IMPROVED FIFTEEN TON CRANE.

THE machine illustrated on first page has been constructed for Port Alfred Harbor, this being one of several harbors now being made by Sir J. Coode in South Africa. The pier for the construction of which the crane will be employed will consist of concrete blocks laid on what is known as the "overend system." The blocks, being brought on trucks direct from the block yard to within the sweep of the machine, are raised by it, swung round, and accurately set, the machine being continually traveled forward as the work advances. The bottom blocks are laid on bags of concrete previously deposited by the crane out of boxes with flap bottoms.

The present machine has been specially designed throughout, and represents the most complete development which block-setting plant has yet attained.

The most striking features of the crane are, the great range of all the motions, the large radius, and the method of providing for the latter by a horizontal jib suspended from a king-post. It was at first intended to have a straight inclined jib, and to alter the radius by pivoting this round its lower end, as is commonly done; it occurred, however, to Mr. Matthews, M.I.C.E., representing Sir J. Coode, that the plan eventually adopted would be in many ways preferable; the crane was therefore constructed by Messrs. Stothert & Pitt with this modification, and as far as can be judged from the trial with proof load, the arrangements can hardly be surpassed for quick and accurate block-setting. In cranes with "derricking" jibs it is necessary to connect the derrick and hoisting gears in such a manner that a variation of the radius may not affect the level of the load; this plan answers sufficiently well for ordinary purposes, but for block-setting it is requisite to have extreme accuracy in all the movements and great quickness in changing from one to another; the arrangements adopted in foundry cranes, in which all the motions are entirely independent of one another, seems therefore more suited for this kind of work. Other not inconsiderable advantages are also secured by the adoption of the foundry crane type, the amount of clear headway under the jib being much increased, and the difficulty avoided of making a jib sixty feet long sufficiently stiff without undue weight.

The principal dimensions of the crane are, total height of lift 46 feet, radius variable from 25 feet minimum to 45 feet maximum, height from rail to underside of jib 22 feet 2 3/4 inches, radius of tail to center of boiler 22 feet, working load 15 tons, proof load 19 tons.

The general arrangement consists of a truck on which is fixed a post, round which the crane revolves; the jib is supported midway by an inclined strut, above which is placed the king-post; the strut is curved round at the bottom and forms one piece with the side frames, which are carried right back as a tail to support the boiler and balance weight.

The hoisting gear consists of a double system of chains 1 1/2 in. in diameter placed side by side; each chain is anchored by an adjustable screw to the end of the jib, and, passing round the traveling carriage and down to the falling block, is taken along the jib over a sliding pulley which leads it on to the grooved barrel, 3 ft. 9 in. in diameter. In front of the barrel is placed an automatic winder which insures a proper coiling of the chain in the grooves. The motive power is derived from two cylinders 10 in. in diameter and 16 in. stroke, one being bolted to each side frame; these cylinders, which are provided with link motion and reversing gear, drive a steel crank shaft 2 1/2 in. in diameter; on this shaft is a steel sliding pinion which drives the barrel by a double purchase.

In the center of the crank-shaft is a large reversing friction clutch which drives, through miter gear, a vertical shaft placed just in front of the post; from the latter the slewing, racking, and traveling motions are obtained.

The crane can be turned through a complete circle by a pinion gearing into a machine-moulded toothed ring bolted to the top of the truck; this ring is 11 ft. 4 1/2 in. in diameter, and contains 172 teeth 2 1/2 in. pitch. The slewing pinion is driven by intermediate gearing from the bottom of the vertical shaft mentioned above. For the turning motion two distinct sets of rollers are provided; these are carried by cross-girders placed between the side frames; one set runs against a cast-iron roller path bolted round the bottom of the post, and the other on the large horizontal roller path seen in the engraving. The latter is 14 ft. in diameter; it is built up of two deep curved channel irons with top and bottom plates forming a circular box girder, on the top of which a heavy flat rail is riveted, and the whole turned up in the lathe. The racking and traveling motions are driven from the top end of the vertical shaft; the racking gear consists of wire ropes attached to each side of the traveling carriage and coiled round a large barrel, the outer rope being brought over a pulley at the end of the jib. The rails for the carriage rest on rolled joints bolted to the underside of jib. This arrangement involves the use of an overhung traveling carriage, but enables the jib to be of a stiff box section, the side stiffness being further secured by wind ties.

The traveling motion is worked by a second vertical shaft, which passes down the center of the post, and by means of a cross shaft is geared to the front axle, from which four of the ground wheels are driven.

The post is octagonal, built up of plates 3/4 in. thick; at the bottom end it is secured to the girders of the truck, and at the top is shrunk on to a large gudgeon 12 in. in diameter, which enters a casting fixed in the back end of the jib; on the top of the gudgeon are two steel disks on which an adjustable cap rests; by means of this and the ties to the tail and the lower end of the strut a proportion of the weight can be brought on to the post so as to relieve the roller path to any desired extent, and enable the crane to be revolved easily.

The truck is 24 ft. long and 16 ft. 4 1/2 in. wide; it is constructed of longitudinal and transverse box girders 2 ft. 8 in. deep, and rests on two axles 6 in. in diameter; round these axles swivel the cast-iron bogie frames which carry the ground wheels. This arrangement was adopted because the crane has to travel up a gradient of 1 in 30, and the bogies enable it to take the incline better; they also distribute the weight more evenly on the wheels. The gauge of the rails is 15 ft., the wheels are 2 ft. 6 in. in diameter, and have heavy steel tires. The weight on each of the front wheels when running with the ballast, but no load, is about 16 tons. A powerful brake is applied to the wheels when descending the incline.

All the clutch levers, break treadle, and handles are brought together, so that one man has the crane under his entire control. An iron house, of which the framing only is shown, extends from the gearing right back to the boiler, forming a most spacious engine room and stokehole. A separate donkey engine is provided for feeding the boiler.

The truck is furnished with legs under which packings can be wedged so as to relieve the load on the wheels when block-setting. The slings seen under the boiler are for hanging a concrete balance weight; this will weigh about 20 tons. The weight of the crane itself without load or ballast is about 80 tons. The crane was tested under steam with a load of 19 tons with the most satisfactory results; the whole machine appeared to be very rigid, an end often very difficult to obtain with portable wrought-iron structures and live loads. The result in the present case is probably greatly due to the careful workmanship, and to the fact that the sides and ends of the plates are planed throughout, so that the webs of the girders get a fair bearing on the top and bottom plates.

The crane showed itself to be very handy and quick in working, the speeds with 19 tons load, as actually timed at the trial, are: lifting 16 ft. per minute, racking motion 46 ft. per minute, slewing through a complete circle 90 ft. diameter, four minutes, equivalent to a speed at load of 60 ft. per minute. The crane was constructed by Messrs. Stothert & Pitt, of Bath, to the order of the Crown agents for the colonies, and we understand that the design and construction have given complete satisfaction to Sir J. Coode, the engineer to the harbor works, under whose supervision the crane was constructed.—*Engineering*.

IMPROVED STEAM-BOILER.

AN improvement in steam-boilers, best understood by reference to the ordinary vertical form, has been introduced by Mr. T. Moy, London. Here the flue is central, and, as shown in the accompanying illustration, is crossed by a number of horizontal water-tubes at different heights. The ends of these tubes are embraced, within the steam chamber, by annular troughs. At the top domed part of the boiler are two annular chambers, the outer one being intended to receive the water upon entry from the feed-pump, and to contain any sedimentary deposit which may be formed. The water next passes, by the pipe, *a*, in the figure, into the inner chamber, surrounding the end of the up-take flue, whence it flows through the pipe, *b*, down into the first of the annular troughs above mentioned, and afterward overflows these troughs in succession until it reaches the bottom. Mr. Moy claims to have secured by this means a boiler of quick steaming capacity, together with a reduction in the weight of metal, and considerable economy of fuel. By the arrangement of the water in a number of shallow layers a large steaming surface is obtained, and there is a good steam space rendered available round the troughs. The

IMPROVED BOILER.

water also enters at a point where it may abstract as much heat as possible from the furnace gases before they escape; and by the separation of the top domed chamber from the rest of the boiler the operation of scaling and cleaning is facilitated. The arrangement is also adapted to horizontal and multitubular boilers, to be fired with solid, liquid, or gaseous fuel.

THE ELEVATED RAILWAYS OF NEW YORK.

BUT few persons who have not been in New York since the construction of the elevated roads, and witnessed their equipments and operations, can have any adequate idea of the extent of them, and of the people, machinery, and appurtenances required in working them. A recent inventory discloses the fact that there are 32 miles of roadway, 161 stations, 203 engines, and 612 cars, while 5,480 trains a day are run. There are 3,274 men employed on these roads, 309 of whom are engineers, 258 ticket agents, 231 conductors, 308 firemen, 395 guards or brakemen, 347 gatemen, 4 road inspectors, 106 porters, 33 carpenters, 27 painters, 69 car inspectors, 140 car cleaners, 40 lamp men, and 470 blacksmiths, boiler makers, and other mechanics employed on the structure and in the shops. Most of the ticket agents are telegraph operators, but there are 13 other operators employed. There are four double-track lines in operation. The aggregate daily receipts vary from \$14,000 to \$18,000; and as many as 274,023 passengers have been carried in one day. Engineers are paid from \$3 to \$3.50 per day; ticket agents, \$1.75 to \$2.25; conductors, \$1.90 to \$2.50; firemen, \$1.90 to \$2; guards or brakemen, \$1.50 to \$1.65; and gatemen, \$1.20 to \$1.50. The above items do not include machinists and other employees in the workshops, or the general officers, clerks, etc.

AMERICAN ANTIMONY.

A BALTIMORE dispatch informs us that a carload of antimony, ten tons in all, was lately received by C. L. Oudesluys & Co., from the southern part of Utah Territory, being the first antimony received in the East from the mines of that section. The antimony was mined about 140 miles from Salt Lake City. The ore is a sulphide, bluish gray in color, and yields from 60 to 65 per cent. of antimony. All antimony heretofore came from Great Britain and the island of Borneo, and paid an import duty of 10 per cent. ad valorem, and there is also some from Sonora. It is believed that with proper rail facilities to the mines of the West there will be no need of importations.

SOME OF THE DEVELOPMENTS OF MECHANICAL ENGINEERING DURING THE LAST HALF CENTURY.*

By SIR FREDERICK BRAMWELL, V. P. Inst. C. E., F.R.S.,
Chairman of the Council of the Society of Arts.

I AM quite sure the section will agree with me in thinking it was very fortunate for us, and for science generally, that our president refrained from occupying the time of the section by a retrospect, and devoted himself, in that lucid and clear address with which he favored us, to the consideration of certain scientific matters connected with engineering, and to the foreshadowing of the directions in which he believes it possible that further improvements may be sought for. But I think it is desirable that someone should give to this section a record, even although it must be but a brief and an imperfect one, of certain of the improvements that have been made, and of some of the progress that has taken place, during the last fifty years, in the practical application of mechanical science, with which science and its applications our section is particularly connected. I regret to say that, like most of the gentlemen who sat on this platform yesterday, who, I think, were, without exception, past presidents of the section, I am old enough to give this record from personal experience. Fifty years ago I had not the honor of being a member, nor should I, it is true, have been eligible for membership of the association; but I was at that time vigorously making models of steam-engines, to the great annoyance of the household in which I lived, and was looking forward to the day when I should be old enough to be apprenticed to an engineer. Without further preface, I will briefly allude to some of the principal developments of a few of the branches of engineering. I am well aware that many branches will be left unnoticed; but I trust that the omissions I may make will be remedied by those present who may speak upon the subject after me. I will begin by alluding to

THE STEAM-ENGINE EMPLOYED FOR MANUFACTURING PURPOSES.

In 1831, the steam-engine for these purposes was commonly the condensing beam engine, and was supplied with steam from boilers, known, from their shape, as wagon boilers; this shape appears to have been chosen rather for the convenience of the sweeps, who periodically went through the flues to remove the soot consequent on the imperfect combustion, than for the purpose of withstanding any internal pressure of steam. The necessary consequence was, that the manufacturing engines of those days were compelled to work with steam of from only 3 1/2 lb. to 5 lb. per square inch of pressure above atmosphere. The piston speed rarely exceeded 250 feet per minute, and as a result of the feeble pressure, and of the low rate of speed, very large cylinders indeed were needed relatively to the power obtained. The consumption of fuel was heavy, being commonly from 7 lb. to 10 lb. per gross indicated horse-power per hour. The governing of the engine was done by pendulum governors, revolving slowly, and not calculated to exert any greater effort than that of raising the balls at the end of the pendulum arms, thus being, as will be readily seen, very inefficient regulators. The connection of the parts of the engine between themselves was derived from the foundation upon which the engine was supported. Incident to the low piston speed was slowness of revolution, rendering necessary heavy fly wheels, to obtain even an approach to practical uniformity of rotation, and frequently rendering necessary also heavy trains of toothed gearing, to bring up the speed from that of the revolutions of the engine to that of the machinery it was intended to drive.

In 1881, the boilers are almost invariably cylindrical, and are very commonly internally fired, either by one flue or by two; we owe it to the late Sir William Fairbairn, President of the British Association in 1861, that the danger, which at one time existed, of the collapse of these fire flues, has been entirely removed by his application of circumferential bands. Nowadays there are, as we know, modifications of Sir William Fairbairn's bands, but by means of his bands, or by modifications thereof, all internally fired boilers are so strengthened that the risk of a collapse of the flue is at an end. Boilers of this kind are well calculated to furnish—and commonly do furnish—steam of from 40 lb. to 80 lb. pressure above atmosphere.

The piston speed is now very generally 400 feet or more, so that, notwithstanding that there is usually a liberal expansion, the mean pressure upon the piston is increased, and this, coupled with its increased speed, enables much more power to be obtained from a given size of cylinder than was formerly obtainable. The revolutions of the engine now are as many as from 60 to 200 per minute, and thus, with far lighter fly-wheels, uniformity of rotation is much more nearly attained.

THE EVAPORATIVE CONDENSER.

Moreover, all the parts of the engine are self-contained; they no longer depend upon the foundation, and in many cases the condensing is effected either by surface condensers, or, where there is not sufficient water, the condensation is, in a few instances, effected by the evaporative condenser—a condenser which, I am sorry to say, is not generally known, and is therefore but seldom used, although its existence has been nearly as long as that of the association. Notwithstanding the length of time during which the evaporative condenser has been known to some engineers, it is a common thing to hear persons say, when you ask them if they are using a condensing engine, "I can not use it; I have not water enough." A very sufficient answer indeed, if an injection condenser or an ordinary surface condenser constituted the sole means by which a vacuum condition might be obtained; but a very insufficient answer, having regard to the existence of the evaporative condenser, as by its means, whenever there is water enough for the feed of a non condensing engine, there is enough to condense, and to produce a good vacuum.

The evaporative condenser simply consists of a series of pipes, in which is the steam to be condensed, and over which the water is allowed to fall in a continuous rain. By this arrangement there is evaporated from the outside of the condenser a weight of water which goes away in a cloud of vapor and is nearly equal to that which is condensed, and is returned as feed into the boiler. The same water is pumped up and used outside the condenser, over and over, needing no more to supply the waste than would be needed as feed water. Although this condenser has, as I have said, been in use for thirty or forty years, one still sees engines working without condensation at all, or with waterworks water, purchased at a great cost, and to the detriment of other consumers who want it for ordinary domestic purposes.

* Paper read in Section G (Mechanical) of the British Association.

poses; or one sees large condensing pumps made, in which the injection water is stored, to be used over and over again, and frequently (especially toward the end of the week) in so tepid a state as to be unfit for its purpose. The governing is now done by means of quick-running governors, which have power enough in them to raise not merely the weight of the pendulum ball, which is now small, but a very heavy weight, and in this way the governing is extremely effective. I propose to say no more, looking at the magnitude of the whole of my subject, upon the engine used for manufacturing purposes, but rather to turn at once to those employed for other objects.

STEAM NAVIGATION.

In 1831, there were a considerable number of paddle steamers running along some of the rivers in England, and across the Channel to the Continent. But there were no ocean steamers, properly so-called, and there were no steamers used for warlike purposes. As in the case of the wagon boilers, the boilers of the paddle steamers of 1831 were most unsuited for resisting pressure. They were mere tanks, and there was as much pressure when there was no steam in the boiler from the weight of the water on the bottom, as there was at the top of the boiler from the steam pressure when the steam was up. Under these circumstances, again, from 3½ lb. to 5 lb. was all the pressure the boilers were competent to bear, and as the engines ran at a slow speed, they developed but a small amount of horse-power in relation to their size. Moreover, as in the land engine, the connection between the parts of the marine engine was such as to be incompetent to stand the strain that would come upon it if a higher pressure, with a considerable expansion, were used, and thus the consumption of coal was very heavy; and we know that, having regard to the then consumption, it was said, on high authority, it would be impossible for a steamboat to traverse the Atlantic, as it could not carry fuel enough to take it across; and indeed it was not until 1838 that the *Sirius* and the *Great Western* did make the passage. The passage had been made before, but it was not until 1838 that the passenger service can be said to have commenced. In 1831, the marine boiler was supplied with salt water, the hulls were invariably of wood, and the speed was probably from eight to nine knots an hour. In 1881, the vessels are as invariably either of iron or of steel, and I believe it will not be very long before the iron disappears, giving place entirely to the last mentioned metal. With respect to the term "steel," I am ready to agree that it is impossible to say where, chemically speaking, iron ends and steel begins. But (leaving out malleable cast iron) I apply this term "steel" to any malleable ductile metal of which iron forms the principal element and which has been in fusion, and I do so in contradistinction to the metal which may be similar chemically, but which has been prepared by the puddling process. Applying the term steel in that sense, I believe, as I have said, it will not be very long before plate-iron produced by the puddling process will cease to be used for the purpose of building vessels. With respect to marine engines, they are now supplied with steam from multiple-tubed boilers, the shells of which are commonly cylindrical. They are of enormous strength, and made with every possible care, and carry from 80 lb. to 100 lb. pressure on the square inch.

It has been found, on the whole, more convenient to expand the steam in two or more cylinders, rather than in one. I quite agree that, as a mere matter of engineering science, there is no reason why the expansion should not take place in a single cylinder, unless it be that a single cylinder is cooled down to an extent which cannot be overcome by jacketing, and which, therefore, destroys a portion of the steam on its entering into the cylinder.

As regards the propeller, as we know, except in certain cases, the paddle-wheel has practically disappeared, and the screw propeller is all but universally employed. The substitution of the screw propeller for the paddle enables the engine to work at a much higher number of revolutions per minute, and thus a very great piston speed, some 600 ft. to 800 ft. per minute, is attained; and this, coupled with the fairly high mean pressure which prevails, enables a large power to be got from a comparatively small-sized engine. Speeds of 15 knots an hour are now in many cases maintained, and on trial trips are not uncommonly exceeded. Steam vessels are now the accepted vessels of war. We have them in an armored state and in an unarmored state, but when unarmored rendered so formidable, by the command which their speed gives them of choosing their distance, as to make them, when furnished with powerful guns, dangerous opponents even to the best armored vessels.

MARINE GOVERNORS.

We have also now marine engines, governed by governors of such extreme sensitiveness as to give them the semblance of being endowed with the spirit of prophecy, as they appear rather to be regulating the engine for that which is about to take place than for that which is taking place. This may sound a somewhat extravagant statement, but it is so nearly the truth, that I have hardly gone outside of it in using the words I have employed. For a marine governor to be of any use, it must not wait till the stern of the vessel is out of the water before it acts to check the engine and reduce the speed. Nothing but the most sensitive, and, indeed, anticipatory action of the governors can efficiently control marine propulsion. Instances are on record of vessels having engines without marine governors being detained by stress of weather at the mouth of the Thames, while vessels having such governors, of good design, have gone to Newcastle, have come back, and have found the other vessels still waiting for more favorable weather.

With respect to condensation in marine engines, it is almost invariably effected by surface condensers, and thus it is that the boilers, instead of being fed with salt water as they used to be, involving continuous blowing off, and frequently the salting up, of the boiler, are now fed with distilled water. It should be noticed, however, that in some instances, owing to the absence of a thin protecting scale upon the tubes and plates, very considerable corrosion has taken place when distilled water, derived from condensers having untinned brass tubes, has been used, and where the water has carried into the boiler fatty acids, arising from the decomposition of the grease used in the engine; but means are now employed by which these effects are counteracted.

LIGHT ENGINES AND BOILERS

I wish, before quitting this section of my subject, to call your attention to two very interesting but very different kinds of marine engines. One is the high-speed torpedo vessel, or steam launch, of which Messrs. Thornycroft's firm have furnished so many examples. In these, owing to the rate at which the piston runs to the initial pressure of

120 lb. and to very great skill in the design, Messrs. Thornycroft have succeeded in obtaining a gross indicated horse-power for as small a weight as half a cwt., including the boiler, the water in the boiler, the engine, the propeller shaft, and the propeller itself.

To obtain the needed steam from the small and light boiler, recourse has to be made to the aid of a fan blast driven into the stoke-hole. From the use of a blast in this way advantages accrue. One is, as already stated, that from a small boiler a large amount of steam is produced. Another is that the stoke-hole is kept cool; and the third is that artificial blasts thus applied are unaccompanied by the dangers which arise, when under ordinary circumstances the blast is supplied only to the ash-pit itself.

THE PERKINS SYSTEM.

The second marine engine to which I wish to call your attention is one that has been made with a view to great economy. The principles followed in its construction are among those suggested by the President (Sir W. G. Armstrong) in his address. He (you will remember) pointed out that the direction in which economy in the steam engine was to be looked for was that of increasing the initial pressure; although at the same time he said that there were drawbacks in the shape of greater loss, by radiation, and by the higher temperature at which the products of combustion will escape. We must admit the fact of the latter source of loss, when using very high steam, it being inevitable that temperature of the products of combustion escaping from a boiler under these conditions must be higher than those which need be allowed to escape when lower steam is employed; although I regret to say that in practice in marine boilers working at comparatively low pressures the products are ordinarily suffered to pass into the funnel at above the temperature of melted lead. But with respect to the loss by radiation in the particular engine I am about to mention—that of Perkins—there is not as much loss as that which prevails in the ordinary marine boilers, because the Perkins boiler is completely inclosed, with the result that while there is within the case a boiler containing steam of 400 lb. on the square inch, and the fire to generate that steam, the hand may be applied to the casting itself, which contains the whole of the boiler, without receiving any unpleasant sensation of warmth. By Mr. Perkins's arrangement, using steam of 400 lb. in the boiler, it was found, as the result of very severe trials, conducted by Mr. Rich, of Messrs. Easton and Anderson's firm, and myself—trials which lasted for twelve hours—that the total consumption of fuel, including that for getting up steam from cold water, was just under 1.8, actually 1.79 lb. per gross indicated horse-power per hour. That gross indicated horse-power was obtained in a manner which it is desirable should always be employed in steamboat trials. It was not got by using as a divisor the horse-power of the most favorable diagram obtained during the day; but it was got from diagrams taken during the regular work; then, every half-hour, when the pressure began to die down, from coal being no longer put upon the fire, diagrams taken every quarter of an hour, and then toward the last, every five minutes; and the total number of foot pounds were calculated from these diagrams, and were used to obtain the gross indicated horse-power.

Further, so far as could be ascertained by the process of commencing a trial with a known fire, and closing that trial at the end of six hours, with the fire as nearly as possible in the same condition, the consumption was 1.66 lb. of coal per gross indicated horse-power per hour. So that, without taking into account the coal consumed in raising steam from cold water, the engine worked for 1½ lb. of coal per horse per hour. I think it well to give these details, because undoubtedly it is an extremely economical result.

ETHER ENGINE.

Our president alluded to the employment of ether as a means of utilizing the heat which escaped into the condenser, and gave some account of what was done by Mons. Du Tremblay in this direction. It so happened that I had occasion to investigate the matter at the time of Du Tremblay's experiments; very little was effected here in England, one difficulty being the excise interference with the manufacture of ether. Chloroform was used here, and it was also suggested to employ bisulphide of carbon. In France, however, a great deal was done. Four large vessels were fitted with the ether engines, and I went over to Marseilles to see them at work. I took diagrams from these engines, and there is no doubt that, by this system, the exhaust steam from the steam cylinder, which was condensed by the application of ether to the surface of the steam condenser (producing a respectable vacuum of about 22 inches), gave an ether pressure of 15 lb. on the square inch above atmosphere, and very economical results as regards fuel were obtained. The scheme was, however, abandoned from practical difficulties. It need hardly be said that ether vapor is very difficult to deal with, and although ether is light, the vapor is extremely heavy, and if there is any leakage, it goes down into the bilges by gravitation, and being mixed with air, unless due care is taken to prevent access to the flues, there would be a constant risk of a violent explosion. In fact, it was necessary to treat the engine room in the way in which a fiery colliery would be treated. The lighting, for instance, was by lamps external to the engine-room, and shining through thick plate-glass. The hand lamps were Davy's. The ether engine was a bold experiment in applied science, and one that entitles Du Tremblay's name to be preserved, and to be mentioned as it was by our president.

THE QUICKSILVER ENGINE.

These was another kind of marine engine that I think should not be passed over without notice; I allude to Howard's quicksilver engine. The experiments with this engine were persevered in for some considerable time, and it was actually used for practical purposes in propelling a passenger steam-vessel called the *Vesta*, and running between London and Ramsgate. In that engine the boiler had a double bottom, containing an amalgam of quicksilver and lead. This amalgam served as a reservoir of heat, which it took up from the fire below the double-bottom, and gave forth at intervals to the water above it. There was no water in the boiler, in the ordinary sense of the term, but when steam was wanted to start the engine, a small quantity of water was injected by means of a hand-pump, and after the engine was started, there was pumped by it into the boiler, at each half revolution, as much water as would make the steam needed. This water was flashed on the top surface of the reservoir in which the amalgam was confined, and was entirely turned into steam, the object of the engineers in charge being to send in so much water as would just generate the steam, but so as not to leave any water in the boiler. The engines of the *Vesta* were made by Mr. Penn, for Mr.

Howard, of the King and Queen Ironworks, Rotherhithe. Mr. Howard was, I fear, a considerable loser by his meritorious efforts to improve the steam-engine.

There was used, with this engine, an almost unknown mode of obtaining fresh water for the boiler. Fresh water, it will be seen, was a necessity in this mode of evaporation. The presence of salt, or of any other impurity, when the whole of the water was flashed into steam, must have caused a deposit on the top of the amalgam chamber at each operation. Fresh water, therefore, was needed; the problem arose how to get it; and that problem was solved, not by the use of surface condensation, but by the employment of reinjection, that is to say, the water delivered from the hot well was passed into pipes external to the vessel; after traversing them, it came back into the injection tank sufficiently cooled to be used again. The boilers were worked by coke fires, urged by a fan blast in their ashpits, but I am not aware that this mode of firing was a needful part of the system.

LOCOMOTIVE ENGINES.

I come now to the engines used for railways. At the British Association meeting of 1831, the Manchester and Liverpool Railway had been opened only about a year. The Stockton and Darlington coal line, it is true, had carried passengers by steam power as early as 1825, but I think we may look upon the Manchester and Liverpool as being the beginning of the passenger and mercantile railway system of the present day. At that time the locomotives weighed from eight to ten tons, and the speed was about 20 miles per hour, with a pressure of from 40 to 50 lb. The rails were light; they were jointed in the chairs, which were generally carried on stone blocks, thus affording most excellent anvils for the battering to pieces of the ends of the rails—that is to say, for the destruction of the very parts where they were most vulnerable. The engines were not competent to draw heavy trains, and it was a common practice to have at the foot of an incline a shed containing a "bank engine," which ran out after the trains as they passed, and pushed them up to the top of the hill. Injectors were then unknown, and donkey-pumps were unknown, and therefore, when it was necessary to fill up the boiler, if it had not been properly pumped up before the locomotive came to rest, it had to run about the line in order to work its feed-pumps. To get over this difficulty, it was occasionally the practice to insert into a line of rails, in a siding, a pair of wheels, with their tops level with that of the rails so that the engine wheels could run upon the rims. Then, the locomotive being fixed to prevent it from moving off the pair of wheels thus endways, it was put into revolution, its driving wheels bearing, as already stated, upon the rims of the pair of wheels in the rails, and thus the engine worked its feed-pumps without interfering (by its needless running up and down the line) with the traffic. It should have been stated that at this time there was no link motion, no practical expansion of the steam, and that even the reversal of the engine had to be effected by working the sides by hand gear, in the manner in use in marine engines. When the British Association originated, although the Manchester and Liverpool Railway had been opened for a year, there is no doubt that the 300 members who then came to this city found their way here by the slow process of the stage-coach, the loss of which we so much deplore in the summer and in fine weather, but the obligatory use of which we should so much regret in the miserable weather now prevailing in these islands.

In 1881, we know that railways are everywhere inserted. Steel rails, double the weight of the original iron ones, are used. Wooden sleepers have replaced the stone blocks, and they, in their turn, will probably give way to sleepers of steel. The joints are now made by means of fish-plates, and the most vulnerable part of the rail, the end, is no longer laid on an anvil for a purpose of being smashed to pieces, but the ends of the rails are now almost always over a void, and thereby are not more affected by wear than is any other part of the rail. The speed is now from 50 to 60 miles an hour for passenger trains, while slow speed goods engines, weighing 45 tons, draw behind them coal trains of 800 tons. The injector is now commonly employed, and, by its aid, a careful driver of the engine of a stopping train can fill up his boiler while at rest at the stations. The link motion is in common use, to which, no doubt, is owing the very considerable economy with which the locomotive engine now works.

As regards the question of safety, it is a fact that, notwithstanding the increased speed, railway accidents are fewer than they were at the slow speed. It is also a fact, that if the whole population of London were to take a railway journey, there would be but one death arising out of it. Four millions of journeys for one death of a passenger from causes beyond his own control is, I believe, a state of security which rarely prevails elsewhere. As an instance, the street accidents in London alone cause between 200 and 300 deaths per annum. This safety in railway traveling is no doubt largely due to the block system, rendered possible by the electric telegraph; and also to the efficient interlocking of points and signals, which render it impossible now for a signal man to give an unsafe signal. He may give a wrong one, in the sense of inviting the wrong train to come in; but, although wrong in this sense, it would still be safe for that train to do so. If he can give a signal, that signal never invites to danger; before he can give it, every one of the signals, which ought to be "at danger," must be "at danger," and every "point" must have been previously set, so as to make the road right; then, again, we have the facing point-lock, which is a great source of safety.

BRAKES

Further, we have continuous brakes of various kinds, competent in practice to absorb three miles of speed in every second of time; that is to say, if a train were going 60 miles an hour, it can be pulled up in 20 seconds; or, if at the rate of 30 miles, in 10 seconds. With a train running at 50 miles an hour, it can be pulled up from 15 to 20 seconds, and in a distance of from 180 to 240 yards. Moreover, in the event of the train separating into two or more sections, the brakes are automatically applied to each section, thereby bringing them to rest in a short time. Another cause of safety is undoubtedly the use of weldless tires. I was fortunate enough to attend the British Association meeting many years ago at Birmingham, and I then read a paper upon weldless tires, in which I ventured to prophesy that, in ten years' time, there would not be a welded tire made; that is one of the few prophecies that, being made before the event, have been fulfilled. I may perhaps be permitted to mention, that at the same time I laid before the section plans and suggestions for the making of the cylindrical parts of boilers equally without seam, or even welding. This is rarely done at the present time, but I am sure that, in twenty years' time, such a thing as a longitudinal seam of rivets in a boiler will be

unknown. There is no reason why the successive rings of boiler shells should not be made weldless, as tires are now made weldless.

MOTORS.

The next subject I intend to deal with is that of motors. In 1831, we had the steam-engine, the water-wheel, the windmill, horse-power, manual power, and Stirling's hot air engines. Gas engines, indeed, were proposed in 1824, but were not brought to the really practical stage. We had then tide mills; indeed, we have had them until quite lately, and it may be that some still exist; they were sources of economy in our fuel, and their abandonment is to me a matter of regret. I remember tide mills on the coast between Brighton and Newhaven, another between Greenwich and Woolwich, another at Northfleet, and in many other places. Indeed, such mills were used pretty extensively; they were generally erected at the mouth of a stream, and in that way the river bed made the reservoir, and even when they were erected in other situations, those were of a kind suitable for the purpose, that is, low-lying lands were selected, and were embanked to form reservoirs. In 1831, windmills and water-wheels are much the same, but the turbines are greatly improved, and by means of turbines we are enabled to make available the pressure derived from heads of water which formerly could not be used at all, or if used, involved the erection of enormous water-wheels, such as those at Glasgow and in the Isle of Man, wheels of some eighty feet in diameter. But now, by means of a small turbine, an excellent effect is produced from high heads of water. The same effect is obtained from the water-engines which our president has employed with such great success. In addition to these motors, we have the gas-engine, which, within the last few years only, has become a really useful working and economical machine. With respect to horse-power motors, we have not only the old horse engines, but we have a new application, as it seems to me, of the work of the horse as a motor. I allude to those cases where the horse drawing a reaping or thrashing machine, not only pulls it forward as he might pull a cart, but causes its machinery to revolve, so as to perform the desired kind of work. This species of horse-engine, though known, was but little used in 1831. With respect to hot-air engines there have been many attempts to improve them, and some hot-air engines are working, and are working with considerable success; but the amount of power they develop in relation to their size is small, and I am inclined to doubt whether it can be much increased.

TRANSMISSION OF POWER.

I now come to the subject of the transmission of power. I do not mean transmission in the ordinary sense by means of shafting, gearing, or belting, but I mean transmission over long distances. In 1831, we had for this purpose flat rods, as they were called, rods transmitting power from pumping engines for a considerable distance to the pits where the pumps were placed, and we had also the pneumatic, the exhaustion system—the invention of John Hague, a Yorkshireman, my old master, to whom I was apprenticed—which mode of transmission was then used to a very considerable extent. The recollection of it, I find, however, has nearly died out, and I am glad to have this opportunity of reviving it. But in 1831, we have, for the transmission of power, first of all, quick moving ropes, and there is not, so far as I know a better instance of this system than that at Schaffhausen. Any one who has ever, in recent years, gone a mile or two above the falls at Schaffhausen, must have seen there—in a house, on the bank of the Rhine, opposite to that on which the town is situated—large turbines driven by the river, which is slightly dammed up for the purpose. These work quick-going ropes, carried on pulleys, erected at intervals along the river bank, for the whole length of the town; and power is delivered from them to shafting below the streets, and from it into any house where it is required for manufacturing purposes. Then we have the compressed air transmission of power, which is very largely used for underground engines, and for the working of rock drills in mines and tunnels.

COMPRESSED AIR LOCOMOTIVES.

We have also compressed air in a portable form, and it is now employed with great success in driving tram-cars. I had occasion last January to visit Nantes, where, for eighteen months, tram-cars had been driven by compressed air, carried on the cars themselves, coupled with an extremely ingenious arrangement for overcoming the difficulties commonly attendant on the use of compressed air engines. This consists in the provision of a cylindrical vessel half filled with hot water and half with steam, at a pressure of eighty pounds on the square inch. The compressed air, on its way from the reservoir to the engine, passes through the water and steam, becoming thereby heated and moistened, and in that way all the danger of forming ice in the cylinders was prevented, and the parts were susceptible of good lubrication. These cars, which start every ten minutes from each end, make a journey of $3\frac{3}{4}$ miles, and have proved to be a commercial and an engineering success. I believe, moreover, that they are capable of very considerable improvement.

HYDRAULIC TRANSMISSION OF POWER.

Then there is, although not much used, the transmitting of power by means of long steam pipes. There is also the transmission hydraulically. This may be carried out in an intermittent manner, so as to replace the reciprocating flat rods of old days; that is to say, if two pipes containing water are laid down, and if the pressure in those pipes at the one end be alternated, there will be produced an alternating and a reciprocative effect at the other, to give motion to pumps or other machinery. There is also that thoroughly well known mode of transmission, hydraulically, for which the engineering world owes so much to our president. We have, by Sir William Armstrong's system, coupled with his accumulator, the means of transmitting hydraulically the power of a central motor to any place requiring it, and by the means of the principal accumulator, or if need be by that aided by local accumulators, a comparatively small engine is enabled to meet very heavy demands made upon it for a short time. I think I am right in saying that, at the ordinary pressure which Sir William Armstrong uses in practice, viz., 700 lb. to the square inch, one foot a second of motion along an inch pipe would deliver at the rate to produce one-horse power. Therefore, a ten-inch pipe, with the water traveling at no greater pace than three feet in a second, would deliver 300 horse-power. This 300 horse power would no doubt be somewhat reduced by the loss in the hydraulic engine, which would utilize the water. But the total energy received would be equivalent to producing 300 horse-power. Such a transmission would be effected with an exceedingly small loss in friction in transit. I believe I am right in saying that a 10 inch pipe a mile long would not involve much more than

about 14 or 15 lb. differential pressure to propel the water through it at the rate of three feet in a second. If that be so, then, with 700 lb. to the inch, the loss under such circumstances would be only two per cent, in transmission. There is no doubt that this transmission of power hydraulically has been of the greatest possible use. It has enabled work to be done which could not be done before. Enormous weights are raised with facility wherever required, as by the aid of power hydraulically transmitted, it is perfectly easy for one man to manage the heaviest cranes. Moreover, as I have said in other places, the system which we owe to Sir William Armstrong has gone far to elevate the human race, and it has done so in this manner. So long as it is competent for a man to earn a living by mere unintelligent exercise of his muscles, he is very likely to do it. You may see in the old London docks the crane-heads covered by structures that look like paddle-boxes. If you go to them, there is, I am glad to say, nothing now to fill them up; but when the British Association first met, these paddle-boxes covered large tread-wheels, in which men trod, so as to raise a weight. Now, although I know that in fact there is nothing more objectionable in a man turning a wheel by treading inside of it than there is if he turn it round by a winch-handle, yet somehow it strikes one more as being merely the work of an animal, a turnspit, or a squirrel, or, indeed, as the task imposed on the criminal. But, nevertheless, in this way there were a large number of persons getting their living by the mere exercise of their muscles, but, as might be expected, a very poor living, derived as it was from unintelligent labor. That work is no longer possible, and is not so, for the powerful reason that it does not pay. Those persons, therefore, who would now have been thus occupied, are compelled to elevate themselves, and to become competent to earn their living in a manner which is more worthy of an intelligent human being. It is on these grounds that I say we owe very much the elevation of the working classes, especially of the class below the artisan, to this invention of our distinguished president.

ELECTRIC TRANSMISSION OF POWER.

In addition to the modes of transmission I have already mentioned, there is the transmission of power by means of gas. I think that there is a very large future indeed for gas engines. I do not know whether this may be the place to state it, but I believe the way in which we shall utilize our fuel hereafter will, in all probability, not be by the way of the steam-engine. Sir William Armstrong alluded to this probability in his address, and I entirely agree, if he will allow me to say so, that such a change in the production of power from fuel appears to be impending, if not in the immediate future, at all events in a time not very far remote; and however much the Mechanical Section of the British Association may to-day contemplate with regret, even the mere distant prospect of the steam-engine being a thing of the past, I very much doubt whether those who meet here fifty years hence will then speak of it as anything more than a curiosity to be found in a museum. With respect to the transmission of power electrically, I won't venture to touch upon that; but will content myself by reminding you that while Sir William Armstrong did say that there were comparatively small streams which could be utilized, he did not inform you of that which he himself had done in this direction; let me say that Sir William Armstrong thus utilized a fall of water, situated about a mile from his house, to work a turbine, which drives a dynamo machine, generating electricity, for the illumination of the house. When I was last at Crag Side, that illumination was being effected by the arc light, but since then, as Sir William Armstrong has been good enough to write to me, he has replaced the arc light by the incandescent lamp (a form of electrical lighting far more applicable than the arc light to domestic purposes), and with the greatest possible success. Thus, in Sir William Armstrong's own case, a small stream is made to afford light in a dwelling a mile away. Certainly nothing could have seemed more improbable fifty years ago than that the light of a house should be derived from a fall of water without the employment of any kind or description of fuel.

The next subject upon which I propose to touch is that of

THE MANUFACTURE OF IRON AND STEEL.

In 1831, Neilson's hot blast specification had been published for two and a half years only. The Buttery Company had tried the hot blast for the first time in the November preceding the meeting of the British Association. The heating of the blast was coming very slowly into use, and the temperature attained when it was employed was only some 600 degrees. The ordinary blast furnace of those days was 35 to 40 feet high, and about 12 feet diameter at the boshes, and turned out about 60 tons a week. It used about $2\frac{1}{2}$ tons of coal per ton of iron, and no attempt was made to utilize the waste gases, whether escaping in the form of gas or in the form of flame, the country being illuminated for miles around at night by these fires. The furnaces were also open at the hearth, and continuous fire poured out along with the slag.

In 1831, blast furnaces are from 90 ft. to 100 ft. high, and 25 ft. in diameter at the boshes; they turn out from 500 to 800 tons a week. The tops and also the hearths are closed, and the blast—thanks to the use of Mr. E. A. Cowper's stoves—is at 1,200 degrees. The manufacture of iron has also now enlisted in its service the chemist as well as the engineer, and among those who have done much for the improvement of the blast furnaces, to no one is greater praise due than to Mr. Isaac Lowthian Bell, who has brought the manufacture of iron to the position of a highly scientific operation. In the production of wrought iron by the puddling process, and in the subsequent mill operations, there is no very considerable change, except in the magnitude of the machines employed, and in the greater rapidity with which they now run. In saying this, I am not forgetting the various "mechanical puddlers" which have been put to work, nor the attempts that have been made by the use of some of them to make wrought iron direct from the ore; but neither the "mechanical puddler" nor the "direct process" has yet come into general use; and I desire to be taken as speaking of that which is the ordinary process pursued at the present in puddled iron manufactures. In 1831, a few hundredweights was the limit of weight of a plate, while in 1881, there may readily be obtained, for boiler-making purposes, plates of at least four times the weight of those that were made in 1831. I may, perhaps, be allowed to say that there is an extremely interesting blue-book of the year 1818, containing the report of a parliamentary committee which sat on boiler explosions, and I recommend any mechanical engineer who is interested in the history of the subject to read that book; he will find it there stated that in the North of England there was a species of engines called locomotives, the boilers of which were made of wrought iron, beaten, not rolled, because the rolled plate was not con-

sidered fit; it was added that if made of beaten iron the boiler would last at least a year.

In 1831, thirteen years later, the dimensions of rolled plates were no doubt raised; but few then would have supposed it possible there should be rolled such plates as are now produced for boiler purposes, and still fewer would have believed that in the year 1881 we should make, for warlike purposes, rolled plates 22 inches in thickness and 30 tons in weight. I have said there is very little alteration in the process of making wrought iron by puddling, and I do not think there is likely to be much further, if any, improvement in this process, because I believe that, with certain exceptions, the manufacture of iron by puddling is a doomed industry. I ventured to say, in a lecture I delivered at the Royal Institution three years ago on "The Future of Steel," that I believed puddled iron, except for the mere hand wrought forge purposes of the country blacksmith, and for such like purposes, would soon become a thing of the past. Mr. Harrison, the engineer of the North-Eastern Railway, told me that about eighteen months ago the North-Eastern Railway applied for tenders for rails in any quantities between 2,000 and 10,000 tons, and they issued alternative specifications for iron and for steel. They received about ten tenders. Some did not care to tender for iron at all; but when they did tender alternatively, the price quoted for the iron was greater than for the steel. I have no doubt whatever that, in a short time, it will be practically impossible to procure iron made by the puddling process, of dimensions fit for many of the purposes for which a few years ago it alone was used.

With respect to steel, in 1831 the process in use was that of cementation, producing blistered steel, which was either piled and welded to make shear steel, or was broken into small pieces, melted in pots, and run into an ingot weighing only some 50 lb. or 60 lb. At that time steel was dealt in by the pound; nobody thought of steel in tons. In 1831, we are all aware that, by Sir Henry Bessemer's well-known discovery, carried out by him with such persistent vigor, cast iron is, by the blowing process, converted into steel, and that of Dr. Siemens' equally well-known process (now that, owing to his invention of the regenerative furnace, it is possible to obtain the necessary high temperature), steel is made upon the open hearth. We are, moreover, aware that, by both of these processes, steel is produced in quantities of many tons at a single operation, with the result that as instanced in the case of the North-Eastern rails, steel is a cheaper material than the wrought iron made by the puddling process. One cannot pass away from the steel manufacture without alluding to Sir Joseph Whitworth's process of putting a pressure on the steel while in a tried state. By this means, the cavities which are frequently to be found in the ingot of a large size are, while the steel is fluid, rendered considerably smaller, and the steel is thereby rendered much more sound. In conclusion of my observations on the subject of iron and steel manufacture, I wish to call attention to the invention of Messrs. Thomas & Gilchrist, by which ores of iron, containing impurities that unfitted them to be used in the manufacture of steel, are now freed from these impurities, and are thus brought into use for steel-making purposes.

BRIDGES.

In the year 1831, bridges of cast iron existed; but no attempt had been made to employ wrought iron in girder bridges, although Telford had employed it in the Menai Suspension Bridge; but in 1831, the introduction of railways, and the improvement in iron manufactures, have demanded, and have rendered possible the execution of such bridges as the tubular one, spanning the Menai Straits, in span of 400 feet, and the Saltash, over the Tamar, with spans of 435 feet; while recent great improvements in the manufacture of steel have rendered possible the contemplated construction of the Forth Bridge, where there are to be spans of 1,700 feet, or one-third of a mile in length. Mr. Barlow, one of the engineers of this bridge, has told me that there will be used upwards of 2,000 more tons of material in the Forth Bridge, to resist the wind pressure, than would have been needed if no wind had to be taken into account, and if the question of the simple weight to be carried had alone to be considered. With respect to the foundation of bridges, that ingenious man, Lord Cochrane, patented a mode of sinking foundations, even before the first meeting of the British Association, viz., as far back, I believe, as 1825 or 1826; and the improvements which he then invented are almost universally in use in bridge construction at the present day. Cylinders sunk by the aid of compressed air, airlocks to obtain access to the cylinder, and, in fact, every means that I know of as having been used in the modern sinking of cylinder foundations, were described by Lord Cochrane (afterwards Earl of Dundonald) in that specification.

The next subject I propose to touch on is that of

MACHINE TOOLS.

In 1831, the mention of lathes, drilling machines, and screwing machines brings me very nearly to the end of the list of the machine tools used by turners and fitters, and at that time many lathes were without slide rests. The boiler-maker had then his punching-press and shearing machine; the smith, leaving on one side his forges and their bellows, had nothing but hand tools, and the limit of these was a huge hammer, with two handles, requiring two men to work it. In anchor manufacture, it is true, a mechanical drop-hammer, known as a Hercules, was employed, while in iron works, the Helve and the Tilt hammer were in use. For ordinary smith's work, however, there were, as has been said, practically no machine tools at all.

This paucity or absence in some trades, as we have seen, of machine tools, involved the need of very considerable skill on the part of the workman. It required the smith to be a man not only of great muscular power, but to be possessed of an accurate eye and a correct judgment, in order to produce the forgings which were demanded of him, and to make the sound work that was needed, especially when that soundness was required in shafts, and in other pieces which, in those days, were looked upon as of magnitude; which, indeed, they were, relatively to the tools which could be brought to operate upon them. The boiler-maker in his work had to trust almost entirely to the eye for correctness of form and for regularity of punching, while all parts of engines and machines which could not be dealt with in the lathe, in the drilling, or in the screwing machine, had to be prepared by the use of the chisel and the file.

At the present day, the turning and fitting shops are furnished not only with the slide lathe, self-acting in both directions, and screw-cutting, the drilling-machine, and the screwing machine, but with planing machines competent to plane horizontally, vertically, or at an angle; shaping machines, rapidly reciprocating, and dealing with almost any form of

work; nut-shaping machines, slot drilling machines, and slotting machines, while the drills have become multiple and radial; and the accuracy of the work is insured by testing on large surface plates, and by the employment of Whitworth internal and external standard gauges.

The boiler-maker's tools now comprise the steam, compressed air, hydraulic or other mechanical riveter, rolls for the beuding of plates while cold into the needed cylindrical or conical forms, multiple drills for the drilling of rivet holes, planing machines to plane the edges of the plates, ingenious apparatus for flanging them, thereby dispensing with one row of rivets out of two, and roller expanders for expanding the tubes in locomotive and in marine boilers; while the punching press, where still used, is improved so as to make the hole for seams of rivets in a perfect line, and with absolute accuracy of pitch.

With respect to the smith's shop, all large pieces of work are now manipulated under heavy Nasmyth or other steam hammers; while smaller pieces of work are commonly prepared either in forging machines or under rapidly moving hammers, and when needed in sufficient numbers are made in dies. And applicable to all the three industries of the fitting shop, the boiler shop, and the smith's shop, and also to that other industry carried on in the foundry, are the traveling and swing cranes, commonly worked by shafting, or by quick moving ropes for the travelers, and by hydraulic power or by steam engines for the swing cranes. It may safely be said, that without the aid of these implements, it would be impossible to handle the weights that are met with in machinery of the present day.

I now come to one class of machine which, humble and small as it is, has probably had a greater effect upon industry and upon domestic life than almost any other. I mean

THE SEWING MACHINE.

In 1831, there was no means of making a seam except by the laborious process of the hand needle. In 1846, Eldred Walker patented a machine for passing the basting thread through the gores of umbrellas, a machine that was very ingenious and very simple, but was utterly unlike the present sewing machine, with its eye-pointed needle, using sometimes two threads (the second being put in by a shuttle or by another needle), and making stitches at twenty-fold the rapidity with which the most expert needlewoman could work. By means of the sewing machine not only are all textile fabrics operated upon, but even the thickest leather is dealt with, and as a *tour de force*, but as a matter of fact, sheet-iron plates themselves have been pierced, and have been united by a seam no boilermaker ever contemplated, the piercing and the seam being produced by a Blake sewing machine. I believe all in this section will agree that the use of the sewing machine has been unattended by loss to those who earn their living by the needle; in fact, it would not be too much to say that there has been a positive improvement in their wages.

The next matter I have to touch upon is

AGRICULTURAL MACHINERY.

In 1831, we had thrashing machines and double plows, and even multiple plows had been proposed, tried, and abandoned. Reaping machines had been experimented with and abandoned; sowing machines were in use, but not many of them; clod crushers and horse rakes were also in use; but as a fact plowing was done by horse power with a single furrow at a time, mowing and reaping were done by the scythe or the sickle, sheaves were bound by hand, hay was tedded by hand-rakes, while all materials and produce were moved about in carts and in wagons drawn by horses. At the present time we have multiple plows, making five or six furrows at a time, these and cultivators also, driven by steam, commonly from two engines on the head lands, the plow being in between, and worked by a rope from each engine, or if by one engine, a capstan on the other head land, with a return rope working the plow backward and forward; or by what is known as the round-about system, where the engine is fixed and the rope carried round about the field; or else plows and cultivators are worked by ropes from two capstans placed on the two head lands, and driven by means of a quick-going rope, actuated by an engine, the position of which is not changed. And then we have reaping machines, driven at present by horses; but how long it will be before the energy residing in a battery, or that in a reservoir of compressed air, will supersede horse power to drive the reaping machine, I don't know, but I don't suppose it will be very long. The mowing and reaping machines not only cut the crop and distribute it in swaths, or, in the case of the reaping machine, in bundles, but now, in the instance of these latter machines, are competent to bind it into sheaves. In lieu of hand tedding, haymaking machines are employed, tossing the grass into the air, so as to thoroughly aerate it, taking advantage of every brief interval of fine weather; and seed and manure are distributed by machine with unflinching accuracy. The soil is drained by the aid of properly constructed plows for preparing the trenches; roots are steamed and sliced as food for cattle; and the thrashing machine no longer merely beats out the grain, but it screens it, separates it, and elevates the straw, so as to mechanically build it up into a stack. I do not know a better class of machine than the agricultural portable engine. Every part of it is perfectly proportioned and made; it is usually of the locomotive type, and the economy of fuel in its use is extremely great. I cannot help thinking that the improvement in this respect which has taken place in these engines, and the improvement of agricultural machinery generally, is very largely due to the Royal Agricultural Society, one of the most enterprising bodies in England.

I now come to the very last subject I propose to speak upon, and that is

PRINTING MACHINERY,

and especially as applied to the printing of newspapers. In 1831, we had the steam press sending out a few hundred copies in an hour, and doing that upon detached sheets, and thus many hours were required for an edition of some thousands. The only way of expediting the matter would have been to have recomposed the paper, involving, however, double labor to the compositors, and a double chance of error. At the present day, we have, by the Walter press, the paper printed on a continuous sheet at a rate per hour at least three times as great as that of the presses of 1831, and, by the aid of *papier mâché* moulds, within five minutes from the starting of the first press, a second press can be got to work from the stereotype plates, and a third one in the next five minutes; and thus the wisdom of our senators, which has been delivered as late as three o'clock in the morning, is able to be transmitted by the newspaper train leaving Euston at 5:15 A. M.

This is the last matter with which I shall trouble the Section. I have purposely omitted telegraphy; I have purposely omitted artillery, textile fabrics, and the milling and preparation of grain. These and other matters I have omitted for several reasons. Some I have omitted because I was incompetent to speak upon them, others because of the want of time, and others because they more properly belong to Section A.

I hope, sir, although your address, dealing with the future, was undoubtedly the right address for a president to deliver, and although it is equally right that we should not content ourselves with merely looking back in a "rest-and-be-thankful" spirit at the various progress which this paper records, it may nevertheless be thought well that there should have been brought before the section, in however cursory a manner, some notice of mechanical development during the past fifty years.

[Continued from SUPPLEMENT, No. 311, page 4954.]
AMATEUR MECHANICS.

METAL TURNING.

In selecting a lathe an amateur may exercise more or less taste, and he may be governed somewhat by the length of his purse; the same is true in the matter of chucks; but when he comes to the selection or making of turning tools

In the engraving accompanying the present article a number of hand turning tools are shown, also a few tools for the slide rest. These tools are familiar to machinists and may be well known to many amateurs; but we give them for the benefit of those who are unacquainted with them and for the sake of completeness in this series of articles.

Fig. 1 is the ordinary diamond tool, made from a square bar of steel ground diagonally so as to give it two similar cutting edges. This tool is perhaps more generally useful than any of the others. The manner of using it is shown in Fig. 23; it is placed on the tool rest and dexterously moved on the rest as a pivot, causing the point to travel in a circular path along the metal in the lathe. Of course only a small distance is traveled over before the tool is moved along on the rest. After a little experience it will be found that by exercising care a good job in plain turning may be done with the tool.

Fig. 2 shows a sharp V shaped tool which will be found useful for many purposes. Fig. 3 is a V shaped tool for finishing screw threads. Figs. 4 and 5 are round-nosed tools for concave surfaces; Fig. 6, a square tool for turning convex and plane surfaces. The tool shown in Fig. 7 should be made right and left; it is useful in turning brass, ivory, hard wood, etc. Fig. 8 is a separating tool; Fig. 9 is an inside tool, which should be made both right and left, and its point may be either round, V shaped, or square. Fig. 24

TURNING TOOLS.

he must conform to fundamental principles; he must profit as far as possible by the experience of others, and will, after all, find enough to be learned by practice.

Tools of almost every description may be purchased at reasonable prices, but the practice of making one's own tools cannot be too strongly recommended. It affords a way out of many an emergency, and where time is not too valuable, a saving will be realized. A few bars of fine tool steel, a hammer, and a small anvil, are all that are required, aside from fire and water. The steel should be heated to a low red, and shaped with as little hammering as possible; it may then be allowed to cool slowly, when it may be filed or ground to give it the required form. It may now be hardened by heating it to a cherry red and plunging it straight down into clean cool (not too cold) water. It should then be polished on two of its sides, when the temper may be drawn in the flame of an alcohol lamp or Bunsen gas burner; or, if these are not convenient, a heated bar of iron may be used instead, the tool being placed in contact with it until the required color appears. This for tools to be used in turning steel, iron, and brass may be a straw color. For turning wood it may be softer. The main point to be observed in tempering a tool is to have it as hard as possible without danger of its being broken while in use. By a little experiment the amateur will be able to suit the temper of his tools to the work in hand.

shows the manner of holding an inside tool. Fig. 10 is a tool for making curved undercuts. Fig. 11 is a representative of a large class of tools for duplicating a given form.

These figures represent a series of tools which may be varied infinitely to adapt them to different purposes. The user, if he is wide awake, is not long in discovering what angle to give the cutting edge, what shape to give the point, and what position to give the tool in relation to the work to be done.

Having had experience with hand tools it requires only a little practice and observation to apply the same principles to slide rest tools.

A few examples of this class of tools are given. Fig. 12 is the ordinary diamond pointed tool, which should be made right and left. The cutting edge may have a more or less acute angle, according to the work to be done, and the inclined or front end of the tool may be slightly squared or rounded, according to the work. Fig. 13 is a separating tool, which is a little wider at the cutting edge than anywhere else, so that it will clear itself as it is forced into the work.

For brass this tool should be beveled downward slightly. By giving the point the form shown in Fig. 3 it will be adapted to screw cutting.

Fig. 14 shows an inside tool for the slide rest; its point may be modified according to the work to be done. Fig. 15