June 11, 1957 H. S. HALL 2,795,409

OPEN HEARTH APPARATUS

Filed July 14, 1954 3 Sheets-Sheet 1

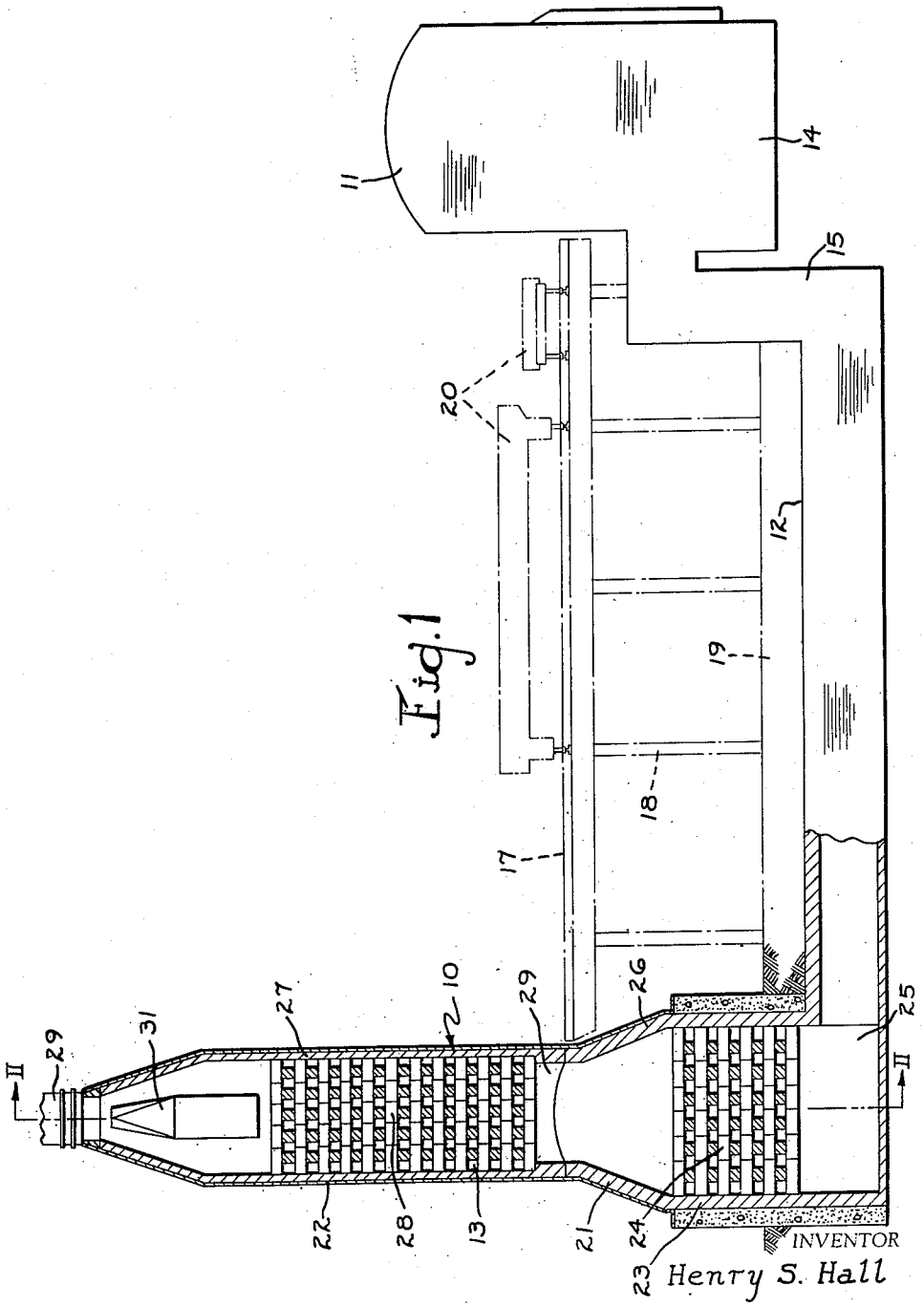


Fig. 1

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OPEN HEARTH APPARATUS

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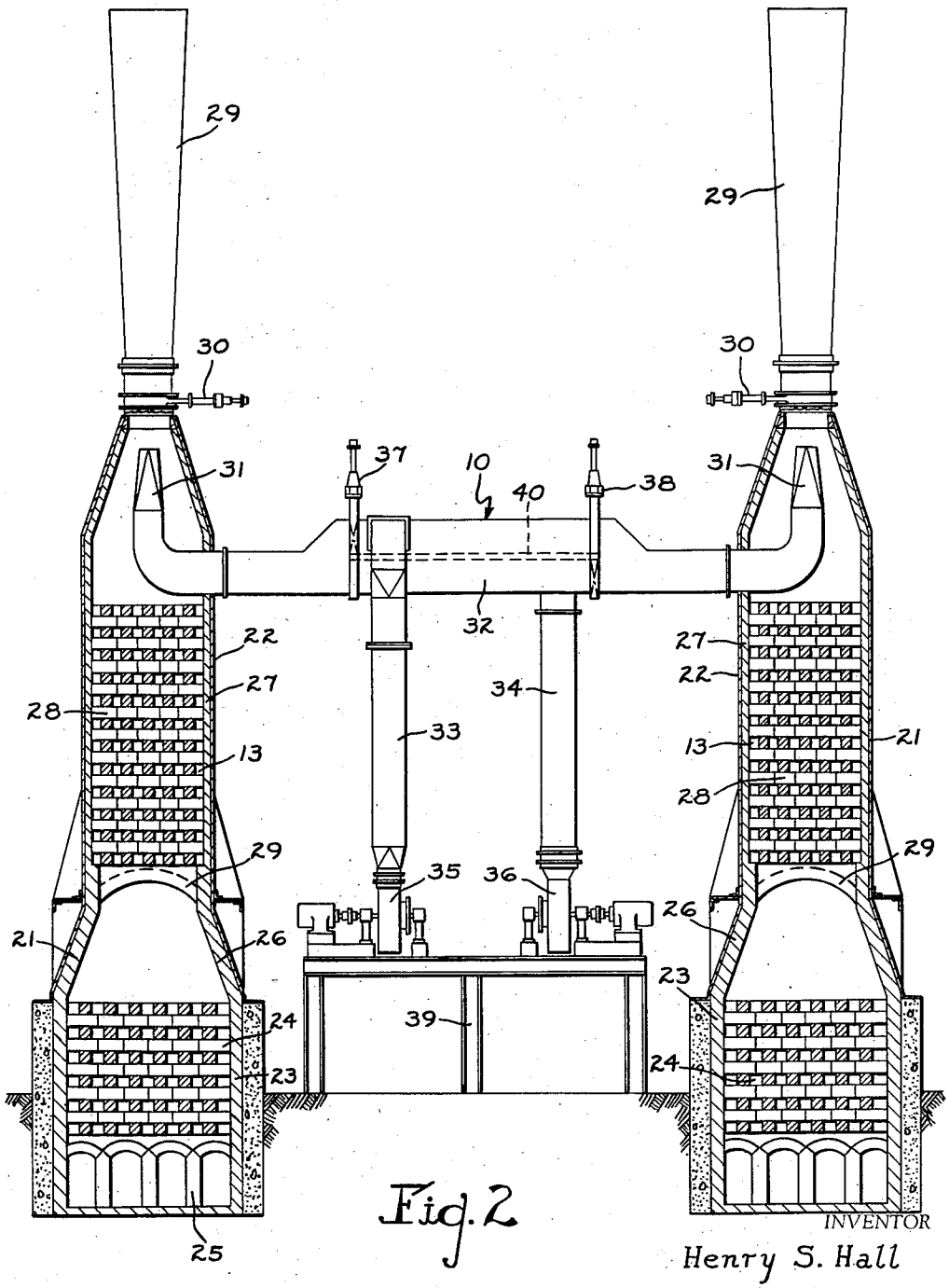


Fig. 2

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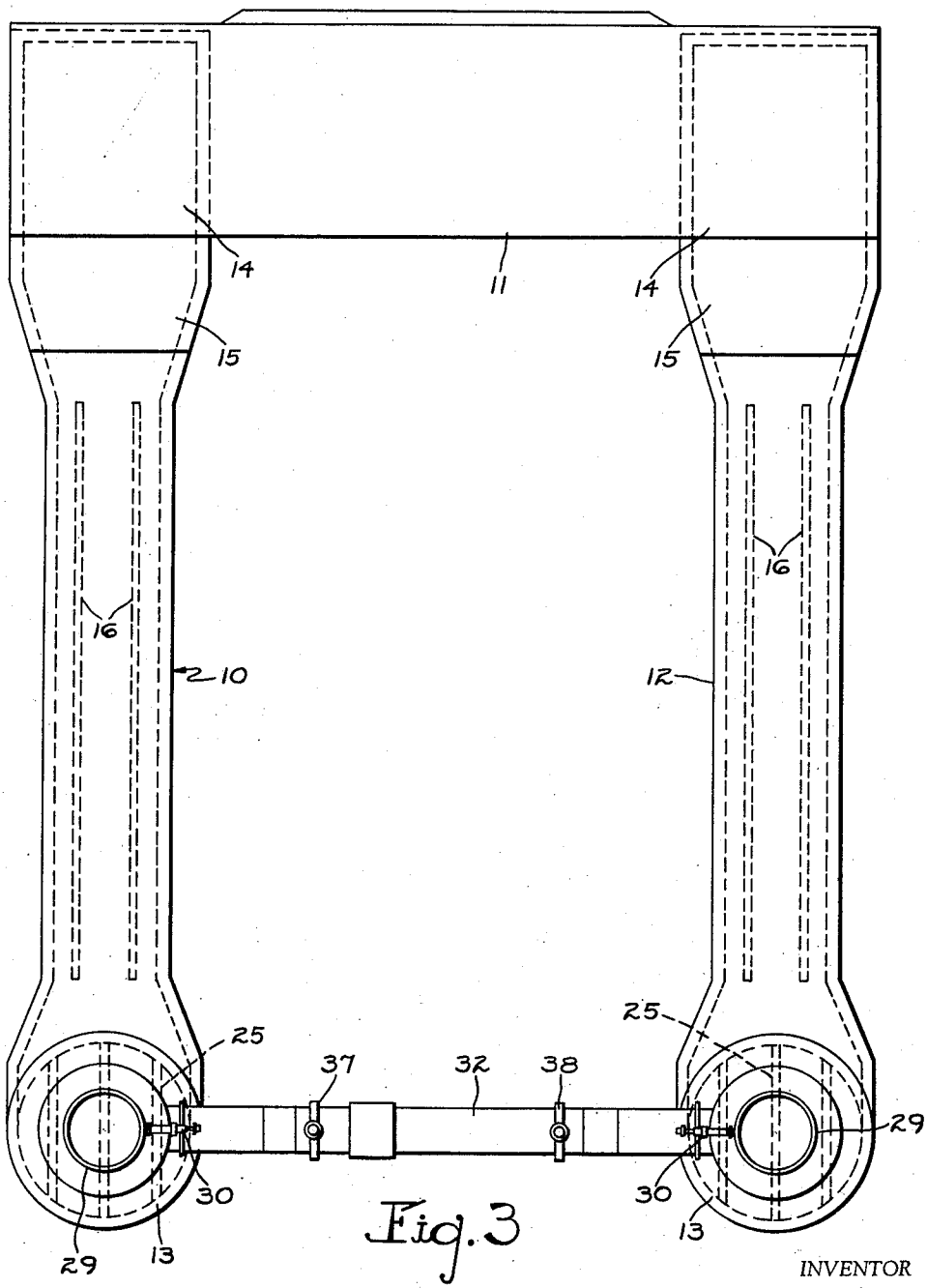


Fig. 3

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OPEN HEARTH APPARATUS

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6 Claims. (Cl. 263—15)

This invention relates to open hearth apparatus and more particularly to the construction of a furnace of the regenerative type and associated elements.

It is usual practice in the construction of open hearth furnaces to situate the furnace in the central portion of the building with a charging floor on one side and a pouring floor on the other. The charging floor must be on level with the furnace to permit the introduction of the metal to be melted, while the pouring floor must be far below the level of the furnace to permit tapping of the molten charge into the ladles and to furnish the vertical height needed for the ingot molds. Furthermore, no gas passages from the furnace may pass over or through the pouring floor, nor can access to the furnace be provided from the ends of the furnace, since it is usual to place these furnaces end to end. Therefore, the only way in which gas passages may be laid is either under the charging floor or vertically toward the roof of the furnace. The last direction is practically out of the question because of the necessity of having crane space over the furnace to replace the furnace roof, etc. In the past, therefore, the regenerative checkers have been situated in a horizontal passage under the charging floor. The vertical depth which is available is limited on the upper side by the charging floor, which must be on a level with the furnace, and on the lower side by the water table. Furthermore, in modernizing old installations, it would be a very expensive matter to carry any passage or the like further downward because of the concrete underlying the furnace and charging floor. Because of these space limitations, in the past the regenerative checkers were placed running under the charging floor. In order that the checkers would not introduce too much resistance into the system, so that impractically large draft would be required, it was necessary to form the checkers as a rectangular parallelepiped which was very large in plan view, the gas was introduced at the top and taken out at the bottom. Because a certain amount of vertical height was required to turn the gas downwardly into the checkers, and to turn the gas horizontally at the bottom of the checkers, the vertical height available for the checkers themselves was very limited. This restricted the length of time in which the gas would reside in the checkers, thus decreasing the heat transfer, raising the flue gas temperature and lowering the efficiency of the unit. Also, the incoming combustion air tended to pass through a section of the checkers which was quite different from the section through which the hot exit gases had previously passed. Construction of new checkers and replacement of old ones was handicapped by this lack of vertical space. Also, considerable leakage was experienced through the walls surrounding the checkers, with resulting inefficiency. Furthermore, with this old construction there was only one reversal of the gases between the furnace chamber and the checkers; the net result was that most of the slag and the like carried by the gases was deposited on the checkers; thus, frequent cleaning and replacement was required to maintain the effective gas passage through the checkers at the required value. These and other difficulties experienced with the prior art constructions have been obviated in a novel manner by the present invention.

It is therefore an outstanding object of the present invention to provide an open hearth furnace in which the restrictions as to vertical height imposed by the charging

floor level and the water table do not affect the operative qualities.

Another object of this invention is the provision of a regenerative open hearth furnace in which the vertical height available for the regenerative checkers is considerably in excess of that available under the charging floor.

It is a still further object of the instant invention to provide an open hearth furnace characterized by ease and simplicity of construction whether intended for a new installation or the replacement of an old one.

A further object of the invention is the provision of an open hearth checker construction offering less leakage of gases.

It is another object of the instant invention to provide a furnace and flue construction offering more reversals of gas flow than in prior art constructions, whereby slag and the like are removed before the checkers are reached.

Another object of the invention is the provision of a furnace and exit duct so arranged as to provide considerable extent of low velocity gas flow before the regenerative checkers are reached, thus promoting the settling of particles carried over from the furnace.

A further object of the invention is the provision of an open hearth furnace apparatus which is so constructed that combustion air passes through the same section of the regenerative checkers through which the hot exit gases had previously passed, the velocity of gas flow through the checkers being considerably higher than in previously-known apparatus.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended thereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Figure 1 is a vertical sectional view of apparatus embodying the philosophy of the present invention taken transversely of the furnace building.

Figure 2 is a vertical sectional view of the apparatus taken on the line II—II of Figure 1, and

Figure 3 is a plan view of the apparatus.

Like reference characters denote similar parts in the several figures of the drawings.

Referring first to Figure 1, which best shows the general features of the invention, the open hearth furnace of the invention, indicated generally by the reference numeral **10**, is shown as comprising a furnace **11**, ducts **12** and regenerative checkers **13**. The furnace is of the usual type and is quite elongated, each end being provided with a slag pocket **14** which is joined to one of the ducts **12** by a fantail **15**. The ducts **12** are provided with refractory walls and may be provided with intermediate walls **16** which act as heat transfer agents. Overlying the ducts **12** is a charging floor **17** supported by beams **18** resting on a cellar floor **19**; charging apparatus **20** is supported on the floor **17** and is movable thereover.

The outer end of each duct **12** is connected to the lower portion of a regenerative checker **13** which rises vertically therefrom and is usually situated outside the furnace building, clear of the path of operation of hoists and cranes. The checkers are provided with a shaft or housing **21** formed of refractory material and covered with sheet metal **22** for preventing leakage. The housing comprises a generally circular lower section **23** containing a primary checker **24** supported on arches **25** of the usual construction. The housing merges by means of a transition section **26** into a circular upper section **27** which contains a secondary checker **28** supported on arches **29**. The primary checker **24** is of considerable horizontal area and small height, whereas the secondary checker is smaller

in horizontal area, but relatively large in vertical extent. To the top of each secondary checker is mounted a stack **29** of the ejector type, having a valve **30** and an ejector nozzle **31**. The two nozzles **31** are joined by a horizontal duct **32**, the central portion of which is joined by vertical ducts **33** and **34** to fans **35** and **36**, respectively. A valve **37** is situated in the duct **32** between the duct **33** and one of the nozzles **31**, while a valve **38** is situated in the duct **32** between the duct **34** and the other nozzle **31**. The fans **35** and **36** are mounted on a supporting member **39** located between the two regenerative checker housings. A separating wall **40** extends horizontally through the central portion of the duct **32** between the valves **37** and **38**. The fan **35** is an ejection air fan and is connected by the duct **33** to the duct **32** above the wall **40**, while the fan **36** is a combustion air fan and is connected by the duct **34** to the duct **32** below the wall **40**.

The operation of the apparatus will now be understood in view of the above description. The furnace **11** is operated in the usual manner, the hot products of combustion being drawn out of the furnace and ejected from one of the stacks **29** after passing through the respective checker. The action is reversed after the checkers over which the combustion air is passing have cooled to such a degree that little further heat transfer takes place. The hot products of combustion leave the furnace and are turned in the slag pocket **14**, leaving a large percentage of suspended material there. The gas then enters the fantail **15** and enters the duct **12** taking part in two changes of direction in doing so. Heat transfer takes place from the gas to the walls of the duct and to the intermediate walls **16**. The cross-sectional area of the duct **12** is quite large and the gas velocity is, therefore, quite low. During the long period of passage through this duct, the particles of molten slag and other materials are permitted to settle to the bottom of the duct, where they may be easily removed at a cleaning period. At the outer end of the duct **12**, the gas is turned and moves upwardly through the arches **25** and through the primary checker **24**. The horizontal cross-sectional area of this checker is such that the optimum gas velocity is used to prevent stratification of the gases and combustion air, thus resulting in more efficient heat transfer. The gas, after passing through the transition section **26** of the housing **21** enters and passes through the secondary checker **28**. This checker is relatively smaller in horizontal cross-section so that the gas velocity is increased; to maintain the total heat absorption somewhat similar to that of the primary checker, it is necessary to provide considerable height in this checker. In the arrangement shown in Figure 2, the parts are being operated to pass the hot gas through the regenerative checker served by the valve **30**, which is open. The fan **35** provides air to the upper part of the wall **40**, the valve **37** being in position to cover the part of the duct below the wall at the end, so that the air flows to the nozzle **31** on that side of the apparatus and draws the gas up the stack **29**, providing the draft needed to overcome the resistance to flow of the gas through the elements of the apparatus. The fan **36**, on the other hand passes air to the part of the duct **32** underlying the wall **40** and, since the valve **38** is arranged to cover that end of the upper portion of the duct, the air flows to the nozzle on that side of the apparatus. The valve **30** on that side would be closed, so that the air if forced downwardly through the secondary checker **28**, the primary checker **24**, the duct **12**, and enters the furnace to be combined with fuel for combustion.

It can be seen, then, that the major difference between the open hearth furnace of the invention and those of the prior art is that the main checker chamber in the latter came immediately after the fantail. The primary checker chamber was, therefore, normally much too large in horizontal cross-sectional area, thus resulting in a very low gas velocity and a very low incoming air velocity; this is very detrimental to heat transfer from the outgoing flue gases to the incoming combustion air, which is, of course, the ultimate function of the checkers. In the prior art, the outgoing flue gases would go down one portion of the checker chamber and the incoming combustion air would enter through another portion of the checker chamber without adequate transfer of heat by the checker brick. Furthermore, this low gas and air velocity brought about a thin film of inert gases which would cling to the checker brick and further reduce heat transfer. Many of the conventional primary checkers do not have sufficient depth to give a good length of travel, this last being an important factor in the heat transfer problem. The reason for this shallow checker chamber is in many cases that the condition of the soil underneath the open hearth foundation prohibits any depth of construction, mainly due to the water table level. In the case of shops which were built many years ago, the depth of checker as originally designed was possibly adequate, but the furnaces have been enlarged from 80 to 100 tons capacity to 175 to 200 tons capacity without any change being made in the checker depth, due to the fact that the concrete mat under the open hearth would have to be disturbed at a large expenditure of money. The old construction of the checkers in an open hearth was inherently wrong because the dust and dirt in the form of oxide and slag carried over by the gases is deposited on top of the checker chamber, this being the normal way for it to fall under the influence of gravity. This results in early plugging of the top rows of the primary checkers and the consequent shutting down of the furnace for cleaning before the furnace campaign is completed or, if such cleaning is not done, the furnace will operate at considerably reduced efficiency. The size of the primary checker in the conventional open hearth is usually limited by the space available under the floor, which at times is very inadequate for checker chamber design. To overcome inadequate depth or length of travel in the primary checkers, the industry has resorted to what are called two-pass checkers to increase this length of travel. These checkers are normally placed in the primary chamber and, due to their inherent design, which includes a blind pass or a vertical flue, the total amount of checker brick heating surface which can be included is greatly reduced, which results in overheating of the first pass of these checkers with consequent damage of the first pass checker brick and high maintenance cost of the checkers. The checker system shown in the present invention results in an ideal cross-sectional area of the checkers and proper length of travel to give the optimum heat transfer from the outgoing flue gases to the checker brick, in turn, to the incoming combustion air. The present construction is not limited by the water table or present concrete mat under the open hearth building, as the checkers are built vertically and none of these previously-mentioned factors need to be taken into consideration. It is possible to provide independent chambers of different diameters and different lengths of travel to give the best heat transfer. It should be noted that the two diameters are different and this change in diameter is made at the optimum temperatures, so that the velocity of the gases and the incoming air will be the very best for efficient heat transfer. The space between the two checkers allows cleaning of the checker brick and also replacement of the bottom sections of the checker work whenever required without disturbing the other checker section. The flow of gases in the present construction is upwardly, which is the normal direction of flow for hot gases and this factor permits operation with less draft for exhausting the products of combustion.

Leakage in the conventional type of primary checkers, as installed in open hearth furnaces of the past, is a very critical problem and the final stoppage of all leakage is an impossibility with construction of the old type. With the present construction, where the checkers reside in a

concrete foundation and within a welded steel shell, infiltration of unwanted air is an impossibility. This results in much higher preheated combustion air temperature and, of course, will result in high output and lower fuel per ton of metal melted. The long flue between the slag pocket and the base of the checkers will allow a large amount of carryover in the flue gases to settle out before the gas reaches the checker brick. This will reduce the cleaning problem considerably. The refractory walls making up the long flue will facilitate heat recovery to the combustion air. With the construction of the invention it will be possible to enlarge the slag pocket, which will result in much greater storage capacity thereof and in some cases will prevent shutting down the furnace for slag removal while the balance of the brickwork of the furnace is still capable of further production. The temperature of the first pass checkers in the present construction will be less than the temperature of the top of the primary checkers in the conventional furnace design, which at times is high enough to cause melting of these checker brick with resultant high checker brick costs. Optimum heat transfer in regenerators is dependent upon low air infiltration, length of travel of flue gases, velocity of the flue gases and air through the checker brick and, time of reversal. With this construction, the first three factors can be manipulated to give optimum results which are not possible with the present conventional design without expenditure of large sums of money. It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft having a plurality of regenerative checkers mounted one above the other for vertical flow of gas therethrough and connected to the other end of each duct on the opposite side of the charging floor from the furnace, and a stack attached to the upper end of each shaft and extending upwardly therefrom, the horizontal cross-sectional areas of the portions of the shaft containing the lower checkers being greater than that of the portions of the shaft containing the upper checkers.

2. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft having a primary and a secondary regenerative checker mounted one above the other for vertical flow of gas therethrough and connected to the other end of each duct on the opposite side of the charging floor from the furnace, the portion of the shaft containing the primary checker underlying the portion of the shaft containing the secondary checker and having a considerably larger horizontal cross-sectional area than the said portion containing the secondary checker, a stack attached to the upper end of each shaft and extending upwardly therefrom, and means for providing an upward draft in one of the stacks for withdrawing gases from the furnace while introducing air under pressure at the upper end of the secondary checker at the other end of the furnace for passage through the checkers into the furnace.

3. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft having a primary and a secondary regenerative checker mounted one above the other for vertical flow of gas therethrough and connected to the other end of each duct on the opposite side of the charging floor from the furnace, the portion of the shaft containing the primary checker underlying the portion of the shaft containing the secondary checker and having a considerably larger horizontal cross-sectional area than the said portion containing the secondary checker, a stack attached to the upper end of each shaft and extending upwardly therefrom, and a housing which is substantially free of leakage surrounding each set of shafts with primary and secondary checkers.

4. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft having a primary and a secondary regenerative checker mounted one above the other for vertical flow of gas therethrough and connected to the other end of each duct on the opposite side of the charging floor from the furnace, the primary checker underlying the secondary checker, a stack attached to the upper end of each shaft and extending upwardly therefrom, an ejection nozzle in each stack, an ejector fan, a combustion air fan, and means for connecting one fan to one nozzle and the other fan to the other nozzle alternately and closing the stack to which the combustion air fan is connected while opening the stack to which the ejection fan is connected, the horizontal cross-sectional areas of the portions of the shaft containing the lower checkers being greater than those of the portions of the shafts containing the upper checkers.

5. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft containing two regenerative checkers each consisting of a primary and a secondary section mounted one above the other for vertical flow of gas therethrough, one shaft connected to the other end of each duct on the opposite side of the charging floor from the furnace, a stack attached to the upper end of each shaft and extending upwardly therefrom, each portion of shaft containing a primary section underlying the portion of shaft containing its respective secondary section and having a considerably larger horizontal cross-sectional area than the said portion containing the secondary section, each regenerative checker having a surrounding housing which is free of leakage, and means for drawing hot products of combustion from the furnace through one checker while introducing combustion air into the furnace after passage through the other checker.

6. An open hearth apparatus comprising an elongated furnace having a charging floor at one side, a duct connected at one end to each end of the furnace and extending under the charging floor transversely of the furnace, a vertical shaft containing a primary and a secondary regenerative checker mounted one above the other for vertical flow of gas therethrough and connected to the other end of each duct on the opposite side of the charging floor from the furnace, and a stack attached to the upper end of each shaft and extending upwardly therefrom, the portion of the shaft containing the primary checker underlying the portion of the shaft containing the secondary checker and having considerably larger horizontal cross-sectional area than the said secondary checker, and an arch lying between the primary and secondary checkers in a transition portion of the shaft between the above-mentioned portions.

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