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 1876, 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 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 peculiar development 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. Boiler-standard machines have been vastly improved, and have been made capable of turning out more and better work at a reduced cost.

These facts, and others which will be presented next week, will illustrate some 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 the 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 work he has inspected, he is not fully equalled by those by which there was not time to visit.

The meeting opens on Tuesday next, the 31st inst, and all the mornings will be devoted to the reception of the President, Professor Alex. B. W. Kennedy, and members at Owens College by the Lord Mayor, and 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. Watton and Co.'s Warehouse, 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 opened to the members.

In the evening the Lord Mayor of Manchester will entertain the members at a reception 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 Pucking 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. John Masgraves and Sons, 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. Robinson and Son's woodworking machinery and roller-milling works at the latter. The third excursion will be to the Manchester Sewage Works at Davenport. 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 meetings, 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 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 visit the engineering works of Messrs. Hick, Hargreaves, and Co., and of Messrs. John Masgraves and Sons. At Horwich the whole party will visit the locomotive works of the Lancashire and Yorkshire Railway Company. The social 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 high pressure works of the Lancashire Watch Company, of which we so recently gave an account in Engineering (vide vol. iv., pages 1, 38, 43, and 69).

It would, of course, be quite impossible, within the limits available, to give even a brief account of the works which will be open to the inspection of the members of the Institution of Mechanical Engineers during the approaching meeting, but it seems to us that 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...

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, etc., which has resulted from the addition of many new members 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. In this country, where we are engaged in producing a fabric which would be useless for us to attempt to give instruction, but a very large proportion of the engineers who visit Manchester will have had no practical experience in the industry, and such knowledge as they may possess of the working details of the various 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 a list of the producers of a factory where the machines used in cotton manufacture are made; and next, again, will be found a description of works where engines are produced. We hope that the two first-named articles will be useful to the visitors to the Manchester district, and perhaps to those who, by our readers who may have previous knowledge of the cotton manufacture, will gain a general idea of the operation of the works. The three subsequent articles have been selected for description as the cotton spinning mills and weaving sheds of Messrs. Richard Haworth and Co., Orladale; the textile machine works of Messrs. Platt Brothers and Co., Limited, at Oldham; and the engine manufacture of Messrs. Hick, Harrison and Co., Limited, at Bolton. Although it is a task we gladly have avoided, it has been necessary to add cotton planting and 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 have a fixed position in dealing with any subject in the way we have, 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 have a fixed position in dealing with any subject in the way we have, and we have given much more interesting, more especially in the case of matters that have an effect on the cotton manufacturing operations as a whole. Some of the observations that should be noted, are too high to be dealt with in papers to be read at the meeting, and we refer our attention to one establishment that we may have to do with this firm to give descriptions in this preliminary series, as the papers will be published by us in due course. Of the London and Northern Company's works at Crewe, and of the works of the Lancashire Company at Horwich, we have also decided to leave out much that would be interesting, and 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 MANUFACTURING WORKS.

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 shall be able to describe the various works as briefly as possible. We have selected for our purpose the series of mills owned by the firm of Richard Haworth and Co., which are situated in Orladale, Salford. In the first place, as reason for our choice, the mills belong to the Lancashire Company, and are consequently thoroughly well equipped with modern machinery of the best type. Secondly, the mills are within a short distance of the main railway line, and are thus easily accessible to the members of the meeting. In the present day Manchester itself is becoming less and less a city, and more and more a great colossus, indeed, assuming the character of a metropolis to the district. Land in the city is now too valuable to be devoted to cotton manufacturing purposes, and the mills are almost as efficiently and far more cheaply conducted in the outlying townships and districts. In this way Stockport, Oldham, Bolton, Rochdale, and other smaller towns have become the centers of manufacture of textile goods, whilst Manchester is the market or warehouse. Naturally those mills that are fortunate enough to be situated in the center of this wide system 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 the whole of the operations are carried on by this firm, the works including both spinning mills and weaving sheds. Before passing over to details of cotton manufacture, as illustrated by these works, something may be said of their general features.

The textile firm of Richard Haworth and Co. was founded by the late Richard Haworth. Like so many of our important manufacturing establishments, it is a small, but energetic company, and the capital at the command of the founder being by no means equal to his abounding energy. Despite all difficulties, he continued the firm, and the small beginning which he made grew from a employing fewer hands to the vast proportions of a modern cotton mill of the first class. The firm's first step was 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 a whole, 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 Orladale are divided into three mills and a weaving department. The mills are known as the Egerton, the Tatton, and the Egerton and Tatton Mills. All these mills are practically one factory, although Egerton and Tatton Mills are a few hundred feet distant from each other, and are all worked and managed as one establishment, and the whole is now under the management of the late Richard Haworth. The second son, Mr. George Haworth and Mr. John Haworth, the former taking the manufacturing operations as a whole, 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 Orlad-
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 broken threads, the breakage of bobbins, and the injury to the workers, have all disappeared. The cloth, the warp, and the weft, are produced with equal regularity. Wherever the number of spindles increases, the number of looms increases in the same proportion, and the laborers increase in the same proportion. This is the case in every part of the world, wherever the system of production is extended. The infantile state of society, so far as the production of goods is concerned, is only a state of infancy. It is not the same as the state of nature, where each individual is independent of all others, and is not subject to any authority. The same principle applies to the cotton industry. The cotton is not produced by one individual, but by a whole community. It is produced by the cooperation of many individuals, who are all engaged in the same work.

The spinning wheel, which is the machine used in the cotton industry, is a simple apparatus. It consists of a frame, a spindle, and a bobbin. The spindle is fixed to the frame, and the bobbin is wound with the thread to be spun. The operator places the cotton on the spindle, and spins it round. The cotton is then wound on to the bobbin, which is fixed to the spindle. The operator then winds the cotton on to the next spindle, and so on, until all the spindles are wound with cotton. The cotton is then made into yarn, which is used to make cloth. The yarn is wound on to a reel, and the reel is then fixed to a lathe. The lathe is a machine which is used to make cloth. The yarn is wound on to the lathe, and the lathe is then turned. The machine turns the yarn into cloth. The cloth is then wound on to a reel, and the reel is then fixed to a loom. The loom is a machine which is used to make cloth. The cloth is wound on to the loom, and the loom is then turned. The machine turns the cloth into fabric. The fabric is then cut into pieces, and the pieces are sold. The cotton is thus made into cloth, and the cloth is sold.

The spinning wheel is a simple machine, but it is not very efficient. The cotton is not spun evenly, and the yarn is not very strong. The spinning wheel is also very slow. It takes a long time to spin a certain amount of cotton. The cotton industry has therefore been improved. The spinning wheel has been replaced by the cotton mill, which is a much more efficient machine. The cotton mill is a large building, which contains many spindles and looms. The cotton is spun in a large number of spindles, and the yarn is then wound on to a reel. The reel is then fixed to a loom, and the loom is turned. The machine turns the yarn into cloth. The cloth is then wound on to a reel, and the reel is then fixed to a loom. The loom is turned, and the machine turns the cloth into fabric. The fabric is then cut into pieces, and the pieces are sold. The cotton is thus made into cloth, and the cloth is sold.

The cotton industry is a large industry, and it is very important to the economy of the country. The cotton is produced in many countries, and it is used to make a large number of different products. The cotton is used to make clothing, and it is also used to make a large number of other products. The cotton industry is therefore an important industry, and it is necessary to keep it healthy and strong.
just by feel. Much practice is required to determine this point accurately. The distance between the cards is obtained by packing 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 sets of wires, which has the effect of placing the fibres so that they lie all in one direction, namely, circumferential to the cylinder. The manner in which the will 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 rigidly in place. In the case of the wires, the wires are put on the card on which is known as the doffer, which is a another revolving cylinder of very much smaller diameter and covered with wires. The fibres are 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 fibres are then released from the wires and are brought, being delivered in the form of a thin web or sheet.

This 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 done before, 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 then treated in the next process, which revolves 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 it is converted into 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 splicer 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 fibres from the long is performed; the short fibres are collected by the doffing comb, and are taken off them by what is known as the stripper comb, and is deposited in a suitable receptacle; the short fibres have a commercial value, being used for many inferior purposes. In some cases in place of flats carding engines are provided with rollers. The Crompton 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 hasten 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 into 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. The means of a spindle and flyy, so that sufficient twist is put into it to enable it to be described as a slubbing, and it is wound into a sufficient twist 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 of slubbing and roving is carried out. Here two slivers are drawn together by rollers as before, and are twisted by a spindle and flyon 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, the twist being twisted at the same time. In Fig. 11, one of our two-page engravings, we illustrate the "slack room" or roving department at Messrs. Hovarth's Ordeal mills, while on page 112, in Figs. 24 and 22, we give two illustrations, namely, a back and front view of one of Messrs. Platt's roving frames similar to that used in the Ordeal shown. They have a certain amount of "drafting" 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 bobbin is carried out continuously and without intervention. 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 brass 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 end 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 the 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. 1734.** (See page 90.)

*"Weft" is the general English term known in the trade. "Warp" is a scriptural or literary expression, whilst the modern American uses the word "filling" to describe the same thing.*
the ring bobbin, through which it passes, and which it causes to rotate. It is necessary, however, to twist the thread as well as to press it, and the necessary twist is put in by reason of the workman putting some drag on the thread; in this way, the ring makes a greater number of revolutions than the traveller, and therefore twists the thread. In order to lay the thread to build up the web, the traveller is provided with a roller on which the thread is fixed or is caused to rise and fall, so that the thread is guided to the right position.

We come now 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 establishment. Figs. 16 and 17, on page 108, we give illustrations which are front and back views of the headstock in Messrs. Haworth's mules, a Platt's Patent carriage also being shown. In the mules the revolving bobbins are arranged at the back of the carriage, and the yarn 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 yarn, and the twist is increased, as is necessary, by a thread, and was made to rotate, the spinner holding the thread in her fingers. When the motion has been reversed, the thread passes by two opposite directions, towards the rollers, the thread is led off from the body of the spindles of the right angles, or approxi- mately, the spindles themselves, 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 "cotton," and hence, therefore, that the thread is twisted by two principal operations, one consisting of twisting the thread, performed when the carriage is running out, and the other, the faller wire loads the thread on to the point of the spindles or in a line with it axis, the second operation consisting of winding the thread when the twist has been put in on to the spindles.

There is, however, one operation which completes the operation, and that is good, keeping the thread always in tension, otherwise it would kink. The line followed by the thread when it leads from the point of the spindles to the rollers is shorter than that taken when the thread leads from the middle of the spindles to the rollers; it will be seen, therefore, that the faller wire attempts to guide the thread to the centre of the spindle, which it does at the pace between the outside of the roller and the point of the spindles, which is the furthest from the outside of the spindle, at that time the thread would be broken by the faller wire. The additional length of line was given. This additional length is obtained by reversing the motion of the spindles, 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 worsted, the worsted over the cotton, being that which is used for the surface. The ring frame is used for warp, where a stronger thread is required. Before the introduction of the mule, worsted was spun on the worsted or flyer frame, and, indeed, for many years the working and more economical ring frames were the order of the day. As, however, the mule has been improved over the cotton, although it had obtained a firm footing in the United States. To the present day warp twisting is largely performed in the United States. As, however, the mule has been improved, both its position and work, and, indeed, for many years the quicker working and more economical ring frames have been the order of the day. As, however, the mule has been improved, both its position and work, and, indeed, for many years the quicker working and more economical ring frames have been the order of the day.

We now have the thread wound on the mule'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 operation is performed by the apparatus by which it is carried on being illustrated by Fig. 29, on page 110. The mule's beam is 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 soap or other material. As many as 3000 to 4000 threads will be passing through the machine at one time. They then travel through the circumference of a big drying cylinder, 9 ft. in diameter, and warmed by steam, and from thence they are wound on to the weaver's beam.

The weaver's beam is put into position, and the head is suspended in front of it; the end of each thread in the warp is then passed through the eye of the corresponding shuttle, 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 frame in Messrs. Haworth's establishment. It is large, and which it may be stated over 800 women are at work under the charge of one man. The threads forming the warp are passed over the back rest, and pass two "shed rods" which, in the ordinary plain loom, divide them into two parts. Each shed rod, by two "harnesses," helps the weaver to pick out a broken thread. As already stated, there are two heads placed one in front of the other, and all the odd number of threads of odd numbers, supposing them to be numbered consecutively, whilst the front head will be the even numbers, and the back head the odd, or the alternate thread will pass through an eye in one of the other heads. The heads are given a vertical motion by a short联动 motion, and therefore, the odd and even numbers in the warp are made to rise above one another alternately. The shuttle now passes from side to side of the loom by means of a hook from the picking stick. As the shuttle passes in one
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The remaining departments in Messrs. Haworth and Co.'s works are, although extensive and important, do not call for particular notice here. Fig. 14, on page 105, shows the cloth folding and examining department, with the folding and measuring machines. The WORKS OF MESSRS. PLATT BROTHERS AND CO., LIMITED, OLIGAM.
The series of works at Oldham which are the property of Messrs. Platt Brothers and Co., Limited, is not restricted to the kind in this or any other country. The works themselves cover an area of 55 acres, a very large works having been built from four or five stories. The number of men employed is between 9000 and 10,000, exclusive of those at the works in other parts of the country. The work is of a pure spinning character. The firm are in all four chief factories, viz., the Hartford Oil and New Works, the Manchester Silk and Leather Works, and the Workhouse. These are the establishments devoted to the manufacture of machinery, mostly for textile purposes. The plans and drawings of these works 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 threequarters of a century ago, by Henry Platt, who died some time before 1821. Henry Platt had previously been engaged in the manufacture of textile machinery, such as it existed in England, after Oldham in his employment about halfa dozen hands. Later on Mr. E. Hibbert, who was then an engineer of Oldham, joined 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 fast, they were later taken, and works what are now known as the old works were started. These works are fully described in the description of the firm. In 1843, J. E. Platt and John, soon after, in 1857, came into the business, and five years later Henry Platt, the founder of the business, died in 1849, and his brother James Platt joined the firm. In 1846 Mr. Hibbert died. In the year 1854 John and James Platt have been growing 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 Richard Hibbert, and Eli Spencer, who had been long connected with the firm, also became a partner. In 1868 the business was incorporated under the Companies Act, under the chairmanship of John Platt. In 1872 the death of the first chairman rendered it necessary to elect another, and Mr. S. E. Platt, succeeded to the post, which he has retained up to the present time. It is, perhaps, Spirited Work, as so 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. 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 readily selecting and engaging of high class of quality for those who would be leaders of men. It was John Platt's far-seeing policy that enabled the establishment to advance steadily, and even in his lifetime, but left it so that those who have followed him have been able to continue its growth. Many of the men who are now in the firm had the trust reposed in them. One of those who has left his mark most strongly on the works was the late Mr. William Richardson, who was a member of the family.

The Force.
The name is itself an extensive engineering establishment, and here to proceed to work may be seen carried on with as much activity as if Bessemer had never made his great invention. The reusing machinery is one of the points on which the firm has a capacity of 30 cwt., and works at six hours per day, so that 180 cwt. is used each day. The refined machine is one in which the furnaces for work which nine hours per day, somewhat a quicker rate, which we believe is only equalled at Lowmoor, where we understand ten hours are worked. Though the Lowmoor heats are not so big as the works of Platt's, the latter being 3½ cwt. The refractories are perfect, and the blast is thick and blast pig. There are 20 puddling furnaces, on the water bath system, and each has a boiler for 15 tons of rail. The same detail is also avoided, and are taken to the reheating furnace, which has a single oxide bottom, and is then put through an 18-in. barrel. Before being replaced in water to remove scale, and is then heated to length and split in a shearing machine, after which it is again put in water to remove all oxide and scale which may have adhered. The iron is then cross-plied and heated and hammered until it is as near to its forming for the work for which it is drawn to a bloom for any size required. For the ball furnaces there are two 70-cwt. steam hammers, and also a half 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 straps 2½ in. in diameter, thus giving increased rigidity to the framework, and adding to the steadiness of the work. There are two cranes for serving these hammers. The furnaces will be for the form of cast iron, for larger work than that recourses has to be had to breaking. At the time of our visit a large hydraulic hammer is being reduced, an operation performed by drilling lines of 11-in. holes and driving in tapered steel drifts. An undesirable feature of the hammer is the silo, which are cast in water, and the train mill any small. There are in all the force one merchant mill, one guide mill, one drawing mill, and one finishing mill.
The general arrangements in this forge are designed to carry out the principle followed in these two previous buildings, and also by the machinery being more compact. The roll store is served with a single rail crane, which will deliver to the mill cranes that conduct the parts of the metal to the respective rolling stands. 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 these one-hundred bushel mill, and a 70 horse-power engine for the puddle bar train and shelve hammer, in addition to which there is an 8 horse-power engine for shears, pumps, &c. The buildings being large and well arranged, there is a mechanic's shop here for fitting and rolling turning; furnished with as many machine tools as can conveniently be employed. The standard-gauge railway runs into this department. Pattern-rooms, store-rooms, and joiners' workshops are connected with the process of gathering into pipes iron 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 one of the most extensive in the country, and requires a special description. There are frame and circular saws for breaking down logs, and other machines. A good deal of timber is used in textile machinery, the suitable carrying 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. WARFING DEPARTMENT.

FIG. 10. POWER LOOMS.
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 speeders, 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 600 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 labor. The shop is equipped with three-cylinder blowers, and four of the cupolas are fitted with Swayne's receivers for obtaining a regular mixture of materials for the blast. The 

true. The fluted roller, which plays so important a part in cotton spinning machinery, is now practically finished, and only requires cleaning by sawcutting, 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 shop a large number of machine tools used exclusively for the purpose of turning the loose boss top rollers and the oval bosses of a long cast-iron roller, which should be explained, is placed above the fluted rollers in spinning machines, and consists of a spindle with a variety of sizes in length and shape in these; the length varying between 1 in. and 10 in., and diameters varying from 0.5 in. to 2 in. The spindles, ordinary and loose boss. The loose roller top consists of a spindle with two loose bosses or revolving cylinders, outside. The method of manufacture consists of a number of workmen making special lathes and boring machines being used, but a good deal of finishing is done by hand tools on left hand to get a polish, and the finished article is sanded and polished. The finish is required, and after the piece has been shaped so far it is case-hardened; after this the work is polished and wiped with a polishing stick and emery powder, and is finally burnished. The make in this department is over 10,000 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 the front and back parts of ring frames and other parts belonging to the same machines. There are shaping machines, drills, milling machines, &c. The milling iron is carried at the average of 8 ft. long. The boards of which the carriages are made are planned on the flat in the sawmill, and brought from the sawmill to the carriage shop in the manner already stated. This department is divided by a packing-room, and the further work for finishing up is done in this room. In this room there are two other rooms; one where the timber is got ready for finishing up carriages, and the other for testing the experimental machines. In this room there are mules fitted up in working order for cotton, wool, and wool worsted. The two other rooms here are milling machines of special type in which several surfacings are cut at one operation upon various 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, as well as the packing of the various parts which go to compose the mule are prepared in the different shops. A number of the employees, along with the others, &c., will be duly referred to in treating of the various departments.

Our Illustrations, Figs. 18 and 19, on page 109, show two typical looms made by Messrs. Platt. The former is an overpick loom, with Ecles drop-box motion, and the latter a dobby loom. In the principal machine shop 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 feature. The loom castings are mainly for the use of planers of the ordinary type, whilst for other work shearing machines, lathes, boring machines, drills, &c., are used; in fact, the types of machines in use are almost without number. The millling practice here is notable, the work lending itself very successfully to this method. The view of the shop is taken from the headstock to the foot of the machine is a place where the same machines will be used, as the same principles are applicable to both. This idea is not new, but it is being put into practice in an unusual manner.

We now pass to a shop where boring, drilling, and plowing of the articles required for ring frames is carried on. All castings for ring frames are taken from the foundry small trucks, which are loaded on to the railway wagons and thus delivered to the nearest point to their destination. The machines used in these shops are mostly of the ordinary type, but have special tool-boxes, and performing the work. Some of these tools have six or more tool-boxes. There are some special drilling machines, some with long beds and two cross-spindles, and others with four spindles, all of which are being used on cross beams. The bed is moved forward intermittently, as the holes in the frame are too large to allow the exact pitch required, thus being obtained by automatic means.

When the holes are bored, the drills are withdrawn by hand, and the boring 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 1/8 in. is made, and both flat and twist drills are used. The twist drills are ground by an emery twist-drilling machine. The frame members are then marked off to the right length, and cut in a miter by a circular saw.

In the grinding shop for ring frames are stones and emery wheels. Here are ground many thin stones and emery wheels, made of iron, which are not thick enough to machine, and other more solid parts are also finished here. Sheet steels from which small parts are punched out, are also ground in this department.

Self-Acting Mule Department.—Carriage Room.—The mule is the most important machine in cotton spinning, and the machine most signalized by the improvements in the manner already stated. This department is divided by a pack-room, and the further work for finishing up is done in this room. In this room there are two other rooms; one where the timber is got ready for finishing up carriages, and the other for testing the experimental machines. In this room there are mules fitted up in working order for cotton, wool, and worsted work. The two other rooms here are milling machines of special type in which several surfacings are cut at one operation upon various 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, as well as the packing of the various parts which go to compose the mule are prepared in the different shops. A number of the employees, along with the others, &c., will be duly referred to in treating of the various departments.

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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 20 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 shop is used principally for preparing the plant required on the works, and for millwork 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 10 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’ olives doing their work in the usual way, and which appear somewhat old-fashioned amongst so much welded on to the short cranked lengths. The size of the crankshaft averages 2½ in., whilst the throw is 3½ 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 adept 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 ½ in. to ¾ 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 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 a short stroke by an eccentric. Each cutter had a separate tool-box, and all were mounted on an elevation 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 22½ 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 large gap lathes, and other machine tools such as lathes, planing machines, drilling machines, &c. This 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 cold in a punching-machine type of press. Fuller 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 part is then removed by cutting with a chisel when hot. These cranks are for looms, and are two-fold; the two cranks being set level with each other. The cranks are made with short lengths of shafting, but some distance apart, and an intermediate shaft is therefore wise 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 from dies. Drawing machines of a special description are used, the shafting being elongated vertically 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 countershaunting 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, spindles, looms, ring frames, shafts, &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 pieces 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 hobbin-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 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 ½ in. to 1½ in. in diameter, whilst the length varies from
COTTON MACHINERY.

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FIG. 16. FRONT VIEW OF MULE HEADSTOCK WITH PART OF CARRELGE.
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 1 in. thick and about 4 in. deep, the head of which has a rib 1½ in. across; projecting from the rib on either side are arms or brackets 3 in. in length. The spindle rail and the brackets, which is a disc at the end, are forced 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 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 what saving 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, etc. The work is laid out so that the atten-
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 recognize 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 20 to 30 times the length of the lap. The Heilmann combing 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 30,000l., and then the wool rights for another 30,000l., whilst they obtained 20,000l. 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 this 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 104 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 the 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 upon 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 35 to 34 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 web. 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 simplifies 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 7½ 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 10½ in. wide. On account of this and other improvements in working, one
girl will produce 450 lb. of combed cotton per machine, whereas with the older one, 30 to 40 horses, it would take several hours' labor for the same quantity, with a corresponding increase in the work of the factory.

The efficiency of this machine, as in all textile machinery, depends on the accuracy with which it works. This accuracy is taken for granted, for the machine has been worked to produce perfect results. The draftsman of the machine has been worked to produce perfect results. The draftsman of the machine has been worked to produce perfect results.

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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 grouped 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. in thick. 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 gridding as little objectionable as possible. In the cellar below the gridding shop is the second motor shaft for driving the whole of the department. On it is an 18-groove rope pulley to take 1½-in. ropes, the diameter being 10 ft. The beautifully steady motor shaft with 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 gridding 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 suspended 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 floor 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 give the number of every room 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 machine frames. The flats consist of an iron plate, generally 45 in. long and of T-section throughout the greater part of the length, being 1½ in. wide on the transverse, whilst the metal is 1 in. thick. At the ends, however, the section varies, being rounded in order to take the chains by which the cards are operated. These bars carry the chains, to which reference will be made further on, their weight being about 7 lb. to 8 lb. each. There are large three-ends 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 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 50 ft. by 60 ft. Each floor is provided with an entrance independent of the other, the floors being fireproof; there are external staircases, so that no openings are made on the one floor to the exterior to the building. When it is stated that the majority of these patterns are but small parts, it will be easily understood that there is a large amount of material to be handled. Books are kept in which all are recorded.

Erecting and Machining Department.—We next pass into 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 large tools employed. 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 glued in them. These ends are of cast iron, and consist of a central boss and radial arms. The ends being assembled in a special lathe having a solid bed, the two sides of which rise up, the space between being semicircular. The piece of thin paper must be laid on this space; there are two slide rests, one on each side. The solid construction of this bed gives the great stiffness 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 machine in this department is the "flexible"; it consists of an iron casting rectangular in section and forming a segment of a circle about three-eighths of the circumference; the ends are tapered, and in the middle there is a projecting piece for attachment. The flexibles are 1 in. wide, 1½ in. deep at the ends, and 1½ in. deep in the middle; they are fitted on their sliding surfaces and concentric with their cylinders. They are turned in a large lathe, two of them at once being mounted on a faceplate, and are ordinarily 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 laid on this space; there are two slide rests, one on each side. The solid construction of this bed gives the great stiffness required in all turning operations in connection with carding engines, a point that will be referred to again further on. It is not of course possible to describe every part of the machine, but we will proceed to picture the whole; the reader will then be able to form a complete idea of the design. There are four large parallel arms, each of 11 ft. 6 in. in length and 6 ft. 6 in. in width. The arms themselves are afterwards finished by gridding.

Proceeding to the turning shop for carding engines, we find a large number of machines, up to 9 in. up to 18 in. This room is 150 ft. long by 60 ft. wide, and is served by a 140 horse-power engine, which is used for turning the carding engine. The engine is provided with a separate head 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.

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

FIG. 25. EXHAUST OPENER AND LAY 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 rivetting 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 holes, 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 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, viz., the preparation of the cards for the slips, all of which 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 backing, or, perhaps, as a wire screen of hair, made of silver wire, or a thin silver leaf, placed over the carding machine, in order to do this the woven foundation is next covered over to the extreme edges with the wire pile which combs the cotton, and the back strips thus left on 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 14 in., the card is then laid on the flat, and by an automatic punching machine, holes are punched in the foundation corresponding 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 ¼ in. broad and ¼ in. thick, *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 therefore, a long flat wire with projecting parts standing up, these projections being about ¼ in. in length.

The next operation is to cut a nick at the high part 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 is fed up and cut automatically. It is necessary to remove one-half of the thickness of the standing-up parts so that they may be flattened through a single hole in the flat; 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 cans.

We will now return to the operation of attaching the card to the flat, the card being placed on 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 of the holes in the flat that 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 are in the same position, and the wires going some distance through the holes in the flat. A roller is then brought up under the card, and the card is then firmly attached to the flat. The resulting projections of the carding machine are made thinner in order that the flat wire may more completely cover the canvas foundation. This department of the works is one of very great importance.

Passing through another room on the same floor, used for light turning, etc., 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 treated and are put on a true plane for testing. These flats are used for textile machinery, great care has to be taken in the preparation of these flats. We have already noticed how accurately they travel, and it will be seen by the description which follows that care must be taken in keeping the flats perfectly straight, or perhaps it would be as well here to give the reason that this great nicety is required.*

The carding of cotton is performed on a machine which is really a steel wire brush. One set of these brushes is placed on the carding cylinder, the other set being those of the same kind on the flats. The two sets of brushes are face to face, the wires all but meeting. If too much pressure is put on the brushes the cotton laid on the flat would not be properly treated; whilst it would be obvious that if the wires were allowed to touch that cast iron could be thus bent under the pressure, the flats being shifted would not be properly straightened; therefore, the plain, straight line, and the face of the flat and the cylinder of the machine, and therefore with its circumference. The space 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 give a description of the preparation of the flats. As stated, they are first placed on a true plane, their faces of course having been previously machine straight. The operator places at first a 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 on a stirrup and brings the part of the flat over a projecting piece of iron, which thus forms a fulcrum; then, pressing on the flat, he, by establishi-

* See also our article on Messrs. Haworth’s mills.
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 somewhat novel planing machine for planing the ends of gin sides and cooler 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 Oil 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 10 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
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 design of this department have certainly been very successful in attaining the result aimed at. The room contains 25 stones and 26 glaziers. It is 30 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 smelty, and contains eight open 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-roped flywheel pulley geared for 12-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 beam frame, the use of which is described in this article on Messrs. Haworth's works. 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 115, shows another form of twiner. Fig. 35 is a bundling press 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 worsted or filling purposes. It has been much used for spinning worsted 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 twist the threads, without any drafting, and builds the cops by means of an iron cup with a steel inner spindle. The winding of the thread on the cup is done by an agency which flowing the thread from the delivery roller passing through the cup 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 cup 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. Copper-smithing for slasher, &c., is done here; whilst bolts and nuts are made by special machinery, and file-cutting is carried on. Mula spindles, roving spindles, ring spindles, and thread 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 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 1200 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 flyer, 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.
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 shaped 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...
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 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 milled 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 gravelcd 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 then 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 trap.

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 the iron flyer there would be a tube and log) 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 bank 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 graters of special shape are used for removing ariss.

The large number of processes that are gone through in making a flyer entail a heavy floating of time being maintained, so that one pair 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 saddle 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 loom 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.