PRESIDENTIAL ADDRESS.

PROGRESS IN TEXTILES.

By E. H. G. Morris.

Australia to-day is being given its opportunity of becoming an industrial nation. Companies are starting every type of industry—many of them entirely new—and, had it not been for the war, they would not have found the incentive to risk the capital necessary to install plant to manufacture, facing, as they would have, oversea competition and home bias. I feel that the period we are at present passing through will be recorded in history as Australia's birth as a manufacturing nation.

Engineers to-day are being asked to adapt their present plant, and design and make new machinery to meet this state of affairs. That their labours are bringing forth results speaks for itself, but it is not of new industries that this paper deals with. Textiles in all their branches have been established in Australia for years, and the progress that has been made in the last twelve years is something to be proud of.

Wool and its substitute was the title of a paper given before this Institute by Mr. Wigglesworth, and those members that had the opportunity of hearing it will still remember what an education it was. Tracing its history from the early ages, as only a man thoroughly conversant with the subject could, he described the crude machinery and methods used in the early stages of manufacture. Passing through its many vicissitudes, he gave such a lucid description of that branch of the textile industry that I will not attempt to add anything, but will pass on to the Hemp, Jute, and Flax section.

THE EVOLUTION OF MECHANICAL IMPROVEMENTS IN THE FLAX, HEMP, AND JUTE SPINNING SECTIONS OF THE TEXTILE INDUSTRY.

Some eighteen years back, British machinery manufacturers put on the market machinery for the foregoing industry of a type which completely revolutionised production costs and the quality of production. This machinery comprised the utilisation of a patent owned by a German engineer, one Dr. Schneider, and also the adoption of labour-saving devices which had been in use in America for a number of years.
Dr. Schneider's patent, in one stroke, eliminated the old practice of spinning with the live spindle. The live-spinning spindle was a spindle running in journal bearings, and driven at its base by a tape on to a small pulley known as a 'wharve.' The bobbin carrier plate, under the influence of the traversing motion, would rise up and down these spindles, carrying the bobbin with them, and the yarn was wound on to the bobbin by a cord which bore against the side of the bobbin, and in turn, made the internal bore of the bobbin bear against the spindle. The flyers of this spindle required to be unscrewed each time the bobbins of the spinning frame became full. Further, the spindle would vary in length up to 30 in., and would protrude up to 15 in. from the last bearing, with the result that spindles bent and lost balance very rapidly. The foregoing had some eighty years of excellent service to the community. It will be readily understood that high speed was nearly impossible, owing to belt slippage, and to the spindle being thrown out of balance by the tensioning arrangement. It will also be understood that with up to 100 spindles per spinning side, the labour cost of doffing, or removing the bobbins, was tremendous, and necessitated for every 20 or 30 sides of spinning a group of 10 to 15 young girls, known as 'doffers.' Not only was this doffing cost a very heavy one, but the cost of the stoppages during the period of doffing was as great, if not greater, representing a high percentage reduction in the efficiency of the machine.

Dr. Schneider's patent comprised the use of an inverted flyer running in ball bearings with a spindle length of only a couple of inches. This flyer was dynamically balanced, and was capable of tremendous speeds with no vibration at all. The flyer is driven by heavy cotton tapes, but slippage is impossible, owing to the adoption of a Lenix tightening device.

The bobbin is carried on the bobbin rail, and fits on to a brass and aluminium carrier precisely the size of the bobbin to be used. On the underside of the bobbin are several movable felt wads which bear on the steel plate of the builder carriage, and provide the retaining tension to wind the yarn on to the bobbin. In addition, an extremely clever device was adopted wherein the machine was equipped to carry two bobbin carrier plates, and when the bobbins are full, it is only a matter of a few seconds to lower the bobbin carrier with the full bobbins, wind it forward away from the flyers, and simultaneously wind forward the second bobbin carrier, which, meanwhile, has been filled with empty bobbins. A few feet of yarn is run on to these bobbins by allowing the machine to turn a few revolu-
tions, the ends are then cut, and the machine goes away again into full production, and during the spinning period the spinner removes the full bobbins from the spare bobbin carrier, and replaces them with empty ones. Having done this, she uses a device on the machine to wind them back into the rear of the machine into their doffing position.

The adoption of these several practices has greatly cheapened the cost of spinning by the elimination of waste labour, and by the addition of about 50% of speed; has greatly improved the quality of the yarn by the elimination of yarn breakages, and the great improvement in the tensioning device, and has completely eliminated bobbin wear, which was a most important factor, for the modern bobbin carrier runs on a metal sleeve, and the sleeve takes all the wear.

The perfect balance of these machines means that one spinner can look after a great number more spindles than was the case with the old type spinning frame, and the result has been that the per capita cost of spinning is only one-third of that under the old system, while the quality of yarn produced is improved at least 100%.

Twisting and doubling machinery has also been similarly improved by the adoption of the same principles, and in every case high speeds and greatly improved quality prevail, with the resultant elimination of a very large percentage of labour.

In the preparation of the fibre for spinning improvements just as revolutionary have also been effected, but these have been chiefly the building of machines equipped with automatic can filling and can changing devices, together with the introduction of very efficient stop motions which ensure that good work is always produced, and eliminate a considerable quantity of labour. These are the improvements which have been in existence in America for a great number of years.

Of course, in building modern machinery with these improvements further great improvements have taken place in the design and the efficiency of the machine itself, but those improvements would not have justified replacement had it not been for the immense economy associated with the automatic can packing and stop motions.

The modern fibre preparing machinery to-day is very nearly foolproof. If anything goes wrong in any part of the machine, the machine either stops or an electric hooter immediately blows, and the operative rushes up and stops the machine before a major breakdown occurs. The net result of these labour-saving devices has been that in the case of one company in Australia
five women look after a system of machinery which previously required 32 women for a given production, with less fatigue than was previously necessary, and infinitely better quality.

Australia is indeed fortunate that the old-established spinners in this country were in a position, with the introduction of this wonderful new machinery, to complete conversion to it in a minimum of time, and it is safe to say that there is not a machine of the old type in work in Australia. Conversion to this modern plant has necessarily been an immense strain on the finances of the companies carrying out these manufacturing activities, and since in company with these improvements in their machinery the introduction by the engineering world of air-conditioning, efficient dust extraction, the elimination of leather belting, embodying the adoption of "V" rope drives, pivot drives, or direct coupling of motors, have all in turn done their part in making the Australian section of this industry most efficient.

It may interest my listeners, who have been following the evolution in the spinning of yarns from flax to hemp, to know that little more than 100 years ago this work was carried out on the old-time spinning wheel, while to-day it is carried out on the modern machines mentioned. Making a comparison with the old spinning wheel, it is astonishing that the people of the world to-day are in continuous employment, for it would require some thousands of women working old spinning wheels to produce the poundage of yarn of a given count which is produced to-day by one girl using modern machinery.

As this branch of the industry is to be the subject of a paper, which will be given to this Institute by Mr. E. H. Kinnear, a member who played a big part in the evolution of mechanical improvements in the spinning section of the textile industry, and is considered a world's authority on soft fibre manufacture, I will pass on to Framework Knitting, but before doing so I would like to mention a few facts of what is actually being done in Australia to-day in the flax industry.

Australia's two leading soft fibre spinners some years back, when sorely embarrassed by sanctions and a lack of supply of Italian hemp, decided that once and for all they would prove conclusively whether or not they could obtain their supplies of strong, soft fibre from local production.

With this object in view they purchased the existing mills in Victoria, and proceeded to expand the flax industry along slow but steady lines. By the outbreak of war their programme had reached a stage wherein Australia would have supplied the whole of their requirements, but unfortunately, owing to
Britain's grave shortage of flax, much of this fibre will now be diverted overseas.

Our Federal Government has taken over the flax mills, and, acting upon requests from the United Kingdom Government, has rapidly expanded the flax industry to such a stage that the 1941 crop will comprise about 60,000 acres, from which 100,000 tons of straw should be harvested, giving farmers an income therefrom of something upwards of half a million pounds. This straw will be processed in 20 or 30 modern flax mills, situated throughout southern Australia, and should give a return of 10,000 tons of high grade fibres, and 7000 or 8000 tons of a lower grade of fibre. The value of this fibre will be approximately £2,000,000 Australian. In addition, very valuable by-products will be produced, comprising chiefly linseed, which should approximate 4000 tons in weight, being worth nearly £100,000.

The mills being erected by the Federal Government are designed in a manner which will make them amongst the most modern in the world. Careful thought has been given to the elimination of waste of both material and labour; in many instances water retting will be undertaken, and the capital of the undertaking will amount to an immense sum. It is quite worthy, however, for it will serve a threefold object—(1) Of the supplying of Australia's internal requirements of an essential product; (2) of sending large quantities of this product to Britain, where it is needed for war purposes, and (3), and most important, it will thoroughly test the economics of an industry which, if successfully established, should be of great value to this country. The whole of the machinery required for these flax mills has been manufactured in Australia to the latest design. Australian engineers have done an excellent job, and have turned out these machines at a figure which is little more than half the cost had the machinery been imported from overseas.

The Origin of Framework Knitting.

As with many other primary inventions, romance and pathos, despair and poverty figure largely in the making of the first "stocking frame," as the first knitting machine was and is still called. Unlike many other early inventions, there seems to be no reasonable doubt as to the personality of the real inventor, although the history of his life is hardly continuous.

The name of this wonderful genius was William Lee, who was curate of the village of Calverton, Nottinghamshire, and who, according to Blackner, a local historian, paid his addresses to a lady of that village. This lady, however, in the words of
the historian, "was more intent on her knitting than on the caresses and assiduities of her suitor," whereupon the disappointed lover in social exile avenged himself by inventing a machine to knit. This version of the invention, however, hardly coincides with that so ably designated in the painting entitled "The Origin of the Stocking Frame," which was the work of a famous Irish artist, and exhibited in 1847. The historical setting of this picture follows the account given by Dr. Thornton in his history of Nottinghamshire. The artist depicts the Reverend William Lee in a wretched room, furnished with little more than the symbols of his office, sitting in an attitude of despair, eagerly and desperately endeavouring to follow the nimble fingers of his wife who knitted incessantly in order that the condition of dire poverty into which they had fallen might be somewhat alleviated.

From watching the movements of his wife's fingers, Lee grasped the idea of knitting, and, provided with the crude tools of the period, he commenced his herculean task of building a machine which would produce a fabric identical with that of hand knitting. His machine, of course, was so constructed as to be worked by manual power, for the age of power, as we understand it, was then long distant. For three years he struggled and combatted with fate, and at the end of that time, in the year 1589, he had completed his first frame and produced a pair of stockings upon this machine.

Instead of this proving to be the end of his trials, as the mechanical perfection of the machine warranted, his troubles had barely commenced, for his chagrin on the receipt of the news that Queen Elizabeth would grant him no rights can be vividly imagined. In Felkin's "History of the Hosiery and Lace Trade," the queen's reply to Lord Hunsden's appeal on his behalf is given:

"My Lord,—

I have too much love for my poor people who gain their bread by the employment of knitting to give my money to forward an invention that will tend to their ruin by depriving them of employment and making them beggars. Had Mr. Lee made a machine that would have made silk stockings I should, I think, have been somewhat justified in granting him a patent for that monopoly which would have affected only a small number of my subjects; but to enjoy the exclusive privilege of making stockings for the whole of my subjects is too important to be granted to any individual."
Still, the wily queen left him one ray of hope, and for nine more years he struggled to produce these silk stockings, and at the end of that time he was again triumphant over the difficulties that beset his path.

He presented the queen with a pair of silk stockings, but, unfortunately, the queen was still obdurate, and refused to grant any rights to him. The accession of King James the First brought him no nearer to the realisation of his hopes, and thus we cannot be surprised to read that in disgust and despair he shook the dust of England off his feet and took his little stock of frames—nine in all—to Rouen, in France. Here King Henry the Fourth of France was eager to reward him, but at the very time he was about to receive his special grant of privilege the king was assassinated. Lee himself was suspected to be a spy because of his Protestantism, and cruel fate again robbed Lee of reaping his well-earned harvest of success. Even Lee’s indomitable pluck and tenacity of purpose were not proof against this last misfortune, for he is said to have died in Paris of a broken heart, being in such a case buried in an unknown grave. For nearly three centuries no memorial was raised to the founder of this great industry, except the myriads of frames whose rhythmic sounds have perpetuated his memory unwittingly but unceasingly.

The first memorial to William Lee was built at the scenes of his early trials and tribulations, at his own village of Calverton, and a block of buildings, comprising of schools and Men’s Institute, now stand as a tribute to him whose personality, grit, and consistency should serve as a model to every worker in the great industry he founded.

Another interesting memorial of William Lee may be found at the Leicester Technical School. On the tercentenary anniversary of his invention the Leicester hosiery students opened a subscription for the purpose of painting a companion picture to "The Origin of the Stocking Frame." This shows William Lee producing the first fruits of his invention. Near the window sits his wife, still knitting, whilst the child, now over three years of age, is pointing gleefully to the stocking knit by her father on the machine he has invented. 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 roomy chamber is portrayed, with a general appearance of comfort and prosperity.

At the time of the Rev. William Lee’s death, his brother was in charge of the frames at Rouen, but the latter, with his
workmen, soon returned to England. Meanwhile Aston, an apprentice of Lee's, and afterwards a miller, had made improvements by the addition of a second set of sinkers, which enabled finer frames to be built. Aston and James Lee commenced building the improved frames in large numbers at Thoroton, Calverton, and Woodborough, and about the year 1640 stocking making had become a staple industry in most of the Nottinghamshire villages. At this period the industry was also commenced in the neighbouring counties of Derbyshire and Leicestershire.

About the time that Aston was bringing out his improvement, the original frames, taken by their inventor to France, were sold in London to a man named Mead. The latter took one of the frames to Venice, and the Venetians, who at that time were considered the first smiths in Europe, endeavoured to make imitations, but their efforts were unsuccessful, and Mead returned.

Early in the seventeenth century the framework knitters resident in London, which was then the principal seat of the manufacture, formed themselves into a company, and attempted to establish a code of rules in reference to the number of apprentices, rating of prices, and other matters. They soon afterwards petitioned Cromwell to constitute them a body corporate, but this petition does not appear to have met with any success. On the accession, however, of Charles II to the throne, the company renewed their application, and finally obtained a charter in 1663.

In 1727 there were 8000 stocking frames in England, 5000 of which were in use in Nottinghamshire. In this year a law was passed making death the penalty for the breaking of frames during rioting, and this apparently had a strong deterrent effect on this class of crime, which at that time was very prevalent.

For over a century after Aston’s improvement the hand stocking frame remained practically unaltered, but about the year 1745 an Irishman, of Dublin, is supposed to have added the “tuck presser,” whereby a distortion of the face of the fabric could be made. This invention was also claimed by the French stockingers, who stated that it was first brought about by Louis XIV about 70 years previous. At that time little was thought of the invention, although a century later great use was made of it.

In 1758 the “rib stitch” was first made on the stocking frame, the invention being by Jedediah Strutt, of Derby.
In 1754 Ferdinando Shaw, in conjunction with two other men named Morris and Betts, obtained a patent for making eyelet holes in the fabric by needles, or hand ticklers. Shaw seems to have been defrauded out of his share of the invention, and he went abroad, where, strange to say, at Valenciennes, he saw an improved method that produced the same results. These eyelet holes were probably what would now be called a knotted or marking stitch, the loop being extended over two needles.

Shortly afterwards Butterworth invented the “top machine” in which were placed points, the latter completely removing loops from certain needles on to other needles.

In 1769 Sam Wise took out an English patent for changing the hand frame into a rotary frame. His description said that in the lower part of the framework a revolving shaft was placed which was capable of being turned by any motive power. On the shaft were tappets which caught against arms and levers, and so moved the working parts of the frame.

In 1775 the warp machine was added, presumably by Crane, of Edmonton, although the invention was also claimed by March, of London, and Vandyke, a Dutchman at that time resident in London. This was the origin of warp knitting. Afterwards the stocking frame was simplified greatly in its adaption for warp knitting by Tarratt, of Nottingham.

In 1777 W. Betts invented a rotary frame in which the needle bar moved backwards and forwards and also upwards in order to press the needles against a fixed presser. Nearly a century later the introduction of a moveable needle bar and fixed presser in a different position caused a revolution in the trade.

In the concluding stages of the eighteenth century several attempts were made to produce a machine-made lace, and the first true machine-made lace fabric was made on a particular kind of stocking frame known as a “two-plain” machine. This invention was claimed by Holmes and Robert Frost, both of whom were Nottingham men.

A year later, in 1778, a point net machine was appended to a stocking frame, and this quickly superseded the previous invention. This invention enabled the sinker loops to be hooked up on to the needles, and was the forerunner of the present pelerine machine.

In 1784 the “elastic machine,” which was really a variation of a top or point machine, was introduced by Samuel Hague. This is still largely used.

In 1786 George Holland, of London, introduced the “fleecy hosiery,” lined with wool. This entailed no additional mechan-
ism, but required a variation in the manipulation of the frame at the lining courses.

In 1789 another important type of fabric, known as "broad ribs," was first made on the hand stocking frame. This was introduced by an unknown inventor, who achieved this distinction by the addition of "press-off" tackle.

In the same year "thread carriers" were invented by Rose, of Nottingham, and a year later framework knitted shirts, drawers, and pantaloons were introduced, the frames being made wider to permit of this.

In 1799 several important inventions were made. In this year William Green introduced the improved "jack machine," now in use for the production of all kinds of open-work knitted fabrics. The Berlin warp fabric was first made in this year, and still more important was the invention of the first "bobbin and carriage" for the production of bobbin nets. This was really the foundation invention of bobbin net, the starting point of a new industry, viz., the "twist lace trade." Three men claim the invention—Lindley of Loughborough, Whitmore of Nottingham, and Brown of Nottingham. This invention culminated in the production of the lace loom in 1813-14 by Lever, and after that date only knitted lace was made on stocking frames.

In 1801 the "spring slur cock," used on all hand frames of to-day, was invented by Hiram Flint, of Arnold. This effected a great improvement in the working of the frame, and saved adjustment of the slur cock for the various qualities of work. In this year an unsuccessful attempt to introduce a moveable needle bar on the hand frame was made by a Leicester clergyman.

In the same year "multiple slur cocks" were introduced for the making of several selvedged pieces of work on the one frame. The name of the inventor is unknown.

"Pelerine work" and "pearl work" were also made on specially built hand frames, and the making of some of these fabrics required no little amount of skill and dexterity.

In 1807 unequal surface wheels for traversing purposes were invented by Dawson, of Islington, these being extensively used to-day. Dawson originally applied them to the warp loom, but they are now used on all classes of knitting machinery, and are universally known as "Dawson wheels." In this year the first patent relating to rotary warp looms was brought out by S. Orgil.

In 1815 the first "thread layer" was invented by Eaton, of Heanor. This enabled the thread to be laid from below the
needles, and the distance the thread was laid was decided by throw-over leads. Thus, wrought work could be made without laying the thread by hand, the fashioning, however, still being performed by hand.

The early years of the nineteenth century, especially from 1810 to 1815, were exceedingly unfortunate for framework knitters. Frames were standing idle by the hundreds, and even the fortunate few who were able to obtain work earned barely seven shillings per week. It was at this period that “Luddism”—the name applied to frame breaking and looting—became rampant, and many hundreds of frames were destroyed. This rioting led to the circumstances under which the stockingers worked and lived being the subject of an inquiry, and many noted people of the day, including Lord Byron, championed their cause. This brought about somewhat better conditions, but in a few years the old state of things prevailed. Little wonder then that while the trade was in such a state of depression no progress was made. Inventions for improving the stocking frame or for originating new types of machines were at a discount, for the reward would have undoubtedly been death at the hands of the impoverished hunger-stricken and workless stockingers.

Yet it was about this time that innumerable patents were brought out, notably by Heathcoat and the Levers, with regard to the production of the bobbin net lace work. The lace trade, an offspring of the knitting trade, was prospering whilst the parent industry was decaying. Indirectly, however, this helped the older industry, for many of the framesmiths turned their skill to the making of lace machinery. As the years rolled on the lot of the framework knitters did not improve, for the system of frame rents and charges, which the middlemen enforced upon the workmen, enabled the former to make more and more extortionate charges as the shortness of work became more prevalent. In 1845 a Commissioner was appointed by the Board of Trade to enquire into the grievances of the oppressed framework knitters. Much information was collected and much evidence was given, statistics were carefully prepared, revealing the dire necessity of some change, but very little appears to have been done, and the stockinger’s lot does not seem to have been greatly ameliorated, for in the succeeding years frequent petitions were forwarded to Parliament appealing for a betterment of their conditions.

At this juncture it will be interesting to describe the manner in which the trade was carried on in the middle of the nineteenth century. In the towns there were a number of hosiery
warehouses, some of which possessed frames worked "inside," but the larger portion of the manufacturers let out their frames to "middlemen" in both town and country districts. The warehouse would supply the middlemen with yarn, and it was the duty of these middlemen to get the work made and take it back to warehouse, and yet pay the same price for making as they received from the so-called manufacturer. This necessitated the iniquitous system of frame rents and charges. These frame rents and charges were sources of anxiety to the stockinger who, out of his meagre nine or eleven shillings per week, was compelled to surrender from two to four shillings. These charges were itemised as follow:—

Frame rent.
Standing room.
Light and fuel.
Winding.
Taking-in.
Deductions for bad work, etc.

Besides these the stockinger had to buy and cast his own needles, and before the Truck Act was passed was often forced to purchase the necessities of life at exorbitant prices from the middlemen. Later, these conditions were changed for the better, but the system of "working to a warehouse," the latter supplying the yarn, was still carried on and is in the hand frame trade even to-day.

The old stockinger and his mode of living and working formed a picturesque study. The frames were mostly in small shops with low ceilings, and the appearance of the huge oak beams which supported the roof, the slates of the latter being visible from the interior, together with the low and fogged windows, and the general musty smell caused by the rancid oil used in the latter, was reminiscent of the dark ages. To complete the scene was the battered condition of the wood works, the unevenness of the floor, and the dusty spare parts and additions which in vain endeavoured to hide the bareness and crudeness of the walls. The incessant rumble of the frames would have been torment to the fastidious person of to-day, but to the stockinger it was music of the type he loved. The old stockinger was born to the frame; he grew up with it and in it, and his affection for it was enhanced as both grew older. In some of the towns, more especially in Nottingham, the workshops were placed in the upper storey of the house occupied by the stockinger, but the characteristics were the same, and the work carried on under the conditions previously mentioned.
As years went on the conditions of the trade changed, and with it the manner in which it was conducted. The middlemen grew more powerful, and disdained to work entirely to one warehouse. Thus one middleman might have frames from more than one warehouse, and if he had no work from one place he would go to another. The manufacturers, as we must call them, found that their frames were worn out, although they themselves had but little work made. This introduced the system of calling in some vital part of the frame, like the presser, so that their frames could not be worked, and many frames at this time possessed two pressers, the missing part being supplied by the middleman for his own purposes. Afterwards the middleman cultivated a home trade, owned their frames, bought their own yarn, and sold their goods in rooms, specially prepared, at many of the public houses in the towns, and here they assembled to sell or mutually exchange their goods. It is remarkable to think that, in spite of the advance of machinery, these conditions flourished until quite recent times, and even to-day are not entirely obsolete.

A perusal of the history of the old trade shows clearly how times have altered for the better, and yet the old stockinger had his compensations. He was his own master; he worked when he liked, played when he liked. In the country the working of the frame could be associated with the joys of gardening without much trouble, for the shops stood midst a plethora of flowers, fruit, and vegetables. The stockinger, although he worked all Friday night and played all Monday, was not "hustled." There was not the strain on the nerves such as is experienced to-day. The stockinger worked hard, played hard, and smoked hard; but he refused to be "bustled" or hurried, and was noted for his longevity.

In comparing the present factories with the old-time hand frame shops, it will be seen that both science and architecture have been brought into play in the construction of hosiery factories. The low, stuffy, griny stockinger shops have given way to the large, well-ventilated, hygienic, and well-constructed modern factories which are a credit to the towns they adorn.

From 1815 to 1838 no important inventions were brought out in connection with the knitting industry, but the year 1838 seemed to be the starting point of a new era for the stocking trade through the introduction of power. Previous to this date the "rotary" frames do not seem to have been power driven, although in 1828-9 a steam stocking frame is stated to have been in existence at Loughborough, and was known as "Warner's steam stocking frame."
In 1830 "Brunel's circular frame" was introduced into England.

In 1838 Coltman, of Leicester, invented a "rotary stocking frame," the jacks of which had no tails, and the jack springs worked in small catches at the head of the jacks. On this frame was a "snail wheel" apparatus which acted as a stop to the thread layer in the narrowing. This mechanism was undoubtedly the combined ratchet wheel and screw thread mechanism now so extensively used on straight bar frames.

In 1838-9 Luke Barton, who was perhaps the greatest inventor in the knitting industry of that period, invented a rotary frame with a horizontal moving needle bar, short sinkers, and knock-ing-over combs. The narrowing was still performed by hand, but the motion of the thread was not shortened, as the leads into which the needles were cast were turned up out of action as the stitches were removed. Whether this was the original invention of the "turn-up" leads is not known, but this method was afterwards extensively used on hand frames, and is so to-day. The introduction of rotary frames did not result in any great improvement of the conditions prevailing in the industry, for about this period the small hand frames from 15 to 22 inches wide on the needle were being transformed or "widdened" into wide frames 30 to 40 inches wide, so that this enabled them to make several selvedged pieces of fabric at once. The introduction of the "narrowing machine" and "thread layer" enabled several fashioned pieces to be made at one time, and the stockings which formerly were made on a single frame were now made in parts, the leg being made first, usually with the heel, and then the legs were taken to a frame with smaller divisions for the production of the feet.

In 1844 the total number of frames in the kingdom was 48,482, including over 10,000 wide frames. From this date the lot of the stockinger gradually improved, although, as previously stated, the improvement was slow, and had to be fought hard for, but up to 1880, in spite of the advance of power machinery, the hand frame worker held his own, chiefly owing to the progress made in the making of fancy fabrics. Framesmiths, especially in the Midland trade districts, were continually making additions to the hand frames, although these contrivances were rarely patented, and usually were brought about through the collusion of the framework knitter and framesmith to make mechanically some design which had been made previously by laying of the thread by hand. Thus four and six thread carriers were placed on one frame for the production of "horizontal stripes." Thread layers were placed on what was
known as a bottom machine, i.e., a machine working from below the needles, by means of which "vertical stripes" and "zigzags" could be made. Later the diamond machine was introduced, enabling "solid diamonds" in colours to be made almost as quickly as plain work. This machine had automatically racked Dawson wheels for the movement of thread layers. The "tuck presser" was greatly improved, a number of tuck plates being placed on the plain presser, and these automatically controlled by cut wheels.

"Press off work" was introduced, and the designs made on this principle were as effective as they were innumerable.

"Chevening machines" and "check machines," both of which were a type of warp machine enabling threads to be laid on a plain ground for producing vertical effects and plated diamonds, were introduced for the fancy hose and glove trade. Fancy tuckrib designs, which were further beautified by the removal of the frame loops by the points in a top machine, were extensively used. The status of the stockinger had greatly improved, and between the years 1870 and 1880 hundreds of framework knitters now emblazoned with the title of "fancy hands," could earn five pounds each week, and disdained to work on Mondays. Unfortunately for them, almost as quickly as the supplementary frames were added to the hand frames the power machines were adapted to perform the same work, so that from 1880 until the present time the hand framework knitters have gradually diminished, although there is still a demand for certain fancy articles which the hand frame can claim as its own.

It was a fancy hosier of Leicester, Matthew Townsend by name, who in endeavouring to do away with the pressing of the second set of needles when making pearl work, invented the self-acting or latch needle in the year 1847. This needle was the first practical alteration of Wm. Lee's original bearded needle, invented 260 years previous; but little attention was paid to it for several years owing to the energies of the machinists being almost entirely occupied in building improved rotary frames which made several pieces at once.

In 1857 Luke Barton made the greatest advance as yet made with power machinery, viz., the introduction of a "self-acting narrowing rotary frame." This frame was extensively built by Moses Mellor, and successfully held its own for some years.

In 1861 Paget, of Loughborough, another mechanical genius, introduced a "self-acting" moveable needle bar rotary frame." These frames were built in single divisions and were no wider
than the small hand frames, although they were power driven, and a number could be worked from a single shaft. This frame was used to some extent in England, but was afterwards taken to Saxony and greatly improved.

The first "vertical moveable needle bar rotary frame" was brought out by McCullum, of Belper, and Woodward, of Nottingham, and this system was afterwards so developed as to completely revolutionise the trade. The man who brought about this revolution was William Cotton, who was born in 1819, at Seagrave, Leicestershire. As a youth he worked for Messrs. Cartwright and Warner, of Loughborough, and remained with them for twenty years. His temperament is described as being reserved and uninviting. Afterwards he established a factory in Factory Street, Loughborough, for the manufacture of warped fabrics, in partnership with Mr. J. Harriman. This partnership did not last long, and soon he removed to another factory in the same street, and it was in this factory he worked out his ideas. He continued in the business of warp fabric manufacture for twelve years, and it was not until 1864 that the patent was issued which made him world famous. Not long afterwards the Nottingham Manufacturing Company purchased the patent rights, but the building of the machines proceeded but slowly. Patents for improvements were continually being added, most of which were purchased by the Nottingham Manufacturing Company, for whom the machines were being built. In 1878 the original patent having expired, Cotton began to build on his own account, and from this has sprung the large and flourishing firm which bears his name. Cotton died in 1887, in his 69th year, but his name will for ever be remembered by knitters in all parts of the world.

In 1868 Cotton and Attenborough further improved the frame by the addition of the "widening" or filling up point.

In 1874 Cotton added the necessary mechanism for the production of "rib fabrics."

In 1881 J. and H. Kiddier produced "broad rib fabrics," and about this time effected several improvements in fashioning both rib and plain fabrics, and the first automatic fashioning frame, which shifted both frame and rib loop, was brought out by them two years previous, i.e., in 1879.

In 1882 Cotton added automatic mechanism for producing French feet, and shortly afterwards Lowe and Lamb brought out several patents for increasing the speed for single course stripes, striping, chevening, and for general improvements. Lowe seems to have displayed great ingenuity in his inventions.
but unfortunately the majority of them did not stand the test of time.

In 1885 J. W. Kiddier contrived arrangements whereby five carriers were introduced for the production of stripe work for insteps, the heels being left plain.

In 1888 Clarke and Mawby took out a patent for "independent moving points," controlled by a design cylinder, for the production of open work or lace designs which previously had been made with fixed points only, whilst in the same year F. Johnson brought out a patent for making lace work with points attached to sliding jacks, the latter being selected by guide bars controlled from a "dropper jacquard" selecting mechanism. The year 1888 seems to have been a favourable one for successful additions to the Cotton's Patent, for in this year C. H. Aldridge brought out a patent for making "tuck or mispressed work" by a moving presser mounted in a groove along the edge of the sinker bar. Vertical stripes, etc., were produced this year on the Cotton's frame by P. Ward.

In 1891 a "stop motion" to throw out the needle bar section on the breaking of the thread was invented by Claringburn and Hunter, but this does not seem to have become very popular.

In 1892 T. J. and J. W. Kiddier brought out another system for "tuck patterns" in complicated designs on gloves, hose, etc., and a year later the Nottingham Manufacturing Company, through Groves and Whatnall, issued a patent for "striped" and "ornamental fabrics" on rib frames.

In 1894 "pure vertical stripes" having clear edges were produced by Hill, Matthews, and Goddard.

In 1894 H. Kiddier took out a patent for "seamless pocket heels" and "seamless toes."

In this year a patent was taken out by Barfoot and Johnson for the making of designs by independent moving needles which were controlled by some selecting mechanism. In this way "press-off work" was made.

In 1895 C. H. Aldridge (Wm. Cotton) took out a patent for the production of "royal rib," "shot" work, etc.

In 1896 W. Lamb and J. Hind took out a patent for the production of "tubular fashioned work" for vests, pants, stockings, sleeves, etc. This, however, has not even reached the practical stage.

In 1896 C. H. Aldridge (Wm. Cotton), representing the original firm of Cotton, took out two patents with reference to making lace or open work by independent moving points
attached to jacks with "droppers," the design being controlled by "jacquard cards."

In 1899 Blackburn, Houldgate, and Davies introduced mechanism for the production of seamless gores simultaneously with narrowing.

In later years innumerable movements have been made, both with regard to the improvement in the build of the frame and also to the addition of all kinds of supplementary mechanism, the most important perhaps being the improvements for "embroidery work" by C. H. Aldridge (Wm. Cotton), and the "lacing attachment on rib frames" for the making of lace tops in conjunction with welt and slack course mechanism by Woodward (Moses Mellor and Son). Nor have our foreign competitors been idle. In Germany frames up to 40 gauge 3 needle frames have been built, and a wonderful jacquard lacing attachment is among the many improvements made by them. In France the most recent improvements are for the making of all kinds of check and fancy work on rib frames. In spite of these foreign improvements, however, England can still say that the English-built Cotton's patent rotary frame holds the supremacy of the knitting world.

The introduction of the circular frame into England has been previously alluded to, but for some years all the improvements made with regard to circular frames were due to the energies of our foreign competitors. The first French circular frames had loop wheels with fixed teeth or blades, similar to those now used on the English frames, and these were in use in 1830. Afterwards Jouve's system, which was introduced previous to 1840, became popular. Jouve kept strictly to the loop forming method of the hand frame, although he placed his needles radially. It is noteworthy, however, that this frame in some respects resembled the present day French circular frames, for the toothed wheels to deliver the thread were an essential part of this frame. Berthelot's frame quickly followed, and in this frame the sinkers were divided into two parts, and a toothed wheel was added to push back the work to the stems of the needles. A wheel afterwards was invented by Jaquin with sliding teeth, which formed and landed the loops, and worked on a central pinion in a similar manner to the presser wheel. In 1856, however, Nopper and Fouquet obtained a patent for the large sinker wheel, with the presser and knocking over cam inside. This was in reality the start of the present French circular frame.

No progress was made in England with circular frames until Moses Mellor transformed Brunel's frame into what is now
known as the English loop wheel frame. The first frames were placed on their sides, so that the work was drawn off horizontally. Later, the machines were placed so that the needles stood vertically and the work drawn off upwards. This system of circular frame was afterwards improved by the addition of the dividing wheel and clearing wheel. A few years afterwards some of these frames were taken to America, and several improvements were added by American machinists, so that to-day the loop or burr wheel feeder frame is one of the standard American circular frames for the production of plain and backed knitted cloths.

The invention of the latch needle, as the years rolled on, opened an entire new field for inventors' enterprise, and a few years after its invention circular frames having this type of needle soldered into jacks were much in use. In these frames the needle cylinder revolved, and the revolving needles passed over and under certain cams to obtain the knitting movement. The machines were placed vertically, and were exceedingly simple in construction.

In 1853 a Leicester man named Thompson added the ribbing mechanism. The rib needles were placed horizontally and soldered into vertical swinging jacks. These frames enjoyed great popularity, and were afterwards adapted by the British machine builders to make all kinds of plain and tuck rib fabrics.

In 1863 the Rev. I. W. Lamb, of America, invented a new type of frame with two horizontal flat beds. This frame was afterwards altered so that the beds were inclined at right angles to each other and at 45 deg. to the horizontal. America, therefore, can claim the invention of that useful and rapidly developed system of knitting frames now known as flat knitting machines.

The feeder circular frame is also said to be the invention of an American whose name was Gist, and who constructed an eight-feeder frame, which was quickly followed by a 32-feeder by Blackburn and Attenborough.

In 1870 the first circular knitting machine was evolved. This machine was known as the "Little Rapid," and was the first machine upon which a complete seamless stocking could be made. This was also an American invention, and it certainly seems that American machine builders made greater progress with the latch needle than did the British machine builders. The idea of completing a stocking upon a circular frame was quickly followed up, and in 1878 the famous "Griswold" machine appeared. In this machine the jacks, both in the frame and rib, were dispensed with; the needles themselves, being bent
at their shanks, were acted upon direct by the revolving or oscillating cam.

A year later the first machine appeared which caused the heel needles to be raised and lowered individually, and was known as the "Shaw" knitter. Step by step these circular knitting machines became more and more automatic, until at the present time there is quite a dozen full automatic circular knitting machines capable of producing, without stopping and without any assistance from the operator save that of supplying them with yarn, plain hose in regular sequence. And this was practically all due to the alertness of the American machinist. These machines were quickly introduced into England, the firm of Blackburn and Sons, Nottingham, being the first English firm to take up the matter, and they undoubtedly scored a great success in presenting, and afterwards building, the Scott-William machines.

Although America was to the front in the production of plain circular automatic machines, it is pleasing to note that the problem of producing rib hose and half hose entirely automatically was unsolved until Stretton and Johnson took out a patent in 1900 for the automatic production of seamless rib half hose in which the rib was changed automatically, in addition to the other changes which had previously been made on the plain machine. Stretton was a Leicester hosiery manufacturer, and Johnson the head mechanician at this place. The patent was for a vertically placed double-ended latch needle, controlled by sliders having hooks and extensions for keeping open the latches. This invention can also be stated to mark an epoch in the knitting industry. The invention, however, cannot be said to be absolutely unique, for double-ended needles had been in use for a number of years for the production of pearl work on both circular and flat frames.

It is interesting to note that the mechanism in the very latest machine still bears traces of the original designs; even as I feel sure William Lee's experience with the lady of the village still remain evergreen, knitting needles are still made.

The author thanked the executive of Prestige Ltd. for their collaboration in compiling these notes, and for making available the excellent film that was about to be shown.

Mr. Brock, their chief engineer and works manager, one of our members, would give the commentary. The progress of this firm in their 14 years' existence gave me the encouragement to try in my small way to give you some idea of what has been done in this industry.