After having been examined as to its exterior appearance, the ingot is taken without delay into a heating furnace, heated to a uniform good yellow heat, and hammered or rolled out to a rectangular or quadrangular bar of not over a square inch in section. This bar is cut instantaneously in pieces of one and a half or two feet in length, and the pieces are brought over to a small forge, there to be tested by a blacksmith. If there is no bar mill nor steam hammer at the works, the ingot, being made of a smaller size, is to be treated at the small forge exclusively.

The fuel used in the small forge for the following operations should be charcoal. If mineral coal is used it must be carefully selected so as to be free from pyrites and other minerals or compounds containing sulphur.

TESTING.

Testing has for its object to discover if the metal is of a good or bad quality in general as well as to investigate its special qualities and aptitude. It is done by forging, hardening and welding: to which three kinds of manipulations there may afterwards be added experiments in relation to the tensile strength and the chemical composition of the metal. The three first-named simple operations will be sufficient, however, for the ordinary and regular testing and classifying of the metal produced by each charge.

FORGING.

Forging is done by heating one or several pieces of the metal in a smith's fire to a good yellow heat, and by hammering, working and distorting it in different ways to show the malleability, the toughness and the equality of structure in the metal. This can be done by all the ordinary kinds of blacksmith operations. A very good way to show the two last-named qualities of the metal, I consider to be the following forging operation: Forge a bar about one-eighth inch thick and one-half inch broad. Cut one end straight off, and split the bar in this place and in the middle of its width to a length of one inch or more ; bend the two separated parts around on both sides, and make a large round hole in the middle of the intact part of the bar, very near the end of the split, so as to present the succession of shapes, C, D, E, as shown in Fig. 3. If the metal at e, in the top of E, gets very thin by extending the hole, without cracking through to the split, the metal is proved to have a high degree of toughness and a very uniform structure, equal in different directions. An ordinary and well-known testing operation, which should never be omitted, is to bend a bar similar to the one above described in several different places, and to hammer the bent parts close together, to see if the metal is liable to crack by bending. The shape of the bar, produced by this operation, is represented at F, Fig. 3.

Every good kind of metal should withstand these two trials without injury. If not, it is not blown enough, or two much, or it contains chemical impurities. In all these or similar operations, at first to be made, great care has to be taken that the temperature of the metal never exceeds a good yellow and never decreases below a dark yellow heat. For in both these instances the metal, being steel-like and perhaps of an excellent quality for many purposes, may crack, owing to the improper temperature. If the bar cracks more or less easily at the yellow heat, it has to be tried afterwards at a white welding heat, and if it keeps good in this state, it shows that the metal is a kind of inferior wrought iron. In all cases the metal has to be tested by simply hammering it at a red heat to see if it is inclined to be red-short.

HARDENING.

Hardening, considered as a testing operation, is chiefly employed to discover if the metal is of a steely nature, because steel is capable of being hardened and tempered and wrought iron is not, or but very slightly. A bar half an inch square is prepared, heated in the smith's fire to a light red, and dipped in water till it is cold enough to be held in the hand. The bar is then laid across an anvil, and strokes are applied with a hand hammer on its free end till it bends or breaks. If the bar so treated does not bend at all, only giving way for a moment to the blow, instantly returning to its former shape by reason of its elasticity, and breaks at once by a harder blow, exhibiting an even or conchoidal fracture, fine-grained structure and bluish gray color, we have a hard kind of steel before us. If, on the contrary, the bar does not show any degree of hardness or elasticity after having been suddenly cooled in water, but gives way to each stroke applied to its end without returning to its original shape, and is so bent gradually to a right angle or further, showing, when finally broken, an uneven and fibrous structure and pretty dark color, the metal is wrought iron, and the results obtained in forging will show whether it is a good or a poor kind of iron. But most of the products of the Bessemer process are of a quality between the first mentioned and the last kind. Nevertheless these products, when free from chemical and mechanical impurities, prove useful and even very excellent for certain purposes, and therefore a well-determined classification of these different kinds of metal, as proposed hereafter, will doubtless be exceedingly valuable.

WELDING.

Welding, when tried with the metal, will serve to complete the tests of the qualities and the degree of usefulness of our Bessemer products.

A bar about half an inch broad and a quarter of an inch thick, is heated in the smith's fire, bent in the middle and hammered down, so that the two parts come together closely. It is then put back into the fire to be heated to a regular white welding heat, using some pure sand or powdered puddling cinders, hammered, cooled in water and broken. If the metal has the welding property in a high degree, as pure Bessemer metal generally has, the seam should not be at all visible in the surface of the fracture.

The result of this operation, however, very much depends on the skill and good will of the operating workman, and a good and reliable smith has therefore to be chosen for the purpose. If the metal is of the harder kinds, hammering has to be done with care and caution.

Welding of Bessemer metal is, in general, one of the most interesting and yet least understood points in this new branch of industry. Ordinary wrought iron welds better than ordinary steel, and corresponding with this fact it may be said that the softer kinds of Bessemer metal weld better generally than the harder ones. But even the hardest Bessemer product very seldom offers in welding so great difficulties as ordinary cast steel, and all steel-like kinds of it are, when compared with the corresponding kinds of steel made in the ordinary way, good welding materials. It occurs, however, not as a rare but a very strange fact, that metal of some one other Bessemer charge, independent of its other qualities, proves entirely unfit for perfect and reliable welding. I shall, perhaps, on some other occasion, communicate some observations on this subject. Remelting the pig iron used in the process, with the mode of doing it, seems to affect this property of the metal.

The three simple testing operations just explained are generally sufficient to determine very nearly the kind and the aptitude of the material produced by a Bessemer charge. However, the trial of the tensile strength and the chemical analysis of the metal are often of great importance too, and every Bessemer works should have the apparatus necessary for ascertaining them. But they require a longer time and may be done after the tests just described. The modes of conducting them are similar to those employed for other kinds of steel and iron.

It is also useful to carefully observe the color and qualities of the resulting slags. There will always be found a more or less visible connection between their appearance and the qualities of the metal, if one and the same kind of pig iron is used.

Science Familiarly Illustrated.

How to Draw an Ellipse in Isometric Projections.

J. Konvalinka, of Astoria, L. I., gives the following method for drawing an ellipse such as is required in perspective drawing for the representation of a circle ; where the three principal planes are viewed at equal angles and the side horizontals drawn at an inclination of 30°.

First, draw the two diagonals, A B, D E. Then with the radius of the circle, which is to be represented in perspective, describe the circle, A D B E. From the points, D and E, and with the radius of the circle mark on it the sextant and points, H H' I I'. Then draw the lines, D I, D I', E H, E H'. From the crossing points of these lines, F and ⦿, describe the arcs, i A h, and h' B i', which form the ends of the ellipse. These are then united by the arcs, h d h' and i e i', from the centers, E and D.
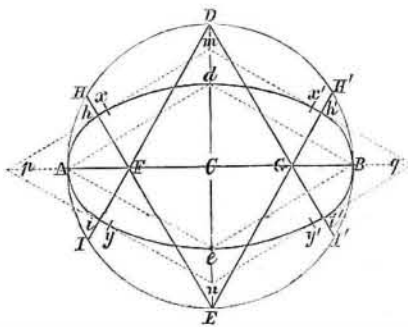
This will more closely and correctly represent an ellipse for the above-mentioned purpose than that shown in Fig. 2 on page 21 of the present volume of your journal. It will coincide in eight points with a true ellipse. Suppose A d B e A is a square, inscribed within, and p m q n p a square, circumscribed around the circle and represented in perspective. A d B e are four points. x x' y y', are other four points. These are the centers of the sides of the outer square, which at these points touch the ellipse as tangents. This will show how little the curve herewith represented differs from a true ellipse, and it also affords an easy means for correction by hand, if something more exact is required.

Correspondence.

The Editors are not responsible for the opinions expressed by their correspondents.

Action and Reaction---The Proper Unit of Measure for Force.

MESSRS EDITORS :—The interesting and instructive article in a recent number of your paper, by Prof. Seely, on the "Recoil of Guns," shows a great intimacy with the subject, and is practically valuable. I wish, however, to object to the doctrine therein advocated, that action and reaction are not always equal, and to the concomitant doctrine, which was advocated by the celebrated Leibnitz, that the force of a moving body is proportioned to the mass into the *square* of the velocity instead of the simple velocity.

Since the velocity of the gun is clearly shown to be to that of the ball, inversely in proportion to their respective weights it undoubtedly follows that if we admit the Leibnitzian measure of force to be correct, i. e, the mass into the square of the velocity, the force of the powder will, under this supposition, be expended *unequally* between the gun and the ball, that acquired by the latter being as many times greater as it is

lighter than the former. But the truth of this supposition is the real point at issue, and it was for many years the subject of a violent controversy between Newton and Leibnitz and between their respective followers. It was at last generally admitted that the dispute was one of definitions rather than facts, either party being in the right providing his definition of force, and of its mode of increase or *diminution*, could be admitted as true. Since that time the Newtonian measure, the mass into the velocity, has been generally adopted as the measure of the *quantity* of a force or a motion. Some attempts have been made to revive the Leibnitzian view of the subject, and Prof. Treadwell read an ingenious paper for that purpose before the American Academy at Boston, some years ago. The eminent mathematician, Prof. Peirce of this country, and the distinguished Dr. Mayer of Germany have also, though somewhat less decidedly, expressed themselves in favor of this revival. The difference in the two ways of estimating the quantity of force associated with a given body in motion, depends upon whether the *time* which elapses, or the *space* which is passed over, while the entire force of the moving body is imparted or overcome by a uniformly accelerating or retarding force, is made the coefficient of the unit of measure.

The Newtonian, and it seems to me, the true conception of the subject is this :—a uniformly acting force, like gravity at the earth's surface, for instance, will add equal increments of force to a body upon which it acts freely, in equal periods of time, and its entire force, since its velocity increases uniformly, is simply as its velocity, and not as the square of its velocity, for if unequal increments are added in equal times, then the cause must act variably, which is contrary to the supposition. The passage of a body through space is not an evidence of the *expenditure* of force, since a moving body, if unopposed, will traverse an infinite distance. A certain portion of the space traversed, then, has no relation to the expenditure of force, and it accordingly follows that the entire space is not a proper co-efficient of the force expended.

Suppose a person to walk with a certain uniform speed upon the deck of a steamboat. He will perceive no difference in the amount of effort required, whether the boat be stationary or in motion, or whether the direction in which he walks is the same as, or opposite to that of the boat's motion. But if the Leibnitzian measure of the entire quantity of force be correct, the force expended under the different circumstances must be widely different. If we suppose the boat's velocity to be 12 miles an hour, while the person walks at the rate of four miles in the same direction, the additional velocity thus attained will impart an increased amount of force beyond that attained by walking on a stationary boat in the proportion of 112 to 16, or 7 to 1. For the square of the walking velocity on a stationary boat is 4×4=16, while the force required to walk forward at the same rate of speed while the boat is in motion would be determined thus: The square of the velocity unincreased by walking would be 12×12=144, increased by walking, 16×16=256, the excess being 112 which is the Leibnitzian value of the different amounts of force in the two conditions. This discrepancy of theory with fact, is greatly increased when we consider the immense velocity of the earth in its motions around its axis and around the sun. The reasoning by which the attempt is made to overthrow the almost self-evident axiom of the equality of action and re-action also leads to the fallacy of applying a measure of one kind to estimate the quantity of something of an entirely different kind. While the product of the mass into the square of the velocity or the equivalent product of the uniform or average intensity of force into the *effective space* is a proper measure of other space products or space effects of the same kind, it does not follow that it is a measure of simple and absolute force.

The proper definition of force seems to me to be,—*that which when associated with water causes it to move*. No mode is known by which we can determine the *absoluteness* of rest or motion and no *practical* error, is found to arise in assuming that the motion of any given body is merely *relative*, or in considering the body as at rest, when referred to another body moving with the same velocity, and in the same direction. The above definition of force thus becomes sufficiently comprehensive to include all that causes *change* of motion whether by acceleration, retardation or change of direction. Since no error ensues from the assumption of the *relativity* of motion it follows that equal increments of force are added or subtracted, in equal units of time, when the velocity of a body is uniformly accelerated or retarded, and consequently that the measure of force in the body is found by multiplying the *mass by the velocity*.

I am, however, quite ready to admit that, while it is not the measure of absolute force, the product of the mass into the *square* of the velocity is the measure of *practical results*. All the operations of mechanics, and even of every-day life, consist in *overcoming resistances*, by which is meant, changing the positions or relative positions of bodies or parts of bodies where *effort* is required. This is called the *performance of work*, and is measured by the product of the resistance into the space through which it acts, or, what amounts to the same thing, the mass into the square of the velocity of the body doing the work. It includes what is called the penetration of bodies, and the overcoming of friction, or, in general, of any kind of resistance. The force acquired by a body falling one hundred feet in vacuum, will lift another body, if thus expended, to a height of one hundred feet or it will lift ten similar bodies to the height of ten feet, or one hundred similar bodies one foot, etc. Since the velocities attained by falling bodies must be squared to make them proportional to the distance fallen, it follows, that these *space effects* are proportional to the squares of the velocities of the gun and ball, are proved to be inversely as the masses, we readily perceive that equal quantities of force are acquired by the two, and that "action