A TREATISE ON WEAVING,

BY

HAND AND POWER LOOMS.

A PRACTICAL TREATISE

ON

WEAVING,

BY

HAND AND POWER LOOMS:

INTENDED AS A

TEXT BOOK

FOR

MANUFACTURERS BY HAND AND POWER LOOMS,

AND

POWER LOOM ENGINEERS;

AND ESPECIALLY DESIGNED TO FORWARD THE EXTENSION OF MACHINERY TO ALL KINDS OF PLAIN WEAVING.

WITH NUMEROUS

ILLUSTRATIVE ENGRAVINGS

OF THE

MACHINERY AND IMPLEMENTS AS THEY SHOULD BE USED IN WEAVING, ACCORDING TO THE ACKNOWLEDGED PRINCIPLES OF THE ART.

BY

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GLASGOW:
JOHN NIVEN, 46 ARGYLL STREET.

LONDON: WHITTAKER & CO.
MANCHESTER: J. & J. THOMSON, MARKET STREET.
EDINBURGH: OLIVER & BOYD. NEW YORK: D. APPLETON & Co.

MDCCCXLVI.

GLASGOW:
PRINTED BY JOHN NIVEN AND SON
GLASSFORD STREET.

PREFACE.

Weaving, as an art, grew out of rude and simple elements; and although the means became more and more complex as the art advanced to maturity, its character was, nevertheless, homogeneous in the whole, so long as it continued to be carried on by hand agency. But when machinery was brought to bear upon it, the agency became of a highly compound character:—the art of weaving became allied with engineering; and the manufacturer by machinery, therefore, was required to combine the knowledge of the weaver with that of the engineer; and, to carry him successfully through the difficulties incident to all new applications of power, to be gifted with ample mechanical resources. These are qualifications, however, which are rarely combined; and indeed the necessary knowledge of the two arts is not easily obtained, from the manner in which they exist in relationship to each other. Weaving, as an art, is nowhere brought within the reach of the engineer: books do not even inform him what it is, and it is rarely well exemplified by the weavers themselves. The manufacturer has thus no available means of enabling him to judge of the requirements of the art, and supposing he had the advantage of a good practical knowledge of weaving, which is more than he can be expected to possess, machinery is a widely different subject, and in advancing into it, he can have little practical assistance from a party who is ignorant of the common ground between them. A compromise is the only course that can take place in these circumstances. The subject is skirted;—the manufacturer shrinks from the difficulties which the engineer cannot meet, and the fabrics, therefore, which are attended with the least difficulty in the weaving, are selected. Hence the application of machinery to the finer and more difficult fabrics of weaving is retarded, from a want of confidence, and apprehensiveness as to the result, which is natural in these circumstances; and thus a great part of the subject remains unaffected by power.

This is the state in which the art of weaving still exists with relation to machinery, and it is the object of the following work to assist in the removal of these unfavourable circumstances, for the purpose of facilitating the extension of machinery to weaving throughout:—

First,—By presenting to the engineer a clear and distinct outline of the principles and best practice of the art, by which he must be guided in making and applying his machinery as it ought to be to weaving.

Secondly,—By presenting the art to the trade so as to lead to the correction of bad and indifferent practice in weaving, by which the success of the best constructed machinery can be but partial.

Thirdly,—By presenting to the manufacturer and the engineer, the best construction and adaptation of machinery for effecting the required purpose in weaving, in accordance with the acknowledged principles of the art.

CONTENTS.

LIST OF ILLUSTRATIONS.

WOOD ENGRAVINGS.

PLATES.

ERRATA.

Page 133, line 14 from bottom, *for* Plate IV. *read* Plate III.
133, line 6 from bottom, *for* u' *read* a'.
136, line 13 from top, *for* r' r' *read* k' k'.
136, line 15 from top, *for* Plate IV. *read* Plate II.
164, line 5 from bottom, *for* h *read* f'''.
166, line 1, *for* Fig. 4th *read* Fig. 5th.
168, line 8 from bottom, *read* "Fig. 1st, Plate VIII. and transverse section of the Power Loom, Fig. 1st, Plate VII. effects," &c.
178, line 13 from bottom, *for* Fig. 1st *read* Fig. 2nd.
179, line 17 from bottom, *for* Fig. 2nd *read* Fig. 5th.
179, line 11 from bottom, *for* Fig. 2nd *read* Fig. 5th.
180, line 16 from bottom, *for* Fig. 3rd *read* Fig. 6th.

INTRODUCTION.

The progress of civilization is attended with great changes, both in the mode and the means, for effecting a supply of the necessaries and luxuries of life, dependent chiefly on the development of chemistry and mechanics. These two agencies, as affecting production, are of recent origin; and present us with a world of new means, by which the old agency of animal power is being relieved from drudgery, to assist in originating and superintending the new.

Mechanics, as applied to manufactures, led the way; and with a success so pre-eminent, as adapted to spinning by Arkwright, that we had previously no idea of a production so enormous by any agency. This department, therefore, became quickly occupied; and, whilst machinery was branching out in numberless new directions over the industrial field, in this it was brought so quickly to maturity, that its growth and development were regarded as tests by which its progress was to be estimated in other directions.

The importance of machinery was thus appreciated from the first, and its application to Weaving was expected to be attended with the same immediate and triumphant results. But as this was far from being the case, it countenanced the idea—which is not yet exploded—that the subject was unsuitable to the agency. This notion respecting the unfitness of machinery arises from overlooking the distinction between the *production* of motion and the *adaptation* of motion—so that errors originating in the application of the means, are regarded as inherent defects in the agency.

Weaving, comprehensively considered, however, is a difficult subject for machinery. The motions themselves are reciprocating—a kind of motion not easily produced without some injurious disturbance, from the reaction arising from the irregularity of the resistance. The yarn, therefore, may be broken in weaving from the *motions*, according to the manner in which they are performed; and both breakage and bad work may result from *inadaptation* of the tools.

In spinning again, almost the whole of the beautifully wrought out agency is the expression of two ideas—namely, *draught*, admirably brought out by fluted rollers, and *twist*, on the fibres forming the threads, in the direction of their axes. The motions in spinning are, therefore, rotatory, and free from the disturbing influences attending the application of motion to weaving. Hence the strain on the yarn in weaving is relatively great; and, accordingly, whilst machinery has done almost all that can be expected from it, at least all at present required of it, in cotton spinning,—in weaving, although the power loom has been more than fifty years in use, from the time of its being invented by Doctors Cartwright and Jeffray, it has as yet established its influence over those fabrics only in which breakage is not to be apprehended from the performance of the motions. The finer departments of goods, which require nice adaptation in the means, have hitherto been unapproachable by it—so great is the difference between the motions as performed in weaving, and the motions as adapted to the weaving. For although cloth may be made by both modes of working, the one effects its object in dependence on the absolute strength of the yarn; whereas, by the other, the yarn is subjected to the least possible strain in weaving. This adaptation is, therefore, the expression of the *art* of weaving, by which the motions are adapted to the yarn, and the tools to both.

The Power Loom, from the first, has been chiefly in the hands of those who by circumstances were necessarily little acquainted with weaving as an art. Weavers, in general, who have the greatest knowledge of weaving, have the least acquaintance with machinery; and engineers and mechanics, to whom the superintendence of weaving by power properly belongs, are necessarily ignorant of weaving. There is thus a want of communication between them, by which the progress of power loom machinery has been very much retarded; and hence a general coarseness of expression characterizes all this sort of agency as applied to weaving.

No attempt has been made in books to communicate this art. Treatises on weaving have, hitherto, confined themselves to the description of the cordings for the formation of figures, in fancy weaving, and tweelings; or calculations connected with the warp. The art of managing the yarn in the loom has been left in the hands of the weavers, untouched by them.

But although the art is to be found among the weavers only, it is very rarely to be met with among them in a state properly or fully exemplified. There is generally so much of a rude and indistinct expression given to the art in their practice, as scarcely to preserve the lineaments of the system, so that a considerable knowledge of weaving is necessary to trace it properly, as even presented by them.

The subject is, therefore, inaccessible to the engineer, and the manufacturer by power looms has no sufficient assistance of which he can avail himself. The method of working out his object by experiment is uncertain, expensive, and too slow for his immediate purpose. He therefore follows the track as it has been opened up, and is followed by others; and as the knowledge by which they are led is chiefly borrowed, it is of little use, (even supposing it were the result of experience obtained in this second-hand manner,) out of the direction from which it was taken.

Hence weaving by power has, almost from necessity, been confined to coarse and heavy fabrics; and the adaptation of the loom even to these, has but lately begun to assume a general character of fitness. At first, the arrangements as used in weaving by the hand loom were closely imitated, and with little success, as the difference in the agency, as influenced by power, was not sufficiently understood. This result, however, gave rise to the reaction in opinion, which is at present so frequently met with,—that they are guided by dissimilar principles. But this opinion arises from attending to the dissimilarity only, as presented in the means, and not to the principles as affecting both.

In hand weaving the weaver is the machine on which the power acts by will at various points on the apparatus, for effecting his purpose. This is done by motion adapted to the work, which is learned by practice, and tools adapted to both by experience. These two conjunctions in art must be present to ensure success, in a high degree, to weaving by either mode.

But as the power loom springs from the hand loom, and is indeed merely the completion of the combination of motions as begun by the use of levers—as treadles, and the invention of the fly shuttle, the same general principles of weaving are applicable to both. The power loom, accordingly, may be so far complete as to motion, and yet inapplicable to the work from a want of adaptation. The motions of weaving are necessary to the loom in any kind of work, to weave at all; and the adaptation of both the motions and the machinery is necessary to weaving, treated as an art. The adaptation of the loom is thus the completion of the machinery as applied to weaving, and requires both a sufficient power in dealing with the capabilities of machinery for the purpose, and a sufficient knowledge of the art of weaving to apply the machinery in accordance with it. This conjunction of machinery with art has never been sufficiently attended to in weaving by power; or, rather, the means have been supposed to be incompatible with it; and, accordingly, weaving by machinery has been confined to work which requires the least art in the adaptation of the means; and hence, from the difficulty of combining a sufficient knowledge of both weaving and machinery, the power loom is still inapplicable to fabrics in which the greatest adaptation is necessary. Fine muslins, for example, in its present state, are beyond its reach; and little has been done with it in the weaving of checks. In the linen manufacture, although it is in use, its success has been much more limited than in the cotton trade; and in the silk, it is perhaps still more so, although it is not less adapted to it. The woollen trade is a more extensive branch of our manufacture than either of the previous two,—employing probably about 50,000 hand looms, and the proportion of the power looms may be about 10 per cent.

Much, therefore, remains to be done with the power loom; and as the art of weaving, by which it must be directed, is best exemplified in connexion with the development of the means, I have endeavoured in this work to trace the progress of weaving from its commencement, for the purpose of pointing out the agency in its simplest state, and the improvements and modifications made in it, to adapt it to the various fabrics which come under the denomination of plain weaving. This forms the subject of the present volume; and as the great design of the work is to forward improvements in the manufacturing of cloth by machinery, the line in the order of their proceeding from hand to power is thus preserved, and, it is hoped, presented sufficiently clearly to enable the engineer, and the manufacturer by power looms, to see what is required in adapting this machinery to the various fabrics to which it is at present applied, as well as to those fabrics to which, as yet, it has made no successful approach. The art of weaving is therefore treated on common principles, and in detail, as applicable to the various fabrics made of the usual materials as worked in the loom; and with the view of facilitating the extension of machinery to the subject, the author has presented drawings of his power loom for fine goods, and likewise of his dressing machine to act in conjunction with it. These two machines are fitted, it is hoped, to bring the muslin trade within their influence; and his loom for weaving checks will, it is presumed, do what the trade requires of it.

The loom for fine goods is worked by springs; and that which he has presented as adapted to sail-cloth, is constructed on the vertical principle of weaving, with the lathe horizontally placed, so as to strike the fell in a manner similar to the tilt hammer.

Three kinds of looms are thus recognised as necessary to bring all the fabrics of weaving successfully under machinery ;—*first*, The common power loom, for the fabrics to which it is at present applied: *secondly*, The vertical loom, to the coarsest textures made of the most rigid fibres; and *thirdly*, The spring loom, to the finest and most elastic,—as muslins, &c.

Thus plain weaving by machinery will be completed; and fancy weaving considered with reference to power, will form the subject of a second volume.

As the hand loom is likely to continue in use for two or three ages, the usual tables are subjoined, which may still be useful in manufacturing by it.

A

PRACTICAL TREATISE

ON

WEAVING.

PLAIN weaving consists in the interlacing together of two lines of threads at right angles to each other. The long threads running from end to end of the piece are called the Warp; and the cross ones from selvage to selvage, or from side to side, the Weft. The interlacing of the warp with the weft by picking up each individual thread with some instrument, such as a needle, on which the weft may be wound, as represented in Fig. 1st, is darning, which is merely weaving in its first stage, and is the state in which weaving exists among all barbarous nations.

2. Any art in this state of society, is necessarily carried on by tedious methods with rude tools; and

in weaving by darning, the production is so disproportionate to the time employed in it, that the

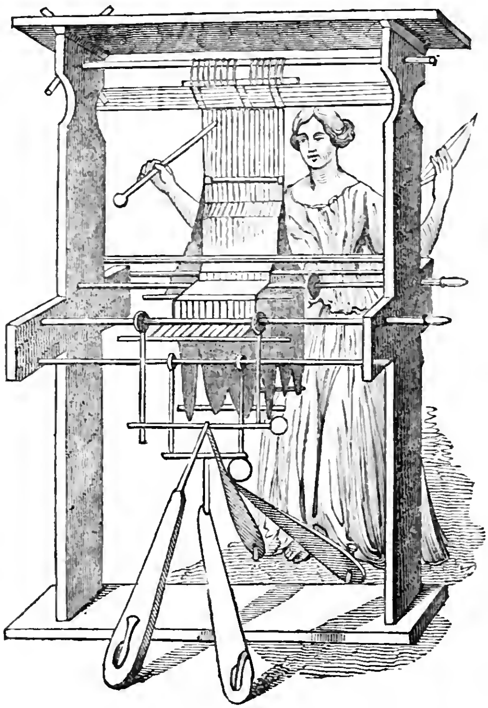


Fig. 1. Loom of the Middle Ages.

The figure introduced above as illustrative of weaving by darning, is taken from a copy as presented by Mr Baines in his History of the Cotton Manufacture, from Montfoucon's Antiquity Explained. It is a representation of European weaving as it may be supposed to have been practiced in the 3d or 4th century, on the authority of some illuminated designs in old books, which are regarded by Montfoucon as belonging to that period.

The figure represented in the act of weaving is a woman standing in front of the frame, which consists of two upright posts attention could not be long directed to it without perceiving that the process was capable of great improvement.

3. Accordingly we find that society had not advanced even into the semi-barbarous state, before it was discovered that by attaching a tool to a certain quantity of the warp, that portion of it could be instantaneously raised to open a passage through the yarn for the introduction of the needle, or shuttle, and thus the weft shot could be thrown across the

connected together by a transverse one at the top and the bottom.

The web is extended in a vertical position; the upper end of it being attached to a transverse rod at the top, and the other end to a rod similarly placed below at the middle of the frame.

But it will be seen that there are several rods here; and about this part of the frame, and the tackling represented below as treadles, there is considerable doubt as to the manner in which they effect their purpose.

Mr Baines speaks of the loom as distinguished by little peculiarity, or as similarly constructed to the common hand loom. But if there is any thing more clear than another about it, it is the dissimilarity as contradistinguishing the two frames, apparent even at first sight, and this impression is not diminished by an attentive examination of it.

European weaving at the time to which we refer, and long afterwards, was a domestic employment carried on chiefly by women; and as the fabrics were designed for their own circle, and frequently for their own personal ornament, the loom contrived for the purpose was rudely made, as might be expected, and intended both for plain and fancy work, according to their notion of the art of weaving; as figures in the cloth were effected rather by the needle than the shuttle.

The art, accordingly, was in that transitory state between darning and the use of some sort of means for shedding the web whole web as soon as one thread of the warp could be picked up in the process of weaving by darning.

4. This shedding tool is called the Heddles, or Healds, and consists of at least two pieces, or leaves, containing together as many heddles as there are threads in the warp. Fig. 2d. is a representation of an individual heddle, with the thread drawn through its eye; and the range of these, as seen in Fig. 3d, connected together and extended on two thin rods,

with treadles, as the representation above evidently indicates.

The loom seems likewise to be designed for two persons to work at it, on different pieces, or on the same piece as might be required, on opposite sides of the frame; otherwise there seems to be no use in representing a pair of treadles on each side of the loom. If the treadles are brought to act on the web here, it follows that the rods are used for the purpose of deflecting the warp, and that the manner in which the treadles act in shedding it, is by a sort of heddles, not represented, but acted upon, by what seems to be, or may be, something like rectangular levers put there for that purpose.

The drawing is doubtless not a correct representation of the art which it endeavours to portray, or it is an imperfect one.

If the view of the matter which is here represented be correct, the web will be drawn from the rod or roller above, as it is wrought, and there seems to be some sort of leverage on the end of it for that purpose; but it does not seem to be wound on any roller below, as the end of it appears to be hanging loose.

The figure is not represented as using the treadles, but in the act of picking up the warp with a spindle in the right hand, which is probably likewise used for squeezing up the shot. The shuttle is in the left hand. But it is not unlikely that this mode of weaving may have been used in conjunction with the treadles for forming a figure on the cloth, and in that case, the pattern may have been drawn from the cross cords at the top of the framing, which do not seem to be there for any other purpose.

or shafts, *a a*, is a leaf. The two leaves D D, making, in this case, a set, are represented in a working state as seen in an end view, in Fig. 4th, having one half of the warp through the fore leaf, and the other through the back leaf; one thread being taken through each heddle of the back and fore leaves alternately; so that by raising either of the leaves, an accurate division of the warp,

Fig. 2. Eyed Heddle.

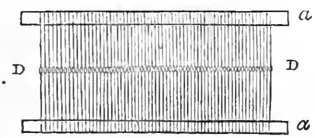


Fig. 3. Single Leaf.

with one thread up and one down all over, is instantaneously formed.

5. This beautiful method of shedding the web with heddles, therefore, effects an immense saving of time in the process of weaving; and is so great an improvement, that it perfects the principle on which weaving is to be carried on, and renders all further improvement applicable only to the *manner* in which the motions of weaving are to be performed, or to the *instruments* for effecting the motions.

6. This method of shedding the web was in use among all the semi-barbarous nations of antiquity, before any record was preserved of their transactions; and when, or where, this great improvement was first invented, is therefore unknown. Weaving with heddles was so generally in use among the

Chinese, Indians, and Egyptians, at a very remote period, that no special notice is taken of it by the

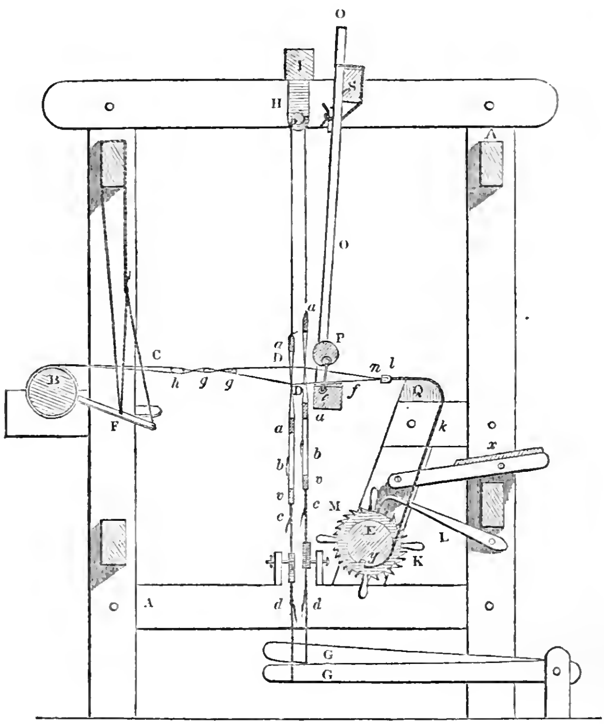


Fig. 4. Lateral Section of the Old Hand Loom.

oldest writers. Indeed, it is rather from incidental notices of the subject, and representations of the Arts in old prints and hieroglyphics, that we have some distinct notion of the state of weaving among the ancients.

7. Fig. 5th is a representation of an Indian

Loom,* as it now is, and as it was, thirty centuries ago; from which it is quite apparent, that little or no further improvement of it was made among those nations that were formerly so celebrated for their skill in manufactures, from a period long before our acquaintance with them commences, to the present day.

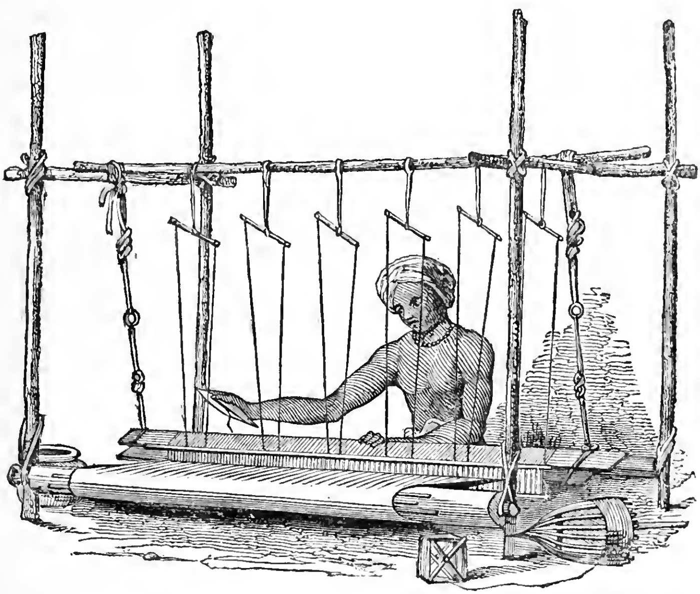


Fig. 5. Indian Loom.

* Among the many passing notices which are frequently met with in books of travel, and in popular works on the state of weaving in the East Indies, there is none that conveys such a notion of it, as a person practically acquainted with the subject can say what really is the state of the *art*, as it exists among them. A rough outline of the mechanical means is given, but the points of value as determining the question are wholly lost

8. Weaving as carried on by this almost universal method, consists in the performance of three motions in succession, and these are :—

First,—The shedding of the web, for the introduction of the shuttle with the weft shot.

Second,—The throwing of the shuttle through the shed.

Third,—The striking home of the shot.

sight of : namely, the adaptation of the tools to the varieties of work, and the skill as manifested by them in the management of the yarn.

It is true that a certain lauding style has long been fashionable in speaking of Indian weaving; and the weaver is represented as being fitted with an organization peculiarly adapted for his work. This sort of testimony, however, is nothing to the point in question, and indeed, in any case, is valueless, from the incompetency of the parties to give an opinion on the subject.

The points in question can be known and estimated aright only by those who are thoroughly acquainted with weaving. Travellers, and mere bookmakers, cannot be expected to possess such a knowledge ; and hence the state of the means by which the art is properly exemplified, as used for fine or coarse work, such as the size of the shuttle—the build of the heddles—the depth of the shed—the tension of the web—the length of the stretch—the state of the paste, and manner of using it in the process of dressing, are nowhere noticed, so far as I have seen, as of any specific value in weaving ; so that we can have no idea, relatively, of the quantity of work so far as labour is considered, which an Indian weaver may be able to turn out, compared with an English one. The tools, doubtless, are in a primitive state, but such a condition is by no means incompatible with some degree of skill in the management of the yarn, although it is unavoidably attended with the use of expedients in weaving by which time is lost, and thus the quantity of the work is diminished, and its quality impaired, notwithstanding every care that can

9. The manner in which these motions are performed varies in different countries, according to the advancement of the art, or the skill of the weaver. But as his object in all the arrangements which he may make for so doing, is to be enabled thereby to obtain the greatest speed in weaving with the most

be taken with it in the weaving. The web is woven, as represented in the above sketch, which is a common print illustrative of Indian weaving, very near the ground, and in that respect, the yarn is placed where it is most easily kept in a proper state for weaving, a circumstance of great importance to the work in a country so warm as India.

The weaver, accordingly, that he may get sitting at his work, digs a hole or ditch, in the ground, immediately under the place where he extends his web. Having suspended the heddles from jacks above, he attaches the leaf of each shed to the respective great toe of each of his feet; or, in some cases, he uses treadles in a rude manner, with the one end resting on the ground, and the other suspended to the heddle cords in place of his toes, on which his feet rest in weaving.

The lathe, or rather the reed, is suspended by a cord at each end to the upper framing of the shed in which he works, or, in case it be in the open air, to the branch of some tree which has been selected on account of its fitness for that purpose.

The shuttle is, in some cases, long, so as to extend from side to side of the web, and is used in that case, for squeezing up the shot to the fell, as well as for introducing it into the shed; in other cases it is short, like the old hand shuttle, and is thrown in a similar manner.

The paste for dressing is stated by some to be made of rice, by boiling it in a little water and using the decoction without the grains; and, according to others, as seen in Mr Baines History of the Cotton Manufacture, the dressing is made from a root called *Kandri*, which yields, by preparation, a starchy matter, used by the weavers of Bengal for that purpose.

case, that method is adopted which he thinks will best enable him to effect his purpose.

10. Accordingly, as it would be inconvenient to have the warp for a long piece stretched out at its full length, the weaver invariably has it wound on a roller, or beam, which he puts in a *frame* to preserve the uniformity of its tension in weaving; having previously drawn the yarn through the heddles, and what is called the reed, represented in Fig. 6th.

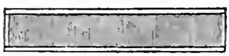


Fig. 6. Reed.

This frame is called the loom, of which Fig. 4th is a lateral section. A A is the frame; B, the yarn beam; C, the warp line: and a section of the plan is seen in Fig. 9th, in which the corresponding parts are referred to by the same letters.

Fig. 7. Heddle Hook, and

Fig. 8. Reed Hook, half the usual size.

11. The two operations of heddling and reeding are performed separately with a thin hook, which, for the heddles, is such as that represented in Fig. 7th, in this manner. The weaver hangs the heddles immediately in front of the yarn beam, and commences the

operation on the right hand side, by taking the first heddle on the back leaf, into the eye of which he

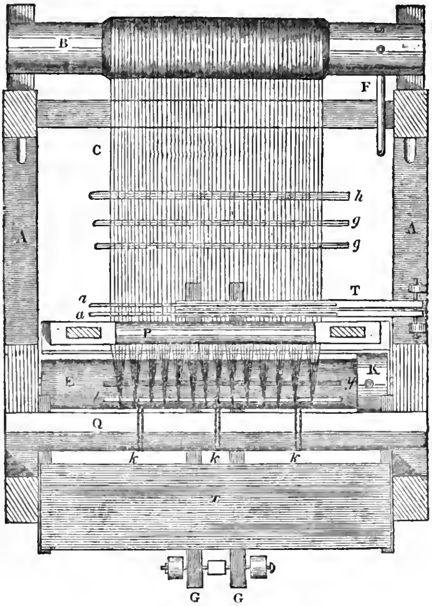


Fig. 9. Section of Plan of the Old Hand Loom, taken immediately above the Heddles.

puts the hook, when an assistant immediately places in its bight the first thread of the selvage, which the weaver pulls through, and then another heddle, the first on the fore leaf, is taken in like manner, and so on alternately, till all the yarn is drawn through.

12. The reeding of the web is more quickly performed than the heddling, inasmuch as two threads, the one from the fore leaf and the other from the back leaf, are taken together with a similar instru-

ment, (represented in Fig. 8th,) through between each split or dent of the reed in succession, till the whole of the warp is reeded. The ends of the threads thus drawn through, are then neatly and evenly fastened to the cloth beam E in front of the loom, as seen in Fig. 9th, by being attached to a rod *l*, which is connected by the cords *k k k* to the groove *y*, in the beam for that purpose; and the web, which is tightened by what is technically called the bore-staff, F, is then in a fit state to be *mounted*, that is, to have those appliances put up and adjusted, with which the weaver performs the motions of weaving.

13. The heddles are the first of these, and are mounted in such a manner, that either the back or fore leaf may be instantly raised with an alternate motion perpendicular to the yarn.

14. This is frequently done, as represented in Fig. 4th, by suspending them from a roller H, attached to the bearer I, the back and fore leaves being on its opposite sides; and as the heddles are worked by the weaver's feet, he places for that purpose two levers, called treadles, G G, so far under the web in the direction of the yarn, that when sitting on his loom at work, his right foot may rest on the one treadle, and his left on the other; and as the treadles are suspended from the under side of the heddles by the cords, *b b*, *c c*, *d d*, the one treadle being attached to the back, and the other to the fore leaf, and therefore balanced by the roller above, the weaver has only to press down the one treadle and the other alternately, as the shot is thrown in,

and the shedding with one thread up, and one down, according to the draught in the heddles, is thus easily and beautifully effected.

15. The throwing of the shuttle is done without the aid of any mechanical contrivance. Fig. 10th is a represention of the shuttle. The weaver merely takes it in his hand, and throws it through the shed from the point of his fore finger, catching it with the fingers of the other hand, as it emerges from the shed on the opposite side. He then strikes the shot home, and the reed is the instrument with which this is done; but as it is slight in its make, like a long comb, its pressure is rendered effective, and weight imparted to it, by its being put in a frame.

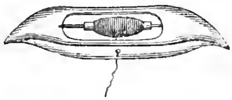


Fig. 10. Hand Shuttle.

16. This frame is called the Lathe, seen detached in Fig. 11th, and suspended from its place

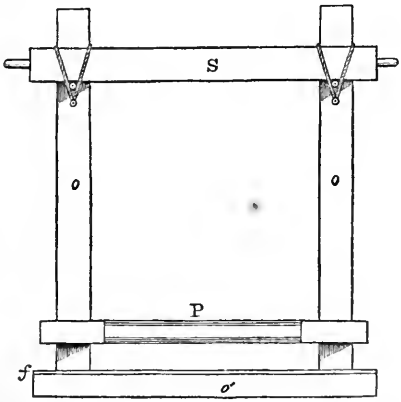


Fig. 11. Hand Lathe.

in the loom at O, Fig. 4th, and moves or oscillates perpendicularly, in the space between the fell or verge of the cloth *n*, and the heddles, like a pendulum. The two arms pendant *o o*, are called the swords and the transverse piece *o*′, the sole. The reed is set in the groove *e*, seen in Fig. 4th, in the sole between the swords; and forms a wall behind to guide the shuttle in its passage through the shed; whilst a projecting piece of the sole in front, or rather a thin strip of hardwood *f*, nailed at this part of it, to prevent the lathe from being worn by the shuttle, and called the race, supports it beneath. Above the reed is supported in a groove in the upper shell P, which likewise forms a handle, by which the weaver, as soon as he has thrown in the shuttle, seizes the lathe with the hand thus disengaged, and drives or strikes the shot up to the fell.

17. Thus each hand is alternately used in throwing the shuttle and working the lathe; and as the operation is carried on, the space in front of the heddles gets worked up, so that the room becomes insufficient for the motion of the lathe. The weaver therefore stops as every two inches or thereabouts of cloth are worked, and withdrawing the bore-staff, turns the cloth beam so much with the handle K, whilst its return is prevented by the click L, acting on the ratchet placed at the end of it for that purpose. This operation is called drawing the bore.

18. This is the manner in which weaving was carried on, with some variation, among all nations down to the year 1738, when a great improvement

was made in the working of the hand loom, which rendered it three times more productive than it was before. This was the invention of the fly-shuttle.

19. This great invention, for which we are indebted to Mr John Key, an ingenious weaver, a native of Bury, in Lancashire, consists merely in adding to the sole of the lathe on each side or end a small box *u u*, made in continuation of the race beyond the swords, for the reception of the shuttle, with a spindle to each *t t*, fixed above it parallel with the race, as seen in elevation in Fig. 12th, and in

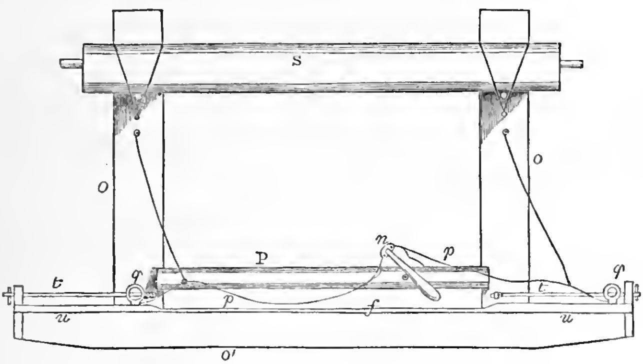
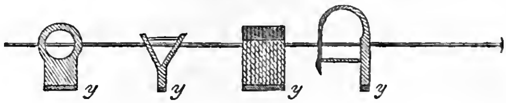


Fig. 12. Fly Shuttle Lathe.

Fig. 13. Section of Plan of do.

section of the plan in Fig. 13th. There is then a bit of wood called the driver or picker, variously made, as represented in Figs. 14, 15, 16, and 17, fitted to slide on the spindle in each box; and to keep it steady in motion, it is furnished with a tongue or tenor *y*, at its lower end, so as to work in a groove or slit, made



Figs. 14, 15, 16, and 17, Drivers, one fifth of the common size.

in the race immediately under it for that purpose. The two drivers *q q* are connected together with the fly-cords *p p*, which the weaver when at work on his loom, holds in his hand by a handle *n*, called the fly-pin. The shuttle, made as seen in Fig. 18, is then

Fig. 18. Fly Shuttle, one fifth of the common size for Muslin.

put in the box in front of the driver; and as the cord is so long as to permit that driver only, with the shuttle before it, to move to the end of the box, whilst the other driver is at the entrance, the weaver has therefore merely to jerk the fly-pin gently in the direction across the web, and the shuttle is thrown through the shed into the opposite box, pushing the driver before it.

20. The shot thus thrown in, is then struck home with the left hand, which always rests on the lathe for that purpose.

21. These motions by this method of weaving are performed in a very short space of time; usually, on yard wide work, at about the rate of an 100 shots per minute. In broad work where the shuttle re-

quires a longer time to traverse the web, the speed is, of course, diminished, perhaps to about 80. But, in work of this sort especially, an increase of speed is not the only gain derived from the employment

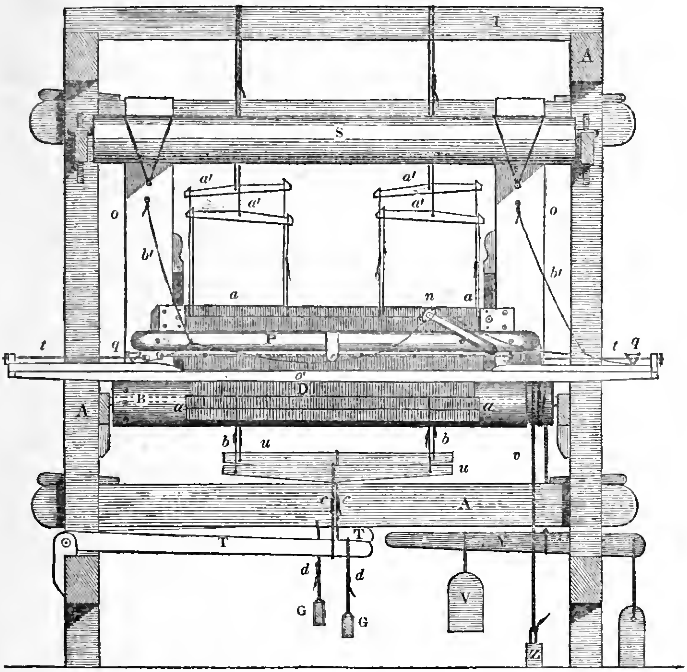


Fig. 19. Transverse Section of the Modern Hand Loom.

of the fly-shuttle, inasmuch as all work woven by the old method, of a greater width than the weaver could embrace within his extended arms, was necessarily done by two weavers, one at each side of the web to receive and return the shuttle, and this they could not do at a rate exceeding 40. Whereas by the fly shuttle, speed is obtained to such a degree, that it is limited only by the strength of the weaver to maintain it, or by his art in managing the yarn and the implements so as to fit them for sustaining a very high rate of working: and in respect to speed in shuttling, therefore, the hand loom is perfected by this invention.

22. But although the success of this very simple contrivance was complete, and effected the greatest possible saving of time in shuttling, a loss was necessarily experienced every bore in withdrawing and adjusting the bore-staff, which was felt to be the more inconvenient, from the very efficiency of this new method of weaving. Attempts, accordingly, were soon made to get rid of this inconvenience, and these ended in the displacement of the bore-staff altogether, by the introduction of that beautiful method of tightening the web, by what is technically called the friction pace, seen in Fig. 19th, on previous page, which is a transverse section of the common hand loom, with the roll removed, to show a full front view of this apparatus.

23. This method of pacing the web consists merely in passing a cord *v*, two or three times round the end of the beam, and attaching to it a weight or loaded lever Y, hung in opposition to the warp, by which the tension of the web is maintained and adjusted, whilst this lever-weight is balanced by a small counter-weight Z, suspended from the other end of the cord in front of the beam. The beam is, therefore, by this means, converted into a friction roller, which not only permits the bore to be drawn without any of the inconveniences and loss of time at-

tendant on the use of the bore-staff, but with the additional advantages of a uniformity of tension, sufficiently so, at least, for practical purposes; and a *resilliance* in action to the motion of the shed, unattainable by the other means.

24. This method of pacing the web was, therefore, highly succesful in practice; not only because of its saving time for shuttling, which is a positive gain, but from its being so completely adapted to weaving, that it has become as essential to it as the fly-shuttle itself.

25. But speed in shuttling is merely a means to speed in weaving; and will be effective in producing the greatest quantity of cloth in a given time, only in so far as the breakage of the yarn is prevented, that the rate of shuttling may be well kept up. For this purpose, therefore, the weaver exerts his utmost skill to devise and employ every means in weaving to save the yarn:—

First,—In preparing the yarn, dressing it in such a manner, as to impart the utmost strength to it of which the process is capable.

Secondly,—As to the position of the yarn or web in the loom, that it suffer the least strain necessary in weaving—and

Thirdly,—That all the motions of weaving are performed with the least possible injury to the yarn.

26. This view of the subject leads us to the consideration of *weaving* as a process carried on by *art;* and *dressing,* as a preparatory process essential to *weaving* :—and

27. First, then,—With reference to dressing, we

may observe;—that threads made of any fibrous material, such as Cotton, Linen, Flax, or Wool, are formed by laying the filaments of which they are composed parallel to each other, and then locking them together by imparting twist to them. But as the ends of the filaments which are not secured by twisting are thrown from the surface of the thread by the centrifugal force of its rotation on its axis, the yarn comes from the spinner in a rough and woolly state, in which it is unfit for being woven, from the unavoidable interuption and breakage of the yarn by these filaments in shedding, especially where the work is fine.

28. Now the process of dressing consists in laying these filaments along the surface of the yarn, and securing them in this position, by the application of paste with a brush. Dressing is, therefore, a preparatory process to weaving properly so called, and so highly necessary to it, especially to fine work, whether cotton or linen, that the success of the weaver may be ascertained from his manner of performing it; and, as the object of the process in giving it a smooth surface, is to impart to the yarn the utmost strength of which it is capable, this must be done with the least waste of its strength in the performance of the process.

29. Now the web is dressed in the loom, stretch after stretch as it is worked, leaving about two inches of the old dressing behind the heddles, to which the new is to be joined; and the general practice in working with clasped heddles, is to draw over the web at the end of the dressing to increase the length

of the stretch, from the supposition that a dressing* a little longer may be done as soon as a shorter one. But this practice is over-done, so that the yarn is very frequently strained from the length of the stretch. Two feet two inches is a sufficient length of dressing for very fine yarn; but for common or coarse fabrics, the weaver may take as much of a stretch as he conveniently can, which is about three feet.

30. As the yarn is warped, of which we shall speak by and by, in half *gangs*, each consisting of a certain number of threads run together from beginning to end of the web, for the convenience of beaming, and starched after it comes off the mill, the threads of the half gangs cohere together as the strands in an untwisted cord; and were the paste applied to them in this state, the brush could not sufficiently reach them to lay the fibres, notwithstanding that the yarn would suffer severely from its friction in working through them, without being able to clear them out individually; and thus much time would be wasted in separating them, when the yarn, after all, would be in an unfit state to be woven.

31. The yarn must, therefore, be prepared for the application of the paste—it must be opened up, so that the threads may, as much as possible, be individually clear of each other. This clearing up of the threads is called *redding* the web, and for the facility of doing so chiefly, a third rod, the lease rod *h*, Figs. 19th and 20th, is used, and put in a shed

* That portion of the web which is dressed at a time, is called a dressing.

formed with the threads, in couples up and down alternately. This shed or rod, is cleared down to

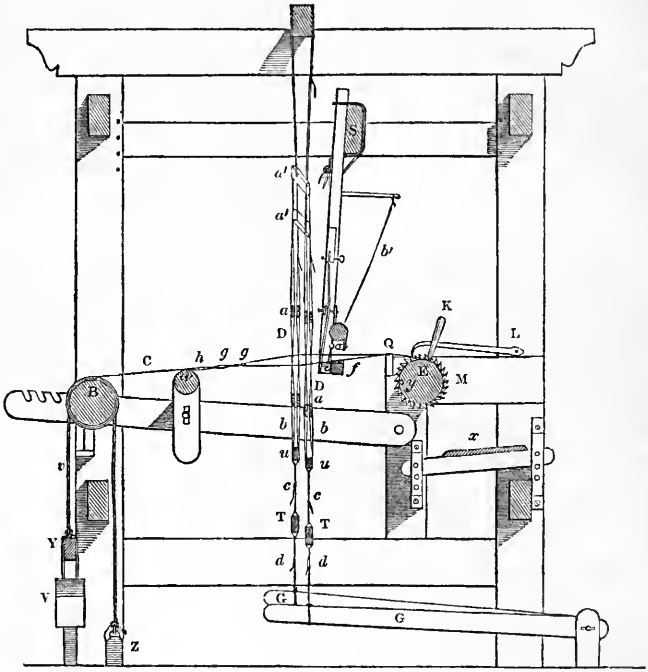


Fig. 20, Lateral Section of the Modern Hand Loom.

the beam; all the rods are then taken out, and the web is effectually cleared up by brushing it once or twice over with a *dry* brush. The yarn is next examined for the purpose of picking it of any knots, and piecing any threads, otherwise faulty, which might give way in weaving; and the web is now in a fit state for the appliaction of the paste or dressing.

32. The dressing is made of flour and water boiled together, till the glutinous and starchy matter

of the flour are thoroughly incorporated. The time necessary for effecting this properly, will vary. It may be sufficiently done with about half an hour's boiling; but the process will be facilitated, and the paste improved, by previously soaking the flour in water for a day or two. The dressing, as made up for use, should be about the thickness of good honey; and as the quality of the paste is essential to the strength of the yarn, it must be made of the best material—of the best American wheat flour.

33. Weavers in general, prefer old dressing, from its being less apt when softened by age to twist the yarn together, or *plait* it, as it is called, in dressing. But as this quality of the paste is the result of a loss of tenacity or strength, the yarn when dressed by it is weak in a proportionate degree; and, moreover, as plaiting is but indirectly dependent on the quality of the paste, and directly on the manner of applying it, and is, after all, an indication of ineffective brushing—either that the dressing is *unequally*, or too *slowly* applied, the remedy must be sought for in the working of the brush.

34. As the brush is the great instrument in dressing, on which the quantity and quality of the work directly depends, it must be made of the best strong boar's hair; long in the staple for fine yarn, and of a length and breadth such as the weaver can handle with ease; 12 inches by 2 is the common size as used in Scotland, although they are generally a little larger in England; and as the dressing is more easily seen on black hair, it is preferable, perhaps, on that account, from its colour. Although *plaiting*,

except from accident, will not take place with a bad brush in a good hand, *bridging*, that is, two or more threads connected together by the filaments transversely, to a greater or less degree, is inevitable from the weakness of the brush. But besides the weakness of the brush from its being made of insufficient stuff, or from the failure of the hair by splitting from use, *bridging*, like *plaiting*, will take place from ineffective brushing, by weakness in its action from working it in a sloping direction on the yarn.

35. Now as the filaments on the surface of the yarn must be laid in the direction of the threads, the brush in laying them, must move in the same direction, with the force of its bristles acting as much as possible at right angles to the threads. The face of the brush must therefore be flat, to have the greatest acting surface on the yarn, and the bristles should be set perpendicularly in the stock, that they may act in the required direction with the utmost effect.

36. This right angular position of the brush in working on the yarn is thus the best, both for laying the filaments and applying the paste; but as the securing of them in this position, so as to impart the utmost strength to the yarn from the paste, is dependent on its quality, the dressing should be as strong as the brush can lay it on, without injuring the yarn by the friction of spreading it.

37. Now this friction is chiefly dependent on the *adhesion* of the paste to the brush, and the *cohesion* of the paste itself; and both of these kinds of friction may be much diminished with advantage to the yarn;

that from the *cohesion*, by rendering the dressing *friable* by thoroughly working it with a flat stick on the board, on which it is made up in small quantities for immediate use. The dressing thus prepared will have a creamy pulpy appearance; and as it will be used before fermentation affects it, it will have the *friability*, without the weakness, induced by that process. And as the *adhesion* of the dressing to the brush is increased by using it with its bristles cloated with old paste, it must be kept clean, washed at least every day; and it will be found highly beneficial in dressing, as it diminishes the friction, and facilitates the distribution of the paste, to wet the brush slightly immediately before it is to be used in applying the paste when commencing to dress.

38. The web and the dressing being thus prepared, the weaver dips the brush lightly in the paste; and as there are two brushes, one for each hand, he spreads the paste over the face of the brushes by rubbing them lightly together, and commences dressing, by stroking the yarn gently near the tail or termination of the stretch towards the yarn beam, against which he is standing in a stooping posture to work the brushes. The next stroke or two is taken a little higher, till he reaches the heddles, when he begins to double the brushing by using both of the hands alternately; always taking care at the end of every stroke, to raise the brush out of the yarn in a sloping direction, to prevent the formation on the threads, of little sliding lumps, from the loose filaments and paste, called beads; and to keep the web as much as possible undisturbed by

the brushing, the one brush should not be raised out of the yarn, till the other has entered upon it in commencing the new stroke; and entered likewise as it left it, but with less obliquity. The motion of the brush should be quick, steady, and light, and carried freely along the yarn; and as there is a tendency in the web, from the want of support, to yield under the brush, however lightly handled, an additional tension must be given it; and this should be done by the bore-staff, which, when thus used, in conjunction with the pace, has an advantage in dressing, that the pace used singly does not possess; inasmuch as the web is brushed in brush-breadths at a time, and there are always three or more in the breadth of the web, the stretching of the portion under the action of the brushes does not expose the rest of the web to the additional tension; and thus, in beginning to weave the new dressing, there is less variation from the straight line of the fell, as left at the previous dressing, and, therefore, less difficulty in joining the new cloth to the old, than if the tightening of the web had been wholly effected by the pace.

39. The paste is applied in repeated portions according as the yarn may have taken it on; and in such quantities at a time, as neither to weaken the yarn by over-loading it with the paste, or by over-wetting it, to strip it; nor in so small quantities as to fret the yarn by the friction of brushing it.

40. By this manner of applying the paste, layer after layer, the yarn is strengthened as the process proceeds, and by the time a sufficiency of paste has

been applied, the body of the thread has acquired a firmness by which it is prepared to undergo the action of drying; and thus, plaiting, which takes place only in this stage, in changing from the wet to the dry, and chiefly from being over-wetted irregularly, is prevented.

41. The drying of the web is facilitated with advantage to the yarn by slightly raising one of the sheds, the lease-rod chiefly, so as to assist the action of the brush, which is used occasionally with the one hand, in clearing the yarn, whilst the other is moving the fan over the web to remove the damp atmosphere from it. The yarn thus managed, is dried equally throughout the stretch, so as to prevent plaiting either by the action of the fan or the atmosphere.

Fig 21, Fan.

42. Fig. 21, is a representation of the fan, which, it will be seen, is wing shaped; and to prevent the yarn from being injured by the ruffling of the filaments, any thread which may give way in the latter part of the process of brushing should not be tied, nor should the yarn be touched, if possible, in any manner that may disturb the threads till it is nearly dry, when it is stroked once or twice over with a brush rubbed with grease, and all danger is then over.*

43. The lease rod is now put in, and cleared

* Dr. Ure in his Dictionary of Manufactures, page 136, 3d edition, article Bleaching, in speaking of the origin of spangs,

down to the beam; and so should the second rod, lest there be some obstruction. But if the process has

i. e. stains arising in the cloth in the process of bleaching, gives his opinion decidedly, that they result from the grease made use of by the weaver in the process of dressing the yarn, and in support of that opinion he says,—

"The stains which come out upon maddered goods, in consequence of defective bleaching, are called in this country *Spangs.* Their origin is such as I have described above, as the following statement of facts will show. The weaver of calicoes, receives frequently a fine warp so tender from bad spinning or bad staple in the cotton, that it will not bear the ordinary strain of the heddles, or friction of the shuttle and reed, and he is obliged to throw in as much weft as will compensate for the weakness or thinness of the warp, and make a good marketable cloth. He of course tries to gain his end at the least expense of time and labour. Hence, when his paste dressing becomes dry and stiff, he has recourse to such greasy lubricants as he can most cheaply procure; which are commonly either tallow or butter in a rancid state, but the former being the lowest priced is preferred. Accordingly, the weaver, having heated a lump of iron, applies it to a piece of tallow held over the warp in the loom, and causes the melted fat to drop in patches upon the yarns, which he afterwards spreads more evenly with his brush. It is obvious, however, that the grease must be very irregularly applied in this way, and be particularly thick on certain spots. This irregularity seldom fails to appear when the goods are bleached or dyed by the common routine of work. Printed calicoes examined by a skilful eye, will be often seen to be stained with large blotches evidently occasioned by this vile practice of the weaver."

The above passage is a striking example of the errors which are frequently committed by men even of great intelligence, in the description of processes with which they are practically unacquainted, in trusting to casual observation only. The description, indeed, is founded on a misconception of the process

been properly done according to the manner here recommended, and with good brushes, the dressing may be finished with scarcely a thread sticking together.

of dressing. The grease is not only nowhere used in the manner represented by the Dr., but it is not even used for the object for which he imagines it designed.

The iron is made use of by the weavers in England for no other purpose than to dry the yarn; and in Scotland it is not used at all, because, in general, as the goods made there are lighter set, and, indeed, in the cotton line, almost altogether of a lighter kind of fabric, than in England, the yarn can be dryed with sufficient ease by the fan, and in a manner more suitable to the yarn. But grease used in any manner in a considerable quantity, is injurious to the yarn; the object in the use of it as a finishing to the dressing, is to prevent the yarn from hardening by desiccation, which is effected by coating the surface slightly with fatty matter. But if it be used in any considerable quantity, so as to affect the body of the thread, it does so by diminishing the cohesion of the paste, and by that means weakens the yarn. It is, therefore, used in small quantities by all weavers, and chiefly to soften the surface filaments, so as to facilitate the gliding of the heddles over them, that the eyes and the yarn in working with clasped heddles, be as little as possible injured by the friction in putting them back.

Muslins are generally wrought in Scotland with clasped heddles, and on that account the grease is the more necessary to the work. But in Lancashire, where the eyed kind is commonly used, it is often dispensed with altogether; and, indeed, this is the case in both countries, when the work is wrought in this manner, from motives of economy. When, however, it is used in either England or Scotland, it is applied with a brush, and the quantity required is so small, that two or three ounces even for Muslins, which relatively need the most, are sufficient, according to the common practice, for a web of 120 yards in length.

The grease used is generally tallow, sometimes palm oil; but tallow is preferred, because as it is harder, it is better adapted on

44. With reference to that position of the yarn in the loom as best adapted for weaving, we may

that account, for being used as required in a sparing manner.

The object in the use of the tallow is thus chiefly to soften the surface filaments of the yarn, so as to prevent them from acting in a filing manner on the heddle eyes in passing over them.

If grease were in any degree a remedy for bad yarn, the weaver would, no doubt, have much occasion for it. The spirit of competition in the struggle for cheap production, throws into his hand a great quantity of stuff which is unfit for weaving. The weft, too, in many cases, is so bad, that it can scarcely be wound. Goods so made, it is obvious, cannot give satisfaction to the consumer, and tend to injure the trade by limiting the demand for the article. This practice is more especially confined to inferior houses, and, no doubt, in time, it will correct itself, like all other evils. But without waiting for the remedy in the usual way, the introduction of machinery to the muslin department, where the practice is attended with the greatest injury, by rendering it directly the interest of the manufacturer to use good yarn, will, by and by, place the trade permanently in a state advantageous for all parties. But at present the manufacturer has little direct interest in the quality of the yarn which he purchases. His object is to get it woven, which he can easily do, and that of the spinner to get it sold. In both cases, competition forces them to produce their respective goods at the least cost. The quality of the yarn is, therefore, too much a secondary consideration with each of them; and must continue to be so, so long as the weaving of it is done by hand. Hence the spinner is induced to work up short stapled, and inferior cotton, which is weakened by overdrawing it for numbers of yarn for which it is not fitted; and the same principle which urges the manufacturer to adopt every means to cheapen his goods, forces the weaver, in the very unfavourable circumstances in which he is placed, to weave it. Thus, there is a general tendency throughout the manufacture by hand looms, to use inferior stuff. But the practice is less general in England than in Scotland, and is accounted for, independently of a greater observe, that, as a certain degree of strain must be borne by it, all that we can do, supposing this strain

tendency to liberality in the southern mode of doing business, by the manner in which the work is engaged for by the weavers there. In England, the weaver who has a loom-shop engages the work from the warehouse at so much a piece, in which pirn winding is included. The manufacturer furnishes him with the heddles and reed for each respective web, and the pirns are wound in the weaver's family, The journeyman weaver takes the work thus brought to him from the master of the shop, and is charged some threepence or fourpence out of the shilling of his earning, or the gross sum drawn from the warehouse, for the pirn winding and loom rent. If the web should not turn out favourably, he wont go on with it when business is in its usual way, as he can get a piece ready to his hand any where; and as it is not the interest of a master weaver to lose a good hand, nor even to go on with the weaving of a bad piece, from which he receives a diminished return, the web is hurried back by mutual consent, unless the manufacturer agrees to make an arrangement suitable to the parties. But in Scotland, circumstances render this course a matter of much greater difficulty. Each weaver there, in general, engages for his own work. The heddles and harness are his own; and a practice is growing up of late, I understand, of making him furnish his own reed. The manufacturer, in case the weaver should return the work on account of its being bad, generally endeavours to bind him in the agreement for it, to do so with the heddles and reed in it. The weaver is, therefore, should he adopt this course to get quit of a bad piece, parting with implements which may be necessary to the next web; and, at any rate, as he cannot lose less than a week by the change, he is induced in most cases, in compliance with his own quiet disposition, to go through with the work without receiving any adequate compensation for his loss, or, indeed, any compensation at all.

Fine yarn, when bad, requires great skill in the management of it in weaving, and is always attended with a great loss of time. The Scotch weavers have so much to do with fine and

at its minimum, is to place it in such a position in the loom, that the strain may be as equally as possible diffused throughout the stretch.

indifferent yarn, that they are greatly superior to the English in the management of it. But it is a matter of regret, that they are called upon to exercise so much skill to so little purpose. Their vocation is, doubtless, in a state of transition, as is the case, indeed, with every class which society has yet formed. Machinery is stepping in to do the labour for them, and till once they find their true places, as managers, attendants, and makers of this agency, they must suffer morally and physically in their relationship in life. The class, indeed, as at present constituted, must disappear, and, by the change, be placed in a position more favourable for the exercise of the faculties which have been already developed, as well as for the improvement of other powers necessary to the individual in maintaining him in a proper relationship in society, so as to fit him for still higher purposes in the changes or phases which the body politic may assume in the further progress of civilization.

There seems to be a tendency in the popular treatises connected with the subject, in accounting for the causes which effect the condition of the hand loom weaver, greatly to underrate the difficulty of acquiring the art of weaving. Mr Baines in his history of the Cotton Manufacture, speaks of cotton weaving as an easy sort of employment, requiring little strength, and less skill, which may be performed by boys and girls of twelve years old, and may be quickly learned by men who have been brought up to any other employment; and this statement is quoted as conclusive so far as it goes, by the Edinburgh Review, Vol. 58, page 46, in accounting for the over-stocking of a department with labour in which it is so ill requited. But the anomaly is fully accounted for, by the relative freedom which the weaver enjoys in following his vocation, compared with that of most other trades, especially of those connected with the factory system, without grounding it on any distinctive difference in the relative difficulty of acquiring the respective mechanical arts. No doubt, if by weaving be merely understood the perform-

45. Now, as the yarn is kept tight by extension between the two beams, it forms a straight line from Q to B, as represented in Fig. 20th; and as this

ance of the motions so as to be able to turn out cloth in some marketable state, it is true; but it is equally true of any art, as understood in a similar sense. Boys and girls of this age are able to do a certain description of work belonging to every trade; and so may men who have been brought up to some other employment. But both the strength and the skill of such boys and girls will be very soon overdrawn upon, in the weaving of very common fabrics; and men who have been brought up at some other business, rarely or rather never acquire the art of weaving, although they may contrive to make cloth.

In point of fact, cotton weaving is one of the most difficult of all the mechanical arts; and if we estimate the highest excellence in it, as consisting in being able to turn out the greatest quantity of work of the best quality which the utmost strength of the yarn can be made to produce, very few are entitled to the name of good weavers. I have seen a good deal of weaving, but I cannot say that I ever saw two good weavers, in this high sense in which I am considering the art; and, indeed, if I were to be more explicit, I should be obliged to acknowledge, that I never saw one who altogether attained this high standard in weaving.

Hand weaving, to be carried to the highest improvement in practice of which it is capable, must be accomplished by weavers placed in the most favourable circumstances for it. The weaver must be exclusively employed at one kind of fabric—never, on any account, changing his hand to any other description of work; and he must, likewise, be naturally well adapted for the peculiar kind of work to excel in it: he must have a nice perception of weight; great command over the muscular system; and sufficient energy to use his faculties in an effective manner.

The number of good weavers, even in a modified sense, is very few. There may be in the Glasgow district, that is throughout Scotland, some six or seven in the muslin department, coming under this description; and, in the same line, about line is merely the result of an attempt made by all the fibres of the yarn to equalize the tension among them, or, in other words, as the strain is in the direction of the warp line, it is in the best position in which the web can be put for weaving.

46. But it is not enough that the warp line is horizontally placed in the direction of the strain, it must also be in the direction of the stroke of the lathe.

47. Now as the lathe, it will be seen by Fig. 20th, is not hung from a point, or rather a line perpendicular to the commencement of its stroke at the fell, for reasons which we shall presently notice, but at about half of the length of the stroke from it, the warp line dips so much from the horizontal line, as to bring it to a rectangular line with the lathe when it strikes the fell, and, therefore, in the direction of the stroke.

48. But although this is the best position in which the web can be put for resisting strain in weaving, the yarn may nevertheless be injured in this position by over-tension, and likewise by an injudicious length of stretch; and therefore some practical knowledge of the strain which yarn is capable of sustaining, becomes here absolutely neces-

Manchester, perhaps, one. There is then a considerable class under these, respectable in their mode of working, in both districts; and, below these, again, the great body of the weavers may be ranged; but out of this body, there is a large proportion who are not, nor never can be, weavers—they are merely labourers. In the coarser descriptions of weaving, again, such as calicoes and very heavy cambrics, a man has not sufficient strength to bring out the quantity of work which the yarn can easily be made to produce.

sary to the weaver. He knows that much of the beauty of the cloth depends on the web being well *paced;* and that under-pacing invariably imparts to the fabric a raw unskinned look and slack feel; on the other hand, breakage in weaving is the inevitable consequence of over-pacing.

49. The rule, therefore, is—That the web is to be paced as highly as it can stand, without injuring the yarn in weaving.

50. The proper length of stretch is far from being an unimportant consideration in weaving; as the yarn may be injured by its being either too long or two short. If it is too long, it must be weakened by the unnecessary continuance under strain in the loom; or it may be strained, from an insufficiency of spring for the shedding of the web, occasioned by the shortness of the stretch. Both of these extremes must be avoided; but when it is recollected, that the length of stroke of the lathe and depth of shedding vary very much with the kind of work in weaving, and that, as that portion of the stretch from the fell to the rods for preserving the lease behind the heddles, is taken up by these motions, its length must be regulated entirely by their size; and so must the other portion, extending to the beam, that a sufficiency of spring to the yarn under the action of shedding may be obtained: and therefore the proper length of stretch, it will be evident, can be determined only as to the kind of work under consideration,—both with reference to material and make.

51. The materials in common use are cotton, linen, silk, and woollen; and each of them has

some peculiarities in the weaving, which must be attended to, dependent on the rigidity of their fibres. Cotton in this respect may be regarded as the mean of these materials; and as it is by far the most extensively manufactured, and presents the greatest variety of fabric, some of the finer sorts of which, as pieces of art, requiring a skill in the management of yarn altogether unequalled in weaving, we shall begin with it; because we shall thereby gain a much better knowledge of the principles of the art, as exemplified in its practice, than by selecting for that purpose the peculiarities of the others, which, after all, will be best brought out and illustrated as varieties of the subject.

52. Of the cotton fabrics, some are very heavy in their make—such as moleskins, corduroys, and imitations of woollen goods for mens' garments: some sailcloth is likewise made of it, although it is not well fitted for that purpose.* Then there

* I am not aware that any sailcloth is made in this country from cotton, but a patent was taken out some few years ago in France, by a house at Rouen, in Normandy, for the manufacture of sailcloths from this material, and the patentees were endeavouring to force the article into notice, by circulating printed testimonials from several marine officers and other masters of vessels who had tried it, and who spoke highly favourably of it; but it did not seem to be taking well with ship-masters generally.

The work was well enough woven, but whatever may be said of cotton as to its being used in fabrics which are so liable to great and sudden strain as ships' sails, the relative weakness of its fibre, compared with linen, is a great objection to it; and, moreover, as it absorbs much more moisture, the sails made from it must thereby be rendered heavy in the handling in wet weather, although, it is true, the cloth is more flexible than linen.

are counterpanes, sheetings, shirtings, heavy domestics, and calicoes. There is next a class of goods made of dyed yarn, comprehended under the names of pullicates, ginghams, and furniture cloth. And, lastly, muslins, the finest of all makes: besides, mixed and fancy goods, of which at present we take no notice. Of all these makes there are a great many varieties. In the muslin alone there are at least six distinct fabrics; such as cambrics, jaconets, mediums, light jaconets, lawns, and books.

53. Now all these sorts of goods and fabrics, made of whatever material, are measured, with reference to fineness, by the reed, and with reference to make, by the grist of yarn in the reed. The reed is made to contain a certain number of *dents* or *splits* in a given space, which, in England, is generally 36 inches, but it is counted by the threads in an inch, or according to another scale, by the number of *beers* in 24 inches and a quarter; and in Scotland by the the splits in 37 inches.*

54. The primary distinction then, between one fabric and another, is a difference in the grist of yarn, for the same count of reed. For example; a 1400 calico, Scotch count, might be made of yarn No. 40^s; but the yarn for a cambric may be about 60^s, for a jaconet, 80^s, 100^s for a medium, for a light jaconet 120^s, for a lawn 140^s, and for a book of this count of reed, perhaps 200^s.

55. In all this adaptation, however, of the yarns to the reeds and makes, which is called *setting* or

* The Beer is 20 dents, equivalent to what is called a *Porter*, in Scotland.

caaming, there is a considerable difference among manufacturers, occasioned chiefly by the market for which the goods are made.

56. The range of reeds from sailcloth makes, up to the finest muslins, is from 300^s to 3000^s Scotch count; and in the yarns for warp, from 7 lbs. in the spindle linen, to about 450 hanks in the pound cotton.*

57. This prodigious variety of reeds and yarns, presents us with varieties of makes in weaving of a character almost opposite to each other. The one

* Cotton and linen yarn, and even woollen, are sized or gristed on reels of different lengths, used exclusively for the respective kinds of yarn; so that the count, or number of the yarn by which it is known, varies accordingly. This part of the subject is explained in the latter part of the work in treating of the sizing of the yarn for different makes of cloth.

Yarn so extremely fine as 450 hanks in the pound, has never yet been used in the making of muslins. Some of it is spun and doubled for the lace trade, as will be seen by Mr T. Houldsworth's list. But for muslins, yarn even so fine as 250^s is very rarely used. Such yarn is necessarily made of the best of Sea Island Cotton, and the cloth as made from it, from the quality of the cotton, when well finished, has something of the lustrous appearance of silk. Were a piece of goods made from 450^s, and woven by one of our best weavers, and properly finished, it would be the most exquisite piece of cloth of the sort, that the world ever saw. But work so exquisitely fine is beyond the demands of the trade; not that the difficulty of weaving it is any obstacle to its production, but it is not wanted. The public taste is not sufficiently improved to appreciate the value of such exquisite pieces of art; and plied as it is, by the most vulgar spirit of competition, puffing, it has fewer opportunities of judging of the relative quality of goods than it otherwise might, from the quantity of trash which is so generally met with every where.

kind of goods so strong and heavy, that weaving in any common manner, can scarcely produce breakage; and *power*, therefore, is the chief element in its production. In the other, where both reed and yarn are very fine, *skill* is the indispensible requisite in weaving, so as to save the yarn.

58. In all this variety of weaving, there must be an adaptation of tools to the work, dependent chiefly on these two characteristics in the makes. But as this adaptation is more especially necessary in fine weaving, where so much depends on the fitness of the implements, and where, therefore, the art of weaving will be exemplified in the highest degree, we shall begin with it:—and first, then, with the tools and their adaptation.

59. As the loom is common to all kinds of weaving, and within a certain range of work, requires no other adaptation to the fabric than merely the necessary strength to stand the work, it should always be substantially made, on the square, and of a sufficient width for common purposes. If iron is preferred, which is incomparably the best material for it, Fig. 22d (on next page,) is a representation of a very good form of hand loom.

60. But whether it is made of wood or of iron, the beams, it may be observed, must be in the same plane, parallel to each other, and above all, *true*, or of the same diameter throughout. This latter condition is absolutely necessary to make good work; and that they may be kept true, they should be made of wood, quite dry, and not liable to warp, such as good American fir.

61. For this reason, built beams are better than those made out of the solid; and, as an additional se-

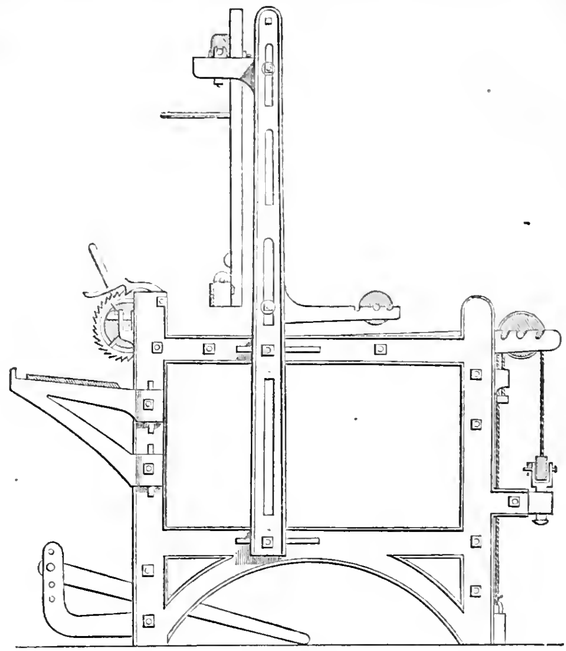


Fig. 22.

curity in all cases where heavy work is to be done with them, the gudgeons must be in one piece throughout the length of the beam. The diameter of the beams may, to a certain extent, be regulated by convenience; but as they are liable to some unequal pressure in weaving, which is very apt to produce unequal drawing of the cloth, more especially with a small beam towards the end of the piece, or when its diameter is much increased by the web, and therefore, influenced by the unequal pressure, some attention to their diameter is advantageous in practice. Six inches may be given as a very good thickness of beam, for common work, with a gudgeon of about an inch.

62. The tools, however, which require adaptation in an especial degree, are the *heddles*, the *lathe*, and the *shuttle*; and we shall suppose that they are designed for the weaving of a fine *lawn*. This kind of fabric, as we have observed, is very light *set*, and invariably what is called in the trade, *even wefted;* that is, that the number of threads of the warp and weft in a given space, is equal. This space is measured with a small microscope, the hole of which, through which the weft is counted, is the 200th part of 37 inches in Scotland; and in England, the measure is a part of an inch, usually a quarter. Were this lawn then an 18^{00} Scotch, there should be on it, as seen through the glass, 18 shots; and so accurately and evenly, are these shots laid side by side in the web, that the eye can discover no inequality in their texture.

63. The tools, therefore, by which work of this sort is so beautifully woven, must be nicely adapted to the fabric; and, if both *art* and *power* in performing the motions of weaving are combined in an equal degree with the adaptation of the tools, so that a high rate of speed is effectively maintained, the production of cloth will be the greatest as to *quantity*, and the best as to *quality*.

64. This combination of skilful efficiency in the use of the means, is the perfection in the practice of weaving; and in directing our attention to the adaptation of the tools, and to the manner in which the motions are performed, for the purpose of attain-

ing it, we must bear in mind, that the production of all motion is attended with a certain tear and wear, or waste of the strength of the material; and, therefore, we have merely the difference between the waste necessarily produced by the motions, and the absolute strength of the yarn, as a security against breakage; and hence this difference must be increased as much as possible, by diminishing the tear and wear to the lowest degree compatible with the effective performance of the motions in weaving.

65. Now supposing this minimum degree of waste to be 25, which is more than it really is, and the absolute strength of the yarn 100, breakage in weaving should result only from accidents and faultiness of the yarn. This is the fact in coarse weaving, and should be as invariably so in fine weaving, were the tools, and especially the motions, adapted to the fabric. Increased breakage is not, then, a result to be expected from the fineness of the yarn, but directly dependent on the waste of strength that it suffers in the process of weaving.

66. Now the motions of weaving that directly affect the yarn, are those of the shed and the lathe; and in performing them so as to render their action as little injurious as possible, all excessive motion must be avoided, more especially in shedding, as this action is by far the most severe on the yarn.

67. As the shed is formed by drawing up the yarn in a state of tension perpendicularly with the heddles, to a certain height, varying in practice from about an inch, to perhaps three inches in very coarse fabrics, the strain from the motion will be not only

in proportion to the *space* travelled through by the yarn in a given time, but also, to the *angle* which it forms to the direction of the *force*; and, therefore, the action of a large and rapidly formed shed, must be very severe on the yarn.

68. Excessive shedding is productive of more breakage in weaving, than all other causes put together; and a very great deal of unnecessary strain on the yarn, arising from the common practice of shedding, will be prevented by acting on the rule,—That the size of the shed must be the smallest that can be rendered sufficient.

69. But it is not enough that the strain dependant on the *size* of the shed is diminished to the utmost; we must also diminish as much as possible, the strain arising from *time* in the motion; and this can be done to a very considerable degree, by diminishing the velocity at which the shed is raised as it approaches its height.

70. Now as the shed is formed on the principle of saving time for the working of the shuttle, whilst it also saves the yarn, the velocity of the shedding is accelerated from its commencement, where there is little angular strain, till it is sufficiently formed for the entrance of the shuttle. The portion of shed thus raised before the shuttle enters, should be about two-thirds of its whole depth, when the motion runs into the retarded form, terminating in a pause, before the shuttle has reached the middle of the web.

71. Now, as about two-thirds of the time taken in performing the motions of weaving, are required by the shuttle in traversing the web, the pause should

extend over a considerable portion of this space. A third of the breadth of the web may be taken as a very good proportion; and as the depth of the shed during the pause, should be barely sufficient to clear the shuttle, some trifling additional force will be required in throwing it; but which will be amply repaid by the yarn being thereby saved from a great deal of unnecessary strain in working.

72. This form of shedding, it will be observed, is not the regularly accelerated and retarded motion of the crank where the greatest velocity is midway between two pauses, practically speaking, equal. The pauses here, on the contrary, are unequal, about as one to two; and the accelerated and retarded portions are respectively as two to one, with a considerable increase of motion, as compared with the crank, immediately after the short pause, and a proportionate decrease in running into the long pause.

73. These two forms of motion in shedding should be so nicely blended and united with the pauses, that not the slightest disturbance of the heddles should be perceptible.

74. The three motions of weaving are performed in a certain relationship to each other with regard to time, which contributes very much to their easiness in action, as well as to the safety of the yarn; and, in this respect, the shed, which is entirely regulated by the motion of the lathe, completes its rising and falling, from the time that the lathe strikes the fell, till it returns to it again.

75. We observed that the yarn was raised in a state of tension by the heddles; and, it is obvious,

that there must be a considerable friction and disturbance suffered by the threads in passing each other, where the heddle eyes meet in turning the shed. Now, as this tension is relaxed by the lathe in striking the fell, advantage is to be instantly taken of it to start the shed, so as to clear the heddle eyes before the yarn has recovered from the blow; and if this is properly done, the practice will be found to be highly beneficial as a means of saving the yarn. Much, indeed, of the success in shuttling depends on the manner in which this rule is exemplified in working.

76. But the yarn may suffer unnecessary friction in shedding, from the make of the heddles. Either the eyes may be too *bulky*, from the coarseness and unevenness of the twine, or the heddles may be too *rigid*, from the shallowness of the build, to give sufficient freedom to the yarn in turning the shed.

77. Both of these evils are corrected by the adaptation of the heddles to the fabric. The twine of which they are made should be smoothly laid, and neither so fine that the heddles may fail in working, by twisting or early breakage; nor so coarse as to obstruct the yarn in shedding.

78. As heddle-making has become a trade, the setting of the twines to the different makes is systematised, and generally well done; but from a narrowness of economy, the depth of the heddles is almost always too shallow. Ten inches is the usual depth; but no set of heddles is sufficiently deep for any shedding, with less than twelve inches.

79. In the old system of weaving, Indian and

European, shedding was performed with two leaves, as seen in Fig. 4th; and were the reed fine, the heddles would necessarily be so closely set on each leaf, that there would scarcely be room for them to stand together. The friction, therefore, of working with such a set of heddles, even at a low speed, would be sufficient to produce a very great deal of breakage on any ordinary yarn; and the increased difficulty experienced more especially in the weaving of fine fabrics with them, gave rise to the introduction of a great improvement in heddle-making, which, practically speaking, removed this difficulty; and that was the division of the heddles into four lines or leaves, by which twice the space was gained to each heddle, so that all interference with each other at the eyes, was thus avoided.

80. The increased space thus occupied by the four leaves, is divided equally among the four threads composing the draught in the heddles, in the manner represented in Fig. 23rd, by taking, first, the fourth leaf; next, the second leaf; then, the third; and the first, last. The fourth and the second, make the splitful; and the third and first to the second split, complete the draught in the heddles.

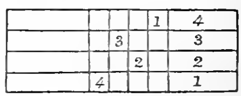


Fig. 23.
Draught in Heddles.

81. This method of shedding the web by four leaves is so great an improvement, that it is almost universally adopted in this country, although the old method is still commonly used on the continent of Europe.

82. There are two kinds of heddles in common use—the eyed, already noticed; and the clasped, as seen Fig. 24th, to which we have scarcely alluded, because it is designed only for a stationary state of weaving, and must ultimately, be entirely supplanted by the eyed kind. But whichever of the kinds is used, if they are properly made on this principle, they will pass so freely through the yarn in any common fabric, that scarcely any obstruction from the eyes in turning the shed, will be felt by the feet.

Fig. 24. Clasped Heddle.

83. But if some little sensation of that sort should be perceptible, which will be chiefly on heavy set fabrics, arising from the coarseness and closeness of the yarn, it will be sufficiently relieved by working with one of the leaves of each shed perceptibly above the other, so as to divide the resistance of the yarn at the turning of the shed, into two lines. The smallest rise of one of the leaves of each shed, the 16th of an inch, will be sufficient for this purpose, as represented in Fig. 25th, on the next page.

84. It will be highly desirable then, that the weaver be brought closely into contact with the yarn, that the resistance made by it in shedding, may be easily felt by him; and, therefore, the heddles should be *mounted* in such a manner, as to combine as much as possible, *firmness*, with *susceptibility* of motion.

85. Although the common roller represented in Fig. 4th, partakes in its motion of firmness in a

high degree, and is, on that account, well adapted for heavy work; yet, as it is inferior in the other

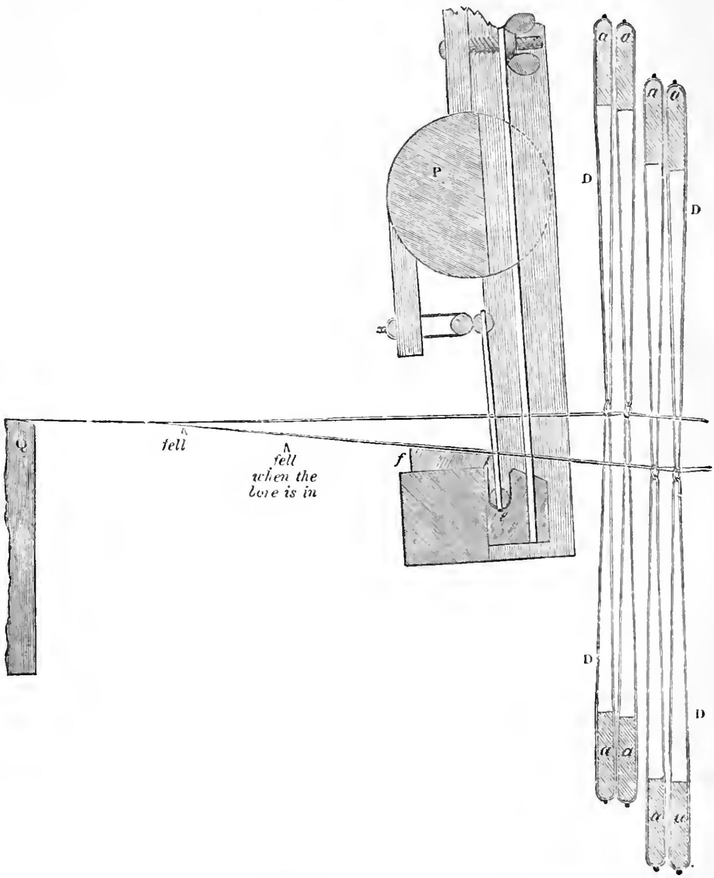


Fig. 25, View of the Shed at a good working angle for fine weaving, scale $\frac{3}{8}$ of an inch to the inch.

quality, to the method known in the trade by the name of the *jacks*, it is less adapted to fine weaving.

86. The jacks *á á á á*, Fig. 19th, are merely two pairs of levers suspended separately from the

heddle-bearer in pairs, by their centres, one pair to each side or end of the heddles, and balanced by attaching the two back and the two fore leaves to opposite ends of each of their respective jacks. They, therefore, cross each other, as seen in the plan, Fig. 26th, so that the heddle shafts may be equally sup-

Fig. 26. Plan of Jacks.

ported; the upper jack being attached by its left arm, to the two front leaves, and by its right, to the two back ones; and the under one, on the contrary, by its right, to the two front leaves, and its left to the two back ones; and so, in like manner, with the other pair. The two pairs are kept sufficiently apart from each other by a thin rod, which is hung between them at each end for that purpose.

87. This method of mounting, secures in a sufficient degree, both of the qualities essential to the motion of the heddles, viz. *firmness* and *susceptibility* in action; and it is, therefore, almost universally adopted by fine weavers, who are careful as to the mounting of their webs.

88. Of the attachment of the heddles to the treadles, nothing particular need be said, which Figs. 19th and 20th do not sufficiently convey. The spring staffs *u u*, are used, it will be seen, to strengthen the shafts in their connexion with the treadles; whilst the short marches T T, maintain the stability of the mounting below.

89. But as the yarn will be strained in working with clasped heddles hung out of the perpendicular

line, the weaver must be careful in attaching them to the treadles so as to preserve accurately their vertical position when at work. Eyed heddles, in this respect, correct themselves; and as there is no strain in working with them, except in drawing the bore, a little obliquity or slope in the direction of the motion of the yarn, as it facilitates the passage of the threads through the eyes, may advantageously be given them.

90. The adjustment of the heddles is an important part in the process of fine weaving, and consists in nicely placing them in the position the most advantageous for work. This position must be such as to secure for them the two conditions essentially necessary to the heddles for this purpose, viz. their *proper level*, and their *proper place* in the stretch; and, first, as to their proper level.

91. On this important point, the plane of the cloth beam is the line by which the heddles must be leveled; but to prevent the level of the web from varying, as the diameter of the beam is affected by the quantity of cloth on it, afixed beam called the slabstock, Q, Fig. 20th, is interposed on the same plane, between it and the lathe, on which the web is supported at an elevation merely sufficient to maintain it under all working circumstances, at a permanent level above the beam. The slabstock, therefore, as it is the fixed line at which the stretch commences, is the proper gauge by which the heddles are leveled, and set parallel with it at the required height to support the warp line in the direction of the stroke of the lathe, according to the rule in section 46, as illustrated in Fig. 20th.

92. The proper place, again, for the heddles in the stretch, or their proper distance from the slabstock, is determined by some nice considerations, dependent on the strain on the yarn by the motions of the shed and the lathe. As the yarn suffers severely from excessive shedding, and, likewise, although in a much smaller degree, from the friction of the reed in working the lathe with a long stroke, these motions must be diminished, according to the rule in section 68, to the smallest size that can be rendered sufficient; and the heddles must be set so as to render the motions as effective as possible.

93. For this purpose, there must be no unnecessary space between the slabstock and the heddles; but as the length of the stretch must bear some proportion to the size of these motions, the proper distance at which the heddles must be set from the slabstock, will depend on what is admitted in practice, as the best working size for the motions; and as the general practice of the trade is the highly injurious one, that of working with too much motion, both of the shed and the lathe, it must be carefully avoided. Three inches for a fine lawn may be taken as a sufficient length of stroke for the lathe; and supposing the breadth of the sole to be two inches and three quarters, and the bore an inch and a half, the distance at which the heddles should be placed from the slabstock for work of this sort, making enough of allowance for spare space, will be about nine inches.

94. The distance of the heddles from the slabstock affects the yarn in shedding, chiefly by the angle at which it stands to the direction of the force. This

angle need, in no kind of weaving, be more than twelve degrees; and for a fine lawn, seven may be taken as a very good working angle for the shed. Now, as a shuttle of a full half inch in thickness, is sufficiently large to carry weft enough for a fine web; and as its distance from the heddles in crossing the web when the lathe is fully back may be two inches, the whole depth of the shed at the heddles, as seen in Fig. 25th, will be about an inch, or seven-eighths; making an angle at the commencement of the bore, of about seven, and about eight at the termination.

95. The other portion of the stretch extending to the beam, is necessary in weaving only as it affords a sufficiency of spring to the yarn in shedding; and two feet, or less with very fine yarn, is a sufficient length for this purpose—making the whole stretch from the slabstock to the beam, about two feet nine inches.

96. But the yarn should be supported midway, or about twelve inches from the heddles, in the direction of the stroke of the lathe, at a fixed level, which is generally done by a small roll, *w*, as represented in Fig. 20th; and to preserve the straight line from beam to beam throughout as much as possible, the elevation of the slabstock should be merely sufficient to prevent the increase of the beam's diameter by the cloth, from affecting the level of the web. Three-eighths of an inch are sufficient for this purpose; and as the support of the roll will be more fully imparted to the web, by placing the yarn beam perceptibly below its level, this should be done, but in so small a degree as not to affect the rule in

practice; whilst that part of the stretch under the action of weaving, is carefully preserved in the required line.

97. The rods *g g h*, for preserving the lease, should be kept at such a distance from the heddles, as to prevent the yarn from being either *strained* or *chaffed*, in shedding. Three or four inches, will be about the proper mean between these extremes.

98. From Fig. 25th it will be evident, that to make the most of the smallest shed, the shuttle must be brought in crossing the web to run as closely to the heddles, as the lathe can be made to permit it. That portion, therefore, of the sole, behind the reed, or from the groove *e* towards the heddles, as seen in the section of the plan of the lathe, Fig. 13th, page 31, must be narrow, in no case projecting beyond the swords.

99. Now, as the resistance of the weft shot in most kinds of weaving, is sufficiently overcome by working the lathe on the principle of the pendulum, rather than according to the impulsive momentum of the hammer; and as the weft shot, in lawn weaving especially, offers very little resistance to the lathe, the chief object in its construction is to gain *firmness* with *lightness* in action, so as to be unaffected with tremor in working at any speed.

100. For this purpose, therefore, the leverage of the swords should be short, but strong, and the sole light. Two feet three inches from the rocking-tree centre to the race, is a sufficient length of leverage for the lathe; with a strength of sword, of inch and quarter by six inches; and of sole, of inch and half, by inch and half.

101. As the rocking-tree forms a band and support to the lathe, it should be sufficiently strong to resist the reaction of its motion; and plain, at least on that side by which it is attached to the swords, so as not to twist them out of the parallelism of their pendulous position. Shaking of the lathe in striking up the shot, is the inevitable consequence of strain in its attachment to the rocking-tree, arising from the change thereby produced in the parallelism of its line to the direction of its motion, in gravitating to the fell. Much, therefore, of the firmness in action of the lathe, depends on the rocking-tree. Its depth should be, at least, equal to the breadth of the swords, from six to eight inches, by two in thickness; and to guard as much as possible against warping, arising from the material, the wood of which it is made, especially that of the lathe, should be well seasoned, and not liable to twist or cast, such as good American fir.

102. From this construction of lathe it will be seen, that the intervening space between the shuttle and the heddles, must be at least an inch and a quarter, equal to the thickness of the swords; and as the lathe, in working, must never touch the heddles, an additional half inch must be allowed for that purpose; making an inch and three quarters of necessary space between the reed and the heddles, when the lathe is fully back. The medial line of the shuttle will then be very nearly as represented in Fig. 25th, two inches from the heddles.

103. For very broad work, it will be found beneficial to increase the breadth of the swords to about seven or eight inches; and instead of making a proportion-

ate increase to the sole, to trust to an increased strength of the *pull-to* or handle, to keep the lathe firm in action.

104. By this mode of making the lathe, with the sole light, but the handle strong, and the swords short, the momentum of the leverage at the sole is diminished, by which it is rendered workable with less fatigue to the weaver; and is, besides, attended with this great advantage, that it enables him to feel more easily the resistance of the weft shot in striking it home. This consciousness of the reaction of the shot is of essential importance in fine weaving; and to render it as complete as possible, the weaver constantly superintends with his ear, to modify the force of the lathe by its sound in striking the fell. But as a very small difference in its force is productive of unevenness in the texture, and it is not possible for any hand, however well regulated, constantly to bring the lathe in varying circumstances with the same force to the fell, recourse is had to a contrivance for the purpose of weakening its direct influence; and this is done by placing the reed in a spring frame, called a flyer, of which there are two

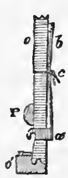


Fig. 27. Single Flyer, End View.

Fig. 28. Front View of Double Flyer without the Cap.

Fig. 29. End View with the Cap.

sorts. The one called a single flyer, represented in Fig. 27th, permits of the motion of the reed on the upper side only; and the double flyer, which it will be seen by Fig. 28th, and end view Fig. 29th, is merely a small lathe within the lathe, with its swords so thin, that they yield, or rebound, with the reed, at every stroke on the fell.

105. The direct force, from this indirect application of the stroke of the lathe, is barely equal to the reaction of the springs or swords of the flyer; and these are regulated as to their tension, by a thumb screw attached to each, as seen in Figs. 25th, 19th and 20th, according to their effect on the work. But if the fabric is light, such as a book or a lawn, the reaction of the weft shot is very slight; and to reduce or relax the tension of the springs to the required resistance of the shot, would injure their stability in action, and produce an irregular and vibratory pulsation by the motion of the lathe, injurious to the evenness of the fabric, and to the motion of the shuttle; and, therefore, the weaving of this sort of work even with the double flyer, with anything like evenness of texture, would be a very difficult thing indeed. This difficulty, however, is completely removed, by a simple contrivance, admirable from its effectiveness, called the *cord*. This contrivance consists merely in using a cord instead of the cap, with the double flyer, to which the reed is attached by small bands, as seen in Fig. 19th immediately under the pull-to; and as the cord is secured between the swords of the lathe, and twisted in its place till it is sufficiently tight to restrain the rebound of the flyer, and thus keep it in a highly active, or elastic state, with little reacting force, whilst, at the

same time, it permits a sufficiency of resilience to the reed, to secure all the advantages sought for by an indirect application of power.

106. The cord is so effective an adaptation to the weaving of lawns and books, and fabrics in which the resistance of the weft shot is slight, that it is the only method in use for work of this description; and so happily does it accomplish its object, that the evenness of the texture is such, as to excite the admiration of even those who are accustomed to the work.

107. We have observed that the lathe is hung on the principle of the pendulum, because this arrangement of leverage is the most susceptible of motion, and, therefore, necessary to work requiring so nice an adaptation of power; and as the most easily applied motion will be that in which the arcs described by the lathe are equal on each side of the vertical line in which it is hung, this consideration of itself points out the medial line as the proper place for the lathe, with the reed midway between the fell and the heddles. But as the fell varies with the working of the bore, and cannot at its commencement be nearer the slabstock than somewhat more than the breadth of the race, or about two inches, and as the bore, when *in*, will make an additional distance of an inch and a half, the medial line in which the lathe is to be hung, may be measured from the half of the mean length of the bore—making the whole distance in this case, from the slabstock to the reed, about four and a half inches.

108. It will be seen from this position of the lathe,

that the arc at the commencement of the bore, measuring from the vertical line on the side towards the fell, is greater than that on the opposite one by nearly a fourth of the whole length of the stroke. But as the momentum is diminished in proportion to this excess of motion, the force with which the lathe strikes the fell, is thus in some measure equalized, throughout the variations in its position arising from the working of the bore.

109. The adaptation of the lathe to the motion of the shuttle, is a part of its mechanism of essential importance to the success of the weaver. The lathe must be made so as to keep the shuttle in its course.

110. Now, as the shuttle is shot from the box by the driver, it endeavours to proceed in the direction of the force, which is that of the spindle and the driver; and as it is guided across the web by the reed behind, and the race below, these guides must be accurately placed in the direction of the shuttle; or, in other words, the reed and back boxing must form a straight line parallel with the spindle vertically, and in like manner, the race must be parallel with it in the horizontal direction.

111. These are conditions essentially necessary to keep the shuttle in its course; and they must, therefore, be carefully preserved. These conditions may, however, be secured, so as to prevent the shuttle from being thrown from its course, and yet a disagreeable twist may be imparted to its motion, from the *obliquity* or *unevenness* of the race groove, in which the tongue of the driver runs, to the spindle. This is a frequent cause of serious injury

to the yarn. The shuttle is thereby thrown in a line between that of the spindle and the groove, and pitching heavily against the reed, it rebounds against the race, beating the yarn at every alternate shot, till it is flattened at a particular place, as if struck with a hammer; and before the bore is in, breakage there becomes inevitable, as the yarn is literally cut by the repeated strokes of the shuttle-wheels, in this manner, against the race. This source of mischief is the more annoying to the weaver, as the cause is generally unknown. All the evil, however, will be entirely prevented, by placing the groove in the direction of the spindle—care being taken that both spindle and groove are straight.

112. The shuttle will thus have a steadiness of motion, imperturbable in running in the lathe at any speed. But still it may be tripped by the shed in its course; or the work may be *scobbed* by the shuttle running under, or over, the shed; and to prevent either of these accidents from taking place, the lathe must be set with the race below the warp line, so far only as to permit the shed to be fully formed, and beveled or sloped towards the reed in accordance with the angle of the shed, so that no part of the yarn may suffer an undue strain from the pressure of the shuttle in crossing the web, whilst its own motion is likewise benefited by this adaptation.

113. It is usual to give a bias to the shuttle, so as to make it in running, keep towards the reed, by placing its wheels or rollers, a little obliquely to its course. If this is done, it should be only in a very small degree.

114. The connexion of the drivers with the fly-pin is made so as to fit the convenience of the weaver, whose seat is in front of the loom opposite the middle of the cloth beam, and as near it as possible not to press on it in sitting, that its diameter may not thereby be affected; and that he may have a full command of himself in working, and bear lightly on the treadles, he should sit as on a chair, with his whole weight on the seat. In this position his feet are manageable, so that he can work the treadles in the gentlest manner, with the advantage of being fully sensible of the resistance of the yarn in treadling; and as the left hand works the lathe, and the right the shuttle, the left flycord should be as much longer than the right, as the distance from the sternum, or middle line in which the weaver sits, to the shoulder joint—or about eight inches. The short fly-cord will thus permit the fly-pin to move no further towards the left hand than the middle of the web; but the left fly-cord, of course, is long enough, with the driver attached, barely to reach to the end of the box, which, in weaving, it shonld never touch.

115. The side cords $b' b'$ are used merely to keep the fly-cords, in working, from getting entangled with the shuttle or the work; but they likewise facilitate, when used as seen in Fig. 20th, the backward motion of the lathe.

116. The weaver having thus loomed his web—that is, having drawn it through the heddles and the reed, and tied it up;—mounted and adjusted the heddles;—hung and set the lathe;—put up the pace;—fitted the drivers, and attached the fly-cords;—

and having, likewise, dressed the neck of his web, is ready to commence weaving.

117. Taking his seat, therefore, as already noticed, close to the beam, that his work may be fully within his reach, he commences, by putting his feet on the treadles; and as all the motions of weaving are carried on in a certain relationship to each other with regard to time, but regulated by that of the lathe, its motion, therefore, is the first in order in the process of weaving. Speed in shuttling is indispensible to speed in weaving; but as its full effectiveness in the production of cloth, is dependent on the rate of shuttling as kept up throughout the work, or, which is the same thing, on the number of shots continuously thrown in for a length of time, a maximum rate of speed can be maintained only in so far as interruptions arising from breakage, or from the performance of the motions, are as much as possible prevented; and, therefore, the motions of the lathe and the shuttle, like that of the shed, must be performed individually and conjointly, on the principle of saving time, to the utmost degree compatible with their own steadiness of action, so that the yarn may thereby suffer no unnecessary disturbance.

118. Now, as the stroke of the lathe on the fell is the signal for the turning of the shed, and as all that has been done is merely preparatory to the motion of the shuttle, without which it is of no avail, it must be brought into play as soon as the lathe and the shed can be properly formed to receive it. For this purpose, advantage is to be taken of the reaction

of the lathe on the fell, so as to run it back into the accelerated form of motion as quickly as possible, without disturbance to itself, that no time may be lost in gaining a sufficient distance from the fell for the entrance of the shuttle. This distance at which the shuttle should be entered, may be about a third of the length of its stroke, and as the lathe is then moving at its greatest speed, the distance quickly increases, till it has gone over about two thirds of its whole length of stroke, when it runs into the retarded form, preparatory to the long pause, during which, the shuttle is traversing the web. The length of this pause must be in proportion to the width of the work; a sixth is probably sufficient, as there is a tendency to angularity in the motion when the pause is long kept up, productive of disturbance to the lathe.

119. It will be observed, then, from this form of motion, that the lathe is accelerated from the fell for about two thirds of its length of stroke, and retarded during the other third, in running into the long pause, which extends over nearly a sixth of the circle, taking the space as the measure, from *b* to *c* on the line tangent with the circle, as seen in Fig. 30th; and as the lathe should now be brought home as quickly as the shuttle will permit it, its motion is accelerated from this point, till it discharges its force on the fell.

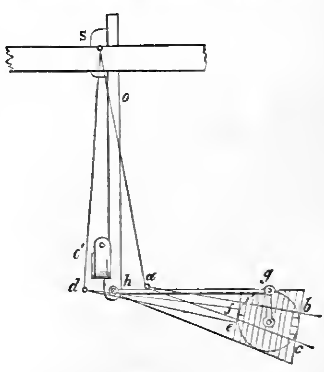


Fig. 30.

120. The chief circumstance to be attended to in the motion of the shuttle, is to prevent its rebound from the driver; and as this is a circumstance of essential importance to the quality of the work, it must be completely effected. As the shuttle is thrown with a jerk of the fly-pin gently given, and caught by the driver on the opposite side, the slightest rebound, or even disturbance, that it may meet with in entering the box, will throw the weft shot loose in the shed, and purling at the selvage, from too much weft being unwound from the pirn, is inevitable from this fault in shuttling. This inconvenience, however, is prevented with a little practice, without much difficulty, by slightly dropping the hand towards the end of the throw, so as to check the shuttle as it comes into contact with the driver; and if this is properly done, the shuttle will be brought to a dead stand at the end of the box, so that purling from its motion, will be completely prevented.

121. Much of the easiness of motion from this manner of throwing the shuttle, will, it is evident, depend on the proportion of the length of the spindle to that of the lathe; a circumstance not sufficiently attended to in practice; and hence the harsh and heavy action in picking, so frequently met with, disturbing both to the motions of the shuttle and the lathe. For common widths, no spindle or box should be less than sixteen inches; and for broad work, eighteen inches are barely sufficient. As to the shuttle, it should not be short—never less than twelve inches; and for work of great width, an additional length of two inches should be given it.

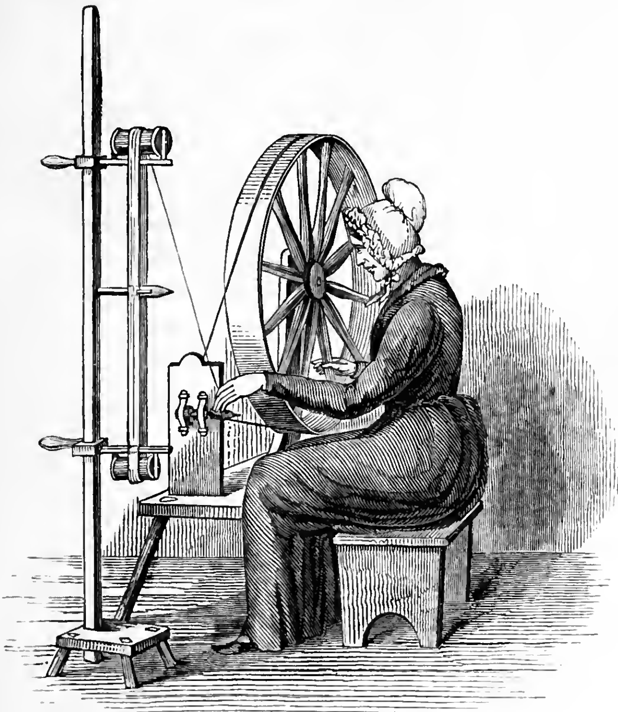
122. The individual and conjoint performance of the motions in shuttling in the manner here pointed out, are essential to success in weaving; and as they embody the principles and best practice of the art, they should be strictly followed. The great rule in the conjoint performance of the motions is,—That the shed is to be turned on the stroke of the lathe on the fell, whilst the weaver's feet are resting lightly on the treadles, to keep them steady, and render their action instantaneous. The projection of the shuttle is the last in order, and is effected as speedily as the safety of the yarn will permit the other motions to be formed for its reception.

123. In fine cotton weaving, the weft shot is always thrown in wet, to tighten the selvage and soften the yarn, and thus, what is called a *clothy* appearance is given to the work, which it retains, if the web has been well paced. But as the contraction of the cloth by the wet weft, acts severely on the selvage splits, and besides, renders the weaver less sensible of the reaction of the lathe on the fell, he employs a stretching frame, called temples, Fig. 31st, consisting of two pieces, usually of wood, jointed near the middle by a cord, and furnished at the butt ends with pin teeth, by which they are fixed on the selvage, soas to keep the web stretched at its width in the reed.

Fig. 31. Temples.

124. The temples are shifted as the cloth is worked, every bore, but not too closely to the fell; as, by doing so, there is a tendency to press forward

the selvages, so that something like *clouding*, or a thickening of the cloth at each side, for a few shots, is then apt to take place in the work. An inch is near enough for light work. But clouding in this manner, may, nevertheless, be produced by the outside reed bands, and is an indication that they are



A

Fig. 32. Wheel and Whisks.

too far from their respective selvages. The contrary fault produces *jesping*, which is the counterpart of clouding; and they must, therefore, be regulated accordingly. About two inches will, in general, be found to be about the proper distance at which the bands should be set from the selvage. But this will vary a little with the fabric, and according to the tension or strength of the cord.

125. The evenness of the work is, besides, affected by the weft shot, as it increases in tension with the friction, towards the end of the pirn; and the cloth frequently, from this cause, gets thinner as the shot runs towards the bottom of the pirn. This, however, will be sufficiently prevented in practice, by using short pirns of a uniform length, wound in the form of a cone, at an angle of about twenty. For very fine weft, they should never exceed an inch and a half in length, with a thickness varying according to the size of the shuttle—in this case, about half an inch.

126. The pirns are usually wound by the females of the weaver's family, on a wheel such as that represented in Fig. 32nd. The yarn, in small portions of about a *skein* or *cut* at a time, is put on the *whisks* A; the pirn is stuck on the spindle, and motion is communicated to it by the wheel, which is turned by the right hand, whilst the left is engaged in guiding the thread on the pirn, so as to build it of the proper size and shape, and with as much firmness as can be given it, without breaking the thread by the friction in passing between the fore and middle fingers, and the thumb.

127. The yarn thus managed, according to the principles and practice of weaving here laid down, is saved from unnecessary strain in the loom, and dressed in such a manner as to have the full benefit of that process. The method which thus combines

these advantages, is, therefore, peculiarly adapted to fine fabrics. And as the yarn thus prepared is quite able to stand the process of weaving carried on in this manner, it would be a waste of time to shuttle at a low speed, when the web is as it ought to be for turning out the greatest quantity of cloth, a result which is wholly dependent on the rate of speed as kept up throughout the work.

128. The velocity, however, at which it will be most profitable to weave, will vary with the width of the web; and, in practice, it will be regulated by the energy of the weaver, and his command over his work. But supposing his power in action equal to his skill in managing the yarn in the best manner, a fine yard-wide lawn need never be wrought at a lower speed than a hundred shots per minute.

129. But although breakage is not a consequence of speed in shuttling, the weaver may, nevertheless, fail in maintaining it with advantage to the work, from the inadaptation of the lathe to the speed. Its momentum may be too great, and thus, fatigue and encumber him in restraining it in throwing on the weft. In this respect, the lathes as usually made are ill adapted for speed in fine weaving. The soles are too heavy, and the leverage of the swords, as used, is too long. The common low rate of speed in shuttling on such work, is, therefore, so far a consequence of this injudicious mode of using the lathe; and in connection with the common practice of working with too much motion, especially of the shed and lathe, it becomes necessary for the safety of the yarn. Thus a slow and timid style of weaving

characterises the common practice, arising both from the defective adaptation of the motions to the work, and a want of sufficient skill in the adaptation of the tools.

130. As the lathe is the great instrument in throwing on the weft, its action, to have the desired effect, with advantage to the work and ease to the weaver, should be neither forced nor restrained in working. Its weight, therefore, must be adapted to the fabric, so as thereby to regulate its momentum independent of its speed.

131. As the cord is admirable for its adaptation to light and fine work in which the reaction of the weft shot is slight, and capable of being applied to a considerable range of fabrics by varying its strength, light jaconets and mediums are wrought by it with great advantage; although, like cambrics and common jaconets, these fabrics are invariably over-wefted, having two, three, four, or more shots over even on the glass, and, in this respect, contradistinguished from lawns, independent of the distinction already noticed as to the warp.

132. But common jaconets are too heavy for it, and are usually worked by the single-flyer, and cambrics with the upper shell. The Manchester goods, however, which pass by the same names, are much heavier set, and, in general, heavier wefted, than the Scotch muslins; and hence their jaconets are always wrought with the upper shell, and their cambrics in the same manner, but with a very heavy lathe.

133. In heavy set fabrics much over-wefted, the

reaction of the weft shot is a great draught on the strength of the weaver; and he endeavours to lessen its exhausting effect, by diminishing the friction of the weft,—soaking it in soap leys; and to diminish the resistance of the warp, he frequently has recourse to the expedient of raising the wheep-roll above the horizontal line of the heddles and beam, so that the half of the warp in shedding, sustains, from this mode of working, the whole, or a very considerable portion of the strain and friction, arising from the throwing on of the weft shot.

134. This mode of weaving, with the roll above the plane of the beams, is, therefore, severe on the yarn; and is rendered still more so, by the practice of those who adopt it generally treading on the shot, that is, turning the shed before the weft shot is struck home. This practice is excusable only in so much as the yarn thus worked is strong and coarse, to be able to stand so harsh a mode of weaving.

135. Ginghams and pullicates are usually wrought in this manner; because, as fabrics with fugitive colours are not generally washed in coming from the loom, the treading on the shot spreads the warp, as if the cloth had been wetted.

136. As the difficulty of weaving is as the fineness of the yarn and reed to the number of shots on the glass, a fine jaconet Scotch, a 27^{00} for example, where both reed and yarn are fine, with about thirty shots on the glass, is not easily woven. To get through the work with effect, the yarn must be well managed. The difficulty, however, lies chiefly in the dressing, so as to prepare it in the best manner

for working. As every little lump, or knot, on the thread, is almost certain to occasion breakage at the reed, from the closeness of the splits to each other, the yarn, in such makes, must be very well picked. Great care must be taken in this part of the process; and the paste must be well prepared—of the best and strongest wheat flour, and well brushed in on the yarn; and of course in greater quantity than is sufficient for a lawn. The practiced eye of the weaver very soon knows when the web has had enough of brushing and dressing to fit it for weaving.

137. Cotton is difficult to dress. From the shortness and spongyness of its fibres, it requires more brushing and paste than linen, whilst silk again scarcely requires any dressing at all. As its threads are formed by doubling the threads already made by the silk-worm, preparation for weaving consists in picking it of the knots, which might obstruct the shed, and then applying a little thin glue or size, with a few strokes of the brush, or simply with a strip of list dipped in it, and used, stretched on a rod, like a fiddle bow, to harden the body of the thread, and bind the filaments together. In the weaving of some kinds of silk for certain fabrics, even this amount of dressing is not needed; and, of course, the process varies a little as with cotton or linen, according to the quality of the yarn and work.

138. In the manufacture of woollens, as the cloth is woven so as to preserve the nap on its surface, no attempt is made to lay the fibres as a preparation for dressing; and, as the reed is not fine, the yarn in the raw state is sufficiently strong to stand the

weaving. The shed in these stuffs is large, and the filaments on the yarn are not sufficient to prevent the rising of the threads in shedding, or offer much interruption to them. But as the loose fibres on the yarn, by the action of the reed, would soon accumulate so as to impede the shedding, this is prevented by their being swept up by a cord, which is tied loosely betwixt the swords, under the upper shell, so as to roll on the yarn between the heddles and the reed, by the motion of the lathe.

139. This contrivance is thus used with advantage in the weaving of most fabrics, linen and cotton, in which the yarn is too coarse to need dressing, such as sail-cloths, &c.

140. In the weaving of these heavy fabrics, and, indeed, of all dry wefted work, some fringyness at the selvage is apt to take place, from the facility with which the weft is unwound from the pirn; woollen and linen in a greater degree than cotton, but, particularly, silk. Its smoothness is such, that without some contrivance for increasing the friction of the weft shot, purling could not be prevented. This is done, however, in a manner that answers the purpose, by merely interposing a tuft or two of hair, fixed inside of the shuttle, in the line through which the thread passes between the shuttle-eye and the pirn. In woollen goods, purling is little attended to except in mixed makes, as the beauty of the cloth, in a great measure, depends on the milling and dressing, in which it shrinks so much, that anything of this sort disappears, or is of no consequence. But this is far from being the case with cotton, silk, or

linen fabrics. With them, the quality of the selvage is generally taken as a test of the character of the work, and care is, therefore, taken in the weaving, to have it clear and clean.

141. As linen, from its wiryness, is more apt to purl than cotton, some means to increase the friction of the shot in coming from the shuttle, is necessary to prevent it. In sail-cloth work, in which the weft is very coarse and heavy, a small roller is placed in the shuttle for this purpose, immediately behind the eye, under which the thread runs in coming through it; and, in other cases, the same thing is endeavoured to be effected by the increased friction from the angular and deflected manner in which the weft shot is led through the shuttle, as seen in Fig. 33rd.

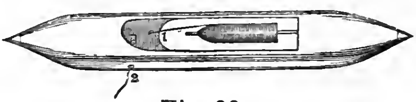


Fig. 33.

In this shuttle there are two eyes, the one perpendicular, and the other horizontal, marked respectively 1, 2. The weft is taken through the perpendicular one, under the shuttle, and up and out at the side through the horizontal one.

142. In the weaving of these heavy fabrics, as the yarn requires little care to preserve it from breakage, the great desideratum is *power*, and its application so as to overcome the reaction of the work, in such a manner as to obtain the greatest quantity of cloth with the least expenditure of strength in the weaving of it.

143. Accordingly, as a very heavy lathe would be

necessary to drive home the weft on such a fabric as a No. 1 sail-cloth, with 18 or 20 pounds to the spyndle; heavier, indeed, than a weaver could work with effect, he has recourse to the expedient of giving a double blow to each shot, with a lathe such as he can manage—thus gaining power, but losing time.

144. In such a mode of weaving, with the double stroke, it would be of less advantage to use the fly-shuttle, more especially as the work is very narrow—two feet generally; and hence the weaver usually retains the old method of throwing it by hand.

145. Linen and silk, from the rigidity of their fibres, require to be heavier paced than cotton, which is a sort of mean in this respect between linen and woollen; and hence, to keep these powerful fabrics firm in the loom, so as to hold the shot on the blow, a very heavy pace is necessary; and the inconvenience of managing it, from its weight, has induced the weaver to continue a method of tightening the web by a modification of the bore-staff. The yarn beam B, as is the case with the plan as seen in Fig. 34th, is furnished with a ratchet wheel with large

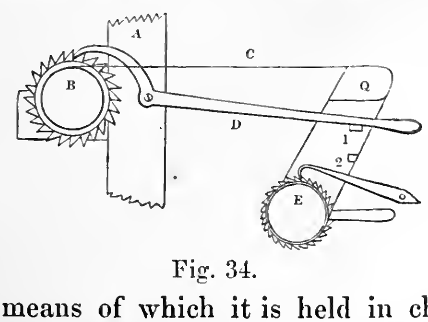


Fig. 34.

teeth, by means of which it is held in check by a transverse sloat which acts upon it between the post

A and the teeth, for that purpose. The weaver has, therefore, to lift the sloat when about to draw the bore. But the plan, as presented in the figure, enables the weaver to manage the operation with less inconvenience to himself, as he has only to press down the lever D, from the upper to the under catch, marked respectively 1, 2, in passing his hand to the beam to draw the bore; and the inconvenience of lifting it again will be prevented, by loading the short arm, or otherwise acting on the long one, so that the lever may fall again into gear, on the withdrawal of the hand.

WEAVING

BY

POWER LOOMS.

146. Power, and the resources of art, in the production of cloth, being thus exhausted, a further increase of the quantity can be made, only in so far as we succeed in combining the motions of weaving, so as to work the loom by a cheaper and more powerful agency than the human hand. This combination of means is machinery, and leads us directly to the invention of the power loom—a machine which is designed to supersede hand labour in the weaving of cloth, so as to furnish an abundant supply of one of the principal necessaries and luxuries of mankind, with greatly diminished labour on their part. The power loom, is, therefore, one of the most important inventions that has emanated from the ingenuity of man.

147. The idea of inventing such a machine is not of recent origin. More than a century and a half ago an attempt was made, as is shown by Hutton, from drawings in the possession of the Royal Society, to combine the motions of weaving in such a manner, as to produce a power loom. In this invention the shuttle was worked with a crooked wire, which entered the shed, and pulled the shuttle after it. The machine, of course, was practically useless, and the idea of weaving by power seems to have excited little notice, till it was brought out by Dr. Edmond Cartwright, a clergyman of the church of England, and brother of the well known Major Cartwright, the political reformer—in the year 1785, or 1786. The Dr. happened then to be on a visit at Matlock, in the neighbourhood of which Mr Arkwright had erected one of his large factories on the Derwent, for spinning with fluted rollers; and the extraordinary success with which his inventive genius was attended, together with the beautifully effective combination of machinery, as presented by Watt in his steam engine, drew the public attention to an agency which seemed alike boundless in the creation of power, and inimitable in its adaptation to art; and this theme chanced to be the subject of conversation at the public table of the inn at which the Dr. was dining. Since the success of machinery is so great as applied to spinning, it was asked, why may it not be made to weave? and so strongly was Dr. Cartwright impressed, in the discussion of the question, with the adaptability of machinery, that he immediately set about the invention of a power

loom, and succeeded in bringing it out with a patent in the same, or the following year.

148. Dr. Cartwright was naturally possessed of great fertility of genius in mechanical creation, aided by a highly finished education, and nothing was wanting which an ample fortune could supply; and yet with these capabilities, he failed to render the power loom effective, although with the true ardour of an inventor, he spent, in his attempts to apply it to practice, and in other mechanical projects, the most of his fortune, £30 or £40,000, and the best of his life.*

149. The Dr.'s failure with the power loom, however, originated entirely from his inacquaintance with weaving. He had at this time, it appears, scarcely seen a hand loom, or, at least, practically knew nothing about it, and imagined that nothing was necessary to complete his success, but the performance, by machinery, of the three primary motions of weaving.

150. The loom, therefore, as brought out in these circumstances, could not have succeeded, from a want of adaptation; and its failure convinced the

* Dr. Cartwright made an application to parliament when the power loom had been brought into use, and some years after his patent right had expired, for some compensation for the loss he had sustained, on the ground, that although he had failed to render it successful, the loom had since become valuable to the public; and as he was backed by considerable influence, he obtained a grant of £10,000, on the evidence, as to the value of the invention, chiefly of Mr Radcliffe, the originator of the dressing machine, and of a Mr Taylor, a mechanic, who had given useful assistance to the Dr. in the working out of his plans.

Dr. of the necessity of some knowledge of weaving, to guide him in the contrivance of his means. Accordingly, such an acquaintance with the subject as he thought would be sufficient for the purpose, as it was chiefly from observation, was soon gained; and with this preparation, he set about the readaptation of his machinery to weaving, and brought out, and patented, his improved power loom, in 1787. He then removed to Doncaster for the purpose of applying his invention to practice, but the Dr. found that his difficulties were now only commencing with it, when he thought he had surmounted them.

151. Machinery is not easily applied to weaving. Its success in this department is dependent on the quality of the motions, as to their being properly performed, and the adaptation of the agency, or tools, to the fabric; and neither of these requirements can be judged of, nor properly conceived, without a practical knowledge of weaving. This the Dr. might eventually have acquired, but he never sufficiently got over the difficulties attendant on the motions, so as to be able to avail himself of improvements which might be suggested by experience. He was, therefore, perplexed by the recurrence of unforeseen difficulties, arising chiefly from the rebound of the shuttle from the driver, and from its accidental stoppage in the shed; so that his attention was necessarily engrossed with the means of remedying this defective mode of shuttling.

152. To prevent the rebound, or rather to prevent the purling of the cloth from it, he interposed between the shuttle and the side of the box, a

small friction pulley, covered with soft leather. The rebound itself was endeavoured to be stopped by a hook-shaped catch, formed something like a heddle-jack, and placed in the box, to vibrate on its centre under the race, so that on the shuttle reaching its destination, the hooked end rose in front of the tip by the action of a lever connected with the picking apparatus, and of course the return of the shuttle was thereby prevented till it was released for the next shot. Neither of these means was practically fitted for effecting its object. The pulley could have little certain effect upon the purling, and its liability to entangle and break the weft shot rendered it wholly inapplicable to the purpose. The catch, again, was unsuitable from the complication in the arrangement of the contrivance.

153. From these defects alone, the loom could not possibly make good work; but the accidental stoppage of the shuttle in the shed was attended with still more serious consequences, as the yarn of any ordinary fabric which covered the shuttle, was liable to be broken should it be caught in this situation, by the lathe striking on it in coming to the fell.

154. The breakage thus produced, is called a *smash*, and might require a worker a long time to repair it; the piece was thereby damaged, and the next shot might produce the disaster again, so far as the loom had any means of preventing it; and, therefore, unless this defect could be remedied, all attempts at weaving by power were fruitless. An expedient was adopted, that of slackening the web

when the shuttle was caught in this situation, by which the breakage was partially prevented. But nothing short of a remedy for these defects in shuttling could ensure success; and this did not appear to be easily effected. Moreover, as experimenting in machinery is expensive, the Dr. must have worked the looms at a heavy loss; and as his acquaintance with weaving was not sufficient to prepare him for what was wanted, his confidence in the successful termination of his labours must have been a good deal abated; more especially as the opinion of the trade itself, was almost universally against the possibility of applying machinery successfully to weaving. It is not, therefore, surprising, that the Dr. was forced in these circumstances to abandon the loom, when it is recollected, that although it has been fifty years in use, it is not long since it has been adapted in a proper manner, to any kind of work; and still, the fabrics to which it is applied with the most success, are those which require the least art in weaving—such as calicoes, heavy domestics, sheetings, shirtings, furniture cloth, moleskins, and work in which there is little apprehension of breakage. In the heaviest of work, where the yarn is rigid—sail cloth, for example, it has not succeeded; and generally in the linen manufacture, the adaptation of the loom is far from being complete.

155. The extraordinary extension of cotton spinning, however, in all its branches, fine and coarse, by the happy genius of Arkwright, Crompton, and others, attended with a productiveness of nearly 300 fold compared with hand labour, and wholly incon-

ceiveable as the result of any agency with which we were previously acquainted, imparted an impetus to trade, which ill assorted with the languid unproductive manner in which weaving was carried on by hand. The manufacturer, therefore, looked with great interest to the approaches of machinery to weaving, as the means to work up the surplus production of the spindle, and thus bring the two departments of spinning and weaving into a fitting state of relationship to each other. But although machinery was regarded, by those who were best acquainted with the manufacture, as inapplicable to weaving, individuals were found sufficiently enterprising to take up a subject, which, if it could be rendered successful, was likely to be so highly beneficial; and hence the loom was not suffered to fall into disuse.

156. Two gentlemen of the name of Grimshaw, spinners and printers, I believe of the house of Taylor, Grimshaw, & Co., Manchester, took up the loom by licence from Dr. Cartwright, and made some improvements on it, it is said. But so highly was the popular feeling alarmed by the approaches of machinery, that the workmen, fearing lest it should deprive them of a means of living, by diminishing the demand for hand labour, formed secret associations for its destruction; and the looms made by these gentlemen were destroyed by fire, originating, it is supposed, in this manner, before they were fully tried.

157. Mankind have hitherto been much more influenced by fear, than reason:—a state of society

very unfavourable to improvement, and indicative of a defective and vitiated education among the people. But as the nature of improvement is progressive, whatever machinery may have been established is safe, because it has become necessary. The loom, however, was not yet in this condition, and experimenting with it was hazardous.

158. But this was not the case in Scotland, where we find that the power loom was at this time making its way as a native invention, favoured by the circumstance, that mechanical improvements were suffered to be tried without risk to person or property, although the opinion of the people was frequently strongly expressed against what they conceived to be the dangerous results of machinery.

159. It happened by a curious coincidence, not uncommon in the history of inventions, that Dr. James Jeffray, the learned Professor of Anatomy in the University of Glasgow, conceived the idea of weaving by power, about the very time that the same idea was engaging the attention of Dr. Cartwright, and brought out his power loom in 1787, without being aware of what was doing in England.

160. Dr. Jeffray was then practising as a physician in Paisley—a town remarkable above almost every other for the weaving of fancy goods—and had thus an opportunity of obtaining some knowledge of the art, of which he availed himself in the construction of the loom. The loom of Dr. Jeffray, as well as that of Dr. Cartwright, was constructed so that the shuttle and lathe were worked by the reaction of springs; and the power applied to them consisted

in repressing them, so as to bring them into a state fit for reacting at the proper time.

161. Dr. Jeffray, however, did not prosecute his invention; and his application to the subject was undertaken in the midst of professional business, and seems to have resulted rather from an extraordinary mental capacity, by which he is distinguished, than perhaps, from any peculiar direction of the mind to the application of machinery to manufacturing purposes. The Dr. is, however, the unacknowledged author of several machines in use; and in one very important respect, his loom was superior to Dr. Cartwright's, viz. as to the means for preventing the smashes caused by the stoppage of the shuttle in the shed, and its rebound from the driver. This was managed by a spring on the side of the shuttle box, which, by its pressure, kept the shuttle from recoiling; and from which a motion was taken, for the purpose of stopping the lathe from getting to the fell, when the shuttle was accidentally caught in the passage.

162. The idea of protecting the yarn from these accidents was perfected by the late Mr Robert Miller, then manager of the Milton Print-field, Dumbarton-shire, near Glasgow, who applied it so as to stop the loom altogether, when the shuttle, in being thrown, was prevented by any cause from entering the opposite box.

163. The loom, by this means, was brought into a state in which the chief difficulty connected with the motion was got over, so that it could now be applied to work without any risk of seriously damaging the warp.

164. This improvement, which was effected by a contrivance called the protector, was patented in 1796, by Mr Miller, who, besides, changed the principle on which the loom was hitherto constructed; substituting for the springs for throwing the shuttle, the direct action of the motive power, the principle on which all power looms have since been made, but carried further in England, by Mr. H. Horrox, of Stockport, who dispensed with the springs altogether in the construction of the power loom.

165. The power loom, as brought out by Mr. Miller, was called the Wiper, from the motion of the shuttle being effected by eccentric wheels of this description; and that of Mr Horrox, the Crank, from this agency being the means for working the lathe.

166. Both of these descriptions of looms are still in use, although the distinctive peculiarities of each have disappeared in the common makes, which are in some measure a combination of both. Thus, the protector, which was so valuable in the loom as brought out by Mr Miller, became indispensable to the loom as constructed by Mr Horrox, where the direct power of the engine, or prime mover, was used, through the crank, in bringing the lathe to and from the fell.* The shuttle in this case, should

* The early state of the power loom, as it appeared in coming from the hands of Drs. Cartwright & Jeffray, and the changes which it underwent in being applied to practice in England and Scotland, are matters that are now fast settling in obscurity. No doubt Dr. Cartwright's loom can be traced by means of his specifications and the drawings connected with them; but as even the last specification connected with weaving, so late as 1792—11th June, is not free from a representation of parts

it be struck by the lathe, was almost certain to carry away the yarn which covered it; but in the wiper

practically unfit for their purpose, it is not unlikely that further changes may have been suggested by the Dr. although we have no notice of them. The real state of the loom as it may have come into the hands of the Messrs. Grimshaw, may so far be a matter of some uncertainty; and so indeed is the improvement which they are said to have made upon it. These points could no doubt still be cleared up, but only, I apprehend, through private sources; and these are now in a great measure closed by the course of time.

The state of the loom as left by Mr Horrox is better known, but the various changes which it underwent in his hands, are not so easily ascertained. Mr Horrox was personally unfortunate in his connection with the loom, and this circumstance may have had some effect in depressing the self-satisfaction that he might otherwise have had in recurring to the subject, and tended, no doubt, to obscure the merit to which he is justly entitled. The same feeling was doubtless experienced by Dr. Cartwright, especially before he received the grant from Parliament.

The early inventors and improvers of a great subject, are seldom aware of the importance of leaving the traces behind them by which they endeavour to attain their object; and as their course is frequently darkened by the spirit of selfishness, the true end and object of their labours are rarely appreciated even by themselves. The immediate or selfish relationships in life are generally enough felt, but the influence of the great universal nature of truth, as affecting every relationship, past, present, and to come, as it points to a higher nature in man than the spirit of commerce, in its present state, is capable of recognising, is distinctly exemplified by very few.

Dr Cartwright has left little direct information respecting his work, except what is met with in his specifications, and from his literary habits and long connection with the subject, it might have been expected to have been otherwise. His letter to Mr Bannatyne, as published in the Encyclopædia Britannica, conloom, where the power of the spring only was acting on the lathe, the breakage, when an accident of this sort occured, was, of course, much more partial.

tains little of importance connected with his invention, although the subject in itself is a highly important one.

Dr. Jeffray, again, does not appear to have taken any trouble at all to preserve his invention. I am not aware that he has ever even recorded it, or that it has appeared in print except through myself.

The changes through which it passed in the hands of Mr Miller, Mr Austin, and others, are so far known, at least the looms as made by them are still preserved. A model of Austin's loom may be seen at the Society of Arts, in the Adelphi, London. Miller's looms are still at work in various places—in the Abbey-Mill at Paisley, and in the Mill at Pollockshaws, near Glasgow. Mr Miller at first set up four looms on the premises at Milton, and very soon afterwards the factory at Pollockshaws was commenced. The looms used there were partly Miller's construction, and partly Austin's, although I believe Austin's were soon set aside, in consequence of some difference at law. Now it happens that three out of the four persons who wrought the first four looms at Milton are still alive. Mr John Barclay, the eminent manager of the Catrine Cotton Works, is one of them. He was then a boy; but before he left Milton he had the charge of the power looms there, and I believe contributed to their success. He is therefore necessarily intimately acquainted with the loom as brought out at Milton, and the state of weaving as it was then carried on there. I am indebted to Mr Barclay for much minute information respecting the early state of power loom weaving, as commenced by Mr Miller.

But as the object of this work, is not the narration of the various changes which power loom machinery may have undergone, but the successive improvements as made upon it progressively considered, and tested by the principles of weaving, which are presented for that purpose, so that by fixing the attention on what the art requires for accomplishing its operations succes-

167. This circumstance of itself, gave a preference, in the estimation of many manufacturers, to the wiper loom, for common calico makes, even after the protector was made available to both; and this preference was not wholly fanciful, at a time when machinery was ill made and imperfectly understood, and, therefore, liable to frequent casualties.

168. The protector, which thus established the efficiency of the power loom as a machine for weaving, is itself a very simple contrivance. It consists merely of an iron rod *a′*, of about three quarters of an inch thick, with two short arms fixed on it, *c′ c′*, and made as seen in Fig. 35th. This apparatus is to be

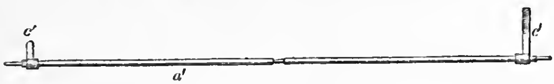


Fig. 35. Protector.

fully, improvements are both suggested and corrected by this course, so as ultimately to lead to the completion of machinery as a means for weaving; the details, therefore, connected with the loom, which may be merely curious, are avoided as leading into too wide a field.

Mr Barclay states that Mr Miller was not in the high sense of the word, an ingenious man. That he depended much on others, and acted rather on their suggestions than on his own. But this, in a great measure, is as might be expected, as Mr Miller was a printer, and I suppose knew little of weaving.

But this circumstance imparted to the proceedings at Milton, much of the experimental character. Project after project was tried both with reference to weaving and dressing. The inconvenience attending the dressing of the yarn in the loom, was endeavoured to be got rid of by sizing the yarn before the web was put into the loom, as a substitute for dressing, a process which afterwards succeeded in Manchester by the adoption of steam-heated cylinders to dry the yarn.

worked by the shuttle, for the purpose of maintaining, or disconnecting, the communication with the power, according as the shuttle may be in a condition to require it.

169. With this view, accordingly, it is placed horizontally, in this case in front of the sole of the lathe, so as to vibrate on its axis, as seen in Fig. 36th; and the manner in which it is acted on will be apparent, when it is observed that the arms are so placed on it, that each of them rests against the respective shuttle spring of each box. Now the spring is so made as to bend horizontally by the pressure of the shuttle, in entering the box. It is, therefore, formed like the blade of a table knife, of thin steel, and fixed with its flat side against the front of the box, immediately above the race, and in such a manner, that the one end projects inwards within the line of the shuttle. When, therefore, the shuttle enters either box, it, of course, presses back the spring, and, consequently, the protector, which is resting against it, follows the motion.

170. Now as to the manner in which this movement of the protector effects the communication with the power:—and this, likewise, is both simply accomplished, and easily understood. But, indeed, there is no difficulty in understanding any machine, if the individual movements of which it consists, be traced out conjointly from the centre of motion; and as the protector leads us directly to the communication by the power, we come at once, by this course, to the source or centre of action in the power loom.

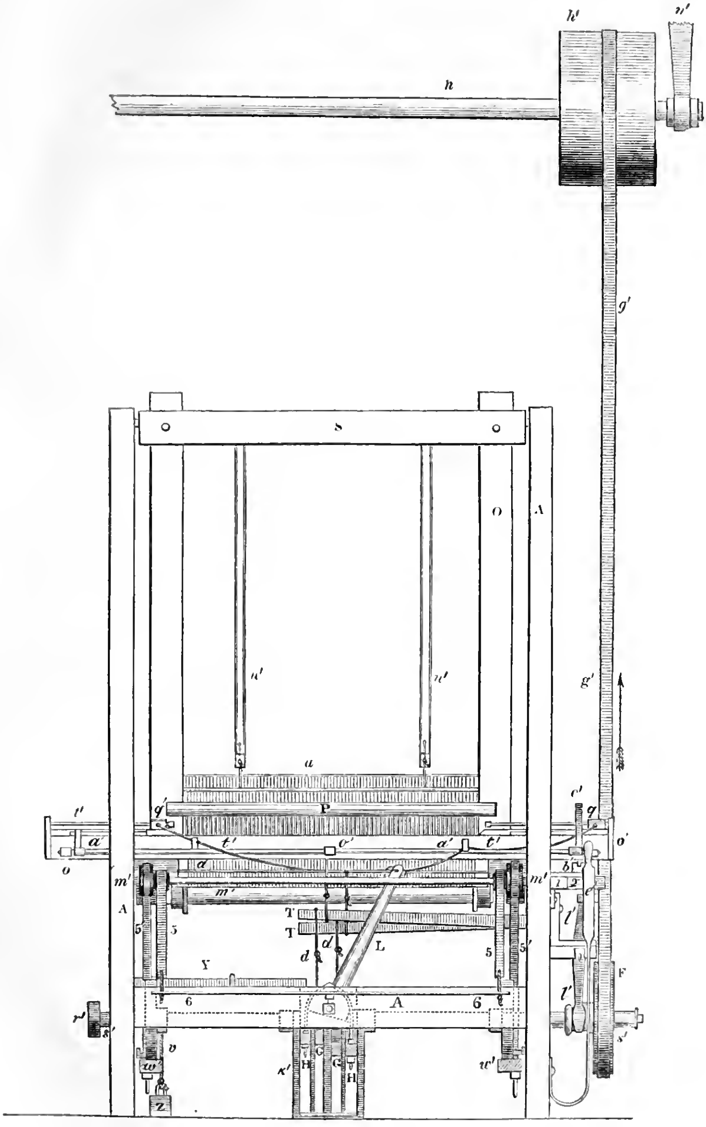


Fig. 36. Front View of the Old Wiper Loom.

171. According to this view, therefore, in examining the power loom, we have

First, to trace out the connection of the protector with the power:

Secondly. The manner in which the three movements included in shuttling are produced by the machinery;

1st, That of the lathe,

2nd, That of the shed,

3rd, That of the shuttle: and

Lastly, the movement of the cloth beam.

These are the common movements, as performed by machinery, which constitute the power loom.

172. Machines are usually driven by rotatory motion, as is the case with the loom, because it is the most convenient mode of communicating power. The lying shafts, as seen in the ground plan of the factory, Plate I. are interposed to regulate the direction and velocity of the motion, between the prime mover and the machinery. The power is thus brought to the house, and the further distribution of it, and direct communication with the machinery, are effected by what are called drum shafts.

173. These shafts, it will be seen, receive their motion by geared wheels from the lying shafts, but transmit it to the machinery by belts, from pulleys fixed on them, called drums. Fig. 36th is a front view illustrative of this mode of communication, and an end view is represented in Fig. 41st. The letters *n h′ g′ n′* refer respectively to the shaft, drum, belt, and end gallows for supporting the shaft from the roof. The loom is likewise furnished with a sim-

ilar pulley F, and shaft, s' s', placed in a parallel plane below it, to receive the belt and transmit the motion which is communicated by it, and, of course, this shaft is the source of all action in the loom, and whence all the movements originate.

174. Now, in order to suspend this action, so as to stop the loom without stopping the power, it was usual to make the shaft feathered, as it is called; that is, a slip of metal is let into it by a longitudinal groove made in it for that purpose, as seen in Fig. 37th, and in an end view of the shaft, Fig. 38th, and left to project above its surface, so as to key the pulley loosely on it, by entering into a corresponding slit, as seen in Fig. 39th, made along the inside of the centre hole for that purpose.

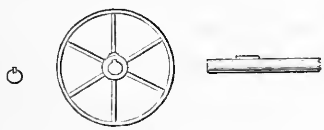


Fig 38. Fig 39. Fig 37.

175. When, therefore, the loom was to be stopped, the pulley was slipped off the feathered part of the shaft, and thus, although it might continue to revolve with the power, it had no effect on the machine.

176. This slipping of the pulley off the feather, is effected by a spring, e' Fig. 36th, and the object in the action of the protector is to set this spring into action, when the shuttle may be in a position dangerous to the yarn, or, which is the same thing, when it has been prevented from getting home to its proper box.

177. The manner in which the protector effects this action on the spring e', will be apparent from Fig. 40th, when it is observed that this figure is an end view of the protector, representing its connexion with the lathe, as fitted for acting on the spring. One arm only, c', effects this connection with the spring, and that arm, it will be seen, is curved or bent over the box, and formed of two pieces hinged together. The second piece b', is pendulous, and jointed to a lever or catch, d', placed at right angles to it, below the sole of the lathe.

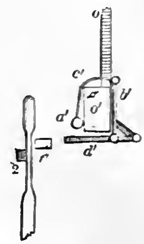


Fig. 40.

178. Now the weight of this hanging apparatus keeps the protector arm against the shuttle spring, and therefore when the shuttle enters the box, the catch d' is lifted, by the pressure of the shuttle against the spring, above the level of the latch f', so that the lathe gets to the fell without any interruption from it. But should the shuttle not enter the box, the catch is not lifted, and the lathe, in coming forward, strikes against the latch, by which the spring is forced forward off the outer notch 2, in which it rests when the loom is in gear; and thus, as the spring is made to bend both forward and laterally, as soon as it is freed from the outer notch in which it is then resting, it springs in towards the side of the loom, against the inner notch, 1, Fig. 36th, and by this movement forces the pulley off the feather, in consequence of the connection between them by the lever l' l', so that the loom is thereby immediately

stopped. The distance between the two notches is merely such as to allow the spring to move the pulley off or on the feather, so as thereby to put the loom in gear or out of it.

179. The spring is thus the handle for engaging and disengaging the loom from the power, and as it must bend in doing so both forward and laterally, it is made, for that purpose, as seen in Fig. 36th, as if two blades were joined together longitudinally by the ends at right angles, or in a transverse direction to each other.

180. The movements of shuttling, in the wiper loom, are all directly produced from the revolution of the wiper shaft. That of the lathe is easily traced. We have observed that the distinguishing peculiarity in the construction of the wiper loom, is that the lathe is brought forward to the fell by a spring, and counteracted, or taken back again, by the power. The spring is seen in an end view of the loom, by the dotted lines at 6, Fig. 41st, and at 6 6, in the front view Fig. 36th, extending from side to side of the loom horizontally, and held fast by the middle by being bolted to the framing. The spring is attached to the lathe at both ends, by a strap or cord *5′ 5′*, which is passed over the roller *m′*, placed in front of the sole of it to change the direction of the force in the direction of the motion of the lathe.

181. The lathe is thus held to the fell; and the withdrawing of it from it again is effected by a wiper or eccentric-shaped wheel or cam, as seen in the end view of the loom, Fig. 41st, marked 7 7. The wiper is made fast to the shaft, so as to act on a treadle *w′*, for

that purpose. The treadle is therefore attached to the lathe, behind the sole, and the direction of its com-

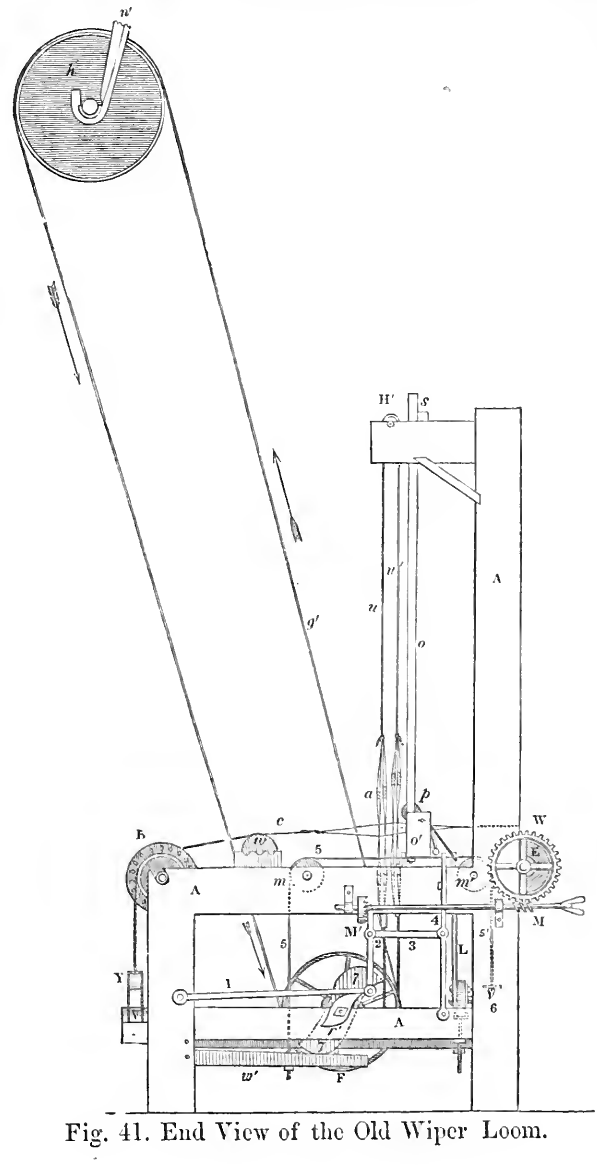


Fig. 41. End View of the Old Wiper Loom.

munication changed by the roller *m*, in a manner similar to that with the spring. The lathe is thus placed between two forces, and as the treadle is alternately depressed by the revolution of the shaft, the spring brings it forward to the fell in the interval between the depressions; and thus the vibrating motion, as necessary to the lathe in weaving, is produced between the action of the power and the reaction of the spring.

182. The kind of motion, as proper for the lathe in weaving, depends on the form of the wiper. The comparative length of its long radius to its short one, and the angle of inclination at which it is brought to act on the treadles, determine both the length of its stroke and the degree of acceleration in its motion from the fell. The duration of its long pause again, for the traversing of the shuttle, depends on the relative length of the circular part of its curve. The absciss at the termination of the curve, is made for the purpose of giving freedom to the action of the spring in bringing the lathe to the fell. It will be seen from Fig. 36th, that there are two wipers and two treadles for working the lathe; but they are made to act simultaneously on it at each end of the sole, and used only with the view of rendering its motion more steady in action. A bracket, it will be observed from Fig. 41st, is interposed behind the lathe at the end of its stroke, to prevent it from rebounding, from the action of the wiper, against the heddles.

183. The movement of the shed is likewise produced by wipers, made more or less eccentric,

according to the form as seen in Fig. 43d, to suit the work. The wipers necessary in treading are two, made on the semicircle, to act on opposite sides of the shaft, on their respective treadles, G G, Fig. 36th; and for the convenience of fixing them, the two are formed together so as to make a double one. As the shaft revolves, therefore, the depression of the treadles is alternate; and to prevent strain on the heddles from the action of the wipers, their short radius should give what their long one requires, so as to render their action properly reciprocal.

184. The picking* is likewise effected by a similar means. Two treadles, H H, Fig. 36th, confined in a frame *k'*, to keep them steady, are attached to the fly-pin, or picking-pin L, by straps, represented by the dotted lines, so as to make it vibrate alternately from side to side, by their alternate depression. The picking-pin is placed, so as to suit this arrangement, loosely on a stud, fixed in the middle framing of the loom, in front of the lathe below the web; and the two fly-cords, or picking cords *t' t'*, are taken down to it, and attached to the top of it. It thus stands vertically, when the drivers are in the middle of their respective spindles; and of course the length of its vibration from side to side, should be about the length of the box, minus the space taken up by the driver. This vibrating action, so as to throw the shuttle,

* The throwing of the shuttle, in connection with the other two motions included in weaving, is called shuttling in Scotland, and in England picking. But in weaving by power the term picking is used in both ends of the Island, but restricted rather to the movement of the shuttle only.

must be quickly effected, more so than can be easily accomplished by eccentrics as commonly made. Tappets, or short arms fixed on the shaft, are therefore employed for this purpose; or, which is the same thing, the wipers themselves are made to act as tappets, by fixing a stud on them, so as to impart the sudden action on the treadles, as necessary in picking, through the intervention of a friction pulley *h'*, as seen in Fig. 43d.

185. But as the treadles should act uniformly on the picking pin throughout the length of its vibration, the pin is mounted for that purpose on a pulley L', Fig. 42nd, as a centre to it, on which it vibrates on its stud; and the strap *n n*, from each treadle, is attached to the circumference of it with a small screw bolt, at the pin, but of course from opposite sides of the pulley, as seen detached in Fig. 42nd, and in its place in the loom in Fig. 36th. The stirrups *x x*, by which the straps *n n* are hooked to the treadles, are screwed and secured to them by a nut on each side, so as thereby to keep the treadles at the required level for the action of the tappets. When, therefore, the shaft revolves, the picking treadles by this arrangement are struck alternately by their respective tappets, so that the fly pin is jerked from side to side, by this means, in a manner similar to the movement of the fore arm of the weaver in working by the action on the elbow joint.

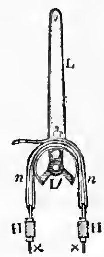


Fig. 42.

186. Thus the three reciprocal motions included in shuttling, are directly produced from the wiper

shaft; and so is the movement of the cloth beam—but its motion is rotatory.

187. The rotatory motion of the beam is here effected by the action of an endless screw. The screw is fixed on an axle M, and placed horizontally at the side of the loom, as seen in Fig. 41st, so as to rotate in gear with the spur wheel W, fixed on the end of the axle of the cloth beam.

188. Now as the lathe, in weaving by power, comes up to a point or line, which is the fell, with very little variation, the cloth must be taken away from it as it is wrought in very small portions, of two or three shots at a time, or it may be done by a slow continuous motion.

189. The motion in this case is intermittent, and produced by the vibration of the horizontal lever 1, Fig. 41st, from its working in contact with the wiper *r′*, on the end of the shaft outside of the loom. This vibrating motion is applied so as to turn the screw axle M; and this it does through the intervention of a ratchet wheel M′, fixed on it for that purpose, and a vertical catch 2, to act on the wheel from the horizontal lever.

190. The wheel is formed, it will be seen, like the crown wheel of a watch, and as the catch is jointed to the horizontal lever below, and placed so as to act on the teeth in one direction only, every vibration turns the wheel a tooth or so, according to the manner in which it is made to act on it.

191. The thickness of the cloth, by this movement, will depend entirely on the rate at which it is withdrawn from the fell by the motion of the beam,

supposing the power of the lathe equal to the reaction of the weft shot. But as this rate will vary with the varying diameter of the beam by the cloth, a means is introduced to prevent the web from being affected by it, or getting thinner towards the end of the piece, as it otherwise must, by prolonging the intervals between the action of the wiper on the crown wheel. This action or regulating movement is managed by the lathe itself, in consequence of a peculiarity in its motion which is taken advantage of for this purpose; and that peculiarity is this, that between the striking of the lathe on the fell and the withdrawing of it from it, there is an interval varying according to the liberty given the lathe between the action of the two forces; and the object is to render this circumstance the means of correcting the variations in the withdrawing of the cloth within certain limits. The lathe, accordingly, is set to act on the fell at the commencement of the interval, where there may be an allowance of some ten shots arising from it, to follow the variations in the motion of the fell forward; and in order to correct the excess of these variations by the corresponding variations in the motion of the lathe, the vertical rod 4, is connected with the crown wheel catch 2, and set, it will be seen from Fig. 41st, so as to come nearly in contact with the sole of the lathe in front, when it strikes the fell in its usual way of working. When, therefore, the cloth is withdrawn from this point or line but a little, the lathe comesin contact with the vertical rod, and withdrawing the catch from the crown wheel, the action of the wiper upon it is interrupted, and of course the uptaking motion is suspended for that shot, and may be so, in the same manner, for the next, according as it may require it.

192. The four principal motions, in weaving by this power loom, are thus directly produced from the revolution of the wiper shaft; and the secondary one, that of the protector, from the shuttle by the action of the lathe.

193. But the individual movements must be combined, so as to be produced in the proper order of succession:

First, The shed should be started at the stroke of the lathe on the fell, according to the great rule, expressed in section 75th, for the conjoint performance of the motions in weaving.

Secondly, The shuttle must be brought into play, to gain speed in shuttling, in accordance with the rule in section 118th, as soon as the shed and lathe are in a state to receive it: and

Thirdly, The protector must be set, so as to stop the lathe, at such a distance from the fell as is merely sufficient to clear the shuttle, should it be stopped in the shed, so as to prevent breakage from it.

194. The fell is, therefore, the starting point or line from which all the motions relatively spring; and in adapting them for this conjoint action, the lathe is set at the fell, and its treadles adjusted for immediate contact with their wipers. The shedding wipers are set, in like manner, on the shaft, so as to be in the act of commencing to depress one of the treadles. These two actions thus follow each other so closely as to seem instantaneous; and are so, ex-

cept as to the effect on the yarn, as some motion is necessary, in working with eyed heddles, to bring the two lines of threads in contact in turning the shed; but that of picking is attended with a longer interval, inasmuch as the lathe and shed are during this time to be put in a state for the passage of the shuttle. The impulse on the picking pin is, therefore, to be imparted so as to have the shuttle on its passage at the selvage, when the shed and lathe are ready for it. The picking pulley is therefore set to act on its treadle accordingly. But as some time is necessarily lost in bringing the shuttle to the selvage, the time thus taken nearly equalizes that required for the shed and lathe, and therefore the interval between this action of the shedding wiper, and that of the picking pulley is likewise short, more so than should otherwise be necessary,

195. Fig. 43rd represents the relationship in which they may be set for working, in accordance with the rules already laid down, although the representation may vary a little. O′ is the lathe at the fell, *q′* the shedding wiper in the act of commencing to depress the treadle G. One treadle only is seen in the representation. *h′* is the picking pulley in its relative place in the circle nearly perpendicular to the treadle pulley. But the position of the picking pulley will, of course, be varied, according to its action on the shuttle.

196. The protector, again, must be set to intercept the lathe as required, at a little more than the breadth of the shuttle from the fell. The catch, accordingly, is set to make the latch stop the loom,

by disengaging the pulley with the spring, when the lathe is at that point.

197. As the velocity of the shuttle must vary with the width of the work, and the speed at which the loom is driven, the impulse is adapted to it accordingly, by screwing the treadle with the stirrup closer to the wiper, or the contrary, as the picking may require it.

198. The speed of the loom, again, is directly dependent on the velocity of the drum shaft, and relative diameters of the drum and wiper pulley. For example, if the drum shaft makes forty revolutions per minute, and the diameter of the drum is sixteen inches, the revolutions of the wiper shaft, as driven from it with a pulley of fourteen inches, will be forty-five; and as there are two shots on each revolution of the wiper shaft, the speed of the loom will be ninety shots per minute. The question, as worked, will therefore stand thus, $40 \times 16 = 640 \div 14 = 45 \times 2 = 90$; and the mode of the operation is applicable to all similar questions, where the result sought is merely the relative velocity of two cylinders rolling together. Some allowance of course is to be made, in such cases, for the slipping of the belt in working.

199. But the force of the lathe must likewise be varied according to the work, and the speed at which the loom is driven. Its momentum must be sufficient to overcome the reaction of the weft shot; and as this reaction varies exceedingly, in the different makes of heavy calicoes, beyond the range within which the same spring can be adapted to the work,

the loom is much limited, on that account, in its application to different fabrics.

200. This was an inconvenience which was compensated by no advantage that such work was capable of receiving from the motion of springs, effected in any manner, and as they were liable to breakage, and expensive on that account, it was obviously a great improvement, where force was chiefly required, to substitute the direct application of the motive power in the working of the lathe.

201. This seems to have been the view very early entertained of the subject by Mr Horrox, which led him to dispense with springs altogether in the construction of the loom, by applying the motion of the crank to the lathe, so as to work it by the direct action of the motive power. By this means, he not only got rid of the springs, but of the two wipers connected with them, the two treadles, the straps, and the two rollers for changing their direction to the lathe.

202. In their stead, this new construction required an additional shaft, the crank, used exclusively for the lathe, two connecting rods to attach it to the swords, and two spur wheels, to work the crank in gear with the wiper. One turn of the crank is necessary to complete the stroke of the lathe, or its motion to and from the fell; and as the shedding wipers are constructed on the semicircle, two shots make the circle, and therefore the crank shaft revolves twice for once of the wiper. This is effected by the relative sizes of the two wheels; that of the crank is exactly half the size of the wiper. The crank shaft is usually the driving one.

203. Fig. 43rd is a transverse section of this construction of loom, which is called the Crank; and as

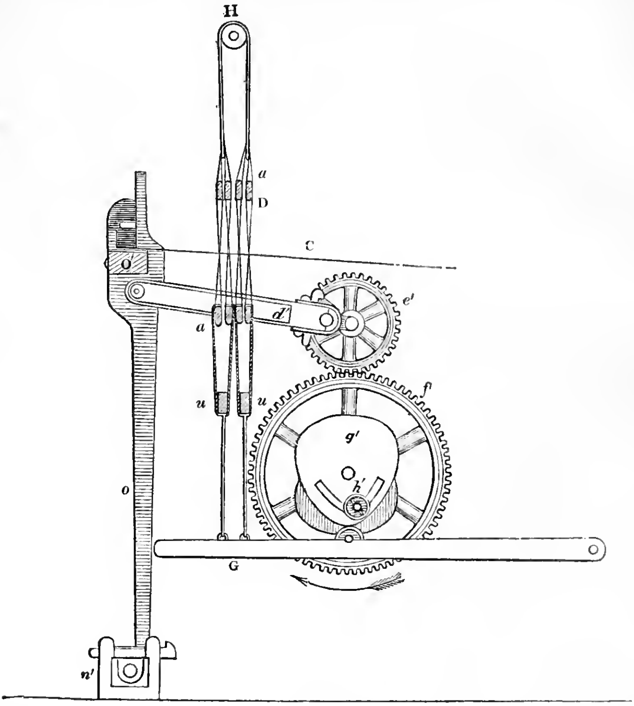


Fig. 43. Section of Moving Parts of the Crank Power Loom, without the Frame.

it has superseded the Wiper, and is almost the only one in use, it is the one with which we have especially to deal in the further consideration of power loom weaving. *o*, *d'*, *e'*, *f'*, refer respectively to the sword of the lathe, the connecting rod attached to it, the crank pinion, and the wiper wheel. The other letters refer to parts which have been already described in connection with weaving by hand.

Plates V, VI, VII and VIII, present two end views right and left, a transverse section, a front elevation, and a plan, of this construction of loom, in its best state as at present used.

204. The lathe, according to this construction, is limited in its adaptation to the work only by its strength in resisting the reaction of the weft shot; so that within this limitation, which is wide enough for common use, all that is required in adapting it to different makes requiring more or less weft, is a corresponding difference in the pacing, to keep the web sufficiently firm to the stroke of the lathe—of course the motion of the beam must be adapted to the shotting.

205. The movement for the beam which Mr Horrox adopted and patented, is similar to that represented in Fig. 44th, with this difference, that in his case the motion was taken from the rocking-tree to the hanging catch C, instead of, as represented, from the end of the marches T T, outside of the bolt.

206. This hanging catch, or bended lever, is put loosely on the axle of the cloth beam, outside of the framing of the loom, so that it may vibrate freely by the lifting of the lower arm. This vibrating motion is to produce the rotatory motion of the beam; and for this purpose the upright arm of the bended lever is furnished with two catches, made to work the ratchet wheel D, whose pinion acts on the spur wheel E, fixed on the axle of the beam. When therefore the bended lever is lifted, as is done in the power loom by the sword, the ratchet wheel is turned so much by the catches, and so must the beam, whilst

the recoil from the action of the pace is prevented by the stationary catches, fixed from the side of the

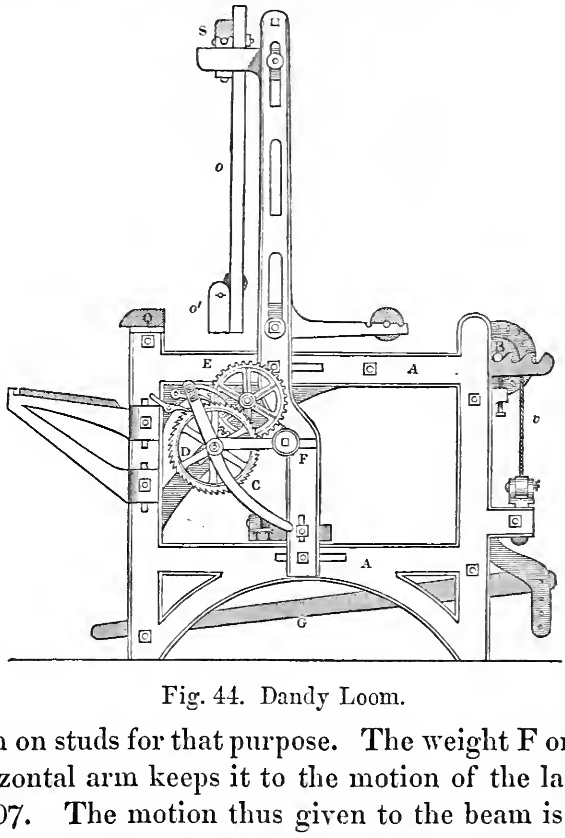


Fig. 44. Dandy Loom.

loom on studs for that purpose. The weight F on the horizontal arm keeps it to the motion of the lathe.

207. The motion thus given to the beam is uniform; and to stop it from going on, so as to prevent gaws* from being made by the intermittent break-

* There are four descriptions of faults to which the work is more or less liable in weaving, namely, *clouds, jesps, gaws,* and *scobs.* A cloud, as has been already noticed, is a thickening of the cloth, either throughout its whole breadth, or, as is commonly the case, at the selvage only. A jesp, on the contrary, is a thinning of the cloth, or rather merely a greater space be-

age of the weft shot, the weight is used so as to act as a counterpoise to the pace, and the balance is turned by the stroke of the lathe on the fell. If then

tween two shots than ought to be, at some particular part of the web—whereas a gaw is this space continued over the whole breadth of the web, or it may be partially interrupted by a broken shot. A scob, again, is a blemish in the cloth arising from the interruption of the threads in shedding, preventing the proper interlacing of the warp and the weft.

These faults affect both hand and power loom goods, but not equally so: scobbing, indeed, is equally common to both, but gawing, as it arises almost wholly from an ill regulation of the hand in working the lathe, to a degree beyond what is to be met with in the trade, is not to be looked for in work of average quality. Clouding and jesping are, however, frequently traceable to the practised eye; and, in a great measure, arise from the stoppages in working to dress and draw the bore; as in these cases, should the diameter of the beam be unequal, the line of the fell is not straight, in commencing again; and where it is concave towards the reed, it will jesp, and cloud, where it is convex. The weaver endeavours to prevent these faults, by squeezing forward the cloth where the fell is off, and taking out a couple of shots at the selvage in its being forward, as it may require it. But the right remedy is true beams, placed in parallel directions to each other, and light and equal brushing in dressing, that the yarn be not unequally stretched, as has been noticed in weaving by hand. But jesping may nevertheless take place from unequal strain on the lathe in its attachment to the rocking-tree. In that case, the fell, although it may be straight, will be in a somewhat slanting direction, not parallel to the lathe when brought slowly forward, more especially if the weaver works at a great speed. The jesping will then be apt to take place at one side only, in commencing again after a stop of any kind, when the lathe has not acquired its full momentum.

But as the power loom is free from the injurious effects on the cloth resulting from the dressing of the yarn in the loom; and likewise from the variations arising from the bore, the

the cloth, from the want of weft, recedes a shot or two from the reed at the fell, the catches are rendered ineffective in moving the beam further, from the want of the impulse of the lathe, and the uptaking motion ceases. The weaver, on seeing this, stops the loom ; and lifting the check catch, lets back the beam so much, according as the cloth may require it, and having supplied the lack of weft, it is ready to begin again. This uptaking motion is uniform, and to prevent the cloth from being affected by the increase of the beam's diameter by the cloth, the pace is increased towards the end of the piece, so as to check the uptaking motion by the increased resistance thus given to the stroke of the lathe.

208. Although the loom was thus brought into a state capable of weaving, it was still attended with no success, nor could it possibly be, so long as there were no means for dressing the yarn by power.

209. Hitherto this important process was done in the loom, as in weaving by hand. A portion of the stretch, that from the wheep roll to the beam, which was lengthened for that purpose, was reserved for dressing ; and the weaver was engaged, when his attendance could be dispensed with in front of

cloth is more evenly than that made by hand, although gaws are more liable to take place with it than in hand made goods. But jesping may, and does, take place, in the power loom, from strain on the lathe in its attachment to the rocking-tree, or from its connection with the crank shaft, by their not being parallel ; and there is another cause which is not sufficiently attended to, namely, the vibration of the drum shafts from unequal weakness in working, which very injuriously affects the lathe, in case it should be suffering from any strain in the loom.

the loom, behind the heddles preparing and dressing the warp, so as to keep time with the loom: and to prevent as much as possible interruptions in weaving from the breakage of the yarn in dressing, in some instances a heavy roll was placed upon the warp, above the wheep roll, so as to keep the threads that might give way between the two beams from *coming in* in the act of weaving. The yarn was thus suffering the action of two processes at the same time; and was not only injured by the strain from this mode of working, but neither of the processes could be sufficiently attended to, nor properly done.

210. There is a total want of adaptation between machine and hand labour, as applied in combination to work out the same process; and the manufacture by power looms was, on that account, in a very unsatisfactory state,—it could not even have maintained itself against hand competition.

211. The gain in working by machinery consists in the excess of production over hand labour, compared with the difference between the cost of the agency; and in this case, as there was one person to each loom, with the expense of machinery to keep up out of a production which could scarcely be greater, all things considered, than a weaver could produce without the machinery, the gain could not be depended on. The average daily production of the power loom was about 14 yards of a 10^{00} even wefted yard wide calico. And this a weaver, even then, might have done in the hand loom—or at least the difference in favour of the power loom in this respect could not be much.

212. The power loom was thus still in a probationary state, and as yet wholly unfit to work up the extraordinary production of the spindle. But as the return in the spinning department was great, that branch of the business was engaged in by men of talent and energy, who extended their business till it was in some measure circumscribed by the difficulty of disposing of the produce. Foreign markets were largely supplied with English yarn. Its exportation to the continent of Europe was very great; and likewise to America; and some was even sent to India itself. It therefore became highly desirable to increase, if possible, the consumption at home; and the power loom was kept in use in the hope of rendering it the means, which might ultimately, effect this object.

213. But as depressions were frequently experienced in the trade, and some of them to an alarming extent, they were almost universally attributed to foreign competition, arising from the exportation of our yarn. 1799 was a year of great general depression in the cotton trade, and meetings were held by the manufacturers throughout the country to see what should be done to mitigate the distress, and if possible, prevent the recurrence of these periodical stagnations, which were regarded as signs of the decline of the British trade. It was urged at these meetings, that as the foreign cotton trade depended on English yarn, the sure way of cutting it up by the roots was to prohibit its exportation; or at least to load it with heavy protecting duties, so as to counterbalance the advantage, as to cheapness of

food, possessed by the foreign manufacturer :—and that petitions and memorials embodying resolutions to that effect should be immediately forwarded to Parliament from all the manufacturing districts in England and Scotland. No one was more zealous and disinterested in advocating this policy and promoting meetings for this purpose, than Mr William Radcliffe, a manufacturer at Melor, about 11 miles from Manchester. He officiated as Secretary to the Association which was formed for carrying these resolutions into effect, and was appointed one of the deputies to wait on the leading ministers, to impress upon them the necessity of acting in accordance with their views. In this way he had several interviews with the principal statesmen of the day—such as Sidmouth, Castlereagh, and others, and although the deputies were generally very favourably received, nothing was ever recommended to be done by the Committees of the House of Commons, before whom the subject had several times been brought—clearly because the exportation of yarn, as of every thing else which we could produce cheaper than our neighbours, was advantageous to the country. Mr Radcliffe however attributed the failure of his representations to the sinister influence of the spinners engaged in the export trade; and called another meeting to see what should be done in these circumstances, when it was agreed that there was no way left for them so as to save the trade, but to cheapen production by the application of machinery to weaving—and he again offered to lead the way; the meeting pledging itself to reimburse him for any loss that he might sustain in carrying out his plans for that purpose. His object was to dress the yarn by machinery, and give the web out to the weaver ready for working, on the beam, so as to simplify the process of weaving, that it might be easily carried on, according to the cottage system, at home. For the purpose of strengthening himself in his proceedings, he formed a partnership with a Mr Ross; and commenced his new career by engaging a young weaver of the name of Johnson, whom he had in his employment, and whom he knew to be ingenious, to construct a neat hand loom made in such a manner that the cloth beam should be turned by the action of weaving, so as to prevent the necessity of stopping to draw the bore.

214. Mr Johnson was an engineer by nature;—indeed mechanical invention was the peculiar mode of action for which his mind was best fitted; and he entered upon the work which Mr Radcliffe pointed out, with a devotion that knew no bounds. The loom as required, was constructed by him in a satisfactory manner; and some hundreds of them were made, and put up in a factory of Mr Radcliffe's at Stockport, for the purpose of training the people to this new mode of weaving, preparatory to their being used by them in their own houses.

215. The loom thus invented by Mr Johnson is known in the trade by the name of the Dandy Loom, and effects almost all that can be done for the hand loom as to motion.

216. The movement of the cloth beam was effected by wratchet wheels, to which motion was given by a hanging catch, from a lever attached at

right angles to the upper extremity of the swords of the lathe, above the centres, in a manner similar to that already described as belonging to the power loom; and indeed the principle part of that motion was borrowed from this loom by Mr Horrocks* of Stockport, as an application to the power loom.

217. The dandy loom has been, and is yet, a good deal used in the factory system for coarse goods: but as the motion of the beam effected in this manner, to some extent disturbs the lathe in its action, and, besides, renders the weaver less sensible of the reaction of the weft shot, it is felt as an incumbrance on the hand, and not, therefore, adapted for fine weaving. Fig. 44th, page 122, is a representation one of of the best forms of this kind of loom.

218. The great difficulty, however, in carrying out this plan of manufacturing, lay in devising the means to dress the yarn by power. Mr Johnson proposed and tried the application of cylindrical brushes made to revolve on their axles, so as to dress the yarn by drawing it over the top of them. But as the breakage from the action of the cylindrical brushes was considerable, it was discontinued on that account; although it was afterwards reinvented and patented by a Mr Quinten Macadam, a Manufacturer in Glasgow, since which it has continued in use, under the name of the circular dressing machine. But the principle of circular brushing is defective; and this will be obvious when we consider that, as the object of brushing is to lay the surface filaments of the thread in the direction of the

* This name was previously printed Horrox, by mistake.

yarn, the application of circular brushing for this purpose is an attempt made to act on the yarn in straight lines by the arcs of a circle; and as this is an impossibility, the filaments, therefore, cannot by this action be laid in the required direction.

219. There is only one point in circular brushing, viz., when the staples in action are at right angles to the yarn, that the brushing is in the proper direction; and although the filaments may have been laid by this right angular action, they are again ruffled by the oblique direction of the bristles in entering the warp,—just at the time too that the yarn is passing from the brush in a finished state: and, moreover, as the brushes, to be effective, must revolve at a considerable speed, there is thereby communicated to the yarn a tendency to follow this motion; and the filaments which are raised by the obliquity of the bristles in leaving the warp act as handles by which the threads are pulled in the direction of the brush. This mode of brushing is, therefore, very ineffective from its obliquity, and severe on the yarn from the form of the motion.

220. As the proper motion of the hand in brushing partakes of neither of these defects, it was therefore attempted to be imitated: but at first sight it did not seem likely to be easily effected. Mr Johnson, however, who was called upon to devise means for the removal of all the mechanical difficulties as they occurred, and on that account passed in the work by the name of the conjurer, has the merit of accomplishing this movement also.

221. He placed the brush, which, of course, was

a little longer than the breadth of the web, transversely on a frame, so as to slide, in the direction of the yarn, on two spindles, one supporting it at each end, and communicated the stroking motion to it, by which it brushes the yarn, from a crank.

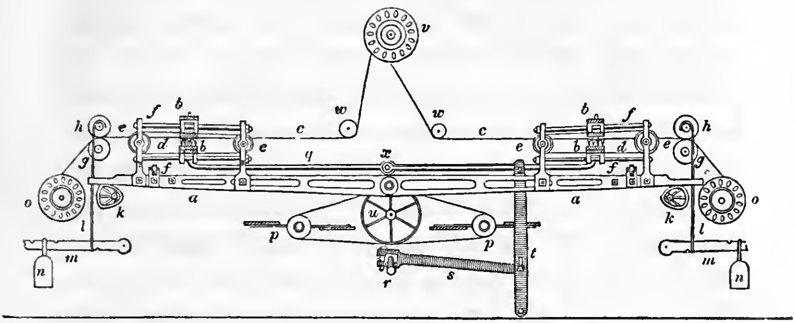


Fig. 45. Side View of Dressing Machine, without the Framing.

222. But as the brushing is to be double, so as to act alternately on the upper and under sides of the warp, two brushes of course are used for that purpose, and placed on spindles in different planes, with their faces towards each other, and the warp line between them, as seen in Fig. 45th, and in the side views of the machine, Plates III. and IV. *a a* is the brush frame, *b b* the ends of the brushes, *c c* the warp line; and the manner in which they are fitted for working alternately on the yarn, will be apparent from this representation, when it is observed that they are connected together by the strap *d* which passes over and embraces the two pullies *e e*, placed singly between the opposite ends of the two pairs of spindles on which they slide. Motion, as communicated to

either of the brushes, according to this arrangement, will move them in opposite directions, from the one pulley towards the other; but as they must act on the yarn in one direction only, they are lifted alternately out of the warp line, at the termination of the stroke, so as to allow each brush to act on the yarn in the direction towards the end of the frame.

223. For this purpose the brush frame is placed in the frame of the machine, so as to vibrate on its centre like the beam of a balance, that the brush may thereby be raised out of the warp line at the termination of its stroke; and it must be kept raised, clear of the yarn, whilst the other brush, which has been brought into action by the same vibration, is, in like manner, completing its stroke on the opposite side of the warp.

224. This motion, by which the brush frame is raised in this manner, is effected by two pairs of eccentrics, acting alternately in pairs, on opposite ends of the brush frame; and the manner in which this is done will be evident from the plan of the machine presented in Plate II. A A, is the machine frame; *a a* the brush frame; *b b* are the upper brushes on the upper spindles *f f*, at each end of the frame; *k′ k′* the two eccentric shafts; *k k* the eccentric wheels, better seen in the side elevation of the machine, Fig. 45th, and so placed on their respective axles, that the increase and decrease of their relative action are reciprocal, as seen from their position in the figure.

225. This machine, from the manner in which

the brush is worked, is called, in contradistinction to the Circular, the Crank dressing machine; and in both the Circular and the Crank, the warp, to increase the facility of the brushes in getting through it, is always put into the machine in two portions; one or more reels containing the half of the warp are put in at each end of the machine, and the united portions making the whole web, are wound from them, on the yarn beam of the loom *v*, which has been put in the machine for that purpose, in the act of being dressed.

226. Each half of the warp is thus dressed singly, but at the same time, in passing separately to the yarn beam where they are united; so that the machine consists of a double apparatus for dressing, worked from a common centre. The pulley shaft *a*′, which receives its motion from the power, seen in the plan of the machine, Plate II. and one of the side views, Plate IV. is the centre from which all its motions proceed.

227. These motions, as essential to dressing, are the two in brushing—the stroking, and lifting;—the applying of the paste;—and the drying of the yarn. The winding of the warp on the beam, and the measuring of the quantity as done, are properly secondary motions,—making six in all as included in dressing by power. Of these, the driving shaft *u*′ directly produces but one, viz. the motion of the fan for drying the yarn; and the crank shaft *r* one directly,—the stroking of the brush; and three indirectly,—the lifting of the brush,—the applying of the paste,—and the motion of the beam. The mea-

suring of the yarn is done by the motion of the web itself in passing to the beam.

228. As the movements dependant on the crank are much slower than that of the fan, the motion of the driving shaft, as communicated to the crank, is diminished accordingly by the difference in the size of the respective spur wheels by which they are connected. That of the driving shaft is 40 teeth, and that of the crank shaft with which it works in gear is 120.

229. The crank shaft is made, like that of the loom, with two cranks, one on opposite ends of the shaft, and from the same side to act in the same direction. The throw is five inches, and the stroke of the brush, as worked from it, is about twentytwo. This difference between the motion of the crank and the brushes is made up in the communication by the leverage of the side vertical levers. There are two of these levers, one of course to each crank, and at opposite sides of the machine. Each lever has thus two connections to maintain, one with the crank, from which it receives its motion, and one with the brushes, to which it communicates it.

230. This double communication of the side vertical levers is well seen in Fig. 45th, as it is a side view of the dressing machine without the framing; and, likewise, although less distinctly, in the two opposite side views in Plates III. and IV. *t* is the vertical lever, *r* the crank, *s* its connecting rod, and *x* the brush frame connecting rod. The length of the arc described by the radius of the lever is the length of the stroke of the brush. The brush con-

necting rod is therefore attached to the top of the lever, and the crank connecting rod at such a distance from its centre as is sufficient to give the required length of stroke for the brush. The slit in the lever is left for the adjustment of the motion, that the stud of the connecting rod may be fixed at the proper place for producing it.

231. It will be seen that motion is to be communicated simultaneously to the brushes at both ends of the machine, and for that purpose the under stocks, on which the brushes rest, are connected together, so as thereby to form a frame in the figure of a parallelogram.

232. Now it is to the opposite sides of this framing, which may be called the stock frame, that the respective brush connecting rods are attached. The stock frame is seen in the plan of the machine, and a side view of it in Fig. 45th; *b b* may be taken to represent the stocks forming the ends of the frame, and *q* the side to which the one connecting rod is attached. Both sides *q q* are seen in the plan, with their respective connecting rods *x x*.

233. By this arrangement, it is clear that the brushes at each end of the machine will be slidden backward and forward on their respective spindles, by the throw of the crank, in opposite directions; but as they must slide on the yarn in one direction only, they are lifted out of it alternately for that purpose by eccentrics; and this action is accomplished by the intervention of three shafts—a vertical, and two horizontal ones. The two horizontal ones run from end to end of the machine, except where

they are separated at the middle to receive the communication from the crank shaft by the vertical one. This communication is effected by bevel gearing, as the action throughout is rectangular in its direction.

234. Plate IV. presents a good view of this communication of the crank shaft with the eccentric one. The vertical shaft *t'*, it will be seen, receives its motion from the crank one by the bevel wheel *f'*, and transmits it to the horizontal one by the bevel wheel *g'*. The two horizontal ones, *h' h'* in like manner, by the same sort of gearing, convey it to their respective eccentric shafts, *r' r'*.

235. The eccentric shafts, it will be seen from the plan in Plate IV. extend from side to side of the machine like the crank; and that they may act on the brush frame without straining it, two eccentrics are put on each shaft, and set immediately under the opposite ends of the frame, to act together in the same direction; but the shafts themselves are set to act on the brush frame in opposite directions, at the respective ends of the machine; so that when the one shaft is lifting the frame at the one end, the other by the reverse position of its eccentrics is permitting its descent. The relative position, in which they are placed for this action, is seen in the side views, more especially in Fig. 45th.

236. The application of the paste to the yarn is effected by rollers. Two are used for this purpose, *g*, *h*, to each portion of the warp, and placed immediately above each other, in a horizontal direction, across the machine, near the termination of the stroke of

the brushes, in front of the reels *o o*, on which the raw yarn is wound. The yarn from the reels is led through between the two rollers in its way to the beam in the middle of the machine. The two rollers lie together in contact, with the yarn between them; and as the under roller is half sunk in a trough filled with paste, the paste is applied to the yarn merely by the rotation of the rollers, in its passing to the beam.

237. Motion for this purpose is applied to the under roller only, as the upper one, by lying upon it, revolves with it; and this is done directly from the eccentric shaft with a pinion and spur-wheels working in gear.

238. This gearing is well seen in the side view of the machine, Plate III. It will be observed from it that the speed of the eccentric shaft, as applied to the rollers, is diminished by it; and, therefore, the pinion is put upon the eccentric shaft, and the other wheel and pinion between it and the wheel on the axle of the under roller are interposed to regulate the velocity as communicated to it.

239. By this means the yarn is brought forward by the revolution of the rollers, coated with paste, and the brushes meet it towards the end of the stroke, and rub the paste into the yarn over the range of their action. The pinion of the eccentric shaft has 16 teeth, and that of the intermediate one 16 likewise. The two wheels have each 80 teeth; and as the diameter of the rollers is $4\frac{1}{2}$ inches, the delivery of the yarn accordingly will be nearly $\frac{5}{8}^{\text{ths}}$ of an inch to each stroke of the brush. The move-

ment as expressed in figures, may stand thus—

$$
\begin{array}{rcrcr}
80 & \div & 16 & = & 5 \\
80 & \div & 16 & = & 5 \\
\hline
 & & & & 25
\end{array}
$$

25 and the circumference of the rollers, say 14 inches, divided by 25, = .56.

240. The yarn is thus delivered to be wound on the beam in a measured quantity, which is varied according as it may require more or less brushing to fit it for weaving, by changing the pinion *a*, so as to give more or less motion to the rollers, according as it may be necessary for that purpose.

241. The motion thus imparted by the gearing is uniform, but the motion of the beam itself must be proportionally decreased as its diameter increases by the yarn, to equalize the uptaking of the warp; and this is accomplished by rendering its motion dependant on friction. It is so arranged that the beam cannot get more than is given it by the rollers, and when its rate exceeds their delivery, a slipping takes place between the motion as received from the vertical shaft, and the motion as communicated to the beam. Two views illustrative of this motion are given in Plate IV. The first is the side view of the machine, which represents the motion as transmitted by the vertical shaft from the crank, and the second is a view of the communication of the vertical shaft with the beam.

242. The vertical shaft runs its uniform rate of motion through its pinion of 20 teeth, and the interposed bevel wheel of 40, and its pinion of 20, on to the plate spur-wheel of 90 teeth, at which the slip-

ping takes place. This slipping is effected by interposing a disc or collar shielded by oiled pasteboard or cloth, between the wheel and the two pinching screws *l l*. The beam is placed in the plane of the axis of the plate wheel, with the one gudgeon in the socket of the catch, and its stud, as seen in the plan of the machine, Plate II, entered into the end of the beam. The motion thus communicated to the beam will be resisted, so as to produce slipping, by the tension of the yarn, as it is wound upon it, according as the pinching screws, by their pressure, keep the friction surfaces of the plate-wheel and its collar together. The delivery of the warp is thus directly dependant on the *motion* of the rollers, and the tension, on the *friction* of the plates.

243. As weight or pressure on the yarn, between the rollers, is necessary to its regular delivery, as well as to maintain the required tension of the warp in dressing, the rollers are made heavy;—of cast iron with malleable axles turned on their journals; and to prevent oxidation from the paste, closely cased in copper, and fitted for work by being covered with a thick roll of woollen cloth sewed firmly on their circumferance. The paste is thus retained on the surface of the rollers; and the yarn in passing between them is imbedded in the dressing.

244. But the quantity of dressing, as applied to the yarn, must be regulated, as well as the brushing; and this is effected by regulating the pressure between the two rollers. For this purpose, a pace lever *m* is hung from the journal of the upper roller, on each side, as seen in the side views of the ma-

chine; and loaded, so as to regulate the quantity of paste between the rollers, as required in dressing, according to the quality of the yarn, or the fabric intended to be made from it.

245. It will be seen by a reference to either of the side views, that the warp line is preserved in the direction of the brushes, by the lower dressing rollers, at each end of the stretch towards the reels; and at the other two, towards the middle of the machine, by the wooden rolls, *w w*; and that the beam is elevated above the plane of the brushes, to get a sufficiency of space for the convenience of drying the yarn, before it reaches it, without lengthening the machine for that purpose.

246. The drying is effected partly by heat from steam pipes, and partly by the removal of the damp atmosphere by fans. There are two fans in the machine under consideration, one to each half of the warp; and these are seen from the end, in the side views, Plates III. and IV.; and from the front, in the plan, Plate II. From these views, it will be seen that the fan consists of a shaft *p* extending from side to side of the machine horizontally, and turned at its extremities, so as to rotate in its bushes. The shaft is furnished with two arms, fixed upon it at right angles, for supporting a leaf or board *y y* on each side of its diameter, (as seen in all the views of the machine,) with which it strikes the air as it rotates in its axle. The rotation of the fan is effected by a strap *l′*, from a pulley *m′* fixed on the driving shaft, and a corresponding one, of course, on the shaft of the fan. Both of the fans are driven in

the same manner, but from opposite sides of the machine, and therefore they have each their respective pulley on the driving shaft. As the action of the fan must not be directed against the yarn under the brushes, a screen *n′ n′* is interposed at that part of the machine behind each fan, to prevent it from affecting the yarn there.

247. The steam pipes are powerful auxiliaries to the fan in drying the yarn. Three branches are usually used in the machine for that purpose; one near each fan, and the other between the two divisions of the warp, where they turn up from the rollers to the beam.

248. The warp is measured in the machine, in the lengths in which the pieces are intended to be woven, by the larger roll *w*, as it is turned by the friction of the yarn in passing under it. As its diameter is known, so many revolutions make a piece; and these are indicated by the horizontal spur-wheel *o′*, which is worked from the worm *p′*, on the axis of the roll *w*. The number of teeth therefore is a measure of the yarn; and one revolution makes a piece. When this has been done, to prevent it from being overlooked, it is made to tingle a bell *q′*, by touching the spring on which it is hung with the steady pin fixed in the periphery of the wheel for that purpose.

249. This description of the dressing machine refers to it as it is now used, rather than as patented by Mr Johnson, for Mr Radcliffe As Mr Johnson left it, the paste was applied by one roller only; and the yarn was drawn over it, in being dressed, by

the rotatory motion of the beam. It was therefore strained from the length of the stretch, in which it was exposed to this traction; and unequally supplied with paste, by receiving it from an exposed surface, as the absorption was thereby partially prevented.

250. These defects were severely felt by Mr Johnson; and considerable as was the annoyance from the breakage of the yarn by the traction, the application of the paste in this manner was attended with the still more injurious consequences from plaiting. This tendency of the threads to run together in twists directly arises from the drying of the yarn unequally, chiefly from its being unequally supplied with paste; and so much was Mr Johnson impressed with the difficulty of working the machine so as to prevent plaiting, that he endeavoured to dissuade Mr Radcliffe from proceeding any further with this new mode of manufacturing, as it was likely to be attended with a useless expenditure of money. Mr Radcliffe however was full of confidence as to the success of the result; and Mr Johnson continued to do his endeavour to bring it to pass. The expedient of using reeds of different fineness, through which the yarn was drawn, so as to keep the threads apart, was tried; and with so much success as to encourage them to proceed with it. But still there were serious inconveniences attending the use of reeds in this manner, from their ruffling the fibres of the yarn by their friction, and from their liability to get clotted with the dressing; and with the view of obviating these inconveniences,

and preventing plaiting by completely isolating the yarn, the late Archibald Buchanan, Esq., of Catrine works, employed a copper plate, in place of them, with a hole drilled for each thread, through which the yarn was individually drawn—and this means for that purpose still continues in use. The plate, of course, is a little longer than the breadth of the web; and the holes are placed in rows diagonally, as seen in Fig. 2d, Plate II., and marked *s'* in the several views of the machine.

251. But the great improvement in dressing by the machine was the substitution of the double rollers; and Mr Buchanan likewise was the first to originate and apply it to practice. By this means the yarn, by being imbedded in the paste in its passage from between the rollers, is placed in the most favourable situation for saturating itself with the dressing, and, therefore, has the chance of being more uniformly supplied with paste; and so far as that is accomplished, the yarn is not only better when dressed, but the tendency to plaiting during the process, is thereby proportionally diminished.

252. The lease of the yarn is preserved in the machine by a set of heddles *v'*, placed to slide horizontally in the framing, a little below the beam, with one thread from each half of the warp drawn alternately through each of the two leaves.

253. Thus the dressing machine, so essential to the power loom, was brought out by the enterprise of Mr Radcliffe, and his own mode of manufacturing established by it. But he was far from being fortunate as a manufacturer. This, however, is attri-

butable rather to his personal character than to the expense he incurred in originating and maturing his machinery. As he engaged in the enterprise from a notion of the necessity of originating some such mode of manufacturing, to meet foreign competition, by which he thought our trade in piece goods was depressed, arising from the vast exportation of our yarn to countries in which hand labour was relatively cheap, he regarded the spinners who supplied the foreign market as fostering a traffic for selfish ends destructive of the public good; and in his public addresses, and in pamphlets which he published on the subject he characterized them as the hirelings of foreign interests, suffered to carry on a trade which they knew to be ruinous to the country, only from their power in bribing or quieting a feeble administration.

254. Mr Radcliffe was of opinion that yarn was not in a sufficiently manufactured state to admit of its being exported under the name of manufactured goods; and that, by prohibiting it altogether, a greatly increased trade would be raised at home, from the employment which would thus he given to our people in manufacturing it into cloth, that the foreigner would be obliged to buy, when he could not get the yarn.

255. This result, from the prohibition of our yarns, was regarded by Mr Radcliffe as a self evident proposition, and, as he was highly honourable himself, from constitutional temperament, he threw a great deal of unnecessary acrimony into the controversy, arising from the motives which he thought actuated the opposite party.

256. Mr Radcliffe was ill fitted for reasoning. He lacked comprehensiveness, and had little regular training, by which it could be much assisted. His activity with his narrowness of perception, therefore, hurried him into conclusions inconsistent with fact; and there was thus a total want of maturity of thought in his views. His decision of character, however, was great; and as he had considerable perception and shrewdness, and a sufficiency of intelligence to render his statements effective, his energy and moral courage made an impression on the public, which his views considered by themselves, without reference to his advocacy of what was supposed to be the rights of native industry, could not have effected.

257. This mode of proceeding, however, created him many enemies; and some of the wealthy spinners are supposed to have taken advantage of an unfavourable turn in trade to whisper down his credit. At all events a run was made upon him; and he met it by converting all his available means into cash, and was thereby enabled to pay about £30,000 in a few months; but he was at length obliged to stop, although the balance which was then against him was not heavy. This balance, however, was paid in full, except some comparatively small sums, towards the last, which were paid with 18*s.* in the pound.

258. Mr Jones, the banker, of Manchester, and Mr Duckworth and some few friends, set him up again; but he never recovered himself, and died a few years ago at Stockport. Mr Johnson was more fortunate, I believe, inasmuch as he made some money in business.

259. The difficulties attending the application of a new invention are not always wholly attributable to the machine, as much of its success in practice frequently depends on the state of the material submitted to it, as best fitted for its action; and this, in a high degree, was the case both with the power loom, and the dressing machine.

260. The chief difficulty in dressing, either by hand or power, is in applying the paste, so as to get it to act properly on the yarn; and not a little of the difficulty is attributable to the state of the yarn itself, as there is in all cotton more or less of an essential oil, which, in so much as it is present, resists the paste.

261. In weaving by hand, the oil is endeavoured to be removed by boiling tbe warp in the chain* for a few hours in water; and in order to strengthen the yarn after being boiled, it is put in a copper of very thin boiling paste or starch; and that portion which is not absorbed is expressed from it again by drawing the warp through the bore of a brass plate, fixed in a frame for that purpose.

* The words, warp, web and chain are all used as referring to the same thing, but understood in a special sense as applicable to different stages of the manufacture. The web is a general term; and is used in reference to the web in the woven or unwoven state. But the warp is specific, and is used as contradistinguishing the one portion of the web from the other, or the warp from the weft. The chain, again, refers to the warp only as it comes from the warping mill, before it is beamed for weaving. The yarn is the material in a state either for warp or weft; and a thread is an individual portion of the yarn referred to. The yarn, however, for warp and weft is never mixed, because as the warp sustains the strain of weaving, it is made of better material, and with more twist than is necessary for the weft.

262. This process is called starching the web; and is almost universally resorted to by hand weavers,—except where colours may be affected by the boiling—as a preparation for dressing. But in weaving by power, as the yarn is wound on the reels, for dressing, directly from the bobbin, as it comes from the spinner, starching in this manner is not adapted to this mode of manufacturing—and much of the difficulty in dressing by the single roller must have arisen from the state of the warp as effected by the oil. For although plaiting might not proceed from this cause alone, much more brushing was neccessary in consequence of it, to get the paste to act on the yarn so as to fit it for working. But in dressing with the two rollers, the yarn in passing between them is imbedded in the paste, and must absorb a portion of the thinner part of it, and thus form a ground on which the brush can act with increased facility in laying on the more substantial part of it. The double rollers are therefore a great improvement in the mode of applying the dressing; and are besides necessary in delivering the warp, so as to prevent the strain on the yarn by the traction in dressing by the old method.

263. The benefit, however, which the yarn receives from this process is so decided that it begot a notion among those who were engaged with power loom weaving, that starching in some modified way, or sizing, was all that the yarn stood in need of to fit it for weaving, as a substitute for dressing; and the attempts have been numerous to construct an apparatus, so that the paste may be applied by it,

and dried in such a manner, as to preserve the free-ability of the yarn.

264. This idea, of sizing as a substitute for dressing, originated with a manufacturer of Stockport, I believe, who was endeavouring to carry it into effect, at the time Mr Radcliffe was engaged with the dressing machine; and the trade was very much divided in opinion as to which of the modes of preparation, dressing or sizing, was likely to be the proper one for their purpose. No doubt the difficulties attending the dressing machine in practice countenanced the attempts at finding a substitute for it; but the grand distinction between dressing, as to its effects on the yarn, and what under any modification could be expected from sizing, was ill understood by the manufacturers themselves. Effects by some were expected from sizing which dressing only could impart, and dressing, again, was regarded by others as unaffected by sizing.

265. The object of dressing, as we have already seen, is to strengthen the yarn by incorporating the filaments on its surface with the body of the thread by the application of paste in brushing. But that of sizing is to gain such an advantage from the hardening of the thread by some sort of paste, as to prevent the opening out of the filaments in weaving.

266. In very coarse work, therefore, where the yarn in a raw state is sufficiently strong, or nearly so, to stand the weaving, sizing, so as to prevent interruption in shedding, is a sufficient preparation of the warp for the loom; and this will appear evident when we consider that the loose or surface

filaments in yarn for work of this sort, are few compared to those composing the body of the thread; and the benefit, therefore, from their being laid with paste, is comparatively little, either as to the strength which it receives, or the strain which is avoided, by the smoothing of the thread. But this is far from being the case with fine yarn. The surface filaments of it bear relatively a great proportion to those forming the body of the thread;—so much so that the friction and traction from them in shedding it in a rough state are insurmountable obstacles to the weaving of it in a fine reed; and the difficulties become less in proportion as the yarn and the reed in which it is used are diminished in fineness.

267. The utmost strength, therefore, and the utmost smoothness which can be given it are both required as a preparation for weaving fine yarn; and this preparation can be obtained only from dressing.

268. It is evident, then, that fine yarn receives a greater accession of strength in dressing than coarse yarn, and it needs it, to fit it for the increased tear and wear which it suffers in weaving. Hence dressing and sizing do not interfere with each other, and are merely modifications of means for effecting the same end; but adapted to different qualities or numbers of yarn.

269. The first attempts at sizing were not successful. The object of the process, of course, was to turn out a greater quantity of work than could be produced, at the same cost, with the dressing machine. But the great difficulty, in rendering it effective, was to dry the yarn sufficiently quickly without plaiting it, or injuring it in the process.

270. Heat is the most efficient agent for this purpose, provided it is properly applied. But so long as it was used, as in the dressing machine, for evaporating the moisture from the yarn by drying the atmosphere around it, there could be no great difference, as to the amount of the production, between the two agencies on similar kinds of yarn. But when the yarn was brought to be dryed in contact with steam-heated cylinders, the relationship between them was very much altered, as there was no longer any difficulty in drying the yarn much faster than the brushes could lay the fibres; and for coarse yarn, therefore, which requires sizing or starching rather than brushing, the application of steam-heated cylinders for this purpose is so great an improvement, that it practically established the existence of this process, as a distinct one from dressing. But by whom this improvement was first originated, I do not know. It seems to have been suggested for that purpose to several individuals throughout the country, from its being used in calico printing to dry the cloth. The Manchester district, however, is no doubt its birth place.

271. But among those who were instrumental in bringing it into practical operation, none seems to have had so great a share as Mr Holroyd of Colne or Manchester. Sizing from him became a separate business for preparing the warps both for hand and power loom weaving.

272. In the process as carried on by Mr Holroyd for the hand loom department, the saturating of the warp with the size or starch, and the drying of it

with steam-heated cylinders, are done separately, and in different rooms.

273. The sizing is effected in a chest *a a*, of about fourteen feet long and two feet deep. The chest is about half filled with size, as seen by the dotted lines, Fig. 1st, Plate XI. The size or paste is kept in a boiling state with steam, and the warps are carried through it, over and under a succession of rollers *b b*, in the box, as seen in the longitudinal section of the apparatus in the same plate. Two warps are led in at a time, in lengths of two webs each. These are put on a bench or table *d*, in front of the apparatus, and carried up in the direction of the arrow over the horizontal framing *c c*, out of the way, from which they descend into the box at *e*, and are led through it, and out of it at *f*, by the rotation of the two squeezing rollers *g*, *h*, which are designed to express the loose size from them before they are delivered in to the receiving can *i*, placed in front of them for that purpose.

274. The squeezing rollers are made, the lower one of iron, and the upper one of hard wood. The upper one is loaded at its journals with a weighted lever *k*, to regulate the pressure between them, according to the quantity of size which the yarn is supposed to require. The paste is supplied to the box from two tubs *m*, *n*, placed above it, and communicating with it by stop cocks *p*. These stoppers are unturned to replenish the waste, as the warps seem to require it from the appearance of paste upon them as they come to the squeezing rollers. Both of these portions of paste are kept boiling. A steam pipe *q* for that purpose, is led over the upper tubs, into each

of which a branch is sent, and down into the box, where it terminates at the further end. The holes by which the steam makes its escape from the pipe in the box are placed so that it strike against the bottom of it, to prevent it from blowing up the paste.

275. The warps are then removed in the can to the drying room, to be run over and under a succession of 23 steam-heated tin cylinders, 36 inches in diameter; or, as represented in Fig. 2nd, as used by others, 24, each 16 inches. The velocity of the rollers, in this latter case, is about 40 revolutions per minute, and the convolutions of the warp 19 times repeated.

276. But in preparing the warp for the power loom, the yarn is run into the machine from reels, and has to be received at the other end on a beam. The two departments of the process, therefore, of sizing and drying, are run together, or rather continuously, in the same machine; at the one end the yarn is sized, and at the other dryed on the cylinders, and delivered on the beam.

277. A few years ago a machine of this kind was patented by Messrs. Kenworthy and Hornby, which has come much into use, and is called the Tape sizing machine. The peculiar object of this invention is to deliver the threads run together in bands like a tape or spread half gang; and the benefit from this arrangement, is, in so far as it may enable the one thread to support the other behind the heddles in the weaving, by the cohesion between the threads from the size in connecting them by the surface filaments. A representation of this machine is given in Plate XII. which will be further noticed when we come to the reconsideration of the process of dressing.

278. Thus the power loom was furnished with an agency for dressing equally efficient, in its own department, for carrying on the manufacture in conjunction with it,—so that its usefulness was established by its co-operation.

279. The practical existence, therefore, of the power loom, properly commences with the application of the dressing machine; and, as this agency was now brought extensively into operation both in England and Scotland, its capabilities and defects began to develope themselves.

280. The construction of the power loom had hitherto been based, as closely as possible, on the arrangements of the hand loom. But it was soon found that there was a great difference between the action of the two agencies; and changes were early made in the power loom with the view of accommodating it accordingly.

281. The inverting of the position of the lathe, as seen in Fig. 43rd, was one of the earliest of these changes; and as it improved the machine in compactness of form without being attended with any injury to the motion of the lathe, as impelled either by the crank or the wiper for calico weaving, it became almost universally adopted in the construction of the power loom.

282. One improvement followed another, and led to a thorough revision of the whole of the mechanical means as applied to weaving:—

First, As to the throwing of the loom out of gear by means of the shuttle protector.

Secondly, As to the motion of the lathe.

Thirdly, As to the means for shedding.

Fourthly, As to the means for picking.

Fifthly, As to the make of the loom—as best fitted to withstand the reaction of these motions.

Sixthly, As to the motion for winding the cloth on the beam.

Seventhly, As to the devising of a means for stopping the loom on the discontinuance or breakage of the weft shot.

Eighthly, As to the invention of a means to render the temples self-acting, so as to keep the cloth at its proper width at the fell without hand interference, so as to save time and save the reed.

283. These are important objects, as comprehended in the foregoing heads, since the completeness in the success of the power loom depends in a great measure on the manner in which they are accomplished by machinery. But as the right origination of the means, as well as the appreciation of the fitness of their application, depends on a knowledge of weaving, the principles of the art, which are detailed in the previous part of the work, must be inseparably associated with the consideration of the state of machinery as effecting it.

284. In all kinds of weaving the lathe is a most important implement; and its steadiness of action in working at any speed, is highly advantageous to the work. All causes, therefore, injuriously affecting its motion must be avoided; and in weaving by power its action must be as little as possible interfered with by other movements, that it be not thereby injured.

285. In the early state of the power loom,

when the art of weaving itself was imperfectiy developed, the fitness of the motion as applicable to it, was, as might be expected, imperfectly conceived; and as the art of constructing machines was equally imperfect, the highly important practice of making one motion as much as possible unaffected by another was not sufficiently considered in the construction of the loom, nor has it yet been sufficiently attended to. It was soon evident, however, that the lathe suffered a considerable shock from the interference of the protector in throwing the loom out of gear by the sliding pulley; and this particular defect, was so far early remedied by the introduction of that elegant mode of stopping the loom by using two pulleys—a fast and a loose one; so that the lathe had merely to overcome the reaction of a spring sufficient to transfer the strap from the fast to the loose pulley.

286. This method, seen in all the five views of the loom, as presented in Plates V. VI. VII. and VIII, in which the corresponding parts are referred to by the same letters, is a great relief to the lathe, and to the machine generally; and has been almost universally adopted from its first introduction, in disengaging the loom; and, for a similar purpose, in almost all other machinery. *a′ b′* are respectively the fast and the loose pulleys, *c′* the spring, and *d′* the strap or belt lever.

287. The protector itself was likewise better accomodated in its connection with the lathe. The pendulous part of the arm overhanging the box was removed, so as to make the two arms alike, as seen

in Fig. 2d, Plate VIII.; and instead of the box springs for staying the rebound of the shuttle, a lever or sloat was used, formed as seen in Fig. 3rd, with its belly *a* projecting within the shuttle line; so that on the entrance of the shuttle into the box, as there was a third arm fixed on the protector, nearly at right angles to the other two, to act on the latch for disengaging the spring, it was raised by this action, and thus the rebound of the shuttle was prevented by the weight alone on the third arm of the protector. By this means the pressure on the shuttle in each box was equalized, and the shuttle thereby rendered less liable to be tripped in its course, whilst the apparatus itself was somewhat simplified by the change.

288. The mechanism of the lathe, as affecting the motion of the shuttle, is subject to the same rules as explained in reference to the hand lathe, and these are:—

I. The reed must be in a straight line with the back boxing at the shuttle line:

II. The race must be level throughout:

III. The spindles must be straight:

IV. They must be in the direction of the shuttle line,—

1st, Parallel with the race;

2nd, Parallel with the back boxing:

V. The race groove must be in the direction of the spindles: and

VI. The race should be beveled to the angle of the shed.

289. But besides these rules, which must be

carefully exemplified in the construction of the lathe, as necessary to keep the shuttle in its course, there is the proportion of the parts, which must be preserved as adapted to the work; and the proper length of box, as best adapted for shuttling, is the most important of these.

290. As easiness in picking cannot be effected with a short box, it should be rather too long than too short. The specific length of box, as proper for shuttling, will, however, depend on the width of the web and the size of the shuttle. For common yard wide calicoes it should be about nineteen inches.

291. But it is not enough that the lathe is made in this manner; it must also be made so as to be kept in this manner, to effect what is required of it in working. The sole, therefore, if it is made of wood, should be of such as is well seasoned, and not liable to warp; and, as a further security from casualties of this sort, it should be cased in front, from end to end, with an iron plate.

292. It would however be better for all purposes, and attended with little additional expense in the first cost, to make the sole wholly of iron, with merely a groove or space in the upper side for a wooden bedding on which the race should be laid, as seen in the transverse section of the loom, Plate VII. By this means the sole could be better formed for the placing of the protector, so that it would require no additional room for itself between the shuttle line and the heddles; and the space, therefore, need not be greater than the thickness of the sword may require it for the sake of strength.

293. The length of the stroke of the lathe in yard wide calico weaving should be about five inches, or about three times the width of the shuttle; but in broad work an additional half inch may be advantageously given it.

294. The proper position of the lathe, again, in acting on the cloth, is, as in hand weaving, at right angles to the fell. But as it is liable, in the inverted position, to be disturbed in its motion, in describing its arc on each side of the vertical line, by the vibration of the centre of gravity from side to side of the centre of motion, it is placed, to prevent this, so as to make the commencement of its stroke spring from the vertical line at the fell. Hence the direction of the warp line, as suited to this position, should be exactly horizontal; and that of the rocking-tree accordingly, perpendicular to the reed at the fell.

295. The length of stroke of the lathe is in some measure affected by the leverage of the swords, according to the distance between the connecting rod and the race. But as this distance when considerable, has a tendency to weaken the action of the lathe on the cloth, it should be made to affect the stroke as little as possible. The connecting rods, accordingly, should be attached to the lathe as near the warp line as they can be made to act; and were the sole made of iron, instead of wood, the lathe would not only stand better to its work, but it would admit of a better connection with the crank and therefore be more effective with the same power.

296. The lathe can thus be made the most effec-

tive with the least motion, as space is economised to the utmost; and what is next required is to economise the time in the motion of the lathe so as to gain the greatest speed in shuttling with the least injury to the yarn or the machinery; and here, again, the motion of the lathe, as worked by a good hand weaver, is the best example for imitation by power.

297. Such a motion to a certain extent, is represented in Fig. 30th, which, as has already been observed, is not the common motion of the crank, where the pauses, theoretically speaking, are equal.

298. The objects in view by the motion of the lathe are two-fold;—First, to bear the shuttle across the web at the proper place; and secondly, to strike home the shot. In accomplishing the first, time must be given the shuttle to cross the web, and in proportion to its width. But for the second, the object in almost every case, is best effected by quickness of motion. The pauses, therefore, to effect these objects aright, should be unequal; and hence by shortening that of the crank at the fell, time will be gained with advantage to the work; and if the time thus gained, or a portion of it, can be applied so as to increase the pause at the the full stroke in a certain proportion as required by the shuttle, the motion, as to form, will be such as is desired for the lathe.

299. Power loom mechanicians were long in quest of a means by which this form of motion could be effected. The celebrated James Watt furnished a plan to Mr Peter Marsland of Heaton-Norris, which

he patented in 1806, for running the motion of the lathe towards the fell, when near the cloth, into a quickly accelerated form. This was effected by what is commonly called the double crank; and although the motion is good as to quality, very little saving is gained from it as to time. It is not the form of motion for speed in shuttling, and has not I believe been much used.

300. Mr Horrocks patented another modification of the crank in 1813, for effecting the required motion of the lathe by a similar combination of levers, which, by adjustment, increased or diminished the duration of the long pause. But this contrivance likewise failed in its object,—it was too complicated for general use.

301. The next attempt to effect the motion required was by eccentric wheels. That of the wiper shaft was formed with a depression on each side of the circumference opposite each other; and the pinion of the crank was made somewhat heart shaped, and set so that the apex worked into the depressed part of the wheel; and thus the eccentricity in the motion of the lathe was obtained to any required degree by the relative forms of the two wheels.

302. This method of effecting the motion was brought out and patented by Mr A. Buchanan of Catrine; but it happened that a similar means for the same purpose had been made in Glasgow many years before Mr Buchanan's invention of it, and applied to canvas weaving in the north of Scotland; so that the patent right was on that account invalidated. But as the motion of the lathe by this means

is somewhat harsh and constrained, from the irregular reaction between the wheels in working, it never came much into use;—and, as it was by and bye discovered, that eccentricity in the motion of the lathe, could be obtained without either eccentricity of the wheels, or combination of levers with the crank, the three preceding kinds of movements may be said to have become obsolete.

303. The new mode of obtaining eccentricity in the motion without eccentricity in the wheels, or complexity of the means, was a valuable discovery as applied to the lathe in weaving; but by whom it was first pointed out, I do not know. It will be seen from Fig. 43d to be effected by merely placing the connecting rods, as attached to the lathe, in a sloping direction to the crank shaft. The crank shaft is, therefore, on a lower plane than the studs of the lathe, on which the connecting rods at that end are hinged, and the degree of obliquity thus given them determines the amount of eccentricity as imparted to the lathe, in connection with that which takes place from the revolution of the shaft. The eccentricity from the shaft in working, will be as the length of the connecting rod to the diameter of the circle as described by the crank.

304. This will appear plain from the inspection of Fig. 30th, page 78; as it will thereby be seen that the space from *e* to *f*, as indicating the duration of the short pause, at the beginning of the stroke, is only about half the length of the long pause, as measured from *b* to *c*, the points by which it is bounded towards the end of the stroke: and as the time required by the crank, in describing these

respective spaces, is as their relative lengths, the duration of the pauses is as the length of the spaces. The length of the pause at the end of the stroke will depend in some measure on the *direction* in which the crank shaft is turned, and this, it will be observed by a little reflection, is occasioned by the shortening of the connecting rods from the increase of their obliquity in following that part of the circle described by the crank in taking the lathe from the fell; and as there must be a corresponding increment, at the opposite side of the circle, the lathe is therefore nearly stationary, whilst the crank is describing that part of the circle from *b* to *c*, so that time in the required proportion can thus be given the shuttle for traversing the web. The degree of obliquity, thus obtained, should, of course, be proportioned to the breadth of the web.

305. As the space, as taken up by the motion of the lathe, is invariable, and the fell, therefore, a fixed line, the heddles, in weaving by power, can be brought nearer the slabstock than in hand weaving; and as the swords of the lathe are made of iron, the space between the reed or shuttle line and the heddles may be diminished on that account, and thus a smaller shed is rendered sufficient for such work, than would be the case, with a similar fabric, in hand weaving. Advantage, however, is not sufficiently taken of this circumstance, and the coarse practice of over-shedding generally prevails, from the attention not being sufficiently directed to the mischievous nature of it, although perhaps it is met with in a less degree than in weaving by hand.

306. But although the yarn were unaffected by

this severe practice of over-shedding, it is attended with a great deal of tear and wear of the heddles, and this is still further increased by the shortness of the stretch, as the power loom is commonly made too much with a view to economize room in the factory; so that there is an insufficiency of spring given the yarn to meet the action of the heddles, and they must, therefore, effect their purpose in shedding through the resilience of the pace.

307. The proper length of stretch, as already noticed, will depend on the grist of the yarn. For calicoes the distance of the beam from the heddles may be from about twenty inches to two feet; and, for coarser work, the stretch should be increased in proportion to the size of the shed. It would, therefore, be as well to make the loom frame as seen in the side views of the loom, Plates VII and VIII, with an accomodation for the beam at different stretches as the work may require it.

308. In the motion of the heddles as worked by eccentrics, there is frequently some unsteadiness manifested in their action, partly from irregular pressure by the angularity of the wipers,—promoted in a small degree, no doubt, by the curving motion described by the treadles themselves, and the motion of the yarn through the heddle-eyes.

309. Mr Roberts of Manchester, with the view of improving their action, adopts the method of hanging the heddles between two rollers; and sheds them by working the lower roller with a rack and pinion from the wiper shaft. This method was very early used for this purpose by Mr Johnson, in his

invention of the vertical loom; but as the diameter of the roller is limited by the space between the middle of the two front and that of the two back leaves, so that each half of the set of heddles be merely kept clear of each other in working, a rather inconvenient amount of traversing motion is required to turn the roller as much as is necessary for shedding,—and in heavy work, this limitation in the size of the roller is apt to be attended with some unsteadiness of motion in shedding.

310. These inconveniencies, however, are obviated by that method as presented by the author in Plates IX and X, which is unattended with any disadvantage from the motion. By this method it will be seen, Plate IX, that the heddles are hung from jacks above in the usual manner (except that they are mounted on studs,) only because this mounting for the heddles is more especially applicable to fine work; but below they are attached to two rollers or axles *b c*, better seen in the end view, Plate X, one for each shedding. These two rollers are set parallel to each other; and have each two arms *d e*, formed at the end into quarter circles, by which they are attached to their respective pairs of leaves, and an arm *f*, vertically set at right angles with the other two, by which they are connected together, and worked by a connecting rod *g* from an eccentric or rather a tappet *h*, with a friction pulley acting on the wiper shaft like a crank. The tappet is seen as acting on the connecting rod in Fig. 2nd, Plate X; and the traversing motion, it will be observed, as necessary from it in shedding, is less than the depth of the shed

by the difference between the arc described by the heddle arms and that by the vertical one.

311. The modes of picking, like the contrivances for producing the other movements of the loom, are various. At first the picking pin was hung in the middle of the loom above the pull-to. But this arrangement was soon thrown aside in consequence of its inconveniencing the weaver in attending the work; although it has since been revived, and even patented, in 1833, by Mr Smallcross.

312. Next it was placed, as already noticed, vertically under the web, and formed like the capital letter T inverted. As the stud, on which it was made to vibrate, passed through it where the two lines intersect each other, motion was communicated to it, by its being alternately struck on the cross-tails by the respective tappets, on the revolution of the wiper shaft.

313. This is a harsh communication of motion, and it, therefore, soon fell into disuse for that modification of the same means for effecting its purpose, by the action of the wipers on two separate treadles. The cross-tail is here formed, as seen in Fig 42d, into rather more than half a circle, and attached by a strap from the circumference to the treadles. But as the action of picking is apt to communicate some disturbance to the shuttle, even after it is boxed, by the dangling of the treadles, so as to occasion purling at the selvages, this defect is remedied by the form of the sweeps, which are interposed on the treadles to receive the action on the tappets.

314. The curve of the sweep G′, it will be seen from

Fig. 4th, Plate VIII. is intended to prolong the action of the wipers on the treadles, so as to keep them still, till the shuttle has been staid in the box; and, therefore, the curve should be a part of a circle of which the wiper is the radius, or more correctly, it should be somewhat elliptically formed, as the treadle recedes from it in shedding. The face on which the wiper acts, is more or less oblique, or inclined to the action of the wiper, that a sufficient impetus may be imparted to it in throwing the shuttle.

315. But there is still some vibration from the length of the fly-cords unaccounted for by this means, besides a great deal of tear and wear which they suffer from friction by rubbing along the sides of the boxes, and likewise from their being tucked to the lathe to prevent them from jerking against the work; and three modes of picking have been brought into use by which these objections are completely obviated.

316. By one of the modes, the picking is at the side from a pendulous picking pin above the driver;—by another, at the side, from a vertical picking pin under the driver;—and by the third, at the side, from a horizontal picking pin above the driver. All the three modes, therefore, have two picking pins, one at each side; but they differ from each other as to the direction in which they act in throwing the shuttle. They are, therefore, differently placed for that purpose. By the pendulous mode, in working with the pendulous lathe, the picking pins are hung from the framing near the rocking-tree, each above its respective box, and attached to its respective driver

by a short cord of about eight inches long; and, as the picking pins are made to hang obliquely towards the ends of their respective boxes by being drawn in that direction by a spiral spring connecting the two together, that they may not interrupt the entrance of the shuttle, the wipers are so placed above the web as to strike them alternately out of their way, and thus throw the shuttle across the web; or by a variation in the mode of driving it, a strap is made to communicate from it with a treadle below, on which the wiper acts in the usual manner under the web.

317. This mode of communicating motion to the picking pins, according to the first variation, is not altogether free from harshness of action from the obliquely transverse direction of the force of the wipers to the picking pins; but, as the picking pins themselves oscillate in the direction of the shuttle, its motion is not affected by it.

318. The arrangement, however, of the means, in both of the variations of picking, is defective rather than the motion. The distant connexion between the wiper and the driving shaft is an inconvenience; and as both the weight and action of the picking apparatus, in one of the variations, is placed above the web, it is apt to be attended with some little disturbance and encumbrance to the machine in working.

319. The vertical picking pin, under the box, is merely the pendulous one reversed as to position. It is placed on a stud near the rocking-tree, as seen in the transverse section of the power loom for working checks, Fig. 1st, Plate XIII, and consequently its action, from the curve it describes in

throwing the shuttle, is forward and a little downwards. The direction, however, is but little out of the line of the driver and does not affect the shuttle; and where several shuttles are used, the arrangement is a convenient one, more especially where the work is not very heavy.

320. But for very heavy work, the horizontal mode of picking is preferable, from the impulse being directly applied to the picking shaft; and indeed this mode is unobjectionable either as to arrangement, or motion; and effects its object by a resolution of the same means. Instead of the picking pins being pendulous, they are here placed to vibrate horizontally on a vertical shaft, immediately above their respective boxes, and are attached to their respective drivers by a cord *q*, Plate VI, so long only as is sufficient, as in the other two modes, to preserve the flexibility and easiness of their action.

321. The picking pins, therefore, act in this position similarly to the weaver's arms in hand shuttling; only that the motion is communicated to the drivers, and from behind the lathe for the convenience of arrangement, that the wiper shaft may be properly placed both for picking and shedding. The position of the wiper, as seen in Fig. 1st, Plate VIII, lateral section of the power loom, effects both of these advantages, inasmuch as it is well placed to act with facility both on the treadles G G, for shedding, and the picking shafts *n′ n′*.

322. The form of the picking shaft, as adapted for this action, is seen detached in Fig. 4th in the same plate. It consists of a round malleable iron rod

of about two feet six inches long with a short arm *n* drawn out from it at right angles, to which the picking pin is bolted. This shaft is placed vertically in the loom, and made so long that its lower end reaches the transverse back framing A′, near the ground, where it rests in a socket which is bolted to the framing there, and so near the wiper shaft that it may be brought to act upon it, whilst the upper end is supported in a bush.

323. Now the most effective action of the wiper on the picking shaft, when placed in this manner, will be at right angles to the picking pin. Accordingly the sweep G′, it will be seen from Fig. 4th, is fixed upon it nearly in this position, and formed something like a bat's wing, that its curvature may be adapted to the action imparted to it by the circular motion of the wiper. The picking shafts are of course made right and left handed, to fit them for their respective sides; and kept at the proper working angle to receive the action of their respective wipers, by a spiral spring extended between them, and attached to each by its respective ends. As the wiper shaft, therefore, revolves with the wipers in their relative places, the sweeps are alternately struck by them out of their circle, and the picking pin by this action describes an arc, of nearly the length of the box, in throwing the shuttle, of which the picking pin is the radius, and as it is advantageous to have the motion of picking in the direction of the shuttle, the pin, therefore, to prevent the curvature of its motion from injuriously affecting the action of the driver, should not be short. About two feet

is a good length for common purposes. But this, of course, should vary a little with the box itself, according to the width of the work.

324. The motion of picking, from the suddenness of the tug, is a severe kind of action on a machine, and so are the other motions included in shuttling: and as the efficiency and durability of the machine depend on its stability in action, the loom should be sufficiently made to resist reaction.

325. Now as the reaction of the work is a certain amount of weight which must be overcome by the power applied to the machine, and as the machine is the instrument by which it is transmitted, it should be strong enough to stand between the two forces, the action and the reaction, undisturbed by either, so as to go through its work without any appearance of effort. Should weakness be any where present in it, it will manifest itself in working, either to the eye or the hand, by tremor—a state of reaction highly injurious to the journals, bushes, and joints.

326. This reaction may be general, arising from the weakness of both the moving parts and the frame; or it may be partial, from the defectiveness of either—and hence the stability in action of the machine depends on the proportion between its relative parts, and the power, and the reaction of the work. A practical knowledge of the work, as to its weight, and the effects of overaction on it, is thus necessary to enable the engineer to adapt the machine to the special fabric under consideration. This knowledge is comprehended in the art of weaving; and the

principles of mechanics must guide him in the construction of the machine, so as to maintain a due proportion of the parts throughout—a combination of skill of great value in the application of this machinery.

327. As the frame sustains the several parts in their relative places, and the sum of their reaction, it must be made strong enough on the whole; and to avoid unnecessary weight, the strength must be adapted to the strain. Sufficient material must therefore be put, both where and as the strain requires it, that the greatest strength may be obtained without waste. Wood in this respect is ill adapted for machine framing, but the engineer has all that he stands in need of for perfecting the proportion of his work, from iron mouldings. By this means he is enabled to combine both weight and strength in the construction of the machine, in a manner the most effectual for overcoming reaction.

328. Hence he must make his arrangements, so as to throw the action, and as much of the reaction as possible, on the central line of gravity in the machine; and both as near the base line as circumstances will permit.

329. The wiper shaft is, therefore, very properly placed, so as to impart its action in picking below the centre of motion in the machine towards the base line.

330. The form of the frame, as best fitted to resist reaction in working, and the disposition of the moving parts, as best adapted for obviating strain, are very important considerations in machine making. But nothing must be sacrificed for the sake of

form, which is advantageous to the machine as required for the work.

331. By the inverted position of the lathe, the frame is improved in compactness of form, so that the height of the loom, in so far as it is affected by the reaction of the work, is limited by the warp line, which should not be higher than is sufficient to support the web at an elevation the most convenient for the weaver in attending to the work. This will be about three feet, measuring from the slabstock to the floor.

332. As the wiper shaft performs the actions of picking and shedding, it sustains the greatest share of the strain from the motions of weaving, and it should, therefore, be well supported by the frame.

333. The form of frame as best fitted to resist reaction from motion, is such as has its greatest strength in the direction of the strain.

334. Now the direction of the strain on the wiper shaft in shedding is upwards, and that from picking is forwards, and, therefore, that form of frame which is best calculated to sustain perpendicular, as well as diagonal pressure, is best adapted for the support of the wiper shaft.

335. Mr Roberts of Manchester uses a diagonal form for this part of the framing, and that which I have presented in the several views of the loom in Plates V, VI, VII, & VIII, is the arch, drawn chiefly from the loom as made by Mr Grandison, Glasgow.

336. The strain on the crank shaft from the action of the lathe on the fell is backwards and a little downwards, nearly in the opposite direction to

that of picking; but this part of the framing which supports the crank, from the arch upwards, is so much intersected, that reaction from the work can affect it only from general weakness arising from a deficiency of material.

337. Every machine should have so much strength and weight in its framing as to be wholly unaffected by its own motion—rockfast within itself; and few machines, from the nature of the motions in weaving, require so much of both of these qualities to withstand reaction in working as the loom.

338. But besides the strain from the separate action of the moving parts, there is that resulting from their conjoint action, which should be disposed of in a manner that the loom is best enabled to resist. This will be effected by throwing this sort of strain as much as possible on the central line of gravity in the machine; and as the greatest portion of it results from the conjoint action of the crank and wiper shafts, it will fall, so far as they affect it, on a point in the framing, somewhere relatively distant from each, in proportion to the amount of individual reaction comparatively sustained by them.

339. Machine makers, from their unacquaintance with weaving, have not sufficiently attended to the kind of motions of which it consists, nor to their quality; and have thus been led to estimate the strength, both for the frame and the moving parts, by the power as necessary to work the machine, rather than by the reaction arising from the peculiarity of the motions; and the cloth manufacturer, again, is apt to judge of the strength as necessary

for it, by what knowledge he may have of weaving by hand; and thus the power loom is almost universally too light made for its work.

340. As the conjoint action of the motions in weaving by power is subject to the same rules as in weaving by hand, and is performed in the same order of succession,—viz. first, the lathe strikes the fell,—secondly, the shed instantly begins to open as by its action,—and lastly, picking follows on the rising of the lathe from the cloth, the reaction from these motions, therefore, takes place at three points in the circle; and as little power is necessary to keep the machine a-going till their recurrence again, the suddenness of their return, from its being attended with a great discharge of force, requires much weight and strength, aided by all the advantages of art, in the construction of the loom, to prevent it from suffering from tremulous reaction in working.

341. To effect this object fully, the weight of the loom frame, as properly made for common calico weaving, independent of that of the moving parts, should not be much under half a ton. Whatever error is committed, it should be on the safe side of weight.

342. But the loom may be well made as to the frame, and yet unfit for its work from a want of strength, and weight, or proportion, in the moving parts; and from an unsuitable disposition of them for action.

343. The weight proper for the shafting of the loom will depend much on its width. But for com-

mon yard wide calicoes, the iron for it should be about $1\frac{5}{8}$ inch in diameter, and properly speaking, to be made in proportion, increased towards the middle to meet the increased strain which it there sustains from turning. This especially should be the form of the crank shaft. But for the wiper shaft it would be inconvenient to be so formed, as it would interfere with the fixing of the wipers. This shaft however should be thicker than the crank, perhaps about one-eighth of an inch.

344. The action of the wiper shaft in picking is at each end, as near the bushes as it can be conveniently taken from it. But that of shedding is from the middle of the shaft, where it is very properly supported in a bush *h′*, as seen in Plate VI. from a transverse piece of framing put up for that purpose.

345. The crank is exclusively employed to work the lathe, and is likewise formed on the shaft as near each of its bushes as it can be made to work.

346. The wheels both of the crank and the wiper, from the reaction which they have to encounter, should be strong and heavy, and formed with their arms set in the direction of the strain; and their momentum will be still further increased, and their steadiness in action improved, by making them of a good size,—nine or ten inches, and eighteen or twenty respectively. For the same reason the driving pulleys should be neither small nor light—smaller than seventeen or eighteen inches should not be recommended. By using the wheels made in this manner they act on their respective shafts with something of the effect of a fly-wheel, which tends

greatly to carry them undisturbed over the reacting points in their revolutions.

347. The movement of the cloth beam is unattended with any injurious reaction to the machine, as its motion is rotatory. The grand desideratum in this movement is that the cloth be withdrawn from the lathe at the fell regularly as it is wrought, without being affected by the varying diameter of the beam by the cloth. But neither of the two movements for this purpose, which have already been described, fully accomplish this object. That noticed in connection with the old wiper loom is objectionable, chiefly, on account of the number of joints in the contrivance, and the consequent looseness between the parts in communicating the motion: whilst that described with the crank loom is defective, more especially on account of its being influenced by the varying diameter of the beam by the cloth.

348, The lathe, within certain limits, regulates the motion of both these movements—on that with the screw, by interrupting its action so as thereby to diminish the excess of its motion arising from any cause,—and on that with the hanging catches and weight, by acting with its stroke on the fell as a counteraction to the pace, so as to assist in giving motion to the beam, according to the impulse as communicated to the cloth.

349. In working, therefore, with this latter method especially, the cloth is prevented from getting thinner towards the end of the piece, by increasing the pace as the diameter of the beam increases. This is done by the worker. But as the

diameter of the yarn beam itself decreases with the increasing diameter of the cloth beam, although in a less relative degree, this circumstance tends to increase the tension, as the motion requires it, without any change of the pace, and, therefore, renders less change necessary in working with it than otherwise would be the case. It is, however, desirable that the machine should effect its work independent of hand intervention, and, accordingly, a motion was early brought out for the purpose of preventing the texture of the cloth from being affected by the varying diameter of the cloth beam.

350. This was accomplished by making the cloth beam a friction roller, which retains its hold on the cloth by the roughness of its surface, and delivers it to another beam, placed below it, (or it may be, as it sometimes is, above it, although that is a more inconvenientarrangement for the worker) but parallel with it and in contact, on which it is wound by the rotation of the two rollers together. The surface of the delivering roller is made sufficiently rough for the purpose by coating it with emery, which adheres to it by being laid on a ground of glue or size, whilst it is as yet in a soft state. The contact of the two beams is maintained by placing the under one on two balance levers, and loading their opposite ends so as to keep the receiving beam against the delivering one, as seen in Fig. 3rd, Plate XIII; or it may be effected, as in other cases, by two springs used instead of the two levers, on which the beam is supported, as required, to rotate on its gudgeons, as seen in Fig. 4th. B, C, D and E are respectively the deliver-

ing beam, as seen from the end, the receiving beam, the lever, and the weight; the corresponding parts in the two figures are marked by the same letters. The beam by this means merely delivers, and its delivery will be uniform with the motion as imparted to it—as its acting diameter throughout is the same.

351. The motion, as imparted, may either be intermittent, from the hanging catch and weight, or it may be continuous or intermittent, from the action of the crank or wiper shaft. In working with an intermittent motion from the hanging catch and weight, the movement, as actuated by the lathe, is still influenced by the stroke of the lathe on the fell,—but with a continuous or intermittent motion from the crank or wiper shaft, it is independent of the lathe. In the former case, therefore, its motion must be qualified by the pace to prevent the cloth from getting rather *thicker* as the yarn beam decreases in diameter by the delivery of the warp,—but in the latter case, as represented in Fig. 1st, Plate XIII, where the motion is intermittent from the action of the wiper shaft, the thickness of the cloth is altogether dependent on the motion as communicated to the beam; and will, therefore, continue to deliver by the working of the loom, whether the weft shot is thrown in or not.

352. This is a disadvantage in practice, which is attended with more inconvenience than is sought to be remedied by the improvement itself—and it has not, therefore, been a favourite with the trade. Something was still wanting to complete its usefulness, and this desideratum has of late been supplied

by the invention of what is called the weft shot protector. By this means, the breakage or discontinuance of the weft shot is made to stop the machine, and thus the inconvenience of turning back the movement, when the breakage of the shot is not immediately perceived, is prevented.

353. This action is effected by the weight or reaction of the weft shot itself. For this purpose, therefore, a very slight lever, highly susceptible of motion, and so balanced on its pivots that the weight or resistance of the weft shot is sufficient to lift it, is placed horizontally, in the direction of the yarn, on a fulcrum in front of the reed, with the end next the reed bent, so as to hang in a transverse slit in the race between the selvage and the sword, as seen in Fig. 2d, Plate XIV, in such a manner that the weft shot, in following the shuttle into the box, is almost certain to press against it by the motion of the lathe, and thus lift the opposite end out of a notch, or projection, against which it must otherwise strike, and thereby throw the loom out of gear.

354. Fig. 2nd is a side view of the manner in which this apparatus effects its action, and from which it will be seen that the motion for disengaging the loom by it, is taken from a tappet fixed on the wiper shaft, which acts, for that purpose, on a two-armed lever. *a* is the wiper, *b* the tappet, *c* and *d* respectively the lower and upper lever arms, and *e* is their centre.

355. Now it is the upper arm *d* that acts directly on the weft shot protector lever, or fork, as it is called, which is likewise formed with two arms. The forked arm or end is marked *f′* and the opposite one *f*; and for the purpose of fitting them for acting together, both the end of the fork *f* and that of the upper arm *d*, where they come into contact, are each furnished with a corresponding ratchet tooth projection by which they are locked, or fitted for acting against each other without slipping. When, therefore, the tooth of the upper arm *d* is brought into contact with that of the fork *f* by the motion of the wiper, the fork moves with it, in consequence of its being placed on a lever, as its fulcrum, which admits of this motion.

356. This lever which supports the fork is marked *g* in the three views as given of the weft shot protector, but as it is placed for the required action, at right angles to the upper arm, and likewise to the fork, it is better seen in the plan Fig. 3rd, where it will be observed to lie close along-side of the spring *h* above the breast beam or slabstock *j*, so that as soon as the upper wiper arm moves it, the spring is slipped off its notch in the rest, and the loom is immediately stopped in the usual manner.

357. Now as the weft shot prevents this action from taking place, by lifting the toothed end of the fork clear of the tooth of the wiper arm, by the reaction of its weight against it from the motion of the lathe,—the whole efficiency of this means depends on the certainty with which the weft shot is made to act upon the fork; and, accordingly, it is formed with the view of obtaining such a resistance from the shot, as will insure the desired result. This is effected by making that end of the fork *f′*

which comes in contact with the weft, with prongs like an eating fork, and setting it so that they may go through the reed, at least partially, at the upper bend *o*, with the weft between them, or rather so as to be resisted by the weft shot in doing so; and thus the pressure is increased in proportion to the number of prongs used, and the relative spaces between the dents of the reed through which they pass. Three are commonly used—and that part of the reed through which they go is made with splits sufficiently strong to be uninjured by their action in working.

358. The space between the dents may vary according to the work, from one-eight of an inch to three-sixteenths or more: and the fork should be set as near the selvage as the temples will permit it, that it may not keep the weft shot too far off, and thus have a tendency to produce purling.

359. In working with the friction rollers, where the number of shots entirely depends on the velocity as imparted to the delivering beam, greater care is necessary with it, to prevent unevenness of the cloth at the joining of a broken shot, as the cloth, in this case, if it should be overdrawn, must be more accurately let back to the line of the lathe at the fell, than is necessary with the ratchet wheel and weight movement worked bythe lathe;—and, therefore, the weft shot protector is more especially necessary to it. The utmost overdrawing that can take place in working with this useful little invention is one shot; and even this amount of aberration maybe prevented, if it be thought necessary to construct the contrivance for acting at each side of the web. This

invention was made the subject of a patent by Messrs. Bullough and Ramsbottom in 1836.

360. But it will be observed, that the friction roller movement, as worked from the wiper shaft, although it produces a uniform texture of cloth, does not obviate the necessity of shifting the pace to equalize the tension on the web as the yarn beam decreases in diameter by the delivery of the warp, and, therefore, this adjustment is still to be done by hand. It might very easily be done by machinery if it were thought desirable, by merely effecting the change in the pace by the decreasing diameter of the beam itself. A bell crank or rectangular lever would do it, by placing it in the direction of the beam above the pace lever, and connecting the pace weight to the vertical arm, whilst the horizontal arm was kept by a spring or weight against the under side of the beam, so as to regulate the removal of the pace weight towards the pace cord in the proportion that was found sufficient to equalize the tension of the warp for practice in working: or it might be effected by a rack acting on a pinion in such a manner as to shift the pace weight as the decrease of the beam's diameter gives it the motion to do so. In this case the end of the rack which comes in contact with the beam, should be shielded so as to prevent it from injuring the yarn by the pressure against it. But as the shifting of the pace is attended with so very little trouble, especially in common fabrics where it is not unhandy from its weight, and is hardly even an inconvenience, the effecting of it in this manner seems not to be thought of.

361. Schemes, however, have been numerous for regulating the delivery of the warp to the uptaking motion of the cloth beam; and Mr Amos Stone of Rhode Island, America, seems to have been the leader in inventing contrivances for this purpose.

362. The principle of the movement as brought out by Mr Stone, is that of making the cloth beam deliver the warp by the rebound of the reed on the fell. The reed is, therefore, set, to render its motion effective for the purpose, in a flyer, which vibrates on pivots by the stroke of the lathe on the fell. Fig. 1st, Plate XIV. is a back view of the flyer in connection with the lathe. *a, b, c c, d d,* represent the reed, the flyer, the swords of the lathe and pivots of the flyer respectively; *e* is the sole of the lathe and the two springs which keep the flyer to its work are marked *f f.* The swords or arms of the flyer, it will be observed, are long—extending from the reed to the rocking-tree, and supported midway on their pivots from brackets *h h,* attached to the swords of the lathe. The lower arm, therefore, of the flyer, from this arrangement, vibrates in an opposite direction from the reed; and it is from this lower arm *i,* that the motion is taken to unwind or deliver the warp from the beam. There is no pace in this movement. The warp is kept at the required degree of tension and the yarn beam is turned or unturned by a screw or worm. The beam is, therefore, furnished with a spur wheel fixed on the gudgeon, in which the worm works at right angles to it. The worm shaft is, therefore, vertically placed, and supported, at each end in bushes from brackets

fixed to the side framing of the loom, as seen in the end view of Mr Stone's loom, Fig. 2nd in the same Plate; *j*, *j'*, *k k*, and *l*, are respectively the worm, worm-shaft, the two brackets bushed for supporting it, and the yarn beam spur-wheel.

363. The motion for turning the worm shaft is communicated to it by a sliding connecting rod *m*,—the one end of which is slit and attached by the slit to a stud in the lower arm of the flyer, whilst the other end is furnished with a catch, or according to another modification, Fig. 3rd, catch-shaped, and free to act by sliding on a ratchet wheel *n*, fixed for the purpose on the worm axle. This sliding connecting rod catch is placed horizontally under the web a little above the plane of the rocking-tree, and is, therefore, subject to the action of two motions—that of the lathe, and that of the flyer. The motion of the lathe is used directly to push back the connecting rod with its catch, so as thereby to turn the wheel; and that of the flyer is simply to bring it forward, so as to put the catch in a proper condition to act on the wheel again at the next stroke of the lathe.

364. The connecting rod is fitted for this double action by being made to slide in a slit in the sword at the one end, and at the other, in a slit in a bracket connected with the framing near the ratchet wheel; and kept down in contact with the teeth by a spiral spring *o*.

365. The motion, as communicated by the sliding catch to the worm shaft, is retained by another lever catch *p*, acting on another ratchet wheel *q*,

which is fixed upon the shaft, but at the upper end of it, for that purpose. Both wheels have, therefore, the same diameter and pitch of tooth to work in conjunction with each other.

366. Now Mr Stone regulates the uptaking motion of the cloth beam by the action of the upper lever catch, so that, when there is no weft thrown in sufficient to produce the necessary reaction on the reed to effect the motion on the yarn beam, there will be no motion of the cloth beam. The opposite end *p′* of the lever, from that which has the catch upon it, is, therefore, made to act on the end of the hanging catch arm *r*, with which the beam is furnished for its own movement, so as to raise it, and thus move forward the hanging catch click *s*, on its own ratchet wheel *t*, and thereby put it in a condition to act in turning the cloth beam in the usual manner, as previously noticed in describing the ratchet wheel movement by the backward stroke of the lathe in receding from the fell.

367. The cloth beam, according to this movement, cannot, therefore, be affected by the delivery of every shot,—as some space must intervene before a tooth be acted on by the pressure of the cloth upon the reed at the fell. This space, of course, will be equal to the length of the ratchet tooth divided by the number of catches that are set at equal distances to act upon it; and, therefore, this peculiarity of action is more or less inseparable from all ratchet wheel movements. It is not, however, an objection of any practical importance, as the spaces may be so small as to produce no inequality in the cloth in the working.

368. An attempt has, however, been made to remove it, or rather perhaps to improve it, but this improvement is deserving of attention rather from the simplicity of the contrivance than from any other superiority attendant on its mode of action. This improvement consists in *directly* acting on the hanging catch of the cloth beam with the flyer-lever, instead of acting on it *indirectly*, as in Mr Stone's loom, through the medium of the upper catch lever of the worm shaft. The flyer-lever is, therefore, placed as seen in Fig. 4th, to act on the hanging catch in the front of the sole of the lathe, with the one end resting on the sole of the flyer against which it is kept there by a spring, and, therefore, influenced by the rebound of the reed, whilst the other arm, extending downwards, is by that very action brought directly on the hanging catch to depress it, so as thereby to withdraw the catches on the ratchet wheel, and thus put them in a state to move the beam by the action of the lathe..

369. The lower arm, therefore, of the flyer lever is bent to act in this manner, as seen in the end view of the apparatus, Fig. 4th. *a* is the flyer lever placed to vibrate on its centre vertically in front of the sword of the lathe, and in contact with the hanging catch arm *b*, of the ratchet wheel *c*. The hanging catch arm at the one end is furnished, in the usual manner, with clicks *e e*, to act in turning the beam by the ratchet wheel, and at the other, with a small weight to keep them engaged with the teeth. The apparatus is not represented in connection with the letting-off motion of the yarn beam, nor is it neces-

sary, as that movement may be as well effected, if it be desirable to effect it at all, by the cloth beam itself.

370. But what advantage, it may very properly be asked, has the action of the letting-off motion over that of the pace in the weaving? and this question can be best answered by considering the effect of the pace on the yarn in weaving compared with that by the worm and ratchet wheel movement.

371. By both modes of pacing, the yarn is to be kept sufficiently tight to retain the shot by the stroke of the lathe on the fell, and this is effected with the pace by a continuous tension, interrupted only by the stroke of the lathe on the fell; but with the ratchet wheel and worm movement—by intermittent tension from fitful action. The yarn by this latter method is, therefore, alternately tight and slack, and this result, from what we have seen, is inseparable from ratchet wheel movements. The cloth may be sufficiently tight when the lathe strikes the fell, and the slackening of the web, by being effected immediately after the stroke, will so far act beneficially as a relief to the heddles and the yarn in the shedding. But when it is recollected that the delivery can only be in proportion to the uptaking of the warp by the weft shot, and that the delivery is commonly intermittent for several shots together, a strain in shedding must take place somewhere on the warp (unless the web is altogether too slack worked to make a good piece,) and that strain it has no means of meeting but by its own elasticity. But in weaving with the pace it has the resilience of the

beam, in addition to its own elasticity, as a complete security against strain from over tension in shedding—and if advantage is taken of the relaxation of the yarn by the stroke of the lathe on the fell, the heddles and the yarn will have all the advantage that the letting-off motion can offer, without the heavy drawback unavoidable from the rigidity of its action. Strong yarn may stand much strain without injury, but the principle, as applied, is inadmissable for common and light work.

372. This objection arising from its rigidity has been met by putting the warp over a whiproll which is made to spring by the reaction of the yarn in shedding. But this method of obviating the objection, not only tends to disturb the proper position of the yarn in the loom, but is adding complexity to a means to attain an end, which is already sufficiently done by the pace beam without it. The only kind of work in which the letting-off motion may have some advantage, is where the weight of the pace, as necessary to keep the web sufficiently tight in weaving, is so great as to be inconvenient, on that account, in the handling.

373. The only regularly recurring action as necessary to the cloth in weaving, which we have not yet noticed, to complete the motions as effected by the loom, is temple shifting.

374. We have seen that the temples are necessary as stretchers to protect the reed at the selvages, so as to prevent it from being too soon worn out, or cut there, by the shrinking of the cloth in working;

and, as the loom is not stopped whilst they are being shifted, two pairs are used in weaving by power;—the one to keep the web on the stretch whilst the other is fetched forward on the cloth, as it is wrought in front of it, towards the fell.

375. This operation requires very little time of the weaver—about five seconds to each shifting. But as it should be regularly done, and as soon as a sufficiency of cloth is wrought in front of the temples to admit of the next shift, it occurs frequently, and is liable when neglected to injure the reed. It is, therefore, desirable, as a saving to the reed, that this operation should be thrown on the machine, and several attempts have accordingly been made to invent contrivances for doing so.

376. Three are in use—one is called the nipper temple—another the rotatory temple—and the third the roller temple. Each of these inventions has some peculiarity in its working dependent on its mode of action.

377. By the nipper temples the cloth is kept extended by being seized in the jaws of a nipper sort of apparatus placed to act on the selvages opposite each other, near the fell; and the jaws are opened for being shifted, so as to permit the motion of the cloth to the beam, by the lathe in striking the fell.

378. Fig. 1st, Plate XV. represents a side view of one of these nippers consisting of the two jaws, marked respectively, *a* and *b*, between which the selvage is held. The under jaw for this purpose is made to spring against the upper one, so as thus to hold the

cloth by the pressure between the two surfaces; and the better to effect it, they are toothed where they come into contact, like a rasp or file. Fig. 2nd, represents the same view of the temple but with the jaws in an open state.

379. This nipper is made right and left handed for its respective sides; and fixed on the slabstock or breast-beam *c*, as seen in Fig. 3rd. This representation is, therefore, a plan of this sort of temple, as fitted for acting on the cloth. Now as the cloth must be permitted to move towards the cloth beam through the jaws, they are opened, for this purpose, by the lathe in its striking the fell. This is done through a lever *d*, seen in the plan, and placed to vibrate horizontally on its centre on the same plate with the nipper, but behind it nearer the slabstock. The one end of this lever is armed with a wedge-shaped blade, which the lathe, in striking the fell, forces in between the jaws by coming into contact with the other end.

380. The cloth is thus released when the reed is at the fell, and allowed to move onwards towards the beam. But by this very means the reed is left unprotected, and at the time too when it stands most in need of assistance from the temples; as there is a tendency in the cloth to shrink at the fell immediately on its being left to itself. This however is not allowed to have its full effect, as the temples close again upon it almost as soon as the lathe rises from the fell, or, at least, when it is clear of the lever. So far however as this circumstance affects the cloth, it is an objection to the action of the nipper temples.

381. The rotatory temple, however, is so far free from this objection, inasmuch as it does not release the cloth from it in working. But it is liable to another of a more serious kind, and one which does not affect the nipper sort—namely that it is apt to injure or tear the cloth and loose hold of it by its mode of acting on it.

382. This will be evident if we consider the manner in which it effects its action on the selvage from the form of the temple. The rotatory temple is a small wheel of about two inches in diameter, furnished on the one side of the rim with sharp pointed spur-teeth. The teeth are set obliquely to the plane of the wheel's axis, so as to enter the selvage as the cloth passes over it—one half of the wheel accordingly, or rather, merely a segment of its circle, is exposed to the cloth. The other portion of the wheel is shielded by an exterior rim, which indeed encircles the whole, but does not exclude the cloth from the segment.

383. The wheel, thus made, is placed to rotate on its centre in front of the breast beam, so that the teeth of the segment only may come in contact with the cloth, and keep it at the required width. The selvage is thus held on the teeth in the arc of a circle, and as neither the teeth, nor the selvage in contact with the teeth, sustain by this action a uniformity of strain, the selvage is apt to be torn between the teeth, or injured from the size of the punctures which they make; and as the teeth are constantly changing their relationship to the cloth,—entering and leaving it as it passes over them in its

way to the beam, they are apt thus to loose hold of it, and the more especially at the striking of the lathe on the fell.

384. Much of the objection, however, attending this mode of action is obviated by a very simple contrivance for taking the strain off the temple-teeth. This improvement is effected merely by a projection, on the exterior rim of the temple, which is made to lap the selvage over it. The strain is thus chiefly borne on the shoulder of the projection, whilst the overlapping by it presents the selvage properly deflected to the teeth.

385. Fig. 4th Plate XV, is a representation of the rotatory temple, as it is placed on the breast beam to act on the cloth. *a* is the exterior rim, *b* the projection on it, *c* the wheel, and the oblique dotted lines point to the segment of it which acts on the selvage. One temple is placed opposite each other to act on its respective selvage; and to guard against injury from the shuttle being driven against it by the reed, the temple is made to slide back in the frame in which it is placed, on such an accident taking place. The frame is consequently made to permit the temples to slide on it in the direction of the warp, simply by its edges overlapping the edge of the plate to which the temple is screwed with the centre pin on which it rotates, so as to guide it in the required direction; and to keep it steady in its sliding-place, the temple plate is pressed up against the overlapping edges of the plate in which it slides by a spring acting from the under side.

386. Fig. 5th is a view of the temple apparatus

from the under side, or the plan as seen in Fig. 4th reversed; and a side view is given in Fig. 6th. The spring is, therefore, seen in both these views. The overlapping plate *c*, again, is seen both in the plan, Fig. 4th, and in the edge, or side view, Fig. 6th. The overlapping plate, it will be observed, is slotted as well as the frame *l*, which carries it, that it may be both set at the required distance from the fell, and adapted as to its position laterally, to different widths of work, so far as the slit in the frame will permit it. The thumb-screw *f* regulates or adjusts the temples as to the width at which they are to be set for acting on the selvage, according to the breadth of the web and the degree of extension that they may be required to make;—whilst the two bolts *g g*, seen in all the views here presented of the temple, secure the overlapping plate to the frame, and thus keep the temple firmly in its place as set for acting on the selvage. The slit or slot, therefore, in the frame, is designed to adapt the temples to different widths of work, and the slot in the overlapping plate, to the distance at which they are to be set from the fell. When the temple in any case is driven back by the accidental stoppage of the shuttle between it and the reed, (which may happen in consequence of the protector not doing its duty,) it must be set forward again by the worker.

387. The roller temple, again, is different from either of these, both as to construction and action,—it consists simply of a roller and a half tube. Both the roller and the half tube are of the same length, a little longer than the width of the web. The rol-

ler is made to turn on its pivots longitudinally in the half tube, with the web between them. The roller is on the upper side of the web, as seen in Fig. 8th, and placed across it, as near the fell as the half tube will permit it. The exterior edge of the half tube, next the fell, supports the web at the required level in front of the lathe. The half tube is, therefore, a fixture, whilst the roller turns by the pressure of the cloth under it in its way to the beam.

388. The web is thus deflected over the edge of the half tube by the roller, as seen in Fig. 9th; and kept distended by the friction which it suffers in passing over it. But as the cloth shrinks more readily towards the selvage, the roller is roughened there like a file, to prevent it; or, what seems to do better, a layer of India rubber about an eighth of an inch thick is run round it for about a fourth of its length towards each end.

389. Fig. 8th is a bird's eye view of the roller in contact with the cloth, and Fig. 9th is an end view. *a*, *b*, *c*, are respectively the cloth, roller, and half tube. The roller is about an inch in diameter, and of course the concavity of the half tube is somewhat more.

390. The roller temple is thus simple in its construction and action,—more so than either of the other two, and, therefore, less liable to derangement; and in one respect it has an advantage in its action, inasmuch as it restrains the cloth from shrinking by pressure, in some measure, throughout its width,—whilst the nipper and rotatory temples, we have seen, keep the cloth extended by pulling the selvage only;

the latter depending entirely on the strength of the selvage threads to withstand the transverse strain which it brings upon them.

391. Neither of the temples, according to their mode of acting, can do more than retain the cloth at the width at which they receive it; and as the cloth shrinks so far according to the distance from the fell at which it is taken hold of, the temples should therefore be set as near the fell as they can be made to work: this is especially necessary for heavy work. The nipper temple may be set at about $\frac{1}{2}$ or $\frac{3}{8}$ of an inch from the fell; and the rotatory and roller about $\frac{5}{8}$. There must thus be some shrinking of the cloth before it reaches the temples, and, of course, the reed will so far suffer a degree of strain whichever of the temples is used.

392. To do their work aright the temples should keep the cloth at the fell in weaving at the width of the web in the reed. Neither of the temples can effect this fully. The nipper temple like the others not only cannot take it at this width, but it looses hold of it when most needed—at the very time the reed is about to strike the fell. The action of the nipper temple, however, is attended with no injury to the cloth, and as it is direct in its contact with the selvage it has a considerable command over the work during its action on it. The rotatory temple in this latter respect is a medium between the nipper and the roller sort;—less efficient perhaps than either, and more liable to injure the cloth, and certainly less simple than the roller, it has no special claim to attention. Its adaptation is to light work, and that

of the nipper is more generally applicable, without being more especially so; whilst the principle of the roller is better fitted for a wider range of work than either of them. But as the roller effects its purpose merely by the friction on the cloth by deflecting it over a fixture, it has no direct power of extension within itself; and were the work very heavy it would be difficult to keep it extended and steady in the deflected state.

393. This objection might be obviated, however, by making the roller a screw-worm with the threads right and left handed, running of course in opposite directions from the centre, and acting on the cloth with little deflection. Motion in this case should be communicated to the roller so as to turn it somewhat faster than the web is moved by the beam, and the threads should be rounded to prevent them from injuring the cloth. The extension from this roller will thus be direct, and in proportion to its speed. The speed, however, should be slow, so as not to injure the cloth; and if the effect require to be increased, this may be done to any degree by using two rollers screwed in the same manner, to work together with the cloth between them.

394. These three temples are the subjects of patents. The two first seem to be American in their origin; but improved and patented in this country. The nipper, by William Graham Esq. Lancefield, Glasgow, in 1834; and the rotatory in 1841, by Messrs. Craig and Cochran of Stockport. The roller temple is of a still more recent date, and is the invention of Mr Bullouch of Blackburn.

395. The power loom is thus brought to such a state that the duty of the weaver is limited to the general superintendence of the work, so as to manage it in such a manner as to keep the loom a-going with the least possible discontinuance. Unavoidable interruptions in working it, take place from breakage in weaving, and from the discontinuance of the weft shot; and as unobserved breakage of the yarn is generally attended with scobbing, and always at least with some injury to the cloth if it were merely from the want of the thread, the weaver has to pay an especial attention to the yarn; because if scobbing has taken place, that part of the cloth should be taken out again, which is time lost; and in either case, the broken thread must be immediately tied, and as quickly as possible. And that no time be lost in supplying the loom with weft, two shuttles are furnished to each loom, one of which is kept ready with a fresh cope to supply the place of the one in use as soon as it may have run out.

396. Little time is lost in taking the cloth from the loom. This operation is usually done at the end of every piece. The pieces are generally, in calico goods, 25 yards in length, or double that number: and as a single piece may be about the daily average production of a power loom, it recurs only once or twice in two days; and five minutes will then be sufficient for effecting it.

397. Thus the business of the weaver in attendance on the power loom, is not laborious; nor do the duties require much time in the aggregate for their performance; nor skill, but rather a nimble-

ness of hand; and hence young women are almost universally the weavers by power in the factories, and each person manages two looms. But although the duties are not toilsome, they are far from being unattended with fatigue, arising from the strain on the arterial system in maintaining the upright or standing position so long at the work.

398. When the web is wrought out, the new one is put in by a manager called the Tenter, who has the charge of a certain number of looms—as many as he can well attend to.

399. The *reeding* and *drawing* of the web are done out of the loom, in a frame in a separate room, usually by boys. These two processes, however, are necessary only when the heddles are worn out; otherwise at the end of the web, the new warp is joined to the old one, by twisting each individual thread of the old warp behind the heddles, to a corresponding one of the new. This process is likewise done by boys; and at a separate frame, that no time be lost by keeping the loom idle.

400. The warps thus prepared are put into the loom, as required, by the tenter, whose business it is to mount the webs, and keep the driving straps and tackling of the looms under his charge in order.

401. The tenter is, therefore, properly speaking, the weaver; and as he has the control of the loom, supposing it properly made, the production of the cloth as to quantity, and even as to quality, will very much depend on the manner in which he exemplifies the art of weaving in his management of it:—

First, As to the yarn, that it suffer no unnecessary strain in the loom;—

I. As to position—That the warp be in a straight line:

II. As to stretch—That it be of the proper length:

III. As to direction—In the line of the stroke of the lathe:

IV. As to support—That it be maintained in the proper line:

V. As to tension—That it be properly paced:—

Secondly, That it suffer no unnecessary strain from the motions in weaving;—

I. As to size—That the motions be the smallest that can be rendered sufficient:

II. As to the arrangement as affecting the motions of the shed and the lathe—That there be no unnecessary space between the heddles and the fell:

III. As affecting the shed—That the shuttle be as thin as is barely sufficient for a pirn or cope not inconveniently small:

IV. That the size of the shed be barely sufficient to receive the shuttle:

V. That the shuttle line in working be as near the heddles as the lathe can be made to permit it:

VI. That the lathe be properly constructed for that purpose;

> 1st, As affecting the shuttle line and the shed—That that part of the sole from the reed to the back of the swords be as narrow as is compatible with the requisite strength;
>
> 2dly, That the protector be so placed as to require no additional space between the swords and the heddles;

3dly, That the sole in front of the race be not inconveniently broad:

VII. As to the stroke of the lathe—that it be of the proper length—about three times the breadth of the shuttle:—

Thirdly, That the motions, as to quality, be good;—

I. As to the lathe—Steady and firm in action:

II. As to the shed—Steady and easy in motion:

III. As to picking—Free and easy in action:—

Fourthly, That the form or kind of the motions be such as is best adapted for speed in weaving; and performed so as to save the yarn, and as quickly as is compatible with their own stability in action;—

I. That of the lathe—eccentric without angularity:

II. Timed in its eccentricity to the motion of the shuttle;

1st, As to the length of the pauses at the full stroke and the fell;

2dly, As to the acceleration of its motion from the fell to receive the shuttle;

3dly, As to its acceleration to the fell:

III. That the shed be eccentric in accordance with the eccentricity of the lathe:—

Fifthly, That the motions be performed conjointly in the proper order of succession—so as to save time and save the yarn;—

I. As to the lathe—Regulating, as by its action, the other motions of weaving:

II. As to the shed—That it rise as by the stroke of the lathe on the fell:

III. As to the shuttle—That the action be imparted to it at the proper time, as the lathe is rising from the fell.

402. The manager of a weaving factory, who has the charge of the establishment, should be well acquainted with the principles and practice of weaving, and with the capabilities of machinery. But these qualifications are not easily acquired, and are rarely combined. Weaving as an art is seldom well exemplified. The management of the yarn in the loom, so as to effect all that can be done with it, depends in a high degree on a nice perception of the strain which yarn is capable of bearing, compared with what it must neccessarily suffer in the process of weaving; and this talent in discriminating weight is best brought out by practice on the hand loom.

403. But the ability to distinguish with niceness and precision the difference between relative forces, and the ability to dispose of them to the most advantage, are not common qualities of mind; and as they are both necessary to the attainment of eminence in the art, it is not surprising that a high degree of skill in the management of the yarn should be rarely exemplified in practice.

404. Hence the practice, so commonly met with, of working with excessive motions;—and as a consequence of its severity on the yarn, a low speed becomes advantageous, as necessary to prevent excessive breakage in weaving.

405. Thus the practice becomes established by common usage, and is adopted as a matter of course in weaving by power; and hence the rule as acted upon in a general way by Mill managers, that the size of the shed is to be sufficient to clear the shuttle.

406. The principles of weaving are homogeneous, and admit of no special exception in their application to fabrics made either by hand or power looms. But they are limited in their adaptation by the qualities of the yarn, and the texture of the cloth. From sailcloths to the finest muslins, the gradation is great. These are extremes in make; and the chief element in the one, as necessary to effect the texture, is power to get through the work: the object, therefore, as most advantageous in such fabrics, is to economize the power. But in the other, where the power expended on the texture is comparatively small, the saving to be effected is chiefly through the means as preventing the breakage of the yarn, so as to maintain the utmost speed in weaving.

407. Calicoes are a sort of mean between these extreme fabrics—requiring neither special power to get on the weft, nor a special arrangement of the means to save the yarn: and the object sought, as necessary to turn out the greatest quantity of cloth, is the highest speed in weaving which the yarn and the machinery can be made to maintain.

408. Now it must never be overlooked, that, in good practice, breakage of the yarn in weaving is not a consequence of speed in shuttling. The only additional strain deserving of notice, which the yarn

sustains from speed in shuttling, is that resulting from the diminution of time in the formation of the shed; and as the strain on the yarn in shedding is as the square of the distance passed over by the warp, divided by the time, this additional strain from the speed—if the shed is properly formed, so as to increase the time from the entrance of the shuttle at the selvage as the strain increases, and above all, if the size of the shed is the smallest that can be rendered sufficient—will be a very small fractional quantity, of no value compared with the absolute strength of the yarn; and, therefore, practically speaking, productive of no breakage.

409. The great source of breakage in weaving arises from overshedding; and this will appear evident if we consider the relative strain, as borne by the yarn in working two similar fabrics, where all things are equal except the shedding, which is two inches and one and a half respectively—a difference such as results from the common practice, that the shed is to clear the shuttle, and the rule as laid down by the author,—that the shed is to be the smallest that can be rendered sufficient to receive the shuttle. In this case these two rules will exemplify a difference of strain on the yarn in working as 9 is to 16.

410. This mode of weaving, in accordance with the practice as presented by the author, will require a very trifling additional force to throw the shuttle, but this deduction will be nearly equalized by the diminished power required in shedding, and an ample return will be made by the saving effected on the yarn.

411. The proper position of the yarn in the power loom is less attended to than its importance requires. Too much is trusted to the absolute strength of the yarn; and hence success in weaving by power has hitherto depended more on the quality of the yarn than on its management in the loom.

412. That harsh method of working with the heddles sunk, as adopted by coarse hand-loom weavers from the ease it affords them in treading heavy work, is frequently met with in weaving by power; and as the injury done to the yarn, from the obliquity in which the warp line is placed by this mode of weaving to the stroke of the lathe, is compensated by no advantage received by the work, it should be discarded from power-loom practice.

413. The object of this arrangement of the heddles, it is true, is to facilitate the action of the lathe on the fell; but the lathe should be sufficient to effect its purpose without any arrangement injurious to the yarn.

414. This harsh mode of working is frequently accompanied by another injurious practice borrowed likewise from coarse Gingham weaving, namely that of treading on the shot. The yarn is thereby deprived of the assistance which it should receive from the stroke of the lathe, in turning the shed, and subjected to severe traction and friction from the driving up of the weft shot, so that a knot or lump on the yarn, such as is frequently met with, in coming within the path of the reed is very liable to occasion the breakage of the thread behind the heddles. This mode of weaving, which is admissible only where the yarn

is sufficiently strong to stand it as a means of spreading the weft in coloured work, or such as has little subsequent dressing in coming from the loom, must not be confounded with the art of weaving as necessary to save the yarn.

415. If then the yarn in the loom, for work of this sort, is favourably placed, as to position, and the motions good as to quality and proportion, and performed in the proper order of succession, speed in shuttling will be limited only by the action that the machine is fitted for undergoing. Time must be given the shuttle to cross the web. This is a measure, which although compressible, has its maximum and minimum, by which the duration of the other motions of shuttling must be regulated; and therefore, to gain the highest speed in shuttling, the motions of the lathe and the shed must be eccentric to the greatest degree compatible with their own stability in action; so as to economize time for the transit of the shuttle. The lathe, therefore, as it leads the shuttle into action, must have such a degree of eccentricity as fits it for the speed imparted to the shuttle.

416. All things being as they ought to be, this speed at which the shuttle may be thrown for yard wide calicoes, may be safely calculated at about 120 shots per minute—a low degree of speed is incompatible with a high degree of art in the make and management of the loom.

417. Some machine makers construct their looms for great speed, with very short connecting rods to increase the eccentricity of the lathe; but as there

is some weakness and hesitancy in the action of the crank in passing its centre of motion, especially when the obliquity in working is great from the shortness of the connecting rods, they therefore employ a small fly-wheel to counteract it, which is placed on the crank shaft inside of the driving pulley for that purpose. But it would be better to make the shaft with its gearing heavy enough for its own action, so as to require no assistance from superadded weight to increase its momentum. In that case a connecting rod and shaft such as those presented in the drawing of the loom as made by Mr Grandison, are sufficient. The bend in the connecting-rod is to clear it of the heddle shafts in working.

418. This loom weighs about thirteen hundredweight in all, and is fitted to work a considerable range of fabrics. Heavy calicoes or domestics with a grist of yarn of about 20^s is the sort of work for which it is especially fitted.

419. But if the work is very much coarser, the loom should be still heavier made; and for the weaving of linen especially, even of the same grist of yarn, it should be not only heavier than is sufficient for a similar fabric of cotton, but likewise longer in the stretch on account of the greater rigidity of the fibres of flax.

420. The quality of the yarn as to its elasticity has not been sufficiently considered in the application of the power loom to linen and woollen weaving. The arrangement and construction of the loom as adopted in cotton weaving have been too closely imitated, and with less success, as might be expected

from the greater defectiveness in the adaptation of the machinery.

421. All fabrics have some peculiarity in the mode of working them dependent on the quality of the material of which they are made.

422. Linen from the strength and rigidity of its fibres requires to be heavily paced in weaving, and as the heddles in shedding have little relief from the elasticity of the yarn, an increased length of stretch of perhaps about six inches should be given the web as an accommodation to their action. And as an assistance to the pace, the beams, especially the yarn roll, should be strong and heavy, with a diameter of nine or ten inches; and for the beam-heads on which the pace runs, from about fourteen to sixteen inches. The inertia of the rolls is thus brought by the action of the pace to counteract the weight of the yarn, by which it is more easily kept in a proper state of tension for weaving.

423. From the rigidity of the yarn in linen weaving the shuttle is apt to be thrown out by any trifling obstruction in the shed. This is a source of considerable annoyance to the trade. In similar cases in cotton and woollen weaving the yarn yields to the force of the shuttle; but in linen weaving by power, as the shuttle used is the same as to size and weight as that adapted for cotton, it is too light to make its way undisturbed by superior resistance frequently obliquely placed to its course, and must in such cases be thrown out.

424. The size and weight of the shuttle should in all fabrics be proportioned to the weight of the

yarn; and in linen an additional allowance of length, breadth, and especially weight should be given it, so as to enable it to overcome any little obstruction in the shed, and keep its course unaffected by it, from its own momentum.

425. In woollen weaving, from the elasticity of the yarn, especially if the fabric is light, the stroke of the lathe on the fell is rendered more effective by its partaking somewhat of the action of a squeeze. This kind of action is easily imparted by diminishing the motion of the lathe a little at the fell, and keeping the cloth forward to it in the working.

426. The flyer, in weaving in this manner by power, is well adapted for producing this action by pressure. But in blanket weaving and in the other heavy sorts of woollen or mixed fabrics such as are made in Trowbridge, any adaptation of this sort, or especial arrangement in the motion of the lathe, except that dependent on the width of the work, is wholly unnecessary.

427. That description of goods which is known by the name of checks is made of all materials in common use for cloth, as cotton, woollen, linen and silk, or a mixture of them.

428. The check is formed by having the warp striped in a certain order by warping yarn of different qualities, either as to grist or colour, and crossing these stripes in weaving, at the proper intervals to form the squares, with the corresponding kinds of weft.

429. Checks are, therefore, woven with a variety of shuttles corresponding to the number of colours, or kinds of yarn, used as weft, to form the pattern with the warp.

430. The shuttles must, therefore, be changed for this purpose in weaving with them, and this is done by rendering the box moveable at least at one end of the lathe, and forming it with a separate berth or box for each of the shuttles intended to be used in the work. The movement of the whole box is, therefore, made in a certain measured manner corresponding to the *breadth* or *depth* (according as the box is made) of each of the separate boxes—so that any of the shuttles may be brought as required to the plane of the race and the reed, and used till another change becomes necessary.

431. In check weaving by hand, there are two methods in common use in which the box is made for effecting the required change of the shuttles. By the one method it is made to slide vertically on guides or spindles, as seen in the transverse section of the power loom, Fig. 1st, Plate XIII, with the shuttle boxes shelving above each other parallel with the race. This is called the Drop box, and was invented by Mr Robert Key, son of the inventor of the fly shuttle, in 1760.

432. The other is the Swing box, seen Fig. 5th, in the same plate, which is made to vibrate horizontally, with the boxes placed in the plane of the race, by being attached to a pendulous framing supported on pivots from a bar made fast to the sword of the lathe for that purpose.

433. Both of these kinds of boxes are worked with the weaver's hand as it is engaged with the lathe. The motion of the hand for this purpose is a traversing one, but in so small a degree as to be attended with little inconvenience to the weaver.

434. In working the drop box, as it requires merely to be raised, and falls by its own weight, the action of the thumb in moving to and from the other fingers of the hand is usually sufficient for this purpose.

435. The communication with the box for effecting the motion in this manner is maintained by a lever, which is placed above it so that it may vibrate horizontally; and from which the box is suspended at the one end like a balance. A cord is attached to it at the other end, and made fast to a sliding catch which moves in a groove in the upper shell, and on which the weaver's thumb rests in working, so as to act upon it by drawing it in towards the other fingers of the hand, as the required movement of the box may render this motion of the thumb necessary. The direction of the catch-cord is changed of course to suit the direction in which the catch slides, by the pulley in the upper shell.

436. The swing box is better fitted than the other for work requiring many shuttles, as their weight in this case in moving them, does not rest on the thumb. But as the motion is greater in proportion to the number of boxes, the radial range of the movement of the thumb becomes insufficient for effecting it, and the swing box is, therefore, usually shifted by a sliding catch in which the whole hand is placed in working with it.

437. The connection of the box with the sliding catch is effected with a cross-cord, by which it is pulled back or forward, as required for the change of the shuttle, according to the direction in which the slider or sliding catch is moved by the hand. This movement is effected by the opposite directions in which the two ends of the cord are attached to the slider, from where the pulley by which they are deflected is fixed on the upper shell.

438. The range in the motion of the box is thus dependent on the number of shuttles it contains, and each move is measured in spaces equal to the breadth of each box by a check-catch, which stops it at the proper place, that any of the shuttles may be brought to run in the plane of the reed and race, as required by the weaver. The check-catch is likewise worked by a cord, which passes over the weaver's hand, and is fixed to the upper shell so that by the motion merely of the finger, it is allowed to act at the first move or not, according as the change in the pattern may render it necessary.

439. Checks are generally heavy made fabrics, about the set of calicoes, especially those of Carlisle and Manchester; and, therefore, no special adaptation of the loom from what has been already described for such work, is necessary for them, except that dependent on the motion for changing the shuttles.

440. Accordingly, this sort of work was very early attempted to be done by power; and Dr. Cartwright has the merit of being the first experimentalist in check weaving by machinery. In his plan

for effecting it, which he patented in 1792, he adopted the swing-box in connecting it with the power; and communicated motion to it from a ratchet wheel, which was turned by the action of the lathe.

441. This movement was effected from tappets, or projections fixed on the same axle with the ratchet, which acted on a lever connected to the box by cords, for moving it in the required direction. The number of these tappets gives a corresponding number of changes to the pattern, whilst the number of teeth, or moves, between the tappets, determines the number of shots in the change, or stripe of the check. The size of the pattern, of course, is limited by the number of teeth, or moves, made in the circumference of the wheel.

442. Dr. Cartwright's plan, however, was not successful; and fell into disuse, or rather never came into use, and indeed was totally neglected. The difficulties under which the power loom itself was labouring were sufficient to account for a result of this sort, without recurring in explanation of it to defects in its construction.

443. But although the loom had been prepared for it, the manner in which the movement was effected was ill adapted for power. The communication by means of cords for effecting a certain measure of motion is inapplicable to machinery, from the alterations as to their length which they undergo in working. But besides, they are attended with a disturbing influence in their action from the dangling of their weight, whilst the vibrating action of the box is that most likely to be affected by the injurious

influence inseparable from this means of communication.

444. The box was thus liable to be affected both by disturbance in its motion and uncertainty in its action. But supposing the loom had been prepared for it, and the defects which we have noticed entirely remedied, it would have been greatly overdrawing on the best construction of which the means was capable, to expect much success from it, so long as the box, or the machinery, was exposed to damage or breakage by any accidental stoppage of the driver or the shuttle in working;—and so it was, when the subject was again recurred to by various mechanics throughout the country, (after the loom itself had been brought into a better working condition,) although their contrivances were free from these objections, so little success was experienced in working by it from this defect alone, that the production of the loom could not be depended on; and notwithstanding that the whole of the time of the weaver was engaged with one loom, he could not be set on piece-work with it. Check weaving by power was long in this condition; and of course the patterns as wrought in this manner are of the simplest kind,—eight or ten shots about with two shuttles.

445. The method adopted and used in various places is that of raising the box by a ratchet wheel, which is worked from the motion of the lathe. The box used is the drop one, as being best fitted from its stability in action for weaving by power. The ratchet wheel is placed horizontally under the box, with a projection on its surface, which raises the

box to the level of the race, and keeps it there as long as the rotation of the wheel is made to do so. The projection on the face of the wheel thus raises the under box to the level of the race, and it drops of course from its own weight on being withdrawn from it as the wheel turns round.

446. In weaving with the drop box, the driver, of course, is placed on its side to slide horizontally on the spindle, with its tongue resting in a small groove in the back of the box. This is an unfavourable arrangement, both for the driver and for its action on the shuttle. The groove gets wide by wear, and gets so unequally, and thus the shuttle, in being thrown by the driver, is disturbed in the plane of its course; besides, the driver is frequently tripped or stopped, from this and other causes, in passing from the groove of the moveable box to the fixed groove at the end of it in the frame, in which it rests till the next shot is to be thrown; and in this case something must then give way, as there is here no means for preventing it. A long spring was used in some cases, it is true, as in check weaving by hand, but this is an inconvenient means, as its action is most exerted where it is useless or mischievous to act at all, and, therefore, it was liable to give way, and attended with other disadvantages, so that a lower speed becomes necessary in working with it than the box is otherwise fitted to bear. A spiral spring was afterwards used, and applied to act on the picking pin placed at the side of the loom, with partial success; but these defects are entirely obviated by the method invented by the author for weaving

work of this sort, and which is more extensive in its range,—adapted indeed to any description of check with any required number of shuttles—by which the apparatus connected with the box is as manageable and as safe as any other part of the machinery.

447. Fig. 1st, Plate XIII, is a transverse section of this check power loom, taken immediately in front of the lathe, and Fig. 2nd is an end elevation. The letters A A A in both diagrams, refer to the loom frame; and the corresponding parts in each are distinguished by the same letters. *o* is the lathe, *u* the drop box, *q* the driver placed to slide on two spindles so as to require no tongue, as seen in the end view of the driver, Fig. 7th. The end of the driver which strikes the shuttle is thus made to need no support either from the box or the end framing, and has no connection with it. The shuttle is, therefore, free from any disturbance, to which it would otherwise be exposed, from the wearing of the tongue or groove, or accidental tripping by the driver.

448. The means for preventing the stoppage of the driver in the way of the box, and, therefore, of preventing the damage and breakage arising from it, without the intervention of a spring, consists of a light lever rod made to communicate both with the driver and the treadle nearest it.

449. The lever is, therefore, formed with two arms set nearly at right angles to each other, and put on a stud near the rocking-tree under the box, in the plane of the treadles, as seen in Fig. 1st. The

long upright arm v' reaches to the driver, to which it is attached; and the short one w' communicates by another lever x' to the nearest treadle, by which on its being depressed by the wiper, the driver is, of course, pulled back to the end of the box; and thus all interference with its movement is effectually prevented, without any strain or inconvenience to the apparatus in picking.

450. The manner in which the movement of the box is effected is evident from Fig. 1st. The power, it will be seen, is employed to raise the box to the level of the race, as the shuttles are to be successively changed; and it falls again in repeating the changes by its own gravity.

451. The box, therefore, requires to be kept up to the level of the race, during the working of each successive change from the first; and this is effected by means of a treadle on which the power is brought to act.

452. The best place for the communication of the treadle with the box is perpendicularly below it, as near the rocking-tree as the space required for its own motion will permit, as there is there little motion of the lathe. A connecting rod accordingly reaches downwards from the box to the treadle, and supports it at right angles. t' is the treadle placed, as seen in Fig. 2nd, Plate XIII, with its centre on a stud on the lower framing of the loom—y' is the connecting rod kept in its place by the guide studs 1, 2, which are screwed to the sword.

453. The treadle is worked, so as to raise the boxes successively as the shuttles require to be

changed, by the pattern wheel itself, which receives its motion for that purpose from a small pinion on the wiper shaft. This motion of the treadle is effected by the segments, 3, 4, screwed to the face of the wheel; and as each segment gives exactly so many shots, according to the pattern, the number of segments in the circle gives the number of changes in the pattern for that shuttle.

454. The next shuttle is brought up by another segment concentric with the last; and so far within its circle as merely to bring the box for which it acts to the level of the race.

455. The number of concentric circles determines the number of shuttles which it is fitted for working; and the number of segments in each circle, the changes in each of the shuttles respectively.

456. When the pattern is larger than the wheel can be made to receive it, another wheel 5 should be interposed between the pattern wheel and the wiper, so as to increase the range for action by diminishing the space for each change, as seen in Fig. 2nd. The circumference of the wiper gives of course but two shots.—Hence the range in the pattern which the wheel is fitted for working will be as the number of times in which two are repeated in its circumference. Pullicate patterns are, however, frequently formed with large bases—so large that the space occupied by them will be more than can be conveniently compressed within the limits of this arrangement, without unfitting the movement for the required action on the treadle.

457. In this case, it would be better to work the

the broad bases by measure, from the motion of the cloth beam, and throw the check or pattern wheel out of gear or in it, as required for the small checking, at the proper intervals. This action may perhaps be best accomplished by working the pattern wheel as a ratchet; and engaging or disengaging it by a catch, with which it may be worked from the motion of the beam.

458. As the working of the boxes, however well managed, is necessarily attended with some loss of time in shifting them, the speed of the loom should be decreased according to the number of shuttles which the box is made to work. Eighty shots a minute may be taken as a good working speed for two shuttles—diminishing the velocity at the rate perhaps of about ten shots per cent. for each additional shuttle used.

459. The box, with the view of diminishing its motion within the narrowest limit possible, should be made with its individual boxes as shallow as the shuttle will permit them to be; and it might be desirable, as it is attended with a saving in this respect, to make the shelves for the shuttles of metal—plate brass. In that case, the outsides of the boxes will be formed by bending down the plate as far as the driver will permit it, which will be sufficient lateral security for the shuttle, without any edging under the driver; and, that the shuttle be prevented from getting through the box, the side at the end may be bent inwards, and secured in that position by soldering a band to it, so as to catch the shuttle by the shoulder when it reaches the end of the box.

460. By making the shuttle shelves in this manner, of metal instead of wood (and indeed the whole of the box should be of the same material) a saving of about one and a half inches in the working of the range of three or four shuttles will be effected, which is of consequence, chiefly as it diminishes the shock to which the box is exposed at the final shift, in falling down upon the under framing; and as a further security in working with many boxes, it may be found beneficial to counterbalance their weight at the opposite end of the lathe,—and it may likewise be advantageous to regulate their weight, as effecting their descent, by the box treadle *t′*, on which the power acts. The author, in working with two boxes, used a lever-spring to raise the box and the power to depress it,—as a means of obtaining stability of action, so as to gain great speed in shuttling,—with the desired effect.

461. As the integrity of the pattern in check weaving depends on each stripe having its exact complement of shots, the attention of the weaver is necessarily much engaged in looking after the shuttles, to prevent the piece from being damaged by unobserved breakage of any of the shots in weaving. The weft shot protector in work of this sort is, therefore, peculiarly serviceable in weaving by power; and valuable, as it may relieve the attention of the weaver by depending on its assistance, so that he may be able to attend to another loom, which without it he could not safely engage with.

462. A loom similarly constructed to that here presented, was patented by Mr Thomas Yates of

Bolton in 1839, several years after it was invented by the author, but without the means for taking back the driver, or the mode of working it on two spindles without a tongue.—Mr Yates uses a spiral spring attached to the picking pin for taking back the driver.

463. The power loom was early applied to sail-cloth and canvas weaving, but hitherto it has been attended with little success.

464. We have observed that in sail-cloth weaving by hand the shot is driven home by two strokes of the lathe—the first on the open, and the next on the cross shed, and that this mode of weaving is adopted in consequence of the insufficient power of the weaver to work with advantage a lathe sufficiently heavy to strike the shot up at once.

465. Now the power loom for sail-cloth weaving is constructed on the same principle, of working with the double stroke (which is effected by a third wheel driven from the wiper,) although the condition as to power in which these two agencies exist is nearly the reverse of each other. In the one there is a deficiency, and in the other, an ample sufficiency of power.

466. But the power, to be effective, must be properly directed. The lathe must have weight enough with its motion to strike the shot home at once; and the yarn sufficient tension to retain the shot on the blow.

467. In the construction of the loom, as already described, neither of these conditions is fully effected

without a waste of power corresponding to the reaction of the work in weaving.

468. From the inverted position of the lathe, its centre of gravity is below the fell, and it strikes it, therefore, with diminished effect, whilst the action of the pace on the web is diminished likewise, by the amount of the weight of the yarn between the two beams.

469. The best position of the web for the action of the pace on the yarn is in the direction of the weight of the warp, as extended between the two beams. This position is a vertical one; and it is also the best for the required action of the lathe on the fell.

470. In this position, the lathe must be horizontally placed, to act on the web at right angles, so that its whole weight may be thrown on the weft shot in working.

471. A loom constructed on this principle was very early invented by Mr Johnson, the inventor of the dressing machine, and patented by Mr Sherriff of Glasgow, as an improvement in general weaving by power;—only that the power was used to force the lathe up against the cloth. It was applied to calicoes, but it was not successful. Nor indeed could it be otherwise; for independent of defects in its construction, its failure as a *general* application to weaving was certain, from the position of the yarn in the loom. The facility with which the broken threads come in, in the direction of their own weight, brings them quickly to the fell; or they are prevented only by entangling themselves with other

threads in shedding, by which the damage is apt to be immediately increased.

472. The vertical position of the web in weaving is, therefore, unfavourable for preventing the extension of damage from breakage that has taken place; and it is likewise the worst in which the web can be placed for repairing the damage when done.

473. This principle of weaving is, therefore, applicable especially to fabrics in which breakage is not to be apprehended from the working of the cloth, both from the strength of the yarn, and the fewness of the threads composing the warp. Sail-cloth is in every respect such a fabric; and it is a *special* one for such a construction of loom.

474. Plate XVI represents a transverse section of the vertical loom, as constructed by the author, for work of this sort, from which it will be seen that two looms are included in the same framing. And as the work can be better attended to when the webs are a little inclined towards each other at the top, a few degrees of angular deviation from the vertical line in that direction is, therefore, given it.

475. As the object in the placing of the lathe in this arrangement of the loom is to gain the utmost effect from its action, which its weight and motion can impart to the fell, a right angular position to the web, as near the horizontal line as possible, is therefore chosen for it,—with a sufficient leverage of the swords to render the weight effective.

476. Mr Johnson, from his view of weaving, constructed his loom so that the lathe was worked

in opposition to its weight from a crank below. The lathe had no swords, and the sole was made to move in the required direction, by being guided in shears. This method of working the lathe in shears or on spindles, has been adopted in the common horizontal mode of weaving; but as it wants that firmness and stability in action, which can be obtained only from leverage, it has found few imitators, and in fact is properly out of use.

477. The force of the lathe in acting on the fell in this manner, is then directly dependent on its weight; and that the momentum be not weakened by interruption in the motion, the wiper, by which the lathe is raised, is so formed as to let it fall with its whole accelerated force on the fell at once.

478. The form of the wiper by which this is effected has the curvature of its circumference increasing in diameter from the centre, till the length of the radius is sufficient for the length of the stroke of the lathe, when the curve becomes circular to produce the pause at the full stroke, and then it terminates abruptly in a cut off portion for the fall of the lathe.

479. The manner in which this is effected will be seen by a reference to the Plate. A A is the frame, B the yarn beam, E the cloth beam, *o* the sword of the lathe, *o′* the sole, *g′* the wiper shaft, *f′* the wiper, which it will be perceived is in contact with the sword, only that the pulley R is interposed to diminish the friction. There are, of course, two wipers, one to act, in the same manner, on each sword; and by the revolution of the shaft, the required motion is imparted to the lathe.

480. The shuttle is thrown in the same manner as that already described and represented in the check power loom, Figs. 1st and 2nd, Plate XIII. But as the fell is below the reed, the race between the swords is moveable to clear it of the weft shot, and permit the reed, on the fall of the lathe, to strike it up.

481. The motion of the moveable race is backwards, in the plane of the race and the boxes, and so far only as is sufficient to clear the web, on the falling of the lathe at the fell. The motion for this purpose will be about half the width of the shuttle or a little more; and as the race enters the shed in a parallel direction to the reed, and is withdrawn from it every shot, it is formed for going through the yarn by being made like a long comb, with the teeth split-shaped, and of sufficient strength to support the shuttle when set at intervals of half an inch apart from each other.

482. The race is fitted for moving in this manner by being fixed in a frame from the swords, and vibrates within them on its axis vertically something in the manner of a flyer, as seen in the transverse section of the loom, Plate XVI. *f* is the race, *h* the vertical lever, *i* the loaded arm by which the race is kept forward whilst the shuttle is crossing the web, *j* is the guide by which it is pressed back on the falling of the lathe to strike up the shot.

483. Thus the principle, as involved in the construction of the loom for these heavy and powerful fabrics, is *weight* so applied as to turn out the greatest quantity of cloth by overcoming the reac-

tion of the work in such a manner as to be attended with the least injury to the machinery.

484. But as the work increases in fineness, we have observed that the reaction from it diminishes in the same ratio; and, therefore, in very fine work—muslins for example, the difficulty in weaving is reversed. It is no longer the reaction of the work on the machinery, but the reaction of the machinery on the work, that constitutes the difficulty of bringing it successfully under the influence of this agency.

485. The power loom for muslins, therefore, must be constructed so as to obviate all injurious reaction on the work from the motion of the machinery; and susceptible likewise of the nicest adaptation of the tools by which the essential operations in weaving are effected, viz. the lathe, the shuttle, and the heddles.

486. Now we have seen that the motions included in shuttling are reciprocating, and discharge their forces in working by power at three different points in the circle; and, therefore, as the power necessary to keep the machine a-going till their recurrence again is not great, a considerable degree of tremulous or vibratory reaction is necessarily inherent in the action of the loom, arising from this irregularity of the resistance to the motive power.

487. This sort of reaction is a certain amount of disturbing influence which is unavoidable, and which can only be relatively diminished, or apparently neutralized or suppressed, in the loom as directly impelled by power (as is already done in its application to canvas and calico weaving) by increasing the weight of the moving parts, so as to render

their momentum, from the greatness of the weight, little affected comparatively by the variable resistance from the work.

488. The loom, therefore, as constructed to work from the direct impulsion of the power, in being applied to fine goods is subject to one or other of two defects, by either of which it is unfitted for the work. It must either be made strong and heavy enough to resist the reaction of its own motion, by which, in fitting the tools to work in unison with the power, they are unfitted, from their weight, for acting on the yarn; or if this defect is sought to be avoided, by making both machinery and tools light enough for the fabric, the work suffers in a greater degree by the deterioration of the motions arising from the deficiency of weight in the parts to withstand the reaction of their own motion.

489. This construction of loom is, therefore, unfitted for muslin weaving. But if, instead of the direct application of power, we substitute springs for the movements of the shuttle and the lathe, whatever vibratory reaction may attend the motive power in acting on the machine, the parts as impelled by the springs will act by their own agency, uninfluenced by it.

490. We shall thus obtain by this means, a construction of loom admitting, in the moving parts, of the utmost susceptibility of motion and steadiness in action, and in the tools, of the utmost adaptation to the fabric. If then this principle of construction is well carried out, so as to combine with these essential qualities *durability* in working, we shall have the

loom all that it ought to be, as adapted for fine weaving.

491. Such a loom, so constructed by the author for muslin weaving, is represented in a front and side or end view, in Plates IX and X. The lathe, it will be seen, is hung in the pendulous manner, as being the best adapted for susceptibility of motion; and that its action be unconstrained, the spring operates on it, in the direction towards the fell, at the middle of the sole immediately under the reed, with a pressure sufficiently uniform for practical purposes; whilst it is withdrawn from the fell again by the action of the crank with a flexible connector R attached to the lathe at each side or end for that purpose.

492. The uniformity of pressure from the action of the spring r' on the lathe, is effected by means of a lever t', from the manner in which the spring is brought to act upon it, as seen more especially in the side or end view of the loom, Plate X, Fig. 1st.

493. The lever acts as a connecting rod to the lathe, and is fixed, it will be seen, Plate IX, upon a horizontal axle T', which extends from side to side of the loom framing, and is placed near the floor, so as to vibrate with its lever t' perpendicularly to the lathe. The short arm t'' is fixed on the axle, nearly at right angles to the connecting rod behind the lathe, and on this arm the lathe spring operates in the required direction to strike home the shot.

494. The motion of the spring by this means is little, so as to prevent it from being liable to breakage; and as it is made lever-shaped and set on a stud

r'' as its fulcrum, its tension is easily regulated by the end opposite the blade being furnished with a pinching screw r''' for that purpose, as seen in Fig. 1st, Plate X.

495. The two springs v' v' by which the shuttle is impelled, are made in the same manner, and placed to act on their respective picking shafts n at each side of the loom, by means of a small arm attached to each shaft for that purpose. The picking shafts themselves, both as to position and form, are similar to that represented in the loom for calicoes in Plates V, VI, VII, and VIII. Fig. 3rd, Plate X, is a detached view of the picking shaft as it is acted on by the wiper f'' and the spring v', the greater portion of which is broken off. n'' is the small arm with a friction pulley on which the wiper acts, and n''' is another small arm on the picking shaft, which receives the action of the spring.

496. The form of the wipers by which the shuttle springs are counteracted, and left in the proper state for acting on the shuttle, is similar to that represented for the motion of the lathe in canvas weaving.

497. The motion of the shed, as to the manner in which the movement of the heddles is effected, is of primary importance in fine weaving. To save the yarn, the heddles should be worked with a movement as smooth and steady as the means can be contrived to make them, and as free as possible from strain, that the twine of the heddles may not require to be heavier to withstand the working than is sufficient for effecting the shedding of the web.

498. The means here represented for effecting

this important motion, have been already described in section 310; and in order to render their action free, and as little affected as possible by any disturbance in the communication of motion, the arms $f\,f$ of the heddle rollers are not jointed to the connecting rod g, but notched; and for the same reason the connecting rod itself is relatively heavy, and mounted on friction rollers g' g', so that in transmitting the motion from the tappet f''' of the wiper, it is not liable to be affected by vibration.

499. As the lathe in this construction of loom is assimilated, as to its motion, to that of the hand loom, it is, therefore, subject to the same rules of construction which have been already considered in reference to it, as to length of sword, strength of rocking-tree, and weight of sole, as fitting it for its work.

500. As to the use of the cord and flyer in weaving by power, it may be observed that as the fell is nearly an invariable line, and the force of the lathe practically speaking a uniform quantity, the equalizing influence of the cord is limited, compared with its action in hand weaving, to a very narrow range.

501. But as there is still some disturbance unavoidable from every movement, and some irregularity in the withdrawing of the cloth, which the best adapted means cannot wholly obviate; and as in fine textures the beauty of the work depends on fine touches, the cord should be employed; and it will be found, if it be properly managed, to have a beneficial effect in spreading the weft and giving a good skin or clothy appearance to the web, in proportion as the work increases in fineness.

502. In applying the loom to muslins, the skill of the mechanic, as to his knowledge of weaving, is put to a severe test. It is not enough that he have such a knowledge of the principles of the art as may be sufficient for calico and coarse weaving. His success in this nice and delicate department of the subject will mainly depend on his clearness of perception as to the relative strain which the yarn is capable of bearing in weaving, so as to adapt his means in accordance with its strength.

503. This ability to estimate resistance in this practical manner is of preeminent value in the origination and application of machinery to a subject so susceptible of strain as fine weaving: the talent of inventing itself, as applied to it, is useful only as it is under its guidance. This faculty, however, in the high sense in which we are considering it, is rarely possessed in such a degree as to be equally applicable to a great variety of fabrics. It may be well fitted for that to which it may have become accustomed, but it is generally inefficient, both in hand and power loom weaving, when applied to fabrics dissimilar either as to make or material. Hence the necessity of a division of labour as a means of cultivating this perception of force, both as applicable to the performance of motion and to the adaptation of it;—and the more so in some respects in weaving by power, as there is a tendency from the habit of handling machinery to blunt its sensibility.

504. Fine and coarse weaving by power, as by hand, should be under separate management, that the work may not suffer from the inadaptation of the means, which otherwise is certain to take place,

arising from an indistinctness thereby produced in the perception of the principles and practice of weaving, as applicable to each.

505. Fine weaving is especially dependent on the niceness in the fitness of the agency as applied to it, so as to prevent breakage and favourably effect the work. It is not enough that every thing injuriously affecting the yarn should be avoided;—the *art* of weaving must if possible be exemplified, in work of this sort, in the utmost state of improvement to which it can be carried.

506. Especial attention must, therefore, be paid to the position of the yarn in the loom—to the length of the stretch—the tension of the web—the manner in which it is supported by the roll, and kept in the direction of the stroke of the lathe—to the level of the heddles and their distance from the fell—to the thickness of the rods, that the yarn be as little as possible deflected by them, and to the distance at which they are kept from the heddles in working.

507. When these arrangements have been properly made, according to the theory and practice of weaving as already explained in reference to muslins, the next grand consideration is as to the performance of the motions; and the first great rule which must be carried out, especially in this sort of weaving, to the utmost extent, is that the size of the motions, especially that of the shed, must be the smallest that can be rendered sufficient.

508. All the arrangements in weaving must be made in accordance with this rule. The size of the shuttle,—the length of stroke of the lathe,—the

distance of the heddles from the fell, must be carefully attended to, as affecting it. The depth of the shuttle, as it chiefly determines the size of the shed, should not be more, especially for this sort of work, than is sufficient in weaving by hand—viz. a full half inch. But its weight in working by power, to act effectively on the protector, should be a little more than is necessary in hand weaving. Its length and breadth should likewise for the same reason be proportionally greater.

509. The quality of the motions, as effected by the springs, is wholly uninfluenced by the motive power; and as their action is susceptible of the nicest regulation, the tools or weaving implements through which they effect their purpose are capable of being made as the work requires them. Adaptation can thus be carried to the utmost, so that practically speaking the two agencies of hand and power are thus assimilated in action.

510. In setting the machine to perform the motions conjointly in shuttling, so as to save the yarn, the great rule that the shed is to be started at the stroke of the lathe on the fell must be carefully and well exemplified in working.

511. The importance of this rule as a means of saving the yarn is not appreciated, or rather is not known; and, is therefore, loosely acted on, as a matter of convenience, both in hand and power loom weaving. But so great is its value, that, all other things being as they ought to be, the success of the weaver may be estimated from the manner in which he acts upon it in practice.

512. But although the motions in weaving may be performed in a manner altogether faultless, and the position of the yarn in the loom the best for sustaining and avoiding strain, there is still another consideration connected with the yarn of essential importance to success in muslin weaving, both as affecting the quality of the work and the quantity—namely, the state in which the yarn is submitted in the loom to the operation of weaving.

513. Two conditions are included in the state of the yarn as fitted for fine weaving. It must be properly dressed, and it must be in a proper state as to elasticity in being woven. It must neither be impaired by insufficient dressing, nor by *brittleness* as affecting it in the working. Both of these conditions must be secured to the yarn, so as to fit it for doing what is required of it in fine weaving.

514. The elasticity of the yarn is preserved, in weaving by hand, by the dampness of the atmosphere in the shop in which it is wrought. On this account a ground floor is universally used as the only kind of housing adapted for fine weaving, and it is endeavoured as much as possible to keep it from being affected by the changes in the atmosphere without. For this reason the floor is generally the bare earth.

515. Frost and drought act very injuriously on the yarn,—both, in preventing it from taking on the paste, and especially the latter, in rendering it very brittle after being dressed.

516. Many weavers, with the view of preventing these injurious effects, use paste which has been weakened by age and impregnated with some salt,

generally common salt. But this is a bad practice; the yarn is thereby injured by the want of strength from the weakness of the paste; and as it is kept in a clammy state by the salt, it never acquires a proper degree of firmness to render it sufficiently elastic in working, so that the heddles and reed get clogged with refuse from the yarn. Hence the yarn suffers an increased strain in weaving, with a diminished strength to sustain it.

517. As the drought acts injuriously on the yarn in being dressed, by depriving it of the necessary moisture to fit it for uniting with the paste, the remedy is simply to supply it again as it is wanted; and this is effected in hand loom dressing by merely wetting the brushes slightly with water before commencing to use them in dressing. This practice, although perhaps not known, is highly beneficial; and if properly done, is attended with the desired effect. As the yarn in the hand loom is worked in immediately after being dressed, this is done, when the shop is good and the weaver clever, before it gets time to become hard and brittle by exposure to the air.

518. But this method of working up the yarn immediately on its being dressed is not practicable by power, nor is it necessary; as the yarn will keep in a dressed state for any required length of time, the object is the simple one of bringing it back to a damp state, as it comes from the beam, in being woven in the loom. This can be easily effected in a variety of ways; by steam,—or merely by a damp woollen cloth, made continuous by passing it over two rollers in contact with the yarn; the one of which

may be the wheep-roll, as already used, and another may be put up at the yarn beam for that purpose.

519. As heat in the air of the room is not at all injurious to the yarn, provided there is a superabundance of moisture with it, it should be such merely as is sufficient to render the place comfortable to the workers.

520. The yarn can thus, according to a variety of modes of managing it, be kept in the required condition for working better than if it were dressed and woven in the hand loom. But although the yarn can be managed in the loom as it ought to be for fine weaving, the great consideration is as to the dressing of it,—and the question is, Can the dressing machines as already used, properly prepare fine yarn for weaving? The answer is *No.*

521. But this answer can be rendered intelligible, so as to lead to the improvement of the machines, only by an examination of their action as it affects the yarn, compared with what is required of it in effecting the process according to the principles as already explained in considering it as performed by hand, and applied in dressing by machinery.

522. We have observed that the object of the mechanical means in dressing, is to lay the surface filaments of the yarn in the line of the thread, and secure them in this position in an effectual manner by the application of some paste, with the least possible waste of the strength of the yarn :—and the means will be successful only in so far as they accomplish these objects.

523. Brushes and the application of the common

paste effect the object sought in the process as to the laying and the securing of the filaments; and the question that requires to be considered is as to the manner in which these actions are performed by the machinery as affecting the yarn.

524. The action of the brushes on the yarn is merely a means of traction effecting their object by drawing or spreading a portion of the paste along the surface of each individual thread; and their effect will therefore be proportional to the quantity of motion in the direction of the threads from each point or hair of the brush in contact with the yarn.

525. Now in the circular dressing machine the action of the brush is not in the direction of the yarn, except at that point at which it is perpendicular to the warp, when its action is rectangular; and as this action bears a small proportion to the sum of the oblique action, the required action in the direction of the yarn is very imperfectly produced; and what little effect it has in the laying of the fibres, although it is assisted in a small degree by the motion of the yarn itself, is produced with a great waste of the strength of the yarn.

526. At best this mode of brushing is merely an approximation towards the required action. And where merely something like a direction is all that is intended to be given to the fibres, from the process partaking more of the nature of sizing than dressing, it may be used with advantage, from the facility with which it can be applied.

527. Hence in the Tape sizing machine a small rotatory brush is used, and, very properly, at a very

slow speed. But its effect is increased by the motion of the yarn in passing through it, being as four to one compared with that in the crank or cylinder dressing machines. Where, however, the yarn from its fineness requires all the aid which it can receive from the incorporation of the surface filaments, and with the least expenditure of its own strength in the process, circular brushing, from its severe and ineffective action, is unfitted for the work.

528. The brushes to effect what is required of them must move in the direction of the yarn, and their movement must be accompanied with the least possible disturbance to it. But this is not the case with the movement of the brushes in the crank dressing machine. Although their motion is in the plane of the yarn, their movement is disturbed and tremulous in a high degree; and, from the manner in which the motion is produced, it cannot be otherwise. The brushes, we have seen, are placed to slide in the direction of the yarn on a spindle and eye, and the motion is communicated to them by means of straps.

529. Now all motion from straps, horizontally placed especially, is attended with vibration arising from their own vibratory action in working; and in this case, the brush is placed in a manner very liable to be affected by this action. The connection of the straps to the sliding eye is not quite in the line of the spindles, and there is, therefore, some disturbance from this arrangement at each change in the direction of the stroke, which the shortness of the distance from eye to eye in the breadth of the slider is

not fitted to prevent. And it is evident, as there must be some looseness between the eye and the spindles which is increased in working, the brush is thus in a condition in which the communication of the vibration from the belt is unavoidably transmitted to it in the course of its stroke.

530. But the movement of the brush is liable to still further injury from the manner in which the crank communicates its motion. We have seen that the throw of the crank is five inches, and that the length of stroke of the brush is about twenty. The power is therefore imparted to the brush-lever at a fourth of its length from the fulcrum; and as the vibration which this arrangement of leverage is in a condition to impart to the brush, is as the square of its length divided by that of the distance of the power from the fulcrum, the sum of disturbing influence with which it is charged, and which the brush is in a fitting condition to receive, is as 4 to 16.

531. The movement of the brush would be considerably improved by increasing the throw of the crank;—indeed no communication of motion in similar circumstances, to effect a tolerable movement, should be imparted at less than two thirds of the length of the lever from the fulcrum. But the means for producing the movement are altogether indifferent.

532. We have observed that the traction in brushing is proportional to the motion and the quantity of brushing surface exposed to the yarn; and, therefore, the effect of the action of brushing on the yarn is as the sum of these two quantities.

Hence to bring out the greatest quantity of work which the brush is fitted to dress, the velocity of its motion should be proportioned to the strength or grist of the yarn.

533. Now to gain the utmost advantage from the motion of the brush, its stroke should be as long as the yarn is well fitted to bear in working; so that it may be attended with no unnecessary ruffling of the threads in entering and leaving the warp.

534. Twenty inches is much too short a stroke for effective action on calico or coarse yarn. Time is lost in working with it by the number of turns unavoidable from it in changing the direction of the brush at the commencement and end of its stroke; and its effect is impaired by the amount of oblique action with which it is attended.

535. In hand weaving, yarn much finer, and of inferior quality, can well stand a stroke of three feet in dressing; and in dressing by power, the stroke of the brush on calico yarns, to do what it is fitted for effecting, should not be less. In adopting a full length of stroke for the brush, the yarn, if the process is properly done, is improved under it, as it should be thereby rendered firmer and drier as a preparation for the fan; and, therefore, less liable to be ruffled from any necessary handling in passing to the beam.

536. But not only is the stroke of the brush much too short, but the motion of it is likewise much too slow. Forty-five strokes a minute may be about the average speed of the brush in the crank dressing machine, although the yarn which the ma-

chine dresses is well able to stand the double of this speed in brushing.

537. Forty-five three feet strokes may be about the velocity at which the brush should be worked on yarn of this sort, to turn out what it is capable of producing.

538. But the machine is not in a condition for maintaining this action, either with advantage to itself or to the yarn, and a lower rate of working is necessary, as advantageous to both. Hence the production of the machine is greatly less than by a proper application of the means it is fitted for dressing. The brush, as worked on spindles in this manner by belts, is ill adapted for steadiness of action, and it is as ill fitted for speed in motion.

539. Attempts have been made to improve the action of the brush by the substitution of another arrangement of means for working it. Fig. 46 is

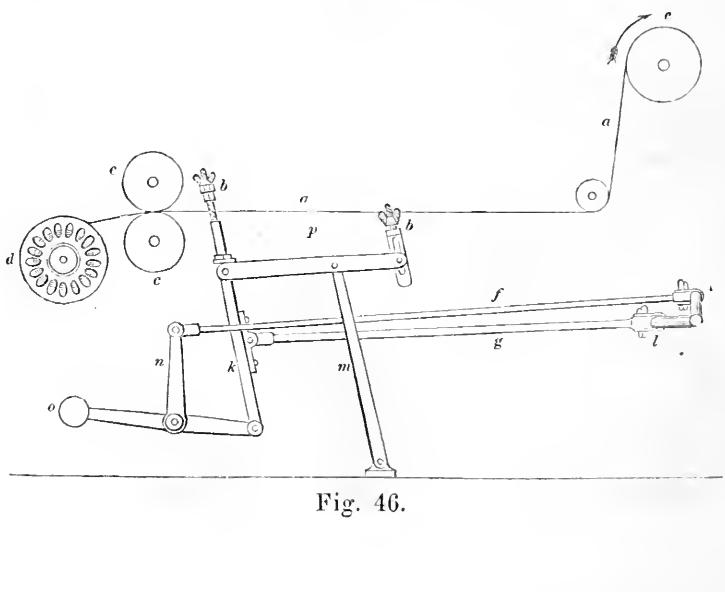


Fig. 46.

a representation of a mode of brushing in which the horizontal or stroking motion of the brush is effected by jointed levers. *b b* are the ends of the under and upper brushes; *a* is the warp line; *g* refers to the connecting rod for giving the stroking motion to the brush, as applied to the levers *k m*, from the crank *l*; and *f*, to that for raising the brush out of the yarn by the rectangular lever *n*, counterbalanced by the weight *o*.

540. This arrangement of means is objectionable on account of the number of moving parts essential to the primary motion. Simplicity is the life of mechanical action. But this arrangement of leverage, when fully resolved into the simplest modification of which it is susceptible for effecting the required action in brushing, presents itself in the form of a carriage with four wheels fitted to run on rails.

541. The brush is placed at the ends of the carriage, and of course transversely—extending from side to side of the web; and the rails are fixed on their respective sides of the machine framing in the plane of the yarn opposite each other, where the brushes are to act on the warp.

542. The carriage carries the brushes in the direction of the yarn, by being made to run on the rails, and the motion for this purpose is communicated to it from the crank. The length of the rail is, of course, equal to that of the stroke of the brush; and as its form guides the brush in entering and leaving the warp, the rail is made inclined at each end, as seen in the longitudinal section of the machine for dressing fine yarn, as invented by the

author, Plate XVII. A A is the machine framing; *a a* the carriage; *b b* the two brushes, placed singly at each end of the carriage to act on their respective portion of the warp; *c c* is the warp-line; *d d* the rails; *e e* the crank-lever; and *f* the connecting rod between the crank-lever and the carriage.

543. Thus it is evident from this arrangement, that the brush is carried with the carriage by the motion of the crank *g*, in the plane of the yarn. But as it must brush in one direction only, and its action must, therefore, be alternately in and out of the yarn, it is raised at the termination of the stroke by the inclination at that end of the rails in the direction towards the reels, so as to clear the warp before commencing to make the return stroke.

544. Now the return stroke is made on moveable rails put up for that purpose; and as they bear the carriage so as to clear the brush of the yarn, they are set accordingly, to act in a higher plane, as seen in Plate XVII. *h h* are the moveable rails placed with their axles under the carriage wheels vertically, so that when the carriage rises on the inclination at the end of the fixed rails, above their level, they fall in under the wheels; and are thus in a condition to bear it at the required level over the yarn.

545. The moveable rails are kept in their vertical position, and fitted for acting in this manner, by being furnished each with a short loaded rectangular arm set on their axles so as to keep the rails steadily against the side framing in the way of the wheels; or the same effect is accomplished, as represented in Plate XVII, by the springs *i i*.

546. But as the ends of the carriage must work alternately on their respective fixed and moveable rails—on the fixed rails in moving towards the reels, and on the moveable rails on returning from them—this alternate action is effected by the manner in which the moveable rails are withdrawn from under the end wheels of the carriage to which they respectively belong.

547. This alternate action of the moveable rails is effected by the wiper shaft which is placed near each end of the machine framing, as in the crank machine, so as to act alternately on its respective pair of moveable rails, and, by withdrawing them when the return stroke has been completed, allow that end of the carriage to descend with the brush into the yarn so as to act in the required direction towards the reels.

548. The tire of the carriage wheels *k k*, accordingly, should be broad enough to extend over both rails, as seen in the plan, Plate XVIII; and formed so as to act on each—grooved for the fixed rail, and flat for the moveable rail, to admit of its lateral motion from the wheel; and to guide the end of the carriage in passing over by it, the side of the groove in the middle of the wheel should be left as a flange to keep it steadily on the line.

549. The end of the carriage on the return stroke is thus kept steadily on the moveable rail, and does not quit it till it has reached the fixed rail, when it is again withdrawn to descend into the yarn. The wheels of the carriage, to prevent it from being disturbed by their looseness, should be well fitted;

and it would perhaps be better, as it is attended with more stability of motion, to mount them on pivots rather than centre pins.

550. The motion of the brush, by this arrangement for working it, is steady and fluent to a degree unequalled by the best hand brushing, and it is therefore applicable either to coarse or fine yarn.

551. The mode of working the carriage in a similar manner was in use in Lancashire before, I believe, the author's attention was directed to the subject. But I have not had an opportunity of seeing it, and am uncertain of the manner in which it is applied. I understand, however, that the ends of the carriage are raised alternately out of the yarn, by the action of eccentrics, in a manner similar to the brush-frame in the crank dressing machines—a mode of movement unfavourable both to the stability of the brush, and to its action on the yarn.

552. The value of an invention depends on its adaptability to the subject. But ere its fitness can be appreciated, or properly brought out, the subject matter must be practically well understood ; and hence, as the great design of this work is to present the theory and practice of weaving combined in such a manner as to assist the manufacturer in the selection and application of his machinery, in accordance with the principles of the art, the mere history of the agency is quite a secondary consideration.

553. In no part of our subject is the right application of the means of more importance than in dressing. If the brushing is not effective, no management can render the process successful. For

this purpose, brushing should be performed with the least amount of friction necessary to lay the fibres, and hence, double brushing acting alternately on opposite sides of the warp, is necessary to turn out the greatest quantity of work which the increased effectiveness of the action can be made to produce; and it is besides advantageous, as it diminishes the friction to which the yarn would otherwise be exposed, from the extra action necessary to prepare it when finished altogether from the one side.

554. The double brushing, in the machine under consideration, is effected with two carriages *a a′*, seen in the plan, Plate XVIII, which act alternately on opposite sides of the warp. The lower carriage for the under brushing is driven, of course, from the crank formed on the opposite semi-diameter of the crank shaft.

555. The strokes are of course alternate by this means; and as the brushes may be worked at a sufficient velocity, without injury to the yarn or the machinery, the brushing, as to the velocity, and likewise as to the quality of the motion, is all that the yarn requires from it in dressing.

556. The quantity of brushing as necessary to the yarn, depends directly on the fineness of the reed in which it is to be woven, and the number of shots thrown on it in the glass, or in other words, on the amount of friction which it suffers in weaving. In common calico dressing, the yarn passes to the beam at the rate of about five-eights of an inch to each stroke of the brush. But in working with the carriage machine, according to the stroke and

velocity of the brush here recommended, the rate in the delivery of the yarn will be nearly doubled in corresponding qualities of work. In all cases the yarn passed to the beam should be proportional to the effectiveness of the brushing.

557. On the other hand, the quantity of paste, as necessary to the yarn, is directly dependent on its grist, and, therefore, in dressing coarse numbers at a high working speed, the difficulty in getting through the work will rest mainly with the means for drying it.

558. But the effectiveness of the brush must not be limited by the defectiveness of the apparatus for drying the yarn. Whatever be the quantity which the brush can be made to turn out, it must be dried in reaching the beam.

559. Now as the space in the machine between the dressing rollers and the beam, contains the two portions of yarn undergoing the two actions of drying and brushing, its length, as fitting it for these operations, must it is obvious be adapted both to the strength of the yarn, that it suffer no unnecessary strain in the process, and to the efficiency of the agency to act on the yarn, so as to get the utmost quantity from it which its strength can be made to yield.

560. Both of these portions of stretch are therefore limited by the fineness of the yarn. There must be a sufficiency of stretch for the stroke of the brush which the yarn is enabled to bear, and likewise for the drying of the yarn, in passing from the brush to the beam—but no more; and that it sus-

tain no unnecessary strain throughout the stretch, the process should be conducted in such a manner as to supply the yarn with increasing strength, for the successive action in dressing, from its commencement to its completion.

561. The action of the machine, in withdrawing the yarn from the reels to the beam as it is dressed, is highly favourable to this mode of conducting the process; and the manner in which the paste is applied by the rollers is likewise very suitable to it.

562. Each stroke of the brush is thereby made to act on a small additional portion of raw warp brought forward by the rollers, so as to prepare it for the increased action of the succeeding stroke, till it reaches the middle of the stretch, when the action again diminishes in the same ratio; and with the diminished supply of paste, especially when the stretch is a long one, the latter part of it is thus undergoing a preparation to meet the fan.

563. The process of drying must likewise be conducted on the same principle of progressive action. As the yarn is weak in a wet state, and there is a want of congeniality between the rapidly drying portion and the wet, inducing a tendency to plait or twist, arising from the contraction of the surface of the threads unequally by desiccation, there must be no strongly marked line between the wet and the dry portions of the yarn, in passing to the beam. The process, therefore, should be completed only when it reaches it.

564. Hence in bringing the fanner to bear upon

the yarn, in coming from the brush, the current of air from it should not be directed against a particular line of the warp, as was the case in some old machines, and is rather a favourite practice it seems in working with them in America, but diffused throughout the portion of the stretch set apart for drying, that there be as little unequal strain as possible thrown upon the yarn, in the traction which it suffers in passing to the beam.

565. That portion of the stretch, however, which is under the brush, must be carefully screened from the effects of the fan; and as the object of its action is to dry the yarn by the removal of the damp atmosphere from it, its velocity should not be very great, as it has a tendency when over driven to encircle itself with the same atmosphere, and thereby weaken its own effect.

566. The fan forms a very good link in acting on the yarn, between the brush and the steam-pipe. Heat must finish the process of drying coarse yarn; and its effect should be increased as it approaches the beam. For this purpose, the steam chests or pipes should be inclined towards the yarn in that direction, and if necessary the yarn should finally be brought in contact with some steam-heated surface, as it cannot then be injured by abstraction or abrasion of the paste, or otherwise, as it must already have been sufficiently secured in the previous part of the process.

567. Dressing is thus completed on the principle of progressive action throughout, so as to impart a gradual increase of strength to the yarn in its pas-

sage from the reels to the beam. This practice is of great importance as a means of saving the yarn from unequal strain; and in applying the machine to fine yarn this principle must be well exemplified. The utmost resources of the art must be drawn upon to save the yarn from all unnecessary strain, so as to be enabled to get the greatest quantity from it which its strength can be made to yield; and the utmost strength must be imparted to it, to fit it for weaving.

568. This manner of conducting the process affects, therefore, to secure two great advantages of essential importance to a high degree of success in fine weaving—viz. to supply the yarn with an increase of strength, as the draught is made upon it, for the necessary strain attendant on the performance of the process; and to leave the yarn in possession of the utmost strength which the process can impart to it, to fit it in the best manner for weaving.

569. All the arrangements, therefore, for carrying on the process must be made so as to effect this grand combination of purpose in dressing. The yarn must neither suffer unnecessary strain from the length of the stretch, nor from causes producing unequal strain throughout the stretch; 1st, from the deflection of the warp; 2nd, from the friction of the brush; 3rd, from the drying of the yarn; 4th, from the application of the paste; and 5th, from the motion of the machinery.

570. These are saving conditions valuable in so far as they are made to economise the strength of

the yarn; and next as to the means as directly imparting strength to the yarn. 1st, The paste made use of must be made of the best material, and used in the most fitting state as adapted for the yarn. 2ndly, It must be applied to it as the yarn requires it, 1st, as to quantity, and 2nd, as to the mode of applying it—it must be brushed so as to impart to the yarn the full benefit of its strengthening influence. And 3rdly, It must be dried so as to secure the benefit which the yarn has received.

571. As to the proper length of stretch for fine yarn, it may be observed, that, as the yarn suffers more from an undue length of stretch than from its being too short, it should be no longer than is necessary for effective brushing and drying. The object is to make the most of a stretch barely sufficient for these purposes, so as to get the greatest possible portion of it under effective action. There must, therefore, be no spare space in the stretch, and hence the brush in working should be brought as near the dressing rollers as convenience will permit it.

572. Now, as fine yarn is well able to stand a stroke of 20 inches in brushing, we shall have a length of stretch for this part of the process of two feet, measuring from the centre of the rollers to where the brushes commence to act on the yarn; and as fine yarn is easily dried, more need not be allowed for this action than perhaps two feet, making the whole necessary stretch which the yarn has to suffer from the beam to the rollers about 4½ feet. But the actual length, it must be observed, as most

beneficial for the purpose, must be finally determined by practice, and varied with the fineness of the yarn.

573. This measurement, as given, confines us within about the narrowest portion of space compatible with effective action on yarn of this sort, with the view of saving it from unnecessary strain occasioned by over extension of the stretch; and that it may be saved from that arising from *deflection*, the warp must be kept as much as possible in a straight line from the rollers to the beam.

574. Now, as there must be some deflection, to the extent of half the diameter of the beam, unless the two portions of warp are placed on different levels, as is here done, the roll is interposed to keep the warp in the required direction; but as there should be as little interference as possible with the yarn, especially in a wet state, it is placed where it can least injure it in the contact with it. This is near the beam.

575. The yarn is thus supported in the required direction for the action of the brush, and as the success of dressing chiefly depends on its instrumentality, its action, as required in the process, must be well understood.

576. We have observed that the brush acts by traction in laying the fibres and the paste along the surface of the yarn, and of course the friction of the traction from it in the operation should be adapted to the strength of the material.

577. Now as the friction of the brush is as its velocity multiplied by the mass of bristles in action on the yarn, it may be diminished by diminishing its

motion. But as this mode of adapting the action of the brush to the yarn is attended with a proportionally diminished production, it must be resorted to as a qualifying means for this purpose, only in so far as is necessary when the adaptation of the brush itself has been rendered all that it ought to be, as to make and material, for the required action on the yarn.

578. Now the object sought for in adapting the brush to the twofold purpose of laying the fibres and spreading the paste, is strength of bristle sufficient to resist the cohesion of the paste without abrading or tearing the fibres of the yarn by its action in dressing. The brush should, therefore, have *strength* sufficient to spread the paste effectively, in a state as strong as the yarn can be made to bear it; and *elasticity* so as to save the yarn from all unnecessary severity from its action.

579. Strength and elasticity of bristle in due proportion are thus the proper qualities in the brush as fitted for going through the greatest quantity of work with the most ease to the yarn.

580. These qualities are obtained in adapting the brush for fine yarn, chiefly from the length of the cut. Its breadth for effectiveness in action should not be diminished; but it would perhaps be advantageous to increase the space between the two middle rows of staples from end to end of the brush, as a means by which its elasticity may be still further increased without weakening its effect in working; and to facilitate the entrance of the bristles into the yarn, they may be slightly ground at the points;

and when they begin to split by wear, they may be recut so as to adapt the brush for coarser work. The brush may thus be fitted with the required strength and elasticity for any quality of yarn, so as to prevent unnecessary strain upon it from its action.

581. Fine dressing is a delicate process, requiring for its successful accomplishment a nice distribution of the paste in connection with the action of the brush, to prevent abrading, so as to get the greatest quantity of work turned out by it, with the least possible action on the yarn.

582. Abrading or the stripping of the yarn in the dressing, can be effectually prevented only by proportioning the quantity and the quality of the paste to the action of the brush, according to the fineness of the yarn.

583. The quality of the paste is a very important consideration in dressing fine yarn. Too much attention can hardly be paid to it. As to the flour for it, care must be taken that it be of the best quality; and even of this quality there is a great difference in flour as fitted for making dressing. This difference is chiefly dependent on the relative proportion in the wheat of the three great constituent materials of which it is composed as necessary to the making good paste—namely, mucilage, starch, and gluten.*

* Several of the varieties of wheat, as well as other corn, have been chemically analysed; but the examination does not seem to have been directed with the view of testing all the varieties of wheat, as best fitted for making paste. But so far as it has been carried, it presents us with a great difference in the constitution of wheat, which quite accounts for the difference in

Some flours make a stringy fiery paste which is highly glutenous, but not freeable ; and as it is very

the qualities of the paste as made from it. The best American wheat flour is superior to every other sort which has yet been found for the purpose that we have in view, and I regret that I cannot present the reader with an analysis of it.

The following tabular view of the analyses of several kinds of grain is taken from Dr. Ure's Dictionary of Manufactures, article Bread, Page 173, 3rd edition :—

Species of Wheat.	Water.	Gluten.	Starch.	Sugar.	Gum.	Bran.	Total.	Water of dough.
French wheat flour	10·0	10·96	71·49	4·72	3·32	-	100·49	50·3
Hard wheat of Odessa flour - - -	12·0	14·55	56·50	8·48	4·90	2·3	98·73	51·2
Soft wheat of Odessa flour - - - -	10·0	12·00	62·00	7·56	5·80	1·2	98·42	54·8
Same sort of flour -	8.0	12·10	70·84	4·90	4·60	-	100·41	37·4
Same sort of flour -	12·0	7·30	72·00	5·42	3·30	-	100·02	37·2
Wheat of the French bakers - - - -	10·0	10·20	72·80	4·20	2·80	-	100·00	40·6
Flour of the Paris hospitals (2d quality)	8·0	10·30	71·20	4·80	3·60	-	97·90	37·8
Ditto (3d quality) -	12·0	9·02	67·78	4·80	4·60	2·0	100·21	37·8

The following table of analyses merits also a place here :—

Species of flour.	Water.	Gluten.	Starch.	Sugar.	Gummi-gluten.	Albumen.	Bran.
Flour of the triticum spelta	1	22·	74·	5·50	1·	1·50	
Ditto triticum hybernum	1	24·	68·	5·0	1·	1·50	
Ditto common wheat -	-	12·5	74·5	12·	2·	-	
Ditto wheat and rye mixed (mastlin) - - - -	6	9·80	75·50	4·22	3·28	-	1·2

The first two of the above analyses were made by Vogel, the third by Proust, and the fourth by Vauquelin.

Analyses of the flour of some other corns :—

Species of flour.	Starch.	Mucilage.	Gluten.	Albumen.	Sugar.	Husk.	Hordein.
White oatmeal - - -	59·00	2·5	-	4·30	8·25	Of a fat oil. 2	
Barley meal - - - -	32·00	9·	3·	-	Of resin, 2	-	55

The first analysis is by Vogel, the second by Proust.

difficult to spread, and generally wants body from a deficiency of starch, the yarn is injured by the action of brushing it, and comes from the process in a raw, bare, husky, and brittle state, very ill fitted for weaving.

584. Other flours, on the contrary, yield a paste the reverse of this as to quality, which is distinguished by body with deficient strength. The object sought for, in paste for fine yarn especially, is body and strength combined with the utmost mildness in its action on the yarn.

585. But the mode of making the paste very much affects its quality. The soaking of the flour well in water before making it into dressing, brings out its mucilage, and improves the glutenous quality of the paste by a thorough incorporation with the starch in the boiling. It tends, moreover, to temper its action on the yarn.

586. Fine yarn, when dressed, should be as pliant as possible—strong and well skinned, or clothed with the paste. A glutenous good body of paste is necessary for the clothing of the yarn in a proper manner to fit it for weaving, especially in a fine reed; and freeability, to effect the covering of the thread with the least waste of its strength in the process.

587. The qualities of the paste, therefore, as especially necessary for dressing fine yarn, are *body*, *strength*, and *freeability*. The last of these qualities is of great importance for work of this sort, and is very much affected by the manner in which the paste is prepared for use, after it is made. The

object sought, in the preparation of it for immediate use, is to break up the cohesion of the mass so as to facilitate the adhesion of the particles of the paste to the threads. In this respect the action of the dressing rollers in the machine is highly advantageous, as a means of preparing it both for the yarn and the brush. By their rotation, the yarn passes through a bed of paste in which the particles are so far individualized and comminuted, and thus put in the proper state for adhering to the threads.

588. The rollers are thus a good means both for preparing the paste and applying it to the yarn. But although a uniformity in the application of the paste is effected by them, a redistribution, to a certain extent, again takes place by the action of the brush; because towards the termination of its stroke it receives that portion of paste which has been brought forward by the advance of the yarn during the previous stroke, and applies it at the commencement of the succeeding one, where it is least wanted.

589. Now towards the middle of the stroke or stretch, according to this application of the brush, the yarn is receiving the least paste where it is sustaining the most action. This means, therefore, does not apportion the supply of paste throughout the stretch according to the action of the brush on the yarn; and in dressing fine yarn, abrading to an extent proportional to the irregularity in its distribution by this means is inevitable.

590. This defect must be remedied in the mode of conducting the process for dressing fine yarn, so as to prevent it from suffering any unnecessary

waste of strength from this mode of treating it; and the manner in which I have effected it, as seen in the longitudinal section of the machine, Plate XVII, is by making the strokes of the two brushes of unequal length—that of the under brush being about three-fourths of the upper one; and so placed in the machine that, from the greater length of its carriage, it may extend its stroke a little beyond the upper one towards the rollers, so as always to receive the loose paste, as the yarn brings it forward; and by applying it at the commencement of its own stroke, which will be about one-third from that of the other, the supply of the paste is thus apportioned to the action of the brushes throughout the stretch.

591. By this mode of working them, the yarn, as it recedes from the under brush, is receiving the action of the upper one, chiefly as a means of preparing it for the fan, whilst a quantity of paste sufficient to lubricate the friction of the brushes, so as to prevent abrading, and thereby render their action, as to effectiveness in laying the fibres, such as it ought to be, is thus obtained without the intervention of a separate means for effecting it.

592. By the yarn being thus strengthened under the brushes, and prepared for the fan, it is better fitted for passing through the copper plate with less injury to itself; and as it has little tendency to plaiting from this mode of treating it, the threads should be kept by it very little apart in drying, that the yarn be not strained by unnecessary deflection.

593. But it would perhaps be better to dispense

with the copper plate altogether, and substitute a needle frame consisting of at least two rows of copper needles, through which the threads should be alternately drawn as in the heddles; and by rendering the rows or leaves separately moveable, chiefly perpendicularly, the space between them could be increased or diminished according to the discretion of the dresser in working; and thus, by this means, any necessary raising of either of the leaves, to enter broken yarn or otherwise, would be attended with no ruffling, to that portion of the warp at least which is not attached to it.

594. Every precaution should be taken that the yarn suffer as little handling and friction in passing to the beam as possible; and to ensure the smoothness of the needle eyes, they should be previously used in a similar manner for coarse yarn.

595. The preservation of the yarn in the line of its own motion throughout, and especially from deflection at the copper plate, is a highly important object; and if properly effected, is a means of saving it from much unnecessary strain. Hence (for a similar reason) all the moving parts affected by the yarn should be made highly susceptible of motion. The friction plates of the beam for regulating the tension of the warp ought to be nicely fitted, as to their interposed surfaces; and the wooden rollers for measuring and leading the yarn to the beam would perhaps be as well to be mounted on centre screws.

596. The strain on the yarn in dressing is so much diminished by the dressing rollers being made to deliver it to the beam, that no dressing machine

for any quality of yarn should be made without this highly important motion. Any attempt, indeed, to dress on the old drag system, is merely working on the absolute strength of the yarn in defiance of art,—and although such a practice is out of use in this country, or nearly so, it seems to be highly popular and extensively used in America. Mr Montgomery, in his "Cotton Manufacture of Great Britain and America Contrasted," speaks of it with approbation, as preferable to those of this country. But this manner of stating the subject originates from a misconception of the object as sought to be effected by dressing.

597. The warp in these machines is divided into a number of parts (four in the machines as used at Lowell,) each being taken through a separate pair of rollers, and drawn forward from between them by the traction of the beam. The several portions of yarn in passing to the beam are dried by the fan and steam conjointly. The fan for this purpose is enclosed, except at the ends, and the upper side where its blast is directed against the particular part of the warp to be dried, as was the case here in some of the early practice with the dressing machine; and, to secure its being effectually dried, to get the quantity out of it, it is passed over a steam-heated cylinder.

598. The cylinder used in this manner is patented there by an American gentleman, Mr Batchelder, agent of the Saco Cotton Works, and is a good means, especially for coarse yarn; but the consideration of the other parts of the machine, as favourably affecting the production, is going back-

wards in the consideration of progressive improvement.

599. The yarn which these machines are applied to dress is coarse—from 10^s to 20^s, for heavy domestics; and as it requires little laying of the fibres—chiefly hardening, and is strong, the object is to make its strength subservient, in the utmost degree, to the bringing out of the greatest possible quantity of work with that preparation only which is sufficient to fit it for weaving. The tape sizing machine is, therefore, the proper means for preparing it for the loom; and thus, by throwing it aside altogether, a good method of starching may be obtained in exchange for a bad mode of dressing.

600. But, in dressing fine yarn, there is another part of the process so necessary to success in fine weaving—especially with a fine reed, that it must be done in a careful manner,—and that is *picking* the yarn before being dressed. This must be done by hand; and for that purpose the reels should be placed at a convenient distance from the dressing rollers, so as to expose a suitable portion of the warp to the eye, that the *lumps* and especially the *snarls* may be detected before they reach the dressing rollers.

601. It might perhaps be beneficial to make the reed which is used for guiding the yarn into the rollers act as a detector, by making it much finer than the reed intended for weaving it, so as to break the threads by the lumps; and, as a means of preventing the yarn in breaking from springing in against the dressing rollers, a small round rod may be laid on the warp between them and the reed for that purpose.

602. Thus the dressing machinery which we have been considering, as applied to fine yarn, is merely a better and a nicer adaptation of the same or a similar means than what may be necessary to coarse yarn; but its application must be guided by a full knowledge of the subject, so as to adapt the means in accordance with the art, to the relative strain which the yarn is capable of bearing.

603. In this manner, by adapting the machine and the material to the work, any quality of yarn, however fine, may be dressed, and in a superior manner to what can be effected by hand. Hence dressing machines differing from each other in the principle of their construction are not necessary for dressing any quality of yarn, but differing merely in the adaptation of their means.

604. The Carriage machine is well fitted for dressing any kind of yarn, fine or coarse. But as the numbers descend to perhaps below 20s—where hardening is the chief object sought as fitting the yarn for weaving, the end will be cheaper effected by using a starching means for that purpose—the tape sizing machine. In this machine, as the yarn passes through boiling paste, the essential oil in the cotton, as well as that which it imbibes in the spinning, is dissipated by the heat, and the paste sinks into the heart of the thread, saturating it to the utmost; but as the strain which the yarn suffers in passing through it, is great, the coarser the yarn is it is obviously the more peculiarly adapted for this machine.

605. The dressing machinery is thus adapted to

all qualities of yarn, cotton and linen, as a means of preparing it for the loom, and in a manner so as to effect what the manufacture requires of it. It is, therefore, fitted as it ought to be for working in conjunction with the power loom ; so that muslins, checks, pullicates, ginghams, calicoes, heavy domestics, and goods that require little or no dressing, such as canvass, sail-cloth, and silk and woollen makes, which are not affected by it, are brought within the range of the power loom, in the view in which we have been considering it, so that all fabrics coming under the denomination of plain weaving are thus within its reach.

606. The object sought, in the adaptation of all the means throughout, is to get the greatest quantity and best quality of work turned out at the least cost. The dressing, in work in which that process is of primary importance, must be well done, to obtain either quantity or quality of cloth. In muslin weaving the work can neither be clear, nor gone through with in a workmanlike manner otherwise. The selvage, if the yarn is not well dressed, is certain to be bad—purled from the roughness of the warp preventing the weft shot from catching it—whatever other faults the work may have ; and this in a description of goods which is chiefly tested by the appearance of the cloth there, renders it in a great measure unsaleable.

607. The web, besides, from the yarn being too lightly dressed, has a rough, woolly, and loose appearance—wanting the clear, tight, glossy, and well skinned or silky look of a well dressed and well

woven piece. The weft, from this condition of the yarn, is not sufficiently straightened in weaving. But *purling* may nevertheless take place in a small degree, however well the yarn may be dressed, from weaving with the weft too dry; and *softness* in the appearance of the cloth, from the pirns being too loosely wound. In muslin weaving, the weft should always be used in so damp a state as to tighten the selvage by the increased friction which it thereby acquires in coming off the pirn, and through the shuttle-eye; and to give a firmness to the weft throughout, it should be wound on the pirn with as much tension as the yarn can well bear.

608. We have observed, in treating of hand weaving, that the uniformity in the tension of the weft shot is affected by the size of the pirn, and the form in which the weft is wound on it, and that, as the manner in which this process is performed may affect the safety of the weft shot, and, in a small degree, the evenness of the work, the winding of the pirns as they ought to be is an important auxiliary process to weaving.

609. They may be wound in a proper manner by hand certainly, but this means of production is uncertain, and so liable to great inequality in the mode in which the work is done, that it is quite unsuitable to weaving by the power loom. Machinery is the only means for effecting the process in a manner so as to accomplish all that the power loom requires of it; and in this respect the cope winding machine in common use is a good means for the purpose. It is capable of making a hard and well

built pirn, and is applicable to any quality of yarn.

610. In yarn, however, where the fibres are smooth—such as silk and linen, and in very coarse yarn, as in sail-cloth weaving, the shot must be prevented from purling by the intervention of some means to hinder it from flowing too freely from the pirn, as already noticed in weaving by hand. But the means for doing so must be more effective for power loom weaving than is merely sufficient for the purpose in weaving by hand. A few tufts of hair fixed in the shuttle in the direction of the thread, as in weaving by hand, effects the object in the common qualities of yarn of this sort; but where the weft is both very coarse and very rigid, as in sail-cloth work, this means is not sufficiently effective for the purpose. Nor is the method in common use, of preventing it by the roller placed in the line of the shuttle-eye, unobjectionable, as it acts in an irregular and jerking manner. But if the traction were made continuous, and according to the strength of the yarn, it would be as the shot requires it; and such a kind of action is precisely that which results from the drawing of the thread through between the staples of two brushes clasped together. In this case a few strong staples fixed in the sole of the shuttle between the eye and the pirn, in the line of the thread, with a few staples above them attached to a spring-presser, jointed like that of the pirn skewer, to keep the bristles in contact and the thread between them, would give quite the kind of traction for strong yarn of any sort, to prevent it from purling. The upper

bristles may, indeed, be unnecessary, as sufficient friction may be obtained by adapting the under ones for the purpose, and using the presser merely as a means of keeping the thread in contact with them in passing to the eye, as seen in Fig. 2d, Plate XVI. *a* is the presser, formed where it meets the thread into an oval ring through which the weft passes to keep it in the right direction; *b* is the under staples; and of course the friction of the weft is regulated, by the strength and numberof the bristles, as required to prevent purling.

611. The kind of housing as best fitted for a weaving factory is a matter of importance. It should be such as is best adapted for preserving a uniformity in the temperature of the air within, that the yarn may have the best chance of being thereby kept in a mild state for weaving, and admitting of an arrangement in the machinery the most convenient for the workers with the least expense or cost in the building.

612. In all these respects a ground floor, as in weaving by hand, is the proper one for the purpose. It is accessible—well fitted for obtaining the stability of motion in working with such machinery—and above all, it is the only one adapted for preserving in the best manner that equality in the humidity of the atmosphere so beneficial to the yarn in working.

613. In cases, therefore, where the situation admits of the necessary ground for building the factory, so as to receive all the looms on the ground

floor, no upper apartment should be taken for cotton or linen weaving. But where this arrangement cannot be fully carried out, the heaviest and the lightest work, if there are extremes in the fineness of the cloth made in the same factory—such as muslins and very heavy domestics—should be wrought on the ground floor. The former, because of the saving of labour with which it may be attended in to the workers, and likewise for the advantage an engineering point of view, in having the heaviest machinery and greatest mechanical action nearest the base of the house; and the latter, because although the machinery may be the lightest, yet the advantage to the yarn, by its being better preserved in such a situation from the changes in the atmosphere without, outweighs every thing else, and renders it, in the weaving of fine yarn, a matter of necessity rather than choice.

614. In large establishments, where spinning and weaving are carried on conjointly in the same premises, it is in general advantageous to have the weaving department in a separate building. This arrangement enables the manufacturer to have such a size of room as is most suitable to the looms for any kind of work which he may possibly want, and which he cannot have, with equal advantage to both kinds of machinery, by placing them in the same building.

615. The house must be such as admits of the best arrangement of the looms with the least expense of gearing as necessary to drive them. With this view the looms are placed, end to end, in parallel

rows extending across the breadth of the house, as seen in the plan of the Factory, Plate I, and in Plate XX, so that one drum-shaft drives two rows. The looms are, therefore, made right and left handed, that they may be placed back to back in the required position for being driven by the same shaft.

616. A drum-shaft is thus placed between each two rows of looms in the breadth of the house; and, as the shaft must be supported where it communicates with the looms, two rows are likewise placed together in the length of the house, as closely as the lathes will permit them, that four looms may be driven from the same drum—or what is better, from two drums, one placed on each side of the gallows, as seen in the plan, that the danger to which the straps are liable from the accidental breakage of any of them in the working, where so many are driven together, may be so far avoided.

617. As four looms are thus connected with the same part of the shafting, the width of the house, therefore, should be adapted for so many double rows of looms. Less than two such rows, or four looms, should not be thought of—from the increased expense attending the gearing for such an arrangement. But where the number of looms is considerable, the breadth of the house should be made to admit of eight or twelve looms or more, according to circumstances. Twelve is the arrangement as presented in the plan of the Factory, Plate I; and eight in the supplementary Plates, XIX and XX.

618. Several fine weaving establishments are arranged according to both of these plans. But

whatever plan is adopted, room enough must be given in the passages to the workers to go about their work. Less than two feet on each side of the double row of looms cannot be allowed, and supposing the middle passage for an arrangement of eight looms to be four feet, there will thus be twelve feet for passages, and, with seven feet for each loom —the usual width for yard wide work—the breadth of the house will be sixty-eight feet within the walls.

619. The length of the room again for a certain number of looms, will depend on their length and the space allowed for passages in front and behind them. The front passage should be wider than the back one, as it is there that the weavers chiefly require to be in attending to their work. Twenty or twenty-two inches may be allowed for the front passage, and about sixteen or eighteen for the back one; and if the length of the loom be four feet, such as represented in Plates V, VI, VII, and VIII, the space between the two drum-shafts will be eleven feet two inches. The room is made up of a repetition of this arrangement of looms, and the length necessary for the required number will be determined by the number of feet between each drum-shaft, with an allowance for the two end passages, and the number of repetitions necessary to include the whole.

620. The height of the rooms, as affecting the work, is of advantage chiefly as it affords a sufficiency of space between the drum-shafts and the looms. When the distance between them is too little, the strap is not readily transferred from

the one pulley to the other, and, therefore, the protector is not apt to be well answered. The height of the shafting from the floor, in the room as presented in the Plates, I, XIX, and XX, is fourteen feet, and is taken from a factory in which the gearing is well arranged. The room is a ground floor, as being the best adapted for the yarn and the most suitable for the machinery.

621. As the reaction from looms in working is irregular, the mill shafting for them must be heavy—much more so than is necessary for the work as calculated by the power required to work it. The common practice is faulty in this respect—the loom shafting, as commonly used, is made too light. Such a practice not only injures the machinery by the vibration with which it is attended, but it likewise injures the work, as it has a tendency to produce jesping, especially where there is some angular strain on the crank shaft as attached to the lathe.

622. Too much care can hardly be bestowed on the generally finishing of the machinery and the mill gearing, as to the bearings of the shafts and their bushes. The crank and wiper shafts of the the loom should not only be parallel to each other, but especial care should be taken that they be embedded in the plane of their bushes, so as to be as free as possible from angular strain. The bushes should, therefore, be opened up, after they are bolted in their places to their respective sides of the loom, with a widener run through them and extending from side to side, so as to fit them accurately for their respective shafts; and the drum-shafts likewise, for the same

reason, should be accurately placed on their respective bushes—parallel to the loom shafts; and turned throughout, so as to guard against any possible vibration from untruthfulness, either of the shafts or wheels, as to their centre of motion being out of their centre of gravity.

623. The admirable tools which are now brought to bear on machine-making render the making and finishing of machinery a very different sort of thing from what it was a number of years ago. The self-acting turning lathe—the planing machine—the boring machine—the slotting machine—and the wheel tooth-cutting machine, have become necessary to the machine-maker; and, therefore, the requirements of the trade are raised by the quality of the tools which they have to deal with. High finishing has thus become more or less necessary to all sorts of machinery.

624. But the tools are not only fitted to finish well at a small cost, but to finish accurately in either the large or the small departments of the trade. The loom, however, was long in being much effected by them. It was thought to be a sort of machine for which any kind of fitting was good enough—and it is only lately, comparatively, that a different opinion is taking hold of the trade. Weight in the parts of the loom and good fitting, we have seen, from the kind of motions of which weaving consists, are especially necessary to the effective action of the loom in weaving by power; and as turned shafting can be produced at so small a cost compared to the value of the work, that the additional price required for it is not a consideration

worth the attending to, the loom should have the advantage of it.

625. The diameter of drum shafting as proper for looms depends on several circumstances, but chiefly on the width of the house (according to the arrangement that we have been considering) or the length of the shaft—the make of the looms—the weight of the work or web—and the velocity at which the looms are driven. The tendency of the shafting to twist by the action of the power and the reaction of the machinery, will be of course directly as its length and inversely as its diameter. And hence the rule for shafting, as acted on by engineers, is—multiply the power in lbs. by the length of the shaft in feet, and the leverage in feet, divide the product by fifty-five times the number of degrees in the angle of torsion, and the fourth root of the quotient is the shaft's diameter in inches.

626. The drum shafts, for the plan of the factory as presented in Plate I, strike off from the lying shafts with a diameter of two and a half inches, which dimimishes proportionally at every range till at the last it is one and three-fourths. The looms which they drive are light calico ones—speed 120 or '30, and this shafting, it must be admitted, is sufficient for them. The lying shafts are six inches in diameter. But it should never be overlooked by engineers, that the shafting, for looms especially, should in every case be rather too heavy than too light.

627. The cost of a weaving shed such as that presented in Plate I, may be estimated at about 22s. the square yard, including ground, and the gearing at £2 10s. per loom.

The looms for light calico may be £9 each, or including what is necessary to complete them for work, perhaps £10. If they are made for heavy work, such as that presented in Plates V, VI, VII, VIII, the price will be about £12 each.

The complement of dressing machines as necessary to the looms will vary with the work, according to its thickness and the fineness of the reeds, or as the yarn may require more or less dressing to fit it for weaving. For common calicoes, in the usual way of working, a machine may dress for twenty or twenty-five looms. The price of the crank dressing machine is £45, and of the cylinder a pound or two less.

The power required to drive the looms is as their speed, make, and the weight of the work to which they are applied. One horse power is sufficient to drive ten common calico looms at a good speed—120 or '30—with preparation, that is, dressing, warping, and reeling. The cost of steam power from a condensing engine will be about £2 10s for each loom.

A reeling machine should be sufficient for fifty looms, and a warping machine for an equal number. The reeling machine will cost about £7, and the warping machine £17.

The cost of the factory as presented in the plan, Plate I, may therefore be estimated as follows:—

Housing and Ground, about 3600 square yards,	£3960
384 Looms, ...	3840
Condensing Steam-Engine, 38 horse power @ £25,	950
Shafting, ...	950
Dressing Machines, 16 @ £45 each, ...	720
Warping and Reeling Machines, 10, ...	240
	£10,660,

Exclusive of Gas Fittings, Steam Pipes, Leather, Furniture, &c.

628. A thorough knowledge of weaving is invaluable to the manufacturer by power looms. It forms the stock in trade on which his success in the making of cloth directly depends; and on that account the principles and practice of the art have been deduced in the previous part of the work with a care in some measure proportionate to their importance.

629. But there are other matters connected with a weaving establishment, either by hand or power looms, which are not, strictly speaking, included in the art of weaving, although essential to the general success of the business. Such as—

First,—The selection of the yarn and the setting of it to the reeds so as to produce the required fabric of cloth.

Second,—Calculations connected with the work.

Third,—The warping or preparation of the webs, and the adaptation of the work to the looms so as to keep them a-going with the hands at the fabrics for which they are best fitted.

Fourth,—The management of the hands so as to employ the skill which they possess to the most advantage.

630. A large manufacturing establishment should present in the whole combination of its operations, an epitome of the principles of political economy. Its professed object is to turn out the greatest produce at the least cost. Its agency and means are, therefore, to be the best and the cheapest. But in many cases the exemplification of the principle is restricted to the cheapest as to money price that can possibly be worked with. The labour is sup-

posed to be cheap if it be purchased, in any circumstances, at the lowest rate; and from the same mistaken policy, the machinery is good enough if it can be got for little money. In many cases, accordingly, the looms are hardly worth house room. Nor does it seem to be sufficiently considered that under-paid labour inevitably weakens the recoil of individual energy, and that in every case a narrow niggardly economy defeats its own object. Articles insufficient for the purpose are dear at any price—no management can render their employment profitable.

631. In the selecting of the yarn for manufacturing purposes, a greater error can hardly be made than the preference of indifferent to good yarn for the difference in the price. Such a practice is inevitably attended with faultiness in the workmanship, and increased waste of stuff in the working of it up.

632. The yarn, to be used with the best economy, should be adapted to the work required of it in the weaving. Fine yarn for overwefted work in fine reeds, should be of the best quality that can be made, and so should very fine yarn for any reed.

633. But there is a great difference in the quality of the best yarn as produced, even by the best spinners, at different times, dependent chiefly on the selection of the raw material. In spinning, the selection and preparation of the wool are almost every thing. Those, therefore, who have large establishments, and make extensive purchases of the raw material, from which they can select the best that can posssibly be had on all occasions for

fine spinning, by disposing of the inferior sort for coarser purposes—such as Mr Thomas Houldsworth of Manchester—possess advantages in the making of the article with which it is hard to compete. The yarn, accordingly, which Mr Houldsworth produces is perhaps unequalled, and it has long maintained this very high character. It is remarkable for the uniform goodness of its quality.

634. The yarn is made up for the cloth manufacturer in measured quantities, and numbered as an index to its fineness according to the weight of a given length of its thread. The measure for cotton in universal use is a reel whose circumference is one and a half yards = fifty-four inches. That for linen, as fixed by act of parliament, is two and a half yards, = ninety inches. For woollen, the reel is usually two yards, = seventy-two inches. For silk, the cotton reel is generally adopted; and for yarn of a mixed make, sometimes one measure, and sometimes another seems to be used in the making of it up.

635. The portions reeled are known by different names as containing a certain number of yards; those for cotton are as follow:—

One circumference of the reel = 1½ yds. = one thread.

80 Threads	=	1 Skein	=	120	Yds.
7 Skeins	=	1 Hank	=	840	—
18 Hanks	=	1 Spyndle	=	15,120	—

The spyndle is the highest denomination of yarn, and is made up of separate skeins tied together in a cluster to form the hank. Twenty of these are put together to make a head of yarn in bundling it for the market. The fineness of the yarn, however, in cotton, is always indicated by the number of hanks in the pound weight avoirdupois.

636. For linen, again, the circumference of the reel is $2\frac{1}{2}$ Yds. = 1 Thread:—

120 Threads	=	1 Cut	=	300	Yds.
2 Cuts	=	1 Heer	=	600	—
3 Heers	=	1 Slip	=	1,800	—
2 Slips	=	1 Hank	=	3,600	—
2 Hanks	=	1 Hesp	=	7,200	—
2 Hesps	=	1 Spyndle	=	14,400	—

Fine linen yarn is counted by the leas or cuts in the pound; and the coarse, such as is used for sail-cloth and canvas fabrics, by the spyndles in the pound, or the pounds in a spyndle.

637. The woollen spyndle is divided into 24 heers of 600 yards each; and the yarn is sized and counted, as in coarse linen, by the weight of the spyndle.

638. The reeds in which the different fabrics of cloth are woven, differ as to the scale to which they are made in different places, and even in the same place for different and similar kinds of work.

639. The Scotch, that is to say the Glasgow manufacturers, make their muslins and all their cotton goods in reeds made to the scale of thirty-seven inches = their yard; and the reeds, as well as the webs woven in them, are counted by the hundred splits in that measure. Thus, what is called a six-

teen hundred (written 16^{oo},) is the number of splits in thirty-seven inches. The difference between one hundred and another is called a set. The reeds are, however, frequently made to half sets; that is to say, so many hundreds and fifty more in the same space. In the last case it would be called a 16^{oo} and a half.

640. In the Scotch linen manufacture, the scale generally used, especially for coarse makes, is thirty-six inches. Thus a sail-cloth may be wrought in a 3^{oo} reed, which, of course, refers in every case to the number of splits in the scale, without any reference to the number of splits in the breadth of the web.

641. The muslins of Manchester are wrought in reeds made to the same scale, thirty-six inches, but counted by the number of threads in an inch. Thus an 130 Manchester Jaconet means 130 threads in the inch, and is equal in fineness to a Glasgow 24^{oo} and five splits more. This scale of reeds is called the Stockport count. The other cotton goods of Manchester, however, are usually made to the scale of $24\frac{1}{4}$ inches; and counted by the number of beers in that measure. The beer is twenty dents or splits. This scale is called the Manchester and Bolton count. Thus 50, according to this scale, is equal to a Glasgow 15^{oo} and twenty-five splits more.

642. The hundred splits in all kinds of reeds is nominally divided into five equal portions for the sake of calculation, called porters in Scotland and beers in England, each porter consisting, of course, of twenty splits. The English beer and Scotch porter are, therefore, synonymous. In the flannel

manufacture of Rochdale, the beer is but 17 dents, and the work is counted by the number of beers in 36 inches.

643. The following Table exhibits a comparative view of the Scotch thirty-seven inch reed with the two English counts. The first column contains the hundreds in the Scotch reed, the second the splits or dents in an inch, the third the beers in the Manchester and Bolton reed of 24¼ inches, and the fourth the threads in an inch, according to the Stockport count :—

Hundreds.	Splits in an inch.	Manchester and Bolton.	Stockport.	Hundreds.	Splits in an inch.	Manchester and Bolton.	Stockport.
5^{00}	13	16½	26	18^{00}	49	59	98
6^{00}	16	20	32	19^{00}	51	62½	102
7^{00}	19	23	38	20^{00}	54	65½	108
8^{00}	22	26	44	21^{00}	57	69	114
9^{00}	24	29½	48	22^{00}	60	72	120
10^{00}	27	33	54	23^{00}	62	75½	124
11^{00}	30	36	60	24^{00}	65	79	130
12^{00}	32	39½	64	25^{00}	68	82	136
13^{00}	35	42½	70	26^{00}	71	85½	142
14^{00}	38	46	76	27^{00}	74	89	148
15^{00}	41	49	82	28^{00}	76	72	152
16^{00}	43	52½	86	29^{00}	79	95	158
17^{00}	46	56	92	30^{00}	82	98½	164

644. The art of adapting the yarn to the different sets of reeds, so as to make fabrics of different fineness, proportional to each other in the relative degree in which the reeds differ from each other respectively, is called setting, caaming, or sleying. The reed, or as it is called in the woollen manufac-

ture, the sley, is the measure, and the relative grist of yarn for different sets of reeds is the proportion sought.

645. Now as the threads are cylinders whose bases are to the measure of the reed, to produce a relative closeness of texture, as the squares of their diameters, the rule will be that—As the square of any given set of reed is to the grist of yarn as adapted for that reed, so will the square of any other set of reed be to the grist of yarn for making the same fabric. Thus, for example, if a 16^{oo} Jaconet is made with yarn No. 130, what number should be used to make a similar fabric in an 18^{oo} reed? In this case the question is one of proportion direct,—16 is to 130 what 18 is to the number sought. The square of 16 or 16 multiplied into itself is 256, and that of 18 is 324. The operation will, therefore, stand thus—

$$16^2 = 256 : 130 :: 18^2 = 324 : 164$$

$$\begin{array}{r}
324 \\
130 \\
\hline
9720 \\
324 \\
\hline
256)42120(164 \\
256 \\
\hline
1652 \\
1536 \\
\hline
1160 \\
1024 \\
\hline
\frac{136}{256} = \frac{17}{32}
\end{array}$$

The fractional quantity may be thrown away, and 164^{s} will be the number of yarn required for a similar fabric in an 18^{oo} reed.

646. In cases where odd porters occur in the scale to which the reed is made, and these cases are very frequent, the reed must be thrown into porters, or half porters as in calculating half sets. Thus, if a 16^{oo} lawn were made with yarn No. 200, what should be the number of yarn for a 16^{oo} and half of the same make?

```
                             Hundreds.
     Hundreds.                 16½
        16                     10 half porters in hundreds.
        10                    ----
       ----                    165
       160                     165
       160                    ----
      -----                    825
      9600                     990
      160                     165
     ------                  ------
     25600  :  200  : :      27225
                                200
                         ------------
                   256|00)54450|00(212
                          512
                          ---
                           325
                           256
                           ---
                            690
                            512
                            ---
                            178 = 89/128
```

647. When the grist of the yarn is given, to find the reed for which it is required to be used, the proportion of the yarn to the reed given is as that of the yarn to the reed sought; and, therefore, the proportion of the terms must be inverted, and the square root of the fourth term extracted for the answer.

EXAMPLE.

If yarn No. 70 make a 16^{00} cambric, what set will No. 93 make?

$16^2 = 256$, then the proportion will be

```
70 : 256 :: 93 : 340                  . .
      93                     and 340.8(18.46
     ----                          1
     768                          ---
    2304                        28)240
7|0)2380|8                       8 224
    ------                       -----
     340-8                      364(1680
                                  4 1456
                                ---------
                                3686(22400
                                     22116
                                     -----
                                       284
```

That is an 18 hundred reed and 46 splits, or $18\frac{1}{2}$ nearly.

648. Caaming Tables may likewise be easily constructed by taking the difference between two adjacent squares. The mean proportional *m n* between any two of the natural series of squares, as 1^2, 2^2, 3^2, 4^2, $=1, 4, 9, 16$, &c. is equal to the less square plus its root multiplied by the difference of the roots; or equal to the greater square minus its root multiplied by the difference of the roots. That is $m\,n = m^2 + d\,m = n^2 - d\,n$; where $d = n - m$ is the difference of their roots. Thus, 16 is the square of 4, and if the root is added to its square and that sum divided by the same root, and the quotient again added to the

dividend, the sum will be the square of a root greater by one than that of the given square; for example,

```
4)16 is the square of 4
   4
----
4)20
   5
----
5)25 is the square of 5
   5
----
5)30
   6
----
  36 is the square of 6, &c. &c.
```

649. Having fixed on the number of the yarn for the required fabric in the given set of reed, divide that number by the set of the reed, and to the dividend add the quotient; and this sum is the number of the yarn for the next half set. Divide again the number thus found by the same set of reed and add the quotient as before, and the sum will be the required number of yarn for the full set. The operation is thus a repetition of the question for each set and half set; the divisor, it must always be observed, is the set or number of the reed for the required set and half set. The numbers are thus ascending in the scale by addition, but where the series is a descending one, from a higher to a lower set, the operation must be done by subtracting the quotient from the dividend: as in the following example, where the opera-

tion is presented both for ascending and descending sets, commencing with a 12^{oo}, yarn No. 72^{s}.

	12)72		
add	6		
	12)78	for a	12½
add	6.5		
	13)84.5	—	13
add	6.5		
	13)91	—	13½
add	7		
	14)98	—	14
add	7		
	14)105	—	14½
add	7.5		
	15)112.5	—	15
add	7.5		
	15)120	—	15½
add	8		
	16)128	—	16
add	8		
	16)136	—	16½
add	8.5		
	17)144.5	—	17
add	8.5		
	153	—	17½

	12)72		
sub.	6		
	12)66	for an	11½
sub.	5.5		
	11)60.5	—	11
sub.	5.5		
	11)55	—	10½
sub.	5		
	10)50	—	10
sub.	5		
	10)45	—	9½
sub.	4.5		
	40.5	—	9

650. Mr Murphy, in his "Art of Weaving," gives two tables of the logarithms of the reeds and yarns, for the purpose of facilitating calculation in constructing caaming tables, which may be useful.

The first table refers to the reeds, and the second to the yarns. The first two columns of the first table contain the two English counts, and the third the Scotch. The fourth is the log. of the hundreds, and the five following the log. of the porters.

The second table contains the log. of the yarn from Nos. 1 to 264.

651. In calculating by them, subtract the logarithm of the given set of reed from 10,000, and to the remainder add the logarithm of the numbers of yarn, as a constant quantity for the construction of the table. The number of yarn for any other set of reed is then found by adding the log. of the required reed to this constant quantity, and their sum will be the log. of the numbers of yarn for the reed sought.

652. For example—Suppose a caaming table were required for Jaconets commencing with a 7^{oo} reed, and the fabric were 72^s in a 12^{oo}, wefted with 80^s. Then take the log. of 12^{oo}, which is 2158, and which will be found in the 4th column, opposite its set of reed, and subtract this number from 10,000 and the remainder will be 7842. Then the log. of the number of yarn 72^s taken from the second table is 1857, and their sum is 9699, the constant quantity for the construction of the table.

Then the log. of the 7^{oo} reed is 1690, and this number added to the constant quantity gives 1389 by omitting the first figure at the left hand, when the sum of the addition exceeds four figures. Now the nearest log. to this number in the table is 1380, and its number 24 is the required number of yarn for a 7^{oo} reed.

653. Then again for a 7^{oo} and a half, the log. for which is 1750, found in the 7th column opposite the full set of reed, and that number added to the constant quantity gives, by omitting the first figure as before, 1449; and the nearest number of yarn to

it in the table is 28^s, the number required for a 7^{00} and a half—and so on according to the following example, where the construction of a caaming table is shown as formed in this manner from the tables.

Reed.	Warp.	Weft.
7^{00}	24	27
$7\frac{1}{2}$	28	31
8^{00}	32	36
9^{00}	40	45
10^{00}	50	56
11^{00}	61	67
12^{00}	72	80
13^{00}	84	94
14^{00}	98	109
15^{00}	112	125
16^{00}	128	142

Constant quantity 9699	Constant quantity 9745
1690 warp.	1690 weft.
7^{00} 11389 = 24	7^{00} 11435 = 27
9699	9745
1750	1750
$7\frac{1}{2}$ 11449 = 28	$7\frac{1}{2}$ 11495 = 31
9699	9745
1806	1806
8^{00} 11505 = 32	8^{00} 11551 = 36
9699	9745
1908	1903
9^{00} 11607 = 40	9^{00} 11653 = 45

TABLE I.

REEDS.

Manch. & Bolton.	Stockport.	Hund. on 37 inches.	Log. hund.	Log. 1 por.	Log. 2 por.	Log. 2½ por.	Log. 3 por.	Log. 4 por.
3½	6	100	0000	0158	0292	0352	0403	0510
6½	10	200	0602	0684	0760	0795	0830	0894
10	16	300	0954	1010	1061	1088	1112	1159
13	22	400	1204	1246	1286	1306	1324	1462
16½	26	500	1397	1432	1464	1480	1496	1526
20	32	600	1556	1584	1612	1628	1639	1664
23	38	700	1690	1714	1738	1750	1760	1784
26	44	800	1806	1827	1848	1858	1868	1888
29½	48	900	1908	1927	1946	1955	1964	1982
33	54	1000	2000	2017	2034	2042	2050	2066
36	60	1100	2083	2098	2113	2121	2128	2143
39½	64	1200	2158	2172	2186	2193	2201	2214
42½	70	1300	2227	2241	2254	2260	2267	2279
46	76	1400	2292	2304	2316	2322	2328	2340
49	82	1500	2352	2363	2375	2380	2386	2397
52½	86	1600	2408	2419	2429	2434	2440	2450
56	92	1700	2400	2471	2481	2486	2491	2500
59	98	1800	2510	2520	2529	2534	2539	2548
62½	102	1900	2557	2566	2575	2580	2584	2593
65½	108	2000	2602	2610	2619	2623	2627	2636
69	114	2100	2644	2652	2660	2664	2668	2676
72	118	2200	2684	2692	2700	2704	2708	2715
75½	124	2300	2723	2730	2738	2742	2745	2753
78½	130	2400	2760	2767	2774	2778	2781	2788
82	134	2500	2795	2802	2809	2813	2816	2823
85	140	2600	2829	2836	2843	2846	2849	2856
88½	146	2700	2862	2869	2875	2878	2881	2888
92	152	2800	2894	2900	2906	2909	2912	2918
95	156	2900	2924	2930	2936	2939	2942	2948
98½	162	3000	2954	2960	2965	2968	2971	2977
102	168	3100	2982	2988	2993	2996	2999	3004
105	172	3200	3010	3015	3021	3023	3026	3031

TABLE II.

NUMBERS OF COTTON YARN.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0000	34	1531	67	1826	100	2000
2	0301	35	1544	68	1832	101	2004
3	0477	36	1556	69	1838	102	2008
4	0602	37	1568	70	1845	103	2012
5	0698	38	1579	71	1851	104	2017
6	0778	39	1591	72	1857	105	2021
7	0845	40	1602	73	1863	106	2025
8	0903	41	1612	74	1869	107	2029
9	0954	42	1623	75	1875	108	2033
10	1000	43	1633	76	1880	109	2037
11	1041	44	1643	77	1886	110	2041
12	1079	45	1653	78	1892	111	2045
13	1114	46	1662	79	1897	112	2049
14	1146	47	1672	80	1903	113	2053
15	1176	48	1681	81	1908	114	2056
16	1204	49	1690	82	1913	115	2060
17	1230	50	1699	83	1919	116	2064
18	1255	51	1707	84	1924	117	2068
19	1278	52	1716	85	1929	118	2071
20	1301	53	1724	86	1934	119	2075
21	1322	54	1732	87	1939	120	2079
22	1342	55	1740	88	1944	121	2082
23	1361	56	1748	89	1949	122	2086
24	1380	57	1755	90	1954	123	2090
25	1398	58	1763	91	1959	124	2093
26	1415	59	1770	92	1963	125	2096
27	1431	60	1778	93	1968	126	2100
28	1447	61	1785	94	1973	127	2103
29	1462	62	1792	95	1977	128	2107
30	1477	63	1799	96	1982	129	2110
31	1491	64	1806	97	1986	130	2113
32	1505	65	1812	98	1991	131	2117
33	1518	66	1819	99	1995	132	2120

TABLE II. CONTINUED.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
133	2123	166	2220	199	2298	232	2365
134	2127	167	2222	200	2301	233	2367
135	2130	168	2225	201	2303	234	2369
136	2133	169	2227	202	2305	235	2371
137	2136	170	2230	203	2307	236	2373
138	2139	171	2232	204	2309	237	2374
139	2143	172	2235	205	3311	238	2376
140	2146	173	2238	206	2313	239	2378
141	2149	174	2240	207	2315	240	2380
142	2152	175	2243	208	2318	241	2382
143	2155	176	2245	209	2320	242	2383
144	2158	177	2247	210	2322	243	2385
145	2161	178	2250	211	2324	244	2387
146	2164	179	2252	212	2326	245	2389
147	2167	180	2255	213	2328	246	2391
148	2170	181	2257	214	2330	247	2392
149	2173	182	2260	215	2332	248	2394
150	2176	183	2262	216	2334	249	2396
151	2178	184	2264	217	2336	250	2398
152	2181	185	2267	218	2338	251	2399
153	2184	186	2269	219	2340	252	2401
154	2187	187	2271	220	2342	253	2403
155	2190	188	2274	221	2344	254	2405
156	2193	189	2276	222	2346	255	2406
157	2195	190	2278	223	2348	256	2408
158	2198	191	2281	224	2350	257	2410
159	2201	192	2283	225	2352	258	2411
160	2204	193	2285	226	2354	259	2413
161	2206	194	2287	227	2356	260	2415
162	2209	195	2290	228	2358	261	2416
163	2212	196	2292	229	2359	262	2418
164	2214	197	2294	230	2361	263	2420
165	2217	198	2296	231	2363	264	2421

654. The calculations connected with the work are chiefly such as are necessary for ascertaining the cost of the goods; or the quantity of yarn, as necessary to make them, without any reference to the cost.

655. In estimating the cost of any description of cloth, the quantity of yarn as necessary to make it must be known, as well as the price of the yarn, and the price of the weaving.

656. The quantity of yarn, as necessary for any given piece of cloth, is dependent on the length of the piece, the number of porters or beers in its breadth, and the number of shots on the glass. The calculations for cotton, linen, and woollen cloth, &c., are based on the length of the spyndle. Thus the cotton spyndle is 15,120 yards, and the linen 14,400. The length of the cotton spyndle is, therefore, to that of the linen as 21 to 20.

657. Now as the piece or web in Scotland is measured in hand loom work by the ell (which is five-fourths or 45 inches,) one round of the reel in calculations for linen warps will make exactly a splitful an ell long,—a cut, 6 porters,—a heer, 12,—a hank, 72,—a hesp, 144,—and a spyndle, 288. Hence the rule to find the number of spyndles in a given length of linen warp is to multiply the ells by the porters and divide by 288.

For example,—How many spyndles will it require to make a web 100 ells long—with seventy porters?

```
      100
       70
288)7000(24 spyndles.
     576
     ----
     1240
     1152
     ----
   72)88(1 hank.
      72
      --
     6)16(2⅔ cuts.
       12
       --
        4 = ⅔
```

658. If the yarn is given, to find the ells it will make with a given number of porters,—multiply 288 by the spyndles, and divide by the porters.

659. If the warp is to be calculated by the yard, 36 inches, instead of the ell, the number 360 must be substituted for 288;—because 36 are to 45 as 288 to 360. And thus the last example if wrought accordingly will be as follows:—

```
100 ells = 125 yards.
                70
               ----
       36|0)875|0(24 spyndles, 1 hank, 2⅔ cuts,
            72          the same answer as before.
            ---
            155
            144
            ---
             11
              4
             --
            )44(1
             36
             --
              8
             12
             --
            )96(2
             72
             --
             24 = ⅔
```

660. The rule for the calculation of cotton warps is the same as for linen; only that the divisor is different in consequence of the difference in the length of the spyndle. The cotton spyndle makes 302.4 porters an ell long, and the hank sixteen porters and sixteen splits, and, therefore, the divisor for cotton warps is 302.4. The fraction, however, may be thrown away as unnecessarily accurate for practice, and the more so if the remainder is divided by 20 for hanks instead of 16.8, which makes an allowance for it.

661. These calculations are made to show the nett produce of the yarn, but some allowance must be made for waste; and five per cent. is generally deducted on that account.

662. To avoid the trouble of calculation as much as possible, tables have long been in use for showing the quantity of yarn as necessary for any length of warp with any number of porters which is commonly made; and likewise for the weft, according to the breadth of the web, and the number of shots on the glass. The followiug tables for the warp and the weft are taken from Mr Macfarlane's Calculator, and are given as being as good as any other. But where indeed the subject is so much restricted, and has been so long before the trade, there can be little novelty or improvement expected in them.

The first two tables give the number of porters and splits in the given breadth as expressed by the figures in the two top lines, from one nail or $2\frac{1}{4}$ inches, to 24 nails, $= \frac{6}{4}$ of a yard or 54 inches The first top line gives the inches in the nail or fraction of the yard as placed in the second line immediately under it; and under these inches and fractions of the yard in their several columns, are found the number of porters and splits respectively in each, according to the fineness of the reed as indicated by the hundreds in the first column.

In the tables for warp the quantity of yarn is given as required for the web from one ell to 205, and from one porter to 150. The weft tables are calculated from eight to 23 shots on the glass, (exclusive of 20 and 22, which are easily found by doubling the quantity of their respective halves 10 and 11, and which have been omitted for the convenience of having the whole line of the shots presented on the same page;) and for widths of 24 inches, 27, 30, 33, 36, 37, 40, 46, 48, and 54. The lengths of the pieces are given from 1 yard to 125, rising by tens after the first denary period.

The warp tables are calculated for the nett quantity of yarn as required for linen, but they are applicable to cotton, especially as they make the usual allowance in the trade, of 5 per cent. for waste.

TABLE OF PORTERS AND SPLITS.

Inches,	$2\frac{1}{4}$		$22\frac{1}{2}$		$24\frac{3}{4}$		27		$29\frac{1}{4}$		$31\frac{1}{2}$		$33\frac{3}{4}$		36	
Nails,	$\frac{1}{16}$		$\frac{10}{16}$		$\frac{11}{16}$		$\frac{12}{16}$		$\frac{13}{16}$		$\frac{14}{16}$		$\frac{15}{16}$		$\frac{4}{4}$	
Hunds.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.
5	1	11	15	12	17	3	18	15	20	6	21	18	23	9	25	..
6	1	17	18	15	20	12	22	10	24	8	26	5	28	2	30	..
7	2	4	21	17	24	1	26	5	28	8	30	12	32	16	35	..
8	2	10	25	..	27	10	30	..	32	10	35	..	37	10	40	..
9	2	16	28	2	30	18	33	15	36	11	39	7	42	3	45	..
10	3	2	31	5	34	7	37	10	40	12	43	15	46	17	50	..
11	3	9	34	7	37	16	41	5	44	13	48	2	51	11	55	..
12	3	15	37	10	41	5	45	..	48	15	52	10	56	5	60	..
13	4	1	40	12	44	13	48	15	52	16	56	17	60	18	65	..
14	4	7	43	15	48	2	52	10	56	17	61	5	65	12	70	..
15	4	13	46	17	51	10	56	5	60	18	65	12	70	6	75	..
16	5	..	50	..	55	..	60	..	65	..	70	..	75	..	80	..
17	5	6	53	2	58	8	63	15	69	1	74	8	79	13	85	..
18	5	12	56	5	61	17	67	10	73	2	78	15	84	7	90	..
19	5	18	59	7	65	5	71	5	77	7	83	3	89	2	95	..
20	6	5	62	10	68	15	75	..	81	5	87	10	93	15	100	..
21	6	11	65	12	72	3	78	15	85	6	91	18	98	8	105	..
22	6	17	68	15	75	12	82	10	89	7	96	8	103	3	110	..
23	7	4	71	17	79	1	86	5	93	9	100	12	107	17	115	..
24	7	10	75	..	82	10	90	..	97	10	105	..	112	10	120	..
25	7	16	78	2	85	19	93	15	101	11	109	8	117	4	125	..
26	8	2	81	5	89	8	97	10	105	12	113	15	121	18	130	..
27	8	8	84	7	92	17	101	5	109	13	118	3	126	12	135	..
28	8	15	87	10	96	5	105	..	113	15	122	10	131	5	140	..
29	9	1	91	12	99	14	108	15	117	16	126	18	135	19	145	..
30	9	7	94	15	103	3	112	10	121	17	131	5	140	13	150	..

It will not be overlooked by the manufacturer, that tho web shrinks in the weaving; and more especially wet and overwefted wrought work. If then the cloth is intended to stand at a certain width when woven, an allowance of some additional yarn

TABLE OF PORTERS AND SPLITS.

Inches,	$38\frac{1}{4}$		$40\frac{1}{2}$		$42\frac{3}{4}$		45		$47\frac{1}{4}$		$49\frac{1}{2}$		$51\frac{3}{4}$		54	
Nails,	$\frac{17}{16}$		$\frac{18}{16}$		$\frac{19}{16}$		$\frac{5}{4}$		$\frac{21}{16}$		$\frac{22}{16}$		$\frac{23}{16}$		$\frac{6}{4}$	
Hunds.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp.	Pr.	Sp	Pr.	Sp
5	26	11	28	3	29	14	31	5	32	16	34	8	35	14	37	10
6	31	17	33	15	35	13	37	10	39	7	41	5	42	18	45	..
7	37	3	39	7	41	12	43	15	45	18	48	2	50	2	52	10
8	42	10	45	..	47	11	50	..	52	9	55	..	57	6	60	..
9	47	16	50	12	53	9	56	5	59	1	61	17	64	9	67	10
10	53	2	56	5	59	8	62	10	65	12	68	15	71	13	75	..
11	58	8	61	17	65	7	68	15	72	3	75	12	78	17	82	10
12	63	15	67	10	71	6	75	..	78	14	82	10	86	1	90	..
13	69	1	73	2	77	4	81	5	85	6	89	7	93	4	97	10
14	74	7	78	15	83	3	87	10	91	17	96	5	100	8	105	..
15	79	13	84	7	89	2	93	15	98	8	103	2	107	12	112	10
16	85	..	90	..	95	1	100	..	105	..	110	..	114	16	120	..
17	90	6	95	12	100	19	106	5	111	11	116	17	121	19	127	10
18	95	12	101	5	106	18	112	10	118	2	123	15	129	3	135	..
19	100	19	106	17	112	17	118	15	124	14	136	13	136	7	142	10
20	106	5	112	12	118	16	125	..	131	5	137	10	143	11	150	..
21	111	11	118	2	124	14	131	5	137	16	144	7	150	14	157	10
22	116	18	123	15	130	13	137	10	144	8	151	5	157	18	165	..
23	122	3	129	7	136	12	143	15	150	19	158	2	165	2	172	10
24	127	10	135	..	142	11	150	..	157	10	165	..	172	6	180	..
25	132	16	140	13	148	9	156	5	164	2	171	17	179	9	182	10
26	138	2	146	5	154	8	162	10	170	13	178	15	186	13	185	..
27	143	8	151	18	160	7	168	15	177	4	185	12	193	17	187	10
28	148	15	157	10	166	6	175	..	183	16	192	10	201	1	190	..
29	154	1	163	3	171	4	181	5	190	7	199	7	208	4	192	10
30	159	7	168	15	177	3	187	10	196	18	206	5	215	8	195	..

must be made for the shrinking in warping the web. A yard wide web will shrink from about half an inch to an inch, according to the kind of fabric and manner in which it is woven.

WARP TABLES.

Yards,	1¼		2½		3¾		5		6¼		
Ells,	1		2		3		4		5		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	..	12½	1	1	1	13½	2	2	2	14½	3000
145	..	12	1	..	1	12	2	½	2	12	2900
140	..	11½	..	23½	1	11	1	22½	2	10	2800
135	..	11	..	22½	1	10	1	21	2	8	2700
130	..	11	..	21½	1	8½	1	19	2	6	2600
125	..	10½	..	21	1	7	1	17½	2	4	2500
120	..	10	..	20	1	6	1	16	2	2	2400
115	..	9½	..	19	1	5	1	14½	2	..	2300
110	..	9	..	18½	1	3½	1	12½	1	22	2200
105	..	8½	..	17½	1	2	1	11	1	20	2100
100	..	8½	..	16½	1	1	1	9½	1	17½	2000
95	..	8	..	16	1	..	1	7½	1	15½	1900
90	..	7½	..	15	..	22½	1	6	1	13½	1800
85	..	7	..	14	..	21	1	4½	1	11½	1700
80	..	6½	..	13½	..	20	1	2½	1	9½	1600
75	..	6	..	12½	..	19	1	1	1	7	1500
70	..	6	..	11½	..	17½	..	23½	1	5	1400
65	..	5½	..	11	..	16	..	21½	1	3	1300
60	..	5	..	10	..	15	..	20	1	1	1200
55	..	4½	..	9	..	14	..	18½	..	23	1100
50	..	4	..	8½	..	12½	..	16½	..	21	1000
45	..	4	..	7½	..	11	..	15	..	19	900
40	..	3½	..	6½	..	10	..	13½	..	16½	800
35	..	3	..	6	..	9	..	11½	..	14½	700
30	..	2½	..	5	..	7½	..	10	..	12½	600
25	..	2	..	4	..	6	..	8½	..	10½	500
20	..	1½	..	3½	..	5	..	6½	..	8½	400
15	..	1	..	2½	..	4	..	5	..	6	300
10	..	1	..	1½	..	2½	..	3½	..	4	200
5	..	½	..	1	..	1¼	..	1¾	..	2	100
4½	..	..	..	¾	..	..	..	1½	..	2	90
4	..	⅓	..	⅔	..	1	..	1½	..	1½	80
3½	..	..	..	..	..	..	..	1	..	1¼	70
3	..	¼	..	½	..	¾	..	1	..	1	60
2½	..	..	..	..	..	..	..	1	..	1	50
2	..	⅙	..	⅓	..	½	..	¾	..	1	40
1½	..	..	..	..	..	..	..	..	..	..	30
1	..	1/12	..	⅙	..	¼	..	⅓	..	½	20
	..	..	..	..	..	..	..	..	..	..	15
	..	..	..	..	..	..	..	..	..	..	10
	..	..	..	..	..	..	..	..	..	..	5

WARP TABLES.

Yards,	12½		18¾		25		31¼		37½		
Ells,	10		15		20		25		30		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	5	5	7	20	10	10	13	1	15	15	3000
145	5	1	7	13	10	..	12	14	15	2	2900
140	4	21	7	7	9	17	12	4	14	14	2800
135	4	17	7	1	9	9	11	17	14	2	2700
130	4	12	6	19	9	2	11	8	13	14	2600
125	4	8	6	12	8	16	10	20	13	1	2500
120	4	4	6	6	8	8	10	10	12	12	2400
115	4	..	6	..	8	..	10	..	12	..	2300
110	3	20	5	18	7	15	9	13	11	11	2200
105	3	16	5	11	7	7	9	3	10	23	2100
100	3	11	5	5	6	23	8	16	10	0	2000
95	3	7	4	23	6	14	8	6	9	22	1900
90	3	3	4	17	6	6	7	20	9	9	1800
85	2	23	4	10	5	22	7	9	8	21	1700
80	2	19	4	4	5	13	6	23	8	8	1600
75	2	15	3	22	5	5	6	12	7	20	1500
70	2	10	3	16	4	21	6	2	7	7	1400
65	2	6	3	9	4	12	5	15	6	19	1300
60	2	2	3	3	4	4	5	5	6	6	1200
55	1	22	2	21	3	20	4	19	5	18	1100
50	1	18	2	15	3	11	4	8	5	5	1000
45	1	14	2	8	3	3	3	22	4	17	900
40	1	9	2	2	2	19	3	11	4	4	800
35	1	5	1	20	2	10	3	1	3	16	700
30	1	1	1	14	2	2	2	15	3	3	600
25	..	21	1	7	1	18	2	4	2	15	500
20	..	17	1	1	1	9	1	18	2	2	400
15	..	13	..	19	1	1	1	7	1	14	300
10	..	8	..	13	..	17	..	21	1	1	200
5	..	4	..	6	..	8½	..	10	..	13	100
4½	..	4	..	5½	..	7½	..	9	..	11	90
4	..	3½	..	5	..	6½	..	8	..	10	80
3½	..	3	..	4½	..	6	..	7	..	9	70
3	..	2½	..	4	..	5	..	6	..	7½	60
2½	..	2	..	3	..	4	..	5	..	6	50
2	..	1½	..	2½	..	3¼	..	4	..	5	40
1½	..	1	..	2	..	2½	..	3	..	4	30
1	..	1	..	1¼	..	1¾	..	2	..	2½	20
	..	1	..	1	..	1	..	1½	..	2	15
	..	½	..	½	..	1	..	1	..	1	10
	..	¼	..	¼	..	½	..	½	..	½	5

WARP TABLES.

Yards,	43¾		50		56¼		62½		68¾		
Ells,	35		40		45		50		55		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	18	6	20	20	23	11	26	1	28	16	3000
145	17	15	20	3	22	16	25	4	27	17	2900
140	17	..	19	11	21	21	24	7	26	18	2800
135	16	10	18	18	21	2	23	11	25	19	2700
130	15	19	18	1	20	8	22	14	24	20	2600
125	15	5	17	9	19	13	21	17	23	21	2500
120	14	14	16	16	18	18	20	20	22	22	2400
115	13	23	15	23	17	23	19	23	21	23	2300
110	13	9	15	7	17	5	19	2	21	..	2200
105	12	18	14	14	16	10	18	6	20	1	2100
100	12	4	13	21	15	15	17	9	19	2	2000
95	11	13	13	5	14	20	16	12	18	3	1900
90	10	23	12	12	14	2	15	15	17	5	1800
85	10	8	11	19	13	7	14	18	16	6	1700
80	9	17	11	3	12	12	13	21	15	7	1600
75	9	3	10	10	11	17	13	1	14	8	1500
70	8	12	9	17	10	23	12	4	13	9	1400
65	7	22	9	1	10	4	11	7	12	10	1300
60	7	7	8	8	9	9	10	10	11	11	1200
55	6	16	7	15	8	14	9	13	10	12	1100
50	6	2	6	23	7	20	8	16	9	13	1000
45	5	11	6	6	7	1	7	20	8	14	900
40	4	21	5	13	6	6	6	23	7	15	800
35	4	6	4	21	5	11	6	2	6	16	700
30	3	16	4	4	4	17	5	5	5	18	600
25	3	1	3	11	3	22	4	8	4	19	500
20	2	10	2	19	3	3	3	11	3	20	400
15	1	20	2	2	2	8	2	15	2	21	300
10	1	5	1	9	1	14	1	18	1	22	200
5	..	14½	..	17	..	19	..	21	..	23	100
4½	..	13	..	15	..	17	..	19	..	21	90
4	..	12	..	13	..	15	..	17	..	18	80
3½	..	10	..	12	..	13	..	15	..	16	70
3	..	9	..	10	..	11	..	12½	..	14	60
2½	..	7	..	8	..	9	..	10½	..	11	50
2	..	6	..	6½	..	7½	..	8½	..	9	40
1½	..	4½	..	5	..	5½	..	6	..	7	30
1	..	3	..	3½	..	4	..	4	..	4½	20
	..	2	..	2½	..	3	..	3	..	3½	15
	..	1½	..	1¾	..	2	..	2	..	2¼	10
	..	1	..	1	..	1	..	1	..	1	5

WARP TABLES.

Yards,	75¼		81¼		87½		93¾		100		
Ells,	60		65		70		75		80		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	31	6	33	21	36	11	39	2	41	16	3000
145	30	5	32	17	35	6	37	18	40	7	2900
140	29	4	31	14	34	1	36	11	38	21	2800
135	28	3	30	11	32	20	35	4	37	12	2700
130	27	2	29	8	31	14	33	21	36	3	2600
125	26	1	28	5	30	9	32	13	34	17	2500
120	25	..	27	2	29	4	31	6	33	8	2400
115	23	23	25	23	27	23	29	23	31	23	2300
110	22	22	24	20	26	18	28	16	30	13	2200
105	21	21	23	17	25	13	27	8	29	4	2100
108	20	20	22	14	24	7	26	1	27	19	2000
95	19	19	21	11	23	2	24	18	26	9	1900
90	18	18	20	8	21	21	23	11	25	..	1800
85	17	17	19	4	20	16	22	4	23	15	1700
80	16	16	18	1	19	11	20	20	22	5	1600
75	15	15	16	22	18	6	19	13	20	20	1500
70	14	14	15	19	17	..	18	6	19	11	1400
65	13	13	14	16	15	19	16	22	18	1	1300
60	12	12	13	13	14	14	15	15	16	16	1200
55	11	11	12	10	13	9	14	8	15	7	1100
50	10	10	11	7	12	4	13	1	13	21	1000
45	9	9	10	4	10	23	11	17	12	12	900
40	8	8	9	1	9	17	10	10	11	3	800
35	7	7	7	22	8	12	9	3	9	17	700
30	6	6	6	19	7	7	7	20	8	8	600
25	5	5	5	15	6	2	6	12	6	23	500
20	4	4	4	12	4	21	5	5	5	13	400
15	3	3	3	9	3	16	3	22	4	4	300
10	2	2	2	6	2	10	2	15	2	19	200
5	1	1	1	3	1	5	1	7	1	9	100
4½	..	22	1	..	1	2	1	4	1	6	90
4	..	20	..	22	..	23	1	1	1	3	80
3½	..	18	..	19	..	20	..	22	..	23	70
3	..	15	..	16	..	18	..	19	..	20	60
2½	..	12	..	14	..	15	..	16	..	17	50
2	..	10	..	11	..	12	..	13	..	14	40
1½	..	8	..	8	..	9	..	9	..	10	30
1	..	5	..	5	..	6	..	6	..	7	20
	..	4	..	4	..	4	..	5	..	5	15
	..	2½	..	2½	..	3	..	3	..	3½	10
	..	1	..	1	..	1½	..	1½	..	1½	5

WARP TABLES.

Yards,	106		112½		118		125		131¼		
Ells,	85		90		95		100		105		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	44	7	46	21	49	12	52	2	54	17	3000
145	42	19	45	8	47	20	50	8	52	21	2900
140	41	8	43	18	46	4	48	15	51	1	2800
135	39	20	42	5	44	13	46	21	49	5	2700
130	38	9	40	15	42	21	45	3	47	10	2600
125	36	21	39	1	41	6	43	10	45	14	2500
120	35	10	37	12	39	14	41	16	43	18	2400
115	33	23	35	23	37	22	39	22	41	22	2300
110	32	11	34	9	36	7	38	5	40	3	2200
105	31	..	32	20	34	15	36	11	38	7	2100
100	29	12	31	6	33	..	34	17	36	11	2000
95	28	1	29	17	31	8	33	..	34	15	1900
90	26	14	28	3	29	17	31	6	32	20	1800
85	25	2	26	14	28	1	29	12	31	..	1700
80	23	15	25	..	26	9	27	19	29	4	1600
75	22	3	23	11	24	18	26	1	27	8	1500
70	20	16	21	21	23	2	24	7	25	13	1400
65	19	4	20	8	21	11	22	14	23	17	1300
60	17	17	18	18	19	19	20	20	21	21	1200
55	16	6	17	5	18	3	19	2	20	1	1100
50	14	18	15	15	16	12	17	9	18	6	1000
45	13	7	14	2	14	20	15	15	16	10	900
40	11	19	12	12	13	5	13	21	14	14	800
35	10	8	10	23	11	13	12	4	12	18	700
30	8	21	9	9	9	22	10	10	10	23	600
25	7	9	7	20	8	6	8	16	9	3	500
20	5	22	6	6	6	14	6	23	7	7	400
15	4	10	4	17	4	23	5	5	5	11	300
10	2	23	3	3	3	7	3	11	3	16	200
5	1	11	1	13	1	16	1	18	1	20	100
4½	1	8	1	10	1	12	1	14	1	15	90
4	1	4	1	6	1	8	1	9	1	11	80
3½	1	1	1	2	1	4	1	5	1	7	70
3	..	21	..	23	1	..	1	1	1	2	60
2½	..	18	..	19	..	20	..	21	..	22	50
2	..	14	..	15	..	16	..	17	..	18	40
1½	..	11	..	11	..	2	..	13	..	13	30
1	..	7	..	8	..	8	..	8	..	9	20
	..	5	..	6	..	6	..	6	..	7	15
	..	3½	..	4	..	4	..	4	..	4	10
	..	2	..	2	..	2	..	2	..	2	5

WARP TABLES.

Yards,	137½		143¾		150		156¼		162½		
Ells,	110		115		120		125		130		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	57	7	59	22	62	12	65	3	67	17	3000
145	55	9	57	22	60	10	62	22	65	11	2900
140	53	11	55	22	58	8	60	18	63	5	2800
135	51	14	53	22	56	6	58	14	60	23	2700
130	49	16	51	22	54	4	56	10	58	16	2600
125	47	18	49	22	52	2	54	6	56	10	2500
120	45	20	47	22	50	..	52	2	54	4	2400
115	43	22	45	22	47	22	49	22	51	22	2300
110	42	..	43	22	45	20	47	18	49	16	2200
105	40	3	41	22	43	18	45	14	47	10	2100
100	38	5	39	22	41	16	43	10	45	3	2000
95	36	7	37	22	39	14	41	6	42	21	1900
90	34	9	35	23	37	12	39	2	40	15	1800
85	32	11	33	23	35	10	36	21	38	9	1700
80	30	13	31	23	33	8	34	17	36	3	1600
75	28	16	29	23	31	6	32	13	33	21	1500
70	26	18	27	23	29	4	30	9	31	14	1400
65	24	20	25	23	27	2	28	5	29	8	1300
60	22	22	23	23	25	..	26	1	27	2	1200
55	21	..	21	23	22	22	23	21	24	20	1100
50	19	2	19	23	20	20	21	17	22	14	1000
45	17	5	17	23	18	18	19	13	20	8	900
40	15	7	15	23	16	16	17	9	18	1	800
35	13	9	13	23	14	14	15	5	15	19	700
30	11	11	12	..	12	12	13	1	13	13	600
25	9	13	10	..	10	10	10	20	11	7	500
20	7	15	8	..	8	8	8	16	9	1	400
15	5	18	6	..	6	6	6	12	6	19	300
10	3	20	4	..	4	4	4	8	4	12	200
5	1	22	2	..	2	2	2	4	2	6	100
4½	1	17	1	19	1	21	1	23	2	1	90
4	1	13	1	14	1	16	1	18	1	19	80
3½	1	8	1	10	1	11	1	13	1	14	70
3	1	4	1	5	1	6	1	7	1	9	60
2½	..	23	1	..	1	1	1	2	1	3	50
2	..	18	..	19	..	20	..	21	..	22	40
1½	..	14	..	14	..	15	..	16	..	16	30
1	..	9	..	10	..	10	..	11	..	11	20
	..	7	..	7	..	7	..	8	..	8	15
	..	5	..	5	..	5	..	5	.	5	10
	..	2	..	2	..	2	..	2	..	3	5

WARP TABLES.

Yards,	168¾		175		181¼		187½		193¾		
Ells,	135		140		145		150		155		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	70	8	72	22	75	13	78	3	80	18	3000
145	67	23	70	12	73	..	75	13	78	1	2900
140	65	15	68	1	70	12	72	22	75	8	2800
135	63	7	65	15	67	23	70	8	72	16	2700
130	60	23	63	5	65	11	67	17	69	23	2600
125	58	14	60	18	62	22	65	3	67	7	2500
120	56	6	58	8	60	10	62	12	64	14	2400
115	53	22	55	22	57	22	59	22	61	21	2300
110	51	14	53	11	55	9	57	7	59	5	2200
105	49	5	51	1	52	21	54	17	56	12	2100
100	46	21	48	15	50	8	52	2	53	20	2000
95	44	13	46	4	47	20	49	12	51	3	1900
90	42	5	43	18	45	8	46	21	48	11	1800
85	39	20	41	8	42	19	44	7	45	18	1700
80	37	12	38	21	40	7	41	16	43	1	1600
75	35	4	36	11	37	18	39	2	40	9	1500
70	32	20	34	1	35	6	36	11	37	16	1400
65	30	11	31	14	32	17	33	21	35	..	1300
60	28	3	29	4	30	5	31	6	32	7	1200
55	25	19	26	18	27	17	28	16	29	14	1100
50	23	11	24	7	25	4	26	1	26	22	1000
45	21	2	21	21	22	16	23	11	24	5	900
40	18	18	19	11	20	3	20	20	21	13	800
35	16	10	17	..	17	15	18	6	18	20	700
30	14	2	14	14	15	3	15	15	16	4	600
25	11	17	12	4	12	14	13	1	13	11	500
20	9	9	9	17	10	2	10	10	10	18	400
15	7	1	7	7	7	13	7	20	8	2	300
10	4	17	4	21	5	1	5	5	5	9	200
5	2	8	2	10	2	12	2	15	2	17	100
4½	2	2	2	5	2	6	2	8	2	10	90
4	1	21	1	23	2	..	2	2	2	4	80
3½	1	16	1	17	1	18	1	20	1	21	70
3	1	10	1	11	1	12	1	14	1	15	60
2½	1	4	1	5	1	6	1	7	1	8	50
2	..	23	..	23	1	..	1	1	1	2	40
1½	..	17	..	18	..	18	..	19	..	19	30
1	..	11	..	12	..	12	..	13	..	13	20
	..	8	..	9	..	9	..	9	..	10	15
	..	6	..	6	..	6	..	6	..	6	10
	..	3	..	3	..	3	..	3	..	3	5

WARP TABLES.

Yards,	200		206¼		212½		218¾		225		
Ells,	160		165		170		175		180		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	83	8	85	23	88	13	91	4	93	18	3000
145	80	13	83	2	85	14	88	3	90	15	2900
140	77	19	80	5	82	15	85	2	87	12	2800
135	75	..	77	8	79	17	82	1	84	9	2700
130	72	5	74	12	76	18	79	..	81	6	2600
125	69	11	71	15	73	19	75	23	78	3	2500
120	66	16	68	18	70	20	72	22	75	..	2400
115	63	21	65	21	67	21	69	21	71	21	2300
110	61	3	63	1	64	22	66	20	68	18	2200
105	58	8	60	4	62	..	63	19	65	15	2100
100	55	13	57	7	59	1	60	18	62	16	2000
95	52	19	54	10	56	2	57	17	59	9	1900
90	50	..	51	14	53	3	54	17	56	6	1800
85	47	5	48	17	50	4	51	16	53	3	1700
80	44	11	45	20	47	5	48	15	50	..	1600
75	41	16	42	23	44	7	45	14	46	21	1500
70	38	21	40	3	41	8	42	13	43	18	1400
65	36	3	37	6	38	9	39	12	40	15	1300
60	33	8	34	9	35	10	36	11	37	12	1200
55	30	13	31	12	32	11	33	10	34	9	1100
50	27	19	28	16	29	12	30	9	31	6	1000
45	25	..	25	19	26	14	27	8	28	3	900
40	22	5	22	22	23	15	24	7	25	..	800
35	19	11	20	1	20	16	21	6	21	21	700
30	16	16	17	5	17	17	18	6	18	18	600
25	13	21	14	8	14	18	15	5	15	15	500
20	11	3	11	11	11	19	12	4	12	12	400
15	8	8	8	14	8	21	9	3	9	9	300
10	5	13	5	18	5	22	6	2	6	6	200
5	2	19	2	21	2	23	3	1	3	3	100
4½	2	12	2	14	2	16	2	18	2	19	90
4	2	5	2	7	2	9	2	10	2	12	80
3½	1	23	2	..	2	2	2	3	2	4	70
3	1	16	1	17	1	19	1	20	1	21	60
2½	1	9	1	10	1	11	1	12	1	13	50
2	1	3	1	4	1	4	1	5	1	6	30
1½	..	20	..	21	..	21	..	22	..	23	30
1	..	13	..	14	..	14	..	15	..	15	20
	..	10	..	10	..	11	..	11	..	11	15
	..	7	..	7	..	7	..	7	..	7	10
	..	3	..	3	..	3	..	4	..	4	5

WARP TABLES.

Yards,	231¼		237½		243¾		250		256¼		
Ells,	185		190		195		200		205		
Porters.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Sp.	Hrs.	Splits.
150	96	9	98	23	101	14	104	4	106	19	3000
145	93	3	95	16	98	4	100	17	103	5	2900
140	89	22	92	9	94	19	97	5	99	16	2800
135	86	17	89	2	91	10	93	18	96	19	2700
130	83	12	85	18	88	3	90	9	92	13	2600
125	80	7	82	11	84	15	86	19	88	23	2500
120	77	2	79	4	81	6	83	8	85	10	2400
115	73	21	75	21	77	21	79	21	81	21	2300
110	70	16	72	14	74	12	76	9	78	7	2200
105	67	11	69	6	71	2	72	22	74	18	2100
100	64	10	66	3	67	21	69	15	71	4	2000
95	61	1	62	16	64	8	65	23	67	15	1900
90	57	20	59	9	60	23	62	12	64	2	1800
85	54	14	56	2	57	13	59	1	60	12	1700
80	51	9	52	19	54	4	55	13	56	23	1600
75	48	4	49	12	50	19	52	2	53	9	1500
70	44	23	46	4	47	10	48	15	49	20	1400
65	41	18	42	21	44	..	45	3	46	6	1300
60	38	13	39	14	40	15	41	16	42	17	1200
55	35	8	36	7	37	6	38	5	39	4	1100
50	32	3	33	..	33	20	34	17	35	14	1000
45	28	22	29	17	30	11	31	6	32	1	900
40	25	17	26	9	27	2	27	19	28	11	800
35	22	12	23	2	23	17	24	7	24	22	700
30	19	7	19	19	20	8	20	20	21	9	600
25	16	1	16	12	16	22	17	9	17	19	500
20	12	20	13	5	13	13	13	21	14	6	400
15	9	15	9	22	10	4	10	10	10	16	300
10	6	10	6	14	6	19	6	23	7	3	200
5	3	5	3	7	3	9	3	11	3	13	100
4½	2	21	2	23	3	1	3	3	3	5	90
4	2	14	2	15	2	17	2	19	2	20	80
3½	2	6	2	7	2	9	2	10	2	12	70
3	1	22	2	..	2	1	2	2	2	3	60
2½	1	15	1	16	1	17	1	18	1	18	50
2	1	7	1	8	1	9	1	9	1	10	40
1½	..	23	1	..	1	..	1	1	1	2	30
1	..	15	..	16	..	16	..	17	..	17	20
	..	12	..	12	..	12	..	13	..	13	15
	..	8	..	8	..	8	..	8	..	8	10
	..	4	..	4	..	4	..	4	..	4	5

663. The calculation as required for the weft of the web is simply the multiplication of the shots on the space measured by the breadth of the web, and the division of the length of the thread thus found by some suitable denominator of the yarn table—to ascertain the quantity. The portion measured by the English web glass is an aliquot part of an inch—usually a quarter; and by the Scotch glass the 200th part of 37 inches. There are therefore five and four-tenths of the Scotch glass-measure in an inch. And therefore the number of shots on an inch by either count may be taken for the multiplier, and the number of inches in the breadth of the web for the multiplicand. This product is then to be divided by some of the denominators in the yarn table, to obtain the quantity of the yarn in the space measured. But as the quantity of yarn for warp and weft in even-wefted work is nearly the same, it is better to take the difference in over or under-wefted work, and add it to the sum, or substract it as it may be, than to make calculations, in a small space, which are liable to errors incident to fractional numbers, &c. But the readiest way is to have recourse to the tables.

WEFT FOR CLOTH, 24 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	9	4	10	7	11	10	12	13	13	16	15	1	16	4	100
120	8	15	10	0	11	2	12	4	13	6	14	8	15	10	96
110	8	2	9	3	10	3	11	4	12	4	13	4	14	5	88
100	7	7	8	6	9	4	10	4	11	2	12	0	13	0	80
90	6	11	7	9	8	6	9	3	10	0	10	15	11	12	72
80	5	16	6	12	7	7	8	3	8	16	9	11	10	7	64
70	5	3	5	15	6	8	7	3	7	14	8	7	9	2	56
60	4	7	5	0	5	10	6	2	6	12	7	4	7	14	48
50	3	12	4	3	4	11	5	2	5	10	6	0	6	9	40
40	2	17	3	6	3	12	4	1	4	8	4	15	5	3	32
30	2	4	2	9	2	14	3	1	3	6	3	11	3	16	24
20	1	9	1	12	1	15	2	1	2	4	2	7	2	11	16
10	0	13	0	15	0	17	1	0	1	2	1	4	1	5	8
9	0	12	0	13½	0	15	0	16½	1	0	1	2	1	3	7⅕
8	0	11	0	12	0	13	0	14½	0	16	0	17	1	1	6⅖
7	0	9	0	10½	0	11½	0	13	0	14	0	15	0	16	5⅗
6	0	8	0	9	0	10	0	11	0	12	0	13	0	14	4⅘
5	0	6½	0	7½	0	8	0	9	0	10	0	11	0	12	4
4	0	5	0	6	0	6½	0	7	0	8	0	9	0	9½	3⅕
3	0	4	0	4½	0	5	0	5½	0	6	0	6½	0	7	2⅖
2	0	2½	0	3	0	3	0	3½	0	4	0	4	0	4½	1⅗
1	0	1	0	1½	0	1½	0	2	0	2	0	2	0	2½	⅘

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	17	6	18	9	19	12	20	15	21	17	24	5	26	11	100
120	16	12	17	14	18	16	20	0	21	2	23	6	25	10	96
110	15	5	16	5	17	6	18	6	19	6	21	7	23	8	88
100	13	16	14	14	15	14	16	12	17	10	19	8	21	6	80
90	12	9	13	6	14	3	15	0	15	15	17	9	19	3	72
80	11	2	11	15	12	11	13	6	14	1	15	10	17	1	64
70	9	13	10	6	11	1	11	12	12	5	13	11	14	17	56
60	8	6	8	16	9	8	10	0	10	10	11	12	12	14	48
50	6	17	7	7	7	16	8	6	8	14	9	13	10	12	40
40	5	10	5	17	6	5	6	12	7	1	7	14	8	8	32
30	4	3	4	8	4	13	5	0	5	5	5	15	6	7	24
20	2	14	2	17	3	3	3	6	3	9	3	16	4	5	16
10	1	7	1	9	1	10	1	12	1	14	1	17	2	2	8
9	1	5	1	6	1	8	1	9	1	11	1	14	1	17	7⅕
8	1	2	1	3	1	5	1	6	1	7	1	10	1	13	6⅖
7	1	0	1	1	1	2	1	3	1	4	1	7	1	9	5⅗
6	0	15	0	16	0	17	1	0	1	1	1	3	1	5	4⅘
5	0	12½	0	13	0	14	0	15	0	16	1	0	1	1	4
4	0	10	0	11	0	11	0	12	0	13	0	14	0	15	3⅕
3	0	7½	0	8	0	8½	0	9	0	9½	0	10½	0	11½	2⅖
2	0	5	0	5	0	5½	0	6	0	6	0	7	0	8	1⅗
1	0	2½	0	3	0	3	0	3	0	3	0	3½	0	4	⅘

WEFT FOR CLOTH, 27 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk	Ells.
125	10	7	11	13	13	0	14	6	15	11	16	17	18	4	100
120	10	0	11	5	12	9	13	14	15	0	16	5	17	9	96
110	9	3	10	6	11	8	12	11	13	14	14	16	16	1	88
100	8	6	9	7	10	7	11	9	12	9	13	10	14	11	80
90	7	9	8	8	9	6	10	6	11	5	12	3	13	2	72
80	6	12	7	9	8	6	9	4	10	0	10	15	11	12	64
70	5	15	6	10	7	5	8	1	8	14	9	9	10	4	56
60	5	0	5	11	6	5	6	15	7	9	8	2	8	13	48
50	4	3	4	12	5	4	5	13	6	5	6	15	7	5	40
40	3	6	3	14	4	3	4	10	5	0	5	8	5	15	32
30	2	9	2	15	3	2	3	8	3	14	4	1	4	7	24
20	1	12	1	16	2	2	2	5	2	9	2	13	2	17	16
10	0	15	0	17	1	1	1	3	1	5	1	6	1	8	8
9	0	14	0	15	0	17	1	1	1	2	1	4	1	6	$7\frac{1}{5}$
8	0	12	0	14	0	15	0	17	1	0	1	2	1	3	$6\frac{2}{5}$
7	0	11	0	12	0	13	0	14	0	16	0	17	1	0	$5\frac{3}{5}$
6	0	9	0	10	0	11	0	12	0	14	0	15	0	16	$4\frac{4}{5}$
5	0	$7\frac{1}{2}$	0	8	0	9	0	10	0	11	0	12	0	13	4
4	0	6	0	7	0	8	0	8	0	9	0	10	0	11	$3\frac{1}{5}$
3	0	5	0	5	0	6	0	6	0	7	0	7	0	8	$2\frac{2}{5}$
2	0	3	0	$3\frac{1}{2}$	0	4	0	4	0	5	0	5	0	5	$1\frac{3}{5}$
1	0	$1\frac{1}{2}$	0	$1\frac{3}{4}$	0	2	0	2	0	$2\frac{1}{4}$	0	$2\frac{1}{2}$	0	$2\frac{1}{2}$	$\frac{4}{5}$

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	19	10	20	15	22	2	23	8	24	13	27	6	29	17	100
120	18	14	20	0	21	5	23	9	23	13	26	5	28	14	96
110	17	3	18	6	19	9	20	11	21	13	24	1	26	6	88
100	15	11	16	12	17	13	18	14	19	14	21	16	23	17	80
90	14	1	15	0	15	17	16	16	17	14	19	13	21	10	72
80	12	9	13	6	14	3	15	0	15	15	17	9	19	3	64
70	10	17	11	12	12	7	13	2	13	15	15	6	16	14	56
60	9	7	10	0	10	11	11	5	11	16	13	3	14	7	48
50	7	15	8	6	8	15	9	7	9	16	10	17	12	0	40
40	6	5	6	12	7	2	7	9	7	17	8	14	9	11	32
30	4	12	5	0	5	6	5	11	5	17	6	10	7	3	24
20	3	2	3	6	3	10	3	14	3	17	4	7	4	14	16
10	1	10	1	12	1	14	1	16	2	0	2	3	2	7	8
9	1	7	1	9	1	11	1	12	1	14	1	17	2	3	$7\frac{1}{5}$
8	1	5	1	6	1	8	1	9	1	11	1	14	1	17	$6\frac{2}{5}$
7	1	2	1	3	1	4	1	6	1	7	1	10	1	12	$5\frac{3}{5}$
6	0	17	1	0	1	1	1	2	1	3	1	6	1	8	$4\frac{4}{5}$
5	0	14	0	15	0	16	0	17	1	0	1	2	1	4	4
4	0	11	0	12	0	13	0	$13\frac{1}{2}$	0	14	0	16	0	17	$3\frac{1}{5}$
3	0	8	0	9	0	$9\frac{1}{2}$	0	10	0	11	0	12	0	13	$2\frac{2}{5}$
2	0	6	0	6	0	$6\frac{1}{2}$	0	7	0	7	0	8	0	$8\frac{1}{2}$	$1\frac{3}{5}$
1	0	$2\frac{3}{4}$	0	3	0	3	0	$3\frac{1}{2}$	0	$3\frac{1}{2}$	0	4	0	$4\frac{1}{4}$	$\frac{4}{5}$

WEFT FOR CLOTH, 30 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	11	10	13	0	14	9	15	17	17	9	18	14	20	5	100
120	11	2	12	9	13	16	15	5	16	12	18	1	19	8	96
110	10	3	11	8	12	13	14	0	15	5	16	10	17	15	88
100	9	5	10	8	11	10	12	13	13	16	15	1	16	4	80
90	8	6	9	7	10	7	11	8	12	9	13	10	14	11	72
80	7	7	8	6	9	5	10	3	11	2	12	1	12	17	64
70	6	9	7	5	8	2	8	16	9	13	10	10	11	6	56
60	5	10	6	5	6	17	7	12	8	6	9	0	9	13	48
50	4	11	5	4	5	14	6	7	6	17	7	9	8	2	40
40	3	13	4	3	4	11	5	2	5	10	6	0	6	9	32
30	2	14	3	2	3	8	3	15	4	3	4	9	4	16	24
20	1	15	2	2	2	6	2	10	2	14	3	0	3	4	16
10	0	17	1	1	1	3	1	5	1	7	1	9	1	11	8
9	0	15	0	17	1	1	1	3	1	5	1	6	1	8	7⅕
8	0	13	0	15	0	17	1	0	1	2	1	4	1	5	6⅖
7	0	12	0	13	0	15	0	16	1	0	1	1	1	2	5⅗
6	0	10	0	11	0	12½	0	14	0	15	0	16	0	17½	4⅘
5	0	8	0	9	0	10	0	11½	0	12½	0	13½	0	14½	4
4	0	6½	0	7½	0	8	0	9	0	10	0	11	0	12	3⅕
3	0	5	0	5½	0	6	0	7	0	7½	0	8	0	9	2⅖
2	0	3	0	4	0	4	0	4½	0	5	0	5	0	6	1⅗
1	0	1½	0	2	0	2	0	2	0	2½	0	2½	0	3	⅘
Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	21	13	23	3	24	11	26	0	27	9	30	7	33	5	100
120	20	15	22	4	23	11	24	17	26	7	29	3	31	17	96
110	19	2	20	7	21	12	22	16	24	3	26	13	29	5	88
100	17	7	18	9	19	12	20	15	22	0	24	6	26	11	80
90	15	11	16	12	17	13	18	13	19	14	21	16	23	17	72
80	13	16	14	15	15	13	16	12	17	11	19	8	21	5	64
70	12	3	12	17	13	14	14	10	15	7	17	0	18	11	56
60	10	8	11	2	11	15	12	9	13	3	14	11	16	0	48
50	8	12	9	5	9	15	10	7	11	0	12	3	13	6	40
40	6	17	7	7	7	15	8	6	8	14	9	13	10	12	32
30	5	4	5	10	5	16	6	4	6	11	7	5	8	0	24
20	3	9	3	13	3	17	4	3	4	7	4	16	5	6	16
10	1	13	1	15	1	17	2	2	2	4	2	8	2	12	8
9	1	10	1	12	1	14	1	16	2	0	2	3	2	7	7⅕
8	1	7	1	9	1	10	1	12	1	14	1	17	2	2	6⅖
7	1	4	1	5	1	7	1	8	1	10	1	13	1	16	5⅗
6	1	1	1	2	1	3	1	4	1	6	1	8	1	11	4⅘
5	0	16	0	17	1	0	1	1	1	2	1	4	1	6	4
4	0	12½	0	13	0	14	0	15	0	16	0	17½	1	1	3⅕
3	0	9	0	10	0	10½	0	11	0	12	0	13	0	14	2⅖
2	0	6	0	6½	0	7	0	7½	0	8	0	9	0	10	1⅗
1	0	3	0	3	0	3½	0	3½	0	4	0	4½	0	5	⅘

WEFT FOR CLOTH, 33 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	12	13	14	6	15	16	17	9	19	2	20	12	22	5	100
120	12	4	13	14	15	5	16	15	18	6	19	16	21	7	96
110	11	4	12	11	14	0	15	7	16	15	18	4	19	11	88
100	10	3	11	8	12	13	14	0	15	5	16	10	17	15	80
90	9	3	10	6	11	8	12	11	13	14	14	16	16	1	72
80	8	3	9	3	10	3	11	4	12	4	13	4	14	5	64
70	7	2	8	0	8	16	9	14	10	13	11	11	12	9	56
60	6	2	6	16	7	12	8	7	9	3	9	17	10	13	48
50	5	2	5	13	6	7	7	0	7	12	8	5	8	16	40
40	4	1	4	11	5	2	5	11	6	2	6	11	7	2	32
30	3	1	3	8	3	15	4	4	4	11	4	17	5	6	24
20	2	1	2	5	2	10	2	14	3	1	3	6	3	10	16
10	1	0	1	3	1	5	1	7	1	10	1	12	1	14	8
9	0	16½	1	0	1	3	1	5	1	7	1	9	1	11	7⅕
8	0	14½	0	16½	1	0	1	2	1	4	1	6	1	8	6⅖
7	0	13	0	14½	0	16	0	17½	1	1	1	3	1	4	5⅗
6	0	11	0	12	0	13½	0	15	0	16½	1	0	1	1	4⅘
5	0	9	0	10	0	11½	0	12½	0	14	0	15	0	16	4
4	0	7	0	8	0	9	0	10	0	11	0	12	0	13	3⅕
3	0	5½	0	6	0	7	0	7½	0	8	0	9	0	9½	2⅖
2	0	3½	0	4	0	4½	0	5	0	5½	0	6	0	6½	1⅗
1	0	2	0	2	0	2	0	2½	0	2½	0	3	0	3	⅘

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	24	8	25	13	27	1	28	12	30	4	33	8	36	11	100
120	23	9	24	8	26	0	27	9	29	0	32	2	35	2	96
110	21	10	22	7	23	15	25	4	26	11	29	7	32	4	88
100	19	12	20	7	21	12	22	17	24	3	26	13	29	5	80
90	17	13	18	6	19	9	20	11	21	14	24	1	26	6	72
80	15	15	16	5	17	6	18	6	19	6	21	7	23	8	64
70	13	7	14	5	15	3	16	1	16	17	18	13	20	9	56
60	11	8	12	4	13	0	13	14	14	9	16	1	17	10	48
50	9	10	10	3	10	15	11	8	12	2	13	7	14	12	40
40	7	12	8	3	8	12	9	3	9	12	10	12	11	13	32
30	5	13	6	2	6	9	6	16	7	5	8	0	8	14	24
20	3	15	4	1	4	6	4	11	4	14	5	6	5	15	16
10	1	16	2	1	2	3	2	5	2	8	2	12	2	17	8
9	1	13	1	15	1	17	2	1	2	3	2	7	2	11	7⅕
8	1	9	1	11	1	13	1	15	1	17	2	3	2	6	6⅖
7	1	6	1	8	1	9	1	11	1	12	1	16	2	1	5⅗
6	1	3	1	4	1	5	1	7	1	8	1	11	1	14	4⅘
5	0	17	1	0	1	1	1	2	1	4	1	6	1	8	4
4	0	14	0	14½	0	15½	0	16½	0	17½	1	1	1	3	3⅕
3	0	10	0	11	0	11½	0	12	0	13	0	14½	0	16	2⅖
2	0	7	0	7	0	7½	0	8	0	8½	0	9½	0	10½	1⅗
1	0	3	0	3½	0	4	0	4	0	4	0	5	0	5	⅘

WEFT FOR CLOTH, 36 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	13	16	15	11	17	7	19	1	20	15	22	10	24	6	100
120	13	6	15	0	16	12	18	5	20	0	21	12	23	6	96
110	12	4	13	13	15	5	16	14	18	6	19	16	21	7	88
100	11	2	12	9	13	16	15	4	16	12	18	1	19	8	80
90	10	0	11	4	12	9	13	13	15	0	16	5	17	9	72
80	8	16	10	0	11	2	12	3	13	6	14	8	15	10	64
70	7	14	8	13	9	13	10	12	11	12	12	12	13	11	56
60	6	12	7	9	8	6	9	2	10	0	10	15	11	12	48
50	5	10	6	4	6	17	7	11	8	6	9	1	9	13	40
40	4	8	5	0	5	10	6	2	6	12	7	4	7	14	32
30	3	6	3	14	4	3	4	10	5	0	5	8	5	15	24
20	2	4	2	9	2	14	3	1	3	6	3	11	3	16	16
10	1	2	1	4	1	7	1	10	1	12	1	15	1	17	8
9	1	0	1	2	1	4	1	7	1	9	1	11	1	14	7⅕
8	0	16	1	0	1	2	1	4	1	6	1	8	1	10	6⅖
7	0	14	0	16	0	17	1	1	1	3	1	5	1	7	5⅗
6	0	12	0	13	0	15	0	16½	1	0	1	2	1	3	4⅘
5	0	10	0	11	0	12	0	14	0	15	0	16	0	17½	4
4	0	8	0	9	0	10	0	11	0	12	0	13	0	14	3⅕
3	0	6	0	7	0	7½	0	8	0	9	0	10	0	10½	2⅖
2	0	4	0	4½	0	5	0	5½	0	6	0	6½	0	7	1⅗
1	0	2	0	2	0	2½	0	3	0	3	0	3	0	3½	⅘

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	26	1	27	14	29	9	31	5	33	0	36	8	39	17	100
120	25	0	26	12	28	6	30	0	31	12	35	0	38	6	96
110	22	17	24	8	26	0	27	9	29	0	32	2	35	3	88
100	20	15	22	4	23	11	25	0	26	7	29	3	31	17	80
90	18	14	20	0	21	5	22	9	23	14	26	5	28	14	72
80	16	12	17	14	18	16	20	0	21	2	23	6	25	10	64
70	14	11	15	10	16	10	17	9	18	9	20	8	22	7	56
60	12	9	13	6	14	3	15	0	15	15	17	9	19	3	48
50	10	8	11	2	11	15	12	9	13	4	14	11	16	0	40
40	8	6	8	16	9	8	10	0	10	10	11	12	12	14	32
30	6	5	6	12	7	2	7	9	7	17	8	14	9	11	24
20	4	3	4	8	4	13	5	0	5	5	5	15	6	7	16
10	2	2	2	4	2	7	2	9	2	11	2	17	3	4	8
9	1	16	2	0	2	2	2	5	2	7	2	11	2	16	7⅕
8	1	12	1	14	1	16	2	0	2	2	2	6	2	10	6⅖
7	1	8	1	10	1	12	1	14	1	15	2	1	2	4	5⅗
6	1	5	1	6	1	8	1	9	1	11	1	14	1	17	4⅘
5	1	1	1	2	1	3	1	5	1	6	1	8	1	11	4
4	0	15	0	16	0	17	1	0	1	1	1	3	1	5	3⅕
3	0	11	0	12	0	13	0	13½	0	14	0	16	0	17	2⅖
2	0	7½	0	8	0	8½	0	9	0	9½	0	10½	0	11½	1⅗
1	0	4	0	4	0	4	0	4½	0	5	0	5	0	6	⅘

WEFT FOR CLOTH, 37 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	14	5	16	1	17	15	19	11	21	7	23	4	25	0	100
120	13	13	15	8	17	2	18	15	20	10	22	5	24	0	96
110	12	10	14	2	15	13	17	5	18	15	20	7	22	0	88
100	11	7	12	15	14	5	15	13	17	2	18	10	20	0	80
90	10	5	11	10	12	15	14	2	15	7	16	13	18	0	72
80	9	2	10	5	11	7	12	10	13	13	14	15	16	0	64
70	8	0	9	0	10	0	11	0	12	0	13	0	14	0	56
60	6	15	7	13	8	10	9	7	10	5	11	2	12	0	48
50	5	13	6	8	7	2	7	15	8	10	9	5	10	0	40
40	4	10	5	2	5	13	6	5	6	15	7	8	8	0	32
30	3	8	3	16	4	5	4	13	5	3	5	10	6	0	24
20	2	5	2	10	2	15	3	3	3	8	3	13	4	0	16
10	1	3	1	5	1	8	1	10	1	13	1	15	2	0	8
9	1	0	1	3	1	5	1	7	1	10	1	12	1	14	$7\frac{1}{5}$
8	0	$16\frac{1}{2}$	1	0	1	3	1	5	1	7	1	9	1	11	$6\frac{2}{5}$
7	0	14	0	16	1	0	1	2	1	4	1	5	1	7	$5\frac{3}{5}$
6	0	12	0	14	0	$15\frac{1}{2}$	0	17	1	0	1	2	1	4	$4\frac{4}{5}$
5	0	10	0	$11\frac{1}{2}$	0	13	0	14	0	$15\frac{1}{2}$	0	$16\frac{1}{2}$	1	0	4
4	0	8	0	9	0	10	0	11	0	12	0	13	0	14	$3\frac{1}{5}$
3	0	6	0	7	0	$7\frac{1}{2}$	0	$8\frac{1}{2}$	0	9	0	10	0	11	$2\frac{2}{5}$
2	0	4	0	$4\frac{1}{2}$	0	5	0	$5\frac{1}{2}$	0	6	0	$6\frac{1}{2}$	0	7	$1\frac{3}{5}$
1	0	2	0	2	0	$2\frac{1}{2}$	0	3	0	3	0	3	0	$3\frac{1}{2}$	$\frac{4}{5}$

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	26	14	28	10	30	6	32	0	33	16	37	8	41	0	100
120	25	13	27	7	29	2	30	15	32	10	36	0	39	7	96
110	23	10	25	2	26	13	28	5	29	15	33	0	36	2	88
100	21	7	22	15	24	5	25	12	27	0	30	0	32	15	80
90	19	5	20	10	21	15	23	2	24	7	27	0	29	10	72
80	17	2	18	5	19	7	20	10	21	13	24	0	26	5	64
70	15	0	16	0	17	0	18	0	19	0	21	0	23	0	56
60	12	15	13	13	14	10	15	8	16	5	18	0	19	13	48
50	10	13	11	8	12	3	12	15	13	10	15	0	16	7	40
40	8	10	9	2	9	13	10	5	10	15	12	0	13	2	32
30	6	8	6	15	7	5	7	13	8	2	9	0	9	15	24
20	4	5	4	10	4	15	5	3	5	8	6	0	6	10	16
10	2	3	2	5	2	8	2	10	2	13	3	0	3	5	8
9	1	17	2	1	2	3	2	6	2	8	2	13	2	17	$7\frac{1}{5}$
8	1	13	1	15	1	17	2	1	2	3	2	7	2	11	$6\frac{2}{5}$
7	1	9	1	11	1	13	1	14	1	16	2	2	2	5	$5\frac{3}{5}$
6	1	5	1	7	1	8	1	10	1	11	1	14	1	17	$4\frac{4}{5}$
5	1	1	1	3	1	4	1	5	1	6	1	9	1	12	4
4	0	15	0	16	0	17	1	0	1	1	1	4	1	6	$3\frac{1}{5}$
3	0	$11\frac{1}{2}$	0	12	0	13	0	14	0	15	0	16	1	0	$2\frac{2}{5}$
2	0	$7\frac{1}{2}$	0	8	0	$8\frac{1}{2}$	0	9	0	10	0	$10\frac{1}{2}$	0	12	$1\frac{3}{5}$
1	0	4	0	4	0	4	0	$4\frac{1}{2}$	0	5	0	5	0	6	$\frac{4}{5}$

WEFT FOR CLOTH, 40 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	15	8	17	7	19	5	21	4	23	3	25	1	27	0	100
120	14	15	16	12	18	9	20	7	22	4	24	1	25	17	96
110	13	10	15	5	17	0	18	12	20	7	22	1	23	14	88
100	12	6	13	16	15	8	17	0	18	9	20	1	21	11	80
90	11	2	12	9	13	16	15	5	16	12	18	1	19	8	72
80	9	16	11	2	12	6	13	10	14	15	16	1	17	5	64
70	8	12	9	13	10	14	21	16	12	17	14	1	15	2	56
60	7	7	8	6	9	5	10	3	11	2	12	1	12	17	48
50	6	3	6	17	7	13	8	9	9	5	10	1	10	14	40
40	4	17	5	10	6	3	6	14	7	7	8	0	8	12	32
30	3	13	4	3	4	11	5	2	5	10	6	0	6	9	24
20	2	8	2	14	3	2	3	7	3	13	4	0	4	6	16
10	1	4	1	7	1	10	1	13	1	15	2	0	2	3	8
9	1	2	1	5	1	7	1	10	1	12	1	15	1	17	7⅕
8	1	0	1	2	1	4	1	6	1	9	1	11	1	13	6⅖
7	0	15½	0	17½	1	1	1	3	1	5	1	7	1	9	5⅗
6	0	13	0	15	0	17	1	0	1	2	1	4	1	5	4⅘
5	0	11	0	12½	0	14	0	15	0	17	1	0	1	1	4
4	0	9	0	10	0	11	0	12	0	13	0	14	0	15½	3⅕
3	0	6½	0	7½	0	8	0	9	0	10	0	11	0	12	2⅖
2	0	4½	0	5	0	5½	0	6	0	6½	0	7	0	8	1⅗
1	0	2	0	2½	0	3	0	3	0	3½	0	3½	0	4	⅘
Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	28	17	30	16	32	14	34	13	36	12	40	9	44	7	100
120	27	14	29	11	31	9	33	6	35	3	38	16	42	11	96
110	25	8	27	3	28	15	30	10	32	5	35	12	39	1	88
100	23	3	24	12	26	4	27	14	29	6	32	7	35	9	80
90	20	15	22	4	23	11	25	0	26	7	29	3	31	17	72
80	18	9	19	14	21	0	22	4	23	8	25	17	28	7	64
70	16	4	17	5	18	7	19	8	20	9	22	12	24	15	56
60	13	16	14	15	15	13	16	12	17	11	19	8	21	5	48
50	11	10	12	6	13	2	13	16	14	12	16	4	17	13	40
40	9	5	9	16	10	9	11	2	11	13	12	17	14	4	32
30	6	17	7	7	7	16	8	6	8	14	9	13	10	12	24
20	4	11	4	17	5	4	5	10	5	16	6	9	7	2	16
10	2	6	2	8	2	11	2	14	2	17	3	4	3	10	8
9	2	2	2	4	2	7	2	9	2	12	2	17	3	4	7⅕
8	1	15	2	0	2	2	2	4	2	6	2	11	2	15	6⅖
7	1	11	1	13	1	15	1	17	2	1	2	5	2	9	5⅗
6	1	7	1	9	1	10	1	12	1	14	1	17	2	2	4⅘
5	1	3	1	4	1	6	1	7	1	8	1	11	1	14	4
4	0	16½	1	0	1	1	1	2	1	3	1	5	1	8	3⅕
3	0	12½	0	13	0	14	0	15	0	16	0	17½	1	1	2⅖
2	0	8	0	9	0	9	0	10	0	10½	0	12	0	13	1⅗
1	0	4	0	4½	0	4½	0	5	0	5	0	6	0	6½	⅘

WEFT FOR CLOTH, 46 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	17	13	19	17	22	3	24	7	26	11	28	15	31	1	100
120	17	1	19	3	21	5	23	8	25	10	27	12	29	15	96
110	15	11	17	10	19	9	21	8	23	8	25	7	27	6	88
100	14	4	15	17	17	13	19	9	21	5	23	1	24	15	80
90	12	14	14	7	15	17	17	10	19	3	20	14	22	6	72
80	11	7	12	14	14	4	15	11	17	1	18	8	19	16	64
70	9	17	11	3	12	8	13	12	14	16	16	3	17	7	56
60	8	9	9	11	10	12	11	13	12	14	13	15	14	16	48
50	7	2	8	0	8	16	9	14	10	12	11	10	12	8	40
40	5	12	6	7	7	2	7	15	8	9	9	4	9	17	32
30	4	5	4	14	5	6	5	15	6	7	6	17	7	8	24
20	2	15	3	4	3	10	3	16	4	5	4	11	4	17	16
10	1	8	1	11	1	14	1	17	2	2	2	6	2	9	8
9	1	5	1	8	1	11	1	14	1	17	2	1	2	4	7⅕
8	1	3	1	4	1	8	1	10	1	13	1	15	2	0	6⅖
7	1	0	1	2	1	4	1	7	1	9	1	11	1	13	5⅗
6	0	15	0	17	1	1	1	3	1	5	1	7	1	9	4⅘
5	0	13	0	14	0	16	1	0	1	1	1	3	1	4	4
4	0	10	0	11½	0	13	0	14	0	15	0	16½	1	0	3⅕
3	0	7½	0	8½	0	9½	0	10½	0	11½	0	12½	0	13½	2⅖
2	0	5	0	5½	0	6½	0	7	0	7½	0	8	0	9	1⅗
1	0	2½	0	3	0	3	0	3½	0	4	0	4	0	4½	⅘

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	33	3	35	9	37	13	39	17	42	3	46	11	51	0	100
120	31	17	34	1	36	4	38	6	40	8	44	14	49	0	96
110	29	5	31	4	33	3	35	3	37	2	41	1	44	16	88
100	26	11	28	7	30	3	31	17	33	13	37	5	40	15	80
90	23	17	25	10	27	3	28	14	30	6	33	10	36	13	72
80	21	5	22	13	24	2	25	10	26	17	29	15	32	12	64
70	18	11	19	16	21	2	22	7	23	11	26	2	28	10	56
60	16	0	17	1	18	2	19	3	20	4	22	6	24	9	48
50	13	6	14	4	15	2	16	0	16	15	18	11	20	7	40
40	10	12	11	7	12	1	12	14	13	9	14	16	16	6	32
30	8	0	8	8	9	1	9	11	10	2	11	3	12	4	24
20	5	6	5	12	6	1	6	7	6	13	7	8	8	3	16
10	2	12	2	15	3	0	3	4	3	7	3	13	4	1	8
9	2	7	2	10	2	13	2	16	3	1	3	6	3	12	7⅕
8	2	2	2	5	2	8	2	10	2	13	3	0	3	5	6⅖
7	1	16	2	0	2	2	2	4	2	6	2	11	2	15	5⅗
6	1	11	1	13	1	15	1	17	2	0	2	4	2	8	4⅘
5	1	6	1	8	1	9	1	11	1	12	1	16	2	1	4
4	1	1	1	2	1	4	1	5	1	6	1	9	1	11	3⅕
3	0	14½	0	15½	0	16	0	17	1	0	1	2	1	4	2⅖
2	0	9½	0	10	0	11	0	11½	0	12	0	13	0	15	1⅗
1	0	5	0	5	0	5½	0	6	0	6	0	6½	0	7	⅘

WEFT FOR CLOTH, 48 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	18	9	20	15	23	3	25	8	27	14	30	2	32	7	100
120	17	14	20	0	22	4	24	8	26	12	28	16	31	2	96
110	16	5	18	6	20	7	22	7	24	8	26	9	28	9	88
100	14	15	16	12	18	9	20	7	22	4	24	1	25	17	80
90	13	6	15	0	16	12	18	6	20	0	21	12	23	6	72
80	11	15	13	6	14	15	16	5	17	14	19	5	20	13	64
70	10	7	11	12	12	17	14	5	15	10	16	15	18	2	56
60	8	16	10	0	11	2	12	4	13	6	14	8	15	10	48
50	7	7	8	6	9	5	10	3	11	2	12	1	12	17	40
40	5	17	6	12	7	7	8	3	8	16	9	11	10	6	32
30	4	8	5	0	5	10	6	2	6	12	7	4	7	14	24
20	2	17	3	6	3	13	4	1	4	8	4	15	5	3	16
10	1	9	1	12	1	15	2	1	2	4	2	7	2	11	8
9	1	6	1	9	1	12	1	15	2	0	2	3	2	6	$7\frac{1}{5}$
8	1	3	1	6	1	9	1	11	1	14	1	17	2	1	$6\frac{2}{5}$
7	1	1	1	3	1	5	1	8	1	10	1	12	1	15	$5\frac{3}{5}$
6	0	16	1	0	1	2	1	4	1	6	1	8	1	10	$4\frac{4}{5}$
5	0	13	0	15	0	17	1	0	1	2	1	4	1	5	4
4	0	11	0	12	0	13	0	15	0	16	0	17	1	0	$3\frac{1}{5}$
3	0	8	0	9	0	10	0	11	0	12	0	13	0	14	$2\frac{2}{5}$
2	0	5	0	6	0	7	0	7	0	8	0	$8\frac{1}{2}$	0	9	$1\frac{3}{5}$
1	0	3	0	3	0	3	0	4	0	4	0	4	0	$4\frac{3}{4}$	$\frac{4}{5}$

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	34	13	37	0	39	6	41	12	44	0	48	11	53	4	100
120	33	6	35	10	37	14	40	0	42	4	46	12	51	2	96
110	30	10	32	11	34	11	36	12	38	12	42	14	46	15	88
100	27	14	29	11	31	9	33	6	35	3	38	16	42	10	80
90	25	0	26	12	28	6	30	0	31	12	35	0	38	6	72
80	22	4	23	13	25	3	26	12	28	3	31	2	34	1	64
70	19	8	20	13	22	0	23	6	24	11	27	4	29	14	56
60	16	12	17	14	18	17	20	0	21	2	23	6	25	10	48
50	13	16	14	15	15	13	16	12	17	11	19	8	21	5	40
40	11	2	11	15	12	11	13	6	14	1	15	10	17	1	32
30	8	6	8	16	9	8	10	0	10	10	11	12	12	14	24
20	5	10	5	17	6	5	6	12	7	1	7	14	8	9	16
10	2	14	2	17	3	3	3	6	3	9	3	16	4	5	8
9	2	9	2	12	2	15	3	0	3	3	3	9	3	15	$7\frac{1}{5}$
8	2	4	2	7	2	9	2	12	2	15	3	2	3	8	$6\frac{2}{5}$
7	1	17	2	1	2	4	2	6	2	8	2	13	3	0	$5\frac{3}{5}$
6	1	12	1	14	1	16	2	0	2	2	2	6	2	10	$4\frac{4}{5}$
5	1	7	1	9	1	10	1	12	1	14	1	17	2	2	4
4	1	2	1	3	1	5	1	6	1	7	1	10	1	13	$3\frac{1}{5}$
3	0	15	0	16	0	17	1	0	1	1	1	3	1	5	$2\frac{2}{5}$
2	0	10	0	11	0	11	0	12	0	13	0	14	0	15	$1\frac{3}{5}$
1	0	5	0	5	0	6	0	6	0	6	0	7	0	$7\frac{1}{2}$	$\frac{4}{5}$

WEFT FOR CLOTH, 54 INCHES WIDE.

Shots on the Glass	8		9		10		11		12		13		14		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	20	15	23	8	26	1	28	11	31	5	33	15	36	8	100
120	20	0	22	9	25	0	27	9	30	0	32	9	35	0	96
110	18	6	20	11	22	17	25	4	27	9	29	14	32	2	88
100	16	12	18	14	20	15	22	17	25	0	27	2	29	3	80
90	15	0	16	16	18	14	20	11	22	9	24	7	26	5	72
80	13	6	15	0	16	12	18	6	20	0	21	12	23	6	64
70	11	12	13	2	14	10	16	1	17	9	18	17	20	7	56
60	10	0	11	4	12	9	13	13	15	0	16	4	17	9	48
50	8	6	9	7	10	7	11	8	12	9	13	10	14	11	40
40	6	12	7	9	8	6	9	3	10	0	10	15	11	12	32
30	5	0	5	11	6	4	6	16	7	9	8	2	8	13	24
20	3	6	3	13	4	3	4	10	5	0	5	7	5	15	16
10	1	12	1	16	2	1	2	5	2	9	2	13	2	16	8
9	1	9	1	12	1	16	2	1	2	4	2	8	2	11	$7\frac{1}{5}$
8	1	6	1	9	1	12	1	15	2	0	2	3	2	6	$6\frac{2}{5}$
7	1	3	1	6	1	8	1	11	1	13	1	16	2	1	$5\frac{3}{5}$
6	1	0	1	2	1	4	1	7	1	9	1	11	1	13	$4\frac{4}{5}$
5	0	15	0	17	1	1	1	3	1	4	1	6	1	8	4
4	0	12	0	13	0	15	0	16	1	0	1	1	1	3	$3\frac{1}{5}$
3	0	9	0	10	0	11	0	12	0	13	0	15	0	16	$2\frac{2}{5}$
2	0	6	0	7	0	$7\frac{1}{2}$	0	8	0	9	0	10	0	$10\frac{1}{2}$	$1\frac{3}{5}$
1	0	3	0	3	0	4	0	4	0	$4\frac{1}{2}$	0	5	0	5	$\frac{4}{5}$

Shots on the Glass	15		16		17		18		19		21		23		
Yds.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	spy.	hk.	Ells.
125	39	1	41	12	44	5	46	16	49	9	54	12	59	16	100
120	37	9	40	0	42	9	45	0	47	9	52	9	57	9	96
110	34	7	36	12	38	17	41	5	43	10	48	2	52	13	88
100	31	5	33	6	35	8	37	9	39	11	43	14	47	17	80
90	28	2	30	0	31	16	33	14	35	11	39	7	43	2	72
80	25	0	26	12	28	6	30	0	31	12	35	0	38	6	64
70	21	16	23	6	24	14	26	5	27	13	30	11	33	10	56
60	18	13	20	0	21	4	22	9	23	13	26	4	28	13	48
50	15	11	16	12	17	13	18	13	19	14	21	16	23	17	40
40	12	9	13	6	14	3	15	0	15	15	17	9	19	3	32
30	9	7	10	0	10	11	11	4	11	16	13	2	14	7	24
20	6	4	6	12	7	1	7	9	7	16	8	13	9	10	16
10	3	2	3	6	3	10	3	13	3	17	4	7	4	14	8
9	2	15	3	0	3	3	3	7	3	10	3	17	4	6	$7\frac{1}{5}$
8	2	9	2	12	2	15	3	0	3	3	3	9	3	15	$6\frac{2}{5}$
7	2	3	2	6	2	9	2	11	2	14	3	1	3	6	$5\frac{3}{5}$
6	1	16	2	0	2	2	2	4	2	7	2	11	2	16	$4\frac{4}{5}$
5	1	10	1	12	1	14	1	16	2	0	2	3	2	7	4
4	1	4	1	6	1	7	1	9	1	10	1	13	1	16	$3\frac{1}{5}$
3	0	17	1	0	1	1	1	2	1	3	1	6	1	8	$2\frac{2}{5}$
2	0	11	0	12	0	13	0	13	0	14	0	16	0	17	$1\frac{3}{5}$
1	0	$5\frac{1}{2}$	0	6	0	$6\frac{1}{2}$	0	7	0	7	0	8	0	$8\frac{1}{2}$	$\frac{4}{5}$

PRICES OF COTTON YARN.

MR. THOMAS HOULDSWORTH'S LIST,

MANCHESTER.

NET CASH PRICES.

NO.	SINGLE YARN OR TWIST.		DOUBLED YARN OR THREAD.	
	s.	d.	s.	d.
120	3	11	4	7
130	4	4	5	1
140	4	11	5	7
150	5	7	6	2
160	6	5	6	10
170	7	3	7	6
180	8	1	8	4
190	9	1	9	3
200	10	1	10	3
210	11	4	11	6
220	13	0	12	10
230	14	8	14	5
240	16	8	16	3
250	19	2	18	4
280	37	0	28	0
300	57	0	37	0
320			48	0
350			70	0
400			120	0
450			227	0

PRICES OF COTTON YARNS,

GLASGOW.

The following List is given as an average of the Net Cash Prices of Yarns in the Glasgow market.

NO.	BEST SECOND WEFT.		BEST SECOND WARP.		DOUBLED YARN.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
10	0	7	0	7½		
20	0	7½	0	8¼		
30	0	9	0	9½		
40	0	10	0	11	1	0½
50	1	0	1	1½	1	2
60	1	2	1	4	1	5
70	1	3½	1	7	1	7
80	1	7	1	11	1	10
90	1	0	2	4	2	2
100	2	2	2	9	2	7
110	2	7	3	2		
120	2	11	3	7	3	7
130	3	4	4	0		
140	3	8	4	6	4	6
150	4	2	5	1		
160	4	9	5	10	5	9
170	5	4	6	6		
180	6	0	7	2	7	0
190	6	10	7	11		
200	7	8	9	1	8	6
210	8	4	10	0		
220	9	6	11	6		
230	11	0	13	6		

PRICES OF LINEN YARN.

MESSRS. BAXTER, BROTHERS & Co.'s LIST, DUNDEE.

REEL.

120 Threads of 2½ Yards = 300 Yards = 1 Lea.
12 Leas = 3,600 „ = 1 Hank.
50 Hanks = 180,000 „ = 3 Bundles.

Prices quoted ℔ Bundle of 60,000 Yards.

Discount 5 ℔ cent. for Cash.

PATENT WET SPUN LINE YARNS.

Leas or Cuts in the Pound.	GREY.	BLEACHED. Cream.	BLEACHED. Half Bleach.	BLEACHED. Full Bleach.
	s. d.	s. d.	s. d.	s. d.
16	9 6	10 6	10 11	11 0
18	9 0	9 11	10 3	10 4
20	8 6	9 4	9 8	9 9
22	8 0	8 9	9 1	9 2
25	7 8	8 4	8 7	8 9
28	7 4	8 0	8 2	8 3
30	7 2	7 8	7 11	8 0
35	7 0	7 5	7 8	7 9
40	6 10	7 3	7 5	7 6
45	6 10	7 2	7 4	7 5
50	6 10	7 2	7 3	7 4
55	6 10	7 1	7 3	7 3
60	6 10	7 1	7 3	7 3
65	6 10			
70	6 10	7 1	7 2	7 3
75	7 0			
80	7 2	7 5	7 6	7 6
85	7 4			
90	7 6			
100	7 10			
110	8 2			
120	8 6			

Messrs. BAXTER, BROTHERS & Co.'s LIST continued.

DRY SPUN LINE YARNS.

Leas.	First Quality.					Second Quality.				
	Grey.		Bleached.			Grey.		Bleached.		
	Dark.	Yellow.	Cream.	Half Bleach.	Full Bleach.	Dark.	Yellow.	Cream.	Half Bleach.	Full Bleach.
	s. d.	s. d.				s. d.				
10										
12										
14										
16	8 10	9 0				8 6				
18	8 6	8 8				8 2				
20	8 3	8 5				7 10				
22	8 0					7 8				
25	7 8					7 4				
28	7 6									

DRY SPUN TOW YARNS.

Leas.	First Quality.				Second Quality.			
	Grey.	Bleached.			Grey	Bleached.		
		Cream.	Half Bleach.	Full Bleach.		Cream.	Half Bleach.	Full Bleach.
	s. d.							
2, 2½								
3, 4								
5								
6	13 0							
7	12 0							
8	10 9							
10	9 9							
12	8 10							
14	8 6							
16	8 6							
18	8 3							
20								
22								
25								

The prices of Sailcloth and Canvass Yarns run from about 8d. to 4d. per pound, according to the quality.

Navy Canvass is made wholly of Flax—both warp and weft. The grist of the warp is from three to nine pounds in the spyndle, according to the kind of canvass which is intended to be made with it, and is sold by the Gourock Company at 8d. per pound. The weft varies likewise with the fabric from ten to twenty-four pounds in the spyndle, and may be bought for 7½d.

Mercantile Canvass is made of Flax warp, but with Tow weft. The weft will be about 5d. per pound.

Inferior descriptions of Canvass are made with both warp and weft of Tow, and the price may be stated at about 4d. per pound.

664. WARPING is the making of the webs or warps for being woven, and the process consists in winding the yarn so as to form the warp of the length and breadth for the required web, in the best manner to suit the weaver for weaving it into cloth. Warping, therefore, precedes the weaving, in the same manner as the spinning of the yarn must precede the warping.

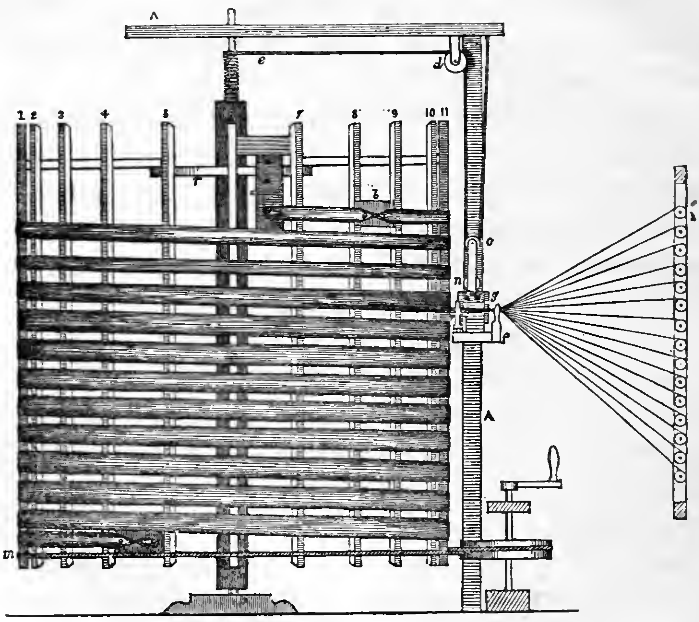


Fig. 47. Warping Mill.

665. Warping for hand loom work is effected on a reel called the warping mill, as seen in Fig. 47th; and as the yarn is usually wound on the hank in coming from the spinner, especially fine yarns, it must be unwound again on bobbins for the warper.

666. This operation of bobbin winding is done by women, on a wheel such as that represented for pirn winding, and is indeed the same operation, except that yarn for fine cotton goods is generally slightly starched with a little flour, after being boiled, to strengthen it, and wound on bobbins with a certain quantity on each—usually five or six hanks. A certain number of bobbins, from 80 to 120 perhaps, is given to the warper to form the warp, with a ticket specifying the length of the web in ells, and the breadth in porters.

667. The first object of the warper is to calculate the number of turns of his mill that will be necessary to make the length and breadth of the web, as required from the given number of bobbins. This is a very simple matter. The number of turns to make the length of the web is found by dividing it by the circumference of the reel or mill, which is generally five ells in Scotland—each ell five quarters, the measure by which the weaver is there paid for his work; and as the web is generally 100 ells, twenty turns in this case will give the required length of piece which is to be woven; but there must be an allowance for a thrumb, and a few inches as a neck for tying up the web—about three-fourths of a yard in all—and an equivalent portion of a turn must be given for these purposes. Then the number of repetitions of this length to form the breadth of the web will be as the number of threads in this section to the number required for the whole breadth. But, as each bobbin makes two threads of warp, when the mill has been returned on the first repetition of the

length, the calculation is performed in splitfuls. Thus, for example, supposing the breadth of the web eighty-five porters and the number of bobbins 100—then $85 \times 20 = 1700 \div 100 = 17$ is the number of repetitions or turns and returns, which are called races, necessary to make this breadth of web.

668. The warper then commences the operation of warping by putting the bobbins on skewers in a frame called the bank, marked *h*, which is made to receive the bobbins in rows placed above each other in parallel lines,—and is usually formed in the segment of a circle, with the concave side towards the mill, so as to allow the bobbins to be unwound freely at right angles to the direction in which the threads are taken from them. The yarn must be warped or wound on the mill in such a manner as to preserve the parallel direction of the threads throughout for the weaver. This is a matter of essential importance; and for that purpose, the lease of the yarn must be preserved, as the only key by which the weaver can prevent the entanglement of the threads, till the yarn is drawn through the heddles for weaving. The *heck* is the means by which the lease is formed; and performs the function of a sort of heddles to the warper. It consists of two rows of steel needle pins, so placed in a frame that the rows may be raised or sunk separately; and as the threads from the bobbins are drawn through the eyes alternately of each row successively, one thread through each needle eye—the lease is formed by raising and reversing either of

the heck frames. There must of course be as many needles in the heck as there are bobbins or runners in the bank.

669. The yarn, thus drawn through the heck pins, is knotted together, and put on the upper pin *a*, of the mill. The mill is then turned, till the upper lease pins *b*, are nearly opposite the heck, when the warper raises one of the heck leaves, and introduces the fore finger of the left hand to preserve the shed till he has reversed the lease by raising that half which was previously down, and sinking the other to its former level. He then secures it in a similar manner with the thumb of the same hand, and carefully transfers both sheds to the two lease pins *b*, by which they are preserved during the subsequent operations.

670. But as the yarn must be wound on the weaver's beam after the warper has done with it, he introduces an arrangement in the yarn to facilitate that operation; that is, he forms the threads into what is called pins or half gangs, so that the weaver, in knowing the number of pins in his web, can thereby spread it equally in the beaming to the required breadth, by putting each pin into a separate tooth of a kind of coarse reed like a comb called a *ravel*, which has a corresponding number of teeth to that of the pins for the required breadth of web.

671. This arrangement of the yarn into pins is effected in warping by dividing the threads equally into a certain number of portions, each of which forms a half gang. These portions are kept separated, by being put individually between two small

wooden pullies; a row of which are placed for that purpose behind the heck towards the mill, with one half gang between each pulley.

672. The warper then commences to wind the yarn on the mill by turning the trundle with which it is connected with his left hand; and thus, though the yarn is led on the mill through the heck from the pullies, in half gangs run together in the aggregate, yet they afterwards preserve their individuality, and open out freely in the beaming.

673. But as the circumference of the mill is the measure by which the length of the web is ascertained, it must be prevented as much as possible from increasing by the winding on of the web; and that is effected by coiling it spirally from top to bottom of the reel or mill.

674. This uniform distribution of the yarn in this manner over the surface of the mill is accomplished by the motion of the heck; and for this purpose it is made to slide up and down on its standard or post, by being suspended from a cord which is attached to the centre pivot or spindle of the mill A. When the mill is turned round, it descends by its own gravity; and when a sufficient number of turns are taken to make the length of the web, the warper forms the half gangs into a lease, and transfers them to the lower lease pins. He then reverses the motion of the mill, till he has got the same length run back again, and the heck of course is wound up by the cord on the spindle, as the mill is turned round, in the same manner as it descended.

675. The yarn is thus coiled spirally on the mill; but, as it is not to be run in ridges, it must not be always run in exactly the same tract. It is therefore to be run so as to spread the warp like a band over the mill; and this is done by altering the height of the heck with respect to the several races. For this purpose the heck is hung with a cord over a pulley. The cord is attached to a spindle or axle, which is furnished with a ratchet wheel, and, as the heck is to be raised or lowered, a tooth or so of the wheel is to be taken accordingly, and secured with a click which is attached for that purpose. The edge of the ratchet wheel is seen at *g*, and the pulley from which the heck is suspended—at *n*.

676. When the required number of races have been run to make the breadth of the web, the two leases are secured by being firmly tied with a cord. The thread lease at the top is the beginning of the web, and the half gang lease at the bottom is the end of the web. The warper, therefore, begins to take the web off at the top, and, as he draws it off, coils it into a succession of loose loops like a chain. Hence the web is called a chain in coming from the warper.

677. In warping stripes or ginghams, the several variable stripes composing the pattern must be multiplied into the length of the web to get the quantity of yarn for each, just as it were a separate web. Thus, supposing in a gingham 100 ells long there are 10 porters red, 8 porters 10 splits blue, 12 porters orange, and 30 porters white, the yarn for each individual stripe is to be found separately, and the

quantities of the several stripes composing the pattern added together make the whole.

```
      100
       10 red.
302.4)1000.0(3 spyndles.
      9072
  168)928(5 hanks.
      840
   24)88(3 skeins.
      72
      16
```

```
      100
       12 orange.
302.4)1200.0(3 spyndles.
      9072
  168)2928(17 hanks.
      168
      1248
      1176
   24)72(3 skeins.
      72
```

```
      100
      8 10 blue.
302.4)850.0(2 spyndles.
      6048
  168)2452(14 hanks.
      168
       772
       672
   24)100(4 skeins.
       96
        4
```

```
      100
       30 white.
302.4)3000.0(9 spyndles.
      27216
  168)2784(16 hanks.
      168
      1104
      1008
   24)96(4 skeins.
      96
```

The several quantities thus are :—

Spyndles.	Hanks.	Skeins.
3	5	3 Red.
2	14	4 Blue.
3	17	3 Orange.
9	16	4 White.
20	0	0 in all.

678. The web after it comes from the warper is usually to be starched, but it is returned to the weaver in the same manner as the warper made it up. The weaver's business is then to beam it, that is to wind it on the beam at the proper width, and sufficiently firm to withstand the tension of weaving. This operation is usually done by a person called a beamer, who makes a business of it, in a room which he keeps for the purpose. The beamer commences the operation by winding the yarn like a rope, on a winch friction roller, beginning with the neck of the web. When this is done, he takes the end of the web which is outwards, and puts the beam shaft through the loop formed there by the doubling of the half gangs. He then spreads the yarn on the shaft, and puts each individual half gang into a separate tooth of a kind of coarse reed like a long comb, called a *ravel*. The ravel is made to consist of two parts, which clasp together to facilitate the operation,—the comb-like part with the teeth exposed, over the ends of which the half gangs are entered, and the sheath which encloses the ends so as to prevent the half gangs from coming out in the beaming. The shaft is put in the groove of the beam. The beam is put into a frame at the end of the room opposite the friction roller on which the web is wound. The beam is then attached to a winch handle in the frame, and turned round, till the web is wound on it from the roller at the other end of the room. The tension of the web on the beam is regulated by the weight as hung on the friction roller; and to prevent the selvage half gangs from

slipping down in the weaving, the yarn is built on the beam, with the selvages sloping inwards. This is managed by holding the ravel more or less obliquely in the beaming, so as to narrow the breadth of the web a little as the operation proceeds. For this purpose the ravel is hung, and a person stands at each side of the web, to guide or build the selvage, as the beam is being turned.

679. The ravel is, therefore, the instrument by which the web is beamed at the proper width, and the number of half gangs in the width of the web is the guide by which the beamer adapts the ravel to the required width. The half gangs in the web are therefore entered in the weaver's ticket, and the beamer has a variety of ravels, of different degrees of fineness, to suit the work. The ravels are numbered according to the teeth, or scores of teeth, in 37 inches. When, therefore, the web is of any other width than 37 inches or yard, the half gangs or pins, multiplied by 16, the nails in the yard, and divided by the nails in the breadth, will give the number of the ravel required for beaming it. Thus, if the web is 19 nails broad, with 236 half gangs, or pins, as they are frequently called—the ravel required will be a 9 score and 18 pins—because $236 \times 16 = 3776 \div 19 = 198\frac{14}{19} = 9$ score and 18 pins, besides the fraction, which is of no value here.

680. In manufacturing by machinery, this operation of beaming is entirely avoided, and that of warping is much simplified. The yarn in power loom weaving is taken directly from the spinner, and reeled by the winders, and from them to the warpers.

The warper winds it in large quantities on a beam or reel, which is taken directly to the dressing machine. It is advantageous to have few changes of fabrics in weaving by power, and certain descriptions of goods are made continuously. There is thus little calculation required in warping for it, and little variety in the operation.

681. In the MANAGEMENT of men so as to turn their talent and energy to the most advantage, the means for doing so must effect their purpose through the instrumentality of the will. The grand distinction between a leading and a forcing direction in the management of people should never be lost sight of, as the consequences, as affecting both parties, are of the utmost importance. According to the manner of proceeding by the former method, the power of both parties is combined so as to act with the utmost effect for the advantage of both. But in the latter case, so far as the object is effected at all, it is done in spite of the instrumentality of the individuals acted on, and, in such a case, is always attended with some reaction which, in so far as it exists, counteracts the controlling power.

682. The art of directing people, so far as it is an art at all, consists in securing their confidence and rendering the discharge of their duties as pleasurable to them as possible. A good practical knowledge of the business in question is indispensable in effecting these results. But as the implicit acquiescence by the governed in the conduct of the

governing party rests on the conviction of their being dealt with in the spirit of truth and justice, intelligence without moral integrity can never fully secure the supremacy of the will.

683. Truth is to the moral nature of man what gravitation is to the physical. It secures the stability of his social relationships—and wherever it is lacking, in whatever degree, confidence in their stability is proportionally weakened; and both parties betake themselves to shifts in self-defence in the spirit of destructive selfishness. Artificial unions, strikes respecting wages, and eye-service giving, have their origin in violations of these principles; and their effects are nearly equally injurious to both parties.

684. In a population so variously constituted as ours, made up, indeed, of elements in very different stages of improvement, as for example in the intermixture of the Irish with the Scotch, and of the Irish with the English, the character of the more improved must be deteriorated; and the effect, accordingly, has been prejudicial to the habits and character of both the Scotch and English working people. Degradation, indeed, cannot be long sustained by any people without debasing their character. But this state of the population has given a sort of countenance to a coarse coercive system of control which seems more or less to taint the system of factory management, arising in some measure from the difficulty in discriminating individual character in otherwise dealing with it; and perhaps

such a state of society where, as with us, labour generally exceeds the demand for it, has a tendency to beget an indifference to its improvement, and it becomes treated as a state of things in necessary association together.

685. Mankind, in the main, have more sagacity and instinctive perception of character, and above all a greater capability of improvement than they are commonly believed to possess. But, indeed, an extensive perception of purpose is not a party accomplishment. In the keenness of the struggle for the possession of the immediate object of pursuit, the ulterior purpose of all actions seems to be almost wholly overlooked—namely, the individual cultivation of the faculties in society—and the consideration of the intercourse as taking place in every relationship among mankind, as the means for effecting that purpose—primarily or more remotely, in so far as they immediately affect the elements from which improvement derives its growth, or originate the power for preserving and enjoying them.

686. All the action of social life, therefore, however directed, tends to the development and improvement of individual character, so as to fit it for the efficient discharge of the duties of life ; and that system is the best which enables the individual under its influence the most effectually to acquire the power of self-government, in connexion with the knowledge of his true relationship in society.

687. The duties of life are various, and the ability as given to discharge them is no less various.

But talent is not only various as possessed by different individuals, but even by the same individuals at different times, dependent on education as well as the disposition to exercise it, and other circumstances: and the manifestation of it again is still more various—by the mode of presenting it.

688. Few individuals seem to be what they really are, without alluding to intentional disguise. Some invariably act below themselves from the peculiarity of their mental constitution, and although capable of great improvement and actually making great advances, are apt to be misunderstood, as they are solicitous about that chiefly which has not been gained. They have little concern about appearances. Superficial and casual observers are liable to make great mistakes in their estimation of such a character. They proceed on the presumption that the most pains is taken with that which is most seen, and for the sake of appearance; and accordingly, a character the reverse of this is generally over-estimated. The buoyant self-satisfied presentation of mind, with a capacity, as is generally the case, adapted for seizing on individual incidents only, is generally mistaken, in the favourable estimation of it, for a manifestation of character indicating considerable mental power. It may amount to cleverness; but it ends there. Such characters, more or less marked, are met with in the every-day intercourse of life, among the educated and uneducated classes of society. All are useful in their relative spheres; and in applying them aright in almost

any business, even those who act from enlightened and conscientious motives, have frequent occasion to regret their inability sufficiently to discriminate character, so as to direct it so well as they otherwise might, to the duties for which it is more especially fitted.

DESCRIPTIVE

INDEX TO THE PLATES.

THE forty-seven WOOD ENGRAVINGS require little special notice.

The 4th and 9th Figures are sections of the old hand loom, as it was used before the invention of the fly shuttle; and Figs. 10th and 11th are its shuttle and lathe.

The Figures from 14 to 20 refer to the hand loom, as fitted for working with the fly shuttle. Fig. 18th is a view of the fly shuttle as seen from the under side. The roller at each end is for the purpose of diminishing the friction of the shuttle in traversing the web, and, that it may turn freely, it is mounted on centre screws. The roller should barely project from the under side. On the upper side it is not seen at all, as the mortice in which it is set is not run quite through the shuttle ; but as near it as will merely leave a whole surface, that the roller may be as large in diameter as possible for the shuttle.

Figs. 14th, 15th, 16th, and 17th, represent different forms of drivers. The first and third are for heavy work, and the second and fourth for light. Fig. 19th is a transverse section taken immediately in front of the lathe, of the common hand loom in its best state as fitted for weaving light work, and Fig. 20th is a lateral section taken near the middle of the loom.

Fig. 22nd is an end elevation of an iron loom for hand weaving. There are many iron looms in use in the trade, but chiefly in factories ; and notwithstanding that the material is unquestionably better than wood for a loom, the hand weavers do not in general seem to be fully satisfied with them. Iron looms, as they are generally made, are not sufficiently convenient for different weavers to suit different work, or their various habits of working it.

There are three things that especially require to be attended to in making the loom for hand weaving so as to fit the weaver, and these are—

1st,—That the bearings for the lathe and the heddles be made that they may be easily shifted to any suitable distance from the fell, according as the fabric may require it in working.

2d,—That the loom may admit of any suitable length of stretch, and the yarn beam be easily adapted to any proper level in working; and,

3d,—That the treadles be easily fitted to the level of any weaver's feet in sitting on his seat in the loom, and the seat easily adapted to suit the level of the hand in working the lathe and throwing the shuttle.

With regard to the placing of the lathe, it will be observed from Fig. 22nd that the socket in which the gudgeon of the rocking tree rests is made to slide in a slit in the bracket by which it is supported from the post of the loom, and fixed, at the required place where the lathe is intended to work, with a nut. The socket is, therefore, screwed at its lower end, and has a shoulder at the top, above the bracket by which it rests on the bearing, and is thus jammed by the nut, which acts upon it on the under side.

The yarn beam is supported on side levers, in which there are several notches to suit any proper length of stretch; and the level of the beam is adjusted by pinching screws—one for each side, which runs through the framing and supports its respective side lever.

The treadle brackets are bolted to the lower bar, and rise behind the weaver so as to support the treadles at any level that any weaver may require to have them in working;—or, for very heavy work, the treadles may be reversed by bolting the brackets to the lower back bar.

Fig. 34th is a representation of a contrivance for disengaging the yarn beam in weaving heavy goods, such as sail-cloth, where the pace is not used, and with little trouble to the weaver. The long lever *d* which acts on the yarn beam is so placed as to be convenient to the hand in turning the cloth beam, and may be kept in gear by a spring, weight, or click, acted on by the foot or otherwise.

PLATES I. XIX. XX.

PLAN OF A WEAVING FACTORY.

Plate I. is the plan of a factory in which the looms are arranged with twelve in the breadth of the shed or house, with the shafting in relation to the spaces as required by the looms.

Plates XIX. and XX. are supplementary to a plan in which the looms are arranged with eight in the breadth, for the purpose of showing the relationship of the looms to the gearing.

Plate XX. is a portion of this plan, and Plate XIX. is a side elevation of that portion as taken from the intermediate passage opposite the side wall of the shed or factory.

The shed or factory both in Plate I. and the supplementary Plates is lighted from the roof.

PLATES II. III. IV.

CRANK DRESSING MACHINE.

The Crank Dressing Machine is presented in three Plates, a Plan in Plate II., and the two reverse side views in Plates III. and IV. All the corresponding parts referred to in the three plates are marked by the same letters.

The Machine Frame is marked, - - - A A

The Warp, - - - - - - - - *c c*

in the act of being dressed, extending from the

Reels, - - - - - - - - *o o*

on which it is taken to the machine to be wound on the

Beam, - - - - - - - - *v*

in a dressed state.

The Driving Shaft, - - - - - - *a'*

whence all the six movements included in dressing by power originate, communicates the motion by the

Pinion, - - - - - - - - - - b'

to the

Spur Wheel, - - - - - - - c' c'

on the

Crank Shaft, - - - - - - - - r

by which the stroking motion is imparted to the

Brushes, - - - - - - - - b b.

The parts essential to this motion are, the Crank shaft, its two

Connecting Rods, - - - - - - S S

which are jointed to the two

Upright Levers, - - - - - - - t t

by which it communicates, by the two

Stock Connecting Rods, - - - - - x x

with the

Stock Frame, - - - - - - - q q.

The Stock Frame is thus connected at each side with its respective crank, as seen by the two opposite side views, Plates III. and IV., and partially in the plan.

The Stock Frame is supported in its place at each end of the brush frame by being placed on

Two pairs of Spindles, - - - - - f f

a pair at each end of the frame. A brush is placed on each end of the stock frame under the web, with its face towards the yarn; and another brush is placed above it, mounted on an upper pair of spindles, with its face towards the under one.

The upper and under spindles are to be placed so that each of the brushes may move in the plane of the yarn when brought in contact with it. But the brushes must move in opposite directions, and on the yarn alternately.

The reverse sliding action of the two brushes is obtained from the crank, by connecting them together by a strap which passes over a pulley placed at each end of the two spindles, to change the direction of the motion.

The Pulley is marked, - - - -

and the

Strap, - - - - - - - - d d.

The parts of this movement are distinctly seen in the side view of the machine, page 131, where the stock frame is more especially seen, which will show it sufficiently in connection with the view of it as presented in the plan, and in the two side views, Plates III. and IV.

The alternate lifting movement is derived through the crank by the

Vertical Shaft, - - - - - - - - *t'*

from the

Horizontal Shafts, - - - - - - - *h' h'*

working in gear by the

Bevel Wheels, - - - - - - - *f' g''*

with the

Eccentric Shafts, - - - - - - *k' k'*

which are furnished with

Eccentric Cams or Wheels, - - - - - *k k*

for effecting the required action on the

Brush Frame, - - - - - - - - - *a a.*

Fig. 45, page 131, presents a good side view of the brush frame, and a bird's eye view is seen in the plan, Plate II., from which it will be seen that it vibrates on its centres by the revolving of the eccentric shaft by the reverse position of the cams.

The means for applying the paste are the pairs of dressing rollers,—the

Upper Rollers, - - - - - - - - *h h*

the

Under Rollers, - - - - - - - - - *g g*

The Dressing Troughs, - - - - - - K K

from which they receive the paste; and the

Levers, - - - - - - - - - - *m m*

and

Weights, - - - - - - - - - *n n*

connected by the

Hooks, - - - - - - - - - - *l l*

(seen in Fig. 45, page 131,) for regulating the supply of the paste.

The Small Rollers, - - - - - - *j j*

at each end of the machine, lead the yarn forward from the reels.

Motion is communicated to the rollers so as to apply the paste by two wheels and two pinions.

The Eccentric Shaft Pinion is marked, - 16
the number of its teeth,

The Spur Wheel, - - - - - - - - 80
on the end of the under roller—and the intermediate wheel 80 likewise, with its

Pinion, - - - - - - - - - a''
by the changing of which the velocity is altered. There is therefore a slit in the frame of the machine to admit of adjusting its position according to its size.

This gearing is seen in the plan, and especially in the side view, Plate III.

The two Rollers, - - - . - - $w\ w$
are for deflecting the warp towards the beam, and supporting it in the direction of the brushes. They turn with the yarn, and the large one accordingly is used as a means for measuring the warp as it is dressed. A

Worm, - - - - - - - - - p'
is therefore fitted on the gudgeon, which turns a

Spur Wheel, - - - - - - . - o'
which is made to indicate the revolution by ringing a

Bell, - - - - - - - - - q'.

The Spur Wheel is therefore furnished with a small stud fixed on the rim, so that when it comes to a certain point in its revolution, it touches the handle from which the bell is hung, and thus causes it to tingle.

The Heddles for the lease are marked - - v'

The Holey Plates, - - - - - - $s's'$

The Screens, - - - - - - - - $n'\ n'$
for screening the yarn under the brushes from the blast of the fans. There are two fans in the machine, each consisting of a

Shaft, - - - - - - - - - p
as seen especially in the plan, and the

Two Boards or Arms, - - - - - - $y\ y$
with which it strikes the air. It receives its motion from the driving shaft by the

Strap, - - - - - - - - - l'
from the driving shaft

Pulley, - - - - - - - - - m'.

The two fans are driven from the opposite sides of the machine by their respective driving pullies, as seen in the plan.

The end of the main steam pipe for drying the yarn is seen behind the bell in Plate IV.

The beam receives its motion from the vertical shaft by the bevel gearing at the top.

The Bevel Pinion, - - - - - - 20

at the top of the shaft, works into a

Bevel Wheel of - - - - - - - 40

teeth, and transmits its motion to the

Spur Wheel of - - - - - - - 90

teeth, against which the slipping takes place, as the motion is in excess between the wheel and the

Collar, - . - - - - - - - *d'*.

This slipping is regulated by

Pinching Screws, - - - - - - - *l l*

which press against the collar *d'*.

The view of the machine in Plate IV. Fig. 1st, presents a front view of this movement, and Fig. 2d a side view.

The Stud fixed in the flange of the socket, is marked *e'* and the

Socket which receives the gudgeon of the beam when in its place in the machine, - - - - *i*.

The Stud enters the end of the beam, and carries it round with the motion of the socket flange, the centre of which is also the centre of the spur wheel 90.

PLATES V. VI. VII. VIII.

POWER LOOM.

The Power Loom, for Heavy Domestics, is presented in four Plates, containing five views of the loom,—a Plan, in Plate V.—a Front elevation, in Plate VI.—an End elevation, in Plate VIII,—and an opposite End view and Lateral Section taken near the middle of the loom, in Plate VII. The corresponding parts referred to in the four Plates are marked by the same letters.

The Frame of the Loom is marked, - - AAA′
The Warp, - - - - - - - C
The Cloth, - - - - - - - C′
The Cloth Beam, - - - - - - B
The Yarn Beam, - - - - - B′
The Pace Lever, - - - - - - Y
The Pace Cord, - - - - - *v*
The Pace Weight, - - - - - V
The Balance Weight, - - - - Z′.

The several parts of the Lathe are as follow:—

The Swords, marked - - - - *o o*
The Sole, - - - - - - - - *o′*
The Boxes, - - - - - - *u u*
The Spindles, - - - - - - *t t*
The Drivers, - - - - - - *q q*
The Upper Shell, - - - - - P.

The Race, the groove in the box for the tongue of the driver, and the groove between the swords for the reed are not marked for want of room. But they are referred to in the hand lathe, Fig. 12th, and in the section of the lathe taken immediately under the spindles, Fig. 13th, page 31.

The Race is there marked, - - - - - *f*
The Reed Groove, - - - - - - - *e*
and the black line near - - - - - - - *u*
is the driver-tongue groove.

The Rocking-tree is marked, - - - S
Its Centres, - - - - - - - S′.

The lathe is worked by the
Crank Shaft, - - - - - - - E

which is furnished with two pullies, a fast and a loose one, for connecting and disconnecting it with the power.

The Fast Pulley is marked - - - - - *a′*
The Loose one, - - - - - - - *b′*.

The Crank Shaft communicates with the lathe by two
Connecting Rods, - - - - - - - R R
one to each sword. The one end of each connecting rod is attached to its respective sword by an axle joint, and, at the other end, to the crank by a strap-bush, keyed with a gibb and catteral, as seen in the transverse section of the loom, Fig. 1st, Plate VII, and partially in the other views.

The movement of the heddles is directly effected by the
Wiper Shaft, - - - - - - - F
from the action of the crank shaft, by the intervention of two wheels—a pinion on the crank and a wheel of double the size on the wiper shaft.

The Crank Shaft Wheel is marked, - - *e′*
The Wiper Shaft Wheel, - - - - *f′*
The Bushes by which these Shafts are secured in their relative places, are marked respectively *e e f h′ f*

and formed so that the flat piece by which they are bolted to the framing of the loom is confined within the beading, whilst that part which embraces the shaft, or through which it passes, is long—about five inches, and bored out of the solid, so as to make a good fit and secure bedding to the shaft.

The Heddles are marked, - - - - - D
The Heddle Shafts, - - - - - - *a a*
The Roller from which they are suspended, - H
by the
Straps, - - - - - - - - - H′.

The Shedding is effected by the alternate action of the
Wipers, - - - - - - - - *f″ f″*
on the
Treadles, - - - - - - - G G

as seen in the Front elevation, Plate VI. and in the section, Fig. 1st, Plate VII.

The intervening parts between the heddles and the treadles, are
the Spring-Staff Cords, - - - - - - - *b b*
the Spring-Staff, - - - - - - - *c c*
the Treadle Hooks, - - - - - - - *g g*.

The Picking is effected by the
Tappets, - - - - - - - - $f''' f'''$
of the Wiper Shaft, acting on the
Sweep, - - - - - - - - - - G′
of the
Picking Shaft, - - - - - - - - n'
in the direction of the Arrow, as seen in Fig. 5th, Plate VIII.

The shuttle is thrown by the
Arm, - - - - - - - - - - *n*
in consequence of its being attached to the
Driver, - - - - - - - - - *q*
by the
Cord, - - - - - - - - - - *p*
as seen in all the views of the Loom.

The two Picking Shafts are connected together by the
Spiral Spring. - - - - - - - - n''
seen in the Front elevation of the loom, to keep the sweeps in the right position for being struck by the tappet.

The parts for disengaging the loom, in connection with the protector and the fast and loose pullies, are the
Spring, - - - - - - - - - c'
the upper end of which is formed as a handle by which the
Strap or Belt, - - - - - - - - d''
is transferred from the fast pulley to the loose one, by the
Belt Lever, - - - - - - - - d'.

This is done by hand when the loom is designed to be stopped by the worker, as the lathe, is rising from the fell; and as a precaution he puts his other hand on the lathe, to prevent it from being brought forward by any portion of spent power with which it may be influenced. But when the shuttle is not boxed, the protector stops the loom by putting the spring into action without the interference of the worker.

The protector, for this purpose, has three arms—two are duplicates, for acting on their respective boxes, and the third for communicating with the spring. The third arm is to be allowed to act on the spring as the shuttle permits it. Accordingly, when the shuttle is right and in the box, the spring is left untouched by it; but if it is not there as it should be, the third arm throws the spring off the notch in the rest in which it is guiding the belt on the fast pulley to that for the loose.

But as the protector is too weak to effect the action on the spring of itself, and if it were made sufficiently strong for the purpose it would be too heavy for the shuttle, a catch is interposed, on which it acts so that it has merely to lift it. This catch is marked *k'*, and is well secured to the sole of the lathe—as seen in the End view of the loom, Fig. 2d, Plate VII.—and vibrates in a horizontal position vertically. But as the spring moves in a vertical position laterally, the catch is brought to act on a sliding catch, horizontally placed, which we may call the latch, and is marked *l'*. The latch lies in contact with the spring—when, therefore, the catch is not lifted as the lathe is approaching the fell, it will strike the latch as it is designed, and instantly dislodge the spring. The distance at which the catch is set to act on the spring, or protect, as it is called, should be such only as is sufficient to clear the shuttle of the fell. There is an inconvenience attending the protecting of the shuttle too soon.

The lathe thus receives the shock in dislodging the spring on the one side only, and to prevent it from being unequally strained, the third arm of the protector is likewise made a duplicate, to act on a catch at the opposite side of the lathe, so as to stop it almost at the same instant by falling in a notch on the side of the framing there, which notch is seen in Fig. 1st, Plate VIII, immediately above the stationary catches.

The parts of the Cloth-beam movement are the
Spur Wheel, - - - - - - - M
on the Axle of the Beam, the
Ratchet Wheel, - - - - - - - M'
its Pinion, - - - - - - *m*
and the
Hanging Catch, - - - - - - - *m'*

which works the movement from the motion of the lathe.

A Stud - - - - - - - - - o''

is fixed in the sword of the lathe for that purpose. The two

Stationary Catches or Clicks, - - - - $m'' \ m''$

to prevent the recoil of the beam, are set to divide the ratchet teeth in working into two equal portions, so that the one is alternately out of gear and in it in working. The two

Moveable Clicks, - - - - - $m''' \ m'''$

on the hanging catch m', are set in like manner to work in co-operation with them.

Far too little importance is attached to the Rods in weaving by power,—they seem to be regarded merely as Lease Pins. Their use in supporting the yarn and binding it together is greatly overlooked, and, therefore, from this mistaken view, two only are used. In work where breakage is not to be apprehended, this practice may do little harm, but in every other description of work three should invariably be used, as a means of strengthening the yarn.

The Rods are marked by the numerals, - 1, 2, 3.

The third is the *lease* rod, and its shed is two threads up and two down alternately,—a good binding lease to the other two.

The Reed is marked, - - - - - p'.

PLATES IX. X.

POWER LOOM FOR MUSLINS.

The parts of the Loom for Muslins which are common with the loom as presented in the previous four plates for calicoes, are almost all marked with the same letters. The parts, accordingly, in which it differs from the common power loom, only require to be especially pointed out. These are the parts connected with the movements of the lathe and the shuttle, as both these movements are effected by springs, that no disturbance injurious to the work be imparted to either of them.

The Lathe Spring is marked, - - - r'
and communicates its action to the lathe at the middle of the sole, under the web, by the

Lever, - - - - - - - t'.
This lever is fixed on an

Axle, - - - - - - - - T
on which it vibrates; and that the spring may have as little motion as possible, it is brought to bear on a

Short Arm, - - - . - - - t''
fixed on the axle T, so that as the lathe vibrates, the tension is equalized by the spring tending in its action towards the centre of the axle.
The spring is mounted on a

Stud, - - - - - - - - r''
and acts on a lever. The one end or arm being a spring blade, and the other end or arm is only used for regulating the tension of the blade by the

Pinching Screw, - - - - - . - r'''.
A side view of the spring in its connection with the lathe is very well seen in Plate X. Fig. 1st, and the connection of the spring with the axle T, in Plate IX.

The lathe is thus impelled by the force of the spring, and, of course, is independent of the motive power as to its effects on the cloth. It is withdrawn from the fell by a

Flexible Connector, - - - - - R.
The length of the stroke of the lathe is regulated by the distance at which the

Stud, - - - - - - - - i
on which the flexible connector is hinged, is set from the centre of the driving shaft.

The shuttle is thrown by a spring of a similar construction to that for the lathe. There are two of these springs, one for each side of the loom, to act on its respective picking pin, *n′ n′*, as seen more especially in Plate IX. Fig. 3d, Plate X. is a detached view of the picking pin, with the wiper shaft as shown acting upon it. The picking pin is similar to that represented in the loom for calico weaving. The object in using a spring for throwing the shuttle, in fine weaving, in preference to the direct action of the motive power, is that it be nicely regulated as to its force, that the lightest shuttle, such as is suitable to the work, may be used for it as in weaving by hand.

But as the protector mars the action of the shuttle, in some measure, and more especially a light one, it would be well to construct it so as to take its action off the shuttle, after it is stayed in the box. This could be easily done, and with very little expense, from the movement of the lathe itself. For instance, as the lathe strikes the fell, it could be made to raise a light spring lever in contact with the lower arm of the protector, and thus support it till it should be disengaged by the backward movement of the lathe. The protector by this means would be prevented from acting obliquely on the tapering end of the shuttle, so that it could not alter its course, and if the movement were properly done, this source of disturbance from the action of the protector would be prevented. The shuttle could thus be made as light as any kind of work would require it.

The parts for shedding are the two

Rollers, - - - - - - - *b c*

with their two

Arms, - - - - - - - - - *d e*

which are, properly speaking, the treadles. Their connection with the heddles is by means of

Cords, - - - - - - - - - *d′ e′*

attached to the

Spring-Staffs, - - - - - - *d″ e″*

and the

Spring-Staff Cords, - - - - - *d‴ e‴*.

The connection of the heddle rollers with the power is maintained by two

Short Arms, - - - - - - - *f f*

one on each rod, and placed exterior to the loom, for the convenience of communicating with the power by the

Crank, - - - - - - - - f'''

Fig. 2d, Plate X. presents a good end view of the connection of the wiper shaft with the heddles.

- - - - - - - - - *g*

is the connecting rod between them, supported by the two

Friction Pullies, - - - - - $g'\,g'$

which are attached to the outside of the framing of the loom, as seen in the front elevation of the loom, Plate IX. The two arms, *f f*, of the heddle rollers, maintain their connection with the connecting rod ; and for this purpose each is furnished with a stud, which is screwed to the arm *f*, and which enters the projecting notch of the connecting rod to be affected by its motion. Each of the arms *f* is likewise slotted, that the size of the shed may be regulated by the distance at which the studs are set from their centres. The depending part of the connecting rod below the shaft F, is designed merely to keep the rod steady by sliding in a groove or guide.

There is nothing peculiar in the movement of the cloth beam. The only circumstance that especially requires to be attended to in deriving motion to it, is that it be not so taken as to mar the movements of the lathe. For this purpose it is represented as taken from the driving shaft. It could, however, be taken from the rocking tree without affecting the lathe.

The reed is mounted with the cord.

The web is paced on the one side of the loom only. A fine web does not require to be paced on both sides.

PLATE XI.

SIZING APPARATUS.

Plate XI. presents four views of the apparatus for sizing the webs for hand work.

Fig. 1st is a longitudinal section of the dressing chest, with the apparatus connected with it for sizing the warps. The chest is marked *a a*, and is represented shorter than is given in the text, to avoid the inconvenience which would otherwise have been unavoidable of having it presented in a folding plate. The chest, as represented, is nearly 9 feet long. Several sizers use them shorter than this; but the practice is not a good one. The yarn, to be thoroughly sized, must be saturated with the paste to the heart of the thread. This can hardly be effectually done in a short box. The yarn requires to be freed as much as possible from the essential oil that may be present with the cotton —to fit it for receiving the paste,—and a long bath is advantageous in this respect, both as it facilitates the removal of the oil by the continued exposure to the heat in the boiling paste, and fits the yarn for receiving it. Hence the advantage of a long dressing bath or chest, both as affecting the quantity and quality of the work.

But the quality of the work is much dependent on the quality of the paste. Sizers differ as to their mode of making the paste, and even as to the materials for making it; and, as the business is as yet recently established, there is a good deal of experimental practice resorted to by the trade in the making of the size.

The following is a recipe for size making, which is adopted by some good sizers, both in England and Scotland:—

Take 1 pound of soft soap,
2 pounds of tallow,
2 pounds of soda;

mix them well with as much boiling water as will reduce the mixture to the consistence of cream—then take 70 or 80 gallons of water, milk-warm, put in it about 240 pounds of good flour,—

and then add the mixture, taking care to stir all well together; and in three or four days the size will be fit for use. It is then to be reduced as the work may require it, on being put into the tub.

The soap, tallow, and soda are designed to qualify the huskiness of the paste as it affects the yarn, and no doubt, when properly used, are highly beneficial in that respect.

The relative proportion in which these lubricants are used by different sizers varies in some measure, in consequence of the quality of the work for which they are used; and likewise, from the notion as to their manner of acting on the work. Some do not use the soda at all,—but this practice is not commendable. If any of the lubricants were to be omitted, the absence of the soap would be less injurious than that of the soda. When the greasy lubricants are in excess, they have a tendency to diminish the cohesion of the paste, as has been noticed in the text; but the soda is attended with little injury to the cohesion of the paste, and imparts a smoothness to the thread which is beneficial to it in the weaving.

Some, again, for the improvement of the colour of the work, substitute white soap for soft; and a practice seems to be adopted by some of using small portions of nitric acid in the paste, to incorporate the ingredients more fully together,—but the practice is a dangerous one. It has undoubtedly done injury to the yarn, and I am not aware of its having done any good.

The sizing is usually done, as represented, on the ground floor, where the boiler is likewise placed; and, for the economizing of the heat, the drying apparatus is placed on the floor above it. The sized warp is led through the floor from the can as it has been received from the sizing apparatus, and carried through the drying machine by the rotation of the cylinders on their axes.

The motion as communicated from the engine to the cylinders by bevel gearing is represented in Fig. 2d, and the direction in which the cylinders turn by the arrows. The gearing is applied to only two of the rows of cylinders—the first and the third. The second is drawn in connection with the first by the warp passing between them; and the fourth in like manner from the third. Fig. 4th represents the manner in which the warp passes over the cylinders, as seen from the opposite side of the machine from that represented in Fig. 2nd.; but without the framing. The warp is led in over the pulley *a′* at each side of the machine, as seen in the front view of the machine, Fig. 3d, till it passes over and under each of the cylinders of the two lower rows alternately. It then passes up to the fourth through the ravel or guide *w′*, and over and under in like manner the 4th and the 3d rows, and down again to the first; and so on till it is run in this manner to the middle of the roller, where the warps are delivered in a dried state through the eye guide, as represented by *w″*.

The steam is introduced into the cylinders through their centres by pipes. The main steam pipe is marked *s*, and the offset to each cylinder *s′*. At each offset where it communicates with the cylinder there is a valve for regulating the admission of steam. The pressure of the steam is ascertained by a valve at the opposite end of the cylinder, as seen in Fig. 4th, where the two little circles on each side of the central one represent the valve. The water from the condensation of the steam is allowed to escape from the centre of the cylinder at the side through the framing.

PLATE XII.

TAPE SIZING MACHINE.

Three views of the Tape Sizing Machine, as it is given, with the specification of the Patentees, in Newton's Journal of Patent Inventions, are presented in Plate XII.

Fig. 1st is a Plan,

Fig. 2d is a side view, and

Fig. 3d is a longitudinal section of the Machine.

Sizing by this means is a combination in principle of the two Machines, designed more especially for hand loom work, as represented in Plate XI.

The Machine, as represented in Plate XII. consists chiefly of a modification of these two operations. The yarn is led into the Machine in the usual manner as in dressing by power, from

Reels marked - - - - - - - *a a a*

placed on the

Frame of the Machine, - - - - - - A

at the end towards the left hand.

The portion of the machine from *f* to *h* inclusive, is the apparatus for sizing. It consists of a dressing trough, or rather two separate ones, in which the size is kept boiling by steam, and four rollers by which the warp is deflected in and out of the size trough, by their rotation on their axes.

A view of this apparatus is very well seen in the section of the Machine.

- - - - - - - - - - $e\ g\ e'\ g'$

are the deflecting rollers, and the direction of the yarn as passing over them is pointed out by the direction of the arrows.

The yarn as it leaves the two

Delivering Rollers, - - - - - - $g'\ g'$

has the superfluous size squeezed out of it by the pressure between them, and passes onwards by their rotation to be dried.

The two Tin Cylinders, - - - - - - *i i*

are the means for that purpose. The yarn passes to the second cylinder first, where, in approaching it, it undergoes a slight brushing from the circular brush marked 15. It passes from the first to the second, and, from it, is deflected by the three

Rollers, - - - - - - - - - *m, m, o,*

to the

Yarn Beam, - - - - - - - - P

at the right end of the machine.

The tension of the warp is regulated by the pressure between the two receiving and the two delivering rollers, *e g*, *e′ g′*, in the sizing apparatus, by their connexion with the winch lever 11. 14, 14, are racks on which the pivots of the upper rollers are mounted, and are worked from the winch handle by small pinions 13, 13. 2 is a loaded lever for increasing the pressure on the delivering rollers.

The chief feature of novelty in the Tape Sizing Machine, or that in which its peculiarity chiefly consists, is that of sizing the yarn in bands, like half gangs or tapes, in passing through the Machine to be wound on the beam.

The object by this arrangement of the threads, is to strengthen them in the weaving by the cohesion between the fibres of the yarn from the action of the paste; and doubtless such an arrangement of the yarn is advantageous in the weaving. But if a proper attention is paid to the use of the rods in weaving, as already pointed out, this peculiarity in the sizing will be of less consequence.

The means for effecting this division of the yarn in the Tape Sizing Machine, is a kind of ravel or reed, marked *b* in the section of the Machine, and seen detached in Fig. 5th. Figs. 4th and 6th are two other forms for the same thing.

The ravel is placed immediately in front of the small roller from which the yarn is deflected into the sizing trough, and the heddles for preserving the lease are placed between it and the nearest reel, at *d*. The reed for keeping the yarn steady, as it enters the heddles, is, of course, on the other side of them towards the reels, at *c*.

The heddles by this arrangement are put in the best place for keeping the yarn *clear* or unintangled in the process.

The yarn is *keeled*, in this machine, by a revolving self-acting marker. The roller *o*, from which the yarn is deflected to the yarn beam, is the measure from which the motion for that purpose is taken. The roller axle is, therefore, furnished with a worm on its pivot, which gives motion by the shaft 4 to the shaft 7 at right angles to it, by the small bevels 5 and 6. The worm 8 on the shaft 7 is the marker, which touches the yarn with the colour—and which receives it as it revolves below the yarn.

Motion is imparted to the machine by the shaft *r*, which is furnished with the usual means for receiving it—a fast and a loose pulley, *q*, and is disconnected from the power by the rod *s*.

The driving shaft is furnished with a conical drum for communicating its motion to the beam, so as to regulate its uptaking action according to its varying diameter. There is therefore interposed between it and the beam another transverse shaft similarly furnished with a cone drum or pulley of the same diameter, but with its apex reversed. The two are connected together with a strap,—and the beam is made to shift the strap, as its diameter varies, so as to obtain a uniformity in its acting circumference unaffected by its varying diameter,—sufficiently so for practical purposes. The interposed shaft *v* is furnished with a pinion *w*, which drives a train of three spur wheels *x*, *y*, *z*, by which the rotatory motion is imparted to the beam.

It will be observed that the web is narrowed as it approaches the beam from the roller *m*, and that is done by a ravel *n*, to bring as much warp as conveniently can be done into a sufficiently narrow space for weaving. Two of these reels or beams are often put together on the same arbor or beam-shaft, to make one web in weaving. The beams therefore are made to slip off their arbor in the machine like a bobbin—and, as their centre hole is square, they are fitted on the square axle of the loom beam without any trouble, and paced together.

PLATE XIII.

POWER LOOM FOR CHECKS.

Plate XIII. presents two views of the power loom for working checks. Fig. 2nd is an end view, and Fig. 1st a front view, but without the parts exterior to the left framing of the loom. Both of these views are presented merely for the purpose of showing the apparatus as constructed for check weaving by power.

The Shuttle-box represented is the drop one,
and is marked - - - - - - - u'
as seen in Fig. 1st. It is fitted for three shuttles. The spindles on which it slides are marked - - 6, 7.
It communicates with the power by the
Sliding Connecting Rod, - - - - y'.
This rod is jointed to the under shelf of the box, and hangs perpendicularly to it, and freely, by being supported in the
Two-eyed brackets, - - - - - 1, 2,
which are bolted to the
Swords of the Lathe, - - - - - O O.
This connecting rod communicates with the power by the
Two-armed Lever, - - - - - t'.
On the one end of this lever the box connecting rod y' rests, and the other end works the box by coming into contact with the pattern wheel. For this purpose the pattern wheel has two
Projecting ledges, bolted on its face, marked - 3, 4,
as seen in Fig. 2d.

The ledges are parts of concentric circles, and are, therefore, interior and exterior to the centre of the pattern wheel. As the pattern wheel is turned round, they therefore come successively into contact with the end of the lever t', which is furnished with the pulley t'', and depress it to a fixed level while they continue to act upon it. The box is thus raised, and successively by the action of the respective ledges, and falls by its own gravity when the lever has escaped from their action. The upper box is then level with the race,—the first ledge raises the second box, and the second ledge, the third. Two ledges are thus sufficient for three shuttles. The circular form of the ledges is necessary to maintain their respective boxes at a uniform level throughout the action of each respectively, and the depression of each ledge must be equal to the height of its box, to bring it to the level of the race. The pattern wheel is made to admit of an adjustment of the ledges for this purpose, and, still further, by the pulley as attached to the lever t'.

The power is communicated to the pattern wheel by the
Wheel, - - - - - - - - 5

and its pinion, from the pinion of the wiper shaft, seen immediately behind the rod marked - - - - o''.

The other parts of the loom are referred to in the text, and in the previous portion of the Index by letters which distinguish the corresponding parts.

Fig. 7th is the end view of the driver for the drop box. The dark sectional lines in the middle, marked *t*, are the spindles.

Figs. 3rd and 4th are for the purpose of showing the action of the friction beam in taking up the cloth. D is the spring which keeps the receiving beam C against the delivering beam B.

Fig. 5th is a front view of the swing box, as made for the hand loom lathe.

PLATE XIV.

MR STONE'S LETTING-OFF MOTION, AND WEFT SHOT PROTECTOR.

Plate XIV. presents seven figures. The second is an end view of Mr Stone's loom, for the purpose of showing the letting-off motion as brought out by that gentleman.

Fig. 1st is a view of a part of the lathe as connected with the letting-off motion, and Figs. 3rd and 4th are modifications of this connection.

The other figures are for the purpose of representing the Weft shot Protector. Fig. 5th is a side view of this useful contrivance, as seen by a section taken near the middle of the loom. Fig. 6th is a plan, and Fig. 7th a front elevation.

The weft shot protector lever is shaped something like an eating fork with long prongs; but the prongs are bent down nearly at right angles to the shank, as seen in the end view, Fig. 5th; f' is the bent arm. The shank is supported so that it may vibrate on pivots horizontally as a lever with two arms. The bent arm f' comes in contact with the weft shot, as carried by the shuttle, in front of the reed, and thus raises the other end, *f*. It does not, then, affect the loom; but when this escape does not take place, the fork is caught by the

Lever, - - - - - - - - *d*

and in consequence of the motion which it receives from the

Wiper, - - - - - - - - *a*

by the

Tappet, - - - - - - - - *b*

through the

Arm, - - - - - - - - *c*

the spring is thrown out of gear, and the loom is stopped. The three views in the Plate sufficiently show the contrivance for this action. The hooked lever *d*, as connected with the fork *f*, and the arm *c*, with the wiper *a*, are fixed on the same centre, *e*, as seen in the three views.

The Lever, - - - - - - - *g*

alongside of the

Spring, - - - - - - - - - *h*

bears the Weft Shot Lever or Fork, *f*.

And if, therefore, the fork is drawn forward by the action of *d*, as it must be if not disengaged from it, the spring *h* will be thrown forward, according to this action, into the front notch, as will be seen more especially by a reference to Fig. 6th.

PLATE XV.

TEMPLES.

Plate XV. presents views of three sorts of Temples,—the nipper, the rotatory, and the roller, for acting on the cloth.

Fig. 1st is a single temple of the nipper kind, consisting of two jaws—the upper and the under, between which the cloth is held, and allowed to open by the under one being a spring. The under one is marked - - - - - - - *a*

and the upper one - - - - - - - - *b*.

Fig. 2nd is the temple in an open state, and Fig. 3d is the plan of the temple, as fitted on the breast beam for acting on the cloth. This temple is opened every shot to allow the cloth to move to the beam, and that is done by the sole of the lathe striking the curved end of the

Lever, - - - - - - - - *d*

and thus forcing the opposite end, which is wedge-shaped, between the jaws.

Four views are given of the rotatory temple—a plan as attached to the breast beam in Fig. 4th,—the plan reversed in Fig. 5th,—a side view of the temple in Fig. 6th,—and an end view, as seen from the side of the loom, in Fig. 7th. *c* is the rotatory temple.

Two views are given of the roller temple. *b* is the roller,—*a* the cloth passing under it,—*c* the half tube in which it revolves by the passing of the cloth to the beam,—*d* is the attachment of the half tube to the breast beam, *e*.

PLATE XVI.

VERTICAL POWER LOOM FOR SAIL-CLOTH, &c.

Plate XVI. presents a lateral section of the vertical power loom for sail-cloth or very heavy work.

It will be observed that the construction of the loom, as presented in the Plate, is little else than the common power loom laid on its face. The beams are, therefore, relatively in a vertical direction. The cloth beam E is below the lathe, and the yarn beam B above it.

The object of this arrangement is to gain the utmost effect in driving home the weft, with the least reaction on the machinery and the power. The lathe is, therefore, to have sufficient weight in itself, and sufficient leverage to render its weight effective on the weft shot. To obtain such a construction of lathe with the utmost economy of room, two looms are constructed in the same framing. The leverage of the swords of each of the lathes is thus made equal to the length of the two looms—as shown in the Plate. The lathe is marked as in the other looms,—*o′* is the sole,—*o* the sword,—and P is the upper shell. There is only one shaft in each loom—the driving one, marked *g′*. This shaft works the lathe, the shuttle, and the treadles, by Cams.

The Cams of the lathe are marked - - - *f′ f′* and raise it gradually, according as they are made for the speed at which the loom is to be driven, and let it fall on the fell like a tilt hammer.

Thus arranged, the race is between the fell and the reed, and it must, therefore, be made moveable to allow the reed to strike up the shot. The race is, therefore, fixed in a swing frame *h*, which vibrates on its centre within the swords, but above the web. It, therefore, hangs pendent, like a little lathe within the lathe, and the sword is formed with a raised part to support it in this hanging position. The form of the race frame is something like a rectangular lever, with the centre of motion at the angle of the square. The upper rectangular arm is loaded, and, therefore, from the position in which it is hung, presses the pendent arm, or tends to keep it against the sole of the lathe. The pendent arm projects forward under the sole, forming a line parallel with the reed, with a space merely sufficient for the shuttle to pass. The end of this projecting piece will be seen, marked *f*, and is in fact a kind of open reed like a comb. This reed part is the race, and must of course be pressed back, as the lathe is descending on the fell, after the shuttle has passed over it, so as to clear it of the cloth.

The projecting part of the frame below the race is the means for effecting this motion. As the lathe is descending, it comes in contact with the pulley *j*, and is thus carried back to the required extent, which should not be more than what is necessary, —a little more than the half of the shed.

If the lathe is constructed on the principle of forcing the weft home by the power in opposition to its weight, the race frame will, in that case, be unnecessary, as the shuttle will run on the reed. But it will probably be found, that the advantage arising from the action of the lathe, as represented in the Plate, will more than compensate for the inconvenience attending an additional moving part.

The treadles are at the side of the loom, and marked G G
and the
Cams by which they are worked, - - - *g g*.

The treadles communicate with the heddles in the usual manner,—by marches *c c*. The marches of course extend from the other side of the loom, and are attached to the springstaffs, *b b*, at the middle of the heddles, and at the further end, to the treadles, G.

The treadles are vertically placed in the loom, and kept steady by the guide framing, A′, in which they move.

The connection of the cams with the Picking shaft *n′* is not seen. The sweep, similar to that represented in the loom for calicoes, is bolted to the shaft; and on this, as a leverage, the cam acts in the usual manner.

The driver is of the usual form, and may be attached to the fly-cord in the usual manner, by means of a button-headed wooden screw pin, screwed into the side of the driver.

There is nothing peculiar about the pacing—*v* is the pace cord. It is attached to a lever in the usual manner. The lever is represented as broken off, and may be placed either to hang in the direction of the swords or transversely to them, with the end outwards; which last arrangement is perhaps the best.

The protector is not represented.

DRESSING MACHINE FOR FINE YARN.

The Plates XVII. and XVIII. present two views of the Dressing Machine for fine yarn. Plate XVII. presents a longitudinal section of the machine, and Plate XVIII. a plan of so much of it as is not of a duplicate kind. The parts of the machine which are common with the Crank Dressing Machine, are generally marked with the same letters.

The Driving Shaft is marked - - - *r*

The chief peculiarity in the Fine yarn Dressing Machine is with respect to the action of the brush. There are

Two Carriages, respectively marked - - *a a'*.

The one carriage performs a shorter stroke than the other; they pass in the yarn and out of it by inclined planes, and return to repeat their action on moveable rails. The

Fixed Rail is marked - - - - - *d*

and the

Moveable Rail, - - - - - - - *h*.

The corresponding parts at each end of the machine are distinguished by the same letters.

The carriages are driven in reverse directions from opposite cranks on the driving shaft, and from opposite sides of the machine. In the longitudinal section, therefore, one only of the carriages can be seen connected with the driving shaft, but both are partially seen in the plan.

The Moveable Rail for the under carriage is marked *h* accented. Both the upper and under moveable rails are opened for the admission of their respective carriages in opposition to the action of their respective springs or weights (whichever may be used,) by the revolution of what corresponds to the eccentric shaft in the Crank Dressing Machine—here marked *k'*. The eccentric is here formed into a disc with two projecting faces in opposite sides of the plate. Each face occupies nearly the half of the disc, as denoted by the line with which it is bisected. The upper moveable rail is brought in contact with the disc by a short arm, pendent,—not seen, but fixed to the centre of the rail behind the disc. The lower rail is acted on by the disc, as seen in the longitudinal section, on the inner side near the top of it. The disc thus acts with its face on the one rail below its centre, and with the reverse face on the other above it. The disc is fixed for this purpose on the spot, so that each of the moveable rails, when brought against its respective face, is clear of its respective carriage wheel. The revolution of the shaft will thus allow the moveable rails to fall alternately under their respective carriage wheels, in being left to the influence of their weight or spring *i*.

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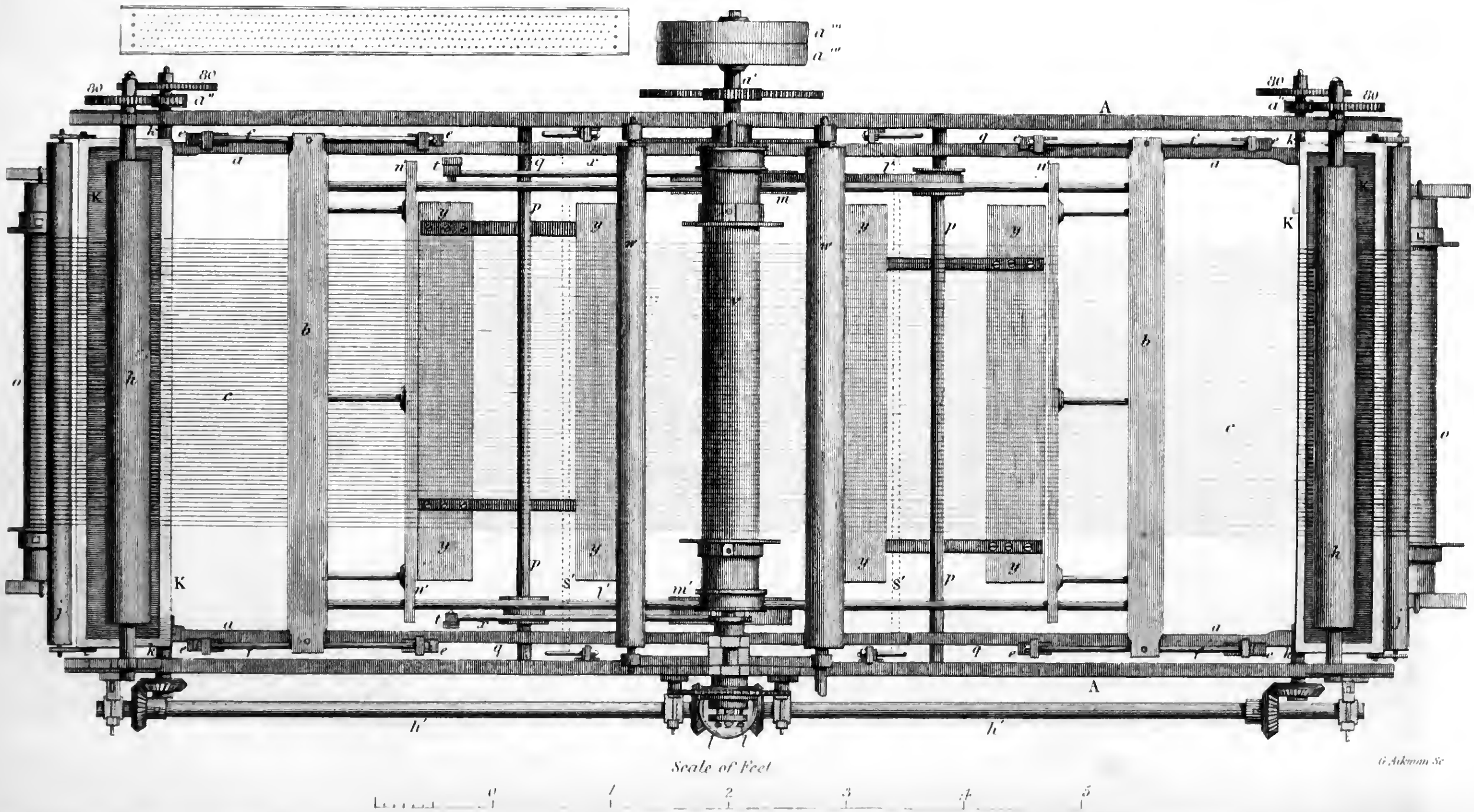
PLATE II.

PLAN OF THE DRESSING MACHINE.

Fig. 2. Fig. 1.



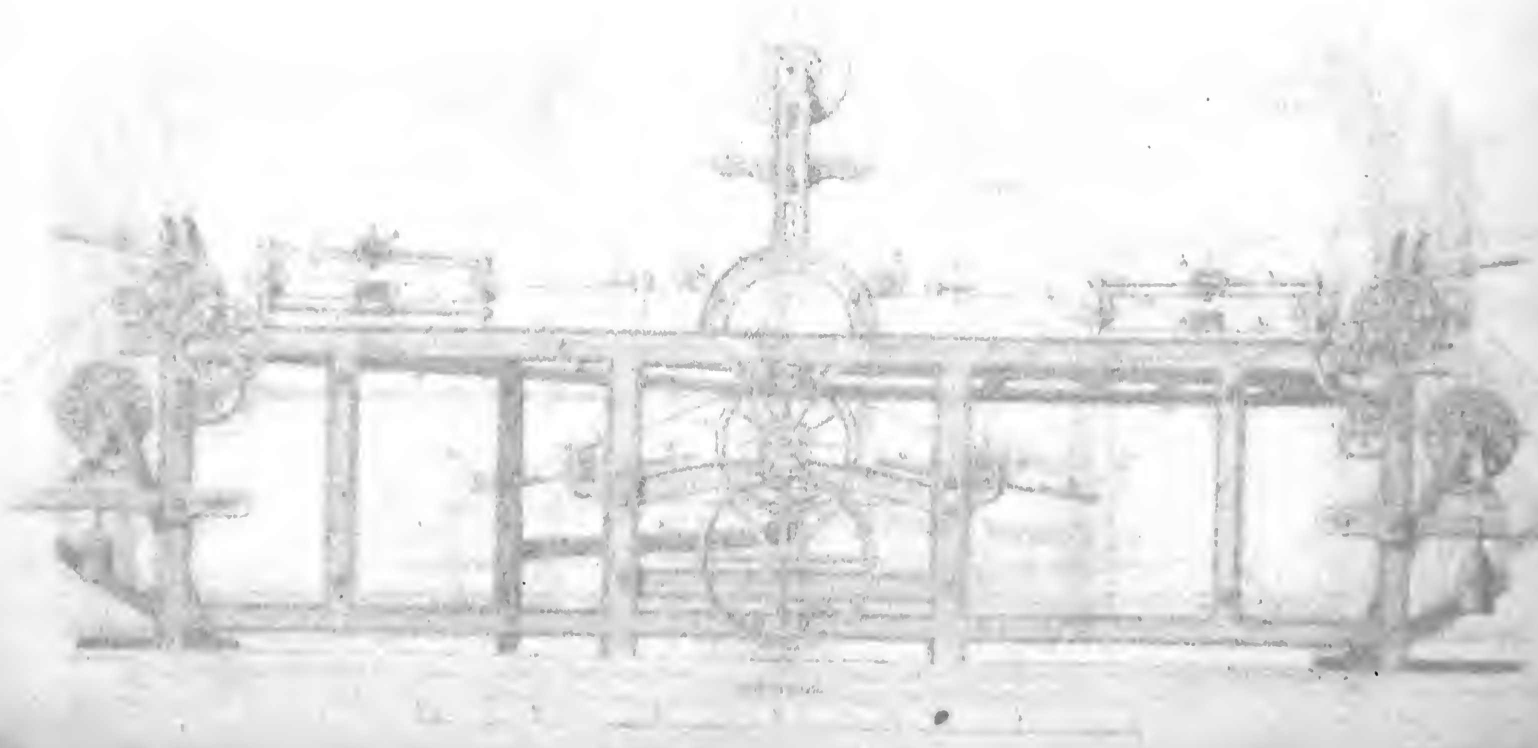
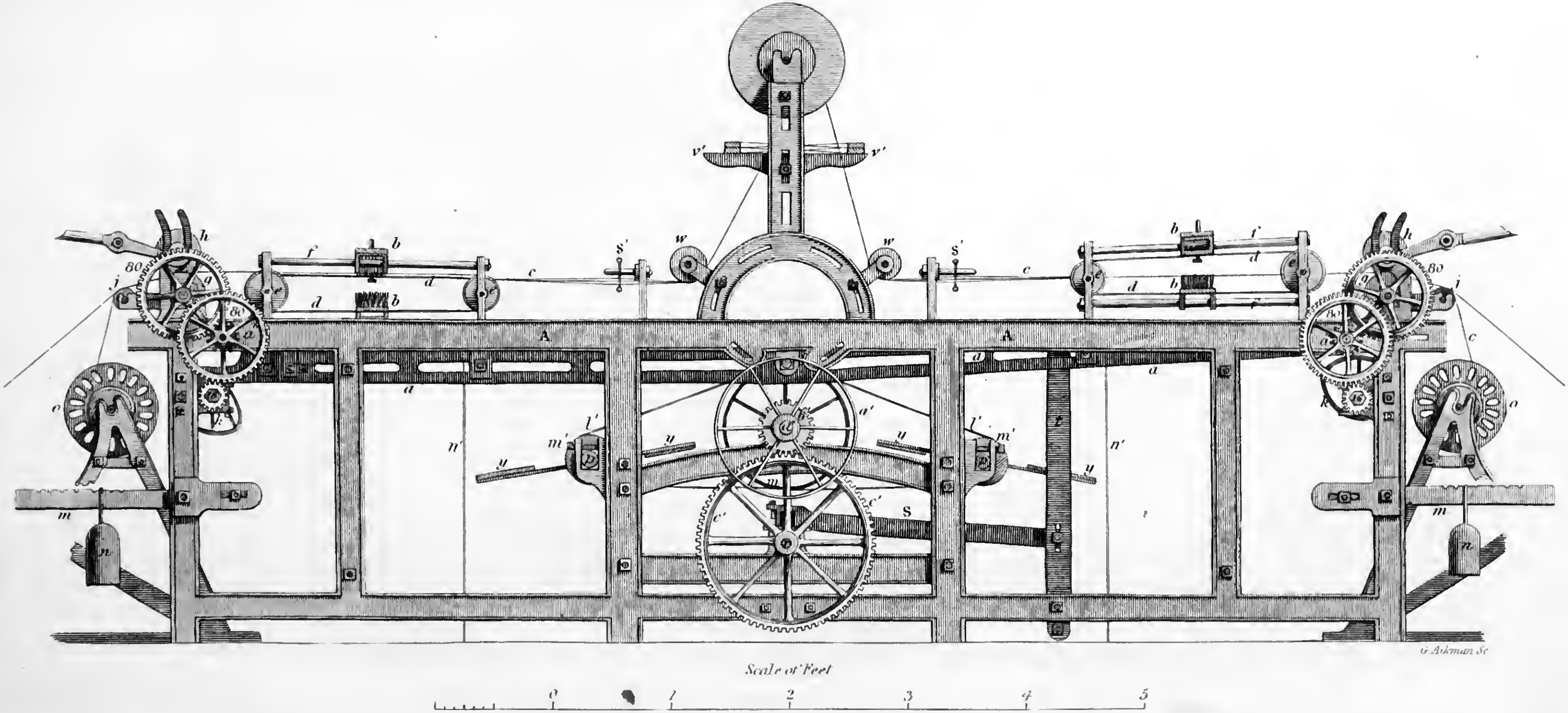


PLATE III.

SIDE VIEW OF THE DRESSING MACHINE.



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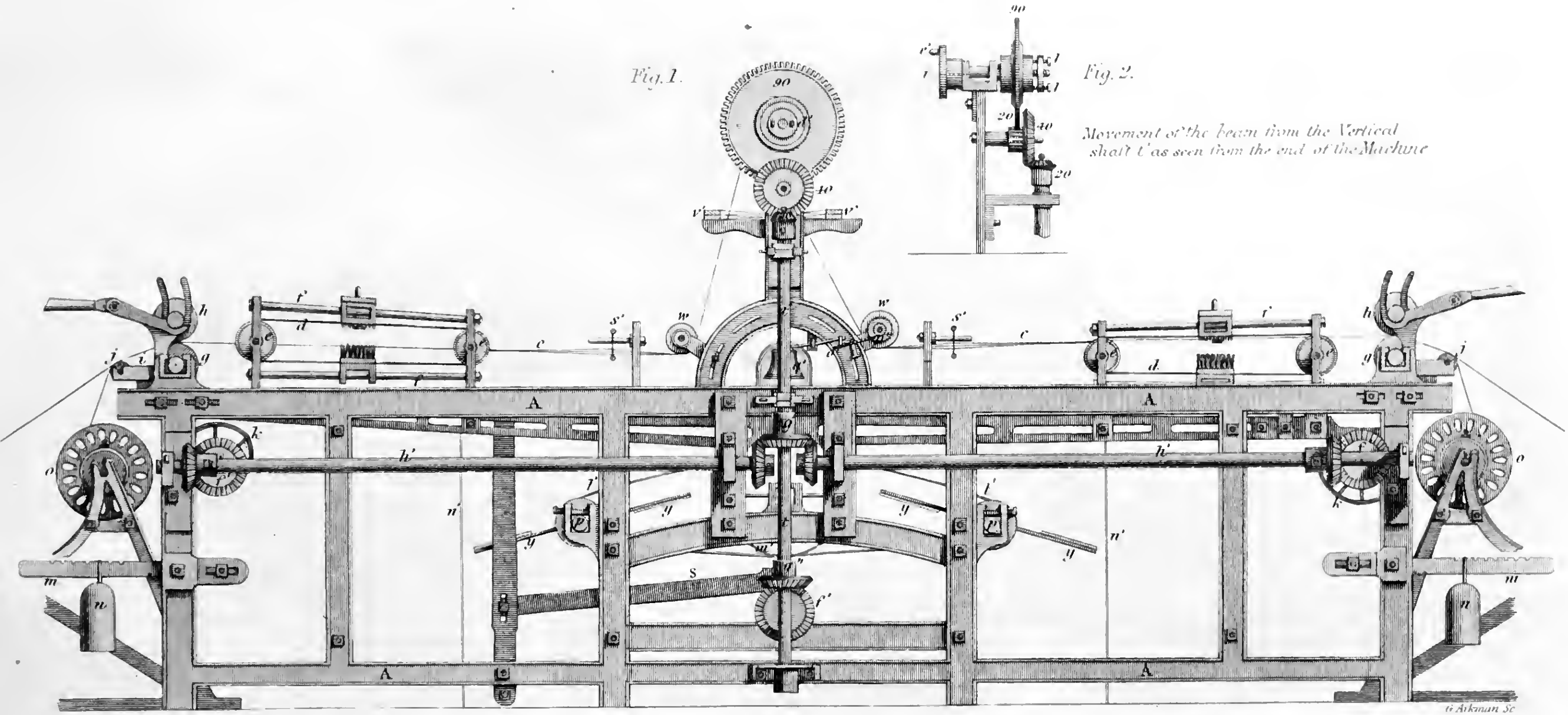
SIDE VIEW OF THE DRESSING MACHINE.

Fig. 1.

Fig. 2.



Movement of the beam from the Vertical shaft t as seen from the end of the Machine

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Scale of Feet

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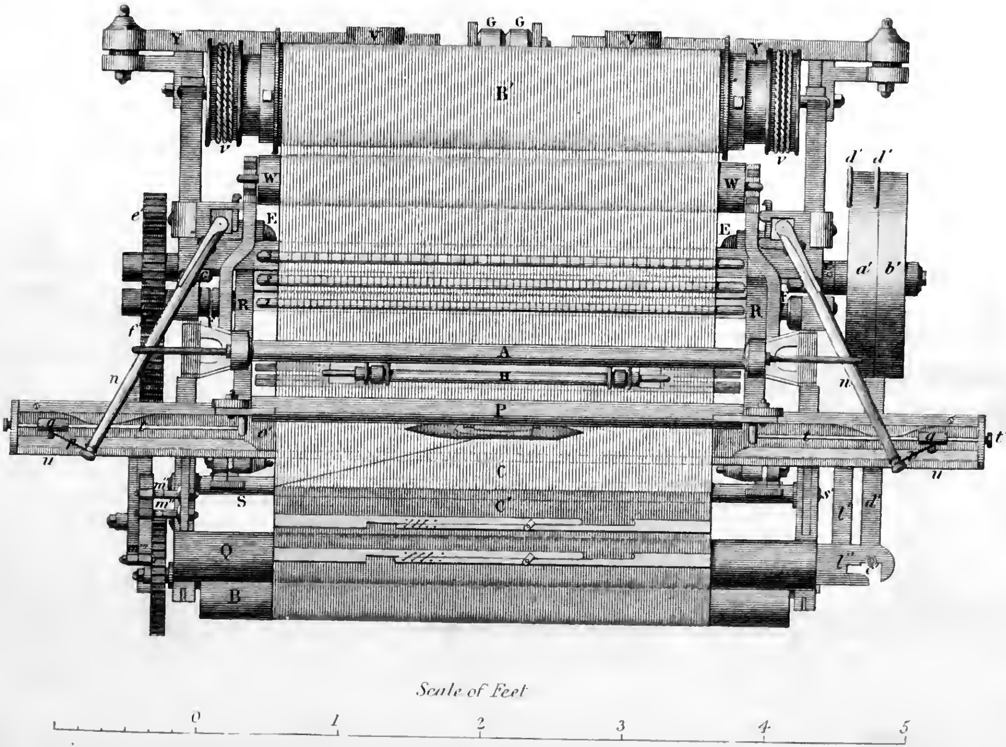
PLATE V.

PLAN OF THE POWER LOOM.



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FRONT ELEVATION.

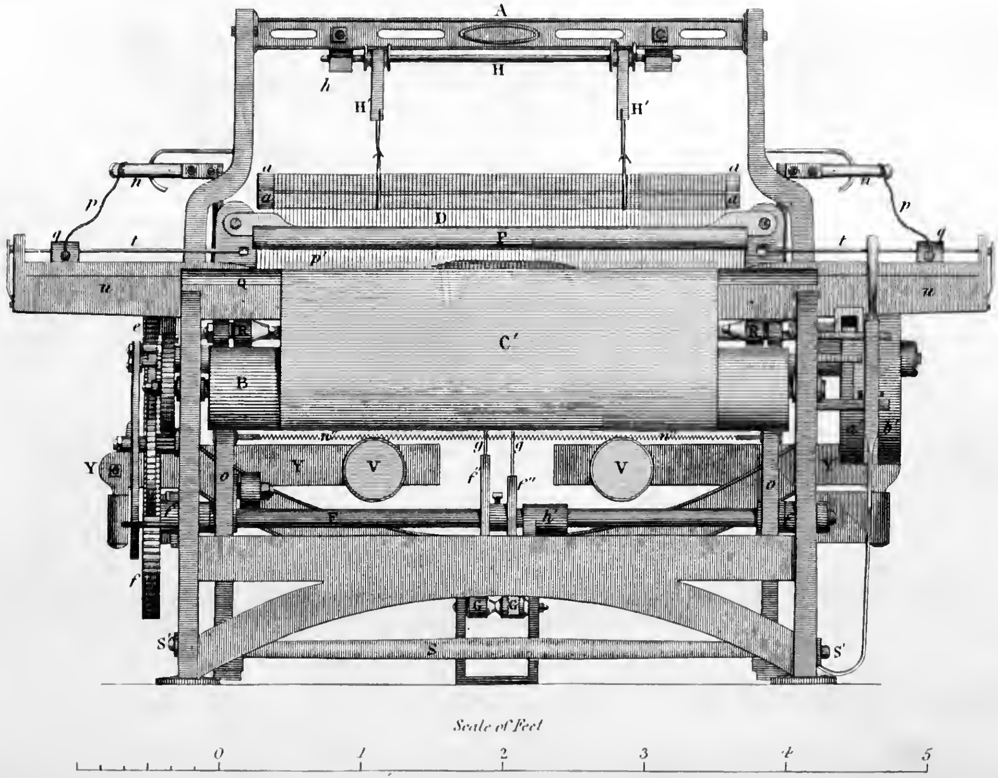

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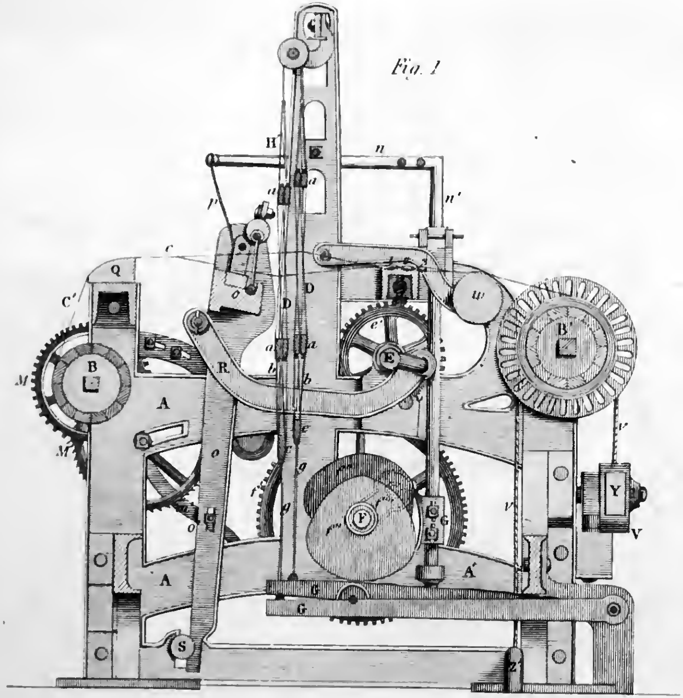
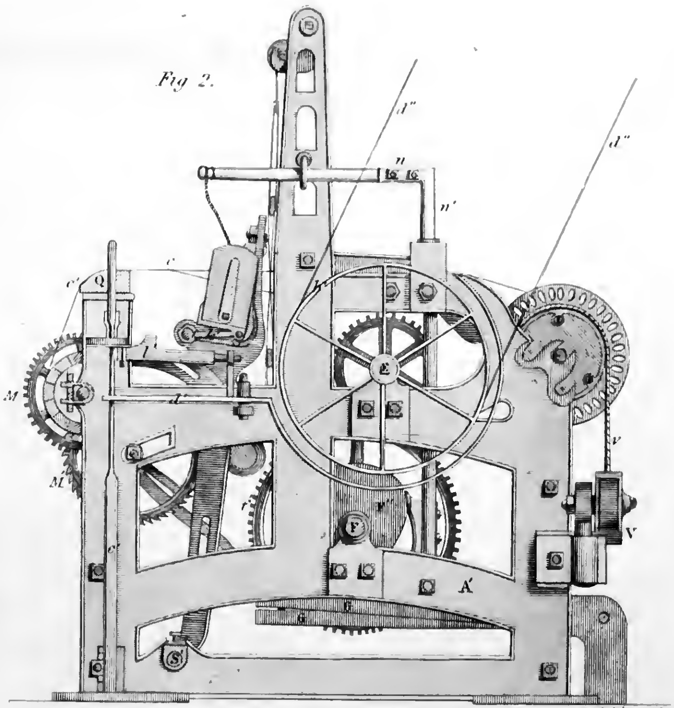
PLATE VII.

TRANSVERSE SECTION TAKEN NEAR THE MIDDLE OF THE LOOM.



END ELEVATION.



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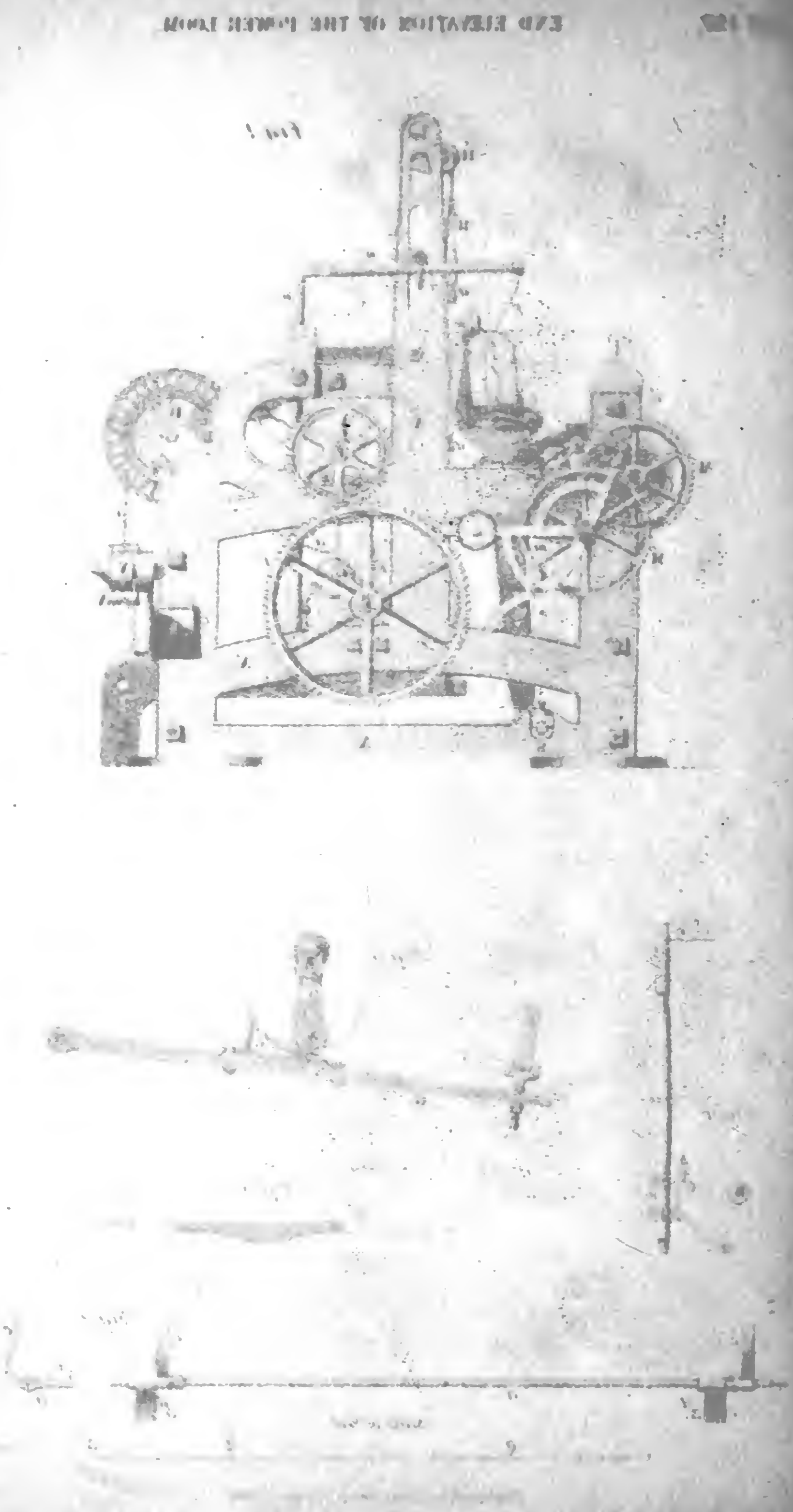
Scale of Feet

0 1 2 3 4 5



END ELEVATION OF THE POWER LOOM.

Fig. 1.

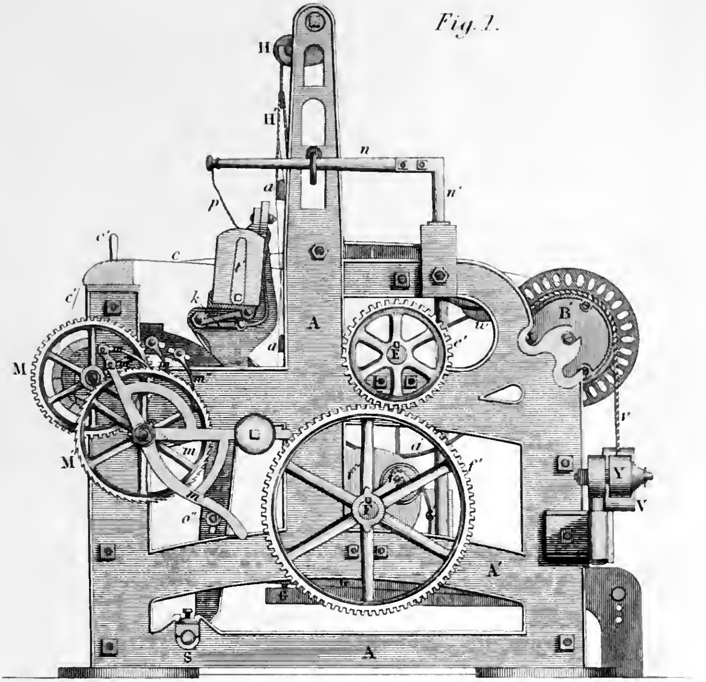


Fig. 5

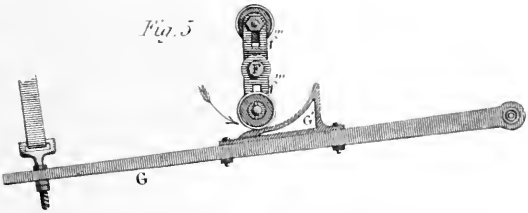


Fig. 4

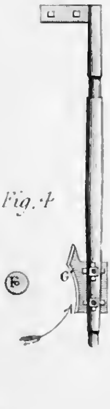


Fig. 3

Fig. 2

Scale of Feet

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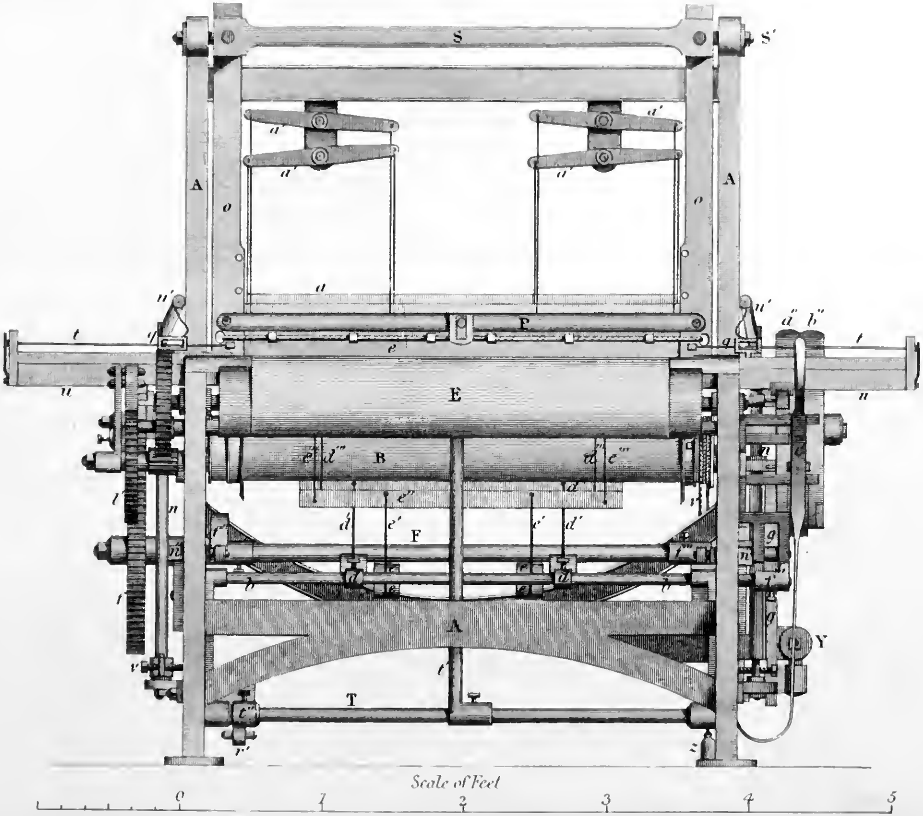
FRONT ELEVATION OF A POWER LOOM FOR WORKING MUSLINS.



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PLAN OF MESS^{RS}. HORNBY & KENWORTHY'S TAPE SIZING MACHINE. *PLATE XII.*

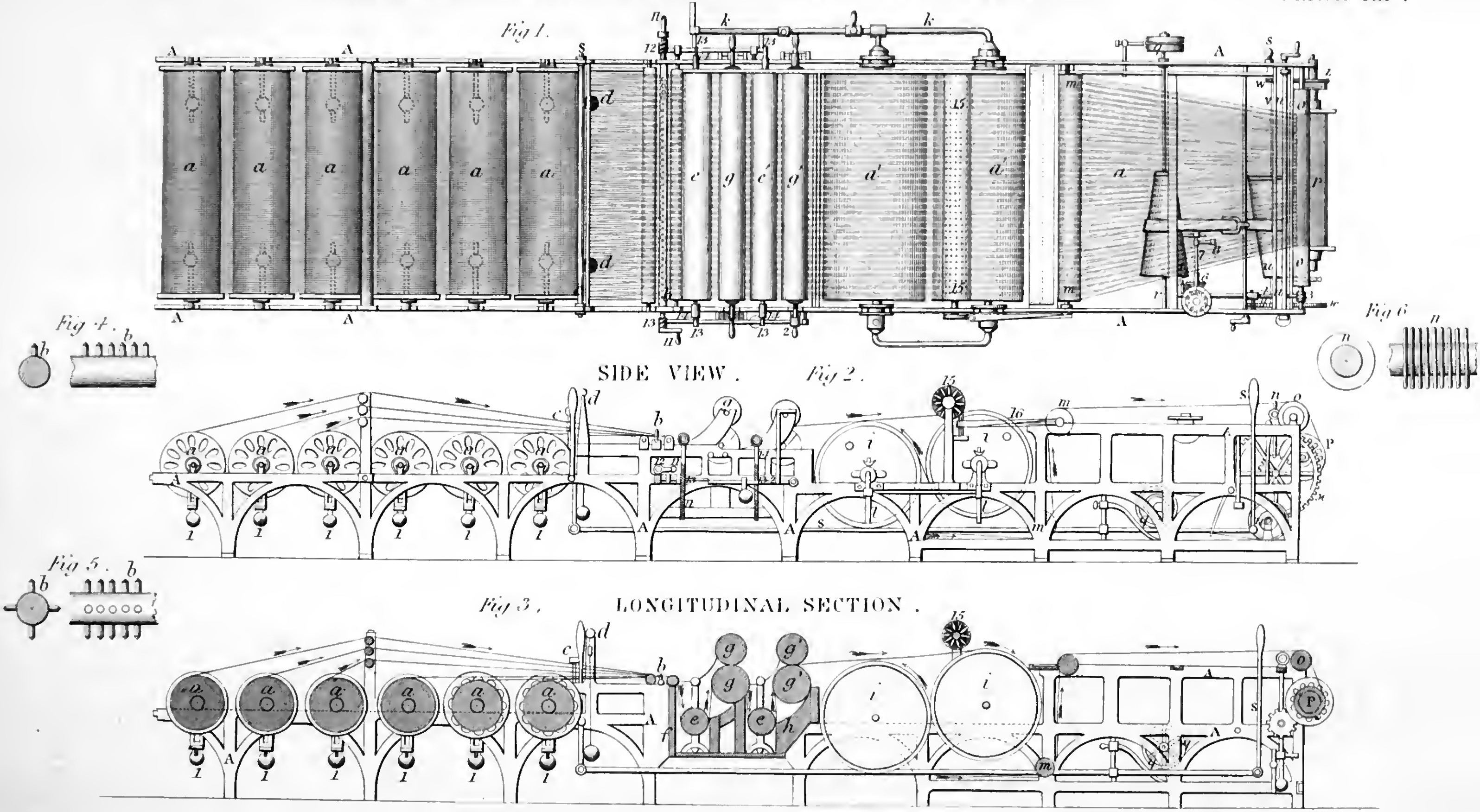

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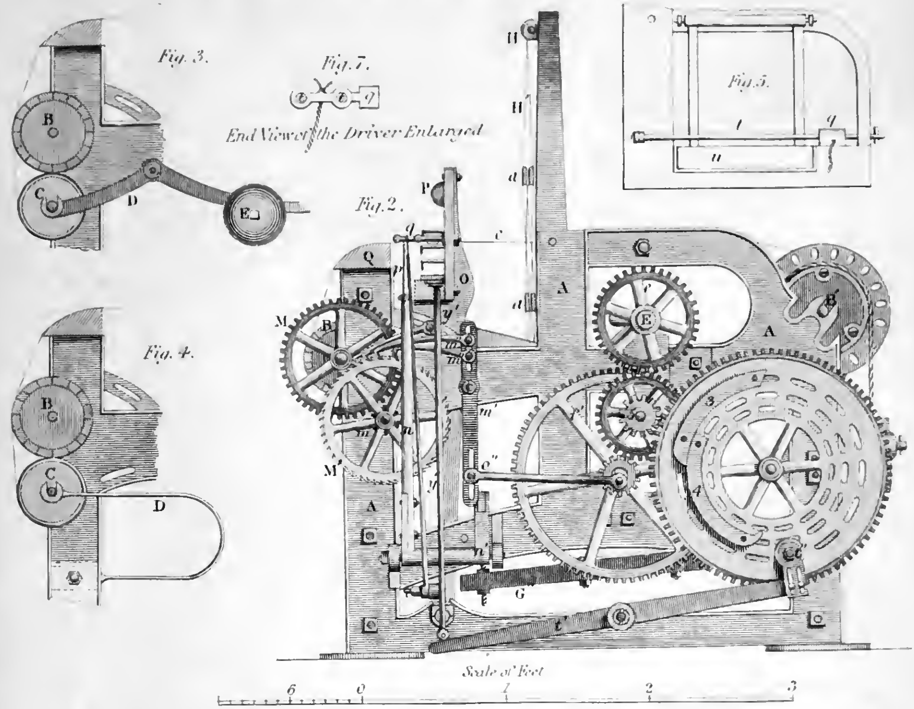
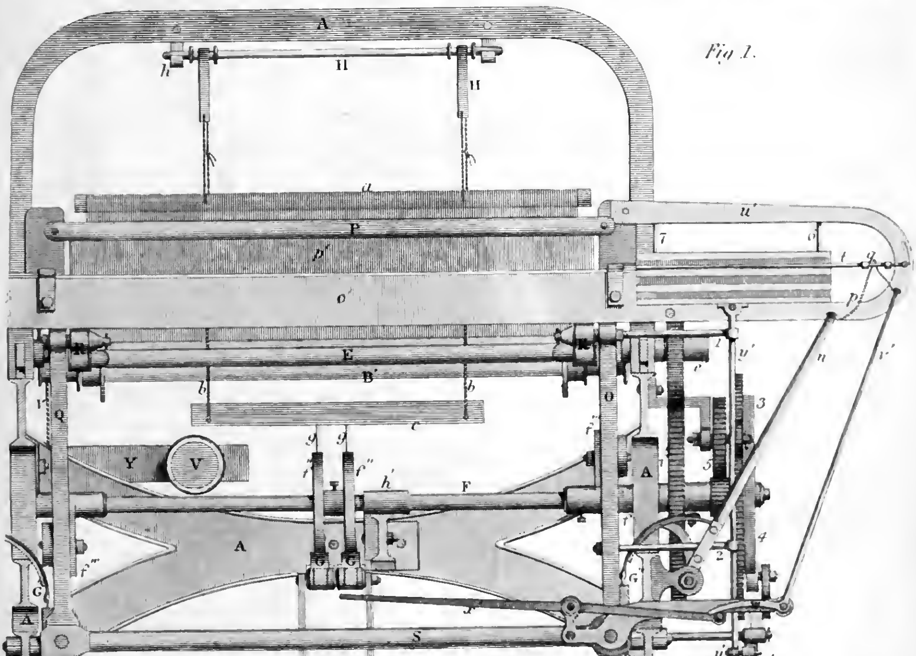
PLATE XIII.

END ELEVATION OF THE POWER LOOM FOR WORKING CHECKS.



TRANSVERSE SECTION, TAKEN IN FRONT OF THE LATHE, OF THE CHECK POWER LOOM.



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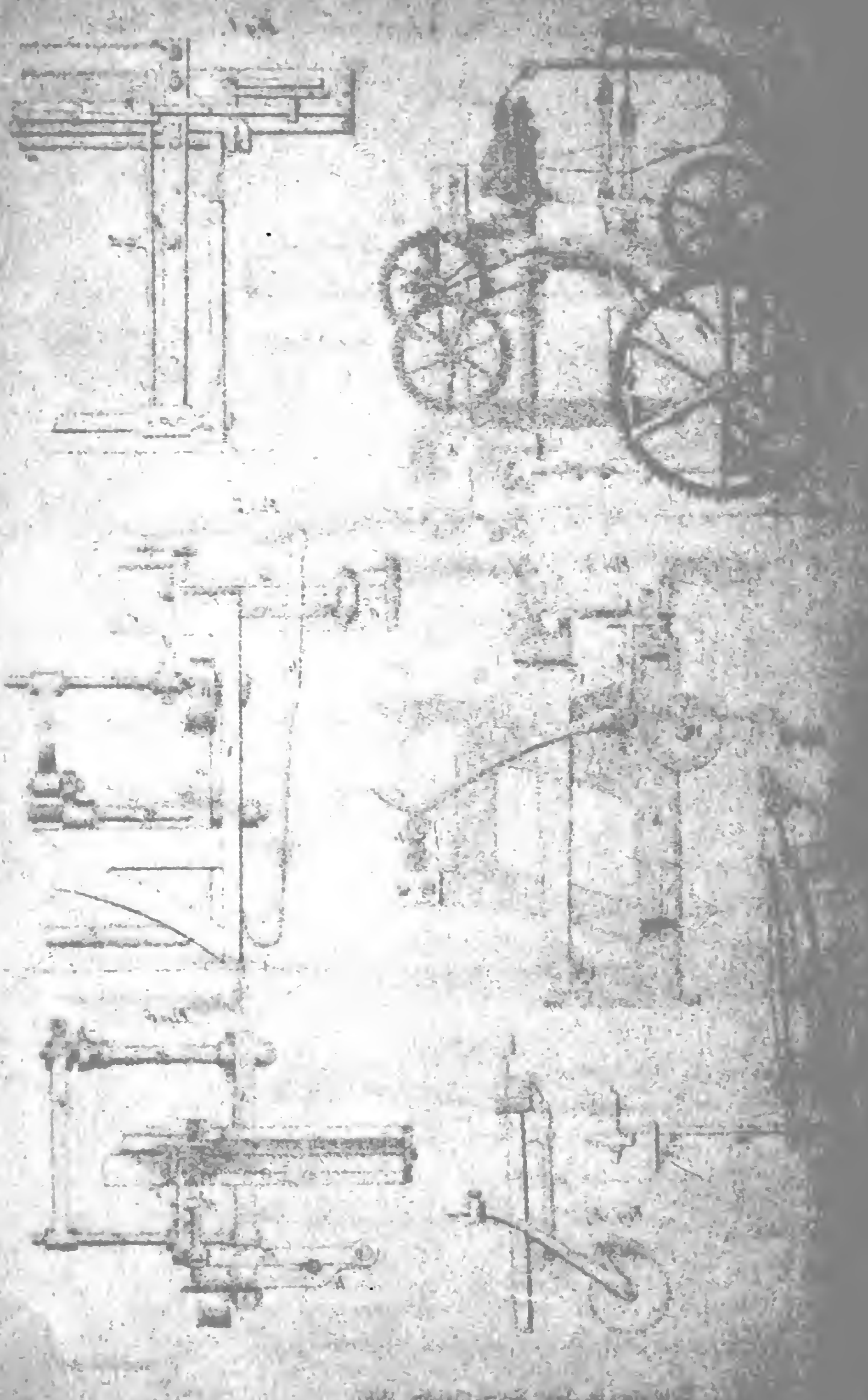


PLATE XIV.

Fig. 2.

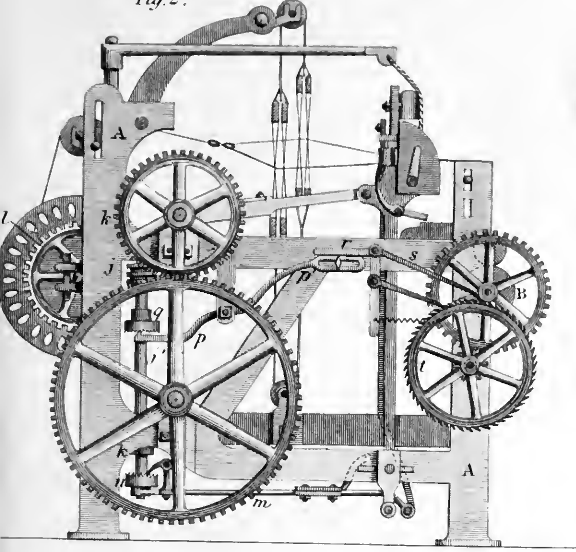


Fig. 1.

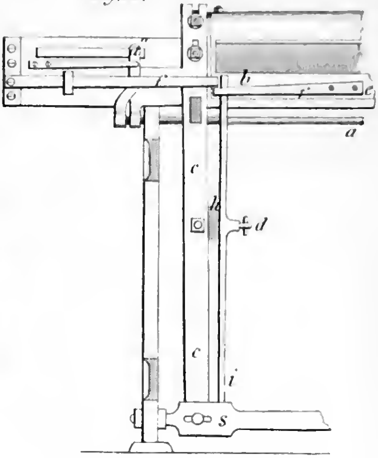


Fig. 7.

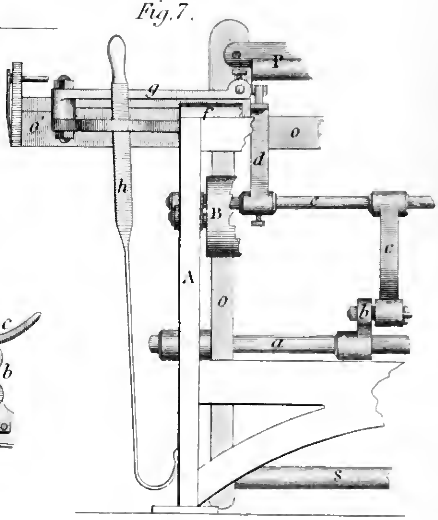


Fig. 5.

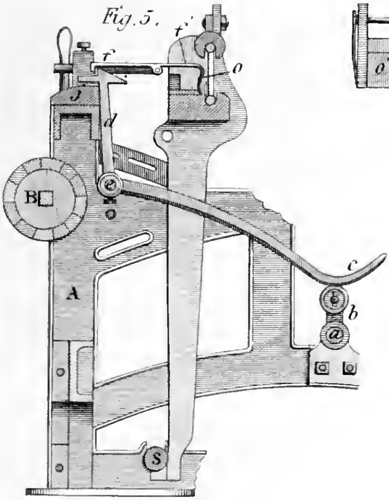


Fig. 3.

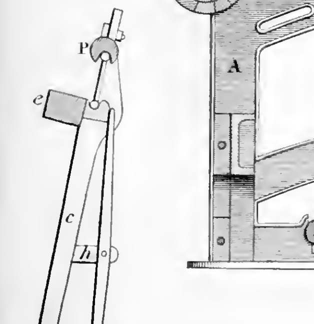


Fig. 4.

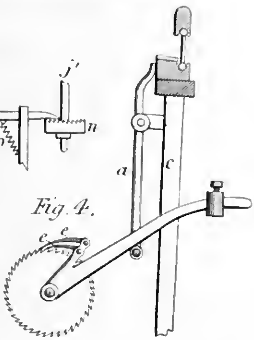
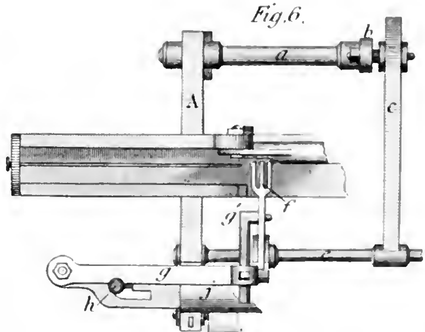


Fig. 6.



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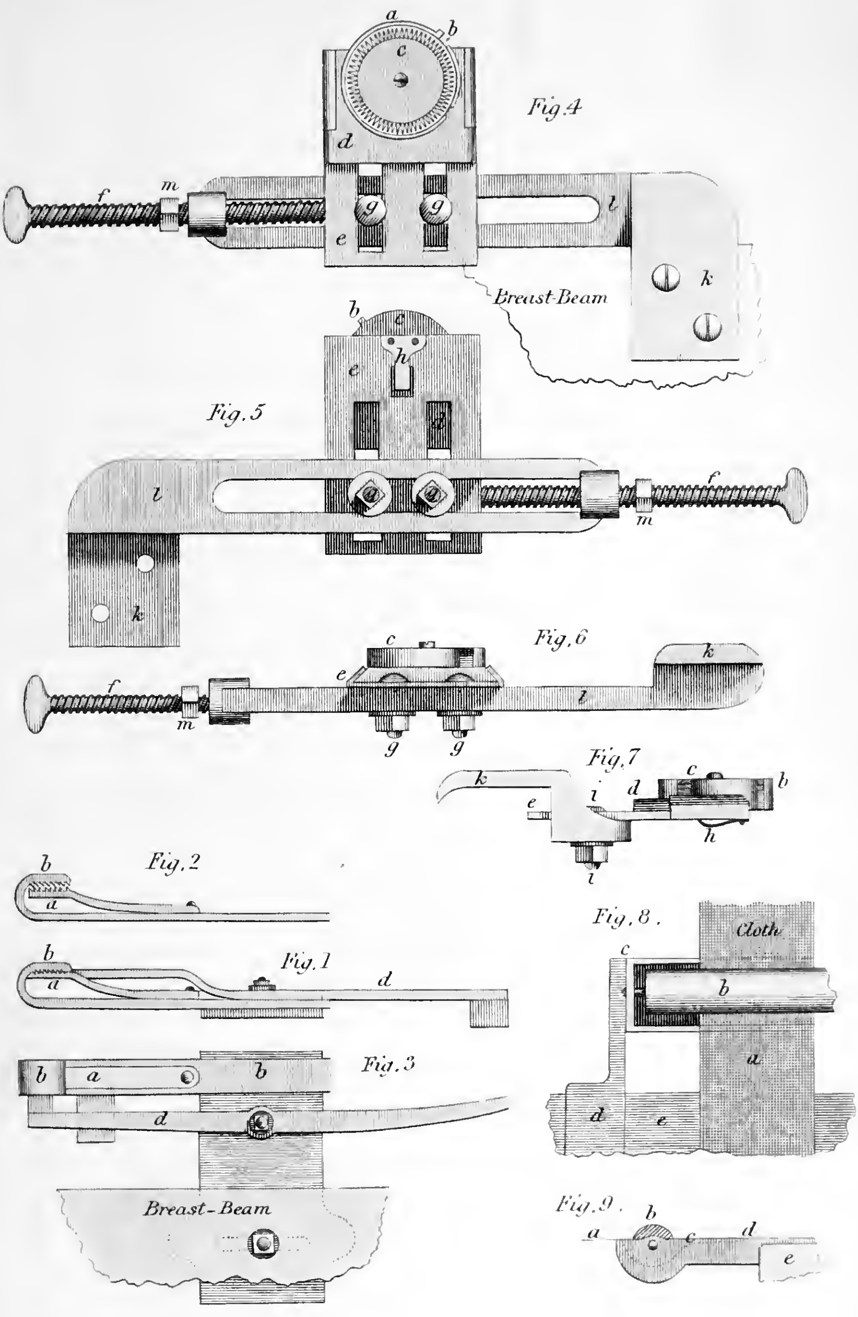

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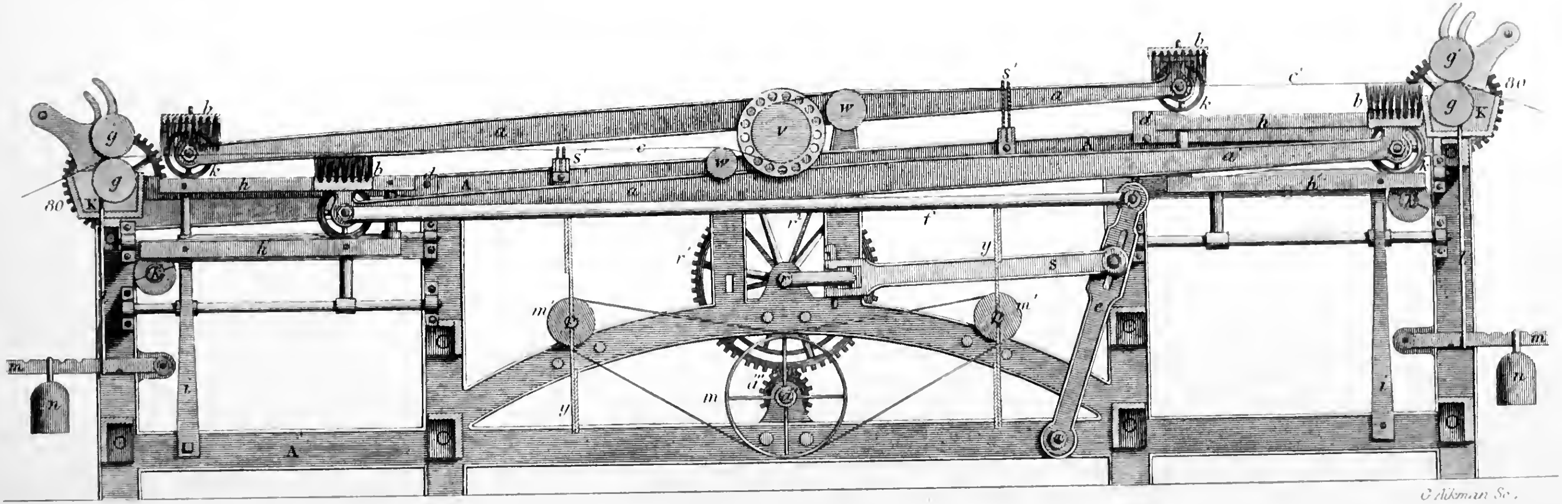
PLATE XVII.

LONGITUDINAL SECTION OF THE DRESSING MACHINE FOR FINE YARN.



Scale of Feet

0 1 2 3 4 5

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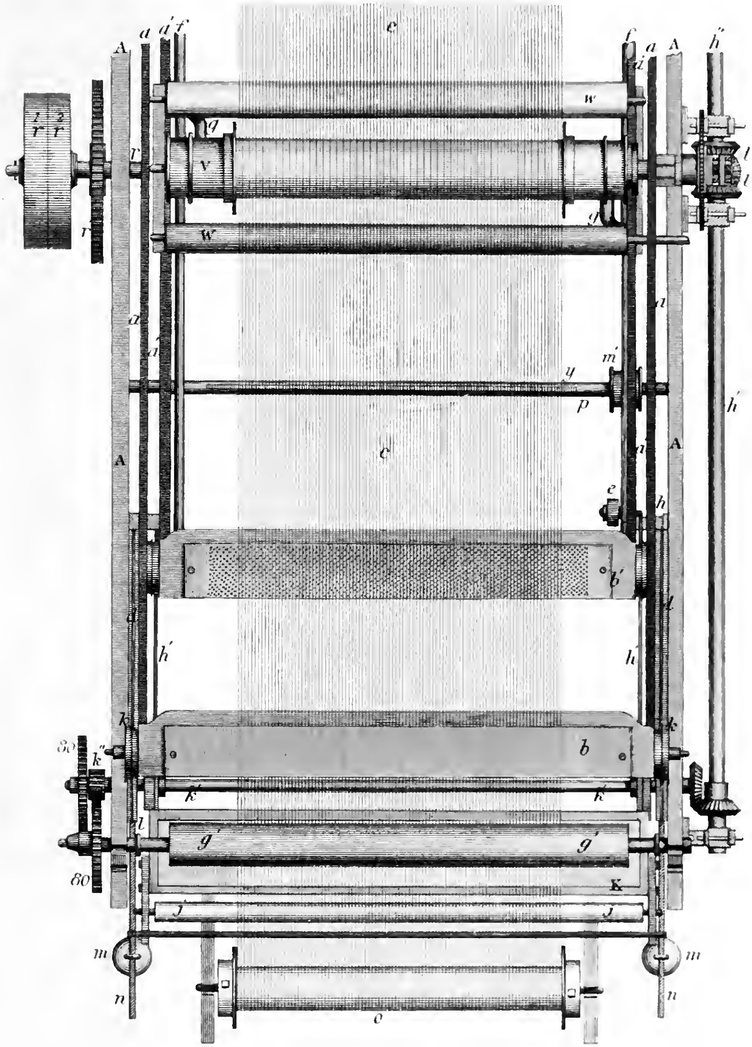
PLATE XVIII.

PART OF THE PLAN OF THE DRESSING MACHINE FOR FINE YARN.



Scale of Feet

0 1 2 3

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PLATE XIX.

TRANSVERSE SECTION OF A WEAVING FACTORY.

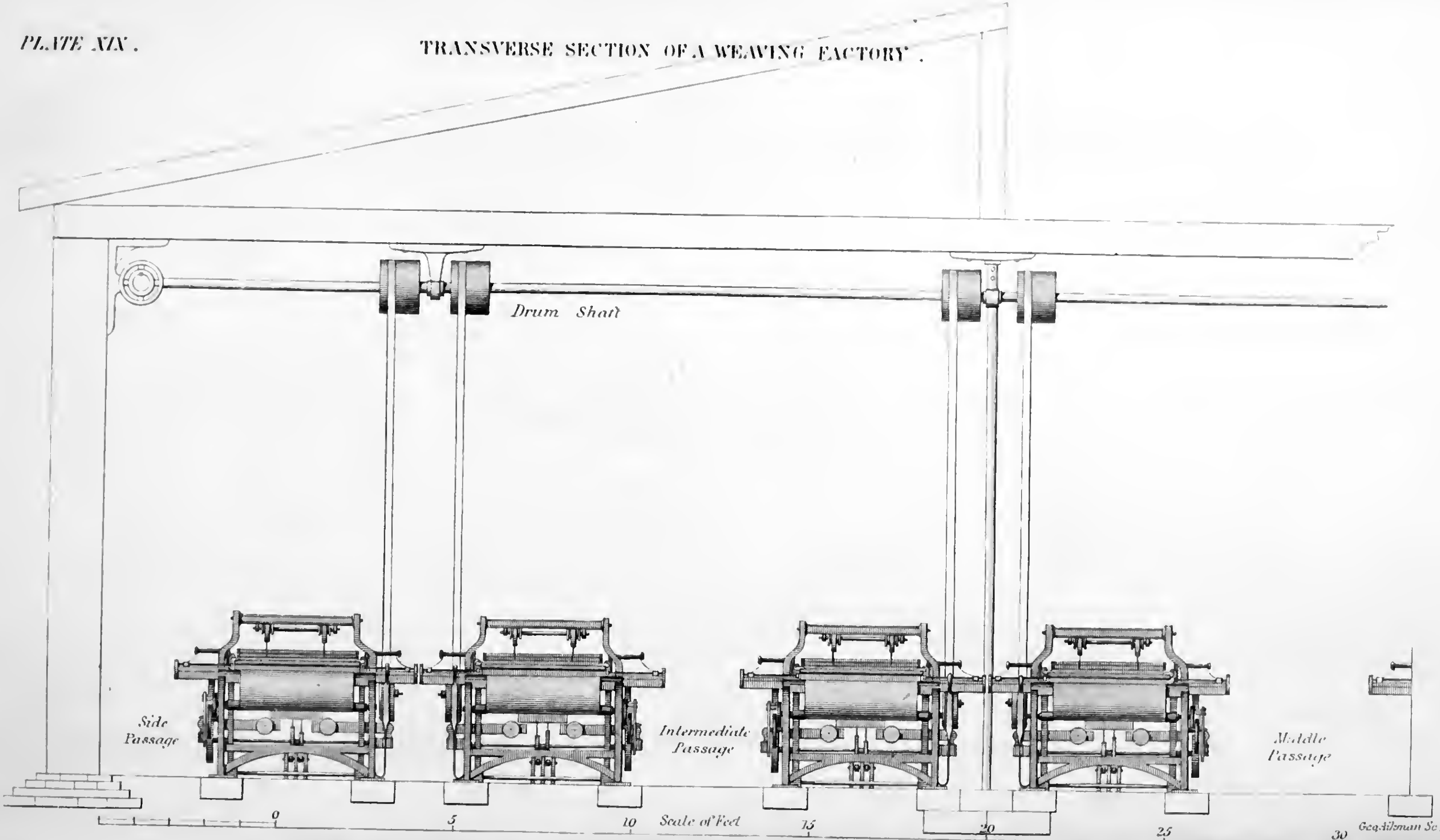

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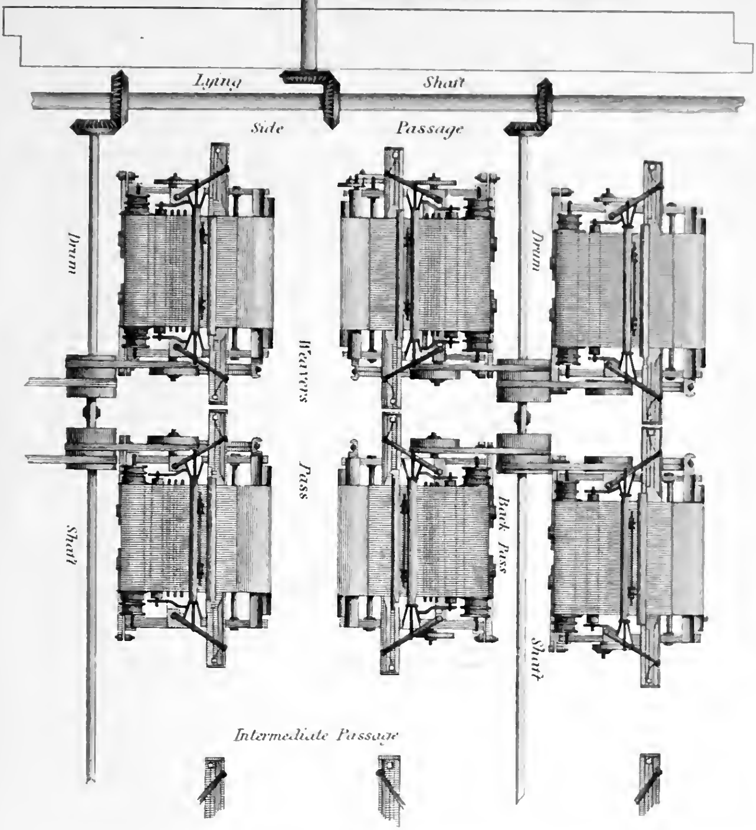
PLATE XX.

Fig. 1.

PART OF THE PLAN OF A WEAVING FACTORY.



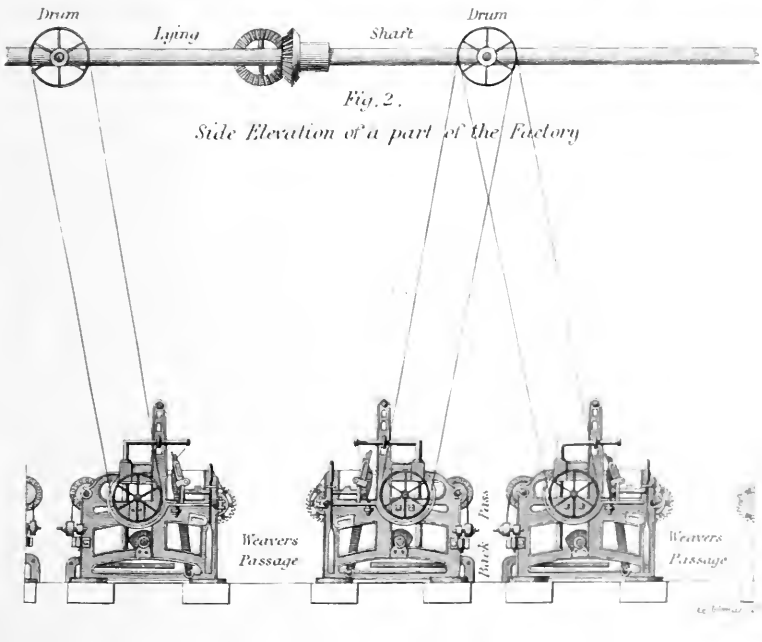


Fig. 2.

Side Elevation of a part of the Factory

[illegible]