The temperature and composition of the cinder are very important. If it becomes too highly oxidising, either from the additions or from the gases, the elimination of carbon becomes too rapid, resulting in a "gobbed heat," that is, the grains of iron are coarse and clot together too early in a compact mass of impure iron, difficult to turn and ball. On the other hand, the absence of sufficient oxygen in the bath, either from lack of additions or from too reducing a flame, results in a slow working heat, high in carbon, and of a steely nature if the furnace be hot.

In closing this brief description of the ordinary puddling process, I again wish to emphasize the necessity of keeping

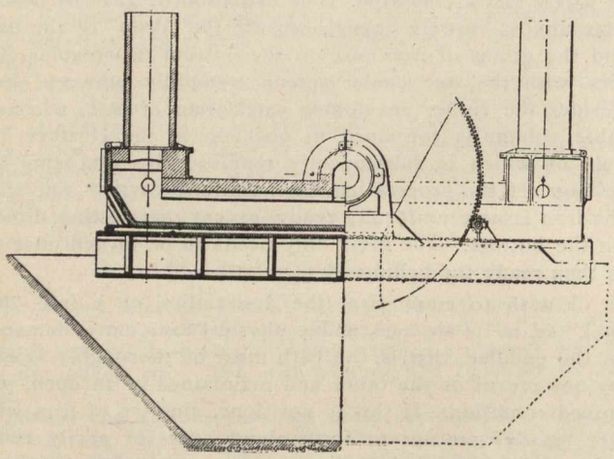

Fig. 1.—Roe Puddling Process.

a clean and smooth bottom and of getting the iron which forms on it, early in the heat, up to the top; since the bottom, being protected from the flame by the bath, is relatively cold. Both of these objects are readily achieved in the ordinary puddling furnace by proper care and skill.

The arduous character of the work in puddling and its consequent high cost, early suggested the desirability of lessening them by the introduction of mechanical means. These means have assumed various forms, too numerous to be discussed in detail. The space at my disposal will only allow the consideration of typical instances.

The mind of man commonly and naturally runs along the line of making modifications in old channels rather than that of seeking for new ones. Therefore, as was to be expected, the earliest efforts were to retain the furnace as it existed and to substitute mechanical for manual power in manipulating the rabbles. These were evolved rather by the mechanical mind than by that of the practical puddler and, although they assumed many forms, they were all open to the same objections. Perhaps as good examples as any of this type of puddler may be found in those of Messrs. James Whitman, John Griffith and F. W. Stoker.*

Since the sides of the hearth are, from the very nature of the lining, irregular in form and, as explained, are called upon to feed the bath, they are constantly varying in size and shape. They are, therefore, ill adapted for rabbles of this type, since the first requirement of a successful mechanical application is a constant condition, or a constant cycle of conditions. The mechanical rabble only attempted to cover the one step of puddling proper, and ignored those of charging, moving the pigs, turning the iron, balling and drawing. It made no improvement in the methods of fettling and firing and was, as a whole, an unproductive complication.

Revolving furnaces may be roughly divided into three classes: namely, those having a variable axis of revolution, those having an approximately vertical axis and those having a horizontal axis. Those having a variable axis, of which the Godfrey-Howson puddler† is the best example, had the advantage over the other revolving furnaces in that they could discharge the ball when finished, but they had most of the disadvantages of the others and, like them, failed to keep the iron open or apart towards the end of the heat, and balled the iron before all of it was ready.

* Jour. L. and S. Inst., 1873, Vol. I., pp. 95, et seq.
† Jour. I. and S. Inst., 1877, No. I., pp. 146, et seq.

The furnaces with axes, which were nearly vertical, had stationary fire chambers, flue sections, roofs and side walls, the latter having the necessary openings for charging, etc. The hearth was shaped much like a saucer and revolved on a plane only slightly inclined. The turning of the pan, even with the assistance of the inclination, failed to produce sufficient agitation of the bath to do more than very slightly hasten the refining and utterly failed to clean the bottom or ball the iron. It was necessary to resort to the use of rabbles and paddles for this work, as in the ordinary furnace, and fettling and firing was done in the old way. They were, therefore, practically in the same category as the ordinary furnace, plus a complication which produced little, if any, improvement. The Pernot* furnace may be considered in this class.

Furnaces revolving about a horizontal axis generally consisted of stationary fire chamber, revolving hearth and removable flue section, the latter being moved to give access to the hearth for fettling, charging and drawing. In some cases the hearth was polygonal in cross section, as in the Spencer furnace,** instead of being circular, or was bodily removed from between the fire chamber and flue as in that of Menelaus,*** instead of having the latter removed from it. The Danks† and the Crampton‡ furnaces may be taken as the highest types of this class. They succeeded in reducing the manual labor of puddling and balling the iron, and possess the important feature of working on a hot bottom. They looked exceedingly promising but ended in failure as far as producing puddled bar was concerned, and their product was only available as stock for the open-hearth furnace. Their shortcomings, common to all, were the excessive time and labor required for fettling: the difficulty in drawing the ball, or balls, the troubles connected with the fact that the lining was alternately serving as roof and bottom so that pieces of the fettling dropped off and were enclosed in the ball: and, worst of all, the balling of the heat before all of the iron was ready and the impossibility of modifying or delaying it in any way, which resulted in raw iron in the ball and blisters in the finished product. The designers of the rotary furnaces generally showed more knowledge of the practical requirements of puddling, but still failed to grasp all of the conditions of the problem.

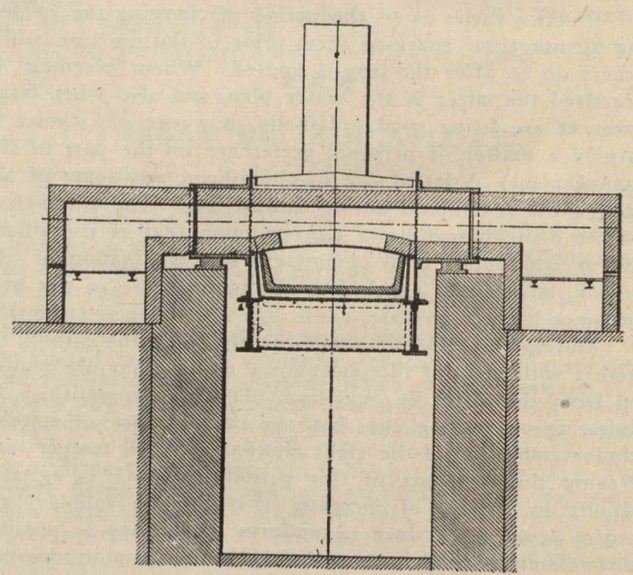

Fig. 2—Roe Puddling Process.

The only remaining kind of furnace to be considered is that in which the hearth is tilted or rocked. There were several varieties of this type. Some of them like regular puddling furnaces mounted upon transverse trunions, the

* Jour. I. and S. Inst., 1874, No. I., pp. 143, et seq.
** Jour. I. and S. Inst., 1872, Vol. I., p. 318, et seq.
*** zeit des Ver. deutscher Ingenieure, 1865, Vol. II., p. 107.
† Jour. I. and S. Inst., 1871, Vol. 2, p. 258, et seq.
‡ Jour. I. and S. Inst., 1874, p. 42, et seq.
‡ Jour. I and S. Inst., 1874, p. 384, et seq.