(No Model.) 11 Sheets—Sheet 1.

F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

No. 341,285. Patented May 4, 1886.

Fig. 1.

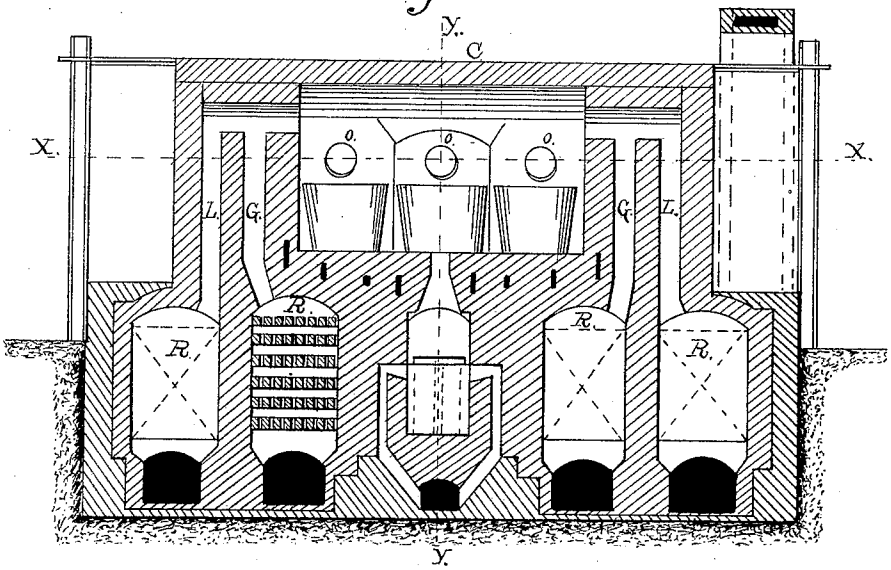
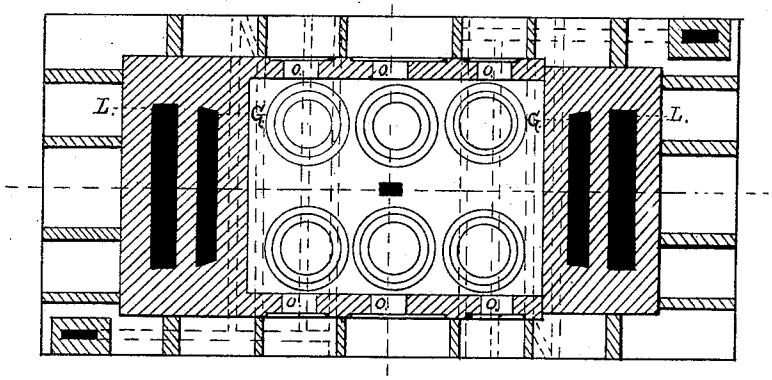


Fig. 2.



WITNESSES

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METHOD OF WORKING REGENERATIVE GAS FURNACES.

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Fig. 3.

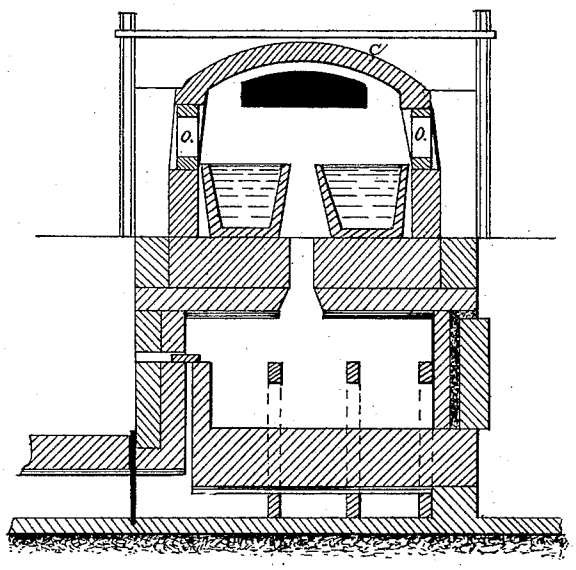
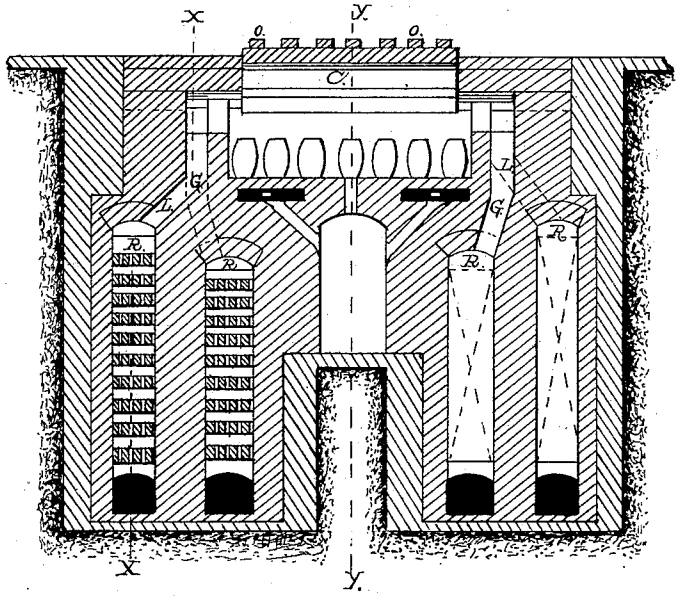


Fig. 4.



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Fig. 5.

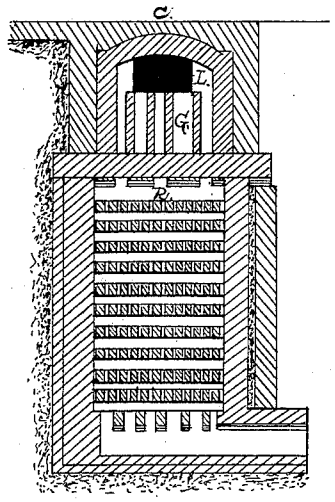


Fig. 6.

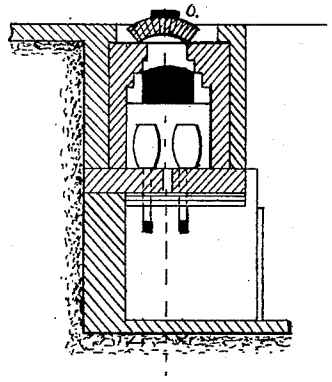
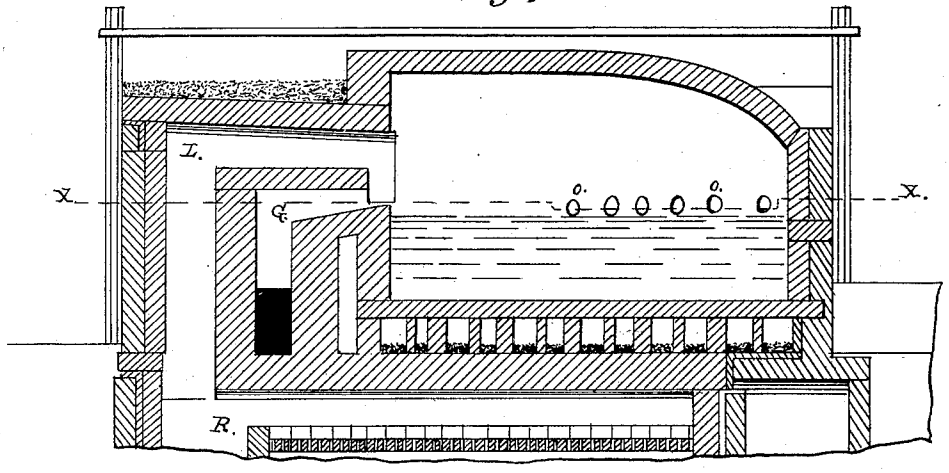


Fig. 1.



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METHOD OF WORKING REGENERATIVE GAS FURNACES.

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Fig. 8.

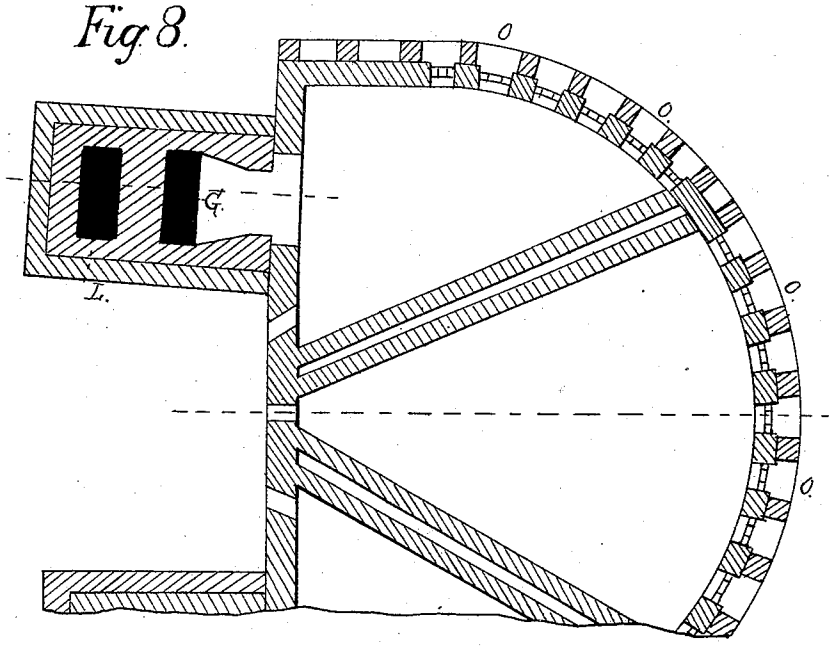
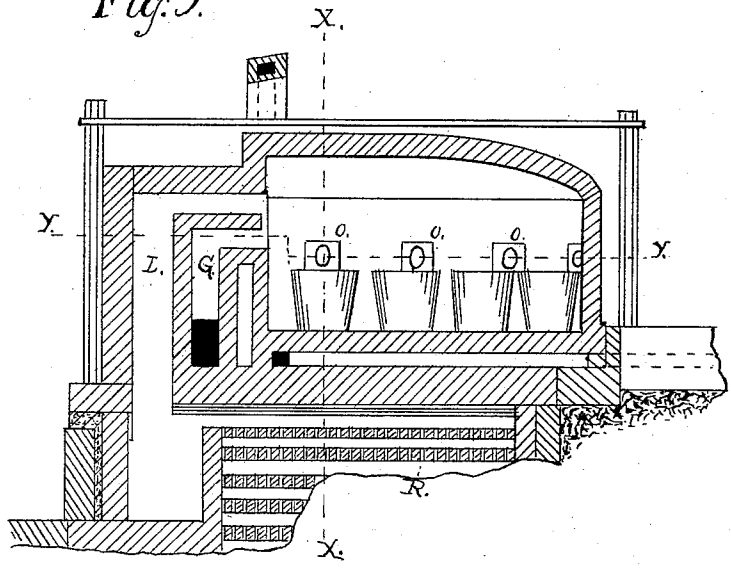


Fig. 9.



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F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

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Fig. 10.

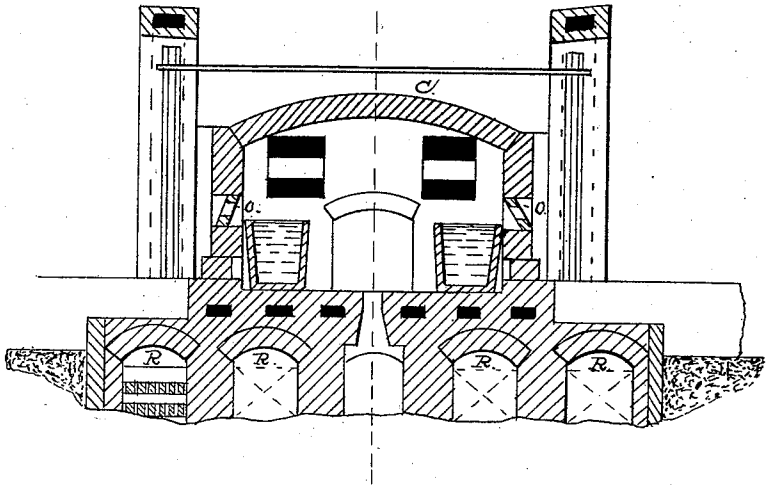
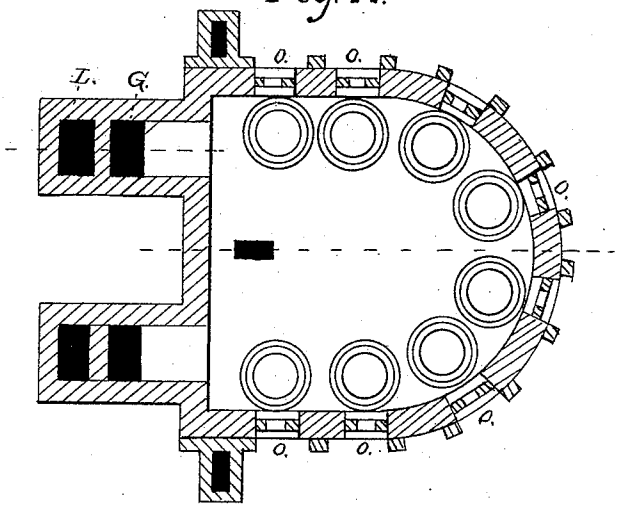


Fig. 11.



WITNESSES

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METHOD OF WORKING REGENERATIVE GAS FURNACES.

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Fig. 12.

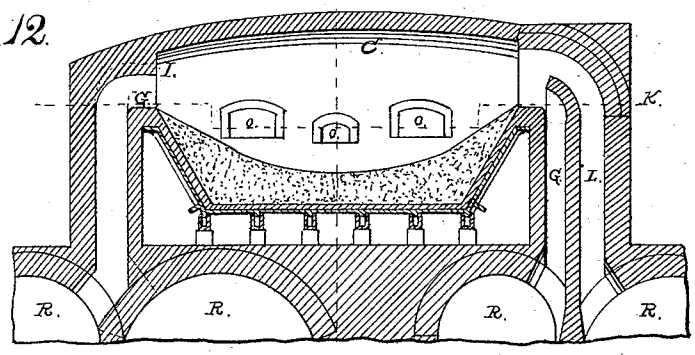


Fig. 13.

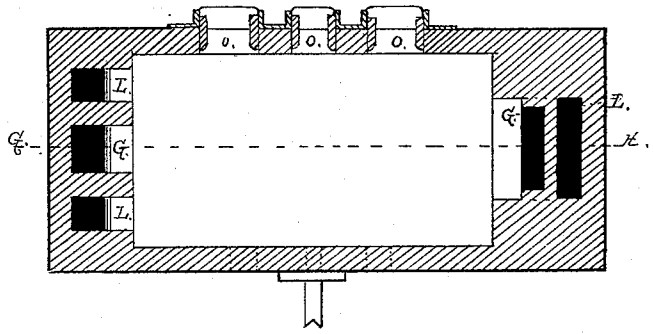
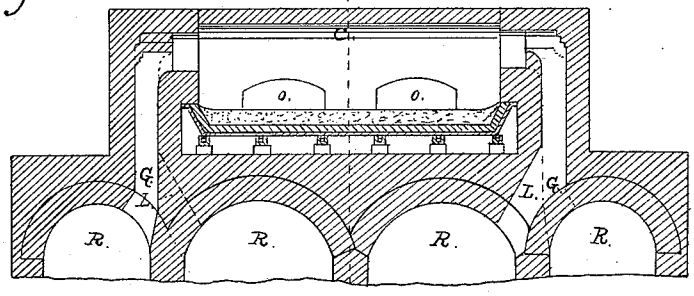


Fig. 14.



WITNESSES

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F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

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Fig. 15.

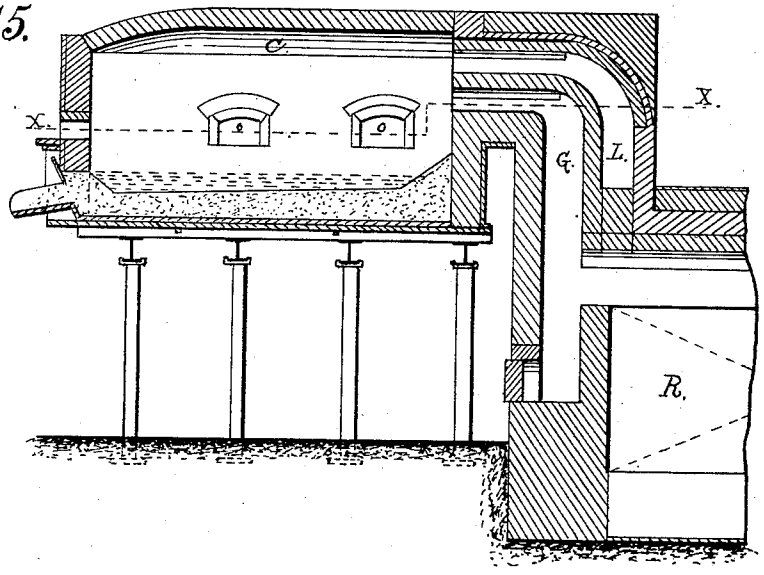
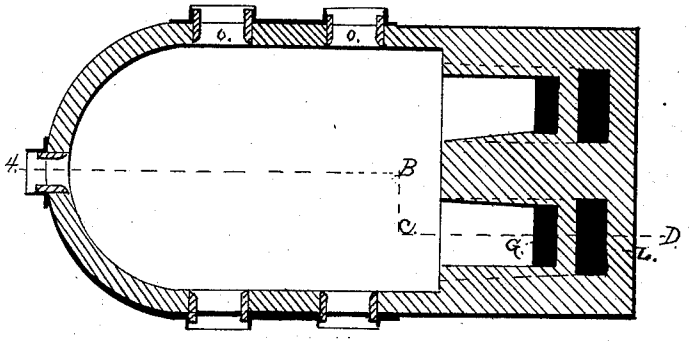


Fig. 16.



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F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

No. 341,285. Patented May 4, 1886.

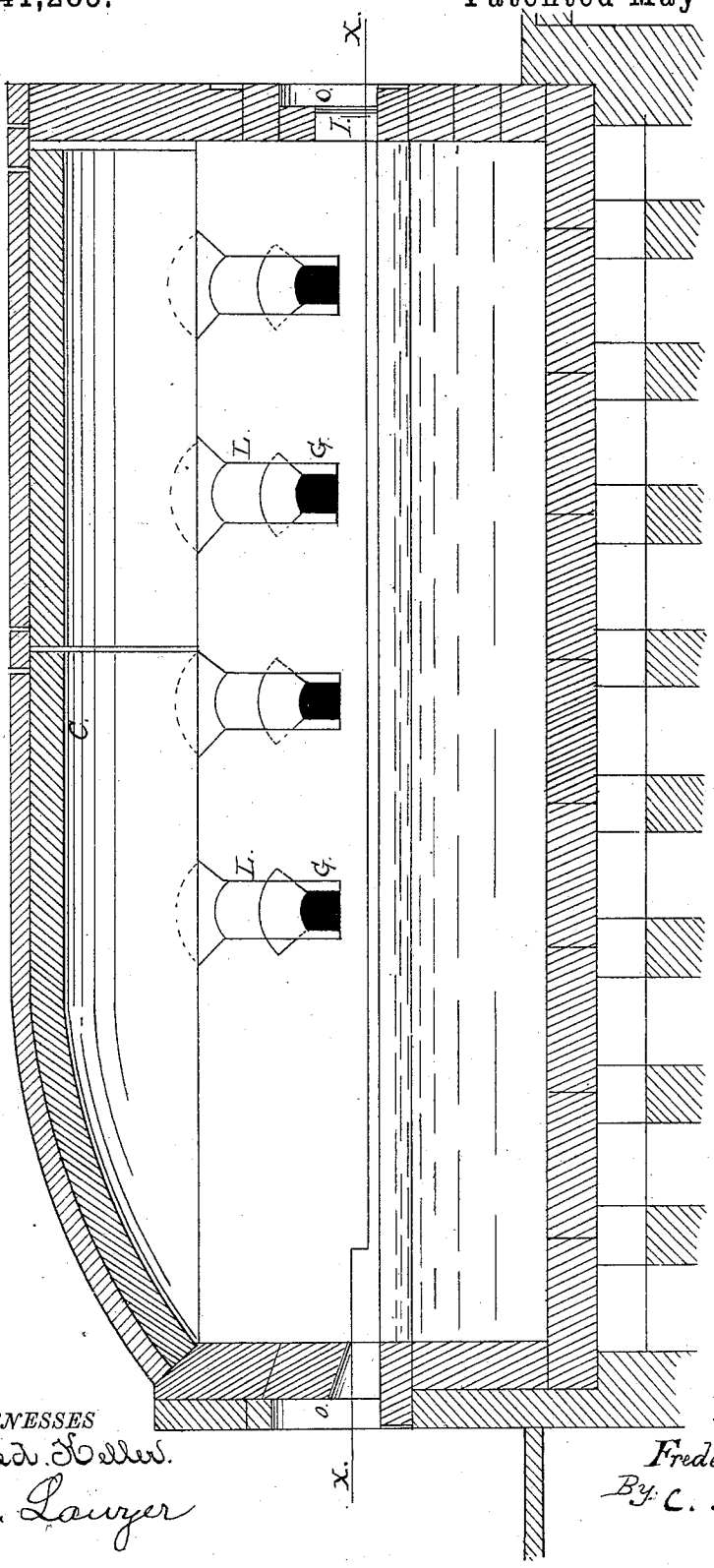


Fig. 17.

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F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

No. 341,285. Patented May 4, 1886.

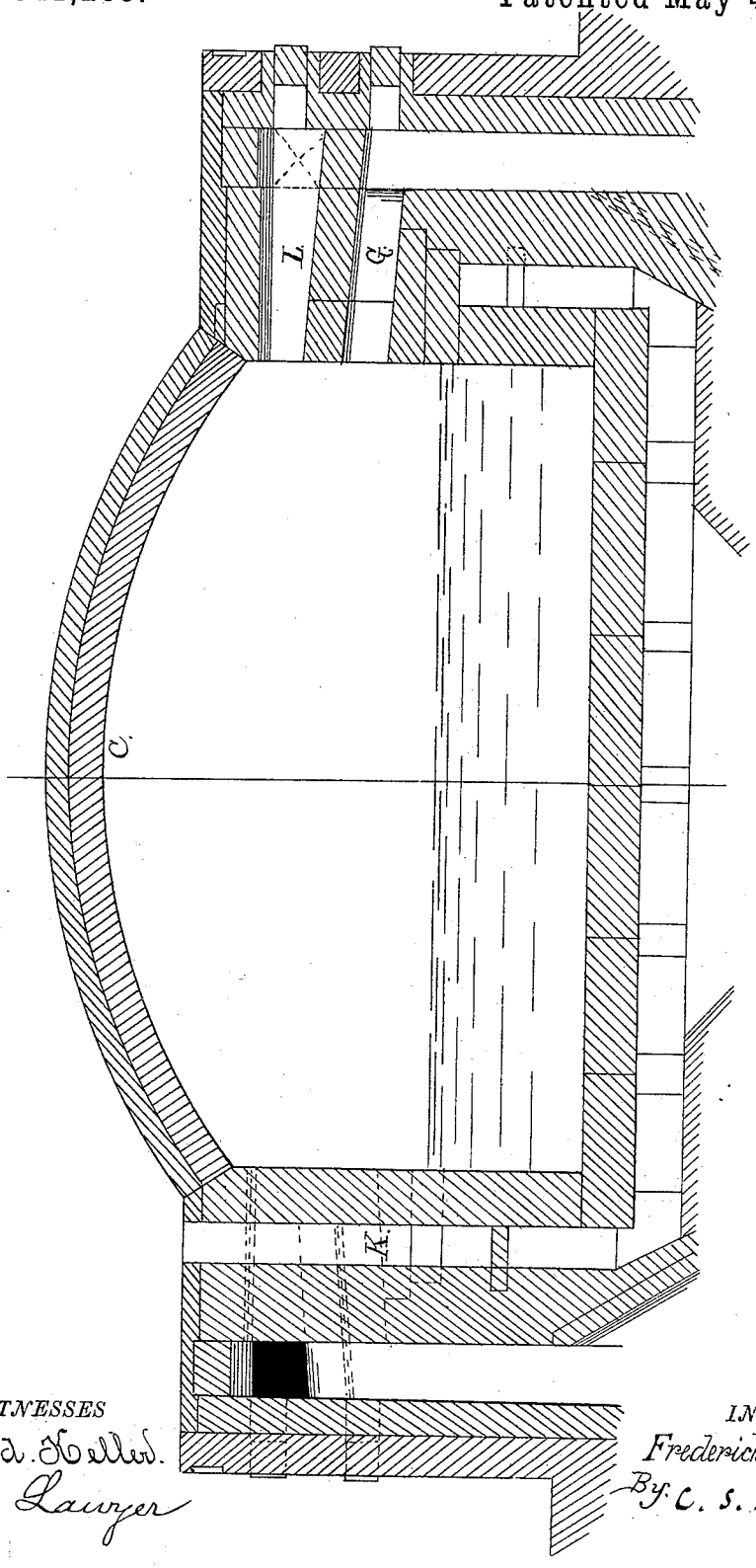


Fig. 18.

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F. SIEMENS.

METHOD OF WORKING REGENERATIVE GAS FURNACES.

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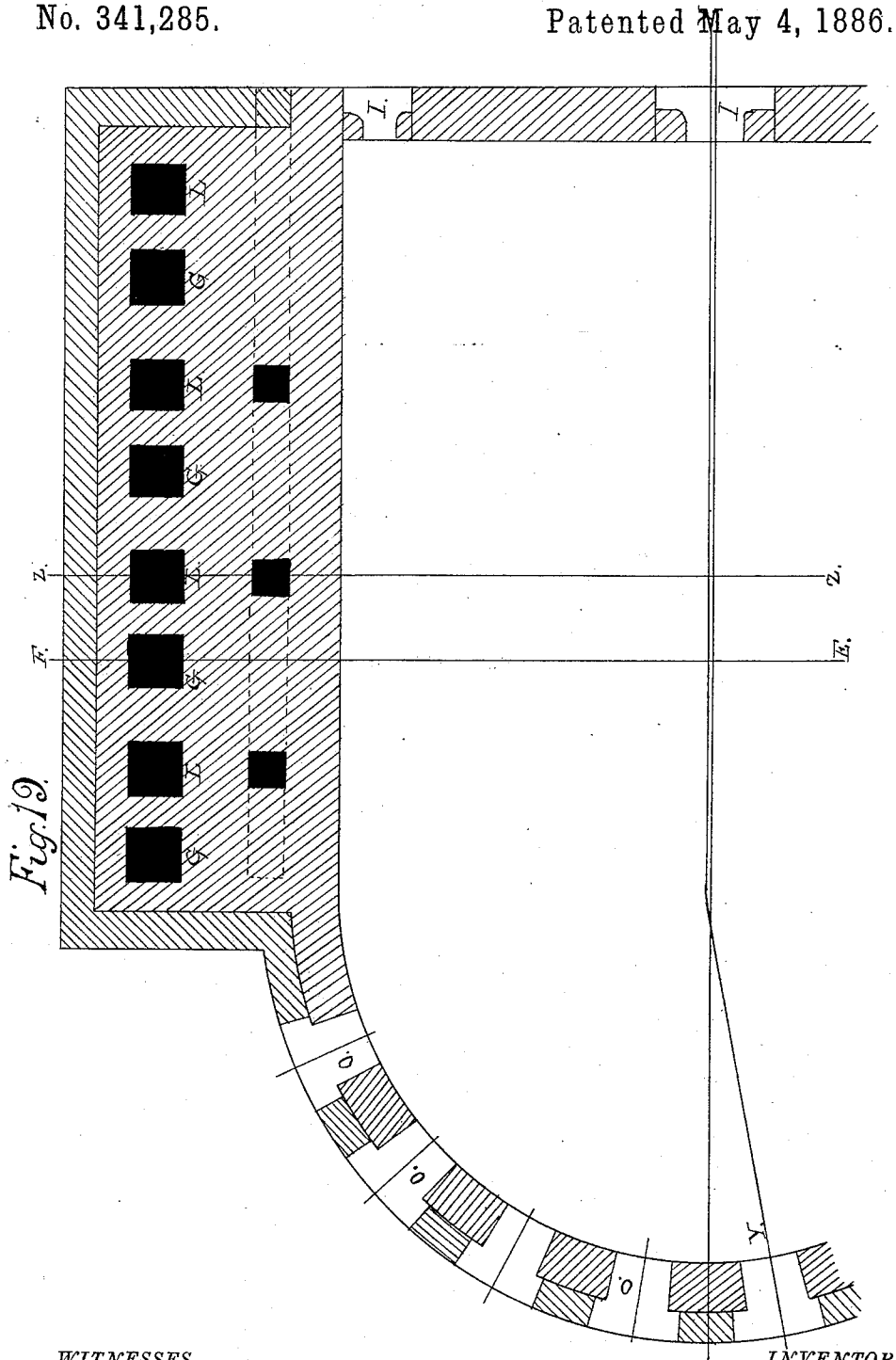


Fig. 12.

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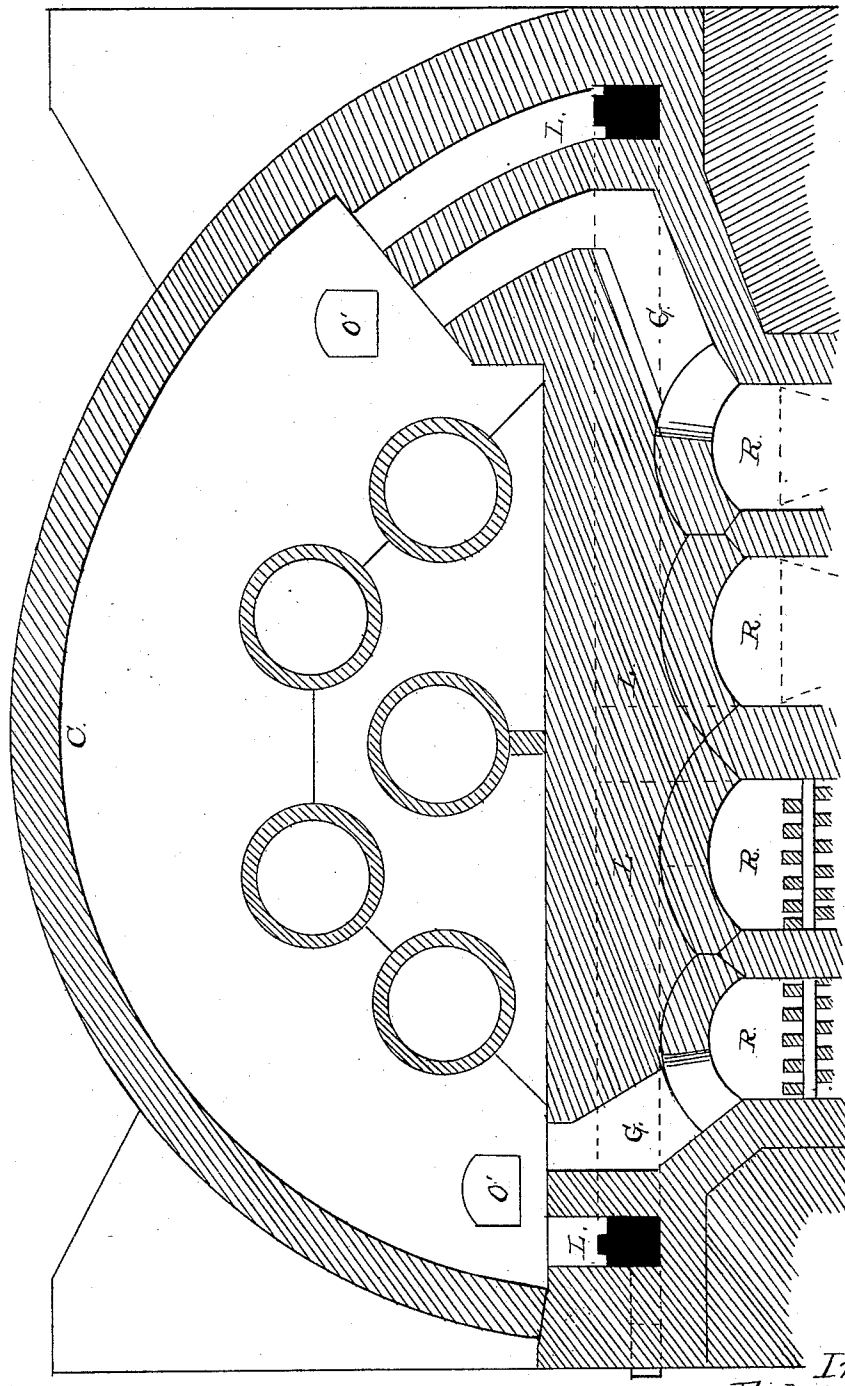
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METHOD OF WORKING REGENERATIVE GAS FURNACES.

No. 341,285. Patented May 4, 1886.

Fig. 20.



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UNITED STATES PATENT OFFICE.

FREDERICK SIEMENS, OF DRESDEN, SAXONY, GERMANY.

METHOD OF WORKING REGENERATIVE GAS-FURNACES.

SPECIFICATION forming part of Letters Patent No. 341,285, dated May 4, 1886.

Application filed December 19, 1884. Serial No. 150,741. (No model.) Patented in England December 8, 1883, No. 5,677; in France December 21, 1883, No. 159,316; in Belgium December 22, 1883, No. 63,626; in Germany January 22, 1884, and in Austria-Hungary June 26, 1884, No. 16,258 and No. 26,486.

To all whom it may concern:

Be it known that I, FREDERICK SIEMENS, a subject of the Emperor of Germany, residing at Dresden, Saxony, in the German Empire, have invented certain new and useful Improvements in Methods of Working Regenerative Gas-Furnaces; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to that class of regenerative gas-furnaces used for high temperatures—such as steel-melting on the open hearth and in crucibles, glass-melting, heating iron and steel, and other purposes—which are constructed with four regenerators, acting in pairs and alternately, one pair serving for heating separately the gaseous fuel and air supplying the heating-chamber, while the other pair serves for storing heat from the products of combustion on their way from the said heating-chamber to the chimney-stacks, the direction of the inflowing and outflowing currents being reversed from time to time. For such furnaces and their application to various purposes in the art my brother, the late Sir William Siemens, and myself, sometimes conjointly, sometimes independently, have obtained Letters Patent in the United States and in other countries, and their general construction and action are now so well known that it will be unnecessary for me to give a full description thereof in this specification, which I shall confine mainly to their construction and working in so far as they are affected by my present improvements.

In these furnaces, as they have hitherto been constructed and worked, the flame has been directed on and caused to strike the objects or materials that are to be heated, and the heating-chambers have been made as small in capacity as possible, having regard to the operations to be effected, so that the flame also impinged upon their walls and roofs. I have found that this method of construction and working often seriously damages the materials to be subjected to the influence of heat, and the crucibles, pots, or other vessels containing them, as well as the walls of the furnace itself. Moreover, when the flame impinges on objects colder than itself, or obstructing it, the combustion is rendered imperfect, and consequently there is considerable waste of fuel.

My invention has for its object to avoid these evils by so constructing and working furnaces that the flame is kept entirely clear from the objects or materials that are to be heated and from the furnace-walls, and that the whole of the heat is obtained by radiation from the flame itself and from the roof and walls of the furnace-chamber, which are heated by radiation from it. Furnaces operating in this manner may be of various forms. They may have chambers of considerable length vaulted over, with the flame passing along their upper part from end to end, or from side to side, or they may be of circular, semicircular, horse-shoe or other forms, such that the combustible gases enter by a suitable opening or openings and sweep across or round the chamber, and the products of combustion issue by an opening or openings conveniently placed for that purpose. The object is to get a flame moving slowly in a line, which keeps it as clear as possible from the walls, roof, and bed of the furnace-chamber. The slow movement of the flame is of advantage, in preventing the agitation of the dust or other fine particles and the injurious effects of these or of the flame itself on the furnace-walls and the materials acted on.

In order to effect these results, my invention consists in traversing only the upper part of the furnace-chamber with the flame, or otherwise keeping the latter entirely clear from the objects and materials that are to be heated, also as much as possible from the furnace-walls, and heating the materials by radiation from the flame itself and from the roof and walls of the furnace-chamber.

My invention also consists in arranging over the heating-chamber a high crown, and combining therewith ports placed at such a height or formed in such a manner as to keep the flame above the working holes or doors of the furnace.

It furthermore consists in the arrangement of the gas and air ports, either at the upper

part of the heating-chamber or otherwise, for the purpose of imparting to the flame such a direction that it will touch neither the material which is to be heated or melted in such chamber, nor, as far as possible, the surrounding walls thereof, in order that an undisturbed combustion may be secured, and that at the same time the surrounding walls and the material in the furnace-chamber may be protected from the injurious direct action of the flame.

The accompanying drawings, in which corresponding parts are designated by similar letters, represent various constructions of furnace as examples, showing how my invention may be carried out in practice under various conditions; but it is to be understood that I do not limit myself to the various forms of furnace herein described, and that some of them shown as applied to certain purposes may also be used for other purposes, whether mentioned or not in this specification.

Figure 1 is a longitudinal section of a furnace for melting glass in pots, illustrating the application of my invention to a furnace in many respects similar in construction to that described in Letters Patent of the United States number two hundred and fifty-six thousand seven hundred and forty-eight, (No. 256,748,) heretofore granted upon an application filed by me. Fig. 2 is a sectional plan on the line X X of Fig. 1. Fig. 3 is a transverse section on the line Y Y of Fig. 1. Fig. 4 is a longitudinal section of a crucible steel-furnace having my invention applied thereto, and Figs. 5 and 6 are transverse sections on the lines X X and Y Y, respectively. Fig. 7 is a longitudinal section of a glass-tank furnace of a "horseshoe" form, somewhat similar in construction to those for which Letters Patent of the United States number two hundred and twenty-nine thousand eight hundred and forty-six (No. 229,846) and number two hundred and thirty thousand six hundred and sixty-eight (No. 230,668) have been heretofore granted to the late Sir William Siemens. Fig. 8 is a part sectional plan taken on the line X X of Fig. 7. Figs. 9, 10, and 11 are respectively a longitudinal section, a transverse section on the line X X, and a sectional plan on the line Y Y of another horseshoe-furnace for melting glass in pots. Fig. 12 is a longitudinal section, and Fig. 13 a sectional plan, of an open-hearth steel-melting furnace of horseshoe form. Fig. 14 is a longitudinal section, and Fig. 15 a sectional plan, of an open-hearth steel-melting furnace of rectangular form, showing different arrangements of gas and air ports on each side or end. Fig. 16 is a longitudinal section of a reheating-furnace for iron or steel, one side or end being taken through a gas-port and the other through an air-port. Fig. 17 is a longitudinal section on the line Y Y of Fig. 19, showing the construction of a tank glass-furnace somewhat similar in construction to that described in Letters Patent of the United States number two hundred and sixty-one thousand and fifty-four, (No. 261,054,) heretofore granted upon an application filed by me. Fig. 18 is a transverse section taken on the line Z Z of Fig. 19. Fig. 19 is a sectional plan on the line X X of Fig. 17. Fig. 20 is a section of a retort-furnace, in which the gas and air ports on one side are shown as delivering the gaseous currents vertically into the heating-chamber, and on the other side they are shown as delivering the gas-currents at an inclination from the vertical.

In all the figures, R are the regenerators; G, gas-flues; and L, the air-flues leading into the furnace-chamber from the regenerators, and acting alternately for supplying from one set of regenerators the heated gas and air to form the furnace-flame and to convey the hot products of combustion to the other set of regenerators.

C is the roof of the furnace-chamber.

O are working-doors or gathering-holes, or, in the case of the crucible steel-furnaces, are removable covers for giving access to the heating-chamber.

The gas and air ports, instead of being arranged so that the flame can impinge on the pots, crucibles, or on the material in the tank or on the bed of the furnace, are at such a height or of such form that the flame shall pass clear of the objects to be heated, and when these are pots or crucibles or lumps or packets of metal or other material, they are placed sufficiently far apart to allow free access of the radiated heat to all parts of them.

In order to prevent the flame of a furnace from coming into contact with the materials to be heated therein, various constructions may be adopted. Thus the gas and air forming the flame may be introduced into the heating-chamber by openings of such form as to impart to the flame a horizontal motion across the furnace-chamber, either from end to end or from side to side, or in the case of a horseshoe flame from the inlets to the outlets on the same side or wall, the flame openings or ports to be located so that their point of delivery into the heating-chamber shall be above the height of the materials to be heated, and the top and bottom walls may be horizontal for some distance, as shown in Figs. 1, 4, 9, 12, 14, and 16; or these walls may be inclined and converge toward each other, as shown in Figs. 7 and 18, or the gas and air ports may be located so that their point of delivery into the heating-chamber shall be partly or entirely below the materials to be heated, provided that they, as also the roof of heating-chamber, are formed in such a manner as to impart a rising or inclined motion to the flame, so that the latter may pass above the materials to be heated, as shown in Fig. 20. It is also to be understood that I prefer the flame to move in the heating-chamber of a furnace above the doors giving access thereto, either for the introduction of fresh materials, watching the operations therein, or for withdrawing substances therefrom, as shown in all the figures, except those

representing a crucible steel-melting furnace, in which the covers O also form the roof of the heating-chamber, and in the retort-furnace shown by Fig. 20, in which kindling-holes O′ are alone shown, which kindling-holes are intended to be kept closed while the furnace is working.

In order to prevent contact of the flame with the surrounding walls or roof of the heating-chamber of a furnace, a free space should be allowed for the development of the flame within it. For this purpose the gas and air ports should open into the heating-chamber at some distance from the roof, also at some distance from the side walls, as shown in the figures; and I prefer that the air port or ports be placed at the top of or at a higher level than the gas port or ports where practicable; also, that the air-ports, when placed immediately above the gas-ports, should be wider than the latter or overlap them, particularly on the side nearest the side wall of heating-chamber, as shown in Figs. 7, 8, 9, 10, 11, 13, 14, 15, (on right-hand side,) and 17, and in cases where the gas and air are delivered in adjoining streams I prefer that air-ports should be located nearer to the side walls and the roof of the heating-chamber than the gas-inlets, as shown in Figs. 4, 5, 14, and 15, left-hand side.

It is not possible to give dimensions of the distances for placing the gas and air ports from the roof or walls of the heating-chamber of a furnace, as these may be varied considerably, according to the form of heating-chamber required and the arrangement of ports adopted. In some cases, although I should not select them by preference, it may be necessary to construct the heating-chamber of a furnace of such a form, height, or width that the flame-ports cannot be entirely kept away from the roof or side walls, and in such cases it will be all the more necessary to place the air-ports nearest to the roof and side walls, for the reason that the air supporting combustion is not so much affected by contact with solid substances as the gas.

The number and form of gas and air delivery ports into the heating-chamber of a furnace may be varied considerably, as shown by the drawings annexed hereto; but it is to be understood that where a long travel is to be provided for the flame the gas and air should, by preference, be delivered into the furnace by one port for gas and one for air, as shown in Figs. 7, 9, 10, and 12, and these ports should be made high, so as to introduce thick volumes of gas and air, which will require time to burn thoroughly. When the length of travel for flame is shorter, and the same form of port is adopted, the gas and air ports are to be made less in height, but broader, than in the former case; or the combustion may be promoted by causing ignition to commence inside the flame-ports, as shown in Figs. 1, 7, and 14, (right-hand side;) or several gas and air ports may be provided, as shown in Figs. 17 and 19; or the gas and air may be delivered into the furnace in several adjoining streams, meeting in the heating-chamber, as shown in Figs. 14 and 15, (left-hand side;) or, again, these streams may be made to ignite before entering the heating-chamber, as shown in Figs. 5 and 16.

In the crucible steel-melting furnace shown by Figs. 4, 5, and 6, as the length of travel of the flame is comparatively short, the gas is brought into the chamber by two ports having an air-port between them, and additional air-ports on either side, the ignition commencing as soon as the gas and air, which are delivered in thin streams, reach the height of a mixing-chamber, from which the flame issues into the wider heating-chamber of the furnace, across which it travels from end to end. A mixing-chamber for flame is shown in Figs. 1, 3, 7, 8, 14, (right-hand side,) and 16, in connection with other forms of furnaces.

As shown by Fig. 13, in some cases the gas-ports may be formed so as to deliver the inflowing gas within the heating-chamber with an inclination toward its center, and the air-ports may be arranged so as to deliver the inflowing air with an inclination toward its surrounding walls, with the view of keeping the gas away from the latter.

As shown by Fig. 20, the gas and air current forming the flame may be delivered into the heating-chamber vertically or at an inclination from the vertical, and entirely or partly below the objects to be heated. These arrangements of flame-ports are shown one at the one side and the other at the other side of this figure; but in adopting these forms of ports the roof should be semicircular or an approximation thereto, or be otherwise constructed so that the flame shall pass clear of the objects to be heated, and, as far as possible, be kept away from the walls and roof of the heating-chamber.

It is to be clearly understood that in the various forms of furnaces above described the principal object aimed at is to prevent contact of the actual flame with any surface or object that is stationary or is colder than itself, as such contact interferes with the completeness of its combustion, and consequently reduces its heat-radiating power, and at the same time to protect the surrounding walls and the material in the furnace-chamber from the injurious direct action of the flame. When the flame ceases, the products of combustion, though not visible as flame, retain, nevertheless, a large amount of heat, and the combustion having been completed when that condition is reached, these products are employed to heat surfaces or objects by actual contact with them—as the bricks of the flues leading to the regenerators and the regenerators themselves of the furnace.

A furnace-chamber constructed according to my invention acts as a muffle, with this difference, that the latter is heated from the outside, while the former is heated from the inside by direct radiation from the flame passing over the materials to be heated and the radiation from the furnace-walls.

Having thus described my invention, I claim and desire to secure by Letters Patent of the United States—

The process of heating objects or materials in a furnace, which consists in first heating the gas and air constituting the furnace-flame by passing them through separate regenerators; second, traversing only the upper part of the furnace-chamber with the resultant flame; third, keeping the flame as clear as possible from the objects or materials to be heated, and, fourth, subjecting the objects and materials only to heat radiated from the flame itself and from the roof and walls of the furnace-chamber.

In testimony whereof I affix my signature in presence of two witnesses.

FREDERICK SIEMENS.

Witnesses:
THEODOR MUNDT,
CL. MAX HERMANN.