THE MANCHESTER MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.

FOR the fourth time in the course of its 47 years of existence, the Institution of Mechanical Engineers will next week hold its summer meeting in the centre of the leading cotton manufacturing district of the world.* The last summer meeting of the Institution was held at Manchester in the year 1875, and during the 19 years which have since elapsed an enormous development has taken place in the mechanical resources of the district. Not only have old-established works been enlarged and new works started, but most important and, in many cases, entirely radical changes have been made in processes of construction and in the plants by which such processes are carried out.

The Lancashire district has long been celebrated not only for its textile machinery, but for its production of stationary engines and boilers and of machine tools. In each of these branches of mechanical engineering the progress made since 1875 has been enormous. Twenty years ago, notwithstanding the good work which had been done by Messrs. Hick, Hargreaves, and Co. and some other firms in introducing Corliss gear and its equivalents, the old type of slide-valve engine was still being extensively made, even for large powers, while high steam-pressures and piston-speeds which have now become matters of ordinary practice were then adopted only in exceptional instances. Boilermaking, too, has been almost revolutionised during the same period. It is not that the best practice now is so much in advance of the best practice in 1875, but that the high class of work which was then being turned out only at a few exceptional establishments is now produced at scores of works, and is accepted as the standard good practice of the present day. In saying this it is only just to pay a tribute to the memory of the late Mr. Daniel Adamson, to whose successful efforts to elevate boilermaking into an important branch of mechanical engineering so much of our progress is due. In the construction of machine tools, too, there has been steady and important progress. Not only have great numbers of special tools been introduced, but standard machines have been vastly improved, and have been made capable of turning out more and better work at a reduced cost.

FIG. 1. COTTAGES FOR WEAVERS. (*See page* 99.)

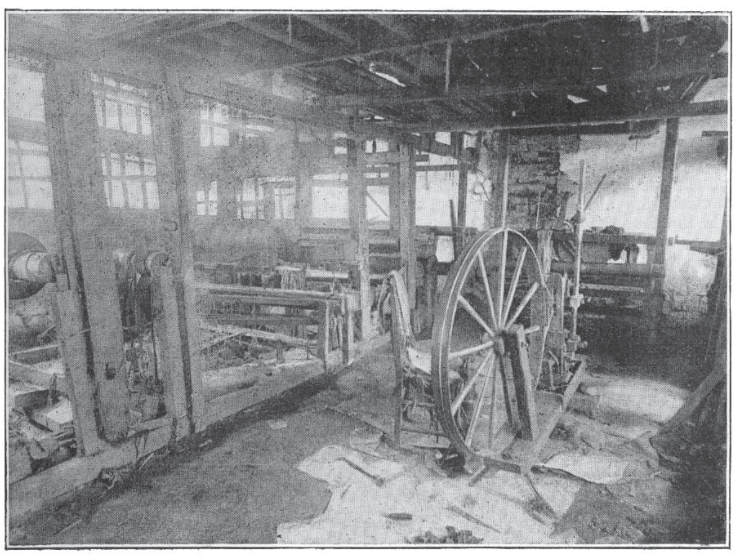

FIG. 2. INTERIOR OF OLD HAND LOOM HOUSE. (*See page* 99.)

Bearing these facts in mind, it is certain that those members of the Institution of Mechanical Engineers who took part in the meeting of 1875, and who may also be present next week, will see most important changes, and it will certainly not be the fault of the local committee if they do not find their visit both instructive and agreeable. The programme which has been arranged is a most comprehensive one, and the only fault that can be found with it is that no individual member can go through the whole of it, and each member at the end of his week's work will be apt to feel that, interesting and important as may have been the works he has inspected, they yet are fully equalled by those which there was not time to visit.

The meeting opens on Tuesday next, the 31st inst., when the morning will be devoted to the reception of the President, Professor Alex. B. W. Kennedy, and members at Owens College by the Lord Mayor of Manchester, Sir Anthony Marshall, and to the reading of papers. For the afternoon three alternative excursions have been arranged, the first being to the Electric Light Station and Corporation Gas Works; the second to Messrs. Thomas Hoyle and Sons' Calico Printing Works, to Messrs. S. and J. Watts and Co.'s Warehouses, and to the printing works of the *Manchester Guardian;* and the third to a number of works and mills in Manchester and its neighbourhood, which have been kindly thrown open to the members. In the evening the Lord Mayor of Manchester will entertain the members at a conversazione at the Town Hall. On Wednesday, August 1, the morning will be again devoted to the reading of papers, while for the afternoon alternative visits have been arranged to the Manchester Ship Canal, and to the new Hydraulic Power Station, the Manchester Packing Warehouse, and Chief Fire Brigade Station respectively. The various works, &c., already referred to, will also be open for inspection, while in the evening the dinner of the Institution will take place at the Grand Hotel.

Thursday, August 2, is to be devoted entirely to visits, three alternative excursions having been arranged for. Of these, the first will be to Oldham, where the Lion Cotton Spinning Mill, the New Electric Light Station, and the important works of Messrs. Platt Brothers and Co. will be visited. The second excursion will be to Bury and Rochdale, the Peel Mills and felt hat manufactories being inspected at the former town, and Messrs. Thomas Robinson and Son's wood-working machinery and roller flour-milling works at the latter. The third excursion will be to the Manchester Sewage Works at Davyhulme. To complete the day a thorough innovation will be introduced into the programme of a scientific gathering, the local members having invited their guests to the Theatre Royal, which they have engaged for the evening, and where there will be a performance of "H.M.S. Pinafore" and "Trial by Jury."

For Friday, August 3, the last day of the meeting, equally complete arrangements have been made. This day, like the preceding, will be devoted to visits, three alternative excursions being provided. Of these, the first will be to Bolton and Horwich. At Bolton the members will be divided into two groups, one group visiting the fine-spinning cotton mills of the North End Spinning Company, and the engineering works of Messrs. Dobson and Barlow, while the second group will inspect the engineering works of Messrs. Hick, Hargreaves, and Co. and of Messrs. John Musgrave and Sons. At Horwich the whole party will visit the locomotive works of the Lancashire and Yorkshire Railway Company. The second excursion will be to the London and North-Western Railway Company's works at Crewe, while the third will proceed to Prescot to examine the highly interesting works of the Lancashire Watch Company, of which we so recently gave an account in ENGINEERING (*vide* vol. lvi., pages 1, 33, and 69).

It would, of course, be quite impossible, within the limits available, to give even a brief account of all the works which will be open to the inspection of the members of the Institution of Mechanical Engineers during the approaching meeting, but it has seemed to us that probably the interest of many of these visits would be increased to those of our readers who take part in them if we gave in advance some notes as to the chief matters to which attention will be directed. Of course the papers

* The preceding summer meetings of the Institution of Mechanical Engineers were held in Manchester in June, 1857, July, 1866, and July, 1875. In addition to these, brief autumn meetings were held at Manchester in December, 1853, November, 1875, October, 1876, November, 1877, October, 1878, October, 1879, October, 1880, October, 1881, and November, 1882.

read at the meeting, and the discussions upon them will be treated by us in our regular way in our next and subsequent issues, while many other matters will also have to be dealt with later on, but in our present number we are giving very considerable space to accounts of some of the works, &c., which will be thrown open to the members, and which may be considered to be representative of the Manchester district.

The attention of members attending the meeting at Manchester will naturally be drawn largely towards the intricate and beautifully designed machinery used in the processes of cotton spinning and weaving. To those who are engaged in the trade it would be useless for us to attempt to give instruction, but a very large proportion of the engineers who will visit Manchester during the coming week will have had no practical experience in the industry, and such knowledge as they may possess of the various processes which cotton goes through before it becomes woven fabric will probably be often of an imperfect and disjointed nature. We have thought it appropriate, therefore, to open our series of articles on the works set down to be visited, by a description of a typical cotton mill and weaving shed. This is followed by an account of a factory where the machines used in cotton manufacture are made; and next, again, will be found a description of works where large mill engines are produced. We hope that the two first-named articles will be useful to the visitors to the works treated upon, and that those of our readers who may be without previous knowledge of the cotton manufacture, will gain a general idea of the processes. The three establishments we have selected for description are the cotton spinning mills and weaving sheds of Messrs. Richard Haworth and Co., Ordsal-lane; the textile machine works of Messrs. Platt Brothers and Co., Limited, at Oldham; and the engineering works of Messrs. Hick, Hargreaves, and Co., Limited, at Bolton. Although it is a task we would gladly have avoided, it has been necessary to make a selection in dealing with the subject in the way we have, and it will be understood that other important establishments of a similar nature to those chosen are on the programme of the meeting. Having, however, decided on the works best suited to our purpose, it was necessary we should confine our attention chiefly to them, as if we had extended our notice to other establishments of a similar nature, we should have been led into an amount of repetition that would certainly have become wearisome to our readers.

With regard to the other works dealt with in this special Manchester issue, as well as those of which we shall give an account in subsequent numbers, there is little need be said, as the descriptions speak for themselves. By the limits of our space we have been reluctantly compelled to leave out much that would have been interesting, more especially in the case of matters that have an historical value. Some of the chief excursions, it should be noted, are to works that are fully dealt with in papers to be read at the meeting, and in such cases we have not considered it necessary to give descriptions in this preliminary series, as the papers will be published by us in due course. Of the London and North-Western Company's works at Crewe, and of the works of the Lancashire and Yorkshire Company at Horwich, we have also been compelled to omit accounts in the present issue, both being far too important to be dealt with in the space now available. Of the Crewe Works, however, we have already published many notices, and we have also given many illustrations of special machines, &c., included in the plant, while with the Horwich works we hope to deal fully on a future occasion. In other cases we have already published accounts of the places to be visited within comparatively recent times, and it is, therefore, not necessary we should repeat our descriptions, although any novel features may find a place in our ordinary description of the meeting.

Messrs. Richard Haworth and Co.'s Cotton Mills.

As will have been seen from the notes given above, there are several cotton mills set down to be visited on the programme of the forthcoming meeting of the Institution of Mechanical Engineers, but, as explained in our introductory remarks, it is necessary, in order to avoid repetition, that we should confine our attention to one establishment. We have selected for our purpose the series of mills owned by the firm of Richard Haworth and Co., which are situated in Ordsal-lane, Salford. In the first place, as reason for our choice, the mills belonging to this firm are of large size, and are thoroughly well equipped with modern machinery of the best type. Secondly, the mills are within fairly easy distance of the headquarters of the meeting-place of the Institution. In the present day Manchester itself is becoming less and less a city where cotton is manufactured, and is, indeed, assuming the character of a metropolis to the district. Land in the city is now too valuable to be devoted to the purposes of a factory which can be almost as efficiently and far more cheaply conducted in the outlying townships and districts. In this way Stockport, Oldham, Bolton, Rochdale, and other towns have become the seats of manufacture of textile goods, whilst Manchester is the mart or warehouse. Naturally those firms that are fortunate in owning mills in the centre of distribution have advantages which are not counterbalanced by the payment of excessive rental.

Another circumstance which makes Messrs. Haworth's establishment one particularly suited for our purpose of describing the conversion of raw cotton into fabric, is that the whole of the operations are carried on by this firm, the works including both spinning mills and weaving sheds.

Before proceeding to describe the details of cotton manufacture, as illustrated by these works, something may be said of their general features.

The firm of Richard Haworth and Co. was founded by the late Richard Haworth. Like so many of our important manufacturing establishments, the commencement was small, the capital at the command of the founder being by no means equal to his abounding energy. The latter, however, is a more valuable commodity than the former for a man commencing business, and under the wise and energetic management of the late Mr. Haworth, the establishment grew from a mill employing few hands to the vast proportions of a modern cotton mill of the first rank. The business is now carried on under the management of the late Richard Haworth's two sons, Mr. George Haworth and Mr. John Haworth, the former taking the manufacturing operations as his department, whilst the latter superintends the warehouse of the firm, which is situated in High-street, Manchester; the latter an important establishment in itself, although it does not come within the scope of our present purpose to deal with it.

At the present time the works of the firm in Ordsal-lane are divided into three mills and a weaving department. The mills are known as the Egerton, the Tatton, and the Throstle Nest Mills, but they form practically one factory, although Egerton and Tatton Mills are a few hundred feet distant from each other. The total number of hands at present employed by the firm in all departments is over 3000. Many of these, of course, are women. The number of spindles in Messrs. Howarth's mills is 140,000, and in connection with this it must be remembered that the whole of the operations in connection with the preparation of cotton are carried out by this firm. The average produce per spindle per year of warp or weft would be 100 lb. nearly, so that the output from these mills reaches the total of 6000 tons of manufactured cotton per year.

It is difficult to give an average of fabric that would be woven from this amount of warp and weft, as the conditions vary so widely in different materials, but if we suppose the whole of the produce were woven into average calico or long cloth, it would amount to about 30,000,000 square yards per annum.

The number of looms owned by the firm is 3200; and these are of all descriptions, as will be more fully explained when we deal with the weaving sheds.

The works are lit throughout by electric light by means of incandescent lamps, of which there are no less than 3500 in all departments. The generating plant consists of several engines driving six dynamos.

Lighting, warming, and ventilation are points which all receive thorough attention in these works, and those who have known the cotton industry for many years past cannot but feel glad to see how much more is now done for the health and comfort of the operatives than was the case in times past. It may be stated in passing, however, that the late Richard Haworth was one of the pioneers in this movement, and though one of the most successful business men of his day, he never let considerations of profit stand in the way of what he considered his duty to those serving him, in whatever capacity they might have been engaged. Richard Haworth commenced life in a very humble way. He was, in every sense of the term, a self-made man of a type which this country has always been exceptionally fortunate in producing; and doubtless the privations he went through in his early days caused him to sympathise with those in a like position to that which he had occupied, but who had not his exceptional talents to enable them to rise above the rank in which they were born. The good he did still remains, and the traditions of the firm are still worthily followed up. Certainly, the people of Lancashire owe much to the small group of large-hearted, thoughtful men of whom Richard Haworth was a very active member. The confined atmosphere of the old-time cotton mill and the physically trying operations of cotton-spinning were fast leading to a degeneracy of the operatives which was tending to serious degradation of the race. In any case the mill hand can never hope to equal in physical development those who are engaged in out-door pursuits, and the increase in the number of factory operatives, more especially amongst women, is one of the most serious problems of the age, and the chief set-off against the advantages of advanced civilisation. Much, however, can be done by light and fresh air to improve the hygienic conditions of the factory; and those who, like the past and present managers of the mills now under notice, do their best in this direction, earn the gratitude of every class, for what affects one affects all. In one of our illustrations of these works there will be seen a detail which tells much of the attention paid to the comfort of the hands; a stool provided for the attendant to rest upon when not required to attend to the machine. To women this small boon is especially grateful. Only those who have spent a long working day afoot can appreciate the value of this small concession.

Even to those most accustomed to the marvels wrought by modern engineering, a cotton mill must always be a wonderful thing. If one counts a large steamship — either an armour-clad, such as the Royal Sovereign, or an Atlantic liner, such as the Campania — the noblest creation of the engineer, the cotton mill will not rank far behind. The steamship impresses by the magnitude of its parts, but the cotton mill almost stuns one's imagination by the endless multiplication of its diminitive constituents. Each of the thousands of spindles in a mule or ring frame is an engine in itself, driven from one central source, but doing a separate operation, which within a period that is historically but a few years ago would have taken the whole energies of one person. This, however, does not tell the whole tale, for not only does one spindle represent one operator, but it will do the work with an accuracy and rapidity that could never be approached by the spinner even with the help of the primitive hand-driven machines.

In order to effect this substitution of mechanism for human labour, the highest intellectual effort must be exercised in the production of the machines. The hand-spinner could watch for and correct mishaps that would arise in the progress of the work, but machinery can exercise no such controlling power. It is necessary, therefore, that its operations shall be absolute, and this can only be obtained by an undeviating accuracy of movement and the insuring of an undeviating supply of regular material. The latter feature is secured by splitting the initial processes up into a number of stages, and depending on the averaging effect of oft-repeated doublings and drawings in the manner hereafter described. The excessively high speed at which the machinery runs, and the absolute certainty of its movement, afford results only obtained by complicated trains of highly ingenious mechanism manufactured with a regard to truth that is little less than marvellous. It is the old story of a principle which dominates the evolution of the factory system, the highest brainwork of a few original thinkers supplanting the skill of the operatives. In engineering practice the hammer, chisel, and file are the most simple and primitive tools. There is no mystery about them, and their production is a simple matter. To produce a flat surface by their aid alone requires an amount of skill only to be obtained by long practice; but the planing machine is invented, and the surface is cut with accuracy by mechanical means. So it is in cotton

MESSRS. RICHARD HAWORTH AND CO.'S COTTON MILLS, SALFORD.

(*For Description, see Page 99.*)

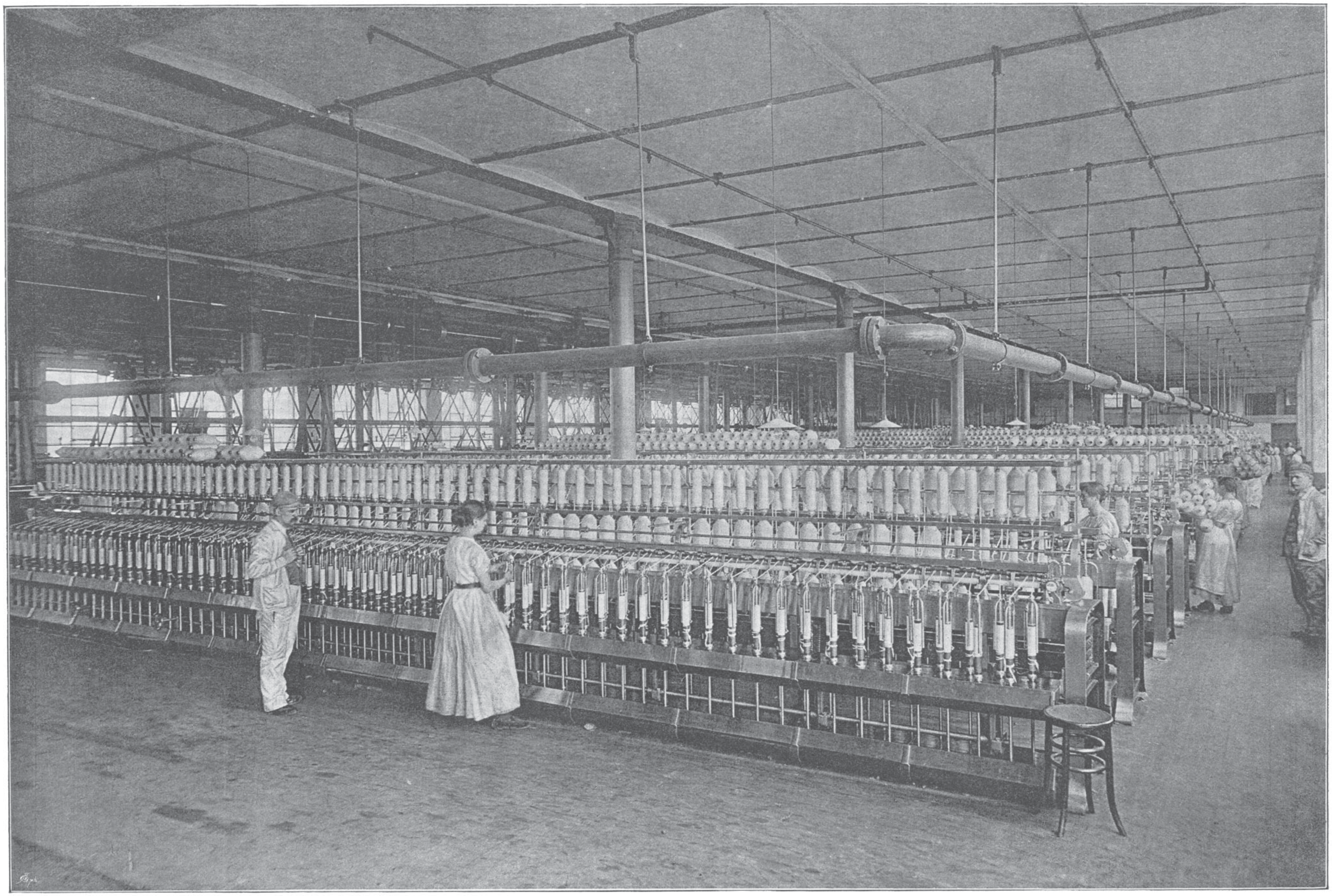

Fig. 11. Roving or Yarn Preparing.

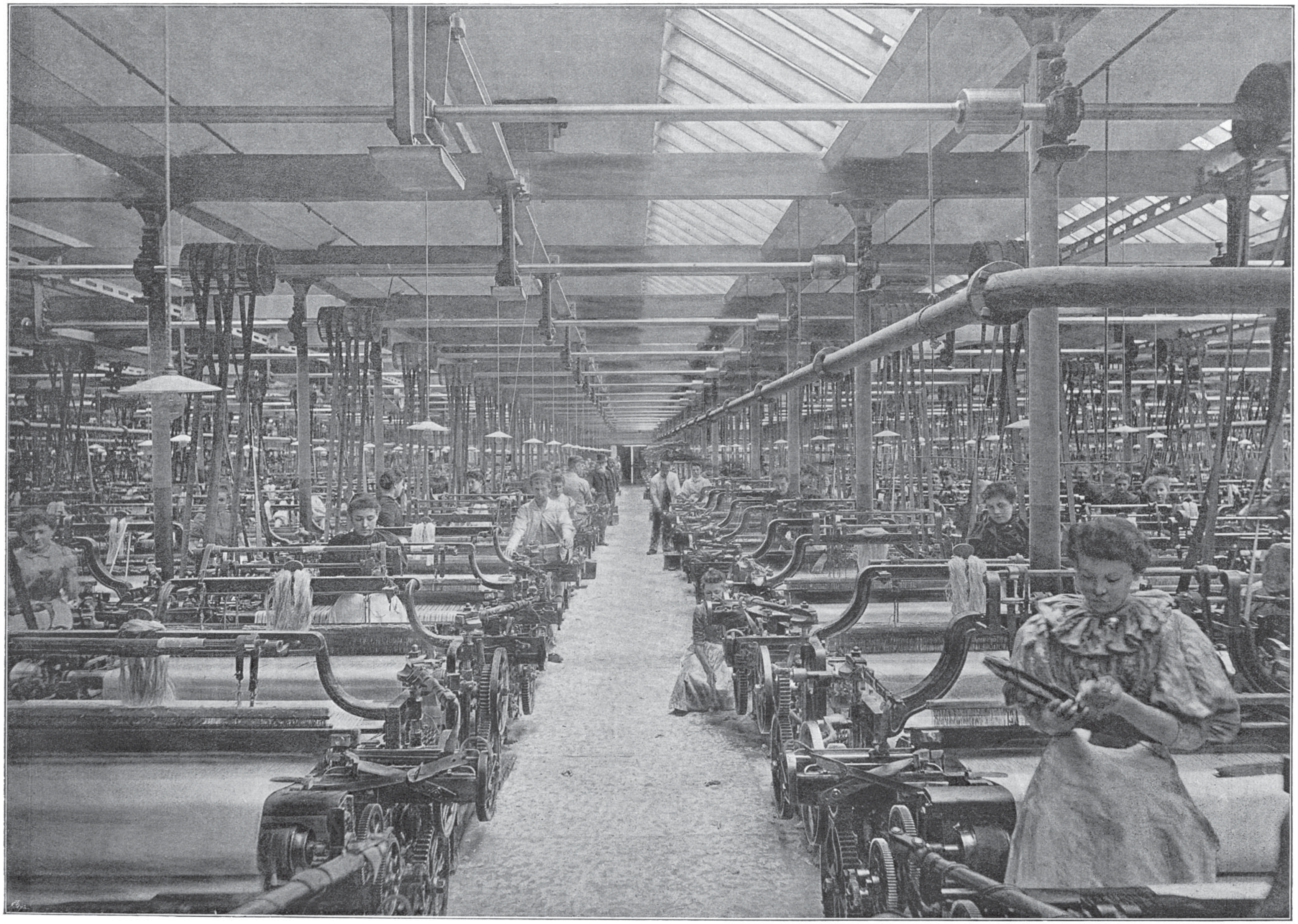

Fig. 12. Weaving Shed.

spinning. The skill required by the operator to produce an even thread is no longer necessary; the burden is taken by the machine. The sinking of brain capital by the inventor bears interest for all time, and the consumer shares in the benefit of what some would call "unearned increment," were we to push our simile home. Were we to revert to the methods of production of a hundred years ago, four-fifths of clothed humanity would go all but naked.

It is satisfactory to know that the operatives share in these benefits also. We have already spoken of the danger of physical deterioration that may arise from the crowding together of workers in factories, but we referred to the mill hand as compared to the open-air worker; in comparison with his forerunner—the worker in the cottage industry—his lot is immensely improved. The spinner and weaver who worked in his or her own home had a life of almost constant toil, working often from the hour of rising to the time of going to bed, with but short intervals for meals.

We are indebted to Messrs. Haworth for photographs taken of houses built expressly for weaving, and these may be regarded as the connecting link between the present highly organised factory system and the more primitive cottage industry when weavers worked, ate, and slept in the same apartment. Fig. 1, on page 97, shows the exterior of some of these houses, whilst in Fig. 2, on the same page, the interior of an old hand-loom house is shown. Another interior is represented by Fig. 3, on page 100. In this view is seen an old hand loom which was made about the year 1710. This loom was presented to the Bolton Museum by Mr. John Ashworth, of Bolton, and at the opening of this museum in 1884 the loom was geared and a piece of cloth woven on it. It is interesting to compare the two interior views just mentioned with those of Messrs. Haworth's mill, to be described later on. In both Figs. 2 and 3 the hand spinning wheel is shown. In the latter illustration the woman is spinning, whilst the man is working the hand loom, and these two are performing, somewhat inefficiently, the whole range of operations performed by Messrs. Haworth's elaborate machinery. In Fig. 4, on page 100, is shown Crompton's spinning jenny, the original mule or old headstock, which has since been elaborated into the beautiful machine which is shown in Fig. 9, on page 104, and Fig. 12, on one of the two-page engravings which we publish this week.

We will now proceed to describe the process of the manufacture of cotton as carried out in Messrs. Haworth's works, which, as already stated, may be taken as an example of a modern well-arranged cotton mill of the best type.

The cotton as it comes from the warehouse is brought to a room where it is examined, and the different qualities or descriptions are sorted according to the grades that may be required. Great care is required in this part of the work, as the cotton has to be selected to be suitable to the class of work it is to produce; for instance, rough long staple cotton will be required for warp or twist, whilst the more silky fibre will be suitable for weft. Formerly, when the bales were opened the cotton was distributed by hand, the men going to the bins and scattering the cotton in handfuls, so as to mix it well up. It should be understood that for the production of warp or weft different descriptions of cotton have to be mixed together. A grade that will give the required qualities in one direction has to be used with another description of cotton that possesses other necessary characteristics.

The first machine used is that known as a bale breaker; an illustration of a machine of this class, as made by Messrs. Platt Brothers, is given in Fig. 24, page 113. This machine consists of a suitable receptable fed by an endless creeper formed by wooden slats mounted on endless bands. The cotton is put on to the creeper by hand, and is then carried to three sets of toothed rollers and one set of fluted rollers, which revolve at different speeds; the first pair running more slowly than the next, whilst the last pair have the quickest motion. In this way the cotton is opened out, and from the rollers it is taken to a receptacle and elevated by creepers, two working together, so that the cotton is seized between them. By a series of creepers the cotton may then be distributed to any of the various large bins into which the floor is divided. By means of suitable mechanism the creepers can be made to deliver their burden into any part required.

When the cotton is wanted for use it is taken from the bins to another travelling creeper which conveys it to a porcupine feeder. In our account of Messrs. Platt's works we give in Fig. 23, on page 113, an illustration of a porcupine feeder made by that firm, but it will be understood the creeper can be extended to any length. This machine consists of a series of toothed rollers, which also have differential speeds, and the cotton is by them further opened; it then passes through fluted rollers and is beaten, the operation being performed by means of a series of discs which have projecting arms that strike against the cotton as it is held by the rollers. It is a great thing in preparing cotton in these stages to handle it lightly and not injure the fibre, whilst it is at the same time necessary to open out the harder masses and to remove the dirt. The operation just referred to is the first of a series of beating processes which have to be gone through, and is a very light one, the beaters not striking close to the rollers, so they do not punish the cotton much, the process forming an easy transition from the opening operation to the beating proper, which takes place later on. The system of using fans in these processes has proved a great advantage to the cotton spinner. The machines used in these stages of cotton spinning are very beautiful specimens of mechanical art, and though they run at a great number of revolutions, there is very little vibration or jar in the best made machinery. This is necessary, as otherwise the cotton would be entirely spoilt by rough treatment.

From the last-named machine the cotton is taken through a trunk by suction to the floor below into the scutching or blowing room, and is then carried in horizontal trunks of considerable length which have creepers inside. Our illustration, Fig. 5, on page 101, is a view of the scutching-room in Messrs. Haworth's Tatton mill. The cotton is carried forward over grids by the draught of air from the fan. Dirt or foreign matter which is mixed with it is generally of a higher specific gravity than the cotton, and this dirt falls through the grids upon which the cotton travels as it is blown along. Underneath the grids there works a continuous creeper which carries the dirt to one end of the trunk, where it falls into sacks provided for the purpose. The dirt, which consists mostly of sand and husk, having thus been removed, the cotton is taken to an opener or porcupine beater, which consists of revolving discs strung on a spindle. Our illustration, Fig. 25, on page 114, shows a machine of this class. In it there are fans which draw the cotton along, and in this way it is further cleansed. The cotton next passes to the second part of this machine, which consists of a pair of cylindrical wire cages. Through the latter there is a continuous air current caused by a fan, the direction of the draught being such that the cotton is drawn on to the surface of the cages very evenly. The latter result is obtained automatically, as when a mass of cotton has become attached to the cage the draught there is naturally checked somewhat, and the remainder of the cage has its normal draught. In this way a very even sheet is obtained, and at the same time a certain amount of cleansing process goes on.

On emerging from the cages of the opener the sheet of cotton is seized by fluted rollers, through which it passes, and is thus consolidated, having the appearance of a thick sheet of wadding, and is then formed into a lap, being wound into a roll on a lap rod, as shown in the left-hand corner of Fig. 5. This roll of lap is taken to another machine, known as an intermediate lap machine, which consists of a pair of fluted rollers. Four of the laps are treated at once, being beaten by revolving horizontal bars in order that more dirt or foreign matter may be knocked out, the cotton being arrested by a grid through which the dirt passes. The chief object of this process, however, is to produce a more even substance. It will be seen that any inequalities there may be in the individual laps will be by the law of averages reduced by working four together.

By the processes we have described, not only is the dirt eliminated in a manner truly surprising to those not accustomed to the operations, but the short fibre also is removed, and in this way the cotton is prepared for spinning processes. Before, however, it is ready for spinning it is taken to another pair of cage rollers, and from thence it passes through a series of lap rollers which are smooth on their surfaces; from thence it passes through three rollers, two of which are fluted, whilst the third, which is smaller in diameter, is plain; these operations again form it into a lap or continuous sheet, which has sufficient cohesion to enable it to be wound on a small hollow roller. The axial hole through this roller is formed in order that the rolled lap may be put on the lap rods without the operation of skewering being performed. When solid rollers were used, the lap rod had to be pushed through the centre of the roll of cotton, and in this way the material was frequently injured. One day it occurred to some bright genius that the rollers might as well have a hole through them, and they could then be pushed out of the cotton and the lap rods be inserted at the same operation. It is satisfactory to know that the man who first thought of this made a fortune by his ingenuity.

We now pass to the finishing scutching, which is a repetition in general principle of the former process. All these processes of cleaning, regulating, breaking up, and making up again into sheets or laps, are performed in order to thoroughly mix the cotton, to cleanse it, and to remove the short fibre. It is very important at this stage that a square yard of the lap should be of a given weight, otherwise the further processes will be affected throughout. It being remembered that the fleecy cotton has to be transformed into a filament, it will be seen that any inequality in the quantity of material contained in a given area of the sheet will affect the thickness of the thread, one of the great virtues of which is that it should be of uniform strength and substance. Although many equalising processes have yet to be gone through—indeed, the whole of the operations at the initial stages consist of cleaning and equalising—yet unless a fairly uniform web be obtained at this juncture, good results cannot be expected ultimately. It may be noticed that in all machines in this department there is a knocking-off motion when a definite number of yards have been produced.

In former days, before blowing machinery had been introduced, the female operatives would take a bratful of cotton, and spread, as nearly as their skill would allow, a given weight on a given area of the creeper which took the fibre to the carding engines. It will be easily understood that, although the women were remarkably skilful in spreading the cotton evenly, the lap produced was not nearly of the equal thickness that is now obtained. A bratful of cotton was an apronful, "brat" being local vernacular for "apron." In those times the cleansing was done by hand-beating with light willow rods, the cotton being placed on a net.

We now pass to another branch of the preparation of cotton for spinning. We have seen the fibre formed into large loose sheets or laps, which have been wound into rolls around rods. Great care and pains have been taken, as stated, to make these sheets of uniform thickness, but the carding engine, which comes next in order, apparently undoes the whole of the work which has been so laboriously performed. In our illustration, Fig. 6, on page 101, we give a view of the carding-room at Messrs. Haworth's mill, whilst in our article describing Messrs. Platt Brothers and Co.'s works we give an illustration and description of the carding engine made by that firm (see Fig. 29, page 116). The method of operation is as follows: The lap is put on the machine, and is unrolled by means of fluted rollers. (In our view of Messrs. Haworth's carding-room, two laps are shown on the machine, the upper being a spare one ready to follow on.) The lap is then broken up by a fine-toothed revolving drum; the small pieces which are torn up are thrown on to a grid, and here any dirt that remains is removed, whilst the short fibre is got out. From thence the fleecy masses of cotton are taken up by the big cylinder of the machine, which is covered with short wires like the pile of coarse velvet, or a long unshaven chin. This revolves at a very high speed; whilst travelling in the same direction, but at a lower speed, are a number of cards or flats; these consist of what may be described as a length of coarse pile of wire, securely fastened to iron flats, as shown in both illustrations. This part of the carding engine will be described in our article on Messrs. Platt's works. The short wires on the cylinder clear those on the flats by a very small distance, perhaps the hundredth part of an inch. The operator regulates this distance by passing a thin steel gauge, and he can tell if properly adjusted by feel. Much practice is required to determine this point accurately. The distance between is obtained by packing up the paths at the edge of the cylinder on which the flats that carry the cards are mounted. The adjustment is done by means of very thin hardened steel bands. As the cylinder travels so much faster than the flats, the cotton is carried forward, being combed between the two series of wires, and this has the effect of placing the fibres so that they lie all in one direction, namely, circumferential to the cylinder. The necessity for this will be apparent when it is remembered that these fibres have to be spun into a thread. The cotton is taken from the cylinder by what is known as a division plate, which is set $\frac{5}{1000}$ in. distance from the points of the wires of the cylinder, and the division plate puts the cotton on what is known as the doffer, which is another revolving cylinder of very much smaller diameter and covered with wires. The fibre is then taken off the doffer by the doffer comb, which is actually a steel comb, and is caused to oscillate very rapidly in front of the doffer. The fibre is thus released from the wires and is not broken, being delivered in the form of a filmy web or sheet.

This sheet is much finer and more regular than that which was broken up by the carding engine in the first part of the operation, and though it seemed that the carding engine, as already pointed out, was undoing all the work before done, so that previous operations were useless, such indeed was not the case, for the regularity with which the cotton was delivered to the carding engine enabled the engine in turn to deliver a web of uniform texture.

The sheet as delivered by the doffer comb is taken through a pair of rolls which revolve at the somewhat higher speed than that which would deliver the cotton at the same rate at which it is fed into them, and the web is therefore a little stretched or drawn out. It then passes to rolls through a trumpet mouth, and by the latter is converted from a flat continuous film to what is really a continuous cylinder of the fleecy cotton; in fact, the trumpet mouth bends it from a flat strip to a pipe. It next passes to another pair of rolls, and from thence into the receptacle or sliver can, which is a long tin drum caused to revolve so as to give a slight twist to the cotton, which is now formed into what is known as a sliver. In the carding process separation of the shorter fibre from the long is performed; the short fibre is collected by the flats or cards, and is taken off them by what is known as the stripper comb, and is deposited in a suitable receptacle; this short fibre has a commercial value, being used for many inferior purposes. In some cases in place of flats carding engines are provided with rollers. In Messrs. Howarth's other mill, machines of the latter description may be seen at work.

The cotton as now formed into a sliver passes through a series of machines which are used for drawing out and doubling; these operations are undertaken in order to harden and equalise the sliver. In our illustration, Fig. 7, page 104, we give a view which shows the department in which the drawing frames are placed. In the first of the drawing machines six slivers are passed through four rollers running at different speeds, so that the material is drawn out; the combined effect is to make the material six times the length it was when it entered the first pair of rolls, and as six slivers are combined, the thickness of the product is naturally equal to that of any one sliver. The machine delivers into a trumpet mouth, and there is a revolving can into which the resultant material is coiled, and in this way a slight twist is put in the fibre. The cans are then taken to another machine where they go through a similar process.

The material next passes to the slubbing frame, in which a single thread is passed through three pairs of rollers, by means of which it is again drawn down, but in place of being coiled in cans it is wound on bobbins by means of a spindle and flyer, so that sufficient twist is put into it to enable it to be described as a fine cord, and to give it strength enough to enable it to undergo the subsequent processes. The first of these is performed in what is known as an intermediate frame, in which a process between slubbing and roving is carried out. Here two slivers are drawn together by rollers as before, and are twisted by a spindle and flyer on to a bobbin, known as the intermediate bobbin. In these processes the sliver is gradually getting finer, but the twist put in it is only sufficient to give it cohesion necessary to enable it to draw the bobbins round in the next process. The roving frame performs operations which are practically a repetition of those already described; two slivers are drawn into one roving, being twisted at the same time. In Fig. 11, on one of our two-page engravings, we illustrate the "jack room" or roving department in Messrs. Haworth's Ordsal mills; while on page 112, in Figs. 21 and 22, we give two illustrations, namely, a back and a front view of one of Messrs. Platt's roving frames similar to that used in the Ordsal mills. The cotton has now been formed into threads which are known as rovings, and it may be next made into twist or warp by means of the ring frame, or it may be spun into weft or woof * on the mule. We will take the first-named operation to begin with.

In our illustration, Fig. 15, on page 107, we give a representation of the ring frame made by Messrs. Platt, this being the machine used at Messrs. Haworth's Egerton mills. The rovings, which, it will be remembered, have been wound on bobbins, are placed on the upper part of the frame as shown. They have a certain amount of "draught" put in them by means of the rollers running at different speeds, the twist being put in by the spindles, and they then become what is technically known as "twist." It is somewhat difficult to describe the action of this machine, as, like all textile machinery, it is complicated in its method of working. It is continuous in its action, for—as opposed to the processes of drawing out, twisting, and winding on the spindle of the mule, which are intermittent—the work of the ring bobbins is carried out continuously and without intermission. The roving bobbins are mounted in the upper part of the machine, and the roving is drawn from them by rollers, and passes through a small bent piece of wire known as the traveller. This traveller is a D-shaped piece of brass wire, with a gap in the vertical part. It is placed on the ring of the machine, which is about 2 in. in diameter, and through which the spindle passes. The traveller is of varying size and weight, according to fineness of the "counts" being spun. From the traveller the thread is carried to the ring bobbin, which is mounted on the spindle. A fair-sized ring frame will have 420 spindles, each with its necessary bobbins, rings, travellers, &c. The operation is as follows: As the spindle revolves it winds the thread from the roving bobbin on to

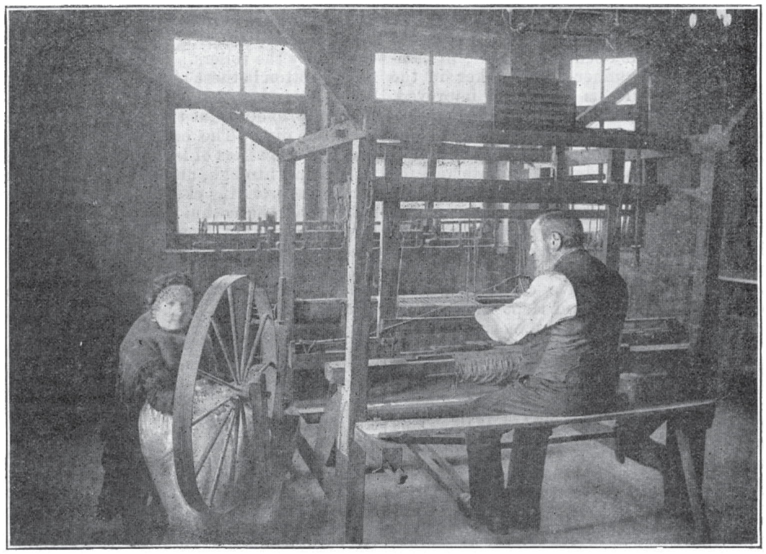

FIG. 3. HAND LOOM MADE ABOUT A.D. 1710. (*See page* 99.)

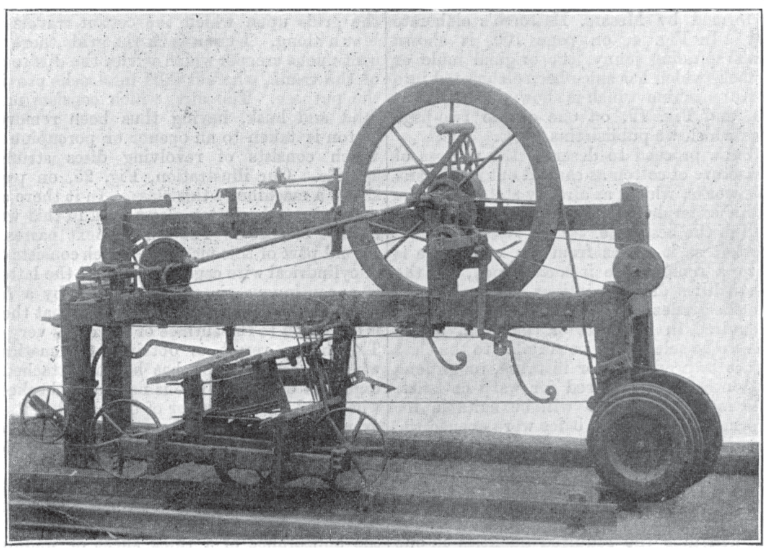

FIG. 4. CROMPTON'S SPINNING JENNY, INVENTED A.D. 1741. (*See page* 99.)

* "Weft" is the general English term known in the trade. "Woof" is a scriptural or literary expression; whilst the modern American uses the word "filling" to describe the same thing.

MESSRS. RICHARD HAWORTH AND CO.'S COTTON MILLS, SALFORD.

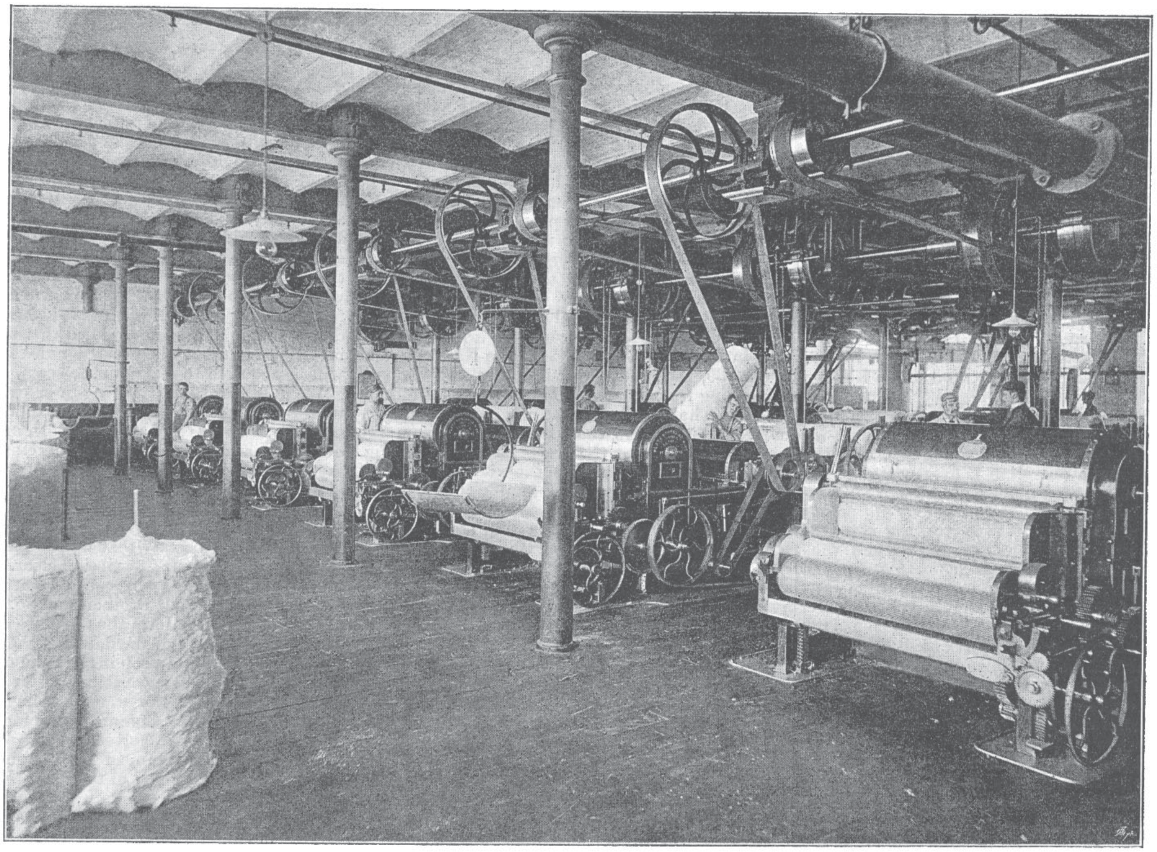

Fig. 5. Scutching-Room ; Blowing and Cleaning Cotton.

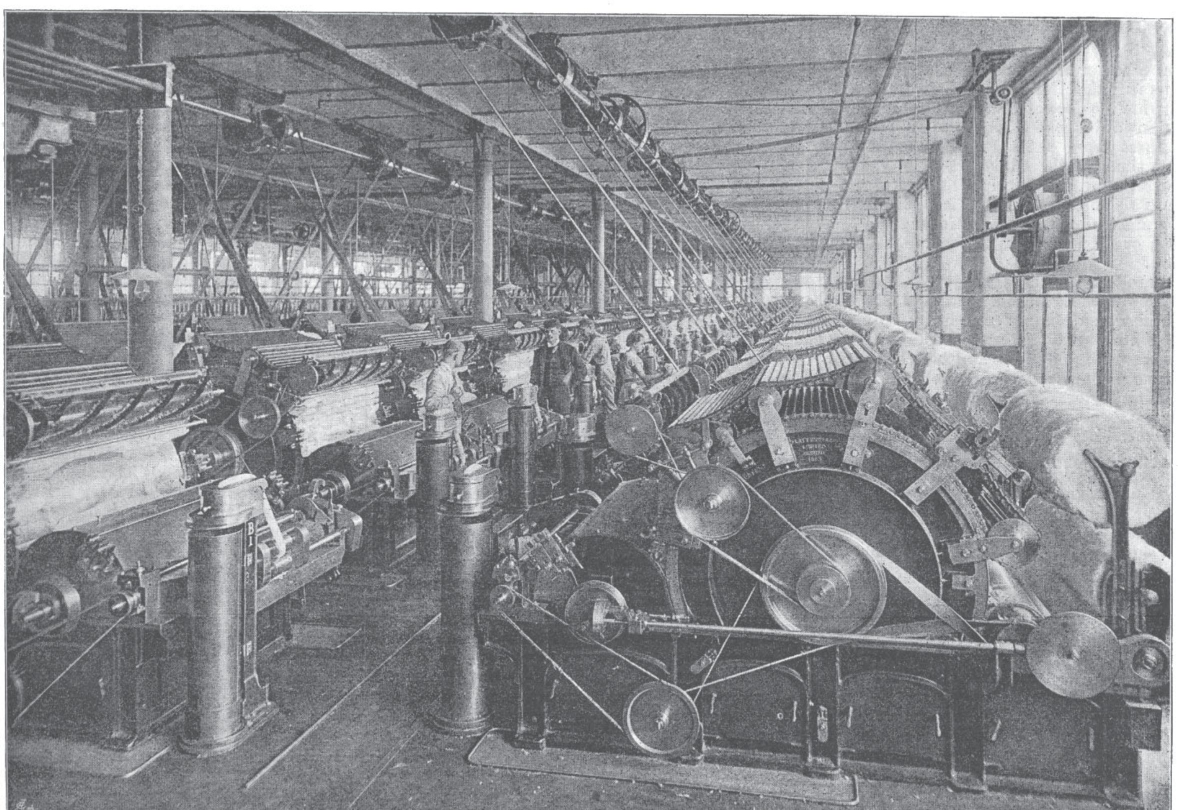

Fig. 6. Carding-Room.

the ring bobbin, through which it passes, and which it causes to rotate. It is necessary, however, to twist the roving into thread as well as to wind it, and the necessary twist is put in by reason of the traveller putting some drag on the thread ; in this way the spindle makes a greater number of revolutions than the traveller, and therefore twists the thread. In order to lay on the thread to build up the bobbin, the rail on which the rings are fixed is caused to rise and fall, so that the thread is guided to the right position.

We now pass to the mule department. In our illustrations (Fig. 8, on page 104, and Fig. 13, on page 105) we give views of the mule rooms in Messrs. Haworth's Ordsal and Egerton mills; whilst in Figs. 16 and 17, on page 108, we give illustrations which are front and back views of the headstock in one of Messrs. Platt's mules, a part of the carriage also being shown. In the mules the roving bobbins are arranged at the back of the carriage, and the roving is drawn from these by means of rollers provided for the purpose. The carriage then comes forward, and whilst it does so the thread is led to the top of the revolving spindles on which it is to be wound, being guided by a long horizontal wire known as the faller wire, which rises for the purpose. During this operation twist is being put in the roving by means of the spindles, which revolve with great rapidity. The operation is exactly similar to that performed by the spinner of primitive ages, when the spindle was held suspended by its point by a thread, and was made to rotate, the spinner holding the thread in her fingers. When the motion of the carriage is reversed, so that it runs in towards the rollers, the thread is led off from the body of the spindle at right angles, or approximately right angles, and as the spindle continues to revolve, it will be seen that the thread will be wound round the spindle, and will form what is known as the "cop." It will be seen, therefore, that there are two principal operations, one consisting of twisting the thread, performed when the carriage is running out and when the faller wire leads the thread from the point of the spindle or in a line with its axis, the second operation consisting of winding the thread when the twist has been put in it on to the spindle.

There is, however, one operation which complicates the action a good deal. It is necessary to keep the thread always in tension, otherwise it would kink. The line followed by the thread when it leads from the point of the spindle to the rollers is shorter than that taken when the thread leads from the middle of the spindle to the rollers; it will be obvious, therefore, that when the faller wire attempts to guide the thread to the centre of the spindle, which it does at the pause between the outward and inward stroke (that is, when the carriage is furthest from the standing part of the mule), at that time the thread would be broken by the faller wire, unless additional length of line were given. This additional length is obtained by reversing the motion of the spindle, it taking a few reverse turns, or "backing off," so as to slacken up the thread.

The mules used in Messrs. Haworth's establishment are of the most advanced kind, and are entirely self-acting, an attendant only being required to join any broken thread. The mule performs the same operations as the ring frame, although, as will be seen, the result is obtained in a somewhat different manner. The mule does finer and more even work, and is, therefore, generally used for weft, the weft of the woven material being that which is generally on the surface. The ring frame is used for warp, where a stronger thread is required. Before the introduction of the ring frame, warp was spun by the throstle or flyer frame, and, indeed, for many years the quicker working and more economical ring frame was strenuously opposed by English spinners, although it had obtained a firm footing in the United States. To the present day warp twist is largely spun on flyer frames. As, however, Messrs. Haworth have broken all their throstles up, and replaced them by ring frames, we are not able to describe them in connection with these works. It may be stated, however, that the throstle differs from the ring frame chiefly in the fact that a flyer is used in place of the traveller and ring.

We have now converted the raw cotton into warp or weft as the case may be, and it remains to weave it into textile fabric, but before this can be done certain subsidiary but important operations have to be performed.

Following up the thread which has been spun, we pass to the room which contains the winding mechanism which transfers the thread from the ring bobbins on which it has been wound in the spinning machines to what are known as the warper's bobbins. The operation is simple, the thread being laid on evenly by a rising and falling guide-plate having a slit in it through which the thread passes; the thread is also drawn at the same time through a brush ; the combined effect of the brush and guide-plate is to remove imperfections, for if there were any thick places in it they would not pass through the slit in the guide-plate.

The yarn is, as we have said, transferred from the ring bobbin to the winder's bobbin. It may be that six ring bobbins will be wound on to one winder's bobbin, the object being to prevent constant creeling. The warping mill, by which this operation is performed, has in it a very clever arrangement for automatically stopping the action should the warp break. A number of the winder's bobbins are next placed in the creel of the warping mill. In Fig. 9, page 104, is shown the warping department in Messrs. Haworth's Throstle Nest mill, and in Fig. 30, page 116, is a view of a warping mill or beaming frame made by Messrs. Platt Brothers and Co. The function of the warping mill is very simple. It transfers the yarn or twist from the bobbins or spools to the warper's beam. In Fig. 30 the beam is empty ; in the view, Fig. 9, of Messrs. Haworth's mill the beaming frame, which is on the left of the picture, is shown full. The threads pass through a reed or fine steel comb on their way to the beam. On each of the threads of the warp is hung a fine steel bent wire, which may be likened to a lady's hairpin. Should any thread break, the hairpin drops into the mechanism below and stops the machine by passing between two rollers and forcing them apart, thus putting into operation a gear which throws a clutch out of action. As there are often as many as 600 threads in a warp, and the breaking of one of these would be sufficient to cause the material to be rejected, it will be seen how necessary it is that automatic gears should be provided, as it could hardly be expected that an attendant would immediately detect the breaking of one thread amongst 600. In Fig. 30 only a portion of the creel containing the bobbins is shown. The sudden stopping of the machine is apt to cause slackness of the thread, owing to the momentum in the bobbins, which go on unwinding after the machine has come to rest. In order to obviate this defect, tin rollers are provided, which automatically fall in the bight of the threads, and thus take up the slack. The machine has also an automatic "knock-off," which comes into play when a predetermined length of thread has been wound.

We have now the thread wound on the warper's beam, but it is not yet ready to be put into the loom, as a sizing or slashing operation has first to be performed. This is a simple process, the apparatus by which it is carried on being illustrated by Fig. 20, on page 110. The warper's beams are placed in the slashing sizing machine. In our illustration they are shown without yarn on them ; but the threads are unwound, passing through a bath of sago or other material. As many as 3000 to 4000 threads will be passing through the machine at one time. They then travel over the circumference of a big drying cylinder 9 ft. in diameter, and warmed by steam, and from thence they are rewound on to the weaver's beam. Fans are provided, the draught from which plays on the yarn and helps to dry it.

We must now retrace our steps somewhat to describe the process followed with dyed or bleached goods, we having hitherto dealt with what are known as "grey goods," which comprise all kinds of calicoes, long cloths, twills, &c. In coloured goods the first distinct operation is reeling. In Fig. 31, on page 117, a reeling machine is shown as made by Messrs. Platt Brothers. The twist is wound from the ring bobbin at the top of the machine round a swift, and is thus made into a hank. These hanks are made up into bundles and forwarded to the bleachers or dyers. The hanks of yarn come back from the bleachers or dyers, and are then transferred to the warper's bobbin. In Fig. 32, on page 117, we show a hank winding machine made by Messrs. Platt, such as is used in Messrs. Haworth's mill. The warper's bobbins are on the top, and the hank is being wound from a swift. This is for coloured goods. Another illustration, Fig. 34, page 118, shows a pirn winding machine. Here the hanks are also mounted on swifts, and are being wound on to pirns shown at the top. The pirns, it must be understood, are used for weft in checks and plaids. The bobbins are taken to a creel, which is a large wooden frame, being arranged according to pattern in the creel, so that the threads of a required colour weave to the proper part. It should be stated that in coloured goods the warps are wound in sections known as "cheeses," and the name is a suggestive one, as each cheese consists of a short but very thick cylinder of thread, as shown in Fig. 9, page 104, in the foreground. It is remarkable how the cheeses will stand together without the thread slipping off its turns; this result is only got by winding very closely and evenly. The number of cheeses required for any given width of cloth are threaded on to an iron shaft. The next process is to wind the thread from the cheeses to the weaver's beam. The object of winding in cheeses is that the parts should not be too unwieldy to deal with. As it is warp we are describing, it will be understood that the wider the material required, the greater number of cheeses will be required to make up the beam.

We now pass to the drawing-in or twisting room, where the weaver's beam is taken to the drawing-in frame. This is all handwork. In order to make our explanation clear, it will be necessary that we say something about the action of the ordinary loom, and though we do not suppose there are many educated people, at any rate amongst the industrial classes, who do not know the general principles of weaving, it is necessary that we should repeat them in order to make our description clear. In Fig. 18, on page 109, we show a calico loom as manufactured by Messrs. Platt Brothers and Co. The various threads which go to form the warp are wound on the weaver's beam as explained, whilst the weft, which has been formed into a cop in the mule or into a pirn on the pirn winder, is contained in the shuttle. By suitable mechanism the warp is being continually unwound from the beam, and is wound on to the cloth roller, which revolves for the purpose, and round which it is wrapped after being converted into cloth. Each thread of the warp passes through what is known as a "heald." There may be two or four healds ; we will deal with the simplest conditions, and suppose there are two. The heald consists of a heald shaft, which is a long lathe, to which is attached a number of threads that hang vertically in the loom. A second or lower heald shaft is attached to the bottom ends of the threads. In the middle of each thread there is worked an eye, and through each eye passes one thread of the warp. We have, therefore, a roller or weaver's beam with the warp wound round it and the end of the warp taken through the eye of the heald, and from thence to the second roller, round which it is in turn wound ; the process of weaving being, therefore, a constant unwinding from one roller and winding on to the other, the cloth being formed from the threads between the two rollers.

Having proceeded so far, it may be as well to describe the operations of the drawing-in or twisting room, which are wholly hand processes. The weaver's beam is put into position, and the heald is suspended in front of it ; the end of each thread in the warp is then passed through the eye in its corresponding heald, and also through the reed, which is a steel comb, the use of which will be afterwards described. The whole is then taken to the loom. Our illustration, Fig. 12, on one of the two-page engravings which we publish this week, shows the principal weaving shed in Messrs. Haworth's mills, in which it may be stated over 800 women are at work under the charge of one man. The threads forming the warp come from the beam over what is known as the back rest, and pass two "shed rods" which, in the ordinary plain loom, divide them into two parts. These shed rods, by holding the warps apart, help the weaver to pick out a broken thread. As already stated, there are two healds placed one in front of the other ; the back heald will take, say, all the threads of odd numbers, supposing them to be numbered consecutively, whilst the front heald will take, say, all the even numbers ; in this way each alternate thread will pass through an eye in one or other of the healds. The healds are given a vertical reciprocating motion by means of tabbets, and, therefore, the odd and the even numbers in the warp are made to rise one above the other alternately. The shuttle now comes into play. In it is placed the weft, as stated, and it is made to pass from side to side of the loom by means of blows from the picking stick. As the shuttle passes in one direction, say from right to left, it will travel above the warp threads of the odd numbers. The heald which carries the warp threads of odd numbers will then rise, whilst the even-numbered warp threads will fall, and the shuttle will make its return journey, uncoiling its weft as it goes. In this way the interweaving of the warp and weft is obtained, the shuttle carrying the weft alternately first above and then below each thread of the warp. In order to press the weft close together, what is known as the reed is provided; this may be described as a flat steel comb, each thread of the warp passing between a pair of teeth. The shuttle race is in front of the reed, and when the weft has been drawn across by the shuttle the reed comes forward, and presses it hard against the preceding weft. The division between the warps through which the shuttle goes is known as the shed. There is a stop motion provided in case the weft breaks; there is also a taking-up motion so as to regulate the closeness of the web, that is, the number of picks per inch of cloth made. As the shuttle always travels at one speed, the number of picks per minute in a given loom is constant; in some cases they go in as high as 250 per minute. The closeness of the weft is therefore obtained by altering the winding or taking-up motion. The process we have described is, of course, the most elementary form of weaving.

There are, however, a large number of looms of all kinds in Messrs. Haworth's works, the need of them being often being governed by fashion. The looms in Messrs. Haworth's weaving sheds are of all descriptions, ranging from the plain calico loom to the intricate Jacquard loom. It would be hopeless for us to attempt to describe them all. A large number have attached what is known as a "dobby," which acts by a series of levers working the healds from above. A dobby loom is shown in our illustration, Fig. 19, on page 109. A good deal of sateen or cotton satin is made on these looms, and is now a fashionable material. There are are sheeting looms which weave bed-sheets up to 112 in. wide; these are plain and twill looms, remarkable only for their size.

Dobby looms are useful for changing the warp when the pattern is made by different coloured threads in the warp, the weft being only one colour. For forming the pattern by means of different-coloured weft, several shuttles have to be used, each carrying the thread of the particular colour required. For instance, if a large square of blue colour has to be formed, the blue shuttle will have to be brought into play for several picks continuously, and the shed will be arranged so that most threads of the warp are down, only, perhaps, one out of every three or four being up and thus passing over the weft. Looking at the cloth from above, therefore, the blue weft will be the predominant feature, whilst on the other side of the material the weft will be almost covered by the warp, and therefore the colour of the latter will predominate. If several colours are required in a pattern, as is usually the case, the shuttles are carried in what is known as the drop box, that is to say, they are packed one above the other in a two, three, four, or five shuttle box, each shuttle resting on its own support. By suitable mechanism the box is raised or lowered so as to present the required shuttle to the blow of the picking stick, and thus send it through the shed. Sometimes the same object is obtained by circular rotating boxes. The shuttles are presented in proper order by means of a card or steel sheet which has holes pierced in it. Steel pins strike against this card, and the one which finds its hole penetrates and thus passes forward to throw a rack on to a pinion which actuates levers and so work the shuttle box to bring the right shuttle into play. Looms are made which combine the drop box and the dobby, so that the warp and weft can both be controlled, and thus produce diversified and intricate patterns.

The picking stick is actuated by a picking tabbet, or cam, which causes the stick to give a smart blow to the shuttle and thus send it through the shed of the loom to the other side, from whence it is returned by another picking stick. The beam has no motive power, but is actuated by the warp threads as they are wound on to the cloth rollers. It is necessary to keep the warp at great tension, and for this reason four weights are used which act in a contrary direction to that in which the warp travels, thus forming a break. Complicated effects and floral patterns are produced by means of the Jacquard loom.

The remaining departments in Messrs. Haworth and Co.'s mills, although extensive and important, do not call for particular description here. In Fig. 14, on page 105, we show the cloth folding and examining department, with the folding and measuring machines at work.

THE WORKS OF MESSRS. PLATT BROTHERS AND CO., LIMITED, OLDHAM.

The series of works at Oldham which are the property of Messrs. Platt Brothers and Co., Limited, are, we believe, the most extensive of the kind in this or any other country. The works themselves cover an area of 55 acres, a very large part being buildings of two, three, and four storeys. The number of men employed is between 9000 and 10,000, exclusive of those at work in collieries and other works the property of the firm. There are in all four chief factories, viz., the Hartford Old and New Works, the Werneth Spindle Works, and the Forge. These are the establishments devoted to the production of machinery, mostly for textile purposes. There are also the collieries referred to, four in number; brickmaking works, and various other departments. The brickmaking works are extensive, and are worked on the dry-clay process. They were illustrated and described in our issue of March 1, 1867.

The firm of Platt Brothers and Co., although under a different name, was founded nearly three-quarters of a century ago, by Henry Platt, who came from Saddleworth to Oldham in the year 1821. Henry Platt had previously been engaged in the manufacture of textile machinery, such as it existed in those days, and when he started in Oldham he had in his employment about half-a-dozen hands. Later on Mr. E. Hibbert, who was an engineer of Oldham, joined in the venture, and the firm was carried on under the style of Hibbert and Platt. The works were, at first, situated at a place known as Ferney Bank, but the business growing rapidly, new premises were taken, and what are now known as "the old works" were started. These works are fully described in the present article. Two sons of Henry Platt, Joseph and John, soon after, in 1837, came into the business, and five years later Henry Platt, the founder of the business, died. Joseph Platt died in 1845, and his brother James Platt joined the firm. In 1846 Mr. Hibbert died. In the year 1854 John and James Platt having become sole proprietors, and the business having grown to large dimensions, three new partners, who had been in the employment of the firm, were admitted, and the title of the house was changed to Platt Brothers and Co. The three new partners were William Frederick Palmer, William Richardson, and Edmund Hartley. In 1864 Eli Spencer, who had long been connected with the firm, also became a partner. In 1868 the business was incorporated as a limited liability company under the Companies Act, under the chairmanship of John Platt. In 1872 the death of the first chairman rendered the position vacant, and the present chairman, Mr. S. R. Platt, succeeded to the post, which he has retained up to the present time.

It is, perhaps, hardly necessary to say that the firm has numbered among its representatives men of unusual ability and strength of character, for it could not have grown to such vast dimensions, and have achieved such unexampled success, unless the business had been conducted with more than ordinary energy and sagacity. Perhaps the chief factor in the success of the firm was the aptitude the late Mr. John Platt had for discovering those fitted to further the interests of the business, and the gift of reading character, which is the first and highest quality for those who would be leaders of men. It was John Platt's far-seeing policy that enabled the business not only to make the most astonishing strides in his lifetime, but left it so that those who have followed him have been able to continue its growth. Many tales are told of the acumen John Platt displayed in the selection of his colleagues; and it is said that in every case he was successful, all those he chose having fully justified the trust reposed in them. One of those who has left his mark most strongly on the works was the late Mr. William Richardson.

For the present it is sufficient to say that the firm is still extending its operations month by month, one might almost say day by day. One very pleasing feature that cannot but strike any one making, as we recently did, an extended visit to these works, is the long time that those employed remain in the service of the firm. The heads of departments, foremen and others, seem nearly all to have been 30 or 40 years engaged in the works, and it is, doubtless, the strong spirit of *esprit de corps* which has contributed to the success of the firm.

THE FORGE.

This is in itself an extensive engineering establishment, and here the process of puddling iron may be seen carried on with as much activity as if Bessemer had never made his great invention. The refining furnace to which the pig is first taken has a capacity of 30 cwt., and works at six heats per day, so that 180 cwt. is used each day. The refined iron is taken from here to the puddling furnaces, which work nine heats per day, a somewhat quick rate, which we believe is only equalled at Lowmoor, where we understand ten heats are worked, though the Lowmoor heats are not so big as at Messrs Platts', the latter being $3\frac{3}{4}$ cwt. The refined iron is used with a mixture of cold blast pig. There are 20 puddling furnaces, on the water bosh system, and each has a boiler for waste heat, and there are two Lancashire boilers besides; the steam generated is used in the forge. For shingling purposes there is a 40-cwt. steam hammer. From the hammer the puddle bloom is taken to the reheating furnace, which has a single oxide bottom, and is then put through an 18-in. puddle train of rolls; after rolling, the bar is placed in water to remove scale, and is then sheared to length and split in a shearing machine, after which it is scoured in a scouring barrel to remove all oxide and scale which may have adhered. The iron is then cross-piled and heated and hammered three times in the ball furnace department, after which it is drawn into a bloom for any size required. For the ball furnace there are two 70-cwt. steam hammers, and also a helve hammer for blooming. In the steam hammers there is a good arrangement by which the two standards are strapped together by means of two wrought-iron stays $2\frac{1}{2}$ in. in diameter, thus giving increased rigidity to the framing and adding to the steadiness of the work. There are two cranes for serving these hammers. The refining furnaces will take up to four tons, for larger work than that recourse has to be had to breaking. At the time of our visit a large hydraulic cylinder was being reduced to smaller pieces, an operation performed by drilling lines of $1\frac{1}{8}$-in. holes and driving in tapered steel drifts. An unsuccessful endeavour had been made to break this cylinder by means of a 30-cwt. tup, with a drop of 25 ft. It may be remarked that it is always safer to break up hydraulic cylinders, even if they are not too big to be dealt with by the furnace, and that is the practice always followed in these works. For blooms or billets there is a 12-in. finishing mill train and a 9-in. guide mill train. There are in all in the forge one merchant mill, one guide mill, and one puddle bar mill.

The general arrangements in this forge are designed to carry out the principle followed in these works of substituting machine for hand labour.

The roll store is served with a single rail crane, which will deliver to the mill cranes that command all parts, and any handling is thus avoided. In this department there are seven pairs of shears and one punching machine.

The output is from 150 to 160 tons per week of finished iron, but that does not include the whole demand of the works. There is a 30 horse-power engine for the merchant mill and guide mill, and a 70 horse-power engine for the puddle bar train and helve hammer, in addition to which there is an 8 horse-power engine for shears, pumps, &c.

The iron warehouse is attached to the forge, and is well arranged. There is also a mechanics' shop here for fitting and roll turning; furnished with lathes, planing machine, and other machine tools. The standard-gauge railway runs into this department. Pattern-rooms, store-rooms, and joiners' shop are connected. It may be interesting to state that the coal used in the forge is 350 to 370 tons per week.

THE HARTFORD NEW WORKS.

The sawmill department in the Hartford Works is extensive, but does not call for any special description. There are frame and circular saws for breaking down logs, and other machines usual in shops of this class, including three powerful overhead steam travelling cranes. A good deal of timber is used in textile machinery, the mule carriages being largely of wood, and parts

MESSRS. RICHARD HAWORTH AND CO.'S COTTON MILLS, SALFORD.

(*For Description, see Page* 98.)

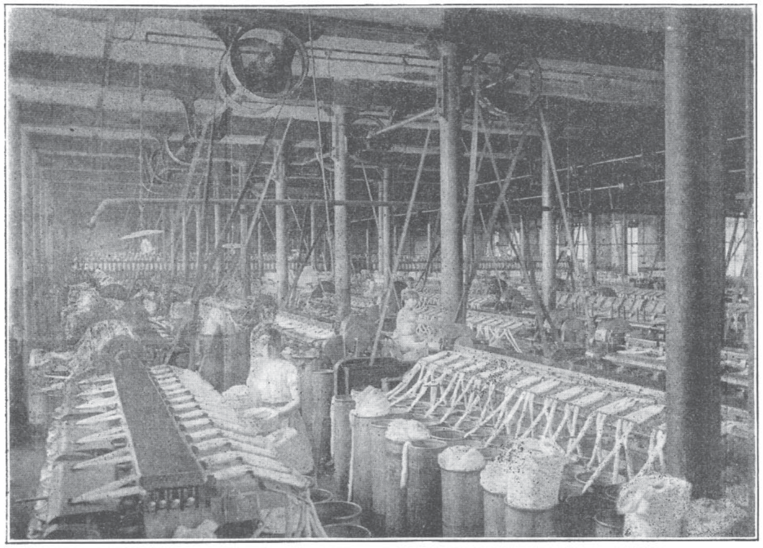

FIG. 7. DRAWING FRAMES.

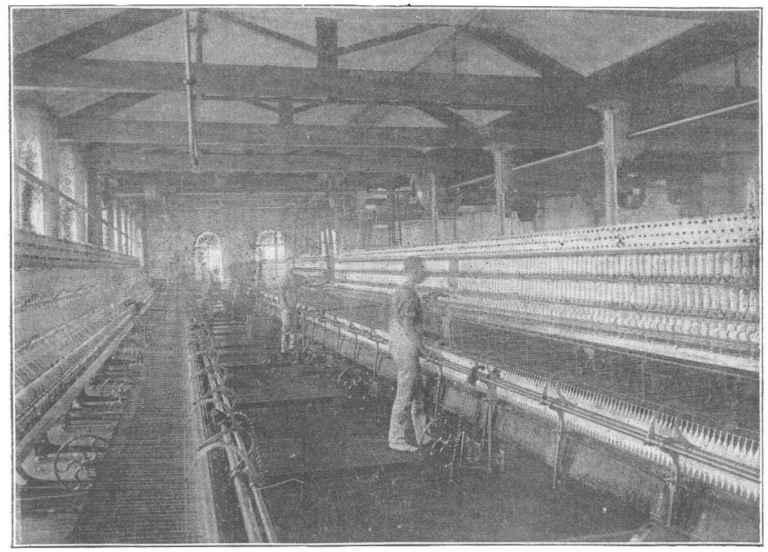

FIG. 8. MULE ROOM.

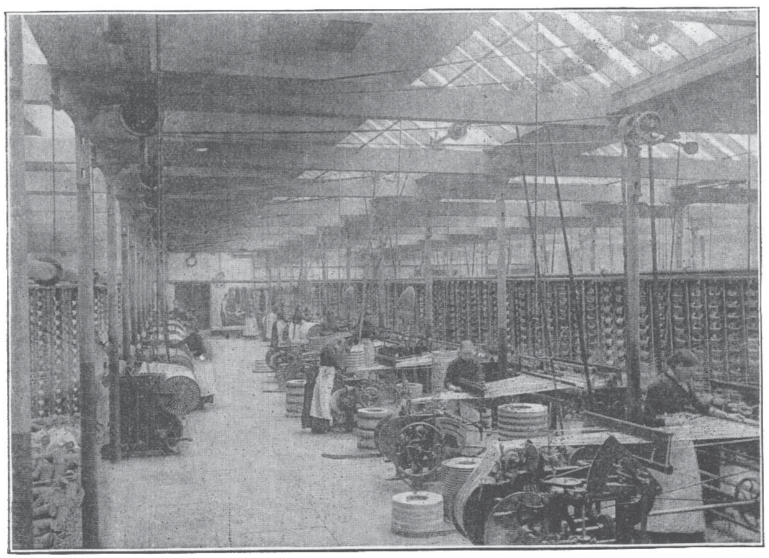

FIG. 9. WARPING DEPARTMENT.

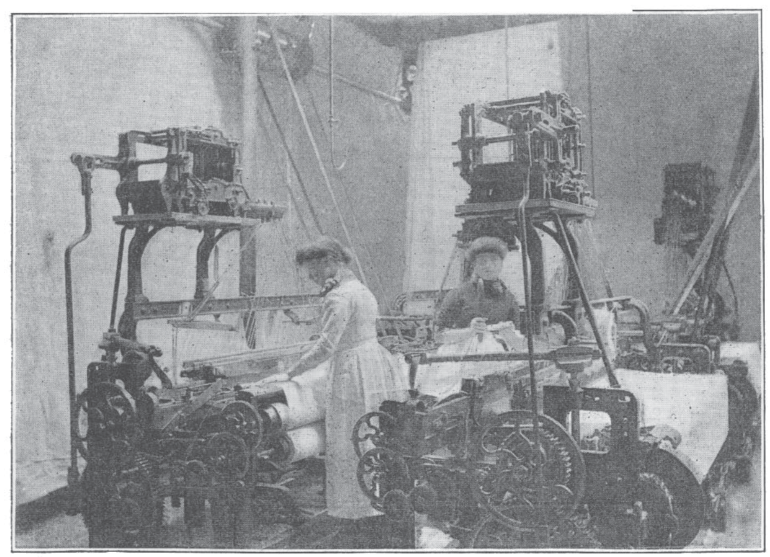

FIG. 10. POWER LOOMS.

MESSRS. RICHARD HAWORTH AND CO.'S COTTON MILLS, SALFORD.

(*For Description, see Page* 98.)

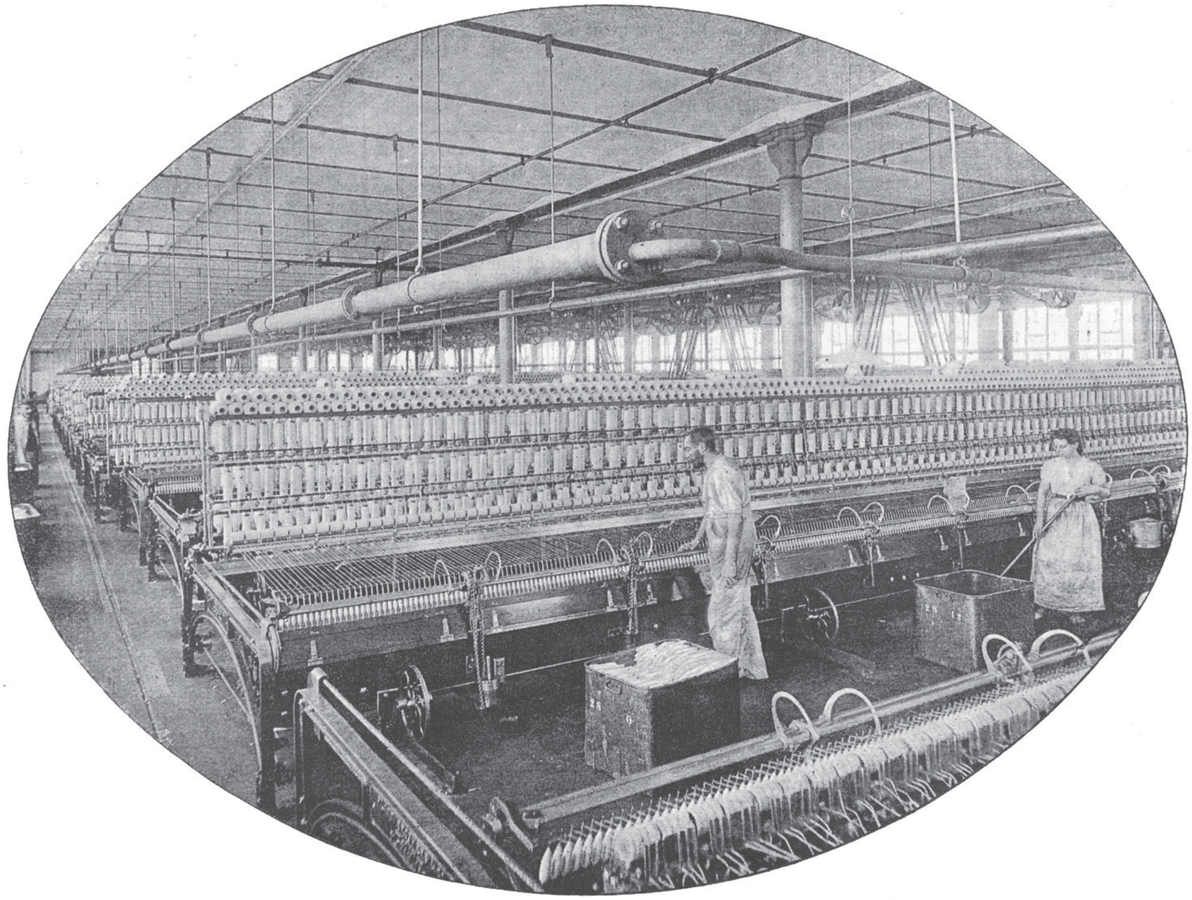

FIG. 13. MULE SPINNING.

FIG. 14. EXAMINING AND FOLDING DEPARTMENT.

of looms are also composed of wood. For use in the manufacturing of machinery Messrs. Platt use 350,000 cubic feet of timber per year. The firm keeps a very large store always in hand. The packing - case department is a notable feature, being a large building fitted with wood-working machinery. The men who make these large packing-cases required for the transportation of big machines, such as mules and speeds, have reduced the practice to a fine art, and it is surprising how quickly two men working together on one of these packing-cases will raise a structure of formidable proportions out of a heap of boards. An adjunct to this part of the works is a wheelwright's shop, where numerous carts, barrows, &c., used in the works are repaired.

The Wood-Turning Department is attached to the sawmill, and here there are a number of wood-turning lathes; whilst there may be seen in process of construction wood rollers for machines, picking-sticks, &c. For squaring the ends of the picking-sticks a special planing machine has been devised. There are also other special wood-working tools which are adaptations of the standard types, such as planing machines, machine saws, &c.; these are largely used for carriages of mules. In another room there is wood-working machinery for making wood top rollers. Here also are turned beams for looms. The equipment is that of an ordinary wood-turning shop, with hand tools for the lathes. There are some wood-working tools for drilling, sawing, &c.

The Foundries.—The foundry department of the Hartford New Works is an extensive one, and the practice is very interesting. There being so much repeat work, machine and plate moulding is carried on to a very large extent, in fact, hand-moulding may almost be said to be exceptional, and is only used for occasional or extra work.

There are in all seven foundries in the new works; the aggregate output of each is 500 tons of light castings per week. In the foundry department 1200 men are employed on an average. There are seven cupolas for melting.

The first foundry is that used for jobbing and for sundries where hand-moulding is practised, and where articles which are not standard are produced. At the time of our visit a large number of heavy iron columns were being cast for the extension of the buildings, especially for the new iron foundry which is being made. Here, also, other castings for the plant are made and parts of machines out of the usual run. It would be impossible to describe the various methods of machine and plate moulding adopted in these works, even if it were necessary. The practice is founded on the usual principles which are familiar to all who are accustomed to foundry work in which there is much repetition of similar parts. The shops are well fitted with hydraulic cranes, some of these being on the rising and falling suspended rail system. Root's blowers are used, except in the case of one three-cylinder blower, and four of the cupolas are fitted with Swayne's receivers for obtaining a regular mixture of the metal. There is also a steel foundry where a speciality is made of light steel castings; malleable castings are also produced here. Calcining ovens are worked by coal for steel castings; whilst ovens for soft malleable iron castings are heated by gas. There are a large number of rumblers or barrelling machines, and emery wheels for cleaning and dressing castings. There are seven hydraulic pumping engines supplying water to three 24-in. and one 16-in. accumulators. The power for blast is supplied by a Corliss engine of the firm's own make. The multiplicity of small castings produced in this foundry is very remarkable, and to make up the total output means a very large variety and number of pieces. For instance, in the case of one small bevel wheel of about 1 lb. weight, over 14,000 are produced in the week. Large as is the foundry department at present, it is insufficient for the work of the firm, and there is in progress a new foundry 390 ft. long by 90 ft. wide. This building will be of two storeys, and under one-half of it there will be also a basement floor, which will be used exclusively for machine moulding.

Fluted Roller Department.—In the process of manufacturing fluted rollers, the lengths are cut hot from the rod by means of a circular saw, to which is attached a stop for cutting to the right length. They are then rolled to straighten them. The ends are next squared off accurately by a planing machine, arranged to work the two ends at once.

There is required at one end of the roller a square hole, and for the purpose of making this hole there are a number of four-spindle horizontal drilling machines, in which flat drills are used; these make a round hole about 3 in. deep. In order to make this the proper square shape the rollers are mounted on a revolving table of a machine, 28 of them being set at once. A square cutting tool, of a size slightly greater than the square which could be inscribed in the hole already drilled, is then forced into the hole, and in its progress cuts four triangular notches; a larger tool of a similar shape increases the size of the notches, and the operation is performed with other tools, each one larger than the one preceding it, until the circular hole has become square. The roller is then heated at the other end and squared in a forging machine; at the same time the round above the square is forged in swages. The roller is then cut to length by shears attached to the same machine. It will be understood that the rollers are worked in lengths; the square end of one fitting into the square hole in the next, so as to make a continuous line for driving when placed in the machine for work. The sides of the squares are machined in a vertical double-slotting machine, two sides of each square being done at once. The rollers are now rough on the outside as forged, except the ends, and they have to be taken to the floor above in order that they may be turned to form the bosses. The bosses are formed by simply turning recesses in the cylindrical part; the projecting parts left standing up form the bosses. These operations are performed in a lathe specially constructed for the work, but designed on ordinary general principles. The iron from which the rollers are made is of an extremely ductile nature, as may be seen from the turnings taken off by the tool.

The next operation is to cut the longitudinal grooves in the rollers. This is done in a seven-cutter planing machine, having a traversing screw in the bed for the table; there is a quick return motion, and the work is turned automatically in order to present a fresh surface for the next groove to be cut; this is done by cam and ratchet motion; six cuts are taken for each groove, the cutter being fed down by hand. These rollers, like all other metal-work which is brought in contact with cotton in spinning machinery, have to be absolutely smooth, without any rough edges which would catch the cotton. The tools, therefore, have to be very sharp, and a cutter only goes round the work once before being re-ground. A grit-stone is used for grinding, one being attached to each machine, and great care is taken to keep the stone true. The fluted roller, which plays so important a part in cotton spinning machinery, is now practically finished, and only requires cleaning by sawdust, after which it is wrapped in paper, the whole package being dipped in tallow to prevent rust.

Turning Shop for Cast-Iron Top Rollers.—In this extensive department there is a large number of machine tools used exclusively for the purpose of turning the loose boss top rollers, and the ordinary top rollers. The top roller, it should be explained, is placed above the fluted rollers in spinning machines, and consists of a spindle with two bosses. There is great variety in length and shape in these; the length ranging between 1 in. and 10 in., and diameters varying from $\frac{9}{16}$ in. to $2\frac{1}{4}$ in. Top rollers are of two kinds, ordinary and loose boss. The loose top roller consists of a spindle with two loose bosses or revolving cylinders, outside. The method of manufacture consists of turning and boring work, a large number of special lathes and boring machines being used, but a good deal of finishing is done by hand tools on lathes. The method of production need not be described, as the various turning and boring tools, although of a special nature to suit the work, are founded on ordinary general principles.

Ring Frame Department.—In this department are prepared the rings for ring spinning and doubling frames. Our illustration, Fig. 15, on page 107, shows one of Messrs. Platt's ring spinning frames. In our article on Messrs. Haworth's mills, a description is given of the process of ring spinning. The ring is formed from a short iron cylinder which varies between $1\frac{1}{8}$ in. up to $3\frac{1}{2}$ in. long in the blank. The blank is prepared from a bar $\frac{3}{8}$ in. thick; the first operation is to bore the blank in a three-spindle horizontal drilling machine; next the ring is turned to the required contour internally and externally by two tools at once. The general procedure is to use in the lathe hand-tools of different shape of cutting edge to get the required profile, and after the piece has been formed so far it is case-hardened; after this the work is polished by emery wheels, and by a polishing stick and emery powder, and is finally burnished. The make in this department is over 10,500 per week.

In this same department there are erected headstocks for ring spinning frames. In an extension of this room there are a number of planing machines for planing frame ends of ring frames, and other parts belonging to the same machines. There are shaping machines, drills, milling machines, &c. The milling machines are of all types and cut on several faces. Adjoining is a grinding shop for the same class of work, having grit-stones and emery wheels.

We now pass to the floor above to the department in which the ring frames are erected. The parts are all machined to standard size, according to the principle followed in these works (which, indeed, is a necessity of the situation), and little fitting, therefore, is required when the parts have to be put together. There are four rooms devoted to the erection of ring spinning frames. There is also a separate room for erecting the head or driving end. These machines run from 200 spindles single-geared to 600 in the double-geared machines. In the latter, the driving mechanism is placed in the centre of the length of the frame. The length of a ring spinning frame of the latter kind is 68 ft., and naturally a good deal of care has to be exercised to make the machines perfectly level and straight. The present output of ring spinning frames by the firm is about 8500 spindles per week; this, of course, not including winding frames, doublers, reels, and pirn winders, &c.

We now pass to a shop where boring, drilling, and planing of the articles required for ring frames is carried on. All castings are brought from the foundry in small trucks, which are loaded on to the railway wagons and thus delivered to the nearest point to their destination. The planing machines are mostly of the ordinary type, but have cutting tools specially arranged for the particular work. Some of these planing machines have six tool-boxes. There are some special drilling machines, some with long beds and two cross beams of the planing-machine type, four spindles being used on each cross beam. The bed is moved forward intermittently, as the holes in the frames which take the spindles are bored, the exact pitch thus being obtained by automatic means. When the holes are bored, the drills are withdrawn by hand, and the traversing mechanism for the table is put in gear, so that it is moved forward to the next place, when a catch arrests the motion by engaging in a notch in the bed. A hole $1\frac{1}{16}$ in. is made, and both flat and twist drills are used. The twist drills are ground by an emery twist drill-grinding machine. The frame members are then marked off to the right length, and cut in a machine by a circular saw.

In the grinding shop for ring frames are stones and emery wheels. Here are ground many thin parts, such as long flat strips of iron, &c., which are not thick enough to machine, and other more solid parts are also finished here. Steel sheets from which small parts are punched out, are also ground to surface.

Self-Acting Mule Department.—Carriage Room.—The mule is the most important machine in cotton spinning, and in Figs. 16 and 17, on page 108, we give two views of the headstock of one of Messrs. Platt's mules with a part of the carriage attached. We refer to the process of spinning by mules in our article on Messrs. Haworth's mills. The carriages of the self-acting mules are erected in large rooms, and as all machines are put together in sections completely before being sent out, it will be easily understood that this is an extensive department, seeing that a mule will be often as much as 130 ft. long. The boards of which the carriages are made are planed on the flat in the sawmill, and brought to the fitting-up rooms ready cut and recessed in the manner already stated. This department is divided by a packing-room, and the further side is used for finishing the carriages. Over this room there are two other rooms; one where the timber is got ready for fitting up carriages, and the other an experimenting room for trying new inventions. In this room there are mules fitted up in working order for cotton, wool, and worsted work. There are also ring frames, and on these experimental machines all new improvements are tried in practical working before being adopted.

Mule Fitting Department.—This is a long room on the second floor of a large building. Here on one side are benches for setting up roller beams and rollers, whilst on the other side the headstocks are erected; at the further end are tools for drilling and planing for the purposes connected with the erection of mules. Beyond is another room at right angles, where parts are assembled, and here are milling machines of special type in which several surfaces are cut at one operation upon various small parts which are clamped together on the table. Multiple drills and other tools are also placed in this part. The packing-room in connection with this department is well arranged; indeed, throughout the works great attention is paid to this feature of packing and loading. A railway in connection with the main lines of the district runs into most of the departments, and where such large and intricate machines as textile machinery have to be dealt with, great care has to be paid to the packing. The various parts which go to compose the mule are prepared in the different shops, and many of them, such as rollers, flyers, &c., will be duly referred to in treating of the various departments.

Loom Department.—Our illustrations, Figs. 18 and 19, on page 109, show two typical looms made by Messrs. Platt. The former is an overpick calico loom, with Eccles drop-box motion, and the latter a dobby loom. In the principal machine shop of the loom-room castings are brought in by train, the full-gauge railways running through the shops. There are a vast number of machine tools, the belting for driving them being a very remarkable sight. The loom sides are planed on all surfaces by planing machines of the ordinary type, whilst for other work shearing machines, lathes, boring machines, drills, &c., are used; in fact, the whole place is a perfect wilderness of machine tools. The milling practice here is notable, the work lending itself very successfully to this method of treatment. There are records that 40 years ago Platts' were milling on six surfaces at once; a statement which somewhat discounts the claims of many persons, both in this country and abroad, who assert themselves to be the pioneers of milling for engineering work. There are here special drills of the multi-spindle type; indeed, the variety of drilling machines is altogether beyond description. There are tapping and boring machines, spurwheel tooth clearing machines, emery wheels, horizontal and vertical slotting machines, whilst at the side of the room are punches for finishing.

One big loom in progress at the time of our visit was 198 in. in the reed space, and would therefore produce material nearly of that width, possibly 18 in. to 2 ft. narrower. This loom was for weaving jackets for paper-making machines; the shuttle was 25 in. long, and ran on wheels in the race. This loom, however, large as it is, is not the largest which has been made in these works, for there has been one constructed of 206 in. width; whilst at the time of our visit there was a carpet loom on order which was to be 330 in. in the reed space. At the further end of the room are the lathes and boring machines. The parts are prepared on this side of the department and are finished on the other side, where they are completed for packing. This firm makes looms of all kinds, both for cotton, woollen, and worsted work. A Terry loom for Turkish towels and bath sheets is interesting.

In another room in the same department the planing work is done, this naturally being the first machine operation on the frames, and here there are various types of planing and milling machines. On one of the former we noticed 10 cutting tools at work at once; whilst the table was traversed for short stroke by an eccentric. Each cutter had a separate tool-box, and all were mounted on an entablature with four columns; the parts to be machined are flat, and the framing may be made low to suit the work, thus insuring great steadiness, and facilitating the use of so large a number of tools. There are other planing and milling machines at work in this department.

Slasher Department.—In the slasher department, sizing and warping machines, cloth-folding machines, and other machines of a like nature are made. Here there are the usual machine tools and other appliances suitable for the wood and iron work required. They do not, however, call for any special mention, although certain of the designs are peculiar to the work. In Fig. 20, on page 110, we give an illustration of one of Messrs. Platt's slashing machines, the use of which is described in our article on Messrs. Haworth's mills.

Millwrights' Department.—In the millwrights' department are some of the larger machine tools on these works. There is a big planing machine which will take 7 ft. square, under the crosshead, and will make a cut of 24 ft. long; it has four tool-boxes, two on the crosshead, and one on each column. There is a gap lathe which will turn in the pit 12 ft. in diameter, and a lathe of 22 ft. 6 in. between centres. There are two screw-cutting lathes 13 in. centres and 24 ft. in length. There is also a large radial drill, which will drill to any angle in any plane. There are two other large gap lathes, and other machine tools such as lathes, planing machines, drilling machines, &c. This shop is used principally for preparing the plant required on the works, and for millwright work for export. There was in process of erection at the time of our visit a large lathe for turning rope pulleys up to 12 ft. The most noticeable piece of work then in progress, however, was a 24-in. ram 15 ft. long, which was being turned for the new foundry. There were also being machined on their ends some of the 18-ft. columns which will be used for supporting the floors of the new foundry. In all there are about 300 of these pillars, one being placed above the other; they are faced on the ends to make square joint and keep all plumb.

Smithy.—On entering the smithy the first thing to attract attention is a number of smiths' olivers doing their work in the usual way, and which appear somewhat old-fashioned amongst so much that is modern. They are, however, very useful for certain work. There are also in this department a large number of steam forging machines, steam hammers, drop hammers of different types, bolt and nut machines, crank-making machines, &c. In fact, the smiths' department is a very busy and crowded one, and it would appear as if the example of the foundry department will have to be followed, and a large extension soon made. A great number of cranks are forged here, some being bent from the round iron by means of drop hammers and dies, whilst others have flat webs. For one machine made by this firm a 2-in. crankshaft is formed by bending under drop hammer and dies; three men are employed on this work, and will turn out 50 crankshafts a day.

Here blanks for the ring spinning frames are made, being stamped out from the bar under the drop hammer in two operations; they are finished by a steam forging machine and swages. Tumblers for drawing frames are stamped out cold in a punching-machine type of press. Faller sickles for mules are also forged here, being stamped in the straight under the drop hammer with a solid boss at the end; the blade itself is at first thick and straight; it is drawn down in a steam forging machine to the right length, and is then bent to a curved form by a press in which the blade is forced on to a curved surface by a roller. The square-web cranks before referred to are forged solid; two saw cuts are taken at the side to form the webs, and the piece is then removed by cutting with a chisel when hot. These cranks are for looms, and are two-throw, the two cranks being set level with each other. The cranks are made with short lengths of shafting, but are some distance apart, and an intermediate shaft is therefore welded on to the short cranked lengths. The size of the crankshaft averages $2\frac{1}{8}$ in., whilst the throw is $3\frac{1}{2}$ in. A certain number of men are engaged entirely on this work of welding up cranks, and become very skilful in it. The two cranks have to be placed at the right distance on the shaft, and have to be exactly level. The men become so apt that they can weld pieces together to exact length without the necessity for any upsetting, allowance also being made for contraction in cooling. This is a very nice piece of smith's work.

Shaft Department.—In the various machines made by this firm for textile purposes a large quantity of shafting is required of approximately small diameters, varying between $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. The output of this description of shafting is about 45,000 ft. per week. It is necessary that this shafting should be smooth, as it would otherwise catch on the material, and as it would be both expensive and difficult to machine long lengths of such shafting, recourse is had to drawing it through dies. Drawing machines of an especial description are used, the shafts being elongated ordinarily about 1 in. in every 12 in. There are a large number of these machines at work, as may be gathered from the output.

General Turning Department.—In this large machine-room there is again an enormous quantity of machine tools at work, and the effect of the belting, pulleys and countershafting by which these are driven, is extraordinary. The belting is so thick that the light is obscured, and it would certainly seem as if here were a position in which electric driving might be tried with advantage. The work done in this shop is very diversified, boring and turning wheels and brackets, band pulleys, &c., in connection with all the machines, speeds, looms, ring frames, throstles, &c. To describe one-half of the processes gone through would take a volume of ENGINEERING. We will, however, take as an example a small skew gear wheel of cast iron and 5 in. in diameter, 11,000 specimens of which are produced per week. It is bored, turned on the rim, drilled and tapped for set screw, in machines specially designed for the operation. To each of these wheels there is a pinion and a bobbin-wheel, so that in all for this one detail 33,000 pieces are required per week, each having several machine operations done upon it. For boring these wheels four spindle lathes are used, one spindle being placed above the other in a vertical direction. Another example of the number of parts produced are the "long collars" for speeds; these are made of cast iron, and are $\frac{7}{8}$ in. to $1\frac{1}{8}$ in. in diameter, whilst the length varies from

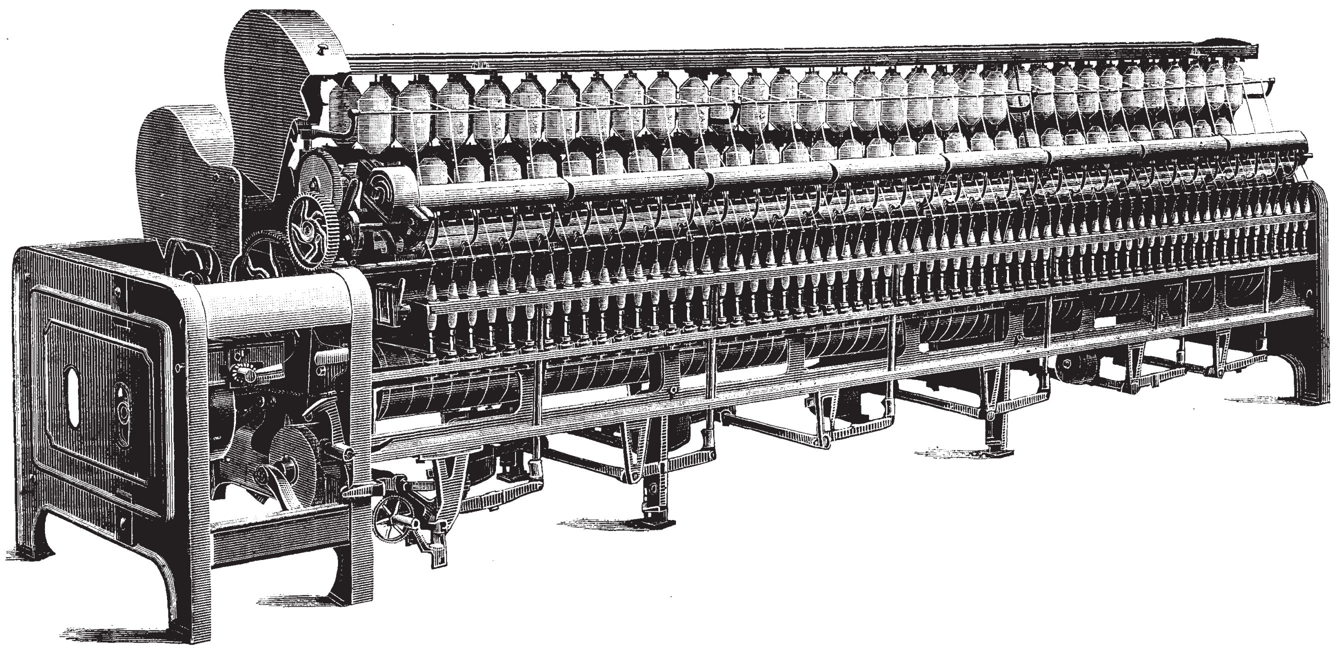

FIG. 15. RING SPINNING FRAME, BY MESSRS. PLATT BROTHERS AND CO., LIMITED.

COTTON MACHINERY.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, ENGINEERS, OLDHAM.

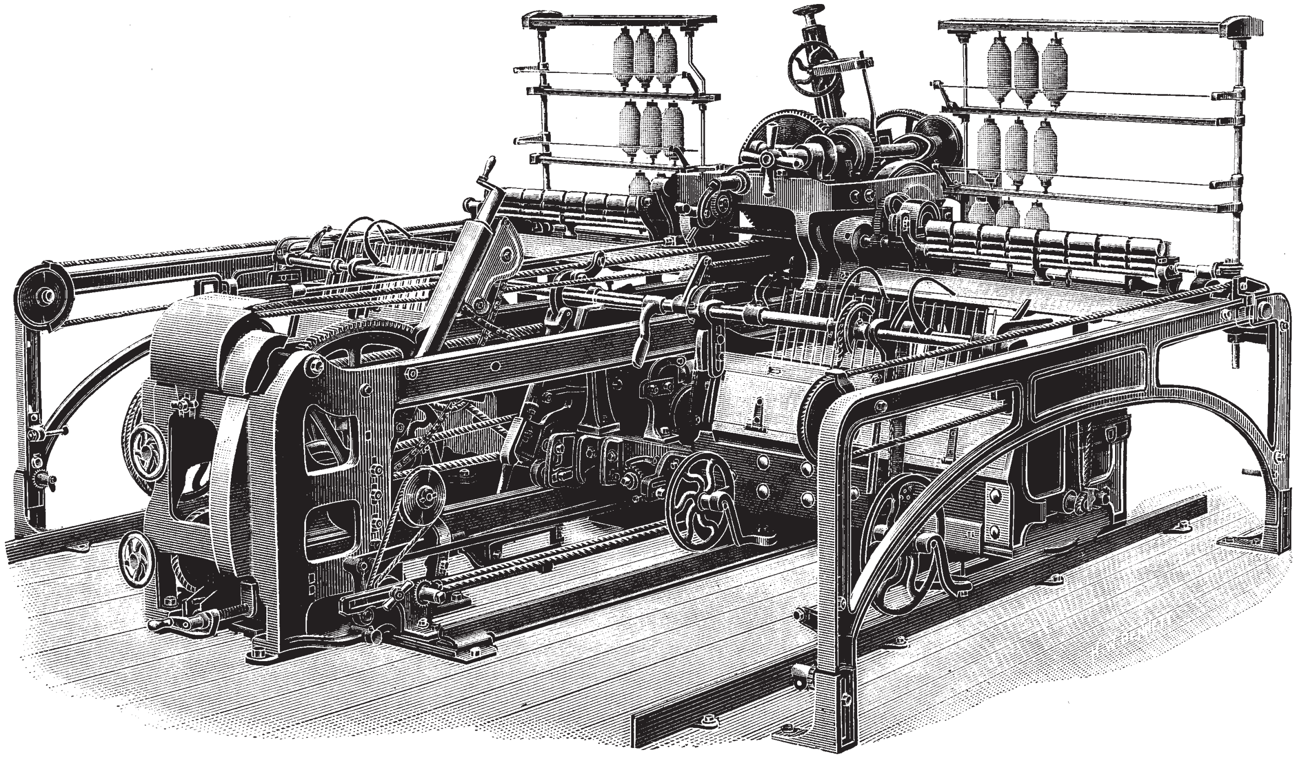

Fig. 16. Front View of Mule Headstock with Part of Carriage.

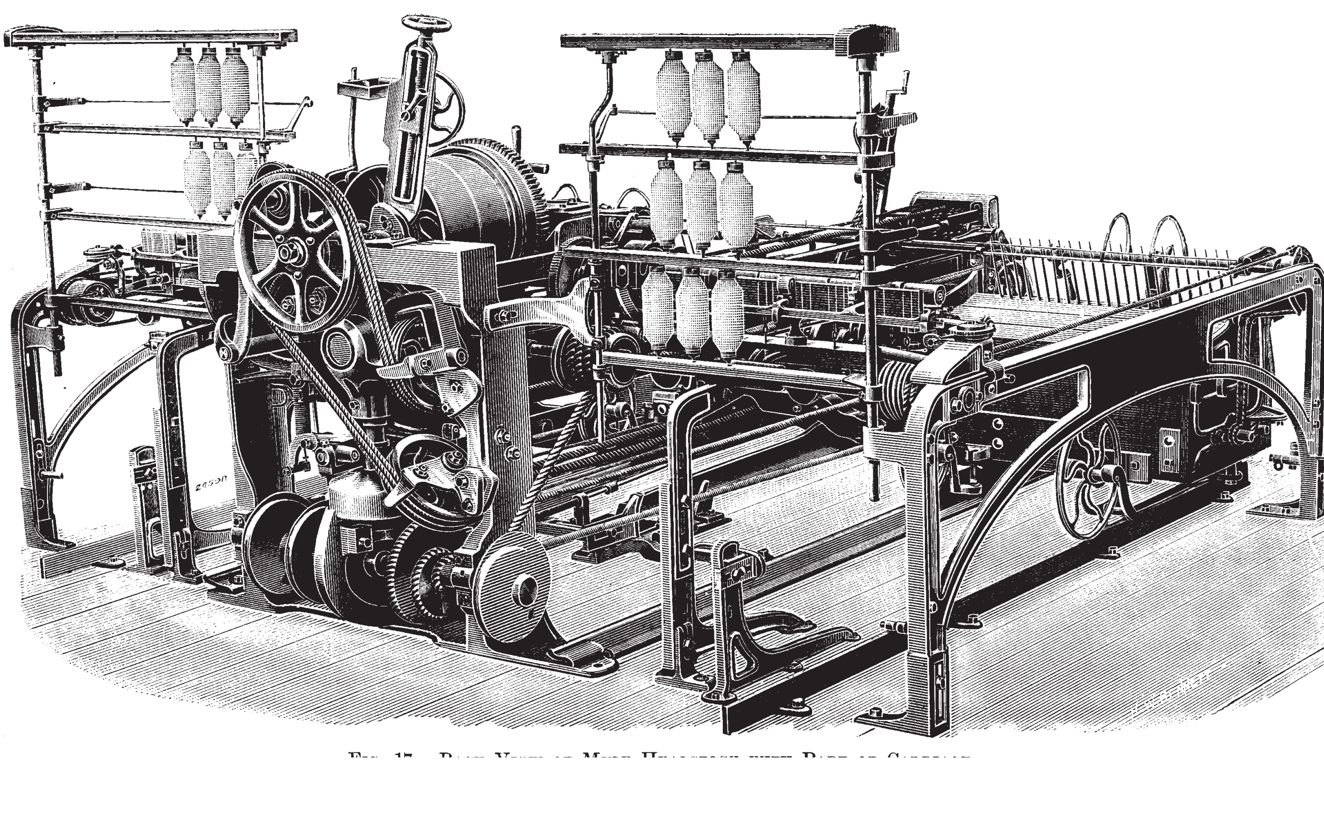

Fig. 17. Back View of Mule Headstock with Part of Carriage.

CALICO LOOMS.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, OLDHAM.

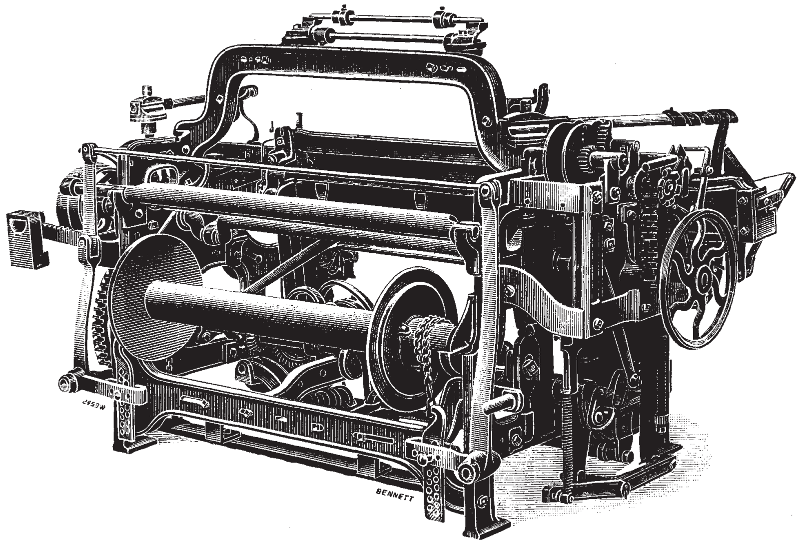

Fig. 18. Overpick Calico Loom with the Eccles Patent Drop-Box Motion.

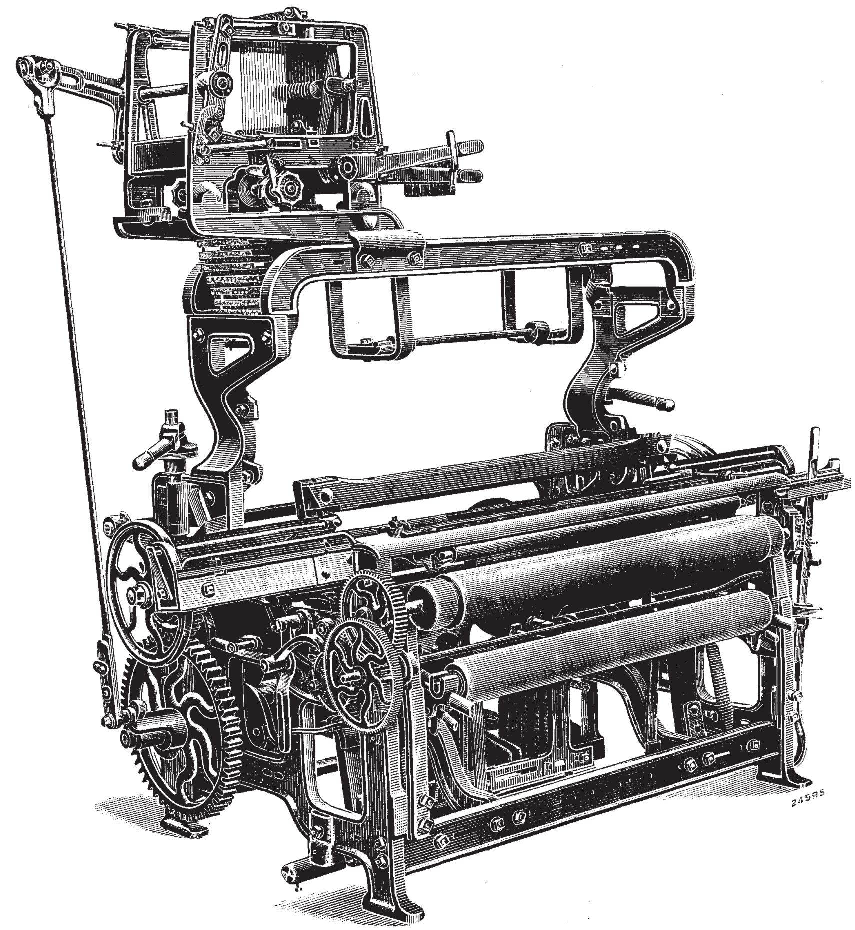

Fig. 19. Calico Loom with Dobby attached.

5 in. to $15\frac{1}{2}$ in. These have a flange formed in the casting about 4 in. from the end in the longer examples; the castings having to be machined in several operations.

Brass-Turning Department.—Here all brasswork is done for the works, over 4 tons of brass castings going through the shops every week for use in textile machinery made. The parts are nearly all small, and the usual brass-finishing machine tools are used in their production, there being a large number of capstan lathes.

Drawing Frame and Speed Making Departments.—In these departments drawing frames and speeds are produced. The speeds consist of slubbing, intermediate, and roving machines, the latter being sometimes known as jack frames; indeed, what would be a "roving frame" in Oldham would be a "jack frame" if transported to Bolton. In Figs. 21 and 22, on page 112, we give back and front views of one of Messrs. Platt's roving frames. One of the most important parts manufactured here are the spindle rails for speeds; they consist of long iron castings, the main part being of the nature of a long flat bar 13 ft. long and about $\frac{1}{2}$ in. thick and about 4 in. deep, the head of which has a rib $1\frac{3}{4}$ in. across; projecting from the rib on either side are arms or brackets 3 in. in length. The spindle rail and the brackets, which have a disc at the end, are bored to take the spindles; they are, as stated, made into lengths up to 13 ft. each, and a rail in one machine will be made up of four lengths, each of which will take 60 spindles. The first operation is to drill the holes in the brackets which receive the spindles; this is done in a four-spindle drilling machine, having a long bed which takes the whole of one length, the headstock carrying the drills being traversed for the work by means of a leading screw in the bed. The bars, it should be stated, are mounted in pairs when erected in the machine, a top and bottom bar being bored at one operation, so that accuracy is insured. This is necessary in order that the spindle may run true in both holes. The traversing of the headstock is performed as stated by a leading screw, but is governed by the operator. Ordinary flat drills are used. The first of these drilling machines was made 40 years ago, and was 36 ft. long in the bed, but the machines since made have been of greater length as each one has been produced, so that 60-ft. rails are now required. This shows the advance made in the size of machinery of this class during the period named. It should be stated, however, that when the first machine was made 36 ft. was thought to be longer than would ever be required. An automatic return motion for withdrawing the drills when the holes are complete, has been attached to this machine; it consists of a weight attached to the end feed wheel. When the wheel has made that part of a revolution which corresponds with feed sufficient to bore the hole, the weight falls over and brings the withdrawing mechanism into play. The holes being bored, the ends of the bar are cut to length in a circular cold saw. This plant will drill and cut off for 40 machines per week.

It is interesting to notice the skill with which these long iron castings are straightened, it being necessary that they should be straighter than can be obtained by casting, there being naturally some warping during cooling in a casting of this irregular section. The straightening is done by hand hammering, the operator striking a few smart blows with a heavy chisel-headed hammer on the side on which it is necessary to extend the surface. The drilling and screwing operations are performed by horizontal drills specially designed for the work.

In the speed milling room various parts are machined by milling, not much planing being done now; indeed, as was remarked by one of the operators, "the place would not hold the work if they had to use planers instead of milling machines." It would be useless to attempt to describe the multiplicity of milling operations required for all the various small parts used in the construction of the machines made in this department. Each tool has been specially laid out for one particular piece of work, and all parts, in this way, are made interchangeable; not being touched by hand except to take off sharp corners, so that there may be no doubt about the pieces fitting accurately. Great care is taken in setting the work in the tool to prevent springing, which, of course, would alter the shape of the piece. In one part of this department there are 56 milling tools, which are entirely looked after by 10 skilled operators. At the side of the shop are benches where the small parts are finished and passed for erecting. In one corner of the department some interesting work is being carried on, showing how much may be done by machine work and what saving may be made in hand labour when repeat operations have to be performed. Two men mind eight machines, which perform entirely different operations, such as drilling, tapping, boring, &c. The work is laid out so that the atten-

SLASHER OR WARP-SIZING MACHINE.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, ENGINEERS, OLDHAM.

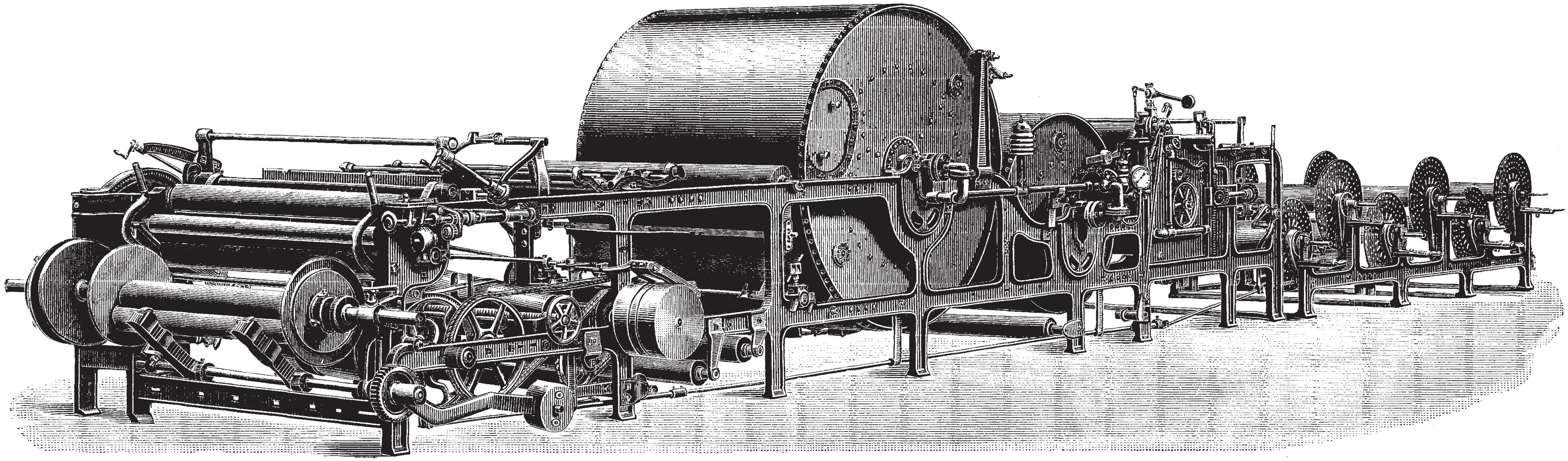

Fig. 20.

tion of the operator can always be given to the machine at the time required; the man turns from one tool to another with the greatest ease, the machines being grouped so that he can pass from one to another at the exact time, whilst in some cases he is able to give one hand to one tool and the other to another.

In the erecting room for slubbing and intermediate frames there are also some machine tools, amongst them multi-spindle drills, which are interesting, and have vertical and horizontal spindles running at different speeds according to the size of hole to be made, the speeds being timed so that all operations are finished at once. These holes naturally are made in the exact position without resetting. The drills are used mostly for brackets for the frames. There is another room adjoining for the same purpose, and yet another large fitting department beyond. Further on there is an erecting room similar to that already described, in addition to which are store-rooms for parts of machines, erecting rooms, &c. Further on there is another department in which the drawing frames are constructed, the character of the arrangements being similar to that described with reference to speeds.

Combing Machine Department.—The department for the manufacture of cotton-combing machinery is on the top floor of one of the large buildings in the Hartford New Works. The process of manufacture of combing machines is in all fundamental respects similar to that already described in regard to other machines of a somewhat similar character. Lathes, planing machines, milling machines, and other machine tools of a like nature are used, but as there is so vast an amount of repetition work here, as in nearly all other part of the works of this firm, a special machine tool can be made for each similar part. It is this fact which gives large establishments such an enormous advantage in competition, and when one sees vast organisations such as the works of Messrs. Platt Brothers and Co., one is comforted by the thought that it will take very many years at least before other countries will overtake us, or that foreign competition, of which we hear so much, will have proved the downfall of our commercial supremacy. The foreign inventor appears to recognise this, as new mechanical appliances seem to gravitate naturally towards England. A good instance of this is given in the department of the Hartford Works with which we are now dealing. In the experimental room is a Heilmann cotton-combing machine. The object of this machine is to separate the long fibres from the short in cotton that is prepared for spinning. The material is put into the machine, is combed and converted into a lap, and is then delivered in the form of a sliver which is 26 to 30 times the length of the lap. The Heilmann comber is, of course, by no means a modern machine, but in the particular example we are now referring to, there are certain improvements which will be described later. The combing machine was invented in France by Heilmann about the year 1844, and it was first brought prominently before the notice of the British public at the Great Exhibition of 1851, by the executors of the inventor, who appear to have conducted the financial part of the trust reposed in them very successfully, for they first sold the rights for cotton manufacture for 30,000*l*., and then the wool rights for another 30,000*l*., whilst they obtained 20,000*l*. for the use of the machine for flax combing. The concession for cotton combing was bought by a syndicate who gave the exclusive right to manufacture to one firm, and who finally obtained an extension of the patent. Messrs. Platt took up the manufacture in the year 1868, and since then have made many improvements; up to that time the general character of the machine having remained as Heilmann left it. Messrs. Platt increased the number of heads and broadened the lap, alterations which have resulted in a very large increase in output; they have also added an automatic knocking-off motion which renders the working more independent of attention. The example of the machine to which we have referred as being in the experimental room, is a new design just brought out; it has eight heads, each of which will produce a lap $10\frac{1}{2}$ in. wide. This is the largest Heilmann comber yet made, and those of our readers who are acquainted with the cotton industry will appreciate the difficulty of making so wide a lap. It was said that with the long length of rollers required the lap would not be of equal substance throughout, owing to spring of the rollers, but the difficulty has been overcome, and the lap produced is certainly of very regular thickness. The actuating mechanism is mounted on a substantial table at the end, in a manner which gives great steadiness in working, so that though the machine runs at 90 nips per minute, it is quite steady.

This machine will produce 450 lb. of combed cotton per week of 53 to 54 hours and two hours for cleaning. The automatic knocking-off motion referred to, is brought into play in case of the lap or sliver breaking. The sliver runs through a guide in the end of a steel tumbler lever, the guide also serving to direct the sliver to the draw-box rollers at the end of the machine. The tension on the sliver in consequence of the draw, holds the tumbler end of the lever down, and whilst the lever is in this position a sliding bar underneath, by which the operations of the machine are carried on, is able to reciprocate. When, however, the sliver breaks, the tumbler overbalances, and the lower end of the lever acts as a catch which engages in a notch with the sliding bar underneath, and thus stops its motion. Through further mechanism, consisting essentially of a spring and cam, the driving strap of the machine is drawn on to a loose pulley. This machine is used for the finer classes of cotton, more especially for sewing cotton, and for single warps that are intended to be woven with worsted weft. The single thread made from combed cotton is more level than the two threads of wholly carded cotton twisted together, though, of course, twisting is an operation which tends to regularity; the combing removes the necessity for twisting the two threads at this stage, and thus cheapens cost to that extent. Where the comber is not used, this part of the process is carried on wholly by carding. The combing produces very superior results, as it more effectively separates the long fibres from the short, and takes out the dirt and neps.

To illustrate the result of advances made in detail it may be stated that with the Heilmann combing machine of the older type one girl would attend to six machines, but these would have only six heads, the laps being but $7\frac{1}{2}$ in. across. At the present time one attendant is also required for each half-dozen machines, but they have eight heads, and the laps, as stated, are $10\frac{1}{2}$ in. wide. On account of this and other improvements in working, one girl will produce 450 lb. of combed cotton per machine per week, whereas with the older type 120 lb. to 140 lb. per week would have been the product of one attendant. These figures may be taken as comparable, but the output is naturally regulated by the quality of the work required, the finer qualities having more short cotton taken out; the average of short cotton and dirt taken out would be, perhaps, about 16 per cent., the range of the machine being 10 per cent. to 30 per cent. of refuse rejected; naturally the short cotton can be worked up again for inferior qualities of yarn.

The efficiency of this machine, as in all textile machinery, depends on the accuracy with which it works. Great care is taken to get durable and accurate bearings; the driving shaft is case-hardened and then ground to exact size. The case-hardening in these works, it may be noticed in passing, is a very special feature, the practice having been elaborated through long experience. These shafts are case-hardened $\frac{1}{16}$ in. deep, and this affords ample material to work upon in grinding true without removing the hardened skin, for the shafts are made pretty accurately to gauge beforehand.

Several of the milling machines used in the production of the combers run with loose teeth cutters, whilst fly-cutting is also had recourse to. There is a fine type of machine for boring brasses in brackets, several being operated upon at once by the same boring bar, which is guided to exact position, and as the table is arranged to take brackets only in one position, all brasses are accurately in line and all interchangeable. This, however, is only another example of what occurs throughout the works. There are three boring bars, and there is a guide between each part to be machined so as to insure accuracy. Some of the drilling machines in this part are also worth attention. There is an automatic drill with self-feed arrangement, the work being traversed automatically by ratchet wheel to bring it into position for a fresh hole; the speed is 12,000 revolutions per minute. Close by is another very beautiful drilling machine, used for brass circular combs; this machine runs at 40,000 revolutions per minute. There is also a radial horizontal drill for drilling curved slots for drop combs in the Heilmann machine. The process of manufacture of the circular combs themselves is an extremely interesting one. The combs in the Heilmann machine are rotary in action; and each length of comb is mounted on a cylinder the length of the lap to be produced, the teeth of the comb being set tangentially to the circumference of the cylinder on which they are mounted. The combs, however, are not placed round the whole circumference of the cylinder, one part of the cylinder being in the shape of a fluted roller. The action of the comber is intermittent, that is to say, the lap is held and combed, the combed part being then fed forward by the fluted part of the cylinder referred to. The separate lengths of comb increase in fineness as they pass through the work, and will range from 32 up to 88 teeth per inch. These teeth are technically known as "needles," and are, in fact, like short needles; they are soldered on to a brass strip which forms the back of the comb; this operation is one which requires a certain amount of skill. The needles are gathered together, and put point inwards between two strips of wood; which are clamped together, the roots of the needles projecting, and it is not difficult then to lay the exposed part of the needles on to the brass strip and solder into position. There are 17 of these lengths of comb to each circular comb. It should be also stated that there is a flat comb which is cut out of the solid and which drops into position so as to further comb the fibre as it is being drawn forward by the fluted part before referred to. At the time of our visit a large number of these combing machines were in hand.

Tool-Making Department.—With very few exceptions the firm has made its own machine tools, the shops in which they are produced being a fairly extensive factory in themselves, and employing about 200 men (this refers to the Hartford New Works alone), not including millwrights or repairers. There is also generally a repairing department for machine tools to each section of the works. The castings are produced in the general foundry. The firm does not make steam engines, excepting small ones for their own use, of 30 to 40 horse-power. They manufacture a large number of Ryder forging machines for use in the works, and also for sale, although the latter is a class of business which does not appear to be pushed. In time gone by, however, a good trade was done in these machines, several having been sold to the Government for small-arms making. As an instance of the requirements of the firm, and the rate at which its operations are being extended, it may be said that during the last 18 months eight of these forging engines have been produced for the firm's own use.

Woollen and Worsted Machinery.—We have confined our attention almost wholly to cotton machinery in dealing with these works, for Manchester is the cotton centre, and, indeed, the great bulk of Messrs. Platt's production is cotton machinery. They have, however, a very large trade in textile machinery for woollen, worsted, and silk fabrics. We cannot pretend to deal at any length with these branches, but a few words may be said of a general nature. For worsted making, machines are made for two systems, which are known as the Bradford and the French processes of worsted spinning. It should be stated that worsted spinning resembles cotton spinning more closely than it resembles woollen spinning, although of course worsted is really spun from wool. In both cotton and worsted the object is to lay fibres parallel, and it is for this reason that the initial operations are generally of the nature of carding or combing, as in cotton, the chief differences of the machines used with the two materials being in detail. In woollen goods there are six processes required to produce the fabric, whilst in worsted the corresponding number would be 14; in cotton spinning there are 10 to 12 principal operations from the time the spinner gets the cotton until he brings it to the thread. Again, there is a total dissimilarity in regard to some of the machines used for the Bradford and the French systems, though the processes for carding, combing, and gilling, to prepare the wool for subsequent operations, are the same in both cases. In the Bradford system the object is to produce a smooth wiry thread, and every machine used puts twist in the yarn; in this system the wool is oiled to enable it to be worked. On the other hand, the object in the French system is to produce a bulky or "lofty" soft thread, and this is accomplished by keeping out the twist until the last process of spinning takes place. In producing yarn for woollen material (as opposed to worsted yarns on the French system), the chief operations are opening, carding, and spinning. In woollen goods the operations are the simplest of all, and can be carried out in fewer stages. The first process is that of opening, which is very similar to that carried on by the cotton-spinner; next follows carding, again somewhat of a similar nature to the cotton carding, the machines resembling each other. This process generally consists of passing the wool through the scribbler engine, intermediate engine, and carding engine, to the latter a condenser being attached. The chief difference comes in carding the wool, the sliver being taken direct from the condenser of the last carding engine to be spun on the mule, thus dispensing with the intermediate processes required in either cotton or worsted on the French systems between carding and spinning.

We have now finished our description of what is known as the Hartford New Works, and which comprise the principal manufacturing branch of Messrs. Platt's business. We cannot claim, however, to have treated even all of the principal features; to adequately do that would be to write a treatise, not an article.

THE OLD WORKS.

These works, which form the third of the large branches of Messrs. Platt Brothers and Company's establishment, are situated at the opposite end of the town of Oldham, and about two miles from the new works. Although they are the parent establishment, they are in many departments more modern than the Hartford New Works, for they have been remodelled and rebuilt since the new works were started.

Blowing-Room Department.—An example of the fact last stated is supplied by a fine new shed 220 ft. long by 160 ft. wide, and 15 ft. high, which constitutes the erecting and machine room for the blowing department. Here bale breakers, exhaust openers, automatic feeders, single and double scutchers, feeders, &c., are made. We illustrate some of the machines made in this department. In Fig. 23, on page 113, we illustrate another form of bale breaker suitable for dealing with hard-pressed or lower qualities of cotton. This machine has two pairs of breaker rollers and one cylinder. Fig. 24, on page 113, is a bale breaker, which is well adapted for long staple cotton. It has one pair of collecting rollers and three pairs of breaker rollers, having the required amount of draft so that the cotton is equally pulled throughout the mass. Fig. 25, on page 114, is an exhaust opener, and Fig. 26, on the same page, is a scutching machine. The various operations performed by these machines are referred to in our article on Messrs. Haworth's Mills.

Underneath the shed with which we are now dealing is a cellar for the storage of castings to be machined, and a few of the heaviest tools are placed here. The blowing-room department of a cotton mill contains machines which require some of the largest parts as regards castings for frames, &c., and the machine tools in this department consist largely of planing and drilling machines. All the tools in this room are of modern make, and, as is the general rule throughout Messrs. Platt's establishments, are produced in the works. The tools in this room, like nearly all tools used by the firm, are for the most part specially designed to produce one particular piece. Nevertheless they are generally of a kind familiar to the ordinary engineer. There are some fair-sized planing machines here, one which will take 5 ft. 6 in. under the cross-slide, and another 4 ft. 6 in. by 10 ft. 6 in.; they are automatic in all motions, the tables being worked by a screw in the bed, and having quick return motion, as in all planing machines used by the firm. There is also in process of construction for this department a larger planing machine which will take 7 ft. 6 in. under the cross-slide. The planing machines for grooving the bale-breaker rollers have an automatic ratchet motion for turning the work on the table to present a fresh groove for each cutter. The tool is ground to the shape of the groove, and so cuts the surface at once; one cut is taken to each groove at one time, the work being gone over again for the roughing, intermediate, and finishing cuts. Although the grooves are deep and widely pitched, it is found best to cut them throughout from the solid, rather than to attempt to cast to shape and machine off the scale. It must be remembered that in these rollers, as in all others used for feeding forward or compressing cotton, great smoothness of surface must be acquired, otherwise the cotton would stick and the machine would be brought to a standstill. A different type of machine is used for planing the edges of large parts of frames; it is like a plate-edge planer in principle, and has a table 10 ft. 6 in. square. We understand that this is shortly to be replaced by a new cross-slide planing machine of the ordinary type, which will operate on the sides and faces of the castings at one setting, having tool-boxes arranged for that purpose.

In the turning department of this shop there are a large number of lathes of various descriptions, amongst them some two-spindle copying lathes for turning pairs of cones for regulators in scutchers and openers; the cones in each pair are respectively convex and concave; each pair is turned on the same machine by means of a former or copy; in this way accuracy is obtained. There are 75 to 80 lathes from 9 in. single gear to 8 in. double gear, they are mostly arranged specially for the production of one particular piece. The department for making fans for exhaust openers and scutchers is in this shed. The operations are chiefly light plating and machining light castings; the fans are all carefully balanced.

In the cellar beneath, where the castings are stored, there are also some boring lathes, and slide lathes for the calender rollers in scutchers, exhaust openers, &c. There is also here a hydraulic press working at half a ton to the square inch, for forcing in gudgeons to rollers. These rollers are of heavy cast iron, and are used for pressing down cotton; they run up to 48 in. long and 12 in. in diameter. They are cast very exact, and are then rough and finished turned in separate lathes, after which they are ground in a discing lathe with emery wheel, being finally polished with a machine lap.

Grinding Shop.—We now pass to a grinding shop adjoining, which is also a new department, 96 ft. long and 90 ft. wide. The shop was not complete at the time of our visit, but contained eight grit-stones which were at work; there are, however, places for 12 stones and 12 glazers. This shop is very well fitted, all shafting being in the cellar below, the bands working up

COTTON MACHINERY.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, ENGINEERS, OLDHAM.

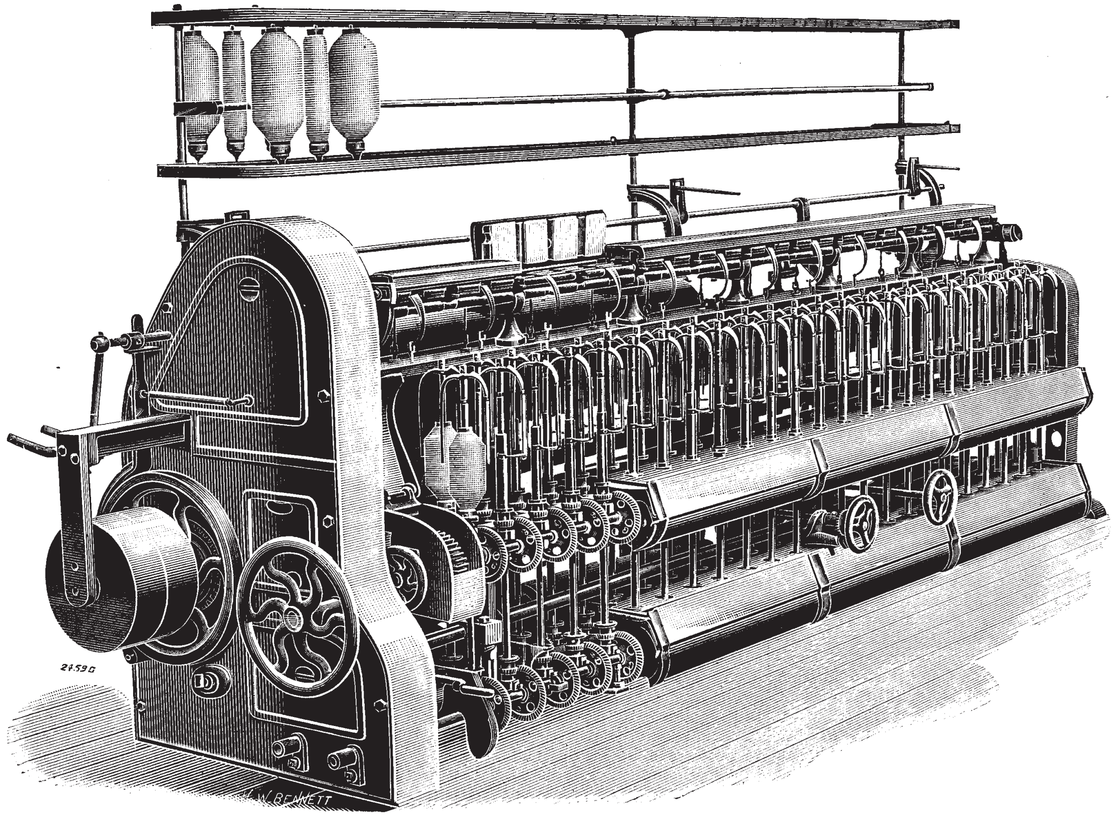

FIG. 21. FRONT VIEW OF ROVING FRAME.

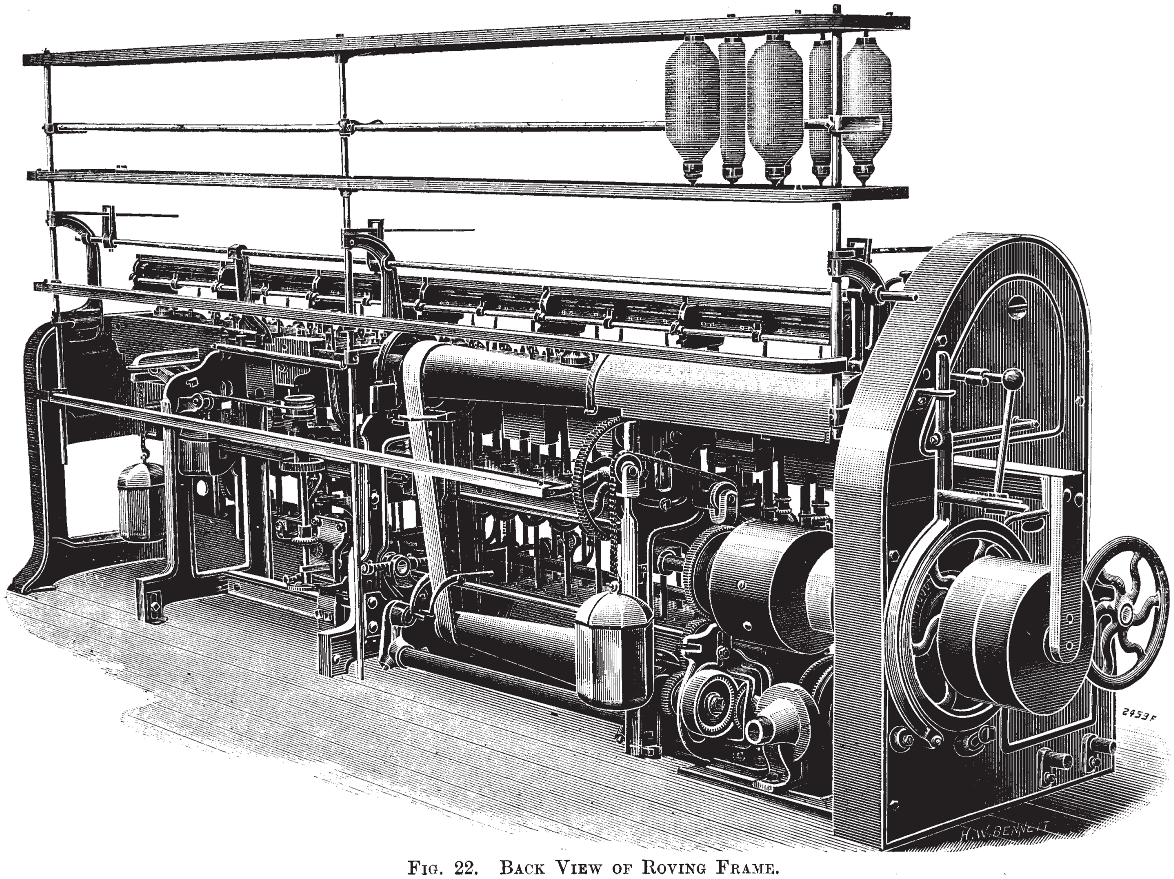

FIG. 22. BACK VIEW OF ROVING FRAME.

through the floor; the light is excellent, and the height of the roof is 18 ft. Here are ground some of the large castings for frame sides, &c. There is a hydraulic crane for shifting stones, which, when new, are 8 ft. in diameter and 14 in. wide. The arrangements for disposing of sludge from the stones are excellent, it being conveyed to iron tanks where it is allowed to settle, the water draining off. All appears to have been done here to make grinding as little objectionable as possible. In the cellar below the grinding shop is the second motor shaft for driving the whole of the department. On it is an 18-groove rope pulley to take $1\frac{3}{4}$-in. ropes, the diameter being 10 ft. The beautifully steady way in which this pulley runs at high speed is well worth noticing, and illustrates the advantage of ample bearings, good workmanship, and adequate foundations.

The Foundry.—From the grinding shop we pass to the foundry, which is a large building having a gallery round. Machine moulding is here carried out to a large extent, and there is but a small quantity, comparatively, of plate moulding. The shop is served by overhead travellers, driven by steel wire ropes, the motive power being in the cellar beneath. The cupolas may be described as of two storeys high, that is to say, one cupola is superposed upon another; there are in this way two hearths, the lower one serving the ground floor, whilst the upper half is on a level with the gallery, and is tapped to produce metal for the castings there produced. In this department a great deal of interesting work is carried on, but it would be difficult to describe the foundry practice without going somewhat minutely into details. A large number of rollers of various types are cast here. Perhaps the most interesting work is the casting of the cylinders for carding engines, which are from 40 in. to 50 in. in diameter. In our illustration, Fig. 29, on page 116, we give a view of a carding engine made by Messrs. Platt, and in this the large cylinder now referred to is a conspicuous feature. The process of carding is described in our article on Messrs. Haworth's mills.

There are in this foundry the usual appliances. In the gallery above, machine moulding for similar work is carried on. There is a room devoted entirely to casting iron flats for carding engines. These flats consist of an iron bar, generally 45 in. long and of T-section throughout the greater part of the length, being $1\frac{3}{8}$ in. wide on the transom, whilst the metal is $\frac{1}{4}$ in. thick. At the ends, however, the section varies, being rounded in order to take the chain by which the cards are operated. These bars carry the cards, to which reference will be made further on, their weight being about 7 lb. to 8 lb. each. There are 10 grounds for casting these flats, each served by a small hand travelling crane on rails. The arrangements are very good for assisting the men in their work; the lines on which the cranes run are planed and laid on good foundations, care being taken to insure accuracy, otherwise the sand would be shaken out of the boxes in transporting the moulds. Below the foundry is a cellar, where all sand, loam, and charcoal are ground in four pairs of edge runners, the blacking mill being in the foundry itself. The Root's blowers are all down here, there being one pair to each furnace. Beyond, in the cellar, is the fettling department, where there are rumblers, emery grinders, &c. The hydraulic turning-over mechanism for machine moulding of the larger castings, works through the floor of this department. The general arrangements here, as elsewhere, are excellent. There is a flue extending right through the department to collect dust, whilst every pillar supporting the floor above is a ventilating shaft, being carried up to the roof above. The hydraulic pumping engine and accumulator are here also. The engines for working the foundry consist of two 20-in. cylinders, 3 ft. stroke, working at 80 lb., and giving off about 250 indicated horse-power. There are no crosshead slides to these engines, a grasshopper motion being used; there are Corliss valves, and the driving strap is 30 in. wide.

On the opposite side of the yard to the foundry is a four-storey building, which is used as a pattern store. The organisation of this department is very complete; there are five rooms on each floor, or 20 in all, the size being 30 ft. by 60 ft. In order to provide against fire, each storey is independent of the other, the floors being fireproof; there are exterior staircases, so that no openings are made through the floors. The hoist is also exterior to the building. When it is stated that the majority of these patterns are but small parts, it will be easily understood what an enormous number there is. Books are kept in which all are recorded.

Erecting and Machining Department.—We next pass to a large three-storey building in which erecting and machining of various machines is carried on. In the basement there are a large number of machine tools employed in various operations. The cylinders of carding engines, the casting of which we have already referred to when dealing with the foundry, are here turned, and the ends are placed in them. These ends are of cast iron, and consist of a central boss and radial arms. The ends being placed in the cylinders, the whole is mounted in a special lathe having a solid bed, the two sides of which rise up, the space between being semi-circular; the back centre slides in the bottom of this space; there are two slide rests, one on each side. The solid construction of this bed gives the great steadiness required in all turning operations in connection with carding engines, a point that will be referred to again further on. There are several of these lathes, which are fine tools, and will take work up to 48 in. in diameter inside the recess in the bed.

Another part of the carding engine machined in this department is the "flexible;" it consists of an iron casting rectangular in section and forming a segment of a circle one-third of the circumference; the ends are tapered, and in the middle there is a projecting piece for attachment. The flexibles are 1 in. wide, $1\frac{3}{4}$ in. deep at the ends, and $1\frac{7}{8}$ in. deep in the middle; they form the path on which slide the cast-iron bars, known as flats, to which the cards are attached. These flexibles must be turned exactly circular on their sliding surfaces, and concentric with their cylinders. They are turned in a large break lathe, two of them at once being mounted on a faceplate. There is an ordinary slide rest, but very strongly constructed; the tool is an ordinary bar cutter. In order to obtain accuracy calipering is carried on continuously. When the operations are complete, the work is put in a standard gauge and tested with pieces of thin paper. The piece of thin paper must be held tight in any position between the gauge and the work without the two being held together by hand. It may be, of course, that the flexible has been truly turned, and remains so as long as it is held on the faceplate, but will spring when taken off. Care has to be taken, therefore, in casting, for if the metal is run hotter for one end than for another there will be a variation due to unequal contraction. In such a case the piece will be rejected and broken up.

An ingenious tool near here is a special milling machine, which is used for milling round the bases of the beater arms which carry the beater knives in machines used in the initial processes of cotton preparation. The beater arms consist of an iron casting, two or three arms projecting radially from the boss. The machine in question will completely mill the boss to the curved section required. In order to do this it is necessary the cutter should work on the circumference of the boss between the arms, and also, of course, in front of the arms. The cutter is formed to provide the proper contour, and works on a horizontal spindle; it is fed forward automatically between the arms, but when it arrives at the part where the arm projects, it is withdrawn so as to escape the arm; this end is attained automatically by means of an ingenious guide plate. The arms themselves are afterwards finished by grinding.

Proceeding to the turning shop for carding engines, we find a large number of small lathes from 9 in. up to 18 in. This room is 150 ft. long by 50 ft. wide, and is served by a 140 horse-power engine, which is used for the turning lathes in this building alone. On the floor above are the lathes for wrought-iron turning, and there are a few at the further end of the room for tool-making. These other lathes are provided with a separate engine which can be brought into play if overtime has to be worked occasionally, an important consideration in tool-making. Proceeding to the floor above, we find a further large

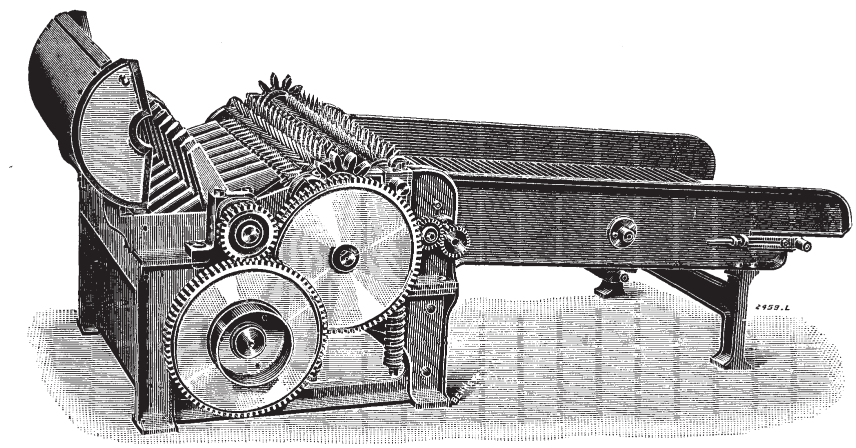

FIG. 23. COTTON BALE BREAKER, WITH TWO PAIRS OF BREAKER ROLLERS.

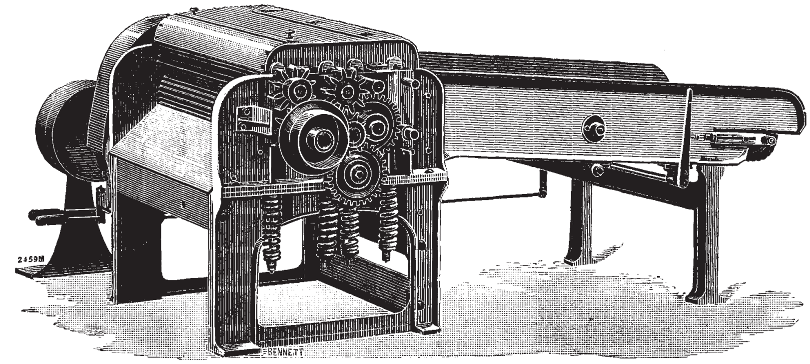

FIG. 24. COTTON BALE BREAKER, WITH ONE PAIR OF COLLECTING ROLLERS AND THREE PAIRS OF BREAKER ROLLERS.

COTTON MACHINERY.

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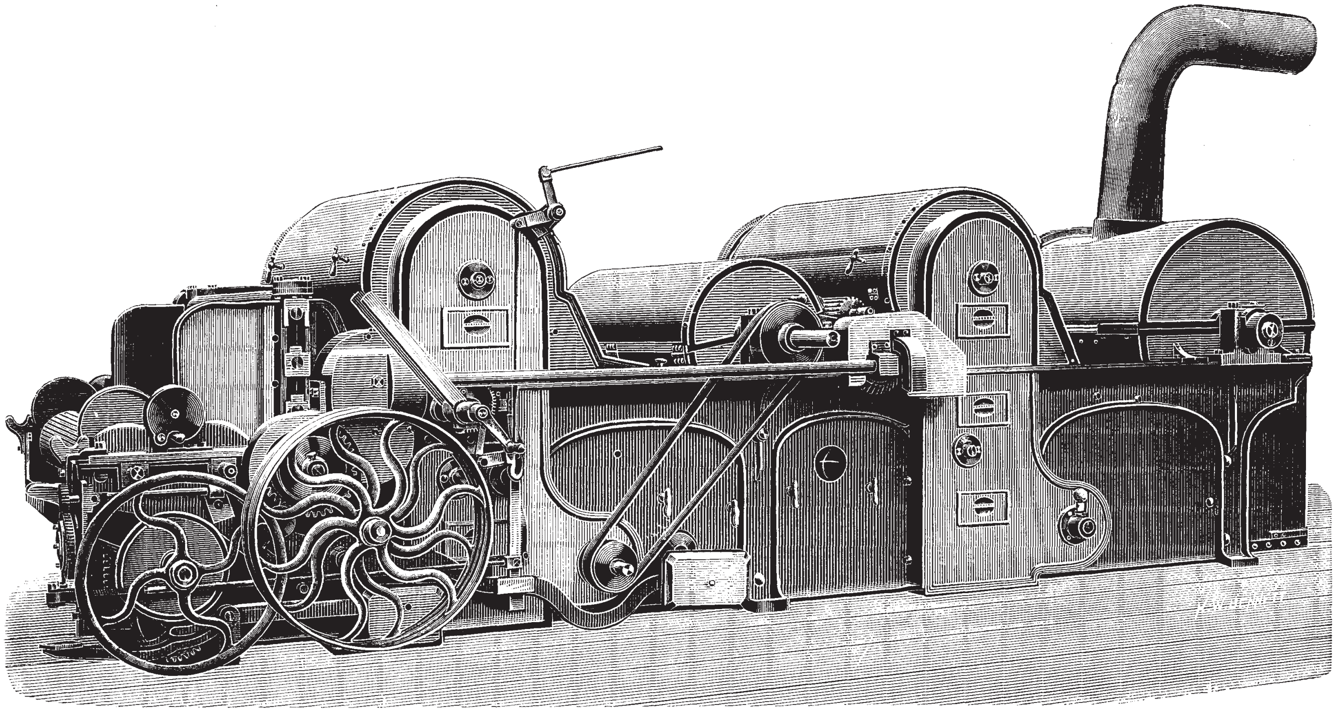

FIG. 25. EXHAUST OPENER AND LAP MACHINE.

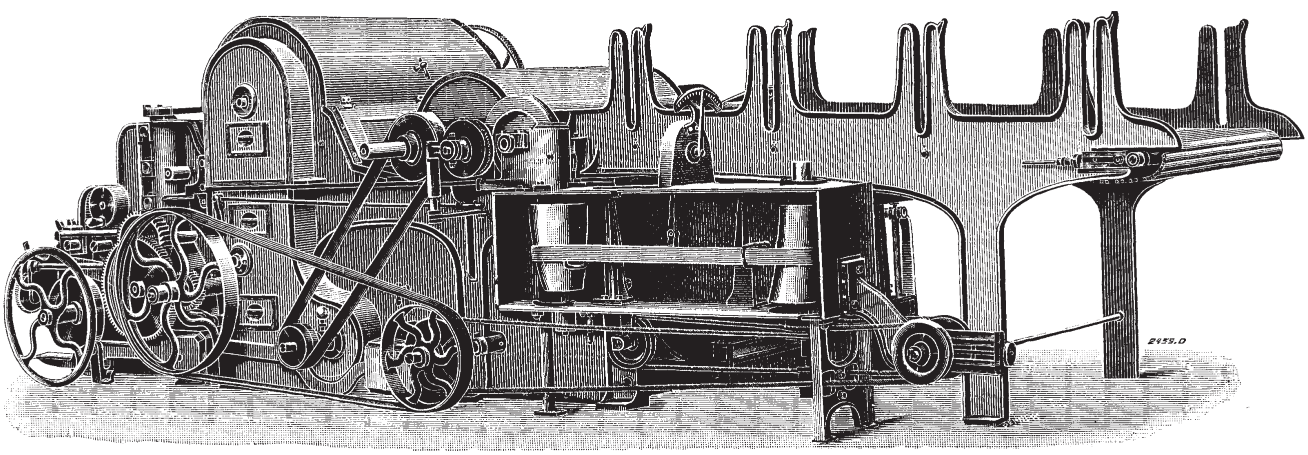

FIG. 26. SCUTCHING MACHINE.

quantity of machine tools. A leading feature here is the making of a flat link chain. These chains are of the bar link type. Blanks are forged out from the steel strip, the holes to take the pin being formed at the same time; the blanks are then brought to the same department and bored in a two-spindle drill. There is a separate machine for putting pins in and riveting them up; it consists of a hammer with spring in the shaft. A large number of brackets are machined here in special tools constructed to perform the operations with accuracy without marking off. Holes are drilled in drilling machines which are arranged to give the proper position of hole, so that neither marking off nor jigs are required. In the top room is the small wrought-iron turning department, where there are about 200 machine tools, composed largely of ordinary turning and screw-cutting lathes.

An interesting operation performed in this department is the arming of the taking-in rollers used for drawing cotton into the machines, and which are covered all over with teeth. It would puzzle a good many people not accustomed to this class of work to say how these rollers are made, the teeth being so thickly planted. The operation, however, is very simple when once seen. The cast-iron rollers are put in a screw-cutting lathe, which

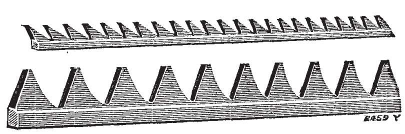

FIG. 27.

turns spiral grooves in them. They are then taken out and put into a machine which is on the same principle as the screw-cutting lathe, having a leading screw, the pitch being the same as that of the thread already turned on the roller. There is then taken a strip which has somewhat the appearance of a long band saw, nearly all teeth, as shown in Fig. 27 annexed. On examination it will be found that these teeth are really set on a somewhat thicker back rib, or perhaps it would be more accurate to describe it as a square wire with teeth projecting from it, the whole being stamped out solid from one strip. The serrated wire has to be run into the grooves already cut in the roller, the teeth, of course, projecting. This operation is performed by means of a roller in the machine already referred to. The rib is then pressed into the groove by means of a wheel presser, which is traversed by the leading screw. The rapidity with which a plain grooved roller can be, in this way, covered with teeth is very surprising. The serrated wire is formed in this department by a series of operations. It consists first of ordinary round wire which is flattened in rolls; and afterwards the rib, by which it is held in the groove, is put on the back; after this it is run through two knives to plane it to gauge, and finally the teeth are punched out by a machine, the wire being fed up intermittently; it is then ready to put on the rollers.

In this same department another very interesting operation is carried on; it consists of making what is known as patent wire for attaching cards to the flats, already referred to as carrying the cards in a carding engine (see Fig. 29, page 116).* The cards themselves might, perhaps, more strictly be described as wire brushes set in a special canvas back, or, perhaps, as a very long pile velvet, with fine wire in place of silk for the pile, whilst the backing or foundation is a strongly woven material. It is necessary to attach these long brush-like strips to the cast-iron flats, which then actually become the back of the brush; in order to do this the woven foundation is not covered up to the extreme edges with the wire pile which combs the cotton, and the bare strips thus left are used for the purpose of attachment to the cast-iron flat. Holes having been drilled with great accuracy to pitch along both edges of the flat, the pitch of the holes being about $1\frac{1}{2}$ in., the card is then laid on the flat, and by an automatic punching machine, holes are punched in the foundation to correspond with the holes drilled in the flat. It will now be necessary to describe how the wire is made which attaches the card to the flat. This wire is flat, and about $\frac{1}{8}$ in. broad and $\frac{1}{32}$ in. thick; it is of steel, coppered, and is put into a bending machine which converts it into a series of square U's, as shown in the upper view in Fig. 28. We have,

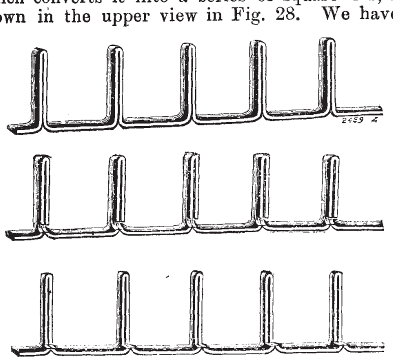

FIG. 28.

therefore, a long flat wire with projecting parts standing up, these projections being about $\frac{1}{2}$ in. high. The next operation is to cut a nick at the root of the projections about half-way through the thickness of the metal, as shown also in Fig. 28; this is done by a circular saw, the wire being fed up automatically. It is necessary to remove one-half of the thickness of the standing-up parts so that they may be thinner, and go through a smaller hole in the flats; the nick having been cut, the rest of the metal is removed, as shown in the bottom view in Fig. 28, by a machine which has a combination of nippers worked by cams.

We will now return to the operation of attaching the card to the flat. It will be remembered that the former is placed upon the latter, the holes in the foundation corresponding with the holes drilled in the cast-iron flat. The prepared wire is then placed above the textile foundation, the projections corresponding with the holes. It should be stated that it is only by the great accuracy with which all operations are performed in the preparation of the flat, the card, and the wire, that this method of attachment can be successfully carried on. Each projection on the wire corresponds with the hole in the flat, so that when the end projection is placed in the end hole all other projections can be fitted into their corresponding holes. That being done, a straight-edge is brought down upon the wire, and clamped to hold it firmly in position, the ends of the projections on the wires going some distance through the holes in the flat. A roller is then brought up from underneath, and is made to pass along the end part of the flat; it turns over all the projecting ends of the wire, and the card is then firmly attached to the flat. The reason the projecting parts of the wire are made thinner is in order that the flat wire may more completely cover the canvas foundation. This department of the works is one of very great interest.

Passing through another room on the same floor, used for light turning, &c., we come to the flat-cutting department, where the flats just referred to, to which the cards are attached, are prepared. These flats are taken from the department where they have been trued and are put on a true plane for testing. As in nearly all the machining operations for textile machinery, great care has to be taken in the preparation of these flats. We have already noticed how accurately the flexibles on which they travel have to be turned, and it will be seen by the description which follows what care must be observed in keeping the flats perfectly straight. Perhaps it would be as well here to give the reason that this great nicety is required.* The carding of cotton is performed by passing it between what are really steel wire brushes. One set of these brushes is placed on the carding cylinder, the other set being those already referred to as being mounted on the flats. The two sets of brushes are face to face, the wires all but meeting. If too much space be allowed between the brushes, the cotton would not be properly treated; whilst it would be obvious that if the wires were allowed to touch, they would destroy each other. For this reason the flats which carry the cards must be perfectly straight, they must be planed accurately on their faces, the cylinders must be turned absolutely true to unvarying diameter, and, of course, concentric to the axis on which they revolve. If these precautions be observed and the flats be properly mounted, their faces will be parallel with the axis of the cylinder, and therefore with its circumference. The space thus formed between the flat and the cylinder has to be filled by the brushes, the wires of which must all be of exact length.

We will now return to our description of the preparation of the flats. As stated, they are first placed on a true plane, their faces of course having been previously machined. The operator tests for deviation from straight line by putting pieces of paper between the true plane and the face of the flat, and thus finds if there is any curve. Should there be, he puts the flat under a stirrup and brings the part of the flat over a projecting piece of iron, which thus forms a fulcrum; then, pressing on the end of the flat, he, by establishing permanent set, takes out the curve. It need hardly be said that great skill is required in this operation, but by practice the exact amount of pressure can be put on, and the right place found upon which to bring the fulcrum to bear. That cast iron can be thus bent seems rather surprising, but, nevertheless, the operation is one which forms a necessary part of the preparation of these flats. This straightening is only an initial process, after which the flats are milled to exact length in a double headstock machine. Then six milling operations are performed for preparing the ends for grinding, after which the ends are drilled and tapped lengthwise for the attachment for taking the chain which causes them to traverse in work. The next operation is to drill them along the sides to form the holes already referred to, for attaching the cards. This is done by a 60-spindle horizontal drill, the drills being $1\frac{1}{2}$ in. apart. As the holes are $\frac{1}{2}$ in. pitch, it takes three operations to drill the whole of them, the spindles being shifted $\frac{1}{2}$ in. along each time. In some flats there are 180 holes on each edge, the time taken to form them being $1\frac{1}{2}$ minutes. This is a very pretty machine, the drills all being worked in train by toothed gearing.

The flats are next tested as to length, and the thickness of the end is gauged. Accuracy in the latter respect is essential to parallelism with the cylinder of the carding machine. For this operation a micrometer gauge is used. For a shop tool this is a very delicate instrument, for an ordinary piece of letter-paper placed between the surfaces showed a deviation of 25 divisions on the dial. The work having to be accurate, even an error equal to one division on the dial, corresponding to the 25th part of the thickness of a piece of letter paper, is sufficient to cause rejection. So truly do the machines in this department work that the flats are brought to the gauging machines with seldom more than a variation of 1 or 2 divisions. The deviation is always in the direction of excess, and the operator removes the superfluous metal by a file, taking naturally a very fine cut until he gets the exact gauge. If he should remove too much metal the bar is immediately broken up, even supposing only 1 degree of variation is shown on the dial. This gauging is brought to so fine a pitch that in setting the flats on the machine, only one is worked to, the operator knowing that if one is properly set all the rest will be in unison. The "set" of the cards varies between $\frac{7}{1000}$ in. and $\frac{11}{1000}$ in., depending on the counts which have to be spun.

We have already described the manner in which the cards are attached to the flats, and it remains to be stated that when the cards are mounted they are put in sets and ground on an emery roller, so that the wires will be of exactly the right length, and flat on their working face. They are tested in a machine which works to $\frac{1}{1000}$ in., and when true are passed for final examination.

We now pass to what is known as No. 2 erecting and fitting-room, where coilers, condensers, Derby doublers, willows, and carding engines are erected, whilst in the No. 1 fitting-room below, carding engines alone are erected. At the time of our visit there were 78 of these latter machines in process of erection, whilst in the No. 2 erecting-room there were 36. In No. 3 erecting and fitting-room below machines for treating cotton waste are erected.

Planing Department.—We next pass to an extensive department which is devoted largely to planing machinery. The first tool we notice is a planing machine of the ordinary description, which will take work 7 ft. 8 in. wide between standards and 7 ft. high on the cross-slide, whilst the table has a traverse of 25 ft. There are four tool-boxes, one on each upright and two on the cross-slide, all motions are, of course, self-acting; there is a travelling crane attached to this tool. Here there are many planing machines of different types, most of them being specially designed for some particular work. An interesting tool is a combined shaping, drilling, and milling machine for machining bends for carding engines. A bend is a flat iron half-ring with a deep rib on the inside, and having projections cast on for facings for brackets. The work is set on a circular revolving table, and the facings are machined radially in a horizontal plane by a shaping-tool worked by worm and wormwheel through bevel gearing, the table being revolved to bring the work up to the cutting-tool. The table is annular in form, and through the centre there rises a drill standard, on which is mounted a horizontal drill spindle, which bores the radial holes required in the piece. There is also on this central upright a radial arm, which carries the spindle for the drill for vertical holes. On this radial arm, also worked by separate gear, is a milling cutter, which will mill on vertical faces between two bosses exactly to length. The machine, therefore, planes on the horizontal surface, drills in two directions, and mills on vertical surfaces all to exact position without marking off. The table is divided and provided with stops in order to bring the work to exact position for drilling holes. This is one out of the large number of examples that could be given of the advantage of producing a large quantity of machines of the same class. Unskilled attendants will operate these machines, the work is beautifully exact and is produced at the very lowest price. The machine itself is, of course, an expensive one, and it is only the assurance of large and continuous demand that authorises the expenditure required in the production of this large number of special tools.

Near here are some large circular planing machines or vertical lathes, somewhat similar in appearance to those we illustrate in connection with our article on Messrs. Hulse's works. They are very useful tools, with quick return motion and self-acting. They can be set to turn by themselves continuously or can be made to jig, that is to say, take short strokes. The motion of cutting and return stroke must, however, be by hand for cuts an inch or two long, the action being obtained by shifting the driving band on the pulleys. For somewhat longer cuts a stop can be placed on the table so that the reciprocating motion is obtained automatically by shifting the band on the pulleys. These machines are great favourites in this department, cutting very steadily and producing remarkably clean work. There are also here shaping machines of various kinds, slot drills and other tools. Special slot-drilling machines are arranged for one class of work, having two horizontal spindles, the table being made to traverse to give the particular form of slot. They are automatic in all respects, the attendant having only to put in the work and the machine runs until the job is finished, when it stops by itself. The slot made is then rimered on a machine acting on the same principle. Other machines have tables

* The use of the carding engine is explained in our article on Messrs. Haworth's mills.

* See also our article on Messrs. Haworth's mills.

COTTON MACHINERY.

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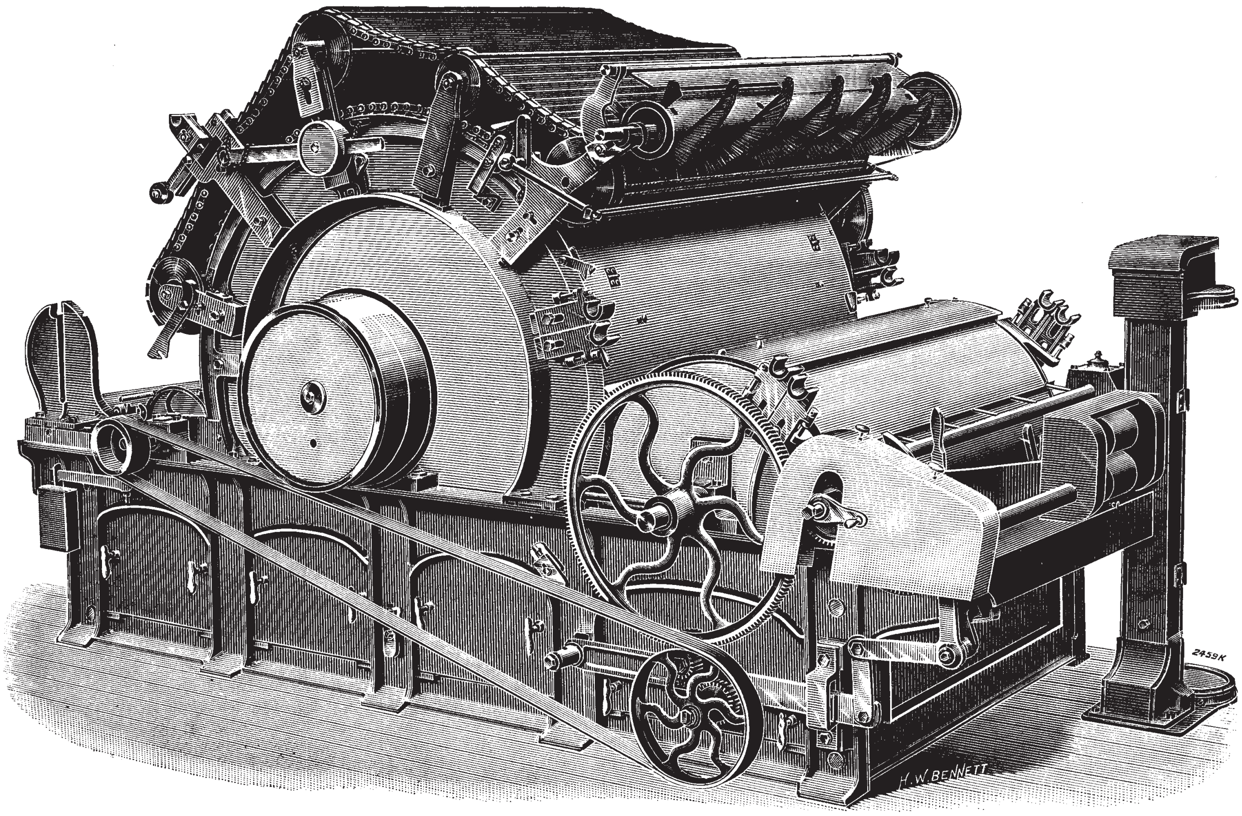

FIG. 29. CARDING ENGINE.

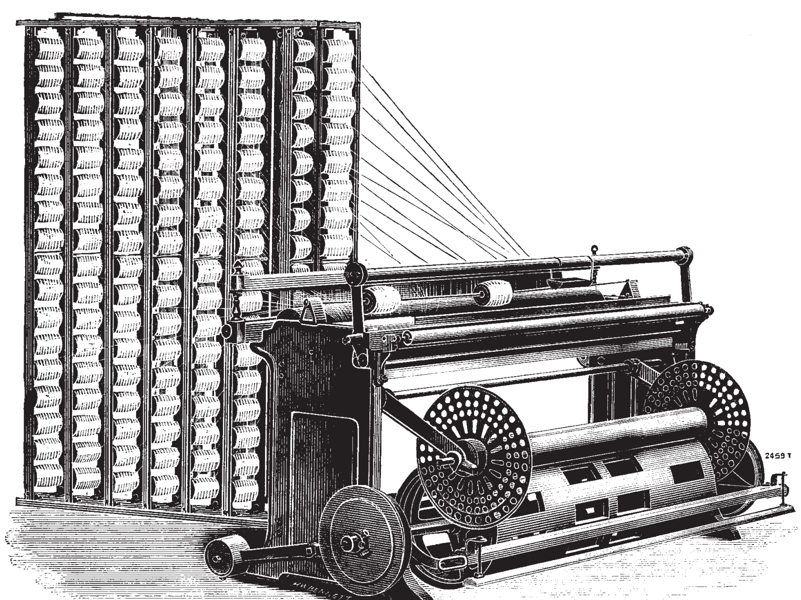

FIG. 30. BEAM WARPING FRAME.

arranged for taking definite parts. There are also some planing machines with six tools on the cross-slide for fluting rollers. The rollers are turned by a motion worked absolutely by a catch engaging with the spring stop on the table. When the required number of operations have been performed, the machine stops automatically. In order to lift the tool from the groove on the return stroke of the table, an arrangement has been devised by which the cutters themselves are made, by a positive motion, to swing upwards on the return stroke, and are allowed to drop into a vertical position for making the cut. In this way the heavy cross-slide is kept always in one position, and forms a firm support for the six cutters, and thus good work is obtained. Adjoining is a good-sized slotting machine with a revolving table; the stroke is 14 in. Further on there is a somewhat novel planing machine for planing the ends of gin sides and coiler ends for carding engines. There is a double table set vertically, the work being mounted on the outside; by means of a double cross-slide two horizontal and two vertical surfaces can be planed at once. There is a drilling machine with a traversing headstock and a bed 18 in. long. It has a leading screw in the bed for traversing the headstock. The table is vertical, the work being clamped on to the outside, the headstock being curved to overhang. By this machine slot drilling can be carried on; indeed, a slot 18 ft. long could be drilled if required. There are five of these machines.

Smithy.—We now pass to the smithing department for the Hartford Old Works, first entering the angle-iron smithy, used mostly for jobbing purposes. There are the usual appliances found in a well-appointed smithy of large size. The main smithy is beyond, and contains 16 hearths. Here are steam hammers, drop hammers, forging machines, shearing and punching presses, saws, &c. In the machine smithy are various presses, punching machines, and stamping machines for different parts innumerable. A noticeable tool is a 6-bladed circular saw for cutting out blanks for bushes, nuts, &c., to any thickness according to the distance apart of the saws on the spindle. A sheet iron flattening machine consisting of 8 pairs of rolls is used, the work being passed through continuously. Another machine of this class was being made which will take sheets 5 ft. wide. The smithy machinery is driven by a 100 horse-power engine. Beyond is the iron store, where bars and sections are kept. This store is well laid out to support the large weight of iron often in stock, ample strength being given to the racks. It is a point sometimes overlooked in designing similar buildings, cases being on record in which racks have given way and the walls of the building have been thrust outwards, thus wrecking the building.

We now pass to the grinding department for carding engines, woollen machinery, and cotton gins. This is similar in general arrangement to the grinding room for the blowing department already described. All driving is done from the floor below, and the arrangements for removing dust and disposing of sludge from the stones being

COTTON MACHINERY.

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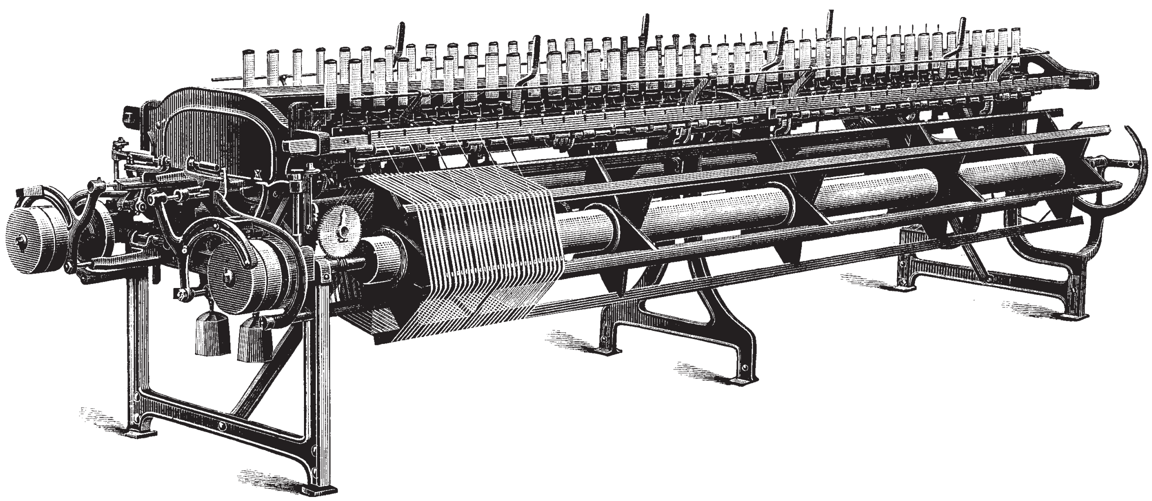

FIG. 31. DOUBLE BOBBIN REEL.

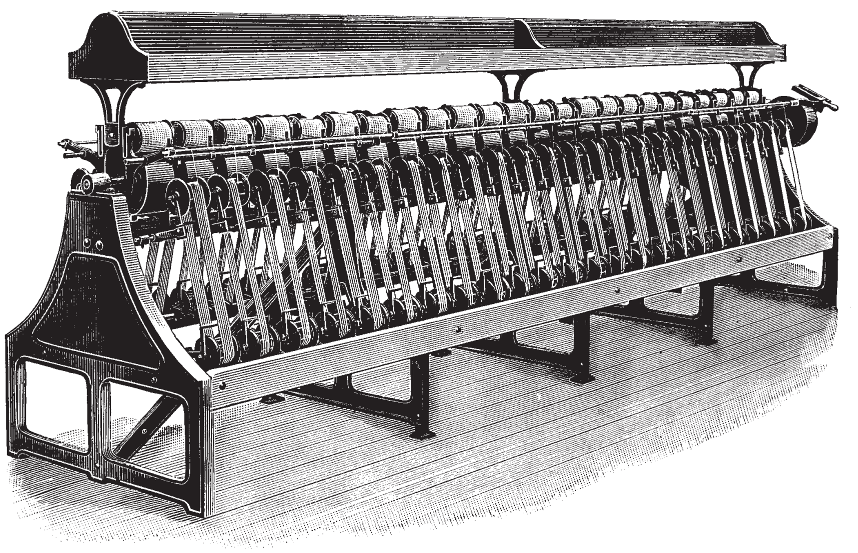

FIG. 32. HANK WINDER.

similar. In order to keep a clear atmosphere, there have been provided air ducts leading to each grinding wheel, with fans which draw down the dust, carrying it to a settling chamber. The designers of this department have certainly been very successful in attaining the result aimed at. The room contains 25 stones and 26 glazers. It is 20 ft. high, and the lighting is ample, both from the roof and through windows in the walls. The firm has also been fortunate in having had no accidents from burst stones in this building; although 1200 grit-stones of 8 ft. in diameter and 14 in. wide as an average, have been put in position. The grinding departments of Messrs. Platt's works may fairly be described as shops or ordinary rooms, the general term of "grinding hole"—frequently used by grinders to describe the place they work in—being by no means applicable to these excellent shops.

The case-hardening department is beyond the smithy, and contains eight ovens coal fired. The principal engine for these works is a very fine example of modern stationary engine construction. It is a tandem compound by Hick, Hargreaves, and Co., of 600 horse-power, and having a 24-rope flywheel pulley grooved for $1\frac{3}{4}$-in. rope, the wheel being 24 ft. in diameter.

There is a millwright's department also attached to these works, where a good deal of the machinery required for working the collieries belonging to the firm is constructed.

Our remaining illustrations relating to Messrs. Platt's productions show standard machines made in these works. Fig. 30, on the opposite page, shows a warping mill or beaming frame, the use of which is described in our article on Messrs. Haworth's mills. Figs. 31, 32, and 33, on the present and next pages, illustrate three descriptions of winding machines. These are also referred to in the article just named. Fig. 34, on page 118, shows another form of winder. Fig. 35 is a bundling press used for pressing hanks and holding them whilst being tied into bundles. The Derby doubler, illustrated by Fig. 36, page 118, is one of the many forms of averaging machines, the use of which is described in our article on Messrs. Haworth's works. Fig. 37, page 119, is a beam warping machine. Our remaining illustration, Fig. 38, on the same page, shows a more modern machine than most of those we illustrate, and we may, therefore, give a somewhat fuller description of it. It is known as the Chapon cup spinning frame, and is used for low counts of yarn and will spin a soft full thread with the least possible amount of twist for weft or filling purposes. It has been much used for spinning weft from cotton waste. The machine has a creel with tin surface drums to receive bobbins taken from the condenser carding engines, the latter making the threads to the required thickness, so that the Chapon frame merely twists the threads, without any draught, and builds the cops by means of an iron cup with a steel inner spindle. The winding of the thread on the cop gradually forces the spindle and cop upwards until the cop is completed, when the spindle is lifted out of the cup. The cup and steel spindle revolve at different speeds, the thread from the delivery roller passing through the curl in one of the legs of the flyer, and then through an eyelet in the cup in order to obtain the twist. The flyer has a vertical movement imparted to it by the lifting rail, by means of which the crossing of the thread on the cop is obtained. Thus the flyer has both a rotary and vertical motion, whilst the cup has a rotary motion only.

WERNETH SPINDLE WORKS.

Messrs. Platt Brothers and Company's Werneth Spindle Works are on the opposite side of the high road to the Hartford New Works, and are in themselves a factory of considerable magnitude, employing 1200 men. Here are made spindles, flyers, tin rollers, and other tin-work. Coppersmithing for slashers, &c., is done here; whilst bolts and nuts are made by special machinery, and file-cutting is carried on. Mule spindles, roving spindles, ring spindles, and throstle spindles are the chief descriptions produced. With regard to the latter there are still a certain number of throstles made, they not having been altogether superseded yet by the ring spinning machine.

The manufacture of flyers is a most interesting process to follow up, although it is one somewhat difficult to describe. To make the flyer from the solid bar there are required 125 different processes in all. These comprise forging, smithing, grinding, and polishing. Flyers made by this firm are, it is well known, of an especially trustworthy kind, being forged out solid throughout from the steel bar, there being no welding or brazing done at all. The only piece that is not solid is a small pin which is riveted in, and into which the head of the spindle fits. It was formerly the custom to weld the part forming the tubes, or the leg and tube of the flyer, as the case may be, on to the head, but this, like all welding processes, was by no means a certain method of construction, and an imperfect welding might prove dangerous at the extremely high speed at which the parts are made to revolve, reaching at times about 900 revolutions, or even up to 1300 revolutions, per minute. The breaking of a flyer was often a serious mishap, as if one went, possibly several in a row would follow. With the solid flyers, as made by this firm, accidents of this nature, we believe, are unknown. There are about 100 different varieties of flyers produced, and all processes have to be carried out with a view to accurate balance being maintained, a quality very necessary at the high speed of revolution.

COTTON MACHINERY.

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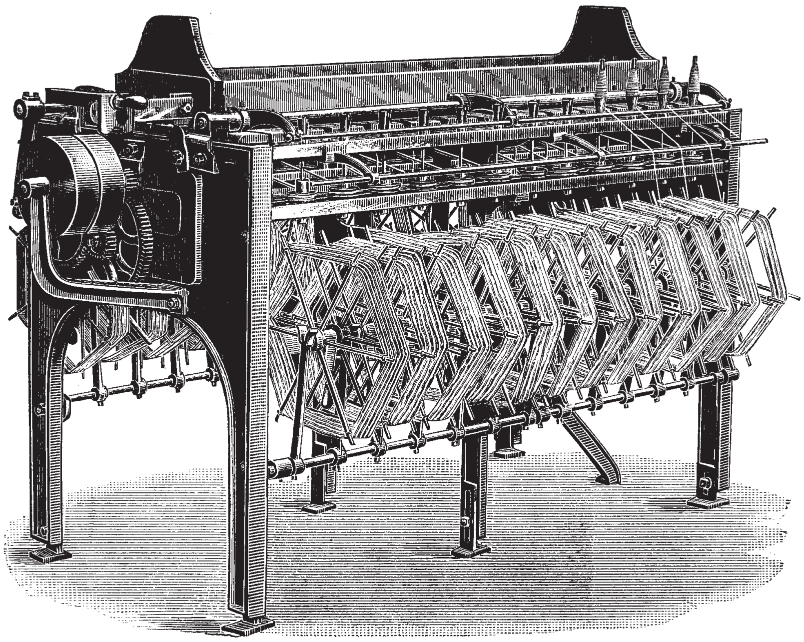

Fig. 33. Hank Winder.

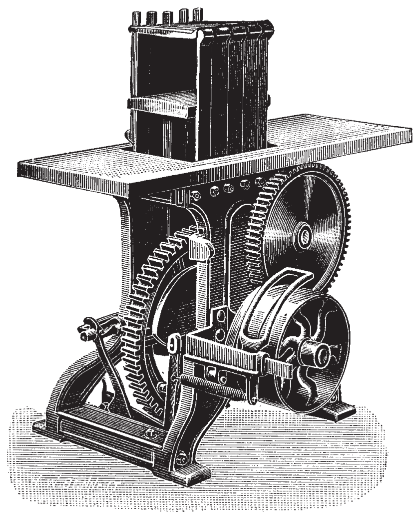

Fig. 35. Bundling Press with Coleby's Patent self-closing and opening Box.

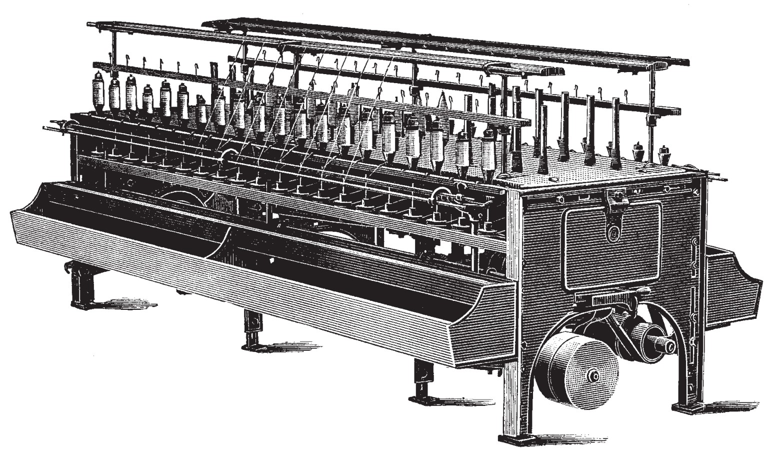

Fig. 34. Pirn Winder.

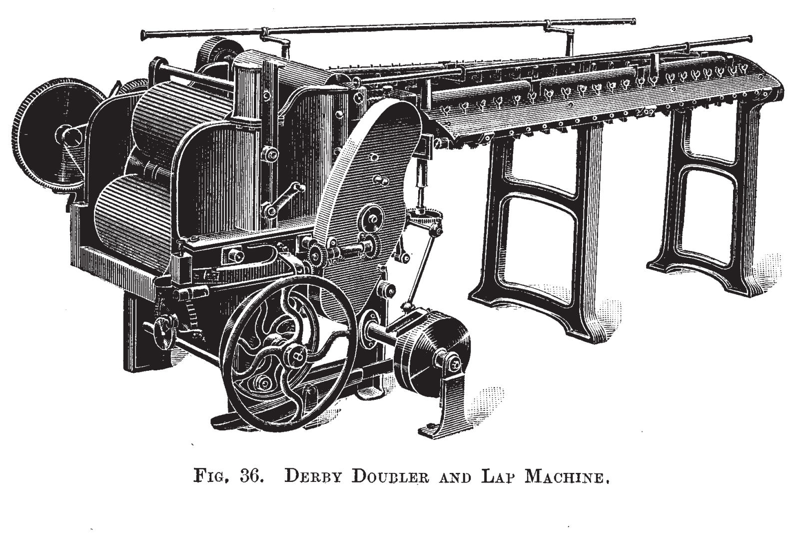

Fig. 36. Derby Doubler and Lap Machine.

The steel bar from which the flyers are made is cut to length, and a blank is formed by heating it and forging in dies. At first the blank is flat, but with projections raised on it in order to form the various parts; thus a socket is roughly formed in the shape of a long boss, projecting from which are two arms which ultimately will be converted into the tubes or tube and leg of the flyer. Drop hammers and forging machines are used for these processes. The arms for the tubes are also drawn down by powerful half-rolls, which make a half-revolution one way and then reverse to make a half-revolution in the opposite direction. In this manner the part to be rolled is drawn in and squeezed between the rolls and returned to the operator. The part having thus been flattened out, is sheared to the shape required in special shearing machines, which perform the whole operation at once. The top and bottom socket are then drilled in a special machine. After this the piece is heated again, and the projecting arms are bent over to give the inverted U-form which they take in the completed flyer; this is done by a blocking machine worked by power, and having a combination of sliding tools with rollers, while the piece is held in a vice by the socket. Great care has to be taken to bring the part to the right heat in performing this operation, the attendant being skilled in the process. The part is then stamped under the drop hammer on dies to insure the proper form being attained, the work having, of course, become colder in the meantime.

We now pass to the grinding shop on the third floor, where flyers only are treated. Here they pass through many operations, from rough grinding to fine grinding of different parts with emery wheels of various forms and degrees of fineness. The two arms which have been bent over to U-shape have to be formed into tubes in the case of double flyers, or into a tube and leg in a single flyer; the closing of the flat part into a tube is performed by drop hammers, which are worked by elevating screws; a side pressing operation also comes into play during this part of the work. At the same time glazing operations by means of emery wheels go on, but, of course, all the bending has to be done cold, as the heat would destroy the glazing. The metal for flyers has naturally to be of a suitable nature; it must not be too soft, neither must it be hard, or it will be liable to crack; but in order to guard against the latter defect, the whole of the operations are performed

COTTON MACHINERY.

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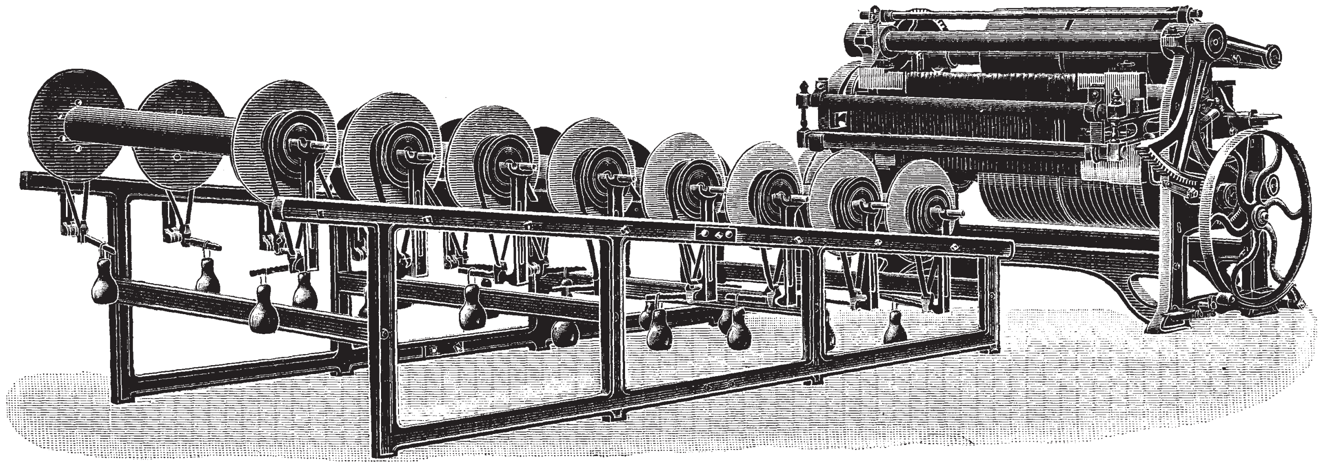

Fig. 37. Beam Warping Frame.

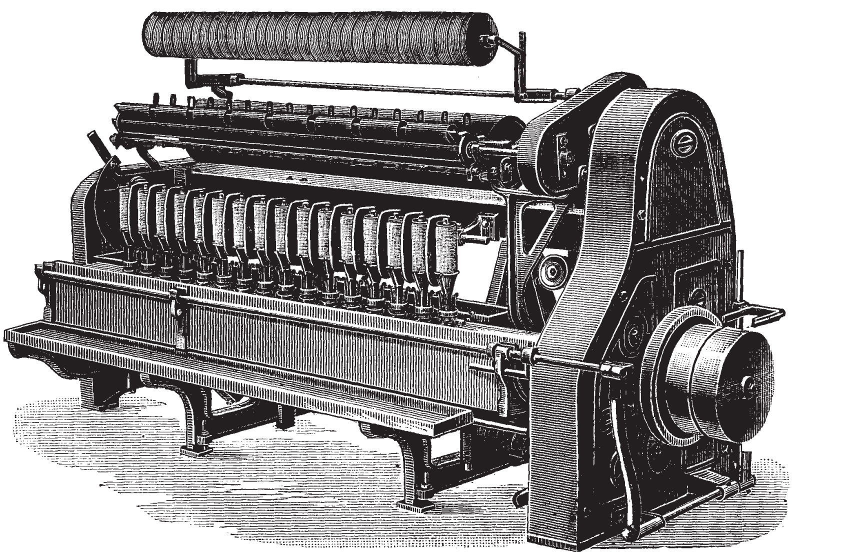

Fig. 38. Chapon's Cup Spinning Frame.

gradually. It is necessary that no rough places should be left, as otherwise the filament which has to pass down the tube and over the ball or top part of the flyer would be abraded, and this would lead not only to the destruction of the thread, but to stoppage of the work. After a final examination, the tube is closed up by a swaging machine on a mandril, after which the ball is closed under the drop hammer. The flyer is then taken to a milling machine of the lathe type, to machine the top socket so as to get the exact form of the part where it joins the ball. An annular crown cutter is used, and a special lubricant, which will answer the purpose without there being a probability of the work rusting, is employed. The flyers are then tested for balance, and if necessary weight is taken off one side by grinding.

On the floor below, flyers have the necessary machine work done upon them. First the tube which forms the socket is cut to length; this is done in a special lathe, the cutting tools having to be fed up inside the U of the flyer. The cutting tool is carried on the end of a tube which feeds up from the back centre and surrounds the part to be operated upon. The bottom socket is rimered out to exact gauge, so that there may be no shake when the flyer is fitted on the spindle. The top socket is also turned; after that the holes for the pin which engages with the top of the spindle are drilled out by double-spindle drills, which work from opposite sides and meet. This round hole is next made into a slot by a punching machine; next the roving hole in the top of the socket is drilled by various processes. It is necessary that there shall be absolutely no roughness of any kind, as the filament passes through this hole, and it has, therefore, to be gravered and smoothed inside and out by hand, no machine work at present having been found to perform this operation satisfactorily. The pin for engaging in the split top of the spindle is next riveted in, after which fine glazing is done to make the surface perfectly smooth. Balancing operations are carried on between the successive processes described, so as to keep the work true throughout. The piece is next brought up to standard weight by grinding, if necessary.

After the various machine processes of pressing and stamping, the flyer is cut to correct shape within a small percentage of error, and though this error would not be apparent to the inexperienced eye, it would be sufficient to be a serious drawback in the operations of cotton-spinning. The flyers are therefore taken to the squaring bench to be got into proper shape by bending to gauge by hand, the operator testing the work with templates. The flyers are also spun on a spindle by hand, and if they are found to be out of balance, a small quantity of material is taken off by the emery strap. This is a very nice operation, and requires considerable skill on the part of the mechanic to know where to take off the material. It is done by the feel of the spin. The final polishing and finishing is then gone through, and also the polishing of the stop. It should be noted here that this important part of the flyer is made solid with the rest, and is not brazed on, as is so often the case. The tubes which constitute the inverted U (in a single flyer there would be a tube and leg) are formed, as stated, by the bending over of a flat strip of metal, and it is necessary that there should be a slit from one end of the tube to the other, so that the cotton may be passed through it when necessary. This slit is formed naturally by the edges of the flat strip of metal which has been bent over not quite meeting, but the gauge of the opening has to be accurately formed so as to suit the hank roving required. This slit must also be perfectly smooth, or the roving when put through would catch. It is worked up by passing emery cloth through the slit, the opening of which is tested by steel gauges for width, and for smoothness by drawing through it cotton. It should be stated that in the process of manufacture the edges have been rough ground, fine ground, and burnished. Inside and outside gravers of special shape are used for removing arris.

The large number of processes that are gone through in making a flyer entail a heavy floating stock being maintained, so that one party of workmen may not be blocked by not having pieces to go on with. There are in the Werneth Works in process of manufacture at one time generally 100,000 flyers. The part which is known as the presser, which is fitted to the flyer, is not quite so elaborate as the flyer itself. It is, however, produced by some similar operations, there being very special machinery for forging and working up this part. Here, again, the principle of making parts from the solid is followed, the wire and paddle being made from a single piece. Formerly the two parts were made separately and joined afterwards, but the solid method of construction is naturally preferable, as being more trustworthy. Those who are acquainted with the form of the presser when finished, will understand that special machinery is required for forging the blank. The presser having been fitted to the flyer, they are run together on a spindle as they would be in actual work on the machine, excepting that the spindle is held in the hand of the operator, by means of a loose tube or sleeve. If the spindle and presser are perfectly in balance, the sleeve will fall quite steadily, but the least deviation from balance will cause it to shake. This is of the nature of a final testing operation, as the parts have been balanced throughout carefully, during the whole process of manufacture, as already stated. Occasionally, however, deviations from true balance will be discovered by the delicate test of the skilled operator, and in that case a small part is taken off the heavier side. A final general inspection is then made, and the parts are ready for delivery.