gray. With the machine, however, this causes no increase of labor to the men, and only increases the time of the process.

"When the iron begins to thicken, or, as it is termed, is 'coming to nature,' the machinery is disconnected without stopping it, by simply knocking out the cotter that fixes the upper end of the vertical working arm; the arm then drops out, leaving the furnace door entirely clear for the puddler to ball up the iron, which is done exactly in the same manner as in ordinary puddling furnaces, without the man being in any way inconvenienced by the machinery continuing at work overhead.

ECONOMICAL RESULTS.

"The machine is applied to ordinary single puddling furnaces without any alteration being required in the furnace, the frame of the apparatus being merely attached to the top of the furnace. The double furnace is preferable, however, as it effects a great economy in the consumption of fuel, as compared with a single furnace, and puddles double the quantity of iron in the same time. With the single furnaces at the writer's works, and charges of 5 cwt., the consumption of coal is 28 cwt. per tun of puddled bar made; but with the double furnace and charges of 10 cwt., the consumption of coal is only 17 cwt. per tun of puddled bar, being a reduction of 39 per cent. The number of heats or charges worked in the single furnace is six heats of 5 cwt. each, and, in the double furnace, five heats of 10 cwt. each, per turn of from nine to ten hours. In working the double furnace it is found best to have one puddler only and two underhands, to avoid the division of responsibility that would arise in the case of two puddlers working the same charge of iron.

"The yield of iron in working 5-cwt. charges in the single furnaces is 12 cwt. 2 qrs. 81 lbs. per tun of pig, or 93½ per cent, and with the double furnace working 10-cwt. charges, the yield is 18 cwt. 2 qrs. 9 lbs. per tun of pig, or 93 per cent.

SIX MONTHS' EXPERIENCE.

"Mr. W. Fisher, manager of Mr. Bennett's works, said, in answer to inquiries, that the puddling machines had now been at work constantly during the day for the last six months at the Wombridge Iron Works, and continued to work as well now as they did when they were first started; and there had been no occasion to repair any of the working parts since then, as the machines had been found very simple and strong. A man went round twice a day, and put a little oil on morning and evening; and they could be worked night and day when desired. At first there had been a little difficulty in introducing the machine; but now the men felt its advantage, and were anxious to have it employed on night work also.

"The six months' experience of the working of the machine had shown that 5 cwt. of iron had been puddled by it in the time that a man would take to puddle 4 cwt.; and it was also found that the machine made a great improvement in the quality of the iron. This was accounted for by the fact that, while in hand puddling there was the liability of the underhands frequently neglecting their work, the machine went steadily on, working the tool constantly to and fro in the furnace, without any intermission, and kept the iron well stirred during the whole time that the work was required to be put into it. The consequence was, that very seldom was a bit of raw iron seen from the puddling furnaces worked by the machine; and the puddling bars were very seldom found to break off short in the rolling, unless the iron were a little too hot. In the heavy operation of puddling, it was impossible for any puddler to stand up to his work as the machine did, since the machine never tired, but kept on steadily at the work without rest, and at a quicker rate of working than in hand puddling. By using the machine to do the heavy part of the work, it was only required for the puddler occasionally to disengage the tool and draw the iron from the sides of the furnace into the center, leaving the machine during the rest of the time to perform its work alone. When the iron was ready for balling up, the puddler came fresh to the work; and from the men being relieved of the severest part of the labor, the furnaces worked by the machine turned out about 5 cwt. at each heat, and six heats during the day, with the same quantity of fuel as was used for ordinary heats only 4 cwt. in hand puddling, with six heats per day. The average result of the day's work with the machine was about 28¾ cwt. of puddled iron from 30 cwt. of pig iron, as compared with about 22¼ cwt. of puddled iron from 24 cwt. of pig iron, by hand puddling. The improvements effected by the machine were, therefore, that it produced a better quality of iron, with a decreased consumption of fuel, and turned out more iron in the same time. The machine did not interfere with the wages of the underhands, as they had to be employed the same as without the machine; whilst the puddler's wages were increased by his being enabled to turn out more iron in the same time."

APPLICATION OF THE SPECTRAL ANALYSIS TO ASTRONOMICAL PHENOMENA.

This was the subject of an inaugural address delivered on the 25th of September, to the Midland Institute, by the President, Lord Wrottesley. As this is the most sublime discovery of the century, the brief history of its progress given by Lord Wrottesley may be interesting.

HISTORY OF THE DISCOVERY.

The celebrated German optician, Fraunhofer, had perceived that the solar spectrum was crossed at right angles to its length by dark bands. Fraunhofer published a description of these, accompanied by a map, in which he represented more than 600 of these lines. Finding that they always occupied the same invariable position on the spectrum, he designated the more important by letters of the alphabet, and the lines so designated still bear his name; thus we say, the line D of Fraunhofer, and so forth. But Sir D. Brewster and M. Kirchhoff have discovered that more than 2,000 of these dark lines exist in the solar spectrum. Fraunhofer observed that when the source of light was changed a different set of lines appeared; but he discovered nothing more. He was unable to account for the appearance of these lines, and, probably, was very far from suspecting the significant part which they would play in future discoveries. Sir David Brewster, and subsequently Professors Miller and Daniell, discovered that certain colored vapors had the power of absorbing the sun's rays, and producing a series of dark bands in the light transmitted through them. In 1822, Sir John Herschel described the spectra of muriate of lime, nitrate of copper, and other substances; and in 1827, in his article on "Light," he states "that the salts of soda give a copious and purely homogeneous yellow, those of potash a beautiful pale violet. The colors thus communicated by the different bases to flame afford, in many cases, a ready and neat way of detecting extremely minute particles of them." Chloride of sodium, or common salt, is so extensively diffused in nature, that it is difficult to procure a spectrum without the line which denotes its presence. The mere stroke of the hand on a garment will throw molecules of this substance into the atmosphere of the laboratory, and thereupon this intensely yellow line immediately appears. In 1835 Wheatstone examined various spectra produced by the electric spark, and in his report to the British Association in that year he says:—"The spectrum of the electro-magnetic spark, taken from mercury, consists of seven definite rays only, separated by dark intervals from each other. These visible rays are—two orange lines close together, a bright green line, two bluish green lines (near each other,) a very bright purple line, and, lastly, a violet line. The spark taken in the same manner from zinc, cadmium, tin, bismuth, and lead, in the melted state, gives similar results; but the number, position, and colors of the line vary in each case. The appearances are so different that by this mode of examination the metals may be readily distinguished from each other" It was by experiments of this kind that the new metals, cœsium and rubidium, were discovered by Kirchhoff and Bunsen. The two lines of cœsium in the blue may be seen, when a quantity of the chloride of cœsium not exceeding 1-170,000 of a grain of the pure salt is thrown into the flame by which the spectrum is produced. A distinguished French savant, M. Foucault, to whom I had the pleasure of presenting the Copley medal of the Royal Society in 1855—M. Foucault, in 1849, wrote as follows:—"I caused a solar image, joined by a converging lens, to fall upon the (voltaic) arc itself, an arrangement by which I was able to observe simultaneously the superposed solar and electric spectra; and I observed myself in this manner, that the double brilliant line of the arc coincided exactly with the double black line D of the solar light." Here we have the germ of that glorious discovery, which, if it be completely established, will constitute a new era in astronomy. But M. Foucault failed to perceive the full significance of the words he had traced. Our sun is surrounded by a vast luminous atmosphere, called the photosphere, which envelopes a solid or liquid nucleus; and, arguing from analogy, we may presume that the stars are so formed also. They must at all events be self-luminous bodies, or their light could never reach us. We have now gone through all the preliminary matter, which it was necessary to state before I even attempted to give you some idea of the nature of the method by which we believe we have arrived at that astounding piece of knowledge—the knowledge of many, at least, of the elements of which the sun and stars are composed.

KIRCHHOFF'S THEORY.

The theory is due to the distinguished German philosopher, Kirchhoff, above mentioned. It is stated as follows by Professor Miller:—"The spectrum produced by the ignition of a solid or liquid always yields a continuous band of light, containing rays of all degrees of refrangibility within the range of its two extremes; but the same body, when converted into vapor, may produce a luminous atmosphere, which may emit rays of certain definite refrangibilities only, so as to produce a spectrum consisting of a series of bright bands of particular colors, separated from each other by intervals more or less completely dark. * * * And the same substance, vapor, or gas, has the power of absorbing rays of these identical refrangibilities"—that is, rays whose vibrations are in harmony with their own. "Now, Kirchhoff supposes that in the luminous atmosphere of the sun the vapors of various metals are present, each of which would give its characteristic system of bright lines; but behind this incandescent atmosphere, containing metallic vapor, is the still more intensely heated solid or liquid nucleus of the sun, which emits a brilliant continuous spectrum, containing rays of all degrees of refrangibility. When the light of this intensely heated nucleus is transmitted through the incandescent photosphere of the sun, the bright lines which would be produced by the photosphere are reversed (that is to say, extinguished); and Fraunhofer's black lines are, therefore, the reversed bright lines of which the spectrum, due to the gaseous atmosphere of the sun, would consist, if the intensely heated nucleus were no longer there." This beautiful and most fascinating theory, rife in important results, has not, I believe, been yet universally received, on the ground that it does not explain facts known respecting the vapors of hydrogen and some others; but this has been the fate of all theories, and pre-eminently that of the wave theory of light, which, after a time, was found in harmony with many facts, which at first appeared fatal, and ended by suggesting experiments which proved its truth, and which otherwise had never been made.

KIRCHHOFF'S EXPERIMENTS.

Kirchhoff constructed a delicate apparatus by which the solar spectrum and the spectra given by the various metals could be compared together, and thus he discovered that the dark line, B, in the orange of the solar spectrum corresponds to a line given by the spectrum of potassium; in like manner C in the orange corresponds to hydrogen; D in the yellow to sodium; E in the green to iron; *b* in the green to iron and magnesium; F in the green to strontium (?), iron and hydrogen; G in the blue to iron; H in the violet to calcium. It must be borne in mind, however, that many of the metals have a great many other lines which characterize their spectra in addition to those above named. Thus, iron has seventeen such lines, magnesium three, and chromium three, in the small space contained between E and *b* of the spectrum. By observations of this kind diligently, carefully, and skillfully carried on—that is to say, by a comparison of the bright lines in the spectra of various metals with the dark lines of the solar spectrum, Kirchhoff concluded that the following metals were present in the sun's atmosphere, viz., potassium, sodium, magnesium, calcium, iron, nickel, chromium, manganese, and perhaps cobalt; and Angstrom believes that he has discovered in the blue and violet extremity hydrogen and aluminium, and perhaps strontium and barium.

OTHER EXPERIMENTS.

Fraunhofer, in 1823, and Donati, in 1862, had described the spectra of a few stars; but more recently Professor Miller and Mr. Huggins have constructed an instrument with which they have compared the spectra of the moon and planets and some of the fixed stars, and even of the nebulæ with the spectra of the principal metals. Professor Phillips, in his late address, thus describes the results of the observations of the spectra of the moon and planets:—"In the moon and Venus no lines are found due to the atmosphere. In Jupiter and Saturn, besides the lines identical with some produced in our own atmosphere, there is one in the red that may be caused by the presence of some unknown gas or vapor. Enough is ascertained in the case of Mars to discountenance the notion of his redness being due to a peculiarity of the soil." The observations of the spectra of the stars and nebulæ are attended with very great difficulty. Professor Miller and Mr. Huggins, in their paper in the "Philosophical Transactions" of 1864, say that "their light, even when concentrated by an object glass or speculum, is found to become feeble when subjected to the large amount of dispersion which is necessary to give certainty and value to the comparison of the dark lines of the stellar spectra with the bright lines of terrestrial matter. Another difficulty, greater because it is, in its effect upon observation, more injurious, and is altogether beyond the control of the experimentalist, presents itself in the ever-changing want of homogeneity of the earth's atmosphere, through which the stellar light has to pass. On any but the finest nights the numerous and closely-approximated fine lines of the stellar-spectra are seen so fitfully that no observations of value can be made." The telescope employed was a refractor, of 8 inches aperture and 10 feet focal length.

THE RESULTS SO FAR.

The results of these observations up to September, 1864, so far as they regard the stars and nebulæ, may be shortly described as follows:—Owing to the great difficulties above alluded to Messrs. Miller and Huggins are only enabled to present satisfactory results, at least actual increases, in the case of three stars. The spectrum of Aldebaran, a pale red star, has been compared with the spectra of sixteen terrestrial elements; and this star has been found to contain sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury. The spectrum of *a* Orionis, an orange star, is described as the most complete and remarkable yet examined. Strong groups of lines are visible, especially in the red, the green, and blue portions. It has been compared also with the spectra of sixteen elements, and the star found to contain sodium, magnesium, calcium, iron, and bismuth. The spectrum of B Pegasi, a fine yellow star, is closely analogous to that of *a* Orionis. It was compared with the spectra of nine of the terrestrial elements, and the star was found to contain sodium and magnesium, and, perhaps, barium, but, owing to the faintness of the star, and the unfavorable state of the atmosphere, the observations of this star are not so satisfactory as the foregoing. The absence of lines corresponding to hydrogen in the spectra, both of *a* Orionis and B Pegasi, is considered a matter of great interest, "as the lines C and F are highly characteristic of the solar spectrum, and of the spectra of by far the larger number of the fixed stars which have been examined;" and these exceptions seem to prove that those two lines are due to the luminous bodies themselves, and not to the earth's atmosphere. Sirius contains sodium, magnesium, hydrogen, and perhaps iron; *a* Lyræ, sodium, magnesium, and hydrogen. Capella, Arcturus, Pollux, *a* Cygni, and Procyon, all contain sodium, and Pollux magnesium also, and iron; but the observations of these five stars were incomplete at the data above-mentioned. Many other stars had been examined, but their spectra had not been compared with those of the terrestrial elements; all this spectra, however, exhibit numerous lines.

THE SPECTRA OF THE NEBULÆ.

The spectra of the nebulæ are most remarkable, and of great interest to astronomers, owing to the results of their examinations bearing upon what is termed the nebulæ hypothesis, a theory which assumes that all stellar systems, our own included, have been formed from nebulous matter by gradual condensation. Nebulæ, or cloud-like masses of light, had, in some cases, been proved to consist of a cluster of stars closely packed together, by observations made with large telescopes; that is, in the language of astronomers, they had been resolved. Other nebulæ could not be resolved by less powerful telescopes, but had yielded to the superior power of the gigantic reflector of Lord Rosse, and thus it was rendered probable that all these nebulæ consisted of clusters of stars, and that if we both possessed telescopes of greater power, and our atmosphere would permit us to utilize them, they might all be resolved; but the observation of their spectra goes far to refute this assumption. Mr. Huggins commenced by observing the planetary nebulæ—that is, nebulæ which appear circular or oval, and present disks like planets. On examination it appeared that the light of these nebulæ, unlike any other celestial light which had been analyzed by observation of the spectrum, was not composed of light of different refrangibilities, and, therefore, could not form a spectrum. It is for the most part of one color, and after passing through the prisms remains concentrated in a bright line, occupying in the instrument the position of that part of the spectrum to which it corresponds in refrangibility. A more careful examination with a narrow slit, however, showed that, a little more refrangible than the bright line, and separated from it by a dark interval, a narrow and much fainter line occurs. Beyond this again, at about three times the distance of the second line, a third exceedingly faint line was seen. The strongest line coincides in position with the brightest of the air lines, and is situated about midway between *b* and F of the solar spectrum, and is due to nitrogen. The faintest line of the three coincides with F, the line of hydrogen. Sometimes a fourth excessively faint line is seen, as much more refrangible than the line at F, as the latter is more refrangible than the brightest line. Sometimes a faint continuous spectrum appears, due to a bright central point; and sometimes, as in the case of the dumb-bell nebula (4,532 in Herschell's catalogue), only the one brightest line is seen. The appearances above described show that the nebulæ from whence they are derived can no longer be regarded as aggregations of suns of the type of our own. They, or at least their exterior envelopes or photospheres, are probably enormous masses of luminous gas or vapor, for matter in the gaseous state alone emits light of certain definite refrangibilities only. It is noted as a remarkable circumstance that only one of the lines due to nitrogen is seen; and Mr. Huggins concludes his paper with the important and suggestive remark that this may denote a form of matter more elementary than even nitrogen, which chemical analysis has hitherto failed to detect. It is observed by the authors of these valuable communications to the Royal Society, and it is a remark which cannot fail to make a very deep and lasting impression on all inquiring minds, "that the elements most widely diffused through the host of stars, are some of them most closely connected with the constitution of the living organisms of our globe, including hydrogen, sodium, magnesium, and iron. These forms of elementary matter, when influenced by heat, light and chemical force, all of which we have certain knowledge are radiated from the stars, afford some of the most important conditions which we know to be indispensable to the existence of living organisms, such as those with which we are acquainted. On the whole, we believe that the foregoing spectrum observations on the stars contribute something toward an experimental basis on which a conclusion, hitherto but a pure speculation, may rest, viz.: that at least the brighter stars are, like our sun, upholding and energizing centers of systems of worlds adapted to be the abode of living beings.

Shot-making in New York.

One of the most interesting manufactures which this busy city of ours presents to the inquiring mind is that of shot-making, of which most people have no other idea than an indistinct one of a huge and lofty tower through which melted lead falls into a water-pit at the bottom.

A visit to the establishment of the New York Lead Co., on Centre street, will disclose all the details of this interesting process. The brick tower is some thing less than 200 feet in hight and about 60 or 70 in circumference. At the bottom is a well of cold water, and the summit is entirely devoted to the melting machinery—the pan or sieve through which the shot falls being situated in the center and quite small, say a foot and a half in diameter. The lead is conveyed to the summit in pigs or bars, and there melted. Before being poured into the pan it is slightly mixed with crude arsenic, to prevent oxydation. Much of the lead, in passing through the holes of the sieve, comes out in elongated drops, in the same way as the dripping of water, thus causing imperfect shot, which are increased by the soft shot touching each other in falling, and adhering together.

Standing on the ground floor of the tower, the shot can be seen and heard falling and hissing into the well beneath, the water of which is splashed up high as it receives the driving, seething rain.

From the well, the shot is transferred to a drying machine, lightly rolled by hot flannel rollers, and, after being thoroughly dry, it passes through the next process, which separates the imperfect from the perfect shot. This consists of a long, smooth, wooden inclined plane, divided into regular ledges, each one a little lower than its predecessor, with a slight break or open space of about half an inch between. The round, perfect shot, in rolling down this plane, leap the openings, while the imperfect, not having the same momentum, fall through, and are gathered up to be re-melted.

The next process is separating the different sizes. This is done by a sort of chest of drawers, the top of each drawer being covered by a sieve—the coarser at the top, and thence becoming finer toward the bottom. This cabinet is kept in a swinging motion to and fro by machinery, thus shaking the mixed shot, which is poured in at the top, from drawer to drawer, until all the different sizes are duly assorted into separate drawers.

The shot has now a dull, dusty color, the finer grades appearing more like sand or black meal than a mass of separate and uniform globules; and the next operation is to polish. This is performed by putting it into revolving cylinders, with black lead, and from which the shot is at length projected, bright and shining as beads of glass. It is next put in bags, and is ready for shipment.

The shot business is now very brisk. More is shipped at the present time than for a number of years past. During the war a large business was done in Minie balls, or slugs, hollowed at the but. The trade is now almost altogether in shot, not including the three sizes of buck-shot, which are molded like bullets.

There are four shot towers in New York and vicinity, viz:—The New York Lead Co., Centre street; Tatham & Brother, Beekman street; T. O. Leroy, Water street, and McCullough's Lead Co., Staten Island. The capacity of all these works is very nearly equal, that of the former being from ten to fifteen thousand pounds of shot per day—or a total of forty to fifty thousand pounds.—*N. Y. Tribune.*

A Singular Casualty.

Some three years since, one of the engines of a construction train on the Louisville and Nashville Railroad needed some attention. The engineer ordered Jerry Collins, a common laborer on that road, to go under the engine while it was standing still, but while steam was up, and fasten some screws on the lower side of the engine. Collins obeyed, and while lying on his back with his face toward the bottom of the engine, the engineer, who was at his post on his engine, either carelessly or purposely touched the lever, and allowed steam enough to pass into the cylinder to cause the engine to start. The motion of the wheel instantly cut off one of Collins's legs. A bystander told the engineer of the injury he had inflicted by the forward motion of the engine, when he immediately reversed the motion and run the engine back so far that it cut off Collins's other leg. Being thus made a cripple for life, Collins brought suit in the Circuit Court at Bowling Green, Ky., for $50,000 damages. He recovered a judgment against the Road for $5,500

THE solar heat in a year is sufficient to melt a coating of ice spread over the globe 46 feet thick.

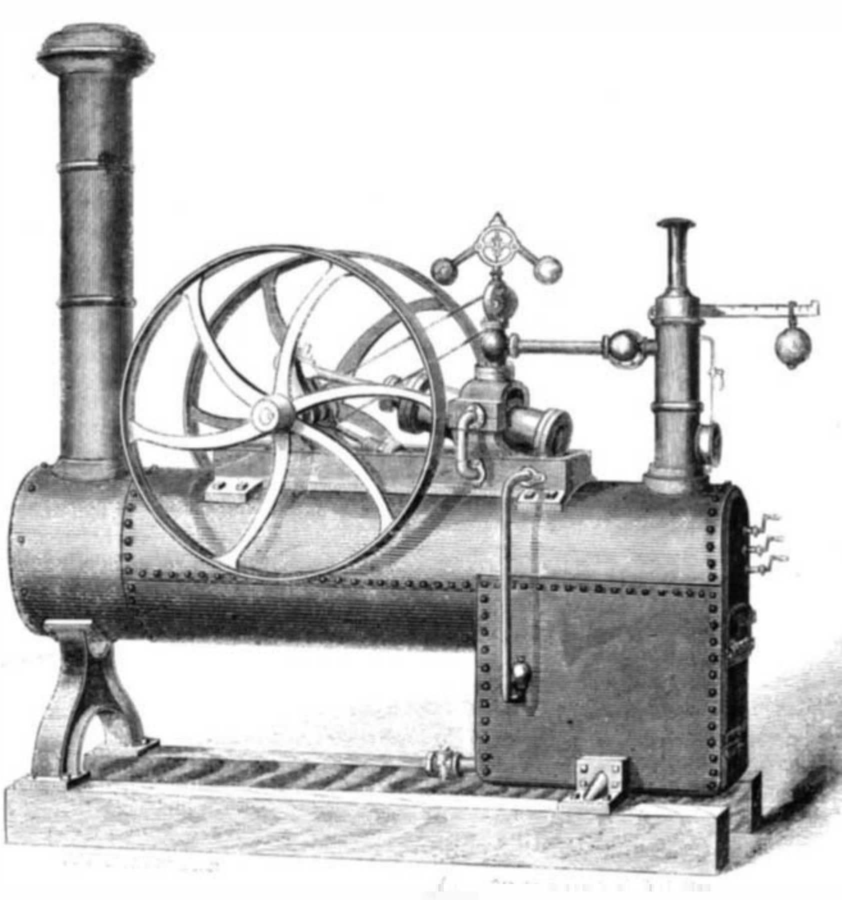
Improved Portable Engine.

This engine is the invention of Mr. Henry T. Carter, and was pateneed through the Scientific American Agency on the 25th of July, 1865. The advantages consist in obviating the leakage of steam from the trunnion, and the simplicity and durability of its working parts. Most of the oscillating engines that have been presented to the public have been constructed so as to take the steam by means of a friction joint on the trunnion or elsewhere. The cylinder, or plate, is kept in its position by means of powerful set screws and springs. These agents are inefficient, and the engine, after a short time wearing, leaks steam. This engine has a tight steam chest and slide valve, so there is no more possibility of its leaking than any slide valve engine. The valve is moved by means of a link and the oscillation of the cylinder. For further particulars of the valve gear we would refer the reader to No. 9 of the present volume of the SCIENTIFIC AMERICAN.

The boiler is made of the best material, and the workmanship of the engine is unsurpassed. These engines are made to reverse, when ordered, and are put upon wheels at a little advance of the regular prices.

The strength of the working parts and the lightness of the engine, insures that point which is so desirable in portable engines—safety in transportation.

The prices are very reasonable, and will no doubt attract the attention of parties wishing a good engine. These engines, as well as stationary ones of the same patent, are manufactured by the Winslow Machine Works, Portland, Maine.



CARTER'S PORTABLE ENGINE.

HOW AMERICAN LOCOMOTIVES ARE MADE.

In the SCIENTIFIC AMERICAN, page 259 of the current volume, we gave an article from an English cotemporary, which treated at some length on the great locomotive manufactory at Crewe, England, and the processes, or, rather, methods, by which the designs and details are carried out. It must have struck the American mechanic that some of the plans therein set forth were "melancholy and slow," or, in other words, not what we should have expected from a great factory where three thousand men are employed, and where millions of dollars must be invested. It may be pardoned in a small machine shop, where there is a lack of capital, if the proprietor thereof sees fit to plod on in the old and not good way, when there are tools and methods in existence far ahead of those rude ones he sees fit to make use of, but it is not a sign of progress that machines are built to square bolt holes in flanges, or to straighten copper bolts for fire-box stays. All this is just so much time wasted, and attention might better have been directed how to dispense with the square holes, and, consequently, the machine to make them, or the substitution of some other material than copper, which would be equally as good.

The great competition in locomotive building in this country has made a resort to system, or fixed plan of procedure, a matter of necessity. There are no less than twenty noted establishments where quantities of engines are turned out, to say nothing of lesser ones, and repair shops, which do a great deal toward renovating and rebuilding engines. In the best of these large shops the same principle is pursued as in the manufacture of Colt's pistol, or a Springfield rifled musket; that is to say, every engine of its class is exactly like its predecessor, and a cylinder could be made and fitted to a locomotive any where with the certainty that it would be right as to its center from the frame, right as to its position on the frame, and of the same dimensions in other respects to insure its proper working.

One of our locomotive shop superintendents, on reading the article on the English locomotive works referred to, said "we could not do much here building engines in that way."

The Jersey City Locomotive Works is a representative shop, and we shall proceed to give some account of the manner in which the principal details are there executed, such as the cylinders, the frames, the drivers and connections. Other parts we are not able to allude to.

THE FRAMES.

These are in two parts for convenience of handling; that is to say, the section which carries the cylinders is bolted to the section on which the pedestals of the driving-wheel boxes are forged. The frames are laid on the planer and faced off, and two sets are thus going on at the same time; the cross-head of the planer being wide enough to carry two tool stocks. The frames are all planed to hardened steel gages, so that the distances and dimensions prescribed by the draftsman are arbitrarily preserved. The pedestal sections are laid one on top of the other on a slotting machine, where the jaws are slotted out together, so that the dimensions and lengths are correct beyond cavil. The two parts, the cylinder sections and that just named, are also bolted together at a fixed distance, so that when the frames are set up they are identical—the bolt holes for the cylinders, brackets, etc., having all been drilled on a press beforehand. On the frame there is a shoulder which the back end of the cylinder flange is fitted against; this shoulder is faced accurately on the planing machine a set distance from the center of the pedestal, and when the cylinder is bolted in place a key is driven in behind it on the forward side, so that it is fast between two solid wrought-iron shoulders, on a solid forging, and can never be displaced or be out of truth.

THE CYLINDERS.

The cylinders are not bored in pairs as in the English works, nothing being gained by that operation as locomotives are here made. They are bored singly, on a machine constructed purposely by Hewes & Philips, of Newark, N. J. The machine consists of a cast-iron bed with a platen laid on top of it. On each end of the bed are two vertical columns which carry shafts, to which boring bars or heads are attached. The cylinder can thus be set on its own bottom as it was planed, and moved any where by means of screws, to be bored accurately. The boring heads are also adjustable by moving a handle, so that in a very few minutes the cylinder can be put in the machine, secured and set; this also by any ordinary workman. The cylinders are faced on the flanges, and turned outside of the same before they are moved from the boring mill.

The cylinders, when on the engine, are bolted to the saddle piece on which the fore end of the boiler rests; they have, therefore, a vertical flange which must be faced off true with the bore. To do this the planing machine is fitted with coned centers—the cones being the diameter of the bore—16 or 18 inches, as the case may be. The cone centers, having been once set, any number of cylinders can be put in and planed off without loss of time in adjusting them.

Moreover, the vertical flange that rests against the saddle, and the valve face, are both planed at one operation, and the cuts are not mincing ones, but the tool takes a good solid chip at first, so that the work is well and speedily done. When the cylinders are bolted to the saddle they are correct, and there is no heavy handling to be done. Formerly, when the cylinders were bolted to the sides of a square smoke box, they were frequently out of center; that is to say, the cylinder had to be made to suit the smoke box of the boiler, and, as it was obviously impossible to rivet that on within a hair's-breadth, much delay ensued. The crank pins could not be turned until it was known where the cylinders were. They were sometimes a sixteenth of an inch in or out, and the shoulders of the pins had to be faced accordingly. All this delay is obviated by the simple means alluded to.

THE DRIVING WHEELS.

The lathe in which the driving wheels are turned is a remarkable machine, and is built by Messrs. Bement & Dougherty, of Philadelphia, Pa., with some additions by Mr. Davis, the efficient superintendent of the Jersey City Locomotive Works.

The wheels are of cast iron, and are mainly completed at one operation; that is to say, at one setting in the lathe, all except the crank pin holes, which are bored in a special machine. The outside or tread of the wheel, the hole for the axle and facing off the hub, are all going forward at the same time. Two wheels a day are turned out complete. Before the wheel is taken off the lathe, the key seat is cut in it by a special attachment. A seat one and an eighth inches wide, and half an inch deep and in length—the depth of the hub—is cut in ten minutes, on an average. In no instance do the cranks exceed one-sixteenth of an inch deviation from being at right angles. The axles are also cut as to their key seats, and when the two parts come together they stay there; there is no fitting and filing, no backing the wheel off, no key seats to be chipped and filed, as in some works. All this is an immense saving of time, while in point of workmanship the quality is unsurpassed.

DETAILS.

In no department of the machine shop can skillful management be shown to better advantage than in the details—in the picking up of the loose ends, so to speak, and the small processes which waste time and add, in no respect, to the value of the work.

In days bygone it was a distinction, coveted by many workmen, to fit up the connecting rods, and all such details as had gibs and keys and brasses. There was