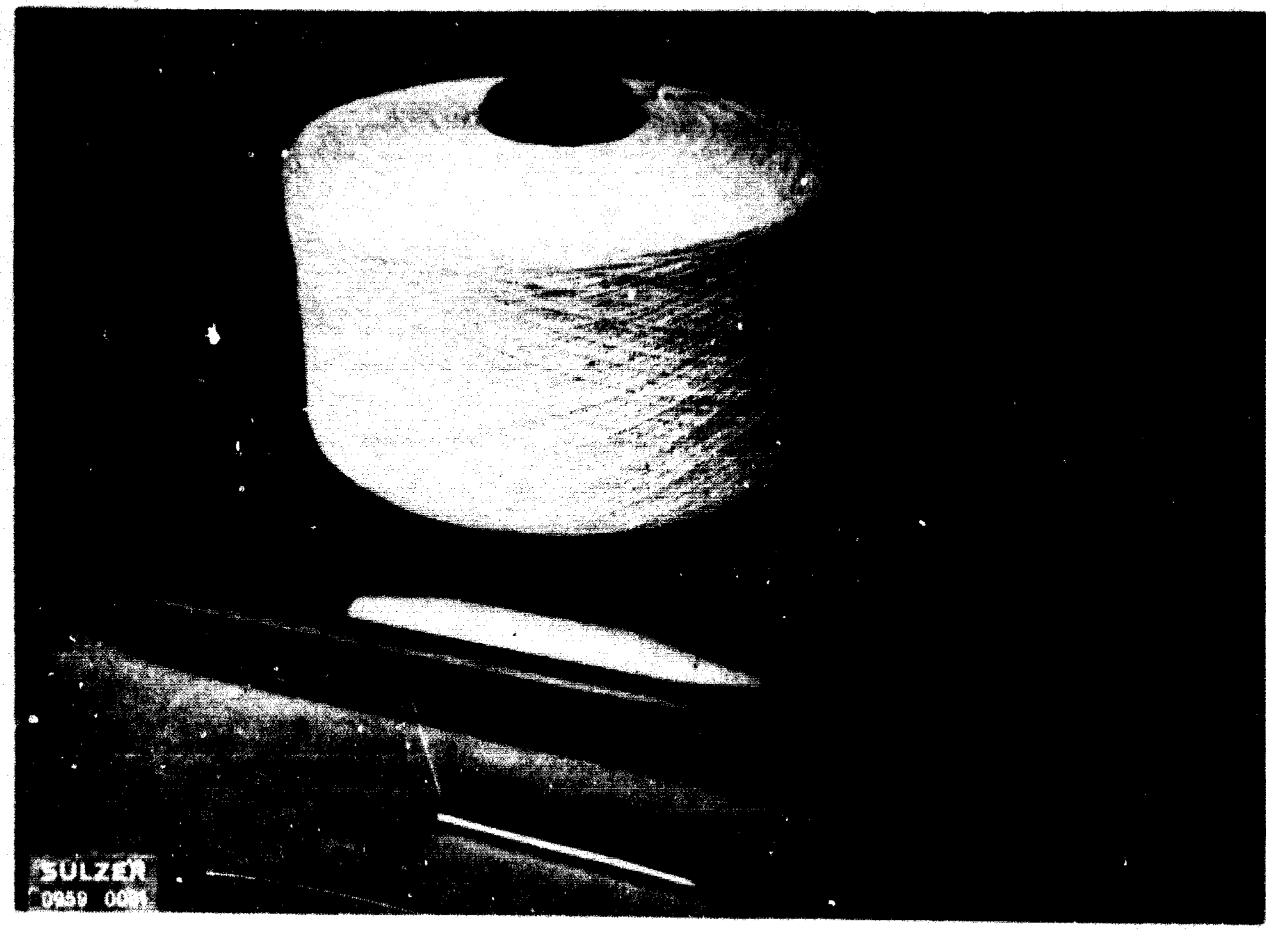


Fig. 9 SULZER - single colour weaving machine,
389 cm width, weaving 4 clothes simultaneously

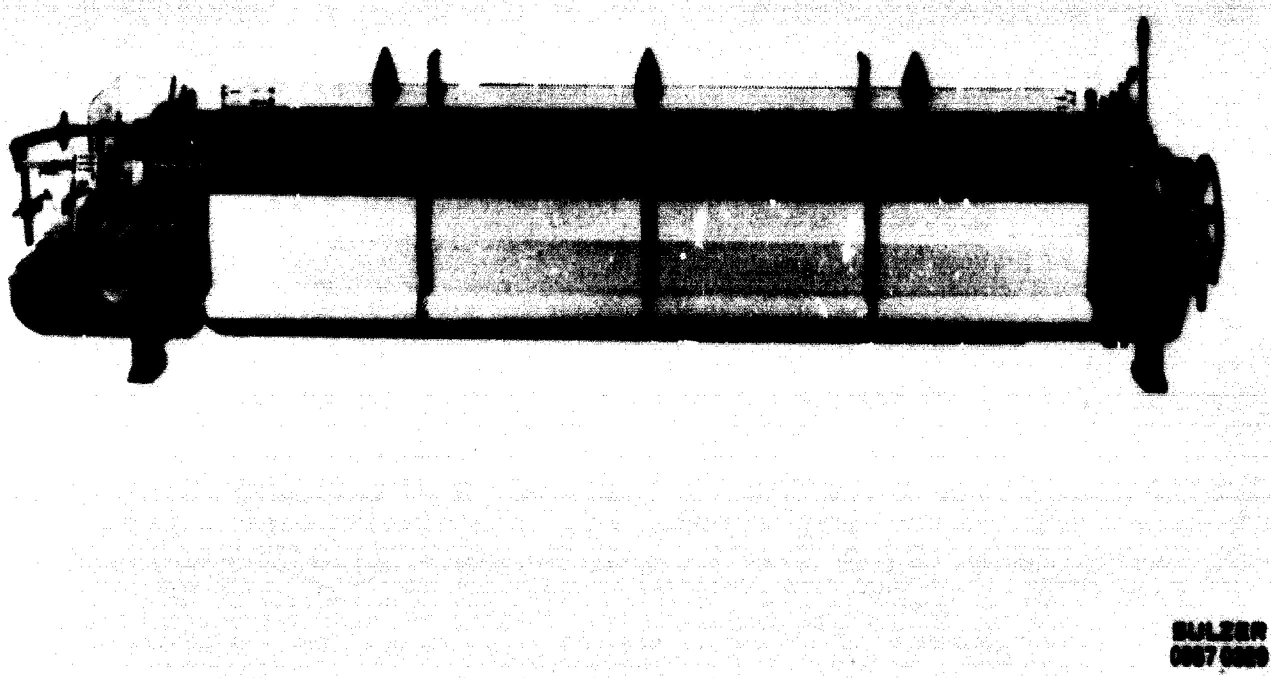


Fig. 10 Weft yarn insertion, tip-to-tip method

Weft yarn is pulled through open shed by right-hand rapier.

Fig. 11 Weft yarn insertion, loop transfer.

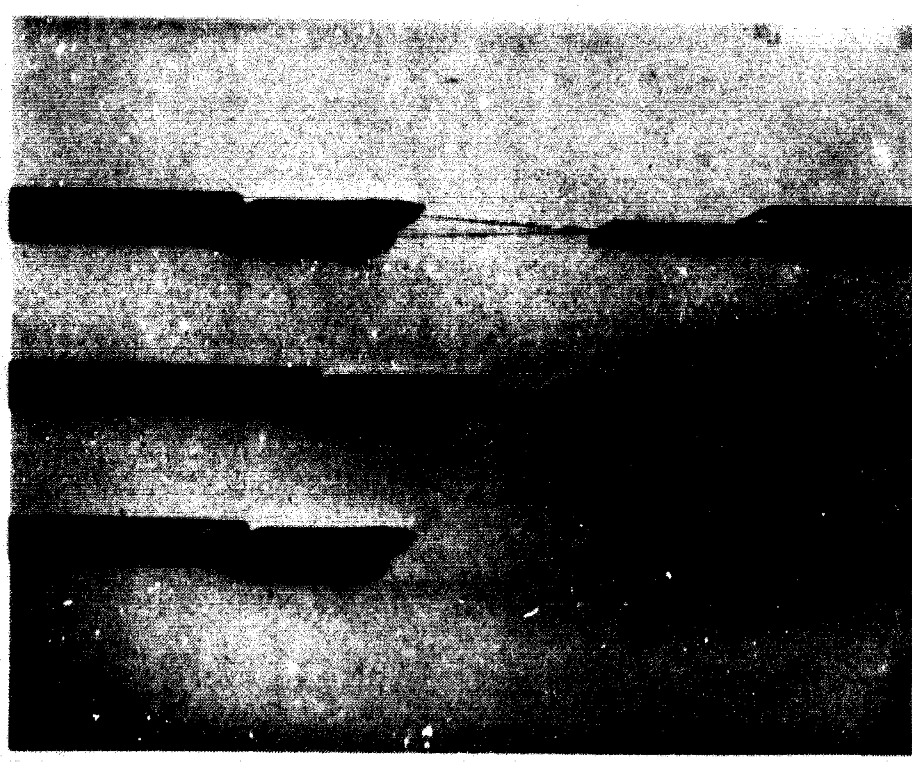
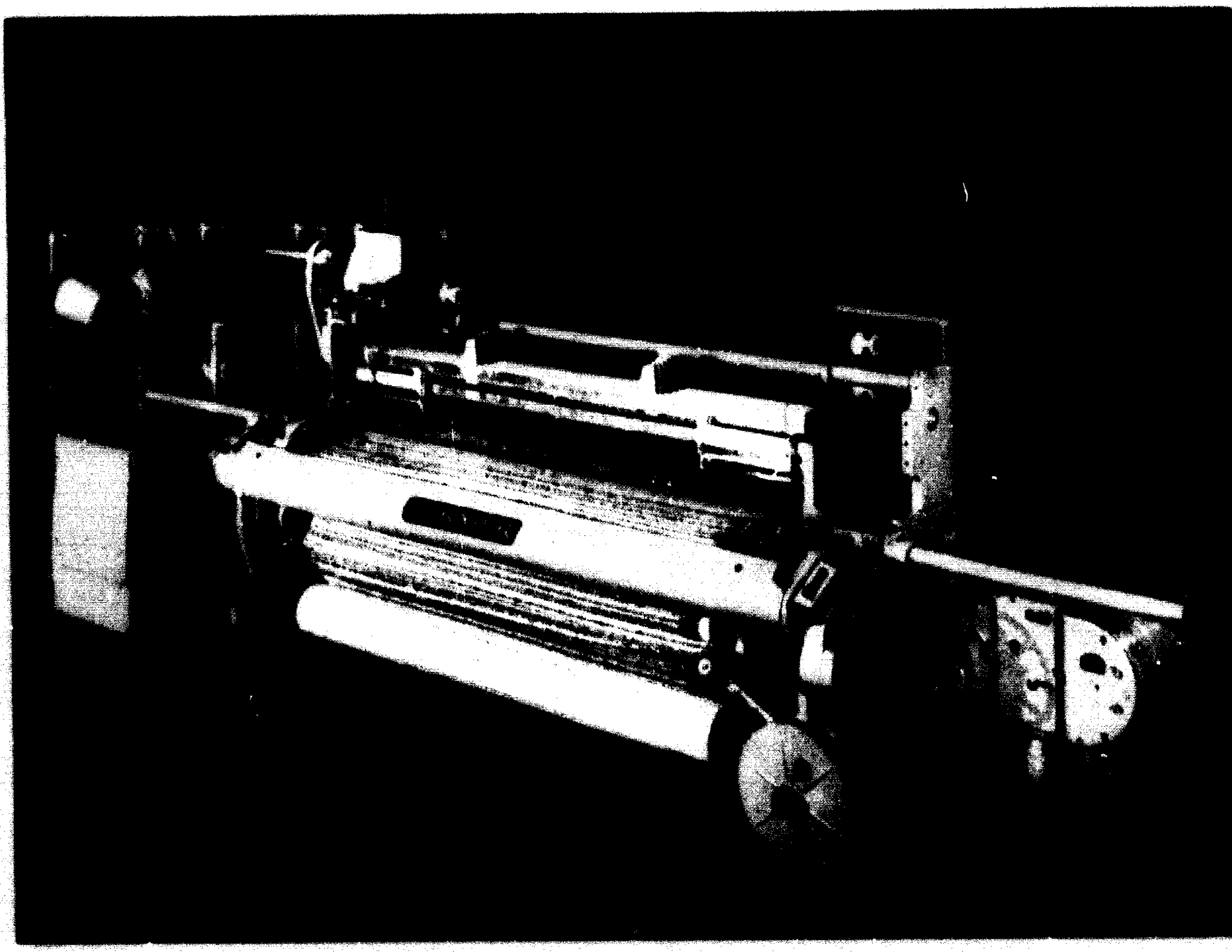


Fig. 12 Rigid Gripper weaving machine
(tip- to - tip method)



COST COMPARISON I.

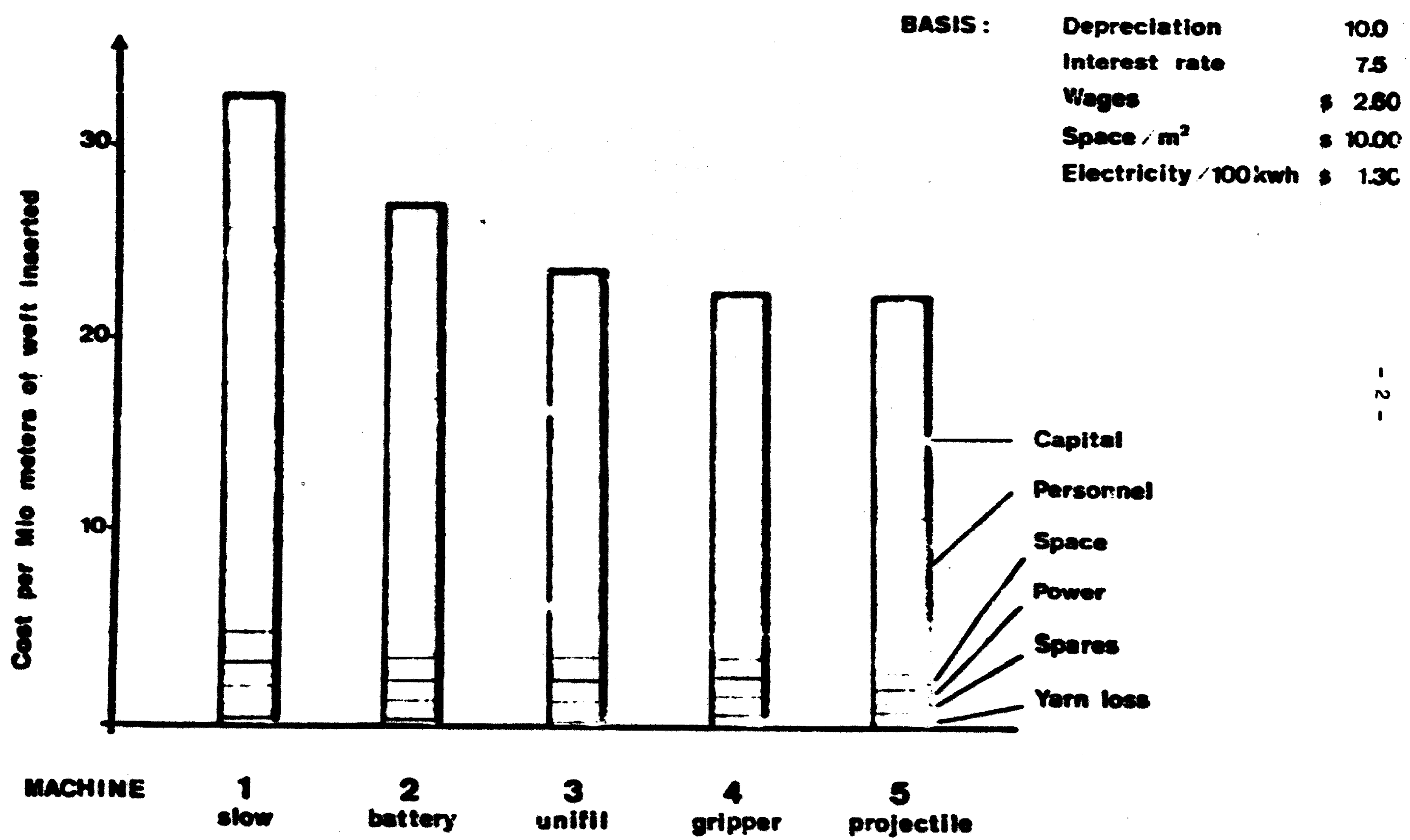


Fig. 13 Rigid Gripper weaving machine (tip - to - tip method)

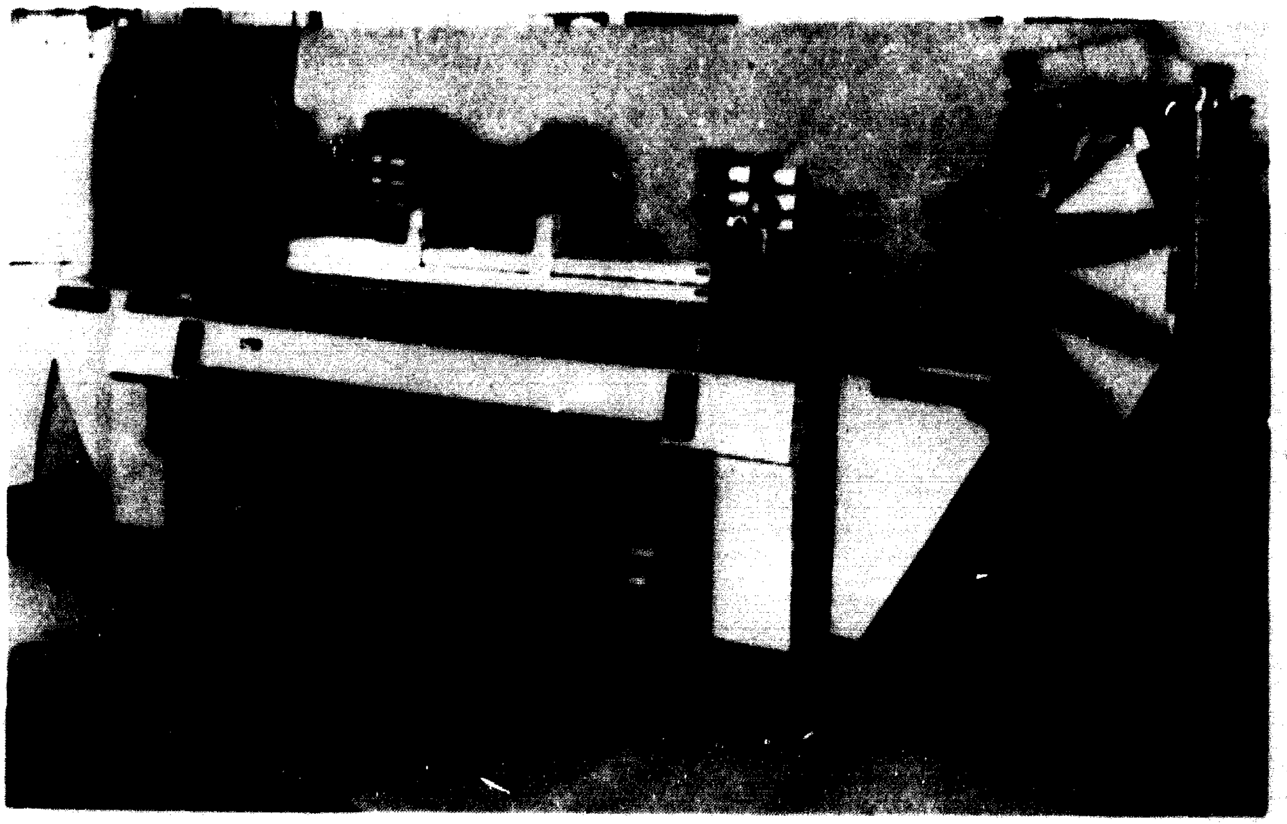


Fig. 14 Rigid Gripper weaving machine, telescopic system, loop transfer.

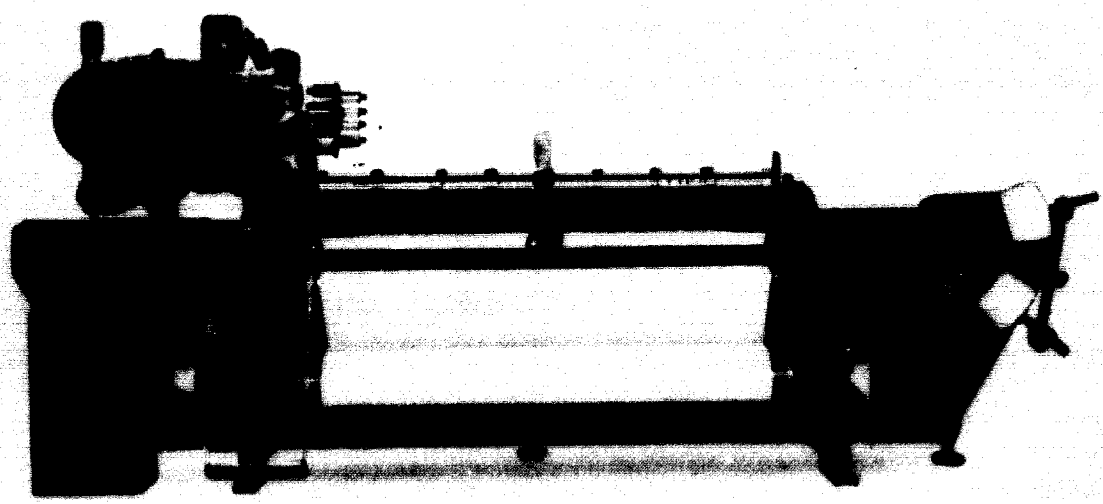


Fig. 15 Large width flexible gripper weaving machine, loop transfer.

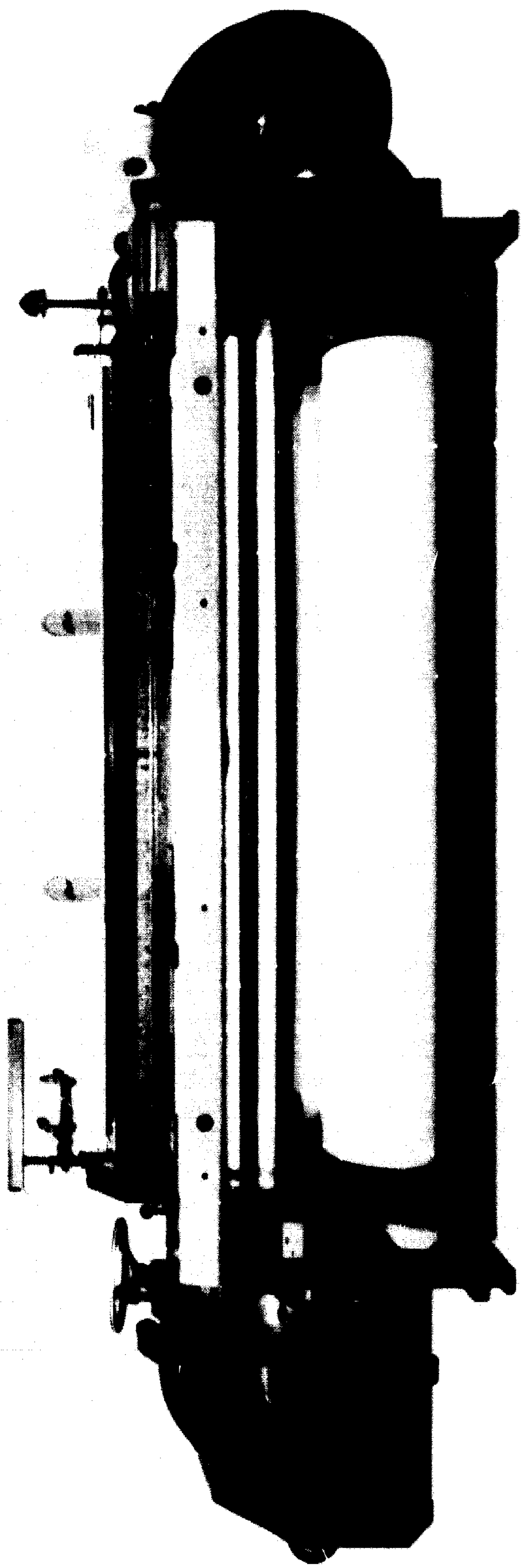


Fig. 16 Pneumatic weft insertion weaving machine

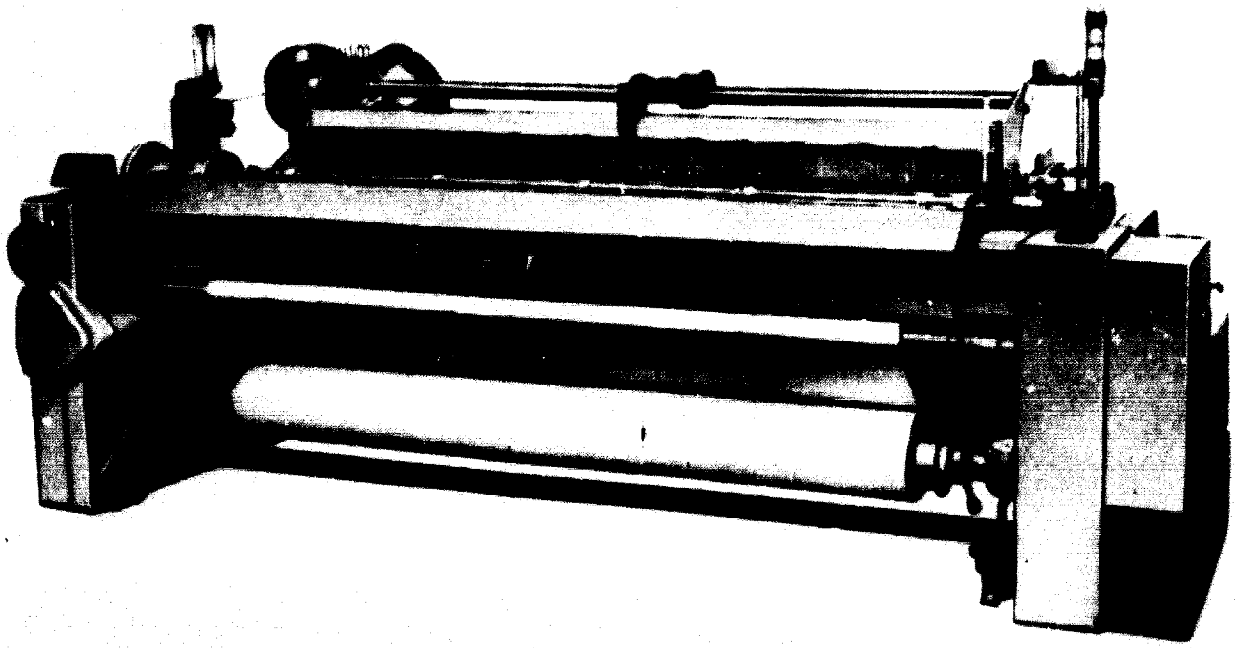


Fig. 17 Working range for air-jet looms

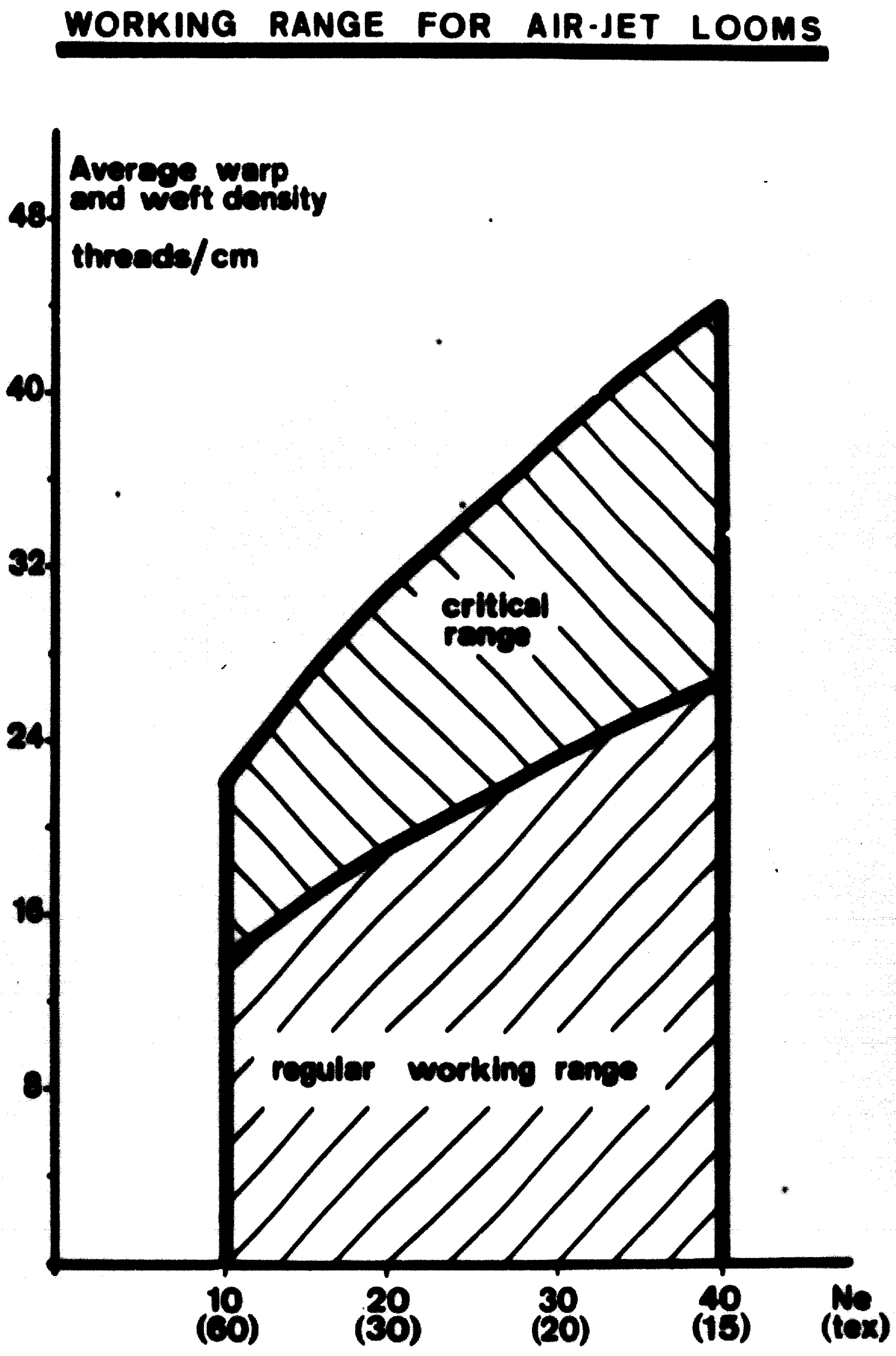


Fig. 18 Multi - air - jet weaving machine

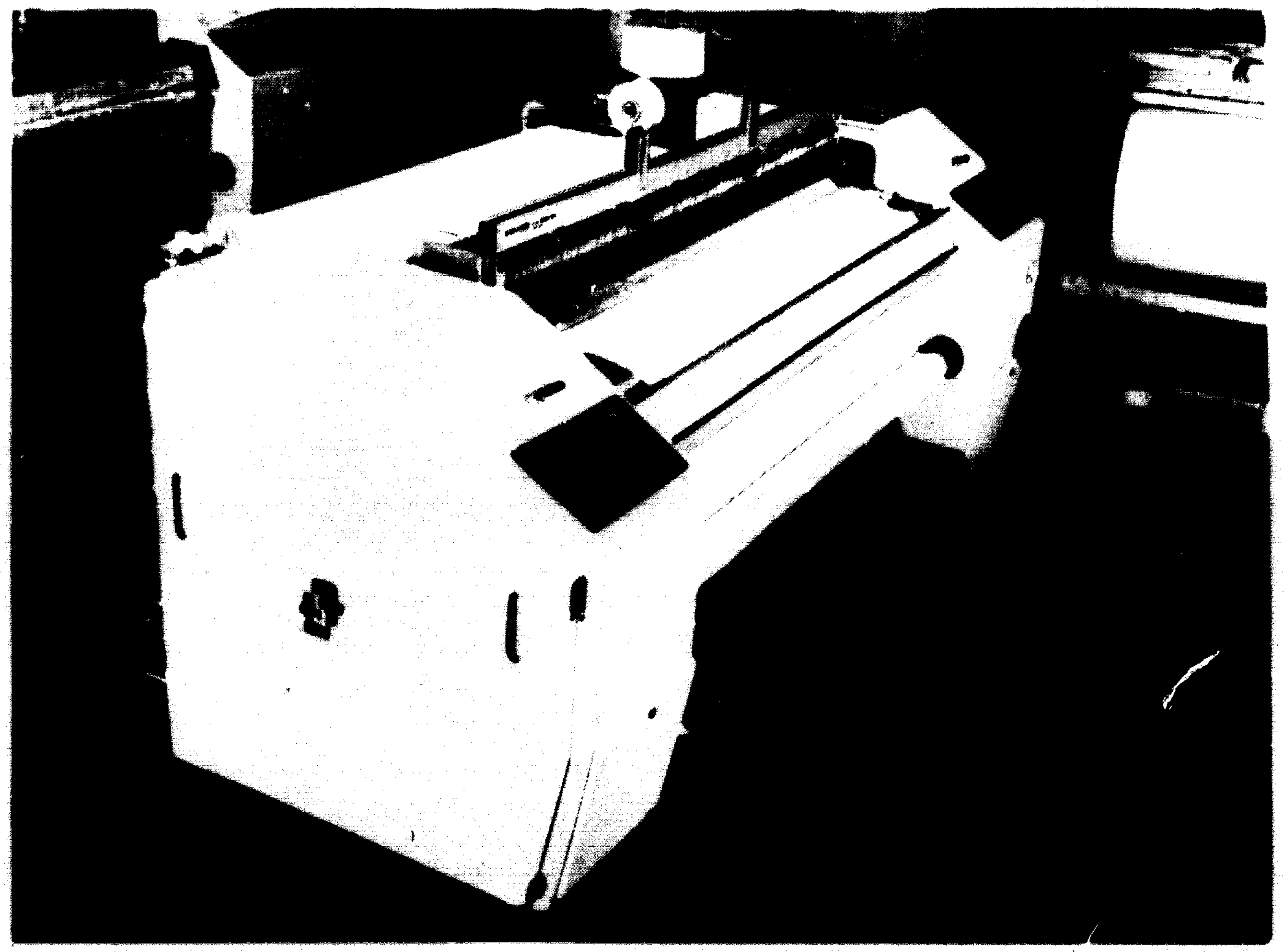
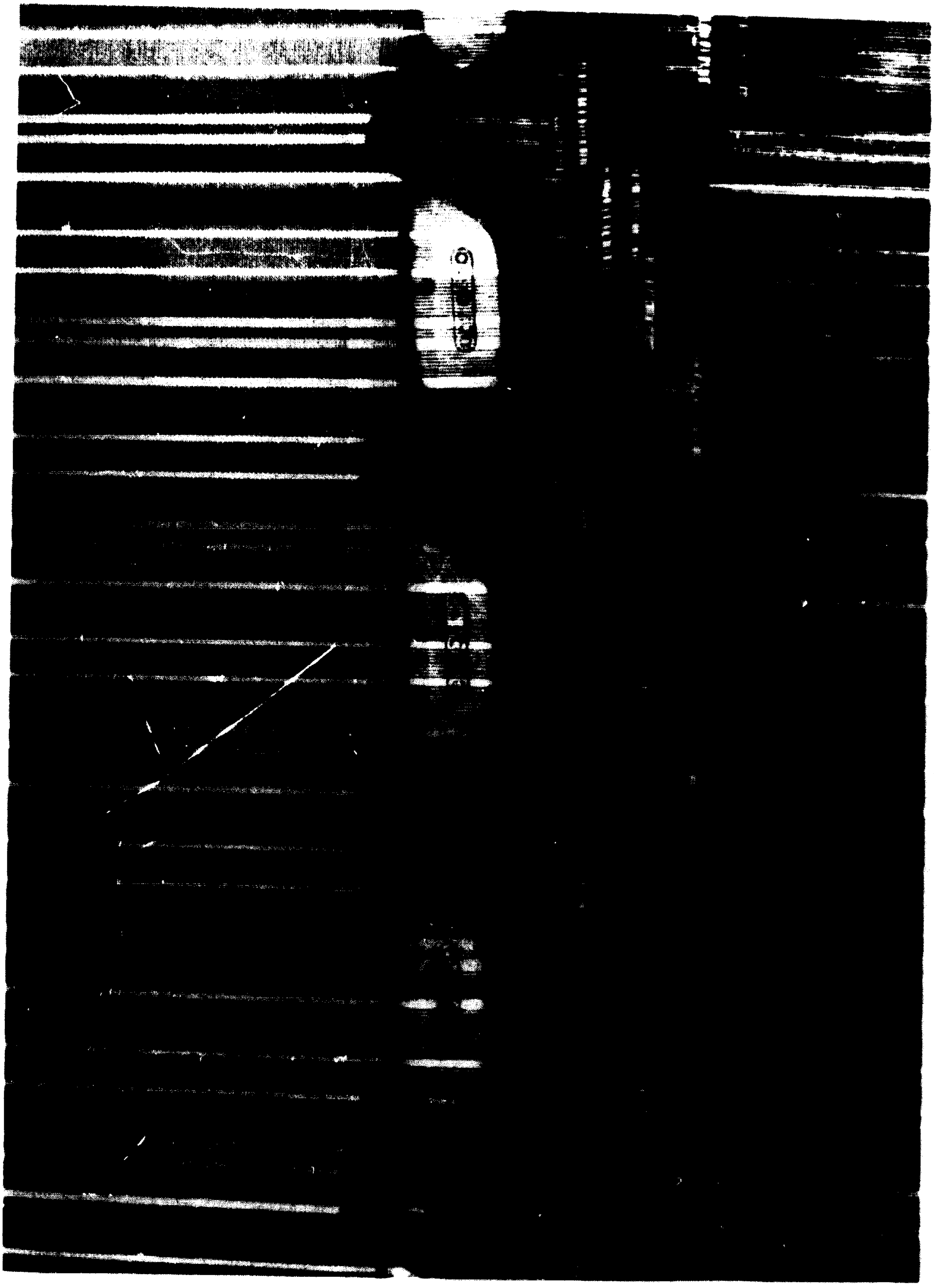


Fig. 19 Multiphase - Wavesbed weaving machine.
Shuttles travelling from right to left



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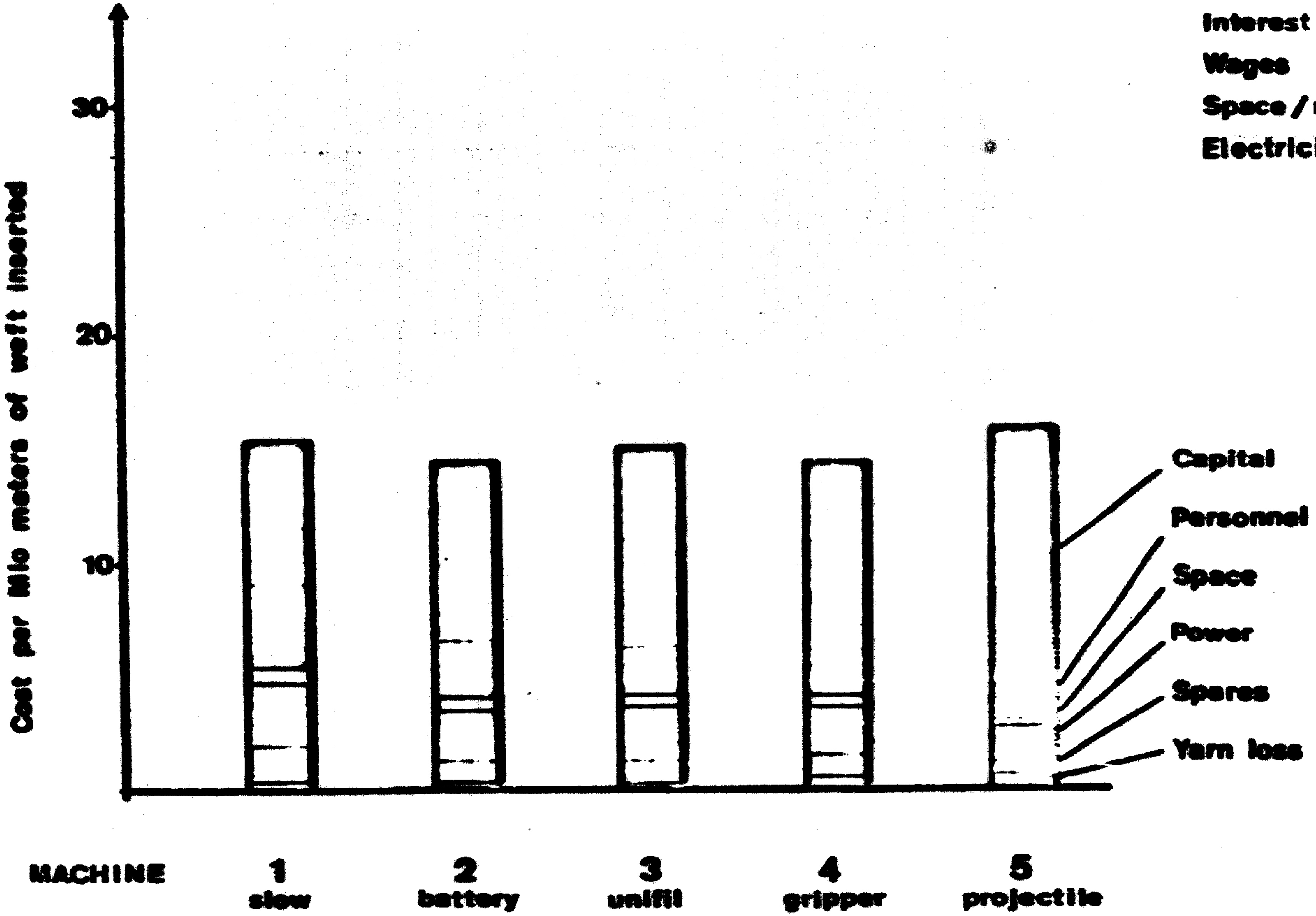
COST COMPARISON II.

BASIS:

Depreciation		10.0 %
Interest rate		7.5 %
Wages	$	-.50
Space / m^2	$	5.00
Electricity / 100kwh	$	3.00

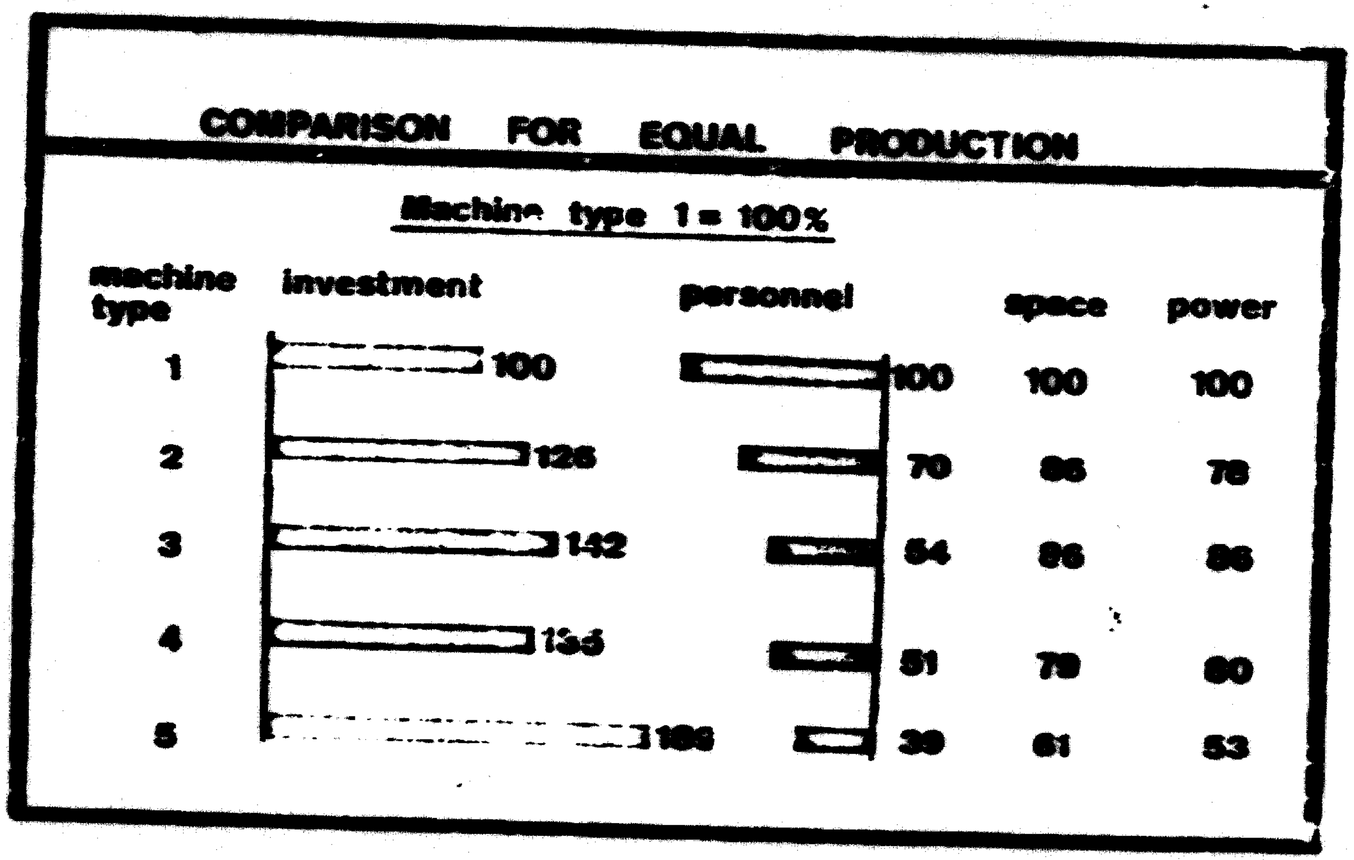


Calculation of Weaving Costs

Fabric: Cotton cloth 48 inches
68/60 threads per inch, Ne 30/30

Types of Machines to be compared:

1. Shuttleloom, simple version, 180 picks/min
2. Weaving automat with pirn battery, 248 picks/min
3. Weaving automat with Unifil pirn winder, 248 picks/min
4. Shuttleless Rapier loom, 260 picks/min
5. Gripper-shuttle weaving machine, double width, 255 picks/min


COMPARISON FOR EQUAL PRODUCTION
Machine type 1 = 100%
machine type
investment
personnel
space
power
1
2
3
4
5
100
126
142
136
186
100
70
54
51
30
100
86
86
78
61
100
78
86
80
53

2 OF 2

DO 3693

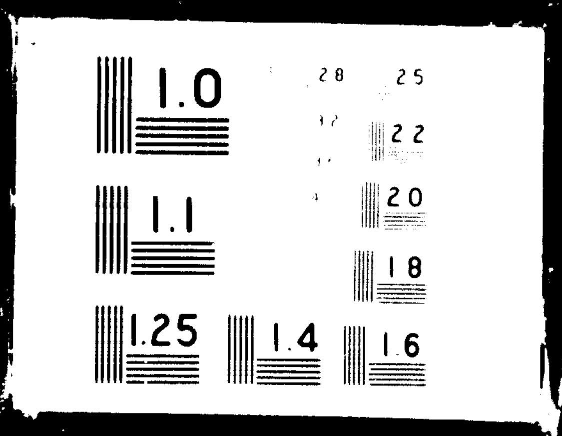


Fig. 20 Operating principle of wavesbed weaving machine showing "Turbo" winding station

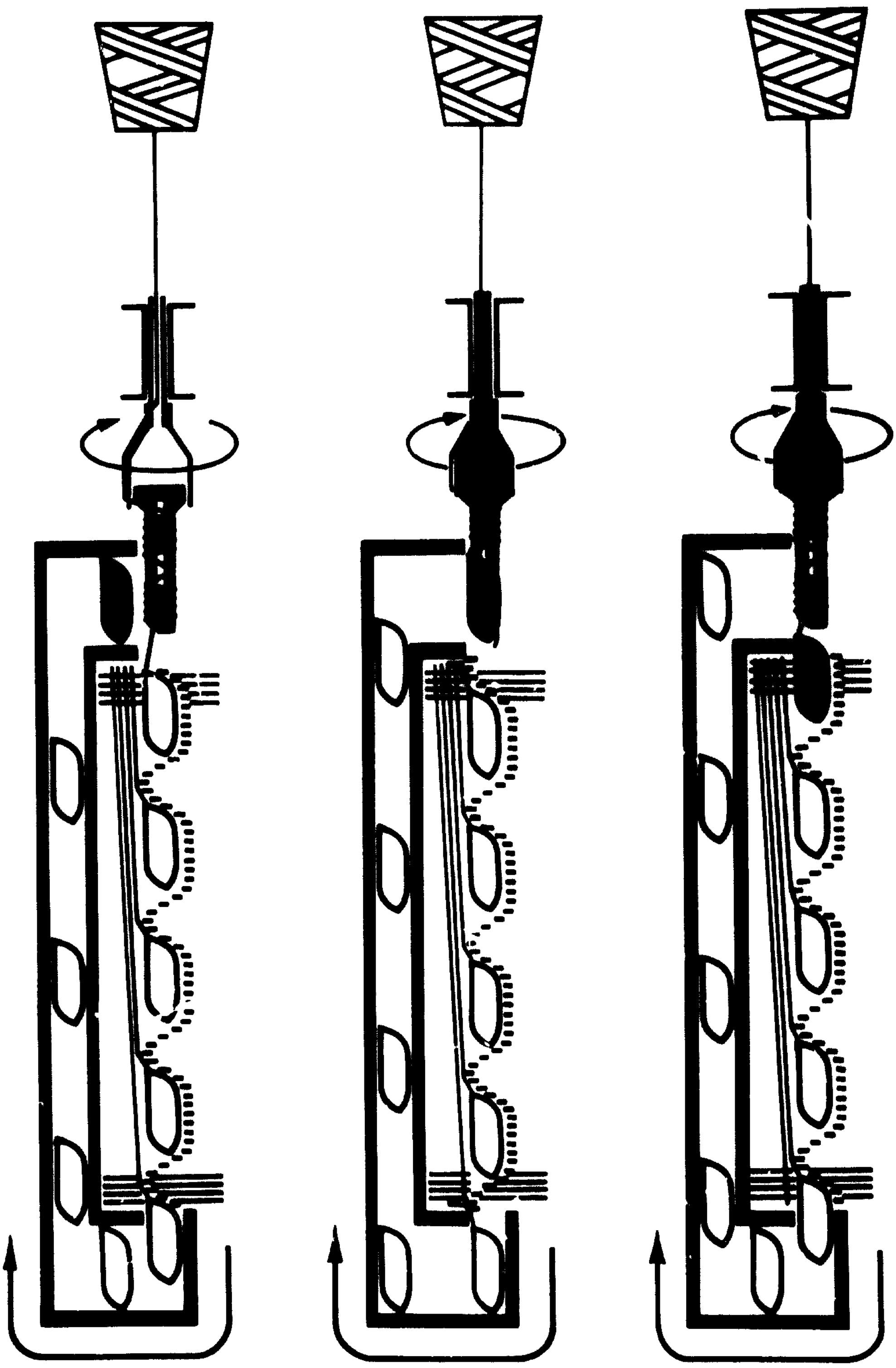
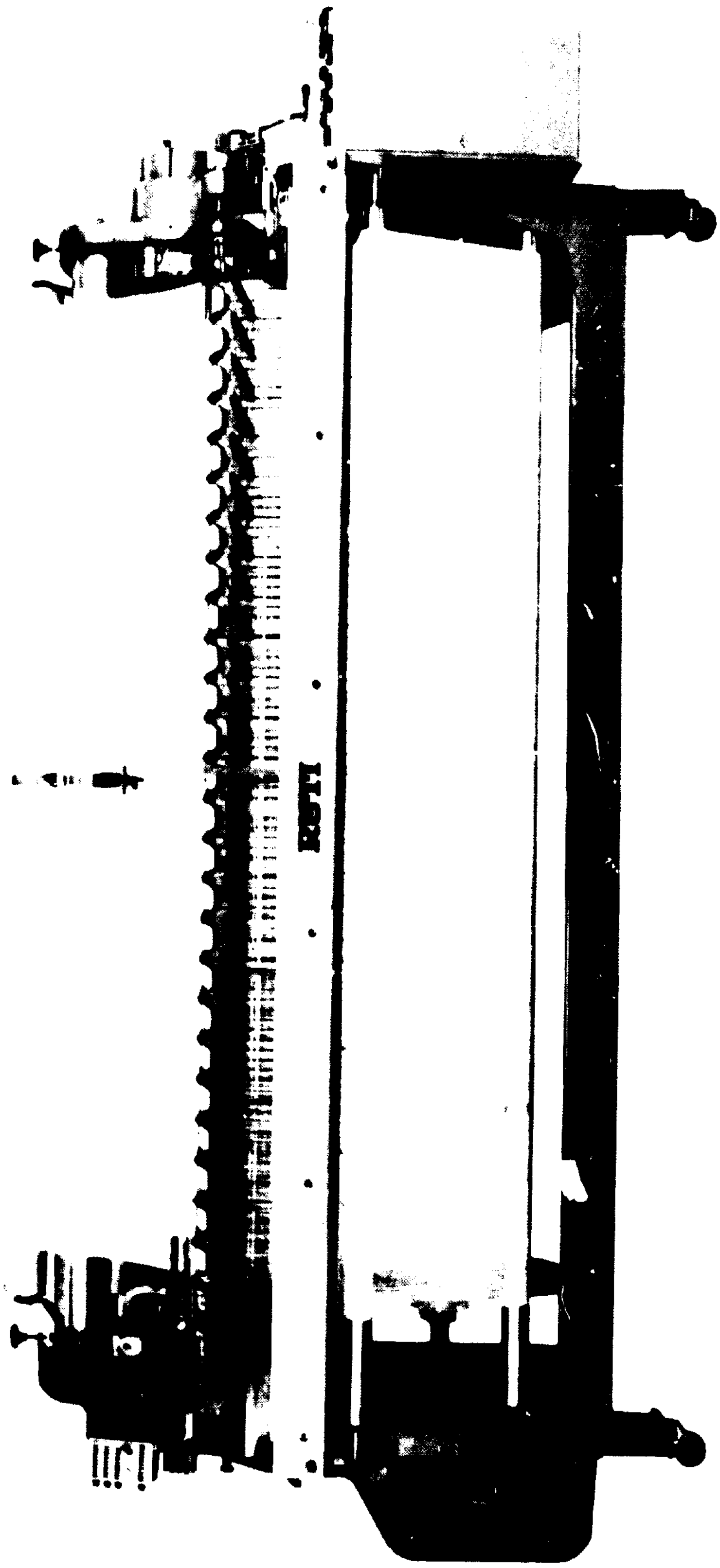


Fig. 21 TWR 250 cm wavesbed machine.



TWR 250

Fig. 22 Weft velocity on different weaving principles

WEFT INSERTION VELOCITY DIAGRAM

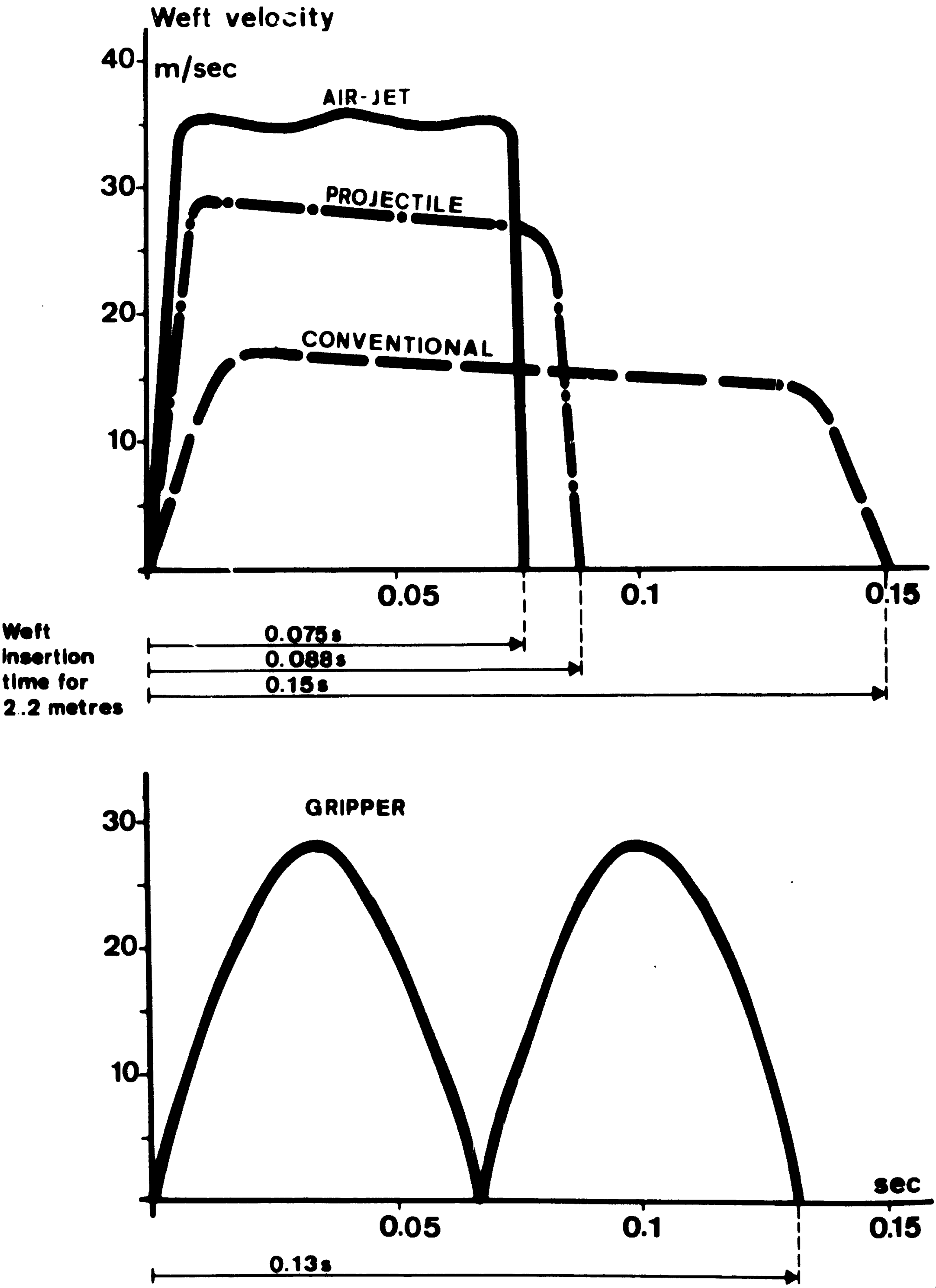


Fig. 23 Productivity measured by weft insertion rate as a function of weaving width.

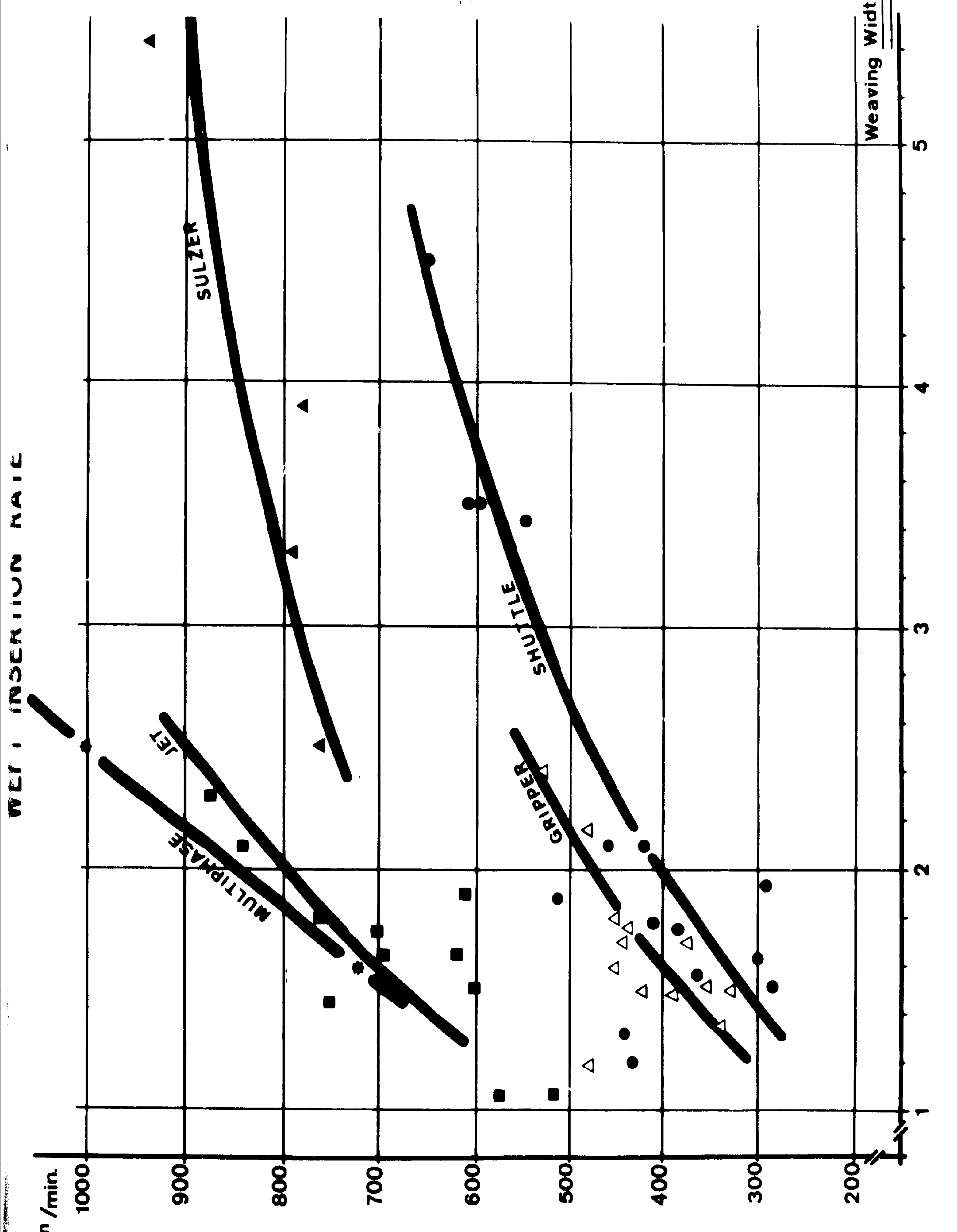


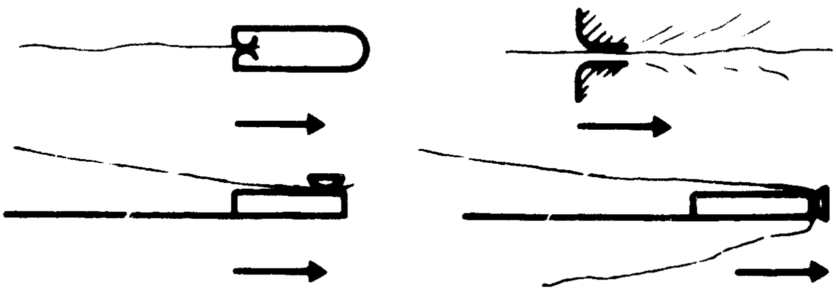
Fig. 24 Criterias for a consi[illegible] comparison of different [illegible] machines

DETAIL COMPARISON

CRITERIA — ALTERNATIVES

WEFT YARN TIP

positively clamped — free

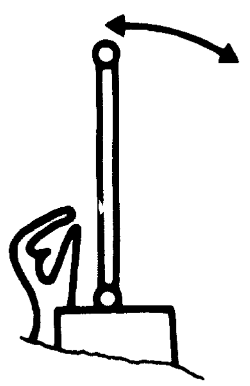


WEFT INSERTION

directly (in one movement) — with yarn transfer (from one gripper to the other)

GUIDE SYSTEM

necessary — not necessary

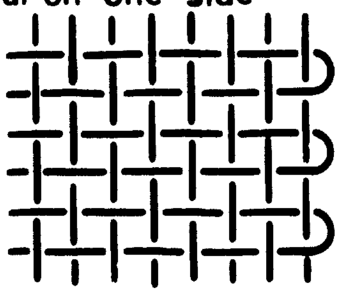


WEFT SEQUENCE

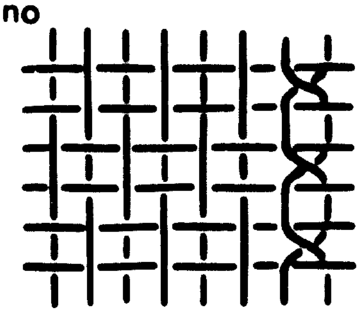
pick-and-pick — 2:2

SELVAGE

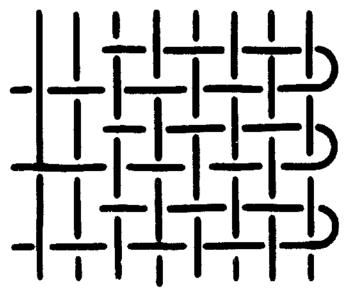
normal on one side



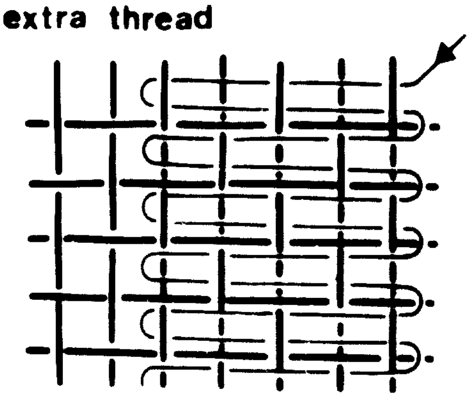
leno



tucked



extra thread



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