grains of sand are thrown on the ends, in order to unite with the oxide necessarily formed on the heated scarfs, and to help the contact of two metallic surfaces. A good portion of the impurities is got rid of by striking the bars across the anvil; the surfaces are then brought together, united by a couple of heavy blows from the smith, when the work is finished by a rapid succession of blows from the "striker," or smith's assistant. The whole *rationale* of welding may be said to possess a peculiar interest at the present time, as there is practically much difficulty and extra uncertainty in getting sound welds in the steel which is now coming so extensively into use. Not very long ago a series of experiments were made at the Woolwich yard on a number of 1½ in. chains, made of various kinds of puddled steel and cast steel. The links broke at the weld, and with a lower stress than good cable bar iron. It thus becomes of the greatest importance to, if possible, get at some reasonable explanation of the process of welding. In the account we gave about a fortnight ago of Messrs. Hawksworth and Harding's steel tube manufacture, we noticed the very interesting fact that they welded steel to iron by "cold pressure" merely, and upon the same principle as the old system of plating—by making silver adhere to copper by passing both through a flatting mill. Two clean surfaces of lead can be thus brought together. The same is the case with india-rubber, and this principle may be almost said to form the basis of the india-rubber manufacture. Steel bearings have deen found welded to their iron journals when run under too great a weight. A whitesmith or fitter often notices similar appearances when at work. He is generally very careful to oil fresh surfaces, even when he brings them only temporarily into contact. The famous patent case of Betts *v.* Menzies, that fat oyster-bank for the lawyers during so many years, is based upon an invention which consists in forming a kind of thin foil by the "cold welding," under pressure, of a sheet of tin and one of lead. Dr. Percy states that "copper in a fine state of division, as when precipitated, will cohere and form a solid mass under great pressure; and copper medals have been struck by Ozann on this principle. Gold and silver, in the state of fine powder, may be converted into a compact metallic mass in the same way. The powder of silver produced by decomposing chloride of silver with zinc, &c., is gently heated, then compressed, hammered and re-heated alternately, the temperature always being sensibly below the melting point of silver. Fournet obtained bars by this means which might be wrought like bars resulting from fusion. He also made damaskeened bars by using gold and silver powder in alternate layers. Fournet regards this as true welding, *i. e.*, union at a temperature below fusion; and he considers that the firm union effected between two freshly cut surfaces of lead by simply pressing them together is welding." The interesting paper, by Mons. Fournet, here cited, was published in our valuable foreign contemporary, the *Annales de Chimie et de Physique* for 1840. There are numberless other instances, in nature, and in other arts besides that of metallurgy, in which solids are formed by the cohesion under pressure of one or more simple substances in a minute state of subdivision, or of even larger parts in a more or less complete state of separation. Sand is thus formed into bricks by means of great pressure, and brick-making machines on this principle are largely used in America. The packing of sand in the ballistic pendulum used for ascertaining the velocity of cannon, is sometimes found converted into sandstone by the impact of the projectiles. Sawdust has been reconverted into a kind of hard wood by means of hydraulic pressure. *Papier mâché* trays are made by subjecting paper pulp to pressure. It would be an interesting inquiry whether the range of pressure that thus forms a body out of (say) similar but smaller component parts, is the exact measure of the range and pressure—the coefficient of rupture—required to destroy the cohesion? Or, is a new force—a kind of attraction—superinduced when the atoms are once brought into sufficiently close contact to the range of the force of cohesion? In an interesting paper which we gave some time last March, Mr. Z. Colburn would explain the phenomenon of welding by stating that:—"In all welding we first employ a degree of heat sufficient to overcome so much of the cohesive force between the atoms of the iron as to allow sufficient motion among themselves to bring all, or most of the atoms forming one surface, within cohesive range of those forming the opposite surface." According to this, heat in welding would appear to have a double function; that of cleaning the surfaces, and that of rendering less pressure necessary. But does this explanation meet the thermal and chemical influences at work in the operation of welding iron? Why is it so difficult to weld "burnt" iron? Why is it so difficult to weld steel? Why is pure iron—the iron of the chemist and the laboratory—and not that of commerce, so difficult to weld? These amongst many other similar questions are yet very far from solution, and they will probably remain so for many years. As was recently very well remarked:—"The navigator plied, and still plies, his oar, ignorant of the manner in which, by its aid, he is enabled to propel his craft with the force of his arms; or he unfurls his sails without insight into the causes whence spring the welcome breeze or the furious wind; or he puts on the steam, uninformed of the cause which produces the expansion of vapours and gases, and thence the motion of his ship. He follows the needle as his guide, heedless of the mystery by which it is made to point with sympathy towards the north."

It is, however, somewhat strange that more of the obvious qualities of iron are not definitely known. There would not seem to be much mystery in the simple question, whether a welded joint is stronger or weaker than the other portions of a bar; but we nevertheless sometimes hear it asserted that the bar is even stronger at the weld—an opinion often very justly controverted by some practical men.

As the ultimate strength of a structure, or of any of its details, must be determined by its weakest part, it is evidently of the utmost importance to know whether the strength of a bar is diminished or not by a welded joint, the workmanship being, of course, supposed to be of the average order. A practical man need scarcely be told that, even with very good workmanship, the results are always somewhat uncertain. There is a peculiarity about all bad welds which is sometimes overlooked. Thus