"TEXTILE MANUFACTURER" MANUALS

PRELIMINARY OPERATIONS OF WEAVING

H. NISBET

VOLUME I

PREPARATION OF GREY OR PLAIN WARPS

"*TEXTILE MANUFACTURER*" *MANUALS*

PRELIMINARY OPERATIONS OF WEAVING

a

Preliminary Operations of Weaving

BY

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VOL. I

PREPARATION OF GREY OR PLAIN WARPS

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PREFACE

THE present volume treats of that system of preparing Grey or Plain Warps by the operations of Cop-winding, Beam-warping, and Slasher or Tape-sizing, and includes a Chapter on Mechanical Knotters for piecing threads, and another Chapter on Looming, containing descriptions of Automatic Warp-drawing, Warp-twisting, Warp-leasing, and Warp-tying Machines.

Whilst the book is of special interest to textile machine makers, manufacturers, and students of weaving, it should also be useful to spinners who conduct the operations of Cop-winding and Beam-warping in their own mills, as well as to students of spinning whose course of instruction includes these operations.

In view of the ascendancy of Air-drying of Yarn during Sizing, no effort has been spared to treat this subject in a comprehensive and exhaustive manner, and in Chapter VIII will be found detailed descriptions of six examples of modern Air-drying Slasher Sizing Machines of the most approved types. The author trusts, therefore, that this Chapter will be of special interest to manufacturers who are investigating the comparative merits of Cylinder-drying and Air-drying Sizing Machines, and the respective modifications of those types of Machines.

This work was first published as a series of articles in *The Textile Manufacturer;* but the original text has been revised and considerably extended by including descriptions of the latest machinery. It is proposed to continue this series of articles in that journal, and to describe different systems of Preparing Bleached and Coloured Warps, and different methods of Preparing Weft, and subsequently to republish those articles as supplementary volumes to the present work.

The author desires specially to thank the publishers for the great care they have taken with this work whilst it was passing through the press, and for their endeavour to bring it to a successful issue.

H. NISBET.

BOLTON, *May* 1914.

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CHAPTER I

INTRODUCTION

§ 1. The manufacture of textile fabrics involves a series of successive operations and processes, each of which constitutes an integral part of a concrete system culminating with the finished fabric. Although most of these operations are conducted separately and distinctly, and sometimes two or three are conducted concurrently, yet they are so correlated that each one has a greater or a lesser influence upon all subsequent operations.

Hence, it is expedient that all who are engaged in any branch of the textile industry should keep in view not only the particular operation or process in which they are respectively employed, but also those preceding and succeeding it, and especially the final one by which the article in process of manufacture is completed.

A cloth manufacturer, whilst requiring to specialize on that which appertains to the weaving trade in particular, should also have some knowledge of the principal allied branches of the textile industry in general, as spinning, doubling, bleaching, mercerizing, dyeing, cloth printing, schreinering, and the numerous methods of cloth finishing. Although in Lancashire and Yorkshire these trades are usually conducted quite independently as separate branches of the textile industry, yet they are so closely allied that the successful accomplishment of each succeeding branch is, in a large measure, dependent upon the results obtained in those preceding.

This is especially true of the spinning and weaving branches which constitute the two principal divisions of the textile industry. The varieties of different kinds of yarn produced by the first are converted into fabrics of infinite variety by the second; and any imperfections in yarn will, if they are not detected and removed, manifest themselves in the cloth produced from it.

It is no uncommon experience to discover faults in cloth which are only revealed after it has passed through the final operation, and which have their origin either in the defective manipulation of the raw material during some stage of spinning, or else in the faulty treatment of yarn during its subsequent preparation as warp or weft for weaving. Defects which occur at any one stage in the routine of manufacture may be transmitted through successive stages to the end before they are discovered.

§ 2. The preliminary operations of weaving may be effected by a variety of optional schemes or systems, each of which comprises a distinctive series of operations, and may be modified to meet special requirements. The character of the operations, and the types of machines by which they are performed, depend chiefly upon the class of fabrics to be manufactured, as regards the nature of the material, and also whether the yarn is to be woven in its natural or "grey" state, or after being either dyed or bleached. They also depend partly upon the preference of manufacturers, and, in a lesser degree, upon local or special circumstances.

There are, nevertheless, certain approved standard types of machines and systems of preparation that are expressly adapted to meet the specific requirements of each class of manufactures with greater efficiency and economy than is possible with other machinery and systems that are not so well adapted for the purpose. The relative merits of these systems, and of the machines employed, may only be correctly estimated with precise knowledge of the specific purpose and exact requirements of each operation, and of the functions of the machines by which they are performed.

Further, the numerous systems of preparing yarn for weaving different classes of fabrics, and the still greater variety of operations and machines which they comprise, are a constant source of perplexity and confusion to many who seek information on this subject, and especially to those who have not the privilege of observing in practice the actual operations in their proper sequence.

Many students of weaving are capable of drawing excellent diagrams of the essential parts of the respective machines employed in the preliminary operations of weaving, and of writing lucid descriptions of their functions—as abstract operations. Yet these students become hopelessly bewildered in their attempt to enumerate and describe the operations in their proper sequence so as to formulate a coherent series of operations constituting a concrete system of preparation.

§ 3. In view of the foregoing considerations, it is the purpose of this treatise to describe the preliminary operations of weaving and the numerous types of machines, and their modifications, by which they are performed; and also to impart information of such a character respecting those operations and machines as will be useful to those engaged in, or desiring information respecting the weaving trade in particular and the textile industry in general.

Also, a distinct departure from the usual practice of treating upon this subject, and one that is designed with the object of obviating the difficulties frequently experienced by students, as stated above will be that of grouping or classifying into distinctive systems the several operations involved in the preparation of warps according to the most approved modern methods adopted in the manufacture of different classes of textile fabrics.

The respective operations and machines comprised by each of the several systems of preparation will be described in their proper sequence, commencing in each case with yarn in the primary condition in which it leaves the spinning machine on which it is produced, and following its progress through the successive stages of manufacture until it is converted finally into a finished warp ready for weaving into cloth.

CHAPTER II

VARIETIES OF YARN

§ 4. YARN is produced primarily in a variety of different forms, chiefly according to the character of material composing it, the particular principle of spinning, and the type of machine by which it is produced. It is also spun into strands or threads comprising an infinite variety of different grades ranging from the coarsest to the finest "counts." The term "counts" signifies any numerical value which, when applied to yarn, indicates the ratio existing between a specific length and weight of a thread. The "counts" or numbers are based optionally upon various standard formulæ which differ not only in respect of threads produced respectively from staples of different raw materials, but also in respect of threads composed of the same staple, according to the accepted customs which prevail in different districts and countries.

Different threads vary considerably in character, not only according to the physical properties of the different staples of textile fibres composing them, but even when they are produced from the same kind of staple, whether of cotton, flax, wool, silk, or any blending of these. The particular characteristics which any yarn is required to possess depend entirely upon the type, style and texture of cloth for which it is intended, and also whether it is to constitute the warp or the weft series of threads in the fabric.

§ 5. Yarn may be obtained in a variety of optional forms and conditions to suit the convenience and varied requirements of manufacturers. It may be purchased in any of the primary forms in which the threads are produced during spinning, or in any other form and condition which it may subsequently assume during any of the successive stages of progress from its original form to that of a finished warp ready for the loom. This is convenient for those manufacturers whose premises are too small to accommodate the machinery necessary to conduct all or any of the preliminary operations of weaving for themselves, and also for those whose production is so small that such a course would not be economical.

They have, of course, to pay a proportionately higher price for yarn according to the particular stage at which it is purchased; but, on the other hand, they are compensated in that they have no capital invested in preparation machinery, and also in being relieved of expenses that would otherwise be incurred for additional rent, motive power, labour, repairs, and many other incidental items.

If, however, capital, accommodation and labour are available for the requisite machinery, and also if the productive capacity of the looms is sufficient to keep the preparation machinery and its attendants fully employed, it would be more economical for a manufacturer to purchase yarn in its primary state, and conduct all the preliminary operations on the same premises and under his personal supervision. Such a course would effect considerable economy in the cost of carriage alone, especially if, under the former condition, yarn were supplied on bobbins or beams—as these would greatly augment the gross weight of a consignment of yarn, and, when empty, are required to be returned carriage paid to the vendor. In addition, it would reduce the risk of injury to which the yarn is exposed by frequent and careless handling during loading and unloading, and also by exposure to unfavourable climatic conditions, as rain, fog, snow and frost, during transport.

But whatever character cotton yarn may ultimately assume after spinning, and in whatever form or condition it is received by a manufacturer, it would, in the first instance, be produced as a single strand or thread and concurrently formed into cops, or else wound on to tubes or bobbins, according to the type of spinning machine by which it is spun. Of these there are several modifications of three principal types—namely: (1) Spinning mules; (2) ring frames; and (3) flyer throstle frames; each of which produces yarn of slightly different character, according to the inherent principle of spinning distinctive of the respective types of machines.

§ 6. A considerable amount of cotton yarn is spun and prepared for many other purposes than that of manufacturing into textile fabrics. For example, it is used in the production of fine lace,

lace curtains, cotton sewing-thread, cotton twine, cord and banding, ropes, and an infinite variety of other articles; but yarn intended for weaving is broadly classified as " twist " and " weft," chiefly according to whether it is to constitute the warp or the weft series of threads in the woven fabric, and may consist either of a single strand as originally spun, or it may be of the folded or of the fancy classes of yarn, as required.

As a general rule, "twist" or warp yarn is finer and stronger than "weft" yarn of corresponding counts and quality of the raw staple. Warp yarn requires to be stronger than weft to enable it to withstand the greater amount of tensile strain and abrasive friction to which it is subjected during its conversion into warps, and especially during the operation of weaving. Its greater strength results from a greater amount of twisting being imparted to the threads during the operation of spinning, whereby the fibres composing them become more firmly interlocked and cohesive, thereby increasing their power of resistance to both tensile strain and friction.

§ 7. Single yarn consists of a single strand of fibrous filaments twisted together so as to cause them to cohere with sufficient tenacity to produce a continuous thread of indefinite length; whereas folded yarn signifies a compound thread produced by combining two or more strands of single yarn and twisting them together in order to obtain a thread of greater strength and uniformity of diameter, and yet one having the outward appearance of a single strand of yarn.

The original single strands composing a folded thread may be either of the same counts of yarn to produce a regular thread of uniform diameter, or they may be of different counts to produce numerous varieties of fancy yarn such as " spiral," " knopped," " slubbed," " knicker," " flaked," " crimped," and many other varieties of the same class. Also, two or more threads of different colours are twisted together to produce what is termed " grandrelle " yarn, of which class there are numerous imitations obtained by printing single strands of yarn to produce " grandrelle " effects. The production of folded and " fancy " yarn constitutes those branches of the spinning trade known as doubling and " fancy " spinning.

PRIMARY AND SUBSEQUENT FORMS OF WARP YARN

Single Yarn

§ 8. The primary forms in which single cotton warp yarn is originally produced by the three principles of spinning named above are represented at A, B and C, in Fig. 1. In mule spinning, twist or warp yarn is invariably formed into cops, as represented at A; but in ring spinning it is usually wound on to bobbins, as shown at B, and sometimes the threads are wound on to either paper tubes or else directly on to the bare spindles as in mule spinning, and formed into cops; whilst in flyer throstle spinning they are wound on to small flanged bobbins, one form of which is shown at C.

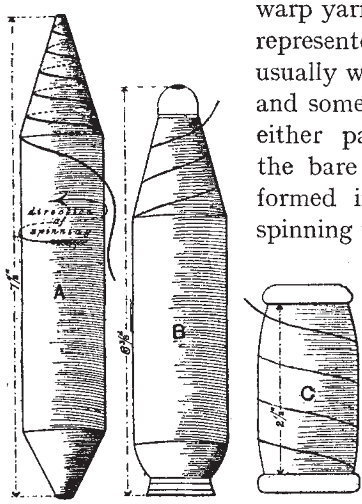

Fig. 1.

Folded Yarn

§ 9. Folded yarn is primarily produced during the operation of doubling spinning, of which there are three distinct systems—namely: (1) Ring doubling; (2) flyer throstle doubling; and (3) twiner doubling. As the several single strands of yarn are being spun or twisted together during doubling spinning, the resulting folded threads are wound concurrently either on to ring doubling bobbins, as shown at D, Fig. 2; or on to flyer throstle doubling bobbins E; or else they are formed into twiner cops, according to the type of doubling machine employed. A twiner doubling machine bears a general resemblance to a spinning mule; but, unlike that type of machine, twiners are usually constructed with the spindles contained in a stationary portion of the machine, whilst the creel containing the single threads travels to and from the spindles.

SUBSEQUENT FORMS OF YARN

§ 10. The subsequent operations of converting yarn into warps, from any of the primary forms just enumerated, strictly constitute the preliminary operations of weaving that are (with the exception of reeling yarn into hanks or skeins) usually conducted on the weaving premises. For the convenience of some manufacturers, however, those operations are sometimes conducted on the spinning premises up to a stage when the yarn is actually converted into either a beamed or else a balled warp of grey yarn, which only requires to be bleached or dyed (if necessary) and sized, ready for winding on to the weaver's beam.

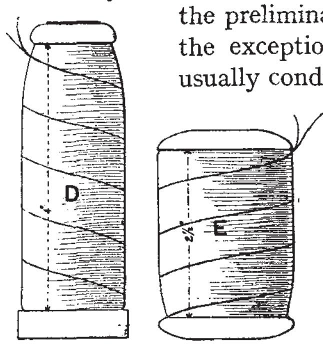

Fig. 2.

Therefore both single and folded warp yarn may be purchased in any of the following subsequent forms: in hanks or skeins, each consisting of a reeled and continuous thread of a specified length; upon warpers' bobbins on which the respective threads may be wound so as to form either convex (barrel-shaped) or else parallel sides, as shown at F and F¹ respectively, in Fig. 3; in the form of spools G, which are suitable only for either strong single or else folded yarn; in the form of either ball or chain warps, consisting of a condensed mass or sliver of threads, formed either into a large ball or else linked into a chain, respectively, ready for either ball-warp sizing for grey warps, or else bleaching or dyeing and sizing for coloured warps. Yarn may also be purchased in the form of beamed warps, consisting of a sheet of parallel threads evenly disposed and wound on to what are variously termed "warpers'," "back," and

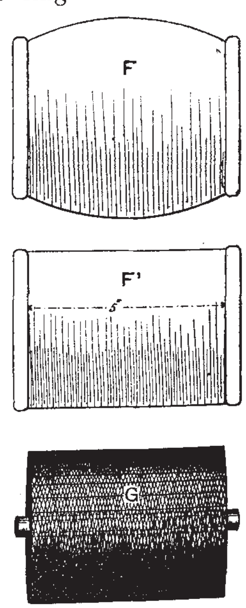

Fig. 3.

"slashers'" beams, ready for either "dresser" sizing or else "slasher" sizing, if the yarn is intended for the production of grey warps; and sometimes, if the yarn is intended for the production of either bleached or mono-coloured warps, it is wound, during the operation of beam warping, on to "back" beams constructed with hollow and perforated copper tubes or barrels on which it is afterwards either bleached or else dyed, as required, and subsequently sized by the method of "slasher" sizing.

CHAPTER III

THE GENERAL ROUTINE OF TEXTILE MANUFACTURE

§ 11. If warp yarn is purchased in any of the primary forms enumerated in § 8, p. 7, its progress through the entire routine of manufacture into cloth (exclusive of bleaching, dyeing, and other incidental processes) essentially comprises a series of not more than eight consecutive operations, which are performed in the following rotation:

1. Reeling yarn into hanks.
2. Winding yarn on to warpers' bobbins.
3. Warping.
4. Sizing.
5. Beaming—*i.e.*, winding warps finally on to weavers' beams.
6. Looming (*optional methods*) { A. Drawing-in, B. Twisting, C. Tying } to pass the warp threads through the shedding harness and reed.
7. Gaiting or tuning—*i.e.*, preparing the warp, shedding harness, and the loom ready for weaving.
8. Weaving.

Of these eight operations, the first five and the last (weaving) are performed mechanically. The sixth (looming) is generally accomplished by hand, although both drawing-in and twisting (or else tying) are sometimes performed by automatic mechanical appliances, as described in §§ 352-360, pp. 365-377. The seventh operation, however (gaiting), comprises numerous incidental functions, which necessarily demand personal labour and skill, in the proper adjusting and timing of the various parts of the loom and its accessories.

The character of the foregoing operations is defined, and their object briefly described, as follows:

1. Reeling

§ 12. This operation consists of transferring separate threads from any of their previous forms, and converting them into hanks or skeins of specific length, sometimes for exportation, but chiefly with the object of placing the respective threads in a free, open, and loose state, and thereby adapting them more suitably for incidental processes, such, for example, as mercerizing, bleaching, dyeing, lustring, polishing or glazing, and also for printing to imitate "grandrelle" yarn, ready for winding either on to warpers' bobbins for warp yarn or else on to pirn bobbins for use as weft.

2. Winding

§ 13. This operation is usually the first in the series of preliminary operations conducted in a weaving mill, where yarn is received either in its primary forms or in hanks. It consists essentially of transferring separate threads from any of their previous forms and winding them either on to flanged warpers' bobbins or else spools, according to the type of winding machine employed, of which there are various modifications of three distinct types—namely: (1) Those variously described as "cop," "bobbin," and "upright" or "vertical" spindle winding machines employed chiefly to transfer grey yarn from cops, ring and throstle bobbins, on to warpers' bobbins; (2) drum winding machines employed chiefly to transfer yarn from hanks that have been previously bleached, dyed, or otherwise treated, either on to warpers' bobbins, or else on to spools; and (3) a more recent type known as "ball warp" winding machines for the purpose of transferring threads from ball warps that have been previously bleached or dyed, and re-winding them on to warpers' bobbins for re-warping.

The primary object of winding is to obtain separate and continuous threads of considerably greater length than that in which they are produced during spinning, and also to place the threads in a more compact form adapted more suitably for the subsequent operation of warping. This is effected by tying together the ends of any number of separate threads as these are wound successively from their respective cops or bobbins.

Opportunity is also afforded at this stage to improve the quality of the yarn by removing from the threads such defects as are liable to occur during spinning, such as thin and weak places, slubbings, snicks or snarls, neps, particles of cotton-seed husks, and other imperfections which are likely to impede the subsequent operations or to produce faults in cloth.

3. Warping

§ 14. Of the respective operations under present consideration, that of warping is of paramount importance; for whatever may be the commercial quality of yarn composing a warp, any carelessness at this stage will prove a hindrance and source of anxiety to the weaver, and also tend to develop faults of a serious character in cloth produced from it.

The operation of warping consists of withdrawing and gathering together any practicable number of threads simultaneously from a corresponding number of warpers' bobbins or spools in order to obtain a series of parallel threads of uniform tension and length. As the warp threads are withdrawn from their respective bobbins they are either wound in the form of an evenly-disposed sheet of parallelized threads on to a back or slashers' flanged beam, or else they are condensed into a sliver of threads, and either concurrently or subsequently formed into a ball or linked into a chain, according to the particular method of warping adopted.

Or again, by another method of warping the warp threads may, on leaving the warpers' bobbins, be converged into a narrow flat band or tape, and wrapped on to narrow wooden circular blocks to form what are termed sections or cheeses, each of which constitutes a sectional unit of a complete warp, with the warp threads disposed in precisely the same relative positions that they are to occupy in the cloth.

The particular form into which yarn is converted at this stage is determined chiefly by the method of warping adopted, of which there are various modifications of three principal methods—namely: (1) Beam warping; (2) that variously described as mill, heck, ball, and chain warping; and (3) sectional warping, according to the particular type of warping machine employed, the choice of which is largely governed by the class of goods for which the warps are intended.

4. Sizing

§ 15. This is a process of impregnating yarn with a compound solution usually composed principally of flour or starch prepared from

* For detailed information relating to sizing, sizing ingredients and size mixing, consult the author's treatise on the *Theory of Sizing*.

wheat and other cereal grains, in combination with various other ingredients of an oily, a mineral and a chemical character respectively. This treatment of warps is chiefly adopted with the primary object of making the yarn smoother and stronger, by laying down the ends of fibres that project from the main body of the threads, thereby enabling them to more effectually withstand the tensile strain and abrasive friction to which they are subjected, chiefly by the chafing action of the shedding harness, and also by the reed and shuttle race-board during weaving.

Other objects sought by sizing yarn are to impart to the finished cloth a certain characteristic soft and mellow feel of a peculiar tone familiar to experienced persons; also to give it a superior finish and the appearance of a cloth of better quality; and sometimes to artificially increase its weight even to the extent of 250 per cent. of the original or net weight of yarn.

The process of sizing may be accomplished by one or other of several modifications of two distinctly different and optional methods —namely: (1) Beam warp or "tape" sizing; and (2) ball warp sizing, according to whether warps are produced by the method of beam warping, or by any of the numerous methods of ball or sliver warping, respectively.

Tape-sizing machines comprise several modifications of two chief types—namely: (1) Slasher sizing machines, in which the yarn, after being sized, is dried by surface contact with steam-heated cylinders; and (2) hot or warm air-drying sizing machines. Tape or beam warp sizing is much better adapted than ball or sliver warp sizing for yarn of medium and fine counts, especially when the drying of yarn is effected by means of hot or warm air, as this method of drying by evaporation does not tend to flatten the warp threads, as does that of cylinder-drying.

Also, when warps are sized by any method of tape or beam warp sizing, the yarn is wound concurrently on to a weaver's beam by the same machine, thereby avoiding a subsequent and independent operation of beaming or winding-on, as is necessary after ball-warp sizing. Ball or sliver warp sizing is a method of sizing warps whilst the yarn is in a condensed or compact form of a sliver of threads, and is only suitable for warps composed of strong yarn of coarse counts. If warps are sized by this method, they are wound subsequently on to a weaver's beam by an independent operation of beaming or winding-on.

5. Beaming or Winding-on

§ 16. This is the final stage in the series of operations involved in the actual production of a warp, and consists of transferring threads simultaneously from a set of ball or other form of sliver warps, or from a set of beam warps, or from a set of warp sections (according to whether the warps have been prepared by any method of sliver warping, beam warping, or sectional warping), and of winding them with an even and parallel disposition finally on to a weaver's beam ready for looming.

6. Looming

§ 17. This is an operation of harnessing the warp to the shedding harness consisting either of a set of healds or of a jacquard mounting, and may be effected by each of three optional methods—namely: (*a*) " Drawing-in," (*b*) " twisting," and (*c*) " tying."

Drawing-in consists of drawing warp threads, in consecutive rotation, through the respective loop eyes or mail eyes of the shedding harness in a specified order, as indicated by a prepared chart or plan termed the " draft," and also of subsequently passing them, usually in pairs, between successive dents or divisions of a reed. The operation of " drawing-in " is absolutely imperative in all instances when a new shedding harness is employed for the first time, and also when the threads of a new warp require to be passed through the eyes of the harness in a different order of succession from that of the previous warp ends, and although it is usually performed by hand, it is sometimes effected automatically by means of a mechanical warp drawing-in apparatus.

Twisting.—If, however, the harness has previously contained a warp which is being replaced by one containing approximately the same number of warp-ends and composed of yarn of similar character and counts, and also if the warp-ends are required to pass through the harness eyes with precisely the same order of drafting as the previous warp, under these circumstances looming may be effected either by means of twisting or else by tying, whereby the successive threads of a new warp are separately joined in consecutive rotation to the corresponding threads forming the remnant of the previous warp whilst this is still retained in both the shedding harness and reed.

The attachment of the respective threads of the old and new warps is usually effected by a peculiar kind of double twist formed by hand, though they may be twisted together automatically by means of a warp-twisting machine; or again, they may be united by knots tied automatically by means of a warp-tying machine. After all the threads of the old and new warps are respectively joined together they are drawn forward *en masse* in order to pass the piecings of the threads through, and quite clear of, both the harness eyes and dents of the reed, in order to give the new warp threads a clear start for weaving.

7. Gaiting or Tuning

§ 18. These terms signify all the preliminary duties involved in the proper relative adjustment, fixing, and timing of the various parts of a loom and its numerous appurtenances so that they will all act in perfect harmony, and which are necessary to establish the loom in good working condition ready for the final operation of weaving.

8. Weaving

§ 19. This is the final stage in the routine of cloth manufacture, and consists specifically of effecting a combination of the respective series of warp and weft threads by interlacing them in a prescribed and systematic order, as indicated by the design, to produce a texture or web of cloth.

Throughout the foregoing operations, excepting that involved in the process of sizing warps, the yarn experiences no change whatever either of a physical or a structural character, but it simply undergoes a transition from one form or state to another, with the object of adapting it more suitably for treatment at each succeeding stage of its progress, and thereby bringing it gradually to its ultimate state of perfection as a woven textile fabric.

Each successive operation is but a means towards attaining that object, which should be accomplished as efficiently and economically as possible; and it is with this object in view that inventors are constantly endeavouring to improve existing methods and types of machines, and to devise new ones of superior merit, or that are better adapted for specific purposes.

§ 20. Although the operations just enumerated are described as if each one constituted a distinct stage in the process of manufacture, there are, nevertheless, sometimes two and even three operations performed concurrently as one operation conducted by the same machine, as, for example, in the combined operations of warping and beaming or winding-on to the weaver's beam for certain classes of warps not exceeding about 1000 warp-ends prepared from hank-dyed and sized yarn: in the combined operations of sizing and beaming as conducted by slasher and all other types of beam-warp sizing machines: in the combined operations of beam warping and sizing; and also in the combined operations of warping, sizing, and beaming as obtain in the preparation of warps for certain classes of worsted and some fustian fabrics.

§ 21. Many deviations are made from the orthodox routine of manufacture in order to meet the special requirements incidental to the production of certain varieties of fabrics, and also to meet circumstances of an exceptional character. These considerations account chiefly for the great variety of systems in vogue of preparing the three principal classes of warps—namely: (1) Grey warps—*i.e.*, of the natural colour of cotton; (2) bleached and mono-coloured warps; and (3) coloured striped warps.

The chief points of difference between the various systems of preparation adopted for the same class of warps are mainly in the methods of warping and sizing. In most other respects the character of the operations is similar. For these reasons it is usual to distinguish the various systems of preparation according to the particular methods of warping and sizing with which they are identified, as, for example, "beam warping" and "slasher" sizing; "ball warping" and "ball-warp sizing"; and so forth.

§ 22. In subsequent chapters, the various operations and machines, required for the preparation of the three classes of warps just named, will be fully explained and described. It is expedient, therefore, at this juncture, to summarize the more typical and distinctive systems of preparation, and the several operations which they respectively comprise, as follows:

I.—SYSTEMS OF PREPARING GREY WARPS

SYSTEM No. 1.

1. Winding	Cop or bobbin
2. Warping	Beam
3. Sizing and beaming (*optional methods*)	A. Slasher or cylinder drying B. Hot or warm air-drying
4. Looming (*optional methods*)	A. Drawing-in B. Twisting C. Tying

SYSTEM No. 2.

1. Winding	Cop or bobbin
2. Warping and sizing	Beam (and sometimes beam warping, sizing and beaming)
3. Beaming	From back, or slashers', beams
4. Looming.	

SYSTEM No. 3.

1. Winding	Cop or bobbin
2. Warping (*optional methods*)	A. Mill or heck B Direct ball C. Chain D. Spool E. Sectional (and subsequent section balling)
3. Sizing	Ball or sliver warp
4. Beaming	Ball or sliver warp
5. Looming.	

§ 23. II.—SYSTEMS OF PREPARING BLEACHED AND MONO-COLOURED WARPS.

SYSTEM No. 1.

1. Winding	Cop or bobbin
2. Warping (*optional methods*)	A. Mill or heck B. Direct ball C. Chain D. Spool E. Sectional (and subsequent section balling)
3. Bleaching or dyeing	Ball or sliver warp
4. Sizing	Ball or sliver warp
5. Beaming	Ball or sliver warp
6. Looming.	

SYSTEM No. 2.

1. Winding	Cop or bobbin
2. Warping	Beam
3. Bleaching or dyeing	On back beams of special construction with perforated copper or other special metal tubes to better resist corrosion, and brass flanges
4. Sizing and beaming	Slasher, or other method of beam warp
5. Looming.	

SYSTEM No. 3.

1. Winding	Cop or bobbin
2. Warping	Beam
3. Bleaching	On back beams of special design
4. Dyeing, sizing and beaming	Slasher, or other method of beam warp
5. Looming.	

§ 24. III.—SYSTEMS OF PREPARING MULTI-COLOURED STRIPED WARPS.

SYSTEM No. 1.

1. Winding	Cop or bobbin
2. Warping (*optional methods*)	A. Mill or heck B. Direct ball C. Chain D. Spool E. Sectional (and subsequent section balling)
3. Bleaching or dyeing	Ball or sliver warp
4. Sizing	Ball or sliver warp
5. Dressing (*optional methods*)	A. Yorkshire (and beaming combined) B. Scotch (and subsequent beaming)
6. Looming.	

SYSTEM No. 2.

1. Winding	Cop or bobbin
2. Warping (*optional methods*)	A. Mill or heck B. Direct ball C. Chain D. Spool E. Sectional (and subsequent section balling)
3. Bleaching or dyeing	Ball or sliver warp
4. Sizing	Ball or sliver warp
5. Rewinding	From ball or sliver warps on to warpers' bobbins
6. Rewarping	Sectional
7. Beaming	Section (or "running-off")
8. Looming.	

SYSTEM No. 3.

1. Reeling	Into hanks
2. Bleaching or dyeing	Hank
3. Sizing	Hank
4. Winding	Drum
5. Warping	Sectional
6. Beaming	Section
7. Looming.	

SYSTEM No. 4.

1. Reeling	Into hanks
2. Bleaching or dyeing	Hank.
3. Sizing	Hank
4. Winding	Drum
5. Warping	Mill or heck
6. Beaming	Ball or sliver warp
7. Looming.	

CHAPTER IV

SYSTEMS OF PREPARING GREY WARPS

§ 25. THE prevailing system of producing grey cotton warps that are not required to be heavily sized is that characterized by the operations of "*beam warping*" and "*slasher sizing*." By this system the entire routine of converting yarn from any of the primary forms of cops, or on ring or throstle bobbins, into completed warps ready for weaving, comprises a series of only four operations, as follows:

SYSTEM No. 1.

1. **Cop or bobbin winding.**
2. **Beam warping.**
3. **Slasher sizing and beaming.**
4. **Looming** (*i.e.* (*a*) **drawing-in ;** (*b*) **twisting ; or** (*c*) **tying**).

COP OR BOBBIN WINDING

The comparatively short length of yarn composing a cop, or contained on a ring or a throstle bobbin, makes it impracticable to produce warps of considerable length by warping the threads directly from any of those primary forms. Such a procedure would not only impede the production of warps by involving an inordinate amount of time and labour for the frequent renewal of spent cops or bobbins in order to obtain continuous threads of much greater length than they contain, but it would also conduce to the presence of faults in warps, as these would inherit many of the defects which occur in yarn during spinning.

Those defects would be more liable to escape detection during direct warping from cops or bobbins than during the operation of transferring the threads therefrom on to warpers' bobbins by means of a cop-winding machine. Thus, the operation of cop winding serves, incidentally, to eliminate from the threads, as they pass on to their respective warpers' bobbins, many faults which, if not removed at this stage, will prove a source of hindrance to the warper, sizer, and weaver, and may also cause blemishes to occur in cloth.

§ 26. The weight of yarn composing a mule twist cop of the usual size is approximately 1oz. 10dr., and of that contained upon a ring twist bobbin 1oz. 3dr. The maximum weight of yarn which may be placed on a warper's bobbin depends upon the size of bobbin, the counts and character of yarn, and the degree of tension imparted to it during winding. For example, a warper's bobbin with flanges 3½in. diameter, a 4¼in. chase, and a barrel 1¼in. diameter, will hold approximately 14oz. of mule twist yarn and 16oz. of ring twist yarn, because the relatively greater strength of ring-spun yarn permits of a higher degree of tension being imparted to it during winding.

Those amounts of yarn are equal to eight or nine mule twist cops, and thirteen or fourteen ring twist bobbins respectively. Therefore, in order to obtain continuous warp threads of considerably greater length than that in which they are produced by mule, ring, and throstle spinning, it is necessary to transfer the threads from each of several cops or bobbins and wind them successively on to a warper's bobbin having a much larger capacity.

This object is attained by the operation of cop or bobbin winding performed by means of what are variously termed "cop," "bobbin," and "vertical spindle" winding machines of the type represented perspectively in Fig. 4, as made by Messrs Thomas Holt, Ltd., and also illustrated by line diagrams in Figs. 5(*a*) and 5(*b*), which illustrate an end and part sectional elevation, and a part plan, respectively, of a cop-winding machine adapted to wind yarn from cops A on one side; from ring bobbins B on the other side; and also (for incidental occasions) from hanks C on both sides of the machine.

COP OR BOBBIN WINDING MACHINES

§ 27. Cop-winding machines comprise various modifications of two standard models that are representative of the English and the American patterns, both of which embody the same essential and distinctive structural features that characterize this type of machine as represented in Figs. 5(*a*) and 5(*b*)—namely: (1) Vertical spindles D, which support and turn warpers' bobbins E; (2) either one or else two tin driving drums or cylinders F, for the purpose of driving the spindles and their warpers' bobbins by means of cotton bands G;

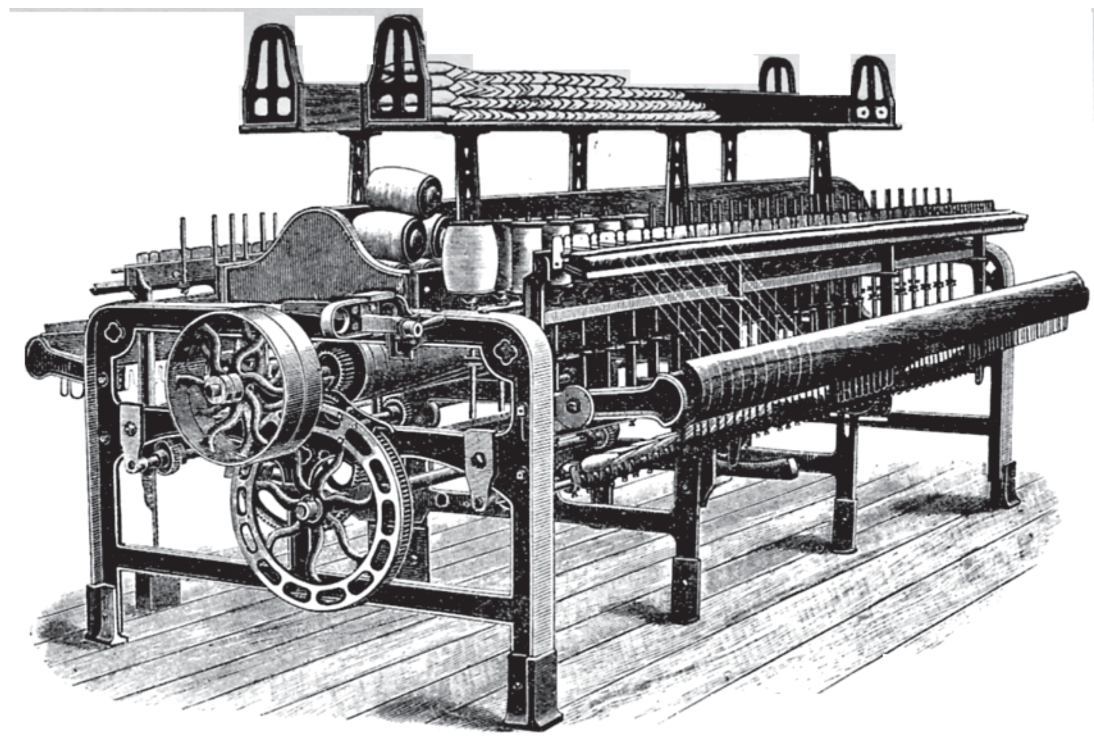

Fig. 4.—Cop or Bobbin Winding Machine.

and (3) a mechanical device constituting a guide or traverse-motion to impart to the guide rails H an upward and downward movement, alternately, for the purpose of guiding the threads so that they will each form a series of successive and parallel layers extending between the flanges of their respective warpers' bobbins.

The machine is put into operation by passing the driving belt from the loose pulley J^1 to the fast or driving pulley J, which is keyed on a short shaft K projecting from one end of the tin drum F. As this revolves it transmits, through the medium of the cotton driving bands, motion to the winding spindles, which revolve with a high and constant velocity.

§ 28. Cop-winding machines of modern construction are usually furnished with winding spindles of the self-contained Rabbeth type, as represented in Fig. 5(*a*). Spindles of that type each have their lower part inserted in a cup-bearing L, which serves both as a bolster to fix and support the spindle in a vertical position on a spindle-rail M, and also as an oil chamber to furnish a continuous supply of oil in which the spindle revolves freely.

Each spindle is furnished with a circular metal disc or washer N which tightly grips the spindle, and forms the support for a warper's bobbin during winding. The bobbin fits quite freely upon the spindle and rests by its own weight upon the disc, which thereby drives the bobbin frictionally by surface contact. Immediately below the disc, and formed out of the same piece of metal, is a small grooved wharve or pulley O, on which runs a cotton band G driven by the tin drum F for the purpose of driving the spindle and its bobbin, which revolve with a constant velocity. Only one spindle-rail is necessary to support each row of Rabbeth spindles; and as each spindle is self-contained, and constitutes a complete unit in itself, they are each adjusted and fixed in their true vertical position on the spindle-rail separately and quite independently of other spindles.

§ 29. This type of spindle marks a great improvement on that of the old style, which is formed with a long shank and requires to be supported by means of two rails placed several inches apart, vertically. The lower rail contains footstep bearings to receive the foot of each spindle, and the upper rail is formed with holes that are placed in vertical alignment with the footstep bearings, and furnished with collars to support the spindles in a true vertical position.

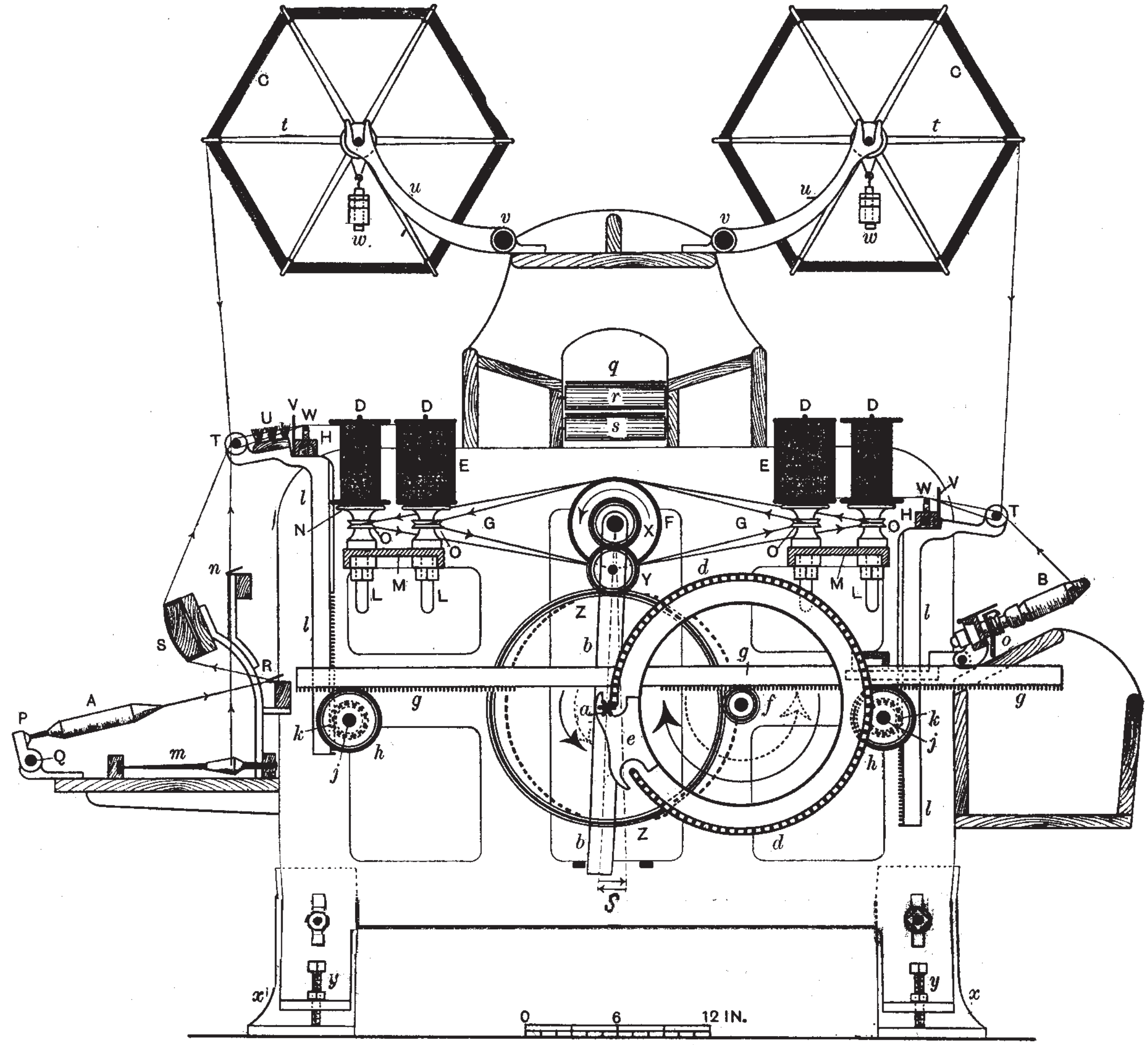

Fig. 5(*a*).—Cop or Bobbin Winding Machine (*End Elevation*).

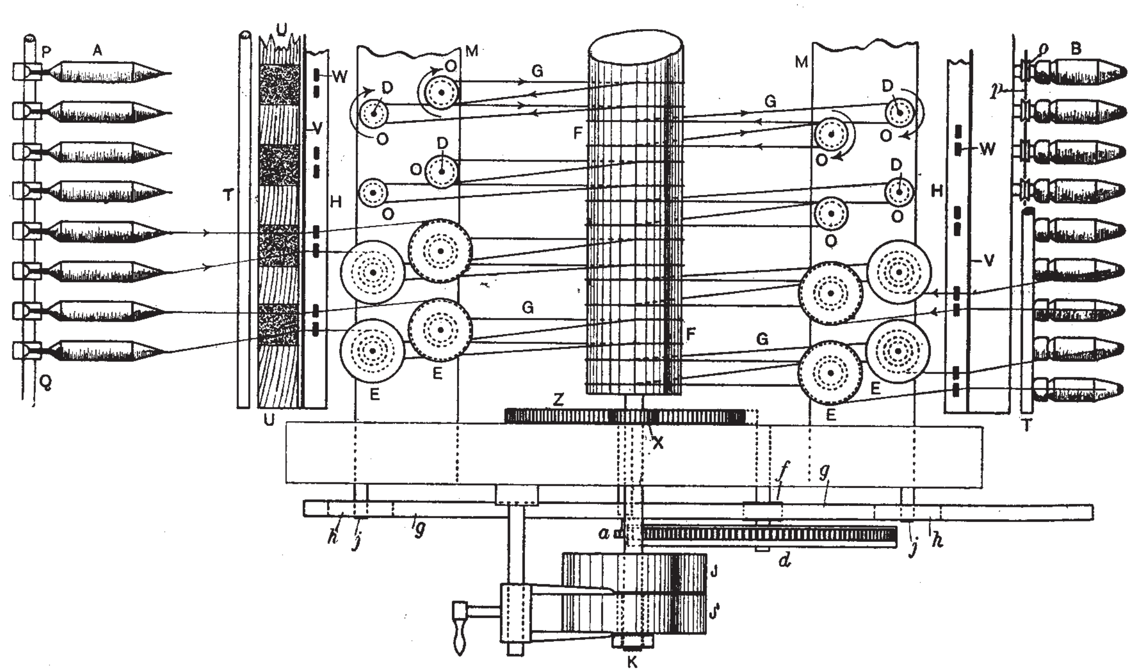

Fig. 5(*b*).—Cop or Bobbin Winding Machine (*Part Plan*).

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By requiring to be supported at two points, the adjustment and fixing of spindles of the old form are a more difficult task than that imposed in fixing Rabbeth or other form of self-contained spindles. Also, as the spindles of the former type are not self-lubricating, their bearings require to be oiled frequently; and in consequence of the bearings being exposed, they become clogged with lint and stray pieces of yarn. These circumstances necessitate the occasional oiling of spindles and the removal of oily lint and yarn from their bearings. This task not only hinders the more essential duties of the winders, but it also incurs the risk of soiling the yarn which is being wound, and of causing permanent oil-stains to occur in the woven cloth produced from it.

§ 30. The chief structural difference between the English and the American modifications is in the arrangement of the winding spindles, and also in the general form of thread guides used in each. Machines based on the English modification, as represented in Figs. 5(*a*) and 5(*b*), are constructed with *two* adjacent and parallel rows of winding spindles extending horizontally on each side of the machine from end to end; whereas those based on the American modification have only *one* row of spindles on each side, thereby affording in the respective models a relative spindle capacity of two to one.

In the English modification the two rows of spindles on the same side of the machine are disposed in such relative position as to permit of alternate threads being wound on to warpers' bobbins contained in the back row without their coming in contact with those in the front row, as indicated in the part plan of the machine, Fig. 5(*b*).

It is not, however, in the mechanical construction alone of the two models that the most important distinction exists between the English and the American practices of cop or bobbin winding. These differ more especially in the methods of directing the threads along their course, and of applying tension to them, as they pass collectively from their independent sources to their respective warper's bobbins, as described in § 87, p. 69.

§ 31. The course along which threads are directed from their source to the warpers' bobbins depends chiefly upon the particular form in which the yarn is obtained, and partly upon minor modifications in the construction of machines by different makers. The winding machine already shown is adapted to wind yarn from cops A, ring bobbins B, and hanks C, simultaneously; although it may be designed for winding yarn from any one of those forms only.

When winding yarn from cops, these are retained upon skewers that are inserted in brackets P, secured to the cop-rail Q, extending down one side or both sides of the machine. After leaving their respective cops, each thread passes separately through a wire guide-hook R; thence over what is termed the " drag," " tension," or " knee-board " S, covered with thick flannel; from which it passes over a guide-rod T. It then passes through a brush U, and a narrow vertical slit formed in a thin steel guide-plate V, which constitutes a yarn " clearer-guide "; whence it passes over an adjustable T-head screw W, mounted in the guide or traverse rail H, and then finally on to a warper's bobbin E.

As the threads pass on to their respective warpers' bobbins, the guide-rail on each side of the machine ascends and descends slowly and alternately, thereby disposing each thread with a close spiral formation along the bobbin chase, and in such a manner that they are each built up to form a series of successive and parallel layers of yarn extending exactly between the bobbin flanges.

§ 32. The guide-rails are operated by a combination of parts constituting the mechanical devices termed traverse or guide motions, of which there are numerous modifications of two distinctly different types embodying the mechanical elements of the " mangle-wheel " and the " heart-cam " respectively.

Traverse motions of each type may be designed to impart to the guide-rails either a uniform velocity or a differential velocity, according to whether they are intended to produce warpers' bobbins with straight and parallel sides, or with convex sides, to develop the barrel form of bobbins, respectively. The barrel-shape is produced by operating the guide-rails with a gradually slower velocity as they approach the centre of their traverse, and a gradually increasing velocity as they approach the bobbin flanges, thereby causing the threads to amass in greater bulk towards the centre of the bobbins, with the object of placing upon them a greater amount of yarn.

§ 33. The machine under notice is constructed with a traverse motion of the mangle-wheel type, which is designed to impart to the guide-rails a uniform speed, and thus build up the yarn to produce warpers' bobbins with parallel sides. The principal parts of this device are erected at one end of the machine, and derive their motion from a pinion-wheel X, keyed on the tin drum shaft. Through the medium of a small carrier-wheel Y, the pinion drives a large spur-wheel Z, keyed on one end of a short shaft, on the other end of which is a small pinion *a* containing only six teeth.

The carrier-wheel Y, and the spur-wheel Z, with its small pinion *a*, are all mounted on a long pendant arm *b*, fulcrumed on the tin drum shaft, on which it oscillates at intermittent periods within a prescribed space, as indicated by arrows *c*. The small pinion, *a*, revolves always in the same direction, and drives a wheel *d* of peculiar construction, termed a " mangle-wheel," in reverse directions alternately as indicated by the full-line and dotted arrows.

§ 34. This characteristic action of the mangle-wheel is effected by leaving a section of its circumference without any teeth, in order to form a gap and thereby prevent it from making a complete revolution in either direction. The teeth are also formed in such a manner that they permit of both external and internal gearing, in alternate succession, by the small pinion, which imparts to it a reciprocal rotary motion.

Thus, at each of the terminal teeth of the mangle-wheel the pinion is transferred automatically from the outside to the inside of the wheel, or *vice versa*, and thereby reverses its motion: hence the necessity to mount the carrier Y, spur-wheel Z, and pinion *a*, on an arm which is capable of a slight side-movement, as indicated.

In Fig. 5(*a*) the small pinion *a* is represented just at the moment of passing from the outside to the inside of the mangle-wheel, in which action it is assisted by a device termed a " crab " *e*, having two curved ends. This part, which is fixed to the rim of the mangle-wheel, is situated in the gap formed between the terminal teeth of that wheel, and performs the function of retaining the pinion in gear with those teeth at the moment of changing from one side of the wheel to the other.

§ 35. In conjunction with the mangle-wheel, with which it revolves, is a rack pinion-wheel *f* which gears with the teeth of a rack *g*, extending horizontally across the end of the machine. The rack is formed with teeth at each end for the purpose of gearing with two wheels *h*, which are respectively fixed on the ends of two shafts *j*, extending one on each side for the full length of the machine. On each of these shafts there are fixed at regular intervals apart a number of rack pinions *k*, which engage with the teeth of a corresponding number of vertical poker racks *l*, constituting the supports for the guide-rails and their appurtenances.

Therefore, since the mangle-wheel revolves in reverse directions alternately, the respective guide-rails are caused to ascend and descend alternately, and thereby guide the threads vertically between the flanges of their respective warpers' bobbins in the manner described in the last paragraph of § 31, p. 24. The respective guide-rails move in reverse directions at the same time. This counterpoise element has the advantage of causing a descending guide-rail to counterbalance, and thus assist in raising the ascending guide-rail, thereby requiring less motive power to drive the machine.

§ 36. The function of the knee or drag-board in a cop-winding machine is to create frictional resistance to the withdrawal of the threads during winding, and thereby subject them to such a degree of tensile strain as will ensure their breakage at all soft and weak places, and also cause the yarn to lie more compactly upon warpers' bobbins, and thus permit of threads of greater length being wound upon them.

The frictional resistance offered by the rough surface of the flannel on the drag-board disturbs and raises the ends of fibres that are exposed on or near the surface of the threads. It is then sought to remedy the evil thus wrought by immediately passing the yarn through a brush which is intended to relay the fibres to the bodies of their threads, although that object may only be effectually accomplished by the subsequent operation of sizing the yarn.

It is, however, becoming generally recognized that this crude method of imparting tension to threads during winding is detrimental to both the smoothness and also the elastic property of the yarn. Hence, the drag-board and its supplementary brush are being discarded in favour of more rational and effectual means of attaining the same objects.

§ 37. The function of the clearer-guides is an important one which, however, they do not always effectually discharge. They are constructed in a variety of different types, of which there are numerous modifications, which not only indicate the difficulty experienced in accomplishing the object for which they are employed, but also the urgent necessity which is felt for some form of " clearer-guide " that will serve adequately to " clear " from the threads, as these pass on to the warpers' bobbins, all such defects which occur during spinning and are liable either to impede subsequent operations or to produce faults in cloth. Therefore, if high quality of material and work are of primary importance, the adoption of efficient means to remove those defects cannot wisely be neglected. In §§ 62-75, pp. 47-60, on the details of cop-winding machines, several forms of clearer-guides and their substitutes are described and illustrated.

§ 38. The T-head screws W provide each thread with a separate and distinct guiding surface, or edge, which, by turning the screws, is capable of adjustment in a vertical direction, whereby the threads may be directed with precision between the flanges of their respective warpers' bobbins, and thereby prevent the formation of misshaped bobbins that would otherwise result from the yarn creeping up the side of one flange, and receding from the other flange, of a bobbin. This adjustment is sometimes necessary in order to compensate for any slight disparity in the thickness of the flanges of different warpers' bobbins, which causes them to occupy slightly different elevations on their respective spindles.

The T-head screws fit tightly into threaded holes formed in the inverted base of an iron channel-rail constituting the guide-rail H, in the recess of which there is firmly imbedded a strip of wood into which the screws enter, and in which they are adjusted by means of a special key provided for the purpose.

If the machine is without any such means for adjusting the threads separately to the bobbins, that object is sometimes effected by adjusting the bobbins to the guide-rails by placing flannel washers between the bobbin flanges and spindle washers, or by removing those washers, as required.

§ 39. In some machines that are furnished with winding spindles of the old form, as represented in Fig. 6, the vertical adjustment of warpers' bobbins to the guide-rails is obtained with greater precision by means of fine setting-screws, one of which is inserted from beneath each spindle footstep bearing as indicated in the diagram.

Rather than incur the slight inconvenience and loss of time involved by having spindles that are too high or too low, properly adjusted to the guide-rails, some winders resort to the evil practice of inverting the bobbins on their spindles when they are about half filled with yarn, and thereby counterbalance the irregularities of winding resulting from their faulty adjustment.

With a view to checking that practice, warpers' bobbins are sometimes employed, of which the bobbin flanges are painted with two different and contrasting colours, as yellow and blue respectively, and winders are instructed to place the bobbins on the winding spindles always with the same colour of flange uppermost. The object of this simple precaution is to enable the overseer readily to detect any irregularity, on the part of winders, in this direction.

§ 40. As yarn is unwound from the cops A, Figs. 5(*a*) and 5(*b*), and they diminish in length, the tension upon the threads gradually increases by reason of the greater frictional resistance which is offered to their withdrawal, in consequence of the threads coiling more frequently around, and thereby clinging more closely to, the exposed length of the cop skewers which has been laid bare by the removal of yarn. Hence, the abnormal degree of tensile strain which is thereby imparted to the threads causes them to break down before the cops are depleted sufficiently to justify the removal of the remnants as unavoidable waste.

Therefore, with the object of preventing an excessive amount of waste in cop bottoms arising from this circumstance, it is usual to furnish a small number of the winding spindles with larger wharves than those of the other spindles, and so cause them to revolve with a proportionately slower velocity. These special spindles, termed "jiggers," are disposed at intervals of about every fifth or sixth spindle in the front rows, so that each winder will have about three or four "jiggers" in a "set" of spindles.

If a winding machine is not provided with jigger spindles, or if additional jiggers are required, equally effective substitutes are sometimes improvised by driving a few of the spindles from the *shanks* of contiguous spindles, instead of from the tin drum in the usual manner.

This provision of slowly revolving spindles enables the larger cop remnants to be still further consumed by placing the skewers containing them in any convenient horizontal position that will permit of the threads being withdrawn freely from the *sides* of the cop bottoms *m*, Fig. 5(*a*), whence they are conducted through wire guide-hooks *n*, thence along the usual course on to warpers' bobbins that are placed on the slowly revolving jigger spindles.

§ 41. If the machine is adapted for winding from ring bobbins, these may be retained in position by various optional methods. Also, the threads may be withdrawn from either the nose or the side of the respective ring bobbins. In the machine described, the ring bobbins B are mounted upon spindles of the Rabbeth type, and the threads are withdrawn from the side of the bobbins, which should fit on the spindles accurately, and grip them lightly, to ensure their true and steady rotation. On leaving the ring bobbins, the threads pass over the guide-rod T; thence through the clearer-guides V, and over the T-head guide-screws W, on to their respective warpers' bobbins.

In some instances of ring bobbin winding, when yarn is withdrawn from the side instead of the nose of ring bobbins, the threads are passed between flannel washers which are closely placed on the guide-rods T. That course is adopted with the object of improving the yarn by laying down the fibres that project from the threads. The spindles containing the ring bobbins are each gripped by a wharve O to receive a tension-band or cord *p* which is passed under and over the wharves in alternate succession, as indicated in the plan Fig. 5(*b*). This band is tautened on the wharves to act as a brake upon the spindles, and thereby impart tension to the threads as they pass on to the warpers' bobbins.

§ 42. For the convenience of winders, the machine is constructed with an endless travelling strong canvas band or apron *q*, which passes down the centre of the machine from end to end for the purpose of conveying empty ring bobbins automatically to one end of the machine and there depositing them in a skip placed on the floor. The apron is extended between, and at each extremity turns around, two terminal rollers situated one at each end of the machine, and runs on a series of intermediate supporting rollers *r* and *s*. The roller at one end of the machine is covered with perforated strips of sheet iron to provide a rough surface which grips the apron. This roller is driven with a slow velocity by means of a worm mounted on the end of the tin drum shaft, and several carrier wheels, thereby causing the apron to travel at a slow pace.

§ 43. When, in order to meet occasional requirements, the machine is adapted for winding yarn from hanks C, these are openly extended around ryces or swifts *t* that are retained in brackets *u* secured to rails *v*, so that the hanks are situated well above the machine, but within easy reach of the winders. On leaving the hanks, the threads are passed under the guide-rods T; thence through the clearer-guides V; and over the T-head guide-screws W, on to their respective warpers' bobbins.

The requisite degree of tension is imparted to the threads by suspending from the hubs of the ryces variable weights *w*, which act as brakes to prevent them revolving too freely as the threads are withdrawn, thereby averting soft-wound bobbins.

In consequence of the greater space occupied by hanks than by cops or ring bobbins, the spindles in one row only, on each side of the machine, may be utilized for hank winding; whilst the spindles in the other rows would be idle, unless employed for cop or bobbin winding.

The machine is mounted on adjustable feet *x*, which afford a ready means of levelling it with precision on uneven floors, without having recourse to "packing," which, owing to vibration, is liable to work loose and become displaced. They also permit of the elevation of the machine being regulated within prescribed limits to suit the stature of the operatives. The vertical adjustment of the machine is effected by means of setting-screws *y*, furnished with lock-nuts. After setting, the feet are secured rigidly to the framing of the machine by means of nuts and bolts *z*.

TRAVERSE MOTIONS FOR COP OR BOBBIN WINDING MACHINES

§ 44. From the foregoing description of a cop or bobbin winding machine, it would not appear that the function of operating the guide-rails was one fraught with any mechanical difficulty; yet it is one to which inventors have devoted a considerable amount of attention, as witness the numerous modifications of the two types of traverse motions based respectively on the "mangle-wheel" and the "heart-cam."

Motions of either type are variously designed to impart to the guide-rails either a constant velocity to build up the yarn on the warpers' bobbins with parallel sides, or else a differential velocity to build up the yarn with convex sides. Each type of motion, and each form of warpers' bobbin, has its adherents, some of whom are unable to assign any definite or special reason for their preference.

It would appear, therefore, that since both types of motions and both forms of bobbins are still in vogue, there cannot be any essential reasons urged either in favour of or against the adoption of a well-designed and well-constructed traverse motion of either type, and of a well-formed bobbin of either shape.

§ 45. It is sometimes claimed that the heart-cam motions are of stronger build, and therefore more reliable and durable than mangle-wheel motions. But whatever particular form of traverse motion is selected it should be designed and constructed so that it will transmit motion from the tin-drum shaft to the guide-rails through the medium of as small a number of working parts as is compatible with efficiency, and also impart to the guide-rails a steady and smooth movement, quite free from jerkiness. It should also embody few parts that are liable to either excessive wear and tear, or to easily get out of order or position, and should permit of all such parts being either easily readjusted to compensate for their wear and tear, or else of being replaced with new parts, both readily and economically.

§ 46. As regards the claim that a barrel-shaped bobbin contains a relatively greater amount of yarn than one with parallel sides, there are some who claim that they can produce parallel-wound bobbins containing the same amount of yarn as those of the former shape, without increasing the tension of the threads during winding. That could only be accomplished, however, by the unwise expedient of building up the yarn beyond the rims of the bobbin flanges, thereby exposing it to the risk of being easily damaged. Albeit, the straight-wound bobbin appears to be gaining in favour with manufacturers, whilst the barrel form of bobbin is declining in favour.

The abnormal projection of yarn beyond the rims of the bobbin flanges, in some barrel-shaped bobbins, exposes it unduly and thereby renders it more liable to injury from handling and in transit. Also, if the convexity of the bobbin sides is very pronounced, the difference between the circumference at the centre and the extremities of the bobbin chase causes a slight fluctuation in the degree of tensile strain imparted to the threads, during both winding and the subsequent operation of warping.

Thus, during winding, the gradually-increasing surface velocity of the bobbins towards the centre of the bobbin chase withdraws the threads from their source at a quicker pace, and thereby imparts a gradually-increasing degree of tension upon them. And, *per contra*, by reason of the greater effort involved in withdrawing a thread from a point nearer to the bobbin axis, the tension upon the threads during warping is slightly increased as they are withdrawn from the smaller diameter towards each extremity of the bobbins.

MANGLE-WHEEL TRAVERSE MOTIONS

§ 47. A cop-winding machine constructed with a traverse motion of the mangle-wheel type which is designed to impart to the guide-rails H a differential velocity, and thereby produce barrel-shaped bobbins, is illustrated in Fig. 6, which represents an end elevation of that winding machine. In its general construction this device is similar to the traverse motion represented in Fig. 5(*a*). The only essential difference between them is in the substitution of eccentric wheels *h* on the lifting-shafts *j*, and the operation of those wheels by means of concave racks *g*, in lieu of concentric wheels operated by straight racks, as in the former motion.

Hence, as the rack moves from side to side, the teeth of the curved ends of the rack engage with those of the eccentric wheels at a constantly-varying distance from their axes, thereby driving those wheels with a quicker or a slower velocity as the racks engage with teeth that are nearer to, or farther from, the axes of the eccentric wheels respectively, thus imparting to the guide-rails H a corresponding differential velocity. The convexity of the warpers' bobbins will be more or less pronounced in proportion to the ratio of the maximum and minimum velocity of the guide-rails, as determined by the eccentricity of the axes of the rack wheels *h*.

In the device under present notice, the rack *g* is supported at each end by means of a flanged runner g^1, upon which it slides. This method of mounting the rack is far more preferable to that adopted in the traverse motion represented in Fig. 5(*a*). In that device the rack is inverted, and is supported entirely by the rack pinion *f* and the rack wheels *h*, on which it bears downward with its full weight, without any means of regulating the depth of gear

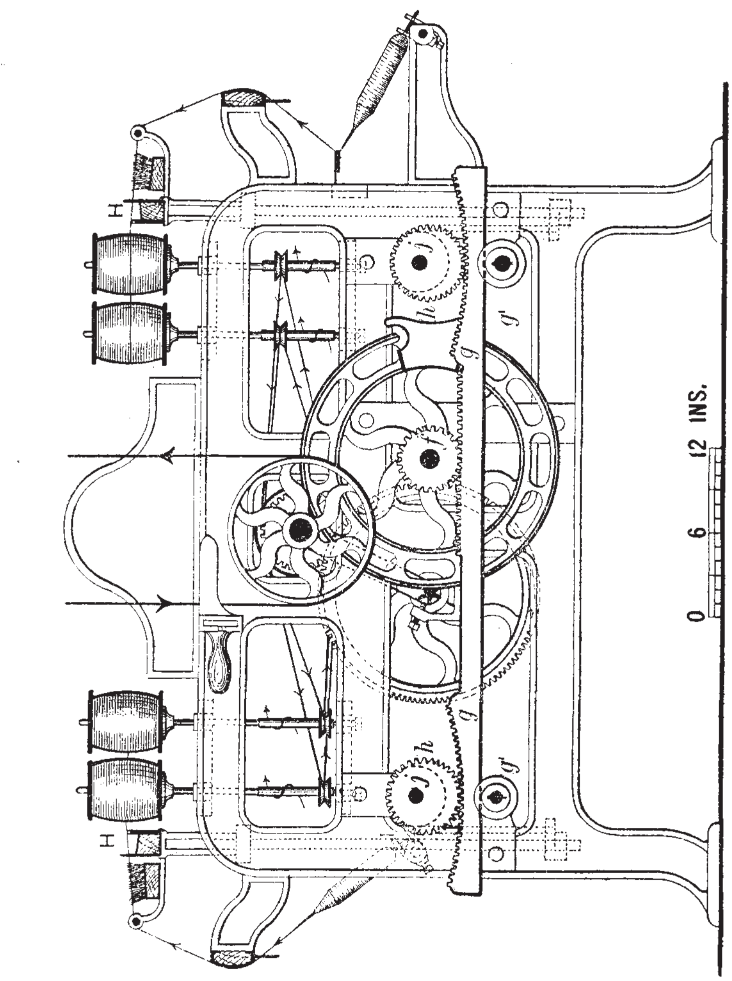


Fig. 6.

between the rack teeth and those of the wheels with which it gears. In this respect, therefore, that device is faulty in constructive design, as such a method of mounting the rack is mechanically bad owing to the tendency of the teeth to gear too deeply and become wedged.

thereby causing the traverse motion to work with a more or less jerky and irregular action, and also increasing the risk of breakages.

§ 48. Another modification of a differential traverse motion of the mangle-wheel type, in which the variable velocity of the guide-rails is effected by means of eccentric wheels, is illustrated in Fig. 7.

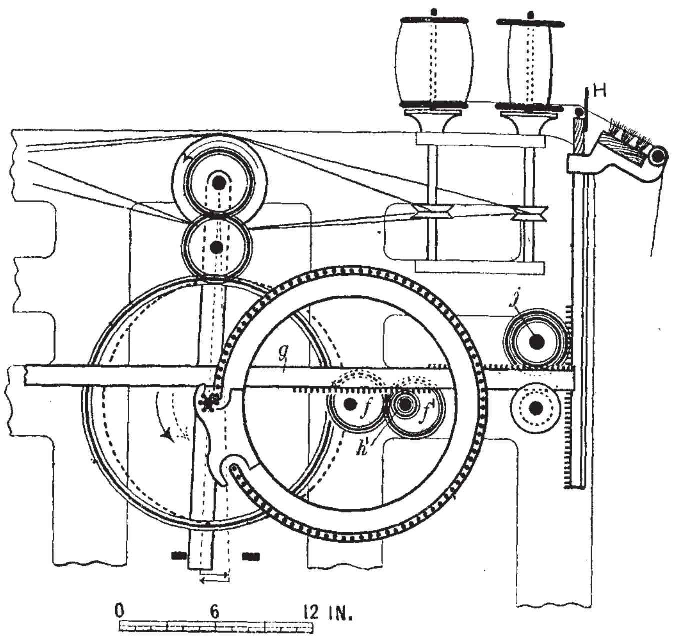


Fig. 7.

In its general construction this device is similar to the two motions described previously. The manner in which motion is transmitted from the tin-drum shaft to the mangle-wheel is also exactly similar to that which obtains in those motions. In the device shown in Fig. 6, however, the eccentric wheels *h*, on the ends of lifting-shafts *j*, are adapted to transform the uniform velocity of the horizontal side rack *g* into a differential velocity which is transmitted through the medium of chains attached to vertical poker-rods surmounted by the guide-rails H.

In the present motion, the eccentric wheels are so arranged that a differential velocity is imparted in the first instance to the horizontal side rack *g*, and thence through the usual intermediate parts to the respective guide-rails. This is effected by fixing on one end of the mangle-wheel stud an eccentric pinion *f*, which gears with a similar eccentric wheel f^1. On the same stud as the eccentric wheel f^1, and compounded with that wheel, is a small concentric pinion h^1 gearing with the lower teeth of the side rack *g*, which it operates with a lateral motion of a variable velocity; and this motion is transmitted to the guide-rails in the manner described previously. The employment of the two wheels f^1 and h^1, and the stud on which they are mounted, increases the number of working parts in this device, and therefore adds to its cost without affording any compensating advantage over that represented in Fig. 6. In fact, they only tend positively to diminish the efficiency of the device, in a manner to be explained presently.

§ 49. An inherent fault of all traverse motions constructed on the mangle-wheel principle is manifested by the mangle-wheel coming to a dead stop at the moment when the small driving pinion is passing from the outside to the inside of the rim teeth of the mangle-wheel, or *vice-versa*, in order to reverse the direction of its rotation.

For this reason, communication between the mangle-wheel and the guide-rails should be effected through the medium of the least practicable number of working parts that are liable to wear, as, by reason of the reciprocal operation of those parts, they tend still further to retard the reversing of the guide-rails at each extremity of their traverse.

§ 50. An adaptation of the mangle-wheel to a traverse motion which differs in many respects from those described previously is that shown in Fig. 8. In this device, which is designed to impart to the guide-rails a uniform velocity, the relatively high velocity of the tin-drum shaft of the winding machine is quickly transformed into a slow velocity by means of worm and worm-wheel gearing. Thus, instead of the usual tin-drum pinion driving a large spur wheel, to effect a slow velocity of the mangle-wheel pinion, that object is accomplished by means of a worm X on the end of the tin-drum shaft K, driving a worm-wheel Z keyed on the upper end of a long vertical shaft Z^1. At the lower end of this latter is fixed the small mangle-wheel pinion *a*. The mangle-wheel *d* is mounted in a horizontal position, and fixed at the lower end of a vertical stud-shaft d^1 surmounted by a pinion-wheel *f*, which gears with a carrier-wheel f^1.

At the bottom of the stud-shaft containing the carrier-wheel f^1 is fixed a rack-pinion *h*, which gears with vertical teeth formed at the side of the horizontal rack *g*, having toothed ends which gear with

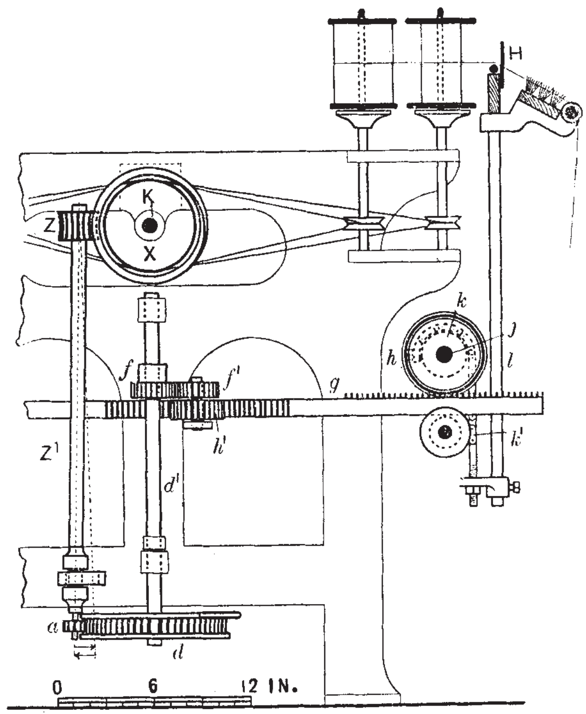


Fig. 8.

wheels *h* keyed on the ends of lifting-shafts *j*. On these shafts there are fixed, at regular intervals apart, small pulleys *k*, to the rims of which are respectively attached the ends of a corresponding number of chains k^1. The other ends of the chains are connected to brackets that are secured to the lower extremities of the poker-rods *l*, supporting the guide-rods H, which ascend and descend alternately as the chains are wound on or unwound from their respective chain pulleys by the reversing of the side lifting-shafts *j*.

With this method, it is important that the sleeve or collar brackets in which the poker-rods slide are kept well lubricated and quite free from lint or fluff; otherwise, the poker-rods are liable to stick or to slide tardily in their brackets, especially on the descent of the guide-rails, which is effected by gravitation, and therefore negatively. In this respect, poker-rods operated by chains possess an advantage over poker-racks operated by pinion wheels; for should the poker-racks, as they move in either direction, tend to stick in their brackets, the pinions on the lifting-shafts would, unless they overcame the obstruction, cause a breakage of the weaker parts of the device.

§ 51. An improvement in this traverse motion would be effected by dispensing with the two carrier-wheels f^1 and h^1, and by gearing the pinion wheel *f* directly with the side teeth of the horizontal rack. This modification would not only simplify the device and thus reduce its cost, but it would also avert the " backlash " or free play which almost inevitably and invariably exists between tooth gearing, and thereby increase its efficiency by ensuring a quicker return movement of the guide-rails at each extreme limit of their traverse. Also the outward projection of the mangle-wheel beyond the other parts constitutes an objectionable feature of this device, which could be avoided by erecting it inside instead of outside the end framing of the machine.

§ 52. It is noteworthy that the traverse motions of cop-winding machines are usually constructed to impart to the guide-rails a traverse of a prescribed and definite distance only, without any means being provided whereby the traverse may be readily adapted to suit warpers' bobbins having a different length of chase, should such a contingency arise. Therefore, a traverse motion which permits of the traverse of the guide-rails being either increased or reduced in order to adapt it to warpers' bobbins of different lengths between the flanges will, in that respect, possess an advantage over others that are not so adaptable.

§ 53. Fig. 9 shows a traverse motion of the mangle-wheel type which is designed to operate the guide-rails with a differential velocity to produce barrel-shaped warpers' bobbins without the aid of eccentric wheels. This device is also one that can be easily and quickly adapted for winding yarn on to warpers' bobbins having a different length of chase or lift. These objects are effected by means of a segment-rack lever f^1, that constitutes the distinctive element of this device which, in all other respects, is essentially similar to previous motions. The function of the segment-rack lever is to transform the reciprocal and uniform rotary motion of the mangle-

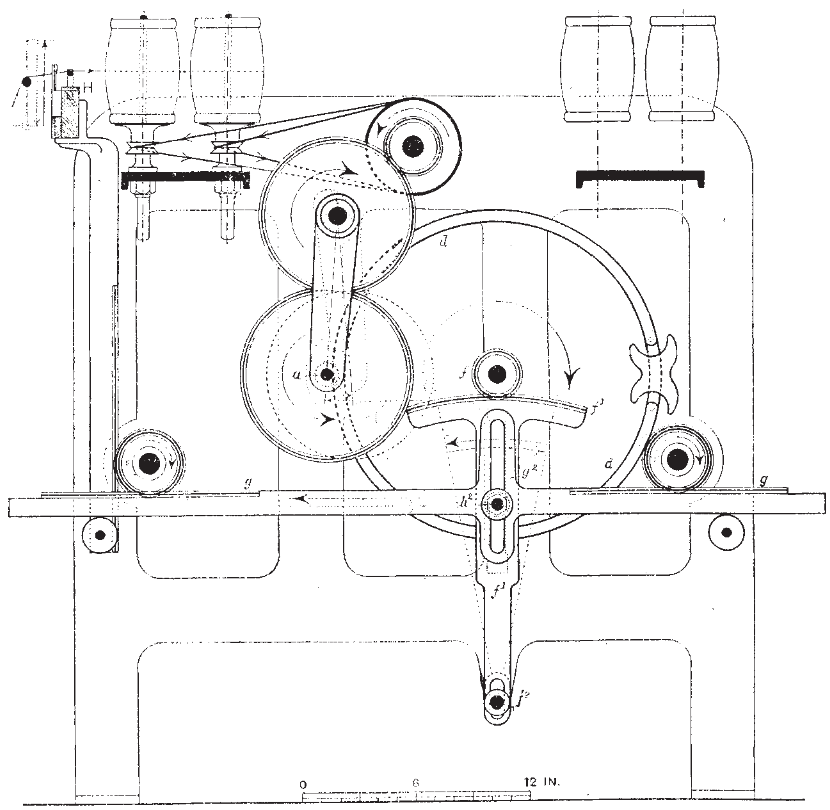


Fig. 9.

wheel *d* into a reciprocal and variable lateral motion which is imparted to the horizontal side rack *g*, whence it is transmitted to the guide-rails H in the usual manner.

This desired object is effected by gearing the rack pinion *f*, on the mangle-wheel stud, with the teeth of the segment-rack, the long vertical arm of which is fulcrumed at the bottom on a stud f^2. The vertical arm of the segment-rack is formed with a long slot, in which there freely enters a small anti-friction bowl or runner, mounted on an adjustable stud-bolt, h^2. This is secured to an arm g^2 branching vertically across the side rack, and also formed with a long slot, in which the stud-bolt carrying the runner may be adjusted vertically. As the mangle-wheel reciprocates, the rack pinion f causes the segment-rack f^1, and therefore the horizontal side rack which it operates, to oscillate with a slow velocity. Thus, by fixing the anti-friction runner at a point nearer to, or farther from, the fulcrum of the segment-rack lever, the lateral movement of the horizontal rack, and consequently the vertical movement of the guide-rails, will be proportionately less or greater respectively. The differential velocity of the horizontal rack and the guide-rails inevitably results in consequence of the segment-rack lever oscillating in the arc of a circle, whereas the anti-friction runner upon which it acts oscillates in a horizontal plane, and is therefore constantly changing its distance from the fulcrum of that lever.

HEART-CAM TRAVERSE MOTIONS

§ 54. Traverse motions of the second-named type, known as "heart-cam" motions, are characterized by the application of heart-shaped cams or tappets that are adapted in a variety of ways for the purpose of operating the guide-rails. The cams are employed as an alternative to mangle-wheels, and are usually adapted to transmit motion to the guide-rails by operating treadle-levers which communicate, by means of chains, with the side lifting-shafts, and thence, through the medium of either chains, or rack pinions and poker-racks, to the respective guide-rails.

In some cases, however, the heart-cams are adapted to operate the guide-rails through the medium of horizontal side-racks, as in all mangle-wheel traverse motions adapted for cop-winding machines. Also, like those of the last-named type, heart-cam traverse motions are variously designed to impart to the guide-rails either a uniform or a differential velocity, according to the form of warpers' bobbin required, and as determined by the shape of the heart-cam.

§ 55. One of the simplest modifications of traverse motions of the heart-cam type is that represented in Fig. 10. In this device two similar heart-shaped cams *d* are placed together in reverse positions and bolted to a large spur-wheel *b*. This, with the two cams, is mounted on a stud *c*, and through the medium of carrier-wheels Y, Z *a*, driven by a pinion X on the end of the tin-drum shaft K, the high

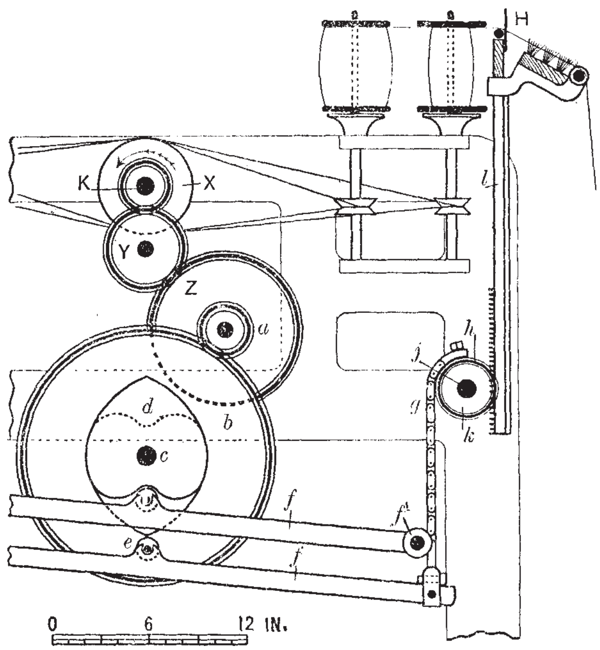


Fig. 10.

velocity of the latter being geared down in order to drive the spur-wheel and the cams with a slow uniform velocity.

The cams operate upon two independent treadle-levers *f* which pass beneath the cams, and are fulcrumed at one end upon separate studs *f*, situated at opposite sides of the machine. On each treadle-lever an anti-friction runner *e* is mounted, which bears upward constantly against the rim of its respective cam, with the object of providing a rolling surface contact with a minimum degree of friction. The free ends of the treadle-levers are connected by means of chains *g* to the rims of pulleys *h* fixed on the ends of the side lifting-shafts *j*, on which are fixed a number of rack-pinions *k* which gear with poker-racks *l*, surmounted by the guide-rails H.

Therefore, as the heart-cams revolve, they depress their respective treadle-levers in alternate succession and in a positive manner, thereby raising their respective guide-rails, which rise and fall alternately, and in a contrary manner to each other, so that one counterbalances the other. After the treadles have been depressed positively by the

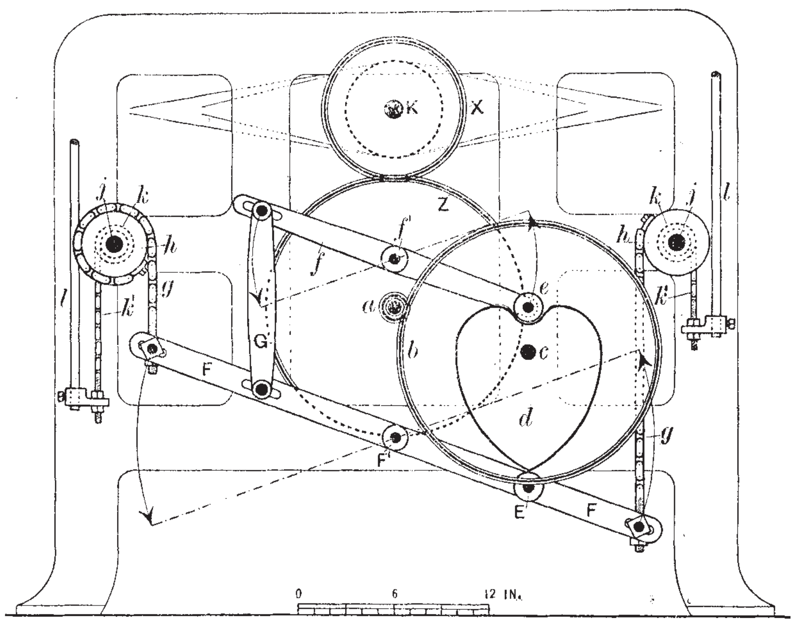


Fig. 11.

cams, their return upward movement is effected negatively by reason of the guide-rails descending by gravitation.

§ 56. A heart-cam traverse motion of different construction from the previous example is shown in Fig. 11. With this device both guide-rails are operated by only one heart-cam *d* which is bolted to a large spur-wheel *b* mounted on a stud *c* and driven by a small pinion *a* compounded with a large spur-wheel Z, geared with the driving pinion X on the end of the tin-drum shaft K. The cam operates two treadle-levers, a long one F placed below and a short one *f* placed above the cam. The lower treadle extends across the end of the machine, and is fulcrumed in the centre on a stud f^1, whilst the free ends of this treadle are connected by means of chains *g* to the rims of chain pulleys *h* fixed on one end of each of the side lifting-shafts *j*. These latter impart motion to the guide-rails H through the medium of chains *g* and poker-rods *l*.

An anti-friction runner E is mounted on the lower treadle at a point immediately underneath the cam, against the rim of which it bears constantly. The upper and shorter treadle is fulcrumed in the centre on a stud F^1 fixed in vertical alignment with the two studs on which the lower treadle and the cam are respectively mounted. On one end of the shorter treadle, which reaches over the cam, there is mounted an anti-friction runner *e*, which bears downward constantly against the rim of the cam, whilst the opposite end of this treadle communicates through the medium of a connecting link-rod G with the lower lever, both of which levers oscillate in unison as the cam revolves. Thus, as the apex of the cam descends, it depresses one end of the lower treadle by direct action upon it, and raises the opposite end; and as the apex of the cam ascends, it effects the reverse oscillation of the lower treadle by operating upon it indirectly through the medium of the upper treadle and the connecting link-rod by which the two treadles are connected.

With this contrivance the treadles are operated in both directions in a positive manner by the cam, and are not, therefore, dependent for their movement, in one direction, upon the descent of the guide-rails, which is effected by gravitation. This element affords a trifling advantage in that respect over the previous device, in which the effort of raising the treadle-levers devolves upon the descent of the guide-rails, and not upon the cams.

§ 57. Another modification of a heart-cam traverse motion is illustrated in Fig. 12. In this, as in the previous device, only one cam *d* is employed to operate both guide-rails. This is bolted to a spur-wheel *b* mounted on a stud *c* and driven from the tin-drum shaft by means of worm-wheel gearing, and thus the higher velocity of that shaft is quickly transformed into a lower velocity. On the end of the tin-drum shaft K is keyed a double-thread worm X gearing with a worm-wheel Z mounted at the upper end of an inclined shaft Z^1. Near the bottom of this shaft there is fixed another double-thread worm *a*, that gears with the cam-wheel *b*, which it drives with a slow and constant velocity.

Two bell-crank levers *f* are erected, one on each side of the cam, and fulcrumed on separate studs F[1]. At the top of the vertical arms of the treadle-levers there are mounted anti-friction runners *e* which bear constantly against the rim at opposite sides of the cam; whilst

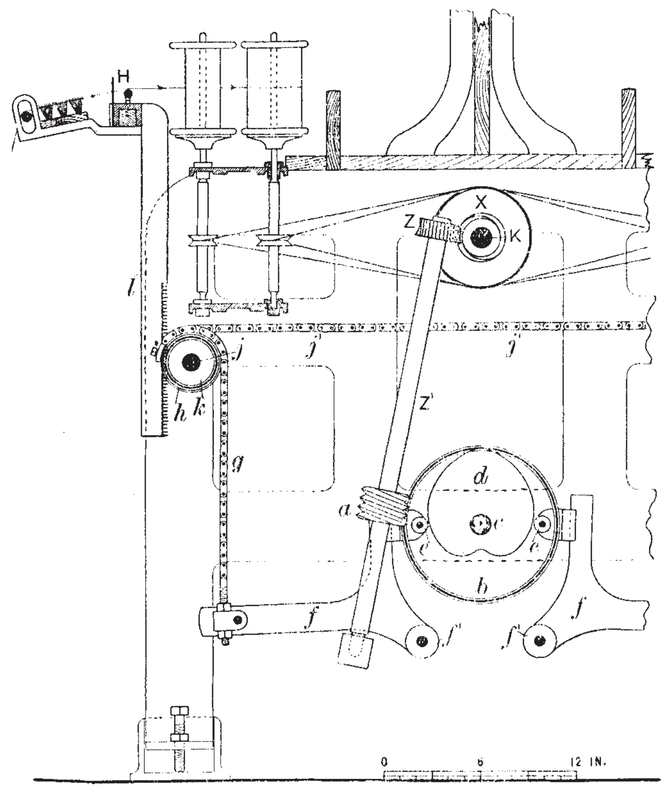


Fig. 12.

the ends of the horizontal arms of those treadles are separately connected by means of chains *g* to the respective side lifting-shafts *j*, on which are fixed a number of rack-pinions *k* gearing with poker-racks *l* surmounted by the guide-rails H. Therefore, as the cam revolves, the treadle-levers oscillate slowly, and operate the guide-rails with either a uniform or a differential velocity, according to the design of the cam. The design and greater structural stability of this traverse motion constitute an improvement upon each of the two previous examples, with their noisy and cumbrous spur-wheel gearing, and the long, slender, and clumsy treadle-levers.

§ 58. A fourth, and final, example of a heart-cam traverse motion of a distinctly different design from any of the previous devices is represented in Fig. 13. The characteristic element of this contrivance is the employment of a heart-cam *d* to impart a reciprocal movement to a horizontal side-rack *g*, thus combining two essential parts that

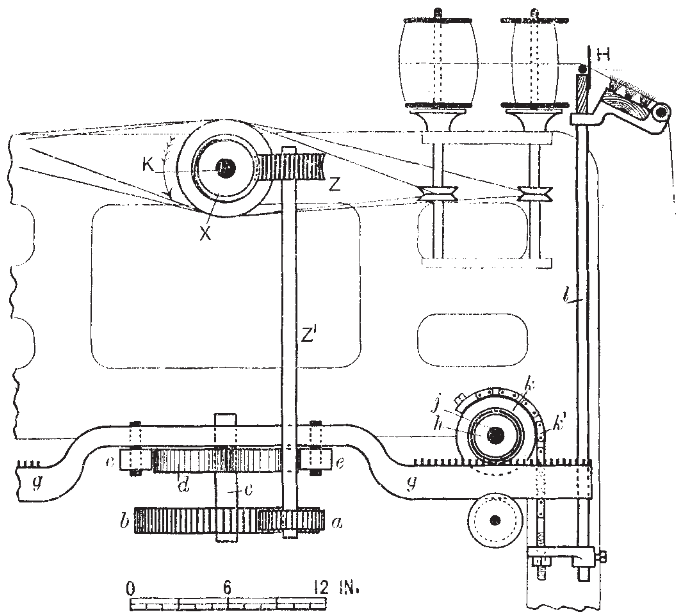


Fig. 13.

are each respectively characteristic of the two distinctive types of traverse motions.

This device is essentially identical in every respect with the mangle-wheel traverse motion shown in Fig. 8, excepting that a heart-shaped cam is substituted for a mangle-wheel. This cam operates the horizontal rack, whence motion is transmitted to the guide-rails through the medium of the side lifting-shafts communicating, by means of chains, with poker-rods surmounted by the guide-rails. The cam *d* is mounted at the top end of a vertical stud-shaft *c*, to the lower end of which is fixed a spur-wheel *b* driven by a pinion *a* keyed at the bottom end of a long vertical shaft Z^1. This is surmounted by a worm-wheel Z driven by a worm X on the end of the tin-drum shaft K.

Bearing constantly against the rim of the cam, with one on each side of it, are two anti-friction runners *e* that are mounted on separate adjustable studs situated on the under side of the horizontal rack. As the cam revolves, it bears in alternate succession against the respective runners, thereby imparting to the rack, and ultimately to the guide-rails, a slow reciprocal movement which may be either of a uniform or a differential velocity, according to the shape of the cam.

§ 59. The use of a horizontal side-rack as the medium by which motion is transmitted from the cam to the side lifting-shafts is not so commendable as the use of treadle-levers for that purpose. This is especially true of traverse motions in which the return movement of the treadles is effected in a negative manner, as in those illustrated in Figs. 10 and 12. That circumstance always ensures contact between the cam and the treadle bowls, and therefore effects an immediate return of the guide-rails at each extremity of their traverse as the treadle bowls pass the absolute meridian at the base and apex of the cam, notwithstanding the inevitable wearing of the surfaces of those and of all other working parts of the device.

With the present adaptation, however, the wearing of the treadle bowls and rim of the cam will create a certain amount of free play or " backlash " between those parts, thereby causing the guide-rails to pause momentarily before they return, after arriving at their extreme high and low altitudes. This, as explained previously in § 49, is an inherent defect of all mangle-wheel traverse motions; but in the present instance the fault may be rectified by readjusting the treadle bowls periodically.

§ 60. The foregoing examples of traverse motions represented in Figs. 5(*a*) and 6 to 13, inclusive, have been selected as representative of the chief characteristics embodied in the two types of those devices, and are not by any means exhaustive of the numerous minor modifications. As a rule, the traverse motions of cop-winding machines are erected on the outside of the end framing; but in some machines (from one of which the device shown in Fig. 9 is selected) they are erected just within the framing, as a protection against the risk of personal accidents, which are more liable to occur if the working parts are exposed.

Whatever particular modification these traverse motions assume, in each of them, the full weight of the lifting and poker chains, pokers, guide-rails, and all their appurtenances, is borne entirely by the side lifting-shafts. Hence, those shafts are subjected to torsional strain in a measure proportionate to their strength and length. With the object of either minimizing or preventing that torsion, various expedients are resorted to in the construction of these devices.

One method adopted in some machines constructed with mangle-wheel motions is to erect the horizontal rack about midway between the two ends of the machine, and extend the shaft, on which are mounted the mangle-wheel and rack pinion, to permit of the latter engaging with, and driving, the rack, which is geared with wheels fixed approximately in a central position, instead of upon the ends, of the respective side shafts.

The same object is attained in heart-cam motions by erecting the cam or cams and treadle-levers in an intermediate position between the ends of the machine, and by extending the shaft on which is mounted the pinion to drive the cam wheel, accordingly. In either of these circumstances the torsion of the side shafts is not entirely prevented by operating them from a central position. Even with that precaution they will still tend to twist slightly about their respective axes, but in reverse directions from the point at which they are actuated by either the horizontal rack or else the treadle-levers, whichever are employed, thereby reducing the torsion by about one-half.

It is a favourable circumstance, however, that the torsion of those shafts is both constant and always in one direction; otherwise the traverse of the guide-rails would be liable to vary slightly in the distance of their movement at different parts along their entire length; also, the constant reverse twisting action of the shafts would eventually fracture them.

§ 61. A much more efficient, simple, and economical method than those described, of entirely preventing the torsion of the side lifting-shafts, and one, moreover, that is applicable to modifications of traverse motions of either type, and also one that can be applied readily to existing machines, is indicated in Fig. 12. The desired object is effected by the simple expedient of connecting the two side-shafts *j* by means of several chains j^1, extending under tension between them, and with the opposite ends of the chains secured to the rims of chain pulleys that are fixed at regular intervals apart on the respective side shafts. Hence, the tendency of those shafts to twist is neutralized by their pulling against each other.

DETAILS OF COP OR BOBBIN WINDING MACHINES

Yarn Clearer-guides

§ 62. The importance of removing defects from yarn at the earliest stage of cloth manufacture has been previously emphasized in § 37, p. 26. It has also been stated in § 13, p. 11, that the operation during which those defects are best removed is that of transferring the threads from cops or ring bobbins on to warpers' bobbins by means of a cop or bobbin-winding machine.

The defects which are incidental to the production of yarn consist mainly of thin and weak places that are often caused by the absence of one of the strands of roving from which the thread is produced; thick places called "slubbings," consisting of dense masses of unattenuated fibres and untwisted roving; what are variously known as "snicks," "snarls," and "curls," that are usually present in thin and highly twisted parts of a thread; "neps," consisting of small bunches of matted and entangled short and immature fibres; small particles of seed-husks with short fibrous cotton "down" clinging to them; and small particles of bare seed-husks.

The function of clearing the yarn of these defects devolves chiefly upon the clearer-guides, which are mounted and fixed either on the front or rear of the guide-rails, and through the apertures of which the threads are directed immediately before they pass on to their respective warpers' bobbins.

§ 63. Clearer-guides comprise many varieties of forms, from the simple flat plates of thin sheet steel, in which are formed straight and vertical slits, to devices of elaborate construction. They are variously adapted for use on machines employed for (*a*) winding single threads on to warpers' bobbins; (*b*) reeling yarn into hanks;

(*c*) doubling-winding—*i.e.*, combining two or more parallel threads that are wound together and usually formed either into spools or large "cheeses" for the subsequent operation of doubling-twisting to produce ply or folded yarn.

Clearer-guides are also used on machines that perform other operations incidental to the manufacture of different varieties of warp and weft yarn, sewing cotton, and lace thread. But whatever particular form clearer-guides may assume, and for whichever type of machine they may be specially adapted, they should be designed with the primary and express object of clearing the yarn effectually of all the defects enumerated above, without disturbing the fibres, or otherwise inflicting injury to the threads. They should also be constructed and fixed in such a manner as will ensure lint and other refuse from the yarn falling clear away from them, thereby preventing the risk of such refuse accumulating about the guides and becoming re-attached to the yarn.

The gauge of the guides should be capable of being readily adjusted by the overlooker to suit threads of different diameters, and each thread should be controlled preferably by a separate and independent guide. The means of adjustment should also be such as to ensure protection against tampering by the operatives after being set by the foreman. Further, they should have hardened guiding edges and permit of the threads moving within prescribed limits as they pass over the guiding surfaces or edges of the clearers, instead of allowing them to pass continuously over or against the same fixed point of the guides; and, finally, they should be of simple construction, strong, durable, and inexpensive.

§ 64. Adjustable guides possess several advantages over those having a fixed gauge of aperture through which the threads pass. Guides of that type are usually designed so that they may be adjusted to threads of different counts, ranging from the finest to the coarsest strands. They also permit of threads of different counts being wound concurrently by the same machine with equally effective results.

The use of separate guides for each thread affords many advantages over those which control several adjacent threads concurrently. Thus, if separate guides are employed for each thread, their adjustment to the respective warpers' bobbins may be effected with greater precision; whereas if several guides or apertures are contained in one fixture extending along the guide-rail and spanning a number of winding spindles, the risk of error in adjustment increases in proportion to the number of threads controlled by that fixture. Further, if they are independent units, worn or damaged guides may be either replaced with new ones, or removed for repair, without incurring loss of production in respect of threads controlled by other guides.

If clearer-guides are constructed with hardened guiding edges, and mounted on the guide-rails in a manner that will ensure a constant changing of position, by the respective threads, along those edges, instead of restricting the threads to pass over a single fixed point of the guides—or if that object is attained by any other means—it will avert the tendency of the threads, by constant friction, to cut fine grooves into the edges of the guides. Hence, the guides will better maintain their efficiency, and also endure for a longer period.

§ 65. For the purpose of their description, clearer-guides may be classified conveniently into four distinctive types—namely: (1) Those having a fixed gauge of aperture through which the threads pass; (2) those of which the gauge of aperture is adjustable to threads of different counts or diameters; (3) those of which one fixture contains several apertures of different gauge, any one of which may be fixed in position as required; and (4) interchangeable guides, of which the aperture is formed in separate and independent steel guide-plates that are retained in fixed brackets which permit of their replacement by other guide-plates having a different gauge of aperture.

In addition to the four types of clearer-guides just enumerated, there is also in use another device, of a totally different character from any of those types, as a means of clearing defects from yarn during winding. This device, which is known as "winding-frame card" and "snarl-catcher," consists of a narrow strip of leather from the surface of which there projects a number of strong and sharply-pointed steel wire teeth, forming a kind of comb or rake, extending, in lieu of clearer-guides formed with slits, along the upper edge of the guide-rails, and between the teeth of which the threads pass on to their respective warpers' bobbins.

§ 66. The simplest and prevailing form of clearer-guides is that represented in Fig. 14, and consisting of plates of thin sheet steel in which are formed a number of vertical narrow slits through which the threads pass separately. A number of these plates, according to their length, which varies from a few inches up to 36in., are screwed optionally on either the front or the rear of the guide-rails, and control from two to fourteen threads respectively. From a point near the top of each vertical slit there are formed two short diagonal slits branching upward, one to the right and one to the left, respectively. The function of these short slits is to check such winders as may be disposed to do so, from raising, out of their guides, threads in which they perceive any imperfection to the passage of which the guides would prove an obstacle and therefore break down those threads, thereby imposing upon the winders the duty of repairing them.

Although this form of clearer-guide, which is probably the oldest, is that which at the present time is in most general use on cop and

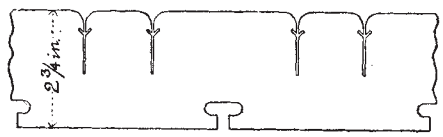


Fig. 14.

bobbin-winding machines, yet the only commendable features which it possess are simplicity and cheapness. It is incapable of adjustment to suit different counts of yarn from that for which the gauge of the slits is specially constructed; each plate constitutes a fixture controlling a number of separate threads, thereby preventing the adjustment of the guides individually to the respective warpers' bobbins; it is structurally weak, and easily damaged; also, unless special means are adopted to cause the threads constantly to change their position in a vertical direction along the guiding edges of the slits, the continual friction of the threads on the same fixed point of those edges eventually wears grooves into them.

§ 67. A further demerit inherent to this form, and all other forms of guides in which the slits are placed vertically, arises from the acute deflection of the threads against the edges of the guides, thereby causing abrasive friction, with detrimental effect upon the yarn. As winding proceeds, that evil is intensified by the constantly increasing diameter of the bobbins as they become filled with yarn, which circumstance not only causes a more acute deflection of the threads on the guide edges, and thereby increases the abrasive friction upon the yarn, but the friction is still further augmented by the gradually accelerating pace with which the bobbins, as they increase in circumference, withdraw the threads through the guides.

With the object of averting the last-named defects, and also of increasing the strength and durability of steel plate clearer-guides of the form just described, a modification introduced by J. Sutton, and shown in Fig. 15, is effected by inserting in each vertical slit a piece of hardened steel wire *a*, of which the cross-section is in the form of the letter **U**. The wire is bent also in the form of a long **U**, so that a hard, smooth, and rounded guiding edge is presented to the threads. A little reflection, however, will show that this device nullifies the

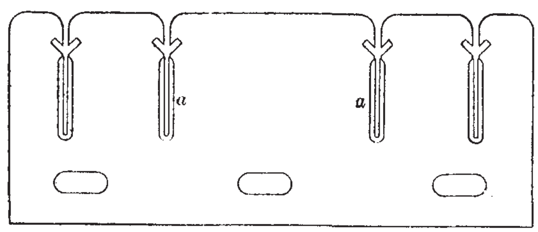


Fig. 15.

essential element of a clearer-guide, as the rounded edges make it suitable for use only as a simple means of guiding folded, gassed and other similar yarn from which the imperfections have previously been removed during the operation of doubling-winding.

§ 68. If in any form of clearer-guide the aperture through which the thread passes is vertical, the guiding edge against which the thread bears is more liable to incision than if the aperture were horizontal; for, in the latter case, the thread is free to glide horizontally as the warpers' bobbin gradually increases in diameter, and thereby constantly changes its position along the edge of the guide.

A device which is designed for use in conjunction with vertical clearer-guides, with the object of preventing their incision by the threads, is represented in Fig. 16. In this device the guide-rod T is mounted at the upper ends of a number of arms *t*, from each of which there branches a short curved arm. The ends of the shorter arms are respectively hinged to brackets *h*, fixed at regular intervals apart along the rear of the guide-rail H, whilst the lower ends of the longer arms bear against, and slide freely along, the smooth surfaces of a corresponding number of inclined bracket-rails *m*, secured to the spindle-rails M.

Hence, as the guide-rail rises and falls, the guide-rod over whic the threads pass also rises and falls in unison with it, but diagonally away from, and then towards, the guide-rail, respectively, as indicated by a dot-and-dash line. By this means the guide-rod is

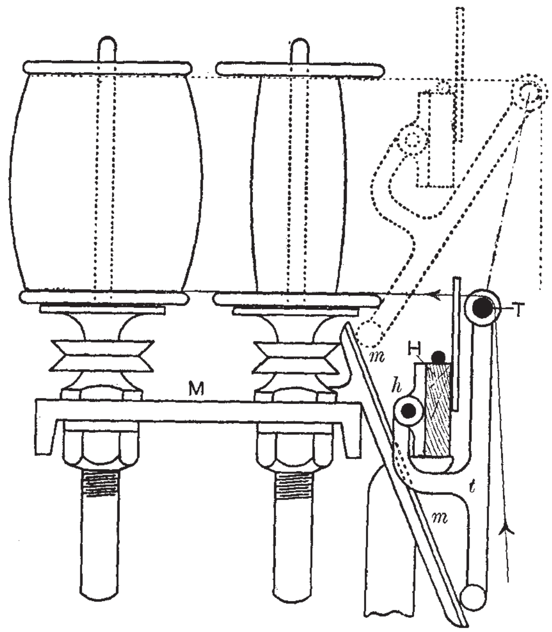


Fig. 16.

caused to move with a velocity which is slower than that of the guide-rail, whereby the abrasive action of the threads is distributed along the edges of the guides.

§ 69. An illustration of a clearer-guide of the adjustable type is given in Fig. 17, which represents a front and an end elevation at Y and Z respectively, of Suggit's guide. This form of guide is one of the earlier and better known guides of the adjustable type, and is made in short length-units, each of which controls only four threads. Each segment consists of two separate and distinct cast-iron plates

A and B, with the clearing edges ground accurately to form vertical apertures of a uniform gauge. One of the two plates, A, is fixed permanently on to the front of the guide-rail by means of two screws, the heads of which are countersunk in the plate. The second plate B, which is adjustable, is retained in position by means of a set-screw C, which binds the two plates together. The adjustment of the guide is easily and readily effected by slackening the free plate to permit of that being moved sideways in order to increase or reduce the gauge of the apertures as required, and then screwing up the set-screw firmly. The adjustment of the guides is facilitated, and greater uniformity is ensured, by inserting between the clearing edges of the two plates a standard template of a gauge suitable to the counts or diameter of the yarn to be wound.

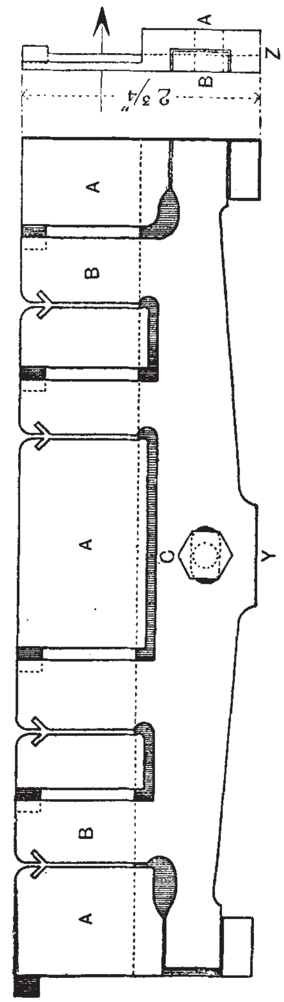


Fig 17

§ 70. Another form of an adjustable clearer-guide, in which the aperture to receive the thread is vertical, as in the previous examples, and of which a separate guide is required for each thread, is that illustrated in Fig. 18. This guide is constructed with two cast-iron plates A and B, having correctly ground and hardened clearing edges better to resist the abrasive frictional action of the threads. One of the plates, A, is fixed permanently to the front of the guide-rail, and secured to it by means of a nut and bolt, or a set-screw. The two plates are connected by means of two flat spring steel links C. These are secured to studs projecting from the rear of the plates in such a manner as to cause the base of the free plate

B to bear downward constantly against a setting-screw D, upon which that plate rests, and by means of which the gauge of the aperture between the two plates may be adjusted as required. The two spring links also ensure such a movement of the free plate that it always keeps its clearing edge quite parallel to that of the fixed plate, thereby maintaining a uniform gauge of aperture. The setting-screw D is inserted in the base of the fixed plate, for the purpose of raising or lowering the free plate, and so closing or opening the aperture between them suitably to the counts of yarn to be wound.

As a precaution against tampering with the guides after they have been adjusted by a responsible person, the heads of the setting-screws are concealed in a recess formed in the base of the fixed plate, and are only accessible by means of a special box-key for that purpose.

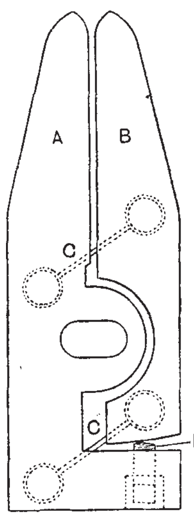


Fig. 18.

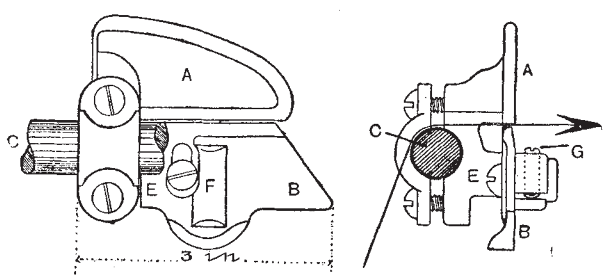


Fig. 19.

§ 71. A third example of an adjustable clearer-guide is represented in Fig. 19. This guide is one of several modifications of an American pattern known as the "Lawrence" guide, and consists essentially of two cast-iron jaws or plates A and B, placed one above the other, with ground clearing edges that lie horizontally. The upper plate A is secured to a round guide-rod C, but the lower plate B, which is adjustable, is retained loosely in position by means of a screw E. This passes freely through a short vertical slot formed in the lower plate, and screws tightly into the rear part of the fixed half of the guide. The lower plate is held up in its normal position by means of a short extended spiral spring, concealed within a small recess F, and bearing upward constantly against that plate, the upward tendency of which is checked by its impinging against two setting-screws G, by means of which the aperture between the two guide-plates is adjusted suitably to the counts of yarn to be wound.

The retaining screw E does not bind tightly against the lower plate of the guide, but it allows that plate a limited movement, on applying to it a slight downward pressure, for the purpose of separating the two plates for the removal of lint and other refuse which gathers upon them. The rod C, on which the guides are fixed by means of small clips or clamps and two screws, as indicated, surmounts the poker-racks, or else poker-rods, and combines the functions of the usual form of guide-rail and guide-rod, over which the threads pass immediately before they enter the apertures of their respective guides.

When fixing these guides in position on the guide-rod, it is expedient to place the apertures of the guides in perfect horizontal alignment with the upper surface of the guide-rod. By observing this precaution the abrasive frictional action of the threads will be borne entirely by the guide-rod; but if the apertures of the guides are situated either in a lower or a higher elevation than that just specified the clearing edges will be subjected to more excessive wear from the rubbing action of the threads upon them.

For reasons stated in § 68, p. 51, clearer-guides are less liable to incision by the threads when they are designed to operate with the apertures horizontal instead of vertical; and in this respect alone the present form of guide, and any other form in which that feature is embodied, marks a great improvement upon clearer-guides constructed with vertical apertures.

§ 72. A form of clearer-guide of another different type of construction, and one that constitutes a distinct departure from any of those described previously, is that represented by an end, a front, and a rear view at X, Y and Z respectively, in Fig. 20. The special feature of this guide is that it contains in one fixture four separate apertures of different gauges, of which any one may be brought into service as required, according to its suitability for the work it has to perform. This guide is constructed of tempered sheet steel, and consists of two chief parts A and B, each in the form of a quadrant.

One part, A, is simply a blank quadrant plate formed with a clip adapted to fit on to the guide-rod, and to grip it tightly on screwing up a milled-edge circular nut C. The other part, B, which constitutes the yarn-clearer, is a quadrant plate in which are formed the four apertures for clearing and guiding the threads during winding.

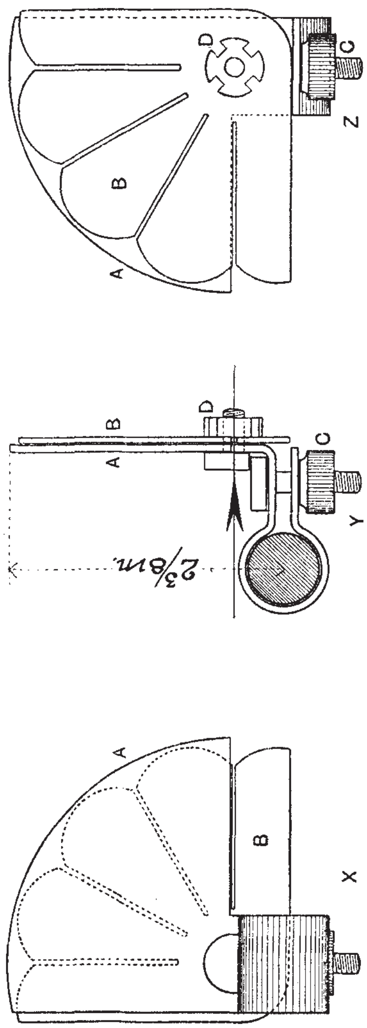
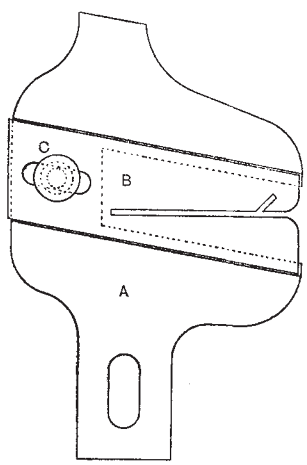


Fig. 20.

The apertures all radiate from a centre-point at which the guide plate is pivoted freely upon a short screw-stud projecting on the rear side of the fixed plate of the guide, thereby permitting of any one of the four slits being adjusted for use as required. This is accomplished by placing the aperture of the requisite gauge parallel with the horizontal edge of the blank and fixed plate. When in its proper position the guide-plate is screwed up firmly against the blank plate by means of a circular nut D, in the rim of which are formed four notches. This form of nut is employed as a precaution against the risk of winders tampering with the guides after being set by the overseer, who requires a special key for that purpose.

§ 73. An example of a fourth type of clearer-guide is shown in Fig. 21. The chief feature of this guide consists of interchangeable guide-plates that are formed with horizontal apertures of different gauges suitable for various counts of yarn, and which may be replaced as required. The guide consists of two parts—viz., a cast-iron bracket A, and a tempered steel-plate clearer-guide, which is shown in position at B, and also detached at B^1. The iron bracket is mounted in a fixed position on the front of the guide-rail; and the clearer-guide is retained in the bracket by means of a milled-head screw C, which passes freely through a short inclined slot formed in the guide-plate, and binds it up firmly against the bracket, into which the screw fits tightly. The bracket is adjustable, vertically, to permit of the guide being placed in position approximately suitable to the elevation of the warpers' bobbins. The guide-plate, which fits into a recess formed in the bracket, is inclined slightly out of the horizontal, so that by moving the guide-plate sideways, the aperture through which the thread passes, and which lies horizontally, may be adjusted correctly to the elevation of the particular warpers' bobbins which the guide serves, so as to direct the thread with precision between the bobbin flanges without distrbuing the adjustment of the bracket.



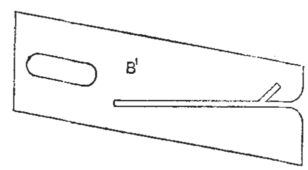


Fig. 21.

Unlike the adjustable clearer-guides described previously, the apertures of the guide-plates in this form of clearer-guide are not adjustable to different counts of yarn. That object, however, is effected by the substitution of interchangeable guide-plates having the correct gauge of apertures suitable to the counts or diameter of yarn for which they are intended. This, of course, involves the expense and care of an assortment of guide-plates, and although that circumstance may be deemed to be a disadvantage as compared with clearers that are self-contained and have adjustable apertures, the use of interchangeable guide-plates having apertures of a fixed gauge not only ensures uniform results with corresponding counts of yarn, but it also secures a certain degree of protection against the risk of being tampered with by winders who may be tempted to enlarge the gauge of the guides in order to allow the passage of faults in yarn, and thereby increase their wages at the expense of the weaver.

§ 74. Instead of employing clearer-guides for the purpose of clearing defects from yarn during the winding operation, that object is sometimes achieved by means of a device known as "winding-frame card," or "snarl-catcher," referred to previously in § 65, p. 49. Although this device differs essentially, both in form and in the manner in which it acts upon the yarn, from any type of clearer-guide constructed with an aperture, it performs the functions of both a guide to control the traverse of the threads, and also a clearer-guide to remove their defects. These objects are effected by conducting the threads through what is virtually a rake or comb consisting of a number of steel-wire teeth or pins projecting upward, with a slightly forward "set," from a long narrow strip of leather extending along the upper edge of the guide-rail for its entire length, as represented by an end view at V, Fig. 22.

The construction of winding-frame card is illustrated by a plan view drawn to a large scale, and shown detached at V^1, Fig. 22. The wire teeth are inserted in a strip of leather three-quarters of an inch wide, and of indefinite length, with the teeth arranged in pairs, in the form of staple hooks inserted from the rear side of the strip of leather, and projecting above the surface for a distance of five-sixteenths of an inch. They are arranged in six rows extending along the strip of leather and occupying a width of three-eighths of an inch, with eight teeth per inch in each row, which produces forty-eight teeth per lineal inch; but since the teeth of the second and fifth rows are in transverse alignment with each other, this form of snarl-catcher is virtually a wire comb containing forty teeth per inch set in a leather foundation, and costs only 4½d. per foot.

This device, which is placed along the upper edge of the guide-rail, with a slight inclination from the front edge of the strip of leather, is retained in position by inserting the front edge into a rebate slot, and also by placing over the rear edge small hooked clamps *a*, that are fixed at frequent intervals apart, and secured to the rear of the guide-rail H by means of tacks. Extending along the top front edge of the guide-rail, and immediately in front of the snarl-catcher, is either a steel rod or tube *b* to provide a hard and smooth surface over which to deflect the threads and direct their course between the wire teeth, on emerging from which the threads pass directly on to their respective warpers' bobbins E.

As the threads are withdrawn from their respective sources, those that are free from objectionable impediments pass without obstruction through the teeth of the snarl-catcher; but should the teeth

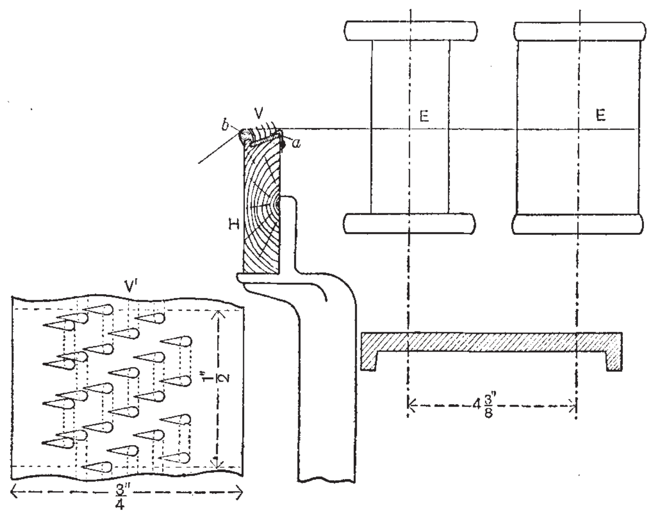


Fig. 22.

encounter any obstacles in the yarn, these latter are immediately caught by them and removed, or else their passage through the teeth is obstructed, and the defective threads break down.

§ 75. Winding-frame card, or snarl-catcher, is a crude and unscientific device, which acts upon the threads in a somewhat drastic manner; and although it serves effectually to clear from the threads, during winding, many of their defects, its adoption for that purpose cannot be wisely advocated in preference to any one of the several forms of clearer-guides described under this head, especially for yarn of fine counts and good quality of material. This device possesses many disadvantages without any compensating merit excepting that of cheapness; and even this aspect is more apparent than real, as the carding does not possess the durability of metal clearer-guides, and therefore requires to be renewed at intervals.

The refuse which is cleared from the yarn, such as snarls, neps, slubbings and loose fibres, remains clinging to the teeth of the carding, and requires to be removed by the winders to prevent it from being caught up and carried forward by the threads. This is sometimes a troublesome and difficult task, as the refuse becomes entangled amongst the wire teeth, and requires to be removed with care to avoid scratching and pricking the fingers with the sharply pointed wire teeth; and as the teeth are quite exposed, they constitute a source of danger to winders, and are liable to inflict injury to their hands and arms when reaching over to the warpers' bobbins for the purpose of recovering and piecing broken threads.

Also, in consequence of the carding being in a nearly flat position, small particles of seed, seed-husks, and lint removed from the threads, and which cannot fall clear away from the carding, remain deposited amongst the teeth, and are therefore liable to be caught up again by the threads and carried forward by them on to the warpers' bobbins.

Yarn-cleansing Devices

§ 76. In the preparation of yarn for the manufacture of some varieties of cotton fabrics of fine texture and superior quality, and also for the production of cotton lace thread, sewing cotton, crochet cotton, and other varieties of cotton yarn for special purposes, some means must be adopted for the purpose of cleansing it thoroughly of all dirt, grit, loose and short projecting fibres, lint, small particles of seed, seed-husk, and other impurities that would impair the quality and appearance of the finished product. The impurities enumerated are frequently so minute and of such a character that they cannot be removed effectually by means of clearer-guides of the types described in §§ 62 to 75, pp. 47 to 60.

The special function of clearer-guides is to detect and remove slubbings or other thick masses of unattenuated fibres, snarls and such other defects in yarn as would impede weaving and also cause faults to occur in cloth; and not to cleanse the yarn of its impurities, although they do, of course, serve that purpose in a small measure. It is necessary, therefore, to adopt some other means in addition to clearer-guides for the purpose of cleansing the yarn. This object is best effected during the operation of transferring the single strands of yarn from their primary forms of cops or ring bobbins to be wound on to either warpers' bobbins by means of a cop or bobbin winding machine, or else on to spools by means of a doubling-winding machine, if the yarn is intended for doubling-spinning to produce folded yarn.

§ 77. The cleansing of yarn at this stage is effected by means of *yarn-cleansing* devices, of which there are many different forms. Most of these devices are constructed as separate and independent pieces of mechanism, each of which operates upon only one thread, and which are readily adaptable to any of the numerous modifications of cop or bobbin-winding machines, or of doubling-winding machines.

Some winding machines, however, are designed specially to embody a yarn-cleansing device as an integral part of their construction, as exemplified in that illustrated in Fig. 23, which represents a cop-winding machine constructed with Haemig's yarn-cleansing motion, and also with two tin drums or cylinders to drive two rows of Rabbeth or other type of self-contained winding spindles on each side of the machine.

The distinctive feature of Haemig's yarn-cleansing device consists of a roller S, about 12in. in circumference, covered with a plush fabric, and extending one on each side of the machine, for the purpose of cleansing the yarn of its impurities. This object is effected by passing the threads, immediately after leaving the cops A, over and in contact with the plush surface of the rollers, which brush away the refuse from the yarn. Each roller has imparted to it a compound movement—namely: (*a*) A rotary motion with a slow velocity of about eight revolutions per minute, with the plush and yarn moving in reverse directions; and (*b*) a reciprocal side movement of 2½in., equal to the distance at which the threads are disposed on the rollers.

The compound motion of the rollers prevents the threads from running continuously on the same part of the roller surfaces, and thereby ensures the abrasive action of the threads being distributed uniformly over the entire surface of the plush fabric. These cleansing rollers are driven from one of the two tin drums, which transmit motion to the rollers by means of simple belt and rope driving, whereby the velocity of the tin drum is reduced from about 190 to about eight revolutions of the rollers per minute.

Thus, a small pulley X, fixed on one end of the shaft of the tin

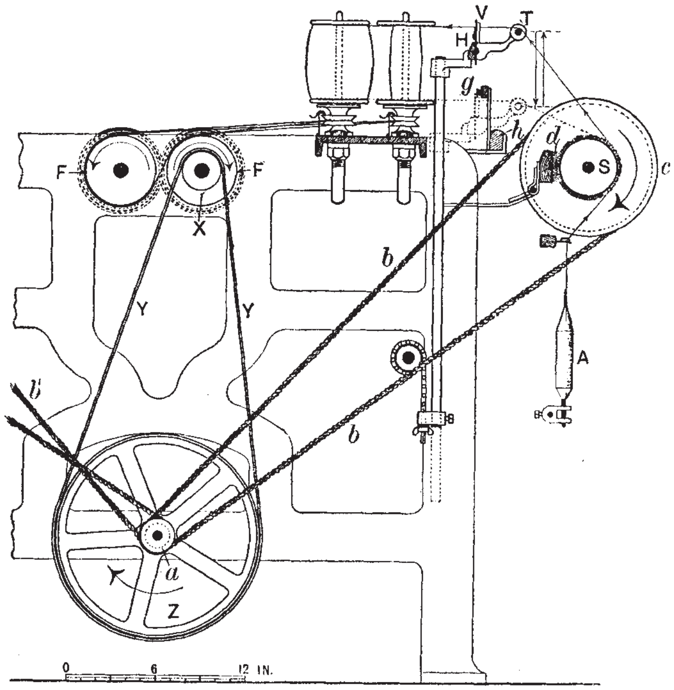


Fig. 23.—Haemig's Yarn-cleansing Device

roller F, drives, by means of a belt Y, a large intermediate carrier pulley Z, with which are compounded two small rope pulleys *a*, and these transmit motion by means of ropes *b*, b^1, to two rope pulleys *c*, fixed on the respective shafts of the plush-covered rollers, at the "off-end" of the machine. The refuse which gathers upon the plush rollers is stripped off continuously and automatically by means of narrow strips of fine wire card-filleting *d*, extending immediately behind the rollers, and adjusted so that the wire teeth of the filleting penetrate just below the surface of the plush. The card-filleting is cut into short lengths of about 36in., and mounted upon separate strips of wood that are freely hinged on brackets to enable them to be easily pushed backward out of contact with the plush rollers, so that the winders may remove the refuse from the filleting at frequent intervals without stopping the machine for that purpose.

§ 78. On leaving the plush cleansing rollers the threads are conducted immediately over the guide-rod T, and thence through clearer-guides V, that are mounted on the front of a flat-iron bar H, which constitutes the guide-rail. The clearer-guides employed on this machine are of a special form, as represented on a larger scale in the detached inset drawing, which shows a front view and a plan of the clearer. The main part of the clearer-guides is in the usual form of a thin plate of sheet steel, in which are formed vertical apertures to direct the threads on to their respective warpers' bobbins.

In the present form of guide, however, a modification is effected by fixing on the front of the guide-plate, and at each aperture, two narrow strips of sheet metal *e*, which extend one on each side of the apertures to form lips that project forward, with the edges of the lips slightly curved outward in order to present a smooth and rounded guiding-edge to the threads. The effect of the metal lips, however, as with the form of guide represented previously in Fig. 15, is to reduce the efficiency of the guide as a yarn-clearer for the purpose of detecting and removing slubbings and other thick places in yarn.

In addition to the metal lips, the guide-plate is furnished with a number of curved metal arms or guides *f*, that are mounted adjustably on pivots at the rear of the guide-plate, with a guide extending horizontally across each aperture. The threads pass over and bear lightly against the upper edge of these guides, which may be adjusted separately, so as to direct the threads with precision between the flanges of the warpers' bobbins without the necessity of adjusting the spindles or bobbins to the guides.

The machine is also provided with means for automatically clearing away from the guides any lint or other refuse which gathers about them. This object is effected by means of narrow strips of brushes *g*, that are fixed permanently in such position as to sweep the entire front surface of the guide-plates whenever the guide-rail moves within the lower half of its traverse. The brushes are mounted in short sectional lengths, coinciding exactly with the disposition of the threads through the apertures of the guide-plates, and are screwed at the top of vertical supports that are secured to a fixed wooden rail *h*, extending for the full length of the machine.

The refuse is also cleared automatically from the small brushes by means of the guide-plates during each downward movement of the guide-rail. Thus, the bottom edge of the guide-plates is serrated with sharply-pointed teeth, like those of a saw, to form a kind of rake or comb, as shown in Fig. 23(*a*). Hence, the teeth encounter the brushes as the guide-rail descends, and thereby comb away their refuse, which falls on to a tray or else on to the floor.

§ 79. Another form of a yarn-cleansing device, and one that is readily applicable to any modification of reeling or winding machine,

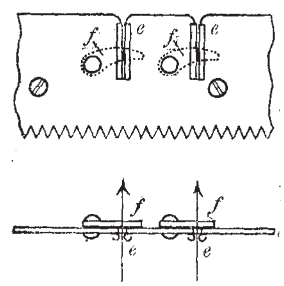


Fig. 23(*a*).

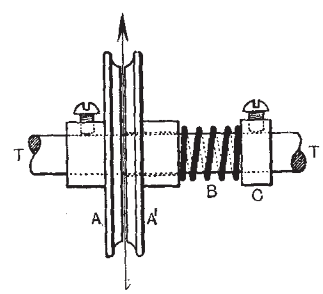


Fig. 24.

is that illustrated in Fig. 24. This yarn-cleanser is a small device of simple construction, consisting of two similar circular steel discs A, A^1, each formed with a perfectly smooth surface on the inside, and a collar on the outside of the discs. The two discs are mounted on the guide-rod T, with their smooth surfaces in contact with each other and in alignment with the apertures of the clearer-guides. A separate device is required for each thread, which is passed between the discs for the purpose of cleansing the yarn, and thence through the apertures of the guides, by which they are directed on to their respective warpers' bobbins. One of the discs, A, is fixed in position on the guide-rod by means of a set-screw, whilst the complementary disc A^1 is mounted quite freely upon the guide-rod, and retained in position by means of an open spiral spring B, inserted between the free disc and an adjustable collar C, by which the pressure of the spring upon the free disc may be regulated suitably to the counts and character of yarn being wound.

Driving Drums and Winding Spindles

§ 80. In § 27, p. 20, it was stated that some cop or bobbin winding machines are constructed with only one tin driving drum, and others with two tin drums for driving the spindles. A comparison was also made, in § 29, p. 22, of the relative merits of the old form of winding spindles and those of the Rabbeth or self-contained type. Machines that are furnished with winding spindles of the old form are constructed with only one tin drum, whilst those with Rabbeth spindles are variously constructed with either one tin drum, or with two tin drums, as represented in Figs. 5(*a*), 5(*b*) and 23, respectively.

In any case, if the machine is constructed on the English modification, with a double row of spindles on each side, and with these set to a gauge of 5 inches apart in each single row, it is the modern practice of machine makers to construct the tin drums in sectional lengths of about 5ft. each, to drive 24 spindles on each side. By this method, the tin drums are connected by means of short shafts that are supported in bearings at corresponding intervals, to prevent the " sagging " which exists in longer drums, thereby reducing the risk of their breaking apart, and also ensuring a much steadier rotation of the drums. Also, in the event of a section of the drum being damaged so that it requires to be repaired or replaced with a new section, it may be removed, and a bar substituted in its place, to complete the connection, and the machine may thus continue working temporarily with only 48 spindles idle, until the repair is effected.

§ 81. In some machines the spindle wharves are fixed uniformly in the same relative position on the spindles on both sides of the machine, with the grooves of the wharves in the same horizontal plane as the axis of the tin drum shaft, as shown in some of the diagrams given previously. In other machines the wharves on the spindles on one side of the machine are fixed with the grooves in a higher elevation than the axis of the drum shaft, whilst those on the spindles on the other side are fixed with the grooves at a correspondingly lower elevation. In these circumstances the tin drum should revolve in such direction that the portion of the driving bands having the least deviation from the horizontal (that is, the negative or slack side) will pass *from* the drum on to the spindle wharve, and thereby reduce the risk of those bands slipping off the wharves.

As regards the relative merits of these two alternative practices of fixing the wharves in different positions on the spindles, it cannot be demonstrated that one method possesses any essential advantage over the other.

§ 82. If a machine with only one tin driving drum is furnished with Rabbeth spindles that are each driven by a separate band, the spindles are always adjusted with the grooves of the wharves in the same horizontal plane as the axis of the tin drum shaft. But if the machine is constructed on the American modification, with a single tin drum and only one row of winding spindles on each side, these are adjusted with the grooves of the wharves at a little higher elevation than the upper surface of the tin drum; and two spindles, one on each side of the machine and nearly opposite each other, are driven by the same band, as represented in Fig. 25, which shows an end view and a plan view of this method of driving the spindles.

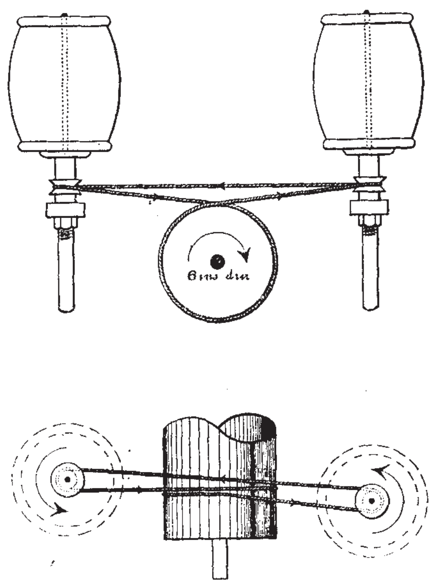


Fig. 25.

By driving two spindles by the same band, the consumption of spindle banding per spindle is slightly reduced. Also, by completely encircling the surface of the tin drum, instead of running on only half of the surface, as in some machines, the driving bands obtain a firmer grip of the drum, and thereby acquire better and steadier driving power, although this is in some measure counterbalanced by the bands each driving two spindles instead of one. A trifling disadvantage of this system is that it involves a stoppage of two spindles, instead of one by the usual method, when replacing a driving band.

§ 83. In winding machines constructed with two tin driving drums and furnished with Rabbeth spindles, as exemplified in Fig. 23, the spindles are likewise adjusted with the wharves in a higher plane than the upper surfaces of the respective drums. By this method, however, the spindles are each driven independently by means of separate bands. The spindles on one side of the machine are driven from the tin drum on the opposite side, thereby requiring the bands to pass around one drum, and then over the top of the second drum, and on to their respective wharves, as indicated in the diagram.

The driving pulley by which the machine is operated is fixed on one end of the tin drum shaft F, on the opposite end of which is fixed a spur wheel, which gears with a similar wheel fixed on the shaft of the second tin drum F^1, which is, therefore, driven positively and in a reverse direction to that of the first drum, as indicated by arrows. By this method of driving the spindles, the bands run on to one tin drum for about three-quarters of its circumference, and then a portion of each of the respective bands bears against about one-quarter of the circumference of the second drum, thereby acquiring additional driving power, and enabling the spindles to be driven with a higher velocity to increase the production.

Methods of Applying Tension upon Yarn during Winding

§ 84. Various means are employed for the purpose of submitting yarn, during the operation of winding, to a certain degree of tensile strain. This is done with the primary object of eliminating from the threads all thin and weak places that are unable to bear the strain and would therefore be liable to break down under the tension imposed upon them during subsequent operations, especially during weaving, thereby causing faults to occur in cloth. The tension is also necessary to ensure that the threads will lie compactly, and thus produce firmly wound warpers' bobbins.

Whatever particular form a tension device may assume, it should attain those objects without creating either excessive abrasive friction or tensile strain upon the threads. Abrasive friction acts detrimentally upon the quality of the yarn, and tends to weaken it by dislodging the fibres of which the threads are composed. Also an abnormal degree of tension deprives the threads of one of their most valuable elements—that of elasticity, which is so essential to good weaving. On the other hand, if yarn is wound with a subnormal degree of tension, it does not lie compactly, thereby producing soft-wound bobbins, which not only incur excessive waste, but they also greatly impede the progress of winding and warping, and tend to produce faulty warps.

§ 85. When a thread breaks on a soft-wound bobbin it is liable to cut deeply into the soft layers of yarn, and thus become imbedded and lost, instead of lying freely exposed on the surface. The attendant will then endeavour to recover the lost thread by scratching along the surface of yarn. This sometimes causes the broken thread to reappear several coils or wraps out of its proper place, and thus create the evil known as " lapped ends."

In order to recover the severed end of a broken thread it is frequently nceessary to break the thread in another place, and then unwind it from the bobbin until the broken end reappears on the surface. But rather than incur the loss of time and wages in recovering and piecing the proper end of a broken thread, some unscrupulous winders resort to the objectionable practice of breaking the thread in another place on the warpers' bobbin to obtain a free end for piecing up; or else they will resume winding on the faulty bobbin without piecing the thread, and thus leave the task of recovering the lost thread to be encountered subsequently by the unfortunate warper. With the object of checking this pernicious practice, and also of detecting those winders who are guilty of it, the custom is adopted in some mills of assigning to winders an identification number which they are required to inscribe in chalk upon the flanges of warpers' bobbins as these become filled with yarn and are removed from the winding spindles in their respective " sets."

§ 86. The oldest and still prevailing method of applying tension upon yarn during winding is that of passing the threads over the surface of rough flannel cloth mounted on a board variously termed the " knee," " drag," and " tension board." The object of this simple device is to induce frictional resistance to the withdrawal of the threads from their source, and thereby subject them to such a degree of tensile strain as will cause them to break down at the weak places.

If yarn is submitted to a greater degree of tension than is necessary to attain that object, its quality will be impaired by the excessive abrasive friction against the rough surface of flannel, and also by the loss of elasticity due to straining the threads. The degree of tensile strain that may be safely applied to threads during winding will, of course, depend chiefly upon the counts of yarn and the quality of staple from which it is spun, and should, therefore, be regulated accordingly.

Tension-boards are situated optionally in different relative positions by different makers, and are usually fixed permanently in their position with the flannel surface placed at any angle between the vertical and horizontal, without any means of adjusting it to regulate the tension upon the threads. In some machines, however, this requirement is provided for by mounting the tension-boards on hinges, so that the angle of their inclination may be varied in order to increase or diminish the frictional resistance of the threads, and thereby regulate the degree of tension upon them suitably to the counts and strength of yarn being wound. Some tension-boards are mounted in such a manner that, when being adjusted, they swivel on one edge; whilst some are mounted at the ends of short arms that are fulcrumed on brackets, and therefore move bodily in the arc of a circle concentric to the fulcrum. But whichever of these alternative methods is adopted, the ultimate results are practically alike.

An example of the first method of mounting tension-boards is represented in Fig. 26, which shows the lower edge of the tension-board S hinged freely in brackets, and reclining with the rear surface of the board resting against setting-screws *t*, by which the angle of its inclination may be adjusted within prescribed limits.

§ 87. Instead of employing flannel-covered tension-boards for the purpose of applying tension upon yarn during cop or bobbin winding, a more rational and efficient method of attaining that object is represented in Fig. 27, which illustrates a yarn tension device of American invention. This device consists essentially of two stationary glazed porcelain tension-bowls S, S^1, that are mounted on small screw-studs fixed about 3in. apart, and projecting at right angles from the ends of two short arms bolted adjustably to a bracket.

After leaving their respective cops A, each thread is conducted through a guide R, and is then passed over the top of tension-bowl S, and underneath bowl S^1, with the thread either crossed between the two bowls, as shown, or else parallel. The thread may then be conducted a second time over the upper tension-bowl S, as indicated, thence over the guide-rod C, and through the

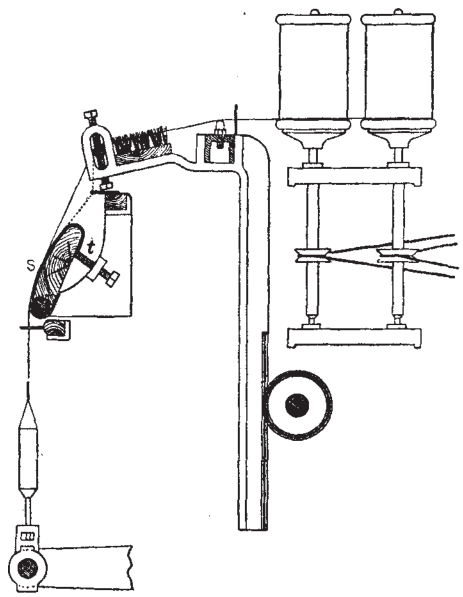


Fig. 26.

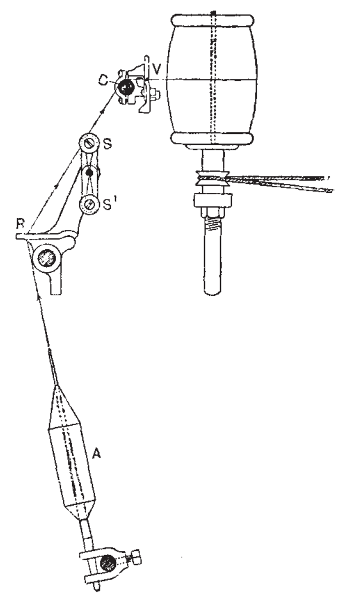


Fig. 27.

clearer-guide V on to the warpers' bobbin; or it may be passed immediately from the lower tension-bowl S^1 to the guide-rod, according to the degree of tensile strain it is desired to apply to the thread.

By varying the positions of the tension-bowls, and also by passing the threads backward and forward between them for a greater or lesser number of times, the degree of tension upon the yarn may be regulated as required. The advantage of passing the threads over glazed porcelain bowls in lieu of a rough flannel surface is that tensile strain upon the threads is obtained without creating abrasive friction, which acts injuriously upon them.

§ 88. The problem of applying tensile strain upon yarn is greater when unwinding threads from ring bobbins than it is with cop winding; and this accounts for the greater number of different forms of devices to attain that object in respect of ring-spun and throstle-spun yarn. The reasons for this will be manifest when the difference between the construction of a mule cop and that of a ring bobbin is considered in conjunction with the different characteristics which exist between mule-spun and ring-spun yarn; and also in view of the circumstance that, with exceptional instances, a thread may be withdrawn optionally from either the tip or nose end, or from the side of a ring and a throstle bobbin.

§ 89. Ring and throstle yarn is usually stronger and more springy than mule yarn of corresponding staple and counts, and is therefore usually submitted to a greater degree of tensile strain than may be applied with safety to mule yarn during winding. Also, by reason of the much larger girth of a ring bobbin than that of a cop skewer, a thread unwinds from the end of a ring bobbin much more freely than it does from a cop contained on a skewer, around which the thread coils and clings closely as it is withdrawn, thereby retarding its delivery. If, however, threads are withdrawn from the sides of tapered ring bobbins, these are usually mounted separately upon free Rabbeth spindles, so that the effort required to turn the bobbins and spindles alone serves to put a certain amount of tension upon the threads.

§ 90. The usual method of mounting ring bobbins to unwind from the side of the bobbin is illustrated in Figs. 5(*a*) and 5(*b*), and briefly described in connection with those figures in § 41, p. 29. A modification of that arrangement is represented in Fig. 28, which shows the ring bobbins, B, mounted on free Rabbeth spindles secured to a rail. The spindles are each furnished with a wharve O, so that a tension-band may be passed under and over the spindle wharves in alternate succession, and tautened upon them, to retard their velocity sufficiently to produce the required degree of tension upon the threads. On leaving their respective ring bobbins, the threads are conducted over a guide-rod T, on which are contained a number of closely-placed flannel washers U which serve the function of yarn-cleansers, whence the threads are directed through the clearer-guides V, and on to their respective warpers' bobbins.

When this method of unwinding yarn is adopted, it is of the utmost importance that the ring bobbins and Rabbeth spindles should fit each other exactly, and that the bobbins should grip the spindles firmly, so that both will revolve together steadily; otherwise, the bobbins are liable to be jerked off their spindles during winding, especially when they are nearly depleted of yarn, and therefore lighter in weight, and the threads are also being withdrawn from them at a point nearer the bases of the bobbins. Also, if the bobbins are too loose on the spindles, they will slip upon them instead of both revolving together. Hence, the bobbins will revolve with a more or less eccentric and jerky movement, which causes a rattling noise, and also wears the bobbins on the inside, so that they eventually become too slack for the spindles of the ring-spinning frame, and have to be discarded.

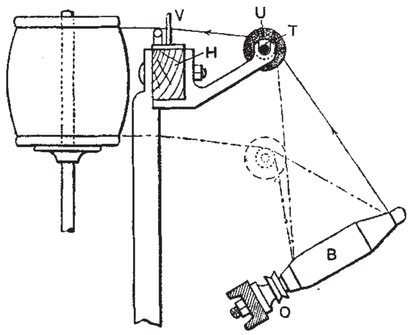


Fig. 28.

§ 91. A defect which is inherent to the foregoing method of unwinding threads from the usual form of tapered or cop-built ring bobbins, and one which constitutes its greatest objection, proceeds from the circumstance that a thread is withdrawn from the bobbin at a point on the periphery which is constantly receding from, and approaching, alternately, the axis of the spindle, as successive coils of yarn are unwound, consequent upon the conical formation with which the thread is built upon the bobbin. This has the effect of producing upon the thread a constantly varying degree of tension, which gradually increases as the point of withdrawal approaches the minor diameter of the bobbin cone and the axis of the spindle and then gradually decreases as the point of withdrawal approaches the major diameter of the cone and recedes from the axis of the spindle.

The variation of the tension upon yarn is also slightly intensified by the constantly changing position of the guide-rod T in relation to the ring bobbins, and also of the point at which a thread is withdrawn from the bobbin as this is gradually depleted of yarn. These combined factors cause the threads to be withdrawn at different angles, varying from 90° to 60°, to the axes of the spindles, according to the relative positions of the guide-rod and the point of withdrawal of the threads, as indicated by dotted lines in the diagram, Fig. 28.

§ 92. With the object of removing the unfavourable elements of the previous arrangement, that represented in Fig. 29 is adapted to unwind the threads from the ends of ring bobbins, which always maintain the same relative position to all other parts incidental to this device, thereby obtaining a much greater uniformity of tensile strain upon the threads during winding, compatible with the constantly increasing pace with which the threads are withdrawn as the warpers' bobbins gradually increase in girth.

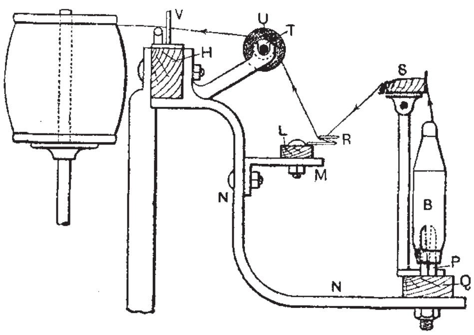


Fig. 29.

In the present arrangement the ring bobbins B are placed in an upright position and mounted on split wooden pegs P, fixed on a rail Q. The threads are conducted from the ring bobbins and passed immediately over a flannel-covered tension-board S, which is mounted on hinges so that it may be adjusted to regulate the tension upon the threads. On leaving the tension-board, the threads are passed separately through wire guides R, secured to a rail L, mounted on brackets M, that are bolted to long curved arms, N, on which they are adjustable to permit of the wire guides R being fixed in a higher or a lower elevation in relation to other parts, for the purpose of still further reducing or increasing the tension upon the threads respectively. From the wire guides the threads are conducted over the guide-rod T containing the flannel-washer yarn-cleansers U, thence through the clearer-guides V, and finally on to the warpers' bobbins.

The special object of this device is attained by mounting the ring bobbins, tension-board and wire guides on to the long bracket arms N, and bolting these, along with the brackets supporting the guide-rod T, to the guide-rail H, so that all these parts rise and fall together, and thereby maintain the same relative position to each other.

§ 93. An ingenious and more efficient device than either of those described previously, and one which is designed for mounting ring bobbins to unwind the yarn from the side, is that represented in Fig. 30. This form of ring-bobbin holder consists of a bracket fixture P secured to a rod Q, on which it may be adjusted to any suitable inclination. In the upturned rear end of the bracket there is mounted a free spindle, which is furnished with a wharve O, and may be constructed with either a short or a long spindle shank on which a ring bobbin B is mounted with its lower end abutting against the spindle wharve. The bobbin is retained on the spindle by means of a hollow retaining cup L (shown in section), which spans and lightly grips the bobbin nose, against which it bears with a slight pressure.

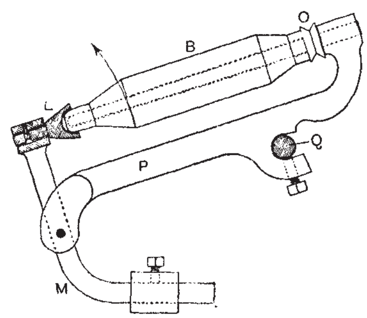


Fig. 30.

A short stud projects from the base of the retaining cup, and is inserted freely in a bearing formed at the end of the vertical arm of an L-lever M, which is fulcrumed freely on a pin fixed in the forward and forked end of the bracket fixture. The horizontal arm of the L-lever is furnished with a small adjustable weight N, by which the pressure exerted by the cup against the bobbin nose may be regulated. This will, in a small measure, affect the degree of tension upon the thread; but that is chiefly determined by the friction of the tension-band upon the spindle wharves. This device does not, however, prevent the constantly varying degree of tensile strain to which the thread is subjected in consequence of the conical formation with which it is built upon the ring bobbin.

§ 94. In some ring-spinning frames the threads are wound upon paper tubes with straight and parallel sides, on which each thread is coiled in a series of successive and parallel layers extending along the entire chase of the tube, thereby necessitating the withdrawal of the thread from the side when unwinding it. These tubes are variously described as "parallel-wound" and "roving-built" ring tubes or spools, from their analogy to the principle on which "roving" is built upon a bobbin tube, and also in order to distinguish them from the prevailing standard type of "cop-built" or "taper-built" ring bobbins.

An American form of spool-holder designed for unwinding from the side of roving-built ring spools is represented in Fig. 31. This device consists of a bracket fixture P secured adjustably to a bar, and on which is mounted a hollow and highly polished metal cradle or bedplate L, on which a ring spool simply rests by its own weight during winding. From the hollow crown of the bracket there are freely suspended two coppered tension or drag wires M, which hang one on each side of the spool, and against which they bear lightly.

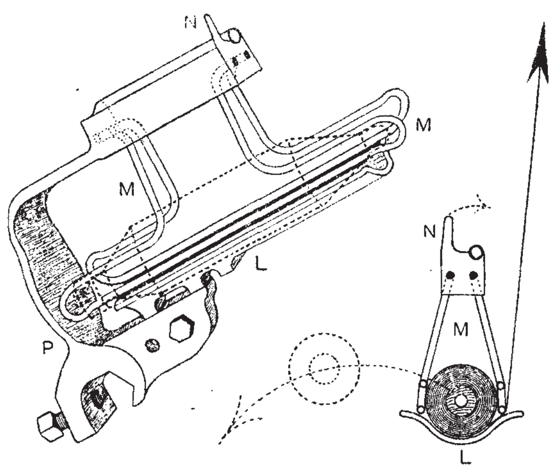


Fig. 31.

These tension-wires serve the twofold function of retaining the spool in the cradle as the spool revolves, and also of applying tension upon the thread as it is withdrawn. This object is attained by passing the thread entirely underneath the tension-wire on that side of the spool from which the thread emerges, when it is withdrawn from the *bottom* side of the tube, which is in contact with the bed-plate, as indicated in the detached diagram, which represents a front sectional view of this method of unwinding yarn.

When a depleted ring spool requires to be replaced by a full one, the former is quickly ejected from the cradle by moving a finger N (projecting from the front of the hollow crown of the bracket) slightly to the right, as indicated by the short arrow. This causes the spent tube to fall out on the left of the cradle, as indicated by dotted lines, and to slide down a chute on to a travelling lattice or apron, by which it is carried automatically to one end of the winding frame and dropped into a skip.

§ 95. As regards the relative merits of unwinding threads from the ends or sides of ring bobbins, there is diversity of opinion amongst practical men, according to personal experience; and since both practices are adopted extensively it would appear that no vital objection has been discovered in either of them, and that each method will yield satisfactory results under equally favourable conditions.

It should be observed, however, in this connection that when a thread is withdrawn from the *end* of a mule-cop, a twiner-cop, a ring or a throstle bobbin, the amount of twist in that thread is *augmented* to the extent of one turn for each coil that is unwound. Thus the additional twist imparted to a thread on withdrawing it from the end of a mule twist-cop of standard dimensions amounts to five-elevenths of a turn per inch of yarn; and in a thread withdrawn from the end of a ring bobbin, the amount of twist is increased only two-sevenths of a turn per inch.

If, however, a thread is withdrawn from the side of a cop or a ring or throstle bobbin, the amount of twist imparted to the thread remains precisely the same as before. These remarks are true quite irrespective of the direction in which the threads are twisted during spinning (for single threads), or doubling (for folded threads), and apply equally to yarn spun "twist-way" and to that spun "weft-way."

This knowledge is sometimes put into practical use during the operation of pirn winding, when transferring threads from cops, ring bobbins or hanks, on to pirn bobbins or tubes, to be used as weft. Thus, if it is required either to slightly increase or reduce the amount of twist in the weft yarn, that object may be easily accomplished, with the ordinary type of pirn cup-winding machine, by simply reversing the driving-bands of the winding spindles, if necessary, to cause those spindles and their pirn bobbins to revolve in such a direction as will either increase or else reduce the amount of twist, as required, in the weft, as this is withdrawn from the pirn bobbins, when these are placed in the loom shuttles, during weaving.

Defects Inherent to Cop or Bobbin Winding Machines

§ 96. Textile threads in general, and especially those produced from cotton, silk, or wool, respectively, possess the property of elasticity in a measure which varies chiefly according to the particular class, growth and quality of the raw staple, as well as the relative amount of twisting imparted to the fibres during spinning, and other circumstances incidental to their manufacture. This elastic property of threads is a most valuable element, as it not only renders them more suitable for the many purposes to which they are applied, but it is essential to enable it to withstand the high degree of tensile strain to which it is subjected during weaving.

In consequence of their flexible character, textile threads become thinner when subjected to tensile strain; but if they are not extended sufficiently either to dislodge or rupture the fibres composing them, they will recover their normal state on being relieved of such tension. For these reasons it is essential that yarn intended for the production of warps should never be subjected to such a degree of tensile strain as will destroy or even impair its elasticity.

This object may only be attained by submitting yarn to a reasonable and uniform degree of tension as it passes through the several operations involved; and although this may not readily appear to present any great mechanical difficulty, yet it is a problem that has for many years perplexed inventors and machine-makers, who have devised numerous contrivances with a view to attaining that object. The difficulties in this direction are mainly, if not entirely, encountered during the operation of cop or bobbin winding, when the threads are transferred separately from their primary forms, and wound on to warpers' bobbins.

§ 97. In cop or bobbin winding machines of the type under present consideration, the spindles and warpers' bobbins revolve with a *constant* velocity. Therefore the threads are withdrawn from their respective sources at a pace which is gradually accelerated as each successive layer of yarn is wound upon the bobbins, and in a measure proportionate to the constantly increasing girth of the bobbins as they become filled with yarn. These factors constitute the prime sources underlying the evils incidental to the operation of cop or bobbin winding by machines of this type, as they cause yarn to be wound with a constantly increasing degree of tension, and also retard production by reason of not maintaining a maximum rate of winding from the commencement to the finish of each warpers' bobbin.

§ 98. In winding machines that are constructed with two rows of spindles on each side, as exemplified in the English modification, it is a common practice, although not a general one, to fix on the spindles in the front rows, wharves of smaller diameter than those fixed on spindles in the back rows, so that these will revolve with a slower velocity than that of the spindles in the front rows. If this course is adopted, the diameter of the wharves on the front spindles is usually $1\frac{1}{4}$in., and that of the wharves on the back spindles $1\frac{1}{2}$in.; hence their velocities will be in a ratio inversely to those diameters, or as 6 to 5 respectively.

The object of driving back spindles slower than front spindles is to permit of some compensation for the accelerating rate of winding caused by the gradually increasing girth of warpers' bobbins. Thus, as bobbins on the front spindles become about half-filled with yarn, a winder removes them on to the slow-running back spindles to be filled. But although this procedure enables some compensation to be made for the increased girth of the bobbins, it is quite disproportionate to the rate of increase from the commencement of winding, as a simple calculation will prove.

For example, if warpers' bobbins with flanges 4in. diameter, and with barrels or tubes $1\frac{1}{4}$in. diameter, are employed, and yarn is built upon them to produce barrel-shaped bobbins having a maximum diameter of 5in., the circumference of the bare bobbin tube, and the circumference at the greatest diameter of a fully wound bobbin, will be in the ratio of those diameters, or as 1 is to 4, respectively. Therefore, assuming the velocities of front and back spindles to be 648 and 540revs. per minute respectively, and that a bobbin is half-filled on a front spindle, and then removed to a back spindle to be filled, yarn would be wound at the rate of only 72yds. per minute at the commencement, and at the excessive rate of 240yds. per minute at the end of winding, when a bobbin is quite filled with yarn. These velocities are, therefore, in the ratio of 1 to $3\frac{1}{3}$ respectively.

Such a considerable advance in the rate of winding greatly increases the frictional resistance between the threads and the flannel-covered tension-board or other form of tension device, and therefore subjects them to a constantly increasing degree of tension. Also the very low rate of winding at the commencement of each warpers' bobbin involves a serious curtailment of production, because the velocity of the spindles and bobbins is determined by the safe maximum rate with which the threads may be wound, and this is attained only when the final layer of yarn is being wound on to a bobbin, and it is then quite filled.

This objection constitutes one of the most serious defects which are inherent to the prevailing type of cop or bobbin winding machines, and its improvement is a problem that still awaits solution.

§ 99. In certain types of spinning machines—as, for example, roving frames and flyer-throstle frames—the strands of roving in the first type of machine, and the spun threads in the second type, are produced, then delivered concurrently and simultaneously to their respective bobbins, upon which they are each wound in a series of successive and parallel layers and at a rate of winding which is maintained at a constant value throughout, notwithstanding the gradually increasing girth of the bobbins as these become filled.

This object is effected by means of differential driving mechanism for the purpose of gradually retarding the velocity of the bobbins to counteract their constantly increasing girth, and thereby maintaining a uniform rate of winding. Such a provision is absolutely essential in consequence of all the bobbins in those machines receiving a continuous supply of yarn simultaneously, thereby ensuring that all the bobbins will be built up with yarn at the same rate, and therefore become filled at the same time.

In cop or bobbin winding machines, however, the supply of yarn to warpers' bobbins is not effected with the same precision and continuity as in the spinning machines referred to, but in a more or less independent manner, with the result that the bobbins are filled separately and irregularly, and not simultaneously. Hence the present necessity of driving the spindles of a cop or bobbin winding machine with a constant velocity.

§ 100. The mechanical difficulties which these problems of winding present were known to exist as early as 1822, when W. Pride patented a device which enabled the velocity of the spindles in a cop winding machine to be reduced from a greater to a smaller uniform value simultaneously, as the warpers' bobbins became about half-filled with yarn. That object was accomplished by employing two different sizes of rope-driving pulleys, of which first the larger pulley, and subsequently the smaller one, were engaged to drive the tin drum. Such an arrangement, however, would require both a simultaneous and continuous supply of yarn to the warpers' bobbins, which, for reasons just stated, is scarcely practicable in cop or bobbin winding machines of the present type.

§ 101. A more recent attempt to solve these problems of winding was made by P. Taylor, who, in 1904, patented an ingenious though impracticable contrivance designed with the primary object of driving the spindles and warpers' bobbins with a differential velocity of a higher average value, and thereby winding yarn with a constant maximum pace throughout.

These same objects, however, were anticipated some years previously by an American firm of textile machinists, who, after experimenting in this direction for some time, found that the advantages to be gained by increasing the average velocity of the winding spindles were not commensurate with the extra cost of machinery which that course involved, and so abandoned the idea.

The cardinal feature of Taylor's invention, as represented in Fig. 32, consists of driving each winding spindle separately and independently by means of two reversed conical drums or pulleys mounted with their axes vertically. One of these cone drums, A, is fixed on a spindle D, furnished at the top with a wharve O, to receive a driving band G, by which it is driven with a constant velocity from the central tin drum F on the main driving shaft K. The second cone drum, B, is fixed on the lower part of the winding spindle proper, D, which supports the warpers' bobbin E, and is driven from the first cone drum A by means of a narrow leather belt C. This is controlled by a double belt-fork under the guidance of a curved and slotted lever H, which, through the medium of a connecting-rod T, is operated by the movement of a yarn "feeler-roller" L, which bears against the yarn on the warpers' bobbin, and is therefore pushed backward slowly by it as successive layers of the thread are wound.

§ 102. With this device yarn would be wound at a constant pace, and therefore with a degree of tension that would be practically uniform throughout. Also, by reason of driving the winding spindles with a gradually diminishing velocity, winding would be maintained at a maximum safe pace from the commencement to the finish of each warper's bobbin, thereby increasing very materially the productiveness of each spindle by, approximately, 50 to 60 per cent. Yet, notwithstanding the fact that this invention is capable, theoretically, of attaining those objects, it does not, from an industrial or commercial point of view, constitute a practicable winding machine, and it has not, therefore, been adopted.

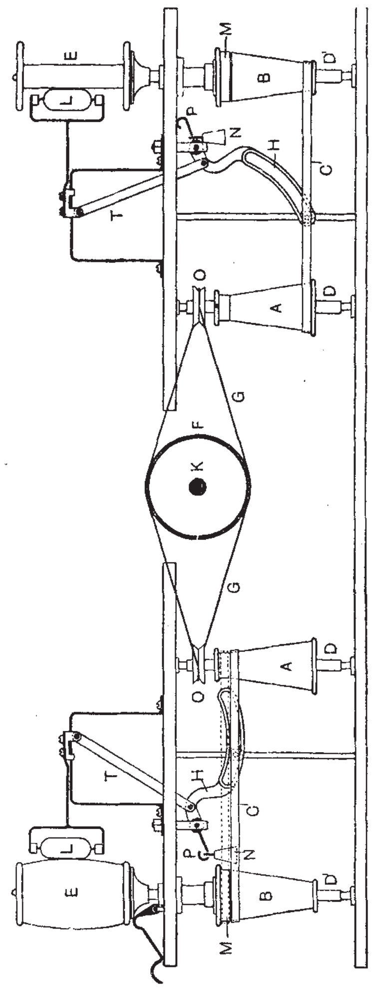


Fig. 32.—Taylor's Cop Winding Machine.

Data Relating to Cop or Bobbin Winding Machines

§ 103. The following data are of actual value for specific instances only, and may be relied upon for the purpose of obtaining an approximate estimate of the values of the respective items enumerated. Since, however, many of these data vary considerably under different local or special circumstances, and according to numerous variable factors, it is advisable, if precise information respecting any particular machine is essential, to obtain from the makers the exact data required.

Dimensions

(*a*) Cop or bobbin winding machines of the English modification, having two rows of spindles on each side, are constructed with a multiple of four spindles, and contain usually from 100 to 300 spindles each. Larger or smaller machines are constructed specially to order. The total length of a machine containing 200 spindles, with two rows on each side, having a gauge of 5in., is obtained as follows:

Length=200 spindles ÷ 4 rows × 5in. gauge + 1ft. 10in.

for both ends of framing=22ft. 8in. If the machine is constructed with a travelling endless apron or band to convey empty ring bobbins automatically to one end of the machine, 8 to 12in. must be added to the above length for the projection of the band beyond the "off-end" framing.

Width=from 5ft. 6in. to 6ft. 4in.

(*b*) Winding machines of the American modification, with only one row of spindles on each side, are usually constructed with from 100 to 200 spindles; or other number of spindles to order. The total length of a machine of this type containing 200 spindles disposed with a 5in. gauge is as follows:—

200 spindles ÷ 2 rows × 5in. gauge + 2ft. 4in.

for both ends of the framing, and including the projecting end of the travelling band=44ft.

Width=4ft. 6in.

Weight

§ 104. (*a*) The weight of an English modification of machine to wind from cops, and containing 200 spindles with a gauge of 5in. apart, varies in different machines from 23 to 30cwt. each, net, with a difference of from 11 to 13½lb. per spindle for larger or smaller machines. (*b*) The weight of a similar machine constructed to wind from ring bobbins varies from 26 to 32cwt. each, net, with a difference of 11¾lb. to 14lb. 9oz. per spindle for larger or smaller machines. (*c*) The weight of an American modification of machine containing 200 spindles, to wind from either cops or ring bobbins, is 42cwt., with a difference of 19lb. per spindle for larger or smaller machines.

Cost

§ 105. The relative cost of a winding machine varies considerably within extremely wide limits, chiefly according to (*a*) the type of machine, as English or American; also whether it is constructed (*b*) with ordinary winding spindles or those of the Rabbeth or other self-contained type; (*c*) to wind from cops only, ring bobbins only, or from both; (*d*) with split wooden pegs on which to mount the ring bobbins to unwind yarn from the nose, or else with Rabbeth spindles to permit of the threads being withdrawn from the sides of the ring bobbins; (*e*) with only one tin driving cylinder, or two cylinders; (*f*) with or without a travelling band to convey empty ring bobbins automatically to one end of the machine; (*g*) with the ordinary form of fixed steel-plate clearer-guides, or with adjustable guides; in addition to the numerous minor modifications and specialities adopted by different machine makers; and also the many incidental accessories and details which are essential to the machine, such as cop skewers, yarn-cleansing brushes, winders' listing or flannel for the tension-boards, spindle banding, warpers' bobbins, skips, oil-cans, hand sweeping-brushes, and sometimes mechanical knotters for the winders.

When estimating for the cost of a winding machine, makers usually specify the net price per spindle, exclusive of specialities and sundries, which are quoted for as separate items. Also, it is customary to quote a less price per spindle for machines containing a greater number of spindles. Thus, for a cop or bobbin winding machine of the English modification constructed with the older forms of winding spindles and steel-plate clearer-guides, and without any of the usual accessories, the approximate net prices per spindle for different sizes of machines are as follows:—

Number of Spindles in Machine.	Approximate Net Price per Spindle.	Number of Spindles in Machine.	Approximate Net Price per Spindle.
52 to 100	at 5s. 0d.	204 to 248	at 4s. 5d.
104 ,, 148	,, 4s. 8d.	252 ,, 300	,, 4s. 4d.
152 ,, 200	,, 4s. 6d.	304 ,, 348	,, 4s. 3d.

To the above net prices there must be added from 1s. to 1s. 2d. per spindle for incidental accessories, as enumerated previously.

If the machine is furnished with any of the following specialities the sums indicated against the respective items are approximate prices per spindle charged in addition to those specified above, viz.:

SPECIALITIES

Rabbeth winding spindles	1s. to 1s. 3d. extra per spindle.
Split wooden pegs for ring bobbins	1½d. to 2d. extra per spindle.
Rabbeth spindles for ring bobbins	1s. 3d. to 1s. 6d. extra per spindle.
Travelling band	5d. to 6d. extra per spindle.
Adjustable clearer-guides	2d. to 6d. extra per spindle.
Haemig's patent yarn-cleansing motion	2s. extra per spindle.

On the basis of the foregoing prices, the approximate cost of an English modification of winding machine containing 200 Rabbeth winding spindles and furnished with Rabbeth spindles for unwinding from the sides of ring bobbins, a travelling band for empty ring bobbins, adjustable yarn clearer-guides, and all the essential accessories complete, would be as follows:—

		£	s.	d.
One English modification cop or bobbin winding machine containing 200 winding spindles	at 4s. 6d. per spindle	=45	0	0

EXTRA ITEMS

		£	s.	d.
Rabbeth winding spindles	at 1s. 3d. per spindle	=12	10	0
Travelling band	at 6d. per spindle	= 5	0	0
Adjustable yarn clearer-guides	at 4d. per spindle	= 3	6	8
Sundries	at 1s. per spindle	=10	0	0
	Total net cost	=75	16	8

For a winding machine of the American modification, containing 200 winding spindles, the approximate net cost per spindle is about 9s. without the usual accessories, for which an additional sum of about 1s. per spindle would be charged. Therefore, the cost of a 200-spindle winding machine of this type, but in all other respects similar to the English modification just specified, would be as follows:—

		£	s.	d.
One American modification cop or bobbin winding machine containing 200 Rabbeth winding spindles	at 9s. per spindle	=90	0	0
Sundries	at 1s. per spindle	=10	0	0
	Total net cost	=100	0	0

Depreciation

§ 106. The actual depreciation of a cop or bobbin winding machine is probably not more than 5 per cent. for a machine furnished with the older type of winding spindles, and $3\frac{1}{2}$ per cent. for a machine containing Rabbeth or other form of self-lubricating spindles. The general depreciation of a winding machine, however, including the cost of keeping the working mechanism in efficient order, of spindle banding, of winders' listing, of oil and all other incidental details, will probably not exceed 10 per cent. per annum for a machine containing ordinary spindles, and 8 per cent. for a machine containing Rabbeth spindles.

Ratio of Winding Spindles to Looms

§ 107. The number of winding spindles required to supply the requirements of one loom will, of course, vary considerably under different circumstances, and will be determined chiefly by the counts of yarn to be wound, the number of warp-ends and picks per inch in cloth, the speed of the winding spindles, and of the looms. The number of spindles required to supply one loom is variously estimated to be approximately from $1\frac{1}{2}$ to 2 spindles; but for medium counts of yarn and normal working speeds an estimate based on $1\frac{3}{4}$ winding spindles for each loom will answer for general purposes. The exact ratio of spindles to looms for a specified production may be calculated with precision only from actual data.

Power

§ 108. The power required to drive a cop or bobbin winding machine is estimated to be from $\frac{1}{3}$ to $\frac{1}{2}$ I.H.P. for 100 spindles.

Speed of Winding Spindles

§ 109. The velocity with which the spindles of a cop or bobbin winding machine may be driven admits of a wide range of speeds, and is therefore to some extent quite optional. Unlike many of the data under present notice, which may be obtained either by actual measurement or by calculation, the proper spindle velocity is not determinable by either of those methods, but only by the test of practical experience. The factors which chiefly determine the velocity of the winding spindles are (*a*) the type of spindle; (*b*) the counts and character of yarn; (*c*) the degree of tensile strain it is desired to impart to the yarn during winding; and (*d*) the size of warpers' bobbins.

In any case, a relatively low spindle velocity is to be preferred, with a proportionately greater number of winding spindles to meet the demand. By adopting that course the elasticity of the yarn will be better preserved; also, it will conduce to fewer breakages of yarn and fewer knots, and thereby produce warps that will weave better, and make superior cloth. The spindle speeds recommended by different machine-makers range from 480 to 900revs. per minute, according to the variable factors just named. In a specific instance a winding machine is working with a spindle velocity of 780revs. per minute, and winding 32's twist yarn on to warpers' bobbins with a 4½in. traverse, a 3½in. flange, and a 1¼in. barrel.

Production

§ 110. The relative productiveness of a winding machine varies within extreme limits, chiefly according to the spindle velocity, the counts and quality of yarn, and the ability of the winders. These variable factors account for the widely different estimates that are sometimes given under this item, which estimates vary from 240 to 600 hanks per spindle per week. In a specific instance the product of a machine winding 32's T averages about 18½lb. per spindle per week of 55½ hours.

Waste

§ 111. The total amount of waste material produced during the operation of cop winding, and which consists of cop bottoms and waste caused by the "readying" of cops, is deemed to be excessive if it exceeds 1½ per cent. of the gross weight of yarn, and about ½ per cent. when winding ring and throstle-spun yarn.

Character and Amount of Labour

§ 112. Winding machines are invariably attended by female operatives. The number of winding spindles allotted to winders varies from 25 to 50 each, according to age, ability and other circumstances. On machines of the English modification winders who are unprovided with mechanical knotters attend to about 33 spindles each; and if they are furnished with knotters, each winder attends to about 40 spindles. On winding machines of the American modification, however, about 40 spindles are assigned to each winder, if these are not supplied with mechanical knotters; but if they are equipped with knotters, winders are allotted about 50 spindles each.

Rate of Wages

§ 113. The rate of wages paid for cop and bobbin winding varies in different districts according to local or special conditions. Most firms pay a rate of wages in accordance with one of several recognized standard lists of prices; but some firms adopt their own independent scale of payment. Price lists for winding are formulated on different bases. Some lists are based on a fixed sum paid for varying weights of different counts of yarn—as, for example, the Blackburn Standard List; and others are based on a fixed weight of yarn for all counts, for which the scale of pay varies according to the counts—as, for example, the Burnley Standard List.

1. BLACKBURN STANDARD LIST

For Winding from Cops

Counts of Yarn.	Lb. for 12 Pence.	Counts of Yarn.	Lb. for 12 Pence.	Counts of Yarn.	Lb. for 12 Pence.
18's	55	32's	36	50's	26
20's	52	34's	34½	60's	22
22's	49	36's	33½	70's	19
24's	45½	38's	32	80's	16½
26's	42½	40's	31	90's	14½
28's	40	46's	27½	100's	13
30's	38				

2. BURNLEY STANDARD LIST

For Winding from Cops

Counts of Yarn.	Price Paid for 60lb.	Counts of Yarn.	Price Paid for 60lb.	Counts of Yarn.	Price Paid for 60lb.
	s. *d.*		*s.* *d.*		*s.* *d.*
16's—18's	1 3	32's—34's	1 8	50's—52's	2 2
20's—22's	1 4¾	36's—38's	1 9½	54's—58's	2 3½
24's—26's	1 5¾	40's—42's	1 11	60's—62's	2 5
28's—30's	1 6¾	44's—48's	2 0½		

3. INDEPENDENT STANDARD LIST

FOR WINDING FROM COPS

This list is based on a uniform sum of one penny for a uniform length of 100 hanks, irrespective of the counts of yarn wound, viz.:

Counts of Yarn.	Price Paid for 10lb.	Counts of Yarn.	Price Paid for 10lb.	Counts of Yarn.	Price Paid for 10lb.
18's	$1\frac{7}{8}$d.	26's	$2\frac{5}{8}$d.	36's	$3\frac{5}{8}$d.
20's	2d.	28's	$2\frac{7}{8}$d.	40's	4d.
22's	$2\frac{1}{4}$d.	30's	3d.	50's	5d.
24's	$2\frac{3}{8}$d.	32's	$3\frac{1}{4}$d.	60's	6d.

BASIS OF PAYMENT FOR WINDING RING AND FLYER THROSTLE YARN

§ 114. (1) The rate of payment for winding ring and throstle yarn is usually based on the respective lists of prices paid for cop winding, but with a reduction of 20 per cent. uniformly from the price paid for winding the same counts and weight of mule-cop yarn. This is equivalent to increasing the weight of yarn to be wound 25 per cent. for the same price.

(2) Some firms pay 20 per cent. less than that paid for cop winding up to and including 26's T; and 25 per cent. less for finer counts. This is equivalent to increasing the relative weights of yarn 25 and $33\frac{1}{3}$ per cent. respectively for the same price.

(3) Other firms make no distinction between cop and ring bobbin winding, and pay the same rate of wages for each. In fact, some winders have demanded a higher rate of wages for ring bobbin winding, on the plea that the extra labour involved in renewing spent ring bobbins (which is required more frequently than the renewal of spent cops) is not compensated by the better winding of ring yarn as compared with mule yarn.

WEEKLY EARNINGS

§ 115. The relative value of the wages earned by winders varies considerably according to the spindle velocity, the number of spindles attended, the counts and quality of yarn, ability, the rate of wages paid, and other variable factors. Winders' wages range from 10s. upward per week of 55½ hours; and in exceptional cases £1 is earned for a full week's wage.

Under normal conditions, however, their wages range from about 15s. to 17s., with an average throughout Lancashire mills of 16s. 10½d. per week. This latter sum would be paid for winding 607½lb. of 32's T if paid according to the Blackburn and the Burnley Standard Lists; and for winding 632.8lb. if paid by the Independent Standard List No. 3.

CHAPTER V

KNOTS; ALSO MECHANICAL KNOTTERS FOR PIECING THREADS

§ 116. DURING the operations incidental to the preparation of threads for weaving and other purposes, the threads are liable to break at weak and other defective parts, and therefore require to be rejoined by means of knots. Also, the limitations of length to which thread may be produced by spinning necessitate the piecing of several successive strands in order to obtain continuous threads of greater length. These factors constitute the two principal causes of knots in yarn prepared for textile manufacture.

Threads are most liable to break during those operations in which they are submitted to tensile strain independently, as during the various methods of winding, and reeling; more especially if the threads consist of single strands of yarn that are withdrawn from cops or ring bobbins, and passed through clearer-guides. It is also during these operations that threads of greater length are obtained by joining the successive units end to end. Hence, these operations are productive of a greater abundance of knots than are caused at any other stage of manufacturing.

After piecing a broken thread or joining the ends of two threads together the operative should either break or cut off the loose tail-ends close to the knot, to leave them as short as is consistent with safety. Instead of this, winders and reelers frequently tie knots in a careless and indifferent manner, and leave them bulky, with long straggling tail-ends, quite regardless of the trouble they give to weavers.

§ 117. It is affirmed that not less than 75 per cent. of the breakages of warp-ends during weaving are directly caused by long-tailed, bulky, and otherwise faulty knots in the warp yarn. Even if this estimate is too high, faulty knots in any measure ought to be averted, as they are not only a hindrance to weavers and produce imperfections in the cloth, but they sometimes cause serious personal accidents to occur during weaving, in a manner to be stated presently.

Bulky knots prevent the threads from passing freely through the shedding harness and reed, thereby causing them to pull and strain until they finally break. The long tail-ends of knots become entangled with adjacent warp-ends during weaving, thereby preventing them from opening out and separating properly to form the warp-sheds. The entangled warp-ends break out, produce " floats " and other imperfections in cloth, and also constitute one of the chief causes of shuttles flying out of the loom, by forming obstructions to the free passage of the shuttle, and thereby diverting it from its proper course, sometimes with very serious consequences.

§ 118. If knots in warp yarn are tied properly and trimmed neatly, their presence in most fabrics is not objectionable; but in velveteen and corduroy fabrics they constitute a source of danger during the operation of fustian-cutting, by which is produced the velvet-pile surface characteristic of those fabrics. Whether fustian-cutting is performed manually, or mechanically in " straight-knife " machines, bulky knots are liable to divert the knife of the fustian-cutter, or the knives of the machine, from their proper " races," and thus cause them to penetrate and injure the cloth. It is therefore essential that all knots formed in yarn intended for these fabrics should be small and tied neatly.

There are, however, some classes of fabrics in which knots of any description are detrimental—for example, the canvas cloth employed in the construction of pneumatic wheel-tyres; fabrics to be afterwards coated or prepared with rubber or other non-porous material to make them waterproof; canvas cloth for the manufacture of card clothing or wire-filleting used for covering the cylinders of carding-engines, nap-raising or perching machines, and many other purposes. The presence of knots in any of these fabrics would not only impede the operation of coating them with the various non-porous substances, but they would also prevent these latter from being laid perfectly level, and produce flaws by projecting above the surface.

§ 119. Again, there are other varieties of fabrics woven with fine reeds, and of comparatively fine texture—such as those containing corded stripes, net leno figuring (cross-weaving), looped and many other effects that are produced by extra warp-ends consisting of thick "net" or corded threads of folded yarn, in which knots would be too large to pass through the harness eyes and dents of the reed during weaving. Weavers engaged in the production of these fabrics have to adopt special means of replacing broken warp ends, or those already containing knots, without having recourse to knots.

This may be effected by either of two alternative methods, by which the breach is repaired temporarily—namely, (*a*) either by substituting a similar thread withdrawn from a bobbin; or else (*b*) by attaching, in a special manner, to the broken thread on the warp-beam a "thrum" (short length) of similar yarn. The "thrum" is attached by means of a slip-knot to the original warp-end at a point about 18 to 24in. from the severed end of that thread, and then passed through the harness eye and dent of the reed through which the original thread passed. In both of these cases the free end of the broken warp thread is allowed to droop backward, until sufficient length is unwound from the warp-beam to enable the severed end of the thread to extend well in front of the reed. When the broken warp-end is long enough, the temporary thread is removed, and the original warp-end is then passed in its proper place through the harness and reed as before the breach occurred.

Winders' or Spoolers' Knot

§ 120. It will now be manifest that yarn intended for the production of warps especially should be kept as free as possible from knots, and that those which are unavoidable should be formed neatly. In the textile trades two kinds of knots are employed universally for piecing threads—namely, that variously described as a "winders'," "spoolers'," and "dove" knot: and that known as a "weavers'" knot. The construction of a winders' knot is illustrated in Fig. 33, which shows the knot both before and after being tightened.

Although this form of knot is almost invariably adopted by winders and reelers for piecing threads, it is, so far as weavers' requirements are concerned, a most unsuitable knot, possessing many disadvantages without a single redeeming feature to commend it. It is a comparatively large and bulky knot which lies entirely on one side of the thread, with both tail-ends projecting outward at right angles to it. Hence this form of knot is very liable to become caught on to the harness eyes and reed wires during weaving, and thus obstruct the free passage of threads, which therefore break down. It is also liable to catch on to contiguous warp-ends during shedding, thereby causing faulty shedding and breakages of threads.

Also, if a thread containing a winders' knot is submitted to tensile strain, the knot tends to enlarge and become still more bulky and less

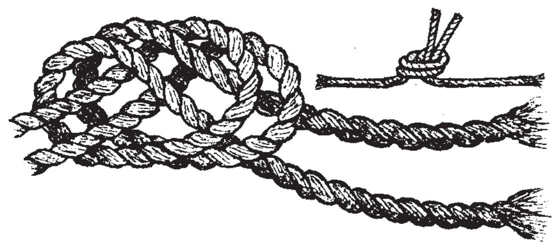


Fig. 33.—Winders' or Spoolers' Knot.

secure, especially if the knot is tied loosely. And, finally, a winders' knot tends to slip and slide towards the extremity of the tail-ends when the thread is under tension—more especially if the knots are tied slack, and also if the yarn is glazed, polished or mercerized. Hence if the tail-ends of these knots are left too short, the knots are liable to come untied.

Weavers' Knot

§ 121. Of the numerous forms of knots, that employed universally by weavers for piecing broken warp-ends is an ideal knot which is in every respect superior to any other form of knot for that particular purpose. The construction of a weavers' knot is represented in Fig. 34, which shows the method of looping the ends of two threads together before pulling the knot tight, and also after it is drawn tight.

This form of knot is more intricate and more difficult to make than a winders' knot, and also takes a little longer time to produce; but its advantages over winders' knots are so conspicuous that some manufacturers of goods from hank-dyed and sized yarn insist on their winders piecing threads by means of weavers' knots only, and recompense them by paying a higher rate of wages.

A weavers' knot possesses all the essential elements of an ideal knot for weaving purposes, as it is relatively the smallest and one of the firmest knots it is possible to make; and if a thread pieced by it is submitted to tensile strain, the knot becomes still smaller and more secure. Also, only one of the two tail-ends projects outward at right angles to the thread, whilst the other loose end lies perfectly close and parallel to it. Further, unlike a winders' knot, which lies entirely on one side of the thread, a weavers' knot is disposed equally all around the thread; and, being less prominent, it is not so liable as a winders' knot to be caught on the harness eyes and reed wires, nor to catch on to contiguous warp-ends and thereby cause faulty shedding during weaving.

But although the advantages of a weavers' knot for piecing warp-yarn are unquestionable, its more intricate construction prevents its general adoption by reelers and winders for piecing single strands of cotton yarn of the grey or raw staple. These would be more liable

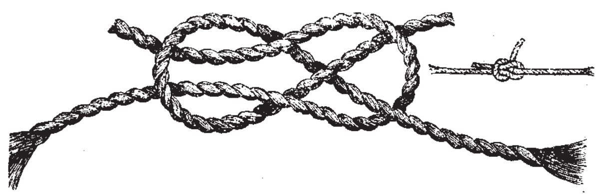


Fig. 34.—Weavers' Knot.

to break under the ordeal of piecing by weavers' knots tied by hand, as the additional fingering of the threads tends to loosen the fibres composing them. For this reason, the tying of weavers' knots by hand is only practicable for piecing threads of sized yarn, folded yarn, or other yarn which is strong enough to withstand the test.

The particular form of knot usually employed by jacquard harness builders to connect the tail-cords from the hooks of the jacquard machine to the harness threads, and also of these threads to the couplings, is essentially the same as a weavers' knot, and is adopted for those purposes expressly because of its extremely small size and great security. In this case, however, the coupling threads each form a continuous loop instead of extending from the knot as a single strand.

Mechanical Knotters

§ 122. The importance of good knots in warp yarn is fully recognized by many employers, who provide their operatives engaged in reeling, winding and similar operations, with some form of mechanical knotter, chiefly with the object of ensuring perfectly tied knots of uniform size and with short tail-ends. In fact, it is not unusual for orders for yarn to stipulate expressly that the knots must be either "mechanically tied," or, if tied by hand, must be formed neatly with short loose ends.

During the past few years there have been introduced numerous types and modifications of mechanical knotters. The function of these devices, however, is of such a subsidiary character that detailed descriptions of them would not here serve any useful purpose, nor would they possess any technical or commercial value or interest. Neither can the manner in which these devices perform the construction of knots be conveyed clearly excepting by the aid of numerous diagrams—or, still better, by ocular demonstration.

§ 123. Of five different forms of mechanical knotters to be described presently, two of them are most complex devices that tie the knots, pull them tight, and cut off the surplus loose ends automatically by simply operating a thumb-lever; whereas the other three forms of knotters are simple hand-tools that merely facilitate the tying of knots of uniform size and with short tail-ends. Four of these instruments, including one of the automatic devices, construct the winders' or spoolers' form of knot; and one, which is semi-automatic, and the most remarkable and ingenious of these devices, constructs weavers' knots, for which reason it is styled the "weaver-knotter."

Weaver-Knotter

The "weaver-knotter" is a clever invention patented in 1909 by Paul Zaiser, who claims that it enables weavers' knots to be employed for piecing the more delicate single strands of raw-stapled yarn that would otherwise break under the ordeal of piecing with such knots tied by hand. The chief features of this device are illustrated in Fig. 35, which represents two reverse side views at A and B, an end view at C, with essential details better exposed to view at D and E. It is designed for carrying on the left hand, and consists essentially of several thread guides in combination with two clamping and shearing jaws, F, G, that are operated by means of a bell-crank lever H, controlled by the thumb which is inserted in the forked end of that lever

The two threads to be pieced are each placed in their respective guides separately and in a prescribed manner, so that the operation of the thumb-lever causes the shears F to grip one of the two threads and

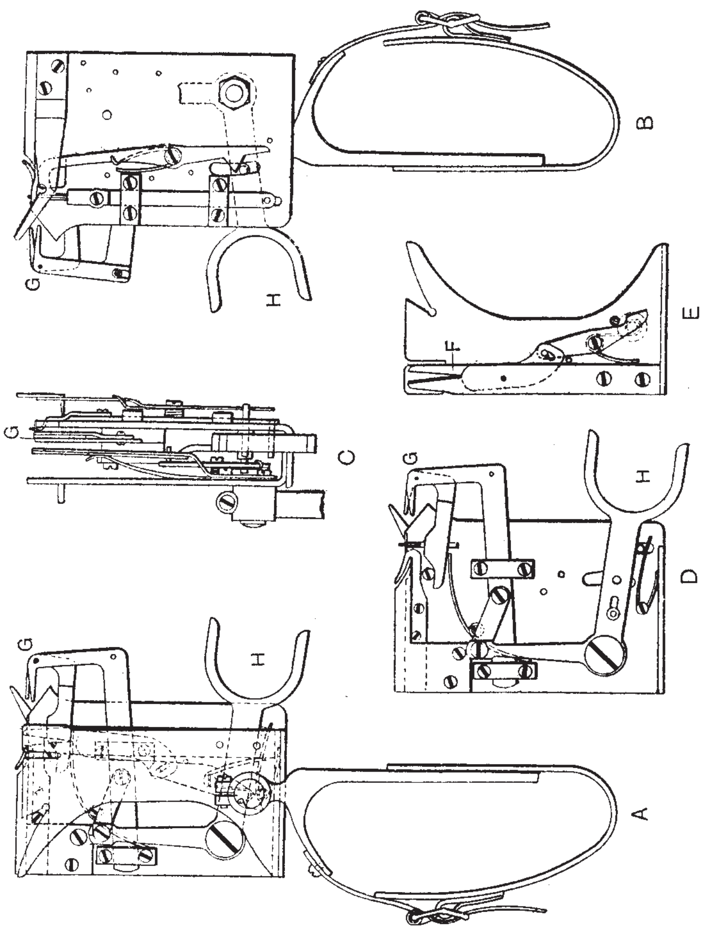


Fig. 35.—Weaver-Knotter.

cut off the surplus loose end; whilst the shears G (which actually tie the knot) grip the other thread, construct the knot, pull it tight, and cut off the surplus free end.

The weaver-knotter, which costs £4, 4s., is a very intricate and ingenious combination of delicate mechanism, the manipulation of which requires a performance of a somewhat complex character. Its constructional details have been greatly improved, and its operation simplified, whereby it will meet with appreciation by many manufacturers who prefer the superior form of weavers' knot.

Barber-Knotter

§ 124. Of the several forms of winder-knotters in use, that patented in 1900 by H. D. Colman, and known as the " Barber " knotter, illustrated in Fig. 36, is an American device that was introduced into this

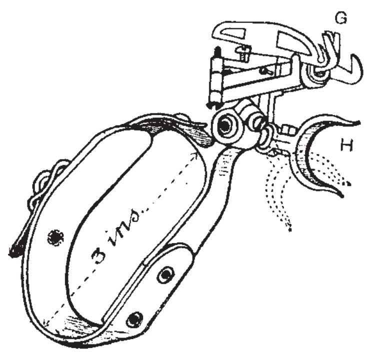


Fig. 36.—Barber-Knotter.

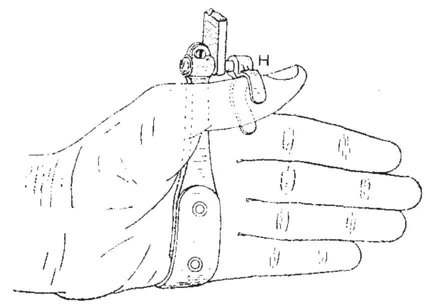


Fig. 37.

country about the end of 1901; and notwithstanding the high price of this instrument (£5, 3s.), which is often urged as a reason against its adoption, it is in extensive use. This device is an ingenious combination of mechanism surmounting a shaped handle which, like the ' weaver-knotter," is adapted to be strapped constantly on the *left hand* to be operated by the thumb, as illustrated in Fig. 37. The central feature of this device is a treble-blade clamping and shearing jaw G, which, on being revolved, grips the threads, loops them into a winders' knot, and cuts off the surplus loose ends. It is made in three sizes suitable for threads of different counts and character, and is the only type of winder-knotter that performs all the necessary functions automatically by simply depressing a forked thumb-lever H.

Stubbs' Knotter

§ 125. Another form of winder-knotter, illustrated in Fig. 38, was patented in 1909 by N. S. Brown and J. Maloney, and is sold for the sum of 10s. 6d. This simple and efficient device is a hand-tool comprising only three integral parts, and may be used either by the right or the left hand. Also, it is capable of piecing threads ranging from the very fine to very coarse counts of yarn, with equal efficiency. This knotter consists essentially of an adaptation of the treble-blade clamping and shearing jaw G of the Barber-knotter, and forms the terminals of two side-plates constituting a haft D which encloses a central thumb-lever H, pivoted on a pin E, and a wire spring F. By manipulating the tool in a prescribed manner, and depressing the thumb-lever to grip the threads, a winders' knot is formed, the waste ends are cut off, the knot is tightened by pulling the threads whilst they are still clamped in the shearing jaws, and the thread liberated by releasing the thumb-lever, which returns to its normal position by the reflex action of the spring. If this tool were furnished at the heel with a small wire loop or ring, it could then be suspended either by a cord, or, preferably, from a small hook, attached to the waist-belt, instead of holding it constantly in the hand when not in actual use.

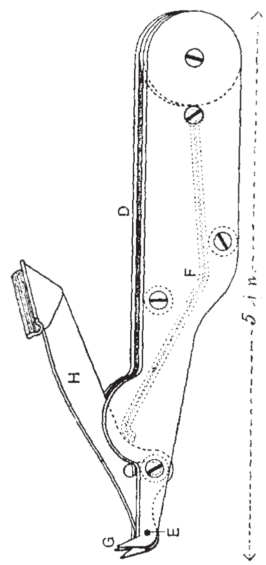


Fig. 38.—Stubbs' Knotter.

Bingham's Knotter

§ 126. A later form of winder-knotter, illustrated in Figs. 39 and 40, was patented in 1909 by T. E. Bingham, shortly after the appearance of the previous device, and, like that instrument, is virtually an adaptation of the clamping and shearing bills G of the Barber-knotter. This tool, however, is adapted to be carried constantly on the index-finger of the right hand, on which it is held in position by means of a strap A attached to a wrist-band B, and with the second finger passing over a short curved arm or yoke C projecting from one side of the central shearing-blade H, as represented in Fig. 40. A winders' knot is formed by this instrument in a manner similar to that of the previous device, by first looping the threads around the hooked bills as indicated in Fig. 40, then depressing the central clamping and shearing blade to grip the threads and cut off the waste ends, after which the knot is tightened, and the finger-lever released to liberate the thread. This knotter is sold at 10s. 6d.

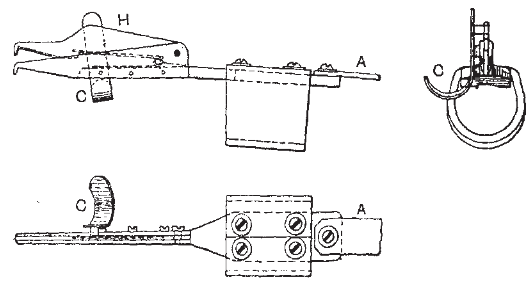


Fig. 39.

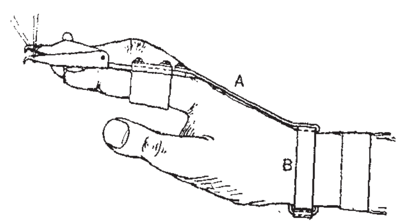


Fig. 40.—BINGHAM'S KNOTTER.

UNIVERSAL-KNOTTER

§ 127. Another type of winder-knotter, and one that has been in use during the past eleven years, is that known as the "Universal" knotter, illustrated in Fig. 41, patented by F. Thomasson. This simple tool consists of a piece of steel wire in the form of a long loop, with one end curved inward, flattened and sharpened to produce a sharp cutting-edge, and either fixed in a wooden handle, or preferably with a white-metal handle moulded around it. It was introduced with a wooden handle to be used as a hand-tool; but a more approved method of using it for cop or bobbin winding is to mount the knotter on small brackets fixed to the guide-rails of the winding machines, as represented in Fig. 42, with a knotter fixed at intervals of about ten spindles on an English machine, and five spindles on an American machine. The price of this knotter, including brackets, is about 3s. each.

§ 128. In addition to their primary object of producing knots of uniform size and with short tail-ends, other advantages claimed in favour of some mechanical knotters are that their use makes it unnecessary for winders to remove warpers' bobbins from their spindles whilst recovering and piecing threads, thereby reducing the wear and tear of those bobbins; also that they increase production, and reduce waste. Against these advantages, however, it is sometimes urged that the practice of keeping bobbins on the winding spindles whilst recovering the lost ends of broken threads is liable to produce "lapped" threads, in consequence of winders scratching along the surface of the yarn in order to recover the lost thread, thereby causing it to pass underneath previous coils of yarn, and reappear several coils out of its proper place on the bobbin.

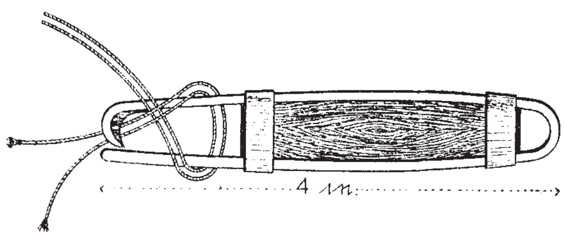


Fig. 41.—Universal-Knotter.

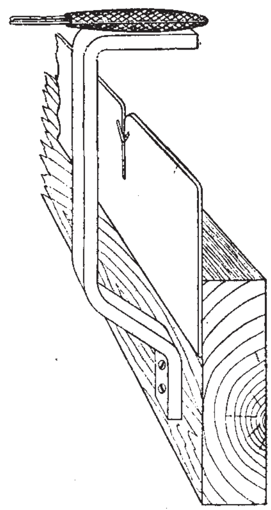


Fig. 42.

In addition to the foregoing examples of mechanical knotters, many other varieties have been invented and patented, but few have met with approval in the trade, and have not, therefore, been adopted.

CHAPTER VI

BEAM WARPING

§ 129. BEAM warping is the second operation of that series constituting the system under present consideration, by which cotton warps are prepared for weaving in the grey or natural colour of the raw staple. It consists essentially of gathering into one group any practicable number of warp-ends, and winding them, evenly distributed, as an expanded sheet of parallel threads, on to a flanged beam. In the method under notice, the warp-ends are withdrawn simultaneously from a number of warpers' bobbins contained in a creel, and at the same time they are wound on to one of a series of large flanged beams, termed "back," "warpers'," or "slashers'," beams.

This is accomplished by means of the type of machine known as a beam-warping machine, represented perspectively in Fig. 43, as made by Messrs Asa Lees & Co., Ltd., and of which there are three chief modifications. The type of bobbin creel usually employed in conjunction with a beam-warping machine is that known as a **V**-creel, consisting of two separate wings or banks placed vertically, and converging towards the machine, so that a plan of the creel presents the form of the letter **V**, with the apex fixed about 2ft. to the rear of the machine headstock.

These creels are usually constructed to hold any number up to 504 bobbins, with 14 vertical rows of 18 bobbins in each wing. Larger creels are sometimes constructed with a capacity for 1000 bobbins or more, to meet special requirements. The warpers' bobbins are retained in the creel with their axes placed horizontally, and are mounted separately upon hard wooden pegs or skewers inserted through the barrels of the bobbins.

§ 130. Each warpers' or slashers' beam prepared by beam warping usually contains only a measure, equal to a third or smaller fraction, of the total number of warp-ends required on the weaver's beam for the loom. The *length* of warp, however, contained on warpers' beams may vary from two to any number of times greater than that usually wound upon a weavers' beam, according to the counts of yarn, number of threads wound upon each warpers' beam (and also upon the weavers' beam), diameters of the respective beam flanges, and other variable factors.

Under these circumstances, therefore, it is necessary to produce a number of similar beams to constitute a series or " set " of warpers' beams, each containing a measure of the total number of warp-ends required on one weavers' beam, and with the same length of warp on all beams constituting the same set.

Thus, if weavers' warps are required to contain 3000 warp-ends of 1000yds. in length, the threads from a set of, say, six warpers' beams, each containing 500 warp-ends of, say, 18,000yds. in length, would be combined. The warpers' beams of one set are placed subsequently in a beam creel or stand situated in the rear of a slasher or other type of beam warp sizing machine. Here the respective groups of threads are withdrawn from the beams simultaneously, and united into one dense sheet of threads of the same width as the separate sheets; and after being sized and dried, they are wound finally on to a weavers' beam situated in front of the sizing machine. Hence, the set of six warpers' beams would produce 18 weavers' beams, each containing 3000 warp-ends 1000yds. in length.

§ 131. The practice of preparing warps in this manner from a set of beams, each containing only a fraction of the total number of threads required in the weavers' warp, instead of producing the latter with its full complement of warp-ends by a combined operation of beam warping and sizing, is merely an incidental contingency imposed by the limitation of space, which prevents the adoption of bobbin creels of inordinate dimensions.

In fact, warps for certain varieties of fustian and other types of fabrics containing not more than about 1000 warp-ends are produced by the operations of beam warping and sizing being performed concurrently as a joint operation, as stated in § 20, p. 16.

A circumstance favourable to the practice of preparing grey cotton warps by independent operations of beam warping and slasher, or other method of beam warp sizing, from a set of several similar warpers' beams, is afforded incidentally by the employment

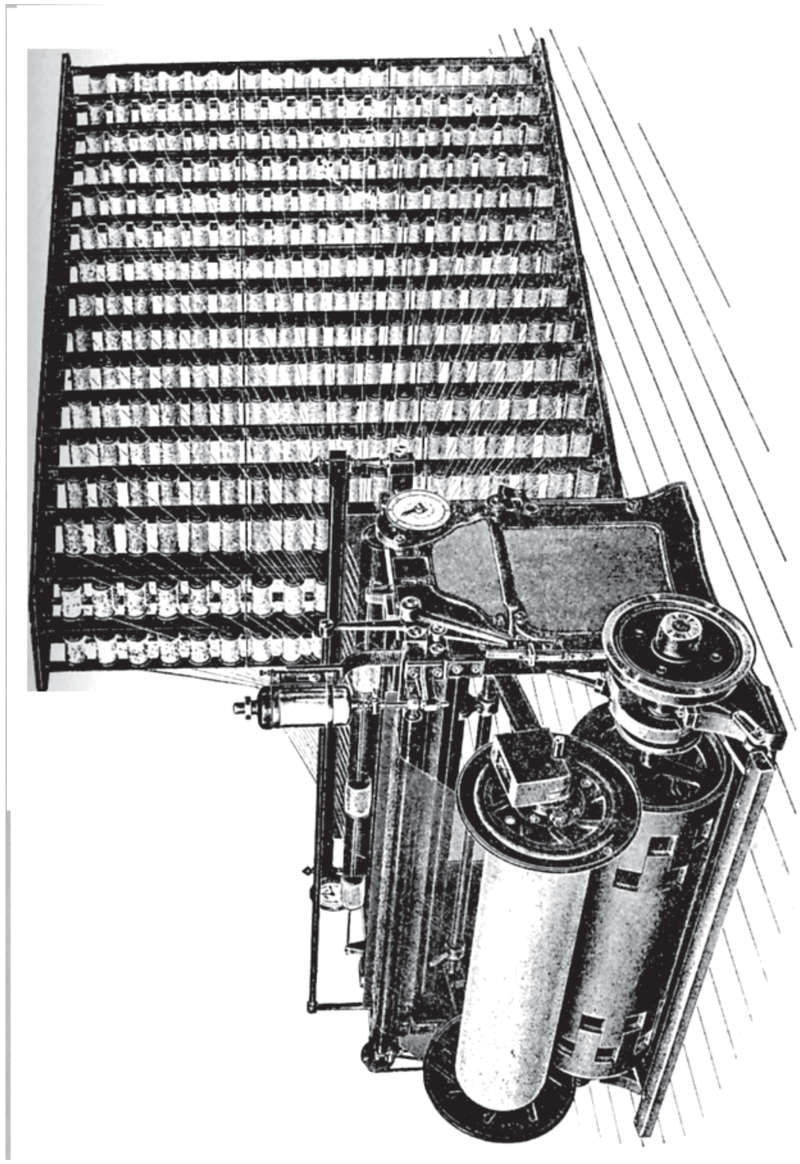


Fig. 43.—Beam-warping Machine.

of large flanges on those beams. This, in conjunction with the warping of comparatively few threads on each beam, permits of warps being wound upon them of such considerable length as will furnish a relatively large number of weavers' beams without the necessity of the attendant having frequently to " gait " or start up new sets of " back " or warpers' beams in the creel of the sizing machine.

BEAM-WARPING MACHINES

§ 132. These machines constitute a distinctive type comprising several modifications of the same general construction, but which are characterized mainly by one or other of three different types of yarn-tension devices, and one or other of two types of automatic thread-stop devices. Thus, yarn-tension devices comprise (1) that consisting of two or three *falling rollers*, usually applied to machines that are employed chiefly in the production of warps from cotton yarn; (2) that consisting of five or six *falling rods*, as exemplified in machines employed chiefly for linen warps; and (3) that consisting of a *rising tension roller*, as exemplified in beam-warping machines constructed in accordance with the American modification. Automatic thread stop-motions comprise (1) Singleton's device, consisting of two iron rollers that operate in conjunction with wire drop-pin detectors; and (2) Brimelow's device, consisting of a winged or vaned roller, and wire drop-pin detectors.

In addition to these principal parts, and also the main driving-gear to operate the machine, beam-warping machines of modern construction are equipped with numerous auxiliary devices with the object of increasing their general efficiency, and also of making them more or less automatic. The two more important auxiliary devices are (1) a length indicator to record, at sight, the length of warp wound at any period during the progress of warping; and (2) a device to stop the machine automatically when a prescribed length of warp has been wound. Or, instead of these two separate devices, their respective functions are sometimes performed jointly by a single device of a more approved type described subsequently in §§ 160-162.

§ 133. A beam-warping machine constructed with two falling tension rollers is represented by an end elevation and a part plan in Figs. 44(*a*) and 44(*b*) respectively. The more important parts of this

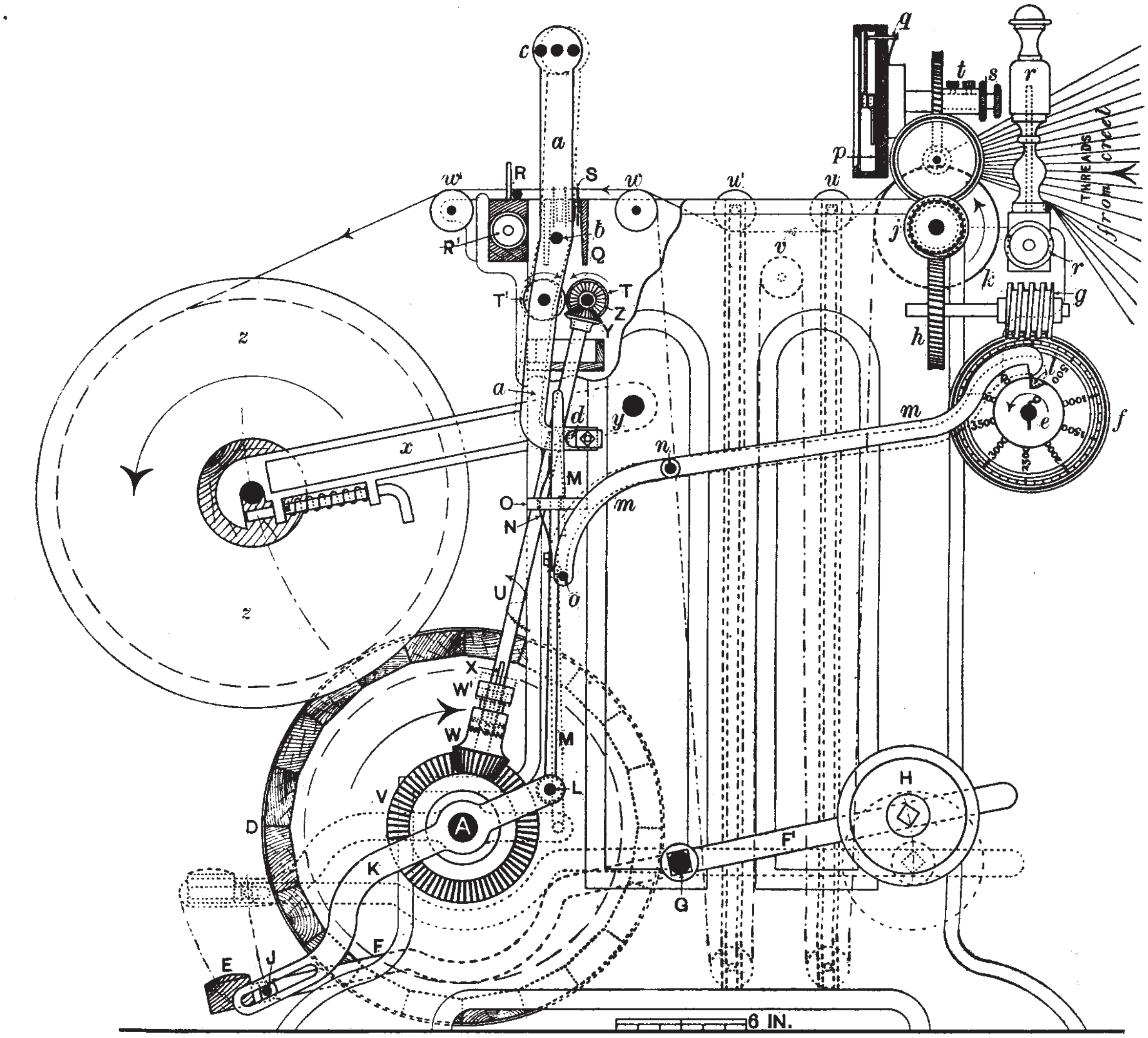


Fig. 44(*a*).—Beam Warping Machine (*End Elevation*).

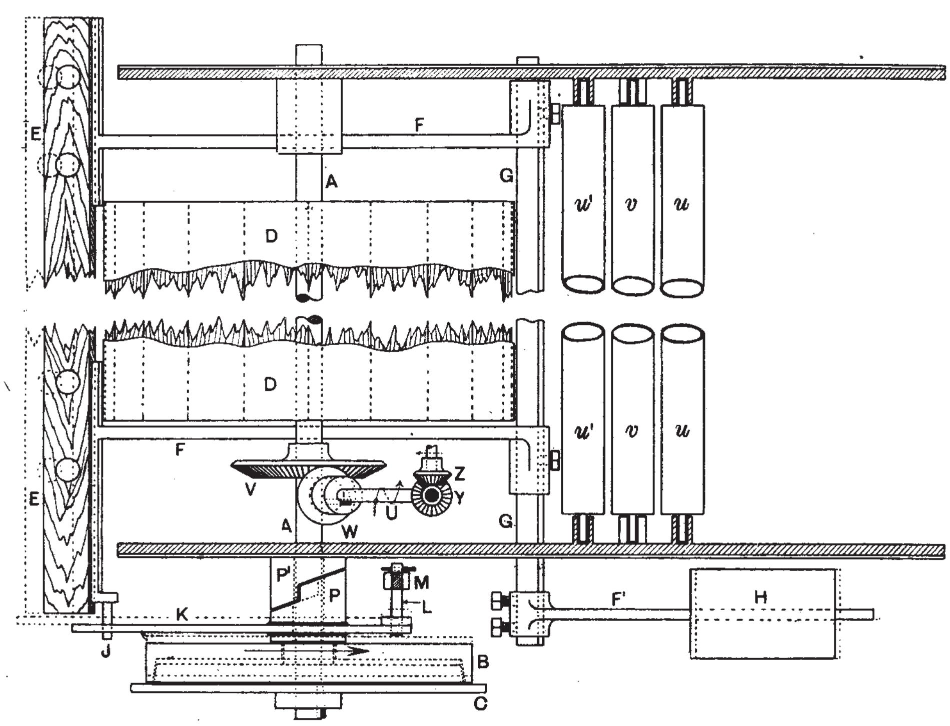


Fig. 44(*b*).—Beam Warping Machine (*Part Plan*).

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machine are (1) the main driving gear, consisting of a frictional cone clutch B, C, mounted on one end of a shaft A, on which is also mounted a large wooden drum D to turn the warpers' beam *z*; (2) an adjustable half-reed or comb R to regulate the width of the warp exactly to the width between the beam flanges; (3) a device consisting of a grid of iron bars Q, wire drop-pins S, two iron rollers T, T^1, and other incidental parts, to detect the breakage of threads, and also to stop the machine instantly when that occurs; (4) a yarn-tension device, consisting, in the present machine, of two light tin falling rollers u, u^1, that rest upon the sheet of threads, and descend by gravitation when the warp beam ceases to revolve, thereby preventing the warp threads from becoming slack and entangled, as would be liable to occur in the event of the warpers' bobbins continuing to revolve and thus deliver their threads for a short period after the warpers' beam stops; (5) a tin measuring and guide roller *k*, 18in. in circumference, over the surface of which all the threads are deflected, and thus turn the roller by surface contact; (6) an adjustable rear or back reed *r* to effect and maintain an even distribution of the warp threads immediately in front of the bobbin creel; (7) an automatic length indicator, consisting of a graduated dial *p*, with two index fingers operated by a train of wheels that derive their motion from the tin measuring roller; and (8) a device consisting of a scroll-disc *e*, on the rim of which is formed a spiral groove to receive the free and pointed "feeler" end of a long side-lever *m*, which operates in conjunction with other incidental parts to stop the machine automatically after a prescribed length of warp has been wound on each warpers' beam. In addition to the foregoing parts, some machines are also equipped with various other devices that perform auxiliary functions of a minor character.

§ 134. In their progress from the warpers' bobbins to the warpers' beam *z* the warp threads first pass separately between consecutive dents of the back reed *r*, which may be either extended or contracted, laterally, for the purpose of distributing the threads evenly to correspond in width approximately to that of the warpers' beam. On emerging from the reed *r*, the threads pass immediately on to, and partially around, the surface of the tin measuring roller *k*, which revolves freely by reason of the surface contact of the threads as these pass over it.

From the tin measuring roller the threads pass underneath the two light yarn-tension rollers *u*, u^1, which extend across the entire sheet of threads upon which they are supported, and revolve quite freely, as the threads proceed along their course. The yarn then passes over a small guide-roller *w*, thence about half an inch above the bars of the grid Q, between which bars each thread supports a light wire drop-pin S, looped in the form of a long staple or hairpin, thus ∏. These pins serve as detectors by falling when their respective threads break, and thereby put the automatic thread-stop motion into operation to stop the machine instantly, and in the manner described subsequently in § 137, p. 109.

After leaving the wire drop-pins, the threads pass separately between consecutive dents of the half-reed or comb R, which, like the reed *r* in the rear of the machine, is also adjustable to regulate the width of warp, and also to direct the threads, with precision, between the flanges of the warpers' beams. On emerging from the half-reed, the threads are deflected over a second guide-roller w^1, whence they pass downward to be wound finally on to the warpers' beam *z*, which bears downward and rests against the wooden drum D, by which it is driven negatively by direct surface contact with the yarn.

The warpers' beam is retained against the driving drum by means of two radial arms *x*, placed one on each side of the machine and each formed with a notch at its forward and free end, to receive the beam pikes or gudgeons; whilst the rear end of each radial arm is mounted freely upon a cross-bar *y*, to permit of the beam rising automatically as successive layers of yarn are wound upon it. When the machine is in operation, the driving drum revolves with a constant velocity. Therefore, since the warpers' beam is driven by surface contact with the drum, yarn is withdrawn from its source and wound upon the beam with a uniform pace from the commencement to the finish of warping, notwithstanding the constantly increasing girth of the beam as it becomes filled with yarn.

Driving Gear

§ 135. The prime motor of a beam-warping machine, as represented in Figs. 44(*a*) and 44(*b*), is the drum shaft A, on one end of which are mounted either a loose and a fast pulley, or else a frictional cone-clutch, as illustrated in the part plan view, Fig. 44(*b*). This form of clutch consists of a free pulley B, constituting the outer portion of the clutch, which closely encircles the conical rim of a flanged disc C that is keyed fast upon the drum shaft. The free pulley may be mounted either on the drum shaft, or preferably upon the wide hub of the flanged disc, to provide a larger bearing surface, on which it revolves continuously and with a constant velocity.

The machine is put into operation by forcing the free pulley outward until it grips the tapered rim of the disc sufficiently to drive the drum D and turn the warpers' beam *z*. This is effected by depressing a footboard E which extends right across in front of the machine and near the floor. The footboard is mounted on the forward ends of two arms F that are secured respectively at opposite ends of a cross-bar G, to which there is also attached a short arm F^1, extending rearward and supporting a heavy counterweight H which overbalances the footboard.

From that end of the footboard on the driving side of the machine there projects a short pin or stud J, which freely enters a long slot in the forward end of a curved lever K, which is capable of oscillating on the drum shaft. The rear end of the curved lever K extends a short distance beyond the drum shaft and is furnished with a short stud L, on which is hinged the lower end of the " trigger-rod " M, formed with a hook or catch on the rear edge near the top, and also furnished on the front edge with a bowspring N.

The upper end of the trigger-rod M, and also the bowspring N, both pass freely through a guide-slot formed in the ledge of a retaining bracket O, so that the spring bears constantly against one end of the slot, and therefore always tends to push the trigger-hook forward to pass it over and hook it on to the retaining ledge of the bracket O whenever the hook ascends above the ledge, which is effected by depressing the footboard E. At one part of the curved lever L, where this oscillates on the drum shaft, there is securely attached the outer end of a short sleeve P, which is mounted freely on the drum shaft, and bears constantly against the hub of the loose frictional driving pulley B. The inner edge of this sleeve is formed with an inclined cam surface that abuts against a similar surface of a stationary sleeve P^1, fixed rigidly to the machine framing.

Hence, by depressing the footboard E the curved lever K oscillates on the drum shaft A, and thus forces the free sleeve P outward to bear against the hub of the driving pulley B, which is also thrust outward until the rim of that pulley grips the rim of the frictional disc C with sufficient frictional resistance to drive the machine. The depression of the footboard E also raises the balance-weight H, and at the same time causes the trigger-rod M to ascend until it hooks on to the retaining ledge of the bracket O, by which it is upheld. By this means the pulley B and disc C, constituting the frictional driving clutch, are retained in gear with each other until, from any cause, the trigger-hook is released from its retaining ledge. Whenever this occurs, the balance-weight H descends, and thereby raises both the footboard and forward end of the curved lever K, whereby the driving clutch separates and the machine stops working.

Singleton's Automatic Thread Stop-motion

§ 136. The necessity of producing warps containing the full complement of warp-ends is fully recognized. In the machine under notice this object is attained, by means of Singleton's device, patented in 1869, and which immediately detects the breakage of threads and stops the machine automatically whenever a breakage occurs during warping. Thus, in combination with other essential parts of this device, there is a grid Q, consisting of several iron bars extending across the entire width of the machine, and situated immediately in the rear of the half-reed or comb R, so that the expanded sheet of threads passes just above the grid as the warp threads proceed along their course from the bobbin creel to the warpers' beam. As each thread passes over the grid it supports a light wire drop-pin S, bent in the form of a staple hook, 1¾in. long. The drop-pins are distributed uniformly over the threads, so as to hang quite freely between the bars of the grid, which prevent the drop-pins being carried forward by the progress of the yarn.

Situated immediately below the grid, and extending parallel with it for its entire length, are two smooth iron rollers T, T^1, that revolve inwardly at the top (as indicated by arrows), with their surfaces in actual contact with each other. These rollers derive their motion from the drum shaft, either through the medium of a short inclined shaft U and bevel-wheel gearing, as indicated in the diagrams, or else through the medium of chain-wheel gearing.

If the former method is applied, a large bevel-wheel V, fixed on the drum shaft, drives a small bevel-wheel W mounted loosely on the lower end of the inclined shaft, upon which it revolves freely.

The bevel-wheel W constitutes the lower portion of a ratchet clutch, of which the upper counterpart W^1 is also mounted loosely upon the inclined shaft, and is capable of sliding freely upon it, lengthwise. It is, however, prevented from revolving upon the shaft by reason of a float or feather key X, which is imbedded in that shaft, entering a slot or keyway cut into the sleeve of the upper and sliding part of the clutch, so that this and the inclined shaft must either revolve together or else become stationary, respectively, at the same time.

The upper end of shaft U carries a bevel-wheel Y, that engages with a similar wheel Z fixed on one end of the iron roller T, which imparts motion to the second roller T^1 through the medium of two similar spur-wheels fixed one upon the opposite end of each roller shaft, and retained constantly in gear with each other. The upper portion of the ratchet clutch is controlled by suitable connections in such a manner that it engages or disengages automatically with its lower counterpart as the machine is put into or out of operation respectively. The object of this device is to put the two iron rollers T, T^1 out of action when the machine stops, and thereby permit of the warpers' beam being reversed by the attendant with less physical effort when unwinding yarn from the beam in order to recover the lost ends of broken threads for piecing.

§ 137. The operation of this stop-motion is dependent entirely upon the surfaces of the revolving rollers T, T^1 being parted asunder by a space of about $\frac{1}{16}$in., which occurs in the event of a wire drop-pin S falling from a severed thread, and passing between them. To permit of the rollers being thus separated, one of them (T) is mounted in fixed bearings, whilst the other roller (T^1) is mounted in swing bearings formed respectively in two vertical arms *a*, situated one on each side of the machine, and mounted freely upon studs *b*. The upper ends of arms *a* are connected to opposite ends of a thick cross-bar *c*, to cause them to act in unison, and so keep the axes of the two rollers always parallel. One of the two vertical arms *a*, which is situated on the driving side of the machine, extends for a short distance below the gudgeon of the roller T^1, which it supports, and terminates with a short horizontal arm on the end of which there is bolted an adjustable lug *d*, that projects immediately before the hook of the trigger-rod M near the top.

Hence, if the machine is in operation, and the cross-bar *c* is pushed backward by the attendant, or in the event of a thread breaking and allowing its drop-pin to fall and pass between the revolving rollers, the free roller T^1 is thrust slightly forward, thereby causing the lug *d* to push the trigger-hook M off its retaining ledge O, to permit of the oscillation of arms F, F^1, and the curved lever K, whereby the frictional driving clutch is disconnected, and the machine stops.

§ 138. It is a high tribute to the inventor of this device that, although it was patented in 1869, it still holds the premier position as an automatic thread-stop device for beam and other types of tape warping machines. It is, however, attended with the following disadvantages: After prolonged use the wire drop-pins become thinner, and therefore ineffective, by their frequent crushing between the iron rollers; but the cost of their replacement with new drop-pins is negligible. The motion is liable to failure when drop-pins fall between the rollers at or near the end farthest from the trigger-rod, in which event the rollers may not part equally all across, but remain in contact or part insufficiently on the trigger side of the machine, and thereby fail to release the trigger-hook from its retaining bracket. Drop-pins are liable to be jerked off their threads, especially if the slack yarn is strained up suddenly when restarting the machine. The device permits of the machine being restarted after being stopped by a broken thread releasing its drop-pin, although the attendant may fail to recover and piece the severed thread. This circumstance affords to unscrupulous attendants the opportunity of restarting the machine regardless of missing threads in the warp, to avoid loss of production and wages; but their negligence in this respect involves the curtailment of production at the loom, extra trouble for the weaver, and the risk of imperfections in cloth.

Automatic Measuring and Stop-motion

§ 139. One of several types of devices applied to beam-warping machines for the purpose of stopping the machine after winding a prescribed length of warp is that represented in Fig. 44(*a*). This device consists of a scroll disc *e*, in fixed combination with a graduated dial-wheel *f*, both of which are mounted together on a stud and operated by a single-thread worm *g* and a worm-wheel *h*, driven by a single-thread worm *j*, mounted on one end of the shaft of the tin measuring roller *k*. In the wide rim of the scroll disc there is cut one complete coil only of a spiral groove that commences near the inner side of the disc, and, after encircling the rim, terminates with a recess *l* near the outer side of the disc.

The function of the scroll disc is to operate a long side lever *m*, pivoted on a stud *n*, which is inserted in a hole bored large enough to permit of the side lever oscillating both vertically and laterally. The extreme end of the long arm of the side lever is hooked and pointed to constitute a "feeler" that rests in the spiral groove of the disc; whilst from the end of the short curved forearm of the side lever there projects a pin *o* that passes immediately behind the trigger-rod M—*i.e.*, on the same side as the trigger-hook—so that the oscillation of the side lever will release the trigger-hook from its retaining ledge O, and thus cause the machine to stop.

This occurs, in respect of the present device, whenever the zero-point (5000) on the dial-wheel *f*, and also the recess in the rim of the scroll disc *e*, reach their zenith, when the pointed end of the side lever falls into the recess. The length of yarn wound on to a warpers' beam during one revolution of the dial-wheel and scroll disc constitutes a length-unit termed a "wrap."

§ 140. The number of yards contained in a "wrap," however, is optional, and varies with different devices according to the relative number of teeth in the dial-wheel *f* and worm-wheel *h*, which in the present device have 100 teeth each, to produce a "wrap" representing 5000yds. for each revolution of the scroll disc and dial-wheel. Thus, since the circumference of the tin measuring roller *k* is 18in., one revolution of the scroll disc represents $\frac{100 \times 100 \times 18}{36} = 5000$yds. per "wrap."

After the completion of each "wrap" the attendant raises the feeler out of the recess of the scroll disc and returns it to its initial starting point in the spiral groove before commencing the next "wrap." Therefore, as the scroll disc revolves, the point of the feeler moves slowly outward, under the guidance of the scroll, across the rim of the disc, until the recess in the disc reaches its zenith, when the descent of the feeler immediately releases the trigger-hook to stop the machine.

If each of the warpers' beams in one set is required to contain, say, three complete "wraps" of 5000yds. each, plus 3500yds., to obtain a length of 18,500 yds. on each beam the attendant would, before commencing each beam, first withdraw the dial-wheel *f* out of gear with the worm *g*, and replace it with that particular tooth which is opposite the number 1500 on the dial-wheel in the absolute zenith. Therefore, when the recess in the scroll disc reaches its highest point, the feeler descends and stops the machine after warping the odd length of 3500yds., after which the three complete "wraps" of 5000yds. each are wound in succession to produce 18,500yds.

Length Indicator

§ 141. In addition to the measuring device just described, the machine is also provided with a length indicator with the object of showing, at sight, precisely the length of yarn wound at any period during the progress of warping, thus serving to guard against the risk of winding unequal lengths of warp on the several warpers' beams constituting one set. This precaution is necessary to avoid waste, as all yarn wound in excess of the shortest length of warp contained on those beams would be quite useless.

The length indicator under present notice consists of a dial *p*, on the face of which are printed two separate circular scales—namely, an outer scale graduated in units up to 100yds., and an inner scale graduated in hundreds up to 5000yds. The two scales are each traversed by separate index fingers controlled by worm and worm-wheel gearing operated from a small pinion wheel mounted fast upon the shaft of the tin measuring roller *k*, at a point between the machine framing and the worm *j* that operates the measuring device. The index fingers are adjustable, separately, by means of two milled-edged finger wheels *s*, so that both fingers may be set quickly to zero on their respective scales before commencing each successive warpers' beam.

After setting the fingers to zero they are secured by means of two small screws *t* to prevent them from slipping accidentally on their respective axes. The setting of the long finger, which indicates yards, in units, is facilitated by the attendant pressing forward a stop-pin *q*, projecting from the upper end of a small flat spring riveted on the rear of the dial case. The stop-pin penetrates small holes that pass through both the dial case and the dial, so that on being pressed forward it projects sufficiently in front of the dial face to stop the long finger exactly opposite zero on the outer scale.

YARN-TENSION DEVICE

§ 142. The type of yarn-tension device in the machine represented in Figs. 44(*a*) and 44(*b*) is that consisting of two or three light tin rollers u, u^1, from the ends of which project short shafts that freely enter vertical slots extending from the top to the bottom of the framing on each side of the machine. These slots are wide enough to permit of the tension rollers revolving, and also of moving quite freely in a vertical direction, but not horizontally. The tension rollers extend across the entire sheet of threads, by which the rollers are supported so long as the machine is in operation, and whilst the yarn is therefore submitted to a certain degree of tensile strain.

If, however, the driving gear is put out of action to stop the machine, the tension rollers descend immediately and thereby take down the threads as these continue to be delivered temporarily from the warpers' bobbins, after the warper's beam stops, and until the momentum of the bobbins is expended, when they cease to revolve. The tension rollers also serve to take down the threads and thereby keep them under tension, whenever it is necessary for the attendant to unwind yarn from the beam for the purpose of recovering the lost ends of broken threads that may have passed on to the warper's beam before it ceases to revolve, after the operation of the thread-stop device.

When reversing the beam, the sheet of threads droops on each side of a central tin roller *v*, which is mounted freely in stationary bearings. By these means it is possible to unwind from the beam about 4yds. of warp before the tension rollers reach the bottom of their respective slots, as indicated by dotted lines in the diagram.

ADJUSTABLE REEDS

§ 143. In any operation of winding an expanded sheet of parallel threads on to a flanged block, tube or beam, it is essential that the width of the sheet of threads, and the width between the beam flanges, should correspond with absolute precision, and also that the threads should be directed exactly between the flanges. Any irregularity in this respect will produce trouble when the threads are withdrawn subsequently, in consequence of the unequal tension that will be imparted to them.

For this reason, the half-reed or comb R, situated in front of a beam-warping machine, is invariably constructed so that it is capable of being expanded or contracted in width to adapt the sheet of threads to correspond exactly with the width of beam on which they are to be wound, and is also mounted in such a manner that by turning a hand-wheel on the end of a worm-shaft it may be adjusted bodily in a lateral direction so as to direct the threads with absolute precision between the beam flanges. The wire dents of the front reed are also sometimes inclined slightly to one side, thus //////, with the object of spreading the yarn into a more evenly distributed sheet of threads as these pass on to the warper's beam, in a manner similar to that sometimes adopted in slasher-sizing machines, and for the same purpose, as described subsequently in § 273.

The back reed *r*, which is fixed in the extreme rear part of the machine to distribute the warp-ends immediately before they pass on to the surface of the tin measuring roller, is also sometimes constructed so that it may be varied in width. Unlike the front reed, however, which is open at the top, the back reed is covered over with a wooden cap. This precaution is observed in order to give greater strength to the reed, and also to guard against the risk of warp threads slipping out at the top of the dents. The expansion or contraction of the adjustable reeds R and *r* is effected by turning the milled-edged hand-wheels R^1 and r^1 respectively. Each of these reeds is furnished with two adjusting wheels R situated one at each end and fixed at opposite ends of a long worm shaft.

The construction of an expansible and contractible reed of this type is illustrated by a front and an end elevation in Fig. 45, in which A represents the long worm shaft, one half of which is formed with a right-hand thread, and the other half with a left-hand thread. Mounted one on each half of this shaft are two traveller brackets B

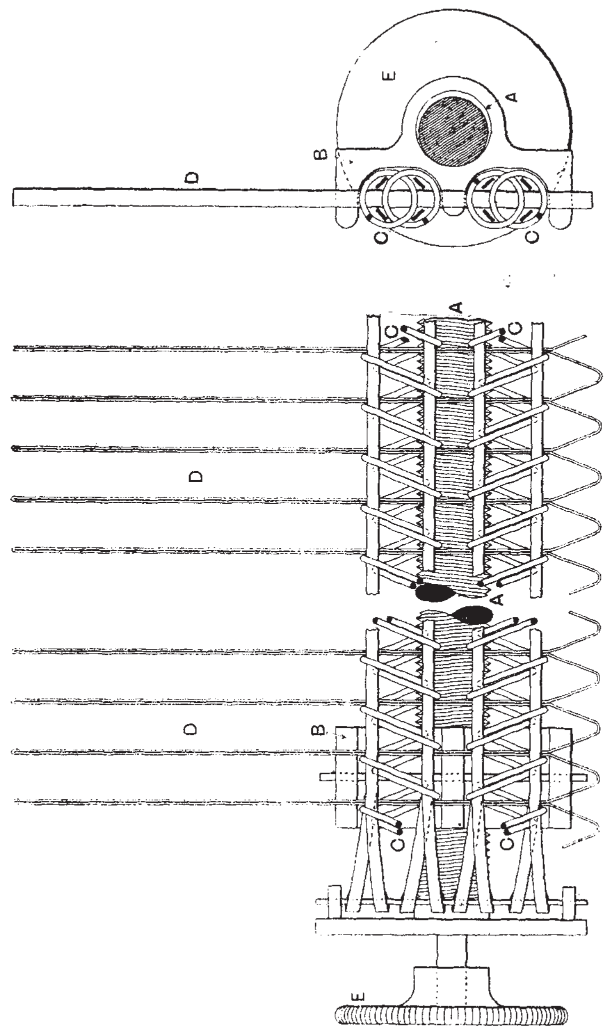

Fig. 45.—Adjustable Reed.

to which are attached the opposite ends of two pairs of intertwined spiral springs C. The successive coils of these springs are intersected by a continuous strip of reed wire which is bent and folded in such a manner as to constitute a series of successive dents to form the reed D. Hence, by turning the adjusting wheel E, the dents of the reed will either expand or contract equally from the central dent, according to the direction in which the worm shaft is turned.

SPECIAL ATTACHMENTS

§ 144. Two devices invented by Hitchon, and which are incidental to Singleton's automatic thread stop-motion, described in §§ 136-138, are those represented by an end and a front elevation in Figs. 46 and 47 respectively. One of these devices relates to a method of driving the drop-pin rollers of the thread stop-motion, so that the gearing will be put out of and into action automatically on stopping and starting the machine respectively.

This is effected by means of a frictional driving clutch (shown in section) of which the driving disc V^1 is fixed on the drum shaft A, whilst the driven disc V, which also constitutes a bevel-wheel, is mounted freely on that shaft, and drives the rear drop-pin roller T through the medium of an inclined shaft U and bevel-wheels W, Y and Z. The outer edge of the hub of the bevel friction wheel V^1 abuts against the bearing P^1, which also, in this instance, constitutes one of the two sleeves, each formed with an inclined edge, and of which the sleeve P^1 is usually fixed to the machine framing.

In the present case, however, the entire sleeve bearing is capable of a slight side movement on the drum shaft, though it cannot revolve. Hence, on depressing the footboard, the second and free sleeve P oscillates on the drum shaft, thereby forcing the main frictional driving pulley B against the fixed flange C, to put the machine into operation, and also the bevel friction wheel V against the fixed disc V^1, simultaneously. One advantage of operating the drop-pin rollers in this manner is that it prevents the end-strain on the drum shaft, which defect exists when the sleeve P^1 and the contiguous bearing are immovable.

Another minor detail, indicated in Fig. 47, is the application of a ball bearing at a point K^1 between the sleeve of the operating lever K (which, normally, is stationary) and the hub of the main frictional driving pulley B, which revolves continuously. The object of this ball bearing is to reduce the frictional resistance between those parts when the machine is in operation.

§ 145. The machine represented in Figs. 46 and 47 is also equipped with another ingenious contrivance applied with the twofold object of increasing the sensitiveness of the thread-stop device, and also of permitting lighter wire drop-pins being suspended upon the warp threads, which are therefore less liable to break during the operation of warping. This device also prevents the drop-pin rollers from failing to operate wherever a wire drop-pin passes between them.

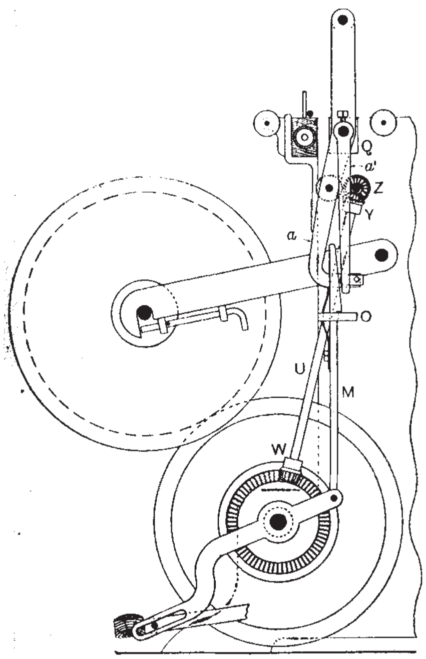

Fig. 46.

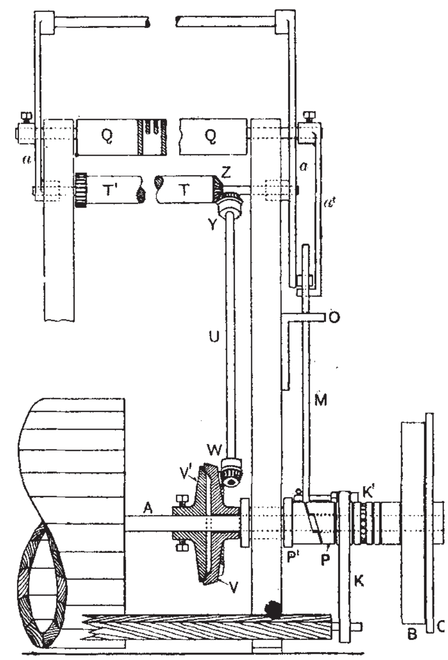

Fig. 47.

It was stated previously, in § 138, that in the event of a drop-pin passing between the rollers at or near the " off " end of the machine (*i.e.*, farthest from the trigger-rod M), the rollers are liable to part insufficiently on the driving side, and thus fail to release the trigger hook from its retaining bracket O to disconnect the driving gear and stop the machine. With the device under present notice, however, this failure of the drop-pin rollers to perform their function is averted by providing the wire drop-pin grid Q with end gudgeons, and mounting these in bearings to permit of that grid oscillating slightly in response to the action of the front and free drop-pin roller T^1. Thus, one of the two vertical arms *a* on which that roller is mounted (namely, that on the " off " end of the machine) is fixed securely to the gudgeon on the same end of the grid; whilst the gudgeon on the driving side of the machine passes quite freely through the corresponding arm *a*, on that side, and which extends downward to pass in front of the trigger-hook M, for the purpose of releasing it from its retaining bracket to put the driving gear out of action. In addition to the releasing arm *a*, a supplementary arm a^1 is fixed securely to the gudgeon on that end of the grid, and which also extends downward for the purpose of releasing the trigger-hook.

By this means, in the event of wire drop-pins passing between the two revolving rollers T, T^1, at or near the trigger end, the releasing arm *a* will liberate the trigger-hook in the usual manner; but if the drop-pins should pass between those rollers at or near the " off " end, the forward movement of the front roller at that end causes a slight oscillation of the grid in such direction as moves the supplementary arm a^1 forward to release the trigger-hook, and thus causes the machine to stop. If, however, the drop-pins pass between the rollers about midway, these part asunder equally for their entire length, and thereby move both releasing arms forward simultaneously to release the trigger-hook from its retaining bracket.

Brimelow's Automatic Thread Stop-motion

§ 146. Some beam-warping machines are constructed with Brimelow's stop-motion to stop the machine automatically when a thread breaks during warping. This invention, which was patented in 1885, and therefore succeeded that of Singleton's by a period of about sixteen years, was adapted specially for use with " falling-rod " machines of the kind described subsequently in §§ 159 and 160, and was conceived with the object of avoiding the disadvantages of its predecessor, as described previously in §§ 136-138; and although it is more intricate, and therefore more costly to apply to a machine, it is nevertheless adopted by some manufacturers.

A beam-warping machine constructed with this invention is represented by a front elevation in Fig. 48, whilst the details and

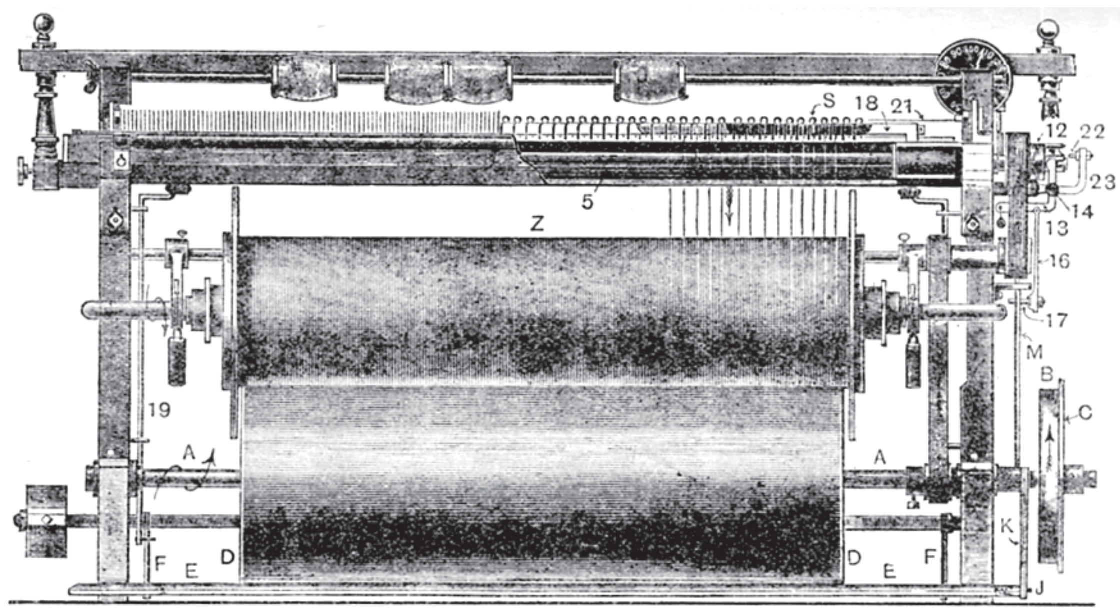

Fig. 48.—Beam-warping Machine with Brimelow's Automatic Stop-motion.

operations of that device are indicated by sectional diagrams 1 to 4 in Fig. 49. The first diagram, on the right of Fig. 49, represents a part sectional front elevation; the second and third diagrams are part sectional end elevations showing corresponding parts in the different relative positions which they occupy when the machine is stopped and when it is in operation respectively; whilst the fourth diagram represents a plan, also a front and two side elevations of the peculiar form of wire drop-pin employed with this device, and which is here drawn on a larger scale.

In combination with other parts of this invention is a multi-vaned or winged roller 5, furnished with either six or eight vanes or wings 6. These lie parallel with the roller axis, and are fixed at an equal distance apart around the circumference, from which they radiate at a tangent. In its progress from the creel to the warper's beam *z* the yarn passes about 3 inches above the winged roller, at which point each thread supports a light wire drop-pin S. These drop-pins are each formed with a large loop at the top, for the reception of a thread, and with a long and short leg.

When the machine is in operation, the winged roller revolves slowly; but in the event of a thread breaking, it releases its drop-pin, which falls a sufficient distance to cause the longer leg to hang in the path of the revolving vanes of the winged roller, as represented in diagram 3, thereby arresting the rotation of that roller, and thus putting into operation the thread-stop device to effect the stoppage of the machine. From each end of the winged roller, and fixed securely to it, is a short gudgeon 7, both of which are mounted in bearings so that the axis of the roller always occupies the same definite position, as indicated by the dotted line 8.

The gudgeon at that end of the roller farthest from the driving side of the machine (not shown) revolves in an ordinary fixed bearing; but that on the driving side, which is longer, passes freely first through a long sleeve 9, which forms the hub of a flanged belt pulley 10 (shown in section, Fig. 49), and thence through a shorter sleeve 11. This is capable of sliding horizontally on the roller shaft, though both must revolve together by reason of a float key that is fixed into the shaft, entering a keyway cut into the sliding sleeve 11. The pulley 10, which is driven by means of a belt from a small pulley mounted on the drum shaft A (Fig. 48), gears with, and drives, the sliding sleeve 11, through the medium of a V-clutch 12, one member of which is cast on the outer side of the pulley 10,

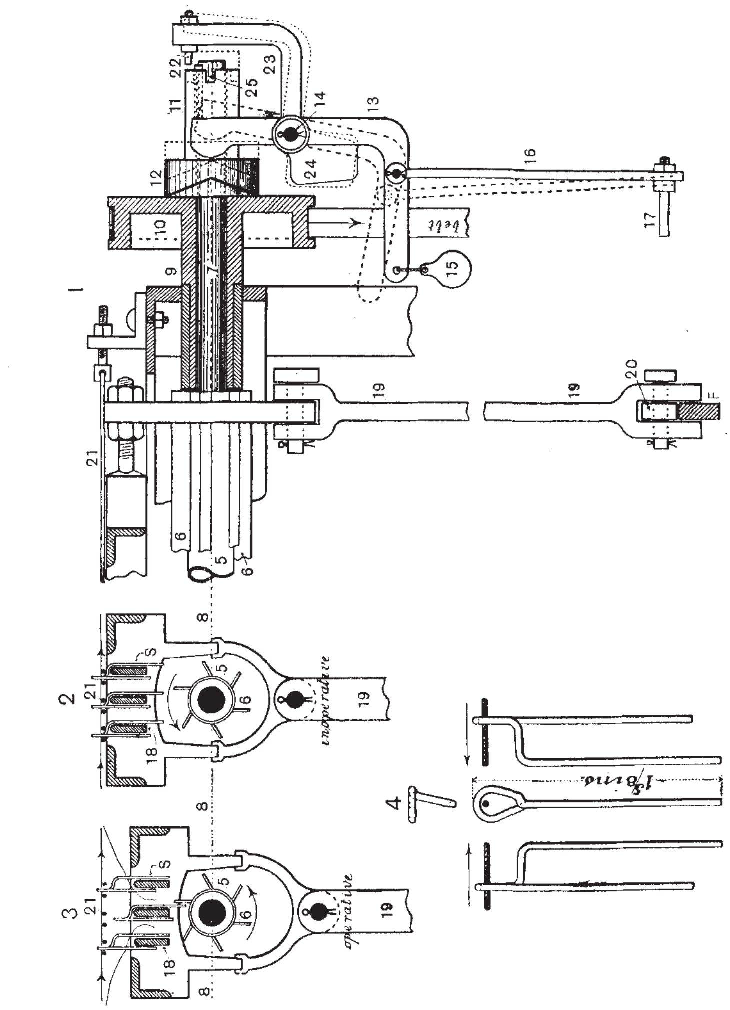

Fig. 49.—Brimelow's Automatic Stop-Motion.

whilst the counterpart of the clutch is cast on the inner end of the sliding sleeve.

Therefore, so long as the clutch is in gear, as shown by full lines, the winged roller will be rotated through the medium of the free half of the clutch; but, on the breakage of a thread, the rotation of the roller and sliding member of the clutch is arrested by one of the vanes of the roller encountering the long leg of the fallen drop-pin. The pulley 10, however, continues to revolve until its part of the clutch forces the loose counterpart of the clutch outward, thereby causing them to become disengaged, and at the same time stopping the machine.

This is accomplished in the following manner: The upper end of the vertical arm of an elbow lever 13, which is hinged on a stud 14, bears constantly against the side of the sliding member of the clutch, and always tends to effect the return of that member to its normal active position after being thrust outward. It is assisted in this action by means of a weight 15, suspended from the end of the horizontal arm, from which there depends a rod 16. At the lower end of this rod is a stud 17, which communicates with the trigger hook M. Thus, as the free member of the clutch is forced outward, it acts upon the elbow lever, which raises the rod 16, and causes it to release the trigger hook from its retaining bracket O, thereby disconnecting the frictional driving clutch B and C to stop the machine.

The wire drop-pins S are distributed uniformly over three flat pin-bars 18, to prevent overcrowding. These pin-bars are contained in a framework supported at each end by means of vertical rods 19. Each of these rods is furnished at its lower end with a runner or bowl 20, that rests respectively upon the arms F, on the forward ends of which the footboard E is carried. Thus, on the ascent of the footboard, when the machine becomes inoperative, the pin-bars 18 also ascend and support the wire drop-pins entirely, as represented in the diagram 2; but on depressing the footboard to put the machine into operation the pin-bars descend by gravitation, and again leave the drop-pins suspended by their respective threads, as indicated in the diagram 3.

If a beam-warping machine is equipped with this device, it cannot be restarted after the breakage of a thread, so long as a drop-pin is allowed to remain on a pin-bar. It is imperative, therefore, on the part of the attendant to recover and piece the broken thread, and to pass it through the loop of the drop-pin to keep it clear of the vanes of the winged roller. Also, the tendency of drop-pins to be dragged forward, or jerked off the pin-bars, by the threads, is effectually checked by means of thin wires 21 stretched above the pin-bars, and immediately below the path of the yarn, so that a wire passes both in front of and behind each row of drop-pins.

Further, the efficiency of this stop-motion is enhanced by an ingenious contrivance that ensures the ready and automatic return of the free member of the clutch 12, to lock in its normal working position on restarting the machine. This is effected by means of a stop-pin 22, fixed at the upper end of an arm 23, which is hinged upon the boss of the elbow lever 13, and unevenly balanced by means of a weighted end 24, which always tends to fall, and thereby cause the stop-pin to assume its present normal position.

The outer end of the clutch sleeve is formed with several notches, 25, large enough to receive the stop-pin 22. Therefore, if, when restarting the machine, the free member of the clutch begins to revolve before it has returned completely to its normal working position, the elbow lever 13, with its stud 17, will be prevented from descending sufficiently to permit of the trigger hook M springing on to its retaining ledge O. Hence, the free member of the clutch will revolve only until a notch in that clutch sleeve comes opposite the stop-pin 22, when this will immediately enter the notch and thus arrest the premature rotation of the free member of the clutch until both members assume such relative positions as will permit of the free member of the clutch sliding home and locking properly with its counterpart, and thereby enable the machine to be restarted.

Hitchon's Combined Length Indicator and Stop-motion

§ 147. It was observed in § 141 that all yarn wound in excess of the shortest length of warp contained on the back beams constituting one set will become waste. Hence the necessity of producing those beams with an exactly corresponding length of warp on each. In some beam-warping machines, as represented in Fig. 44(*a*), that object is effected by means of a length indicator operating in conjunction with a measuring motion adapted to stop the machine after warping each successive " wrap " of 5000yds., after which the device requires readjusting each time before the machine is restarted for a succeeding "wrap." The same object, however, may be attained with less vigilant attention and greater precision by some devices that combine the functions of a length indicator and a measuring and length stop-motion, of which there are various modifications of several distinctive types that are in more or less general use, and of which the motion designed by Hitchon, for that purpose, or some modification of that motion, is adopted very extensively. This simple and efficient device requires only one adjustment, which is easily and readily effected before commencing each successive warper's beam.

A general view of this device is illustrated in Fig. 50, which represents a broken elevation of the driving end of a beam-warping machine; whilst the details are better exposed in Fig. 51, which also shows (detached) a rear view of certain parts. This ingenious device is designed to release the trigger hook M from its retaining bracket O, and thus stop the machine only after the prescribed length of warp has been wound on to the beam.

This object is effected by means of a simple combination of wheel gearing and levers operated by the rotation of the tin measuring roller K, which controls both the length indicator and the automatic stop-motion. The precise length of yarn wound at any stage during the operation of warping is recorded at sight by the relative positions of a graduated dial p, a recording finger l^1 which traverses the dial, a stationary zero pointer q^2 and a sector rack e.

Both the dial plate and recording finger revolve always in the same direction as each other, but each with a slightly different velocity, which is in the ratio of 50revs. of the dial to 51revs. of the finger, corresponding to one "wrap" of 5000yds. The dial plate is graduated with two separate scales—namely, an outer scale, to indicate, by the aid of the stationary pointer q^2, the number of yards, in units, up to 100; and an inner scale to indicate, by the aid of the dial finger, the number of yards, in hundreds, up to 5000.

§ 148. The operation of this device is effected by means of a single spiral worm j, on the end of the measuring roller shaft, gearing with a worm wheel h, of 24 teeth, carrying a small bevel pinion g, of 12 teeth. This gears with a large bevel wheel f, of 100 teeth, containing the dial plate, and on the hub of which is carried a pinion wheel

f^1, of 51 teeth, from the front of which there projects what may be termed a " peg " or " riding " tooth f^2.

The dial pinion gears with a carrier wheel m^1, of 50 teeth, having a wide rim and mounted on a stud fixed in the short arm of an elbow lever q fulcrumed on a stud q^1, and from the front of which carrier

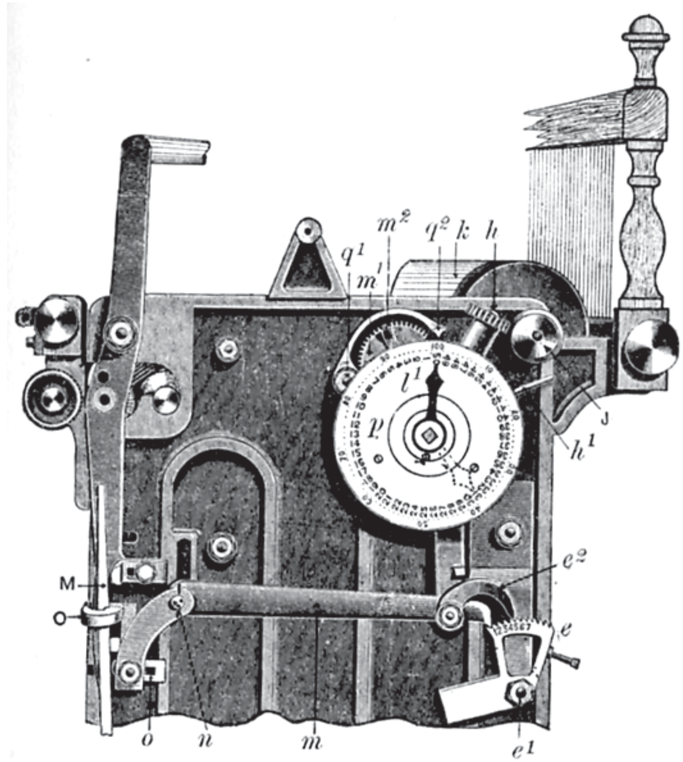

Fig. 50.—Automatic Measuring and Stop-motion.

wheel there also projects a " peg " or " riding " tooth m^2. The carrier wheel m^1 also gears with another wheel l, of 50 teeth, constituting the finger wheel. This is mounted immediately behind the dial pinion f^1, and on the rear end of a spindle shaft, which passes quite freely through the sleeve hub of the dial wheel, to receive on its forward end the recording finger l^1.

Therefore, as the measuring roller is 18in. in circumference, it will require to make 200revs. to 1rev. of the dial, and $1\frac{1}{50}$rev. of the recording finger l^1 for every 100yds. of warp wound, thus:—

$$1\text{rev. of dial} = \frac{\overset{f}{100} \times \overset{h}{24} \times \overset{k}{18\text{in.}}}{\underset{g}{12} \times \underset{J}{1} \times 36\text{in.}} = 100\text{yds.}$$

also:—

$$1\text{rev. of dial} = \frac{\overset{f^1}{51} \times \overset{m^1}{50}}{\underset{m^1}{50} \times \underset{l}{50}} = 1\tfrac{1}{50}\text{rev. of finger.}$$

Hence, if the machine is put into operation with the wheels gearing as indicated in the diagram, and with the dial and finger both set to zero under the stationary pointer q^2, these will both revolve in the direction indicated by the full arrow. After the first 100yds. of warp, corresponding to one revolution of the dial, the finger will point to the figure 1 on the inner or "hundreds" scale on the dial, to indicate 100 yds.; then to the figure 2 (200yds) after the second revolution of the dial; and so on for each successive 100yds. until there is wound the first "wrap" of 5000yds., during which the dial has made 50revs. and the finger 51revs., and both are again together under the stationary zero pointer q^2.

Whenever the zero point on the dial, and also the recording finger, reach their zenith immediately below the stationary zero pointer, the projecting peg or riding teeth f^2 and m^2 on the dial pinion f^1 and the stud carrier wheel m^1 are timed to encounter each other. When this occurs, the obstruction of the riding teeth forces the carrier wheel m^1 slightly away from the dial pinion f^1, thereby causing the elbow lever q to oscillate for the purpose of propelling the sector rack e intermittently as each successive "wrap" is completed, and finally to put the machine out of action after the prescribed length of yarn is wound.

This is effected in the following manner: On the lower end of the longer and curved arm of the elbow lever q is a stud on which is freely hinged a pawl e^2 which engages with the teeth of the sector rack e. This is fulcrumed freely on a stud e^1, and contains eleven notches, of which the first seven are numbered consecutively from 1 to 7. The sector supports the free end of a long side lever m,

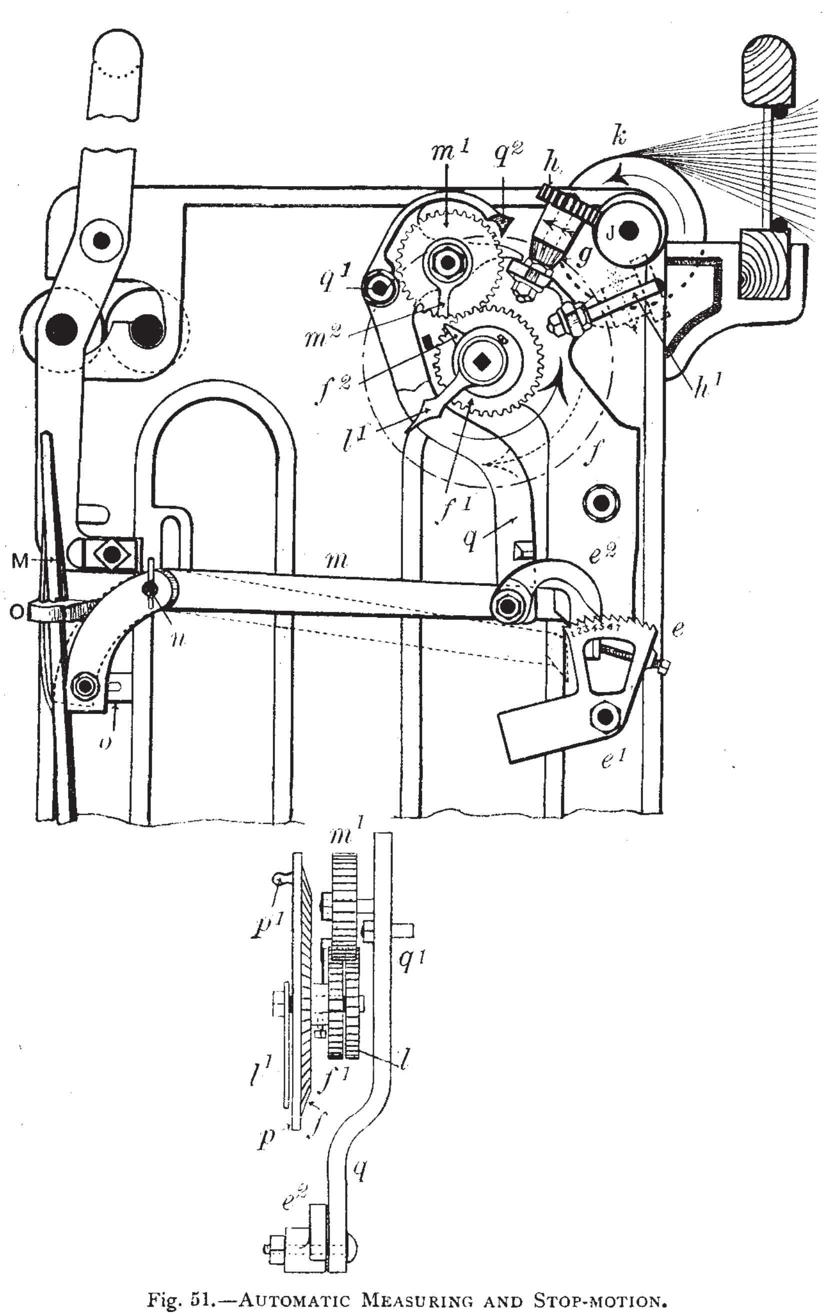

Fig. 51.—Automatic Measuring and Stop-motion.

fulcrumed on a stud *n*. The short downward curved forearm of the side lever is furnished with a short pusher *o*, that projects immediately behind—that is, on the hooked side of—the trigger rod M, so that the oscillation of the side lever will release the trigger hook from its retaining ledge O, to stop the machine.

Thus, at each impulse of the elbow lever *q*, the sector rack is propelled one tooth until it is pushed away entirely from underneath the "feeler" end of the long side lever, which then falls and causes the machine to stop, as described.

§ 149. If the length of warp to be wound on each of the several beams constituting one set includes a fractional part of a "wrap," it will be necessary for the attendant, before commencing, to readjust the dial and finger, and also the sector rack and side lever. But if the beams are to contain a complete number of "wraps," the dial and finger will both reach their initial position at zero when the machine stops, so that the sector and side lever only will require re-setting.

If the total length of warp is to be 28,100yds., this is equal to $28{,}100 \div 5000 = 5\frac{3100}{5000}$ "wraps." In that case, the compound worm wheel *h* and bevel pinion *g* would first be removed from their stud; then, by means of a small knob p^1 projecting from the zero meridian of the dial, this would be turned by hand, preferably in a clockwise direction, until the recording finger pointed to 31 (3100) on the inner or "hundreds" scale of the dial, as indicated by dotted lines, and with zero (100) on the outer scale exactly under the stationary zero pointer q^2. The worm wheel and bevel pinion would then be placed into gear, temporarily, on the "reversing" stud h^1, to revolve the dial and finger in the "reverse" direction, as indicated by the dotted arrow in Fig. 51. The pointed end of the side lever is next inserted in the *first* notch of the sector rack as indicated, when the machine is ready for starting.

With the first revolution of the dial, the finger will pass from 31 to 30; after the second revolution the finger will point to 29, then to 28, and so on retrogressively until both the finger and zero point on the dial are coincident simultaneously with the stationary zero pointer q^2, when the fractional length of 3100yds. will then have been wound.

Whenever this coincidence of parts occurs, the projecting peg or riding teeth on the wheels f^1 and m^1 meet, and cause the elbow lever *q* to propel the sector one tooth, and thus release the side lever *m*, which falls, and thereby stops the machine. After this the worm wheel *h* and bevel pinion *g* are replaced on the "forward" stud; also, the pointed end of the side lever is, on this occasion, inserted in the *fifth* notch of the sector rack, with the pawl e^2 resting in the ninth notch. The stop-motion will not again operate to stop the machine until the remaining five "wraps" are wound. Thus, on the completion of the first "wrap," with the dial and finger revolving "forward," the sector recedes one tooth from the fifth to the fourth notch; then after the second "wrap" the sector moves another tooth backwards; and so on for each successive "wrap" until the fifth "wrap" is completed, when the side lever descends to stop the machine.

Instead of readjusting the dial and finger, and also the sector and side lever, at the commencement of each beam, to stop the machine after warping the first length of 3100yds., precisely the same object may be attained with less trouble and attention by starting with the dial finger pointing at the outset to 19 (1900) on the inner scale of the dial, because $5000 - 3100 = 1900$. In this case the worm wheel and bevel pinion would remain on the "forward" stud, and the pointed end of the side lever would be inserted in the *sixth* notch of the sector rack. Hence the side lever *m* will not be released until there is wound a total length of $5000 \times 6 - 1900 = 28{,}100$yds., when the machine will stop automatically.

Driving Gear

§ 150. The prevailing forms of driving gear for beam-warping machines consist of a frictional clutch, or else frictional discs or flanges, mounted on one end of the winding-drum shaft, as represented in Figs. 44(*a*), 44(*b*), and also in Figs. 52, 53, respectively. In both modifications the main driving belt runs continuously on a loose pulley, which also constitutes the free driving member of the clutch, or of the discs, and thus imparts motion directly to the drum shaft. These frictional devices are also sometimes employed in combination with a fast driving pulley, cone drums, and wheel gearing, for differential driving, as represented in Fig. 65. In some machines, however, a loose and a fast driving pulley are mounted on the drum shaft for direct driving, as in the falling-rod machine represented in

Fig. 60; and in others, a loose and a fast pulley are employed in conjunction with cone drums and wheel gearing to impart motion indirectly to the winding drum, as exemplified in the American modification represented in Figs. 62-64.

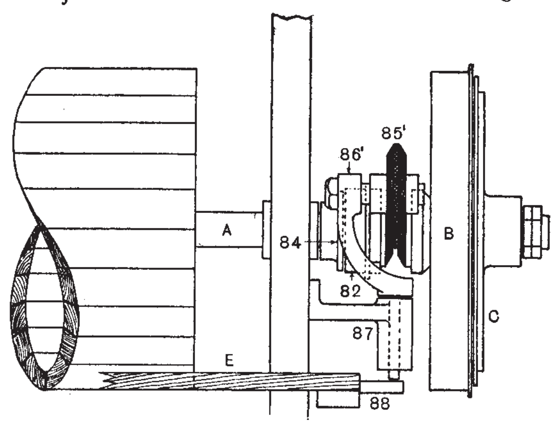

Fig. 52.

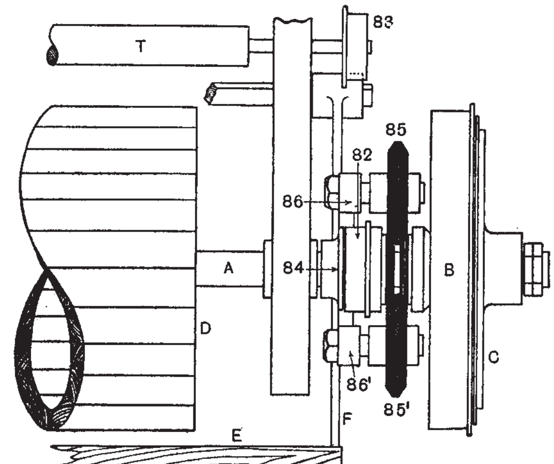

Fig. 53.

§ 151. Whatever particular form the driving gear of a beam-warping machine assumes, however, it should be designed to put the machine into operation gradually, and thus prevent a sudden strain or jerk being imparted to the yarn. At the same time, it should also be capable of being put out of action to stop the machine instantly, in the event of warp threads breaking, and thereby spare the attendant the consequent inconvenience and loss of time in turning backward the warper's beam to recover and piece the broken threads. These two objects have not, up to the present time, been attained successfully, although many attempts have been made to solve the problems involved.

The desired conditions, however, are more nearly approached by the principle of frictional driving than by direct driving through the medium of either a fast pulley or tooth clutches secured to the drum shaft. The advantage of frictional driving power is that it may be applied to overcome inertia gradually, and yet be disconnected instantly. Hence, some inventors have endeavoured to perfect some means of putting the frictional driving gear into operation to start the machine gradually, and to put it out of operation to stop the machine instantly; whereas others have sought to accomplish the same objects by the application of brakes of various forms.

§ 152. The frictional driving gear of most beam-warping machines is controlled by means of the simple device consisting of two sleeves or bosses with inclined edges which are in sliding contact with each other, as described in § 135, with reference to Figs. 44(*a*) and 44(*b*). This device, however, as it is usually applied, has the inherent defect of causing an end-thrust on the drum shaft, and thus creating frictional resistance between the stop-washers on that shaft and its bearings. To avoid this defect, and also to put the machine into operation gradually, the device shown in Figs. 52 and 53 has been designed by Swarbrick & Grimshaw.

In this arrangement a small pulley 82, which drives a pulley 83 fixed on the gudgeon of the rear drop-pin roller T, is mounted freely on the drum shaft between the frictional driving pulley B and a stop-washer 84 fixed securely on the drum shaft. Between the hub of the driving pulley B and that of the smaller pulley 82 there are carried two bevelled rollers or bowls 85 and 85^1, each consisting of two metal flanges separated by a washer of leather or other resilient material.

These bowls are each mounted on separate studs projecting one from each of two arms 86 and 86^1, the lower ends of which terminate in a poker rod that passes through a guide bracket 87 and rests directly on a short arm 88 projecting from the forward part of one of the treadle levers by which the footboard E is carried. Hence, on depressing the footboard the two bowls, 85 and 85^1, descend by gravitation, and thus force the free pulleys B and 82 outward simultaneously. This has the effect of compressing the main driving pulley against the friction plate or disc C, and also the smaller pulley 82 against the stop-washer 84, both of which are fixed securely to the drum shaft. Thus the opposing side-thrusts serve to neutralize each other, and so prevent end-strain, and consequent friction, between the stop-collars and bearings of the drum shaft.

§ 153. Another method of driving a beam-warping machine is that designed by Lancaster, and represented in Figs. 54 and 55. This device is constructed on the principle of positive driving by means of ratchet-tooth clutches, and is also designed to prevent end-strain on the drum shaft. It has the serious defect, however, of putting the machine into operation at full speed instantly, instead of gradually. Thus, the outer end of the hub of the main driving pulley B and that of the smaller pulley 82, which drives the drop-pin rollers, are each formed with ratchet teeth to gear with similar teeth formed in two stop-collars 84 and 84^1 respectively, that are secured to the drum shaft.

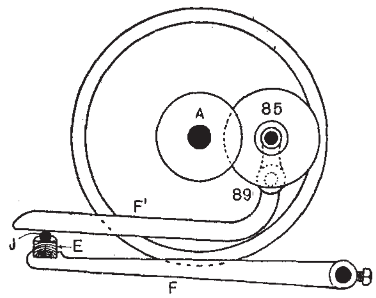

Fig. 54.

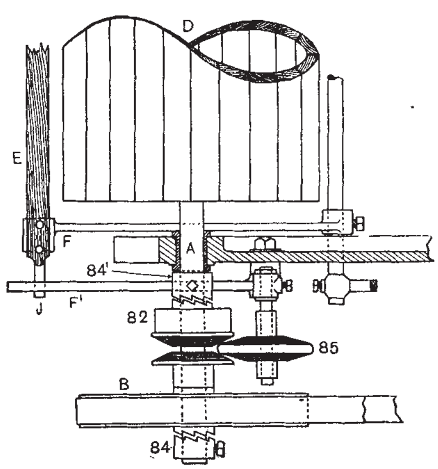

Fig. 55.

The inner ends of these hubs are bevelled to form a V-groove for the reception of a bevelled roller 85 mounted on the upper end of a short vertical arm of an elbow lever F^1. This latter is fulcrumed on a stud 89, and rests with its long horizontal arm bearing on a stud J projecting from one end of the footboard E. Hence, by depressing the footboard, the bowl 85 forces the hubs of both the pulleys outward, and thus puts the ratchet-tooth clutches into gear simultaneously.

By this means the machine is put into operation at full speed instantly, and even more abruptly than by the loose and fast pulley method of driving with a movable belt.

Brakes

§ 154. Brakes are adapted to some beam-warping machines to operate in conjunction with the driving gear. They assume a variety of forms, and are designed to meet the special requirements of beam warping, during which the severed ends of broken warp threads are liable to pass on to the beam before the machine stops in response to the automatic thread-stop device. These severed threads may only be recovered by the attendant turning the beam backward by hand, to unwind the yarn until they reappear on the surface. It is desirable, therefore, not only to stop the machine as quickly as is consistent, but also to leave the beam quite free.

Two brakes that meet these requirements are represented in Figs. 56 and 57. In the first example, as constructed by Messrs Butterworth & Dickinson, Ltd., a long lever F^1, formed with a toothed segment at the rear end, is situated at one end of the machine, and fulcrumed on a stud 90. The segment gears with a wheel 91, to which is secured a cam 92, which operates a bowl 93. This is mounted on one end of a strong flat spring 94, secured to a brake lever 94^1, fulcrumed on a stud 95. The end of this brake lever farthest from the bowl is furnished with an adjustable socket pillar 96 for the reception of a tongue 97, suspended freely from a stud, to which is secured one end of a band-brake 98. After nearly encircling a brake pulley 99, secured to the drum shaft, the band-brake is attached to a bracket 100 hinged on a fixed stud. As the footboard E descends to start the machine, and ascends to stop it, the quadrant lever oscillates, and thus turns the wheel 91 and cam 92 for a complete revolution, thereby operating the spring lever first to apply the brake and then release it in quick succession.

§ 155. Another form of brake, invented by Stanworth, and represented in Fig. 57, operates only when the driving belt becomes inoperative, to stop the machine quickly. In this device a lever 94 is fulcrumed on a stud 95, and carries, at its rear end, a tongue 93 hinged freely on a stud, so that the free end of the tongue rests upon a ridge or beading 94^1 projecting on one side of the lever. The opposite end of the lever 94 is formed with a slot to receive an adjustable stud, on which there rests the free end of a short arm 96

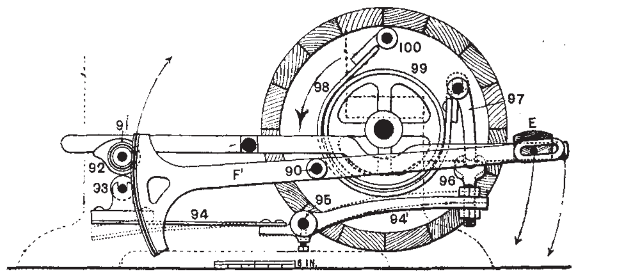

Fig. 56.

fulcrumed on a stud 96^1. To this arm there is attached, by means of a link-rod 97, one end of a band-brake 98, which, after nearly encircling a brake pulley 99, is attached at the opposite end to a fixed bracket 100.

From one end of the cross shaft G, on which the treadle levers

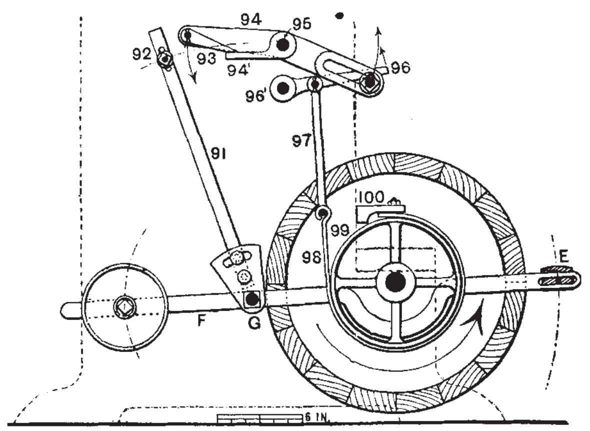

Fig. 57.

F oscillate, and adjustably secured to that shaft, there is a long arm 91 extending upwards, and to the upper end of which there is fixed a stud containing a bowl or runner 92. Thus, by depressing the foot-board E to put the machine into operation, the runner 92 passes underneath the tongue 93 on the lever 94 without effect; but on the ascent of the footboard the runner passes over the tongue, and thereby depresses the rear end of the lever 94, first to apply the brake and then to release it, in immediate succession.

Beam-evener and Retaining Device

§ 156. In most beam-warping machines the warper's beam is usually retained in position against the winding drum by means of the two radial arms *x*, as represented in Fig. 44(*a*). These arms permit of the recession of the beam quite freely as it increases in diameter with successive layers of yarn. With such an arrangement, however, the beam simply bears in surface contact with the drum by gravitation only, with complete freedom of movement vertically. Hence, instead of revolving steadily, the beam frequently revolves with a more or less jolting, bumping and jerky motion, with the result that full beams are sometimes produced which are neither perfectly cylindrical nor of uniform diameter at all points between the beam flanges.

These evils are especially liable to occur when two or more different counts of yarn are employed in the same warp, as in some classes of fancy striped fabrics. In such cases the threads of greater bulk tend to increase the diameter of the beam more rapidly where those threads are placed, thereby producing unevenly-wound beams.

With the object of preventing these defects, some beam-warping machines are equipped with a special form of beam-retaining and yarn-evening device, as illustrated in Figs. 58 and 59, which represent an end elevation and plan respectively of Kay & Rossetter's device fixed in position on a machine. This simple attachment is arranged in duplicate, with one at each side within the machine framing, and it is designed to operate in such a manner that although the beam may ascend quite freely as its yarn diameter increases, yet it cannot descend from whatever altitude to which it may have been raised.

§ 157. The device is constructed on the mechanical principle known as the "silent feed," and consists of a radial arm *x* mounted freely, one on each side of the machine, on either stud-bolts or else a cross-bar *y*. On the inner side of each radial arm, and hinged freely upon stud-bolts a^1, is a pawl or dog-wedge b^1 which enters a concentric V-shaped groove in the rim of a quadrant c^1. This is

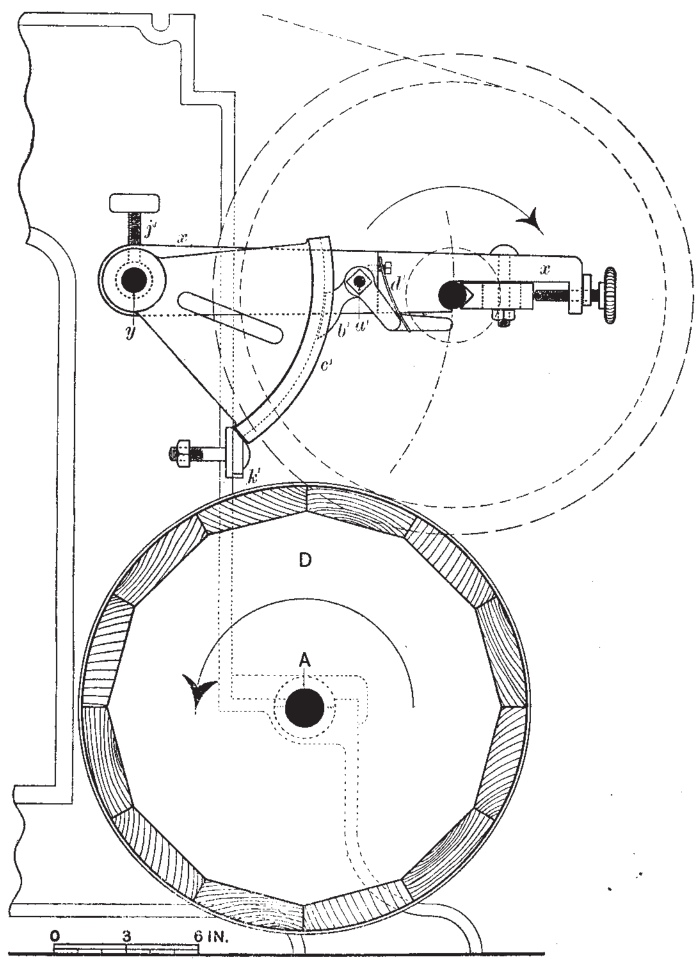

Fig. 58.—Beam-retaining Device.

secured upon the cross-bar y by means of a thumb-screw j^1, and bears against a stop bracket k^1 bolted to the machine side. A flat or blade spring d^1, set-screwed to the radial arm, acts upon the dog-wedge b^1 in such a manner as to cause it to bear constantly and firmly against the sides of the quadrant groove. The point of contact between the quadrant and dog-wedge is situated in such relative position to the stud-bolt on which the wedge is hinged, that although the latter may slide *upward* quite freely along the quadrant groove, yet it cannot descend, as any downward pressure on the radial arm causes the wedge to become still more firmly locked in the groove. Hence, any tendency on the part of the beam to descend is checked immediately.

By thus keeping the warpers' beams under better control during warping it is claimed that they revolve more steadily, and are there-

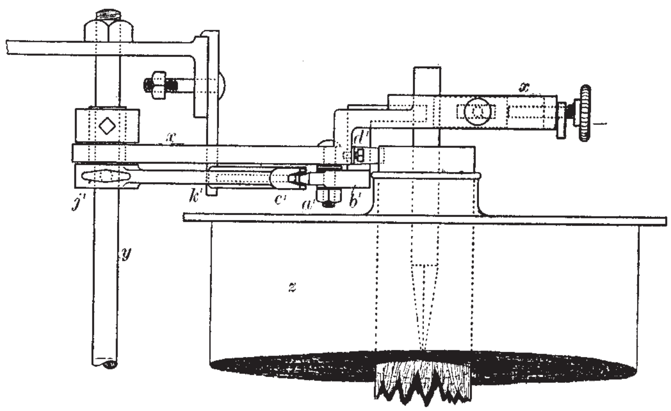

Fig. 59.

fore wound more truly cylindrical; also that they bear downward with a constant degree of pressure upon the surface of the driving drum, thereby winding yarn upon them more compactly and with a more uniform density.

§ 158. Apart from their chief structural modifications beam-warping machines also differ in many minor details, as well as in the numerous accessories with which they are usually equipped, and by which they are specially adapted for particular requirements. Thus some machines are constructed with expansible driving drums that are capable of adjustment, within a range of about 12in., to warpers' beams of various widths between the flanges.

If a machine is intended chiefly for the production of warps to be prepared from yarn of coarse counts, folded, bleached, or dyed yarn, it is furnished with radial beam-retaining arms adapted to receive heavy weights to give additional pressure for the purpose of winding the yarn more compactly on the beams.

A damping apparatus is also applied to some machines employed in the production of grey warps. The object of this device is to " condition " or " age " the yarn by moistening it with water as it passes on to the warpers' beams. The damping of yarn at this stage conduces more effectually to the formation of compactly-wound beams, and also renders it more pervious to the size paste during the subsequent process of sizing.

Several modifications of the V-type of bobbin creel have, within recent years, been introduced. One of these, designed by Tattersall, is effected by hinging the forward portion of one of the two convergent wings. Thus, that portion of the wing containing the first seven or eight vertical rows of bobbins is hinged to enable it to be swivelled outward by the attendant, and so provide more space in that part of the creel, when creeling bobbins.

Another modification, invented by P. Taylor, consists of securing to rotatable vertical ribs one end of all the creel pegs forming each of the respective vertical rows, whilst the free ends of the creel pegs enter freely into short horizontal slots formed in the opposite vertical ribs, which are fixed. The object of this invention is to enable all the creel pegs contained in each of the respective vertical rows to be swivelled simultaneously, in order to facilitate the operation of creeling the warpers' bobbins.

Falling-rod Machines

§ 159. A beam-warping machine in which there are adopted a series of five or six falling tension rods, instead of two or three falling rollers, as were employed in the machine described previously, is illustrated in Figs. 60 and 61, which represent Kenworthy's modification, patented in 1843. This machine also embodies several other constructional features that differ materially from those of the previous machine. For example, this machine is constructed with duplex driving gear consisting of a loose pulley and a fast-driving pulley mounted on each end of the drum shaft to permit of both forward and reverse driving. An open driving belt runs on one pair of

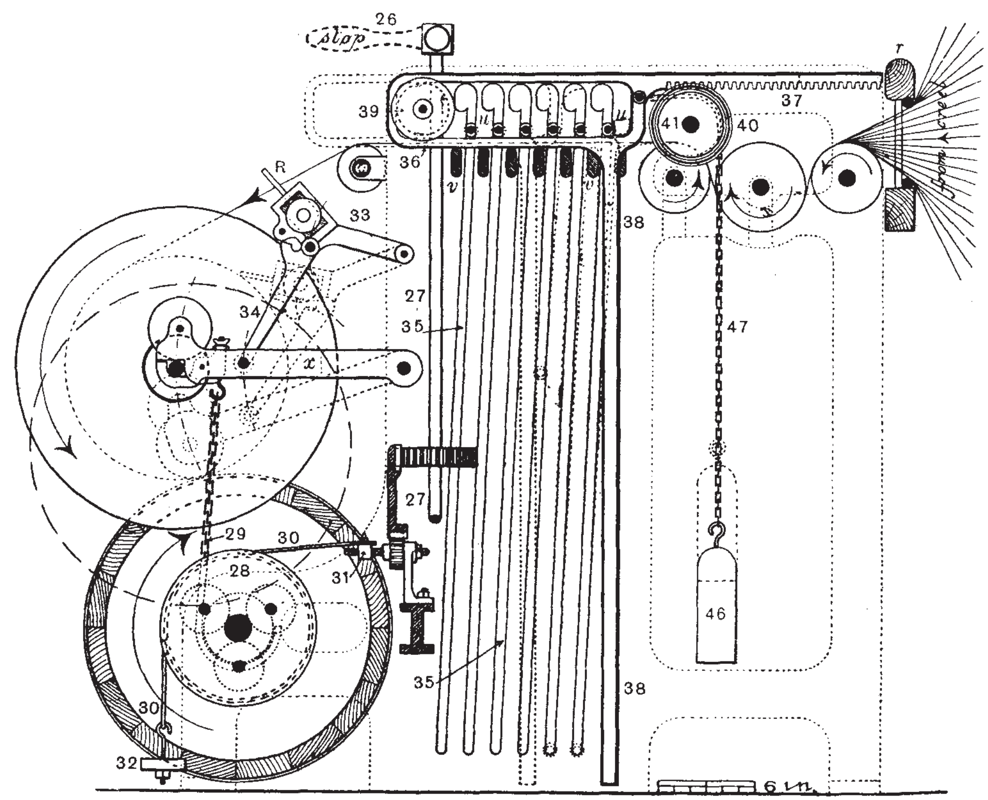

Fig. 60.—Beam-warping Machine—Falling-rod Type.

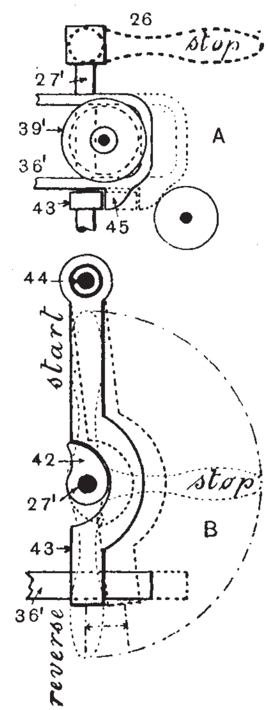

Fig. 61.

pulleys and a crossed belt on the second pair, with each belt under the guidance of separate strap-forks controlled simultaneously by either of two setting-on handles 26. These are fixed respectively at the top of two vertical shafts 27, placed one on each side of the machine, for the convenience of the attendant. The loose pulleys are constructed with rim faces twice the width of the driving belts, and are mounted on the extreme outer ends of the drum shaft, with the fast-driving pulleys on the inside. By mounting the pulleys in either this or the reverse relative position, it permits of both driving belts being transferred simultaneously on to their respective loose pulleys, although only one of the two belts may be passed, at the same time, on to its fast pulley, according to whether it is required to turn the beam forward or backward. The sole purpose of the second pair of driving pulleys is to relieve the attendant of the physical exertion of turning the beam backward by hand, when recovering broken threads.

The machine is also provided with a frictional beam-retarding device for the purpose of retarding the ascent of the beams, and thereby winding yarn more compactly, with the object of obtaining a greater length of yarn on them. This object is usually effected by suspending heavy weights from the ends of the radial arms x that retain the beam in position; but in the present case it is accomplished by means of two band-brakes situated one on each side of the machine, and adapted to exert their influence upon the radial arms. This arrangement consists of a large flanged brake pulley 28, in combination with a smaller pulley (shown in dotted line) fixed on one side of it, and a chain 29. These two pulleys are mounted together quite freely, with a triple-roller bearing, on the drum shaft, between the drum and the side framing of the machine, and do not, therefore, revolve with the drum shaft, but remain practically stationary on that shaft.

A steel band-brake 30 is coiled several times around the rim of the larger brake pulley, with one end attached to a nut 31, and with one or more than one weight 32 suspended from the free and drooping end, according to the amount of frictional resistance desired. One end of the chain 29 is secured to the rim of the smaller pulley, and the other end is attached to a radial arm x, so that as the beam ascends it overcomes the frictional resistance of the brake, and thus retards the ascent of the beam as warping proceeds.

The adjustable half-reed or comb R, situated in front of the machine for the purpose of guiding the yarn between the beam flanges, is not retained on fixed brackets in the usual manner. In the present machine it is carried at the forward ends of two arms 33, that are connected, by means of link-rods 34, to the radial arms *x*, to which the beam pikes are secured. Therefore, as the beam ascends, the half-reed also ascends in unison with it, and thereby always maintains, approximately, the same distance from the point at which yarn passes on to the beam, irrespective of the constantly increasing diameter of the latter. The object of mounting the reed in this manner is to keep it nearer to the warper's beam, whereby it retains much better command over the sheet of warp threads as these pass on to the beam.

Falling-rod Yarn-tension Device

§ 160. The function of the falling rods, like that of the falling rollers in the machines described previously, is to keep the threads under moderate tension, both when the driving gear is put out of action to stop the machine, and the threads continue to be delivered from the warpers' bobbins until the momentum of these is expended, and also when it is necessary to turn the beam backward to unwind yarn for the purpose of recovering broken threads.

Falling-rod machines are employed chiefly for linen and worsted yarns, which are relatively stronger than cotton yarn of similar counts, and therefore less liable to breakage during the operation of warping. For this reason, machines of that kind are not constructed with an automatic thread-stop device. Also, it is found that such a device cannot be employed successfully with worsted yarn, as the oily nature of wool causes the light wire drop-pins of the stop-motion to become clogged with greasy lint, and the pins are, therefore, liable to fail in their function.

The absence of such a device, however, is compensated for by the employment of five or six tension-rods, as compared with only two or three falling rollers in a self-stopping machine. Hence, the greater number of rods enables a proportionately increased length of yarn to be turned backward from a beam whenever that is necessary through the attendant failing to stop the machine before the severed end of a broken thread becomes obscured under succeeding layers of yarn on the beam.

The machine represented by the diagrams is furnished with six falling tension-rods *u*, disposed at intervals of $1\frac{3}{4}$in. apart, in the front part of the machine, and extending horizontally across the entire sheet of threads with the rods only just clear above the yarn. Immediately below the threads, and just clear of them, are seven stationary cross-bars *v* extending across the machine from side to side. These bars are disposed alternately with the tension-rods, and midway between them, for the purpose of supporting the yarn which droops over the bars in a series of long festoons whenever the tension-rods descend. The extreme ends of the falling tension-rods are furnished with small bowls or runners, and also pass freely through long guide-slots 35, extending from the top to the bottom of the side framings, and reclining backward from the base at an angle of $2\frac{1}{2}°$ from the true perpendicular. The guide-slots permit of the tension-rods moving quite freely in a vertical direction, but not horizontally.

The tension-rods are supported at each end, with the runners resting normally upon two side rails 36, erected one on each side of the machine, and mounted in such a manner that they are capable of sliding freely in a horizontal direction. Each of these rails is constructed with a horizontal rack 37, extending rearward, and also with a long vertical arm 38, extending downward to the bottom of the machine.

The side rails are each supported in front by resting respectively upon flanged rollers 39, 39^1 mounted upon short studs; whilst they are supported in the rear by the racks, each resting upon, and gearing with, one of two rack wheels 40 that are fixed at opposite ends of a cross shaft 41. The rack gearing ensures that the side rails move simultaneously and in unison whenever the yarn-tension device comes into operation, both when stopping the machine and when the beam is turned backward to unwind yarn. In either event, the sliding rails advance slowly, and thereby release the tension-rods separately and successively from the rearmost rod, as represented in Fig. 61 A and B.

On one of the two vertical shafts, 27^1, surmounted by the setting-on handles (namely, that situated on the left-hand side of the machine when facing it), there is secured a short curved arm 42, which acts upon a horizontal lever 43. This is fulcrumed at one end upon a stud 44, as indicated in the plan (Fig. 61 B), whilst the free and outward end acts upon a lug 45, that projects a little below the forward end of the sliding rail 36^1, which is situated on the same side of the machine.

Thus, when the setting-on handles are moved from the starting position to either the stopping or reversing positions, the two sliding rails which support the tension-rods are forced forward positively for a short distance, and thereby remove the support of the rearmost tension-rod, which commences to descend slowly by gravitation, and therefore take downward the entire sheet of warp threads to keep them tense.

The rear edges of the sliding rails are rounded off to cause the rods to commence their descent gradually, and thus prevent their full weight being applied to the yarn with a sudden jerk. As the first tension-rod descends it bears against the long vertical arms of the sliding rails, which, when once started, continue to move forward, and thereby release the tension-rods in succession until yarn ceases to be delivered from either the warpers' bobbins or from the beam, as the case may be.

The slight inclination of the guide-slots from the true perpendicular in relation to the vertical arms of the sliding rails, forms a V-shaped support for the tension-rods as these descend, and thereby prevents them from bearing downward with their full weight upon the threads; but as the drooping threads are drawn upwards when restarting the machine, the tension-rods are supported and raised entirely by the threads.

In some falling-rod machines the guide-slots that receive the ends of the tension-rods are quite vertical, in which case the long arms extending downward from the sliding rails are inclined slightly backward from the top to the bottom, with precisely similar results.

When restarting the machine the fallen tension-rods are raised in succession from the front, and on reaching their highest elevation the sliding rails return slowly and pass underneath the tension-rods to support them in their normal position above the yarn. The return of the sliding rails is effected by means of counterpoise weights 46, suspended from chains 47, that pass over guide pulleys on shaft 41, and are attached to the rear ends of their respective sliding rails on each side of the machine, so that the weights pull constantly against those rails.

As each tension-rod is capable of taking down about two yards of warp, it is possible, in the present machine, with six rods, to turn backward from the warpers' beam a maximum length of about twelve yards of warp before all the tension-rods reach the bottom of their respective guide-slots.

American Modification

§ 161. In their outward appearance beam-warping machines of both English and American modifications bear a general resemblance to each other; but they differ in several essential details. The American modification is characterized by (1) differential driving gear operating in conjunction with " slow-speed " or starting gear; (2) a cast-iron winding drum of small diameter, mounted and geared in such a manner as to permit of the warpers' beam flanges overlapping the ends of the drum shaft, which does not, as in the English modification, project beyond the ends of the drum; (3) a *rising* yarn-tension roller; and (4) mechanical gearing to facilitate the hauling of warpers' beams in and out of the machine.

1. Driving Gear

The differential driving gear is designed with the object of driving the frictional winding drum with a gradually-diminishing velocity as the yarn diameter of the beam increases. This reduction in the speed of the drum, and therefore in the rate of withdrawing yarn from the warpers' bobbins, is governed automatically, and regulated so that the completion of each beam coincides with the depletion of yarn from a " set " of full warpers' bobbins, irrespective of the counts of yarn and number of threads being warped.

It is claimed for this method of differential driving that it maintains a constant degree of tension upon the threads by counteracting the additional strain that would otherwise result from loss of leverage upon warpers' bobbins, as their yarn diameter becomes less. Other claims advanced in its favour are that it permits of a higher average speed of warping being attained; and also that there are fewer yarn breakages by running the machine at a slower speed as the yarn diameter of the bobbins diminishes.

The essential parts of the differential driving gear of this beam-

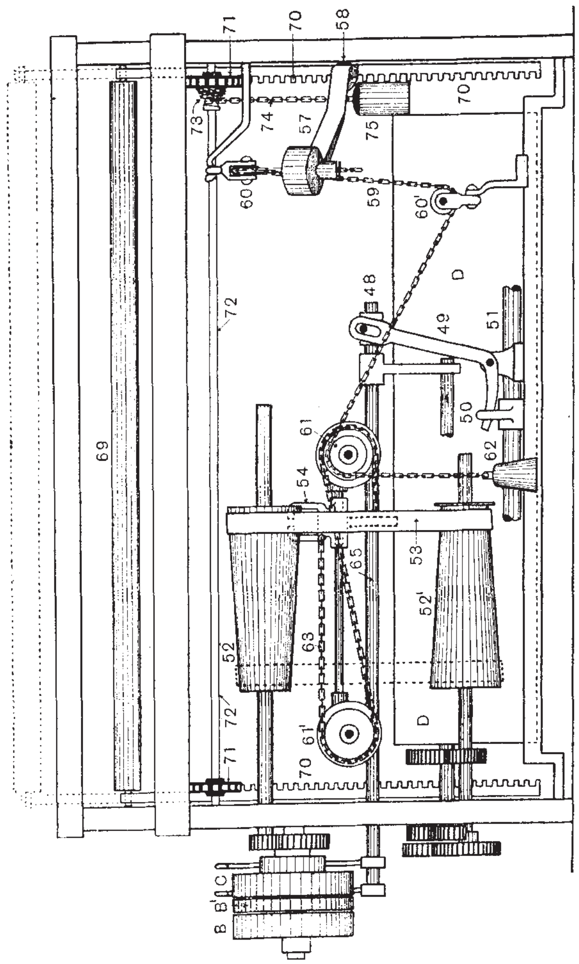

Fig. 62.—Beam-warping Machine—American Modification.

warping machine are represented by a rear elevation and a part plan in Figs. 62 and 64 respectively, which also illustrate the proper sequence of the combined spur-wheel and belt gearing by which motion is transmitted from the fast-driving pulley C to the winding drum D; whilst several parts incidental to this machine are indicated in sectional elevation in Fig. 63.

The main driving belt is under the guidance of a strap-fork fixed at the end of a rod 48, which is controlled by an elbow lever 49 fulcrumed on a stud. The end of the short horizontal arm of this elbow lever passes freely through a slot formed in the end of an arm 50 which is fixed on, and extends to, the rear of the horizontal cross-shaft 51 on which the footboard arms oscillate. Thus, on depressing

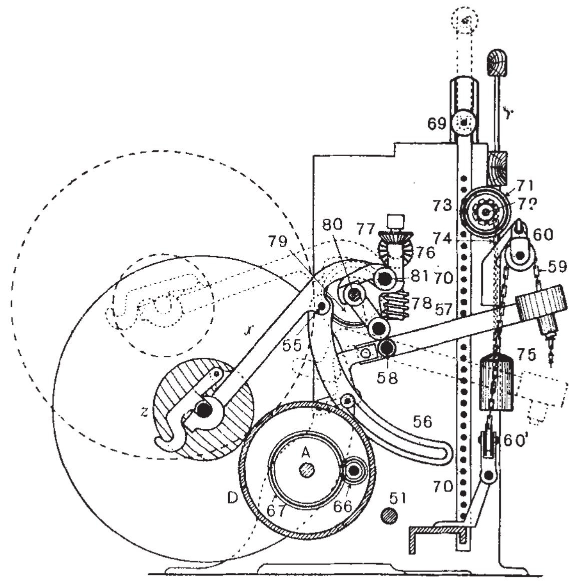

Fig. 63

the footboard, the main driving-belt passes from the loose pulley B, first on to the narrow-rimmed " slow-motion " pulley B^1, and thence on to the fast quick-driving pulley C, to put the machine into operation at full speed.

With this method of driving, the speed of the winding drum D is retarded automatically as the warpers' bobbins diminish in diameter, which coincides with the ascent of the warp beam as its diameter gradually increases. This is effected by driving the winding drum through the medium of a pair of inverted cone-drums 52 and 52^1, placed horizontally one above the other. The upper cone

52 drives the lower one, 52^1, by means of a belt 53 under the guidance of a strap-fork 54, controlled by chain connections and levers in direct communication with the warpers' beam Z. Hence, the cone-belt fork moves in response to, and in unison with, the ascent of the beam, and in such a manner as to transfer that belt from the greater to the lesser diameter of the driving cone, and *vice versa*, as indicated by full lines and dotted lines in the diagram, Fig. 62.

These extreme positions of the cone-belt correspond to the commencement and finish, respectively, of each warper's beam. The movement of the cone-belt is controlled from one of the two radial beam arms *x*, Fig. 63, by which the warpers' beams are retained in position on the drum during warping. The radial beam arm on the left, when facing the machine, is furnished with a stud 55, from which there is suspended a curved arm 56, formed with a slot freely to receive a stud projecting from the short angle-arm of a peculiarly shaped lever 57, fulcrumed on a stud 58 fixed to the machine framing.

The longer arm of this lever is cranked, and also cast with a heavy weight at the end, so that it always tends to fall by gravitation, at a very slow pace, which is controlled by, and in perfect unison with, the pace at which the beam ascends. To the weighted end of the gravity lever 57 there is attached one end of a chain 59, which passes over and under guide pulleys 60 and 60^1, then over the smaller of two combined chain pulleys 61, after which the chain suspends a weight 62 at its free and drooping end.

In combination with the parts just described there is a second chain 63, of which the extreme ends are attached to opposite sides of the strap-fork 54, which guides the cone-belt 53. One end of this chain 63 passes from the lower part of the strap-fork, partly around the larger of the two chain pulleys 61, and thence over a guide pulley 61^1, after which the opposite end is attached to the opposite side of the strap-fork. Hence, as the beam ascends from its lowest to its highest elevation, as indicated by full and dotted lines, respectively, in Fig. 63, the gravity lever 57 descends and takes down the chain 59, thereby rotating the chain pulleys 61, and thus moving the strap-fork, which guides the cone-belt slowly along the cone-drums to diminish, gradually, the velocity of the winding drum, as described.

After replacing a full beam with an empty one, the cone-belt returns quickly and automatically to its initial position on the cone-drums immediately on putting the machine into operation. Thus, when an empty beam is placed in position on the drum, the depressing of the radial arms *x* and the curved arm 56 raises the rear end of the gravity lever 57, and thereby slackens the chain 59. Therefore, on starting the machine, when the cone-drums commence to revolve, the gravitation of the weight 62 rotates the chain pulleys in a reverse direction to that in which they turn as the beam rises, thereby effecting the return of the cone-belt to its first position.

The " slow-speed " gearing of this beam-warping machine constitutes an auxiliary driving motion analogous to the " slow-motion " of slasher sizing machines. It is also applied with a similar object —namely, to enable the machine to be started slowly, and thereby avoid the risk of imparting a sudden strain upon the warp threads sufficient to cause them to break. The " slow-motion " pulley B^1 is placed conveniently between the loose pulley B and the full-speed fast-driving pulley C. Therefore, when transferring the main driving belt from the loose to the fast pulley, it passes first on to the " slow-motion " pulley B^1, and thereby puts the machine into operation very slowly before the belt arrives on the fast pulley to drive it at full speed.

2. Cast-iron Winding-drum

§ 162. The machine is constructed with a cast-iron winding drum of only 12in. diameter. Yet it is mounted and geared in such a manner that it is capable of driving a warper's beam having a barrel 9in. diameter, and furnished with flanges up to 27in. diameter. This is effected by employing a short drum shaft A, of which the ends do not project beyond the drum sides; and also by mounting the shaft in bearings that permit of the beam flanges overlapping the ends of the drum shaft, and extending beyond its axis, in the manner indicated in the plan view, Fig. 64, which also illustrates the proper sequence of gearing between the driven cone 52^1 and the winding drum.

The special feature of this arrangement is the driving of the winding drum by means of wheel gearing situated within the drum shell. This gearing is better exposed to view (in the diagram) by showing part of the drum shell cut away. Motion is transmitted from the driven cone 52[1] to the winding drum through the medium of a train of wheel gearing terminating with a spur-wheel 67. This is secured, in combination with an inner flange 64 and cover-plate or shield 65, to the drum shaft, and driven by a pinion wheel 66. Torsional strain of the drum shaft is minimized by furnishing the spur-wheel with two strong pins 68, that enter radial slots formed in the inner flange, whereby the driving force is exerted at two points on that flange some distance from the axis of the drum shaft.

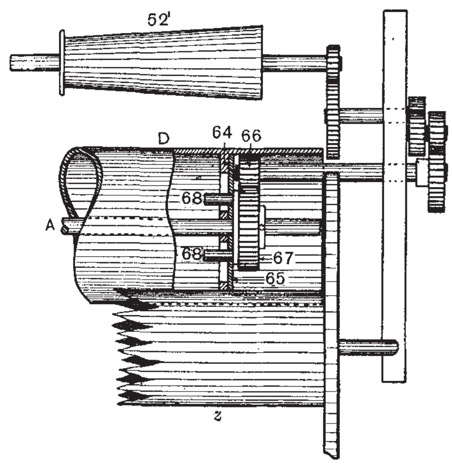

Fig. 64.

3. Yarn-tension Device

§ 163. The yarn-tension device consists of a single light metal roller 69, placed directly in front of the reed *r* situated in the rear part of the machine. Immediately after emerging from that reed, on their course to the beam *z*, the warp threads are conducted over the tension-roller, which is capable of moving freely in a vertical direction, according to the varying degree of tension upon the sheet of threads.

This is accomplished by mounting the tension-roller at the upper end of two vertical poker racks 70, situated one on each side of the machine, and extending downward near to the floor. These racks engage respectively with the teeth of two wheels 71, fixed at opposite ends of a shaft 72, which extends across the machine. Near one end of this shaft there is also fixed a graduated scroll chain pulley 73, to the larger diameter of which is secured one end of a chain 74. After being coiled several times around the spiral groove of the chain pulley, the free and drooping end of the chain suspends a counterweight, 75, which slightly overbalances the combined weight of the poker racks and tension-roller, and thereby always tends to *raise* that roller and keep it bearing constantly against the sheet of threads by which it is held down, normally, at its lowest elevation. But in the event of either stopping the machine or reversing the beam to unwind yarn, the tension-roller *ascends* automatically and takes upward the sheet of threads which are thereby exposed clearly to the view of the attendant for inspection.

The exposure of the threads by raising them is held to be an advantage over the falling-roller type of yarn-tension device which, by taking down the sheet of threads, not only obscures them from the view of the attendant, but also involves the risk of the warp threads picking up the lint and dirt which accumulate on the floor.

4. Warp-beam-hauling Gear

§ 164. The adaptation of mechanical gearing, to be operated by the attendant, for the hauling of beams in and out of the machine, whilst not being an essential element, it is a feature which nevertheless constitutes a desirable adjunct in the construction of beam-warping machines, especially when full beams attain to a gross weight of about 500lb. Such an appliance increases very materially the efficiency, convenience and personal comfort of the attendant, who is, by its aid, not only able to manipulate the beams without assistance, but is also relieved of great physical exertion.

The mechanism by which this task is accomplished is of a very simple character, as represented in Fig. 63, and is operated by means of a handle fixed on one end of a short horizontal shaft, on the opposite end of which is fixed a small bevel wheel 76. This gears with a similar wheel 77 secured at the upper end of a short vertical shaft on the bottom end of which is fixed a single-thread worm 78. The latter gears with a worm wheel 79, fixed on a shaft 80 extending across the machine.

By a suitable arrangement of short connecting arms and links, as indicated in Fig. 63, the cross-shaft 80 communicates with the pins 81 forming the movable fulcrums of the radial arms x that retain the beam in position on the winding drum D. Hence, the rotation of the cross-shaft 80 moves the radial arms either forward to lower a beam, or else draws them backward to raise one into position, according to the direction in which the handle is turned.

LIVESEY'S MODIFICATION

§ 165. A beam-warping machine constructed with a modified arrangement of the differential driving gear of the American modification, and as described in § 161, is that represented by a front and an end elevation in Figs. 65 and 66. The present gearing, however, is adapted to a machine constructed on the English modification by Messrs Henry Livesey, Ltd., and is erected at one end of it, thereby increasing the width of the machine by about 27in. In its essential features this driving gear is similar to that of the previous machine, in which a pair of inverted cone-drums, 52 and 52^1, are employed to

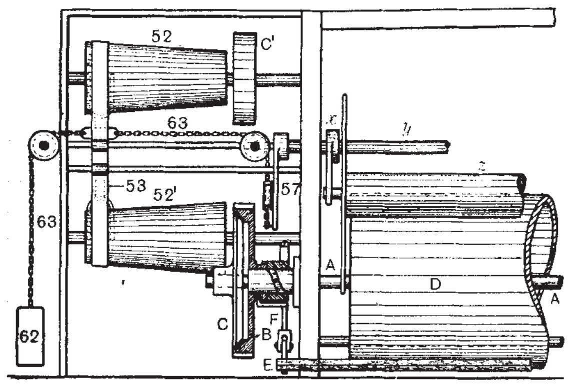

Fig. 65.

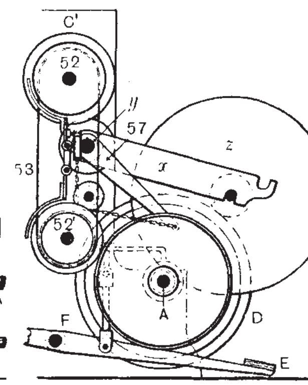

Fig. 66.

impart a differential velocity to the winding drum D. Motion is transmitted, through the medium of a belt 53, from the upper driving cone 52 to the lower driven cone 52^1, and thence to the winding drum D by means of wheel gearing operating in conjunction with a frictional driving clutch B, C, mounted on the end of the drum shaft A.

As the yarn diameter of the beam increases, and that of the warpers' bobbins decreases, the cone-belt 53 is transferred slowly along the cone-drums to retard the velocity of the winding drum. This is effected by controlling the cone-belt guide-fork by means of a chain 63, one end of which is attached to the end of an arm 57 fixed on the cross-shaft y on which the radial beam arms x are secured; whilst the opposite end of the chain suspends a heavy weight 62. Hence, as the beam ascends, the arm 57 also rises, and thereby causes the chain and strap-fork to move the cone-belt slowly along the cone drums as described. At the commencement of each beam, the gravitation of the weight 62 effects the return of the cone-belt to its initial position on the cone-drums quickly and automatically.

The driving gear is operated by a main belt that runs continuously on a single fast pulley C^1 fixed on the shaft of the driving cone 52. On the shaft of the lower and driven cone 52^1 is fixed a small pinion wheel that gears with a large friction wheel B (shown in section), which constitutes the driving member of the frictional driving clutch, and therefore revolves continuously. The friction-wheel is mounted loosely on a stationary sleeve which freely encircles the drum shaft A, and on which sleeve the wheel is capable of a slight lateral movement to enable it to grip or release the friction disc C. This is fixed on one end of the drum shaft A, and constitutes the driven member of the frictional driving clutch, which is controlled in the usual manner by means of suitable connections from one of the two treadle levers F on which the footboard E is carried.

DATA RELATING TO BEAM-WARPING MACHINES

Dimensions

§ 166. Beam-warping machines are made in various standard widths, to each of which there is assigned a recognized index or number which signifies the width of winding drum, and therefore the width between the flanges of warpers' beams which it is capable of receiving. These dimensions vary in units of 6in. each, ordinarily from 54in. to 84in. wide on the face of the drum, and are indicated by the following expressions:—

Index of machine . .	9/8's	6/4's	7/4's	8/4's	9/4's	10/4's
Width of drum . .	54in.	60in.	66in.	72in.	78in.	84in.

Larger or smaller machines are constructed specially to order. The dimensions of beam-warping machines by different makers vary slightly; but the following measurements may be accepted for general guidance. The floor space occupied by a 9/8's machine, and a **V**-creel with a capacity for $14 \times 18 \times 2 = 504$ bobbins, is as follows:—Length of headstock, containing a full beam=4ft.; length, including creel=about 15 to 17ft.; width=7ft. 9in., with an addition of 6in. for each larger size.

Weight

§ 167. (*a*) Of English modification, without creel=11cwt. net, with an addition of about 7½ per cent., cumulatively, for each larger size.

(*b*) Of American modification, without creel=18cwt. net, with an addition of about 3 per cent., cumulatively, for each larger size.

Weight of creel=about 2½cwt.

Cost

§ 168. The cost of a beam-warping machine varies according to style, as "falling tension roller," "falling tension rod," or American modifications, size, and the character of the various incidental accessories with which the machine is equipped. Estimates of the cost are sometimes inclusive of all usual and essential accessories; and sometimes the cost of the headstock, the chief accessories, and the bobbin creel are specified separately.

(*a*) An inclusive estimate of the cost of a 9/8's ordinary English modification is £22, with an addition of about 15s. for each larger size. This estimate comprises the following items:—

	£	s.	d.
Headstock, constructed with Singleton's automatic thread stop-motion; falling yarn tension rollers; and a non-expansible wooden driving drum to take beam flanges 21in. diameter	13	10	0
Expansible back reed	1	10	0
Expansible front comb	1	5	0
Length indicator and automatic measuring and length stop-motion of the ordinary type	1	5	0
Bobbin creel of the V-type, with a capacity for $16 \times 16 \times 2 = 512$ bobbins, and constructed with boxwood steps for the creel pegs; also a supply of boxwood creel pegs	4	10	0
Total net cost	22	0	0

Specialities: If the machine is furnished with any of the following specialities, the amounts specified against the respective items are extra approximate charges on those named above:-

	£	s.	d.
Combined length indicator, measuring and automatic length stop-motion (Hitchon's), instead of the two ordinary separate devices .	1	0	0
Expansible wooden driving drum	2	0	0
Glass creel steps instead of boxwood steps	1	17	6
Glass rods instead of iron rods to outer vertical ribs of creel . .	0	4	0

(*b*) An approximate estimate of the cost of a 9/8's American modification of a beam-warping machine, replete with bobbin creel and all usual accessories, is £35.

Depreciation

§ 169. The allowance for depreciation of a well-constructed beam-warping machine, including the cost of oil, repairs, renewal of wire drop-pins for the automatic thread stop-motion, renewal of creel pegs and the application of modern improvements, will probably not exceed about 6½ per cent. per annum.

Ratio of Warping Machines to Looms

§ 170. The number of looms that may be supplied with warps produced by one beam-warping machine varies considerably according to the speed of the machine and of the looms, the counts of yarn employed, and other variable factors. With average speeds and counts of yarn, an estimate of one warping machine for about 80 looms may be given as a general basis.

Power

§ 171. The power required to drive a beam-warping machine is estimated to be from ⅓ to ½ I.H.P., according to size of machine and number of threads warped simultaneously.

Speed

§ 172. The velocity of the frictional winding drum may range from 40 to 50revs. per minute, according to counts of yarn.

Production

§ 173. The relative productiveness of a beam-warping machine varies within a very wide range, according to speed, counts of yarn, number of threads warped, and ability of the attendant. An actual example of the product of a warping machine of the English modification is: Two beams, each containing 510 warp threads, 16,000yds. long, of 32's T.=303½lb., during a working day of 10 hours; or 1685lb. per machine per week of 55½ hours.

An estimated production by an American beam warper for the same counts of yarn and number of hours is approximately 1565lb., which is based on a velocity of the frictional driving drum ranging from 52 to 26revs. per min. from full to empty warpers' bobbins. These speeds are equivalent to a uniform average velocity of about 40revs. per min.

§ 174. A convenient formula for calculating the approximate weight of yarn of any counts that may be contained on a warper's or a weaver's beam, of any dimensions, is based on the yarn being wound with a normal density estimated at 60cub. in. of yarn to a pound, as follows:—

Transverse sectional area (in inches) of yarn × width (in inches) of warp ÷ 60 = weight of yarn (in pounds).

Therefore, since the area of a circle=dia.^{2} × 0·7854, the net sectional area of yarn on a beam=the total sectional area of the beam barrel and yarn—the sectional area of the beam barrel. Hence, if this difference is multiplied by the width of warp, in inches, and the product divided by 60, the quotient will indicate the net weight of yarn in pounds.

Example: The weight of yarn on a full beam 54in. wide, with a barrel 6in. diameter, and flanges 21in. diameter, is approximately as follows:—

$$\frac{(21^2 - 6^2) \times 0.7854 \times 54}{60} = 286 + \text{lb.};$$

or

$$\frac{(21 + 6) \times (21 - 6) \times 0{\cdot}7854 \times 54}{60} = 286 + \text{lb.}$$

Waste

§ 175. Provided an exactly corresponding length of yarn is wound on each of the several warpers' beams constituting one set, the amount of waste material produced during the operation of beam warping is practically nil, and therefore of no account. Such waste as does occur is caused chiefly by surplus yarn which is left on warpers' bobbins that are removed from the creel as empty bobbins; and also in some mills by discarding the first 5 or 6yds. of yarn withdrawn after re-creeling a set of fresh bobbins, in order to keep the warp free from knots formed by piecing up the ends of the old and new threads.

This course, however, may only be adopted when the depletion of yarn on the bobbin coincides with the completion of a warper's beam; otherwise, if fresh bobbins are creeled when a beam is only partly formed, it will be necessary to pass the knots on to the beam to be afterwards encountered by the weavers.

Character and Amount of Labour

§ 176. The operation of beam warping is variously conducted by adults of both sexes according to the locality and other circumstances; but it is usually performed by female operatives, who also creel the warpers' bobbins. In Burnley and other populous East Lancashire weaving centres, however, where male labour is not absorbed by a diversity of other trades as it is in many of the large manufacturing towns of South Lancashire, it is employed extensively in the weaving trade.

Hence, in those districts, beam warping is conducted by adult male attendants, who, with the help of a youth to creel the bobbins, control two machines. One female attendant, without an assistant, controls two, and sometimes three, beam-warping machines of the American modification, and also creels the warpers' bobbins.

Rate of Wages

§ 177. The rate of wages paid for beam warping grey yarn varies considerably, not only in different districts, but even in the same district, chiefly according to the varying character and special conditions of the work.

Many firms pay on a basis in accordance with some recognized Standard List, as the Blackburn or the Burnley Lists; whereas other firms adopt an independent list of their own, specially adapted, in some instances, suitably to the particular character of their goods.

The Blackburn and Burnley Lists, which are the two prevailing Standard Lists, are each based on a constant length of warp, for which is paid a sum that varies according to the number of warp-ends, quite irrespective of the counts of yarn warped.

Some lists are based on a graduated scale of prices paid for a constant weight of warp according to the counts of yarn; whilst others are based on a scale of prices paid for a constant length unit of 1000 hanks, according to the counts of yarn.

Also, instead of paying piecework rates according to a Standard List, some firms pay a fixed day wage, which varies according to circumstances. In any case, it is agreed that the respective rates of wages paid for beam warping fluctuate with those of weavers' wages, and also in a corresponding measure.

1. BLACKBURN LIST.

(For Grey Beam Warping.)

Basis.—For each wrap of 3000yds., and 300 or fewer warp-ends of any counts of yarn, including creeling: Price, 3·12 pence; and proportionately for fractional parts of wraps.

Variations: For every 10 and fractional part of 10 threads:

From 300 to 420, an additional sum of	0·09	pence.
,, 420 to 500 ,, ,,	0·10	,,
Above 500 ends, ,, ,,	0·11	,,

Example:—The price paid for warping one wrap of 3000yds. and 504 warp-ends is obtained as follows:—

Basis: 300 ends of 3000yds. .	= 3·12	pence.
$(420-300) \div 10 \times 0{\cdot}09$.	= 1·08	,,
$(500-420) \div 10 \times 0{\cdot}10$.	= 0·80	,,
$(510-500) \div 10 \times 0{\cdot}11$.	= 0·11	,,
Price . .	5·11	,,

2. BURNLEY LIST.*

(For Grey Beam Warping.)

Basis.—For 5 wraps of 3500yds. each (17,500yds.), and 400 warp-ends of any counts of yarn: Price, 21·25 pence, with an additional sum of 4·5 pence for creeling.

Variations: For every 10 and fractional part of 10 threads:

If more than 400 ends, an addition of 0·5 pence.
If less than 400 ends, down to a minimum of 370, a deduction of 0·5 pence; but no deduction below 370 ends.

Example:—The price paid for warping 5 wraps of 3500yds. each (17,500yds.) and 504 warp-ends, on one beam, is as follows:—

Basis:	400 ends of 5 wraps .	=	21·25 pence.
	$(510-400) \div 10 \times 0{\cdot}5$.	=	5·5 ,,
	Creeling. extra . .	=	4·5 ,,
	Price . . .		31·25 ,,

This list regulates the wages of approximately 800 beam warpers.

3. INDEPENDENT LIST (A).

This list is based on a standard net weight of 20lb., for which the price varies according to the counts of yarn, and includes creeling—namely:—

Counts of yarn . .	30's	32's	36's	40's	42's	50's	60's	70's	80's	100's
Price	$2\frac{3}{8}$d.	$2\frac{1}{2}$d.	$2\frac{3}{4}$d.	$2\frac{7}{8}$d.	3d.	$3\frac{3}{4}$d.	$4\frac{1}{2}$d.	$5\frac{1}{4}$d.	6d.	$7\frac{1}{2}$d.

Example:—The price paid for warping 5 wraps of 3500yds. each, and 504 warp-ends of 32's T., is as follows:—

$$\frac{504 \times 17{,}500 \times 2{\cdot}5}{840 \times 32 \times 20} = 41{\cdot}2 \text{ pence.}$$

4. INDEPENDENT LIST (B).†

This list is based on a standard net length of 1000 hanks of 840yds. each (840,000yds.) of yarn, for which the price varies according to the counts of yarn, and includes creeling—namely:—

Counts of yarn	7's to 12's	16's	20's
Price	12d.	9d.	8d.

† This list is adopted by some firms when warping a specially soft spun cotton mule yarn, of poor quality, termed "lino," employed for the pile warp in some terry towels.

Weekly Earnings

§ 178. The amount of wages earned by beam warpers varies within very wide limits, ranging from 10s. to 36s. per week of $55\frac{1}{2}$ hours, according to the basis of payment, ability and sex of the attendant, and many other variable factors.

On the basis of the Independent List No. 3 (A), female attendants with only one machine each earn 22s. and more per week, with an average of 18s. to 20s. per week, which represents the average wages of beam warpers in the South Lancashire districts.

In Burnley and other East Lancashire centres, male attendants with two machines earn 34s. and 36s. per week, less the amount paid to the creelers.

The wages paid to a female attendant with three American beam warpers amounted to 26s. per week for an estimated production of 4800lb. of 31's grey twist.

Beam warpers throughout Lancashire, of whom 80 per cent. are stated to be paid a fixed weekly wage varying from 12s. to 20s., are said to earn an average wage of 28s. per week, whether paid a regular fixed wage or by list; but that sum is probably about 3s. too high.

CHAPTER VII

SLASHER OR TAPE-SIZING

§ 179. BEAM-WARP sizing follows immediately after beam warping, and constitutes the third stage in the series of operations involved in preparing grey cotton warps by the particular system under present consideration. During this operation of sizing, the threads are withdrawn simultaneously from a set of two or more back or slashers' beams, and either immersed into and passed through a solution of *hot* size, or else passed between a pair of sizing rollers and impregnated with *cold* size paste, according to the method of sizing which is adopted. After the yarn is sized, it is dried and then wound finally on to the weaver's beam ready for looming and weaving.

The functions of sizing, drying, and beaming, as well as those of cooling and separating the threads, measuring the length of warp and of marking it into cut-lengths, and pressing the yarn compactly on to the weaver's beam, are all performed concurrently by the same sizing machine.

Machines of this class comprise several modifications of two distinctive types that are characterized chiefly by the method of drying the yarn after its saturation with size. One type comprises those machines in which the drying of yarn is effected by passing it partially around and in direct surface contact with one, two, or more cylinders heated with low-pressure steam, as exemplified in what are variously described as " slasher," " tape," and " cylinder " sizing machines, one of which, as constructed by Messrs Howard & Bullough, Ltd., is represented perspectively in Fig. 67.

The second type comprises those machines in which drying is effected by evaporation induced by means of dry air of a relatively high temperature, and which absorbs the moisture from the yarn.

In some air-drying machines hot air is generated by passing high-pressure steam through pipes enclosed within an iron chest from which hot air radiates and is fanned on to the yarn, as exemplified in what are described as " Scotch dressing or sizing " machines.

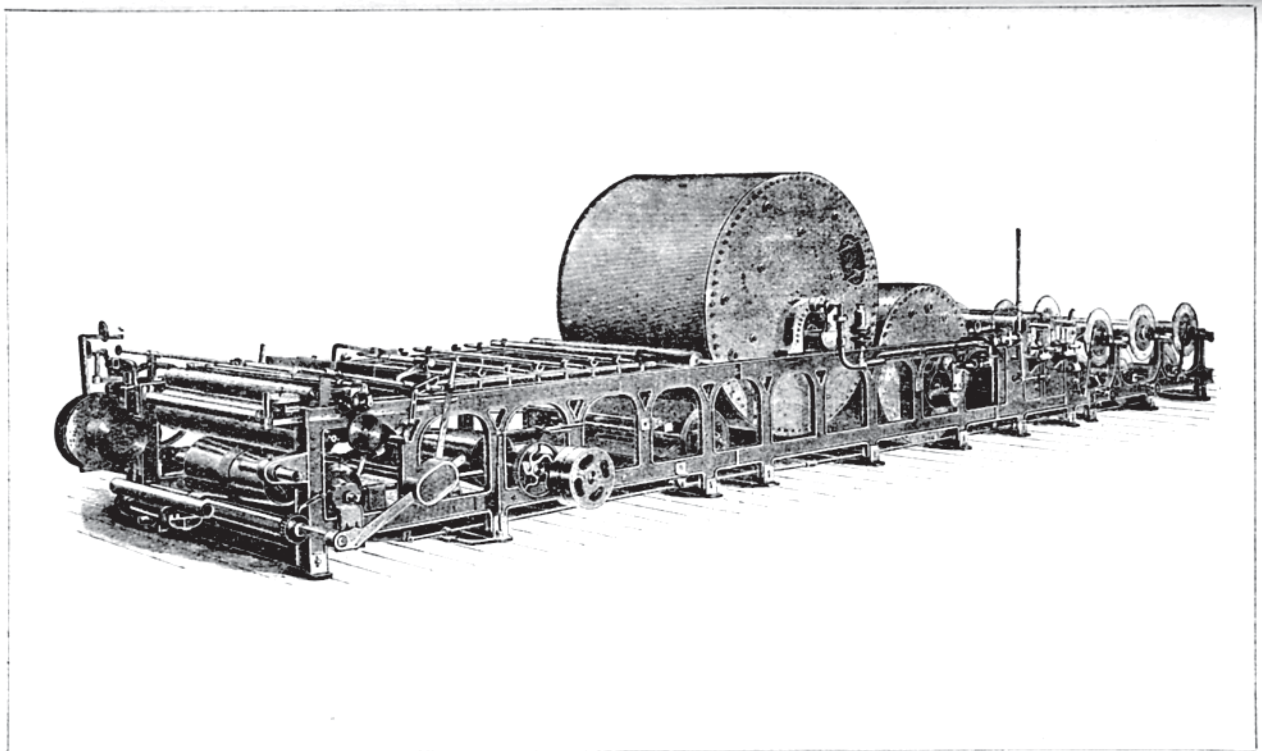

Fig. 67.—SLASHER OR TAPE-SIZING MACHINE.

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In other machines of this type, warm or hot air is generated by passing either low-pressure or high-pressure steam through pipes enclosed within a large drying chamber. This is divided into several compartments, through which the yarn is conducted in a circuitous course in order to expose it to the hot air for a prolonged period, and so effect a thorough drying of the yarn.

SLASHER OR TAPE (CYLINDER-DRYING) SIZING MACHINES

§ 180. Of several modifications of the two chief types of machines for sizing beamed warps, that which is in most general use is known as the "slasher" or "tape" sizing machine constructed with two steam-drying cylinders of 6 or 7ft. and 4ft. diameter respectively, as illustrated in Figs. 68(*a*) and 68(*b*), which represent a side elevation and plan of a sizing machine constructed by Messrs Wm. Dickinson & Sons.

In their chief and essential constructive features, and in their general outward appearance, slasher sizing machines made by different makers bear a close resemblance to each other; but they differ somewhat in respect of their minor mechanical details of construction, and also in the numerous auxiliary devices and attachments with which they are equipped. Before entering into a minute description of these details and of their respective functions, however, the more important sections of the machine in its entirety will be examined.

A slasher sizing machine, as represented in Figs. 68(*a*) and 68(*b*), is a composite machine comprising three principal portions—namely: (1) The section containing the sizing apparatus, forming the rear part of the machine; (2) the section containing the steam drying cylinders and cooling fan, in the centre; and (3) the headstock, forming the fore part of the machine. In addition to these essential parts there is also an auxiliary part consisting of a beam creel or stand, 1A, situated immediately behind the sizing apparatus, for the purpose of supporting the back beams containing the yarn to be sized.

1. THE SIZING APPARATUS comprises a size-box containing an adjustable copper immersion roller, one pair or two pairs of copper sizing rollers and cast-iron finishing or squeezing rollers, and a perforated copper steam-pipe. The copper immersion roller is for the

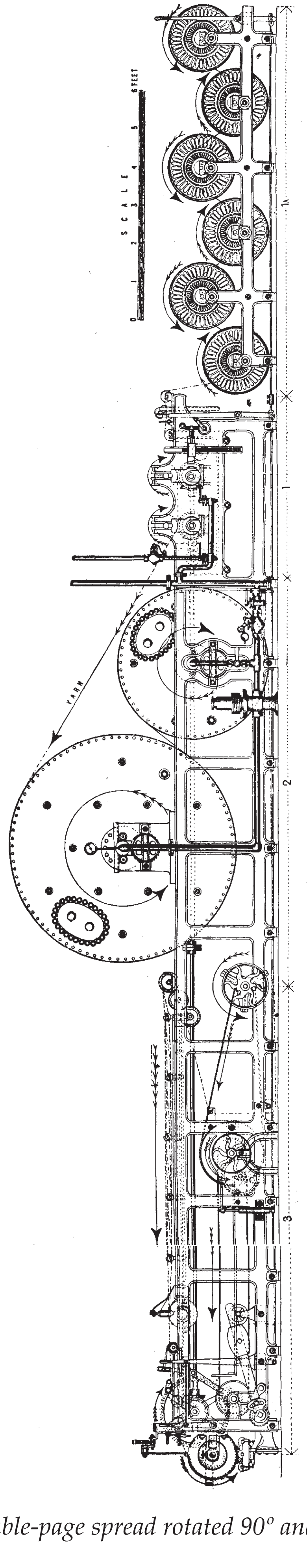


Fig. 68(*a*).—Slasher or Tape (Cylinder-Drying) Sizing Machine (*Side Elevation*).

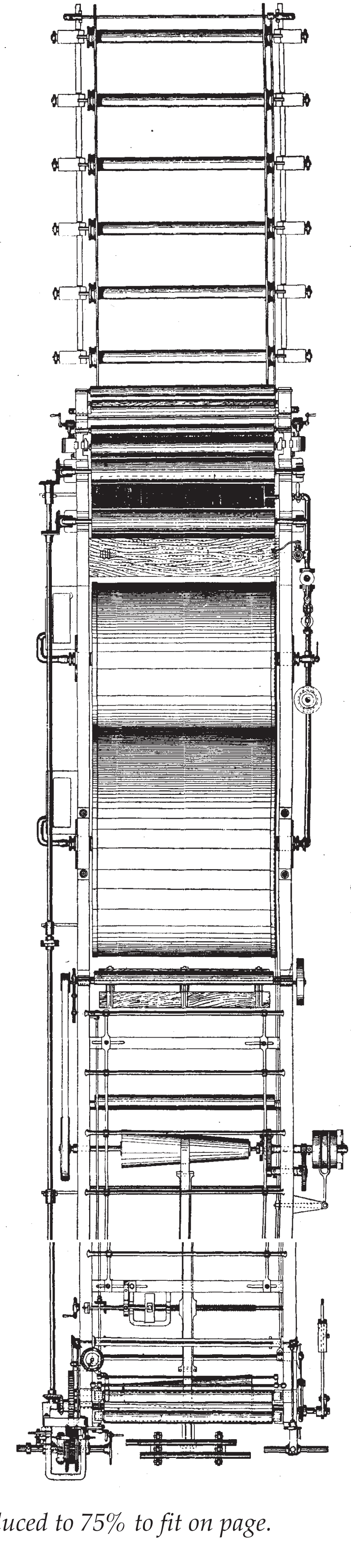


Fig. 68(*b*).—Slasher or Tape (Cylinder-Drying) Sizing Machine (*Plan*).

Double-page spread rotated 90° and reduced to 75% to fit on page.

purpose of deflecting the sheet of threads, as these are withdrawn from the back beams, into the solution of size which is kept in a boiling condition by injecting high-pressure steam through the perforated copper steam-pipe. The sizing and finishing rollers are situated immediately over the size-box, with the lower copper sizing rollers revolving partly immersed in the size.

2. THE DRYING AND COOLING APPARATUS usually consists of two steam-heated cylinders and one or two revolving fans. If the machine is constructed with two drying cylinders, these are usually of 6 or 7ft. and 4ft. diameter respectively, although some slasher sizing machines are constructed with only one large cavity cylinder, 9ft. diameter, formed with an annular space of about 6in. in depth extending around the cylinder, with the object of effecting economy in the consumption of steam.

3. THE HEADSTOCK is a combination of numerous devices and motions consisting of differential full-speed and slow-speed main driving gear to operate all the working parts of the machine; in addition to the more important auxiliary appliances comprising a differential frictional driving motion to rotate the weaver's beam, a length indicator, a measuring and cut-marking motion, and a pressing roller device to compress the yarn compactly on the weaver's beams.

The differential driving gear is adapted to operate the machine in such a manner that the speed with which the yarn passes through it may be either increased or reduced within certain extreme limits ranging from a maximum to a minimum velocity in the ratio of 5 to 2 approximately. The object of this provision is to enable the progress of the yarn during the operation of sizing to be regulated in any required manner suitably to such variable factors as the counts and strength of yarn, the number of warp threads, the particular character of the size-paste, and also the percentage of size to be applied to the yarn, the pressure of steam in the drying cylinders, of which the drying power will be greater or less in proportion to the steam pressure, and many other circumstances.

The object of the slow-speed driving gear is to enable the machine to be operated at a dead-slow speed, instead of stopping it entirely, during the removal of a full weaver's beam and its replacement with an empty one; and also on other occasions when only a brief pause is required. If the machine were stopped entirely for such purposes, the yarn on the drying cylinders for the time being would be liable to become baked or scorched.

The frictional winding motion is designed to revolve the weaver's beam with a differential velocity and in such a manner that its speed gradually diminishes in a measure corresponding exactly with the constantly-increasing girth of the beam as successive layers of yarn are wound upon it, thereby winding the yarn with both a uniform velocity and tension from the commencement to the finish of a beam.

The measuring and cut-marking motions are for the purpose of subdividing a warp into uniform " cut " or piece-lengths of any required length by imprinting upon the warp, at prescribed intervals apart, according to the length of " cuts " required, certain coloured marks or stains indicating the positions where a weaver is required to insert fancy " headings," borders, or other distinctive trade marks.

The function of the pressing rollers is to bear against the yarn with considerable pressure as the warp beam revolves, and thereby ensure the formation of a firm, compact, and evenly-wound warp of maximum length.

DETAILS OF THE SLASHER OR TAPE-SIZING MACHINE

§ 181. In its progress through the sizing machine, from the back beams to the weaver's beam, the yarn is withdrawn from all the back beams simultaneously, and immersed immediately, by means of the submerged copper immersion roller, into the solution of boiling size contained in the size-box. On emerging from the size, the yarn passes between two successive pairs of sizing and squeezing or finishing rollers, which serve the threefold function of (*a*) withdrawing the yarn from the back beams; (*b*) compressing the size into the yarn; and (*c*) expelling surplus size from the yarn.

From the last pair of sizing rollers the yarn passes partially around the large drying cylinder, and from this to the smaller cylinder, on leaving which it is conducted along near the floor, and passes under a revolving fan, by which it is cooled. Shortly after passing the cooling fan the yarn is directed upward by passing it underneath a guide roller, and over an iron guide rod, thence backward to a guide roller mounted immediately in front of the large cylinder.

The warp threads are then subdivided into such number of separate sheets of threads as correspond with the number of back beams constituting the set from which the respective sheets of threads are withdrawn. This subdivision of the threads is effected by means of a corresponding number, less one, of iron rods or bars placed horizontally across the machine, and fixed at regular intervals of about 12 to 18in. apart, immediately above the framing of the headstock. The function of these rods is to keep the respective sheets of threads from the several back beams separate and distinct from each other, and thereby facilitate the recovery of broken and missing warp threads. They also serve, incidentally, to effect a separation of threads that may have been sized and dried in contact with others, and therefore cling together. (See also §§ 208 and 228.)

On leaving the dividing rods the yarn passes in groups of several threads between the dents of an adjustable half-reed or comb, which may be expanded or contracted to regulate the width of warp exactly to the distance between the flanges of the weaver's beam. From the half-reed the yarn passes partially around a tension or delivery roller by which the yarn is withdrawn forward from the point at which it emerges from the second pair of sizing rollers, and from which it is also delivered to be wound finally on to the weaver's beam, ready for looming, and then weaving.

§ 182. Before severing the warp threads to remove a weaver's warp from the sizing machine, however, the attendant obtains a division of those threads into small groups, ranging from two to about five threads in each group to constitute what is termed a "slasher's lease" for the purpose of facilitating the process of selecting those threads, in their approximately correct rotation, either by the "reacher" or else by the "twister," according to the particular method of looming which is adopted—as drawing-in, or twisting.

A slasher's lease is a crude and imperfect division of the warp threads obtained by means of a "slasher's comb" or "half-reed" having ribs along one edge only, and formed with pointed teeth of flat reed-wire about 1¼in. long and containing about twenty-five dents, more or less, per inch, according to the "pitch" or "sett" of teeth required. The teeth of the comb are inserted between the warp threads which are thereby divided into irregular groups, as described previously. A grooved strip of wood, similar to that employed as a joiners' saw-guard, is then tied over the exposed edge of the comb, which is not removed from the warp until the operation of looming is completed.

Beam-Creels

§ 183. During the operation of sizing by any of the various methods of beam-warp sizing, the set of back beams containing the yarn to be sized is supported in a creel or stand, of which there are three different forms. The form of creel usually adapted to sizing machines of the " dresser " type is designed to support the back beams (which are frequently in two sets placed in creels at opposite

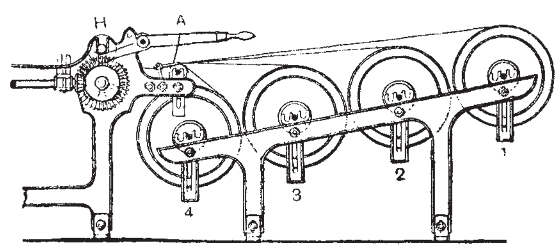


Fig. 69.

ends of the machine) in one row inclining from the ends of the machine, and with each successive beam from the last one in each set, next to the size-box, mounted in a higher elevation than the preceding beam, as represented in Fig. 69.

With this disposition of the back beams, the yarn is withdrawn from the upper side of all the beams, from which the separate sheets of threads converge until they all unite into one sheet on the surface of a guide-roller A, over which the threads are conducted immediately before they pass between a pair of sizing and squeezing rollers H, to be sized with cold starch paste.

This form of beam creel occupies a little more floor-space than that occupied by the alternative form of creel, of equal capacity, and as represented in Fig. 71; but it has the advantage of keeping the several sheets of threads from the respective beams under better observation by the attendant. Also the sheets of yarn are more easily accessible for the purpose of recovering and piecing missing and broken warp threads.

§ 184. A more prevalent form of beam creel is that which is invariably adapted to sizing machines of the "slasher" type, and in which the back beams are mounted in two horizontal rows, with an alternate disposition, as represented in Fig. 71. With this arrangement of beams the yarn is withdrawn from the upper side of those

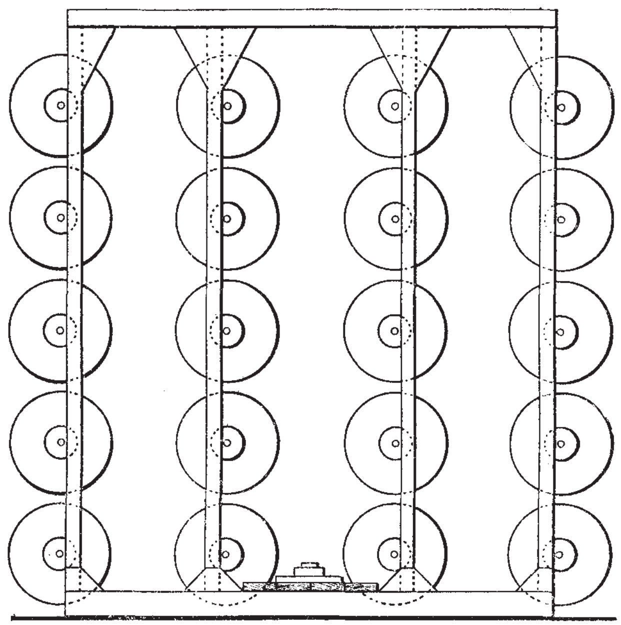


Fig. 70.

beams contained in the top row, and from the lower side of those in the bottom row.

As the several sheets of threads leave their respective beams they unite in successive rotation from the first beam to the last beam next to the size-box in the bottom row. Thus, from a set of six back beams the threads are withdrawn from the top side of the first or rearmost beam, and passed underneath the second, where they unite with the threads that are withdrawn from the bottom side of that beam, and so on until all the threads are gathered into one sheet of warp threads that pass over a guide-roller, whence they are immersed in a solution of boiling size-paste contained in the size-box of the sizing machine.

This form of beam creel occupies relatively less floor-space than that occupied by a creel of the former type; but there is greater difficulty in tracing and piecing lost and broken warp-ends, and in locating their position on the respective beams, than when the several sheets of threads are kept separate and distinct between the back beams and the size-box.

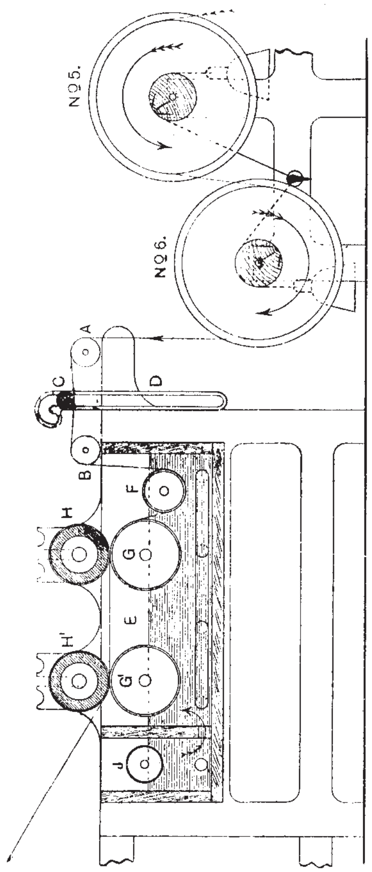


Fig. 71.

§ 185. A third form of beam creel is designed to support the warpers' beams disposed in either two or else four vertical rows, with five beams in each row, as illustrated in Fig. 70, and is employed in conjunction with the Masurel-Leclercq hot-air sizing machine, described subsequently in §§ 328 to 338.

This arrangement of back beams occupies relatively less floor-space than either of the two previous types of beam creels, but the extreme height of the fourth and fifth beams in each row makes those beams inaccessible, without assistance, for the recovering and piecing of broken warp threads. Thus, with beam flanges of only 18in. diameter, the gudgeons of the fourth and fifth beams are situated approximately at an elevation of 6ft. 6in. and 8ft. 4in. respectively from the floor, but the special advantage claimed for this form of creel is that it permits of the warp threads being exposed more effectually to observation by the attendant. It is usual to construct this type of creel as a duplex stand with two vertical tiers, to support two distinct sets of back beams, with one set on each side of a central pivot on which the creel may be rotated to place the second set of back beams into position, and without loss of time, when the first set is finished. The creel is also surmounted with chain winches for hauling the back beams in and out of the beam stand.

Methods of Regulating the Tension upon Yarn

§ 186. As the yarn is withdrawn from a set of back beams during the operation of slasher sizing in a machine of ordinary construction, the back beams are prevented from revolving too freely by passing over one end or both ends of each beam barrel a weighted leather band, rope, or chain, as represented in Fig. 71, to serve the function of a brake with the object of applying to the yarn a moderate degree of tensile strain before the threads are immersed into the bath of boiling size.

Opinions differ respecting the relative merits of two optional methods of applying the brakes to the back beams. Thus, some advocate the plan of suspending the weights in the manner represented in the diagram, so that the brake-bands will pull *against their secured ends;* whereas others prefer the reverse method, so that the brake-bands will pull *against the weights.*

By the first method, a relatively greater amount of frictional resistance is obtained between the brake-bands and beam ruffles than is obtained by the second method for corresponding weights; although it is quite immaterial which of the two methods is adopted, so long as a degree of frictional resistance is obtained sufficient to ensure the required amount of tensile strain upon the warp threads.

After leaving the last beam, No. 6, in the set, next to the size-box E, the combined sheets of threads are usually passed over two guide rollers A, B, between which there is an iron or a wooden tension-roller C, supported by the threads, upon which it rests freely by gravitation, and revolves with its ends retained in the vertical slots of brackets D, which permit of a vertical movement by the tension-roller, as the tension upon the yarn fluctuates.

It follows, therefore, that the entire weight of the tension-roller C is borne only by such warp-ends as are already subjected to the greatest tension, which is still further intensified until the gravitation of that roller is counterbalanced by an equivalent force exerted by the tensile strain of a greater number of warp-ends. Hence, the effect of this tension-roller is still further to deprive of their elasticity those warp-ends that are already most deficient in that quality which is so essential both to good weaving and superior cloth, without affording any compensating advantage.

From the second guide-roller B the sheet of yarn is deflected downwards and passed underneath a copper immersion roller F. This is partially or entirely submerged in the solution of size, and may be adjusted to any desired elevation by means of worm and worm-wheel gearing to operate two vertical side racks which support the roller ends, and which are operated by turning a handle K, Fig. 72. On emerging from the size, the yarn passes between the first pair of sizing and squeezing rollers G, H, and thence usually through a second pair of similar rollers G^1, H^1, as represented in Fig. 71.

In most sizing machines that are furnished with two pairs of sizing and squeezing rollers, both of the bottom rollers, which are of copper, are geared by means of a long side shaft and bevel wheels with the tension and delivery roller situated in the front part of the head-stock, thereby driving the lower sizing rollers positively.

In other machines, however, only the second pair of rollers G^1, H^1 are driven positively, in which case the rotation of the first pair, G, H, is effected solely by the frictional surface grip of the yarn as it is drawn forward by the second pair, G^1, H^1.

Under these circumstances, therefore, the withdrawal of yarn from the back beams devolves entirely upon one of the two pairs of sizing rollers, and the threads are submitted, whilst under tensile strain, to be sized with a viscous solution which is thereby prevented from penetrating the threads effectually; whereas the yarn should be quite free from abnormal tension when it is immersed in the size, to ensure a more thorough penetration of the threads by the size.

Also, if only the second pair of sizing rollers are driven positively, the yarn is thereby submitted to considerable tension between the two pairs of rollers, and at a stage when the threads are saturated with size, and therefore more susceptible to tensile strain, which impairs their elasticity.

With the object of averting these defects, by equalizing the tension upon the warp-ends, and also by delivering them without undue tension to the solution of size, some sizing machines are equipped with Hitchon's yarn-tension device, illustrated in Fig. 72. With this attachment the combined sheets of yarn pass from the last back beam, and thence over a drawing roller A, which is driven positively, by means of a chain, from a chain wheel L, fast on one end of the shaft of the first lower sizing roller. The surface velocity of the drawing roller A is slightly greater than that of the sizing rollers, with the three-fold object of assisting the latter to withdraw the yarn

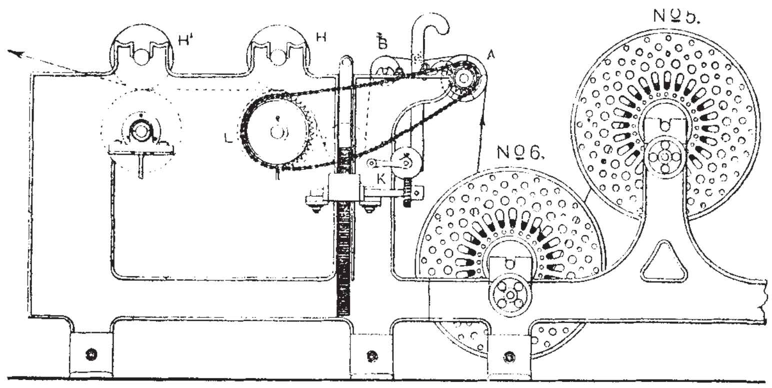


Fig. 72.

from the back beams; of equalizing the tension upon the threads, and of submitting them to be sized whilst they are not subjected to an excessive degree of tensile strain.

§ 187. Another form of yarn-tension device applicable to beam-warp sizing machines is that of Eastwood's, illustrated by a side elevation and part plan in Figs. 73 and 74. This device is designed with the object of withdrawing yarn from the back beams, and delivering it with a minimum and uniform degree of tension to the size and the sizing rollers, instead of imposing that function, as hitherto, upon the sizing rollers alone. By this means the yarn is not subjected to abnormal tension whilst it is saturated with size; hence the maximum strength and elasticity of the threads are better maintained.

These objects are attained by passing the sheet of yarn immediately after leaving the last back beam partially around a drawing roller A placed between the beam creel and the size-box, and mounted quite freely on a shaft B. This shaft is driven *positively*,

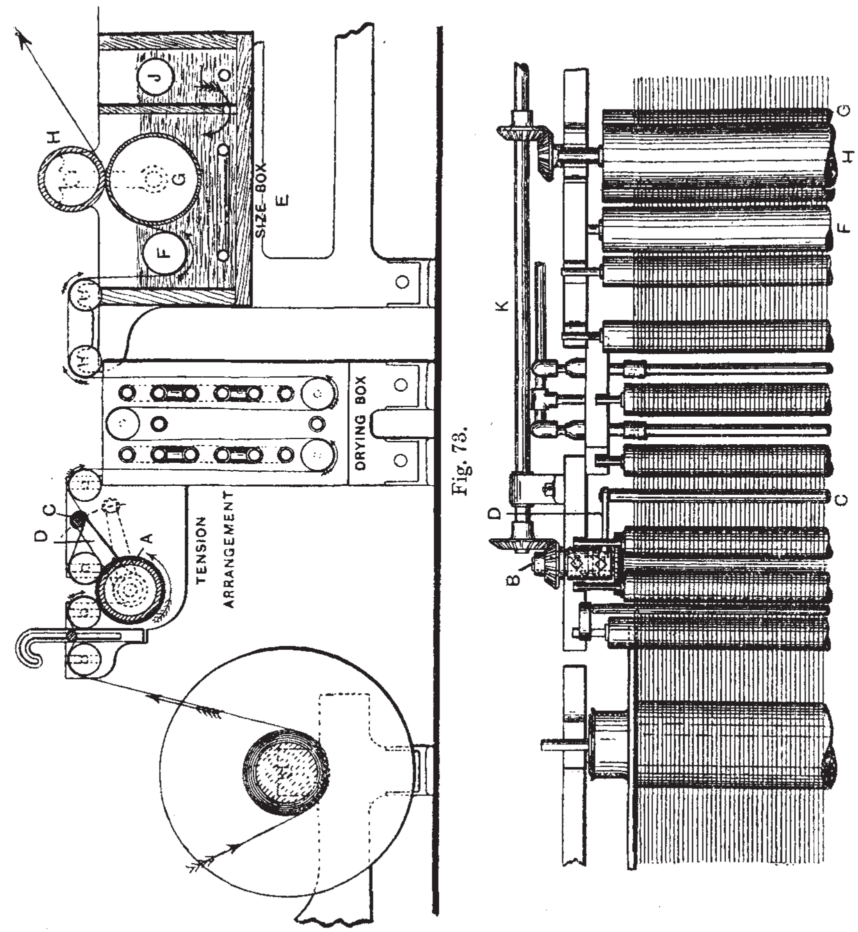


Fig. 73.

Fig. 74.

through the medium of bevel wheels, by the long side shaft K, which also drives the sizing and squeezing rollers G, H; but the drawing roller A is driven *negatively* by the roller shaft B, which transmits motion to the roller through the medium of two frictional driving discs. These are placed one on each side of the roller, and controlled by the slight oscillation of a gravity tension roller C, which is retained at the ends of two side arms D that are mounted freely on the end sleeve bearings of the drawing roller shaft, whereby the gravity roller bears freely and constantly upon the sheet of yarn.

Thus, as the tensile strain upon the yarn fluctuates, the retaining arms of the gravity roller respond readily and automatically to the variation of tension by rising and falling accordingly. The effect of this is either to increase or reduce the degree of compression between the frictional driving discs, to regulate the velocity of the drawing roller, and withdraw yarn from the back beams and deliver it to the size and the sizing rollers with both an approximately constant velocity and a minimum degree of tensile strain.

Yarn-conditioning Apparatus

§ 188. When the cotton staple is in its natural or " raw " state, whether in a loose fleecy condition or spun into yarn, it is much less absorptive than when it is cleansed of the natural oil, wax, and other impurities by washing or bleaching. It also tends more readily to repel dye, size, and other solutions that are not of a detergent or cleansing character, as bleaching and other similar agents. The repellent action of cotton is also due to the presence of air amongst the fibres composing the threads. This air must therefore be expelled during the process of applying the size to the yarn, in order to effect a more thorough penetration of the size into the body of the threads, instead of forming merely an outer coating upon them.

Numerous devices have been adopted with the object of increasing the penetration of size into the yarn during the process of sizing. Some of these devices are based on entirely opposite conceptions. For example, some are designed to increase the absorptive power of the yarn by moistening it previous to immersing it into the solution of size; whilst others are designed to achieve the same object by the exactly opposite procedure of passing the yarn, immediately before it is immersed into the size, through a chamber of hot and dry air, which has the effect of spreading out the fibres, thus causing the threads to expand and become more open and porous, and therefore capable of being penetrated more effectually with size.

A conditioning apparatus constructed on the principle of heating and drying the yarn immediately before it is immersed into the solution of size is represented in combination with Eastwood's yarn-tension device in Figs. 73 and 74. An improved construction of this device, however, is that illustrated in Fig. 75, which represents a heating apparatus designed by Smith, Hodkinson & Chorley. This device consists essentially of an enclosed iron chamber L, situated immediately behind the size-box of the sizing machine. The iron chamber is divided vertically into two separate compartments, of which the second one is twice as large as the first. Both compartments are furnished with several relays of steam-piping M, for the purpose of generating, within the chamber, hot and dry air, through which the sheet of yarn is conducted over guide rollers immediately before it enters the size-box E.

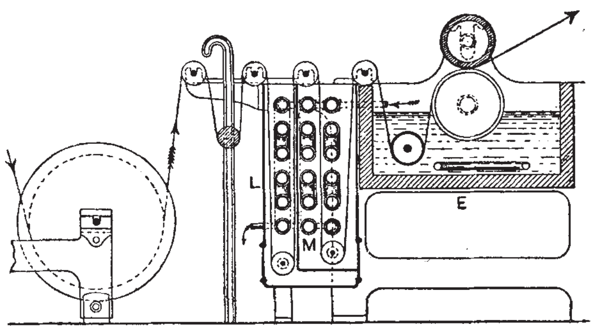


Fig. 75.

Sizing Apparatus

§ 189. The sizing apparatus consists essentially of a size-box, an immersion roller to deflect the yarn into the size, sizing and finishing or squeezing rollers to compress the size into the yarn, and also to expel surplus size from the yarn as it emerges from the size; also steam-pipes, preferably of copper, to keep the size in a boiling state. These chief parts vary in the details of their construction and operation, in different sizing machines; and they are also supplemented by numerous accessories to increase their efficiency.

But whatever general form the sizing apparatus and its appurtenances may assume, they should fulfil the following requirements: The size-box should be constructed so that it may be easily emptied and cleansed. To maintain the homogeneous character of the size it should be kept at a constant level, density, and temperature in the size-box, and at the same time be kept in constant motion to prevent it from becoming lumpy, and also to prevent the heavier ingredients from settling down at the bottom. This object may be accomplished more effectually by previously passing the steam employed for boiling the size through a condensing-box to prevent any water of condensation from passing into the size and thereby reducing its density.

The length of time during which the yarn is actually submerged in the size should also permit of variation, within prescribed limits, without affecting the speed at which the machine is worked; and the size should penetrate thoroughly into the body of the threads, from which all surplus size should be expelled without raising the free ends of the fibres or impairing the strength and elasticity of the yarn.

Size-boxes

§ 190. The size-box is usually constructed in the form of a rectangular wooden box, sometimes lined with either copper or zinc sheeting, to prevent leakage, and is divided vertically into two compartments of different sizes. These communicate with each other at the bottom either by means of holes cut into the lower edge of the partition, or by leaving a narrow aperture between the partition and the bottom of the size-box, as represented in Fig. 71. The larger compartment E, of the size-box, next to the beam creel, contains the copper immersion roller F: one pair, but more frequently two pairs, and sometimes three pairs, of sizing and squeezing rollers G, H; and perforated copper steam-pipes to keep the size in a boiling state. Also, sometimes two immersion rollers, J, are employed, with their axes situated about 9in. apart, horizontally, with the object of keeping the yarn immersed for a longer period in the size.

The smaller compartment of the size-box, which serves as a receptacle for supplies of fresh size from the last mixing beck, is also provided with a perforated copper steam-pipe for the purpose of reboiling the fresh size before it combines with that contained in the larger compartment in which the yarn is immersed and submitted to the actual process of sizing. By adopting this course the temperature of the size in the larger compartment is maintained at a constant value; whereas if the fresh size were permitted to flow immediately into that compartment, the temperature of the size would be liable to fluctuation and thus involve the risk of producing irregular sizing of the yarn. The smaller compartment of the size-box is sometimes furnished with a floating copper roller **J**, to control a valve and thereby regulate the supply of fresh size to the size-box automatically, and so maintain the size at a constant level in the size-box.

§ 191. The size-box should be constructed deep and narrow, with a fairly large capacity, as a small size-box tends to produce uneven sizing in consequence of a smaller volume of size being more susceptible than a larger volume to variation of temperature and density. Also, the supplies of fresh size should enter the size-box in the *centre*, and not at one side of that box; otherwise, the fresh size will cause the warp threads on that side to be sized softer than the other threads. Further, the boiling of the size in the size-box will be effected more efficiently by employing copper steam-pipes that are perforated with very fine holes, and arranged in the bottom of the size-box in the form of a double letter **H**, as recommended by Mr Ibzan Sagar, and represented in Fig. 76, as this arrangement of the boiling pipes ensures a better and more uniform distribution of the steam as it issues in fine jets from the small holes in those pipes.

§ 192. A modification of the usual type of size-box is that of Rushton, Hopper & Hardacre's, as illustrated in Fig. 77, which represents a perspective sectional elevation through the centre. The distinctive feature consists of a large rectangular cavity N formed midway in the wooden partition which separates the smaller and larger compartments of the box. On each side of this cavity there is screwed a brass or copper plate O, in which is cut a rectangular hole. The holes in these plates are in such relative positions as to cause the size to flow from the upper part of the smaller compartment, and to enter the lower part of the larger compartment, as indicated by arrows in the diagram. The inventors claim that by this means the size is boiled more thoroughly in the smaller compartment, and also better distributed in the larger one, with the result that the warp threads are sized more uniformly and efficiently.

Although the boiling of size in the size-box of a slasher sizing machine is usually effected by injecting high-pressure steam through perforated copper pipes that are placed at the bottom of the size-box (as stated in the previous section), and which are therefore in actual contact with the size, that method of boiling the size is, however, attended with several disadvantages. For example, the steam-pipes are perforated only on the *upper* side with very small holes, disposed at intervals of two or three inches apart, and through which the steam issues into the size in a series of fine jets, as represented in Fig. 77. Therefore, excepting at these small holes, where the size is repelled by the jets of steam, the size is liable to become scorched or baked into hard-burnt crusts that sometimes peel off, and thereby make the size lumpy and discoloured, and also stain the yarn. Hence it is necessary to remove the incrustation of size from the steam-pipes at intervals of three or four weeks, in order to reduce the risk of those evils, and also to maintain the heating efficiency of the steam-pipes by keeping them clean.

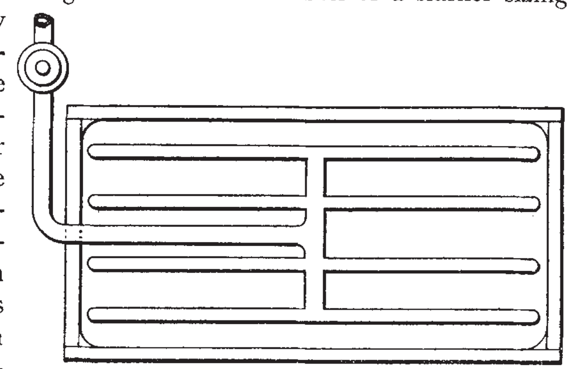


Fig. 76.

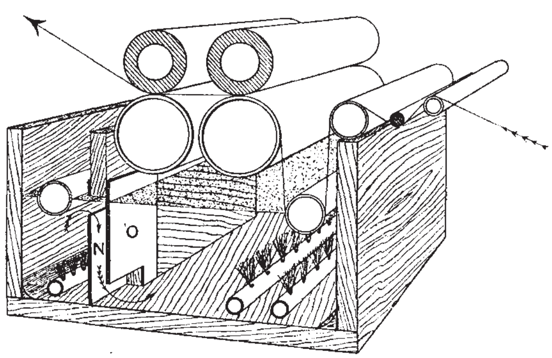


Fig. 77.

§ 193. An improved method of injecting steam into the size-box, for the purpose of heating the size, is illustrated in Fig. 78, which represents Pickup's plan of injecting steam from several perforated gun-metal nozzles or jets Q, disposed around either the bottom or the sides of the size-box, and forming the terminals of a corresponding number of short wrought-iron pipes P. These branch either vertically or horizontally from a main-service cast-iron pipe R, which may be placed either underneath the size-box, with the branch pipes

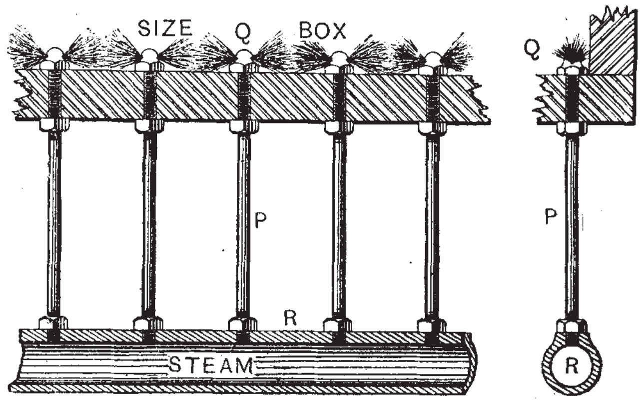


Fig. 78.

entering the base, or else around the size-box, with the branch pipes entering the ends and sides, near the bottom of the box.

§ 194. One of the greatest objections, however, to any method of injecting steam into the size-box, for the purpose of boiling the size, arises when the size has been allowed to cool, and therefore requires to be reboiled before it is again ready for use. Thus, when the steam is turned on for that purpose, it forces the water of the condensed steam through the steam-pipes into the size, diluting the size to such a degree that its adhesive and strengthening properties are so weakened as to be sometimes quite useless.

This objection, however, is avoided in Gregson's cavity size-box, represented in Fig. 79. Instead of the usual form of a wooden box furnished with a perforated copper steam-pipe, as indicated in Fig. 80, this cavity size-box is constructed of thick copper sheeting, and formed with a cavity or steam-jacket extending as a single chamber along the sides and base from end to end of the box, as represented by a transverse section in Fig. 79.

The outer and inner sheets of metal forming the shell of the size-box are fixed to a support which is bolted at the ends to the side framing of the sizing machine; and the size is maintained in a boiling condition by passing high-pressure steam through the steam-jacket, instead of injecting it into the solution of size for that purpose.

Also, if required, the heat radiated from the size-box could be fanned on to the yarn either before it is immersed in the size, for the purpose of conditioning the yarn by heating and drying it, as described previously; or the radiant heat could be utilized for partially drying the yarn immediately after it emerges from the size, and before

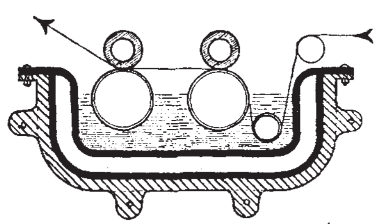


Fig. 79.

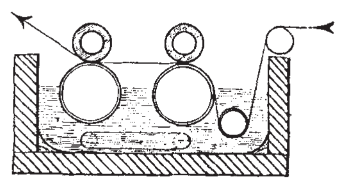


Fig. 80.

it comes into contact with the hot metal surface of the large drying cylinder of the sizing machine.

§ 195. Another modification in the construction of size-boxes for sizing machines, and one that marks a distinct departure from the usual type, is that of Kaye & Crowther's, illustrated in Figs. 81 and 82, which represent a sectional elevation and a part rear elevation of a size-box constructed in accordance with their invention.

This size-box is designed with the object of simplifying the construction of the sizing apparatus, and of effecting economy both in the consumption of size and in the use of steam for heating it. These objects are effected by employing only one pair of sizing and squeezing rollers G, H, and also by constructing the size-box with either a single trough or channel, with mitred corners, or else with two narrow and shallow troughs that are capable of holding an extremely small quantity of size paste, as represented in the diagram.

The copper immersion roller F revolves in the rear and smaller trough, and the copper sizing roller G revolves in the second and larger trough; whilst the size is maintained at the required temperature by means of steam-pipes Q placed in a small chamber or recess formed immediately underneath the size-box, instead of by the usual arrangement of perforated copper steam-pipes placed inside and along the bottom of the size-box, for the purpose of injecting live steam into the solution of size.

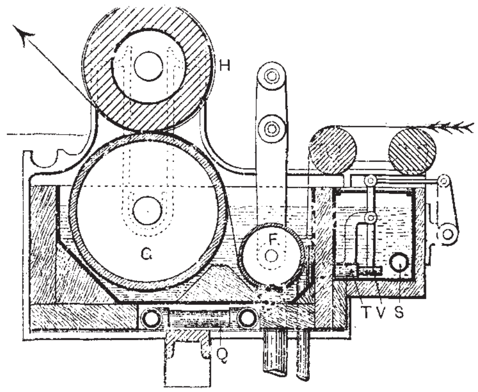


Fig. 81.

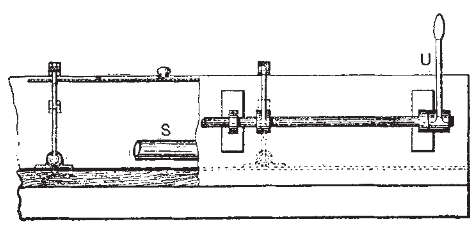


Fig. 82.

In addition to the size-box there is also a separate size-storage compartment adjoining the rear side of that box, next to the beam-creel or stand, and covered with a lid to confine the heat. Both the size-box and storage compartment are lined preferably with thick sheet copper to ensure greater cleanliness and durability, and also to prevent the leakage of size.

The supplementary size-box is for the purpose of storing a reserve supply of fresh size, which flows along a feed-pipe S opening into that box, and leading from the last size-mixing beck. With that object the storage box is provided with a valve T, which opens into the size-box, and is controlled by the attendant, who, by operating a lever U, withdraws the stop-plug V from the valve to allow a fresh supply of size to flow from the storage box into the size-box whenever it is necessary to replenish that box with size, to replace that which has been absorbed by the yarn.

There is, however, no reason why even the supplementary storage box could not also be dispensed with by supplying fresh size from the last mixing beck to the size-box directly by means of a feed-pipe opening into the size-box proper.

SIZE-AGITATORS

§ 196. Size-boxes are sometimes equipped with some form of device, of which there are several different types, constructed for the purpose of keeping the solution of size in a state of constant motion during the operation of sizing. The object of such appliances is to better maintain the homogeneous character and uniform consistency of the size by maintaining it in a condition of more or less vigorous agitation, and thereby effecting a more thorough blending of the respective sizing ingredients by preventing the heavier substances from settling down to the bottom of the size-box.

The necessity for employing these devices, however, is not so great in respect of the lighter grades of sizing as when excessive quantities of china-clay or other mineral weighting material are employed for the heavier grades of sizing. Furthermore, such devices increase the cost and complexity of the sizing apparatus, and also the difficulties of cleansing it.

One of the earliest forms of these size-agitating devices is that of Tulpin's, illustrated in Figs. 83 and 84, which represent a sectional end elevation and a plan respectively of a size-box only, equipped with such an appliance. This device consists essentially of two copper shafts W, each of which is constructed with a considerable number of small copper blades X, set at an angle of about 45° to the axes of the shafts, similarly to the blades of a fan or a ship's propeller. These shafts extend parallel from end to end near the bottom of the size-box, and revolve in reverse directions with the blades of one shaft intermeshing closely with those of the other shaft, whereby the size is maintained in a condition of vigorous commotion.

§ 197. A more recent type of device for keeping the size in a state of constant ebullition in the size-box during the operation of sizing is that of Holden's, illustrated in Figs. 85 and 86, which represent a side elevation and a sectional rear elevation of a size-box to which this device is applied.

This apparatus is not only less complex and costly than the previous device, which agitates the size only, but it also possesses the additional advantage of combining the functions of both agitating and boiling the size without the necessity for employing the usual arrangement of perforated copper steam-pipes at the bottom of the size-box to inject live steam into the size for that purpose.

The essential features of this device consist of a spiral copper steam-pipe Y, of coarsely-pitched coils, extending, between two or three parallel bars or rods Z, from end to end, about midway between the top and bottom and in the fore part of the size-box, and which revolves slowly, along with the parallel bars, for the purpose of keeping the size in constant motion when the machine is in operation.

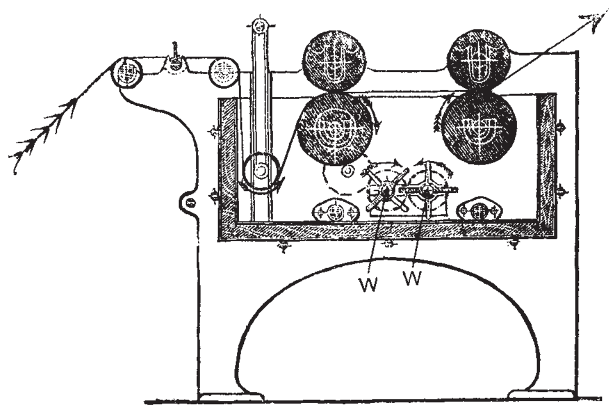


Fig. 83.

This object is effected by connecting the extreme ends of the spiral copper steam-pipe to short wrought-iron steam-pipes, to form gudgeons, that are mounted freely in journals provided with packing or glands to prevent the leakage of size; and also by fixing on one of the steam-pipe gudgeons a worm-wheel *b*, which gears with, and is driven by, a double-thread worm *a* on the long side-shaft K of the sizing machine, whereby the coiled steam-pipe, and also the parallel rods, are caused to revolve slowly as described.

Instead of mounting this device in the front part of the size-box, as indicated in the diagram, an improvement would be effected by mounting it in the rear part of the box, either between the immersion roller F and first pair of sizing rollers G, H, or preferably between the rear end of the size-box, next to the beam creel, and the immersion roller F, and constructing the size-box accordingly. By adopting this course both the temperature and ebullition of the size will be greatest just at the point where the yarn is immersed into it, thereby effecting better penetration of size into the yarn, and also a more uniform quality of sizing.

§ 198. Another and still later device for the purpose of keeping the size in constant motion is that designed by Tattersall and described by the makers, Messrs Butterworth & Dickinson, Ltd., as a "circulating size-box." The essential features of this device consist of a supplementary size-storage box, immediately adjoining the rear part of the principal size-box, and employed in conjunction with a rotary type of pump for the purpose of forcing size from the auxiliary box to the principal size-box, whence the unconsumed size overflows and returns again, automatically, to the storage box, thereby maintaining a continuous and constant circulation of size between the two boxes.

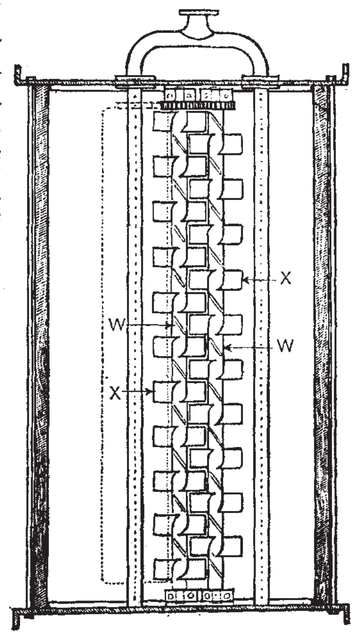


Fig. 84.

This object is accomplished by constructing the size-box with two quite distinct compartments which are completely separated from each other by means of a strong wooden partition. One of these compartments, which constitutes the principal size-box, is furnished with the usual immersion roller and sizing and finishing rollers, and is situated in a higher elevation than the supplementary or storage compartment, to one end of which is attached the rotary pump. When this pump is in operation the size is forced from the storage compartment and flows along a short pipe which terminates, with several branch pipes situated in the base of the principal size-box, and from which the size issues through a number of jets into that compartment, in which it is well distributed. Also, the pump is driven quite independently of the sizing machine so that it may continue in operation even when the machine is either running "on the slow-motion," or stopped entirely for a short period only. But if the machine is stopped for a long period after closing down work for the night or during the week-end, provision is made whereby the size may be drained entirely from the principal box into the storage compartment, whence it may, by means of the same pump, be returned again to the boiling beck of the size-mixing plant from which the

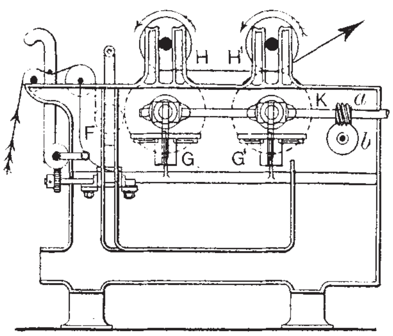


Fig. 85.

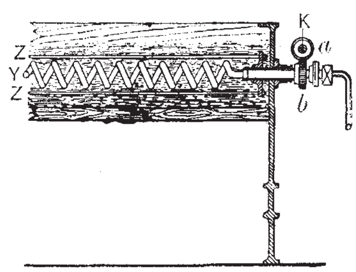


Fig. 86.

size is supplied originally, either by hand-service or else by means of an automatic size-feeding apparatus.

By adopting this course of emptying the size-boxes there is no size left to harden on the sides of the boxes and on the sizing rollers, thereby conducing to much greater cleanliness, and also keeping the size free from incrustations and hard lumps. If, however, such hard lumps or other impediments should appear in the size, their passage into the principal size-box is obstructed by means of a sieve which is secured detachably in front of the pump, to permit of the sieve being removed for cleansing, without stopping the machine.

Both compartments of the size-box are furnished with perforated steam-pipes for the purpose of keeping the size in a boiling state; and the steam employed for that purpose is passed previously through a special form of steam-trap or condensing-box to discharge any water of condensation which, if allowed to pass along with the steam, would dilute, and thereby weaken, the size.

Sizing and Finishing or Squeezing Rollers

§ 199. As stated in § 188, various methods have been adopted for the purpose of effecting a more thorough penetration of size paste into the yarn, both by damping the yarn and also by adopting the extremely contrary procedure of super-drying it previous to immersing it into the solution of size.

It is also with this same object in view that some manufacturers prefer to pass the yarn between two pairs, and sometimes even three pairs, of sizing rollers, instead of between only one pair of those rollers; although there is a diversity of opinion as to the policy of employing more than one pair of sizing and finishing or squeezing rollers in a sizing machine, as represented in Figs. 73, 75 and 81. Also, the yarn is sometimes immersed in the size for a little longer period by passing it underneath two immersion rollers which are mounted about 9in. apart, as stated previously in § 190.

Nevertheless, with the express objects of imbuing the yarn more thoroughly with size, and also of ensuring a more uniform character of sizing, some size-boxes have been furnished with *three immersion or sizing rollers,* mounted in alternate succession and in combination with *three pairs of finishing or squeezing rollers,* as illustrated in Fig. 87, which represents a side elevation of a size-box constructed in accordance with Sutcliffe & Smith's invention.

With this arrangement of immersion and finishing rollers the warp threads are immersed into the size, and then passed between a pair of finishing rollers for *three times in alternate succession,* whereby it is claimed that the air is expelled more effectually from the interstices of the threads, which become more completely saturated with size, and are therefore sized more uniformly.

The three immersion rollers are constructed preferably of thick sheet copper, and in the form of hollow cylinders, having a diameter of about 18in., to permit of a long and continuous length of yarn being immersed for longer intervals into the solution of size. These rollers or cylinders are not submerged completely in the size, but are partly exposed above the surface with the object of enabling the attendant more readily to detect and remove broken threads in the event of these wrapping around them and forming what are termed "lapped ends," or "lappers."

The immersion rollers are also furnished with tubular gudgeons to permit of the admission of air into the interior, as a precaution to guard against the risk of their collapsing from external atmospheric pressure when cooling. The gudgeons are also mounted in journals which are packed with glands to prevent the leakage of size from the size-box; and the journals are surmounted with roller bearings to ensure the free-and-easy rotation of the immersion rollers without involving undue tensile strain upon the yarn, upon which the effort of turning those rollers devolves entirely, and whilst the yarn is in a saturated condition.

The three pairs of sizing and finishing rollers employed in this size-box are of the usual forms, with the lower roller of each pair

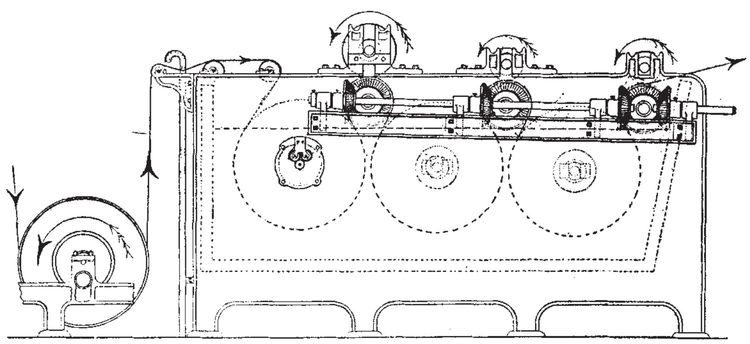


Fig. 87.

driven positively, and to which motion is transmitted through the medium of bevel-wheel gearing operated from the long side-shaft of the machine. These lower rollers, however, which correspond to the usual sizing-rollers, are not immersed partially in the solution of size, in accordance with the usual practice, but are quite clear above the surface of the size. Also, the first of the three upper finishing rollers is of larger diameter and heavier than the second and third rollers, so as to exert greater pressure upon the yarn after its first immersion into, and emergence from, the size.

§ 200. Even if, under any circumstance, it would really be of any material advantage to submit warp yarn to more than one immersion into the solution of size, and to more than one operation of squeezing, in immediate and alternate succession, that object could be easily effected—in any sizing machine of the usual type, and constructed with a size-box furnished with only one immersion roller and two pairs of sizing and finishing rollers of the usual dimensions and arrangement—by adopting the simple expedient to be described presently and as indicated in Fig. 88.

Thus, on emerging from the size, after their first immersion by the roller F, the threads are conducted over the *top* of the first finishing roller H, thence between that roller and the first sizing roller G, to be immersed for the second time into the size, in which they remain completely submerged until they again emerge in front of the second sizing roller G^1, to pass between that roller and the

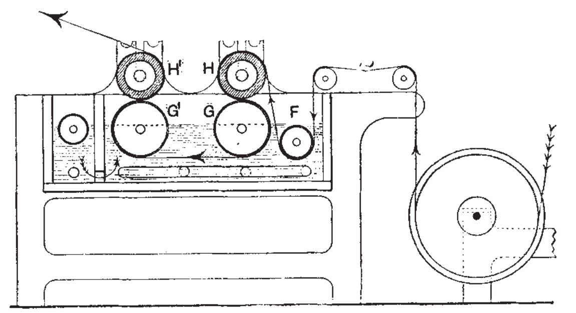


Fig. 88.

second finishing roller H^1, from the *upper* surface of which the threads are conducted at once to pass around the large drying cylinder.

This procedure is here offered merely as a suggestion by the writer as a novel departure from the usual practice observed in slasher sizing, and one which may very easily be put into practical application and tested on its own merit, simply by changing the position of the bevel driving wheels on the long side-shaft, which gear with the bevel wheels on the sizing rollers G, G^1, so as to drive these rollers and the finishing rollers H, H^1 in the reverse direction to that in which they revolve under normal working conditions. At the same time it will be necessary to reverse the finishing rollers to prevent the risk of the cloth, with which these rollers are covered, from unwrapping or creasing in consequence of those rollers revolving in the reverse direction.

Construction of the Sizing and Squeezing or Finishing Rollers

§ 201. The construction of the lower copper sizing rollers, and also the method of driving the upper squeezing or finishing rollers of a slasher or other type of beam-warp sizing machine, vary in machines made by different makers. The lower sizing rollers are constructed preferably from seamless copper tubing, with an external diameter of about 9in., and a shell up to half an inch thick.

One method of constructing a sizing roller is illustrated in Fig. 89, which represents a longitudinal section of such a roller formed by driving tightly into each end of a copper tube blocks of either brass or iron. The tube and end-blocks are then secured firmly by brazing,

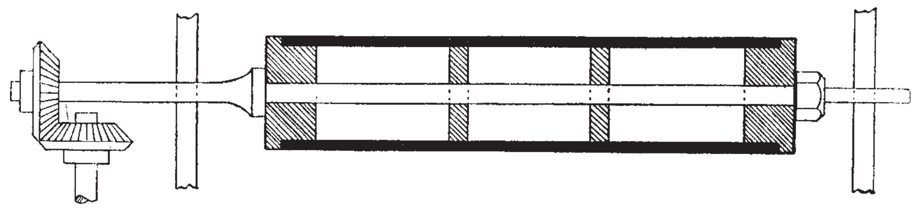


Fig. 89.

to seal up the joints thoroughly, and thereby prevent the risk of size paste percolating through them to the interior of the roller.

A strong wrought-iron or steel shaft passes through the entire length of the roller, and projects at each end to form gudgeons. These are mounted in bearings formed in the sides of the size-box and furnished with packed or stuffed glands to prevent the leakage of size. The roller shaft is formed with a forged collar near one end, against which there abuts one of the roller end-blocks, whilst a nut on the opposite end of the shaft is screwed up sufficiently to effect a secure binding of the roller tube and shaft. These revolve together and are driven positively through the medium of a bevel wheel, fixed on one end of the roller shaft, and geared with a similar wheel on the long side-shaft of the sizing machine.

Additional stability is imparted to the sizing roller by fixing between the end-blocks two or more mid-feather or inner blocks of iron, placed at regular intervals apart. These blocks serve to offer internal resistance to the copper shell of the roller, and thereby reduce the risk of this becoming deflected by the external pressure exerted by the heavy cast-iron squeezing or finishing roller, which rests by gravitation with its entire weight upon the copper sizing roller, so that both rollers revolve together in close surface contact.

Sizing rollers that are constructed in the manner just described are, however, attended with several disadvantages, owing to their tendency to develop serious structural defects arising from the disparity in the expansive and contractive properties of the different metals—copper and steel or iron—of which they are constructed.

Hence, the frequent alternation of expansion and contraction of the copper tube, the iron or brass end-blocks, the intermediate iron blocks, and the steel or wrought-iron shaft of the roller—resulting first from their expansion by the heat of the boiling size at the commencement, and of their contraction when cooling down after working hours, in alternate succession—causes severe straining of the copper tube and steel shaft, which thereby become distorted out of their true forms.

Also, in consequence of the differential expansion and contraction of those parts, the brazed joints of the copper tube and end-blocks sometimes yield and part under the excessive strain, thereby allowing size paste to percolate through the fractures to the interior of the roller.

§ 202. With the object of averting the evils just stated, various contrivances have been adopted in the construction of sizing rollers, whereby the respective parts of these rollers are quite free to expand and contract differentially and independently, without involving the risk of straining those parts and distorting the rollers, or of fracturing the brazed joints.

A sizing roller constructed on this compensating principle is that of Gregson's, illustrated in Fig. 90, which represents a longitudinal section of a sizing roller furnished with iron end-blocks that are driven tightly into the ends of the copper tube, to which they are secured by brazing to seal up the roller ends. The end-blocks of this roller, however, are formed with very long sleeve bosses, through which the roller shaft passes *quite freely*, and thus permits of the sleeve bosses and roller shaft sliding freely and independently in a *lateral direction only*, to compensate for the differential expansion and contraction of the copper tube and steel shaft. The copper roller with its sleeve bosses, and also the roller shaft on which these are mounted, are, however, driven in such a manner that, although they are free to slide in a lateral direction, they must revolve together with a corresponding velocity.

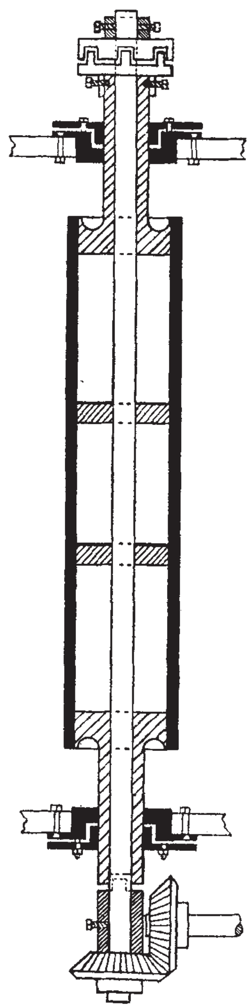


Fig. 90.

This is effected by transmitting motion, through the medium of either box clutches or other type of flexible coupling, from the positively driven roller shaft to the sleeve bosses of the roller tube. A clutch is placed preferably at each end of the roller instead of at one end only, to prevent torsional straining of the roller shaft and copper tube.

In the diagram (Fig. 90) there are represented two of several optional forms of clutches placed at opposite ends of the roller. That on the left is a simple form of clutch constructed by mortising or notching the inner end of the boss of the bevel wheel which is fastened on to the roller shaft, and also the inner end of the sleeve bosses of the roller. Thus, when placed in their proper positions on the shaft, the mortises and tenons of the two complementary bosses interlock, but without the ends abutting against each other, so as to permit of the differential expansion and contraction of the copper roller and steel shaft in a lateral direction, and thereby avert the risk of straining and fracturing the roller from the unequal expansion and contraction of those parts.

An alternative form of box clutch is represented on the right of the roller. This clutch is constructed on exactly the same principle as that of the previous one, but is of larger dimensions to obtain greater driving power, which object is effected by employing two large notched discs. These are secured respectively to the sleeve bosses of the roller end-blocks, and also on one end of the roller shaft in one case; and on the inner end of the boss of the bevel wheel in the other case, so that when the respective clutches are in position the mortises and tenons of the complementary discs interlock quite freely.

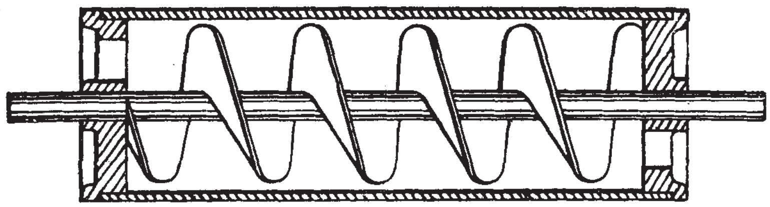


Fig. 91.

A third method of driving a sizing roller of the compensating type is by means of float or feather keys that are fixed in the ends of the roller shaft and freely enter slots or key-ways cut into the bosses of the roller end-blocks, so as to permit of the lateral movement of the sleeve bosses and roller shaft freely and independently, according to the differential expansion and contraction of the copper tube and steel shaft.

§ 203. A later improvement by Gregson in the construction of copper sizing rollers is that illustrated in Fig. 91, and of which the cardinal feature consists of a spiral copper blade coiled around a wrought-iron roller-shaft and extending, in the form of a long Archimedean screw, within the roller shell for its entire length. The special purpose of this screw is to propel the size quickly along the

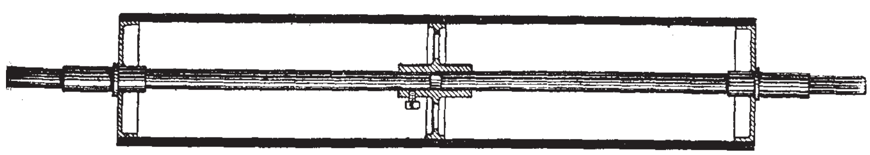


Fig. 92.

interior of the roller from one end of the size-box to the other end, with the object of maintaining a continuous circulation of the size, and thereby performing the additional function of a size agitator of which three other modifications are described and illustrated in §§ 196-198. The ends of this sizing roller, as constructed by Messrs

Atherton Bros., Ltd., may be either of brass or cast iron, and are each formed with a large aperture equal to one-half their areas, to permit of the ingress and egress of the size as the roller revolves.

§ 204. Another modification in the construction of sizing rollers is that of Hitchon & Ormerod's, represented in Fig. 92. In this roller the end-blocks are driven firmly into the copper tube, and the joints are sealed by brazing in the usual manner. Instead of the end-blocks being mounted *freely* upon the roller shaft, as in the roller last described, they are *fixed* securely on that shaft. This shaft, however, does not pass in a continuous length through the roller, but is formed in two equal lengths, of which the inner ends enter an internal coupling block fixed midway between the roller ends. The inner end of one of the shafts is secured, by means of a set-screw, to the coupling block, but the inner end of the other shaft enters the coupling quite freely and without the two ends of the shafts touching each other. By this means a flexible junction is effected in such a manner as to permit of the copper tube and roller shaft expanding and contracting differentially without the risk of straining those parts.

The Squeezing or Finishing Rollers

§ 205. The squeezing or finishing rollers of a sizing machine are invariably hollow cast-iron rollers of considerable weight, ranging approximately from 3cwt. upward, according to the width of the machine, the number of warp-ends, and the grade of sizing. For yarn of medium counts, ranging from about 30's to 50's T, it is found in actual practice that the best results are obtained with sizing or squeezing rollers weighing 65lb. per lineal foot for warps containing 1000 to 1500 warp-ends; 70lb. per foot for 1500 to 3000 warp-ends; 75lb. per foot for 3000 to 6000 warp-ends; and 80lb. per foot for warps containing 6000 to 9000 warp-ends.

The finishing or squeezing rollers are turned with a true and even surface, and afterwards clothed with cotton and woollen fabrics of suitable texture manufactured specially for that purpose. Before clothing iron squeezing rollers, however, it is advisable to coat them thoroughly with red oxide paint or, preferably, with one of the various anti-corrosive materials to prevent them from rusting, and thereby avoid the risk of causing iron-mould. They should then be wrapped with about 12 or 15 yards of special sizer's flannel, coiled neatly and evenly around the rollers, and finally wrapped with two or three yards of good calico cloth to produce a smoother finishing surface which does not tend, as does the flannel, to pick up the exposed ends of fibres projecting from the warp threads as these pass between the sizing and squeezing rollers.

The object of covering the squeezing rollers with cloth in this manner is to produce a soft and resilient surface of a spongy character, and one in which the threads will become embedded as they pass between the finishing and sizing rollers. By this means the threads are imbued more effectually with size; also surplus size is expelled from the yarn without involving the risk of injuring the threads by the excessive compression of the squeezing rollers.

In most sizing machines the rotation of the squeezing or finishing rollers is effected entirely by their surface frictional contact with the copper sizing rollers. Hence, unless the clothing is wrapped upon them tightly and evenly it tends to " pull " or " drag " on the rollers, thereby causing creases and other irregularities to develop on their surfaces, and thus greatly impair their efficiency.

With the object of averting this evil various methods have been devised whereby motion is transmitted negatively, through the medium of frictional driving discs, from the copper sizing rollers to the finishing rollers, thereby averting the risk of the clothing being " dragged " or creased on those rollers, as described.

§ 206. One of the earliest forms of frictional driving devices of this character is that of Bretherick's, illustrated in Figs. 93 and 94, which represent a part front and part end elevation respectively, of a sizing and a squeezing roller to which this method of frictional driving is applied. In combination with other parts, there is a coarsely-pitched pinion wheel in conjunction with the usual bevel wheel, fixed on the shaft of the copper sizing roller. This pinion wheel gears with a similar wheel mounted freely on the shaft of the squeezing roller in such a manner that it may slide in a lateral direction upon that shaft, although both the wheel and shaft must always revolve together with a corresponding velocity. This is effected by means of a float or feather key fixed in the boss of the wheel, freely entering a keyway cut into the roller shaft, Also this wheel is placed between two frictional driving discs that are mounted freely on the roller shaft in such a manner that they may both revolve quite independently of that shaft, and also slide upon it in a lateral direction. Thus, by turning a handle provided for the purpose, the discs and wheel are submitted to that degree of compression which is necessary to drive the squeezing roller with a surface velocity coinciding exactly with that of the copper sizing roller upon which it rests. By this means the excessive wear and tear caused by the "dragging" of the clothing of the squeezing roller is minimised; also the creasing of the cloth on the surface of the roller is prevented.

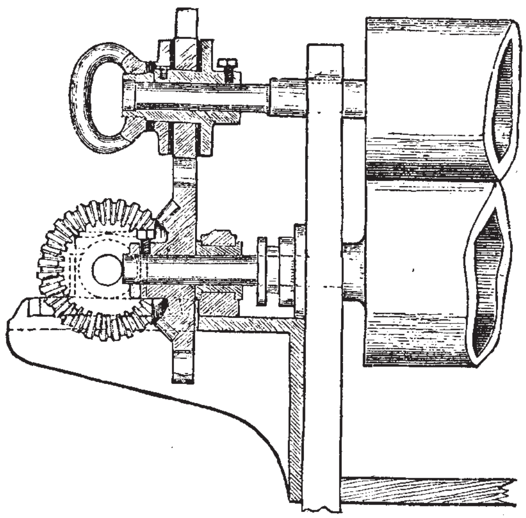


Fig. 93.

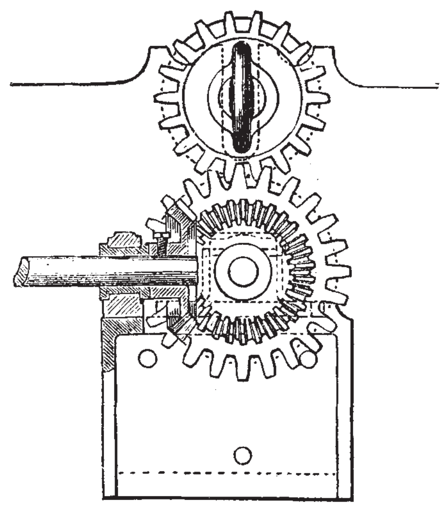


Fig. 94.

§ 207. Another example of frictional driving for squeezing rollers is that of Tattersall's, as represented by a part side elevation and a part plan, in Figs. 95 and 96 respectively. In this instance, however, a frictional driving wheel and a disc are mounted contiguously on the long side-shaft of the machine, and are adapted to transmit motion to the *second* squeezing roller only, through the medium of suitable driving gear, which operates in a manner to be described.

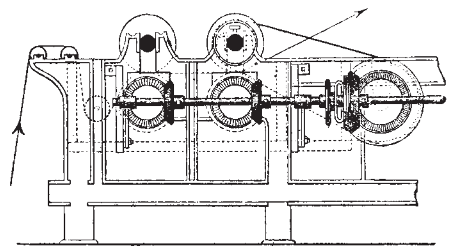


Fig. 95.

The bevel driving wheel is mounted with its boss quite free, both laterally and rotary, on the long side-shaft; whereas the frictional driving disc, which is situated on the rear side of that wheel, is mounted so that it may slide freely in a lateral direction only on the side-shaft, by which it is driven through the medium of a float or feather key fixed in that shaft, and freely entering a slot cut into the hub of the disc.

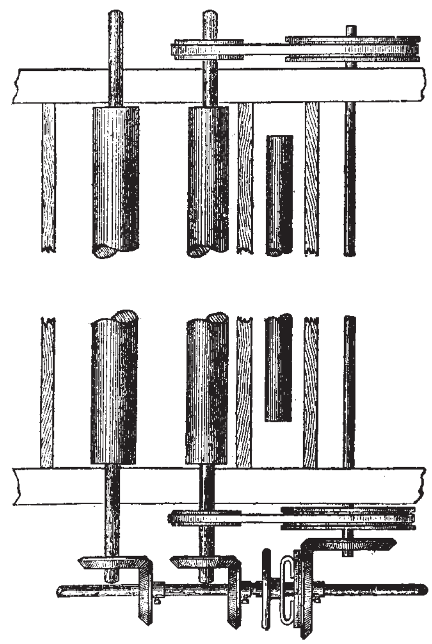


Fig. 96.

The frictional driving wheel is put into operation by turning a hand-wheel so as to compress the friction disc and wheel together until there is sufficient frictional resistance between them to drive the second squeezing roller with a surface velocity equal to that of the lower copper sizing roller, on which it revolves quite independently of its surface contact with that roller.

This is effected by gearing the bevel frictional driving wheel on the long side-shaft with a similar wheel fixed on one end of a cross-shaft which is furnished with two narrow flanged pulleys of large diameter. These are fixed one at each end of the cross-shaft and, through the medium of narrow leather belts, transmit motion to smaller flanged pulleys that are fixed on each end of the shaft of the squeezing roller, the velocity of which may be regulated, within prescribed limits, as described.

When the frictional driving wheel is in operation, it is prevented from gearing too deeply with the teeth of the bevel wheel on the cross-shaft by abutting against a stop-collar fixed on the long side-shaft of the machine.

Yarn-brushing Device

§ 208. One of several disadvantages of slasher sizing arises from the tendency of warp threads to cling more or less firmly together from their adhesion with size, thereby incurring the risk of those threads becoming obstructive during weaving, and thus impeding the weaver, and also causing imperfections in cloth. This evil of clinging threads arises in consequence of the threads being dried whilst they are in close contact with each other, without any means of separating them, whilst they are still wet with size immediately after they emerge from the last pair of sizing rollers, and before they pass on to the hot surface of the large drying cylinder to be dried.

At a later stage of the sizing operation, however, and after the yarn has been dried and cooled, some means are adopted with the object of effecting a separation of the warp threads before they are wound finally on to the weaver's beam ready for looming. This function of separating the threads is effected in a more or less imperfect manner by passing the respective sheets of threads, from the several back beams, above and below a corresponding number, less one, of iron bars or dividing rods situated in the fore part or head-stock of the sizing machine, as described in § 181.

That course, however, is not only a very crude procedure, which acts very harshly and detrimentally upon the threads, but is one that fails to separate many of the clinging threads, whilst others are parted asunder forcibly in such a rough manner that the fibres composing them are broken or disrupted and raised by their " plucking " each other, thereby impairing the good qualities of the yarn, and also nullifying the beneficial effects which constitute the primary object of sizing.

With the object of preventing the evil of clinging warp-ends, and also of effecting a more uniform distribution of size upon the threads, slasher sizing machines have been equipped with a revolving brush or with two revolving brushes mounted in such a position as to brush the yarn immediately after it leaves the last pair of sizing and finishing rollers, and before it comes into contact with the large drying cylinder, as represented in Fig. 97. When two brushes are employed, one is mounted above, and the other below, the sheet of threads, so as to brush these from the top and bottom simultaneously,

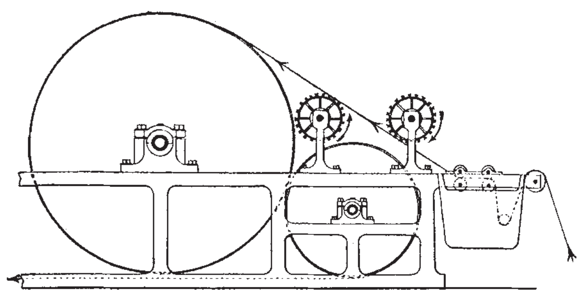


Fig. 97.

as the brushes, which are driven positively, revolve in the same direction as that in which the yarn travels, as indicated by arrows.

It is questionable, however, whether the brushing of yarn by means of *revolving* (not stationary) brushes, whilst it is still wet with size paste, has any really beneficial effect upon the threads. As the brushes revolve, and the bristles penetrate between the threads, the points of the stiff bristles are liable to catch against and thus disturb and raise the ends of those fibres which, previous to sizing, protruded from their respective threads; albeit it is the laying down of such projecting fibres, in order to produce smoother threads, which constitutes the primary and essential object of sizing warp yarn.

Drying Apparatus

§ 209. The drying cylinders of slasher sizing machines vary in the number employed in a single machine, as well as in the type of cylinders, their constructional details, relative disposition, method of mounting, driving, and heating, and also in their numerous incidental accessories and attachments. Thus, some machines are constructed with one drying cylinder only, and others with two and three cylinders of different diameter. The cylinders are usually of the hollow-drum type, with tubular journals; and others are of the "cavity" or open-end type which are constructed with a shallow steam-jacket or chamber having a radial depth of about only 6in., and enclosed between an internal and an external shell extending round the cylinder.

Cavity cylinders are so named because they are constructed with open ends that may be either left open to the atmosphere of the room, or preferably encased to form a central hot-air chamber to prevent currents of air from passing through the cylinder and thus dispelling the radiant heat from the interior.

Sizing machines of the regular standard type, as represented by an elevation and a plan in Figs. 68(*a*) and 68(*b*), are constructed with two cylinders of different diameter. These are usually 4ft. and 6 or 7ft. diameter respectively, with first the smaller cylinder and then the larger one following in that rotation immediately after the size-box. In some machines, however, the relative positions of the cylinders are reversed.

Cylinders are sometimes mounted with their journals or trunnions revolving in ordinary cup bearings, whilst some are mounted on roller bearings, and others revolve in ball bearings with the object of reducing the frictional resistance between the journals and bearings to the minimum. The rotating of the cylinders usually devolves entirely upon the tensile strain of the threads, which pass around and grip the surface of the cylinders as the yarn is drawn forward by the tension and delivery rollers situated in the front part of the machine.

In some machines, however, the cylinders are driven negatively (never positively, as this method is sometimes erroneously described) by means of frictional, and therefore *negative*, driving gear. By this means the cylinders revolve quite independently of their surface contact with, or of the tensile strain upon, the warp threads, and with a surface velocity which may be regulated to coincide exactly with that of the progress of yarn through the machine; thereby relieving the warp threads of the effort of driving the cylinders, and thus preserving their valuable properties of elasticity, so essential to good weaving and to the production of superior qualities of cloth.

The drying cylinders are usually heated by injecting through one of the cylinder journals, which are tubular, low-pressure steam to exert a gauge pressure usually of about 10lb. to the sq. in., which is equal to 0·68 of an atmospheric unit of 14·7lb.

In some machines, however, the drying cylinders are heated by the injection of hot air instead of steam; whilst a French modification is designed to heat the drying cylinders of slasher sizing and calendering machines by means of hot air generated by a number of gas flames flaring from jets contained within the cylinders.

§ 210. In addition to the foregoing chief parts constituting the drying apparatus of a slasher sizing machine, there are also numerous incidental accessories and attachments, comprising, amongst others, a service of pipes to conduct steam from the boiler to the sizing machine, where it enters the cylinders through one of the two tubular journals on which the cylinders revolve. The steam service pipe is provided with valves to regulate the pressure, and also to control the supply of steam to the cylinders; with a steam gauge, and a graduated dial, on which a recording finger indicates the steam pressure, to be read at sight by the attendant; and also a safety valve, preferably of the " deadweight " type, which is adjusted to " blow-off " steam automatically when the gauge pressure exceeds the prescribed limit of about 10lb.

Another service of pipes leads from the cylinder journals, on the opposite side to those through which steam is admitted to the respective cylinders, to convey from these the waste water as it is deposited by the condensing of the exhaust steam in the cylinders. The waste water is conducted by this service of pipes from the cylinders and passed through a steam-trap to prevent the escape of steam from the cylinders before it is exhausted and condensed. The removal of water from the cylinders, as the steam condenses, is effected in a variety of ways, as described subsequently in §§ 214 and 215.

The cylinders are each constructed with a manhole, so that they may be entered for the purpose of effecting repairs internally. Also, they should each be provided in one end, or in both ends, with an air-inlet or vacuum valve to open automatically and thus admit air as a precautionary measure against the risk of the cylinders collapsing from external atmospheric pressure—a contingency which is liable to occur in the event of a partial vacuum being created within the cylinders when the supply of steam is shut off from them. If, under these circumstances, air were not admitted to the cylinders, the internal air pressure would, owing to the sudden condensing of the confined steam, be liable to fall below that of the external atmospheric pressure, and thereby involve the risk of the cylinder ends collapsing by caving inwards.

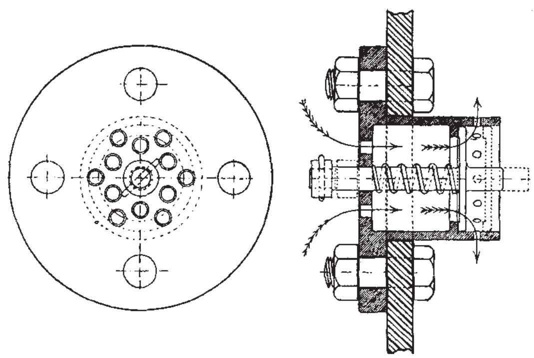


Fig. 98.

§ 211. One of several types of air-inlet valves adapted for use on the steam-drying cylinders of slasher sizing and calendering machines is that illustrated by a front and a sectional end view in Fig. 98, and as applied by Messrs Wm. Dickinson & Sons. As indicated in the diagram, this air-valve is bolted on the outside of one of each of the cylinder ends, and consists of a flanged cylinder furnished with a piston rod containing a disc on the inner end and a stop-collar on the outer end, with an open spiral spring inserted between the flange and the disc. Also, air-holes are formed in both the flange and the inner end of the valve cylinder, which enters the steam cylinder.

Thus, under normal conditions, when the internal steam pressure is greatest, the piston rod is forced outward with the disc bearing closely against a diaphragm to close the valve, as indicated by full lines in the diagram, and thus prevent the escape of steam from the cylinder. But, in the event of the internal steam pressure falling below that of the atmosphere, the piston rod and the disc of the air-valve, assisted by the spiral spring, are forced inward until the disc passes beyond the air-holes in the valve cylinder, as indicated by dotted lines in the diagram, thereby admitting air to the interior of the cylinder, as indicated by arrows. When the piston rod and disc have moved inward sufficiently to open the valve for the admission of air, their further movement is prevented by the stop-collar abutting against the flange of the valve. The air valves close automatically, on readmitting steam to the cylinders, immediately the internal steam pressure exceeds the external atmospheric pressure, plus the resistance of the spiral spring.

Cylinder Construction

§ 212. Some drying cylinders are constructed with an external shell of tinned sheet iron or steel, whereas others are formed with a shell of sheet copper. If sheet iron or steel is employed, there is less risk of the joints becoming strained and fractured where the shell and cylinder ends are united, because the expansion and contraction of those parts by the heating and cooling of the cylinders in frequent and alternate succession are equal.

Iron and steel, however, are much more susceptible than copper to the corrosive influence of a moist atmosphere, and are therefore liable to rust and thus stain the yarn with iron-mould. For this reason a copper shell is preferable, because its use eliminates the risk of iron-mould. Copper is also better than iron or steel as a conductor and retainer of heat; and being more ductile than these metals, it is capable of being more easily and effectually bent over at the edges to form a short right-angular flange, which permits of a more perfect steam-tight joint being constructed where the copper shell and cylinder ends are united.

But in consequence of the unequal expansive properties of iron or steel, and copper, cylinders constructed with a copper shell were, by the older method of construction, more liable to develop structural defects at the joints, owing to the differential expansion and contraction, and therefore unequal straining, of the copper shell and cylinder ends.

By a more approved method of constructing cylinders, however, as devised by Messrs Howard & Bullough, Limited, and as illustrated by a sectional view in Fig. 99, the risk of joints fracturing from the unequal expansion and contraction of the shell and cylinder ends has been overcome successfully. This method of construction is applicable to both copper and also tinned sheet iron or steel shells, and is effected by flanging both the shell and the cylinder ends at right-angles, and then binding both firmly and closely together by means of strong wrought-iron junk-rings and large set-screws, with the shell bound between the respective junk-rings and cylinder ends, as indicated in the diagram. Also, as a precaution against the risk of cylinders either collapsing or bursting, additional stability is imparted to them by means of several strong cross-bars or rods that extend between the cylinder ends, and to which they are bolted.

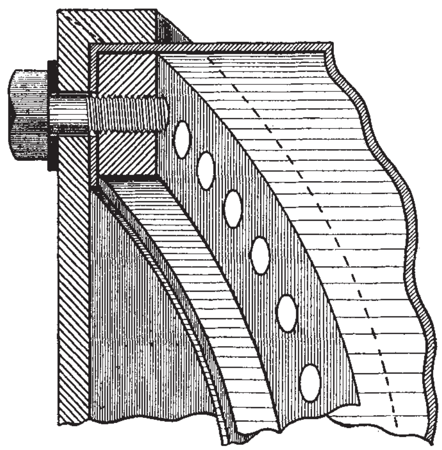


Fig. 99.

Admission of Steam to the Cylinders

§ 213. Steam is admitted by various methods to the cylinders of slasher sizing machines, but the usual practice is to inject it through the journal at one end of the cylinder, and into a perforated cast-iron tube or pipe which constitutes the cylinder axle, whence it issues in a series of small jets, and thus diffuses by expansion within the cylinders. This practice, however, is not an economical one, by reason of the steam radiating from the centre of the cylinder, and consequently losing heat as it becomes exhausted by expansion before it comes into actual contact with the cylinder shell, where the greatest amount of heat and drying efficiency are required.

With the object of overcoming the disadvantages of that method of admitting steam to drying cylinders, and also of increasing their drying efficiency even with a smaller consumption of steam, this may be admitted to the cylinders by means of Bury & Ormerod's device, as illustrated in Fig. 100, which represents the interior of a cylinder to which that device is applied. By this plan steam is admitted in the usual manner through one of the cylinder journals, and into the tubular cylinder axle, whence it is distributed through branch pipes that lead to a corresponding number of annular perforated pipes fixed a short space from the cylinder shell. Thus, from the small holes in the annular pipes the steam issues in a series

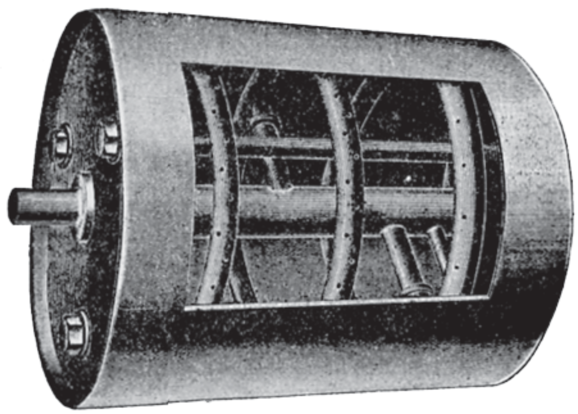


Fig. 100.

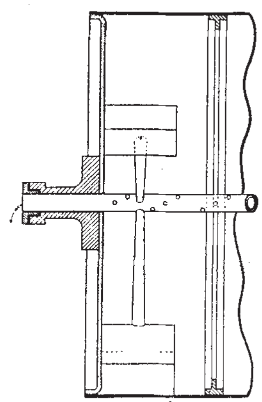
of small jets that impinge directly against the cylinder shell before the steam is exhausted of its maximum degree of heat by diffusion, as it expands within the cylinders.

Cylinder Water-buckets

§ 214. After the steam has entered the drying cylinders it gradually loses pressure as it becomes exhausted of heat, and finally condenses into water, which gathers in the bottom of the cylinders, whence it requires to be expelled automatically as quickly as possible and without loss of steam, whilst the machine is in operation. Otherwise, if the water of condensation is allowed to accumulate inordinately in the cylinders, it not only very considerably diminishes their drying efficiency by cooling the cylinder shells, but it also conduces to a much more rapid condensation, and increased consumption of steam.

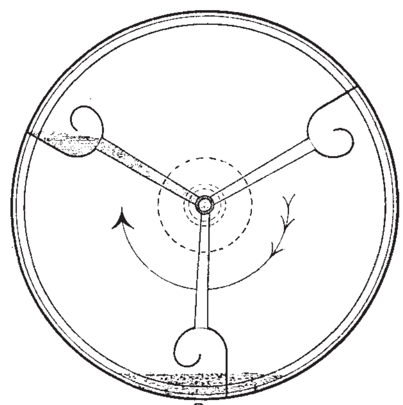
Further, the water becomes a constant deadweight rolling continuously in the bottom of the cylinders, thereby augmenting their weight, which impedes their free-and-easy rotation, and thus requiring additional motive power to drive the machine. Moreover, the additional effort required to turn the cylinders imparts a greater degree of tensile strain upon the warp threads, to the detriment of their elasticity, unless the cylinders are driven negatively by means of frictional driving gear, and therefore revolve quite independently of the frictional grip of the yarn around the cylinders, as stated in § 209, and described subsequently in §§ 220 and 221.

The effectual discharging of the water of condensation from steam-heated cylinders is a problem which presents several practical



A

Fig. 101.



B

Fig. 102.

difficulties that have engaged the attention of many engineers, who have devised numerous methods of accomplishing that object. Of several types of these devices that are in use, the "water-bucket" or "ladle," of which one form is illustrated in Figs. 101 and 102, is the one most frequently applied. This simple device consists usually of two or else three buckets or ladles placed at regular intervals apart, and fixed in the angle formed by the cylinder shell and one end of the cylinder, as indicated in the diagrams (Figs. 101 and 102), which represent a sectional front elevation and an interior end elevation, respectively, of that end of the cylinder carrying the water-buckets.

From each of these water-buckets a pipe leads into the inner end of the cylinder journal, to the outer end of which there is attached, by means of a packed gland coupling, to prevent the escape of steam, an external pipe leading into a steam trap. Therefore, as the cylinders revolve, the water-buckets arrive successively at their lowest position, and scoop or ladle the waste water of condensation, which, as the buckets ascend, flows down the outlet pipes and is thereby discharged into the cylinder journal, whence it flows along the external pipe to the steam trap which intercepts and prevents the escape of steam, although it allows the water to pass away freely, and be either returned again to the steam-boiler or else into a reservoir.

§ 215. Water-buckets of the pattern illustrated in Figs. 101 and 102 are, however, capable of taking up the water, provided the cylinders revolve in one direction only. If perchance a cylinder furnished with that form of water-bucket is mounted the wrong way about, so that it revolves in the reverse direction to that which is intended, the buckets fail to perform their function. As a precaution against such a contingency Messrs Wm. Dickinson & Sons furnish their slasher sizing cylinders with reversible-acting buckets that are capable of taking up the water of condensation in whichever direction the cylinders may revolve. This object is effected by the simple expedient of constructing the water-buckets symmetrically, and dividing the opening into two corresponding parts by inserting a mid-feather partition right across them, as indicated in the diagram (Fig. 103), which represents an internal side elevation of a cylinder provided with this improved form of water-bucket.

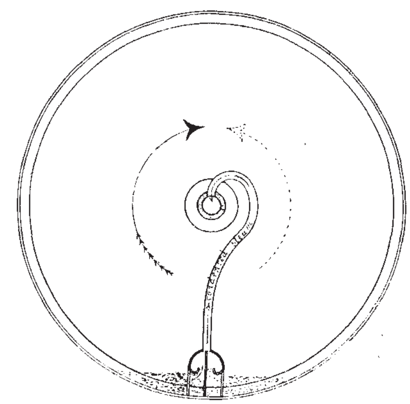


Fig. 103.

Another type of device for the purpose of discharging the water of condensation from steam-heated drying cylinders is that of Messrs Bentley & Jackson's, illustrated in Fig. 104, which represents the interior of a steam-drying cylinder constructed with this simple device, consisting essentially of an internal spiral gutter or channel secured to the cylinder shell, and extending with one, or more than one, coil from that end of the cylinder at which steam enters, to the other end, at which the water of condensation is expelled, where the spiral channel approaches towards the axis of the cylinder and terminates in a receptacle which opens into the cylinder journal at that end.

Thus, as the cylinder revolves in one direction only, as indicated by an arrow, the water of condensation, lying in the bottom of the cylinder, is conveyed along by the propelling action of the spiral channel to the discharging end of the cylinder, where it is raised and emptied into the receptacle which discharges it into the cylinder

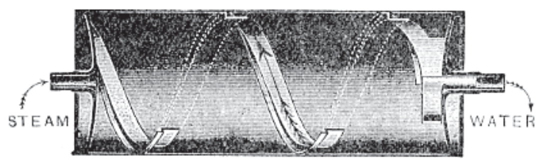


Fig. 104.

journal, whence it passes along a pipe to a steam trap, and finally escapes to return either to the boiler or to the reservoir. It is claimed, by the makers, that this device not only increases the drying efficiency of the cylinders to which it is applied, but also that the spiral channel gives them additional stability, and thereby diminishes the risk of cylinders collapsing.

Cylinder Explosion Risks

§ 216. Steam-heated cylinders of slasher-sizing and other types of machines are not only liable to collapse after the supply of steam is shut off from them, unless this risk is guarded against by furnishing them on one side or both sides with a vacuum or air-inlet valve of the type described in § 211 and illustrated in Fig. 98, but they are also liable to explode and burst if, perchance, the internal pressure exceeds the maximum and uncertain limit which sometimes (though fortunately very rarely) occurs with disastrous consequences.

Accidents of this character are generally caused by some defect occurring in one or other of the parts incidental to the steam-service and exhaust-steam equipments, as the reducing valves, safety valves, and steam traps. If such defects prevent the proper action of those parts, the steam might attain to a pressure within the cylinders greater than these are capable of withstanding, when they are liable to burst.

Hence, the possible risk of such accidents occurring without previous warning, suggests the expediency of furnishing each cylinder independently with a suitable type of safety valve to open automatically and thus allow the steam to escape from them in the event of the internal pressure attaining a prescribed limit. By adopting this course the auxiliary cylinder safety valves would constitute an additional precaution against the risk of explosions that are liable to occur as a result of defects in other directions.

Possibly a suitable type of safety valve to employ for this purpose would be one designed on a similar principle to that inherent to the vacuum or air-inlet valve illustrated in Fig. 98, but with the steam valves fixed on the cylinder end-plates in a position which is the reverse to that of the vacuum valves, so that they will open and allow the steam to blow off whenever the internal pressure attains the prescribed limit.

§ 217. In March 1911, the small cylinder of a slasher sizing machine exploded after being in use for a period stated to be not less than twenty years. This cylinder was constructed with end-plates of $\frac{1}{4}$in. steel formed with flanged rims 2in. wide, and stayed with six $\frac{7}{8}$in. cross-bolts formed with a forged collar at each end, against which the end-plates were held by means of nuts, externally. The cylinder shell consisted of four tinned steel sheets $\frac{1}{20}$in. thick, soldered to the flanged rims of the end-plates, and pieced horizontally by overlapped, single-riveted, and soldered joints or seams. The shell was also supported, internally, by three circular **T**-iron hoops placed at regular intervals apart between the cylinder ends, to prevent the shell from collapsing.

Further precaution against this risk was taken by fixing an air-inlet or vacuum valve in each end-plate, and the water of condensation was removed from the cylinder by means of three water-buckets. Also the main steam-service pipe leading to the cylinder trunnion or journal, through which steam was admitted to the cylinder, and which had an internal diameter of 1in., was furnished with a reducing valve, a deadweight safety valve loaded to blow off at a gauge pressure of 12lb., and a steam-pressure gauge. The steam pressure in the boiler was equal to 100lb. per sq. in., which was supposed to be reduced finally to a gauge pressure of about 10lb. before it entered the cylinder; but in consequence of the piston or plunger of the reducing valve having worn, it failed to act properly, and thus allowed the steam to pass it and enter the cylinder at a pressure which it could not withstand.

Furthermore, the attendant in charge stated that he had not observed anything unusual, and even that steam was not blowing off at the safety valve, previous to the cylinder bursting. When this occurred, one of the seams of the cylinder shell was torn open and wrenched from the rivets right across the cylinder, and the shell was also torn away for nearly three-quarters of its circumference from the flanges of the cylinder end-plates to which it was soldered. The cylinder end-plates were bulged, the machine framing was broken in several places, and the large cylinder and the floor were also damaged by the explosion.

§ 218. Another cylinder, also the smaller one, exploded in May 1911, after being in use for a period of thirty-three years. In its general constructive features this cylinder was similar to the previous one, excepting that the end-plates were made of $\frac{1}{4}$in. Low Moor iron plates stayed with eight cross-bolts; and the shell consisted of four tinned iron sheets $\frac{1}{20}$in. thick, supported internally by three T-iron hoops. (The number of sheets of metal employed in the construction of the cylinder shells usually coincides with the diameter of the cylinders, expressed in foot-units.) The cylinder was also provided with the usual number of three water-buckets, from which tapered outlet pipes led to the discharging journal of the cylinder.

The several accessories incidental to the steam-service range of piping comprised a main steam-reducing valve; a final reducing valve for each cylinder, a safety valve loaded to blow off at a steam gauge pressure of $11\frac{1}{2}$lb. per sq. in., and also a pressure gauge for the large cylinder only; a vacuum or air-inlet valve in both ends of each cylinder; a manhole 15 by 10in. at one end of each cylinder; and a steam trap with an outlet valve of $1\frac{1}{4}$in. diameter for each cylinder.

The cylinders were supplied with steam generated in water-tube boilers, and conveyed along 70ft. of 4in. piping to the main reducing valve, whence the steam passed through 32ft. of 2in. piping to the final reducing valves on the machine, where the steam pressure was further reduced from 20lb. to the working pressure required in the cylinders, to which it was admitted after passing through another 15ft. of 1in. piping leading from the final reducing valves to the admission journals of the cylinders.

But since the steam-service pipe, leading to the small cylinder which burst, was not provided with either a safety valve or a steam-pressure gauge, it was impossible at any time to ascertain, with certitude, the cylinder pressure, which was controlled primarily by the main reducing valve that was supposed to reduce the boiler steam pressure from 175lb. to a pressure of 20lb., although the actual pressure in the boiler sometimes attained to 190lb., indicating a steam-gauge pressure of 22lb. per sq. in.

The primary cause of the cylinder exploding in this instance was attributed to some defect occurring in the steam trap, which caused the outlet for the water of condensation to become choked, whereby the steam attained an abnormal pressure in the cylinder, and finally burst it. When the explosion occurred, the cylinder shell was wrenched from the rivets along one of the seams right across the cylinder, and the shell was torn clean away from the soldered joints on the flanged rims of the cylinder end-plates for nearly the entire circumference of the cylinder, thereby demolishing the wooden casing which enclosed the cylinders, and also displacing several parts of the machine.

Methods of Mounting and Driving the Drying Cylinders

§ 219. It was stated in § 209 that the journals or trunnions of the drying cylinders of slasher sizing machines were variously mounted (*a*) in ordinary stationary cup bearings; (*b*) on roller bearings; (*c*) in ball bearings; and also that the cylinders in some machines were rotated by means of frictional driving gear, instead of imposing that function upon the warp threads, and thereby depriving them of their valuable property of elasticity.

Frictional resistance between the cylinder journals and bearings is greater with ordinary cup bearings than with roller bearings, and is least with ball bearings. Therefore, when the rotation of the cylinders devolves entirely upon the frictional surface grip and progress of the yarn, the degree of tensile strain imparted to the threads is reduced to the minimum if the cylinder journals revolve in ball bearings. But if the cylinders are driven through the medium of frictional clutches, these may be regulated to turn the cylinders with a surface velocity coinciding exactly with the progress of yarn from the back or slashers' beams to the weaver's beam, whereby the degree of tensile strain upon the threads is absolutely nil.

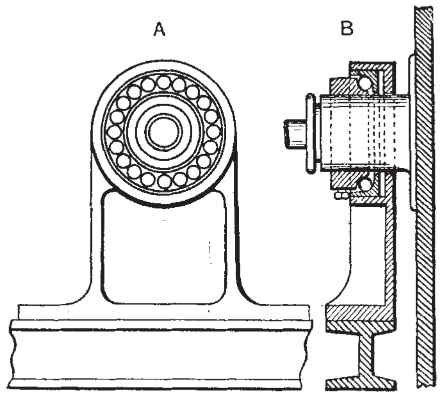


Fig. 105.

If, however, the cylinders are driven by frictional driving gear, the advantages to be otherwise derived from mounting them on either roller or in ball bearings would be nullified so far as the effect upon the threads is concerned. And although a small reduction of driving power would be effected by adopting cylinder ball bearings in conjunction with frictional driving gear, the gain would be so inappreciable that it would not be worth the extra cost of ball bearings, albeit such a combination of cylinder bearings and driving gear has been actually adopted.

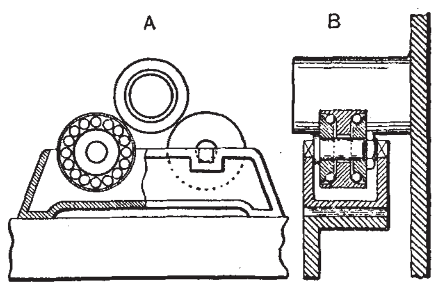


Fig. 106.

Two illustrations of the application of ball bearings to the journals of drying cylinders are given in Figs. 105 and 106, which represent Rossetter & Briggs' alternative modifications of that type of bearing. By one method, represented by a side and a front sectional elevation at A and B respectively, Fig. 105, the cylinder journals revolve each within an external ring of balls that are retained in position by, and roll freely around, an angular recess formed in a hub, as indicated in the sectional diagram B.

An alternative method of supporting the cylinder journals is illustrated in Fig. 106, A and B, which represent another type of bearing consisting of a combination of both balls and flanged rollers, operating in conjunction. With this type of bearing the journals are borne by and revolve upon two flanged rollers that revolve around two internal rings of balls retained in angular recesses formed in the hub around which the balls roll freely, as indicated in the diagram B.

Frictional Driving Motions for Cylinders

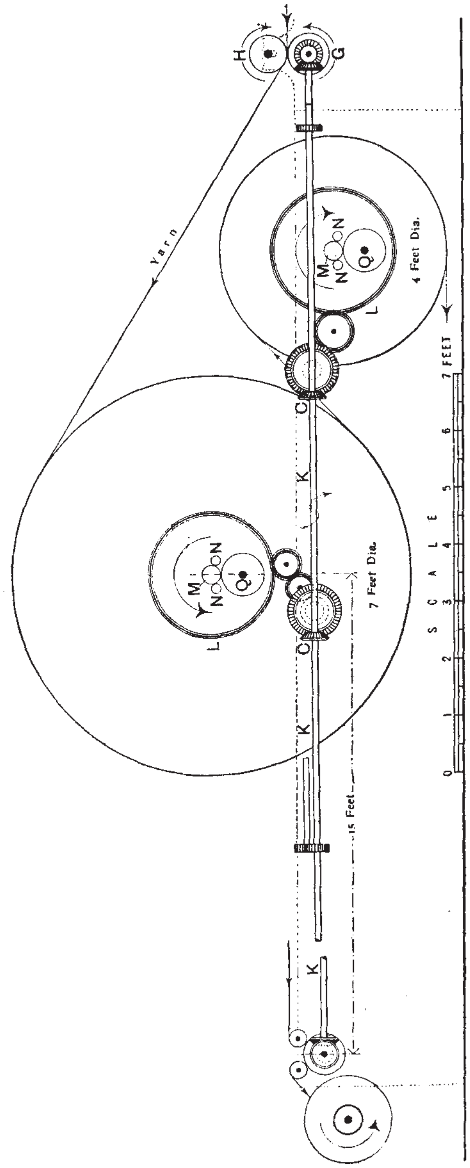
§ 220. One of several methods of frictional driving adapted to the cylinders of slasher sizing machines is that of Messrs Henry Livesey's, illustrated in Figs. 107 and 108, which represent a side elevation and a part plan respectively of a sizing machine to which that method of driving is applied. This device consists essentially of two flat metal friction discs in combination with, and separated by, a bevel friction wheel to constitute a simple form of frictional driving disc or clutch, as represented separately on a larger scale in Fig. 109, to be described later.

Two separate clutches are employed, one for each cylinder, and they are each operated by bevel pinions on the long side-shaft of the machine, from which motion is transmitted positively and directly to the frictional driving clutches, whence it is transmitted *negatively*, through the medium of wheel gearing, to the respective drying cylinders.

This is effected, in respect of both cylinders, by gearing a bevel pinion wheel C on the long side-shaft K, with a bevel friction wheel B mounted quite freely on the hubs or bosses of two friction discs D, E, that are situated one on each side of the friction wheel, but separated from it by interposing flannel or felt washers F, F, that are kept well lubricated as a precaution against the risk of generating frictional heat. The parts just enumerated constitute the driving clutch, of which Fig. 109 is an enlarged sketch.

The friction wheel B and the friction discs D, E, are contained on the forward portion of a short shaft or stud J, on the rear part of which there is also keyed a spur pinion wheel A, which drives a short

Fig. 107.



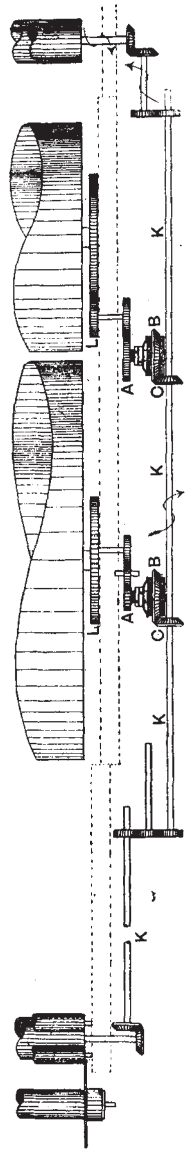


Fig. 108.—Frictional Driving Motion for Cylinders.

train of wheels terminating with one L, that is keyed on one of the cylinder journals M, which are mounted on single-roller bearings Q of large diameter, and between two small steadying rollers N, to keep the cylinders in position. One of the two friction discs D is fixed on the shaft J; but the second disc, E, is quite loose, and capable of sliding freely in a horizontal direction upon the shaft, though both this disc and the shaft must necessarily revolve together by reason of a float or feather key, which is fixed in the shaft, entering a keyway or channel cut into the boss of the disc D.

Hence, the friction wheel B is capable of transmitting motion to the friction discs D, E, and thence through the trains of wheels to the respective cylinders, only by compressing the friction discs against the friction wheel until there is produced such a degree of frictional resistance between them as is necessary to rotate the cylinders with a surface velocity that will coincide exactly with the pace at which yarn is delivered to them by the sizing and finishing rollers G, H, and at which it is withdrawn from them and delivered to the weaver's beam by the tension or drawing rollers.

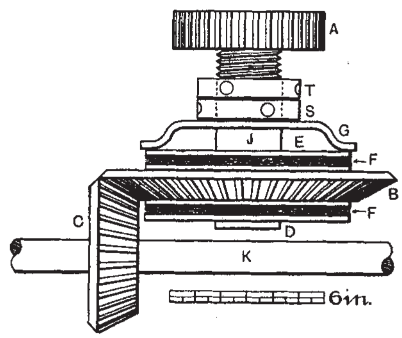


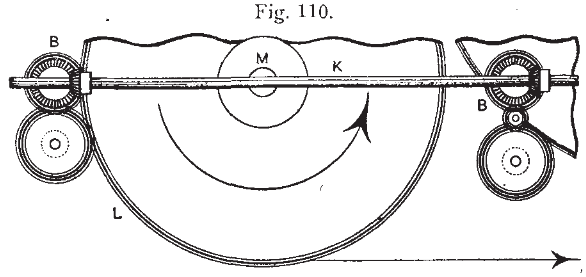
Fig. 109.

The compression of the friction wheel and discs is effected by means of a spring clamp G and a circular nut S. This is screwed up on a threaded part of the shaft J until the frictional resistance between the friction wheel and discs is sufficient to drive the cylinders with a velocity that will maintain a uniform degree of tensile strain upon the yarn without stretching the threads, and thereby destroying their property of elasticity. When, according to the judgment of the attendant, the requisite degree of tension upon the yarn is obtained, the first nut S is secured by a lock-nut T to prevent it from unscrewing accidentally, and thereby reducing the compression, and therefore the driving efficiency, of the frictional driving clutches.

§ 221. Another method of frictional driving adapted for turning the cylinders of slasher sizing machines is that of Messrs Howard &

Bullough's, illustrated by a part end elevation and a part plan in Figs. 110 and 111 respectively. By this method of driving, motion is also transmitted from the long side-shaft K to the respective cylinders, through the medium of frictional driving clutches; but in this example the friction wheels B of the driving clutches gear directly with spur-teeth formed around the rim at one end of each cylinder, as indicated in the diagrams. The degree of compression between the friction wheel B and the single friction disc D, of the respective driving clutches, is regulated by varying the tension of an open spiral

Fig. 110.



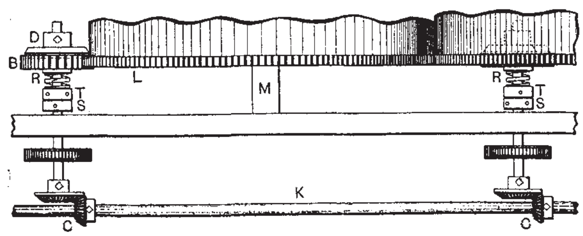


Fig. 111.

spring R by means of a circular nut S secured by a lock-nut T.

By reason of the frictional driving wheels B of this motion gearing directly with teeth formed around one end of the respective cylinders, the clutches acquire a much greater purchasing power or leverage in turning the cylinders. This circumstance, combined with the relatively high velocity with which the frictional driving wheels must revolve, gives this motion much greater driving power than is attainable by driving the friction wheels with a slower velocity and gearing them either directly or indirectly with wheels of which the teeth are nearer to the axes of the respective cylinders.

When putting into operation, for the first time, a slasher sizing machine which is furnished with frictional driving gear to rotate the cylinders, the driving clutches should be quite free from compression. Then, whilst the machine is in operation, with yarn passing through it, the clutches may be compressed gradually and cautiously until the cylinders acquire a velocity that will ensure the requisite tension upon the yarn according to the experienced judgment of the attendant, whose only guide is to feel at the yarn in its progress through the machine, and on the weaver's beam.

Also, if under any special circumstance it is deemed expedient to impose upon the warp threads the effort of rotating the drying cylinders, this may be easily and readily effected by simply releasing the compression of one or both of the frictional driving clutches, thereby leaving one or both of the cylinders quite free to revolve solely by the frictional surface grip of the threads upon the cylinder shells.

Relative Disposition of the Drying Cylinders

§ 222. It has been observed that some slasher sizing machines differ from those of the regular standard design in respect both of the number of drying cylinders employed and also of the relative disposition of the usual 7ft. or 6ft. and 4ft. cylinders. These modifications assume a variety of different forms, chiefly according to the particular object which they are designed to accomplish. For example, some machines are constructed with only one drying cylinder; others with three cylinders; whilst some that are constructed with two cylinders of the usual diameters have those mounted in the reverse order, in relation to the other parts of the machine, from that which usually obtains.

These variations are effected usually with some specific object in view. Thus, single-cylinder machines are designed with a view to effecting economy in the consumption of steam, and also in the amount of floor space which they occupy; whereas others are constructed with an additional drying cylinder either to increase the general efficiency and productive capacity of the machines, or else with the object of adapting the machines suitably to meet some particular technical requirement involved in the manufacture of certain classes of fabrics, such as dhooties, handkerchiefs, and others in which different colours of warp threads are employed.

In this case it is usual to construct the machine with an auxiliary size-box placed at a higher elevation, and equipped with the usual accessories, to permit of the coloured warp threads being separated and sized apart from the other warp threads to prevent the risk of these becoming stained from fugitive dye, such as would be liable to occur if the different colours of threads were passed together through the same solution of boiling size.

§ 223. If slasher sizing machines are constructed with only one drying cylinder, this is usually of the cavity type, having an external diameter of 9ft., and formed with an annular space having a radial depth of 6in., to constitute a steam jacket or chamber extending between an inner and an outer cylinder shell. Sizing machines constructed with a 9ft. cavity cylinder not only occupy relatively less floor space than those constructed with two hollow-drum cylinders of 6ft. and 4ft. diameter respectively, but a cavity cylinder also possesses a relatively much greater drying efficiency than the two ordinary cylinders, in proportion to the consumption of steam, which is in the ratio of 1 to 3 respectively. Thus, the drying efficiency of a 9ft. cavity cylinder supplied with steam indicating a gauge pressure of 3 to 4lb. is equal to that of two ordinary cylinders of 6 and 4ft. diameter supplied with steam indicating a gauge pressure of about 9 to 12lb. Also, the effective drying surface afforded by a cylinder 9ft. diameter, and with a yarn contact of 300°, or five-sixths of the circumference, is quite equal to that afforded by two cylinders of 6 and 4ft. diameter respectively, with a yarn contact on each cylinder of 270°, or three-fourths of their circumference.

§ 224. One of several modifications designed with the object of increasing the drying efficiency, and thereby the productive capacity, of slasher sizing machines, is that of Crook's, illustrated in Fig. 112, which represents a part side elevation of a machine constructed with an auxiliary drying cylinder having a diameter of about 4ft. This cylinder is placed at a high elevation in front of the large cylinder, and supported by an iron girder rafting suspended by roof hangers, so that the additional cylinder does not involve additional floor space for the machine. With this arrangement of three drying cylinders, the progress of yarn through the machine follows its usual course until it is deflected from a horizontal course near the floor, and conducted upwards immediately in front of the large cylinder, to pass over the auxiliary cylinder, whence it again descends near to the floor and passes forward and backward, first below and then above a cooling fan, after which it follows the usual course to the weaver's beam.

It is claimed that this method of drying and cooling the yarn not only permits of an increased production to the extent of about

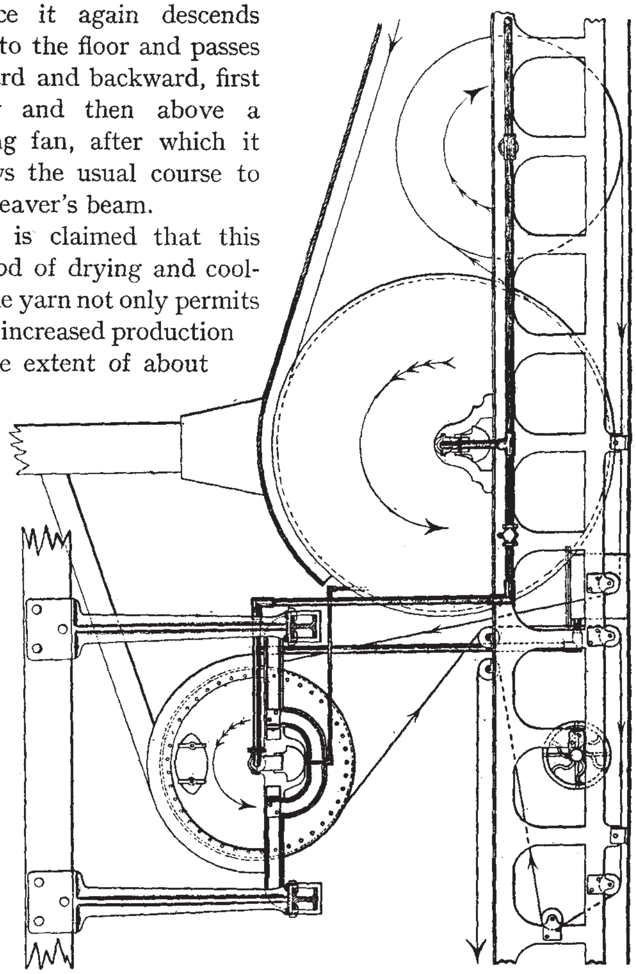


Fig. 112.

one-third, but that it also conduces to a mellower tone and superior quality of yarn, resulting from the longer exposure of the threads to the air-drying influence of the cooling fan. Also, that in consequence of conducting the yarn along a more circuitous course, when it is not in actual contact with the hot surface of the drying cylinders, the tension of the warp threads is of a more uniform degree. Further, that heavily-sized warps are dried and finished more perfectly and with less risk of scorching the yarn on the cylinders.

§ 225. Another method of adapting an auxiliary drying cylinder to an ordinary slasher sizing machine is that of Martin's, illustrated in Fig. 113, which represents a part side elevation of a machine

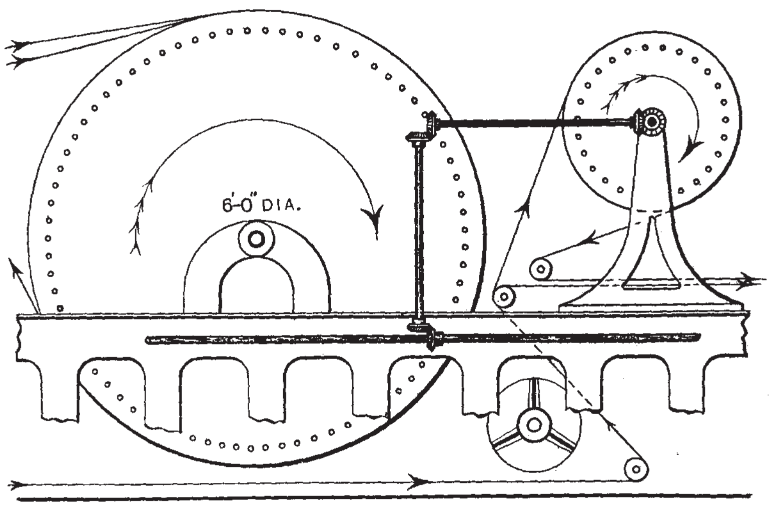


Fig. 113.

adapted expressly for sizing warps composed of both grey and coloured threads, for the production of dhootie bordered fabrics and other coloured stripe warp effects. When sizing warps of this class it is usual to separate the grey and coloured threads and pass them through separate size-boxes to prevent the risk of staining the grey yarn with dye from the coloured yarn. On emerging from their respective size-boxes, both the grey and coloured threads are conducted around the two ordinary drying cylinders in the usual manner, and on leaving the smaller cylinder the coloured yarn is then passed over the auxiliary drying cylinder to be dried more efficiently, after which both series of threads are again united and wound together on to the weaver's beam.

The auxiliary drying cylinder may be mounted either before or behind the large drying cylinder, and supported by girders fixed either to roof hangers or else to standards bolted to the machine framing. Also, it may be driven either by the surface grip of the yarn, or else through the medium of toothed gearing operated from the side shaft of the machine, as indicated in the diagram.

§ 226. A departure from the usual practice of withdrawing the yarn from the respective back beams in the creel of a slasher sizing machine, and also of passing it around the drying cylinders, is that represented in Fig. 114, which illustrates Hargreaves' modification of a sizing machine in which the respective sheets of warp threads from the several back beams are kept quite separate and distinct from each other until they are all combined into one sheet of threads as they pass underneath the copper immersion roller in the size-box; further, the large and small drying cylinders are mounted in reverse positions, relatively to other parts of the machine, to those which they usually occupy. With this arrangement of the drying cylinders the yarn is capable of extending around the large cylinder for about eight-ninths of its circumference, but for only about one-half the

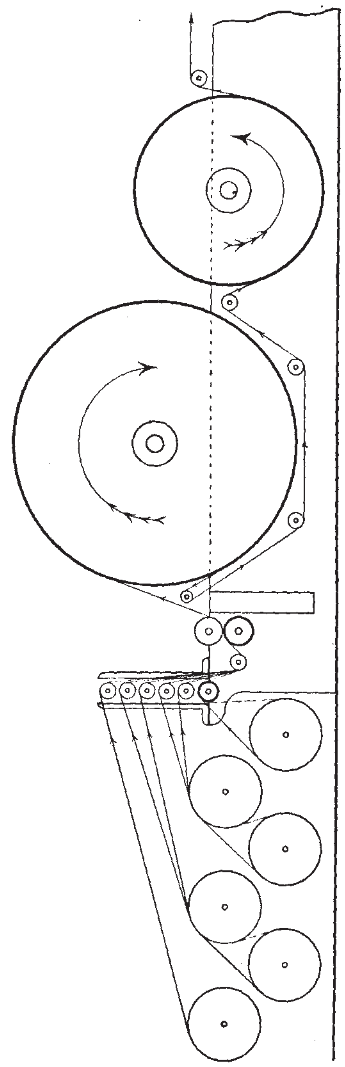


Fig. 114.

circumference of the smaller cylinder. Thus the effective drying surface afforded by the two cylinders in this case is approximately the same as that afforded by two cylinders of corresponding diameter mounted in the usual manner, and with a yarn contact on each cylinder for three-fourths of their circumference.

The object of keeping each sheet of threads separate is to permit of their immersion into the solution of size whilst the warp threads are in a more open and free state, whereby they become more thoroughly impregnated with size. Also, the closer proximity of the large cylinder to the sizing rollers has the advantage of shortening very considerably the stretch of yarn between those parts, thereby reducing the tendency of the warp threads to curl and become entangled when, on stopping the machine, they are relieved of tensile strain and therefore become slack.

Cooling Fans

§ 227. Slasher sizing machines are furnished with either one fan only, as represented in Figs. 112 and 113, or else with two fans, for the purpose of cooling the yarn after being dried by the hot cylinders, and before it passes on to the weaver's beam. If the yarn were wound, whilst in a warm state, on to the weavers' beams, and then allowed to cool naturally, the process of cooling would create moisture in the yarn, thereby conducing to the development of mildew, and also causing the warp threads to adhere together.

The cooling fans are mounted in front of the large cylinder, near the floor, as indicated in Figs. 112 and 113, and are driven with a high velocity to create a strong current of cool air which is fanned on to the yarn as this is deflected upward from near the floor, to be conducted under and over the dividing rods.

Dividing Rods

§ 228. It has been stated previously in § 181 that the several sheets of threads from the respective back beams are all immersed simultaneously into the solution of size, and afterwards dried as one single sheet of threads, with the result that the threads adhere to each other, and therefore require to be separated before they are wound finally on to the weavers' beams.

This is effected by passing the threads in a prescribed manner under and over a series of iron bars termed "dividing rods" that are placed in the rear part of the headstock framing, and extend horizontally across the entire width of the machine in a little higher plane than the upper edge of the framing. The rods are disposed parallel with each other at regular intervals of 12 to 18in. apart, and at slightly different elevations, to avoid unnecessary chafing of the yarn.

The number of dividing rods employed is always one less than the number of back beams; and, with the exception of the rearmost rod (from the front of the machine), which is about 2in. diameter, the rods are of a uniform diameter of about $1\frac{1}{4}$in. Therefore, in order to divide the combined sheet of sized warp threads from six back beams into that number of separate sheets of threads, precisely as these left their respective beams, only five dividing rods are required with the threads passed under and over them in the manner indicated in Fig. 115, and specified as follows:—

Yarn from No. 1 beam passes	over rods No.	—	2	—	4	—
	under rods No.	1	—	3	—	5
Yarn from No. 2 beam passes	over rods No.	1	2	—	4	—
	under rods No.	—	—	3	—	5
Yarn from No. 3 beam passes	over rod No.	—	—	—	4	—
	under rods No.	1	2	3	—	5
Yarn from No. 4 beam passes	over rods No.	1	2	3	4	—
	under rod No.	—	—	—	—	5
Yarn from No. 5 beam passes		—	—	—	—	—
	under rods No.	1	2	3	4	5
Yarn from No. 6 beam passes	over rods No.	1	2	3	4	5
		—	—	—	—	—

This method of separating the warp threads forcibly by tearing them asunder whilst they adhere more or less tenaciously with size, acts detrimentally upon the yarn, and not only partially destroys the beneficial effects of sizing, but the separation of the threads is also more or less imperfect, since it is possible, and in fact sometimes actually occurs, that two or more contiguous warp threads from the same back beam may pass on to the weaver's beam without being separated.

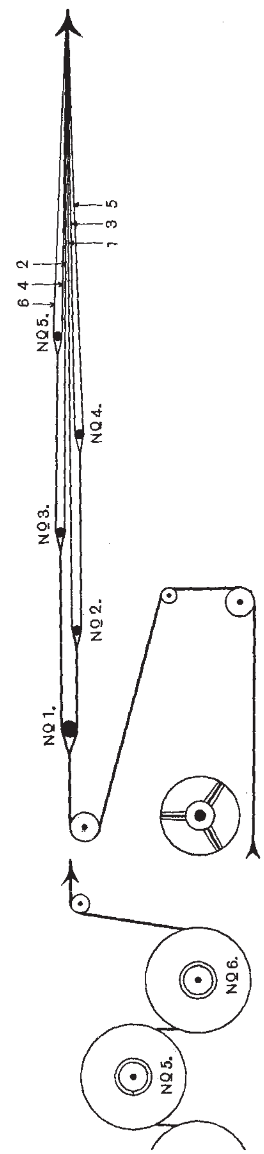


Fig. 115.

Driving Gear

§ 229. Slasher sizing machines are usually constructed with driving gear designed both for differential speeds and also to operate the machine optionally at either the full speed or at a dead-slow speed. The special object of employing differential gearing is to provide for the varying requirements arising from the difference in the counts and strength of yarn, the number of warp threads, the character and percentage of size-paste applied to the yarn, the drying efficiency of the cylinders at different steam pressures, the atmospheric condition of the sizing room as regards both the temperature and the relative humidity of the air, and many other variable and uncontrollable factors which necessitate either an increase or a reduction of the speed with which the machine is driven.

The slow-speed driving gear is adopted as a precaution to guard against the risk of parching or scorching the yarn on the drying cylinders by enabling the machine to be operated at a dead-slow speed, instead of stopping it entirely when recovering and piecing broken warp threads, and also when removing a filled weaver's beam and replacing it with an empty one.

Full-speed Differential Driving Gear

§ 230. The driving gear of slasher sizing machines made by different makers varies in minor details of construction.

In some machines the driving mechanism consists of a simple train of wheel gearing which permits of a variation of speed being effected only by substituting different sizes of change-pinions whilst the machine is stopped. The more prevalent method of driving, however, is effected by the employment of two reversed cone drums that are in gear through the medium of a driving belt which may be moved along the cone drums to vary the speed of driving whilst the machine

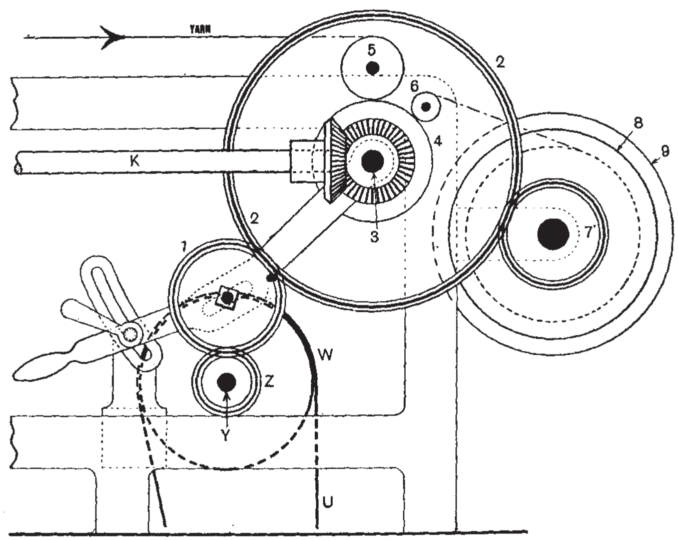


Fig. 116.

is in operation. Also, in order to obtain a still wider range of speed variation than that afforded by either change-wheel gearing or with cone drums, if each method is employed alone, the driving mechanism sometimes consists of a combination of both those methods.

An example of change-wheel driving gear is illustrated in Fig. 116, which represents a part end elevation of the foremost end of the headstock of a machine constructed by Messrs Wm. Dickinson & Son. With this method of gearing motion is derived from the main driving belt U, which runs on the fast and loose driving pulleys W that are mounted on one end of a shaft Y. On the opposite end of this shaft there is fixed the change-pinion Z, which, through the medium of an adjustable carrier wheel 1, transmits motion to a large spur-wheel 2, keyed on one end of the shaft 3 of the tension or drawing roller 4. In addition to turning the tension roller 4, the spur-wheel 2 also drives a smaller wheel 7, which puts into operation the frictional winding motion 8 to turn the weaver's beam 9 in a manner described subsequently in § 239.

In conjunction with two supplementary drawing rollers 5 and 6, of which roller 5 is very heavy, the roller 4 draws the yarn forward from the sizing rollers and delivers it to be wound on to the weaver's beam 9. The supplementary drawing rollers cause the yarn to make a larger arc of contact with the surface of the larger tension roller, and thereby obtain a firmer grip of that roller, which is driven positively by the wheel gearing in the manner described.

The surface of the roller 5 is wrapped with several coils of cloth to prevent injury to the threads, and it is usually made slightly greater in circumference than that of the lower sizing rollers which, through the medium of the long side-shaft K and bevel wheels, derive their motion from the tension-roller shaft 3, as described in § 186. The object of having the drawing roller of greater circumference than that of the lower sizing rollers is in order to prevent the delivery of yarn by those rollers exceeding its rate of withdrawal by the tension roller, as that would cause the yarn to become slack, and thereby fail properly to grip the surface of the drying cylinders.

The advantages of this method of driving, as compared with belt driving with cone drums, are that, being positive, it is thereby more certain and reliable than the frictional grip of driving belts, which are liable to slip and thus lose their driving power. Also, the initial cost, and that of maintaining it, are less than the cone-drum method of driving.

It has the disadvantage, however, of being much less convenient than cone drums for effecting a variation of speed; for should it become necessary, as it frequently does, to vary the speed of the machine during the progress of sizing, the machine would have to be stopped entirely for the purpose of changing the pinion; and this not only necessitates either shutting off steam from the drying cylinders, or else reducing the steam pressure, to prevent the risk of scorching yarn whilst the machine is temporarily stopped, but it also hinders production.

Further, wheel gearing alone does not afford either the same range of speeds, nor the same graduation of speed variation, between the maximum and minimum velocities, as may be obtained by the employment of cone drums.

§ 231. An adaptation of the cone-drum principle of differential driving is illustrated in Figs. 117 and 118, which represent a side elevation and a plan respectively of the headstock of a slasher sizing machine. In combination with that method of driving there is also illustrated, in Fig. 118, a plan of Hitchon's adaptation of what is

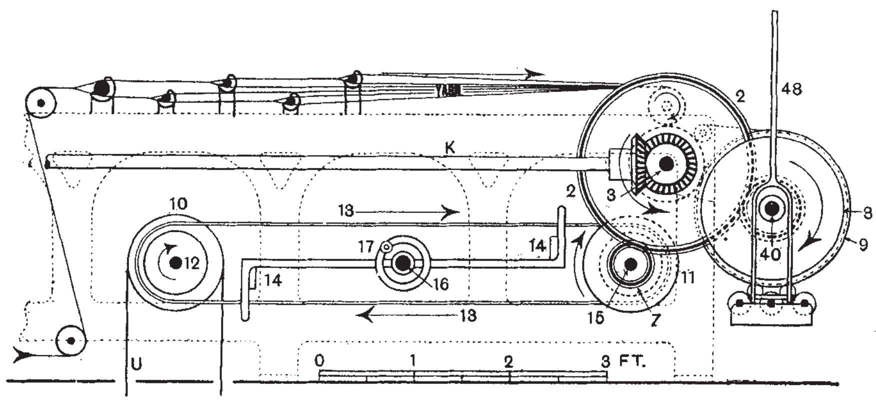


Fig. 117.

variously described as the "Lancaster" slow-driving motion and the "click" motion, which is also applied to spinning mules. The differential driving motion consists essentially of two wide cone drums 10 and 11, situated about 5ft. apart, with their axes in the same horizontal plane and parallel to each other.

When the machine is in operation at full speed, drum 10 is the prime motor which transmits motion to all other working parts of the machine. This is put into operation at full speed by passing the main driving belt U from the loose pulley V to the fast pulley W keyed on one end of the shaft 12 of the cone drum 10, which is always driven with a constant velocity. Motion is transmitted from the driving cone 10 to the driven cone 11 by means of a belt 13, under the guidance of a double belt-fork 14. On one end of the shaft 15 of cone drum 11, there is keyed a pinion wheel Z which gears with and drives a large spur-wheel 2' keyed on the large tension-roller shaft 3, thereby rotating the tension or drawing roller 4 with a constant velocity. The belt-fork 14 is controlled by means of a worm shaft 16 furnished at one end with a hand-wheel 17 which, on being

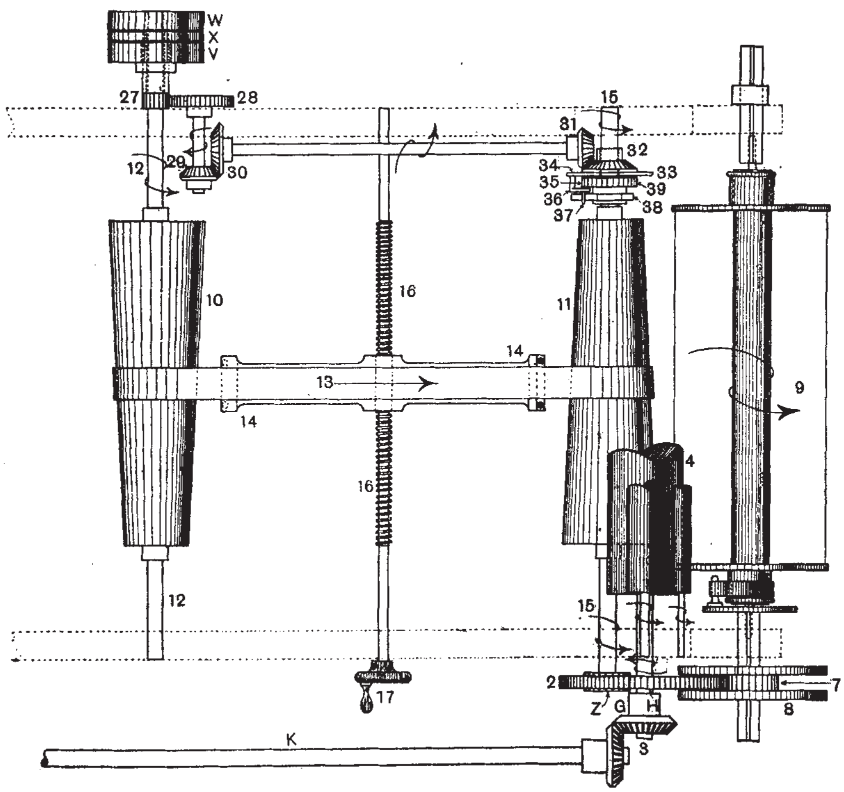


Fig. 118.—Differential Cone-drum Driving Gear.

turned, moves the cone belt to different parts of the surfaces of the cone drums, and thereby varies the speed with which the machine is driven. Thus, by passing the cone belt to a larger diameter of the driving cone 10, and therefore to a smaller diameter of the driven cone 11, the velocity of the latter, and consequently the progress of yarn through the machine, will be accelerated; whereas, if the cone belt is moved in the opposite direction, the speed of the machine will be retarded.

By this method of driving, the operation of the machine devolves entirely upon the cone belt, which not only tends to slide towards the smaller diameters of the cone drums, but is also liable to become slack, and therefore slip upon them. Hence the belt loses its grip and driving power, thereby retarding the speed of the machine, and thus curtailing production. This absence of reliability and certainty of action, as well as the extra cost incurred by the additional mechanism of the cone-drum method of driving, are the chief considerations urged against its adoption.

§ 232. Numerous methods have been adopted with the object of overcoming the slipping of belts on cone drums, and thereby increasing their driving efficiency. For example, instead of employing a single wide belt, two or three narrow strips of belts are sometimes employed side by side. In some cases the narrow belts are quite separate, and in others they are connected by means of cross-bands or strips of leather. The object of this arrangement is to obtain a belt of greater flexibility, and also one that can adapt itself more readily to the inclined surfaces of the cone drums. Sometimes two or three belts have been superimposed with the object of increasing the frictional grip of the belt on the surfaces of the cone drums; but this method is not very successful, probably in consequence of the outer belts tending to run quicker than, and "creep" along, the inner belts. A method patented by Thompson is to superimpose a wide belt upon, and rivet it to, another belt of about one-half or one-third the width, and which runs in contact with the drums.

§ 233. Another form of driving belt which has proved to be very effective for cone-drum driving is one composed of leather links placed on edge and pinned together so as to constitute a wide chain belt which tapers in thickness across the width of the belt. The belt is placed in position on the cone drums by giving it a half-twist in such a manner as to cause the thicker edge of the belt always to run on the smaller diameter of both cone drums, and *vice versa*.

§ 234. Another type of differential driving gear, adapted to some slasher sizing machines made by Messrs Butterworth & Dickinson, Ltd., is that illustrated in Figs. 119 and 120, which represent a side elevation and part sectional plan, respectively, of what is known as the "Hunter" type of variable speed driving motion, which permits of a

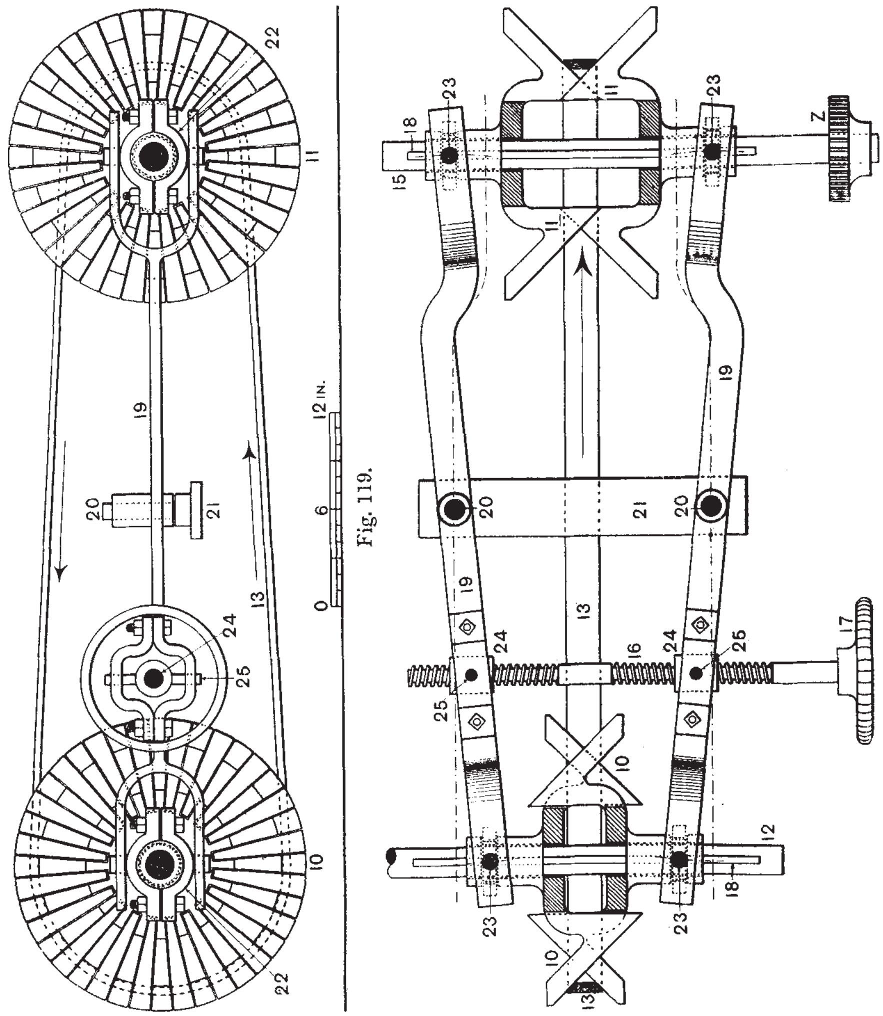


Fig. 119.

Fig. 120.—"Hunter" Type of Differential Driving Gear.

differential velocity being effected whilst the machine is in full operation, without the employment of either change-wheels or cone drums.

The central feature of this ingenious device consists of two special forms of grooved pulleys 10 and 11 that are capable of being either expanded or contracted in the direction of their axes, whereby their diameters are reduced or enlarged respectively. These two pulleys correspond to, and are employed in lieu of, the two cone drums represented in Fig. 118 and described in § 231. Thus, the pulley 10 on the main driving shaft 12 corresponds to the driving cone which, through the medium of a thick belt 13, transmits motion to the pulley 11, on the shaft 15, and which corresponds to the driven cone.

With this present method of driving, however, the tread of the pulley belt 13 is always in the same prescribed circuit, and the speed of the machine is regulated by varying the diameters of the driving and driven pulleys in a converse ratio, simultaneously, and in a manner to be described presently.

The pulleys 10 and 11 each consist of two complementary and reversed halves, as indicated in part section. Each half of the pulleys is constructed with a long hub or boss, from which there radiate twenty angular staves or arms disposed at regular intervals apart. When the two complementary halves of a pulley are united, their respective arms slide freely between each other in dovetail manner, and thus become intermeshed and freely interlocked, after the character of a multiple claw-clutch. The hubs of the pulleys are capable of sliding quite freely in a horizontal direction upon their respective shafts, which are furnished with long feather or float keys 18, that enter mortised grooves or keyways cut into the hubs of the pulleys, so that both the shaft and its pulley must revolve together in unison.

The expanding and contracting of the pulleys are effected by means of two long levers 19 fulcrumed on studs 20 fixed at opposite ends of a cross-rail 21. These levers are forked at each end for the purpose of spanning hoops or rings 22, each of which enters an annular recess formed near the outer end of each hub; and a swivel connection is formed between the lever forks and hoops, by means of pins 23. Each lever is also formed with a loop to receive a bush or sleeve 24, which is attached to its lever by means of a pin 25 to form a swivel connection with it. Bushes 24 are each formed with an internal screw thread—that of one bush being a right-hand thread, and that of the other a left-hand thread—to receive corresponding threads formed respectively at opposite ends of a worm-shaft 16, furnished at one end with a hand-wheel 17.

By turning the hand-wheel 17, levers 19 are moved in reverse directions, and thus cause the respective pulleys 10 and 11 to expand and contract simultaneously and conversely in an exactly corresponding measure, thereby changing their relative circumferences, and varying the speed with which the machine is driven, accordingly.

By this method of driving, the difficulty experienced with cone-drum driving, arising from the tendency of the cone belt to slip, is entirely avoided by reason of the pulley belt always running in a **V**-shaped groove formed by the radial angular staves of the pulleys.

Slow-speed Driving Gear

§ 235. A slow-speed driving motion is an almost indispensable adjunct of a slasher sizing machine, as it very considerably increases the efficiency of that machine. The slow-speed driving gear really constitutes an auxiliary driving motion which operates quite independently of that by which the machine is driven at full speed, although both schemes of driving gear are operated by the same main driving belt, but from independent driving pulleys.

The special function of the slow-speed driving gear is to transform the relatively high velocity of the driving pulley and transmit it with a considerably-reduced value to the various parts of the machine. This object is usually effected through the medium of what is known as the "Lancaster" or "click" slow-driving motion, of which one of several modifications is represented in conjunction with the cone-drum driving mechanism illustrated in Fig. 118, whilst the details of that device are represented on a larger scale by a part sectional front, and a side elevation, at A and B respectively, in Fig. 121.

The original conception of this device was designed and employed to drive, as the prime motor, the first or driving cone 10, with a very slow velocity, which was transmitted to the driven cone 11 through the medium of the cone-driving belt 13, as it does when the main driving belt is running on the full-speed driving pulley W to drive the machine at full speed. That application of the slow-speed driving gear, however, was found in practice to be mechanically defective and unreliable from the fact that a driving belt loses power as its velocity diminishes.

This circumstance, therefore, led to the adoption of wheel gearing as a medium for transmitting motion positively to the second or driven cone 11, which thereby becomes the *prime motor*, and is therefore quite independent of the cone-driving belt whenever the slow-speed driving gear is in operation to drive the machine at a dead-slow speed. And in one form or another this method of slow driving in conjunction with cone drums is adopted in all slasher sizing machines of modern construction.

§ 236. One of several adaptations of the "Lancaster" slow-driving motion is that of Hitchon's, as illustrated in Figs. 118 and 121. This motion is put into operation by passing the main driving belt U (Fig. 118) on to a narrow-rimmed pulley X which is mounted freely on the shaft 12 of the driving cone drum 10, and placed preferably *between* the loose pulley V and the fast or full-speed driving pulley W, which is keyed on the end of the cone-drum shaft 12. The narrow pulley X, and a pinion wheel 26, are fixed at opposite ends of a long sleeve or hub 27, which, being mounted loosely on

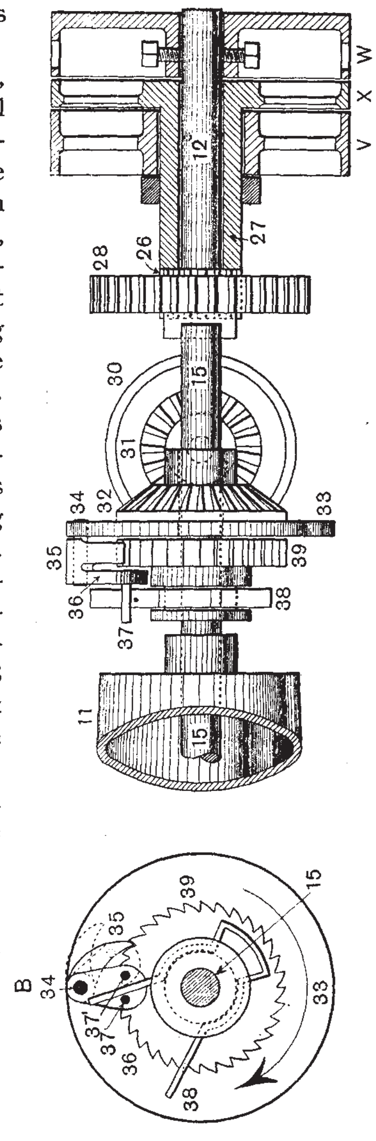


Fig. 121.—"Lancaster" Slow-motion Driving Gear.

the drum shaft 12, revolves quite freely and independently of that shaft; whilst the loose pulley V is mounted and revolves freely upon the hub of the slow-driving pulley X.

When the slow-driving motion is in operation, the main driving belt U runs partly on the rim of the loose pulley V, and also partly on the rim of the narrow slow-driving pulley X, whence motion is transmitted to the cone drum 11 through the medium of a simple train of carrier wheels 27, 28-29, 30, and 31, and the Lancaster click-motion mounted on one end of the cone-drum shaft 15, which it drives with a very slow velocity.

The details of this ingenious device are better represented by a part sectional front, and a side elevation, at A and B respectively, in Fig. 121. A bevel wheel 32, and a disc 33, are secured together and mounted freely on the end of the drum shaft 15, which may revolve quite independently of the wheel 32 and disc 33, although these latter cannot revolve without also rotating the cone drum 11 with a corresponding velocity.

Near the rim of the disc 33 is a stud or pin 34, on which there is freely hinged a catch or pawl 35, cast with a pendant weight 36, from one side of which there project two short pins 37 and 37^1 fixed about one inch apart. These two pins are intercepted by one of two projecting ends of a thin steel spring clamp 38, which spans and grips an annular channel or recess formed in the extended hub of a ratchet wheel 39, termed the " click " wheel, keyed fast upon the cone-drum shaft 15. Hence the cone drum 11 and the ratchet wheel 39 must always revolve together with a corresponding velocity whenever the driving is effected through the medium of the slow-speed driving gear, which is put into operation in the following manner:—

On passing the main driving belt U from the loose pulley V to he slow-driving pulley X, the disc 33, with its catch 35 and weight 36, commences to revolve slowly in the direction indicated by an arrow in diagram B, and thus causes one of the short pins 37 to bear against the spring clamp 38. The frictional resistance of this spring against the hub of the " click " wheel 39 will then cause the catch 35 to become deflected until it engages with a tooth of that wheel and thereby puts the machine in operation at a dead-slow speed.

If the main driving belt U is passed from the slow-driving pulley X to the full-speed driving pulley W, the slow-driving mechanism at once becomes inoperative, although it continues to move involuntarily by reason of frictional resistance between that mechanism and that of the full-speed driving gear.

The slow-driving motion is put out of action automatically as soon as the cone drum 11 and the " click " wheel 39 attain a velocity greater than that of the disc 33. When that velocity is attained, the spring clamp 36 bears constantly against the short pin 37^1, and thereby raises the pawl catch 35 and keeps it clear of the teeth of the " click " wheel 39, as indicated by dotted lines in the diagram B.

If, on the contrary, the main driving belt is passed from the full-speed driving pulley to the slow-speed driving pulley X, the driving cone drum 10 and the cone belt 13 become inoperative, albeit the slow-driving mechanism does not become the driving factor until the velocity of the driven cone drum 11 has so far diminished that it is on the point of falling below the velocity with which it is driven by that mechanism.

When that point is reached, however, the fractional and momentary disparity which occurs between the velocity of the disc 33 and that of the cone drum 11 causes the pin 37 to bear against the spring clamp 38, whereby the pawl 35 is deflected until it engages with a tooth of the " click " wheel 39, thereby maintaining the velocity of the cone drum 11, and therefore the speed with which the machine is driven, at the dead-slow speed to which it has declined.

§ 237. A simplified adaptation of the " Lancaster " slow-driving motion to slasher sizing machines is that of Messrs Wm. Dickinson & Sons, and which is represented in Fig. 122. With this modification of the driving gear, the reduction from the maximum velocity of the driving pulleys to the minimum velocity of the driven cone drum is effected more quickly, and also by the employment of fewer working parts, which ensure more direct and therefore easier driving, than by the former method.

These objects are attained by gearing the bevel pinion wheel 27 on the hub of the slow-speed driving pulley X, directly with the bevel wheel 30, and also by employing a single-thread worm 31 to drive a worm-wheel 32, which is mounted loosely on the cone-drum shaft 15, and corresponds to the bevel wheel 32 in Figs. 118 and 121. Also the stud 34, on which is hinged the catch or pawl 35 with its pendant weight 36, is fixed to an arm 33, instead of to a disc, secured to the wheel 32. In all other respects this device is similar to, and operates in the same manner as that described in the preceding section, 236.

A commendable feature of both of the foregoing slow-speed driving gearing is the particular arrangement of the slow-speed driving pulley in relation to the loose and full-speed driving pulleys, and also the incidental advantage, afforded by that arrangement, of mounting the loose pulley on the hub of the slow-speed driving pulley. As indicated in the diagrams, the slow-speed driving pulley is situated *between* the loose and full-speed driving pulleys. Hence, on passing the main driving belt from the loose pulley, it passes first on to the slow-driving pulley, thereby putting into operation the slow-speed driving motion, which starts the machine gradually, and without undue straining of either the driving mechanism or the yarn, before the driving belt passes on to the fast pulley to operate the machine at full speed. Also, the hub of the slow-driving pulley provides a much larger and therefore steadier and more durable bearing for the loose pulley, than if this were mounted directly on to the shaft as formerly.

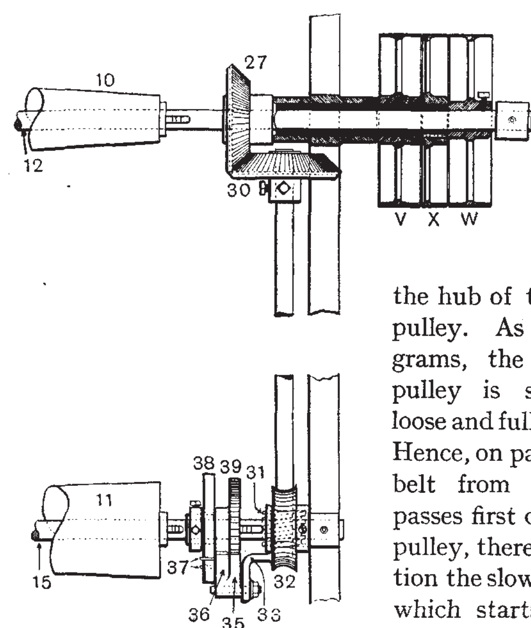


Fig. 122.

An improved form of " click " motion designed primarily for use on spinning mules, but one that is equally applicable to slasher sizing machines, is that represented in Fig. 123, which illustrates a double-acting " click " motion. This improvement is effected by constructing the device with two catches or pawls, thereby ensuring greater certainty of action, and also increasing its durability.

Frictional Beaming or Winding-on Motions

§ 238. The operation of winding the yarn, after it has been sized and dried, with both a uniform tensile strain and velocity, finally on to the weaver's beam, is a function of a slasher or other type of beam-warp sizing machine which might not readily appear to present any great mechanical difficulty to its successful accomplishment. Nevertheless, the attainment of that object satisfactorily is a problem that has taxed the ingenuity of textile machinists and inventors, as evinced by the numerous and varied devices which they have designed to accomplish it. The difficulties presented will become manifest when the precise conditions under which it is performed are known; and this knowledge will enable the relative merits of the respective appliances by which it is variously accomplished to be correctly appraised.

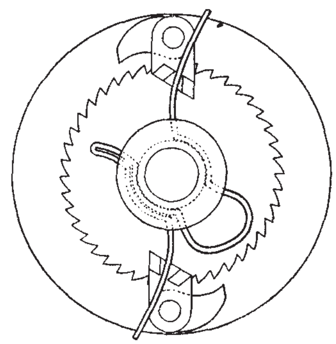


Fig. 123.

In order to ensure uniform sizing and drying of the yarn, and also a uniform degree of tensile strain upon it during its progress through the sizing machine, it should be withdrawn from the back beams and passed through the solution of size paste, thence conducted around the drying cylinders or through an air-drying chamber (according to the particular type of sizing machine employed), and then wound finally on to the weaver's beam with a constant velocity throughout, notwithstanding the gradually-increasing girth of the beam as successive layers of yarn are wound upon it.

To permit of these conditions being observed, it is imperative to employ some method of driving the weaver's beam so that its angular velocity may diminish gradually and automatically from a greater speed at the commencement of an empty beam to a slower speed as it becomes filled with yarn, and in a ratio inversely proportionate to its increasing girth, so as to maintain a surface or winding velocity of the beam that will coincide exactly with the rate with which the yarn is delivered to it by the tension or delivery rollers.

Winding-on motions of the type under present notice are invariably designed to transmit motion to the weaver's beam by frictional and therefore negative driving, which is both unmechanical in principle and unreliable in practice. This method of driving, however, has the supreme advantage of enabling the weaver's beam to diminish its angular velocity automatically as its diameter increases, and thereby accommodate its surface velocity to that with which yarn is delivered to it, albeit the frictional winding motion itself continues to revolve with a constant velocity which always bears the same ratio to that with which the yarn is delivered to the weaver's beam.

In fact, the frictional winding-on motion of a slasher sizing machine transmits motion to the weaver's beam in such a manner that it permits of the velocity of the latter being actually regulated and controlled by the pace with which yarn is delivered to it, although the velocity of the winding-on motion is of such a value that it tends always to rotate the weaver's beam *quicker* than the delivery of yarn to it will allow.

§ 239. One of several approved forms of frictional winding-on devices adapted for slasher sizing machines is that of Hitchon's, illustrated in Fig. 124, which also indicates the manner in which it transmits motion to the weaver's beam.

With a view to better demonstrating the operation of this device and displaying the details of its construction, the upper portion in the diagram represents a sectional view to expose the internal and obscure parts; whilst the manner in which the frictional device itself derives its motion is represented in Fig. 125. Thus, a pinion Z, fixed on one end of the second or driven cone-drum shaft 15, gears with and drives a large spur wheel 2 fixed on one end of the delivery roller shaft 3, through the medium of which wheel motion is transmitted to a friction wheel 7. This wheel constitutes the prime motor of the frictional winding-on device, which is usually mounted at one side of the machine only; but with one at each side of very wide machines.

As indicated in Fig. 124, the frictional driving wheel 7 is constructed with two inner flanges 7^1, that extend some distance beyond the teeth of the wheel, on each side of it, and terminate each with a broad rim which projects outward at right angles to the flanges. In combination with the flanges of the friction wheel 7 are two outer

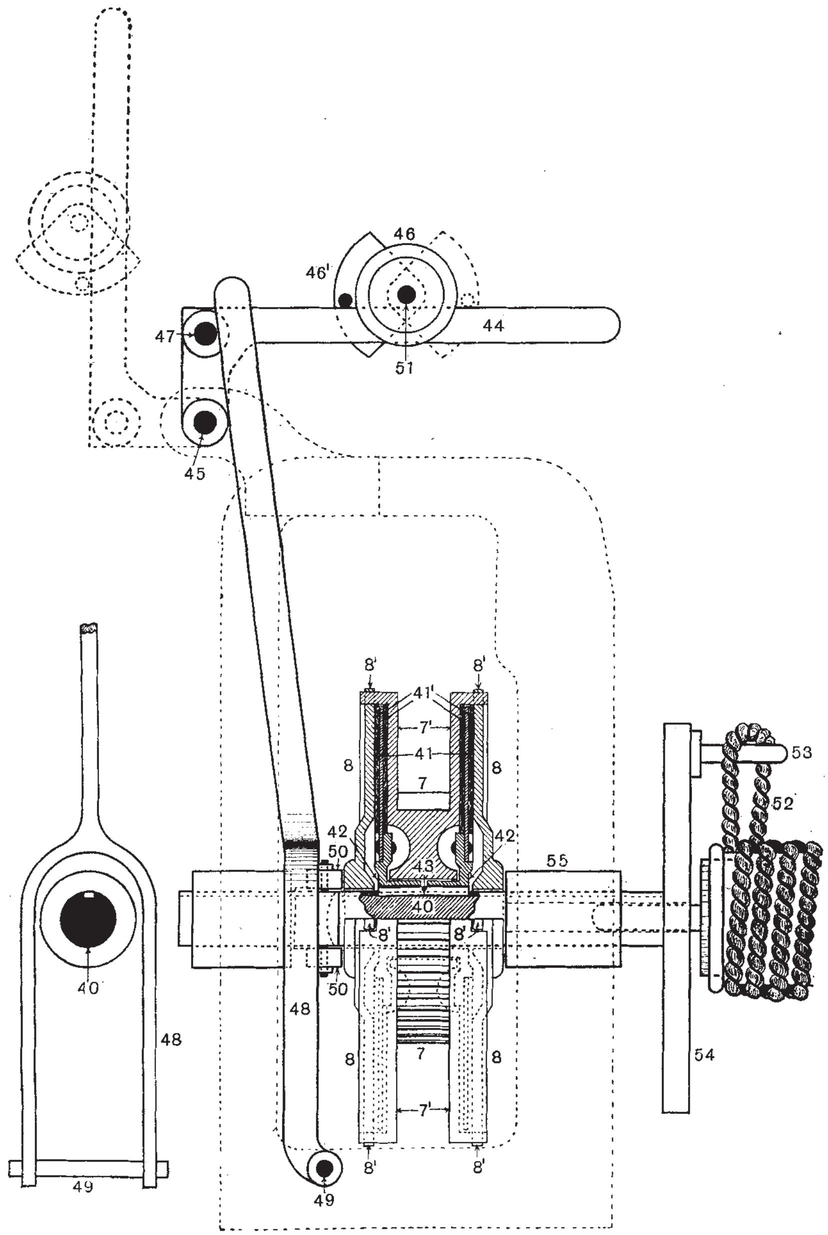


Fig. 124.—Frictional Winding-on Motion.

discs 8, each cast with lugs 8^1, that project slightly beyond the rims of the wheel flanges, and freely enter recesses formed in the rims, in which the lugs become locked.

Hence, the friction wheel 7, with its flanges 7^1, and also the outer discs 8, always revolve together and with a corresponding velocity, but quite independently of the beam shaft 40, upon which they are all mounted quite loosely and in a manner that permits of a slight horizontal sliding movement by those parts upon the shaft, albeit the wheel flanges 7^1 and discs 8 impart rotary motion to that shaft, and thence to the weaver's beam, in a manner to be described presently.

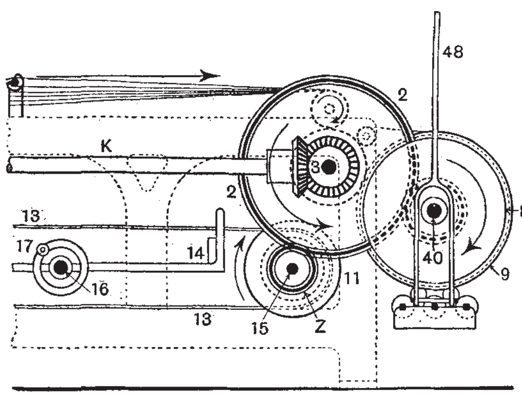


Fig. 125.

The positive motion of the friction wheel 7, with its flanges 7^1 and outer discs 8, is transmitted frictionally to the beam shaft 40, through the medium of a pair of thin sheet steel friction discs 41, each of which is riveted to separate hubs 42, and enclosed within two thick felt washers 41^1. These hubs are mounted loosely upon the beam shaft 40, along which they are capable of a slight horizontal movement, although they cannot revolve without also rotating that shaft.

This is effected by the employment of a feather key 43, which is fixed into the shaft and freely enters a keyway cut into the hubs of the friction discs 41. The hub of the friction wheel 7 revolves freely upon the hubs of the friction discs 41, whilst the hubs of the outer flanges 8 revolve freely upon the beam shaft 40.

§ 240. It will now be manifest that by compressing the steel friction discs 41 between the outer discs 8 and the flanges 7^1 of the friction wheel 7, whilst this wheel is revolving, any degree of frictional resistance up to the highest possible limit may be induced between those discs and flanges for the purpose of rotating the beam shaft 40.

The required degree of compression between those parts is effected by means of an L-lever 44, termed the tension lever, fulcrumed on a stud 45 and furnished with an adjustable compound weight 46 and a stud 47.

When the tension lever is placed in a horizontal position, as indicated by full lines in the diagram, the stud 47 bears against the upper and free end of a vertical friction lever 48, fulcrumed on a stud 49, and furnished with two anti-frictional bowls that bear against the hub of the adjacent outer flange 8, thereby compressing the several discs and flanges together sufficiently to create such degree of frictional resistance between them as is necessary to turn the weaver's beam with a velocity that will ensure both a constant rate of winding-on the yarn, and also a uniform degree of tensile strain upon the warp threads, from the commencement to the finish of a weaver's beam.

The degree of frictional resistance between the friction discs and flanges may be varied by adjusting the weight 46 along the tension lever 44. Thus the amount of compression between those parts, and therefore their driving efficiency, may be either increased or reduced by placing the weight farther from, or nearer to, the fulcrum stud 47 of that lever respectively, and is regulated as required according to the discretion of the attendant, who is guided in his judgment by feeling occasionally at the tension of the yarn, and also at its density on the weaver's beam, during the progress of sizing.

The circular weight 46 is furnished with an auxiliary quadrant weight 46^1 pivoted on a pin 51 to enable this weight to be turned over on either side of the principal weight 46, and so effect a slight variation of pressure on the tension and friction levers, without the necessity of disturbing the position of the principal weight on the tension lever. The object of this contrivance is to enable the yarn to be wound with slightly *less* tension at the commencement of a new warp, until the yarn attains a firm and even foundation on the weaver's beam, whereupon the auxiliary weight 46^1 is then turned over so as to exert a little *greater* pressure on the tension lever.

Thus, when commencing a new warp on an empty beam, the auxiliary weight 46^1 should occupy the position relatively to the principal weight 46, as indicated by full lines in the diagram; after which it should be turned over to the position indicated by dotted lines to exert more pressure on the tension lever, and thereby slightly increase the velocity and driving power of the frictional winding-on device.

When this is in operation, motion is transmitted, in the first instance, from the frictional driving wheel 7 and the outer discs 8 to the internal friction discs 41, thence to the beam shaft 40, and finally from this to the weaver's beam through the medium of a rope 52, a chain, or a leather band. This is first coiled several times around one of the iron ruffles on the beam ends, and then lashed securely to a lug-pin 53 bolted to a large disc 55, or else to an arm secured on the inner end of the beam shaft 40, which is bored out at that end to form a tubular hole to receive the beam pike or gudgeon, whilst the gudgeon in the opposite end of the beam is supported in a similar manner by entering another beam shaft, both of which are adjustable in a lateral direction to accommodate beams of different width.

§ 241. A distinctive feature which the makers, Messrs Howard & Bullough, Ltd., claim to be an exclusive one in the construction of this device, is that none of the pressure on the flannel washers is expended in useless friction against stationary parts of the machine, but that it is all fully utilized in performing effective work. Thus, when the friction discs are under compression, the outer disc nearest to the weaver's beam abuts against a stationary sleeve bearing 55, to receive the beam shaft 40; whilst the corresponding outer disc is in rolling surface contact with two anti-friction bowls or runners 50 that are mounted on the vertical friction lever 48.

As, however, these outer discs 8 are driven positively by the flanges of the friction wheel 7, and not frictionally as in some other devices of this class, the frictional resistance between the hub of the disc and beam shaft bearing 55 does not impose the least tax upon the flannel washers, which therefore give less trouble and are also more durable.

It may here be stated, incidentally, that some attendants keep the flannel washers thoroughly lubricated with the object both of increasing their efficiency and of prolonging their usefulness; whilst others prefer to keep those washers quite dry without employing any lubricant whatever, and with equally effective results in each case. It is quite obvious, therefore, since each of these practices has its respective votaries, that neither of them possesses any distinctive advantage over the other, and that their relative merits are dependent upon varying circumstances.

§ 242. With the object of eliminating all unnecessary friction in the operation of the frictional winding-on device as constructed by Messrs Butterworth and Dickinson, Ltd., and illustrated by a front and an end elevation in Fig. 126, A and B respectively, the friction disc next to the machine framing is caused to bear against two anti-frictional rollers 56, instead of the stationary beam shaft

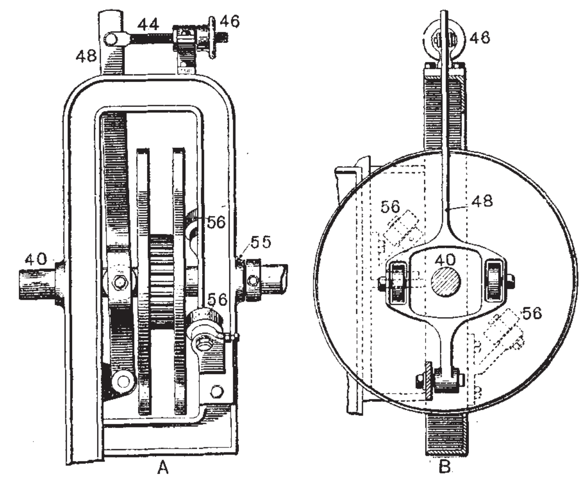


Fig. 126.

bearing 55, as in the device illustrated in Fig. 124. Also, instead of employing a horizontal tension lever provided with an adjustable weight for the purpose of regulating the degree of compression against the several friction discs, that object is effected by means of a hand-wheel 46, screwed on to a threaded rod 44, which is hinged on the upper end of the vertical friction lever 48, as indicated in the diagram.

§ 243. Frictional winding-on devices of this type are constructed with various modifications by their respective makers, but they all embody the same general principle and essential features, and differ in minor details of construction only. Thus, some are constructed with only one set of frictional driving discs, whilst others are constructed with those parts in duplicate to permit of either one set only or both sets of discs being employed to obtain driving power of lesser or greater efficiency, according to the requirement of the work in progress. Also, the compression of the frictional discs is effected in a variety of different ways, for each of which the respective makers claim some special advantage.

Thus in the earlier forms of these devices the degree of compression upon the discs is regulated by means of a hand-wheel and clamp spring contained upon a worm-screw cut on the outer end of the beam shaft. The hub of the hand-wheel impinges against the clamp spring which is placed between that wheel and the outermost friction disc against which it bears, thereby forming a flexible or yielding contact instead of a hard and rigid one between the hand-wheel and the friction disc. This method of compressing the friction discs is, however, superseded by the more approved and efficient arrangement of compound leverage, of which the power is regulated either by means of an adjustable weight, as exemplified in Fig. 124, or else by means of a hand-wheel on a threaded rod, as in Fig. 126, each of which methods comprises several modifications that are of equal merit. Either of these alternative devices is preferable to the earlier method, as they enable the degree of compression between the friction discs to be regulated with much greater precision, and thereby permit of the tensile strain upon the yarn being maintained at a more uniform value.

§ 244. An example of a compound frictional winding-on motion constructed with duplicate sets of friction discs, by which it is adapted for either extremely light or very heavy work, is that illustrated in Figs. 127 and 128, which represent a part sectional front elevation and a plan, respectively, of Haworth's modification.

Either one set of friction discs only, or both sets of discs, may be put into operation as required by the attendant, who controls a lever for that purpose. Thus, when sizing warps containing comparatively few threads, or those composed of fine counts of yarn, one set of friction discs only may be employed to obtain the requisite driving power to turn the weaver's beam; but for warps containing a greater number of threads, or those composed of stronger or coarser counts of yarn, it might be necessary to employ both sets of discs to obtain greater driving power.

When the machine is in operation, motion is transmitted from a pinion wheel on the end of the second or driven cone-drum shaft to a wheel 56 keyed on the end of a short shaft, on which there are also mounted two pinion or driving wheels 57 and 58, that gear with and drive two friction wheels 7 and 7^1. These are mounted quite freely on the wide hub of a central friction disc 41, and this is mounted freely on the beam shaft 40, which it drives through the medium of a feather key 43 in the manner described previously in § 239.

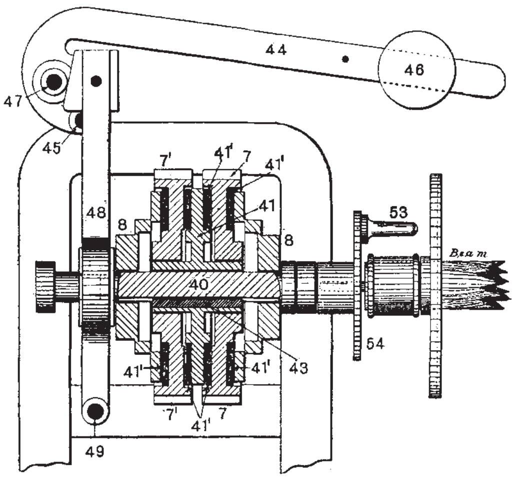


Fig. 127.

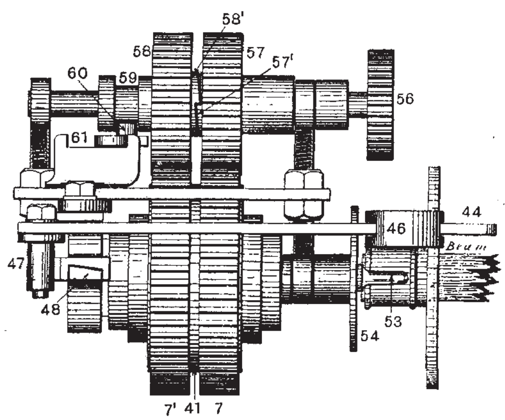


Fig. 128.

The first of the two driving pinions, 57, is keyed fast on the shaft, whereas the second pinion 58 is loose, and revolves quite freely on that shaft. The first pinion 57 drives the second pinion 58 through the medium of a clutch, of which the two complementary counterparts 57^1 and 58^1 are formed on the contiguous ends of the hubs of the respective pinion wheels, as indicated in the plan, Fig. 128. The hub of the second driving pinion 58 is also recessed to form an annular groove or channel 59 for the reception of an anti-frictional bowl 60 carried by a vertical controlling lever 61, by means of which the attendant may slide the second pinion 58 on the shaft, either to engage or disengage the clutch, and thereby employ either both sets of frictional driving discs or one set of discs only respectively as required. Frictional contact is made between the frictional driving wheels 7 and 7^1 and the central friction disc 41 by the usual means of four thick flannel washers 41^1, and the degree of compression between them is regulated in a manner similar to that represented in Fig. 124, and described previously in §§ 239 and 240.

§ 245. Although some modification of the type of frictional winding-on motion under review is invariably employed on slasher and other types of beam-warp sizing machines, and albeit these devices perform their function with a greater or lesser measure of success, their efficiency, nevertheless, depends almost entirely on the skill, intelligence, and diligence of the attendant. Hence, the liability of these devices—whatever merits they possess mechanically—to produce variable results as regards the degree of tension upon yarn and its density on the weaver's beam.

These variations arise chiefly from the circumstance that, with such devices, the driving power is exerted at a point which always occupies a definitely fixed position in relation to the beam axis, albeit the radius of the winding surface of the beam is constantly varying in relation to that point as successive layers of yarn are wound on to the beam. The said fixed point is the lug-pin or stud 53 in the disc 54, which is situated approximately midway between the surface of the bare beam barrel and the rim of the beam flanges.

It follows, therefore, that unless some method is adopted to counteract it, the driving efficiency of the frictional winding-on device will diminish in value as the winding surface of yarn recedes from the beam axis, thereby gradually diminishing the tensile strain upon the yarn, and therefore producing soft-wound warps that are so troublesome during weaving.

The loss of driving efficiency from this cause, however, is counterbalanced by the attendant adjusting, at intervals, the movable weight 46 on the tension lever 44 in such a manner as will *increase* the compression between the frictional driving discs and thereby maintain their driving efficiency, and therefore the tension upon the yarn, at a constant value from the commencement to the finish of a weaver's beam.

§ 246. The compression of the frictional winding discs suitably to ensure the proper degree of tensile strain upon the yarn is usually regulated promiscuously according to the judgment and experience of the attendant, who is guided solely by the sense of touch as he feels occasionally at the yarn to estimate the degree of tension to which it is submitted, as the warp threads extend between the tension or delivery rollers and the weaver's beam. He then slightly *increases*, if necessary, the degree of compression between those discs, periodically and according to his discretion, in order to increase the frictional resistance between them, and thus obtain greater driving power commensurate with the gradually-increasing diameter of the weaver's beam as this becomes filled with yarn, with the twofold object of maintaining both a uniform degree of tension upon the yarn and also of winding it more compactly on the weaver's beam and thus obtaining warps of greater length. The function of regulating the compression of the frictional winding discs during the progress of winding-on may, however, be performed automatically and with much greater precision and regularity by means of a special auxiliary attachment, of which there are at least two different modifications to be described presently.

One of the earliest forms of these devices, as constructed by Messrs Platt Brothers & Co., Ltd., and represented by a side and a front elevation in Figs. 129 and 130, respectively, consists essentially of a quadrant wedge 67, formed near the forward end of an arm 65, fulcrumed on a stud 66, and communicating, by means of a connecting-link rod 64, with the forward end of an arm 63, extending from one end of the shaft 62, which supports the yarn-pressing rollers. The quadrant wedge 67 tapers to a thin edge at the lower end and intercepts two bowls or runners 68, that are mounted respectively on studs fixed in the upper ends of two similar vertical friction levers 48, that are situated one on each side of the frictional winding discs 8, and fulcrumed on studs 49, in such a manner as to cause their lower ends, that are furnished with anti-frictional bowls 50, to approach towards, and bear against, the two outer discs 8, and thus compress all the friction discs together from both sides, simultaneously, instead of applying pressure on one side only, as in the several modifications described previously. This method of compressing the frictional winding discs together affords the incidental advantage of entirely preventing a side thrust of one of the outer discs against any stationary part of the machine framing,

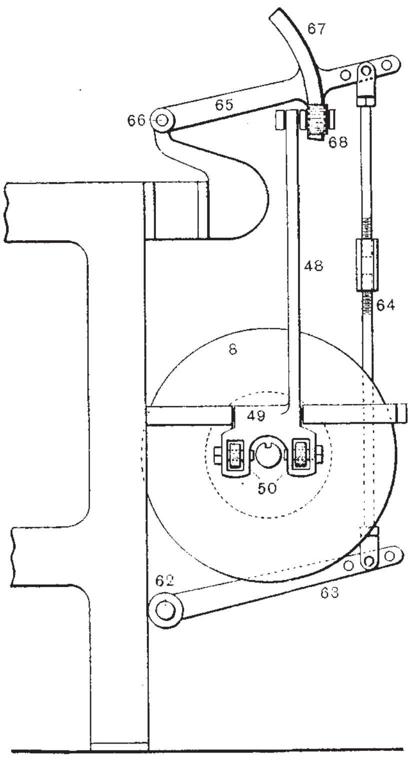


Fig. 129.

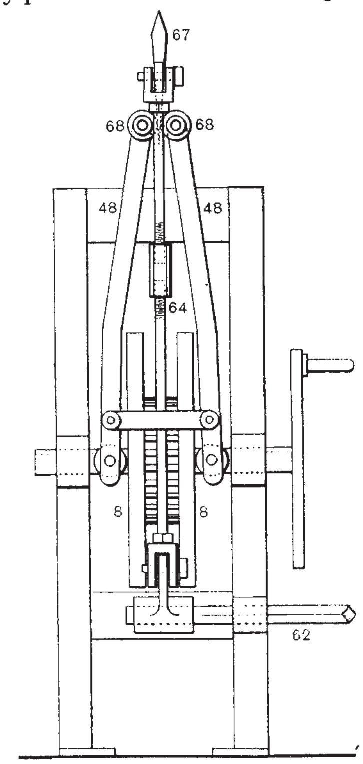


Fig. 130.

AUTOMATIC FRICTIONAL WINDING-ON DEVICE.

as explained in § 241, thereby requiring less motive power for driving the machine.

As the operation of sizing proceeds, the curved wedge 67 descends in unison with the yarn-pressing rollers, thereby bearing with a constantly-increasing pressure against the runners 68, on the friction-levers 48, and thus increasing the compression of the frictional winding discs automatically and continuously in a measure coinciding exactly with the gradually-increasing diameter of the weaver's beam, without any attention or adjusting of parts, irrespective of the counts of yarn or number of warp threads being sized. Also, on depressing the yarn-pressing rollers for the purpose of replacing a full weaver's beam with an empty one, the runners 68 on the friction-levers 48 enter recesses that are formed in the upper end of the curved wedge 67, thereby relieving the friction discs, temporarily, of compression, during that operation, after which the curved wedge returns automatically to its initial position when the yarn-pressing rollers are replaced in contact with the bare barrel of the empty beam.

§ 247. Another device of this character, of more recent invention than that described previously, is that of Rigby's modification, of which a side and a front elevation are represented in Figs. 131 and 132 respectively.

This ingenious device is conceived with the twofold object of controlling and regulating—without personal attention, after the initial adjustment of the parts—both the degree of compression between the friction discs and also that of the pressing rollers against the yarn on the weaver's beam.

These objects are effected entirely by the expansion of the yarn diameter of the weaver's beam. Thus, on one end of a strong cross-shaft 62, on which is mounted the carrier to support the yarn-pressing rollers (not shown), there is secured a short arm 63, from the end of which there extends a vertical connecting-rod 64, attached adjustably to the horizontal arm of an elbow-lever 65, fulcrumed on a stud 66.

The vertical arm of this elbow-lever 65 is engraved with a graduated scale of divisions, and through the medium of an adjustable horizontal connecting link 67 communicates with a vertical arm 68 fulcrumed on a stud 69, and also engraved with a scale of divisions corresponding to those on the elbow-lever. The vertical arm 68 is also furnished with a bowl or runner 70 that bears constantly against the upper edge of the horizontal tension-lever 44, which in turn acts upon the vertical friction lever 48 to compress the frictional driving discs, as explained previously in § 240.

Therefore, as the pressing roller shaft 62 oscillates slowly in response to the gradually-increasing diameter of the weaver's beam, the short arm 63 descends, and thereby depresses the horizontal arm of the elbow-lever 65. Hence the vertical arm of that lever oscillates

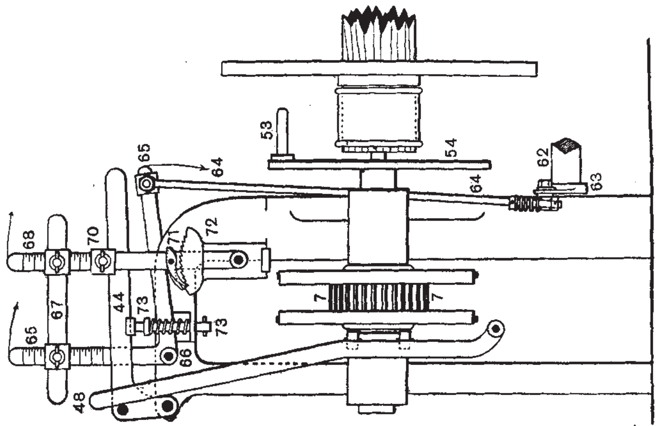


Fig. 132.

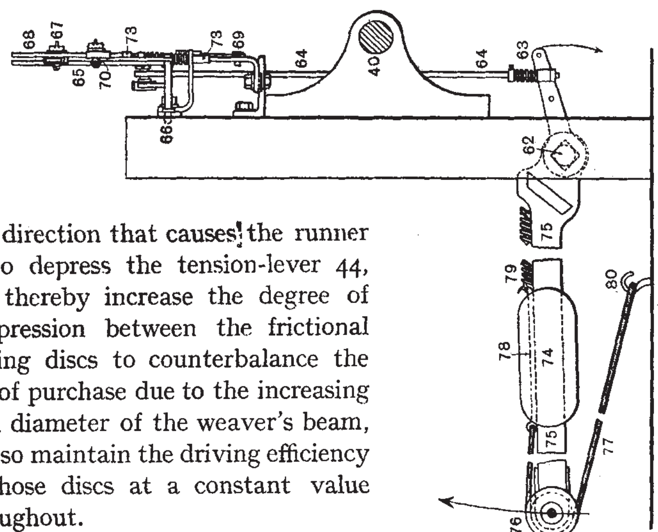


Fig. 131.

AUTOMATIC FRICTIONAL WINDING-ON AND YARN-PRESSING DEVICE.

in a direction that causes the runner 70 to depress the tension-lever 44, and thereby increase the degree of compression between the frictional driving discs to counterbalance the lòss of purchase due to the increasing yarn diameter of the weaver's beam, and so maintain the driving efficiency of those discs at a constant value throughout.

Although the vertical arm 68 is quite free to advance, it cannot retract, but is held forward by means of two half-pitch retaining pawls or catches 71 that are pivoted freely on that arm, and encounter ratchet teeth formed in the upper edge of a bracket 72. This provision, however, necessitates a flexible or yielding connection being formed preferably between the vertical rod 64 and the short arm 63 on the pressing roller shaft 62, as indicated in the diagrams. Otherwise, if this precaution were not adopted, a rigid connection of those parts would involve the risk of straining and breaking them, owing to the slight oscillation of the pressing roller shaft caused by the rolling surface contact of the pressing rollers against the yarn on the weaver's beam.

Also, the replacement of the various parts to their initial starting position, when commencing each successive weaver's beam, is performed instantly by the attendant without in any way disturbing the original adjustment of the several connections. This is effected by means of a stud 73, which, under the influence of a compressed spiral spring, bears upward constantly against the lower edge of the horizontal tension lever 44, and thereby always tends to raise that lever automatically whenever it is liberated from the control of the runner 70 on the vertical arm 68.

Thus on the completion of each weaver's beam the attendant raises the retaining pawls 71 on that arm from the ratchet teeth, and replaces the runner 70 to bear in its initial position upon the tension lever, and thereby reduce the compression of the frictional driving discs for the commencement of the next weaver's beam. Also, by the aid of the graduated scales engraved on the vertical levers 65 and 66 the position of the connecting link 67 on these levers may be recorded, so that when conducting similar classes of work in the sizing machine the connecting link may be secured in exactly the same position to ensure corresponding results.

§ 248. As stated in the previous section, this device is also adapted automatically to regulate and control the degree of compression by the pressing rollers against the yarn on the weaver's beam. That object is effected by means of a sliding weight 74 carried by an arm 75 extending from the pressing roller shaft 62, and provided at the free end with a grooved pulley 76 around which there passes a chain or rope 77. One end of this rope is attached preferably to a hooked rod 78 that passes between the weight and the upper face of the arm 75, on which it slides freely; whilst the opposite end of the rod is connected to a spiral spring 79 attached to a retaining pin on that arm. The opposite end of the rope 77 is then secured to a hook 80, fixed adjustably either in the floor or to the machine framing.

Thus, as the weaver's beam increases in diameter and depresses the yarn-pressing rollers, the shaft 62 oscillates slowly and raises the arm 75 in the direction indicated by an arrow, thereby increasing the distance between the fixed hook 80 and the rope pulley 76, thus causing the weight to slide towards the end of the arm 75 as this assumes a steeper inclination.

This has the effect of counterbalancing the loss of force exerted by the weight, and either maintaining or even increasing the degree of compression by the pressing rollers upon the yarn on the weaver's beam. The function of the spring 79 is to keep the rope 77 always under tension, and thereby ensure the return of the weight 74 automatically and readily to its initial position on the arm 75 when re-adjusting the pressing rollers at the commencement of a new weaver's beam.

By means of this combined automatic friction and pressing motion, the adjustment necessary to ensure both a constant tension and an increasing pressure upon the yarn is both continuous and of a uniformly increasing value from the commencement to the completion of a weaver's beam, and not of an intermittent and variable character, as when the adjustment is effected promiscuously at the discretion of the attendant; thereby ensuring more firmly wound and compact weavers' beams containing a relatively greater length of yarn.

The inventor of this device states that by its aid he has sized warps containing as few as 600 threads of 60's T, and also warps containing from that number up to as many as 6000 threads of various counts of yarn, ranging from 28's T to 100's T, successfully, during a period extending over twelve months.

Yarn-beam Pressing Rollers

§ 249. The pressing rollers of a slasher sizing machine are employed for the purpose of levelling the yarn, and also of compressing it firmly and compactly on to the weaver's beams, thereby producing firmly-wound warps having an even surface and a uniform yarn diameter across the entire width of the beams, and also enabling warps of considerably greater length to be wound upon them.

The degree of compactness with which yarn is wound on to a weaver's beam, however, is also dependent upon the degree of tensile strain imparted to the threads between the delivery rollers and the weaver's beam. Therefore, since the degree of yarn tension is regulated by the compression of the several discs of the frictional winding-on device, it follows that both this and the pressing rollers should operate in harmony with each other, in a manner similar to that described and illustrated in §§ 247 and 248.

Yarn-beam pressing rollers are constructed in a variety of different forms, and consist essentially of one or else two iron rollers supported in such a manner that they bear constantly, and revolve freely, in contact with the yarn surface of the weaver's beam, against which they are retained by means of a heavily-weighted arm extending rearward from the pressing roller shaft, from which there also extends, forward, a carriage or frame to support the pressing rollers.

§ 250. One of the several modifications of yarn-pressing rollers is that illustrated in Figs. 133 to 135, which represent an end elevation, a front elevation, and a plan, respectively, of Ormerod, Crook & Crossley's yarn-pressing device, as constructed by Messrs William Dickinson & Sons. The central feature of this device consists essentially of a tubular roller 81, formed in two exactly similar and complementary half lengths that are united, endwise, in such a manner as virtually to constitute a single roller. This is capable of expanding in length, automatically, until it bears across the entire width of the warp between the beam flanges, thereby preventing the risk of selvage warp ends building up too quickly against the flanges; also averting such other defects as are liable to occur, and which prove a source of constant trouble to the weavers, who are expected to produce cloth having perfect selvages, and free from warp threads of unequal tension.

The expansion of the pressing roller is effected by forming several long notches in one end of each half-roller, and interlocking these after the manner of a claw or box clutch; and also by mounting the pressing roller freely upon two pairs of anti-frictional rollers 82, that are placed at opposite ends of a swing beam 83. One of the rollers in each pair is conical, with the larger diameter innermost, so as to force the respective halves of the pressing roller outward from the centre as it revolves, and also to keep it expanded continuously during winding-on.

The pressing roller bears constantly against the yarn by the gravitation of an adjustable weight 74, secured to a long arm 75, extending rearward from one end of the shaft 62, which also supports the pressing roller. Hence, as the yarn diameter of the weaver's beam gradually increases and thereby depresses the pressing roller in a corresponding measure, the oscillation of the pressing roller shaft raises the weighted arm, which cannot descend until it is returned by

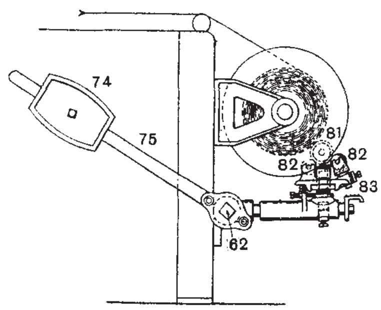


Fig. 133.

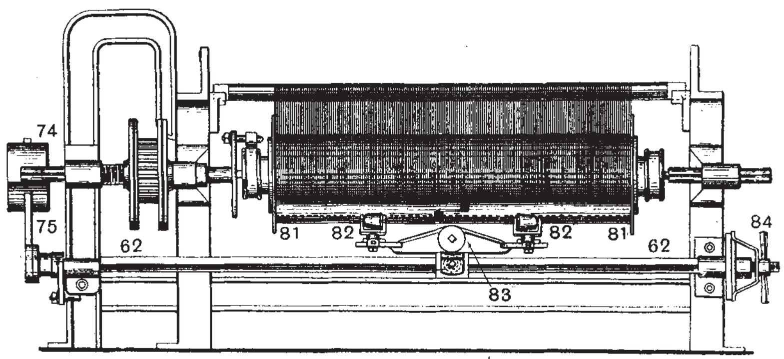


Fig. 134.

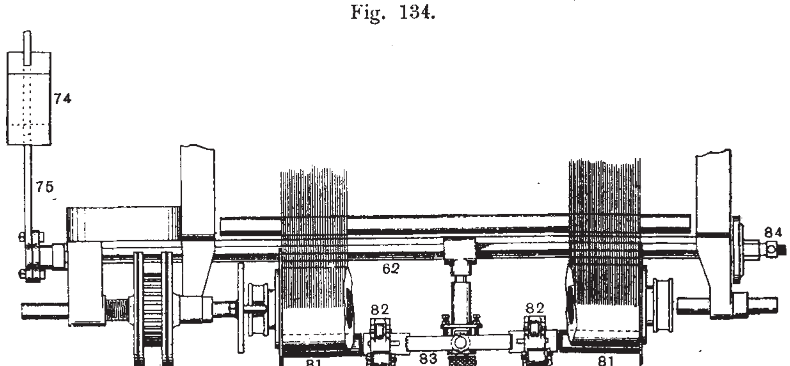


Fig. 135.

the attendant to its initial starting position at the commencement of a new weaver's beam. The return of the weighted arm is prevented by means of a simple contrivance of either a ratchet wheel and stop-catch or pawl, or preferably by a friction clutch controlled by a handle, as indicated at 84, on the right of Figs. 134 and 135.

By regulating the amount of frictional resistance between the discs of this clutch, the degree of compression by the pressing roller against the yarn may be either increased or diminished, as required, without the necessity of either adjusting the weight 74, on the arm 75, or of substituting other weights, for that purpose.

Also, the attendant may return the pressing roller to its initial position against a new beam when he is in *front* of the machine, instead of doing this from the side, as would otherwise be necessary in order to liberate the stop-catch from the ratchet wheel.

Since the weighted arm 75 occupies a horizontal position at the commencement of winding-on, and assumes an inclined position as it ascends, it follows that as the weight 74 attains a higher elevation it will lose its purchase on the arm, with the result that the compressive force of the pressing roller will therefore diminish gradually and constantly from the commencement of winding-on, to the completion of a weaver's beam, instead of remaining either constant, or preferably increasing slightly, as the yarn diameter of the beam increases.

It is with the object of overcoming this defect, which is inherent to all ordinary applications of yarn-beam pressing rollers, that Rigby conceived the idea of causing the weight to slide automatically further away from the pressing roller shaft, and thereby cause the pressing roller to exert either a constant or an increasing degree of compression against the yarn surface of the weaver's beam throughout the operation of winding-on, in the manner described previously in § 248.

§ 251. Another adaptation of a single pressing roller is that illustrated in Figs. 136 to 138, which represent a sectional elevation, a plan, and a detail, respectively, of one of Hitchon's modifications as made by Messrs Howard & Bullough, Limited. This device consists essentially of a single tubular roller 81, which is made shorter than the width between the flanges of the weavers' beams, and to which is imparted a slow reciprocal traverse between the beam flanges, so that no part of the yarn surface escapes its action altogether.

This object is effected by supporting the pressing roller upon two pairs of anti-frictional bowls 82, mounted in castor or swivel bearings placed at opposite ends of the swing beam 83, and also by operating those bowls in such a manner that they become inclined in opposite directions, from the vertical, alternately, thereby causing the pressing roller to slide first to one extreme end of the beam and then return to the opposite end, slowly, and in alternate succession.

This peculiar action of the anti-frictional bowls is obtained by fixing on the extended axle of one of those bowls, 82^1, a worm 85, which gears with a worm-wheel 86 mounted on a stud bearing 87 projecting from an arm 88. This arm extends from the bearing which supports that bowl, as indicated on a larger scale at A, Fig 138.

From the rear of the worm-wheel 86 there projects a pin 89, which is fixed eccentrically to the wheel axis, and freely enters an inclined slot formed in a stationary bracket 90, shown detached, at B, Fig. 138. Also, the swivelled bearings of the anti-frictional bowls are connected by means of two parallel rails 91, and a cross-rail 92, as indicated in the plan, Fig. 137.

Therefore, as the leading anti-frictional bowl 82 revolves, the pin 89 slides freely along the inclined slot in the stationary bracket 90, thereby causing the arm 88 (which extends from the bearing of the leading anti-frictional bowl) and also its appurtenances to oscillate slowly through an angle of about 14°, as indicated in Fig. 138.

This action causes the anti-frictional bowls to incline first to one side and then to the other side, in alternate succession, during each complete revolution of the worm-wheel, with the object of imparting to the yarn-pressing roller a reciprocal traverse between the warp beam flanges in the manner described.

§ 252. A third example of a yarn-beam pressing device is that illustrated by a front elevation, an end elevation, and a plan, in Figs. 139 to 141, which represent another of Hitchon's modifications of this type of device.

Unlike the two previous examples, however, the one under present notice is constructed with two pressing rollers 81 and 81^1, supported on three pairs of anti-frictional bowls 82, and placed one immediately behind the other, as seen in Fig. 140. The rear roller 81 consists of one tubular length which is shorter than the width

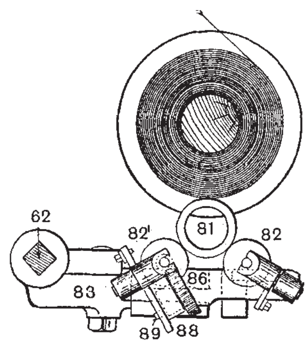


Fig. 136.

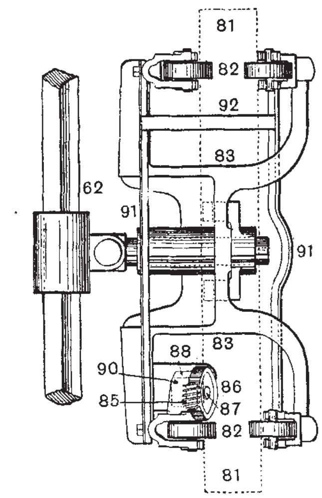


Fig. 137.

between the beam flanges, and bears always in the same place against the yarn surface of the beam; whereas the front roller 81^1 consists of two shorter tubes, of which the total length is shorter than the beam width. These are each contained freely on opposite ends of a solid shaft or mandrel formed with a central forged collar that fits into a retaining slot to keep the mandrel constantly in the same position, whilst the two portions of the front roller are forced apart from the centre until they extend across the entire width of the warp and bear close up to the beam flanges, thereby spanning the short intervals of space between the ends of the rear pressing roller and beam flanges.

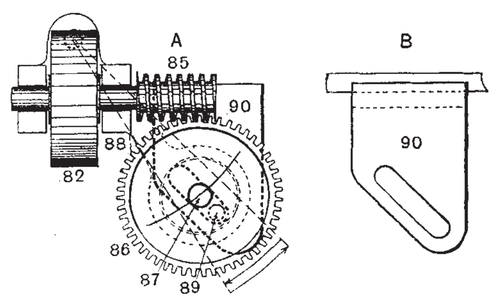


Fig. 138.

The expansion of the front pressing roller is effected by inclining outward the front pair of anti-frictional bowls 82^1, that are mounted in swivelled bearings, and on which that roller is supported, as represented in Fig. 139. After this roller is fully expanded, at the commencement of a new beam, it is maintained

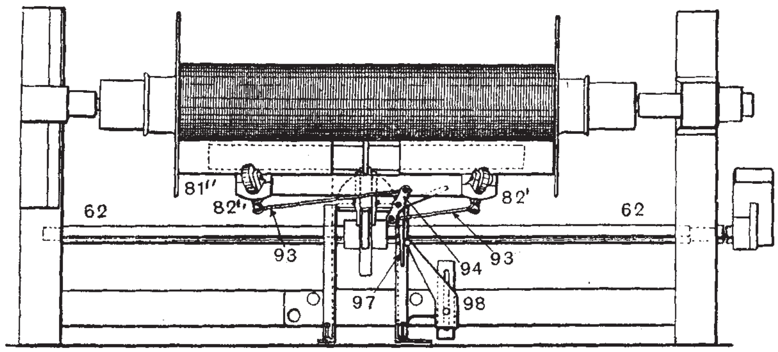


Fig. 139.

at the maximum extension until the beam is nearly filled with yarn, when the roller begins to contract, automatically, to prevent the two portions from running outward beyond the beam flanges, and thereby involving the risk of spreading the yarn, and cutting the threads, on the rims of those flanges.

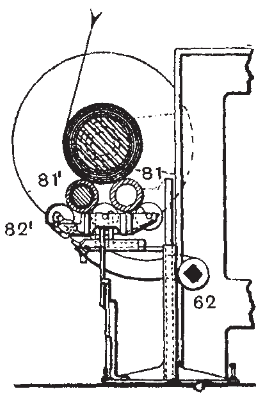


Fig. 140.

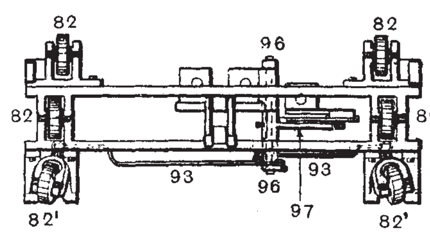


Fig. 141

The contraction of the front pressing roller is effected by reversing the inclination of the front pair of anti-frictional bowls until they assume the position indicated in the plan, Fig. 141, drawn to a larger scale. The two castor bearings of those bowls are each connected, by means of link rods 93, to opposite ends of a short arm 94, secured to the forward end of a shaft 96, to which there is also secured an elbow lever 97.

At the commencement of winding-on, when the pressing rollers are at their highest elevation, the vertical and drooping arm of the elbow lever bears lightly against the upper end of an adjustably fixed bracket 98 until the beam is nearly filled, thereby keeping the front pair of anti-frictional bowls inclined outward, and keeping the pressing roller fully extended, as seen in Fig. 139. But when the beam is nearly filled, the depression of the pressing rollers causes the horizontal arm of the elbow lever 97 to come into contact with the upper end of the stationary bracket 98, and thus oscillate the short arm 94 in a direction that reverses the inclination of the front pair of anti-frictional bowls, as seen in Fig. 141, thereby causing the front pressing roller to contract, for the purpose described.

§ 253. Two other modifications of double-roller yarn-beam pressing devices, also designed by Hitchon, are sometimes employed in very wide machines. In one of these devices the two pressing rollers are each shorter than the beam width, and they bear constantly in the same relative position, with one roller close against each beam flange, to ensure the compression of yarn across the entire width of the beam without imparting to the rollers any lateral movement. In the second of these devices both pressing rollers are of equal length, but only one-eighth of an inch shorter than the beam width, and they bear constantly in the same position against the yarn surface.

But whatever particular forms yarn-pressing devices may assume, and however perfect they may be mechanically, they cannot ensure the formation of perfectly wound, firm, and level warp beams unless the barrels of these are quite true, and revolve truly in their bearings during the operation of winding-on, and are also provided with perfectly straight flanges that are fixed truly and secured firmly in position on the beam barrels, to ensure their steady rotation.

§ 254. In some machines, however, instead of yarn-pressing rollers of the usual form, there is employed an improvised and crude pressing device consisting either of a flat or a round heavy iron bar which extends between the beam or tube flanges and bears downward upon the yarn. This bar is secured to two iron arms that are hooked to, and suspended from, a cross-bar in front of the machine, to permit of the pressing-bar rising freely as the beam increases in diameter. This method, however, is generally confined to warps composed of coarse and strong yarn, as the excessive friction produced by a *stationary* pressing bar would act detrimentally upon fine yarn, against which a presser should bear with a *rolling* contact.

Cut-marking and Measuring Motions

§ 255. Many varieties of cotton fabrics that are known in the trade as " piece-goods " are woven from warp and weft yarn of the grey or natural colour of the raw cotton staple, and produced as continuous pieces of cloth of considerable length. The cloth is then sold either in its original grey state, or else it is bleached, dyed, or printed in the piece, and afterwards cut up into unit-lengths of any prescribed dimension up to 120yds. or more, to constitute what are termed cut-lengths, " dhootie scarves or shawls," turbans, handkerchiefs, and many other articles for domestic use.

Each length-unit is indicated, at the required intervals apart in the continuous piece-length of cloth, by means of some distinctive mark, usually consisting of cross-bands or stripes of coloured or other different kinds of weft, to produce what are variously termed " fancy headings," cross-borders, or " cut " (cutting) marks. Also, in some cases, the weaver " strains up " the warp and cloth, by means of the taking-up motion, to produce short gaps or " frets," without any picks of weft, across the cloth where it is to be severed.

The intervals at which these " headings " or other distinctive cloth-marks are to be inserted by the weaver are indicated previously upon the warp threads by smearing them with coloured stains termed " cut-marks," that are impressed upon the yarn during its progress through the slasher sizing machine, and just before it passes on to the weaver's beam.

These cut-marks are produced automatically by means of an auxiliary device termed the cut-marking motion, which also operates in conjunction with a measuring motion, and of which there are various modifications of two chief types.

Some of these devices are constructed to make only one cut-mark at regular intervals of any prescribed length, uniformly; whereas others are designed to make a double impression at once, with two separate and distinct marks placed three or four inches apart, lengthwise of the warp; whilst other modifications are constructed with duplicate sets of parts to operate alternately when it is required to produce cut-marks of two different colours, and placed either at uniform or varying distances apart.

Also, some sizing machines are equipped with two separate cut-marking motions, placed one on each side of the machine, to operate in conjunction either simultaneously or alternately to impress two marks of the same or of different colours, one on each side of the warp, according to requirements.

§ 256. In machines of pre-modern construction, the cut-marking and measuring motion is operated by the tin guide-roller situated in the extreme rear of the headstock, in the same plane as the dividing rods, and known as the tin measuring roller, which revolves entirely by surface contact with the yarn, whereby the effort of driving the cut-marking motion devolves entirely upon the warp threads.

This objection, however, is entirely eliminated in modern machines, in which the measuring and cut-marking motion is driven by the heavy iron nip-roller that rests upon, and is driven by surface contact with, the large iron or wooden tension or drawing and delivery roller situated in the extreme fore-part of the machine. In either case the roller employed to operate the marking and measuring motion constitutes the measuring roller, which is always made with a standard circumference of 14.4in.($=\frac{2}{5}$ths of a yard) in English machines.

§ 257. A cut-marking and measuring motion of the prevailing type for marking single impressions, at one side of the warp only, is illustrated by aside elevation and plan in Figs. 142 and 143 respectively. This device consists essentially of a striking hammer A and a colour block or disc B, that are controlled by a simple combination of wheel gearing and a stepped cam C, of which an enlarged side view is shown detached at E^1, Fig. 142.

The hammer is placed above the warp threads, with the colour block immediately below them, so that the cut-marks will be impressed upon the yarn several inches from one side, and between the iron measuring or nip-roller 5, and an adjustable wraith or comb D, which is fixed in front of the foremost dividing-rod for the purpose of regulating the width of the warp suitably to that of the weaver's beam.

The striking-hammer is secured to a short stud or shaft E, which freely enters a sleeve-bearing F, supported by a fixed bracket G. In its normal position, as represented by full lines, the hammer is held quite clear, by a space of several inches, above the warp threads until it is required to strike a cut-mark, when it descends quickly, as indicated by dotted lines, thereby deflecting those warp threads beneath it to produce a momentary contact with the colour block,

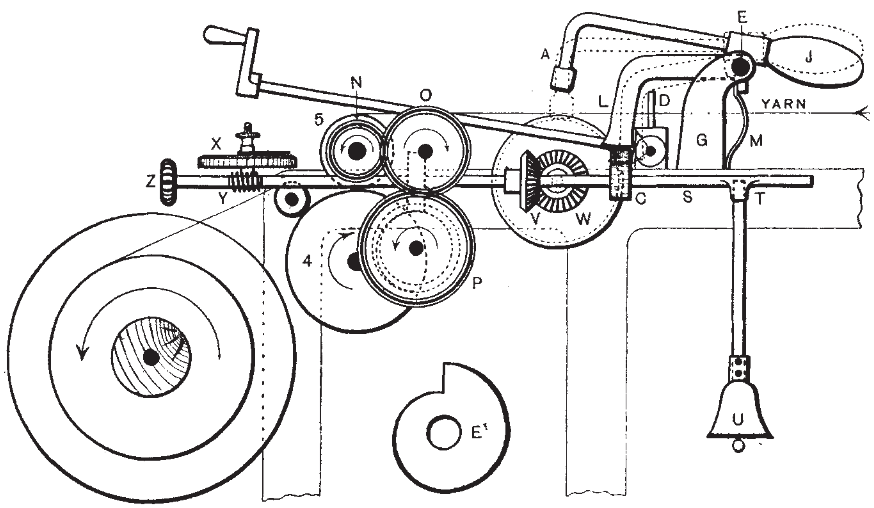


Fig. 142.

and thus stain them with a mark of about $1\frac{1}{2}$in. by 2in., after which the hammer rebounds instantly to its normal position.

The recoil of the hammer is effected by means of a heavy counterweight J at the rear end of the hammer to overbalance it. The colour block is usually a circular wooden disc fixed on one end of a short shaft K, both of which revolve together with a slow velocity.

The rim of the colour disc is covered with cloth to produce a soft pad against which the threads are struck by the hammer without the risk of injuring them, and it revolves with its lower portion immersed in a solution of colouring material, of any vivid hue, contained in a narrow chamber, which entirely encloses the disc excepting for an opening at the top where the rim is exposed, as indicated in the diagrams.

The hammer A descends upon the yarn and strikes a cut-mark for each revolution of the stepped cam C; and the intervals of length between successive cut-marks are determined by the velocity with which that cam revolves, in relation to the velocity of the measuring roller 5. Bearing constantly downward against the rim surface of the stepped cam C is the free end of an ⌐ - shaped arm L, termed the cam lever, extending from the same bearing as that which supports the striking hammer, and which is always held downward by means of a blade spring M.

A free union or clutch joint between the shanks of the cam lever

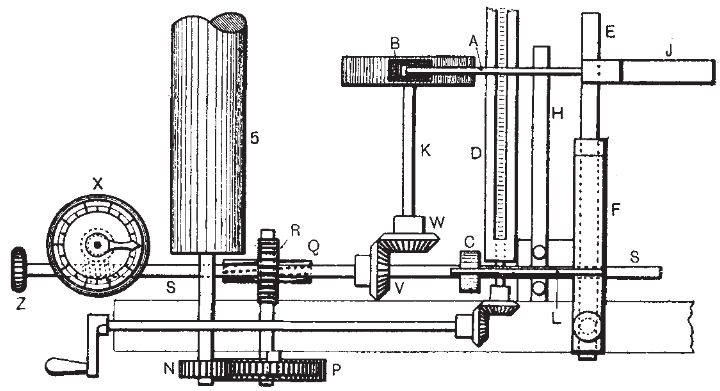


Fig. 143.

and striking hammer permits of each of these arms oscillating independently and instantly on the step of the cam passing from underneath, and thereby releasing the cam lever. Whenever this occurs, that lever descends with a sudden impulse, and thereby projects the striking hammer upon the warp threads to impress a cut-mark, after which it rebounds to its initial position in the manner described.

§ 258. As stated previously in § 256, the cut-marking and measuring motion is operated primarily from the measuring roller 5, which transmits motion to the stepped cam C, through the medium of simple wheel gearing designed to reduce the relatively high velocity of the measuring roller to the very slow velocity of the stepped cam.

The wheel gearing commences with a pinion or driving wheel N fixed on one end of the measuring roller shaft, and termed the "measuring roller wheel," which, through the medium of a simple carrier wheel O, transmits motion to a wheel P mounted on a short stud, and known as the "stud-wheel." This is compounded with a single-thread worm Q, of large diameter, which gears with a worm-wheel R termed the "bell-wheel," fixed on the same shaft S as that on which the stepped cam is also fixed, and known as the "bell-shaft."

The bell-wheel contains a constant number of teeth—namely, 45—and is moved only one tooth during each revolution of the worm Q and stud-wheel P. These will, therefore, require to make 45revs. to revolve the bell-wheel and stepped cam once, to mark successive cut-lengths of the warp. The bell-wheel is so named from the fact that a tongue T projecting from one side of the bell-shaft is caused to ring a bell U, and so warn the attendant of each approaching cut-mark, so that he may keep a record of the number of cut-lengths wound on each weaver's beam. The bell-shaft also contains a bevel wheel V, which, through the medium of a similar bevel wheel W (but preferably one tooth larger) fixed on the short shaft K, which also carries the colour disc, revolves that disc with a very slow velocity to bring up the colouring material. By having a difference of one tooth more or less between the bevel wheels V and W, it will prevent the colour hammer from striking in succession always on the same part of the rim of the colour disc.

§ 259. As stated in § 257, the intervals of length between successive cut-marks are determined by the relative velocity of the measuring roller, which is of a constant value, and that of the stepped cam, which may be regulated according to the length of cuts required. The length between the cut-marks varies in a measure inversely proportionate to the speed of the cam, which may be varied by changing the size either of the measuring-roller wheel or the stud wheel P, or of both of those wheels, in order to obtain the correct ratio between them for the prescribed cut-length. This ratio is calculated on the basis of a measuring roller with a standard circumference of 14.4in. and a bell-wheel R with 45 teeth, which are constant factors.

Therefore, since the bell-wheel and stepped cam make one revolution for each cut-mark, the worm and stud wheel must always make 45revs. for any length of cut; whereas the number of revolutions by the measuring roller varies according to the length of cut, and is obtained by dividing the cut length, in inches, by the circumference of the measuring roller in inches—viz., 14.4in. $=\frac{2}{5}$ths of a yard.

The most convenient method of calculating the number of teeth in the roller wheel and stud wheel is to obtain a constant number of such a value that the ratio between this number and the length of cut expressed in inches, or else in yards, will be in direct proportion to the number of teeth in the roller wheel and stud wheel respectively. Thus, $14.4 \times 45 = 648$, the constant for inch units of length; and $\frac{14.4 \times 45}{36} = 18$, the constant for yard units of length.

A set of change-wheels for this purpose usually comprises 104 wheels, ranging in size from 17 to 120 teeth, of which any two wheels may be employed in combination to give the required ratio of teeth.

Example 1.—What sizes of roller wheel and stud wheel are required to indicate cut-lengths of 32yds. 18in.? In this example the ratio of the R W and S W is 648 to 1170 respectively; but as wheels of that size are impracticable, any two wheels in the nearest practical ratio may be employed. Therefore—

R W = 648 or 36 teeth
S W = 1170 or 65 teeth

which in this case is the only practical combination.

$$\text{Proof: } \frac{14{\cdot}4 \times 45 \times 65}{36} = 1170\text{in., or } 32\tfrac{1}{2}\text{yds.}$$

Example 2.—What sizes of R W and S W are required to indicate cut-lengths of 40yds.? In this example the ratio of the R W and S W is 18 to 40 respectively. Therefore—

R W = 18 or 27 or 36 or 45 or 54 teeth
S W = 40 or 60 or 80 or 100 or 120 teeth

$$\text{Proof: } \frac{14{\cdot}4 \times 45 \times 40}{18 \times 36} = 40\text{yds.}$$

§ 260. In combination with the cut-marking motion as represented in Figs. 140 and 141, there is also a cut-measuring motion to indicate cut-lengths of warp wound on. This is a very simple device, consisting of a fixed dial-plate X on the face of which there revolves a finger operated by a single-thread worm Y on the bell-shaft S, which transmits motion to a worm-wheel fixed at the bottom of the finger stud.

The dial-plate is usually graduated in both quarters and unit-lengths of cuts to indicate either up to 10 or else 20 cuts for one revolution of the finger, according to whether the worm-wheel on the finger stud contains 10 or 20 teeth respectively.

Before commencing each new weaver's beam, the step of the cam C is set close up to the cam lever L. This is effected by means of a small hand-wheel Z on the forward end of the bell-shaft S, which is turned until the step of the cam stops against that lever; after which the finger is also re-set to zero on the dial-plate.

§ 261. An example of a double cut-marking motion to impress marks of two different colours either at equal or unequal distances

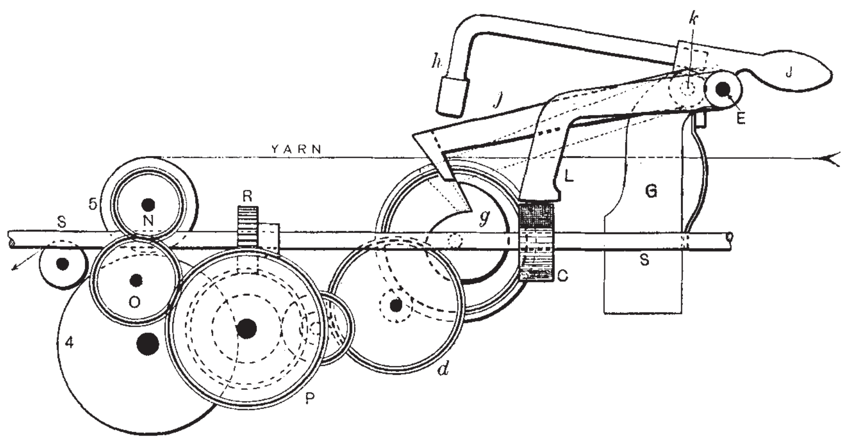


Fig. 144.

apart, as required for dhootie and other varieties of fabrics, is that illustrated in Figs. 144 and 145, which represent an elevation and a plan of one of Hitchon's cut-marking motions.

In addition to the usual cut-marking mechanism similar to that just described, the present device also embodies a supplementary striking hammer, colour block, and stepped cam, operated by separate wheel gearing which may be regulated so as to impress one mark only, or any number of extra marks, between the regular cut-marks which indicate the extremities of a cut-length.

Thus, a pinion wheel *a* on the usual stud-pin transmits motion, through the medium of compound carrier wheels *b*, *c*, *d*, and a change pinion *e*, to a wheel *f*, which carries the additional stepped cam *g* to govern the action of the supplementary striking hammer *h* controlled by the extra cam lever *j*, both of which are secured to the same cross-bar *k*.

The cam wheel *f* and the stepped cam *g* are secured together, but mounted quite freely upon the shaft K, which carries and rotates both of the colour blocks B and *l* which are driven in the usual manner, by means of lever wheels V and W, from the bell-shaft S. Therefore, the wheel *f* and its stepped cam *g* may be driven with any desired velocity according to the number of extra coloured marks required

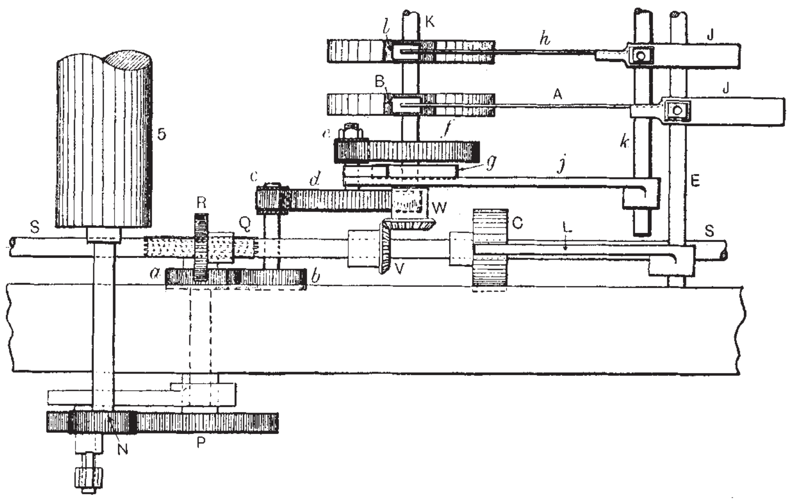


Fig. 145.

between the ordinary cut-marks, and quite independently of the speed of the colour blocks.

The velocity of the additional stepped cam *g*, and therefore the intervals between the extra marks, is regulated by employing different sizes of change pinions *e*. The wheel gearing is such that the cam makes one revolution, and thus causes the supplementary hammer to strike once for every 10 teeth contained in the change pinion *e*. Therefore, the number of extra marks required in each cut-length of warp multiplied by 10 equals the number of teeth in the change pinion required to give that number of marks.

§ 262. As stated in § 255, some cut-marking motions are adapted to mark, at one stroke, a double impression upon the warp threads, with two distinct marks, at an interval of about 4in. apart lengthwise, and placed at the extremities of each cut-length, to indicate where the cloth is to be subdivided. The chief object of impressing double cut-marks is to make them more conspicuous than single marks, and thereby reduce the risk of these escaping observation by the weaver, and "weaving-in" before the "headings" are inserted, as sometimes occurs inadvertently.

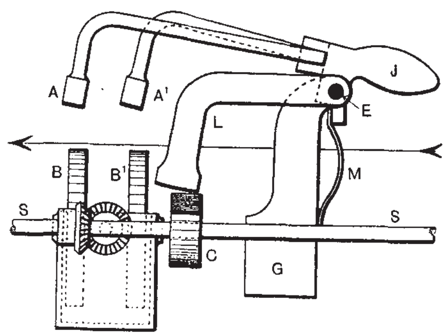


Fig. 146.

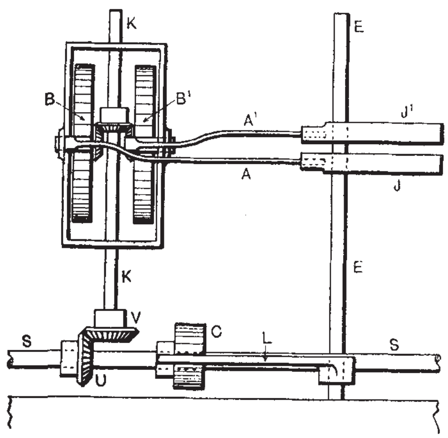


Fig. 147.

By means of another of Hitchon's modifications, illustrated by a part elevation and plan in Figs. 146 and 147, a double cut-mark is impressed by a single stroke of two separate marking hammers A and A¹ that are secured by the same bar E, and controlled by the stepped cam C on the bell shaft S, as in the single cut-marking motion illustrated in Figs. 142 and 143. In the present device the hammer shanks are bent in such a manner as to place the two heads in tandem about 4in. apart, so that each hammer will strike upon colour blocks B and B¹ which are disposed at right angles to the warp threads, and driven through the medium of bevel-wheel gearing, as indicated in the diagrams.

§ 263. Another of Hitchon's modifications in the details of cut-marking motions is that illustrated in Fig. 148, which represents an improved form of marking hammer head and colour blocks that are capable of impressing both double and single coloured marks in alternate succession, and at regular intervals apart, for successive revolutions of the stepped cam.

Double marks are struck to subdivide the warp into cut-lengths of the required dimension; and single marks, known as " middle " or " middling " marks, are impressed exactly midway between two cut-marks to indicate where the weaver is required to insert " fancy " cross-stripes, as exemplified in what are known in the weaving trade as " madapollams," and many other varieties of cloth.

In the present modification, the striking hammer A is formed with three distinct faces, disposed lengthwise, and controlled in the usual manner by means of the stepped cam on the bell shaft. Three separate colour blocks B, B^1, and B^2 are employed—one for each face of the marking hammer, of which the two outer faces descend on the two outer colour blocks B and B^2, to impress the double cut-marks; and the central face descends on the middle colour block B^1 to impress the " middle " marks.

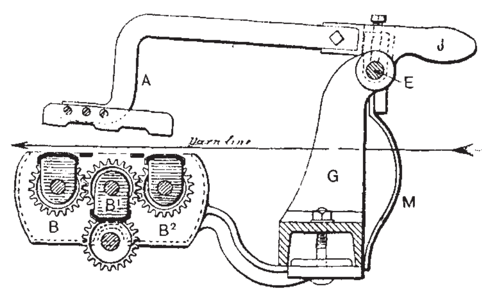


Fig. 148.

The three colour blocks are geared by means of toothed wheels, each containing an equal number of teeth. These are driven from the bell shaft with a corresponding velocity, but at exactly one-half the speed of that shaft and of the stepped cam, whereby the respective colour blocks make only one revolution for each descent of the marking hammer.

The colour blocks are adjusted in such relative positions to each other that first the two outer colour blocks only are uppermost, and then the central block only is uppermost, alternately, for each successive revolution of the stepped cam, and at the moment when the marking hammer descends, thereby impressing double cut-marks and single marks in alternate succession, as described.

§ 264. Another example of a warp measuring and marking motion is that illustrated in Figs. 149 to 151, which represent part elevations and a plan of Heatley & Field's modification as constructed by Messrs Butterworth & Dickinson, Ltd. This modification is

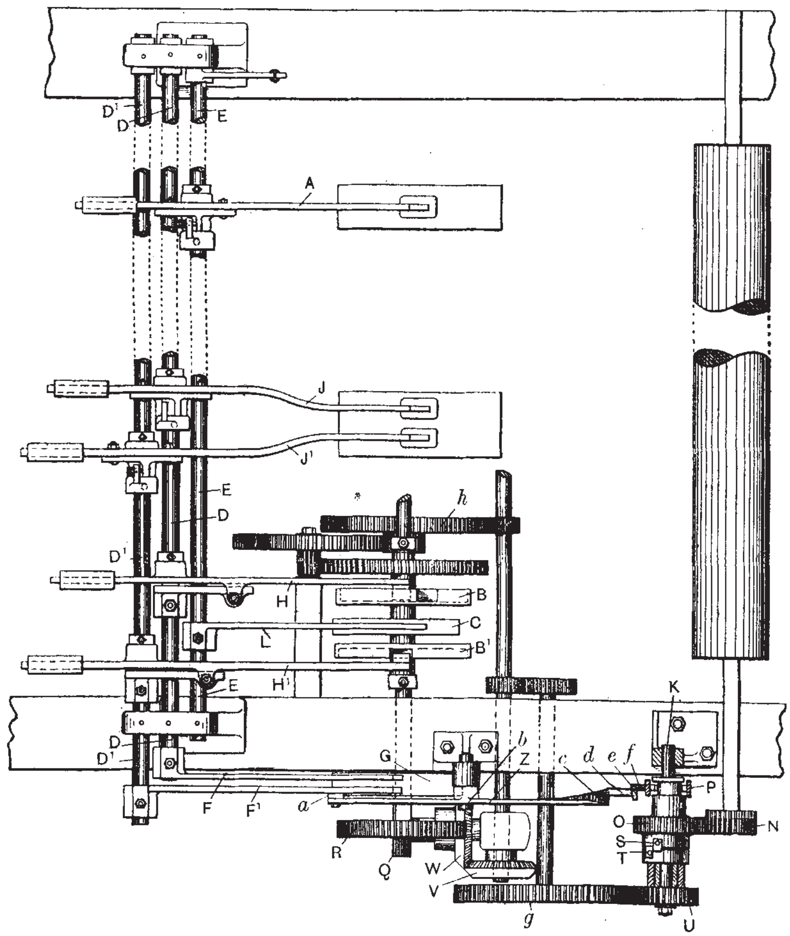


Fig. 149.

adapted expressly for measuring and marking off warps into any desired number of length-units to constitute a series of shawls or scarves of uniform length, and also to provide an additional short interval of warp impressed with a cutting-out mark exactly midway between the last and first marks of consecutive series of shawls. This object is effected by employing two sets of marking mechanism operating in unison, and driven by a change pinion wheel on one end of the measuring-roller shaft whence, through the medium of a clutch, motion is transmitted to the entire combination of marking mechanism in such a manner that its operation may be stopped automatically for a short interval, although the warp still continues to proceed along its course.

Thus, through the medium of a simple train of wheels commencing with the change pinion N, on the measuring-roller shaft, and terminat-

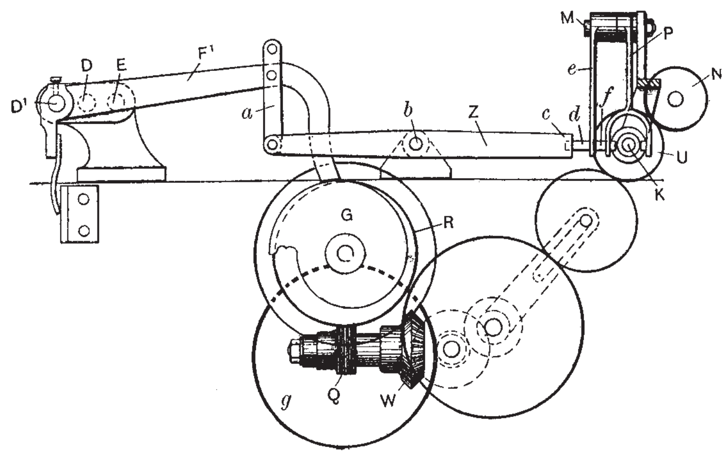


Fig. 150.

ing with a large spur wheel *h*, motion is transmitted to a stepped cam C, and two notched discs, B, B', all of which make only one complete revolution for *each shawl length* of warp. In combination with the stepped cam C there is a cam lever L secured to a cross-bar E, with the free end of the cam lever bearing downward constantly upon the rim of the stepped cam C, to govern the action of a marking hammer A, which is also mounted with a flexible joint on the same cross-bar E, that contains the cam lever L, and which is employed for impressing only the *second and subsequent marks*, including the last one, of each series of shawls.

Through the medium of another train of wheels branching from the previous train and consisting of two bevel wheels V, W, and a worm Q, gearing with a worm wheel R, motion is transmitted to another stepped cam G, which makes only one revolution for *each complete series* of any prescribed number of shawls including the interval of warp that separates one series of shawls from another series. This second stepped cam is employed to control the action of two cam levers F, F¹, that are fixed on the ends of separate cross-bars, D, D¹, on which there are also mounted, with flexible joints, two disc or timing levers H, H¹, that are controlled by the joint operation of the second stepped cam G and the notched discs B, B¹, to govern the action of two supplementary marking hammers J, J¹, which are also mounted with flexible joints on the same cross-bars D, D¹, containing the cam levers F, F¹, and the timing levers H, H¹, respectively. The marking hammer J is employed for impressing only the *cutting-out mark*, whilst the hammer J¹ impresses only the *first mark* of each series of shawls, in a manner to be described presently.

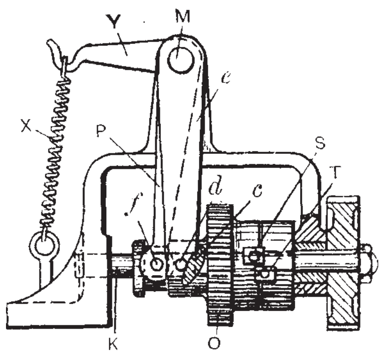


Fig. 151.

§ 265. The measuring-roller pinion N gears constantly with a clutch change wheel O, which revolves freely on a short shaft K, on which it is also capable of sliding, but without moving out of gear with the teeth of the roller pinion N, whereby the clutch wheel O revolves continuously whenever the machine is in operation. The clutch wheel O is constructed with a long boss or hub extending on both sides of that wheel and of which the rear end is formed with a recessed annular groove or channel spanned by the forked end of a pendent arm P, fulcrumed on a stud M; whilst the opposite or near end of the hub is furnished with a projecting lug S which, by the sliding movement of the clutch wheel O, either engages with, or else disengages from, a similar lug T, projecting from the hub of another clutch change wheel U, keyed fast upon the shaft K.

The sliding movement of the first clutch wheel O is effected by means of the clutch fork P, which is controlled in one direction to disconnect the clutch wheels O, U by the descent of the cam lever F^1; whereas the reverse movement of the clutch fork P, to connect the clutch wheels, is effected immediately by the sudden reflex action of a distended spring X, secured to the hooked end of a short arm Y, which projects from the upper end of the clutch fork, so that the spring always tends to keep the clutch wheel O in its normal position, whether the lugs S, T are engaged or disengaged.

The free end of the cam lever F^1 is connected by means of a link-rod *a* to one end of another lever Z, fulcrumed centrally on a stud *b*. An inclined edge *c*, formed on the opposite end of that lever, engages with a stud *d*, projecting from the lower end of a pendent arm *e*, fulcrumed on the same stud M as that on which the clutch fork P is also fulcrumed, and with the lower end of the pendent arm *d* bearing against a stud *f*, projecting on one side, at the lower end, of the clutch fork P.

Therefore, on the descent of the cam lever F^1, the lever Z oscillates and thus causes the inclined edge on the free end of that lever to move both the pendent arm *e* and also the clutch fork P, so as to disconnect the clutch wheels O, U momentarily, and thereby put the entire combination of marking mechanism out of action, temporarily, until such a length of warp has passed forward as corresponds to the extra length required between the last shawl mark of one series and the first shawl mark of the next series of shawls. The interval between those two extreme shawl marks is determined by the relative sizes of the measuring roller change pinion N and the first clutch wheel O, which may be in such a ratio as to permit of the measuring roller making one, or more, or less than one complete revolution before the lug S, on the first clutch wheel O, again encounters that on the second clutch wheel, to resume the operation of the marking mechanism. As the stepped cam G revolves slowly the lever F^1 returns gradually to its normal position and passes on the opposite side of the stud *d*, projecting from the pendent arm *e* without imparting to the clutch fork P, any movement whatever.

§ 266. After the marking hammer A has descended to impress the last shawl mark of one series of shawls, the second stepped cam G then liberates the two cam levers F, F^1, which descend, not to the bottom of the cam step, but only a sufficient distance to permit of the disc or timing levers H, H^1 to bear downward upon the rims of their respective discs B, B^1 until notches cut in the rims of those discs are brought immediately underneath the ends of their respective timing levers H, H^1. When this occurs, the timing levers descend suddenly and thereby operate first the marking hammer J to impress the *cutting-out mark*, and then the marking hammer J^1 to impress the *first shawl mark* of the following series of shawls, in succession, and at such intervals apart as is predetermined by the relative adjustment of the stepped cam C, and the discs B, B^1, and also by the relative sizes of the change wheels N, O and U, *g*. After the timing levers have descended through the notches and below the rims of their respective discs, they rebound instantly, but cannot return from inside to the outside of those disc rims until they have made a complete revolution, when the timing levers again ascend automatically, through the notches, into their normal position.

With the descent of each timing or disc lever, their respective cam levers F, F^1 are thereby depressed from their neutral position until their free ends bear downward against the rim of the cam G. Therefore, when this further movement occurs, in respect of the cam lever F^1, only—which operates in conjunction with the timing lever H^1, governing the marking hammer J^1, to impress the *first shawl mark* of each series—the lever Z oscillates and thereby disconnects the lugs S, T of the clutch wheels O, U momentarily, to put the marking mechanism out of operation in the manner and for the purpose described previously.

§ 267. A later example of a shawl-marking motion is that illustrated in Figs. 152 and 153, which represent an elevation and a plan of Henderson's modification, as constructed by Messrs Grimshaw & Brock. This device, like the shawl-marking motion described in the two previous sections, operates automatically without the necessity to stop the machine at the end of each series of shawls and then draw forward, by hand, as formerly, a short length of warp to produce the interval between two consecutive series of shawls.

With this present modification, the shawl-marking hammer R is governed by a ratchet-wheel B, termed the "shawl-marking wheel," which, through the medium of wheel gearing, is operated from a pinion D, on one end of the shaft of the measuring roller A; whereas the cut-marking hammer S is controlled by means of a separate segment tooth C, termed the " cut-marking tooth," which is adjustable and may be fixed, in relation to the teeth of the ratchet wheel

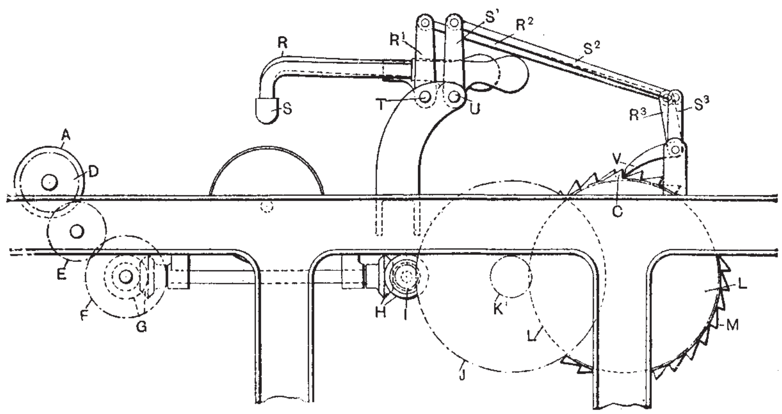


Fig. 152.

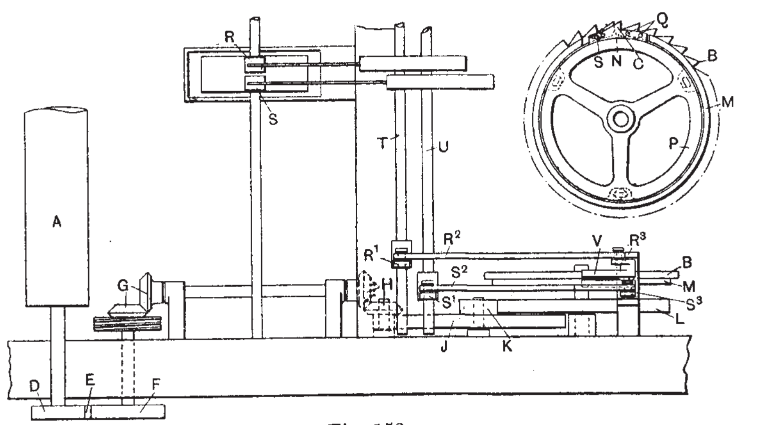


Fig. 153.

B, according to the interval required between two consecutive series of shawls.

Motion is transmitted from the measuring roller A to the shawl-marking wheel B through the medium of a train of wheels commencing with the pinion D and terminating with a large wheel L secured to the ratchet wheel of which the teeth extend partly across a gap N formed in a ring M, to one end of which the cut-marking segment tooth C is riveted (as indicated in the detached diagram, Fig. 153) in such a manner that the gap in that ring may be expanded or contracted in order to adjust the segment tooth to the teeth of the ratchet wheel as required.

The marking hammers R and S are each mounted upon separate shafts T and V, and operated through the medium of short arms and connecting-link rods R^1, R^2, R^3, and S^1, S^2, S^3 respectively. Therefore, successive teeth of the ratchet wheel raise a pawl V and the shawl-marking hammer R, which descend as each of those teeth releases the pawl V to impress a shawl mark for each tooth; whereas the cut marks are impressed by the marking hammer S only after each complete revolution of the segment tooth C, and therefore of the ratchet wheel B, with which it revolves.

§ 268. A cut-marking and measuring motion of a distinctly different type from any of the previous modifications is that illustrated in Figs. 154 to 159, which represent different views and details of another example of Hitchon's devices of this class, and one that has met with considerable approval. This improved type of device is designed with the primary object of enabling a warp to be subdivided into unit lengths of any measurement without the necessity of changing wheels for that purpose, as is required with marking motions of the previous type, whereby the changing from one cut-length to another is effected instantly and with precision.

This device also combines a length indicator in addition to that which simply indicates the number of "cut-lengths" that are wound on; so that by reading the two indicators in conjunction, they record, at sight, the exact length of warp that has passed on to the weaver's beam. These objects are accomplished by a modification of the same inventor's measuring and automatic stop-motion adapted for beam-warping machines, as described and illustrated in §§ 147 to 149 of the previous chapter.

The operation of these two devices depends chiefly upon the application of a type of spur wheel that is provided on one side with what may be described as "peg" or "riding" teeth. In two wheels of this type that gear with each other there is usually a difference of only one tooth between them. Therefore, after two such wheels have made a prescribed number of revolutions, which is in a measure inversely proportionate to the respective number of teeth they contain, the " peg " teeth encounter and ride upon each other.

If both wheels are mounted on fixed bearings they must stop whenever the riding teeth meet, as in the Geneva stop-winding motion; or else the two wheels may reverse their movement and revolve in the reverse direction until the peg or riding teeth again encounter each other. If, however, one of the two wheels is mounted

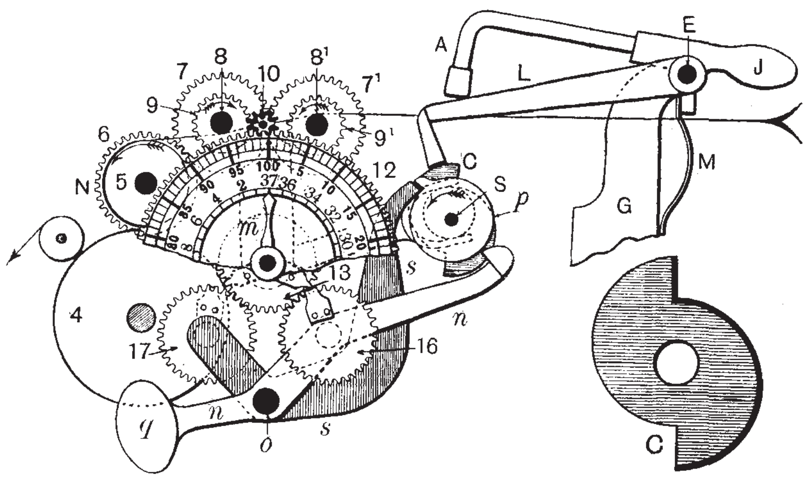


Fig. 154.

on a movable bearing secured to an arm or lever, as exemplified in Hitchon's measuring motions under present notice, the meeting of the two riding teeth causes the movable wheel to part momentarily from the driving wheel, and thereby vibrate the arm or lever on which the movable wheel is mounted, for the specific purposes for which these respective devices are designed.

The distinctive feature of this new type of cut-marking and measuring motion, as represented in Figs. 154 and 155, consists essentially of a graduated dial wheel and plate 12, with an index finger M, constituting a length indicator which, through the medium of an ingenious combination of spur-wheels provided with peg or riding teeth, levers and cams, controls the operation of the colour-marking hammer A in a manner to be described. The length indicator is operated primarily from the measuring or nip roller 5, which, through the medium of ordinary wheel gearing commencing with a pinion wheel 6 on the far end of the measuring roller and terminating with a small pinion 11, transmits motion to the dial wheel 12.

Thus, the measuring roller pinion 6, with 36 teeth, gears with a spur-wheel 7, with 35 teeth, which in turn drives a similar wheel 7^1.

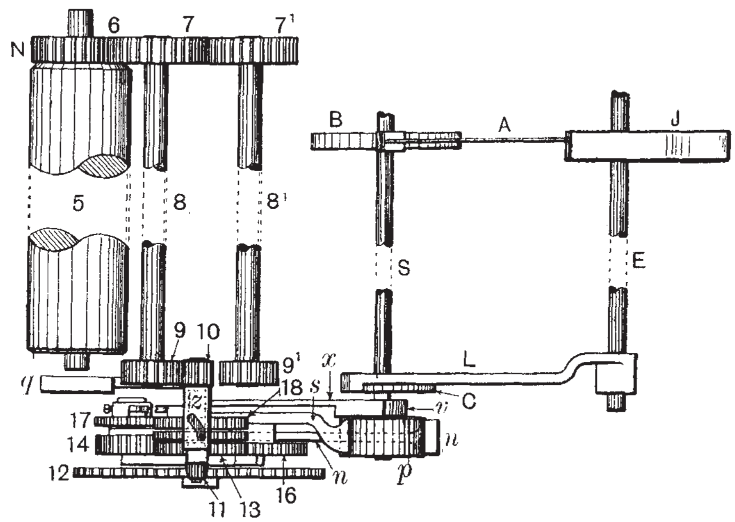


Fig. 155.

These two wheels 7 and 7^1 are fixed respectively on the rear ends of two iron "sheeting" or yarn-spreading rollers 8 and 8^1, that revolve in reverse directions and assist in spreading the yarn into a more evenly distributed sheet of threads as these pass *over* the rear roller 8^1, and *underneath* the front roller 8, as indicated in Fig. 154. On the fore ends of the two "sheeting" rollers there are fixed two pinions 9 and 9^1 respectively, each containing 30 teeth, with which there gears, in alternate succession, another wheel 10, with 15 teeth. This wheel is secured to the rear end of a short spindle shaft on the fore end of which there is mounted a small pinion 11, with 7 teeth, which drives the dial wheel 12, containing 100 teeth, with a velocity of one revolution for every 100in. of warp length, thus:—

$$\frac{14 \cdot 4 \times 35 \times 15 \times 100}{36 \times 30 \times 7} = 100\text{in. per rev. of dial wheel.}$$

§ 269. From this point, the dial-wheel now becomes the essential factor which controls both the measuring and cut-marking mechanism. On the front of that wheel there is fixed a white enamelled plate containing two separate scales—namely, an inner scale to indicate units of 100in. each up to 37 hundred inches = $102\frac{1}{9}$yds., and an outer scale to indicate inch units up to 100in. The figures on the inner scale of "hundreds" are always read from the point of the index finger *m* wherever they may be; but the figures on the outer scale of unit inches are read only when they are in the zenith, directly over the axis of the dial.

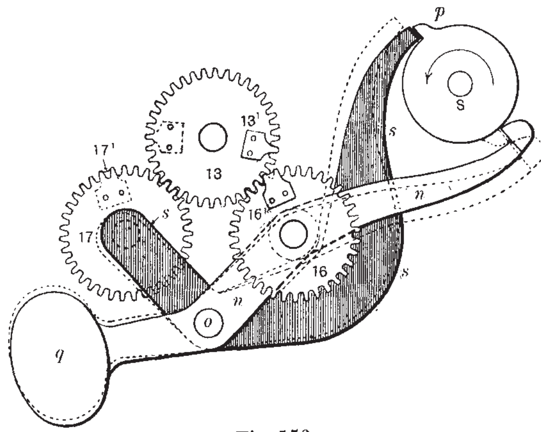


Fig. 156.

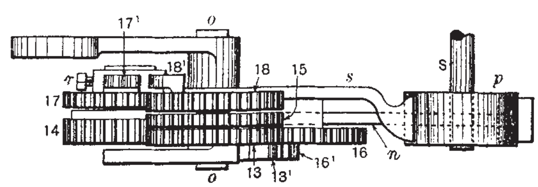


Fig. 157.

Both the dial and recording finger revolve with a slightly different velocity and in the same direction simultaneously, but in reverse directions alternately, in a manner and for a purpose explained in the last paragraph of this section. The recording finger *m* is secured on the fore end of a spindle shank which passes quite freely through the hollow hub of the dial-wheel. On the hub of that wheel there is fixed a pinion 13, containing 38 teeth, and also provided with a "peg" or "riding" tooth 13^1 on the front, as represented on a larger scale in Figs.

156 and 157. Through the medium of a simple carrier wheel 14, having a wide rim and 37 teeth, the dial pinion 13 transmits motion to the finger wheel 15, with 37 teeth, secured to the spindle carrying the recording finger. Hence the relative velocity of the dial-plate and the recording finger is in the ratio of 37 to 38revs. respectively.

Thus, if the finger and dial are both set to zero on their respective scales—*i.e.*, to 37 (3700) and 100 respectively, as represented in Fig. 154—and the dial is then turned one revolution in an anti-clockwise direction, the finger will make $1\frac{1}{37}$th of a revolution, and therefore point to 1 (100) on the inner scale. After the second revolution of the dial, the finger will point to 2 (200), and so on, thus advancing one unit, representing 100in. each, for every complete revolution of the dial-plate. Therefore, when this has made 37revs., the index finger will have made 38revs., and both will again indicate zero on their respective scales.

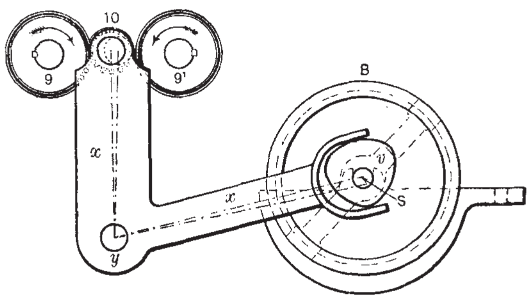


Fig. 158.

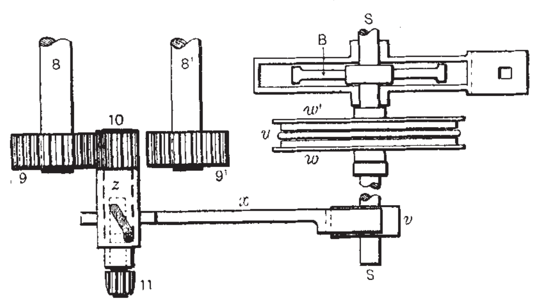


Fig. 159.

The dial pinion 13 also gears with another wheel 16, containing 37 teeth, and provided with a riding tooth 16^1 on the front. This wheel is mounted on one side of a lever *n* fulcrumed on a bar *o*, and formed with a hook at the end of the longer arm which extends immediately below a hooked disc *p* fixed on the extreme fore end of a shaft S, as represented on a larger scale in Figs. 156 and 157.

The shorter arm of the lever *n* is cast with a heavy counterweight *q* to overbalance that lever, and yet permit of its vibrating slightly whenever the riding teeth on the dial pinion 13 and the lever wheel 16 meet each other, and thereby depress the hooked end of the lever *n*. This occurs only when the index finger and also the outer scale on the dial-plate both indicate zero simultaneously, as represented in Fig. 154.

On the hub of the carrier wheel 14 there is also mounted an adjustable pinion 17, containing 37 teeth and secured to the hub of the carrier wheel by means of a set-screw *r*, so that both of these wheels revolve together as one wheel. This pinion 17 is provided with a riding tooth 17^1 at the back, and gears with a wheel 18, containing 38 teeth, also provided with a riding tooth 18^1 at the back, and mounted quite freely on the hub of the finger wheel 15.

Both the carrier wheel 14 and the pinion 17 are mounted together on one side, and near the end, of the shorter arm of a second lever *s* (shaded), also fulcrumed on the bar *o* that supports the first lever *n*. The longer arm of this second lever *s* is formed with a blunt end, and is cast much heavier than the shorter arm which it overbalances and yet permits of that lever vibrating slightly whenever the riding teeth on the pinion 17 and the wheel 18 meet each other, and thereby raise the blunt end of the lever.

By previously adjusting the pinion 17 and the wheel 18, in relation to the index finger and dial-plate, in a manner to be explained presently, the vibration of the second lever *s* is timed to occur precisely, and only, when the figures at the point of the index finger and those that are in the zenith on the outer scale of the dial-plate jointly indicate the prescribed length of cut, expressed in unit inches.

The adjusting of those two wheels 17 and 18, and also of the dial-plate and recording finger, to mark any prescribed length of cut, is accomplished easily and quickly by first releasing the pinion 17, then sliding the small pinion 11 backward out of gear with the dial-wheel, and turning this wheel until the required length of cut is indicated jointly by the index finger and also the outer scale on the dial-plate. The small pinion 11 is then replaced in gear with the dial-wheel, when the pinion 17 and the wheel 18 are turned until their respective riding teeth meet, after which the pinion 17 is again secured on the hub of the carrier wheel 14, and the adjustment is complete.

For example, if it is required to mark a warp into cut-lengths of 62yds. (2232in.), the dial would be turned until the index finger pointed to 22 (2200) on the inner scale, with the division mark denoting 32in. on the outer scale, in the absolute zenith over the axis of the dial-wheel; after which the riding teeth on the pinion 17 and the wheel 18 meet each other in the manner just described, and with the wheel 10 in gear with the pinion 9 on the front "sheeting" roller 8 as indicated in the diagram, Fig. 155.

Therefore, when the sizing machine is put into operation, the dial-wheel will revolve first in a clockwise direction for $22\frac{32}{100}$revs., when a cut-length of 2232in. has passed on to the weaver's beam, and both the index finger and the outer scale on the dial-plate will indicate zero simultaneously. This position of the index finger and dial-plate always coincides with the meeting of the riding teeth on the dial pinion 13 and the wheel 16 on the hooked lever *n*, whereby that lever is depressed, as described in the first paragraph on p. 279.

The instant that lever vibrates the shaft S makes one-half of a revolution with the twofold object of deflecting the marking hammer to impress a cut-mark on the warp threads, and also to transfer the wheel 10 from the pinion 9 on the front "sheeting" roller 8, and put it into gear with the pinion 9^1 on the *rear* "sheeting" roller 8^1 automatically; thereby immediately reversing the movement of both the dial-wheel and index finger. These will then revolve in an anti-clockwise direction until they jointly indicate the prescribed cut-length of 2232in., when the riding teeth on the pinion 17 and the wheel 18 meet, and thereby raise the second lever *s* to permit of the shaft S making another half of a revolution, to impress another cut-mark, and at the same time transfer the wheel 10 back again from the pinion on the rear "sheeting" roller to that on the front roller, and so again reverse the movement of the dial-wheel and index finger. These will now revolve again in a clockwise direction until they both indicate zero simultaneously, on their respective scales, and so on continuously until the weaver's beam is completed.

§ 270. The intermittent rotation of the shaft S is effected primarily, not from the measuring roller which operates the length indicator, but from the second or driven cone-drum shaft of the main driving gear. Thus, through the medium of a narrow leather belt, motion is transmitted from a small flanged pulley, on the cone-drum shaft, to a narrow disc *u* fixed on the shaft S, on which there are also fixed the hooked disc *p*; an eccentric cam *v*; a double-stepped cam C; and the colour block B.

On each side of the disc *u* there is mounted a single-flanged loose pulley *w* and w^1, which serve merely to retain the narrow belt in its proper track. The narrow rim of the disc *u* is rounded to prevent it from cutting into the driving belt that runs continuously on the rim of that disc, which it is constantly endeavouring to turn, and thus rotate the shaft S to impart the intermittent movement to the eccentric cam *v* and the double-stepped cam C.

The driving power of the narrow belt, and therefore the intermittent rotation of the shaft S, are, however, held under restraint by causing the projecting hook on the rim of the disc *p* to catch and thus stop against either the blunt end of the lever *s* or else against the hooked end of the lever *n*. Both of these levers vibrate in alternate succession, and thereby liberate the hooked disc to permit of the shaft S making half a revolution, when its further movement is arrested by first one and then the other of those two levers, until the hooked disc is again liberated for the purpose of impressing cut-marks upon the warp threads, and also of reversing the movement of the length indicator and its appurtenances, in the manner described in the last paragraph of the previous section.

The eccentric cam *v* is spanned by the forked end of the horizontal arm of an L-lever *x* fulcrumed on a stud *y*, as represented in Figs. 158 and 159. In a sleeve bearing *z* carried at the upper end of the vertical arm of that lever there is mounted a short spindle shaft, on the opposite ends of which there are contained the wheel 10, and the small pinion 11 which gears with the dial-wheel.

Hence, with each intermittent movement of the cam shaft S the eccentric cam *v* oscillates the L-lever, and thereby transfers the wheel 10 from the pinion on one "sheeting" roller, to gear it with that on the other roller, with the object of reversing the movement of the dial-wheel, the index finger, and other parts incidental to the length indicator. At the same time, the double-stepped cam C releases the cam lever L, and thereby deflects the marking hammer on to the colour block to impress a cut-mark on the warp threads.

Sheeting or Yarn-spreading Rollers

§ 271. One of the evils to which slasher-sized and cylinder-dried warps are liable, and one that is detrimental to the quality both of the yarn and the cloth produced from it, is that which results from the clinging or adhering together of two or more contiguous warp threads that sometimes pass on to the weaver's beam without being separated. This not only impedes the weaver by those threads pulling and sometimes breaking either against the lease-rods or else the shedding harness in the loom, but it also involves the consequent risk of producing imperfections in cloth.

This evil of clinging warp threads results from the passing of yarn, in the form of an evenly-distributed sheet of threads, through a solution of hot size paste, and conducting it immediately around heated drying cylinders whilst the threads are in contact with each other, and without any means of separating them and keeping them apart whilst they are still moist with size.

The risk of warp threads clinging to each other is, of course, mimimised by employing a number of dividing-rods for the purpose of separating the threads after these leave the drying cylinders, and immediately before they pass finally on to the weaver's beam. This division of the warp threads, however, is but a very imperfect one, and consists of separating the yarn into such a number of divisions or sheets of threads as correspond with the number of back beams from which they are withdrawn, as described in §§ 181 and 228.

But, even with this precaution, frequently two warp threads may be found clinging to each other, and in some warps containing a considerable number of threads even three contiguous threads have sometimes been found adhering together. Whenever this occurs it follows that those threads must necessarily come from the same back beam, since all warp threads that are withdrawn from the same beam are passed uniformly above and below the same dividing-rods in the manner explained in § 228, and as illustrated in Fig. 115.

§ 272. Correlated with the evil of warp threads clinging together during the operation of slasher sizing, there is also another defect which arises in consequence of passing the yarn in "half-beers" of, say, five or more threads through an expansible and contractible half-reed or spreading comb, by which the width of warp is adjusted to that of the weaver's beam. On emerging from that reed, the threads tend naturally to run together in groups or "half-beers," instead of spreading out to form an evenly-distributed sheet of threads as they pass on to the weaver's beam. Hence, these groups of threads tend to form ridges and furrows, and thereby produce an uneven surface of yarn on that beam, with the result that the warp threads are of slightly unequal tension.

Numerous expedients have been devised with the object of remedying these two evils of clinging and grouping warp threads, by assisting them to separate and spread out into an even sheet of threads. In most sizing machines the remedy is left entirely to the levelling influence of the yarn-pressing rollers, which, by force of compression against the yarn surface of the weaver's beam, causes the more prominent ridges of threads to become imbedded, without, however, effecting an even distribution of those threads.

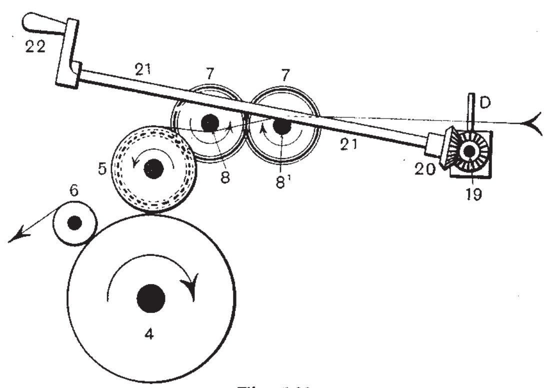


Fig. 160.

Thus, after leaving the dividing-rods, the warp threads pass, almost immediately, in "half-beer" groups, through the expansible and contractible reed D (Fig. 160), which is situated about midway between the last dividing-rod and the cut-marking colour-block. The yarn is then conducted, *en masse*, first *over*, and then *under*, two iron "sheeting" or yarn-spreading rollers 8^1 and 8 respectively, whence it passes over the measuring roller 5, and between this and the large tension or drawing roller 4, thence over a small iron guide roller 6, and finally on to the weaver's beam.

§ 273. The type of reed or comb usually employed to distribute the sheet of warp threads to the required width is similar to that employed with the same object in beam-warping machines and as illustrated in Fig. 45. Such a reed is constructed with several long spiral springs that extend for the entire length of the reed, and of which the coils are intertwined and intercepted by the reed wires in such a manner that the extension and contraction of the springs increases and reduces the width between those wires uniformly.

This adjustment is obtained by securing the opposite ends of the springs respectively to two bolts, one of which receives a right-hand thread, and the other a left-hand thread, that are formed at opposite ends of a rod extending along the entire length of the reed-base. On one end of that rod there is fixed a bevel wheel 19 gearing with a similar wheel 20 on the rear end of an inclined shaft 21. On the fore end of this shaft there is fixed a handle 22, to permit of the warp being adjusted whilst the attendant stands in front of the machine, and with the weaver's beam under his immediate observation.

By their impinging more or less against the vertical reed wires, these tend to impart to the respective "half-beer" groups of threads a quarter twist or turn from their original horizontal plane, thus, ..., and thereby cause the threads of each separate group to assume a vertical plane, thus, ⋮ ⋮ ⋮ ⋮. It is then the function of the "sheeting" or spreading rollers 8 and 8^1 to reverse the effect of the reed wires by replacing the groups of threads from their vertical to a horizontal plane, and thereby spread them into an evenly-distributed sheet of threads.

One of the earliest forms of reeds employed for this purpose consisted of round wire pins inserted in a long piece of india-rubber, about an inch square in cross-section, and was expanded or contracted to the required width by simply stretching the rubber foundation of the reed.

§ 274. In sizing machines of earlier date, the "sheeting" bars were quite stationary, but in those of modern construction they are usually mounted freely in their bearings to permit of those bars revolving simply by their frictional surface contact with the sheet of yarn as this passes over and under them respectively. The rotation of the sheeting rollers not only tends to effect a better distribution of the warp threads than when they are stationary, but it also prevents their incision from the constant chafing by those threads.

In some machines as made by Messrs Howard & Bullough, Limited, the effort of turning the "sheeting" rollers is not imposed upon the warp threads, but they are driven positively through the medium of wheel gearing operated from a pinion on one end of the measuring-roller shaft, as represented in Figs. 154 and 155.

A still later improvement, however, adopted by that firm is to mount the "sheeting" rollers eccentrically to the respective axes of the spur-wheels by which they are driven, as illustrated in Fig. 161. By this means the eccentric motion of those rollers keeps the yarn moving continually upward and downward alternately, with the twofold object of effecting both a more perfect separation and distribution of the warp threads.

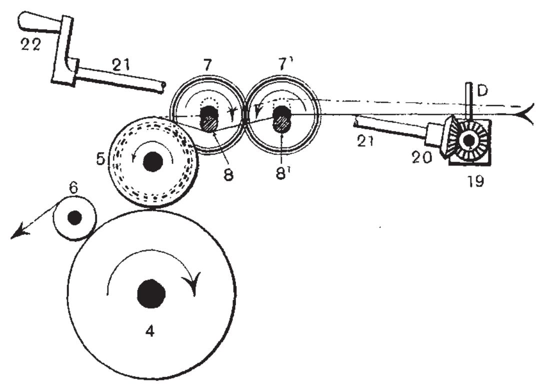


Fig. 161.

Some machine makers, however, adopt the extreme contrary method of fixing two, and sometimes three, oval-shaped iron "sheeting" bars, instead of perfectly round ones, for the purpose of effecting an even distribution of warp threads, and of which two different applications are represented at A and B, Fig. 162.

§ 275. Also sometimes other measures are adopted with the object either of minimising or averting the risk of warp threads clinging and grouping together during sizing. For example, one method is to interpose an additional reed D^1 between the usual reed D and the measuring roller 5, as represented by a part elevation and plan in Figs. 163 and 164. Both of these reeds are precisely similar in construction, excepting that instead of the wire dents of the additional reed D^1 being quite vertical, they are inclined at an angle of about 25° from the vertical, as represented in Fig. 165.

The objects of inclining the dents of that reed are to effect a more thorough separation of the warp threads by causing them to spread out as they bear preferably against the *upper* surfaces of the inclined reed wires; and also to ensure the turning or twisting

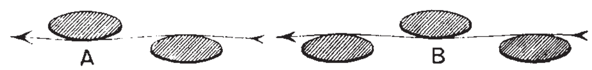
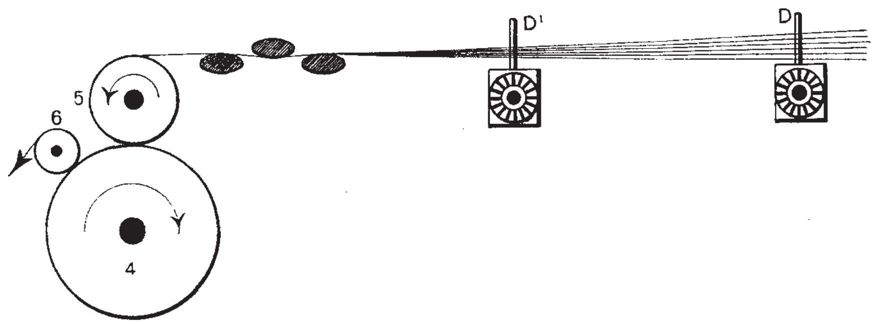


Fig. 162.

of the half-beer groups of threads always in the same direction, uniformly, as indicated in Fig. 166. Instead of employing an additional reed, however, some attendants attain the same object by

Fig. 163.



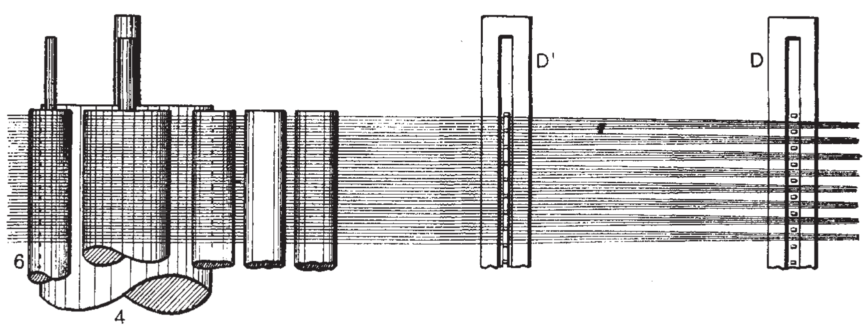


Fig. 164.

inclining the dents of the usual reed or comb in a manner similar to that represented in Fig. 165.

Instead of the usual form of half-reed or comb constructed with flattened reed wire, and of which the dents are arranged in one long straight row, as represented at D, Fig. 160, there is sometimes employed a vandyked reed of the type illustrated in Fig. 167. Reeds of this type are constructed with round steel wire, and with the dents arranged in zig-zag rows on a number of short bars that are

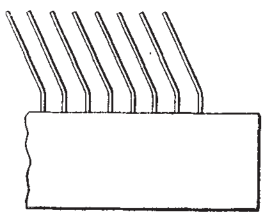


Fig. 165.

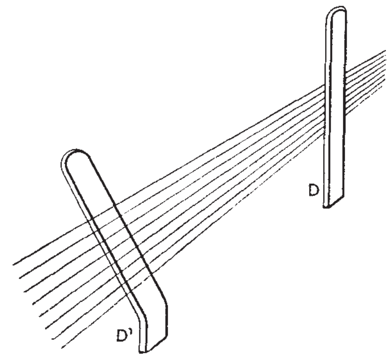


Fig. 166.

hinged together freely to permit of the reed being expanded and contracted. This is effected by means of reversed screw threads formed at opposite ends of a rod which extends along the reed-base as in the previous form of reed, but without the aid of the intertwined spiral springs that are employed for that purpose in the former reed.

The advantages claimed for reeds of the vandyke type over those of the straight type are that the employment of round steel wire

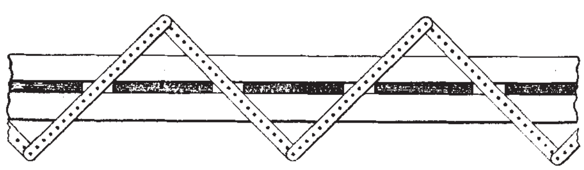
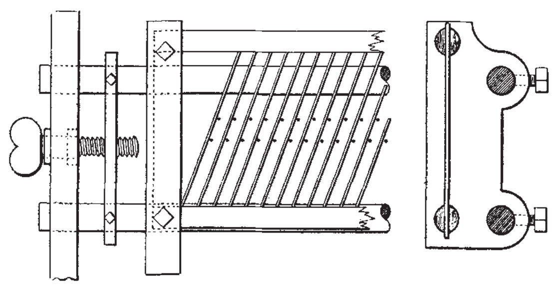


Fig. 167.

gives greater strength and firmness to the dents, and also that the positive adjustment of the reed ensures a more perfectly even and precise distribution of the dents than is possible by the aid of spiral springs that become clogged with lint and dust, and are therefore uncertain and unreliable in their action.

Another example of a reed constructed with inclined dents, and intended for use in sizing machines, is that illustrated at A and B, Fig. 168, which represents a part front and a sectional view of a reed designed more particularly for " dresser " sizing of warps of which the threads are passed in pairs only, and whilst they are still moist with size-paste, between successive dents of the reeds.

Excepting for the inclination of the reed wires, the reed is similar to one of ordinary construction, with upper and lower ribs bound together with pitched twine or cord, and of which the dents, therefore, are closed and fixed. This, of course, necessitates the passing



A Fig. 168. B

of warp threads between the dents of such a reed, in the first instance at least, by the operation of " drawing-in," and those of subsequent warps by that of " twisting-in," instead of by the method of " laying-in," as with the usual form of half-reed or comb in which the dents are open at the top.

Economy in Steam Consumption for Sizing

§ 276. Of the several economic problems incidental to warp sizing by means of any of the different types of machines in vogue, the more difficult ones are those of securing (1) the most effective results with the least consumption of steam for boiling the size, and also for drying the sized yarn; and (2) an effective system of heating and ventilating the sizing room to ensure the best atmospheric conditions, in respect of temperature and humidity, by removing the vapour of partially - condensed steam that issues chiefly from the boiling size, and also from the yarn, as this is submitted, after being sized, to the process of drying.

These two objects may be attained more or less successfully only by conforming to certain conditions that are imposed by the special technical requirements of warp sizing, as regards the constructional features of the room in which that operation is conducted, as well as the position of the building in relation to the steam-boiler house and other adjacent buildings.

Although it is impossible to specify exact particulars and conditions that would best meet the special requirements of sizing rooms generally—since these particulars may be acquired only from definite knowledge and data respecting local and special circumstances—yet there are certain expedients and precautions of general application which, if adopted, conduce to greater efficiency and economy both in the consumption of steam and also in ventilation.

The chief economic difficulties encountered in the operation of sizing by means of slasher sizing machines consist of an excessive condensing of steam both in the main service pipe leading from the steam boilers to the sizing department, and in the drying cylinders, with the consequent loss of heating power in those cylinders; and also of the atmosphere becoming surcharged with vapour of partially-condensed steam that lingers in the air, and thus prevents the yarn from drying sufficiently. This not only causes the warp threads to cling to each other, and also to the drying cylinders, but it also conduces to the subsequent development of mildew in cloth.

§ 277. Consistent with all other essential considerations affecting the relative disposition of the various departments of a weaving mill, in order to facilitate the transit of yarn in the various stages of its progress through the preliminary operations of weaving, the sizing department should be situated as near as convenient to the boiler house, with the object of reducing the length of main service piping necessary to convey steam from the boilers to the sizing machines, thereby preventing excessive condensation of steam in that piping, with a corresponding loss of pressure and efficiency.

The steam service pipes should not have a diameter larger than is necessary to supply the volume of steam required for sizing purposes; nor should they, if it can be avoided, pass outside and thus become exposed to cold air that would induce the condensation of steam. Also, the main service pipe should be insulated for its entire length by covering it with a good non-conducting material, such as magnesia, silicate cotton (slag-wool), asbestos, cork, hair-felting, or other suitable material, of which there are numerous preparations for covering steam boilers, steam pipes, and drying-cylinder ends, with the object of preventing the radiation of heat from them, and thereby reducing the condensation of steam.

For only one sizing machine and the usual size-mixing plant, a main service pipe of 2in. in diameter is recommended, with an increase in diameter of $\frac{1}{2}$in., 1in., $1\frac{3}{8}$in., $1\frac{3}{4}$in., and 2in., for from two to six machines, respectively; and with branch pipes of not more than 1in. to $1\frac{1}{4}$in. to supply steam to the drying cylinders, size-boxes, and size-mixing becks.

The joints of all steam-pipes, and also the glands or stuffing-boxes of the cylinder journals where these are connected to the steam-pipes, should be well packed and made perfectly steam-tight; and all leakages of steam, however small, should be stopped immediately on discovery.

All branch pipes leading to the drying cylinders, size-boxes, and size-boiling becks, should pass from the upper side of the main service pipe with a syphon bend, thus ꞃ, to prevent the evil known as " priming," or the passing either of water that escapes from the steam boilers, or else that of condensation, together with steam, down the branch pipes and into the cylinders.

Also, all steam-pipes that run horizontally should be set with a slight inclination in such a direction as will assist the water of condensation to gravitate towards the steam-traps, and thereby reduce the risk of that water lodging in the pipes, especially after the steam is shut off for a prolonged period.

Further, all the water of condensation, unless it is contaminated with oil, grease, or other harmful impurities, should be conducted back again to the steam boilers and not run to waste.

§ 278. An additional precaution which is sometimes adopted is that of applying to the cylinder ends a large circular mat or pad composed of any suitable non-conducting material to prevent the radiation of heat, and thereby reduce the condensation of steam within the cylinders. Such mats are sometimes secured detachably, by means of several radial iron bands that are clamped to the rims of the cylinder ends, to permit of their easy removal whenever that becomes necessary for the purpose of effecting repairs within the cylinders; and sometimes the mats are fixed in position more effectively by boarding them up, and thus enclosing them completely. In either case, care should be taken to leave vent-holes in the pads so as not to interfere with the free-and-easy action of the air-valves in the cylinder ends.

This method of insulating the cylinder ends, however, is disparaged by some, who prefer to utilise the radiant heat therefrom for the purpose of maintaining the required temperature in the sizing room.

In fact, in a specific instance of comparative tests that were conducted with the object of ascertaining the difference in the amount of steam consumed, in a stated period, by the *large* cylinder of a slasher sizing machine, when sizing 1140 warp threads of 20's T, and with a steam pressure of 14lb. per sq. in.—first with the cylinder ends uncovered, and afterwards covered with insulating mats—it was found that the volume of water of condensation recovered in one hour was virtually equal in both tests and measured practically 13gall. (=130lb.), but with an *excess*, however, of about *one-half* (0·05) per cent. when the cylinder ends were *covered* with the non-conducting mats which, by these tests, proved to be useless.

§ 279. Although the cost of generating steam consumed only for sizing purposes represents a considerable proportion of the productive cost of manufacturing certain classes of textile fabrics, and especially those comprised under the trade description of "grey cloth" as distinguished from the bleached and coloured varieties, there is, nevertheless, very little available information or data relating to that subject, for the purpose of formulating a basis on which to calculate the proportionate cost of this important item.

The absence of such information is, no doubt, owing chiefly both to the practical and technical difficulties which are encountered in conducting, with sufficient accuracy, the tests and observations that are necessary to furnish reliable data. Hence, it is the usual practice in most weaving mills to include in the item of "general working expenses" a proportionate sum for the cost of coal, water, and other miscellaneous expenses incidental to cloth manufacturing, and to base the amount of that sum on a certain percentage of that paid in wages for weaving.

The amount of coal consumed in vaporising a definite volume of water may be calculated from known data Therefore, if all the water of condensation formed during a specified period were collected from the steam-traps and measured, the volume of water thus obtained would furnish an approximate basis on which to calculate the amount of coal and water consumed in respect of the drying apparatus only, but not for size-mixing and boiling also.

There would, therefore, still be a considerable disparity between the original volume of water that was vaporised into steam and consumed for sizing purposes only, and the volume of water recovered from the steam-traps, from the fact that a great quantity of steam is consumed in boiling the size with which it combines, and is, consequently, quite irrecoverable.

Also, if the small branch pipes that serve steam to the drying cylinders, size-boxes, and size-boiling becks, pass from the *upper* side of the main service pipe with a syphon bend, as indicated in § 277, and, further, if the water of condensation from the drying cylinders of each sizing machine, in addition to that which condenses prematurely in the main service pipe, were passed respectively through separate steam-traps, it would then be possible to estimate the respective volumes of steam utilised effectively for drying the yarn, and that which condenses prematurely, and therefore passes through the steam-trap without serving any useful purpose whatever.

Therefore, by conducting careful and systematic observations and tests extending over a period of several weeks, to allow for different results arising from atmospheric changes and from other variable factors, such observations would provide sufficient data to establish a reasonable basis on which to calculate, at least approximately, the expenditure incurred in respect of coal and water required to generate the volume of steam consumed for sizing purposes only.

The actual consumption of steam for that purpose, and also the relative cost of producing it, will, of course, vary considerably, even during equal specified periods, not only in different weaving mills, but also in the same mill, according to the relative proximity of the sizing department and steam boilers: the structural features of that department; the type of steam boilers; the type and dimensions of the drying cylinders—that is, whether they are of the usual "drum" or of the "cavity" type; the fluctuation in the price of coal; the different varieties of warps to be sized; the character and grade of sizing, and many other varying factors.

Thus, the condensation of steam will be relatively greater when sizing warps composed of coarser counts of yarn, or containing a greater number of warp threads, and also with the heavier grades of sizing, because of the longer period of time or greater heat required for drying the yarn. Under these circumstances, therefore, either the speed of the machine is reduced, or else the steam pressure in the cylinders is increased in order to augment their drying efficiency, according to requirements.

It is manifest, therefore, that if the proposed observations and tests are to be of any practical value, it will be necessary to extend them over a prolonged period in order to comprehend all the variable conditions just enumerated, and also to observe the different results in respect of warps composed of dissimilar counts of yarn or containing a different number of warp threads, and with different percentages of size applied to them.

§ 280. From observations that were conducted with this object in view, and of which the results were recorded in a foreign textile journal, it was ascertained that the volume of steam condensed in the cylinders of a sizing machine during the first hour following a prolonged interval of rest exceeded four times the volume consumed during each of the succeeding hours, when it became of a normal and practically constant value. In one specific instance these observations extended over a period of ten hours' continuous working, and were conducted during the operation of sizing a warp containing 2530 warp threads of 30's T, 12,000yds. in length.

With coal at a high price (which, however, is not stated) it was estimated that the productive cost of steam consumed amounted to a sum of 21·25 pence during the first hour, after which it declined to only about 4·91 pence, at which sum it remained constant during each of the succeeding nine hours, and aggregated a total sum of 65·4 pence for the ten hours' continuous working.

Therefore, on the reasonable assumption that a corresponding volume of steam is also consumed for boiling size in the size-boxes and boiling becks, the total productive cost of steam condensed in respect of that particular warp amounts to a sum of 130·8 pence, which is equivalent to a sum of 0·1086 pence per pound of the *net* weight of yarn sized.

§ 281. The abnormal rate of condensation of steam in the drying cylinders during the first period of working, after a prolonged interval, is owing chiefly to the cooling influence of the water of condensation that lodges in them and becomes quite cold before the machine is restarted. Consequently, on resuming work, this cold water rolls continuously at the bottom of the cylinders, thus absorbing a considerable amount of heat from them, and thereby retarding their drying efficiency. This evil, however, may be easily averted by the simple expedient of fixing in one end of each cylinder, and at a point as near as possible to the cylinder shell, a plug-tap, with an internal bent piece of piping extending near to the shell. By adopting this or similar means, the water of condensation could be expelled and drained completely from the cylinders by simply opening the tap and then turning on the steam for only a few seconds.

In certain instances, therefore, it might prove to be more advantageous and economical to work the sizing machines continuously throughout the entire working day, or until the back beams are depleted of yarn, without stopping for meal-times, whereby the relative consumption of steam is reduced. But if, on the contrary, work is suspended for a long interval before the "set" of back beams is exhausted, the steam service pipes, drying cylinders, size-boxes, and temperature of the atmosphere in the room will cool down during that interval. Consequently, on resuming work, the condensation of steam will be much greater up to a certain period, when it declines gradually until it assumes a normal and practically constant value.

Continuous working, of course, incurs additional expense for auxiliary driving power to drive the sizing machines whilst the main driving gear is stopped; besides imposing additional physical strain and discomfort upon the attendants by depriving them of regular intervals of rest during meal-times—disadvantages that will not, in some instances, compensate for the advantages that may accrue from continuous working.

Ventilating and Humidifying

§ 282. Considerable diversity of opinion exists amongst both engineering and textile experts concerning the best position and constructional features of sizing rooms, and also the relative merits of different methods of heating and ventilating those rooms in order to ensure the temperature and humidity of the air that will be most congenial both to the yarn for weaving purposes, and also to the peculiar conditions under which the operation of sizing is conducted.

Consequently there are many examples of faulty construction, imperfect methods of heating and ventilating of sizing rooms, in some of which it is quite impracticable to conduct the operation of sizing with reasonable economy and satisfaction. Indeed, success in this direction may be attained only by conforming to such conditions and requirements as are prescribed from definite knowledge of the practical details of the operation of sizing, and also of the atmospheric conditions that are most favourable to its successful accomplishment.

A relatively high temperature of air, ranging from about 70° to 80° F. (20° to 26·6° C.), according to the character of yarn and the grade or percentage of size, is found from experience to be the most suitable for a sizing room. For strong yarn of coarse and medium counts, and the heavier grades of sizing, the lower temperature might be suitable for maintaining that percentage of humidity which is necessary to retain the size on the yarn; but the higher temperature is preferable for delicate yarn of fine counts with pure and the lighter grades of sizing.

Air of a high temperature, if not too dry, imparts to the yarn a soft, supple, and mellow tone or "feel" without leaving it dry and harsh, and also conduces to a pure and clear atmosphere with a suitable percentage of humidity. This arises from the fact that air of a higher temperature is capable of absorbing and retaining in suspension, as invisible vapour, a much greater weight of water without increasing the relative degree of atmospheric humidity.

§ 283. The maximum weight, in grains, of vapour per cubic foot of saturated air (= 100 per cent. humidity) at temperatures ranging from 60° to 90° F. (15·56° to 32·22° C.) is specified in the following table:—

Temperature (Fahr.)	60°	62°	64°	66°	68°	70°	72°	74°	76°	78°	80°	82°	84°	86°	88°	90°
Grains of Vapour per Cubic Foot of Saturated Air	5·8	6·2	6 6	7·0	7·5	8·0	8·5	9·1	9·7	10·3	11·0	11·7	12·4	13·2	14·0	14·8

The position and structural features of a sizing room should, therefore, be of such a character as will conduce both to steam economy and to a warm and relatively dry atmosphere. These objects may be attained successfully by erecting the sizing room in close proximity to the steam boilers, and also by avoiding, as far as practicable, undue exposure, within the room, of cold building materials, as iron, stone, bricks, concrete, cement, slates, and glass.

All these materials absorb heat from the atmosphere, and thereby reduce the temperature of the air, in their immediate vicinity, to that of the "dew-point," when condensation begins, and the excess of vapour in the air is deposited as dew on those materials.

§ 284. On the basis of the foregoing considerations, therefore, the essential conditions which should be observed in the construction of sizing rooms are specified as follows:—

1. Position

A sizing room should be in close proximity to the steam boilers, to minimise the condensing of steam in the main service pipe. If erected as a single storey, the floor should be well elevated from the earth to permit of a good current of air in the space beneath it. If, however, the room is in a storeyed building, it should be uppermost, to permit of *vertical* ventilating trunks passing outside through the roof, to expel vapour from the room by means of natural ventilation only, without having recourse to fans.

This object may only be effected successfully, however, by having the trunks exposed sufficiently to permit of the free access of air-currents to the orifices of those trunks. These will then operate on the same principle as that of tall chimney-flues in which up-draughts or currents of air are induced naturally.

If the ventilating trunks are surrounded by lofty adjacent buildings, these will tend to obstruct the air-currents, and thereby impede natural ventilation by creating atmospheric stagnation around those trunks.

If, however, the room is in a lower storey of a building, either *vertical* trunks of inordinate length would be required to extend outside through the roof, or else *horizontal* trunks would require to pass outside through a side wall, in which case the vapour could be expelled only by the aid of an extraction fan mounted in the orifice of the trunk to create a draught or air-current.

2. Floor

§ 285. The floor should be double-boarded with tongued and grooved thick boards of closely grained hard wood, such as birch, maple, or similar wood, to keep the floor quite dry and warm. Flags, stone pavement, concrete and cement are most unsuitable materials for the floor of a sizing room, as they keep the temperature low, thereby causing excessive condensation of vapour, and consequently a floor which is always cold and wet.

3. Walls

§ 286. The walls should be constructed with a wide cavity, and plastered and wainscotted on the inside, with tongued and grooved boards extending from the floor to the roof (or ceiling if in a lower storey), and previously soaked thoroughly in creosote oil to preserve the wood from decay.

4. Windows

§ 287. All windows, and especially those facing any point of the compass in the north-east quadrant, should be double-glazed, with a space of at least six inches between the two panes of glass.

The cushion of air in the wall and window cavities serves better to insulate the interior from the exterior by constituting a neutral stratum of air which reduces the radiation of heat from the room, and makes the air within less susceptible to atmospheric changes without. Further, the risk of excessive condensing of vapour against the cold panes of single windows is thereby eliminated.

5. Roof

§ 288. The roof should be of angular formation, and constructed either with one long steep slope for a small room, or else with shorter steep slopes of the saw-tooth () or the bay () type of roof for larger rooms.

The entire roof should be slated or tiled, and, if practicable, without sky-lights. If, however, these are necessary, they should be double-glazed like the side windows, and the slates or tiles of the roof should be underboarded, with ample air space allowed between the roof and boards. These boards should be well soaked with creosote oil, and also lined on the upper side with roof felting. The steep slopes of the roof will ensure quicker draining after rain or snow, and thereby prevent the roof from remaining in a wet and cold state.

6. Dimensions

§ 289. The dimensions of a sizing room depend chiefly, of course, on the number of sizing machines and the dimensions of the size-mixing plant which it is required to contain. The room should be lofty, so as to afford ample air-space; and sufficient floor-space should be allowed for extending the capacity of the beam-creels if that course becomes necessary.

A larger volume of air conduces to a more equable temperature, because it is less susceptible than a small volume of air to variation of temperature.

7. Heating

§ 290. Heating may be effected by means of a steam-pipe of about 2in. diameter, suspended at an elevation of 7 or 8ft. from the floor, and extending around the room, as well as between two adjacent sizing machines.

8. Ventilating

§ 291. A system of ventilating for the supply of fresh air to a sizing room (apart from that for removing the vapour from the drying cylinders and size-boxes) may be effected by means of inlets formed in the walls, at about the floor level, and by directing the air up vertical ducts that open into the room about 7ft. to 8ft. above the floor, and from which the air is diffused without creating perceptible currents of cold air that would act detrimentally on the yarn.

Foul air may be expelled from the room through outlets formed in the highest parts of the walls or roof; but care should be taken to adopt a form of ventilator for this purpose that will prevent the possibility of reverse currents or down-draughts of cold air passing on to the yarn.

9. Size-mixing Becks

§ 292. If possible, the size-mixing plant should be situated in a separate room immediately adjoining the sizing room, but not actually in that room. By adopting this course it would conduce to a much drier atmosphere in the sizing room by keeping it free from the vapour that issues from the size-boiling becks and pans. If, however, these cannot be isolated, an auxiliary ventilating trunk, similar to those adopted for removing the vapour from the sizing machines, should be erected above them, so as to conduct the vapour outside through the roof.

10. Protection of Wood and Iron Work

§ 293. All wood-work should be treated periodically with creosote oil or other antiseptic material for preserving wood from the destructive effects of a moist atmosphere. Also, all structural ironwork should be protected with anti-corrosive material, and, if possible, encased either with wood or non-conducting material, both to protect it from the influence of moisture and to reduce the condensation of vapour in the air in its immediate vicinity, thereby conducing to a warmer and therefore a drier atmosphere.

Ventilating Sizing Rooms

§ 294. The function of removing from sizing rooms the vapour that issues from the size-boxes, and that which is also expelled from the yarn as this passes over the drying cylinders, is performed by a variety of different methods of ventilating, respecting the relative merits of which there is great diversity of opinion not only between ventilating engineers, but also between textile experts.

Thus, whereas some advocate the principle of natural ventilation only, some advise the adoption of mechanical ventilation by means of a forced draught induced by the aid of what is variously termed an "exhaust," "extraction," "suction," and "pressure" type of fan; whilst others again recommend a combination of both natural and mechanical ventilation. These conflicting opinions are, of course, the result of varying experiences, gained under different circumstances, of the respective systems of ventilating which their several advocates have found to give the best results.

It is manifest, therefore, that there has not yet been devised any particular system of general application to all sizing rooms, and that each instance requires to be considered independently from definite knowledge of all the circumstances that bear specially upon it.

§ 295. The removal of vapour from sizing machines is usually effected by means of a system of ducts or flues that span across and open immediately above the size-boxes and drying cylinders, whence the vapour is conducted into and expelled from large vertical or horizontal trunks that emerge through, and terminate several feet above, the roof, or else they terminate in a side wall, as determined chiefly by the situation and structural features of the sizing room, the number of machines employed, and personal preference.

For example, if the machines are contained in a room situated either on the ground floor or in a storeyed building, and with only the roof above, it is usual to adopt the vertical type of ventilating trunk, of which there are three chief modifications—namely:—

1. Sagar's modification of two separate and distinct trunks that project vertically and independently from the size-box and cylinder cover of each machine, as represented in Figs. 169 and 170.

2. Lancaster and Waddington's modification of a single trunk extending vertically and directly above the size-box only, and into which there opens a short inclined duct leading from the roof of the cylinder cover, as represented in Fig. 171; and

3. Stanworth's modification, also consisting of a single trunk projecting vertically and about midway between the size-box and centre of the large cylinder, and into which there open, near the base of the trunk, two separate short ducts, one of which is slightly arched and leads from immediately above the size-box, whilst the second duct is straight and leads with a slight inclination from the roof of the cylinder cover, as represented in Fig. 172.

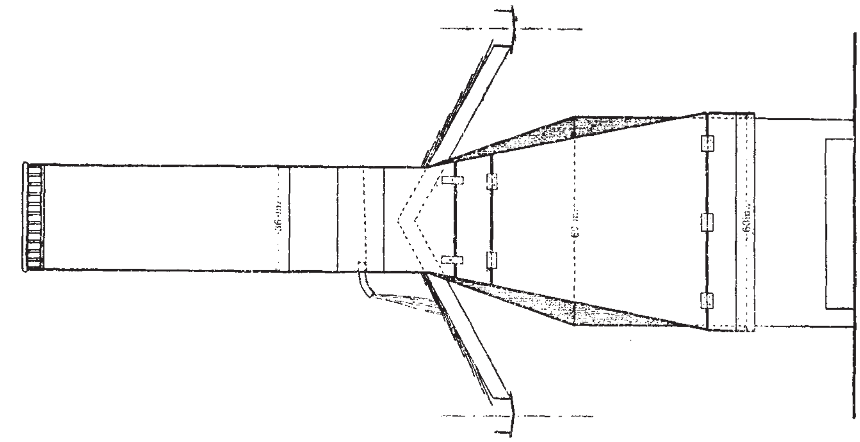


Fig. 170.

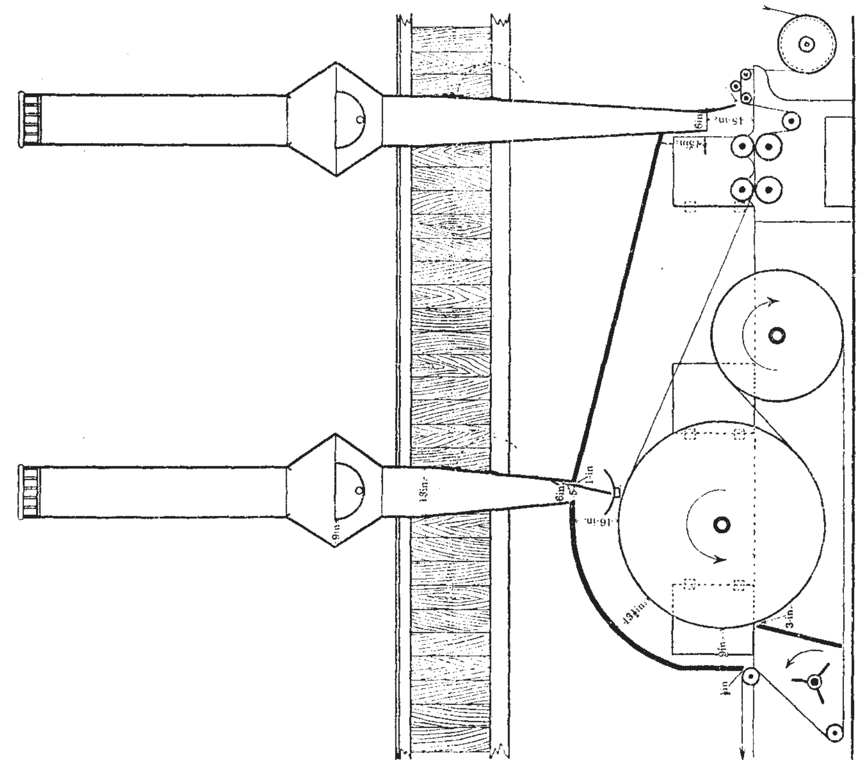


Fig. 169.

Sagar's Two-trunk System of Ventilating.

§ 296. Under favourable circumstances, vertical trunks generally operate effectively by natural ventilation only, without the assistance of extraction fans. In some instances, however, in which the single-trunk system is adopted, ventilation may be effectually accomplished only by mounting such a fan in the trunk immediately above the junction of the short duct with that trunk, as illustrated in Fig. 173.

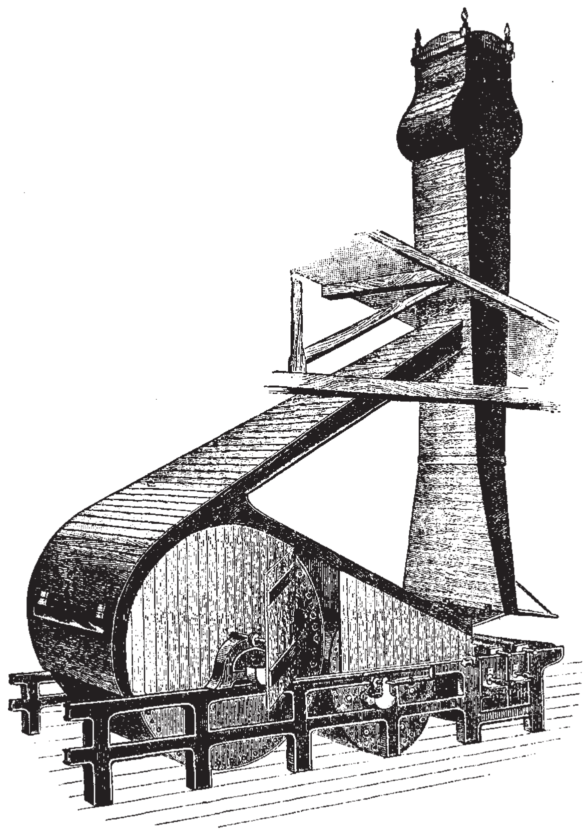


Fig. 171.

The particular method of constructing vertical trunks as represented in Figs. 169 and 170 was conceived by Mr Ibzan Sagar, who evolved that method by observing the well-known law governing air-movement by natural ventilation as exemplified in the construction of modern fire-grates that are formed with a very narrow initial aperture which expands into a comparatively large cavity constituting the flue, whereby a continuous draught is induced solely by natural means.

After many years' practical application under different circumstances and climatic variations, this form of ventilating trunk has proved to be one of the most effective and economical methods in vogue for removing vapour from sizing machines entirely without the assistance of fans. One of these trunks extends from the roof of the cylinder enclosure, and another from the size-box of each machine, whence both trunks pass through the roof for a distance of 8ft. above the ridge.

The dimensions of the trunks and cylinder cover, along with other measurements of important details as specified by Mr Sagar, and which it is essential to observe in order to ensure the greatest efficiency by this system of ventilating, are indicated in the diagrams.

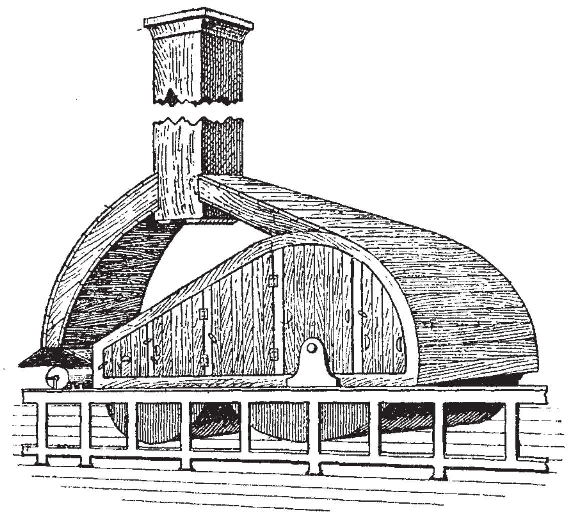


Fig. 172.

At a point immediately outside the roof of the sizing-room each trunk is formed with a wide cavity in which there is fixed a zinc or copper-sheathed wooden trough to catch both rain-water and any water condensed from the vapour, as this is cooled suddenly in that portion of the trunk which is exposed to the cool air outside. From each water-trough there projects a short outlet pipe through which the water runs on to the roof, and is thereby prevented from dropping on to the drying cylinders and sizing rollers.

Additional precaution is also taken to guard against the risk of condensed vapour dropping from the lower portion of the cylinder trunk on to the large cylinder. This is effected by fixing immediately above and across the entire width of the cylinders, so as to overlap the cylinder ends, and below the aperture of the trunk, a zinc or copper trough, which should incline slightly from a space of about $2\frac{1}{2}$in. from the face of the cylinder at one end to a space of about $1\frac{1}{2}$in. from the cylinder at the opposite end, whence the water trickles down on to a large zinc plate or tray which is usually fixed to the floor underneath the size-box and drying cylinders, to collect waste water that drips from the steam-pipe joints, valves and glands.

The stream of vapour is directed upwards from the front of the large cylinder and into the trunk by fixing between that cylinder and the cooling fan a large wooden baffle that reclines backward from the lower edge which is placed immediately above the sheet of warp threads as these extend between the small cylinder and the lower guide-roller, with the upper edge of the baffle fixed 3in. from the face of the large cylinder.

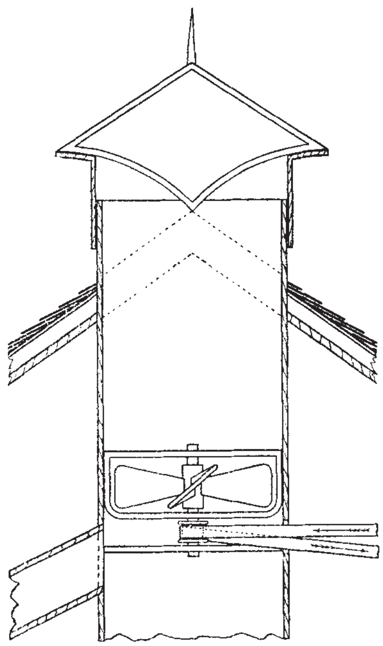


Fig. 173.

Also, the risk of any vapour escaping from the cylinder trunk and passing over to the rear of the cylinder is effectually prevented by fixing just below the aperture of that trunk another wooden baffle that reclines backward from the lower edge which is placed in the water trough and enters the trunk for a distance of 3in., with the upper and rear edge of the baffle chamfered and fixed a space of 1in. from the trunk, as indicated in Fig. 169, thus permitting of the small amount of vapour which is expelled from the yarn by the small cylinder being drawn into that trunk.

§ 297. If Lancaster and Waddington's single-trunk method of ventilating is adopted, with the improved form of trunk having a narrow initial aperture, as in Sagar's modification, and also as represented in Fig. 171, it generally operates satisfactorily under favourable structural and atmospheric conditions.

But if this method of ventilating by means of the old form of trunk, constructed with a wide bell-mouth, should prove inadequate, it is sometimes found necessary to mount in the trunk a 24in. extraction fan placed immediately above the junction, as represented in Fig. 173, and of which the blades should either be constructed of brass or else coated or plated with sheet lead or zinc, the better to resist the corrosive influence of the vapour.

Instead of employing ventilating trunks of the vertical type for the purpose of removing vapour from sizing machines contained in a roofed storey, that object is sometimes accomplished by Gregson's modification, consisting of only one main trunk extending horizontally across any number of successive machines, and then turning upward to pass vertically through the roof, as represented in Figs. 174 and 175. In fact, if the machines are contained in a lower storey, the horizontal type of trunk, terminating in a side wall, as represented in Fig. 176, becomes a virtual necessity.

Further, a horizontal trunk may be employed successfully for this purpose only by the aid of a forced draught induced by means of an extraction fan mounted in the main trunk, into which there open short ducts leading separately from the size-box and cylinder cover of each machine, as represented in the diagrams.

To ensure efficiency by this method of ventilating, a fan 3ft. diameter for two or three machines, and one 4ft. diameter for four machines, are advised by Mr Sutcliffe, a ventilating engineer, who states that he would not employ ventilating trunks of any type whatever for any number of sizing machines, but would build the room in one span, with the roof at an angle of about 45° and under-boarded, and in which he would fix, between every two adjacent machines, a 3ft. fan, which he affirms would keep the sizing room quite clear of free vapour.

Data Relating to Slasher Sizing Machines

§ 298. Slasher sizing machines are constructed in a variety of different sizes that vary in both length and width, chiefly according to the type, diameter and width of the drying cylinders, and also according to minor structural modifications adopted by different makers.

They are, however, constructed in various standard widths, ranging in multiples of 6in., ordinarily from 60in. to 90in. wide on the face of the cylinders, and expressed by index numbers of the

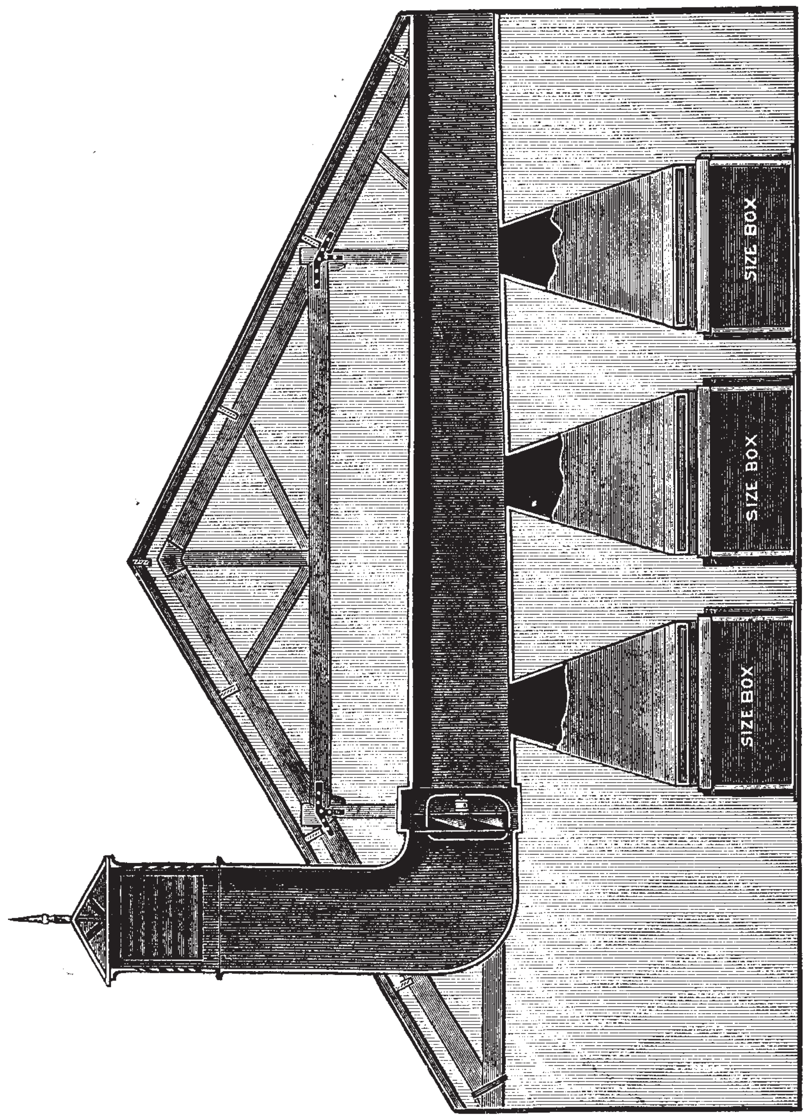


Fig. 174.—Gregson's Horizontal Trunk System of Ventilating.

same series as those which indicate the width of the drums in beam warping machines, excepting that the cylinders of sizing machines are uniformly 6in. *wider* than the drums of beam warping machines of the same denomination, to allow a margin of 3in. at each side of the cylinders over and above the maximum width of warp.

The respective widths of drums in beam warping machines, of cylinders in sizing machines, of reed-spaces in looms, and maximum width of cloth for corresponding index numbers of beam warping and sizing machines, are expressed in inches in the following table:—

Index of Machine	9/8's	6/4's	7/4's	8/4's	9/4's	10/4's
Width of drum . .	54	60	66	72	78	84
Width of cylinders .	60	66	72	78	84	90
Reed-space of loom .	52	58	64	70	76	82
Maximum width of cloth	50	56	62	68	74	80

Machines of other widths than those specified above are made specially to order.

DIMENSIONS

§ 299. The floor-space occupied by sizing machines of the same denomination varies slightly according to such variable factors as the type of size-box, the number of sizing and finishing or squeezing rollers, the number and diameters of the drying cylinders, the method of driving, and the capacity of the beam creel or stand.

Machines of the same denomination and by the same maker are of uniform width over-all, but those by different makers vary as much as 18in. in width. The accompanying dimensions are those of 9/8's sizing machines constructed with 6ft. and 4ft. drying cylinders, and including a beam creel to support up to six back beams:—

Width=7ft. 6in. to 9ft. over-all, and increasing 6in. for each higher denomination.

Length=30ft. 6in. to 38ft. 6in. over-all, increasing 3ft. for every two back beams above six beams; and varying according to the difference in the diameter of either of the two cylinders.

A 9ft. cavity cylinder sizing machine with a beam creel to support six back beams occupies a floor space of—

Width=8ft. 6in. Length=36ft.

Weight

§ 300. The net weight of a 9/8's machine with 6ft. and 4ft. cylinders, and a 6-beam creel, ranges from about 67 to 103cwt.;

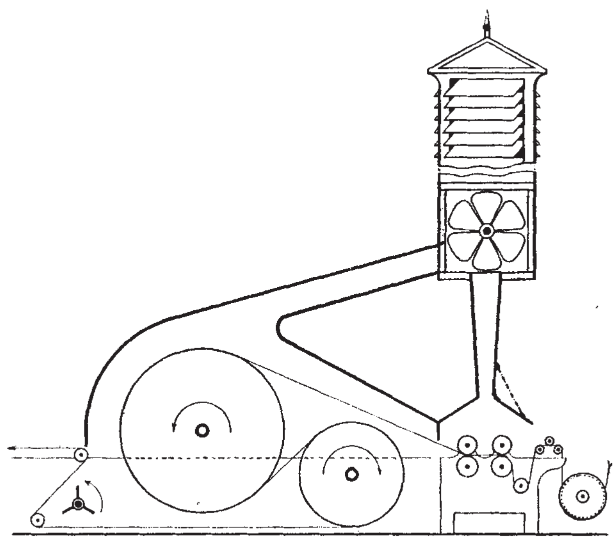


Fig. 175.

and that of a 9ft. cavity cylinder machine of the same capacity= about 80cwt.

Cost

§ 301. The cost of a 9/8's machine equipped with only the most essential parts of the simplest character ranges from about £120 to £150, to which must be added a sum ranging from about £60 to £75 for incidental and necessary items, comprising the steam-service piping, steam-valves, steam-gauges, steam-traps, ventilating trunk, and many other essential accessories, but not including devices or mechanical attachments of a special character, or those for performing special functions, all of which are charged for as extra items.

Depreciation

§ 302. The rate of depreciation of a slasher sizing machine does not exceed 5 per cent. per annum, including the cost of general repairs; renewing cylinders, broken and worn-out parts; oil and belting.

Ratio of Sizing Machines to Looms

§ 303. The number of looms that can be accommodated by one sizing machine ranges in actual practice from about 200 to about 500, with a fair margin in each direction, and is determined chiefly

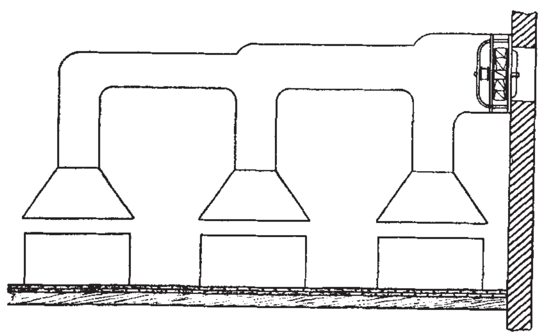


Fig. 176.

by the particular character of warps as regards the counts and quality of the yarn, total number of warp threads, picks per inch, length of warps, character and grade of sizing, and many other variable factors.

For cloth of medium width ranging from about 42in. to 54in., containing about 64 picks per inch, and produced from warps composed of yarn of low, medium, and fine counts respectively, the approximate number of looms that could be served by one sizing machine may be reasonably based on the following estimates:—

For counts of warp yarn up to 30's T., one machine for 300 looms.
For counts of warp yarn from 30's T. to 60's T., one machine for 400 looms.
For counts of warp yarn from 60's T. upward, one machine for 500 looms.

Power

§ 304. The power required to drive a 9/8's slasher sizing machine is estimated to range approximately from $1\frac{1}{2}$ to 2 I.H.P., according to the speed of working, number of back beams, and number of warp threads.

Speed

§ 305. The velocity of the driving pulleys depends on the particular form of driving gear employed, as this varies in different machines. If the usual cone-drum method of differential driving is adopted, with the driving pulleys mounted on the shaft of the first or driving cone, the velocity of those pulleys may range from about 160 to 210revs. per min. according to the diameter of the drying cylinders, number of warp-ends, counts of yarn, and other considerations. The lower speed is suitable if the cylinders are only 5ft. 6in. and 3ft. 4in. diameter respectively; but if these are 7ft. and 4ft. diameter, the higher speed will be required.

The relative velocity of the drying cylinders may, of course, be regulated by the attendant, according to his discretion, and within extreme limits ranging approximately in the ratio of 2 to 5, by means of the differential full-speed driving gear as described in § 180. For warps composed of coarse yarn, or those containing a greater number of warp ends, and also for the heavier grades of sizing, it is sometimes desirable to work the machine at a slower speed to allow more time for drying the yarn efficiently; but for warps composed of delicate yarn of very fine counts, or those containing comparatively few warp ends, and also for the lighter grades of sizing, it is sometimes expedient to work the machine at a slow speed, with a reduced steam pressure in the cylinders, and also to pass the yarn over either the small or else the large cylinder only, with the object of reducing to the least possible degree the tensile strain upon the warp threads.

Production

§ 306. The productiveness of a slasher sizing machine is dependent upon so many variable factors that information respecting this item can be of value only when it is based on actual data relating to specified classes of work, of which the following table gives six typical and authentic examples:—

Example.	Counts of Yarn.	Number of Warp Ends.	Production per Working Hour.	
			Yards of Warp.	Pounds of Yarn.
No. 1	30's T.	3000	1800	214
No. 2	36's T.	1600	2250	119
No. 3	40's T.	3500	1700	177
No. 4	50's T.	4000	1000	95
No. 5	100's T.	5000	800	48
No. 6	140's T.	6000	600	30

Waste

§ 307. The amount of waste material incidental to the operation of slasher sizing should not exceed about 30yds. of warp for each set of back beams, irrespective of the length of yarn they contain. Thus, on a total length of, say, 15,000yds. the above amount of waste is equivalent to only 1 in 500, or one-fifth of 1 per cent., and is therefore practically a negligible amount.

Character and Amount of Labour

§ 308. Male operatives only are employed on slasher sizing machines, with one skilled attendant to each machine, and one or more than one labourer, according to the number and productiveness of the machines. The number of labourers employed is usually one for each machine up to three, then three labourers for four or five machines according to requirements.

These labourers are paid 18s. to 20s. per week, and their duty is to assist the attendants by performing work incidental to slasher sizing, as, for example, creeling full and removing empty back beams; removing full and replacing empty weavers' beams; mixing the size and supplying it to the size-boxes, where this function is not performed automatically; repairing defective back beams; and performing other minor duties as they arise.

In some mills it is customary to employ intelligent labourers to assist the skilled attendants, and thus give them the opportunity of learning the trade with a view to promotion as skilled attendants.

Rate of Wages

§ 309. The rate of wages paid, and the basis of payment adopted for slasher sizing, vary considerably not only in different districts but even in the same locality, according to the character of work and special circumstances.

Thus, some sizers are paid fixed and regular wages, of which the respective amounts range from 36s. to 50s. per week, work or play, but without any extra payment for overtime; whilst others are paid fixed wages of similar sums, but with a proportionate addition for overtime, and a deduction for lost time; and some are paid similar fixed sums for the schedule number of working hours per week, but with extra payment for overtime.

Instead of paying a regular fixed wage, however, many firms in the East Lancashire district pay their sizers on the basis of piece-work rates for actual work performed, and for which the amount of wages is calculated on the basis of a recognized standard list of prices, of which the Blackburn Standard List is that generally adopted, as follows:—

BLACKBURN STANDARD LIST.

For Slasher Sizing.

Standard Basis:

Number of warp-ends : 2460 to 2510 inclusive.
Length : 100 "cuts" of 37½yds. each, equal to a total length of 3750yds.
Price : 28½ pence.

Additions and Deductions.—One halfpenny extra to be paid for every 50 or fractional part of 50 warp-ends over and above 2510, for every 100 "cuts" of 37½yds. each, or 3750 yds.; and *three-eighths of a penny* less to be paid for every *complete* 50 warp-ends below 2460, for every 100 "cuts" of 37½yds. each, or 3750 yds.

Other lengths of "cuts" to be paid for proportionately.

An addition of 10 per cent. is now paid on this list, which is adopted for yarn of medium counts ranging from about 30's to 50's T. inclusive. For yarn of coarser and finer counts than these extremes the rate of payment is by special agreement.

Example 1.—Calculate the amount of wages to be paid, in accordance with the above list, for sizing yarn for 80 weavers' beams, each containing 3480 warp-ends, 1100yds long, equal to a total length of 88,000yds., per week of $57\frac{1}{2}$hrs., thus:—

Length by proportion:

3750 : 88,000 : : 28·5 : 669 pence.

Extra warp-ends:

3480 − 2510 = 965;

therefore, 965 ÷ 50 = 19 + *i.e.*, 20 at $\frac{1}{2}$d. = 10 ,,

Total	= 679 pence.
Plus 10 per cent.	= 68 ,,
Net price	= 747 pence.

The amount of wages, therefore, is £3, 2s. 3d. per week.

Example 2.—Calculate the amount of wages to be paid for sizing yarn for 64 weavers' beams, each containing 1980 warp-ends, 1400yds long, equal to 89,600yds. per week of $57\frac{1}{2}$hrs., thus:—

Length by proportion:

3750 : 8960 : : 28·5 : 681 pence

Less warp-ends:

2460 − 1980 = 480;

therefore, 480 ÷ 50 = 9 + *i.e.*, 19 at $\frac{3}{8}$d. = 3 ,,

Total	= 678 pence.
Plus 10 per cent.	= 68 ,,
Net price	= 746 pence.

The amount of wages, therefore, is £3, 2s. 2d. per week.

Other and independent price lists and rates of wages are adopted by different firms, according to agreement, for work of a special character.

Weekly Earnings

§ 310. The amount of wages earned by slasher sizers who are paid piecework rates ranges from 40s. to 64s. per week, with a general average wage of about 45s. per week.

CHAPTER VIII

AIR-DRYING TAPE SIZING MACHINES

§ 311. It has been observed previously, in § 179, that in some tape or beam warp sizing machines, the process of drying the yarn, after being saturated with size, is effected by submitting it to the influence of dry air, of a relatively high temperature, which quickly absorbs the moisture from the yarn, instead of passing the yarn around, and in actual contact with, the surface of steam-heated cylinders, as in the ordinary type of slasher sizing machines.

The principle of air-drying is generally conceded to be superior to that of cylinder-drying, inasmuch as it does not tend to flatten the warp threads, which is one of the chief objections to cylinder-drying; whereas air-drying preserves the roundness, fulness, smoothness and elasticity of those threads, and also imparts to the yarn a softer and mellower tone or feel when handled. Air-drying also reduces the tendency of the warp threads to cling together and dry in contact with each other, thereby enabling them to separate more readily at the dividing rods with less risk of raising the free ends of the exposed fibres composing the yarn.

The relative steam consumption in respect of drying the yarn is, however, usually considered to be greater in air-drying than in cylinder-drying machines, albeit during the past few years air-drying sizing machines have attained to such a high degree of proficiency as regards their relative productive capacity and steam consumption that they are gaining considerably in favour with manufacturers, who are now adopting them much more extensively than formerly.

In fact, they are now frequently adopted in preference to cylinder-drying machines; and in cases where the cylinders have worn out, or require to be repaired, many manufacturers prefer to discard them entirely and adopt one or other of the several methods of air-drying which bid fair, in the immediate future, to gain supremacy over cylinder-drying, which is declining in favour with many manufacturers.

§ 312. Air-drying sizing machines consist of two distinct types, each of which comprises several modifications, namely:

(1) Those variously described as Scotch or linen dressing or sizing machines, in which the yarn is completely exposed to view throughout its entire progress from the warpers' beams to the weaver's beam, and in which the yarn is dried by fanning on to the threads a current of hot air radiated from one or two small steam-chests situated below the sheet of threads and on each side of a central headstock, as represented in Fig. 177; and

(2) Those constructed with a large enclosed hot air-chamber extending either horizontally or else vertically between the sizing apparatus and the headstock of the machine, and in which the yarn is conducted with a circuitous course in a series either of horizontal or vertical sheets of threads, whereby a very considerable length of warp is submitted, for a comparatively long period, to the drying influence of hot air confined within the drying chamber, and which is generated by a service of steam-pipes supplied with high-pressure steam.

Both of these types of machines comprise numerous modifications in the details of their construction, especially those of the second type, which differ considerably in their general outward appearance, in the construction of the drying chambers, in the method of heating them, and also in the particular manner of conducting the yarn through them.

Of these various modifications there are several distinctive makes of machines that are respectively characterized by certain special features whereby they have established their superiority over other machines of their type, and have therefore met with a greater measure of appreciation in the weaving trade.

Scotch Dressing or Sizing

§ 313. Dresser sizing is the earliest method of sizing beamed or taped warps by machinery, and is still the prevailing method adopted for sizing warps for the production of linen damask and similar classes of fabrics. It is also sometimes employed for warps composed of very fine cotton yarn for the manufacture of superior qualities of certain varieties of cotton fabrics, of which the warps require to be only very lightly sized with " pure " size, with the sole object of facilitating the operation of weaving by the simple process of making the threads smoother and stronger, without materially increasing their weight or bulk.

This particular method of sizing yarn, which is invariably described as " Scotch dressing," should not be confused, as frequently it is, with that system of preparing coloured striped warps and which is also known as " Scotch dressing," although there is nothing whatever in common between these two quite different and distinct operations.

It is advisable, therefore, to describe briefly the operation of Scotch dressing as observed in this particular method of preparing striped warps, and which consists essentially of first splitting off or separating from reserved ball-warps, that have been previously dyed or else bleached and sized, such number of warp threads of the respective colours as are required on the weaver's beam; after which the yarn is transferred from the respective sections, *in succession*, and wound *separately* with the threads evenly distributed between the dents of a reed, on to a *corresponding number of flanged warpers' beams*, virtually to constitute a " set " of " back " beams of coloured yarn.

The threads are subsequently withdrawn from all the back beams *simultaneously*, and passed in groups of two or three threads between successive dents of a reed, in which they are distributed according to the required warp pattern, and from which they emerge to be wound finally on to the weaver's beam, either by means of a " tension " or a " presser " beaming or winding-on machine, and in a manner similar to that adopted in the preparation of coloured striped warps by the more modern method of beaming known as " dry-slashing "—so-called, because this operation is accomplished by means of a machine (constructed by Messrs Butterworth & Dickinson, Ltd.), which is virtually the headstock, including the usual type of frictional winding-on motion, of an ordinary slasher sizing machine.

§ 314. The system of preparing coloured striped warps by the method of beaming known as " Yorkshire dressing " is identical in all respects with that of Scotch dressing, excepting that the warp

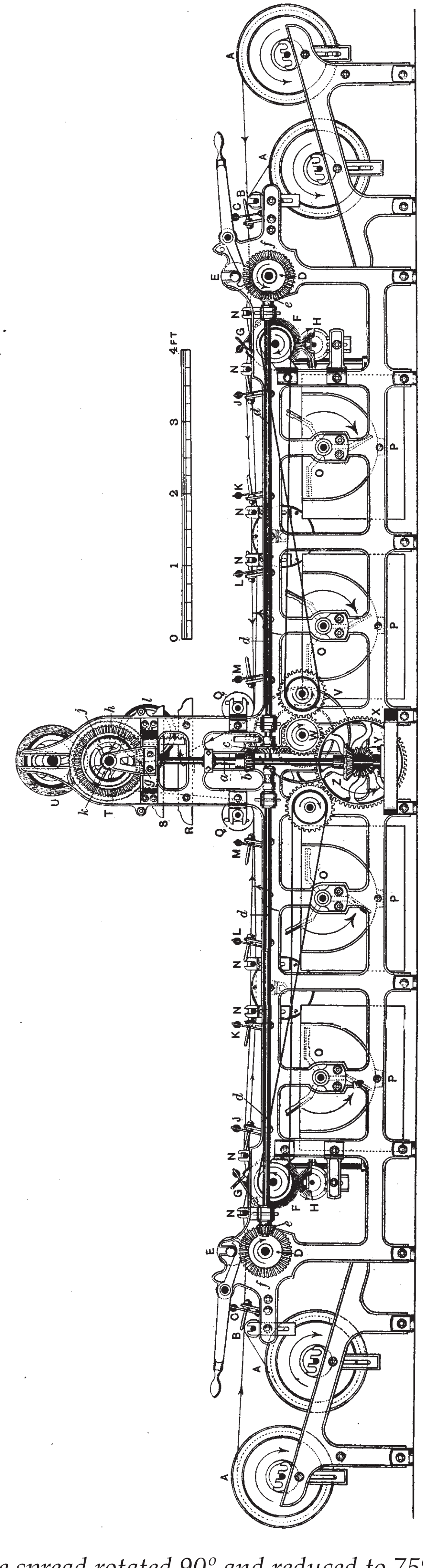


Fig. 177.—Scotch or Linen Dressing or Sizing Machine.

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threads from the several sections of differently-coloured yarn are disposed according to pattern, with two or three warp threads passing together between successive dents of a reed, and wound immediately and concurrently on to a weaver's beam without the intermediate operation of winding the yarn from each of those sections separately on to a series of flanged beams, and then from these on to weavers' beams, as in Scotch dressing.

The process of Scotch dressing or sizing, however, is characterized by the applying of either hot or cold size or starch paste to warp yarn as this is withdrawn simultaneously from a " set " of any number of " back " or warpers' beams, in the form of an evenly-distributed sheet of threads which, by means of brushes, reeds, dividing rods and leasing healds, are kept quite separate and distinct from each other from the moment of leaving the back beams until they pass on to the weaver's beam; and also by effecting the drying of the yarn by means of hot air fanned from steam-heated radiators above which the yarn is conducted.

By observing these extreme precautions of keeping the warp threads well separated from each other, the clinging, sticking, or crossing of warp threads is virtually impossible, and the threads are also left perfectly smooth and round. This high degree of perfection in sizing may, however, be obtained only at great expense, in consequence of the very slow rate of progress with which the yarn is conducted through the sizing machine, and also because of the high rate of wages paid for dresser sizing, which requires highly-skilled attendants. For these reasons, dresser sizing is almost entirely superseded in the cotton trade by the more modern and productive method of slasher sizing, and it is now retained, in the cotton trade, only for the purpose of sizing warps of fine yarn for cotton fabrics of special quality.

Scotch Dressing or Sizing Machines

§ 315. Scotch dressing machines as made by different makers embody the same general features of construction, although they differ in numerous minor details of their equipment the better to adapt them suitably to the special requirements of the particular class of warps and character of yarn for which they are chiefly intended.

A typical example of a modern dresser sizing machine is that illustrated in Fig. 177, which represents a side elevation of one of several modifications of this type of machine as constructed by Messrs W. Dickinson & Sons. This machine is constructed with duplicate parts in almost every detail, excepting those of the driving gear constituting the headstock, which occupies a central position, with the various parts arranged symmetrically on either side of the headstock, and from which all the working parts of the machine are operated. Thus, a beam creel or stand is placed at each end of the machine to support the back beams that are divided into two sets, with an equal number in each set, and from both of which the warp threads are withdrawn simultaneously.

After being sized and dried independently in their respective sections of the machine, the two groups of warp threads converge towards a point where they both become merged into one sheet of threads as they pass finally to be wound on to the weaver's beam, which is mounted in the upper part of the headstock and turned through the medium of frictional driving gear, which ensures a constant rate of winding, notwithstanding the gradually-increasing diameter of the beam as it becomes filled with yarn.

The particular form of beam creel which is invariably employed in conjunction with dresser sizing machines is that which extends with a slight inclination from the ends of the machine, to permit of the warp yarn being withdrawn uniformly from the upper surfaces of the back beams as quite separate and distinct sheets of threads, which are thereby not only under better observation by the attendant, for the quicker detection of broken and missing warp threads, but are also more easily accessible for recovering and piecing those threads than when the back beams are arranged in two horizontal tiers with an alternate disposition, as in the form of creel which is almost invariably adopted in conjunction with slasher sizing machines, and as described in §§ 183-4.

Further, the object of dividing the back beams into two equal sets, that are placed at opposite ends of the machine, is to prevent overcrowding the threads on those beams and so keep them more thoroughly separated from each other.

§ 316. In their progress from each set of back beams A to the weaver's beam T, the several sheets of yarn from the respective beams in each " set " all converge towards a guide roller B, on the surface of which they unite to form one sheet of threads, with two threads passed together uniformly between successive dents of the first of several brass reeds C, whence they are conducted between a pair of sizing and squeezing or finishing rollers D and E respectively, that revolve in close surface contact.

The lower sizing roller D revolves partially immersed in the size paste or starch contained in a narrow size-box or trough and which is brought up to the yarn by that roller which is constructed of cast iron and is either clothed or bare, at the option of the attendant. The upper squeezing or finishing roller E, which is also of cast iron, and sometimes encased in a thin copper shell wrapped with cloth, is of considerable weight, and serves the twofold object of impressing the size thoroughly into the threads, and also of expressing from them surplus size, which returns to the size-box.

After leaving the sizing rollers, the threads are passed immediately over a revolving yarn-brush F, between the bristles of which the yarn is deflected by means of a half-round brass rod extending across the second brass reed G, between the dents of which the threads are passed in pairs. The brush F revolves slowly in opposition to the progress of the yarn for the purpose of laying down the projecting fibres, and also of distributing the size equally on the threads, which thereby become perfectly rounded and smooth. A second and smaller brush H is placed immediately below, but in contact with, the bristles of the yarn-brush F, and revolves in opposition to that brush for the purpose of cleansing it of particles of size paste or lint that may cling to it. After leaving the second reed G, the warp threads are passed in pairs through four more brass reeds J, K, L and M, that are placed in succession and at different intervals apart.

In addition to separating the warp threads in pairs by passing them through the several reeds, the respective sheets of threads from the several back beams are also separated by means of dividing rods N, that are placed at frequent intervals apart, whereby the risk of threads clinging together and drying in contact with each other is entirely avoided.

During the interval between the second and third, and also between the fourth and fifth reeds, the yarn is submitted to the drying influence of hot air, which is fanned upward on to the threads by means of two fans O which revolve immediately above two steam-chests or radiators P that are heated with high-pressure steam at a pressure ranging from about 10 to 15lb. per sq. in., according to whether the counts of yarn being sized is finer or coarser respectively.

After leaving the sixth reed M, the warp threads pass under a light-ribbed guide-roller Q, whence they are deflected upward from a horizontal to a vertical course, and passed separately first through two leasing-healds of special construction, that are fixed horizontally in a frame R, thence in pairs between the dents of a very wide horizontal reed fixed in a frame S. On emerging from this reed, both sheets of warp threads unite to form one sheet of threads that pass on to the weaver's beam T, which is sometimes surmounted by a heavy presser roller U that bears downward on the yarn by gravitation, and thereby conduces to the formation of a firmly-wound and compact beam.

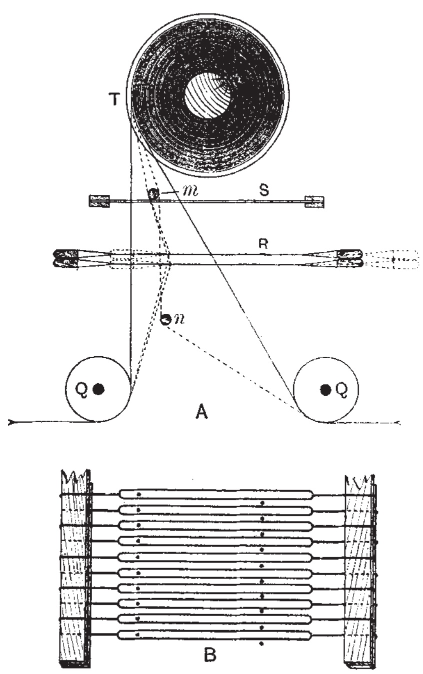

Fig. 178.

On the completion of each weaver's beam the attendant strikes an "end-and-end" or "looming" lease in the final extremity of each warp, for the purpose of drawing-in or twisting-in. With the object of enabling those leases to be formed in the warp whilst the yarn is still contained in the sizing machine, the leasing-healds R are knitted with very long eyes 14in. in length, through which all warp threads from one set of back beams are passed uniformly, whereas those from the other set of back beams are passed *between* them, as indicated in the plan of those healds at B, Fig. 178.

A lease is obtained by first inserting a rod or stave *m* between the two separate sheets of warp threads, above the reed S, on which that rod rests, then by bringing a second rod *n* to bear right across, on the outside of those warp threads that pass *between* (not through), the heald eyes, so as to force those threads inward towards the centre of the headstock. At the same time the leasing healds also are pushed inward towards the centre until the two sheets of warp threads, which constitute the odd and the even series respectively, pass and cross each other, and thereby produce an " end-and-end " lease or crossing, as indicated by dotted lines at A, Fig. 178, and which is preserved by inserting a lease-band or cord between the two divisions of warp threads thus obtained.

Driving Mechanism

§ 317. The driving gear of some dresser sizing machines is adapted for differential driving, which is effected through the medium of two reversed cone drums as usually adopted in slasher sizing machines, and with the same object of enabling the working speed of the machine to be varied, within prescribed limits, according to the number of warp threads and counts of yarn being sized, the steam pressure, and other variable factors.

The machine represented in Fig. 177, however, is constructed with driving mechanism which is designed to work the machine at a constant speed only, without any means of varying it. Thus, the driving gear consists of a loose pulley and a fast driving pulley V, mounted on the rear end of the main driving shaft, on the fore-end of which there is also fixed a small pinion W.

Through the medium of a large spur-wheel X and bevel wheels Y, Z, the pinion W transmits motion first to a vertical shaft *a*, and thence, through the medium of bevel wheels *b* and *c*, to a long side shaft *d*, on the opposite ends of which there are fixed small bevel pinions *e*. These gear with larger bevel wheels *f* fixed on one end of the lower sizing rollers D, which are driven positively, and, in conjunction with the upper squeezing or finishing rollers E, they not only serve the function of impregnating the warp threads with size paste, but they also withdraw the yarn from the back beams and deliver it to the weaver's beam at a constant rate of speed.

The vertical shaft *a* also transmits motion to a frictional winding-on device by which the weaver's beam is driven negatively and in such a manner that its velocity diminishes automatically and in a measure which ensures a constant rate of winding, notwithstanding the constantly-increasing yarn diameter of that beam as successive coils of yarn are wound upon it. Thus, a small bevel pinion *g* (Fig. 177) gears with and drives a large bevel friction-wheel *h* secured to a friction-disc which, on being compressed against another friction-disc or plate, operates the frictional winding-on device and thereby turns the weaver's beam T, with a gradually-diminishing velocity.

The degree of compression between the friction-discs, and therefore their driving power, is regulated by means of a hand-wheel *j* mounted on a screwed stud, and with a clamp spring *k* intercepting the hubs of the hand-wheel and friction-wheel, to constitute a yielding or flexible contact between them.

When a weaver's beam is completed, the heavy presser roller U is raised by means of racks and pinions operated by a hand-wheel *l* to permit of the removal of that beam and its replacement by an empty one, after which the presser roller is again lowered until it bears against the new beam.

§ 318. The headstock of some dresser sizing machines is constructed with two separate beaming or winding-on devices, as represented by a side and a front elevation in Figs. 179 and 180, thereby enabling two weavers' beams to be produced independently and concurrently either from two corresponding sets or from two different sets of back beams, as may be required.

Also, in addition to the steam-heated radiators, some machines are furnished with two auxiliary drying cylinders of about 20in. diameter, one of which is placed in each half of the machine in lieu of one of the two radiators, and around which the warp threads may be passed with the object of accelerating the process of drying the yarn, and thereby increasing the productiveness of the machine. That procedure, however, tends to nullify the advantages of hot air-drying by flattening the warp threads, and also making them less supple.

Dresser sizing machines are also usually equipped with a measuring and cut-marking motion placed either on one side only, or else on both sides, of the headstock, for the purpose of marking the warps into cut-lengths of any prescribed dimensions, and also of indicating the number of cut-lengths of warp that pass on to the weavers' beams.

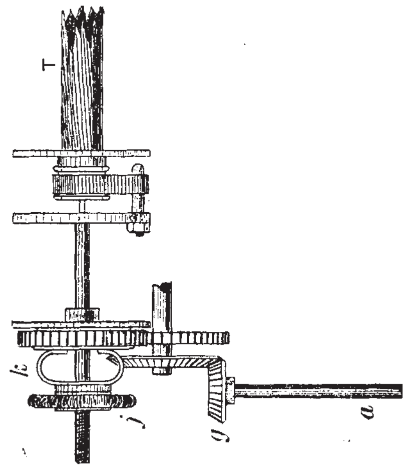

Fig. 180.

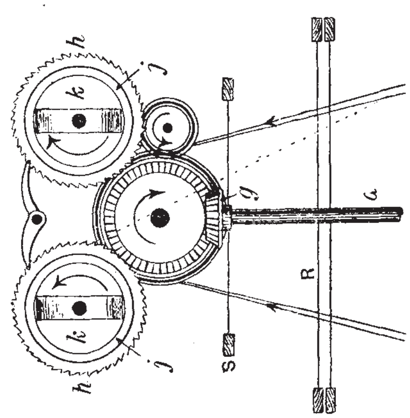

Fig. 179.

§ 319. When starting or gaiting a new machine with the first set of back beams, it is necessary to pass the warp threads separately through the several reeds and leasing healds by the operation of drawing-in; but the threads of subsequent sets of back beams are attached to the final extremities of the previous warp threads by the more expeditious operation of twisting, described in § 355.

The hot air-radiators are heated with steam at a pressure of about 12lb. per sq. in. when sizing 50's T., and at a correspondingly reduced pressure for yarn of finer counts. Also dresser sizing machines are situated in closed rooms that are protected from draughts of cold air and maintained at a high temperature, ranging from 90° to 100° F.

The driving pulleys revolve with a velocity of about 230revs. per min., and yarn is sized at the rate of about only 180 to 210yds. of 60's T. per hour, according to the number of warp threads and other circumstances.

The relative amount of wages paid for dresser sizing and slasher sizing for work of a similar character and on piece-work rates is in the ratio, approximately, of 9 to 1 respectively. For example, in two specific instances the following sums are paid for the work specified—namely: (1) A dresser sizer receives a sum of 6s. 8d. and a slasher sizer a sum of 9d., for sizing 3860 warp threads of 60's T., 720yds. long; and (2) sums of 5s. and 6¾d. respectively, for sizing 2870 warp threads of 50's T., 720yds. long.

If, however, a fixed sum is paid, the amount of wages is 50s. per week for both dresser sizing and slasher sizing alike, although the dresser sizer only is paid both for working and playing, and also during holidays.

AIR-DRYING SLASHER SIZING MACHINES

§ 320. Although slasher sizing machines of the type in which the yarn is dried by conducting it through an enclosed chamber of hot air have been in use for a period of about fifty years, it is only during the past few years that they have established their irrefutable claim to superiority over the heated cylinder method of drying yarn during sizing, and they are now, in one form or another, being adopted more extensively and meeting with a greater measure of appreciation than they have received hitherto.

Their more extensive adoption is due chiefly to the great improvements that have been effected in the application of the principle of air-drying, and also in the construction of the machines, for some modifications of which it is claimed that their relative productive capacity is at least equal to, and, indeed, much greater than, that of cylinder-drying machines.

These improvements have been effected chiefly in the direction of increasing the drying efficiency of the machines, with a relatively smaller consumption of steam; and also of submitting to the drying influence of the hot air a considerably greater continuous length of yarn at the same time, and thereby keeping it exposed in the drying chambers for a longer period, whereby the progress of yarn through the machines, and therefore their productiveness, are greatly increased.

Other improvements consist of economy of floor-space occupied by the drying chamber; of a reduction in the power required to drive the machine; also of relieving the warp threads of excessive tensile strain resulting both from the greater length of warp yarn exposed at once in the drying chamber, and from its being deflected over a greater number of guide rollers. These objects are achieved by mounting the gudgeons of the guide rollers either on roller bearings or in ball bearings in order to reduce frictional resistance to the least possible amount.

The drying chambers of most modifications of air-drying sizing machines may be readily adapted to the sizing apparatus and headstock of any ordinary cylinder-drying machine, by simply removing the drying cylinders and erecting one or more than one air-drying chamber in their place.

§ 321. One of several modifications of air-drying slasher sizing machines, of which the drying chamber is readily adapted to present cylinder-drying machines from which the cylinders have been removed, and one that has merited a high reputation for efficiency, is that of Messrs Tattersall & Holdsworth's, as illustrated perspectively in Fig. 181, and also by a scale diagram, in Fig. 182, which represents a sectional elevation throughout the length of the air-drying chamber which is situated between the size-box and the headstock of the machine, of which only the adjoining portions are shown in the diagram.

In its general construction, this air-drying chamber, as constructed by Messrs Butterworth & Dickinson, Ltd., consists essentially of two distinct sections, comprising an air-heating chamber containing a steam-heated multitubular radiator situated in the lower part, and a yarn-drying chamber forming the upper part of the structure, which is divided by thin partitions into a series of seven horizontal and shallow compartments extending across the entire width, and along the entire length of the drying chamber, as represented in the diagram.

In its progress through the sizing machine, after emerging from the last pair of sizing rollers, the sheet of warp threads passes immediately between a pair of guide rollers A that are mounted in front of a narrow aperture extending across the rear end of the drying-chamber, and through which the yarn enters the lowest com-

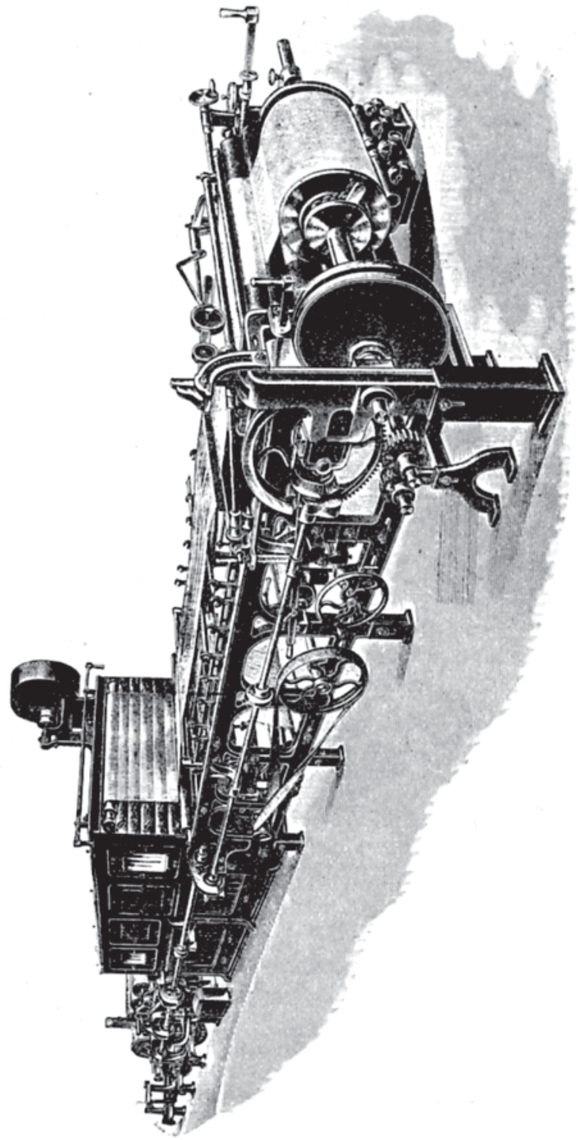

Fig. 181.—Tattersall & Holdsworth Hot Air-drying Slasher Sizing Machine.

partment of that chamber, whence it passes forward and backward in alternate succession along the entire length of the seven compartments, at each extremity of which it returns around guide rollers B until it enters the uppermost compartment, from which it emerges finally through a narrow aperture extending across the fore-end of the drying chamber, and is immediately deflected downward by passing it over a guide-roller C, and thence underneath another guide-roller D mounted in the lower and rear part of the headstock, where the yarn is cooled by means of a revolving fan E, and afterwards separated by conducting it under and over a series of dividing rods, whence it passes along its course in the usual manner, to be wound finally on to the weaver's beam.

In a drying chamber of 10ft. in length, the yarn traverses a total distance of about 70ft. from the moment of entering until the time when it emerges from that chamber; and, assuming a yarn delivery at the rate of 1000yds. per hour, the yarn would therefore remain exposed to the drying influence of the hot air for a duration of nearly $1\frac{1}{2}$mins. With the object of preventing excessive tensile strain upon the warp threads by passing such a considerable and continuous length of yarn through the drying chamber, simultaneously, all the guide-rollers are mounted on roller bearings immersed in oil-baths to reduce frictional resistance to the minimum.

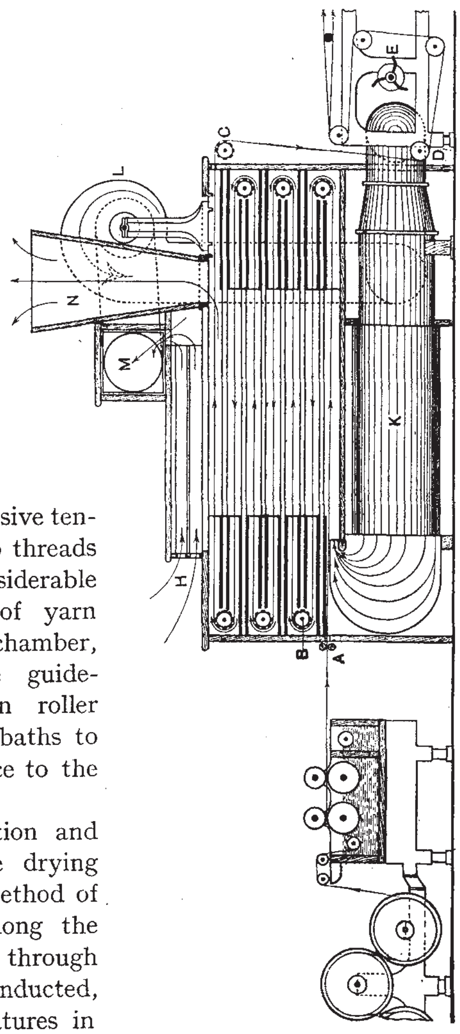

Fig. 182.—Tattersall & Holdsworth Hot Air-drying Chamber.

§ 322. The construction and method of heating the drying chamber, and also the method of propelling the hot air along the several compartments through which the yarn is conducted, constitute distinctive features in the construction of this particular modification, of which a sectional rear elevation and plan are represented in Figs. 183 and 184 respectively.

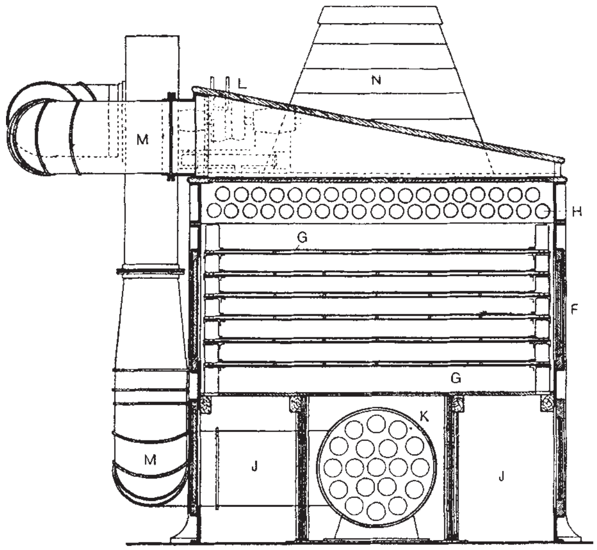

Fig. 183.

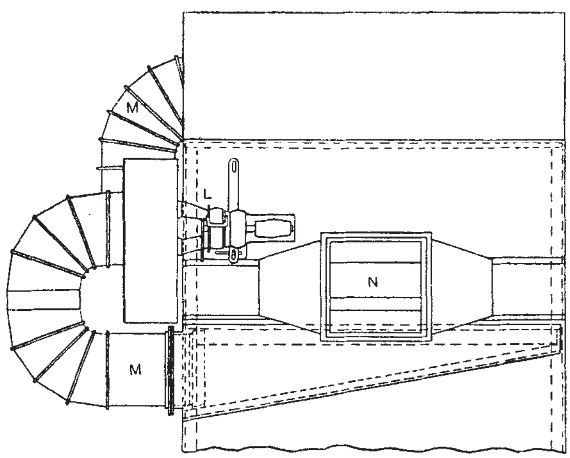

Fig. 184.

These objects are attained by constructing the drying chamber with a number of small air-ducts or channels F extending along the interior of both sides of that chamber, and also by leaving spaces to form shallow air-cavities G between the partition boards that separate the seven compartments into which the drying chamber is divided, and through which the yarn is conducted along its course.

Both the side channels F and the shallow air-cavities G communicate with each other by means of small holes to permit of air passing from the cavities into the side channels, in a manner to be described presently. In addition to those air passages there is also a series of air-tubes H contained in a separate compartment extending along the roof of the drying chamber, as represented in Figs. 182 and 183, besides two isolating chambers J extending one on each side of the large multitubular heater K, which occupies a position in the lower division of the drying chamber midway between the two isolating chambers.

The special object of constructing the drying chamber with these air-channels, cavities, tubes and isolating chambers is to provide means for previously warming the supply of fresh and dry air which is abstracted from the sizing room and passes through gratings fixed in the sides of the drying chamber, and also through small apertures formed in each end of that chamber, and thus enters the isolating chambers, cavities, side channels and tubes, in which the fresh air becomes warmed by abstracting heat radiated from the heater and the drying chamber.

From all these various passages, the warmed fresh air is directed by the operation of a fan L into a large tube or duct M, whence it is propelled along an extension of that duct which passes downward and opens into the rear end of the multitubular heater K, which consists of a large cylindrical steam-chest containing a great number of air-tubes through which the warmed fresh air is forced, and from which it issues as a current of hot and dry air having a temperature of about 212° F. (100° C.), and enters the rear end of the lowest compartment of the drying chamber. The stream of hot air then passes forward and backward in alternate succession along the several compartments, following the same course as that of the yarn, and finally, with its charge of vapour absorbed from the yarn, it emerges from the uppermost compartment and enters a short vertical flue or duct N that opens into a larger ventilating trunk, whence it is expelled into the atmosphere outside.

§ 323. The isolating chambers J, side channels F, and air-tubes H, not only serve to insulate the upper division of the drying chamber from the relatively cool air of the sizing room, and thereby prevent the radiation of heat from that chamber, and also from the heater, into the cooler atmosphere of the room, but these various air-passages also perform the additional function of a steam economiser by warming the fresh air before it is allowed to enter the heater, in a manner precisely analogous to the method of heating water by passing it through the tubes of an economiser before the water enters a steam-boiler, thereby utilising the waste heat that passes from the furnaces, along the flue, and which would otherwise be lost by radiation and diffusion.

The tubular heater is tested up to a pressure of 250lb. per sq. in., although it is usual to work it with a steam pressure of only about 90lb. per sq. in., which, by testing, was found to produce air-temperatures of 212°, 172°, 160°, 162°, 157°, and 141° F. at the several guide rollers in successive ascent from the first or bottom roller to the sixth or topmost roller. Also, the steam consumption was found to be relatively small, as indicated by measuring the amount of water of condensation discharged, during a specified period, from the heater.

Further, in two specific instances, in each of which 15% of size was applied to the yarn, the production of two sizing machines equipped with this system of hot air-drying, when sizing a warp containing 6000 warp threads of 28's T., was at the rate of about 810yds. per hour in one instance; and in the second instance, when sizing a warp containing 3600 warp threads, the rate of production was about 1120yds. per hour.

§ 324. Another method of adapting the principle of hot air-drying to slasher sizing machines is that illustrated in Fig. 185, which represents Zach's modification of an air-drying chamber as constructed by Messrs Robert Hall & Sons, Ltd., and through which the yarn is conducted in a series of nine zig-zag folds extending horizontally along the entire length of that chamber which, unlike that described in the three previous sections, is quite open inside, and not divided into a number of separate shallow compartments for the respective layers of yarn.

The present modification also differs essentially from the previous one, not only in the structural features of the drying chamber, but also in the methods both of heating the fresh air and of diffusing it throughout that chamber. Thus, instead of separating the drying chamber proper, which forms the upper portion of the chest, from the heating apparatus contained in the lower portion, they are both contained in what virtually constitutes an open chest, which is partially divided by means of a wooden diaphragm O extending horizontally from the forward end for one-half the length of the chest, as represented in the diagram.

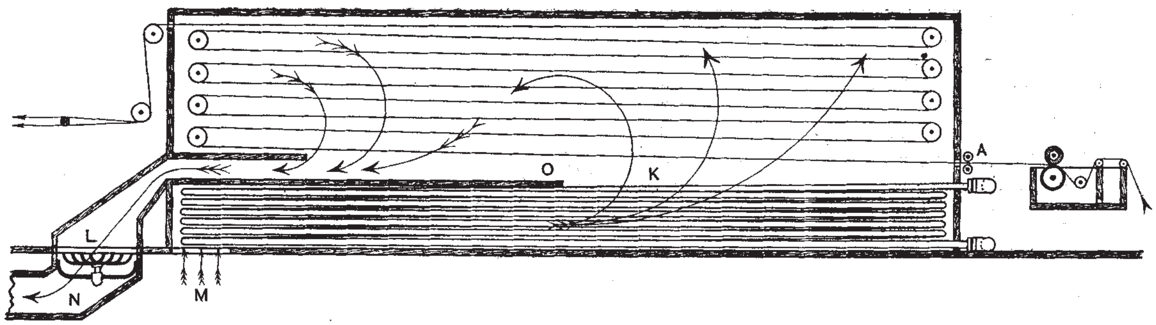

Fig. 185.—Zach Hot Air-drying Chamber.

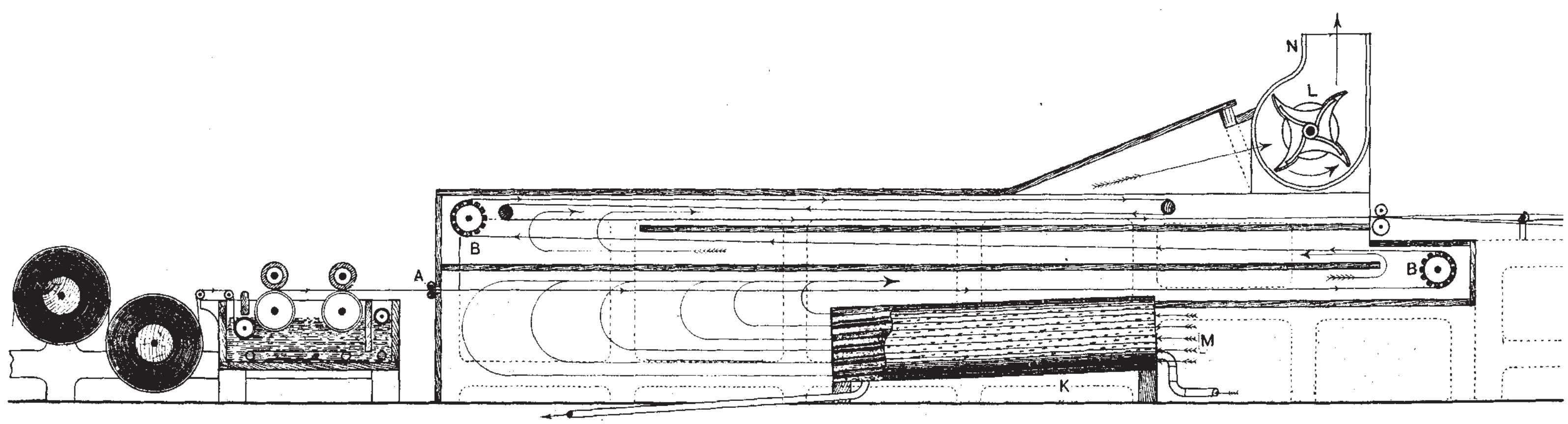

Fig. 186.—Bullough & Whitehead "Cool" Air-drying Chamber.

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The heating apparatus of this modification consists of several zig-zag coils of steam-piping extending the entire length and width of the chest. Each of these coils, which contains from 60 to 100ft., according to the dimensions of the chest, is constructed entirely from one continuous length of piping, without any joints, to prevent the risk of steam leaking within the drying chamber, and the several coils are heated, either separately or collectively, with high-pressure steam, for generating hot air.

This object is effected by directing a current of fresh air along a duct that terminates with a wide orifice M extending across the entire width of the chest, and opening into the base of the heating chamber, at the fore-end of it, where the current of fresh air enters and then passes between the coils of steam-piping K, whence it issues as a stream of hot and dry air, which is directed by means of the wooden diaphragm O, towards the centre of the drying chamber, in which it diffuses amongst the layers of yarn, from which it absorbs the moisture, and is, along with its charge of vapour, ultimately expelled from the drying chamber into the air outside the room.

The supply of fresh air to the *heating* chamber; its diffusion, after heating, throughout the *drying* chamber; and also its expulsion, after it has become saturated with vapour, from that chamber, are effected and controlled entirely by means of an exhaust fan L mounted in a duct N leading from a wide opening in the fore-end of the drying chamber, whence the duct passes downward and extends underneath the floor until it terminates with its orifice opening into the outer air.

Therefore, under the influence of the exhaust fan L, which creates a partial vacuum in the duct between this fan and the drying chamber, the large volume of air within the chamber moves slowly towards the opening in front, and passes along the duct, by which it ultimately escapes into the air. At the same time, the saturated air expelled from the drying chamber is replenished with fresh air which, under the influence of atmospheric pressure without, rushes through the fresh-air inlet M in the floor of the chest, whence it percolates between the coils of steam-pipes and enters the drying chamber as a stream of hot air, as described.

The foregoing method of expelling the saturated air from the *lower* part of the drying chamber is contrary to the more general practice of removing the air from the *upper* part of the chamber, and constitutes one of the chief and distinctive features in the construction of this particular air-drying chamber which may also be substituted for the drying cylinders of ordinary sizing machines.

This departure from the usual method of removing saturated air from the drying chamber is based on the circumstance of the relative absorption of moisture from the damp yarn being greater in that part of the chamber where the stream of hot air first encounters the yarn, which, in the present case, is in the *lower* part; and that it is, therefore, obviously a more rational procedure to expel the air *immediately* from that part of the chamber, and thereby leave the upper layers of yarn exposed to a current of *hot and dry air only*, instead of causing the saturated air to ascend and pass through the yarn into the upper part of the chamber, and from thence to be expelled into the air outside.

§ 325. The principle of drying yarn by submitting it, immediately after it emerges from the size-box, to the influence of hot air having a very high temperature of, say, 212°F. = 100°C. (which is the boiling point of water) or thereabout, is strongly deprecated by some manufacturers, who submit that *hot* air-drying tends to bake the size, which forms a hard, dry and parched crust around the warp threads, and is, therefore, liable to crack and peel or rub off those threads during weaving.

Drying by means of *hot* air is also found to be unsuitable for drying worsted and other varieties of yarn that are usually sized with what is termed "animal size," prepared from various substances of animal origin, as distinguished from size prepared from vegetable substances. Under these circumstances, therefore, drying by means of *warm* or relatively *cool* air having a temperature of only about 80°F. (26·67°C.) is sometimes adopted in preference to hot air-drying; but the relative productiveness of a "cool" air-drying sizing machine is necessarily of smaller value than that of a hot air-drying machine.

From the foregoing considerations it is manifest, therefore, that the relative advantages of the alternative systems of hot and of relatively cool air-drying of yarn, during sizing, are determined chiefly by the particular character of warps to be treated, as regards the staple and counts of yarn and the character of sizing materials employed; and also that one system of air-drying is preferable to an alternative system only in respect of different classes, and not of necessity in respect of the same class, of warps.

It is because the technical and special treatment required for the different classes of warps is not sufficiently understood by mechanical experts that these differ in their opinions respecting the theory of air-drying and its practical application to slasher sizing machines; and also that some advocate the use of relatively cool air at about 80° to 100°F. in preference to air having a much higher temperature.

§ 326. It is well known that hot and dry air possesses a high power of absorption, and also that its absorptive power increases considerably as the temperature rises, as explained in §§ 282 and 283. Hence, it is generally accepted that effectual air-drying of yarn may only be accomplished by submitting it to hot air having a very high temperature that cannot be too great provided it does not involve the risk of parching or scorching the yarn.

Such a procedure, however, would only be practicable provided the air within the drying chamber is of the normal atmospheric pressure of 14·7lb. per sq. in.; but if the internal air-pressure is reduced sufficiently to create a partial vacuum within the drying chamber, it is established by actual experience that the process of drying may be accomplished effectually even with a considerably lower air-temperature.

This, of course, arises from the more rarefied condition of the air, which accelerates the process of drying more on the principle of "extraction," rather than by "absorption," of vapour, from the yarn, in a manner precisely analogous to the method which is adopted on a commercial scale for the purpose of drying timber by confining it within a large air-tight drying chamber from which some of the air is extracted to create a partial vacuum.

§ 327. One of several modifications of what are commonly described as "cool" air-drying chambers is that designed by Bullough & Whitehead, and illustrated in Figs. 186 and 187, which represent a longitudinal and a transverse section, respectively, of that air-drying chamber as constructed by Messrs Howard & Bullough, Ltd. In this modification the heating and drying compartments are not contained in separate divisions of the same chest, as in that illustrated in Figs. 182 to 184; but, like those of the previous modification illustrated in Fig. 185, they form the lower and upper portions, respectively, of what virtually constitutes a single chamber.

In the present instance, however, the upper portion of the chamber extends forward for a considerable distance (equal to about one-third the total length of the entire structure) beyond the lower portion, and is also divided, by means of two wooden partitions or diaphragms that extend horizontally across the entire width, and for nearly the full length of the drying chamber, to form two shallow compartments, above a lower and larger one, which also contains the heating apparatus.

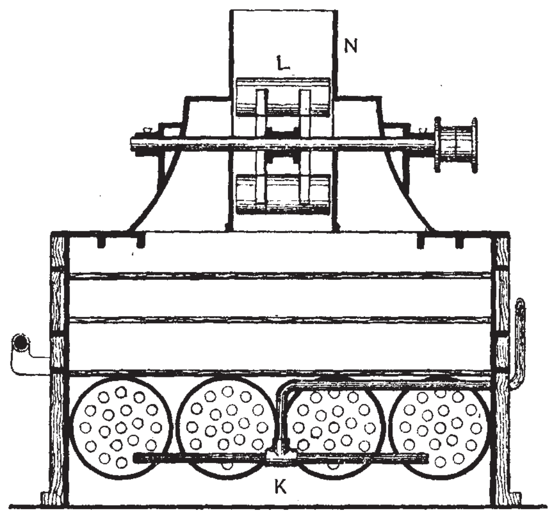


Fig. 187.

In its progress through the drying chamber, the sheet of yarn passes forward and backward, in alternate succession, extending in a series of five zig-zag folds of peculiar disposition, whereby the fourth and fifth layers of threads are folded between the second and third layers, as represented in Fig. 186. The fifth layer of yarn emerges finally through a narrow aperture, extending across the front of the drying chamber, whence it is conducted in the usual manner to be wound on to the weaver's beam.

The heating apparatus of this so-called "cool" air-drying chamber consists of four multitubular steam-chests K, similar in construction to the single steam-chest employed in conjunction with the hot air-drying chamber illustrated in Fig. 182, and described in §§ 321-323. In the present instance, however, steam is employed only at a very low pressure, whereas in both of the previous devices steam is employed at a very high pressure to generate *hot* air. Each of the four steam-chests encloses a considerable number of air-tubes through which there is directed a current of fresh air which issues from the rear of those tubes as a volume of warm and dry air having a temperature ranging from 80° to 100° F. (26·27° to 37·78° C.).

On emerging from the air-tubes in the steam-chests the warm air passes immediately into the lower and rear portion of the drying chamber, through which it flows, following the same course as that of the yarn, and ascending gradually to the upper portion of the chamber, from the fore-end of which the saturated air is extracted by the action of an exhaust fan L and passed into a short flue or duct N leading into a ventilating trunk, whence it escapes into the atmosphere outside.

In the present drying chamber, as in all probability it is similar with those described previously, the volume of air extracted from the chamber, *at the commencement*, is slightly in excess of its renewal by fresh air, until, of course, the volume of the outgoing air is exactly counter-balanced by the inrush of fresh air. The momentary disparity between the outgoing and incoming volumes of air creates, within the drying chamber, a partial vacuum equivalent to a reduction of air-pressure of about 1¼lb. per sq. in., which is maintained so long as the exhaust fan L is in operation at full speed, thereby accelerating the drying of yarn, for reasons explained in § 326.

§ 328. Each of the three modifications of air-drying chambers described previously extends horizontally for the entire length of the chamber, and therefore occupies a comparatively large floor-space, although they have a relatively low elevation; whereas air-drying chambers of the vertical construction occupy a relatively small floor-space, but extend vertically, sometimes to a considerable height, ranging from 16½ft. to 44½ft., according to the particular class of warps for which they are specially constructed.

A hot air-drying chamber of the vertical form, designed by Masurel-Leclercq, and constructed by Messrs Knowles & Co., is illustrated in Figs. 188 to 192, which represent various modifications of this chamber adapted for drying different classes of warps.

This chamber consists of one, or more than one, wide trunk or duct extending vertically for any practicable height, immediately above the size-box, and terminating each with a small outlet or chimney, whence the vapour from the sized yarn escapes by ***natural*** ventilation into the atmosphere.

The method of heating the chamber constitutes a distinctive feature in the construction of this modification, and is effected by passing high-pressure steam through a considerable length of gilled piping disposed in a series of parallel zig-zag coils extending horizontally at different elevations across the entire width of the trunk. The steam enters the piping in the upper extremity of the trunk, and passes in a downward direction along the successive coils of the piping, which leads, finally, to a steam-trap, whence the waste water of condensation escapes. By this means, hot air is generated directly within the actual drying chamber itself, and not, as in other modifications, by supplying to that chamber air that has been heated previously by passing cool fresh air through steam-heated radiators that are contained either in the same chamber or else in a separate compartment of that chamber.

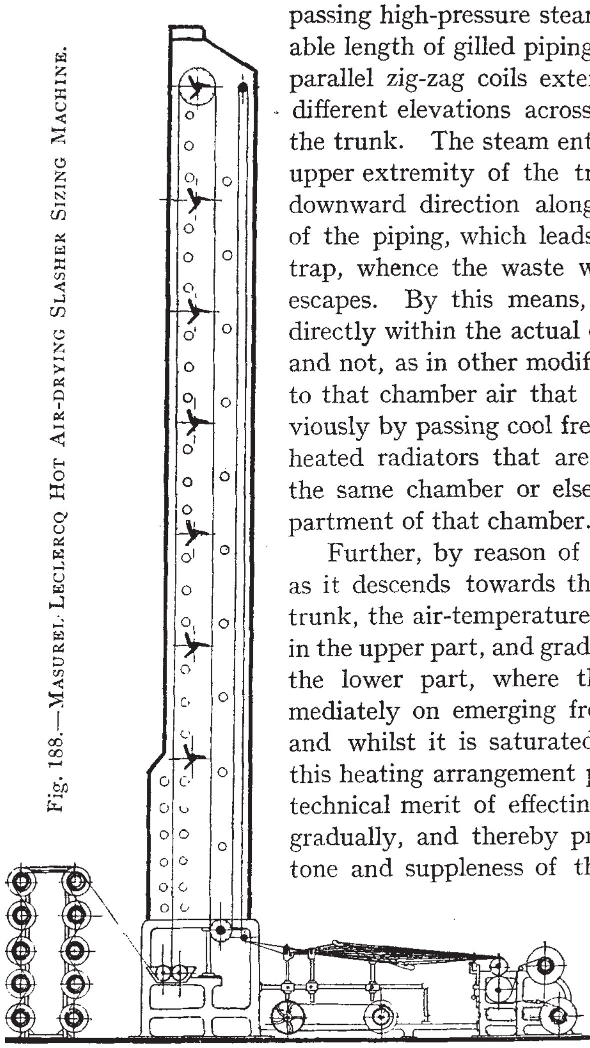


Fig. 188.—Masurel-Leclercq Hot Air-drying Slasher Sizing Machine.

Further, by reason of the steam condensing as it descends towards the lower part of the trunk, the air-temperature is therefore greatest in the upper part, and gradually declines towards the lower part, where the yarn enters immediately on emerging from the sizing rollers, and whilst it is saturated with size. Hence, this heating arrangement possesses not only the technical merit of effecting the drying of yarn gradually, and thereby preserving the mellow tone and suppleness of the warp threads, but it also conduces to economy by promoting natural ventilation within the trunks, whereby the vapour is expelled from them without the aid of exhaust fans for that purpose.

In addition to the gilled steam-piping, there are also mounted at regular intervals apart, vertically, several wide-vaned fans, of special design, extending horizontally across the entire width of the trunk for the purpose of accelerating the process of drying the yarn by fanning the hot air between the warp threads, which are thereby vibrated as they pass upward and downward in the form of sheets of threads extending vertically from the summit to the base of the trunk, as represented in Fig. 188.

§ 329. The vertical form of drying chamber, extending for a considerable height, in conjunction with the particular method of heating just described, is the chief factor that conduces to a degree of efficiency which, it is claimed by the makers of this chamber, will produce results that are in many respects greatly superior to those obtained by any form of horizontal air-drying chamber.

This claim is based chiefly on the easy flow of vapour by natural ventilation within the trunks, *and its immediate and direct discharge from them*, because of their vertical position, which also permits of a *long interval or span of yarn between the sizing rollers and the first of the several guide rollers* over which the threads are conducted after leaving the sizing rollers.

The hot air, with its charge of vapour, rises naturally within the trunks, whence it escapes through small chimneys directly and without coming into contact with the folds of yarn that may be contained in adjacent trunks of the same drying chamber. As the air ascends, it meets successive lengths of steam-piping, which is hotter as it approaches the summit, where the live steam first enters the piping and then descends towards a steam-trap at the base. By this ingenious arrangement, therefore, the temperature of the air increases as it ascends within the trunks, whereby its power to absorb moisture from the yarn, and also its capacity to retain it as vapour in suspension, are constantly increasing, thereby preventing the vapour from condensing within the trunks and remoistening the yarn.

§ 330. The long interval or stretch of warp threads between the sizing rollers and the first guide-roller with which the yarn comes into contact, after being saturated with size, permits of a relatively longer time for the threads to dry sufficiently to prevent the risk of these clinging to, and depositing size on, the surface of the guide-roller which, like other guide-rollers around which the yarn is conducted, is mounted in ball bearings to reduce, to the least possible degree, the tensile strain upon the warp threads.

This object is also still further effected by the vertical disposition of the folds or relays of warp threads, whereby the descending sheets of threads exactly counterbalance the ascending sheets of yarn. Under these conditions, therefore, the tension upon the warp threads is not appreciably increased by increasing either the length or the number of folds or relays of yarn that are exposed within the drying chamber at the same time. Hence, the warp threads retain their roundness, fulness, strength, and elasticity, and being of a more supple character, they are therefore less liable to breakages when subjected to sudden strains or shocks during weaving, and the cloth produced is said to be of a much superior character of texture.

§ 331. In contrast with the foregoing advantages, it is urged by the makers of this particular form of hot air-drying chamber that warp-drying by any of the several modifications of horizontal air-drying chambers is neither so effective nor so economical, because of the vapour being expelled from those chambers by the aid of a forced draught induced by means of an exhaust fan, which is mounted in a common outlet formed at one end of the chamber only, albeit the sheet of warp threads extends in a series of horizontal folds that lie in different horizontal planes throughout the entire length and width of the drying chamber, which consists either of one large and open compartment, or else of several shallow compartments, as described and illustrated previously.

These circumstances are held by the advocates of the vertical form of drying chamber to constitute serious obstacles to the efficiency of horizontal chambers, not only by impeding the process of drying the yarn, and thereby curtailing the productiveness of the machine by causing the stream of hot air to flow along the same course as the warp yarn continuously, but also because, in consequence of the air becoming gradually cooler as it passes through the chamber, the air loses both its power of absorbing moisture and of retaining the vapour in suspension, as explained in §§ 282-3, with the result that the vapour condenses before it is expelled from the drying chamber, and is, therefore, again partially reabsorbed by the yarn.

This circumstance is, indeed, not only freely admitted by the makers of the horizontal hot air-drying chamber described in §§ 321-3 and illustrated in Figs. 181 to 184, but the makers of that modification actually adduce this result as a highly commendable and desirable feature which enhances the merit of their system of air-drying, by leaving the yarn slightly moistened, and therefore in a much better condition for weaving, than when the yarn is dried more thoroughly.

It is also urged as an objection against both cylinder-drying machines, and also the horizontal form of hot air-drying chambers, that by subjecting the warp threads, immediately after they emerge from the sizing rollers, and whilst they are completely saturated with size, to the influence of a very high initial temperature, the process of drying is effected so suddenly that the size forms a hard, crisp, and brittle film or sheath around the threads without properly binding together and consolidating the fibres composing them, with the result that the size rubs off the warp threads when passing through the comb during beaming, and also through the healds and reed during weaving, when the benefits accruing from sizing are most urgently needed.

In the vertical form of chamber just described, however, both the cold fresh air and the saturated warp threads enter the drying chamber concurrently at the base, and ascend together in the trunks, whilst the air-temperature is gradually increasing, and thereby effecting a progressive and gradual process of drying, which is said to have the effect of fixing the size more securely upon the threads, so that it is less liable to rub off and become wasted during the operations of beaming and weaving.

§ 332. With regard to the interval or stretch of warp yarn extending between the sizing rollers and the first guide-roller with which the yarn makes its first contact, after being saturated with size, that interval may be of any practicable length, or there may be any number of folds or relays of yarn exposed at the same time within a vertical drying chamber, without materially affecting the degree of tensile strain upon the warp threads, for reasons stated in § 330.

In a horizontal chamber, however, the length of span between the sizing rollers and first guide-roller is necessarily restricted because of the sagging or drooping of warp threads between those rollers, which subjects the threads to a degree of tension which is proportionate to the length of span.

Also, unlike the vertical form of drying chamber, each fold or relay of yarn which extends horizontally imposes additional effort, and therefore tension, upon the threads when passing through the chamber, because the horizontal folds of yarn do not counterbalance each other as do vertical folds. Under these circumstances, therefore, it is necessary not only to restrict the span of yarn, especially between the sizing rollers and first guide-roller, but also the number of folds in horizontal chambers, and consequently to submit the yarn to heat of a high initial temperature to dry the threads sufficiently before they pass around the first guide-roller.

As stated in § 328, this form of drying chamber is constructed with a variety of modifications, each of which is adapted suitably to the special requirements of the particular class of warps for which it is intended. For example, the height of the trunk may be constructed to any dimension according to the length of warp traverse required; also two or more trunks may be employed in combination to permit of a greater number of folds or relays of yarn within the drying chamber, and thus keep it exposed to the hot air for a relatively longer period, with the object of accelerating the progress of yarn through the machine, and thereby increasing its productiveness. The trunks may also be employed in conjunction with only one or more than one size-box to permit of single, double, or treble sizing as required; or the size-boxes may be employed for sizing the same or different counts or colours of yarn from one, or more than one, set of back beams, simultaneously, without the risk of threads of one colour becoming tinged with other colours.

§ 333. One of these modifications, which is specially adapted for woollen yarn of fine counts, consists of a single trunk of extra width from front to back, and of considerable height, erected above only one size-box. The trunk is furnished with one short vertical zigzag row, and two long vertical rows of gilled steam-pipes, and also with seven wide-vaned fans mounted about 4ft. 6in. apart, as represented in Fig. 188.

In this modification, the warp threads emerge from the sizing rollers whence they pass immediately between several steam-pipes that are placed with a close parallel disposition in the lower part of the trunk. From this lower range of steam-pipes the warp threads continue their upward course to the top of the trunk, where they pass over a ribbed or lattice guide-roller and descend to the bottom of the trunk, whereby the first two folds or relays of yarn extend on both sides of the first row of steam-pipes and the seven fans referred to previously.

If, on arriving at the bottom of the trunk, the warp threads are dried sufficiently, they pass underneath another lattice guide-roller, whence they are conducted to be wound immediately on to the weaver's beam. But if, from any circumstance arising from the state of the weather, yarn of coarser counts, a greater number of warp threads, or a greater percentage of size applied to them, it is necessary, in order to ensure its thorough drying, to pass the yarn for a second time up and down the trunk, that course may be adopted by conducting the yarn underneath the bottom lattice guide-roller, then over a plain guide-roller at the top of the trunk, and downward again to be passed under a plain guide-roller at the bottom of the trunk, and thence on to the weaver's beam or beams, in the manner represented in Fig. 188. By adopting this course, the yarn is exposed for a second time to the drying influence of an additional long row of steam-pipes, whereby the drying of the yarn is greatly accelerated and the relative productiveness of the machine thereby considerably increased.

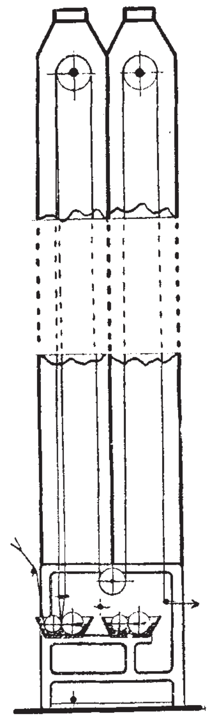


Fig. 189.

§ 334. Other adaptations of this particular form of hot air-drying chamber are illustrated in Figs. 189 to 191, which represent modifications of this chamber which are employed specially for sizing and drying three distinctly different classes of warps. In each of these examples, the drying chambers consist of two trunks in combination, erected above two separate size-boxes, whereby they are adapted to any of the following requirements—namely: (*a*) For single sizing only, as represented in Fig. 189; (*b*) for double sizing—that is, sizing and drying the same warp threads twice in succession and in the same machine, as represented in Fig. 190; (*c*) for sizing two separate and distinct warps, composed either of the same or different counts or colours of yarn, and to be wound on to separate weavers' beams simultaneously, as represented in Fig. 191; and (*d*) for sizing warps composed of two or more different colours of yarn, and of which the warp threads are combined into one sheet only when they reach the top of the drying chamber, and they are dried sufficiently to prevent the risk of threads of one colour becoming tinged with other colours, and which is also represented in Fig. 191.

§ 335. A third modification of this drying chamber is illustrated in Fig. 192, which represents three trunks in combination, erected above two size-boxes, whereby it is adapted for yarn of coarser counts and for the heavier grades of sizing, without curtailing production, as the additional trunk permits of the exposure of the warp threads to the hot air for a considerably longer period, to ensure thorough drying.

When two or more trunks are employed in combination, they virtually constitute a single drying chamber consisting of a corresponding number of vertical compartments that are separated from each other by means of sheet-metal partitions. Each trunk or compartment, therefore, forms a separate flue or duct that may be employed quite independently of the others, as they are each equipped with fans and a separate system of steam-piping, whereby the heating of the several trunks, and therefore their drying power, may be controlled independently and regulated suitably to the character of the warp, grade, and character of sizing, and the rate of production required. Also each

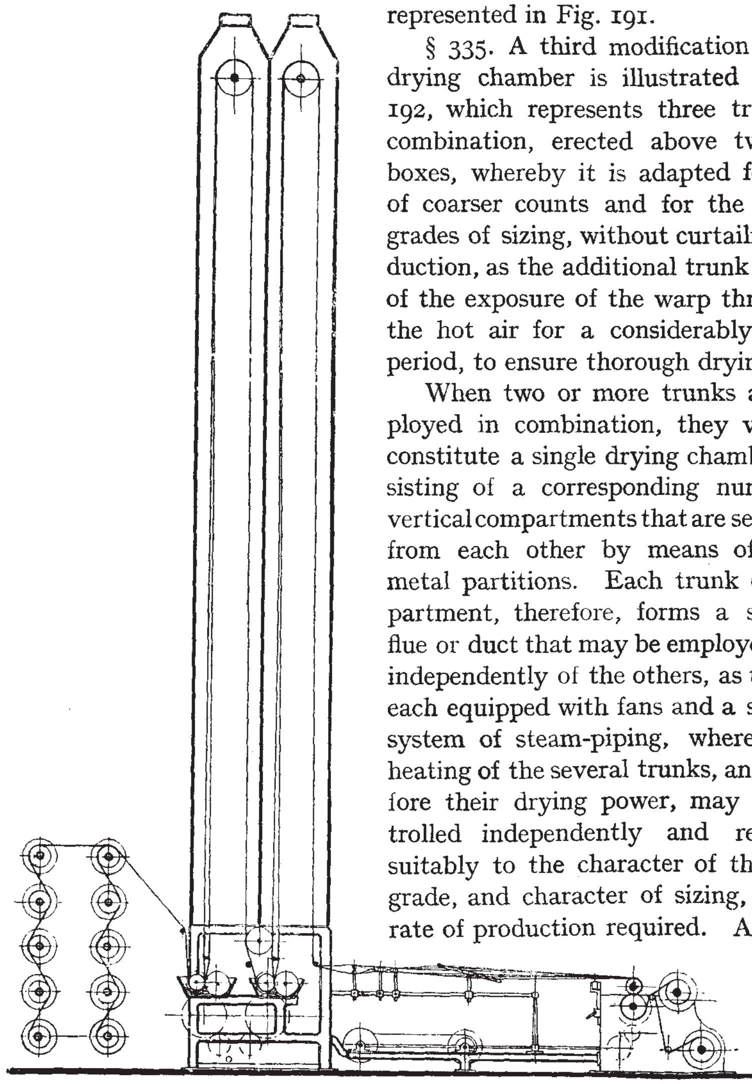


Fig. 190.

trunk is surmounted by a separate small chimney outlet provided with a damper or baffle-plate which opens or closes automatically on starting or stopping the machine, and may be adjusted as desired to regulate the discharging of vapour from the trunks, and thereby control the rate of condensation of the steam consumed in drying the yarn.

§ 336. The form of beam creel which is usually, though not necessarily, employed with these drying chambers, is that in which the back beams are disposed in two, or more than two, vertical rows, with the axes of the several beams in each row placed in the same vertical plane and with not more than five beams in each row, with the object of keeping the highest beam within convenient reaching distance by the attendant when he is recovering and piecing missing or broken warp threads, as described in § 185.

The vertical form of beam creel occupies relatively less floor space than the more prevalent form of creel in which the back beams are mounted with a zigzag or alternate disposition in two horizontal rows having two slightly different elevations. There may also be employed a duplex rotary beam creel constructed to support two distinct sets of back beams, as indicated in Fig. 192, thereby enabling a new set of back beams to be creeled without loss of time, and in readiness to be placed in position by simply revolving the creel on its axis immediately the previous set of beams is depleted. The hauling of the back beams in and out of the creel is performed mechanically by means of an overhead winch erected immediately above the creel.

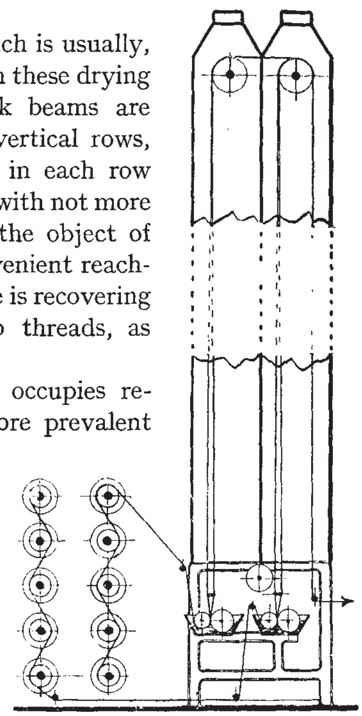


Fig. 191.

§ 337. Another departure from usual practice is also made by placing the dividing rods all in the same inclined plane, as represented in the diagrams, whereby the several sheets of threads from the respective back beams are more effectually and completely separated from each other, and the recovering and piecing of broken threads thereby effected more readily. The headstocks are constructed with two separate and distinct winding-on devices, which permit either of two similar or else different warps being sized, and wound upon separate weavers' beams, simultaneously, by the same machine.

The machines are also provided, if required, with a special form of length indicator and cut-marking motion, which operates automatically without the use of change-wheels, and produces cut-marks at the required intervals apart, by simply moving an adjustable cursor, which slides on a graduated scale, opposite the particular number which denotes the cut-lengths in yards required, and then securing it in position.

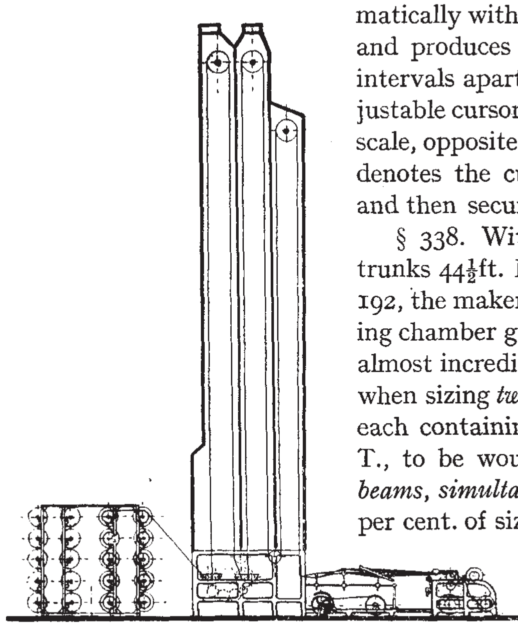


Fig. 192.

§ 338. With a combination of three trunks $44\frac{1}{2}$ft. high, as represented in Fig. 192, the makers of this form of hot air-drying chamber guarantee a production at the almost incredible rate of 4250yds. per hour, when sizing *two* cotton warps *in duplicate*, each containing 1600 warp threads of 24's T., to be wound on *two separate weavers' beams, simultaneously*, 63in. wide, with 10 per cent. of size, and a working steam-pressure of 105lb. per sq in. in the first range of steam-pipes.

Indeed, a record of tests published by the makers reveals the fact that this enormous rate of production was actually attained even when sizing cotton warps containing 2500 warp threads of 30's T., as specified in the last item in the accompanying instructive Table of Particulars, which also records many interesting data relating to no fewer than twenty-four different tests, with both cotton and woollen warps of various counts of yarn and numbers of warp threads, and which were conducted with the several modifications of this particular construction of hot air-drying slasher sizing machine when winding the warps both on to one weaver's beam only, and also on to two separate weavers' beams, simultaneously.

§ 339.

TABLE OF PARTICULARS.

Reference Letters Indicating Different Types of Drying Chambers.	Height of Drying Chamber in Ft.	Length of the Machine Only.	Production in Lb. per Hour.		Examples of Production per Minute : English Counts.		H.P. Required at Medium Speed.	Steam Consumption in Lb. (Pressure 105lb.)	Warps for which the Different Types are Chiefly Intended.
			Cotton.	Wool.	Cotton Warps of 1600 Ends. 24's T.	Woollen Warps of 3000 Ends. 50's.			
A	16½	14½	100	90	60ft.	39ft.	2	165	For short cuts, fancies and samples.
AB	19¾	20¾	120	110	75½ ,,	49 ,,	3½	220	For fine woollen warps.
B	44½	20¾	264	240	164 ,,	98 ,,	4	484	
AC	21½	20¾	176	165	108 ,,	75 ,,	3½	375	
BC	26	20¾	240	200	147½ ,,	92 ,,	4¼	440	
					Cotton warps of 4000 Ends. 24's T.	Woollen warps of 4000 Ends. 42's.			For any counts of cotton and medium counts of woollen.
C	38	20¾	363	297	88ft.	85ft.	5½	660	
C (On two separate warp beams)	38	20¾	430	350	105 ,,	102 ,,	5½	660	
					Cotton warps of 3000 Ends. 24's T.	Woollen warps of 4000 Ends. 50's.			
CE	44½	20¾	440	363	144ft.	124ft.	6	726	
CE (On two separate warp beams)	44½	20¾	530	430	174 ,,	150 ,,	6	726	
						Woollen warps of 5600 Ends. 38's.			For cotton and woollen warps of coarser counts.
E	44½	23½	660	440	220ft.	85ft.	—	—	
E (On two separate warp beams)	44½	23½	790	530	262 ,,	105 ,,	—	—	
					Cotton warps of 2500 Ends. 33's T.	Woollen warps of 2400 Ends. 43's.			
E (On two separate warp beams)	44½	23½	790	530	426ft.	262ft.	—	—	

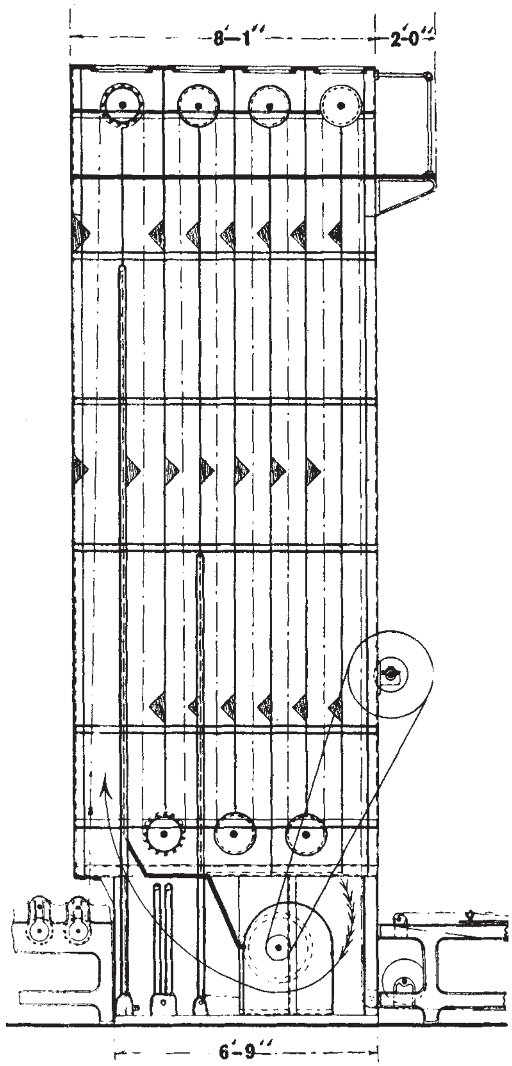


Fig. 193.—MARR HOT AIR-DRYING CHAMBER.

§ 340. Another, and a later, example of the vertical type of hot air-drying chamber is that represented by a side sectional and a front (or rear) elevation in Figs. 193 and 194 respectively, which illustrate Marr's modification of a vertical chamber that differs in several respects from that described in §§ 328 to 338 and illustrated in Figs. 188 to 192, both in the construction of the chamber itself and also in the methods of heating and drying that are adopted.

The present modification, which is constructed by Messrs Vincent, Roberts and Marr, consists of only one large vertical chest, about 25ft. 6in. in height, erected immediately above a lower chamber, forming the base, and in which the heating and drying apparatus are contained. This chest is divided into any desired *even* number of separate vertical compartments, each about 12in. deep from front to back, and extending across the entire width of the chest, in which respect, therefore, this air-drying chamber bears a very close similarity to that described in §§ 321-3 and represented in Figs 182 to 184, if that chamber were placed on end vertically, instead of horizontally.

In their progress through the sizing machine, the warp threads are conducted upward from the last pair of sizing rollers, whence they pass through a very narrow aperture extending across the base of the first of several compartments along which the warp is conducted, first upward and then downward, in alternate succession, until it emerges from the base of the last compartment and is passed under a guide-roller near the floor, whence it is conducted in the usual manner to be wound finally on to the weaver's beam.

As the yarn passes along the several compartments, it is submitted to the drying influence of a stream of hot and dry air which flows continuously along these compartments

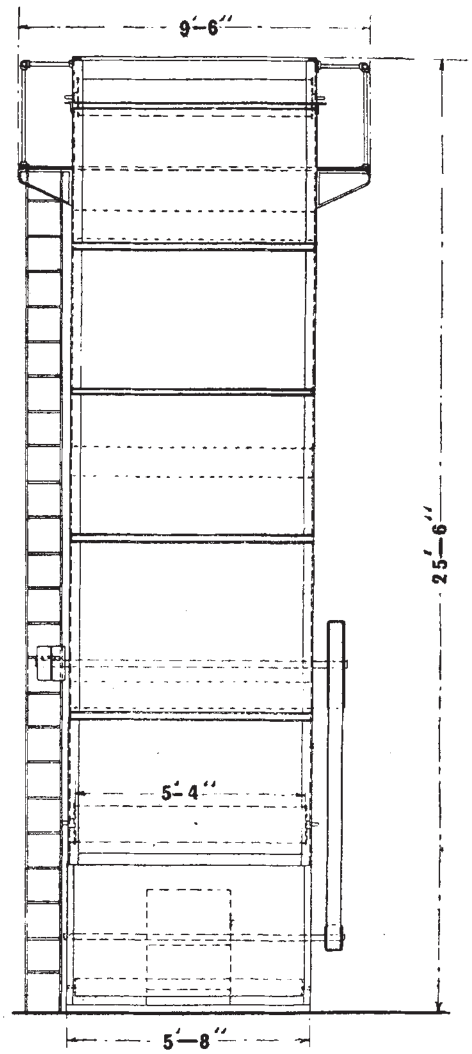


Fig. 194.

in the same direction as that in which the yarn travels, but with a very much greater velocity, which is in the ratio of about 1 to 10, so as to remove the vapour quickly away from the warp threads, and also to bring in a fresh supply of hot and dry air to react upon them. As the yarn is conducted through the drying chamber, it passes around a number of guide-rollers that are mounted at the extreme opposite ends of the chamber, and by which the threads are deflected from one compartment to another.

The first two of these guide-rollers, following immediately after the size-box, are formed with a ribbed or fluted surface to prevent the risk of the newly-sized threads adhering to, and depositing size upon the rollers, and all the guide-rollers are mounted in ball bearings, in which they revolve quite freely, simply by the surface contact with the warp threads, and without imposing appreciable tensile strain upon them.

The casing of the drying chamber should be covered externally with thin sheets or felt boards of non-conducting material about one-eighth of an inch thick, the better to insulate the chamber and thereby prevent the radiation of heat from it, and also to protect the upper part of the structure, which projects through the roof, and is therefore exposed to the destructive influence of the atmosphere. The chamber is also covered in at the top, and may, if required, be provided either with sliding or hinged trap-doors, or else adjustable louvres, placed above each pair of compartments for the purpose of controlling the escape of vapour from them as required under different atmospheric and other conditions.

Instead of employing fans, as in the previous chambers, to agitate the air within the compartments, this object is accomplished by a much more simple and economical method by fixing, at regular intervals apart, on the partitions, and also on the forward and rear ends of the drying chamber, a number of inclined baffles extending horizontally across the entire width of the chamber. The function of these baffles, which constitute a specially distinctive feature of this modification, is to contract the air-passages at those points, and thus cause frequent and temporary resistance to the free and regular flow of the air-current, thereby impelling the air against and between the warp threads, and producing an erratic movement and commotion of the air, which causes the threads to vibrate slightly and separate from each other, and thus accelerate the process of drying the yarn.

§ 341. It is, however, more particularly in the method of heating the drying chamber, and also that of directing the stream of air, through the several compartments, that this particular modification marks such a distinct departure from any previous example of air-drying chamber. Thus, the hot air is generated by means of two or more steam-heated radiators contained in a separate compartment situated underneath the rear part of the drying chamber, and operating in conjunction with one or more than one air-propeller fan of the " multivane " type contained in another compartment underneath the fore part of the chamber, whereby a continuous stream of hot air is *circulated* through the several compartments in succession, whence the moist air is extracted and again conducted to the radiators, where it is redried and reheated, and from which it again proceeds to circulate through the drying chamber and back again to the radiators, and so on continuously, instead of being expelled entirely from the chamber as in the air-drying systems described previously.

As the hot air circulates through the drying chamber, and thereby becomes charged with vapour absorbed from the moist yarn, only a comparatively small proportion of the entire volume of that air is allowed to escape with its moisture into the atmosphere, whilst the greater volume of air, which still retains a considerable amount of heat, is again utilized for drying the yarn, thereby effecting considerable economy in steam consumption, and also retaining a sufficient amount of moisture in the air to leave the warp yarn in good condition for weaving; whereas in some air-drying chambers, the entire volume of air, after passing only once through the chamber, is expelled into the atmosphere, from which that air is replenished with an entirely fresh supply of cold air, which must be heated to the required temperature before it is allowed to enter the drying chamber, thereby involving a much greater consumption of steam.

Although, under normal atmospheric conditions, and other circumstances, practically the same stream of air circulates continually through the drying chamber, in the manner just described, and with but little replenishing with cool fresh air, that chamber is, nevertheless, provided with air trunks and valves to permit of the entire current of air or any portion of it being discharged directly into the atmosphere, whence a fresh supply of cool air may be abstracted and passed through the heating chamber before it is allowed to combine with the air already in circulation. Also, instead of allowing the saturated air to escape from the louvred or other openings at the top of the drying chamber, that air may be expelled at a point immediately above the size-box, and thereby assist in removing the vapour that arises therefrom.

§ 342. The radiators employed for generating the stream of hot air each consist of a continuous length of steam-piping arranged in such a manner as virtually to constitute a number of vertical pipes with a close parallel disposition, to form a zigzag coil of piping extending across the entire width of the drying chamber. These radiators, of which any convenient number may be employed, are all contained in an isolated chamber which opens directly into the base of the first or rearmost of the vertical compartments into which the drying chamber is divided.

One row of steam-piping, forming a separate radiator, extends upward into the drying chamber for a distance of about three-quarters of the height of that chamber, and occupies a position midway between the first two folds or layers of warp threads following after the size-box. This row of steam-piping is succeeded by two or more rows of shorter vertical length, which do not extend into the drying chamber; whilst an additional supplementary row of steam-piping extends upward for a distance of about two-fifths the height of the chamber, and occupies a position midway between the third and the fourth folds of yarn for the purpose of accelerating the process of drying during cold and damp weather, or in other circumstances, when the process of drying proceeds tardily, and additional heating power is required. This air-drying chamber also may be substituted in place of the cylinders of ordinary slasher sizing machines.

§ 343. From the results of two actual tests conducted on sizing machines equipped with this hot air-drying chamber, the following authentic data were obtained:

Test No. 1.—When sizing 2240 warp threads of 34's T.
Production = 2400yds. per hour.
Steam consumption = 200lb., or 20gals. water, per hour.

Steam pressure = 70lb. per sq. in.

Air temperature in first compartment (over size-box) of drying chamber ranged from 114° to 124° F. (45·56° to 51·11° C.).

Test No. 2.—When sizing 2814 warp threads of 12's T.

Production = 1074yds. per hour.

Steam consumption = 472lb., or 47·2gals. water, per hour.

Steam pressure ranged from 71 to 77lb. (Av. 74lb.) per sq. in.

Air temperature in first compartment of drying chamber ranged from 158° to 166° F. (Av. 162·5° F.) = 70° to 74·45° C. (Av. 72·5° C.).

Air temperature in last compartment of drying chamber ranged from 123° to 131° F. (Av. 125·37° F.) = 50·56° to 55° C. (Av. 51·87° C.).

§ 344. Another different type of hot air-drying chamber, and one which constitutes quite a distinct variation from any of the foregoing examples, not only in the construction of the chamber itself, but also in the methods of heating it and of effecting the process of drying the yarn, is that illustrated in Fig. 195, which represents a longitudinal section of a German type of sizing machine invented by Sucker, about 1869, and for which a British patent was granted in 1889. Since this date, the machine has undergone several important modifications and improvements, and as constructed by Gebrüder Sucker, Grünberg, it is regarded as a hot air-drying machine of a very high standard of efficiency, and is now adopted by a few Lancashire manufacturers, in whose mills a number of machines of this type are in successful operation.

The principal feature which distinguishes this type of hot air-drying chamber from those described previously consists of the employment of three, five, seven, nine, or eleven large skeleton cylinders or swifts (according to the production desired), each having a diameter of about 2ft. 6in., and extending across the entire width of the chamber, in which they are enclosed, but easily accessible through small doors erected in the sides of the drying chamber, and within each of which swifts there is mounted a four-vaned fan.

During one part of their progress through the drying chamber the warp threads are conducted under and over these successive skeleton swifts, that are mounted with an alternate or zigzag disposition in two horizontal rows or tiers, and enclosed in a separate compartment situated between a lower one which constitutes the heating chamber, in the base, and a supplementary drying compartment

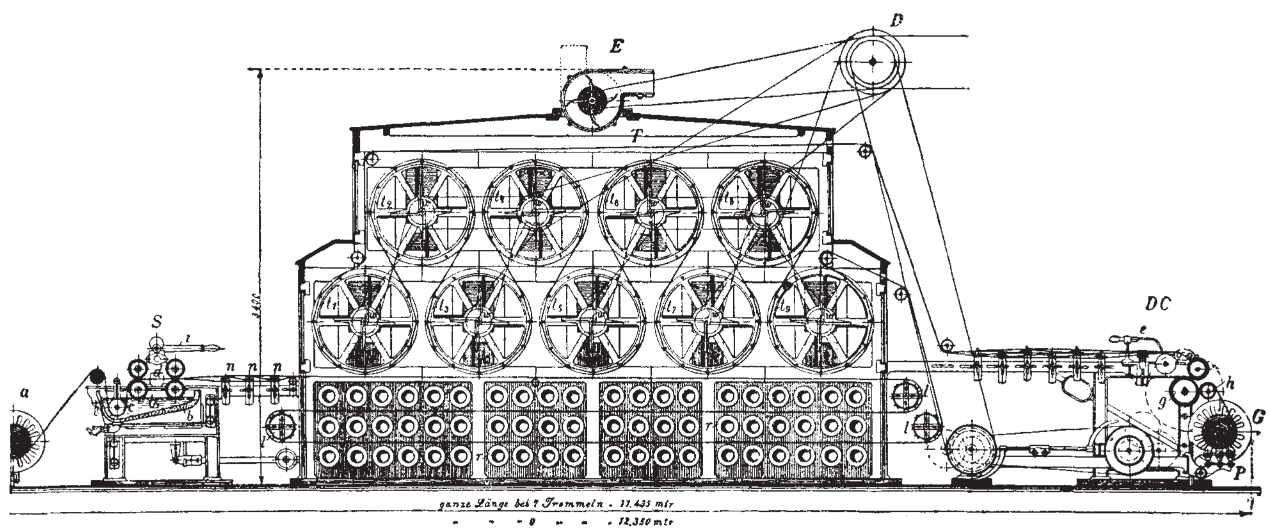


Fig. 195.—Sucker Hot Air-drying Slasher Sizing Machine.

situated in the upper part of a large chest of considerable dimensions and constructed with a number of glazed panels through which the yarn in the drying chamber is always exposed to view.

The cylinder fans are driven positively, and revolve with a high velocity which is considerably greater than that of the cylinders, but in the same direction as these, with the object of driving the hot air with considerable force between the sheet of warp threads, and thereby accelerating the process of drying the yarn. Also, by causing the fans to revolve in the same direction as the skeleton swifts, it ensures that in the event of warp threads breaking, these will be carried along safely until they emerge from the drying chamber, when they can be recovered and pieced by the attendant.

Before the yarn is conducted around the skeleton swifts, however, it is first submitted to a preliminary process of drying by passing it forward and backward in three zigzag folds extending horizontally for the entire length of the lower division of the chest, which also contains the heating apparatus, consisting of an enormous and continuous length of gilled steam-piping arranged in three parallel and zigzag rows extending throughout the entire length and width of the heating chamber, and heated with high-pressure steam up to 100lb. or more, per square inch.

Thus, immediately after leaving the last pair of sizing rollers, the warp threads are conducted forward over the top of the third or uppermost row of steam-pipes, then backward between the third and second rows, and again forward between the second and first rows of pipes, whence they are conducted upward and passed under and over the skeleton swifts in the lower and upper tiers in alternate succession, with a zigzag formation, and from the last or rearmost of which swifts the yarn is again directed upward and conducted along the upper supplementary drying compartment, from the front of which it emerges through a narrow aperture, whence it is deflected downward to pass under and over the dividing rods, and finally to be wound on to the weavers' beam or beams, as indicated in the diagram.

Whilst the yarn is passing between the rows of steam-piping contained in the heating compartment, and when it is therefore extended in three long spans between the guide-rollers, the warp threads are supported at several intervals to prevent them from sagging or drooping, and thereby coming into contact with, and becoming scorched or burnt by, the steam-piping. Also, the larger guide-rollers, around which the yarn is conducted, are mounted in ball bearings to reduce frictional resistance and thus minimise the degree of tensile strain upon the warp threads.

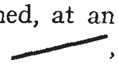
The fans in the skeleton swifts of the *lower row* communicate at both ends of the fans, and by means of ducts, with the heating compartment in the lower part of the chest, whereby these lower fans draw only a current of *hot air* from that compartment, and deliver it with considerable force between the warp threads in the manner and for the purpose stated previously; whereas the fans in the *upper row* of swifts, which do not communicate with the heating compartment, draw in from the sizing-room a current of cool air which passes through louvred openings formed in the sides of the drying chamber, and thence to those fans.

By adopting this unusual procedure the yarn is submitted to currents of *hot air* and *cool air* in alternate succession, which, it is claimed by the makers, has the effect of imparting to the warp threads that peculiarly soft and mellow tone which is much appreciated, and also of preserving their original property of elasticity so essential to good weaving. The warp threads are also relieved of undue tensile strain, which would otherwise be imparted by the effort of turning the skeleton swifts, by mounting these in ball bearings that are lubricated in a special manner, whereby frictional resistance in those bearings is practically nil. In addition to this refinement, the skeleton swifts contained in the lower row are driven *negatively* from the long side-shaft which, through the medium of frictional driving-gear, transmits motion to those swifts in such a manner that the degree of tensile strain upon the warp threads may be regulated to any desired tension.

Also the removal of saturated air from the drying chamber is effected by means of an exhaust fan mounted in an outlet formed in the roof of the chamber, whence the moist air is discharged into a vertical form of ventilating trunk, and finally expelled into the atmosphere in the usual manner.

In machines of more recent construction, of which that illustrated in Fig. 195 is an example, the three lattice guide-rollers around which the warp threads are deflected and then conducted backward and forward between the three rows of steam-pipes contained in the lower part of the drying chamber, as represented in the diagram, are each mounted immediately *outside* the ends of that chamber, with the object of displaying the yarn more effectually to observation by the attendant.

The size-box constitutes a special feature distinctive of this particular type of sizing machine, and is constructed of thick sheet copper to constitute a size-box of the cavity or jacketed type, of which another example is described in § 194, and illustrated in Fig. 79. Instead, however, of utilizing the cavity as a steam-jacket for heating the size, as in the previous example, it is, in the present machine, converted into a water-jacket which is heated by injecting steam through a perforated pipe passing through the water. Provision is also made whereby the size may, if it is desired, be heated by the usual method of injecting steam into it directly through a perforated pipe fixed *inside* the copper size-box, as described in §§ 190-1.

Also, the rear part of the size-box, containing the copper immersion-roller, is deeper in that part, whence the base of that box is inclined, at an angle of 12 degrees, towards the front of the box, thus , which is, therefore, very shallow in that part, thereby reducing its relative capacity to about one-half the usual volume of size. For reasons stated previously in § 191, however, the constructing of wide and shallow size-boxes of relatively smaller capacity is considered, by some practical sizers who advocate the use of deep and narrow size-boxes of relatively larger capacity, to conduce to uneven sizing of the yarn.

By a simple adaptation of levers furnished with adjustable weights, provision is also made whereby the degree of compression, exerted by the heavy squeezing or finishing rollers, may be regulated suitably to the requirements of different warps, according to the number of warp threads, counts and character of the yarn, grade of sizing and percentage of size required on the finished warp.

Also, when sizing warps with the heavier grades of sizing, the productiveness of the machine is maintained by a special arrangement whereby the yarn, as it leaves the last skeleton swift, is conducted backward, immediately *above* the rows of steam-piping, for the entire length of the drying chamber, and then forward again *between* the rows of steam-piping, thereby ensuring the effective drying of the yarn without diminishing the speed of the machine, which would involve a proportionate loss of production.

The driving gear of this machine consists of a combination both of cone-drum and change-wheel gearing which permits of differential driving with a speed variation in the ratio of 1 to 6, with an actual yarn-speed of 5 to 30 yards per minute, according to varying conditions and requirements. Also, by means of slow-speed driving gear, the working speed of the machine is reduced to one-tenth of the normal full speed.

A special form of cut-marking and measuring motion enables the warps to be subdivided into unit-lengths ranging from 5 to 150 yards, in length-units of only 2in. each, and without employing change-wheels. A length-indicator also registers the number of cut-lengths of warp produced.

It is claimed by the makers of this type of air-drying sizing machine that when sizing dyed yarn the colours retain their original hue, purity and brilliance of tone; that it is superior to Scotch dressing or sizing, for linen warps; that when sizing light cotton warps containing from 400 to 800 warp threads of 32's T., and heavy cotton warps containing up to 6000 warp threads of 16's to 20's T., there was recorded, under actual tests, 25 per cent. more elasticity than is obtainable by any other type of hot air-drying sizing machine. Also, if required, the air-drying chamber only, of this machine, may be adapted to operate in conjunction with the headstock and sizing apparatus of any other type of slasher sizing machine of modern construction.

CHAPTER IX

LOOMING

1. Drawing-in. 2. Twisting-in. 3. Tying-in.

§ 345. After a warp is wound finally on to the weaver's beam, the warp threads require to be passed, in a prescribed order according to a prearranged plan termed the "draft," first through the respective eyes of the shedding harness, consisting either of a set of healds or else a jacquard mounting, whence they are passed usually in pairs, or else in groups of three or four threads uniformly, between successive dents of a reed, ready for weaving. The function of placing the warp threads through the shedding harness and reed of the loom is accomplished by an operation termed "looming," which is usually performed manually, by seniors of either sex, although it may be accomplished by various types of automatic mechanical appliances, and may be effected by any one of three optional methods, namely: (1) Drawing-in; (2) twisting-in; and (3) tying-in, which is sometimes adopted as an alternative method to twisting-in, and is usually performed mechanically. In some instances, however, warps that are produced from very thick folded yarn, as employed in some net leno and other fabrics containing "corded" warp threads; warps produced from yarn composed of artificial silk, glazed or polished; and other yarn which is of a wiry and refractory character, are sometimes tied-in by hand.

1. Drawing-in

The operation of drawing-in consists of drawing the warp threads separately first through the shedding harness, and then, usually in pairs, between the dents of the reed, and is the only method of looming by which warp threads may be passed for the first time through any new harness and reed. Drawing-in is also essential whenever the threads of a new warp require to be passed through the shedding harness with a different order of drafting from that of the previous warp, even if the same harness and reed are employed, and also if both warps are identical as regards the counts of yarn and number of warp threads.

If, however, the same order of drafting is to be adopted for the new warp as that of the previous warp, and provided the " setting " or counts of the harness and reed is the same in both cases, and also that the counts of yarn and number of warp threads in both the preceding and succeeding warps are the same, or even approximately similar, it is usual, under these circumstances, to adopt the manual twisting-in method of looming, which is both easier and cheaper than manual drawing-in, although the operation of looming may be effected much more expeditiously and economically either by mechanical drawing-in, twisting-in, or else tying-in, whenever circumstances are favourable to either of those operations being performed automatically.

If warp threads are required to be passed through the eyes of a jacquard harness, any operation of looming must necessarily be performed at the loom itself, as it would be quite impracticable to remove the jacquard machine with its harness mounting away from the loom for that purpose. If, however, warp threads are to be drawn through a heald harness, it is usual to adopt the more expedient practice of performing that operation in a separate looming department, where the threads of new warps may be passed through duplicate sets of healds and reeds, without the necessity of waiting until the previous warps are finished in the looms, and of keeping these stopped whilst the new warp threads are being drawn through the same healds and reeds that were employed for the previous warp.

§ 346. If the operation of drawing-in is performed in the looming department, the warp beam and healds are suspended in a vertical stand which is adapted suitably for the purpose of supporting the warp beam in an elevated position, to permit of the warp threads drooping immediately behind the healds which are secured firmly in the same relative positions that they will occupy when they are gaited up in the loom, and as represented in Fig. 196. The warp threads are then ready for the operation of drawing-in, which requires to be performed with great care to avoid what are termed

" misdrafts," that would cause wrong interlacings of warp and weft, and thus produce faults in the cloth, during weaving.

The actual drawing-in of the warp threads is, therefore, usually performed by a senior of either sex who sits *in front* of the harness and is assisted by a boy or girl, described as a " reacher-in," who sits *behind* the harness on the same side as that on which the sheet of warp threads droop. But the procedure varies amongst operatives in different weaving mills, chiefly according to personal preference, and also, in some measure, according to the particular character of the work as regards both the type of shedding harness and the class of fabrics to be woven.

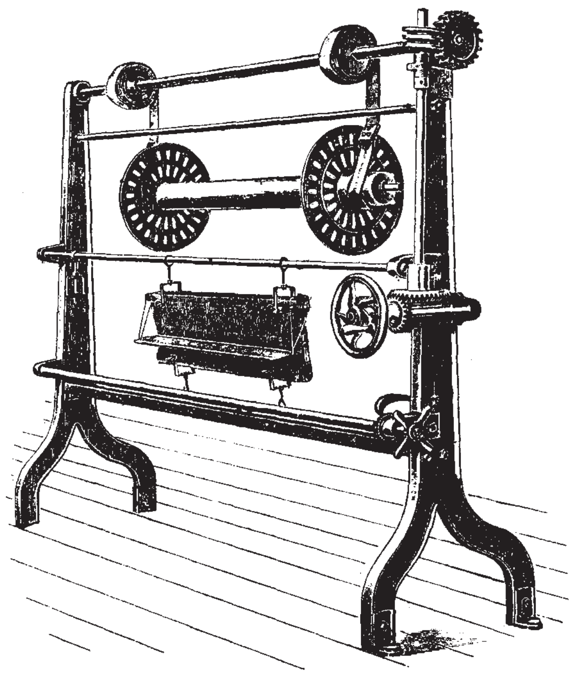


Fig. 196.

Under ordinary circumstances, however, it is usual to commence drawing-in on the *left-hand side* of the harness when facing it, although this practice is quite optional and is not governed by any technical consideration. The reacher, with the right hand, then proceeds to select the warp threads from a bunch held in the left hand, and delivers them in consecutive rotation to a reed-hook which is inserted through successive eyes of the harness by the drawer-in, who draws the warp-threads forward through those eyes in a prescribed order indicated by the drafting plan.

§ 347. In the task of selecting warp threads to deliver them in their proper rotation to the reed-hook of the drawer-in, the reacher is assisted by what is known as a " lease," of which there are several different forms, according to the purpose which they are intended to serve. Thus, there is the imperfect form of lease termed the " slasher's lease," which is obtained by inserting the short dents or teeth of a slasher's half-reed or comb between the warp threads of slasher-sized or other beamed warps, for the purpose of retaining those threads in their proper relative positions, as described in § 182.

A slasher's or comb lease, however, does not constitute a perfect division of warp threads into uniform groups, and is liable, therefore, to cause the warp threads to be somewhat crossed after being drawn in, so that they tend to pull and strain at the lease-rods and to break during weaving, and thereby impede production. For these reasons this form of lease is adopted only when there are no means of obtaining an " end-and-end " or " looming " lease, which is the only perfect form of lease, inasmuch as it disposes the warp threads alternately into an odd and an even series, constituting two distinct sheets of threads that cross each other, thus ><, in such a manner that they may be selected from the lease only in their proper rotation, and without the risk of being crossed excepting by culpable negligence on the part of the reacher-in.

§ 348. When warp threads are drawn through a heald harness with a perfectly regular and simple order of drafting, such as that employed for plain, twill, and other simple weaves, an expert drawer-in usually employs a double hook, consisting of two separate reed hooks of different lengths inserted in the same handle, about half an inch apart, and parallel with each other, whereby two warp threads may be drawn through separate heald eyes simultaneously, and thus increase the speed of drawing-in.

After the warp threads are drawn through the harness eyes, they require to be passed through the reed, usually with two threads in each dent. If the work is of a simple character, that function is usually performed concurrently with the operation of drawing-in the warp threads through the healds, and is accomplished by fixing the reed in a flat horizontal position, immediately in front of the healds, and about an inch lower than the heald eyes, as in Fig. 196.

Thus, as successive pairs of warp threads are drawn forward through their respective heald eyes, the drawer-in passes them immediately under a special form of a broad and thin hook, usually made of boxwood, and inserted from *abovc*, between successive dents of the reed, but withdrawn from *below*, thereby drawing the warp threads also through the reed.

When drawing-in warp threads for what is described as " fancy," as distinguished from " plain," weaving, however, and as exemplified in such weaves as require an irregular scheme of drafting, it is a common practice first to draw these threads separately through their respective harness eyes until all the threads are drawn in, and afterwards pass them between the dents of the reed in a manner similar to that just described.

A more approved method of procedure, however, when drawing-in warp threads with an irregular scheme of drafting through the eyes of a heald harness is, first to draw all the warp threads through their respective heald eyes only, with the warp beam elevated so that the warp threads droop immediately behind the healds, as in the two methods described previously. After all the warp threads have been passed through the harness eyes in this manner, the warp beam is placed on the floor, and the reed is then fixed immediately above, and resting upon, the upper heald-staves, in a reclining position, thus /, and preferably with a broad strip of white paper placed immediately below it, whereby the divisions of the reed are revealed more distinctly to the vision of the drawer-in.

The *reacher in*, who remains at the back of the healds, on the beam side, then performs the duty, *temporarily*, of *drawing-in*, and proceeds to draw the threads through the reed by means of a short and broad metal denting or reed-hook, which is served with warp threads by the *drawer-in*, who remains on the same side in front of the healds and assumes, *temporarily*, the part of a *reacher-in*. When the operation of drawing-in a warp is completed, the warp beam, healds and reed are all taken together to be fixed in the loom and " gaited-up " ready for weaving.

§ 349. Although the operation of drawing-in does not demand, on the part of either the drawer-in or the reacher-in, any mental or strenuous physical effort or special technical ability, it is, nevertheless, a most tedious and monotonous occupation, requiring dexterity combined with diligence. It also imposes a strain upon the vision in selecting the warp threads, harness eyes, and dents of the reed in their proper order to prevent the risk of misdrafts; for should these occur, it will be necessary to withdraw all the misplaced warp threads, and then redraw them in their proper positions; otherwise the misdrafts would be liable to cause more or less conspicuous defects in the cloth.

Indeed, it is asserted that drawers-in, more than any other class of textile workers, suffer more frequently from the distressing effects of eye-strain; especially if they are employed constantly in drawing-in coloured warp threads; or engaged upon healds and reeds of fine counts; or if the lighting is inadequate; each of which conditions has a very injurious effect upon the eye-sight, with the result that the work becomes still more difficult, and the risk of misdrafts consequently increases.

Therefore, with the object of facilitating the operation of drawing-in, both by relieving the drawer-in of excessive visual strain and also by expediting the work, there have been devised numerous mechanical appliances, of which there are but very few, however, that have met with any measure of appreciation or that have been adopted extensively.

These mechanical devices assume quite a variety of different forms, ranging from simple hand-tools that are designed merely to facilitate or expedite the work of drawing-in, to elaborate machines of the most ingenious conception and intricate construction, and which are capable of performing the function of drawing-in warp threads through both the heald-harness eyes and dents of the reed simultaneously and automatically with the greatest precision, at the almost incredible rate of 260 warp threads and 130 dents per minute.

But whatever special merit these devices may possess economically as auxiliary aids, their functions are of such a subsidiary character, both from a technical and a commercial aspect, that it is proposed only briefly to describe the cardinal features of several of the more typical examples of these devices, which, from some special merit they possess, have succeeded in establishing themselves with some measure of appreciation in their respective spheres of usefulness.

§ 350. One of these devices, described as a "sleying" or "denting" hook, is a simple and ingenious hand tool that costs only 5s., and is specially adapted for "denting" of a simple and regular character (although it is employed also in some sections of the "fancy" weaving trade), for the purpose of passing the warp threads between the dents of the reed, concurrently with their being drawn through the harness eyes.

This device is illustrated in Fig. 197, which represents several views of an improved form of a German invention, patented in 1906, and which consists essentially of a long, flat, steel hooked blade A—either curved, as in the original invention, represented at A¹, or else straight, as in Smith's modification, patented four years subsequently—and a forked spring clamp B fixed to a small wooden handle. The spring clamp grasps the base of the hooked blade, freely but firmly, and in such a manner that by a simple downward and upward movement of the blade, when this is inserted between the dents of the reed, the blade is thereby propelled along the successive dents which are selected in their proper rotation, mechanically, and entirely unaided by the vision of the drawer-in.

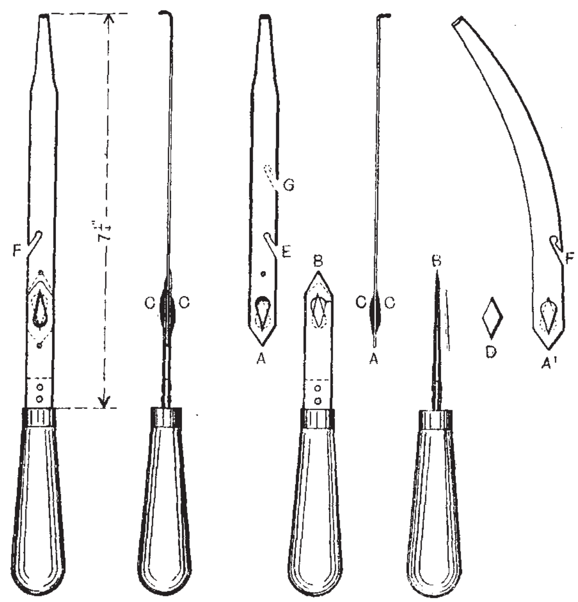


Fig. 197.

The special object of forming this denting hook with a straight instead of a curved form of blade is to prevent the free end of that blade—which is bent over at right-angles for about an eighth of an inch, thus ┐—from hooking or catching on to the heald-twine during the operation of drawing-in.

Another modification, of a very trivial character and of no real advantage whatever, to the user, was patented by Johnson in 1911, and is effected by slightly varying the shape of the two *reversed* metal studs or buttons C that project a little on each side, near the base of the hooked blade, and which enter holes of exactly the same size and shape formed in the forks of the spring clamp to retain that blade in position, with a firm and yet a yielding grasp.

This modification is effected simply by forming those studs with *both ends pointed* to form diamond-shaped studs, as represented at D, instead of forming them with *one end pointed* and *one end rounded*, as in the original conception, and which are, indeed, preferable to the diamond-shape of studs, by reason of their greater circumference.

A still further modification of this denting hook, and one which is the conception of an ingenious drawer-in who adopted it for his own special and personal benefit, is effected by constructing, in the blade A, an additional slit or hook, placed about an inch or more further from the first hook, as indicated at G by dotted lines, so that in the rare event of one or both of the warp threads, that are to pass through the same dent of the reed, being missed by the first hook E, the blade may be returned through the *same* dent before it has selected and entered the next one, whereby the missing thread or threads may be passed under the second hook F and drawn through the correct dent of the reed. Although this particular modification has not been patented, yet, like those noticed previously, it emphasizes the ease and readiness with which an original invention of real merit may be seized upon and modified in trivial and quite unimportant details of construction, unless an inventor is cautious enough to protect himself against such risk by a clear and comprehensive statement of claims embracing minor modifications.

§ 351. When this form of denting hook is employed, the blade is inserted from below the reed, through the first dent to be filled, on the extreme left, with the hooked edge *facing* the drawer-in, who holds the handle constantly by the *left* hand and draws the warp threads through the heald eyes by means of the usual form of double drawing-in hook held by the *right* hand. Then as each successive pair of warp threads is drawn through the heald eyes, they are passed at once on to the " denting " hook, which is pulled downward to pass those threads through the reed, and then returned immediately for the next pair of warp threads, and so on, until the operation of drawing-in is completed.

Therefore, by selecting the dents of the reed mechanically in the manner described, the use of this device relieves the drawers-in entirely of the visual effort of selecting the dents by the usual method, whereby they are at liberty to concentrate their attention entirely to the healds, without requiring to do more than just glance at the reed occasionally for reassurance that the work is progressing satisfactorily; and for plain work, this device is highly commended.

It is affirmed, by users of this device, that it increases their efficiency as much as 10 to 25 %, according to their previous capabilities and the particular class of work on which they are engaged.

Many other mechanical appliances of various types have been conceived with the object of facilitating the operation of drawing-in warp threads either through the eyes of a heald harness only, or else between the dents of a reed after all those threads have been passed through the heald eyes. These devices, however, do not operate automatically, but serve only to select, by mechanical means, either the heald eyes or else the dents of the reed in consecutive rotation, and require to be operated, intermittently, by an attendant, who also delivers the warp threads to the drawing-in hook by hand, in the usual manner. Machines of this character, therefore, have a very limited productive capacity, and are of so little practical utility in a properly-organized weaving mill that they have not received the general approval of British manufacturers.

Automatic Warp Drawing-in Machine

§ 352. It has been stated previously, in § 349, that the entire operation of drawing-in warp threads through both the heald harness and the reed, simultaneously, is sometimes performed quite automatically by means of a special type of machine designed for that purpose. This machine is operated under the personal supervision of a senior attendant of either sex, with junior assistants to perform minor duties incidental to the use of the machine, which selects the warp threads separately and delivers them in consecutive rotation to a hook which draws them through the heald eyes and between successive dents of the reed simultaneously by a single operation, and with unerring precision, at the enormous rate of 250 to 260 threads per minute.

In addition to this, the machine may also be adapted for drawing the warp threads through three banks or rows of drop-wires, that are sometimes employed in conjunction with certain types of automatic warp-stop devices as applied to some power-looms.

The automatic warp drawing-in machine referred to is that invented by Field, Hathaway & Lee, as illustrated in Fig. 198, and introduced into this country from America in 1909 by the agency of Weaving Appliances Limited. The advent of this machine constituted an important development with far-reaching influence in promoting the welfare of the weaving industry, by solving in a con-

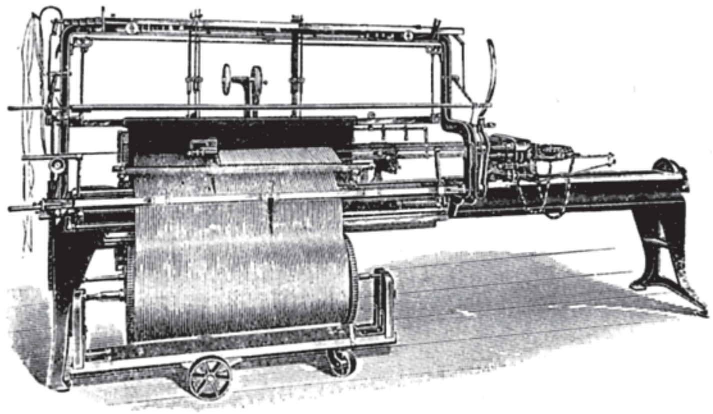


Fig. 198.—Automatic Warp Drawing-in Machine.

clusive and thoroughly practical manner the erstwhile difficult problem of drawing-in warp threads through both the shedding harness and reed simultaneously by a single operation performed mechanically and automatically, and in a manner that confidence in the efficiency and reliability of that machine, for the particular sphere of work for which it is expressly adapted, is quite established.

This machine is a triumph of mechanical invention, and in the ingenuity displayed in the construction and combination of the numerous and intricate parts composing it, all of which operate in perfect harmony and perform their respective and sometimes very delicate functions with considerable dexterity, it is probably not surpassed by any other machine incidental to the weaving branch of the textile industry.

Nevertheless, when in operation, drawing-in warp threads even at the rate of 250 to 260 per minute, the working parts of the machine operate harmoniously and with such rhythmical sequence, precision, and rapidity, that the performance appears to be almost of quite a commonplace character.

Since the special function of this machine, however, is essentially one affecting only considerations of an economic rather than those of a technical character in the general routine of manufacturing, and not one that involves any modification whatsoever in its effect either upon the character of the yarn or the disposition of the warp threads—such as, for example, those produced during the operations of winding, warping, and sizing—it will serve the present purpose to give a brief but concise description only of the cardinal features and operation of the machine, as follows:

§ 353. The chief groups of mechanism constituting this machine are classified under five distinct divisions—namely: (1) THE DRAWING HOOK OR NEEDLE DRIVE; (2) THE REED OPENER; (3) THE HARNESS EYE SELECTOR; (4) THE WARP THREAD SELECTOR; (5) THE DRAWING HOOK OR NEEDLE STRIPPER.

1. THE NEEDLE DRIVE comprises the drawing-in hook, termed the needle, and all other mechanism incidental to the operating and guiding of that hook between the dents of the reed and through the heald eyes, and it constitutes the leading group of mechanism in relation to which all other working parts of the machine are adjusted and timed to act in unison.

2. THE REED OPENER consists of a thin circular disc formed with a spiral edge or rim, by means of which successive dents of the reed are selected and opened out sufficiently to ensure the proper entering by the drawing hook for any number of successive thrusts, according to the number of separate warp threads to be inserted in each dent.

3. THE HARNESS EYE SELECTOR constitutes a most ingenious feature of the machine, and performs one of the most delicate of its many functions by selecting from the respective healds, successive eyes, and presenting them with their apertures directly facing the drawing hook, which may draw one or more than one warp thread in succession, but not two or more warp threads simultaneously, through each heald eye, as required.

4. The Warp Thread Selector is another very ingenious device, which selects the warp threads separately and delivers them in consecutive rotation to the hook of the needle, which immediately draws the respective threads through the particular heald eye and dent of the reed penetrated by that needle.

5. The Drawing Hook Stripper consists of a device for the purpose of removing the warp threads from the drawing hook, by striking those threads downward immediately in front of the reed, to remove them out of the path of that hook as this emerges through the dents of the reed, and thereby prevent the risk of the threads being again caught up by it during the forward thrusts to receive successive warp threads.

§ 354. Any method of power transmission, or direct driving by means of an electrical motor, may be employed to operate these machines, which are constructed with different capacities ranging from two to eight staves of healds only, or else up to six healds in conjunction with one, two, or three rows of warp-stop drop-wires.

These machines, however, are restricted to drafting plans of a simple and uniform character, such as the plain, twill, V-pointed or herring-bone, broken or skip, and other similar schemes of drafting plans. They are not adapted for drawing-in warp threads with an intricate and irregular scheme of drafting, such as sometimes becomes necessary in certain branches of "fancy" weaving; albeit they are capable of drawing-in any prescribed number of separate warp threads through each heald eye and dent of the reed, either uniformly or at specified intervals apart, to produce corded or ribbed effects in cloth.

They are also capable of dropping or casting-out surplus heald eyes, if it is required to employ a set of healds for a reed of coarser counts than that for which they were knitted. Thus, if, for example, it is required to employ, with a 56's reed, a set of any number of healds that have been knitted for a 64's reed, the machine would drop or leave empty eight out of every sixty-four eyes, or one in eight, by drawing warp threads through seven eyes, and missing one on each heald stave, uniformly.

The functions of selecting the particular number of warp threads to be inserted in the respective heald eyes and dents of the reed, and also that of leaving heald eyes empty, in a prescribed order, are governed by means of automatic selecting mechanism controlled by perforated metal pattern cards, in a manner analogous to the controlling of a multiple shuttle-box motion of a check-loom.

The machines may be constructed for any practicable width of reed-space or any counts of yarn; and with an expert operator one machine is capable of drawing-in an aggregate of 70,000 warp threads through 30 different sets of healds and reeds during a working day of ten hours, at a net average rate of 120 threads per minute, including all necessary stoppages for the rectifying of errors and the replacing of harnesses and warps.

2. Twisting-in

§ 355. As stated previously in § 345, the operation of "twisting" is an alternative method of "looming" whereby the threads of a new warp are united, *separately*, by means of a peculiar twisting, to the corresponding remnant threads of a previous warp whilst these threads are still retained in the shedding harness and reed. It is therefore restricted to new warps that are to be controlled by the same harness and with precisely the same scheme of drafting as were employed for the previous warp, which must also correspond, approximately, with the new warp, both in the character and counts of yarn from which they are produced. Otherwise, the twistings by which the threads of the respective warps are united will tend to untwist and break down immediately on being subjected to tensile strain when "straining up" the warp in the loom, in order to draw forward the piecings of the warp threads and pass them quite clear through both the harness eyes and the dents of the reed before commencing to weave the cloth.

The circumstances under which the twistings, by which the warp threads are united, are more liable to untwist and break down are specified as follows: (*a*) If the respective warps are produced from yarn of different counts; (*b*) if one warp is produced from normal yarn and the other from mercerized, glazed or polished yarn; (*c*) if one warp is produced from single yarn and the other from folded yarn; (*d*) if either one or both warps are produced from artificial silk (which is usually tied-in by hand); and (*e*) if both warps are produced from folded yarn in which the doubling-twist runs in reverse directions, respectively.

§ 356. Although the function of twisting, like that of drawing-in, is at the present time usually effected by hand, and performed by seniors of either sex, it is now actually accomplished, with a great measure of practical success, by means of an automatic mechanical device, described briefly in § 358.

As a manual operation, the function of twisting, like that of drawing-in, does not demand, on the part of the twister, either physical exertion or special technical ability. It is, nevertheless, a most wearisome and monotonous task, amounting almost to drudgery, which is totally devoid of any interest whatsoever, and for which manual dexterity, combined with patient diligence and care, is the only qualification required to ensure proficiency both in speed and avoiding the risk of missing and crossing the warp threads.

The operation of twisting, like that of drawing-in, may be performed optionally either at the loom itself or else in the looming department, if the warp is to be governed by a heald harness; but if it is to be controlled by a jacquard harness, the operation of twisting must then be performed at the loom.

§ 357. The usual method of procedure when preparing to twist a warp to be controlled by a heald harness is to support, in opposite ends of a suitable frame or stand, as represented in Fig. 199, both the new warp beam and the heald harness and reed containing the remnant threads of the old warp, with the warp beam and healds placed about 4ft. apart, to provide sufficient space for the twister, who sits between the two series of warp threads, usually with the healds on the left-hand side, and the warp beam on the right. In this case, the twister performs the actual twisting by means of the thumb and index finger of the left hand, although there is no technical reason why a twister may not, at the commencement, reverse these conditions, and twist with the thumb and first finger of the right hand, a course which is, on very rare occasions, sometimes adopted in actual practice. Indeed, ability to employ either hand for twisting would be a great advantage in the event of a twister being disabled because of some trivial injury to the hand usually employed, and which would otherwise involve loss of work and wages.

When the healds and warp beam are fixed properly in position, the twister then gathers from each warp a small group of about 100 to 200 threads, more or less, according to the counts of yarn, and ties the end of each group into a knot, after which both groups of threads are inserted together through what is termed a "twister's hook," consisting of a wire ring about 2in. diameter, and formed with a narrow neck or loop about $1\frac{1}{2}$in. long, to the extreme end of which there is brazed a curved piece of steel formed with a ground cutting

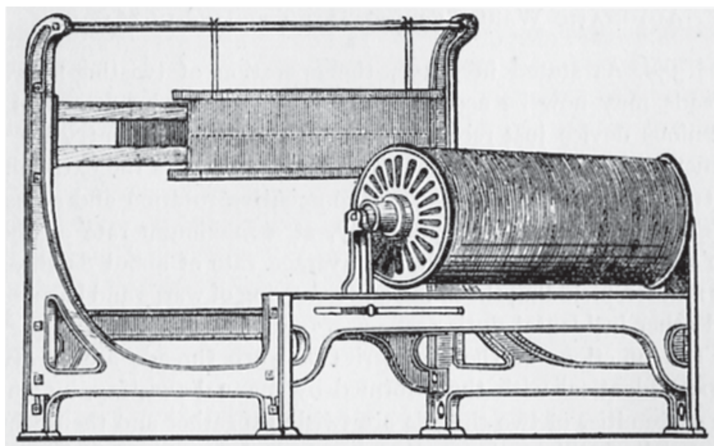


Fig. 199.

or breaking edge, against which the warp threads are severed as they are selected in succession for twisting together.

The twister's hook or ring is attached (with the break-edge downward) to a cord which is tied around the waist, and it serves to retain the respective groups of warp threads in an extended form to enable them to be selected readily by the twister, who, being guided by the "looming lease" formed at the end of the previous warp and at the beginning of the new warp, selects the corresponding threads from each group in consecutive rotation, and severs them simultaneously against the lower edge of the steel cutter under which the warp threads are sharply deflected. Then, finally, by an adroit rolling movement of the thumb and index finger of the left hand, the extremities of both warp threads are deftly twisted together, first by twisting the ends without their overlapping each other, and then turning them backward, whilst still rolling and twisting them, upon the new warp thread, so that the severed extremities of the two threads *will point away* from the harness eyes and dents of the reed, and thereby avoid the risk of these obstructing the free passage of the twistings when drawing the warp threads forward *en masse* to bring those piecings well in advance of the reed before commencing to weave.

Automatic Warp Leasing and Twisting-in Machine

§ 358. As stated in § 356, the operation of twisting-in warp threads may now be accomplished automatically by means of an ingenious device just recently introduced into this country by the agency of Messrs Cook & Co. This machine selects the extremities of two series of warp threads in consecutive rotation and actually *twists* them together, automatically, at a maximum rate of about 110 threads per minute, or a net average rate of about 85 threads per minute, including the fixing and removing of warps and harnesses, and other incidental duties.

The junctions of the two series of warp threads are in every respect identical with those formed by manual twisting, by which the extremities of two threads are twisted together and then, whilst the twisting still continues, they are turned downward and twisted upon the *new warp thread* with the severed ends lying away from the harness and reed so that these will not impede the free passage of the twistings, when drawing forward the warp threads, through the harness eyes and between the dents of the reed, ready for weaving.

It is claimed by the makers of this machine that it will twist together with equal success not only threads of the same kind of staple as cotton, linen, wool, mohair, silk and artificial silk of any counts of either single or folded yarn, but also that it will twist together two series of threads composed of different kinds of staple, respectively, as cotton to linen, and cotton to worsted threads.

The successful operation of this twisting-in machine is, however, dependent entirely upon the correct formation of an "end-and-end" looming lease in both series of warp threads that are to be twisted together. Therefore, since there are no means provided in slasher sizing machines for the forming of such leases, and with the object of adapting slasher-sized warps to the conditions imposed by this twisting-in machine, the same inventor has conceived an automatic warp-leasing machine which is capable of separating an expanded sheet of warp threads into odd and even series respectively, to constitute a perfect " end-and-end " looming lease, with absolute precision, at a net average rate of 200 threads per minute, irrespective of the counts of yarn, and density of warp threads.

This object is accomplished by passing two leasing-bands or cords transversely across the sheet of warp threads in such a manner that the respective bands pass under and over consecutive warp threads in alternate succession and in a contrary manner, whereby the " lease " or division of those threads is retained until the warp beam is placed in the twisting-in machine, when the temporary leasing-cords are replaced by thin iron rods. The thread-selecting mechanism is so sensitive and adapted so ingeniously to its special function that, if it fails, during the first attempt, to obtain a warp thread, it will make repeated attempts until that thread is secured; after which the work proceeds normally and without the slightest discrepancy.

The operating of one twisting-in machine in conjunction with two or three leasing devices, and the performing of all duties incidental to the use of these machines, requires the services of a senior attendant of either sex, who prepares the warps both for the leasing and twisting-in machines, and also passes the twistings of the warp threads through the harness eyes and reed; and a junior assistant, of either sex, who attends both to the twisting and the leasing machines.

3. Automatic Warp-tying Machine

§ 359. Another type of automatic machine, conceived with the object of superseding the usual method of warp twisting, is that invented by H. D. Colman, as illustrated in Fig. 200, and known as the Barber warp-tying machine, that was first used in America, in August 1904, and introduced in 1906 into this country, where it has received the approval of many British manufacturers, who have adopted it successfully in many of their weaving mills.

The special function of this ingenious device is to join the extreme

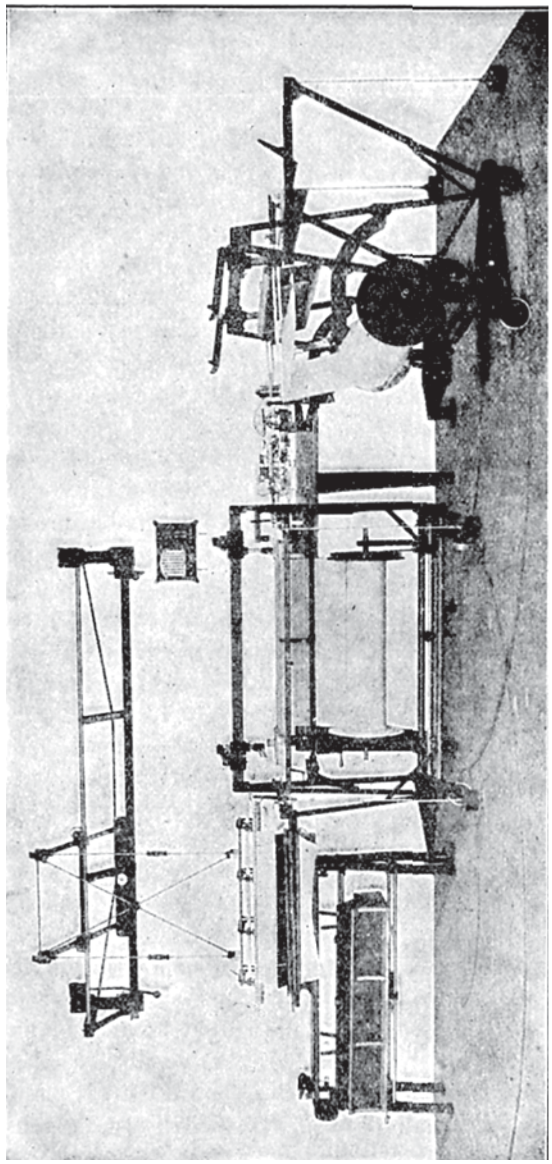


Fig. 200.—Automatic Warp-tying Machine.

ends of two corresponding series of warp threads by tying them together by means of knots, instead of twisting them. This tying-in machine also is a triumph of mechanical invention, and, as such, of real merit not only in its conception and in the ingenious combination of intricate mechanism, but also in the subtle manner in which the various parts of the machine perform their numerous and sometimes very delicate functions, with a perfectly rhythmical sequence and almost infallible accuracy and precision, at the rate of about 250 to 260, and sometimes even 270, warp threads per minute.

This tying-in machine selects, in consecutive rotation, the corresponding threads of the old and the new warps; ties them together by means of winders' or spoolers' knots; trims the knots by cutting off the surplus waste ends to leave them very short; and finally expels the waste material by means of an air-suction or extraction tube, along which it is conveyed and ultimately deposited into a waste-box fixed at one end of the machine.

The thread-selecting devices, which consist of two sharply-pointed spear-like hooks, are so cleverly conceived and adapted for their particular function, that although they are virtually incapable of seizing more than one thread each from either of the two warps at the same time, yet they are capable of selecting threads of slightly different counts of yarn. Also, if the thread selectors meet with certain defects in the warp yarn—as, for example, slubbings or other abnormally thick places, neps, snarls, hard particles of size or other impedimenta—whereby either of the two selectors are prevented from securing the warp threads easily and readily during their first attempt, they will make up to five successive efforts to obtain the same warp thread, and if they still fail to secure it, the machine will stop automatically, and cannot again be restarted until the obstructive thread is rectified by the operator.

The mechanism by which the ends of two corresponding warp threads are actually tied together, and the superfluous yarn cut away from the knots, to leave short tail-ends, is identically the same as the Barber mechanical knotter, and ties precisely the same form of knot. In fact, it is interesting in this connection to note that this ingenious device was conceived originally as an integral unit of the warp-tying machine, and afterwards perfected independently as a separate and distinct device adapted specially as an automatic mechanical knotter for the use of winders and warpers, as described in § 124.

One model of this machine is operated by means of a $\frac{1}{3}$ H.P. electric motor attached permanently to the machine and adapted for direct driving, which is recommended as the most efficient method of power transmission. The machine is also supplied with several auxiliary appliances, comprising two beam-trucks, a harness-loading frame and a small overhead traveller or runway for transporting the healds and reed, containing the remnant threads of the previous warp, into their proper position in the machine ready for the operation of tying-in, thereby saving both time and physical exertion on the part of the operator.

§ 360. The use of this model of a warp-tying machine is virtually, though not of absolute necessity, restricted to grey and mono-coloured warps, and is, therefore, not so well adapted for tying-in multi-coloured warps in which the different colours of warp threads are arranged in *narrow* stripes, although the machine is quite suitable for warp patterns consisting of *broad* stripes, whereby the risk of broken patterns is minimized. There has also been designed a smaller and transportable model of this machine adapted specially for use in the weaving-shed, where it may be placed behind the looms and employed for tying-in warp threads that are governed by means of jacquard harnesses, so that its utility is no longer confined, as formerly, to heald harnesses only. This small model is also provided with a hand-driving wheel to be turned by the operator, although it could be adapted for electric driving also.

The relative productive capacity of a warp-tying machine varies chiefly according to the character, quality and counts of warp yarn, the number of warp threads per inch, the average number of warp threads contained on the weavers' beams, the proficiency of the operator, and many other variable factors. But one machine for 800, 1000 and 1200 looms is considered a reasonable proportion, according to whether the cloth produced is of coarse, medium or fine quality.

In a specific instance, one machine tied 115,600 warp threads during a working day of ten hours, at a net average rate of 193 knots per minute, which represents a net working efficiency of 77% of the maximum rate of 250 knots per minute.

In another instance, one machine, working at the rate of 250 knots per minute, tied five warps, containing 2500 threads each, of about 28's T., or an aggregate of 12,500 warp threads, in one hour, at a net average rate of 208 threads per minute, thereby yielding a net working efficiency of 83%.

One tying-in machine requires the services of a senior skilled operator, and a junior assistant to help in the loading and unloading of the warp beams, to recover and piece missing and broken warp threads that have escaped previous detection during the operation of tying-in; and to perform such other incidental duties as may arise during the progress of the work. When the operation of tying-in is completed, the warp beam, harness and reed are then quite ready for conveying immediately to the loom, without any further preparation whatever, to be gaited-up ready for weaving.

Data relating to Manual Looming

§ 361. *Character of Labour.*—As stated previously, in § 345, the manual operation of looming, by means either of drawing-in or of twisting-in, is variously performed by seniors of either sex, and also that a drawer-in is assisted by a junior reacher-in of either sex.

§ 362. *Production.*—The amount of work which is capable of being performed in a specified time by drawers-in and twisters varies within a very wide range according to many different and variable circumstances; and even with those who are engaged on exactly the same character of warps, it would be quite futile to compare the relative productive capacity of different operatives engaged in either of the optional methods of looming.

Also, the difficulty of such a task would be still greater from the circumstance that, with purely manual work of that character, everything depends upon the human faculty, and such attributes as personal ability, dexterity and special aptitude for the work, qualifications that are in no way assisted either by mechanical agency or any other external influence.

An expert drawer-in engaged on "plain" work has attained a rate of 3000 warp threads per hour, with a net average rate for the week of about 2000 threads per hour. A general net average rate for drawing-in, however, is about 1500 warp threads per hour.

An expert twister-in, engaged on "plain" work, has attained a rate of 2000 warp threads per hour, with a net average rate for the week of 1700 threads per hour. A general net average rate for twisting-in, however, is about 1500 warp threads per hour.

§ 363. *Rate of Wages.*—The rate of payment for both drawing-in and twisting-in varies not only in different localities, but also even in the same district, chiefly according to the different classes of fabrics that are manufactured, and many other circumstances. If, however, the work is of a regular and not of an exceptional character, it is the invariable custom to pay on the principle of piece-work rates of wages, in accordance with some recognized fixed rate of payment based on a specified sum for 1000 warp threads, with certain allowances above and below the standard basis according to such variable factors as the counts of reed, counts of warp yarn, number of heald staves, number of warp beams, plain or multi-coloured warps, and an infinite variety of other items that are too numerous to specify, but, of course, with a different basis for each of the optional methods of looming.

It is proposed, therefore, to specify the rates of wages paid for both drawing-in and twisting-in "grey" (natural colour) cotton warps, according to three of the principal standard lists for "plain" work only, and which are more generally adopted for those alternative methods of looming, viz.:

1. BLACKBURN AND DISTRICT STANDARD LISTS.

(A) DRAWING-IN.—*Basis* (*not* including reaching-in): 5¼d. per 1000 threads for reeds up to 80's counts (= 80 threads per in.); plus ¼d. per 1000 threads for each 10 or fraction of 10 counts of the reed up to 100's counts; finer than which, the same rate is paid for each 20 or fraction of 20 counts of the reed (= 20 threads per in.), irrespective of the counts of yarn.

For drawing-in of an exceptional character, a time-rate of 8d. per hour is paid.

Reachers' wages range from 10s. to 14s. per week, according to age, sex and ability.

(B) TWISTING-IN.—*Basis:* 4d. per 1000 warp threads for yarn ranging from 26's to 80's T.; plus ¼d. per 1000 threads for yarn coarser than 26's T.; and also for each 10 or fraction of 10 counts finer than 80's and up to 100's T.; finer than which, a sum of 5d. per 1000 threads is paid, irrespective of the counts of reed. But if the reed contains only one warp thread in each dent, uniformly, a sum of ¼d. per 1000 threads is to be paid in excess of the above rates.

For twisting-in of an exceptional character, a time rate of 6d. per hour is paid.

2. NELSON AND DISTRICT STANDARD LISTS.

(A) DRAWING-IN.—*Basis* (including reaching-in): 6½d. per 1000 threads for reeds up to 80's (= 80 threads per in.); plus ½d. per 1000 threads for each 20 or fraction of 20 counts of the reed (= 20 threads per in.), irrespective of the counts of yarn.

For drawing-in of an exceptional character, drawers-in are to be paid a time rate equivalent to their average earnings.

(B) TWISTING-IN.—*Basis:* 4d. per 1000 warp threads for yarn ranging from 21's to 60's T.; plus ¼d. per 1000 threads for each 10 or fraction of 10 counts finer than 60's and up to 100's T.; finer than which, the sum of 4¾d. per 1000 threads is paid, irrespective of the counts of reed. For counts of yarn coarser than 21's and down to 15's T., a sum of 4½d.; and for 14's down to 12's T., a sum of 5d. per 1000 threads is to be paid for both single and folded yarn. But all yarn coarser than 12's must be drawn-in and not twisted-in.

Also, if the reed contains only one warp thread in each dent, uniformly, a sum of ½d. per 1000 threads is to be paid in excess of the above rates.

For twisting-in of an exceptional character, twisters are to be paid a time rate equivalent to their average earnings.

3. COLNE AND DISTRICT STANDARD LISTS.

(A) DRAWING-IN.—*Basis* (*not* including reaching-in): 6½d.; but including reaching-in, 8d. per 1000 warp threads, irrespective of counts.

(B) TWISTING-IN.—*Basis:* 4½d. per 1000 warp threads for yarn of counts finer than 15's T.; coarser than which, and down to 10's T., a sum of 5d. per 1000 threads is to be paid.

§ 364. *Weekly Earnings.*—(A) DRAWING-IN.—The amount of wages earned by drawers-in varies within a wide range according to their proficiency, more especially as they are dependent almost entirely on their own individual effort and ability. Hence, their wages range from about 20s. to 46s., and sometimes more, with a general average sum of about 32s. per week, after paying the reacher-in.

§ 365. (B) TWISTING-IN.—Twisters, even to a greater extent than drawers-in, are wholly dependent upon their own individual resources, as they do not employ even a hand-tool of any kind, nor have they any other assistance in their monotonous occupation (like drawers-in with their reachers-in), but perform their task quite alone. Also, as twisting-in requires even a lesser degree of skill than that required for drawing-in, twisters are therefore paid a lower rate of wages, which range from about 15s. to 30s., with a general average of about 24s. per week.

§ 366. *Gaiting.*—" Gaiting," or getting ready, is a term signifying the final preparation of a loom and its numerous appurtenances ready for weaving, and includes the proper adjusting of the warp beam, shedding harness, lease-rods, reed, temples and all incidental accessories, in order to prepare the loom in good working condition before leaving it in charge of the weaver.

In the case of a new loom, gaiting also includes the setting and timing of all the working parts to operate in unison, as well as the equipment of the loom with picking and check-straps, pickers, heald-straps and cords, ropes or chains for the weight-levers of the warp-tension (letting-off) device, and such other incidental parts as are necessary to establish the loom as efficiently as possible and in thorough working order, thereby concluding the final stage in the preliminary operations of weaving.

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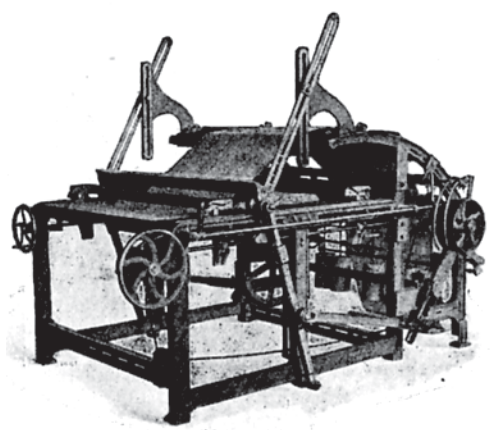

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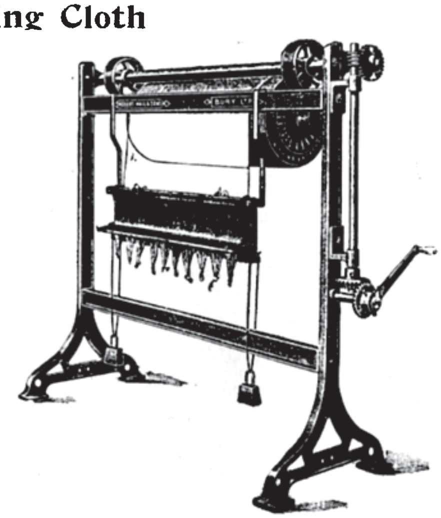

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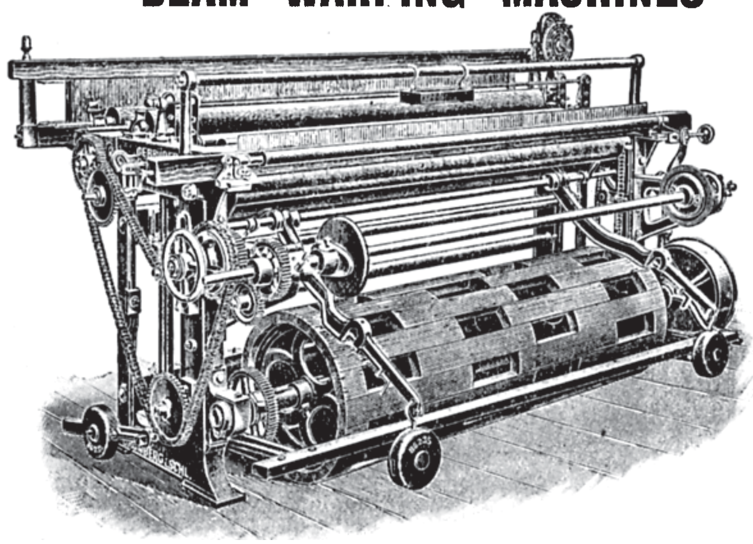

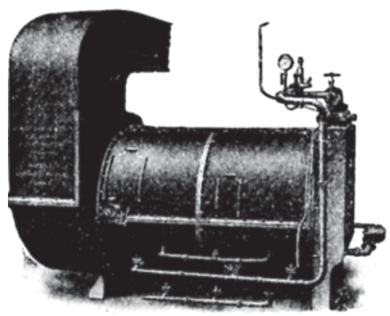

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