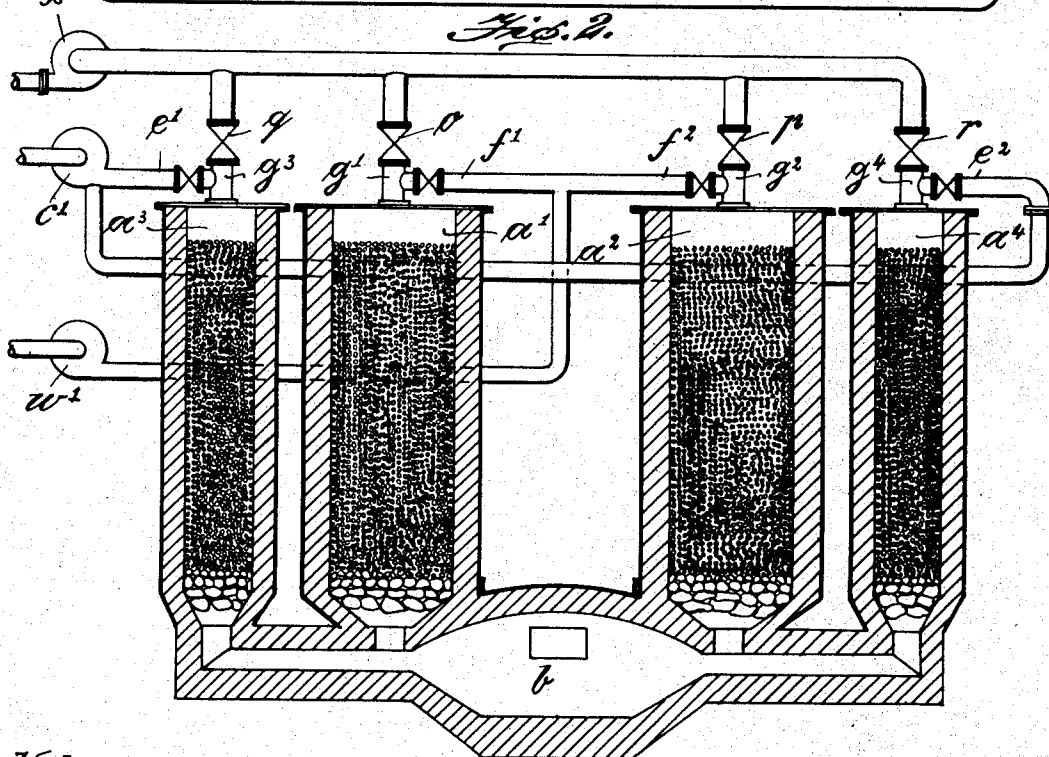
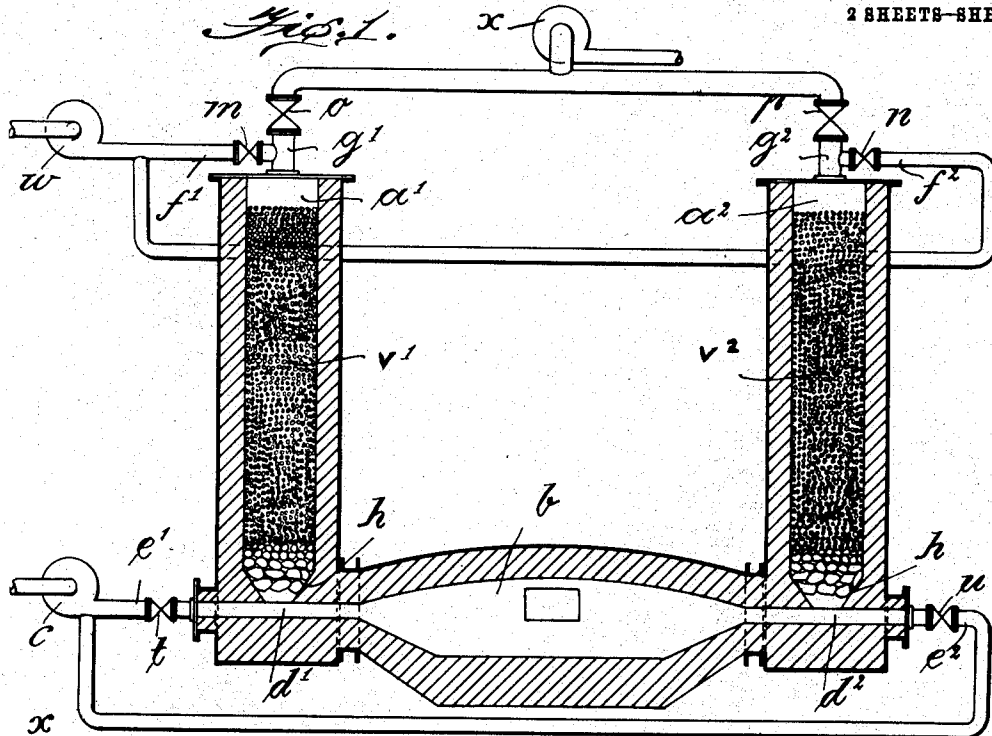


M. SCHROEDER & H. REINHARD.
 REGENERATOR OR HOT BLAST STOVE.
 APPLICATION FILED APR. 30, 1912.

1,062,122.

Patented May 20, 1913.

2 SHEETS—SHEET 1.



Witnesses:
 G. P. Kramer
 C. A. Brown

Inventors
 Max Schroeder
 Hugo Reinhard
 by
 Foster Freeman Nelson & Co. Attorneys

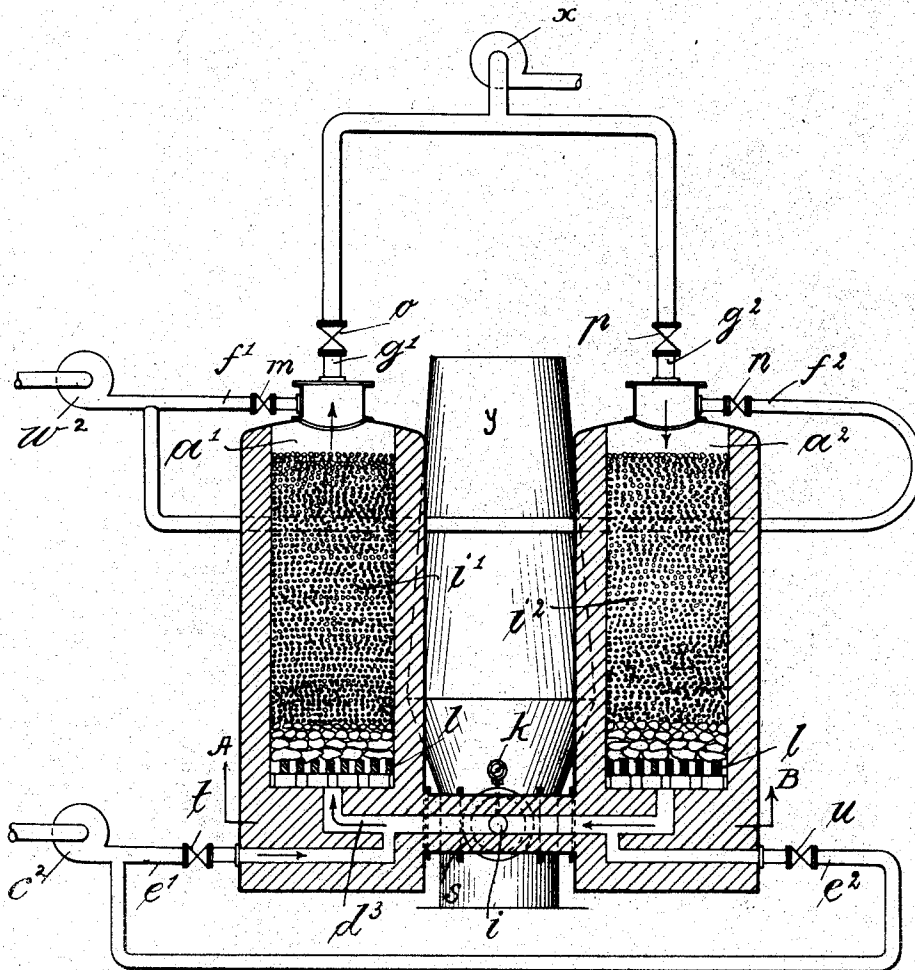
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Fig. 3.



Witnesses:
 G. P. Kramer
 C. S. Brown,

Inventors:
 Max Schroeder
 Hugo Reinhard
 by
 John Herman Watson & Co. Attorneys

UNITED STATES PATENT OFFICE.

MAX SCHROEDER, OF BERLIN, AND HUGO REINHARD, OF OBERHAUSEN, GERMANY.

REGENERATOR OR HOT-BLAST STOVE.

1,062,122.

Specification of Letters Patent.

Patented May 20, 1913.

Application filed April 30, 1912. Serial No. 694,201.

To all whom it may concern:

Be it known that we, MAX SCHROEDER, a subject of the King of Prussia, and resident of 41 Klopstockstrasse, Berlin, Germany, and HUGO REINHARD, a subject of the King of Prussia, and resident of Oberhausen, Province of the Rhine, Germany, have jointly invented certain Improvements in Regenerators or Hot-Blast Stoves, of which the following is a specification.

This invention relates to improvements in regenerators, hot blast stoves or the like. Hitherto it has been usual to construct the interior brick work filling of such apparatus either in checkered form or so as to provide vertical flues, the interstices or the flues of which are of a sufficient width to permit the gases to pass through the regenerator without being subjected to too great a resistance and also to enable the flue dust to be readily removed, but the more regenerators of this type fulfil these conditions, the less efficient and complete is the utilization of the waste heat from the hot gases. In order to utilize the waste heat as efficiently as possible it is therefore necessary to provide an interior brick work having a large surface area, thus necessitating the provision of large regenerators, but it has hitherto been found that the efficiency of such regenerators is only about 50% of the total possible efficiency. As a result thereof the gases leave the regenerator at a high temperature averaging between 300 and 500° C. Not only is this a great loss but is at the same time the reason why, by the present apparatus, the highest possible temperatures cannot be attained, as at each stage of the regenerating action a considerable percentage of heat is lost, so that the excess heat which is necessary to effect a further increase in the temperature of the regenerator, will rapidly cease to exist. Moreover it has been hitherto difficult to obtain the proper proportion of gas to air for combustion, so that frequently more than twice the necessary amount of air was supplied than was necessary for the combustion.

The object of the present invention is to obviate the foregoing disadvantages and for this purpose the interior of the regenerator is provided with a loose filling of small pieces of granular refractory material which are either simply dumped into the regenerator or laid in close layers therein. The size of the pieces may vary from about the

size of a hen's egg to about the size of a small nut or bean. Inasmuch as this filling offers a much greater resistance to the flow of air and gases through the regenerator than heretofore usual, it is necessary to employ forced draft for this purpose, this being effected by means of compressors, blowers or other suitable mechanical means. By the employment of mechanical means such as compressors or blowers the advantage is also presented that the combustible gases and the air for combustion may be suitably proportioned, so as to prevent an excess of gas or of air creating a diminution in the temperature caused by the combustion. Moreover as the air and gases are supplied to the combustion chambers or channels under forced draft a rapid mixture is effected, thus dispensing with the necessity for large combustion chambers hitherto unavoidable, owing to the fact that the air and gases in regenerators of known type flow side by side without completely mixing with one another.

A further advantage of the present construction is that in cases where gastight fittings such as valves and the like cannot be employed, the air and gases may be drawn through the regenerator under an induced draft which may be created by means of exhaust fans or the like. Such an arrangement was hitherto impossible, as the gases for reheating the regenerator were at too high a temperature to enable mechanical draft producers to be employed, whereas by the present invention the gases before leaving the regenerator may be reduced to a temperature of below a 100° C. and even as low as 50° C., so that the mechanical draft producing devices employed are not damaged thereby.

It is already known to use blowers or fans in connection with hot blast stoves, but hitherto such devices have been employed not to overcome the resistance offered by the stove filling, but to overcome the resistance of the blast furnace, and were used only during the heating of the blast whereas the inducing draft of the chimney was employed to draw the air and gases through the generator during the reheating thereof. It is also known in reverberatory furnaces such as the Martin-furnace, when used in conjunction with a hot blast stove of the Siemens type, to supply the gases or air under the action of a blower when using coke oven or

blast furnace gases, but in this case also the stove filling offers little resistance to the flow of the gases and the latter would be forced into the furnace as soon as the resistance of the stove filling became greater than could be overcome by the inducing action of the chimney, nor can an exhaust fan be substituted for the chimney for the reasons hereinbefore given. It will thus be seen that the employment of a regenerator filling of great resistance and of a mechanical forced or induced draft are interdependent upon one another.

In order that the invention may be more clearly understood, reference is made to the accompanying drawings, which show by way of example various methods of carrying out the present invention.

Figure 1 illustrates in vertical section an arrangement in which only the air blast is heated, this arrangement being particularly adapted where coal gas, coke oven gas, water gas and the like of high calorific value is employed. As these gases require several times their volume of air for complete combustion, it is unnecessary to heat the gases provided the air for combustion is sufficiently heated. Fig. 2 illustrates an arrangement in which both the gas and air are heated. This arrangement being applicable in cases where the gases possess a considerably smaller calorific value, such as generator gases, blast furnace gases and the like. Fig. 3 illustrates an arrangement applicable for heating the blast of blast furnaces.

Referring to Fig. 1 of the drawings: The apparatus comprises two regenerators a' a^2 between which is arranged a reverberatory furnace b . The filling v' v^2 of the furnaces for the regenerators a' a^2 consists of very refractory material such as magnesite or dolomite and where very high temperatures are to be attained, pure burnt lime may be employed. This filling may either rest upon a grating l of fire-clay or the like, as shown in the regenerators of Fig. 3, or it may rest upon the conical lower end h of the regenerator, as shown in Fig. 1, the lower part of the filling comprising pieces of larger size, while the upper part of the filling consists of finer granular material. As the hot combustible gases in the lower part of the regenerator occupy a much greater volume than the cool gases passing out at the upper end of the regenerator, it is preferable to employ a filling whose particles gradually decrease in size from the lower end of the regenerator toward the upper end thereof, so as to provide a substantially uniform resistance to the flow of the gases.

As the transference of heat takes place more rapidly and completely, the smaller the particles the size of the latter may be so chosen, that the loss due to the remain-

ing heat in the waste gases escaping from the regenerator, is reduced to a minimum.

The particles constituting the filling may be either of irregular form or may be of any desired shape laid in close contact with one another.

As the temperature of the regenerator in the upper part thereof is considerably less than in the lower part thereof, the upper zone of the filling may be of material of less refractoriness, such as fire clay, brick or the like. In cases where the hot gases of combustion pass in a downward direction through the regenerator, it will of course be understood that the filling must be arranged in the opposite manner to that hereinbefore described.

The operation of the arrangement illustrated in Fig. 1 is as follows:—The gases for combustion in a cold state are supplied by a compressor, blower or other suitable device c to the regenerator at the necessary pressure in order to overcome the resistance offered by the filling v' v^2 . These mechanical devices may also be adapted to enable the quantity supplied thereby to be determined in any known manner. The gas from the compressor c is supplied to the pipes e' e^2 which are provided with suitable valves t u respectively, so that the gas can be alternately supplied to the regenerators a' a^2 respectively. The air for combustion is supplied in like manner under pressure by means of compressors or suitable mechanical means w to pipes f' f^2 respectively, which are likewise provided with valves m n , while the waste gases from the regenerator can escape by way of the exit pipes g' g^2 provided with the controlling valves o p respectively and an exhaustor x . The air for combustion is first of all supplied by way of the pipe f' , while the valves o u n are closed. The air traverses the regenerator a' in a downward direction and meets the gases entering by way of the pipe e' in the channel d' where the mixture is ignited and passes through the furnace b into the channel d^2 in the regenerator a^2 , in which it gives up its heat to the filling v^2 in said regenerator and escapes by way of the exit pipe g^2 . After the lower part of the filling v^2 in the regenerator a^2 has been raised to a glow, the gas current is reversed by closing the valves t , m , and p and opening the valves u , n , o . As the combustion now takes place with preheated air, the temperature in the furnace b will be raised and the lower part of the filling v' in the regenerator a' raised to a higher temperature than the filling v^2 was raised. On again reversing the direction of the gas current a further increase in the temperature will take place, as the air will be raised to a higher temperature at each reversal of the operation, until the furnace b absorbs as much heat as is supplied by the

combustion. If the furnace chamber *b* is of comparatively small dimension and be only used for such processes as require relatively small quantities of heat, very high temperatures can be attained by this arrangement in spite of the use of cold furnace gases.

The increase in temperature may be accelerated and still further increased if both the gas and air are previously heated. In this case gases may be employed of considerably lower calorific value, such as generator gases, blast furnace gases and the like. The method in this case corresponds somewhat to the "Siemens" type of regenerator but differs therefrom in the type of filling and in the employment of mechanical means for passing the gas therethrough. An arrangement suitable for carrying out this method is illustrated in Fig. 2. The regenerators *a'* *a''* serve in like manner as in Fig. 1 for alternately heating the air for combustion, while additional regenerators *a'''* *a''''* are provided for heating the furnace gases. The pipes *e'* *e''* serve for the admission of the furnace gases being connected to a blower or the like *c'* and the pipes *f'* *f''* serve for the admission of air being connected to a blower or the like *w'*. The exit for the gases of combustion takes place on one hand through the exit pipes *g'* and *g''* and in the reverse direction through the exit pipes *g'''* *g''''* respectively, provided with the valves *o*, *p*, *q* and *r* respectively and a common exhaust *x*. In operation the air and gases are supplied in the usual manner, firstly through the pipes *e'* *f'* while the pipes *g'* and *g''* are closed by means of the valves *o* and *q* respectively and in the reverse direction through the pipes *e''* and *f''*, while the pipes *g'''* *g''''* are closed by means of the valves *p* and *r* respectively.

In cases where the regenerator is to be employed as a hot blast stove for heating the air blast of blast furnaces and the like, the arrangement illustrated in Fig. 3 may be employed, which differs only from Fig. 1 in that the regenerators *a'* *a''* are connected by means of a pipe *s*, which is provided with a lateral hot air outlet *i* connected to the hot blast furnace *y* and in connection with a manometer *k* for the purpose hereinafter set forth. In order to enable part of the hot air to be supplied to the blast furnace through the connection *i*, it is necessary that the air mix with the furnace gases after having passed through the connecting pipe *s* and for this purpose, when air is supplied by way of the blower *w''* and the pipe *f''*, the furnace gases are supplied by way of the blower *c''* and the pipe *e'* instead of the pipe *e''*. The combustion then takes place in the lower channel *d'''* of the regenerator *a'*, the products of combustion rising through the regenerator *a'* and giving up their heat to the filling *v'* and escaping by way of the

outlet pipe *g'*. The passage of the air and gas therefore takes place during one phase in the direction of the arrows in Fig. 3. When the gas current is reversed, the valves *n*, *t* and *o* are closed and the valves *m*, *p* and *u* opened. As the heat of the products of combustion in this case is not absorbed, as in Figs. 1 and 2, an increase in temperature will take place on each reversal of the current through the apparatus, until the upper part of the filling in the regenerators is so hot that it is unable to absorb more heat. As soon as this takes place, the regenerator is then ready for use. The reading of the manometer *k* is then taken in order to ascertain what pressure is necessary to force the combustible gases through the apparatus. In order now to utilize the additional quantities of heat on further combustion in the apparatus, it is necessary to considerably increase the current of air alternately blown into the apparatus by the blower *w''* through the valves *m* and *n*, so that a greater quantity of air is supplied than is necessary for the combustion of the furnace gases. As soon as this greater quantity of air is supplied, the friction and resistance in the filling is increased and in consequence thereof the pressure registered by the manometer *k* will be raised. If now hot air is conducted away through the connection *i* so that the pressure is reduced to its previous state, the quantity of air removed will correspond exactly to the air in excess of that necessary for combustion. Inasmuch as the connection *i* leads to the blast furnace, it is thus possible to supply a uniform hot blast to the furnace independently of the direction of the flow of the gases through the regenerator. The amount of air drawn off through the connection *i* may be regulated by inserting suitable resistances in front of or behind the blast furnace, so that the required pressure is maintained in the apparatus. Furthermore the size of the regenerators may be so chosen, that the resistance therein equalizes the resistance present in the blast furnace, slight variation being capable of compensation by varying the drive for the compressors or the like *c''*, *w''* according to the pressure registered by the manometer *k*. It will of course also be understood that the supply of air to the blast furnace can be accurately regulated by ascertaining the quantity of waste gases exiting from the blast furnace and calculating the quantity of air necessary therefor.

As a general rule the excess quantity of air supplied to the regenerators must be sufficient to absorb the heat generated at each combustion, this quantity not being dependent upon the calorific value of the combustible gases but upon the temperature to which the air supplied to the blast furnace is to be

raised, while the quantity of excess air can be so regulated that the loss of heat caused by the waste gases escaping through the exit pipes g' g^2 is reduced to a minimum.

5 Should the temperature of the waste gases leaving the regenerators considerably increase, the direction of the flow of the combustible gases through the regenerators can be reversed each time.

10 It will be readily understood that the apparatus illustrated in Fig. 3 may be employed in a similar manner for obtaining a current of heated combustible gas for the purpose of reduction at high temperatures, 15 the combustible gas being admitted in this case by way of the blower w^2 and the pipes f' f^2 and the air being admitted by way of the blower e^2 and pipes e' e^2 , in which case an excess quantity of combustible gas will 20 be supplied to the regenerators and conducted away through the connection i to the reducing furnace in a similar manner to that already described.

If the arrangement illustrated in Fig. 3 25 is duplicated so that one of the apparatus supplies a heated current of air and the other a heated current of combustible gases, the apparatus may then be employed in conjunction with a reverberatory furnace, at 30 the same time enabling combustible gases of low calorific value to be employed. In this case the waste gases will not be returned to the regenerator thus particularly adapting the apparatus to sublimation and other 35 chemical processes, in which the volatile component escapes with the combustible gases and is subsequently separated therefrom by cooling.

We claim,—

40 1. In a regenerator, hot blast stove or the

like, a compact filling of granular refractory material consisting of pieces of such a size that the total resistance offered thereby to the flow of gases therethrough is such as to require the gases to be forced through the 45 said filling by mechanical means other than the draft of a chimney.

2. In a regenerator, hot blast stove or the like, a filling of granular refractory material, the size of the particles decreasing 50 from the lower to the upper end of said filling, and mechanical means for forcing the gases therethrough.

3. In combination with a furnace, a regenerator tower on each side thereof, a compact filling of granular refractory material 55 in each of said towers consisting of pieces of small size, a connection between said towers, a branch pipe from said connection to said furnace, mechanical means for supplying under pressure air to the one tower 60 and combustible gas to the other tower first in one direction and then in the opposite direction alternately, whereby the air or gas after passing through the one tower into 65 said connection is divided, one part thereof passing to the furnace and the other part thereof passing into the other tower and being used for creating combustion in the latter. 70

In witness whereof we have hereunto set our hands in the presence of witnesses.

MAX SCHROEDER.
HUGO REINHARD.

Witnesses:

HENRY HASPER,
WOLDEMAR HAUPT,
THEODOR HÜSSMANN,
EMIL PRESSMANN.