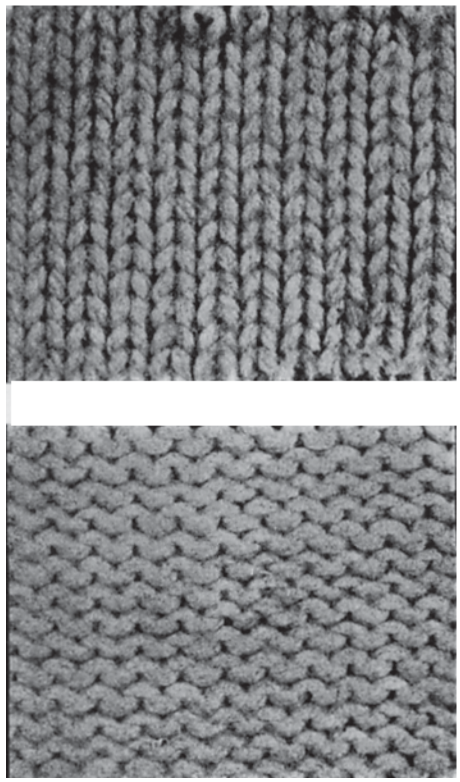
COMMON COMMODITIES AND INDUSTRIES

KNITTED FABRICS

I. Chamberlain & J. H. Quilter

KNITTED FABRICS



PLAIN KNITTED FABRIC

Frontispiece.

PITMAN'S COMMON COMMODITIES
AND INDUSTRIES

KNITTED FABRICS

BY

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PREFACE

THE knitting industry forms an important branch of the textile trade, but it is one of which little is known by many textile manufacturers. The object of the publication of this small manual is to show the great possibilities of the Knitted Fabric which have been recognized in other countries to a much greater extent than in Great Britain. The book is sufficiently technical in character to be useful both to technical students and to those engaged or about to be engaged in the knitting industry. Obviously it is not possible to give all the details of the modern automatic knitting machines in such a small work, but the principles of knitted stitches and fabrics, as well as the manufacturing and finishing of all types of knitted goods and garments, are given in a precise manner without any fundamental omissions.

J. C.

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CHAPTER I

HISTORICAL

Origin of Knitting. The origin of the art of knitting is unknown, and, although there are indications of classical references, it is impossible to state definitely that the allusions were made to knitting, as the ancient writers would probably regard knitting as a type of weaving. "Knit," in the specific sense, is first mentioned in an old grammar published by the daughter of King Henry VIII of England in the year A.D. 1530, which gives the verb "to knitt." Other accounts of the same period show that "hosen, bonnets and the like" were knitted by women in all grades of society. The word knitting is derived from the Saxon word "cnyttan," meaning the making of a fabric from threads by hand, and mention was made of this word by historians in the year A.D. 1492. During these early periods the knitting was accomplished by the aid of two or more rods made of wood or bone, and probably the articles produced were coarse and primitive.

Origin of Machine or Framework Knitting. In the year A.D. 1589 a poor clergyman named William Lee, who was the curate of Calverton, a Nottinghamshire village, sought to alleviate his poverty-stricken position by inventing a machine that would knit at a much quicker rate than that obtained by hand-knitting, so in conjunction with the local craftsmen he constructed a machine, which was worked by manual power, to produce a knitted fabric. Historians differ somewhat in their version of Lee's position and economical condition, but there is little room for doubting that necessity had much to do with the dogged perseverance of the clergyman who finally evolved what must be considered to be the most perfect of primary inventions. Lee's machine, even to-day, can be considered a complicated machine possessing a large number of interesting mechanisms. The romance and pathos connected with the invention afterwards so aroused the feelings of an Irish artist that in 1847 a painting, entitled "The Origin of the Stocking Frame," was exhibited publicly, and a reproduction is given in the accompanying illustration (see next page).

Fig. 1

HAND KNITTING

In this picture the artist depicted the Rev. William Lee soliloquizing in a wretched hovel furnished with little more than the symbols of his office, eagerly and desperately endeavouring to follow the principles of knitting from the movements of his wife's nimble fingers. In three years William Lee brought his efforts to a successful conclusion and produced knitted fabric by means of a machine. He applied to Queen Elizabeth for exclusive rights to construct such machines, but the Queen would not grant this privilege on the ground that such a machine would deprive the poor hand-knitters of a means of livelihood. The Queen, however, offered to allow him the rights to knit silk stockings, which were knitted only by the richer people. Probably the Queen, in making the offer, was advised that it would be impossible to knit fine stockings on a machine, as afterwards, when Lee had so improved his machine that it would make silk stockings, the Queen was still

FIG. 2

ORIGIN OF STOCKING FRAME

obdurate and would grant him no rights. The accession of James I to the throne brought him no nearer the realization of his hopes, so in despair he took his little stock of nine frames, as they were called, to Rouen in France. Here the King, Henry IV, received him heartily, but before Lee could settle down the King was assassinated and Lee, owing to his Protestantism, was thrown into prison. Later he is said to have died broken-hearted and to have been buried in an unknown grave near Paris. Thus the founder of the great knitting industry, pursued by bad luck, died forsaken, but his memory still lives, and at Calverton, in the year 1892, an institution, shown in the illustration, was dedicated to his memory. Another interesting memorial of William Lee can be found in the Hosiery and Knitting Department at the Leicester Technical School. This consists of a companion picture to the "Origin of the Stocking Frame," and is entitled the "First Frame-made

FIG. 3

MEMORIAL SCHOOLS AT CALVERTON

Stocking," and depicts the Reverend William Lee showing to his wife the first fruits of his invention. In this picture, in order to represent the success of the inventor, the scene is changed, and instead of the small, squalid room a large chamber is portrayed with a general appearance of comfort and prosperity.

In 1620 the frame was made capable of knitting still finer stockings by an invention of Aston, an apprentice of Lee's. Aston and James Lee, a brother of the original inventor, commenced building the improved frames at Thoroton, Calverton, and Woodborough, and, about the year A.D. 1640, stocking-making had become a staple industry in many of the Nottinghamshire, Leicestershire, and Derbyshire villages. At this period a frame was taken to Venice, and, although the Venetians

FIG. 4

THE FIRST FRAME-MADE STOCKING

were considered the finest smiths in Europe, they were not successful in producing the frames. The trade prospered so that in the year 1727 there were 8,000 frames at work in England.

In 1745 an Irishman of Dublin invented the tuck presser, which enabled raised patterns to be made, an invention which afterwards turned out to be of great importance. In 1758 the ribbed stitch, now so universally used, was first made on the stocking frame, the invention being brought out by Jedediah Strutt, of Derby, who also effected several improvements on the spinning frames then in existence. Previous to this all rib work was made either by hand or with alternate slip stitches which afterwards had to be looped up by hand on the opposite side of the fabric. This invention was a complete success, and there was a corresponding improvement in the making of the goods, as the elasticity of the rib fabric was previously well known.

In 1764, Ferdinando Shaw, in conjunction with two others, originated a method whereby eyelet-holes could be made in the fabric, and shortly afterwards Butterworth invented a point machine by means of which knitted lace could be made on the hand stocking frame. From this time to the end of the eighteenth century many attempts were made to produce a machine-made lace, and the first true machine-made lace fabric, as apart from ordinary lace knitted fabrics, was made on a particular style of stocking frame known as a two-plain machine. Thus the knitting industry can legitimately claim the lace manufacturing trades as having originated in knitting, although lace was afterwards made on different principles.

The invention of warp knitting is usually assigned to Crane, of Edmonton, who in 1775 produced a knitted fabric made from all warp threads and thus founded a specialized section of the knitting industry which is becoming of more importance every year. Shortly afterwards Tarratt, of Nottingham, greatly simplified the frame in its adaptation to warp knitting.

In 1778 a point net machine was added to the hand frame. This machine was the forerunner of the present pelerine machine. Elastic stockings were first made in 1784, whilst in 1786, fleecy hosiery fabric was introduced, and pearl work was made on the hand frames before the dawn of the nineteenth century.

Thus, before the close of the eighteenth century, practically all principles of knitted fabrics had been made, but so perfect was Lee's invention that his frame was still the only type of machine used in the knitting industry. Thus even to-day the many and diverse patterns made are merely modifications of the original stitches invented before the nineteenth century, and although, by the introduction of different colours, styles, shapes and uses, the knitted fabric has now become so useful for a variety of purposes yet the fundamental stitches are unchanged.

It is not surprising to find that the stocking frames were, at the commencement of the nineteenth century, still worked by hand, as the day of mechanical power had not yet arrived, and even if the movements of the hand frame could have been obtained by a simple rotating motion the machine would still have required the sole attention of the worker, howbeit that the skill of the latter would not have needed to be so great. Evidently, however, some interest was taken in this proposition, as it was undoubtedly seen that, if the frame could be worked by a simple rotary movement, the toil and time required in becoming proficient in working the machine would be considerably lessened, so that in the year 1769 a man named Wise fitted a revolving shaft in the lower part of the machine and introduced levers, cams or tappets, so that the machine could be worked by the turning of a handle or crank. From that time onwards many attempts were made to produce a rotary drive to the stocking frame, but as the speed could not be increased the attempts met with but little success until 1857, when Luke Barton, who had previously built rotary frames, introduced a frame with mechanically controlled narrowing mechanism, which not only allowed the frame to work by rotary power but also enabled fashioned or shaped pieces of fabric suitable for hosiery or underwear to be made on the frame without any further manipulation by the worker. This invention was undoubtedly the prime factor in the introduction of the modern power machine, although it was quickly superseded by faster and improved machines.

Trade Conditions in the First Half of the Nineteenth Century. The early years of the nineteenth century were exceedingly unfortunate for the framework knitters. Frames, by the hundred, were standing idle, and even the fortunate few who could obtain work earned barely seven shillings per week. At this period Luddism, the name applied to frame-breaking and looting, became rampant, and a commission championed by Lord Byron, the famous poet, was appointed to inquire into the plight of the poor stockinger. Inventions were at a discount, as the reward would undoubtedly have been death by the hands of the hunger-stricken stockingers.

As the years went by, conditions did not materially improve, for the system of frame rents and charges which the middlemen enforced on the workers was rigidly adhered to, and in many cases the workmen were obliged to take food and clothing in lieu of money.

The charges debited to the worker consisted of payment for frame rent, standing room, light and fuel, winding, taking in and deductions for bad work, the latter often due to the worn-out condition of the machine. The stockinger had to buy and cast his own needles, and the middleman in supplying food and clothes charged exorbitant prices. So harsh were the terms under which the stockinger worked that finally the Truck Act was passed which made it illegal to pay workers other than with the coin of the realm. Later it became an offence to deduct charges for frame rent, standing room, etc., so that the stockinger's lot was gradually ameliorated.

The old stockinger and his mode of living and working in the past formed a picturesque study. The frames were mostly housed in small shops with low ceilings or in a specially built upper storey of the house, and the appearance of the oak beams which supported the roof, the slates or thatch of the latter being visible from the interior, together with the small and dirty oil-stained windows and the general musty smell caused by the rancid lubrication known as lather, was reminiscent of the dark ages. To complete the scene there were the battered condition of the woodworks, the unevenness of the floor, the dusty spare parts and additions which in vain endeavoured to hide the bareness and crudity of the walls. The incessant rumbling of the frames would have been torment to the neurasthenic person of to-day, but to the stockinger was the type of music he loved. The old stockinger was born to the frame; he grew up with it, and his affection for it and his knowledge of it increased as both grew older.

A general perusal of the history of the trade shows clearly how times and conditions have altered for the better, and yet the life of the old stockinger had its compensations. He was practically his own master; he worked and played at will. In the country the working of the frame was associated with the joys of gardening, and the little workshops, as shown in the illustration, were surrounded by flowers, fruit and vegetables. The stockinger, although he may have worked, as many did, all Friday night, played all day on Monday. He was not hustled, the strain of modern business was missing, and as a rule he was long-lived, many men working merrily up to the age of ninety. To-day the workers in an up-to-date, well-equipped

FIG. 5

COUNTRY STOCKINGER'S SHOP

hygienic knitting-mill wonder however their predecessors existed under the old conditions, but the few old stockingers still left are equally amazed at the terrible pace at which the modern machines are manipulated and would by no means change their lot.

The Advent of Power Machinery. The invention by Luke Barton in 1857 of an automatic narrowing rotary frame was quickly followed up, and in 1861 Paget, of Loughborough, invented a movable needle bar frame which, although crudely constructed, could be driven at a much higher speed, whilst in 1864 Cotton, of the same town, brought out the vertical movable needle bar, and established the modern system of straight bar machines which are to this day known as Cotton's Patent Frames, although the original patent has long since elapsed. In 1878 Kiddier invented the modern type of rib frame, and since then many additions and improvements have been made to Cotton's original invention.

The honour of inventing the first circular frame must be given to a Frenchman, Decroix, in 1798, whilst in 1816 the famous French engineer, Marc Brunel, brought out a machine with radiating horizontal needles. This frame was afterwards developed on the Continent and became the standard French circular frame with bearded needles, and many thousands of these machines are now in use in all parts of the world. The English loop wheel circular frame was brought into its modern form by Mellor in 1847, and at a later date was improved and standardized by American knitters with great success. This machine is now largely employed in both England and the U.S.A.

Discovery of the Latch Needle. Up to the year 1849 the bearded needle, invented by the Rev. Wm. Lee, was still the only successful type of needle known, but in that year Matthew Townsend, of Leicester, invented the self-acting or latch needle which has since absolutely revolutionized the knitting industry. Townsend, who was a fancy hosiery manufacturer, whilst producing pearl work on the hand stocking frame, experienced a great deal of difficulty in pressing the second set of needles which it was necessary to employ. In his old stockinger's shop he thought of and finally worked out ideas whereby a needle could be constructed which would knit automatically without being pressed, *i.e.*, a needle without the familiar spring beard. Townsend, although absolutely successful in his efforts, was not able to reap the fruits of his invention as the needle was more difficult to make, and few needle makers would undertake to make this type of needle which necessitated the use of new and finer tools, so that slow progress was made. Finally, hoping to get on more quickly with the manufacture of his needle, Townsend went to America, but died there in poverty shortly after landing.

This invention of the latch needle, however, was of the most vital importance, and must reckon as secondary to William Lee's invention alone, as it paved the way for the builder of the modern plain and rib circular and straight bar machines and the automatic seamless hosiery machines, the production of which would have been impossible without the latch needle.

Like William Lee 260 years before, Townsend worked in solitude and precariousness, but like Lee, although his efforts were crowned with success he received no reward, no publicity, and eventually, like Lee, he was compelled to seek his reward away from the country of his birth. No monument or memorial stands to bear the memory of Townsend, but his needle is now used in every knitting mill the wide world through, an ineffaceable testimony to the greatness of his work and the completeness of his invention.

After Townsend's departure from England, the manufacture of latch needle machines was commenced, the first machine being brought out by Thompson, of Leicester, in **1856**, and since then great progress has been made.

The latch needle cannot be regarded as an improvement on the bearded needle with regard to the quality of fabric produced, but by its simplicity of working it has rendered possible types of fast running machines which otherwise could not have been produced.

Another notable invention which was the direct result of the production of Townsend's latch needle was that of the so-called flat machine which was brought out by the Rev. Isaac Wixom Lamb, of U.S. America, in the year **1863**. This machine had originally two flat parallel beds, but afterwards the beds were placed at **45°** to the horizontal and at right angles to each other. These machines were afterwards developed in Switzerland and Germany with the result that most of the machines, even up to the present, have been built in those countries.

The seamless hosiery machine was an American invention, the hand machine being first produced in **1870**, and the first semi-automatic power machine in **1880**. Since then America has been foremost in the production of plain automatic knitting machines, although the invention of the automatic rib knitting machine was evolved in Great Britain by Stretton and Johnson, of Leicester, in **1900**, and these machines are still built exclusively in this country.

Production, Past and Present. The evolution of the modern hosiery or underwear machine is noted for the great strides made in connection with increased speed of production. In the old days a worker on the hand frame would produce a few pairs of hose or one or two articles of underwear per day. At the present time one operator can produce up to 150 dozen pairs of Army half-hose on a set of machines, whilst the average production of a set of underwear machines making tubular web would be 1,000 lbs. weight of fabric per week. A circular knitting machine containing 240 needles, and running at a speed of 300 revolutions per minute, makes no fewer than 72,000 perfect loops a minute from a single weft thread, and knits up the yarn at an average rate of one mile in six minutes. A ribbed underwear machine having twenty-four yarn feeders and possessing a diameter of 36 in. makes one and a half million (1,500,000) stitches a minute, and will produce 15 in. of fine underwear fabric 64 in. wide in that period.

Plain circular machines with 80 to 100 yarn feeders will produce a ton of knitted web a week, but this fabric is not of a high class quality. Hence it will be seen that knitting is the cheapest method of producing a textile fabric, and users of cheap coverings should bear this in mind in the future. On the other hand, the highest class fabrics, the texture of which is unrivalled, can be made on a knitted principle. The uses of knitted fabric are unlimited, and in course of time the art of knitting will not only occupy first place for the production of underwear but will even seriously rival the art of weaving in the production of outer garments.

CHAPTER II

OPERATIONS PREPARATORY TO KNITTING

Knitting Yarns. The knitting industry is entirely dependent upon yarn as its raw material. Yarn is the term given to the comparatively soft thread-like substance used in the manufacture of textiles, and may be distinguished from thread owing to the absence of hard twist, excessive doubling, sizing and polishing. Thus in the knitting industry the goods are made from yarn, but in the making-up operations thread is used for seaming and other purposes. The yarns used in the knitting industry are many and diverse in character, but differ in most cases from those used in other branches of the textile trade. The necessary properties of a yarn used for knitting are softness, strength, and pliableness, although yarns can be knitted which do not satisfy these requirements. Speaking broadly, however, a knitting yarn should be full and soft, so as to cover the interstices of the knitted loop, and many yarns are spun specially for knitting and are called knitting yarns or hosiery yarns.

Cotton Yarns. The yarns are named in the first case after the fibres of which they are composed, viz., cotton yarns, wool yarns, silk yarns, etc., but in the trade many important divisions are made, so that under the heading of cotton yarns we get mule spun or hosiery cotton yarns, mercerized cotton yarns, Lisle thread yarns. A hosiery cotton yarn is one that is spun specially for knitting, and possesses but little twist, so that a soft and full feel is obtained. Mercerized cotton yarns are those which have been lustred by chemical and physical means. Lisle thread yarns possess two strands which are spun in opposite directions and finally doubled together. Cotton yarns are used largely in the manufacture of knitted goods because of their hygienic and wearing properties. They are cheaper than wool or silk yarns but not so hygroscopic, *i.e.*, they do not absorb moisture so readily. Cotton is also used largely in the production of mixed cotton and wool yarns which are sold under the names of union, cordon and merino yarns.

Wool Yarns. Yarns made from wool yarns are classified broadly into woollen yarns and worsted yarns. Woollen yarns go through fewer processes than worsted yarns and no serious attempt is made to arrange the fibres in a parallel manner, and the reduction in the thickness of the sliver is not obtained by the drawing frame as in the making of worsteds, but by a mule frame where the drawing and twisting are done at the same operation. Woollen yarns are neither combed nor gilled and hence do not possess the smooth, level appearance of worsted yarns. In the knitting industry the chief woollen yarns used are (1) lambswool, (2) wheelings, (3) skein yarns. The lambswool yarns are not composed of the actual wool of the lamb, but are merely short staple yarns which are of necessity thick and coarse, and the length of the individual fibres would not permit of the spinning of a fine yarn. The wheeling yarns are made from a longer staple of wool and can be spun somewhat finer. In most cases two strands are folded together and a stronger and finer yarn is produced of a better quality than the lambswool but still of a coarse character. Skein yarns are produced from superior fibres, and as a rule are of better quality. The yarns are often three or four fold, full in character, and are used for hand and coarse machine knitting.

All these yarns, however, are spun on the woollen principle and do not possess the smoothness and regularity of the worsted yarns.

Worsted Yarns are treated the same as woollens up to the point of carding, *i.e.*, the fibres are opened, scoured, dried and carded, but afterwards the sliver is gilled and usually combed Both these processes tend to place the fibres in parallel order and the combing rejects all the short fibres. After these processes have been performed the sliver is passed to a drawing frame and certain slivers are placed together and drawn out to the size of one of them. This sliver then passes to other drawing frames which reduce the width of the sliver until it is reduced to what is known as a roving. From this roving, different counts are produced by a combined system of drawing, twisting and winding known as throstle spinning. There are many varieties, counts and qualities in worsted yarns; the majority, however, are called Bradford worsteds, other varieties being known as Leicester worsteds, fingering yarns, a high-class folded yarn used for hand and machine knitting. Fancy mixture yarns such as the popular heather shades, have their individual strands dyed with different colours which blend harmoniously in the resulting folding.

Cashmere and Botany Yarns are spun on the French or "dry" spun principle, *i.e.*, are spun without added oil. These yarns are manufactured as far as the roving in a similar way to worsteds with the exception that all unnecessary twist is avoided and only moisture is added. Finally, however, they are mule spun, and thus these yarns possess the smoothness and regularity of worsted yarns combined with the softness and fullness of woollens.

Silk Yarns are classified as real, spun and artificial. Real silk yarns are those obtained by direct reeling from the cocoons of the silkworm. Spun silk yarns are spun from the torn-up silken fabrics, cocoon waste, etc. Another class of silk yarns is spun from the cocoons of the wild silkworms, and these yarns are known as Tussah silk yarns. Artificial silk yarns, sometimes called art silk yarns, are made from wood pulp. These artificial silk yarns have a lustre exceeding that of real silk, but are susceptible to hot liquids although constant improvements are being made with regard to this drawback, and they are now used extensively in the manufacture of ladies' hosiery and outer garments.

Systems of Numbering Knitting Yarns. All yarn systems are comparative only and are based upon the length of a given weight or the weight of a given length. The number of a cotton or spun silk yarn can be found by ascertaining the yarns per lb. avoirdupois, and dividing by 840. Worsted yarns are numbered on a principle of 560 yards the hank, the number of hanks weighing one pound giving the count. Woollen yarns are numbered on various systems which are fast becoming obsolete. Real and artificial silk yarns are numbered in quite a different manner, the count being the weight in deniers (an Italian weight) of 520 yards A denier equals ·001875 of an ounce.

To test yarns for correctness of count, the tester should reel off a number of yards, usually eighty, and weigh carefully to the grain. From this the number of yards per lb., or 7,000 grains, is obtained by calculation. This number divided by 840 gives the count in the cotton system and divided by 560 gives the number in the Bradford worsted system. The count of a real or artificial silk yarn is most easily found by obtaining the cotton count by reeling and then dividing the constant 5282·5 by this number.

Comparisons of Weight and Yarn Count in Mixed Fabrics. Many fabrics are now made of mixed cotton and wool or worsted yarns, the latter being put at the front of the fabric and the cotton used as a filling yarn at the back of the fabric. These goods are termed plated as the worsted or woollen yarn forms a covering for the cotton back. The weights of the yarns used are

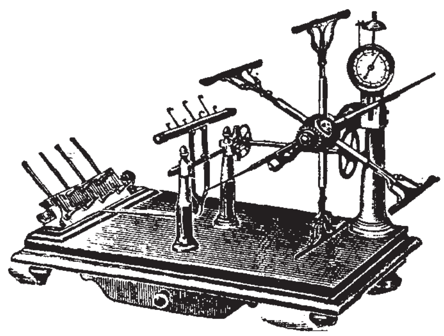


FIG. 6

YARN TESTER

inversely proportional to the counts of the yarns, but if worsted and cotton yarns are employed both counts must be calculated on the same system of yarn count before the inversion is made. Thus a fabric made from 12's worsted and 6's cotton would possess proportionate amounts of worsted and cotton determined as follows—

6's cotton has $6 \times 840 = 5{,}040$ yards per lb.

Hence equivalent worsted count $= \dfrac{5040}{560} = 9$'s.

Therefore equivalent worsted counts are 12's and 9's, and in 21 lb. of mixture 9 lb. of 12's and 12 lb. of 9's would be required, giving a percentage of 42·8 of worsted and 57·2 of cotton.

Assuming worsted to cost 10s. per lb. and cotton 4s. per lb., then cost of 100 lb. of fabric for the yarn used in manufacturing without any waste allowance will be—

42·8 lb. at 10s.	=	£21	8	0
57·2 lb. at 4s.	=	£11	8	10
100 lb. of mixed yarn	=	£32	16	10

Average price per lb. for yarn = 6s. 7d. (approx.).

All yarn problems can be similarly solved by arithmetical or algebraic calculations.

Yarn Preparation. In many cases hosiery yarns can be knitted up without preparation, but, if hard twisted, lively yarns are employed these should be prepared by lubrication. For woollens and worsteds the chief preparation used is an emulsion of soap and vegetable oil. To prepare this lubricant, which is technically known as lather, dissolve 1 lb. of white curd soap in boiling soft water and add ½ pint of "Gallipoli" oil, or some other vegetable oil such as cotton-seed oil. Neatsfoot oil may be used, but mineral oils must not be employed as they cannot subsequently be removed by scouring. The emulsion must afterwards be diluted by the addition of soft water so that the final quantity is made up to 1 gallon.

The lubrication of yarn makes it plastic and prevents dropped stiches and imperfect knitting.

Cotton yarns are lubricated by means of paraffin wax or some other hard fat.

The yarn lubrication is usually performed during the winding process, although some knitters also lubricate the yarn by passing it over oily waste during its passage to the needles in the knitting operation.

Yarn Winding. The value of good winding is often underestimated by knitted goods manufacturers, but without good winding it is impossible to obtain good knitting, hence the winding operation may be regarded as the key to knitting. Yarn, as received by the manufacturer, may be in the form of hanks, or it may be on cops, spools, or cones, but in most cases, whether it has been wound or not, it should be wound by the manufacturer before using. Much time and material have been lost in neglecting to perform the winding operation, and it undoubtedly pays to wind or re-wind the yarn.

Hosiery Yarn Winding Machine. Several types of winding machines are used in the knitting industry, but for general purposes the vertical or " bottle " bobbin machine will be found the most useful. In these machines the bobbins are placed on vertical spindles, each of which carries a disc at its lower end. The disc is driven frictionally by a wheel carried on the main shaft, which has a controlled lateral movement so that the linear speed of the yarn winding is kept constant. The traverse of the yarn up and down the bobbin is performed sectionally, so that the bobbin is gradually filled from the bottom to the top. The base of the bobbin is conical so that the bobbin always retains a yarn cone and the yarn can be drawn off without any undue friction.

These machines are built in sections, and the standard machines usually possess 24 spindles so that 24 bobbins are being filled at once. They can be fitted to wind from hank, cop, or cone, and in ordinary circumstances one operator can attend to 24 spindles. The usual size of the bobbin is from 13 to 17 in. in length, and the yarn package of the full bobbin weighs from 1½ to 3 lb. The spindles are rotated at a speed of 600-700 revolutions per minute, and the weight of yarn wound is proportional to the yarn number, although the state of the yarn is by no means a negligible factor. Several hundredweights of yarn can be wound in one week by a good operator. The machines may be fitted with automatic lubricating apparatus, which consists of a trough containing the lubricant. A roller is rotated in the liquid and carries a small portion of the liquid on its outer surface over which the yarn passes. In this manner the yarn is systematically lubricated.

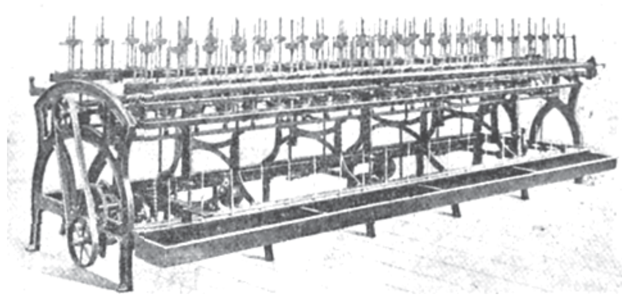


FIG. 7

HOSIERY YARN WINDING MACHINE

Quick Traverse Winding Machine. These machines are now employed largely in the knitting industry for winding yarns from cop or cone. The spindles are horizontal and are fitted with paper cones. The yarn is wound with a quick traverse, the thread guide passing along the entire length of the cone in approximately three or four revolutions of the spindle. The cones are usually from 6 to 7 in. in length and rotate at a speed of 900-1,000 revolutions a minute. Very large yarn packages can be wound, and owing to the principle of winding a very compact package is made which does not easily become ravelled.

A modern machine of this type is known as the "Universal" winding machine. In this machine each spindle has its own driving pulley which is constantly rotating, and each spindle is started or stopped individually by altering the position of a handle controlling the clutch mechanism which forms the connecting driving agency between the pulley and the spindle. The standard machine consists of six spindles carrying steel cones on which the paper cones are placed. The spindles run in bearings which are kept lubricated by means of rings, the oil being supplied from a well, placed in the upper part of the spindle casing. The thread guide is driven positively from a groove cam mechanism, and the ratio of the speed of the traverse of the thread guide, and the revolutions of the spindle can be varied by increasing or decreasing the size of the gainer pulley, so that the individual strands touch but do not overlap irrespective of the thickness of the yarn. Each spindle has a differential pressure and tension device as shown in the accompanying figure. The differentiation in tension is obtained from the position of the small weight on the tension lever DT. Thus by the leverage action of the weight the tension can be varied through the opening or closing of the comb tensions TC. The differential pressure is adjusted through the agency of the small weight on the pressure lever DB, as the traverse frame segment TS is counterpoised by the balance weight CW so that the true pressure factor is caused by the leverage of the pressure lever weight. Another feature of this machine is that each spindle is automatically stopped if by any reason the yarn is prevented from being wound. The thread is passed between the comb tensions underneath the triangular shaped wire

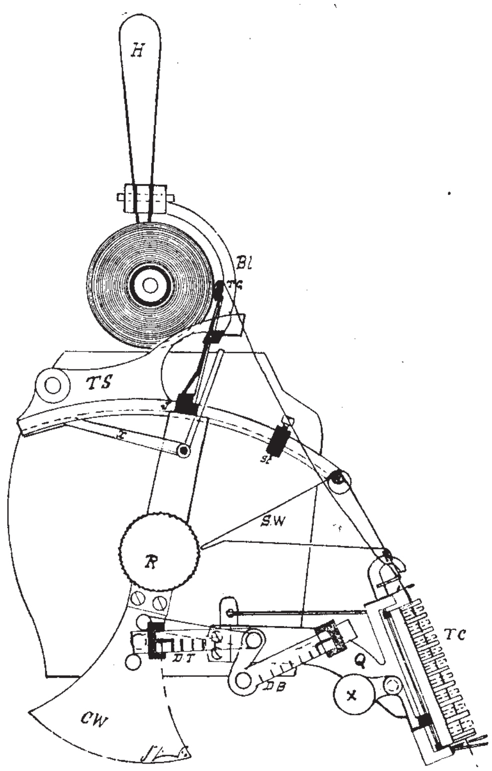


Fig. 8

SPINDLE AND TENSIONS—UNIVERSAL WINDING MACHINE

SW and holds up the wire clear of the rotating disc R. If the thread breaks, or is prevented by any reason from continuing the winding action the triangular wire falls on to the rotating disc R, and the rotation of the disc lifts the wire and consequently the frame segment TS, thus releasing the lever BL. This action alters the position of the clutch so that the driving pulley no longer operates the inner driving cone. This movement also causes a brake shoe to be released so that the winding action is immediately stopped and no difficulty is experienced in finding the loose end of the yarn. The amount of yarn wound can be varied in accordance with the position of the stop ST on the traverse frame segment TS, owing to the fact that when the thread guide touches this stop by reason of the increasing cone diameter, the machine is stopped through the same series of levers as already described.

Knot Tying. The tying of knots is a most important factor in winding, as knitting machines, with their multiplicity of needles, are peculiarly susceptible to knots or thick places. Most winding machines are fitted with clearing devices which are gauged so that big knots and slubs or thick places will not pass through to the bobbin or cone. The ordinary round knot should never be employed as it is too bulky and will cause damage to the delicate parts of the knitting machine. The best knot to tie is the "weaver's" knot, because this knot lies flat and has its loose ends on opposite sides of the join.

Too much emphasis cannot be laid on the importance of efficient winding, and yet it is still generally assumed that this operation is the least skilful of all operations connected with knitting. Good knitting is impossible without good winding, and many common faults in knitting which are assigned to defective knitting machines are really caused by imperfect winding. Thus irregular loops are often caused by the yarn being wound at unequal tension. Dropped stitches are caused by neglecting to lubricate properly. Holes and cuts in the fabric are often found to be due to drag on the yarn caused by bad winding. Loose ends cause press-off and waste. Thus every manufacturer should first of all look to the winding when faults occur in the fabric. Good winding is a preventive more than a cure for imperfect knitting, but it is useless to overhaul knitting machinery without first ascertaining whether it is the winding which is at fault.

Winding is fast becoming a specialized branch of the knitting industry, and the knitter must not expect to wind all sorts and conditions of yarns on a single machine without adjustment. Woollen, worsted, cashmere, cotton, silk and artificial yarns all require special treatment, proper adjustment of pressure and tension, specialized lubrication, and if the manufacturer wishes to get the best results he must study his yarn from a winding point of view.

Warping. The art of warp knitting is becoming more and more important in connection with the manufacture of fabric gloves, knitted scarves, ties, coats, and other articles suitable for outer wear; hence warping is now an important subsidiary operation in knitting. The warping operation is not necessary for ordinary framework knitting as in that case only weft threads are used, but in the making of many classes of fabrics and designs it is found impossible to knit from individual bobbins and in such cases the wound yarns must be warped. Warping consists of winding a large number of threads side by side on to a beam or on to a number of flanged rollers. The threads are first wound on to bobbins, which are placed in tiers on a wooden stand called a creel. Usually the warping is effected in sections from seventy-two bobbins. The threads are measured round a large drum or reel, each section being warped from the same number of turns of the reel. From the reel the threads pass through holes in a warping plate, which decides the distance the threads are apart, and from thence to the warp roller. In warping care must be taken to see that the various colours occupy their correct position on the beam, so that they can be threaded up in a direct manner to the guides in the warp knitting machine. In warping, the question of tension is of vast importance, as the size of the loop drawn is absolutely and solely dependent upon the tension.

CHAPTER III

PRINCIPLES OF KNITTED FABRICS

KNITTING forms a distinct and important branch of the textile industry and must not be confounded with weaving, as the characteristics and texture of the knitted fabric are totally different from those of a woven fabric. Textile fabrics may be classified as follows—

1. *Felt Fabrics* formed direct from the fibres by heat, moisture and friction.

2. *Woven Fabrics,* consisting of warp and weft threads connected on a principle of intersection.

3. *Twist Fabrics,* consisting of all warp threads and made by twisting one set of warp threads round another set.

4. *Looped Fabrics,* or Knitting. Made by first bending the yarn into loops and simultaneously or subsequently connecting the loops to one another to form a continuous fabric.

Felt Fabrics are manufactured into hats, caps and other like articles where pliability and rain-resisting powers are required. They are non-porous, durable and, as a rule, thick and comparatively weighty.

Woven fabrics are manufactured into all classes of textile goods where elasticity and porousness are not of primary importance and form by far the largest classes of textile fabrics.

Twist fabrics are employed for braids, twisted laces, ornamental trimmings, lace curtains, and nets.

Knitted Fabrics are invariably used for the manufacture of hosiery and underwear, but owing to their admirable properties are now becoming more and more used for outer wear. As a rule, knitted fabrics are elastic, porous, pliable, and adapt themselves to shaping. In many cases knitted fabrics are erroneously called woven, and some merchants and shopkeepers persist in styling

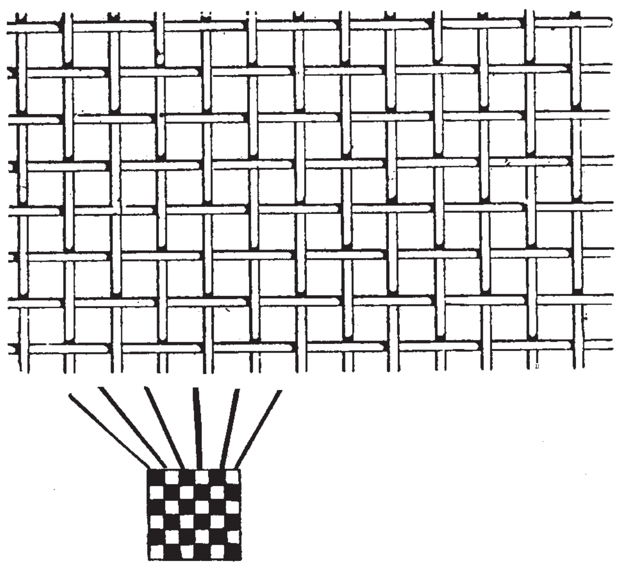


FIG. 9

WEAVING PLAIN 1 × 1 WEAVE

knitted underwear and hosiery as woven. This title is entirely wrong, as can soon be ascertained by a cursory examination of the material.

The Woven, Twisted and Knitted Fabrics Contrasted. Woven fabrics are composed of two distinct sets of threads, one set of which extend the full length of the fabric. These threads are called warp threads. The other set of threads are called wefts, and these are placed at right angles to the warp threads and are connected with the latter by a process called shedding. In the making of plain weaves it is only necessary to use a single weft thread, and in the simplest calico, or 1 × 1 weave, this weft thread is passed under the odd warp threads and over the even warp threads at one pick and *vice versâ* at the next pick. Fig. 9 gives a diagrammatic representation of this simple weave, and it will be noticed that the threads are perfectly straight so that no elasticity is obtained from the structure of the fabric. Variation in the warps, wefts, and methods of shedding cause big alterations in the fabric, but the general basis, viz., longitudinal and lateral threads intersecting each other in tension, is unaltered.

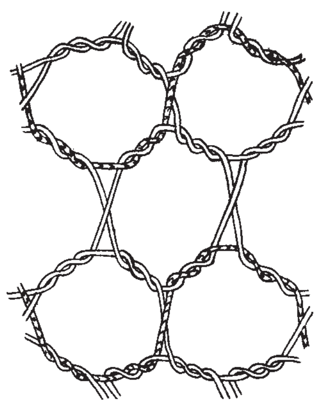


FIG. 10

LACE NET. TWISTING

A twist or lace fabric is composed of two sets of threads both of which are warp threads, and called respectively warps and bobbin warps. The warp threads proper are supplied from beams and hang vertically, the bobbin warps are wound individually on to small discs or bobbins so that about 100-120 yards of thread is wound on to each bobbin. These threads swing between the true warps, and the latter having an endwise or sideway movement effect the twist. Fig. 10 gives a diagrammatic representation of a common net made on the principle described.

Knitted fabrics may be classed into (*a*) Framework Knitted or Weft Fabrics and (*b*) Warp Knitted Fabrics. In the most elemental form the first-mentioned fabric is called plain hand knitting, as effected by the aid of two pins of steel, wood or bone, and the second fabric is hand crochetting, effected by means of a hook. In

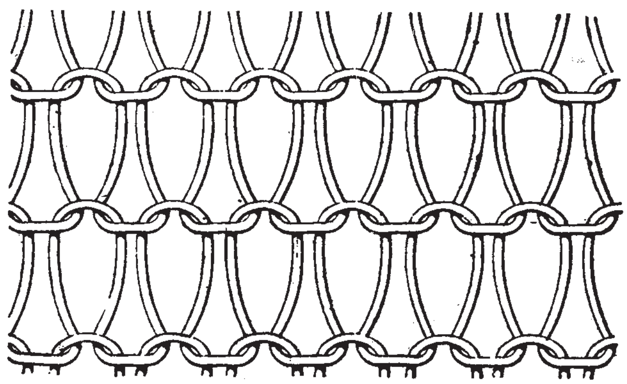


FIG. 11

PLAIN WEFT KNITTING

each case a looped structure forms the basis but in the first case the loops are joined row by row, and in the second case chains of loops are made which are afterwards connected to other chains.

Ordinary weft knitting, as shown in Fig. 11, consists of rows of loops, each row being supported by the succeeding row. The yarn is bent into a series of waves but the interlooping changes the character of the loops and the sides become S-shaped. The drawings of knitted stitches, loops, and fabrics are usually taken from the back of the fabric, and the drawing in Fig. 11 represents a plain knitted fabric as viewed from the back.

The upper part of the loop N is known as the needle loop as it is the part which hangs on the needle, and the lower part S is known as the sinker loop, as this part was, and is now, in many cases, formed by a loop-forming part called a sinker.

Warp knitting in its simplest form consists of a chain of loops as shown in Fig. 12, but these chains must be

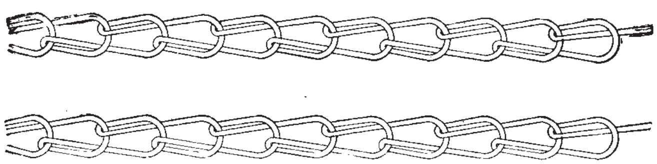


FIG. 12

CHAINS OF WARP KNITTED LOOPS

connected up to form a continuous fabric. Hence the simplest close warp fabric is knitted by longitudinally connecting the odd threads of the one course or lap with the even threads of the next lap, and *vice versâ* at the next lap, and so on alternately so that a continuous fabric is produced by the use of warp threads only, a system which can be adopted only with fabrics made on a looped basis.

Plain Weft Knitted Fabric. Plain weft knitting, or frame-work knitting as it is called, is made from one or more weft threads and can be knitted flat with selvedged edges or tubular. The face, or front, of the fabric shows the sides or vertical components of the loops. These form a longitudinal line along the fabric which is technically known as a wale. The back of the fabric shows the semicircular horizontal components, the upper parts being the needle loops and the lower parts the bottom parts of the sinker loops. These dual loops form what are termed courses, and the number of these in an inch can most readily be obtained from examining the back of the fabric, whilst the number of wales can be best obtained by counting them from the front of the fabric. The number of loops to the square inch is the product of the number of courses and the number of wales in one inch.

Rib-knitted Fabrics. The rib-knitted fabric is composed of exactly the same type of loop as the plain-knitted fabric, except that the interlooping is accomplished in a different manner. In the manufacture of ribbed fabrics, which are so-called owing to alternate wales or parallel tracks of wales being in two different planes, some loops are connected on the one side of the fabric and others on the reverse side of the fabric. In rib fabrics, if the looping is started on the one side, it continues throughout the making of that character of rib on this side, and if it is changed to loop on the other side of the fabric then the character of the rib fabric is changed. Thus, if alternate loops in a fabric are connected up on opposite sides of the fabric, then a 1×1 rib formation is obtained, *i.e.*, one longitudinal line or wale of loops shows the side stitches or face and the next wale the upper and lower parts of the loop or back of the fabric. Thus a 1×1 rib fabric has a similar appearance back and front.

Other ribs like 2×1, 3×1, 4×1 have 2, 3 and 4 stitches showing face loops alternating with one stitch showing the back loops. Broad ribs are those possessing 2 or more adjoining loops of each type, such as 2×2 rib which shows 2 face loops alternating with 2 back loops, 6×3 rib, 11×2 rib, which show 6 and 11 front loops alternating with 3 and 2 back loops respectively.

The rib fabric is noted for its extreme elasticity, and owing to the plain and rib loops being situated in two parallel planes the contraction of the fabric is much greater than that of the plain knitting. Hence it can be expanded or stretched to nearly double its width before any loop expansion takes place, so that its elasticity is increased by the concertina-like character of the wales. This property makes it extremely valuable for the making of parts which need to exert frictional contact with the body. Thus rib tops are used in the manufacture of men's socks, rib bottoms in making knitted trousers or pants, rib cuffs for the ends of sleeves, and rib welts for the extremities of vest bodies, jerseys, sweaters, etc. If the rib fabric is not stretched, then its thickness is practically double that of a similar plain fabric. Next to the plain knitted fabric the rib fabric is the most used of all knitted fabrics.

Pearl or Purl-knitted Fabrics. Pearl knitting or Purl knitting, as it is more properly called, is the plain knitting as made on the knitting pins without reversing, and consists in its simplest form of one row of loops connected on the one side of the fabric and the next row connected on the other side of the fabric. This type of knitting has parallel rows or courses of loops in two planes and thus contracts in length. Consequently the stretch is in the length of the fabric, a property which in most cases is not desired; hence it is seldom used in the manufacture of hosiery and underwear where longitudinal elasticity would be objectionable. It is, however, largely used in the manufacture of fabrics for children's wear, gaiters, putties, scarves, coats, etc., and by connecting up the loops in the one course in different ways, some to the back of the fabric and some to the front of the fabric, a design in back loops may be made on a ground of front loops or *vice versâ*. The effect of the loop contrast is very pleasing and forms a suitable medium for design in outer garments.

The three classes of fabrics, plain, rib and pearl have all the same simple loop foundation and the only difference that is made occurs in the interlooping. Consequently all three types of fabrics can be varied on similar lines, and, whilst it is not always practical to make such variations with respect to all three main types of fabrics, the theory of so doing is undoubtedly correct.

Variations from Plain Weft-knitted Fabric. These variations may be classified primarily as follows—

(*A*) Variation in stitch or loop formation.

(*B*) Variation in colour, yarns employed, and methods of loop selection.

(*A*) Examples of the variation of the character of the stitch formation are not numerous, but the possibilities affecting the question of design of each of these stitch variations are practically unlimited.

Strictly speaking the actual variations in stitches are limited to the following—

1. The tuck stitch or loop accumulation.
2. The open stitch or loop removal.
3. The pelerine stitch or sinker loop manipulation.

These stitches form designs which are visible without any extraneous assistance from the colour of the threads used, although the effect may be heightened by the use of colour variations.

(1) **The Tuck Stitch.** The tuck stitch can be employed on plain, rib and pearl weft-knitted fabrics, although if used in a simple manner in connection with the last it converts the fabric to a tuck rib-stitch. The tuck stitch is primarily used to form raised designs, although in some cases open designs may be produced by its employment.

The tuck stitch is a common defect in a plain knitted fabric, and is caused by loop accumulation arising from defects in the knitting machine adjustment or mechanism. If, however, loops are systematically accumulated and cleared then the surface of the fabric shows small prominences, or knops, regularly arranged over the face of the fabric. Thus if one loop is allowed to accumulate whilst the next loop is cleared, the tuck loop occupies a position behind the uncleared loop, and

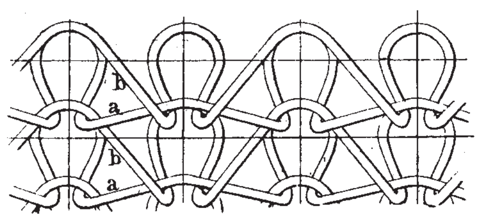


FIG. 13

DRAWING OF 1 × 1 TUCK LOOPS

if both loops are cleared at the next course it is evident that the uncleared loop from the first course and the tuck loop from the second course are both interlooped with the corresponding wale loop at the third course. This centralizes the position of the dual loops to midway between the courses. If two or more successive wale loops are accumulated then bigger knops or prominences are obtained. In practice it is found that loops must not be allowed to accumulate too much, as the strain on the needle is too great, so that the maximum number of loops accumulated should not exceed from four to six according to the definition of the machine used.

Tuck Stitch on Rib Knitting. The tuck stitch is really an incomplete knitted loop, and hence if two or more adjoining loops are tucked they eventually form one large loop and the true tuck effect is lost. Consequently on plain fabrics, to produce true tuck effects, not more than two adjoining loops should be tucked, but on rib fabrics the whole of one series of loops may be tucked as the loops formed are held by the other series of loops, and the fabric is widened and becomes thicker. On the 1 × 1 rib fabric, if a complete row of the one series of loops is tucked at alternate courses, whilst the other series of loops are knitted at each course, a fabric is produced which shows twice the number of loops on the one side to that on the other side. This tuck rib-stitch is known as the Royal Rib or Half Cardigan Rib. If both series of loops are knitted and tucked alternately, the one series knitting whilst the other series tuck, a wider, thicker, but symmetrical tuck rib fabric is made, known as Polka or Full Cardigan Rib, and if a heavy, hard-wearing rib fabric is required there is no doubt that the Cardigan Rib is the most suitable. This stitch is used largely in the production of men's sweaters, waistcoats, jackets, etc., and so popular has it become that men's jackets made with this stitch are known as Cardigans.

Use of Tuck Stitch for Colour Designs. The tucked loop, as will be seen from the previous loop drawing, is positioned at the back of the held-up loop. Hence it will be understood that its colour is not shown at the front of the fabric. Advantage is taken of this feature in the formation of colour designs for gloves, neck-ties, scarves, coats, and many fancy garments. By using the tuck stitch vertical or longitudinal stripes may be made. For instance, if one colour is used at one course and a different colour at the next course, and so on for alternate courses, horizontal stripes are made, but, if the odd loops are tucked at one course and the even loops are tucked at the next course, then in each case only the held-up loops are visible at the front of the fabric and longitudinal stripes in the two colours are produced.

The Open Stitch. The open stitch is made by the interlooping of a new stitch with two or more old stitches and allowing the next stitch, following the wale of the shifted loop, to be interlooped only with the stitches of the adjoining wales. This causes an opening to appear

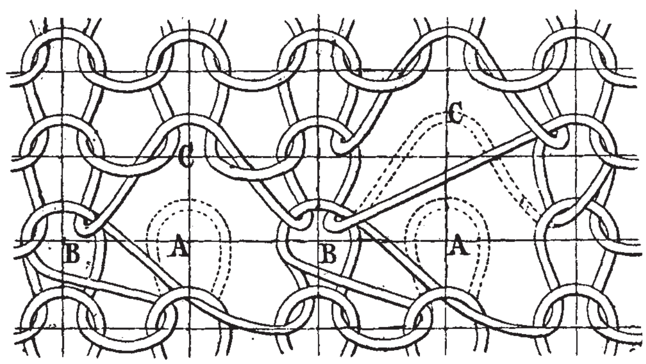


FIG. 14

OPENWORK LOOPS OR KNITTED LACE

as shown in Fig. 14. If this shifting of loops is systematized then small holes appear in the fabric and a cellular effect is obtained. By careful designing, elaborate patterns can be made which are used extensively in the manufacture of children's socks, ladies' hose, vest fronts, shawls, wraps and to a limited extent for cellular underwear.

The open stitch can be employed on the rib fabric either to produce an open effect or in conjunction with tucking to produce raised effects. This system of loop shifting or loop transferring is of great use to knitters, as it enables garments to be fashioned to shape on a system of narrowing and widening.

Fashioning by increasing or decreasing the Number of Wales. To narrow a piece of flat or tubular knitted fabric so that the quality of the fabric may be unimpaired it is usual to bring a number of loops inwards one or two loops and knit at the next course on the reduced number of wales. This necessitates the doubling of one or two loops so that a small prominence occurs at that point. This gives an enhanced appearance to the fabric and distinguishes it from fabric shaped by cutting or alteration of the stitch length or "quality" as it is technically called.

Widening the fabric is effected by transferring loops outwards, or, as it would be termed in hand-knitting, by "making" stitches. In framework knitting it is usual to transfer loops outwards, one loop only at the one course, as an open stitch is made which is partially closed by picking up a loop made at the previous course to take the place of the transferred loop.

Rib fabrics can also be similarly narrowed and widened, but the operation is more complicated as loops from both series must be transferred.

Pelerine Stitch. This stitch is made by picking up the sinker loop and causing it to be interlooped with the stitch of the next course. Where this is effected the loops are drawn close together and a peculiar peaked prominence is made, whilst where the sinker loop is left untouched an opening appears, caused by the extra length of the loop. Sometimes one sinker loop is expanded and interlooped with two needle loops to give a central effect, and adjoining sinker loops looped with one needle loop.

This stitch is known as the porcupine stitch but it is made only on hand frames. It is, however, of fine appearance and would be more popular if it could be produced more cheaply by making it on power machines.

(*B*) **Variations in Colour, Yarns employed and Loop Selection.** Simple variations in colour may be made by introducing yarns of different colours at different courses. This method causes stripes to appear across the fabric in the order as predetermined by the design, and by carefully blending the colours employed many simple but artistic designs can be produced. These designs are called horizontal stripe designs as they are positioned across the whole width of the fabric.

Longitudinal stripes can be produced by employing different colours of yarns which are looped in vertical sections of the fabric. Such stripes can easily be made on a warp knitted principle, but if weft-knitted longitudinal stripes are made a little difficulty occurs in the joining of the stripes without producing a variegated coloured edge. Pure vertical stripes, however, can be made on this principle, and if only one thread is used for each section of knitting the stripes are known as "solid," *i.e.*, composed of one thread only. In these cases the joining must be effected at the back of the fabric only on a principle of tucking or sinker manipulation.

Plated Fabrics. A plated knitted fabric may be compared with plated metallic goods, and should not be confounded with "plaiting" or twisting. A plated fabric is composed of two separate yarns, one of which appears on the face of the fabric and the other at the back of the fabric. Thus many classes of goods are made possessing a woollen or worsted face and a cotton back. In plain plating the loops are made from the two yarns by the knitting taking place simultaneously, but in such a manner that one yarn always appears at the front and the other at the back. The chief object in plain plating is to cheapen the cost of the fabric and yet preserve its appearance, although in the case of cotton and wool plating a hygienic advantage is also gained.

Design Plating. Plating is largely used for the purpose of design, as, if a plain ground of knitted fabric is made, no trouble is experienced in the joining up of the threads. Plated designs are made on several principles, and the plating threads used may be many or few. In some cases two yarns are used in the production of each loop, and mechanism is provided so that either the one or the other can be brought to the front in accordance with a predetermined design. In other cases design threads are arranged at intervals to produce a design on a plain knitted ground. Plating, plain and fancy, is also effected on both rib and purl fabrics.

Method of Loop Selection. To produce designs in colour a system of loop selection is often employed, so that certain needles knit at intervals as predetermined by the design. If only one set of needles are used, then the thread where not knitted lies as a straight thread at the back of the fabric. On the earlier machines this class of work was known as press-off fabric, as the loops were formed on the needles and afterwards pressed off at the parts required. The modern method, however, is to select those needles required to knit by means of Jacquard cards, so that any design which can be plotted out on squared paper can be made. By these means the designing scope is greatly increased, and this method of selection is applied not only for the purpose of loop selection but in connection with the formation of all the previously mentioned stitches.

The great advantages gained in knitting and in the production of knitted fabrics may be summed up as follows: Knitted fabrics can be made from a large number of weft threads which knit simultaneously so that knitted fabric can be produced more quickly than any other class of fabric. A still further advantage is gained owing to the fact that the comparatively slow process of warping is not required.

Knitted fabrics are elastic, but by means of stitch variation the elasticity can be reduced to a minimum so that knitted fabrics can be produced in competition with woven fabrics.

Many variations of stitch can be made, and in all these variations the same range of manipulation for purposes of design can be assured.

Knitted fabrics can be made from warp threads only so that again time is saved in crossing of the weft as necessitated by the process of weaving, or the twisting of the bobbin warps as used in lace manufacture.

Knitting is a comparatively new fabric, and its scope and possibilities have not yet reached their limit. Knitting machinery is capable of being improved so that the production may be further increased and new type of fabrics may be knitted.

Knitting, in this country at all events, has been a comparatively neglected art, fettered by prejudice, and the importation of knitted goods and garments into this country has in the past greatly exceeded the exports. This fact also applies to knitting machinery, so that if a progressive policy is introduced much of this leeway can easily be regained, and in the future it will be essential to put more zest and spirit into the knitting industry, so that the country which gave birth to the knitted fabric will regain its position as the premier producer.

CHAPTER IV

HAND-KNITTING MACHINES AND KNITTING OPERATIONS

THE first knitting machine was, of course, operated by hand, but this does not really convey any information as to its working, for both hands and feet were used in obtaining the necessary motions. To-day the old hand frame, as it is called, still flourishes, and many high-class articles of hosiery, underwear, and sports garments, gloves, etc., are made upon it. The hand frame still knits the best quality of fabric and will work the coarsest yarn as to gauge, and must, therefore, still be included in the list of hand machines. The chief drawback to its employment is that it takes some months for an operator to become skilled, and secondly, unless small frames are used, it requires too much physical energy to be suitable for female labour. Another point is that owing to the slowness of the knitting it cannot hold its own against other hand machines, which are worked by a handle and do not require so much manipulative skill on the part of the operator. The hand frame, however, is a most instructive machine from a technical point of view, because the knowledge of the looping movements of the bearded needle with the subsidiary loop-forming actions of the sinker and divider can readily be obtained by a study of the hand frame.

Briefly speaking, hand-knitting machines can be classified as follows—

1. Hand frames for making wrought goods of all types.

2. Hand circular knitting machines for the manufacture of plain and ribbed seamless hosiery.

3. Hand flat knitting machine for making gloves, ties, scarves and other fancy articles.

All these types of machines are used both as domestic and factory machines, and for the manufacture of certain classes of goods are to be preferred to power machines. The student of knitting can learn much from these machines, and, indeed, can only become proficient in the art of knitting by actually performing the operations which are essential in the working of the hand machines.

(1) The hand frame has four primary loop-forming parts, viz., the needle, sinker, divider, presser.

The needles are of the spring bearded variety, as shown in Fig. 15. These needles possess the important parts as shown. The total length of the needle varies in accordance with the type of machine in which it is employed, but in the hand frames is comparatively long, varying from $1\frac{1}{2}$ in. to 3 in., according to the gauge. It is made from round wire, and the stem and shank is battered or flattened, and at the end, corrugated so that a key is formed to prevent it from pulling out of the lead into which it is cast. The casting metal consists of one part lead and one part tin, and the needles are leaded in order to consolidate them and allow of their removal and replacement when broken without disturbing adjoining needles. The spring beard is of great importance, as during the life of the needle it is depressed into the eye millions of times, and after each pressing operation the spring of the beard must be sufficient to cause it to return to its original position. In the hand frames the beards are cramped so that the new loop is locked in the head of the needle. This needle was invented by the Rev. William Lee, and for

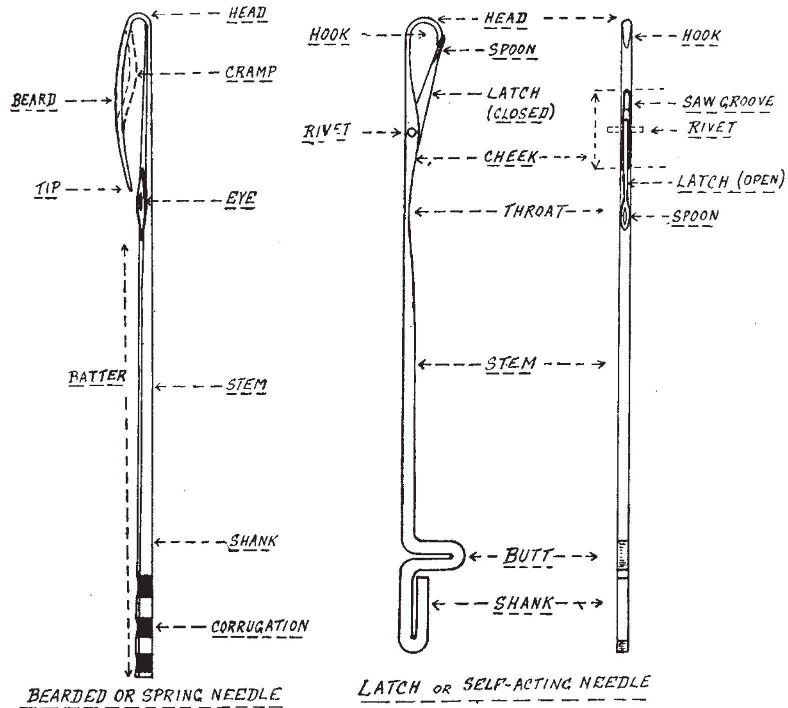


FIG. 15

PARTS OF SPRING BEARDED AND LATCH NEEDLES

250 years stood without a rival, but in 1849 Matthew Townsend, of Leicester, England, invented the latch or self-acting needle, which is shown in the same figure as the bearded needle for purposes of comparison. This needle is more complicated and consequently more difficult to make, but the knitting action is far more simple than that of the bearded needle as the operation of pressing can be dispensed with and the needle can knit without the aid of loop-forming sinkers. The latch needle can knit by means of a simple reciprocal motion and can be used in any position. The chief parts are enumerated in the illustration, and it will be observed that at the lower end a projecting part, known as a butt, is shown which provides a shoulder so that the reciprocal movement can be imparted to the needle by means of shaped steel plates known as cams. At its upper end is a hook which catches the yarn and draws the loop. To close the hook and so allow a loop to pass off the needle a pivoted latch is used, which is automatically controlled by the looping movement. It will be obvious from the illustration that a loop inside the hook will open the latch if the needle is raised, and conversely a loop on the throat of the needle will get under the latch and so by a downward movement of the needle close the latch and in consequence be cleared from the needle. The knitting movements of this needle will be considered at a later stage when machines employing this needle are being described.

The sinkers and dividers in the hand frame are similar in shape at their looping points but differ in the mode of attachment. The sinkers are attached to levers and operated singly to form the loops, whilst the dividers, or lead sinkers, as they were originally called, work collectively and divide the sinker loops. Usually the sinkers alternate with the dividers, and necessarily

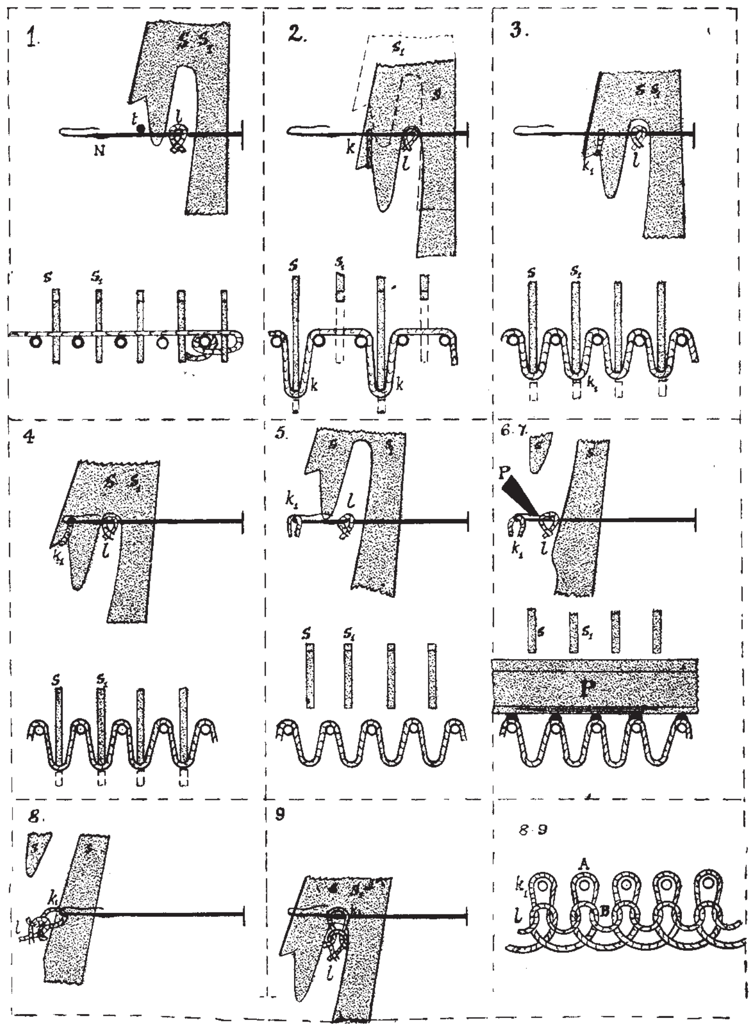


Fig. 16

DIAGRAM OF LOOPING MOVEMENTS OF HAND FRAME each must have its adjoining needle. The looping action of the hand frame is shown in Fig. 16.

The hand frame is used both in the home and in the village shops and for the making of fancy fabrics, such as shown in Fig. 17, which depicts a stockinger working his frame, is still unrivalled if quality of fabric and excellence of design is placed before production.

Part of the movements of the hand frame are obtained by moving the bars by means of the hands whilst the individual loop-forming and the pressing is done by means of the feet through the agency of treadles. The hand frame industry is of great interest and forms a link with the past, which it is to be hoped will not be entirely broken, for the sake of the memories and associations of the good old days when the present rush and turmoil of the modern knitting mill did not exist.

(2) **Hand Circular Knitting Machines.** These simple hand machines, simpler by far than the hand frame, are most adaptable for female labour and can even be worked by the blind. They are of much later origin than the hand frame as latch needles are used, and the first machines which were built in the U.S.A. did not reach this country until 1870. The machines are so constituted that not only tubular work can be produced, but by means of turning the handle of the machine backwards and forwards flat selvedged fabrics can be made. They are eminently suitable for domestic use, as anyone can quickly become expert enough to produce two or three pairs of hose or half-hose in one hour, a fact which many hand knitters will read with surprise and envy. The modern type of machine is fitted to produce both plain and rib knitting, and the machine is often called the " Griswold " machine, after the name of the inventor of the modern ribbing attachment which contributed largely to the success of the

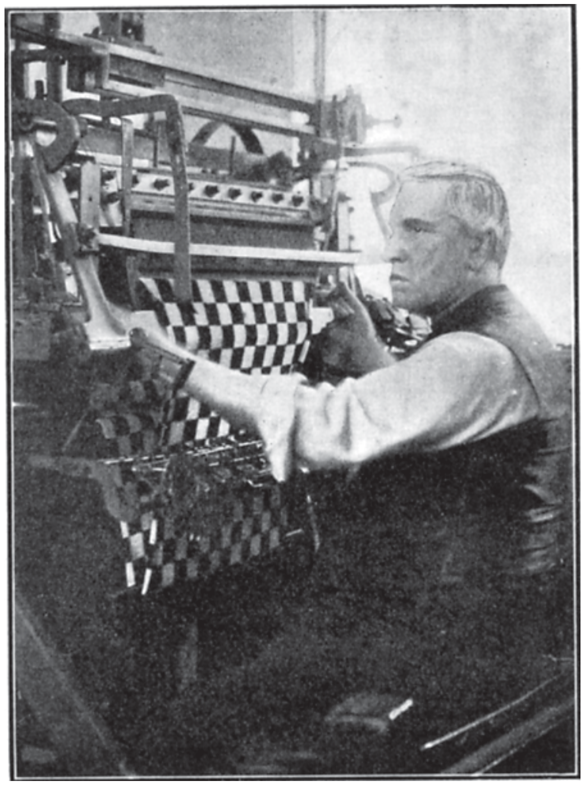


FIG. 17

HAND FRAME IN OPERATION

machine. The simple character of these machines will be seen from the accompanying illustration, Fig. 18, and they can be screwed either to an ordinary table or bench, or a specially constructed pedestal or stand, so that the operator can be seated whilst working the machine.

The looping movements will be easily understood by reference to Fig. 19. At 1 is shown the normal rest position of the needle with its butt resting on the ledge of the cam cylinder and, the old loop securely round the latch. The cam cylinder is shown in section at D and the needle cylinder likewise at E. The needles are kept in position by a circular band shown at C. At 2 is shown the incline on the block K, which raises the clearing cam A. Two clearing cams are used, but only one is in action at a time, viz., the one preceding the knitting cam B in accordance with the direction of motion. The knitting movements of the latch needle generally are as follows: (1) Old stitch cleared from the latch; (2) Yarn supplied to needle; (3) Needle draws yarn into loop and simultaneously by the closing of the latch casts off the old loop. On hand machines, weights are required to draw off the fabric as it is knitted.

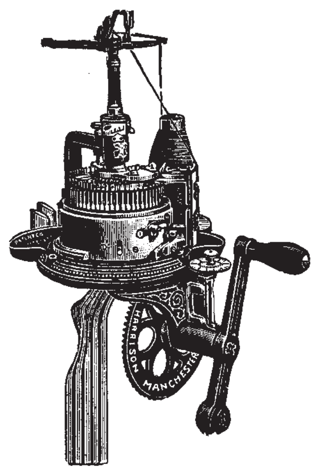


Fig. 18

HAND CIRCULAR KNITTING MACHINE

As shown in the diagram at 2 the yarn is supplied to the needles by the thread guide H, which is constructed so that the latch is prevented from closing at this point. In the same diagram at 3 is shown the final knitting action, the needles being pulled downward to draw their stitches to a length decided by the adjustment of the knitting cam B. The length of the stitch can be

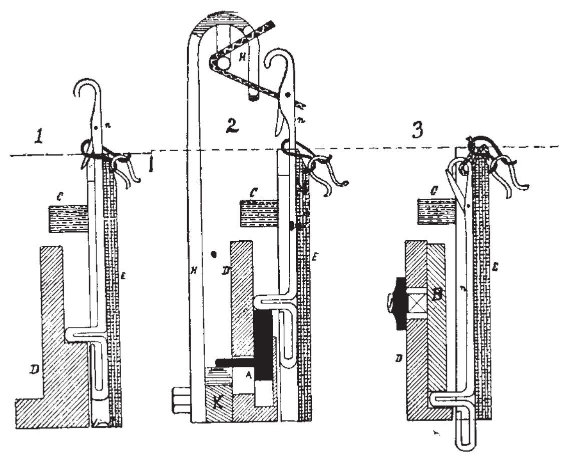


FIG. 19

LOOPING MOVEMENTS OF HAND CIRCULAR KNITTING MACHINE

altered to a known degree by the aid of a pointer and scale situated on the outside of the cam cylinder, the pointer being directly connected to the knitting cam B. The number of courses is registered automatically when tubular work is being made by means of a small worm and wheel, but when the machine is operated reciprocally the courses must be counted by the operator.

In all the hand machines the needle cylinder is stationary, and the movement to the needles is given by means of the rotating or oscillating cams.

Other necessary adjuncts to the machine are (1) Yarn take-up, which supplies the necessary tension for taking up the loose thread when the machine is knitting flat work. (2) Setting up comb, which consists of a collapsible circle of hooked wires equal in number to the number of needles. This is used when knitting is to be commenced, and the first course is made by wrapping the yarn alternately round these hooks and the needles. The weight must be attached to this comb. (3) Heel weight. During the making of the reciprocal knitting as in the knitting of heels and toes it is necessary to attach an extra weight to draw off that section of knitting. The heel weight consists of a double-hooked wire with the weight attached.

Making of Seamless Hose on Hand Circular Knitting Machine. Generally speaking the following operations are required: (1) Setting on; (2) Knitting the leg; (3) Shaping the calf; (4) Raising needles in the back half; (5) Bringing in splicing thread, altering stitch cam for quality and putting take-up on yarn; (6) Raising and lowering heel needles which are situated in the front half one by one; (7) Depressing heel needles cutting out splicing, re-adjusting stitch length and removing take-up; (8) Knitting foot; (9) Knitting toe by repeating operations 4 to 7.

Previous to setting on, a trial piece should be knitted to ascertain the correct length of stitch required for the given thickness of yarn. Before setting on it will be necessary to notice that the yarn guide is at the front ready threaded. When setting up it is advisable to work anti-clockwise as the yarn rotates in this direction so that a portion of the loops may be set up and the handle turned to get the cams from the needles. The weight should be attached to the setting-up comb immediately the setting on is finished. The indicator should be set at zero, and the necessary courses worked for the knitting of the leg. The graduation of the calf should then be effected by slightly raising the knitting cam at short intervals. To make the heel it is necessary to stop with the yarn guide at the front and raise the back half of the needles. The splicing thread should now be twisted in and handle turned so that the cams are at the back. The stitch must be adjusted at this point and the take-up placed on the yarn. The first low needle on the right must now be raised and the handle turned backward for the full revolution. The motion must again be reversed after the first low needle on the left has been raised. These actions must be continued until one-third of the heel needles on each side have been raised, but when a few needles have been raised it will be found necessary to attach the heel to prevent the loops rising with the needles. The second part of the heel is made in a similar manner except that one needle is lowered at each oscillation of the handle. An actual example of heel forming is shown in Fig. 20.

In this case the machine possesses eighty-four needles, forty-two of which are raised before the heel making, and fourteen on each side are raised and lowered individually during the heel making. Thus a fashioned pocket or pouch is made which is of a closed formation on one side of the tube of knitting. After knitting has been resumed on the whole of the heel needles, the back half of the needles must be lowered, stitch adjustment made, take-up removed, and circular knitting resumed for the knitting of the foot. The toe is knitted in exactly the same way as the foot, and when it has been finished two or three courses of tubular knitting are made, and the hose is cast off the needles or, if preferred, the next leg may be commenced. The toe must afterwards be closed either by hand seaming or by a process, afterwards described, known as linking.

Rib Attachment. Most of these hand machines are capable of making rib knitting, and this attachment

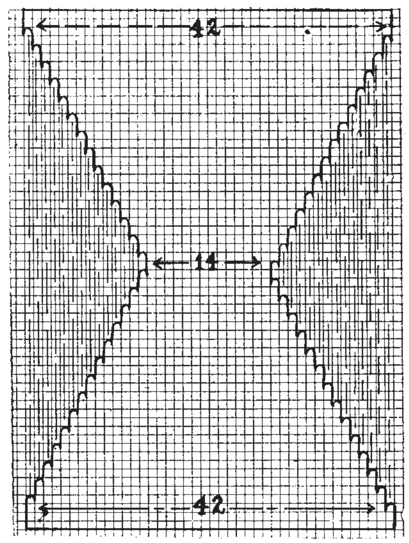


FIG. 20

SEAMLESS HEEL FORMATION

consists of a flat needle dial cut radially into tricks in which are placed short latch needles. The dial is carried on a centre axle, which is posed vertically over the centre of the machine and carried on an arm attached to the cam cylinder. The butts of the needles project above the dial and are actuated by cams.

There are two operating cams: (1) Knitting cam, which is adjustable; (2) Clearing cam, which is movable by means of handle. When not knitting the needles lie round a circular part. The knitting action is similar to that of the cylinder needles except that the rib needles are placed horizontally. When heels and toes are made the clearing cam must be brought backward so that the rib needles in the back half do not knit.

Making of a Men's 3 × 1 Ribbed Half-Hose. A men's 3 × 1 ribbed half-hose is made with a 1 × 1 rib-top, 3×1 rib-leg and instep, plain heels, toe and sole. The 1 × 1 rib is made by arranging the needles in the cylinder and dial in alternate order, *i.e.*, one cylinder needle, one rib needle. The machine must first be set up on plain work with cylinder needles in every other trick only. The ribbing attachment is placed in position and a few courses of 1 × 1 rib are made. The rib needles must then be put out of action by moving the clearing cam to an inactive position. Four or six courses are now worked and the cam is returned to its former position. Knitting may then be resumed for the making of the 1 × 1 top. At this juncture every other rib needle must be taken out and its loop transferred to a substitutionary cylinder needle, which is placed in the empty trick opposite the rib needle. The knitting is continued on the 3 × 1 formation for the leg, after which all rib needles in the front or heel half must have their loops transferred to substituting cylinder needles as before, so that the front part is entirely plain knitting. The instep needles must then be raised and the rib knitting cam put out of action, and all the changes incidental to heel-making must be performed as stated in the directions for making a plain hose. To knit the foot the normal positions of the parts must be regained so that a ribbed instep and plain sole is made.

The toe is made on the same principle as the heel, and a few courses must be knitted for the toe-joining, and the cylinder and rib needles re-arranged to get back to the 1 × 1 formation. These half-hose are made in string formation and then separated by cutting just below the welt.

Fashioned rib hose can also be made on these machines by commencing with a full set of cylinder needles *plus* a number of rib needles, and the fashioning is effected by removing those needles only which adjoin the rib needles and transferring their stitches to adjoining cylinder needles. In this manner the empty cylinder trick is always opposite a rib needle, so that no defect, such as would be caused by merely removing a cylinder needle, viz., a run-down stitch, will be made.

Hand Flat Knitting Machines. The term flat knitting machine does not correctly represent the appearance of the machine as it now possesses two needle beds, which are inclined at an angle of 90° to each other and at an angle of 45° to the horizontal plane. Originally, however, the machines possessed two parallel and horizontal beds placed in the same plane, and hence the term flat was introduced. The first machine of this class was invented by the Rev. Isaac W. Lamb, an American, who afterwards became interested in the building of these machines. It certainly seems remarkable that the knitting industry should have been supplied with machines by two clergymen, who must rank not merely as casual but as primary inventors, and who both founded knitting machinery establishments. The flat machine is the most versatile and adaptable of all knitting machines, as it can produce a large range of knitted fabrics the width of which can be varied without any trouble.

The modern hand flat knitting machine is used largely for the production of flat and tubular plain fabrics as well as plain, tucked and racked rib fabrics. Hand machines of this type are chiefly used for the production of small articles such as gloves, ties, scarves, sporting hose tops, etc., especially where great variations are required in the designs, and the number of like articles produced is very small.

The machine consists primarily of two needle beds in which are cut tricks for the reception of the latch needles. At the bottom of each needle groove is a small spring to keep the needle from falling below its knitting position. Thus, those needles not required to knit can be pulled down and kept out of action. The needles are actuated by means of cams, which are carried on a camplate attached to a cam carriage, the latter being moved backwards and forwards across the needle beds by hand. Sometimes the handle is rotated, but in many cases the operator prefers to move the carriage reciprocally. The machine may be attached to a table or stand, and the yarn is placed at the back of the machine and is threaded through the hole in the take-up and finally through the yarn guide.

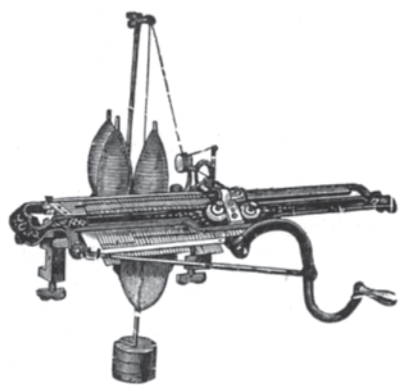


FIG. 21

HAND FLAT KNITTING MACHINE

Even on hand machines, automatic cams are employed by means of which the machine can be set to produce (1) Plain flat work on one bed; (2) Plain tubular knitting; (3) Plain rib fabric; (4) Half cardigan or full cardigan rib.

Knitting, however, can only be commenced on rib work, and the method of starting to knit is as follows—

A set-up comb carrying a number of holed wires is employed. One movement must be made across the beds with cams set so that the needles in both beds knit. This causes each needle to draw a loop, and the loops lie across the opening between the beds. The wires of the set-up comb are pushed up between the loops and a wire passed through the whole of the holes. Thus the set-up comb wire rests on the loops. A weight is placed on the comb, the take-up spring is placed on the yarn and the cams then reset to produce the class of knitting required.

Fashioning on Hand Flat Machines. Both flat and tubular fabrics may be fashioned on flat machines, and this machine is the only type that will successfully produce fashioned tubular knitting. Tubular knitting is made by knitting first on one bed and then on the other, the same yarn being supplied to each bed. Owing to the fact that the distance between the needle beds is the same as the distance between adjoining needles, the end loops of each bed are connected in precisely the same manner as two adjoining loops in the one bed, and if the take-up is properly adjusted the fabric, when removed from the machine, is perfectly tubular. To narrow this class of fabric straight pieces of hard steel wire with eyelets in one end are used. The other end is fixed to a holder, and usually three of these points are placed to the holder so that the end three loops are transferred. The action is as follows:—The narrowing points are placed on the hooks of the needles and the needles pulled upwards so that the loops are below the latches. The needles are next pushed down by means of the points and consequently the loops come off the needles on to the points. The latter must then be removed from the needles and placed on the needles to which the loops are to be transferred. These needles are drawn up slightly and the loops transferred from the points to the needles. After the fashioning has taken place the empty needles must be drawn downwards to a passive position. Rib fabrics may be similarly narrowed, but they can also be widened by simply raising a needle from passive to active position prior to the return of the cam carriage. Tubular fabrics cannot be widened in this manner on hand machines as a hole results.

In addition to the previously-mentioned fabrics, racked designs can be produced on most hand machines by knitting a tuck-rib fabric and moving one of the needle beds one needle distance sideways after a certain number of cam carriage movements.

Knitting Operations. All knitting operations cannot be performed automatically, and hence operators, especially those employed in the working of hand machines, must acquire a certain amount of skill in a number of operations. The chief knitting operations which must be performed manually are as follows—

1. *Running on.* This operation consists of placing a complete course of knitted loops of a previously made fabric upon the needles or upon points. The fabric is placed on the needles, loop by loop, at a distance of three or four courses from the end row of loops, and when the loops of this course have been securely placed on the needles the fabric is unroved until this course is reached.

In many cases the fabrics are run on to a series of points and afterwards transferred to the needles in order to save loss in the running time of the machine. Rib tops, flat and tubular, are often transferred in this manner.

2. *Jobbing on.* This method is employed in cases where it is impossible to run the fabric on loop by loop, and consists in placing the fabric on the needles irrespective of the loops. In such cases it is impossible to "clear," *i.e.*, unrove the fabric down to the loops on to the needles.

3. *Turning a Welt.* A plain welt can be made on plain machines and is performed as follows:—The operator seizes the loops of the first course by means of welt-hooks carried in a welting bar. A welt hook has a large eye on one side and a turned hook on the other. After the loops have been caught by means of the hooks the weight is attached to the welt bar and a piece of fabric twice the length of the finished welt is knitted. The fabric is then pushed back to the welt bar and the eyes of the hooks placed on the beards of the needles. The loops are moved so that they are transferred to the needles, and the welting hooks, by a turning movement, are disconnected from the loops. It is possible to make the welt only at the commencement of the fabric so that the other welt is finished on a kind of seaming machine.

Definitions of Technical Terms. Many knitting operations formerly done by hand are now performed mechanically and known under different terms. The following gives the most important of such operations—

1. *Turning-off or Linking.* This substitutes the old hand process of binding off, and is used for joining two courses of knitted loops or for edging the last course to prevent running down. The method consists of placing the fabrics, loop by loop, on a circle of points which travel slowly round and finally pass into a

stitching zone so that the loops are connected by some form of chain stitching. These machines often possess knives or cutters, so that the fabrics are cleared automatically, no hand-roving being required.

2. *Seaming*. Hand seaming has practically become obsolete in the knitting industry as machines are now employed. There are four kinds of seaming: (1) Point seaming; (2) Cup seaming; (3) Overlock seaming; (4) Flat-lock seaming. Point seaming can be used only on selvedged fabrics and is a similar operation to linking, except that the selvedge loops are run on to the points and that an over-seam chain stitch is employed. Cup seaming is suitable only for fabrics with selvedge edges, and is much quicker than point seaming although the fabrics are not strictly joined loop by loop. Overlock seaming is employed for joining cut fabrics. It consists of placing the fabrics together, trimming and over-edging the cut parts. It is the most popular and cheapest method of joining cut fabrics in a thoroughly efficient manner. Flatlock seaming consists in the joining together two pieces of knitted fabric irrespective of loops by means of a butt seam. Four rows of double chain stitching are used, and the joining of the fabrics is covered on both sides. By these means a perfectly sound flat seam is obtained. This is the best method of joining cut underwear fabrics, although it is not so cheap as the overlocking system.

Slack Course. A term used for a row of loops slightly longer than the normal, and made so that the operator can distinguish the running-on course.

CHAPTER V

MANUFACTURE OF HOSIERY

THE term hosiery is often used to denote a knitted fabric, but strictly speaking the term should only be used in connection with knitted coverings for the legs, and it is in this sense only that it is now used. There are many styles of hosiery which include men's hose and half-hose, ladies' hose, children's socks, golf hose, elastic stockings, opera hose, etc.

A hose implies that a long leg is knitted reaching above the knee. Three-quarter hose are shorter. Golf hose have a fancy turn-over top and reach just below the knee. Half-hose are exclusively men's wear, and have a short leg and a ribbed top. Children's socks are made with short legs and ribbed tops. Three-quarter socks have longer legs and are made, inclusive of the ribbed top, three-quarters the length of the corresponding size of hose. Elastic stockings or surgical hose are re-inforced where required with elastic threads. Opera hose are made the full leg length. The manufacturing styles of hosiery may be classified as follows—

1. *Cut hosiery*, made from cut fabric or from small tubular fabric with cut heels or attached wrought or seamless heels.
2. *Wrought hosiery*, which is fashioned by narrowing to the shape of the leg, heel and foot.
3. *Seamless hosiery*, made from tubular fabric with seamless pouches which serve for heels and toes.
4. *Fashioned seamless hosiery*, made and fashioned in a tubular manner.

Hosiery may be either plain or ribbed, but not purl, and is usually styled in accordance with material used, type of manufacture and whether ribbed or plain. Thus, men's hose or half-hose may be sold as Plain Worsted Hose, Cotton Seamless Hose, Cashmere Half-Hose, etc., ladies' hose are similarly designated, for example: Lisle thread Lace Hosiery, Cashmere Seamless Hosiery, Ladies' 2 × 1 Ribbed Hose, etc. Other terms are used, such as Re-inforced Heels and Toes, High Spliced, Double Sole, Split Sole, etc., the meaning of which will be understood by the methods of manufacture given later in this chapter.

(1) **Cut Hosiery.** This class of hosiery is not made in such large quantities as was formerly the case owing to the ease with which the seamless variety can be made, but it is still employed in the making of a cheap class of fancy hosiery, the leg and instep parts being cut from fancy fabrics, and the heel, sole and toe are afterwards attached.

Hosiery as a class may be considered as possessing the following parts (1) the Leg; (2) the Heel; (3) the Instep; (4) the Sole; (5) the Toe. Sometimes part is made in the cut style and the remainder wrought or seamless, but the general method of making a shaped hose will be better understood by showing how a wrought hose is made.

(2) **Wrought Hosiery.** This class of hosiery is chiefly made on straight bar machines working with bearded needles, and the modes of manufacture differ only in the making of the heel and foot portions, the latter including the instep or upper foot portion, the sole or lower foot portion, and the toe.

Two styles of feet are made, the first being known as the English foot and the second called the French foot. In each case the hose is commenced by turning a welt at the top of the leg and then working a straight piece of knitting to the length required. At this point the width of the fabric is gradually narrowed to suit the shape of the calf. After the fashioning has been performed a straight piece is worked for the ankle. All types of wrought hose are similarly made up to this juncture but afterwards differ in the manner knitted. In the making of hosiery with the English foot, a style on which fully 90 per cent. of the British made wrought hose are manufactured, the fabric is made in three selvedged strips, the two outer strips forming the heel and the centre part the instep. After the three strips have been knitted to the length desired for the heel parts the latter are pressed off the needles, and the instep is continued and finally narrowed to shape at the toe and then pressed off.

The whole of these operations are performed on what is known as the legging frame, which is usually built to make twelve or eighteen hose legs at once. This part is transferred to the footing frame, which makes from eighteen to thirty feet simultaneously. The inner selvedge loops of the heel strips are transferred to the needles and the knitting of the foot bottom or sole is commenced. Usually this is commenced on a slightly greater width than the upper instep part, but it is immediately narrowed to this width. This fashioning gives more room for the thicker part of the foot which adjoins the heel. The foot bottom is continued and finally fashioned for the toe to match the upper foot portion. The hose is finished, so far as the knitting and seaming are concerned, by seaming down the back of the leg and along the sides of the foot. The heels and toes are closed by the process of linking.

In the making of the French foot the heel strips are made without the instep portion, and the selvedge edges of the inner parts, in conjunction with the pressed-off instep portion, are transferred to the footing frame so that the foot is made in a single piece. The gusset narrowings are put in, a straight piece knitted for the foot, and the toe shaped by a special system of narrowing. The hose is afterwards seamed at the back of the leg and along the middle of the foot bottom. Thus, the English foot can easily be recognized by the fact that it has two seams, one down each side of the foot, and the French foot can be recognized by the presence of the single seam along the middle of the foot bottom or sole. Men's half-hose and children's socks having short legs are not fashioned in the leg but are commenced by running on a ribbed top and afterwards worked straight for the leg portion.

3. **Seamless Hosiery.** By far the greater bulk of knitted hosiery is now made, on a seamless principle, on fast-running seamless hose machines which are entirely automatic in their action and which produce hosiery complete with heels and toes in "string," *i.e.*, continuous, formation, but which follow the principles of the hand circular knitting machine already described.

This style of hosiery has its leg shaped, to some extent, by the shortening of the loop, and the heels and toes are made on precisely the same principle as that described in connection with the hand machines. When a heel or toe is about to be commenced the tubular knitting ceases and the machine knits reciprocally, *i.e.*, backwards and forwards on one-half of the needles only. The fabric is narrowed one loop at each oscillation, until only one-third of the needles in that half are knitting. This part is then widened one loop at each oscillation, until the original half width is reached. Tubular knitting is now resumed for the foot, and afterwards the toe is made in exactly the same manner as the heel. When the toe has been made the machine starts to knit in a circular manner for the next leg. The hose are afterwards separated by cutting the fabric a few courses from the completion of the toe, and the latter is joined up by means of linking. Some machines make their own welt, and in this case each hose, as made, is cast off the machine, but in the majority of cases no welt is made, and the welting is afterwards done on an overlock welting machine which hems the edge so that none of the stitches shows through to the front.

4. Plain seamless fashioned hosiery can only be made on flat-knitting machines which possess two needle beds on which knitting takes place alternately. On hand machines the fashioning is performed manually, but on power machines the hose is commenced at the toe, widened out for the foot, the heel is made seamless, and the leg fashioned by widening.

Hosiery Knitting Machines. For making plain wrought hosiery two kinds of straight bar bearded needle frames are required, viz., legging and footing frames. These machines differ only in the width of the divisions and work on exactly the same principle. This type of machine was invented by William Cotton, of Loughboro', Leicestershire, in the year 1864, and the machines are often called, even to-day, Cotton's Patent Frames. The main features of the machine are vertical moving needle bars and horizontal sinkers.

The "Cotton" system of rotary frame was the first successful attempt to modify the knitting action of the original stocking frame as, although power machines were in vogue, these machines were working on exactly the same principle with the same loop-forming parts as Lee's hand frame. Cotton introduced a vertical moving needle bar with horizontal loop-forming and dividing sinkers so that the long sinker motion of Lee's frame was avoided, and the loop forming was done partly by sinker movement and partly by needle movement. This condensing of the movement enabled his machine to be driven at twice the speed of the existing power machines. Moreover, he introduced a perfect system of narrowing so that the fashioning could be effected automatically at any predetermined interval. Cotton's frame was a huge success, and so sound was the principle that it is now used in all countries, and machines of this type are still the premier ones for the manufacture of all types of fashioned goods.

An illustration of one of these machines is shown in Fig. 22. The chief loop-forming parts are (1) Bearded needles; (2) Horizontal sinkers and dividers; (3) Fixed knocking over bits; (4) Fixed Presser. The loops are formed by the individual forward movement of the sinkers and then divided by the collective action of the dividers in conjunction with a slight outward movement of the needles. The latter are then moved towards the fixed presser and the old loops are landed on to the beards. The needles are brought downwards to knock over the old loops and afterwards rise to their original position.

The fashioning takes place at intervals by the shogging of the main cam shaft, which brings other cams into action, so that the transferring points make contact with the needles. The descent of the needles and points brings the selvedge loops, usually six in number, on to the points, and the latter are liberated from the needles, rack two needles inwards and deliver the stitches on to the needles, which are now opposite to them. The number of knitting courses between the narrowing courses is decided by a wheel, which can be racked in accordance with the number of courses required.

The Cotton system of rotary frame has also been

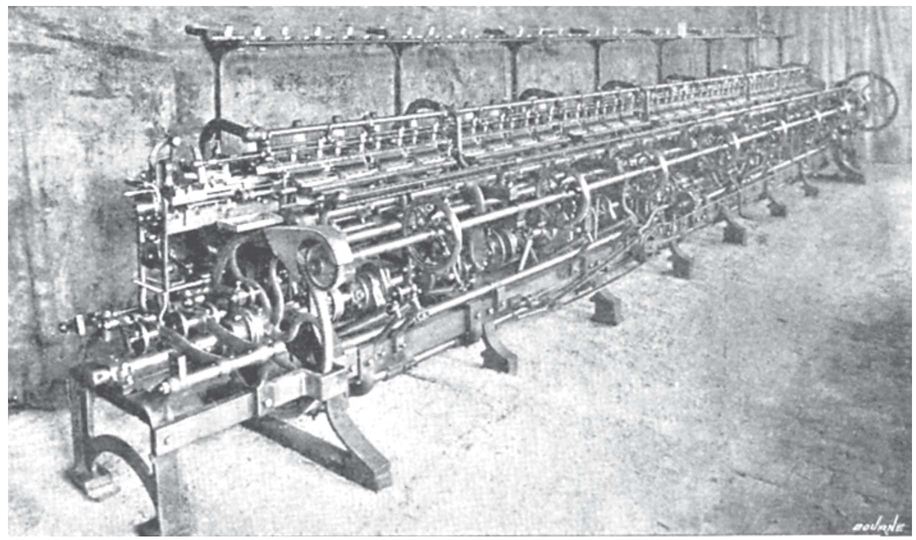


Fig. 22

COTTON'S PATENT HOSE FRAME

adapted to the making of rib-work, and for this purpose a second set of needles, working horizontally, are placed in position between the vertical needles. The loops are formed on the vertical frame needles, and the function of the rib needles is to knit the sinker loops of the frame needles into proper rib-loops. Mechanism for making welts and for fashioning is attached to these frames so that either rib tops or ribbed hose can be made on separate frames. Wrought ribbed hose are usually made from 2×1 rib, as less fashioning of the rib loops is required.

The Cotton system of hosiery machine is a well-designed mechanically perfect machine, and produces a hose of a very high class quality, but owing to its reciprocal action cannot produce goods so cheaply as the circular knitting machines.

Circular Automatic Knitting Machines. The first of these machines was invented in the U.S.A. in 1879, and was called the "Shaw" automatic knitting machine. A few years after, the first Scott and Williams machine was invented. This machine was fitted with a cam which, during the making of heels and toes, brought all needles to a high position, and those needles on which knitting was to continue were brought down by an expanding and contracting fan mechanism which operated on the needle heads. Shortly afterwards, the picker was introduced. The picker is a short radial arm which is placed in the path of the needles so as to change the position of the first needle it meets but leaves the position of the remainder unaltered. Since the introduction of these machines the mechanism has been so changed and perfected that to-day a machine with a diameter of 4 in., containing up to 260 needles, can be rotated at a speed of 300 revolutions a minute and thus make stitches from a single weft thread at the rate of

78,000 stitches a minute and make a complete hose in a few minutes. Moreover, a girl, when making hose, can attend to six or eight machines.

The latest type of plain seamless hose machine completes the hose with the exception of linking the toe, and produces and casts off, in regular automatic succession, hose with welt, garter top, anti-run-down course, shaped leg, high spliced and reinforced heels, double sole and spliced toe. Many other machines produce hose similar in every respect except that the tops of the legs are not welted on the machine.

The modern type of plain automatic seamless hose and half-hose machine possesses the following essential parts—

1. Needle cylinder and sinker ring. Long and short butt needles and web holders.
2. Cam and picker system and splicing apparatus.
3. Two-speed gear for circular knitting and quadrant gear for oscillating knitting.
4. Controlling cam shaft or drum and timing chain.

In addition, the revolving needle cylinder machines have a number of thread guides and means for high splicing above the heel and along the sole.

Broadly speaking there are two types, viz.—

1. Revolving cylinder machines in which the needle cylinder is the part revolved or oscillated.
2. Stationary cylinder machines in which the cam cylinder is rotated or oscillated.

The former are the more recent machines and possess several advantages, such as multiple yarn guides, positive splicing mechanism, high splicing; and are faster but are slightly more complicated and more expensive.

The latter are somewhat slower and are not easily adaptable for the use of multiple thread guides and high splicing but are simpler and less expensive.

For the making of children's socks and half-hose there is but little to choose between the two types of machines, but in the making of hose the greater speed and the extra thread guides render the former much more productive.

The gauge of these machines is usually expressed in needles per diameter; thus a machine marked 200-4 in. contains 200 needles in a diameter of 4 in., *i.e.*, in a circumference of $4 \times 3\frac{1}{7} = 12\frac{4}{7}$ in., or practically sixteen needles to the inch.

All the modern machines employ latch needles and, indeed, only one successful bearded needle seamless hose machine has been produced, and even this is practically obsolete at the present time. The machines are simple to operate and are invariably worked by female labour supervised by a knitter-mechanic, who has charge of a number of machines and who alters the machine for changes in yarn and lengths.

These machines are built in diameters from 3 in., for children's socks, to 4 in. and $4\frac{1}{2}$ in. for women's and men's hose respectively. Lengths are altered by the number of plain links between the movement links on the timing chain. Usually the length of the stitch is altered on rotating needle cylinder machines by the vertical displacement of the cams, and on the stationary needle cylinder machines by the vertical displacement of the needle cylinder. Stitch adjustment can be made to suit the yarn knitted, but the alteration of stitch for shaping the leg and for knitting the reinforced heels and toes is made automatically. The machines are usually placed in double rows about a yard apart and 4 ft. from middle to middle of the rows. They are driven from a countershaft carried between the rows in bearings screwed to the floor.

When half-hose are being made, the ribbed tops are

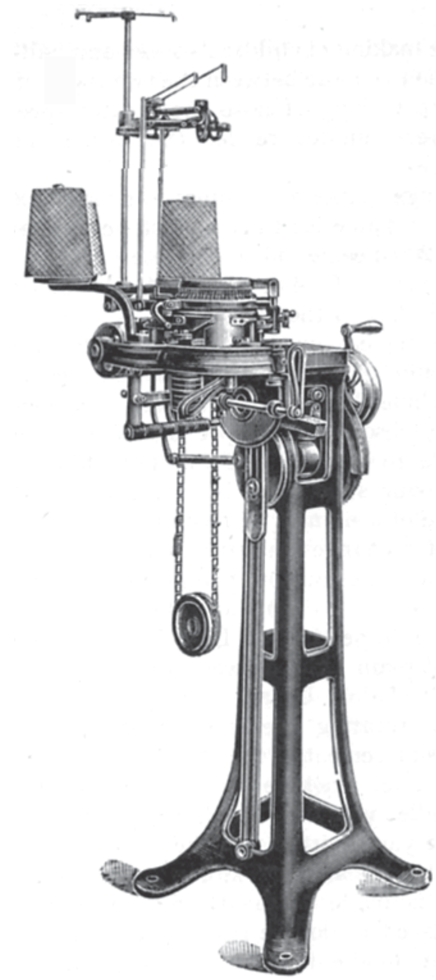


Fig. 23
TYPE OF PLAIN SEAMLESS SOCK MACHINE

first made on a rib-top machine and are cut into lengths and transferred to the needles in the half-hose machine in one of two ways. The old method, as used on some stationary cylinder machines, is for the tops to be run on to the needles of a second cylinder not in use on the machine, and when one half-hose is completed the whole cylinder and sinker ring is taken out and the one upon which the rib-top has been placed put in the machine. The new method which is always used in connection with revolving cylinder machines is to run the rib-top on a circle of points, and then to place the points on the needles while the cylinder is in the machine and transfer the top to the needles. For this purpose it is necessary to get all needles to one height, which is performed automatically after the previous half-hose has been cast off the needles.

Finishing Seamless Hose and Half-Hose. Practically only one operation is essential after knitting, viz., that of linking, although, if hose are made on the non-welting machines, a second operation carried out on an overlock welting machine is necessary. The linking machine is explained and illustrated in the next chapter.

Linking is a slow operation, and attempts have been made to dispense with the operation and replace it by some form of stitching device where the loops are not joined individually. These attempts have not proved very successful, although for joining the toes of cheap goods the " Merrow " Sewing Machine Co. have designed a special type of overlock machine which makes a very close and compact join, and if the operator exercises care as to the exact place of the join a satisfactory result is obtained in but a fraction of the time taken up by the linking.

If the hose are not welted on the machine the welt is turned on an overlock welting machine. This machine is practically the same as the overlock seaming machine, described in the next chapter, but has a special guide so that the join is effected on the needle loops which are at the back of the fabric ; it thus makes what is termed a "blind" stitch, *i.e.*, the welting stitches are not visible on the face of the fabric. The hose is manipulated face side on the exterior and the edge is doubly folded. The knives trim off the raw edge, and the guide, adjustable for various gauges of fabrics, allows the triple fabric to be connected in the manner described.

Seaming of Wrought Hosiery. The chief machines are: (1) The point seamer, which enables the selvedged edges to be joined loop by loop; (2) The cup seamer, which joins the selvedges in an efficient manner but not exactly loop by loop. These machines are practically the same as those used in seaming wrought underwear, and will be described in the next chapter.

Seamless Ribbed Hose and Half-Hose. For a long time seamless ribbed hosiery could only be made upon semi-automatic machines, and all changes of stitch, from rib to plain, or *vice versâ*, were done by hand as explained in connection with the hand machines. In 1900, however, Stretton & Johnson, of Leicester, invented the superimposed needle cylinder machine, in which "double headed," *i.e.*, latch and hook at each end, needles were used. These needles were operated by means of sliders which engaged with the hooks of the needles. This machine proved an immediate success, and to-day practically all men's medium and coarse ribbed half-hose are made on these machines.

The principle of the machine is as follows: Two vertically positioned needle cylinders are used, one being placed directly above the other. Ordinary latch needles are used in either cylinder where no change of stitch is required, but double-headed needles are used where a change in stitch is to be made. To control the double-headed needles hooked implements, called sliders, are required, one in each trick of the upper and lower cylinders at all parts where double-headed needles are used. If the upper slider engages the needle a rib stitch is formed as the lower head is the operating one, whilst if the lower slider engages the needle a plain stitch is made. The sliders possess two operating butts, a knitting butt and a transfer butt, and when the change of stitch is required both sliders momentarily engage the needle until the cam action causes the previously active slider to be released. In the making of a 3 × 1 half-hose the following changes are necessary in addition to all those changes mentioned in the manufacture of plain half-hose.

Start. Machine is knitting plain loops on front half and 3 × 1 rib loops at back.

1st change. Lower sliders transfer needles to upper sliders to make 1 × 1 rib.

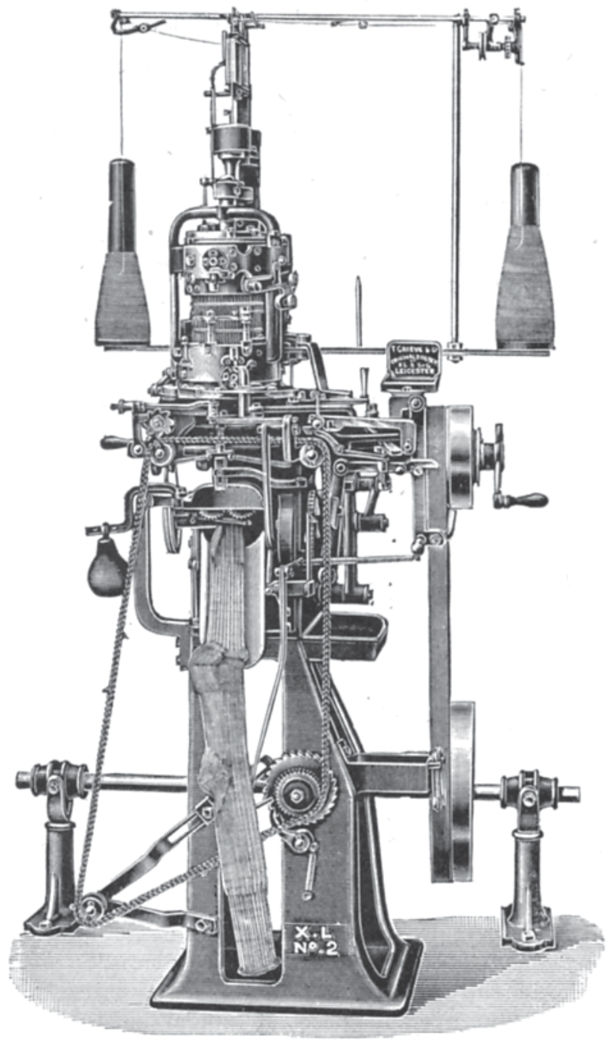
2nd change. Rib cylinder cams cause needles and sliders under their control to become passive for the making of welt.

3rd change. 1 × 1 rib is resumed for the top.

4th change. Character of rib is changed to 3 × 1 for the leg.

5th change. All stitches on front half of machines are changed to plain before the making of heel, foot bottom and toe.

Fig. 24 shows a general view of one of the machines which are generally known in the trade as XL machines. These machines, owing to the mode of needle control, cannot be run at nearly as high a speed as the plain machines, the average speed on tubular knitting being 120 revolutions per minute. One operator can attend to six machines, which should average 25 dozens each



SEAMLESS RIBBED HALF-HOSE MACHINE

per week, thus enabling an operator to make 150 dozens a week on the six machines.

Circular Rib Fashioning Machines. The methods adopted in fashioning circular ribbed hose on power machines follow the principle given in connection with the hand machines, viz., by employing a full set of cylinder needles plus a number of rib needles and afterwards reducing the number of cylinder needles by the number of rib needles employed. In fashioning on power machines, however, the loop is transferred from the cylinder needle to the opposing rib needle. The chief type of fashioning accomplished on automatic machines is fashioning from 4 × 1 rib to 3 × 1. The machine makes a 1 × 1 fast welt, 2 × 1 rib top, 4 × 1 leg, which is fashioned two loops after every few courses to 3 × 1 ankle. Plain heels, soles and toes and a 3 × 1 instep are then knitted as in the making of a 3 × 1 hose or half-hose. Fig. 25 shows a modern type of fashioning machine capable of producing a fashioned hose as stated.

The manufacture of hosiery to-day is a vastly different operation from that of the past. In the early days men and women laboured late and early to produce one article at once. Later, the wide hand frames were built and a man could make 6 legs or 10 feet at once, and the women, owing to the physical strength required, could make only 3 legs or 6 feet at once. The next stage was the introduction of the power frame, when men or women could attend to a machine making 8 legs or 12 or 16 feet, and finally the Cotton's system was introduced to produce 18 legs or 30 feet. The introduction of the hand circular knitting machine, however, placed the whole trade on a different basis, and to-day, although the operator actually attends to the making of a much less number of hose at the one time, the speed of production

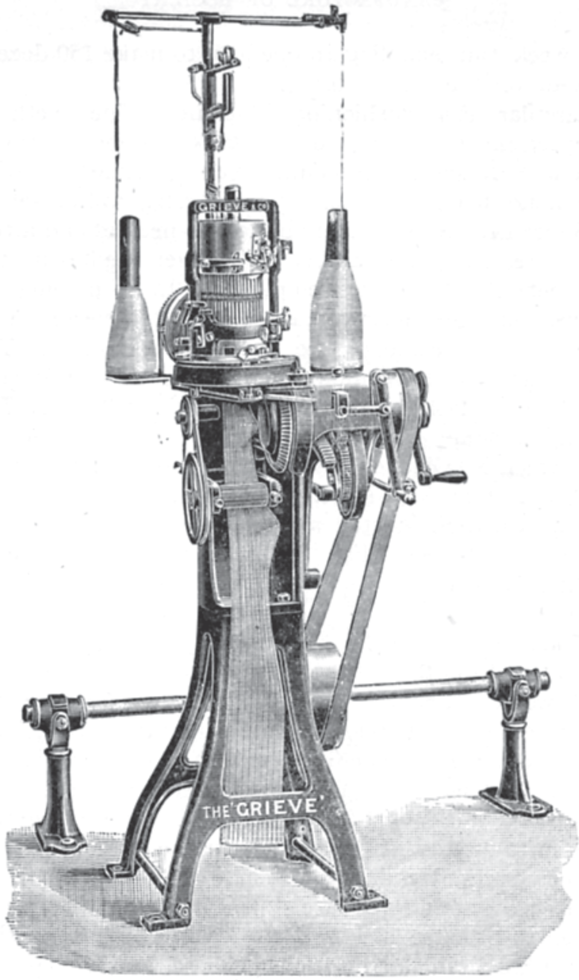


FIG. 25

CIRCULAR RIB FASHIONING MACHINE

is much greater, as will be understood when it is stated that the average speed of the latest straight-bar legging frame may be taken as fifty courses a minute and the latest plain automatic circular knitting machine as 300. Moreover, there is no stoppage for welting, changing for heeling, and no blank fashioning courses. Hence it will be understood that for production the seamless machines must be used, whilst for quality, shape and style of the hose produced the modern straight bar machines are unequalled.

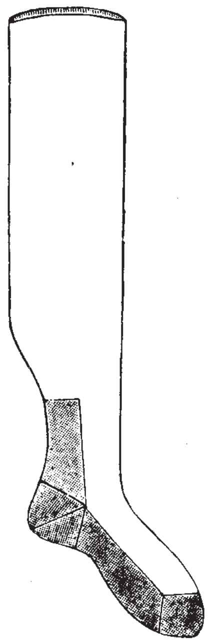


FIG. 26*a*
SEAMLESS HOSE (PLAIN)

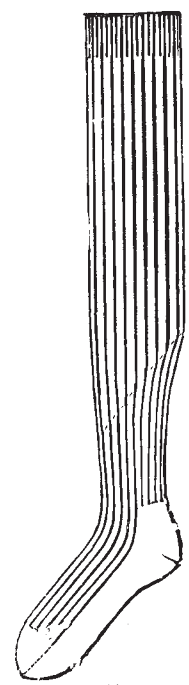


FIG. 26*b*
SEAMLESS HOSE (RIB)

CHAPTER VI

MANUFACTURE OF KNITTED UNDERWEAR

KNITTED underwear includes all those knitted garments which are worn under ordinary clothing but does not include such articles as cardigan jackets, sweaters, etc., which, from a knitting standpoint, are regarded as outer garments.

A large number of garments are included under the heading of knitted underwear, such as men's vests and trousers, union suits, ladies' vests, and combinations, etc. The knitted fabric is undoubtedy the most suitable for underwear, especially that worn next to the skin, as it is more elastic, hygroscopic, and hygienic than any other textile fabric.

The knitted fabric has many outstanding properties, and whilst the majority of these are in its favour there is one property, that of contraction and shrinkage, that requires to be overcome. The combined contraction and shrinkage of knitted fabrics is due in the first place to its looped formation and secondly to the yarn composition. Generally speaking knitted fabrics contract when released from the knitting machine action, because the interstices of the loops, caused by the use of the loop-forming parts, *i.e.*, needles and sinkers, allow the fabric to contract in both width and length. It is found in practice, however, that wool yarns of all types cause more contraction in the fabric than cotton yarns. This fact is due to the loops being formed under tension and so causing more stretch in the yarns possessing greater elasticity. The contraction in the fabric width on circular machines is much greater than that on straight-bar machines, and roughly speaking the flat width of the fabric, as it comes from the machine, is equal to the diameter of the machine. But the fabric is made on a needle circle which is equal to the circumference of the machine cylinder, hence the width of the fabric is practically only two-thirds of the making width. If the fabric is afterwards boarded out to a greater width then the extra width will be lost the first time it is laundered.

Underwear is made as follows—

1. From knitted web which has been made in the roll and finished.

2. From cut or wrought fabrics, in the making of which allowance is made for subsequent contraction.

The first method is undoubtedly the most popular, as it enables net measurements to be employed and, moreover, the finished web, as the fabric is called, lies flatter and does not curl like unfinished web, so that the seaming is more readily accomplished.

The second method must necessarily be applied in the making of wrought garments, as the respective parts are selvedged to shape, and coarse cotton garments are often cut from the unfinished web. Seamless underwear is made to some small extent on the flat knitting machines, and this is also finished after making up.

1. Manufacture of Cut Underwear from Finished Web. The general method is to unroll the web along a counter, placing the patterns on the web and afterwards cutting by means of scissors or shears. Another quicker method is to put a number of fabrics one above the other, and use an electric cloth-cutter. The parts, being cut out, are passed to the seaming room where the various parts are sewn together. Afterwards the garment is made up by the attachment of beige, buttons, etc. Necessarily each article requires a different amount of seaming and making up so that, for explanatory purposes, a standard article must be taken. Accordingly the seaming and making of a men's pant or trouser will be given in detail.

Men's Cut Pant. *Material required.* Finished knitted web in the roll. Pattern cut to shape of leg, thigh, seat and waist. Gusset for fork. Ribs for bottom of legs, beige for banding and fronting, buttons, cotton for machining.

Machines required. Electric cloth cutter. Flatlock or overlock seaming machine. Lockstitch machine, Twin needle chain stitch machine, Linking machine or machine for attaching ribs, button-holing and button-sewing machines.

Pants are made from two pieces, shaped as shown in Fig. 27. The average proportions are given in terms of the half body width. A to B is known as the band, B to C as the body, C to D as the seat, D to E as the thigh, E to F as the knee, F to H as the calf, the remaining portion being the ribbed bottom. Another similar piece is required for the other half and the parts are joined together down the back of the body from A to D, a square gusset is put in to close the fork and the legs seamed from below the gusset to the end of the rib. A piece of beige, suitably shaped to serve as a band and front for the button-sewing and holing, is attached to the upper part of the body so that the open front can be closed by buttoning. Brace loops are attached to the band. The proportions will enable a range of sizes to be compiled by taking different body widths. Thus if the half-body width is 18 in. the width of the seat will be approximately 21½ in., the total length, 43 in.; length of leg, 28½ in.; length of back, 18 in. It will be observed that the length of the leg and back total more than the full length, but this is because

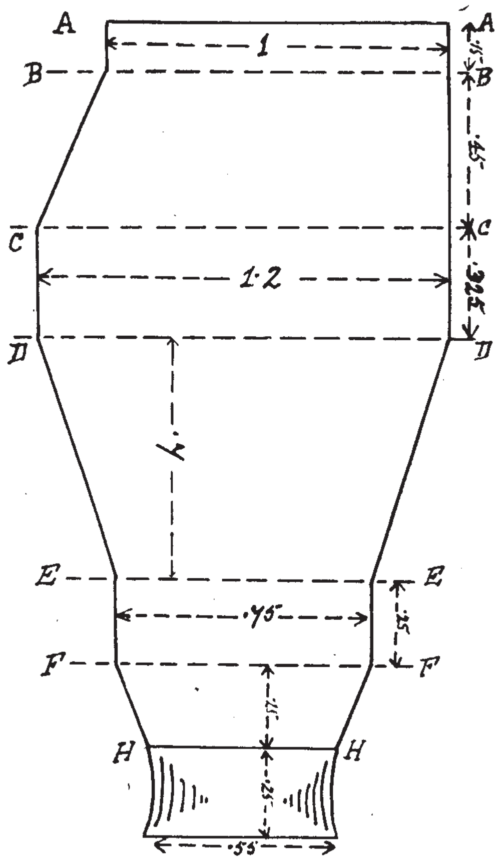


FIG. 27

PROPORTIONATE MEASUREMENTS OF PANT

they are both measured from the tip of the fork gusset. The gusset square (not shown in diagram) is ·16 as compared with the half-body width, and hence in this case would be 3 in. Length of rib, 4½ in.; length to end of calf (F), including rib, 9 in.; to end of knee (E), 13½ in.; to end of thigh (D), 26 in.; to end of seat (C), 32 in.; to end of body shaping (B), 40 in.; total length, 43 in. Width of rib, 10 in.; width of knee, 13½ in.

In like manner other garments can be designed, cut out, and finished. Men's vests have straight tubular bodies and either short or long sleeves. Ladies' vests have shaped bodies and diamond-shaped or curved pieces of fabric sewn in to the bodies to give more room for the breasts. Ladies' combinations are cut from tubular fabric in many ways, in fact the modern manufacturer of knitted underwear is now compelled to study cut and design in the same way as a costumier. Economy in cutting plays an important part in underwear manufacture, as the waste fabric makes but a fraction of its cost. Hence the object of the designer is to design the garments in such a manner that practically all the fabric is usefully employed. The various diameters of knitting machines are used for the different sizes so that the bodies of men's vests are tubular. Sleeves are cut in pairs from a tube, the correct width, so that the upper part of one sleeve and the lower part of the other adjoin. Parts of pants are arranged to give proper widths with little or no cutting waste, as also are the parts of ladies' combinations. Indeed, the secret of success lies in making as little waste as possible, for if large amounts of waste are made then the older and superior method of making the parts selvedged to shape will prove to be quite as cheap in spite of the much greater cost of production. This is especially the case when expensive yarns are used.

Knitting Machines for Cut Underwear. Both plain and rib knitting machines are used for making the rolls of fabric from which the garments are subsequently cut. For the making of fine plain fabrics, machines with bearded needles are generally used, but for knitting coarse and medium gauged fabrics machines working with latch needles are decidedly preferable owing to their greater productive capacity. The available machines may be classified as follows—

1. *Plain Fabric Machines.* (*a*) Loop-wheel circular knitting frame with bearded needles.

(*b*) French or sinker-wheel circular frame with bearded needles.

(*c*) Plain circular latch needle web frames.

2. *Rib Fabric Machines.* Latch needle circular rib knitting machines.

Straight-bar machines are not used for making cut underwear, because they cannot be compared with the circular frames with reference to the speed and cost of production, and hence they are only used for the production of selvedged fabrics straight or fashioned.

(*a*) **English Loop Wheel Frames.** The loop wheel frame is of British origin, being introduced in the year 1847 by Mellor, of Nottingham. Since then, however, it has been greatly improved by American machinists, so that large numbers of these machines have been imported from the United States. These are known as the American Loop Wheel Frames.

The loop wheel frame possesses a revolving needle cylinder around the periphery of which are placed leaded needles which are held by plates. The needles are vertically disposed and are short, being little more than double the beard length from the lead. The loops are formed and finished by means of bladed wheels.

The fabric, as it is knitted, is drawn upwards by means of rollers and wound on to a fabric roller. These machines are built in varying widths, from small heads, $2\frac{1}{4}$ in. in diameter, to large heads, 3 ft. or more in diameter. For underwear two series of sizes are used, and these are called body machines and sleeve machines. The former vary from 15 to 24 in. in width and the latter from $5\frac{1}{2}$ to 10 in. The machines are built in many "gauges," *i.e.*, comparative distance from needle to needle, so that some machines may possess five needles in the space of 1 in. and others up to twenty needles per inch. The machines are speedy, a 20-in. head being capable of making up to sixty revolutions the minute when working good cotton yarn, and forty-five revolutions the minute when knitting from worsted yarns, but they cannot employ as many "feeders," *i.e.*, complete sets of loop-forming parts, as the latch needle machines and are not quite so suitable for female labour. They possess one great advantage, however, and that is with reference to the interchangeability of the gauge and, in the case of the American machines, the diameter of the head. Moreover, they will knit from a greater range of yarn counts, and for these reasons are largely employed.

Fig. 28 shows a general view of an English loop wheel frame, the chief parts of which are—

1. Needle cylinder and gear.
2. Plain and bladed wheels.
3. Drawing-off mechanism.

To form a circle of loops a thread guide supplies the yarn to the needles near the loop wheel, which possesses blades, to form the loops by meshing with the needles. The loops are levelled up by a dividing wheel and the needles are pressed by a presser wheel. The loops are landed and knocked over by internally placed bladed

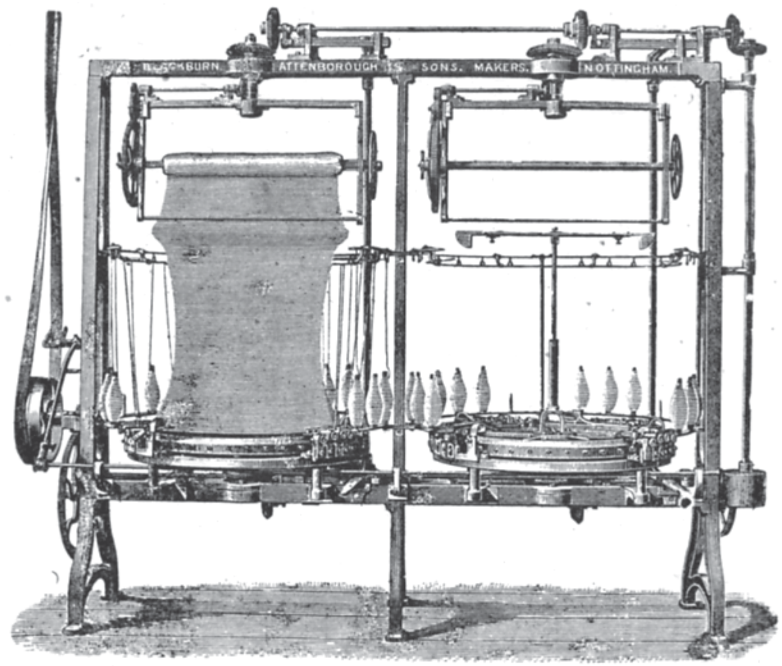


Fig. 28

LOOP WHEEL CIRCULAR FRAME

wheels and cleared by an external bladed wheel. The fabric loops are held down by means of a holding-down iron, whilst the new loops are being formed. The whole of these parts are repeated a number of times in accordance with the number of weft threads knitting. Usually a 20-in. machine possesses four feeders, 15-in. machine three feeders, and other widths approximately in like proportion.

American Loop Wheel Machine with Fleecy Attachment. The American machines differ somewhat from the British types and possess wheels having interchangeable blades. These machines are also fitted with a fabric stop motion so that if a hole occurs the machine automatically stops. Another improvement in these machines has enabled fleecy fabric, which is so largely used in the manufacture of ladies' divided skirts, to be made. Curiously the machines are made to rotate in the opposite direction, viz., anti-clockwise, to the British machines.

(*b*) **French Circular Frame.** To France belongs the honour of inventing the first circular knitting frame, and even as early as 1830 machines were built which proved quite successful. Later on the sinker wheel frames were introduced, and this system has proved so successful that for the manufacture of fine knitted fabrics it is still the most used circular frame in Great Britain, although it is slower than the loop wheel and latch needle machines. The chief points in favour of its employment are (1) Adaptability to female labour; (2) Number of machines worked by one operator; (3) Excellence of fabric. The last point is most important, as it undoubtedly produces the best fabric of all circular frames.

The machine is of peculiar construction, and it is not placed on the floor or on a stand like all other knitting

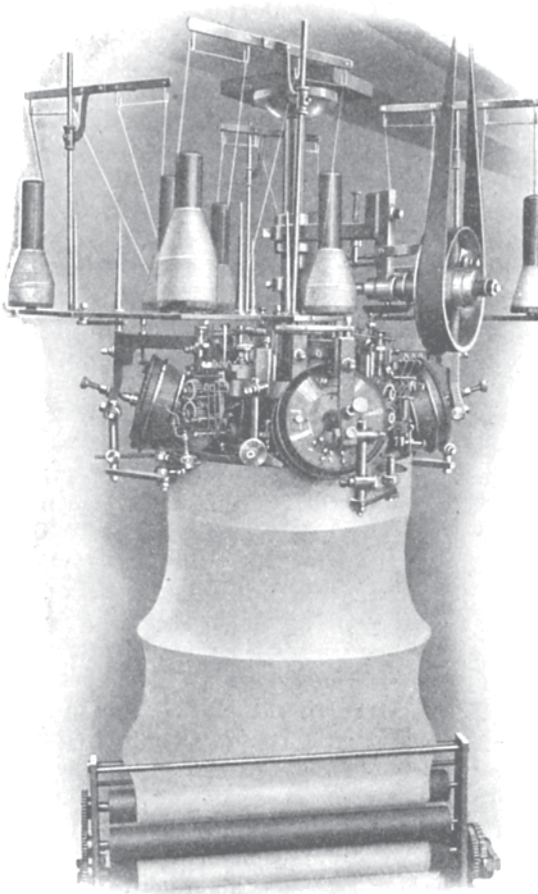


Fig. 29

FRENCH CIRCULAR FRAME

machines but is suspended from overhead beams, as will be seen in the illustration on page 89.

The needles are horizontal in position, and are radial. They have cranked stems which fit in small holes in the needle ring to which they are held by means of plates. The needle ring and the drawing-off rollers rotate, the fabric being drawn off in a descending direction and wound up automatically. The loops are formed by means of loop-forming sinkers placed in a large, positively driven, sinker wheel, and are completed by means of knocking over sinkers or platines which stand vertically between the needles. These machines cannot be built in diameters under 9 in. in width, but may be made in very large widths up to a diameter of 9 ft. They possess some very distinctive features, some of which have since been employed on other types of machines. The first of these is the mode of regulating the amount of yarn supplied to the sinkers. This is called the thread regulator, and consists of two small toothed wheels between which the thread passes. The lower wheel is driven positively so that in accordance with the mesh of the wheels a certain length of yarn is delivered in a tensionless form to the sinkers. The second of these features is the clutch-drive and stop-motion device working in conjunction with it. This mechanism not only stops the machine when the thread or a needle breaks but prevents the machine from casting off the fabric even though it should continue to rotate, by reason of acquired momentum.

To form a circle of loops on this machine the yarn is measured out by the thread regulator to the sinkers, which sink the loops and draw the latter under the needle beards. A circular disc causes the needles to be pressed, and the knocking over sinkers, by means of cams, land and knock over the loops. A clearing wheel ensures that all loops are cast off, and the fabric is taken to its original position by means of push-back wheels and a guard. Usually four feeders are fitted on the regular underwear machines, but the latter cannot be driven safely at more than twenty-two revolutions per minute. The slowness, however, is compensated to a great extent by the number of machines which can be worked by one operator.

(*c*) **Plain Latch Needle Web Frames.** The circular latch needle machines for making knitted web for underwear may be classified as follows—

1. Machines with a large number of feeders for producing cheap fabric.
2. Machines with a moderate number of feeders for producing good qualities of fabric.

(1) Machines of this class are often built in very large diameters and may contain up to 100 feeders. Strictly speaking these machines cannot be regarded as underwear machines, as the fabric produced is of a low grade owing to the spiral trend of the courses. The spiral depends upon the number of feeders and the diameter. For instance, if twenty feeders are used and the diameter of the machine is 20 in., it will be evident that before a needle knits again at a certain feeder it must pass and knit at each of the other nineteen feeders, so that in one revolution of the machine each feeder knits in a twenty-course spiral per diameter. Hence it is impossible to get a straight course and wale and the stretch of the fabric is not the greatest across the fabric but spirally round the fabric. Consequently these machines are only used on cheap yarns for producing cheap grades of underwear. In this class of machine the needle cylinder is invariably rotated and the bobbins are stationary.

(2) **Modern Latch Needle Web Frames.** These

machines are built either with revolving or stationary needle cylinders, and usually possess one feeder to approximately each 6 in. of circumference, so that the course spiral is small and may be neglected. Thus, the usual sizes of underwear machines, viz., 16 to 22 in. generally possess eight or ten feeders only. The machines are easy to operate, one operator being able to attend to four machines, and on medium gauges of machine 1,000 lb. of knitted fabric can be made per week by a single operator working a set of four machines. The machines usually possess holding-down sinkers or web-holders, drawing-off mechanism, friction drive and stop motion, so that the machine stops immediately any single thread breaks. The fabric is drawn off in a downward direction and is wound on to a roller in the lower part of the framework of the machine.

The knitting action of these machines is extremely simple, being practically the same as that described in connection with the hand circular knitting machine, except that as knitting takes place continuously in one direction only one clearing cam is needed. The web-holders are for the purpose of holding down the loops whilst the needles rise, and are similar to those used on the seamless hose machines. In some cases, however, the web-holder also acts as a loop forming part so that a measured loop is made as on the bearded needle machines.

The general construction of these highly productive machines will compare favourably with any other type of knitting machine for plain web. These machines are deservedly popular, as they make a good quality of fabric at a high speed and, moreover, are simple and reliable.

Rib Circular Knitting Machines for Underwear Fabrics. In this country practically all the rib circular machines work with latch needles. They are built in diameters from 6 to 36 in., the former being used for making ribbed cuffs and ribbed bottoms, whilst the larger sizes are for vest bodies and for cut ribbed underwear in general. Some machines are constructed to make 1 × 1 plain ribbed fabric only, whilst others are fitted to make 1 × 1 plain rib as well as royal or half cardigan rib. The most complete machines make 1 × 1 rib, half cardigan, full cardigan and automatic welt. The knitting principle is similar to that of the plain machine so far as the cylinder needles are concerned, and the rib action follows the principle of the hand circular rib machine except that the clearing cam of each feeder can automatically be set to clear, tuck or welt.

As has been already explained the width of a fabric may be varied by the use of the tuck stitch, and advantage is taken of this to produce shaped garments on a circular machine. Thus, ladies' rib vests are produced to the shape of the body by knitting half cardigan rib for the upper or chest portion, plain 1 × 1 rib for the waist, and half cardigan or full cardigan for the lower or skirt portion. Similarly, the sleeves are shaped by employing plain 1 × 1 rib for the cuff and making the rest of the sleeve on the half cardigan stitch. The welt is usually made by knitting on the cylinder needles for a few courses and retaining the loops on the rib needles but causing the latter to stop knitting. Another kind of welt, known as the French or tubular welt, is made by knitting on the cylinder needles at one course and on the rib needles at the next course.

Interlock Fabric. This fabric, which is now used largely both for underwear and in finer gauges for the making of fabric gloves, is made on a modified form of circular rib knitting machine by knitting on the odd cylinder needles and even rib needles at one feeder, and the even cylinder needles and the odd rib needles at the next feeder, and so on at alternate feeders. This produces a fabric which has the face appearance of the plain fabric on both sides of the fabric. It is a close-knit fabric and, comparatively speaking, is not very elastic, but is very hard wearing.

(2) **Wrought Underwear.** The Cotton's Patent frames are generally used in the manufacture of wrought underwear, and these work on exactly the same principle as

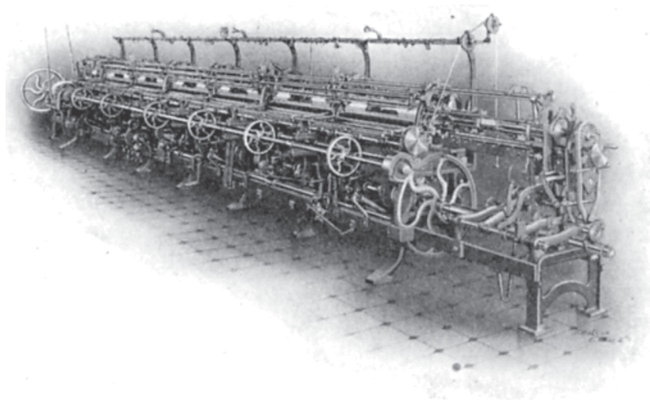


FIG. 30

COTTON'S PATENT UNDERWEAR FRAME

the hose frames except that the divisions are wider, and that in most cases the plain frames are capable of fashioning by widening as well as by narrowing. These machines are now built to produce eight vest bodies, vest sleeves or pant legs at once. The shirt bodies are made the half-width and double length, and are seamed down the sides. The sleeves are made and fashioned in the one piece and afterwards attached to the bodies so that the sleeves are as wide as, or slightly wider at the shoulder, than the half bodies. Hence, bodies and sleeves are made on the same machine. Pant-legs necessitate the use of a slightly wider division, and are made by running on the rib bottoms, fashioning the calf by widening, working straight for the knee, widening for the thigh, knitting straight for the seat, and narrowing on one side only for the body, or by commencing at the waist and knitting the pant in the opposite direction. The relative proportions given in the making of a cut pant hold good in all respects in the making of wrought pants. All classes of underwear are made on a wrought principle, but necessarily are of a higher class and are considerably more costly to make than cut goods. One great advantage of making goods on this principle is that as the garment is shaped or fashioned there is no cutting waste, so that a saving of yarn results. When expensive yarns are used this is a considerable advantage. In addition, the shape is often much more well-defined as the selvedge loops are joined without being trimmed. Cut garments are trimmed before being seamed by the action of the knives, so that the amount cut off depends entirely on the carefulness of the operator. Moreover, the straight-bar machines have a much longer life, require less attention with regard to mechanical repairs, and pressed off parts can be run on again and waste is avoided.

Generally speaking, high-class goods made from expensive yarns should be made in a wrought manner, whilst cheaper goods should be cut from fabric made in the roll.

Seaming and Finishing Machines for Making-up Underwear. There are alternative processes in the seaming of cut underwear, viz.—

1. Overlocking and felling.
2. Seaming and seam covering.
3. Flatlocking.

The first of these processes is the most used, and if the felling is omitted it is undoubtedly the cheapest. The "Overlock" machine employs a two-thread over chain stitch and has knives which cut the edges of the fabric to the "bight," *i.e.*, distance from the seaming line, required. This machine was invented by Willcox & Gibbs some thirty years ago, and will join all classes

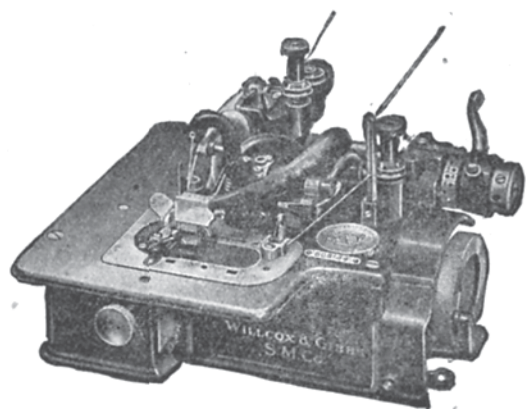


FIG. 31

WILLCOX & GIBBS OVERLOCK MACHINE

of knitted fabrics at a rate of 2,700 to 3,000 stitches the minute, or an equivalent of 15 ft. of close stitching the minute. All parts of the garments cannot be joined at this rate as the operator, in putting in sleeves, keeping fabrics straight, etc., cannot continuously feed the machine at this rate. The Willcox & Gibbs overlock machine is shown in the accompanying illustration. The overlocking joins the fabrics together, but the resulting seam has a tendency to place itself at right angles to the fabrics so that it is advisable to sew down the seam to one side of the join. This operation is known as felling, and is done by means of a single chain stitch machine which is capable of making 4,000 stitches a minute. This machine, which is shown in the illustration, is also used largely in the making up of garments for attaching beige, etc.

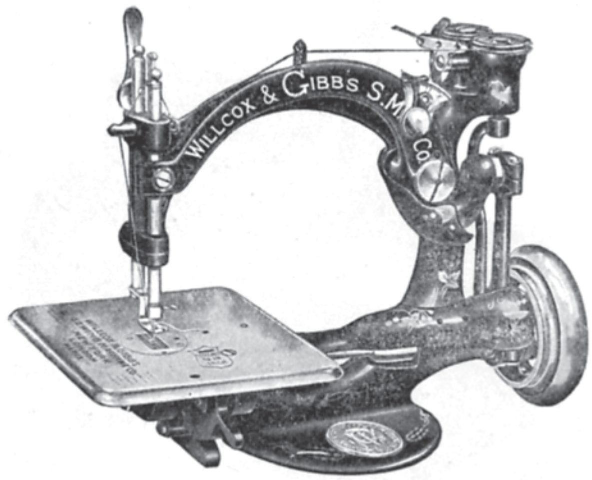


FIG. 32

WILLCOX & GIBBS MEASURING TENSION CHAIN-STITCH MACHINE

The Singer Sewing Machine Company build special types of overlock machines which can be fitted to work with two or three threads. The three-thread machine possesses certain advantages over the two-thread machines as it makes the seam closer and less visible, and, moreover, does away with the necessity of felling, thus reducing the process to a single operation. This machine, which is shown in the accompanying illustration, makes a treble-chain overstitch and can be operated at a speed of 3,000 to 3,300 stitches a minute.

The process of seaming and seam covering is used to

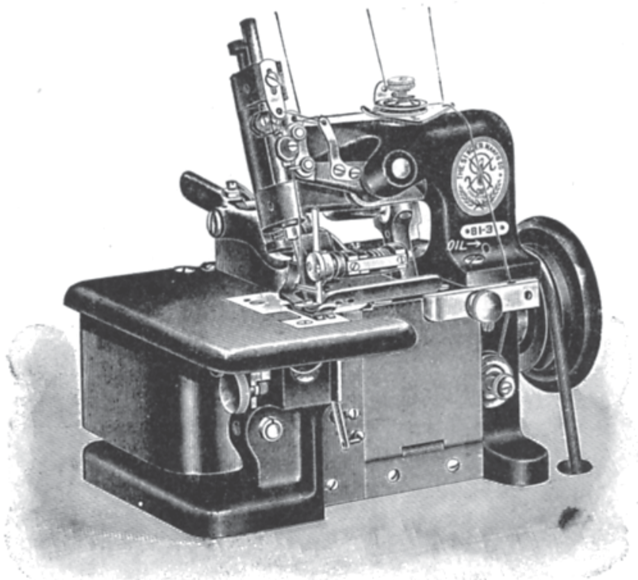


FIG. 33

SINGER THREE-THREAD OVERLOCK MACHINE

some extent in connection with the joining of fabrics for underwear, but is mostly used in connection with the making up of outer-garments. The parts are first sewn together on an interlocking looper, which trims and joins up the fabric at a high speed. The seam is then covered by means of a seam-covering machine which has two needles and a thread-carrying looper. The sides of the seam are flattened by means of the presser foot of the machine, and each side is sewn down whilst the seam is covered by the looper thread being chained in the two lines of stitching.

The flatlocking is a new process and makes, as its name indicates, a perfectly flat seam. The fabrics are fed separately along a sloping arm, and trimmed so that they enter the stitching zone edge to edge. Four rows of interlocked double chain stitches are made, two in each fabric, the loops of the outer rows are spread out to join with the inner rows, and the loops of the inner chains are spread out to connect up with each other, so that the whole tendency is to draw the fabrics towards each other. The seam is covered on the upper side by means of a covering thread, and so in all nine threads are employed.

This machine has practically revolutionized the cut underwear trade as it enables perfectly flat seams to be made, and it is largely used for all kinds of seaming operations as well as for the attachment of ribs.

Making-up Machines. Making-up machines include all those machines used in the trimming or ornamenting of knitted fabrics or garments. The following list gives some of these machines.

(1) Lock-stitch machines; (2) Chain-stitch machines; (3) Button-sewing machines; (4) Button-holing machines; (5) Eyeletting machines. In addition to these a number of machines are used in the making up of underwear for the attachment of lace trimmings, or for simultaneously crochetting and attaching the crochetting as produced.

Lock-stitch Machines are used for all kinds of stitching, such as the lining of gussets in the forks of pants, attaching beige fronts and linings, and can be employed in all operations where no stitch elasticity is absolutely essential. The machines used in the knitting industry work with rotating hooks and run at a high speed of 3,500 to 4,000 stitches a minute.

The lock-stitch is made with two threads, a needle thread and a shuttle thread, and is effected by forming a loop with the needle thread on the underside of the fabric so that the shuttle thread can pass through it. The take-up then draws up the slack thread as the stitch is made. The accompanying figure shows the stitch formation. For some purposes twin needle machines are employed. These make two rows of stitching at one operation at a definite distance from each other.

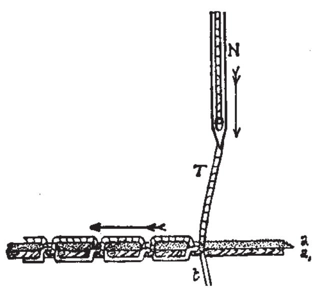


FIG. 34

FORMATION OF LOCK-STITCH

Chain-stitch Machines are used where the stitch elasticity is of vital im portance. One of the best machines of this type for the stitching of knitted goods is the Willcox & Gibbs measuring tension machine which is also used for felling.

The Singer Co. also make many types of chain-stitch machines, so that two, four or more rows of parallel stitching can be made at one operation. These machines are especially useful for "striping" pants and for attaching button-hole flies, etc. For necking shirts a chain-stitch machine employing an embroidering thread is used.

Button-Sewing Machines are now used to a large extent, and a special machine is supplied by the Singer

Co. This machine will attach two or four-hole buttons at the rate of 5,000 a day. The operator positions

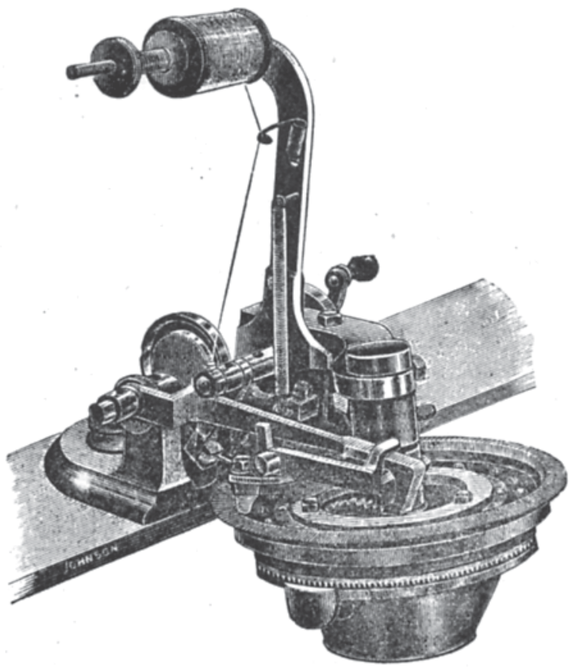


FIG. 35

POINT SEAMING MACHINE

the button and the machine sews it on and cuts off the ends so that no further attention is required.

Button-holing Machines. These machines, supplied by the same company, make different types and sizes of button-holes according to the class of machine used. The average production is 600 button-holes an hour.

For vests, combinations, etc., a straight hole is made with a square cross-bar at each end, whilst, for pants, the end of the button-hole is followed by a tapering bar, and in some cases a re-inforcing cord is put round the button-hole and enclosed by the sewing.

Machines for Seaming Wrought Underwear. The ideal method of seaming wrought goods of all types is by means of a point seaming machine whereby the selvedged edges are joined loop by loop. The machine is similar in appearance to a linking machine but employs either a single or a double over-chain stitch. This method however, is very slow and trying to the operator, so that it has been replaced to a very large extent by the cup seaming. This machine joins the selvedged edges at regular and frequent intervals, making up to fourteen stitches the inch, but does not take each individual loop. The fabrics are passed between two intermittently racked cups and a double chain overstitch is used.

Fig. 36 shows an illustration of the Singer High Speed Cup seaming machine which can be operated at the rate of 3,000 stitches a minute, and thus enables wrought goods to be seamed at the same speed as cut goods. All classes of wrought fabrics may be seamed on these machines.

The manufacture of knitted underwear, which is often erroneously called woven underwear, has greatly increased during the past few years, and when it is considered that many of both knitting and seaming machines can be employed in the making of outer wear as well as underwear it will be seen that there is little chance of over-production. The versatility of the knitted fabric is becoming more and more acknowledged, and it is no longer thought that knitting is suitable only for stockings and pants. The modern underwear manufacturer recognizes this, and it is by no means uncommon to find a machine knitting from cashmere yarn one week for

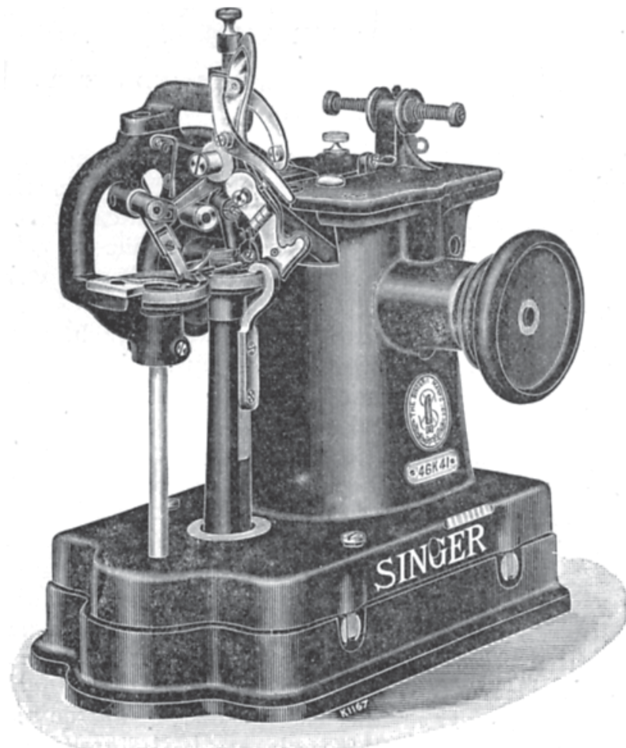


FIG. 36
SINGER HIGH-SPEED CUP SEAMING MACHINE

the manufacture of underwear and the next week producing artificial silk fabrics for the making of outer garments. The knitted fabric is well known, but the uses of knitted fabric are only just being discovered.

CHAPTER VII

MANUFACTURE OF FANCY FABRICS AND OUTER GARMENTS

FANCY knitted fabrics are used for hosiery, and to a small extent for underwear, but principally in the manufacture of outer garments, such as knitted coats, scarves, ties, jerseys, caps, gloves, etc., and may be broadly divided into two classes as previously indicated, viz.—

1. Those made by means of variation of stitch.
2. Those made by variation in colour.

In some cases both stitch variation and colour effect are employed, and in the making of outer garments warp knitted fabrics are used to a large extent as well as weft knitted fabrics. Necessarily the question of design is entirely dependent upon the class of garment knitted, so that although designs may be of a similar principle, the character and definition are very different.

Fancy Hose and Half-Hose Designs. Designs for fancy hose and half-hose are, as a rule, simple in character, consisting chiefly of colour designs made on a principle of plating so that the design is shown on a plain ground. Diamond designs are the most popular, as will be seen by the illustrations, but checks and plaids are also in good demand. Practically the only fancy stitch used in the making of hosiery is the lace stitch, and a large trade is carried out in connection with the manufacture of ladies' lace hosiery. These lace stockings are made solely on straight bar bearded needle machines, which have special lacing attachment. In many cases the patterns are very ornamental, tree and flower patterns

FIG. 37
FANCY HALF-HOSE

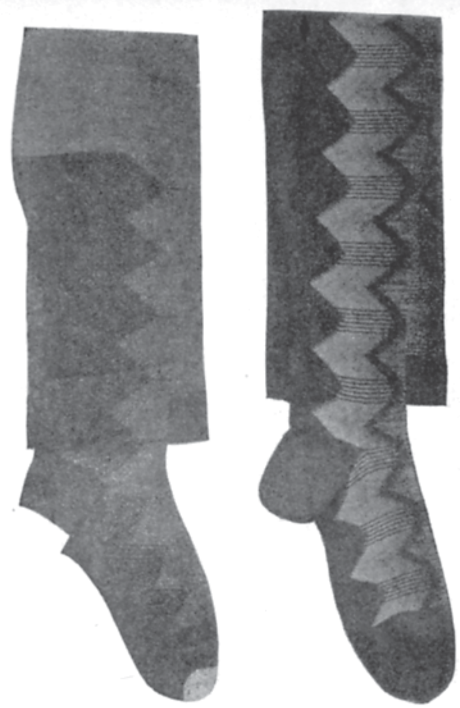


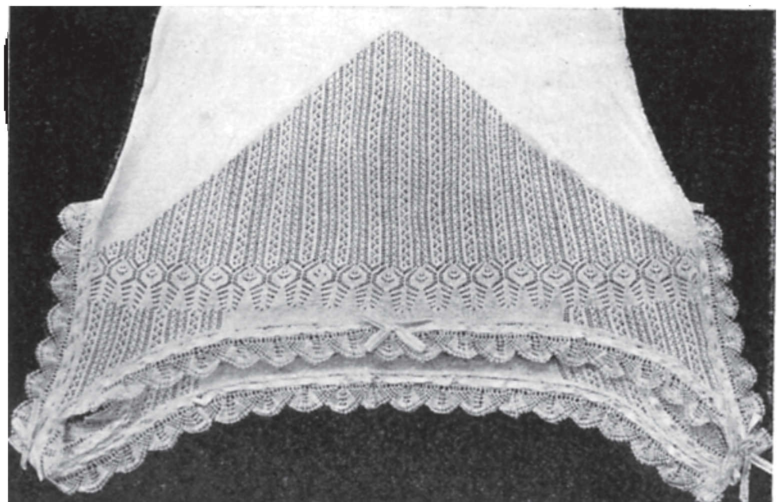
FIG. 38
TYPES OF FANCY HOSIERY

in lace showing on the plain knitted ground. On the modern machines jacquard cards are used, and these are holed in accordance with the design, which is first plotted out on squared paper. Circular hose machines are capable only of making imitation lace designs on a principle of tucking, and the designs are limited and are as a rule, only used in the making of children's socks.

Underwear Designs. Very little fancy underwear is manufactured unless cellular stitches are made. These are a modification of lace, pelerine or tuck designs. Apart from this class of underwear, which is becoming more popular for summer wear, designs are limited to a very few simple sinker plated effects in plated squares and checks, and to the ornamentation of vest front by means of knitted lace designs as shown in Fig. 39.

Cellular underwear is chiefly made on fabric frames. The true lace stitch is made on the French circular frames by a special method. A form of pelerine stitch is made on the latch needle circular machines by means of expanding points placed in a dial. Many cellular stitches, however, are made on a warp knitted principle and sold under various registered titles.

Knitted Coats and Costumes. The knitted fabric is at last becoming acknowledged as the premier fabric for the making of sports coats and other outer garments for feminine wear, and since the introduction of the artificial silk yarns many types of knitted coats and costumes have been made in self colours from these yarns. In these cases more is dependent upon the style and cut of the garment than upon the knitted design, and if only this question of cut and design is kept in mind by the fancy manufacturers, so that the vagaries of fashion may be satisfied in full, there is but little doubt that the demand will be permanent.



Sports coats, on the other hand, show great variations in stitch and colour as well as in style and cut. Coats made from plain brushed fabrics, half cardigan and full cardigan rib fabrics, shot rib fabrics—which are made by using different coloured yarns at alternate courses on the cardigan rib stitch—purl designs, tuck patterns, printed designs as well as many types of vertical effects produced on a warp principle, are now made in large numbers. Many of these knitted coats are made on a wrought principle, but the majority are cut from fabric made on circular weft knitting machines or on straight warp knitting machines. Similar machines to those used in the making up of underwear are employed for the seaming, ornamenting, and the attaching of beige, linings, braid and buttons.

Many of the stitches used have previously been described, but it is in the manufacture of coats, especially children's coats, that the purl stitch is used. These designs are dependent upon the manner in which the looping is effected, and also upon the arrangement of a number of reverse or back stitches on a ground of face stitches. Fig. 40 shows two typical designs. The first, known as a " basket " pattern, consists of seven back or purl stitches, alternating with three plain or face stitches, and the design is centred after a number of courses to obtain the effect shown. The second is another popular pattern with a varied set out of loops arranged in vertical columns. Other fancy stitches are produced, chiefly on flat machines, on a principle of racked cardigan rib work.

Fig. 41 shows two designs. The upper part of the first design is made by racking one needle bed after every two rows of knitting, and the lower part is effected by racking after every four rows, the racking taking place alternately, one needle to the right and one needle to

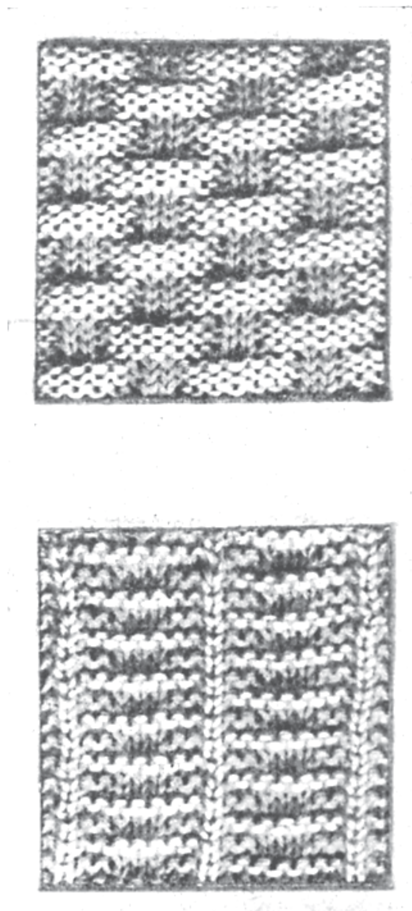


FIG. 40

PURL DESIGNS FOR COATS

the left. In both parts every fourth needle in each bed is retired to a non-knitting position. The second designs shows a fancy effect in straight and racked wales by racking in conjunction with the arrangement of the needles.

These designs are also used largely in the making of cravats and scarves.

Knitted Neck-ties, Mufflers, Scarves, Shawls, etc. Knitted neck-wear is chiefly made from the various fancy stitches of both weft and warp knitting. In the making of neck-ties the tuck stitch predominates as, by using a tuck stitch for forming the ends of the tie and plain knitting for the middle portion, a smaller width is obtained for that portion of the tie which encircles the collar. Neckties are usually made on small diameter circular machines possessing two feeders and a number of thread guides, so that different colours may be introduced.

Two designs suitable for ties are shown in Fig. 42. Both of these patterns are made on a tuck principle. More elaborate designs are made by producing the ties on a straight bar frame. In such cases the ties are fashioned to shape, and may be made on any of the fancy stitch principles, viz., tuck, lace or embroidered.

Knitted ties can also be produced on straight bar warp machines, although this trade has not yet been developed to the limit of its possibilities.

Scarves and mufflers are made on practically all principles of stitch variation. Shetland and ordinary wraps are made from a special lace stitch, and many shawls are made on the same basis. Summer neck-wear is light and attractive, and in accordance with the vagaries of fashion; warp fabrics, showing vertical stripes, may be used one year, and purl designs in the

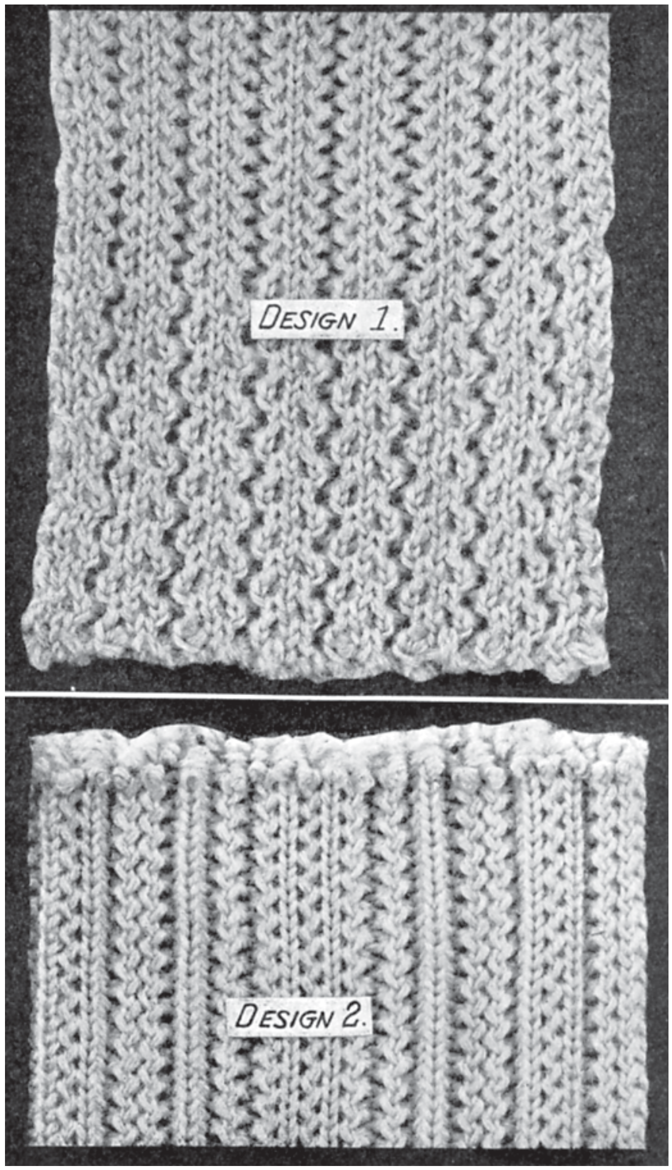


FIG. 41
RACKED RIBBED DESIGNS

white another year, or, perhaps, some of the various rib stitches may be used.

Manufacture of Gloves. The trade in the manufacture of knitted gloves is a large one, but it is capable of being increased to a very large extent. Up to the present time practically only the heavier types of wrought and seamless gloves have been made in this country whilst the fine fabric gloves have been made abroad.

A glove consists of three main parts, viz., (1) The rib cuff or top; (2) The hand; (3) The fingers and thumb. Seamless gloves are produced quickly in large numbers by making the rib-top and plain hand automatically on a circular rib machine of the super-imposed cylinder type, but the fingering has to be effected one finger at a time on hand flat knitting machines, which is a very slow process. Wrought gloves have all the parts made selvedged to shape on straight bar bearded needle machines, the selvedged edges being finally seamed on a cup seaming machine. Wrought gloves are made in many kinds of stitches and colour variations. Plain wrought gloves are called Aberdeen gloves, tuck gloves are called Ringwood gloves, whilst other varieties are known as Check gloves—which are made in fancy plated effects—fleecy lined gloves, gauntlet or long armlet gloves, etc. Wrought gloves are chiefly made on straight bar machines, and are afterwards seamed on cup seaming machines.

Fabric Gloves. The manufacture of fabric gloves has in the past been much neglected in this country, but at the present time the trade is developing very rapidly. The most suitable fabrics are light, close knitted, and moderately elastic fabrics, and these are best made with a warp knitted stitch, although the interlock fabric, as described in the last chapter, which is a weft fabric, is also largely used.

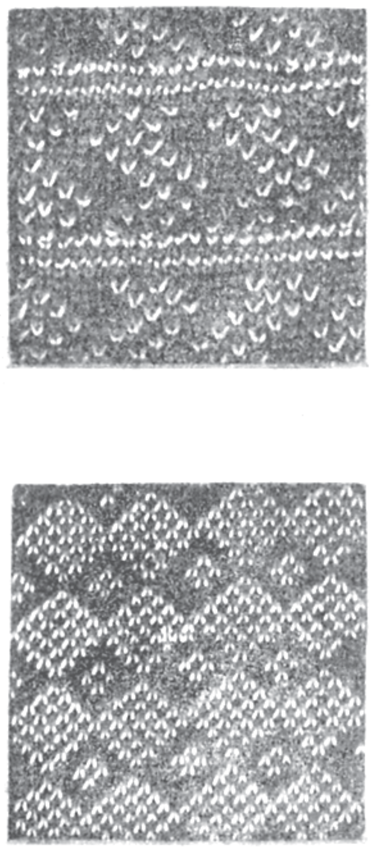


Fig. 42

KNITTED TIE DESIGNS

The chief warp knitting machines used for making glove fabrics are the vertical needle fast warp and the Milanese loom. The former makes a variety of stitches, such as the Atlas, Tricot, etc., whilst the latter employs only what are known as the Cotton and Silk Laps. These machines are built in great widths, so that 90 in. and upwards of fabric is made at one time on the single machine. The fast warp is capable of making from 100 to 150 laps per minute, the lap being the warp equivalent to a course of weft knitting.

The gloves are cut out in pieces by the following processes: Several thicknesses of the fabric are placed under a press and a block knife, suitably shaped, is placed on the top of fabrics so that the hand and upper and lower parts of the fingers are cut out. This constitutes the main part of the glove, but in order to get more room for the fingers, forchettes, or gores, are cut, whilst the thumb pieces are cut out separately. The gores are sewn to the inner parts of the fingers and the thumb to the thumb opening.

The average proportions are as follows: Taking the width of the hand as unity, length to thumb-hole is ·6 and length beyond thumb-hole is ·8, giving a total length of 1·4 times the hand width. The length of the thumb is ·8, forefinger, ·5; 2nd finger, ·55; 3rd finger, ·52; little finger, ·45. The width of the thumb is ·4, whilst the finger widths, including the gores, are respectively ·33, ·33, ·31, ·30. All dimensions are given in terms of the hand width. The cuff or bracelet, if required, is afterwards attached. The Singer Co. make a complete range of sewing machines for the making up of the cut parts.

Knitted Jerseys, Sweaters, Cardigans, Waistcoats. The manufacture of these articles constitutes a special branch of the knit goods industry. Jerseys are made, after the style of men's vests, from both plain and rib fabrics, and may be made from cut fabric or may be wrought. Usually a rib collar is attached, and the bottom parts of the body and the sleeves are also ribbed.

Sweaters are a heavier class of goods, and are often made from ribbed fabrics, many kinds of tuck ribbed stitches being used in conjunction with racked rib stitches.

Cardigan jackets are chiefly made from the cardigan rib stitch either on flat knitting machines or on circular rib knitting machines, and also possess racked rib sections for borders, pockets, etc.

Knitted waistcoats are made in a great variety of fancy stitches, chiefly fancy rib stitches, such as racked cardigan, knopped designs, etc.

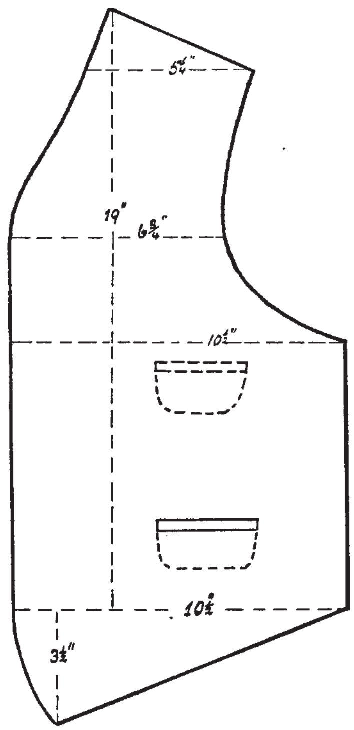


FIG. 43

CUT OF KNITTED WAISTCOAT

The cut of a men's knitted waistcoat is shown in the accompanying diagram.

Bonnets, Caps and Head Gear. Caps of all descriptions are made from knitted fabrics for ladies', children's, and men's wear. The Scotch bonnet, Tam-o'shanter, and aviation helmet are constantly being made, but each year a new type of cap is devised suitable for sporting or recreative wear. Caps and scarves are made to match the sports coats and so make up a complete knitted outfit for outdoor wear. Head gear is made on all principles, cut, wrought, seamless and plain, and rib and purl fabrics of all types are used.

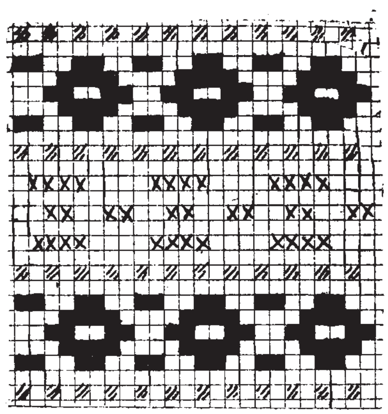


FIG. 44

HAND FRAME GOLF HOSE TOP DESIGN

Manufacture of Golf and Sports Hose Tops. This is another specialized industry in which the designer plays a great part. Many of these fancy tops are still made on the hand frames and others on flat or circular machines.

The designs may be classified as follows: (1) Coloured tuck designs with knop, roll, and wave effects; (2) Combined tuck and check designs.

The former are made on both hand frames and hand and power flat knitting machines, whilst the simple designs may be made on circular machines.

A typical golf hose top design is shown in Fig. 44. This is made on a hand frame with 1 × 1, 2 × 2, and 4 × 4 cut pressers on a press-off principle. The first row is made in two colours by the aid of the 1×1 presser, after which the diamond is made by using the 2×2 and 4×4 pressers. Another bar of 1×1 work is made, and the centre part also made by the 2×2 and 4×4 pressers.

The order of the design is then reversed to complete the pattern to a suitable length.

FIG. 45

ROLL DESIGN

A roll design is shown in Fig. 45. These patterns give raised effects which are suitable for this class of design, and are usually made on flat knitting machines to which jacquard mechanism is attached.

Colours are often introduced to heighten the effect. An illustration of a hand flat knitting machine capable of producing diamond patterns, is shown in Fig. 46.

Many elaborate combined tuck and check designs are made on the hand frames, and it is in the making of such fancy articles that the old industry of framework knitting still holds its own.

Football Shirts and Swimming Costumes. These garments are chiefly made from cut fabric made on large circular feeder frames. Football shirts are, as a rule, made in horizontal or vertical stripes or in large squares or quarters of different colours. The difficulty in making vertical stripes on a weft basis has been explained, but for the making of cheap vertical stripe goods the difficulty is got over by making the stripes horizontally or slightly spiral by employing a number of feeds carrying one colour and a corresponding number carrying the other colour, and by finally cutting the fabric so that the stripes, although spirally made, appear vertical on the finished article. True vertical stripes are made on a circular machine which is driven by an oscillating movement. In this case two lengths of needles are used, and the operating cams of one section pass over the needles of the next, and the cams for the adjoining section pass under the former. The joining loops are made by the needles at this point having two controlling butts so that they can rise to get the thread round them yet not allow it to appear on the face of the fabric.

Other forms of stripes can be made on a system of plating.

Swimming costumes are usually cut from light weight fabrics of a plain or striped character, and are seamed by means of the overlock machine.

Miscellaneous Knitted Articles. Knitted fabrics have been used for many purposes, and even to-day new uses are constantly being found. The following examples of the use of knitted fabric are arranged by way of contrast to show the manifold uses of the fabric, and further to enlighten even many members of the trade itself.

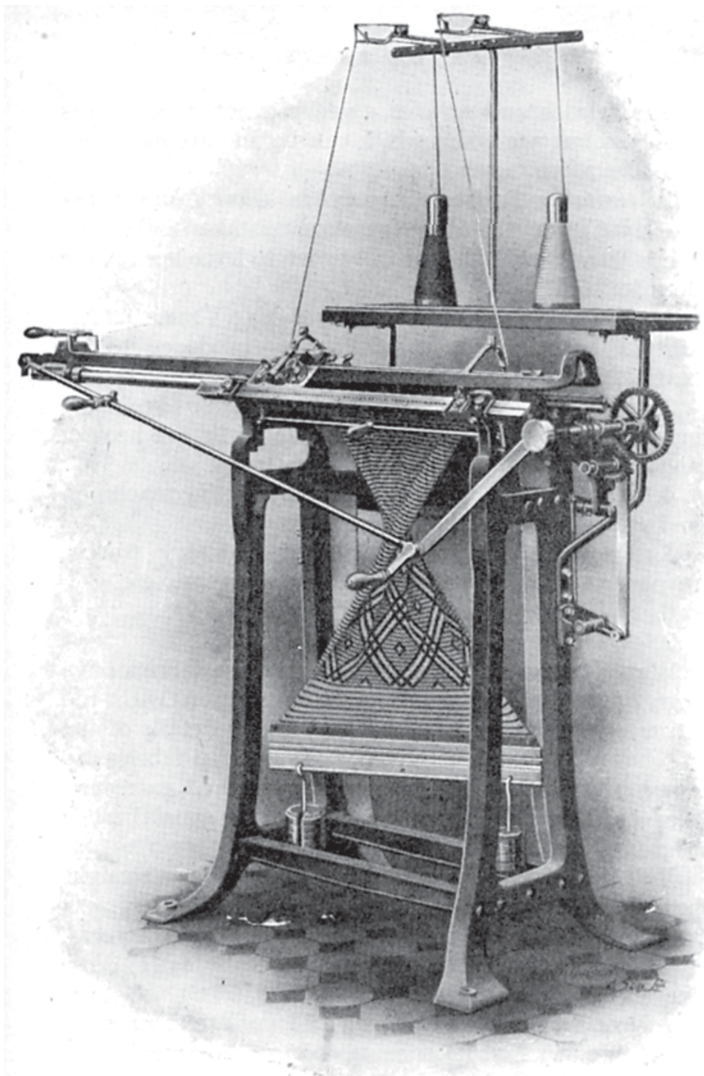


Fig. 46

JACQUARD FLAT KNITTING MACHINE

The fabrics and articles given are not experiments or freaks, but are goods which can be and are manufactured on a commercial basis.

1. *Imitation Sealskins, Astrachan, Glove Linings, and Backed Cloths.* Many of these are mistaken for woven goods but on examination will prove to have been made on a knitted basis.

2. *Knitting Coverings for Meat during Transit.* The knitted fabric is the most cheaply produced of all textile fabrics.

3. *Lace Curtains.* High class lace curtains are made on warp knitting machines, and the goods are heavier and more durable than the twist lace types.

4. *Hair Nets.* Made on fine warp knitting machines, and are again superior to twist nets.

5. *Toilet and Surgical Articles.* Sanitary towels, suspenders, elastic stockings, chest protectors, etc.

6. *Silk Facings, linings, cords, trimming, etc.*

7. *String bags, dusters, polishers, etc.*

Warp Knitted Fabrics. Although these fabrics have been mentioned incidentally in connection with the manufacture of the foregoing articles, no details of the stitches used have been given, and, as warp fabrics are essentially piece goods rather than finished garments, they are better explained by giving their general mode of manufacture.

With few exceptions warp fabrics are made on straight bar machines, as no advantage is gained by using a circular machine when the motion must be reciprocal.

Warp fabrics may be classified generally as (1) Close fabrics; (2) Open fabrics.

A close fabric is one in which all loops are recurringly interlooped so that no openings occur. An open fabric is one in which the warp wales are connected at intervals only. The chief close fabrics are as follows—

1. *Plain Laps* made on one set of needles by the aid of one or more sets of guides.

2. *Ribbed Laps* made on two sets of needles by the aid of one or more sets of guides.

3. *Knock-off Laps* made as in (1) except that some

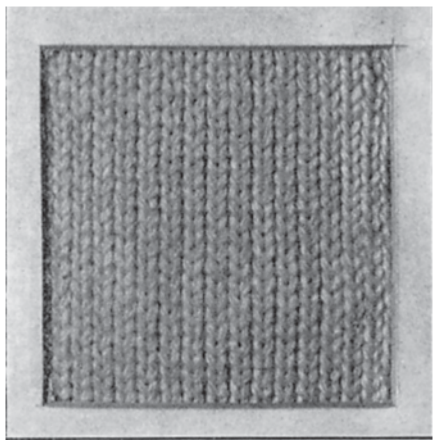


FIG. 47

TRICOT WARP FABRIC

laps are not cleared until one or more other laps have been made.

4. *Crêpe or Knop Laps* made on two sets of needles, one set knitting continuously and the other set at fixed intervals.

Open fabrics may be classified under the following headings—

1. *Pillar or Chain Nets* produced by the aid of one needle bar and two guide bars.

2. *Lace Nets* produced by the same agencies.

3. *Gimped or Inlaid Nets* produced with one needle bar, one guide bar and other special guide bar or steel bar mechanism.

4. *Satin Net* produced by divided needle bars, two guide bars and jacquard apparatus.

The above is a rough classification destined only to show the wonderful possibilities and scope of warp

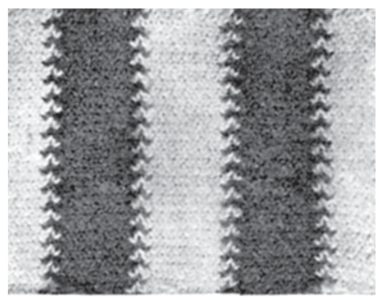


FIG. 48

VERTICAL STRIPE WARP DESIGN

knitting. Tuck, crochet, fleecy, plush, super-imposed, tubular, and many other classes of warp fabrics can be made.

Fig. 47 shows a simple warp fabric which greatly resembles frame work or weft knitting, and which is known as single tricot. It is made on one set of needles with two full sets of warp threads, each set making similar laps but in opposing directions.

Fig. 48 shows another well-known lap making a vertical stripe effect.

Fig. 49 illustrates a warp fabric made on two sets of needles and shows a fabric having a similar appearance to the weft knitted racked ribbed fabrics previously given.

Warp Knitting Machines. These may be classified in the first instance into—

(*a*) Bearded needle warp knitting machines.

(*b*) Latch needle warp knitting machines.

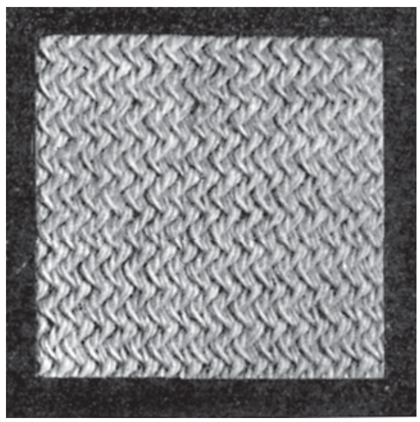


Fig. 49

RACKED WARP DESIGN

Many of these machines were originally called looms, and in some localities the old term is still employed.

Bearded needle machines may be sub-divided into—

1. *Flat Looms* for making plain, knock-off and open laps. The modern variety is known as the chain loom. These machines have horizontally positioned stationary needles.

2. *Fast Warp* for making plain laps at high speed. Has vertically disposed moving needles.

3. *Milanese Loom.*

4. *Double Warp Machines* for making warp lace fabrics.

5. *Double Bar Warp Knitting Machines* for making double warp fabrics suitable for manufacture of imitation suède gloves.

Latch Needle Warp Knitting Machines.

1. *Sinker Loom* with one movable needle bar, vertically placed and possessing holding-down sinkers.

2. *Double Rib Loom* with two needle bars, crêping and fringing apparatus.

Many special types of machines are also built, such as jacquard looms, picker looms, plush looms, and a few circular looms for producing small diameter fabrics such as neck-ties and gas-mantle fabrics.

The manufacture of fancy knitted goods is of great importance and in the future, when the trade has been properly organized with regard to specialization of labour, great strides should be made. The present system of obliging customers by submitting a large number of samples and making small orders, renders it difficult for the manufacturer to produce cheaply, but in future the system of making a number of designs each year, and that number only, and allowing customers to place their orders from the patterns submitted, must be strictly adhered to if cheap production is to be obtained.

CHAPTER VIII

TRIMMING AND FINISHING OF KNITTED FABRICS

THE trimming and finishing operations are all those operations performed after the fabric has been knitted, but usually the term is not inclusive of seaming and making-up, which, however, may correctly be called finishing operations.

Thus, fabrics or garments complete in a knitting sense require still further treatment before they are fit for sale, and it is such operations that are indicated in the heading of the chapter.

There is no exact line of demarcation between the terms trimming and finishing, but trimming is usually understood to mean operations not necessitating the use of alkalies or other chemical products, and is more especially applied to the pressing of knitted goods.

The finishing of a knitted garment depends upon the class of yarn used, the type of garment and the quality of the article. Some operations are common to the finish of a number of articles whilst others are special operations only performed on certain classes of goods.

Broadly speaking the chief finishing operations are as follows—

(1) Scouring; (2) Rinsing; (3) Milling or fulling; (4) Brushing; (5) Pressing; (6) Calendering; (7) Mordanting; (8) Dyeing; (9) Unshrinking; (10) Stoving and bleaching; (11) Hydro-extracting; (12) Singeing; (13) Drying.

Hosiery is usually scoured, rinsed, dyed or mordanted and dyed, and pressed. The hose are then put in pairs and afterwards folded by the counter worker. These goods are twice searched for defects, once before trimming and next after trimming; the repairs done in the first case are known as rough mending and in the second as dress mending.

The goods are finally examined during the process of folding.

Underwear is usually scoured, rinsed, made unshrinkable and pressed. Some classes of underwear are also milled and brushed.

Knitted Web is scoured and rinsed in the piece, made unshrinkable, and if composed of cotton or mixed cotton and wool is calendered. Woollen, worsted and cashmere fabrics are put under the press.

Yarns and Fabrics may be bleached with per-oxide, and mixed fabrics must be so treated. Woollen yarns and fabrics may be stoved with sulphur fumes, whilst cotton yarns and goods must be bleached with the liquid bleach.

Finishing Operations and Machines.

1. **Scouring.** This is a cleansing operation which is performed for the purpose of getting rid of dirt and added oil. Scouring is effected by one of two methods according to whether goods or fabric are being treated. Goods, such as hosiery, underwear, gloves, etc., are scoured in a large rectangular tub known as a dolly or tom-tom. Fabrics are scoured in a machine by a continuous process.

The chief scouring agent used for hosiery goods is soap which may be in the form of bars or in flakes, in which case it is known as soap-meal. If common goods are being scoured it is usual to add a quantity of soda crystals. The strength of the liquor or lye, as it is called, is dependent upon the state of the goods, but better

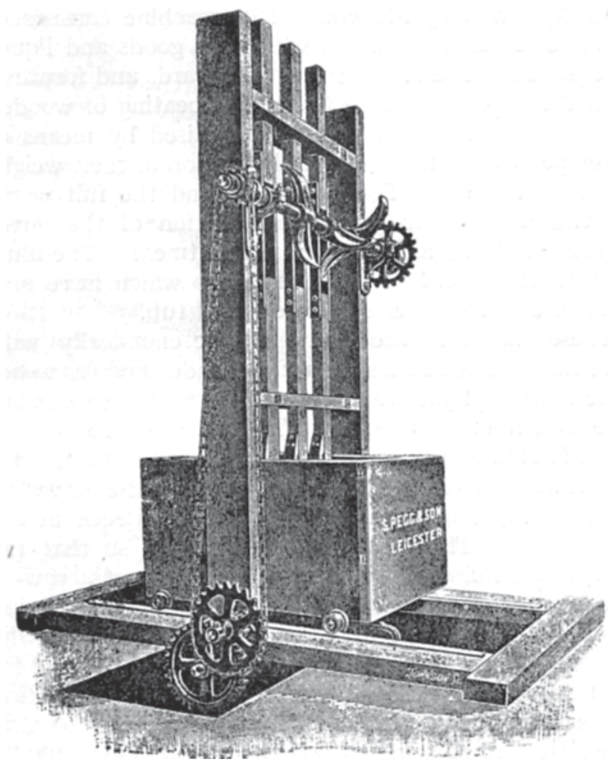


FIG. 50

SCOURING MACHINE FOR HOSIERY GOODS

results will be obtained if plenty of liquor is used of a moderate strength at a temperature of about 120 deg. F.

Dolly Scouring Machine. This machine consists of a large rectangular tub in which the goods and liquor are placed. The tub is driven backwards and forwards and the goods are subjected to the beating of wooden hammers or tom-toms, which are raised by means of S-shaped cams but which fall by reason of their weight on to the goods. The beaters extend the full width of the tub and the rectilinear motion of the latter causes all goods to receive equal treatment. The illustration shows one of these machines which have now almost entirely superseded the round tub.

These machines are built most economically with two tubs. The beaters are usually made of poplar wood. The motion of the travelling tubs is much slower than the action of the beaters. The reciprocation of the tubs is obtained from the driving shaft by means of a chain and pinions. The driving shaft of the actuating pinion is situated below the floor line as seen in the illustration. The pinion shaft is jointed so that the pinion can follow the rack, which consists of a row of steel spindles. An extension of the pinion shaft works in a slot so that the pinion gears alternately with the two sides of the row of pegs and thus gives the to and fro motion to the tubs. There is a clutch connection between the main shaft and the traverse gear so that the latter can be instantly stopped at will. Up to 100 lb. of goods can be scoured in each tub.

Continuous Scouring Machine. Fabric in the roll, to be finished economically, must be scoured by a continuous process similar to that of cloth scouring. A typical machine will treat up to 180 lb. of fabric. The fabric is passed in the open width over guide rollers and between width rollers to two large squeezing rollers, between which the fabric is carried by the rotation of the rollers at a speed of 300 ft. per minute. When it has passed between the rollers it is cuttled in a milling box so that it obtains a slight mill. It then drops into the bottom of the machine, which carries the scouring liquor and finally is again drawn up to the squeezing rollers.

2. **Rinsing** can be carried out in most of the scouring machines by using water instead of the scouring liquor. Usually a little ammonia is added to the water, as it gives a softer feel to the goods.

A machine often used for scouring and rinsing goods which are not very dirty is the rotary washing machine. This machine consists of an inner rotating cylindrical cage in which the goods and liquor are placed. This is surrounded by a fixed outer casing which is stationary. The machine is driven from a shaft which carries three pulleys, the belt being moved after a given number of revolutions so that the machine is driven alternately in both directions, and thus a more efficient cleansing is obtained.

3. **Milling or Fulling.** The operation of milling as a knitted goods finishing operation is really a fulling operation, as it is not intended to reduce the superficial area of the goods but to cover up the interstices of the knitted loops so as to present a closer-knit appearance to the fabric and at the same time to give a more lofty look to the goods and to get rid of any harsh feel. The success of the milling operation depends upon obtaining these results without impairing the natural elasticity of the looped structure. Excessive milling results in shrinkage, and, although this reduction in size may be temporarily regained by the application of the board, the garments, when washed, resume their reduced size. Hence the milling must be carefully

carried out in accordance with the characteristics of the wool fibre. Cotton fabrics will not mill. The actual operation is carried out in a fulling mill. The treatment of the goods consists of beating them with wooden hammers or beaters. The machine is shown in the accompanying illustration. The outer casing is of cast iron to which the wooden mill is affixed. The beaters or fullers are hinged from above and have their lower

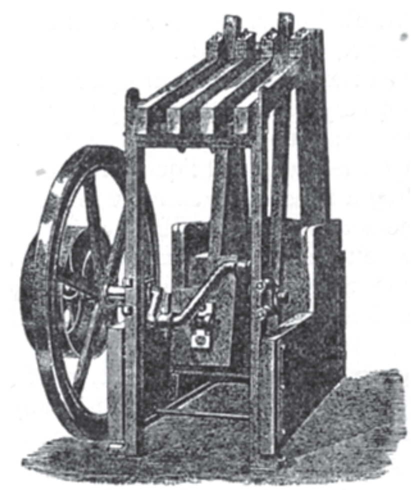


Fig. 51

HOSIERY GOODS FULLING MACHINE

operating ends cut into a series of wedge-shaped steps. These are driven positively from cranks on the main driving shaft. The action is as follows: The beaters or fullers drive the goods against the curved part of the mill, and in doing so, owing to the wedge-like shape of the steps and the curvature of the mill, press heavily on the goods and at the same time lift them until they get beyond the radius of the hammer, when they fall down again into the soap lye. The length of the operation and the temperature and strength of the soap lye depend upon the class of goods being milled and the amount of milling required.

4. **Brushing.** The brushing of fabrics and garments

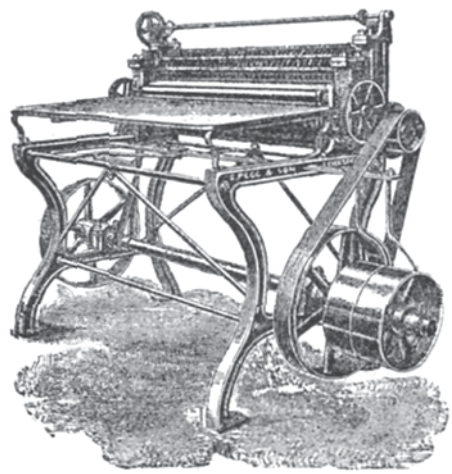


Fig. 52

GARMENT BRUSHING MACHINE

is performed on many classes of goods to effect a more saleable appearance by raising the surface fibres so as to give the fabric or garment a soft feel and a lofty and woollen appearance.

Garment brushing is usually performed on a teazle brushing machine. This machine consists of a revolving cylinder along the periphery of which are light shafts which carry the teazles. The goods are fed into the machine by means of feeding rollers which are usually covered with india-rubber to prevent damage to the goods. The feeding rollers are driven at a much slower rate than the brushing cylinder. The machine is shown on page 131.

Fabric Brushing Machine. For the continuous brushing of fabric in the roll the planetary system of napping machine is usually employed. These machines can be adjusted to brush all classes of fabrics and are especially suitable for the brushing of fleecy back fabrics.

Planetary napping machines as a rule consist in general of a large drum which carries two series of rollers, one set of rollers being used for advancing and felting the fabric and the other set for creating the fleece or pile. Both series of rollers are covered with wire carding, the points being usually bent in opposite directions on the alternating series of rollers.

The principle of brushing will be understood by referring to Fig. 53. The fabric is fed round the carrier roller R between the fabric or cloth rollers C and from thence over the card rollers. The rollers B are the pile card rollers, whilst the rollers D are the counter pile rollers. The fabric is brushed over half the cylinder and passes out of the machine between the cloth rollers C, which are situated at the back of the machine. From thence it is carried to the front of the machine and is automatically folded. The wire cards on the rollers are kept clean by means of the pile brush P and the counter pile brush P, the direction of rotation is shown by the arrows. The relative speeds of the two series of rollers B and D may be varied in accordance with the amount of brushing required, but the average speed of the pile and counter pile rollers is as 11 is to 16.

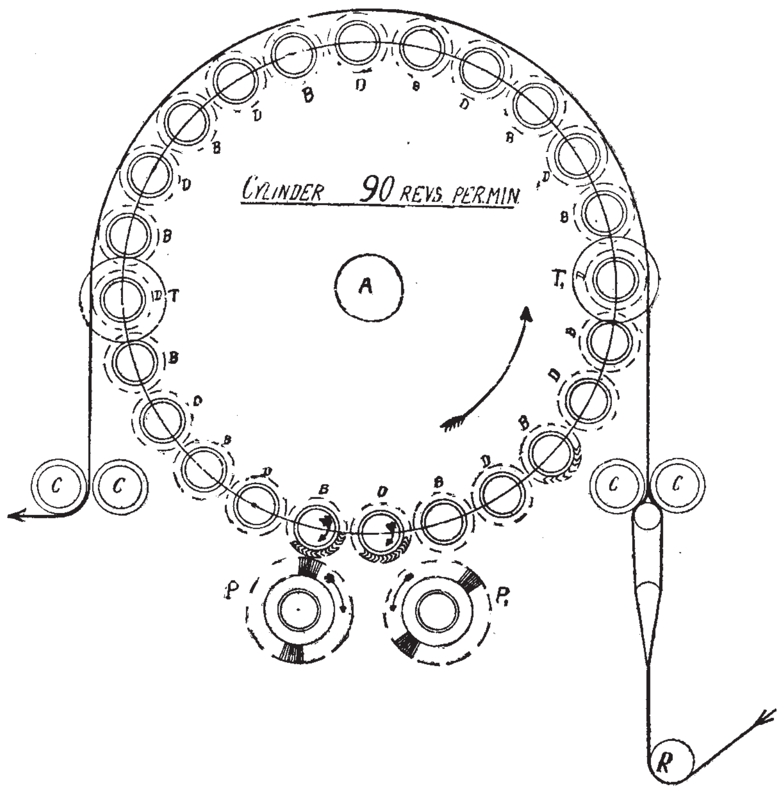


Fig. 53

SECTION OF PLANETARY NAPPING MACHINE

These machines are heavy and require some 4 or 5-horse power to drive, and should be fitted with suction plant to draw off the floating fluff.

5. **Pressing.** The object of pressing is to impart shape into the goods and to give them a superior finish. It really produces a finish which resembles that

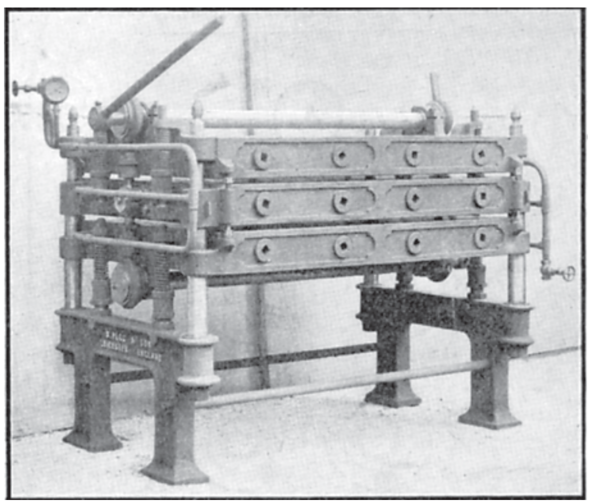


FIG. 54

STEAM PRESS

obtained by hand ironing. The goods are slightly damped and are drawn on to shapes which are made of wood. They are then placed between the steam-heated beds of a press. In reality the goods are not pressed, *i.e.*, flattened, as they are not subject to pressure. Indeed, the object of the pressing is to set the goods according to the dimensions of the board and to raise the surface fibres by means of the moist heat. Gas and electrically heated presses have been tried but without success. The usual type of press has two steam-heated beds the lower one of which is fixed and the upper one movable by means of a screw and fly. A later type has three beds, a centrally disposed fixed bed and movable upper and lower beds. This is worked by two operators, one on each side of the press, by means of a leverage action obtained from suitably-positioned handles.

The size of a press for hosiery is usually 50 in. by 40 in., whilst the underwear size is 72 in. by 42 in.

In another type of pressing operation the finished goods are placed between felt-covered boards and are subjected to the action of live steam.

This operation is often performed on goods which have previously been pressed or on goods made from finished fabrics.

Up to the present, fabric in the roll, if composed of cashmere or worsted, is still finished under the press, as all attempts at endeavouring to finish it by a continuous operation have been unsuccessful. The press is a useful finishing machine, but it can be abused, and in some cases a great increase is given in width to garments by pulling them on to shapes and setting them by placing them under the press. The effect is temporarily to gain the width, but this width is lost on the garment being washed.

6. **Calendering.** This is a kind of continuous pressing or ironing operation, but can be performed only on cotton or mixed fabrics, as it is difficult to keep cashmere and worsted fabrics straight. The simplest method is to press the fabric between a pair of gas-heated rollers, but the better class of machines have a

number of steam-heated rollers and a travelling apron which moves at a different surface speed to the rollers.

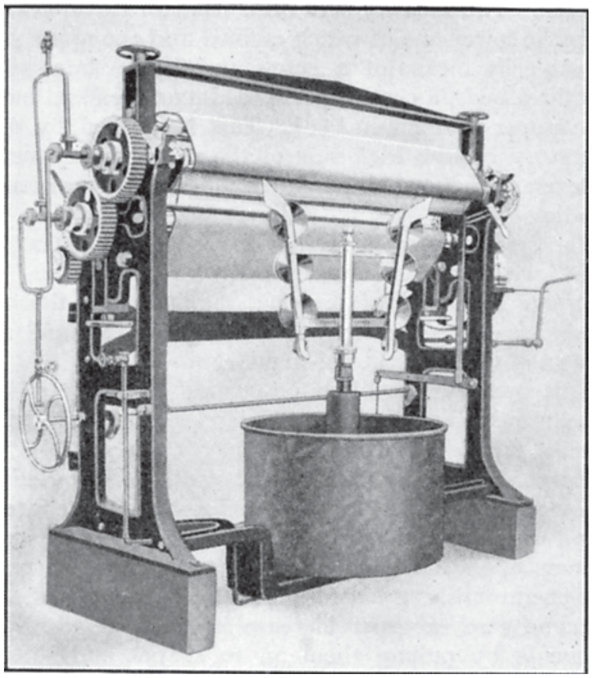


FIG. 55

CALENDERING MACHINE FOR KNITTED FABRICS

The fabric is passed between the rollers and apron and is subjected to a motion which is equivalent to ironing.

7. **Mordanting.** This is a preparatory process in most cases to dyeing although it can in certain cases be performed after dyeing. The operation consists of

impregnating the goods with some agent that will combine with the colouring matter used to form the real dyeing principle, and as the combination of the mordant and dyestuff takes place within the fibres the resulting colour is usually much faster to light and washing.

Hosiery goods, afterwards dyed with logwood, are usually mordanted with potassium bi-chromate which is applied with a reducing assistant. The previously well-wetted out or scoured goods are entered into a lukewarm bath, raised to boil and boiled for one and a quarter hours. The goods are then lifted and passed between squeezing rollers.

8. **Dyeing.** Blacks and blue-blacks are dyed on hosiery after the above process by dyeing them with 10 per cent., reckoned on the weight of goods, logwood extract. The goods are entered warm and raised to boil and finally dyed at the boil for one and a quarter hours.

Cheaper worsted goods are often dyed with acid dyestuffs which require no mordant. The general method is to make up the bath with 4 to 6 per cent. of dyestuff, 20 per cent. of Glauber's salt and 4 per cent. of sulphuric acid. Enter at boil and boil for three-quarters to one and a quarter hours. All shades may easily be obtained by this method in accordance with the dyestuffs used.

Mixed goods of wool and cotton or cotton goods are often dyed by means of direct dyestuffs which will dye cotton or wool. The method is similar to the previous one, but if cotton is present no mineral acid must be added. In all cases acetic acid is more preferable but the quantity used must be small if cotton is present.

Very fast colours are obtained on all cotton goods by the use of the sulphur dyes, which, however, cannot be applied to wool.

The dyeing of hosiery goods is usually carried out in a paddle dyeing machine. This comprises a large semi-circular trough in which the goods are placed. Over the trough is a specially-designed paddle wheel which rotates in the liquid so that the goods and liquor are kept constantly in motion.

A special machine is used in connection with the dyeing of sulphur colours, whilst for dyeing fabric continuous dyeing machines may be employed.

9. **Unshrinking.** The process of unshrinking worsted and cashmere goods has now become very general and is invariably performed after scouring and milling. The object is to fuse the outer scales of the wool so that washing will not tend to felt the fibres.

The active agent is usually calcium hypochlorite or bleaching powder, which, if hot and strong, will completely dissolve wool, so that great care is needed in the operation.

To prepare the bleaching powder solution the hypochlorite must be dissolved in clean cold water. The scum should be removed and the vat covered over.

The preliminary acid treatment is effected by working the goods for thirty minutes with a weak solution of sulphuric acid at a temperature of 170 deg. F. Another bath is prepared sufficient to cover the goods and the clear liquid from the chlorine vat is added.

The amount of solution added depends upon the character of the goods. Soft woollens, like cashmere, need less chlorine, coarse and heavy goods require more. Goods are treated in this bath at 80 deg. F. for about fifteen minutes. They are afterwards washed and hydro-extracted, a process which will be explained later. To avoid harshness, ammonia, or some other softening agent, should be added to the clearing baths. The unshrinking of knitted goods is a typical example of the benefits of applied chemistry, and, if a study of the characteristics of the wool fibres used in the spinning of the yarn is made, the delicate operation of annulling the felting properties of the serrated wool scales without injuring the true wool substance can be effected.

10. **Stoving and Bleaching.** Stoving is carried out in a large wooden chamber in which the yarn or goods are suspended on poles. The sulphur is placed in an iron pot, ignited, and the room closed for about twelve hours. The sulphur dioxide, formed by the burning of the sulphur, bleaches the goods if the latter are in a damp condition, by the formation of sulphurous acid which is the true bleach. Unfortunately the effects of this gaseous bleach are not fully permanent, as on exposure to air the goods slowly become re-oxidized and the yellow colour returns. It is, however, a simple and cheap method and is largely practised.

Cotton Fabrics are bleached by means of bleaching powder, being first boiled under pressure with caustic soda. Many operations are required, but the bleach, being an oxidizing one, is permanent.

Mixed Goods must be bleached by the per-oxide bleach as the cotton is weakened by stoving and the wool by the bleaching powder solution. The per-oxide bleach is an ideal method for all fabrics but is more expensive. For the per-oxide bleach the bath is made up with a 5 per cent. solution of sulphuric acid and $4\frac{1}{2}$ per cent. of sodium per-oxide is added with stirring. The bath must be made alkaline with ammonia. The goods are entered at 120 deg. F. and allowed to remain in the bath for several hours, and are lifted, rinsed, and slightly acidified.

11. **Hydro-extracting** is an operation whereby all the water is slung out of the goods by means of a centrifugal action. The hydro-extractor has an outer fixed case

and an inner revolving cage in which the goods are placed. This cage is then rotated at a high speed and all moisture is driven out of the goods.

12. **Singeing** is an operation applied to cotton yarns and fabrics in order to remove the protruding surface fibres and so obtain a perfectly smooth fabric. Many different types of machines are used, but the principle involved is that of singeing or burning off the superfluous fibres by means of heated plates.

13. **Drying.** This is best carried out in the open air, but, in order to dry the goods more quickly and at the same time be independent of atmospheric conditions, the goods are often hung in a heated chamber. Drying machines are also in use, and these consist of large heated chambers through which the goods or fabrics pass and repass by mechanical means until they are completely dried.

The finishing and trimming of knitted goods is of great importance, as the appearance of the articles often decides the choice of the merchant or buyer as well as the salesman and also of the purchaser who wears the goods.

It is futile to argue that it is not the finish which decides the quality of the article. If goods are not finished well, it at least denotes a lack of thoroughness which may be also applied to the manufacturing. Briefly speaking, high-class knitted goods must be finished in a high-class manner if the sales are to be proportionate to the true value of the goods. Low class goods must be finished in an attractive manner that will render them at least as attractive to the eye as those of our foreign competitors who excel in this class.

Again, the textile industry as a whole is dependent to a large degree upon the finishing trade, for finishing operations are not performed solely to improve the appearance of an article but to improve or alter the texture, to obtain effect, to rid the fabrics of objectionable qualities, in short to improve the fabric for longevity of wear, for non-irritation, for warmth and feel, to prevent shrinking and to present to the public a garment which is pleasing to behold, handle and wear.

The finishing of knitted goods is a highly specialized trade, and is, in many cases, carried out quite apart from the actual manufacture of the goods. Some operations, however, can readily and conveniently be carried out even by small manufacturers, but other operations require much knowledge and skill and involve the use of special apparatus and machinery, and therefore can be carried out only by specialists.

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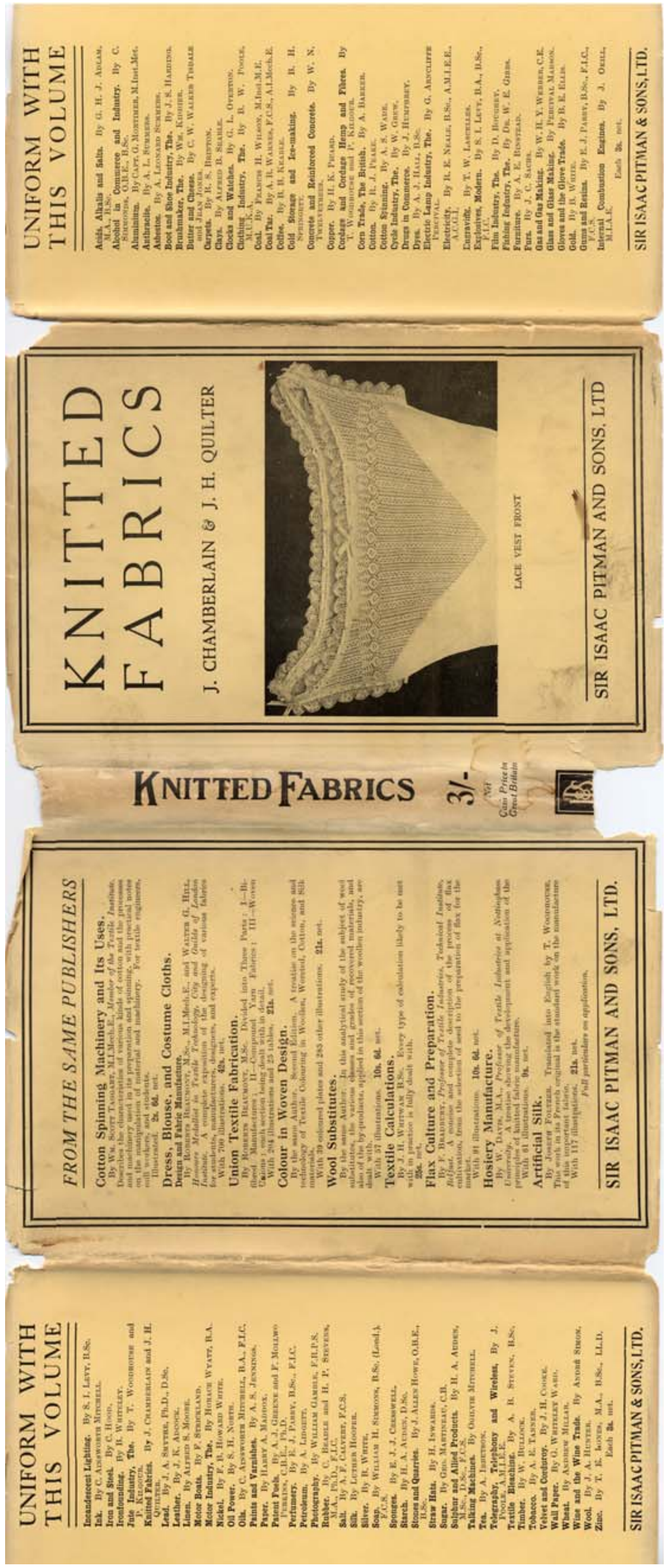

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