# WEAVING

## MACHINES * MECHANISMS * MANAGEMENT

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# PREFACE

The authors are pleased to present a book on WEAVING-MACHINES-MECHANISMS-MANAGEMENT to weaving technicians and technologists, giving an exhaustive account of weaving technology from its early inception to the modern shuttleless weaving technology. The authors have tried to paint the technological history of weaving on a very big canvass so that some details about weaving technologies might have remained obscure. Even then, the book with the present contents has become voluminous, which was not imagined by the authors when they started with the work.

The aim of the authors was not to give only the details about the weaving machines and the mechanical working of the same, but to inculcate 'why and how' viewpoint in designing of machines and the research work available on the subject, so that an overview of the mechanisms will be stressed on the mind. This should help to develop an analytical thinking about the machines and mechanisms so that further improvements and/or modifications could be made, based on the knowledge obtained on a particular topic of weaving technology though technicians may be interested in machine drives, production calculation, settings, maintenance and other problems, the technologists should think that how the gap between the so called theory and practice could be reduced. This should be the aim of higher technical education at degree or post graduate level to distinguish between the student who has undergone a trade or diploma course and the one who has completed graduate or post graduate studies in textiles. The graduates should also be able to fulfill the expectations of the industry when they work for the industry.

Fortunately all the three authors had a good experience of the shopfloor working in textile mills as all of them had worked in textile units before they voluntarily choose the careers in teaching line, where also they had an experience of teaching students of weaving technology from apprentice students to post graduate students of the university. Not only that, but all of them enriched their personal achievements by participating actively in Seminars, Symposia, Conferences and even organising such activities and refresher courses. All of them had worked individually in advisory committee of various co-operative research institutes. They had prepared projects for textile units as well as for teaching programmes for various levels of management, for workers training to executive's training programmes.

This book is, therefore, an outcome of their varied experience of over thirty years in teaching and their association with the Indian xtile Industries. The chapters of this book are written in such a anner that an experienced teaching faculty member can scriminate which chapters or the portion of a chapter can be scussed to the students of diploma, degree or post graduate dents. Instead of writing special book for three levels of students king technical education, the authors have made a sincere effort to ter to the needs of these students.

It should also prove useful to the executives or other managerial rsonnel, who have not been technically qualified but have a good actical/shop-floor experience. The book should be useful to the search workers because many references and cross-references e given at the end of each chapter so that they need not exert to the references required for their research work.

At the end, the authors thank the staff members of V. J. chnical Institute, Mumbai, Textile & Engineering Institute, alkaranji and the Raymond Woollen Mills, Kenya, Kusumgar rporates with whom the three authors had an opportunity to work d discuss on various topics included in this book.

Thanks are due to Mr. V. Subramanium for all the figures and A. K. Rakshit, SASMIRA for the cover design. The authors are lebted to Sulzer Ruti Ltd. for giving permissin to reproduce the otographs and literatures. They are also thankful to other textile chinery manufacturers like Dornier, Lakshmi Ruti, Somet and many ers.

It is hoped that the teachers in weaving technology will be able cover or rather 'uncover' the principles behind the weaving hnology in a more meaningful way with the help of this book. ere may be some lacuna and shortcomings of the book and the hors will welcome the comments from the readers so that those be useful while bringing out the next edition of the book.

Prof. M.K. TALUKDAR
Prof. P.K. SRIRAMULU
Prof. D.B. AJGAONKAR

## CONTENTS

# 1 AN INTRODUCTION TO WEAVING

## 1.1 HISTORICAL BACKGROUND

Since the beginning of civilisation weaving of cloth has been carried out in one form or the other by people of many countries. Fig. 1.1 shows two Egyptian women of first century weaving a cloth by hand. Whoever produced a cloth in the early days, must have followed a similar method, that is, converting the textile fibres like cotton and wool into yarns (threads) by spinning process and then weaving those yarns into a cloth.

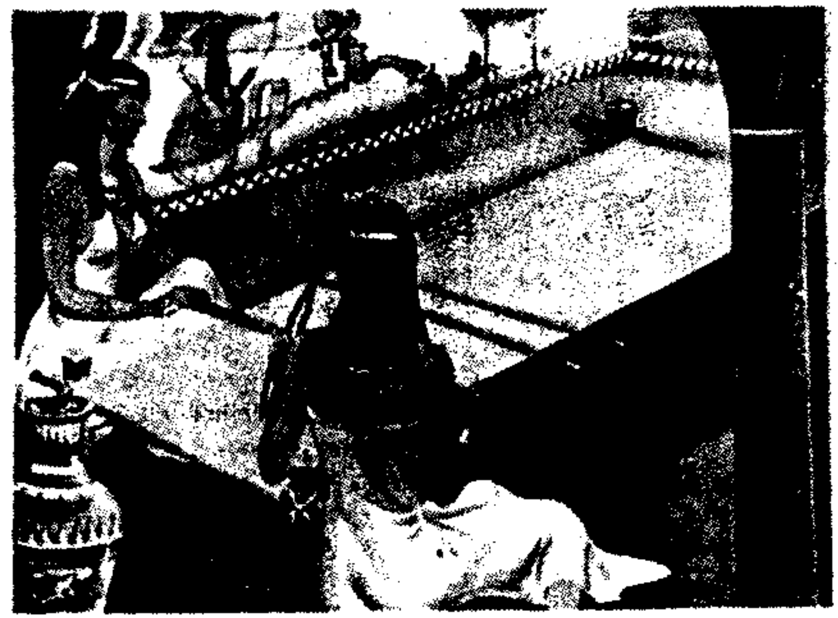


Fig. 1.1 Egyptian Women Weaving a Cloth in the First Century

A woven cloth consists of two sets of yarns, namely, warp and weft. The yarns that are placed lengthwise or parallel to the selvedges (edges) of the cloth are called warp yarns. Each thread or yarn in the warp is called an **end**. The yarns that run crosswise are called **weft** ('filling' American term) yarns and each thread in the weft is called a **pick**. The weaving of a cloth is the result of interlacing of a single weft thread over and under a number of warp ends (Fig. 1.2) according to a particular design or weave.

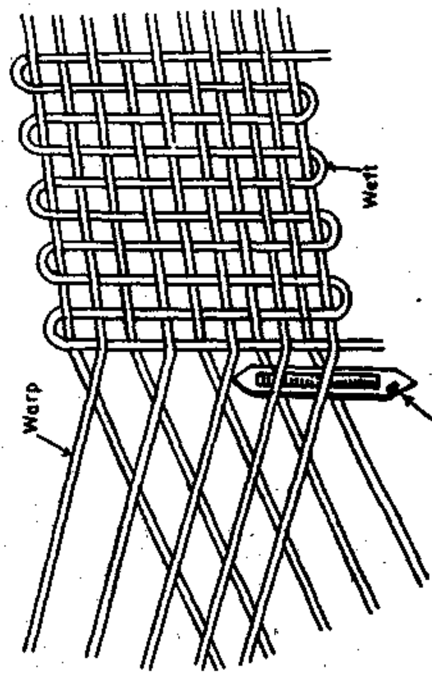


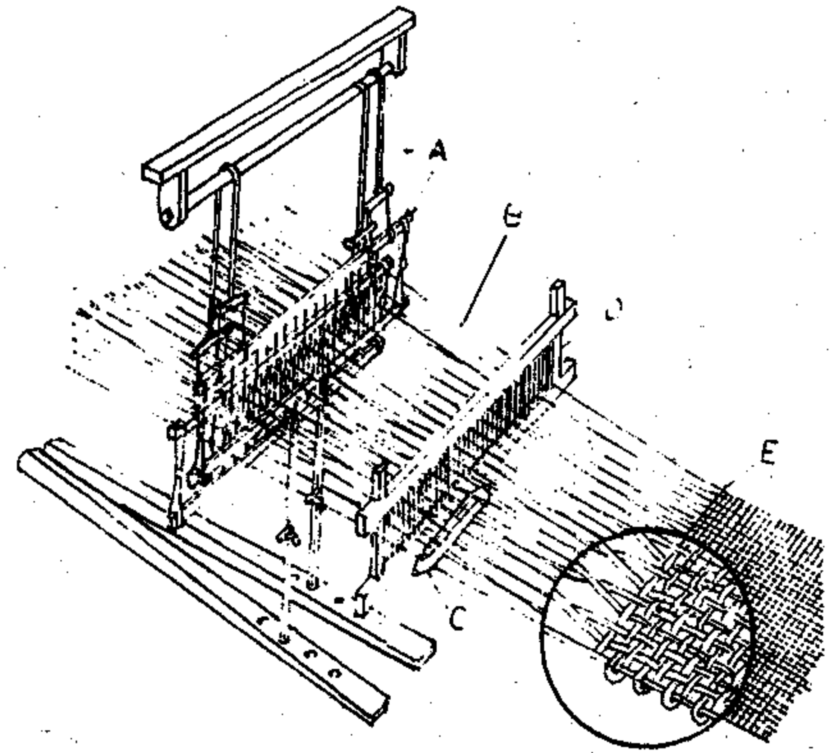

**Fig. 1.2 Interlacing of Warp and Weft**

In the beginning when weaving was carried out by hand, as shown in Fig. 1.3 there were three main operations, namely, shedding, picking and beating up. The warp ends were stretched between two sticks and separated by some crude means. Some warp ends were raised and others were lowered according to a particular design, to form an opening called a **shed**, for insertion of a pick. This operation is called **shedding**. Then a weft thread (a pick) was inserted one at a time in the space between the raised and lowered ends. This operation is called **picking**. The third operation, called **beating up**, consists of pushing of a weft thread (a pick) which was laid inside the shed, against the preceding weft, by means of a comb like part (reed). All the three operations are illustrated in Fig 1.3.

One of the earliest methods employed for the insertion of weft in the warp shed was by means of a stick with a hooked end and the weaver would pass the weft through the shed, first in one direction and then in the other. In 1733 a fly **shuttle** was invented by Kay (1)



and this **shuttle** with a weft package inside, was thrown through the warp shed from one side and then from the other. A shuttle is a rectangular piece of wood, tapered at each end to a point. The main body is hollow to accommodate weft package known as **pirn**. With the advent of power, the shuttle was propelled mechanically from one side of the weaving machine to the other. A **weaving machine** is also known as a **loom**.




A = Heald, B = Warp, C = Shuttle, D = Reed, E = Fell of cloth

**Fig. 1.3 Shedding, Picking and Beat - up**

A simple hand loom illustrated in Fig. 1.3 explains three motions of a weaving machine. The raising and lowering of warp ends is carried out by the heald frames that hold the ends by means of healds and heald eyes. As the heald frames move up and down, an opening is formed between the ends, called a **shed**. Then a shuttle with a weft pirn is passed through the shed from one end to another. As the shuttle passes through the shed a length of weft thread is unwound from the weft pirn and it remains in the warp shed. Then a comb like device called the **reed** pushes the pick towards the cloth already woven. The line separating the woven cloth from the warp is called the **fell of the cloth**. After a new pick is pushed into the fell, the reed moves back towards the heald frames. The three motions repeat again. The cycle of motion consists of (i) shedding, (ii) picking, and (iii) beat up.

## 1.2 MAIN AND AUXILIARY MOTIONS

Besides the three main basic motions, there are other two subsidiary motions necessary for weaving continuously a cloth on a weaving machine. They are, **take-up** and **let-off** motions to move the cloth away from the weaving zone at a desired rate. To accomplish this function a take-up motion to wind the cloth onto a roller is required.

As the cloth is rolled up, the warp ends from the warp beam must be unwound so that yarns will not be stretched to the point of break and the cloth fell position is maintained at the desired point keeping the average warp tension constant. This function is accomplished by the let-off motion.

In order to produce a good quality of cloth and to prevent damages it is necessary to have some stop motions provided on the loom. They can be termed as auxiliary motions : (i) **Warp Protector** (ii) **Warp Stop** (iii) **Weft Stop**. Another auxiliary motion known as temple motion is used to keep the width of cloth fell same as that of warp in the reed.

The various motions on the loom should be fixed and set properly to perform their functions to produce a faultless cloth that is acceptable to the consumer. For example, the take-up motion not only pulls the woven cloth forward and winds on the cloth roller, but it is also responsible for the correct spacing of the weft threads in the cloth so that thick (cramming) and thin places (cracks) i.e. cloth unevenness are avoided. Similarly the let-off motion should not only maintain a constant length of warp between the fell of the cloth and the beam but also maintain a constant average tension of warp as it weaves from the full beam to the empty one. The importance of this will be discussed later in the chapter 7.



To summarize, the motions and their functions on weaving machines or looms are as follows :

**Shedding** : To separate the warp threads into two layers, one layer is raised and the other lowered.

**Picking** : To insert a weft thread across the warp ends through the shed.

**Beat-up** : To push the weft thread that has been inserted across the warp ends, upto the cloth fell.

**Take-up** : To pull the cloth forward after the beat-up of weft, maintaining the same pick density and spacing throughout weaving of a cloth and winding the woven cloth on to a roller.

**Let-off** : To allow the warp to unwind from the warp beam during weaving and also to maintain an average constant tension of warp as it weaves down.

**Warp protector**: To protect the warp threads by stopping the loom when the shuttle fails to reach, and box properly into either the shuttle box during picking.

**Warp Stop** : To stop the loom when a warp thread breaks or excessively loose.

**Weft stop** : To stop the loom when a weft breaks or the weft runs out of the pirn (weft package).

**Temple** : To hold the cloth firmly at the fell to assist in the formation of a uniform width cloth.

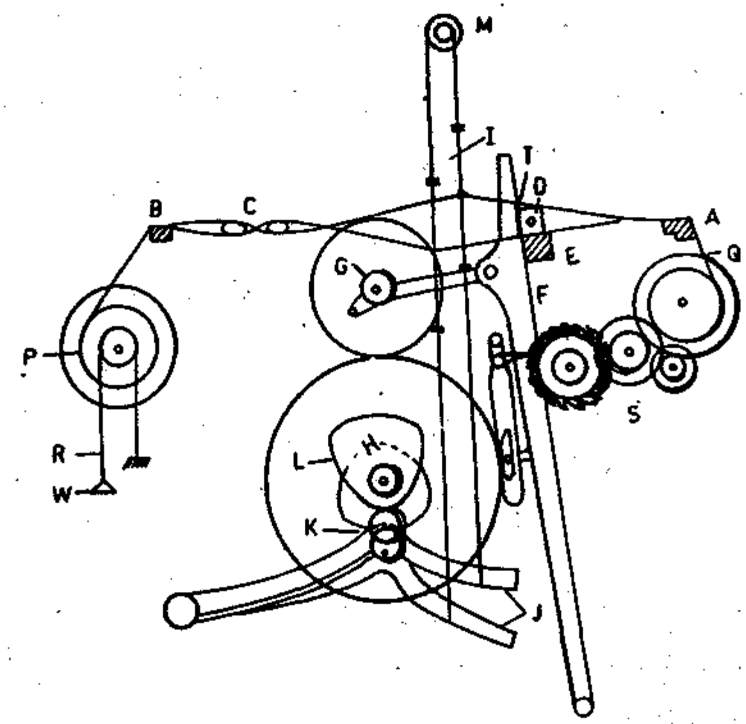
## 1.3 TYPES OF LOOMS OR WEAVING MACHINES

At present the types of looms or weaving machines now available can be broadly divided into two classes : **shuttleless** looms, and **shuttle** looms. Shuttleless looms are also called **unconvenional weaving machines** as the shuttle is associated with any type of conventional looms. In shuttle looms, we have (a) handlooms, (b) nonautomatic power looms, (c) automatic power looms, and (d) circular looms. In all shuttle looms, winding of weft yarn on pirns and picking and checking of shuttle which carries the pirn are common features which limit the speeds of the looms. The medieval handloom operated by hands and feet were mechanised by transferring the manual operations of the worker to a more or less intricate system of rollers, levers etc., with driving electrical power. Since the most important textile fibres of the earlier period were cotton, silk and wool, three basic types of looms for medium, light and heavy weaving were respectively developed. The weight of the shuttle determined to a large extent the structural massiveness of the whole loom. However, inserting a fresh pirn in the shuttle or changing the whole shuttle is an unproductive work. Towards the end of the nineteenth century an Englishman, J.H. Northrop (1) devised an automatic pirn changing motion that proved a great commercial success. Along with the pirn changing automatic looms, shuttle change motions were also developed primarily for silk and viscose weaving. In circular weaving the shuttle is kept in continuous one way motion and is not alternately accelerated and decelerated. However, these looms were not proved commercially much successful because of technological problems except for sacks/bags. With the introduction of the Sulzer Weaving Machine in 1950s, the shuttle was replaced by a projectile, which would draw the weft yarn directly off the large supply cone. The yarn is always inserted from the same side and in most of the cases each pick of the weft is a separate piece of yarn and the weft does not form a continuous thread in the fabric. In some cases every adjacent pair of weft picks is connected at one end. A new technology of shuttleless weaving was thereafter developed and many versions such as (i) rapier, (ii) air jet, and (iii) water jet weaving machines are now in vouge in addition to gripper projectiles. All these weaving machines are generally wider width machines compared to shuttle looms and two or more narrow fabrics are woven simultaneously, next to one another. These looms are versatile, in that not only cotton, silk or woollen yarns but all other weft yarns, made from different chemical fibres and their blends can be used without difficulty. The recent addition to the development of the weaving machine is that instead of having one shedding, one picking and one beat-up motion for one revolution of the main driving shaft many sheddings, pickings and beating ups operations are taking place for one revolution of the main shaft. Thus instead of one phase many phases of weaving are taking place simultaneously from one end to the other end of the warp threads on the weaving machines. They are therefore called multiphase weaving machines and at present the highest rate of weft insertion is available on these machines. Small shuttles or spools rapiers or airjets are used for weft insertion.

The majority of the looms are now-a-days provided for use of one or more kinds of wefts. If wefts of different colours, counts, materials, or twist-levels are to be used in the same fabric then a provision should be made to accommodate these wefts on looms. Such looms are called looms with multiple box motions on one or both sides. In some shuttleless weaving machines many types of wefts or colours even upto 16, are now-a-days used.

This preliminary knowledge of types of loom is just elementary to understand the text in the following chapters.



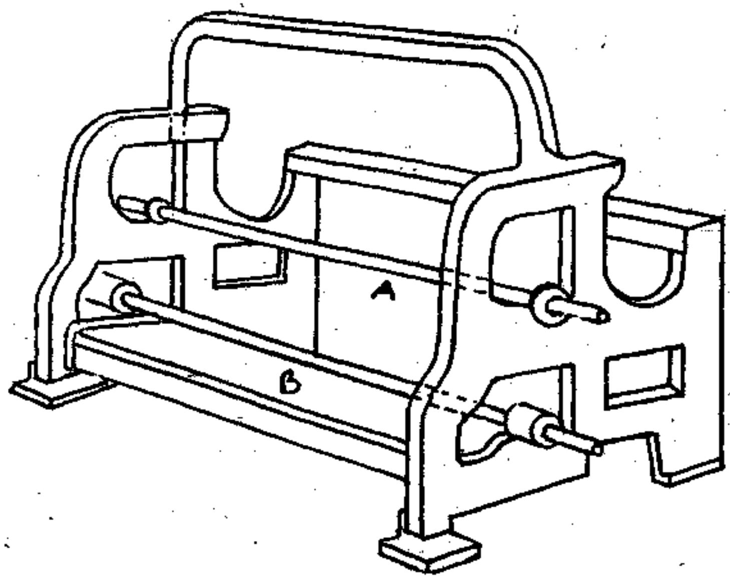



A = Front rest, B = Back rest, C = Lease rods, D = Shuttle, E = Sley, F = Sley sword, G = Crank shaft, H = Bottom shaft, I = Heald frames, J = Treadle levers, K = Treadle bowls, L = Shedding tappets, P = Warp beam, Q = Cloth roller, R = Let-off motion, S = Take-up motion T = Reed, W = Weight

**Fig. 1.4 Main Parts of a Loom**

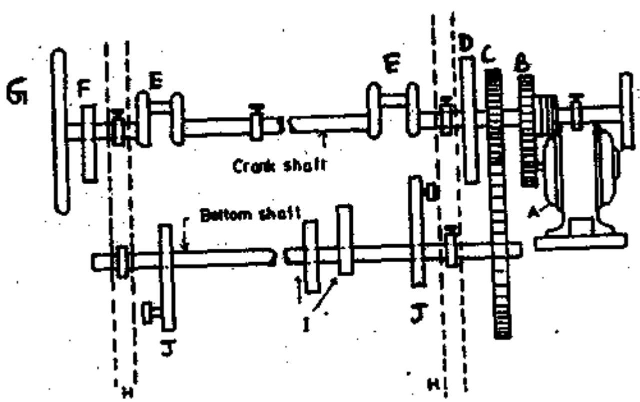
The parts giving main and subsidiary motions are illustrated in Fig. 1.4. The warp yarns from the warp beam (P) pass over the back rest (B) and come forward through the healds (I) and reed (T) and form the cloth at the fell. It is then passed over the front rest (A), round the take up roller and wound on the cloth roller.

All the motions are put into operation by a main shaft in an ordinary power loom and this shaft is called a crank shaft. It is driven by an electric motor. There are two other shafts, bottom and tappet shafts. For a plain weave design (which will be discussed later) normally two shafts are required. They are, a crank shaft and a bottom shaft. The crank shaft always makes one revolution for one pick insertion, while the bottom shaft makes half a revolution. In other words, for every one revolution of the bottom shaft the crank shaft makes two revolutions. Therefore, the ratio of the teeth of the gear wheels connecting the crank shaft to the bottom shaft is always 1:2 e.g. a 20 teeth gear wheel on crank shaft will drive a 40 teeth gear




A = Crank Shaft, B = Bottom Shaft

**Fig. 1.5. A Loom Frame**




A = Motor, B = Gear Wheels, C = Driving Gear to bottom shaft,
D = Brake drum, E = Crank, F = Back rest oscillating cam,
G = Fly wheel, H = Loom side frame, I = Shedding tappet, J = Picking cam.

**Fig. 1.6 Crank Shaft and Bottom Shaft**

wheel on the bottom shaft. There are two picking mechanisms on a conventional loom, one on each side, and they are operated by picking tappets mounted on the bottom shaft. Similarly the shedding mechanism is normally operated by two shedding cams mounted on the bottom shaft. This is only in case of plain weave design, that is,



a design requiring only two heald frames. In the case of design requiring more than 2 picks per repeat, a separate tappet shaft is required and the shedding cams are mounted on that shaft. A loom frame with crank shaft and bottom shaft is shown in Fig. 1.5. Some of the important parts mounted on these two shafts are shown in Fig. 1.6.

## 1.4 TIME DIAGRAM FOR A LOOM CYCLE

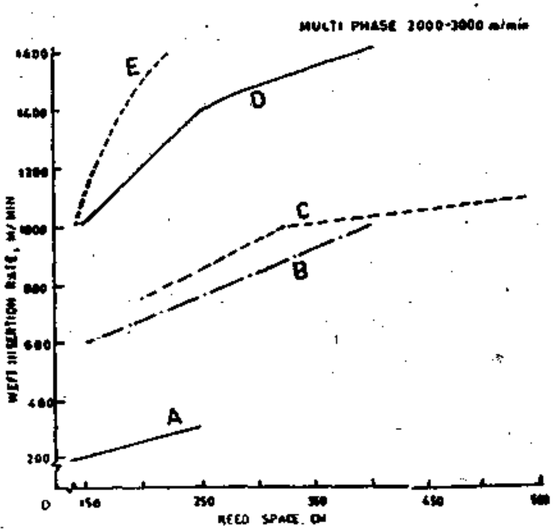
On a conventional loom, the crank shaft is normally driven by an electric motor either through a gear or a belt. Within one revolution of the crank shaft various loom mechanisms function at different times with different time intervals. The timings of the most of motions in the loom cycle are governed by the position of the reed (and the sley). For studying the various motions of a loom the timings are described in relation to the angular position of the crank shaft from which the reed (and the sley) derive their motions. The path traced by the crank pins represents a crank circle. It is then graduated in degrees, starting from the forward most position. This position is 0° or 360° (Fig. 2.17). Any timing can then be indicated in degrees. For example, the healds are normally levelled at 270°. In some literature of loom timings, the terms front, bottom, back and top centres are used for 0°, 90°,180°,270° respectively. For most of the looms the crank shaft moves from top to front to bottom to back and back to top centre, while in some of the looms such as Draper, Crompton and Knowles, Jute looms the crank shaft turns in opposite direction.

It may also be indicated here that though we have said 270° as the top centre position, it is not exactly so because the line passing through the axes of the sword pin of the sley and the cranks shaft is tilted or inclined. The exact position at which the healds are normally levelled is, therefore, 300°. Hence it is advisable to use the degrees of crank shaft instead of the terms top centre, etc.,

For timing the loom, it is recommended to provide a graduated wheel or disc on the crank shaft and a fixed pointer.The loom may then be turned to any desired position and the disc may be adjusted to 0° on the graduated scale when the reed is at the forward most position. In this text we have referred to these timing scale while describing the various loom motions. However, on certain looms, the manufacturers indicaté the timings with reference to the position of reed from a fixed reference mark on the breast beam.

## 1.5 WEFT INSERTION RATE

For one revolution of a loom crank one shedding, one picking and one beat-up takes place. This is called a single phase of weaving. Except the weaving machines of mutiphase types, all the looms are single phase machines. The production of cloth depends on the revolutions of the crank shaft. The speed of a loom, expressed as the picks per minute (ppm) or revolutions per minute (rpm) depends on weft insertion system, the reed space, type of shedding, type of box motion, cloth quality and yarn quality. There is an optimum limit of revolutions as maximum high speeds may lead to more warp and weft yarn breakages and more wear and tear of the loom parts, thereby involving stoppages and expensive repairs. However, expressing the loom speed in terms of revolutions per minute, the importance of the loom width for reed space and the number of phases are over-looked. Hence a concept of **Weft Insertion Rate** (WIR) has been evolved wherein the quantities picks per minute, reed space in meters and number of phases are taken into account [WIR (meters per minute) = reed width meters X picks per minute X number of phases]. Thus, if two loom shafts with the same reed space run at different speeds of rotation, for mechanical reasons such as dwell period available for shuttle passage or for the length of the shuttle varying, the WIR will be different. A circular loom can achieve a very high rate of weft insertion as it is inserting the weft continuously throughout the pick cycle. Looms using jets for weft insertion do not require dynamic forces of the same magnitude as those involved in a conventional shuttle loom. It has been found that though the revolutions per minute decrease as the reed space increases, the rate of weft insertion increases. Hence, WIR has now




A = Shuttle Loom, B = Rapier Weaving Machine, C = Projectile Weaving Machine, D = Airjet Weaving Machine, E = Waterjet Weaving Machine.

**Fig. 1.7 Weft Insertion Rates of Different Weaving Machines**



replaced rpm for modern weaving machines as the major design criterion of loom manufacturing. Weft insertion rates for different looms are shown in Fig. 1.7 (Latest development in WIR is given in last chapter). Also economical aspects of investment are based on the ratio of cost to WIR. This will be discussed later in this book.

## 1.6 WEAVE STRUCTURES

It is also essential to know the basic principles of fabric forming and weave structures before we go ahead with the mechanisms. The most common and simple interlacement of warp and weft threads is represented by a **plain weave**, the thread diagram of which is shown in Fig. 1.8 a. As mentioned earlier, the threads, parallel to the selvedges called warp threads, interlace with the threads at right angles to them called weft threads. Each individual thread of warp and weft is called end and pick respectively. It is seen that two ends and two picks complete one repeat of the plain weave. Most of the commonly used apparel fabrics use this simple weave, though the ornamentation or decoration of this weave can be achieved by a number of ways. From the thinnest light weight fabric known as muslin to the thickest and the heaviest fabric such as canvas cloth, can be formed by using a plain weave. The same plain weave can be represented on a point paper or a graph paper as shown in Fig. 1.8b where the solidly filled squares of the graph paper represent the warp thread on the top of the weft thread, while the blank positions represent the reverse, that is, the weft thread on the top of the warp thread. Thus, in a plain weave there are two different ways of lifting the ends. On the first pick end number one and all the odd ends are lifted and on the second pick end number two and the even ends are lifted. As there are two different liftings minimum two healds are required for drawing the ends - all the odd ends through, say the first

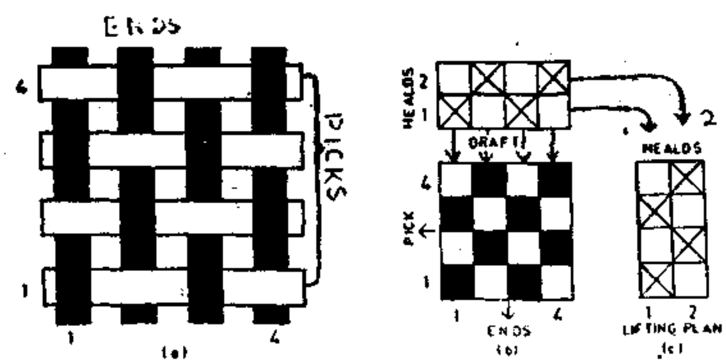
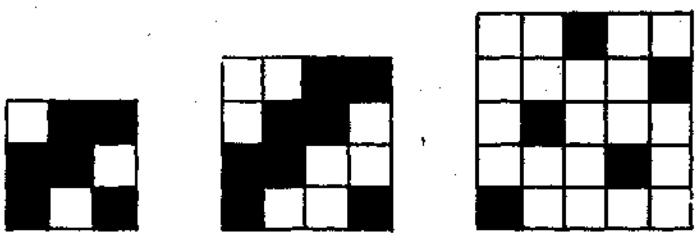



Fig. 1.8 Weave Notation

heald and all the even ends through the second healds (but in practice 4 healds are used to reduce the cramming of heald eyes). This is shown at the top of the design by two horizontal spaces of graph paper. The cross in the squares indicates the ends drawn through that particular heald. This is called the draft on the loom. In the given illustration the first and the other odd ends are drawn through the first heald and the second and the other even ends are drawn through the second heald. This order of drawing the ends through the healds is called a draft. In order to get the interlacement of ends and picks as per the weave shown in the design, a certain order of lifting and keeping the healds down is required. (This lifting and lowering of healds is achieved by the shedding mechanisms which is discussed in Chapter 2). For example for the given design and with the given draft of the ends, on the first pick, heald number 1 is to be lifted and on the second pick heald number 2 is to be lifted. This is shown conventionally by making use of a graph paper Fig. 1.8c. The vertical spaces to the right of the design represent a heald while a cross in the square indicates that a heald is lifted on a particular pick. This order of lifting the healds pickwise is called a **lifting plan.** In the case of a dobby shedding it is called a peg plan of the weave and in the case of a jacquard shedding, it gives the card cutting instructions.



2/1 TWILL 2/2 TWILL 5 END SATEEN

**Fig. 1.9 Basic Weaves**

All these preliminary terms of design, draft and peg plan should be understood properly before the fabric forming on the loom could be discussed. Some other basic weaves e.g. Twill, Satin etc. are also shown in Fig. 1.9

REFERENCE

1. Fox T.W., The Mechanism of Weaving, Macmillan Co. Ltd. 1961.

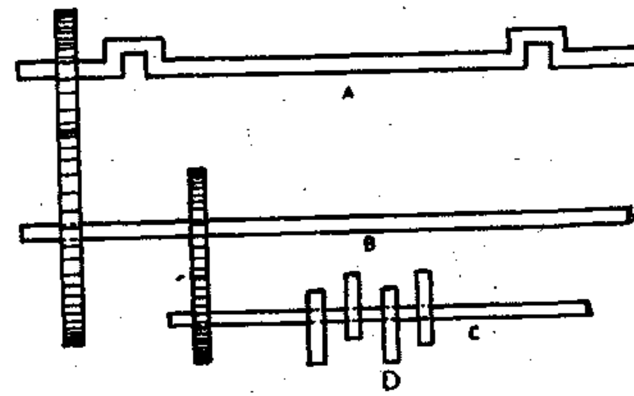


# 2 TAPPET SHEDDING MECHANISM

## 2.1 FUNCTIONS OF SHEDDING

The function of shedding mechanism is to raise and lower the heald frames which carry the warp ends, to make an opening for the shuttle to pass through and to change the position of warp threads after each pick so that warp and weft yarns will be interlaced as per weave/design. There are three types of shedding mechanisms namely, tappet, dobby and jacquard. Weaving machines are available with the required type of shedding mechanism. Sometimes the looms are classified as tappet looms, dobby looms and jacquard looms though these are the shedding motions on the loom and except the type of shedding, the looms are almost the same. These are in fact only attachments which can be fixed to any loom.

### 2.1.1 Tappet Shedding




A = Crank shaft, B = Bottom shaft, C = Tappet or counter shaft, D = Shedding tappets

**Fig. 2.1 Three Shafts of a Loom.**

The heald frames are operated by shedding tappets which are mounted either on a bottom shaft or a separate shaft called tappet shaft, also known as, counter shaft (Fig. 2.1). Each tappet has to be designed according to the weave structure. The number of tappets for a repeat of the design depends upon the weave. For a plain weave structure, normally two tappets are required. They are normally mounted on the bottom shaft. For a twill weave, repeating on 4 ends and 4 picks, four tappets are required. For all the weaves other than the plain tappets must be mounted on the tappet shaft nevertheless, for plain weave woven with four tappets, they may be mounted on the tappet shaft. Once the tappets have been designed and cast for a particular design, they cannot be used for any other design. This means a weaving factory has to store a number of tappets and change them whenever a change in weave structure is required. Along with this, the gearing that drives the counter shaft on which the shedding tappets are mounted , is also to be changed to give the correct speed ratio between the crank shaft and tappet shaft (Fig. 2.1). Changing of tappets and gear wheels require stopping of the weaving machine for longer times, thus losing production. The other disadvantage of the tappet shedding is that the number of tappets that can be used economically and conveniently, for a particular weave repeat, will be up to eight or maximum twelve. So weave structures repeating on more than 12 heald shaft and 12 picks require a more versatile shedding mechanism than the tappet shedding, i.e. **dobby** or **jacquard** shedding mechanism.

The advantages of tappet shedding are :

(a) the mechanism is simple; (b) the initial cost is low; (c) maintenance is easy; (d) the mechanism does not cause design faults in the woven fabric; and (e) it does not impose limitations on the speed of the weaving machine.

Plain, simple twill and simple satin designs can be produced by tappet shedding mechanism.

### 2.1.2 Dobby Shedding

In dobby shedding the heald frames are operated by jacks and levers (Fig. 2.2). The order of lifting or lowering of the heald frames, as per a lifting plan, is controlled by a pattern chain that gives unlimited scope for weaving designs, repeating on large number of picks. This mechanism can control upto 24 heald frames, depending upon the crank arm length.

The design possibilities are twill, satin, crepe, honeycomb, huck-a-back, mocklero, bedford cord, double cloth etc.

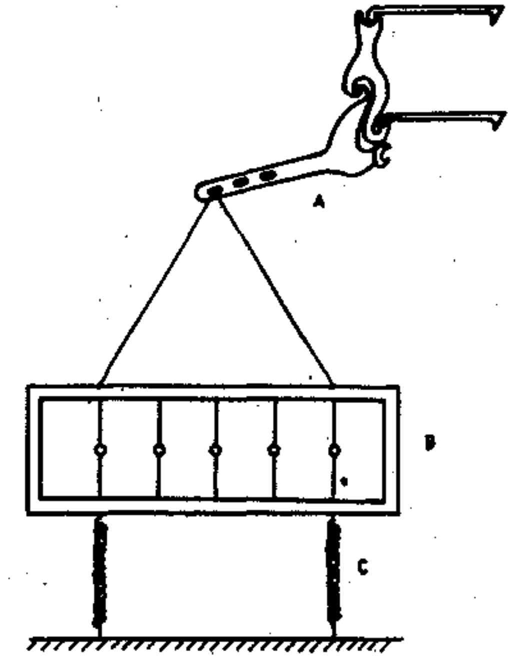
The disadvantages of dobby mechanisms are :

(a) mechanism is complicated; (b) initial cost high; (c) maintenance cost is high; (d) can produce design faults in woven fabric; and (e) tend to limit the loom speed when compared to the tappet shedding.

### 2.1.3 Jacquard Shedding

In this shedding the warp ends are controlled individually by harness cords, Fig. 2.3. There will be as many cords as there are ends in the warp. There are no heald frames. Because the warp ends are






A = Jack, B = Heald Frame, C = Spring reversing motion

**Fig. 2.2 Dobby Shedding**

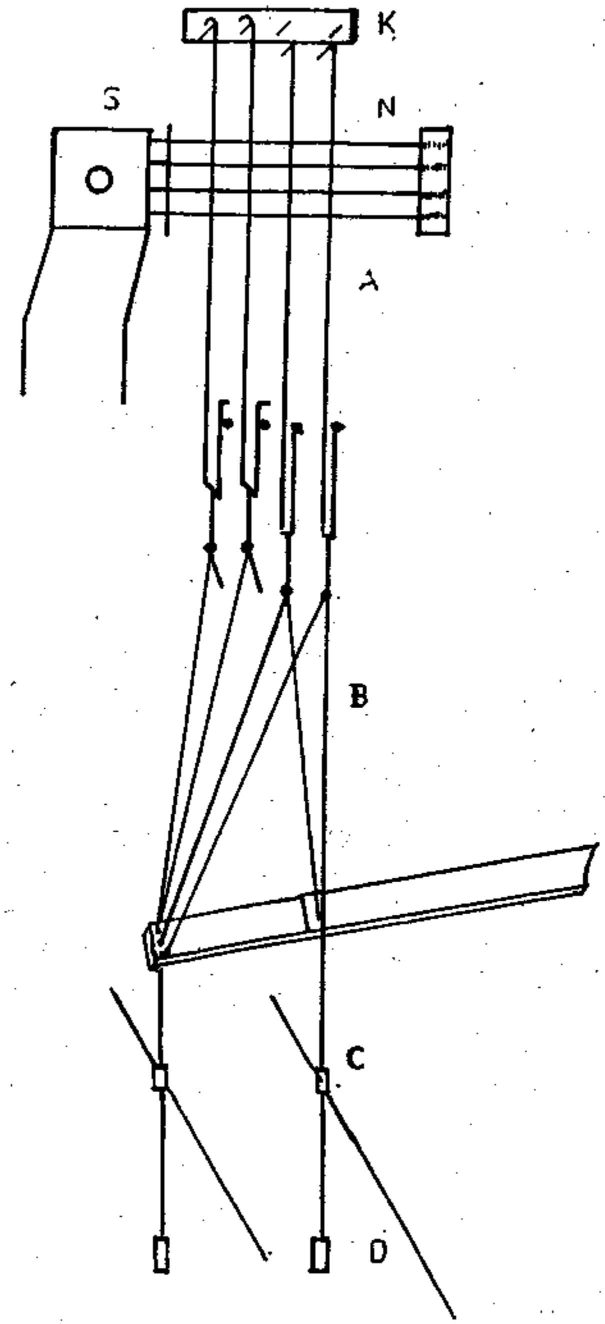
controlled individually by the shedding mechanism, the patterning possibilities are virtually unlimited. Therefore, complicated designs like portraits, animals, geometrical figures or even a landscapes can be woven with this type of shedding mechanism.

Disadvantages of jacquard shedding are :

(a) the mechanism contains more moving parts; (b) initial cost is very high; (c) maintenance cost is also high; (d) can produce design faults in the fabric; (e) preparing a design and cutting pattern cards require skilled labour; and (f) limitations on the speed of the loom due to complex mechanism.

## 2.2 NEGATIVE OR POSITIVE TAPPET SHEDDING AND LINK MECHANISM

There are two types of shedding mechanisms, namely, negative and positive. In the former the heald frames are either raised or lowered by the shedding mechanism but the reversing of the motion is carried out by a separate reversing mechanism which consists of simple springs or lingoes, or connections to top rollers or some special mechanism. The simple commonly used tappet




A = Hooks, B = Harness cord, C = Harness, D = Warp end, K = Lifting knife, N = Needles, S = Pattern cylinder.

**Fig. 2.3 Jacquard Shedding**



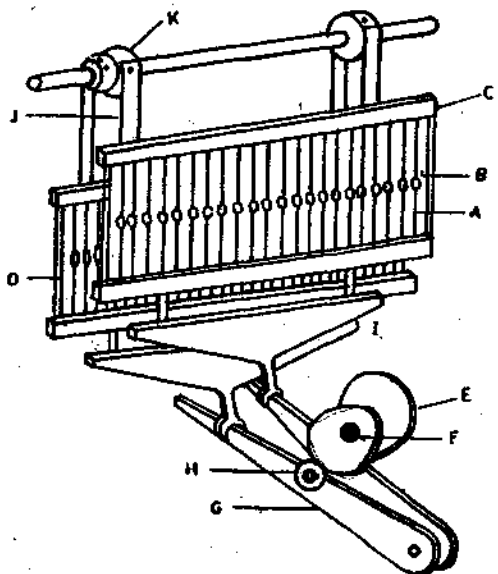
shedding mechanism shown in Fig 2.4 seems apparently to be positive in action, but the shedding tappets are negative, since they only lower the heald frames positively but do not raise them positively.

The reversing is carried out by the top roller connections to the healds. In the case of positive shedding, the heald frames are lowered as well as raised by the shedding mechanism without the aid of a reversing motion. Fig. 2.10. There is no separate reversing mechanism. These tappets are generally slotted or grooved tappets. The bosses and recesses disposed over the tappet counter, determine the sequence of heald lifting or lowering of frames. Sometimes counter tappets (matched cams) are provided to ensure the displacement of healds in both directions. Such tappets can be called positive tappets. These tappets are required for the dense warps and for high speed weaving machines. These two types of shedding are discussed below in detail.

### 2.2.1 Negative Tappet Shedding

The negative tappet shedding mechanism shown in Fig. 2.4, consists of two tappets, keyed to the bottom shaft. When the loom is started the tappets rotate along with the shaft and put the shedding mechanisms in action. The whole mechanism consists of treadle levers, treadle bowls, tappets, heald frames, healds and top roller reversing motion. The heald frames are tied at the top and bottom by means of heald cords or leather straps. While tying the frames at the bottom, it is necessary to see that the treadle bowls should be in contact throughout with the shedding tappets. The treadle levers are fulcrummed at one of the crossbars at the back of the loom. The number of levers depends upon the number of shedding tappets which, in turn depends upon the weave design. Each lever carries an antifriction bowl or a treadle bowl which should be always in contact with the tappet face. The far end of the treadle levers is connected to the lower part of the heald frames, by means of metal rods. The heald frames carry a number of healds and each heald has a heald eye through which generally one warp end is passed during the preparation of the warp. In the case of a plain weave the warp ends are divided into odd and even ends. All the odd ends are drawn through the healds belonging to one heald frame and all the even ends are drawn through the healds belonging to a second frame. The two heald frames are controlled by two separate shedding tappets.

The top of the heald frame is connected to a roller reversing motion by means of cords and leather straps or chains which are flexible links (sometimes the connections are by rigid links of metal tie-bars).




A = Heald wire, B = Heald eye, C = Heald stave, D = Heald frame, E = Shedding tappets, F = Bottom shaft, G = Treadle levers, I = Lamb rod, J = Leather strap, K = Top roller

Fig. 2.4 Negative Tappet Shedding Motion (seen from backside of a loom)

The top rollers are different in their diameters. The front heald frame is connected to the top roller of a smaller diameter and the back heald frame to the top roller of a larger diameter. This is because the throw of the tappet operating the back heald frame should be greater than that of the tappet operating the front frame. The reason for the greater throw for the back heald frame will be discussed later in the topic on the geometry of shedding.

Each shedding tappet in the case of a plain weave, normally makes a complete revolution for every two picks. When one of the heald frames is pressed down by its tappet the other frame is lifted by the partial rotation of the top roller connected to it.

### 2.2.2 Eccentric motion of the Shedding

The designing of the shedding tappet is very important because the movement of heald frames entirely depends upon it. The heald frames move slowly, either coming from the top or bottom positions and then slightly increase in speed when the warp threads cross each other, and again move slowly until the shed is fully opened. The advantage of this kind of motion is that the warp is made to move fast when it is slack and slow when it is tight thus reducing the chances of breakages of warp to a minimum. There is shed formation and hence tension variations occur during a shedding



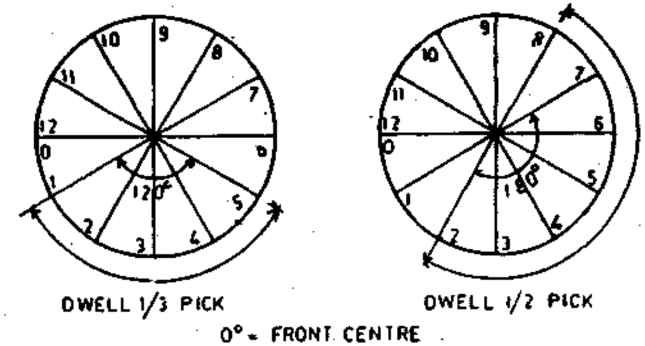



Fig. 2.5 Plain Loom Timing Diagram

always a cyclic deformation of warp yarn taking place during each cycle. This is discussed briefly in the Appendix –I. After the formation of a warp shed the heald frames have to remain stationary for some period to allow the shuttle to pass through from one shuttle box to the other. This period is called a dwell period of the heald frames and it is varied according to the width and the speed of the loom. For a narrow width loom, for example the dwell is one third of a pick (120° of crank cycle), and for a wide, slow running loom the dwell is about half a pick (180° of the crank cycle), Fig. 2.5.

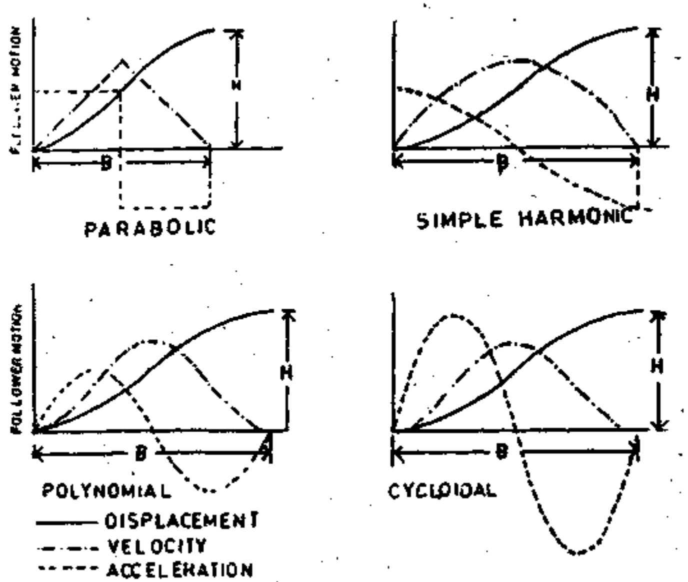
### 2.2.3 Designing of a Shedding Tappet

#### 2.2.3.1 Points to be noted in constructing a shedding tappet profile

1. During one revolution of the bottom shaft two sheds are formed. To obtain an equal height of both sheds, it is necessary to lower and lift the back heald over a greater distance than the front one. The back heald tappet has a greater eccentricity and the rollers for this heald are of greater diameter. (The eccentriciy is the difference between the greatest and smallest radius of tappets).
2. The eccentricity and the leverage system transmitting the movements to the healds determine the shed height.
3. The dwell of the healds is generally 120° of the main shaft revolution and therefore, two thirds of main shaft revolution is for the heald displacements.
4. Shed height at the shuttle front wall must be 3 to 5 mm greater than the height of the shuttle front wall.
5. A small point to which an attention may be drawn in consrtuction of a tappet is that the warp threads do not exactly move through the same distance as the healds, but there is a little difference due to the size of the heald eye and hence an allowance of one cm is made for heald-eye depth.

### 2.2.3.2 Movement of healds

The design of the shedding mechanism should be such that at the start velocity of the healds should be less than normal, at the middle its velocity is maximum and then at the end it is again less. This type of movement can be obtained by **simple harmonic motion** (SHM), **parabolic, polynomial** and **cycloidal** motion. The kinematic characteristics (1) i.e. displacement, velocity and acceleration are shown in Fig. 2.6.




B = Angular Rotation of a Cam, H = Lift of follower

**Fig. 2.6 Motions of Cams**

SHM is the most commonly used motion for shedding, especially for conventional non-automatic shuttle looms. With this motion, amplitude of acceleration is comparatively low, but at the beginning and the end of the stroke, this motion has sudden changes in acceleration which leads to jerks and is not suitable for high speed looms.

There is a constant positive or negative acceleration with the tappets imparting parabolic motion, the healds velocity increases and decreases at a constant rate upto half lift and after half lift respectively. This helps in getting approximately 15% higher crossing velocity, but the motion has sudden change in acceleration at the beginning and end of motion. This will result in considerable jerks to the healds and is unsuitable for high speed looms.



Polynomial and cycloidal motions have higher amplitudes of ...eleration, but the acceleration changes gradually throughout the ...le without any sudden change and has finite jerk. So this motion ...uitable for high speed looms.

### ...3.3 Construction of shedding tappets

The following factors are to be considered while constructing ...ppet :

The weave structure (e.g. plain, twill, satin etc.).

The number of picks to a repeat.

The point where the treadle bowl is nearest to the boss of the tappet (nearest point of contact i.e. npc).

The distance the bowl is moved from the nearest point to the farthest point, that is, stroke of the tappet.

The diameter of the treadle bowl; and

The dwell period of the heald frame.

The essential data required for the construction of a shedding ... are therefore :

...ave; (b) dwell period; (c) stroke; (d) nearest point of contact ...; and (e) treadle bowl diameter.

...ple : Plain weave

| | |
|---|---|
| dwell period | : 1/3 pick (120°) |
| stroke | : 60 mm. |
| npc | : 40 mm. |
| treadle bowl diameter | : 40 mm. |

The construction of the shedding tappet is shown in Fig. 2.7 ...ter scale used).

Construct a circle A with a radius of 60 mm. (ncp + radius of treadle bowl.)

Construct another circle B from the same centre with radius 120 mm (add 60 mm of the stroke to the radius of the circle A.)

Since the plain weave repeats on two picks to a round of the crank cycle, divide the circle B into two equal parts by the line XY; each part represent one pick.

Since the dwell periods is 1/3 pick, divide each segment between XY into three equal parts by the lines MN and PQ. The segments MP and QN represent the dwell of the tappet. The segments MQ and PN represent the heald change periods as in Fig. 2.7 a.

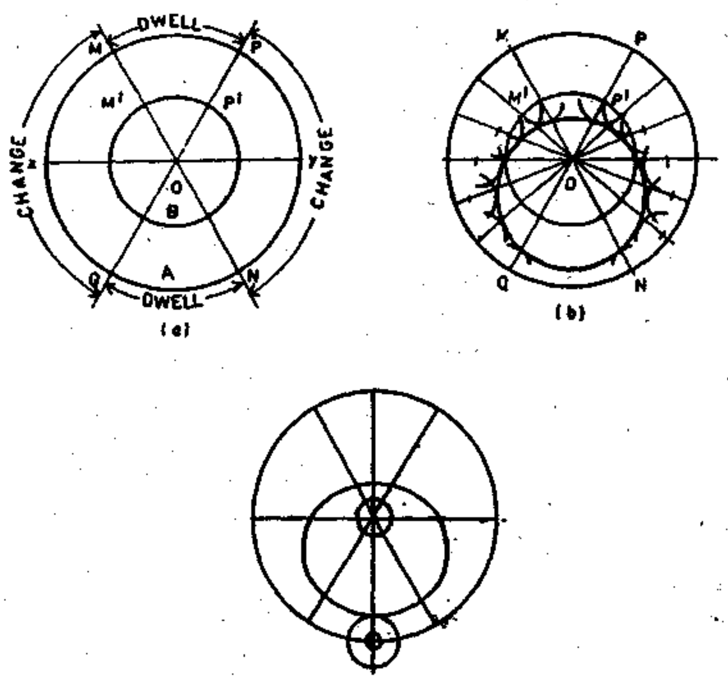



Fig. 2.7 (a) and (b) and (c) Construction of a Negative Shedding Tappet

(e) Divide the segments MQ and PN into six equal parts (for greater accuracy in the tappet outline, the segments can be divided into more than six number of equal parts) by drawing radius from centre O.

(f) With MM' or PP' as diameters draw semicircle and divide this also into six equal parts (the same number as in the case of step 5). (Fig. 2.7 a.).

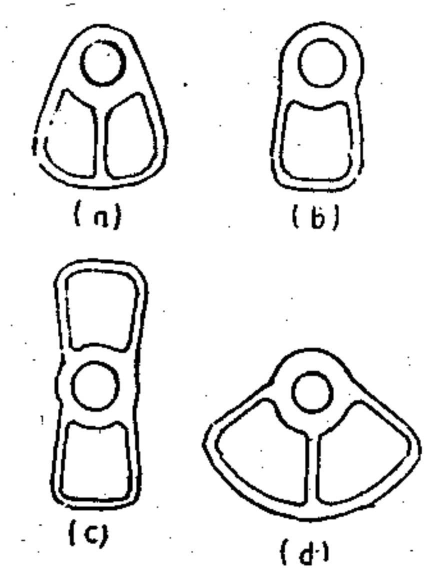
(g) From each point in the semicircle drop a perpendicular to cut the lines OM and OP.
The purpose of this graduation is to enable the heald frames to move quickly at the time they are crossing each other and move slowly as they reach the extreme points of shed opening.

(h) With O as centre and radius equal to each of the bisecting points on the lines OM and OP, mark of points of intersection on the radial lines as shown in Fig. 2.7 b.

(i) From each of the points on the radial lines construct circles equal in size to the treadle bowl.



j) Draw a smooth curve joining the edges of the bowl in its different positions as shown in Fig. 2.7 c. Shapes of different types of tappets are shown in Fig. 2.8.




A = 2/1 Twill, B = 3/1 Twill, C = 1/1, 1/1 Plain (Four picks to the round) D = 2/2 Twill

Fig. 2.8 Profiles of Different Types of Tappets

A smooth movement of heald frames is possible when a large treadle bowl is used since it is the circumference of the treadle bowl that decides the outline of the shedding tappet.

### 2.2.4 Geometry of the Warp Shed

The **stroke of the tappet** is decided from the following measurements ;

(a) height of the shuttle front inside the warp shed;

(b) the position of the heald frames in relation to the cloth fell;

(c) the distance of the heald frame connection on the treadle lever from the fulcrum of the treadle lever;

)d) the distance of the centre of treadle bowl from the fulcrum of the treadle lever; and

(e) the sweep of the sley.

In Fig. 2.9 a simplified diagram of the relative positions of the above mentioned parts, with numerical values, are given :

(a) the angle between the reed and the raceboard, which is known as the bevel is taken as 90°;

(b) the sley -sword has moved from the vertical beat - up position to its backward most position through 15°;

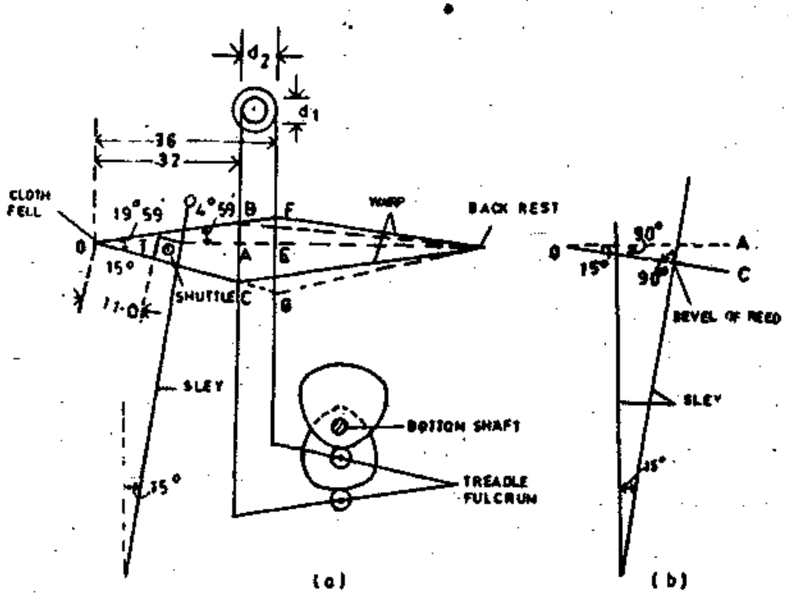



**Fig. 2.9 Tappet Shedding with Top Rollers**

(c) the distance of the shuttle front from the fell of the cloth is 11.0 cm;

(d) the height of the shuttle at the front is 3.5 cm;

(e) a clearance of 5 mm. is given between the top front edge of the shuttle and the top warp line;

(f) the distance of the front heald frame from the fell of the cloth is 32 cm;

(g) the distance of back heald frame from the fell of the cloth is 36 cm;

From the data given above, it is possible to calculate the total movement of the front and back heald frames, for the same shed angle.

The detailed calculations are as follows :

— ∠BOC is the shed angle ; — OB is the top warp line ;

OC (OG) is the bottom warp line ;

AO is the horizontal line joining the front and back rests.

Bevel of the reed (angle between the raceboard and the reed is 90°).

Since the sley has moved 15° from the front position to the backward position the angle ∠AOC is 15° (see Fig 2.9 b and considering that the sum of angles of a triangle is 180°).

To find out the shed angle ∠BOC :



tan ∠BOC = [ Height of the shuttle + Shuttle clearance with the top line of the warp ] ÷ ( Distance of the shuttle from the cloth fell)

= [ 3.5 + 0.5 ] ÷ 11.0 = 0.3636

∠BOC = 19° 59' ; ∠BOA = 19° 59' — 15° = 4° 59'

In triangle AOB, AB = tan ∠BOA x OA = 0.0872 x 32 = 2.79 cm.

In triangle AOC, AC = tan ∠AOC x OA = 0.2679 x 32 = 8.57 cm.

BC = AB + AC = 2.79 + 8.57 = 11.36 cm.

Since the triangles BOC and FOG are similar = (FG/BC) = (OE/OA) = 36/32)

FG = 11.36 x 36/32 =12.78 cm.

Thus, the front heald frame has to move through a distance of 11.36 cm and the back heald frame has to move through a distance of 12.78 cm.

**2.2.4.1 Calculation of the stroke of the shedding tappets and relative diameters of the two top rollers**

S1 = stroke of the tappet that controls the front heald frame;

S2 = stroke of the tappet that controls the back heald frame;

h1 = vertical movement of front heald frame;

h2 = vertical movement of back heald frame;

L1 = the distance of the front heald frame from the treadle fulcrum;

L2 = the distance of the back heald frame from the treadle fulcrum;

d1 = the diameter of the top roller which controls the front heald frame;

d2 = the diameter of the top roller which controls the back heald frame.

S2 / S1 = (h2 / h1) X (L1 / L2)

Let L1 = 50 cm., L2 = 46 cm.

then, S2 / S1 = (12.78 / 11.36) X (50 / 46) = 1.22

The stroke of the tappet operating the back heald frame should be 22% greater than that operating the front heald frame.

The relative diameters of the top rollers should be :

d2 / d1 = h2 / h1 = 12.78 / 11.36 = 1.125

that is, the diameter of the top roller of the back heald frames reversing mechanism should be about 12.5% greater than that controls the front frame.

Since the treadle levers controlling the heald frames are fulcrummed at the back of the loom, the actual leverage of the treadle lever operating the back heald frame is less than that of the front frame. Because of the shorter leverage the back heald frame will move a shorter distance compared to the movement of the front frame, whereas, as per the calculation shown before, the back frame should move a greater distance to maintain the same depth of shed. Therefore, the tappet operating the back heald frame has a greater throw (or stroke) than the front tappet.

### 2.2.5 Positive Tappet Shedding

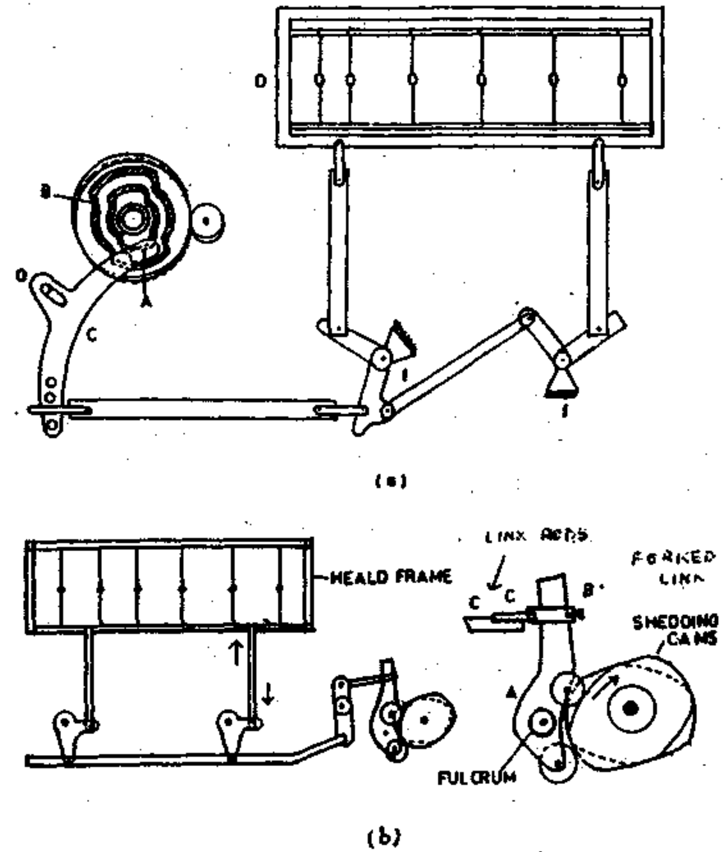
In positive shedding the heald frames are raised as well as lowered by the shedding mechanism. There is no need of reversing mechanism. All modern high speed weaving machines have positive shedding motion. The tappets are made to control the healds movements in both directions. An outline of the heald connections for a positive action is shown in Fig. 2.10.

As shown in Fig. 2.10 a tappet follower A follows the groove or the tappet track in the tappet B. The tappet is mounted on a tappet shaft and driven by pinion and bowl wheels from the main shaft. When the tappet rotates, the tappet follower moves up and down and the tappet lever C, which is fulcrummed at O, moves to and fro, thus raising and lowering the heald frame D.

On Sulzer Ruti Projectile Weaving Machine and other shuttleless weaving machines, shedding cams are mounted low at the side of the machine. Each pair of cams operate one shaft as shown in Fig. 2.10.b. The metal heald frames move up and down in the heald frame guides provided on either sides of the frame. The bottom of the heald frame is connected to the roller lever through guide plate, angle lever, connecting rod, driving rod, treadle lever and link rods. The two link rods C are adjustable by loosening the lock screw. Similarly the forked link may be adjusted by unfastening the clamp screw. Moving the forked link B upward on the roller lever A makes the healds frame opening larger. Moving it downwards makes the opening smaller. The height of the heald frame can be adjusted by unfastening the locking screw and moving the link rod C. The antifriction rollers are always in contact with the cam face. As per weave, the shedding cams are fitted on the tappet barrel, clamped together and placed in oil casing. When the cams rotate, the treadle levers oscillate and through the connecting rods raise or lower the heald frames.

With the positive shedding motions the weaver has a clear view of the warp behind the reed since there are no mechanical parts to obstruct his view. There is also no risk of oil falling on the warp from the lubricated parts of top rollers.






A = Tappet follower, B = Tappet, C = Tappet lever, O = Fulcrum

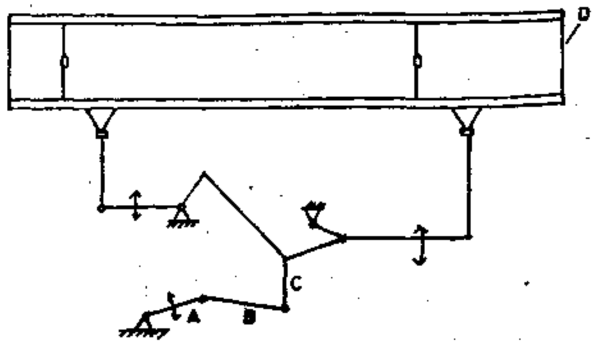
**Fig. 2.10 Positive Cam Shedding Motion**

Since the heald frame ends are supported by guides fixed to the loom frame, the heald frames remain straight during their up and down movement.

The terms positive and negative are also used with reference to dobby shedding. However, this will be discussed in a separate chapter under dobby shedding.

### 2.2.6 Link Mechanism

The movements of heald shaft in both the directions with a shorter dwells can be controlled by a link mechanisms as shown in Fig. 2.11. Rotating crank A along with the coupler B rocks the three arm follower C which gives the healds shaft D upward and downward movement through a series of links. The link mechanism is simple and its cost of production is lower than that of tappet mechanisms.




A = Crank, B = Coupler, C = Three arm rod, D = Heald

Fig. 2.11 Shedding by Link Mechanism

urther it gives less vibrations which result in reduced warp eakages. The mechanism is suitable for high speed looms.

## 3 HEALD REVERSING MOTION

As explained earlier, the heald reversing motion is necessary the case of negative shedding. The reversing is carried out by top llers or by simple springs or a special mechanism. The simple top ller system for plain weave has already been discussed under egative shedding. The top roller arrangement for operating three, ur and five heald frames is shown in Fig. 2.12. However, this echanism is used for a weave where the same number of shafts re lifted on each pick. In Fig. 2.13 separate top roller arrangement r three, four-and five- healds weave designs are shown. In all these ystems the top most roller A rotates in fixed bearings and the others se and fall. In the case of five roller system, the top roller A and B tate in fixed bearing, and the lower rollers C,D and E work in slots that they can move up and down.

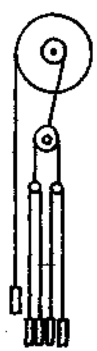


Fig. 2.12 Top Roller for Operating upto Five Heald Frames



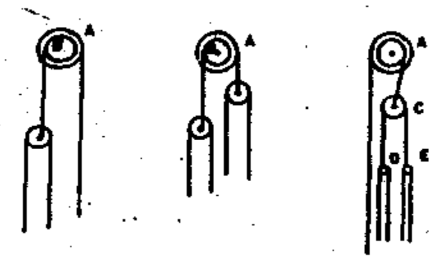
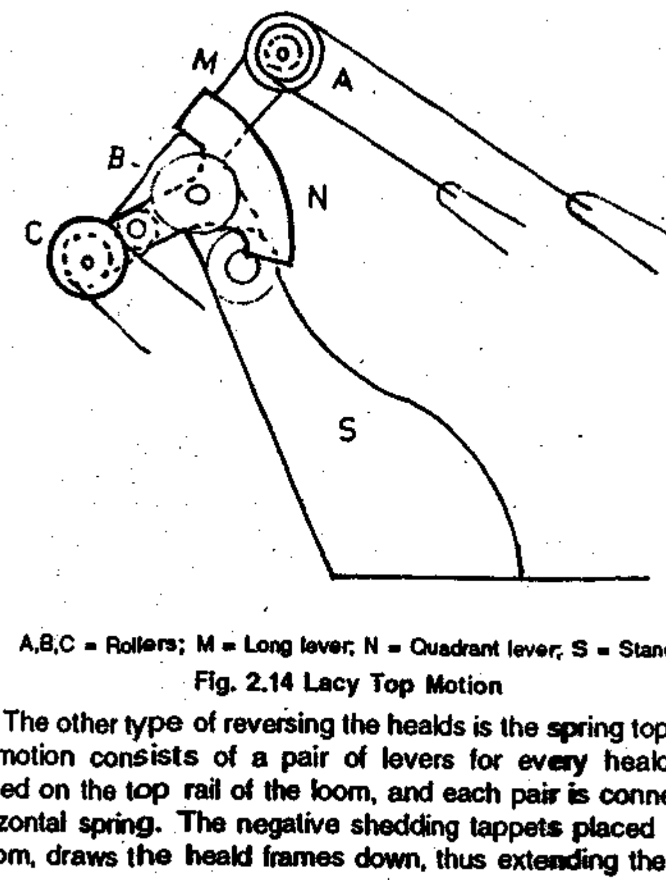



Fig. 2.13 Top Roller for Three, Four and Five Heald Frames

An all purpose Lacy top motion used on British Northrop Loom is shown in Fig. 2.14. It is mounted on a stand S at one end of the top rail of the loom. It consists of three rollers A,B and C, a long lever M and a short quadrant lever N. These two levers can be locked in position or they can be made free to escillate.

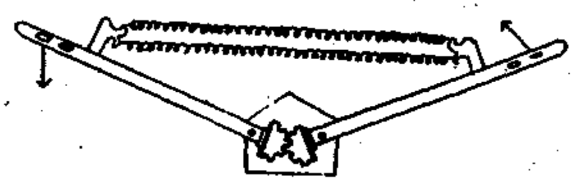



A,B,C = Rollers; M = Long lever; N = Quadrant lever; S = Stand

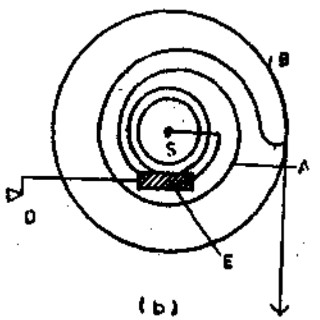
Fig. 2.14 Lacy Top Motion

The other type of reversing the healds is the spring top motion. This motion consists of a pair of levers for every heald frame, mounted on the top rail of the loom, and each pair is connected by a horizontal spring. The negative shedding tappets placed beneath the loom, draws the heald frames down, thus extending the springs of the reversing mechanism. As soon as the tappet completes its stroke, the springs contract returning the heald frames to the top position. One example of such a motion is shown in Fig. 2.15 a. The spring tension can be varied to suit the warp strength.

Clock spring type reversing motion as shown in Fig. 2.15 b, is mounted on the side. This does not obstruct the view so much. Heald shaft is lifted by the tension of a spiral spring A whose one end is fixed to tension drum B and the other to the shaft S. The spring is prestressed by the hand wheel D and worm gearing E. The spring reversing motion has a distinct advantage over the roller reversing motion since the former operates individual heald shafts independent of one another.



(a)




(b)

Fig. 2.15 Spring Reversing Motion

## 2.4 SHEDDING MOTION PRINCIPLES

Shedding motions are designed on four different principles, namely Open shed. Semi-open shed, Bottm-closed shed and Centre-closed shed. These are illustrated in Fig. 2.16. The principles are based on the position of warp threads after each pick.

### 2.4.1 Open Shed Principle

In this case the heald frames move continuously from the top position to the bottom position or vice-versa, unless some ends, as per design, require to remain up or down for two or more consecutive picks. In Fig. 2.16 a the first heald moves up and the second moves



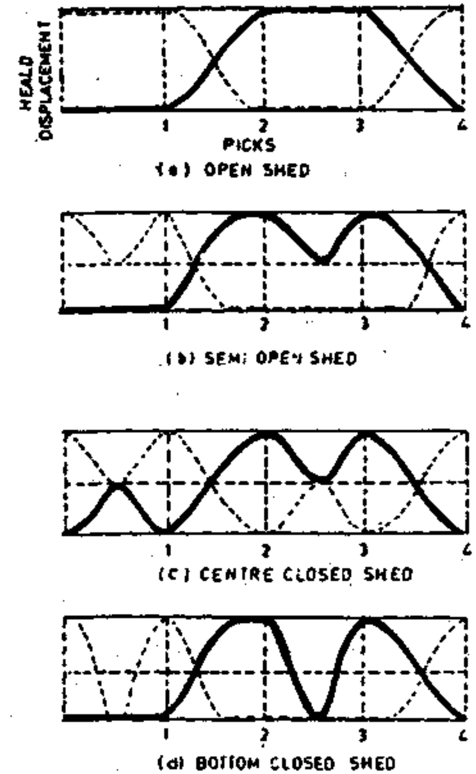



Fig. 2.16 Type of Sheds

down after the insertion of the first pick . Then they remain stationary in their respective positions for the second and the third pick. On the fourth pick they move again changing positions. This type of shedding can be attained in tappet shedding, double acting double lift dobbies and certain jacquards. The maximum speed of working is achieved with this shed formation. The unnecessary movement of the threads is avoided. Hence, less power is required to drive the loom. However there is difficulty in levelling the threads during repairing of warp ends for weaves other than plain.

### 2.4.2 Semi-Open Shed Principle

In this case the healds that are required to remain stationary for two or more consecutive picks at the bottom position remain at rest.

However, the heald frames which are required to remain stationary at the top position for more picks in succession, do not remain stationary but move about half the distance of the depth of the shed and go back to their top position for the formation of a shed for the next pick. Here, it is seen that some warp ends are unnecessarily strained. This type of arrangement is found in jacquard, Fig. 2.16 b. The speed of working is slightly reduced as the top shed line moving from the top to the centre line and again back to the top line - an unnecessary inevitable movement. The disadvantage of this principle is the difficulty of levelling the healds when broken threads have to be repaired.

### 2.4.3 Centre Closed Shed

In this case, after every pick, the raised and lowered ends return to the centre position before a new selection is made. This means all the warp ends are strained unnecessarily. Some of the dobby shedding used for gauze and leno weaving form the centre closed shed (Fig. 2.16 c).

### 2.4.4 Bottom Closed Shed

Here all the ends, whether they are required to remain up for two or more consecutive picks, come down to the bottom position before they are lifted up for the next shed opening. This means no end will remain stationary at the top position after a pick is inserted. All of them move down before a new selection is made for the next shed. There is unnecessary strain on a few ends. This type is found in single lift jacquards, (Fig. 2.16 d). The speed of the mechanism gets reduced due to this extra movement of the healds. As all the threads come to one level after every pick this principle is especially suitable for weaving gauze cloth. But this requires large amount of power to drive the loom.

## 2.5 TIMING OF SHEDDING AND OTHER PRIMARY MOTIONS

The timing of the shedding motion varies considerably for different kinds of cloths but it should always be such that the traverse of the shuttle through the shed should be a clear one. If the picking is too early the shuttle will have to force its way into a partly opened shed and yarn breakages may take place. For this reason the shed should be in a substantially open condition when the picking takes place. It is usual to time the picking to confirm to the shedding and not vice versa. For cotton weaving looms, the shedding motion is generally set in such a way that the healds are levelled when the crank reaches at 270°. This is shown in the time diagram Fig. 2.17. The tappet has dwell of one third pick. The shed is fully open from points 1 to 5 in the crank cycle F (30° to 150°). The shuttle enters the shed at about bottom centre. The normal setting is that reed is about 80 mm away from the cloth fell.

### 2.5.1 Early Shedding

Early shedding (healds are levelled at 260-265 degrees) ensure substantially open shed at the beat up point. This facilitates



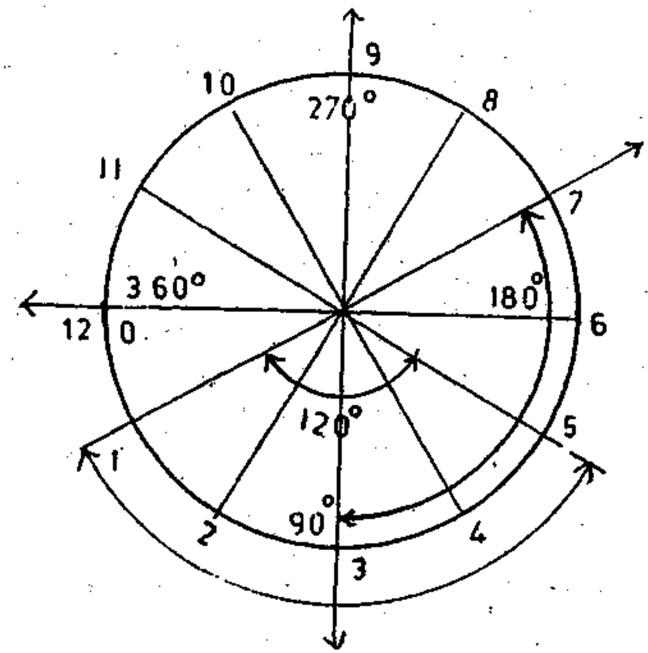



Fig. 2.17 Normal Timing of Primary Motions

the production of a well covered cloth. Good cover is usually obtained by troughing the warp line so that the weft at the beat-up can spread the slacker warp threads in the top shed line between the tighter ends in the bottom line. But this difference in tension can only exist when the shed is open. It is therefore necessary to have an open shed at the beat up. The early shedding gives steadier cloth fell than the late shedding and this is of special advantage when weaving heavy plain cloths which are likely to have unsteady fell. An unsteady fell is generally caused by the last pick of weft slipping backwards. This slipping backwards may cause uneven spacing of the picks whenever the loom is stopped and restarted and thus resulting in cracks in the cloth. However, with early shedding the warp threads have already crossed to form the next shed before the reed beats up so that last pick inserted has no chance to slip back.

### 2.5.2 Late Shedding

With late shedding healds are levelled at 275-280 degrees. The motion may be so set that he healds are levelled i.e. the shed is closed when the cranks are at point 11 or even at the beat up position (or at point 12). Such timings ease the strain on the warp threads as the increase in the warp tension due to the opening of the shed does not coincide with the additional tension brought about by a sudden impact of the reed against the cloth fell. Further, as the weft is beaten up to the fell before the warp and weft yarns have not the same chance to get inter-locked and there is thus less strain on the yarn as the reed moves forward.

The point in the crank circle at which the shed is fully open varies from beat-up position 1 to about 4 point. Early shedding is generally adopted for plain weave fabrics of the medium and heavy types, particularly when reedines has to be avoided. When lighter and fancier types of fabrics and specially filament yarns are being woven or when the warp threads are tender, late shedding is usually adopted.

### 2.5.3 Other Adjustments of Shed

Other adjustments of shed are :

a) The depth of the shed should be as small as possible consistent with the size of the shuttle used. When a shed is fully open it should only just clear by about 2-5 mm the top front edge of shuttle.

b) All sheds should be of equal depth.

c) The healds should be set as near to the front of the loom as the movement of the sley allows as this reduces the amount of lift necessary to give the required depth of the shed.

d) The bottom line of fully open shed line should touch the race board only lightly (about 1 mm above the race board and to the top shed line should be clear of the sley cap by about 2 mm). Care should be taken to ensure that the bottom shed line lies at the same angle as the face of race board when the sley is in its rearmost position.

## 2.6 SPLIT SHEDDING OR STAGGERING OF HEALDS

With the normal shedding mechanism all the healds are levelled at the top centre or very near to it for cotton and other spun warps. The threads cross at this position. If the ends per cm are 12 or less, then two healds are sufficient to weave a plain weave structure. If the ends per cm are between 20 and 40, generally four healds are used and six healds shafts will be required for weaving more than 40 ends per cm though the weave is plain. During the crossing of the warp threads, considerable friction and therefore abrasion takes place amongst the ends. This abrasion is likely to cause warp breakages, particularly for high warp density fabrics such as poplin or polyester blended fabrics, affecting the productivity adversely to a large extent on both the conventional and unconventional looms. Also it affects the smooth movement of the



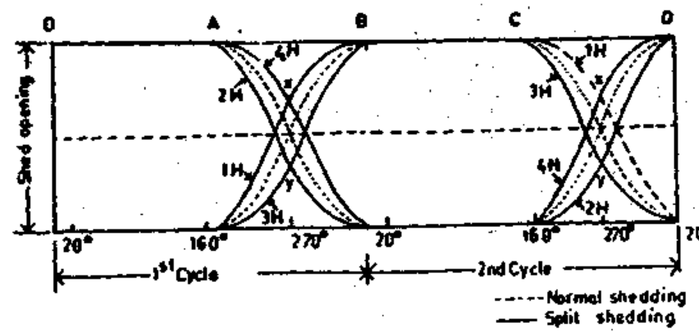
healds. This abrasion and obstructed movement can be reduced by using a **split shedding** in which the warp is made to cross in separate layers instead of all the threads of one shed line crossing all the threads of the other shed line at the same time. By split shedding the total number of threads and healds crossing at a given time is reduced. This is also known as **staggering of healds.**

### 2.6.1 Fixed Heald Staggering

Staggering of the healds can be achieved by securing mechanically the two heald shafts moving together in the same direction in such a manner that the line of heald-eyes in the other shaft are a fixed vertical distance throughout the shedding cycle. This type of staggering is known as fixed heald staggering and is not very effective in reducing the warp breakages. This is because when the shed fully open there is vertical separation of warp sheets. With fixed staggering the extent of staggering cannot generally exceed 8 mm or so.

### 2.6.2 Variable Heald Staggering

Better results are obtained by moving each of the four (or more) heald shafts independently by four (or more) specially designed tappets. Starting simultaneously from the open shed position, the two heald shafts controlling the same shed are accelerated and decelerated differently over the shedding cycle in such a way that there is always some vertical separation of heald eyes between them except in the final open shed position. The extent of separation varies over half the cycle of shedding and is maximum midway during the half cycle. The manner in which the heald shafts move in a four-heald variable staggering device is shown in Fig. 2.18.




D A = Dwell Period, A B = Change Period,
B C = Dwell Period, C D = Change Period.

**Fig. 2.18 Heald Displacement of Staggering Tappet**

DA is the dwell period (120° of the crank shaft movement in this case) and AB is the shed change over period of the first cycle of plain weave; BC is the next dwell portion and CD is the shed change over period of the second cycle. Y axis represents the shed opening (heald displacement), X axis the crank shaft position.

At A (Fig. 2.18) the healds 2 and 4 are forming the top shed and healds 1 and 3 are forming the bottom line of shed. As the heald shafts begin to move, the heald shafts 2 is given a higher acceleration than shaft 4 and shaft 1 also a higher acceleration than shaft 3. The shafts 1 and 2 cross at crank shaft position 250°. This timing depends upon the degree of staggering. At this position, shaft 4 is well above and shaft 2 is well below the half lift position. After the crossing, the shafts 1 and 2 are slowed down whilst shaft 3 and 4 continue to accelerate. Shafts 2 and 3 cross each other and so do the shaft 1 and 4 at crank shaft position 270° below and above the half lift position respectively. Finally, sheets 3 and 4 meet crank shaft position 290° and then healds shafts afterwords slowed down so that all the shafts reach the next open shed simultaneously. The distance XY represents the maximum extent of staggering. The angular distance (in this case 20°) through which the crank shaft moves between the successive instants of crossing is called the characteristic **angle of staggering.**

### 2.6.3 Factors to be Considered while Staggering of Healds

The following factors are to be considered in order to obtain the best results with split-shedding :

(a) In order to work the loom with variable staggering tappets, all the heald shafts should be moved individually and spring type top reversing motion should be used.

Rigid and adjustable type heald connections as employed in automatic looms should be used.

(b) Specially designed tappets should be prepared. This requires change of tappets, treadle levers and suitable reversing motions.

)c) When working with four healds, a skip draft (1,3,2,4) or a straight draft (1,2,3,4) can be employed for weaving plain fabrics. Studies carried out by ATIRA (2,3,4) have shown that the straight draft on healds gives significantly lower end breaks than skip draft. This is because the effective separation of threads being enhanced by the physical disposition of the shafts that carry the ends forming a shed line while employing a straight draft.



## 2.7 ASYMMETRIC SHEDDING

The object of the asymmetric shedding, that is, troughing off the shed is to create a tension difference between top and bottom layers of the shed at the time of beat-up. Main advantages of this shedding are :

(i) to improve the cloth cover, that is, equal distribution of warp threads in the fabric;

(ii) to reduce the beat-up tension. This is specially useful for weaving fabrics having area density above 300 g/m².

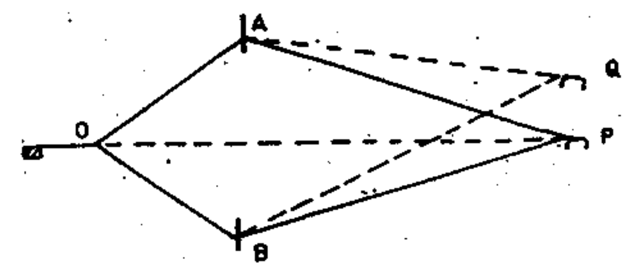
Asymmetry in the shed at the time of beat-up can be obtained by :

(i) raising the back rest (Fig. 2.19);

(ii) raising the cloth fell;

(iii) periodically raising the lease rods; and

(iv) designing tappets to give asymmetry at the time of beat-up.




A = Top shed, B = Bottom shed, C = Fell of cloth; P, Q = Position of back rest

**Fig. 2.19 Troughing the Warp Line**

When the back rest is raised, the hypothetical line of minimum tension moves up. Hence the strain on the top layer in the open shed position is reduced while that in the bottom layer is increased. Thus a differential tension is created in the top and bottom layers and the shed asymmetry is obtained. This method is extensively used to improve the cloth cover. But the extent of asymmetry that can be achieved is very small because of the fact that the back rest position can be varied within a small limit. This is also limited for raising the fell of the cloth or the lease rods.

Shed asymmetry by using shedding tappets (5,6) gives largest scope for varying the extent of shed asymmetry. These types of shedding tappets are extensively useful for weaving fabrics like denim, heavy drills. This is because as shown in the figure the top layer is made slack and the bottom layer is tight. They meet the cloth at an angle and beats the weft against the warp yarns of the slack top layer. The slack top layer would yield for the weft as dictated by the reed whereas the tight bottom layer would retain the weft in position after beat-up. This will give less beat-up tension.

In the case of the heald displacement diagrams with normal tappets shown in Fig. 2.18 the healds start simultaneously to move from both the shed lines at crank shaft position of 150° and at 30° the next shed is fully formed. So, it is observed from the figure that at the time of beat-up a limited extent of shed asymmetry exists even with conventional tappets.

Heald displacement diagram for asymmetry tappet shown in Fig. 2.20 indicates that the top line starts to move down in a simple harmonic motion at 190° and reaches the bottom line position at 10° past beat-up. The bottom line has a dwell period of 240° i.e. upto 250°. It starts to move up again in a simple harmonic motion at 250° and reaches the top line position at 90°. From the Fig. 2.20 it can be seen that at the time of beat-up the bottom line is fully formed but the top line is only partially formed. Thus shed asymmetry is achieved at beat-up. By modifying the heald movement diagram using tappets of different contours, the extent of shed asymmetry can be varied.

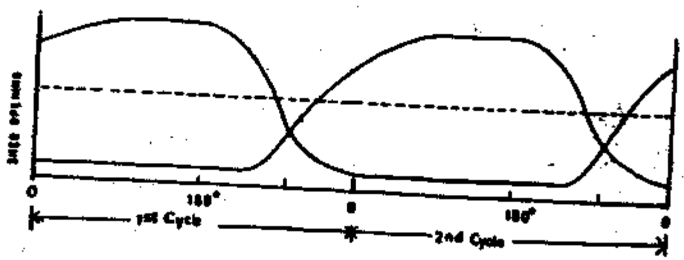



Fig. 2.20 Heald Displacement of Asymmetric Shedding

## 2.8 LEASE RODS

The main use of the lease rods is to keep the warp threads in a given relation to each other so that if a thread breaks its proper place can easily be found out so that it can be avoided from getting crossed with the other threads at the back. They consist of two



wooden rods of different sizes (cross section) generally covered with tin to give smooth surface to the warp and are placed between the back rest and the harness or healds. The larger lease rod is nearer the back rest whereas the smaller is nearer the healds. Their positions require to be carefully regulated to the style of cloth which is being woven. For finely set or rough warps they should be as near to the back heald as the cloth is to the front heald, while for cloths which require to have cover they should be placed a long way back as bringing them near the healds tightens the top shed.

A disadvantage they cause is that they give an uneven tension upon the warp threads when one of the shed opens on to the front rod and the other closes over it. This disadvantage is counter balanced in plain weaving by using four healds, two for each shed and drafting the threads into first, third, second and fourth healds consecutively; so that if the lease is made two-end-two and the healds which carry the threads that are over the front rod are raised a little higher than those which carry the threads that are under it, an even tension will be produced. In addition, the threads will pass each other easier, when the warp is finely set owing to being at slightly different heights. It is practised that the larger rod is placed in the warp an equal distance between the fell of the cloth and the centre heald, the smaller one is about 15 cm apart from the front one. Lease rods are avoided when dropwires are used to detect warp breakages.

## 2.9 BACK REST

The vertical and horizontal position of the back rest influences the shed geometry. As mentioned earlier in sec. 2.5 the raised back rest gives better spreading of warp ends on the face of the fabric. If the back rest is horizontally away from the healds, the tension per unit length of the warp ends is reduced. That is why for silk and filament weaving the back rests are away from the healds as compared to their positions for cotton weaving. BTRA studies (7) have shown the scope for improving productivity and quality by varying the vertical and horizontal positions of the back rest.

For non-automatic looms weaving plain cotton fabric, the back rest is given an oscillating movement by means of a cam on crank shaft through a lever to ease the warp threads during shedding.

## 2.10 EFFECT OF SHED TIMING AND BACK REST SETTINGS ON PROPERTIES OF FABRICS

The effect of loom parameters on properties of fabrics has been studied by a number of research workers. Joshi (8) has made the following observations unless otherwise stated while weaving a plain cotton fabric with 32 epc, 33 ppc, 2/60 Ne warp and 2/60 Ne weft on Northrop Vicker Stafford Loom.

### 2.10.1 Back Rest Position

Raising the back rest to 25 - 50 mm above the normal height reduces the warp crimp, increasing the weft crimp. Lowering of the back rest below the normal height increases the warp crimp decreasing the weft crimp.

Positioning of back rest does not have any effect on breaking strength of fabric. The fabric elongation at break, both warp and weft is affected by a change in the back rest position. It has been found similar trend as that of yarn crimp.

Similar observations have been made by Salam and Natarajan (9).

### 2.10.2 Effect of Shed Timing

Early shed timing has a significant effect on fabric properties, whereas late shed timing has limited effects. When shed timing is changed from normal to early, Joshi (8) found that the warp crimp decreases and weft crimp increases, but the fabric thickness decreases.

Iyer (10) has found that the back rest position has greater influence on thread crimps than shed timing. According to Agarwal (11) both earlier shedding and raised back rest give higher limit of weft packing density however, the former is more effective than the later, when used alone.

Joshi, Salam and Natarajan have observed that the warp way fabric strength is not effected by change in shed timings.

Finally it can be concluded that several secondary factors, e.g. loom settings and timings, affect the relationship between fabric structure and fabric properties.

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# 3 SHUTTLE PICKING AND CHECKING MECHANISMS

## 3.1 FUNCTION OF PICKING

Picking means inserting a weft thread across the warp through the shed during weaving.

After the shedding mechanism opens the warp threads to from a shed, the picking motion comes into play to insert a weft thread (known as a pick) across the warp through the shed. There are different methods of carrying the weft through the shed shown in the Chart 3.1 and each of these will be discussed under separate heading.

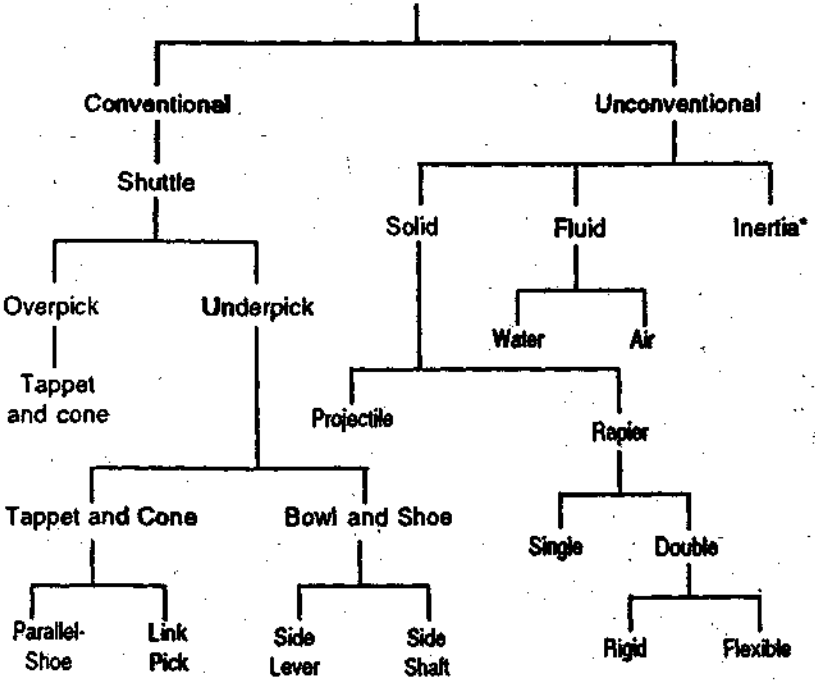



**Chart 3.1 Methods of Weft Insertion**

(* Inertia method of weft insertion is not used in practice.)

However, the earlier method is conventional i.e. wind the weft yarn on to a pirn (or a weft bobbin) and insert this pirn into a wooden shuttle as shown in (Fig. 3.1). Then the shuttle is pushed through the



warp shed from one shuttle box to the other. As the shuttle carries the weft bobbin through the warp shed, the weft thread which is held at the selvedge is drawn from the pirn and is laid across the warp as shown in Fig. 3.2. The interlacing of these picks with the warp ends results in the formation of a cloth. In the case of weft insertion by shuttle there are two main types, namely, the **over picking** and the **under picking**. Here in this chapter conventional picking by means of shuttle is discussed in detail.

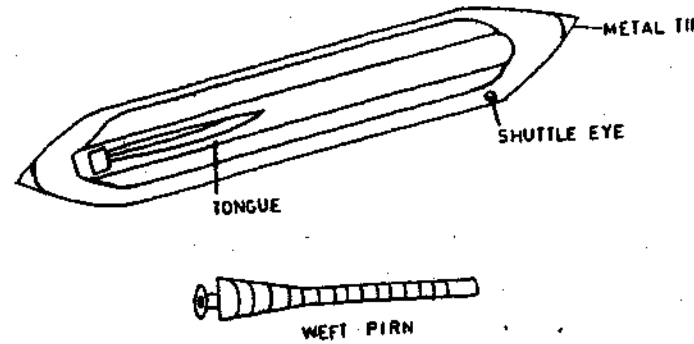



**Fig. 3.1 Non-Automatic Loom Shuttle and Weft Pirn**

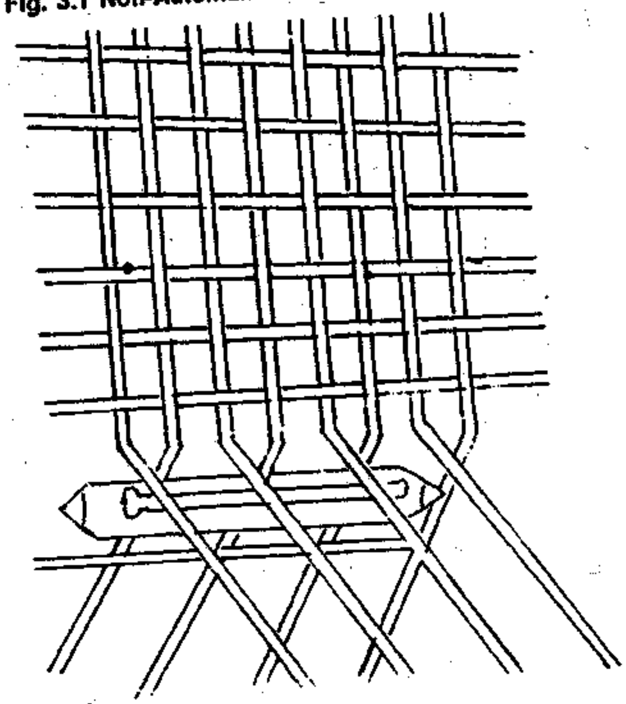
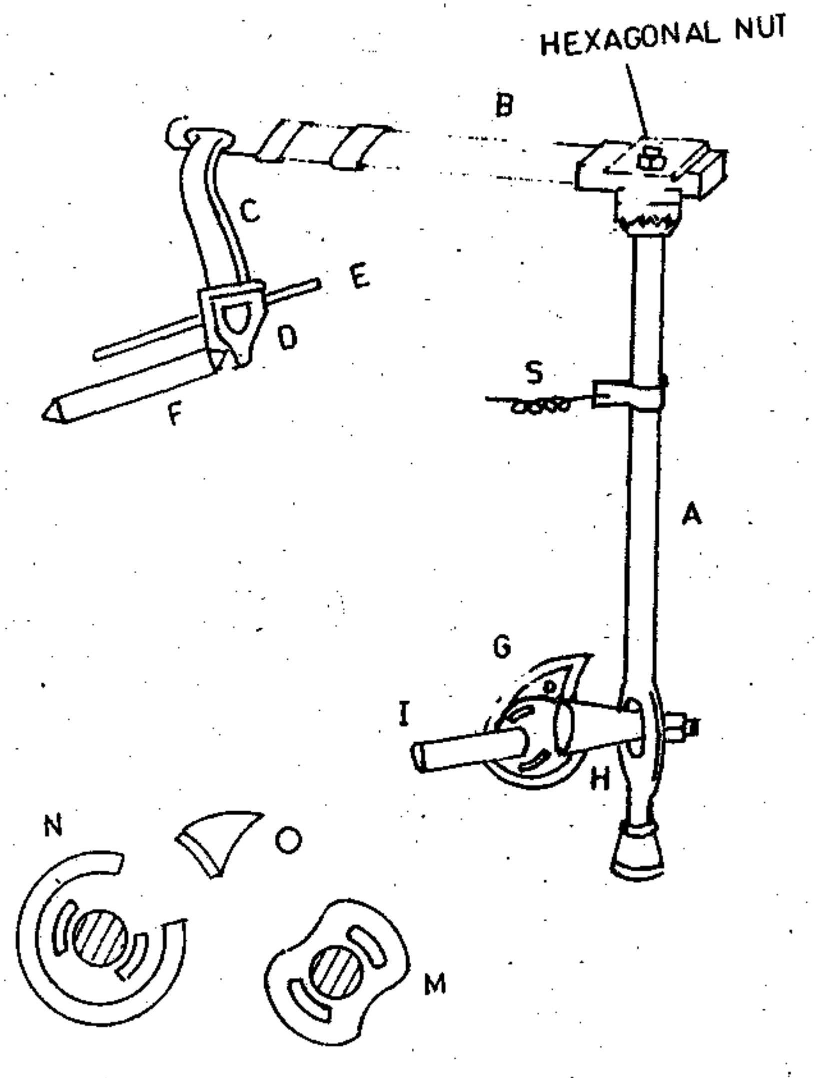


**Fig. 3.2 Weft thread laid across warp**

## 3.2 OVER PICKING

The over picking also known as cone over picking motion, as shown in Fig. 3.3 consists of the following parts :




A = Picking Shaft, B = Picking Stick, C = Picking Strap, D = Picker, E = Spindle, F = Shuttle, G = Picking Tappet, H = Picking Cone, I = Bottom Shaft, S = Spring, M = Boss, N = Shell, O = Nose Bit.

**Fig. 3.3 Cone Over Picking**



(a) Each of the two shuttle boxes, one at each end of the sley to hold the shuttle, consists of a metal spindle A, a picker B, box front D, box back E, box end F, swell spring S, check strap K and a buffer L, as shown in fig. 3.4. The picker which is normally made of raw hide or plastic material runs on the spindle which is secured in place by a spring clip at one end and a spindle stud at the front end.

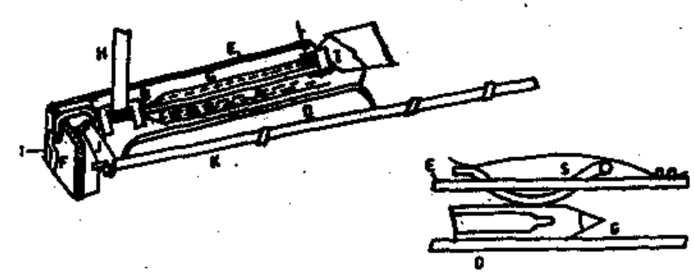
(b) A wooden picking stick B (Fig. 3.3) coupled to the picker D by the picking strap C, is attached to a matel picking shaft A by means of a disc, a stick holder and a cap. All the three parts are locked in position by a hexagonal nut.

(c) A picking tappet G (Fig. 3.3) keyed to the bottom shaft I moves the picking stick A by striking the picking cone which is fixed to the picking shaft.

(d) A spiral spring connected to the picking shaft returns the cone to the surface of the picking tappet after every throw.

(e) The picking tappet is made up of three parts; the boss M, the shell N and the nose bit O. The boss is keyed to the bottom shaft and holds the shell by means of two bolts. Slots are provided in the boss to move the shell to the required position as per the timing of the picking motion. The nose bit which is fixed to the shell can be changed easily whenever it is worn out. The power and the speed of the shuttle flight largely depends upon the length and the shape of the nose bit.

(f) The leather buffer L (Fig. 3.4) is threaded on the spindle between the picker and the spindle stud. The function of the buffer is to prevent the picker from beating up against the metal part of the spindle stud.



A = Spindle, B = Picker, C = Control Strap, D = Box Front, E = Box Back, F = Box End, G = Shuttle, H = Picking Strap, I = Spindle Stud, J = Spindle Strap, K = Check Strap, L = Buffer, S = Swell Spring, T = Flat Spring Clip

**Fig. 3.4 Shuttle Box of a Non-Automatic Over Pick Loom**

(g) Three leather straps, namely, check strap, spindle strap and control strap. The spindle strap and control strap are threaded on the spindle and the check strap is connected to the spindle strap through the adjustable buckles. All these straps are used to ease the impact of the incoming shuttle on the picker. The check strap passes along the entire front of the sley, linking up the two spindle straps. Swell springs are provided at the box back as an additional check for the incoming shuttle (Fig. 3.4).

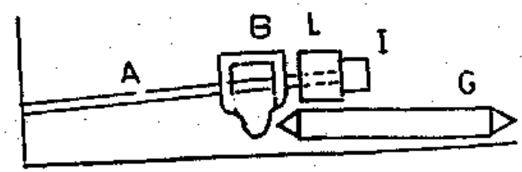
### 3.2.1 Picking Action

The aim of a well designed picking tappet is to move the stick slowly at first, and then to tighten the picking strap and transmit its power to the picker. At this point the blow of the nose bit is given and a short, swift and powerful movement takes place, sufficient to send the shuttle from one box to the other. The greater the speed of the loom the smaller must be the nose bit. A wide slow running loom needs a longer nose bit.

After the shuttle is driven from one box, it passes over the race board and is brought to rest by the action of the spring loaded swell inside the other box and by stretching action of the leather strap, known as check strap. These two actions, picking and checking, of the shuttle consume a large amount of energy, the major part of which is simply dissipated in the form of heat and noise. The research work on the projection of shuttle is immense and this has been reviewed in the next chapter. There are two such picking mechanisms, one on each side of the loom and in the ordinary loom they work alternately (In **pick-at-will** loom, picking can be manipulated to work from either of the side for odd or even number of picks depending upon a weft way design).

#### 3.2.1.1 Setting the over picking mechanism

1. Nose bit and shell are bevelled to coincide with taper of the picking bowl. The inner edge of the nose bit should be about 3 to 5 mm from the thick end of a cone.
2. The picking cone or bowl should always be in contact with the picking tappet.
3. If the cone is below the centre line of the picking tappet, harsh and jerky pick will result.
4. The picking strap should be long enough to allow the picker to move freely on the spindle with the picking stick in its extreme forward position. The clearance between the picker and buffer should be 6 cm or normal four-finger distance when the picker should be comfortably touch against the fingers at the extremity of the stroke.
5. If the picking stick is too much forward the stick is liable to hit the heald frames. On the other hand if the stick is too much far back there is a loss of power of picking because the stick will move forward for some distance without moving the picker. With the loom crank at the top centre the part of stick from where the picking band leaves should be just above spindle axis. When the picking stick has moved three-fourth of its total movement, it should be parallel with loom frame. The picking stick can be moved forward or backward by slackening the nut at the top of the picking shaft and turning the stick holder on the serrated disc.
6. The spindle stud which holds the spindle is set a little higher (about 3 mm) and little outer than the other end of the spindle. This setting will enable the picker during its forward most position, to raise the farthest shuttle tip so that the front tip of the shuttle will be slightly pointing down and towards the reed surface thus avoid the risk of shuttle flying out and causing accident (Fig. 3.5).




A = Spindle, B = Picker, G = Shuttle, I = Spindle Stud, L = Buffer.

**Fig. 3.5 Spindle Setting**

7. The spindle end at the box mouth is set a little forward by 1 mm than the other end so that the shuttle will move in the backward direction, along the reed support.
8. The box mouth is set a little wider about 3 mm than the rear. This can be adjusted by the box fronts.
9. The angle formed between the box backs and the bottom plates should be true to bevel and should correspond with the angle formed by the back and the base of the shuttle (normally 87-90°).
10. The reed and box backs should be in line and the reed should not overface the box backs as this will cause the shuttle to be deflected from its normal course.
11. The weft groove in the box front should coincide with the groove in the shuttle.
12. A broken or poorly fitted picker will cause a weak or erratic throw of the shuttle. It will also cause the weft breaks.

13. The strength of the pick can be increased by :
(i) tightening the picking strap.
(ii) slightly moving the picking stick forward,
(iii) moving the picking tappet nearer to the loom frame, and
(iv) on lowering the height of picking bowl.

### 3.3 UNDER PICKING

With the introduction of automatic looms wherein a full weft pirn is automatically replenished in the shuttle, the cone over picking was found unsuitable. The picking spindle which is placed above the shuttle box comes in the way of automatic pirn changing. Therefore, it was necessary to redesign the picking mechanism. The underpicking mechanism was found to be suitable, not only for automatic looms but also for other types of looms. Oil on the picking spindle is a common cause for oil stains in the woven cloth. So elimination of the spindle was most welcome when over pick mechanism is dispensed with.

There are two main types of underpicking, namely :

(a) Tappet and cone mechanism -
(i) Side shaft - parallel shoe pick (ii) link pick.

(b) Bowl and shoe mechanism -
(i) Side - lever (ii) side - shaft.

#### 3.3.1 Cone Under Pick Mechanism

The important change in this mechanism is the elimination of the picking spindle. The picker is fixed to the picking stick. In some cases it is slotted over the top of the stick and prevented from flying off as it slides along the box by a rib at the box back. However, most of the looms have the picker fixed to the stick.

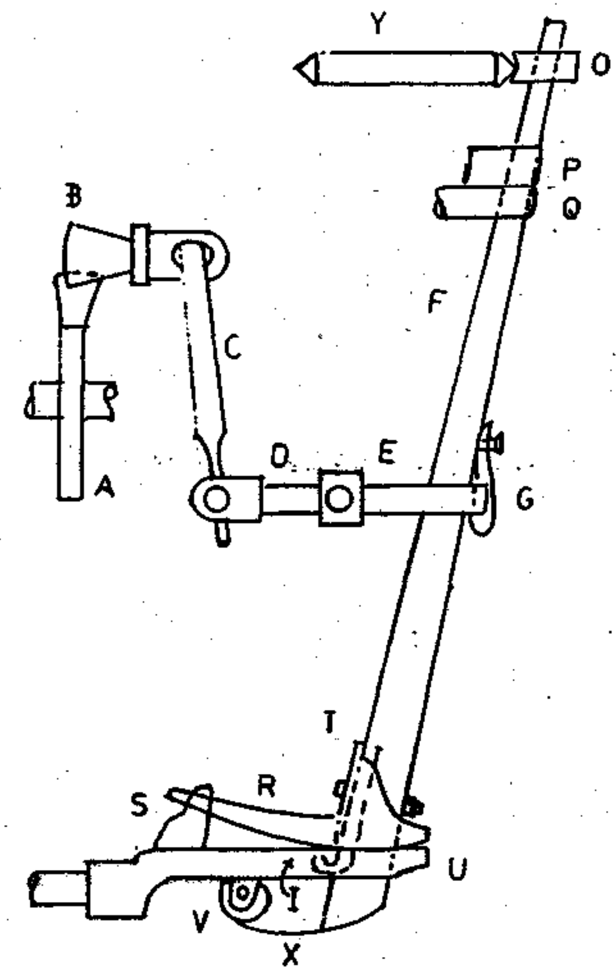
The only main disadvantage of this type of mechanism is the tendency for the shuttle to fly out owing to the downward movement of the fixed picker as it nears the end of its inword movement. The top of the picking stick is moving in an arc of a circle and the downward pressure at the end of the stroke reacts on the tip of the shuttle making the other end to slightly tilt upward, thus causing the shuttle to fly out.

However, this defect has been removed by a device in which the height of the fulcrum at the bottom of the picking stick is varied during the pick so that the picker may follow a horizontal path. Two common methods of achieving this to get substantial horizontal movement of picker are :

(a) **Parallel pick (Fig. 3.6)** : In this method a curved shoe R fixed to the base of the picking stick rides on the parallel plate U fixed to the rocker shaft. A guide piece S fixed on the latter



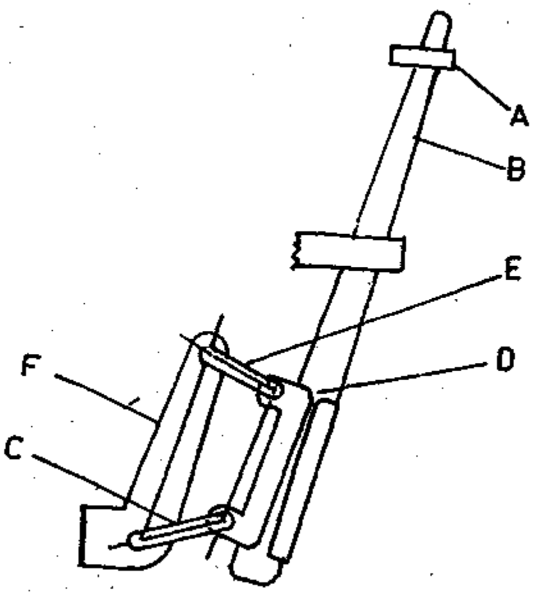
passes through a slot of a plate and prevents the shoe from sliding along or across the plate. Parallel pick motions are widely used, but with the high speed loom, there is a difficulty to maintain the contact between the shoe and the plate. To overcome this problem, link pick method has been developed.




A = Picking Tappet, B = Picking Cone, D & E = Lug Straps, F = Picking Stick, G = Strap, I = Wooden Insert, O = Picker, P = Check Strap, Q = Buffer, R = Rocker or Shoe, S = Guide Piece, T = Metal Sheath,V = Parallel Plate, V = Drum, X = Strap, Y = Shuttle

Fig. 3.6 Cone Under Picking

(b) **Link pick (Fig. 3.7)** : In this method, a 4 bar rocker - rocker link mechanism has been designed to give horizontal




A = Picker, B = Picking Stick, C = Link, D = Clamp, E = Link, F = Bracket

**Fig. 3.7 Link Pick Mechanism**

movement to the picker A with sufficient accuracy. The mechanism consists of two rockers C and E coupled by clamp (coupler) and fixed link (bracket). The link pick gives positive control of the movement of picker and is suitable for high speed looms.

### 3.3.1.1 Parts of cone under pick mechanism

The cone under picking mechanism shown in Fig. 3.6 has the following parts :

1. A picking tappet A is keyed on the tappet shaft. It has an adjustable shell for altering the timing and a removable nose bit that can be changed if necessary.
2. A picking cone B fixed to the short picking shaft c.
3. D and E are lug straps coupling the picking shaft to the picking stick F.
4. The strap G which holds one end of the lug strap E, can be moved up or down the stick; the lug strap is raised if a softer or weaker pick is required.
5. The picking stick F.
6. The rocker (or shoe) R is slotted at the back to receive the



base of the picking stick and forked at the front to encompass a projected guide piece S. It is fixed to the bottom of the stick.

7. A metal sheath T is bolted to the front of the picking stick, with a curved tongue at the base that bears on a wooden insert I.
8. The parallel plate U fixed to the rocking rail at the foot of the sley, has also a slot at the back to receive the base of the picking stick.
9. A coiled spring in the drum V is coupled to the base of the stick by a strap X. This is provided to return the stick after picking.
10. A picker O is screwed firmly to the stick at the top.
11. Check Strap P.
12. Leather buffer Q placed immediately below the check strap, bolted to the loom frame. It limits the forward stroke of the picker. When the loom is started the picking tappet strikes down on the cone and the picking stick moves forward throwing the shuttle into the shed. During this movement of the stick the curved rocker rides on the horizontal parallel plate thus enabling the picker to move in a horizontal plane.

### 3.3.1.2 Settings of cone under pick (Ruti B)

(a) With the picking cam in top most position, the picking bowl must be perfectly aligned laterally with the nose (toe) of the cam.

(b) At bottom centre of the crank shaft, nose is to be verticaly below the centre of the picking bowl.

(c) The length of the picking arm depends on the width of the loom, the number of picks per minute and the weight of the shuttle. For standard weight shuttle, the length of picking arm is as follows :

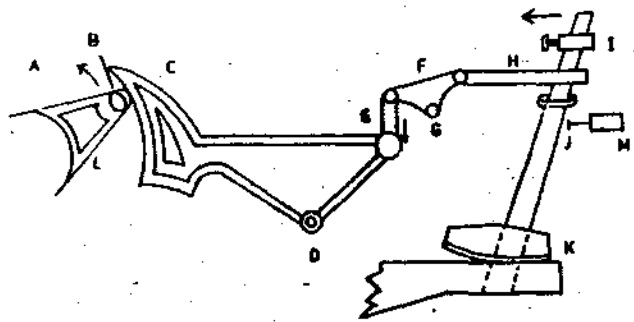
| Width of warp in loom in cm | Picking arm length in mm |
|---|---|
| 100 - 110 | 40 - 45 |
| 150 - 170 | 45 - 50 |
| 190 - 210 | 55 - 60 |

(d) There should be no clearance between the picking arm and the sweep stick. As shown in the Fig. 3.6 in the rear most position of the picking stick (resting on check leather) the clearance between the lug strap and picking stick is to be as small as possible.

(e) In the extreme forward position of the picking stick, there should be a clearance of about 10 mm between the picking stick and the buffer.

(f) The rise of the picker from its rear to its forward position should be 0.5 mm.

### 3.3.2 Picking Mechanism of Lakshmi - Ruti C - Type Loom




A = Picking Cam, B = Picking Bowl, C = Picking Curve, D = Fulcrum, E = Short Lug Strap, F = Triangular Piece, G = Pivot, H = Lug Strap, I = Picker, J = Picking Stick, K = Shoe, L = Bowl Bracket, M = Hydraulic Buffer

**Fig. 3.8 Lakshmi - Ruti - C Picking Motion**

Fig. 3.8 shows the diagrammatic representation of the picking system in which actually the picking bowl B, picking curve C, short lug strap E are in one plane and the others are at right angle to the former. Mounted on the gear wheel A of the bottom shaft is a blow B which strikes the upper face of the picking curve, the shape of which depends on the reed space of the machine and keeps its contact with the bowl during the period of picking. The curve bracket fulcrummed at D moves in the clockwise direction when the other end is depressed to pull the short lug strap E down. This action causes the triangular piece F to move in the clockwise direction giving motion to the picker stick S through lug strap H. The coiled springs at the triangular piece pivot G and picking stickshoe (not shown in the figure) bring back the stick to its original position. Any change in the timing of pick can be affected by the position of bowl bracket by means of slots made in it. Change in the picking force can be altered by the change in the height of the lug strap. A parallel pick is used to give a horizontal motion to the picker I. A hydraulic buffer is used to check the shuttle and the picking sick on the return journey.

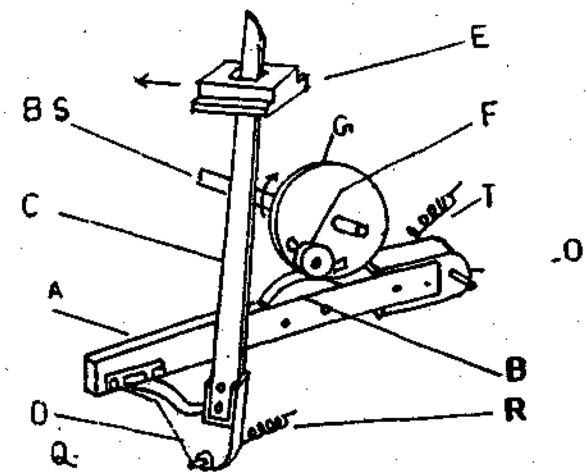
### 3.3.3 Side Lever Under-Pick

The side lever under-pick motion shown in Fig. 3.9 is the simplest under-pick motion which is used for weaving all types of fabrics. All the parts shown in the figure are fitted outside the loom end-frames. It is therefore, easy to maintain the mechanism. The mechanism consists of the following parts :

(a) A wooden side lever A fulcrummed at O.

(b) A picking shoe B fixed on the side lever.






A = Side Lever, B = Picking Cam (Shoe), C = Picking Stick, D = Bracket (Iron Shoe), E = Picker, F = Bowl, G = Disc, O = Fulcrum of Side Lever, Q = Picking Stick Fulcrum, R = Spring, B.S = Bottom Shaft, T = Spring

**Fig. 3.9 Side Lever Under Pick Motion**

(c) A wooden picking stick C fixed to an iron shoe D. The forward end of the side lever is resting on this shoe.

(d) The picker E is loose on the picking stick and is guided between the bottom groove of the shuttle box and a projected part along the top edge of the box.

(e) The side lever is struck down by a bowl F as it revolves with the striking disc G fixed to the bottom shaft. The picking stick fulcrummed at Q is mounted on a casting that is fixed to the rocking rail.

(f) A spiral spring attached at the bottom of the iron shoe D returns the picking stick after each forward stroke.

The picking shoe can be replaced in case of damage or wear. Cleanliness is a decided advantage of this motion because of the absence of the picker spindle and many leather belts.

However, the action is harsher and noisier than that of the cone over pick. The shuttle speed can be increased or decreased by altering the height of the fulcrum of the side lever. Raising the fulcrum position will increase the shuttle speed.

#### 3.3.3.1 Settings of side lever under pick (Cimmco)

(a) Picking starts when the sley is about 60 mm back from the front dead centre (85° crank shaft revolution) and the picking bowl comes in contact with the nose.

(b) Stroke i.e. movement of the picker when the loom is rotated by hand depends upon the width of the loom. Picking mechanism on the off side of the loom is given about 5 cm more movement than to the starting handle side. The length of strokes :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reed space cm | 40 | 44 | 48 | 52 | 56 | 60 | 64 |
| Stroke length cm | 27 | 28 | 28 | 29 | 30 | 31 | 31 |

(c) Picking stick return spring should be just sufficient to bring the stick back after picking.

## 3.4 DISADVANTAGES OF SHUTTLE PICKING

(a) The weft is supplied on a smaller package in order to accommodate in a shuttle. Hence the weft replenishments to be carried out frequently.

(b) Weft unwinding tension varies from 25 cN to 150 cN from full package to almost empty package (this aspect is dealt separately). The high tension at the end of the pirn will, in certain fabrics, cause the selvedges to be pulled in and the picks to be more widely spaced. The reverse effect occurs immediately a full pirn is inserted in the shuttle because the weft tension is low. This variation in case of continuous filament yarn may lead to a fabric defect known as diamond barre.

(c) The power to operate the shuttle during picking is about one-half of that to drive the whole loom and is directly proportional to the cube power of the loom speed. So any increase in loom speed leads to disproportionately large increase in energy consumption. This is an important obstacle to achieve higher loom speeds with fly shuttles.

(d) Difficulty in the design of efficient picking and checking mechanism is experienced because of the gradual change in the weight of the pirn during weaving.

(e) In the case of automatic looms it is necessary to have a pirn or a shuttle changing mechanism for replenishing the weft.

(f) High acceleration (100 - 150g) and retardation (150 - 300 g) of shuttle during picking and checking respectively, tend to disintigrate the weft package, resulting in occasional sloughing off.

(g) Kinetic energy possessed by the shuttle as it leaves the shed is destroyed by friction and impact results in wear and tear of the picker, shuttle etc. and heat generation.



(h) In the case of multicolour weft insertion there is the necessity of a multiple box motion. This will again limit the speed of the loom.

(i) There is the danger of shuttle flying out and causing serious injury to the person nearby.

(j) In a large weave-room fitted with shuttle looms the noise level may be as high as 105 dB. Such a high noise level is undesirable and causes temporary deafness and impedes communication between those who are working. Table 3.1 shows the damage risk percentage of workers exposed to sound level of 85 dB or more.

**Table 3.1 Damage Risk Criteria**

| Equivalent Continuous Sound Level (dB) | Risk percentage Years of exposure (Age 18 yrs.)* | | | |
|---|---|---|---|---|
| | 10 | 20 | 30 | 40 |
| 85 | 3 | 6 | 8 | 10 |
| 90 | 10 | 16 | 18 | 21 |
| 95 | 17 | 28 | 31 | 29 |
| 100 | 29 | 42 | 44 | 41 |

* A 40 - hour week with 50 weeks per year.

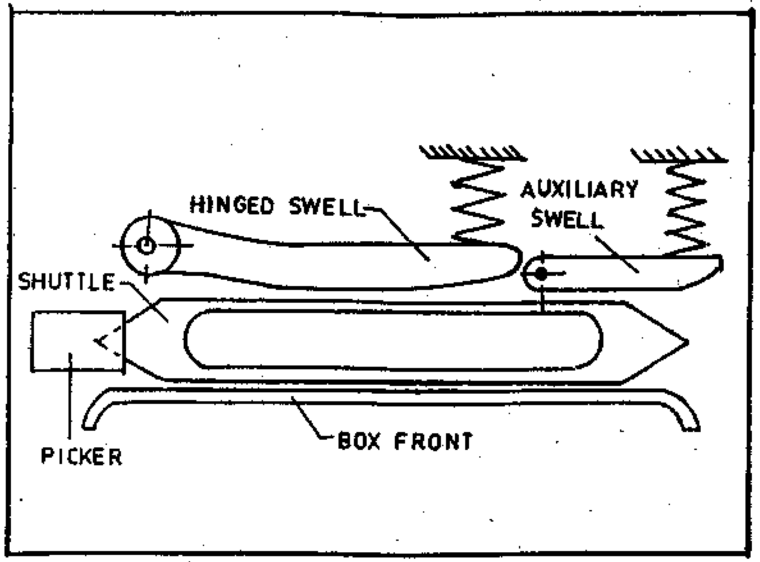
## 3.5 SHUTTLE BOX AND SHUTTLE - CHECKING DEVICE

The shuttle box shown in Fig. 3.4 is seen on cone over picking loom. The picker B runs on a picker spindle A which is screwed in place by means of a flat spring clip T at the box end. The other end of the spindle is held by a spindle stud I. The picker is connected to the picking stick by a strap H. A buffer L composed of several pieces of leather, is threaded on the spindle between the picker and spindle stud. It prevents the picker during its forward movement from beating up against the solid steel stud.

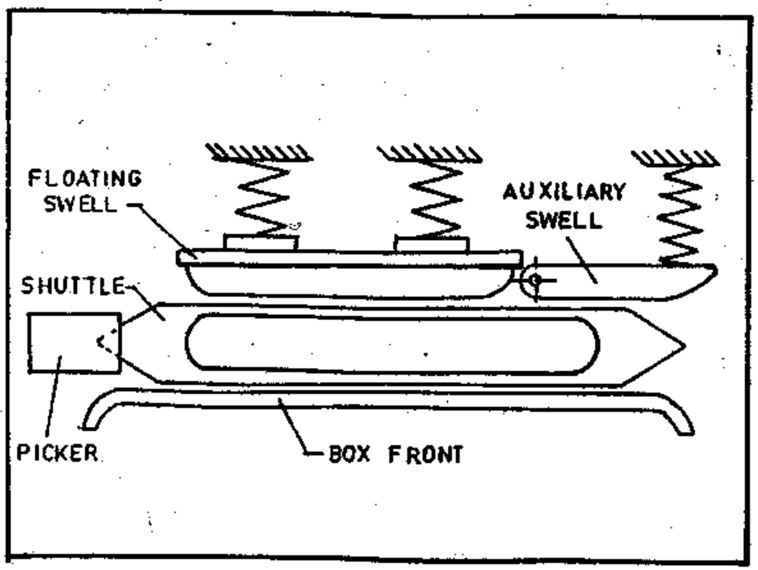
The other two important parts in the shuttle box are :

(a) Check Strap; and (b) Swell.

The function of these parts is to act as checking devices for the incoming shuttle. The shuttle which has been pushed by the picking mechanism from the opposite end, has to be decelerated within a short distance. This is only possible by effective checking device. Immediately the shuttle enters into the box it strikes against the swell which is placed in the back of the box, fulcrummed at one end and kept projected through the gap in the box back by means of springs as shown in Fig. 3.10 a. The effectiveness of hinged swells is low, that is why they are not suitable for high speed shuttle looms. For such looms, floating swells as shown in Fig. 3.10 b are used. These aspects are discussed in detail in the next chapter. The frictional force between the shuttle




(a)




(b)

**Fig. 3.10 Swell Motion**



back and the swell reduces the shuttle speed but the final breaking action is obtained when the shuttle strikes the picker. However, the inertia of the picker alone is insufficient to produce the necessary retardation to the shuttle and some additional means of absorbing the residual energy of the shuttle are required. This is provided by the check strap K which consists of two additional straps, namely spindle strap J and control strap C.

The check strap passes along the entire front of the sley, linking up with a similar arrangement at the other end. It is therefore, seen that the check strap eases the impact of the shuttle on the picker.

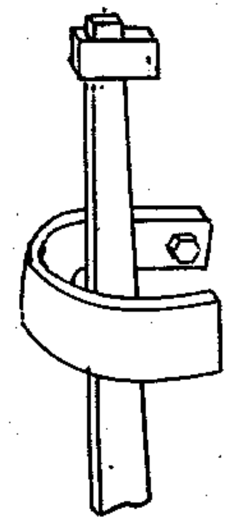


**Fig. 3.11 Check Strap for Under Pick Loom**

In the case of underpicking motion where the picker is fixed to the picking stick a check strap shown in Fig. 3.11 is provided as a restraining device. In addition, a buffer, spring loaded, hydraulic or pneumatic is provided. In the case of hydraulic and pneumatic buffers a plunger is displaced by the picking stick (Fig. 3.8).

In some of the modern looms a swell easing motion is used instead of ordinary swells. The function of this swell easing motion is that it reduces the pressure of the swell on the shuttle back when the shuttle is ready to be pushed inside the warp shed, thus saving a great amount of power in picking. Swell easing motion consists of a L - shaped lever controlled by a pin on the crank arm. Research work carried out with these types of swell is discussed in the next chapter.

# 4 ADVANCED STUDY OF SHUTTLE PICKING AND CHECKING MECHANISMS

## 4.1 ESSENTIAL FEATURES OF A GOOD PICKING

In the last chapter different mechanisms used to propel a shuttle have been described. Many forces are acting simultaneously or successively, which tend to make the movement of a shuttle a complex one. Before discussing the complexity of picking mechanisms, the features (1) that are considered essential to an ideal picking of shuttle are enumerated as follows :

1. The weight of a shuttle and the time taken to move it are of greatest importance. Only sufficient force to pass a shuttle across a warp in the time allotted should be employed to reduce the consumption of power and the momentum of a shuttle on entering a box.
2. Kinetic energy in the picking mechanism should remain constant, irrespective of fluctuations in the speed of loom and variation in the weight of shuttle.
3. A shuttle should begin to move slowly, develop a speed until it reaches the middle of the sley centre and from the centre to the opposite side a corresponding decrease should take place. This will give low and uniform acceleration and retardation values.
4. A shuttle should be under complete control throughout its movement and that the shuttle and loom should be capable of starting and stopping together, whether the shuttle is in or out of the warp.
5. The picking and checking mechanism should be integrated so that the kinetic energy of the shuttle as it enters a box can be utilized in the subsequent picking thus reducing the energy required for picking instead of dissipating in the form of heat and noise generation.

The shuttle picking motions now in use do not fulfil the above mentioned conditions because of economical reasons and the other complexities in the shuttle propulsion as discussed below.



## 4.2 COMPLEXITIES OF SHUTTLE PROPULSION

1. A shuttle weighting about half a kilogram is used to insert a weft yarn weighing only a few grammes. This is necessary to overcome the resistance of drawing the weft for the shuttle as well as to reduce the risk of shuttle flying out.
2. Since a shuttle leaves a line of weft behind each time it moves across a loom, a constant diminution of weight and energy occurs until the shuttle is empty.
3. During the traverse of a shuttle through the shed, it does not move in a straight line but follows a complex path in all the three co-ordinates with the motion of sley. As the sley moves from the bottom centre to back centre, the shuttle travels across, moving back and falling with the sley. At the back centre of the sley where a slight pause of sley takes place for the reasons given in chapter 5, the shuttle simply continues to move across the loom. Between the back centre and the top centre, the shuttle moves up and forward with the sley until it finally reaches the opposite shuttle box.
4. The centre of gravity in a shuttle does not occupy a fixed position but is constantly changing. If a shuttle is loaded with its centre of gravity is at the centre of the mass, every time it moves across the warp, the point recedes in proportion to the weight of weft drawn away, because the weft is pulled from the forward end of a pirn. If the line of force does not pass through the centre of gravity, then the shuttle has a tendency to revolve. In practice, rotation is checked by the reed and race board. The shuttle tips are fixed to the shuttle nearer the top and the front than that at the back and base of a shuttle. By this the line of force will be above and before the centre of gravity so that the pressure is exerted against the reed and race board.
5. There is a variation in loom speed (Section 4.8) resulting in variation in the picking force.
6. There is variation in the rest position of the shuttle (section 4.10.2) due to ineffectiveness of the shuttle checking mechanism. This also results in variation of shuttle speed from pick to pick.
7. Because of the asymmetric position of the shuttle, a side way pull of varying intensity is exerted depending upon the direction of movement of shuttle.
8. The shuttle is accelerated from rest to a speed of 10-15 m/s in a distance of only 15-20 cm.

Considerable research work has been carried out to deal with the problem of shuttle propulsion. The basic mathematical theory of shuttle propulsion was first investigated by Vincent (2) and later that work was extended by Vincent and Catlow (3). Earlier, Hanton (4) used graphical mehods to determine the velocity and acceleration of shuttle during propulsion. Thomas and Vincent (5) carried out experimental studies and compared their results with those obtained from the Vincent's theory with a view to give, the loom designer a sound footing to optimize the design parameters of a picking mechanism. What follows in this chapter are the excerpts of research work carried out by Vincent, Thomas, Catlow and others to understand the complexities of the picking mechanism.

## 4.3 FACTORS AFFECTING THE INITIAL SPEED OF SHUTTLE

Initial shuttle speed is the velocity of a shuttle at the instant it leaves the picker and starts its free flight. This velocity is very important for satisfactory working of the loom. The initial speed of shuttle is almost equal to the average shuttle speed unless the movement of shuttle is seriously impeded by the top shed. The factors which influence the initial speed of shuttle are discussed below with reference to most lucid and comprehensive work by Thomas and Vincent (5).

(a) **Shape of picking tappet**

The shape of the picking tappet in contact with the picking bowl is the primary factor controlling the shuttle speed at a given loom speed. This can be specified in terms of relation between the nominal displacement of shuttle (refer next section) and the rotation of the crank shaft. Higher the nominal movement of a picker more is the strength of picking. Dots are often punched on the picking nose to indicate the strength of picking; higher the number of dots, more is the strength of picking.

(b) **Loom speed**

As the loom speed increases the initial shuttle velosity also increases but is not strictly proportional to the loom speed. This means that the relative shuttle speed which is the ratio between the shuttle speed and loom speed decreases as the loom speed increases. This is due to deflection of picking device under dynamic condition.

(c) **Timing of pick**

There is a tendency for a later timing to give a higher loom speed. Hamed and Lord (6) established a correlation relatng time of departure of shuttle with its velocity; in most cases the strong picks are late and the weak ones are early, as shown in Fig. 4.1, because of the following reasons :



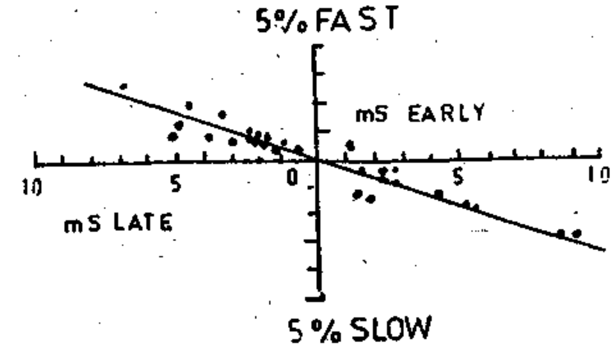



**Fig. 4.1 Relation Between Picking Timing and Shuttle Speed**

(i) A variation in the position of lug strap relative to the picking stick.

(ii) The picking mechanism might be having different amount of strain energy at the commencement of each pick due to inefficiency of the checking mechanism.

(iii) Torsional vibration of bottom shaft during normal running of the loom caused to change the position of picking tappet with respect to picking bowl thus altering the timings.

(d) **Length of the picking band**

A change in the length of picking band of an over pick loom produces a double effect. It alters the timing of the pick and also the position of a nose bit with respect to the bowl at which the picking band is taut. Shortening of the picking band and making no other alterations lead to a marked increase in shuttle speed. This is a common method adopted in the industry to increase the picking force. However, the students must note that the change in the length of picking band can be nullified by a corresponding change in the position of a nose bit with respect to bowl .

(e) **Swell resistance**

Changes in the swell pressure affect the initial speed of the shuttle in two ways :

(i) Direct effect resulting from changes in the resistance offered to the shuttle during propulsion.

(ii) Indirect effect resulting from the variation in the position of the shuttle at rest.

Thomas and Vincent have found that when the shuttle is inserted manually to nullify the variation of rest position of shuttle, an increase in swell pressure increases the initial shuttle speed marginally. The explanation is that the picking mechanism is placed under strain by swell resistance, and when this strain diminishes suddenly there remains an unbalanced force which is available for accelerating the shuttle. However under normal working condition of a loom, with an increase in swell pressure, there is a corresponding decrease in the initial shuttle velocity becasue of variation in position of the shuttle at rest in the shuttle box (7).

**(f) Mass of the shuttle**

The effect of mass of shuttle on the shuttle velocity is insignificant. However, it has been observed that with higher mass, there is a tendency to late picking.

**(g) Height of picking bowl**

Raising the picking bowl of an overpick loom within the limits set up by the makers (1-3 cm) reduces the shuttle speed.

**(h) Distance of picking tappet from the picking shaft**

Shuttle speed is inversely proportional to the distance of picking tappet to the picking shaft. As the distance reduces, there will be a larger increase in the angular movement of the picking shaft.

**(i) Position of buffer**

No significant effect is found as long as it does not interfere with the picking.

**(j) Initial gap between picker and shuttle**

With sandard nose bit the fall in shuttle velocity is considerable when the initial gap exceeds 2.5. cm.

## 4.4 NOMINAL MOVEMENT OF SHUTTLE

The nominal movement of the shuttle, as defined by Vincent (2) is the position of the shuttle for a given crank position occupied by the shuttle when the loom is turned over slowly by hand. Thus profile of the cam gives the nominal movement when all the flexible parts of picking mechanisam are rigid. Thus nominal movement of the shuttle is same as that under static condition. Tappets are designed with different types of nominal movements.

Linear cam, $S = p\theta$

Parabolic cam, $S = q\theta^2$

Polynomial cam, $S = p + q\theta + r\theta^2$

Where S = Nominal movement of shuttle and picker.

$\theta$ = Angular rotation of crank shaft in degrees.

p, q, r = Constants.



The nominal movement of the shuttle differs from the actual movement, because under the latter condition the mechanism is not stiff and deflections of the flexible parts of the mechanism e.g. picking stick, picking strap, bottom shaft etc., take place. For example, for a linear cam the maximum velocity of a shuttle is twice that of under nominal condition. The actual displacement of shuttle can be calculaed by using Vincent's Theory.

## 4.5 THEORY OF PICKING

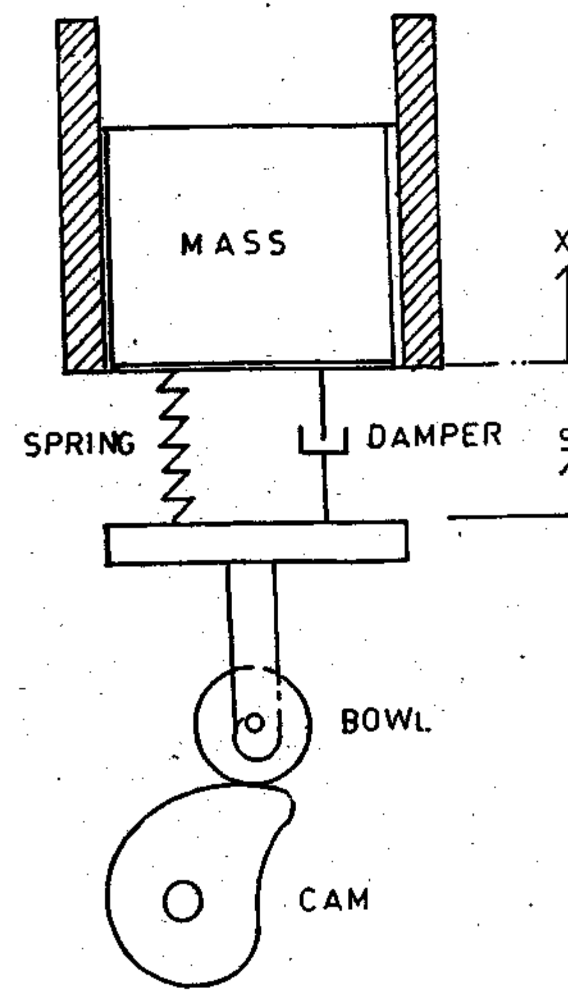



**Fig. 4.2. Spring Mass System**

Vincent (2) represented the picking mechanism by a simple system as shown in Fig. 4.2 which consists of a weight M lying on a smooth plane with one end attached to a spring having a stiffness λ. For simplicity, he has ignored damping.

Force = $\lambda$ (S – X)..........(4.1)

Force = MX"..........(4.2)

So, MX" = $\lambda$ (S – X)..........(4.3)

Where, M = Mass of shuttle and picker

X" = Actual acceleration of the shuttle

X = Actual displcement of the shuttle

$\lambda$ = Stiffness of the system.

S = Nominal movement of the shuttle i.e. function of $\theta$ depending upon the shape of picking cam.

$\theta$ = Angle in radians through which the crank shaft has rotated since the movement of the shuttle began.

Eq (4.3) can be written as : X" = ($\lambda$ / M) (S – X)..........(4.4)

or X" = $n^2$ (S – X)..........(4.5)

Where n = $(\lambda / M)^{1/2}$

The quantity n expressed in number per sec may conveniently be expressed as alacrity of the system (The form was orginally suggested by Dr. P. S. H. Henry of Shirley Institute, Manchester). Alacrity is a term which expresses the degree of rapidity with which a shuttle responds to the picking stick. It is related to the natural frequency of the picking mechanism. The alacrity of the two side of the loom is not same because on the off side of the loom considerable bending and torsion of the bottom shaft take place. Due to this profile of cam on one side has to be different from the other side so that the picking force from the two ends can be matched. That is why stroke length of picking stick on the off side of the Cimmco underpick loom is more.

The equation (4.5) is a differential equation which can be solved as shown in Appendix-II to get the equations of motions for displacement, velocity and acceleration. Equations of motions for linear and parabolic cams are as follows.

### 4.5.1 Linear Cam

Linear cam having a nominal movement of S = p$\omega$t has a constant nominal velocity and found on cotton and rayon looms. Equation (4.5) for linear cam can be expressed as :

X" = $n^2$ (p$\theta$ – X) = $n^2$ (p$\omega$t – X)..........(4.6)

Where, $\omega$ = Angular acceleration of crank shaft ; t = time



The equation (4.6) is solved (Appendix-II) considering the initial condition X, X' = 0 at = 0 to get the following equations of motion.

**Under nominal condition,**

Displacement S = p$\omega$t..........(4.7)

Velocity S' = p$\omega$..........(4.8)

Acceleration S" = 0..........(4.9)

**Under actual condition,**

Displacement X = p$\omega$ (t – Sin nt / n)..........(4.10)

Velocity X' = p$\omega$ (1 – Cos nt)..........(4.11)

Acceleration X" = p$\omega$n Sin nt..........(4.12)

Equation (4.11) indicates that maximum velocity of 2p$\omega$ which is double of the nominal velociy p$\omega$ [Eq. 4.8] takes place at time t = $\pi$ / n. The displacement of picker when the shuttle leaves, that is, stroke of picker, is $\pi$ p$\omega$ / n.

The maximum acceleration of p$\omega$n occurs after a time of $\pi$/2n i.e. half way through the acceleration period. From the above equations, there are two points of interest :

a) The total time for the movement cannot exceed a very small quantity $\pi$/n, so as large volume of the maximum acceleration takes place automatically and makes it impossible to use the whole of the distance available in the shuttle box for its movement. Because of these limitations, this type of cam is not suitable for high speed looms.

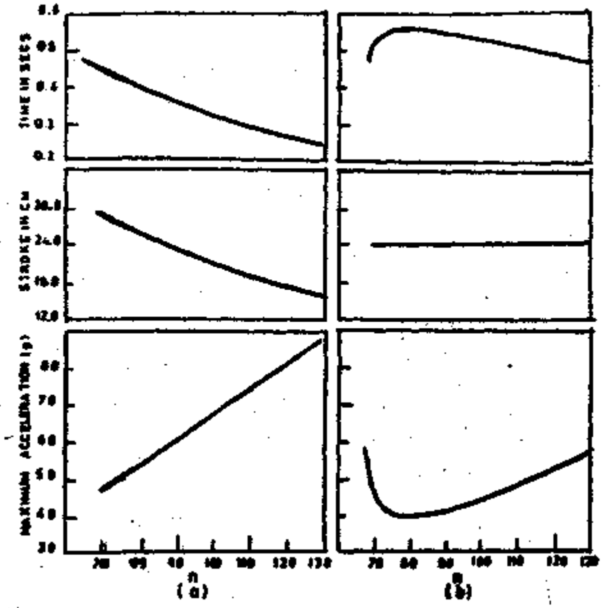
b) Although the movement of the shuttle may persist for a period longer than $\pi$/n, but it has no further effect on the shuttle speed.

Catlow found out the relation beween the maximum acceleration and alacrity (Fig. 4.3). Low value of maximum acceleration takes place from a low alacrity and a long stroke.

So, the best results with a linear cam can be obtained when the mechanism is relatively elastic (i.e. a low value of alacrity) and the stroke operating over most of the distance is available in the shuttle box.

### 4.5.2 Parabolic Cam

Parabolic cam (S = q $\theta^2$) is having a constant nominal acceleration and is used on many cotton and rayon looms combined with a linear movement [i.e. S = p$\theta$ + q$\theta^2$]. Equations of motions of this cam under nominal and actual conditions are as follows :



a) $S = p\theta$ movement, b) $S = q\,\theta^2$ movement

**Fig. 4.3. Influence of the Alacrity on the Main Movement Characteristics.**

**Under nominal condition**

| | | |
|---|---|---|
| Displacement | $S$ | $= q\omega^2 t^2$ ............(4.13) |
| Velocity | $S'$ | $= 2q\omega^2 t$ ............(4.14) |
| Acceleration | $S''$ | $= 2q\omega^2$ ............(4.15) |

**Under actual condition**

| | | |
|---|---|---|
| Displacement, | $X$ | $= q\omega^2 [\, t^2 - 2\,(1 - \text{Cos}\; nt / n^2)\,]$ ............(4.16) |
| Velocity | $X'$ | $= 2q\omega^2\,(t - \text{Sin}\; nt / n)$ ............(4.17) |
| Acceleration | $X''$ | $= 2q\omega^2\,(1 - \text{Cos}\; nt)$ ............(4.18) |

With this movement, the acceleration $X''$ is never negative since $0 \leq (1 - \text{Cos}\; nt) \leq 2$. The actual velocity $X'$ has no maximum value but continues to increase as long as the cam operates. The actual acceleration reaches a maximum value of $4q\omega^2$ after a time lapse of $\pi/n$. Fig. 4.3 indicates that the maximum value of acceleration with parabolic cam is comparatively lower than that of linear cam under similar conditions. The alacrity of the system has no effect with stroke of the system as with the former cam (Fig. 4.3b). Maximum value of accleration is about 60g and falls to a minimum



value of about 40g when, $n = 80\ s^{-1}$. Catlow and Vincent (8) theoretically investigated several alternative forms of nominal movement with the objective to minimize the maximum accelerating force consistent with a particular projection velocity. They showed theoretical optimum conditions are achieved with a curve giving actual acceleration in a sinusoidal movement $X'' = A\ \text{Sin}\ Kt.$, where, A is the maximum acceleration and K is a constant controlling the time. Catlow (9) selected the most promising one for further investigation. By working on this it was found that a polynominal cam in the form of $S = p\theta + q\theta^2 + r\theta^3$ gives a much closer approach to uniform acceleration. These types of cams are now-a-days used for cone-under pick mechanism.

## 4.6 EXPERIMENTAL STUDIES OF SHUTTLE PROPULSION

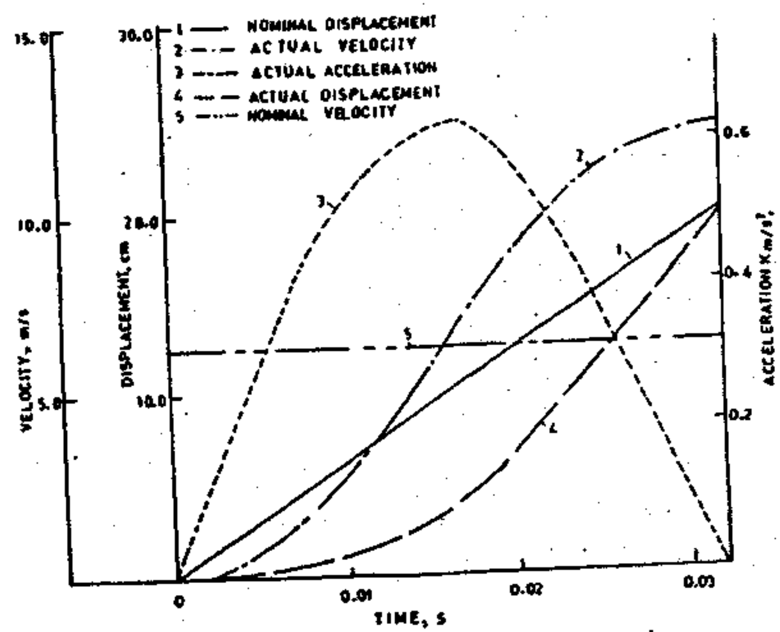



**Fig. 4.4 Nominal and Actual Movements of a Shuttle**

Thomas and Vincent used optical method to plot the displacement of the shuttle during picking and checking with respect to the angular position of crank shaft and a time scale with the loom running at full speed confirms the validity of Vincent's theory of shuttle propulsion. Results shown in Fig. 4.4 show that for a linear cam the actual and nominal positions of the shuttle are coincided initially, reached a maximum separation of 7.5 cm after 0.0152s i.e. $\pi / 2n$ s where, n is the alacrity and coincided again at 0.0305s i.e. $\pi / 2n$ s at which the maximum shuttle speed is attained.

Initially the rate of movement of shuttle is very slow, when the maximum acceleration has taken place, the shuttle has moved only about 20% of its acceleration stroke. This lagging is due to the deflection of the flexible parts of the picking mechanism. These deflections cause strain energy to be stored in the system prior to the flight of shuttle. Some of the strain energy is transferred into the shuttle giving a higher velocity than that under nominal condition. Thus, the picking takes place in two stages.

(a) In the first stage of shuttle acceleration from 0 to $\pi/2n$ s stresses and strains are built up in the picking mechanism- the picking band or lug strap stretches, then the picking stick bends, and the bottom shaft twists. This is because the picker is trying to move more quickly than the shuttle.

(b) In the second stage of shuttle acceleration ($\pi/2n$ to $\pi/n$ s) the stresses and strains diminish and eventually disappear when the shuttle leaves the picker and the nominal and actual displacement curves cross at $\pi/n$ s.

Thomas (5) compared the second stage of the picking to a catapult in which the projectile represents the shuttle, the leather part of the catapult represents the picker and the rubber band represents the flexible parts of the picking mechanism. When the rubber band is stretched, and released, the force due to stretch causes the leather and the projectile to gain speed until the missile is projected and the rubber band becomes slack. In the case of picking system, the fully stretched rubber band corresponds to the positions of maximum lag at $\pi/2n$ s.

A study of the nominal and actual movements of a shuttle gives a better understanding of the behaviour of the picking mechanism. For a loom designer this is very important, although it does not have immediate practical application in the weaving shed. The true behaviour of the shuttle and the theoretical values obtained by Vincent's Equation may show some discrepancies (7, 10) because of the following aspects that have not been considered in the equation.

(i) Resistance offered due to swell pressure is not considered and it also ignores the gap between the shuttle and picker, if any.

(ii) The impact force and jump condition are not taken into account in the theory. Jump phenomenon is the separation between the picking bowl and picking tappet after the initial contact.

(iii) Stiffness of the system measured under the static condition and mass of the picker and the shuttle used in the theory does not represent the actual condition.



(iv) It is assumed that bottom shaft continues to rotate at a constant speed during propulsion but in practice it varies considerably. This aspect has been discussed later on. Later Catlow (2) improved the simple theory of Vincent by taking into account the variation in bottom shaft speed during picking.

## 4.7 STRAIN ON THE PICKING STICK DURING PICKING

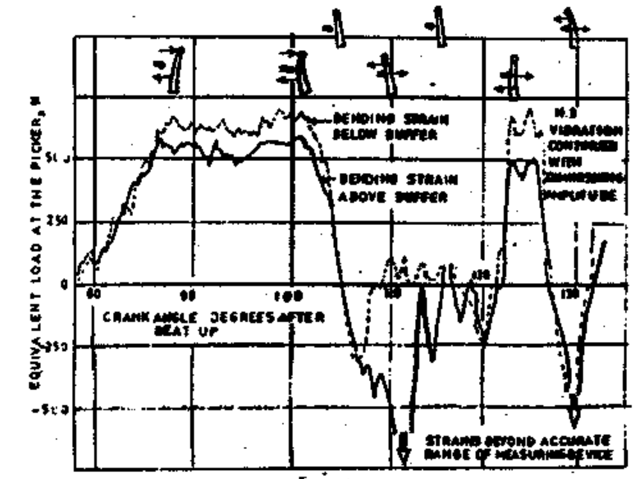



Fig. 4.5 Strain on the Picking Stick during Propulsion of a Shuttle

Strain on the picking stick can be measured by using strain gauges and photo elastic techniques (8,10). Strain is maximum at the fulcrum and minimum at the free end of stick; that is why cross-section of free end of the stick can be reduced without any danger of over stressing during acceleration period. Maximum stress is not during acceleration of shuttle but during checking of picking stick when it collides against buffer as shown in Fig. 4.5. According to Lord (10) following the first collusion the stick bounces away from the buffer, reverses its direction of movement so as to move towards the cloth selvedge, makes a second collusion with buffer and then returns to its rest position. Because of the movement of sley, this double blow gives double markings in case of an underpick loom on the picking stick buffer. These various blows set up considerable bending, torsional and longitudinal vibrations in the system which create considerable noise.

## 4.8 VARIATION OF LOOM SPEED DURING PICKING

Measurement of cyclic fluctuation in loom speed during each revolution of the crank shaft indicated considerable variation especially during picking. Lord and Mohammed (11) have measured the instantaneous speed using a loom phase meter consisting of a seismic disc which has been running at an instant rotational speed equal to the average loom speed, and the angular displacement of the main shaft has been also measured. The differenciation of the curves derived from this gives the variations in loom speed. It has been found that the variations are irregular and do not repeat exactly. They show that though the overall variation is mainly due to the oscillation of the sley, the picking mechanism also affects the overall pattern. Not only energy is extracted from the system but some of this is later returned by some means or the other as shown in Fig 4.6. This is much more prominent when the shuttle is propelled from the off-side of the loom. By progressive disconnections of various mechanisms, the coefficient of irregularity of crank shaft as found by Lord and Mohammed (11) is shown in Table 4.1. Coeff. of irregularity = (Maximum speed – Minimum speed) / Maximum speed.

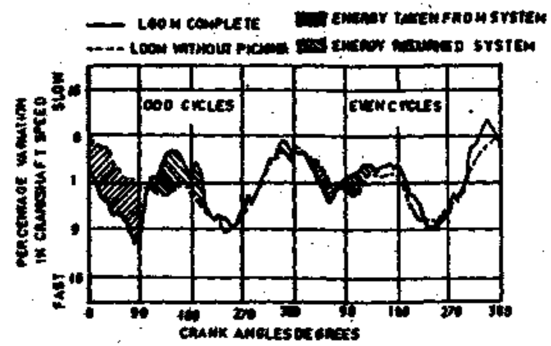


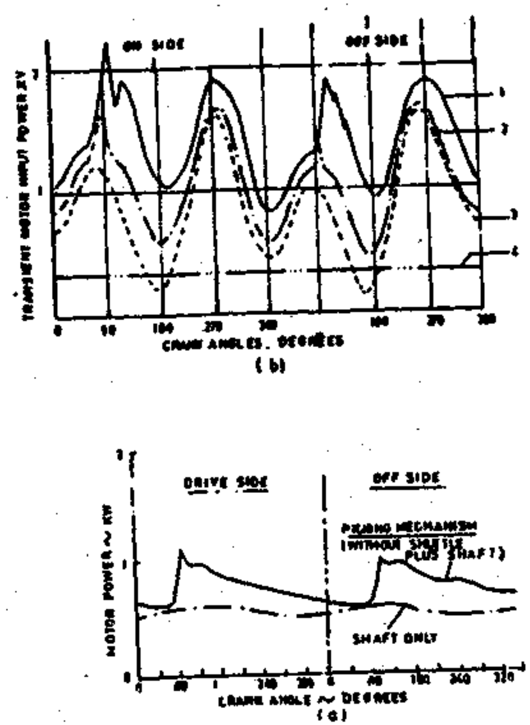

**Fig. 4.6 Variation in Loom Speed for the Complete Loom and without Picking Mechanism**

**Table - 4.1 Variation of Loom Speed**

| Loom state | % Coeff. of irregularity of crank shaft | | |
|---|---|---|---|
| | Picking from | | Mean speed |
| | On side | Off side | (rpm) |
| Loom Complete | 23.6 | 24.6 | 154 |
| Loom without picking mechanism | 19.4 | 17.2 | 158 |
| Loom with shafts only | 4.4 | 4.0 | 162 |



## 4.9 POWER CONSUMPTION DURING PICKING




1 = Complete Loom, 2 = Loom without shuttle, 3 = Loom without picking mechanism 4 = Motor and fly wheel

**Fig. 4.7 Variation in Input Power to the Loom Driving Motor**

Mohammed (11) has measured the instantaneous power on a loom by using Hall effect device. It is a semiconductor magnetic circuit which accepts two input electrical currents and produces an output voltage in proportional to the input voltages and currents to the loom. So the output of the multiplier is proportional to the electrical power supplied to the loom. The output is fed to a UV recorder. Fig. 4.7. shows that the majority of the sinusoidal variation is found to arise due to the reciprocating motion of the heavy sley and a considerable amount of power is dissipated in this way. The picking mechanism cause there sharp peaks. When the shuttle is added, both the magnitudes of the peaks and general level of power are considerably increased. There are differences in shapes of the curves as the shuttle is travelling from the on-side to the off-side and vice versa. The curve relating to shuttle travelling from on side to the off side indicates a tendency for a double pick whereas the other one shows a multitude of pulses.

The effect of picking alone is shown in Fig. 4.7, where the length of time needed for the loom to recover from a pick is also shown. The continuing oscillation noted when picking from off-side is because of bending, torsional and longitudinal vibrations of the bottom shaft.

## 4.10 SHUTTLE CHECKING

### 4.10.1 Ideal Shuttle Checking

The four conditions that an ideal checking system should fulfil are (5, 7)

(i) The shuttle should come to rest in contact with the picker at the same position in the shuttle-box after each pick.

(ii) The maximum value of retardation should be kept as small as possible.

(iii) There should be a certain amount of impact between the shuttle and the picker but that should be as small as possible.

(iv) Kinetic energy of shuttle entering the shuttle box should be conserved.

The first condition aims at ensuring the shuttle velocity on the following pick to have constant value. In addition on automatic looms, it also aims to reduce the length of yarn left on ejected pirns.

The second condition aims at avoiding sloughing off the weft package.

The third condition aims at preventing the intial gap between the shuttle and the picker, to have a uniform shuttle velocity on the subsequent pick as well as to reduce the heat generation, noise level and wear and tear of the picker and checkstrap.

The fourth condition aims to reduce the power consumption by utilising the conserved energy during picking.

It is shown later that conventional swells hardly fulfils the above conditions.

### 4.10.2 Movement of Shuttle during Checking

A systematic study of shuttle checking was carried out by Thomas and Vincent (5) by obtaining the displacement/time relation for the shuttle during the course of its checking in the shuttle box. On a conventional loom, shuttle after entering the shuttle-box at a very high velocity (10-15 m/s) is brought to rest within a short distance of 15 to 20 cm by means of combined action of swell, picker, check strap/buffer etc. as mentioned earlier. It has been accepted by many research workers that retardation of a shuttle by a conventional



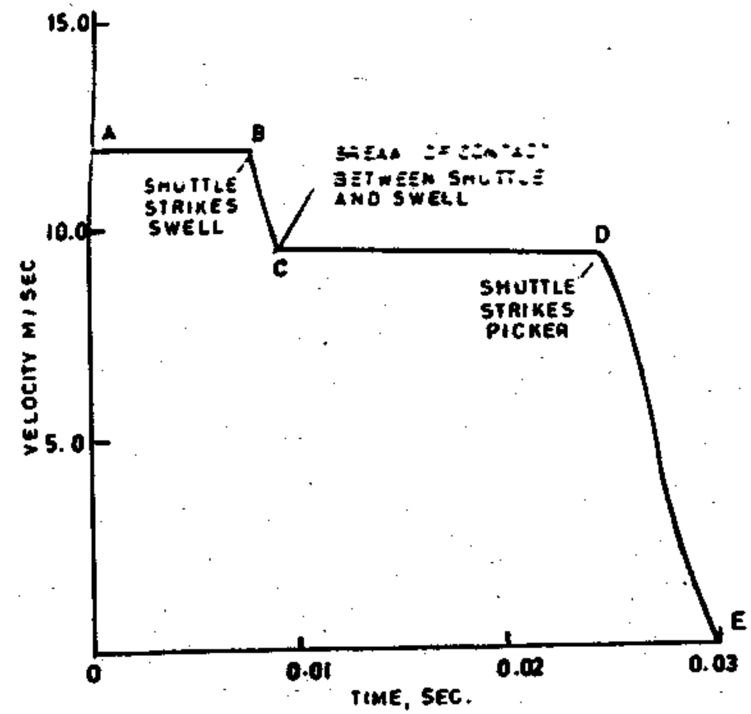
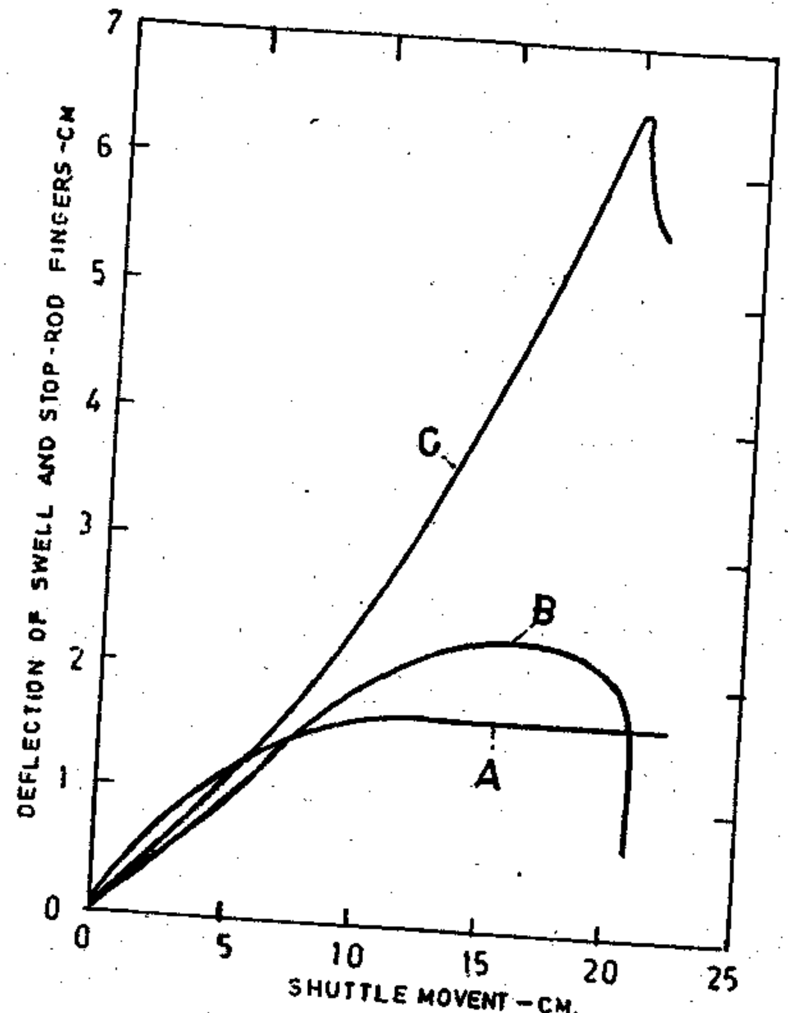



Fig. 4.8 Shuttle Velocity - Time Curve during Retardation of a Shuttle

pivoted swell takes place in two stages. Firstly, swell alone retards the shuttle to a small extent and secondly combined action of picker, swell, buffer etc., brings the shuttle to rest. The velocity-time curve during checking can be divided into four zones (5, 7). Referring to Fig. 4.8, in the first zone extended from A to B, the shuttle has entered the shuttle box but does not come in contact with the swell. In this zone there is very little drop in the shuttle velocity contributed by the friction between the shuttle wall and the shuttle box. In the second zone from B to C, the shuttle strikes the swell and is in contact with it for a short duration. Due to this impact, shuttle velocity is dropped by about 10-20% for uncontrolled swell depending upon the magnitude of swell pressure, configuration of swell, shape of shuttle, swell covering, mass of shuttle and swell, initial velocity of shuttle and contact time between the swell and the shuttle. Once the swell starts moving, it continues to move because of its own momentum and in the third zone from C to D, a break of contact between the swell and shuttle takes place and there is




A = Nominal movement of swell and finger ; B = Actual movement of swell ; C = Actual movement of finger

**Fig. 4.9. Movement of Swell and Finger during Retardation of Shuttle**

negligible amount of retardation in this zone and considerable checking distance is lost. Similar observations (5) are found in case of fast reed loom as shown in Fig. 4.9. which indicates the break of contact between the shuttle and the swell and also between the stop rod finger and the swell. In the fourth zone from D to E , the shuttle makes an impact against the picker; action of picker, buffer/check strap and swell (which comes back due to damping action) takes place simultaneously and shuttle is brought to rest within a short



distance of about 2 cm and retardation value is very high (1.5 - 2.0 km/s²). This peak retardation is the serious draw back of a conventional loom since it causes wear and tear of the picker, shuttle etc., and generates considerable noise, vibration and heat. It is also a potential source of disintigration of the weft package. The position at which the shuttle is brought to rest is varied between 1.5 to 3.0 cm.

With controlled swell, retradation is uniform and its value is much lower than that of an uncontrolled swell (Fig. 4.10). It has been observed that minimum value of the retardation is obtained when the shuttle just reaches the picker, that is, retardation is effected by the swell alone. If the swell pressure is increased above the value necessary to achieve this, then retardation takes place over a small distance and reaches a higher value. On the other hand, if the swell pressure is reduced, impact of picker occurs and this also leads to a higher value of retardation. Because of precise settings required for the controlled swell to have a low retardation value it is not widely used in the industry. Further the retardation by swell along raises problems of heat dissipation which is aggravated if the swell is covered with high frictional material. If bare metal is used, the pressure at the side of the shuttle needs to be increased. This increases the bending of the shuttle wall and resulting in permanent distortion of the shuttle (12). The remedy of thickening the walls of the shuttle reduces the weft capacity and is self defeating to the extent that the mass of the shuttle is increased and there is more kinetic energy to be dissipated. The other problem to check the

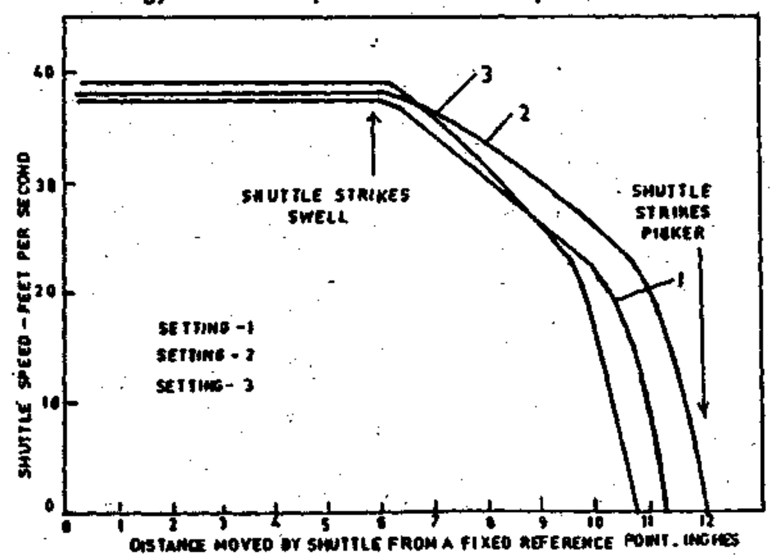



**Fig 4.10 Retardation of a shuttle on a Loose-Read Loom with Controlled Swells**

shuttle by means of a swell along without any impact with the picker is that if the speed of the shuttle is low on entering the box owing to obstructions in the shed or subnormal initial speed, then contact with the picker will not be made and the next pick will be defective. From checking point of view the fast reed is superior in that a larger fraction of the unchecked speed is destroyed before the impact with the picker and this is because the swells on fast reed looms are longer than that on loose reed looms due to the absence of the box flap. Moreover the swells combined with the stop rod mechanism provide a more effective checking than the simple swell on the loose reed loom.

**4.10.3 Effect of certain Parameters on the Retardation of Shuttle with Different Swells.**

**4.10.3.1 Swell geometry**

Ashour and Poonawalla (13) have studied the effect of various parameters on checking by means of a Shirley Accelerometer using eight swells each of 24.13 cm long and five of different shapes and four different coverings. Particulars of these swells are given in Table 4.2

**Table 4.2 Particulars of Swell Used by Ashour and Poonawalla**

Box setting = 0.238 cm.

| Swell | Lift (cm) | Checking distance (cm) | Covering Material | Coefficiant of friction |
|---|---|---|---|---|
| A | 0.476 | 16.51 | Leather | 0.34 |
| B | 0.635 | 5.36 | Leather | 0.34 |
| C | 0.635 | 8.39 | Leather | 0.34 |
| D | 1.111 | 13.97 | Wood | 0.23 |
| E | 1.111 | 13.97 | Steel | 0.15 |
| F | 1.111 | 12.06 | Leather | 0.34 |
| G | 1.111 | 13.97 | CN 889 Armstrong* | 0.37 |
| H | 1.111 | 12.06 | CN 889 Armstrong* | 0.34 |

*Armstrong cork loaded synthetic swell covering.

They have found considerable improvement in the linearity of the velocity time curves from the swell C compared to swell A, thus reducing the peak deceleration value, in contrast with former. The later has a gradual lift and its nominal pressure is inffective because



of its short checking distance whereas the swell F whose checking distance in between A and C but having more lift is very efficient. It reduces the velocity of the shuttle by 40% compared to 30% for swells A and C and 15% for swell B.

**4.10.3.2 Swell pressure**

Talukdar (7) has found that contact time between swell and shuttle increases with an increase in swell pressure and the shuttle velocity is dropped by about 10-20% depending upon the amount of swell pressure and initial velocity of the shuttle, at higher pressure of 38.3 N and above it, is about 19% as shown in Table 4.3.

**Table 4.3 Effect of Swell Pressure on Retardation of Shuttle**

Swell Spring stiffness- 18.25 N/cm; Loom- 110 cm R.S.

Cimmco Automatic loom - Loom speed (180 ppm)

| Swell Pressure N | Velocity of shuttle m/s: Before contact with swell | Velocity of shuttle m/s: After contact with swell | Reduction in velocity of shuttle % | Peak retardation km/s²: Swell | Peak retardation km/s²: Picker etc. |
|---|---|---|---|---|---|
| 24.5 | 9.45 | 8.00 | 15.34 | 0.20 | 1.65 |
| 28.5* | 9.90 | 8.80 | 11.10 | 0.25 | 2.20 |
| 33.4 | 9.35 | 8.30 | 11.22 | 0.20 | 1.60 |
| 38.3 | 8.90 | 7.20 | 19.10 | 0.22 | 1.31 |
| 42.2 | 8.70 | 7.10 | 18.39 | 0.20 | 0.90 |
| 47.1 | 8.10 | 6.55 | 19.13 | 0.25 | 0.60 |

* Normal setting on loom.

Table 4.3 shows that the effect of swell pressure on the retardation of shuttle due to swell alone is very limited and maximum retardation due to swell alone is about 0.25 km/s². Ashour and Poonawalla (13) have also observed that increase in swell pressure by 90% brings only 15% increase in the efficiency of checking. This is because of the following reasons.

(i) The reaction force generated by the impact between the shuttle and the swell almost acts in the direction perpendicular to the line of movement of the shuttle,

(ii) The damping force which takes place due to rubbing action of swell spring the friction at the fulcrum does not increase in proportion with the increase in swell pressure.

#### 4.10.3.3 Swell inertia

Grushin et al (14) have found that checking is more effec with swell of higher moment of inertia, for example a swell havin moment of inertia of 0.0262 kg/m², 54% of the kinetic energy of shuttle is absorbed in the shuttle box whereas in case of moment inertia of 0.0111 kg./m² only 34.1% of the kinetic energy is absorbe

The maximum displacement of the swell increases with increase in the swell moment of inertia but contact time decrease The plain swell with higher inertia in conjuction with a higher sw pressure gives better performance (13).

#### 4.10.3.4 Swell covering

Metwally (12) used four different coverings viz; leather, wood rubber layer between leather and wood and steel and found tha maximum retradation is possible with steel face in spite of its low coefficient of friction and the short contact time. This is associated with a high kinetic energy imparted to the swell by the impact which is a function of coefficient of restitution. Table 4.4 shows some of the Metwally's results and these have been manipulated to show the relative importance of the factors.

**Table 4.4 Factors in Conventional Shuttle Checking**

| Type of Swell | Relative time of contact | Relative coefficient of friction | Relative swell mass | Relative maximum shuttle deceleration | Relative change in shuttle velocity |
|---|---|---|---|---|---|
| Wood | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Leather Covered | 1.0 | 2.34 | 1.10 | 1.10 | 1.10 |
| Rubber layer between leather and wood | 2.84 | 1.71 | 1.20 | 0.69 | 1.28 |
| Steel faced | 0.50 | 0.43 | 1.60 | 2.70 | 1.36 |

(All units are arbitrary and are only intended for comparison)

#### 4.10.4 Theory of Conventional Checking

Morrison (15) has made an attempt to analyse theoretically the shuttle checking on a fast reed loom. According to him the swell system is a spring mass system and derived the following equation.

$V_2 / V_1 = 1 - 2.0\ (\mu_1 + \mu_2)\ (L / T)\ (1 / V_1)\ (M / m)$ ....................(4.19)

Where, $V_1$ = Shuttle speed before contact with swell.

$V_2$ = Shuttle speed after contact with swell.

$\mu_1$ = Coefficient of friction between the shuttle and the box front.

$\mu_2$ = Coefficient of friction between the shuttle and the swell.

L = Lift of the swell.



$T = \pi\ (M/K)^{1/2}$ = Duration of contact between the swell and shuttle.

M = Equivalent mass of swell, stop rod and stop rod finger.

K = Equivalent stiffeness of the systems

m = Mass of shuttle.

If the total elasticity of the system is appropriately chosen, the frictional reduction in shuttle velocity would depend on :

(i) the frictional coefficients of shuttle on the working surfaces;

(ii) the ratio of the effective mass of the stop rod system to that of shuttle; and

iii) the velocity ratio between the shuttle motion and swell lifting action.

Lord and Mohammed (16) used a simple mathematical model by splitting the swell system into two parts : one acting on one side of shuttle and the other on the opposite side and assuming both of them acting on the same way. Finally they derived the following equations.

$\Delta Vs / Vs = [(1+e)\ \mu\ Mb] / (Ms + \mu\ Mb)$ ....................................(4.20)

Where Vs= Initial velocity of shuttle before impact.

$\Delta Vs$ = Small change in velocity of shuttle after impact.

$\mu$ = Coefficient of friction between the shuttle wall and swell.

Ms = Mass of shuttle

Mb = Mass of swell

e = Coefficient of restitution.

They have also given the impact equation at the instant between shuttle and picker which is as follows :

$\Delta Vs / Vs = [(1+e)\ Mp] / (Ms+Mp)$ .................................... (4.21)

Where, Mp = Mass of picker and other notations are same as in Eq. (4.20)

Model of Morrison is open to criticism because it is based on the assumption that all the deceleration produced by the swell results from friction only, this means in the absence of friction, impact would produce no loss of velocity of shuttle which is unrealistic. In addition idealized curves of stop rod and swell movements considered by Morrison do not give actual picture.

Gorkov (17) considered a more realistic model in which the checking system is broken into three parts viz. (i) impact checking, (ii) frontal checking, and (iii) lateral checking. He derived an equation relating the angles of impact (L1), angle after impact (β) coefficient of restitution (K) and coefficient of friction (μ) during impact.

- Finally, he derived the following equation to determine the velocity of shuttle after nth impact.

$$Vn = Vo\, K_2^{\,n/2}\, K_1^{\,n/2}\, (\cos \alpha_0 / \cos \beta_0)\, (\cos \beta_1 / \cos \alpha_1) \ldots\ldots [\cos \beta_{(n-1)}] / [\cos \alpha_{(n-1)}]\, \sin \alpha_n \ldots\ldots (4.22)$$

Where Vn = Velocity of the shuttle after nth impact
Vo = Initial velocity of the shuttle
n = Number of impact
$K_1$ = Coeffiecient of restitution between the shuttle and the box front
$K_2$ = Coeffiecient of restitution between the shuttle and the swell.

## 4.11 WEFT TENSION DURING PROPULSION AND RETARDATION OF SHUTTLE

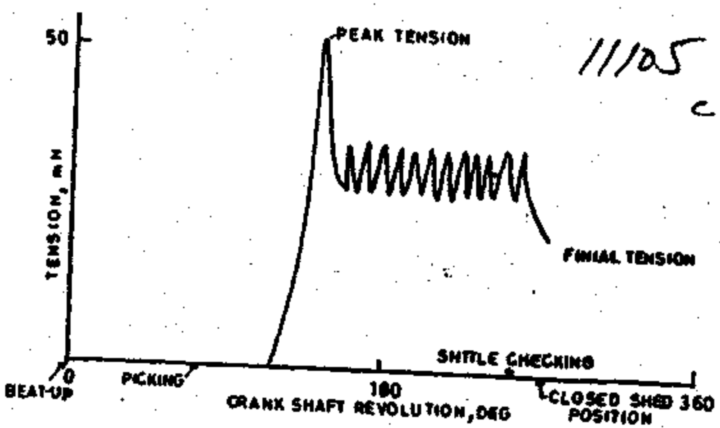



Fig. 4.11 Weft Tension Variation during a Loom Cycle

The magnitude of the tension in the weft immediately before it is trapped by the crossing warp threads is very important as this is the crucial tension governing to a large extent, the weft-way appearance of a fabric. A number of papers (18-22) are available on the subject mostly during with the effect of changes in the average level of yarn tension dealing weaving. Fig. 4.11 shows the variation in the tension in the weft as it is unwound from shuttle during its traverse. It does not refer to any loom, or weft, in particular but is useful in focussing attention on to the important aspects of the behaviour in respect of changes of the weft. At the front centre, the shuttle is stationary and the free weft yarn between selvedge and



shuttle-eye is having a steady tension. The moment picking begins, the yarn is slackened and its tension drops to zero, and remains at zero until all the slackness in the yarn is taken up. At some point the weft begins to be withdrawn from the shuttle, the tension then rises rapidly to its high value and then fluctuates rapidly during unwinding. The magnitude of the tension level when the shuttle is in free flight across the loom is determined by the nature of weft, the internal fitting of shuttle, shuttle velocity, asymmetric position of shuttle-eye and so on. The weft tension across the free flight of shuttle is known as the **unwinding tension or running tension.**

When the shuttle is checked, immediately the tension begins to fall. The rate at which the tension falls must depend, to some extent, on the efficiency of the shuttle checking arrangements in the shuttlebox. Obviously, if the shuttle rebounds from the picker, the tension will fall to zero. The actual tension in the weft immediately before it is trapped by the warp threads, known as **retained weft tension**, will depend not only on the running tension, but also on the position of the loom cycle, at which the closed shed occurs.

Another special feature of weft tension traces for the conventional looms is the difference in duration of the unwinding tension plateau between consecutive picks. The difference results from the asymmetric position of the shuttle eye creating different lengths of slack yarn between the selvedge and shuttle eye (21).

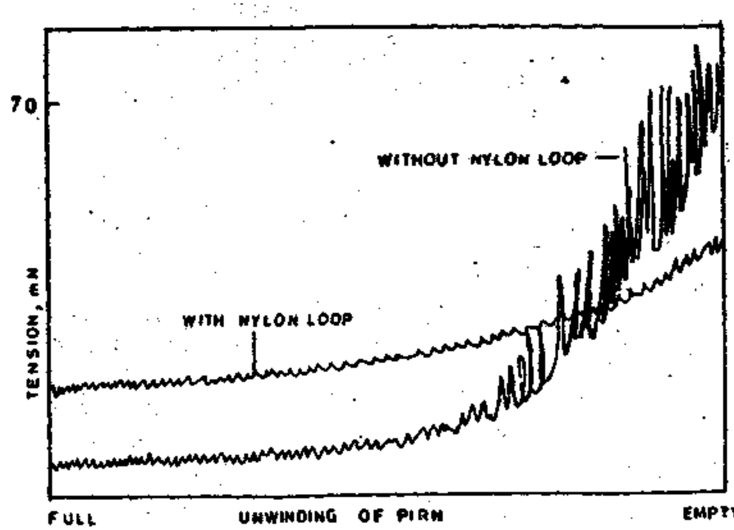



Fig. 4.12 Weft Tension Variation during Complete Unwinding of a Pirn

The tension in the yarn while the shuttle is in either box, does not remain completely static between picks. There are tension peaks associated with the lateral contraction of fabric as the reed leaves the shed. This effect may be seen in the weft tension traces starting from the point where beat-up takes place. A secondary effect here is the withdrawal of yarn from the shuttle as the sley undergoes its back swing, thus increasing the distance from selvedge to shuttle eye. With side weft motion, there is a small peak tension immediately after the shuttle enters the box (approx. 335°)

A variation in tension during the complete unwinding of a pirn is shown in Fig. 4.12. The width of the trace arises from the rapid variation in tension as unwinding proceeds in rapid succession from the nose and shoulder of a pirn. At first the magnitude of tension is low but as unwinding proceeds, the average tension increases and eventually reaches a value of about 5-6 times its value at the beginning. It is this abrupt tension change from the end of the pirn to the beginning of next that give rise in some fabrics to the well known cop change defect. On an automatic pirn changing loom, the weft on the first pick of a pirn is not fully threaded and the tension is as low as 2 g.

The way in which the tension towards the end of a pirn comes about is as follows : When unwinding starts from a full pirn the yarn balloons away from the axis of pirn, but as it proceeds the balloon lengthens and there is some licking of the yarn round the pirn. As the unwinding continues the licking extends over a greater length of empty pirn and it is this that is mainly responsible for rise in tension on account of the frictional resistance to the movement of the yarn.

It has been found that the best way of reducing the rise in the tension is to use a conical base pirn or inside of the shuttle be glued with a nylon loop strips (23-24) or fur. Use of 5 monofilament nylon loops at an angle of 30-45° to the shuttle walls also helps in controlling tension. The diameters of monofilament nylon yarns are 0.8 to 1.0 mm. for medium and coarse counts and 0.4 to 0.6 mm for fine and superfine counts.

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# 5 BEAT UP MECHANISM

## 5.1 FUNCTION

The function of beat up mechanism is to push the weft thread that has been inserted across the warp threads in a shed, upto the fell of cloth. Fell of cloth is the position of the last pick in the cloth woven on the loom.

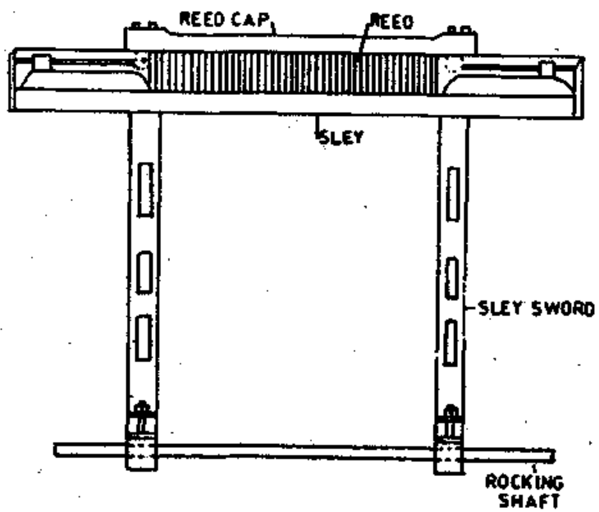



Fig. 5.1 Sley Mechanism

The beating up of the weft to the fell of the cloth is carried out by the reed which is fixed on the sley by means of a reed cap as shown in Fig. 5.1. The sley mounted on two sley swords, each sley sword being fulcrummed on the rocking shaft, receives its motion from a crank on the crank shaft through a crank arm as shown in Fig. 5.2.

In technical terms, a sley mechanism is a four bar linkage mechanism as shown in Fig. 5.2b. $O_2$ $O_4$ is the fixed link (loom frame), $O_2$ A is the crank, A B is the coupler, known as connecting arm, $O_4B$ is the rocker, known as sley sword. The positions and dimensions of these links affect the sley movement.



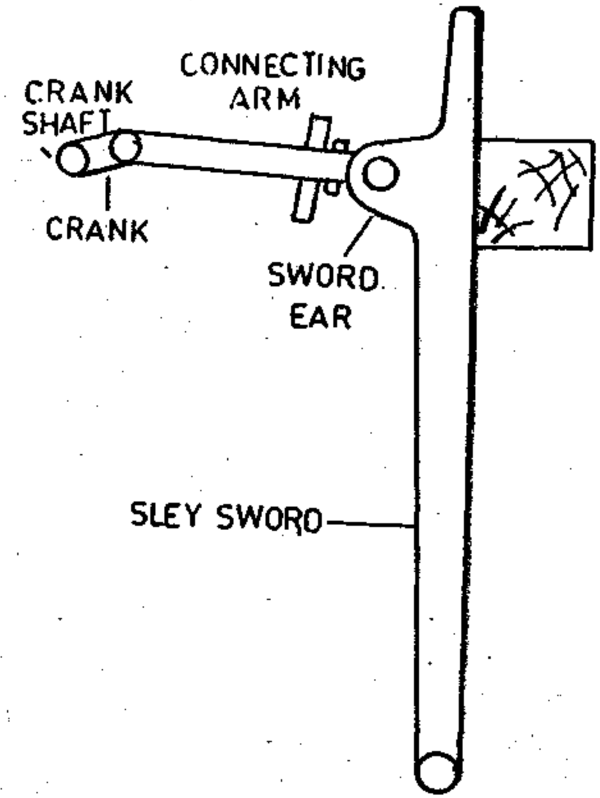
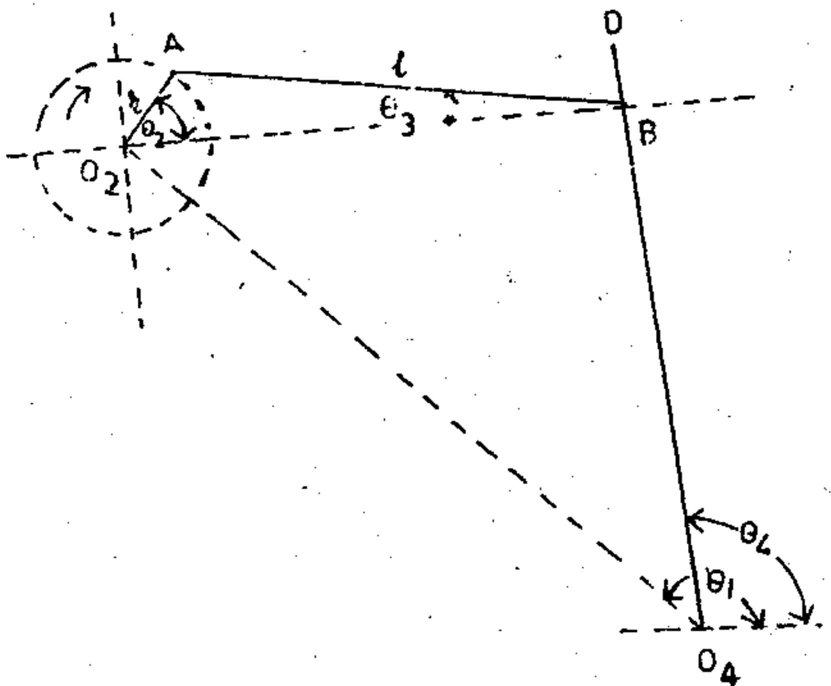



Fig. 5.2 (a) Connecting of Crank, Crank Arm and Sley Sword

## 5.2 KINEMATICS OF SLEY

Kinematic analysis is the study of displacement, velocity and acceleration etc. of a mechanism involving only two physical dimensions viz. length and time. This analysis can be done by (a) graphical method and (b) analytical method. The first method involves a lot of graphical construction and so chances of introducing errors are very high, especially, while measuring the relative positions of two points. Hanton ( 1 ) and Lord ( 2 ) used a simple analytical technique to calculate the displacement of the sword pin from the beating up position with respect to crank shaft rotation. They assumed that the point B in Fig. 5.2b moves along a straight line rather than in an arc (since the radius $O_4B$ is very large as compared to crank) with respect to $\theta_2$ and the angular speed of loom is constant.




$O_2 O_4$ = Fixed link, $O_2 A$ = Crank
AB = Crank arm, $O_4B$ = Sley sword, BD = Reed.

$\theta_1$ = Angle of fixed link with respect to horizontal,
$\theta_2$ = Angle of crank with respect to horizontal,
$\theta_3$ = Angle of crank arm with respect to horizontal,
$\theta_4$ = Angle of sley sword with respect to horizontal.

**Fig. 5.2. (b) Sley Mechanism as a Four Bank Linkage Mechanism**

$$X = r + l - r \cos\theta_2 - r \cos\theta_3$$
$$= r(1 - \cos\theta_2) + l\ (1 - \cos\theta_3) \quad \text{......(5.1)}$$

where, X = displacement of point B i.e. displacement of sley from beginning of its stroke.

r = length of crank

l = length of connecting rod

$\theta_2$ = crank angle with respect of dead centre position i.e. $O_2B$ (radius).

$\theta_3$ = angle of connecting rod with respect to $O_2B$

Again $h = r \sin\theta_2 = l \sin\theta_3$



where, h = Perpendicular distance of point A

$\sin\theta_3 = (r / l) \sin\theta_2$

$\cos\theta_3 = (1 - \sin^2\theta_3)^{1/2}$

$= (r / l)\ \{(l / r)^2 - \sin^2\theta_2\}^{1/2}$ ..........(5.2)

Substituting $\cos\theta_3$ in Eq. (5.1), we get

$X / r = 1 + (r / l) - \cos\theta_2 - \{(l / r)^2 - \sin^2\theta_2\}^{1/2}$

or, $X = r[1 + (r / l) - \cos\theta_2 - M]$..........(5.3)

where, $M^2 = (l / r)^2 - \sin^2\theta_2$

$X' = \omega r[\sin\theta_2 + (\sin^2\theta_2 / M)]$

or, $X' = \omega r(\sin\theta_2 + (r / 2l) \sin 2\theta_2)$..........(5.4)

Since, $\sin^2\theta_2$ is negligible as compared to $(r / l)^2$

$X'' = \omega^2 r[\cos\theta_2 + (r / l) \cos 2\theta_2]$..........(5.5)

But in practice, the sword pin moves in an arc of a circle and is placed at the top or bottom of the horizontal line of the crank centre. Ray et al (3) observed that, these assumptions are valid for looms upto about 200 cm wide, but for wider looms, Raven's (4) complex conjugate method or Chace's Vector (5) method should be used which takes into account all the four links and their positons.

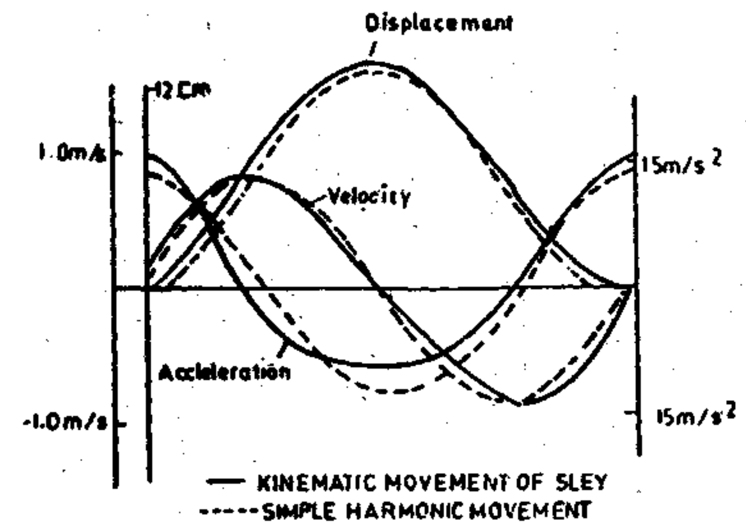



**Fig. 5.3 Kinematic Movements of Sley**

The positions and the dimensions of links affect the movement of the sley mechanism. The extent to which it deviates from simple harmonic motion is known **eccentricity of sley**. Typical displacement velocity and acceleration diagrams of a nonautomatic loom is shown in Fig. 5.3; for comparison the simple harmonic motion diagrams are also shown by dotted line.Because of eccentricity, the sley moves at a faster speed during beat-up and a slower speed during shuttle flight.

## 5.3 SLEY ECCENTRICITY RATIO 'e'

The sley eccentricity ratio 'e' is referred to the ratio r/l, where r is the radius of the crank circle and l is the crank arm length. This eccentricity ratio can be changed as per the loom design requirement. High sley eccentricity facilitates the passage of shuttle in wide width looms and also tends to increase the effectiveness of beat up of weft. By increasing the eccentricity ratio the sley could be made to remain longer nearer its most backward position thus giving more time for the shuttle flight. However, increasing the eccentricity ratio increases the forces acting on the sword pins, cranks, crank arms and to some extent on the loom frame resulting in excessive vibration. It is, therefore, necessary to manufacture a more rigid loom frame and robust loom parts. This of course increases the cost of the loom.

**Table 5.1 : Eccentricity Values**

| Make of the Loom | Loom Type | Width cm | r cm | l cm | e' = r/l |
|---|---|---|---|---|---|
| Saurer Loom | Cotton tappet automatic | 110 | 6.25 | 15.0 | 0.42 |
| Ruti Loom | Cotton dobby automatic | 110 | 6.99 | 27.94 | 0.25 |
| CIMMCO | Cotton tappet automatic | 110 | 6.67 | 29.53 | 0.126 |
| Picanol Loom | Cotton dobby automatic | 110 | 7.2 | 32.4 | 0.225 |
| Northrop | Cotton automatic | 110 | 6.35 | 30.48 | 0.208 |
| Prince | Rayon tappet shuttleless | 190 | 3.33 | 22.9 | 0.145 |
| Northrop | Wide loom tappet automatic | 320 | 10.8 | 20.3 | 0.54 |
| Cooper | Cotton non-automatic | 90 | 5.08 | 30.48 | 0.167 |
| Butterworth | Cotton non-automatic | 230 | 8.89 | 21.59 | 0.418 |



Northrop blanket loom, with a reed space 3.2 m and a loom speed of 65 picks/min has an eccentricity ratio of 0.54. The higher ratio is obtained by a shorter crank arm and a larger crank radius. In the case of some normal width looms the crank radius varies from 6 to 8 cm and the crank arm length from 15 to 34 cm. However, the length of the crank arm has to be considered according to the number of heald frames provided by the shedding mechanism. A dobby shedding motion can be designed to control up to 28 heald frames. Similarly a wider loom weaving heavy fabric requires thicker frames for operating the healds, which means more space between the sword pin and the crank shaft. One way of increasing this space without affecting the eccentricity ratio is by having large sword ears. Table 5.1 shows the eccentric ratio of different looms.

## 5.4 SETTING

(a) The sley is normally set at such a height that a line drawn through the extreme sword pin position will pass the axis of the crank shaft as shown in Fig. 5.4. However, in certain special cases where larger dwell of the sley is required for the shuttle traverse, the crank shaft centre is lowered below the line.

(b) The rocking shaft should be set in such a position that the two sley swords are vertical when the reed touches the cloth fell. This position will enable the beat-up force exerted on the cloth fell, along the warp line and the reed will not exert an upward or downward cutting action on the weft. This setting will also allow the race board to closely follow the angle formed by the bottom line of the warp, and thus providing a smooth traverse of the shuttle during its flight across the warp.

(c) The two crank arms should be of exact length. The pick spacing will be affected if one end of the reed is beating up before the other. Similar faults will occur in the cloth if the crank arms are slack. The bushes are likely to wear in the long run and this can be remedied by positioning the cotter properly. Fig. 5.5 (a,b) shows different types of crank arm.

(d) The wooden race board must be smooth.

(e) While weaving silk or synthetic filament yarns the race board is covered with felt or corduroy cloth.

(f) The race board and the box base plates should be maintained in good order and periodically tested by means of a template to see whether it is true in all details.

(g) If the race board is worn out by the constant rubbing of the shuttle then a new one should be fitted or can be repaired by fixing sunmica sheet.

(h) The reed should not overface the box back as this will cause the shuttle to be deflected from its normal course and shuttle back wall wears out or even break the shuttle.

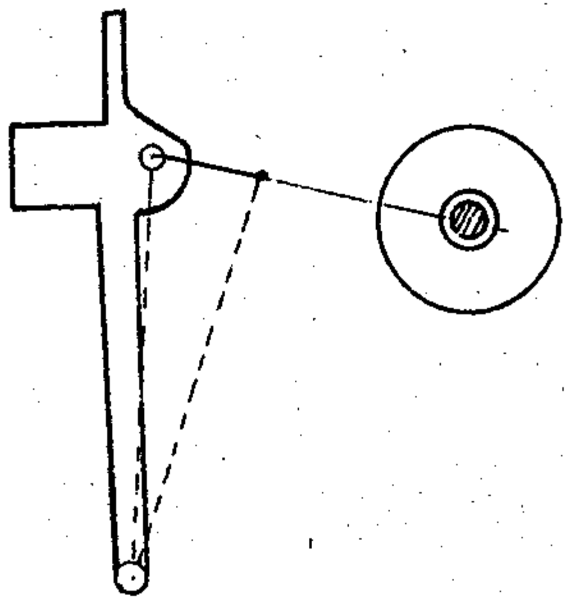


Fig. 5.4 Sley Height Setting

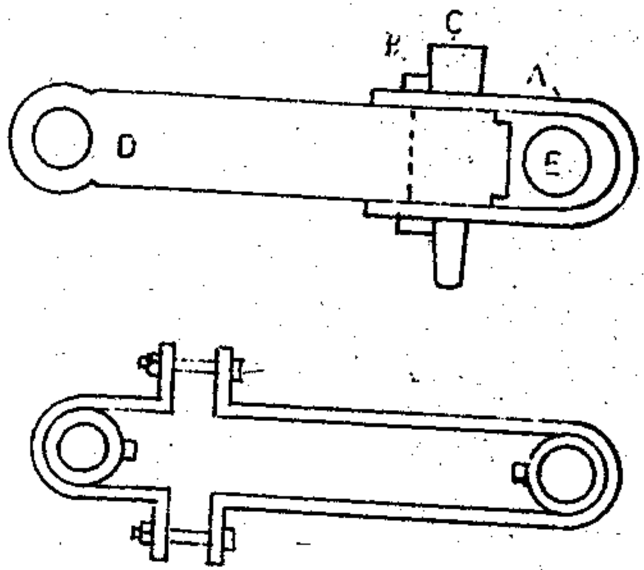
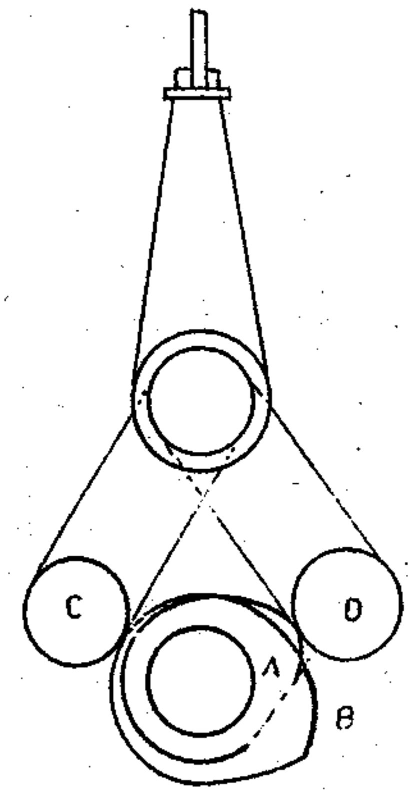



Fig. 5.5 Crank Arm



(i) The angle formed between the reed and the race board and between the box back and box plate should correspond with the angle formed by the back and base of the shuttle. This is called the 'bevel'. It is normally 87°-90°.

## 5.5 SLEY THAT DWELLS




A,B = Matched cams; C,D = Antifriction bowls

Fig. 5.6. Reed Drive by Matched Cams

With certain projectile weaving machines, jet and rapier weaving machines, the picking mechanism is mounted stationary on the machine frame and the reed must, therefore, be at rest during the weft insertion. Cams have been used for sley driving to give a definite dwell to the sley with the required range of 220° to 250° depending upon the width of the loom.

The reed is driven by two matched cams (Fig. 5.6) through a rocker with antifriction rollers. Sley driven on a projectile weaving machine is described in Chaper 16. The cam mechanism gives the following outstanding advantages.

(i) The time available for weft insertion can be increased and this will allow a higher loom speed to be achieved.

(ii) Dwell can be varied depending upon the working width of the loom by changing the cams.

The main disadvantages are :

(i) Cams are higher pair mechanism having a line or a point contact and because of this wear and tear of cams will be more.

(ii) Amplitude of the sley's movement has to be a small one (say about 102 mm in case of Saurer Rapier Loom) to avoid large forces of acceleration and retardation.

(iii) The manufacture of this mechanism has to be very precise, only a small clearance is admissible between both the cams with rollers to avoid impacts in the mechanism.

### 5.5.1 Sley Dwell in Shuttle Loom

The difficulties in incorporating dwell to the sley on shuttle looms are :

(i) Amplitute of the sley movement is large enough for the passage of shuttle and this will produce a large acceleration and retardation forces since its movement is confined to a relatively small part of the pick cycle.

(ii) The movement of the sley, especially during the latter part of the shuttle transit, helps to control the flight of the shuttle. During the latter part of its flight, the sley is moving forward and rising and this helps to maintain contact between the shuttle and the reed and the shuttle and the race board. This ensures that the shuttle is boxed correctly. This effect would not have been possible if the sley would have been stationary during the passage of shuttle.

## 5.6 ACCELERATING FORCE

The accelerating force which is applied at the loom sword pin, tangentially to its path to accelerate the sley is directly proportion to the acceleration of sword pin.

The value of the force F= Moment of inertia x Angular acceleration of sley.

Moment inertia = $mk^2$

Where, m = Mass of sley; k = Radius of gyration about rocking shaft.

Angular acceleration of sley = $X'' / l$

Where, X = Linear acceleration of sword pin

l = Distance of rocking shaft to sword pin.

Force $F = [(mk^2 X'') / l] = M' X''$



[where $M' = (mk^2)/l$] = equivalent mass)

Substituting value of X" from Eq. (5.5)

$F = M' \omega^2 r [\cos\theta_2 + (r / l) - \cos 2\theta_2]$

The maximum values of this accelerating force are reached at the beat up position when $\theta = 0$ and minimum value at the back centre when $\theta = 180°$. These values are :

$F_{max} = (W/g)\,\omega^2 r\,(1 + r / l)$ ; $F_{min} = (W/g)\,\omega^2 r\,(1 - r / l)$

Where, W = Weight of sley ; g = Gravitational force.

## 5.7 MECHANICS OF BEAT UP

### 5.7.1 The Beat up of Weft

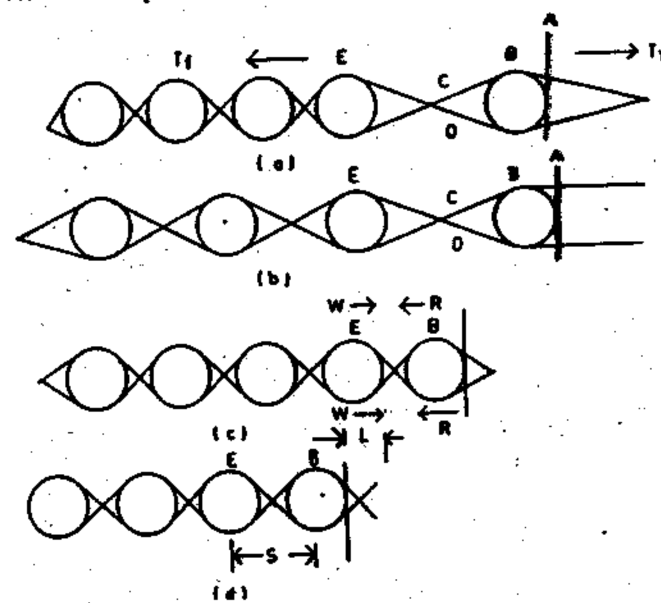



**Fig. 5.7 Beat-up Action**

While moving towards the front centre position, reed A comes in contact with the weft B (Fig. 5. 7) and pushes it in the direction of the warp advances. The reed at first encounters only a slight frictional resistance of the weft as it is pushed and then a distinct resistance to the reed motion begins to be felt in the area where crossed warp ends C and D begin to fill in the space between the fell of the cloth E and the last weft inserted B. At this crimping of the warp round the weft takes place. The reed does not encounter any other resistance during weaving of fabrics with low weft density in which the reed simply pushes the weft to its correct position and leaves it there (Fig.5.7b). Thus the minimum pick spacing which can be obtained by beating an open shed is determined by the coefficient of friction between the weft and the warp.

With medium and high weft density fabrics, the reed exerts substantial pressure on the fell E. This force is known as **beat up force** (R). As the weft B pushes the weft E, the latter offers a resistance to displacement, this is known as **weaving resistance** (W). The beat up force (R) and weaving resistance (W) are equal and opposite. The fell resists displacement by virtue of tension in the warp and cloth.

The beat up force increases rapidly as soon as the reed pushes the fell of cloth E through the newly inserted weft B [Fig.5.7c.] At that moment the space between weft threads B and E is nearly completely packed with warp ends when the reed continues to move, the fabric recedes and the pull in the warp increases.

The beat up force attains the maximum value when the reed is at the front centre position. At this point the distance between the new pick (B) and the cloth fell E is reduced to pick spacing S. L is the cloth fell position (c. f. p.) which is the distance of the basic position of the clothe fell E from the front position of the reed. Greenwood et al (6) adopted sign convention for the purpose of mathematical treatment to indicate the position of c.f.p. All distances are positive if measured from the front position of the reed towards the weaver and negative if measured from that towards the beam. This means, if the cloth fell positon (L) is – 7.0 mm, then before beat up the position of the fell is 7 mm behind the front position of the reed.

Since the cloth fell was at a distance L before the beat up and is at a distance S at the end of the beat up, the distance Z by which the cloth fell has moved during the whole beat up is given by S–L.

## 5.8 RELATION BETWEEN C.F.P. AND BEAT-UP FORCE

As shown in Fig. 5.7a before the displacement of fell, $T_y = T_f$

Where, $T_y$ = Warp tension ; $T_f$ = Fabric tension

As the reed strikes the fell and displaces the latter, the warp will stretch, say to $T_y'$ and the fabric will contract to have a tension $T_f'$. The magnitudes of $T_y'$ and $T_f'$ depend upon the displacement of fell. At that time the beat up force (i.e.the pressure extended by the reed on the fell) i.e. the weaving resistance (the resistance offered by the fell to displacement) is equal to the difference between $T_y'$ and $T_f'$.

$$\text{So, } R = T_y' - T_f' = (T_y + ZE_y / l_y) - (T_f - Z E_f / l_f)$$
$$= Z (E_y / l_y + E_f / l_f) \quad \ldots\ldots(5.6)$$



Where, R = Beat up force or weaving resistance.

Z = The distance by which the cloth fell is displaced

E = Modulous of elasticity ; l = Free length

Subscript y = Yarn ; Subscript f = Fabric

Eq. (5.6) applies at any instant during beat-up when the reed reaches its front position, both the displacement of the fell of cloth from its basic position and the weaving resistance reaches this maximum values for the given loom cycle.

## 5.9 RELATION BETWEEN BEAT UP FORCE AND PICK SPACING

A rigorous derivation of the relation between beat up force and pick spacing would be very complex and difficult. Greenwood and Cowling (6,7) derived a simple empirical formula which is as follows.

$$Rs = k / (S - D) \quad \ldots\ldots(5.7)$$

where, Rs = Weaving resistance ; S = Instantaneous pick spacing; D = Theoretical minimum pick spacing corresponding to maximum weft density (The practical minimum will always be higher than D); k = Empirical constant.

Eq (5.7) indicates that the weaving resistance approaches infinity as the pick spacing approaches to a minimum value. This means as the pick density inceases, the weaving resistance and beat-up force will increase.

By substituting the desired pick spacing $P_2$ for S in Eq. (5.7) the beat-up force that needs to be applied in order to obtain the required pick spacing $P_2$ can be obtained.

## 5.10 RELATION BETWEEN CLOTH FELL POSITION AND PICK SPACING

The effect of cloth fell position on the pick spacing can be obtained by substituting S–L for Z in Eq (5.6) and by substituting for R from Eq (5.7) as $k/(S-D) = (S-L)\ (E_y/L_y + E_f / L_f)$

$$\text{or} \quad k / [(E_y / l_y + E_f / l_f)\ (S-D)] = (S-L)$$
$$\text{or} \quad L = (-K') / (S-D) + S \quad \ldots\ldots(5.8)$$

Where, $K' = R/ [(E_y / l_y) + (E_f / l_f)]$

The cloth fell position is zero for a weft density of 10 per cm (Fig. 5.8). This means that the fell of the cloth is not displaced by the reed if the weft density is 10 cm or less than 10 cm. So for a very open fabric, the first term of Eq. (5.8) becomes negligible and L = S.

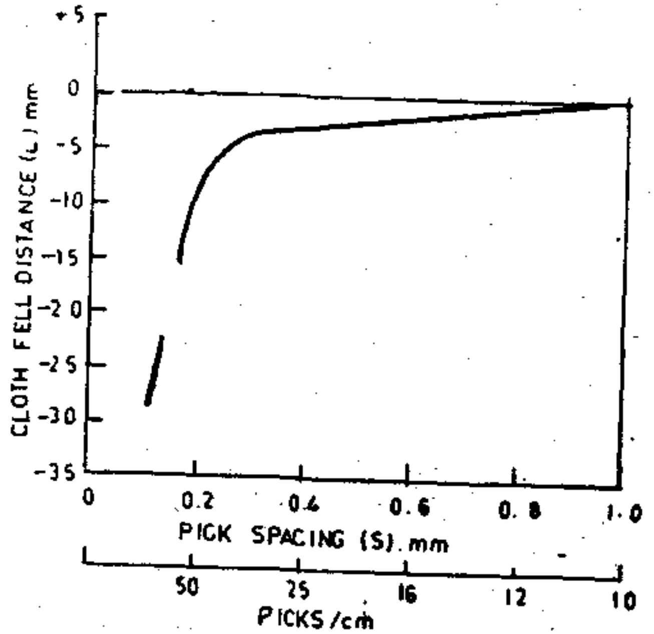



**Fig. 5.8 Relation between Cloth Fell Position and Pick Spacing**

With most fabrics the first term is larger than the second term S and Eq. 5.8 reduces to the form

$L = (-K') / (S - D)$ ......................................................(5.9)

The subtitution of $P_2$ for S in Eq (5.9) gives the position (–Lp) which cloth fell must occupy to beat up in order to produce desired pick spacing. It is the function of the take-up motion to bring the cloth fell to that position (for desired pick space of $P_2$ take-up motion moves the fell by $P_2$).

Suppose due to some reason, at the nth pick, the cloth fell assumes a distance Ln, where, $Ln \neq Lp$. At the subsequent beat up, a pick spacing Sn is produced which differs from $P_2$. With the addition of a new pick i.e. (n + 1) th pick, the cloth fell will be nearer to back of the loom by a distance Δ L. The subsequent take up moves the cloth fell forward by a distance $P_2$. Thus the next change in the cloth fell position from n th pick to (n+1) th pick will be,

$$L_{n+1} - L_n = \Delta L = P_2 - S_n$$

If Ln is larger i.e. if the c.f. p. was intitially too near the front of the loom, Sn will be large then $P_2$. So the take up motion will cause the cloth fell to move in negative direction (i.e. away for the weaver) on the other hand if Ln < Lp. the take up motion will cause



fell of cloth to move towards the weaver i.e. towards the positive direction which brings it again nearer the position Lp. This means if there is a displacement of the cloth fell, say due to prolonged loom stoppage, there will be a temporary variation in pick spacing to cause starting mark or setting on places. The take up motion will cause it to move towards the position that will give the required pick spacing $P_2$ and then its position will be stable. A large number of picks (Fig. 5.9) may be required to get the stability from a disturbed fell of cloth. The closer the construction of the fabric, the longer it takes to obtain stable condition.

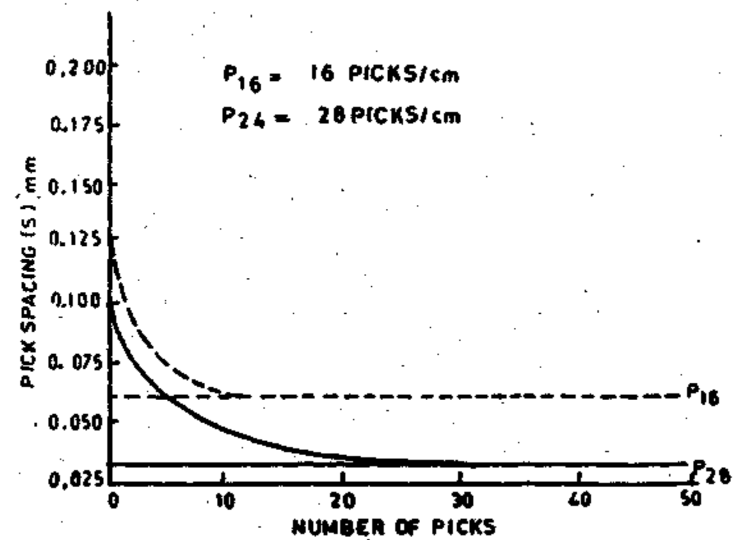
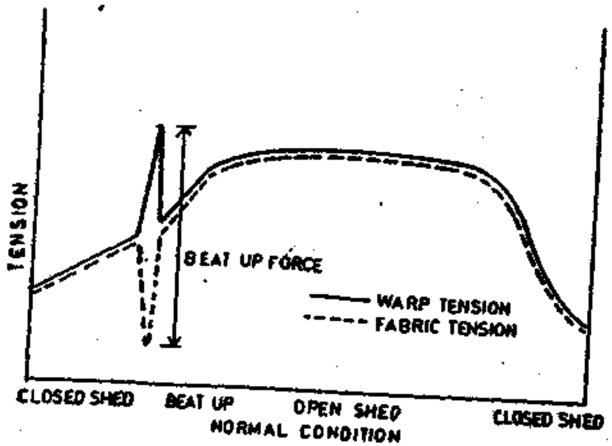



**Fig. 5.9 Number of Picks Required to Get Stability from Disturbed Situation of Fell**

Thus the pick spacing controlled by means of the take-up motion has the advantage of compensating for various yarn and loom irregularities, but, it gives rise to fabric faults due to displacements of the cloth fell position as compared to the direct control of beat-up force on hand looms.

## 5.11 BUMPING CONDITION

The condition under which the fabric is completely slack at beat up is known as **bumping condition**. This is recognised by the noise that the cloth makes as it becoms taut again when the reed moves back. This condition is likely to occur when the fractional weft cover factor tends to attain its limiting value.



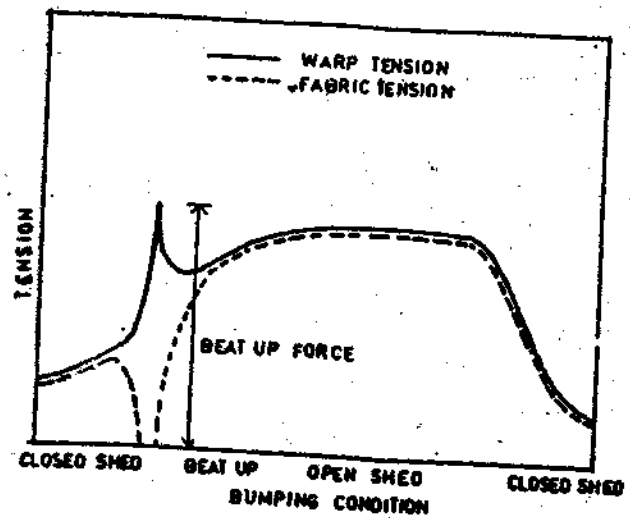




**Fig. 5.10 Warp and Fabric Tension Cycle under Normal and Bumping Condition.**

Eq. (5.8) cannot be applied here as it applies only as long as the fabric remains taut at beat up. Fig. 5.10 shows the warp and cloth tension under normal and bumping conditions.

By definition bumping takes place when the change in fabric tension ($\delta T_f$) during beat up is equal to or more than the basic fabric



tension, i.e. $\delta T_f = (E_f/Zs) / l_f \geq T_f$ ..........................................(5.10)

Eq (5.6) gives the value of $Zs$, as $Zs = K/(S-D)\ [(E_y / l_y) + (E_f/l_f)]$

So, Eq. (5.10) becomes ; $K / (S-D)\ [(E_y\, l_f / E_f\, l_y) + 1] \geq Tf$ . . (5.11)

Equation (5.11) applies to the general case where S is not equal to $P_2$ and conditions are unstable. For stable conditions, S is replaced by $P_2$ and the Eq (5.11) takes form of

$K / (P_2 - D)\ \{(E_y\, l_f / E_f\, l_y) + 1\} \geq T_f$..............................(5.12)

The equation (5.12) shows that the bumping condition takes place under the following conditions,

i) a decrease in pick spacing i.e. greater no. of picks/cm.

ii) a decrease in free length of fabric ($l_f$)

iii) an increase in free length of warp ($l_y$)

iv) a coarser weft.

An increase in warp tension will prevent bumping. The extent of increase in warp tension should be such that the tip of the cloth tension (Fig. 5.10) is just not cut off. This is the minimum warp tension that will avoid bumping. Beyond this point there is no point of increasing the warp tension with the possibility of increase in warp break rate unless other conditions require it.

## 5.12 EFFECT OF WEFT YARN IRREGULARITY ON PICK SPACING

Random or periodic variations in the weft densities take place in case of yarns spun from staple fibres. Often some changes in the weft densities are deliberately introduced. It is, therefore, of interest to see how the loom reacts to this and affects the pick spacing.

It has been already mentioned that the pick spacing taken place during a beat up depends upon the cloth fell position and their nature of relationship depends upon the type of fabric being woven.

For every open fabric the relation is as in Eq. (5.9) : $Ls = S$

With these fabrics the changes in the weft diameter has no effect on pick spacing.

But majority of the commercial fabrics with reasonable density is affected by the weft yarn irregularity. For these fabrics, the relation between the cloth fell position and pick spacing is given by Eq. (5.9) $Ls = (-K) / (S - S\ min.)$

The above eqauation can be written in the form :

$S = S\ min - (K/Ls)$..............................................................(5.13)

The above equation applies for reasonably dense fabrics in which L has a negative value, S is always higher than S min.

Weft cover factor of a fabric is given by $F = D/S$.........(5.14)

where, F = Weft cover factor ; D = Diameter of weft yarn.

So , $S = D / F$..........................................................................(5.15)

$S_{min} = D / F_{max}$.........................................................................(5.16)

Substituting the values of S and S min in Eq (5.8)

$Ls = (-K) / \{(D / F) - (D / F_{max})\}$

or $Ls = (-K) / \{D(1/ F - 1 / F_{max})\}$

or $(1/F - 1/ F_{max}) = (-K) / (Ls D)$

or $(1/F) = (1 / F_{max}) - (K) / (Ls\ D)$

or $F = 1 / \{ (1 / F_{max}) - (K) / (Ls D)\}$......................(5.17)

Eq. (5.17) shows the effect of yarn diameter or the weft cover under actual weaving conditions for fabrics where an appreciate force has to be applied during weaving. Here the beat up force is negligible, i.e. with open fabrics, the weft diameter has no effect on pick spacing. Greenwood (7) calculated the weft cover factors for a range of cloth fell distances and weft diameters by substituting these values in Eq. (5.17) for a plain weave with a particular warp for which $K = 0.5\ mm^2$, where, $F_{max} = 0.40$ Eq (5.17) gives corresponding pick spacing for F. The results of such tabulation are shown in Table 5.2.

**Table 5.2 Cloth Fell Position, Weft Cover Factor and Pick Spacing**

Weft diameters D (mm)

| Cloth Fell | 0.10 | | 0.15 | | 0.20 | | 0.25 | | Mean Value |
|---|---|---|---|---|---|---|---|---|---|
| Distance (mm) | S | F2 | S | F2 | S | F2 | S | F2 | of F |
| -2 | 0.50 | 0.20 | ↑ 0.63 | 0.24 | 0.77 | 0.26 | 0.86 | 0.29 | 0.25 |
| -4 | 0.39 | 0.26 | 0.50 | 0.30 ← | 0.63 | 0.32 | 0.76 | 0.33 | 0.30 |
| -6 | 0.32 | 0.30 | 0.47 | 0.32 | 0.57 | 0.35 | 0.70 | 0.36 | 0.33 |
| -8 | 0.31 | 0.32 | 0.43 | 0.35 | 0.56 | 0.36 | 0.70 | 0.36 | 0.37 |

Table 5.2 can be also used to study the effect of changes in weft count. Let it be assumed that a fabric is woven with a weft diameter 0.20 mm and a rate of cloth take-up $P_2 = 0.63$ under stable condition; pick spacing S is equal to 0.63 that is, 16 picks per cm and the weft cover factor is equal to 0.32 and the fell of the cloth will have a stable position -4 mm. Now due to weft mixing, the weft diameter is changed to 0.15 mm and remains at that value indefinitely. Table 5.2 shows that a cloth fell distance of -4 mm, with a weft diameter of 0.15 mm will produce a pick spacing of 0.50 mm and a weft cover factor of 0.30 which is only slightly lower than the original cover factor. At the next operation of the take up motion, a



change in the cloth fell position will take place because the pick spacing S (0.50 mm), is not equal to the normal take up rate (0.63 mm). The change in cloth fell position will be ;

$\Delta L = P_2 - S = 0.63 - 0.50 = 0.13$ mm

Thus, the cloth fell at the next pick will be 3.87 mm. The pick spacing will be slightly more than 0.50 mm and the cover factor will be slightly less than 0.30

This process will continue till the pick spacing S is equal to take up rate ($P_2$) i.e. 0.63. Table 5.2 shows that this will take place when the cloth fell position is -2.00.

This means that change over from higher to the lower value of the weft cover factor due to a decrease in weft diameter has occurred slowly because of the slowness of the cloth fell in changing its position to the new weft diameter. This slowness of the movement of cloth fell is due to inertia of the cloth fell.

The immediate change in pick spacing and weft cover factor is derived in Table 5.2 by horizontal arrow and the slow return to the original pick spacing is indicated by a vertical arrow.

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# 6 TAKE-UP MECHANISM

## 6.1 FUNCTION

After the beat up of the weft, the woven cloth is drawn away from the reed at a regular rate and wound on to a cloth roller. The main part of the mechanism is the take up roller which draws the cloth at regular rate and this rate is decided by the number of picks per unit distance (either per inch or per centimetre). The take-up roller is covered with perforated steel fillet or hard rubber depending upon the type of fabric being woven. The drive to the take-up roller is by a train of gear wheels put into motion, either from a stud on the sley sword or directly from the main shaft.

There are two types of take-up motion ; the negative and the positive. The negative take-up has very limited use because the number of picks inserted per unit distance cannot be precisely controlled. It was designed for fabrics where the bulk and weight were the main considerations; for example, heavy fustians and cotton corduroys.

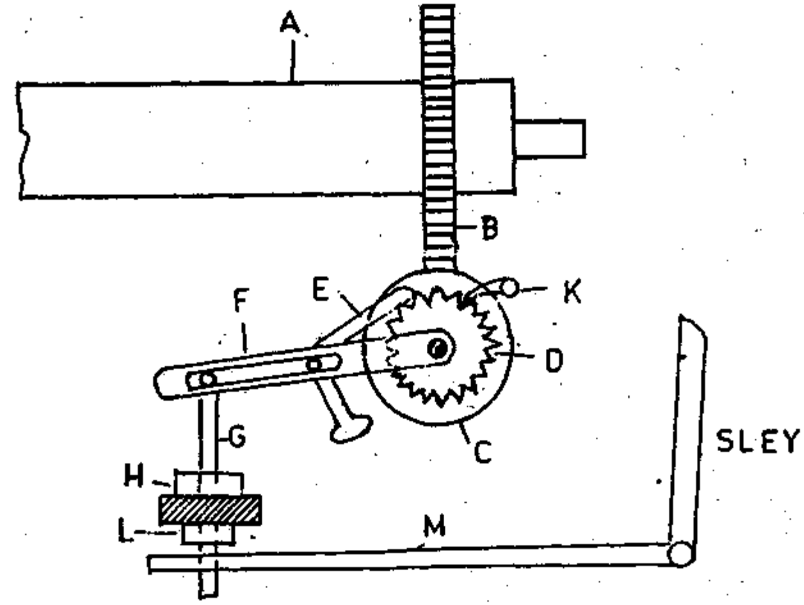
## 6.2 NEGATIVE TAKE-UP

The negative take-up illustrated in Fig. 6.1 is controlled by the tensions of the warp. The cloth roller A is rotated by the worm C and the worm wheel B. The worm C and the rack wheel D are compounded together so that when the catch E operates the rack wheel D, the worm C also rotates. The catch E is mounted on a lever F and also adjustable so that the pull on the rack wheel can be increased or decreased. A rod G attached at the free end of the lever F, has a disc at the bottom for holding the weights H. Beneath the disc, the rod G passes freely through a hole in a lever L which is actuated from the rocking shaft M. The lever L is raised when the sley moves back and lowered when the sley comes forward.

When the lever L is raised, it comes in contact with the disc and raises the rod G and along with it the lever F. The lifting of the lever F enables the catch E to move forward and engage another tooth of the rack wheel. However the downward movement of the lever F along with the rod G, is dependent on the warp beam tension, the weft thickness and the weights H.

As the reed touches the fell of the cloth, the cloth tension falls and the downward pull of the weights makes the catch E to turn the






A = Cloth Roller, B = Worm Wheel, C = Worm, D = Rack Wheel, E = Catch, F = Lever, G = Rod, H = Weights, L = Lever, M = Rocking Shaft, K = Holding Pawl.

**Fig. 6.1 Negative Take-up**

rack wheel D. This pull of the take-up catch is maximum when the weft pick is excessively thick. A holding pawl K prevents the rack wheel D from turning in the opposite direction.

The number of picks per unit distance can be increased by reducing the weights H and decreased by adding more weights.

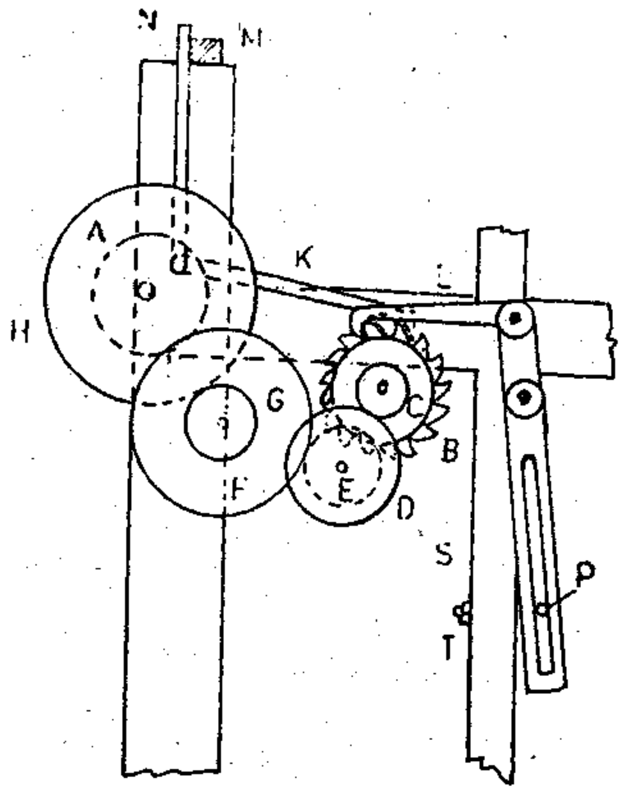
The cloth is wound directly on the cloth roller A. In case the cloth has to be removed from the roller, the worm is disengaged with the worm wheel and the roller is taken out from the frame.

## 6.3 POSITIVE TAKE-UP

### 6.3.1 Seven Wheel Take-up Motion

In positive take-up the cloth is drawn forward by frictional contact with the emery covered take-up roller, which is positively driven through a number of gear wheels, at a uniform rate. The woven cloth on the loom passes over the front rest, around the take-up roller, over a smooth bar and down to the cloth roller.

The take-up roller which draws the cloth forward is covered with perforated steel fillet for weaving heavy fabrics. In case of cloth woven with delicate yarns, cork or rubber covering is suitable.




A = Take-up Roller, B = Ratchet Wheel, C = Standard Wheel, D = Change Wheel, E = Swing Pinion, F = Carrier Wheel, G = Compound Pinion, H = Beam Wheel, L = Pawl, K = Retaining Catch, P = Stud on the Sley, S = Sley

**Fig. 6.2. Seven Wheel Take-up.**

A commonly used seven wheel take up motion is shown in Fig. 6.2. The take-up roller A is driven through gears consisting of seven wheels. The first wheel B called a ratchet wheel is driven by means of a pawl L operated by the sley S. The other wheels in the mechanism include a standard wheel C, a change wheel D, a swing pinion E, a carrier wheel F, a compound pinion G and a beam wheel H. The retaining catch K prevents the ratchet wheel from turning in the reverse direction as soon as the pawl moves back from the teeth.

The number of teeth on each wheel, except the change wheel,



and also the circumference of the take-up roller are constant, so that a direct relation is possible between the picks per unit space and the number of teeth on the change wheel. For example, a 40 teeth change wheel would give 40 picks per inch.

(Note : These calculations are based on established mechanisms, of which most are designed to give the same number of picks per inch as the number of teeth of the change of wheel. The condition would be upset if they are expressed in S.I. Units. That is why the traditional unit of picks per inch is retained here).

In this mechanism ratchet wheel is turned by one tooth for every pick inserted. However, for very less pick density with normal available change or pick wheel, ratchet wheel is turned two teeth.

The amount of cloth drawn forward for each pick can be calculated from the following gear wheels.

A : Circumference of take up roller 15.05 inch
B : Ratchet wheel 24 teeth
C : Standard wheel 36 teeth
D : Change wheel CW
E : Swing pinion 24 teeth
F : Carrier wheel 89 teeth
G : Compound pinion 15 teeth
H : Beam wheel 90 teeth

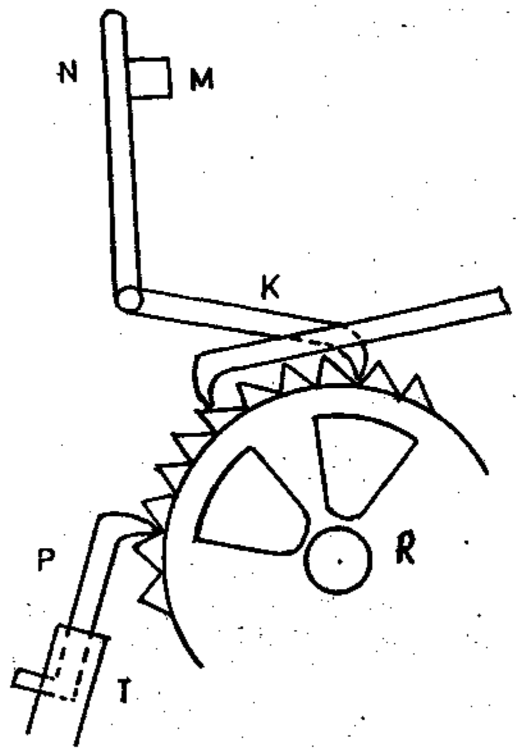
Picks / inch = (24 x CW x 89 x 90) ÷ (36 x 24 x 15 x 15.05)
= CW x 0.98

The picks per inch will be slightly less than the number of teeth in the change wheel. However if 1.5% is considered for the contraction of the cloth lengthwise when it is taken out from the loom, the picks per inch will be equal to the number of teeth in the change wheel. Normally standard wheel is 36, however, for very high or low pick densities, if the change wheel is not available, then standard wheels are also changed.

**6.3.1.1. Setting**

Since different change wheels have to be fitted from time to time to obtain the required picks per inch, every care has to be taken to see that the wheels mesh properly. If a wheel binds at any point, thick place will occur in the cloth that is being woven. If they are meshed too closely the teeth on the wheel may be broken; on the other hand, if they are not meshed close enough, the gears might slip.

If a tooth in a gear is broken, there will be variation in pick spacing and it would recur with an interval corresponding to one revolution of that wheel. For example if a tooth on the compound pinion G is broken, the defect in the cloth would recur as per the following calculation: (15 X15.05) ÷ 90 = 2.51 in. i.e. every 2.51 in.




K = Retaining Catch, M = Weft Fork Lever,
N = Finger Lever, P = Stud, R = Ratchet Wheel, T = Bracket.

**Fig. 6.3 Slip Catch**

A faulty setting of the pawl that works the ratchet wheel may also cause defect in the cloth. Keeping the sley at the back position and the cranks at the back centre, the ratchet pawl is adjusted so that it is about half a tooth beyond the one it will engage at the next forward movement as shown in Fig. 6.3. This setting can be tested by moving the sley forward until the full stroke of the pawl has moved the ratchet wheel one tooth plus a little clearance between the tooth and the retaining catch. In case it is required to cause the motion to take two picks it is possible by changing the position of the stud P on the sley sword. The setting of retaining catch. K is also important. If it fails to drop over the tooth of the ratchet wheel thick places will occur in the cloth.

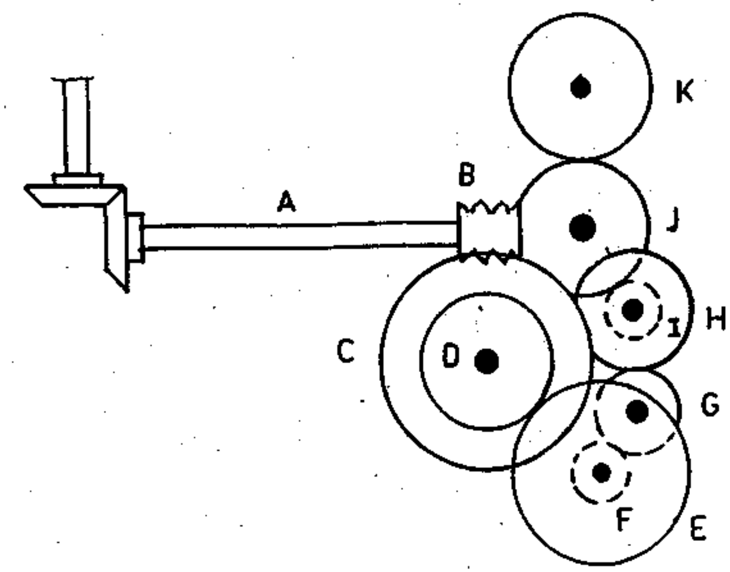
Provision is made for the take-up motion to work in conjuction with 'Side or Centre' weft fork motion, and to let back for 1, 2 or 3 teeth when the loom is stopped by the action of weft fork. This



arrangement will prevent "Cracks" or thin places in the cloth as shown in Fig. 6.3. This motion is known as **Anti-Crack motion.**

Anti-Crack motion : When the loom is stopped by the weft fork motion, the weft fork lever M moves back against the finger lever N thus lifting the catch K out of contact with the ratchet wheel teeth. So the ratchet wheel slips back but the number of teeth the wheel can move backward depends upon the slip catch P and its setting. The slip catch slides loosely in the bracket T.

### 6.3.2. Worm Wheel Take-up Motion




A = Side Shaft, B = Single Worm , C = Worm Wheel, D = Pinion,
E = Pinion Wheel, F = Pinion, G = Carrier Wheel, H = Change Wheel,
I = Change Pinion, J = Carrier Wheel, K = Take-up Wheel.

**Fig. 6.4 Worm Wheel Take-up Motion**

The worm wheel take-up motion shown in Fig. 6.4. is usually geared to the positive rotary dobby. Whenever the dobby is turned forward or backward for pick finding, the take-up motion is also put into working. The object of this is to bring the fell of the cloth to the correct position when the broken pick has been found thus to avoid "Starting place." This type of take-up motion is most suitable for weaving continuous filament yarns.

The side shaft A, which drives the take-up motion, being geared direct to the dobby and crank shaft, turns one complete revolution for each pick. At free end of the shaft is a single worm B which drives a 72 teeth worm wheel C.

Compounded with this worm wheel is a pinion D which gears with another pinion wheel E. Wheel E is mounted at one end of the cross shaft which extends to a position inside the loom framing. At the other end of this shaft is mounted another pinion F which gears through a carrier wheel G with the pick change wheel H. Compounded with the change wheel is a change pinion I which gears through another carrier wheel J, with the take-up roller wheel K. In this mechanism the pick change wheel H is a driven wheel.

The motion is designed to give one pick per tooth of the change wheel and the number of teeth on the wheels are as follows.

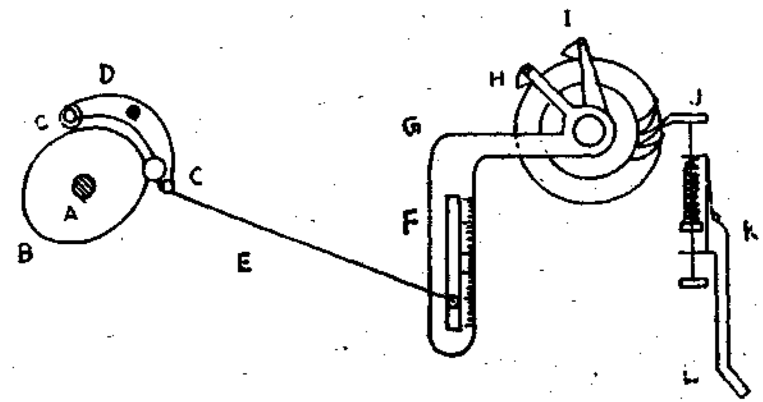
| | |
|---|---|
| Worm Wheel C | . . 72 teeth |
| Pinion D | . . 14 teeth |
| Pinion Wheel E | . . 28 teeth |
| Pinion F | . . 28 teeth |
| Carrier Wheel G | . . 14 teeth |
| Change Pinion Wheel H | . . Change Wheel |
| Change Pinion I | . . 14 teeth |
| Carrier Wheel J | . . 54 teeth |
| Take up or roller wheel K | . . 42 teeth |

The worm take-up shown in figure is directly driven by the tappet shaft or bottom shaft.

### 6.3.3 Lakshmi Ruti C Take-up Motion

Take-up motion of Lakshmi Ruti C type loom is illustrated in Fig. 6.5. This is similar to pickles 7 wheel take-up motion, but the intermittent drive system is obtained by means of a double throw take up cam B, mounted on the picking shaft B and oscillating the follower bracket D. The motion is transmitted to the actuating lever G, loosely mounted on the ratchet wheel stud, through a connector E. The left hand of the connector E rests in a scaled slot of the actuating lever. The scale F facilitates the quick adjustment of pick density. By adjusting the position of the connector on the scale, the actuating lever is made to ride over selected number of teeth at a time. The actuating lever has a driving pawl which actually rides over the ratchet wheel. When it is adjusted to scale 6, only one tooth is taken per stroke and for scale of 10, the number of teeth taken per stroke are two. A stop pawl is mounted on the spring loaded hand release lever A. Catching or limiting pawl J also acts as a retaining pawl and can be disengaged by pressing the pull release lever L when the pawl release bracket allows limiting pawl to swing out.






With the

A = Picking Shaft, B = Take-up Cam, C = Followers, D = Follower Bracket, E = Connection, F = Scale, G = Actuating Lever, H = Driving Pawl, I = Stop Pawl, J = Catching Pawl, K = Pawl Release Bracket, L = Foot Release Lever

**Fig. 6.5 Lakshmi Ruti-C Take-up Motion**

simultaneous operation of foot release lever the take-up roller cam G can be rotated backward or forward.

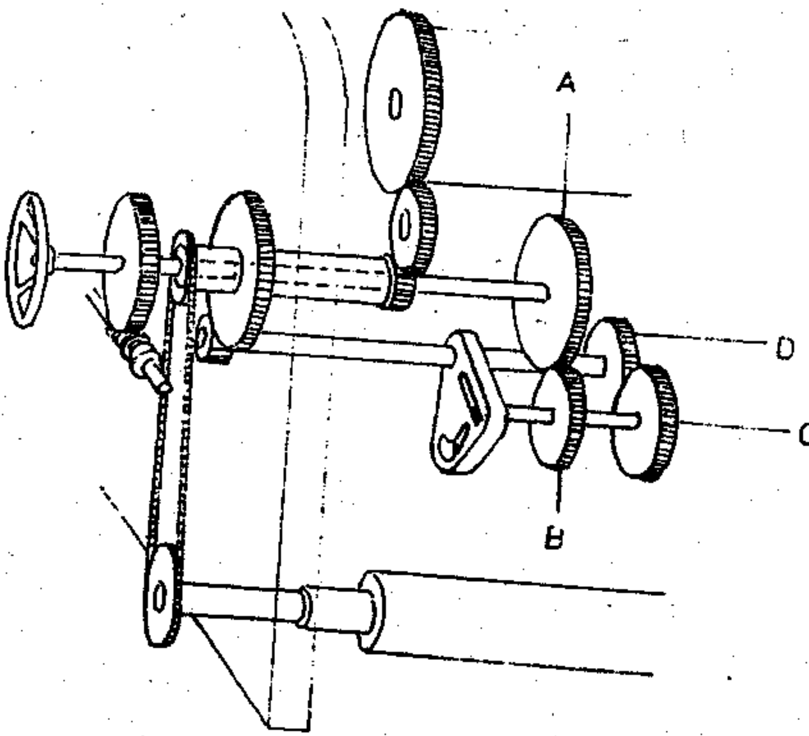
### 6.3.4 Sulzer Ruti Take-up Mechanism

The take-up motion of Sulzer Ruti Weaving Machine as shown in Fig. 6.6 is positively operated. The cloth is wound continuously on a cloth roller by a definite amount at every revolution of the machine. The cloth take-up is adjusted to the required weft density by providing four gears. It is therefore possible to have weft densities between 4 and 75 threads per cm. The manufacturer supplies an elaborate table for the change gears. As per this table it is possible to weave a fabric with a fraction of a pick. For example, to weave a cloth with 10 picks per cm., the change wheels are ; A (38), B (46), C (49) and D (42).

## 6.4 WINDING OF CLOTH ON THE CLOTH ROLLER

Winding of cloth on the cloth roller without creases is another important factor in the take-up motion. The old system of turning the cloth roller by frictional contact on the take-up roller was responsible for the following faults.

1. Whenever the cloth creases as it leaves the breast beam, such creases are ironed out into the fabric while winding on the cloth roller.



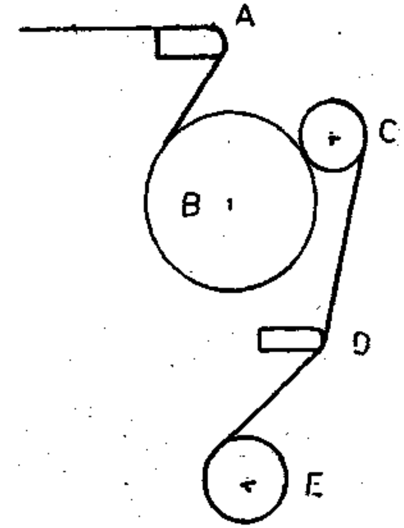

A, B, C, D, = Change Wheel

**Fig. 6.6 Sulzer Ruti Cloth Take-up Motion**

2. Slipping of cloth roller against the take-up roller due to large circumference of the cloth roller at the selvedges, especially with fabrics woven with rayon threads, having strong selvedge. The hard ridge of thicker salvedge at each side of the cloth will cause the take-up roller riding on the selvedges instead of the full width of material.

The take-up arrangement shown in Fig. 6.7 has the cloth passing over the breast beam A, around the emery covered take-up beam B, the spring pressure felt covered roller C, and the crease board D to the cloth roller E. This cloth roller is turned through gears. It is therefore, possible to remove the cloth while the loom is running.






A = Breast Beam, B = Take-up Beam, C = Felt Covered Roller, D = Crease Boards, E = Cloth Roller

**Fig. 6.7 Winding of Cloth on Cloth Roller**

For Industrial fabrics and coarser cloth it is wound on a roller mounted separately at the front of the loom. This system known as batching device; can accommodate more length of fabric than the above system.

## 6.5 ELECTRONIC TAKE-UP

Electronics take-up motions were exhibited at ITMA-91 by which it is possible to control the pick spacings precisely by means of a servo motor. Emery or rubber covered rollers are now dispensed with.

# 7 LET-OFF MECHANISM

## 7.1 FUNCTION

Function of the let-off mechanism is to allow the warp to move forward by unwinding it from the weaver's beam maintaining a predetermined warp tension. The warp tension is essential to form a clear warp shed for the easy passage of the shuttle or the other weft insertion element and in helping the fell of the cloth to remain in the same position during the beat-up. The beaten pick is also retained at the fell after beat-up because of tension and also due to crossing of warp shed. The warp should be kept under predetermined tension which must obviously remain uniform for good weaving to produce fault-free fabrics. Throughout the weaving process the tension of warp must follow the criteria which are as follows :

(i) The warp sheet is repeatedly divided into two layers to form a shed for the passage of shuttle resulting in variation in warp tension during a weaving cycle. This cyclic variation is necessary to get a good cover. This aspect will be discussed in detail later on.

(ii) The tension on warp should be minimum, for a particular quality of fabric, as tension above the optimum value tends to increase the warp breakage rate and affects the dimensional and physical properties of the fabric. For heavy fabrics more tension is required.

(iii) The warp beam diminishes in diameter as the weaving continues, necessitating a gradual increase in the angular movement of the beam for letting-off a constant length of warp.

(iv) During weaving, warp threads undergo frictional contact with different parts of the loom, such as back rest, dropwires, lease rods, healds, reed etc.

Since all the factors must be taken into consideration before adjusting the warp tension ideally suited for a particular fabric, some skill and judgement on the part of the weaver is required.

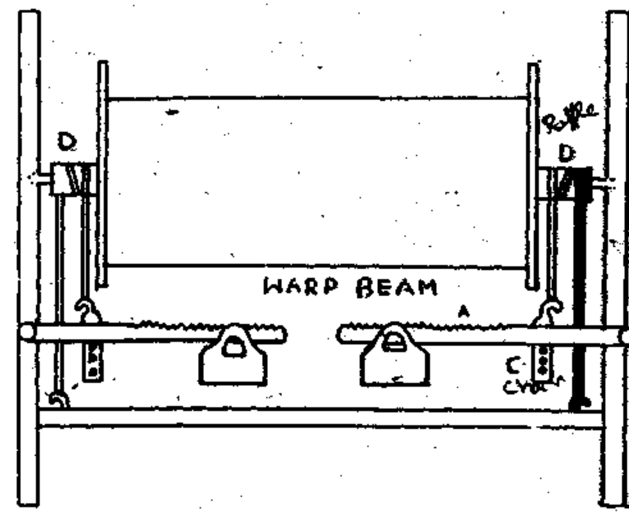
The ideal condition in the case of let off motion would be to deliver the warp in lengths corresponding exactly to those taken up by the take-up roller plus crimp of warp, maintaining the uniform tension or strain throughout the unwinding of warp from the beam without any adjustment and a constant length of warp sheet between the fell of cloth



and the beam. However, such condition is not possible in all types of let off motions. Only positive automatic let-off motions can fulfill this condition.

As in the case of take-up motion, the let-off motion is also classified as negative and positive.

## 7.2 NEGATIVE LET-OFF MOTION




A = Lever, B = Stud, C = Hook, D = Ruffle.

**Fig. 7.1 Negative Let-off Motion**

The negative let-off motion illustrated in the Fig. 7.1 is the most common type used on many non-automatic looms. Though this mechanism is very simple and less costly, cloth faults like cracks and thick places cannot be avoided. It is also liable to cause short, medium and long term warp tension variations throughout the weaving down of the warp. In the Fig. 7.1 the warp beam mounted at the back of the loom is tensioned by dead weights placed on a lever A fulcrummed on stud B and is coupled to the weight chain/rope by the hook C. The other end of the long chain/rope coiled around the ruffle D is connected by a hook to the loom frame. The friction between the chain/rope and ruffle resists the movement of the beam. The number of laps on the beam ruffle depends upon the tension required on the warp. Higher the number of loops, more will be the tension on warp. However, number of loops should not exceed two.

In this mechanism, when the cloth is pulled forward by the action of the take-up motion assisted by the action of reed beating the weft to the fell of cloth, the warp tension increases. The let-off occurs when the increase in warp tension is sufficient to overcome the static resisting the rotation of the beam. The beam starts moving and the tension drops down. It continues to move until the warp tension sufficient enough to over-come the dynamic friction. The beam stop again starts moving when the tension increases. The frequency cycle of short term tension variation depends upon (i) the diffe between the *static and* dynamic friction (note : static friction is g than *dynamic friction*), (ii) the modulus of elasticity of warp ; and (i *rate of take-up* for normal fabrics, the cycle repeats in two, three o picks. This **stick-slip** action which is an *inherent feature* of the neg let-off, causes short term tension variation. With this type of let-off, must be taken that the cycle occurs *regularly* and not too infrequ Otherwise the consequent variation in tension may cause fabric consisting of thick places as tension builds up, followed by thin one even cracks, when the let-off occurs.

Medium term warp tension variation takes place due to ch in the co-efficient of friction between the *faces* of the ruffles and ropes/chains. Patches of oil, dirt, rust or, rough or excessively sm surfaces cause a variation in the co-efficient of friction.

Long term tension variation occurs as the beam weaves *from start to finish*. This variation is also inherent in the syste *negative let-off*. As the beam weaves down, if the weights on the w lever remain unchanged, the warp tension increases. For example, diameters of full and empty beams are 60 and 20 cm respectively, would be an increase in tension 1:3 times between full beam and en beam. The gradual increase in tension does not produce any vis fabric faults, but warp breakage increases. To maintain the tension reasonably constant level, the weaver has to reduce the weights or them towards the fulcrum of the weight lever at intervals. However, th is no correct guidance for the weaver as how much to reduce the weig and at what intervals. It is left to the experience and discretion of weaver and such a practice will always cause a thin place if the wea is not careful.The *removal* of weights cause strain on weavers and also lead to *accidents* through weights falling over or being dropp accidentally. On certain negative let-off motions there are provisions *reduce* the total force exerted by the weights as the beam diame decreases by means of a beam feeler through the action of a cam. T type of let-off is known as 'modified' or 'controlled' negative let-off motio

When ropes are coiled around the ruffles French chalk is the b material. In some mills French chalk or black lead is applied to the ro at the end of every cut.

There are many factors that determine the correct warp tensi and these are (a) weave, (b) counts of warp and weft yarns, (c) picks p cm (or inch) and warp ends per cm (or inch), (d) the size of the wa



shed, (e) timing of the shed, (f) length of the warp, (g) the diamete the warp on the beam.

## 7.3 POSITIVE LET-OFF MOTION

The basic objective of the positive let-off motion or controlled off motion is to prevent the long term tension variation as the be diameter decreases from full beam to empty beam. Certain positive off motions e.g. Roper, Bartlett, Ruti etc. where the beam is positiv released by the driving mechanism, the actual let-off takes place by tension of the warp. This is sometimes called as 'semi-positive let- The advantage of this mechanism is that once the mechanism is correctly to produce the desired tension further adjustments are necessary. The weaver does not have to adjust the weights dur weaving down of the warp. There are no loose weights, ropes or chai

### 7.3.1 Basic Requirements

Basic requirements of a positive let-off motion (1) are :

(i) It should maintain a uniform warp tension throughout weaving of warp. This means the mean warp tension during every lo cycle should be the same throughout.

(ii) It should be capable of turning the warp beam at a rate wh will maintain a reasonably constant length of warp sheet between beam and the cloth fell.

(iii) It should meet these two requirements without any furth adjustment after the initial setting up at the beginning of the warp.

In order to obtain the two conditions of uniform tension constant warp sheet length, it is necessary to employ two disti mechanism–a tension controlling mechanism and a beam drivi mechanism.

### 7.3.2 Tension Control Mechanism

In positive let-off motions, the most common way of apply tension i.e. force is by means of the back rest which is set to pr against the warp sheet, as shown in the Fig. 7.2. Back rest is also term as whiproll, back roller or back rail. The force F exerted by the back on the warp sheet can be calculated as follows.

$$F = \{W \times (a / b) \times (c / d)\} + f \quad \text{..........(}$$

where, f is the constant force due to weight of levers connecting rods.

With this system warp tension would be constant if the tensio solely dependant on the force F. But, in fact with the positive le motions, there are possibilities of three sources of variations which as follows.

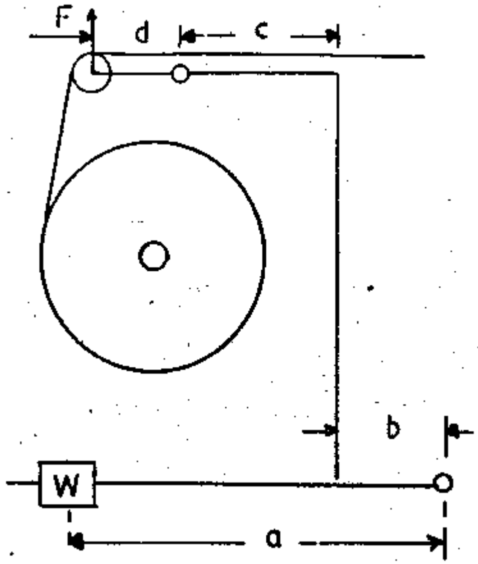



Fig. 7.2 Warp Tensioning by Weight

### 7.3.2.1 Effect of warp beam diameter

As the beam goes down, the angle of warp sheet from the beam changes and this chage in angle is responsible for a gradual change in warp tension. The reason for the variation in tension is explained as follows.

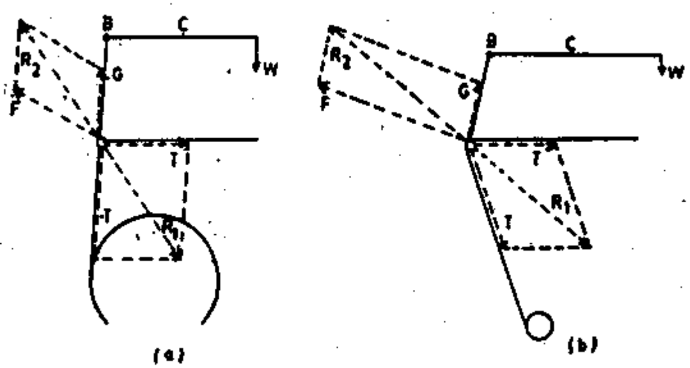



Fig. 7.3 (a, b) Change in Warp Tension on the Beam Falls

As shown in the Fig. 7.3, the resultant of the warp tension T before and after the back rest is $R_1$. Since the system is in equilibrium, $R_1$ is



balanced by an equal and opposite force $R_2$. The magnitude of $R_2$ is determined by the resultant of force F and another force G which is the stress in the short arm or swing arm from which the back rest is supported. The lengths and directions representing the various forces give the relative size and directions of the forces. Marks and Robinson (2) derived equations for forces acting at a backrest as follows.

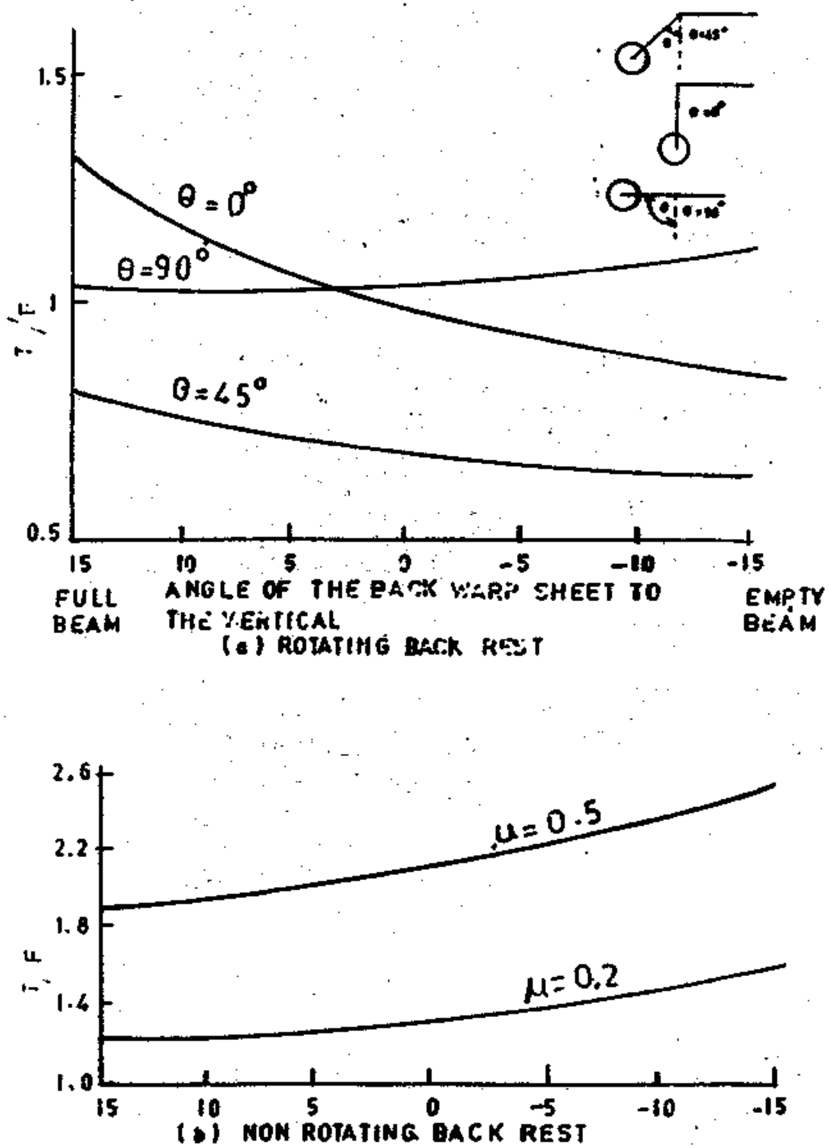



Fig. 7.4 Effect of Angle of Warp Sheet at Back Rest on Warp Tension

(a) **for freely rotating backrest, the equation is**

$T = F / \{2 \cos \alpha . \cos (\alpha - \theta)\}$ ..........(7.2)

where, T = Warp tension

F = Force exerted by back roller on warp threads.

$\alpha$ = Half the angle between top and bottom sheet.

$\theta$ = Inclination of swing lever with respect to vertical.

As the beam weaves down, the angle between the top and bottom warp sheet reduces as shown in Fig. 7.3b. This cause the resultant forces $R_1$ and $R_2$ to rotate in anti-clockwise direction but force F has the same magnitude and direction because the weight W has remained constant. So this changes in direction may reduce the length of the resultant forces $R_1$ and $R_2$ representing the warp tension T. So merely by decreasing the beam diameter a drop in warp tension occurred (this is opposite to what occurs with a negative let-off).

The precise way in which the warp tension changes as the beam diameter reduces can be calculated by using Eq. (7.2). It is found by Foster (1) that this also depends upon the angle at which the back roller is suspended from the swing lev pivot i.e. the angle $\theta$. Fig. 7.4 shows the changes in tension from full beam to empty beam for three such angles. The figures indicate that when $\theta$ is 90°, (which is more common) the warp tension will remain more or less constant from start to finish of a beam. But when the angle is 45°, the warp tension will decrease by 20% or more from start to finish of a beam. This reduction can be overcome by placing an extra rail between the warp beam and the normal back rest as shown in Fig. 7.5. This method is used on Crompton and Knowles, Toyoda let-off motions when $\theta = 0°$, there is a large fall in tension. This method of suspension of back rollers is used on Cimmco looms.

(b) **for fixed back rest**

So far it is considered that no frictional effect occurs at the back rest because back rest is rotating freely on bearings at the ends of the two swing lever arms. However, when the bearings are crude and if there are any obstructions in rotation, then there will be a middle term tension variation. Even with perfect bearings, a further warp tension variation can arise if the back rest is not perfectly straight or parallel with the floor.

When the back rest is fixed to the swing lever e.g. Saurer looms, in that case it cannot rotate. This means, as the warp sheet passes over the back rest, friction between them takes place. This makes the tension in the top warp sheet greater than the back warp sheet. Further, the angle of warp with back rest increases with the decrease in beam diameter. Marks and Robinson (2) derived equation to calculate the tension, under this condition as follows.



$T_1 = F. \sin \alpha / \{ \cos (\alpha - \theta) \sin (\alpha + \beta) \}$ .......... [7.3]

$T_2 = F. \sin \beta / \{ \cos (\alpha - \theta) \sin (\alpha + \beta) \}$ .......... [7.4]

where, $T_1$ = Tension of top warp sheet,

$T_2$ = Tension of bottom warp sheet,

$\alpha$ = Angle of top warp sheet with respect to resultant force $R_1$

$\beta$ = Angle of back warp sheet with respect to resultant force $R_1$

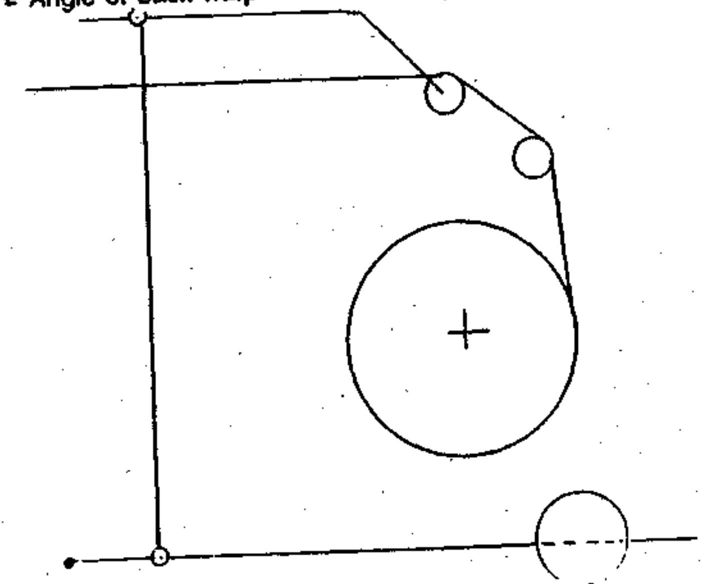


**Fig. 7.5 Extra Roller between Warp Beam and Back Rest**

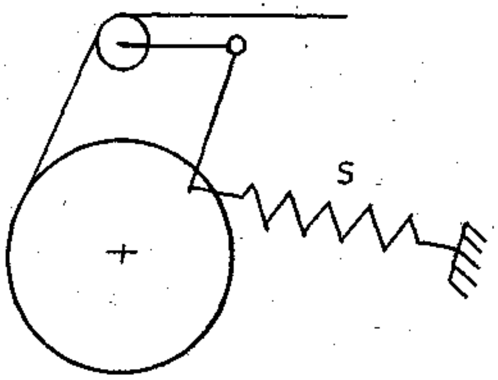
Other notations are same as in Eq.(7.1)

Marks and Robinson found that when $\theta$ = 90°, which gives the minimum tension variation with freely rotating back rest, the effect of coefficient friction of 0.2 is negligible but that of a value of 0.5 is considerable as shown in Fig. 7.4. For synthetic yarn weaving where the value coefficient of friction may reach 0.5, rotating roller is recommended. Since the trend of the curves in Fig. 7.4 is opposite, a value of $\theta$ between 45° and 90° will give the best results for a non-rotating back rest, however exact value will depend upon the expected coefficient of friction and the angle of warp.

### 7.3.2.2 Tensioning by spring

In some positive let off motions, the dead weight is replaced by a spring as shown in Fig. 7.6 and this introduces an additional warp tension variation which is super impossed on those already discussed. This is because in the case of weighted motion, the downward motion of the back rail in order to keep a constant rate of let-off has no appreciable effect on the warp tension because the value of F remains reasonably constant over the range of upward movement of weight lever. But in the case of spring loaded motion the downward movement of the back rail compresses the spring and therefore F increases. Thus, with this type of loading arrangement the decrease in the beam diameter causes an increase in the warp tension by virtue of the spring compression. This variation can be avoided to a certain extent by employing beam diameter feeler.

The abrupt changes in the back rest position have no effect on the warp tension when using a weighted motion, but with a spring loaded motion the spring length changes at these points and so the tension of the warp also changes.




S = Spring

**Fig. 7.6 Warp Tensioning by Springs**

#### 7.3.2.3 Beam driving mechanism

It has been mentioned above that one of the basic requirements of a positive let-off motion is that it should maintain a reasonably constant length of warp sheet betweem the fell of the cloth and the beam. To achieve this, the rate at which the warp is unwound from the beam should be the same as that at which the warp is being pulled up into the cloth at the fell. The positive drive to the beam from some moving part of the loom which may be the sley or a separate cam on the bottom shaft. One of the beam flanges is generally provided with gear teeth so that the beam can be rotated suitably through a gearing, or alternately a separate gear wheel may be fixed on the beam ruffle for this purpose.

A large number of positive let-off motions have been developed and used on looms. Some of these are discussed in this chapter to illustrate the principles of positive let-off motions.

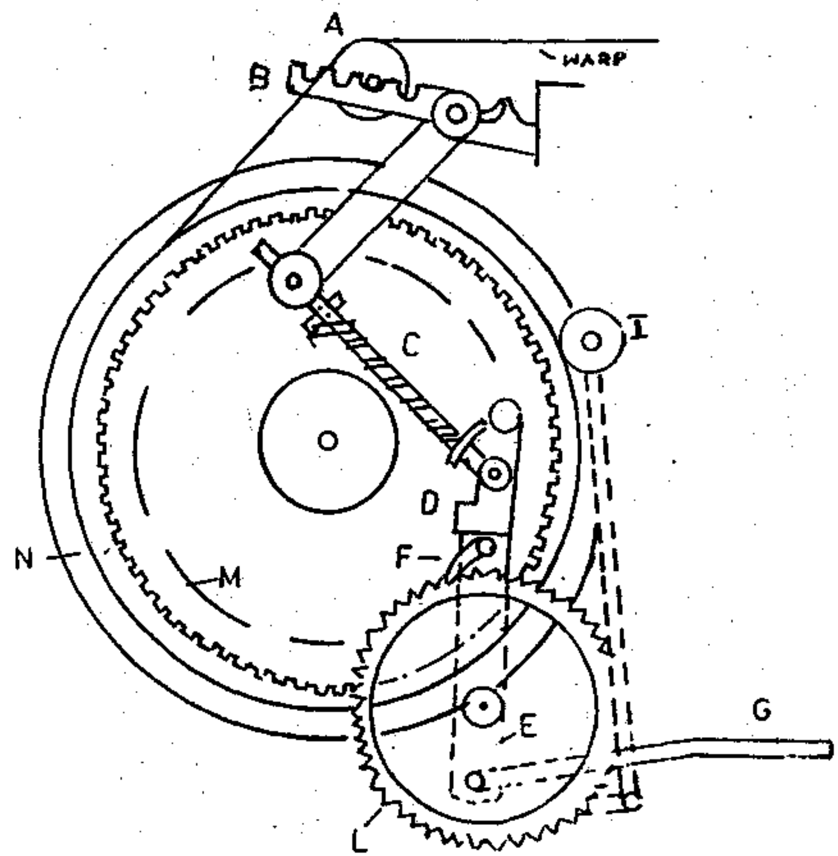


## 7.4 ROPER LET-OFF MOTION

This automatic let-off motion which is designed to weave light to medium weight fabrics is shown in Fig. 7.7. For better understanding the mechanism can be divided into six main sub-units.

### 7.4.1 Control Unit

Comprising the back rest (whip roller) A, back rest arms B, pillar spring C and control lever D.




A = Back Rest, B = Back Rest Arms (Swing Lever), C = Pillar Spring, D = Control Lever, E = Let-off Pawl Lever, F = Pawl, G = Driving rod, H = Double Ended peg, I = Beam Feeler, J = Beam Feeler Shaft, K = Connecting Link, L = Ratchet Wheel, M = Beam Wheel, N = Warp Beam.

**Fig. 7.7 Roper Lef-off Motion**

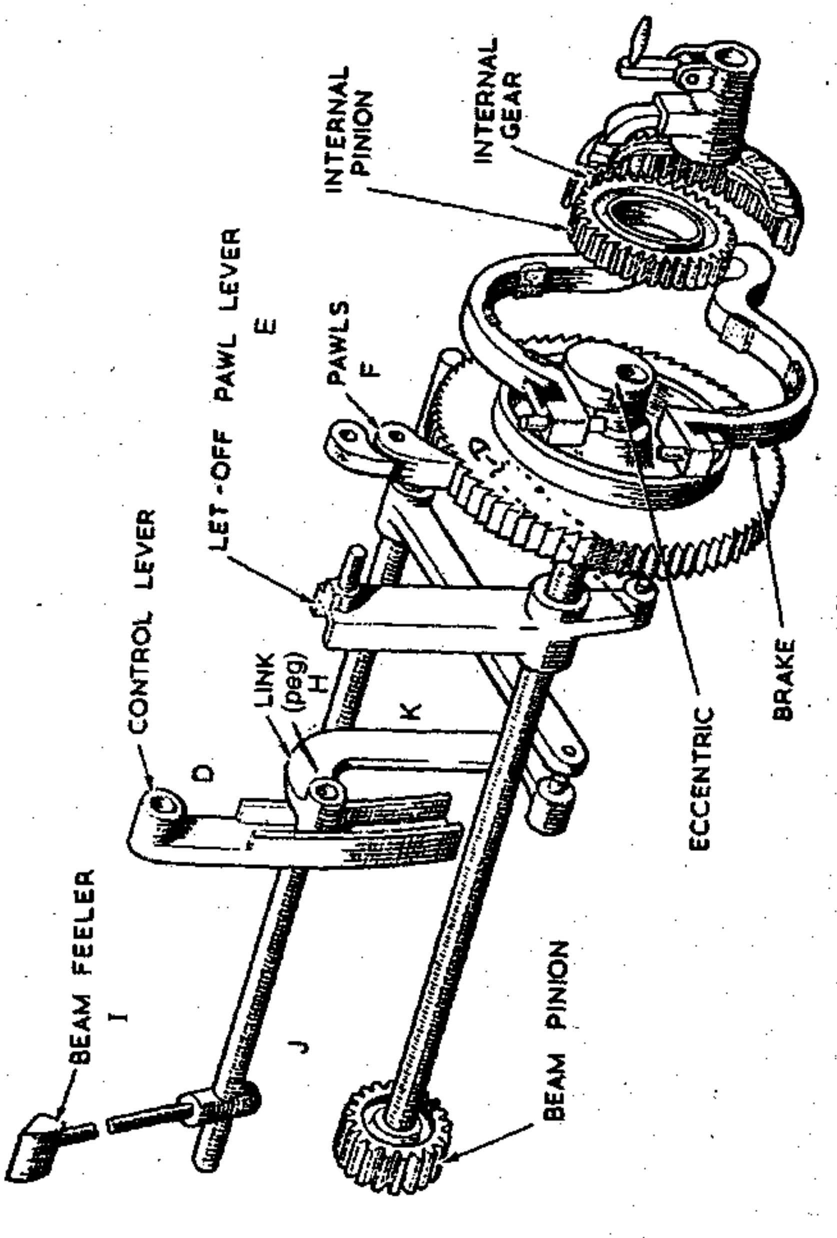



Fig. 7.8 Control Lever and Beam Feeler



### 7.4.2 Let Off Pawl Unit

Comprising the let off pawl lever E, the let off pawls F (fulcrummed at the upper end of let off pawl lever) and driving rod G extending to the sley sword.

The control lever D and the let off pawl lever E are provided with long grooves into which slides the double ended peg H provided at the upper and of the connecting link. These grooves face each other as shown in Fig. 7.8.

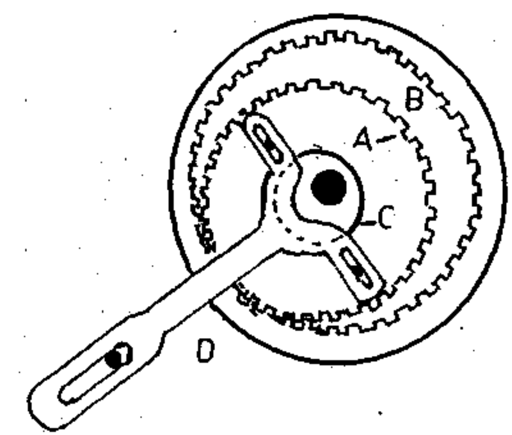
### 7.4.3 Beam Feeler Unit

Comprising the beam feeler I which rests on the warp beam, the beam feeler shaft J and the connecting link K. This link is provided with a double ended peg which slides into the grooves of the control lever and let off pawl lever (Fig. 7.8).

### 7.4.4 Internal Gears

Comprising an internal wheel (46T or 56T) mounted on the main shaft and an internal pinion mounted on an eccentric.

The internal pinion is prevented from turning by being attached to an eccentric lever. The eccentric which is compounded with a ratchet wheel imparts a reciprocating motion to the internal pinion which causes it to move round the teeth of the internal wheel, thus turning the wheel slowly (Fig. 7.9).




A = Internal Pinion, B = Internal Wheel, C = Eccentric Cam, D = Eccentric Lever

Fig. 7.9 Internal Gearing on Roper Let-off Motion

If the eccentric makes one full revolution, the internal pinion (42T) will turn the internal wheel of 56T, 42/56ths of a complete revolution. The movement of the internal wheel is transmitted to the beam the pinion and finally to the beam.

### 7.4.5 Brake

Comprising the brake drum, the brake band, the spring loaded tensioning device for increasing or decreasing the pressure on the drum thus preventing over running (not shown in the figure).

### 7.4.6 Hand Turning Gear

Comrising a handle mounted on the main shaft which when pulled outwards, presses against a spring loaded plunger to lift the release pawl out of gear from the ratchet teeth provided on the outer face of the internal gear. This handle is provided to turn the beam by hand at any required speed, either forward or backward to slacken or tighten the warp (not shown in the figure).

### 7.4.7 Working of the Mechanism

As the sley moves forward to the front centre, the driving rod is pulled forward and this pulls the lower end of the let-off pawl lever, thus turning the ratchet wheel through the pawls. However, the throw of the let off pawl lever depends upon the position of the peg on the sley sword with reference to the slot in the end of the driving rod. This position of the peg depends upon the initial movement of the driving rod which in turn depends upon,

(a) throw of the control lever,

(b) the position of the double ended peg in the grooves of the control lever and let-off pawl lever.

The throw of the control lever is maximum when the tension on the sensitive back rest is the highest. The beam feeler follows the diminishing diameter of the warp beam and carries with it the connecting link. When the beam is full the double ended peg rests at the top of the groove but as the diameter diminishes in size, it slowly moves down. The effect of this movement is to increase the throw of the let-off pawl lever and turn the beam at a gradually increasing speed. The pressure of the coil spring on the spring pillar can be increased or decreased to suit the weight of the fabric. Similarly the whip roller position can also be altered to suit the weight of the fabric. When weaving heavier fabric, the whip roller is placed in the inner slots and vice-versa for light weight fabrics.

### 7.4.8 Setting

(i) With the loom at the front centre, adjust the drag rod so that there is 18-20mm clearance between the top of the let-off lever and the stop on the control lever bracket.

(ii) The beam feeler should be set so that connecting peg is 6 mm from the bottom of the groove in the control lever when the feeler is resting on an empty beam.

(iii) If the motion is set correctly, the action of depressing the back rest as far as possible by hand, with the sley at back centre should move the let-off pawl the full length of its throat.



### 7.4.9 General Comments

(i) Even though the variable linkage and the sensitive back rest with θ=90° is provided to ensure that there is no significant rise in the warp tension, beyond the pick to pick variation before the mechanism reacts, there is actually some variation taking place because the spring is provided only on one side unlike in the Bartlett let-off and it does not give proper compensation.

(ii) The unwinding of the beam at any moment should be just sufficient and should follow instantaneously after the demand has been indicated by the depression of the back rest. However, for Roper let-off, if the assembly of driving agency is analysed, there are in all seven mechanical links through which the motion of the sley is transmitted to the beam. These points are (i) Stud on sley sword and link, (ii) the driving rod and the let-off pawl lever, (iii) the lever and pawls, (iv) the pawls and the ratchet wheel, (v) the ratchet eccentric and the internal pinion, (vi) the pinion and the internal wheel fixed on the shaft, and (vii) the shaft pinion and the beam wheel. With this nature of drive involving several mechanical links, it is quite likely that there is a possibility of time lag between the instant when the back rail demands let-off for a pick and the instant of actual let-off from the beam.

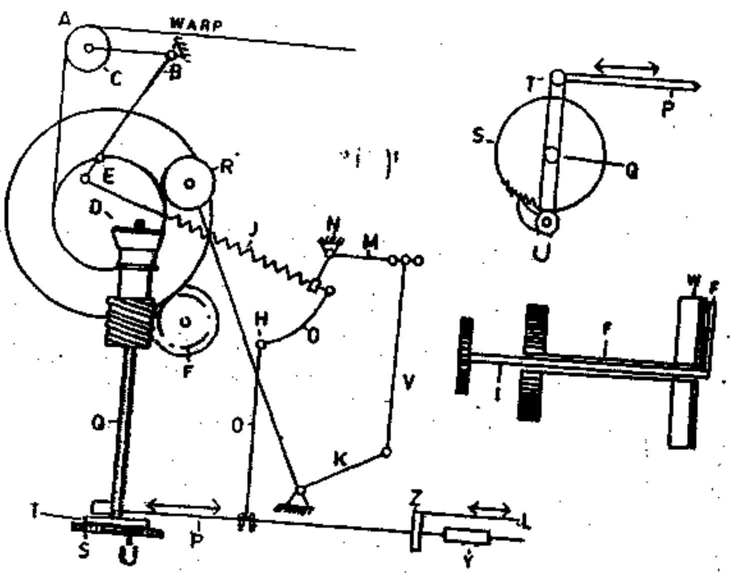
## 7.5 BARTLETT LET-OFF MOTION

This motion is fitted to Northrop Looms and is suitable for weaving medium or light weight fabrics.

### 7.5.1 Tensioning System

Tensioning system comprises a whip roller, a swing lever and a spring. As shown in Fig. 7.10, a whip roller A is carried on two swing levers C, one at each side of the loom, which are pivoted on the studs B on the loom frame. The other arms of levers C have two holes E. One end of the rod D is secured to one of the holes by means of a stud. Two rods D, one at each side, have a threaded portions for adjustment of the length of compressed spring. At one side of the loom (the side illustrated in the fig 7.10), the other end of the spring is compressed against the end of lever M pivoted on the loom frame N; rod D passes through a slot in

M to a stud on lever O. As the beam feeler R is lowered due to the decrease of the diameter of beam, it functions through the medium of connecting rod V, and lever K so as to cause the lower end of the lever M to allow the spring to expand on the shaft D. Because of the lengthening of the spring, it is necessary to increase the compression of the spring on the other side of the loom (not shown in the Fig.) by an equal amount, so that the sum of the forces exerted by the two springs will remain constant. This is achieved by compressing the spring against a fixed stud on the loom frame.




A = Back or Whip Roller, B = Studs, C = Swing Levers, D = Rod, E = Two Wholes, F = Let-off Shaft, G = Catch, H = Stud, J = Spring, K = Lever, L = Draw Rod, M = Lever, N = Loom Frame, O = Lever, P = Drug Rod, Q = Vertical Shaft, R = Beam Feeler, S = Ratchet Wheel, T = Let-off Lever, U = Pawl, V = Link, W = Hand Wheel, X = Brake Drum, Y = Collar, Z = Collar on Draw Rod.

**Fig. 7.10 Bartlett Let-off Motion**

### 7.5.2 Beam Driving Mechanism

Lever, O to the top of which is connected rod D, swings on stud H mounted on the loom frame, whilst its lower end carries a slot through which passes rod P. The operating position of lever O on the rod P is set by two collars, one on each side of O, which are fixed to P in any desired position. One end of the rod P is pivoted on the end of let off lever T which is free to move on the vertical shaft Q. The opposite end of T carries a pawl U which is spring loaded against a ratchet wheel S keyed on the shaft Q.



The shaft Q also carries a worm which drives a worm wheel mounted on a sleeve. The release wheel is mounted on the end of the sleeve. As the release wheel rotates because of the action of the pawl, it actuates the release assembly, since the catch G is located in one of the teeth of the release wheel the catch is mounted on the let-off shaft F. As a consequence of the releasé wheel being turned, the release handle assembly also rotates and allows the beam to rotate by tension through the let-off shaft and let-off wheel.

On the top end of the shaft Q is a hand wheel W for turning the warp beam manually and immediately below this is a brake drum X around which is located a brake strap to prevent over running of the motion. At the other end of the drag rod P is a collar Y. Oscillation of the sley imparts to and fro movement to the collar Z through draw rod L (To and fro movement of collar Z can be also obtained by a cam mounted on bottom shaft). The contact between collar Y and Z and movement of the collar Z, moves the drag rod.

### 7.5.3 Working of the Mechanism

As the sley moves forward to the front centre the ratchet wheel turns through the action of draw rod and let-off lever. The throw of the pawl depends upon the distance between the collar Z on the drag rod and collar Y on the bottom part of draw rod. The tension of the warp felt by the whip roller, either decreases or increases the effective throw of the pawl lever.

As the beam weaves down the beam feeler feels the dimishing diameter of yarn on the beam and through various lever connections, the spring J is lengthened. This allows the drag rod to move further due to expansion of the spring, but the whip roll assembly is able to increase its oscillating movement and this permits greater freedom of movement to the lever O. As the whip roll is depressed, the lower part of the lever O will be moved towards the rear of the loom taking with it the drag rod P, through contact with the collar. This results in the greater throw of the let-off lever thereby turning the beam at increasing speed to maintain an even rate of yarn let-off.

### 7.5.4 Settings

(i) Turn the loom to top centre.

(ii) If Y and Z are not in contact, wind warp on to the beam by hand until they bear against each other.

(iii) The pawl lever T should now be at right angles to the loom frame. If it is not correct, correct this by loosening Y or Z and moving them to the position on the corresponding rod which will give this position of T, Y, and Z should, off course, remain in contact whilst this is being done.

(iv) The lever O should be vertical. If this is not, move it by repositioning the two collars on rod P.

(v) Place the rod D in the required hole E. Normally upper one is used. Changing from upper to lower one increases the warp tension.

(vi) Place the back rail in the required position on the swing levers C. The inner one gives the maximum tension.

(vii) The whip roll should be horizontal along its length so long as the heights on the bearings B on the loom frames are the same at both sides.

(viii) Place the top end of the rod V in the appropriate hole in lever M. Using the hole nearest to the pivot N results in the largest movement of M for a given change in the beam diameter and this setting is suitable for low picked cloth. The centre hole is suitable for most fabrics, but when high picks per cm are being woven, the outer hole gives the least tension variation.

(ix) The warp tension is adjusted by changing the compression of the springs J by means of screws on the rod D.

### 7.5.5 Comments

Because the whip roller is carried horizontally outwards from the pivot B, the tension changes caused by the gradual reduction will be similar to those shown by the curve θ=90°. Barlett motion with three pawls instead of single pawl is preferred becuase abrupt changes in warp tension occur very freqently along the warp.

## 7.6 RUTI-B LET-OFF MOTION

The Ruti-B let-off motion resembels the Bartlet let-off motion in many respects. The motion shown in Fig. 7.11 is driven from a cam on the bottom shaft but it may also be driven from the sley sword.

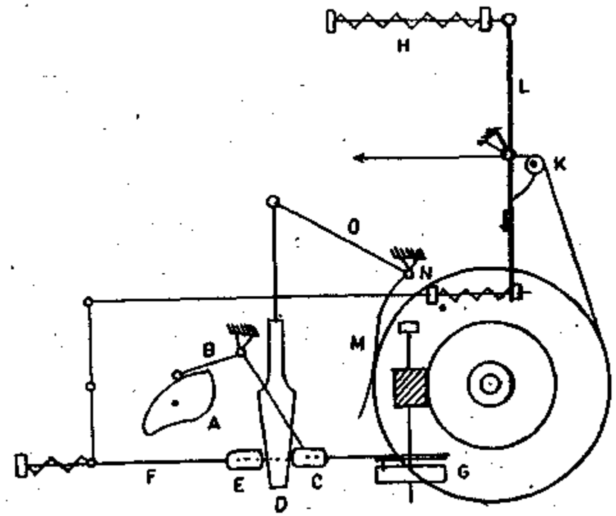
### 7.6.1 Tensioning Device

As shown in Fig. 7.11, the tensioning device comprises of sensitive back rest K, vertical lever L and tension springs H. According to kind of fabrics woven, springs are supplied with either 5, 6,7 mm diameter wire; heavier the fabrics, more is the diameter of wire.

The sensitive back rest K is supported on small arms projecting from the vertical lever L which is connected to the horizontal tension spring at the top. The movement of the back rest is trasmitted to the driving rod F at the bottom through a series of links. An increase in the warp tension causes the back rest to be depressed and the whole



system moves in such a way that stop E is brought nearer to the stud C (or compensation lever D) with consequent increase in the rotation of the ratchet wheel. A decrease in warp tension causes the reverse action, which reduces the amount of let-off.




A = Cam on Bottom Shaft, B = Lever, C = Stud, D = Compensating Lever, E = Stop, F = Driving Rod, G = Ratchet Wheel, H = Tension Spring, K = Back Rest, L = Vertical Lever, M = Beam Feeler, N = Fulcrum, O = Link.

**Fig. 7.11 Ruti Let-off Motion**

### 7.6.2 Beam Driving Arrangement

Each time the cam raises the bell crank lever B, the stud C is moved towards the left so that it presses the compensator D against the stop E fixed on the link F. The resulting motion imparted to this link turns the rachet wheel G and the beam through a warm reduction gear. The amount of let-off or the extent of ratchet wheel movement is determined by the position of the stop E on the link F which is controlled by the movement of back rest as mentioned earlier.

The beam feeler arrangement consists of the feeler M fulcrummed at N, and connected to the wedge D through the link O. As the beam diameter is reduced, the feeler M moves in and lowers the compensator D in between the driving stud C and the stop E on the link. This causes the effective distance between C and E to be reduced, so that the stud comes in contact with the stop earlier and gives increased rotation to the ratchet wheel.

### 7.6.3 Settings

(i) With the sley at the front position, adjust the cam so that antifriction bowl on the bell crank lever B is at its highest position.

(ii) With the sley at the back centre, the driving lever must be inclined at angle of 30° towards the front of the loom.

(iii) The horizontal spring should be tightened so that the link L is in vertical position.

(iv) Bring the stop E to rest against the compensator D.

(v) Pressure spring of the brake band (not shown in Fig.) should only be tightened as much as will be required for the ratchet to be advanced by the pawls the exact distance covered by horizontal rod and lever.

### 7.6.4 Comments

Comments on this mechanism are similar to those of Barlett let-off. Different compensators are used according to the number of picks.

## 7.7 CIMMCO LET-OFF

This type of let-off is being used on Cimmco looms, Sakomoto looms.

### 7.7.1 Tensioning Device

Tensioning device consists of a whip roller A as shown in Fig. 7.12 which is made to press against the w... sheet by means of a weight through a series of levers. The whip roll... held by means of a whip roller bracket which is almost parallel with the vertical i.e. θ=0°

### 7.7.2 Beam Driving Arrangement

The ratchet wheel G is driven from the rocking movement of the sley sword C through the driving arm D, auto beam adjustor E, vertical lever F. The ratchet wheel G drives the beam wheel I through bevel wheels and worm H.

As the beam diameter reduces, beam feeler J moves the stud on the auto adjuster down through a series of levers.

### 7.7.3 Working

As the sley moves forward and backward, the pawl swings forward and backward. Its movement is controlled from the whip roller and the beam feeler. As the whip roller moves down, it swings the pawl backward to give movement to the ratchet on its subsequent forward motion.

As the beam goes down, the stud on the auto beam adjustor goes down to give a more swinging motion to the lever and this motion is transmitted to provide more movement to the pawls to increase the angular rotation of the beam.

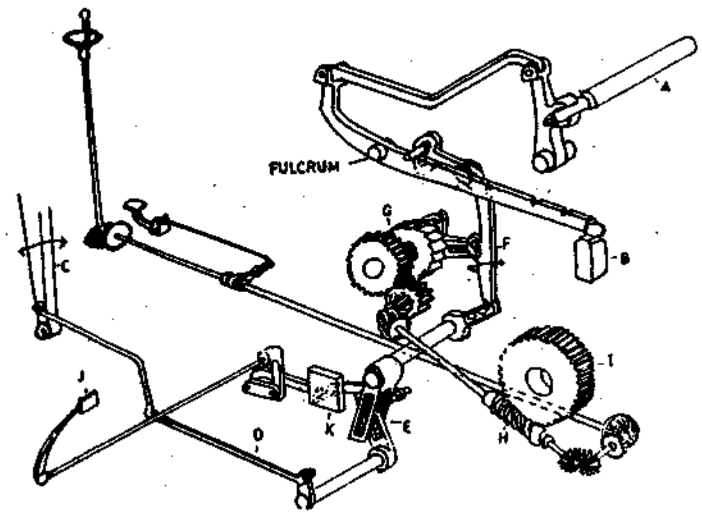
### 7.7.4 Comments

The particular form of mounting the whip roller in relation to the whip roller bracket fulcrum results in a graudal fall in the warp tension as



the beam empties (see section 7.3.2) so long the weight B remains at the same fixed position on the weight lever. This would be corrected by keeping the weight nearest to the fulcrum at the starting of the beam and then moving the weight outwards, on the weight liver as the beam diameter decreases, but this method is not recommended. If this tension drop is considered to be serious, extra rail should be provided a mentioned earlier.

There is a provision to rotate the beam from the front of the loo by means of hand wheel as shown in Fig. 7.12




A = Whip Roller, B = Weight Lever, C = Sley Sword, D = Drive Arm, E = Auto Beam Adjustor, F = Vertical Lever, G = Ratchet, H = Worm, I = Beam Drive Gear, J = Beam Feeler, K = Slot Plate.

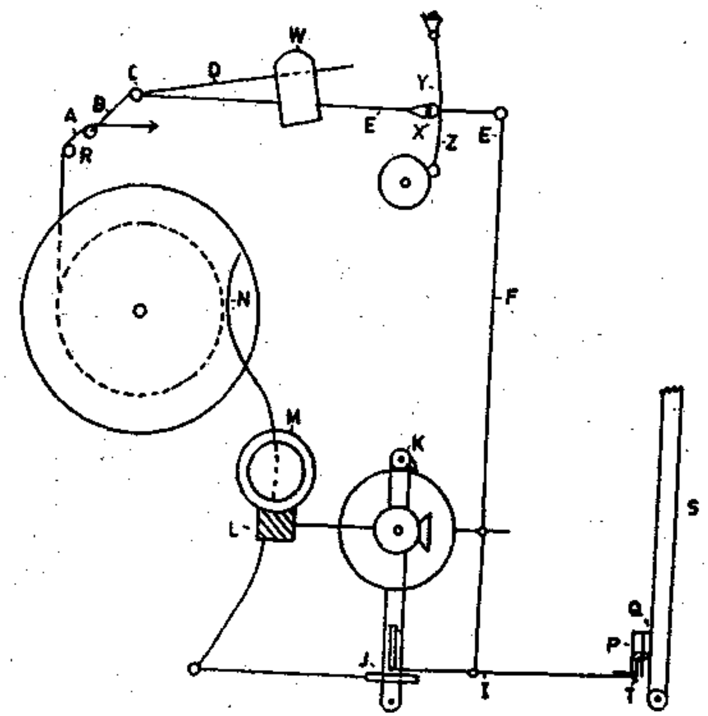
**Fig. 7.12 Cimmco Let-off Motion**

## 7.8 TOYODA LET-OFF

Toyoda let-off mechanism has certain interesting features w are different from those of Barlett, Roper or Ruti-B motions. The tension is developed through a sensitive back rest which is weight means of a dead weight arrangement. The tension adjustment made by shifting the weight on the weighted lever. In between beam and the back rest, a guide roller is provided. Thus a variation angle of the back warp sheet to the vertical as the beam weaves has no effect on the variation in warp tension. The other feature of Toyoda let-off motion is the arrangement provided for locking the sensitive back rest at the beat up position. This locking is a very useful feature especially for weaving heavy fabrics, as it ensures better conditions during beat-up.

### 7.8.1 Tensioning Device

The principle of woking of Toyoda let-off motion is discussed with reference to Fig. 7.13. The sensitive back rest A is supported on two arms B secured to the shaft C. The dead weight supported on the arm D from the same shaft C to give the warp tension. The warp sheet from the beam is taken round the roller R before it passes over the sensitive back rest.




A = Back Rest, B = Two Arms, C = Shaft, D = Arm, E = Sector Lever, F = Link, G = Lever, I = Link, J = Pawl Lever, K = Ratchet Wheel, L = Worm, M = Worm Wheel, N = Beam Feeler , P = Lever, Q = Slotted Bracket , X = Sector, Y = Brake Shoe, Z = Short Lever.

**Fig. 7.13 Toyoda Let-off Motion**



### 7.8.2. Beam Drive

The beam is rotated through a ratchet wheel K and a worm reduction gear L and M from the sley sword. A double slotted lever arrangement is provided near the bottom of the sley for this purpose. The slotted bracket Q is fixed on the sley itself while the lever P is fulcrumed on a fixed casting. As the sley takes the slotted bracket Q forward, the lever P rocks forward due to a common stud that passes through the slots of both P and Q. This motion of the lever P, through the link I, rocks the pawl lever J and turns the ratchet wheel K.

The regulator arm E fixed to the back rest shaft C rises and falls according to the changes in the warp tension and through the link F, and the lever G varies the position of the stud T in the double slotted levers P and Q. The rotation of the beam varies accordingly to maintain the warp tension at uniform level. As the beam weaves down, the feeler N moves in and raises the end of the link I in the slot of the pawl lever, thus giving an increased movement to the ratchet wheel and the beam.

The locking or braking arrangement to hold the back rest stationary during beat up, consists of a sector X on the sector lever E and the brake shoe Y on the short lever Z. A bowl at the bottom end of the lever Z is acted upon by an eccentric on the crank shaft. This eccentric is set to allow the brake shoe Y to come in contact with sector on the regulator lever at the front centre position, so that the back rest is firmly locked for beat up. As the crank passes the front centre position, the eccentric moves the brake lever away from the sector X so that the regulator lever is free to move under the effect of the warp tension.

An eccentric on the crank shaft rocks the back rest through an arm of the back rest which rests on the eccentric. This oscillating motion of the back rest reduces the strain on warp during shedding.

## 7.9 HUNT LET-OFF

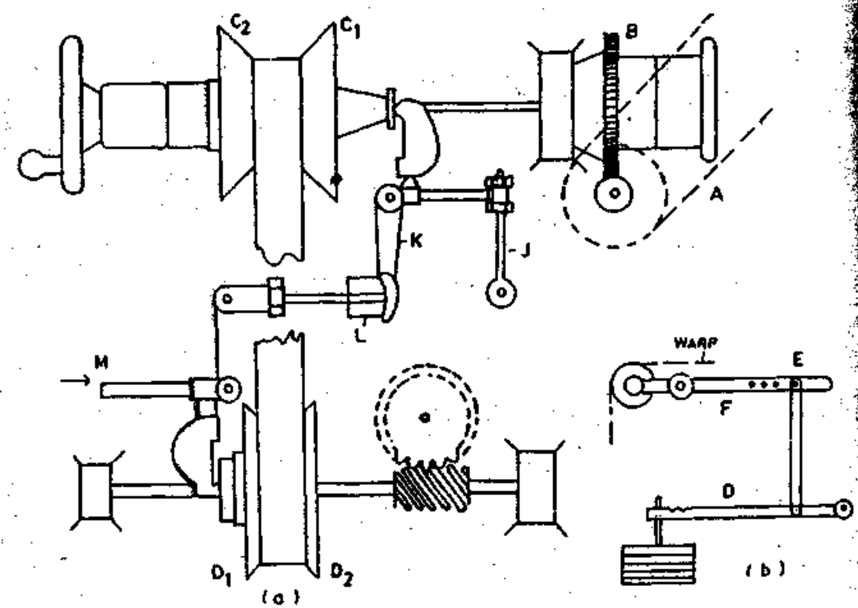
Hunt let-off motion is widely used on automatic looms e.g. Drapper, Crompton & Knowles and shuttleless weaving machines. This let-off works directly from the warp tension via the whip roller which responds instantly to the slightest change in the tension. There are no beam feelers on the warp.

### 7.9.1 Tensioning Devices

The desired tension is obtained by means of weight on the weight lever D. (Fig. 7.14) After it has been set for a particular cloth, no further adjustment is required.

### 7.9.2 Beam Drives

The let-off motion is driven from the bottom shaft or crank shaft o the weaving machine by means of chain A and worm gearing B. a shown in Fig. 7.14. The subsequent gears in the train are variable. Th variable speed control arrangement consists of two V-belt pulleys and belt. One of the conical V-belt pulleys $C_1$ and $D_1$ can be moved axiall where as opposite ones $C_2$ and and $D_2$ are always fixed firmly on th keys. The axial pulley movement is interconnected by means of lever and K. As the warp tension is increased, the whip roller is pressed dow and moves the variable control unit through lever M and the warp i unwound more rapidly.




A = Chain, B = Worm Gearing ; $C_1$, $C_2$ = Pulleys, D = Weight Lever, $D_1$, $D_2$ = Pulleys, E = Link F = Swing Lever ; J, K. = Levers.

**Fig. 7.14 (a, b) Hunt Let-off Motion**

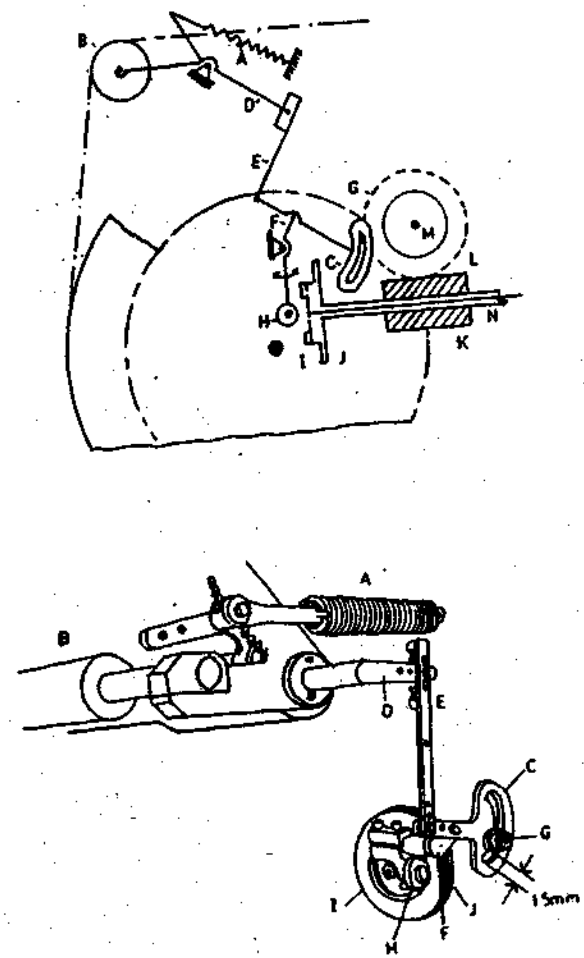


### 7.9.3. Setting

(i) Position of link E should be in the appropriate hole of the swing lever F. The hole nearest to the fulcrum is for low tension, middle hole for medium tension and the outer hole for high tension.

(ii) The weight lever should be approximately level during weaving and can be adjusted by varying the position of levers K and J.

## 7.10 SULZER RUTI LET-OFF




A = Spring, B = Carrier Roller, C = Double Arm Lever, D = Regulating Arm, E = Connecting Arm, F = Clutch Lever, G = Pivot, H = Antifriction Roller, I = Driving Clutch, J = Driven Clutch, K = Worm L = Worm Wheel, M = Spur Gear, N = Shaft

**Fig. 7.15 Sulzer Ruti Let-off Motion**

The tension on the warp on Sulzer Ruti let off motion is imparted through the whip roller B as shown in Fig. 7.15 by means of springs A. The whip roller is mounted on a roller bracket which is perpendicualr to the vertical direction. So variation in the angle back warp sheet has very little or no effect on the warp tension as the beam weaves down. The movement of the whip roller turn the regulator lever C through the linkages D and E. The regulator lever is mounted on the short arm of clutch lever F. The groove on the regulator lever is led through pivot G on the machine frame. Since the centre of the groove curvature is not coincident with the centre of rotation of the regulator lever, the clutch lever is rotated in the direction indicated. As a result of this, rollers H are moved into the path of the projections of the driving clutch I, which is moved axially and rotates the driven clutch J. The movement is transmitted to warp beam via worm K, worm wheel L and spur gears M.

The driving clutch is driven from the main shaft through shaft N. There is an arrangement to rotate the warp beam by hand, when the weavng machine is stopped, the shaft N is disconnected from the main machine shaft by a claw clutch.

Differential motions are used to drive the beams on the other side.

### 7.10.1 Settings

The ratio of the worm and worm wheels for different pick densities are shown in Table 7.1.

Table 7.1 Ratio of Worm Driving

| Particulars | Gear Ratio | Recommended Pick density/dm |
|---|---|---|
| Normal | 1:39 | 100-150 |
| Coarse | 2:39 | 35-150 |
| Very Coarse | 3:38 | 18-4 |
| Fine | 1:66 | 150-1800 |

The position of the whip roller in whip roller support determines the length of the back shed. The length of back shed depends on (i) number of shafts, (ii) nature of the warp yarn and (iii) type of fabrics.

The inside position is used for the following application.

(i) Fabrics which need upto 14 shafts.
(ii) Heavy fabrics of all types of fibers.
(iii) Bad (soft) warps.

The middle position is used for the following applications.

(i) Fabrics which need more than 14 shafts.
(ii) Jacquard fabrics.
(iii) Satin fabrics.
)iv) For warp yarns with low breaking strength.

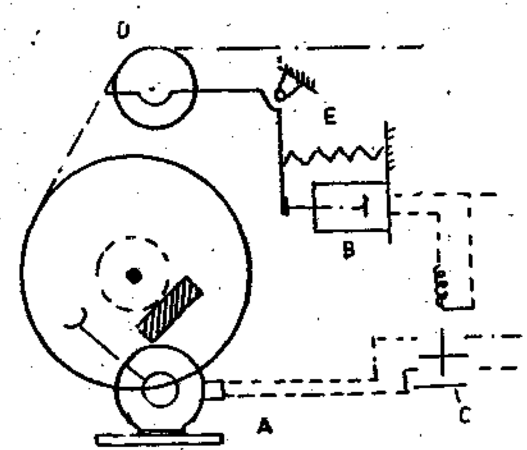
Outside position is used for the following applications.



(i) For fabrics with a high number of shafts and a very wide range of float variations in the warp ends.

## 7.11 WARP LET-OFF WITH ELECTRICAL DRIVE

Warp let-off motions driven by electric motors are used on shuttlelss weaving machines because tension can be set accurately with no variation. Several types of such motions are available. One such system is shown in Fig. 7.16. The let-off drive motor A with the reduction gear and main gear moves the warp beam continuously forward to such an extent that the whip roller D is always located at the same height and the tension of the warp beam remains constant from start to finish of the warp beam. The whip roller is mounted on the springs E one on each side and the position of the whip roller is determined by the Sensor B and the signal is transmitted to the electronic control equipment in the control panel C. As soon as the whip roller tends to leave its predetermined position, the electronic control equipment takes the necessary action and accelerates or brakes the warp let-off drive motor accordingly. When the machine is stopped, the preset speed for the warp let-off drive motor is stored, so that the motor starts up with the correct speed when the weaving machine is started again. However, the present speed is lost, if the power supply to the control cabinet is interrupted. In such cases, the warp let-off drive motor starts with the average speed, which is then corrected within a short period, Provisions have been made to tension or slacken the beam by means of buttons.




A = Drive Motor, B = Sensor, C = Control Panel D = Whip Roller, E = Spring

**Fig. 7.16 Electrical Let-off Motion**

## 7.12 WARP TENSION VARIATION

Several workers studied the variation of warp tensioning d weaving.

Badve and Bhattacharya (3) studied the cyclic variation of tension at Sakamoto negative and Northrop Roper let-off motio Sakamoto and Northrop T model looms respectively. Northrop loo 100 cm reed space running at speed of 165 ppm was equippped plain tappets with 1/3 of a pick as dwell period. The healds were lev at 260° (0° = F. C) and the ratchet pawl of the Roper let-off sta acting at 285° and ending at 7° of crank shaft revolution.

On a Sakamoto loom the healds were levelled at 275°. Lo speed was 176 with similar reed space of 100 cm.

Same quality of fabric with 18 Ne warp and 24 Ne weft with Stockport reed and 220 picks per dm was woven on both the loo Comparative study of tension traces from Roper and Sakamoto motio are discussed as follows; with reference to Fig. 7.17.

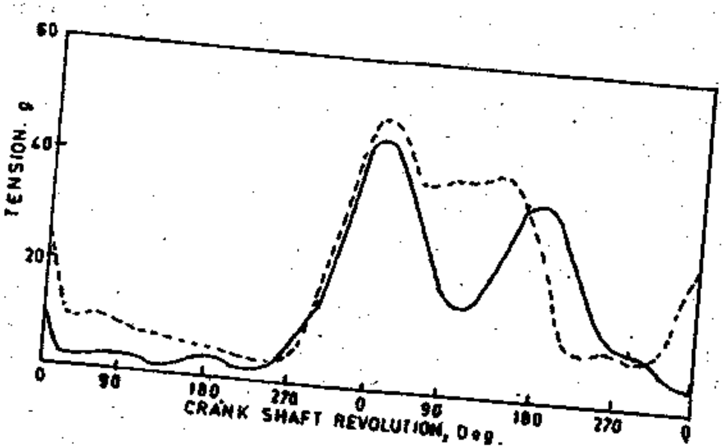



**Fig. 7.17 Cyclic Warp Tension Variation on Roper and Negative Let-off Motions**

(a) The tension cycle repeats on two picks for a plain weave and is closely related to the movement of the healds. Similar observations were made by Snowden (4), Owen (5), Kulkarni (6), Farrag (7).



(b) The static tension traces follow a trend similar to a tension trace obtained on a running loom, but the values tend to be comparatively higher but the difference is small. This behaviour is because on a running loom, let-off is actuated and tension equilibrium is attained quickly throughout the warp sheet.

(c) The average tension for a thread in the bottom shed is higher than that for the top shed in both the let-off motions as it should be. This is due to the **troughing of the shed**, which is necessary for obtaining a **good cover** of the fabric. They observed that the extent of difference between the tensions on the threads at the bottom and that at the top sheds is about 72% for Roper motion and 108% for Sakamoto motion.

(d) On both these let-off motions, the maximum values of warp tension in top and bottom shed are observed at the beat up. This is due to the fact that the beat up is taking place in a crossed shed. The beat up tension for the bottom shed is much higher than that of the top shed. This is due to higher average tension for the bottom shed line. This behaviour of beat up tensions is similar to the observations made by Owen, Snowden and Chamberlain. However, Kulkarni observed the maximum tension at the full opening of the warp shed on a rayon loom as shown in Fig. 7.18. This is because for weaving of filament yarns, the beat up is necessarily, with the shed almost closed, contrary to the usual practice followed on cotton looms.

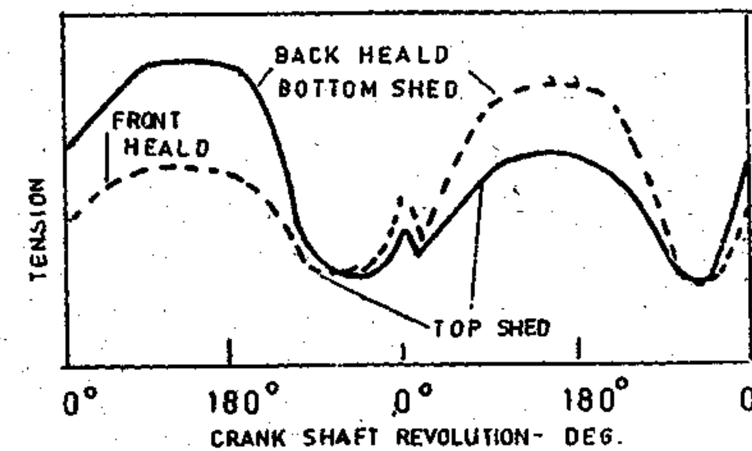



**Fig. 7.18 Cyclic tension Variation for Filament warp**

(e) The tension at the beat up for the top line for Roper is about double to that for negative let-off. However, almost similar values are obtained for the bottom shed line. This behaviour may be attributed in general to a higher warp tension on top shed line for Roper motion. However, because of the early commencement of let-off and instantaneous yielding of the sensitive back rest and delayed attainment of tension equilibrium the difference is the beat-up tension values for the bottom shed line is much less in the Roper motion.

(f) Badve and Bhattacharya observed because of a comparatively higher value of difference in tension between top and bottom shed line at beat up in the Sakamoto negative let-off, there is a tendency of a beaten pick to roll back at the fell of the cloth. However, the tendency is not so marked on the Roper motion.

(g) The peak warp tension at beat-up followed by an immediate drop appears almost uniformly throughout in the case of the negative let-off motion indicating an instantaneous let-off. However, this peak tension and the drop does not always appear uniformly and are comparatively less prominent on the Roper let-off motion indicating thereby a gradual let-off. This is because in the case of negative let-off motion, when the maximum warp tension is reached, the unwinding force overcomes the braking force on the beam, resulting in instantaneous let-off.

In the Roper motion, the beam is turned positively by a reduction gearing from a ratchet wheel. The let off pawl actuates much earlier than the beat-up and completes its action only at 7° after the beat up. Since the movement of the ratchet wheel is complete after the beat-up and since several mechanical links are involved in the drive from the ratchet wheel to the beam, the let-off is bound to be gradual. It is quite likely that the driving force from the ratchet wheel and the unwinding force from the beam meet somewhere in the middle of the chain of links, especially at the internal gear pinion and the wheel. This results in the let-off in two stages.

- An instantaneous but partial let-off because of the impact at beat up.

- Gradual but a major portion of let-off obtained from the drive.

Thus immediately after the beat-up, the tension is suddenly decreased resulting in tension reduction to a minimum.



(h) The trend of tension for the top shed line on the Roper motion is reduced due to the gradual let-off and delayed attainment of tension equilibrium. However, in the case of negative let-off motion, the tension is fairly constant during the dwell period of healds with a tendency to increase slightly at the end till the healds are levelled and then it rapidly increases to the beat-up tension. This behaviour indicates that the vibrating back rest of the Sakamoto motion is not effective and loses control temporarily on the top shed line.

### 7.12.1 Cyclic Tension Variation on Sulzer Weaving Machine

Holdcombe et al. (8) measured the tension of warp sheet on Sulzer Weaving Machine (SWM). They observed that average weft warp tension on SWM is about three times higher than that of the conventional weaving machines e.g. Northrop (9) and Picanol. Beat up tension is about 1.3 times higher than open shed tension for SWM where it is about 1.6 to 1.8 times for conventional weaving machines. Thus, although the shed

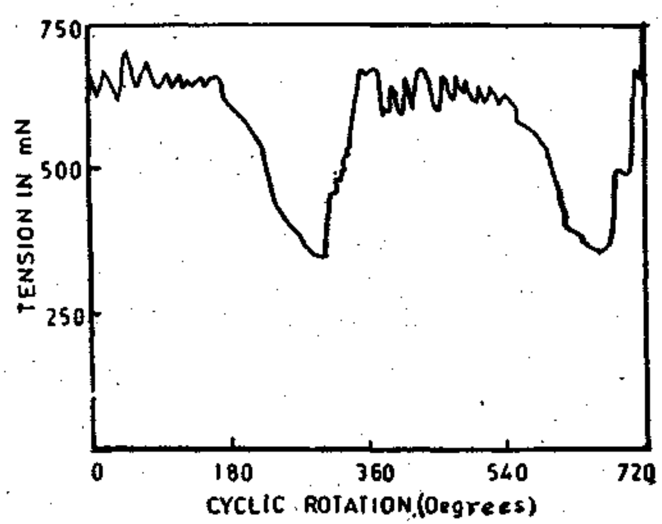



**Fig. 7.19 Cyclic Warp Tension Variation on Ruti Sulzer Projectile Weaving Machine**

opening required for weft insertion is much less for Sulzer Weaving Machine than its conventional counterparts, a greater level of base tension is employed for Sulzer Weaving Machines. Fig. 7.19 a indicates that following a beat up on Sulzer Weaving Machine, warp undergoes a marked transient vibration in the form of a damped simple harmonic motion. Such vibrations are the natural response of the spring system comprising the mechanical components of the warp let-off control and the warp yarns themselves to the impulse of beat-up.

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# 8 STOP MOTIONS

## 8.1 FUNCTION

Different types of stop motions are provided to stop the loom either on a thread breakage of warp or weft or when the shuttle fails to reach the shuttle box.

These stop motions include weft stop, warp stop and warp protector. They are necessary for a weaving machine in order to weave a faultless fabric.

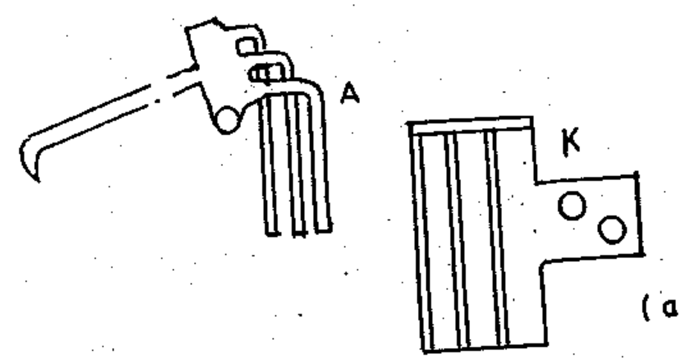
## 8.2 WEFT STOP MOTION

This motion enables to stop the loom immediately after a weft break or weft running out. In case the loom is allowed to run even after the weft breaks there will be no woven cloth except long threads of warp.

There are two types of weft stop motions on a conventional weaving machine :

(a) Side weft fork motion. (b) Centre weft fork motion.

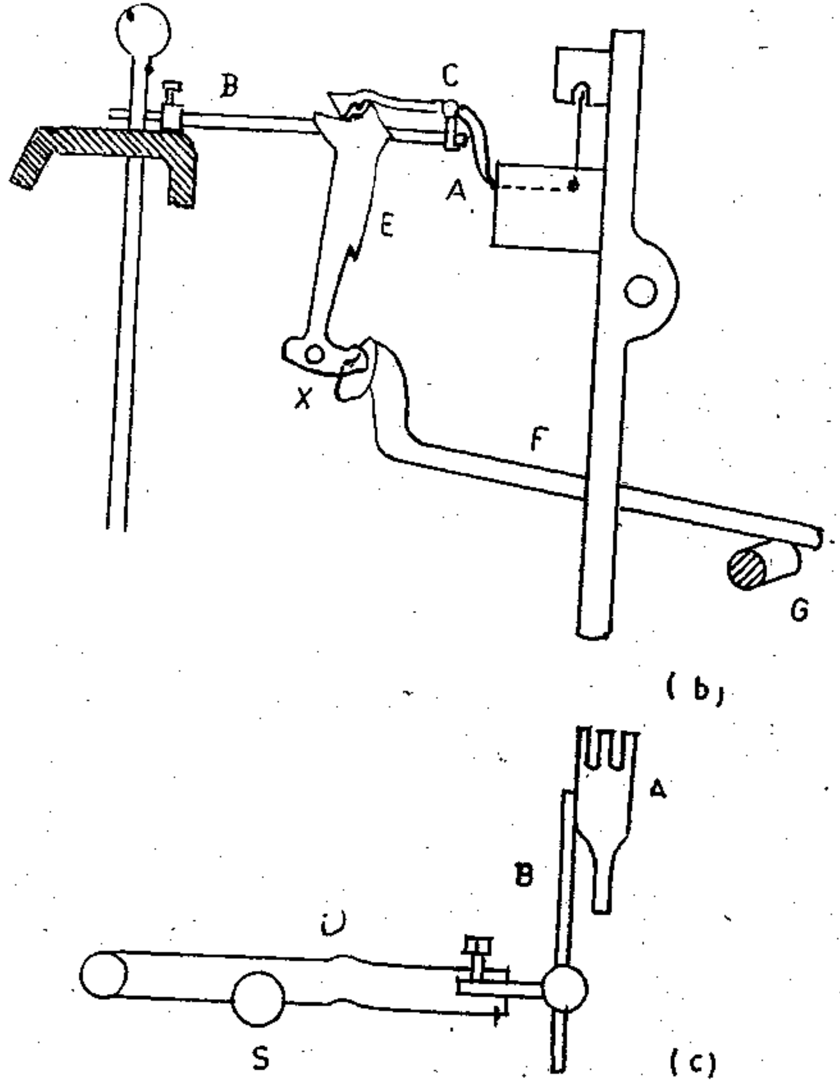
### 8.2.1 Side Weft Fork Motion




A - Weft Fork, K = Grate

Fig. 8.1 (a) Side Weft Fork Motion

The basic principle of the side weft fork lies in the fork and grate. A metal grate (Fig. 8.1a) is placed between the end of the reed and the shuttle-box mouth on the starting handle side as shown in the Fig. 8.2. A weft fork made of light metal which has three prongs




A = Weft Fork, B = Weft Fork Holder, C = Fulcrum, D = Knock off Lever, E = Hammer Lever, F = Grey Hound Tail, G = Weft Fork Cam, K = Grate, S = Starting Handle.

**Fig. 8.1 (b, c) Side Weft Fork Motion**

bent at right angles is situated in front of the grate. The complete weft fork motion is illustrated at Fig. 8.1(b).

A weft fork A with a single tail hooked at the end is held by a weft fork holder B at C. The other end of the holder is held by knock-off lever D, which is in contact with the starting handle when the loom is in running.



The tail end of the fork is slightly heavier than the forked end. A hammer lever E fulcrummed at X is connected to a greyhound tail lever F, the bottom end of which is resting on a weft fork cam G which is fixed on the bottom shaft. During the rotation of the bottom shaft the cam raises the greyhound tail lever on every two picks and causes the hammer lever to rock towards the loom front.

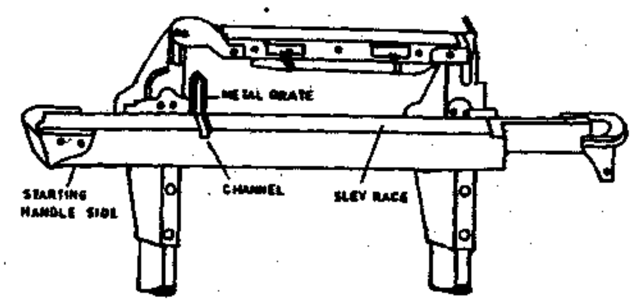
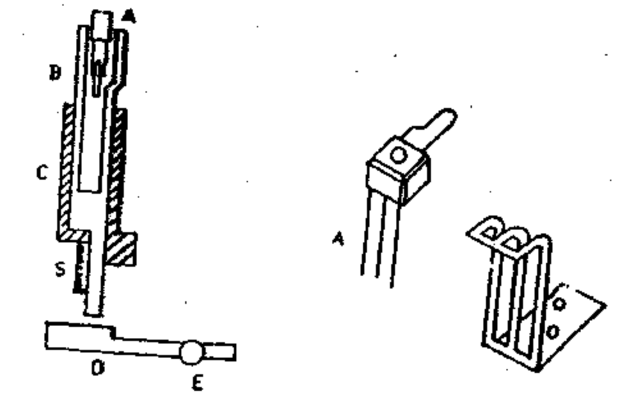



**Fig. 8.2 Position of Metal Grate and Channel**

A channel is cut in the wooden raceboard H (Fig. 8.2) opposite the weft fork so that when the sley comes forward to beat up position the weft fork prongs will remain below the raceboard level until it is touched by a weft thread lying across the channel from the selvedge to the shuttle.

In this case the shuttle should be on the starting handle side. If the weft thread is not broken or missing, it will push the weft fork prongs, thus lifting the hooked tail clear of the hammer lever E. At the same time the rotation of the cam G makes the hammer lever move towards the front rest. In case the weft is absent either through breaking or from running out, the weft fork remains horizontal and the prongs pass freely through the bars of the grate. Then the hook tail of the fork is caught in the notch of the hammer lever E as shown in Fig. 8.1b and when this lever moves towards the front rest it carries the fork along with its holder resulting in the weft fork lever D pressing against the starting handle S and knocking off the loom (Fig. 8.1.c).

One fault in the mechanism described early is that the weft fork lever and the holder move in an arc of a circle because of the fixed fulcrum of the weft fork lever. This sometimes causes the prongs of the fork to hit against the side wall of the channel in the raceboard and cause damage. In the British made Northrop looms this arc of movement does not exist since the weft fork acts directly upon the starting handle with a straight backward push.




A = Weft Fork, B = Weft Fork Sliding Bracket, C = Fixed Bracket, D = Knock-Off Lever, E = Starting Handle, S = Spring.

**Fig. 8.3 Weft Fork Acts Directly upon the Starting Handle**

In the mechanism illustrated in Fig. 8.3 the weft fork A is mounted on a sliding bracket B which slides forward and backward in a fixed bracket C. As usual the hook tail of the fork is caught in the notch of the hammer lever on weft failure and the backward movement of this lever will push the knock-off lever D, Thus the releasing the starting handle E. The spring S returns the sliding bracket B to its original position.

#### 8.2.1.1 Important points to note while setting the weft fork mechanism

1. The weft fork might be a possible source of weft cutting if it protrudes too far through the weft fork grate.
2. The grate must be smooth.
3. The weft fork prongs, during the forward movement of the reed, should not touch the grate wires or any part of the grate or raceboard groove.
4. The weft fork prongs protrude neither too less nor too far through the grate.
5. The clearance between the hook tail of the fork and the notch of the weft fork hammer is very important. If the clearance is too wide the weft thread may not keep the hook tail raised till the tail is clear off the weft fork hammer notch. This will result in unnecessary knock off of the loom even though the weft has not broken. On the other hand if the clearance is too close the hammer notch might prevent the hook tail from lifting when the weft thread applies pressure on the prongs.



6. The fork must be properly balanced so that the tail end is slightly heavier than the forked end.
7. An accumulation of fluff at the base of the grate will unnecessarily press the prongs of the fork thus raising the tail end when no weft is present. This will make the loom run without the presence of weft.
8. The side play in the rocking rail and sley might cause the grate foul the fork. Sometimes, loose cranks might also cause this trouble.
9. Weft thread catching on the prongs because of inadequate tension will cause the loom to run on.
10. Bent prongs, binding of the fork through rust on the fulcrum pin, fork fulcrum worn out etc. might affect the good working of the mechanism.
11. Faulty timing of the hammer lever may cause the loom running even after the failure of weft.
12. Weak or late picking from the off side of the loom may cause the shuttle to strike the prongs and damage it.
13. Insufficient tension in the weft fail to lift the fork sufficiently causes the loom stoppage.
14. If the hammer lever begins to move too soon before the weft has had time to lift the fork tail clear, the loom will keep stopping.

#### 8.2.1.2 Disadvantage

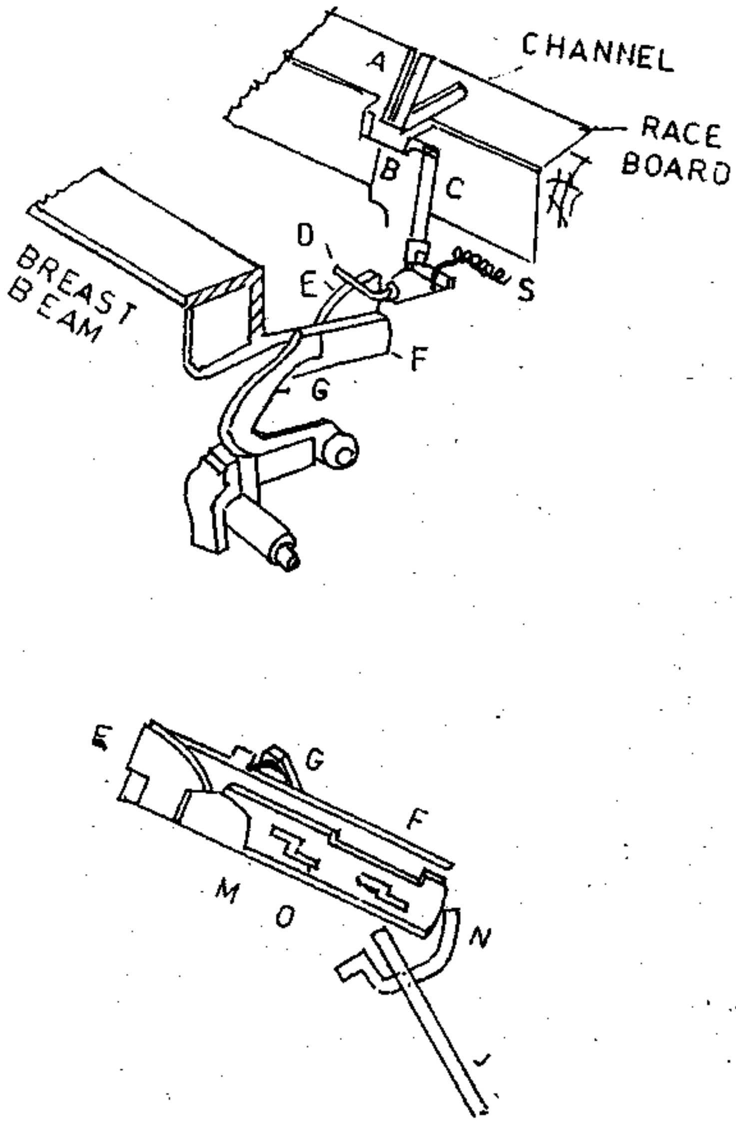
Since this mechanism is situated only at the starting handle side of the loom, the stopping is effected only when the shuttle reaches the starting handle side. This will result in missing a maximum of two picks when the weft breaks or exhausts as soon as the shuttle leaves the starting handle side.

In case such a device is to be provided on both sides of the sley the cost factor and the complicated knocking off arragement has to be thought of.

### 8.2.2 Centre Weft Fork Motion

This motion has been designed to feel the weft thread every pick and stop the loom in case the weft thread breaks or runs out, no matter which way the shuttle is running at the time. The shuttle can be housed in any one of the boxes.

It is for this reason the mechanism is situated in the centre of the raceboard. The loom is brought to a stop before the beat-up action takes place. It is not necessary that the shuttle should always




A = Weft Fork, B = Lever, C = Connecting Rod, D = Knock-off Arm, E = Cam, F = Projecting Stand, G = Knock-off Lever, M = First Pick Slide, N = Lever, J = Flat Spring, O = Cutout, S = Spring

**Fig. 8.4 Centre Weft Fork Motion**

be in the starting handle side box for effecting the loom stop. Therefore, this device will not allow two missing picks before the loom stops. This device is useful for looms weaving pick and pick coloured wefts. If there are two different coloured picks weaving alternately and if one of the coloured threads is broken, it is



necessary to stop the loom immediately before another coloured thread of the second pick is inserted in the shed. It also helps to weave faultless cloth free from pick finding marks or broken picks. With effective braking system, the loom can be stopped dead on the broken pick. In addition a device is incorporated to turn back the loom, opening the previous shed with a broken pick laid inside, so that the weaver can rethread without making any bad mark on the cloth. Centre weft fork motion is, therefore, suitable for weaving fabrics made of filament yarns, e.g. polyester, nylon and yarns made out of other delicate fibres. Though several types of centre fork motions are designed the basic principle remains the same. A channel (Fig. 8.4) is cut in the raceboard, at or near the centre depending upon the length of the weft from the shuttle eye to the fork and also on certain attachments like pirn changing and box changing. The weft fork with prongs is fulcrummed on a bracket fixed to the front of the sley. When the sley moves towards the back centre, the fork tilts upwards through the warp far enough to allow the shuttle to pass underneath, and the weft is laid under the fork. During the forward movement of the sley the fork drops downwards upon the weft and is held from moving further down in the channel by the grid effect of the warp threads belonging to the bottom shed, suporting the weft thread against the light pressure of the fork. In this condition the weft fork holds the knock-off arm away from the knock-off lever. The fork is pulled out of the shed just before the reed reaches the fell of the cloth for the beat up of the weft. If, however there is no weft underneath the fork as the sley moves forward, the fork drops into the channel in the sley and the knock-off arm D is moved into contact with the knock-off lever G thus stopping the loom. One important device which is necessary in all the centre weft fork motions, is to enable the loom to restart after the weft replenishment without the presence of a weft thread across the shed. This means that the knock-off arm should be made ineffective for the first pick without the help of the weft thread.

A shield has been provided in all such motions to enable the sley to move forward, on the first pick, without stopping the loom. On successive picks the shield moves out to enable the weft thread to act as a preventive device to knock-off the loom.

The centre weft fork motion shown in Fig. 8.4 has two important parts. The first part, the weft fork, is attached to the sley and moves with it. The second part consisting of, cam, knock-off lever, brake lever, the rod that connects the mechanism to the shipper lever, all attached under the breast beam, which is stationary.

The weft fork A is pivoted in a stud and is connected to a lever B pivoted in a bracket on the lower end of the stand by a connector rod C. An adjustable knock-off arm D which is connected to the lever B slides over the face of the cam E projecting from the breast beam assembly. The knock-off arm D is held against the cam face by a special spring S on the opposite end of the lever.

During the backward movement of the sley the fork is raised, and during the forward movement it drops down. The projecting stand F mounted under the breast beam, has a knock-off lever G on one side and a first pick shield M on the other. The knock-off lever projects above the lug stop of the stand F. If the weft thread is not holding the fork from falling down in the sley channel, that is the absence of the weft, the knock-off arm D will follow the cam E during the forward movement of the sley and engage the knock-off lever G. If the weft thread is present in the shed and holding the fork, the knock-off arm D will pass over the knock-off lever G. When the knock-off lever is pushed back by the knock-off arm, a round bracket on the lower part of the lever will press a brake tube lever, turn the brake and stop the loom.

Immediately the loom is knocked off, a flat spring J clamped to the shipper shaft pushed back the first pick shield M through an intermediate lever N. Since the shield M is held by pins that follow the curved shape of the cam slots, a push at the back will enable it to raise above the top of the stand F and also above the top of the knock-off lever G. When the loom is started after the repair of the broken pick, the flat spring is moved away from the lever N but the shield F stays in position owing to the dwell in the cam slots. On the first pick the advancing knock-off arm after sliding along the edge of the shield and past the knock-off arm, strikes the end of the cut out O in the shield pushing it forward into the normal position.

#### 8.2.2.1 Improved centre weft fork motion

One disadvantage of the motion described before is that the whole mechanism is difficult to approach for any adjustments. The looms, namely, the German Zang, the Swiss Ru and the American C&K for silk have designed to have all the working parts in an easily accessible position at the side of the loom. Therefore setting and adjustment of the parts is made easier.

#### 8.2.2.2 Problems associated with centre weft fork motion

1. Weft curls in the middle of the cloth. Causes :
   (a) the prongs of the fork press the weft through the bottom shed,
   (b) early or strong picking,
   (c) irregular loom speed.
   Remedy :
   (a) correct tensioning of weft in the shuttle.
   (b) shortening the prongs a little in case of rayon weft,
   (c) a longer setting for the prongs in case of nylon weft.



2. Loom stopping constantly although weft has not broken.
   Causes:
   (a) slack warp,
   (b) slack weft,
   (c) fibrous or hairy warps.
   Remedy : Correct tensioning of warp and weft.

### 8.3 WARP STOP MOTION

The purpose of warp stop motion is to stop the loom when a warp thread breaks. The loom also stops when a warp thread becomes excessively loose. The warp stop motion is useful not only for the efficient production of high quality fabrics but also to allot more looms to a weaver. If a broken warp thread is not detected immediately, it wil tend to get entangled round adjacent threads thus causing more end breakages or create a fault known as a float in the woven cloth.

There are two types of warp stop motions, the mechanical and electrical. In both the cases the basic principle of working is the same, that is, every warp thread is sensed by a thin strip of metal, known as a drop pin. When a warp thread breaks the corresponding drop pin falls by its gravity into a moving part of slide over which it is threaded. The laterial motion of the slide is thus arrested and a knock-off mechanism will operate and stop the loom.

There are different types of drop pins depending upon the use. viz. close and electrical as shown in Fig. 8.5.

#### 8.3.1 Drop Wires

Standard types of drop wires for use in weaving cotton, silk, wool and man-made/synthetic fibre fabrics are

(a) Mechanical warp stop motions.
- closed end drop wires (Fig. 8.5a)
- open end drop wires (Fig. 8.5b)

(b) Electrical warp stop motions.
- closed end drop wires (Fig. 8.5c)
- open end drop wires. (Fig. 8.5d)

Open ended drop wires are most popular type used for dropping in the warp threads after the warp has been gaited in the loom (in some cases while the loom is actually running). This can be done mechanically (300-350 thread/min.) or manually (5000 threads/hour).

Closed type drop wires are positioned in the preparation department, the warp threads being drawn through the drop wires and the heald eyes at the same time. When the warp is taken to the loom for gaiting, the drop wires are threaded on both slider bars of

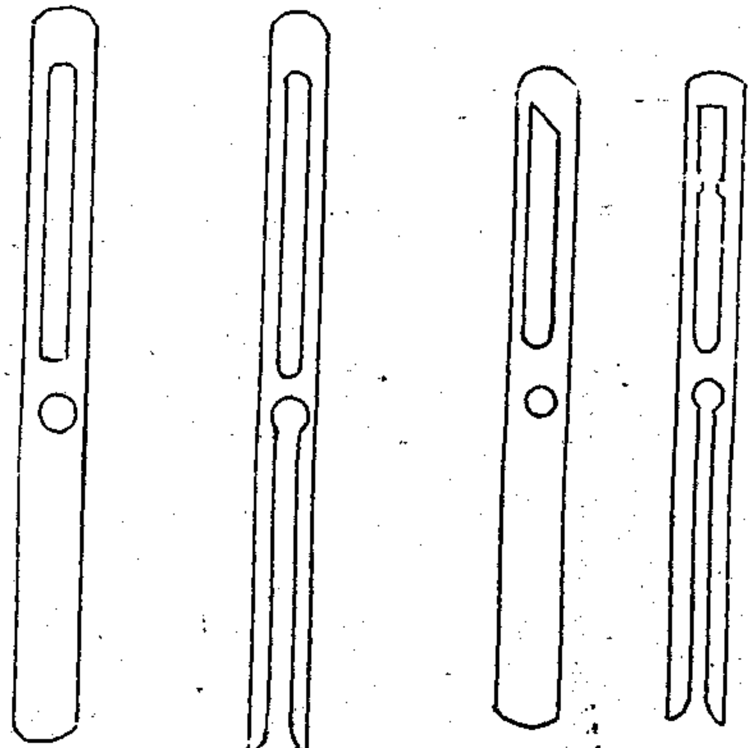



Fig. 8.5 (a, b, c, d) Different types of Drop Pin

the warp stop motion. When the warp runs out, the drop wires are left on the thrum, the old warp can be knotted or twisted to a new warp of similar sett and thus save the initial trouble of pinning.

**Materials**

The drop wires are made from cold-rolled hardened and tempered steel strips having the following chemical composition. Thereafter the drop wires are plated with zinc or nickel and chromium. The drop wires should be smooth and free from cracks, rough or sharp edges which would cause warp breakage.

| Chemical Composition | | |
|---|---|---|
| Carbon, per cent | .. | 0.65 to 0.75 |
| Silicon, per cent | .. | 0.10 to 0.35 |
| Manganese, per cent | .. | 0.60 to 0.90 |
| Phosphorous, per cent, Max | .. | 0.030 |
| Sulphur, per cent, Max | .. | 0.030 |



**Dimensions**

The normal range of dimensons and mass of drop wires for mechanical and electrical warp stop motions as per standards of Bureau of Indian Standards is given in Table 8.1.

**Table 8.1 Dimensions and Mass of Drop Wires**

| Type | Length mm | Width mm | Thickness mm | Upper Slot Length of mm | Mass mg |
|---|---|---|---|---|---|
| Mechanical | 120, 125<br>135, 145<br>165, 180 | 11 | 0.2, 0.3<br><br>0.4 | 53, 65 | 1.6 - 4.4 |
| Electrical | 125, 135<br>145, 155<br>165 | 7,8,11 | 0.2, 0.3<br>0.4 | 53, 63 | 0.9 - 4.4 |

### 8.3.2 Mechanical Warp Stop Motion

There are two types of mechanical warp stop motion .

- Vibrator bar type, - Castellated bar type.

#### 8.3.2.1 Vibrator bar type

The vibrator or oscillating bar type warp stop motions were previously being used on almost all types of looms. Now-a-days, these warp stop motions are being superseded by castellated bar type because of the following disadvantages :

(a) Open type drop wires connot be used and hence pinning at the loom is consequently not possible.

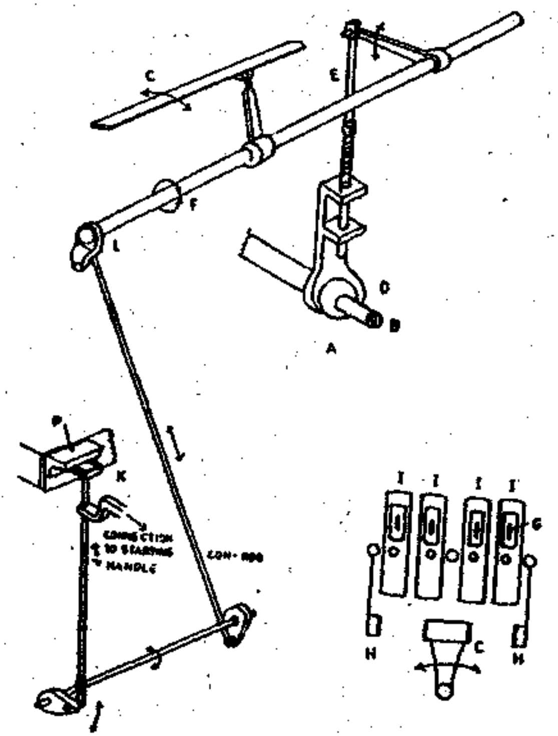
(b) Maximum four banks can be used.

(c) Shaking movement due to the oscillating bar disturbs the lower edges of the drop wires thus causing them prone to jump and unnecessary friction is created between the yarn and drop wires.

The working principle of Cimmco - Sakamoto vibrating bar warp stop motion is described below with reference to Fig. 8.6.

The eccentric A fitted on the bottom shaft B rocks the vibrating bar to and fro through the fork lever D, connecting rod E, oscillating shaft F. The fork lever D and the rod E are connected through a spring G so that the motion imparted to the vibrator bar is a negative one.

The two sides of the vibrating bar have five vertical serrations. On each side of the vibrating bar there is a fixed bar H (Fig. 8. 6 a)




A = Eccentric, B = Bottom Shaft, C = Vibrating Bar, D = Fork Lever, E = Connecting Rod, F = Oscillating Shaft, G = Spring, H = Fixed Bar, I = Drop Pin , J = Bar, K = Hitter, L = L-shaped Link, M = Cross Rod, N = Cross Lever, O = Knock-off rod, P = Striker.

**Fig. 8.6 Cimmco Warp Stop Motion**

having vertical serrations on the inner side. The drop wires I are supported by the warp threads. For each bank there is a bar J of with smooth rounded edges which pass through the slots of the drop wires. These bars are stationary and serve the purpose of holding the drop wires in the event of an end breakage.

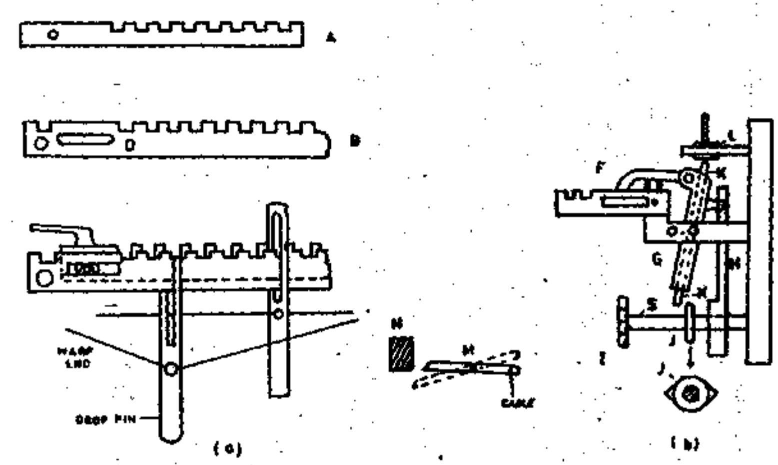
Under normal working conditions, the bottom ends of the drop wires are clear of the path of the oscillating bar which makes to and fro movement between the fixed bars during the one complete revolutions of bottom shaft. This movement gives complete up and down movement to the hitter through L-shaped link L, connecting rod M cross-lever N, and knock-off rod O. K mounted or the top of knock-off rod escapes the striker P on the sley every time the later comes forward. However, whenever a drop wire falls down on the



drop wire bar due to a warp breakage, the path of the vibrating bar is obstructed; serrations of these drop wires prevent them to slip off and turn over. When its movement is obstructed the hitter K is in the middle of its path, the striker P on the sley hits the hitter as the sley moves forward. The hitter is pressed back resulting in the release of the starting handle from the knotch.

### 8.3.2.2 Castellated bar

**Northrop Warp Stop Motion**




A = Slide, B = Slider Bar, C = Hole in the Bars, D = Slot, F = Forked Bracket, G = Tubular Lever, H = Cam Coupling, S = Shaft, I = Chain driven Wheel, J = Double sided Cam, K = Spring Loaded Finger, L = Knock-off Lever, M = Knock-off Finger, N = Striker

**Fig. 8.7 (a, b) Northrop Warp Stop Motion**

The mechanism consists of a slide A, slider bar B, the slide oscillating device and the knock-off device. All of these parts are illustrated in Fig. 8.7 a. The slide is placed into the groove of the slider bar which is secured firmly at both ends at the side brackets. The top of each bar is castellated. The number of bars used depends upon the density of warp (10-12 drop pins per cm. on each bar). Normally four bars are used.

The warp threads are drawn through the drop pins, heald eyes and reed dents at the same time in the preparatory department. When the warp beam is taken to the loom for gaiting of warp, the drop pins are threaded on to the slide bars. Then the slides are coupled to the mechanism by a pin passing through the holes C and the slots D. The slider bars are held firm in their end frames by bolts passed throught the holes. The whole unit is placed behind the heald fames.

The warp tension has to be adjusted in order to keep the drop pin clear of the slides. When a warp thread breaks, the corresponding drop pin falls down into the moving cut out of the slider. The free movement of slide A is arrested as the drop pin comes against the rigid cut-out of the slide bar B and the knock off mechanism is actuated and the loom stops.

The basic principle of all types of warp stop motions attached to the Northorp loom, the Crompton and Knowles loom, the Ruti loom are more or less similar. The variation is in the driving and the knock off motions.

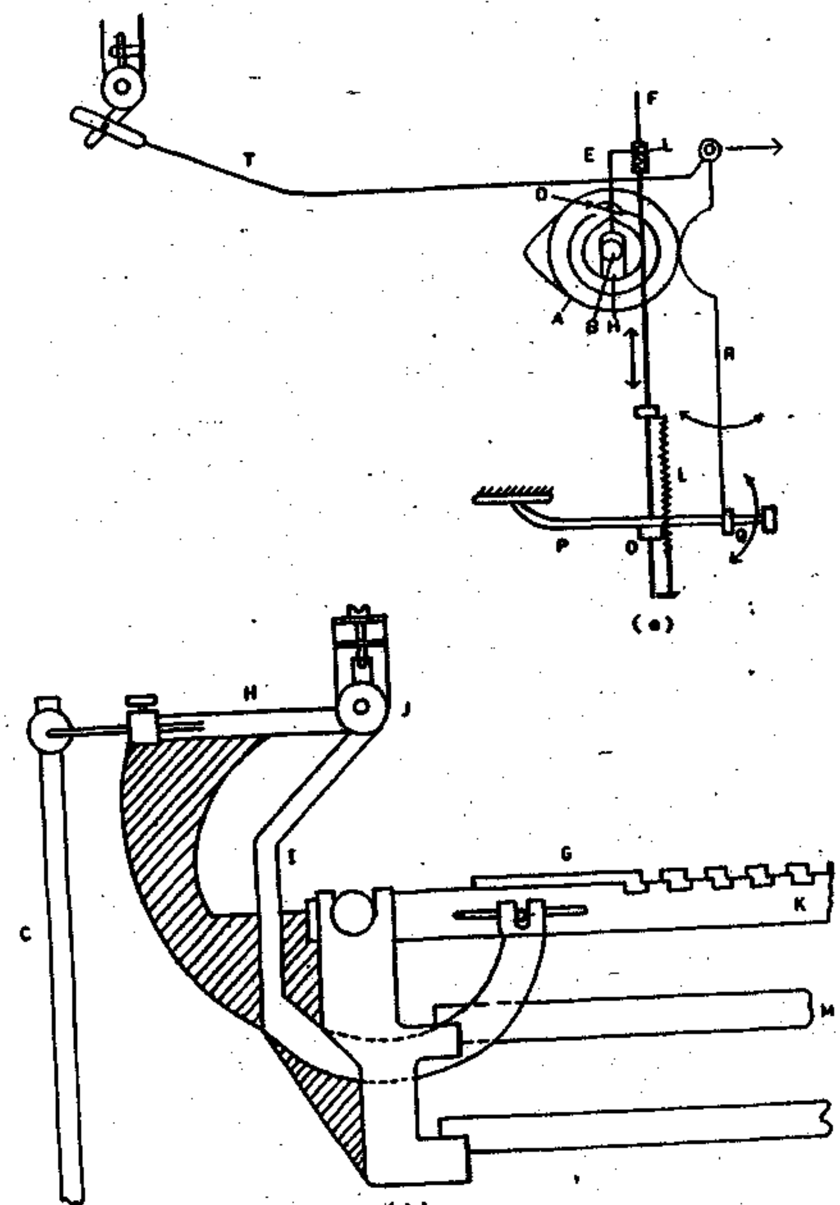
The slide A moves forward and backward by means of an eccentric in the driving box (Fig. 8.7b) The slide A is connected to the forked bracket F of the Northrop loom which attached to a tubular lever G fulcrummed at O. The lever G is oscillated by a cam coupling H. A small shaft S inside the driving box consists of a chain driven wheel I a double sided cam J and the cam coupling H. The motion to the shaft S is given from the crank shaft through a chain and chain wheel I. In the hollow part of the tubular lever G a spring loaded finger K passes through. The finger K during its oscillation above the double sided cam J clears the flat sides of the cam with each complete movement.

If a slide is locked by a falling drop pin, the free motion of the lever G is arrested with a finger K positioning immediately above the cam J. The continuously rotating cam J with the projecting part lifts the finger K which in turn lifts the knock off lever L. The lever L is connected to a knock off finger M by means of a cable. When the lever is raised by the finger K, the cable pulls the knock off finger M infront of the striker N which finally knocks off the starting handle.

**Ruti Warp Stop Motion**

On Ruti B loom, the reciprocating motion of the sliding serrated bar is obtained from a grooved cam A (Fig .8.8) fixed on the bottom shaft B. The rod C which is moved up and down by the grooved cam A through the gliding shoe D, fork E, connecting rod F, drives the slide G to and fro through the arm H and curved lever I fulcrummed in the stud J. The slide G is slotted in the slider K. The motion of the slider bar G is negative as the rod F is driven from the cam through a spring L which is compressed whenever the motion of the sliding bar is arrested due to the falling of a drop wire. The stationary serrated bars i.e. slides are fixed to the stop motion






A = Grooved Cam, B = Bottom Shaft, C = Rod, D = Gliding Shoe, E = Fork Lever, F = Vertical Rod, G = Slide, H = Arm, I = Curved Lever, J = Stud, K = Slider, L = Spring, M = Smooth Rod, N = Smooth Rod, O = Collar, P = Lever, Q = Latch, R = Sliding Lever, T= Draw Rod.

**Fig. 8.8 (a, b) Ruti B Warp Stop Motion**

bracket. Two round smooth rods M are placed an either side of the serrated bars and warp sheet is taken over these bars. Below these two bars, five similar bars N (for four banks) of smaller diameters are placed to hold the drop wires in between them and prevent undue vibrations during working.

The grooved cam and knocking off arrangement consists of a gliding shoe D, in the groove of the cam A and the fork E. A collar O fitted in the vertical rod F moves the lever P up and down on its fulcrum so that the latch Q at the end of this lever moves off the stop of the sliding lever R.

Sliding lever R rocks continuously to right and left by means of a nose on the grooved cam A. When the movement of the slide is blocked by a fallen drop wire, the rods C and F cut short half way in their movement. Latch Q will then come in the path of the bottom part of the sliding lever P. The bottom end being locked, the upper end is moved and the starting handle is knocked off through the draw rod T.

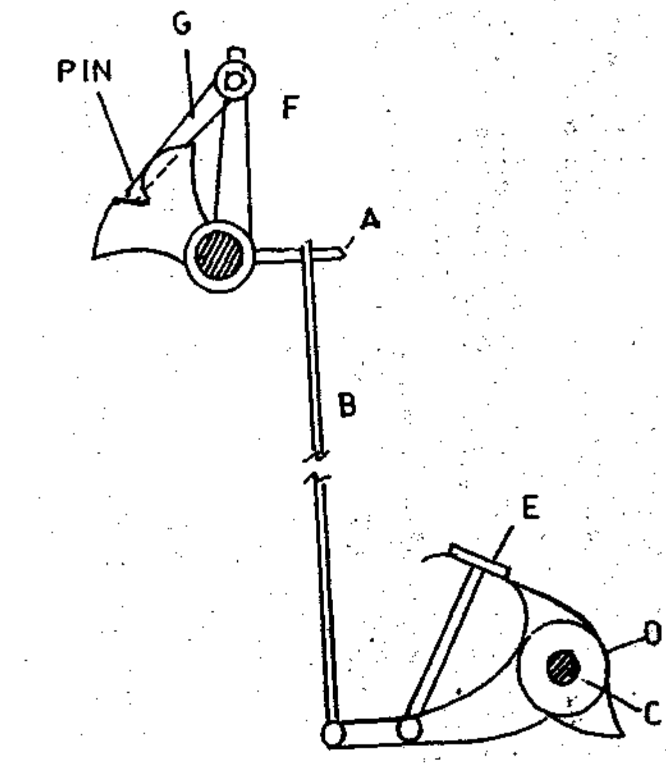
**Cimmco Warp Stop Motion**

Castellated bar type warp stop motion on Cimmco loom is similar to its vibrating bar type warp stop motion, only difference is that the eccentric cam on the bottom shaft is driving the slides instead of the vibrating bar through the forked lever.

**Lakshmi Ruti C Type Warp Stop Motion**

This is a castellated bar type warp stop motion, but the distinct feature of this motion as compared to the other warp stop motions is the use of a microswitch to stop the machine. A loose lever A (Fig. 8.9) rocks on a small rocker shaft being operated by a link B from the bottom shaft C. A double throw cam D is situated on the bottom shaft which actuates a spring loaded curved faced lever E on a stud. The motion of the curved lever is transmitted to the castellated bars (not shown in the figure) by means of links. The cam is so set that the castellated bars have reached the extreme left position when the picking takes place from the driving end. The fast lever F which is connected to the bars and the loose lever are locked while in operation by a locking pin in the V-recess of the loose lever segment. When a warp thread breaks, the castellated bars are prevented from to and fro motion and thus stopping the movement of the fast lever. But the loose lever segment will still be rocking over the shaft. This causes the locking pin which is fixed on a lever with fast lever and is spring loaded by means of a torsion spring to rise up the incline of the segment and operate a micro switch which energises a solenoid which ultimately declutches the machine pulley and at this time, brake is applied and stops the machine with the healds at level.





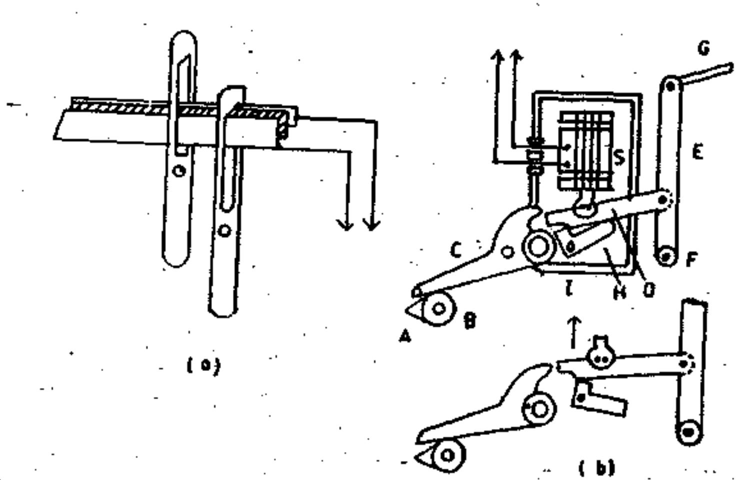

A = Loose Lever on Shaft, B = Link, C = Bottom Shaft, D = Double Throw Cam, E = Curved Faced Lever, F = Fast Lever on Shaft, G = Spring Loaded Lever.

**Fig. 8.9 Lakshmi Ruti Warp Stop Motion**

### 8.3.3 Electrical Warp Stop Motion

Most of the modern looms are provided with electrical warp stop motion. The reason for the preference of electrical warp stop motion might be due to the general trend towards electrification of most of the mechanism and individual driving of the looms. Where a loom is individual motor driven, it is a simple matter to fit an electrical warp stop motion that relies on electrical impulses for its operation.

The drop pin used in electrical warp stop motion is shown in (Fig. 8.5c). It can be noticed that the slot of the drop pin is slightly indented at opposite sides at the top. The bar units are not castellated but they are smooth topped and known as electrodes. The unit consists of a copper plated steel bar, grooved on one edge like the slide bar used in mechanical warp stop motion, carrying an insulated copper strip moulded with the bar (Fig.8.10a). The outer




A = Cam, B = Bottom Shaft, C = Rocking Lever, D = Bar, E = Knock-off Lever, F = Fulcrum, G = Push Rod, H = Pawl, I = Fulcrum, S = Solenoid.

Fig. 8.10 Electrical Warp Stop Motion

casing of the electrode is wired to one pole of the ransformer and the copper strip is connected to the other, with a magnetic unit for knock-off device completing one of the connections. When a drop pin falls down due to a warp end breakage the electrical circuit is completed, energising the magnet and causing the knock-off mechanism to knock-off the loom. The cut out in the drop wire ensures completion of the circuit by connecting the blade and the body.

#### 8.3.3.1 Knock-off mechanism

As shown in Fig. 8.10b cam A on the bottom shaft B raises and lowers a rocking lever C fulcrummed at O. A bar D attached at one end of the knock-off lever E can be raised by a solenoid S which can be energised by connections to the electrodes. The knock off lever E which is fulcrummed at F is connected at the top to a push rod G.

When a warp end breaks and the corresponding drop pin falls down on the electrodes, the electrical circuit is completed and the solenoid is energised to lift the bar D. Simultaneously the pawl H swings upwards on its fulcrum I and retains the bar D in the raised position. The swinging of the pawl is due to the bar D releasing its catch and the heavy weight at the lower part of the pawl helping the lighter part to move up. The cam A during its rotation makes the rocker lever C push the bar D, the knock-off lever E and push rod G, and finally the starting handle is knocked off. When the loom is



restarted the electric supply to the electrodes is cut off by a switch operated by the starting handle. In the absence of the current the bar D drops down pushing the pawl H to the bottom position.

While setting, care has to be taken to set the cam A on the bottom shaft so that the loom should stop in a convenient position for the weaver to mend the broken thread. Normally the convenient position is when all the healds are level. The bar D should be set so that it just clears the tip of the lever C during the normal running position.

## 8.4 WARP PROTECTOR MOTION

The function of the warp protector motion is to stop when the shuttle fails to reach the shuttle box during picking. The shuttle failure or the shuttle trap inside the warp shed may cause many broken warp ends during the forward movement of the sley. In order to prevent this from occurring a device is necessary to stop the loom whenever the shuttle fails to reach the shuttle box. The cause for such a failure might be due to : slack ends, improper opening of the warp shed, wrong shed, wrong timing of picking, mechanical failure of parts such as broken picking straps, loose or badly worn picking tappets, picking shaft springs broken, faulty pickers, odd sized shuttles, shed too low and stop rod brackets loose.

There are two types of warp protector commonly available for shuttle looms.

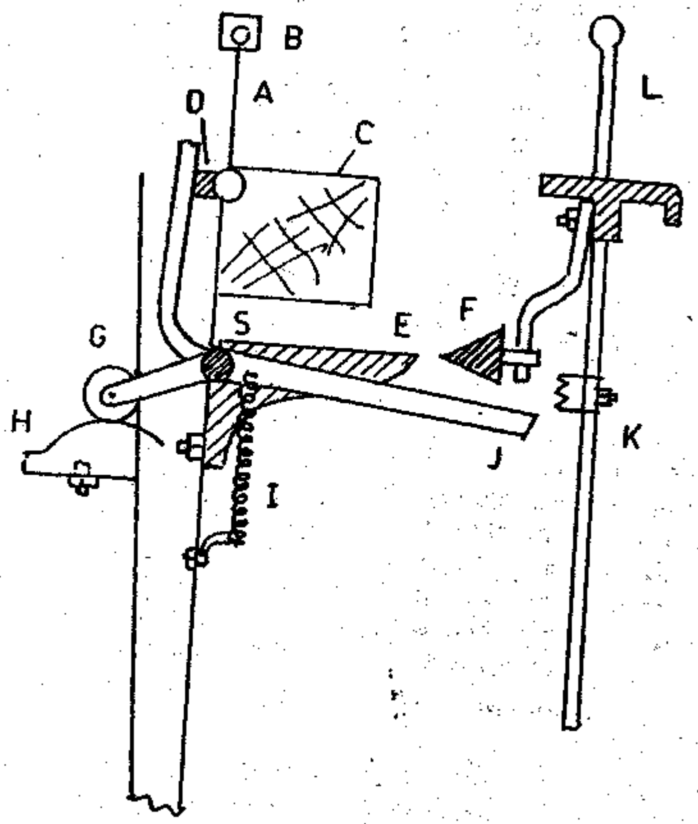
Loose reed and fast reed warp protectors. On high speed shuttle looms, electromagnetic warp stop motions are used.

### 8.4.1 Loose Reed Warp Protector

The principle of the mechanism is that the reed is forced out of its support whenever the shuttle is trapped in the shed and this backward inside movement of the reed will cause a knock off device to act and stop the loom (Fig. 8.11).

The reed A is held at the top in the slotted reed cap B. The bottom part of the reed is held firmly against the raceboard C by the reed case D which extends the whole width of the reed. This reed case is connected to a stop rod S by means of several brackets. The stop rod also extends the width of the sley and it is fixed to the sley below the raceboard. There are two, three or four frogs (duck bills) E, depending upon the width of the loom, mounted on the stop rod. Infront of each frog (duck bill) there is a heater F fixed by means of a bracket to the breast beam.

During the normal working of the loom there are three devices to keep the reed firm.




A = Reed, B = Reed Cap, C = Race Board, D = Reed Case, E = Frog (Duck Bill), F = Heater, G = Bowl, H = Bow Spring, J = Stop Rod Finger, S = Stop Rod, K = Serrated Bracket, L = Starting Handle.

**Fig. 8.11. Loose Reed Warp Protector**

- frog (duck bill) E engaging the heater F
- bowl G riding the bow spring H
- a light spiral spring I

#### 8.4.1.1 Frog and heater

When the sley moves forward the frogs (duck bills) slide under the heaters thus locking the reed firmly for a good beat up of weft.

#### 8.4.1.2 Bowl and bow spring

During the backward movement of the sley the bowl G rides on the flat bow spring H and keeps the reed firm to enable the smooth flight of the shuttle during its traverse from one box to another.



#### 8.4.1.3 Spiral spring

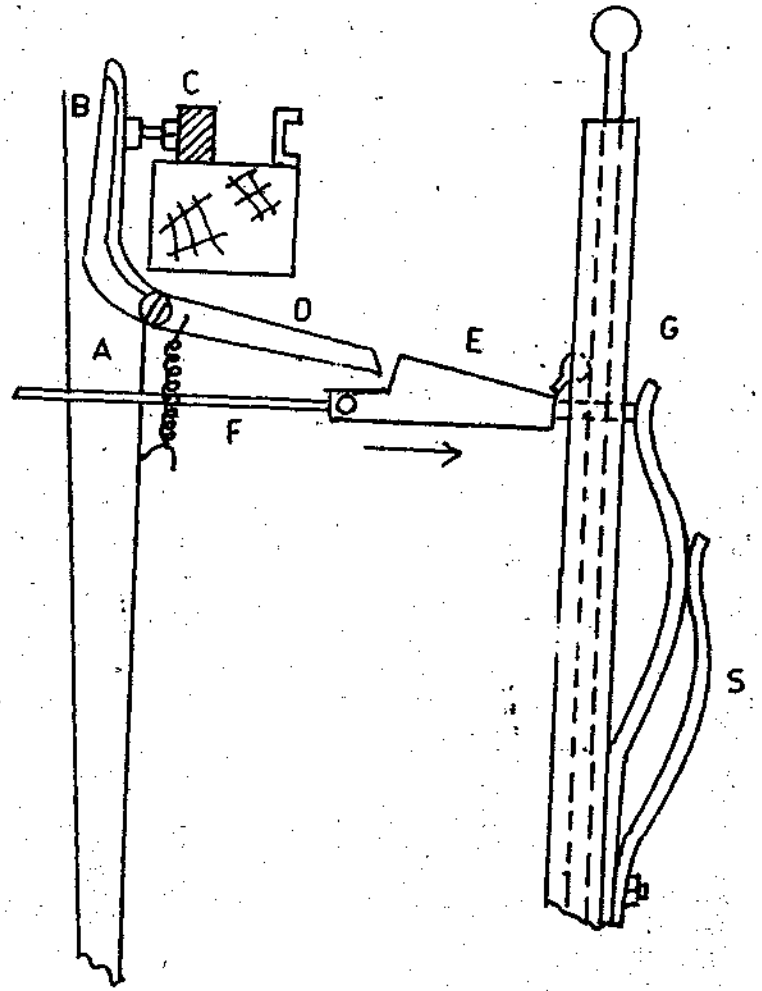
The light spiral spring keeps the reed case tensioned all the time. A stop rod finger J is also mounted on the stop rod, and facing this finger is a serrated bracket K fixed to the starting handle L. When the shuttle is trapped in the warp shed it presses against the base of the reed during the forward movement of the sley, with the result the reed is swung backwards turning the stop rod S through the reed case. When the stop rod is turned all the frogs and the stop rod finger are raised. During further forward movement of the sley the frogs ride over their respective heaters and the stop rod finger hits the serrated bracket and stop the loom. The frogs riding over the heaters will enable the reed case to move backwards easily.

The loose reed motion is only intended for light and medium weight fabrics. It is therefore necessary that the spiral spring I should only be strong enough to prevent the reed case from vibrating during running of the loom. If it is too strong the shuttle has to exert a greater force to push the reed back, which means more strain on the warp threads. Delicate warp used for light weight fabrics will not stand such strains with the result more warp breakages will occur.

### 8.4.2 Fast Reed Warp Protector

Fast reed warp protector is used for heavier fabrics because it works on the principle of fixed reed and the protector mechanism is operated by the shuttle box swell that reacts directly through the stop rod and the stop rod dagger to knock off the loom (Fig. 8.12). Also, for heavier fabrics the beat-up of weft by the sley should be very firm.

The stop rod A which runs beneath the sley has two fingers B fixed to it; one finger on each side of the shuttle box. These fingers with adjustable nust are kept pressed against the swell C. To the same stop rod are fixed two daggers D, one on each side of the shuttle box. The daggers face a sliding frog E mounted on the side frame. The sliding frog on the starting handle side carries the brake lever F at the rear and at the front it contacts the adjustable bolt that knocks off the starting handle. When the shuttle enters the box at either side, it presses the swell which makes the daggers raise above the frogs and the loom continues to run. If the shuttle fails to reach the box or if it rebounds owing to insufficient checking, then the swell will not be pushed back sufficiently to raise the daggers clear off the frogs with the result the daggers will dash against the frogs and push it backwards. Then the sliding frog will knock off the starting handle and the loom will stop. At the same time the brake lever F pulls the brake close on the brake drum to an almost instantaneous halt of the loom. The shock of the sudden stoppage




A = Stop Rod, B = Fingers, C = Swell, D = Daggers, E = Frog,
F = Brake Lever, G = Bolt, S = Vertical Springs.

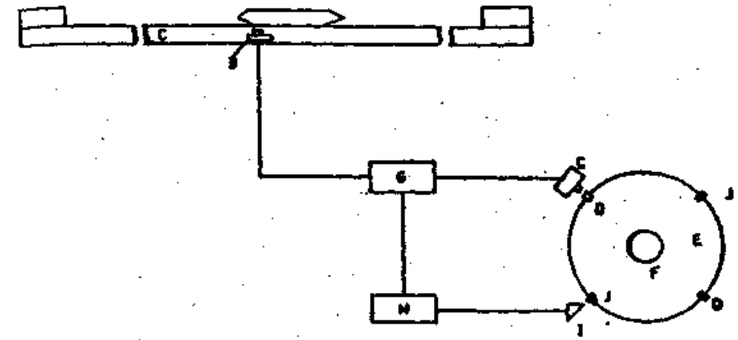
Fig. 8.12 Fast Reed Warp Protector

is taken by the two strong vertical springs S which are connected to the frog through a bolt G.

While setting the frogs with respect to the distance from the daggers, it is better to set so that the sley comes to a halt before the crank has passed the top centre. The sudden impact of the dagger on the frog is commonly known as **bang-off**. Sometimes *frequent* bang-off will cause the parts that are taking such force of the shock to fracture.



### 8.4.3 Electromagnetic Warp Protection



A = Magnet in the Shuttle, B = Coil in the Sley, C = Sley, D = Magnet,
E = Disc, F = Bottom Shaft, G = Electrical Control Unit, H = Solenoid,
I = Knock-off Lever, J = Knock-off Catch.

**Fig. 8.13 Electromagnetic Warp Protecting Mechanism**

The mechanism consists of a magnet in the end of the shuttle opposite to the shuttle eye (Fig. 8.13). A coil B is mounted slightly off the centre position in the sley. As the shuttle passes over the coil, a pulse is generated which is fed to an electrical control unit G. A second pulse is generated by a coil C and magnet D mounted on the disc E on the bottom shaft F and this occurs at a fixed time in each loom cycle. Under normal working these two pulses synchronise. A late passage or non-passage of the shuttle causes a break in the sequence of the two pulses. The solinoid then activates and then knock lever I will then be positioned in the knock off and catch and the loom will be brought to rest. The position of the knock-off catch depends upon the width of loom, loom timings, speed of loom. This type of motions are on Ruti C, Picanol, C&K looms.

**Advantages of this system are**

(i) Banging off shock is eleminated since there more time is available for stopping of the loom.

(ii) Unlike loose and fast reed methods of warp protection, there is no possibility of damage to the fell of the cloth since the loom is stopped before shuttle trapping can occur.

# 9 MULTIPLE BOX MOTIONS

## 9.1 FUNCTION

Multiple box motions are used to insert yarns of different colour, linear density, or fibres or twists across the fabric. With conventional looms, for each variety of weft one shuttle is required and there must be an empty box on the opposite side to receive the shuttle.

A loom may have two, four, six boxes one side and one box on the opposite side, normally referred as 2 x 1, 4 x 1, 6 x 1 box motions respectively. There may be box motions on both sides such as 2 x 2 or 4 x 4. Multiple box looms may be classified under the following groups.

(a) 2 x 1 looms, continuous acting type, for mixing weft in pair of picks. These are known as weft-mixing looms which intend to reduce the possibility of weft bars which occur specially with filament weft due to the change in the weft package and variation in package diameter. This motion is also suitable when cloths are to be woven with alternate double picks of 'S' and 'Z' twist.

(b) 2 x 2 weft mixing looms, continuous acting type, for mixing in single picks.

(c) 2 x 1, 4 x 1 or 6 x 1 shuttle looms for inserting coloured weft or different types of weft as per weft pattern. The main limitation of this type of box motions is that picks must be inserted in multiples of two. This is because the shuttle has to travel from multiple box inside to the opposite and back before a change can take place.

(d) 2 x 2, 3 x 3, 4 x 4, box motions in which multiple boxes are situated on both sides. Insertion of single picks in odd or even numbered groups can be effected.

(e) With 4 x 4 box looms, pick-at-will motions are applied to permit two or more shuttles to be driven from one end before a return movement is made from the other end. On this loom, with judicious choice, single picks of different colours upto seven colours of weft can be inserted, when it becomes a pick and pick loom.

It may be mentioned here that pick and pick weft insertion is more easily achieved in looms with gripper shuttles or rapiers.



Now-a-days this facility is also available in air and water jet looms.

## 9.2 TYPES OF BOX MOTIONS

Multiple box motions for shuttles are of two types :

- Circular box; Drop box

### 9.2.1 Circular Box

With this type of box motion, the boxes are arranged on a spindle in the form of a cylinder which is rotated to bring the required shuttle in line with the race board. The most common number of boxes is six, although five and seven boxes are also available.

Although, circular box motion was extensively used for producing light woolen dresses, and for silk weaving, now-a-days it has become obsolete. Main reasons are,

(i) Generally it is possible to rotate from one box to its one of the adjacent boxes, nevertheless skip boxes are available for random selection. The latter motion is not used in practice because of considerable reduction in the loom speed.

(ii) Fast reed cannot be used with this type of loom, because of the arrangement of boxes. So, the cloth made on circular box loom is limited to light or medium weight.

(iii) Under pick motion cannot be also used. So, this motion cannot be used on automatic loom.

(iv) Since the size of the boxes are fixed, it is difficult to adjust for worn out shuttles.

(v) Special small shuttles used on this loom reduce the efficiency.

### 9.2.2 Drop Box

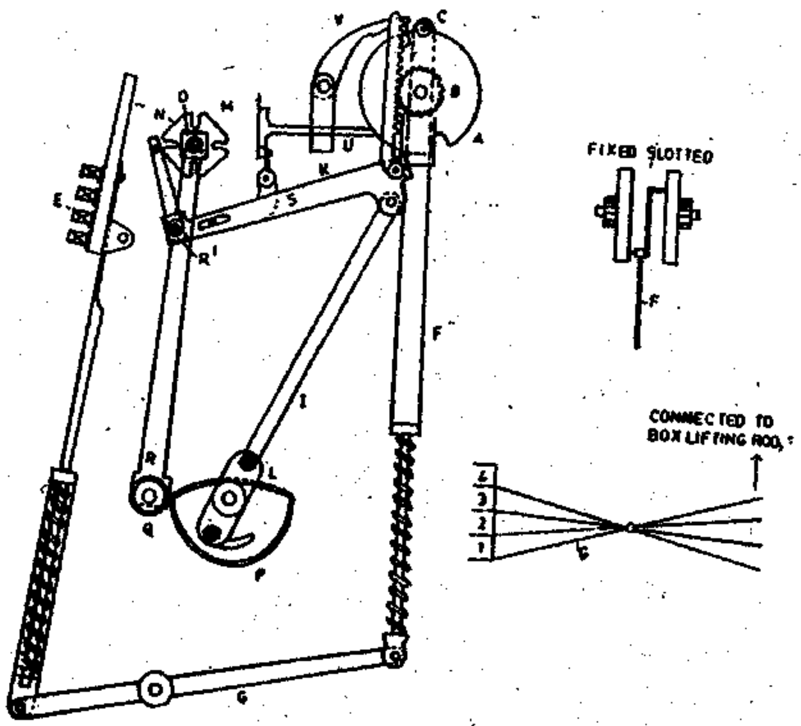
In drop box (sometimes also called as rising box) motion there is an arrangement of flat steel shelves, each shelf carrying a shuttle, which rises or falls in a predetermined order to bring a particular shuttle in line with the race-board and picker. 2 x 1 box is used for weft mixing; 4 x 1 is the most popular type of shuttle loom for weft patterning, although 6 x 1 box motion is also available.

Since Diggle invented a drop box motion, for a power loom, over a hundred and fifty years ago, a number of box motions are used of which Cowburn and Peck, and Eccle's box motions were extensively used. Now-a-days, these motions are also replaced by sliding gear type box motions.

### 9.2.3 Cowburn and Peck Drop Box Motion

Cowburn and Peck (C and P) drop box motion consists of the following parts (Fig. 9.1).

(1) Shuttle box E : There are four shelves, each carrying one shuttle. Normally the boxes are numbered from top to bottom.




A = Disc, B = Pinion, C = Crank, E = Shuttle Box, F = Box Lifting Rod, G = Spear Rod, I = Connecting Rod, J = Rack, K = Cradle, L = Crank, M = Card Barrel, N = Start Wheel, O = Bar, P = Cam, Q = Bottom Shaft, S = L-Shaped Lever, U = Needle, V = Catch.

**Fig. 9.1 Cowburn and Peck's Drop-Box Mechanism**

(2) Double Disc A : Each disc is free to rotate on a stud in the framing and has a pinion B formed on its boss. Outer disc A carries a stud on which a crank C is loosely fitted. Other end of the crank is fitted freely through a slot of the other disc. The box lifting rod F passes down from the crank inside the disc to a spear rod G. The discs move in one direction only and through half a revolution, each time.



(3) Rack J : The rack when engages with the pinion of disc rotates the latter during its downward movement. The racks are attached to the outer end of the cradle K and are centered to be kept away from the disc pinion by gravitation force and rest on the needles. There are two racks, one for each disc.

(4) Cradle K : The cradle is rocked on a stud by an adjustable crank L and a connecting rod I.

(5) Card barrel M : A four sided card barrel has a star wheel fixed on one end of its shaft. It is mounted upon the top of a bar O. The card cylinder rocks forward and backward by means of a cam P on the bottom shaft Q.

(6) Pattern cards : There are eight types of cards as shown in the Fig.9.2.

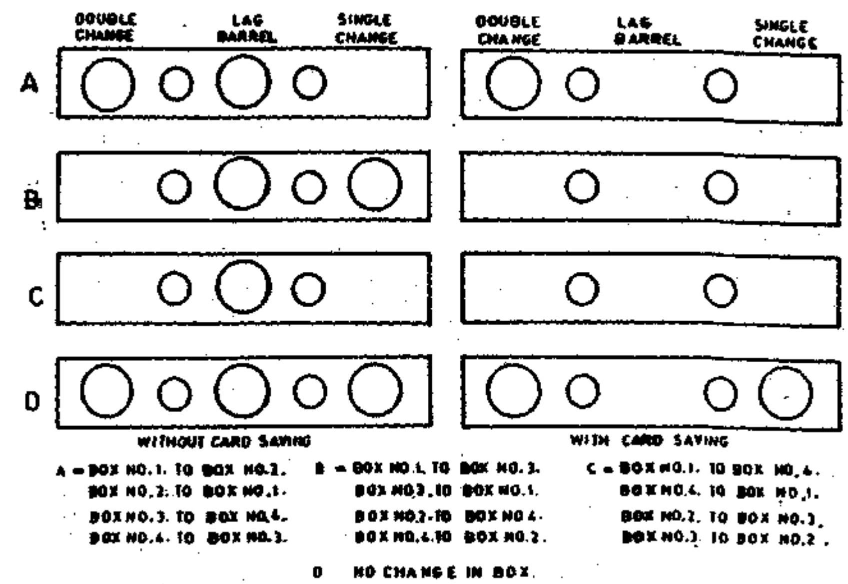



**Fig. 9.2 Pattern Cards**

(7) L-shaped lever S : The card barrel is rotated by one of the two pins in an L-shaped lever. It gets its reciprocating movement from the cradle.

(8) Needles U : Needles cause the racks to engage with their respective pinions. There are three needles, the two outer

needles are for rotating the discs. The third one is used for rotating the hexagonal lattice barrel of card saving device.

(9) Card saving device (not shown in the figure) : A card saving motion is often fitted to this type of drop box motion in which two star wheels are provided for the card cylinder, either of which will turn it. One of the star wheels is connected by spur wheels so that it gives a reverse movement to the card cylinder. Thus, it is possible to rotate the card barrel in the forward direction, reverse direction, or to present the same card against the cylinder for successive picks.

(10) Disc locking : When not in action, each disc is locked by a flat spring that forces a catch V into the upper most of the two notches cut in the disc's rim.

(11) Safety device : Connections to the shuttle box from the disc crank are made through springs to avoid smash in case a picker or a shuttle is trapped.

### 9.2.3.1 Working

When a hole on the pattern card is against a needle, the rack is clear of the disc pinion and the disc is locked. So a change in the box does not take place. A blank card pushes the needle to engage the rack with the pinion during its descending movement. When the fixed pin disc (outer disc) is turned half a revolution, it gives a one-box change while rotation of the slotted disc gives a two-box movement. For three-box movements, both the discs should be rotated as shown in Fig. 9.2. For working card saving device, a central hole is provided in the flat steel cards of the pattern chain. When it is blank, a third rack engages with a pinion to rotate a secondary card barrel of wooden legs. A bar which rests on these legs gives lateral movement to the L-shaped lever either to give a clockwise movement of the pattern cylinder or to stop it from turning. Another star wheel (not shown in the figure) is used to give an anticlockwise movement. Wooden legs are of three types viz. flat, medium and raised. The first is used to give a forward movement, the last one for reversing of the pattern barrel and the middle one to stop its movement.

### 9.2.3.2 Setting of box motion

Setting of the C and P box motion is as follows :

1. Picking from the single box side is made 10° early as compared to normal.
2. Shuttle of the opposite hand should be used. This is because the multiple boxes are situated on the offside of the loom. Thus, for a right hand loom, a left hand shuttle is used.



3. When picking from the starting handle side is finished, the tip of the cam on the bottom side should be in one line with the centre of the antifriction bowl. The large part of the cam should be faced downwards.
4. At the above mentioned position, the rack should be at the top most position and if pressed inwards by hand, its teeth should coincide with the teeth of the pinion.

### 9.2.3.3 Weft pattern designing

The following weft colour pattern has been taken as an example:

| | |
|---|---|
| White | 8 picks |
| Red | 2 picks |
| Blue | 2 picks |
| Yellow | 2 picks |
| Blue | 2 picks |
| Red | 2 picks |
| Total | 18 picks |

Assume that card No. 1 will carry the top box level with the sley and the shuttles are boxed as follows.

| | | |
|---|---|---|
| Box No. 1 | - | White colour |
| Box No. 2 | - | Red colour |
| Box No.3 | - | Yellow colour |
| Box No. 4 | - | Blue colour |

Pattern chain without a card saving device is shown in Fig. 9.3. One must note that while preparing a pattern chain to avoid a three-box movement as it gives a considerable strain on the mechanism.

By using pattern saving device only four cards are required for 18 pick design as shown in Table 9.1.

**Table 9.1 Pattern Chain with Saving Device**

| Card No. | Box No. | Type of picks inserted | Lag Barrel |
|---|---|---|---|
| 8 | 1 | 2 White | Medium |
| 8 | 1 | 2 White | Flat |
| 1 | 2 | 2 Red | No change |
| 3 | 4 | 2 Blue | No change |
| 2 | 3 | 2 Yellow | Medium |
| 2 | 4 | 2 Blue | Raised |
| 3 | 2 | 2 Red | No change |
| 1 | 1 | 2 White | No change |
| 8 | 1 | 2 White | Medium |

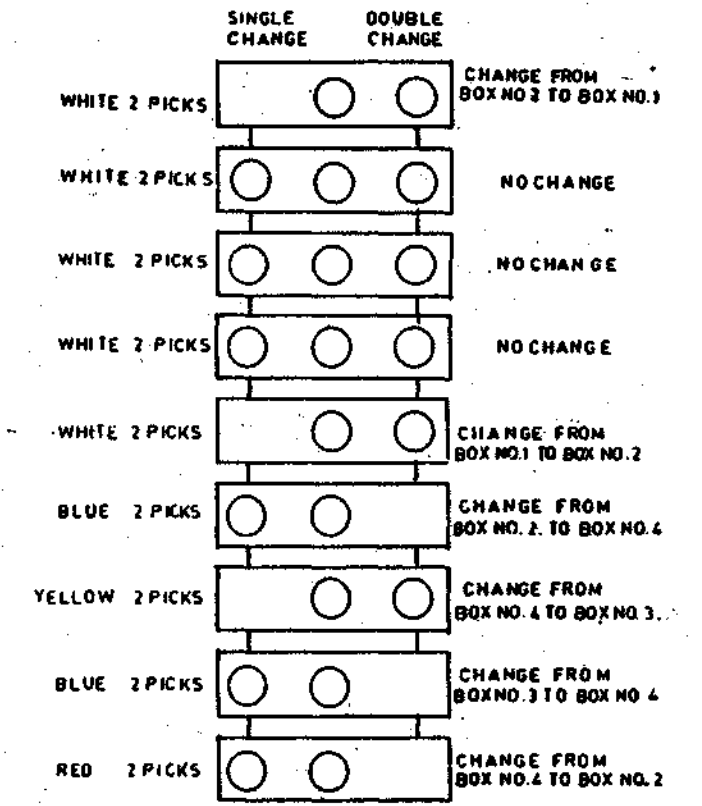



**Fig. 9.3 Pattern Chain Without Card Saving**

### 9.2.4 Eccle's Drop Box

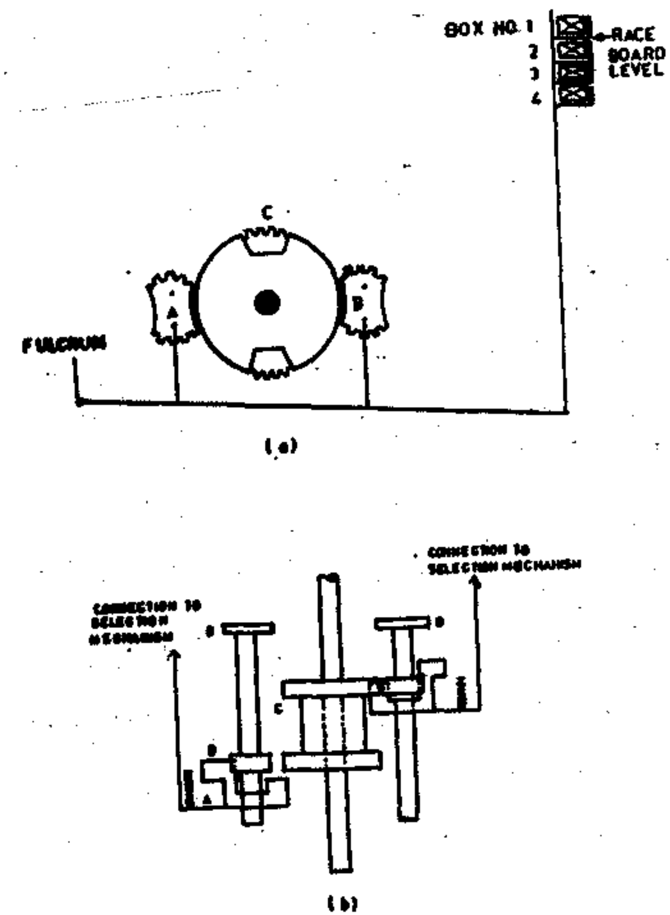
Eccle's Drop Box is similar to Cowburn and Peck Drop box, only differences being :

- Cradle is rocked by an eccentric instead by a crank on the bottom shaft.
- Spear rod is fulcrummed at one end instead of at the centre.

### 9.2.5 Sliding Gear Box Motion

This type of box motion which is employed on Northrop, Ruti, Zang, Icol, Honest looms is controlled from either a dobby, a jacquard or a card motion. When the box selection mechanism indicates for a particular shuttle to be brought to sley level, one or both of the cranks will actuate the long box motion lever in order to impart the necessary movement to the box, lifting rod on the upper end of which are mounted the shuttle boxes. The main parts of the mechanism as shown in Fig. 9.4 are :






A = Sliding Clutch, B = Mutilated Crank Gear, C = Disc Gear, D = Crank.

**Fig. 9.4 (a, b) Sliding Gear Drop-Box motion**

1. Sliding clutch A : A sliding clutch forms the toothed segment of a mutilated crank gear. The opposite side of the sliding clutch (Fig. 9.4b) has two segments or teeth of different lengths. They are designed to move freely in and out of the spaces provided on the mutiliated crank gear B. Normally the disc gear C misses the segment gear. But, when a selection is made, the shorter tooth slides into the position on the crank gear and at the same time comes into line in readiness to engage the teeth of the disc gear.

2. Disc gear C : The disc gear C which is mounted on the bottom shaft has two series of teeth as shown in the figure. The disc gear revolves once in every two picks when a selection is made. The teeth of the disc gear engage the crank gear. It rotates the crank D through half a revolution.

3. Crank D : There are two cranks D for four box motions. The rear clutch operates the rear crank while the front clutch operates the front crank. Since each sliding clutch is operated independently of its counterpart, it is possible to have both clutches in operation at the same time. Due to the positioning of each crank on the box motion lever and also to their different sizes, varying degrees of movements are imparted to the box motion lever and it is through the difference in leverage that the correct movement of the shuttle boxes is obtained. The front crank gives a one box movement and the rear crank gives a two box movement.

4. Locking device : The locking plate is secured to the crank shaft. It maintains the crank gear in a stationary position when out of mesh with the teeth of the driving gear.

5. Safety device : If the sliding clutch is unable to slide inwards when indicated, an effective escape arrangement is provided by a spring at the end of the connecting rod.

An escapement device is also provided for the driving gear in the event of the boxes jamming.

#### 9.2.5.1 Working

The intermittent drive to the crank is dependent on selection. The selection mechanism through links slides the sliding clutch in the cutout of the crank gear so that disc gear engages the short segment tooth of the clutch to turn the crank gear through half a revolution. Now further rotation of the crank gear is no longer possible because the long segment does not come in line with the disc gear until the selection changes again. The latter allows the clutch to slide back to a driving position. With this mechanism, a blank followed by a bank or a hole followed by a hole means no change, whereas a hole followed by a blank or vice versa mean a change in the box.

#### 9.2.5.2 Setting

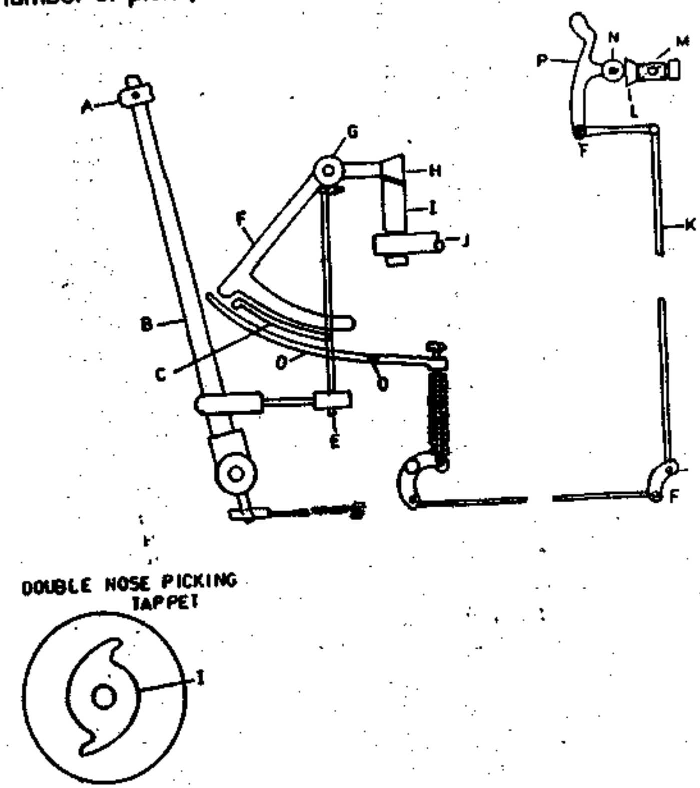
1. With the shuttles in the multiple box side and No.1 Box at sley level and the loom is at the top centre, the disc gear should be about to engage the crank gear when the sliding clutch is in the depressed position.

2. The escape spring should be so set as to exert sufficient pressure to keep the boss of a crank disc location with the driving gear under normal condition.



### 9.2.6 Pick-at-Will Motion

As mentioned earlier, for pick-at-will looms it is necessary to have multiple boxes at both sides of the loom. In such looms it is usual to have picking mechanism which will allow several picks made in succession from either side of the loom, in order to insert a weft at any number of picks, either even or odd at will.




A = Picker, B = Picking Stick, C = Picking Latch, D = Latch Support Lever, E = Loose Picking Arm, F = Driving Arm, G = Picking Shaft, H = Picking Cone, I = Double Nose Picking Tappet, J = Bottom Shaft, K = Vertical Rod, L = Swell, M = Shuttle, N = Bowl, O = Fulcrum, P = Swell Feeler.

**Fig. 9.5 Pick- at- Will Motion**

A double nosed picking tappet I (Fig. 9.5 inset) used on this loom is different from a normal picking tappet used on conventional looms. The tappet is fixed on the bottom shaft J and pushes the picking cone H, which is fixed by a short stud on the picking shaft G. On the same picking shaft there are two picking arms, one loose E and the other fast F. A latch C is fitted to the picking arm E and the end of the latter is connected to the picking stick. Below the picking latch, there is a latch support lever D, fulcrummed at O, which is connected to a small vertical rod K with a spring inserted in it and finally it is connected to the swell feeler P through a vertical rod and other lever connections. The swell feeler has a bowl N rested against the swell L of the shuttle-box. Since picking can take place from only one side, mechanical or electrical communicaition is necessary. In the figure when a shuttle is present on one side, clutching or declutching takes place mechanically with the swell feeler, bowl and suitable lever connections to the other side. If clutching takes place on one side, then declutching takes place on the opposite side. When the shuttle is boxed and is in line with the sley race, it declutches the picking latch on the other side through the swell and other connections. This means, picking is not working on this side, then the respective clutch moves inside and in turn lifts the latch support lever. The lifting of the latch support lever makes the picking latch to come in the way of fast picking arm and turns the picking stick. This means that picking is possible on this side because the clutching of picking latch takes place. If both the boxes are empty, then micro switches give indication to stop the loom instanteneously.

## 9.3 WEFT PATTERNING ON UNCONVENTIONAL WEAVING

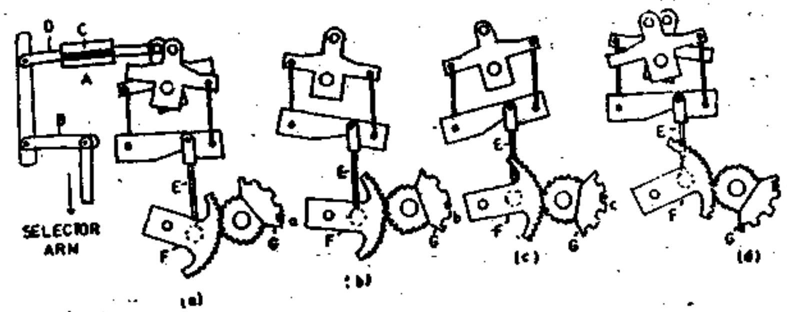
With the advent of unconventional weaving machines, weft insertion has become comparatively easier because the weft patterning especially pick and pick weft insertion makes the loom very complicated and needs reduction in the loom speed by about 20-25% as compared to a single shuttle loom. On an unconventional weaving machines, each type of weft is supplied from a large stationary package situated at the side of a loom. Each package must have its own tensioning device, weft accumulator, guide arm, feeding device etc. There are normally two, four, six, even ten or twelve colour arrangement but most common one is either four or six colour arrangement.

### 9.3.1 Weft Patterning Device on Projectile Weaving Machines

On a Sulzer-Ruti gripper projectile weaving machine, the initial speed of the projectile is so high that the weft of the required type must be fed to the projectile before the latter is accelerated. So, it is necessary to have individual feeder unit for each type or colour of weft. The feeder house is moved by a level gear which in turn is driven from a segment gear. The position of the segment gear determines the position of the feeder assembly as shown in Fig. 9.6.

A lifting rod is suspended from one end of the lifting lever and a second rod is from the other end of the other lever. The driving lever can be rocked by one or both of the lifting levers. The driving






A = Lifter Levers, B = Lifter Rod, C = Spring, D = Driven Arm, E = Driving Rod, F = Segment Gear, G = Feeder Housing.

**Fig. 9.6 (a, b, c, d) Sulzer Four Colour Box Motion**

rod is suspended from a point on the drive lever, that is one-third of the distance from the right hand lifting rod. The driving rod is connected to the segment lever.

A hole or a selection from the dobby or jacquard will cause the lifting lever to operate through a selection arm bell crank lever, spring damper as shown in Fig. 9.6a. Six colour weft patterning device on Sulzer-Ruti is similar to a four colour system but in the case of the former three control points, three lifting levers and three lifting rods are used.

### 9.3.2 Weft Patterning on Rapier Weaving Machines

On rapier weaving machines, the rapier starts moving with a low acceleration and cam, therefore, take-up the weft at the start. The feeder merely has to place the weft of the selected colour/type in the way of a rapier and the weft is taken by it.

On Dornier loom (rapier type), direct selection is made from the dobby or jacquard. As shown in the Fig. 9.7, the upward movement of the selection lever by means of a dobby jack or a jacquard hook lowers the guide. In this case, selection must be carefully timed because the guide must be in position at a time when the knives or griffes of the shedding mechanism are actually changing from one position to other.

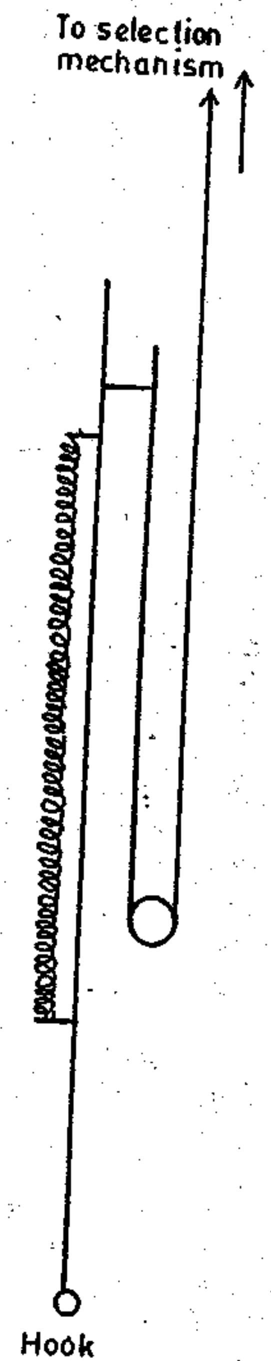



**Fig. 9.7 Multicolour Motion on Rapier**



### 9.3.3 Weft Patterning on Jet Weaving Machines

On the jet weaving machines the weft must offer very low resistance to the unwinding and there is a necessity of measuring a pick length of weft. In addition, a coloured weft change motion on a jet weaving machine obviously needs a change of nozzles and additional weft measuring devices. Such a system is rather sophisticated and difficult to design. Now-a-days on jet looms pick and pick insertion upto six colours is possible. The operation of the weft change motion on jet weaving machines requires the following elements to be programme-controlled.

- a brake for each weft,
- switching off of measuring device to an accuracy of ± 5 mm on the disc circumference,
- weft storage in a loop form,
- a distributor to eject the jet through the selected nozzle.

# 10 AUTOMATIC WEAVING MACHINE - Weft Feeling

## 10.1 INTRODUCTION

Ever since the shuttle loom was invented the main function of a weaver was to replenish a weft bobbin into the shuttle as soon as the weft gets exhausted in the shuttle. To do this he has to stop the loom with the shuttle on starting handle side, remove the shuttle from the box, remove the empty pirn from the shuttle and replenish it with a fully wound weft pirn. Everytime this job is carried out there is a loss of production and the weaver is not able to attend the other looms. The chief aim was, therefore, to provide conditions under which a loom can run for a long period without requiring the attention of a weaver, who is thereby able to attend to more looms. since the wage bill of a weaving shed with non-automatic loom is very high, it was essential to find some way to reduce it. It could be possible either by increasing the loom speeds or by increasing the number of looms per weaver. So the idea of automatic weft replenishment came into the inventor's mind, when the optimum loom speeds were reached.

However, it was in 1889 that the idea was conceived of forcing a bobbin of weft into a shuttle without stopping the loom, thereby replenishing the weft automatically. Along with this new development the automatic loom is fitted with an automatic warp let-off motion and a reliable warp stop motion. The automatic warp let-off motion maintains the correct tension in the warp throughout the weaving of the warp beam from the start to the end. By automatically replenishing the weft the weaver is relieved from a major portion of his work and he can look after more number of looms. Automatic let-off also helped him to get relieved of the adjustment of let-off of negative type.

Spring cloth roller motion and individual drive are some of the additional features of an automatic loom.

There are two methods of replenishing the weft automatically.

(i) bobbin or pirn changing

(ii) shuttle changing

Since the shuttle changing method requires more number of shuttles of matching size and weight and also being expensive, it has not become very popular. However, it had two chief advantages.



(a) Shuttles of conventional type which could use cops or pirns with those used for non-automatic looms, could be used. Hence no special type of shuttles are required.

(b) Shuttle-changing looms are more suitable for weaving fine and delicate yarns e.g. synthetic yarns with special characteristics which are somewhat difficult to weave with the bobbin changing mechanism.

However, with the improvement in bobbin changing mechanism it is now possible to weave fine and delicate yarns, on such looms instead of on shuttle changing looms.

## 10.2 PIRN CHANGING WEFT REPLENISHING MOTION

The following parts or attachments are found essential for operating this mechanism.

- a large shuttle and pirn with a few changes in the design;
- changes in the design of the shuttle boxes and sley;
- a rotary magazine to accommodate 24 to 30 fully wound pirns;
- a feeler mechanism on the starting handle side (opposite side of the rotary magazine) to detect the almost exhausted weft pirn;
- a mechanism to push the fully wound pirn from the magazing into the shuttle and at the same time eject the empty pirn;
- a self threading device in the shuttle;
- a device to cut the two ends of weft at the selvedge of the cloth at the pirn changing side. Among the two weft ends, one of which was from the outgoing almost empty pirn and the other from a new fully wound in-going pirn;
- a mechanism, known as shuttle protector, to prevent the changing mechanism from trying to insert a new fully wound pirn in the shuttle, should the shuttle fail to be exactly in the correct position for receiving the bobbin.

At this stage it is important to note that under-picking mechanism is only suitable for bobbin changing. In the case of cone-over picking the picking spindle will come in the way of fully wound pirn from the magazine getting into the shuttle.

### 10.2.1 Shuttle and Other Accessories for Pirn Changing Automatic loom

#### 10.2.1.1 Shuttle

The shuttle (Fig. 10.1) used on automatic pirn changing loom is large in size in order to carry large quantity of weft yarn. For instance, the shuttle of a 110 cm wide Northrop automatic loom, running at a speed about 170 picks per minute, weighs, together with a full pirn, about 454 g. In the case of the Picanol automatic loom, running at 220 picks per minute, the shuttle with a full pirn weighs

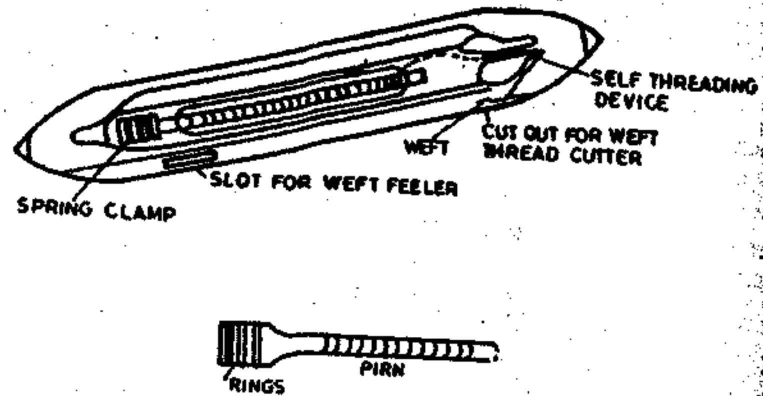



**Fig.10.1 Automatic Loom Shuttle and Pirn**

about 567 g. If smaller size shuttles are used, the pirns will carry a smaller quantity of weft yarn, with the result that there will be greater number of pirn changes in a given time. This will give greater wear and tear of the pirn changing mechanism. Also, a greater amount of waste yarn will result arising from the bunches on the pirns (the purpose of yarn bunch will be discussed later in this chapter). The work of a battery filler will also increase.

The automatic loom shuttle should be so designed as to allow for free entry of the full bobbin, and ejection of the empty bobbin, at the same time having the necessary means for holding the full bobbin firmly after it had been placed in the shuttle.

A shuttle for a pirn changing automatic loom should be provided with a self threading device. Therefore the design of the threading device has to be changed. It is not possible to take out the weft end through the shuttles eye like the one adopted in the case of a non-automatic loom, where two holes are provided and the weaver, while replenishing the weft, draws the thread through these holes. In a pirn changing automatic loom, the threading has to be done while the loom is running. This is achieved by having a shuttle with self threading device. When the shuttle is picked from the magazine side, the weft thread is held on the top of the eye because the weft end is wrapped round the mandrelle of the magazine front and gives sufficient tension for the first pick after the transfer. On the second pick, that is, after the shuttle has been picked from the feeler side, the weft thread settles down in the groove of the self-threading device.



The weft pirn is also different from that used on ordinary looms. The pirn base is fitted with suitable rings whereby it could be clipped in the spring jaw in the shuttle. Most pirns are fitted with three rings, but where conditions require them, four rings are also provided. When the fully wound pirn is transferred into the shuttle, it should lie perfectly at centre for correct unwinding.

Since most of the automatic looms are "left handed" (the starting handle being on the left) the self threading eye on the shuttle is fitted at the right hand end when viewed from the front of the shuttle. Manufacturers of shuttle will provide different types of shuttle eyes to suit the weft yarn being used. Twist way and weft way eyes are used according to the direction in which the weft is unwound from the pirn. The other feature of the automatic loom shuttle is that it is provided with a slot at the front wall near the spring jaw. This slot allows the feeler blade of the weft feeler mechanism to pass through and touch the weft pirn (the details of this mechanism will be studied under a separate heading).

The foregoing discussion on the automatic shuttle and pirn, may be summarized as follows.

(a) The shuttle has a wide mouth at the top to allow for free entry of the fully wound pirn.

(b) It has also a wide opening at the bottom for the ejection of empty pirn.

(c) The shuttle is provided with a spring jaw to hold the pirn. This has replaced the metal tongue used on ordinary loom shuttle.

(d) A self-threading eye is fitted at the right hand end when viewed from the front of the shuttle. The spring jaw is at the left hand end.

(e) A slot is provided at the front wall near the spring jaw.

(f) The shuttle is big, heavy and has thicker side walls.

(g) The pirn base is fitted with three or four metal rings so that it could be clipped in the spring jaw of the shuttle.

#### 10.2.1.2 Shuttle boxes

(a) There is no picker spindle since cone over picking is not suitable for pirn changing system.

(b) The bottom metal plate on the battery end has a wider opening for an empty pirn to pass through.

(c) The front plate on the starting handle side (opposite to the battery) has a slot corresponding to the slot in the shuttle front, for the feeler blade to pass through.

(d) The front plate on the battery side has a slot for the shuttle-eye-cutter to pass through.

#### 10.2.1.3 Rotary magazine (battery)

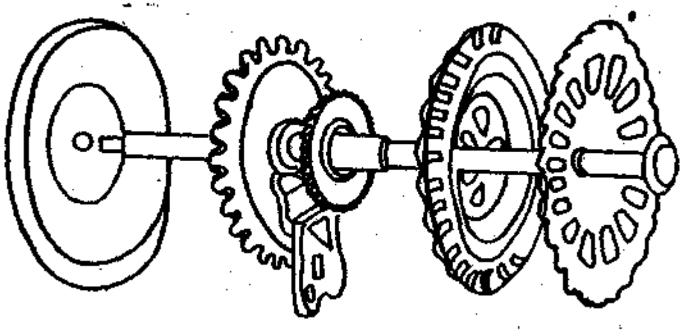


Fig. 10.2 Rotary Magazine

The rotary magazine (Fig. 10.2) which can accommodate 24 to 30 full pirns is mounted on the right hand end of the breast beam, so that its bottom centre is above the shuttle when the sley is at the beat up position and the shuttle is in its box. The magazine consists of three main circular plates. One plate is used for holding the pirn base, the second for holding the tip of the pirn and the third to guide the unwound thread before it is anchored by wrapping it around a boss on the magazine front. Each fully wound pirn is placed individually in the magazine, where it is held by a spring clip at its tip. To prevent any possibility of damage from the pirns touching each other in the magazine, the spacing of spring clips is such as to leave a gap between each pirn. A little length of weft unwound from the pirn is anchored by wrapping it around a boss on the magazine front so that it will not be taken into the cloth when the first pick is inserted into the warp shed after a pirn change.

## 10.3 WEFT FEELER MECHANISM

The function of the feeler mechanism is to sense the weft on the pirn and initiate the pirn changing mechanism to act when the weft has been almost exhausted on the pirn. If the weft is present on the pirn the feeler will allow the loom to continue working.

There are three main types of feelers;

(a) Mechanical,

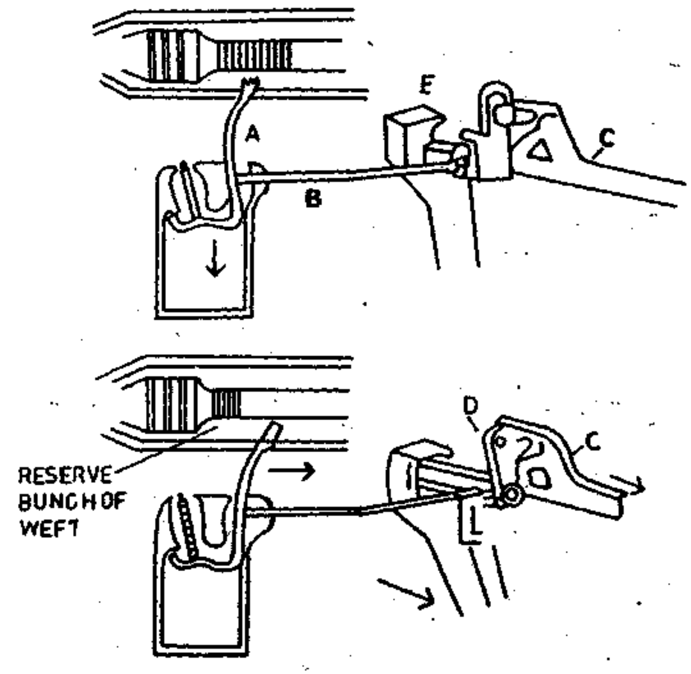
(b) Electrical, and

(c) Photo electrical.



### 10.3.1 Mechanical Feeler

#### 10.3.1.1 Midget side slip feeler



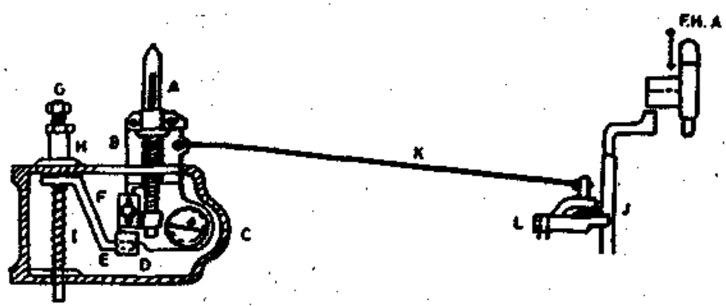

A = Feeler Blade, B = Trip Lever Connecting Rod, C = Trip Lever, D = Bell Crank Lever, E = Tripper Heel.

Fig. 10.3 Midget Mechanical Feeler

When the sley moves forward the feeler blade A, as shown in Fig. 10.3, passes through the slots in the front plate of the box and front wall of the shuttle and contacts the pirn. If there is sufficient weft yarn on the pirn, the blade A is pushed straight back into the feeler casing and no indication of a pirn transfer takes place. With the reserve bunch of weft, approximately a length of three picks of yarn is left on the pirn base. The feeler blade contacts the smooth polished surface of base pirn and slides side-ways, contacting the trip lever connecting rod B, which in turn raises the trip lever C through the bell crank lever D.

A tripper heel E attached to the weft fork hammer F, oscillating to and fro along with the weft fork hammer, comes in contact with the raised trip lever C and pushes it back in the direction of the arrow shown in the figure. This will cause the change shaft G (see Fig 11.1) which runs across the width of the breast beam, to turn and effect a pirn change at the magazine and during the next forward movement of the sley with the shuttle on the magazine side box. The return spring in the feeler casing pulls the feeler blade to its normal position as soon as the contact of the blade with the pirn is over.

### 10.3.1.2 Cimmco weft feeler




A = Feeler Blade, B = Feeler Slide, C = Spring Loaded Stud,
D = Tail End, E = Arm, F = Z Piece , G = Plunger Screw Head,
H = Plunger, I = Plunger Spring, J = Change Lever,
K = Connecting Rod, L = Bell Crank Lever, S = Spring,
F.H.A. = Weft Fork Hammer Assembly.

**Fig. 10.4 Cimmco Side Sweep Weft Feeler**

This feeler shown in Fig. 10.4 like the Midget feeler is of side sweep type, but its principle of working is entirely different from the latter. The feeler blade A is fixed in the feeler slide B which is pivoted on a spring loaded stud C. The feeler slide is extended beyond the fulcrum to form a central square and a tail end D. The arm E of the Z piece F acts at one side of the central square.

As the sley moves forward with the shuttle boxed on the feeler side, the feeler blade contacts the weft on the pirn first and is pressed back slightly against the spring S. As the sley advances still further, the loom front presses the plunger screw head G so that the plunger H is pushed back. In the normal position the plunger spring I keeps the Z piece F pressed against the plunger to hold the slide B in a straight position and prevents the same from tilting due to the action of the coils springs at stud C. So, when there is sufficient weft on the pirn and the blade contacts the same before the plunger screw head, there is no change of the feeler slide to tilt side ways, as serrations of the feeler blade are in contact with the weft on the pirn.



### 10.3.1.3 Weft fork cam

The shape of the weft fork cam on automatic loom is different from that used on a non-automatic loom. In the case of latter its function is only to effect a stop of the loom whenever a weft breaks or exhausts, whereas in automatic loom the cam not only puts the pirn change mechanism in action but also holds the raised latch in position till the bunter and latch lock together for action. The cam is designed to give a full throw for a period of just over 180° of crank shaft rotation.

### 10.3.2 Electrical Two Pronged Feeler

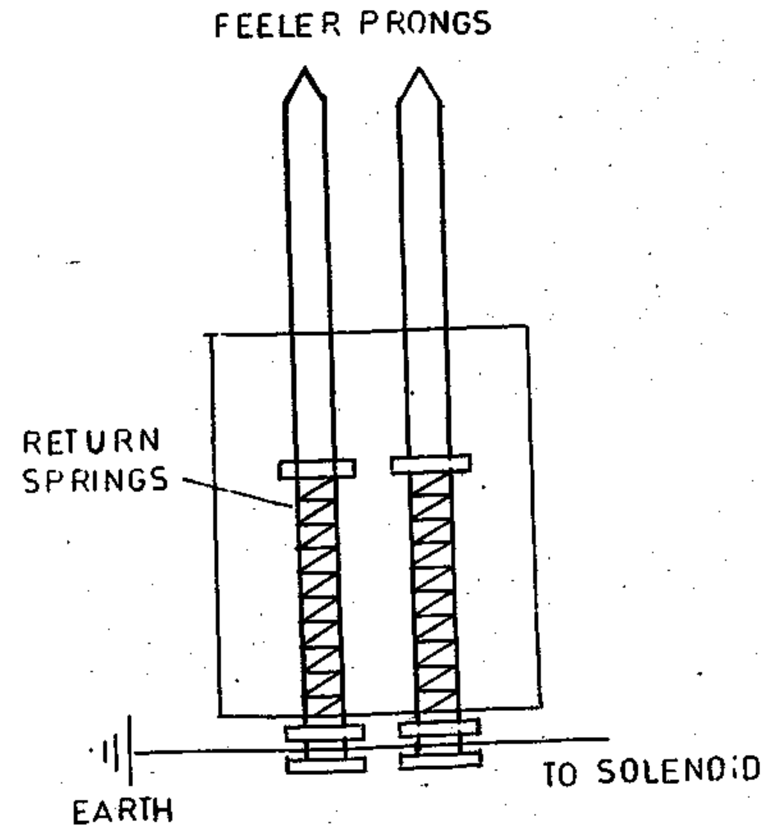



**Fig. 10.5 Electrical Weft Feeler**

This type of feeler shown in Fig. 10.5 has been designed where the transfer of the fully wound pirn from the weft replenishing unit to the shuttle is initiated electrically. It can be used with advantage on looms weaving delicate weft. The feeler is mounted on a bracket fixed to the rear wall of the starting handle casing. The weft pirn is fitted with a metal sleeve on the barrel. A bunch or reserve of weft, sufficient for four picks across the loom must be wound at the base of the pirn. Under normal running conditions, as the sley moves forward and is almost at the front centre, the weft on the pirn contacts the feeler prongs which are pushed backwards into the feeler casing, against the pressure of return springs. However, when the pirn is empty, except for the reserve weft, the metal sleeve on the pirn barrel is exposed and comes in contact with the feeler prongs.

The feeler prongs are connected to an electrical circuit as seen in Fig. 10.5. The circuit is incomplete until contact is effected across the feeler prongs. As soon as the prongs come in contact with the metal sleeve on the pirn barrel the circuit is completed energizing the solenoid and the electrical magnet box so that the trip lever is lifted in line with the tripper heel (as discussed under the mechanical feeler) which puts the pirn changing mechanism in action. The electrical circuit is broken when the sley moves backwards to break contact between the metal sleeve on the pirn and the feeler prongs.

Area of contact between the feeler and yarn is very small and does not damage the yarn. But it requires special type of pirns with a metal sleeve.

### 10.3.3 Optical Electronic Weft Feeler

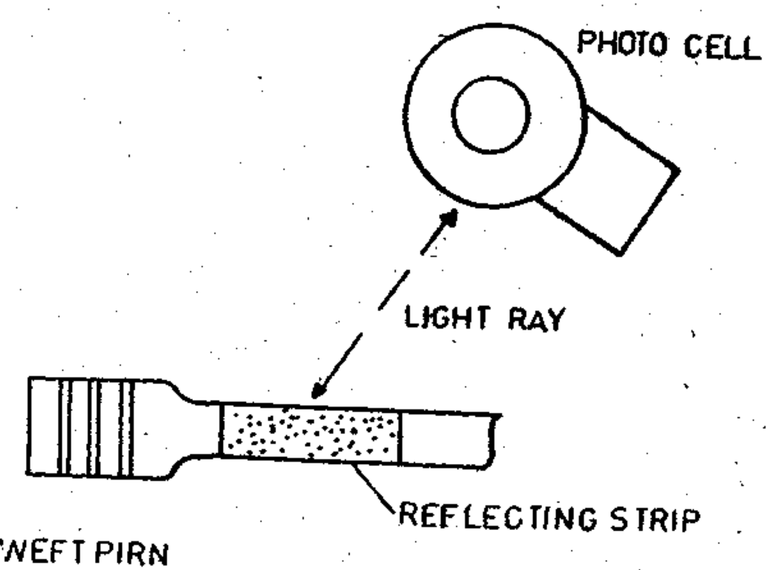



Fig.10.6 Optical Electronic Weft Feeler



The weft pirn used for this type of feeler (Fig. 10.6) is covered with a reflective strip which has the property of reflecting a beam of light back to its source. The light source and the photocell are housed together in the feeler head and both the searching beam and the reflected ray pass through the same optical system.

Incident light ray is directed on the pirn constantly and as soon as the weft is exhausted the light ray is reflected back to the feeler head. On reaching the photocell, the reflected light is tranformed into an electrical impulse and transmitted to the switch box, which contains the whole electrical supply for the feeler and feeds the appropriate selection mechanism in order to initiate the transfer of pirn. Advantage of this feeler is that there is no physical contact between the feeler and the weft yarn. Main disadvantage is that it is very expensive. Now-a-days for filament weaving, this feeler is extensively used.

### 10.3.4 Reserve Bunch of Weft

When a weft feeler of any type is in use, it is essential to wind a length of yarn at the butt end of a pirn, in such a way that it does not hinder the working of the weft feeler. This length of weft is known as reserve bunch. A special attachment is required to prepare this bunch on pirn winding machines.

The length of yarn on the reserve bunch has an effect on the quality of the cloth as well as on the cost of production. If the bunch length is too short, it sometimes happens that the yarn on a number of pirns runs off completely. In this case, there may be broken picks in the cloth causing a considerable reduction in the selling price of the cloth or the loom may be brought to rest by the weft fork, resulting in a loss of production. On the other hand, if the length of yarn on the bunch is too long, an excessive amount of yarn will be left on the ejected pirns and this will result in an increase in the production of waste. Waste in the weaving room is more expensive than that of the other departments because the cost of yarn is added to each by every process upto and including weaving. The amount of waste is especially more important when expensive yarns e.g. nylon, polyester are in use. The cost of defective cloth would, in all probability, be greater than the cost of waste occurring from the bunches on the pirns. A bunch with about four pick lengths of weft is, reasonably, well founded (1).

## 10.4 WEFT FORK AS A MEANS OF INDICATING THE PIRN CHANGE

The pirn change mechanism can be put into operation either by the use of.

(a) a feeler; or (b) the weft fork.

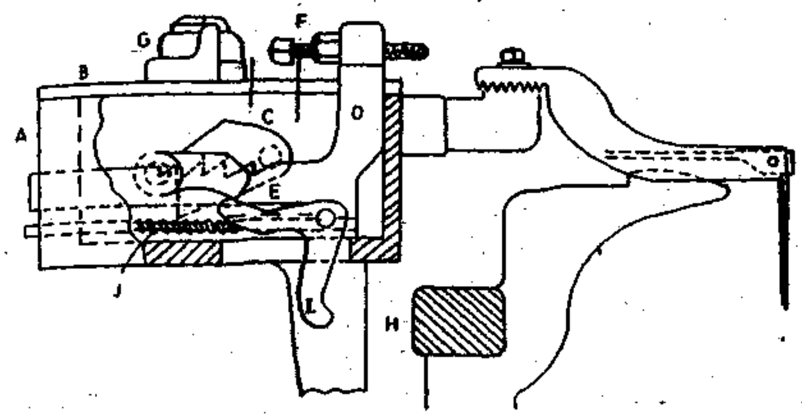
If the weft fork is used for operating the change mechanism, the change of a full pirn will take place whenever a weft breaks or runs out completely. In either case there will be possibility of a missing or an incomplete pick in the fabric. This defect will not be tolerated for quality fabrics and now-a-days weft fork as a means of indicating pirn chnage is no longer in vogue. The advantage will be a slight increase in the production because the loom will not stop whenever a weft breaks. A change of full pirn will take place ejecting the pirn which is still having sufficient weft yarn. The operator in this case has to take out such pirns from the containers kept for collecting empty pirns and put them back in the battery.

### 10.4.1 Three Try Motion on Weft Fork

When the pirn changing mechanism is operated by a weft fork a safety device is required to stop the loom if the weft continuously breaks during or after the transfer of the pull pirn. For instance, if the weft breaks during the transfer or after due to the defects in the shuttle, or accumulation of fluff in the shuttle eye, the weft fork will again act and bring about the transfer of a fresh pirn from the magazine. If such break of weft is continuous the change mechanism will continue acting exhausting all the full pirns in the magazine till the weaver observes the same and brings the loom to a stop. It is, therefore, necessary to have a device to stop the loom automatically after a few trials of successive weft brakes. This device is known as Three-Try Motion. When changing from the weft fork, if the weft breaks or fails, the motion is designed to effect a second transfer. If this also fails, due to either of the above causes, a third transfer will take place, but then the loom will stop.

The three-try motion of a Cimmco-Sakamota loom is completely enclosed in the casing A (Fig. 10.7) and covered from the top by a plate B. When the weft is exhausted or broken, the weft fork slide is drawn back by the weft fork hammer so that the feed pawl C, carried by the slide pushes the three-try slider D through one tooth. As the weft fork slide returns back to the original position, the three try slider is retained in the new position by the hold back pawl E pivoted on the wall of casing A. On transfer of the first full pirn into the shuttle, if the weft breaks again, the weft fork slide will be drawn back second time in succession and the three-try slider E will be moved back, by one more teeth so that the head of screw F carried by the arm of the slider now comes immediately behind the shifter lever G. If the weft breaks on the transfer of the second pirn and the weft fork slide is drawn back for the third time in succession, the screw F move the shifter lever G with the result that the starting handle is released from the catch and the loom stops.






A = Casting, B = Top Cover Plate, C = Feed Pawl, D = Three Try Motion, E = Hold Back Pawl, F = Head of Screw, G = Shifter Lever, H = Weft Fork Hammer, I = Release Lever, J = Compression Spring.

**Fig. 10.7 Three Try Motion**

In case, the loom continues to work satisfactory, after the first or the second weft break, the three try slider is reset to the starting position by the weft fork hammer H striking against the tail of the release lever I. As the hold back pawl and feed pawl are raised the slider jumps back to the original position due to compressing of this spring J. The release lever is pivoted on the weft fork slide itself so that the hammer H cannot contact it when the weft breaks. The set screw F can be adjusted to knock of the starting handle after one, two, three or four picks of which three is commonly used.

The three-try motion on Ruti loom is similar to that of Cimmco-Sakamoto loom, but the resetting takes place after 90 picks by means of a pin fitted on the take-up ratchet wheel.

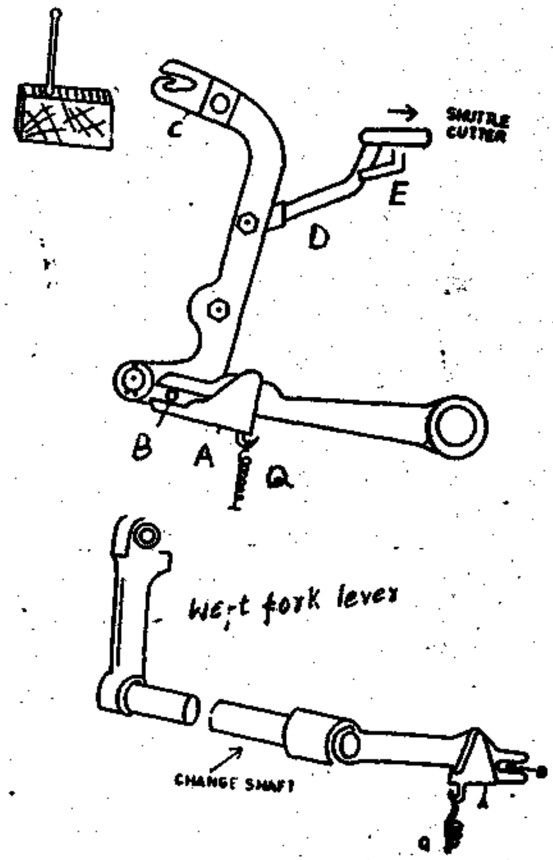
REFERENCE

1. Talukdar M.K., M.Sc. Thesis, Victoria, University of Manchester, 1967.

# 11 AUTOMATIC WEAVING MACHINE - Changing Mechanism

## 11.1 PIRN CHANGING MECHANISM

Following an indication from the weft feeler for a full pirn transfer, the change shaft which runs across the width of the breast beam (Fig. 11.1) is partially rotated so as to impart an upward movement to the shuttle protector lever A, which contacts the peg B and gives a forward throw to the shuttle protector C. The latch

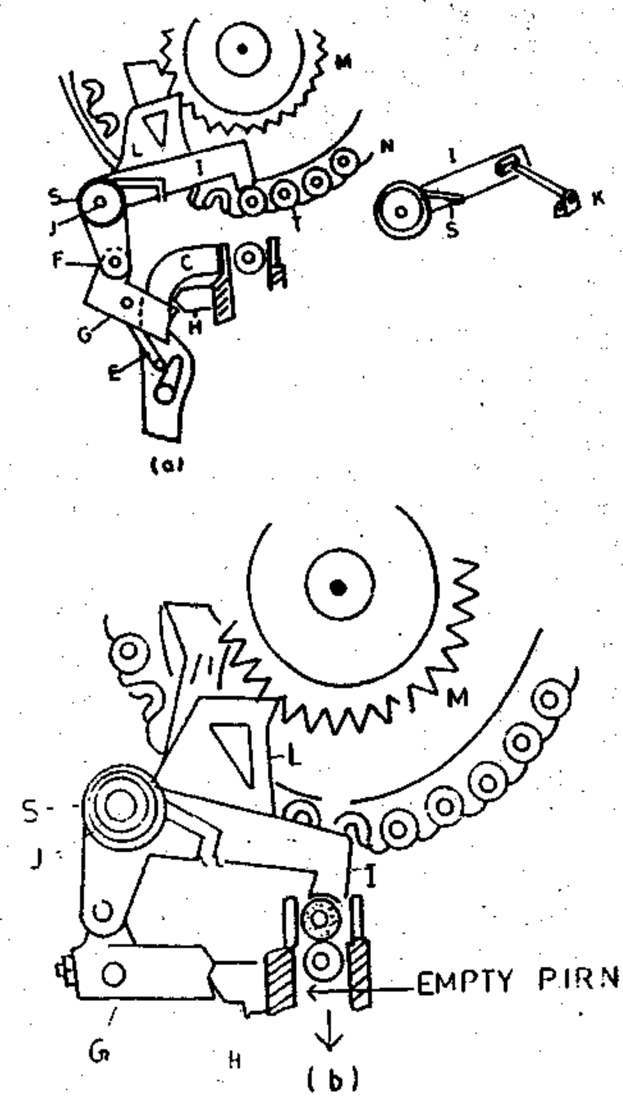



A = Shuttle Protector Lever, B = Peg, C = Shuttle Protector, D = Latch Depressor, E = Peg resting on the Depressor, Q = Return Spring.

Fig. 11.1 Change Shaft and Shuttle Protector



depressor D which moves along with the protector C releases its hold on the peg E with the result that the peg follows the depressor under pressure from the latch spring F (Fig. 11.2) and ultimately




E = Peg Resting on the Latch Depressor, F = Latch Spring, G = Transfer Latch, H = Bunter, I = Transfer Hammer, J = Stud, K = Transfer Depressor, L = Feed Pawl, M = Ratchet Wheel, N = Battery, T = Fully Wound Pirn, S = Hammer Coil Spring.

Fig. 11.2 (a & b) Pirn Changing Mechanism allows the latch G to swing upwards into line with the bunter H which is fixed on the sley front. Under normal running conditions the spring loaded transfer latch G is held in the depressed position by means of a peg E which rests against the latch depressor D.

As the sley moves forward for beating up of weft and the shuttle having reached the battery end, the bunter H engages the notch on the latch G, (Fig. 11.2b) forcing it backwards against the resistance of the hammer coil spring S thereby depressing the transfer hammer I fulcrummed on the stud J, together with the transfer depressor K. During the downward movement, the hammer and the depressor K imparts a sharp blow to the fully wound pirn that is immediately underneath, held by the battery. When a full pirn is forced into the shuttle, it expels the almost empty pirn out of the shuttle, making it pass through the slots provided in the bottom of the shuttle and the box and fall into a container. The new pirn which is forced into the shuttle is firmly held in the spring jaws of the shuttle.

Connected to the transfer hammer I is the feed pawl L, the catch of which rests in one of the teeth of the ratchet wheel M. As the hammer is depressed for the transfer of the new pirn into the shuttle, it lowers the feed pawl L so that the catch slips into the next tooth of the ratchet wheel. As soon as the transfer of the pirn has taken place, the receeding sley breaks the contact between the bunter and the latch and enables the hammer to move up to its original position due to the pressure of the hammer coil spring S, and in doing it pushes the feed pawl L upwards aided by a spring underneath the pawl, and turns the ratchet wheel M one tooth bringing the next full pirn in the battery right below the hammer for the subsequent transfer.

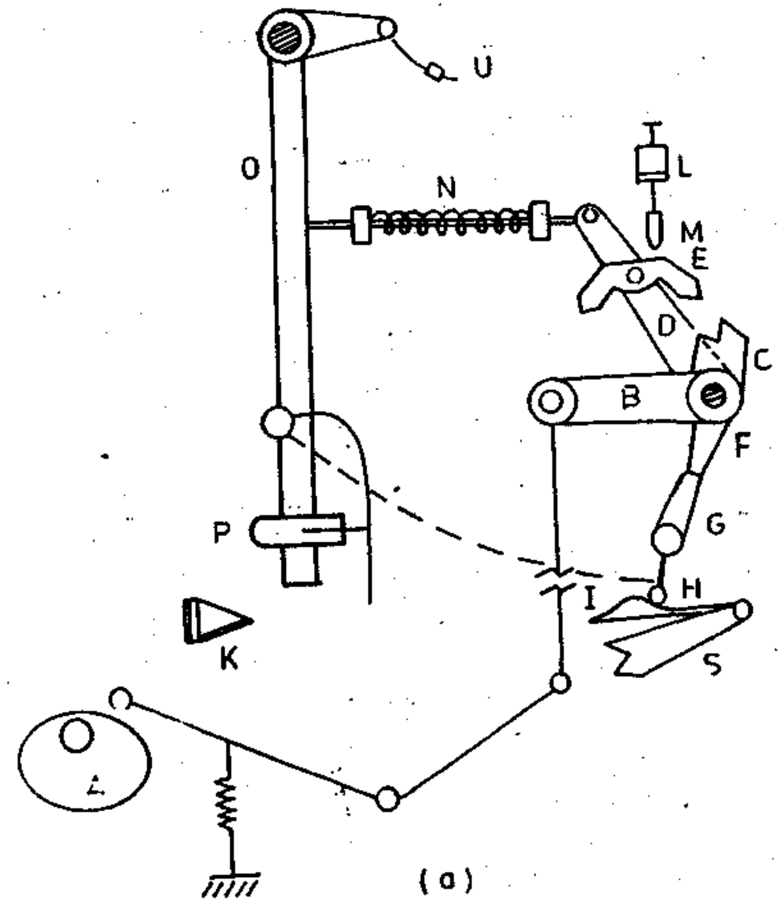
As the sley recedes the tripper heel (Fig. 11.3) releases its pressure on the tripper lever and enables the return spring to pull the protector arm and latch to their normal positions.

### 11.1.1 Pirn Change on Lakshmi-Ruti C Type Loom

The distinguishing feature of Lakshmi-Ruti C type loom is its electomechanical pirn changing mechnism as shown in Fig. 11.3. The initiating lever B is actuated by an initiating cam A, mounted on the bottom shaft of the loom, through various links as shown in the figure. This in turn causes a catch lever C to oscillate over initiating lever shaft.

A protector fork lever D is mounted on the initiating shaft and on this lever is mounted a small convex shaped metal piece which in the normal running is always kept away from the path of the oscillating catch lever C by a spring (not shown in figure). A plunger M is placed above this piece when it is not energised by the solenoid





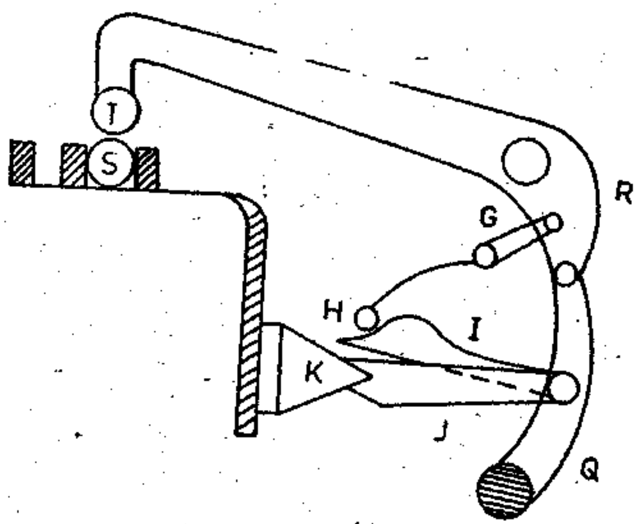

A = Initiating Cam, B = Initiating Lever, C = Catch Lever D = Protecting Fork Lever, E = Convex Shaped Metal Piece, F = Short Lever, G = Connector Lever, H = Antifriction Bowl, I = Cam Face, J = Latch, K = Bunter, L = Solenoid, M = Plunger, N = Spring Loaded Eye Rod, O = Protector Lever, P = Protector Insert, Q = Latch Lever, R = Spring Loaded Hammer, S = Exhaused Pirn, T = Full Pirn to be Placed, U = Cable.

**Fig. 11.3 (a) Pirn Changing Mechanism on Lakshmi-Ruti C Loom**

L. The top part of the fork lever D is connected to a protector lever O through a spring loaded eye-rod N. A short lever F which is connected to the connecting lever G is mounted on the initiating lever shaft. The latter is fulcrummed and extends to a bowl H which bears against the spring loaded cam face I. Cam face I and latch J are mounted on the same stud of which the latter is normally in the down position, so as to be away from the path of the bunter K during beat-up position. The protector lever O is pivoted on the magazine shaft and another lever to its right is connected to a cable M to stop the machine in case of failure of the shuttle being properly boxed at any time. The lower end of the protector lever ends in a curved lever with protector insert P and other part of the same end is connected to the lower member of the connector lever G as shown in the figure.

### 11.1.1.1 Working

When the two pronged weft feeler indicates a change, the solenoid is energised. The spring loaded plunger M immediately pushes the metal piece E to bring the latter in the path of the catch lever C. As the catch lever is oscillating, it will turn the protector fork lever D and the short lever F in the anti-clock wise direction, resulting in lifting of the bowl H through the lever. This causes the spring loaded face cam I and latch S to swing up (Fig. 11.3b) so that the latter is positioned in front of the on coming bunter. When the bunter hits the latch, the latter rocks over the latch lever Q and actuates the spring loaded hammer R to insert a full pirn T and eject the empty pirn S.




(b)

A = Initiating Cam, B = Initiating Lever, C = Catch Lever D = Protecting Fork Lever, E = Convex Shaped Metal Piece, F = Short Lever, G = Connector Lever, H = Antifriction Bowl, I = Cam Face, J = Latch, K = Bunter, L = Solenoid, M = Plunger, N = Spring Loaded Eye Rod, O = Protector Lever, P = Protector Insert, Q = Latch Lever, R = Spring Loaded Hammer, S = Exhaused Pirn, T = Full Pirn to be placed, U = Cable.

**Fig. 11.3 (b) Pirn Changing Mechanism on Lakshmi Ruti C Loom**



The engagement of catch C with the metal piece also causes the protector fork lever to push the protector lever through the spring loaded eye-rod and causes the protector insert to move forward towards the shuttle box mouth. When the shuttle is not positioned properly in the box, the protector insert will be pushed back so that the curved lever connecting the protecting lever and the cam bowl will be pushed back so that the cam face and the latch will move down against the spring tension. When this happens, no transfer takes place.

**Ringless pirns and a split shuttle** are used on this loom. In this case the shuttle back springs out at the time of a pirn transfer and then returns to its original position under the force of a spring. The shuttle is tapered inside at the point of pirn bottom entry to allow an increase degree of latitude in the pirn rest position. The device eleminates the danger, as sometimes seen in the case of pirns with rings, getting into the shuttle and supported by one ring only. A pirn held in this manner may cause warp breakages.

### 11.1.2 Calculation of Pirn Transfer Time

Assume the speed of the loom as 180 picks per minute.
The number of picks per sec. = 180 / 60 = 3
The time taken for one pick = 0.33 sec.
Out of this time the shuttle remains in the box (approx) = 0.15 sec.

The pirn transfer takes place approximately 70% of this time that is, in about 0.1 sec.

It is, therefore, very clear that accurate setting of all the parts is very essential for smooth working of a pirn changing mechanism.

Since the time required for a transfer of pirn vary according to the speed of the loom, it is advisable to run automatic looms a bit slower (10%) compared to nonautomatic looms of similar width. However with high speed automatic looms like Lakshmi-Ruti C it is possible to run at higher speed.

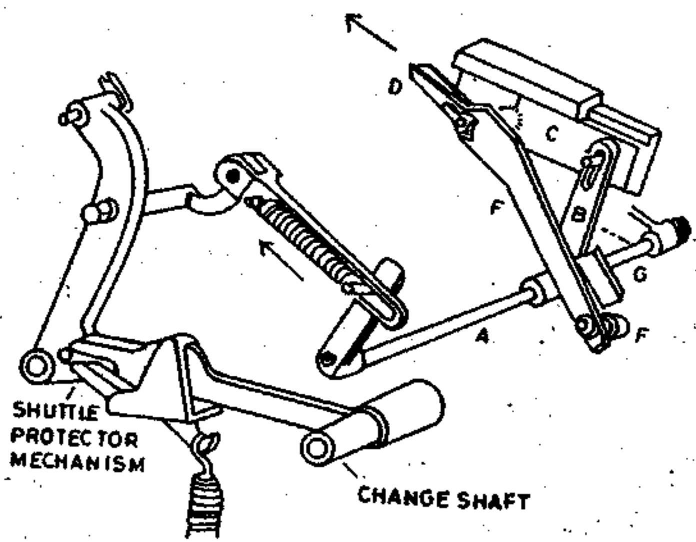
### 11.1.3 Shuttle Protector

Shuttle protection mechanism is necessary to prevent damage to the shuttle when it is incorrectly boxed at the time of a pirn change. A pirn transfer should not take place if less than three rings on the pirn are not in correct position to engage the spring jaw on the shuttle. The position of the shuttle in the box sometimes may be disturbed because of various reasons as discussed in chapter under picking. If the shuttle is not correctly housed the pirn and shuttle might be damaged.

When the pirn changing mechanism is put into action the protector arm (Fig. 11.1) moves forward and reaches a position infront of the shuttle mouth. If the shuttle is not correctly boxed and projecting out of the box mouth, the top part of the protector arm will be arrested from moving further, with the result the spring loaded transfer latch will not swivel upwards into the path of the bunter and the transfer of the full pirn will not take place. The loom will then stop because of weft running out completely. A spring S is provided to prevent damage to the protector arm in case the forward movement of the arm is arrested by the projecting shuttle.

### 11.1.4 Shuttle-eye Thread Cutter

The purpose of the shuttle-eye thread cutter is to cut the ends of weft from almost empty pirns, after the transfer takes place, and to withdraw those ends and hold them out of the shuttle box until they are cut by a temple thread cutter a few picks latter. Such an action prevents those ends being dragged into the cloth by the shuttle resulting in occurring a defect known as 'lashing-in'.




A = Cutter Operating Shaft, B = Lever, C = Cutter Slide, D = Cutter Blades, E = Roller, F = Roller Arm, G = Swivel Plate.

**Fig. 11.4 Shuttle-Eye Thread Cutter**

The thread cutter assembly (Fig. 11.4) is mounted underneath the battery and works in conjuction with the shuttle protector. When the shuttle protector moves forward the cutter operating shaft A rotates and activates the cutter unit consisting of lever B, the cutter slide C, cutter blades D, nylon roller E, roller arm F and swivel plate G. The blades D pass the cut outs in the box front and the shuttle wall. As the cutter unit moves forward the roller E rides over the top face of the swivel plate G, which raises the roller arm F and thus

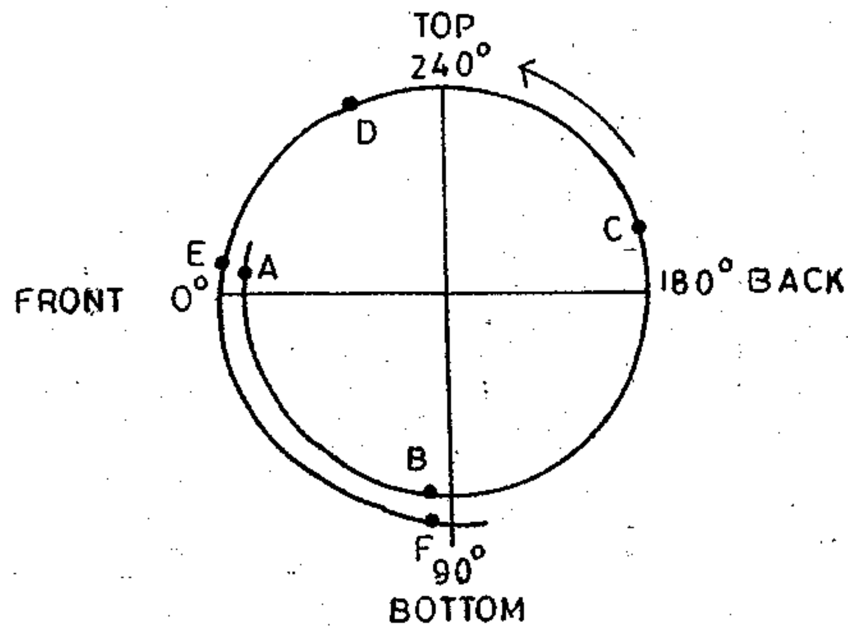


opens the cutter blades. When the shuttle protector returns to its normal position the cutter unit is also returned, the roller E this time passing under the swivel plate G to lower the roller arm F so closing the cutter blades. The cutter unit consists of four blades, two for cutting the ends of weft and two for holding them when cut.

### 11.1.5 Temple Cutter

A cutting blade attached to the temple block on the battery side is made to oscillate from the reciprocation of the sley. As soon as the weft ends of new and ejected pirns, that are held respectively by the boss of magazine and the cutting blades, reach the temple cutter they are cut, say, after a few picks.

### 11.1.6 Timing and Setting




A = Weft Feeler Indicates for a Change, B = Shuttle is Picked from Feeler Side, C = Shuttle Reaches to Battery Side Box, D = Bunter Engages with the Latch E = Change of Pirn is Completed, F = Shuttle is Picked from the Battery Side.

**Fig. 11.5 Pirn Changing Timing Diagram**

The timing diagram shown in Fig. 11.5 indicates various actions of the pirn change mechanism. It is seen from the timing diagram that the shuttle is picked from the feeler side 10° to 15° before the bottom centre and reaches the magazine side 20° to 30° after the back centre. It remains in the shuttle box for over 240° before it is picked from the magazine side. In spite of this long dwell it is not possible to actuate the change mechanism before the sley could reach the front centre. The transfer of the full pirn can be effected only at the front centre or a few degrees before. However to avoid a sudden impact on the bunter, sufficient time is allowed for the action of the pirn transfer and it is about 55 to 60 degrees.

#### 11.1.6.1 Setting

Since the pirn changing mechanism operates during the running of the loom, it is very essential to set all the motions for correct timing. For this reason the loom manufacturers have provided suitable gauges. Fully comprehensive settings are given in the appropriate operating instruction leaflets.

## 11.2 SHUTTLE CHANGING MECHANISM

The shuttle changing automatic looms are suitable for weaving very delicate wefts like silk, rayon and fine counts of cotton yarns, because there is no hammer action on the weft package. As soon as the weft gets exhausted on the pirn the entire shuttle is replaced by a new shuttle with a fully wound pirn.

There are two main types of shuttle changing looms.

(a) One which does not stop for a change or in which change is effected during the running of the loom. e.g. Toyoda (Japanese).

(b) One which stops for a few seconds for a change and restarts automatically e.g. Vicker Stafford (English); Hattersley (English)

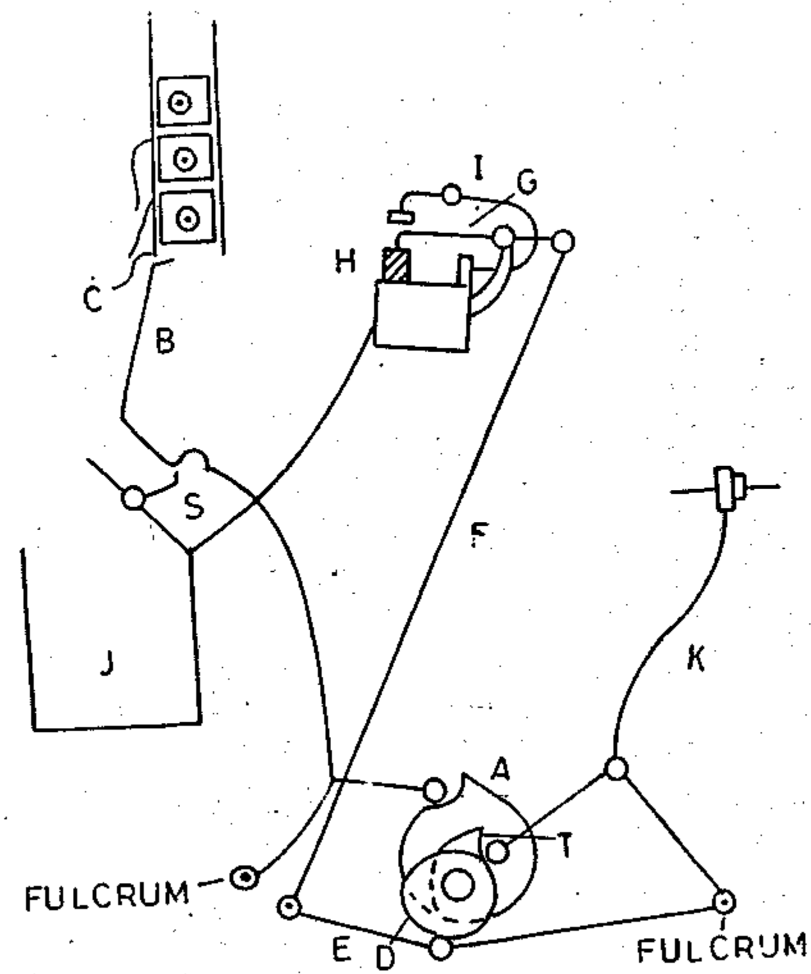
In the second type, that is one which stops for a change, the action is gentle, taking as much as three seconds for a change. However, there is some loss of production and there are chances of showing starting marks in the cloth after the loom is restarted. Because of these disadvantages this type of loom hardly exists in practice, nevertheless due to the gentle treatment, accidents to the shuttles and to the mechanism are minimum.

In the case of non-stop changers, there is a harsh treatment to the shuttles and the mechanism. The time available is as small as 1/18 of a second. But due to non-stop there is no loss of production and no chances of starting marks in the cloth. The shuttle consumption might be very high, if settings are not precise.

### 11.2.1 Vicker-Stafford Automatic Shuttle Changing Loom

The mechanism illustrated in (Fig. 11.6) has three special cams mounted on a separate cam shaft which operate the change mechanism. Cams are shipper cam, front board cam, conveyor cam.






A = Conveyor Cam, B = Lever, C = Shuttle Supporting Lever, D = Front Board Cam, E = Lever, F = Lever, G = Short Link, H = Box Front Plate, I = Ejector Lever, J = Receptacle, K = Lever, T = Shipper Cam, S = Safety Catch.

**Fig. 11.6 Vicker Stafford Aut[illegible]ic Shuttle Changing Machine**

Having detected the need for a change of the almost exhausted pirn, the loom is stopped with the shuttle on the magazine side and the sley at the back centre position and the cam shaft is actuated. In this case the magazine is stored with a number of shuttles having fully wound pirns. The shuttles are placed one above the other. When the shuttle at the bottom is transferred into the shuttle box, the next shuttle in the magazine moves down by gravitation.

One complete rotation of the cam shaft results in the following operations being carried out in a proper sequence.

a) Shuttle box front plate is raised.
b) Shuttle with the empty pirn is ejected from the box from the front side.
c) The conveyor takes a shuttle from the magazine and places it into the box.
d) The shuttle box front plate is fully lowered.
e) The starting handle is put on and the cam shaft is disengaged.

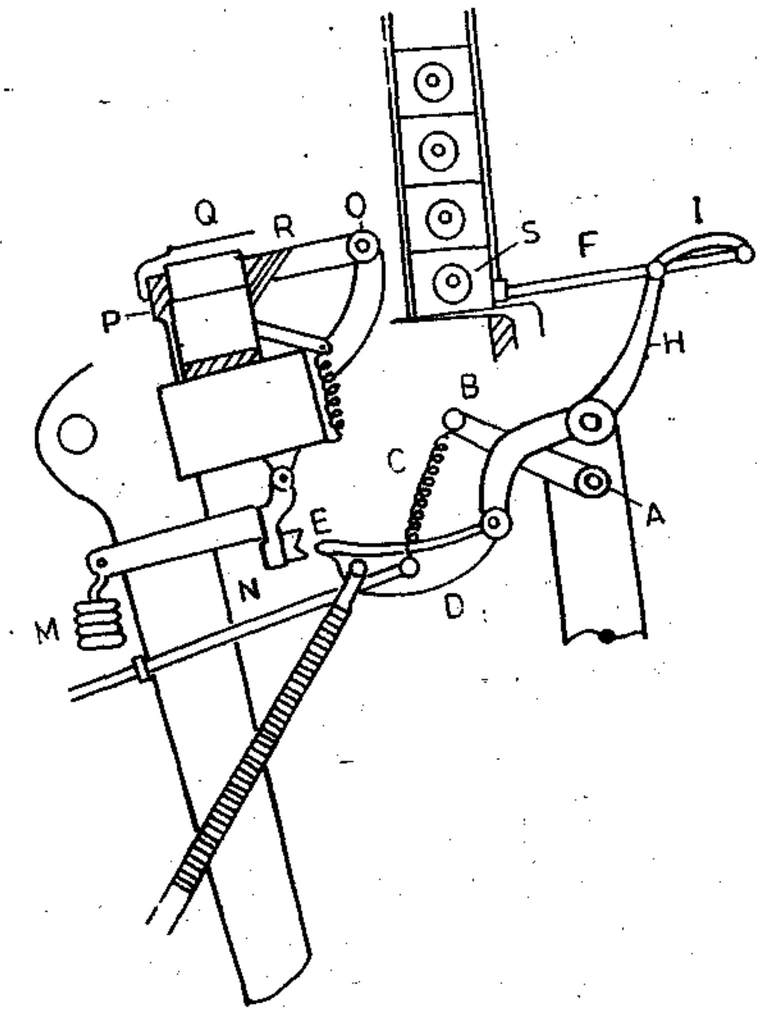
During the rotation of the cam shaft, the conveyor cam A moves its lever B slightly to the left so that the shuttle supporting lever C also moves back allowing a shuttle from the magazine to fall on to a platform fixed at the top of the lever B. The cam A then allows the lever B to move to the right towards the box front, where the lever is held temporarily by a safety catch S. Meanwhile the front board cam D operates to depress the lever E and pulls through lever F upon the short link G (fulcrummed at the box back) to lift the box front plate H. The raising box front plate comes in contact with the ejector lever I which sweeps through a slot in the box back to eject the shuttle with the empty pirn through the box front. This shuttle glides down to the receptacle J. As soon as the shuttle is ejected from the box the spring acting on lever B moves its bowl to come in contact with the conveyor cam A again to allow the conveyor lever B to carry the new shuttle forward into the box, where it leaves the shuttle behind. During this time the front board cam D operates the link G to lower the box front plate slightly to prevent the shuttle to move back with the top of the lever B.

Continued rotation of the cam shaft causes the cam A to move the conveyor back to the original position, while at the same time cam D lowers the box front plate completely. As soon as this is carried out the shipper cam T operates the lever K and restarts the loom.

A fourth cam is used to move the picker away from the shuttle tip before the shuttle when the em[illegible] [illegible]rn is ejected.



### 11.2.2 Toyoda Nonstop Shuttle Changing Motion




A = Change Shaft, B = Lever, C = Spring Rod, D = Knocking Bill, E = Stricker Block, F = Pushing Slides, H = Lever, I = Link, P = Flyback Q = Bracket, R = Lever, O = Stud, N = Rod, M = Spring.

**Fig. 11.7 Toyoda Nonstop Shuttle Changing Mechanism**

As explained earlier the Toyoda shuttle changing loom effects the transfer of shuttle with the empty pirn when the loom is running. The feeler mechanism and weft fork is provided on the starting handle side and the magazine with ten shuttles, placed one above the other, is on the off side. Both the feeler and weft fork can be made to effect the change of shuttle.

The weft pirn in this case has a slot and the feeler enters the slot as soon as the weft gets exhausted on the pirn. In the normal case when there is sufficient yarn on the pirn the feeler is pushed back and no change is effected.

When the feeler feels the necessity for a change of shuttle, the change shaft A situated under the breast beam is turned thus putting the mechanism (Fig. 11.7) into action. This turning of the shaft A enables the spring rod C which is connected to the lever B to move up dragging along with it the knocking bill D in the path of the forward movement of the striker block E which is fixed on the sley. As the sley moves forward the striker E pushed the bill D backward enabling the pushing slider F through the levers H and link I, also moves forward, thus pushing the shuttle S into the shuttle box.

The front and back of the shuttle box are guided by the lever R fulcrummed on a stud O. The fly back P which is supported by two brackets Q is connected to the lever R. Supported by a spring the fly back and the front guard form a complete box for the shuttle. When the pushing slider J pushes the shuttle from the magazine, the shuttle in turn presses against the wedge shaped front guard, thus lifting it and allowing the shuttle to enter the box. The shuttle with an empty pirn is pushed out through the box back by the incoming shuttle.

When the sley moves backward a set screw on the rod N attached to the bill lever comes in contact with a block on the sleyboard and pulls the pushing slides F backward to the original position.

Whenever the forward movement of the pushing slider is obstructed during the shuttle change, the spring M mounted on the striker block lever E, yields to prevent any damage to the shuttle or transfer mechanism. If however the transfer is completed but is not satisfactory, the loom is brought to a stop by a knock-off arrangement.

The procedures of changing shuttles are done spending comparatively long time, for the slider begins to push the full shuttle when the crank is positioned at about five degrees before the top center and the shuttle change is finished at the front centre, the crank revolving in the meantime about 95 degrees. As the shuttle with full pirn contacts the wedge shaped front guard for ejecting the old shuttle at the point advanced about 35 degrees from the top centre of the crank, it may be taken that about 40 degrees is for preparatory process of the shuttle change and about 55 degrees for the actual changing process.

Toyoda manufacturers admit that the shuttle change automatic loom has a longer timing period for the change than the pirn changing device. They conclude that the impact on the related parts is lighter resulting in their decreased wear and tear, and possibility



of higher loom speed. A Toyoda automatic loom of 110 cm reed space can successfully run at 200 picks per minute.

## 11.3 BOBBIN LOADER MECHANISM

The conventional weft battery, which can accommodate only 24 to 30 full pirns, is considered uneconomical in view of the increased wage rates. A special battery filler is required to fill the batteries and the number of looms he or she can attend depends upon the weft unwinding time. If the weft yarn on the full pirn can last for 5 minutes then each loom will require about 12 pirns per hour. The operator can put 20 pirns in every minute and a half or about 520 pirns in 40 minutes, which is the normal working time per hour. Therefore the battery filler can attend to 45 looms only.

In order to eliminate the work of a battery filler and at the same time increase the pirn storage capacity in the magazine, George Fischer Ltd. of Switzerland and others have developed a device called Bobbin Loader. This replaces the conventional weft magazine. The full pirns, 72 to 180, are placed in a special container and automatically stacked at the pirn winding machine. These pirns are stacked with all the heads to the same side. Then these containers are placed on the side of the transfer mechanism of the loom. Sometimes two containers are placed on each loom.

The weft pirns from the container moves down through a slot provided at the bottom of the container by gravity to the preparation and change position. Bobbin change is initiated in the normal way by the weft feeler. The shuttle protector, the shuttle-eye cutter and the transfer mechanism are all operated by the change motion shaft, as in the case of a conventional automatic loom. However, certain modifications are necessary to operate this mechanism.

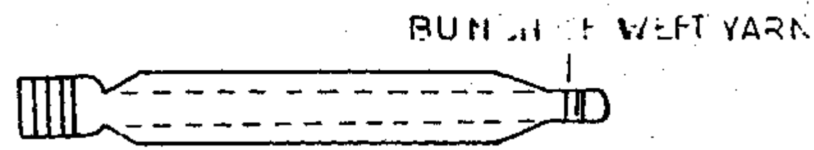


**Fig. 11.8 Pirns for Bobbin Loader**

They are,

1. Pirns are wound with a bunch of yarn near the tip (Fig. 11.8).
2. The pirn winders are equipped with a special attachment to produce the bunch of yarn near the pirn tip.
3. The base of the pirn container is provided with a movable slide or shutter controlled by a hand lever.

4. A lifter is provided for the safe transfer of the full pirns through the shutter opening to the pirn guide.
5. Each loom is connected to a compressed air system providing a pressure of about 6 bars.
6. A central motion is arranged, which consists of a vertical shaft on which are mounted a number of eccentric cams. This shaft is operated by a special electric motor switched on when the pirn transfer hammer is depressed for a pirn change.
7. Compressed air valves to carry out various functions in the required sequence of pirn preparation and transfer of the same into the shuttle are provided.
8. A weft holding device which incorporates a pneumatically operated gripper plate and a suction nozzle for drawing in the weft end and holding it with tension during the time of pirn transfer, is also provided.

### 11.3.1 Working

When the transfer hammer is depressed for a pirn change it switches on the motor and releases the pneumatic control to carry out the following functions in the required sequence.

(a) a pair of stripping jaws move to the left and close behind the pirn tip bunch.
(b) the gripper plate is opened.
(c) closed stripping jaws move to the right thus stripping the pirn nose bunch which is drawn into the nozzle by suction.
(d) the weft end is clamped by the closing gripper plate.
(e) the pirn lifter delivers a new full pirn to the pirn guide.

Thus, the preparation of the full pirn completes for the next transfer into the shuttle.

In actual commercial use the bobbin loader is not very successful because of the following reasons.

(i) It has limited advantage over the rotary battery as compared to a loom winder.
(ii) Partly used pirns cannot be used since they may roll side ways and cause a jam.
iii) It takes time to prepare a bobbin and a second transfer cannot take place within 3-5s.

## 11.4 AUTOMATIC LOOM WINDER

Automatic loom winder (Fig.11.9) section in the yarn preparatory eliminates the pirn winding section in the yarn preparatory department.



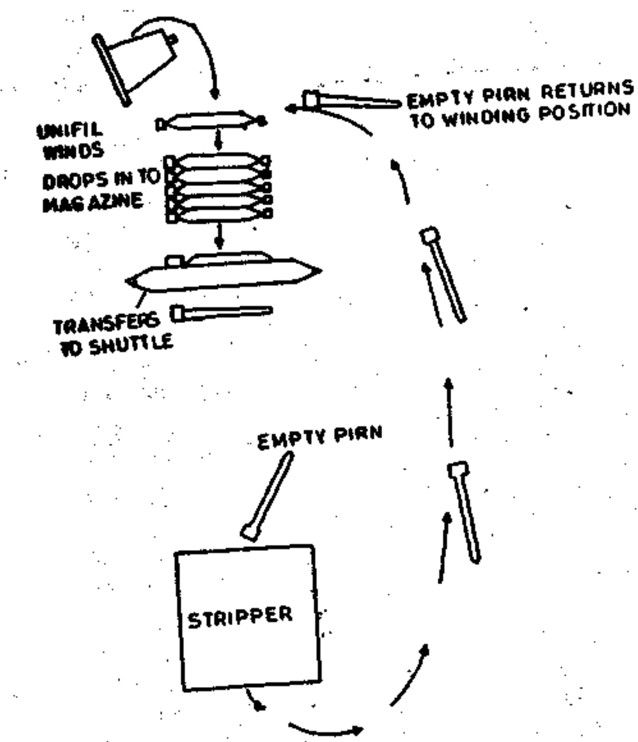



Fig. 11.9 Unifil Loom Winder

Instead, the pirn winding unit becomes a part of the automatic loom. Universal Winding Company; U.S.A. have introduced one such machine, known as Lessona UNIFIL loom winder. This winder can be easily fitted to most types of pirn changing automatic looms. The advantages are,

1. No separate winding room is required, hence some saving in floor space, and floor related costs.
2. No winding operations, hence saving of labour.
3. No pirn carrying and battery fillings, hence saving of labour.
4. No stripping of almost empty pirns that are ejected by the pirn changing mechanism, hence saving of cost.

In general this automatic loom winder reduces labour cost and the loom produces high quality of fabrics with higher efficiency and greater economy. Automatic looms with loom winder have increasing versatility, permitting the use of a winder variety of yarns-natural and synthetic. Yarns ranging from 4 Ne to 120 Ne (30 to 500 dtex) can be woven but economical only for coarse counts. The changes from one count to another or from cotton to synthetic can be made without any major departmental reorganization. Loom winders are mostly used for weaping tyre cord fabrics.

The weft is wound automatically from a large supply package and transferred automactically to a small capacity magazine that holds five to six pirns. After the transfer of the full pirn with the shuttle the spent pirn is ejected and carried to a stripper which removes the last bit of weft thread left at the pirn base. The cleaned pirns are then dropped in a tray to be picked up by the magnet on the conveyor belt and deliver to the winding head.

There are thus six important attachments to carry out these functions.

1. The supply creel : It is located at the back of the loom and takes all conventional packages such as cones, cheeses and bobbins.
2. The tension device : It is mounted on a heavy iron plate suspended on spring to reduce vibration. To increase or decrease the tension it is necessary to add or remove the washer type of weights.
3. The winding head : It is the heart of the loom winder. It includes a winding spindle, a traverse cam and a builder mechanism.

   The cycling mechanism controls the transfer of full pirns to the magazine and the feeding of empty pirns to the spindle. All mechanisms operate in a carefully designed lubricating system assuring long service life with low maintenance.

   The spindle speed can be adjusted to suit all conditions. Normally, a spindle speed of 5000 r.p.m. is considered sufficient to keep well ahead of loom consumption.
4. The magazine : The magazine contains six full pirns. As the full pirn drops down into the magazine from the winder, the yarn is cut automatically and the end from the pirn is positioned on a drum that holds the thread in readiness for transfer to the shuttle. A clearer system automatically draws away the loose ends after the temple cutter has operated, and deposits in a waste can.
5. The stripper : The stripper automatically removes the bunch or waste yarn from the ejected pirn from the shuttle. After stripping, the pirns are automatically dropped into a conveyer trough.
6. The conveyor system : A permanent magnet attached to an endless conveyor carries the empty pirns from the conveyor through back to the winder.

For the entire operation, only eleven or twelve pirns are needed and out of these only six or seven will carry yarn at any one time.



Disadvantages of the loom winder are,

1. Additional capital cost is required.
2. Under Indian condition, it is only economical for coarse yarn counts e.g. 2-10 Ne.

## 11.5 MULTIPLE BOX AUTOMATIC LOOM

Although the bulk of the fabrics woven on automatic looms are those which require only one weft, automatic weaving is not confined to fabrics of this type. In fact, automatic replenishment of the weft supply is quite as desirable in a multiple shuttle loom as it is one with a single shuttle only. The provision of a box motion does not affect the basic principle of weft changing mechanism, the only additional requirement being a magazine to accommodate the two or more types of weft required and a selecting mechanism to ensure that each shuttle in use is replenished with a correct type of weft, or replaced by a shuttle carrying the particular weft required. Commercially multiple box automatic looms are of pirn changing type with multiple box at one end of the sley and a single box at the other end. Multicolour shuttle changing loom or pick and pick multicolour automatic looms are non-existent because of complicated mechanism.

The advantages of using multiple box automatic looms over multiple box non-automatic looms are,

(i) It relieves the weaver of anxiety in connection with the weft supply resulting in the production of a better quality fabric and reducing the work load of a weaver.

(ii) Number of looms assigned to a weaver can be increased.

Disadvantages of this loom is that pick and pick colour cannot be inserted that is why these looms are replaced by shuttles looms.

The majority of the fabrics for the weaving of which multiple box automatic looms are used are :

(a) cloths of mono colour woven from coloured yarns which require to be woven on a weft mixing type of a loom to cover variation.

(b) crepe fabrics, chiefly of plain weave in which weft yarns of S and Z twist are employed.

(c) cloths of plain or twill check fabrics when various colours or counts of weft and warp are used.

### 11.5.1 Principle of Working

There are various types of multiple box automatic looms in use but they differ as regards the following aspects :

(a) The type and arrangement of the weft magazine : There are two types available viz. vertical magazine and rotary magazine. The former is used on Northrop, Ruti looms whereas the latter is used on Saurer loom.

(b) The method of selecting the weft colour for the transfer, is mechanical or electrical.

The functions performed by the mechanism are similar. A weft feeler placed at the magazine side is used to register the need for weft replenishment. The change is effected when the shuttle concerned has completed two picks and returned to the magazine side. It will be apparent, therefore, that operation of the weft change mechanism must be related to the box motion, so that in the event of a box change taking place during the two picks referred to, the weft transfer will be delayed until a further change brings the particular shuttle again into the operation. In the meantime, a transfer of the correct colour of weft may be made to any of the other shuttles which may require renewal of their weft.

Multiple shuttle box automatic looms are normally operated at speed about 10-15% lower than that of a single shutlle loom.

### 11.5.2 Northrop 4 x 1 Shuttle Automatic Looms

Northrop check looms are made for two shuttles or four shuttles working as per weft pattern and the principles of working are the same in both the types.

The stationary four colour magazine is mounted on the breast beam at the right hand side of the loom ; the four compartments of the magazine are numbered 1 to 4, reading from front to back and work in conjunction with the box motion, the four shuttles are also numbered 1 to 4 reading from top to bottom. Thus No.1 shuttle is replenished from No. 1 compartment in the magazine and so on.

On this loom, the operation of the replenishing the weft is effected partly mechanically and partly electrically. The actions of indicating for the change of weft, and also initiating the weft transfer mechanism are performed electrically; thereafter, the actual transfer of the weft is done by mechanical means.

The box motion on this loom may be controlled from a dobby, a jacquard or a card motion.

### 11.5.3 Electrical Equipment

Whenever a change of shuttle boxes is made, the mechanism controlling the box motion causes a plunger in the contact box C (Fig. 11.10) to be depressed, thereby indicating which of the shuttle boxes is about to be brought to sley level, and also putting into circuit in the solenoid box D the electromagnet controlling the weft supply



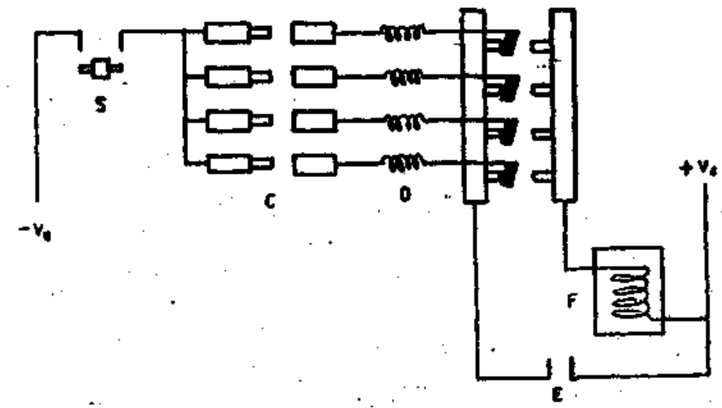



Fig. 11.10 Electrical Connections for Multicolour Cop Changing Loom

for that particular shuttle. As the weft on the bobbin nears exhaustion the feeler E at the magazine or single-box side of the sley completes the first circuit. Electrical energy then causes a plunger inside the solenoid box to depress a trigger above the magnet and a spring controlled rocker unit changes position, breaking the feeler circuit and making the transfer circuit. The feeler is now out of circuit for that particular shuttle; the magnet box F is energised and lifts the trip lever G into line with the upper end of the cam operated trip heel H. The shuttle is then picked across the loom to the four-box end of the sley, and when it again returns to the magazine side, a full bobbin is automatically transferred into the shuttle by the mechanical part of the motion.

Should a change of boxes occur before the transfer can be made, the transfer circuit is broken by a contact box, the magnet box de-energised and the trip lever dropped before it can engage with the trip heel. The rocker unit in the solenoid box remains in the transfer position, however, in readiness for the return of that same shuttle to sley lever and the subsequent completion of the circuit once more by the contact box. Thus, the actual transfer is delayed until that shuttle again returns to the magazine side. In the meantime, however, changes of other colours of weft may occur without affecting the indication which has been recorded previously.

### 11.5.4 Mechanical Equipment

In addition to the trip heel mechanism referred to previously which operates the shuttle protector and the transfer mechanisms, the following ancillary equipment is also employed.

(a) the weft tension device for holding the threads from the bobbins under tension until after the transfer;

(b) the shuttle-eye thread cutter which cuts and holds the end of weft from the expelled bobbin; and

(c) the temple thread cutter, housed in the right-hand temple which cuts the weft ends from both the expelled and newly-transferred bobbins near to the selvedge of the cloth.

The mechanism of the magazine is composed of three separate but complementary devices,

(a) the trigger or bobbin release mechanism;

(b) the transfer mechanism for completing the actual transfer of the bobbin; and

(c) the bobbin protectors a safety device to prevent the operation of the transfer mechanism should the bobbin be incorrectly positioned.

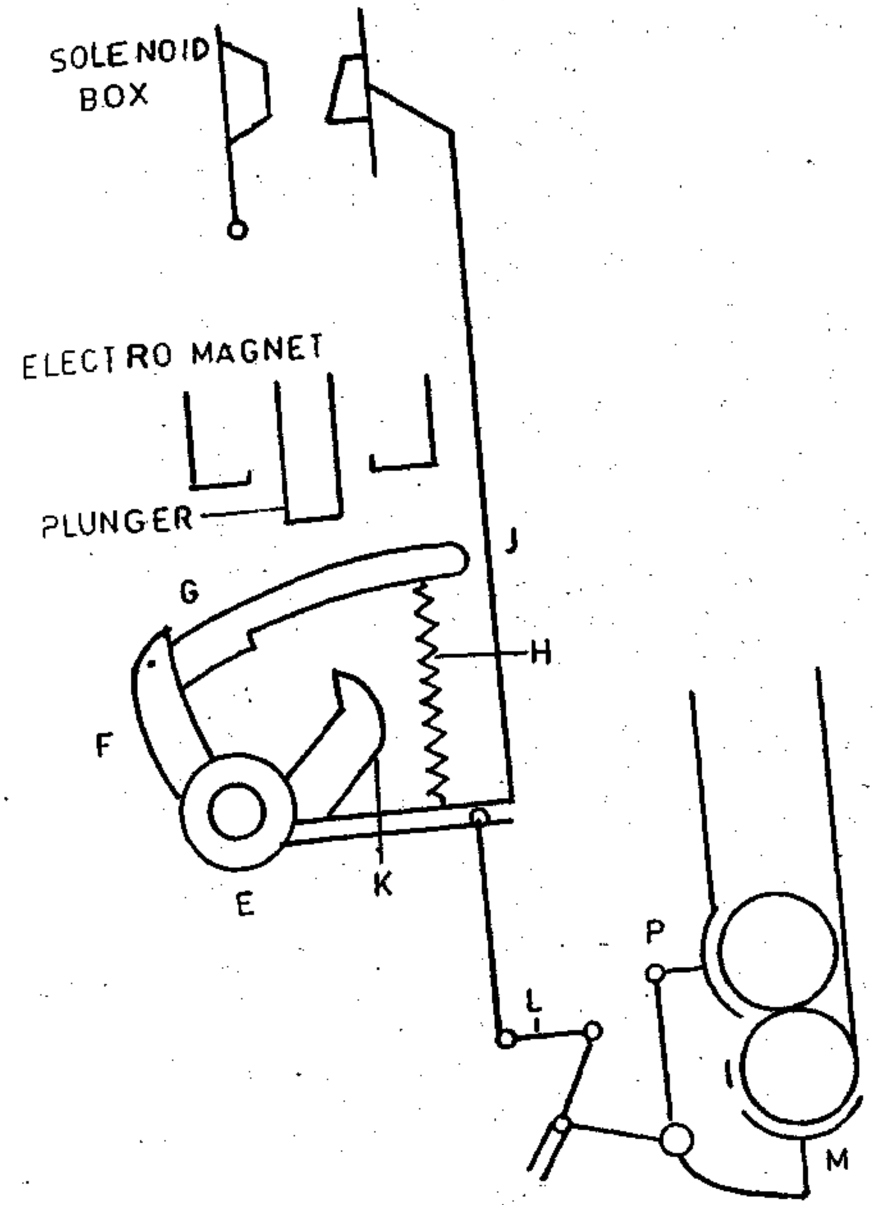
### 11.5.5 Trigger Mechanism

A bobbin is released from its compartment in readiness for transfer by the operation of a trigger mechanism mounted on an oscillating shaft, the movement of which is controlled by a driving unit situated immediately behind the magazine. This unit is driven by a chain from the loom crank-shaft and consists of the cam which actuates the driving arm. As the cam rotates, five-toothed quadrant attached to the driving arm meshed with the quadrant fixed to the rocker shaft E, causing this shaft to oscillate approximately 50° every pick.

The trigger mechanism itself comprises four trigger units-one for each compartment in the magazine-which are mounted on the rocker shaft E (Fig. 11.11), directly beneath their respective plungers in the solenoid box. Each trigger unit is composed of the lifting lever F which swivels on the rocker shaft, the trigger lever G which is held in its normal or inoperative position by the spring pillar H, and the screwed eye rod J connected to the resetting cam in the solenoid box. When the magnetic coil in the solenoid box is energised, the internal plunger descends and depresses the trigger lever G bringing it into line with the trigger boss K which is secured to the rocker shaft. As this shaft turns, the trigger lever engages with the trigger boss to form one complete "trigger unit" that turns with the rocker shaft.

In consequence, the bobbin holder arm L is raised, swivelling both the bobbin base holder M and the tip holder N to allow the






E = Rocker Shaft, F = Lifting Lever, G = Trigger lever, H = Spring pillar, J = Eye rod, K = Boss, L = Bobbin Loader, M = Bobbin Base Holder, P = Retaining Clip.

**Fig. 11.11 Bobbin Release Mechanism**

bottom bobbin to fall into the central well of the magazine, ready for transfer. At the same time, the movement of the trigger unit pushes the screwed eye rod upwards, breaking the contact in the solenoid box and resetting it for the next indication.

Each bobbin holder is provided with a bobbin retaining clip P which is so designed, that as the bobbin is released, the one immediately above is held and prevented from falling; thus it is impossible for two bobbins from the same compartment to be dropped simultaneously.

A hand lever Q is provided on the outside of the tip end casting for each compartment. This enables the bottom bobbin in the compartment to be dropped by hand, and is useful for setting-up purposes or for checking existing settings.

### 11.5.6 Transfer Mechanism

When the magnet box is energised, the cam-operated trip heel engages the raised trip lever to bring the shuttle protector into the operative position. The subsequent forward movement of the shuttle protector permits the spring boss, to raise the latch socket. If the shuttle is fully home in the box, this rise will be sufficient to bring the transfer latch into the path of the bunter on the front of the sley. As the sley advances towards front centre, the bunter engages with the V shaped cut-out on the front of the latch, forcing it back and since the latch unit is attached to the base of the transfer hammer, the latter pivots on its fulcrum and the transfer stud projecting inside the magazine descends to strike the bobbin at both the butt and tip ends through the agency of the depressors.

At the rear of the magazine the spring-controlled, arm H holds in position the back release lever J which slides in guides on the underside of the butt end casting; this lever, together with the tip holders K and L, supports the bobbin prior to transfer. When, therefore, the loom crank reaches front centre, the hammer forces the new bobbin past these supports to replace the spent bobbin in the shuttle.

### 11.5.7 Bobbin Protectors

Due to the fact that the butt end of the bobbin is the heaviest part, there is always a tendency for this end to fall first. Thus, it is possible for a bobbin to fall into a crooked position, with the



attendant risk of a faulty transfer and broken parts. In order to obviate this, therfore, a device is incorporated consisting of two flaps which pivot on either side of the central position that is occupied by the bobbin awaiting transfer; its purpose being to try and straighten the bobbin, or failing this, to prevent the transfer from taking place. If, however, a crooked bobbin prevents the bobbin protectors from assuming the vertical position, no transfer can take place, since the transfer latch is prevented from coming into line with the bunter, due to the fact that the stop slide does not move out of the path of the latch socket until the bobbin protectors are in the vertical position.

In the event of two or more bobbins being in the central position, additional protection is afforded by the fibre bowl N on the pendlum lever - this also serves to prevent a transfer by restricting the movement of the bobbin protectors.

# 12 GENERAL DRIVES WITH REFERENCE TO LOOMS

## 12.1 FUNCTION

A source of power is always needed to drive a weaving machine. Electricity is the means of conveying power to all looms other than the handlooms. The power is supplied in the form of rotational energy. Electricity, that is, electrical energy is converted into rotational energy by means of an electric motor and the weaving machine i.e. loom converts the input of rotational energy to manufacture cloth.

The driving function may be divided into four steps which are as follows.

(a) The rest position of the weaving machine : The machine is at rest, the clutch is disengaged with most of the weaving machines, the electric motor and gearings are on the main shaft is braked. With the weaving machine e.g. Cimmco loose reed loom, which is not equipped with a friction clutch, the electric motor is at rest and is switched on by switching over the starting lever which operates the motor switch.

(b) Starting a weaving machine with friction clutch : When the starting handle is switched over, at first the main brake is released and thereafter, the friction clutch is operated. The speed of the machine is gradually increased to normal speed when the clutch is fully engaged. For loose and fast pulleys, the belt is shifted from loose pulley to fast pulley to run the loom.

(c) Normal running of loom : The clutch is fully engaged, brake is released and the weaving machine is at its normal operating speed. However, as mentioned in Chapter 4, the angular velocity of the main shaft is not constant. On an average the variation ranges from 6 to 10%.

(d) Stopping the weaving machine : When a stop motion acts or the starting handle is knocked-off manually, at first the clutch is released and simultaneously brake is operated to stop the weaving machine instantaneously. For a pulley drive, the belt is shifted from fast to loose pulley.



## 12.2 METHODS OF DRIVE

Looms are driven by one of the following two methods : (i) Individual Drive, and (ii) Group Drive.

### 12.2.1 Individual Drive

In this modern system each loom has its own electric motor and a starter. The motor may drive the loom through a belt or gears. Individual drive should be used for automatic looms, and unconventional looms. Now-a-days, it is also used for non-automatic looms. The main advantages of an individual drive are :

(a) There is considerable economy of power as power losses are small.

(b) In case of motor failure, only a particular loom remains idle and this does not affect the working of other machines.

(c) It gives a clear view of the shed and the working hazard being reduced. There is practically no chance of any accident. Cleanliness and lighting are also improved because of elimination of overhead shafts and long belts.

(d) Layout of looms is very easy.

(e) Replacement of belt takes place very little time as direct-drive motor employs grooved pulleys and V belts.

The disadvantages of individual drive are :

(a) High initial cost. (b) High maintenance cost.

### 12.2.2 GROUP DRIVE

In this system a very powerful motor drives an overhead shaft (sometimes underground shaft) called main shaft, that runs from one end to the other end of the loomshed. This main shaft drives the pulleys on the crank shaft of a loom through flat belts. For starting and stopping the loom, fast and loose pulleys are provided on the crank shaft. Advantages of group drive are :

(a) Economical with respect to fixed charges and maintenance.

(b) Initial cost is very low.

Group drive is obsolete now-a-days because of the following disadvantages.

(a) Shafts, pulleys, belts etc. absorb greater power and the efficiency is considerably low.

(b) In case of motor failure, all the machines become idle.

(c) Gives a clumsy appearance and there are greater chances of accidents. Cleanlines and lighting are badly effected by the presence of overhead shafts and main belts. Fluff accumulates and occasionally falls on loom, warp and cloth causing damage to cloth.

(d) Gives greater power cost for driving, because of power losses.

(e) Layout is difficult.

## 12.3 POWER TRANSMISSION ELEMENTS

The elements which are commonly used to drive a loom are belt driving, clutches, toothed gearing.

### 12.3.1 Belt Driving

Belt drive is one of the most common and effective devices of transmitting motion and power to looms by means of a thin inextensible band running over two pulleys. Belts can transmit, however, upto a distance of about 10 m with a maximum surface speed of 1400 m per min when flat belts are used while a maximum surface speed of 1500 m per min can be obtained with V-belts.

In a belt-drive arrangement, one of the pulleys called driver is mounted on the driving shaft while the other, which is mounted on the shaft to which power is to be transmitted is called the driven pulley. When the belt moves over the pulleys, there is always the possibility of some slippage between the belt and the faces of the pulleys and hence the character of the motion transmitted is not positive. For high speed weaving machines, gears must be used.

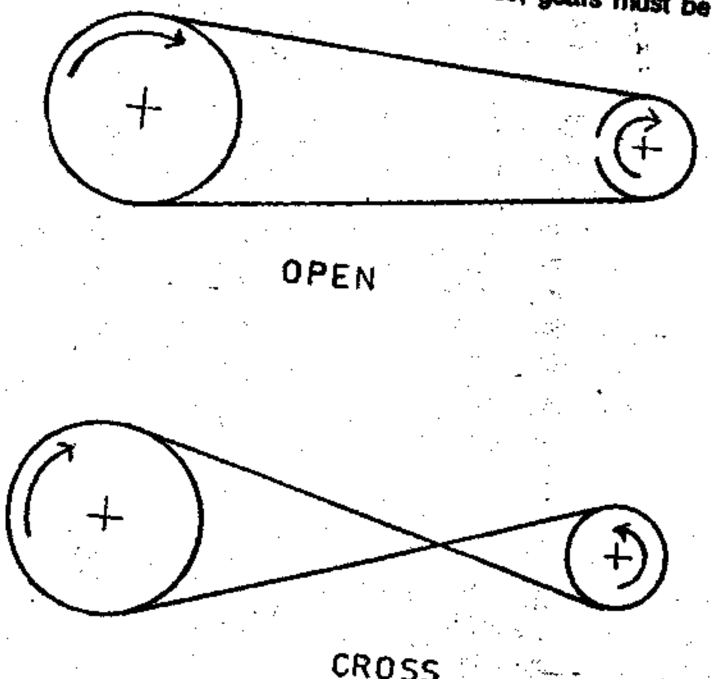



Fig. 12.1 Types of Belt Drive



There are two common types of belt drives. (Fig. 12.1)

(a) Open belt type, (b) Crossed belt drive.

In open belt drive the driver and the follower move in the same direction, while in the crossed belt drive, the sense of rotation of the driven pulley is opposite. For belt drive it is important that the centre line of that part of the belt approaching a pulley must lie in the central plane of that pulley; the angle at which the belt leaves the pulley is immaterial. The velocity ratio of a belt drive is,

$$\frac{\text{(r.p.m. of driven pulley)}}{\text{(r.p.m. of driver pulley)}} = \frac{\text{(diameter of the driver pulley)}}{\text{(diameter of the driven pulley)}}$$

#### 12.3.1.1 Belting

Belts are made of different materials and of varied cross-section (Fig. 12.2) flat or V-shaped. The materials commonly used for power transmitting in loom are : i) leather, ii) cotton and canvas, and iii) Indian rubber.

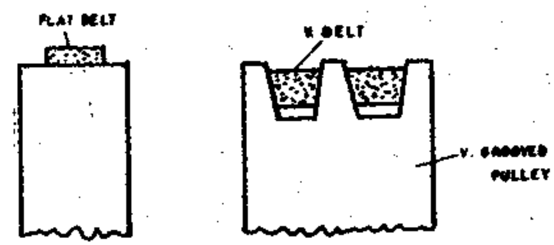



Fig. 12.2 Types of Belt

Leather belts, are made from the butt portion of the hide. The method or cutting up the butt for the production of belting of the highest quality is very important. The butt is only 1.5 m long, but belts of any length can be made by joints at about every 1.5 m.

Belts are made of single and double thickness. Single belting i.e. with the thickness composed of one piece only is now made in hard standard thickness viz; 4, 5, 6, or 7 mm. Double belts formed by cementing, sewing or reveting together two thickness of leathers are sometimes employed for heavy looms, but should be avoided as far as possible because they are less flexible and absorb more power in bending round the pulleys. Oak tanned and chrome tanned leathers are chiefly used, the latter being usually combined with the former as it stretches too much alone. The belt slippage should be controlled within 3%. Canvas or woven belts are manufactured from cotton or camel hair. They are made in two distinct varieties, known commercially as canvas and solid woven respectively. Canvas belting is made from stout canvas or cotton duck folded to the required width and thickness. Solid woven belting is produced in the loom in one piece of the required width and thickness. Canvas and woven beltings are stronger.

Indian rubber belts are made by cementing together the canvas plies with a composition of vulcanised India rubber. This kind of belting is considered the best in damped situations, but is expensive and must be kept free from oil or grease.

Two ends of a belt are jointed by some form of fastener to produce an endless belt. Three methods are used, namely lacing, metal fastener of various kinds, cemented or solution joints.

Leather belts are often jointed by raw hides. For lacing the ends of the belts are cut square and butted together, and the lace is threaded through round or oval holes made with a hand tool known as belt punch.

Metal fasteners in common use are alligator type fastener, jackson button fastener, clipper fastener etc. Number of joints should not be more than three per belt.

**12.3.2 V Belts**

When a belt, trapezoidal in section and designed to run in a V-shaped groove, is known as a V-belt. The modern V-belts are made of a fabric and vulcanised rubber with a cotton-cord tension element. The belts run in V-grooves. V-belts are largely used in looms. V-belt transmits a larger amount of power from a pulley of a given width of face, and being almost positive and slipless in action, when calculating speed ratios for V-belt drives, pulley diameters measured at the centre of the belt should be taken into account, since contact between belt and pulley extends over appreciable distance.

**12.3.3 Advantages and Disadvantages of V-belt Drive Over Flat Belt Drive**

**Advantages**

(a) The V-belt gives compactness due to the small distance between centres of pulleys.

(b) The drive can be considered as positive, because the slip between the belt and the pulley groove is negligible.

(c) The operation of belt is quiet.



(d) The belts have the ability to cushion the shock when machines are started.

(e) The velocity ratio that can be obtained is high (maximum 10).

**Disadvantages**

(a) Belt cannot be used with large centre distances.

(b) V-belts are not as durable as flat belts.

(c) Construction of pulleys for V-belts is more complicated than pulleys of flat belts.

**12.3.4 Care and Maintenance of Belts**

The life of a belt will be prolonged and its driving powers kept at capacity by giving it proper attention. Driving surface of the belt should be kept clean and free from any dirt and other foreign matters. Such dirt if allowed to get into surface, forms into lumps, tearing or distorting the driving face of the belt and preventing it from forming proper contact with the face of the pulley.

Care should be taken to prevent oil or grease from getting at the belt. It will cause loss of power by slip. An application of French chalk will absorb oil on a leather belt and make it workable. If belt slip becomes troublesome, there are many compositions in the market e.g. powdered resin, to increase the friction between the belt and the pulley.

The face of the belt is also very important. For leather belt, the grain side is the correct driving side. It should transmit nearly twice the power conveyed by the flesh side. The flesh side, which has the greatest tensile strength, will stand the stretching strain necessary in the outside bend around the pulleys.

**12.3.5 Pulleys**

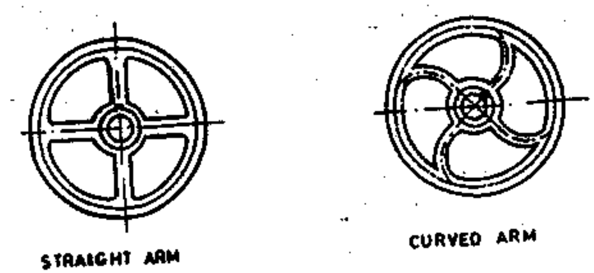



Fig. 12.3 Pulleys

Pulleys are used to transmit power from main shaft to crank shaft of a loom by means of a belt or strap running over them. They are usually made of cast iron, wrought iron, pressed steel. They have a thin rim of rectangular section over which the belt runs.

Usually, pulleys are provided with arms (as shown in Fig. 12.3) which may be straight or curved and the cross-section is usually described 'oval'. The central part of pulley is called boss. To add strength and stiffness large pulleys are provided with rib between the rim and the boss. The rims of cast iron pulleys are generally crowned, that is, slightly greater in diameter at the centre than at the edges. As the belt seeks the highest position on the pulley, the effect of crowning is to keep the belt in the central position.

### 12.3.5.1 Loose and fast pulley

Two pulleys, known as fast pulley and loose pulley are mounted on the crank shaft of a loom. A fast or loose pulley arrangment enables the loom to be started or stopped at will, without stopping the motion of the belt. Loose pulley revolves freely on the shaft, but the fast pulley is firmly fixed on the shaft. To stop a loom the belt is moved from the fast pulley to the loose pulley by means of a shifter. The diameter of the loose pulley is often made slightly smaller than that of fast pulley. A loose pulley is usually produced with a brass or gun metal bush and needs efficient lubrication for smooth running.

### 12.3.6 Clutches

A clutch is a form of connection between a driving and a driven member in the same axis. It is so designed that the two members may be engaged or disengaged at will either by a hand-operated device or automatically by the action of some power driven device. The common types of clutches which are used in weaving machines are, (i) friction clutch (ii) electromagnetic clutch.

### 12.3.6.1 Friction clutch

A friction clutch is used in the transmission of power of shafts and machines which must be started and stopped frequently as in the case of weaving machines. The force of friction is used to start the driven shaft from the rest and gradually brings up to the proper speed without excessive slipping of the friction surfaces. In operating such a clutch the following care should be taken.

(a) The friction surfaces should engage easily and gradually bring the driven shaft upto a proper speed.

(b) The proper alignment of the bearings must be maintained and it should be located as close to the clutch as possible.

(c) The heat generated due to friction should be rapidly dissipated and tendency to grab should be at a minimum.

(d) Lateral displacement of the frictional clutch involves forces of high magnitude resulting in wearing of main shaft bearings. This can be avoided by using expanded clutches.



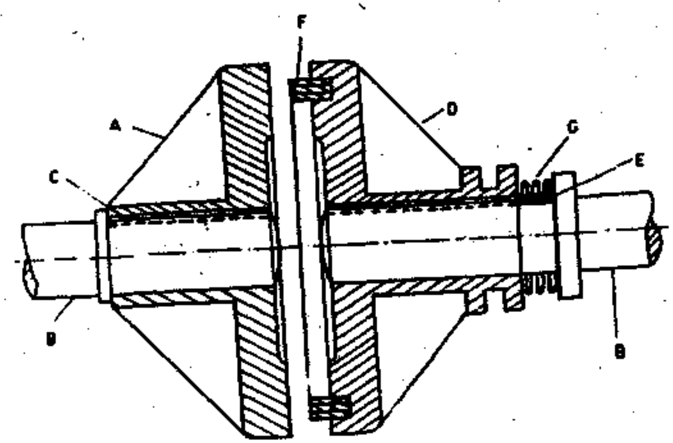
(e) The surfaces should be backed by a material stiff [illegible]ugh to ensure a reasonably uniform distribution of pressure.

The friction clutches are of the following types :

(a) disc or plate clutches. (b) cone clutches.

### 12.3.6.2 Disc or plate clutches

In a disc or plate clutch, as shown in Fig. 12.4 the driver A is rigidly keyed to the driving shaft B by means of a sunk key C and the driven pulley D is placed on the driven shaft with the help of a feather key E, so that it can move along the shaft. The driven member is faced with a friction lining F and is held against a driven member by means of axial pressure provided by a spring. The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to take place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place and the power is transmitted from the driving shaft to driven shaft H.




A = Driver Pulley, B = Driving Shaft, C = Sunk Key, D = Driver Pulley, E = Feather Key, F = Frictional Lining, G = Spring, H = Driven Shaft .

**Fig. 12.4 Disc or Plate Clutch**

Sideways movement of clutch is derived from the starting handle through links.

Total frictional torque on the friction surface, ......(12.1)

$T = \mu WR$

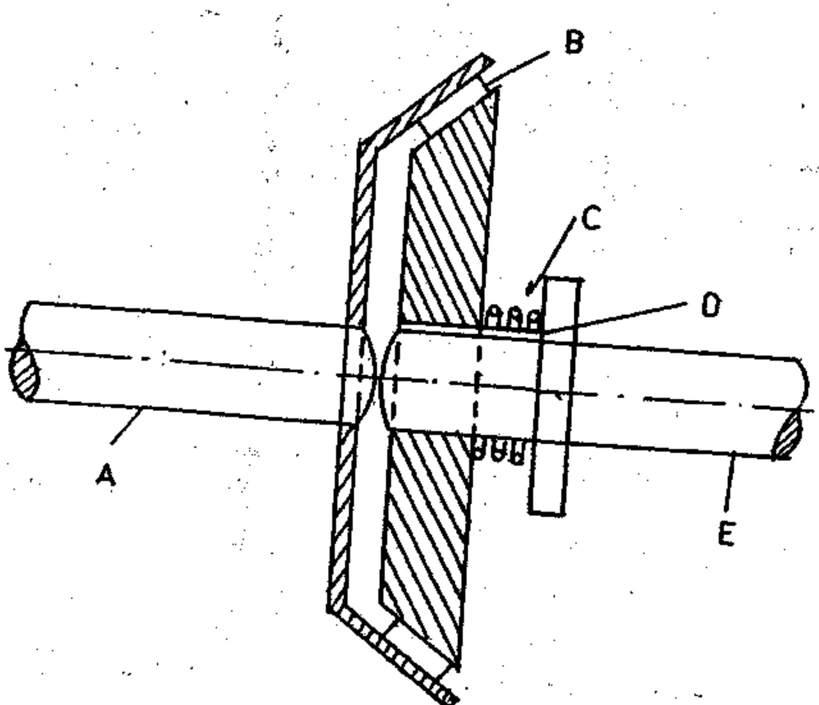
where, $\mu$ = Coefficient of friction.

W = Axial thrust with which the contact surfaces are held together.

R = Radius of frictional surface.

### 12.3.6.3 Cone clutch

A cone clutch has a conical friction surface as shown in Fig. 12.5. The driver which is keyed to the driving shaft by a sunk key has an inside conical surface or face which exactly fits into the outer side of the conical surface of the driven member. Like the plate clutch, the driven pulley is mounted on the shaft with a feather key and the two conical surfaces can be engaged or disengaged by means of starting handle through levers. The contact surfaces of the clutch may be metal to metal, but more often the driven pulley is lined with felt or cork.




A = Driver Shaft, B = Friction Lining, C = Spring, D = Feather Key, E = Driven Shaft.

**Fig. 12.5 Cone Clutch**

Total friction torque on the frictions surface,

$$T = \mu W R \operatorname{Cosec} \alpha \qquad (12.2)$$

where $\alpha$ = The angle of friction surface to the axis of clutch.

Other nomenclatures are same as in Eq. (12.1)

### 12.3.6.4 Plate clutch versus conical clutch

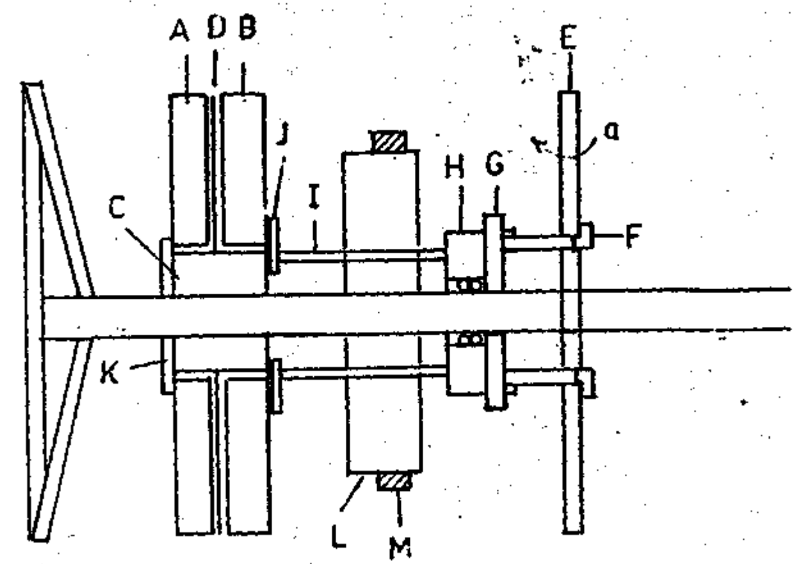
The plate clutch has been used extensively because it is capable of spreading the area of wear over a larger area, but the



conical clutch is capable of transmitting a greater torque i.e. more power for a given pressure W applied to the friction faces (1) because of the term cosec $\alpha$ (lower the angle, lower will be the force required to drive). Hence a conical clutch requires less lateral force. However, the amount of wear and tear will be greater for a conical clutch.

### 12.3.6.5 Single plate Sulzer Ruti clutch

The clutch pulley on Sulzer Ruti Weaving Machine consists of two parts A and B, rotatable on hub C as shown in Fig. 12.6. The latter is connected with a friction plate D. When the starting handle E is turned in the direction 'a', fork F gives a lateral movement to the pin I in the left hand direction. This lateral movement is transmitted to the inner part of the clutch pulley A through a flange C thrust bearing H, pins I and a ring J. As the outer part of clutch pulley A is axially secured by a hub shoulder K, the plate is clamped, due to axial thrust, between both the clutch pulley parts and the clutch is engaged. The brake is applied on the brake disc L by a brake band M.




A = Clutch Pulley (fast), B = Clutch Pulley (loose), C = Hub, D = Friction Plate, E = Starting Handle, F = Fork, G = Flange, H = Thrust Bearing, I = Pin, J = Ring, K = Hub Shoulder, L= Brake Disc, M = Brake Band.

**Fig. 12.6 Clutch Pulley on Sulzer Projectile Weaving Machine**

### 12.3.6.6 Electromagnetic clutch

With the conventional looms, the drive to clutch is usually controlled by means of a starting handle through a train of levers. The knocking of the starting handle should be done in such a manner that the loom is stopped with the shuttle in the starting handle side and the healds are at top centre in the event of a warp breakage or between bottom and back centre in the event of a weft breakage. With the high speed looms, it is very difficult to judge when to knock-off.

This difficulty can be overcome by using an electrically controlled clutch unit which is controlled by means of a push button. Because of the following advantages, it has gained wide acceptance for high speed looms.

(a) No physical strain is required to handle the weaving machine.

(b) Electric power transmission enables the controls to be operated anywhere on the weaving machine. The control pulses given by the stop motions and safety devices of the weaving machines are easy to connect. Thus when the weft breaks or stop motion button is pressed, the loom is stopped at the back centre position, but when the warp breaks, it is stopped at the top centre so that drawing-in can take place without any further adjustment of the loom.

(c) It ensures a quick and accurate start.

(d) The loom can be run at a normal speed, or slow speed (inching) to a predetermined position. There is a provision to reverse the loom. The reversing motion takes the loom to the back centre for starting. Further, reversing can be done for a few picks for the purpose of pick finding. It may be mentioned that majority of the shuttleless weaving machines cannot be operated in the reverse direction because they are equipped with unidirectional cams.

(e) Variation in the loom speed during picking is less. The principle of working of electromagnetic clutch drive (2) is explained with reference to Fig. 12.7.

(f) When the loom is to be started the pressing of starting button completes an electric circuit and energizes clutch solenoids so that the plate which is fixed on the main shaft spline is attracted to the driven fly wheel. This will result in rotation of a planet gear through the main shaft gear and thus the loom driving pinion will be rotated.

(g) When the loom is to be stopped, the clutch solenoid is de-energized and the brake solenoid is energized so that the plate is taken away from the fly wheel on to the fixed motor casing. The timing is such that the loom is brought to rest exactly at the desired crank position depending upon the cause of stoppage.

(h) When the loom is to be reversed, reversing solenoid is energized. Instead of the fly wheel gears driving a shaft gear with an additional tooth to give a forward drive, the shaft position is adjusted, and the drive occurs on a gear with one tooth less so that the loom will run in reverse.

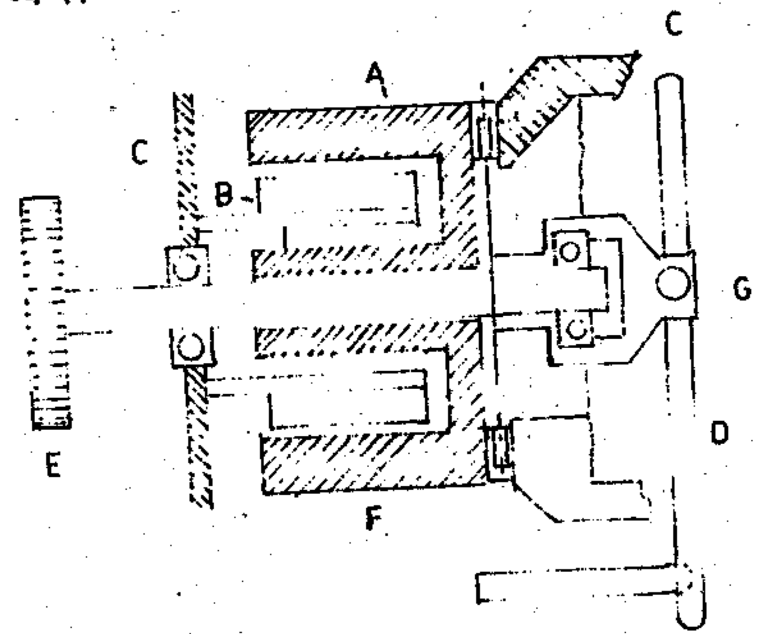
## 12.4 REVERSING MOTION

The reversing motions are mainly used for the conventional weaving machines and are broadly classified into three groups.

(a) The reversing motion is operated by a reversing motor drive.

(b) The reversing motion is given by a special motor.

(c) The reversing motion is operated mechanically. As mentioned earlier a majority of the shuttleless weaving machines cannot be operated in the reversing direction because they are equipped with unidirectional cams. Sulzer Ruti gripper




A = Rotor, B = Starter, C = Motor Casing, D = Diaphragm, E = Driving Pinion, F = Plate, G = Thrust Bearing.

Fig. 12.7 Electromagnetic Clutch

projectile weaving machine cannot be set into reverse motio at all because its picking mechanism is designed fo unidirectional rotation only. On the jet looms, the jet controlle cams exhibit steep slopes in the picking region. If the machin is reversed, the roller balance would be disturbed. Domie rapier weaving machine is provided with a push button whic when depressed, makes the warp let-off, fabric take-up an picking motions and the weft colour selector rotate throug one reverse revolution when the rapier drive and beat u mechanisms are at rest.

## 12.5 BRAKE

A brake is a device by means of which artificial frictiona resistance is applied to a moving body in order to stop the motion o a loom.

### 12.5.1 Types of Brakes

Though there are many types of brakes, the following ar commonly used in looms. i) Shoe brake, ii) Band brake.

#### 12.5.1.1 Shoe brake

A simple block of brake as shown in Fig. 12.8 consists of a shoe which is pressed against the rim of a revolting drum or wheel. The friction between the block and the drum causes a tangential braking force to act on the wheel which retards the rotation of drum. The shoe is pressed against the drum by force applied to one end of a lever (usually by means of a dead weight).

The tangential braking force on the drum, (if the angle of contact is less than 60°)

$$F = \mu R \qquad \text{.......(12.3)}$$

Braking torque, $TB = F.R. = \mu.R.r.$

where, $TB$ = Braking torque.

$F$ = Tangential breaking force on wheel.

$R$ = Normal force pressing the brake shoe on the drum.

$\mu$ = Coefficient of friction.

#### 12.5.1.2 Band brake

A band brake consists of a flexible band of leather, or a steel lined with friction material, which embraces a part of the circumference of the drum as shown in Fig. 12.8. The ends of the band are joined at A and B to a lever pivoted on a fixed pin (or fulcrum) at O. When a force P is applied to the lever at C, the lever turns about the pin O and tightens the band on the drum and hence the brake is applied. The friction between the band and the drum provides the braking force. It may be noted that for the band to be tight, the braking torque on the drum be,



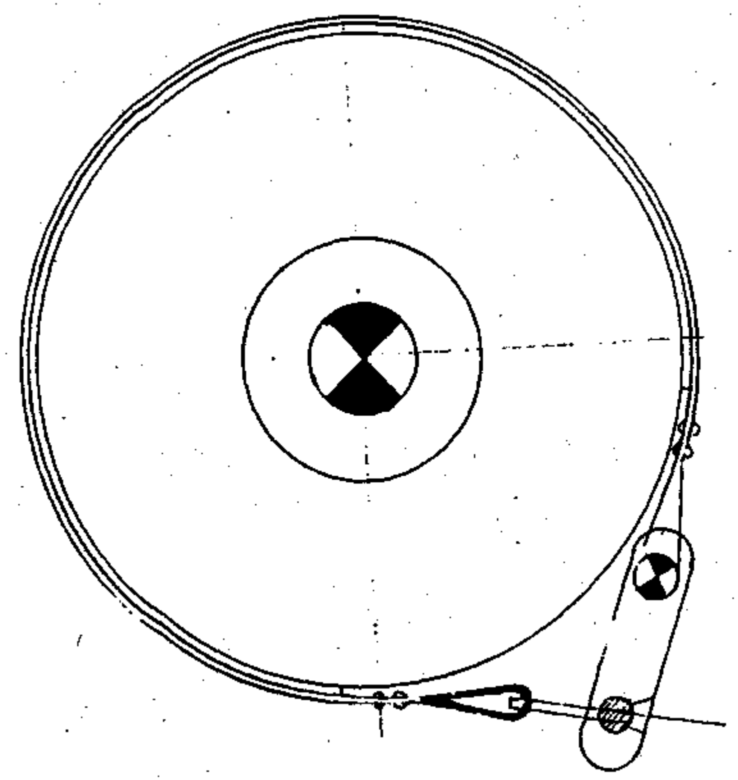



Fig. 12.8 Band Branke

$$TB = (T_1 - T_2)\, r \qquad \text{.......(12.4)}$$

where, $TB$ = Braking torque

$T_1$ = Tension on the tight side of the band

$T_2$ = Tension on the slack side of the band

$r$ = Effective radius of the drum i.e. (radius of drum plus thickness of the band)

### 12.5.2 Factors to be Considered During Braking

It is essential to bring the loom to a standstill firmly and smoothly with the shuttle in proper position when the loom is stopped manually or by stop motions. A brake when brought into operation should not impart a shock or strain to any part of the loom. It is preferable that the braking system should be such that the loom should be brought to rest at the desired position of crank in order to facilitate certain operations as follows.

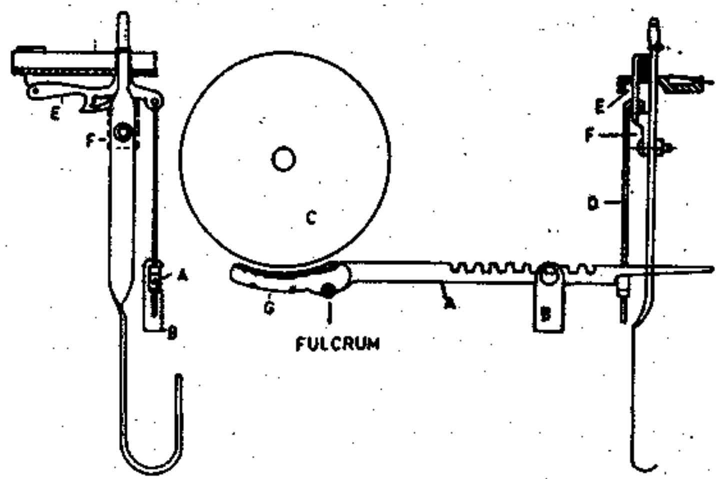
(i) If a weft is broken, a loom should always stop with its crank at the back centre.

(ii) If a warp stop motion stops the loom for an end break, the loom should be stopped with the healds levelled.

(iii) Before beat up on the actual pick of the weft break in the case of a loom with centre weft fork.

(iv) In multiple box looms, where a pattern must not be broken, means should be provided for holding the brake off while a weaver turns manually to find the proper starting place.

### 12.5.3 BRAKE ON CONVENTIONAL LOOM




A = Brake Lever, B = Weight, C = Brake Wheel , D = Link, E = Tumbler Lever, F = Curved Bracket, G = Brake Shoe.

**Fig. 12.9 Brake Motion on Conventional Loom**

The simple type of braking system used in non-automatic looms is shown in Fig. 12.9. The brake wheel C is mounted on the top shaft of the loom. The brake shoe, G, lined with leather or other types of linings, is fulcrumed on a stud and the amount of pressure exerted by the brake is determined by the weight B and its position on the brake lever A, greater pressure is exerted as the weight is shifted away from the fulcrum. The brake lever A is coupled to the tumbler lever E by a link D and a collar. The tumbler lever E rests upon either a bowl, or a curved bracket F affixed to a starting handle. When a loom is put in motion, E is raised by the pressure of F against its full side and the link D lifts the heavy end of the lever A to release the brake. If the starting handle is knocked off, tumbler



lever E falls and the brake is applied. To release the brake when the loom is stationary, the weaver lifts the brake handle, which now rests on the weft fork lever and is retained in that position until the loom is once more set in motion. More powerful brakes are used on fast reed looms and looms with centre weft fork where the loom must be brought to a stand still at once. Usually larger angles of lap, the brake band having a high coefficient of friction and covering almost the whole perimeter of the brake drum are used in order to spread the wear over a greater area and dissipate the heat generated due to braking action.

## REFERENCES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2. Marks, R. and Robinson, A.T.C., Principles of Weaving, The Textile Institute Publication, 1976.

# 13 DOBBY SHEDDING

## 13.1 INTRODUCTION

Since the production of the patterns on tappet shedding is limited to 8 or 16 heald frames, as discussed earlier, improved shedding mechanism was found necessary for greater range of patterns. **Dobby shedding** is one such improved mechanism for patterns requiring upto 24 heald frames. In this case the healds are all operated by jacks and levers (Fig. 13.1) and occupy less spaces as compared to tappet shedding mechanism. The other important advantage is the order of lifting and lowerig the heald frames, as per the lifting plan, which is controlled by a pattern chain that gives a good scope for weaving designs repeating a large number of picks and ends. It is very easy to change the pattern chain whenever a new design is required to be woven; provided of course, the number of heald frames and order of drawing the ends remains the same. In certain cases, for example, dhoti and sari border, the dobby shedding can operate, up to forty ends per repeat. In such cases heald cords are used instead of heald frames.

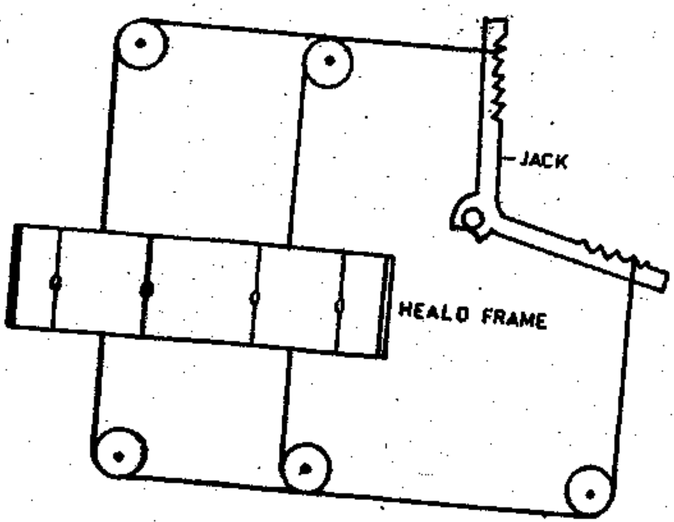



Fig. 13.1 Positive Dobby



## 13.2 TYPES OF DOBBY

There are many types of dobbies available, both for general and special purposes. As in the case of tappet shedding, dobbies are also classified as negative and positive in action. They are further subdivided into; (a) single lift, single jack; (b) double lift, double jack.

### 13.2.1 Single lift or Double lift

Single lift dobbies are characterised by the following facts, that the sequence of movements for (a) effecting shaft movement takes place by using the same machine element for every pick. Consequently (b) this element must be ready for operation for any required pick in the selected pattern.

The advantage of such a dobby is its relatively simple construction; but the main drawback lies in its restricted speed due to short time span between two consecutive picks for the reading in action i.e. selection of healds.

Double lift dobby is provided with two elements or systems having opposite working cycles. One element is responsible for the even numbered picks and the other for the odd numbered picks. Alternatively they can co-operate to ensure that the shafts are lifted in the manner required. There is available time taken by two crank revolutions of the loom for the selection of the healds. This permits a high dobby speed to be obtained.

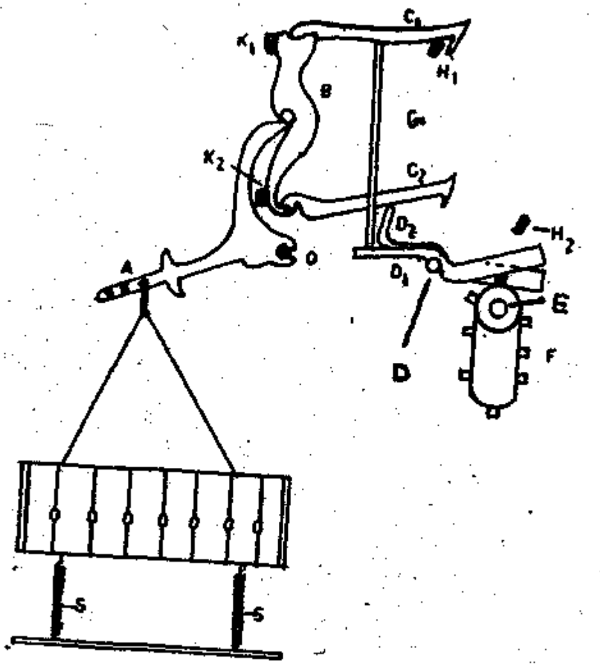
Single lift and double lift dobbies may be of open or closed shed machines.

### 13.2.2. Positive and Nagative Dobby

**A positive dobby**, Fig. 13.1, raises and lowers the heald frame without the use of a reversing motion. They are used for weaving heavy cotton, woollen and worsted fabrics and on high speed looms. The negative dobby shown in Fig. 13.2 can only control the heald frame in one direction. They can either raise or lower the heald frame. Most of the dobbies are mounted on the top of the loom and therefore they lift the heald frame. The reversing is carried out by springs, elastics or a special reversing motion.

### 13.2.3. Open and Closed shed

Negative dobbies may be subdivided according to type of shed formed viz. open and closed. With the closed shedding, all the warp thread are levelled after each pick. To change the position of the shafts in closed shed dobby, the heald shafts are first accelerated and then slowed down until they stop; they are then accelerated again and once more slowed down. This double cycle of




A = Jack, B = Baulk Lever; $C_1$ $C_2$ = Draw hooks; $D_1$ $D_2$ = Feelers,
E = Wooden pattern cylinder, F = Pattern chain, G = Needle;
$H_1$ $H_2$ = Draw knives, $K_1$ $K_2$ = Stop bars, O = Fulcrum
S = Reversing spring

**Fig. 13.2 (a) Negative Dobby (Double Lift Single Jack)**

acceleration and deceleration has an adverse effect on the dobby itself and the service life of the heald shafts. On the other hand it may be successfully adopted in wool weaving where all warp threads are at approximately the same tension during the beat up. However in practice, it has been found that about 5% of all articles are woven by closed shed method, whereas 95% of woven goods are produced by open shed method, because of the following reasons.

(a) The desire for high speeds.

(b) Open shed method showed a reduction in warp thread breakage [1] by about 20%. This is attributable on one hand to a reduction of the continuous friction of warp threads in the reed and on the other hand to the smoother shaft movement of open shed weaving.

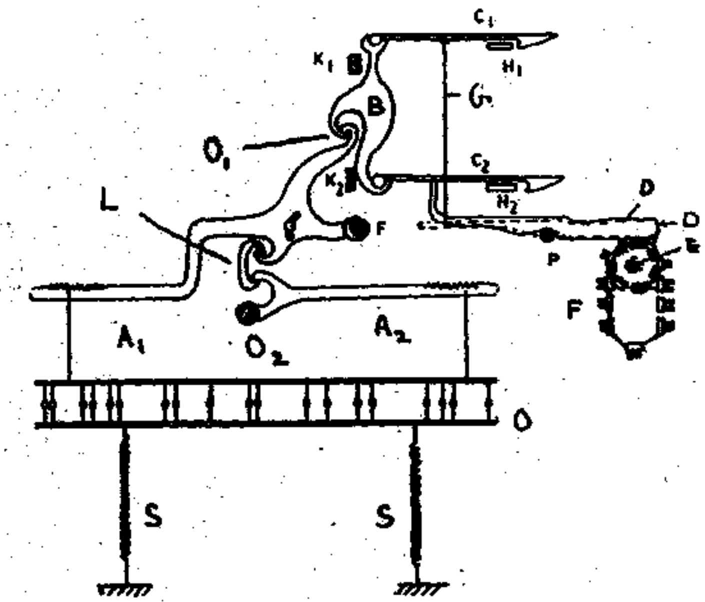


Although several types of dobbies are marketed, the **Keighley dobby** manufactured in England, has become very popular because of its simplicity and reliability. This dobby can be used for weaving from the finest silk to the heaviest upholstery fabrics without much problem. There are two types available in Keighley dobby ; double lift, single jack and double lift, double jack. Keighley dobby forms open shed.

### 13.3 DOUBLE LIFT NEGATIVE DOBBY

#### 13.3.1 Double Lift Single Jack

Keighley double lift negative dobbies are of two types : viz. single jack (Fig. 13.2a) and double jack (Fig. 13.2b). Single jack dobby during lifting gives a lateral movement to the healds. Various attempts had been made to overcome lateral movement. Ultimately solution has been found by using two jacks as shown in the figure. Working of the two dobbies are exactly the same excepting the connection of jacks. Double lift double jack dobby is also referred as **Climax dobby.**




A = Jack, B = Baulk Lever; $C_1$ $C_2$ = Draw hooks; $D_1$ $D_2$ = Feelers,
E = Wooden pattern cylinder, F = Pattern chain, G = Needle;
$H_1$ $H_2$ = Draw knives, $K_1$ $K_2$ = Stop bars, L = C-link, O = Heald frame,
S = Reversing spring, $A_1$ = Outer Jack, $A_2$ = Inner Jack
$O_1$ $O_2$ = Fulcrum

**Fig 13.2 (b) Negative Dobby (Double Lift Double Jack)**

In Fig. 13.2a the essential parts of the double lift nega dobby are shown. The dobby is mounted at the top of the loom special supports.

The essential parts are :

1. Heald lifting jack A fulcrumed at O.
2. Baulk lever B : It holds the lifting jack A.
3. Draw hooks $C_1$, $C_2$ : The knuckle end of each draw hook held in the upper and lower ends of the baulk lever.
4. Feelers $D_1$, $D_2$ :
   $D_1$ is a straight end feeler; $D_2$ is a curve-end feeler. Both the feelers are fulcrumed at P. The back part of the feelers are heavy so that they o always remain on the top of the wooden pattern cylinder
5. Wooden pattern cylinder E : It is placed directly beneath th feelers and is given one eighth of a turn every second pic The cylinder is grooved lengthwise to enable a wooden la to house properly during its rotation.
6. Pattern Chain F : It consists of number of lags linked one the other by wire rings to form a continuous chain to run o the cylinder. Each lag is provided with two rows of holes an each row represents one pick. The lags are pegged, usin small wooden pegs, as per the lifting plan (Fig. 13.5).
7. Needles G : They rest on the straight edge feelers $D_1$ and support the top draw hooks $C_1$. The bottom draw hooks $C_2$ are supported by the curve edges of feelers $D_2$.
8. Draw knives $H_1$, $H_2$ : They extend the full width of the dobby and reciprocate in the slots of the side frames .
9. Stop bars $K_1$ $K_2$ : They also extend the full width of a dobby.
10. T-lever L in Fig. 13.3 : The horizontal arm is connecated to a driving rod which is connected to a bracket on the bottom shaft. The two ends of the vertical arm are connected to draw bolts $M_1$, $M_2$. The T-lever is keyed to a shaft passing through the dobby at X. The other end of the shaft is connected to a vertical lever which also carries other pair of draw bolts.
11. Draw bolts $M_1$, $M_2$ : They carry the knives $H_1$, $H_2$ respectively. For each heald frame there are lifting jacks, baulk levers, two draw hooks, two feelers and one needle. The number of jacks provided in the dobby mechanism depends upon the capacity of the machine. A 24 dobby contains 24 jacks and can operate 24 heald frames.



neously with the movement of the knives, the pattern the lags move one eighth of a turn bringing a lag with ank-directly beneath the feelers. A peg in the lag will corresponding hook which will engage with the draw knife. ple, if the straight edge feeler is lowered by lifting it up at by a peg on the lag, the top draw hook $C_1$ is also lowered with the top knife $H_1$. Similarly if the curve edge feeler is the bottom draw hook $C_2$ is lowered to engage with the ife $H_2$. Than the draw hook which has been dropped down with the knife will be drawn forward along with its baulk the knife during the sweep of the T-lever. If the top part of lever is pulled forward the bottom part rests solidly against bar $K_2$. Conversely if the bottom part of the same lever is ward the top part rests against the stop bar $K_1$. Thus the $K_1$ $K_2$ act as a fulcrum for the forward moving baulk levers, turn lift the jack lever and the heald frame. A blank in the ep the respective draw hook raised above the knife and so frame is not lifted.

a heald frame is to remain up for two or more consecutive th the top and bottom draw hooks $C_1$ $C_2$ belonging to that lowered through the action of pegs provided on the two holes corresponding to that particular heald (This will be d later by line diagrams). However, one of the draw hooks forward by its knife, and the fulcrum for the same baulk s automatically changed, either from $K_1$ to $K_2$ or to $K_1$.

For example, if the top knife pulls the baulk lever forward to jack lever and for the next pick if the same heald frame has ain up, the bottom knife pulls the same baulk lever again d, transferring the work of lifting the heald frame from the top moving in, to the bottom knife moving out.

### Drive to the Pattern Cylinder

The pattern cylinder is driven by a pawl and a ratchet wheel 13.3). The pawl A is connected to the lower end of the draw bar and it engages with a ratchet wheel B on pattern cylinder C. g the forward movement of the lower draw knife, that is, every d pick, the pawl A pushes the ratchet wheel B one tooth and ylinder C moves one eighth of a turn. Then the cylinder is ed by a spring acting finger N fulcrumed at D, resting on a flat star wheel P. This star wheel is also mounted on the pattern er shaft on the opposite end of the ratchet wheel.



13.3.5 Ar

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10. T-lever L in Fig. 13.3 : The horizontal arm is connecated to a driving rod which is connected to a bracket on the bottom shaft. The two ends of the vertical arm are connected to draw bolts $M_1$, $M_2$. The T-lever is keyed to a shaft passing through the dobby at X. The other end of the shaft is connected to a vertical lever which also carries other pair of draw bolts.
11. Draw bolts $M_1$, $M_2$ : They carry the knives $H_1$, $H_2$ respectively. For each heald frame there are lifting jacks, baulk levers, two draw hooks, two feelers and one needle. The number of jacks provided in the dobby mechanism depends upon the capacity of the machine. A 24 dobby contains 24 jacks and can operate 24 heald frames.



...aneously with the movement of the knives, the pattern ...n the lags move one eighth of a turn bringing a lag with ... blank-directly beneath the feelers. A peg in the lag will ... corresponding hook which will engage with the draw knife. ...ple, if the straight edge feeler is lowered by lifting it up at ... by a peg on the lag, the top draw hook $C_1$ is also lowered ...e with the top knife $H_1$. Similarly if the curve edge feeler is ... the bottom draw hook $C_2$ is lowered to engage with the ...nife $H_2$. Than the draw hook which has been dropped down ...e with the knife will be drawn forward along with its baulk ... the knife during the sweep of the T-lever. If the top part of ... lever is pulled forward the bottom part rests solidly against ... bar $K_2$. Conversely if the bottom part of the same lever is ...ward the top part rests against the stop bar $K_1$. Thus the ... $K_1$ $K_2$ act as a fulcrum for the forward moving baulk levers, ... turn lift the jack lever and the heald frame. A blank in the ...ep the respective draw hook raised above the knife and so ...d frame is not lifted.

...f a heald frame is to remain up for two or more consecutive ...oth the top and bottom draw hooks $C_1$ $C_2$ belonging to that ...e lowered through the action of pegs provided on the two ... holes corresponding to that particular heald (This will be ...d later by line diagrams). However, one of the draw hooks ... forward by its knife, and the fulcrum for the same baulk ...s automatically changed, either from $K_1$ to $K_2$ or ... to $K_1$.

For example, if the top knife pulls the baulk lever forward to ...ack lever and for the next pick if the same heald frame has ...ain up, the bottom knife pulls the same baulk lever again ...d, transferring the work of lifting the heald frame from the top ...moving in, to the bottom knife moving out.

**... Drive to the Pattern Cylinder**

The pattern cylinder is driven by a pawl and a ratchet wheel ...13.3). The pawl A is connected to the lower end of the draw bar ... and it engages with a ratchet wheel B on pattern cylinder C. ...g the forward movement of the lower draw knife, that is, every ...nd pick, the pawl A pushes the ratchet wheel B one tooth and ...ylinder C moves one eighth of a turn. Then the cylinder is ...ed by a spring acting finger N fulcrumed at D, resting on a flat ... star wheel P. This star wheel is also mounted on the pattern ...der shaft on the opposite end of the ratchet wheel.



13.3.5 Ar...

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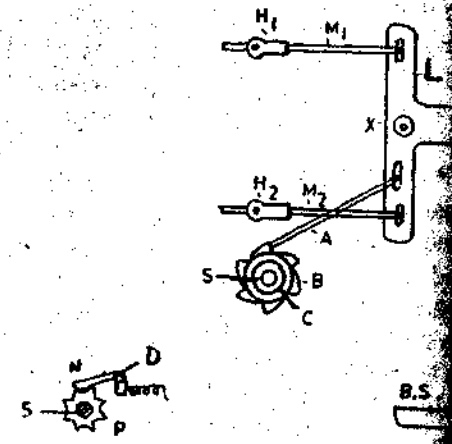



A = Pawl, B = Ratchet Wheel, C = Pattern cylinder; H
L = T-lever; $M_1$, $M_2$ = Draw bolt, N = Spring
P = Star wheel, S = Pattern Cylinder shaft, X

**Fig. 13.3 T-lever and Pattern Cylin**

### 13.3.2 Double Lift Double Jack

The disadvantage of a single jack Ke
difficulty of getting a straight lift to the heald shaf
were used to prevent the shafts from swinging on
such as passing the shaft cords over spaced
from parallel bars, and passing the shaft cords
pair of angle iron bolted to the top frame of the
not successful in practice. The problem wa
introduction of a second jack.

The Climax double jack dobby combines
of a single short link known as 'C' link. As show
outer jack A fulcrumed at $O_1$ is controlled directly
B as with the single jack Keighly dobby. The sho
outer jack $A_1$ to the inner jack $A_2$, fulcrumed at O
are lifted together without the aid of either teet

### 13.3.3 Working of a Keighley Dobby

When the loom is started the T-lever s
the knives through draw bolts, and the kni
reciprocation every two picks because they are dr



### 13.3.5 Arrangement of Feelers

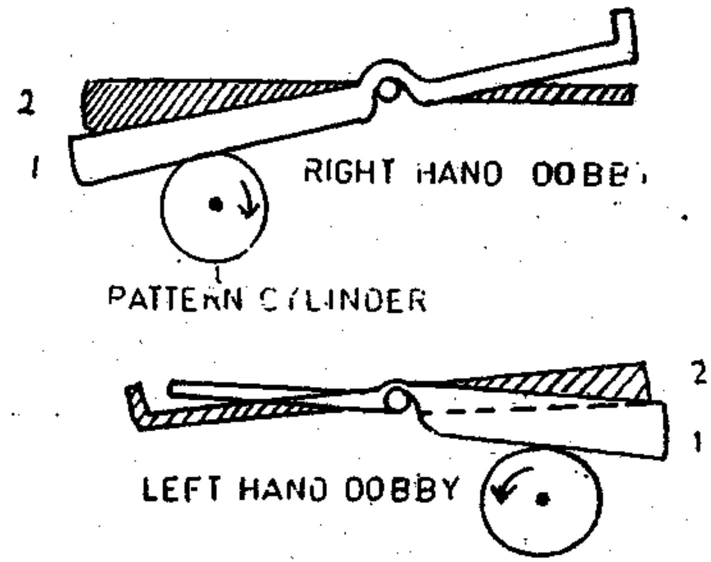
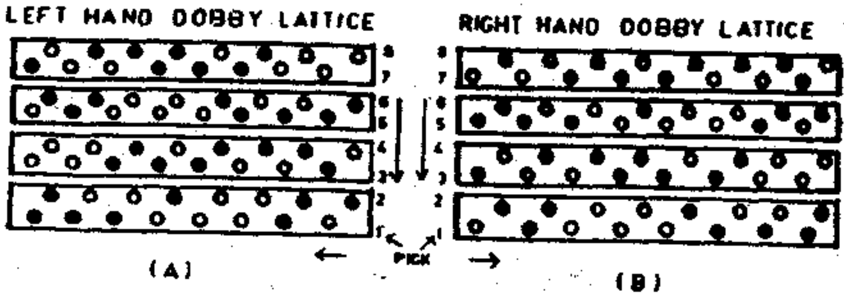



**Fig. 13.4 Feelers for Right and Left hand Dobby**

The straight edge and curve edge feelers shown in Fig. 13.4 are arranged in a particular order according to the starting handle position. If the starting handle is on the right hand side of the loom, the dobby is mounted on the left hand side. Such a dobby is known as **right hand dobby.** Conversely, if the starting handle is on the left hand side the dobby is mounted on the right hand side, the dobby is called **left hand dobby.** Therefore, the terms right hand and left hand dobbies refer to the 'hand' of the loom and not on the position of the dobby on the loom. The first feeler on the right hand dobby is a curve edge and operates the bottom row of draw hooks and pattern cylinder rotates in a clockwise direction. In the case of left hand dobby the first feeler is a straight end operating the top row of hooks through the needles, and the cylinder rotates in the anticlockwise direction. The idea of arranging the feelers in this order is to simplify the pegging of lags for a particular lifting plan. The first row of holes in the lags should represent the first pick in each case. In Fig. 13.5 the pegging plan for a fancy twill repeating on 8 ends with 8 heald frames is shown for both the left and right hand dobbies. The arrows indicate the direction in which the pattern lags would turn. A left hand dobby lattice is shown in Fig. 13.5a and a right hand dobby lattice in Fig. 13.5b.



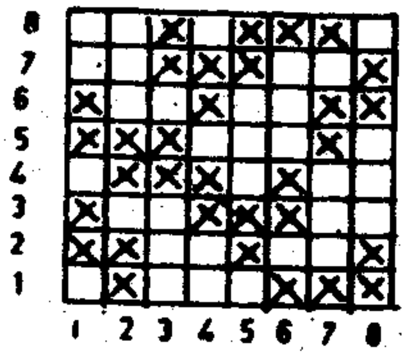



**Fig. 13.5 (a, b) Design and Pegging Plans to Left hand and Right Hand Dobbies**

However in each case the pegging plan on the point paper is read from left to right and first pick starts at the bottom of the lags. A close study of the lags meant for right and left hand dobbies, will show that the first hole of the first row is at different positions. Along with this, one should understand that the pattern card cylinder is turned in both cases by a pawl that is fixed to the lower arm of the front draw bar lever, and the cylinder is turned as the bottom knife moves in. It is therefore apparent that the first pick of any lag must always operate on the bottom knife of the dobby. Taking these two



cases it should be clear why the first feeler is different for different hand of the dobby. Fig. 13.5a, 13.5b show the direction of movement of lags and the position of the first hole of the first row of holes corresponding to the first pick for each hand of the dobby.

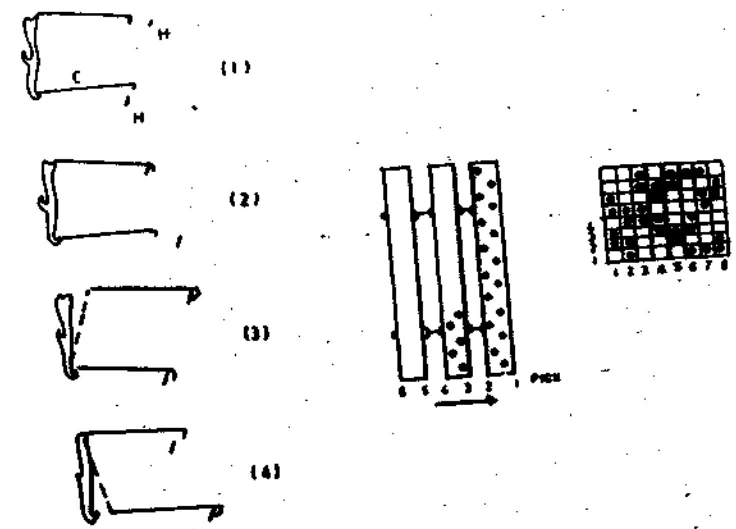



**Fig. 13.6 Cycle of Operation of the Draw Hooks**

In Fig. 13.6 the cycle of operation of the draw hooks corresponding to the right hand dobby, for 4 picks of the 8 end fancy twill design, is illustrated by line diagrams.

Diagram 1 : Lower draw hook $C_2$ is kept raised by virtue of a hole in the second row of lag. At the same time the peg in the first hole in the second row corresponding to second pick lowers the top draw hook $C_1$. At this stage knife $H_1$ is out, knife $H_2$ is in.

Diagram 2 : Since the lag number 1 is not moving out for the second pick, the position of draw hooks will remain the same. Knife $H_1$ is in and $H_2$ is out.

Diagram 3 : The lag mumber 2 is moved to the operating position along with the knife $H_2$ which has now moved in. As per the arrangement of pegs on the second lag, the bottom draw hook $C_2$ is down and the top hook is up, corresponding to 3rd and 4th pick.

When the knife $H_2$ moves out the heald frame which has already been raised by knife $H_1$, is again raised for 3rd pick by $H_2$. However, the raised heald by $H_1$ moves down a little till the two knives $H_1$, $H_2$ cross, and move up along with the knife $H_2$.

Diagram 4 : Since the lag No. 2 is not moved out, the position of draw hooks will remain the same, that is, the top draw hook is kept raised because of a blank on the 4th pick. Therefore, the knife $H_1$ which is now moving out will be down.

### 13.3.4 Dobby Settings

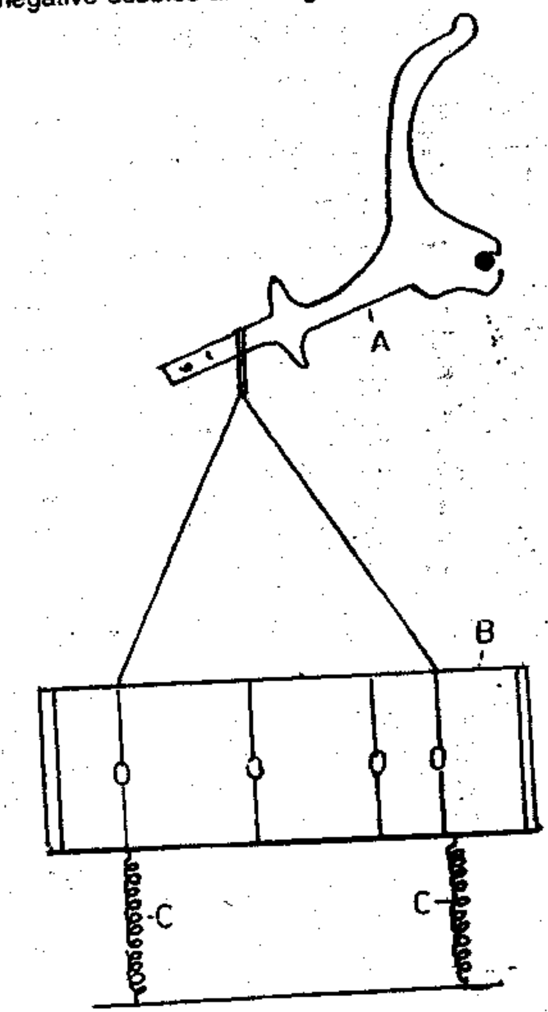
1. The sweep on the bottom shaft connecting the driving rod to the T-lever should be at dead level when the crank is between top and bottom centres. This position can be changed depending upon the type of fabric being woven.
2. With the sweep in the horizontal position the T-lever of the dobby should also be horizontal.
3. The driving rod connecting the sweep to the T-lever should be straight.
4. When the T-lever is horizontal the two knives are equidistant from the ends of their respective slots in the T-lever. At this position they are about half way along their traverse.
5. The draw bolts are fixed in the slots provided in the T-lever. They can be raised or lowered to increase or decrease the traverse of the knives.
6. The driving rod is coupled to the sweep on the bottom shaft, and a slot is provided in the sweep for increasing or decreasing the traverse of the knives; which in turn affects the depth of the warp shed.
7. When the draw knife goes in, to the limit of the slot in the frame, there should be a clearance of about 10 mm between the knife and the hook. When the knife moves out again to engage the hooks, there will be sufficient dwell period for the heald frames that are lowered. However this should not be mistaken as the real dwell period discussed under the tappet shedding. It is not possible to provide a real dwell period because of the type of drive given to the knives. The modern dobby shedding with cam driven arrangement is therefore an improvement over the connecting arm drive, where such a dwell period is possible.
8. The amount of movement given to the cylinder is important in order to bring the lag exactly under the feelers. It is, therefore, important to check the throw of the pawl whenever the dobby sweep is altered. When the bottom knife is in its extreme outward position, there should be about 8 mm clearance between the tip of the pawl lever and the engaging teeth of the ratchet wheel.



9. The pegs of the pattern lattice should be of the same height and should be firmly held in the hole. A broken or missing peg will result in a wrong design. Steel pegs are proved better than wooden pegs.
10. The setting of the cylinder is also important. If it is too close to the feelers the turning might be difficult; on the other hand, if it is too much away, the feelers may not be raised sufficiently.

### 13.3.5. Heald Reversing Motion

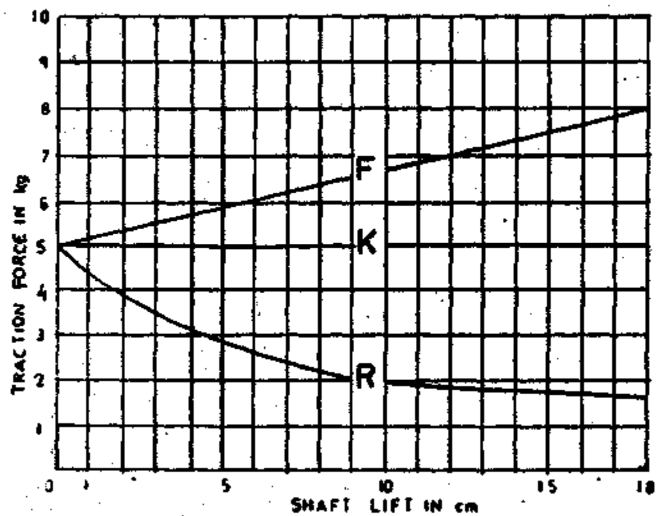
Since the negative dobbies can control the movement of the heald frame in one direction a heald reversing motion is necessary. Most of the negative dobbies are designed to raise the heald frame.




A = Single Jack, B = Heald Frame, C = Spring

Fig. 13.7 Spring Reversing Motion

The simplest form of reversing motion, shown in Fig. 13.7 has two coiled springs for each heald frame attached at the bottom. The main disadvantage of this system is that when the heald frame is raised, the spring stretches thus adding strain on the lifting mechanism as shown in graph F (Fig. 13.8). The other disadvantage is that the heald frame will vibrate in case the spring position is not correct or very light springs are used or the elastcity of the springs is reduced due to constant oscillating movement. An improved heald reversing motion shown in Fig. 13.9 gives less tension on a raised heald than when the frame is down. The mechanism consists of two stands M which are mounted on a rail beneath the heald frames. At the top of the stand there is a tumbler lever N fulcrumed at O. It is held against a check pin P by springs. The lower end of the




F = Down Pulling springs, K = Spring under motions, with constant force, R = Spring under motions with diminishing force.

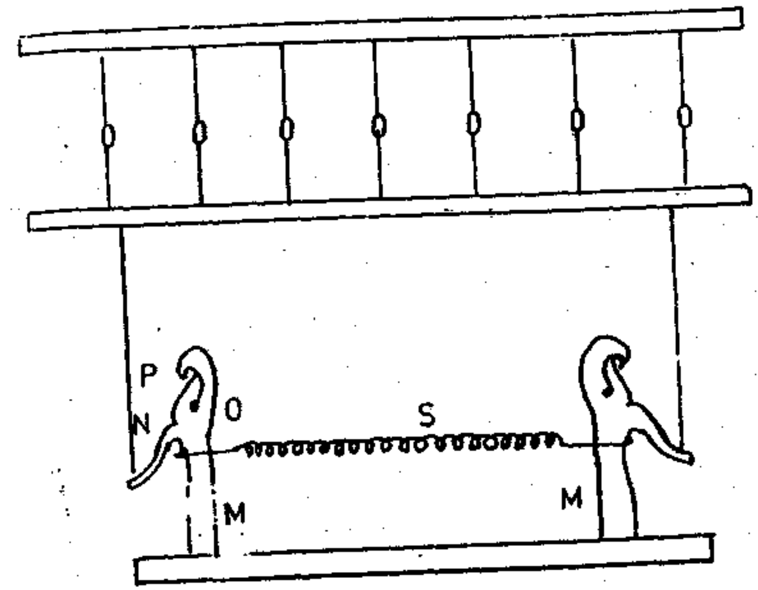
**Fig. 13.8 Down pulling Force on Heald Shafts**

tumbler lever is connected to the heald frame by means of a spring. When the heald frame is raised the point of connection for spring passes the centre and so the stress is transferred to the fulcrum pin O, and there is less tension on the heald frame. The maximum spring tension is exerted on the heald frame when point of connection is below the check pin P, that is, the heald is down as shown in curve R of Fig. 13.8.

Developments in the last few years have shown a constant increase of the weft insertion performance of weaving machines



Since the lifting of the shafts is carried out by a motion following the form of a cam and increase in shaft mainly requires more force (1) as shown in Fig. 13.9. So a down pull system with diminishing traction, in the upper shed is not always sufficient (loosening of traction organs etc.). To overcome this difficulty Staubli has developed spring undermotions with a constant down pulling force in order to allow for the increased speed of the shafts (Fig. 13.8 graph K).




M = Stand, N = Tumbler lever, O = Fulcrum, P = Chech pin, S = Spring.

**Fig. 13.9 Heald Reversing Motion**

## 13.4 CAM DOBBY

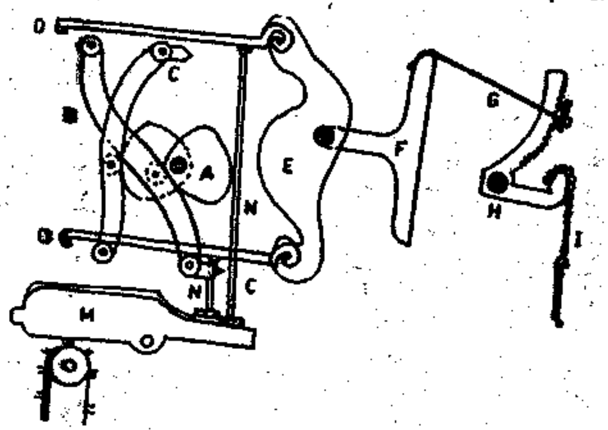
In the case of modern dobbies the knives are actuated by means of cams mounted on a shaft. The T-lever and the connecting rod to the bottom shaft sweep is totally discarded. The cams are driven by a chain from the crank shaft. With the design of cam shape, a **dwell** can be provided as obtained in the case of tappet shedding.

The advantages are :

1. Clearer loom alley space.
2. Reduced warp breakages because of smaller depth of shed and provision of dwell period of healds.
3. Very smooth movement of the healds, thus protecting heald frames and heald wires from damage.

4. Amount of lift can be raised or reduced to suit a particular type of warp.

5. The cams can be designed to give the required dwell period for 60°, 90° or 120° of crank shaft revolution according to loom width, speed of operation and type of fabric, which in turn gives other advantages like, clearer passage for the shuttle flight, economy in power due to reduction in picking force and a corresponding reduction in wear and tear of the picking parts.




A = Cams, B = Hever, C = Knife, D = Hook, E = Baulk lever, F - Jack, G = Connecting rod, H = Sector, I = Chain, M = Feelers, N = Needles

**Fig. 13.10 Cam Dobby**

A simple line diagram shown in Fig. 13.10 illustrates the actuating of the knives by cams. The bowls on the knife levers are kept always in contact with the cams, by special springs. The knives are only pushed by the cams and the returning is carried out by springs. Therefore these cams can be considered as negative in action. The selection of hooks is the same as per the Keighely dobby with T - lever drive or needles of paper card dobby. The pattern cylinder is driven by a different arrangement.

## 13.5 DOBBY WITH PAPER PATTERN

In **paper pattern dobby** the useful chain of wooden lags is replaced by a paper or plastic roll. Holes are punched in the paper corresponding to the pegs in the lag, that means, a hole in the paper makes the heald frame raise and a blank keeps it down through a mechanism.

Comparison between wooden lags and paper synthetic cards (1) is given in Table 13.1.



**Table 13.1 Wooden Lags Versus Paper or Synthetic Cards**

| Comparison | Wooden lags | Paper/Synthetic Card |
|---|---|---|
| Number of picks/m | 72 | 333 |
| Length of pattern for 100 picks | 1.39 m | 0.3 m |
| Weight of pattern for 100 picks | 2.3 kg. | 0.05 kg. |
| Time required for making up pattern for two picks | 1.1 Hour | 0.5 Hour |

Other advantages of the paper/synthetic cards over the wooden lags are :

(i) Pattern cards of paper or synthetic material are more economical as they can be cut and copied much quicker and easier on card cutting machine. At present computers can be used to punch cards.

(ii) It is possible to have very long designs repeating on more number of picks than with wooden lag chains.

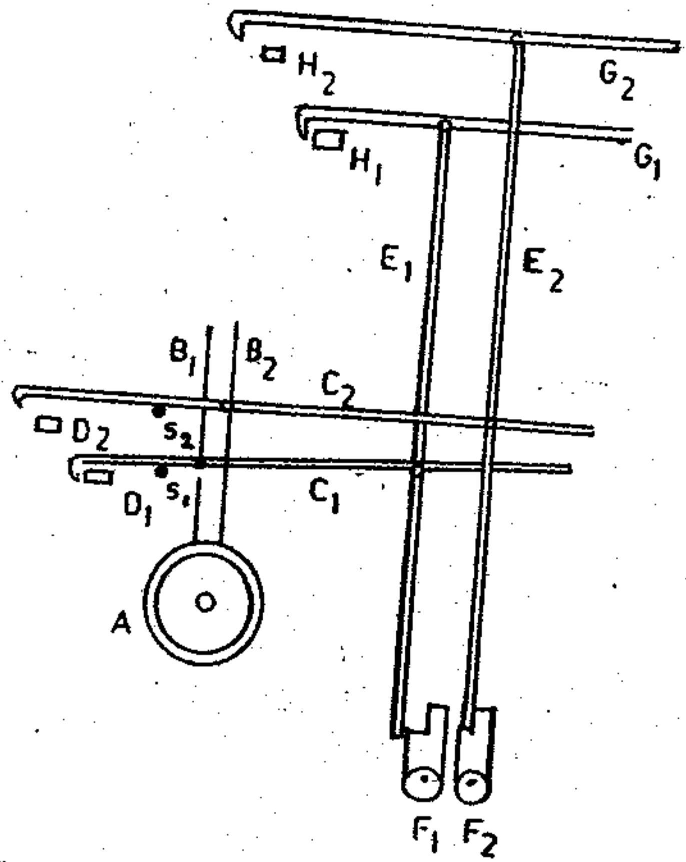
(iii) Reduced fabric defects as chances of wooden lags being taller/shortened due to wear do not exist.

(iv) The punched paper patterns can be stored in a small area, if required again for the future use.

The principal of the hook selection mechanism used on paper pattern dobby is outlined in simplified form in Fig. 13.11. The mechanism consist of the following parts :

1. Paper pattern and cylinder A
2. Selection needles $B_1$, $B_2$
3. Supplementary hooks $C_1$, $C_2$
4. Reciprocating supplementary knives $D_1$, $D_2$
5. Vertical needles $E_1$, $E_2$
6. Lifting bars $F_1$, $F_2$
7. Main hooks $G_1$, $G_2$
8. Knives $H_1$, $H_2$
9. Control bars $S_1$, $S_2$

The paper pattern is cut on a separate card cutting machine. The cylinder rotates every second pick to present two rows of holes representing two picks. Corresponding to these rows of holes, there are two rows of selection needles, one row of long needles controlling the top main hooks and the other row of short needles controlling the bottom main hooks.




A = Cylinder, B = Selection needle, C = Short hook, D = Knife, E = Needle, F = Lifting bar, G = Main hook, L = Main Knife

**Fig. 13.11 Dobby with Paper Pattern**

The lifting bars and the knives are driven by special cams. The lifting bars move up and down to lift or lower the main hooks. The movement of the bar is restricted to the time taken by the knife to pass under the hooks.

As soon as the knife moves in and the hooks are left free, the lifting bar moves down for the next selecting, and moves up again before the knife moves out with the lowered hooks. A control rod placed below the supplementary hooks lifts the selecting needles at the time of the cylinder movement to prevent the needles damaging the pattern paper.



### 13.5.1. Working of the Paper Dobby

As soon as the cylinder A brings the paper pattern under the selecting needles $B_1$, $B_2$, the needles are lowered on to the paper by the control rod S. A hole in the pattern paper allows the corresponding needle $B_1$ or $B_2$ drop into the cylinder hole and the corresponding hook $C_1$ or $C_2$ is lowered. Than the reciprocating knife $D_1$ or $D_2$ will pull the corresponding vertical needle $E_1$ or $E_2$ out of the path of its lifting bar $F_1$ or $F_2$, with the result that the main hook $G_1$ or $G_2$ is lowered to engage its knife $H_1$ or $H_2$. A blank in the paper will allow the corresponding lifting bar $F_1$ or $F_2$ to lift the main hook out of the path of its knife. The lifting or lowering of the jacks and heald frames is similar to that of the ordinary dobby.

## 13.6. POSITIVE DOBBY SHEDDING MOTION

As mentioned earlier, the characteristic of the **positive dobby** is that the movement of the heald frame in both directions follows the profile of a cam. The healds are usually pulled into the upper shed and pushed down into the lower shed. Unlike in negative dobby, springs or spring under motions are eliminated. The spring tension together with the weight of the healds must be overcome by the negative dobby in the lifting movement from the lower to the upper shed. It may be considerable and put in unfavourable load on the dobby where great spring tension is necessary to pull down the healds.

The higher loom speeds specially used for shuttleless weaving machines, make the movement downwards more important, as insufficient spring tension, together with warp tension resist the changing of the healds fast enough from the upper shed to be in lower shed in time. It may happen that due to insufficient force pulling downwards, the dobby runs ahead of the heald when changing from upper to the lower shed. These difficulties can be overcome by using positive dobbies.

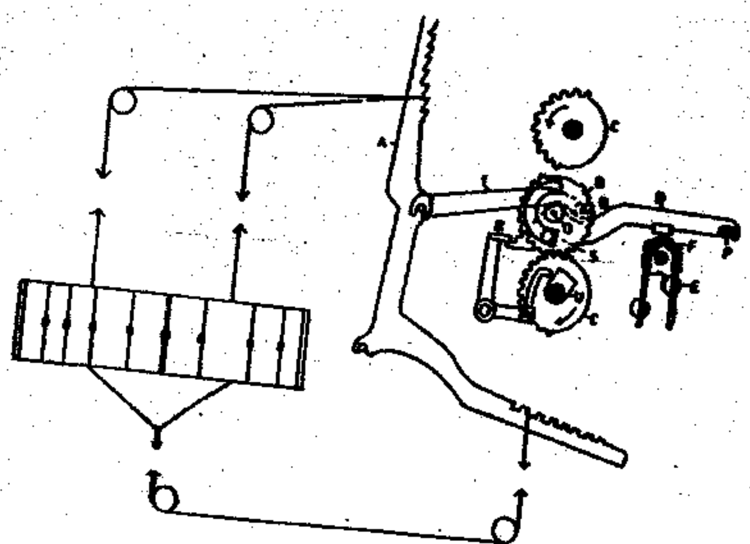
While choosing a positive dobby, it is not only the working speed which has to be considered, but the fabric to be produced. As a general rule, negative dobbies are for articles of light to low medium weight fabrics. High, medium and heavy fabrics and such fabrics requiring great warp tension are woven with a positive dobby. In borderless case, preference is given to the positive dobby.

### 13.6.1. Knowle's Positive Dobby

A simple diagram showing the essential working parts of the Knowle's positive dobby is shown in Fig. 13.12. It is a sectional view from the side and therefore only one heald connected to its jack lever is shown. However, there are 26 heald frames with 26 jack levers. This type of dobby is used for weaving heavy fabrics composed

of woollen and worsted yarns. The top of the heald frame is connec
to the top arm of the jack lever A and the bottom of the lower ar
Each jack lever is connected at the centre to a vibrator gear B
means of a connector T. Directly above and below the row of vibra
gears are two cylinder gears $C_1$ and $C_2$ that extend across the ent
dobby.

The cylinder gears have teeth cut on only half of th
circumferences, the other half being blank. They are driven in th
direction of the arrows, and rotate continuously making one revolutio
every pick. The vibrator gears B are made out of steel discs of 4.7
mm thick, with teeth cut to match those on the cylinder gears. Howev
the entire circumference of the vibrator gear is not covered wi
teeth. On one side a blank space of one tooth is left, and diametrica
opposite side a blank space of 3 teeth is left.



A = Jack liver, B = Vibrator gear, C = Cylinder gears, D = Vibrator liver, E = Pattern chain, F = Pattern cylinder, O = Pin, P = Heel pin, Q = Connector pin, R = Lock knife, S = Steadying, T = Vibrator connector

**Fig. 13.12 Knowle's Positive Dobby**

The vibrator gear turns freely on a pin O of the vibrator lever D which is fulcrumed on the heel pin P. This vibrator lever D which is resting on the pattern chain E which moves rounds on the pattern cylinder F.

The pattern chain consists of small rollers called risers and links called sinkers. When the chain moves along the pattern cylinder



either a riser or sinker, according to the lifting plan, is brought under the vibrator lever. There is one vibrator lever for every one jack lever. Therefore when the pattern chain is brought under the vibrator levers, there may be number of risers and sinkers in the whole width of the pattern chain, corresponding to the number of jack levers.

A riser lifts its corresponding vibrator lever and brings its vibrator gear in contact with the top cylinder gear which is constantly rotating. When the teeth of the two mesh together, which is made possible because of a missing tooth on the vibrator gear, the cylinder gear $C_1$ turns the vibrator gear B about half revolution, that is, until the blank space of 3 teeth, is brought on top. This movement of the vibrator gear causes the connector pin Q of the vibrator connector T to move from one dead centre to the other, with the result the corresponding heald frame is lifted. The vibrator gear continues to keep the heald frame raised as long as the rollers on the pattern chain, for each pick comes under the vibrator lever. As soon as a tube comes under it the vibrator lever will bring down its vibrator gear in contact with the bottom cylinder gear $C_2$ and again vibrator gear turns half a revolution, this time lowering the heald frame.

A steadying pin S which is part of the vibrator gear, moves in the semicircular slot of the vibrator gear and controls the extent of movement of the gear.

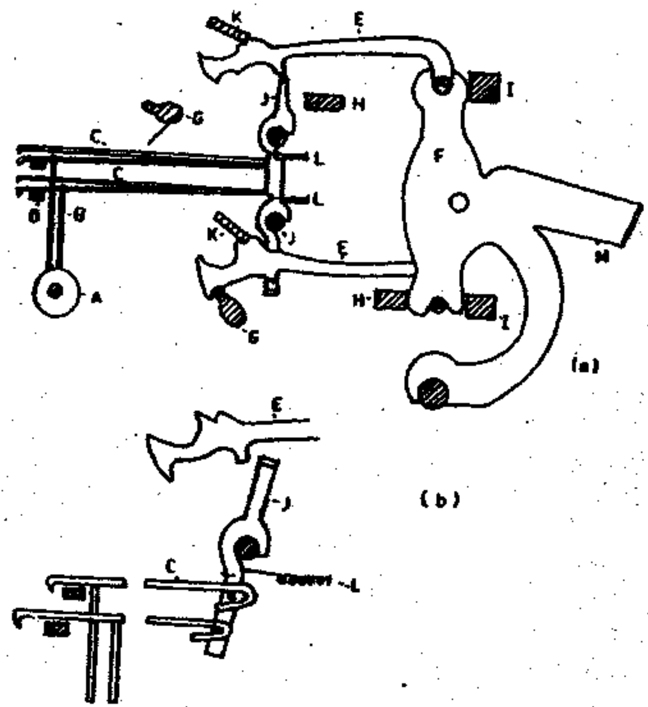
A lock kinfe R locks the vibrator levers in position while the corresponding vibrator gears are in motion. This prevents the vibrator from being forced out of contact with cylinder gears. However the lock knife is moved from contact when the pattern chain is about to bring a new pattern below the vibrator lever by means of a cam V fixed on the shaft of the bottom cylinder gear.

### 13.6.2. Staubli Positive Dobby

Staubli of Switzerland is one of the leading manufacturers of various types of dobbies. Most of the unconventional weaving machines like Sulzer-Ruti gripper and Somet rapier are fitted with Staubli dobbies having cam drive. This new model has revolutionized the earlier concept of hooks, draw lever and feelers. Instead of these parts, cams have been introduced with the result a 220 cm weaving machine can achieve a maximum speed of 360 r.p.m. and weft insertion rate of 1250 m per minute.

The important development in the Staubli positive dobby is the introduction of push bars connecting to the draw knives. During the backward movement of the draw knife when it returns after displacing a lowered hook, the corresponding baulk lever is pushed back by the push bar against its stop bar. The Staubli dobby shown in Fig. 13.13 has the following important parts.

1. Pattern Cylinder A
2. Feeler needles B
3. Traction needles C
4. Traction bar D
5. Main hook E
6. Baulk lever F
7. Jack M
8. Draw Knife G
9. Push bar H
10. Stop bar I
11. Returning lever J
12. Retaining Knives K
13. Traction Spring L



A = Pattern Cylinder, B = Feeler needles, C = Traction needles, D = Traction bar, E = Main hook, F = Baulk lever, G = Draw knife, H = Push bar, I = Stop bar, J = Returning lever, K = Retaining Knives, L = Traction spring

**Fig. 13.13 (a, b) Staubli Positive Dobby**

### 13.6.2.1. Working of Staubli positive dobby

A paper pattern is cut as per the lifting plan and placed on the cylinder. The cylinder rotates every second pick presenting two rows of holes representing two picks. Then the feeler needles are



lowered by a control rod (not shown in the diagram) and the selection takes place. The hole in the pattern paper drops the feeler needle down and its corresponding traction needle falls down in the path of the traction bar. Then the traction bar moves forward pulling the traction needle also forward. This causes the corresponding returning lever tilt back on its fulcrum as shown in the Fig. 13.12 so that the main hook held by it, fall down to engage its draw knife.

The draw knife and the push bar are connected together. When the draw knife carries the lowered hook forward the push bar also moves forward. This will enable the corresponding heald frame to lift. During the backward movement of the draw knife the hook is taken back to its original position and the push bar pushes the end of the baulk lever against its stop bar. As soon as the draw knife reaches the normal position it tilts to raise the lowered hook to be held by its returning lever. Then the retaining knife will engage the upper hook until the next selection takes place. Two extra feeler needles are provided for pick finding.

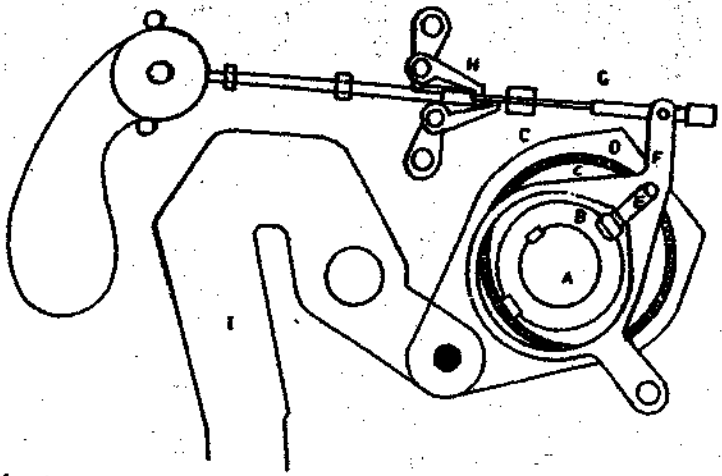
### 13.6.3. Rotary Dobby

As weft insertion rates of weaving machines are increased with the advent to high shuttleless weaving machines, there is a need for a dobby mechanism to match the speed of the weaving machines. This objective has been achieved with the development of dobbies operating on rotary principle.

The term rotary has been chosen because the straightline motion of the the healds is derived from rotating elements in the dobby.

**Cam unit :**

The cam unit consists of a heart shaped crank disc Fig. 13.14 which encloses the cam C mounted on a coupling ring B with ball bearings. Ring B is keyed to the main shaft A. One such cam unit is required for each heald and occupies a space of 12 mm. Each of these cam units designed as a building block is fitted with an indexing arm F which is connected with the radially displaceable switching key E. The latter engages in one of the two carrier grooves on the coupler ring B. The crank disc D is mounted in ball bearings in the cam, and its end is connected with the jack I through a needle bearing. When the key E is withdrawn from the groove, the transmission of movement from the main shaft A to the cam C is interrupted. The fact that the key E can be controlled, means that the cam C can be moved into its reverse position or halted by means of two reading mechanisms at the two dead points, depending on whether the heald is moved into the upper or lower shed position or should stop in one of these positions.




A = Main shaft, B = Coupling ring, C = Cam, D = Crank disc, E = Key, F = Indexing arm, G = Traction element, H = Puller, I = Jack

**Fig. 13.14 Rotary Dobby**

**Reading mechanism :**

The reading device is a very simple construction element which reads information off the pattern card and transmits it to the key F in the cam unit. The reading is effected by light spring pressure and does not damage the pattern cards. The upper horizontally placed feeler needles control forward direction of the dobby the lower ones correct sequence for **pick finding** when reversing the loom. The ends of the the feeler needles facing away from the pattern card glide in the spring operated traction elements G and control the pullers H which move forward and backward.

When the spring operated feeler needle finds a hole in the pattern card, its end moves within the reach of puller H, where upon the latter engages the traction element. In this way the key is controlled by the indexing arm. The key E, connects the cam and disconnects it for the rotating main shaft, the heald moves into the upper shed position or remain there as the case may be.

When a **feeler** needle touches a solid surface on the pattern card it rests on it with its end protruding beyond the reach of puller on the traction element. Thus the oscillating puller glides over its build ramps past the traction element and does not engage, so that neither the arm nor the key is moved. The harness then leaves the upper shed position or remain in the lower shed position as the case may be. The pullers are driven by complimentary cams in the driving block via oscillating bars. A worm gear on the main shaft enmeshed with an **indexing wheel** turns the pattern card cylinder.



It is clear that the positive coupling of the two elements with a key offers no problem at rest. The rotating motion of the main shaft A on the rotary dobby is therefore, controlled in such a way that the angular speed is zero the moment the key grooves in the ring B of the main shaft A reach a dead point of the cam C and the main shaft A remains in this coupled position until the key E has been reliably engaged or released.

The standstill position is the result of the kinematics of a so-called variable rotary gear. The function of this gear is to convert the drive motion of the main shaft in such a way that the heald frame moves with absolutely no vibration.

The variable rotary gear works on the super imposed speed principle. The constant initial speed obtained from the weaving machine is overlapped by a rotary generated in the gear itself. The initial rotary motion is the sum of the two movements. A rotary gear consists of a combination of toothed wheel and cam planetary gears. The toothed wheel gear comprises an inner toothed wheel and two gear segments which can carry out oscillatory motions round the fulcrum. The bearing pivots fixed to the roller N which is driven from the weaving machine, rotate uniformly. The toothed segments are equipped with two rolls which rotate about the periphery of the complementary cams, depending on the turning position give a fixed oscillating angular motion like a system of scales. The motion set up by the rotating movement round the complementary cams is in conjuction with the interlocking of the gear with inter toothed wheel superimposed on the actual speed of the weaving machine either positively or negatively. The resulting gear movement is the characteristic motion needed for the key switching and the movement of the heald frame.

Advantages of method, design and application of rotary dobbies are :

(a) The elements in the driving mechanisms e.g. shaft, ring, cam and crank are arranged concentrically round each other and positively connected. Where a relative motion is functionally required, precision ball bearings are used, to engage a movement which is free from play and to transmit the movement without vibration.

(b) The coupling of cam and main shaft is effected by a key which is specially designed to connect the two machine elements. Since the key itself is only under strain with shearing, a considerable rigidity is assured and wear is impossible.

(c) For the production of flat woven fabrics, the advantages of the rotary dobby are smooth operation at high speeds.

(d) In the production of pile fabrics, extremely high shifting forces are set up by the increased shed lift needed for the formation of two sheds simultaneously one above the other. The **three position dobby** is used for this purpose.

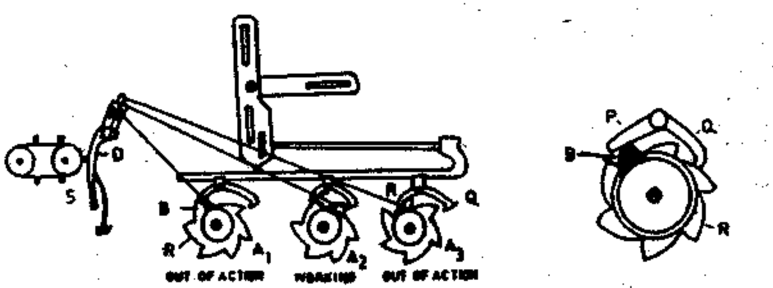
## 13.7 CROSS BORDER DOBBY

Cross border dobby is used when two or three different weaves are required to be woven for the same number of heald frames and drawing order. For example, in towel headings, or bordered handkerchieves or serviettes, two different weaves are required, one for the body and the other for the cross border. Such an arrangement is possible by providing additional one, two or even three pattern cylinders and changing them automatically. When one pattern cylinder is in operation the others are put out of action. In each case there is an extra cylinder used for making the change from one lag of cylinder to another with older types of cross border dobbies; the cylinders are bodily moved in and out of contact with the feelers to make them operative and inoperative respectively. This type of cross border dobbies have the disadvantage of wear and tear of moving parts. In recent types of cross border dobby e.g. Climax or Yamada, the rocking shaft is dispensed with and the lattice barrel works in fixed bearings.

### 13.7.1 Climax Cross Border Dobby

The **Climax cross border dobby**, illustrated in Fig. 13.15 changes the pattern cylinders automatically. When the repeat of a particular pattern is completed the pattern cylinder is given a part turn, enabling the lattice pegs clear of the feelers. At the same time the other cylinder is brought into action automatically by a selection cylinder.

In the illustration three pattern cylinders $A_1$, $A_2$, $A_3$ and one selection cylinder S are shown. Each cylinder is operated by a pushing pawl P and a pulling catch Q. Both of them are mounted on the same stud. The selection cylinder is turned by the action of the last jack of the dobby, while the jack itself is put into action by a peg or the working pattern lattice after completing the required repeat.




$A_1, A_2, A_3$ = Pattern Cylinders, B = Cam, D = Finger lever, P = Pushing Pawl, Q = Pulling catch, R = Ratchet wheel, S = Selection Cylinder.

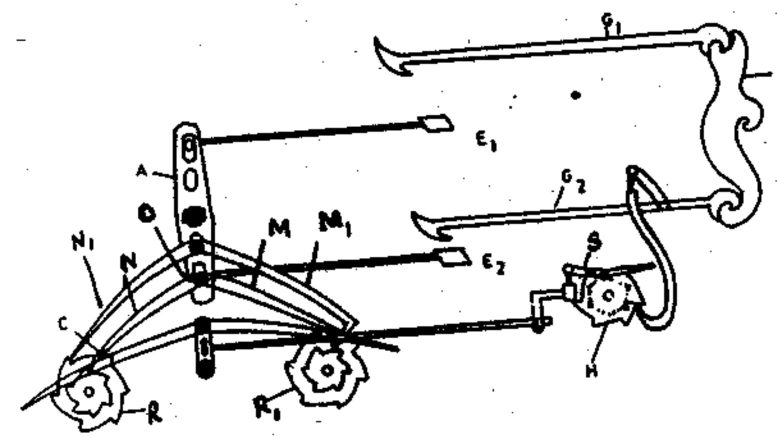
**Fig. 13.15 Climax Cross Border Dobby**



Each pattern cylinder is coupled with a cam B which is connected by a link to the finger lever D. There are three finger levers corresponding to three pattern cylinders. These finger levers are operated by a selection pattern mounted on the selection cylinder S. A blank in the selection lag lowers the cam B and puts its cylinder out of action by lifting the pushing pawl P clear of the ratchet wheel R. When the pushing pawl P is lifted, the pulling catch Q drops into gear with the ratchet wheel R and turns the cylinder through half a tooth movement making the pegs inoperative. The oscillating motion of the pushing pawls and pulling catches, is derived from the bar E which is connected to the rod F and T-lever G.

### 13.7.2 Yamada Two Cylinder Cross Border Dobby

**Yamada cross border dobby** with two lag cylinders and a selection cylinder works with the cylinders in a set position. In this case a chain of lattices has been rendered inoperative by stopping a lattice barrel with the space between the two lattices directly opposite the feelers. As shown in Fig. 13.16 working cylinder is provided with two ratchet wheels R, $R_1$ each having six teeth. One of the cylinders is driven by pushing pawls M and $M_1$ and other is provided with pulling pawls N and $N_1$. This pawls M and N are mounted on the same stud O fixed at the bottom of I lever A. These pawls give one sixth of the revolution after each alternate picks, one



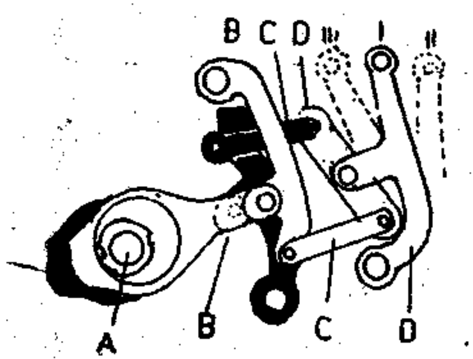

A = I lever, C = Position, D = Pattern Cylinder, $E_1$ = Top knife, $E_2$ = Bottom Knife, F = Baulk lever, $G_1$ = Top hook, $G_2$ = Bottom hook, H = Pilot Cylinder, O = Stud, S = Lever, M, $M_1$ = Pushing Pawls, N, $N_1$ = Pulling Pawls, R, $R_1$ = Ratchet wheel

**Fig. 13.16 Two Cylinder cross Border Dobby**

of two pawls M and N is lifted out to make corresponding cylinder inactive and the other is in operation. The pawls $M_1$ and $N_1$ are mounted in between fulcrum and I, P and stud O to give one twelveth rotation of the cylinder. The projections C of two pawls M and N are resting on curved lever. When the curved lever is partially rotated in clockwise direction, it lifts the pulling pawls up and its anticlockwise movement lifts the pushing pawl up. The rotational movement of the curved lever is controlled from selection lattice through levers S and connecting rod. When a peg of the selection lattice mountain on pilot cylinder H is acting on the lever S the curved lever moves in a clockwise direction. When there is a flat lag, then the lever rotates in an anticlockwise direction. The selection cylinder is driven by a rotated wheel and a pawl from a rocking lever controlled by the first bottom hook of the dobby. H is moved forward one lattice at the end of the repeat of a pattern, but whether change of pattern takes place or not depends on whether the lattice brought under the lever S differs from its predecessor or not. For example, in order to make a change, a flat lattice is followed by a pegged lattice or the selection cylinder. This will move the curved lever in the clockwise direction to pull the pulling pawl M out of contact of its ratchet wheel and bring the pulling catch N in contact with its ratchet wheel. The cylinder 2 will then be pushed to an inoperative position by its pawl $M_1$, the pawl $M_1$ then rides on its corresponding ratchet wheel $R_1$ or the same tooth as long as the cylinder 2 remain inoperative. Simultaneously with the pawl N will be in contact with the ratchet wheel R, N comply its stroke and places the first lattice of the pattern on the cylinder A into working position.

In this way any number of repeats can be made from any pattern and a change can be easily made from one to other.

## 13.8 THREE POSITION DEVICE




A = Double Cam unit, B = Rocker arm, C = Connecting Plate, D = Torsion Lever, E = Jack

**Fig. 13.17 Three Position Dobby**



The principle of working of three position device is described with reference to Fig. 13.17. The device needed for the production of double pile fabrics is based on the system of two independent heald motion units which by means of a different lever, operate a single heald. The three position device has an accumulating gear onto which the movements of two cam units (A) are transmitted and combined into a single motion. This is effected by a special configuration of segments rocker arms B, connecting plates C and the torsion balance D. This combined motion is transferred to the three position lever, which can assume positions I, II or III. The heald frame is moved into these positions by the heald frame motion. With this design, the bearing points are subjected to relatively little strain. This factor, together with the smooth operation of the cam motion, results in the wear and tear so common in pile weaving, considerably reduced.

## 13.9 PICK-FINDING DEVICES FOR DOBBIES

Errors in weaving can have many causes, often they are due to broken weft threads. If possible such errors should be corrected by the weaving personnel in order to have faultless fabrics leaving the weaving machine. It is of importance that such mistakes may be corrected in the shortest possible time in which the loom must stand still. Devices enabling a quick correction of such errors can influence the number of looms operated per person.

In order to correct an error due to broken weft threads, it is usually necessary to follow the weaving process backward upto the point where the error occured, so that the weaving process may be continued without fault.

Bascially this operation may be carried out in various ways.

(a) The loom is turned back (by hand or with the appropriately steered weaving machine motor).

(b) The pattern card of the dobby is turned 2 picks back by hand and loom is then turned one pick forward.

(c) The shed forming device-the dobby has a pick-finding device by which it may be turned backward, the picking, beat-up and take-up motions remaining inoperative during the reversing operation of shedding mechanism.

## 13.10 DOBBY MOUNTINGS

Keighley dobbies are placed at the top of weaving machines. Disadvantages are :

(i) Chances of oil drops may fall on the warp thus staining the warp.

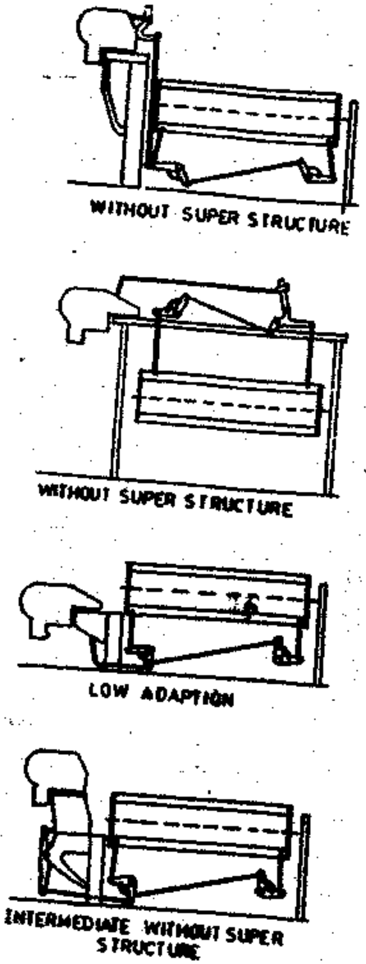



**Fig. 13.18 Mountings of Dobby**

(ii) Not easily accessible to dobby for repairing purpose.

(iii) Obstruction of light.

Cam dobbies are mounted at the sides above the heald shafts with super structure. This permits a better supervision and overcomes the disadvantages of the Keighley dobby. On the other hand, positive dobbies are mounted at high position, low position or semi-high position (Fig. 13.18) depending upon the various areas of application.

**REFERENCE**

1. Staubli Bulletin, Private Circulation



# 14 JACQUARD SHEDDING

## 14.1 FUNCTION

Most of the fabrics are used for domestic and industrial purposes, but some of the fabrics have decorative uses. A **fabric** may be ornamented by (i) **embroidering,** (ii) **printing,** or (iii) **figured weaving.** In the first two cases the fabric is first manufactured and ornamentation is done subsequently but in the case of figured weaving the cloth is ornamented simultaneously with its production. Dobbies can be suitably used for the production of the designs in which a pattern of interlacement of threads repeats on 32 to 40 heald-shafts. Even this number is unusual and only feasible with special dobbies. A dobby shedding cannot be used suitably for producing beautiful and intricate ornamental designs in forms and colours, in which a large number of warp threads are required to be controlled individually and in such cases a **jacquard shedding** appliance is employed.

The expression **jacquard loom** which is frequently used, is a misnomer since the term jacquard applies to the sheding mechanism only which can be mounted on almost any loom by making a few alterations. There is no **heald-shaft harness** as is used in tapped or dobby shedding mechanism but instead a thread harness is used. Every warp thread in one repeat of a jacquard design is controlled individually and may be raised, lowered or kept at a desired position at will, during weaving. One repeat of a jacquard may be woven to cover the full width of the cloth but smaller repeats, each measuring 20 to 30 cm in width are used more frequently. All fancy or figured fabrics such as silk or cotton **brocades, damasks, toilet quilts, extra-warp** or **extra-weft** figured fabrics, figured equal or unequal **double cloths, Madras muslin, swivel fabrics,** leno brocades, **tapestries** etc. require the jacquard shedding mechanism to weave them on the loom. A number of weaves may be used in combination to produce a Jacquard design with the desired effects. Jacquard weaving is, however, an expensive form of weaving as it is accompanied with designing, card cutting, lacing and all other jobs associated with. The speed of the loom with jacquard shedding mechanism is also lower than that of a similar loom with dobby or tappet shedding.

The jacquard loom consists of two parts - the **loom** and the **jacquard.** The loom is bolted to the flooring and jacquard is suspended from the ceiling resting on heavy beams. The two are connected by a series of cords known as **harness.** Jacquard shedding is a piece of mechanism for selecting and lifting or lowering a group of ends in a repeat individually for each shed. It is a negative type of shedding, the lifting of the ends being done by hooks and lowering is done by dead weights, suspended from the harness, termed as lingoes. Jacquard machines are simply a frame containing a number of wire hooks and needles. The hooks formed at the end of the vertical wires can be allowed to remain over to be pushed away from a lifting griffe by the presence of absence of holes in paper cards that is pressed against the needles by a perforated cylinder. The cards tied together in a set, revolve around the cylinder of a jacquard. When these cards engage the needles that control the harness strings through the mails of which are drawn the warp threads of the cloth, they move up or down the warp threads. These hooks can be raised in any required number or order corresponding to the warp threads to be raised for the passage of the shuttle. Those desired up are revealed on the cloth and those not wanted just at that point are suppressed and concealed in back of the fabric. The shuttle flying across, binds the weft yarn with the warp threads and completes the weaving. After the shuttle has been passed through the shed the hooks are lowered to their former or normal position and a fresh selection is made for the next throw of the shuttle. The griffe is operated by a suitable mechanism at every insertion of the pick in the fabric.

## 14.2 TYPES OF JACQUARDS

Jacquard machines used at the present time are numerous and varied. However, they may be broadly divided into two groups: ordinary and special.

Ordinary jacquards may be further classified on the basis of the type of the shed formation achieved.

(i) **Bottom closed shed** type with single lift, single cylinder.
(ii) **Centre closed shed** type.
(iii) **Semi-open shed type** like double lift, single cylinder on double lift, double cylinder.
(iv) **Open shed type.**

Special jacquards are modification of the ordinary ones. These are designed to increase the figuring capacity of the jacquard or to weave special types of fabrics. Some of the special jacquards are listed below :.

(i) Cross border jacquard,
(ii) Leno jacquard,
(iii) Scale-harness or Banister jacquard,
(iv) Pressure harness jacquard,
(v) Twilling jacquard,
(vi) Inverted hook jacquard,
(vii) Jacquard with working comber boards,
(viii) Fine pitch jacquards.

In the present treatise only the ordinary jacquards are dealt in detail.



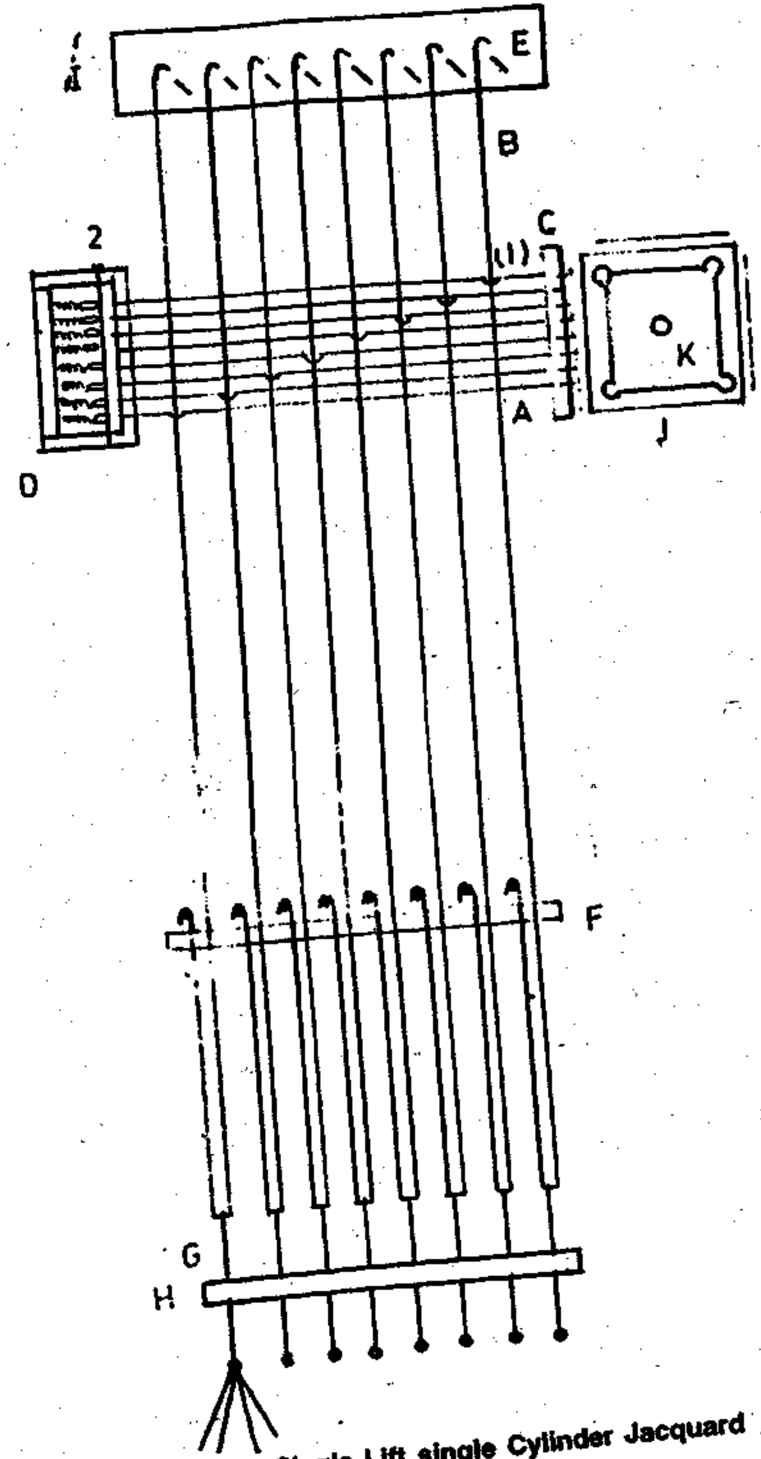



Fig. 14.1 Single Lift single Cylinder Jacquard

## 14.3 PRINCIPAL PARTS OF THE JACQUARD MACHINE

A jacquard machine consists of three different parts :

(1) An engine i.e. shedding motion (2) Harness, and (3) A mechanism which connects the engine to the loom.

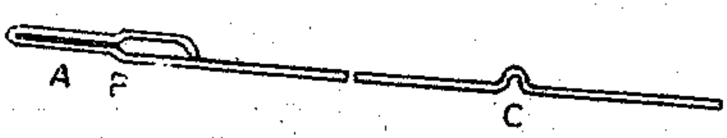
A single lift, single cylinder machine shown in Fig. 14.1 is still a representative of the original invention and uncharged in most of its main feature. Hence, a study of the Fig. 14.1 will make the reader familiar with most of the parts of any jacquard.

### 14.3.1 Engine

This part of the machine contains the mechanism by which the warp threads are selected and lifted to form the top shed line. Main parts of the engine are needles, needle board, spring box, hooks, griffe, cylinder and card chain.

#### 14.3.1.1 Needles

In Fig. 14.1, A are the **needles** while a single needle in a plan view is shown in Fig. 14.2. A needle is bent at point (A) horizontally out of a straight line. Vertical hooks B pass through the looped portion of the needles. Fig. 14.1 represents the sectional cut of one cross or in the jacquard machine containing 8 hooks. The needles rest with their heads in the needle-board C, the needles extending outside the needle board towards the cylinder by about 4 mm. The rear part of the needle – a loop – passes in the spring-box D. Eight different positions of the distance of the bent portion of the needle will be required by an 8-row machine. The top row has a bent portion nearer the needle–board C and the bottom row has a bent portion nearer to the spring-box D. Arrangement of eight needles in a vertical row is a common one but in some machines there are four, or ten or twelve or sixteen needles in a short row. Usually the top needle controls the hook nearest to the cylinder and the bottom needle controls the hook farthest from the cylinder. In a single lift jacquard, the **figuring capacity** of the jacquard is equal to the number of needles or the number of hooks the machine contains. A needle carries at its rear end small light helical spring contained in the spring-box. The needles are constantly pushed towards the cylinder by these springs. If the needles are not pushed backwards towards




A = Eye, B = Shoulder, C = Curve

**Fig. 14.2 Jacquard Needle**



the spring-box, the upper crooks of the hooks will remain in position, as in the figure, over the **griffe-bar** E, and raising the latter will raise every one of these hooks; but when the heads of the needles are pushed backwards, the hooks are also moved out of the way of the rising griffe-bars, thus causing an empty lift when they are raised.

#### 14.3.1.2 Spring-box

As mentioned earlier,the rear part of the needle, a loop, is passed in the spring-box and the loop permits a flat wire or a pin (2) to be inserted which holds the needle in position. One pin is required for each vertical row of the needles. A brass spiral spring is securely held on one end by the wider part of the loop and on the other end by the pin inserted in the loop. Pressing the needle at the head compresses the spring and removal of the pressure at the head of the needle will bring the spring to its natural position, pushing the needle to its original place.

#### 14.3.1.3 Needle-board

It is a wooden board perforated with holes corresponding the number of needles and it serves as a guide for the needles to be presented to the cylinder.

#### 14.3.1.4 Hooks

The vertical wires B are turned over at the top to from a hook for which reason they are called **hooks** of the jacquards machine. The top protion of the hook in its upright position, is over the **griffe-bar** or **knife** E. As the hook passes through the bent portion of the needle, it can be taken away from the knife if the needle is pressed back. The hooks are doubled at the base and turned upwards for about one third of their lengths. This double end is passed through a narrow slot in the **grate** F. The end of the double wire also forms a hook which normally rests on the semicircular ribs. The double wire portion combined with the cross wire in the grate F effectively prevents the hook from twisting around. At the bottom portion of the double wire of the hook, short but strong cords G known as **neck cords** are looped and are subsequently passed through the perforations of the **tug board** H. Thus when a hook is raised a neck cord is also lifted up along with it. In a single lift jacquard, there are as many hooks as the number of hooks to that of the needles.

#### 14.3.1.5 Griffe

The knives E are made of strong hoop iron and these horizontal knives (or griffe-bars) are contained in the iron frame called the **griffe on head** I. The griffe I with the knives is operated to rise and fall in a vertical plane. There are as many knives in a jacquard as there are hooks in the short row. Every knife is fitted close to the hook but is not allowed to press against them. The sides of the knives facing the hooks are levelled off. This is to avoid the striking the top of the hooks, that are kept down, by the decending knives. Since the upper crooks of the hooks are made to occupy such a position that they will be caught by the knives, the hooks and consequently the harness lines are lifted up when the griffe moves up.

**14.3.1.6 Cylinder**

The perforated cards are laced to form and endless chain over a four sided wooden prism called a **cylinder** J. (Though called a cylinder, it is not circular in its cross-section). It is made of very hard and well seasoned wood to prevent any tendancy to subsequent warping in the humid atmosphere of the weaving department. Each face of the cylinder is perforated to correspond with the number and arrangement of the needles in the machine. The tapering wooden pegs are driven into every face, midway between the cylinder edges. These pegs help in drawing forward and holding each card in turn, with its holes over those in the cylinder. Two flat springs on the outer and two wire springs on the inner faces of the cylinder assist the pegs to hold the cards in position during operation. The function of the card cylinder is to present on jacquard cards to the needles, one at a time. A metal supporting end called **lantern K** is fixed on each end of the cyliner. The cylinder is supported by gudgeons, their bearigs being in a frame that moves horizontally. The cylinder is given two types of motions : (i) to-and fro motion, and (ii) rotary motion to the extent of one fourth revolution.

Resting on the lantern of the cylinder is an inverted T-shaped hammer. A strong spiral spring keeps the hammer in contact with the iron part of the cylinder.

**14.3.1.7 Pattern on Jacquard Cards**

The cards are laced together to form an endless chain of pattern cards. Circular holes are punched in the cards to correspond with the warp threads that are required to be raised for designing purpose. The holes and blanks in the card serve the same purpose as pegs and empty spaced in a peg-lattice of a dobby. Jacquard cards are made of cardboard and their function is to control the needles. One card with all the holes punched out is shown in Fig. 14.3. The large holes at each end of the card are 'per holes'. The small metal pegs provided on the cylinder pass through these holes to hold the card in its exact position on the cylinder during Jacquard operation. The small holes at each corner of the card are **lace holes.** The two holes in the centre are also lace holes. The centre lace holes are punched if the card length demands strengthening at the centre. Lace holes are used for lacing the cards into a long continuous



**Fig. 14.3 Fully Punched Card**

pattern chain. One card acts for one pick only and therefore as many cards are required to be cut as there are picks in one repeat of the woven design. At each insertion of a pick, a new card is presented to the needle board by the cylinder and the card determines the hooks to be raised or lowered forming top or bottom warp shed lines respectively. By turning the card cylinder one-quarter revolution as it moves out away from the needles, succeeding cards will be brought in for presentation to the needle board.

The cards are used in three main pitches, viz. **English** or **Coarse** Pitch, **Verdol** or **Standard** Pitch and **Vincenzi** or **Fine** Pitch. The English Pitch used a fairly larger hole and larger card than the Verdol or Vincenzi. Vincenzi or the endless paper has the smallest holes of all and the card area is also the smallest for the same number of needles. Usually the modern trend is to use English pitch for jacquard upto 600 needles. A standard card for a 400-needle machine measures about 6 cm in width and 40 cm in length. 100 such cards weigh about 1.5 kg.

**14.3.1.8 Card Cradle**

When a large number of cards is to be worked on the machine, the entire weight of the cards will have to be borne by the Jacquard machine. A long endless chain of cards suspended above will also obstruct the working and vision of the loom parts. It is also necessary to keep the bulk of the cards in a convenient position so that they may be taken up by the cylinder in a proper sequence. In order to achieve all these functions, a **card-cradle** is provided below the iron on steel girders on which the jacquard machine is mounted. Wires, slightly longer than the length of the cards, are attached to the set of cards at regular intervals of say 12, 16, 20 or 24 cards. A card cradle consists of two curved iron rods kept at a distance slightly in excess of the length of the cards. When the attached wire reaches these curved rods, its ends rest on them thereby supporting the cards.

**14.3.2 Harness**

One line of harness with all its attachments is shown in Fig. 14.4. A neck cord B is attached to the base of each hook A. The


Fig. 14.4 Harness Line

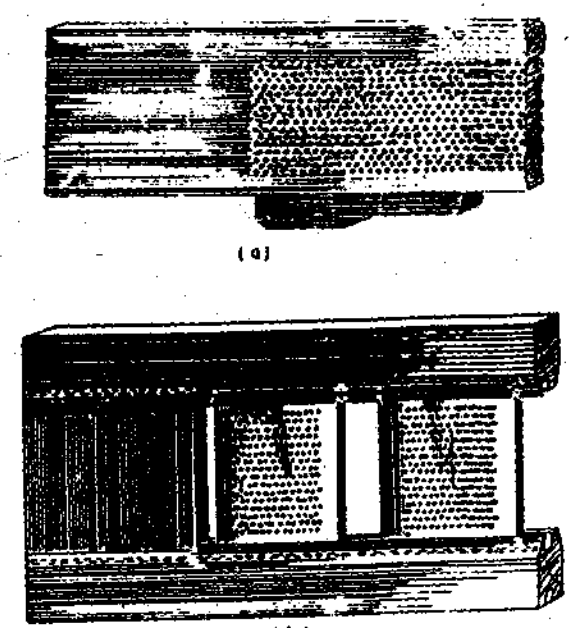
neck cords are sometimes threaded through the holes in the tug or **bottom board**. The **harness cords** C are connected to the neck cords B and are passed separately through the holes of the **comber board** D, extending across the loom. There are as many harness lines attached to each neck cord as there are repeats in the width of fabric being woven. For example, if a repeat of a design completes on say, 400 ends and if there are 2400 ends in the warp in the reed it means 6 repeats in the width of the cloth. Each hook of the jacquard will threrefore control 6 harness cords and 6 corresponding warp threads. All the harness cords are stitched in one bunch so that all are raised or lowered simultaneously. The harness cords support the **coupling** which consist of a **top coupling** E, **bottom coupling** G, **mail eye** T, and **lingo** H. The end I is the drawn individually through each mail.



**14.3.2.1 Comber board**

The comber boards are made of a close grained wood such as beech, maple, persimmon or dogwood. It is seasoned to resist bending and splitting. It is a long perforated board extending the width of the loom. The object of the comber board is to spread the harness cords uniformly. It also determines the density of ends in the cloth. The reed number should correspond to the number of holes per unit length in the comber board. The number of holes in the width of the comber board is generally the same as the number of needles in the short row of the jacquard. The number of holes in length direction of the comber board depends on the density of the ends in the cloth being woven. For example, if the jacquard machine contain 8 needles in the short row, there will be 8 holes in the short row of holes in the comber board while if the reed contains 96 ends per inch (2.54 cm), there will be 12 holes in each inch of the long row thus giving in total 96 holes per inch in the comber board lengthwise. Once a comber board is drilled and threaded, the width of the fabric and the width of the repeat is determined. The threads per unit width may be decreased but never increased. This is one of the restrictions of the jacquard weaving.

There are mainly two types of comber boards used in the industry, (i) solid comber board, and (ii) slip comber board.



(a)

(b)

Fig. 14.5 (a) Solid Comber Board, (b) Slip Comber Board

#### 14.3.2.2 Solid comber board

Fig. 14.5 (a) shows a portion of a solid comber board. It about 20 to 25 cm thick 150 mm wide and long enough to occu the width of the loom. Small holes are pierced through the wood rows. It is necessary to take care not to have the comber board to deep, as the result would be a formation of a bad shed.

The solid comber boards have some disadvantages :

1. The texture cannot be reduced without **casting out** of th hooks. This is not very convenient to do.
2. As the thickness of the solid comber board is about 20 t 25 mm there is friction as the harness line rubs when movin up or down through the board.
3. With wide looms there is a tendency for the board to sa in the middle.

#### 14.3.2.3 Slip comber board

It consist of small sections of wood or strips of wood about 3 to 80 mm in width and about 8 to 10 mm thick. Fig. 14.5 (b) show such a comber board in part. These small sections are also pierce with holes as in the case of the solid comber board. The advantag of the slip board is that the outer strips which wear out more rapidl than those in the centre can be renewed without discarding th whole comber board as is the case with the solid comber board. Th width of the harness can also be increased to a certain extent b inserting thin wooden strips in between the sections. Similarly, the density of ends in the cloth can be reduced slightly without altering the number of hooks to be used in weaving the design.

Slips are of the greatest advantage for the bordered fabrics which are sometimes required to be woven in different width from the same pattern. The number of body repeats can be varied at pleasure by adding or removing the slips.

#### 14.3.2.4 Coupling

The **coupling** of a jacquard harness of all parts below the harness cords. It consists of a top loop, a mail, a bottom loop and a lingoe. The top and bottom loop may be of linen twine. Use of steel healds instead of twine coupling has been a common practice in recent times. It is a flat steel strip, about 35 cm in length with an eye punched at the centre. It is similar to the flat steel head wires used for looms. The mail is made either of brass, steel, glass or galvanised iron. The advent of the inserted eye-wire heald during the early twenties was undoubtedly a greater step forward in harness construction. The inserted eye wire heald with its smooth surface and long wear life came into its own.



#### 14.3.2.5 Lingo

A **'lingo'** or a **'lead'** is dead weight suspended from the end of the bottom loop of the coupling to keep the harness pulled down when not required to be raised. It is cylindrical or flattened wire and punched at one end to receive the lower portion of the coupling. Its length varies from 16 mm to 50 cm and weight depends chiefly on the count of yarn and number of ends per centimeter, the coarse the yarn more the number of threads, heavier should be the lingoes. In wider width loom it is advisable to use heavier lingoes at the sides, owing to the increased friction. For ordinary cotton goods lingoes weigh about 45 to 65 per kilogram. Recent trend is to cover the lingoes with enamel or by electroplating or galvanising to prevent rusting. The length of the bottom coupling should be about 15-25 cm so that it should not carry the lingoes amongst the warp. Lingoes are designated by a number which indicates the number of lingoes per lb. For example, a number 10 lingoe means 10 lingoes weight one pound (454 g).

### 14.3.3 Mechanism which Connects the Engine to the Loom

A jacquard is installed on a support over the loom in many ways. The support is known as **gantry**. It is made of steel or wooden beams carried on columns resting on the ground or hung from the ceiling. The best height for a jacquard is generally decided by the width of the warp in the reed. Table 14.1 gives a general idea of the height of the jacquard over the loom, though circumstances may not always permit the ideal height to be used.

**Table 14.1 Height of a Jacquard over a Loom**

| Reed space in cm. | Height required from the warp line to the bottom of hooks in cm. |
|---|---|
| 250 | 250 |
| 225 | 225 |
| 180 | 210 |
| 135 | 200 |
| 105 | 180 |
| 70 | 165 |

Jacquard are usually driven from the loom shaft by means of rods and levers. Modern driving motions are either by steel roller chains with machine cut wheels or by a vertical revolving shaft with a bevel and bevel wheel drive.

In jacquard shedding two drives are essential :

(1) To drive the griffe in a vertical plane so as to operate the hooks and

(2) To drive the cylinder.

The cylinder in its turn, needs two types of drives :

(a) Cylinder with its cards facing the needle board should move towards the needles to accomplish the selection of hooks as per design and after the selection is over, the cylinder should move away from the needle board so that it should be turned through a quarter turn to present another card when it moves into the needle board next time. This is to-and-from motion of the cylinder.

(b) When the cylinder moves out, it should get a quarter turn, as mentioned above to present the next card in the series. This is a rotary motion of the cylinder.

There are many ways in which the above motions and drives are obtained which one can easily study on machine with which he has to work.

## 14.4 SIZES AND FIGURING CAPACITIES OF JACQUARDS

Jacquards are usually built in standard sizes. It is necessary to decide the pattern and type of cloth to be woven, before ordering a jacquard. As mentioned earlier, there are three main pitches : coarse, standard and fine. The size and the figuring capacity of a jacquard is also standardised to a certain extent. Table 14.2 indicates the size and the figuring capacity of different jacquards.

Table 14.2 Size and Figuring Capacity of Jacquard

| Size of the machine | Hooks in a short row | Hooks in a long row | Total hooks |
|---|---|---|---|
| 100 | 4 | 26 | 104 |
| 200 | 8 | 26 | 208 |
| 300 | 8 | 38 | 304 |
| 400 | 8 | 51 or 52 | 408 or 416 |
| 500 | 10 | 51 | 510 |
| 600 | 12 | 51 or 52 | 612 or 624 |
| 800 | 12 | 70 | 840 |
| 900 | 12 | 72 | 924 |
| 1000 | 10 | 100 | 1000 |
| 1200 | 12 | 104 | 1248 |

Usually one row of hooks is intended to be used in operating the selvedge threads of the cloth. 300, 400 and 600 are the most common sizes used. Large machines are obtained by placing two smaller machines.

Verdol machines are made with 16 hooks in each short row. The machines are made in multiples of 112 hooks, the common sizes being 448, 896, 1344 and 1792.



Vincenzi types are also arranged with 16 hooks in each short row and is generally available in sizes 440, 880, 1320 1760 and 2640.

## 14.5 TYPES OF SHEDS IN JACQUARDS SHEDDING

Before going in details about the working of various ordinary jacquards it is necessary to know the types of sheds formed in jacquard shedding.

There are two main principles of warp shedding :

(1) Closed, and (2) Open.

Closed shedding is one in which all the warp threads are borught to the same level after insertion of each pick, irrespective of the position which the warp threads may occupy on the succeeding picks. The closed shed may be formed in two ways : (i) **bottom closed**, or (ii) **centre closed**. For details refer chapter 2.

In the bottom closed shedding, the mails of the harness in their normal position coincide with the lower division line of the warp threads. After insertion of each pick all threads remain at the bottom line of the shed before the next selection of threads take place.

In the centre closed shedding, the position of all the warp threads is a straight line drawn from the surface of the breast beam to that of the warp rail. All warp threads meet at the centre of the shed before the next selection of the threads occurs.

Open shedding is one in which the warp threads remain in their top or bottom position in the shed for as many picks as the pattern desires. The threads required to be lowered down from the top shed line are depressed and those required to be raised from the bottom line are lifted after every pick. A variation of open shedding is a semi-open shedding in which the bottom shed line is permanently stationary, but part of those threads which form the top shed line and which should remain stationary in their top position for as many picks as the pattern indicates, descend a little and are subsequently raised to the top position. The threads which are required to change for new picks pass directly from bottom to top or vice versa.

## 14.6 SINGLE LIFT SINGLE CYLINDER JACQUARD

This is the original and the simplest type of Jacquard. It works on bottom closed shed type of shedding mechanism. The details of the machine are already shown in the Fig. 14.1. During the cycle of operation, one of the faces of the cylinder together with a card is brought against the needle board. If a hole is punched in the card the corresponding needle will project through in the cylinder and the hook controlled by that needle will remain in such a position that its upper hooked end will be caught by the rising griffe blade. The unpunched portion of the card will press back the needle and consequently the hook controlled by that needle will be away from the path of the rising griffe-blades. Thus, a selection of the hooks and hence the connected or controlled by these hooks will be according to the design cut for a particular card.

When the hooks are lifted by the griffe-blades, the cylinder moves out a limited distance when a catch holds it against the top corner of the cylinder and the cylinder is turned about its axis and a new card is presented to the needles during its next cycle. By this time the griffe along with its knives descend to lower the warp threads to the bottom shed line for a fresh selection of the hooks for the insertion of the next pick and this cycle of operation continues. As only one hook is used to raise or lower one neck cord it is called a **single lift machine.** It has only one cylinder to present the endless chain of cards and hence the name single-cylinder, and as all the warp threads are brought to the level at the bottom shed line it is a bottom closed shed type of jacquard.

### 14.6.1 Characteristics of Single Lift, Single Cylinder Jacquard

As single lift jacquard works on a bottom closed shed principle all the warp threads are required to be brought to a level at the bottom of the shed on every pick, even though some of the threads are required to be in the top shed line for two or more consecutive picks. In other words, such threads have to move twice the depth of the shed at every pick. This means an unnecessary movement is given to some of the warp threads and thus a great strain is also put on them. Because of the formation of closed shed, the speed of picking is restricted to about 120 per minute. It is therefore uneconomical to run this jacquard compared to semi-open or open shed jacquard. (The speed of 120 picks per minute is for a jacquard loom having reed space of about 100 cm). This jacquard is therefore not in common use at present except for very special fabrics.

It has however, a limited use for the manufacture of special fabrics like leno, and silk brocade in which for other reasons, quick running of the loom is not advisable. They are also found suitable for some carpet manufacturing. Single lift bottom closed jacquard can conveniently be fitted to handlooms which run at a very slow speed. As beating up takes place in this jacquard in a closed shed, a relatively softer feel is obtained in the woven fabric which may be considered as an advantage.

## 14.7 DOUBLE LIFT, SINGLE CYLINDER JACQUARD

As the single lift jacquard machine works on the bottom closed shed principle, its speed is limited to about 120 picks per minute. In order to obtain a higher production but at the same time to reduce the speed of the operating parts of the jacquard and therefore, to



reduce their wear and tear, a double lift machine was developed. A double lift machine is one in which a single end or neck cord can be lifted up by any one of the two lifting hooks. The double lift machine works on the semi-open shed principle described earlier. In a double lift machine, therfore, all the threads are not brought to a level before the formation of every shed. If the same warp threads are to be kept up for two or more consecutive picks, the distance travelled by the desired warp threads is reduced considerably compared to that travelled by the warp threads in a single lift jacquard. These threads move down upto half the depth of the shed and are then raised up while the threads from the bottom shed line. (In a single lift jacquard the distance through which the warp thread have to move is two times the depth of the shed even if the same warp threads are required to be kept up on two or more consecutive picks). The speed of the double lift machine can be increased to about 180 to 200 picks per minute because of the semi-open shed type of shedding. This double lift machine was introduced in 1854 by John and William Grossely. The introduction of double lift machine is a great stride in jacquard weaving.

### 14.7.1 Working Parts and Mechanism

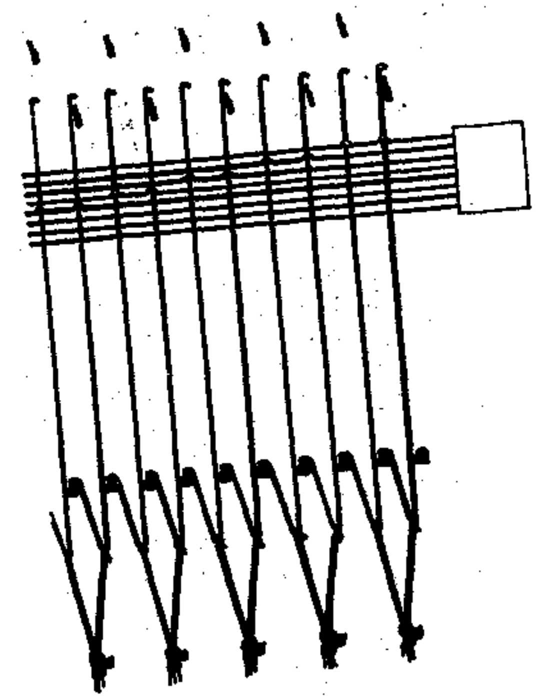


Fig. 14.6 Double Lift Single Cylinder Jacquard

The double lift machine has fundamentally the same working parts as those for a single lift machine; but in order to accomplish a **double lift**, two griffes and two hooks are used for controlling the working of one neck cord. The number of hooks and griffes are therefore double in number to that in the single lift machine. Thus, a 408 needle jacquard will have 816 hooks and two griffes in a double lift machine compared to 408 hooks and a single griffe in a single lift machine. Fig. 14.6 is a diagram of the working parts of a jacquard head of a double lift single cylinder machine. In this machine two hooks are controlled by one needle. The needles have doubled cranked eyes to actuate two rows of hooks. Hooks from continuous rows are coupled by tyeing two neck-cords together. This necessitates a speical design in the lower part of the hooks. The connection of the two hooks at the bottom may be of the **cord type** as shown in Fig. 14.7 (a) or of the **metallic link type** as shown in Fig. 14.7 (b). At present, the cord type connection is rarely used. In the cord type connection in one of the cords break, the harness cord will still be supported by the other cord and a defective design would result.

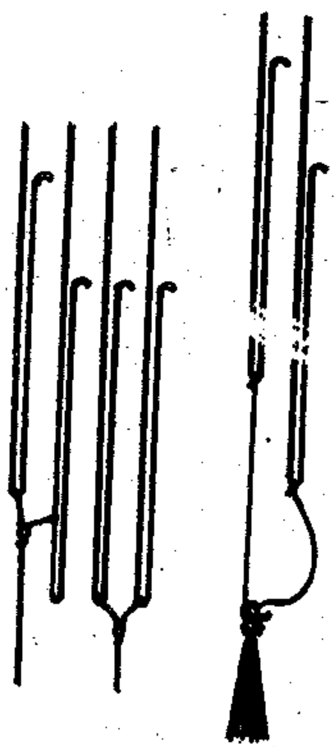


**Fig. 14.7 (a) Neck Cord Attachments with Cords, (b) With metallic Link**



If the same warp threads are required to be raised on two consecutive picks, the action will be as follows. One of the hooks lifts the threads to the top shed line. When that hook begins to come down the threads controlled by that hook also begin to descend with it. At the same time another card is against the needle board with a hole punched for the same needle. Therefore the paired hook starts ascending with its griffe. The ascending hook and decending hook therefore meet half way between their upper and lower limits of movement. The descending threads are thus raised again by the ascending hooks to form the top shed line. The bottom shed line remains stationary. Threads that are required to be down from the previous raised position continue their movement to the bottom shed line. Thus a warp shed on semi-open shed principle is formed.

As two hooks are used to control the same ends, two griffes are essential to lift the hooks in alternate order. One set of knives of one griffe passes through the other set of knives and the griffes move in the alternate picks. The hooks and the griffes therefore move at half the speed as compared with the single lift jacquard.

### 14.7.2 Characteristics of the Double Lift , Single Cylinder Jacquard

As the double lift machine forms a semi-open shed, it remains open for a longer time than the closed one. It is therefore possible to increase the speed to about 160 picks per minute. At this speed each knife moves up or down at the rate of 80 times a minute while the cylinder moves 160 times a minute. The rising and falling sheds act as counterpoise to each other and therefore less power is required for the formation of a shed. As there is less strain on the warp relatively weaker yam can be tolerated for working on the double lift machine. As the weft is beaten up in the crossed shed in the bouble lift machine, the weft cannot recede from the fell of the cloth and thus produces a better cover of distribution ot threads. (In a single lift machine the weft is beaten up in the closed shed in which case the pick has a tendency to slip back from the fell of the cloth). This also enables one to insert more picks per unit space than in the case of a single lift machine.

## 14.8 DOUBLE LIFT, DOUBLE CYLINDER JACQUARD

In **double lift single cylinder jacquard**, the limiting factor for the increase in speed is the movement of the cylinder. The increase in the cylinder speed will result in throwing off the cards from the cylinder, besides increase in wear and tear of the cylinder and other parts. In order to obviate this difficulty, two cylinders are provided on this machine. With such an arrangement the two cylinders present their cards at alternate picks. The loom could be operated at a speed

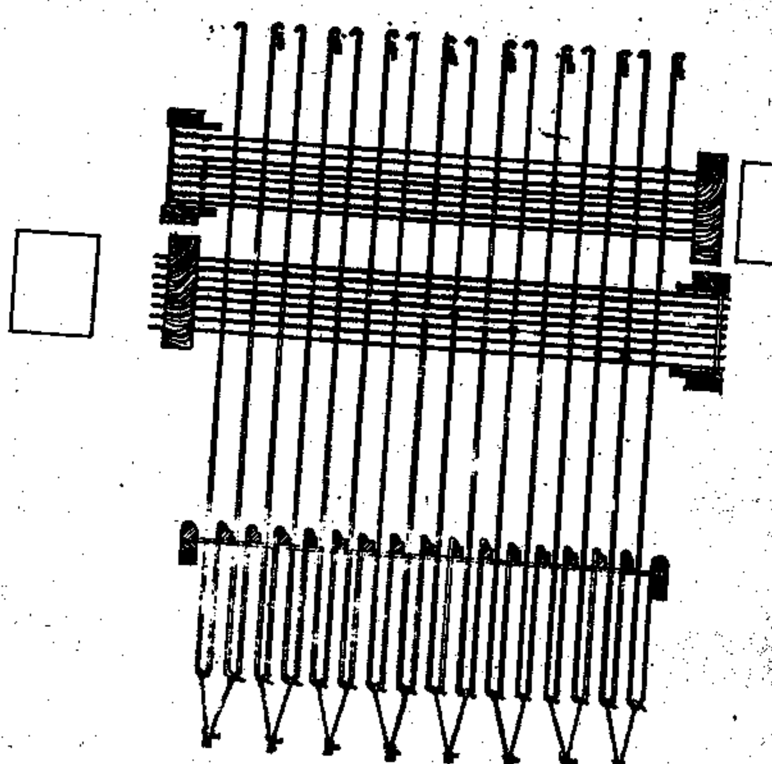


Fig. 14.8 Double Lift Double Cylinder Jacquard

of 180 picks per minute but each set of knives and each cylinder is moved at only 90 times per minute. It is possible to increase the speed of the machine because of the slowing down of the cylinder movement and the griffe speeds. Fig. 14.8 is a diagram of the working parts of the double-lift, double-cylinder jacquards. It has two sets of needles, two sets of hooks, two spring boxes, two needle borders, two griffes, two cylinders etc. Thus a double lift, double cylinder machine can be considered as two single lift single cylinder machines combined in one frame with the difference that two hooks control only one set of harness cords tied to a neck cord. Thus, though the machine contains 800 needles and 800 hooks it can give a repeat only on 400 ends.

### 14.8.1 Working Parts and Mechanism

Each cylinder moves in to present a card in on one pick and moves out on the next pick. The hooks controlled by one set of needles face the direction opposite to that of the hooks controlled by



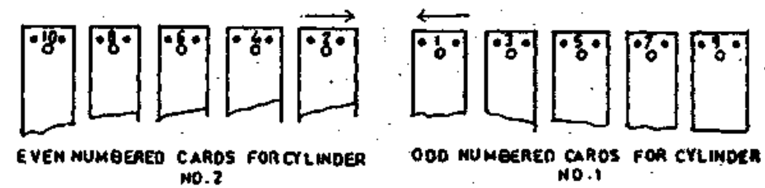



Fig. 14.9 Cord Lacing for Even and Odd Cards

the other set of needles. The knives of one griffe are also angled in the direction opposite to that of the other set of knives. One set of knives rises as the other set is lowered. The rising griffe engages the hooks selected by the card which is presented by the cylinder for that pick. It is, therefore, necessary that half the cards, say all odd numbered cards like 1, 3, 5 etc. are laced together to form an endless chain for one cylinder and the remainder, all even numbered 2, 4, 6 etc. laced for the other cylinder. If the odd numbered cards are laced forward then the even numbered cards are laced backward. This is shown in Fig. 14.9. This is necessary because one cylinder turns in clock-wise direction while the other turns in an anti-clockwise direction. A peculiar lacing of the odd and even numbered cards seperately, is a special feature of a double-lift, double-cylinder jacquard.

As in double-lift single-cylinder jacquard, two neck cords are tied together and therefore a pair of hooks control the same warp end. Though the hook tops are bent in opposite direction, the bottom portions of the hooks, resting on the grate, are all turned in the same direction. It is also interesting to note the arrangement of needles controlling the pair of hooks. For example, the first hook is controlled by the top needle and its companion or neighbouring hook is controlled by the bottom needle of the other set.

Suppose a right-hand side cylinder moves in. If a punched hole is presented to the top needle by a card on the cylinder, the knife will engage the hook controlled by the top needle and the hook will be lifted when the griffe rises. On the next pick, the left-hand side cylinder will move in and the right-hand side cylinder will move out. If a hole in the card on the left-hand side cylinder is presented to the lowest needle it will cause the second hook from the right to be engage by the knife and this hook will be lifted when the other griffe rise. The two hooks lift the same neck-cord and therefore the same harness lines on warp ends. The warp ends are thus not levelled before a new shed is formed. Thus a double-lift, double-cylinder machine also forms a semi-open shed as in case of double-lift, single-cylinder type.

### 14.8.2 Characteristics of Double-lift Double-cylinder Jacquard

The advantage of using two cylinders results in much higher operating speed than that of a single cylinder jacquard. Other advantage of this machine is that, if a very long set of cards is to be worked the distribution of the cards on two cylinders help in reducing the strain or drag on the pattern cards and cylinder. There are also less vibrations among the hooks, when the cylinder strikes its respective needle-board.

However, the main drawback of the double-cylinder machine, is that, if by chance one cylinder gets ahead of the other or is out of sequence with the other, a wrong design will be woven. For example, if card No. 2 is skipped accidentally, after card No. 1, then the sheds may be formed in the order of say, 1, 4, 3, 6, 5, 8 etc. instead of the correct order of 1, 2, 3, 4, 5, 6 etc. As the speed of this machine is more than that of the other jacquard, the liability of one cylinder getting ahead of the other is also more, and because of the speed a considerable length of defective fabrics will be woven, before the mistake is recognised. Some fabric manufacturers consider this as a serious drawback and prefer the double-lift, single cylinder jacquard, running at a lower speed.

## 14.9 OPEN SHED JACQUARDS

In a single lift jacquard each thread moves to the lowest point on each pick and if required to be up for the next pick, it is again lifted. In the centre shed jacquard the threads move half the distance they move in bottom closed shed. With the introduction of the double lift machine, if a thread is required to be up for two picks in succession, it only drops halfway from the top shed line when it is again lifted up by the ascending griffe, the bottom shed line remaining stationary. The ideal system of shedding would be to make the thread movements only when necessary. Jacquard machine working on this type of shedding is known as **open shed jacquard**. In open shed jacquard there is less wear and tear on the hooks, needles and harness than with semi-open, centre or bottom closed shedding systems. Swinging of the harness is also reduced. A perfect open shed jacquard has not been developed till recent years. The top shed line does not remain stationary but it falls slightly on every pick to allow sufficient clearance for the hooks to be pressed clear of the knives.



### 14.9.1 R. Wilkinson's Open Shed Jacquard

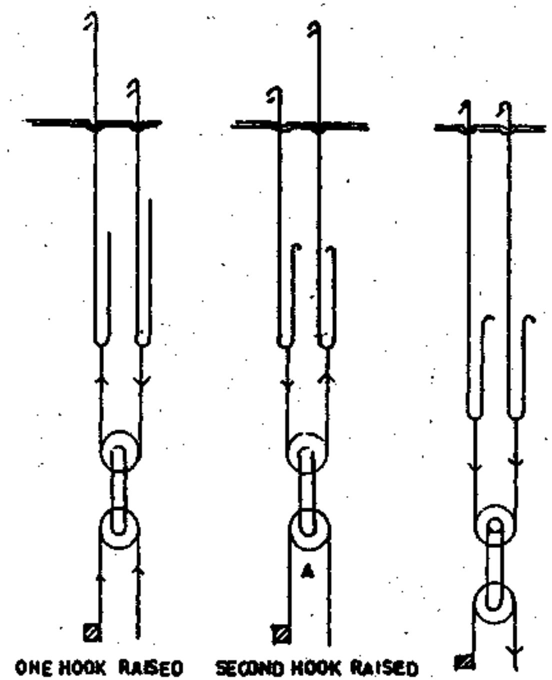



**Fig. 14.10 R. Wilkinson's Open Shed Jacquard**

Fig. 14.10 shows only the pertinent parts of the open shed jacquard which are not common in other jacquards studied so far. A neck-cord passed over a bottom grooved pulley and is attached at one end as at A. The bottom grooved pulley is connected to the top grooved pulley by two plates. A tail cord passes around the top grooved pulley also which is connected to two separate hooks either of which can be operated by one needle as in the case of a single cylinder double lift jacquard. If the blank portion of the card faces the needle the ends are kept down in the bottom shed line. If a hole is against a needle one of the hooks will be lifted by one griffe. If the same end is required to be up for the next pick in succession, the other hook moves up with the other griffe so that the slack cord of the desending hook is taken up by the ascending hook and the neck-cord remains in the unaffected raised position.

### 14.9.2 Modern Open Shed Jacquard

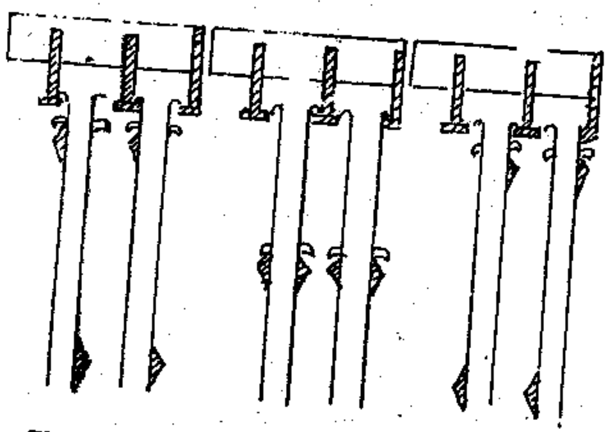


**Fig. 14.11 Modern Open Shed Jacquard**

Repeated attempts have been made in the past to build a perfectly open shed jacquard. However it was only in 1955, that a novel mechanism was developed successfully to work a jacquard with open shed principle. Fig. 14.11 shows some of the working parts of the machine necessary for the explanation of the working of the machine. The horizontal bars at the top are just above the jacquard hooks and they have small inverted T-sections which extend between the pair of hooks in the machine. These bars are given a small to-and-fro movement by means of levers operated from a crank plate on the main shaft of the jacquard. The operation of one pair of hooks is described here to show the working principle of the open shed jacquard of this type. As this is a double lift machine, there are two griffes moving simultaneously in opposite directions. One griffe lifts the left hand hooked portion if a hole is punched against the needle controlling the hook. When the hook completes its upward movement, the hooked portion or the neb of the hook A is just above the inverted T-bar. The T-bar is then moved to the left so that the T-bar on the right hand side is under the other neb of the same hook if a hole is again punched on the card for the next pick. The hook thus remains suspended and is not allowed to be lowered as in case of semi-open shedding. The other griffe then lifts the neb B clear of the inverted T-bar when the first griffe descends down and the second griffe moves up. During this time the T-bar is moved to the right so that the T-bar on the left hand side is under the neb A of the hook if a hole is again punched on the succeeding pick. This process is repeated as long as it is desired to retain a particular thread in the upper shed line. The only movement given to the hooks is a slight lift to raise the neb clear of the T-bar so that they can be changed over from one T-bar to another.



When it is desired to lower a thread, the appropriate needle is pressed by the blank portion of the card on the cylinder and the neb portion of the hook concerned is pressed out of line with the bar so that the particular hook can descend down in the normal way with the descending griffe.

### 14.9.3 Characteristics of Open Shed Jacquard

As mentioned earlier, as operation of warp ends is made only when required in the open shed jacquard, friction and warp breakage is reduced. The other advantages claimed for open shed jacquards are :

(i) fabrics normally woven **face down** can be woven **face up** as there is no heavy lift.

(ii) as two griffes are used to lift the hooks, the individual knife moves only at half the speed of the loom. There is thus less wear and tear on hooks and of harness.

(iii) less power is required for driving the jacquard due to reduced lifting of the harness,

(iv) higher weaving speeds are possible.

However, one of the problems of open shed weaving is that some kind of warp levelling arrangement is necessary to mend the broken warp thread. As also certain warp threads are unnecessarily strained when the loom is stopped for night or week ends. Sometimes semi-open shed is preferred to open shed as the semi-open reduces the strain on the warp end, at the time of the beat up.

### 14.10 HARNESS BUILDING

The harness building is a specialised and costly job. Therefore, all factors should be thoroughly considered before starting the building of the harness. The important points to be considered are

(i) arrangement of the tie (draft),

(ii) threads per unit space in the cloth, (It is not possible to increase the threads per unit space after the harness has been tied although they may be decreased within certain limit by a process known as **casting out**),

(iii) the number of hooks to be used. For example, in a 416-hook machine, the number of hooks to be used for working the regular harness may be 400. In selecting the number of hooks to be used, it is advisable to take the number that will give the best variety of small number as a factor. For example, for a 400 machine weaves completing on 2, 4, 5, 8, 10 or 16 ends can be used for the ground weave, while if all 416 hooks are used, the ground weave the ground weave must complete on 2, 4, 8, 13 or 16 end.

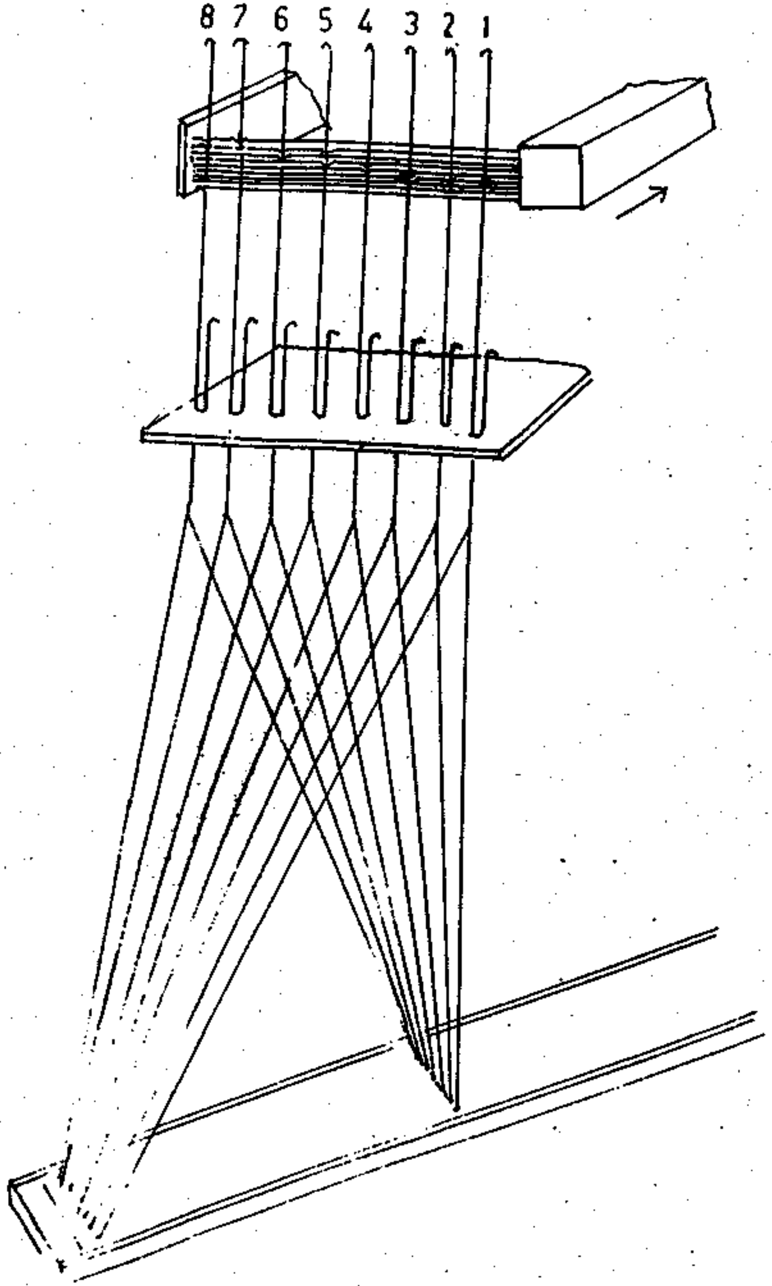



Fig. 14.12 Norwich Tie



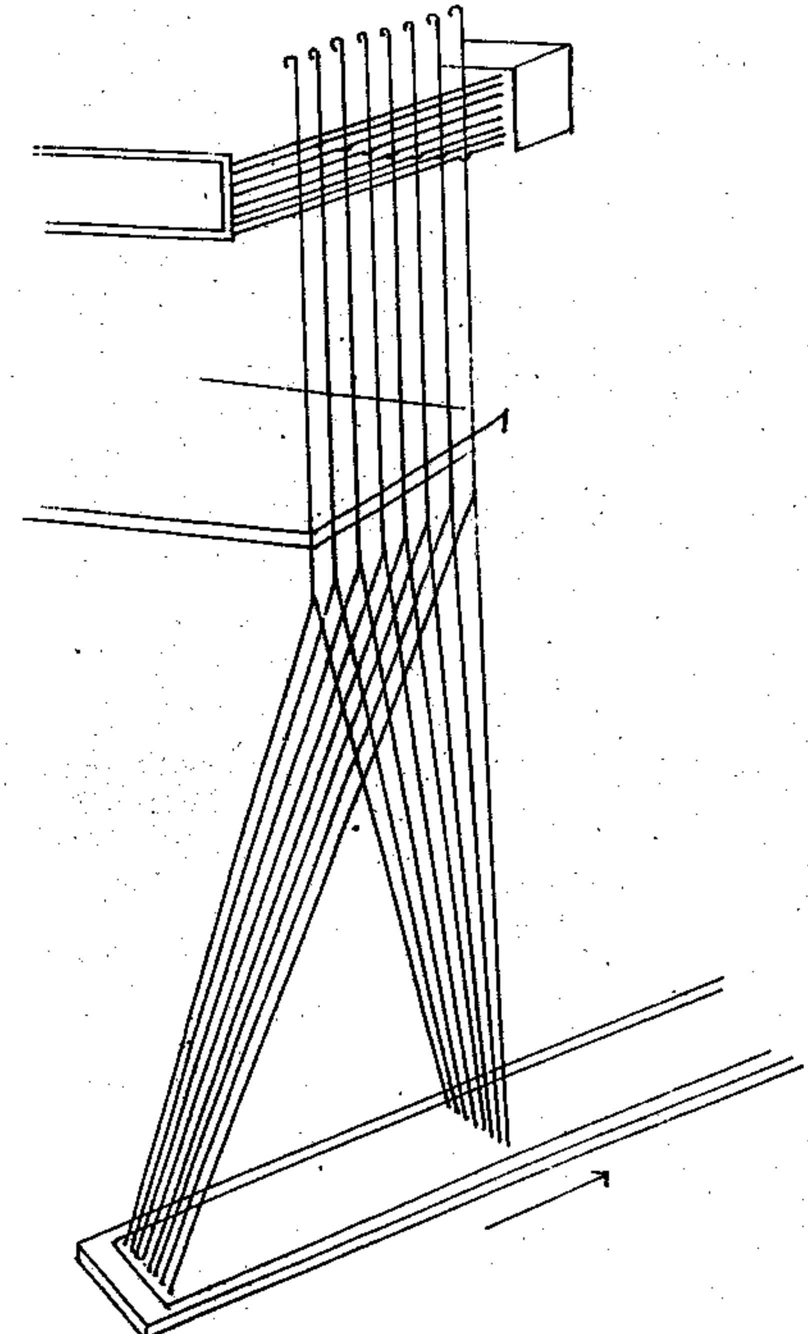


Fig. 14.13 London Tie

The harness should be carefully prepared and levelled. Successful working on jacquard machine largely depends upon the care taken while tieing up the harness. Badly tied up harness is a constant source of trouble to the weaver. It is advisable to prepare the harness away from the loom but where the work is of very heavy nature, the best results are obtained by tieing up the harness on the loom itself.

## 14.11 HARNESS TIES

**Harness tie** indicates the position of the jacquard engine above the loom. The jacquard cylinder may be parallel to the reed or it may be parellel to the warp ends. There are these two main systems in common use for the harness ties.

### 14.11.1 Straight or Norwich System

When the jacquard machine is placed over the loom in such a position that the cylinder is either at the back of the loom over the warp yarn or at the front, above the head of the weaver, the harness is said to have a **straight** or **Norvich** tie which is shown in the Fig. 14.12. In this method, the long rows of hooks in the machine are parallel with the long rows of holes in the comber board.

### 14.11.2 Cross or London System

When the jacquard machine is so placed above the loom that the cylinder is either to the right or left side of the loom, the harness is said to have **a cross** or **London** tie which is shown in the Fig. 14.13. The long rows of hooks in the machine are at right angles to the long rows of holes in the comber board and the harness receives a quarter turn or a partial crossing in passing from the hook through the comber board. The only difference between this method of harness tie and the stright tie, is that the jacquard machine is turned one quarter way round with relation to the loom. When this method is used, the cards of the jacquard machine hang either over the right hand or left hand side of the loom.

### 14.11.3 Relative Merits and Demerits of Two Systems

(i) In the stright tie there is no crossing of the harness cords as such wear and tear of the harness cords due to friction is less. Cross tie produces abrasion which reduces the life of the harness.

(ii) Repairing and mounting of the harness can be done more easily in case of straight tie than in cross lie.

(iii) In the straight tie, light is obstructed over the cloth or the warp sheet depending whether the jacquard engine is at front or back of the loom.



(iv) Straight tie is seldom used when a repeat represents hundreds or thousands of picks because the long endless chain of cards will hang over the weaver's head or at the back of the loom in case of single cylinder jacquard or at both places in case of a double cylinder jacquard. In case of a double cylinder jacquard, it is usually not suitable to use a straight tie because of the limited space available in weaver's alley.

(v) In the case of cross tie the weaver will have sufficient free space in front or back of the loom and both the chains of cards can be watched from the front of the loom in case of double cylinder jacquard.

In general, the cross tie is more commonly used than the straight tie.

### 14.11.4 Position of the First Hook of the Jacquard

Before cutting the cards of a jacquard design, it is absolutely necessary to note the first hook of the jacquard, the order in which the harness lines are threaded through the comber board, and the order of drawing the warp threads through the harness. The order of card cutting and card laceing will primarily depend on these factors. It is essential to synchronise all these operations to guarantee the perfect woven design.

There is no absolute rule regarding the position of the first hook of the jacquard but the first hook always governs the first end of the design and it is a matter of convention whether the warp end at the extreme left or extreme right is to be considered as the first end of the design. Similarly, the comber board has four corners and the harness lines from No. 1 hook of the jacquard could be drawn through any of these points.

There are two recognised methods of determining the first hook of the jacquard.

(i) Philadelphia Method : Facing the needle board, the No. 1 hook is the one which is controlled by the needle at the lower left hand corner.

(ii) New England Method : Facing the needle board, the No. 1 hook is the one which is controlled by the needle at the upper left hand corner.

The most common method, conventionally used, is the Philadelphia method.

## 14.12 DESIGN TIES

The harness cords of the jacquard need not necessarily pass through the holes of the comber board in the same order as they are connected to the hooks. In tieing of harness, several orders of drafting the cords are employed for the purpose of special forms of designs to be economically woven. The term **harness tie** is used ambiguously in many text books. Sometimes it refers to the position of the jacquard engine above the loom is as in **Norwich tie** or **London tie** as described earlier and sometimes it refers to the method of passing the harness cords through the comber board for governing the character of the design that can be woven, that is, the order of drawing the ends through the harness mail eyes. In order to avoid the confusion between these two usages of the same term, the authors of this book use the term **design tie** to latter, instead of **harness tie** normally used. The main design ties are :

(i) Straight-through tie, (ii) Lay-over or Repeating tie,

(iii) Centre or Point or Turn-over of Vandyke tie,

(iv) Border tie, (v) Combination or Complex tie.

**14.12.1 The Straight-Through Tie**

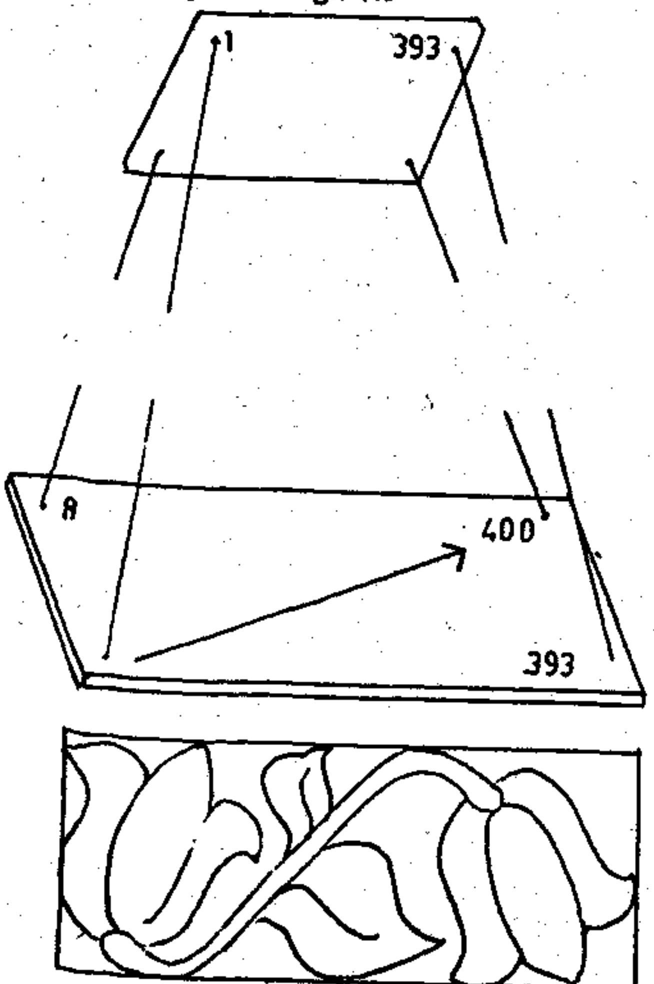



**Fig. 14.14 Straight Tie**



This tie is used to produce a fabric containing only one repeat of the design in the full width of the fabric. (Fig. 14.14). Only one harness cord is attached to one neck cord or to a hook and there must be as many hooks as there are threads in the width of the fabric. If there are 400 hooks in the jacquard then the total ends in the width of the fabric will be only 400. Or, if the design is required to be woven on 3600 ends then three jacquards each having capacity of 1200 hooks should be built side by side. This tie is therefore not extensively used as it is either suitable for narrow width fabrics or for portraits and for a copy of a painting.

**14.12.2 Lay-over or Repeating Tie**

This is the most common design tie used for, both Norwich and London harness ties. The fabric contains more than one repeat of the design in its full width. Fig. 14.15 shows a portion of the repeating pattern. In this tie there must be as many harness cords tied to each neck cord as there are repeats in the full width of the fabric. Thus if there are 4 repeats of the pattern, in the width of the fabric then there will be 4 harness cords tied to each neck cord or hook.

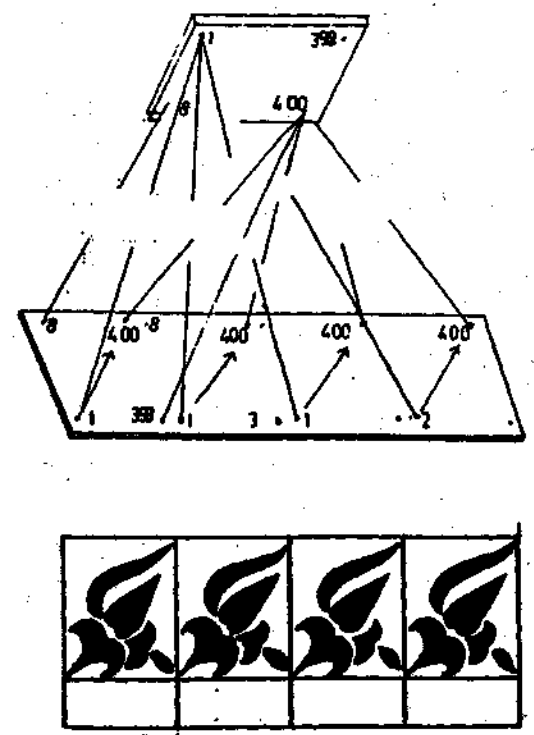


**Fig. 14.15 Repeating Tie**

### 14.12.3 Centre Tie

This type of tie is suitably used, when a design is symmetric if turned over its central line. One such design is shown in Fig. 14.1 For example, suppose the design shown in the above figure complet on 800 ends in its full repeat, the number of ends from the centr line to each dotted line is 400, representing a half repeat of th design. The threading of the harness lines through the comber boar is indicated in Fig. 14.16. The harness lines are connected from 1s to 400th hook in a regular order and then from the 399th hook, th harness lines are connected in the reverse order i.e. from 399th to the 2nd hook from where the order is again reversed and the harnes cord is passed through hole no. 1 in the comber board No. 400 is in the centre and No. 1 repeats at the right. By this arrangement the texture of the cloth is slightly affected, as no end is drawn through the No. 400 and No. 1 marked with a solid mark in the Fig. 14.16 The design with the omission of these ends will have totally 79 ends instead of 800 ends originally assumed. The centred tie is largely used for silk ribbons, curtains, serviettes tray cloths, upholstery and carpets.

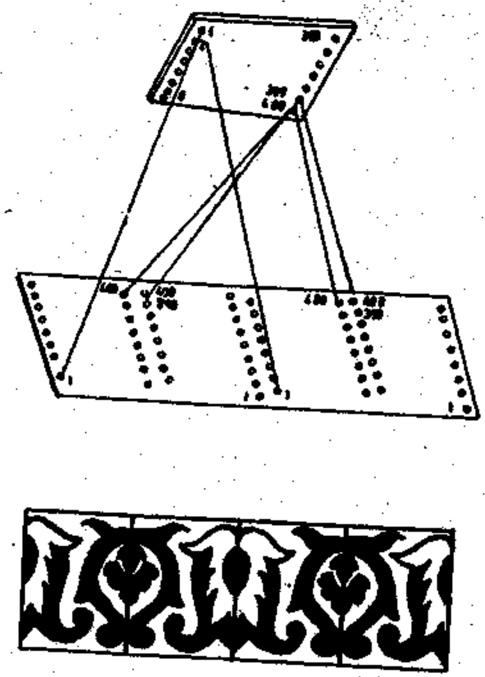


Fig. 14.16 Centre Tie



### 14.12.4 Bordered Tie

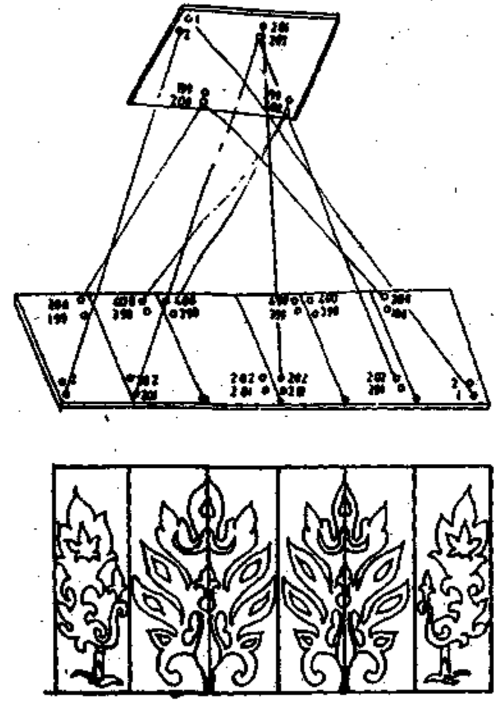


Fig. 14.17 Bordered Tie

A **bordered tie** is the same as the name suggests, a tie which is mainly used for bordered fabrics like handkerchief or table cloth. In this tie, as shown Fig. 14.17, one repeat of the border figure is made at each side of the fabric only. The central design is, however, repeated a number of times. The central portion may have a repeating tie or a central tie and any appropriate number of hooks may be assigned for the border and the body design of the fabric. The illustration in the figure indicates the border figure is turned over at the sides and the body figure is developed by a centred tie repeating two times. A number of permutations can be used for a variety of effects.

### 14.12.5 Combination Tie

If a large repeat pattern is to be produced with the existin capacity of the jacquard, this type of tie can be suitably manipulated A great skill and ingenuity on the part of a designer can result i creating an impression that the design required a greater capacity c the jacquard than has been actually used.

## 14.13 CASTING OUT

Once a harness is built-up, the set of the harness is fixed and it is normally changed. The set of a harness is defined as the number of harness mails per unit length of the comber board. Sometimes however minor modifications are required because of either, the warp set desired is different from the harness set or the design required to be produced is repeating on less number of ends than the figuring capacity of the jacquard. For example, the figuring capacity of the jacquard is 600 and the harness is tied with a set of 100, i.e. 100 cords per inch (or 2.54 cm), the machine is therefore perfectly suitable for weaving a design repeating on 600 ends and with 100 ends per inch (2.54 cm). Suppose now it is required to weave a cloth with 80 ends per inch on the same jacquard. The warp threads should occupy the same space in the harness as in the reed but as in this case only 80 ends per inch are to be accommodated in the reed and harness set is 100 mail eyes per inch, 20 of the harness cords per inch must be left out or **cast out**. When the harness cords are cast out it is natural that the hooks are also cast out in same proportion. Thus the reduced figuring capacity would be, $R = (A \times B) / C$

Where, $R$ = Required figuring capacity;

$A$ = Standard capacity;

$B$ = Required set;

$C$ = Standard set.

$R = (600 \times 80) / 100 = 480$

Hence, 120 hooks needles and harness lines will become extra, which will have to be cast out, to get the same width of the figure but with less number of ends per inch in the fabric. Casting out is therefore defined as a process by which a jacquard is used without retyeing to suit the warp sett which is lesser than the harness set already existing.

Another situation in which the casting out of hooks is desired is one in which the number of hooks required for one repeat of a design is not divided evenly into the number of hooks in the jacquard. For example, a 600 hook jacquard is suitable for designs that repeat on 300, 200, 150, 120, 100, 60, 50, 40 or 30 hooks. If the number does not divide evenly but leaves a remainder, then it is necessary to cast out the hooks that are left over. For example, the repeat that completes on say 80, 140 or 280 hooks leaves 40 hooks idle in a 600 hook jacquard. These hooks have to be cast out.

The process of casting out consists of leaving some mail eyes without drawing any ends through them. Generally, casting out is



done in short rows and the rows cast out are distributed as regularly as possible across the machine. For example, a 600 machine will have 12 hooks in a short row and there are 50 rows. For a new design of 80 ends per inch, the total short rows to be used are 40 ($40 \times 12 = 480$). Thus one short row in every five rows are 5th, 10th, 20th, 25th, 30th, 35th, 40th, 45th and 50th.

To cast out, the griffe is lifted to raise all the hooks and then the hooks that are to be cast out, are thrown off the knives. The warp is then drawn through the harness lines which are lifted. A pilot card is cut for reference without cutting rows which are to be cast out. This pilot card is placed on the card cutting machine for the guidance of a card cutter who is instructed to miss the rows when the pointer pin points the uncut row on the pilot card so that the design is cut only for those hooks which are controlling the harness lines for weaving.

One thing should be remembered that the cloth already in the loom cannot be reduced in texture by casting out because the pattern would be broken.

## 14.14 CARD CUTTING

### 14.14.1 Preliminaries to Card Cutting

The purpose of the jacquard weaving is to produce designs that are too expensive to be woven with tappets or dobbies. Any design that can be painted can be woven on a loom with a jacquard. A good jacquard designer should study applied art and textile designing. It is not intended here to describe in detail the elaborate process of transfering the jacquard design from an artist's motive, or methods of inserting sketches such as half drop designs, ogee system, satin order etc. but a brief description of the processes involved in transferring the design from paper to graph paper design suitable for card cutter is given.

First a design is drawn on a plain paper and then repeated a sufficient number of times vertically and horizontally to see the overall and general effect of the repeating pattern. The design is then transferred and enlarged on a suitable graph paper. The enlarging is usually done manually but someitmes the use of pantograph or projecting apparatus is made. Every square of the graph paper through which the outline of the figure passes, is completed or left empty using a discretion. The figures are then painted in some transperant colour to indicate the warp or weft. If the colour in the figure indicates weft, then another colour is used to indicate the binding points of warp in the figure. The colour used for figures is also used to mark the weft in the ground portion of the design. Usually the figure is in weft plush weave and ground in warp plush weave. A combination of both can also be used in the same figure if it can produce a good effect. Care should be taken that the binding points, whether in ground or in figure should not be near the boundary line of the figure. Before cutting the cards, it is also necessary to decide whether the fabric has to be woven right or wrong side on top. This is generally decided by the lift of the threads required for the design. The specific instructions for card cutting are mentioned on the design paper for the information of the card cutter.

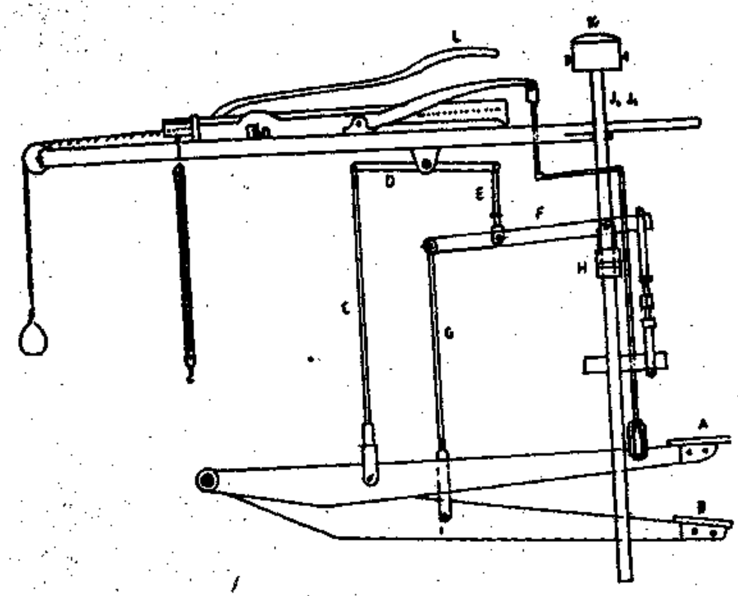
Before starting the card cutting it is necessary to divide the graph paper by heavy vertical lines into a number of sections, according to the number of hooks in a short row. The bar on design paper is a guide to the card cutter. This, with a 8-hooks in the short row of the jacquard, the design paper should be marked with heavy lines after every 8 small squares horizontally. This is essential because the working of all the hooks in each short row is read at a time for punching a card. Thus, in a 400-machine with 8 hooks in each short row, 50 operations of punching are required to transfer the working of 400 ends from the graph paper to the pattern card. In ordinary jacquard each card represents only one pick of the design. As many cards will be required to be cut as there are picks in a repeat of a design. Thus, if a repeat completes on 300 picks then it is essential to cut 300 cards. It is necessary to use a good quality of cards as they have to resist the strain and wear on account of their constant movement and the pressure of the needles.

### 14.14.2 Card Cutting Machine

The most common type of manually operated card cutting machine used in the industry is known as **Piano Card Cutting Machine**. Fig. 14.18 shows one such machine in line diagram. The **head** part of the machine is shown in elevation and in plan view in Fig. 14.19 (a) and Fig. 14.19 (b) respectively. In the head there are twelve keys numbered from 1 to 12. When these keys are pressed in with the finger tips, they come directly over vertical punches which are also 12 in number. In addition to 12 keys there is a key 13, which when pushed in, can lock a bigger diameter punch konwn as a 'peg-hole' punch. When the pressure of the finger is released the springs return the keys to their original positions.

The entire head is supported by two upright rods J and J1, shown in Fig. 14.18. These rods together with the head are lifted or lowered by means of levers that are controlled by the feet of the card cutter. Connected to the foot lever A is a rod C that connects the lever D, attached to the rod E which in turn is connected to the lever F. The lever F and the foot lever B are linked by a rod G. The lever F extends to the front of the machine and a casting which is bolted to a cross-piece H is attached to the lever F. The cross-piece is secured to the rods J-J1. By pressing down a foot lever B the cross piece H together with the rods J and the head K is lowered. With the lowering of B the other foot lever A is raised through the lever connections shown in the figure. On the other hand, when the foot lever A is pressed down the inner end of the lever F will be raised thus raising the cross-piece H together with the head. This also raised the other foot lever into position to be pressed down for the next cutting operation.





A1, B = Foot levers, C = Rod, D = Lever, E = Rod, F = Lever, G = Rod, H = Cross piece, G = Rod, K = Heald

**Fig. 14.18 Card Cutting Machine**

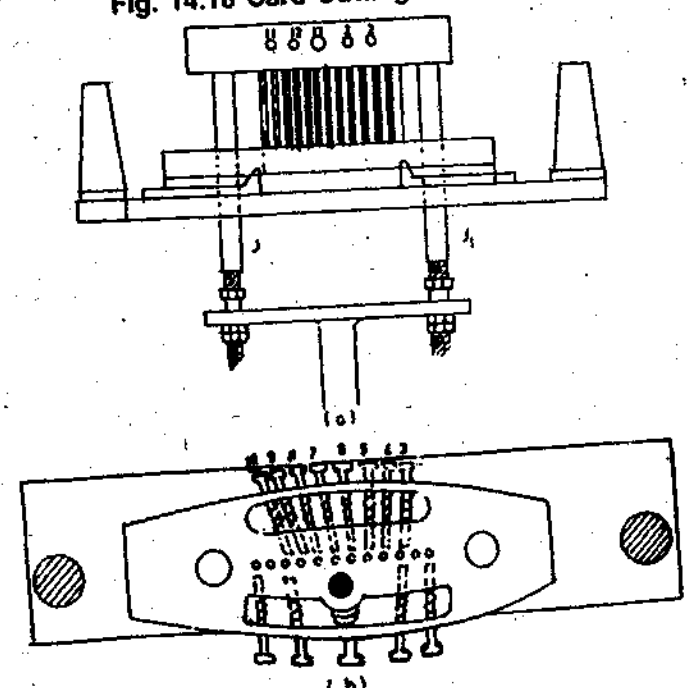


**Fig. 14.19 Card Cutting Head - (a) Front view, (b) Plan**

#### 14.14.3 Operation of Card Cutting

The card is inserted and is held into its place by pressing a lever L which lifts a catch to insert the card for securing it firmly in its position. The card cutter with his finger tips presses in the keys that lock the punches for the holes to be cut as per design and the instructions given to him. With the punched locked by the keys, the card cutter presses the lever B which brings down the head together with the punches so that the punches that are locked by their keys penetrate the card as shown in Fig. 14.20. If the punch is not locked by its respective key the card coming in contact with it, remains uncut. Keys 1 and 2 are controlled by the thumb of right hand and keys 3, 4, 5, 6 by the fingers of the right hand. Keys 7, 8, 9 and 10 by the fingers of the left hand and keys 11 and 12 by the thumb of the left hand. Peg hole key is controlled by thumb of the right hand.

Before card cutting is to be started it is necessary to note the position of the first hook in the jacquard and cutting procedure corresponding to the first hook and the design transferred on the point paper.

The design paper or the point paper with the design marked on it is placed on the reading board and is fixed with the thumbtacks. The guide rule on the board should be then moved until the first horizontal line to be read from the design paper is below the guide rule. Depending upon the instructions given to the card cutter, either for the blanks or filled in squares, a hole should be cut in the card. A hole cut in the card means a corresponding warp thread will be lifted.

An indicator card is provided at the lower edge of the reading board. This card is fully cut to indicate the position of the peg hole lace holes and each row of holes. A cord attached to the carriage passes over a small pulley and an indicating pin or a knot in the cord indicates the lines of holes in the card that correspond to the line of the card to be cut.

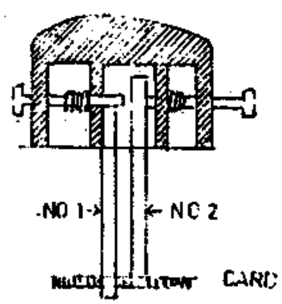



**Fig. 14.20 Card Cutting Head Details**



The card is marked with a number corresponding to the pick number of the design. The numbered end is inserted in the catch of the carriage as mentioned earlier. The carriage is brought to the starting position by pulling a cord provided. The peg hole and the lace holes are cut by making use of the indicator card. An arrangement known as **skip motion** is provided on the machine by means of which after one row of holes is cut, the card is exactly moved forward through a distance equal to the pitch of the short row to bring in position the next row of holes to be punched on the card. By reading the marks of the design paper card cutting is followed, section by section, till the end of one horizontal row of the design is reached. Again the lace holes and peg holes are punched in and then the card is ready for lacing. The guide rule is then moved so that the second pick of the design can be read from the design paper, and the card cutting is continued in the same manner.

### 14.15 CARD LACING

The next operation after the cards are cut, is the lacing of the cards to form an endless card chain. The card lacing operation is usually done by hand in small firms but big firms use automatic lacing machine.

#### 14.15.1 Hand Lacing

A wooden lacing frame consisting of two long narrow supports for the cards is used to place about 30 to 50 cards at a time, for lacing. The wooden lacing frame is studded with small metal or wooden pegs representing the pegs of the cylinder of the jacquard. The pegs are equidistant and coinside with the pitch of the peg holes

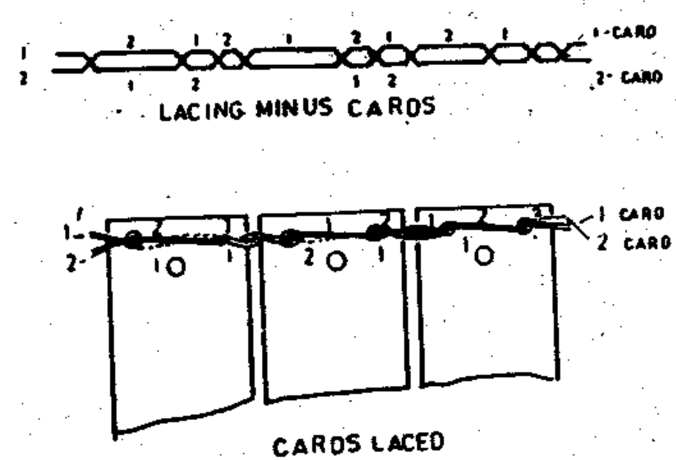



**Fig. 14.21 Card Lacing**

in the card cylinder. The cards are placed in a serial order in th
frame, the peg holes of the card fitting on the pegs of the laci
frame. A needle, threaded with a lacing twine, is used to lace th
cards. The manner in which the cards are laced is shown in the Fi
14.21. It is clear from the figure that the lacing cords are crossin
between two consecutive holes and also betwen two consecutiv
cards. Hand lacing is a slow operation involving some skill of th
operative to regulate the uniform tension of lacing the cards throughou
a set of cards.

### 14.15.2 Automatic Lacing Machine

Machine lacing is resorted to for two reasons (i) for speedier
operation, and (ii) for lacing the cards with uniform lacing tension on
the cards so that cards can fit on and rotate round the cylinder in a
smooth manner. In india no automatic lacing machines are used and
hence the description of such machine is omitted.

## 14.16 HIGH SPEED JACQUARD

**High speed jacquards** are suited for use in high speed shuttleless weaving machines and is recommended also for double width weaving. The knife frames are actuated by bilateral baulk levers in combination with a connecting arm with cams and large surface heavy duty ball bearings. All other pivots also have ball or needle bearings. The knife frames are guided by low friction sliders.

### 14.16.1 Harness

The harness contributes to the efficiency of a weaving machine. Downpull is effected either by elastomer elements or stainless steel springs.

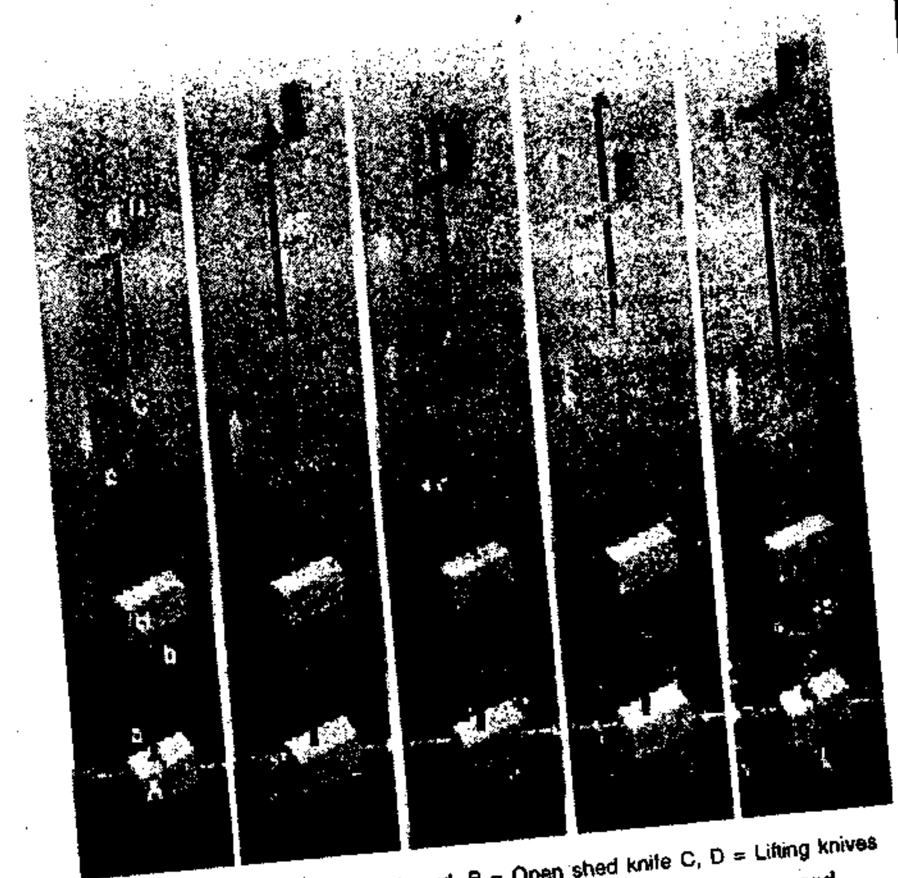
### 14.16.2 Reading - in Mechanism

Readings – in of a high speed jacquard is carried out by endless paper in verdol pitch. It is conceived in such a way that it meets all the requirements for rapid function and low maintenance. The reading - in needles are fitted with pressure springs, the needle guide is easy to remove for clearing.

**Electronically** controlled **jacquards** are also development by Staubli, Bonas etc. The features of the multi-task control and its highly diverse possibilities are :

1. Reading patterns, weaves or programs from an appropriately formated floppy to the hard disc or vice versa.
2. Combining and creating of basis patterns, weave and program data for a new weaving program.
3. Weaving of patterns accoding to a desired and programmable production program.
4. Modifying and correcting such as inserting, changing and deleting of crossing points.





a, b, c, d, = Nebs, A = Bottom board, B = Open shed knife C, D = Lifting knives

**Fig. 14.22 Working Principles of High Speed Jacquard**

Outstanding features of computer control are :

1. Keyboard for selecting and editing different functions and programs.
2. Screen for displaying all stored data plus a facility for displaying selected enlarged areas of the pattern.
3. Hard disc for storing program data specific to machine and number of picks with a maximum of 2,30,000 picks with 1344 hooks or 1,15,000 picks with 2688 hooks on Staubli C X 860 jacquard machine.
4. Floppy disc for loading hard disc. Each floppy can hold upto 136 different patterns within the maximum possible number of picks of 8722 with 1344 hook configuration.
5. It is also possible to connect the jacquard to a network systems.

### 14.16.3 Functional Principle

The functional principle of Staubli CR720 is illustrated with reference to Fig. 14.22. The positive drive of the Staubli rotary hooks by the knife frames allows vibration free working speeds. Each hook has 4 nebs (a, b, c, d). Regarding position of neb a, neb c is placed 45° to the left and neb d 45° to the right. The five operational phases are :

**1. Lower shed position :**

Rotary hook is positioned by neb a on bottom board A. Lifting knives C and D are moving down and up, respectively.

**2. Upper shed position :**

Rotary hook with neb d is caught up lifting D turned 45° to the left and lifted into upper shed. Neb c is rotated and thus beyond the catching range of lifting knife.

**3. Upper shed position :**

Rotary hook is positioned on open shed knife B by neb a and turned back 45° to original position (1). Lifting knives C and D move up and down, respectively.

**4. Upper shed position :**

Rotary hook with neb c has been caught up by lifting knife C turned 45° to the right and lifted into upper shed.

**5. Upper shed position :**

Rotary hook is returned by neb a to bottom board a and rotated 45° to original position (1). Lifting knives C and D initiate the following and lowering motion, respectively.

### REFERENCE

1. Staubli AG, Private Communication.



# 15 SOME PLAIN LOOM ACCESSORIES AND THEIR CARE

## 15.1 IMPORTANCE OF LOOM ACCESSORIES

During the discussion on loom mechanisms references have been made about many loom accessories such as shuttles, pickers, picking bands, buffers, reeds, healds etc. Though these are minor loom mountings their importance cannot be under-estimated. If due care about the service life of these accessories is not taken, not only the cost-economics of a weaving shed will be affected but the loom efficiency and quality of cloth produced on these looms will be adversely affected. A survey on 'Consumption of Accessories' conducted by ATIRA (1) in sixties showed that an average mill spends Rs. 300/- per year per loom working two shifts. This figure will be now four times in nineties compared to that in sixties. A few other things were revealed by ATIRA and other Indian weaving technicians: shuttles, pickers, picking bands, healds and reeds together contribute 90% of the total expenses on loom accessories. Also, the service life variability of these accessories is quite wide in different mills.

One can, therefore, understand the importance of these accessories so that proper care and control can be exercised during use. It is, therefore, necessary to know as much as possible about the raw material, specifications and the qualities of these accessories so that their selection, storage, handling on looms during actual use would be done so that their performance will be optimum.

Fortunately the Bureau of Indian Standards (earlier known as ISI) has laid down Indian standards for more than 100 important textile accessories. However, the unfortunate part of the situation is that very few mills and technicians insist upon getting the standard accessories. Unless the users and manufacturers of these accessories are serious in accepting and producing the standard accessories, the wide variability of the service life of these accessories would not be reduced. This chapter is intended to give an idea about a few important accessories and minor mountings on a plain non-automatic loom so as to create an awareness about the material and specifications of these products.

## 15.2 THE SHUTTLE

The symbol of conventional weaving is the **shuttle**, which has been used for picking the weft yarn for centuries. It is figuratively called the pulse of the weaving shed (it gives a rhythmical beat). Depending upon the type of a loom, a shuttle speeds through the shed at anything 50 km/h – 130 to 250 times a minute and over three shifts covers a distance of upto 200,000 km a year i.e. upto five times the circumference of the earth. It is braked right down to zero and then accelerated again up to 13,000 times an hour. The lightest shuttle has a weight of approximately 150 g and the heaviest 450 g with lengths ranging from 200 to 1250 mm. The type of weaving machine, the weft yarn to be processed, the reed width, the cloth weight and the bobbin changing mechanism on the automatic loom govern the choice of a shuttle. Other important factors are the shedding mechanism on the loom, as well as the shuttle checking and braking system.

The high strain to which the shuttle is subjected to, is due to the continual bursts of braking and acceleration mentioned above, which succeed one another without transition. During these processes the bearing surfaces and tips get heated and the seating of the metal parts is put under terrific strain. It is, therefore, essential that inevitable vibrations are absorbed by specially selected raw materials and good design.

Generally natural or processed wood is used as a raw material. By processing the wood it has been possible to increase the density of natural woods by 25% or more and the tensile strength and stability is improved. A dense wood is more resistant to compression, harder, more stable, and wear resistant than a light wood. However, since the accelerating and braking forces increase proportionately with the weight of the shuttle, a compromise has to be made with the use of medium weight wood. The shuttles are usually made of Persimon Dogwood, Wie Beach, Box Wood, Indian Oak, Teak or Comel Wood of closed grain. The timber should be knot free. It is also necessary to **season** the wood naturally before it is ready for further processing. This means a considerable amount of locked-up capital. In order to overcome this difficulty the finished shuttles are dipped in boiled linseed oil and then stored for several months. In spite of the impregnation, the shuttle wood still remains hydrophilic so that volume as well as the weight will change in humid atmosphere of the weaving shed. Wood treated chemically possess this character to a lesser degree.

Shuttle made of plastic has high resistance to splintering and reduced wear. The life expectancy of plastic shuttles is claimed to be



twice as that of wooden shuttles. Some foreign shuttle manufacturers are combining plastic and wood in their shuttles for reason of economics.

### 15.2.1 Forces Acting on the Shuttle

When the shuttle is in the box ready for picking it is pressed between the swell and the box front plate, the swell exerting a load to the order of 100-150 N through the centre of the back wall which gives a bending stress of about 90° Pascal. During the picking, the shuttle is hit with a force of about 500 N along its axis. In case the picker movement is not parallel to shuttle axis, there will be a large stress at the joint of the tip due to bending moment of skewed picking force. Maximum damage is done to the shuttle at the time of checking, when a force as high as 1000-1500 N may be acting along the axis. The damage is mainly due to fatigue stressing of its walls and mechanical abrasive wear due to friction with solid loom parts and sized yarns. The fittings on the shuttle like shuttle tips, shuttle tongue and shuttle-eye get loosened due to impact blows especially during checking. Hence, to ensure smooth shuttle flight all these fittings also have a part to play. The increased speeds and the use of plastic in place of buffalo-hide picker has a deleterious effect on shuttle tip. The tip is not also struck uniformly on the picker and the shuttle tip becomes loose because of eccentric striking on the shuttle with the picker. The tip also gets hot and the tip fastening is put under considerable strain. Hence, proper care of the shuttles and alignments of various parts of the shuttle and shuttle box is desired.

### 15.2.2 Care of Shuttles

#### 15.2.2.1 Loom setting

1. The stress factor of the loom is defined as follows :

   $C = M \times Va$

   where, M = Weight of the shuttle including the full pirn;

   Va = Average shuttle speed.

   In the case of change of loom speed or size of the weft packages, this factor should be kept constant.
2. The checking by swells should provide uniform and slow deceleration.
3. The picking mechanism should not give a skew force into the shuttle. The parallel movement of the picker depends upon the spindle and on the design of the picker.
4. The warped or twisted sley and vibrating sley can disturb the flight of the shuttle.

5. Alignments of the shuttle boxes and sley, shuttle boxes an reed, and box-settings should be checked regularly. Shuttl box should be about 16 cm longer than the shuttle. The ree should be 0.2 to 0.4 mm behind the box back plate. The bo bottom plate and the sley should be at the same level. Th angle of the reed with the sley race bevel should be the sam as that of the shuttle back wall. The shuttle rear tip should b raised by the picker by about 0.5 mm and simultaneously tilte 1 mm towards the front of the loom, when the shuttle leave the picker.

6. Shuttle eyes and shuttle pegs for tongues should be checke

All the above settings should be checked at the time of bea gaiting or when a new shuttle is provided.

### 15.2.3 Shuttle Inspection of New Supply

Dimensions of the shuttles should be checked agains specifications. The important dimensions are length. Indian Standa BS 2058-1973 gives certain important specification of a shuttl Suitable gauges should be prepared for checking these dimension The grain of the shuttle wood should be fine and the grain lin should be parallel to the shuttle axis. Dimension of shuttle mountin should be also checked. The shuttle material should be checked fo splinter strength (60 - 100 kg/cm² for natural wood and 180-250 kg cm² for processed wood), hardness (natural wood 250 - 400 kg/cm and processed wood 1200 - 1400 kg/cm²), density (0.35 to 0.6 g/cm for dry wood or 0.5 to 0.8 g/cm² for 15% moisture control and 0.9 to 1.20 g/cm² for processed wood), should be checked by samplin technique. Shuttles should be stored in somewhat drier atmospher (with 50 – 60% RH) than in the weaving shed. Seasoning of the wood is, recommended to increase their life. Steeping the shuttles particularly those made of non-compressed wood should be done by dipping in two-third raw and one third boiled linseed oil for a period of two months would be adequate. The shuttles should be placed vertically, in the steeping tank with the eyes at the top then the oil should be run off from the shuttle and fixtures and allowed to dry sufficiently. Such shuttles should be stored in dry place.

All the shuttles must be checked for unusal wear, loose tips, rough surfaces, cracks etc. All these faults have assignable causes and hence remedies could be followed in time.

### 15.2.4 Hand of the Shuttle

Hold the shuttle vertically with the shuttle peg at the top and shuttle top facing you. Shuttle is **right hand** or **left-hand** depending upon whether the front wall is to the right or left of you.



## 15.3 PICKER

Picker is a loom accessory for propelling the shuttle from one box to the other. The durability of the picker depends on the material, design, fitting on the loom, design and construction of other parts and proper manufacturing. The picker should posses the following properties :

| | |
|---|---|
| (i) shock resistance | (ii) high compressibility |
| (iii) wear resistance | (iv) fatigue resistance |
| (v) heat resistance | (vi) low coefficient of friction |

For over a hundred years buffalo raw hide has been acclaimed as the most suitable material for pickers, possessing the required properties mentioned above.

The hide has to be free from defects like sunburn and putrefaction. The important dimensions of the picker are described in BS : 1906-1972. The foot of the picker seems to be the most vulnerable point related to manufacturing deficiency. The spindle hole is another weak point in the picker. The spindle hole becoming oblong suggests the low frictional characteristics of the picker. Greater care is needed to keep check on these two dimensions. Manufacturers and users should prepare suitable gadgets to check these two dimensions accurately. Reversal of the picker in time increases the life of the picker. It is desirable to change the side of the picker before less than half of the service life is picked.

### 15.3.1 Care of Pickers

#### 15.3.1.1 Loom Settings

The pickers must slide freely in the slot of the bottom box plate which should be kept clean. Check strap setting and buffer thickness should be such that the foot of the picker does not strike the ends of the slot. A little oil (preferably coconut oil) applied to the spindle after every two hours prevents the hide from being burnt due to the heat generated by friction. The adjustment of swell spring and the shuttle guide should be such that the shuttle strikes the centre of marked embossed on the picker for this purpose. Buffers should be changed as soon as they lose their shock absorbing capacity. The rejected pickers should be examined to find out whether the damage is due to quality of the material or loom mechanism. The spindle hole, of small, should be bored by a spiral drill 1 mm thicker than the spindle diameter.

### 15.3.2 Inspection of Picker

From each consignment of pickers a sufficient number of randomly chosen pickers should be checked for physical dimensions,