The producer, Fig. 117, is a cylindrical shaft, with this revolving circular plate *AA* at its lower end, supporting the deep bed of ashes *BB*, and through these the deep bed of fuel overlying those ashes.

The ashes are removed occasionally by turning, or "grinding," the revolving bottom, *i. e.*, rotating it about the vertical axis of the producer by means of the crank *K*. This grinding both so disturbs them that they slide down the talus *CA*, falling thence into the closed ashpit *D* beneath; and, more particularly, it makes

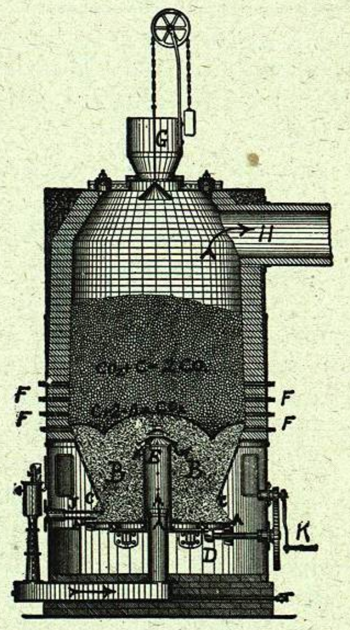

Fig. 117. The Taylor Gas Producer with Revolving Bottom.

the fixed bars *J*, set at four points in the periphery, plough the ashes outwards, and over the edge of *A*. As the ashes which at a given moment have formed this talus are thus discharged, those above them sink down to take their place; and while the ashes vertically above *C* doubtless descend somewhat faster than those to right and left, so that the imaginary surface which separates ashes from fuel probably follows the triple curved line which I have sketched, rather than the horizontal line which the makers of the producer show, yet no harm has been traced to this.

The air for gasifying the fuel is forced by a steam jet through the central pipe *E*, and thence discharged laterally. The fuel is fed through the hopper *G*, and the gas is drawn off through the pipe *H*. At intervals of, say, 6 to 24 hours the ash is "ground" down so as to keep its upper surface at a proper height, as seen through the peepholes *FF*. Should the ash descend too fast on, say, the left-hand side, the bars *J* on that side are withdrawn so as to retard the discharge there.

The lower edge of the cup *C* is high enough above the revolving plate *A* to give room for clinkers of usual size to pass; larger ones can be broken up by means of bars inserted through the holes shown in the iron cup above *C*. *C* is so placed horizontally with regard to *A* that the talus-slope *CA* is flatter than the angle of repose of quiescent ashes, but steeper than the angle of repose of ashes in motion; hence the discharge of ashes occurs only during grinding, — in short, it is under control.

The bed of ashes is made very deep, so as to give ample opportunity for any coal which passes below the region of active combustion to burn; and also so that the ashes shall cool thoroughly in their slow descent from the region of combustion to their discharge, and thus that the moving parts of the mechanism shall remain cool, and that the ashes, when removed at intervals of perhaps 24 hours from the ashpit, shall also be cool, and therefore cheaply handled. To avoid the expense of a blast pressure strong enough to force the blast through this deep bed of ashes, the blast pipe is carried up nearly to where the region of combustion is expected to be.

In a plain cylindrical producer, with a plain grate extending clear across it, the natural tendency would be that the fuel would descend fastest in the axis, and that the blast would travel fastest up the walls; in the Taylor producer both these tendencies are opposed, the former by placing the ash discharge near the periphery of the producer, and the latter by introducing the blast in the axis. These dispositions probably carry matters somewhat towards the opposite extreme, so that the fuel descends fastest along the walls, or rather just above the edge *C* of the iron cup, and that combustion is fastest in the axis; but the makers believe that any irregularity thus induced is much less than that of the plain cylindrical producer which it replaces. And, indeed, the great depth of the beds, both of ash and of fuel, appears to remedy well any residual irregularity in this respect.

325. THE DUFF GAS PRODUCER.* — The distinctive feature of this producer (Fig. 118) is the water seal at its base, through which the ashes are raked without interrupting the working of the producer itself.

The fuel is charged through the hopper *G*; the blast is introduced beneath the comb-roof-shaped grate; and the gas is drawn off through *H*. The pan below is filled with water. As in the Taylor producer, the ashes form a very deep bed, here resting on the bottom of the pan and extending above the comb of the grate; while above them rests a deep bed of coal. The condition of the fire is learned by looking through the poke-holes *FF*; and is regulated (1) by charging, and (2) distributing fresh coal; (3) by poking from above; and (4) by raking out the lower end of the talus of ashes through the overlying water in the pan. As fast as these are thus raked out, the ashes and coal above descend.

The sensible heat of the ashes is utilized in evaporating water, which, in passing up through the producer, is in turn converted into water gas by the incandescent carbon.

The holes in the grate are in reality narrow slits. So narrow are they that most of the ash slides over them to right and left, instead of falling through them; though that which does fall through is, like the rest, eventually raked out through the water seal. The grate itself runs nearly completely across the producer.

Like the Taylor producer, this one has (1) the deep bed of ashes, favoring the thorough combustion of the fuel; (2) the blast admitted near the upper surface of the ash layer, so as to reduce the frictional resistance to its passage; (3) the combustion probably most rapid in the region where the descent of the fuel is probably the slowest. For combustion is doubtless fastest in the transverse band overlying the grate, and descent of the removal of the ashes is doubtless most rapid at the outside, *i. e.*, in the part nearest to the talus which is actually raked out; and because the ashes here descend the fastest, so should the overlying fuel. Thus the imaginary boundary between the burning fuel and the ash should be somewhat as here sketched in

* U. S. Patent, re-issue, 11,323, Jan. 28, 1896, The Duff Patents Company, 924 Carnegie Building, Pittsburgh, Pa.

Fig. 118. By making the ash-bed very deep this irregularity is kept within harmless limits.

326. THE USE OF STEAM IN THE PRODUCER. — In § 323, p. 425, we saw that the use of steam as a means of forcing the blast into the gas producer lessened the formation of clinker, thus both facilitating the cleaning of the fires and lessening the mechanical loss of fuel. A further and probably very great advantage is that it increases the quantity of combustible gas obtained from each ton of coal.

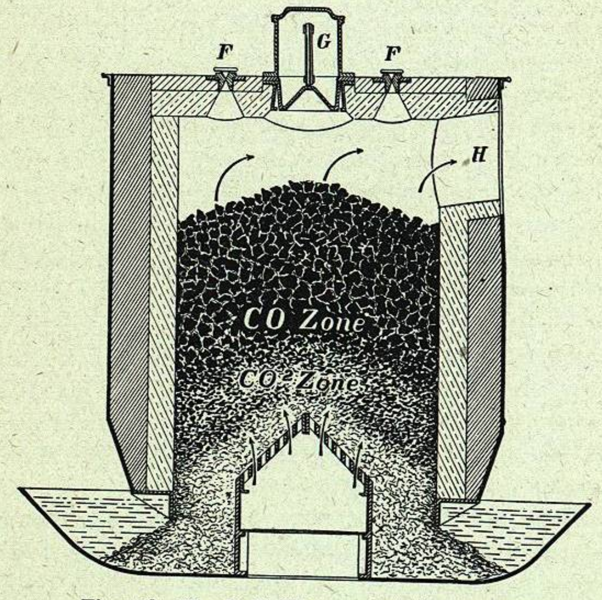

Fig. 118. The Duff Water-sealed Gas Producer.

For, whereas each equivalent of carbon gasified in the producer by atmospheric air gives only one equivalent of carbonic oxide ($C + O = CO$); each equivalent gasified by steam by the reaction $C + H_2O = CO + 2H$ yields in addition to this two equivalents of hydrogen. And whereas the gas made by means of air, the true producer gas, is diluted with the atmospheric nitrogen, that made by means of steam, the water gas of the producer, is not thus diluted. Of course, the total quantity of heat to be obtained from a ton of fuel is not changed; but the use of steam causes an absorption of heat in the producer, to be restored in the working chamber by the combustion of the additional hydrogen formed in the producer at the expense of the heat thus absorbed. Manifestly, a calory evolved directly in the working chamber is more efficient than had it been evolved in the producer, because if evolved in the producer it would be in considerable part dissipated in bringing it forward into the working chamber.

Of course the gasification of the fuel in the producer requires that the fuel itself be hot, otherwise it will react neither on air nor on steam; the temperature must be kept up to the range in which both the atmospheric oxygen and the steam itself will react on the fuel and gasify it. But in the producer itself any heat over and above that needed to keep up this temperature is not only less efficient than if that same heat was generated in the working chamber of the furnace, because in passing from the producer to the furnace much of it would be wasted, but positively injurious because it tends to melt the ash into unmanageable clinker. Introducing steam along with the air used in gasification then stores energy in the producer by there utilizing part of the locally inefficient and harmful excess of heat, increases the quantity of combustible gas formed, and so restores that energy in the working chamber of the furnace where that excess of gas is in turn burnt. In short, it absorbs heat in the producer where it is harmful, and reproduces that heat in the working chamber of the furnace where it is used most efficiently.

Producers are often run now in such a way that the gas contains 5 or 6 per cent of carbonic acid, and this is not considered a loss of energy provided that much steam is used. The explanation of this is as follows: All the heat required in the producer is enough to keep up the temperature to the point of ignition of the coal. The amount of steam we can use is limited by this: it must not cool the temperature below that point. Manifestly, if we burn part of the carbonic oxide to carbonic acid we get thereby more heat in the producer, and this extra heat enables us to decompose just so much more steam without dragging the temperature below the needed point. Thus, in this sense the increase of carbonic acid does not necessarily represent a loss of energy, but merely that part of the energy, instead of being delivered in the form of carbonic oxide, is delivered in that of hydrogen.

APPENDIX I

327. FURTHER NOTE ON THE CONSTITUTION OF GRAY IRON.—As the conception of matrix and graphite is fundamental to the theory of the constitution of cast iron adopted in this work, it is important that it should be grasped firmly. To this end the following series of suppositious cases is here elaborated.

Case 1. Suppose that, within a strong iron mould, stands a cylinder of quartz, quite as the cylinder of white cast iron in Fig. 119*A* stands within its mould. Suppose, next, that this ingot is shattered by a powerful blow from above, but that its fragments remain in the mould, like those of the white cast iron in Fig. 119*B*. Then suppose that liquid asphalt or Portland cement is run into the crevices so as to fill them completely, as sketched in Fig. 119*C*, and that the whole is allowed to solidify.

Here we have a conglomerate of which the matrix is quartz and the cementing or filling matter is asphalt or Portland cement. Let this illustrate clearly what is meant by a matrix.*

328. *Case 2.* Next, let us suppose that the cylinder of quartz is replaced by a cylinder of white cast iron, Fig. 119*A*; that this in the same way is shattered as at *B*; that, by some means not explained, graphite is closely packed into all the crevices between the particles of iron, as at *C*, and that it cements them firmly together like the asphalt of Case 1.

---

* Matrix, "that which contains or gives shape or form to anything;—(Geol.)—or the mass in which a fossil or mineral is imbedded." *A Standard Dictionary of the English Language:* Funk and Wagnalls Company, 1898, p. 1090.

I am not wholly satisfied with this word "matrix" for expressing the conception to which it is applied in this work, especially because in the not wholly dissimilar case of concrete it is the filling of cement or other material which is called the matrix. The filling of a concrete forms a much larger proportion of the whole than the filling in our present series of cases; and the use of the word matrix is, as I understand it, governed rather by homology than by analogy. Hence the apparent discrepancy. The sense in which I use "matrix" in this work is related closely to the sense in which it is used in geology and mineralogy; at the same time, a better word is needed to express this idea. I use matrix simply because I do not think of any better word.