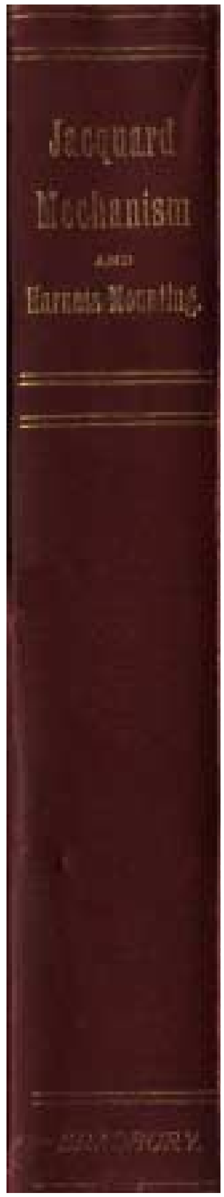
Jacquard
Mechanism
AND
Harness Mounting

Jacquard Mechanism

AND

Harness Mounting

BY

Fred Bradbury.

JACQUARD MECHANISM AND HARNESS MOUNTING.

PRINTED BY

F. KING & SONS LTD., GEORGE STREET,

HALIFAX.

Jacquard Mechanism

AND

Harness Mounting

BY

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PREFACE.

FOLLOWING my usual plan, this work, as the title suggests, treats of only one, but that an important section of Textile manufacture. It is only by adhering tenaciously to this idea that it is possible to deal comprehensively and exhaustively with any of the vital departments of spinning or weaving.

The Jacquard machine is the prime factor in the manufacture of woven figured goods of every description, whether made from cotton, wool, silk, linen or other textile material, singly or in combination, including dress goods, damasks, tapestries, carpets, etc. In this treatise all the chief types and varieties of modern Jacquards used for the above purposes have received some consideration and treatment. No effort has been spared to first obtain a clear conception of the evolutionary developments in figure weaving and in turn to place before the reader in a progressive manner, a clear delineation of the main features of the fundamental and epochal changes in mechanism employed in figure weaving, and subsequently to build on such foundation structure as complete and up-to-date a description of mechanism and mounting as shall be, not only interesting but useful and instructive.

In describing the numerous mechanical details, consideration has first been devoted to the relation and function of each part before attempting any description of its action in combination with its conterminous and remote connections, a plan which, no doubt, the student and reader alike will find advantageous.

The subject is divided into four parts. In Part I., which deals with the evolution of figure and Jacquard weaving the object has been, not so much to describe ancient methods as to draw upon the past to introduce the present ; it is much easier to write on present methods in comparison with past systems since a study of the latter always involves unlimited research and much verification from contemporary sources. Much time has necessarily been spent poring over the pages of the patent specifications and dating as far back as the records in the files of the patent office, but a more certain method of procuring correct and adequate information cannot be conceived. Inventors and inventions, which have laid the foundation of our successes should never be forgotten apart from the fact that past masters in Textile invention cannot be ignored any more than past masters and masterpieces in art ; most things that are good and lasting have their roots reaching far into the past.

No chronological order of invention has been strictly followed since it is more often fatal than helpful to a clear conception and concise explanation of the growth of ideas ; on the contrary, the safer plan of treating the subject according to current order of simplicity has been adopted.

The vital section of the book is in Part II. which embraces the mechanism and fundamental principles of Jacquard weaving, including descriptions with illustrations of all the best standard and special types of Jacquards employed in modern practice. The special and exhaustive treatment of Twilling, Cross border and Index Jacquards it is hoped will merit appreciation.

Typical examples have been selected to illustrate fundamental principles and where more than one example has been supplied, the object has been to demonstrate the diverse methods of clothing the same principle—comparisons being always helpful.

The drawings are chiefly in outline or line diagrams, a mode of elucidation which is necessary in order to show the internal construction of the various machines which the actual framing and supports ordinarily conceal and which in no way affects the principle of the mechanism.

The diagrams have been designed to present as many as possible of the mechanical details and so simplify the subsequent description. They are all original in conception and depiction and have been specially prepared directly from machines of the most recent construction and approved types in modern practice.

Technical trade terms with a local significance and limited expression, while not excluded, have been supplemented by the most general and universal terms.

All the general and fundamental principles of Harness Mounting together with a description of the preparatory processes relating thereto, are fully dealt with in Part III. together with some consideration and treatment of a variety of complex ties, each of which is designed to demonstrate a special feature of mounting and suggest some specific line of thought upon which other "ties" may be conceived and by the aid of which an indefinite number of figured patterns may be produced. The possibilities in harness mounting are so extensive as to leave no room for repetition or multiplication of examples.

The illustrations and treatment of Part IV., which embraces Card Cutting, Repeating and Lacing, have been dealt with upon the same principle as Part II. since it is also largely a description of mechanism and an exposition of how it works.

This treatise will be found to abound in detail, explained largely by the fact that for several years the writer has recorded any thought, observation and result of conversation and discussion and retained his many copious lecture notes, specially prepared for various Textile classes ; hence much of the subject matter has been accumulated over a period of years, most of it valuable for the time and specific purpose, but at this juncture requiring "squaring" and fitting to its place.

In a work of such magnitude embracing as it does innumerable technical details and problems the writer anticipates some slight omissions and may be mistakes, but generally speaking the reader or critic is to be feared least whose knowledge is most extensive.

Comment on the work done by the printers, Messrs. F. King & Sons Ltd., Halifax and the block makers, Messrs. Gilchrist Bros., Leeds, would be superfluous—it speaks highly for itself.

F. B.

September, 1912.

CONTENTS.

PART I.

PART II.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

PART III.

CHAPTER XVII.

PRESS OPINIONS ON 'CARPET MANUFACTURE.'

'Textile Manufacturer.'

"Hitherto there has been no standard book on carpet manufacture and although some works have dealt with it from the designer's standpoint, they have either ignored or barely touched upon the mechanical side. This book therefore meets a long felt want and not only meets it but fills it, for in turning over its three hundred and odd pages we meet with no occasion to criticise adversely .. .. the artistic side has been considered in about seventy pages and the rest of the book is devoted to the manufacture of Brussels, Wilton, Tapestry, Axminster, Chenile, Kidderminster and Scotch carpets. Each type of carpet is taken separately and not only are its various structures illustrated and described, but the various mechanical appliances used in its manufacture explained."

'Textile Recorder.'

"Although we have occasionally come across books on weaving in which certain sections have been devoted to carpet manufacture, we have never, as far as our knowledge serves us known a book which devotes the whole of its contents to this special subject .. The scheme of the book is decidedly good and very clear. ....The first chapter on designing fits into this scheme admirably and possesses many points we have not observed in any previous work. Colour, which forms the subject of the second chapter, is of extreme importance, and its harmonising is something that cannot be taught by books. Mr. Bradbury is quite aware of this, and thus devotes the first few pages of this chapter to a little essay on 'Taste.' It is conceived in a true spirit and should be read with interest."

'The Scotsman.'

"This valuable technical work is obviously the outcome both of an intimate acquaintance with the mechanical processes by which carpets are made, and of experience in expository teaching in technical schools....Clear, full and eminently practical, the volume cannot but prove welcome and serviceable to students in this important industry."

'The Factory Times.'

"..The price of the book is ten shillings but it is worth it; for whether the reader be student or expert it will help by its simplicity of teaching. It contains over two hundred illustrations .. .. the chapter on colour is excellent. The book is most interesting, and can safely be recommended to all manufacturers, designers and managers of carpet factories, to heads of departments and to dyers and textile workers in general. The wealth of illustrations and clearness of description make it a cheap volume."

'The Halifax Courier.'

"..An elaborate work on the above subject .. .. .. It is needless to say that Mr. Bradbury has thoroughly gone into all the mechanical details of his subject and we heartily congratulate him on his clever book."

'Museum and Library Report.'
Textile Industries Dept. Technical College, Bradford.

"Mr. Bradbury's work on 'Carpet Manufacture,' being a quite unique treatise, should claim the attention of all interested in Pile Weaving."

'The Glasgow Herald.'

"The author has handled the various subjects coming under the head of carpet manufacture in a most interesting and efficient manner. The sections on design and colour are excellent and are most suggestive as to the lines along which the intelligent assistant may develop his faculties. The remaining seven chapters treat from the foundation of the structure .. .. An excellent set of illustrations of preparatory machinery, loom parts, etc., as well as sectional diagrams of the various fabrics serve to elucidate the text and greatly enhance the value of this satisfactory work."

'The Publishers' Circular.'

"..In addition to its practical value for manufacturers it will be useful to students in art schools in towns where textiles are not made. It often happens that admirable designs on paper are useless for expression in cloth simply because the artist has not understood the limits within which he must work to make his design suitable for reproduction."

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6. Set systems or various methods of counting reeds and healds.
7. Quantities and weight of warp and weft in plain and fancy fabrics.
8. Weight and cost of woven fabrics.
9. Calculations involved in the analysis and reproduction of woven fabrics.
10. Conditioning or the standard allowances of moisture in textile materials.
11. The construction of woven fabrics (A).
12. The construction of woven fabrics (B).
13. The construction of woven fabrics—angle of curvature considered (C).
14. The construction of woven fabrics—compression considered (D).

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"....An interesting and useful chapter is devoted to the testing of textile materials and the standard allowance for moisture in each kind........Mr. Bradbury's book supplies a kind of information useful to textile manufacturers which, so far as we know, has not been published in anything like the abundance presented in his 'Calculations.'"

The "TEXTILE MERCURY":—

"....The volume contains an abundance of useful information, and should be in the possession of students, teachers, managers, and all persons having to deal with the matters of which it treats."

The "GLASGOW HERALD":—

"....a book which embodies knowledge and experience....and which will prove of great service to the spinner and manufacturer of textile materials.'

The "NEW YORK COMMERCIAL":—

"....A most excellent work."

The "YORKSHIRE OBSERVER":—

"Mr. Bradbury, who is well known in the West Riding....now makes a valuable contribution to the literature on textile subjects. In handy form, though with minute detail, he enters into the various systems of counting yarns, and *the whole field of calculations, for cost, weights, and all technical purposes, is carefully traversed.* The work is divided into twelve chapters, each of which treats on some different system connected with the subject. After analysing and explaining the system in a manner which is easily understood, the author enforces his lessons by a number of examples and tables. At the end of each chapter space is devoted to exercises in the form of questions to which answers are given. By this means the student will be able to test his knowledge as he goes on. It is impossible to give an epitome of the whole book but a few extracts from one chapter will give an idea of the way in which every branch of the subject is treated. In the chapter dealing with 'The Weight and Cost of Woven Fabrics,' details are given full of interest, especially to those who look forward to a manufacturing career, and also to merchants engaged in the sale of textile fabrics......"

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The fabric contains 3600 threads in the repeat, and involves the use of an equal number of individual figuring hooks to produce it.

Part I.

THE EVOLUTION OF FIGURE AND JACQUARD WEAVING.

CHAPTER I.

Origin and Growth of Pattern Design.

In the earliest days it was considered ample to produce woven structures which were useful and durable. These conditions were, to a considerable extent, satisfied by the production of *plain cloth;* subsequently twilled cloth was manufactured, but with the advance of time, increase of knowledge and the development of 'taste,' the desire was created and evolved for the supply of *figure woven textures.* This made it imperative that a shedding mechanism should be introduced which would produce ornamental as well as serviceable fabrics.

Methods of Ornamenting Textiles.

A textile fabric may be ornamented after the cloth is manufactured, or simultaneously with its production. In the former case, the plain cloth is subsequently embroidered (by hand or machine), embossed, printed or painted, whilst in the latter case the principle of ornamentation or figure weaving may be accomplished by one of the following methods.

1. The introduction of variously coloured threads of warp or weft, or both.
2. The arrangement of yarns differing either in quality of material or thickness of thread.

3. The constant variation in the number of warp threads elevated and depressed on each successive shed and shot, so as to alter the order of interlacing the two sets in such a manner as to reveal or conceal and contrast each other, in large or small masses to suit any predetermined effect of pattern.

The Jacquard machine and its predecessor—the draw loom, were invented to produce woven figure effects of pattern of the last type. But while the Jacquard is of comparatively modern conception, the draw loom, with its cumbrous details, dates from remote antiquity, as does also figure weaving. Herodotus* speaks of a curious breast-plate or cuirass, covered with linen, which was sent by King Amasis to the Lacedemonians, and which was highly *ornamented* with numerous figures of animals *woven* into its texture.

Before entering into the details of figure weaving and the mechanical contrivances employed in the modern Jacquard machine for producing the same, it is proposed to explain generally and trace progressively the production of the simpler varieties of structural woven patterns, the fundamental principles of weaving, especially with respect to warp shedding, and finally to indicate the salient features of epochal developments of figure producing machinery.

Fundamental Types of Woven Fabrics.

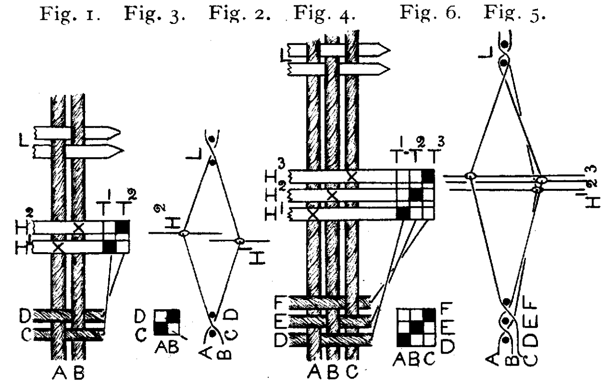
All woven fabrics are composed of two sets of threads, one of which is denominated warp and the other weft; the former is arranged longitudinally and the latter transversely, by interlacing them at right angles in the process of manufacture.

A few examples representative of the chief and standard types of interlacing adopted in the manufacture of the simpler kinds of woven textures are illustrated at Figs. 1 to 30, where plan views, transverse sections and point paper designs are given. These will serve to illustrate the probable line of original development of pattern variety, prior to figure weaving. They are also intended to demonstrate that each warp thread which works differently on any given shot of weft from any other thread of warp in one com-

* Lib. iii., c. 47.

plete repeat of pattern, must of necessity be so drawn through the heddles that it can be controlled independently of the others. *This is a factor of vital importance* which in sympathy with the demand for an increased size of pattern, eventually involved the introduction of the draw loom and the Jacquard machine.

Fig. 1. Fig. 3. Fig. 2. Fig. 4. Fig. 6. Fig. 5.



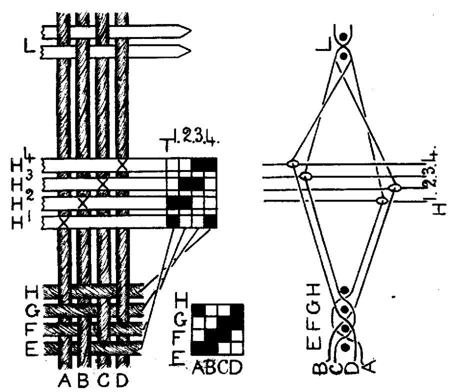


Fig. 7. Fig. 9. Fig. 8.

In all the illustrations from Figs. 1 to 30, the following indications are common.

L = The lease rods.

H^1 etc. = the heddles.

X = The order of drafting the warp threads through the heddles.

T = The order of lifting the heddles, denominated 'tramp,' 'pegging plan' or 'shedding.'

■ = The heddle or heddles for the given shed to be raised.

T^1 = The first 'tread.'

T^2 = The second 'tread,' and so on to the end of the pattern.

FIG. 1 is a plan view of plain cloth, showing its relation to the smallest number of heddles on which it can be produced. A and B represent the warp, C and D the weft threads, and H^1 and H^2 the heddles required.

FIG. 2 is a transverse section through the weft, heddles and lease rods.

FIG. 3 is the point paper design for Fig. 1.

FIG. 4 is a plan view of a three end twill or 'drill.' A B C and D E F indicate the warp and weft threads respectively in one complete repeat of pattern, and heddles, H^1 H^2 and H^3 are requisite.

FIG. 5 is a transverse section through the weft heddles and lease rods. The last two figures demonstrate that three heddles or shedding factors are necessary to produce this pattern, as compared with only two for plain cloth as in Figs 1 and 2.

FIG. 6 is the point paper design for Fig. 4.

FIGS. 7, 8, 9 are plan, transverse section and the point paper design respectively, of a four leaf common twill. A B C D and E F G H indicate the warp and weft threads. Heddles, H^1 H^2 H^3 and H^4 are required.

FIGS. 10, 11, 12 are similar views of a five leaf weft, sateen or satin. A B C D E indicate the warp threads, and F G H I J the wef threads. Heddles H^1 H^2 H^3 H^4 and H^5 are required. For the successive sheds it will be observed that the heddles 1, 3, 5, 2 and 4 are respectively raised, which is the order for the sateen pattern.

FIGS. 13, 14 and 15 similarly illustrate the eight end sateen.

FIGS. 16, 17 and 18 represent a plan, transverse section and point paper design of the heddles, draft and tramp requisite for the production of a 'herring-bone' pattern, which, though complete on eight threads of warp and four shots of weft, requires only four heddles, because there are only four *different* threads of warp in the complete pattern repeat. It is representative of an example of

Fig. 10.

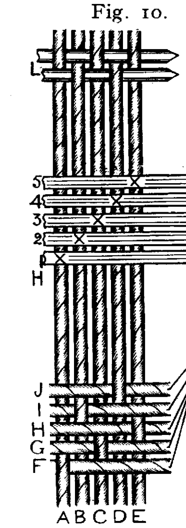


Fig. 12.

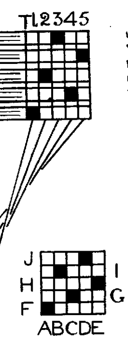
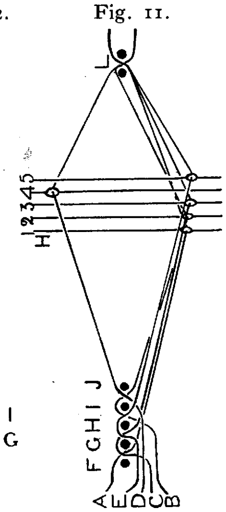


Fig. 11.



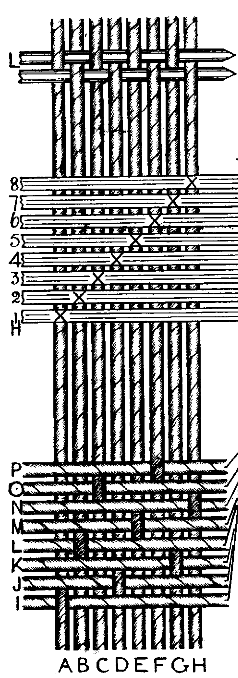


Fig. 13.

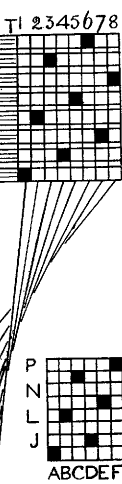


Fig. 15.

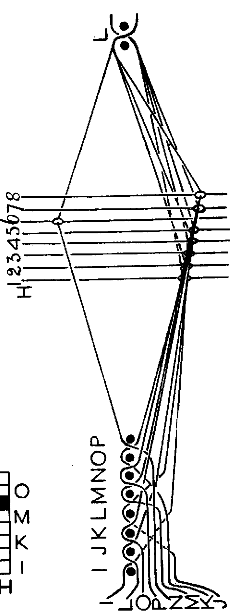
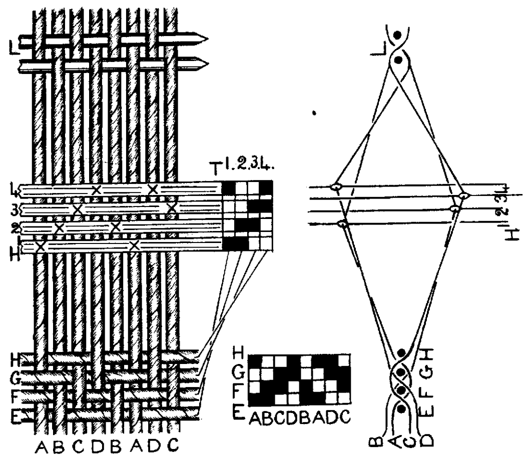


Fig. 14.

probably the first effort to produce variety of effect in the woven texture with limited shedding mechanism.

Fig. 16. Fig. 18. Fig. 17.



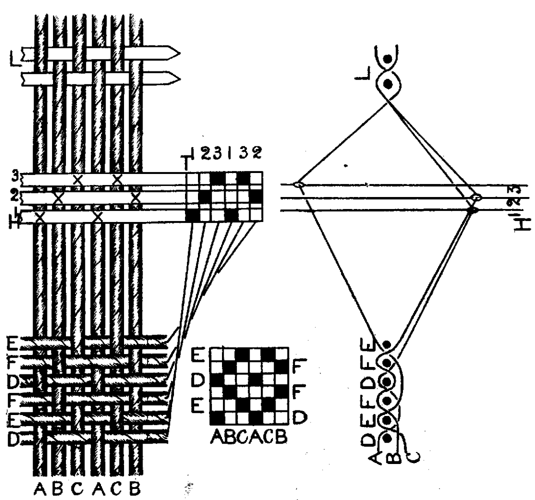


Fig. 19. Fig. 21. Fig. 20.

FIGS. 19, 20 and 21 correspondingly indicate the factors for the standard 'three end diaper;' this type of pattern also belongs to the earliest attempts at *figure* production by means of varying a common weave.

Fig. 22. Fig. 24. Fig. 23.

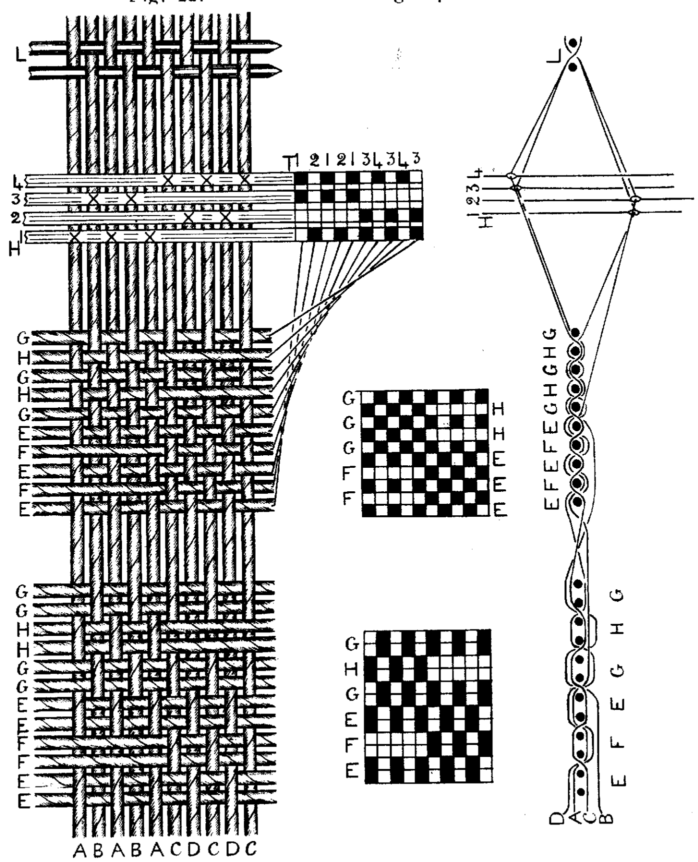


Fig. 25. Fig. 27. Fig. 26.

Figs. 22, 23 and 24 indicate similar details for the 'ordinary huck' pattern; this weave, which is of ancient practice, is also characterised by its departure from the regular twill or sateen type; when finished it possesses a rough or raised surface, which feature makes it very suitable for towelling and toilet purposes. It should be observed that this pattern is made with one shot of weft in each shed.

FIGS. 25, 26 and 27 are respectively a plan, section and point paper design, showing a modification of the foregoing structure where the pattern is produced with the same heddles and draft, but tramped to give two shots of weft in each shed. This modified effect is of more recent origin and termed the 'Devon huck.' The draft for both the huck patterns is the same, but the tramp for Fig. 22 is only given.

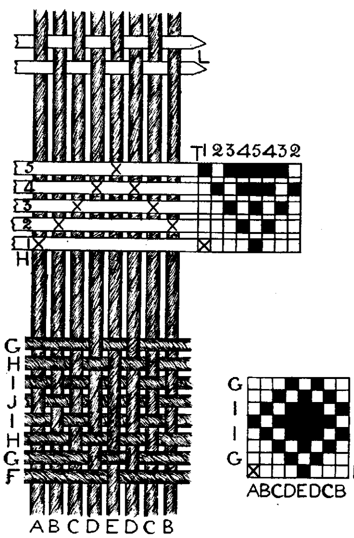


Fig. 28. Fig. 30.

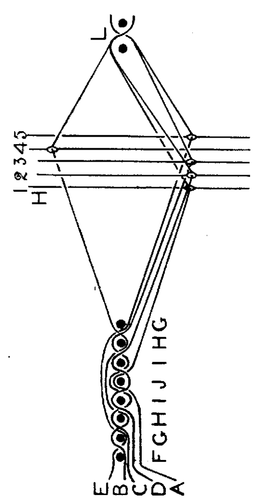


Fig. 29.

FIGS. 28, 29 and 30 show the plan, section and point paper design respectively of another type of modification, composed of tight and loose interlacings, which the predetermined design combines to produce an effect corresponding to the 'honey-comb,' from which the pattern is so designated. The additional rising mark, thus x, on the first end and pick (Fig. 30) is sometimes added to this pattern.

The point paper method of representing the order of interlacing the warp and weft threads is modern, comparatively speaking. It is economical in time and space, and is therefore the only system that can be commercially adopted, but the textile *student* in the initial stages should not fail to make plan views and sections of cloth on the same basis as hitherto demonstrated, as this plan will be found most exhaustive and instructive in obtaining a knowledge of first principles in cloth structure.

From the foregoing praiseworthy attempts at figure weaving with limited warp shedding mechanism, it is the purpose of this treatise to demonstrate not only the principle and development of figure shedding details, but eventually also to show how the most elaborate designs and almost unlimited variety of effect can be produced at the present time with the aid of the most approved types of modern Jacquards—the frontispiece is a fine example to wit.

CHAPTER II.

Fundamental Principles of Weaving.

THERE are three essential mechanical principles involved in the actual weaving of a piece of cloth, viz.:—(1) warp shedding, (2) picking, and (3) beating up the weft to the 'fell' of the cloth. Two other necessary but supplementary motions must be added, viz.:—taking-up the cloth simultaneously with its production, and letting-off the warp in sympathy, or to correspond with the amount of web woven or taken-up.

This treatise is chiefly concerned with the first and most important of these mechanical principles—*Warp Shedding*—and more especially with the manufacture of the class of goods which involves the use of a Jacquard machine to produce the requisite variety of warp sheds.

Warp Shedding.

The object of warp shedding is to divide the warp threads into two portions, producing an upper and lower line of threads; this division is technically known as the "shed." The weft which is contained in a shuttle has to be propelled through this shed from side to side of the loom, so as to interlace and lay the weft threads transversely to those of the warp. The shed must be of sufficient depth to allow the shuttle to travel through it with the least possible amount of friction.

For the purpose of shedding, 'healds' or 'harness' are employed, both of which are free to move in a vertical plane. An important feature in both the healds and harness is a small eyelet, technically called a 'mail', through which the warp thread is drawn. The number of warp threads corresponds with the number of eyelets in the healds or harness. The warp threads normally lie longitudinally and in a horizontal plane, but when the healds or harness are operated by suitable mechanism, they are elevated, depressed or remain stationary according to the requirements of the pattern and type or principle of the actuating mechanism.

Any movement which is imparted to the warp threads should be eccentric, since any sudden or undue strain upon them would result in many breakages. The most satisfactory movement which can be imparted to the shedding mechanism is a slow motion at the commencement, with a gradual increase in velocity until the centre of the traverse is reached, then a decrease in the same velocity ratio. Further it is necessary that the shed should remain open for as long a period as is possible during the passage of the shuttle through it.

There are several fundamental principles of warp shedding, the clothing of which has involved the introduction of numerous mechanical contrivances.

Chief Principles of Warp Shedding.

There are two chief principles of warp shedding, viz. :—'*Closed*' and '*Open*;' the former may be sub-divided into 'centre' and 'bottom' and the latter into 'open' and 'semi-open.'

Closed Shedding is so called because all the warp threads are placed in the same plane at the completion of each shot of weft, irrespective of the position which they must occupy on the succeeding shots.

Open Shedding is so termed because the warp threads remain in their highest or lowest position in the shed for as many shots as the pattern indicates.

Centre Shedding.

In centre shedding the normal position of all the warp threads is a straight line drawn from the surface of the breast beam to that of the warp rail; the shed is formed by an elevation of all the warp threads required to form the upper division of warp and a corresponding depression of those threads which must form the lower. After the insertion of each pick of weft these two sets of threads again meet in the centre preparatory to the next division. This principle is illustrated at Figs. 31 and 32. The former shows the shed, in its normal state, *closed*, and the latter, when the machine is in action or *open*.

A indicates the normal line, where all the warp threads meet, before and after the insertion of each shot of weft; B and C show the temporary positions of the upper and lower lines of warp respectively, during the insertion of weft; Y, the yarn beam; BR, back rail; L, lease rods; H, healds or harness; M, mails; W, plan of web; S, transverse section through the weft; FR, front rail; PR, perforated roller; CR, cloth roller. In this example the shed is formed by causing the upper division B and the lower division C to travel half the distance of the shed in opposite directions, during the period of the pick allowed for the change of *heddles*. This method economises time and power and reduces tension, but it generates a constant vibration among all the warp threads, which constitutes its most objectionable feature.

Bottom Shedding.

In bottom shedding, the mails of the harness, when in their normal position, coincide with the lower divisional line of the warp threads, *i.e.* slightly below a straight line drawn from the front to the back rail. The production of the shed therefore simply involves the elevation of all those warp threads which are required to form the upper division. After the insertion of each shot of weft, they are lowered to the bottom preparatory to each new division. Fig. 33 indicates the normal or stationary position of the warp threads when the shed is closed. Fig. 34 shows the same warp threads when the shed is formed.

A indicates the normal or lower division and B the upper division of the shed; the remaining letters refer to similar parts as shown in Figs. 31 and 32. This type of shedding is not suitable for high speeds; it requires double time to form the shed, increases the *strain* upon the warp threads, and consumes the maximum amount of power. The factors which modify the relative *strain* upon the warp threads during the formation of the shed are:—(1) the size of the shed or distance moved through by the warp, and (2) the time occupied. It is a well known mechanical law that the strain put upon any material will vary in the ratio of the square of the distance moved through, by the body under tension, in a given time.

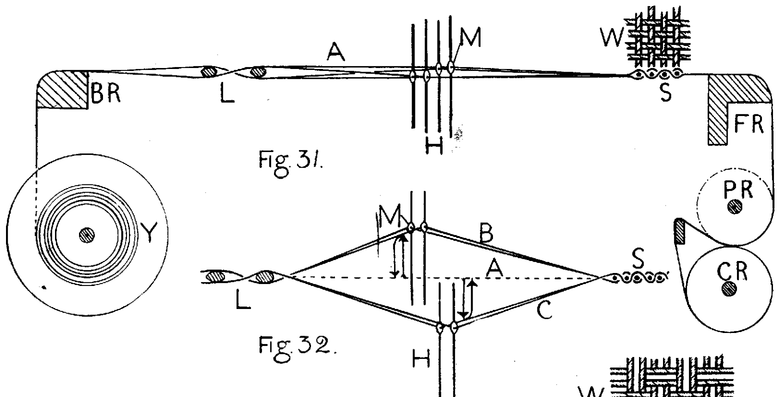


Fig. 31.

Fig. 32.

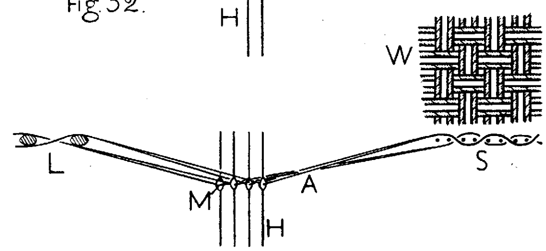
Fig. 33


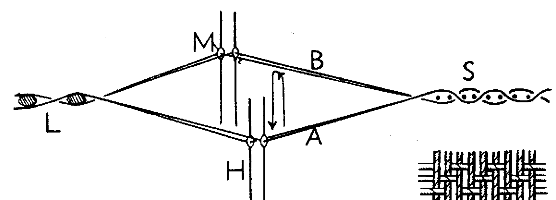
Fig. 34


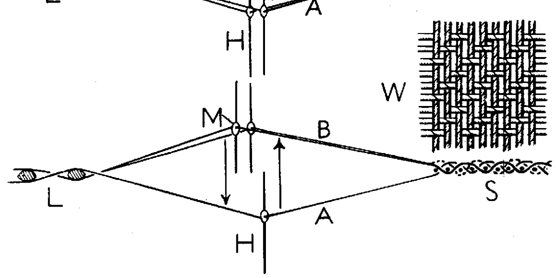
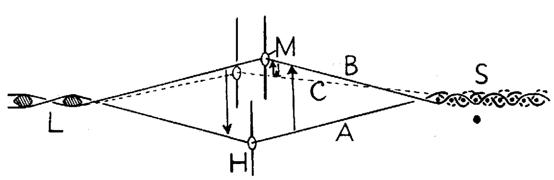
Fig. 35


Fig. 36.


Open Shedding.

Normally, in open shedding, the shed is always open. The threads required to change from the upper line are depressed, while those required from the lower set are elevated and *vice versa* for every new shot of weft (see Fig. 35). A is the lower fixed line and B the upper; the remaining letters correspond to similar parts described in Figs. 31 and 32. This method of shedding economises time, and being of the counterpoise type, also effects a saving of power. It is an ideal system.

Semi-open Shedding.

Strictly speaking, this principle of shedding might be correctly described as *imperfect* open shedding. Normally, the shed is always open and the bottom line of warp is permanently maintained, whereas part of those threads which form the top shed, and which should remain stationary in their highest position for as many picks as the pattern requires, descend about $\frac{1}{7}$ of their normal traverse and have subsequently to be raised to their highest and former position, but those threads which are required to change for a new shot pass directly from the bottom to the top and *vice versa*. This, as intimated, is not a principle but rather a defect of mechanism to which further reference will subsequently be made. Fig. 36 illustrates this method of shedding, A indicates the permanent bottom line, B the upper, and C the position to which the upper line of threads B descends, even though these same threads are required to be up on the next pick. The remaining letters refer to similar parts as before.

Warp Shedding Mechanisms.

There are four mechanical systems of warp shedding, viz.:—Treadle, Tappet, Dobby and Jacquard. All warp shedding mechanisms are either negative or positive. The *negative* arrangement produces movement in the heddles or harness in one direction only, the reverse motion being accomplished by the addition of external mechanism involving the use of springs, weights, pulleys and levers, and springs and levers. The *positive* arrangement controls the shedding apparatus in both directions, without the aid of any external mechanism.

Treadle, tappet and dobby systems are designed for either the negative or positive. All Jacquard machines are necessarily negative in their action upon the warp threads. Single lift Jacquards are constructed so as to produce motion in the upper division of the warp threads only, *i.e.* they produce a 'warp shed' on the closed principle of the 'bottom' type. The depression of the lower division is accomplished by the use of weights or 'lingoes' suspended from the harness cords. Double lift Jacquards clothe the bottom, centre and semi-open principles. The ideal open shed is still a desideratum in Jacquard weaving. The mechanical contrivances adopted in practice to clothe the foregoing mechanical principles are legion; to treat them technically and exhaustively would require many volumes. In this treatise attention will be devoted chiefly to warp-shedding mechanisms as employed for figuring purposes, which machines, combined with harness mounting, represent the most complex of all mechanical devices extant for producing woven figured effects.

CHAPTER III.

Hand Loom Weaving—Treadle Shedding.

BEFORE detailing the principle of figure weaving as practised in the *draw loom*, it is necessary and perhaps more advantageous to consider the salient features of the *hand 'treadle' loom* system of weaving, noting its possibilities, limitations and modifications, which eventually led up to the introduction of the draw loom and development of *figure weaving*. In the earlier types of hand looms, when shedding was chiefly produced by the aid of treadles designed to actuate the heddles through suitable connections, the extent of pattern production during the process of weaving was necessarily very limited.

Hand loom weaving of the treadle order, as a commercial enterprise, has undoubtedly passed the zenith of its days. It will, however, always be used for specific purposes, such as weaving very fine and light cambrics and figured goods of silk and linen material. It should also be given a place in the weaving section of all technical institutions. Students who desire to obtain a thorough knowledge of the process of weaving and the production of cloth will find it of considerable advantage to first study the constructional details of the original hand 'treadle' loom, and where possible, produce their first patterns on this type of loom, since every movement requisite in the manufacture of a piece of cloth, thus having to be performed actually by the students' own efforts, must of necessity be conceived, considered and allowed to dwell in the mind a sufficient time to make it their own, which could not obtain in the case of the power loom where so many of the motions are automatic and repeated in rapid succession.

Fig. 37 is an illustration of a hand 'treadle' loom mounted with four heddles complete for weaving, with treadles on the *centre* principle of the *closed* shed type. It was upon this type of loom that all the subsequent improvements for figure weaving were made, from simple and complex treadle shedding to the draw loom and Jacquard machine. The letters A, C, E, G, H and K in this sketch refer to corresponding parts, illustrated and described in the detailed sketch Fig. 38, which represents in elevation and partly in perspective the essential features of a treadle loom containing 8 heddles and 8 treadles, and while it further demonstrates the whole principle of

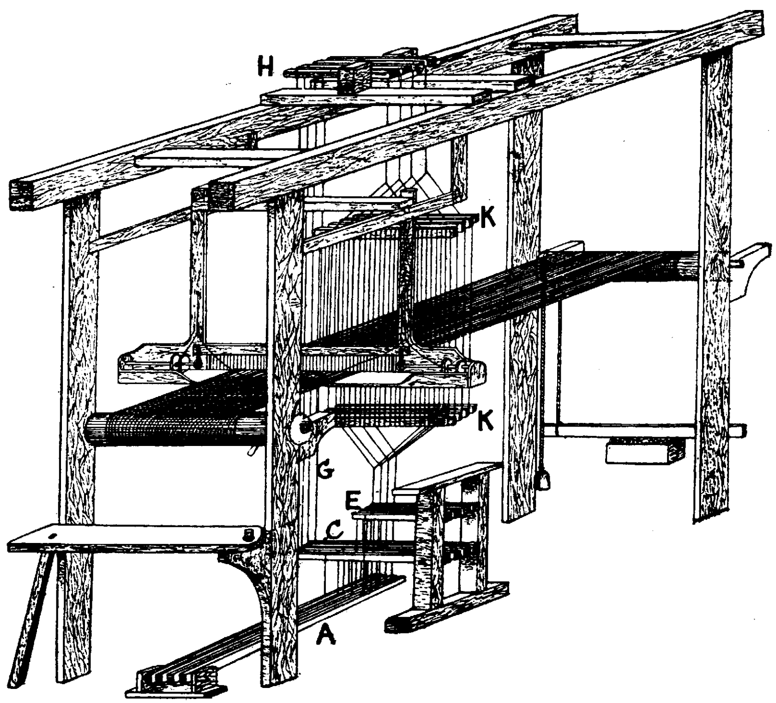


Fig. 37.

this system of weaving, it also forcibly illustrates its limitations. A^1 to A^8 indicate the treadles, each of which is free to oscillate about the fulcrum pin B. C^1 to C^8 are long levers fulcrumed at D; these were commonly called 'marches.' E^1 to E^8 are short marches free to move about the point F. G indicates connecting cords between the levers C and H. H^1 to H^8 are known as 'jack' levers, sometimes called 'coupers'; they are pivoted and free to oscillate about the stud I. J^1 to J^8 are denominated 'bow' bands; they connect the jack levers to

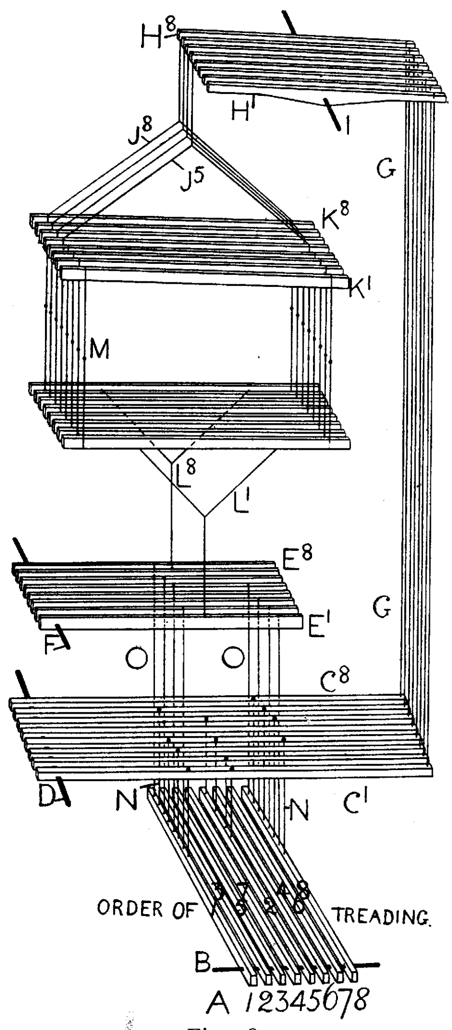


Fig. 38.

the heddles, K^1, K^8 as shown. The lower staves of the heddles are similarly connected by bow bands L to the short levers E in corresponding arithmetical order. The heddle, harness and mails are shown at M.

Each treadle must be so connected that it can, independently of all the rest, control and operate *all* the heddles to form the required shed. Consequently there must be as many treadles in the loom as there are different shots in one given repeat of pattern.

The point paper design of the required pattern is shown at 39. The order of drafting is straight, as shown, together with the tie-up at Fig. 40. The manner of connecting the treadles to elevate or depress the heddles is termed 'tieing-up' or 'cording'; the first and last shots or treads only of this pattern, are shown tied-up to both the long and short levers C and E (Fig. 38). This is to simplify the illustration. Referring to the first shot of the pattern it will be observed that the warp threads 1, 3, 4, 7 are required to be raised, and since these are drawn respectively on to the corresponding heddles, separate cords are connected between No. 1 treadle and the long levers C 1, 3, 4 and 7, which through their connections are free to elevate the corresponding heddles whenever the weaver presses this treadle down. The same treadle is also shown connected to the short levers E 2, 5, 6, 8, and through their attachments to the underside of the corresponding and respective heddles, it is free to operate and depress them in sympathy with the elevation of heddles K^1 K^3 K^4 K^7. Passing over to the eighth shot, the method of connecting the cords with the eighth treadle is as follows. The eighth pick or shot on the point paper design indicates that warp threads Nos. 4, 6, 7 and 8 require to be lifted, and since these have been drafted on to the corresponding heddles it is first necessary to connect the long levers C 4, 6, 7, 8 to the given treadle A^8, by which means the corresponding heddles can be elevated. The remaining four heddles 1, 2, 3, 5 have to be depressed, and they are therefore shown connected to the short levers E 1, 2, 3, 5, which in turn are corded to the same treadle A^8. For the second shot of this pattern the treadle is only shown connected to the long levers C 1, 2, 4 and 6, which require to be operated to lift the corresponding and respective heddles and warp threads. It will now be evident that when a *long* lever is *not* connected with any given treadle, the corresponding *short* lever must be corded to it, so that it can be depressed to form the bottom shed; hence when the order of tieing-up or cording requires to be indicated to suit any specific draft and pattern it is only necessary to mark the connections between each respective treadle and *long* lever.

This plan is illustrated at Fig. 40, where the heddles are shown at K^1 to K^8. The order in which the warp threads are drawn through these heddles is indicated on the left hand side of the sketch, and the 'tie up' and order of treading at the right hand side. The treadles are shown at A. The X's denote that the particular heddles are connected to the *long* levers (C Fig. 38) of corresponding numbers. These long levers in turn are tied up to the treadles in order of *picking* or treading, through the action of which they operate on the jack levers (H Fig. 38) to lift the requisite heddles on each pick.

No marks are put on the remaining heddles, since it will be understood that they must of necessity be depressed and therefore linked with the corresponding *short* levers.

It is not essential that the treadles be connected in arithmetical order; they may be connected to the 'marches' to suit any desired plan which will facilitate convenience of treading and production and variety of pattern, *e.g.* at Fig. 40 the order of tieing-up for pattern, Fig. 39 has been arranged so that the weaver can work the treadles with the left and right foot alternately; all the odd treads are on the left, and the even on the right hand side of the weaver.

An important feature in treadle weaving is that when once the 'tie-up' has been completed, several different effects of pattern can be produced without any further alteration of the loom mechanism or the tie-up—the weaver simply changes the order of operating the treadles. By working the treadles as at X Fig. 40 the pattern at Fig. 39 is produced; when the order of treading is changed as indicated at Y Fig. 40 the pattern produced is a perfect stripe composed of the $\frac{3}{1}$ and $\frac{1}{3}$ twills, as pattern Fig. 41 (which it should be observed consists only of the first four shots of the original pattern Fig. 39), four treadles out of the eight only being used. When the order is further changed to the scheme shown at Z Fig. 40, a mat effect is the result, and two out of the eight treadles are only necessary. This pattern is supplied at Z (Fig. 42).

It has now been fully demonstrated that the simplest kind of cloth, such as 'plain' and its modifications, required the use of only two mechanical units or factors, the construction and operation of such

Fig. 40.

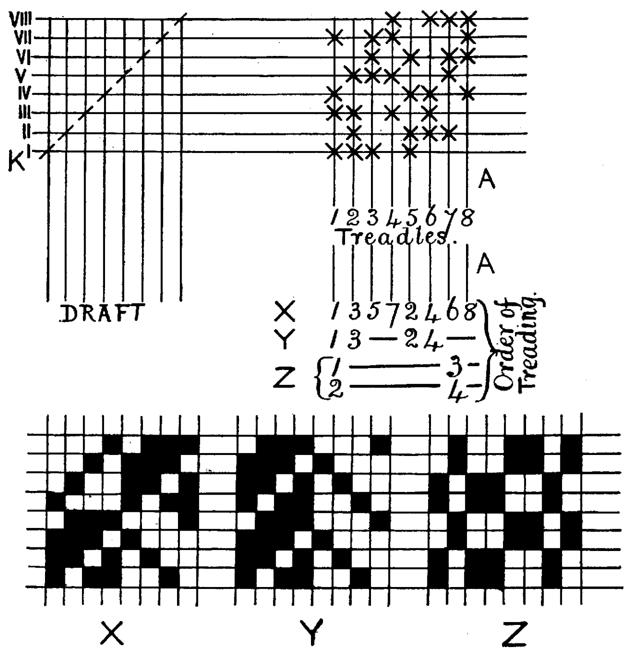


Fig. 39. Fig. 41. Fig. 42.

apparatus being fundamentally simple. For purposes of increased strength and effect of surface, the interlacing of the warp and weft yarns took a different form, involving an increase in the number of warp controlling unit factors, *e.g*, when the repeat of pattern contained 3, 4, 5, 6, 7 and 8 threads of warp, its production involved the use of respective and corresponding numbers of mechanical parts, which had to be free to permit of their being independently controlled.

Factors in Pattern production in Treadle Weaving.

The possibilities of pattern production with the foregoing mechanical aids, simply consist of mechanical repetition of all patterns, whether simple or complex in design.

All patterns in which the repeat is small can be woven by the aid of heddles controlled by treadles or 'witches' in the hand loom, and tappets or dobbies in the power loom. The possibility of pattern production by the use of heddles in some respects is considerable, especially when combined with special *drafting* and *tramping* which in former times was carried to a fine art—the warp threads being so drafted, arranged and repeated, and the treadles so corded and worked, as to produce the best fancy effects with the least number of heddles and treadles. Even after the draw loom and harness mounting had been long in practice, many fancy patterns were preferably woven with heddle and treadle mounting. The importance of tying-up was so considerable that all the complex woven patterns depended principally upon the arrangement of the ties, and the better the weaver was skilled in the art and intricaties of drafting, the further he increased the possibilities of pattern production. The increase in heddles and treadles, and especially when grouped in two or more tiers for diapers and drafted patterns generally, involved the use of more treadles than could be conveniently worked, and since the number which could be so manipulated was necessarily limited, and rarely exceeded eight, it soon became evident that other contrivances must be adopted if the weaver were to successfully cope with the growing demand for variety of pattern. The number of heddles and treadles required to accomplish the production of patterns where variety was extensive, would be so great that one man could not possibly manage to work the treadles with his feet, and the number of heddles could not possibly exceed the space limits of the loom, and at the same time produce the depth of shed necessary to allow the passage of the shuttle through it. Various methods were adopted to work as large a number of heddles as possible—as many as ninety, involving the use of external mechanical aid, were not uncommon for weaving some of the finer silks and old diapers in the early part of the 19th century. The shafts for this purpose were about $\frac{1}{8}$ inch thick and arranged in three tiers of different depths to prevent the staves touching each other, when the sheds were opened.

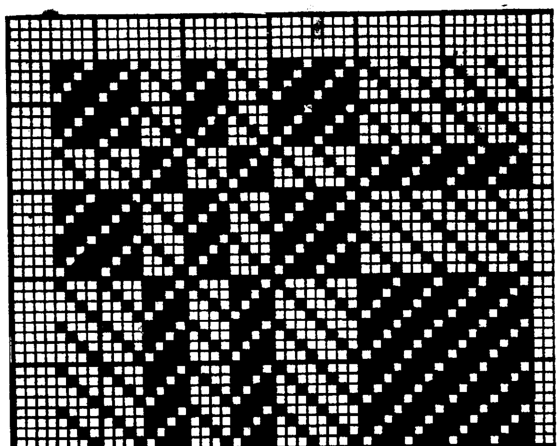


Fig. 43.

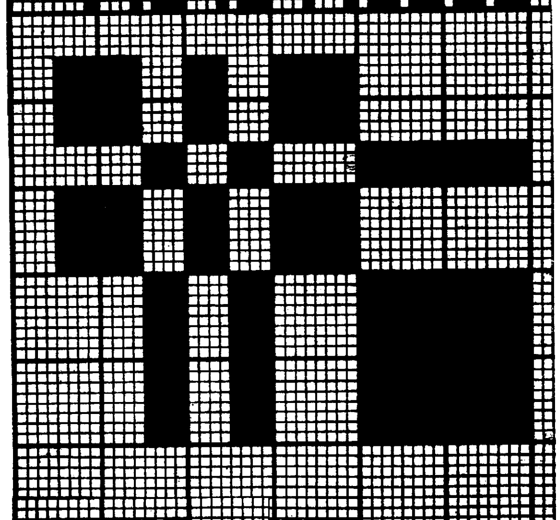


Fig. 45.

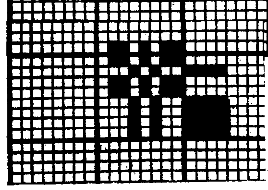


Fig. 44.

Old Diaper Patterns.

Fig. 43 supplies a point paper design of a class of patterns known as the old diaper type. This style is in reality an attempt at figure weaving by mechanical expansion, repetition and re-arrangement of elementary weave effects. It is representative of a system which was once extensively employed, especially prior to the introduction of the Jacquard machine. The pattern under consideration is developed from the small fancy mat weave, Fig. 44, which is used as a base; each square of warp and weft is then made to represent four threads of warp and weft. The block plan pattern as enlarged is shown at Fig. 45. There is no limit to the number of threads of either warp or weft which each square in the base design may be made to represent; it is only determined by the size of pattern required. When the base weave is thus enlarged and blocked out, the contrasting masses of warp and weft are too large to intersect with each other and at the same time produce a firm texture. The floating masses of warp and weft must be bound down in some regular twill or satin order. It is probable that this old block plan of weave development was the first cause which led to the introduction and practice of passing the warp threads in groups of 2, 3, 4, 5 or 8 through the mails of the back harness, and then separating them and passing them individually through the mails in a set of front heddles called pressure heddles, which had to be worked once over as binders to each separate lift of the back harness. It will therefore be apparent that this plan increases the figuring capacity of any shedding mechanism, a number of times equal to the number of threads drawn through each mail on the back set of heddles or harness.

It is important to note that the pattern supplied at Fig. 43 can, by special drafting, be woven on eight heald shafts. The student might with advantage work out the draft and tramp or pegging plan to weave this pattern on the reduced number of heddles.

Combined Treadle and Twilling Mechanism.

The following method of duplex warp shedding was designed with the object of reducing the number of treadles to a minimum when weaving old diaper and similar varieties of patterns, where the warp threads are first lifted in blocks of *three*, *four*, or *five*, with only *one* out of each group left down for binding purposes and conversely one out of each group of threads, lifted in the remaining parts of the pattern.

Fig. 46 shows a front elevation of the shedding and twilling mechanisms, employed to weave a pattern on twenty heddles but involving the use of only five treadles.

Fig. 47 is a side elevation of the twilling details.

The same letters and numerals in each diagram refer to corresponding parts.

A represents the top front rail which supports the principal parts of the shedding apparatus. B and C are supports for the principal and secondary jack levers (coupers) respectively; the usual series of jack levers are indicated at D^1 and pivoted to the support B as shown. The secondary series of jack levers E^1 are similarly supported and pivoted to the supports C. From the ends of D^1 and E^1 cords F and G respectively and successively connect the jack levers to the heddles H, by which means the heddles are supported and elevated as desired. Weights I are suspended to the heddles to normally depress them after they have been raised, thus obviating the use of short "marches."

The five treadles are indicated at J^1 to J^5. A corresponding number of cords K^1 to K^5, connects each respective treadle and then passes through a perforated guide board L, and through the warp and heddles to an upper set of levers M^1 to M^5, which correspond to the ordinary "long marches," but are placed above instead of below as in the ordinary treadle loom.

The five levers M^1 to M^5, are pivoted at X. The march lever M^1 is shown directly connected by tight cords N^1 N^2 N^3 N^4 to the *first* of each respective series of jack levers, D^1 to D^4. Three slack cords O^1 and duplicate groups O^2, O^3 and O^4, are suspended from the *second*, *third* and *fourth* jack levers respectively of each series, D^1 to D^4. Each group of three slack cords is looped to respective small rings P^1 to P^4, from which a corresponding number of cords

Y^1 to Y^4, passes down through the lever M^1. The *fifth* jack lever of each series is unattached in any way with the march lever M^1.

Similarly the march lever M^2 is connected with the *second* jack lever in each series from D^1 to D^4, the march lever M^3 with the *third* jack lever in the series D^1 to D^4, and so on with march levers M^4 and M^5.

There are four distinct groups of *slack* cords for O^1, O^2, O^3 and O^4, combined with each of the march levers M^2, M^3, M^4 and M^5, *e.g.*, the third, fourth and fifth jacks in each series D^1 to D^4 are combined with M^2; the fourth, fifth and first in each series D^1 to D^4 with M^3; the fifth, first and second in each series D^1 to D^4 with M^4, and the first, second and third in each series D^1 to D^4 with M^5. The remaining jack levers unattached to march levers are the first jacks in each of the series and M^2; the second jacks and M^3; the third jacks and M^4, and the fourth jacks and M^5.

For the complete order of tying-up, see diagrammatic representation (Fig. 50).

The four cords, Y^1 to Y^4, after emerging from the underside of the march lever M^1 are passed up through a grid box Q of which a plan is supplied at Fig. 48. They are next combined with intermediary and adjustment levers R which are in turn connected to the levers S which are virtually the *twilling* levers, and are pivoted as shown to the fixed support T.

Suspended from the opposite ends of levers S are knotted cords U, with handles V fixed at their lower extremity.

The parts O to V, inclusive, are repeated in duplicate for each march lever M^2 to M^5.

The cords U pass through a special perforated trap board W, a plan of which is shown at Fig. 49.

Action of the Combined Treadle and Twilling Mechanism.

The weaver begins by pulling down the cords U, as required by the pattern, until the knots are below the underside of the board W, when he places them under the narrow slits. In the given Fig. 47, the cord U^4 and the left arm of lever S^4 are depressed so as to draw tight the cords Y^4 and O^4 as shown. The treadles J^1 to J^5 are then worked once over, and these in turn depress the levers M, which through the medium of the cords N, depress one out of each group of the series of jack levers D^1 D^2 D^3 D^4 and through these elevate the heddles.

In group D^4, where cords O are tightened as already described, the march lever M^1 as it descends pulls in sympathy the first four jack levers in D^4. The shed thus formed gives one warp and four weft for the first fifteen shafts, and four warp and one weft for the last five shafts. By working over the remaining four treadles in twill or sateen order, a like warp and weft twill stripe will be produced, which can be repeated as often as desired.

Fig. 46.

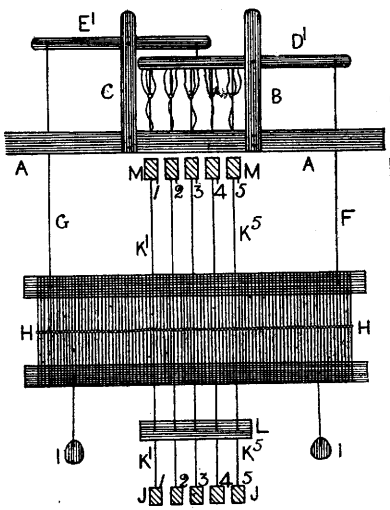
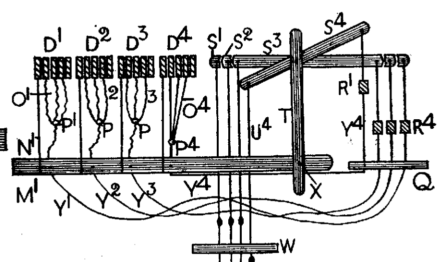
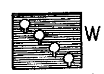
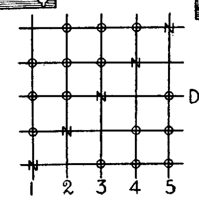


Fig. 46.

Fig. 47.







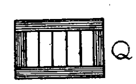


Fig. 49. Fig. 50. Fig. 48.

If now it be assumed that *all* the cords U are depressed and the knots placed in the narrow slits of the board W, where they may remain for as many repeats of the twilling weave as desired by the predetermined pattern, then through the connections described above, the slack cords O will be drawn down tightly to correspond with those of N, so that when any one of the treadles J is depressed it will operate through its connections described to depress the lever

M^1 together with four out of every five of the jack levers D, and thereby elevate this series of heddles and produce a pattern of four warp and one weft on the surface of the cloth.

If however all the cords U are released, the cords O will be normally slack, so that if any one of the treadles J is depressed it will through its connections draw down march lever M and the tight cords N (the slack cords O being unaffected), and one jack lever D out of each group, thereby elevating only one heddle out of every five to produce a pattern of one warp and four weft. Between these two extremes, any variety of pattern can be produced.

It must of course be understood that the order of connecting the treadles E with the marches M is designed to depress the latter, in simple order, one at a time, whereas for the block figure pattern the tight and slack cords will vary in their arrangement of attachment to jack lever D according to pattern, so that a different selection of heddles may be raised on each of the five successive shots of weft. The cording plan of this arrangement is illustrated at Fig. 50. The *first group* of jack levers is represented by the horizontal lines D, the tight cords N and the slack cords O; the march levers M by the vertical lines 1, 2, 3, 4, 5. The remaining three groups of jack levers are corded in exactly the same order and hence not repeated.

It will now be manifest that by increasing the groups of heddles, or number in each group, the figuring capacity for diaper and like patterns can be extended in multiples according to the number of jacks in each group.

This invention, which was the prototype of 'pressure harness' or 'shaft mounting,' is an example of an indefinite number of attempts, many of them successful and full of ingenuity, to overcome difficulties presented by the ever increasing desire for variety of pattern.

CHAPTER IV.

The Draw Loom.

THE 'draw loom' represents the first real attempt at 'figure weaving,' beyond the reach of treadles and eventually of heddles. It had its origin in the East in prehistoric ages, and was introduced into the West so long ago that even the date is uncertain. There is no authentic record of its introduction into England; tradition fixes the period at or about the middle of the 16th Century, when, through the persecutions of the Duke of Alva, the Dutch and Flemish weavers fled from their homes and found refuge in England.

The working of the draw loom *originally* required the constant attention of two persons, one of whom—the 'draw-boy,' raised the heddles, or their equivalent, in the requisite order of succession, by pulling cords connected to the various heddles in the order of succession as required by the tramping of the pattern, while the other performed the usual operation of weaving.

The 'draw boy' was used both for heddle and harness weaving; it would be difficult to determine with which type of mounting he was first employed, though very probably he was originally used with heddles when they so increased in number as to be uncontrollable by the weaver. The first English patent record which I have been able to trace bears the date 3rd October, 1687. The following is an exact copy from the file of patent specifications No. 257 bearing the above date:—

"Joseph Mason of our citty of Norwich invented An Engine By the Help of which a weaver may pforme the whole worke of Weaveing such stuffe as the greatest Weaveing Trade of Norwich doth now depend upon without the help of a draught boy which engine have beene tryed and found to be of Great Vse to the said weaveing trade."

In the year 1727, June 1st, James Christopher Le Blon obtained a patent No. 492 in which he claimed to have discovered, "The art of weaving Tapestry in the loom, a secret never practised before ....and which will be extremely beneficial to this our kingdom if carried on with effect."

Details of the Draw Loom.

The essential features of the draw loom combined with harness mounting are illustrated at Fig. 51, which is a sectional elevation showing one front row of the harness cords together with its connections. These cords were gathered into groups to correspond with the number of warp threads which required to be woven the same way according to the pattern, each group being equivalent to an ordinary heddle with its complement of mails and cords.

A represents the cords, denominated 'harness,' B the necks or leashes by which each group (as above) is free to be supported and operated, C is a perforated board, four or five inches in depth, and slightly longer than the required width of the web—technically termed the comber-board; the perforations in the board must equal at least the number of warp threads and harness cords; they are equidistant for the subsequent purpose of distributing the warp threads evenly in the web. At D the harness cord is double, being looped through the mail F and then taken upwards through the board and knotted above it as at E; suspended from mail F through the medium of a cord G called the lower coupling is a tension lead weight H called the 'lingoe,' the purpose of which is to keep the harness cords and warp threads normally in their lowest position when not required to be elevated. I is a crossbeam supported on the framing at the top of the loom, and combined with its duplicate, supports a box J, known as the pulley box; the pulleys are arranged on an inclined plane as shown at K; passing individually over these pulleys are a series of cords L, technically termed *tail cords*. These are attached to the necks of the harness and after passing over the pulleys in the pulley box, they are shown attached to the position at M which represents a stick, denominated the *tail stick*, which is secured to or near the ceiling, about 20 feet from the loom. A lease is formed in the tail cords at N, which are then grouped into

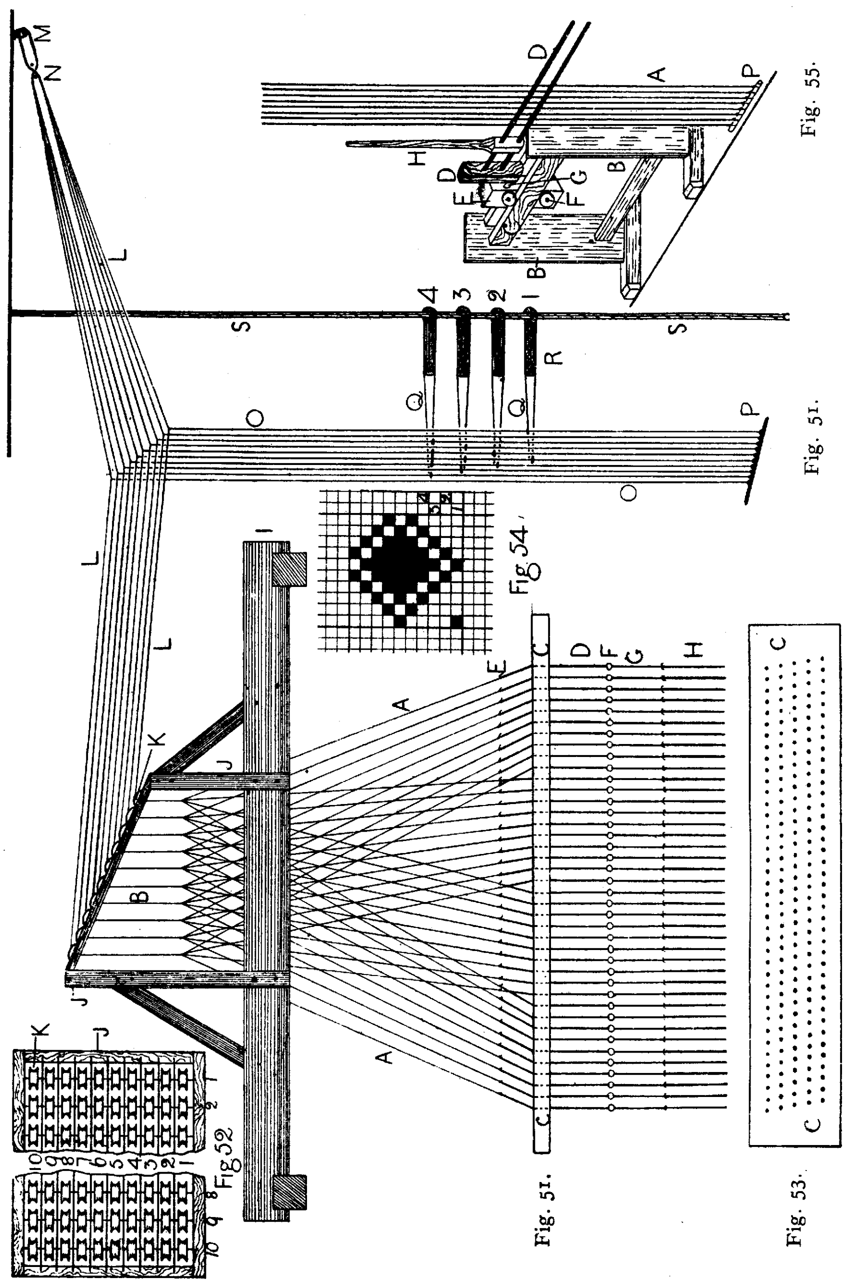


Fig. 51.

Fig. 51.

Fig. 53.

Fig. 55.

small lots of about five tails each and fastened at equal distances apart, around the tail stick M, so that they approximately occupy a space equal to that of the full complement of the tail cords.

Only one out of ten rows of pulleys and tail cords is shown which represents a figuring capacity of 100, being at that time a common number. The remaining nine rows of pulleys, etc., are duplicates of the one illustrated. To each tail cord L is suspended a cord O formerly called a '*simple*' or '*symbolt*'; these are arranged in parallel lines and are fastened to a stick P near the floor of the room. Similarly all the remaining harness, tail cords and simples were duplicated until the full complement of cording was completed according to the demand of the figure to be woven. In some instances for fine linen damasks, the number of harness necks and tail cords reached 1000. It will be perceived that by drawing or pulling any group of simple cords O, they in turn will draw down the tail cords L which will elevate the neck B, harness A, mails F and warp yarns to form the upper division of the warp shed, *i.e.*, a shed on the bottom and closed principle. It was therefore upon the 'simples' that the pattern was 'lashed' as it was then styled. It consisted in passing the lash twine Q (8 to 12 inches in length) round the simples O as indicated by the pattern on the point paper, for any pick or particular shed; each loop was called a '*tack*, and the complete number of tacks necessary for each shed was designated a '*lash*'—one lash was therefore equal to one treadle and one shot of weft. The ends of the lash cords were connected to small pieces of strong twine R called '*heads*' (9″ to 10″ long), which were doubled and formed into loops or nooses and through each a strong, vertical 'gut' cord S passed, being suspended from the ceiling and fastened to the floor. Upon this gut cord the 'heads' with their respective lashes were arranged in consecutive order for the requisite shedding, each head being free to slide up or down the gut cord when necessary. When the pattern to be woven was small, one gut cord was ample, but for larger patterns two or more were used, in which case the heads were attached to the cords alternately when there were two, and in corresponding order when three or more.

Coloured work always required one gut cord for each separate colour. For 'covered' colour work, each colour required a separate lash and these were linked together, for every given line of weft, by a small cord called a '*bridle*.' Each lash therefore represented one colour and *one* tread, but the bridle represented all the colours and requsite treads in one line of weft.

Plan views of the pulley box and comber-board are shown at Figs. 52 and 53 respectively.

Principle of Lashing the Pattern.

A small pattern is given at Fig. 54 by the aid of which the principle of lashing the pattern will be explained. On the first shot of weft, threads 1 and 6 require to be lifted, therefore the lash twine Q is tacked behind the corresponding simples O and then fastened to one of the heads R. On the second shot of weft, threads 5 and 7 require to be raised, therefore simples 5 and 7 must be lashed in a similar manner. For the third shot, simples 4, 6 and 8 require to be lashed; for the fourth shot, simples 3, 5, 6, 7 and 9 must be lashed, and for the fifth shot, simples 2, 4, 5, 6, 7, 8 and 10. The first four of these five shots are shown lashed to the simples at Q, Fig. 51. The lashing of the simples for the remaining shots is treated in the same way, and whether the pattern capacity of the machine be large or small, and the number of simples few or many, the process of manipulation is the same and requires no further demonstration. Provision was made on the lashing frame, so that when the lash cords were drawn or pulled by the draw boy, the simples to which they were looped were all depressed a like distance, so that a shed of uniform depth was formed. The work of the draw boy consisted in drawing each lash on the simple in succession. He grasped the threads of the simple and separated them from the rest, then pulled them down so as to operate on the tail cords and raise the requisite harness cords with the warp threads, to form the shed through which the shuttle was propelled.

Mechanical aids for the Draw Boy.

With frequent use it was evolved that the shedding capacity of the draw loom could easily be increased to meet the growing demand for variety of pattern, consequently when the number of 'simple cords' was increased from 100 to 200, 300, 400 and over, it became evident that some mechanical means must be devised to assist the draw boy to control the increasing number of simples, together with the corresponding tail cords, necks, harness, warp threads and lingoes, apart from the increase of friction generated by the multiplicity of cords. The most important invention designed for this purpose was a fork and lever mechanism, constructed to travel to and fro in a lateral direction on a carriage, so that when the lash coupled with the required number of simples was drawn forward by hand, one rod or leg of the fork was made to pass behind and the other leg in front of the selected simples. The fork lever was then brought forward by hand, which caused the forks to turn about their common centre and simultaneously depress the selected simples on the given lash for one figuring shed. This invention dates from the beginning of the 17th century; it is supposed to have been designed by M. Dangon about the year 1606.

The chief features of this apparatus are illustrated at Fig. 55. A represents a few of the simples of the usual draw loom, B a fixed frame carriage, C the carriage rails. A fork D with two prongs is supported to a movable carriage E, with antifriction pulleys F as shown. The fork D is free to turn about the carriage E at the point G, and the carriage E is free to travel inwards and outwards at will along the carriage rails C. A hand lever, as shown at H, is secured to the fork D by the use of which the fork can be vibrated. The mode of operation is as follows:—The lash twine with its complement of simples is first selected by the draw boy and drawn a sufficient distance forward to allow the top prong of the fork D to pass through the opening thus formed into the simples, instead of grouping these by hand as heretofore; lever H on being depressed rotated in sympathy with the upper prong of the fork, by which means the simples were held downwards until the weaver inserted the shot of weft or until he worked over all the heddles, when they were combined with the harness for twilling the figure. The draw boy had ample time to bring the lash twine for each tread over the fork lever, preparatory to producing the figuring shed, with all those cloths where the weaver had to tramp over the treadles for the twilling details, but with full harness mounting and one shot for one warp thread, the boy had to lose no time in the performance of his duties.

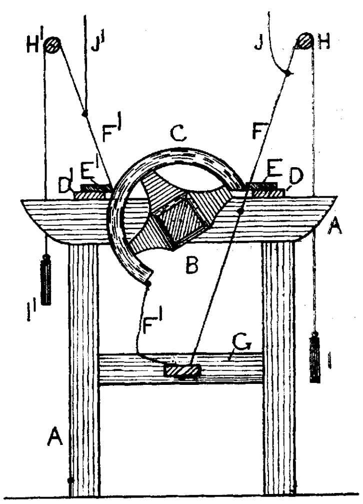
Mechanical Draw-Boy.

The next important and epochal advance was the introduction of an apparatus which altogether displaced the human draw-boy. It automatically selected in successive order the required tail cords or their equivalent, which controlled each figuring shed. There were many mechanical contrivances conceived and attempted to attain the above object and relieve the weaver of much physical and mental effort in the production of special weaves and figured patterns. The most important of these was a small apparatus, placed on one side of the loom and heddles or harness, called the 'Parrot or Pecker,' which was brought into general use in the year 1807. It was afterwards denominated the 'draw-boy,' since it actually performed automatically, the work the boy had done.

It not only successfully saved the labours of one attendant, but it performed the sequence of operations with unerring certainty, and so removed all possible chance of pulling a wrong string and consequently lifting the wrong series of warp threads—a mistake of frequent occurrence so long as the work was performed exclusively by human agency.

It must not be assumed however that this was the first mechanical draw-boy introduced, nor yet the only one adopted, but inasmuch as it embodied all the best features of the several inventions of this kind it has been selected as the type to illustrate the process of evolution in mechanism used to produce the most comprehensive patterns, and though now out of date, it serves to display the ingenuity that was exercised in past days. *The most singular feature in the long series of inventions is, that most of the improvements were designated to operate on parts of mechanism considerably remote from the object to be controlled.* The essential features of this mechanism are given at Figs. 56 and 57, the former shows a sectional elevation and the latter a plan. The same letters in both illustrations refer to corresponding parts. A represents the frame supports at one end only, the duplicate is indicated at A^1, Fig. 57. B represents a square prism, free to oscillate between the frame supports $A.A^1$. C is a grooved segment pulley secured to a sliding carriage placed on the square prism B, designed to oscillate with it, but free to be moved laterally from end to end. D D^1 are wood rails connecting the frame supports A A^1; secured to these wood cross rails are perforated brass plates E E^1; through each of these perforations knotted

Fig. 56.



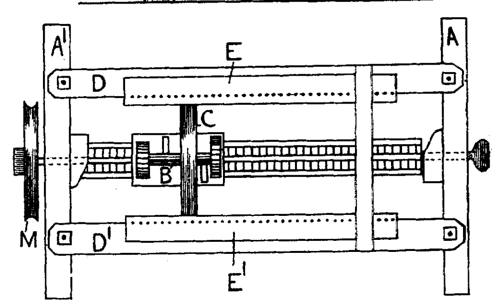


Fig. 57.

cords F F^1 are alternately passed, one end of each cord being secured to the cross rail G, whilst the other end after passing through the perforation is carried over a rod H and kept in tension by a weight I; the rod H is suspended by cords from the ceiling. A second cord J J^1 connects the cords F F^1 in respective order to a series of tail cords L,

Fig. 51, according to any required pattern. Near to one end of the square prism B is fixed a small rope pulley M; two cords are fastened to it, one on each side of the wheel pulley. The cords are then individually connected to two treadle levers which can be operated alternately by the feet of the weaver. The alternate treading of these levers causes the pulley M, prism B and 'pecker' or segment wheel C to oscillate first to the right and then to the left. In each string of the series F and F^1 there are large knots immediately below the perforations of the brass plates E and E^1. When the square prism is made to vibrate by the action of the treadles, the groove in the end of the pecker just catches the knotted cord F as the vibration is clockwise, and the cord F^1 when it turns counter-clockwise, and through their respective connections J and J^1 operate on the tail cords and harness necks to produce the requisite shed. After each complete vibration, the pecker moves laterally forward a distance of two perforations in plate E and E^1 before again vibrating to lay hold of the knots in the cords F and F^1. These vibratory and lateral movements are continued until the pecker has travelled to the end of the machine and rack, when it automatically begins the return journey and engages with the remaining alternate cords on each side of the parrot frame, until all the different sheds in one repeat of the figured pattern have been woven over once.

CHAPTER V.

British Efforts to Supplement or Supersede the Draw Loom.

THE first authentic British record, in which pressure heddles are mentioned as being employed, was in connection with the draw loom, which was still extensively used in the latter quarter of the 18th Century, and many efforts continued to be made to improve its details, notwithstanding the numerous attempts to supersede it. The draw loom was also used long after the introduction of the Jacquard machine, or *French draw loom* as it was first denominated.

The pressure system of weaving may have been in vogue very many years previously, but it is recorded that on Nov. 23rd, 1779, Wm. Cheape secured a patent No. 1237, in which he claimed to have "Invented a new method of weaving diaper and damask linens for tableing and other purposes, also some kinds of figured silks, cottons and worsteds, where three or more woof shots are necessary betwixt each draught, without the assistance of draw boys."

The Original Compound Harness and Shaft Mounting.

At this juncture it is only proposed to briefly enumerate the fundamental principles of 'shaft mounting,' or 'pressure heddle weaving,' as it is sometimes called. A more exhaustive treatment, with illustrations, of this important branch of figure weaving is given in Chapter XII, where this principle is embodied and used with modern Jacquard weaving machinery. The subject is referred to here because, being of ancient origin, it forms a link between the past and the present. It will be perceived to have connection with the old diaper system of figure weaving (Fig. 46, pages 40 to 44) from which method the system of compound shaft mounting and pressure weaving has possibly been evolved.

From a study of the specification and drawing of Wm. Cheape's invention, the following are the important points and essential details of difference, from the ordinary draw loom. The tail-cords, instead of passing over the side of the loom, are carried over the weaver's head and suitably secured. The simples are suspended right down in front of the weaver in a perpendicular direction, so that they are all under his immediate control without requiring the aid of a draw boy—human or mechanical. Combined with the ordinary harness are five pressure heddles. The spacing of the heddles, harness, etc., it is very important to note, was as follows:—

Centre of warp rail,	... to centre of harness ...	...	36 inches
„ harness	„	pressure heddles	24 „
„ pressure heddles	„	lay, when vertical	9 „
„ lay, when vertical,	to cloth rail ...	... ...	12 „

The duty of the weaver, by this method, was first to select the simples in the natural order of succession, then by suitable leverage to depress the requisite tail cords to form each successive figuring shed, and having raised such parts of the warp as were necessary for any given part of the figure pattern, provision was made to keep up the said parts of the warp yarn until all the five heddles were woven once over, after which the operation was repeated for the next and successive figuring sheds.

The chief characteristics of this compound pressure system of weaving were as follows:—The warp was first drawn through the harness in groups of five or eight threads, and afterwards the same threads were separated and individually passed through the mails of the heddles, which, together with the harness, operated upon the same warp threads, but performed distinctive duties. The function of the harness was to form the pattern on a large scale by lifting the warp threads for the large masses of figure in multiples of five or eight according to the number drawn through each harness mail. The heddles served to break these groups of threads into minute detail of intersection represented by either a common sateen or an ordinary twill weave.

The Comb Draw Loom.

This invention was introduced about the year 1803; it represents a further attempt to supersede the draw boy. Its figuring capacity was very small. It is very probable that the single lift 'witch' machine of a subsequent date, used for dobby work, was derived from the comb draw loom. Various persons appear to have had a share in its introduction, but I have been unable to discover any authentic patent specification. It however embodied a new and fundamental principle of warp shedding. The tail cords were replaced with vertically suspended cords from a fixed board above the top of the shedding apparatus; to these suspended cords the necks of the harness twines were attached. The suspended cords were knotted immediately above a corresponding number of perforations in the free end of a single lever, under control of a single treadle lever. The perforations in the end of the lever made it appear like a *comb*, hence the designation 'comb draw loom.' The knot cords were connected and operated by simple cords which extended horizontally, immediately over the weaver's head. The simples were lashed according to each required warp shed; and each lash was placed within the weaver's reach as he sat in his weaving position; these he pulled down in regular succession to form the figuring shed, without the aid of an assistant. Whenever the lash was drawn down, the simples in turn drew the knots of the suspended cords into the teeth of the comb lever, which when operated by the treadle lever produced the requisite figuring shed. Each lash when drawn downwards could be 'notched' into a recess and held in position until the weaver worked over all the ground or pressure heddles.

Cross's Counterpoise Harness.

This invention represents perhaps the last of the most important efforts repeatedly made to replace the services of the draw boy and to perfect the draw loom. It was introduced by James Cross, of Paisley, North Britain. The fame of the French draw loom or Jacquard machine had by this time begun to spread into England. It had reached such a state of perfection as to threaten to remove for ever not only the draw boy or his mechanical substitute, but the draw loom itself. It is perhaps important to record, however, that for many years after this period, the weavers continued to use the draw loom, declining to be torn away from old methods to which they were attached by long and familiar custom, until the force of circumstances absolutely determined otherwise. Such adherence to tried methods and well beaten paths may be considered safe by some, while others experiment with new ideas and schemes, and run risks; but in this respect as in all commercial undertakings, *to stand still invariably means to drop out.* I have heard it said of a certain manufacturing centre in Yorkshire, that every firm which stuck to the old methods went to the wall.

The Cross's Counterpoise Machine was characterised by three distinctive features: (1) a double lift arrangement or counterpoise harness; (2) a combined lashing frame, and (3) treading details. The last two parts, though very ingenious, do not essentially differ from the methods hitherto considered and designed for the same purpose; the first part, however, records a new departure and therefore merits a brief consideration. Fig. 58 shows a front elevation of the essential parts of this invention. A B C D represent four boards, all perforated with a number of holes which correspond to the number of neck twines supporting the harness. The top and bottom boards A D are permanently fixed to the two upright supports E and E^1, which are in turn fixed to a permanent cross rail F. B and C, called trap boards, are free to rise or fall at will; they are respectively supported by connecting and lifting arms G H and G^1 H^1, which are supported and free to oscillate on respective stud pins I J and I^1 J^1 fixed to the wheels K and K^1 called the rotators. These are free to oscillate on the shafts L and L^1 by connection with the treadles. M represents a flat straight bar which joins the rotators K and K^1 in such a manner that whatever motion K makes, K^1 similarly responds. They are shown in the sketch in the centre of their movement. There is *no tail*—an important departure—connected to the harness, but 'knot' cords N, as they are called, are suspended from the top board A, then passed through the perforations of B C D and connected to the necks of the harness cords. The cords N are all suitably knotted as shown in the illustration. The perforations in the trap lifting boards B and C consist of holes and continuation slits or 'saw cuts'—the holes being large enough to permit the knots of cords N to pass through, but the slits are too narrow for this purpose. The suspended knot cords are connected at right angles by a corresponding number of cords O O^1, etc., called the simples, which are thus arranged in a horizontal plane instead of vertically, as in the original draw loom. Each simple is lashed at the right hand side, according to pattern, in a similar manner to the principle hitherto described. On the left hand side of the machine the simples are supported by a half heddle P suspended from the support Q. The ends are then fastened to the ceiling in the direction R. Weights S are suspended from the simples O, by which means they, together with the knot cords N, are kept steady and in their normal position, *i.e.* with their knots immediately opposite the large holes in the boards B and C.

The lashes are automatically selected in arithmetical progression and through their connection with the treadles, they are drawn down together with the simples, a distance sufficient to place the knots of cord N, according to the requisite shed, immediately opposite and over the narrow slits of B or C whichever is in its lowest position and ready for rising on the given lash or shed. Consequently, when the figuring treadle is depressed, the wheels K K^1 partly rotate with shafts L L^1 and elevate rods G G^1 but depress H H^1 as shown in the illustration. The top board B thus raises all those cords N where the knots were drawn into the narrow slits, and so lifts the necks and harness to produce the requisite figuring shed. For the next figuring shed the corresponding lash is drawn. The weights S, in the meantime, have been free to recover the normal position of the knot cords N. The board C then rises taking up with it all the knotted cords drawn into the narrow slits; simultaneously the upper board B descends, and with its load acts as a '*counterpoise*' and to a certain extent assists in lifting the lower board C. Should any of the knotted cords lifted in the previous lash be required to be raised on this, the next and subsequent lash, the particular cord will be caught by the rising board C when the two boards are passing their respective centres.

These operations are similarly repeated until the complete pattern is woven.

Fig. 58.

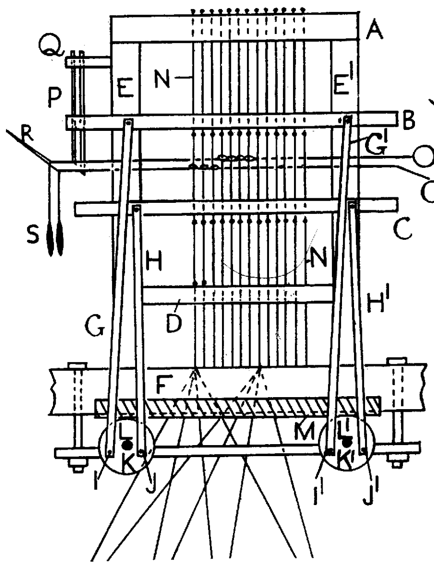
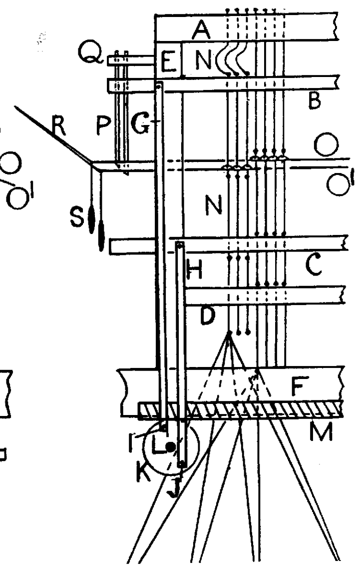


Fig. 59.



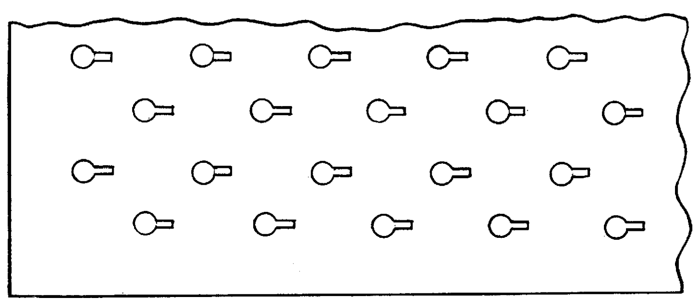


Fig. 60.

Fig. 59 shows the position of the mechanism when the figuring shed is fully open. The trap board B, together with the first three knot cords—lashed to the given simple—is shown in its highest position and the trap board C in its lowest. For the next figuring shed the two boards B and C operate as already described.

Fig. 60 shows a plan of part of the perforated board B or C.

The foregoing invention is most interesting since it is characterised by the inherent principle of the centre shed and double lift Jacquard machines of subsequent date and discovery.

Taylor's Double Necks.

On 13th January, 1818, Benjamin Taylor took out a patent No. 4216, which possessed some of the characteristic features of Cross's Counterpoise Harness, and which are interesting inasmuch as they serve to demonstrate that Cross's machine was meriting favour and receiving attention from other inventors.

Taylor claimed that his "loom could be worked without a draw-boy and shift the different lashes required for the changes without stopping........." The harness had a *double neck* and as one *lash* fell the other rose, and by the falling of one, the weight assisted the rising of the other. This use of the double neck is the first record of its advent into practice; it marks an important forward step and contrasts with Cross's machine where two knots, in different positions on the same cord, were employed for lifting the same neck twines and harness cords.

CHAPTER VI.

French Efforts to Supersede the Draw Loom.

DURING the period that the British weavers were engaged in improving the shedding mechanism for producing figure effects in woven cloths, the French weavers were similarly engaged in developing and perfecting machinery for the same purpose, which efforts finally resulted in the Jacquard machine.

Bouchon's Draw Loom.

The first important improvement of the French draw loom, from which the Jacquard machine was subsequently evolved, took place in the year 1725, when M. Bouchon introduced the principal of applying a perforated band of paper, according to pattern, in lieu of 'tacking' the 'simples' with the 'lash' twine for each separate tread. A continuous roll of paper was punched by hand, in sections, each of which represented one lash or tread, and the length of the roll was determined by the number of shots in each repeat of pattern. The respective sections of paper were subsequently pressed by hand on every figuring shot against a single row of needles which were connected to and controlled the simples,—these being attached to the tail cords in the usual manner. The non-perforated portions of the paper operated to press the needles and through them the simples into a rack comb or trap board, which, when depressed by the treadles, drew down the simples together with the tail cords, and thus raised the necks, harness and warp yarns to form the shed according to pattern. Since the arrangement of the harness, tail and simples is the same as in the common draw loom no further illustration is necessary; the single row of horizontal needles connected to and free to operate the simples whenever they were pressed by the non-perforated paper into the rack comb lever referred to, represents the only point of difference. The main features of this machine are embodied with Falcon's subsequent improvements in the illustration at Fig. 61.

M. Falcon's Improved Draw Loom.

In the year 1728, M. Falcon arranged the 'simples' in four rows, and consequently used four rows of needles to operate them, instead of one, as in Bouchon's machine. This arrangement considerably increased the figuring capacity. Falcon also designed a square prism for supporting the cards, and instead of the continuous roll of perforated paper he used paste board paper cards—one for each figuring shot—equivalent to each 'lash,' and each card was perforated by hand, according to pattern; these, he strung or laced into an endless chain series.

It is important to note at this juncture that the separate cards, square prism, and plan of the needles are retained in the modern Jacquard machine. Fig. 61 illustrates these important parts. A represents the harness twine; B the neck cords; C the neck guide board; D the pulleys detached from the pulley box; E the tail cords; F the simples; G a perforated guide board for the simples; H a series of iron rods (with hooks at their base) which are individually connected to the simples at the position indicated immediately below the guide board G; I shows four horizontal wires or needles constituting one row of the series; these are supported and kept in position by the needle boards J and K. The needles at the back are looped and terminate against a flat board L which serves to keep them in position but recedes whenever any pressure is applied to the front of them, but immediately the pressure is released the board L is clamped, through the medium of suitably adjusted springs, against the looped terminals of the needles, and thereby replaces them in their normal position as shown. M represents a wooden frame containing four iron rods N, a plan of which is shown at Fig. 62. This frame being suitably connected with the treadles, is designed to rise and fall at will. Fig. 63 is a sketch of the hand bar. The process of operaton is as follows:—The perforated cards Q, being supported by and rotated over the non-perforated square prism P, are pressed in progressive order against the needles J by the aid of the hand bar O. A non-perforated card would press all the hooks of the suspended wires H immediately under the iron rods N, so that when the frame M was depressed by the treadle it would pull down all the simples and tail cords and lift all the harness and warp. A fully perforated card would produce the opposite results. Between these two extremes any desired variety of effect of warp shedding could be obtained compatible with the capacity of the shedding apparatus.

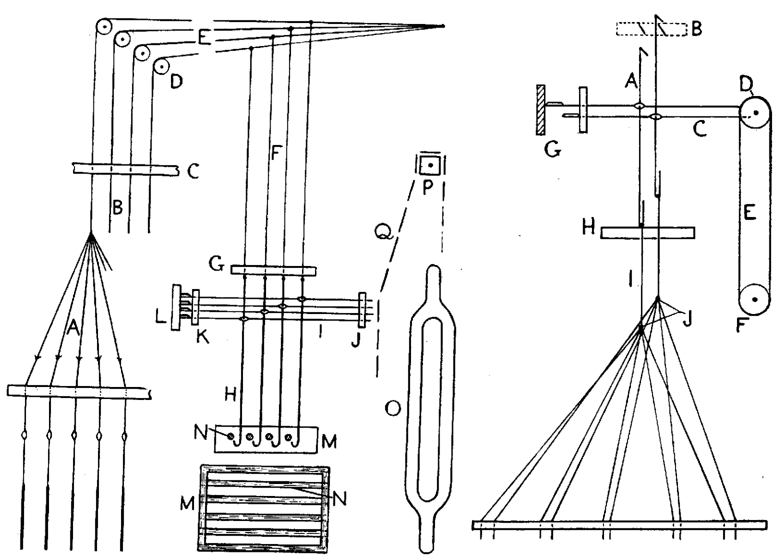


Fig. 61. Fig. 62. Fig. 63. Fig. 64.

Vaucanson's Epoch-making Changes.

The next important step embodying a change in fundamental principles, and which was destined to live, occurred in the year 1745, when M. Jacques de Vaucanson, a mechanician of considerable note, altogether dispensed with the mass of tail cords, simples, lashes and adjuncts to same.

In lieu of the tails and simples he arranged a series of hooked wires in a vertical plane and connected these with a corresponding number of cross wires; he further introduced the rising and falling griffe to lift the upright hooks, together with the suspended necks and harness twines, and controlled the correct selection of these by applying Bouchon's roller and band of perforated paper to operate at the top of the loom in approximately the same position as now prevails in all modern Jacquard machines. Vaucanson virtually combined the apparatus of Bouchon and Falcon, and made them to operate on the top of the loom *directly above the harness necks*, instead of as heretofore, *remote* from the object, on the simples and through them on the tails and harness.

Vaucanson's invention therefore most nearly approached the machine which has revolutionised figure weaving in every kind of cloth, and which has been perfected so much in detail as to make it well nigh impossible to improve any of its main details. Fig. 64 illustrates all the chief principles of Vaucanson's machine. In the illustration there are two rows of needles and uprights, but his original conception was an arrangement with only one row of each, very similar in detail to the existing 'witch' machine as used in many modern hand looms. A indicates the upright wires with the hooks at the top; B the griffe, with two knives free to rise and fall through its connection with the treadle lever; C the cross wires which are looped to the needles in the order shown, and are therefore free to operate them whenever required; D indicates the position of the perforated roller or barrel over which the roll of perforated paper travelled; the barrel was made to rotate on its axis; E the continous roll of paper perforated to pattern; G a striking-up or levelling board for the needles; H a board for supporting the uprights A and a guide for the neck twines I; the harness is shown connected to the necks at J.

Vaucanson's discovery, though facilitated by the inventions of Bouchon and Falcon, was no accident, but rather the result of continuous study and close application.

Joseph M. Jacquard.

Jacquard, a native of Lyons, France, was born 7th July, 1752, of humble parents, and died 7th August, 1834, near to his native city. M. Jacquard first directed his attention to the machine which bears his name in 1790. It was not until 1801 that he completed his first model, which he exhibited at the National Exposition, Paris. For the success of his invention he received a bronze medal, an annuity of 1,500 francs, and a royalty in cash of 50 francs for each machine sold. The machine produced was designed on the same lines as its predecessors, was simple in detail, and economical in space as compared with the common draw loom, and sufficiently practical in working arrangement to merit universal adoption.

The introduction of Jacquard's first machines into actual practice caused annoyance and was much resented by the weavers of his day, and as happened with most other important textile inventions, they were pulled down and wantonly destroyed by infuriated mobs whose knowledge was in the inverse ratio to their misguided enthusiasm.

Little did such people realise that good inventions invariably mean relatively greater cheapness in production, and hence a greater demand for the goods produced, which indirectly results in more work.

Near to the place where his first machines were burned, a statue of M. Jacquard now stands.

Speaking technically and from an analysis of what had been done by other inventors, it is very difficult to state exactly what particular part of the 'Jacquard' machine, Jacquard himself designed. He may have combined the best mechanical elements of other inventors, but at any rate the machine he made must have differed from its predecessors in arrangement and minor working details. It was similar in most general principles to Vaucanson's arrangement, except that he made use of Falcon's individual paste board paper cards and his square prism or card 'cylinder,' which he is credited with having fully perforated on each of its four sides in lieu of Vaucanson's perforated 'barrel.' Jacquard's machine also contained eight rows of needles and uprights as compared with Vaucanson's double row, which modification enabled him to increase the figuring capacity of the machine. In his first machine he supported the harness by knotted cords, which he elevated by a single trap board on the principle still used in a Brussels Carpet Jacquard. (Bradbury's *Carpet Manufacture*, p. 86).

The advent of Jacquard machines into the British Isles was between the years 1816 and 1820, when Stephen Wilson, an English silk manufacturer, employed them in his own works. One of the chief advantages which he claimed for this machine was that, whereas in weaving damasks the figuring shed was usually drawn once for every four shots, with the new apparatus it could be drawn on every shot, thus producing a fabric with greater definition of outline, which, he stated, was obviously a more difficult operation.

In the succeeding years 1822-1823, it was introduced into Coventry, and in 1827 into Halifax, in Yorkshire, after which the machines were rapidly distributed into every manufacturing centre, and in the course of a very few years the Jacquard almost entirely replaced every other method of figure weaving. It has certainly been the chief instrument in bringing the important and beautiful art of ornamenting textile fabrics, simultaneously with their production, to its present state of perfection, see frontispiece.

Part II.

MODERN JACQUARD MECHANISMS.

CHAPTER VII.

The Single Lift Jacquard Machine.

THE modern Jacquard machine is the product of many minds. It is an accessory to the hand and power looms, designed to control, and independently operate a large number of warp threads, and produce the maximum variety of warp sheds, for ornamenting purposes, with the minimum amount of mechanism, mounting and space.

Jacquard weaving is characterised by two distinctive features. (1) The shedding mechanism and (2) the harness mounting or parts which supply the place of heddles exclusive of its appendages. Harness mounting, though inseparably combined with the Jacquard of the present day, was in use hundreds of years before Jacquard himself was born—a fact made demonstrably clear in Chapter IV.

Jacquard machines, as used in modern practice, are numerous and varied, ranging from the ordinary single lift to the more complex automatic cross border, leno, twilling, index and double-cloth Jacquards.

The single lift of to-day is still representative of the original invention and unchanged in all its main features, though many important improvements have been and are constantly being made and details added.

It is simple in construction and therefore the only type of machine adopted for figure weaving in the hand and smallware looms. Being built upon the 'bottom' and 'closed shed' principle of warp shedding it is not suitable for high speeds—about 120 picks per minute being a fair average for 5/4 looms. For this reason it is used in power looms for the manufacture of silk brocades and all woven figured goods where the character of the material precludes fast running. A further factor which sometimes contributes to the adoption of single lift Jacquards with power looms, is the desire to imitate—as near as possible—the 'kind' or 'soft handle' of the hand loom woven products.

Details of the Single Lift Jacquard.

The essential features of the single lift Jacquard for either hand or power looms are fully illustrated at Figs. 65, 66 and 67. Fig. 65 is a perspective sketch of a standard single lift Jacquard combined with harness mounting but showing only one harness cord for each upright hook in the machine to avoid confusion and simplify demonstration. Fig. 66 is a perspective sketch illustrating the chief features which operate and control the 'swing batten' lever, card cylinder and pattern cards. Fig. 67 shows in elevation one row of 'uprights,' 'crosswires' or needles, needle board, spring box, tug cords, tug and grate boards.

Corresponding numerals in each diagram refer to similar parts. 1 indicates the upright wires turned over at the top to form a hook, for which reason they are usually designated the 'hooks.' The wires of these upright hooks are doubled at the base and turned upwards for about one third of their length until they reach and pass between the cross wires of a fixed grate 2. This double wire combined with the cross wires in the grate 2 neutralises any tendency on the part of the hooks to twist round. The double wire at the bottom is also turned up to form a double hook which normally rests in a perforation of the board 3, called the 'tug' or 'resting' board for the uprights 1. Upon each of the double wired hooks, short and strong cords of twine, 4, are looped and afterwards passed through the perforations in the tug board 3; these short

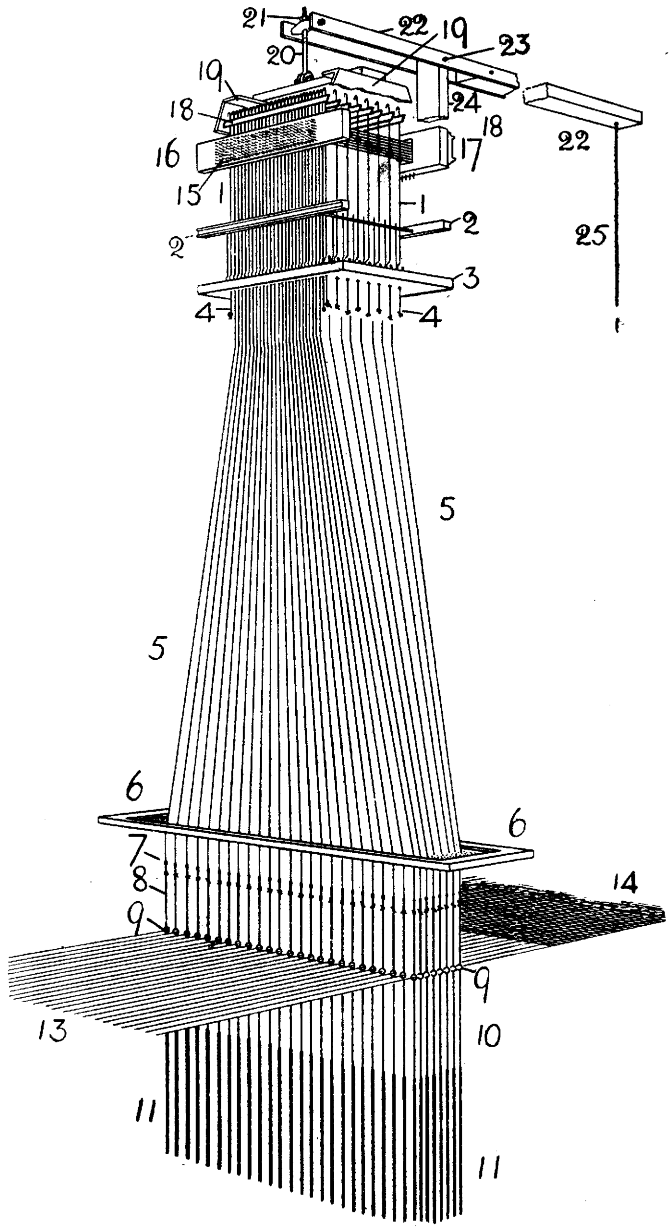

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Fig. 65.

cords are technically called 'tug cords' and in some localities 'neck cords.' In many machines the upright wires 1 are simply bent and turned upwards without forming the double loop, shown at the base, in which case the tug cord has to be looped on to the single wire with the result that it is much sooner worn or cut. To each of the tug cords 4, any required number of harness cords 5 may be tied—one only is shown in Fig. 65. There are twenty-eight rows with eight hooks in each row, but only twenty-five rows are shown to be in use, making 200 hooks in all; the first and last two rows are reserved for selvedges and other special purposes. The harness cords 5 are all passed through the perforated board 6, usually termed the 'comber board.' 7 indicates the knots which connect the harness cords *below* the board to the cords 8 called the *upper* couplings. These are double and pass through and support the eyelets or mails 9 and double cords 10 designated the *lower* couplings which connect the mails 9 to the iron weights or 'lingoes' indicated at 11, which weight the harness cords and draw down the warp threads. The parts 8, 9 and 10 are usually and collectively called the couplings. The warp threads 13 pass through the mails 9 as indicated and a portion of the woven fabric is shown at 14. A series of cross wires 15, corresponding in number to the uprights are linked to the upright hooks in the order as shown by the thick markings, where the hooks and wires cross each other. These wires or needles pass through a perforated board 16 called the needle board. At the opposite end the needles are turned back to form a loop and supported and kept in position by a series of springs contained in the box 17, Fig. 67. The needles serve to press the hooks of the uprights 1 normally over a set of horizontal knives 18 which are contained in the iron frame 19 (part of which only is shown) and variously called the 'head,' 'griffe' or 'brander.' The head or griffe with the knives is free to rise and fall in a vertical plane; a threaded bolt 20, connects the head 19 by a swivel link and nut 21 to a simple lever 22, which is pivoted at 23 on a fixed upright 24. When the Jacquard is placed above a hand loom, a cord 25 connects the head lever 22 with the foot lever, but when used on a power loom, the lever 22 is pivoted near the top of the bracket 26 (see Fig. 66) forming part of the framework of the Jacquard machine.

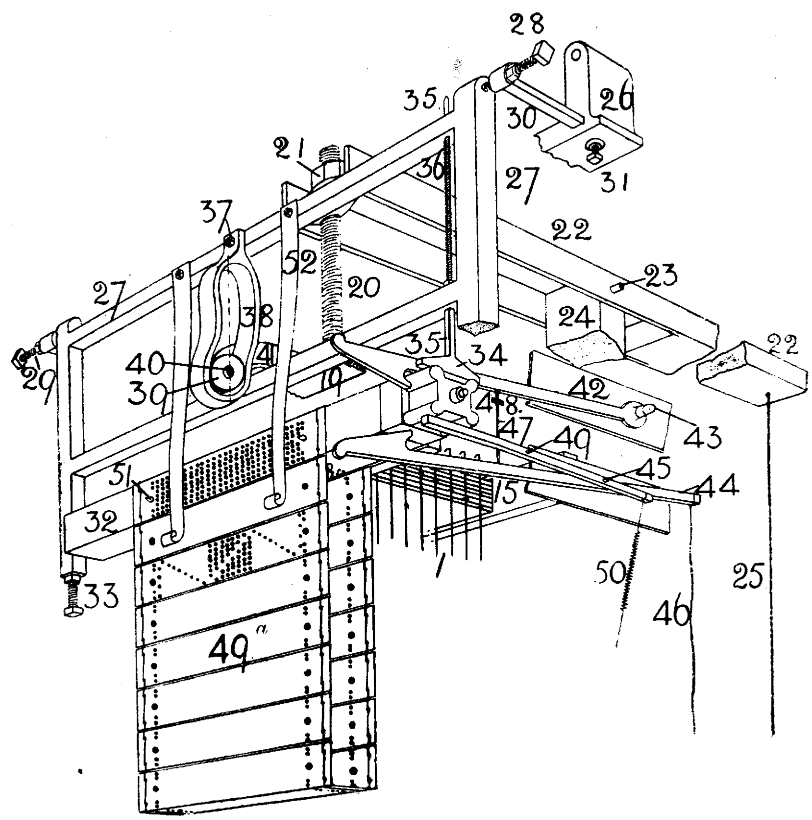


Fig. 66.

Swing "Batten" Card Cylinder.

The swing batten and card cylinder is shown at Fig. 66. The swing lever 27 is suspended between the two adjustable studs 28 and 29, which are in turn supported by adjustable rods, one of which is shown at 30, secured to the bracket 26 by the lock nut 31. The card cylinder 32 has to be made from very hard and specially well seasoned wood to prevent any tendency to subsequent warping; the ends are made of iron with rounded corners and a gudgeon pin in the centre of each; the whole must be absolutely true. The card cylinder is placed into and supported between the free ends of the arms of the swing lever 27; the arm on the right hand side has been omitted so as to give a clearer view of the cylinder end. The cylinder is adjusted by means of the set screw and lock nut 33, duplicated on the opposite side. It is perforated to correspond with the number of needles. Resting square on the iron part at each end side of the card cylinder is an inverted T shaped 'hammer' 34, the spindle or shaft (35) of which passes through the lower and upper cross bars of the swing frame 27. A spiral spring 36 circumscribes the spindle 35 between a shoulder on the spindle shaft, near to its base, and the underside of the top cross bar 27, by which means the hammer 34 is kept in close contact with the iron part of the card cylinder. Secured to the top cross rail of the swing frame 27 at the point 37, is a grooved casting 38 known as the 'Swan neck.' Adjusted and free to move between the two sides of the swan neck is an antifriction bowl 39 which is free to rotate around a stud pin 40 fixed to the end of a connecting arm 41; this arm is fixed and projects from the lifting head of the Jacquard and therefore rises or falls with it.

A special hooked catch 42 is pivoted to the stud 43 which projects from the fixed frame of the Jacquard machine. The free end of the catch rests passively on the lantern end of the card cylinder with the hook projecting just clear of one of the shoulders. A similar catch 44, but inverted, is shown on the underside of the card cylinder. This catch is pivoted to the stud 45 fixed in the machine framing. The arm of this catch projects beyond the stud pin, and a cord 46 is attached to it and suspended to within reach of the weaver. This 'bottom' catch, as it is usually called, normally rests with its hook just clear of the card cylinder. A vertical iron pin 47 rests upon the face of the bottom catch and its head just touches the under side of the top catch 42. The pin 47 is kept in its vertical position by passing it through the perforation of a bracket 48 secured to the machine. A small lever catch 49, called the cylinder protecting catch is pivoted on the common stud 45; a spiral spring 50 fastened to the machine keeps the short arm of the lever catch down; the upward movement of the long arm is regulated by a fixed stop. It will thus be evident that by pulling down

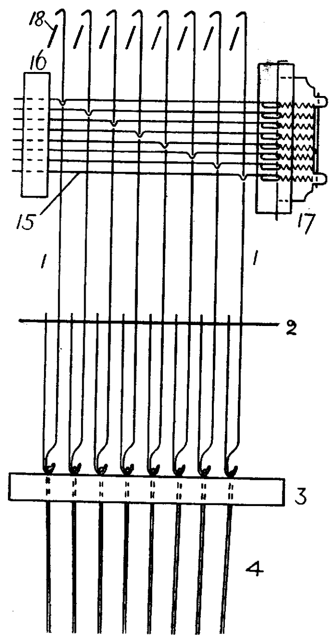


Fig. 67.

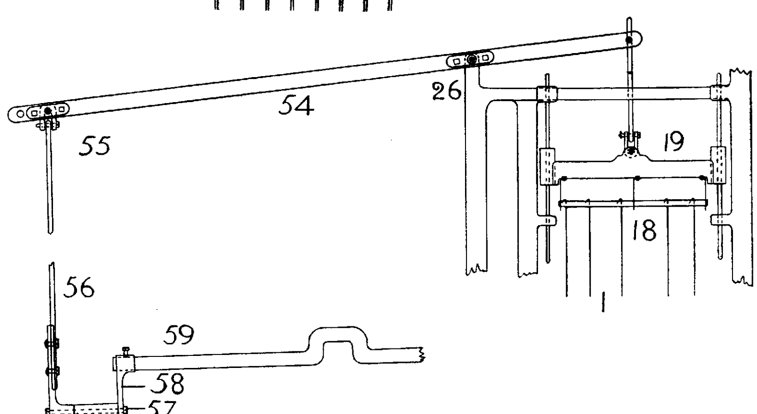


Fig. 68.

the string 46, the catch lever 44 will turn about the stud 45 until it is in contact with the underside of the cylinder, and also lift through the pin 47, the catch lever 42 until the hook of the top catch is above and perfectly clear of the shoulders of the card cylinder. A series of perforated cards 49*a* are placed over the card cylinder and kept in their true position by means of pins 51 or cylinder pegs. Two iron springs 52 are fastened to the top of the swing frame, the lower ends being turned up and free to press against the card which is on the back square of the prism and so help to keep it in contact with the cylinder 32.

Reciprocation of the 'head lever.'

In the hand loom, Fig. 65, the head lever 22 is combined through cord 25 with a simple tread lever of the second order adjusted near the weaver's foot and conveniently vibrated by the same.

Fig. 68 is a front elevation showing the method of communicating reciprocating motion to the Jacquard head. The head 19 is combined with the head lever 54, pivoted at 26. Suspended from the stud 55 a reciprocating rod 56 combines the lever 54, through stud 57, to a crank lever 58 which is set screwed to the crank or loom shaft 59.

Action of the combined parts in the Jacquard.

In power loom weaving the constant rotation of the crank shaft 59 with crank lever 58 reciprocates the rod 56, head lever 54 and head 19. In *hand loom* weaving, when the foot lever is pressed down, the connecting cord or chain 25 (Fig. 65), draws down the free end of the lever 22 about its centre 23 and thus elevates the connecting swivel 21, link 20 and the lifting head 19 together with its full complement of knives 18.

Simultaneously with the elevation of the lifting head, the projecting arm 41 (Fig. 66) rises, carrying with it the antifriction bowl 39, which, travelling inside the groove of the swan neck lever 38 causes the card frame 27 to swivel about the centres of the two studs 28 and 29 and so to carry the cylinder 32 and pattern cards 49*a* away from the points of the needles 15. When the card cylinder has travelled outwards a given distance, the catch 42 holds against the top corner of the cylinder and resisting any further outward movement causes the cylinder 32 to rotate about its axis. The hammer 34 keeps it from turning too far and ensures it being kept perfectly square with the points of the needles when brought into contact with them. With the descent of the head 19, the bowl 39 falls to the bottom of the swan neck lever and draws it, together with the card cylinder, into close contact with the needles 15, so that if a *fully* perforated card, as shown at the top of the cylinder, is brought into contact with the needles, they enter the perforations in the card and cylinder but in *no* way exercise any influence over the normal position of the uprights which are over the lifting knives 18, so that as the knives ascend they lift *all* the uprights, harness and warp. The second card is shown *blank*, *i.e.*, without any perforations, so that on the succeeding lift when it is brought into contact with the needles, it forces *all* the hooks *clear* of the ascending knives 18 and consequently the uprights, harness and warp all remain down. The third card is shown to be *partly* perforated, so that it combines the factors of a non and a fully perforated card. Then as the griffe ascends, the uprights left in their normal position are caught and lifted together with the harness and warp to form the *top* division of the warp shed, but the remaining uprights which have been forced *clear* of the knives together with their harness and warp are left down to form the *bottom* division of the warp shed. Thus by varying the perforations in the card any number of uprights may be lifted or left down and so any variety of warp shedding may be produced.

Rotating the Card Cylinders.

There are two chief systems in use for operating the Jacquard card cylinders, viz. :—The swing lever and the slide or horizontal. Either system may be compounded with that of the lifting 'head' or operated by an independent drive.

Principle of the Swing Lever Card Cylinder.

Figs. 69, 70 and 71 show elevations of this type of card cylinder mechanism together with the principle of operation. The numerals in these diagrams refer to corresponding details given in Fig. 66. Fig. 69 shows the position of the mechanical parts when the card cylinder is *normally* in close contact with the face of the needles.

Fig. 70 shows the card cylinder at a point midway between the needles and the limit of its traverse. It will be perceived that the top catch has operated on one corner of the lantern to make the card cylinder rotate through an angle of 45° and in the process has caused the hammer 34 and hammer shaft 35 to overcome the resistance of the spiral spring 36, as the swing lever 27 continues to travel outwards until the card cylinder gradually passes through an angle of 90°. During the whole of this period the action of the spiral spring 36, has been to keep the movement of the card cylinder steady and also to prevent it from rotating too rapidly or too far, so that on its return it will strike 'square' with the face of the needles. A further factor which contributes towards this object is the small protecting 'catch' lever 49. Immediately the lantern corner of the card cylinder passes the free end of this lever, the spring 50 operates to depress the opposite arm of lever 49 until the free end of the cylinder protecting lever is raised to its maximum height—a position, such, that if the card cylinder has not rotated through 90° it will assist it to complete the right angle and also prevent its tendency to exceed this limit, thus ensuring that the face is presented squarely to the needles.

Fig. 71 indicates the position of the swing lever 27 at the extreme end of its traverse. The spiral spring 36 has also assumed its normal position and caused the hammer 34 to rest on the square of the card cylinder so that the latter is in position ready to return and strike against the face of the needles with the next pattern card as in Fig. 69.

The chief advantages of the swing lever system are:—It is easy to operate and the amount of friction generated is small. It is well adapted for reversing the Jacquard cards, whether for finding the broken pick and pattern, or for reversing the pattern cards when weaving bordered goods and similar designs. The chief defects are:—The oscillating motion of the card frame has a tendency to divert the pattern cards from the cylinder. The arc described by the card cylinder also alters the relative position of the centres of the holes in it with the points of their respective needles, which makes

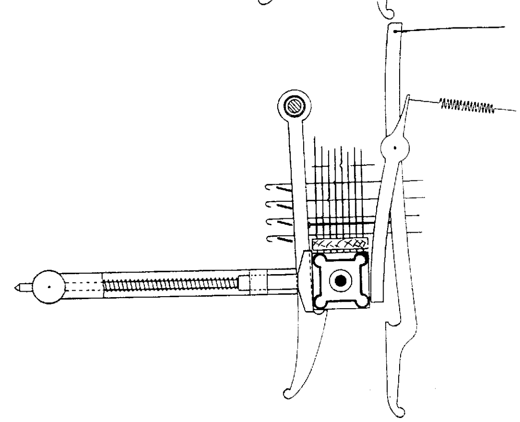


Fig. 69.

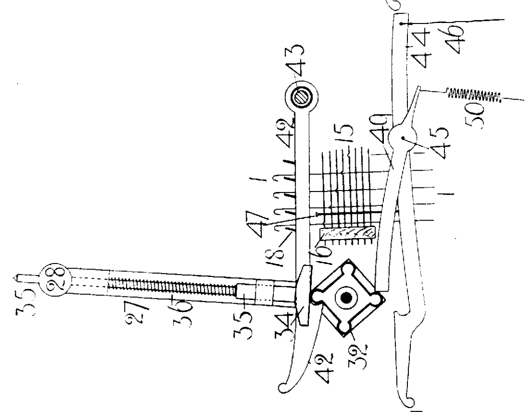


Fig. 70.

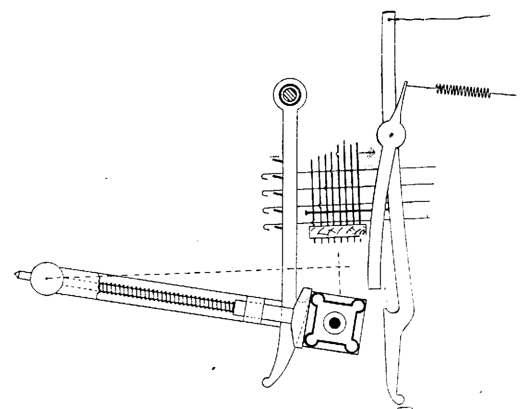


Fig 71.

it difficult for the cylinder to strike "square." A higher frame is also required with this system, which is an objection, especially where the ceiling is low.

Rotating the Card Cylinder on Slide Principle with "Swan Neck."

Fig. 72 illustrates the detached parts of the Jacquard mechanisms which actuate the card cylinder on the slide principle, combined with the lifting head and a swan neck attachment to the slide. A is the antifriction bowl and stud which are secured to the lifting head of the Jacquard. B is the "swan neck" casting with a slotted groove, up which the bowl A is free to move. The casting B is secured by the bolt and nut C to the slide bar D which, in turn, is supported and free to move laterally in two fixed slide brackets E and F. The gudgeon spindle of the card cylinder G is adjusted and supported in the end of the slide bar D. A right-angled hammer H is kept in close contact with the 'lantern' part of the card cylinder, by means of the constant action of a spiral spring I which is connected to a fixed part of the machine frame and to the horizontal arm of the hammer H in the position shown. J is the top catch, fulcrumed at K, for turning the cylinder G; L is the bottom catch with its fulcrum at M. The two catches are joined together by a rigid upright wire N. A cord O, under control of the weaver, is suspended from the catch lever L.

Action of the Mechanism.

It is evident that with the ascent of the head and bowl A, no movement will take place in the swan neck B nor slide D, until the bowl A reaches the angle formed in the swan neck. This affords sufficient time for the knives to reach and catch under the hooks of the uprights, before the cylinder begins its outward movement. Immediately the bowl A begins to slide up the incline of the swan neck casting, the latter moves out laterally carrying with it the slide bar D and the card cylinder G. The pressure of the card cylinder against the upper catch J is sufficient to cause the former to rotate a quarter of its revolution, which action is facilitated by fixing the position of the fulcrum for the catch J above the point of contact of the catch with the shoulder of the 'lantern.' When the string O is pulled down, the lower catch L is raised into close contact with the underside of the card cylinder, so that whenever the latter travels outwards, it is made to rotate in the reverse direction. Because the position of the pivot for this catch is *above* the *centre* of the axis of the card cylinder, the rotation of the latter is more difficult than if it were pivoted *below* the centre. The combined action of the hammer H and spiral spring I results in keeping the card cylinder steady during rotation. When the bowl A is travelling up or down or at rest, in the vertical groove at the *top* of the swan neck B, the card cylinder dwells in a position *remote* from the needles, and in a similar way it dwells in *contact* with the needles when the bowl A is in the *bottom* vertical groove.

Rotating the Card Cylinder on 'Spindle Slide' and Bell Crank lever principle.

Fig. 73 represents the essential features of this principle of operating and controlling the card cylinder on a Devogé single lift Jacquard. A is an antifriction bowl combined with a fixed stud to the lifting head of the machine. B is a connecting link between the bowl and stud and the bell crank lever C. A loose stud D passes through the link B and the lower arm of lever C in the position shown. The lever C is pivoted and free to oscillate about the fixed stud E. The horizontal arm of the lever is joined by a stud F to a connecting and pushing rod G, which is in front of the lever C. The stud F is bolted to rod G but passes freely through the arm of lever C. The opposite end of the rod G is connected to a bracket casting H through the medium of the stud I. The casting H, of which a portion is indicated by the dotted lines, supports the card cylinder L. A round spindle J is bolted to the machine at K. Upon this spindle the bracket or casting H is placed and free to slide alternately forwards and backwards. The spindle shaft of the hammer M passes through and is free to slide between two projections on the remote side of the upright part of the bracket H. A spiral spring N circumscribes this spindle shaft and combines with the hammer to keep the cylinder steady during rotation. The catches O and P for rotating the card cylinder either forwards or backwards are compounded and oscillate about a common centre Q. The projecting arm R and the string S provide the means for lifting the upper catch O clear and the lower catch P into position for reversing the rotation of the card cylinder.

Action of the Mechanism.

With each ascent of the griffe and bowl A in the direction of the arrow T, the centre of the loose stud D describes an arc of a circle U by which means the lower arm of lever C is gradually elevated but the upper is simultaneously depressed. The centre of the stud F describes an arc of a circle F V. This same end of the pushing rod G also follows the same arc F V by which means it pushes outwards to the left, bracket H combined with the hammer M, spring N and the card cylinder L. The *normal* position of the rod G when the card cylinder is in close contact with the needles is indicated by the dotted line which joins the two centres F I. The *relative* position of this rod G with the horizontal, gradually changes until it assumes its final inclined position indicated by the dotted lines V W, which represent the respective positions of the centres F I, when the card cylinder is at the extreme end of its traverse outwards. Conversely, the falling 'head' brings all the described operating parts into their original and normal position, the card cylinder bringing the next pattern card against the needles for the next warp shed.

At first sight this arrangement appears to suggest undue friction in the various working details, but if the connection with the head is detached and the catches lifted, it will be found that the weight of the horizontal arm of lever C is sufficiently counterpoised to push out, by gravity, the bracket H, card cylinder L etc., their full distance, consequently when the 'head' ascends, it has only to rotate the card cylinder a quarter of a revolution, by overcoming the resistance of the catches, hence the friction is very small when the parts are properly adjusted.

Timing the various movements in Single Lift Jacquards.

The following actual particulars were ascertained from a single lift Jacquard, mounted on a 5/4 single shuttle loom running at the rate of 120 picks per minute. The griffe or lifting head of the Jacquard was driven by a rotating crank, set screwed to the extreme

Fig. 72.

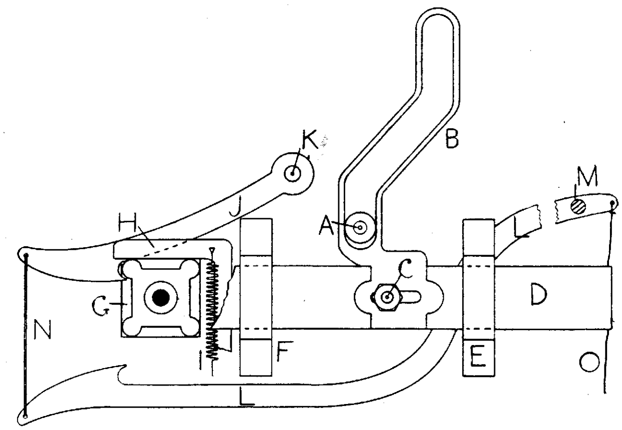


Fig. 73.

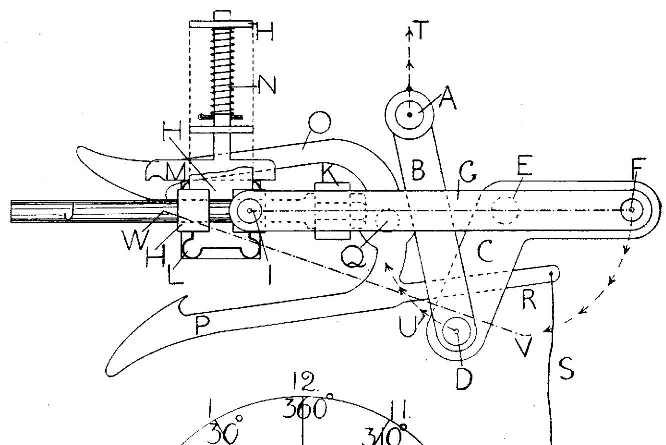
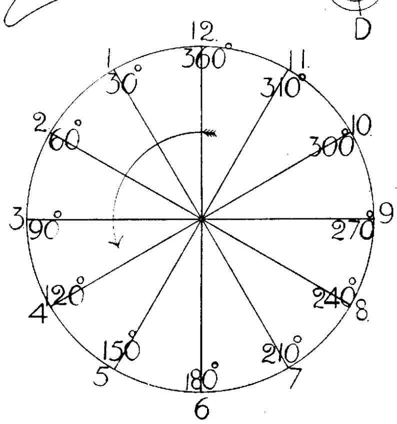


Fig. 74.



end of the top or crank shaft as in Fig. 68. The card cylinder was driven independently by an eccentric also secured to the crank shaft.

Assume the circle described by the crank shaft to be divided into 12 equal parts, each part being equal to 30° (Fig. 74). The *rotating lever* 58 (Fig. 68) is adjusted 35° *i.e.*, approximately one part behind the crank of the top shaft. Commencing with the loom at rest, the warp shed absolutely closed, the *lifting lever* on the crank shaft at the top centre and the griffe at the bottom. The card cylinder is in initial acting contact with the needles, pressing on or leaving clear such uprights as are necessary for the next shed Fig. 69. The loom crank is then at 1 Fig. 74, *i.e.*, 30° past its top centre. The full details are summarised as follows :—

	Positions of Card Cylinder.	Time	Positions of Loom Crank	
				Divisions
1.	Initial acting contact of c c with needles -		30°	1
2.	Dwell of c c in contact with needles - -	40°	70°	2-3
3.	Initial contact of c c with turning catch - -	40°	110°	3-4
4.	c c in centre of rotation thus ◇ Fig. 70 -	60°	170°	5-6
5.	When c c reaches the limit of its outward traverse	40°	210°	7
6.	Dwell of c c at the limit of its outward traverse -	25°	235°	7-8
7.	Traverse of c c into initial contact with needles -	155°	30°	1

The griffe commences to rise when the circle described by the crank shaft is 55° past the top centre, approximately division 2. The shed is fully open at 210°—division 7 where it 'dwells' to 230° midway between divisions 7 and 8. From this point the griffe begins to descend and reaches rest at 40° immediately past division 1 where the closed shed 'dwells' preparatory to a repetition of its cycle of movements.

Figuring Capacity of Jacquards.

The figuring capacity of a Jacquard is represented by the number of warp threads which it can independently operate and control. In single acting Jacquards where each lifting hook is controlled by a separate needle, the figuring capacity is always equal to either the number of uprights or needles which the machine contains. These are usually made with 208, 304, 408, 608 or 612 uprights and needles, and respectively designated for convenience of expression, 200, 300, 400 or 600 machines. Larger figuring capacities are obtained by combining and working together, two or more of any of the foregoing, or by using a fine pitch Jacquard, either on the English or French system.

CHAPTER VIII.

Double Lift Jacquard Machines.

THIS type of machine is designed with the object of facilitating a greater relative speed of the power loom, and at the same time reducing the relative excessive speed of the operating parts of the Jacquard, *e.g.* a single shuttle power loom, mounted with a single lift Jacquard and making 120 shots per minute could be increased to 180 shots per minute by the substitution of a double lift Jacquard, while all the working details of the Jacquard could be reduced to half the speed of the loom as will be demonstrated shortly.

The double lift Jacquard is further designed to produce a warp shed on the semi-open shed principle, as illustrated at Fig. 36, Chapter II, and it therefore possesses all the advantages of the semi-open shed, as compared with the closed shed principle, *e.g.* The rising shed acts as a counterpoise to a falling shed and *vice versâ*; the distance travelled by the warp is only equal to one and a half times the depth of the shed, whilst in the single lift machines, the warp must travel twice the full distance for each shot of weft. Further, with the double lift machine more shots of weft can be relatively driven into the cloth than is possible with the single lift, because with the former the weft is driven into a '*crossed*' shed, which after having once been 'beaten up" cannot recede from the fell of the cloth, whereas, with the latter type of machine, the weft being driven into a '*closed*' shed, has a tendency to slip back from the 'fell' as the reed recedes. The beating up of the weft in the crossed shed produces a better 'cover' or distribution of warp threads in the web, than obtains when beating up on the closed shed principle.

The introduction and perfecting of the double acting Jacquard machine combine to make a very *great advance* in *figure* weaving and have proved to be of inestimable benefit to this branch of the textile industry.

Double Lift Single Cylinder Jacquard.

This type of machine is representative of the simplest class of the double acting series of Jacquards. The chief details of the system will be illustrated and described under this heading, the remaining varieties will only be considered in so far as they differ from the main and essential features. Fig. 75 shows in elevation

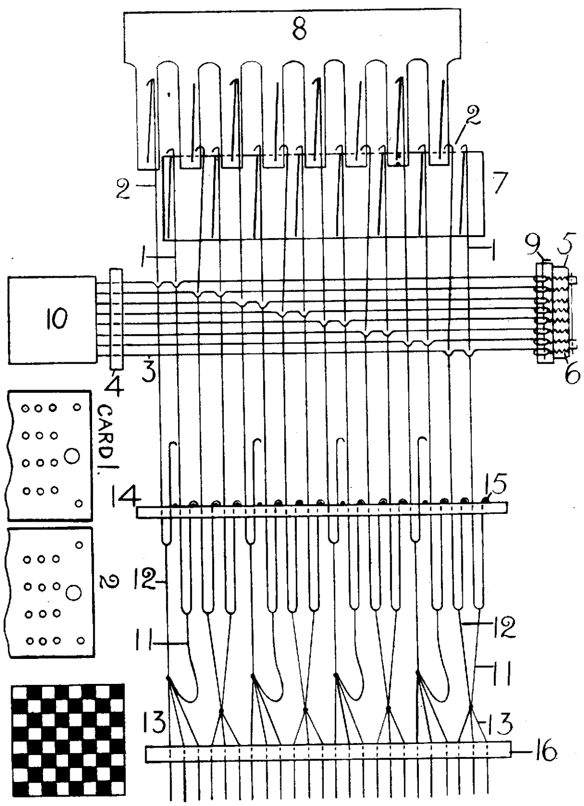


Fig. 76. Fig. 75.

one row of needles, uprights, tug cords and harness, together with the lifting knives of a '400' machine as seen from the left side of a right hand loom. Altogether the machine contains 51 rows of needles and uprights, each of which is a duplicate of the one illustrated in the figure. All Jacquard machines are usually provided with one or two extra rows of uprights for working the selvedges, controlling the shuttle boxes, cross-borders and any other specific purpose which may arise when conducting experiments or weaving specialities. There are two sets of uprights, indicated at 1 and 2, and one set of needles, 3; each needle is looped round and controls two uprights.

The needles are shown supported in the needle board 4 and the spring box 5; spiral springs 6, consistently press against the returned ends of the needles in the box 5 so as to keep the uprights normally in a true vertical plane, with their hooks immediately over the two sets of lifting *deep* knives or griffe blades 7 and 8. A fixed vertical pin 9 passes through the loops at the returned ends of the needles for the purpose of limiting their lateral traverse in either direction. The card cylinder is indicated at 10, the neck cords at 11 and 12 looped respectively to the uprights 1 and 2. The cords are fastened *direct* to the same series of harness twines, 13. Sometimes they are secured to a single strong *tug* cord, which acts as an intermediary between the neck cords and the harness twines, which adjunct possesses no apparent advantage. 14 is a grate which serves as a guide for the uprights, which being double near their base are thus prevented from turning on their axis. The grate contains fixed cross bars, 15, which act as resting places for the uprights when in their lowest position, and also determine the limit of their fall; 16 is a guide grate for the harness, technically termed the 'heck.'

Each series of griffe blades, 7 and 8, is supported in an iron frame compounded with two vertical spindles 17 and 18, and their duplicates 17^1 and 18^1, as shown in Fig. 77, which is a side elevation in perspective of the parts variously denominated the 'head,' 'griffe,' and 'brander.'

The spindles 17 and 18 pass through sockets in the fixed bracket 20, through which they are free to slide up or down; iron cross heads 21 and its duplicate, compound the respective pairs of spindles 17, 17^1 and 18, 18^1, see also plan Fig. 79. The spindles 17 and 17^1 are compounded with the top griffe 8 in the position 22, and its duplicate at the opposite side, whilst 18 and 18[1] are similarly compounded with the bottom griffe 7. This arrangement, is common for all double acting Jacquards, whether for single or double cylinder machines.

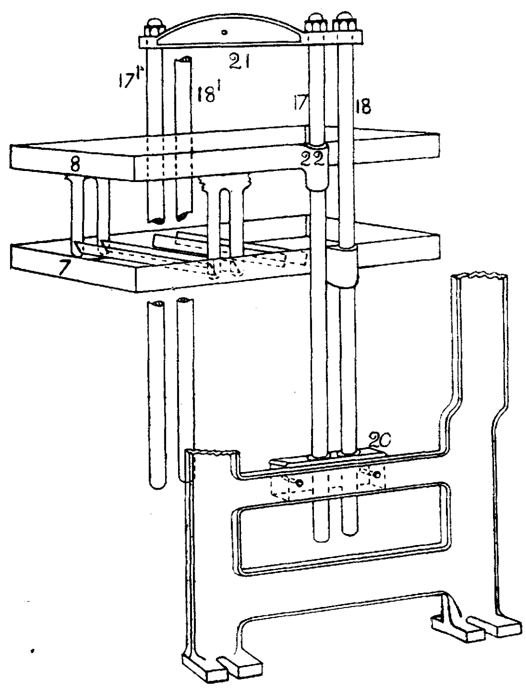


Fig. 77.

Driving the 'Head Levers,' ordinary method.

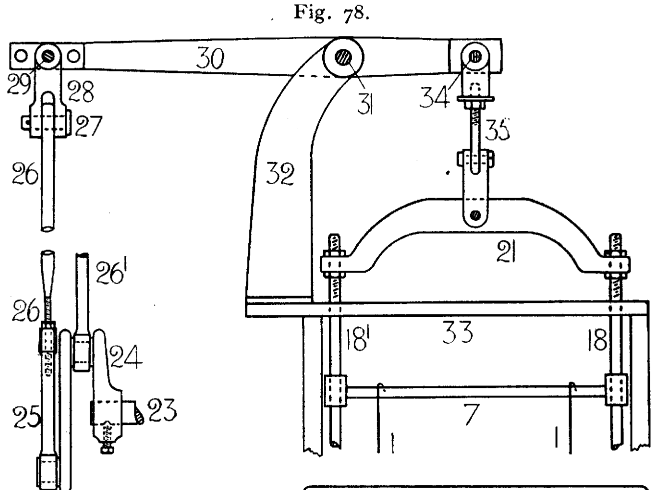
Fig. 78 is a front elevation and Fig. 79 a plan, of the common method of communicating the requisite motion to the cross heads and lifting knives. 23 represents the bottom or picking shaft which rotates at half the speed of the crank shaft; 24 is a double throw crank, set screwed or otherwise adjusted to the shaft 23. An adjustable link 25 fits loosely on the outer stud of the double crank. A steel 'steam' rod 26 is welded on to a solid end, threaded and bolted to the link 25. The rod is joined by the stud

27 to a swivel link 28. Stud 29 combines the swivel link 28 to th 'head' lifting lever 30.

Parts 25 to 30 inclusive and 35 are in duplicate.

The head levers 30 and 30^1 are pivoted on the common fulcrun stud pin 31 in the bracket chair 32 which is secured to the top cros rail 33 of the Jacquard machine. The free ends of the lifting lever 30 and 30^1 are connected through the stud 34 to the cross head 2 by swivel links and short connecting rods 35 as shown.

Fig. 78.



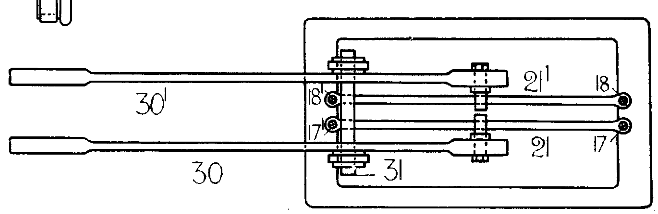


Fig. 79.

Action of the Combined Mechanism.

The bottom shaft 23 rotates at a constant rate and with it the double crank 24 produces a reciprocatory motion in the connecting rods 26 and 26^1 and head levers 30 and 30^1, thus causing the two heads 21 and 21^1 to rise and fall on alternate and opposite picks to each other, by which means the griffe blades 7 and 8 are similarly reciprocated. Then, if the card cylinder 10 Fig. 75, is pressed with a fully perforated card, against the needles 3, when, for example, the griffe 7 is about to ascend, the whole of its set of hooks (being normally over the blades) will be lifted together with the whole of the harness and warp. For the next pick, the griffe 8 will be at the bottom. Assume the card cylinder with a blank card to be pressed against the needles, the action will cause all the upright hooks 2 to be moved clear of the lifting knives 8. The same action will *tend* to *push off* the uprights 1 from the top blades, but the upright wires are made sufficiently long to permit of a slight bend which counter balances this tendency. The griffe 8 therefore ascends without any hooks whilst the griffe 7 descends with its load of uprights, harness and lingoes, allowing all the warp to fall to the bottom. As in the case with the single lift, any variety of warp sheds may be produced up to the limit of the capacity of the machine by perforating the cards according to the required pattern. In the illustration Fig. 76, the card has been perforated for plain weave and consequently alternate uprights 1 Fig. 75, are shown elevated with griffe 8. The chief defect of the single cylinder is the high speed at which it must run which somewhat neutralises any advantage gained by the double acting Jacquard.

Independent drive, for *Single* Cylinder, double lift Jacquard.

The value of all *independent* driving of the cylinder is apparent when it is considered that it can be timed to strike the needles at any convenient moment with the rising griffe, whereas, when the mechanism is combined with the 'head' such variation in the time of striking is impossible. Fig. 80 shows the main mechanical features of the single acting card cylinder. A gives the position of the crank or loom shaft. B is a split eccentric secured to the crank shaft A. The periphery of the eccentric B is sunk between two side projections, indicated by the dotted line. An iron collar strap C is adjusted between these side projections on to the periphery of the eccentric which is free to rotate inside the collar and freely reciprocate it, together with the connecting rod D which joins the collar to an adjustable swivel link E and the simple lever F, which is secured to a short shaft G, supported and free to oscillate in the bearing of two small brackets or chairs H. These rest upon the fixed gantry I, which carries the

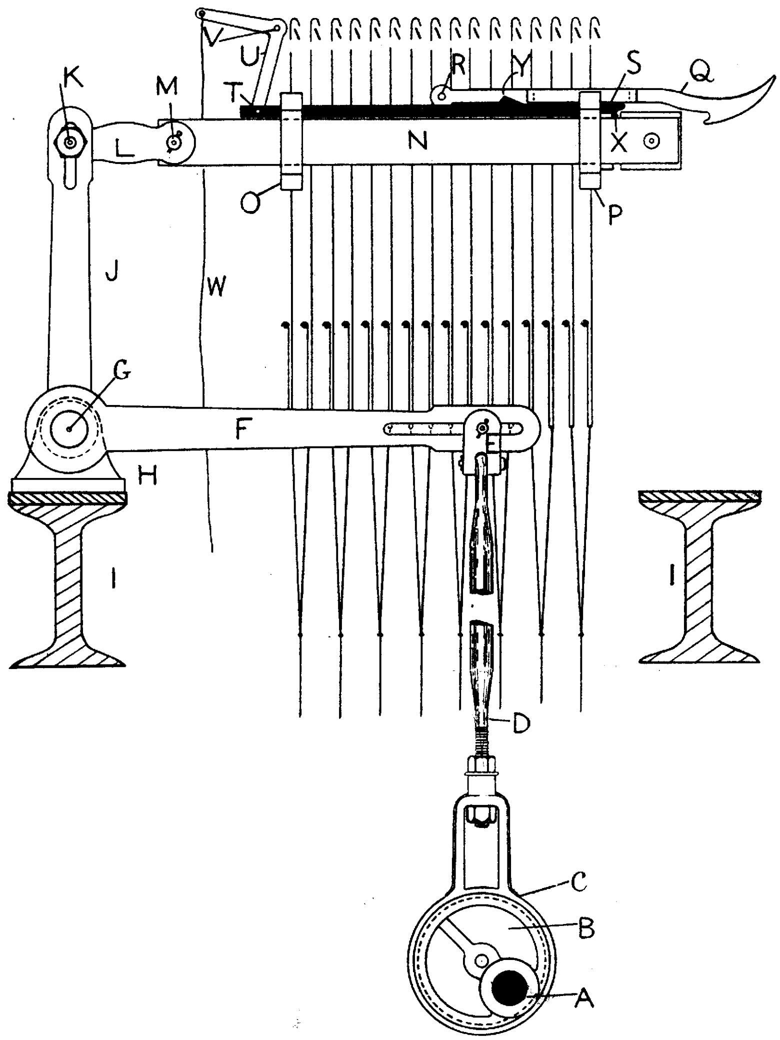


Fig. 80.

Jacquard machines independently of any direct support from the loom. A second lever J is also secured to the shaft G, but at right angles to the lever F. An adjustable stud K combines the lever J and a short connecting link L. A second and loose stud M joins the link L to the slide bar N which supports the card cylinder at the opposite end in the position shown. The slide bar is supported and free to slide between the two brackets O and P, which form part of the Jacquard fixture. The top catch for rotating the card cylinder is shown at Q. It is pivoted on the stud R fixed to the machine. A second and 'pushing' catch for reversing the direction of the card cylinder is shown at S, one end of which is secured by the stud T to the vertical arm of the bell crank lever U, pivoted at V. A string W is suspended from the horizontal arm of the lever U to within control of the weaver. The free end of the pushing catch S rests loosely over the top of the needle board on the inside of the machine framing. The small hooked projection X is directly opposite the top corner of the 'lantern' on the end of the card cylinder. A shoulder Y, on the top of the pushing catch S, is provided to simultaneously lift the top catch out of action, whenever the catch S is made to travel towards the card cylinder for the purpose of reversing its motion. The combined action of the various foregoing parts for turning the card cylinder is as follows:—With the constant rotation of the crank shaft A, the eccentric B operates to reciprocate the collar strap C, lifting lever F and oscillating the shaft G, which in turn reciprocates the lever J, link L, slide N and the card cylinder. With each outward traverse the last is brought into contact with the hook of the catch Q and rotated a quarter of a revolution, thus bringing up the next pattern card. To reverse the motion, the weaver pulls down the cord W, reciprocates the bell crank lever U and the pushing catch S which through Y lifts the catch Q clear of the cylinder and through the projection X rotates the card cylinder clockwise.

The Bradford Card Cylinder Motion with Escapement Apparatus.

This accessory is designed to drive the card cylinder *independently* of the 'head' and it can be rotated *by hand* forwards and backwards, while the loom itself is not in motion. Hence, if it is necessary to turn over any number of cards to find a broken pick or pattern, the operation can be readily accomplished.

If the *loom* were 'turned over' with the rotation of the cylinder for each card, the web would be carried forward out of reach of the forward movement of the 'lay' unless the finger connected with the taking-up catch' were *lifted clear* of the ratchet wheel for each turn of the loom. Therefore with the adoption of the above mechanism, the necessity of letting back the web, drawing the warp back on to the yarn beams and adjusting the reed to the fell of the cloth, is obviated.

This mechanism is used with single or double lift Jacquard machines, but the apparatus reaches the limit of its application where two or more heavy double lift Jacquards are mounted over the same loom, since they involve more labour than can be performed by hand.

Fig. 81 is a side elevation of the main features of the escapement apparatus, and Fig. 82 a sectional elevation of the parts immediately behind those of Fig. 81.

Fig. 83 shows a plan of these combined parts. The same letters in each diagram refer to corresponding details. A is a shaft suitably supported on chair brackets, immediately above the top rail at the back of the loom and behind the Jacquard harness. B is a double or bell crank lever made fast to the shaft A by two set screws C C. One arm of the lever B is straight and below the shaft A; the other arm forms a quadrant and is in a horizontal plane. A second lever D carries a sleeve E which fits loosely on the shaft A. The lever D is provided with two slot holes F and G as shown. An iron slide H is placed into close contact with the face of the lever D and is held in sliding position by means of a bolt and nut I. The shank of the bolt, which is square in section, passes through and just fits the slotted hole F. The slide has also cast with it a small spindle J, which passes through a hole of similar diameter in a bracket projection K cast with the lever D. A small rectangular stud L is cast upon the slide H at the point where the slide and spindle meet. Normally the stud L fits closely into the recess M formed in the centre of the arc circle in the quadrant lever B. Two other studs N and O are also cast on the face of the slide H. A special shaped or 'finger' lever P is pivoted to the stud pin Q, which passes through the centre of the lower arm of the lever B. The upper arm of the lever P

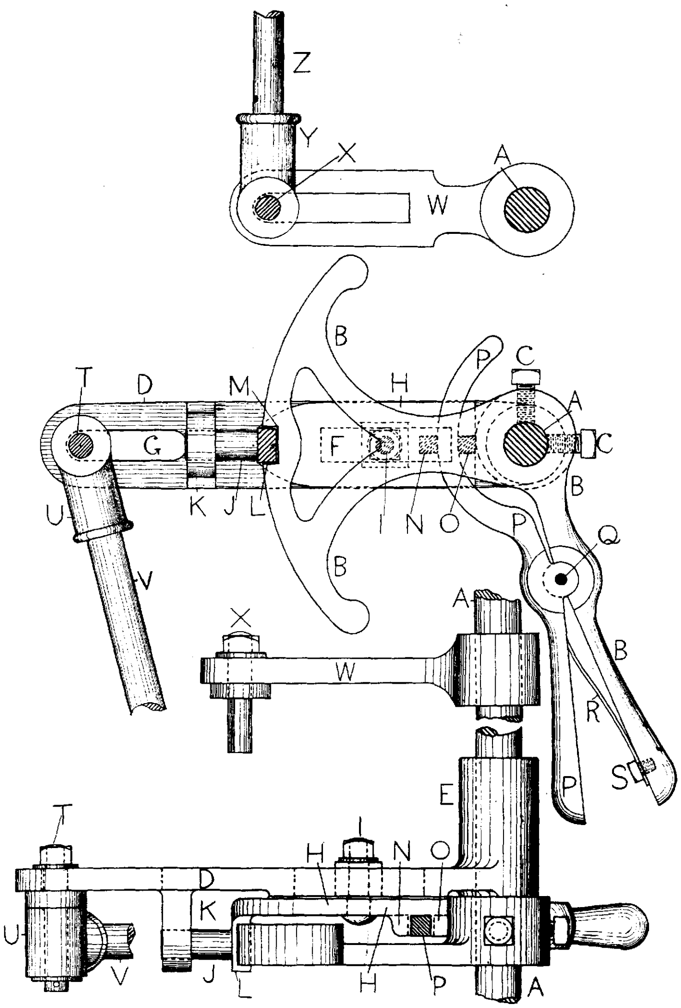


Fig. 82.

Fig. 81.

Fig. 83.

which forms an arc of a circle, fits closely but is free to slide between the two studs N and O. A strong steel spring R is set screwed at S to the lower arm of lever B. The free end of the spring R presses with its maximum energy against the lower arm of the lever P, and thus normally keeps B and P apart. The upper arm of lever P then, turning clockwise, presses against the stud O, and thereby keeps the slide H and its respective parts normally in the position illustrated. Adjusted to the lever D in the slot G is a stud T which supports the sleeve connection U. A connecting rod V joins U to a 'split' eccentric operating from the crank shaft in the loom. Upon the shaft A beyond the lever B is secured a small lever W. A stud X passes through the sleeve Y and joins the latter to the free end of the lever W. A connecting rod Z passes up to the parts which actuate the card cylinder.

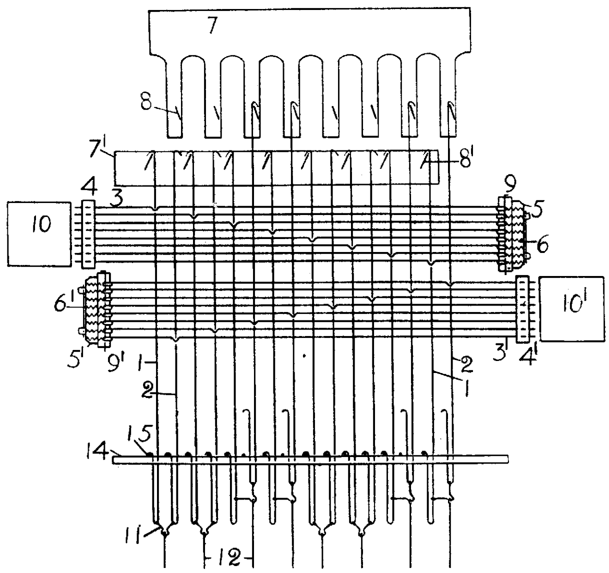
Action of the Mechanism.

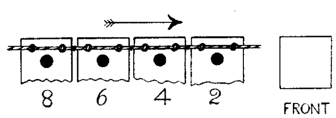
With the continuous rotation of the crank shaft, the eccentric reciprocates the rod V and lever D with which the slide H is compounded, and since the stud L is also fitting closely into the recess M of the quadrant arm of the lever B, this lever is also reciprocated, and through its medium the shaft A is oscillated, which in turn alternates the lever W, and operates to alternately press, in and out, the card cylinders, on each pick of weft. Suppose now the loom to be stationary and the lower arms of the levers B and P pressed together by the weaver, the arc arm of lever P then operates against the stud N to move the slide H and spindle J to the left, until the stud L cast with the slide, is clear of the recess M and so long as the weaver keeps his grip upon the levers B and P, he can, by reciprocating them in unison oscillate the shaft A independently of the lever D, and so move the card cylinder, in and out at will, turning the cards forward so long as the cylinder catches remain normal; but by pulling down the string W, Fig. 80, attached to the free ends of the catches, the lower catch is elevated into contact with the card cylinder and the cards are reversed with each reciprocation of the levers B and P. Immediately the pressure on B and P is released the steel spring R operates to separate them and bring the stud L into the recess M on the quadrant arm of lever B combined with the correct adjustment of the same.

Double Acting Jacquard—Double Cylinder.

In a machine of this type there are *two* sets of needles, each being actuated by a separate card cylinder and set of cards. One needle of the upper set and one of the lower are attached to an adjoining pair of uprights which are combined by two neck cords to a single tug cord.

Fig. 84.





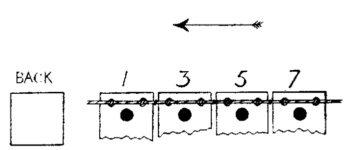


Fig. 86. Fig. 85.

Fig. 84 is a side view of one complete row of both sets of uprights together with one row of each set of needles and transverse sections of the two card cylinders, as seen from the right hand side of a right hand loom. The hooks of the two sets of uprights are opposite to each other, for if this plan were not adopted a non-perforated card would push the hooks on to the griffe blades at the one side and off at the opposite.

The chief details of the mechanism are indicated as follows:— 1 and 2 are the uprights, 3 the upper set of needles, 4 the needle-board, 5 the spring box, 6 the springs, 7 the griffe, 9 the needle stop pin and 10 the card cylinder for operating the uprights 1. Duplicates of these details to operate the uprights 2 are indicated from 3^1 to 10^1 respectively. A link 11 is employed instead of the double neck as in Fig. 75. Combined with the link 11 is a stout tug cord 12 to which all the harness twines 13 are knotted. 14 is the hook guide grate, 15 the resting bars.

The arrangement enables the pattern cards to operate upon the correct hooks from either side of the machine. Half the cards—all the odd numbers—are laced together for the bottom cylinder; the remainder—all the even numbers, are laced for the top cylinder. The odd numbered cards are laced forwards as at Fig. 85 and are usually arranged to work at the back of the loom. The even numbered are laced backwards and work at the front of the loom as at Fig. 86.

Driving the two Card Cylinders. Fig. 87 shows the essential details and the arrangement for operating the two card cylinders. Fig. 88 shows the left card cylinder and its details on an enlarged scale. A indicates the reciprocating rod, worked from the eccentric rotating on the bottom shaft in the loom. B is a lever connected to A and fulcrumed to the shaft C which is supported in brackets and free to oscillate near to the foot of the Jacquard. D is a second lever, set screwed to the shaft C. The free arm of D is adjusted to the stud E, fixed in one end of the connecting and reciprocating link rod F which is attached to the stud G, firmly fixed in the cylinder slide H. This slide is supported and free to move laterally in the two slide brackets I, I^1, affixed to the Jacquard framework L. At opposite ends of the slide bar H, brackets J, J^1, are securely fixed. Supported and free to rotate between the bracket J^1 and its complement at the opposite side of the machine, is the bottom card cylinder K^1. The top card cylinder K is similarly supported and free to rotate between the bracket J and its complement. The hammers M and spiral springs N prevent the card cylinder rotating too far during action.

With the constant rotation of the bottom shaft the reciprocating rod A acts through the lever B, oscillating shaft C, lever D and link F to alternate the slide bar H supporting the brackets J and J^1 and the card cylinders K and K^1 and brings them alternately into striking contact with each respective set of needles.

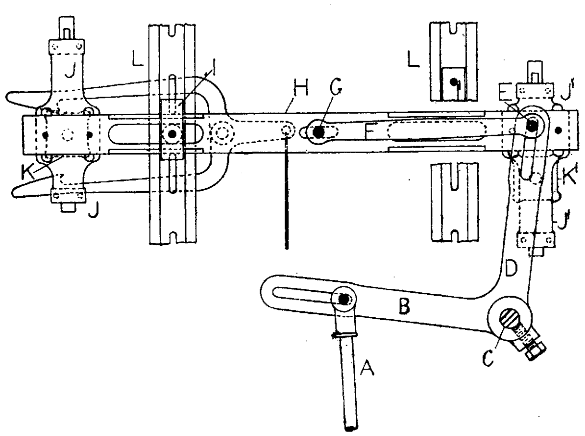


Fig. 87.

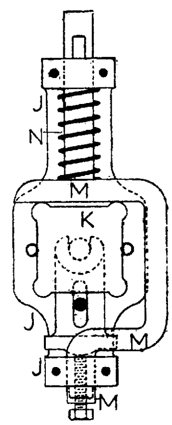


Fig. 88.

The chief advantages of this system as compared with the single cylinder are :—An increase of time is afforded for the rotation of the two card cylinders since they are required to strike only on alternate picks, which makes it possible to run the loom at a relatively higher speed. This is the principal advantage, since it involves fewer repairs and ensures a longer life to the Jacquard details and its connections. There is also less vibration among the uprights because the card cylinders only strike against the needles when the bottom knives are clear of the bottom hooks. The drag upon the pattern cards is reduced, especially where large sets are necessary and the working, generally, of the machine is easier.

The foregoing advantages will be seen to far outweigh the disadvantages of this system, the chief of which are:—The two sets of cards frequently get out of their consecutive order which increases the difficulty in finding a broken pick, or adjusting correctly both sets of cards after the pattern has been broken. Originally the uprights, for the top set of knives, were made longer than those for the bottom, but this plan interfered with repair work among the hooks, hence, they are now all made of uniform length.

The upright wires are necessarily longer than in a *single lift machine*, but the length is virtually no greater than for *one cylinder* in the *double lift machine*.

Devoge's 'Swivel Slide' Double Cylinder Motion.

The chief feature of this arrangement is the ready adjustment of the card cylinders in the vertical and horizontal planes. Fig. 89 is an elevation in perspective of the mechanism. A is the slide shaft, freely supported in the adjustable swivel bearings B and C by the four set screws and sleeves as shown. The bracket bearings are bolted fast to the machine gable D. The brackets E and F securely fastened to opposite ends of the slide shaft A support the card cylinders G and H respectively. The reciprocating motion of A is obtained from an eccentric on the crank shaft operating through the usual links, rocking shaft and bell crank levers combined with shaft A.

Automatic Stop Motion for Double Cylinder Jacquards.

One of the chief and inherent difficulties of the two cylinder system is the liability of a card to be presented to the needles out of its proper sequence. Various devices have been invented to overcome this defect and immediately detect any irregularity of order in the pattern cards. Fig. 90 is an elevation of Devoge's effective 'Jacquard Stop Motion,' as applied to and viewed from, the right hand side of a double acting double cylinder Jacquard, mounted over a right hand loom, as illustrated at Fig. 84. The mechanical parts are few and the action is simple. A and B are two special hooks added to the '25' row side. A is linked with needle H in the second row of the top set of needles, under control of the front card cylinder. B is linked with the needle I in the second row from the bottom of the lower set of needles. A spiral spring C circumscribes this needle and exercises its influence to press the hook B *clear* of the griffe knife and to keep the end of the needle normally out of contact with the card cylinder. The hook A is normally *over* the griffe knife. A bell crank lever D made of strong wire is pivoted at E in the fixed bracket F. The horizontal arm of this lever passes through a loop W formed in the upright A and the vertical arm passes through a loop Y formed in the needle I. A heavy lingoe J is suspended from the upright A to keep it normal. A cord K combines the upright B with the weft fork lever L. The remaining details are the same as the parts illustrated in Fig. 84.

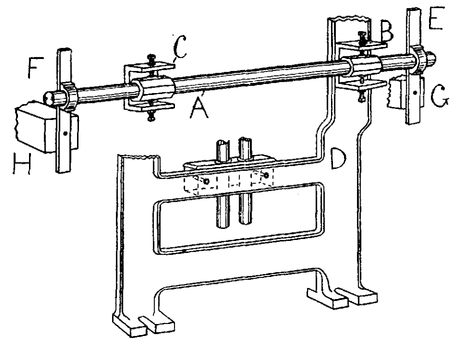
The odd numbered cards rotate over the bottom and back cylinder, and the even, over the top and front cylinder.

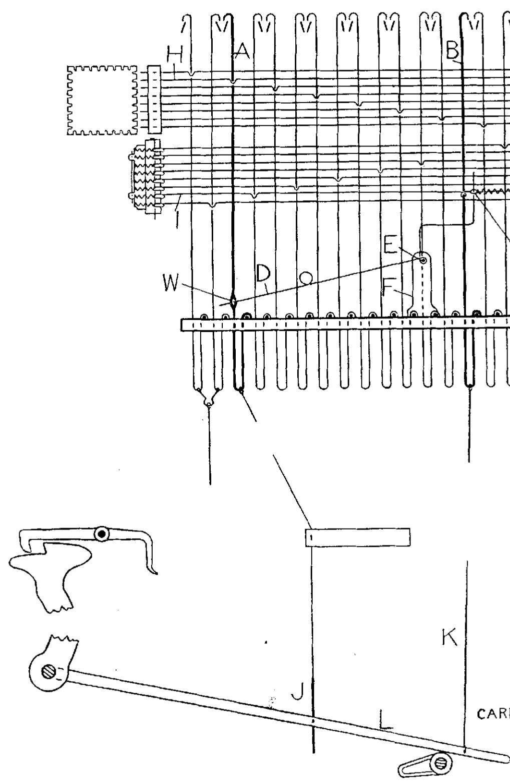
The principle of the mechanism is as follows:—A *blank* in the card opposite needle H pushes the hook A clear of the griffe knife and no action results. A *perforation* in the card opposite needle H permits the rising griffe to lift the hook A which in turn raises the horizontal arm of lever D and moves the upper arm with the needle I to the right, until the end of it projects slightly through the needle board.

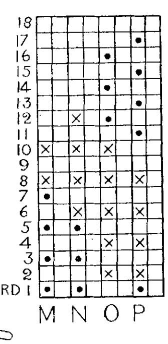
A perforation in the next card presented to the same needle I permits the elevation of 'stopper' hook B, cord K and weft lever L which last operates through the weft fork to release the starting handle and automatically stop the loom in the usual manner. If however, a blank card is presented to the needle I it will press the hook B clear of the lifting knife and thus neutralise the action of the hook A. Briefly then, a perforation in an 'even' card opposite needle H followed by a perforation in an 'odd' card opposite needle I stops the loom, but followed by a blank, the loom continues to run.

It is therefore essential to design some order of stamping the cards which will *primarily* not interfere with the constant motion of the loom so long as the pattern cards are in the correct sequence, but immediately this sequence is broken, the order of stamping

Fig. 89.







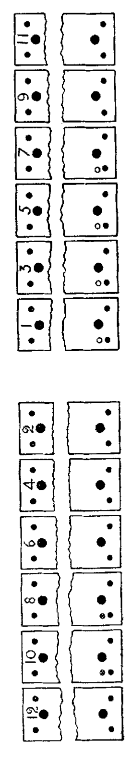


Fig. 90.

Fig. 91.

Fig. 92.

should be such that a perforation opposite needle H in any of the even cards is followed by a perforation opposite the needle I in any of the odd cards, so that the hook B is lifted and the loom is brought to a standstill.

The scheme of punching or stamping the cards must be on any number of picks which is a measure of the complete number of cards in the figure pattern. Fig. 91 supplies four such examples M N O P containing 12, 14, 16 and 18 cards respectively to the repeat —1008 cards. The marks $\boxed{\bullet}$ represent perforations in the odd cards to act opposite needle I, and $\boxed{\times}$ perforations in the even cards to act opposite needle H.

The 12 pattern cards for design M are shown stamped at Fig. 92 from which it will be perceived that so long as they maintain their regular sequence, this order of stamping will not interfere with the motion of the loom.

The hook A is only lifted on the even picks 8 and 10 which are followed by the blank cards 9 and 11 respectively, but if the order is broken so that any of the perforated cards, 1, 3, 5 or 7 succeeds either of the cards 8 or 9, the hook B will immediately follow the rising lead of A until it operates through the details described to immediately arrest the loom.

Double Neck Cords and Link Motion.—A Comparison.

Double Neck Cords.

Fig. 93 illustrates the original style with *two* neck cords in the position where both uprights are level; they pass each other in the centre of the shed. $A\ A^1$ are the uprights, B the resting board for the uprights when in their lowest position, $C\ C^1$ the neck cords, and D the group of harness twines controlled by either of the uprights A or A^1, or the neck cords C or C^1.

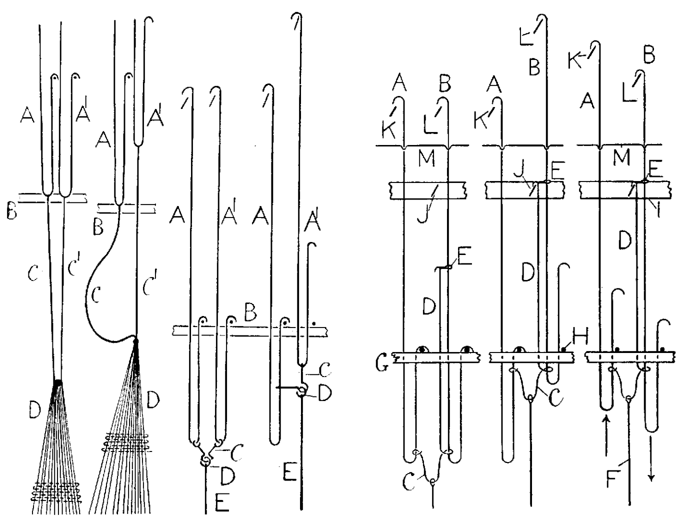
Fig. 94 illustrates the same details when the upright A^1 is lifted to its highest altitude, and when its companion A is at the bottom. It will thus be seen that while the neck cord C^1, looped to the lifted upright A^1, is under tension and supporting all the weight of the group of harness twines to which it is connected, its duplicate neck cord C hangs 'slack' as shown. In a full machine, especially where the figuring capacity is large the slack neck cords constitute the chief defect. The sudden pull on the cords after hanging slack, tends to cause very frequent breakages and to generally shorten their life, and further, if any of the neck cords break, they are somewhat difficult to repair and correctly adjust.

Link Motion.

Fig. 95 completely represents the details and principle of the '*link*' motion, introduced in the year 1890 by Hancock, Rennie and Hudson. A, A^1 are the two uprights, and B is the resting plate combined with horizontal iron rods for supporting the uprights when in their lowest position. C is a double link which combines the uprights A, A^1 and constitutes the special feature of the invention. D is a single link which combines the special double link C with the tug cord E.

Fig. 96 illustrates corresponding details but shows the upright A^1 lifted; one arm of the double link C is suspended from the bottom of the raised upright A^1 and rises with it, but the opposite arm of link C slides freely up the short shank of the upright A which remains down; the tug cord E together with the harness twines and warp threads simultaneously ascend with the double link C. If the requirements of the pattern determine that this same group of warp threads must be lifted on the next pick of weft, the upright A will gradually ascend until it meets the upright A^1, half way, and continuing its traverse carry upwards the link C and its load to the top again, whilst the upright A^1 continues its descent to the bottom. Of course where no warp threads are required to be lifted on any given pick, both uprights remain down. The effect of this action upon the warp is less sudden and severe than that of the double neck system.

From a mechanical point of view this invention works very well whenever the pull of the harness on the links is almost perpendicular as in narrow looms, but when weaving wide fabrics, the angular pull on the links, especially from the harness nearest the sides of the Jaquard machine, is very great. The amount of friction thus generated neutralises the tendency of the links to freely slide up or down their respective short shanks of the uprights A or A[1]. This difficulty is to a certain extent overcome by using the *link motion* only for the *central* parts of the machine and *double necks* at the *sides*. A better method has recently been adopted by Devoge and Co. by which the tug cords are made to pass freely through a '*cord*' board before they are attached to the harness twines, which ensures that the links rise and fall in a vertical plane, and reduces to a minimum any tendency to stick during their action.



Figs. 93 94 95 96 97 98 99

The adoption of the link motion necessarily generates a certain amount of friction and increases the wear and tear by the sliding action of the links over the surface of the uprights, but nevertheless its introduction marks a step forward in Jacquard mechanism.

'Open Shed' Jacquard with Link Attachment.

A perfect open shed Jacquard machine is a desideratum. Numerous attempts have been made to attain this object. The following illustration from Dracup's machine is one of them. This invention produces an open shed after the double lift dobby principle. The top shed only falls slightly on every pick to allow sufficient clearance for the hooks to be pressed clear of the knives when desired.

Fig. 97 shows two uprights A and B in their lowest positions, combined with the modified link attachment C. The special feature of this link is an extended shank D with a hook at the top and a loop E. The loop is linked to and free to slide up or down the shank of upright B. The tug cord is shown at F, the hook resting board at G with the usual cross bars at H. The board G contains *five* perforations, instead of the usual four, for each pair of uprights. An additional fixed board I contains a series of steel knives J on which the hook of shank D may be placed and continue holding up link C and tug cord F for as many picks of weft as the pattern requires. The bottom griffe and knives are shown at K, the top griffe and knives at L, and the needles at M.

Fig. 98 shows the same details but hook B lifted to the top and the hook of D immediately over knife J.

In Fig. 99 the hook B is descending; the hook of D is retained on the knife J; the hook A is rising to carry the link C up to its highest point and to permit the hook of D to be pressed clear of the knife J in sympathy with hook B of the knife L if the warp thread for the next pick is required to be down.

Springless Jacquards.

Hardaker's. This type of machine is designed to work with two card cylinders but only one row of needles, each of which controls two uprights. By this method a shorter length of upright is required and thus a saving of space is effected at the top of the loom; an ordinary *single* cylinder machine can be readily converted into a *double* cylinder; one row of needles is only required.

Fig. 100 illustrates the essential features of this principle of mechanism. A indicates the position of the uprights, arranged in pairs with their hooks facing each other and normally over the knife blades. B is the resting board. C and C^1 the griffe knives. D is a series of round rods, in pairs, one on each side of an upright;

these serve as a fulcrum against which the respective uprights can press and so be induced to assume their normal upright position after having been subjected to pressure by their controlling needles. They are easily detachable whenever it becomes necessary to remove the uprights for repairs, etc. The needles are shown at

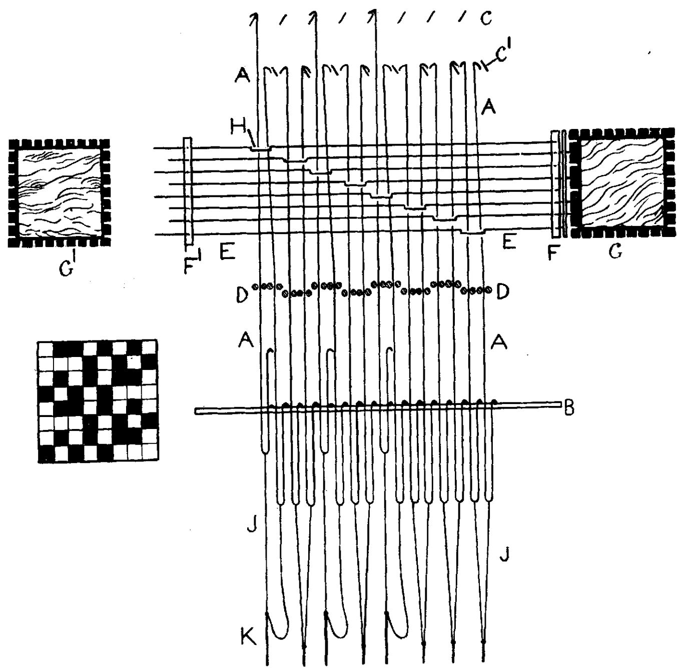


Fig. 101. Fig. 100.

E, the needle boards at F, F', the card cylinders at G, G', the neck cords at J, and the tug cords at K. A crank H is formed in each needle of sufficient length to just enclose two uprights.

In the given illustration, to coincide with the first pick of pattern Fig. 101, griffe C is shown raised, with uprights 1, 3 and 5 left over the knives by the last pattern card. Cylinder G has just struck against the needles for the next shot. This card has left, in their normal position, uprights 2, 4, 6 and 7 to be lifted by the griffe blades immediately they commence to rise. The remaining uprights 1, 3, 5 and 8 are shown pressed by the right shoulders of the corresponding needles *clear* of the griffe blades. In a similar manner the operation is repeated according to pattern for the whole design and length required.

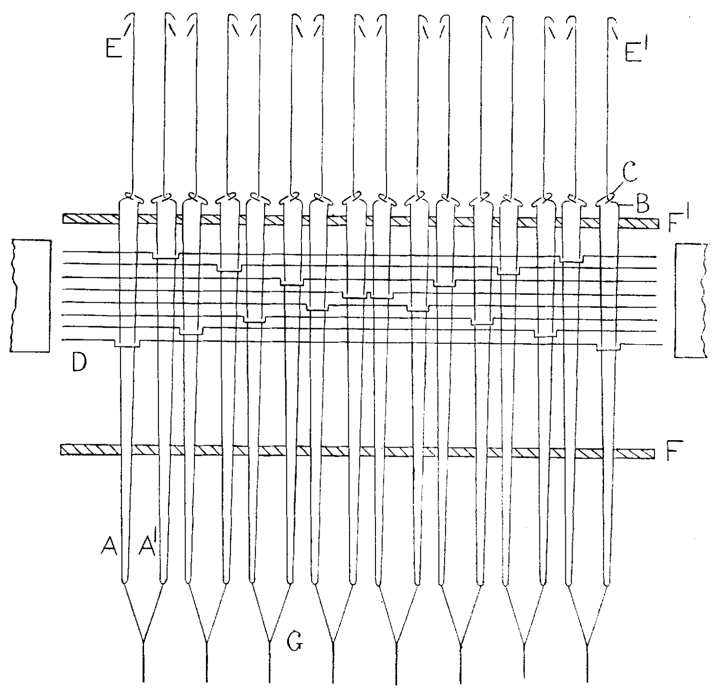


Fig. 102.

Wadsworth's

Fig. 102 shows the main features and chief points of difference in this machine as compared with the former. The uprights A, A' are of special construction. A crank is formed at B in the long shank of A and a loop at the top of the short crank at C; through this loop the long shank passes. The cross wires or needles are shown at D, in each of which is a crank of sufficient length to just contain one pair of uprights A, A'. E, E' are the two sets of knives. F, F' are fixed grid plates which serve as supports and act as fulcrums for the uprights, when subjected to lateral pressure by the needles. Immediately this pressure is released the long shank assumes its normal upright position. The loop C regulates the extent of the lateral traverse so that the hook of each upright is just over its respective griffe knife. The neck cords connecting the same tug cords are shown at G.

Varieties of Jacquard Driving.

Cam Driven Jacquards.

Many reasons and advantages can be advanced in favour of using *cams* for operating the draw rods and reciprocating the 'head' levers of both single and double lift Jacquard machines. The system imparts a straight lift, and generates the minimum of friction combined with a uniform movement in the various parts of the actuating mechanism. The cam or cams can be constructed to produce any *variety* of motion and period of 'dwell' in the head levers and shed, and may be effectively employed where a steady movement among the warp threads is essential during the period of shedding and where the nature of the yarn and structure of the material preclude high speeds, as in figured leno weaving of the gauze reed and leno Jacquard types. This principle is most useful with pressure harness, double cloths, Brussels and Wilton Jacquards (see also *Carpet Manufacture*, pages 92 and 130) and similar arrangements where the head is required to *dwell* up for two or more shots of weft.

The principle details of the mechanism for producing the necessary movement in the draw rods for a double acting Jacquard machine are illustrated at Figs. 103 and 104. The former is an end and the latter a side elevation; the same letters in each, refer to similar details. A indicates the position of the crank shaft; B the low shaft running at half the speed of A; C is a cast iron support for the driving apparatus. The remaining details are chiefly in duplicate. The function of both drawing rods is consequently the same, but they operate alternately. Set screwed to the low shaft B are two cams or tappets D, D^1, adjusted diametrically opposite to each other. E, E^1 are two cam slides connected through the adjustable links F, F^1 to the draw rods G, G^1 respectively. I, I^1 are antifriction rollers between which the slides E, E^1 can reciprocate. Mounted and free to rotate upon studs secured to the cam slide plates E, E^1 are antifriction rollers J, J^1 below the cams D, D^1 and similar rollers K, K^1 above the cams respectively. The cams are kept in rolling contact with their respective top or bottom antifriction rollers.

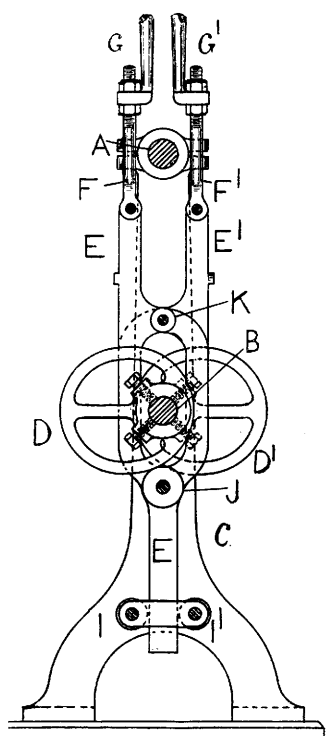


Fig. 103.

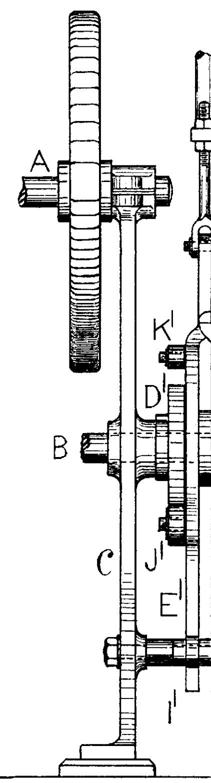


Fig. 104.

Action of the Mechanism.

The reciprocation of the draw rods G, G^1 is as follows :—With the constant rotation of the low shaft B, the cam D rotating counter clockwise, presses upon the roller J to depress the cam slide, the link F and the draw rod G to produce the upper division of the warp threads constituting the shed. Simultaneously, but conversely, the cam D^1 also rotating counter clockwise gradually releases its pressure upon roller J^1 and approaches roller K^1 until when in rolling contact it assists in checking the falling shed, acting almost with a positive controlling force for this purpose. For the next half rotation of the shaft B the two cams D and D^1 continuing their rotation produce exactly, but conversely, the same operation.

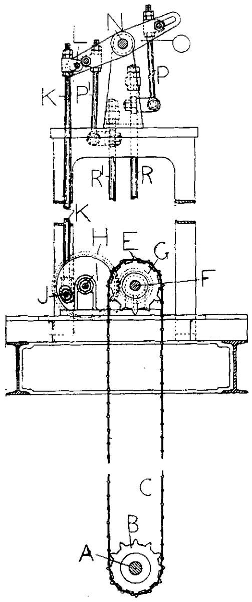


Fig. 105.

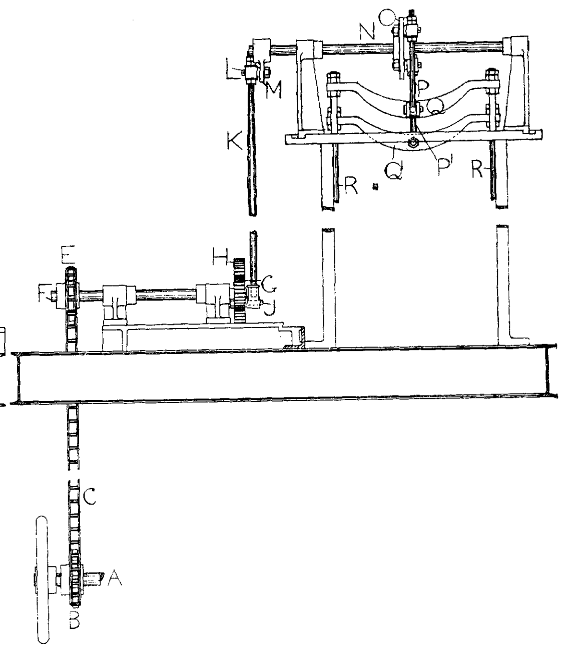


Fig. 106.

Chain Driving Motion.

This system is designed to produce a steady drive in the reciprocating parts of the head and to economise room by obviating the use of the ordinary *long* head levers.

Figs. 105 and 106 are sketches made from Hardaker's machine. The former shows an end elevation and the latter a front elevation of the operating details. The same letters in each diagram refer to corresponding parts.

A is a portion of the crank shaft, supported in the loom framing. B is a chain wheel secured to the crank shaft in the position indicated. C is a link chain of the bicycle type. The chain passes upwards and over a second sprocket or chain pulley E secured to the shaft F which is mounted and free to rotate in bracket supports at the top of the Jacquard gantries as shown in the front elevation, Fig. 106. Compounded with the chain shaft F is a spur wheel G which gears into and drives a second spur wheel H containing double the number of teeth of G and, therefore, revolving at half the speed and being centred and free to rotate upon the fixed stud I. A pin stud J passes through one of the arms of the wheel H and rotates with it. A reciprocating and connecting rod K joins the stud J with a second stud L fixed in the simple lever M centred and free to oscillate on the shaft N to which a rocking lever O is connected. The link P connects lever O to the cross head Q, Fig. 106, with which is compounded the spindles R, in turn fixed to the griffe and knives. Duplicates of P, Q, R attached to the second griffe and set of knives are shown at P^1, Q^1, R^1.

Action of the Mechanism.

With the constant rotation of the crank shaft, the sprocket chain wheel B and chain C rotate in sympathy and at the same rate as the driven chain wheel E and driving spur G, which in turn rotates the spur wheel H once every two shots of weft. The rotation of the stud J affixed in H, reciprocates in sympathy the rod K and lever L and oscillates the shaft N. The oscillation of this shaft elevates and depresses, through the medium of parts O, P, Q, R and the duplicates P^1, Q^1, R^1, the two griffes with their respective sets of knives on the required alternate shots of weft.

Compound Driving of Two Double Lift Jacquards.

Whenever it is found necessary to combine two or more machines to work together over the same loom it is of vital importance that they should be operated from the same source so that both heads rise and fall exactly in unison.

Oscillating Pulley.

Fig. 107 shows Devoge's application of a pulley combined with a rocking shaft for alternately lifting the Jacquard heads in a double lift machine. A, A^1 are sections through the two cross heads. B, B^1 are loose bolts which combine the heads with swivel links C and C¹. Bolts D and D¹ combine respectively the leather straps or steel chains E and E¹ which are fastened to the periphery of the pulley F at G. This pulley is fixed on the square section H of bar I which is suitably supported and free to oscillate in fixed bearings. On the top of the Jacquard a simple lever J, set screwed to the bar I, is combined with bolt K to the reciprocating rod L which receives its vibratory motion direct from the bottom shaft. The lever J in turn oscillates the rod I and pulley F through which the two heads of the machine are alternately elevated and depressed.

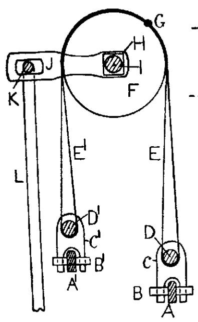


Fig. 107.

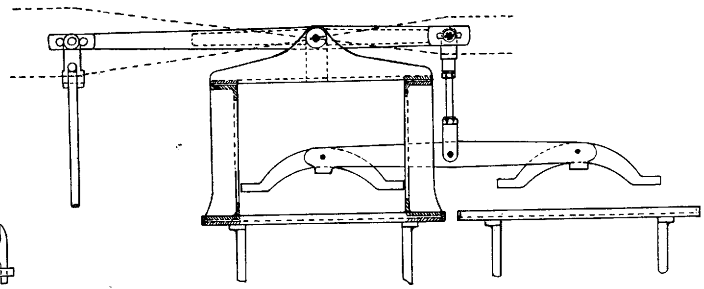


Fig. 108.

In some instances the two Jacquard heads are simply combined by a cross bar, and this is then lifted from the centre with the two heads suspended—one at either end, Fig. 108. This arrangement is not very satisfactory. A compounding of levers on one of the following methods is preferable.

Two Lever Principle.

Fig. 109 shows, in elevation, a front view of the head levers with their respective 'heads' for driving two 600 double lift machines. Fig. 110 is an end view of one of the two reciprocating rods which connect the head levers with the eccentric on the low shaft, and Fig. 111 is a plan of the essential parts and connections given in Fig. 109.

The same letters in each diagram refer to similar parts. A and A¹ represent the two head levers. B is a stud pin which serves as the common fulcrum for both lifting levers. The stud pin and the levers are supported in the bracket C fixed to the top of the Jacquard framing. A stud D is adjusted and bolted in the slot as shown, midway between the fulcrum pin B and the right arm of lever A. This stud supports a link E and a short rod F. A short stud G joins the rod F to the swivel link H which is free to oscillate to the right or left and forwards or backwards. A third stud I at right angles to G joins the swivel link H to the cross head J, to which last, the spindles and griffe bars are attached. Adjusted near the end of the right arm of lever A, are a stud K, link L, rod M and stud N which, in turn, is adjusted to the free end of the lever O, pivoted on the fulcrum pin P in the bracket chair Q fixed to the top of the Jacquard machine as shown. In *lever* O, the stud R, link S, rod T, stud U, swivel V, stud W, and cross head X correspond and respectively agree with the details D, E, F, G, H, I, J, in the *lever* A.

Duplicates of parts shown from A^1 to W^1 refer to similar details which are connected with the back or second griffe of each Jacquard machine. It should be observed that the head lever A belongs to the first order and the head lever O to the second order of levers.

Action of the Mechanism.

With the constant operation of the low shaft in the loom or its substitute, for reciprocating the driving rods already described, the head levers A and A^1 alternately rise and fall on opposite shots of weft. Then, with the depression of the left arm of A, the right arm ascends carrying with it the free arm of lever O, which, through its connections previously detailed, elevate simultaneously the heads J and X. The reverse motion is produced by the *rising* of the left arm of lever A. The operation of the second griffe for each machine is exactly the same in principle, but the mechanism is adjusted so that the first griffe is at the top when the second is at the bottom and vice versa. The descending griffe assists the elevation of the rising griffe and thereby acts as a counterpoise.

Problems on Uniform Depth of Shed with Two or more Machines.

It is of first importance that the two heads J and X should be lifted exactly the same height, and start from the same level. This involves that the centres of the connections in the given levers A and O, Fig. 109, should be adjusted exactly.

The dimensions for the given parts are as follows:—The throw of the crank eccentric, reciprocating the rods and connecting the crank with the levers A and A^1 is $9\frac{1}{4}$ inches; consequently the traverse of lever A at the centre of its connection with the reciprocating rods is also $9\frac{1}{4}$ inches. The distance between the fulcrum B and the lifting stud in the left arm of lever A = $23\frac{1}{2}$ inches. Between the centres of B and K, where K connects lever O in N = $23\frac{1}{2}$ inches, therefore, the traverse of lever O at the point N

Fig. 110. Fig. 109.

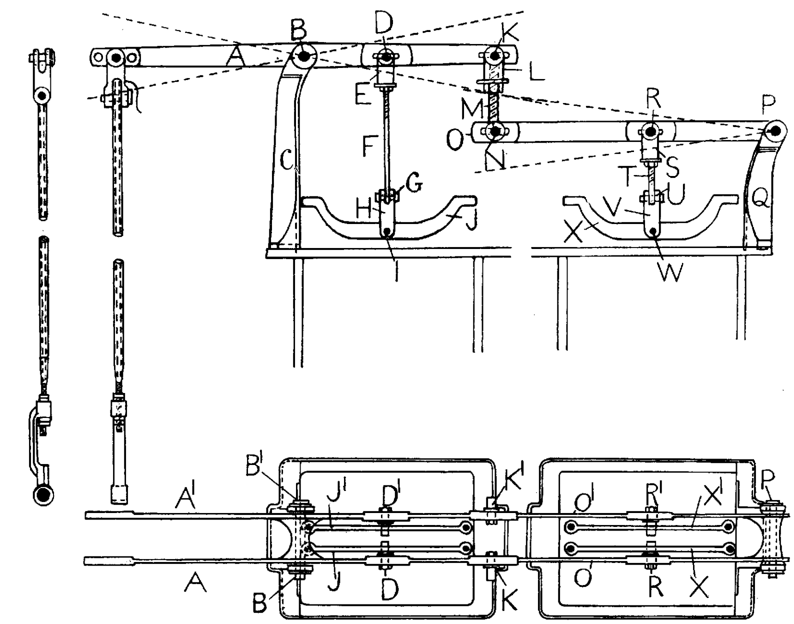


Fig. 111.

is also $9\frac{1}{4}$ inches. The distance between the centres of B and D in lever A = $10\frac{1}{8}$ inches, the distance of K and P or N and P in lever O = $33\frac{1}{2}$ inches, and that of R and P = $14\frac{3}{8}$ inches.

Then the traverse of the head in No. 1 machine equals the amount of reciprocation imparted to the lever A at the point D

$$= \frac{9\frac{1}{4}'' \times \text{B D}}{\text{A B}} = \frac{9\frac{1}{4}'' \times 10\frac{1}{8}''}{23\frac{1}{2}''} = 4 \text{ inches.}$$

and in No. 2 machine the traverse of the head equals the amount of reciprocation imparted to the lever O at the point R.

$$= \frac{9\frac{1}{4}'' \times \text{R P}}{\text{N P}} = \frac{9\frac{1}{4}'' \times 14\frac{3}{8}''}{33\frac{1}{2}''} = 4 \text{ inches.}$$

Slight adjustments can be made to equalise the lifts if necessary.

Bradbury's Direct Lever Counterpoise.

This method differs somewhat from the former in respect to its simpler mechanical details and the relatively smaller number of parts employed.

With the ordinary and former method each head lever has necessarily to lift *one* head in *each* machine; the counterpoise acts through the two opposite Jacquard heads, lever and double crank.

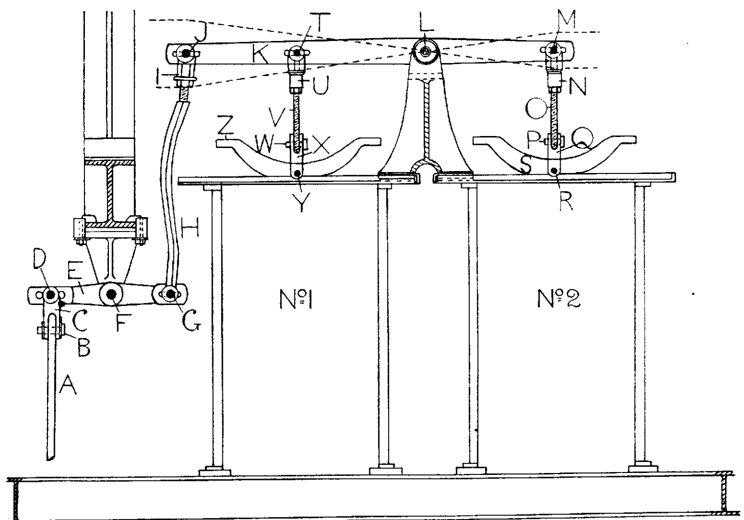
In the following design the *counterpoise* acts *directly* through each head lever, each of which is simultaneously an elevator and a depressor.

The result of this modification is a reduction in friction and a maximum saving of power equal to about 25%.

Fig. 112 is a front elevation of the working details of this mechanism. Fig. 113 is a plan of the same details. The same letters in each refer to similar parts. A indicates the reciprocating rod which joins the double eccentric on the bottom shaft to the intermediate rocking lever E. A stud pin B connects the rod A to the swivel link C which, in turn, is attached by a stud D to the left arm of the rocking lever E, pivoted on the stud F in the fixed bracket. This is, in turn, bolted fast as shown to the underside of the steel beam which forms part of the building structure. This arrangement produces a direct pull on the head levers and considerably reduces the amount of friction generated, whenever the horizontal distance, from the crank eccentric to a plumb line dropped from the point of contact with the head levers, is great.

G is a stud connecting the lever E to the reciprocating rod H which is adjusted into the link I, pivoted to the stud J in the head lever K fulcrumed on the stud L in the bracket fixed to the top of the two Jacquards as shown. The free end of lever K is connected with the bottom griffe of No. 2 machine on the principle of the *first* order of levers. An adjustable stud M connects and supports a link N to the lever K. A short, threaded bolt O screwed into N supports the stud P and the swivel link Q, in turn, joined by the stud R to the cross head S.

Fig. 112.



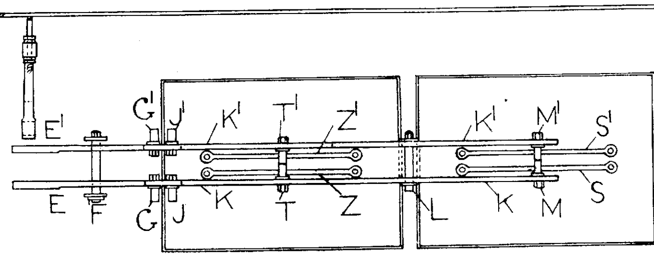


Fig. 113.

The top griffe of No. 1 machine is similarly connected to the head lever K, acting at this point as a lever of the *second* order, through the stud T, swivel link U, bolt V, stud W, swivel link X, stud Y and cross head Z. These parts are respectively duplicates of parts M to S inclusive.

In a similar manner the bottom griffe of No. 1 machine and the top griffe of No. 2 are combined by the parts A^1 to Z^1 inclusive.

Action of the Mechanism.

The constant rotation of the double eccentric on the low shaft causes the rods A and A^1 to rise and fall on alternate picks; thus, when the rod A ascends, the left arm of lever K *falls*, together with the cross head Z and the top griffe knives of No. 1 machine, but the right arm *ascends* and lifts the cross head S and bottom griffe knives. Simultaneously and conversely the rod A^1 descends, thus causing the left arm of lever K^1 to ascend and lift the *bottom* griffe of No. 1 machine, but the right arm of this lever descends with the top griffe of No. 2 machine.

On the next, and every subsequent alternate pick, these movements are reversed.

This mechanism was designed for the Textile Industries Department of the Municipal Technical Institute, Belfast, and performs its work most effectively with a considerable saving in power, especially in weaving 3 or 4-ply tapestries.

The principle is also applicable to double acting, double cylinder Jacquards.