"TEXTILE MANUFACTURER" MANUALS

PRELIMINARY OPERATIONS OF WEAVING

H. NISBET

VOLUME I

PREPARATION OF GREY OR PLAIN WARPS

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Preliminary Operations of Weaving

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VOL. I
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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.

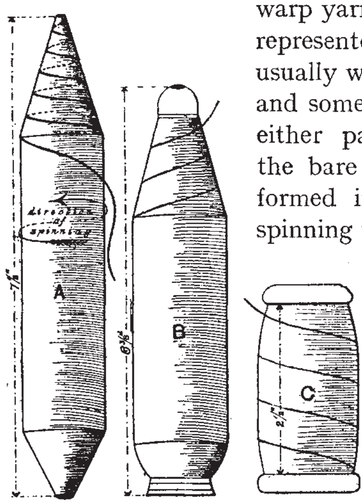

Fig. 1.

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.

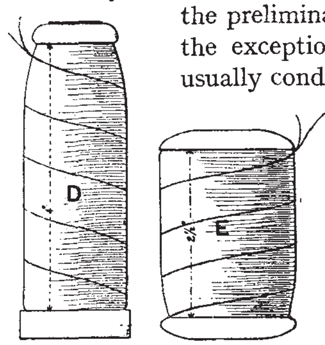

Fig. 2.

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

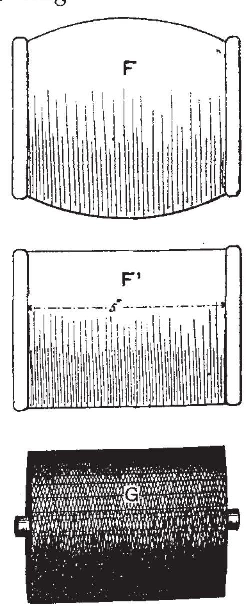

Fig. 3.

"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 $3\frac{1}{2}$in. diameter, a $4\frac{1}{4}$in. chase, and a barrel $1\frac{1}{4}$in. 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;

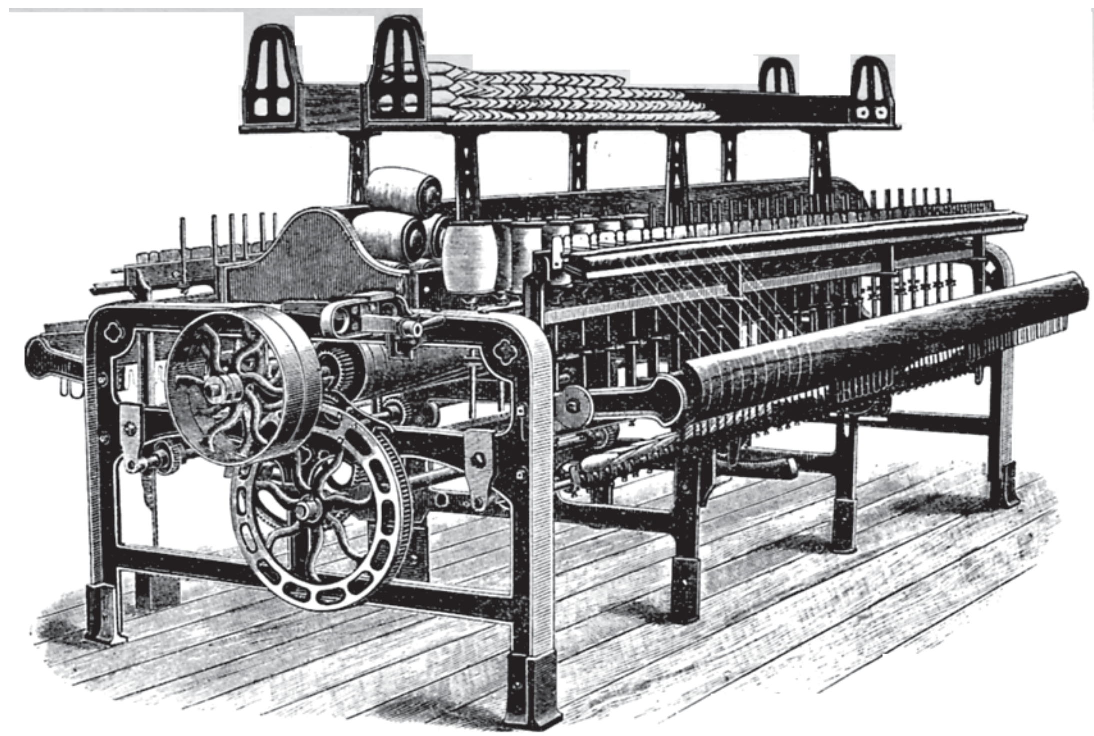

Fig. 4.—Cop or Bobbin Winding Machine.

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.

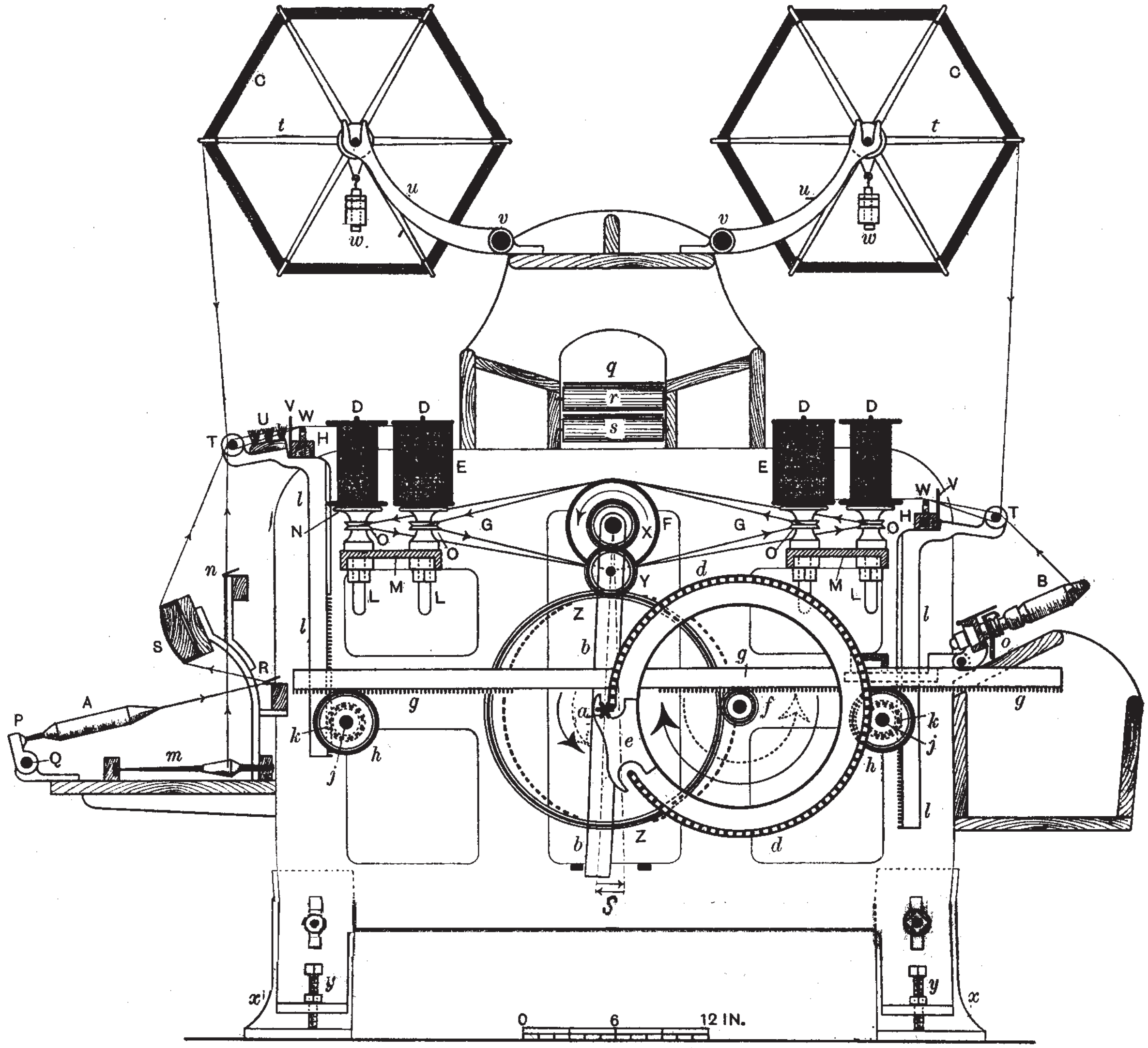

Fig. 5(*a*).—Cop or Bobbin Winding Machine (*End Elevation*).

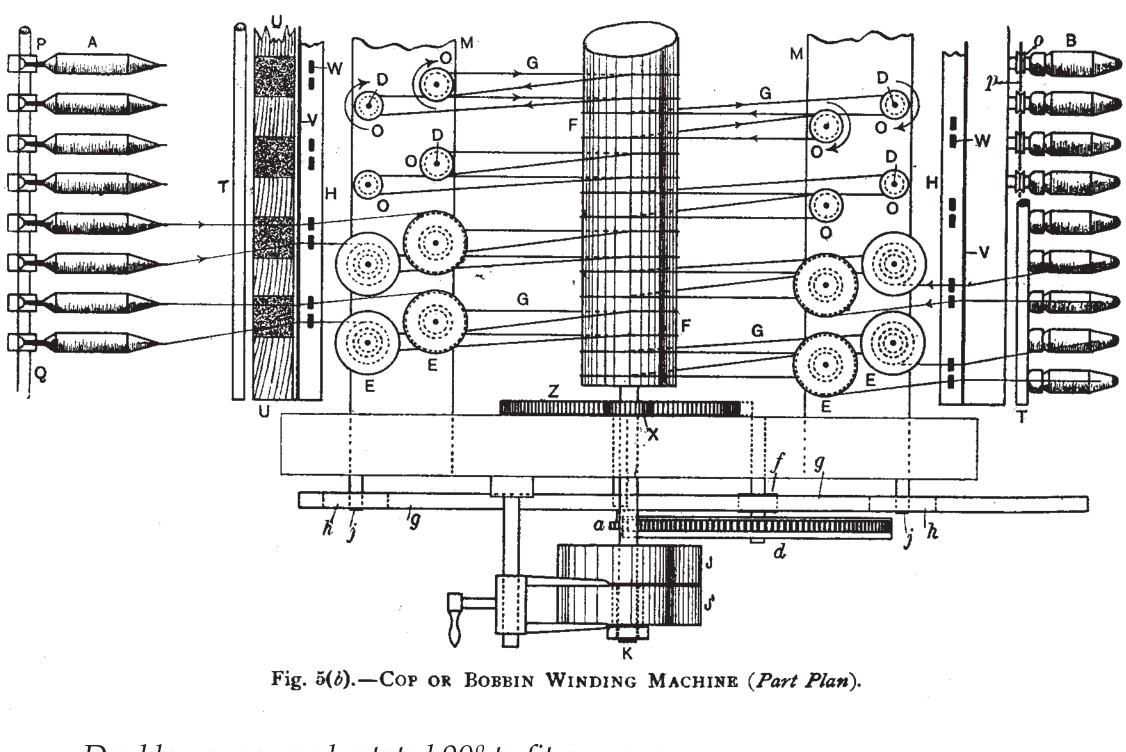

Fig. 5(*b*).—Cop or Bobbin Winding Machine (*Part Plan*).

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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

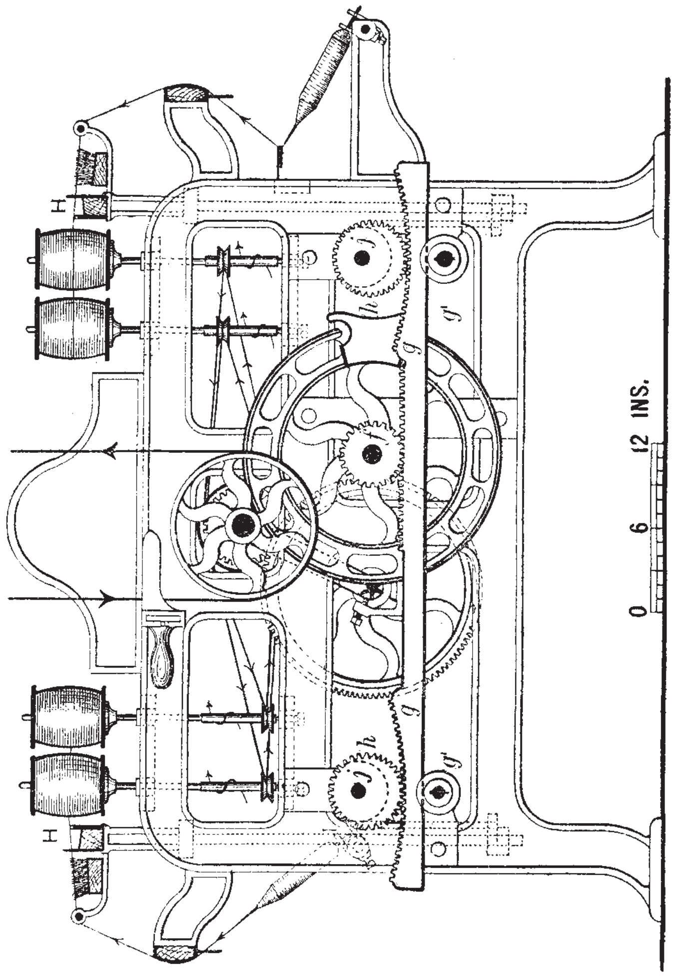

Fig. 6.

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.

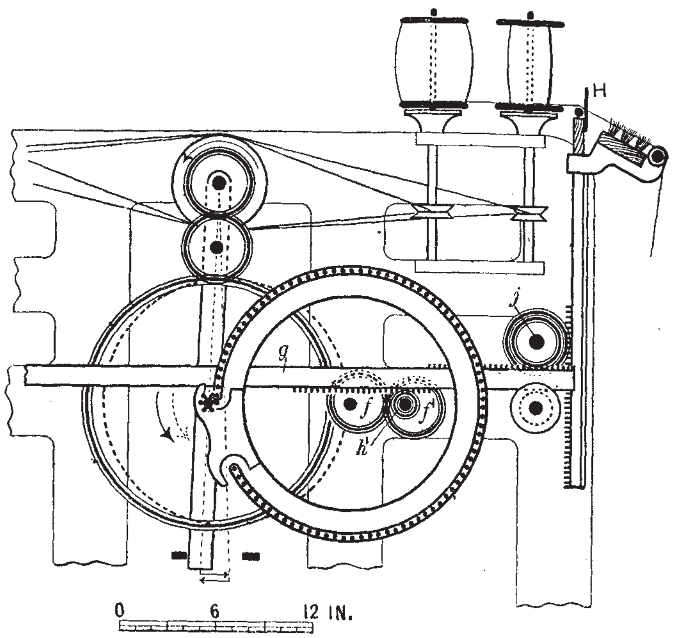

Fig. 7.

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

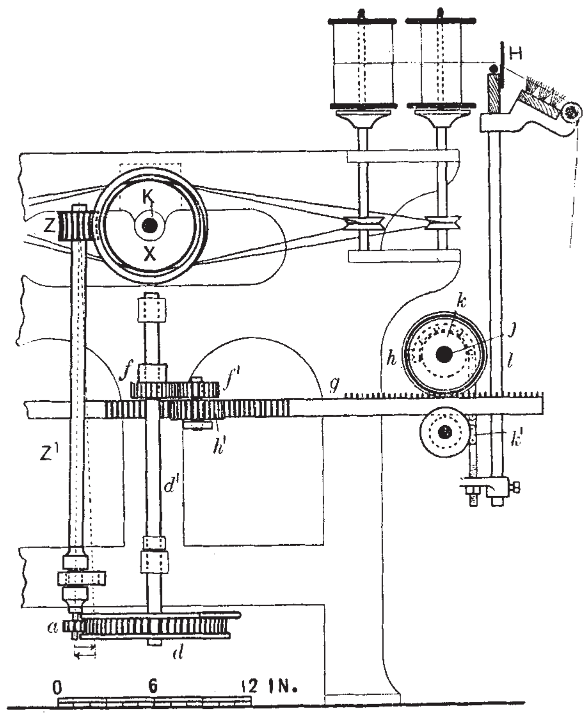

Fig. 8.

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-

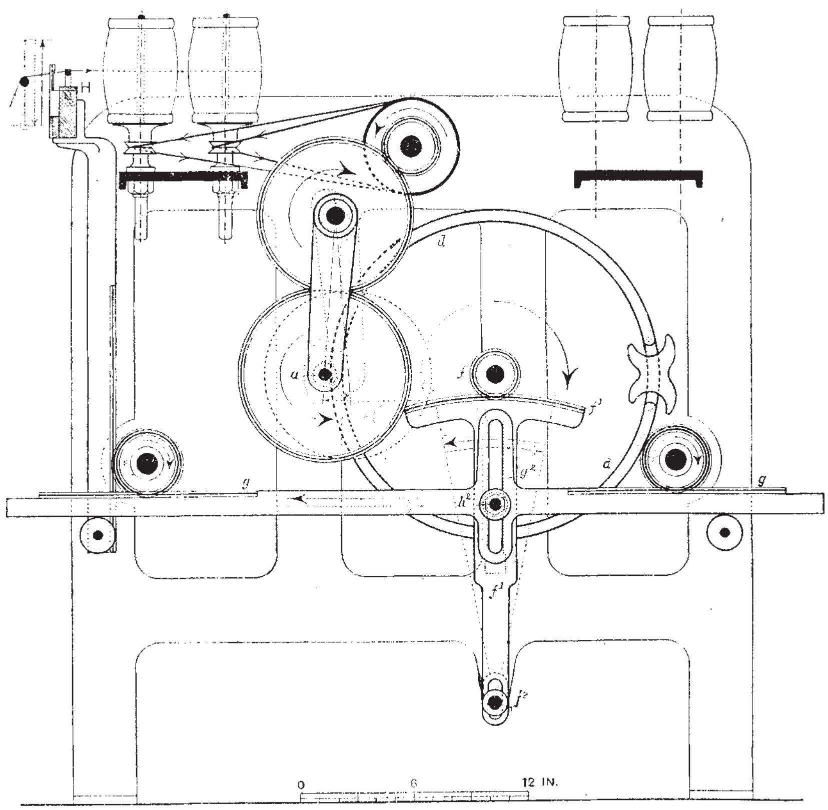

Fig. 9.

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

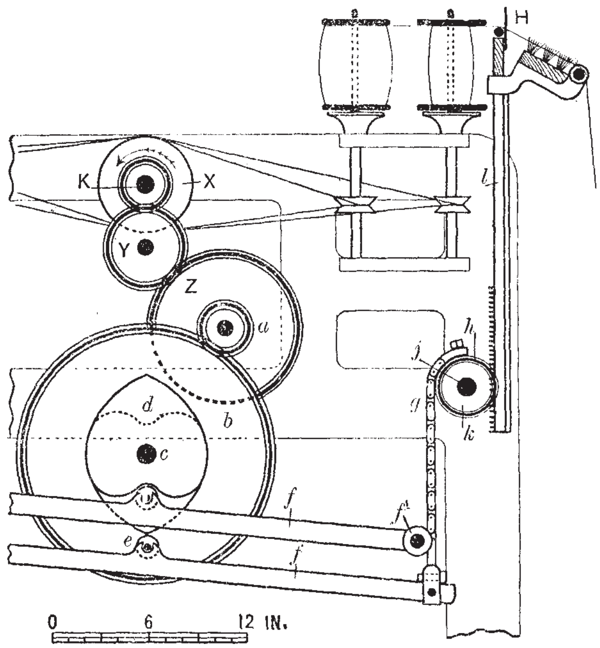

Fig. 10.

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

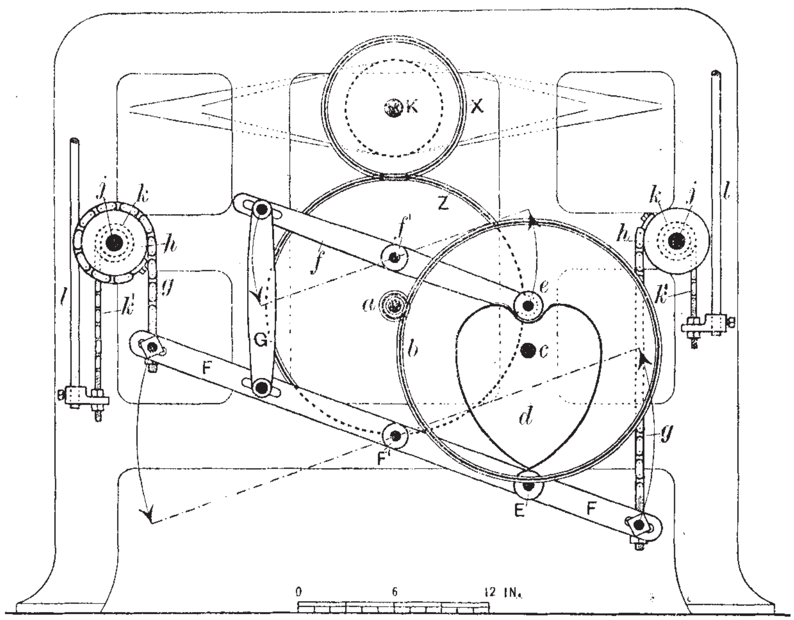

Fig. 11.

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

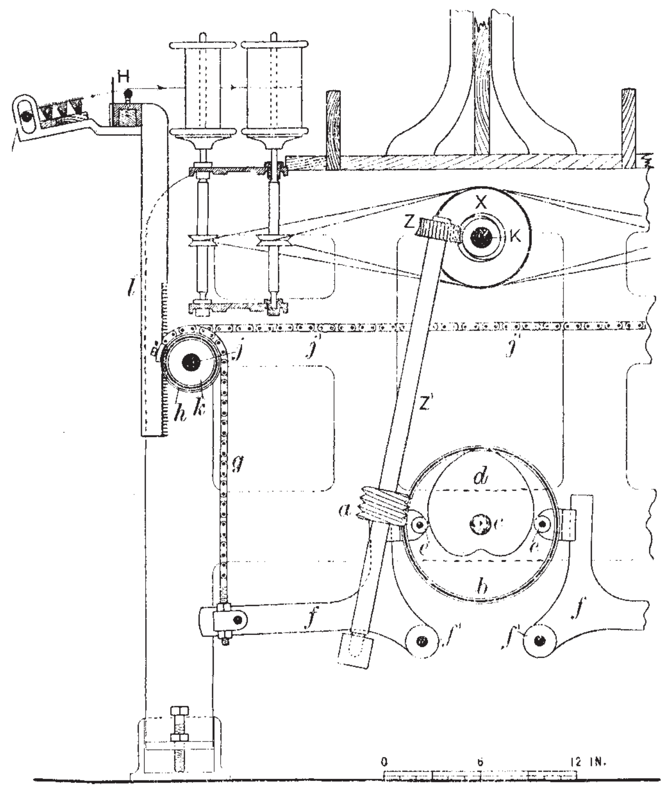

Fig. 12.

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

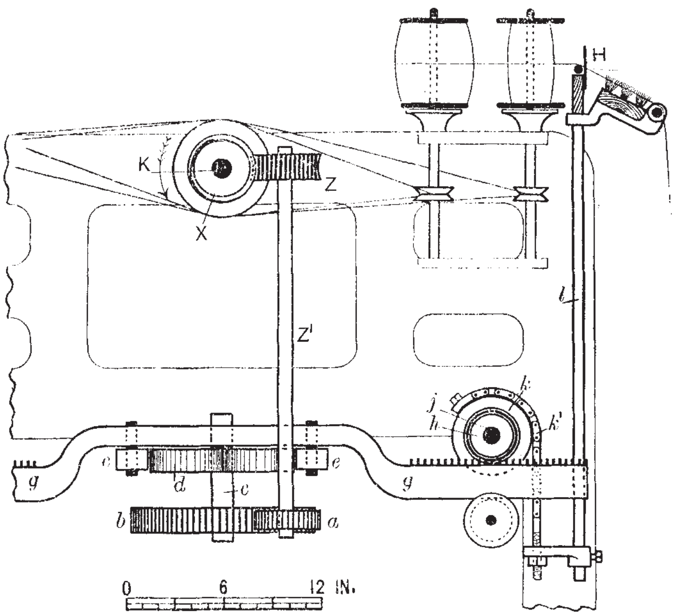

Fig. 13.

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

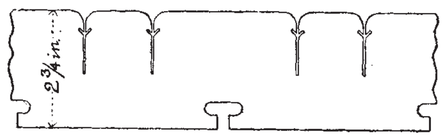

Fig. 14.

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

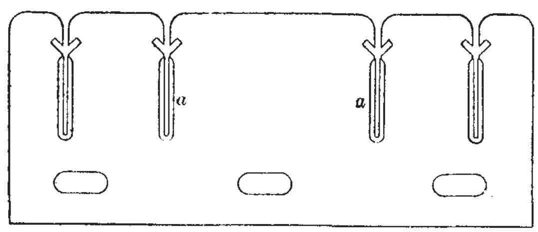

Fig. 15.

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

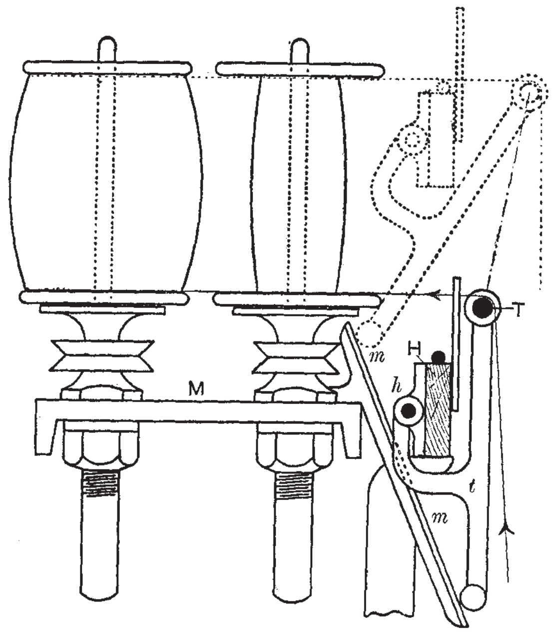

Fig. 16.

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.

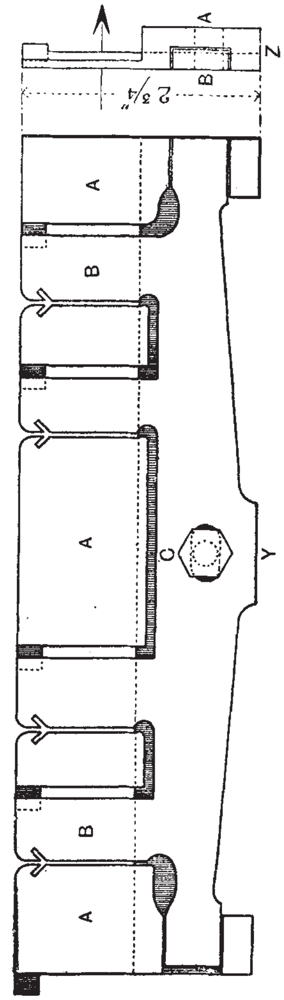

Fig 17

§ 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.

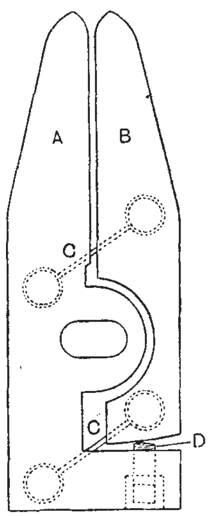

Fig. 18.

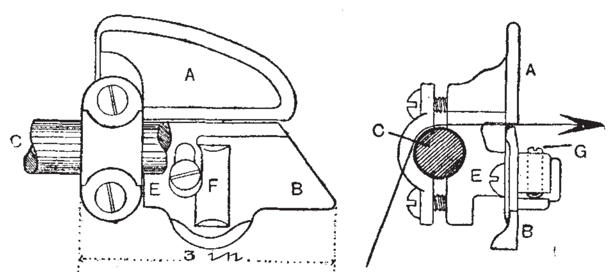

Fig. 19.

§ 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.

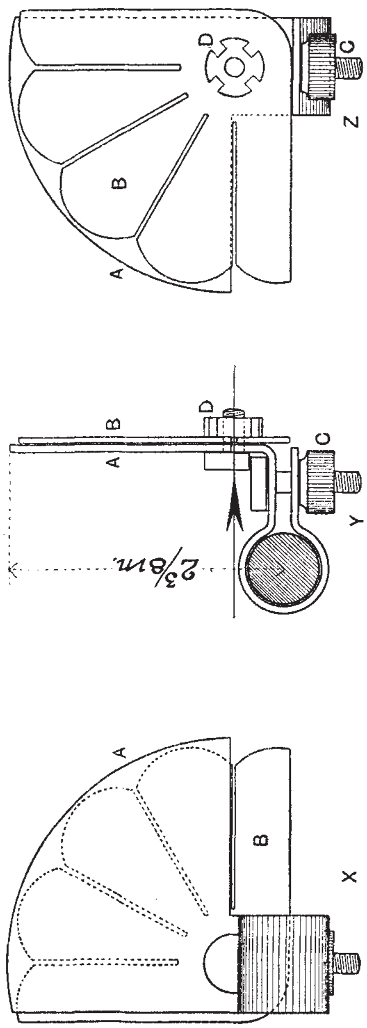

Fig. 20.

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.

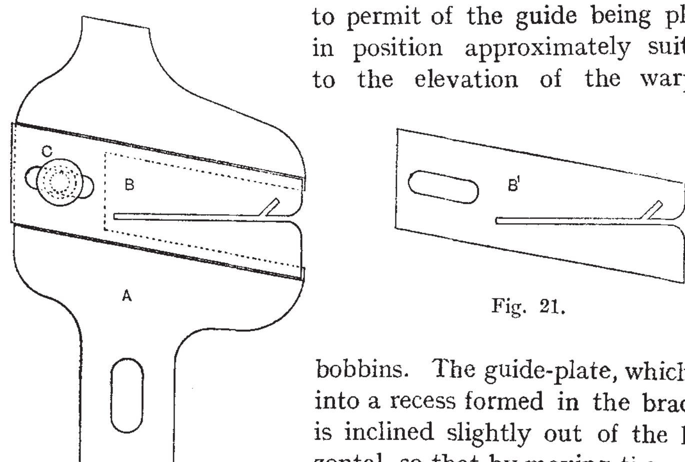

Fig. 21.

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 $4\frac{1}{2}$d. 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

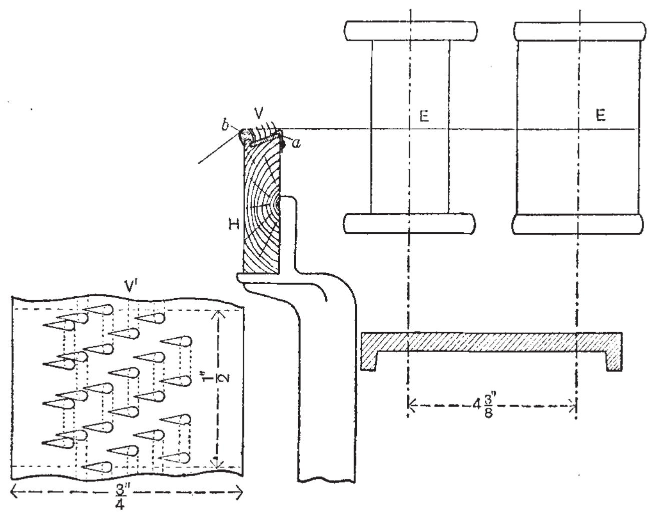

Fig. 22.

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

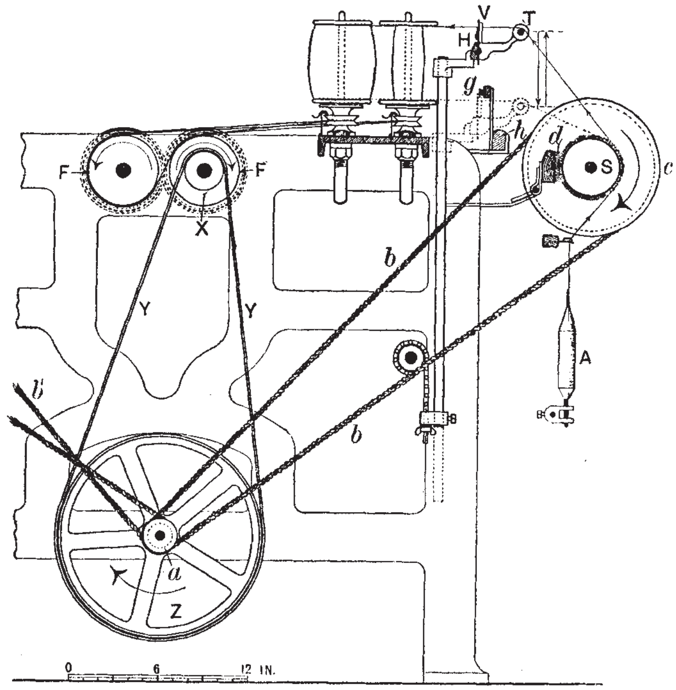

Fig. 23.—HAEMIG'S YARN-CLEANSING DEVICE

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,

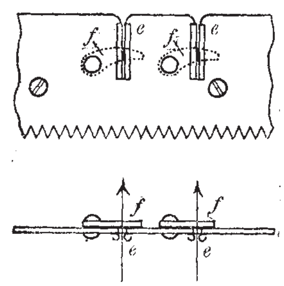

Fig. 23(*a*).

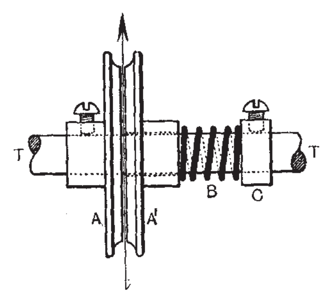

Fig. 24.

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.

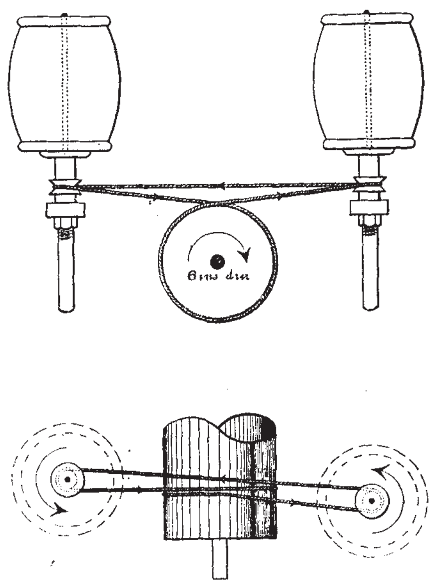

Fig. 25.

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

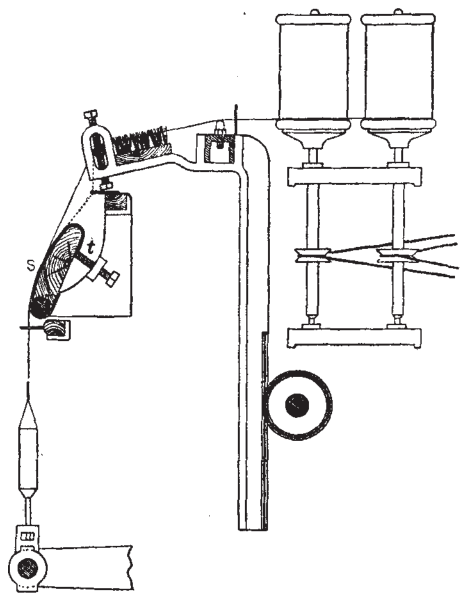

Fig. 26.

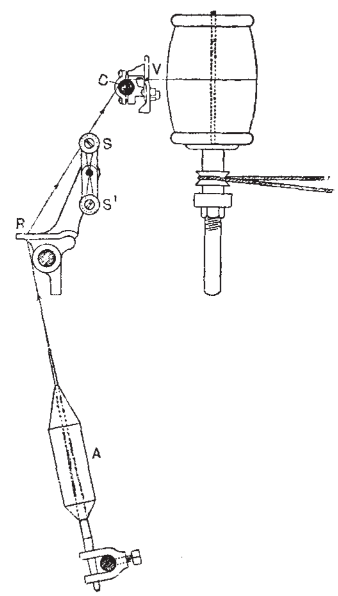

Fig. 27.

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.

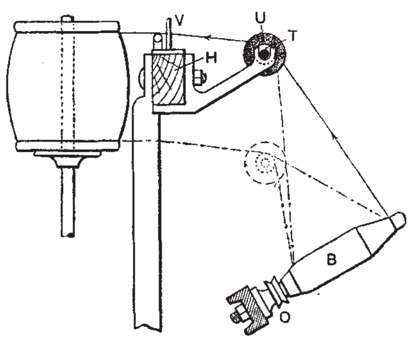

Fig. 28.

§ 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.

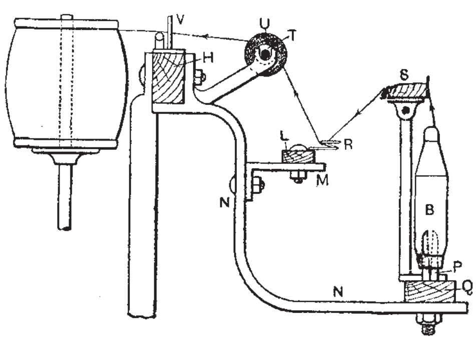

Fig. 29.

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.

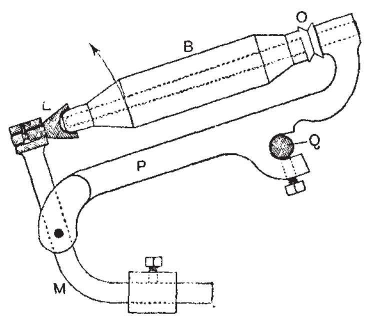

Fig. 30.

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.

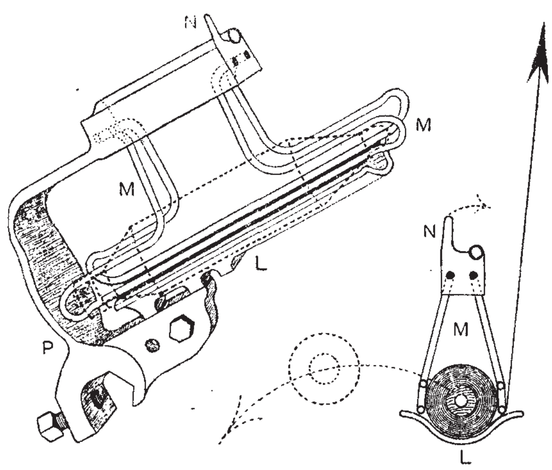

Fig. 31.

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.

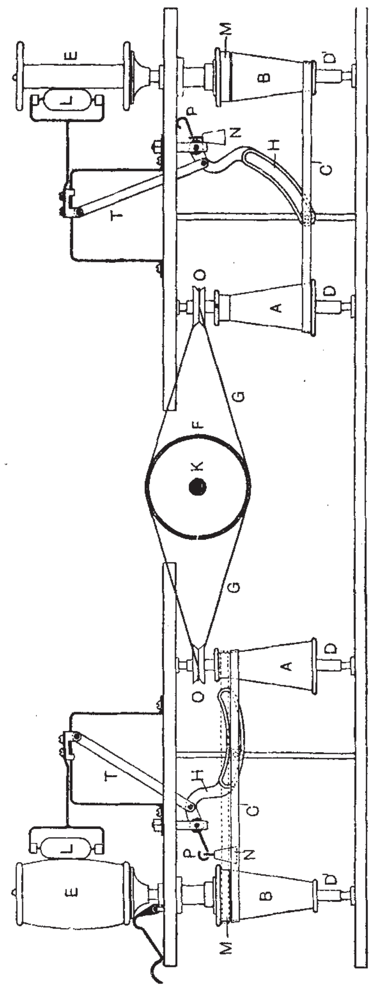

Fig. 32.—Taylor's Cop Winding Machine.

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 $13\frac{1}{2}$lb. 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 $11\frac{3}{4}$lb. 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

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 $4\frac{1}{2}$in. traverse, a $3\frac{1}{2}$in. flange, and a $1\frac{1}{4}$in. 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 $18\frac{1}{2}$lb. per spindle per week of $55\frac{1}{2}$ 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 $1\frac{1}{2}$ per cent. of the gross weight of yarn, and about $\frac{1}{2}$ 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

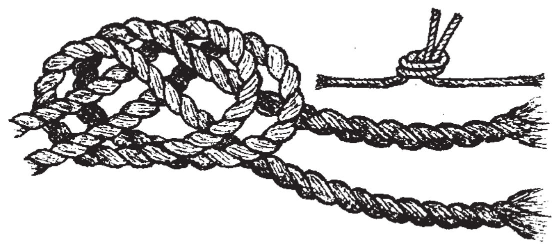

Fig. 33.—Winders' or Spoolers' Knot.

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

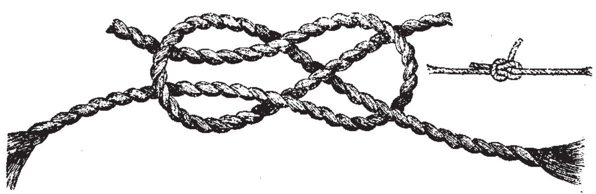

Fig. 34.—Weavers' Knot.

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

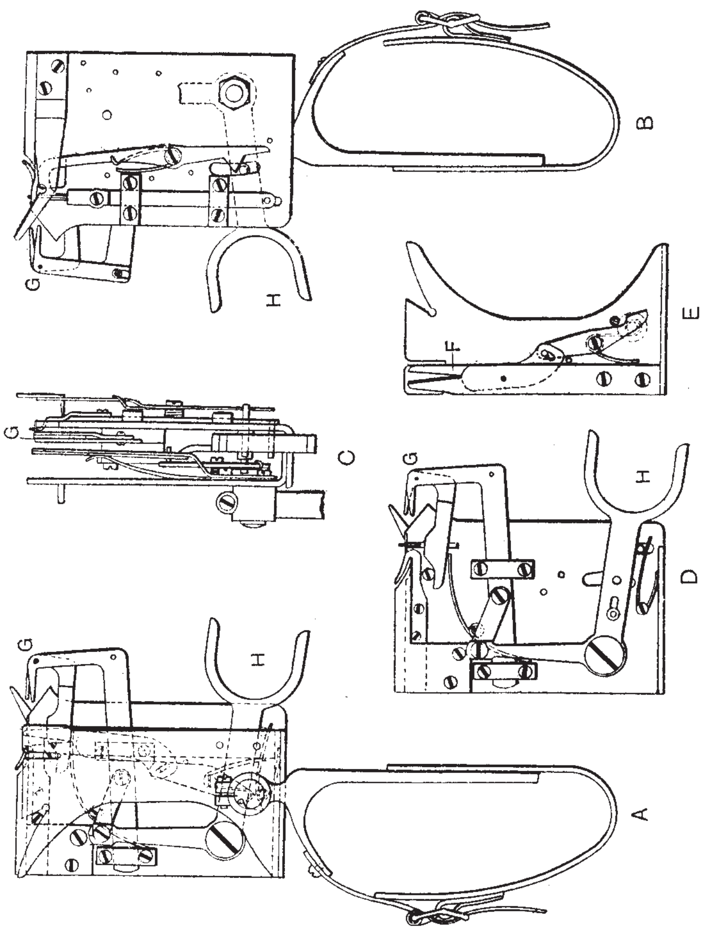

Fig. 35.—Weaver-Knotter.

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

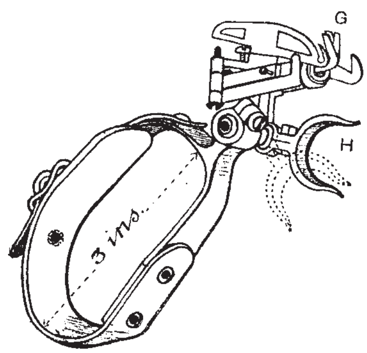

Fig. 36.—Barber-Knotter.

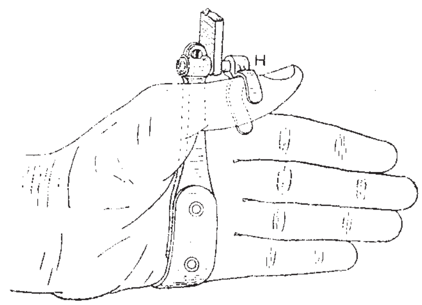

Fig. 37.

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.

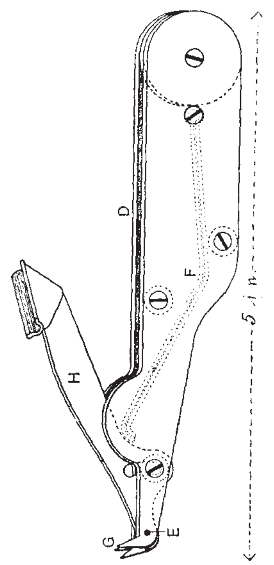

Fig. 38.—Stubbs' Knotter.

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.

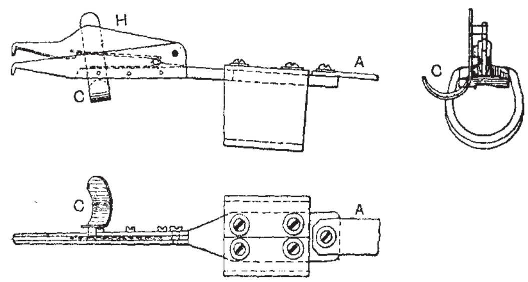

Fig. 39.

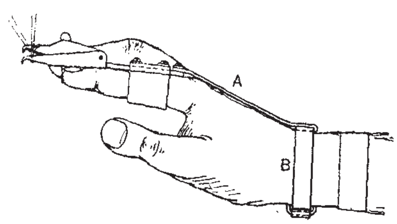

Fig. 40.—Bingham's Knotter.

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.

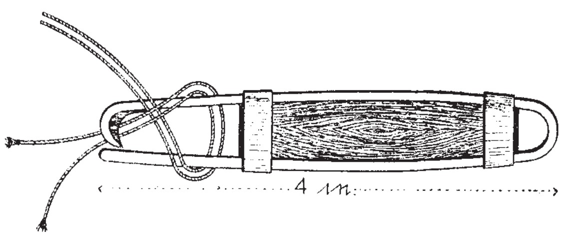

Fig. 41.—UNIVERSAL-KNOTTER.

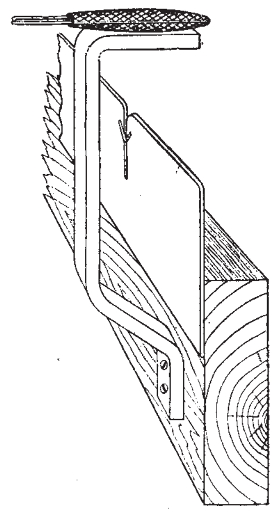

Fig. 42.

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

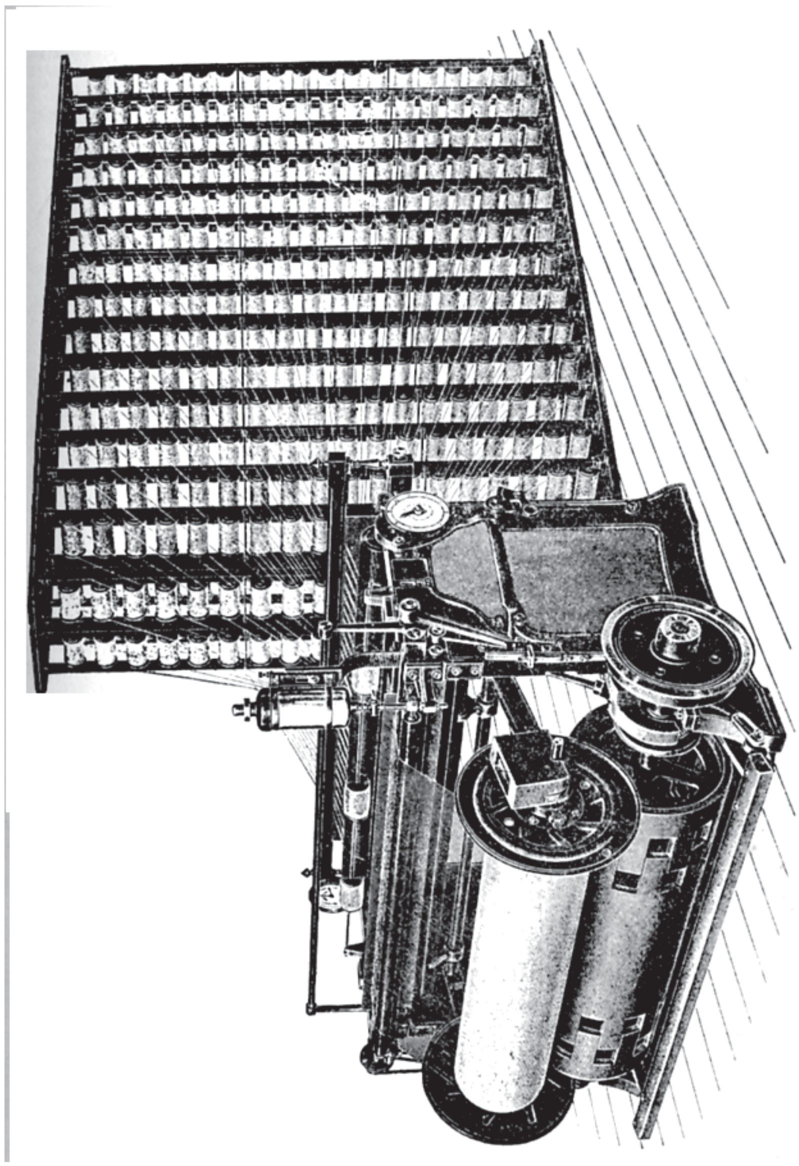

Fig. 43.—Beam-Warping Machine.

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

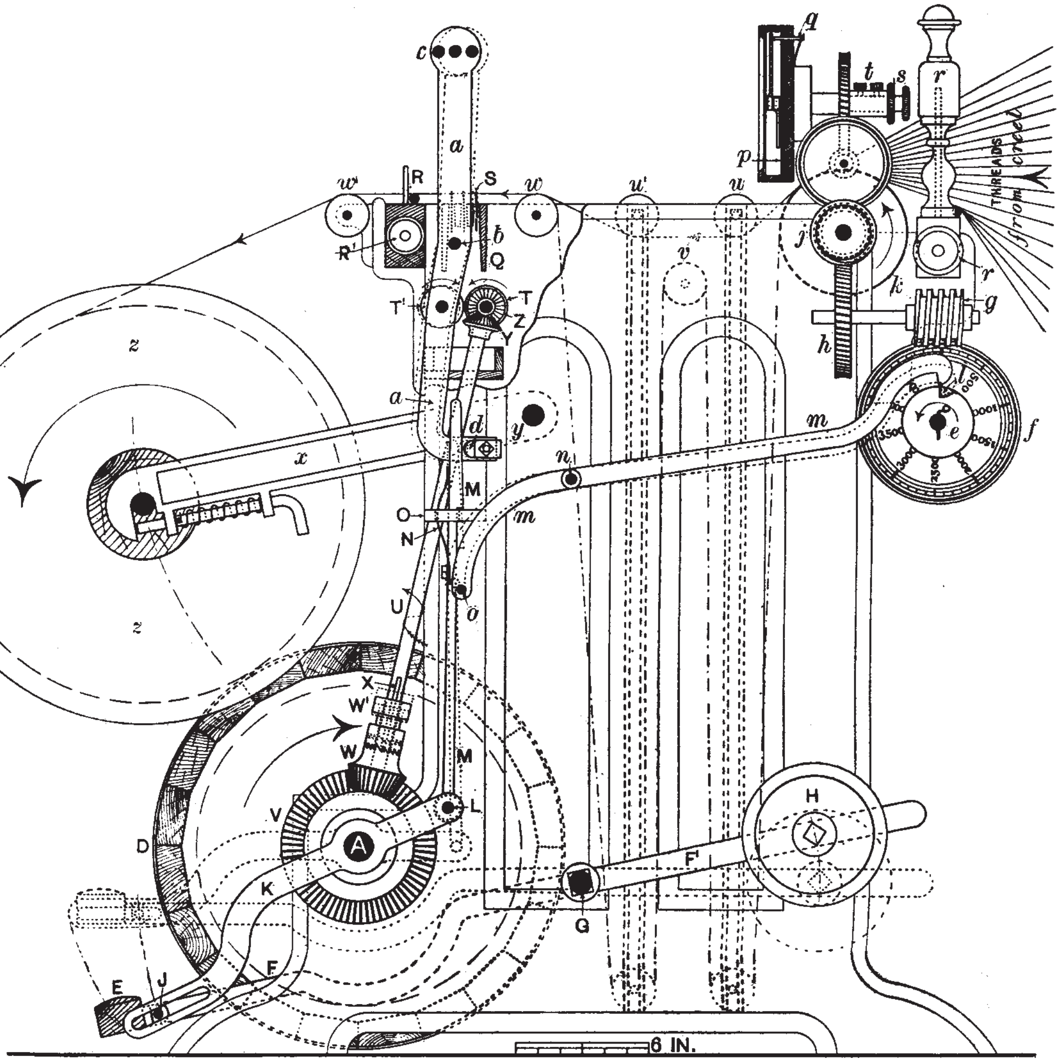

Fig. 44(*a*).—Beam Warping Machine (*End Elevation*).

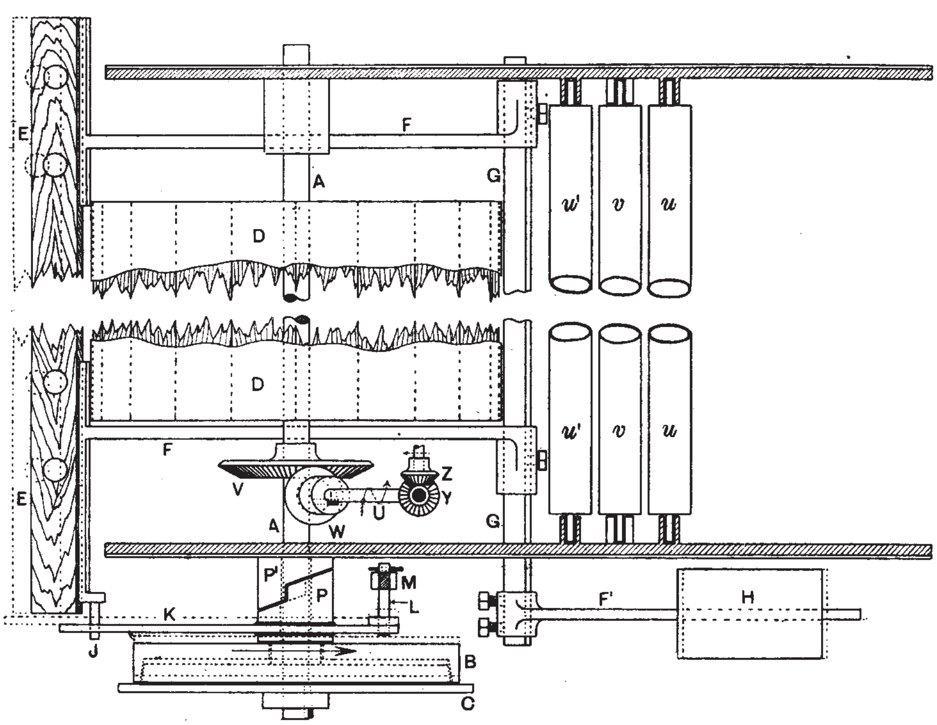

Fig. 44(*b*).—Beam Warping Machine (*Part Plan*).

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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, $1\frac{3}{4}$in. 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

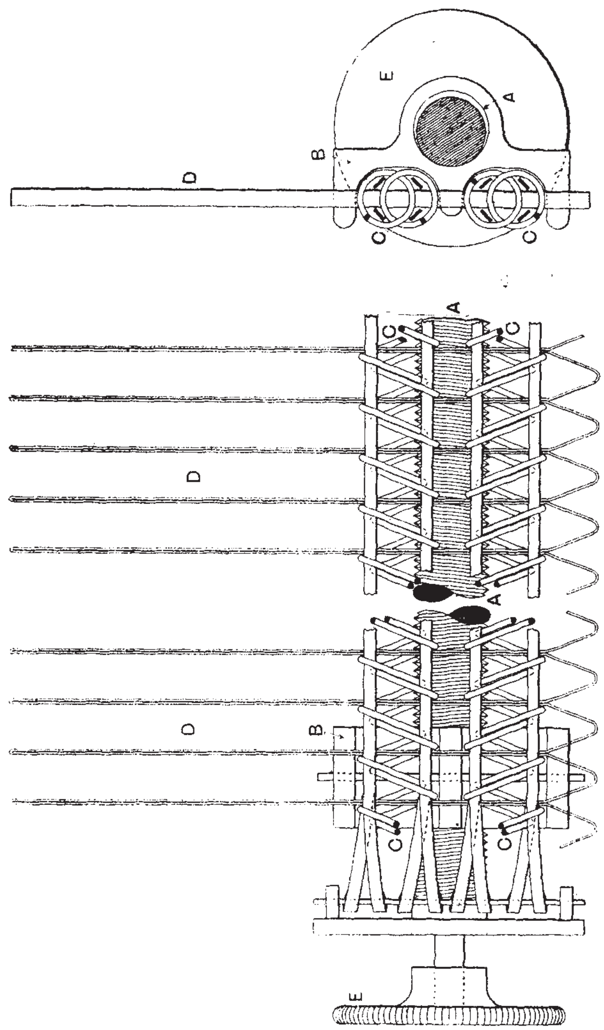

Fig. 45.—Adjustable Reed.

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.

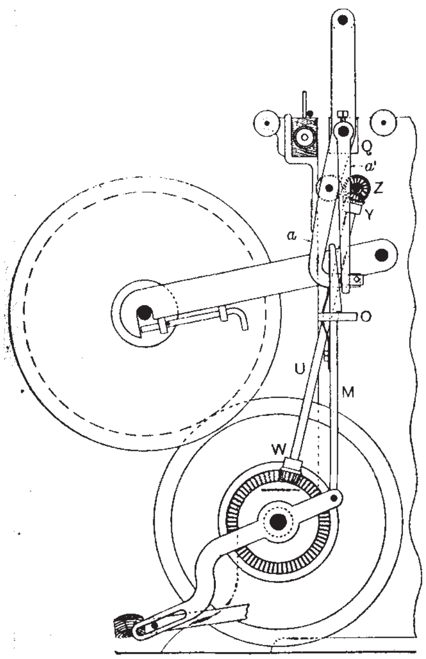

Fig. 46.

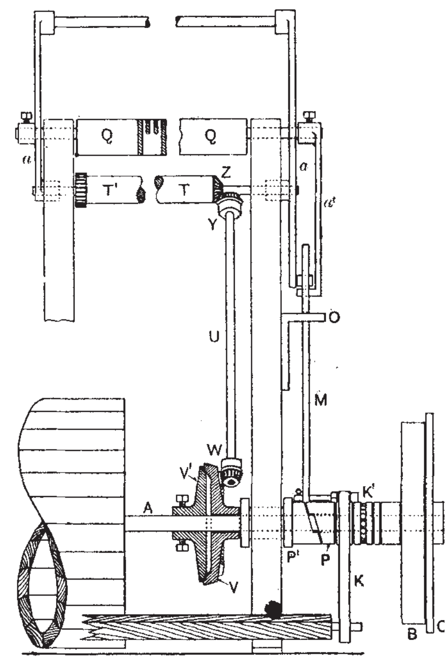

Fig. 47.

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

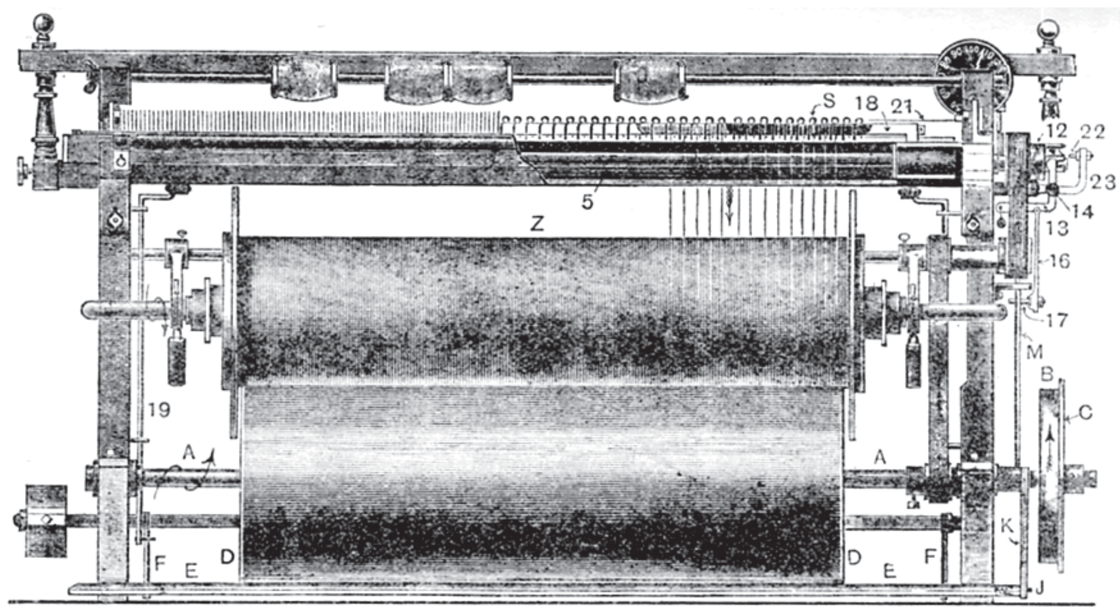

Fig. 48.—Beam-warping Machine with Brimelow's Automatic Stop-motion.

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,

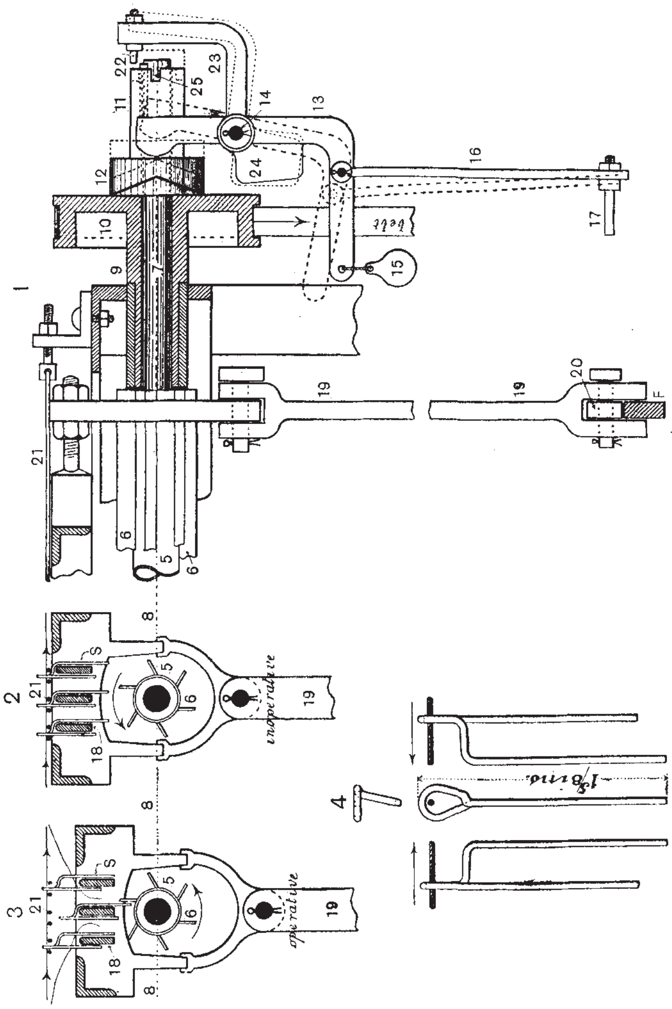

Fig. 49.—Brimelow's Automatic Stop-Motion.

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

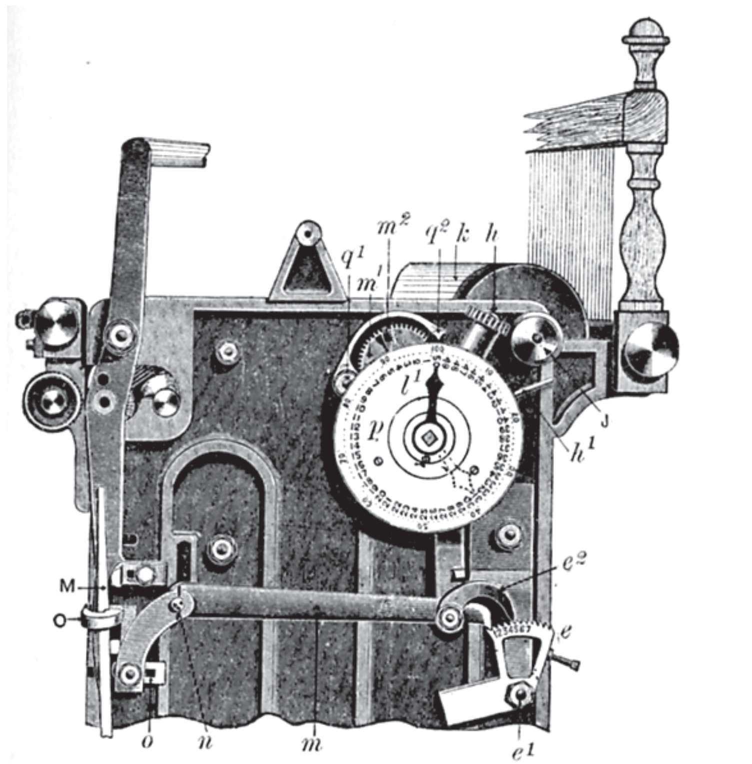

Fig. 50.—Automatic Measuring and Stop-motion.

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,

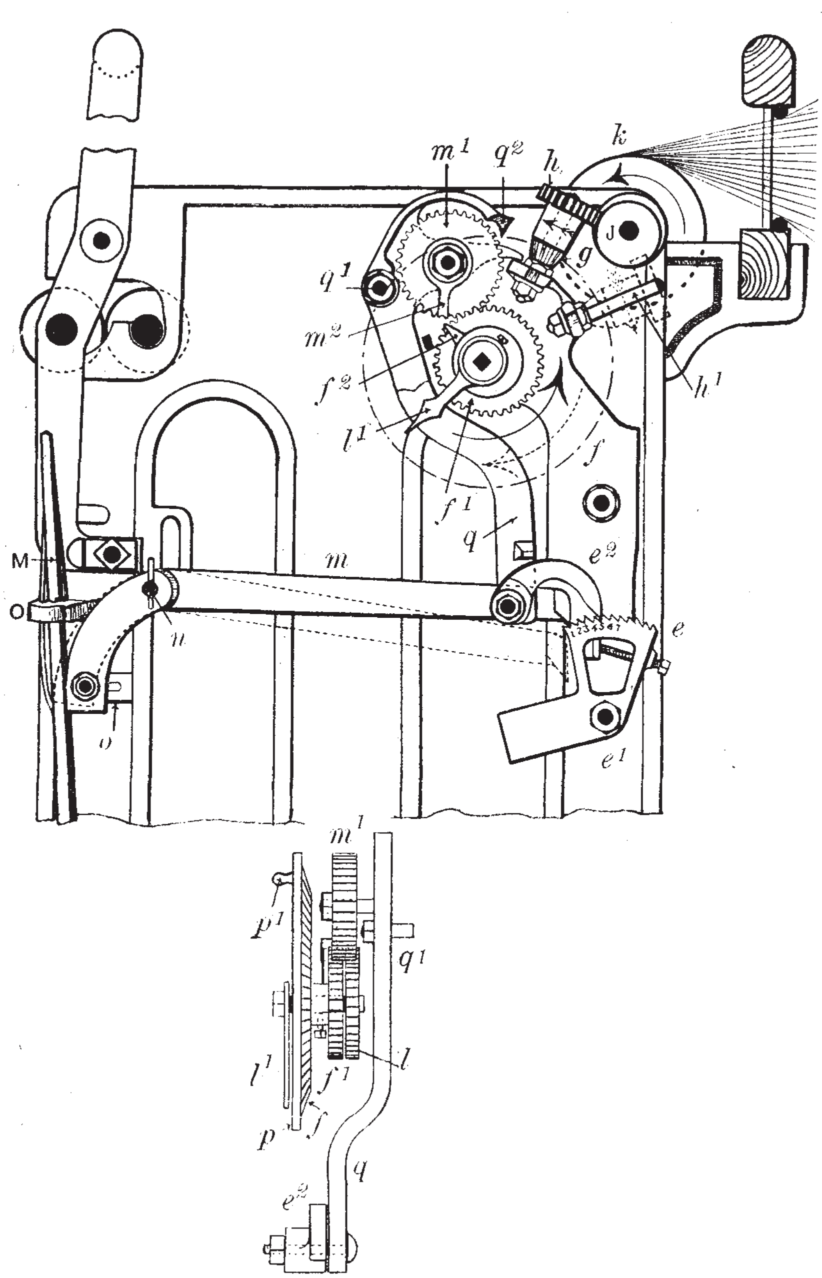

Fig. 51.—Automatic Measuring and Stop-motion.

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.

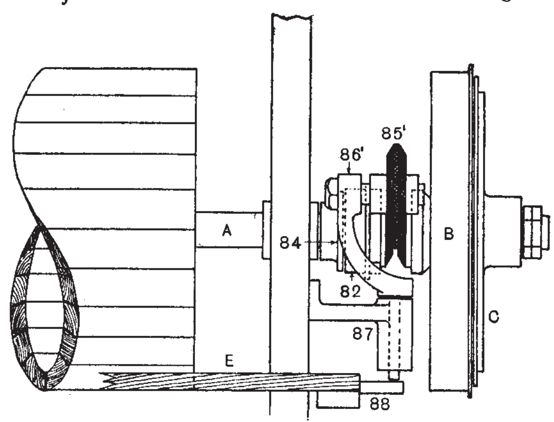

Fig. 52.

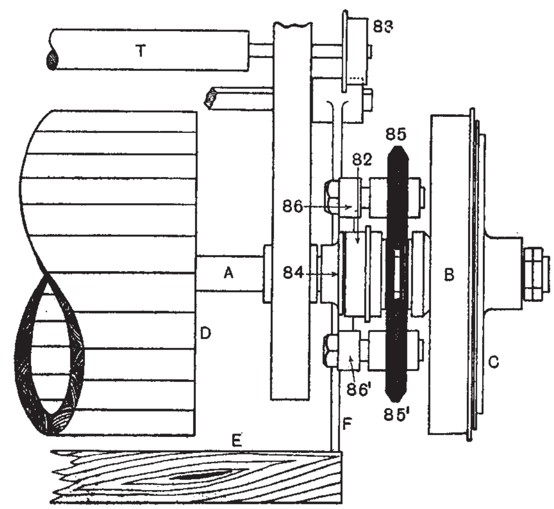

Fig. 53.

§ 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.

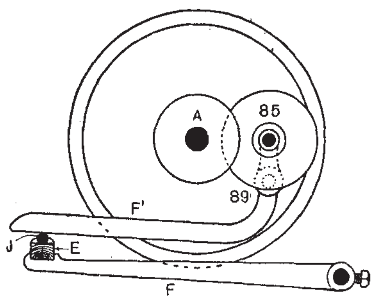

Fig. 54.

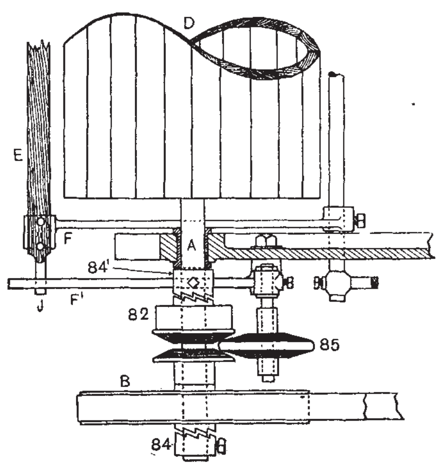

Fig. 55.

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

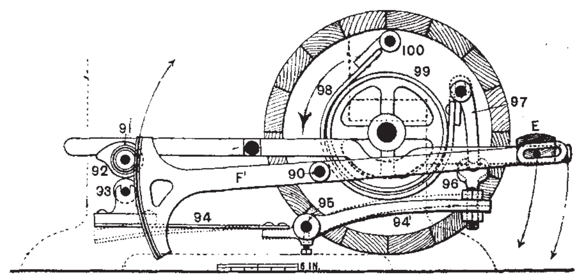

Fig. 56.

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

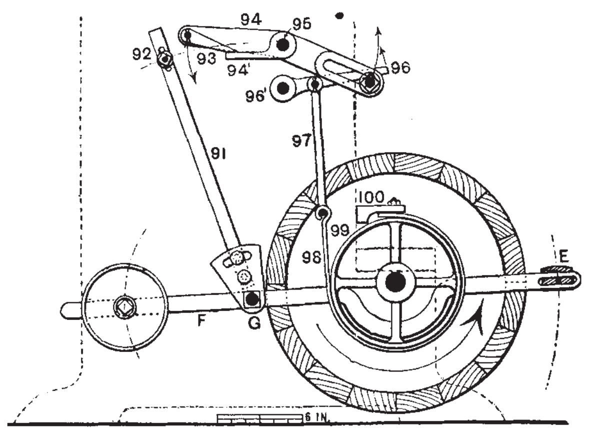

Fig. 57.

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

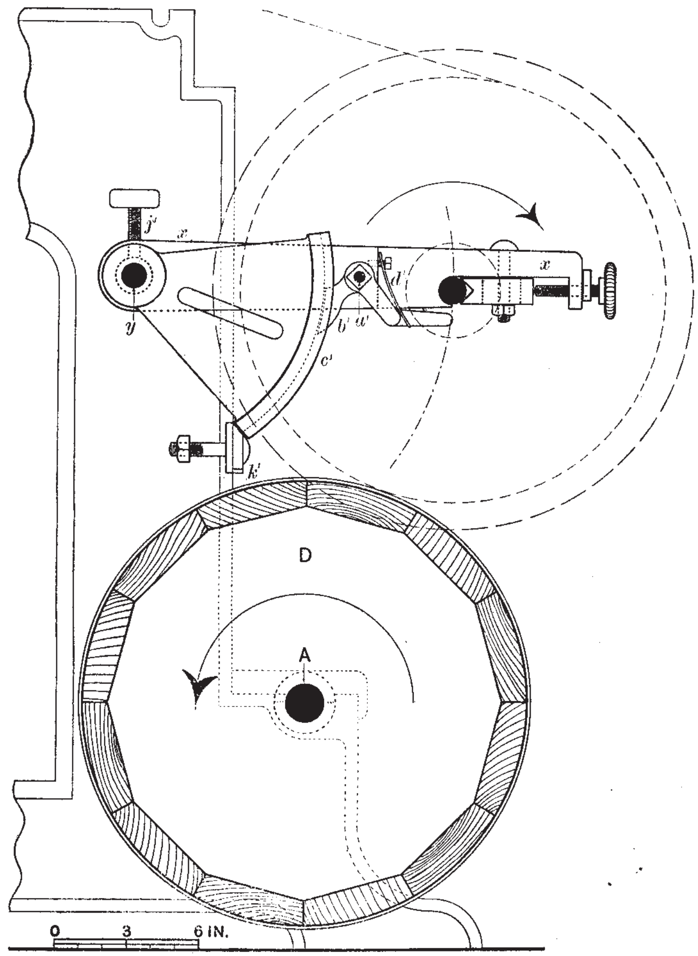

Fig. 58.—Beam-retaining Device.

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-

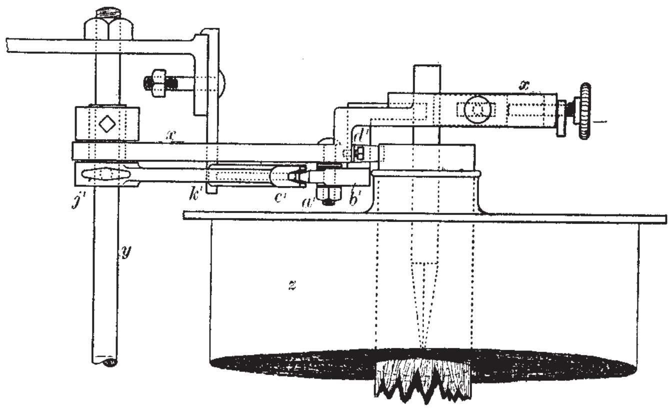

Fig. 59.

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

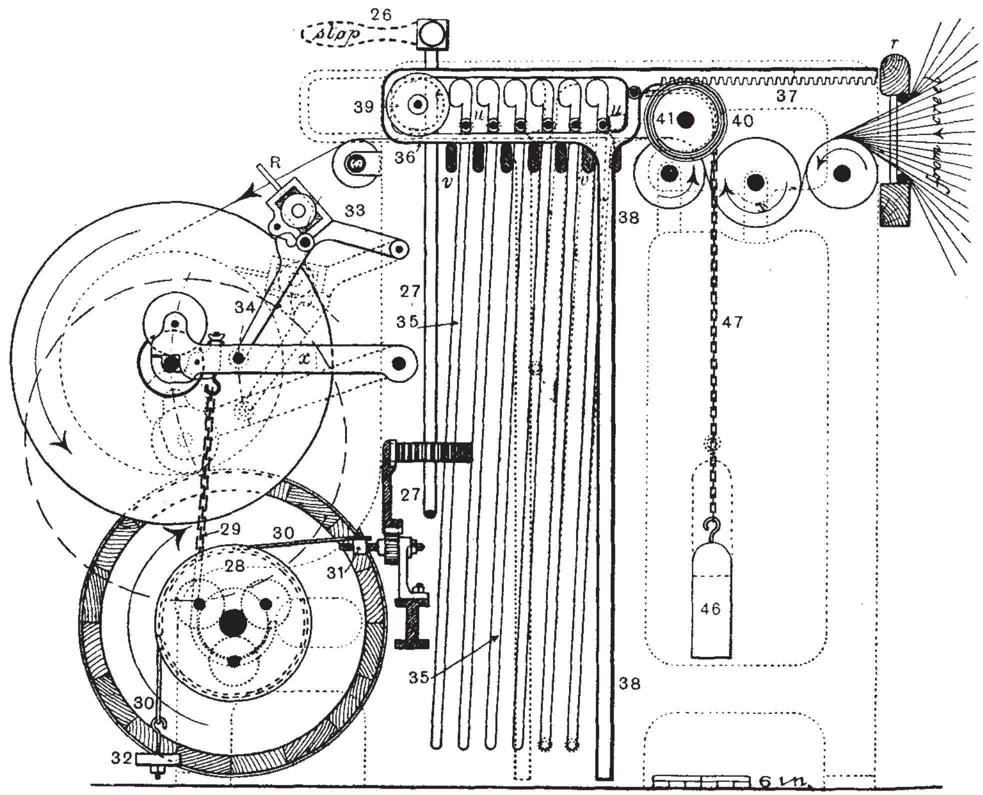

Fig. 60.—Beam-warping Machine—Falling-rod Type.

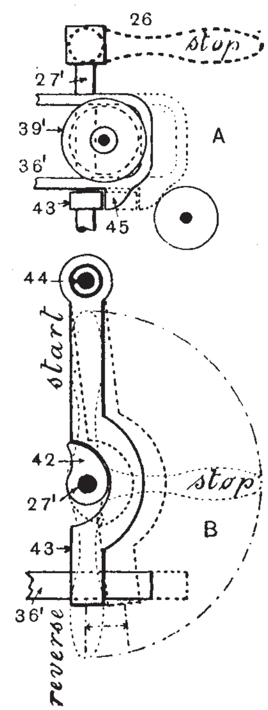

Fig. 61.

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-

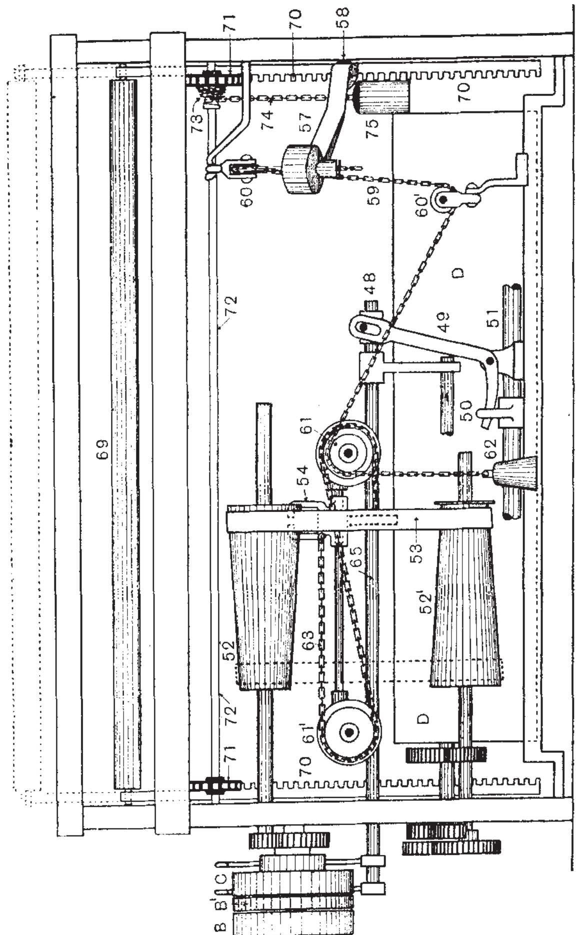

Fig. 62.—Beam-warping Machine—American Modification.

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

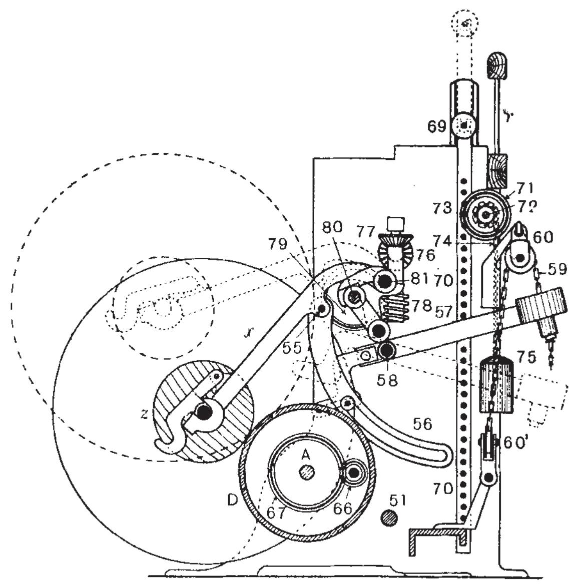

Fig. 63

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.

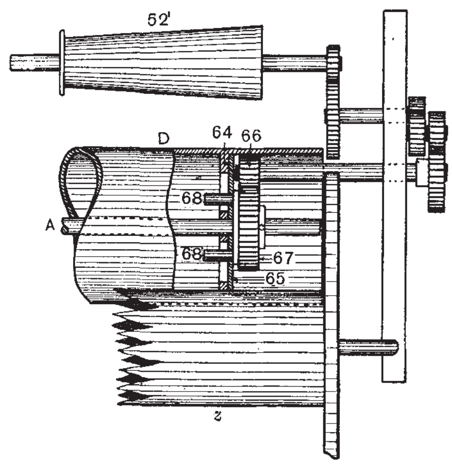

Fig. 64.

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

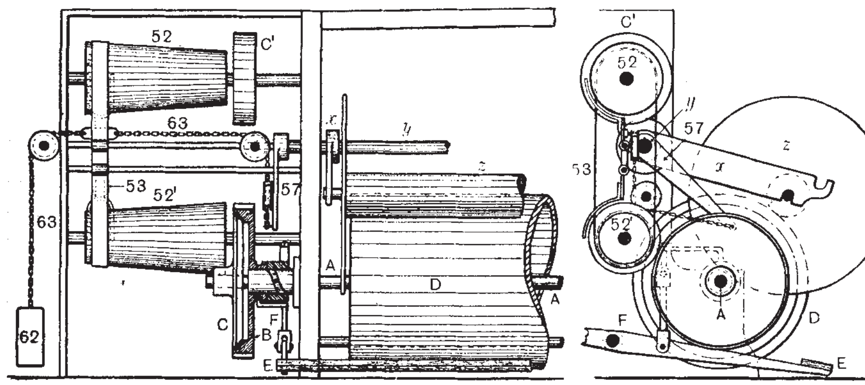

Fig. 65. Fig. 66.

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 $7\frac{1}{2}$ 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 $2\frac{1}{2}$cwt.

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 $6\frac{1}{2}$ 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 $\frac{1}{3}$ to $\frac{1}{2}$ 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.$=303\frac{1}{2}$lb., during a working day of 10 hours; or 1685lb. per machine per week of $55\frac{1}{2}$ 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.$^2 \times 0{\cdot}7854$, 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) ÷ 10 × 0·5 .	=	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.

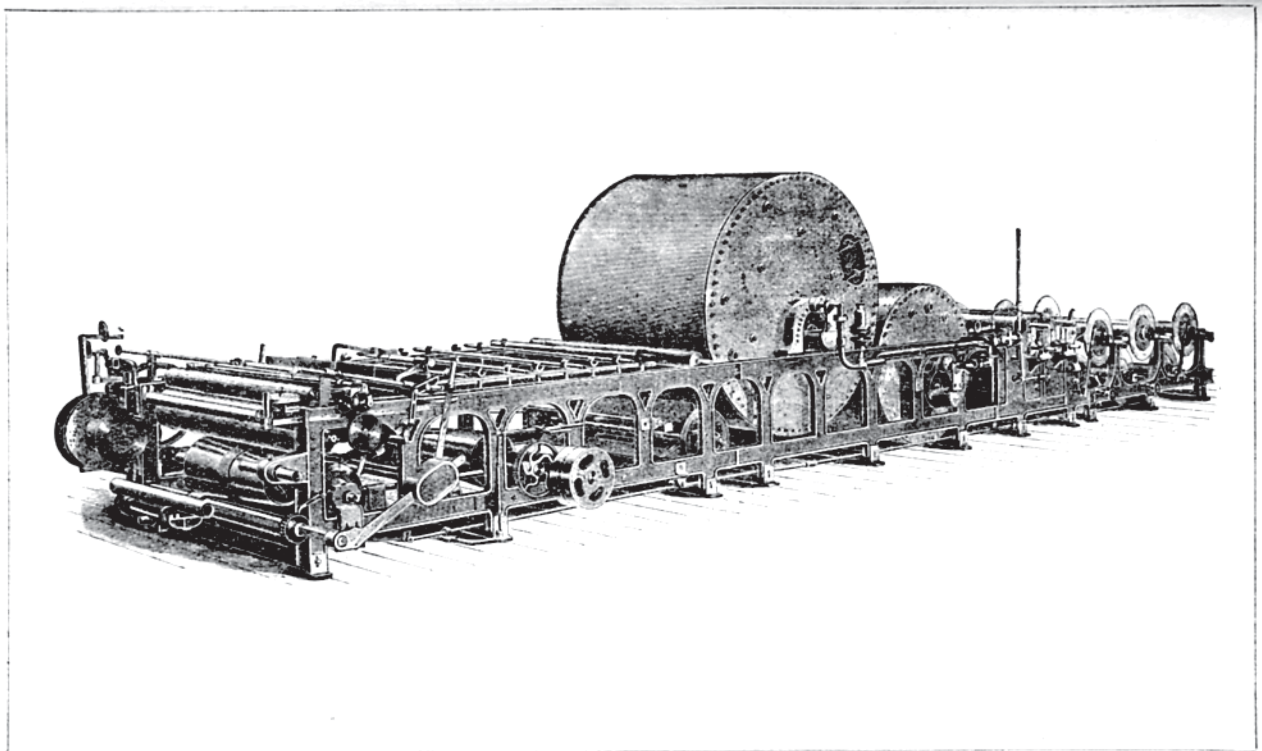

Fig. 67.—Slasher or Tape-sizing Machine.

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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

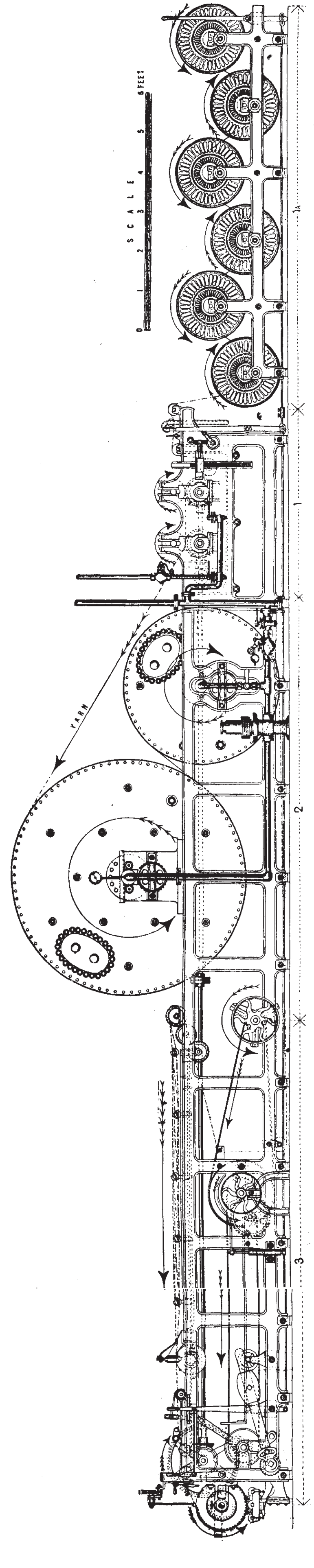

Fig. 68(*a*).—Slasher or Tape (Cylinder-Drying) Sizing Machine (*Side Elevation*).

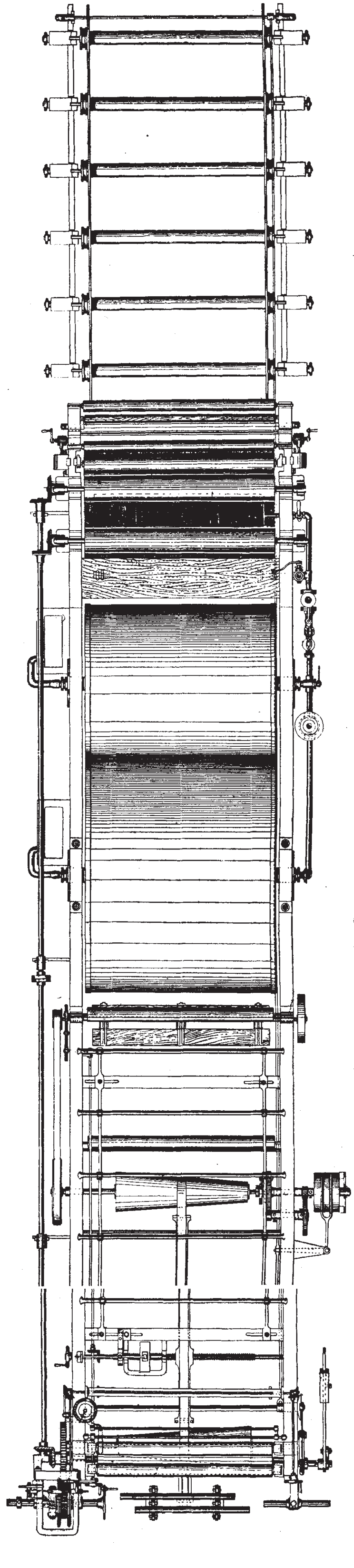
Fig. 68(*b*).—Slasher or Tape (Cylinder-Drying) Sizing Machine (*Plan*).

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

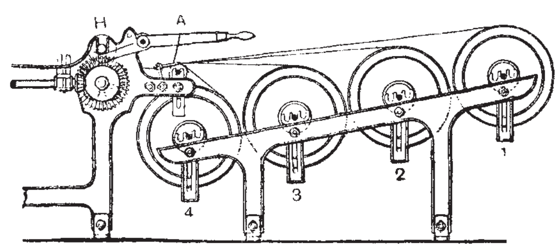

Fig. 69.

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

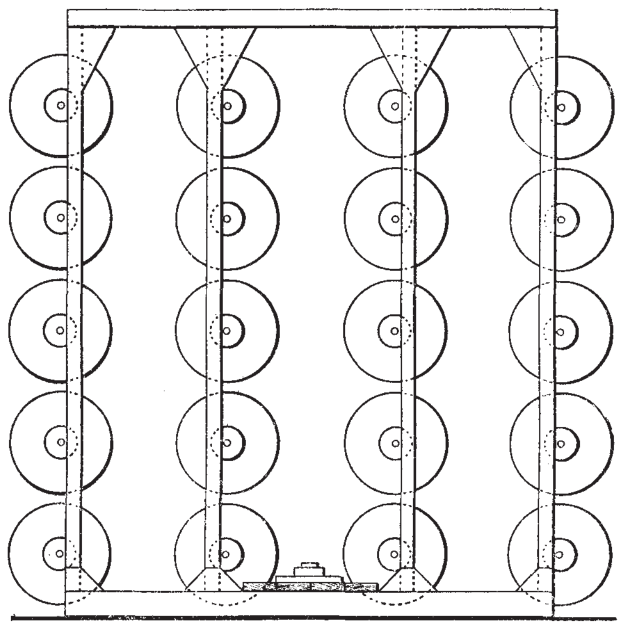

Fig. 70.

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.

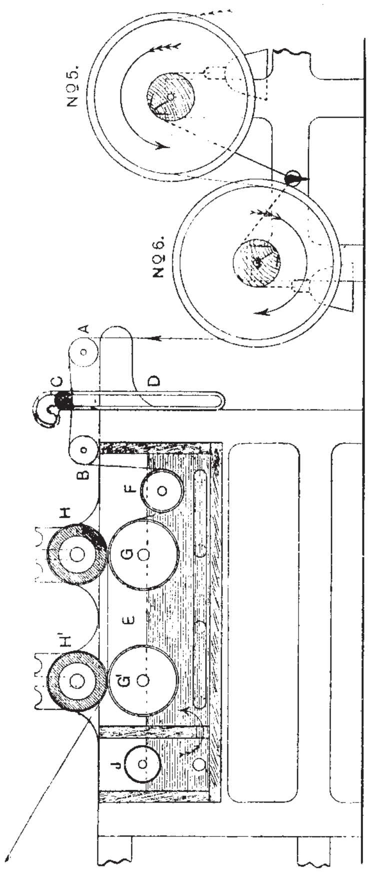

Fig. 71.

§ 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

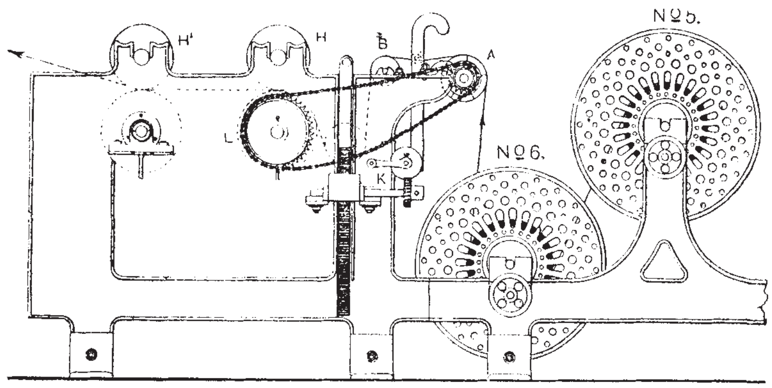

Fig. 72.

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*,

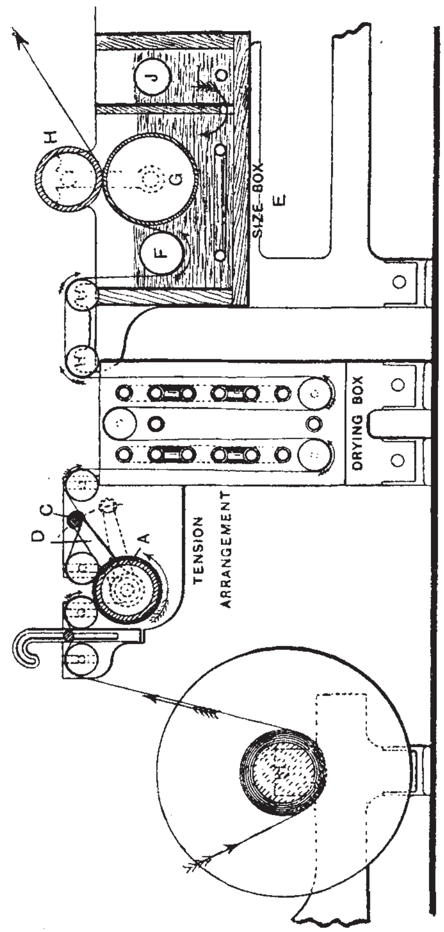

Fig. 73.

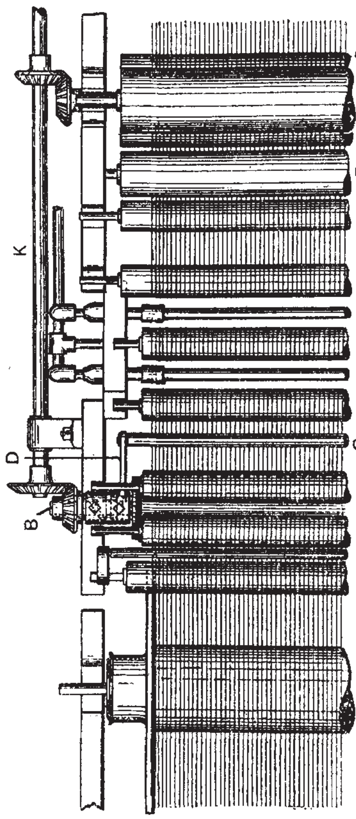

Fig. 74.

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 compart-

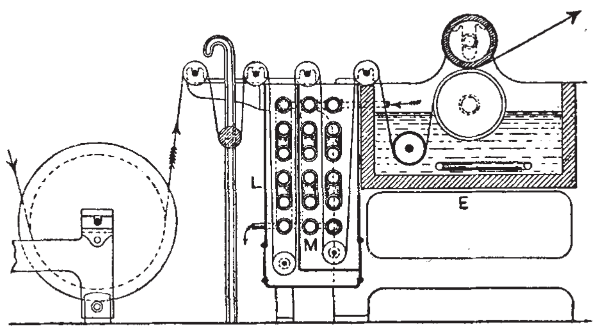

Fig. 75.

ments 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.

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.

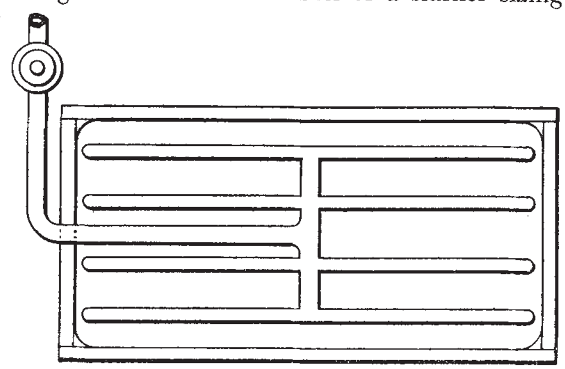

Fig. 76.

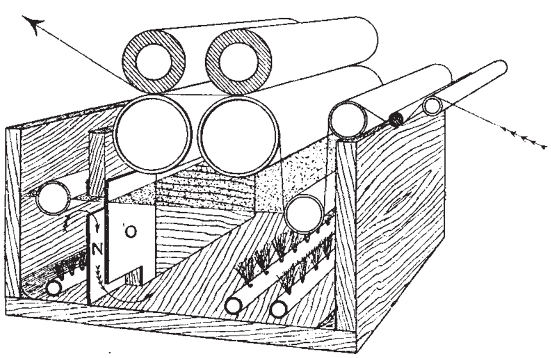

Fig. 77.

§ 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

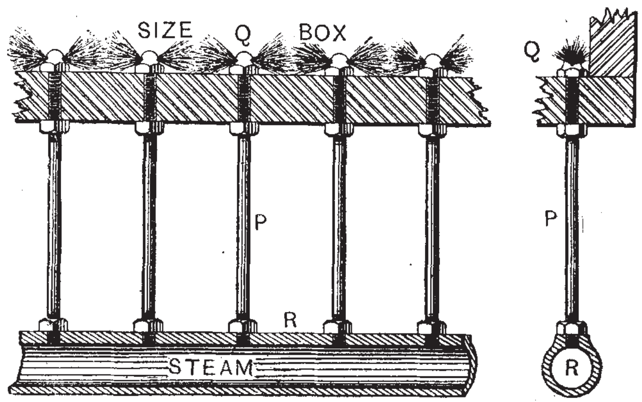

Fig. 78.

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

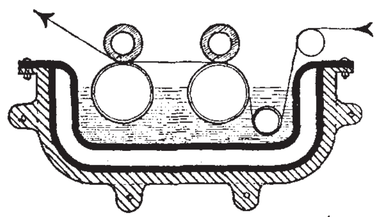

Fig. 79.

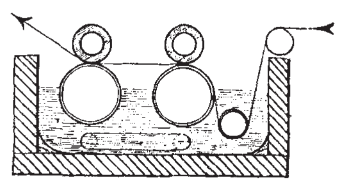

Fig. 80.

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.

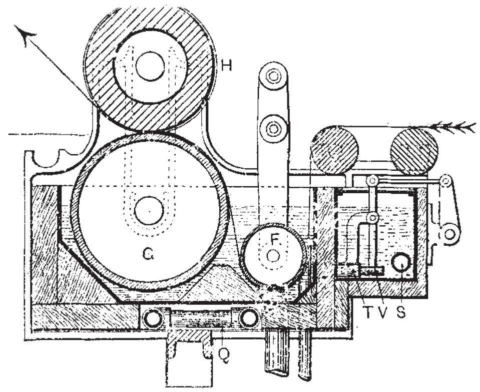

Fig. 81.

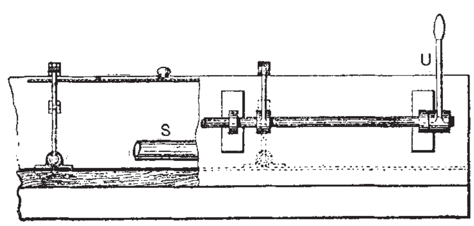

Fig. 82.

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.

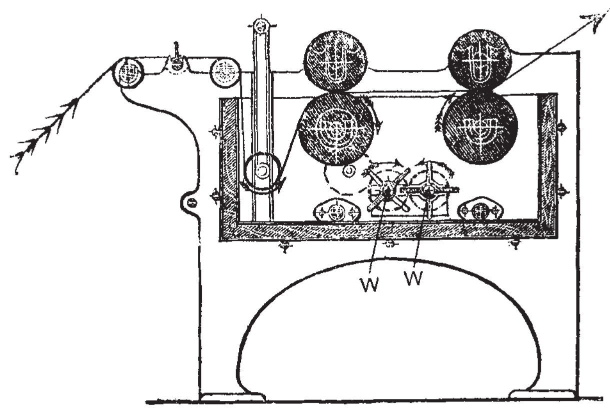

Fig. 83.

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.

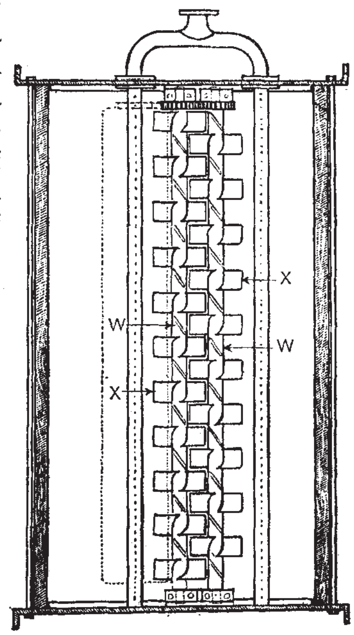

Fig. 84.

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

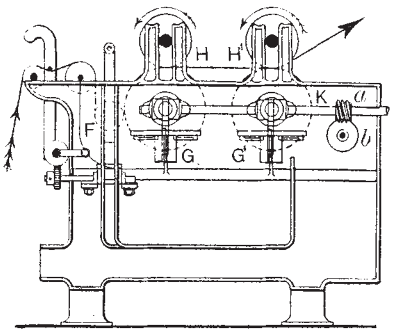

Fig. 85.

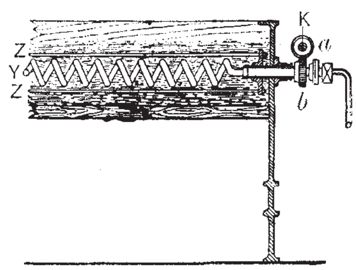

Fig. 86.

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

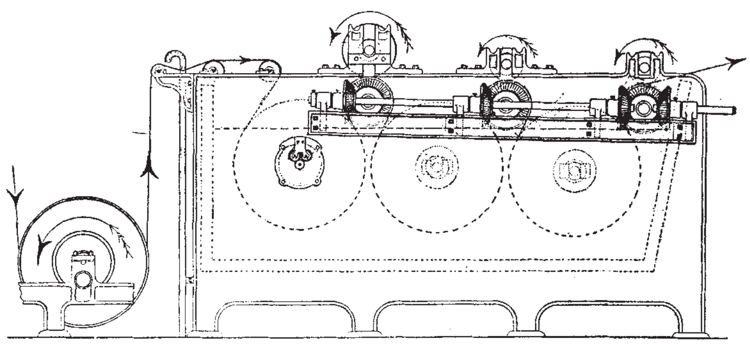

Fig. 87.

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

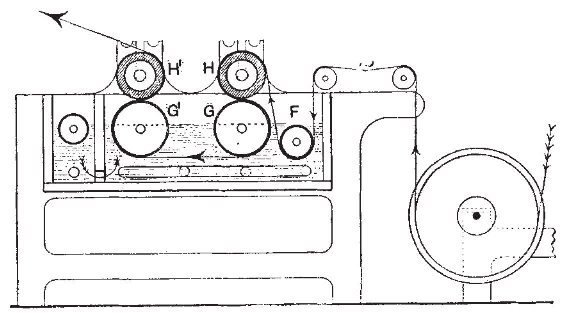

Fig. 88.

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,

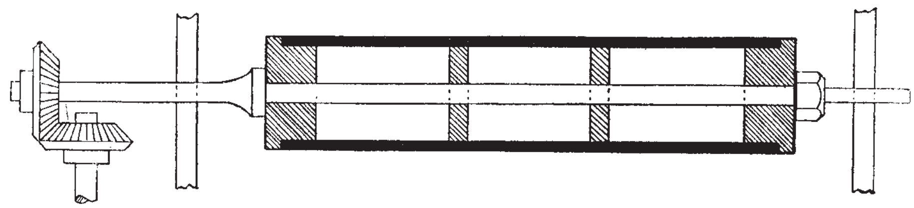

Fig. 89.

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.

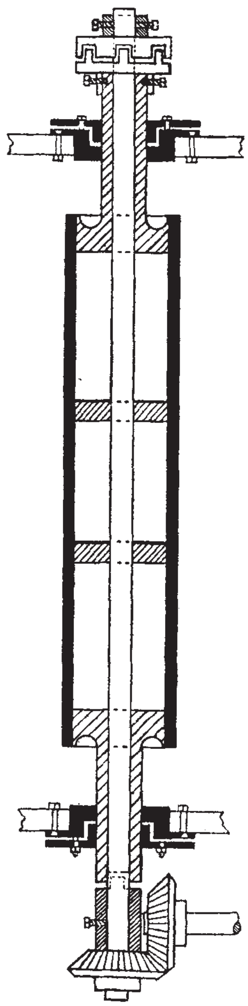

Fig. 90.

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.

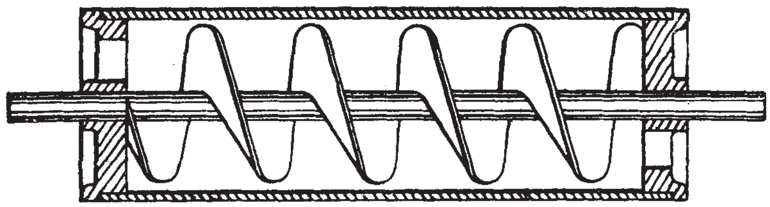

Fig. 91.

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

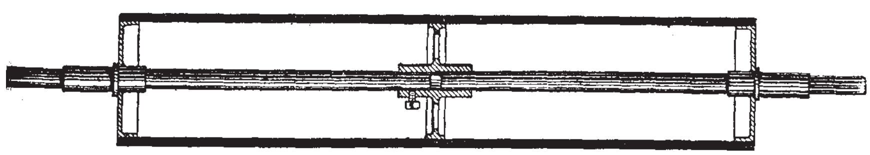

Fig. 92.

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.

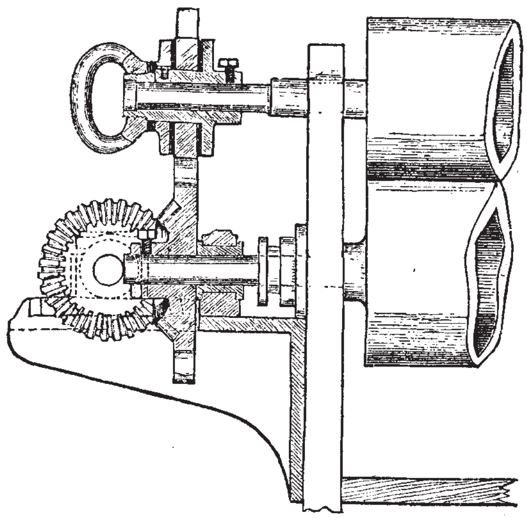

Fig. 93.

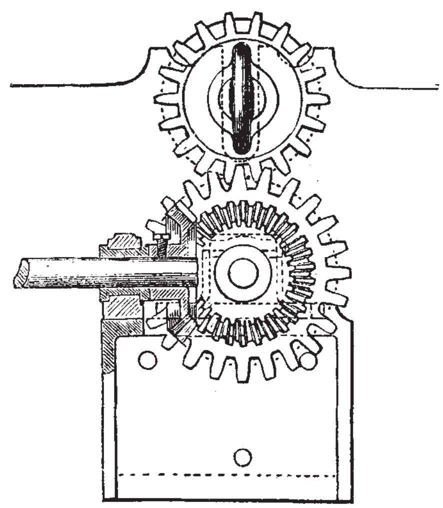

Fig. 94.

§ 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.

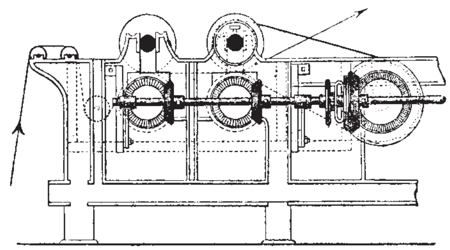

Fig. 95.

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.

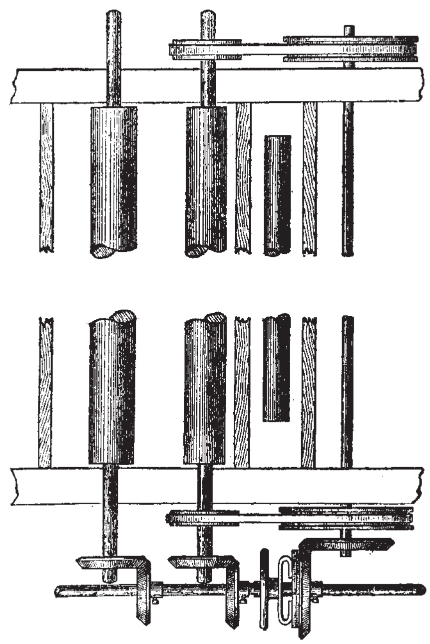

Fig. 96.

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,

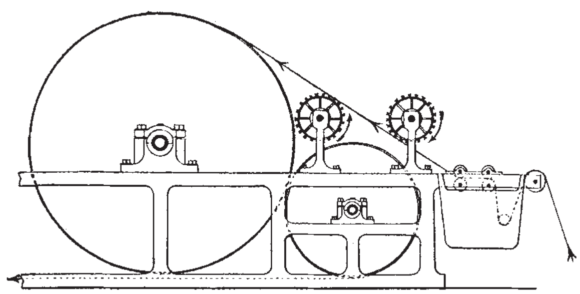

Fig. 97.

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