Appreciating the difficulty which engineers encounter when explaining by mere drawings any novel devices required to meet the ever increasing demands of commerce, Mr. Eads has wisely determined to construct a working model of the ship railway, which shall illustrate in miniature every detail of the work. By it will be clearly seen the great simplicity of the devices needed for raising and lowering the ships at the harbours, distributing their weight equally upon all the wheels of the cradle on which they will be borne, the precautions for supporting every part of them to avoid injury during their journey by rail, and the safe and rapid method by which they may be shunted to permit of their passing each other, or to change their direction so as to avoid curves in the railway tracks, or to enable them to be run out of the way for painting or repairing.

The ship will be 7 ft. in length, the car or cradle on which the ship is carried will be 6 ft. 4 in. long. The floating dock will be 7 ft. 6 in. long, and 30 in. wide, and the basin in which it floats will require about two tons of water to fill it. By this means the public will become familiarised with the method proposed by Mr. Eads for working the traffic upon this gigantic line of railway.—*Engineering.*

A PROCESS FOR MAKING WROUGHT-IRON DIRECT FROM THE ORE.*

By Willard P. Ward, A.M., M.E.

The numerous direct processes which have been patented and brought before the iron-masters of the world, differ materially from that now introduced by Mr. Wilson. After a careful examination of his process, I am convinced that Mr. Wilson has succeeded in producing good blooms from iron-ore, and I think that I am able to point out theoretically the chief reasons of the success of his method.

Without going deeply into the history of the metal, I may mention the well-known fact, that wrought-iron was extensively used in almost all quarters of the globe, before pig or cast-iron was ever produced. Without entering into the details of the processes by which this wrought-iron was made, it suffices for my present purpose to say that they were crude, wasteful, and expensive, so that they can be employed to-day only in a very few localities favored with good and cheap ore, fuel, and labor.

The construction of larger furnaces and the employment of higher temperatures led to the production of a highly carbonized, fusible metal, without any special design on the part of the manufacturers in producing it. This pig-iron, however, could be used only for a few purposes for which metallic iron was needed; but it was produced cheaply and with little loss of metal, and the attempt to decarbonize this product and bring it into a state in which it could be hammered and welded was soon successfully made. This process of decarbonization, or some modification of it, has successfully held the field against all, so-called, direct processes up to the present time. Why? Because the old-fashioned bloomeries and Catalan forges could produce blooms only at a high cost, and because the new processes introduced failed to turn out good blooms. Those produced were invariably "red-short," that is, they contained unreduced oxide or iron, which prevented the contact of the metallic particles, and rendered the welding together of these particles to form a solid bloom impossible.

The process of puddling cast-iron, and transforming it by decarbonization into wrought-iron has, as everybody knows, been in successful practical operation for many years, and the direct process referred to so closely resembles this, that a short description of the theory of puddling is not out of place here.

The material operated on in puddling is iron containing from 2½ to 4 per cent of carbon. During the first stage of the process this iron is melted down to a fluid bath in the bottom of a reverberatory furnace. Then the oxidation of the carbon contained in the iron commences, and at the same time a fluid, basic cinder, or slag, is produced, which covers a portion of the surface of the metal bath, and prevents too hasty oxidation. This slag results from the union of oxides of iron, with the sand adhering to the pigs. and the silica resulting from the oxidation of the silicon contained in the iron.

This cinder now plays a very important part in the process. It takes up the oxides of iron formed by the contact of the oxidizing flame with the exposed portion of the metal bath, and at the same time the carbon of the iron, coming in contact with the under-surface of the cinder-covering, where it is protected from oxidizing influenees, reduces these oxides from the cinder and restores them to the bath in metallic form. This alternate oxidation of exposed metal, and its reduction by the carbon of the cast-iron, continues till the carbon is nearly exhausted, when the iron assumes a pasty condition, or "comes to nature," as the puddlers call this change. The charge is then worked up into balls, and removed for treatment in the squeezer, and then hammered or rolled.

In the Wilson process the conditions which we have noted in the puddling operation are very closely approximated to. Ironore, reduced to a coarse sand, is mixed with the proper proportion of charcoal or coke dust, and the mixture fed into upright retorts placed in the chimney of the puddling-furnace. By exposure for twenty-four hours to the heat of the waste gases from the furnace, in the presence of solid carbon, a considerable portion of the oxygen of the ore is removed, but little or no metallic iron is formed. The ore is then drawn from the deoxidizer into the rear, or second hearth of the puddling-furnace, situated below it, where it is exposed for twenty minutes to a much higher temperature than that of the deoxidizer. Here the presence of the solid carbon, mixed with the ore, prevents any oxidizing action, and the temperature of the mass is raised to a point at which the cinder begins to form. Then the charge is carried forward by the workmen into the front hearth, in which the temperature of a puddling-furnace prevails. Here the cinder melts, and at the same time the solid carbon reacts on the oxygen remaining combined with the ore, and forms metallic iron; but by this time the molten cinder is present to prevent undue oxidation of the metal formed, and solid carbon is still present in the mixture to play the same *rôle*, of reducing protoxide of iron from the cinder, as the carbon of the cast-iron does in the ordinary puddling process. I have said that cast-iron used as the material for puddling contains about 3 per cent. of carbon; but in this process sufficient carbon is added to effect the reduction of the ore to a metallic state, and leave enough in the mass to play the part of the carbon of the cast-iron when the metallic stage has been reached.

It would be interesting to compare the Wilson with the numerous other direct processes to which allusion has already been made, but there have been so many of them, and the data concerning them are so incomplete, that this is impossible. Two processes, however, the Blair and the Siemens, have attracted sufficient attention, and are sufficiently modern to deserve notice. In the Blair process a metallic iron sponge was made from the ore in a closed retort, this sponge cooled down, in receptacles from which the air was excluded, to the temperature of the atmosphere, then charged into a puddling-furnace and heated for working. In this way (and the same plan essentially has been followed by other inventors) the metallic iron, in the finest possible state of subdivision, is subjected to the more or less oxidizing influences of the flame, without liquid slag to save it from oxidation, and with no carbon present to again reduce the iron-oxides from the cinder after it is formed. The loss of metal is consequently very large, but oxides of iron being left in the metal the blooms are invariably "red-short."

In the Siemens process pieces of ore of the size of beans or peas, mixed with lime or other fluxing material, form the charge, which is introduced into a rotating furnace; and when this charge has become heated to a bright-red heat, small coal of uniform size is added in sufficient quantity to effect the reduction of the ore. The size of the pieces of the material employed prevents the intimate mixture of the particles of iron with the particles of carbon, and hence we would, on theoretical grounds, anticipate just what practice has proved, viz., that the reduction is incomplete, and the resulting metal being charged with oxides is red-short. In practice, blooms made by this process have been so red-short, that they could not be hammered at all.

It would be impracticable in this process to employ ore and carbon in as fine particles as Wilson does, as a very large portion of the charge would be carried off by the draught, and a sticking of the material to the sides of the rotating furnace could scarcely be avoided. I do not imagine that a division of the materials into anything like the supposed size of molecules is necessary; we know that the graphitic carbon in the pig-iron employed in puddling is not so finely divided, but it is in much smaller particles than bean or pea size, and

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