No. 708,705. Patented Sept. 9, 1902.

H. L. GANTT.

FURNACE FOR HEATING AND MELTING IRON, &C.

(Application filed Mar. 22, 1901.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1

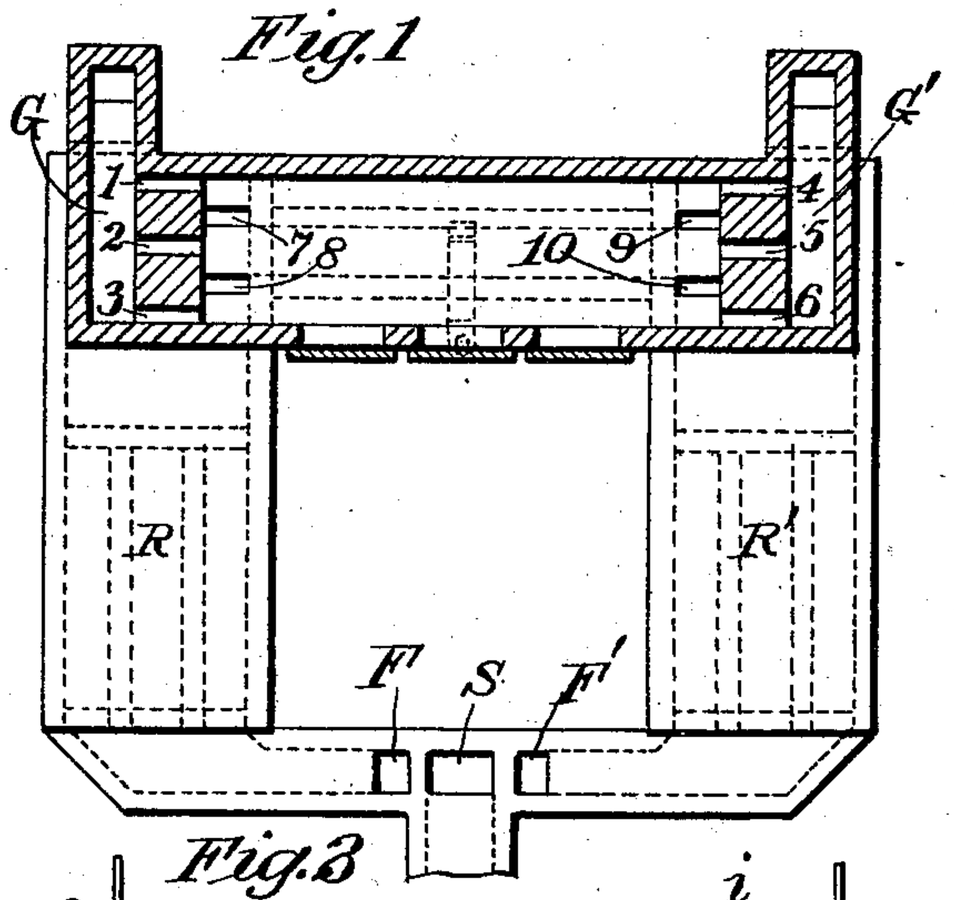


Fig. 2

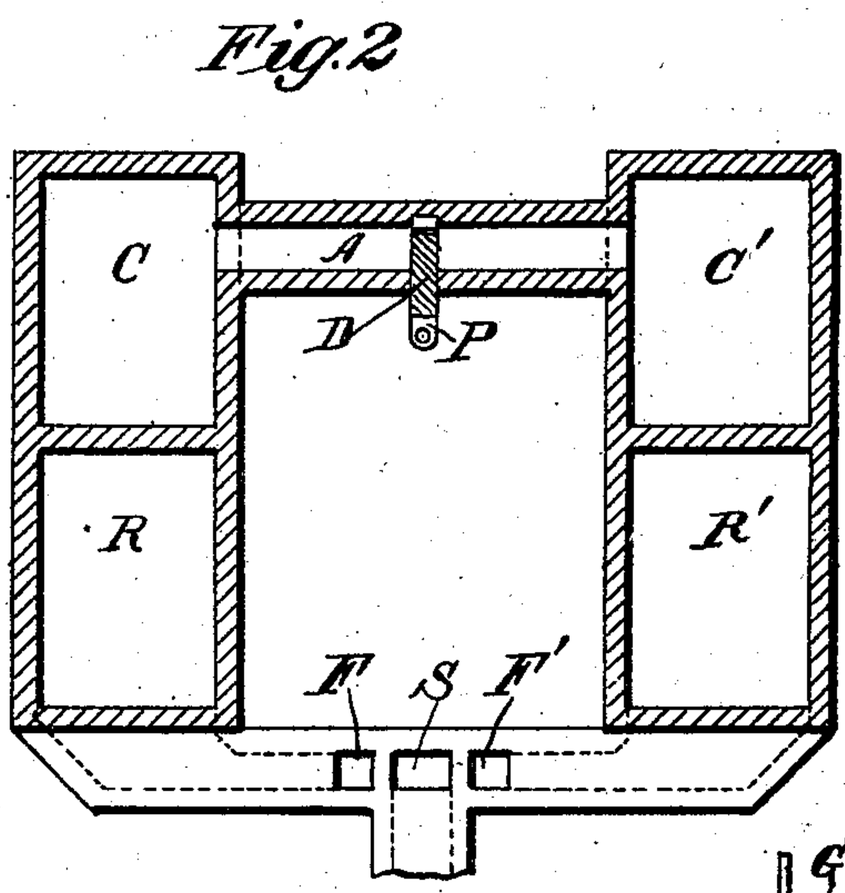


Fig. 3

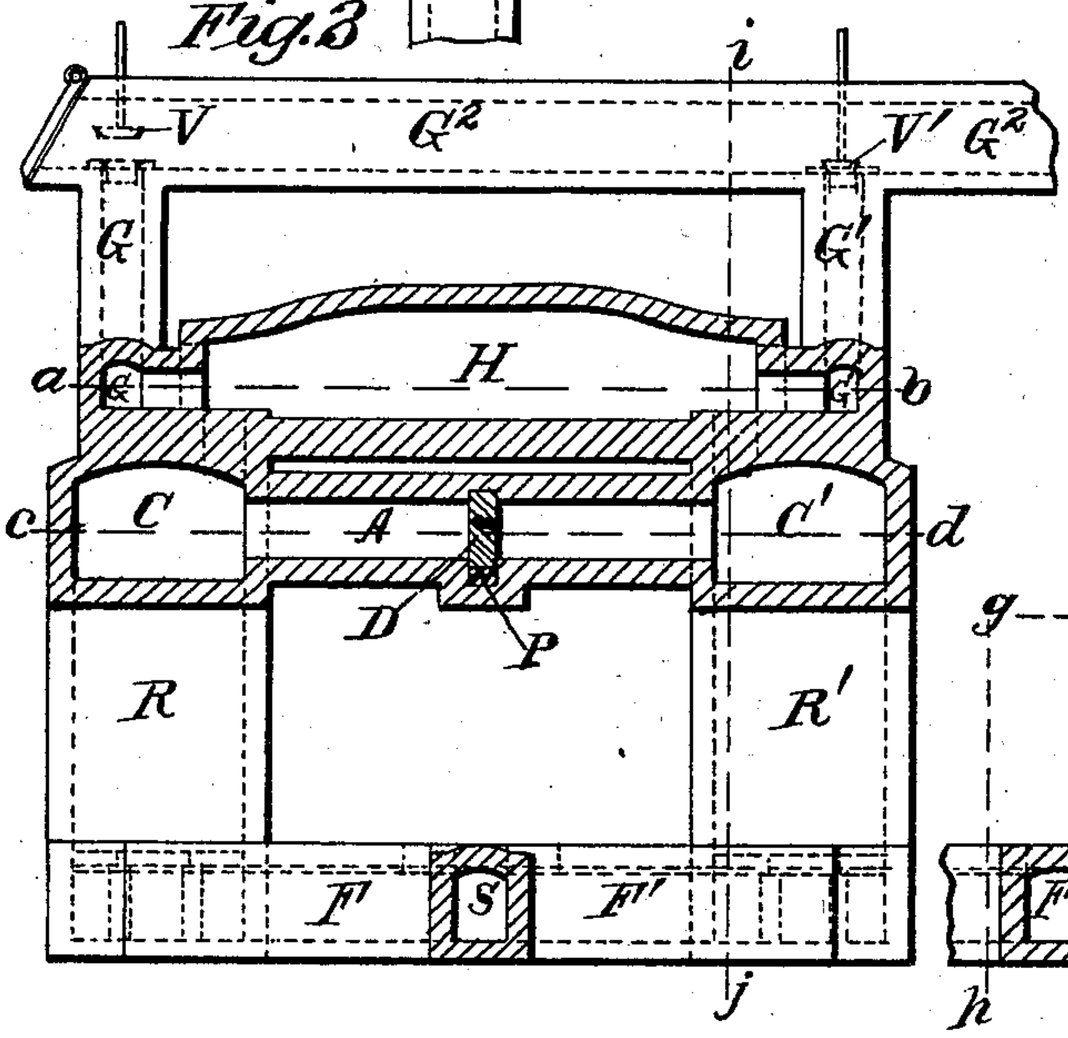
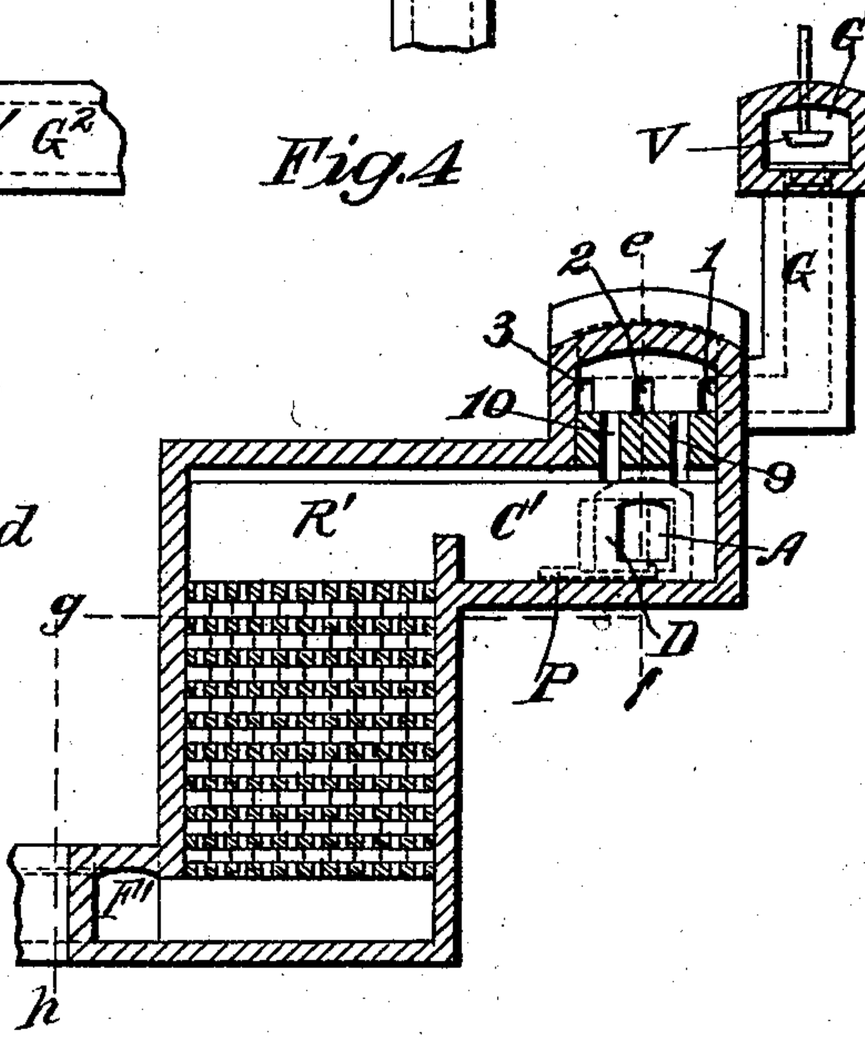


Fig. 4



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(No Model.) 2 Sheets—Sheet 2.

Fig. 5

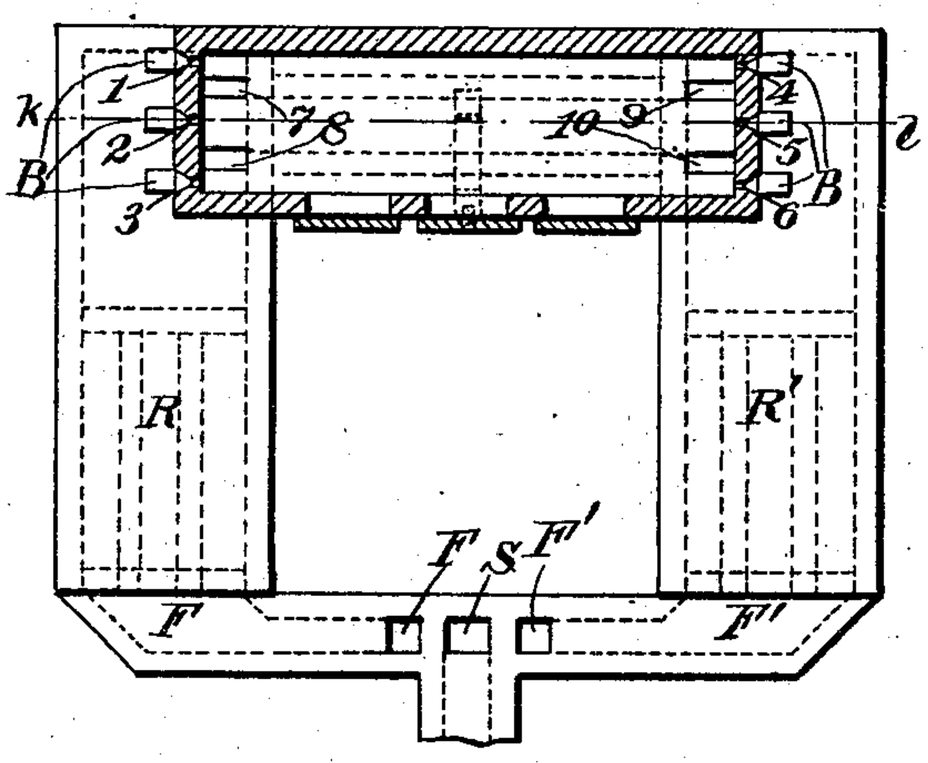


Fig. 6

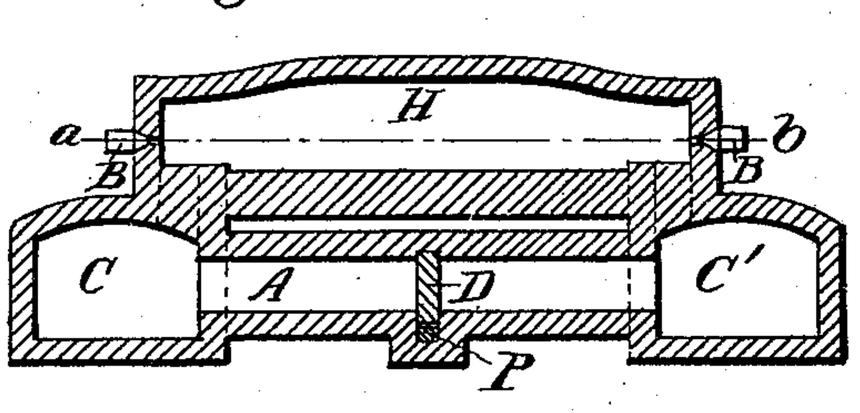


Fig. 7

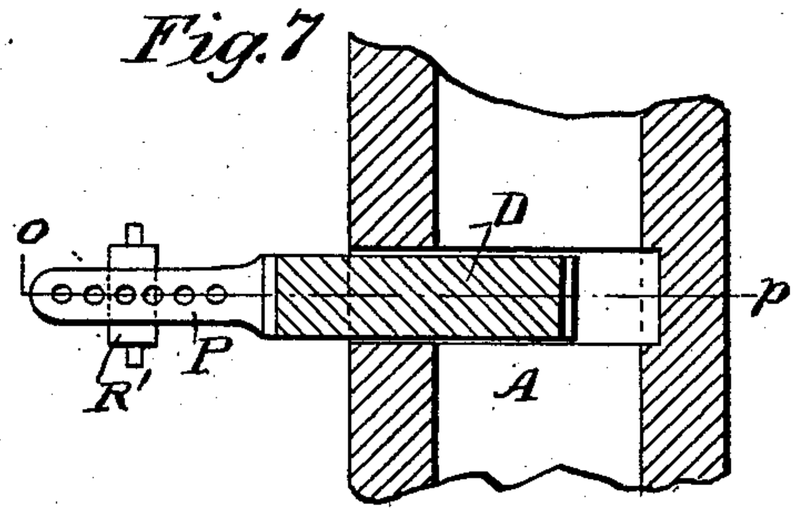


Fig. 11

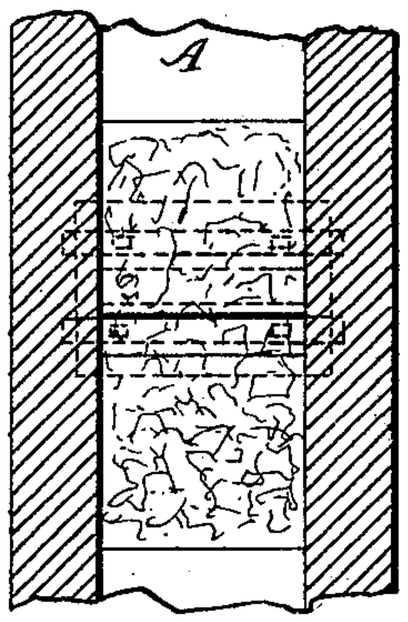


Fig. 8

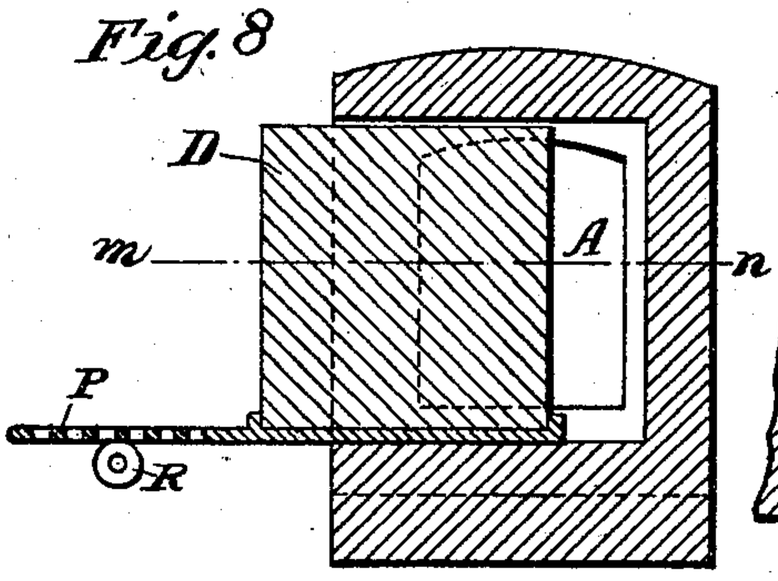


Fig. 9

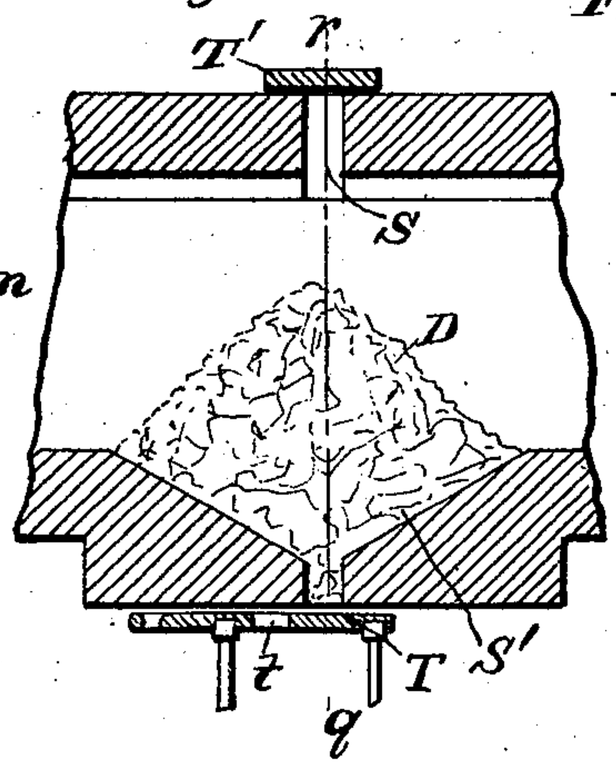
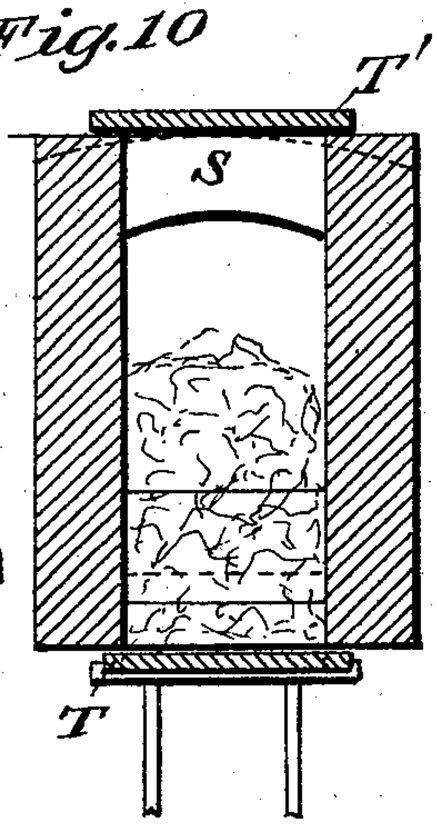


Fig. 10



Witnesses
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UNITED STATES PATENT OFFICE.

HENRY L. GANTT, OF FOUNTAIN HILL, PENNSYLVANIA.

FURNACE FOR HEATING AND MELTING IRON, &c.

SPECIFICATION forming part of Letters Patent No. 708,705, dated September 9, 1902.

Application filed March 22, 1901. Serial No. 52,326. (No model.)

To all whom it may concern:

Be it known that I, HENRY L. GANTT, a citizen of the United States, residing at Fountain Hill, in the county of Lehigh, State of Pennsylvania, have invented certain new and useful Improvements in Furnaces for Heating or Melting Iron and Steel and for other Purposes, of which the following is a specification.

This invention relates to a class or type of furnace constructed on the regenerative principle wherein part of the air entering through one regenerator, and so being highly heated, is diverted directly to the other regenerator to complete therein the combustion of unconsumed gases leaving the combustion-chamber of the furnace. Such a furnace is shown in my Patent No. 559,940, dated May 12, 1896. The prior art, so far as I am informed, contains nothing more pertinent or more nearly resembling the present invention than the furnace described in said patent. In that patent there are two regenerators which respectively connect each with a fuel-chamber, and between the two fuel-chambers is interposed a chamber or hearth to contain material to be operated upon. The two fuel-chambers are charged with solid fuel (*i. e.*, coal or coke in relatively large pieces which lie at rest in the fuel-chambers and through which air to support combustion is forced or drawn as in the ordinary way of burning such fuel) and the incoming hot air from one of the regenerators passes into the fuel in combustion in one of the fuel-chambers. The products of combustion of such fuel, mainly carbonic oxid at a high temperature, pass thence through the middle chamber, operating upon any material that may be placed therein, thence into the fuel in combustion in the other fuel-chamber, the products of combustion whereof pass into the other regenerator, at the entrance to which they are met by the hot air diverted from the first-named regenerator, the carbonic oxid or unburned products of combustion so entering the second regenerator being thus burned to carbonic acid, a very high temperature developed, and the heat thereof taken up by the checker-work of the regenerator. The direction of draft or run of the furnace is reversed from time to time, the operation always being the same. In a furnace of that character the atmosphere in the middle chamber (or that interposed between the two fuel-chambers) where the material to be treated is placed is necessarily of a strongly-reducing character and can in no way be modified or controlled. While it is true that the heat of combustion of the gases at the entrances to the regenerators is in the main taken up by the checker-work of the regenerators and subsequently given up to the incoming air and is not therefore wasted, still in the operation described there is danger of the checker-work being injured by the high temperature developed, particularly when the products of combustion entering the regenerators carry with them from the fuel (as in practice they will) material acting as fluxes upon the bricks of the checker-work. Further, when the furnace is running in a given direction the combustion of the fuel in the fuel-chamber most distant from the regenerator through which air is at the moment entering is only available for heating up of the adjacent regenerator and is not capable of being directly applied in the intermediate chamber where the work for which the furnace is being used is accomplished.

The present invention provides, first, for definite control of the character of atmosphere in the chamber where the material is under treatment, and, second, that such atmosphere may be varied at will from a non-oxidizing atmosphere to an oxidizing one, according to the results sought in any particular case, and while retaining the feature of diverting part of the incoming heated air to complete the combustion of gases leaving said chamber provides for the protection and preservation of the checker-work of the regenerators.

In regenerative furnaces (other than those of the type disclosed in the before-mentioned patent) as heretofore built there is no means of obtaining very high temperatures without an oxidizing effect and no means of producing a non-oxidizing atmosphere without a very material reduction of temperature. In all such furnaces when it is attempted to get less oxidation it is always accomplished at the

cost of a waste of fuel and a loss of temperature. Even then the result is not satisfactory, especially for heating iron and steel.

The object of the present invention is to obtain high temperatures and to maintain them with an economical use of fuel whether the heating-atmosphere be oxidizing or non-oxidizing in character. Instead of solid fuel, as above defined, I use a fuel that is burned in suspension and may be supplied continuously in regulated quantity, and hence one that is in an attenuated, fluid, or finely-divided form. Such fuels may be producer or other gas, oil, or pulverized coal or coke. I prefer to use gas, as it is more satisfactory, not only in the results obtainable, but also in the general operation of the furnace.

I provide a regenerative furnace having regenerators for the air only and use a fuel capable of being consumed in suspension and fed in regulated quantity, which when gas should preferably be taken from a gas-producer placed as close as possible to the furnace to avoid loss of heat. The solid-fuel chambers before described are dispensed with, and connected with each regenerator-chamber and between it and the heating-chamber I provide what may be called a "waste-gas-burning chamber," which is practically an enlargement of the well-known slag-pocket in the flue running from the regenerator to the heating or melting chamber of an ordinary regenerative furnace. These waste-gas-burning chambers are connected with the heating or melting chamber by a flue or flues and are also connected with each other by another flue or set of flues, through which a determined or regulated relatively large or relatively small portion of the incoming air may be taken directly from one of the said chambers to the other. Such air having already passed through one of the regenerators is highly heated and suitable to efficiently complete in said other chamber the combustion of any combustible gases that may pass out of the heating-chamber unconsumed. The checker-work in the outgoing regenerator is thus highly heated, and when the direction of the air and gas is reversed the air passing into the heating-chamber is of such a high temperature that but a small quantity is needed to combine with hot gas taken direct from a producer to develop a high temperature. I may therefore have in the heating-chamber a high temperature even though an excess of gas or fuel in suspension produces a reducing flame or atmosphere. At the same time the hot air that is transferred from the incoming waste-gas-burning chamber to the outgoing one completes in the latter the combustion of the gases leaving the furnace and heats the regenerator to a high degree. To get all the advantages of this method of burning gas, the regenerators should be relatively large, so that the heat of the outgoing gases may be thoroughly absorbed. The said chambers may, it is true, be part of the regenerator-chambers themselves; but I prefer to have them separate, as the high temperatures produced will injure the checker-work if the combustion takes place in direct contact with the checker-brick. In any event there should be a space or chamber of material dimensions between the checker-work of each regenerator and the flue or flues leading to the heating-chamber, and these spaces must be in communication through the cross-connecting air-passage referred to. For reasons herein stated I prefer to enlarge and so divide them from the checker-work as to make the comparatively distinct or separate chambers, which I term "waste-gas-burning chambers," although they in fact constitute in part the passage-ways leading from the checker-work part of the regenerators to the heating-chamber. These chambers serve to intercept and hold dust and unconsumed particles that would choke the openings in the checker-work and also act as a flux on the bricks. When a furnace is to be designed for a special purpose and the required atmosphere and amount of fuel to be burned are known, the cross-sectional area of the air shunt or passage connecting the two waste-gas-burning chambers may be determined and the furnace so constructed. A better way, however, of determining or regulating the quantity of air admitted to the heating-chamber or the chamber where the combustion of fuel in suspension initially occurs is to make the flue connecting the two waste-gas-burning chambers quite large in cross-section, so that nearly all the air has a tendency to take the course through it, and provide it with a damper or controlling device of any suitable character, by which it may be more or less closed, thus causing any desired quantity of the heated air to enter the heating-chamber. In this way any character of flame or atmosphere in the heating-chamber of a furnace may be obtained. When a large proportion of air is allowed to pass through the flue connecting the waste-gas-burning chambers, the atmosphere in the heating-chamber may be of a strongly non-oxidizing character and yet be of a high temperature, for it is apparent that the waste-gas-burning chambers and the upper portion of the regenerators will be heated to an extremely high temperature and the incoming air correspondingly raised in temperature. By more or less closing the said flue a greater quantity of the incoming air may be compelled to pass to the heating-chamber, and such control of the air may be carried to such point as to develop an oxidizing atmosphere in the heating-chamber and yet enough of the air be diverted from the incoming to the outgoing waste-gas-burning chamber to properly burn therein any unburned combustible gases leaving the heating-chamber. Such a furnace therefore affords at will a heating-atmosphere which may be oxidizing or non-oxidizing, according to the position of the damper, and under all con-

ditions is smokeless, as all the smoke or unconsumed fuel leaving the heating-chamber is burned in the waste-gas-burning chambers.

A furnace having the characteristics above described may be built in a variety of ways; but the general plan which I prefer is that shown in the accompanying drawings, in which—

Figure 1 shows a horizontal section of the furnace on the line *a b* of Fig. 3; Fig. 2, a horizontal section on the line *c d* of Fig. 3; Fig. 3, a vertical section on the line *e f g h* of Fig. 4; Fig. 4, a vertical section on the line *i j* of Fig. 3; Fig. 5, a horizontal section on the same plane as *a b*, Fig. 3, taken on the line *a b* of Fig. 6 and showing a modification of the way of introducing the fluid fuel; Fig. 6, a section on the line *k l* of Fig. 5; Fig. 7, an enlarged detail horizontal section showing the damper and taken on the line *m n*, Fig. 8; Fig. 8, a like vertical section on the line *o p*, Fig. 7; Fig. 9, a sectional view taken on the same line as Fig. 8, but showing a different character of damper; Fig. 10, a section through Fig. 9 on the line *q r*, and Fig. 11 a detail horizontal section showing in plan the bottom of the flue in which the damper is placed.

H is the heating-chamber, R R′ the regenerators, and C C′ the waste-gas-burning chambers, respectively, introduced between the regenerators and the heating-chamber.

A is a flue directly connecting the two waste-gas-burning chambers, and in it is a damper D.

G^2 is the gas pipe or flue connected with the gas producer or producers.

V is a valve serving to connect the gas-pipe with the passage G, having flues 1, 2, and 3, that admit gas directly to the heating-chamber, the valve V′ serving to connect the gas-flue G^2 with the passage G′, having flues 4, 5, and 6, which admit the gas to the heating-chamber.

F and F′ are passages connected either with the stack S or the air-supply passage at will by the ordinary four-way reversing-valve commonly employed in regenerative furnaces and not shown in the drawings. This valve may be so set that the air will enter F′ while the products of combustion pass through F to the stack S, or the connections may be reversed, so that the air enters F and the products of combustion pass through F′ to the stack. Assuming that the valve is so set that the air enters F′ from F, it passes through the regenerator R′ into the chamber C′, from whence a portion of the heated air enters the heating-chamber H through the flues 9 and 10, while another portion of the air passes through the air-flue A into the chamber C, where it combines with and completes the combustion of the unburned gases that leave the chamber H and enter the chamber C through the ports 7 and 8. While the air is taking this course the valve V′ is open, allowing gas from the producer to pass through G^2 and G′ and the ports 4, 5, and 6 into the heating-chamber H. From H the products of combustion pass through flues 7 and 8 to the waste-gas-burning chamber C, and from whence the products of combustion pass through the regenerator R, the flue or passage F, and through S to the stack. If the air enters F, the valve V is opened and V′ closed, combustion is completed in C′, and the products of combustion go out through F′ to S. By manipulating the damper D as much or as little of the combustion as is desired may be caused to take place in the heating-chamber H, the remainder of the combustion taking place in either the waste-gas-burning chamber C or C′, according to the direction in which the furnace is being run. Thus while there is complete combustion of the fuel and utilization of the heat any character of flame or atmosphere may be obtained.

On account of the high temperature in the flue A the problem of putting a suitable damper therein is different from what it would be if the temperature were not so high. This damper should preferably be of highly refractory material—for instance, fire-brick or fire-sand. Figs. 7 and 8 show a damper D made of fire-brick and mounted on a metal plate P, preferably steel, the outer end of which is perforated and rests upon a roll R. By means of a bar passed through the perforations and bearing upon the roll as a fulcrum the damper may be drawn out or pushed in. The groove in the walls of the flue A, in which this damper slides, should be so deep that the bottom plate P is entirely below the bottom of the flue, and thereby protected from the intense heat of the air passing through the flue. A suitable damper may also be made by the use of fire-sand, (preferably silica-sand,) as shown in Figs. 9, 10, and 11. In order to use a damper of this kind, a transverse slit S is made in the top of the flue and one S′ in the bottom directly underneath. The sand may be introduced at the top slit to close or partly close the flue and allowed to run out of the bottom slit to open it, the walls of the bottom slit being preferably inclined at S^2, as shown. A sliding plate T, having a slot *t*, placed under the flue at the bottom slit, will prevent the sand from running out, and a tile over the top slit will prevent the hot air from escaping. A refractory silica-sand, such as "Cross keys" sand, will not be fluxed by any temperature that is likely to be obtained in this flue and may be put in and taken out without any difficulty.

Instead of introducing gas as fuel into the heating-chamber H in the manner described or in any suitable manner I may in the same way introduce vaporized oil, or the fuel may be introduced as shown in Figs. 5 and 6, where B represents injectors or burners. These injectors may be used in the ordinary way to inject or introduce into the chamber H liquid fuel, as oil, or pulverized coal or coke. The injectors or burners B are dia-

grammatically indicated. Many forms or styles of such burners for feeding oil and for feeding pulverized fuel and using air or steam as the injecting medium are well known. For practical reasons I prefer in most cases to use producer-gas.

I claim as my invention—

1. A furnace comprising regenerators for air, a heating-chamber, waste-gas-burning chambers respectively connecting on one side with the space at the end of the regenerator checker-work, and on the other side with the heating-chamber, and that act as dust-collectors to protect the regenerators, means for introducing into the heating-chamber a finely-divided or attenuated fuel that is burned in suspension in said chamber, and a passage, connecting the waste-gas-burning chambers, through which part of the incoming heated air passes, and which is of such cross-sectional area as compared with the passages between the combustion-chambers and the heating-chamber that the incoming heated air passing to the heating-chamber is of such volume as to produce therein a partial combustion only of the fuel the unconsumed parts of the fuel leaving the heating-chamber being completely burned in the waste-gas-burning chambers.

2. A furnace comprising regenerators for air, a heating-chamber, waste-gas-burning chambers, one for each regenerator, respectively interposed between the regenerators and the heating-chamber, means for introducing into the heating-chamber a finely-divided or attenuated fuel that is burned in suspension in said chamber, a passage connecting the waste-gas-burning chambers, and means for varying at will the cross-sectional area of said passage to so control the quantity of air passing to the heating-chamber as to produce therein the desired character of flame or atmosphere.

3. A furnace comprising two regenerators, a heating-chamber interposed between their inner ends with a space of material dimensions between the checker-work of each regenerator and the heating-chamber, means for introducing into the heating-chamber a finely-divided or attenuated fuel that is burned in suspension in said chamber, an air-passage connecting said spaces at the inner ends of the regenerators, and means for varying at will the cross-sectional area of said passage to so control the quantity of air passing to the heating-chamber as to produce therein the desired character of flame or atmosphere.

4. A furnace comprising regenerators for air, a heating-chamber interposed between the inner ends of the regenerators with a space of material dimensions between the checker-work of each regenerator and the heating-chamber, a passage connecting said spaces, means for introducing into the heating-chamber a finely-divided or attenuated fuel that is burned in suspension, and means for regulating the relative quantities of incoming heated air passing through the passage connecting the regenerators, and into the heating-chamber, respectively.

5. A furnace comprising regenerators for air, a heating-chamber, waste-gas-burning chambers, one for each regenerator, respectively interposed between the regenerators and the heating-chamber, means for introducing into the heating-chamber a finely-divided or attenuated fuel that is burned in suspension, a passage connecting the waste-gas-burning chambers, and means for varying at will the quantity of incoming heated air passing to the respective combustion-chambers and to the heating-chamber to produce in the latter the desired character of atmosphere.

In testimony whereof I have hereunto subscribed my name.

HENRY L. GANTT.

Witnesses:
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JAMES HENNESY.