

July 29, 1941.

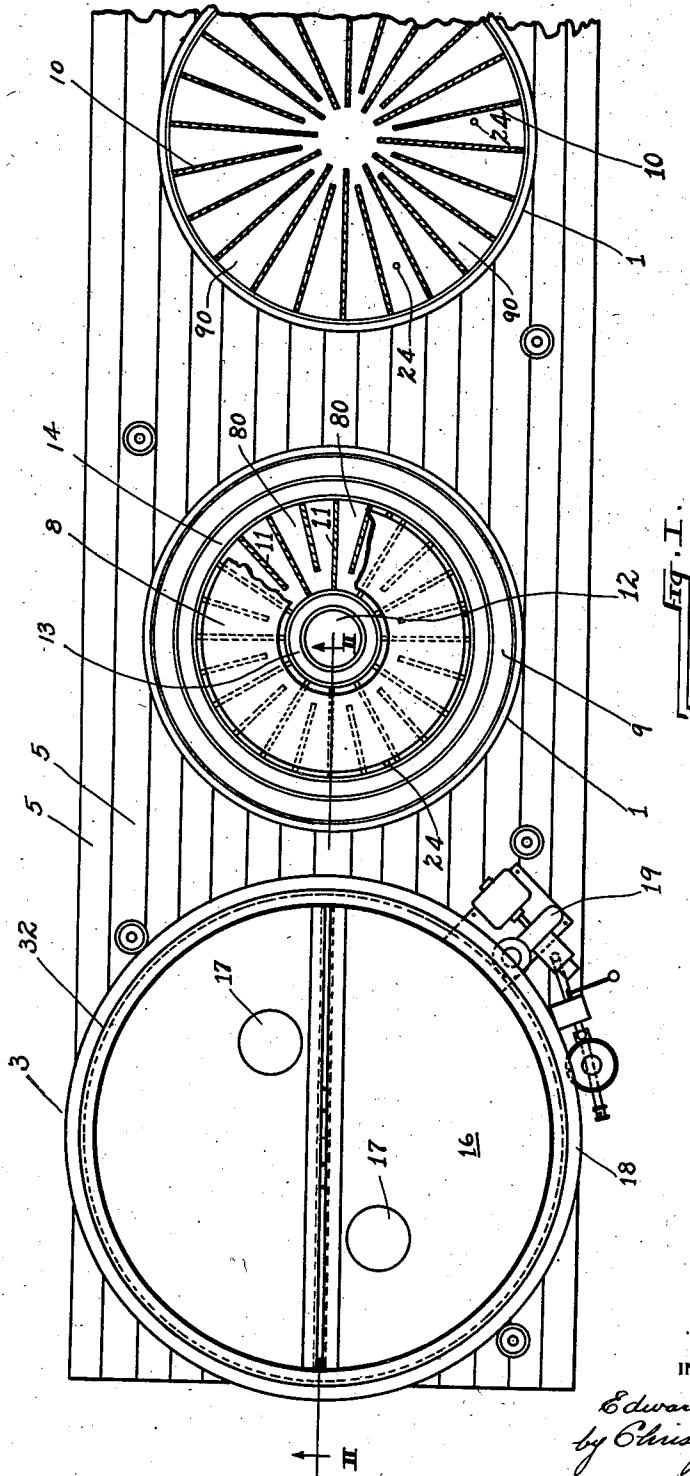
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COIL-ANNEALING FURNACE

Filed April 3, 1940

2 Sheets-Sheet 1



INVENTOR

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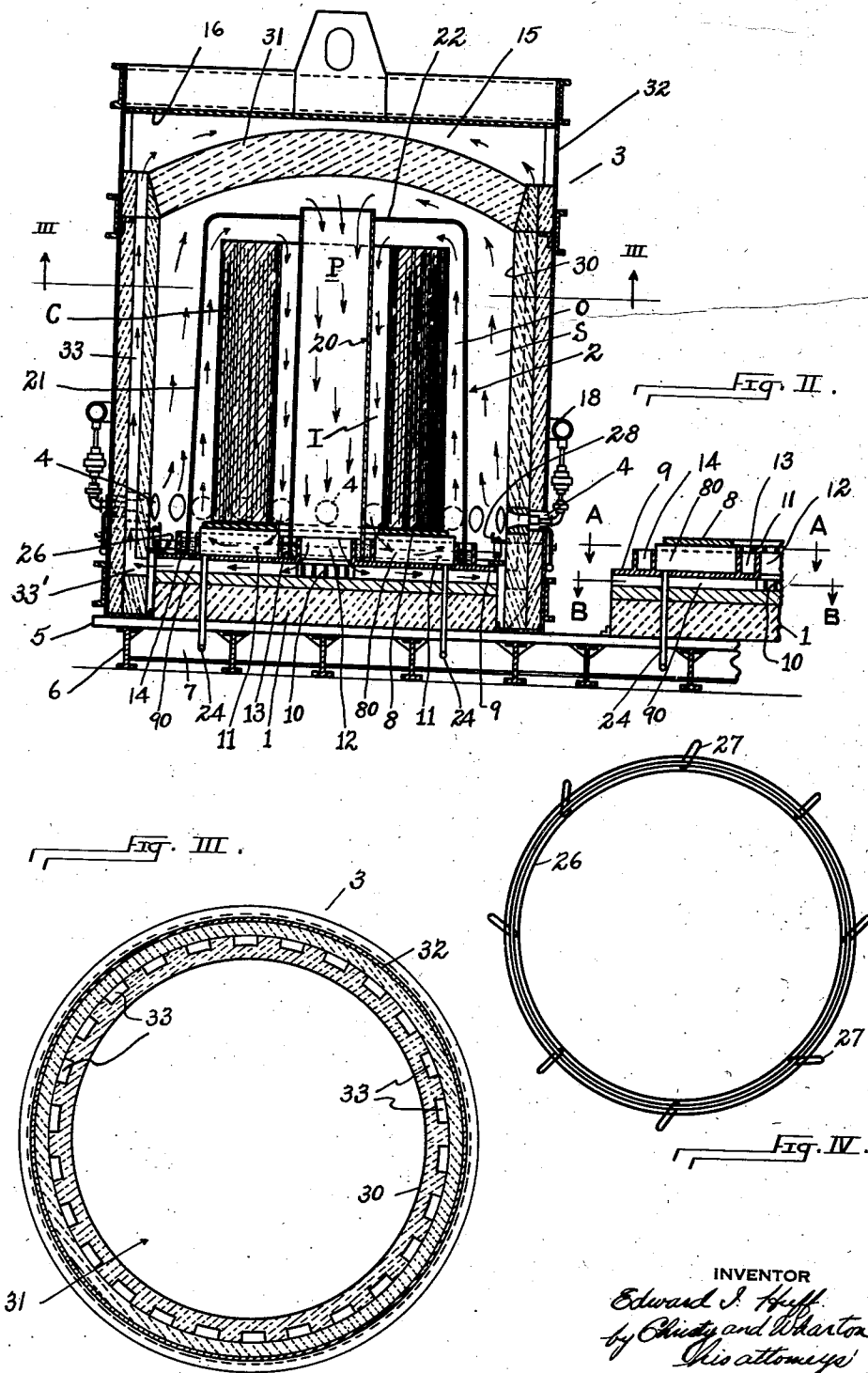
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UNITED STATES PATENT OFFICE

2,250,868

COIL-ANNEALING FURNACE

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Application April 3, 1940, Serial No. 327,612

9 Claims. (Cl. 266—5)

My invention relates to the annealing of metal, and consists in an annealing furnace particularly adapted to the annealing of coils of rolled steel strip. The objects are economy in furnace construction and maintenance, efficiency in furnace operation, and excellence of product.

The modern practice in continuous strip mills is to reduce ingots and billets of steel in continuous rolling operation to highly attenuated strip of great and indefinite length. On completion of the rolling operation the strip is in the form of a compact spiral coil that may be handled as a unit. In such form the strip may be, and it is desirable that it should be, subjected to the requisite annealing operation. The object of the invention is to accomplish the annealing of such a coil of strip steel, and to accomplish it in such manner that the annealed article shall be of uniformly high quality throughout its entire extent.

The operation of annealing consists in heating the material to a peak temperature and cooling it again; and, while the rate of heating, the peak temperature, the time at peak, and the rate of cooling must conform to a certain standard, there is a margin of tolerance; and if throughout all its extent the strip in its treatment be brought within such margin, the product will be of required uniform quality throughout. In the operation of the furnace of this invention the material is so brought within the margin of tolerance, and the annealed product is of uniformly high quality.

The furnace of the invention is essentially of the muffle type. It consists in a stool-like hearth, borne upon a suitable foundation, and adapted to support a coil of steel strip on end, or several coils stacked in axial alignment one upon another. Over the coil (or coils) upon the hearth, an annular muffle with heat-conducting walls is assembled, and over such assembly an all-enclosing cylindrical hood is seated. Heat is generated within the hood, and in this case the heat is generated by the combustion of fuel in the annular region or space between the side walls of the muffle and the encompassing wall of the hood. The coiled strip within the muffle is brought to peak annealing temperature, and held at such temperature for the required interval of time. Then the firing of the furnace is reduced and interrupted, and the coiled strip allowed to cool at proper rate. When the annealing operation has been completed, the hood and muffle are lifted from the hearth, and the product is removed.

More particularly, the invention consists in refinements and elaborations in the construction of such furnaces. In the accompanying drawings, I illustrate a furnace installation in which the structural features of the invention are embodied.

Fig. I is a fragmentary view of the installation in plan from above. In this case the installation includes a battery of three furnaces, mounted in alignment upon a common base or foundation; the furnace at the left-hand end of the base is shown with its hood assembled in service position upon its hearth, while in the case of the other two furnaces the hearths alone appear; the hearth of the central furnace of the battery is shown partly in plan and partly in horizontal section, on the plane A—A of Fig. II, and the hearth of the right-hand furnace is shown in horizontal section, on a plane represented by the line B—B in Fig. II;

Fig. II is a fragmentary sectional view of the furnace structure, as seen on the vertical plane II—II, Fig. I;

Fig. III is a view in cross section of the hood of one of the three furnaces, as seen on the plane III—III, Fig. II;

Fig. IV is a view in plan of a sealing ring included in each furnace structure.

Referring to the drawings, each furnace unit includes a circular stool-like hearth 1, upon which the charge of material to be annealed (a coil C of strip steel in this case) is supported, a heat-conducting muffle 2 seated upon the hearth and enclosing the charge, and a cylindrical heat-insulating hood 3 assembled over the muffle and hearth, and provided with burners 4 that develop heat-affording flame in the region or space S between the walls of the muffle and the hood.

The hearths 1 of the three furnaces of the battery are borne and secured upon a common base, formed of steel channel-beams 5 laid side by side, with their flanges directed downward, and resting upon transverse I-beams 6 that are rigidly integrated, by means of webs 7 below the channel-beams. Cf. Figs. I and II. Each hearth structure includes a basal portion of refractory material, to which the reference numeral 8 is immediately applied, and a charge-supporting seat, to which the numeral 9 is applied. The upper surface of the base of the hearth consists in a deck 9 of steel, borne upon a plurality of spaced-apart vanes or ribs 10. The vanes or ribs 10 consist in strips of steel-plate welded on edge to the deck 9, and extending radially of the hearth. In like manner the seat 8, consisting in

a ring of plate steel, is sustained by a circular series of radial vanes or ribs 11 upon the deck 9. The spaces between the vanes 10 provide in the hearth, beneath the deck 9, a plurality of radial flues 90 that communicate with a central intake 12, opening through seat 8 and deck 9, while the spaces between the vanes 11 provide passages 80 beneath the seat 8. As presently will appear these hearth flues form a constituent part of the particularly effective flue system of my furnace, and the passages between the vanes 11 provide for a beneficial circulation of gas around and beneath the charge C within the muffle 2.

The muffle 2 is of the structure of the muffle described in my United States Letters Patent 2,146,432, dated February 7, 1939, consisting of integral and imperforate inner and outer cylindrical side walls 20 and 21 and top wall 22. It is open at the bottom, and adapted to rest with the peripheral bottom edges of its inner and outer side walls in annular troughs 13 and 14 provided on the hearthdeck 9. A luting of suitable material, such as sand, is provided in the troughs, and the annular muffle, as so organized, encloses and seals the coil C upon the hearth seat.

The all-enclosing hood of each furnace is, as has been said, formed essentially of heat-insulating material. More specifically, the cylindrical side wall 30 and the dome-shaped top wall 31 are formed of refractory brickwork, carried within and reinforced by a supporting shell 32 of steel. In service the hood is positioned over the assembled muffle and hearth, and rests at its lower edge upon the base formed of the steel beams 5. The refractory side wall 30 of the hood includes a plurality of vertical flues 33; these flues are spaced apart circumferentially of the cylindrical hood wall 30 (Fig. III); they are provided at their lower ends with inlets 33' (Fig. II) that open through the internal surface of such hood wall, and severally communicate with the outer ends of the hearth flues 90; and such flues 33 open at their upper ends, either into a flue-chamber or into the outer atmosphere. Preferably I provide a flue-chamber 15 at the top of the hood, and advantageously such chamber is formed by continuing the steel shell 32 of the hood upward from the roof 31, and closing off a space above such roof by means of a transverse wall 16 of steel plate. One or more outlets 17 are provided in the wall 16, and such outlets may be connected to a stack or not, as desired.

The burners 4 open through the side wall of the hood at points between the flues 33 and above the inlets 33' thereof, and above the deck 9 of the hearth. In this case the fuel is a gaseous fuel, supplied to the circumferential series of burners from a bustle-pipe 18, and ordinarily a fan or pump unit 19 (Fig. I) will be provided to supply the fuel, or a mixture of air and fuel, to the bustle-pipe at required pressure. In service the tongues of flame that spring at the base of the muffle and at the outer periphery thereof stream upward, together with the hot products of combustion, over the outer side wall 21 of the muffle, and, upon reaching the top of annular space S between the muffle and the hood, the flames and hot gases converge and form a stream that flows downward through the central passage P, formed by the inner cylindrical wall 20 of the muffle, to the hearth intake 12. Upon entering the intake 12 the hot burning gases and products spread outward through the radial

hearth flues 90, whence they enter the flues 33 in the wall of the hood, and ascend to the flue-chamber 15, and ultimately escape through the outlets 17. The arrows in Fig. II illustrate the course of flow. The hot products of combustion, rising in the flues 33 and mingling in the flue-chamber immediately above the roof 31, augment the heat-insulating value of the hood walls, and substantially increase the thermal efficiency of the furnace. During such furnace operation the circumferential succession of vertical flues 33 provides in effect an outer circumferential curtain or envelope of hot gases, within which the heat-affording flames are propagated; the combustion of fuel in the annular space S provides within such outer envelope of hot gases a muffle-encompassing curtain or envelope of flames, and it will be noted that the heat thus generated is greatest where the circumferential walls of the muffle are most extended. The flames and hot gases, upon rising from the space S and converging over the top wall of the muffle, enter the central passage P and form a column of gases that stream over the inner side wall of the muffle. Thus, within the furnace in operation the streaming flames and hot gases flow progressively through three concentric vertical regions of flow one in the form of a column or core in the passage P formed by the inner side wall of the muffle, and the other two in the form of cylindrical envelopes or curtains, arranged one within the other and encompassing the outer side wall of the muffle. The streams of hot gases converging above the top wall of the muffle, and the streams flowing through the radial hearth flues 90, complete the envelopment of the muffle, and effect with greatest efficiency the essential transfer of heat to the charge.

Often it is desirable, for reasons with which this invention is not concerned, to establish and maintain within the muffle an atmosphere other than air, and to such end I provide inlet and outlet pipes 24 that open through the hearth into the muffle chamber. Through such pipes the air initially in the muffle chamber is removed, and such gas as will afford the desired atmosphere is introduced. It has been found that a circulation of the gas within the muffle is effective to accelerate the transfer of heat from the hot muffle walls to the body of the charge. Additionally, it may be noted that such circulation insures a substantially uniform distribution of heat in the body of the charge, and prevents localized overheating. These circumstances bring into focus the particular utility of the radial passages 80 provided beneath the annular charge-supporting deck 8 and within the muffle chamber.

The gas in the annular channel O between the body of the charge C and the outer peripheral wall 21 of the muffle tends (under the influence of heat received from the flames playing upon the outer surface of muffle wall 21) to rise, and in like manner the gas in the channel I between the body of the charge and the inner wall 20 of the muffle tends (under the influence of the heat received from the flames and hot products flowing downward in passage P) to move upward. However, it will be manifest that the outer peripheral wall 21 of the muffle will in the charge-heating operation of the furnace be maintained at higher temperature than the inner muffle wall 20, wherefore the buoyancy or energy of the gas in the annular channel O within the muffle is greater than that of the gas in the channel I. Through the provision of the passages 80 utility

is made of this differential buoyancy of the gas in the two channels. The two annular channels, in open communication at their upper ends, are by the passages 80 interconnected at their lower ends, throughout the entire circumference of the charge C. Such structural refinement establishes conditions that permit and promote continuous circulation of the atmosphere within the muffle. The arrows in Fig. II indicate this circulation of gas within the muffle, and it is noteworthy that the flow of gas upward over the outer side surface of the coil C, inward across the top of the coil, downward over the inner side surface and then outward beneath the lower end of the coil, parallels in every respect the course of the flames and hot products over the outer walls of the muffle. In consequence the coiled material within the muffle chamber is heated more uniformly and is brought at optimum speed to the desired peak temperature.

A valuable elaboration in structure remains to be considered. It consists in means for readily obtaining the desired hermetic engagement of the lower end of the hood 3 with the hearth, an engagement that does not necessarily provide between the parts a hermetic seal in the strictest sense, but a seal that is effective for all practical purposes. Such means consist in a ring 26 that extends, in horizontal plane, peripherally of the inner surface of the refractory side wall of the hood, and that rests upon the peripheral edge of the hearth, that is, upon the rim of the hearth deck 9. The engagement of the ring with the hearth and the side wall of the hood is effective in the vertical interval between the circumferential line of burners 4 and the line of inlets 33' of the flues in the wall of the hood. Thus, there can be no short-circuit flow of the burning fuel between the burners 4 and the out-go flues 33. Advantageously, if not essentially, the sealing ring is formed of metal, and in this case it is a continuous metal ring of inverted T-shape in cross section. The ring is carried in loosely suspended position upon the internal wall of the hood, as by means of links 27 hung upon hooks 28 rigid with and extending from the inner wall of the hood. When the hood is lowered into service position on the hearth, the so-suspended ring 26 seats and adjusts itself snugly upon the peripheral edge of the hearth. The ring is thermally expansible, and is at room temperature of less overall diameter than the inner surface of the cylindrical hood wall upon which it is borne. In consequence of this tolerance the ring is carried in "floating" suspension, such that when the hood (in cool condition) is lowered upon the hearth, the ring is free to adjust itself in the desired snug contact with the rim of the hearth. When the furnace is fired, the ring expands into tight contact with the wall of the hood, and thus establishes the desired seal between the furnace parts.

In some cases the sealing ring may be a split ring. Again, it may be formed of a circular succession of abutting segments or sections. And it will be found that the ring, suitably modified in form, may be used in furnaces whose hearths and hood walls are rectangular, or square, etc., in horizontal section. These and other modifications of the structure described are held in contemplation, within the terms and intent of the appended claims.

I claim as my invention:

1. An annealing furnace including a circular hearth with a central intake and a plurality of

flues extending radially from said central intake to the periphery of the hearth, a cylindrical outer inclosing furnace wall of heat-insulating material seated upon said hearth and including a circumferential succession of outlet flues in communication with the radially outer ends of said hearth flues, an inner muffle of annular shape and including imperforate inner and outer peripheral side walls and a top wall of heat-conducting material, said muffle being open at bottom and removably borne by the hearth within said outer furnace wall and when so seated spaced from such outer furnace wall, the region or space within the inner side wall of the annular muffle in open communication with the central intake of the hearth, said muffle adapted when in place to enclose a charge resting on the hearth, a plurality of burners arranged in spaced relation circumferentially of and extending through the outer furnace wall at the base thereof and adapted to deliver flames to the space between the outer side wall of the muffle and the inclosing furnace wall, whereby the flames and hot products of combustion springing at the base of the muffle and at the outer periphery thereof flow upward over the outer side wall of the muffle, converge and descend over the inner side wall of the muffle to the hearth flues, spread radially in the hearth to the outgo flues in the inclosing furnace wall, and ascend through such flues to an outlet.

2. An annealing furnace including a stool-type hearth with a central intake and a plurality of flues extending from the intake and opening through the periphery of the hearth, a hood with heat-insulating walls inclosing said hearth, the peripheral side wall of said hood including a circumferential series of vertically extending flues, a horizontal ring engaging the rim of said hearth and providing a seal between the hearth and the peripheral side wall of the hood, the inlets of said flues in the hood wall communicating below said sealing ring with said hearth flues, an inner muffle of annular shape and including imperforate inner and outer peripheral side walls and a top wall of heat-conducting material, said muffle being open at bottom and removably borne by the hearth within said hood and when so seated spaced from the walls of the hood, with the region or space within the inner peripheral side wall of the muffle in communication with the central intake of the hearth, said muffle when in place adapted to enclose a charge resting on the hearth, a plurality of burners arranged in spaced relation circumferentially of said side wall of the hood and opening through such wall at points above said sealing ring and adapted to deliver flames to the space between the muffle and hood walls, whereby the flames and hot products of combustion springing at the base of the muffle and at the outer periphery thereof flow upward over the outer peripheral wall of the muffle, converge and descend over the inner peripheral wall of the muffle to said hearth intake, spread outward in the hearth flues and flow beneath said sealing ring to the flues in the hood wall, and ascend in such flues to an outlet.

3. An annealing furnace including a stool-type hearth supporting a ring-shaped seat for a charge of material to be annealed, two systems of radial flues in said hearth one system arranged above the other and both systems arranged beneath said seat, the flues in said lower system having outlets opening in the periphery of the hearth, a central intake that opens through said seat to

said lower hearth flues, a hood with heat-insulating walls inclosing said hearth, the peripheral side wall of said hood including a circumferential series of vertically extending flues, a horizontal ring engaging the rim of said hearth and providing a seal between the hearth and the peripheral side wall of the hood, the inlets of said lower flues in the hood wall communicating below said sealing ring with said hearth flues, an inner muffle of annular shape and including imperforate inner and outer peripheral side walls and a top wall of heat-conducting material, said muffle being open at bottom and removably borne by the hearth within said hood and when so seated spaced from the walls of the hood, with the region or space within the inner peripheral sidewall of the muffle in communication with the central intake of the hearth, said muffle when in place adapted to enclose said seat and a charge resting thereon, said upper system of radial flues being inclosed within the walls of said muffle and extending beneath the charge-supporting surface of said ring-shaped seat, with the effect that gas may circulate around and beneath the charge within the muffle, a plurality of burners arranged in spaced relation circumferentially of said side wall of the hood and opening through such wall at points above said sealing ring and adapted to deliver flames to the space between the muffle and hood walls, whereby the flames and hot products of combustion springing at the base of the muffle and at the outer periphery thereof flow upward over the outer peripheral wall of the muffle, converge and descend over the inner peripheral wall of the muffle to said hearth intake, spread outward in the hearth flues to the flues in the hood wall, and ascend in such flues to an outlet.

4. An annealing furnace including a stool-type hearth adapted to support a charge of material to be annealed, a muffle with heat-conducting walls inclosing the charge on the hearth, a hood with heat-insulating walls inclosing said hearth and muffle, and a thermally expansible ring extending peripherally of the internal surface of the hood side wall and externally of the muffle wall, and adapted in the assembled furnace peripherally to engage the hearth, said ring in service comprising a peripheral seal between the internal surface of the side wall of the hood and the periphery of the hearth over which the hood is removably seated.

5. An annealing furnace including a stool-type hearth adapted to support a charge of material to be annealed, a muffle with heat-conducting walls inclosing the charge on the hearth, a hood with heat-insulating walls inclosing said hearth and muffle, and a thermally expansible ring extending peripherally of the internal surface of the hood side wall and externally of the muffle wall, and adapted in the assembled furnace peripherally to engage the hearth, and firing ports opening through the side wall of the hood above said ring, said ring comprising a seal

against the flow of flame and hot gases downward between said hearth and hood.

6. A hood for a furnace of the class described including a peripheral side wall and two top walls spaced vertically one from the other, said side wall and the lower top wall being formed of heat-insulating material, a series of circumferential spaced-apart vertically extending flues formed in said side wall, said flues provided with inlets opening through the inner surface of said side wall at points adjacent to the lower peripheral edge of said hood, the region between said top walls comprising a flue-chamber at the top of said hood, with which chamber said flues at their upper ends communicate, and an outlet opening from said flue-chamber.

7. A hood for a furnace having a stool-type hearth, said hood including a peripheral side wall of heat-insulating material within a steel supporting structure, a series of circumferential spaced-apart vertically extending flues formed in said wall, said flues provided with inlets opening through the inner surface of said wall at points adjacent to the lower peripheral edge of said hood, a flue-chamber at the top of said hood, with which chamber said flues at their upper ends communicate, an outlet opening from said flue-chamber, and a circumferential series of burners opening through said side wall of the hood in the intervals between said flues, and above the inlets of said flues, and a sealing ring extending circumferentially of the internal surface of said side wall of the hood and adapted peripherally to engage the hearth of said furnace, and to form a seal between such hearth and the hood side wall in a horizontal plane between said burners and the inlets of said flues.

8. An annealing furnace including a stool-type hearth adapted to support a charge of material to be annealed, a muffle with heat-conducting walls inclosing a charge on the hearth, a hood with heat-insulating walls inclosing said hearth and muffle, firing ports opening through the side wall of the hood, outgo ports opening laterally from said hearth at an interval below said firing ports, and a sealing ring extending peripherally of the internal surface of the hood side wall in the vertical interval between said firing ports and said outgo ports, said sealing ring engaging the rim of the hearth and providing a seal between the hearth and the side wall of the hood in said vertical interval between the firing ports and the outgo ports.

9. In an annealing furnace including a stool-type hearth adapted to support a charge of material to be annealed, and a hood with walls of heat-insulating material adapted to seat over said hearth; the invention herein described that consists in a sealing ring yieldingly suspended upon the hood and extending peripherally of the side wall of the hood, the outer edge of said ring engaging the side wall of the hood, and the inner edge of the ring engaging the rim of said hearth.

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