BOARD OF EDUCATION

CATALOGUE OF THE COLLECTIONS IN THE SCIENCE MUSEUM SOUTH KENSINGTON

WITH DESCRIPTIVE AND HISTORICAL NOTES AND ILLUSTRATIONS

TEXTILE MACHINERY

1921

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PREFACE

The Science Museum, with its Collections and Library, aims at affording illustration and exposition in the fields of mathematical, physical, and chemical science, as well as their applications to astronomy, geophysics, engineering, and to the arts and industries generally. To that end the Museum includes objects which are of historical interest as marking important stages in development, and others which are typical of the applications of science to current practice.

A Museum of Science was contemplated as an integral part of the Science and Art Department from its beginning in 1853, and in 1857 collections illustrating foods, animal products, examples of structures and building materials, and educational apparatus, were brought together and placed on exhibition.

The first of the Engineering Collections, that of Marine Construction was formed in 1864, when the Royal School of Naval Architecture was established at South Kensington, and the ship models belonging to the Admiralty were transferred to the Museum from Somerset House, where they had previously been. This collection of ships of war was of great historical interest, and with the assistance of private donors and by purchase it was rapidly increased by the addition of many models of mercantile ships as well as of later ships of war, with the result that when the Admiralty removed their models to the Royal Naval College, Greenwich, in 1873, an important collection still remained at South Kensington. Engineering and Manufactures were first included in 1867, from which time the development of this portion of the Museum advanced steadily ; but the transfer of the Museum of the Patent Office to the Department of Science and Art in 1883 added to the collection many machines of the highest interest in the history of invention and greatly increased its scope and value.

The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was held in that year in London brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum.

In 1893, many Mining and Metallurgical objects were transferred to South Kensington from the Museum of Practical Geology in Jermyn Street, and to these many others have subsequently been added.

Mention should be made, too, of certain special Collections : The Watt Collection was presented to the Patent Museum in 1876 and contains original models made by James Watt ; the Maudslay Collection, consisting of models of marine engines and machine tools, was purchased in 1900 ; and in 1903 a valuable collection of engine models, portraits, etc., was bequeathed by Bennet Woodcroft.

The Museum Collections are being continually increased by gifts and loans, and also by the purchase of such examples as are required to illustrate the application of science and the development of various types of instruments, machinery, etc.

Notes.—A large number of objects in the Collections have been photographed. Selected prints from the negatives may be seen in guard books at the entrance stiles. Particulars of available prints and lantern slides may be obtained by personal application at the entrances or by letter addressed " The Secretary, The Science Museum, South Kensington, S.W.7."

A compressed air service furnishes the power for driving such of the machines as are shown in motion, and the service is available daily from 11 a.m. (Sundays 2.30 p.m.) till closing time. Where practicable, these objects are fitted with self-closing air valves, by means of which Visitors may start them at will. Other objects are arranged so that Visitors may work them by other means, and there are a few that can be shown in motion only by an Attendant.

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CATALOGUE

OF THE

COLLECTIONS

IN THE

SCIENCE MUSEUM,

SOUTH KENSINGTON.

Numerical references in the text refer not to the page but to the serial numbers placed at the beginning of each catalogue title. When an object is illustrated the reference to the plates of illustrations (bound at the end) is given immediately after the title. The number at the termination of each description is that under which the object is registered in the Museum Inventory. If the object has been photographed, the Inventory number is followed by the negative number; and where a lantern slide exists, the letters "L.S." are added.

COTTON MACHINERY.

Cotton is the cellular fibre found round the seed of a family of plants growing in temperate and tropical climates. The individual fibres vary from 0·5 in. to 2 in. in length and have a silky lustre, which is, however, lost during the severe treatment of manufacture, but it can be regained by a special finishing process. The length of the fibre is a most important quantity in determining the value of the cotton, and is known as its staple. Under a microscope it appears like a twisted ribbon with thick edges tapering from the seed to the free end; the diameter varies from ·00032 to ·000143 in., and there are from 300 to 500 twists per inch of length. The irregularity of the edges makes it possible to spin even the short-stapled cotton into yarn by reason of the mutual engagement of the adjacent fibres. Flax fibres have not the same adhering surfaces, and could not be worked into fine yarn were it not for their great length.

Important work is being done by the Textile Institute and the British Cotton Industry Research Association in various directions with a view to eliminating defects in the raw material and to improving the processes so as to prevent injury to the fibre, and so to secure an evenness of yarn which is most important to the weaver. Independent investigators also are doing useful work; for example, it has been found possible to effect a considerable saving of raw material in several spinning mills in the Bolton district by the microscopic examination of cross sections of cotton fibres; by observing the distribution of the cellulose it is possible to trace to their origin the defects in the fibre which lead to waste. A matter which is receiving attention from the Research Committee of the Textile Institute is the reduction of the noise of looms in a weaving shed, the effect of which on the nerves of weavers impairs efficiency. In an ordinary plain loom the shuttle attains a speed of 75 ft. per second, and it has to be arrested 12,000 times an hour ; so that the problem of eliminating the noise is a difficult one.

The earliest method of preparing the material was to detach the fibres and twist them together by the fingers into a thread or yarn, and in this way the Hindoos prepared a remarkably fine calico which has not been surpassed by that from modern machinery. The wisp of cotton wool was supported on the end of a wooden stick about 3 ft. long, called a distaff, from which the spinner pulled out the fibres and twisted them into thread which, as completed, was wound upon a reel. The one-thread spinning wheel was first used about 1530, and greatly reduced the time spent in twisting the fibres together, but the operation of separating them was still performed by the fingers. To assist in straightening the fibres, hand cards or wire brushes were used, and by such simple means all the cotton yarn used in weaving was made till the commencement of the eighteenth century.

The present system of manufacture follows the process adopted by the early workers ; but, as the operations are done entirely by machinery, the number of stages has increased, owing to the more distinct separation that has become necessary. A series of labelled specimens is arranged in the collection which shows the cotton as it comes from each successive class of machine (*see* No. 3).

Cotton Bolls.—The cotton plant or shrub (*Gossypium*) bears a flower which is succeeded by a capsule or pod, the boll, containing the cotton and the seeds. The pods are plucked by hand, and usually contain about one third of their bulk of cotton, the remainder consisting of leaves, seed, dust, etc. These impurities are usually removed at the plantation, the process being known as "ginning."

Ginning.—The earliest known method of performing this operation was by working the cotton on a flat stone with a bar of iron rolled by the foot, the roller carrying the seed before it and leaving the fibre. The churka (*see* No. 6) is a machine acting in a similar manner but running continuously. In 1793 Eli Whitney, of Massachusetts, U.S.A., invented the saw gin (*see* Nos. 8 and 9), which is the type still most used for American cotton ; it has circular saws with pointed teeth, which drag the fibre away from the seeds, and revolving brushes that strip the cotton from the saws. The Macarthy gin (*see* No. 10) is slower than the saw gin, but is preferred for many qualities of cotton, as it injures the cotton less ; it prepares from 10 to 60 lb. of clean cotton per hour, varying with the staple. After being ginned the cotton is packed in bales, pressed by hydraulic power, and shipped to the different countries where it is spun.

Opening and Scutching.—When the bales are opened the ginned cotton is found to be much matted together, and is therefore generally passed through an opener, which loosens it by revolving beaters ; thence it is carried by an air current along tubes to a scutcher or blower, where it is again beaten. The remaining leaves and other impurities fall through grids, and the cotton fibres are deposited on a wire drum, from which the cotton is delivered in a continuous sheet or lap (*see* No. 12). When the scutcher was first brought out by Snodgrass, at the beginning of last century, it delivered the opened cotton from the revolving beaters on to a travelling apron ; afterwards the dust cage and fan were added, and in 1814 Creighton attached an arrangement that delivered the cotton in a continuous roll. Subse quently, Edward Lord introduced the present arrangement with the fan below, and afterwards invented the self-regulating feeder for giving a lap of uniform thickness. It is now the custom to pass the cotton through several of these machines, each taking several laps simultaneously, so as to equalise the product. The scutcher-waste consists of fragments of leaves and seeds together with short fibres of cotton.

Carding.—The laps from the scutcher are fed into a machine called a carding engine (*see* No. 17), in which the fibres are laid out straight and parallel by brushes of fine wire, known as cards. The earlier cards were about 12 in. by 5 in., one being held in each hand. Subsequently the size was greatly increased and one card was fixed vertically, while the other, which was counterbalanced by a weighted cord, was worked up and down. In 1748 Daniel Bourn patented a carding engine with a revolving cylinder, and several months later Lewis Paul patented another carding machine. Bourn's engine had four cylinders moving in contact with each other, and resembled the roller carding engine of the present day, while Paul's had a roller with 20 transverse fillets on it working against fixed cards in a concave frame and so resembled the fixed flat carding engine. The carded fibres were stripped from Paul's machine by using a stick with needles projecting from it. In 1773 Hargreaves introduced a reciprocating comb for this purpose, and about the same time the carded sheet was contracted into a sliver by passing it through a funnel, whence it was led into a rotating can, as still generally practised. These improvements were combined in one machine by Arkwright in 1775 (*see* No. 25), and 10 years later he introduced an improved carding machine, which was very like the present roller carding machine except that it had not the self-stripping arrangement for cleaning the cards. This last feature was introduced in 1823 by Archibald Buchanan (*see* No. 17).

Carding greatly reduces the thickness of the laps and removes impurities and short fibres as "card-waste," which is used for working up into shoddy. The sliver from the carding engine is a round unstranded rope which, in being coiled into the rotating can, is slightly twisted to the extent of one turn in two feet.

Combing.—Carded cotton contains many short fibres which would detract from the strength of the fine yarns, and to remove these the combing machine is now extensively employed. The original machine was invented by Heilmann, of Mülhausen, about 1845, and about the same time Lister and Donisthorpe in England invented a similar machine. In the modern comber usually eight laps of from 7·5 in. to 10·5 in. in width are combed separately in each machine, and the slivers from these combined. As the cotton passes through, the long fibres are carried along and delivered as a uniform sliver in a rotating can, while the short ones are at the same time combed out and delivered in a thin sheet which is rolled up by a coiler. This "comber waste" is afterwards used for making inferior yarns.

Drawing.—This process introduces the important method of drawing by rollers. The lap of cotton is uniformly lengthened by the sliding of the fibres past each other by a regulated amount so that the individual fibres are caused to take up a nearly parallel position. From six to eight slivers are passed through the drawing frame simultaneously and worked into a single sliver, so that considerable uniformity is secured by the averaging action thereby introduced. In a drawing frame in which the slivers from six cans are drawn together through four pairs of rollers the speed of the successive pairs would be in the ratio of 1 : 1·5 : 3·75 : 6 ; the fourth pair revolving six times as fast as the first, so that the final combined sliver is of the same " count " (*see* page 10) as each of the original slivers, but of six times the length. By the successive passages an amount of extension is gradually attained that, if attempted at once, would break the lap, but the distance between each successive pair of rollers must always be greater than the length of the longest fibres, as the drawing process does not stretch the fibres but simply slides them on each other. The extension or draught is greatest between the second and third pairs of rollers. The drawn sliver is delivered as a coil in a can in front of the machine. The operation of drawing is repeated twice more upon the material, so that the original six slivers going through three drawings have experienced $6 \times 6 \times 6$ or 216 doublings. If eight slivers had originally been placed together the number of doublings would be 512. This method of drawing out the material, by successive rollers revolving at increasing circumferential velocities, is used in every subsequent process in the manufacture of yarn. The first separate drawing machine in which this valuable invention was applied was Arkwright's lantern frame (*see* No. 24).

Slubbing, Intermediate and Roving.—Soon after the invention of the " spinning jenny " (*see* No. 23), which spun fine yarn, a similar machine was introduced for drawing and slightly twisting the heavier sliver, and this machine was called the " slubbing billy." As the process is twice repeated on similar machines, before it is delivered as the fine roving, the second process is known as the intermediate, and the latter as roving. The object in all of these is to draw out the fibres into a thinner sliver or roving ready for spinning, and also by continued doubling to obtain still greater uniformity. To give the sliver sufficient strength to withstand the drawings a certain amount of twist is put in by each frame, but it must be as little as possible, owing to its interfering with the subsequent drawings.

The cans from the drawing frames are placed behind the slubbing frame, and two laps are led through four pairs of rollers with a draught between each pair. The combined sliver is then led down one arm of a flier which winds the cotton on to the bobbin and at the same time twists the sliver, one turn for each revolution. As the bobbin fills, more sliver is wound in for each revolution of the flier, so that the twist would be decreasing and the strain increasing. To prevent this, many devices have been invented : that used by Arkwright was a friction brake which allowed the bobbin to be dragged round by the yarn, but the first true differential motion for varying the relative speed of the bobbin and flier as the bobbin filled was that of Houldsworth. He drove the fliers at a constant speed, while the bobbin was rotated by a shaft, which received its motion through a pair of conical drums and an epicyclic train of wheels. There are many arrangements of differential, or jack-in-the-box, motions now made, but the object is the same in all, viz. : to secure that the slubbing shall be wound on the bobbin at a constant rate without any stretching.

In winding the material on the bobbins it is important to have it uniformly distributed up and down, a requirement that was at first somewhat neglected. In Arkwright's first frames this distribution was performed at intervals by leading the yarn from different hooks placed on the flier, as was done when using the old spinning wheels. In 1772 Coniah Wood gave the bobbins an up-and-down motion for this purpose, but the heart-cam arrangement for lifting the rail which holds the bobbins, as seen on Arkwright's machine (*see* No. 26), was a complete solution, and is found in all subsequent winding machinery.

The main difference between the intermediate and slubbing frames is in the size of the bobbins, which decreases as the yarn becomes finer, but the number of spindles is usually from 100 to 200 in each. For counts of yarn up to 20's the intermediate process is omitted, but for fine yarns (60's and upwards) many manufacturers repeat the roving operation.

Spinning.—This, the final process in the manufacture of cotton yarn, differs from the earlier drawing processes in the large amount of twist that is given to the thread, which twist greatly increases the strength of the yarn and the regularity of its surface, but would absolutely prevent any subsequent drawing. The introduction of machinery for this purpose dates from the middle of the 18th century. Lewis Paul and John Wyatt in 1738 introduced the practice of drawing by rollers. In 1767, James Hargreaves invented the spinning jenny (*see* No. 23), while Arkwright's water frame, the forerunner of the throstle frame, was introduced about 1775. In 1774 Samuel Crompton invented the mule (*see* No. 27), which was so named from its intermediate position between the spinning jenny and the water frame. He and the other great inventors of the time suffered severely from poverty and mob violence, the one exception being Sir Richard Arkwright, who, though his patents were upset, succeeded in making his machinery commercially successful.

In the jenny, Hargreaves placed his rovings on a moving frame and ran his spindles in a fixed one, but Crompton placed the spindles on a carriage which moved to and fro in front of the creel of fixed rovings, fed out by drawing rollers. The carriage, in its outward movement, drew with it the extended rovings, which were being twisted by the revolution of the spindles, and then the finished yarn was wound upon the spindles during the return motion of the carriage. These are the features of the modern mule, which is the only machine by which the finest yarns can be spun (*see* No. 36).

The throstle frame is a simpler machine, but has a more limited range. In it, the roving passes through a series of drawing rollers and then down the hollow arm of the flier, which winds it upon a bobbin and at the same time gives the requisite amount of twist. The machine is generally used for spinning the hard and strong yarns used for warps, known as twist.

The ring-spinning frame is a much later invention, which, although unable to spin the finest counts, is of the greatest importance from its simplicity and large output. It was invented in America about 1828, and two English patents of the next year describe a similar machine. In 1834, Messrs. Sharp and Roberts made a few ring frames, but they were not at that time appreciated. About 1868, Messrs. Brooks and Doxey reintroduced the ring frame, which has since been extensively adopted for work previously done by the throstle frame, and for yarns up to 60's count. The ring frame is a development of the throstle frame, the flier being replaced by a steel loop, which travels loosely round a fixed steel ring owing to the pull of the yarn. The lightness of this flier permits of the very high speed of 8,000 rev. per min. for the spindles. An example of the modern ring frame is seen in No. 33.

Yarns intended for warps must be stronger than those for wefts and so are given more twist, while the looser wefts give the soft surface to the cloth. The various yarns are described by the spinners by their "counts," thus: 60's means that 60 hanks of such yarn, each hank of the standard length of 840 yds., will weigh 1 lb. Double yarns are described thus: 60's 2, signifying that two single yarns, each of 60's count, have been combined in a single thread, so that 30 hanks of this thread would weigh 1 lb. The spinner's long measure is:—

54 inches	=	1 thread.
80 threads	=	1 lea or warp.
7 leas	=	1 hank = 840 yards.

It is, however, often impossible to obtain the exact count desired, for, in 60's for example, there may be 51 fibres in the cross section, and one fibre more or less makes an alteration of more than one in the count. Hanks of various yarns are shown (*see* No. 3), labelled with the spinner's numbers, from 60's 2 to 240's 2. Weft yarns, having to be used in a shuttle, are wound up in small cops, while the warp material is usually twisted into skeins as shown. For certain purposes an exceptionally smooth surface is required and this is obtained by singeing off the ends of the fibres, by passing the yarn through a gas flame. This process raises the count somewhat; for instance, 90's may become 95's.

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1. SPECIMENS OF COTTON. Presented by W. S. Murphy, Esq., 1914.

The cotton plant (natural order *Malvacea*, genus *Gossypium*) is widely distributed throughout the world between latitudes 40 degs. N. and 30 degs. S. It requires for its best development, as for its finest spinning, a moist and warm atmosphere. The fibre when matured becomes flattened, and has a helical twist amounting to as many turns as 180 to the inch. This is of great importance in the operations of spinning. The finer the fibre the more it is twisted, and the finer the yarn that can be spun from it.

The length of the fibre is called the staple, and in the case of the best cotton of all, that grown in South Carolina and known as Sea Island cotton, the staple sometimes reaches 2 in. The commercial value of a cotton is determined by its length, fineness, strength, pliability, smoothness, uniformity, colour, and cleanliness. Some varieties of cotton are best suited for spinning into twist or warp yarn—these have a hard strong fibre; weft yarns require a softer and more pliable fibre.

These specimens are representative of the different varieties of cotton grown throughout the world. Sea Island cotton has a staple 1·8 in., diam. 0·0006 in., will spin into yarn up to 400's counts (*i.e.*, 400 hanks of yarn to the pound) and is suitable either for warp or weft. American cotton (Uplands, Texas, Memphis, etc.) is white, soft, pliable, fairly strong. Length 0·9 in. to 1·1 in., diam. ·00076 in. The Uplands sub-variety is especially good for weft. West Indian cotton has a helical twist more perfectly developed than any other variety, but it is short in staple and rather harsh and dry, diam. 0·00077 in. It is only used for coarse yarns up to 40's. The supply from this source is rather small. Egyptian cotton has a staple 1·3 in., diam. 0·00071 in., will spin up to 150's counts and can be used either for warp or weft. Brazilian cotton (Pernams, Ceara, etc.) is rather harsh and dry but fairly strong. Staple 1·1 in. to 1·3 in., diam. 0·00077 in. It will spin up to 60's and is better suited for warp than for weft. Peruvian is of two principal kinds, the smooth is soft and flexible and easily spun; the rough is harsh and wiry and mixes well with wool. Staple 1·28 in., diam. 0·00077. It will mix up to 70's; the rough is suitable for warp and the smooth for weft. Indian cotton (Broach, Dharwar, Oomrawattee, Tinnivelly, etc.) is fairly strong but varies considerably in the different provinces, in some of which the heat is too great for a good development of the plant. The staple varies from 0·4 in. to 1 in., diam. 0·00083 in. Useful only for coarse yarns up to 36's and chiefly for warp. West African cotton is small in quantity and harsh, but of good colour. Staple 1 in., diam. 0·00083 in. It will spin warps up to 40's counts. Inv. 1914–112.

2. PHOTOGRAPHS SHOWING COTTON PREPARATION IN INDIA. Presented by Messrs. Dobson & Barlow, 1895.

Six views in the cotton plantation and ginning houses, concluding with the final bale-pressing preparatory to shipment, are shown. M. 2738.

3. SPECIMENS OF COTTON, SHOWING STAGES IN THE MANUFACTURE. Presented by Messrs. McConnel & Co., 1891.

Commencing with the cotton as found in nature, in bolls, the effects are seen of the successive manufacturing operations, viz.: ginning, carding, combing, drawing, roving, and spinning. The waste materials removed by each process are also shown. M. 2389.

4. PHOTOGRAPHS OF MODERN COTTON MACHINERY. Presented by Messrs. Howard & Bullough, 1894.

These 12 views show in order the successive machines through which the ginned cotton passes from the opener to the final winder. M. 2759.

5. COTTON GIN. Presented by R. Burn, Esq., 1862.

This is a small roller gin, or churka, for separating cotton fibre from the seeds.

The machine has two equal horizontal iron rollers geared together and rotated by hand. The raw cotton is fed from the front table and drawn through between the rollers to the other side, while the cotton seeds, being too large to be nipped by the rollers, remain behind, and when stripped fall down through the grid provided between the lower roller and the feeding table. Small rollers are essential in such gins or the seeds would be carried through and crushed. To adjust the distance between the rolls the bearings of the upper roll are each tightened down by a wedge, the wedges being moved simultaneously by a right and left-handed screw connection. Inv. 1862–24. 20,504, L.S.

6. TREADLE CHURKAS. Presented by H.M. India Office, 1880.

These two churkas are examples of the Indian roller gin arranged for working by treadle, but are possibly both of English manufacture.

In each gin, the treadle by means of a crank drives a large flywheel and pulley, which by a band transmits the power to a small pulley on the axis of the larger of the two rollers. The upper roller is of iron ·5 in. diam., and the lower of wood 1·5 in. diam., and they are connected together by gearing, arranged to give them equal peripheral speeds. Behind each roller is a revolving four-bladed fan or scraper, driven by gearing from the rollers. The cotton fibre is drawn between the rollers, but the smallness of the upper roller prevents the cotton seeds being carried through. The revolving scrapers remove any fibres that may be carried round by the rollers.

In one example the smaller roller is fluted helically to increase its hold on the cotton fibres, and instead of the revolving scrapers a stationary comb is fixed below the lower roller to clean it. M. 1497–8.

7. COTTON GIN. Made by Messrs. J. M. Dunlop & Co. Received 1880.

This machine is a self-contained roller gin, specially arranged for hand driving, and was patented in 1859. The upper and smaller roller is of metal and finely fluted. The lower roller is of wood, and driven by a belt on its spindle, or by a pinion gearing into a large internally geared spur wheel driven by hand. The rollers are geared together so as to have equal peripheral speeds, and each is cleaned by a stationary scraping blade. The bearings of the upper roller are pressed downward by springs, adjustable by wing nuts. The smaller fluted roller pulls the cotton fibres off but cannot grip the seeds which, when cleaned, fall down and through the grating. M. 1429. 20,505, L.S.

8. COTTON GIN. Made by W. Jamieson, Esq. Received 1880. Plate I., No. 1.

This is a small hand-power saw gin intended for cottage use. Similar gins have been made almost entirely of wood.

The machine has a horizontal shaft carrying four circular saws, the teeth being of a special form known as thorn teeth. These teeth project to the extent of ·5 in. through closely fitting slots in the back of a hopper, in which the raw cotton is placed. Parallel with the saw spindle is another shaft having on it an eight-bladed revolving brush, at such a distance that the brushes touch the saw teeth. These two spindles are rotated by an endless band which passes over a large pulley driven by hand, and also round a tightening sheave.

The saw teeth drag off the cotton fibre from the seeds in the hopper, and carry it round with them till the revolving brushes are reached, when, owing to the higher speed of the brushes, the fibre is taken from the teeth, and by the air current resulting from the fan action of the brushes is carried out of a delivery spout at the back of the gin. The brushes also touch a fixed ledge of hard wood by which any entangled fibres are released. The cleaned seeds drop out of the hopper through an adjustable slot at its base.

M. 1501. 20,498, L.S.

9. MODEL OF COTTON GIN. (Scale 1 : 4.) Presented by H.M. India Office, 1880.

This is a model of a saw gin made at the Dharwar factory, India, in 1872. The machine is intended for use in the cotton plantation, and is driven by a belt from a flywheel on an external shaft.

The gin contains 18 fine circular saws, which partly project through 18 slots in the inclined side of the hopper. Further back is a five-armed revolving brush which touches the saws and also the edge of the containing frame. The main belt drives the saw spindle, and from this the brush spindle is driven by a short belt provided with a tightening pulley.

The fibres of the cotton fed into the hopper are pulled from the seeds by the saw teeth, and carried round by them till the revolving brushes sweep them off. They are then carried by the air current created by the brushes out through the large delivery orifice at the back of the machine, the lower side of the delivery passage being in the form of a grid through which dust may fall into a closed chamber below. The cotton seeds remain in the hopper till stripped, when they fall down and escape through an adjustable outlet at its lowest edge. The hopper is carried by hinges at its upper edge so that it can be swung back to leave the saws accessible for cleaning. M. 2739. 20,500, L.S.

10. COTTON GIN. Contributed by W. Wanklyn, Esq., 1860.

This is a small hand-power machine, on the principle of the Macarthy gin. A large helically-grooved and leather-covered roller is arranged for driving by hand. Below is a cranked shaft driven from the roller shaft, at five times its speed, by a belt. In front of the roller is a stationary blade or scraper, and below is a blade or doffing knife reciprocated vertically by the crank. The raw cotton is fed from the table on to the roller which, owing to its rough surface, carries the fibre round under the fixed blade. The seeds, being too large to pass under, are stopped by this blade and then cleared off by the reciprocating blade, when they fall down through the grid in the table. M. 363. 20,499, L.S

11. MODEL OF COTTON BALING PRESS. (Scale 1 : 8.) Presented by J. J. Eckel, Esq., 1863. Plate I., No. 2.

This model represents a form of press for compressing ginned cotton into bales, and is arranged so that the bales can be securely bound while under pressure, in order that the cotton may not return to its original bulk when the pressure is removed.

The loose cotton is tumbled into a vertical box which has hinged sides; the bottom of the box is formed with ribs, as is also the lower face of the platen of the press working in guides above. The cotton is usually trodden down by men inside, and, when no more cotton can thus be added, the platen is forced down by gearing, so compressing the cotton into a rectangular bale, which is then bound by external bands that can be inserted through the spaces between the ribs of the platen and base ; when bound the platen is released, and the bale pushed out by the side doorway.

The press, patented by Mr. Eckel in 1860, has two vertical racks attached to the platen which, by pinion and spur gearing, are simultaneously moved, pawls and rack teeth preventing any running back. When the greatest pressure obtainable by this mechanism is reached, the crosshead carrying the gearing is pulled down by a connecting rod at each end, the other end of each rod enclosing an eccentric sheave ; these eccentrics are driven by spur gearing, and so can pull the crosshead and platen downward through a short distance with very great power. Pawls engaging with racks in the side frames prevent the return motion of the platen, so that by this gear the platen is forced down successively by the space of one tooth for each revolution of the eccentrics. M. 900. 20,502, L.S.

12. MODEL OF SCUTCHING MACHINE. (Scale 1 : 8.) Presented by Messrs. Lord Bros., 1895. Plate I., No. 4.

This is a model of a four-lap scutcher with a single beater. The adjacent photograph of the actual machine shows some details of the gearing that are not fully represented in the small model.

The cotton, which has already been ginned and passed through an opener, is received by this machine in the form of rolled laps ; these it has further to clean from seed, leaf, and other impurities, and to deliver in a very regular sheet. As many as four of these laps are supported on horizontal spindles, over a travelling apron upon which the ends of the laps rest. These are, by the apron, conveyed to a small fluted reed roller which delivers them into a chamber within which revolves a two-bladed beater, making 1,300 revs. per min. These blades pull off the cotton in small pieces as it is fed in, and throw it on a fine screen. At the upper end of the screen are two hollow revolving cylinders with finely perforated surfaces ; their ends communicate with two air trunks from which air is continually being drawn by a fan arranged in the base of the machine. These air currents carry with them the dust and finer particles, but deposit the cotton on the surface of the cylinders, from which it is drawn off in two laps by a pair of rollers. The rollers compress them into a single lap, which is wound up on a cylinder resting upon two live cylinders with fluted surfaces.

To obtain a cleaner and more regular product, two or more of these machines are generally employed, the cotton going through them successively before it is passed on to the carding engine. The scrutcher represented cleans about 250 lbs. per hour, and requires about 4 indicated H.P.

A very important feature in these machines is the " piano motion," patented by Mr. Edward Lord in 1849, by which the speed at which the cotton is fed into the machine is automatically varied, so that the lap delivered shall be of uniform thickness notwithstanding any irregularities that may exist in the original lap. The arrangement consists in a number of levers, placed side by side on a common axis ; the short end of each lever presses upon the feeding roller, and between these ends and the roller the cotton is fed. The thicker the cotton the greater the extent to which the lever is depressed, and the total motion of all the levers is proportional to the quantity of cotton being fed in at any instant. From the long arm of each lever hangs vertically a wedge, and between each wedge is an anti-friction ball, the whole series being kept in place by a channel that stretches across the machine. One end of the channel is solid, and the other end is closed by a bar that is connected with a fork that controls a belt running over a pair of opposite cone pulleys. These cones transmit the motion to the feed roller, and when the wedges lift, owing to thick portions of lap being fed in, the belt is shifted so as to diminish the velocity of feed, and thus secure a uniform deposit of cotton on the perforated drums, which are running at a constant speed. M. 2914. 20,507–8, L.S.

13. ORIGINAL CARDING ENGINE. Received 1860. Plate I., No. 6.

This machine, made by Sir Richard Arkwright about the year 1775, is very similar to the cylindrical carding engine invented and constructed by Daniel Bourn, of Leominster, in 1748. The object of the machine is to remove from the cotton any fragments of leaves, seeds, etc., and also to straighten out the fibres by a combing action. This is accomplished by small wire teeth fixed in leather strips upon three cylinders. The cylinders are arranged horizontally with their axes parallel, and by bands are rotated at different speeds.

The cotton, having been previously ginned and beaten, was fed on by hand to the small cylinder, which would now be called the licker-in. Its wire teeth, which are bent or set towards the direction of motion, lay hold of the fibres of cotton and carry them downward and round to the second or main cylinder. This moves in the same direction at the line of contact, and also has its teeth set in the direction of motion, but its surface velocity is about 80 times that of the licker-in, and this greater speed causes its teeth to take the cotton from the first cylinder, but at the same time, by a combing action, somewhat to straighten the fibres. The third, or doffer cylinder, has the same direction of motion at the line of contact as the main cylinder, but only one-tenth the surface velocity, and as its teeth are set in the opposite direction to that in which it moves, it takes the cotton from the teeth of the main cylinder.

A reciprocating comb, which receives its motion from a crank on the axis of one of the pulleys, takes the carded cotton from the doffer cylinder and delivers it in strips. This comb was invented by James Hargreaves in 1773.

Inv. 1860–7. 21,747, L.S.

14. CARDING ENGINE. Presented by the English Sewing Cotton Co., Ltd., 1907.

This machine came from the works of Messrs. Strutt at Belper, where it was made about 1830.

It exhibits advances over the machine of Arkwright [*see* No. 13] in size, the general substitution of iron for wood, and more particularly in the addition of narrow flat cards placed transversely and close to the top of the main cylinder, an improvement of the latter end of the 18th century that greatly increased the carding action obtainable. There are now nine of these flats; originally there were twelve, the remainder having been replaced at a subsequent date by three card-covered rollers for the same purpose, worked by pitch chain from the doffer cylinder. The distance between the flats and the cylinders is adjustable by set screws. The flats are easily detached and were cleaned from fly and waste by the coarse hand card shown on the floor of the case. The cotton is fed in by fluted rollers. The main cylinder, 36 in. diam., is directly driven by fast and loose pulleys from the engine shafting. From the fast pulley is driven also the eccentric and comb for stripping the lap. The doffer cylinder, 12 in. diam., is covered with fillet card put on helically and not in strips and, therefore, gives a continuous lap. Its surface velocity is roughly one-eighth of that of the main cylinder, from which it is driven by spur-and-bevel gear. The latter is enclosed by wooden frames fixed between the standards and supporting a hinged sheet-iron casing. The hand grinder shown—a board with rough emery glued on—was used to sharpen the cards on this cylinder. The width on the wire and of the lap produced is 18 in. The lap is formed into a sliver by a funnel and two rollers.

M. 3491.

15. MODEL OF CARDING ENGINE. (Scale 1 : 8.) Lent by R. Bodmer, Esq., 1857.

This is a model of an arrangement, included in J. G. Bodmer's patent of 1824, in which two carding engines are placed side by side, and the slivers led through a trough and united into a single lap. Twenty or more carding engines could be combined in this way, the machines being arranged ten on each side of the trough, and the twenty slivers combined into a single lap. Mr. Bodmer's object in arranging so many carding engines together was to compensate for irregularities in the thickness of the sliver by averaging, but this result is obtained in modern practice by doubling in the finishing lap machine and in the drawing frame.

The cotton has been previously opened, scutched, and formed into a lap. The lap is fed into the carding engine by rollers, and is carded in the usual way by wire cards or combs, carried upon the large main cylinder, the smaller rollers, and the top flats. The last are secured by pegs to the circumference of a ring concentric with the main cylinder, and there is an automatic arrangement, not shown in this model, however, which lifts the flats one by one and takes them to a revolving brush where they are cleaned, and then returns them to their working position.

M. 8.

16. MODEL OF WIRE CARD CLEANER. Lent by R. Bodmer, Esq., 1857.

This model shows the mechanism by means of which the top flat cards in J. G. Bodmer's carding engine, patented in 1824, were cleaned. The object sought was to clear the cards of the dust and impurities which accumulated on them while the cotton was being carded.

In this machine the flat which is nearest to the taking-in end of the carding engine, where most of the dirt would be, is turned over and taken hold of by two hooks on a radial arm, by which it is carried past a revolving brush or cleaning cylinder, and being now clean is placed at the other end of the series, or near the doffer cylinder. Thus the clean flat is put where the finest carding is to be done and gradually works its way back to the other end; the frame carrying the flats being, by ratchet teeth, moved through the space of one flat for each one lifted. In the framing there are two grooves concentric with the main cylinder, running the length of the set of flats and connected at each end by radial grooves. The flats move along the upper groove from left to right to be cleaned and put each in its new place, and they return along the inner groove while carding. The mechanism for turning over the flats and taking hold of them is contained in a radial arm, which swings upon the main axis of the carding engine and receives its motion through a crank and connecting rod. The radial arm terminates in a cylindrical piece which serves as a guide for a sliding piece to which one end of the connecting rod is jointed. At the outer end of the sliding piece is a hook for taking hold of a pin on the flat. Another curved piece with a hook at its end for a like purpose is centred on the extreme end of the radial arm. It has a curved surface, upon which a pin, fixed to the radial arm, moves and gives the last-mentioned hook a motion sideways with respect to the first hook, so as to turn the flat over. M. 7.

17. CARDING ENGINE. Presented by Messrs. J. Finlay & Co., 1871.

This carding engine, with the first successful form of automatic stripping or cleaning arrangement, was patented by Archibald Buchanan in 1823, and made by him probably at a somewhat later date, as some of the parts are arranged in a slightly different way to that described in his specification [No. 4875, A.D. 1823]. Before Buchanan's invention, the cards or combs of wire were cleared by hand of the fly and waste cotton which adhered to them during the process of carding; this was, however, irregularly and unsatisfactorily done, and the invention of a means of doing it mechanically without stopping the machine marked a great advance in the development of the modern carding engine.

The machine is a combined roller and fixed flat carding engine; the main cylinder revolves close to eight revolving rollers, and above them are 12 flats, the cylinder, rollers, and flats being all clothed with the usual wire cards or combs. The flats are arranged so that they can be turned over on to their backs, so that the wire teeth are outside. When thus reversed a revolving brush, carried by a counterbalanced radius arm centred upon the axis of the main cylinder, brushes them as it slowly passes backward and forward, and so strips off the accumulated fly and waste.

The flats are supported at each end by a hinge at one corner, the other corner resting upon an adjustable screw fixed to the frame of the engine. A tappet fixed to each flat is acted on by a sliding rod attached to the radius arm, and the lower end of this rod comes into contact successively with a series of pointed cams fixed to the rim of a ratchet wheel. As the radius arm swings round, the rod is thus pushed up, and the flat is raised into such a position that a curved recess upon the head-rail of the radius arm catches a stud on the flat and turns the flat completely over. It is held in position there until it has been brushed, when a rack on the radius arm meets a segmental pinion on the hinge at the other end of the flat, and, gearing in with it, returns the flat into its working position. The ratchet wheel is turned through the space of one tooth in each oscillation of the arm, so that those flats which lie on the same radius as the tappets on the ratchet wheel will be cleaned in one oscillation, and those between them in the next.

The brush is continuously rotated by a band passing over a pulley on its axis and over another on the main axis, and the radius arm is oscillated by a crank and connecting rod. At the end of its travel furthest from the doffer cylinder, the brush is itself cleaned by a needle frame or comb, the needles taking off the motes and fly; this comb is in turn cleaned by a sliding copper plate, and the strips of card waste fall into a wide box fixed to the back of the machine. The carded cotton is removed from the main cylinder by two doffer cylinders, each cleaned by a reciprocating comb, and then passed through a funnel-shaped orifice delivering into a sliver can. M. 1257.

18. KAY'S WIRE CARD-MAKING MACHINE. Contributed by W. Horsfall, Esq., 1860. Plate I., No. 5.

This machine is believed to have been made by John Kay, of Bury, about 1750, for cutting, bending, and inserting the wire in the cards used in the preparation of cotton. Previously these tedious operations had always been done by hand, and Kay was the first to make a machine to perform the work. Card-making machines did not, however, come into general use till 50 years later, when Amos Whittmore introduced an improved form.

In Kay's machine the card clothing, which consisted of cotton or linen cloth with a backing of leather, was fixed in two vertical stretching-frames, each capable of sliding vertically in an outer frame, which could move horizontally along the length of the bed. It is a duplex machine, two cards being simultaneously prepared, one in each frame. The main shaft is horizontal, and various cams, by which the following operations are performed, are fixed along its length at different points. The wire is led along parallel to the shaft, and the operations performed by the mechanism are :—

(*a*) Feeding on a given length of wire.
(*b*) Gripping the length of wire which has been fed on.
(*c*) Pricking holes in the card clothing.
(*d*) Cutting off a length of wire.
(*e*) Bending it into a staple.
(*f*) Pushing the staple forward and bending its legs to give the proper set.
(*g*) Pushing the staple into its place in the cloth.
(*h*) Moving the stretching-frame into position for the next staple.

The first movement is performed by a jointed frame between two bars of which the wire passes, the arrangement being driven intermittently by a peg on the shaft, and the wire nipped during the forward motion. The holes are pricked in the cloth by piercers fixed at the ends of two levers which swing about joints below ; they have a quick motion forward and then fall back again. The cutting is done by a shear blade moving over a plane face through which the wire passes. When forming the staple, the cut length of wire is held between an arm, which swings vertically at right angles to the main axis, and a steel spring. The arm is moved upward and enters a recess in the fixed cover plate just wide enough to admit the arm and the wire, so that the latter receives two short bends and becomes a staple. After this, a part of the arm which slides upon it is pushed forward and carries the staple with it, but the legs being caught in two inclined grooves at the side are bent and so receive the necessary set. Finally, the steel spring, which is thickened at the end, slides further forward than the rest of the sliding piece, and pushes the staple into its place in the cloth. The horizontal feed is given, after each staple has been inserted, by a lever which engages with a rack fixed to the stretching-frames. The vertical feed is given when the end of each row of staples is reached, an arm on the shaft striking a tooth on a star wheel fixed to a pinion which engages with the teeth of a vertical rack at the back of the frame. Inv. 1860–8. 21,925, L.S.

19. COMBING MACHINE. Presented by Messrs. Dobson & Barlow, 1894. Plate II., No. 6.

This machine represents an improved form of Heilmann's comber. It is used in the preparation of the materials for the higher counts of yarn, and finishes the work of the carding engine by laying out the fibres parallel and removing all dust and short fibres. The cotton, before it arrives at the combing machine, has been opened, scutched, and carded ; the slivers from the carding engine have been put through a Derby doubler and a ribbon lap machine, and in this way the cotton is obtained in an even lap from 7·5 to 10 in. wide.

The lap to be combed is placed on the wooden rollers at the top of the machine, and is fed on to the combing cylinder by a pair of rollers which turn intermittently. The combing cylinder, which is as long as the width of lap treated, carries on its surface two sets of teeth arranged in rows, those coming first to the cotton being coarse, but gradually they become finer as the combing progresses. After one set of teeth there is an interval of smooth cylinder, slightly sunk in, then a fluted segment and another smooth space, then the other set of combs, followed by another smooth space and a second fluted segment.

The feeding rollers by their intermittent motion having delivered a certain length of lap slightly less than the length of the shortest fibre to be retained, a pair of nipper blades move together and hold the lap, while the teeth on the cylinder comb out the dust and shorter fibres. This being done, a top comb descends and holds the ends of the fibres, while the delivery rollers turn backward and bring up to these ends those of the fibres last combed, when a leather-covered roller descending presses them together and the delivery rollers turn forward and remove the combed cotton.

The short fibres are meanwhile carried round by the combing cylinder, from which they are removed by a revolving brush at the back, and a slowly revolving doffer cylinder, with sharp wires projecting from its surface, takes them from the brush. A reciprocating comb strips the doffer cylinder and delivers this comber waste as a continuous fleece, which is wound in by the waste shaft at the back of the frame.

The cycle of operations is completed twice in each revolution of the combing cylinder, which is driven continuously by a pinion on the driving axis. The feed rollers receive their intermittent motion from a pinwheel with two pins, on the axis of the cylinder, engaging with a wheel shaped like a Geneva stop, and giving to the feed rollers a slight rotation twice during each revolution of the cylinder.

The nipper blades, that hold the fibres fed on for combing, are closed by the top blade moving downward and pressing against the turned-up lip of the lower blade. Motion is received through a lever, which carries the lower blade beneath its centre and is driven by a vertical rod moved up and down by a crank on a shaft. This shaft is oscillated by a cam on a continuously-revolving shaft, running the length of the frame, and carrying several other cams.

The delivery rollers are worked by a segmental rack oscillated by an arm, whose end works in a cam shaft, and the rack drives a pinion fixed on a shaft which can turn independently of the rollers. A leather-faced friction clutch, opened and closed by a cam on the cam shaft, couples the shaft so that the backing motion of the rollers takes place when the segmental rack is moving upward, and the combed cotton is delivered when it moves downward again. While the combing is going on the friction coupling is open, and when it ceases the friction cones close and the rollers turn back, and then, the ends of the fibres having been pieced up, they turn forward again and deliver the continuous fleece, at the same time drawing the lap for the next combing through the nippers.

The sheet of combed cotton is now led through a small hole in the tin dish in front, and then taken through a pair of heavy rollers. The resulting slivers from each head are joined, and pass together through three pairs of rollers, and then through a trumpet-shaped tube to a pair of rollers delivering into a vertical cylindrical can carried on a revolving table. The doffer cylinder is revolved slowly and continuously by worm-gearing, driven by bevel wheels from the roller gear at the end of the frame.

The machine shown is shorter than those generally used in cotton factories, having only two heads instead of the usual six or eight; accordingly, there are only two sets of operations going on at the same time and two laps being combed. The combing cylinder makes 60 revs. per min. while 120 nips are given, and a standard machine of eight heads will produce in one day of 10 hours from 100 to 130 lbs. of combed cotton.

This machine is called a duplex comber because it goes through the cycle of operations twice for every revolution of the doffer cylinder. M. 2725.

20. SPINNING WHEEL. Received 1860.

This is an example of a hand spinning wheel, once the property of Sir Richard Arkwright, as used at the time when Hargreaves's spinning jenny and the former's water frame were first introduced.

The fibrous material was held in the creel, drawn from there by hand, and worked up into a thread. This was led through the hollow axis of the flier, over one of the hooks, or hecks, on the flier, and wound upon the bobbin, which was loose upon the flier spindle. There were two bands from a double-grooved fly-wheel, driven by a treadle and a crank, to two small pulleys of slightly different sizes, one fixed to the flier spindle, the other to the bobbin. The rotation of the flier put twist into the thread, and the difference between the speeds of the flier and bobbin caused the thread to be wound upon the latter. Very fine yarns could be spun with these wheels, as fine as any which can be made with the machinery of the present day, but a great deal depended upon the skill of the spinner, and the output was very small.

Cotton spun by such wheels had not sufficient strength for general use as warp thread, so that warps were usually spun from flax, but Arkwright's machinery, by the greater twisting and consequent strength that it gave to the thread, rendered the use of cotton general for both warp and weft. Inv. 1860–6. 21,220, L.S.

21. SPINNING WHEEL. Woodcroft Bequest, 1903. Plate I., No. 3.

The earliest appliance for twisting fibres into a thread appears to have been the distaff, which was a stick with a bundle of carded fibres wound on the end; the distaff was held under one arm and a tuft of fibres was drawn from it through the finger and thumb of the right hand by the weight of the bobbin, which was set spinning by the left. The length of thread or yarn thus formed was wound on the bobbin and fixed temporarily while the next length was spun.

The spinning wheel, in which these two operations are performed simultaneously, was introduced into this country in the 16th century, but was used earlier abroad; the small example shown is, however, comparatively modern, dating probably from the latter half of the 18th century, when spinning was a home industry. It consists of a wheel moved by a treadle and crank, and giving motion by bands to two pulleys, the larger of which is attached to a flier, and the smaller to a bobbin loose on the flier spindle. The fibrous material already carded, *i.e.*, laid with its fibres parallel, is held on the distaff, and from this a quantity, regulated in thickness by being passed between the finger and thumb of the operator, is drawn through the axis of the flier, and guided by hecks or hooks on it on to the bobbin; as the latter fills, the thread is changed to another heck. The bobbin-pulley, revolving faster than that of the flier, has a motion relative to it and, therefore, winds on the thread, while the rotation of the whole system twists the length of fibres between it and the operator's fingers; to put more twist into the thread there is an alternative pulley on the flier nearer in diameter to that of the bobbin. M. 3286. 26,750, L.S.

22. SPINNING WHEEL. Presented by W. W. Midgley, Esq., 1905.

This is a portable form of the flax-spinning wheel made by James Webster (*fl.* 1768), of Mardol, a suburb of Shrewsbury.

The distaff and bobbin are supported on a turned spindle in a wooden base with two horns by which it could be strapped to the waist, so that the machine could be used by a person walking. The distaff can be clamped at any angle by a wing nut. The flier is driven by a handle and gearing in the ratio of 6 : 1, and the retardation in speed of the bobbin necessary to put in the twist is obtained by the friction of a cord over the bobbin, wound round a peg in the spindle.
M. 3427. 209, L.S.

Photographs of two similar machines are shown. M. 3902.

23. HARGREAVES'S SPINNING JENNY. A replica of the original machine. Presented by Messrs. Platt Bros., 1912. Plate II., No. 1.

This important machine, which marks one of the first steps in the development of cotton-spinning machinery, was invented by James Hargreaves, a poor weaver of Blackburn, between the years 1750 and 1757, and patented in 1770. The principal merit of the invention lay in the fact that one spinner could spin 120 different threads at a time, whereas previously, on a spinning wheel, he could only spin one thread at a time. Other new features of great importance were: the travelling carriage which drew out from the bobbins of roving definite lengths, stretched them, and, by the rotation of the spindles, twisted them; and a wire guide which, pressing on the twisted yarn, formed it into cops on the spindles as the carriage returned. The method of drawing out a roving finer by passing it between pairs of rollers revolving at different speeds had been invented by Lewis Paul in 1738, but Hargreaves may not have heard of it, for, although the patent had expired in 1752, he did not use it in his jenny. Arkwright, however, incorporated the arrangement in his water-frame in 1769.

Hargreaves was the victim of the popular resentment against labour-saving inventions and of the prevalent opinion that such machines would throw large numbers of people out of work. His machines were broken up and he fled for his life to Nottingham.

The method of spinning cotton yarn on this machine was as follows:—Rovings, with a very slight amount of twist, wound on bobbins, were carried in a fixed creel beneath the carriage. They passed from the bobbins to the spindles between two wooden rails on the carriage, which could grip the rovings between them and release them when the carriage was moved out by the spinner. When sufficient length of roving had been unwound from the bobbins the wooden rails were closed up. The carriage, which had a traverse of about 6 ft., was then moved further out, giving a stretch to the roving. When the stretch had become as great as the roving would bear the wheel was turned by the spinner and the spindles thus driven by means of a band. This gave a twist to the threads and they were then strong enough to bear a further stretch, which was given to them by moving the carriage a little further out. When the stretch was sufficient the carriage was stopped and the wheel continued to turn until enough twist had been given to the threads. The carriage was then pulled in and the wire guided the yarn on to the spindles, which continued to turn and so to wind on the yarn, forming cops.

The spinning jenny led directly to Crompton's mule, but lacked most of the motions which enabled the latter machine to spin the finest counts and, when made automatic by Roberts, to survive without essential alteration until now.

M. 4039.

24. ORIGINAL DRAWING FRAME. Received 1860.

This is Sir Richard Arkwright's first drawing frame, and was made by him about 1780. It was commonly known as the "lantern" frame, owing to the fact that the sliver-can employed had an opening in the side closed by a door through which the sliver was removed, and so somewhat resembled a lantern.

In this machine the front rollers turn at three times the speed of the back pair, and the sliver is fed on from the back of the machine through a fork which travels to and fro continuously, guiding the sliver to different parts of the rollers. It receives its reciprocating motion from a crank pin on a pulley, turned by bands from the main driving drum, the axis of which is vertical. After passing through the drawing rollers the sliver is led down through a short tube to a pair of rollers attached to the top of a vertical can of conical shape. The can is driven by a band from the main drum, and on its axis is fixed a pulley, from which a band passes over guide pulleys to the pair of rollers on the can, so that they feed the cotton into the can at a definite speed, while the turning of the can puts into the sliver a slight twist. Inv. 1860–3. 21,750, L.S.

25. ORIGINAL SPINNING MACHINE. Received 1860. Plate I., No. 7.

This machine, made by Sir Richard Arkwright in 1769, shows his first application of drawing rollers to cotton spinning. The roving, wound upon bobbins placed at the back of the frame, was led successively through four pairs of rollers, each pair revolving more quickly than the preceding pair, so as to draw out the cotton to a finer thread. The bottom rollers are fluted and are geared together so as to give speeds in the ratios of 1 : 1·16 : 1·33 : 6·25, so that the last pair is rotated more than six times as fast as the first. Each roller is in four lengths, so that four threads were being prepared simultaneously for winding on the four spindles below. The upper rollers are covered with leather, and were pressed upon the lower ones by pulleys over which small lead weights hung, but these have not been preserved and only the hooks to which the cords were attached remain.

From the drawing rollers the thread passes through a wire guide, placed over the centre of a revolving spindle upon which were carried a bobbin and flier, both of wood. On one leg of the flier hooks or hecks were fastened, and the thread was passed round one of these and afterwards round another as different parts of the bobbin filled. The flier was fixed to the spindle and turned with it, but the bobbin was loose and driven by a twisted worsted band, which was fixed by one end to the sheave of the spindle, and at the other was "put about the whirl of the bobbins, the screwing of which tight or easy causes the bobbins to wind up the thread faster or slower" [*see* Arkwright's specification, A.D. 1769].

The rotation of the flier, carrying the thread with it, gave one turn of twist to the yarn for each revolution. The bobbin, under the pull of the yarn, rotated in the same direction as the flier, and if it went at the same speed would wind in no yarn. "The screwing of the band," however, put a drag upon the bobbin, and it wound in yarn equivalent to the number of revolutions that it lagged behind the flier.

The motive power was intended to be that of a horse, and it was applied by a vertical shaft standing on a wooden bracket projecting from one side of the machine, and driven by spur gear from the vertical shaft of the horse wheel. A pulley of large diameter, keyed on at the lower end of the countershaft, turned the four flier spindles by an endless belt, and by a friction wheel drove an upright shaft, which gave motion through crown gearing to the drawing rollers.

This machine could be used only for spinning the hard and strong yarns used for warp. The softer yarns for weft had still to be made by hand, except in one or two places where James Hargreaves's spinning jenny was in use.

Inv. 1860–4. 21,748, L.S.

26. IMPROVED SPINNING MACHINE. Received 1860. Plate I., No. 8.

This machine was made by Sir Richard Arkwright about 1775, and is an improvement on his first machine, No. 24, in having an arrangement for guiding the yarn over the bobbins evenly, and in containing more spindles.

The driving arrangement is very similar to that described in No. 25. The belt from an external main driving pulley, in addition to turning the spindles, drives two drums, placed on the vertical axes, which transmit motion to the drawing rollers above. Each of these vertical shafts drives four sets of rollers, and there is an arrangement for throwing either shaft out of gear.

There are three pairs of rollers, the top ones covered with leather, and the lower ones fluted, their speeds being in the ratios 1 : 1·6 : 18·4.

The spindles, of which there are eight, are provided with fliers which carry the thread round the bobbins and at the same time twist it, just as in the earlier machine. Regular winding upon the bobbins was secured by the following mechanical means: at the back of the machine, near the ground, is a wooden shaft driven by a belt from the roller gear, and having a cam fixed at each end pressing against a roller fixed in a frame, which swings in trunnion bearings above, and has the lifting rail attached to it in front. This rail has eight plates projecting from it, through which eight spindles pass, and on these plates the bobbins rest. As the heart-shaped cam revolves, the swinging frame or bell-cranks move the rail and bobbins up and down, so that the thread is wound on at different parts of the bobbin in succession. This very important improvement is believed to have been first introduced by James Hargreaves.

Machines of this kind driven by water power were used by Arkwright at Cromford, in Derbyshire, hence the name of water frames by which they were known. The throstle frame is the same in principle as this machine, the improvements being chiefly in its details and mechanical construction.

Inv. 1860–5. 21,749, L.S.

27. CROMPTON'S MULE SPINNING FRAME. A replica of an old machine. Presented by Messrs. Dobson & Barlow, 1912. Plate II., No. 2.

From the combination in this machine of Paul's method of drawing out the roving by rollers and Hargreaves's reciprocating carriage, it was called a mule. It was invented by Samuel Crompton of Bolton between the years 1774 and 1779 and called at first from the name of Crompton's house, the Hall-i'-th'-Wood wheel, as well as the muslin wheel, from its ability to spin very fine yarn. The mule, essentially the same as Crompton made it, but now elaborated into what is probably the most beautiful of all mechanisms and made self-acting, is still the only means of spinning the finest yarns. The important principle is that the lengths of roving are held between the ends of the spindles and the front pair of rollers without strain, while the amount of twist necessary to give strength to the yarn is put into it by the revolution of the spindles. Hargreaves drew out the roving and twisted it at the same time in the outward movement of the carriage, and Arkwright used Paul's roller method to draw out the roving, winding it on the spindle by a flyer arm; both of these processes put more stress on the thread than the finer counts would bear without breaking.

The machine is arranged for working by hand, but there is a fast and loose pulley for driving by power, with a wooden lath to shift the fork. The handle on the spindle of the big rope pulley is turned in a contra-clockwise direction. From this axis by bevel gearing and an inclined shaft the rollers receive their motion.

There are three pairs of rollers through which the rovings are drawn from bobbins which are held in a frame, not shown in this machine; the front pair revolve at three times the speed of the back pair and the middle pair are idle.

Thus the roving is drawn three times finer in passing through the rollers. The spindles are carried in a carriage which is moved to and fro on rails by means of two cords, one end of each of which is fixed to the carriage and the other to a hellically grooved drum. The drum is rotated by spur gearing, having a speed ratio of 1 to 9, from the main driving shaft. A crossed rope from the big pulley drives a speed pulley which is carried on an arm, slotted for adjustment, bolted to the frame. From the speed pulley an endless rope passes once round a pulley fixed to a tin drum and round a fixed pulley at the other end of the frame. From the tin drum bands work on to wharves on the spindles. The speed pulley allows a varying amount of twist to be put into different qualities of yarn.

The action was as follows :—A roving was fixed to each spindle and led off from its top end. The handle being rotated the rovings were delivered by the rollers and the carriage travelled from left to right at the same speed as the rollers delivered, the spindles at the same time rotating to twist the roving. This went on until a projection on the carriage came against the curved arm of a stop lever which caused the roller gearing to be put out of gear and so stopped delivery of rovings. The carriage then went on, stretching the length of yarn held between the spindles and rollers, and now strong enough by reason of the twist put into it to bear this strain, until the carriage came against another curved lever arm by means of which the helically grooved drum which traversed the carriage was put out of gear and so the carriage stopped. The spindles still went on turning, giving more twist and so shortening the length of yarn which was being spun ; while this was going on the carriage received a slight receding motion to the left in order to avoid strain on the yarn. M. 4032.

28. ORIGINAL WRAP REEL. Received 1860.

This is a measuring appliance, invented and made by Sir Richard Arkwright, for winding yarn into hanks of measured length and convenient for packing. As yarn is sold by weight the price depends largely upon the number of hanks that go to the pound—a quantity known as the " count " of the yarn (*see* p. 10)—and for determining the count this wrap reel is also most convenient.

The reel consists of a six-armed star turning on a horizontal axis and rotated by a winch handle. From the axis reducing gearing transmits motion to an index moving over a horizontal circular dial, the reading on which indicates the length wound on.

One revolution of the reel winds on 1·5 yd. of yarn and moves the index through $\frac{1}{560}$th of the circle. The dial is divided into seven equal parts so that one division represents 80 turns of the reel or 120 yd., which makes one " lea " or " wrap." Seven " wraps " make one " hank " or 840 yd., a quantity represented by the index having moved once round the dial.

When reeling to find the count of the yarn, one wrap is wound off and weighed. As there are 7,000 gr. in a pound and seven wraps in a hank, the number or count of the yarn is obtained by dividing 1,000 by the weight of the measured wrap in grains. Inv. 1860–2. 21,219, L.S.

29. MODEL OF DRAWING AND LAPPING MACHINE. (Scale 1 : 5.) Contributed by R. Bodmer, Esq., 1857.

This is a model of J. G. Bodmer's machine, patented in 1824, for treating the cotton after it has been scutched and formed into a lap ; the leading idea of his process was to keep the slivers in the form of lap as long as possible before placing on bobbins.

In this machine two laps are unrolled side by side and pass together through three pairs of drawing rollers, the last pair of which moves at about 12 times the linear speed of the first ; then through a pair of pressing rollers which deliver it upon a travelling band. Upon this band are also delivered the slivers from 11 other heads, and the lot passes to a conductor along which it travels to the lap-forming attachment, which is in duplicate. This conductor is pivoted near the end of the travelling band, and when a lap is completed at one side of the lap machine the conductor is slewed round so that it delivers the slivers to the other side ; then the completed lap is removed, so that the running is continuous.

The last set of rollers, through which each sliver passes before it reaches the travelling band, is placed obliquely so that each sliver as it comes off is delivered upon the band parallel with the others, without overlapping. M.9.

30. MODEL OF DRAWING FRAME. Contributed by R. Bodmer, Esq., 1857.

This model represents a form of stretching or drawing machine included in J. G. Bodmer's patent of 1824.

The lap, which has been prepared in the form of a roll by his lap machine (No. 29), is placed upon two horizontal rollers, which, revolving in the same direction, rotate the lap at a uniform linear speed, and unwind it. The several slivers of the lap are passed together through drawing rollers, by which their length is increased from 12 to 15 times ; each passes through a separate hole in a horizontal guiding rail, and they are then wound together into a fresh lap or roll.

As the extension greatly reduces the diameter of the slivers, they cannot form, after drawing, a lap of the original width ; so, to close them together uniformly, the final lap is wound on a horizontal axis at right angles to that of the drawing rollers, an intermediate directing roller dividing the 90 deg. unequally. The guiding rail is reciprocated longitudinally by a double-grooved cylindrical cam, and to permit of the adjustment of the inclination of the directing roller it is driven by a universal joint.

Mr. Bodmer intended to place 25 of these heads in one machine and to wind up the 200 slivers so treated in one roll, which was then to be sent on to the throstles or mules. To give strength to the roll, he wound in with the lap a cloth of equal width. Inv. 1857–102

31. DRAWING ROLLERS. Contributed by Evan Leigh, Esq., 1858.

These are special constructions of leather-covered rollers for drawing cotton or other fibrous material, as patented by Messrs E. and G. P. Leigh in 1856–57. Instead of allowing the rollers to turn on pivots, as before, they are made hollow and turn on a fixed spindle ; while, in order to lubricate the bearings, the ends of the spindle are turned down so that the oil used shall gravitate to the larger portion, where it is required, without escaping at the ends and on to the rollers. Inv. 1858–21.

32. DOUBLING FRAME. Presented by Sir T. Bazley, Bart., 1858.

This is a machine for doubling cotton yarn to form thread for sewing or other purposes. It is similar to a throstle spinning frame, but is without drawing rollers, and is arranged for spinning two yarns into one thread.

The cops containing the yarn are placed in the creel along the centre of the frame, and the yarn for each spindle is led down underneath a glass rod in a trough of water, and between a pair of brass rollers, to a flier fixed at the top of the vertical spindle. From the flier it passes to a bobbin loose upon the spindle, and as the flier rotates it twists the two yarns together, and at the same time winds them on to the bobbin. As the rollers do not feed out the yarn as fast as the flier would wind it on a fixed bobbin, the difference is made up by the bobbin slipping round under the pull of the yarn. The bobbins rest upon a rail which is raised and lowered by heart cams placed below the machine, so winding the thread uniformly on the whole length of each bobbin.

A feature of this machine is the extent to which frictional driving is employed. From the main central shaft two parallel shafts are driven by leather-covered pulleys, and each of these shafts has on it 24 metal discs or friction cones, each driving a leather-covered conical pulley, formed on the base of a flier spindle, no cords or belts being used. The rollers are, however, connected by positive gearing with the driving shaft. Inv. 1858–4.

33. RING-SPINNING FRAME. Presented by Messrs. Dobson & Barlow, 1894.

This is a shortened example of a double-geared modern ring frame. It has 48 spindles, but in the complete frame, as used in a cotton factory, there would be about 400 spindles. This machine is designed to spin cotton yarns up to 60's, *i.e.*, yarns of which 60 hanks, of 840 yds. each, would weigh one pound. The cotton is brought from the roving-frame in the form of roving wound upon bobbins, which are placed in the creel of the ring frame.

From the three pairs of rollers, which have drawn it finer, the yarn passes through an eye, placed over the centre of a spindle, and is then threaded through the traveller, which is a bent piece of steel wire holding loosely to the rim of a horizontal ring fixed in the traverse rail. The axis of each spindle passes accurately through the centre of each ring, and the front pair of drawing rollers is placed at such an angle that the yarn may be free from the nip of the rollers to the travellers, thus allowing twist to be put into the whole length. The bobbin is fixed to and turns with the spindle, and by its rotation carries the traveller round with it. The friction of the traveller upon the ring, however, impedes its motion, so causing the yarn to be wound upon the bobbin, while giving it sufficient tension to wind on tightly, and one turn of twist is put into the yarn for every revolution of the traveller.

The traverse rail, which holds the rings, is raised and lowered by lifting pillars, which derive a vertical motion from a heart cam and shaper, connected by chains with levers beneath the frame. The rail is balanced by counter-weights, so that it is easily moved up or down. The main chain of the lifting or traverse rail is gradually drawn in, so raising the mean position of the rail as each conical layer forming the cop is added, but the copping traverse remains constant, and continues to form cones on the bobbin until it is full.

The spindles which carry the bobbins are driven at about 8,000 revs. per min. by cotton bands working on small pulleys on the spindles, from two tin drums which run the length of the frame underneath. The rings are made of steel or case-hardened iron, highly polished. The plates, supported by hinges from the rail which carries the rollers, are called anti-balloon plates, and are for the purpose of preventing the yarn of adjacent spindles from diverging sufficiently to come into contact. Short fibres accumulate upon the travellers while working, and unless removed would cause increased drag upon the yarn, which would ultimately break. To clean the travellers, short pieces of iron flattened at the ends are fixed into the ring rail, so as just to clear the traveller as it flies round, while scraping from it any adhering fibre.

To prevent grooving of the drawing rollers, the roving is guided to different parts of their length by the following arrangement. The top back roller terminates in a worm, which gears into a wheel containing an eccentric, and this gives a reciprocating motion to a bar having vertical slots, through which the roving passes to the rollers.

A worm on the end of one of the front rollers works a counting apparatus which registers the length of yarn delivered by the front pair of rollers.

Messrs. Dobson & Barlow about 1894 made a ring frame which spun cops upon the bare spindles, instead of on bobbins as in this machine, and 80's yarn was spun in this way. The improvement consisted chiefly in the construction of the traveller, which was much longer than the ordinary form and differently balanced; both forms are here shown for comparison. M. 2676. 31,142, L.S.

34. DIFFERENTIAL GEARING FOR SPINNING MACHINERY. Presented by Messrs. Dobson & Barlow, 1896.

This is an example of a modern arrangement of gearing for correcting the motion of the bobbins in textile machinery, so as to neutralise the effect of the growing diameter of the bobbin as it fills.

In this construction the main driving power is received by the central shaft, to which in the model a hand wheel is attached. This shaft moves with the fliers, and also carries a reversed-cone arrangement, through which some motion can be transmitted to the central sleeve. The large spur wheel at the end drives the bobbins, and its motion is a combination of that received from the central shaft and that from the central sleeve.

On the driving shaft is secured a bevel wheel of 32 teeth, and on the sleeve that drives the bobbins one of 36 teeth. Between these two wheels is a spherical surface supporting a double-face bevel wheel, with 36 teeth on each face. The edge of this wheel extends outward as a flange which rests against a cam or swash-plate connected with the central sleeve. As the swash-plate revolves it rocks the ring on the spherical centre, causing it to gear with the two facing bevel wheels, so giving a mechanical ratio of 36 : 32. If the central sleeve is stationary, the bobbin wheel revolves at 0·8 of the speed of the driving axle, while if the sleeve also revolves it adds 0·1 of its speed to that of the driver; if it revolves in the reverse direction it deducts this amount. By a belt moved along the reversed-cone pulleys the amount of adjusting motion introduced through the central sleeve is accurately controlled. M. 2930.

35. BOBBINS FOR COTTON SPINNING. Presented by Messrs. Wilson Brothers Bobbin Co., Ltd., 1909. Plate II., No. 3.

In the manufacture of cotton, as soon as the spinning processes are reached bobbins come into use to hold the material while undergoing treatment. Their number and variety is consequently very great so that first cost is important, while wear and tear are such as to require close attention to design and construction.

The bobbins shown are typical, and are arranged in the sequence of the processes in which they are employed; in most cases full and empty bobbins are shown, together with sectional drawings to elucidate the construction, details of which were patented between 1880 and 1904 by members of the firm and others.

1 and 6. *Slubbing Tubes.*—These—the first and largest bobbins employed—are used in drawing and slightly twisting the sliver. No. 1, long collar, is 10 in. lift by 1·5 in. diam. The end of the tube is strengthened by a metal shield beaded on and with serrations in it. The wooden "skewer" or spindle on which the bobbin revolves is also shown.

2 and 7. *Intermediate Tubes.*—These and the next are used in further drawing and twisting the sliver. No. 2 is 8 in. lift by 1·3 in. diam.

3, 5 and 8. *Roving Tubes.*—No. 3, long collar, is 7 in. lift by 1·25 in. diam. No. 5, the skewer for No. 3, is fitted with "grip" ring and renewable tip. No. 4, short collar, is 7 in. lift by 1 in. diam. The skewer for this is shown.

9 and 10. *Warping or Winding Bobbins.*—The yarn at this stage is practically finished. No. 9 is fitted with steel binders and steel-plated bush. No. 10 has steel tires and bush; it is 5 in. lift, 1·5 in. diam. barrel, and 3·5 in. head.

11 and 12. *Cross-winding Tubes.*—No. 12 is 6 in. long by 1 in. diam.

13 and 14. *Taper-winding Bobbins.*—No. 13 is 8 in. lift by 4 in. head, with steel tire and "grip" brass cap.

15 to 17. *Ring Doubler Bobbins.*—No. 15 is enamelled to resist moisture, and is 5 in. lift by 1·75 in. diam., with metal "holdfast" drawer shield and "grip" cap. No. 17 has the same lift but 2 in. diam., and has the "Rex" driver shield "grip," metal rim and cap.

18. "*Wadia*" *Pirn.*—7 in. lift, fitted with beaded brass shield.

19 and 20. *Ring Twist Bobbins.*—No. 19 is 5 in. lift; No. 20 is 6 in. lift, with improved brass shield.

21 and 22. *Ring Weft Pirn.*—No. 21 is 5·87 in. long; No. 22 is 7·75 in. long, with duplex brass shield.

23 and 24. *Shuttle Pirns.*—No. 24 is fitted with brass shield and corrugated brass tip. M. 3592.

36. MODEL OF SELF-ACTING MULE. (Scale 1 : 4.) Woodcroft Bequest, 1903. Plate II., No. 4.

This is a model of a mule for cotton spinning, patented in 1839 by James Smith, of Deanston. The machine was a rival of Roberts's self-acting mule, and this model was made when Smith unsuccessfully attempted to obtain an extension of his patent.

The driving wheels and pulleys, together with the mechanisms by which the various operations are performed, are contained in the head-stock, which is arranged parallel to the "race road." Upon this track a carriage holding the spindles traverses backwards and forwards, and while so doing draws and twists the yarn. At one end of the track is the beam, a transverse fixed frame holding the creels in which the bobbins are placed, and also the rollers through which the rovings from the bobbins are delivered for spinning.

When the carriage is in near the beam, the rollers are set going and the spindles rotated rapidly, the yarn leading off the end of each spindle being thereby twisted; the carriage meanwhile moves outwards slowly, gaining slightly upon the rollers and so extending the yarn, and when it has reached the end of the stretch it is stopped. The spindles, however, still continue to rotate and further twist the yarn, the carriage moving very slightly backward to keep the tension constant, as the twisting of the yarn shortens the threads. When enough twist has been put into the yarn the spindles are stopped, and a stripper moves up and takes off the few coils of yarn round the end of each spindle. The carriage now begins to move quickly back to wind in the finished yarn, and the upper faller wire comes down and guides the yarn to the spindle, so that it shall be wound into a cop by the superposition of conical layers upon the cop-bottom, formed at first by special movements of the faller wire.

The running in and out of the carriage is performed by a long rack attached to it, and supported in guides on the headstock. This rack is driven by a spur-wheel on the headstock, and the reversal of the motion is obtained by a mangle-wheel gear. A pair of large spiral wheels introduced in the train gives the variation of velocity necessary for quickly starting and stopping the carriage, while the slight motion of the carriage inward required when the extended yarn is being finally twisted is obtained from the motion of the mangle pinion when moving radially from external to internal gear. The difference between the diameters of the internal and external gears gives the much higher speed required by the carriage when winding in, compared with that while drawing.

The whole of the spindle and carriage motions are derived from two crossed belts, running uniformly, but each shifted during the cycle. The upper belt drives the carriage and rollers, and also the spindles during the winding in, but the power to the spindles is transmitted through a three-spur wheel differential gear. One of these wheels has a **V** rim, in which rests a brake rope under constant tension, and when the power transmitted exceeds this tension the wheel slips round idly and the speed of the spindles is reduced by this lost motion. In this way the variable velocity required by the spindles while winding on is obtained, the gear slipping when the tension on the yarn rises above the normal amount, through attempting to wind on faster than the motion of the carriage allows.

The lower belt runs at a higher speed, and when on its fast pulley drives the spindles while the twist is being put into the yarn. The spindles are rotated by quarter-twist belts, from a drum extending the whole width of the carriage, and driven by an endless rope that passes round pulleys at the extremities of the headstock. The cop-builder receives its motion partly from a travelling wheel of the carriage and partly from a roller that comes in contact with an incline fixed to the floor. The feed rollers are driven from the headstock by a claw clutch, which, by a lever worked by a cam, is only in gear while the carriage is running out.

In modern mules the mechanism employed differs considerably from that in this model, and the front rollers are always arranged as drawing rollers.

M. 1775. 21,045–6,L.S.

37. MODEL OF MULE HEADSTOCK. (Scale 1 : 4.) Presented by H. Brierly, Esq., 1871.

This is a model of a headstock in which several of the mechanisms patented by James Potter in 1836 are introduced. The general mode of action of the mule to which this headstock belongs is similar to that of other spinning mules, and it is described in the adjacent model of a complete mule, No. 36.

The distinctive features of the headstock are : the vertical arrangement with the intention of saving floor space ; the use of a " spiral drum and hyperbolic screw " for regulating the speed of the spindles while winding on ; the employment of a revolving crank motion for taking in the carriage, and the use of a sector rack with a varying stop, for effecting the operation of backing off. The model is not complete, but shows the leading peculiarities of Potter's arrangements.

The varying velocity of rotation required by the spindles, while winding on and building up the cop, is obtained from a conical spiral drum, made of sheet metal. Within it was to have been a nut, which could be screwed along axially, and that carried one end of the chain which, after passing round the drum, is connected with the spindle driving gear by the usual endless rope. The drum is driven uniformly by bevel gearing during the winding-in of the carriage ; and when forming the cop-bottom the drum chain is at the large end of the drum, so receiving its maximum motion with a moderate variation in velocity but, as the spindles fill, the drum chain is slowly advanced towards the other end of the drum, where the mean speed is less and the variations greater ; when the end is reached the nut ceases to travel, so that the cop, after this, is completed in a series of similar conical layers. The winding-on gear is driven through a clutch at the top of the headstock, and when this clutch is released the chain is unwound from the drum by a weight ready for the next winding on.

For the backing-off motion this clutch is put into gear with a sector rack and cam, the varying amount of backing off required while building the cop being provided for by a vertical rod raised by a cam, so as to limit the motion of the rack. The motion of the carriage is given by a band on the pulley on the lowest shaft, which is reversed for the in-and-out movements. When the carriage is running in, this shaft is driven by a chain attached to an overhanging crank arm, which is slotted concentrically and rotated by a stud playing in the slot. When the crank has reached its highest position its weight causes it to swing round in advance of the stud, so leaving the carriage free to commence its outward motion, which is obtained from gearing connected with the drawing rollers.

M. 1224. 20,514.,L.S.

38. COTTON-BALL WINDING MACHINE. Presented by Lady Hawes, 1858.

This is a small example of the machine invented in 1802 by Sir M. I. Brunel for winding cotton thread into balls. Cotton and flax thread at that time were sold in skeins, but the convenience of the balls turned out by this machine had an important influence in increasing the demand for cotton sewing thread. The first of these winders was used at Mr. Strutt's mills at Belper.

The model consists of a flier on a horizontal axis, through the centre of which the cotton is introduced. The motion of the flier winds the cotton round a revolving spindle set at an angle, a coil being put on the spindle at each revolution, but the position of the coil or ring changes with each turn. The angle at which the spindle is set can be altered by hand and in this way the shape of the ball produced can be greatly modified. Universal joints and a sliding hollow shaft communicate a slow motion from worm gearing to the inclined spindle, and a band from a grooved pulley gives a high speed to the flier.

Inv. 1858–20. 20,503, L.S.

39. WINDING OR SPOOLING FRAME. Presented by Messrs. Robert Broadbent & Son, 1901.

This is a short length only of the machine used for winding yarn from cops into large spools, of either cylindrical or conical shape, ready for use in doubling or in knitting machines. The example represented embodies several inventions patented by Mr. R. Broadbent between 1886 and 1893, and is usually arranged for winding 20 cylindrical spools along one side, and 20 conical ones along the other, with the driving pulley at one end and the special mechanism at mid length, as shown in the attached photographs of a complete frame. If the spools are being prepared for treatment in a doubling frame the yarn from several cops is simultaneously being wound on a spool, but if for knitting the yarn is wound singly.

The cops are placed on vertical skewers in front of the machine, and the yarn from them passes through wire eyes and over an angularly adjustable blanket-covered rail, by which the winding tension can be controlled; it then passes through detector wires, by which the winding of the spool is stopped should any of its yarn break, and is wound on its spool at a constant peripheral speed owing to the spool resting on a revolving drum which drives it by contact. In the conical winder the driving surface is conical, as is also the central core of the spool.

As the spools are formed on cores without flanges, the requisite cohesion is obtained by winding the yarn in reversed helices of large pitch, obtained by the motion of a traverse bar driven by a crank whose arm is varied by the action of a fixed pointed oval groove or cam which gives uniform winding and a rapid reversal at each end of its travel. The winding drums or cones are driven by ropes from a continous central shaft, while the detector wires are so arranged that should any yarn break its wire drops and comes into contact with a revolving wiper, by which the corresponding spool is lifted off its drum and its motion promptly arrested by a stop on its centre. M. 3199.

LINEN MANUFACTURE.

40. HECKLES FOR FLAX. Presented by C. E. Cowper, Esq., 1897.

The first process in obtaining a linen yarn from the flax plant consists in soaking the stalks in water for about three weeks to dissolve the adhering material that binds the long fibres together. After drying, the stalks are passed between fluted rolls which crimp them and so loosen the contained pithy matter; they are then hung vertically and beaten with a wooden blade till the waste material is removed.

The prepared flax is now ready for the heckling process, by which the long fibres are separated and straightened, while the coarse ones are split so as to secure greater uniformity, and the short fibres and some impurities, constituting together about one-half of the total quantity, are removed.

Heckling by hand is performed by taking a bunch of prepared flax and whipping it down upon the upstanding teeth of a fixed comb, drawing it through them repeatedly, and then reversing the bunch or strick, so as to treat the other end.

The heckles shown are of French make, and are to be secured on a horizontal bench, when the teeth will slope away from the operator at an angle of 70 deg.

with the horizontal. There are 32 long tapered teeth in each of the three rows, the length giving great flexibility, and they are secured in two stout plates of horn which also prevent the wooden base from splitting. At the back of the bench is a sloping board (not shown) by which the flax is confined to the upper extremities of the teeth.

The long flax, or line, is by this treatment left in a fit state for hand spinning, while the short fibres removed are afterwards worked up into an inferior linen yarn. M. 2978.

41. YARN TESTING MACHINE. Lent by Messrs. Cook & Co., 1905.

This is a machine, patented in 1902 by Mr. J. B. Moscrop, for automatically testing and recording the strength and regularity of yarn or thread. Successive lengths of the material are taken, held by grips at each end, and stretched until they break, the breaking strength being recorded by needle pricks on a strip of paper. This method is superior to that in which a number of turns of yarn are tested at once, because in that case the average result may differ from the actual strength.

The machine consists of a framework having at one end a row of horizontal grips attached by springs for measuring the tension. Opposite to these is a carriage having a similar set of grips, and the cops of yarn to be tested; this moves inward to carry the yarn to the fixed grips and then runs back to stretch it. The carriage is traversed by the upper end of a slotted lever pivoted at its lower end, and the slot engages with a crank pin fixed to a shaft driven by spur gearing from a belt shaft supported on the frame. This gives a quicker motion to the carriage on the inward stroke.

On the same crank shaft is a cam which raises one end of a weighted lever, the other end of which actuates the fixed grips and pricking mechanism. The fixed grips each consist of a pair of jaws pressed together by plate springs, and opened by the partial rotation of a flattened pin passing through a slot between them. The lower end of the pin carries a crosspiece having turned-up ends with inclined top edges; above the jaws is fixed a flat spring having at its free end corresponding inclines which, when depressed by studs fixed to a cross bar pulled down by the cam lever, turn the pins and spread the jaws. The grips are each mounted on a long slotted plate resting on anti-friction rollers, and are attached by adjustable helical springs to the end of the main frame. Above the grips is mounted a frame pivoted at the rear end, and held up by springs; this carries a pair of bars over each grip-plate, along which slide carriers holding vertical needles. When the yarns are pulled the needles are moved forward by the grips, but when they break the grips fly back, leaving the needles behind. The needle frame is depressed by the same bar that opens the grips, by means of bell-crank levers which, after moving a certain distance, are released through their free ends coming into contact with stops, thus causing the needles to rise rapidly while the bar goes on descending. After the records are made, the needles are returned to their normal position by a bar, which is moved back by the carriage, and restored by springs. Below the needles a padded table is arranged upon which the recording paper is clamped; this is moved transversely after each test by a screw rotated by a ratchet, which is moved by the carriage when it reaches the end of its inward stroke. The table, at the end of its traverse, throws out a clutch on the driving pulley and stops the machine. When the grips are open to receive the new lengths of yarn, strippers pass between them to remove the broken ends, which fall into a tray below; these are also actuated by a lever and spring bar moved by the carriage. The travelling carriage runs on four flanged wheels along the top edges of the frame, which partly incline downward toward the fixed grips. At the front of it a corresponding number of grips are arranged, similar to the fixed ones, but with their jaws placed vertically. The spreading of the jaws is performed by oval pins, to which are attached arms projecting downward from behind; the arms engage with notches in a cross bar, which slides transversely through holes in the carriage sides and is pushed from side to side by its projecting ends coming into contact with fixed stops. A notch in the bar engages with the frame and prevents it from springing back, or the jaws from closing, until the carriage reaches the closing stop. The cops are arranged on horizontal spindles at the back of the carriage, and the yarn passes round wire guides before reaching the grips. In order that the yarn may be placed in the fixed grips, the end portion of it is raised to a vertical position by a notched and perforated plate attached to the carriage normally lying flat under the yarn, but raised up at the end of the inward stroke by levers attached to it. The inclination of the rails lowers the carriage, and allows the orifices in the plate to pass over the fixed grips, and thus carry the yarn between their jaws.

The sequence of operations is repeated until the necessary number of 12 in. lengths of yarn have been tested, the successive tests being recorded side by side on the paper, and forming a diagram showing the strength and regularity of the yarn. The paper shown is arranged for 80 tests, after which the machine is automatically stopped. M. 3408. 30,890, L.S.

42. TEXTILE SCALES. Presented by the Torsion Balance Co., 1915.

These scales are for finding the weight of cloth, expressed in both the English and the metric systems.

The feature of the construction is that in place of ordinary knife edges there are three taut steel tapes. In the original form, patented in 1882 by Mr. F. A. Roeder, steel wire was used. The tapes are stretched over frames, one of which is rigidly fixed to the base plate and forms the fulcrum, while the other two connect the ends of the two beam members, so that any displacement, due to a weight on one scale, causes twisting of the tapes. Adjustable poises are mounted on the beam, and these partly neutralise the torsional resistance, and so increase the sensitiveness of the scales.

The scales shown are a modification without loose weights. First the scales are brought to zero by the weight at the left. A sample 2 in. square, cut from the cloth to be tested by the punch and mallet shown, is then placed with its right-hand edge at the graduation on the carrier that corresponds with its woven width. The scales are then again brought to zero by sliding the weight on the graduated beam and the weight in oz. per yd. or gram. per metre, to an accuracy of 0·2 oz. or 5 gram., can be read off. Inv. 1915–45.

WOOLLEN MANUFACTURE.

Wool is a fibrous growth of the nature of hair, but different in its structure. Each fibre is about 0.001 in. diam., and is covered with minute scales in rings which overlap one another like those of a fir cone. There are sometimes nearly 3,000 of these rings to the inch. It is due to the roughness caused by the scales, assisted by the curled form that the fibres assume when heated, that woollen materials can be made to give so close a texture, as in milled and felted goods. The working of wool into a textile fabric has for centuries been one of the staple industries of this country, but until within comparatively recent years the wool was washed, combed, and spun by hand and then woven into cloth on a hand loom. With the exception of the original shearing and the sorting processes, all of the manufacturing is now done by machinery, and the processes followed in many respects resemble those of the cotton industry. A series of labelled specimens (*see* No. 45) shows the wool during various stages in its manufacture, and will assist in explaining the action of the successive machines, some of which are not at present represented.

Raw Grease Wool.—This is the term applied to the wool as it is taken from the sheep. Such wool differs greatly, even in the same fleece, and it is consequently sorted and classified by hand, according to its fineness. Most wool is white, the dirty colour of grease wool being due to impurities, chiefly greasy matter secreted by the skin and dirt that this accumulates, the impurities making about one-half of the weight of the grease wool.

Scouring.—Some of the dirt is frequently removed by passing the wool through a form of "devil" that knocks the material about, so loosening the dust, which then escapes through the netted sides of the machine. Where the sheep are washed before being shorn, the wool is cleaner, and is at once scoured, this being the general practice.

Scouring is a gentle washing in hot alkaline water, which removes the grease and dust; the former is afterwards extracted from the soapy solution by sulphuric acid. The scouring is performed in long hot-water tanks, or bowls, with double bottoms, the upper one being perforated so that the dirt may pass through it and settle. The wool is dragged through the water by mechanically moved forks, which at the delivery end lift the wool on to an apron, where a squeezing roller expels much of the water. The wool then falls into a similar tank for a final scouring in cleaner water. It is then conveyed to a heated drying chamber, through which it slowly travels, at the same time being exposed to a draught of hot air propelled by a fan. (*See* Nos. 43 and 44.)

The wool having now lost its natural grease is harsh, and the fibres do not adhere, so before further working it is usually found necessary to add oil, about two gallons of olive oil are used for 120 lb. of wool, the oil being sprayed on by a revolving brush as the wool travels along on a feed sheet.

The different kinds of wool are now blended, and thoroughly mixed and disintegrated by being passed through a machine called a "fearnought" that somewhat resembles a carding engine. It has a large cylinder revolving quickly, and three pairs of small rollers working close to it. Each of the cylinders is covered with teeth, and the wool, which is carried on by a travelling apron, is taken in by a small feed roller, passed through the series of workers and strippers, and is then drawn off by a fan.

Carding.—This process, when employed in the preparation of wool, is usually performed in a series of three carding engines, called respectively the scribbler, intermediate, and carder, the reason being that the carding process has to deliver the material as sliver ready for spinning, without combing or drawing. After carding, the breaking up of the lap is performed by a condenser, which is a machine with card-covered cylinders with the card clothing arranged in rings, leaving spaces between equal to the width of the rings. The ribbons which these rings strip from the doffers pass through a pair of rubbers, which press or round them into slivers ready for the mule frame.

Wool is, however, worked into two entirely different yarns, known as worsted yarn and woollen yarn. In worsted yarn the fibres are all long, and are arranged nearly parallel, so giving the material a smooth surface. In woollen yarn the fibres are of various lengths, and lie in al directions with many loose ends projecting, so giving the yarn a rough surface. This irregular surface of the woollen yarn is of great importance, as cloth woven from it will, when felted or milled, present a smooth and even surface, concealing the individual threads, owing to the interlacing of the adjacent fibres during the milling process. This three-stage carding and condensing practice is followed in preparing woollen yarn, everything being done to prevent drawing or any parallel arrangement of the fibres.

For worsted yarns carding is not much used, as the long fibres may be broken by the cards. A better result is obtained by cleaning and separating the fibres in screw gill-boxes. This process, known as "preparing," consists in feeding the wool by rollers into one end of a gill-box and drawing it out at about three times the speed by rollers at the other end, the wool between the two rollers being gently combed by spiked rods that travel at an intermediate speed. These rods are called fallers, and are driven by endless screws. On reaching the end of the travel, each faller drops down upon similar but reversed screws that return it. Five or six of these gill-boxes are used in preparing, the wool passing through the first three as a lap and through the others as sliver, six slivers being united or doubled by each of the succeeding boxes so as to secure uniformity as well as gradual straightening.

Combing.—Just as in cotton manufacture, the object of this operation is the removal of the short fibres from the carded lap. The three machines most common are the Lister, or nip; the Noble, or circular; and the Holden, or square-motion machine. They all act by pulling the wool through teeth, but without separating it, and then delivering it as sliver for winding into rolls or upon bobbins for drawing. The noils, or short wool, are at the same time being continuously cleaned from the teeth and deposited in cans.

Drawing.—In order to prepare fine roving for the spinning frame the sliver from the combing machines is successively drawn by rollers in six or nine different drawing frames. Six ribbons would be combined in the first machine, six in the second, five in the third, four in the fourth, four in the fifth, and two in the roving frame. In all the wool is thus doubled 5,760 times. In each machine there are two pairs of rollers, of which the front pair revolves more quickly than the back pair, and thus a drawing action goes on, the sliver getting thinner as it goes from one machine to the next. There are two kinds of drawing machines used in England, which differ chiefly in the method of controlling the motion of the bobbin. The open drawing machine gives no positive motion to the bobbin, but the thread pulls it round against the frictional resistance of a disc of leather placed between the lifting rail and the lower flange of the bobbin. In the cone drawing machine the bobbin is driven through a pair of conical drums, which adapt the speed to the varying diameter of the bobbin. The wool from the last drawing box is called slubbing (*see* No. 45)

Roving.—This process is a continuation of the preceding drawing process, but in winding in a twist of about one turn per inch is given, and the yarns from two bobbins from the last drawing box are drawn and twisted into a single roving.

Spinning.—Worsted yarn, which has been through the process known as French drawing, in which no twist is put in, is spun finally in the mule frame, a cop being formed by winding the yarn on the spindle. Other methods of spinning are by the bobbin and flier, the cap, and the ring frame. The first of these is the ordinary throstle frame; it is used for spinning thick and medium worsted yarns, the spindles being run at 3,000 rev. per min. The cap frame contains fixed spindles, a cap outside each bobbin resting on the spindle, and a tube inside each bobbin which turns with the bobbin. This frame can be run at about twice the speed of the throstle and is suitable for spinning fine worsted yarns. The ring frame is similar to that which is used for cotton spinning. It produces the same kind of yarn as the throstle, which it is fast superseding, as in cotton spinning. Cops of yarn for weft and warp on the paper tubes on which they have been spun, and samples of double yarn are shown. They have been formed by the combination of two or more threads of yarn in a ring or throstle frame.

Wool which has been scoured is usually white, and the whiter it is the better, but some kinds of East Indian, Egyptian, and Spanish wool are coloured gray or brown naturally. The natural colours of yarns obtained by careful selection are permanent.

43. MODEL OF McNAUGHT'S WOOL-WASHING MACHINE. (Scale 1 : 8.) Presented by Messrs. J. and W. McNaught, 1914.

The machine represented by this model is one of a series of four through which the wool is passed in order to separate from it the impurities which consist of Yolk, or wool fat, Suint, or sheep's perspiration, and dirt. Yolk is insoluble in water and does not form soluble soaps with alkalies, but it emulsifies, and the washing process is based on this property.

An inner tank with a perforated bottom is fixed inside a large tank. The inner tank holds the wool, which is propelled and agitated by a number of bars of brass prongs fixed to two long tubes which are lowered into the sud and then moved forward a short distance by means of cranks, cams, and levers. The forks at the delivery end of the machine are shortened and carry the wool over a chute and between rollers on to an apron which transfers it to the second machine in the series, and so on. The first machine has a bowl, or tank, 30 ft. long, the second 24 ft. long, the third 18 ft. long, and the fourth 12 ft. long.

The liquor in the washing bowls consists of water heated up to a temperature of about 120 deg. F., with soap and sodium or potassium carbonate; but the fourth bowl usually contains hot water only, to rinse the wool. The fats rise to the top and are carried at the delivery end into a third or settling tank, from which they are flushed and from which the liquor is pumped from a point near the middle of this tank back into the washing bowl. The dirt falls through the perforations of the inner tank and is collected from one side of the bottom of the outer bowl, which is inclined.

The propelling forks make from 15 to 18 strokes per minute and the delivery rollers make 8 revolutions per minute. 1,000 to 1,200 lb. of greasy wool per hour can be dealt with by a set of four bowls with an expenditure of 10 h.p.

A sectional drawing of the machine is exhibited near the model.

Inv. 1914–751. S.M. 584, L.S.

44. MODEL OF McNAUGHT'S WOOL-DRYING MACHINE. (Scale 1 : 4.) Presented by Messrs J. and W. McNaught, 1914.

This model represents part of a machine, usually consisting of seven compartments, which dries the wool, previously washed, by volumes of dry warm air which are passed continuously through the wool.

The wet washed wool is fed on to the travelling feed apron of the machine from the washing machine, and enters the first compartment through a pair of rollers and is carried forward over a specially shaped plate or bridge by an upward current of air set in motion by a fan which runs at 1,350 revolutions per minute and heated by steam in a tubular heater. The damp air passes out of the compartment through a perforated plate at the top. Short fibre, small particles of dirt, and fine kemps, blown through the perforations, collect on the upper surface of the plate and are removed by hand. From the last three or four compartments the hot air, which now contains little moisture, is collected and taken back into the fan chamber. The temperature in the compartments can be varied to suit different kinds of wool by means of a slide valve which regulates the amount of air admitted.

Drying is effected in from 1½ to 3½ minutes, and the output of the machine is about 400 lb. per hour.

A framed diagram which is exhibited near this model shews how the machine works. Inv. 1914–752. S.M. 581, L.S.

45. SPECIMENS OF WOOL, SHOWING STAGES IN THE MANUFACTURE. Presented by Messrs. W. Holland & Sons, 1890.

These commence with wool as taken from the sheep, and show the material after it has undergone each of the successive operations of scouring, carding, combing, drawing, and spinning. The shades obtainable by blending the various colours of natural undyed wool are also indicated. M. 2318.

46. MODEL OF HEILMANN'S WOOL-COMBING MACHINE. Contributed by J. Wilson, Esq., 1860. Plate II., No. 4.

This represents the combing machine invented by Josué Heilmann, of Mülhausen, for use in combing wool, cotton, or other fibrous substances, and patented by him in this country in 1846. The complete combing machine by Messrs. Dobson & Barlow, No. 19, is a development of Heilmann's invention, but constructed for treating cotton, while this model is arranged for combing material with a longer fibre, and was made to illustrate the patent specification.

The wool is fed in through a slot and passes first between the teeth of two fixed combs, and then between two blades which form a pair of nippers. The blades are fixed to levers moved on fixed centres by cams on the main shaft, so that at the proper time the nippers move down towards the main cylinder, upon which are rows of needle points forming combs. These combs take out the short fibres and foreign matter, while the nippers hold the long fibres, the cylinder turning continuously. After the combs on the cylinder follows a portion which is fluted, the nippers then open and a single comb below them is moved so that its teeth enter the wool from below, and carry it forward towards two rollers which are mounted upon an arm operated by a third cam. The upper roller is covered with leather and the lower one is fluted; the former, which is turned by contact with the fluted portion of the cylinder, takes up the long fibres which have been pushed along towards it; the lower roller at this time is not in contact with the cylinder. Then a part of the cylinder which is covered with leather comes round, and the lower roller is moved by the arm to which it is attached into contact with the cylinder, and, being in contact with the top roller also, turns the latter back a little way, and with it the fibres. The combs now coming round again, comb the other ends of the fibres, and when the next nip of wool is brought on by the reciprocating comb, the ends are laid over the ends of the former nip, which project from between the rollers, and a continuous sliver or sheet is formed.

The combs are cleared of short fibres by a bar between each pair; they fall on the surface of a roller which is not represented in the model. One of the rollers is turned by gearing and the other by friction, and their motion is reversed at each nip for the purpose of allowing the short fibres last taken out to be joined on to the preceding ones so as to deliver the combed waste wool as a continuous sheet. M. 738. 31,772, L.S.

47. MODEL OF HEILMANN'S WOOL-COMBING MACHINE. Contributed by J. Wilson, Esq., 1860.

This is an incomplete model of Heilmann's combing machine. It is intended to represent the same machine as No. 46, with a different arrangement for feeding the wool. It shows the combing drum and the detaching rollers.
M. 738A.

48. MODEL OF WOOL-COMBING MACHINE. Contributed by J. Wilson, Esq., 1860.

This is a sectional model of part of a machine for combing wool, patented by Messrs. Donisthorpe & Whitehead in 1849.

Before reaching this portion of the machine the material has been fed along by a travelling apron, pressed between two pairs of rollers, and carried forward at 50 or 60 times the speed of the first apron on a second apron, the one shown in the model. The wool now passes out between two brushes, and is taken hold of by a comb which projects through a gap in a rotating cylinder. On the cylinder there are four such combs, each fixed to the end of an arm centred at the other end on the boss of the rotating cylinder and having at its middle a roller which runs in a cam groove cut in a fixed plate. Four other combs are fixed to the outside of the cylinder, working in pairs with the first four. As a pair of combs comes round to a point opposite to the delivery rollers, the arm comb is leading and standing out from the cylinder, but the shape of the cam now makes it travel slower than the cylinder and allows it to take the wool gently from between the brushes. The comb fixed on the cylinder then overtakes it, combs the wool out, and carries it round to the opposite side. Here there is a travelling band, carrying combs that pass near enough to the cylinder for the combs on the band to loosen the wool in the teeth of the former comb. The band and the cylinder are moving in the same direction at this point, and the two combs hold the wool jointly and place it upon the teeth of a circular comb. A brush follows the cylinder comb, and, under the action of a cam plate, presses the fibres well into the teeth of the circular comb, which is revolving, and so carries the fibres round till they are seized by a pair of fluted rollers which draw them off and deliver the combed wool as a sliver. Each of the four combs acts in this way so as to give a continuous output. The arrangement for removing the short fibres from the combs is not shown in the model. M. 735A.

49. MODEL OF PORTION OF A "LISTER" WOOL-COMBING MACHINE. Contributed by J. Wilson, Esq., 1860.

This shows the arrangement, patented by Messrs. Lister and Donisthorpe in 1850, for holding or nipping the ends of woollen fibres while combing.

Before arriving at this part of the combing machine the wool has been fed in on a travelling apron, passed between fluted rollers and through a box of screw gills. The gills are combs that travel from end to end of a box, and draw out the fibres and straighten them by the action of their teeth. The nipping arrangement then takes hold of some of the fibres and carries them over till they are taken up by a revolving brush and transferred to combs on the edge of a large circular plate. By these combs the long fibres are taken hold of as the plate moves round, and further on the noils, or short fibres, are taken out.

The model shows a fluted cylinder with two blades, each of which is made to project as it comes to the endless band. To assist in taking hold of the fibres a guide plate, fixed to the end of an arm centred below, is moved slightly beneath the band by an eccentric from the main driving axis, but this is not shown in the model. M. 733A.

50. MODEL OF WOOL-COMBING MACHINE. Contributed by J. Wilson, Esq., 1866.

This represents the combing machine patented in 1859 by Mr. C. Whipple, of Providence, U.S.A.

The lap of wool is fed in at one end of the machine on an endless apron of leather. It then passes through a box of screw gills placed over a chest heated by steam, the heat softening the wool and assisting the action of the gills or combs. At the end of the gills there is an upper vertically-sliding blade and a lower fixed one, which act together as nippers. When a certain length of lap has been fed on, the upper blade is moved downward and holds the ends of the fibres. The small combing cylinder, which is mounted on swinging brackets, is then moved up from below; it turns and combs out the short fibres and then is moved down again. The combs of the screw gills and the screen combs in front of the nipper blades now move up and pass their teeth through the lap of wool. The movable blade is then raised and a second pair of nippers slide towards the first pair, take hold of the ends of long fibres, and then, moving back, they lay the fibres on the travelling sheet, which is covered with teeth. The combed wool is thus passed to the delivery rollers and out through a guiding funnel.

The short fibres, called noils, are collected from the revolving comb, when in its lowest position, by a revolving brush which in turn is cleared by a cylinder set with long teeth. From this the short fibres are removed by a comb which delivers them in the form of a lap or sheet. The nippers and teeth are also cleaned by brushes. M. 1015.

SILK MANUFACTURE.

Silk is a fibrous substance produced by the larvæ of many insects as a protective covering during the chrysalis stage, and in structure somewhat resembles the web of a spider. The silk fibre used in manufacture is, however, almost exclusively derived from the mulberry silk-moth (*Bombyx mori*). When the larva is fully mature it forms its cocoon by ejecting from a pair of glands in its head two filaments, each about 1,400 yards long, which stick together and form a single thread of two strands, but without twist. The diameter of the fibre is from 0·005 in. to 0·001 in., and its breaking strength is equivalent to over 20 tons per sq. in. Owing to the form and properties of this fibre the manufacture of silk is free from the complications seen in the preparation of cotton or wool.

Reeling.—When the caterpillar has completed its cocoon, which is learnt by rattling it, the larva is killed by heating to 70 to 90 deg. C., and the cocoons are placed in warm water to soften the gummy material. After removing the external flossy silk, the filaments from four or five cocoons are unwound and reeled up together into hanks, in which state the material is known as raw silk. The reeling appliances used are seen in No. 51.

Throwing.—This is a general term used to include the various processes of winding, twisting, doubling, and retwisting raw silk, by which a uniform thread of greater strength and bulk is obtained. The raw silk is dipped into warm water to soften the adhering gum, wound on skeleton reels, or swifts, and then upon bobbins by revolving fliers which give some twist, but very little, as twisting reduces the brilliancy and softness of the material. The finished thread is dyed and afterwards woven in power looms.

Spun Silk.—Floss silk, damaged cocoons, and similar materials were for many years treated as waste, but in 1857, Lord Masham, then Mr. S. C. Lister, of Manningham, discovered a method of converting it into thread by a series of processes resembling those employed in cotton manufacture. This material is known as spun silk, and its production has become a most important industry.

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51. SILK-REELING MACHINE. Received through Sir Thomas Wardle, 1882.

This is a complete machine of the type most generally used in the south of France and Italy.

The cocoons after sorting are placed for a few minutes in boiling water in order to remove the outer covering and to find the end of the filament. They are then transferred to the basin in the large tray, containing water that is maintained at a temperature of 85° C. to 90° C. by a steam pipe or a small stove. The ends of the filaments are collected to the hook in front of the tray, and detached in two threads of four or five filaments at a time. Each thread is passed through an agate or porcelain draw-plate in an arm attached to a standard fixed beside the basin. The two threads are crossed or twisted for the purpose of rounding them, and are then led by glass hooks to a reciprocating guide, by which they are distributed over the face of the reel. The reel is driven by hand through friction gearing, and has a friction brake for stopping it. M. 1788.

52. MODELS OF PORTIONS OF SILK MACHINERY. (Scale 1 : 2.) Transferred from the Tower of London, 1857.

These are the remains of the three models deposited in the Tower of London in 1741. Sir Thomas Lombe had introduced certain silk-working machinery into this country from Italy, and in 1718 had patented three of these machines, one to wind raw silk, another to spin it, and the third for twisting organzine silk. In 1719 he established a silk mill at Derby. In 1732 Parliament granted him 14,000*l*. in lieu of an extension of his patent, but required that models of his machines should be deposited for public reference. The portions shown are a reel, three spindles with bobbins and fliers, and a segment of a circular frame, but particulars have been preserved that make clear the construction of the throwing machine to which it evidently belonged.

Each spindle has a bobbin secured to it, and at its top runs loosely a double-ended flier by which the silk is led from the bobbin and delivered, with a certain amount of twist, to a reel or swift that was supported above. The spindles were arranged vertically, in 16 sets of six, forming a complete circle, and they were driven by frictional contact from a central driving wheel. The silk from each set of six bobbins was wound on to one swift; the swifts were driven by reducing gearing from the main shaft, and the whole mill was driven by water power. The model was half size, with a bobbin circle 6 ft. diam., the usual size being about 12 ft.

A drawing (scale 1 : 16) is attached showing plans and elevations of the silk-throwing machine as it would have appeared. A drawing of a hand-power throwing mill also shows that the general arrangement of this early machine is still followed. M. 351.

53. MODEL OF SILK-THROWING MACHINE. Presented by the Commissioners for the Exhibition of 1851.

This is a model of a portion of a machine for winding silk upon bobbins. On the vertical spindle runs a sleeve that carries a bobbin, and from the top of the spindle two flier arms, by which the silk threads are led on to the bobbin, extend downward. The bobbin and flier are driven independently by skew bevel gear, so that in winding on any desired amount of twist may be put into the thread. A modified form of spindle is also shown in which the bobbin is driven by a band pulley. A small cistern provided with wire guides is arranged above the model, so that probably this machine was intended to wind directly from cocoons on to bobbins. M. 651.

54. SILK-THROWING MACHINE. Presented by Thomas Dickins, Esq., 1873 Plate II., No. 5.

This machine has a vertical spindle which is driven by bevel friction wheels below and has on it a frame carrying two bobbins. On these have been wound the two threads that are to be twisted together, and the machine does the twisting while the threads are being unwound from the bobbins and wound together upon the single reel above. The frame rests upon a shoulder on the spindle, and revolves with it by friction. To stop the machine instantly, should either thread break, an automatic arrangement is fitted. The thread from each bobbin is drawn through an eye in a wire whose other end projects a little through a hole in the base of the revolving frame; should a thread break, the wire which it supported drops further through the frame, and so in revolving strikes an arm which is fixed to a loose collar on the spindle. The arm has on it two rollers which, being forced up fixed inclines, lift the collar, which thus comes in contact with the bobbin carrier and arrests its motion; the winding reel above is driven by gearing from the bobbin, so that the winding also ceases. M. 1763. 25,832, L.S.

55. SILK-DOUBLING MACHINE. Lent by Mrs. T. Foxley, 1910.

This is an element of a silk Spinning-machine formerly used at Messrs. Eaton & Co's mill, Glemsford.

Two bobbins, wound with thread, are mounted upon pins on a cross-piece at the top of a rotating spindle, while loosely fitting cap-pieces on the tops of the bobbins carry guides through which the threads are led to a reel above, which is not shown. The threads are thus twisted together, and as the lower parts of the bobbins touch a fixed belt which is stretched in the shape of a square, each thread separately receives a twist in a direction opposite to that of the combined thread, forming the material known as organzine. The spindle rotates in a hinged frame and carries a pulley which is kept in contact with a driving belt by the action of a weight.

In the event of one thread breaking, the winding of a single thread on the reel is prevented by a device consisting of a hook, which is mounted on a pivoted frame and is kept in a vertical position by passing the threads on opposite sides of it. If one thread breaks, the hook takes up a horizontal position owing to the action of centrifugal force and prevents the rotation of the thread guides, with the result that the remaining thread is broken.

The complete machine included a number of these elements, all of which were driven by one belt, a portion of which is shown. 1910.

WEAVING MACHINERY.

The art of forming a cloth by interlacing fibrous threads was evidently in use long before spinning was attempted as a means for obtaining suitable threads from such natural materials as cotton or flax. Grasses or straw and shreds of the inner bark of trees were used for both systems of threads, and were worked into mats by a process similar to darning. In very early times, however, yarns were spun from cotton and flax, but "fine linen" usually consisted chiefly of cotton, very finely spun.

The first step from this primitive darning towards the modern process of weaving seems to have been made by the ancient Egyptians, who arranged a series of vertical threads representing our present warps, and provided the alternate threads with a loop attached to a rod that served as a heald-shaft, by which one-half of the warps could be deflected from the common plane, so leaving a wedge-shaped space, or shed, for the passage of the cross-thread, or weft. By a similar heald-shaft the other warps were deflected for the return passage of the weft, and so the interlacing was obtained in a much more rapid manner than was possible by a darning system. Subsequently the ancient Egyptians, Greeks, and Romans used an elementary form of loom, in which the warp threads were suspended vertically from a beam and weighted below. Two lease rods were passed through the warp to separate the odd threads from the even. The weft was wound on a reel serving as a shuttle, which was passed through, or thrown, by hand, and a flat wooden sword, afterwards introduced in the shed, was used for beating up or pushing the weft thread home. A comb was employed about this time for keeping the warp threads apart, and soon afterwards was used instead of the sword for beating up the weft.

An early Indian loom had the warp placed horizontally, and worked by two healds suspended from above and connected with treadles below. To keep the cloth out to the proper width a temple was used; it consisted of two wooden bars tied together with cords, and having at their ends brass pins to hold the cloth. Such primitive looms are still in daily use in the East.

From these early times, until early in the 18th century, very little improvement was made in the hand loom, the construction of which was such that the warp was rolled on a beam, round the ends of which ropes suspending a weight were coiled, and so kept the threads stretched. There were two healds worked by treadles below, and the beating-up was done by a batten swung from above. The upper surface of the batten, or lay, together with the reed, formed the shuttle race, and the shuttle was thrown by one hand and caught by the other at the other side of of the shed.

In 1733, John Kay, of Bury, invented the fly-shuttle, by which the speed of weaving was immensely increased, and the labour diminished. His shuttle was made of light material, and ran upon four wheels. Pickers at each end of the web were connected with a stick which the weaver held in his right hand, so that by a quick movement of the wrist either way, the shuttle ran through the shed, and was caught by the other picker, ready for the return passage. In 1760, Robert Kay, son of the inventor of the fly-shuttle, invented the drop box, an arrangement whereby several shuttles with different-coloured wefts could be used, instead of only one. It consisted of a vertical board at each end of the lay upon which several shelves were fixed. Each of these were designed to hold a shuttle, and was capable of being brought level with the picker when the weft of any particular shuttle was required in the pattern.

The method of picking remains essentially the same as it was in the 18th century. Many efforts have been made to improve it, but it is still uncertain in action, costly, and dangerous. Many multiple box-motions, beginning with Dr. Cartwright's sliding tray in 1792, have been introduced in order to weave fabrics with different colours of weft by automatically changing the shuttle. Swivel-weaving is a method of producing small figures in extra weft carried in swivel shuttles over the ordinary ground weft. It gives an embroidered appearance, and the extra weft is only used where the figures are made. Lappet weaving produces similar but somewhat inferior effects by means of floating warp threads.

Open and Closed Sheds.—In shedding, that is raising or depressing the warp threads to make a passage for the shuttle, there are two principal methods in use, the sheds being known as open and closed respectively. An open shed is formed when the warp threads pass directly from their highest to their lowest position, so that an open space is constantly preserved except during the instant when the warp threads are passing one another. There are two ways of producing a closed shed: in the first, the warp threads that are to lie above the weft are lifted up, and those that are to lie below the weft are drawn downward to make a passage for the shuttle; after each pick all the threads are brought back to the centre line. The other way is to keep a fixed line of warp below the centre line, and to lift all threads that are to lie above the weft, up to a line above the centre line. Less strain is put upon the warp by the open than by the closed shedding, and the former occupies less time, but it is a difficult matter to piece broken warp threads in the lower warp shed. An open shed is the usual form, and is found in all ordinary tappet and dobby looms; a closed shed of the first kind is formed by single-lift jacquards, and one of the second kind by the Woodcroft tappets and certain jacquards.

Mechanisms for effecting the shedding operations are of three different kinds according to the complexity of the pattern. The simplest of all is the tappet motion, in which cams placed upon a shaft act upon treadles which are connected with the heald-shafts. Each heald has an eye through which a warp thread passes, and in general there are as many heald-shafts as there are weft threads in a repeat of the pattern, but by an arrangement known as drafting the number necessary for weaving some patterns may be reduced.

The power loom was invented by the Rev. Edmund Cartwright, D.D. (1743-1823), in 1785. His loom contained the beating up, letting off, taking up and stop motions, and the self acting temples which have survived in the present-day loom. He started a spinning and weaving factory in Doncaster in 1785, in which the machinery was at first driven by a bull, but in 1789 he applied a steam engine for the purpose.

The ordinary power loom can now work up to a speed of 240 picks per min., with from four to six looms per weaver for plain cotton goods. Automatic looms, especially the Northrop and the Steinen, have been developed in recent years. They run at 160 to 180 picks per min. with one weaver tending 18 to 24 looms; and three weavers have been seen tending 100 looms. The Northrop loom is a weft bobbin changer with a single shuttle and a circular magazine holding 24 to 30 bobbins of weft. Instead of the magazine, the Steinen loom has 150 bobbins placed in a box away from the loom and the thread is drawn down the centre of the bobbin by the suction of a vacuum pump. The bobbins are fed automatically into the shuttle. When the loom stops through any fault, an electric light is automatically turned on and remains alight until the fault has been remedied.

Tappets cannot be used with advantage when the heald-shafts exceed 12, so that to produce the shedding motion for patterns beyond the scope of the tappets a mechanism known as a dobby, or witch, is used. Even where the pattern is not so intricate as to be beyond the range of tappets the dobby is often used on account of the greater facility with which it can be changed from one pattern to another. The dobby appears to have originated separately and to have been earlier than the Jacquard machine; some kinds of dobby are very like the latter in their parts, but they are not suited for the most complicated patterns. In cotton weaving 24-shaft dobbies, and in worsted weaving 36-jack dobbies are used. For more complicated designs a jacquard of 200 to 1,200 needles is used; or several jacquards may be coupled together to weave still more intricate patterns.

The Jacquard machine was invented partly by Falcon in 1728, partly by Vaucanson in 1745, and completed by Jacquard in 1804. Falcon invented the prism with its chain of cards, Vaucanson applied the griffe to lift the hooks, whilst Jacquard appears to have combined the previous inventions and made the machine a commercial success. Improvements in the details of the Jacquard of late years have been numerous, and they have aimed at increased speed and reduced cost of production. For cutting holes in the cards two classes of machines are used—those for cutting cards from a design on squared paper, and those used for repeating a set of cards. No machine has yet been successful in automatically reading the design on the cards. The piano card-cutting machine is the one most used for complicated designs (*see* No. 85). Since 1853 attempts have been made to control the lifting of the needles and hooks by electricity instead of by punched cards; experiments in this direction are still being carried on very actively.

Some of the recent developments in weaving include the sponge cloth looms which weave the centre in cross or doup weaving, automatically changing in turn to plain weaving, to a finer weft, to weft of another colour, and finally inserting a fringe. Double and up to eight-ply fabrics are made by binding the successive plys together by means of a stitching warp thread or by interlacing each ply with its neighbour. From two to six-ply goods, as stiff as a board, may be made in widths up to 16 ft. Turkish towels are made up to 100 in. in width. Carpets up to a width of three yards or more are produced at the rate of 2 in. a minute, the pile being formed by automatically inserting and withdrawing thin wires of over three yds. in length at the rate of 20 a minute. Cocoa fibre mats have been successfully made by power with a four-fold increase of production. Driving belts in cotton, hair, hemp, ramie, and other materials are now produced without difficulty; and there have been developments in conical weaving and special fabrics such as tire duck, aeroplane wing covering, and asbestos brake bands. Power looms are now frequently driven by a separate electric motor for each loom.

In the cottage industry, for the manufacture of tweeds, homespuns, serges, and blankets, a hand loom is used which only needs one movement, which can be made with one hand, to give all the necessary motions; so that this loom is being used by ex-service men who have lost a limb. Such a loom can attain a speed of 40 to 50 picks a minute. In the manufacture of some of the most delicate silk fabrics the hand loom is preferred to the power loom, and in the neighbourhood of Lyons there are at the present time over 15,000 hand looms at work.

Details of recent progress in weaving machinery have been taken from the Journal of the Textile Institute, and particularly from a paper entitled "Woven Fabrics: Achievements and Possibilities," read by Mr. Oscar S. Hall, O.B.E., M.I.Mech.E., on October 1st, 1920.

56. MODEL OF HAND LOOM. (Scale 1 : 4.) Presented by the Royal Society of Arts, 1857. Plate II., No. 7.

This model represents the general form of hand loom in use prior to the invention of the fly-shuttle in 1733; most of the features of the modern power loom are, however, to be found in it in an elementary form, and in a state that renders the action of the later developments more evident.

The longitudinal, or warp, threads are wrapped round a roller at the back of the loom frame, from which each one passes through an eye in a separate vertical thread, or heald, and then between a grid or comb, called a reed, to a roller in front, known as the cloth-beam, upon which the fabric is wound up as it is woven. The healds of alternate warp threads are secured above and below to transverse bars, called heald-shafts, which can be moved vertically by treadles, and the healds of the intermediate warp threads are similarly controlled by another set of heald-shafts. By this means the alternate threads of the warp can be moved so as to leave a wedge-shaped space, called a shed, through which the shuttle, containing a supply of the transverse or weft thread, can be passed by hand. After each passage of the shuttle the healds are so moved as to reverse the relative positions of the two groups of warp threads, thus securing a complete interlacing of the two systems of thread; the weft thread is at the same time driven close up to the preceding thread by the reed, which is pulled forward to beat it up.

The loom is represented weaving a stair carpet, with longitudinal stripes given by the use of warp threads of different colours; three threads are passed through each loop of the healds and the weft thread is quadruple. A full-sized shuttle is also shown. Inv. 1857–104. 30,887, L.S.

57. BRAID LOOM. Received 1912.

This is an ornamental example of a loom for weaving by hand narrow fabrics such as braid and other trimmings. Such looms were used in Yorkshire in the latter half of the 18th century, and probably had their origin in Norway or Sweden.

The warp is wound on a beam, which is turned by a handle and checked by a ratchet and pawl. Alternate sets of threads pass through 12 slots and 11 holes in a frame which can be lifted up. Lifting up the frame also lifts the warps which pass through the holes, and so a shed is formed. The weft is passed through the shed on the spool. A shed may be formed also by selecting certain warps and holding them up by means of one of the flat meshes, which may also be used for beating up. The woven material is kept taut by pinning it to the dress of the weaver. M. 4027.

58. MODEL OF VELVET LOOM. (Scale 1 : 8.) Presented by Mrs. Reynolds, 1907.

Plush or pile fabrics have a raised surface, which is produced by the introduction of threads in addition to the ordinary warp and weft forming the ground or body of the fabric. They are of various classes, depending upon whether the pile is caused by additional warp or by additional weft threads, and also upon whether the threads are cut or uncut.

The model represents a hand loom for weaving velvet, in which material the pile is produced by a great number of short silk warp threads, the ends of which stand up closely enough together to conceal completely the structure of the ground. The warp for the pile is carried upon an additional beam placed above the ordinary one, and separate heald-shafts are provided for its threads. In operation, the latter are raised and depressed, together with one-half of the ordinary warp, until three picks have been completed, when a brass wire is inserted below the pile warp and above the whole of the ordinary warp. The pile warp and half of the ordinary one are then depressed, three more picks are executed, another wire inserted, and the process repeated. In this way the pile threads are made to form loops around the wires, which loops are cut through by means of a special form of knife known as a trevette, each wire being provided with a groove along its upper side to facilitate this process. Two wires only are used, the loops round the one being cut after the other has been inserted. The intermediate picks are well beaten up by a reed, so that when cut the pile threads are securely gripped by the weft. As many as 50 or 60 insertions of the wires are made per inch, and about six yards of pile warp are required for each yard of velvet produced. Smaller weights are employed on the pile warp beam

than on the ordinary one, as less tension is required in the threads of the former.
The woven velvet passes to a cloth beam, but is not wound round it in the ordinary manner. To avoid crushing the pile, when the beam has completed nearly one revolution the material is unfastened and passed through a slot near the top of the side of an adjacent box. M. 3489.

59. MODEL OF POWER LOOM. (Scale 1 : 3.) Made by Messrs. Sevill & Woolstenhulme, 1857.

This model represents an ordinary form of loom, such as is used for weaving calico, and it is arranged to be driven by power. The following description of the construction and arrangement of this simple loom applies generally to other models of looms in the collection.

The warp threads, or those that run lengthwise of the calico, are wrapped on a long roller placed at the back of the loom. Each thread passes separately from this roller through a loop in a separate vertical cord, known as a heald, and then forward in pairs through a grid or reed formed of vertical wires or dents, and finally on to a front roller called the cloth beam, upon which the woven calico is wound. The weft thread, or that which runs across the calico, is contained within a shuttle, which by a simple mechanism is thrown backward and forward along a ledge or shuttle race formed on the front of the reed. The interlacing of the weft and warp threads is due to the lifting and lowering of the alternate threads of the warp after each throw of the shuttle. The alternate healds are attached above and below to a frame or heald-shaft, and those intervening to a similar heald-shaft; but by means of cams below, these frames and healds are alternately lifted and depressed, so that the shuttle is passing at one throw above and at the next throw below each alternate warp thread. The wedge-shaped passage left for the shuttle between the lifted and depressed halves of the warp is called the shed, and each passage of the shuttle is a pick. To secure close interlacing, so that the weft thread from one throw shall be as near as possible to the preceding, a swinging motion is given to the reed by which its dents push the weft right home into the vertex of the shed. The swinging frame carrying the reed is called a lay, and its beating-up motion is known as battening.

The motion of the shuttle is derived from a swinging arm or picking-stick, which passes through a picker made of buffalo hide, and is arranged in the boxes for the shuttle at each end of the shuttle race. The picking-stick is driven by a cam on the shaft, the return movement being given by springs. The lay is reciprocated by a pair of cranks and connecting rods. To move the heald-shafts up and down so as to form the shed, a tappet shaft is provided below, which makes one revolution for every two of the lay crank-shaft, and the tappets move treadles by which the motion is conveyed to the heald-shafts through leather belts. The warp is fed out as the work proceeds by a ratchet wheel, and the tension is regulated by a roller over which the warp passes. If too much warp has been fed out the roller rises and holds back the pawl by which the feeding is performed. The winding-in of the finished cloth is accomplished by a similar gear.

There is an arrangement for stopping the loom if the shuttle does not reach its box after being picked; this consists of a lever held by a spring, and forming the outer side of a shuttle box. When the shuttle boxes, the lever is moved outward and a finger is raised; if the shuttle does not box properly the finger remains down and, as the lay moves forward, catches a lever fixed to the stop rod, and the loom is stopped by the driving belt being thrown on to the loose pulley. Should the weft break, the loom is stopped by a fork and grid arrangement, described in connection with No. 70.

The cloth is kept stretched to its proper width by a self-acting temple, which consists of a serrated roller cut with a right-hand screw thread for one half, and a left-hand thread for the other half of its length. The cloth passes beneath this roller and over an iron trough in which the roller turns. M. 1765

60. MODEL OF POWER LOOM. (Scale 1 : 2.) Woodcroft Bequest, 1903.

This is a model of a loom fitted with Bennet Woodcroft's positive tappets, patented in 1838. This form of tappet is still used for heavy work, and where from 8 to 12 picks are needed for a pattern. The shed formed with these tappets is a closed centre shed—that is, the warp threads return to a common plane after every pick, and are then moved to their respective positions for the next pick.

There are four heald-shafts, each raised or lowered by the motion of a tappet plate, the projections upon which operate a lever or treadle. Each tappet-plate consists of two corresponding plates bolted together, and the plates are made in sections, which form either an elevator or a depressor. The sections may be interchanged so as to work different patterns by a different sequence of these cams. There are usually as many sections as heald-shafts, and the tappet-shaft makes one revolution for each section of the tappet-plate ; in this example there are three sections, so the tappet-shaft makes one revolution for three of the crank-shaft.

Contrary to the present practice, the lay is supported by arms, or swords, from above, but it is driven by the usual cranks and connecting rods. The picking-stick is moved by the pull of a strap fixed to one arm of a bell-crank lever. The other arm of the lever is flattened, and is brought by the movement of the lay against an arm fixed to a shaft which is turned through an angle of 90 deg. every pick, so as to pick the shuttle from either side.

Both the letting-off and taking-up motions are of the ratchet-and-worm kind, but in the former there is a finger which presses against the warp beam and limits the motion of the pawl, so that the feed is corrected for the varying diameter of the roll. From the beam the warp passes over a spring-supported roller, so as to maintain the tension on the warp during shedding. M. 1778A.

61. MODEL OF POWER LOOM. (Scale 1 : 4.) Woodcroft Bequest, 1903.

This loom has Bennet Woodcroft's adjustable cams or tappet-plates for rearranging the pattern ; five plates and treadle levers are employed. To keep the fabric to its full width a simple form of temple, to be moved by hand, is provided. M. 1776.

62. POWER LOOM. Presented by Messrs. J. Harrison & Sons, 1858.

This is an example of an ordinary plain loom fitted for driving by power. Four tappets, on a shaft which turns at a quarter the speed of the crank-shaft, move the heald-shafts in the usual way ; with this arrangement a four-thread twill can be woven.

Between the crank-shaft and the tappet-shaft there is an intermediate one, upon which is a cam for actuating the picker that drives the shuttle. A small conical roller fixed to an arm on the lower part of a vertical shaft, whose upper end carries the picking-stick, is held in contact with the cam, and the edge of the latter is bevelled to suit the conical roller. The cam is so shaped as to give a quick swing to the picking-stick, which is connected by a leather strap with the picker that throws the shuttle.

To protect the warp if the shuttle does not box, there is a loose reed motion. The upper rib of the reed is held in a groove in the lay cap, so that it can turn when the lower rib moves backward. A bracket, fixed to a rod beneath the sole running the whole length of the lay, supports a rail which bears against the lower rib. It is held there by a flat spring, pressing upon a finger fixed to the same rod. A lever, also fixed to this rod, carries a roller which runs on a bent spring, to keep the reed steady when the shuttle is passing. Should the shuttle stop in the shed, the lay when beating up swings the reed backward, the finger turns the bracket, and its point comes into contact with a roughened surface on the stop rod, which it then pushes out of the notch and the belt is guided on to the loose pulley. In order that the reed may be quite firm whilst beating up, a curved arm fixed to the rod which carries the rail is so arranged that, when the shuttle has boxed and the reed is in its place, it shall be pressed upon by the lower surface of a chisel-edged piece fixed to the framing ; one of these arms is at each end of the lay.

The arrangement for stopping the loom if the weft should break is the usual weft fork and grid, described in connection with No. 70. The requisite tension on the warp is given by a rope coiled round the warp beam at each end and attached to a flat spring fixed to the loom frame. When weaving heavy cloth the ropes are connected with a lever acted upon by the lay at the time when the heald-shafts are being moved ; by this means the warp is slackened when the shed is opening, and tightened when it is closing. The cloth is wound up as it is woven, by a ratchet wheel and spur gearing driven from one of the swords. It is wound upon a roller whose ends rest upon those of weighted levers that keep the cloth roller in contact with the roughened roller. A self-acting temple keeps the cloth out to a uniform width ; it consists of a roller fluted at each end, one cut with a right-handed and the other with a left-handed helical groove. Inv. 1858-5.

63. MODEL OF POWER LOOM. (Scale 1 : 2.) Presented by W. E. Taylor, Esq., 1862.

This loom is a good example of the ordinary power loom, but has Mr. Taylor's improved mode of driving the lay and shuttle race. By using a very short connecting rod, the lay moves very slowly when back, but quickly when beating up the weft. One half of the lay is fitted with a connecting rod of the usual length, so as to show the different action of the very short one. There is the usual self-acting temple to keep the cloth out to the proper width, and self-acting arrangements for stopping the loom in case the shuttle does not run fully home into its box, or if the weft should break. Inv. 1862–25.

64. MODEL OF POWER LOOM. (Scale 1 : 3.) Lent by the Royal Society of Arts, 1867.

This is a model of a plain calico loom, invented by G. White, of Glasgow, about 1829. Its chief features are that the shuttle is picked by springs which give a uniform throw, irrespective of the speed of the loom, and that the levers and cams are all driven from one shaft.

From the driving shaft, motion is taken through a crank and connecting rod to an upright shaft, to which is keyed a horizontal arm with two rollers upon it. One of these causes an arm, centred below, to rock through a small angle, and so give motion to the healds; it also moves a long horizontal rod endways, thereby compressing springs which pick the shuttle. The other roller oscillates a frame connected with the lay, and so effects the beating up.

The cloth is taken in by motion derived from a ratchet wheel, the pawl of which is worked from the horizontal arm which gives motion to the healds and lay. The movement of the pawl is controlled by a finger which presses upon the cloth beam, so that less motion is communicated to the beam as the diameter of the roll increases. M. 1755.

65. MODEL OF PROPOSED POWER LOOM. (Scale 1 : 6.) Presented by J. E. Hodgkin, Esq., 1898.

This form of loom was patented by Mr. S. C. Salisbury in 1860; it was tried on a practical scale with some success, but was ultimately abandoned. The chief features of the loom are the shape of the shuttle, and the method of driving it, whereby the beating-up motion of the lay is dispensed with.

The shuttle is moved to and fro in the race by a roller, upon which it rests; this roller is carried on a frame that is reciprocated horizontally along guides by a pin projecting from the side of an endless belt, that passes over end pulleys, and is continually driven by power. The pin on the belt engages in a vertical slot in the reciprocating carriage, moving in the slot as it passes round the pulleys at the end reversals of its motion.

The construction of the shuttle is better seen in the larger detached model of the same. It is supported and guided by friction rollers, while the spool of weft is carried sideways through the reed. The weft thread leaves the shuttle centrally at its front, and passes between grooved rollers which press it into the shed, thus avoiding the use of a beating-up motion for forcing the weft home.

The headles, harness, and reed are of the usual construction, as are also the drums and rollers for the warp threads and for the finished yarn. The motions for all of these parts are, however, derived from a pair of connected levers that are moved by the reciprocating carriage at each end of its travel; from these levers the motion is transmitted by segmental gearing and the usual ratchet feed motions. M. 3019. 20,510, L.S.

66. MODEL OF POWER LOOM. (Scale 1 : 2.) Lent by the Royal Society of Arts, 1869.

This is a model of a loom that will weave plain calico or checks; it has two tappets and a double shuttle-box, so that two colours of weft may be used.

The shedding is open, and the tappets work negatively. They are moved by cords passing over segmental arms fixed on two shafts which are rocked by an oscillating frame, operated by a cam on the lower shaft. The picker at each end is moved by cords attached to an arm fixed to a pulley, which is turned through a small angle by a leather strap, whose ends are pulled down alternately by cam-moved levers. To move the shuttle-boxes a spur wheel, driven from the lower shaft, carries a cam on its face which acts upon a horizontal lever that depresses the boxes. When released, the shuttle-boxes return to their normal position through the action of a spring, attached beneath the sole of the lay. The letting-off motion is governed by a rope brake, and the taking-up arrangement consists of a ratchet wheel and gearing, moved from the crank-shaft. M. 1756.

67. MODEL OF POWER LOOM. (Scale 1 : 2.) Lent by Messrs. Platt Bros. & Co., 1892.

This represents a modern plain loom for weaving calico, and is in complete working order with the unfinished work in position. In most respects it resembles the earlier examples, somewhat modified by accumulated experience, and its size is such as to show very clearly the general arrangement of a power loom.

To keep the warp threads taut during the interval when the shed is closed, the bar over which they pass from the warp-beam is given a swinging motion by a lever at its end rocked by a cam on the crank-shaft. The frictional resistance to the rotation of the warp-beam, required to keep the warp threads tight, is given by weighted chains passing round smooth pulleys, but is also increased by the large bearings provided. The temples, which secure uniformity in the width of the cloth, are carried on the beam by sliding guides fitted with springs. The finished cloth is wound in by a roughened roller round which it wraps through an arc of 240 deg.; it then passes round a guide roller and is wound on to the finished cloth roller below. This roller is forced against the roughened roller by springs, so that it winds in the cloth at a uniform rate irrespective of its diameter. There is a weft fork that automatically stops the loom when the shuttle thread breaks or runs out, and on the back of each shuttle box is an arrangement of levers that stops the loom if the shuttle does not go completely home in either box. These automatic stoppages are made by a trip gear that, when anything is wrong, releases the starting lever from the driving position, which, under the action of a spring, throws the driving belt on to the loose pulley, at the same time applying a powerful brake to the crank-shaft, so as instantly to arrest the motion.

M. 2453. 19,948, L.S.

68. MODEL OF LOOM FOR WEAVING SACKS. (Scale 1 : 8.) Lent by the Royal Society of Arts, 1867.

This is a hand loom invented in 1802 by Thomas Clulow for weaving two fabrics by a single shuttle, so as to form sacks or other cylindrical articles without a seam, owing to the selvedges being common. The shuttle passes first through the top warp and then through the lower one, so that the weft thread passes continuously round the sack. The bottom is closed by working the two fabrics into one for a short length. M. 1758

69. MODEL OF LOOM FOR WEAVING FISHING NETS. (Scale 1 : 4.) Lent by the Royal Society of Arts, 1867.

This machine was invented by J. Robertson, of Edinburgh, in 1806, and at the time received considerable attention. The model only makes a row of five meshes, but the actual looms were to be 3·5 ft. wide and to make 33 meshes in this width; the length of the net was unlimited.

The loom has a series of warp threads, each passing through a separate curved tube carried on a swinging frame, while across the framing extends a race in which is a like number of mounted bobbins or shuttles which are simultaneously moved sideways by a handle. At the back is a swinging and sliding frame containing a series of hooks which is so manipulated by the operator as to crochet a knot in each of the warp threads, and through these knots the shuttle threads are passed. M. 1759.

70. WEFT FORK. Presented by Thomas Sibley, Esq., 1861.

This is a detached example of a weft fork, which is part of an arrangement for stopping a loom if the weft should break. It can be seen in position in Nos. 59 and 62.

This device is used in all plain looms at the present time, but for fancy looms, where several shuttles are used and several picks made from the same side consecutively, it does not give a sure means of stopping if any one of the shuttles breaks its weft. For such looms a weft fork is placed in the centre of the reed space.

At one end of the fork there are prongs, and at the other end a hook; the fork is nearly balanced on a pin, the prong end being left lighter so that the hook tends to fall. The pin is fixed to a rod attached to a bracket on the stopping lever which, while the loom is running, is retained in a notch. A bell-crank lever, with its upper end notched so that it can catch the hooked end of the fork when both are at the same level, is oscillated by means of a cam on the tappet or picking-shaft. At one end of the shuttle race, in the reed frame, there is a grid between which the prongs can pass when the lay moves up. If the weft be unbroken, it lies across the grid and causes the fork to tilt up the hook, so that the oscillating notch does not catch. If the weft be broken, however, the prongs go through the grid and the hook is caught by the notch, so that the stopping lever is moved out of its notch and sprung to the end of its slot. The belt fork connected with the stopping lever throws the driving belt on to the loose pulley and at the same time applies a brake, so that the loom is stopped at once.

The feature of Sibley's fork, patented in 1860, is the method of supporting it; with the object of reducing friction, and also taking up any slackness that may arise, the axis is carried between cone-centres. Inv. 1861–34.

71. REED HOOKS. Presented by James Parr & Son, 1908 and 1911.

The reed hook is used by the "drawer-in" when preparing the warp for the weaver, *i.e.*, when drawing it in through the healds and reed; it is also used by the weaver in a similar way when the warp breaks.

The drawing-in hook has a handle in which are fixed two lengths of wire each flattened at the end and with an inclined slot in which the thread is held; it is used with the slot upward.

The weaver's hook is similarly made, but there is only one wire and its end is bent at a slight angle; it is used with the slot downward. Three sizes are shown; the long one is for fine goods, the short one for coarse goods, and the exceptionally large one is for blanket or canvas weaving. M. 3559 & 3845.

72. HAND-LOOM WEAVERS' APPLIANCES. Received 1906.

The shuttles are of primitive type. The larger ones, for coarse fabrics, are of beech, and the smaller ordinary ones of boxwood; they are rectangular in section, pointed and tipped with iron at both ends, while the centre is mortised out to receive the pirn or cop of yarn, which is retained spring-tight on a fixed tongue. The yarn is threaded through an ivory eye in the side of the shuttle, at such a point as to give a fair lead when drawn off the pirn during weaving. One of the large shuttles has a spring, to put a drag on the weft as it is drawn out. Another has two pirns, so as to pick a 2-ply weft. All these shuttles run on anti-friction rollers, except one, which was used in a loom where it was thrown by hand; this has a brush to put a drag on the weft.

The pluck-pin, or picking-stick, is a handle attached by cords to the pickers in each shuttle-box to throw the shuttle. This was the great improvement introduced in 1733 by John Kay, and known as the fly shuttle. M. 3606.

73. VARIOUS SHUTTLES FOR LOOMS. Contributed by Messrs. J. Harrison & Sons, 1862.

Shuttles for looms of various classes are shown, some opened and some with the cop of cotton weft in position. A later form of shuttle is seen in No. 35.
Inv. 1862–9.

74. SHUTTLE FOR NARROW FABRICS. Contributed by W. E. Newton, Esq., 1862.

This is an example of a shuttle patented by Archibald Turner in 1858. It is for use in weaving very narrow pieces, such as ribbons. The shuttle is shaped at its base to fit into grooves in the batten of the loom, the increased bearing surface thus secured reducing the length of shuttle necessary. Inv. 1862–10.

75. WEAVERS' SHUTTLES. Presented by Messrs. Wilson Brothers Bobbin Co., Ltd., 1894 and 1909.

These shuttles only differ in shape from the earlier ones (*see* No. 73) by the provision, along the cloth side, of a groove for the weft to lie in when picking.

The tongues or pegs of the shuttles are arranged to hinge in one tongue the spring is compressed when up, so as to set free the pirn, and expands when down, where guards fit into a collar on the base of the pirn. In another shuttle the tongue is cleft, with a flat spring between, to expand into the pirn.

This has also the " Amerik " self-threading device ; it consists of a piece of steel, shaped and curved so as to guide the thread to the eye, where it may be seized by the finger and thumb. The " Dux " threader is also shown ; this has a saw cut, guarded by a curved guide of steel, through which to pass the thread.

Boxwood being now very expensive, other woods, such as cornel or dogwood and persimmon, which are nearly as dense and close-grained as box, are now used, as shown, for shuttle making. M. 2726 & 3592.

76. SHUTTLE PICKER. Contributed by W. E. Newton, Esq., 1862.

To drive the shuttle of an ordinary calico loom, a blow of about three foot-pounds must be struck for each throw, and this energy is transmitted to the shuttle by the picker. At even an ordinary speed of 200 picks per min., the wear upon the picker is serious, so that many materials have been tried in place of buffalo hide, the material most generally employed. The picker shown is made of hard vulcanised rubber, and was patented in 1857. Inv. 1862–11.

77. SAMPLES OF CALICO. Presented by C. W. Harrison, Esq., 1865.

These two pieces of calico were woven by Mr. Harrison in a pneumatic loom, in which the shuttle was driven by compressed air. Inv. 1865, 19A & 19B.

78. HAND LOOM WITH LAG DOBBY. Received 1908.

This loom differs from No. 79 chiefly in the arrangement for raising and lowering the shafts ; it consists of pegs inserted in holes in wooden lags, travelling round a spindle turned by a hand wheel at the front of the loom.

Dobbies are used for patterns which are beyond the range of tappets but not sufficiently complex to require jacquards.

There are 25 heald-shafts and three shuttle boxes on each side. Pegs are inserted in the lags according to whether in any one pick, or throw of the shuttle, a warp is shown in the design as passing over or under the weft. The peg projecting from the face of the lag presses against one arm of a fork, the other arm of which is connected with a vertical hook from whose lower end the heald shaft hangs. A horizontal knife is raised by pressing down on a pedal at the front of the loom and in its motion upward it carries with it all the hooks which have been pressed by pegs towards it. A quarter turn of the hand wheel in front brings another lag with its pegs into operation for the next pick. M. 3571.

79. HAND LOOM WITH CARD DOBBY. Presented by Messrs. Platt Bros. & Co., Ltd., 1921.

This loom is designed for the use of students in technical schools, and is the same in principle as the wooden hand loom used in village industries. It is made of an unusually narrow width with a view to economy in warp and weft. The loom is placed here chiefly in order to enable students in design to follow the mechanisms by which their designs are translated into woven fabrics. From the drawing, on squared paper, holes are punched in a series of cards to determine the action of a hooked needle which raises or depresses a warp thread according to whether it meets a hole in the card or not. A piano card-cutting machine is shown in an adjacent case.

The loom is of 14 in. reed space and there are 20 shafts. There are two shuttle boxes on each side, actuated by a hand lever, so that two colours of weft may be used. Inv. 1921.

80. SPITALFIELDS LOOM WITH JACQUARD. Presented by Messrs. Warner & Sons, 1914.

This is a hand loom for silk weaving, with a jacquard machine of 400 needles which was made by Guillotte, 37, Crispin Street, Spitalfields, about 1810. The jacquard was introduced in France in 1804, and was adapted from Falcon's Loom of 1728, and Vaucanson's of 1746, the only new feature being the perforation of the prism or cylinder. The loom itself is simple in construction, consisting of a heavily weighted warp beam, a cloth beam, a batten hung above with a reed 24ins. wide, all supported in a wooden frame. The jacquard which is supported on a frame overhead is of the original French type of 1804. The function of the jacquard is to divide the warp for each pick, or throw of the shuttle, so that the weft goes over or under the warp according to the pattern which is to be woven.

Each warp thread in the loom goes through an eye in the harness, one of a series of weighted vertical cords, which at the upper end is fixed to a vertical hook capable of moving a little way forward or backward at the top in agreement with a horizontal needle pressed by a spring against the perforated prism or "cylinder." Whether the needle enters the hole in the cylinder each pick or not is determined by the "card" which is then covering the operating face of the cylinder. There is an endless chain of cards supported in a creel and moving round the cylinder, which is provided with pegs to hold them. Each card has been punched with a series of holes in accordance with the design (*see* No. 88).

A needle which does not enter pushes back the hook and so prevents it from being lifted by the "griffe," a frame containing horizontal knife edges which catch the hooks left vertical and so lift the healds and place the corresponding warps in the upper shed. The weaver presses down the treadle with his foot and so opens the "shed," through which he then throws the shuttle catching it at the other side. The treadle is then released and the batten is moved forward to beat up the weft. Various colours of weft may be used and there is a frame holding spools of different colours ready for changing into the shuttle.

One side of the case containing this loom has been copied from a weaver's window at No. 8, Mape Street, Bethnal Green, where, in 1915, hand-loom weaving was still being carried on. Inside the case are placed various accessories of the hand-loom weaver. Inv. 1914—469.

81. MODEL OF JACQUARD APPARATUS. (Scale 1 : 2.) Lent by the Royal Society of Arts, 1867.

This is a model of a loom with a jacquard apparatus attached, the latter being used to raise and lower the sets of healds through which the warp threads pass in the order required for weaving complicated patterns that are beyond the scope of tappets. As seen in this model, the machine contains Falcon's prism and a chain of punctured cards for determining the pattern, together with his needles and hooks invented in 1728. The griffe, or arrangement of standing bars which catch the hooks and lift them, was invented by Vaucanson in 1745.

The griffe is reciprocated vertically by the crank-shaft of the loom through levers. Fixed behind the guides of the griffe on each side is a plate, curved on its opposite sides; two rollers on the horizontal sliding piece, which hold the card cylinder, are in contact with the curved plate, one on each side, and by this means the cylinder is reciprocated horizontally. The prism is turned through a quarter of a revolution at every pick by a catch, centred at one extremity of a bell-crank lever driven by pins fixed to the griffe guide bar.

There are 100 needles arranged in four rows of 25 each. Each needle passes through a needle board at one end, and at the other end projects into a spring box, where its end is pressed upon by a small helical spring tending to force it towards the cylinder. A loop is formed in each needle at its middle, and through this the vertical hook passes. In order to keep the ends of the hooks in position for being lifted by the griffe, they are bent at the base, and the **U** thus formed rests in a groove when the needles are down. The healds are attached to the bases of the hooks.

Through each face of the prism as many holes are drilled as there are needles, and in corresponding positions. The pattern cards have holes through them at points opposite to the needles connected with those hooks which are to be lifted in any pick, and there is one card for each pick of weft in the pattern. When the prism moves in towards the needle board, the cards press upon the ends of the needles and push them back, but the needles which are opposite to the holes are not moved, and thus the respective hooks are moved into position for being lifted or missed by the bars of the griffe when it next moves up. Each heald is held down by a hanging leaden weight. The eye for the warp thread is formed in a small link of brass, instead of being formed in the heald string, as is now the practice.

The loom to which the jacquard machine is attached in this model is weaving a narrow silk ribbon. There is no special feature in the loom, except that the picking-stick is operated by a double-grooved cam. M. 1757. 25,833, L.S.

82. WOVEN PORTRAIT OF JOSEPH MARIE JACQUARD. (1752-1834.) Woodcroft Bequest, 1903.

This complex pattern was woven by a jacquard loom with a single shuttle. M. 1777.

83. JACQUARD APPARATUS. Woodcroft Bequest, 1903. Plate III., No. 1.

This is an example of Bennet Woodcroft's jacquard, and is similar to No. 82. The needles are, however, operated by pegs, fixed in a pattern chain of boxwood strips, which take the place of the ordinary cards. The chain passes round a four-sided prism, and the flat ends of the needles are pushed by the pegs as the prism moves inward, and so press back the corresponding vertical bars. Different patterns are arranged by moving the pegs, which in this example control 16 heald-shafts. M. 1780.

84. JACQUARD APPARATUS. Woodcroft Bequest, 1903.

This is an example of a jacquard machine designed by Bennet Woodcroft; it is similar in its general mode of action to No. 81.

Cards passing over a square prism determine by their perforations which of the 27 needles shall pass into the holes in the prism. An upright bar passes through a slot in the needle, and is moved sideways when the latter goes into a hole. There are two shoulders on each vertical bar, and two griffe-blades and racks operated by a pinion. This pinion is turned by a sector wheel, which gears with a sector on the end of a long lever, which receives its motion from the tappet plate of the loom. One griffe-blade acts upon the vertical bars to lift them and the other to depress them, according to whether they are moved to one side or the other by the needles. The latter are pressed in towards the prism by helical springs.

A hook centred on the frame pulls the prism round a quarter of a revolution each time the latter moves out. The prism is swung to and fro by levers driven by an arm on the sector wheel. Two flat stops, held down by springs, lock the cylinder in position. M. 1779.

85. MODEL OF JACQUARD APPARATUS. (Scale 1 : 4.) Woodcroft Bequest, 1903.

This is a model of an apparatus designed by Bennet Woodcroft (Letters Patent No. 7529, A.D. 1838) on the jacquard principle, but to work in conjunction with his tappet loom.

Instead of single healds being operated by the jacquard needles, in this example there are only six needles, and each of these operates a heald raising many warp threads at the same time.

The driving is from the tappet plate, not shown in the model, through the steel levers which are connected with a horizontal shaft cut into a six-sided prism, which corresponds with the "griffe" in the ordinary jacquard machine. It is fixed on each side to a sliding bar whose lower end forms a rack, and a pinion gears into this rack and into another one which is connected with a second griffe similar to the first. The jacquard prism has four faces, and is moved to and fro by bell-crank levers operated by the racks.

The needles have slots at their centres through which the ends of six vertical bars pass. Each bar has two shoulders upon it turned in opposite directions. One of these would be caught by the lifting griffe if the needle had pushed to that side: if to the other side, the other shoulder would be caught by the second griffe, and so the six horizontal levers are operated to lift or depress the six healds in the order required by the pattern. M. 1778.

86. JACQUARD MACHINE. Received 1891.

This is an example of a modern jacquard machine, with two prisms and two sets of needles and hooks, 400 of each in each set; the needles are arranged in eight tiers of 50. There are two griffes with eight blades each; the two sets of blades alternate with each other from front to back, and are inclined in opposite ways, as are also the rows of hooks that they lift, but both griffes are connected with a common crosshead above, by which they are simultaneously lifted once for every pick of the shuttle.

The prisms are swung in frames connected by adjustable bars, so that one swings in while the other swings out, and this motion also rotates them, by a pawl engaged with a four-toothed pinion formed on the axis of each prism. The warp threads that are to be lifted for one pick are determined by the card on one prism, and those to be lifted the next pick by the card on the other prism; the cards are therefore arranged in two sets, one containing the odd and the other the even cards in the order of the pattern.

A spring box is secured to the frame, on the same level as each prism but on the opposite side, containing a spring to return each needle; the needles pass freely through the mass of upright wires or rods, except that each needle loops round its particular upright wire and so is able to deflect it. M. 2259. 21,044, L.S.

87. HAND LOOM WITH JACQUARD. Presented by Messrs. Platt Bros. and Messrs. Devage & Co., 1912.

This is a loom used for instructional purposes to illustrate the action of the jacquard machine in forming a pattern more complicated than can be woven by means of tappets or the dobby. The pattern being woven is shown, four times enlarged, in the adjoining Piano Card-cutting machine, where the cards for controlling the shedding of the warp are cut. This jacquard, in order to avoid complications, has only 100 needles, but for ordinary commercial purposes there would be 400 or 600 needles.

The series of cards, one for each pick in a repeat of the pattern, laced into an endless chain, is held in a creel and led over the prism or cylinder which holds the cards by pegs which enter holes as the cards reach it. When a card reaches the operating face of the cylinder it presses against the needles and when a needle meets a hole it goes through and the hook connected therewith remains vertical, but when a blank space in the card is met a needle is pushed back and its hook thereby tilted so that the " griffe " with its knife blades, when it rises, misses this hook and leaves the corresponding warp thread in the lower shed, but it lifts the vertical hook and with it its warp thread.

There are six shuttles to provide for changes of colour in the weft, and three shuttle boxes on each side, which are brought into position for being thrown by the picking stick by means of a worm and rack operated by a hand wheel in front of the loom.

The weaver before each pick presses down the treadle which is under his seat, the jacquard cylinder is thus turned through one quarter of a revolution, the needles are pressed against the operating card, the hooks not to be raised are deflected, and the griffe with its knife edges rises, carrying up the hooks of the upper shed; by this one operation of the treadle the proper shed is formed and a quick movement of the picking stick throws the shuttle from its box on one side to that on the other side. Inv. 1912.

88. PIANO CARD-CUTTING MACHINE. Received 1912.

This is a machine for transferring a design drawn to a larger scale on squared paper to a series of cards, one for each pick of the shuttle. A hole may be punched on each card to correspond with each of the 600 needles of the jacquard.

There are twelve vertical punches set in a row in the headstock at distances apart equal to the pitch of the holes in a jacquard cylinder. Eight keys on the further side of the frame and four on the side next to the operator are set at such an angle that, on being pushed in, each of them covers the head of one of the punches. Each key is threaded with a helical spring which pushes it out again upon release. A fifth key on the front of the frame connects with a punch of larger diameter than the rest; this is for the holes which fit on the pegs of the jacquard cylinder.

The design is placed on the vertical frame and is read line by line by the operator, his eye being guided by a straight edge which is lowered by turning vertical screws at each end. The card to be punched is placed between nippers on a carriage traversed from front to rear by means of a pin rack and slip catch, one tooth for each downward movement of the left treadle. Each card, in addition to the holes which determine the pattern and those for the pegs, is punched with six holes for the purpose of lacing the cards into an endless chain, two on each edge and two in the centre. The peg and lace holes on one edge are first punched; the corresponding keys being pushed in, the right treadle is then depressed. This latter movement carries the top of the headstock down on to the punches and those whose heads are covered by keys move with it and perforate the cards, the rest slide through their holes, merely touching the card. Each downward movement of the right treadle cuts one short row of the holes. There are 51 such rows for each card, the 51st row being a spare one, for selvedges. The middle lace holes are placed betweeen the 26th and 27th rows and the peg holes one at each end, inside the end lace holes.

To enable the operator to see exactly where he has got to an, index card fully perforated and with each row numbered consecutively is nailed to the pattern board and a cord, one end of which is fastened to the carriage and the other to a small weight, is led across it by guide pulleys. When the carriage is close in to the headstock and the first row of holes is being punched a knot or arrow point is tied in the cord, and as every row is being cut the knot will be opposite the corresponding row of the index card.

The design is numbered for each pick and each card as it is cut is marked with the corresponding number.

This machine is capable of cutting cards for a 600 needle jacquard, but the pattern shown on the board is for a 100 needle jacquard and it is being woven in the adjoining hand loom, No. 87. Inv. 1912.

KNITTING MACHINERY.

Knitting differs from weaving in that only a single thread is used, a surface being obtained by the continuous interlooping of the thread in a way that is most obvious in that form of knitting known as crocheting. The result of this looping, together with the absence of weft or warp threads, is that the cloth formed is extensible in every direction, so that a knitted garment can be put on, and will fit the body in a way that is quite impossible with a woven fabric that has been cut to shape and sewn.

Knitting is the most modern of the textile processes, and although now universally practised it is supposed to have originated in Scotland as recently as the 15th century; as the tools required consist only of a single crochet hook, or of the four sticks or wires known as knitting needles, it is remarkable that the more complicated weaving process should have so long preceded it. Net-making is, however, a universal art of the greatest antiquity, and in some respects resembles knitting, but requires a shuttle.

The first machine to knit mechanically was the stocking frame, invented by the Rev. William Lee in 1589, in which was introduced the fundamental principle of a successful knitting machine, which is that a separate needle shall be used for each loop; in this way he at first made flat webs which by being sewn together along their selvedges made a cylinder. He afterwards found the means of producing shaped articles by throwing out of action some of the hooks as required. Lee, failing to get support in this country, took his machines to France, where he settled successfully at Rouen, and in 1640 his frames were adopted in Leicester.

The knitting by machinery of the ribbed surface, which gives so much greater elasticity in one direction, was first accomplished by Jedediah Strutt in 1758 by the introduction of a second set of needles at right angles to the first set. The circular knitting machine by which cylindrical work could be produced without seams was brought into a form suitable for practical use in 1845 by Mr. Peter Claussen, but such an arrangement had been suggested much earlier.

The needles in a stocking frame or knitting machine have hooked ends, with the hook extending backward to form a long spring barb, or beard, which is capable of being pressed close to the body of the needle, so that the loop of thread on the needle can be pushed over the hook when the beard is depressed, or will be retained on the hook if the beard is up. In this way the loop in the hook is drawn through the loop that has been formed round the needle. In 1858 Mr. M. Townsend introduced the latch-needle, in which the beard is replaced by a finger hinged to the needle; this arrangement simplifies the work of the machine, and the small knitters for domestic use usually have needles of this type. It has been stated that a hand knitter can work 100 loops a minute, that Lee's machine did 1,000 to 1,500 loops, and that the circular frame does from 250,000 upwards, depending upon the total number of needles.

Knitting is one of the few industries in which the factory system has not completely displaced home industry, and the tendency seems to be to extend the employment of small machines worked by hand or treadle at the operator's home rather than the larger installations of a factory. The knitting and hosiery industries are now of the greatest importance, and include the manufacture of underclothing, caps, stockinet cloth, etc., while the bags in which frozen meat is imported, and the mantles for the Welsbach burner are examples of the varied application of this interesting process.

89. MANUAL STOCKING FRAME. Lent by Messrs. Cooper, Corah & Sons, 1897. Plate III., No. 4.

This is a knitting machine for producing a flat web, and is somewhat similar to the original frame invented in 1589 by the Rev. W. Lee, although this example was made about 1770, it represents the stocking frame in general use till 1840.

There is a horizontal row of needles, with hooks, or beards, turned upward, which, however, can all be depressed by a bar above them, known as the presser, so as to let the thread pass over the hooks. Between each two needles is a notched steel plate, or sinker, and the alternate plates are formed into two sets, known as jacks and leads, the members of which can be successively raised or lowered. In working the apparatus, the operative places the thread loosely above the needles, and under the notches of the sinkers. He then depresses the jacks, so causing the sinkers to carry the thread between alternate pairs of needles so as to form a series of loops below. The lead sinkers are next lowered to half the depth of the jacks, whilst the jack sinkers are raised until the thread is equally sunk between all the needles., The sinkers are now all brought forward and the newly formed loops left under the beards of the needles. The last set of loops of the fabric already finished is around the needles and held by the sinkers, so that by closing the beards and moving the sinkers forward the previous course of loops is slipped off the needles ; the newly formed loops in the beards have now only to be forced by the sinkers to the back of the needles for everything to be ready for the next row of loops to be added as before.

The downward movement of the presser bar is derived from the central treadle, the return being secured by a spring. The motion of the jack sinkers is obtained from a cord connected with a flywheel which is reciprocated by two treadles, while the lead sinkers are moved by two plates at the sides of the machine which depress them simultaneously.

A diagrammatic model, (M. 3094) made in the Museum workshop, and illustrating the principle of the stocking frame, is also shown.

M. 3007. 31,814, L.S.

90. STRAIGHT KNITTING MACHINE. Contributed by Sir Joseph Whitworth, 1860.

This machine, patented in 1846 by Sir Joseph Whitworth is a greatly improved form of a machine jointly patented by himself and Mr. John Wilde in 1835. It is intended for straight work, but owing to the ease with which the width, or number of stitches in a row, can be varied, it is suitable for shaped articles.

The machine consists of a cast-iron frame carrying a long slide holding the knitting needles, which hook upward, but have no beards. Behind the guides is a horizontal shaft with four cams on it, arranged for driving by hand or by belting. The bobbin of thread or yarn is supported in a frame at the back, and is pressed by a weighted lever that gives the necessary tension ; beneath this bobbin are supports for a second one, the thread from which could be passed through the machine with the other thread when knitting portions of garments requiring extra thickness. The stitch is made by the hooked needles and three moving pieces : one is the feeder or eye that leads the thread between the needles and round the hook ; the second carries the hook that lifts the back thread on the needle, up and over the hook of the needle ; the third is a presser that forces back the work from the hooked end of the needle.

The feeder that carries the thread leads it horizontally between the two nearest needles ; the row of needles then advances, and the thread is led outward again, so getting hooked by the needle ; the lifting hook then moves along the upper surface of the needle, which is grooved, and lifts the loop from the previous row over the hook of the needle, so looping it over the thread that is still retained in the hook of the needle. The presser now swings horizontally, and then descends between the lifting hook and the needle, so removing the loop from the lifting hook, and then by a backward motion presses the work back along the needle ; at the same time the needle forms a loop round the presser, which loop is retained until the thread has been led by the feeder round the next needle hook. The intermittent movement of the slide holding the needle is given by a rack in which engages a lever from the largest cam ; the groove of this cam has a swinging tongue in it, and when the stops limiting the travel are reached, this tongue is automatically thrown over so as to reverse the feeding direction of the cam.

These motions are given by cams on the main shaft; the complex movements of the presser are obtained from a single cam and a double one, the arrangement being equivalent to three cams that give a controlled motion in three directions at right angles. M. 585.

91. CIRCULAR KNITTING MACHINE. Lent by Messrs. Cooper, Corah & Sons, 1897.

A circular machine for knitting cylindrical objects was first patented by Sir M. I. Brunel in 1816, but many years elapsed before the construction was sufficiently perfected to enable the high speed possible by such an arrangement to be utilised. The example is an early form of the construction now found in the machines of this class, and was built for knitting the material used in making stockings; the large circular machines now employed for making knitted cloth have the ring of needles arranged horizontally, while the finished pipe of fabric descends vertically.

The machine shown has two knitting heads secured on a single frame and driven by bands from pulleys at one end. In each head the needles are arranged horizontally in a vertical ring, with their hooks, or beards, turned outward. As the ring revolves these needles act as wheel teeth, engaging with the teeth of three skew-bevel pinions which turn freely on inclined axes secured to the main framing. The first of these pinions presses the thread between the needles and also under the beards; the second pinion more uniformly distributes the thread amongst the loops thus formed, and a fixed roller now closes the beards, whilst the third pinion pushes the loops on the back of the needles over the beards, thus virtually drawing a new loop through each loop of the preceding row, as required in the knitting process. A stationary circular wedge held within the ring of needles forces the work backward along the needles; it is thus ready for the commencement of the formation of the next series of loops by the insertion of the thread under the needle barbs. The finished work is kept taut by the horizontal pull of a weighted cord.

In the large modern machines previously referred to, several threads and groups of wheels are simultaneously being acted upon by the single ring of needles, thus greatly increasing the output. M. 3008. S. M. 806, L.S.

92. CIRCULAR KNITTING MACHINE. Contributed by W. Smith, Esq., 1860.

In this early circular knitting machine the needles are arranged vertically, and held by a wide flexible band or chain, inside of which the finished work passes downward. At the front of the machine is a clip that holds a length of the band equivalent to 12 needles, and by the motion of the machine the band is forced through the clip a distance equal to the pitch of the needles at each stroke. At the top the needles are hooked outward, and over the centre of the clip rises and oscillates a hook that lifts a thread over a needle; while two side levers keep down the work, another lever leads the thread under the hooks of the needles.

The freedom of the needles and the way the thread is led cause this machine in its working to resemble somewhat knitting by hand; it appears to have turned out good work, but the stitch-at-a-time action probably rendered it somewhat slow. M. 584.

93. CIRCULAR KNITTING MACHINE. Woodcroft Bequest, 1903.

This machine was patented by Mr. J. A. Tielens in 1842, and is designed for circular work. It is suspended from a vertical frame, and the needles are arranged radially in a horizontal circle with their barbs, or beards, upward; the closing of the beards at the right time is performed by an inclined roller. Between the needles are vertical jacks, worked by a cam below in such a way that they drag down and retain the thread as required for the operation of knitting; a central cam gives to the jacks a radial motion that enables them to lift the loops off the needles.

The machine is worked by a winch handle at the top, and the finished knitting is wound upon a roller carried on a suspended frame that pulls down the work as completed. M. 28.

94. CIRCULAR KNITTING MACHINE. Lent by Messrs. W. H. Dorman & Co., 1889.

This is a modern circular knitting machine, arranged for driving by hand or steam power and suitable for knitting stockings or similar articles.

It has a set of vertical needles, raised and lowered by a revolving cam, which engages with a projection near the bottom of each needle; the needles hook outward, and are provided with hinged latch pieces which, when up, mask the hooks. As each needle is raised, the loop already within the hook, being pulled down by a weight suspended from the end of the fabric, opens the latch piece, and as the needle continues to rise, the latch piece is pressed completely through the loop. When the needle is lowered this loop pushes the latch piece up and passes off the needle.

There is a rotating arm carrying a guide piece, which leads the threads into the hooks whilst the needles are being lowered, and also prevents the latches from closing too soon. The needles move up and down in slots, between which there are ridges which act as sinkers in forming the loops. As the needles are lowered, the newly formed loops remain in the hooks, whilst the previous course of loops pass off the needles, so that the new loops are drawn through those previously completed as required in the operation of knitting.

To give the ribbed pattern necessary where extra elasticity is required, a second set of similar needles is provided, which, however, move radially in a horizontal plane. These needles are arranged at regular intervals between the vertical needles, and are moved in and out by a cam. They have their hooks upward, and form a series of stitches in which the direction of looping is reversed. In each of their stitches the newly formed loop is drawn through the previous one in the opposite direction to that in which the stitches are formed by the vertical needles, but the ribbing needles form their stitches by the same operations as the vertical ones; the nature of the ribbing loops is determined, however, by the height of the cam disc by which their needles are moved.

M. 2263. 808, L.S.

95. ELEMENTARY MILLAR LOOM. Lent by Millar Loom Co., 1902.

This straight knitting machine or knitting loom, patented by Mr. John Millar in 1891-8, was designed for the purpose of making a more compact and less elastic cloth than that produced by simple knitting.

The structure of the fabric produced, shown in the loosely knitted enlarged specimen adjacent, consists of a series of straight longitudinal warp threads, a series of straight transverse filling threads laid continuously along under the warp threads, and an upper series of weft threads alternating with the filling threads. The knitting threads are looped singly into each other, and pass between and around the warp threads and under the filling threads, thus holding the latter in place.

In the explanatory machine shown there are one set of knitting needles, two bobbins of weft and one roller of warp threads. Each needle consists of a hook provided with a swinging latch, and is guided vertically in a slot formed in the needle bar, whilst a horizontally reciprocating slide, provided with a cam slot, engages with lugs formed on the lower part of the needles and so raises and lowers them successively. An upper cam block, driven from the main slide by spring catches actuated by cam plates at each end of the stroke, carries the filling thread guide and, moving along under the warp guides thrusts them forward at the right instant, whilst the guide over the needles carries the knitting thread. By these arrangements the relative positions of guides, and elevated needles are maintained during both strokes, and the warp guides are successively thrust outward just in advance of the filling guide. At the same instant the needles commence to rise above the needle bar, and the filling thread is laid under the warp thread behind the needles and upon the previously formed knitting thread loops around them. The guides then draw the warp threads back across the filling thread, and this is followed by the introducing of the knitting thread, which is at once converted into loops by the hooks of the advancing needles being drawn through the previous loops which, by means of the latches, slip over them.

A complete Millar loom consists of a framework carrying two straight sets of vertical reciprocating needles arranged in groups and actuated by revolving cams, a series of mounted and guided warp threads, an upper series of knitting threads, and a lower series of filling threads. It has as many pairs of bobbins as there are groups of needles, and they are attached to endless chains which carry them continuously round the whole range of needles, by which arrangement the speed of working is increased and two connected webs or widths of fabric are simultaneously produced. M. 3220.

FINISHING TEXTILE FABRICS.

After having been woven into cloth by the loom, very many materials require further treatment to fit them for their special uses; such processes are here arranged under the head of finishing, with which are included the dyeing and printing of fabrics.

Washing, saturating with various sizes, and subsequent calendering give to calico goods a smooth surface, but, owing to the increase of weight that can be obtained by heavy sizing, the process has sometimes been carried to great excess. Beetling is a process by which a cotton fabric is rendered softer and is also consolidated, usually by some form of drop hammer or stamp, but a similar action has been obtained by chequered rollers (*see* No. 96). With woollen materials it is usually desired to obtain a finish that hides the individual threads of the warp and weft. This is given by brushing or treating the surface with hot water, by which treatment the stray fibres projecting from the threads are matted together so as to form a nap that conceals the individual threads; when worn off it leaves them visible and gives the appearance known as threadbare. An early machine for raising a nap or pile is seen in No. 97.

Colouring or dyeing is chiefly a chemical process, the machinery employed being usually simple; three examples of washing or dyeing machines for calico are in the collection (*see* Nos. 98-100).

Printing is a means of embellishing textile fabrics far more cheaply than by weaving the pattern in a loom. For many years the printing was done from heavy wooden blocks having the pattern on their faces, those parts being cut away where no colour was required. The blocks were furnished with colour by placing them face downward on a cloth stretched on a frame which floated on gum-water, and on this cloth the printer continuously brushed the required colour. Such blocks are seen in Nos. 102–104. When the pattern required more than one colour these were supplied successively by different blocks (*see* No. 106). Instead of applying coloured matter, however, the printer frequently used a chemical mixture known as mordant, which, where present, acted on the dye when the article was subsequently immersed in the dye vat; white spots are sometimes obtained by printing them with wax before dyeing, so preventing these spots from absorbing the colouring matter. In modern calico printing, however, rotary machines are almost entirely employed, the pattern being engraved on the copper surface of the roller, and the impression taking place when passing between the printing and platen rollers.

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96. MODEL OF BEETLING MACHINE. (Scale 1 : 4.) Lent by Messrs. Ridgway, Bridson, Son & Co., 1857.

Beetling is a process employed on certain cotton goods requiring the soft finish which is obtained by hammering or flattening the surface of the cloth.

This model shows a form of machine patented in 1855 by T. R. Bridson, in which, however, no hammering action occurs, but a somewhat similar effect is produced by the use of an indented roller.

There are three horizontal rollers, the top and botttom ones, which are smooth, being carried in sliding bearings, while the central one, which has on its surface diamond-shape projections, is rotated in fixed bearings. By this motion the cloth is wound off the upper roller and, passing round one side of the central roller, is then wound on the lower one; when this is full the motion is reversed, and so on until the desired finish is obtained. The upper and lower rollers are pressed against the central one by weighted levers, and in its repeated passages between the rolls the cloth is being pressed by the projecting surfaces of the central roll upon the soft padded surfaces given by the cloth on the winding rolls, so causing a uniform working of the material. M. 97. 20,776. L.S.

97. MODEL OF TEASING MILL. (Scale 1 : 8.) Received 1895.

Teasing is a process for raising a pile or nap on the surface of woollen cloth by scratching the material with teasels, which are prickly seed balls covered with minute hooks that open and loosen the uppermost fibres when drawn over the cloth. Originally the teasels were set in a frame which was rubbed over the cloth by two men, but by arranging them on a cylindrical drum a more convenient method was developed, that led to the construction of the teasing or gig-mill shown. The model was constructed more than a century ago in the West of England, whence the gig-mill was introduced into France in 1802–7 by State assistance.

The mill has a large open horizontal drum, between the bars of which can be secured metal frames carrying teasel balls. The cloth is teased during its contact with the hollow drum while being wound from a roller above it to another below, and *vice versâ*. The upper roller and the drum are directly connected by spur gearing, giving a linear speed to the teasels of about 18 times that of the cloth. The lower roller is driven by the drum through friction gearing only, the contact of which is controlled by a lower lever. Each roller is in two lengths, and is provided with a claw clutch, by which it may be released, and a friction brake.

As the teasing must be repeatedly performed before the surface is finished, the cloth when all wound on to the lower roller is wound back again on to the upper roller and so on, the direction of motion of the cloth being continually reversed, but, owing to the form of a teasel, the teasel cylinder must run continually in one direction only. This is arranged as follows : when winding on to the upper roller, the friction gear of the lower roller is open, the roller being simply retarded by its brakes ; when winding on to the lower roller, this latter is driven by its friction gear, and the upper one, which is released by its clutches, is only retarded by its brakes, which are weighted to maintain the requisite tension on the cloth. M. 2749. 20,689, L.S.

98. MODEL OF WASH-WHEEL FOR CALICO PRINTERS. (Scale 1 : 4.) Contributed by Messrs. Hoyle & Son, 1857.

This machine consists of a large wheel or drum divided into four parts by radial divisions. There is a large hole in the front of each compartment, through which the pieces of calico to be washed are introduced. At the back of the wheel is a circular slit through which a jet of water is directed from outside, so that as the wheel revolves on its axis the goods are thrown over and over in front of the jet of water, and also fall heavily to the bottom of the compartment, the combined treatment thoroughly washing them. At the outer edge of the back is a series of small holes through which the foul water runs off as each compartment passes the lower portion of its path. Inv. 1857–109. 20,777. L.S.

99. FLANNEL WASHER. (Scale 1 : 4.) Made from information supplied by Messrs. Armitage & Crossland. 1914.

This model represents a machine patented by G. A. Crossland (No. 6436, A.D. 1912) for use in steam laundries. Flannels and woollen goods have always presented difficulties in washing, and the dolly-tub method had been considered preferable to any mechanical process. This machine is an elaboration of the dolly tub. Its action consists in the alternate pressure and suction of four cups which move up and down in a tub and come down in a different place each time.

The power is transmitted through a horizontal shaft and a pair of bevel wheels at the top to a vertical shaft carrying a crank arm, in the outer end of which is socketed the upper end of an inclined spindle whose lower end turns in a spherical bearing centrally placed on the boss of the tub, which carries at the top a fixed horizontal bevel wheel gearing with another on the inclined spindle. Above the latter bevel wheel, fixed to the spindle, is a shoe on which are centred four rocking arms which carry, pivoted by shackles on their outer ends, the four cups or pressers. The rocking arms are held down by springs fixed to the shoe, so that when it meets with thicker fabric in the tub a presser adjusts itself to the resistance encountered. The number of teeth in the bevel wheel on the inclined spindle is thirteen, and that of the fixed central wheel is fifteen, so that the inclined spindle turns to the extent of two teeth on its own axis for each revolution of the crank arm, and the pressers come down in different parts of the tub each time. To provide against the sides of the tub being hit by the centrifugal tendency of the pressers the short vertical arms which carry them are connected by rods passing round the spindle. Only one such rod is shown in the model.

The washing liquor is soft water at a temperature of not more than 100° F., with potash soap and sometimes a little ammonium hydrate. The flannels are treated in two waters, and the time taken for one batch is half an hour.

Inv. 1914–121.

100. MODEL OF WASHING AND RINSING MACHINE. (Scale 1 : 4.) Contributed by Messrs. Ridgway, Bridson, Son & Co., 1857.

This machine, which was patented in 1852 by Mr. H. Bridson, is intended to wash and rinse calico in the piece, two lengths passing simultaneously several times through a tank, at the same time receiving a flapping motion to assist in the removal of impurities.

At the top of the tank at one end are weighted feeding rollers from which the calico passes to guide rollers at the bottom of the tanks; it then passes horizontally to a revolving flat frame or wince and back to another revolving wince, round and under which it passes to a lower guide roller, then upwards to an upper guide roller, and finally to a pair of squeezing or drying rollers over the tank. The squeezing rollers and the two winces are all connected by gearing, so that a regular flapping motion can be maintained. The level of the water is varied to suit the work upon which the machine is engaged; for washing it is considered that the material should strike the surface of the water, while for use in dyeing continual immersion is recommended.

Inv. 1857–110. 20,890, L.S.

101. MODEL OF DYEING APPARATUS. (Scale 1 : 8.) Contributed by Messrs. Hoyle & Son, 1857.

This machine runs pieces of calico, whose ends have been stitched together into an endless length, repeatedly through dye liquor contained in a tank, so ensuring complete and uniform saturation.

There are two long dye baths arranged in line, with a space between for mechanism; over each bath is a square horizontal revolving prism, and at the bottom of each bath are two rollers. The baths are divided into compartments by open partitions to keep the calico pieces separate, and centrally along the bottom of the tank runs a steam pipe for maintaining any desired temperature. Above one of the immersed rollers is a sloping shelf, on which the piece being dyed rests in a pile that is being continually added to at the top and drawn from at the bottom, a great length of fabric being thus under treatment in each tank. Inv. 1857–108. 20,779, L.S.

102. BLOCKS FOR PRINTING CHINTZ. Received 1875.

There are seven cases containing specimens of the wooden blocks used for printing chintz by hand, as used in England about the year 1800. Each block consists of a mahogany or oak base with a thin face of the more expensive boxwood. The pattern is drawn in reverse on the boxwood and then cut into it, but a small border pattern shown has been prepared by the use of brass pins.

Block printing for textile fabrics with repeating patterns is now almost superseded by rotary printing from engraved copper rollers, such as are shown n No. 107. M. 1774. 21,074, L.S.

103. BLOCKS FOR PRINTING SILK AND CALICO. Contributed by Messrs. Hoyle & Son, 1857.

Two blocks and a portion of a metal stereotype are shown. The blocks are built up of soft wood at the back, where are provided recesses by which a firm hold can be obtained with one hand when using them for printing. At the corners are pins by which in a repeating pattern correct register is attained.

The patterns are cut in small pieces of boxwood with which the block is faced, but fine lines and dots are rendered in metal tape or pins; in one case the pattern is outlined in copper tape, the solid portions being obtained by filling in the outlines with cement. In large patterns containing blotchwork the surfaces were often recessed and then filled in with felt, which readily took up the colour. Inv. 1857–105.

104. TWO-COLOUR PRINTING BLOCK. Received 1900.

This is a hollow block, built up in sheet iron, with handles on the top and provided on its lower face with projecting pieces corresponding with the portion of the pattern that is in the most prevalent colour. Within the block is a plate, pressed upward by springs and provided with a knob by which it may be forced downward; from the lower face of this plate project pins, corresponding with the portion of the pattern in the second colour, and passing freely through holes in the lower face of the block.

When the block is placed on an inking pad the fixed portions only are in contact with the colour; but when removed and the knob depressed, the second portion of the pattern becomes the more prominent, so that it can be inked on a second pad of a different colour. The block is thus charged with both colours, which can be simultaneously printed by placing it on the work and pressing downward both the block and the knob.

Making the patterns in two portions, for different inkings, and placing them together when impressing, ensures good register with rapid production, and is the device by which the Government stamps on patent medicines are printed.

M. 3131.

105. MODEL OF CALICO PRINTING MACHINE. (Scale 1 : 6.) Maudslay Collection, 1900.

This is a platen machine patented by Henry Maudslay in 1805 to reduce the time and labour required in printing from blocks by hand (*see* Nos. 102 and 106).

The engraved block, or copper plate, is supported on a table which, by two eccentrics on a horizontal shaft, is lifted and powerfully pressed upwards against the calico whilst it is resting under a flat platen that forms the connection between the side frames. There are three blanket rollers, the upper one of which is in adjustable guides, while the front one is fluted, and receives a periodical feed motion by intermittent gearing driven from the eccentric shaft, so that after every impression the calico is carried through by the blanket a distance equal to the width of the block. The frame carrying the printing plate is in duplicate and hinged, so that while one plate is printing the other is in a convenient position for being inked; this arrangement also permits of printing in two colours. In the specification, arrangements are mentioned for drying the work by steam as finished.

The machine appears to have achieved considerable success, but was supplanted by the cylindrical form (*see* No. 111). M. 3123.

106. MODEL OF BLOCK-PRINTING MACHINE FOR CALICO. Scale 1 : 4.) Contributed by Messrs. Hoyle & Son, 1857.

This is a model of a machine, patented in 1840 by Mr. R. Hampson, for printing calico from blocks. It is arranged for printing in five different colours, but can also be used for single work.

The block is supported face downward in a frame that slides in vertical guides; it is counterbalanced by a chain that passes over pulleys and is attached to a weighted rod. The calico is supported on a blanket-covered table below the block, so that by lifting the rod the block descends by its own weight and so impresses the calico. On rails secured to the sides of the table runs a carriage supporting the inking arrangements, and after printing an impression on the calico the carriage must be pushed under and the block be lowered upon it for a fresh inking, before a second impression can be properly printed.

The calico is on a roll at one end of the machine, and after being printed passes over a hot-water or steam plate and round a long course, to dry it before it is wound up in a finished roll. The blanket beneath the calico is protected by a second calico piece which passes through the machine with the actual work. The machine is arranged for printing in five colours, which are shown on the inking carriage. The block is in five sections, and after each impression the calico is wound forward a distance equal to one-fifth of the width of the block, so that at each impression an additional colour is printed. The colour reservoirs and the spreading brushes are shown in position. Inv. 1857-107. 20774, L.S.

107. CALICO PRINTING ROLLERS. Presented by J. D. Mucklow, Esq., 1865.

These short specimens of small diameter illustrate a method, patented in 1857 by Mr. Mucklow, of reducing the cost of calico printing rollers by making them of iron and coating them by electro-deposition with the more valuable metal which resists corrosion.

I. represents a roller before engraving; II. is a similar roller engraved by one of the methods described in an adjoining exhibit; III. is an engraved roller electro-plated with copper, and IV. is a similar roller coated with nickel.

Inv. 1865-20

108. ENGRAVED STEEL MILL. Presented by Robert Leigh, Esq., 1914.

This is a steel mill for preparing the copper rollers used in calico printing. Such rollers were engraved laboriously by hand until 1808, when Joseph Lockett applied to them the method of using dies, introduced earlier by Jacob Perkins for multiplying engraved plates used in printing bank notes, etc.

The pattern is engraved in intaglio on a steel roller known as the die, which is usually of such a circumference as to take one repeat. The die is then hardened and placed against a similar steel roller two to four times its diameter in a "clamming" press, where, by rotation under pressure, the design is transferred in relievo to the second roller, which, when hardened, is known as the mill—the object here shewn.

This mill is now used in a similar manner in the engraving machine for impressing its designs on the copper printing roller which is some multiple of its diameter. There is a screw arrangement for moving the mill laterally to repeat the design till the whole roller is engraved. The design can thus be faithfully reproduced as often as desired with the minimum of skilled labour.

A specimen of calico printed by a roller engraved by the mill is shown.

Inv. 1914–211.

109. MODEL OF CARPET PRINTING MACHINE. (Scale 1 : 8.) Woodcroft Bequest, 1903.

This is a model of a machine, patented in 1839 by Mr. Joseph Burch, for printing from blocks on textile fabrics or paper. The machine and a modified form of it (*see* No. 110) were first tried on a practical scale at Messrs. Crossley's works at Halifax.

The tapestry, carpet, or other material is wound on a roll that is well clear of the floor level; from the roll the carpet passes through a tension device and over a large drum, then over a printing table within the machine, and round another large drum. From this it returns at a lower level to a frame of 15 guide rollers, round which it passes with its printed surface always outward; by this exposure it is sufficiently dried to be wound in a finished state on the roller in the centre of the frame.

The printing blocks, of which there are six in the model, are carried in frames which, by plate springs, are supported face downward on a large reciprocating frame, which travels in a direction at right angles to that of the carpet being printed. When either set of blocks is over the printing table the reciprocating frame stops, and several spring pressers force the frames down under the action of a crank or toggle mechanism; the other set of blocks is at the same time over the inking tray, upon which, by similar pressers, the blocks are forced downward for inking; the printing pressers contain within them a trigger gear by which they are enabled to give a blow when down on the block.

Within the machine is a large endless apron or blanket, which forms an elastic covering for the printing table and one which is being continually changed; with the blanket also passes an endless oilskin apron upon which the colour squeezed through the material being printed is deposited, and this apron is being continually washed and dried by an arrangement of guide rollers, etc., at one end of the machine.

The fabric is advanced by a step motion given to the main drums, driven by a cam on the main shaft; a similar motion traverses the blanket and oilskin apron. The reciprocation of the carriage and most of the motions are derived from cams. By the arrangement of the blocks six different colours can be printed at the same time by this machine, or two pieces of fabric may be passing through the machine at once and receive different patterns, each of which contains three colours.

Inv. 1860–9. 20,894, L.S.

110. MODEL OF DRUGGET PRINTING MACHINE. (Scale 1 : 8.) Woodcroft Bequest, 1903.

This is a model of a machine patented in 1843, by Mr. Joseph Burch; it is a simplified form of his earlier machine, No. 109, and although stated to have been designed for printing druggets, it is also suited for general block-printing in colours. His patent also describes an arrangement that embodies the important features of the modern cylinder machines for calico printing.

The general object of the design is to ensure accurate registering of the several blocks by which the pattern is printed, and to prevent the accumulation on the table of colouring matter that has been pressed through the work in progress.

In the model six blocks are mounted three abreast and face downward in a reciprocating frame, each set when at the centre of the machine being depressed by a cam mechanism, the other set of blocks being at the same time inked by inking rollers that are driven so as to have the same surface speed as the blocks. The reciprocation of the frame is performed by two cams and a multiplying gear that drives a rack secured to the frame.

In the centre of the machine is a printing table, and beneath it a large drum that moves the fabric at each reciprocation through one-half the pitch of the blocks in the frame. Over this table and round the drum passes an endless apron that is led to rollers on the outside frame, where also is a tightening roller. Outside the apron is an under-cloth, which receives any excess of colour pressed through the drugget during printing ; this under-cloth is on a roll at the bottom of the machine, controlled by a brake, and after passing with the apron over the table is wound on a similar roll above the end frame. The drugget to be printed is on a roll, from which it passes round tension bars and over the printing table ; it is then carried by the apron to the end of the frame, where it is separated from the under-cloth and conveyed to a drying screen (not shown), and is finally wound in a finished state on the highest roller of the frame.

Inv. 1860–10. 20,895, L.S.

111. MODEL OF ROTARY PRINTING MACHINE FOR CALICO. (Scale 1 : 4.) Contributed by Messrs. Hoyle & Son, 1857.

This is a model of a single-cylinder calico-printing machine, and resembles the four or more cylinder machines now used. The pattern to be printed is engraved on a copper roller, which is inked or coloured by a roller that runs in a bath of colour and has its upper surface in contact with the printing roller ; the excess colour is wiped from the revolving printing roller by a fixed steel blade that has a slight longitudinal reciprocation ; this blade, called the colour doctor, wipes off all the ink except that in the engraved lines. The calico to be printed is on a roller near the machine, and its delivery is controlled by a friction brake which keeps it tight ; it is stretched widthways by passing over two bars, the upper surfaces of which are grooved in opposite directions. The calico then passes under the platen cylinder that presses it upon the printing cylinder, the two cylinders being pressed powerfully together by the lever arrangement in which the bearings are carried. After printing, the calico passes upward and then horizontally over a series of steam-heated chests, then vertically downward in front of similar chests, then horizontally and vertically through a long course, during which the drying is sufficiently completed for the calico to be wound on a roller at the drying end of the machine. The cylinder is continually being wiped on its leaving surface by a second flexible blade, called the lint doctor, which frees it from any fibres deposited by the calico.

An endless felt or blanket passes round the platen cylinder with the calico, and then round beneath the drying chests, returning backward by a circuitous course in which arrangements for taking up the stretch are provided. This blanket forms an elastic cushion for the calico while being printed ; it also absorbs and carries away any excess colouring matter.

The application of engraved copper cylinders to the printing of textile fabrics was patented in 1764 by Messrs. Fryer, Greenough and Newbery ; the employment of the steel-strip doctor as here used was patented by Mr. T Bell in 1783.

Inv. 1857–106. 20,783, L.S.

SEWING MACHINES.

Needles of the present shape, but more clumsy and made of bone, were used in prehistoric times. The common steel needle is a comparatively modern invention, and was probably introduced into England in the 16th century ; the manufacture has been carried on in the district of Redditch for about 200 years, and during this time the shape has undergone but little change. As in the case with many simple appliances, the work done with it has not been surpassed by machinery, but the skill and attention required are great, and the speed of hand sewing, about 30 stitches per minute, is exceedingly slow when compared with machine work.

In 1775 C. F. Weisenthal patented a needle with a point at each end and the eye in the middle of its length so as to avoid having to turn the needle over when sewing, and such needles pulled and pushed by mechanical pincers have been used in some sewing machines.

In 1790 T. Saint patented a machine (*see* No. 112) which, if constructed at the time, was the first sewing machine; his drawings embody many of the features that have now become permanent. The stitch is, however, of the single thread or chain type, and two needles are required, one acting as an awl, and the following one, with a notched end, passing the loop through the prepared hole; the machine was intended for leather sewing. In 1830 B. Thimmonier invented and constructed a successful sewing machine, and, with financial assistance from friends started a factory in which many of these machines were used and their arrangement improved (*see* No. 113). His machine did the chain stitch, and used a single pointed needle with a side notch for the eye. Elias Howe, in 1845, constructed and subsequently patented the first lock-stitch sewing machine, using an eye-pointed needle and an independent shuttle, each threaded (*see* No. 114). He at once disposed of his English interests to W. F. Thomas, of Cheapside, in whose name the English patent stands. Although Howe was the first man to make a practical success of the lock-stitch sewing machine, he was not the first inventor of the devices that rendered it practicable. In 1832-34 Walter Hunt constructed such a machine with an eye-pointed needle and an oscillating shuttle, and the eye-pointed needle had been patented in England in 1841, but Howe re-invented them, and made the machine a commercial success. In 1849 A. B. Wilson invented the rotary-hook lock-stitch machine, in which the shuttle is reduced to a circular spool round which the needle thread is taken by a revolving hook; examples of this machine are seen in No. 124. He also introduced the spring presser-foot and cloth plate, now universal, as well as the four motion feed below the plate that moves the work after every stitch. I. M. Singer, who patented his first machine in 1851, did much to accelerate the commercial introduction of the sewing machine, but till Howe's (or Thomas's) extended patent expired in 1867, royalty had to be paid by all lock-stitch machine makers.

Sewing machines are now made in many modified forms, to suit special purposes, but in their action they may be divided into two classes, the chain stitch and the lock-stitch.

In the chain stitch or single thread machine, which was that first invented, the needle passes down through the work to the bottom of its stroke and then lifts a little so as to leave a loop of thread, which by the revolving hook is opened and held while the needle retires. When the needle again enters the fabric in a fresh place it passes through the loop retained by the hook so securing it, while the hook disengages itself and enters the fresh loop, and so on. The high speeds possible with these chain stitchers and the ease with which their work may be undone are great advantages, but for many purposes the sewing is not sufficiently secure, so that domestic machines are not usually of this class.

In the lock-stitch machine the needle, after passing through the fabric and reaching the extremity of its downward stroke, rises a little, then stops, so causing the thread to loop out from the needle. Through this loop a small metal shuttle with one side flat and having a sharp point, is passed, so leaving its thread through the loop; the needle then lifts completely, and the stitch is drawn tight, there being one thread above the fabric and another below, these crossing each other at the centre if the needle and shuttle tensions are correctly adjusted. As such sewing can only be undone by picking it out a stitch at a time, the work is very secure. In some lock-stitch machines the shuttle is cylindrical and does not move, the loop from the needle being carried round it by a revolving hook, but the resulting stitch is the same. By giving a variety of motions to the needle or to the work-plate a sewing machine will do such work as herring-boning and ornamental stitching, and the sewing of button holes is done in this way (*see* Nos. 141 and 143).

112. SAINT'S SEWING MACHINE. Bequeathed by Newton Wilson, Esq., 1894.

This machine was constructed in 1874 by Mr. Wilson, from the drawings contained in a patent granted in 1790 to Thomas Saint, cabinet-maker, of London. The specification describes methods of making a kind of artificial leather for use in the manufacture of boots and shoes, but the drawings show and describe three machines which Saint says may be worked by hand or steam power, and be used in making boots and shoes. The first machine is for spinning and doubling thread, the third machine is for plaiting or weaving, while the second, as here represented, he says is for " quilting, stitching, and sewing." It would now be described as a chain-stitch or single-thread sewing machine, and will be found to embody many of the most important features of the modern machines. It is not known if Saint actually constructed such a machine, although the drawings suggest that he did. He probably did not proceed with it, however, as the only subsequent patent in his name was granted in 1802, and is in connection with steam-boilers.

The machine consists of a table with an overhanging arm, as in the present machines, and a horizontal revolving shaft which by cams or tappets reciprocates a vertical needle-bar, traverses or feeds along a box supporting the work, and reciprocates a two-pronged lever and ratchet by which the thread is tightened and the looping performed. The needle-bar contains two tools, the first being an awl and the second a needle, which, instead of an eye, has a simple notch at the lower end, the thread being carried by the notch through the hole already perforated by the awl. The loop so formed below the material was carried along by the ratchet and held for the next loop to be forced through it, and so on, in a way that we now know to be quite easy and satisfactory. The thread in use was contained on the reel on the arm of the machine just as at present.

M. 2688. 20,516, L.S.

113. THIMMONIER'S SEWING MACHINE. Received 1881. Plate III., No. 2.

This is a copy of a sewing machine used in some patent litigation in America and stated to have been sent to that country from France in 1830.

In 1830 Barthélemy Thimmonier, a tailor of St. Étienne, patented in France a sewing machine resembling this copy, and obtained with it such success that, by 1841, 80 were in use, but a mob then destroyed them all. Thimmonier constructed fresh machines which, it is stated, would make 200 stitches per minute, and this improved type is described and illustrated in his English patent of 1848. One of his machines was shown in the great Exhibition of 1851, but was unnoticed, and the inventor died in poverty and obscurity on 1857. Although the machine shown has a flywheel driven by a treadle for reciprocating the needle-bar, Thimmonier's patents show the reciprocation obtained directly from the treadle without any flywheel, but whatever the date of the original of this copy, the sewing and knotting mechanism appears to be the same as that of his early machines.

A vertical reciprocating rod carries a horizontal arm from the extremity of which projects downward the needle-bar, and also a presser-foot which is in the form of a nipple that may completely cover the needle. The work to be sewn is supported on a hollow horizontal fixed arm, with a hole above, through which the needle projects downward when at the lower end of its stroke. In this arm is a hook that, by a sliding rack and a pinion, is partly rotated at each stroke, and the thread passes from the reel below to the hook, which wraps it round the needle. The needle is pointed, but also barbed, and having the loop of the thread from the last stitch round it and above the cloth, descends, making a fresh hole, and, while below, the thread carrier winds the lower portion of the thread round the needle which, then rising, draws the lower thread through the upper loop, and so on, thus forming a chain stitch, but one having the loops on the top side. The needle-bar is partly rotated during the upstroke, so as to prevent the barb from catching the upper loop, and it is rotated back again on the downstroke.

The work is fed along by hand between each double stroke, and the presser-foot or nipple holds it down during the upstroke. The return motion of the reciprocating parts is obtained by springs, and the lifting of the presser-foot is done by a catch from the needle arm, but the catch is thrown off automatically when the necessary height has been reached. M. 1527. 20,515, L.S.

114. COPY OF HOWE'S ORIGINAL SEWING MACHINE. Presented by the Howe Machine Co., 1862. Plate III., No. 3.

In this, the first successful lock-stitch sewing machine made by Elias Howe in 1845, the cloth to be sewn hangs vertically and is fixed on pins embedded in the edge of a thin strip of metal (capable of bending easily to the curve of the seam to be sewn), and this metal strip is drawn through the machine by a pinion gearing into it, and so carries the cloth forward in front of the needle.

The needle is curved, and near its point has its eye, through which the thread passes from a reel above. The needle is attached to a swinging lever, and when its point has passed some distance through the cloth and is returning, a shuttle which slides in a small trough passes through the loop of thread that extends from the cloth to the eye of the needle, so leaving the shuttle thread in the loop. The needle then withdraws completely and both threads are pulled tight, the needle thread being in front of the cloth and the shuttle thread behind, but both threads cross in each hole made by the needle, as in the case of the modern lock-stitch machines.

The several motions for moving the needle, shuttle, and work, as well as for tightening the thread at each stitch, are given by cams on a shaft that is rotated by a hand wheel. The cloth being sewn hangs vertically, while the needle, though swinging in a vertical plane, passes through the cloth horizontally. The shuttle race is horizontal, the face and point of the shuttle being downwards; the shuttle is thrown from end to end of its travel by blocks jerked by levers, in a similar way to that in which a shuttle is thrown in a loom.

Inv. 1862–92. 20,524, L.S.

115. STITCHING MACHINE. Contributed by C. Morey, Esq., 1858.

This machine was invented in 1849 by Mr. C. Morey, and, although not intended for general sewing, is much used in dyeing and other operations in which calico pieces have to be stitched together in a way that when the work is completed will not present any difficulty in unpicking. The machine consists of two spur wheels on horizontal shafts arranged vertically over each other and geared together. In the middle of the teeth of each wheel a groove is turned as deep as the teeth, and opposite the point of contact of the wheels is a bracket supporting a stout horizontal needle that reaches into the groove; on rotating the spur wheels and placing the ends to be joined between the gearing, the teeth crimp or fold the cloth, forcing it forward in this condition and so driving it on to the fixed needle. When the fabric is through, it and the needle are removed from the machine and the needle is used to pull through the thread for the stitching. Inv. 1858–18.

116. COPY OF JUDKINS'S SEWING MACHINE. Lent by Messrs. Platt Brothers & Co., 1909.

The machine, which was made at Messrs. Platt's works, was shown at the 1851 Exhibition by Mr. C. F. Judkins, and, it is stated, worked at the rate of 500 stitches per minute. The work is placed against a vertical table and the needle moves to and fro horizontally. It is a lock-stitch machine, and the shuttle, which is always visible, is held in a carrier working in guides at the front of the machine. The presser-foot takes the form of a flat steel spring, but also contains a toothed roller, free to revolve but held by flat springs that press it on to the work. The feeding is performed by a roughened disc behind the work, that receives intermittent motion from the internal mechanism. Within the cast-iron box that forms the frame of the machine is placed a large cylindrical cam, which can be driven by a hand wheel or by belt pulleys arranged outside. A stud, projecting downward from the needle-bar, engages in a double groove in the cam, the needle making two stitches for one revolution of the shaft. Parallel with this shaft is another, driven by gearing at twice the speed. The second shaft, by an overhanging crank and connecting rod, reciprocates the shuttle carrier, and by an eccentric drives a pawl fitting into a ratchet wheel on the feed shaft, on which is a pinion gearing into teeth on the feed disc. M. 2562. 20,496, L.S.

117. LOCK-STITCH SEWING MACHINE. Presented by Mrs. S. E. McCulloch, 1898. Plate III., No. 5.

This is an early example of the Howe machine made by Messrs. W. F. Thomas & Co., of Cheapside, who had purchased the British rights in Howe's invention. The machine shown is No. 1231 and is in accordance with Mr. Thomas's patent of 1853.

The needle-bar is reciprocated in vertical guides by a lever actuated by a cam groove on the flywheel disc, and the shuttle carrier is reciprocated in its long horizontal guide by a similar cam. The feed is given by the presser-foot, which receives a scuffing motion from a pair of cams on the flywheel shaft. The thread tension is adjusted by a strap brake acting on the spindle to which the reel is secured. The flywheel shaft is at right angles to the operator, and this arrangement caused the use of a peculiar form of treadle motion in which the treadle bar resembles an inverted **T**. The shuttle bobbins were filled by the independent winder shown, which was attached to the table; the work table of the machine was formed by the small upper board. M. 3014. 20,880, L.S.

118. LOCK-STITCH SEWING MACHINE. Made by Messrs. W. F. Thomas & Co. Received 1883.

This machine closely resembles the construction patented by Mr. Thomas in 1853. The overhanging arm and vertical sliding needle-bar are employed as at present, but the motions for the needle and the shuttle holder are derived from cams in the face of the main driving wheel. The feeding is also derived from a cam motion but is performed by the presser-foot. M. 673.

119. ORIGINAL SINGER SEWING MACHINE. Presented by the Singer Manufacturing Co., 1892. Plate III., No. 6.

This is one of the first Singer sewing machines and, though constructed in 1854, is still in working order. It is a lock-stitch machine, and the shuttle, which is of the elongated form, is worked traversely by a carrier having on its side a **V**-shaped slot in which moves a crank pin attached to the underneath shaft. The needle motion is obtained from a crank pin on the upper shaft working in a **V**-shaped slot in the needle bar. The needle thread tension is adjusted by altering the extent to which the thread is coiled round a smooth wire, and the thread is held at the commencement of the downstroke by an additional tension put on by a cam at the back of the crank plate. The feed is of the wheel type, the feed wheel being moved intermittently by a band, worked by a rocking lever from a cam on the underneath shaft, a wooden brake block giving sufficient friction to prevent the backward motion of the feed wheel during the return of the band.
M. 2456. 20,523, L.S.

120. SEWING MACHINE. Contributed by W. F. Thomas, Esq., 1858.

The special features of this machine were patented by Mr. Thomas in 1855, but in its general arrangement it resembles No. 118. The feeding is done by the presser-foot, but to vary the direction of feed so as to give a curved seam, the foot is carried in a cylindrical guide within which it can be turned. In modern machines this result is generally obtained by turning the work. An independent driving arrangement is added for winding the shuttle bobbins.
Inv. 1858–19. 20,887, L.S.

121. EARLY SEWING MACHINE. Lent by Lawson Tait, Esq., F.R.C.S., 1892.

This roughly constructed machine is said to have been made during the first half of the last century by Charles Kyte, a native of Snowshill, near Evesham. It is uncertain whether Kyte invented or simply copied the important features in this machine.

A four-legged wooden stool supports the table on which the machine is carried. The treadle acts upon a crankled axle carrying a wooden flywheel which is weighted near the circumference by lead run into auger holes. A small pulley on the spindle of the machine is driven by a belt from another pulley on the flywheel, and a crank in the spindle communicates a vertical reciprocating motion to the needle-bar by means of a long rocking lever. A steel ring, fixed eccentrically to the side of the upper pulley, acts as a cam and gives motion to a long arm which works the shuttle carrier. On the other side of the crank which works the needle-bar is a small cam giving a side motion to a horizontal rocking lever which feeds forward the work. The light flat spring on the table, fitted with a small pulley, appears to have been a tension arrangement. The needle and shuttle are missing and their form is unknown. M. 2495. S.M. 576, L.S.

122. CHAIN-STITCH SEWING MACHINE. Presented by H. A Gunby, Esq., 1908.

This double-thread chain-stitch machine, in which an oscillating needle is employed to feed the work, was patented by Mr. G. Whight in 1861.

The upper thread is carried through the work by a needle and forms a loop below, through which a second needle, carrying the under thread, passes. The latter is caught by a hook and held aside, so that when the upper thread needle again descends, it passes through a loop of the under thread. By interlooping the upper and under threads in this manner a form of chain-stitch, wasteful in thread, is obtained.

The upper needle-bar is connected with a disc crank at the end of a horizontal driving shaft and slides in a hinged guide below. An oscillating motion is thus imparted to it in addition to an up-and-down motion, and the oscillations, when the needle has perforated the work, give the feed motion. The length of the stitch can be varied by adjusting the position of the hinged guide, while the thread tension is obtained by placing the reel between centres, which can be forced together by a screw.

Within a vertical arm there is a forked lever which receives a vibrating motion from cams on the main driving shaft, and in turn transmits its motion, by means of a pin and slot, to a horizontal lever below. The under thread needle is mounted upon this lever, which also carries a projecting piece operating the hook, the return motion of the latter being ensured by a spring. The winder for filling the bobbins is shown. M. 3564.

123. LOCK-STITCH SEWING MACHINE. Presented by the Florence Sewing Machine Co., 1867.

This is an early form of machine, and has a very low arm carrying the presser-foot, while the needle, which is curved, is carried on a separate rocking arm and, being directly driven by a crank, has not a preliminary upward loop-forming motion. There is the usual toothed feeding surface projecting through the work-plate, and it receives its motion from a crank; but the direction of feed is immediately reversible, the fulcrum of the feed lever being movable in a slot in the lever, by which arrangement also the rate of feed is varied; this adjustment is made by a milled head at the side of the table. Inv. 1867–2.

124. LOCK-STITCH SEWING MACHINE. Presented by A. C. Hyde Parker, Esq., 1904.

Another contributed by Messrs. Newton, Wilson & Co., 1868.

The earlier of these machines, shown with its work-table removed, was made by the Howe Sewing Machine Co. about 1867, while the other specimen is a slightly improved copy of it. In each machine the power is transmitted from a treadle wheel below (not shown) by a belt running over a small pulley on a horizontal shaft beneath the work-table, there being no spur gearing.

At one end of this driving pulley is an eccentric which actuates a rod connected with an arm capable of being oscillated between centres and provided with an extension piece that serves as a needle-bar; the needle is, consequently, of the curved variety, and there is no special loop-forming movement. The shuttle is of the cylindrical or disc type introduced by Mr. A. B. Wilson, and is carried in a revolving holder provided with a hook by which the loop in the needle thread is carried round the shuttle, so as to be locked by the lower thread; there is a brush in contact with the revolving hook, to check the thread while being carried round. The shuttle hook is on the shaft of the driven pulley, and near it the flange of this pulley is so shaped as to form two cams, one of which gives the vertical movements to the feed bar while the other causes the horizontal reciprocations required to complete the motion; the return portion of the horizontal reciprocation is given by a spring, and there is a cam beneath the table by which the length of stitch can be adjusted. The tail end of the revolving shaft serves as a shuttle-winder, and the shuttle is removable by withdrawing a circular bracket that is retained by a clamping screw. In the latter machine this bracket is carried on a swinging arm fitted with a spring, and the presser-foot is provided with a transparent glass plate. M. 3315. Inv. 1868–10.

125. LOCK-STITCH SEWING MACHINE. Contributed by Messrs. Newton Wilson & Co., 1868.

In this machine the needle-bar moves vertically in a long guide and is driven by a bell-crank that receives its motion from a cam on a horizontal belt-driven shaft below. A similar cam and bell-crank lever, arranged beneath the table, move the shuttle-holder backwards and forwards in a straight horizontal race, while a four-motion feed is given by a toothed lever operated by two small cams on the main shaft. Inv. 1868–11.

126. LOCK-STITCH SEWING MACHINE. Contributed by Messrs. Newton Wilson & Co., 1868.

In this machine a hand wheel provided with internal teeth drives two horizontal shafts arranged above and below, each shaft being fitted with a pinion. The upper shaft oscillates the vertical sliding needle-bar by a crank-pin working in a straight transverse groove. The lower shaft extends below the table and terminates in a revolving hook that encloses a circular shuttle; a cam on this shaft gives the usual feed motion. Inv. 1868–9.

127. CHAIN-STITCH SEWING MACHINE. Contributed by Messrs. Newton Wilson & Co., 1868.

This machine has a rocking needle-bar and a curved needle. It is driven by a belt on a shaft below the table and almost directly under the needle, so that the complete needle-bar is of a **U** shape. The needle motion is given by a crank-pin working in a straight slot in the needle-bar, and the looping hook is on the top of a vertical shaft that has a quick-pitched screw upon it, into which engages a nut fixed to the lower end of the needle-bar. Inv. 1868–12.

128. CHAIN-STITCH SEWING MACHINE. Contributed by Messrs. Newton Wilson & Co., 1868.

This is arranged very similarly to the lock-stitch machine, No. 1396. The lower shaft, however, terminates in a revolving hook that retains the loop of the preceding thread till it is engaged by the next one, in the usual manner of single-thread machines. Inv. 1868–8.

129. LOCK-STITCH SEWING MACHINE. Received 1881.

This represents the original form of a lock-stitch machine manufactured by the Remington Co., and appears to have been made about 1867.

The needle-bar is reciprocated by a cam-groove in a face plate on the horizontal driving shaft, which is provided with a flywheel and arranged for belt driving. By a crank, this shaft rocks a shaft below the table, and this moves the shuttle-holder and the feeding arrangement. The feed is given by a serrated wheel, just showing above the level of the table, and actuated by a lever and friction pawl very similar to the silent feed of a saw frame. M. 1526.

130. LOCK-STITCH SEWING MACHINE. Made by the Howe Machine Co., 1871.

The needle-bar is carried in vertical guides, and is oscillated by a bell-crank that receives its motion from a cam on the main driving shaft below. A similar cam and bell-crank oscillate the shuttle-holder in a straight horizontal race, while a double cam gives a four-motion feed. M. 1236.

131. LOCK-STITCH SEWING MACHINE. Made by the Howe Machine Co., 1888.

This represents the final form of machine manufactured by the Howe Co. The arm is high, and contains a horizontal driving shaft, which by a crank-pin and **V** slot gives motion to the needle-bar that works in vertical guides. The shuttle works in a curved horizontal race beneath the table; it is oscillated by a lever turning on a centre below and driven by a vertical lever swinging on a centre some way up the standard. This vertical lever is oscillated by a crank on the main shaft, a similar crank and lever working the feed motion. For winding the shuttle bobbins uniformly, a spring plate is fitted that presses the thread being wound on the bobbin close to the preceding coil; the thread is supplied from a swinging arm above that gives it a straight lead. M. 1942.

132. LOCK-STITCH MACHINE. Lent by the Singer Manufacturing Co., 1888.

This is described as a family machine and is arranged for driving by hand or treadle.

On the horizontal shaft is an overhanging crank-pin that by a connecting rod reciprocates the needle-bar, while an adjacent cam rocks a lever that forms the thread-tightener. The shuttle is in the form of an oscillating hook containing a short cylindrical bobbin; the hook passes through the loop of the needle thread, carries it round the shuttle and then releases it, so virtually passing the shuttle and its thread through the loop of the needle thread. The oscillation of the shuttle is performed by a horizontal rocking shaft, driven by an arm on a parallel shaft that is rocked by a connecting rod from a crank on the upper shaft. The feed is of the four-motion type and is driven by two horizontal rocking shafts beneath the table; one of these is rocked from the shuttle motion and the other from a cam on the upper shaft which rocks a lever having its fulcrum within the vertical standard. This fulcrum is carried on a rocking lever by which its position can be altered from the front of the standard, and so the length of stitch may be varied. A shuttle-winder is driven by friction from the rim of the flywheel. Beneath the machine is an inclined mirror by which the shuttle and feed motions are rendered visible. M. 1961.

133. LOCK-STITCH SEWING MACHINE. Lent by the Wheeler & Wilson Manufacturing Co., 1888.

This is a treadle-driven machine with the driving belt passing over a pulley on a shaft, contained in the horizontal arm of the main bracket; the needle-bar reciprocates in vertical guides. From a crank on this shaft a slotted connecting rod passes downward and slides on a stationary block; the prolongation of the connecting rod is fitted with a pin that slides in a slotted crank arm on the extremity of a horizontal shaft, extending below the base of the machine. In this way continuous rotary motion is transmitted from the upper to the lower shaft without the use of gearing, but with the required variation in the velocity necessary to give time for the passage of the shuttle. At the extremity of the lower shaft is a revolving hook, which encloses a cylindrical shuttle; when the needle is down the point of the revolving hook passes between the needle and the thread, so opening the loop, carrying it round the shuttle and then releasing it, the result being that the shuttle with its thread passes through the loop between the needle and its thread. The four-motion feed is driven from a cam on the lower shaft. M. 1955.

134. LOCK-STITCH SEWING MACHINE. Lent by the Wheeler & Wilson Manufacturing Co., 1888.

This machine is similar to No. 133, but the communication of the motion from the upper shaft to the lower one is by two cranks at right angles on each shaft and coupling rods, a uniform motion being transmitted, but at the extremity of the lower shaft is a crank pin which, by a short connecting rod, transmits to a crank on the shuttle-hook shaft a rotary motion with the desired variation in velocity. The feed is derived from two cams on the lower rotating shaft and is very pronounced; it is adjusted by a lever near the hand wheel. M. 1956.

135. MOLDACOT SEWING MACHINE. Presented by T. A. Bowler, Esq., 1897.

This portable lock-stitch sewing machine was patented by Mr. S. A. Rosenthal in 1885, but improved and manufactured by the Moldacot Pocket Sewing Machine Co. in 1886-7.

The machine is provided with a cramp for securing it to a table, and, when fixed, is worked by vertically reciprocating the needle-bar, to which, however, the upward movement is given by a spring; in the later form shown, an eccentric and winch handle were introduced for driving, but without any multiplying gear. The shuttle is carried in a segmental holder, which receives a swinging motion owing to a pin on the lower end of the needle-bar engaging with a curved slot in the carrier. The presser-foot is held in an arm forced down by a spring, and rocked by a projection on the needle-bar at each extremity of the stroke; there is, however, an adjustment provided by which the length of the stitch can be varied. The loop-tightener is directly worked by a pin on the needle-bar, but the needle, from its lowest position, rises continuously, leaving a loop behind it without resorting to the usual intermittent loop-forming motion. The tension of the needle thread is regulated by friction plates. M. 3001.

136. JACQUARD SEWING MACHINE. Lent by the Singer Manufacturing Co., 1888.

This is a multiple machine with four independent needles and shuttles at work at the same time; it is designed for sewing the successive pattern cards of a Jacquard loom on to continuous tapes or cords with great exactness, so that they shall all be parallel and at a uniform pitch. The cards are placed on pegs on the rim of a skeleton drum, and by the machine are sewn to four tapes above the cards and four tapes below them; each tape supply is contained on a separate bobbin. The secured cards are carried round by the drum, and then leave it as a continuous pattern chain. All parts are adjustable sideways so that cards of various widths can be dealt with.

The power is received by a shaft near the floor which transmits motion to a rocking shaft that reciprocates the needles, and to four racks that partially rotate four shuttle hooks, which carry the loops of the needle threads round the circular shuttles. The feeding of the cards under the needles is done by the motion of the skeleton drum, which is slowly rotated by a ratchet feed from the main shaft. M. 1962.

137. TWIN-NEEDLE SEWING MACHINE. Lent by the Wheeler & Wilson Manufacturing Co., 1891.

In this machine two needles and threads are carried by a single needle-bar, while a shuttle below passes its thread through both loops, so that two parallel seams, connected by the lower thread, can be simultaneously sewn. In addition, the needle-bar is carried in a swinging guide, oscillated in a direction perpendicular to the feed by a rod fixed in a rocking quadrant on the machine arm and driven by a cam on the driving shaft. By this device the threads can be made to follow a zig-zag course, which is adjustable by altering the rate of feed or the swing of the needle-bar guide. A single needle may be used, and then, with the zig-zag motion thrown out of gear, the machine does the ordinary stitch for general work, the fancy stitching being chiefly employed on leather. M. 2335.

138. BOOT-SEWING MACHINE. Lent by W. H. Beck, Esq., 1885.

This is an experimental model of a machine for sewing boots, patented in 1869 by Mons. A. Destouy, and in an improved form by Mr. Beck in 1876. Its construction is interesting, as a loose needle is used, which is pulled and forced through the material in a way that resembles hand sewing.

The needle is in the form of a ring with a portion of its circumference removed, one extremity is pointed and the other hooked so as to form an eye. This needle is revolved intermittently in a circular path and so sews through the work; the thread does not, however, remain all the time in the eye, but during a portion of the stitch is held by an auxiliary finger. The step-by-step rotary motion is given to the needle by pincers, formed by two nipping levers arranged on opposite sides of the main centre and rocked by cranks on an upper shaft. The thread used passes through a hot-water-jacketed chamber to soften it. M. 1635.

139. LOCK-STITCH SEWING MACHINE. Made by the Howe Machine Co., 1888.

This is a lock-stitch machine for sewing leather and other heavy work. There is a single rotating shaft arranged beneath the bed and driven by a belt. A cam on this shaft rocks a bell-crank lever that reciprocates the needle-bar, which slides in vertical guides; a second cam and bell-crank lever reciprocate the shuttle-holder, which runs in a straight horizontal race. At the end of the shaft is a steel cam of conical shape, adjusted in position along the shaft by a nut having a milled head. This cam actuates a lever which forms part of a nipping lever or silent pawl, that intermittently rotates a steel disc with serrated edge, the top of which projects through a slot on the work table. The work is held down on this feeding arrangement by a loose wheel carried on the presser-foot. There is a shuttle bobbin winder very similar to that on No. 131. M. 1940.

140. LOCK-STITCH SEWING MACHINE. Made by the Howe Machine Co., 1888.

This is a heavy sewing machine particularly designed for shoemakers' use, but it is provided with a removable table for use on ordinary flat work. The needle is reciprocated by a needle driven by a cam in the face of the main driving wheel; another cam in this wheel moves horizontally a rod that terminates in a rack, gearing into a small pinion with its axis vertical, arranged beneath the table. This pinion turns to and fro a revolving hook enclosing a circular shuttle which, by the hook, is enabled to pass its thread through the loop formed in the needle thread. The small size of the lower arm enables the machine to work on portions of a boot that would otherwise be inaccessible. A cam on the main shaft vibrates a lever that gives a vertical motion to the presser-foot, and a similar cam and lever give a horizontal motion to this feed, so that the feed is given by the foot itself. The presser-foot and needle bar are contained in a cylindrical plug which can be turned within the sleeve holding it to the main casting, so that the direction of the feed can be continually changed without altering the position of the work. Some spare shuttle bobbins and a multiplying gear for winding them are also shown.
M. 1941.

141. BUTTON-HOLE SEWING MACHINE. Contributed by Messrs. Newton Wilson & Co., 1868.

This is an early button-hole machine, manufactured in America in 1868. Beneath the table is a horizontal belt-driven shaft on which are three cams and a crank; one cam rocks a bell-crank lever that reciprocates the needle-bar in its vertical guides, another oscillates a shorter arm beneath the table and rocks a curved needle, while the third cam controls a swinging hook, also beneath the table, which acts as the hook in the chain-stitch machine. The crank works a four-motion feed, while a helical sleeve encircling the upper needle-bar carries a hook that acts as a looper for the thread of the lower needle. In this way two chain-stitch machines are combined in one, and both sew round the cut button-hole.
Inv. 1868–13.

142. BUTTON-HOLE SEWING MACHINE. Lent by the Singer Manufacturing Co., 1888.

In this machine the button-hole is cut by a die attached to a hammer, then the hole is sewn round by a needle, the motion of the work at the time being controlled by an external cam plate that agrees with the shape of the hole. There is a thick filling thread below and a thinner sewing thread which is interlocked with the needle thread, these two threads sewing over the cut edges and at the same time enclosing the filling thread. An inclined mirror is arranged to render the lower mechanism visible. M. 1964.

143. BUTTON-HOLE SEWING MACHINE. Lent by the Wheeler & Wilson Manufacturing Co., 1891.

This is a machine for sewing round the edges of the material where a button-hole is required, and then cutting the hole. The work is placed on a movable plate and secured to it by a small rectangularly slotted frame, which covers the intended position for the button-hole and is held down by a spring. The needle and shuttle movements are the same as in the ordinary sewing machine of this type, but the feed motion given to the plate is quite different. The plate, carrying with it the work, receives three separate motions: a quick vibratory one at right angles to the hole to make the stitches, one along the length of the hole, and a third to move the work across when one side of the hole is completed so that the other side may be stitched. When the two connected rows of stitches have thus been inserted, a knife moves rapidly down and cuts the enclosed cloth, so completing the button-hole.

The special movements of the plate are obtained from a switch cam, secured to the main shaft beneath the table. This cam directly gives the vibratory motion to the plate, and the feed is derived from a lever driven by the cam and moving a pawl over a ratchet wheel on the top of a turntable. A block which works in the switch cam is held by a helical spring on each side, so that when the stitching of one side is finished one spring has been compressed sufficiently to force the block against the action of the other spring into another groove in the cam, so that the work then returns and the other row of stitching is done. The knife-bar is forced down by springs which are released when the turntable has completed a revolution, a projecting pin upon it catching a lever connected with these springs.

All the movements, including the cutting, take place automatically when the work has been adjusted in the proper place, and it is stated that six button-holes a minute can be sewn with this machine. M. 2336.

144. LOCK-STITCH SEWING MACHINE. Presented by the Singer Manufacturing Co., 1897.

This is a domestic machine intended for treadle driving, but it has been sectioned and supported on a special stand with a mirror below, to show the means whereby the various movements are obtained without the employment of toothed gearing.

The horizontal driving shaft is in the arm, and has an overhanging crank-shaft which, by an edge cam, reciprocates the needle-bar, while an adjoining face cam rocks the thread tightening lever. Another crank on the driving shaft rocks an upright shaft carried between coned adjustable screws, which gives motion by means of a connecting rod to a bell crank connected with a light shuttle carrier, which thus receives an oscillating or "vibrating" movement; in this way the shuttle is swung through the loop of the needle thread, which thus slips round the shuttle before again being tightened. The feed is of the four-motion type, and has the vertical component given by a swash-plate attached to the shuttle carrier, while the horizontal movement is obtained from a shaft below the base, rocked from an edge cam on the driving shaft which oscillates a lever having its fulcrum in a slotted lever within the vertical standard; the position and angle of the slot can be so varied by a thumbscrew as to give any required length of stitch.

The bobbin winder is driven by the main driving band, and the thread is automatically distributed over the bobbin by a guide moved by a cam driven by worm gear. M. 2982.

145. SHUTTLES FOR SEWING MACHINES. Presented by the Singer Manufacturing Co., 1897.

A is a shuttle for a family machine; it has the bobbin inserted through the side, and the tension adjusted by threading the cotton through certain of the five holes provided.

B is for a family machine; it is oscillated horizontally in a curved path, and has the bobbin inserted through the end so as to be completely protected. The tension is given by side springs under which the cotton is passed without threading.

C is a vertically oscillating hook-shuttle used in domestic machines, and also in those for factories where they are driven at from 1,500 to 1,800 stitches per minute. The bobbin is of the short-cylinder type, and the hook and guides loop the needle thread round it, which is equivalent to passing the bobbin through the loop of the needle thread.

D is an oscillating hook-shuttle, intended for speeds of from 2,000 to 3,000 stitches per minute; to reduce the momentum the hook only is oscillated.

E is an oscillating hook-shuttle with a large bobbin, the axis of which is in the plane of the hook; it is used in heavy textile and leather work.

F is a small horizontally oscillating shuttle, which can be used in a small work-supporting arm. This arm will reach into difficult positions, such as the interior of a child's boot, so that stitching can be done close to the toe of the boot.

G is one of the three or four large oscillating shuttles used in a machine for lacing together the pattern cards of a Jacquard loom; from 1,000 to 3,000 of these cards are frequently sewn together to form a continuous pattern chain in a machine resembling No. 136, but dispensing with the use of tapes. Both the shuttle and needle threads are in the form of braid, which is found to be a sufficient connection; the needles do not, however, pierce the holes through which they pass. M. 2983.

146. LOCK-STITCH SEWING MACHINE. Lent by the Singer Sewing Machine Co., Ltd., 1908.

This is the latest domestic sewing machine made by the Singer Co., and is an improved form of No. 144. It is a lock-stitch machine, and the stitches are formed by means of a hook, which oscillates below the work plate about a vertical axis and carries the loops of the upper thread around a stationary bobbin containing the under-thread. The needle-bar is actuated by a crank and connecting rod, and, consequently, moves up and down without any intermittent loop-forming motion, while, owing to its not being continued through the top of the machine, the bar is shorter than usual. The take-up mechanism is operated from the same crank as the needle-bar, and the four-motion feed is similar in general features to that employed in the earlier example. An arrangement is provided whereby, when the presser-foot is raised, the upper thread is released from its tension, and, when the under-thread bobbin needs refilling, it is readily removed from its casing by means of a push piece and a lever.

The example has been sectioned and mounted upon a stand with a mirror below to render visible all the mechanism employed. M. 3554.

147. LOCK-STITCH SEWING MACHINE. Lent by Messrs. Vickers, Ltd., 1919.

This is a hand-driven machine in which the main spindle is cranked near the flywheel and rocks a vertical rod whose upper end is forked and is given a horizontal rotary motion by means of the cranked portion of the spindle. The lower end operates the shuttle, through a connecting rod and two cranks at right angles, in a circular race.

Sewing may be reversed and the length of stitch altered by means of a lever passing through a vertical slot near the flywheel. The inner end of the reversing lever carries a slide in which a stud, on the eccentric rod of the feeding arrangement, moves to and fro; the inclination of the slide being altered so that when the screw at the outer end of the reversing lever is at the bottom of the vertical slot the feeding plate under the needle is raised when it is moving away from the operator, and the maximum length of forward stitch is then made. When the screw is at the top of the slot the feeding plate is raised when it is moving towards the operator and the work is reversed. Intermediate positions of the screw give shorter stitches.

Attachments for tucking, hemming, cording, braiding, and quilting are provided. Inv. 1919–418.

ROPE-MAKING MACHINERY.

Hemp has been employed for the manufacture of rope and canvas from a very remote period, its use being mentioned by Herodotus, B.C. 450. In the manufacture of rope, the earlier stages by which the hemp is prepared and its fibres straightened out do not possess any general interest, the process chiefly consisting in a prolonged soaking in water and a subsequent drying, breaking and heckling.

In making the hemp into rope, the coarseness of the fibres and their great length, about 3 ft., have rendered the advantages of machine over hand work less pronounced than in many industries, so that hemp is still extensively spun by hand, assisted only by the very primitive machines of a rope-walk. The spinner wraps a quantity of prepared hemp round his waist, and then pulling forward a tuft, twists it and attaches it to a hook at one end of the walk. This hook, or whirl, is rapidly rotated through multiplying wheels by an assistant, so twisting the fibres into a yarn, while the spinner walking backward continues to feed more fibres, end on, into the yarn, until he reaches the limit of the walk, sometimes 400 yds. After some minor operations, the completion of the rope is proceeded with by combining three or more of these yarns into a single cord in such a way that there shall be no tendency for the rope to untwist. This process, known as laying, is of great interest, and in a rope-walk is performed by attaching the three strands at one end to a single hook on a carriage at one end of the walk, and the other end of each yarn to separate hooks at the other end of the walk. The three yarns are at first consolidated by twisting each separately, and then the three strands are twisted into a single rope by the revolution of the single hook on the carriage, which slides up as the twisting reduces the length. When the strands are twisting together, their individual hooks are being revolved at the same rate as the main single hook, so that the twist of the fibres of the strands is not altered by the laying twist. A conical plug of wood with three grooves in it, called a lay-top, is squeezed along the three strands as they close together, and by its presence secures uniformity in the strand.

The first important machine for laying rope was the cordelier, patented in 1792 by the Rev. E. Cartwright; in 1805 Capt. J. Huddart improved it and introduced it with other machinery into Chatham Dockyard, where he made great advances in the manufacture of hemp ropes and cables. In Cartwright's laying machine three bobbins of twisted yarn were attached to a revolving disc, but through epicyclic gearing the bobbins, although going round in circles, do not rotate on their axes, the top of the bobbin remaining uppermost right through the revolution. The three strands laid together by this arrangement do not have their individual twisting altered, but are simply formed into a twisted rope that itself strongly resists untwisting. Instead of the axis of the machine being horizontal it may be arranged vertically. (*see* Nos. 149 and 150).

Another modification is to arrange the machine horizontally with the bobbin-holders in line along the axis where their rotation can be prevented by gravity. The strands are led along the revolving frame to a common lay-top; this machine runs at a high speed owing to all weights being so near the axis, and the bobbins not revolving except to unwind.

To place all the bobbins of yarn in a stationary frame or creel and strand them together while winding on to a revolving drum is a very simple way of arranging the parts (*see* No. 148), but it does not offer such facilities for inspecting the work in progress as does the moving bobbin system and the length of rope that can be formed is limited.

In laying hemp rope, the correcting motion of the bobbins rather exceeds that of the lay-top, the excess twisting, or " forehard," so given forming a firmer rope. For wire rope, which is made in similar machines forehard is not required, as this would only be twisting the individual wires, and so weakening them. Rope made of wire was first used for mining in 1831; for rigging and general hauling its use has greatly extended, while for lifting purposes it has now, to a considerable extent, displaced chain.

Another method of forming a rope is by plaiting, but it is much less convenient than stranding, and such ropes cannot be spliced. They have, however, the great advantage that stretching does not tend to twist them, so that a suspended load does not spin. For covering other cords, and even whips, similar plaiting is resorted to. The bobbins containing the strands are mounted vertically, and, under the guidance of cam grooves on a lower plate, describe the zig-zag courses necessary for plaiting. Similar machines are used for plaiting candle wick, but a later form of machine for this purpose is seen in No. 152).

148. ROPE-MAKING MACHINE. Presented by H. Cotton, Esq., 1874.

This is a machine for laying together as many as 49 strands to form a cotton rope such as is used for driving purposes. The separate bobbins holding the material to be stranded are contained in a stationary creel, from which the strands pass through an eye to the twisting and winding-up machinery. This consists of an open frame that can be rotated round a horizontal axis, while through a hollow trunnion at one end the strands enter twisted together into a rope. This rope passes round two friction sheaves, driven at constant speed, and on to a winding drum, which is driven by a friction coupling, so that as the drum fills, increased slipping can take place to allow for the enlarged diameter. The rope is led on to the drum by a fork moved by a cam. The mechanism is all driven by a stationary spur-wheel gearing into a wheel attached to the revolving frame.

This machine does not strand in the ordinary way, and to lay a rope that shall not unwind it requires that a definite excess of twist shall be given to the yarn of the individual strands to correct the untwisting done in the machine; stationary creel machines require each bobbin to be mounted in an epicyclic frame if general work is to be done. M. 1764.

149. WIRE ROPE MACHINE. Contributed by W. Smith, Esq., 1872.

This machine, patented by Mr. Andrew Smith in 1849, differs from the earlier machine of Cartwright in that the epicyclic motion of the bobbins is obtained by linkwork instead of gearing, also that it is arranged vertically.

It consists of a frame having below a disc-wheel that is driven by bevel gear from a horizontal shaft. Above this disc is attached a revolving cage that carries six bobbins supported in separate frames; above the cage is a seventh bobbin which carries the material for the core of the rope. The cage is not concentric with the lower disc, and the carriers of its bobbins are each provided with a crank arm which fits on a separate pin on the lower disc, so that as the disc is driven these arms pull round the cage, but at the same time prevent the rotation of the bobbin frames, the arrangement being a "parallel-crank" chain. From the bobbins the wires pass over guide sheaves to a lay-top above, then, after being stranded together, over a return sheave they pass to a winding-off sheave below, and are finally wound as a finished rope, on a drum which is driven by a slipping belt so as to be independent of the variation of diameter. The winding-off sheave has three grooves of different diameters, so that the pitch of the strands may be altered. A counter driven by the return sheave records the length of rope made. M. 1265.

150. WIRE ROPE MACHINE. Contributed by W. Smith, Esq., 1872.

This machine is similar in its action to No. 149, but strands together 36 wires round a central core which is led from a fixed external bobbin. The small diameter of the individual wires renders the rope very flexible, while their number gives the required strength. M. 1266.

151. CORD-COVERING MACHINE. Contributed by J. Lewis, Esq., 1860.

This machine, patented by Mr. W. H. Zahn in 1855, is for wrapping the strands of a cotton cord with silk, and then laying the strands together into a finished ornamental cord of possibly four differently coloured strands.

The machine is arranged vertically, with four bobbin frames projecting from a face plate, beneath which is a lantern ring that gears with a spur-wheel attached to each of the frames. Each frame carries two bobbins, a large vertical one holding the core material and a small horizontal one supplying the covering silk, which is in the form of sliver. Above the bobbin frames is a disc, that steadies them and also carries guide sheaves leading to the lay-top; above all is a return sheave round which the finished cord passes down to the winding-off rollers, which deliver it to a large reeling bobbin.

If the cord is merely to be covered without stranding it together, the lantern ring is alone driven, so rotating the bobbin frames and winding the silk round the core, as delivered, the twisting so introduced not being objectionable. If the four cords so covered are required to be stranded together, the lantern ring is held stationary and the upper disc driven, so that, in addition to the covering action, the four cords are closed together into a rope. Inv. 1860–11.

152. PLAITING MACHINE. Presented by Messrs. Douglas Fraser & Sons, 1889.

This is a machine for plaiting wicks for candles. Before the introduction of plaited wicks, unconsumed carbon accumulated at the top of the wick, and greatly reduced the luminosity of the flame, which was only restored by the removal of the top of the wick by snuffers. By plaiting the wick, the free end, as the candle burns, has a tendency to curl over, thus bringing it into a portion of the flame where carbon is completely burnt, and preventing any accumulation.

In this machine the cops of cotton from which the wick is made are arranged on a stationary creel at the back. The 45 threads are made into three equal strands, which pass through the eyes of three equidistant tubular arms, oscillating round horizontal axes carried in stationary bearings. These arms are moved by a double cam, cut on a central vertical cylinder, and owing to their circular motion do not vary the tension in the strands. The three strands meet in the centre of the machine, where there is an eye attached to a revolving frame that carries the bobbin on to which the plaited yarn is wound. As the arms rock up and down, the frame carrying the bobbin acts as a shuttle in passing alternately above and below the respective strands from the three arms. The machine is driven by power from below, and is provided with an automatic motion that stops it should any thread break. From its cop each thread passes between tension pegs and then under a hook on a weighted lever. Should any thread break, its lever drops, and so is struck by a revolving bar which then throws the driving belt on to the loose pulley.

Early plaiting machines had the bobbin moving in a figure-of-eight course, and could only be run at a low speed. This machine works at 600 revs. per min. turning out 90 in. of wick, with 10 folds to the inch each side. M. 2282,

153. LANG'S WIRE ROPE Presented by Messrs. George Cradock & Co., 1894.

In round wire ropes of ordinary construction, the component wires of their strands are twisted in one direction, whilst the strands forming the rope are closed the opposite way about. With hemp ropes this arrangement is necessary to secure a firm result, and it also simplifies splicing. In 1879, however, Mr. John Lang introduced wire ropes in which the wires forming the strands, and the strands themselves, were all laid in the same direction. The result is that such a rope, when passing over a drum, has a longer continuous bearing for each individual wire, as the crowns are less pronounced, and consequently the cutting tendency is reduced. In this way the life of a wire rope for running or winding is considerably increased owing to the more uniform wear experienced throughout the component wires.

Four specimens of rope are shown : No. 1 is a new rope of ordinary lay 2·5 in. circumference ; No. 2 is a portion of similar rope much worn ; No. 3 is a new rope closed in the manner introduced by Mr. Lang ; No. 4 is the same rope worn down to less than 2 in. circumference. M. 2723.

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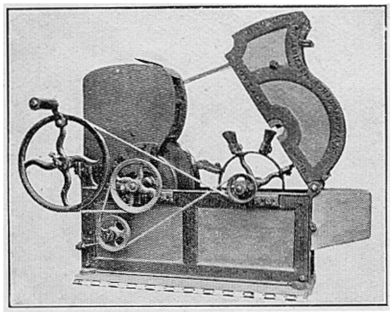
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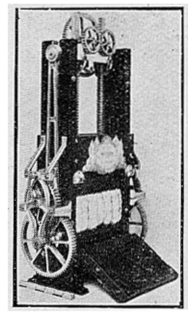
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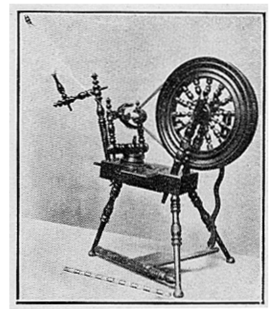
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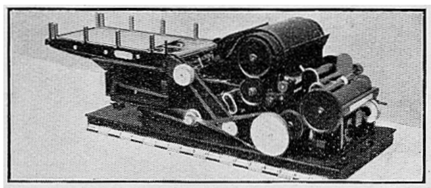
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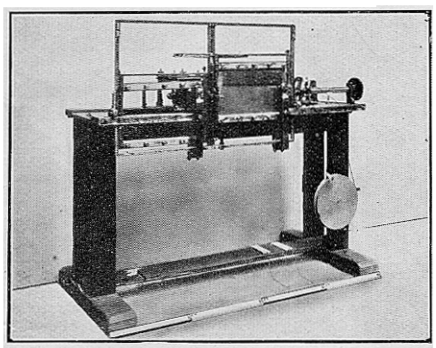
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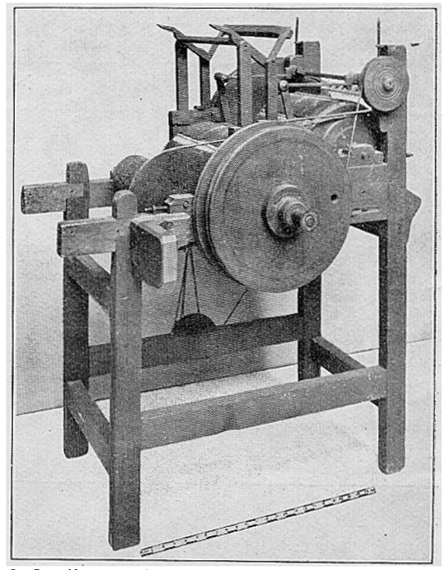
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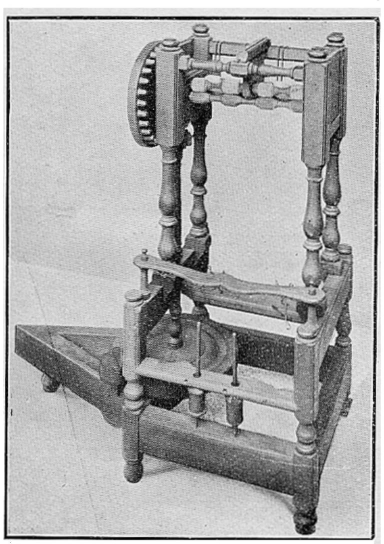
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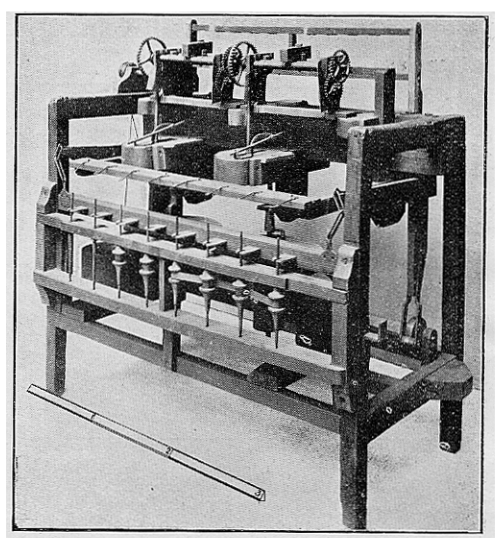
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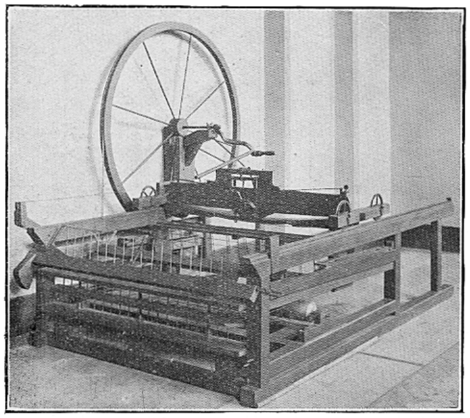

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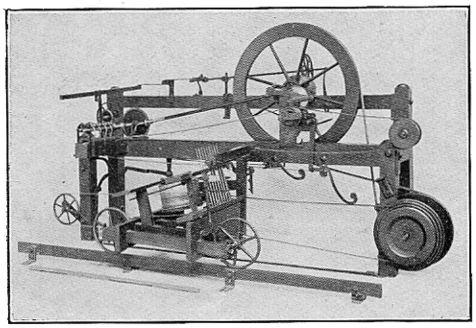

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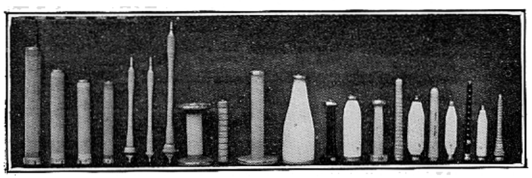

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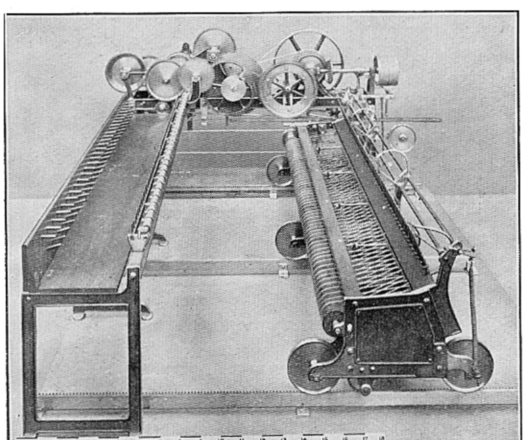

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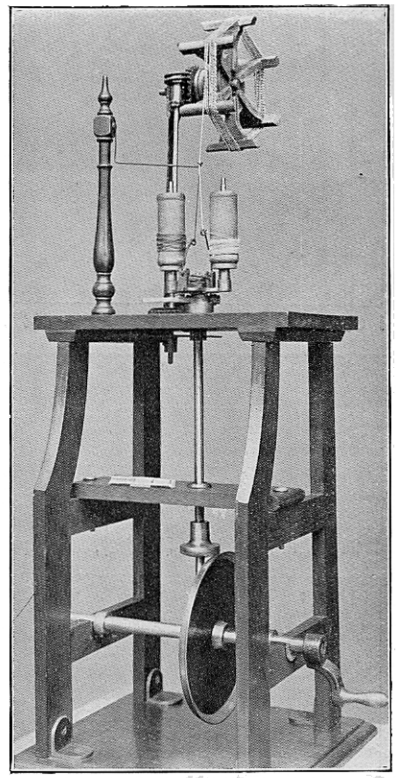

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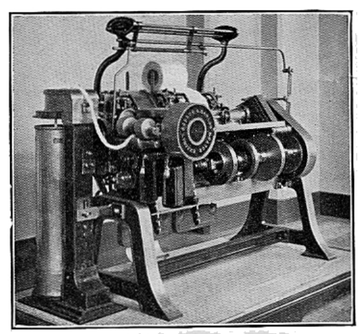

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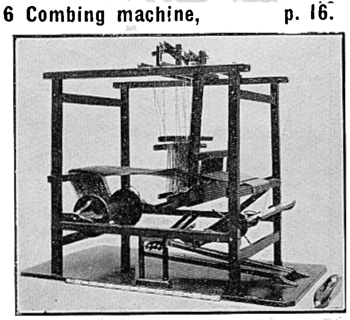

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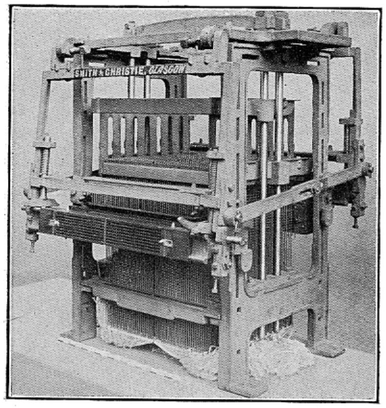

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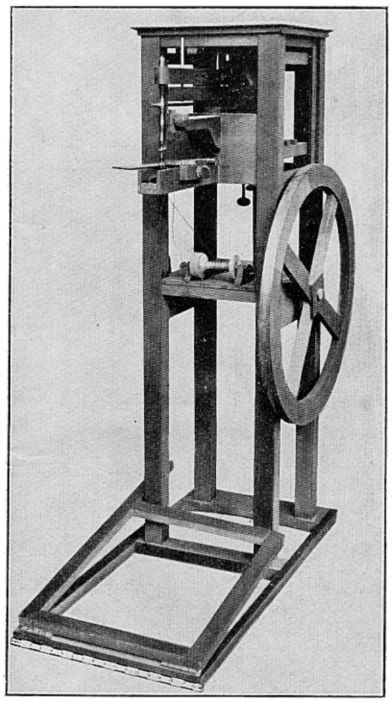

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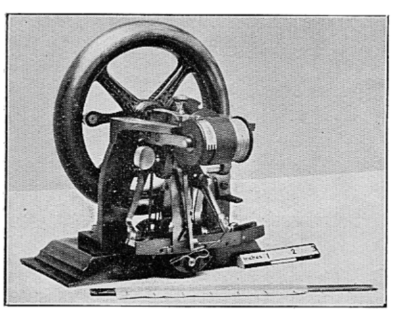

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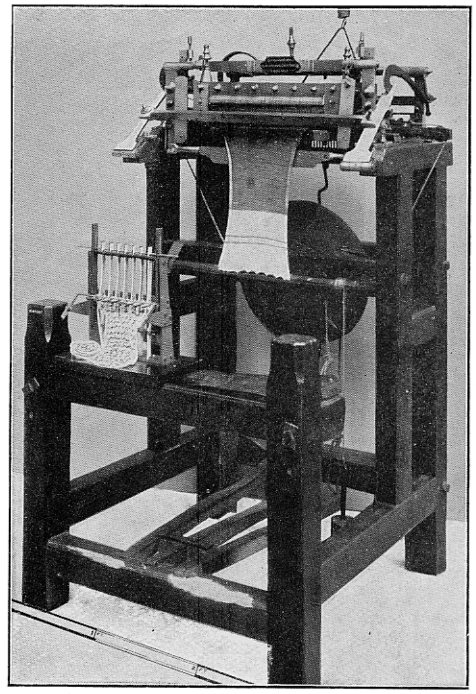

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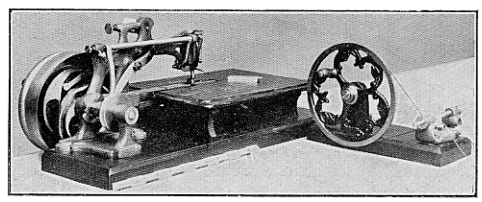

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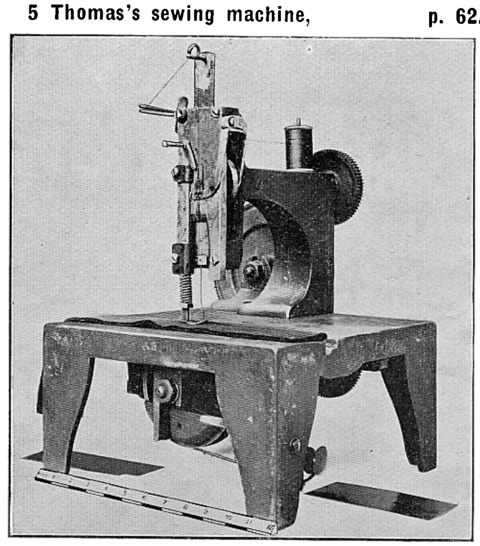

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