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in the Chair.

No. 966.—“On the Conversion of Wood by Machinery.”¹ By
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THE subject of the conversion of wood by machinery is of such magnitude, that the Author cannot but be diffident of his power to treat it satisfactorily, within the ordinary limits of a communication to the Institution. He hopes, nevertheless, in recording his experience in this branch of engineering, to present points of practical interest, to those who are not as yet conversant with it; and to call the attention of engineers to a subject, of which but few records exist in engineering literature.

Although a great advance has been made in the conversion of wood during the present century, the application of machinery to that purpose is of very early date.

Saw-mills, actuated by water-wheels and by the vanes of wind-mills, existed on the Continent as early as the fourth century. Some were then at work in Germany, though the exact date of their introduction is uncertain. They were introduced into Norway in 1530, soon afterwards into Holstein, and in 1596 a mill was erected at Saardam, in Holland. In England they were not introduced until much later, as, owing to the probable injury which, it was feared, the sawyers' trade might experience by their use, they were prohibited by Act of Parliament. In 1663, a mill was erected in London, by a Dutchman, but he was soon compelled to abandon it. In 1767, Mr. Houghton erected, at Limehouse, a windmill for sawing, which was destroyed by the mob; but it was soon afterwards rebuilt.

Circular saws, though of a much later date, are of the same doubtful origin. They were used, on the Continent, for small work, in all kinds of materials, but were not generally employed in England, for wood, until the close of the last century.

The names of Bentham and Brunel stand most prominent in the history of the conversion of timber. The first idea of a planing machine is generally, but erroneously, ascribed to Sir Samuel Bentham; for in 1776, one was invented by Hatton. In this machine the work was fixed on a platform, while the plane had

¹ The discussion upon this Paper extended over portions of three evenings, but an abstract of the whole is given consecutively.

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a reciprocating motion given to it, by a rope passing over pulleys to a drum, actuated with a semi-rotatory movement, by a pendulous lever. The advantages of this machine were not, however, sufficient to bring it into general use. Sir Samuel Bentham's planing machine followed in 1791. In this, also, the principle of having the wood fixed and the plane reciprocating was adopted; but it was not much used.

In 1793, Sir Samuel Bentham patented several inventions; and had his ideas been carried out, and the appliances of engineering been more perfect, he would doubtless have introduced many of those inventions, which were, years afterwards, brought out and patented as new. The rotatory planing and moulding machines were both included in this patent; as was also the idea of forming augers with spiral stems, and the principle of forming large circular saws of several segments, to be fastened to cast-iron flanges, bevilled off and extending to the roots of the teeth. This principle was afterwards adopted and brought into practice by Brunel, in his veneer saws. Circular saws were, however, introduced before that time, having been used by Mr. Smart, of Lambeth, and Mr. Taylor, of Southampton, about the year 1790. Bentham also patented the plan of grooving with circular saws, and of bevilling them, so as to produce dovetail grooves in wood, set to a proper angle. In 1805, Brunel took out a patent for constructing large circular saws, of several parts, which were secured between iron cheeks, and were drawn tight by wedges; at the same time, he introduced a much more extensive system of sawing, in the Royal Dockyards, than had before been attempted. In 1807, he brought out his famous block machinery, the notoriety of which renders description in this Paper unnecessary.¹ It will be sufficient to observe, that it was not only of importance to the manufacture of that particular class of work, but was the commencement of a new practical era in the conversion of wood, and paved the way to many further inventions.

In 1808, William Newberry patented the band-saw, which has lately excited much attention in France, and is coming into general use in this country. In consequence of the difficulty of manufacturing the saws, in making the joints and preventing them from breaking, this patent was almost abandoned. It was patented in France, in 1815, by M. Touroude, but, from the objections before mentioned, it was not much used. In 1845, M. Thouard again patented the same principle, but with no better success. It was, however, at last brought to perfection by M. Périn, and excited much attention, at the French Exposition

¹ A description of this machinery is given in Tomlinson's "Cyclopædia of Useful Arts," under the article 'Block.'

in 1855. It was then again patented for Great Britain, by a Belgian of the name of Parienté, and, again, in 1856, by Mr. Exall and Mr. Barbour.

Machinery is much more extensively adopted, and greater progress has been made in the conversion of wood, in America than in England. The scarcity of skilled labour, and the abundance, cheapness, and universal application of timber to all purposes, have given great stimulus to this branch of invention; and the eagerness, with which labour-saving machines are adopted, has caused much attention to be devoted to the subject. In England the case is different; skilled artizans are plentiful, whilst the material is more expensive. In most cases, the manufacture of articles in wood is in the hands of a class, who employ a few men in a very varied trade. With this class, machinery can only, in a few instances, be successfully employed; as the interest on the capital, the fuel, depreciation, and wear and tear of machinery, as well as the time employed in adjusting the machines to the different kinds of work, soon counterbalance the advantages of rapidity of working, in a limited and varied trade, insufficient to keep machines in full work. In America, on the contrary, the principle of the subdivision of work is carried to a greater extent; and, by confining themselves to the manufacture of one article, men of small capital can manufacture it at a much lower rate, than can be done at other establishments, where this system is not practised. Mr. Whitworth, in his report upon the machinery of the United States,¹ mentions several instances of this system. In one manufactory he states, that twenty men were employed in making panelled doors, at the rate of one hundred per day; in another, eighteen men were employed in making one hundred pairs of boot-lasts per day; and in another, seven men made thirty ploughs per day. Staircases, the spokes of wheels, window-sashes, and many other things of a similar kind are carried on as separate manufactures. In England, the combinations of workmen have had a great effect in retarding the progress of machinery; and, though not so openly, the prejudices of foremen have, in many cases, prevented its introduction. Instances have occurred where foremen, in opposing the introduction of a new machine, have been strongly prejudiced against it, either as members of trades' unions, or as otherwise interested, and after predicting its failure, have caused it to be thrown aside, at the first difficulty which occurred, without giving it a fair trial, or making any allowance for its being a new machine in the hands of inexperienced workmen.

¹ Vide "Special Report of Mr. Whitworth, on the New York Industrial Exhibition." Presented to the House of Commons, by command of Her Majesty, in pursuance of their address of February 6th, 1854.

In England, machines have too frequently been designed, without a view to economy of material, as well as labour; the result has been, that expensive woods have been cut to waste, and the profits upon the labour counterbalanced by the additional cost of material. Machinery is, however, becoming gradually more extensively used, and its value is better recognised. Most of the large builders and timber merchants, now employ machinery on a large scale, and there are many instances of the subdivision of labour, though not to such an extent as might be expected. The machines of English manufacture are, in general, of too expensive a character for the adoption of men of small capital; whereas the object in America is to produce them at a small cost, as well as to render them simple in their action and appliances. Mr. L. D. Owen has lately imported many American machines, of the most improved kinds, into England, several of which are working very satisfactorily, in the Royal Arsenal, at Woolwich. In these machines there are some characteristics, which may be mentioned as peculiar to them. The bearings are chiefly composed of an alloy of 100 parts of tin, 10 parts of antimony, and 2 parts of copper. For these light, high-speeded machines, this alloy is found to last longer than brass, and when worn, it is more easily replaced. In forming the bearings, the spindle is accurately fixed in its place, and the alloy is cast round it, into an iron shell, which forms the plummer block. The parting of the base and cap is made, by inserting a thin sheet of iron in the proper position; the bearing thus formed, may, when worn away, be easily re-cast. Another peculiarity is the method of securing steadiness in high-speeded shafts; this consists in cutting in the journal a succession of angular threads, (Plate 1, Fig. 12). The alloy is cast round the journal, as before, and great steadiness of action is secured, whilst the oil remains in the bearings without difficulty. The adjusting axle-box (Figs. 13 and 14) is also much used; it is centered on two set screws, so as to allow it to turn slightly, in the event of the opposite bearing being unevenly worn, and thus to obviate the extra wear and chatter which would otherwise ensue at high speeds. Wooden pulleys are used to a great extent, being preferred by American engineers, because they are light, safe at high velocities, and are easily balanced; but it seems questionable, whether they are superior to well-constructed iron pulleys, such as are made by modern millwrights; oil and dirt are liable to accumulate upon them, though perhaps this objection is not of much force in wood-working shops. Figs. 15 and 16 show the method of constructing this kind of pulley. It is built up of several thicknesses of segments glued together, the arms being let into the periphery, and fastened with screws. Wooden frames are also much used, and are well suited for some wood-working machines;

the vibration of high-speeded cutters is absorbed by the elasticity of the wood, and the working parts are less liable to chatter, and become deteriorated, than when on iron frames. There are several other peculiarities in these machines, which generally exhibit much simplicity, in the methods adopted for fixing the work, and the arrangements for producing a repetition of any piece.

The principal agent, in the conversion of timber, is the saw, which exists in many forms; but they may be all classed under three heads,—the reciprocating, the circular, and the band saw. The former of these is so well known, that it is unnecessary to describe it. It has been brought from its rough state, and perfected in its details, as the mechanical arts have advanced. Several improvements were made by Brumel, and the machines now manufactured by Messrs. McDowall are brought to a high state of perfection. One of the latest improvements is the silent friction pall, which has superseded the old system of ratchet wheel, for giving motion to the timber. It consists of a turned wheel with a friction pall, acting upon its rim, so as to turn the wheel, when moving in one direction, and to allow it to slip, when moving in the other; a detent, upon the same principle, clutches the rim of the wheel, whilst the pall slips, and allows it to slip, when the pall moves it forward; the lever which gives motion to the pall has a slotted link, so that by adjusting the block of the pall rod, by a screw, the advance of the timber may be altered, with accuracy, to any desired speed. Messrs. McDowall's saws have a separate engine fixed to the top of the frame, and are complete in themselves. This method has its conveniences, in allowing the velocity of the saws to be altered with the greatest facility, without affecting the other machines. The saw-blades have usually a tensile strain of upwards of one ton per inch of breadth of blade.

In the United States, a new kind of saw has been introduced, for making single cuts, where, at present, the large circular saw is used; it is called the 'Muley saw,' and consists of a single reciprocating blade, without a 'gate;' the face of the saw is not quite parallel with the back, so that the blade tapers towards its base; it is thicker than the saw generally in use, and is gripped, just above the work, by guide rollers. The wood is fed up with a continuous motion, and the saw-blade makes from five hundred to six hundred strokes per minute. It is preferred to the circular saw, as taking less power and making a more rapid cut.

In taking a single cut, in large timber, with this, or the circular saw, the friction of the wood against the saw causes much loss of power; and it is the practice, to drive wedges in the cut to relieve it. If this is done to too great an extent, a split will precede the saw in some places, and the loose parts will be torn

up. To avoid this, and to render the wedge self-acting, the Author proposed the arrangement of a revolving wedge, Figs. 17 and 18. The revolving wedge is a wheel, thick at its centre, and sloping down to an edge at its circumference. It revolves on centres at the end of a lever, which is free to traverse along the feather of a rocking shaft. The rocking shaft has a weighted lever, which causes the wedge to be held with an even pressure within the cut. The whole is arranged close behind the saw, and it is evident, that the wedge will revolve with the friction of the wood as it advances, and will always exert an uniform pressure in relieving the saw, while it can, at the same time, adjust itself to irregular, as well as to straight sawing.

The circular saws used in America are generally thicker than those in England, but they waste more wood and consume more power. The American saws usually revolve at very high speeds, and the teeth are placed at greater distances apart. Mr. Eastman's saw, for cutting weather boards out of the log, had only four teeth, as the saws with the ordinary number of teeth were found to heat, when they were completely buried in the wood. This saw was 20 inches in diameter; the body was formed of an iron plate, one-eighth of an inch thick, with dove-tailed notches for four teeth, and was driven at a velocity of 1,200 revolutions per minute. In some of the American circular saws four segmental portions are cut out, so that only about one-fifth of the periphery is serrated. The speed generally adopted for saws, in America, is about 7,000 feet per minute on the periphery; whilst Mr. Topham, in his Tables of Saws, gives about 4,500 feet, as the best speed.

The largest circular saws are those used for cutting veneers; they are composed of segments fixed, by counter-sunk screws, to a cast-iron disc, which is sometimes made as large as 14 feet, or 15 feet in diameter, and has a velocity of about 3,000 feet on the periphery. The log is fed up against the saw by self-acting machinery, and the veneer is bent away and carried off by a guide, through a curved trough; by these means from ten to fifteen veneers of the largest dimensions may be cut from each inch of timber. It has been attempted to supersede this saw, by a revolving knife-edge; but though it effects a saving in the wood, it is said to damage the quality of the veneer, as it has a tendency to split it. The method of cutting veneers in Russia is very different. The log is roughed out in a lathe, and steamed for a considerable time; it is then placed in the machine, and is made to revolve at a moderate speed, whilst a long straight knife is brought by a self-acting motion to pare a fine continuous veneer, commencing at the exterior of the log and gradually reducing it towards the centre. The veneer, as it is pared off, is rolled up on

a cylinder, in one continuous sheet. This method, though it is undoubtedly productive of economy both in material and time, is not practised in England, as the steaming spoils the colour of many delicate woods, and depreciates the value for ornamental purposes; and by paring off the veneer in a spiral direction, the beautiful variations of the grain are, to a great extent, lost. The wood is found also to be more porous, than when it is cut in the usual manner, and it allows the glue to soak through it.

In France, veneers are almost invariably cut by a machine somewhat similar to the 'scale-board' machine, used for making the wide shavings for bonnet-boxes and similar articles. The log is steamed and clamped in the frame of the machine, upon which slides another frame, carrying a broad knife-edge, on the principle of the ordinary carpenter's plane. The timber is fixed at an angle of about 70° with the travel of this slide, so that the cutting edge has an oblique slicing motion across the grain. The knife-edge must exceed the log in length, be kept in good order, and be extremely sharp. The veneer is then delivered through an aperture in the sliding frame, in fine unbroken sheets.

The forms of saw teeth generally used in England, are given in Plate I. Fig. 1 shows the saw ordinarily used for ripping soft wood; Fig. 2, for wet spongy wood; Fig. 3, for resinous wood; Fig. 4, for ripping hard wood; Fig. 5, for cross-cutting hard wood; and Fig. 6, for cross-cutting soft wood. Fig. 10, shows the form of tooth used in scroll and band saws; and Fig. 11, the form used in reciprocating saws for hard wood. The tooth is nearly of the same form for soft wood, but with more 'hook' and set, and this shaped tooth is sometimes adopted in circular saws. The form of the tooth, chiefly used in America, both for circular and for reciprocating saws, is shown in Fig. 4.

In England, the practice of bending the teeth of saws with the 'set' is almost universal. In America, this method is also used; but in large saws, the teeth are frequently 'burred,' Fig. 8, with a tool struck sharply with a hammer, and they are afterwards dressed up with the file. A new method of filing the teeth of saws has been tried in the United States, with great success. One tooth is filed to a point from the right-hand side; the next is filed from the left-hand side; and the third is filed from both sides equally (Fig. 7). Every third tooth is thus filed alike. This method is found to work very smoothly, and with less power than the ordinary teeth. In hard dry wood no set is required; but in soft and sappy wood a set is still necessary, though less than with the ordinary tooth.

Several appliances are now in use for cross-cutting large balks. The old-fashioned plan was with a blade, to which motion was given by a crank, the saw moving between guides and descending

by its own weight. Brunel introduced the circular pendulous saw into the Portsmouth Dockyard, with great success. It is easily managed, and is expeditious in its work. The only objection to it is, that it has a tendency to rise on the work, when brought beyond the perpendicular line, and will jam, if it is not kept back.

In small work, the wood is placed upon a tray, which slides upon V pieces against the saw; but when light pieces, of greater length than 4 feet, are used, the pendulous saw is invaluable. In America, the pendulous saw is sometimes centred from below, and is brought forward by a treadle.

The new cross-cut saw which Mr. McDowall has lately erected at the Royal Arsenal, Woolwich, is one of the largest in the kingdom, being 6 feet 6 inches in diameter, in a single piece. It travels on rails beneath the floor of the saw-mill, and provision is made to cant it, so as to bring the teeth to any required height above the floor. In order to render available as much of its diameter as possible, as well as to steady it, at the point where it cuts, the power is not applied as usual through its spindle, but by coned friction rollers which grip it on each side close underneath the work. In this manner, nearly half the diameter is available. When the balk is in its place, the saw is canted to the desired height, and it then travels across the timber.

Perhaps the simplest and most easily managed cross-cut saw, is that used in Messrs. Ransome and May's railway key and trenail machinery. The saw-blade is strained on a triangular frame, which oscillates like a pendulum, by means of a crank, and is counterbalanced, so as to leave a sufficient excess of weight in the saw and frame, to cut through the timber. The centre of oscillation is raised, or lowered, in the guides of an upright frame, by a rope, moved by means of a handle, so that as the saw reciprocates, its own weight regulates the depth of the cut.

For cutting out curved forms, the dished circular saw, invented by Mr. Trotter in 1806, is sometimes employed; but the reciprocating scroll saw is in more general use, for all sorts of irregular-shaped work. This machine is made in various forms; but generally with a small blade, the back of which is much thinner than the cutting edge, so as to obviate the necessity of a set to the teeth. For light work, a saw having a length of stroke of 9 inches, and making about 300 strokes per minute, is most generally used. This saw is now, however, almost superseded by the band-saw, Figs. 19 and 20, which has already been alluded to. It consists merely of an endless belt of steel, serrated on one edge, and strained over pulleys. The platform, upon which the work rests, is placed between the two pulleys, and the saw passes through it. This table is adjustable on a centre, so as to cut

bevelled work. Mr. Exall has introduced several novelties,—such as the combination of two of these saws, so as to make a double cut, and the application of small pulleys to guide the saw; but it is found, that a slip of hard wood into which the saw cuts its ‘kerf,’ answers the purpose better. The ordinary covering to the pulleys is of two thicknesses of leather, whereas Mr. Exall introduced gutta-percha for that purpose. Another novelty was straining the saw with a weighted lever, which may have some advantage over the usual mode of straining it with a screw, because the tension will always remain the same under all temperatures; but this method requires some care, to prevent any irregular action from occurring, which may vitiate the accuracy of the work. The saw generally revolves at a velocity of 2,500 feet per minute, and cuts out all irregular forms, with great rapidity. The chief drawback to this machine is the frequent fracture of the saw. Now, however, that its use is becoming more general, improvements will probably be made in its manufacture, so as to lessen this liability. At Sheffield, a method has lately been invented, of manufacturing saws of this kind out of a single piece of steel, without a joint. Hitherto saws so made have been found to be inferior to those brought from France. The pulleys upon which the saws work should be of as large diameter as possible, as the saws suffer less than upon those of smaller diameter.

For sawing ship-timber, in curved forms, the saw invented by Mr. Hamilton, of U.S. America, is the most effective.¹ The saw-gate of this machine is formed of hollow wrought-iron bars, so as to combine stiffness with lightness; in this gate there are two internal gates, so attached as to be capable of a transverse sliding motion along the external gate; to each of these internal gates a saw-blade is attached by buckles, which admit of their being turned on their centres, whilst in motion, by a forked lever of wood, which the workman applies to the back of the saw, to guide it along any required line which may be marked out on the timber. The oblique lateral motion is provided for, by the traversing inner gates and by the swivelling motion of the blade. The timber is attached by chocks at either end, turning on centres, so that the wood may be swivelled on its axis, by means of gearing, and thus enable the timber to be cut to any variable bevil, as it travels against the saw. Mr. Green invented an ingenious method of insuring accuracy of variable bevil, in this sawing-machine, obviating the necessity of trusting to the eye of the workman, and producing the required bevil from scale drawings. The machine is furnished with a small roller, which is put in motion by gearing, so that the travel of its periphery is proportional to the movement

¹ Vide “Artizan,” vol. viii., pp. 177 and 226.

of the timber against the saws; a tracer is also attached, by gearing, to the swivelling chock of the log, so that if it is brought into any position with regard to the roller, it will indicate a certain amount of bevil given to the wood. A small diagram is drawn out on paper to a proper scale, and is wound round the roller, in the same manner as the steam-engine indicator diagram is usually done. The workman keeps the tracer, by means of a screw, on the lines of the diagram, as it slowly revolves, and the log will be cut to a variable bevil, corresponding proportionally to the diagram drawn out.

M. Normand, of Havre, has invented a saw for cutting out ship-timbers, somewhat on the same principle as that of Hamilton. The arrangement of the saw-gates and blades is so similar as not to require any description, but the method of supporting the log is different. The log rests upon four horizontal rollers, which are capable of movement in the same plane, so that their axes may be either parallel, or in such a position, that the imaginary lines, formed by the production of their axes, shall meet at one centre, and be portions of radii of a circle of large, or small diameter at pleasure. By altering the positions of these rollers, by means of a handle, the workman may cause the log to travel through any segment of a circle, the centre of which is indicated by the roller axes; and as this centre may be altered, while the machine is in motion, the curve described may be varied to any extent. A framework, upon which the rollers are supported, is arranged on a longitudinal axis, so as to be turned with the rollers and the log, for cutting any desired bevil; and a ratchet movement is added, to make this motion self-acting, if required.

The varieties of planing-machines may be classed under five heads:—

- 1st. The reciprocating planing-machine.
- 2nd. The machine with fixed cutters.
- 3rd. The plane with cutters revolving on a horizontal axis.
- 4th. The cutters revolving on a vertical axis.
- 5th. The socket-plane.

Before describing the planing-machines, it may be as well to say a few words on the principle of the common carpenter's plane, which is almost perfect in its action. The carpenter's plane performs four distinct operations. The tool cuts the shaving; the edge of the mouth holds it down, thus preventing it from splitting in advance of the cut; the breaker iron bends it up, and breaks it so as to lessen the liability of splitting; and the sole prevents the tool from cutting too deeply. It is generally found, that when the sole has been worn, so as to produce a wide mouth, the shavings come out unbroken, while the work is left rougher than with the narrow

mouth. In most of the planing-machines, in general use, these features of the plane are absent. In the reciprocating-machine they may be adopted, but this machine has been found too cumbersome, and too slow in its work. The plane with fixed cutters has also the properties of the ordinary plane. It was first brought into operation by Muir, in 1827, for giving a surface to flooring-boards. It is generally used in combination with the rotatory cutter, but disadvantageously, as the revolving cutters should be fed slowly, whilst with fixed cutters the feed should be very rapid. In America, the machine with fixed cutters is only used in the largest establishments, for giving a surface to boards, which are fed through it at the rate of 100 feet per minute, passing under six cutters in succession, each one being slightly lower than that which preceded it, so that each takes off a light shaving. The cutters are similar to the ordinary hand-planes, but the mouths are formed by small rollers.

The principle of the cutter revolving on a horizontal axis is not confined to simple planing-machines, but is the basis of a great number of machines used, for different purposes, in the conversion of wood. The leading features of the plane, the mouth and breaker irons, are absent from cutters of this kind, and the action is not identical with that of the common plane. The latter cuts the wood into long shavings, whilst the revolving cutter adzes off a succession of minute chips. Several attempts have been made to assimilate this cutter to the action of the plane. A close cylinder has been adopted, with cutters slightly protruding, and though the action of the sole is thus imitated, the mouth rises from the work, as the cutters come into action. Narrow cylinders are made on this principle for halving, or letting-in timber, and answer very well. The chief conditions to be observed for producing good work are—a high velocity; the travel of the work not too quick; the bearings firm, and without chatter; a solid bed to cut against; the working parts well balanced; the wood dry, and the cutters set at the proper angle with the work.

The usual mode of determining the angle of the cutters with the work, is to form a square block, and allow the cutter to project a little beyond it. This method is rather empirical, for though the proper angle may be approximated to in some cases, it does not hold good in all. The cutting angle is altered by employing a similarly-shaped cutter-block for all sorts of cutters, whether acute, or obtuse. The amount of projection from the block also alters the angle considerably, as shown in Fig. 21. It is, therefore, desirable to lay down some fixed principle, by which the proper angle may be determined. The character of the work, and the nature of the material, must be considered, and from these, the proper angles may be deduced. Tools of this character are

formed to a bevil on one side by grinding, and are afterwards sharpened on the oilstone, so as to produce another bevil, or facet, with the upper surface of the cutter. This bevil should lie at an angle of 8° or 10° with the work, or from 80° to 82° with the radius line drawn from the centre of motion to the edge of the cutter. In practice, the Author has found the best angles for sharpening to be;—for planing across the grain of soft wood, the tool should be sharpened to an angle of 30° ; for ordinary planing-machines, in which Memel, or soft woods are employed, the tool should be sharpened to an angle of 35° . Gouges and ploughing-irons should be sharpened to an angle of 40° ; and tools for hard wood to an angle of from 50° to 55° . In most cases, the tool should be ground to an angle of 8° or 10° less than the above-mentioned angles. Where machines are used for a variety of work, it is not possible, in practice, to alter the angle to suit each particular case; but in designing a machine for any special purpose, due attention should be given to the formation of the cutters and the blocks, so as to attain the most advantageous angle. In cutters of small radius, these angles must be somewhat modified, and the extent of modification must depend upon the radius, the thickness of the cutter, and the angle at which it is ground; obtuse cutters being less affected by a small radius than those which are more acute, Figs. 22, 23, and 24. In planing across the grain of soft wood, the cutter should be set at an angle of 15° with the axis, so as to cut obliquely on the fibres, and to avoid the risk of tearing them up; but most of the hard woods may be planed with equal facility in any direction of the grain.

Planing-machines, with cutters revolving on a horizontal axis, have been so frequently described, that it will be unnecessary to do so in this Paper.¹ It will suffice to say, that they are chiefly used for flooring-boards, which, by means of a series of friction rollers, are fed under the cutters, revolving at a speed of from 3,000 feet to 4,000 feet per minute. The American machines of this class have a velocity of 6,000 feet per minute, and are capable of planing from 2,000 to 3,000 superficial feet, without the cutters requiring to be sharpened on the oilstone, and ten times that amount, without being ground. This kind of planing-machine is not well adapted for squaring, or for taking work out of winding.

The planing-machine with cutters revolving upon a vertical axis, is better adapted for producing an accurate surface and for squaring up. It was first patented by Mr. Bramah, in 1802, and one of his machines is still at work in the Royal Arsenal, at Woolwich. It

¹ For drawings and descriptions of McDowall's and Worssam's machines, *vide* "Practical Mechanics' Journal," vol. ii., p. 274; vol. v., p. 6; vol. vi., pp. 33 and 230; and vol. viii., pp. 102, 223, and 247; and "Artizan," vol. x., p. 217, and vol. xi., p. 98.

consists of a large wheel, revolving on a vertical axis, armed with twenty-eight gouges and two plane-irons, so arranged as to cut in succession, one deeper than the other, as the wood advances on a platform beneath them.

Mr. Worssam manufactures a machine on a similar principle, but smaller and less cumbersome. The American machine on this principle is very well adapted for all kinds of work. Fig. 26 shows a cross section of a machine of this kind, as imported by Mr. Owen. Two gouges and two finishing chisels are attached to an iron disc, which revolves with a velocity of from 7,000 feet to 8,000 feet per minute, at its periphery, while the work travels under it, upon a traversing table, at the rate of about 30 feet per minute. The cutters and disc can be raised, or lowered at pleasure, by turning the small handle attached to the guide columns. The gouges, Fig. 27, are set about half an inch in advance of the chisels, Fig. 28, which have their edges rounded, and slightly lower than those of the gouges, so as to finish the work gradually with light cuts. The reversing gear is simple and worthy of notice; it consists of two spur wheels, Fig. 29, one twice the diameter of the other, gearing into a worm wheel, which is driven by a strap from the disc pulley. The opposite ends of the shafts, upon which these wheels are keyed, rest on a lever, so centred that when one is raised, the other is lowered; small pinions upon them are then brought into gear alternately with the platform rack, as the motion is required; the larger wheel giving the slow forward motion, and the smaller giving the quick return movement of the platform. The breaker-iron is advantageously used in this machine, though in practice the workmen simply turn the chisel for cross-grained wood; thus closely imitating the action of the ordinary carpenter's mitre-plane. In some cases it is desirable to turn the chisel, in order that it may stand at an angle of from 18° to 20° with the radius of the disc, so as to plane obliquely. The cutters are more easily kept in order in this machine, than in Muir's machine, and the Author has seen instances of smooth work being produced, though working with an accidentally-notched cutter.

The socket-plane, Fig. 30, is used for producing cylindrical work, with greater rapidity and accuracy than could be done with the lathe. It consists of a rapidly-revolving tube, from the inner surface of which a plane-iron projects slightly. The wood is sawn to a square section, and is passed through a square guide, which prevents it from turning with the friction of the plane. The cutter is turned up at the mouth of the tube, so as to take off the angles of the square as the work advances, and to allow it to enter the tube. The cutter is set at an angle of about 35° with the tangent, and is furnished with a breaker-iron; it produces very smooth and true cylindrical work, at a rate of from 15 feet to 20 feet per minute.

Moulding-machines are usually made upon the principle of Muir's planing-machine. The observations on that head will, therefore, in a great measure, refer to them. In moulding-machines, when a sharp angle is to be formed, it is desirable to have a separate cutter, on the same block, to produce it, as it is more easily adjusted and kept in order, than when a single iron is used to produce the same result. In some of the American machines, when a deep cut, such as ploughing, is taken, the cutter revolves in the same direction as the travel of the wood: this produces a much cleaner cut, though only one cutter can be used.

The American shaping-machine, Fig. 31, is very useful for giving irregular forms; it consists merely of a cutter projecting above a flat bench, and revolving on a vertical axis,—a fixed collar of the same diameter and concentric with the cutter, standing about an inch above the table, serves as a bearing for the cutter-spindle. It acts as a guide for a pattern of the same thickness as itself and of the desired form. The work is planted on the pattern, and kept steady by a few sharp points projecting from it, and both are moved together by hand towards the cutter. It is evident, that the cutters will plane away all portions which project beyond the pattern, but they are prevented from cutting more away, when the pattern comes in contact with the collar. Some of these machines have two cutters on the same table, revolving in different directions, so as to plane with the grain in all cases, without turning the work; others have the cutters bevelled, or moulded, so as to produce bevelled, or moulded work. Others have a motion given so as to plane irregular forms, with a variable twist, or bevel, by moving the cutter-spindle out of the perpendicular.

Tenons were formerly cut by reciprocating chisels; but this is a slow and uncertain method of performing that operation. An assemblage of circular saws has also been used for the same purpose; but owing to the difficulty of adjusting them rapidly to different sizes of tenons, they have been superseded by the ordinary tenoning-cutters. In some of the machines, for large work, the wood is fixed on a platform, and the tenoning-cutters move past its end, forming the tenon in their transit. For ordinary light work, the wood is placed upon a sliding tray, and is pressed by hand against the cutters, the length of the tenon being determined by self-acting stops. Figs. 32 and 33 show two views of the ordinary American tenoning-cutters; they are set at an angle of 15° with the axis, so as to plane obliquely across the grain; and small lancet-cutters, slightly in advance of the main cutter, on a circular cheek of the block, form a clean shoulder.

Several methods have been invented for turning irregular forms, such as gun-stocks, boot-lasts, spokes of wheels, &c., but

that most generally in use is on the principle shown in Fig. 34. A cast-iron pattern of the required article, as well as the wood to be turned, are chucked on two separate mandrils of a lathe, so that both revolve simultaneously. A small guide-wheel, pressing against the pattern, is so connected with a set of revolving gouges, that the wheel has the same relative position to the pattern, that the gouges have to the work. A slow traversing motion is given to both, and the work thus formed is a counterpart of the pattern. A machine was patented by Mr. Hughes, for planing the spokes of wheels, or similar articles, in the direction of their length, as being more rapid and complete in its motion than the above-mentioned machine. The principle of this machine is shown in Fig. 35; the frame is pivoted at one side, so as to rise and fall as acted upon by a pattern. The cutter-shaft is hollow, so as to allow the cutters upon the block to approach, or recede from, one another, as acted upon by another set of patterns, so as to produce the desired form.

Jordan's wood-carving machinery is somewhat similar in principle to the machine for copying irregular forms, though its details are very different. The wood and the pattern, in this machine, are fixed upon a horizontal platform furnished with four wheels, which run in a transverse direction on a frame, the frame itself also moving on wheels in a longitudinal direction; so that by the combined straight-line movement in two directions, the table may be made to pass through any required path, and have a species of floating motion in every possible direction of its own plane: as this is accomplished without angular motion, every part of the table, with the pattern and the work, must describe similar figures. The chocks, by which the pattern and the work are fixed to the platform, are made to swivel on centres, and are connected together, so that when the pattern is turned on its axis by a lever, the pieces of wood operated upon are also turned simultaneously with it. The platform is moved under a vertical slide, in which are several small drill-cutters, making about 5,000 revolutions a minute, and a tracing knob which does not revolve, but which occupies the same relative position to the pattern which the cutters do to the pieces of wood to be operated upon, so that as many as six, or eight fac-similes of the pattern may be carved simultaneously. The vertical slide is raised by a treadle, and the tracer knob bears on the pattern, by the weight of the slide, while the workman moves about the table, so that every portion of the pattern shall come successively under the tracer. The under-cut portions are carved by swivelling the pattern and the work upon their axes.

The railway-key machine, Figs. 36 and 37, was invented by the Author, to supply a want which he has found to exist upon

many railways. Frequently, the keys are produced from remnants of wood in the locomotive and carriage departments, and are generally so badly made by hand, that they shake loose and come out; or if made very accurately they become costly. The object of the machine is to enable unskilled hands to make keys of an accurate form with great rapidity. The wood must be roughed out by sawing, and the keys are produced from the machine in a continuous form, Fig. 38, and are afterwards cross cut by a circular saw. To arrive at this result, the cutters are arranged at the middle of a moveable frame, one end of which turns on a fulcrum, whilst on the other an adjustable stud is fixed. This stud works in a zig-zag slot fixed to the traversing platform, so as to raise and depress the cutters as the platform traverses, according to the taper required. The wood is fixed on the platform, so as to have its angle uppermost, and to enable two sides to be dressed at once. The moveable frame is first fixed by a set screw, so that when the first cut is taken off, two sides of the wood are moulded without any taper. When any given quantity of wood has been thus moulded, the frame is released, and the stud is adjusted in the slot, so as to cut the tapers. The remaining two sides of the keys then receive the taper, so as to be ready for cross cutting. Their ends are afterwards chamfered, by a broad circular saw on the cutter-shaft, the depth of the chamfer being determined by a trough, through which the edge of the saw protrudes.

The railway-key machine is only intended to be used, in cases where the waste wood from the locomotive and carriage-departments of railways, is worked up into keys. The Author recommends in preference the use of Ransome and May's 'compressed keys,' as being far superior to any that are made without compression, whilst they are not much more expensive. As great ingenuity has been displayed in the manufacture of these keys, a description of it may be interesting. The first process is that of cross cutting the wood, by means of the pendulum saw before described; they are then roughed out, by circular saws, into rectangular pieces with parallel sides; being afterwards rendered slightly taper, by another set of circular saws, and the angles chamfered off at the ends; they are then lubricated with soft-soap and black-lead, and are forced by plungers, moved by cams, into strong iron moulds of the proper form, tapered considerably at the mouth, so as to cause a compression of about one-fifth of their original bulk; they are then subjected to heat in a drying kiln for some hours, before being forced out again. The manufacture of the trenails is somewhat similar: after having been cross cut and roughed into rectangular sections, by circular saws, they are turned up in a lathe to a cylindrical section, and then receive a more finished

shape in a second lathe. These lathes are so arranged, that the head stock is moved along its bed by a treadle, and the trenails are centred, turned, and dropped with great rapidity, without stopping the lathe. The required diameter and form are given by a guide for the tool, so that the workman has only to draw it quickly along the guide, and the trenail is finished. The heading the trenails and chamfering the points is done by driving them by hammers into a revolving socket, turned to their form, so as to chuck them truly, and when they are finished, they are driven out by a hammer, in the same manner. The socket revolves continuously, and is not stopped either to fix, or to remove the trenails, which are compressed one-eighth of their bulk, into iron moulds, in the same manner as the keys.

In the manufacture of trenails for the Government, at Portsmouth, a method is adopted, by which the action of the socket-plane is reversed. In order to convert split wood, which is of twisted form, into trenails, with as little waste as possible, the socket-plane is mounted in gymbal rings, and is stationary while the trenail is made to revolve. The plane thus adapts itself to all the irregular twists of the wood.

The oar-machine which is now at work in Chatham Dock-yard, making oars for the Navy, is one of the most perfect and ingenious of modern wood-working machines. The wood is first roughed out by circular saws, Fig. 39, which are mounted upon swivelling cylinders, so arranged as to be capable of being turned on their centres, while a sliding bed allows them to approach, or recede from each other by the action of an adjustable 'feeler bar,' on the traversing platform. Two sets of these saws are used in the roughing-machine, from which the work emerges with the general outline of an oar, but with rectangular section. It is then taken to the finishing-machine, where the loom and blade are finished, simultaneously, by two sets of cutters.

Fig. 40 shows the action of the cutter in forming the loom. The 'feeler bar' is used in this machine, as well as in the roughing-machine, and causes the cutter-heads to traverse, as required, sliding freely on a feather of the cutter-shaft. The cutters commence their action, where the blade joins the loom, and the section is almost square. They gradually sweep from a pointed oval to a flat elliptical section; and then to the rounded ellipse, which becomes finally cylindrical. At the same time the other cutters, Fig. 42, form the blade. They are attached to brass blocks, which turn on a centre, in grooves of the cutter blocks. The tails of the brass blocks are linked to bosses, sliding freely on the cutter shaft. Motion is given to the bosses by a 'feeler iron,' acting upon guide rollers, and the cutters, turning on their centres, gradually sweep from the flat obtuse angle of the

end of the blade, to the small rectangular section where it joins the loom. The upper side of the oar is thus finished. It is then reversed, and passed under a similar series of cutters, to finish the other side. The handle is shouldered and finished in a socket-plane, similar to that which has already been described (Fig. 30). Fig. 41 shows the sections of different parts of the oar, and the position of the cutters in forming them.

Hitherto, dove-tails have not been much made by machinery. Sir Samuel Bentham patented the plan of cutting dove-tail grooves, with a circular saw bevelled upon the edge, in wood set to the proper angle. Mr. Wimshurst lately took out a patent for dove-tailing with a series of cutters, one of which, Fig. 43, cuts the dove-tail out of the wood, which is moved up to it from below, while the dove-tail socket is cut out by a series of cutters, Fig. 44. The objection to this mode is, that it is difficult to keep the sharp points of the dove-tails, and the corresponding points of the socket-cutter, perfect. The machine patented by Burley answers well for small work. The dove-tails are cut out by reciprocating chisels, Fig. 45, acting upon the work placed on an inclined bed. When half the cut is made, the work is placed on a bed, inclined in the reverse direction, for the cut to be finished. The dove-tail sockets are cut out by a series of saws on the same axis, Fig. 46. The work is placed on a sliding tray, at an angle to the edge of the saws, so that when the tray is moved up to them, an oblique cut is made. The work is then placed upon the other side of the tray, and the second oblique cut completes the socket, whose depth is regulated by stops, with which the tray comes in contact. A new species of dove-tail, lately introduced in America, seems likely to come into general use; this dove-tail is formed on the mitre of the joint, Fig. 47, and extends along the whole length of the work.

The old-fashioned augers and centre-bits have given place to the spiral augers, formed out of thin rectangular steel bars, twisted with a pitch of about one and three-quarters their diameter. There are three sorts of augers in general use, each of which has its advocates. The auger with a chisel bottom, Fig. 48; that with cutting edges, Fig. 49; and that with the ends worked off finely and turned round, so as to form a species of gouge, or hook tool, Fig. 50. Fig. 48 has its advantages in hard timber, while Fig. 49 is better in soft wood. Fig. 50 is superior to either in execution and facility of working, but is more liable to be broken than the other two. The augers of 2 inches in diameter should make about 800 revolutions per minute, while the smaller sizes, such as those $\frac{3}{4}$ of an inch in diameter, should run at 1,100 or 1,200 revolutions per minute.

Mortising-machines were first used by Brunel in his block

machinery. In England, the small mortising-machines are generally worked by hand with a lever. The American machines, on the contrary, are worked with a treadle, leaving the hands free. Some of the English machines have a self-acting motion, which moves the work along after each cut. In the American machines the wood is moved along by hand: this allows the workman to use more judgment in mortising, proceeding slowly through knots, and more rapidly through the softer parts of the wood. He can also set his work more quickly, than if fixed to a self-acting frame, though it requires a little practice to work the machine with the foot, and at the same time to move the work on with regularity. In power-mortising, there are several modes of giving action to the chisel; the best method appears to be that invented by Buck, of the United States, and lately adopted by Mr. Worssam. The tool-holder slides between guides, and is actuated by a link, similar to that used in the slide-gear of locomotives, worked by a crank, or eccentric; the link is shifted by a treadle, so that when the block of the tool-holder is at the fulcrum end of the link, no motion is given to the chisel; and the further the block is from the fulcrum, the longer is the stroke. There are many modes of reversing the chisel, so as to cut each end of the mortise properly; the most simple and ingenious is shown in Fig. 51. The motion is given by a toothed segment, gearing into teeth which wind round the tool-spindle; so as to allow it to turn, and still remain geared into the segment. The lowest guide is fitted with two feather-ways, through one of which a feather acts as a guide to the spindle, but when the tool rises beyond a certain height, the feather is freed from the guide, and a small stud, near the top of the spindle, enters a spiral groove in the upper guide, which gives the chisel more than a quarter turn. The remaining quarter turn is completed in the descent, so that when the feather returns to the lower guide, a half turn has been given to the chisel, and it enters the second feather-way.

The mortising-chisel for soft woods, Fig. 52, bears great resemblance to the ordinary carpenter's mortising tool, but is frequently rounded with an easy curve from the point, instead of being bevilled with a straight face. The chisel used for hard woods, Fig. 53, is formed with two edges. For most of the hard woods, it is necessary to bore a hole in the centre, to make room for the wood displaced by the chisel; in soft wood this is not necessary. Fig. 54 shows a chisel, of a similar character, patented by Meyer, having serrated edges and a bird's-mouth point. This, however, leaves a ridge-bottom to the mortise. Several contrivances have been adopted for the removal of chips from the mortise. In Brunel's block-machinery, a piece of steel was fastened to the chisel, to thrust the chips through. Fig. 55 shows a

mortising-chisel, patented by Varvell, in 1853. A small double-pointed tooth is centred in a recess of the chisel, so as only to project when the chisel rises, when it draws the chip out with it. The objection to this is, that chips are liable to get into the recess, and to force the tooth out, so as to impede it in its downward stroke. The simplest way of clearing out the chips, is to jag, or barb, slightly, the inner edge of the chisels; this is found to clear them well. Brunel's mortising-chisels were furnished with small lancet-cutters, which formed the mortise slightly in advance of the main cut, so as to produce smooth work. It is found, however, that the ordinary chisels, Figs. 52 and 53, perform the work with sufficient smoothness for all practical purposes. General Bentham, in 1791, used, for mortising, the tool shown in Fig. 56. This was a cruciform boring-bit, which left the ends of the mortise round, to be finished by the ordinary mortise-chisel. A modification of the above, Fig. 57, is still in use, for small mortises, in the Royal Arsenal. It is an S shaped boring-bit, with its edges chamfered; it works with considerable speed, when small mortises of great length are required.

The system of bending timber by subjecting it to pressure, after it has been exposed to the action of either fire, steam, or boiling water, has long been in use, but is supposed to have been first generally employed in Russia. Mr. Hookey, in the year 1812, introduced a new method of bending ships' timbers, by sawing them along the line of the neutral axis, in those parts where the greatest amount of curvature was required; so that when the timber was bent over blocks to the required shape, the outer part in tension, was allowed to slide over the inner part which was in compression, and the two portions were secured by bolts in that position. Mr. Meadows, in 1849, patented an ingenious method of bending veneers, round and into the angles of mouldings, however acute; the covering is formed of a single piece of veneer, instead of being built up of many pieces, as in the ordinary mode. The moulding is first glued, and is then clamped down with the veneer, to a hollow metal bed, which is heated by steam. This bed is fitted with a thin metal filling-piece, formed exactly to the reverse shape of the moulding, which presses the veneer into the indentations of the moulding. A hollow metal bar, similarly heated, is brought up by levers, and secured by a ratchet, for forming a second edge to the moulding if required. As soon as the moulding has been clamped in its place, the steam is shut off, and the bed is allowed to cool, either gradually, or by passing water through it. In 1853, a new mode of bending timber, Fig. 58, was invented by Mr. Blanchard, of the U.S. America. The timber is steamed at a low temperature, for an hour for each inch of its thickness. It is then placed in the machine, and wound

round a cam of any desired shape; pressure being applied at its end at the same time, by means of a screw which follows it up. The timber is forcibly kept against the cam, at the point of flexure, by a weighted platform, on which it slides, and a flexible band of thin metal keeps it in its place, and prevents the fibres from rising, after it has passed that point. The object of applying the end pressure is to compress the inner fibres of the curve, instead of elongating the outer fibres. This operation renders the timber dense and close-grained, and when once set, it shows little tendency to return to its original form. Timbers of the largest dimensions may be bent with great facility by this mode, but it is necessary, in the larger timbers, with sharp curves, to encase the sides during the operation, so as to prevent the fibres from spreading laterally.

Perhaps in no branch of manufacture has more talent been misapplied, than in the manufacture of casks by machinery. Numerous ingenious machines have been invented, for performing the various operations in manufacturing casks, but most of them have failed, owing to their not being designed with a view to save material. The wood of which casks are composed being expensive, the saving of manual labour cannot compensate for much waste. A brief description of some of the machines and processes may be interesting. The first process is that of cutting up the blanks, which is done by circular-saws, when the wood is regular, and 'tonguers,' or 'doublets,' are not required for strengthening the stave on the 'chine,' or making it of greater thickness, where the heads are fitted in. In such cases the circular-saws are too wasteful; and gang-saws are used, the wood being kept up against a fence, by a weighted lever, so as to have an even thickness taken off, notwithstanding the irregularity of the wood. For cutting 'tonguers' and 'doublets,' a template of the required shape travels with the blank and the fence, which slides in a dovetail groove, and is moved as required by the template. In Her Majesty's dockyard, Deptford, the end of the plank is grasped in a travelling-frame, to which a transverse, and also a swivelling, motion may be given by the workman, who follows it up, as it passes against the saw, adjusting the irregularities of twisted wood by his eye. In cutting 'tonguers' and 'doublets' at Deptford, the same apparatus is used, with a single saw-blade, and the form of the 'tonguer,' or 'doublet,' is marked out in chalk on the blank. An American method of cutting up the blank for dry casks, of a rough description, is by steaming the wood, and passing it against a rapidly-revolving disc armed with knives, by which the staves are cut to the required thickness, with great rapidity; but as the texture of the work is injured by this process, it is only used for casks of inferior character.

The next process in the manufacture of casks is that of jointing the staves, or cutting the edges to the proper bevil and curve, so that when trussed up they may form a cask. The most practicable method of effecting this, is to pass them in the direction of their length against circular-saws; the proper shape being given by a guide, so arranged that the stave moves through a curved path; the bevil being obtained by having a canted bed, upon which the stave rests, whilst being passed against the saws.

The 'backing' and 'hollowing' is the next process, for giving the proper curve to the periphery of the cask, of which each stave is a segment. There are many methods of carrying this into effect, but Robinson's and Green's are most worthy of notice. In Robinson's plan the staves are laid upon a travelling platform, similar to that of the ordinary iron planing-machine, whilst they are dressed by revolving-cutters to the proper form—the stave being kept down, before and behind the cutter, by small weighted rollers. Green's machine has a narrow roller about 2 feet diameter and $\frac{3}{4}$ of an inch thick, upon which the stave travels; being fed up by a heavy fluted roller—which rests directly over the narrow roller, and presses the stave upon it. The narrow roller revolves freely on its own axis, and is so arranged between two revolving-cutters of small diameter, that combined with them, the upper edges give the curve required to back the stave, which being pressed down by the fluted roller, is shaped by the two cutters, whilst the narrow rollers support it, and prevent the cutters from taking off more than is absolutely necessary to reduce it to its proper form. The upper surface of the stave is, at the same time, brought into a horizontal position, by being in contact with the weighted roller.

The process of 'trussing,' or bending, and putting the staves together, is also effected by machinery. Many plans have been devised, by using curved frames, ropes, or other contrivances; but Rosenberg's and Robertson's methods, are alone worthy of notice. Rosenberg's machine consists of a number of forcing-levers, arranged round the space in which the staves are built up. These forcing-levers are made to approach the centre simultaneously, by means of radial screws geared into each other; each of the forcing-levers bends a stave to its right position, and when they have all met at the centre, a hoop is slipped over their ends to keep them in their places. This process, though very expeditious, is apt to break the staves. Robertson's plan is much more perfect; the staves are loosely put together, and steamed for five, or six minutes, at a temperature of about 220° Fahr., which renders them sufficiently flexible to be placed in the trussing-machine, consisting of two iron cones, the inside periphery of each of which nearly corresponds with half the exterior of the finished

cask. The upper cone is widened out at its lower extremity, so as to surround the staves as they are forced up into it by hydraulic pressure, and to bring them gradually together, until when they are forced home, they assume the form of the interior of the cone. Strong temporary truss-hoops are let into recesses, so as to be flush with the inner surfaces of the cones, and when the pressure is taken off, and the cones opened by hinges, the cask falls out completely trussed, with five temporary truss-hoops upon it. This process occupies only from a minute and a half to two minutes and a half. The processes of 'chining' and 'crozing,' for forming the recess for the head of the cask and bevelling its ends, are effected by setting the cask upon the face-plate of a lathe with a vertical axis, and cutting the bevel and recess with overhanging fixed tools. In some instances, however, the staves are 'chined' and 'crozed' separately, before the cask is set up. The heads are put together after having been planed in the ordinary planing-machine, and are then turned up in a lathe with an oval motion, so as to allow for the unequal shrinking of the wood across the grain.

For estimating the depreciation and wear and tear of wood-working machinery, the following rates may be safely adopted, as an annual per centage on the first cost :—

	Depreciation.	Wear and Tear.	Total.
Engines	6 per cent.	3 per cent.	9 per cent.
Boilers	10 „	3 „	13 „
Machines	7½ „	3½ „	11 „
Millwork and Gearing	4 „	2½ „	6½ „
Bands and Belts	45 „

In concluding, the Author feels that he has to appeal to the indulgence of the Institution, for the unavoidable length of the Paper, induced by the necessary details of the subject, and also for the imperfect descriptions, which condensation within reasonable limits rendered indispensable. His own time and labour he will not regard as having been misapplied, if the statements and explanations are the means of directing the thoughts and ingenuity of others, to a branch of engineering which is not yet fully developed in this country.

The Paper is illustrated by an extensive series of diagrams, from which Plate 1 has been compiled.

Mr. WILSON explained the principle of a machine of his invention, in use at the Midland Counties Timber Company's works, at Banbury, for rounding timber, and principally employed in the conversion of wood into mop and broom handles, of which very large quantities were manufactured. In this machine a cylindrical gouge-cutter and a paring-tool, in the form of a disc, were employed; and by turning them gradually round in their sockets, from time to time, when required, the whole of their circumferences were made available. By this means they always presented a cutting edge, which would work for 10 or 15 hours, without requiring to be removed from the frame for the purpose of sharpening, and they had been known to last for three months. The surface produced was excellent, and at the present time, some machines of a smaller description were being manufactured, to be employed in the preparation of wood for lead pencils. It was now proposed to use these tools in the ordinary horizontal planing-machine, so as to obviate the necessity of constantly changing the tools, and so stopping the work.

Mr. JORDAN said, the machine just described was similar in its main features to one he had designed some years ago, and which was now employed in the cleaning off of school slate-frames. He remarked that, in using revolving tools for shaping wood, experience had taught him, there was no theoretical limit to advantageous speed, so long as the speed which destroyed the temper of the tool, or caused injurious heating of the bearings and shafts, was not exceeded. These were practical limits varying so greatly with the material under treatment, the state of the tool, the construction of the machine, and a number of other circumstances, that it was utterly impossible to fix a constant speed of cutting edge, which should be the best under all circumstances. In illustration of this, he referred to the vertical spindles of his carving-machines. In this case, the cutters varied from 3 inches to less than $\frac{1}{10}$ th of an inch in diameter, and it was found impossible, owing to the heating of the mandrels, although the greatest care was taken to insure lubrication, to keep these spindles going constantly at a higher rate than 7,000 revolutions per minute. The cutting edges of even the largest tools used, had not reached nearly to the desirable speed; but the practical limit was found in the rate at which the spindles could be kept in order with convenience. Therefore, it was evident, that when tools of small, or moderate diameters must be used, the object to be sought was, such a construction as would admit of the highest speed, without heating the spindles. Another of the conditions of success, very properly laid down in the Paper, was the necessity for perfect balance, in all fast-running machines. The tools were fixed in the carving spindles by a small capstan-headed screw, weighing

not more than 150 grains; and although about half that weight was buried in the spindle, it was found requisite to balance the screw-head, by a similar weight on the opposite side of the spindle; as if it was left unbalanced the vibration was increased very injuriously. The general construction of the carving-machine, and the extent of its application, in decorating the Houses of Parliament, were so well known, that further description was unnecessary.

He had since designed a very different kind of wood-cutting machine, for the Hon. Col. Pennant, which he would briefly refer to. The object of this machinery was to convert logs of American birch into the frames of school-slates. The logs were converted into planks $\frac{3}{4}$ of an inch in thickness, by the usual saw-frame, and after these planks were cross-cut and edged, by appropriate machines, they passed into the framing-room, where the first operation was to cut, mould, and plough three strips at a time from their edges. The strips left this bench complete in sectional form, for frame sides, and were then passed forward to the mortising and tenoning machines. About forty strips were placed in the clamps of these machines at one time, with one end of each resting against a previously-adjusted stop. The clamp was then moved forward on its slide, and brought the work in contact with the cutters, first with a saw, which reduced them to the required length, and then with two sets of cutters on vertical axes, which formed the tenons, or the mortises, as the case might be. One operation on forty pieces was only the work of a few seconds; the first attendant boy then refilled the clamp, while the second placed the finished sides, or ends, in the framing-bins. The framers then placed the sides and ends around the prepared slates, brought in from another part of the establishment, and they were next passed forward to the boring-bench, which was a carving-machine without its horizontal movements, its object being to drill a small hole in each corner of the frame, into which a peg was immediately inserted, by other lads at the same bench. The product of these arrangements was two thousand slates, of various sizes, framed in ten hours, by fourteen persons, a great majority of whom were under sixteen years of age. Only eight of these lads were employed in feeding the machines, the others being engaged in putting on the frames. After the frames left the machine-shop they were cleaned off by hand, and this process employed a few men, not included in the above estimate. He had found it impossible to construct a machine for finishing, which should be capable of producing a finish equal to that of the smoothing plane, at less cost than hand-work.

Mr. Jordan said, some years ago he designed a machine for cutting the seats, on the timber-sleepers, for the iron railway-chairs.

It consisted of an oblong cast-iron frame, the long sides of which formed a railway for the traverse of a horizontal table, on which the sleepers were fixed with their faces downwards, with the parts to be planed projecting beyond the sides of the table. The cutter mandrels were vertical, and ran in bearings fixed to the bottom frame. The distance between the centres of the mandrels was equal to the gauge for which the sleepers were intended, and they carried cylindrical cutters, at such a distance from their centres, as to plane the seating of the required width, so that one traverse of the table over the cutters finished several sleepers. The seatings, so planed, were sure to be accurate, and might have any required inclination given to them, without the employment of skilled labour.

MR. G. W. HEMANS remarked, that a machine had been in use in Ireland, for nearly the last fifteen years, for cutting the beds in which the rails, or railway-chairs, lie on the sleepers. This machine was designed by Sir John Macneil, M. Inst. C.E. Soon after its introduction, Mr. Hemans presented a Paper to the Institution, giving an account of the rails, sleepers, and fastenings on the Dublin and Drogheda Railway, in which this machine was minutely described.¹ It had, however, been found, that when the shape of the sleeper was irregular, too much of the wood was cut away, in producing the requisite parallelism.

MR. ALLEN RANSOME noticing the rough edges of the work as left by the tools, agreed in the belief, that there would be difficulty in getting the amount of finish necessary for high-class work. The machinery used for operating on wood, at the manufactory of Messrs. Ransome and Sims, which had been alluded to, was of the ordinary character to be found in establishments of that class, and in most of the railway-carriage factories. There was not any great amount of original machinery. The pendulum-saw, as described in the Paper, was, however, he believed, entirely original. It was the design of a practical workman in the establishment, and had succeeded perfectly. The machinery for railway-keys and trenails was arranged under the management of his late partner, Mr. Charles May, M. Inst. C.E., and had been working so satisfactorily ever since, as still to retain very much of the same character as when he left it. With reference to the formation of the keys, he wished to correct the statement, that they were cut to a taper. They were sawn parallel, and the taper was given by the compression, in order that when driven and exposed to moisture, the ends of the key protruding beyond the jaw of the chair, should expand to the fullest extent. The amount of the compression attained was from one-fifth to one-fourth of the original bulk.

¹ *Vide* Minutes of Proceedings, vol. v., 1846, pp. 233-239.

Mr. C. MAY remarked, that the pendulum-saw far exceeded in utility the circular-saw in use at the Dockyards, inasmuch as there was no limit to the diameter which the pendulum-saw was capable of cutting. It was a simple cross-cut saw, and worked to the greatest perfection in cutting oak and elm timbers. To give an idea of the rapidity of cross-cutting with this saw, he stated that the speed of cutting was about one inch in diameter for two seconds of time. This rule would apply to trees 24 inches in diameter, about the largest size ordinarily met with in this country, and he believed the same rate would obtain with one double that diameter. As an instance of the rate at which sawing might be performed, he might state, that in cutting a large number of triangular fir sleepers out of blocks 9 feet long, the average period of the passage of the saw through the whole length—the depth of the cut being 16 inches—was eighty seconds. The whole power of a condensing-engine, having a cylinder 24 inches in diameter, and a length of stroke of 5 feet, was absorbed by the saw, which was about 4 feet in diameter, and the engine indicated about 50 H.P., using steam of 12 lbs. to the square inch, with a low degree of expansion. With this engine was used a Siemens' governor, which acted so perfectly, that very little acceleration of the speed was perceptible, when the saw came out of the timber, although the full power was reduced to nothing in from five to seven seconds.

With respect to the trenails, they were compressed by his process, in the cylindrical part, about 25 per cent. of their bulk; but they went through two, or three operations. It was well known that timber shrank much more in the direction of its circumference, than in the direction of the radius of the timber. The consequence was, that if a piece of green oak was turned into a cylindrical form, $1\frac{1}{2}$ inch in diameter, and then dried, it would become fully $\frac{1}{8}$ of an inch oval; the long diameter being the radius of the timber. There was in timber, and more especially in oak, what was technically called the 'chink,' a membrane, or division, radiating from the centre, which did not shrink uniformly with the pores, or sap-vessels. By his process, in order to get the greatest quantity of wood in a trenail, it was turned roughly, just to take off part of the square, then thoroughly dried, and again turned, before the compression. He mentioned this to show the difference between the properly-prepared trenail, and those which were sold under the pretence that they were properly prepared. A large number of these latter were cut out of top-wood, and turned in a green state, and to impart to them a legitimate appearance, the makers were careful not to omit the black-leading. The effect of the black-lead and soft soap in the patent trenails was to lubricate the wood, in compressing them into the iron mould. The spurious ones were black-leaded to deceive those

who used them. The same remarks, as to the proper preparation of railway trenails, applied also to ships' trenails, which could be produced 3 feet long, reduced in bulk in the same proportion as the railway trenails.

As an instance of the holding power of these trenails, he might refer to the first Liverpool landing-stage, the whole framework of which was held together by compressed trenails, 3 feet in length, driven through three thicknesses of whole balks, upon which the planking, 5 inches in thickness, was secured, by small compressed trenails. This structure had been in use more than ten years, without showing a symptom of weakness.

Mr. G. GREEN remarked, that the stave-sawing machine described in the Paper, was the only one in use for sawing all kinds of staves for casks, but this machine cut two staves at the same time. Some time since, he directed the attention of the authorities, at Somerset House, to his machine for sawing staves, believing that it would be of service to the Government, and requesting that competent persons should be appointed to examine and report upon it. He was then referred to the Captain-Superintendent and the Master-Attendant at the Deptford Dockyard, who placed the matter in the hands of the Chief Engineer and the Master-Cooper at that yard. When Mr. Green met the Captain-Superintendent and the Master-Attendant on the subject, a large sheet was unfolded, containing a drawing of every kind of sawn stave. It was then said, by the Chief Engineer, that with their present machinery, all the different kinds of staves thereon delineated could be cut, and that, as Mr. Green did not propose to saw any other description of stave, it was not considered that the machine would be of any service to the Government; and even if the machine did cut two staves at the same time, it would take double the power to saw two staves which it did to saw one, and therefore no advantage would be gained by its use. Mr. Green explained, that he did not propose a new description of stave, because he was not aware that one was required, and while admitting that to do double the amount of work with his machine would require double the amount of power, he remarked that it would be performed with half the number of hands. Shortly afterwards he received a letter from the Admiralty, stating that the report was to the effect, that his machines would not be of advantage to the Government, and therefore they declined to order any.

Mr. Green proceeded to remark that some staves were very irregular. There was no difficulty in sawing crooked, and twisted staves, because the pressure-roller brought the stave vertical at the part being acted upon by the saw, so that parallel boards were cut off. He had lately brought out a machine for sawing the worst

description of stave, and he was now erecting another machine (similar to the first) for a cooperage, which he believed would come into general use. The wages of the man who attended to the machine were five shillings per day, and the machine required about 4 H.P. to work it. In a day of ten hours, with that power, a man could cut two hundred and forty pipe-staves, each 6 feet long (all staves 6 feet long being denominated pipe), with two cuts in each stave, making forty dozen cuts in pipe-staves. This rate of working could be continued day by day, and as many as three hundred and four pipe-staves, with two cuts in each, had been sawn in ten hours. As the pit-sawyers received one shilling and eleven pence per dozen cuts (not staves), he considered that these facts proved the invention to be a valuable one.

Since he had introduced the 'backing machine,' described in the Paper, he had made some improvements in it, which enabled him to execute another description of work, emigrants' water-casks, which required to be of the uniform thickness of 1 inch from end to end of the staves. The top-fluted roller was fixed, to prevent it from rising, or falling, whilst the bottom roller was set so as to rise, or fall. If the top roller was fixed 1 inch above the cutters, the wood, being passed through the machine, between the cutters and the top roller, would come out of the machine exactly 1 inch in thickness from end to end. The bottom roller gave to the irregularities of the stave, being pressed upwards by a weighted lever. If the stave was thicker than 1 inch, then a narrow rib, $\frac{3}{8}$ ths of an inch in width would be left up the middle; whilst if the stave was thinner than 1 inch, the bottom roller would press it up against the bottom of the top-fluted roller, and it would pass over the cutters untouched. By this machine two thousand hogshead staves, each 36 inches in length, could be 'backed' in ten hours.

Mr. WORSSAM differed from the Author of the Paper, as to the alleged superiority of the American wood-cutting machines. He had never known the wood-cutting machines manufactured in England, to be surpassed by those constructed upon the American plan. Nor did he agree with the opinion, that wooden framework was preferable to iron, for this class of machinery. He thought the latter were stiffer and steadier in their work, besides being much more durable, and less likely to require repairs. Iron might be more costly in the first outlay, but for the above reasons he preferred it to wood. He had seen American machines in operation, and he found that, although they might be adapted for the description of work required in that country, they were not so suitable for English work, in which latter high finish and economy of material were of the greatest importance. In America, the saws were much thicker than those used in the English saw-mills, so that they consumed more power, wasted more material, and

did not cut so clean, or so true, though there was less care required in working them. There had been great improvements in circular sawing, in England, during the last twelve years, and he believed that this country could not now be excelled in that department. The old method of steadying the circular-saw was by running it between stops attached to the bench, but the friction created on the saw, where it came in contact with the stops, caused it to heat, and to expand unevenly. To obviate this, the modern saw-benches were provided with strips of hard wood, fixed underneath the table in front of the saw-spindle, between which the saw ran loosely; on the top of these strips oiled hemp was packed against the saw, and thus an even pressure being given to the whole surface of the saw, an uniform expansion resulted. By this improvement in packing, circular-saws as thin as No. 14 or No. 15 gauge could be used, which, when properly worked, would cut deals 9 inches in thickness, at the rate of 40 feet to 50 feet per minute. With thin circular-saws the speed of the cutting-edge should never exceed 7,500 feet per minute; but with thick saws, any speed might be employed.

In reference to planing-machines, he had never seen any from the United States which could compare with those made in this country. He had manufactured them, both with revolving cutters and with fixed irons. The former class was superior for some descriptions of work, such as grooving, edging, tonguing, and thicknessing boards, where a glazed face was not required; but it would not produce the high finish exhibited in the specimens of boards he produced, and which had been planed in a machine with fixed irons. The specimens of mouldings produced were cut at a speed of about 3,500 revolutions per minute; it was useless to run at a higher speed, as the work could not be smoother.

Mr. HOLMES said, as a practical sawyer of eighteen years' experience, he had tried many experiments to determine the best form for the teeth of saws, as well as the best methods of sharpening them, so as to perform the greatest amount of work, with the least expenditure of power. He had found, that the old-fashioned gullet-tooth, with the throats filed to a bevel alternately on either side, surpassed all other forms, and that it was applicable to all sizes of circular-saws, from 1 foot to 5 feet in diameter. The form referred to in the Paper (Plate 1, Fig. 2) was a modification of the gullet-tooth, and was probably as nearly like it as could be readily sharpened with the kind of file in general use; but it could not cut, or clean itself, like the gullet-tooth.

Mr. GREEN thought the peg-tooth was superior to the gullet-tooth for circular-saws, as when the latter came in contact with any nails in the wood, nearly the whole of the hook was broken off, and the shape of the tooth was entirely changed, so that it would not cut

at all; whereas if a similar accident happened to a peg-tooth, the remaining portion of the tooth was left at the original angle, and continued to work almost as well as before. The gullet-tooth required to be differently sharpened for hard and for soft woods. In frame-saws, when cutting hard wood, if the gullet-tooth had too much hook, the saw would hang in the wood, and break down the frame. In reciprocating saws, the face of the tooth required to be more upright for hard than for soft woods, such saws not being sufficiently rigid to prevent the teeth drawing into the wood. Circular-saws could hardly have too much hook, and the greater the angle of the teeth, the less power would it take to cut the timber. He preferred the 'parrot's-bill' tooth for circular-saws, and when cutting soft timber, the number of teeth should be reduced.

Mr. DINES said, at the large establishment of the late Mr. Thomas Cubitt, all the work was done, as far as possible, by the common circular-saw bench, the planing-machine not being employed at all. In the old saw-benches, the spindles and the tops of the benches were fixed, and the height of the saw was regulated by a wedge-shaped piece attached to the fence; but now, by means of rising and falling spindles, the saw and also the moulding-tool could be brought to any required height above the bench. He exhibited specimens of mouldings which had been so executed, the tool working upon the same spindle as the circular-saw, at a speed of about 2,500 revolutions per minute. Tenoning and rabbeting were also performed in the same way. It was quite possible, by means of conical drums, to work at a speed of 6,000 revolutions per minute, and he agreed in the opinion, that the greater the speed of the cutting-tool the better would be the quality of the work. But there were many difficulties in the way of excessive speed, and the workmen generally preferred from 2,500 to 3,500 revolutions per minute, the latter being, probably, the practical limit. The bearings could not be kept cool, or the balance be so perfectly maintained, as to prevent injurious vibration, or the frames be made, or fixed firmly enough, to carry higher velocities. At Mr. Cubitt's factory the frames were placed upon solid brick piers carried up from the basement, and unconnected with the floor on which the men worked. Many attempts had been made to supersede the carpenter's smoothing-plane, but hitherto without success.

Mr. L. D. OWEN urged, on behalf of American tools, that they were found to be sufficiently strong and steady for the work they had to perform, and that was all that could be required of any machinery. In the United States, wooden framing was much cheaper than iron, and it could be easily renewed when it became unsteady. It also possessed other advantages: there was a degree

of elasticity about it, which absorbed a certain amount of vibration, at high speeds, and the bearings lasted longer than with iron frames.

The forms of the teeth of saws must be dependent on the work to be done, hard woods requiring a different kind of tooth from soft woods. English circular-saws had generally too many teeth, the number of which should be regulated by the diameter. In America the teeth were frequently filed in triplets, the first with a bevel to the left, the second straight, and the third with a bevel to the right, so that each tooth did a separate amount of work; thus they cleared themselves more readily, cut much cleaner, and less power was consumed. The tooth, Plate 1, Fig. 2, was extensively used in America. It was dressed with a flat file, and the proper set was given by a blow with a hammer and a piece of steel set against the point of the tooth.

He thought there would be great difficulty in getting the planing-machine to do the work of the smoothing-plane. As far as his experience went, he had found, that in working cross-grained, hard, knotty woods, the rotary cutters lasted longer, would do the work equally well, and required less power, for a given quantity of work, than stationary planes. Practically speaking, a stationary cutter did not give a smooth surface, for any length of time, but only when the tools were first sharpened. The stationary cutter had been much used in America, but was rapidly being discarded. It had a 'set' similar to the common plane, and the board was passed through the machine, either underneath, or above the cutter. This class of machine would be very useful where a large amount of work was required, without any great degree of nicety.

Mr. VIGERS had for the last twenty years given his attention to planing-machines. Before the expiration of Mr. Muir's second patent, Mr. Worssam had constructed for him two machines, both of which had remained in constant work ever since. Until the expiration of these patents, one of which was for fixed cutters, and the other for adzes having a rotary axis moving above the surface of the board horizontally, he had used a machine on the American plan for thickening boards. This he had afterwards abandoned, as he found that though rotatory cutters produced a smooth surface when in good order, yet after a few cuts, especially if the top surface was at all gritty, an irregular board, varying in thickness as much as one-sixteenth of an inch, between the edge where the cutters entered and that at which they came out, was the result; and unless the wood was hard, the edge was broken. That was one reason why, in his opinion, so little wood-working machinery, of that description, had been introduced into this country. The wood framing of the American machines might be sufficiently strong,

when first made, but after a time, in consequence of the vibration, the plummer-block bolts became so loose, and the whole of the framework got so unsteady, that a new wood frame was required for the iron bearings. With iron frames, the jar might be counteracted by introducing a sheet of lead, or pewter, or a piece of hard wood, between the plummer-block and the bed. The principal plummer-block of one of his fast-going deal frames was originally seated upon a block of Portland stone, weighing 7 tons, when the holding-down bolts were continually breaking. He then put a piece of hard English oak, $\frac{3}{8}$ ths of an inch in thickness, between the plummer-block and the stone, and since that time the bolts had never been broken. The common carpenter's plane, as had been observed, was as nearly as possible a perfect instrument. But in the machine there was this difficulty; when a knot was met with, it was not possible to turn the work round as the carpenter could do. However, this occurred to so small an extent, that with a machine capable of producing from 30,000 feet to 40,000 feet of flooring-boards per week, one man was sufficient to follow the work, and to remedy the defects so occasioned. There was a great difference of opinion as to the best speed for circular-saws. As a general rule his saws were 36 inches in diameter, with a space of 2 inches between the teeth. Thus there would be fifty-four teeth in the whole circumference. When the saw was smaller, the teeth would become less, and the saw would require to be driven at a higher speed. He had two circular-saw benches, in one of which a saw 36 inches in diameter was used, making 700 revolutions per minute; and another in which saws 24 inches or 30 inches in diameter were employed, making 900 revolutions per minute, giving 6,300 feet as the mean speed of the teeth of the saws in the latter case. The description of tooth he preferred was a modification of that shown in Plate 1, Fig. 2. About thirty years ago Mr. Smart used saws 4 feet in diameter, and $\frac{1}{8}$ th to $\frac{1}{4}$ th of an inch in thickness, but a large quantity of wood was cut to waste. After that, the late Sir Isambard Brunel, in conjunction with Mr. Smart, invented the large veneer-saw, put together in segments; and fifteen years ago, Holland, who was employed by Budde, of Emscott, near Leamington, introduced the system of hemp and cotton packing on each side of the saw. By that means, circular-saws of No. 13, No. 14, and No. 15 gauge, and 36 inches in diameter, could be employed.

With regard to Blanchard's timber-bending machine, he produced a specimen which had been reduced 3 inches in length on the inner circumference in a length of 3 feet, due to the end pressure applied by the machine, during the operation of bending.

Mr. MOLESWORTH remarked, that the production of high finish
[1857-58. n.s.]

by machinery was not impracticable, though it might be attended with difficulty. Hitherto perfection of machinery had not been attained, because quality had been sacrificed to quantity. The importance of high speed and perfect balance had been confirmed by all who had taken part in the discussion; and steadiness of bearing, solidity of bed, and above all, that the angle of the cutters should be properly adapted to the work to be performed, were equally indispensable. The correct proportion between the travel of the work and the speed of the cutters was a point too generally overlooked. In American machines, under ordinary circumstances, the work travelled about $\frac{1}{20}$ th of an inch for each stroke of the cutters. Even this was too high a speed to produce perfect work, for which purpose there ought to be less travel, in proportion to the speed of the cutter. The system of reducing the work, by sawing, as nearly as possible to its finished dimensions, leaving only a small amount to be taken off by the plane, involved less risk of tearing up the fibres, and tended to produce smooth work, with economy of material. There was also an advantage in making the cutters cut with the travel; and although not always practicable, as the motion of the cutters forced the travel and choked the machine, yet it might be adopted with success in many cases. Another expedient which might be resorted to, occasionally, was to have a series of roughing cutters to do the heavy work, but not trenching too closely upon the finished dimensions; followed by a set of finishing cutters, which, as they would have little to do, might be kept much sharper.

He thought the effective speed of the cutting edge of Mr. Jordan's drill-cutters was slow, when compared with some machinery. Assuming the drill-cutters to be $\frac{1}{2}$ an inch in diameter, which was above the average, the speed, at 7,000 revolutions per minute, would only amount to 900 feet per minute. Now some of the American machines ran as high as 12,000 feet per minute on the cutting edge, which enabled the wood to be passed through, even against the draft of the plank, with much greater rapidity than could otherwise be the case. In machinery of this kind, the ear was a good guide, as to the perfection of working. When working well, it should produce a hissing sound, rather than a chattering noise, which was too common. The progress made in America was more in the extended application of machinery to all kinds of work, than in the actual perfection of the workmanship of machines. Some of the best wood-machine manufacturers, in England, had paid great attention to the subject, and had made highly-finished and efficient machines; but as a class, the English wood-working machines were inferior in design and capabilities to those of America.

He had lately visited a wood-working establishment, in order

to report on the efficiency of the machinery, and he found scarcely a machine in the place in which there was not some practical blunder. In one machine for cutting oak, the speed of the cutters was not more than 700 feet per minute, whilst upwards of $\frac{1}{8}$ th of an inch was taken off at each cut. He thought that wooden frames had their advantages, and that much of the prejudice which existed against them, in England, was owing to their not having been properly constructed. They should be built of hard wood, and the joints be made so as not simply to depend on mortise and tenon, but be shouldered in. If properly constructed, they would be found to last a long time, without shaking loose, and they absorbed the vibration of the cutters, at high speeds, to a much greater extent than solid iron frames. His views on the subject of American machinery of this character had been so well expressed, in the Report by Mr. Whitworth, on the New York Exhibition,¹ that he would conclude by quoting the following passage:—"Although it cannot be said, that in England nothing has been done in this branch of manufacture, it must be confessed, that the improvements which have been made have not been extended, as they might have been, to ordinary purposes."

November 24, 1857.

ROBERT STEPHENSON, M.P., President,
in the Chair.

The discussion upon the Paper No. 966, "On the Conversion of Wood by Machinery," by Mr. G. L. MOLESWORTH, having been renewed, was continued to such a length as to preclude the reading of any other communication.

GIBSON'S SELF-ACTING RAILWAY SIGNAL.

After the meeting a model was exhibited of Gibson's self-acting Signal and Telegraph for Railways. This apparatus was described, as being intended to supply the want of a system of railway signalling, which should be efficient, and whilst answering every purpose, for which Railway Signals could be required, should be simple in construction, and not liable to be misunderstood, or to get out of repair; being, at the same time, independent of the attention, or the neglect of servants.

The apparatus consisted of a continuous arrangement of signal-

¹ Vide "Special Report of Mr. Whitworth on the New York Industrial Exhibition." Presented to the House of Commons by command of Her Majesty, in pursuance of their Address of February 6th, 1854.

ling, set in motion by the engine, which, in passing over a lever placed close withinside the rail in any desired situation, caused a signal-post (No. 1) to rotate partially, and so to indicate to the following train the close proximity of a preceding train. The signal-post (No. 1) remained in this position, until the engine arrived at the next signal-post (No. 2), the lever opposite to which, when depressed by the engine, caused it to rotate similarly to the signal-post (No. 1) previously passed, which was at the same time replaced in its original position. The engine then reached signal-post (No. 3), and it and No. 2 would be simultaneously acted upon as were Nos. 1 and 2. Then No. 4 received the responsibility, and released No. 3, and so on. It answered equally well by night and day, and the present signal-posts could be adapted to it.

By the same motion of the horizontal levers, audible, or visible telegraphic communications could be made with any station, or stations, either in advance, or in the rear of the moving train; thus indicating, by the continual ringing of a bell, if necessary, the approach, departure, present position, or passage through a tunnel, or over any dangerous part of the line. On foggy, or stormy nights, or where there were sharp curves, &c., this would be found valuable.

Another important part of the system was the contrivance for the self-acting contraction and expansion of stretched wire, by means of which hand-signals, &c., could be acted upon at a distance of 2,000 yards, being far beyond the present working distance, and the wire, both in summer and winter, would always be at the same degree of tension.

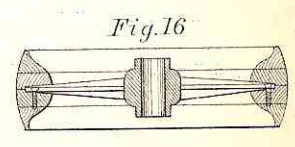
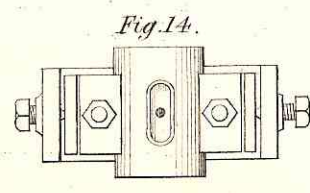
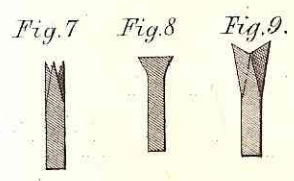
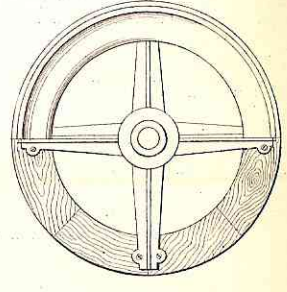
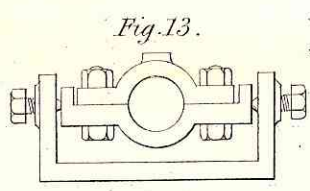
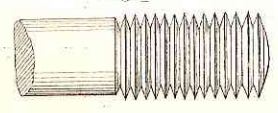
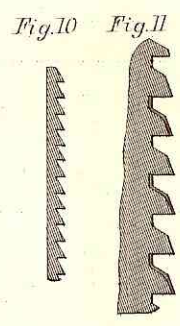
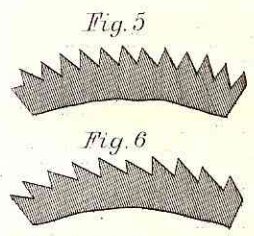
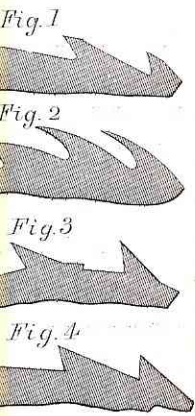
The whole apparatus was described as having been in efficient action for some time, at Binn's Junction, on the North Eastern Railway, where thirty trains passed daily.

December 1, 1857.

ROBERT STEPHENSON, M.P., President,
in the Chair.

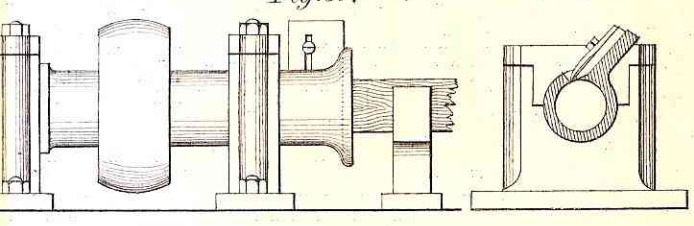
THE following Candidates were balloted for, and duly elected:—
JOSEPH HAMILTON BEATTIE, as a Member; ALEXANDER HILL
MACNAIR, JAMES SHAND, EDWARD WALKER SHAW, JAMES JENKIN
TRATHAN, and THOMAS BURDETT TURTON, as Associates.

The discussion upon the Paper No. 966, "On the Conversion of Wood by Machinery," by Mr. G. L. MOLESWORTH, having been renewed, was continued to such a length as to preclude the reading of any other communication.



SOCKET PLANE.

Fig. 30.



TENON CUTTERS.

Fig. 32

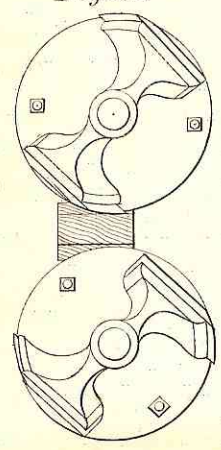
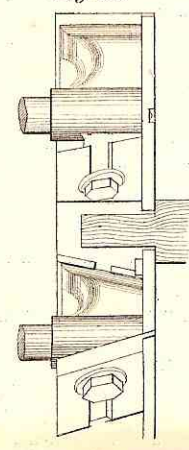
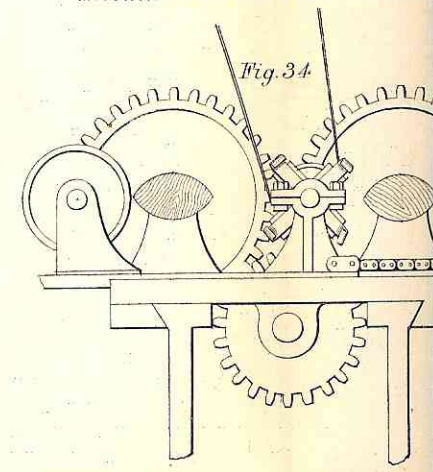


Fig. 33



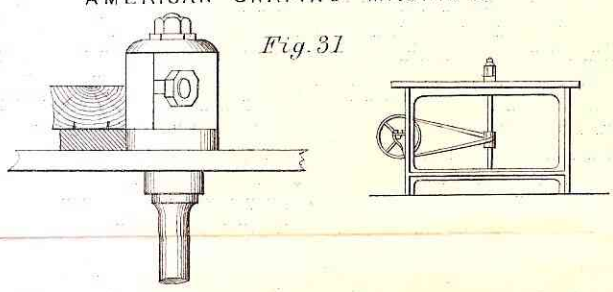
MACHINE FOR COPYING IRREGULAR

Fig. 34



AMERICAN SHAPING MACHINE.

Fig. 31



OWAR SHAPING MACHINE.

Fig. 40

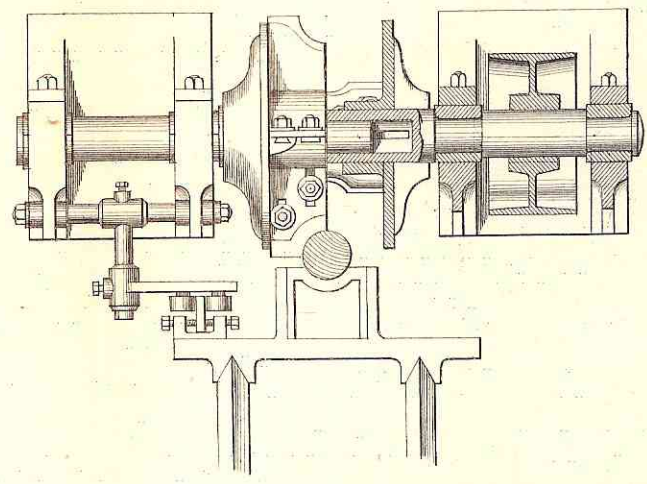
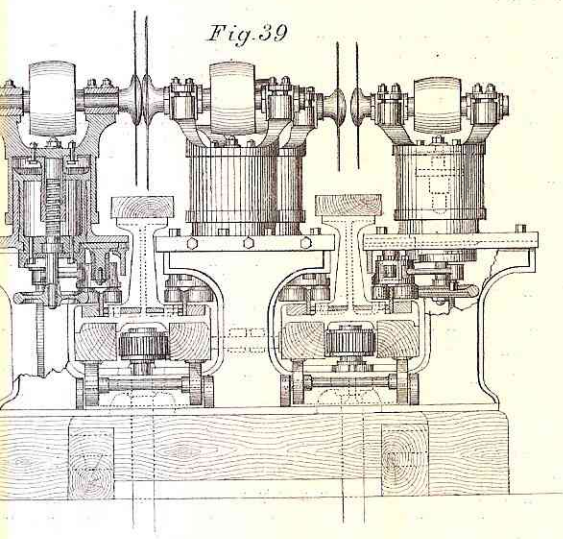
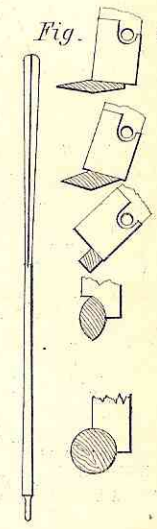


Fig. 41



CONVERSION OF WOOD BY MACHINERY.

DETAILS OF MACHINES.

Fig. 12.

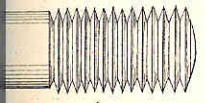


Fig. 13.

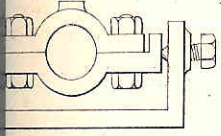


Fig. 14.

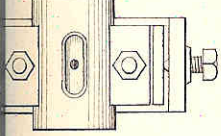


Fig. 15.

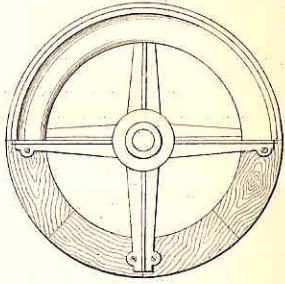
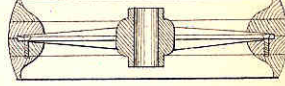


Fig. 16.



REVOLVING WEDGE.

Fig. 17.

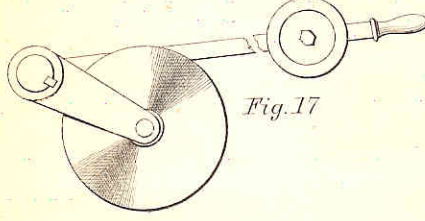
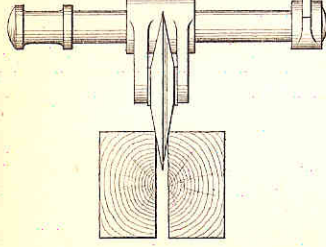


Fig. 18.



THE BAND SAW.

Fig. 19.

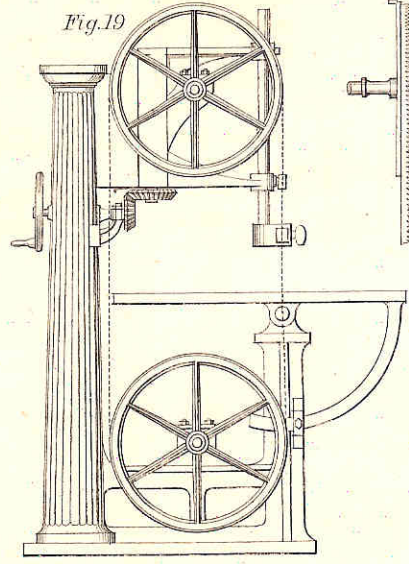


Fig. 20.

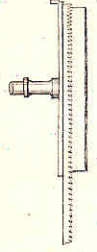
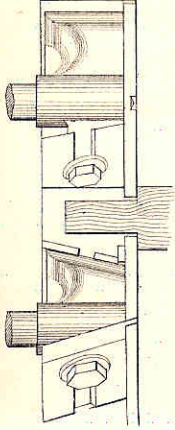


Fig. 21.



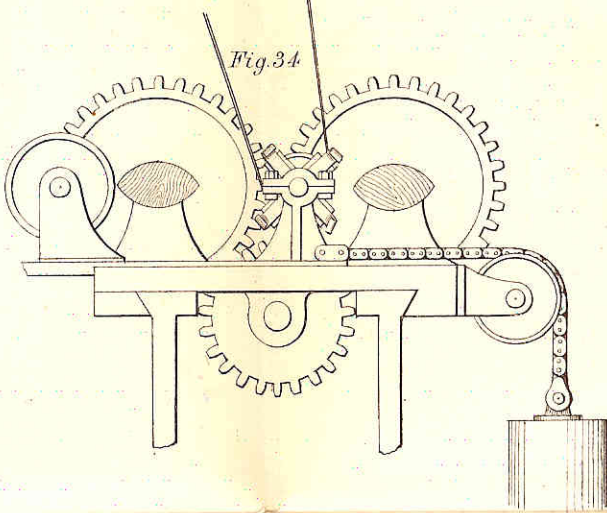
ON CUTTERS.

Fig. 33.



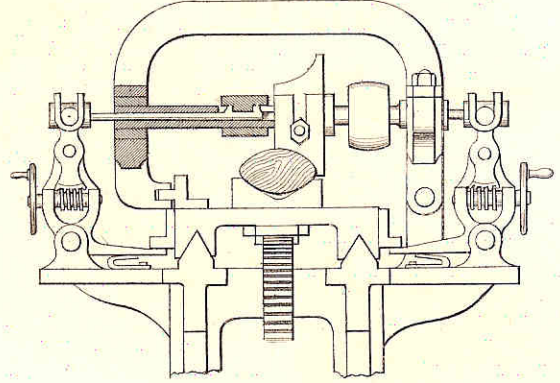
MACHINE FOR COPYING IRREGULAR FORMS.

Fig. 34.



HUGHES'S SPOKE MACHINE.

Fig. 35.



IG MACHINE.

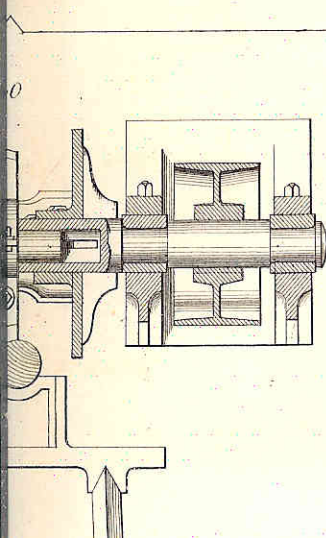


Fig. 41.

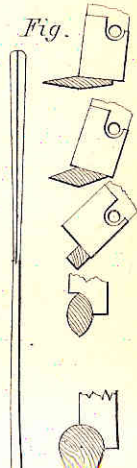
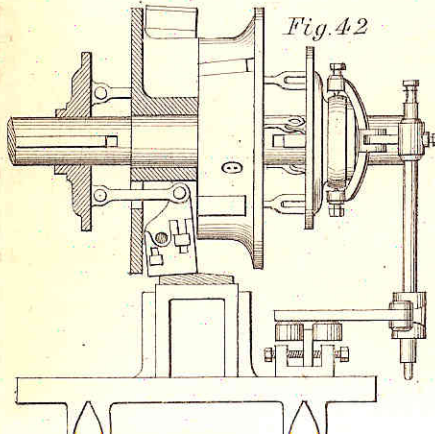


Fig. 42.



WIMSHURST'S DOVETAIL MACHINE.

Fig. 43.

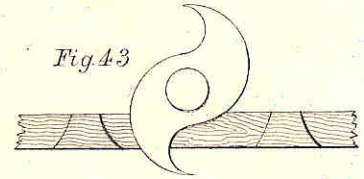


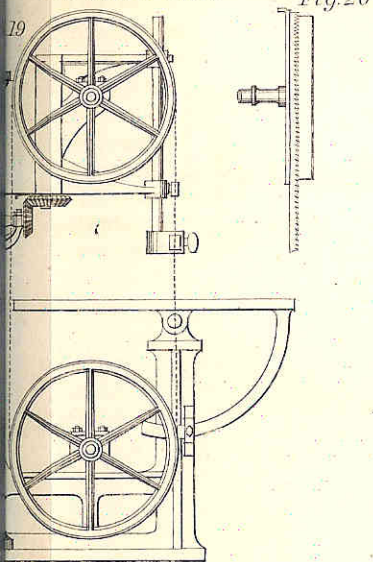
Fig. 43 a.



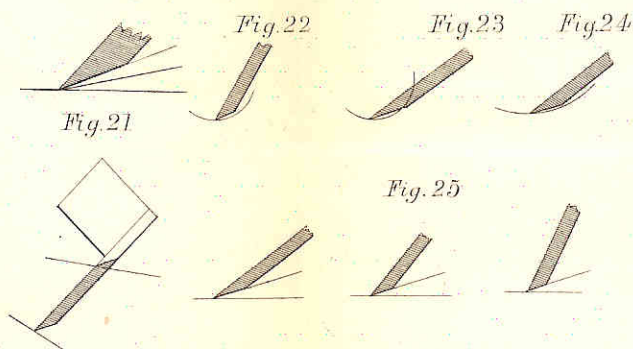
Fig. 44.



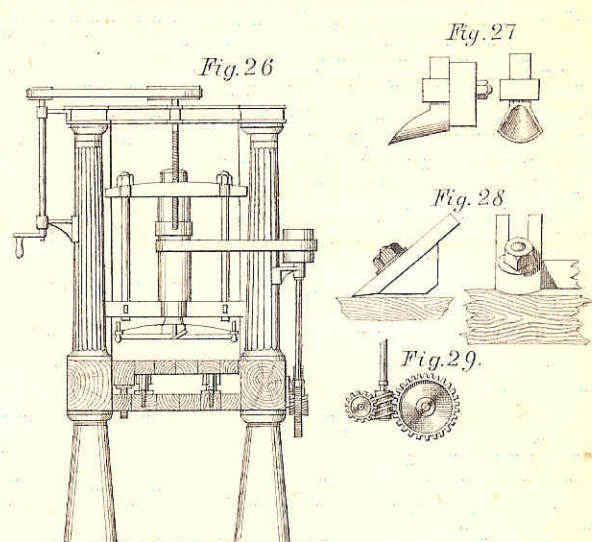
THE BAND SAW.



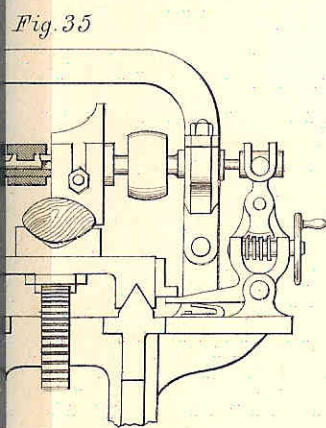
ANGLES OF CUTTERS.



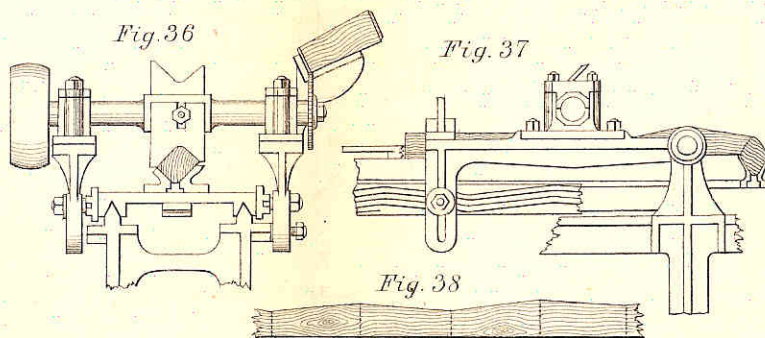
AMERICAN PLANING MACHINE.



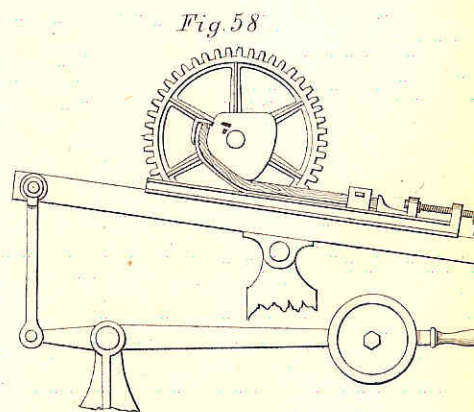
SPOKE MACHINE.



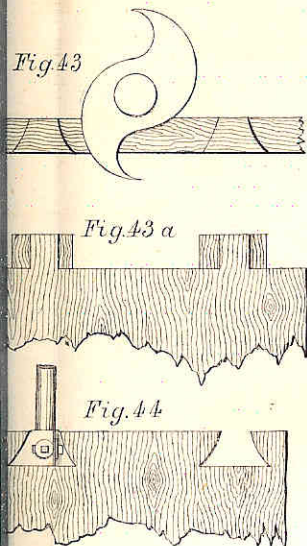
RAILWAY KEY MACHINE.



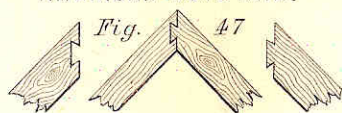
BLANCHARD'S TIMBER BENDING MACHINE.



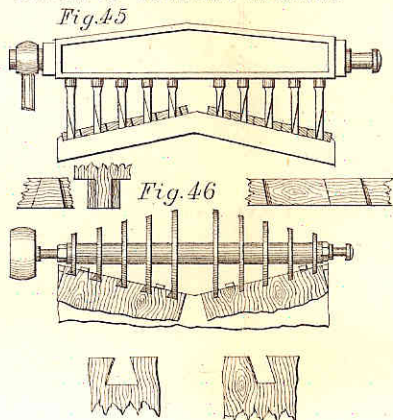
WIMSHURST'S DOVETAIL MACHINE.



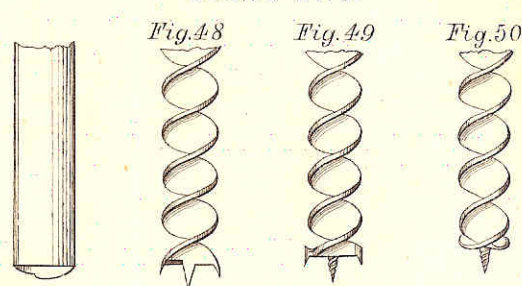
AMERICAN DOVETAIL.



BURLEY'S DOVETAIL MACHINE



BORING BITS.



MORTISING TOOLS

