Oct. 15, 1940. J. D. KELLER 2,218,354

METHOD AND APPARATUS FOR ANNEALING STRIP

Filed March 13, 1939 3 Sheets-Sheet 1

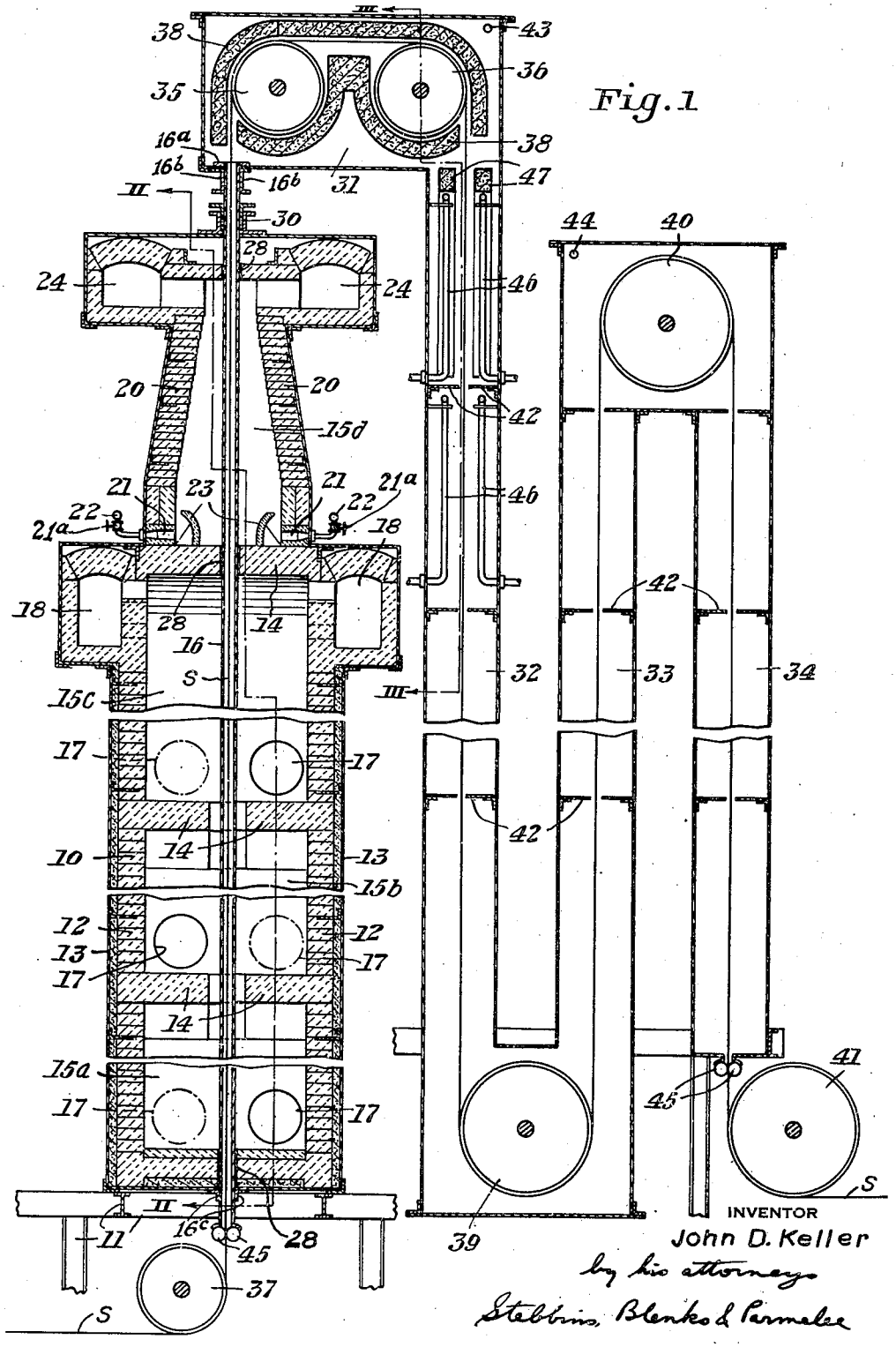

Fig. 1

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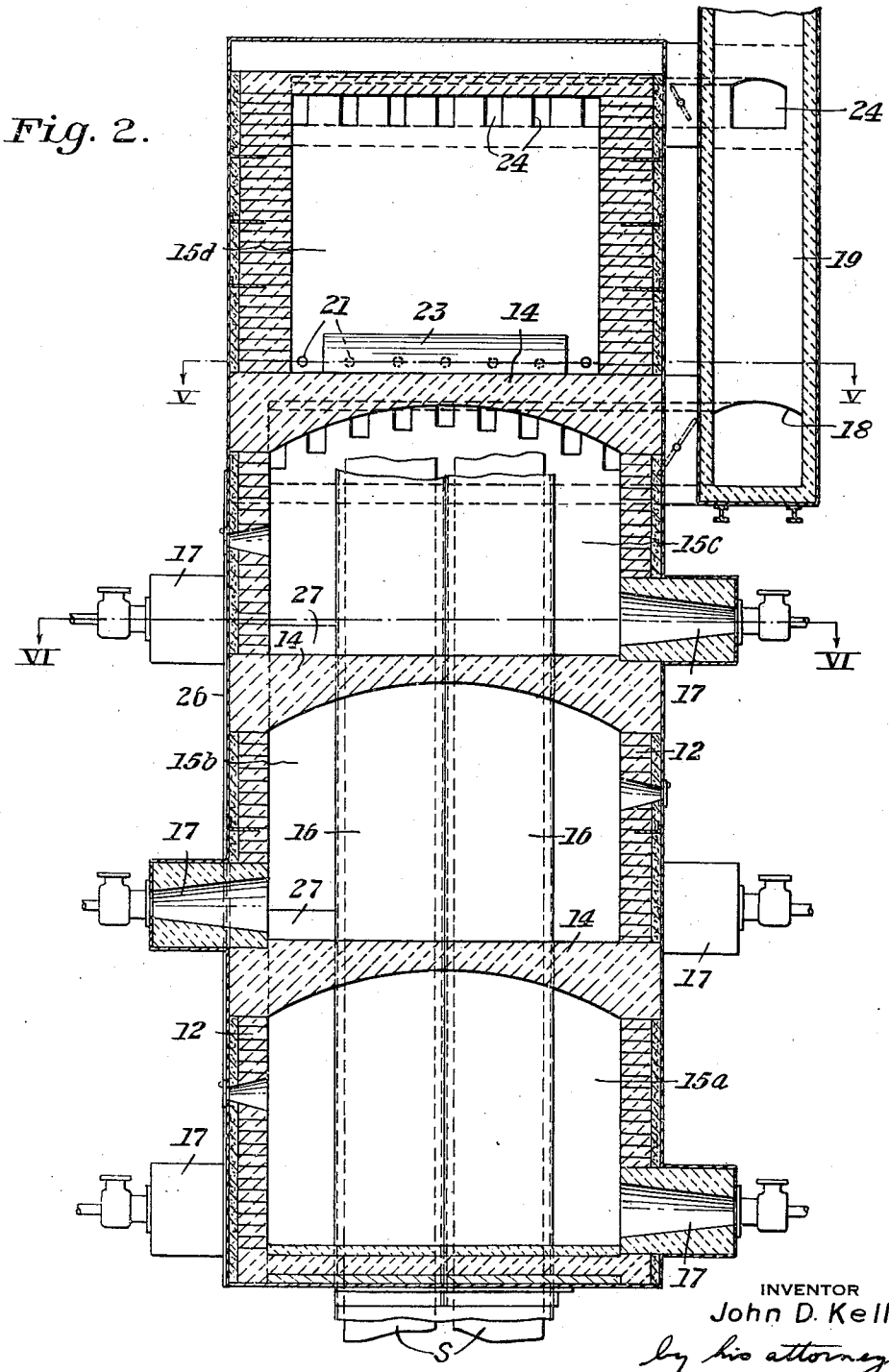
Fig. 2.



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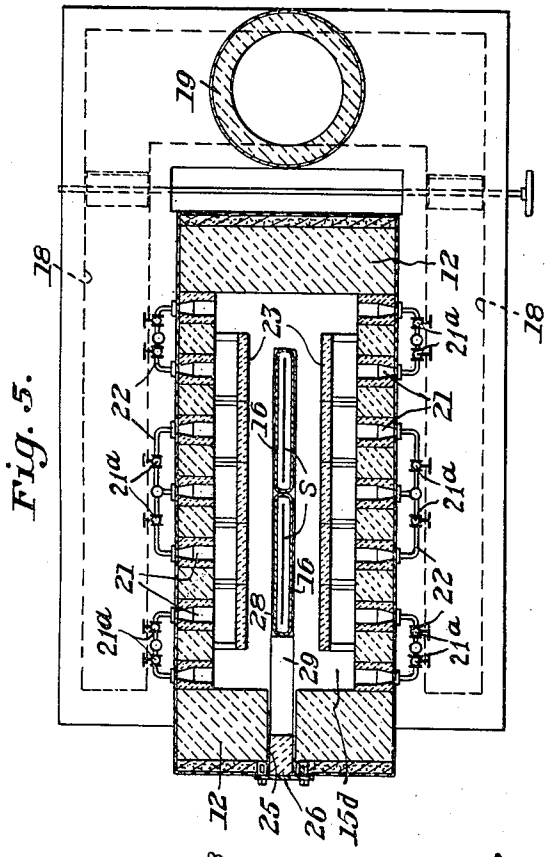

Fig. 5.

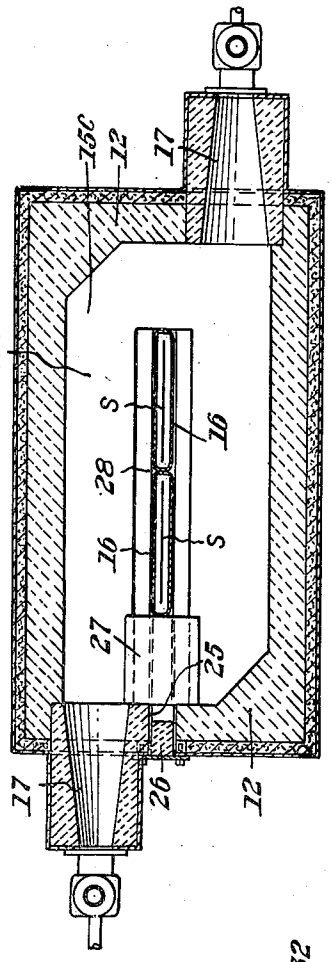

Fig. 6.

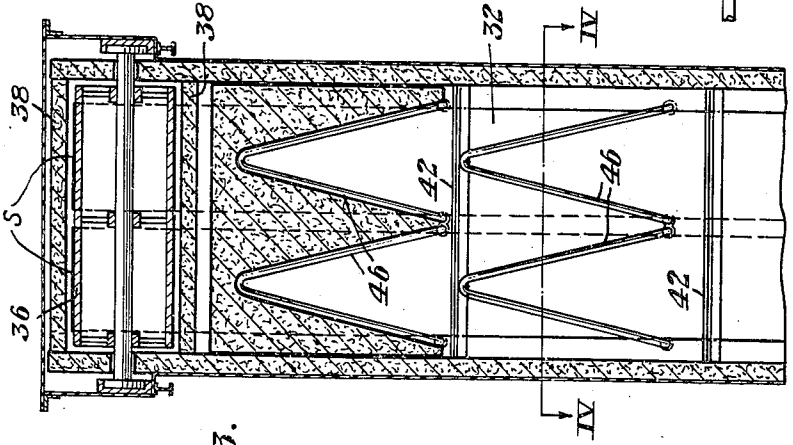

Fig. 3.

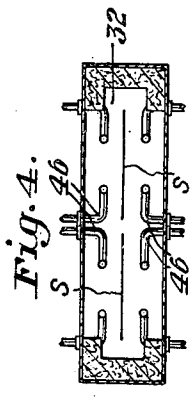

Fig. 4.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR ANNEALING STRIP

John D. Keller, Pittsburgh, Pa., assignor to The Wean Engineering Company, Inc., Warren, Ohio, a corporation of Ohio

Application March 13, 1939, Serial No. 261,414

8 Claims. (Cl. 263—52)

This invention relates to the metallurgical processing of rolled metal and, in particular, to material in strip form such as cold rolled steel strip.

Rolled material has been annealed heretofore in the form of coils or stacks of sheets by the use of conventional annealing boxes and furnaces or in cover type furnaces. In either case, the process is slow because of the time required to bring the material up to the desired temperature. A further objection is that the characteristics of the finished product are not uniform because all portions of the mass are not raised to exactly the same temperature. The long time required for annealing under the conventional practice makes the cost thereof high because the annealing facilities necessary for a substantial capacity represent a large investment.

I have invented a novel method and apparatus for annealing strip which overcome the aforementioned objections and are characterized by other novel features and advantages. In a preferred embodiment and practice of the invention, I provide an elongated heating chamber having a muffle extending therethrough, and pass the strip progressively through the muffle in strand form, while applying heat to the exterior of the muffle. I also provide cooling chutes or ducts through which the strip is led after passing through the muffle, whereby it is gradually reduced to atmospheric temperature. I maintain a non-oxidizing atmosphere in the muffle and cooling chutes to protect the material from oxidation during treatment. Other novel features and advantages of the invention will become apparent in the course of the following detailed description and explanation which refers to the accompanying drawings illustrating the embodiment and practice outlined above. In the drawings

Fig. 1 is a vertical central section through the heating chamber and cooling ducts constituting a complete annealing apparatus embodying my invention;

Fig. 2 is a sectional view taken along the plane of line II—II of Fig. 1;

Fig. 3 is a partial sectional view taken along the line III—III of Fig. 1;

Fig. 4 is a sectional view taken along the plane of line IV—IV of Fig. 3;

Fig. 5 is a sectional view taken along the plane of line V—V of Fig. 2; and

Fig. 6 is a sectional view taken along the plane of line VI—VI of Fig. 2.

Referring now in detail to the drawings, the apparatus which I prefer for annealing strip in accordance with the invention includes a heating chamber 10. The heating chamber 10, in the preferred construction, is disposed with its greatest dimension substantially vertical and is carried on any suitable supporting framework 11. It may conveniently be built up of refractory or refractory-insulating brick 12 within a suitable enclosure formed by sheathing plates 13 and structural frame members such as may be needed to sustain it. Baffles or cross walls 14 divide the chamber into a plurality of zones 15*a*, 15*b*, 15*c*. In these zones, the rough heating of the strip is accomplished. A final heating and temperature-regulating zone 15*d* above the zones 15*a*, 15*b* and 15*c*, or beyond them in the direction in which the strip moves, effects the heating of the strip to the desired final temperature and insures the temperature of the strip being uniform across its width. A cross wall 14' separates the zone 15*d* from the zones therebelow.

Muffles 16 extend upwardly through the heating chamber in side by side relation and have supporting flanges 16*a* secured thereto. The muffles are long, flat, tubes of suitable metal, preferably heat-resistant alloy and are supported on beams 16*b*, with their lower ends free to move vertically and laterally between angle bars 16. While I have shown two such muffles, it will be apparent that the number and width of the muffles will be determined by the width of the strip to be treated. The zones 15*a*, 15*b* and 15*c* are provided with burners 17 adapted to circulate hot combustion gases around the muffles whereby to heat the portions thereof located in the several zones. These burners are supplied with air and combustible such as fuel gas under a slight pressure and in such a ratio as to provide a luminous flame adapted to heat the muffle to a temperature of about 1600° F. The combustion gases delivered by such burners are of a reducing character. This, together with the fact that the gases do not impinge directly on the muffles but circle therearound, precludes rapid deterioration of the portions of the muffles in the lower zones.

The combustion gases pass upwardly around the muffles through the slots in the cross walls or baffles 14 and are finally discharged into exhaust gas ducts 18 leading to a stack 19. The draft through the ducts 18 is regulated by dampers 18*a*. The baffles 14 are so disposed and dimensioned that the average pressure of the combustion gases in each zone is substantially atmospheric, thus preventing any excessive draft

or positive pressure at any point in the chamber 10.

The uppermost zone 15d of the chamber 10 is defined by converging side walls 20 and is provided, adjacent the bottom thereof, with a plurality of burners 21. Fuel is supplied to the burners 21 from manifolds 22. Preferably a substantially perfect fuel air mixture is delivered to the manifolds from any suitable mixer, to cause complete combustion with a blue flame. Refractory baffles 23 extend the width of the zone 15d in front of the burners 21 for the purpose of directing the flames therefrom upwardly along the converging side walls 20. The burners 21 may be so adjusted, individually or in groups, by suitable control valves 21a, as to produce the desired temperature at each point along the width of the muffles 16, the average temperature of the portion of the muffle in the zone 15d being only slightly higher than the desired final temperature of the strip, and usually from 1300 to 1500° F. Preferably the flow of gas-air mixture to the manifolds 22 is regulated by an automatic temperature controlling device effective to maintain constant the temperature of the strip at the top of zone 15d. The heating of the muffles in the zone 15d is effected principally by radiation, the heat of the combustion gases being absorbed by the refractory brick composing the wall 20 and then radiated to the muffles. The combustion gases are deflected by the baffles 23 and prevented from coming in contact with the muffle until they reach the top of the zone, where, as waste gases, they finally flow through exhaust ducts 24 to the stack. By means of dampers 24a in the flues leading from these ducts to the stack, the pressure in zone 15d may be maintained nearly atmospheric, independent of the pressure or draft in the lower zones.

One end wall of the chamber 10 is provided with a slot 25 extending the full height thereof, to permit the sidewise removal of the muffles 16. A closure 26 which may conveniently be made in sections, normally overlies the slot 25. As shown in Fig. 6, refractory blocks 27 are laid on the cross walls 14, bridging the slot therein, after the muffles have been placed. The top and bottom of the chamber 10 and the topmost cross wall 14' are provided with slots 28 extending laterally and intersecting the slot 25. Removable closures 29 are disposed in these slots.

The muffles 16 extend upwardly from the heating chamber 10 through a seal 30 to an initial cooling chamber 31. The chamber 31 communicates with a series of cooling chutes or ducts 32, 33 and 34, through which strip is adapted to pass successively after emerging from the muffles. Guide drums 35 and 36 are disposed in the chamber 31, the former cooperating with a similar drum 37 below the chamber 10 to guide the strip S progressively through the muffles. The drums 35 and 36 may be of any suitable material and, if desired, may be provided with scrapers (not shown) to remove any accretions which might be picked up therefrom by the strip and cause scratches in the surface of portions of the strip subsequently traversing the drums. The drums may be of a heat-resistant alloy such as Nichrome with a highly polished surface so that the strip will not adhere thereto. Alternatively, the drums may be of material which is softer than the strip being treated, such as copper or Monel metal. The strip may be fed from coils suitably supported, around the drum 37 and thence upwardly through the muffles, by tension applied to the strip by means at the exit end of the apparatus.

The strip ascending through the heating chamber is quickly heated to the desired maximum temperature and then enters the initial cooling chamber 31. The drums 35 and 36 are provided with shrouds or jackets 38 of thermal insulation to prevent excessively rapid cooling of the strip which would cause it to buckle. The walls of the chamber 31 and the several cooling ducts are subjected to atmospheric cooling and the strip gradually loses heat to the walls as it traverses its path, being guided therein by drums 39 and 40 at the opposite ends of the several chutes or ducts and a similar drum 41 at the exit end of the apparatus. The chamber 31 and the cooling ducts are composed of sheet metal supported by a suitable framework. The ducts are provided with baffles 42 to limit the circulation of the atmosphere contained therein, and with insulation 42a to prevent too rapid loss of heat from the outer edges of the strip. This atmosphere is preferably a non-oxidizing gas supplied through inlets 43 and 44 whence it flows downwardly through the chamber 31, the muffles 16 and the cooling ducts, thereby preventing oxidation of the strip being treated. The downflowing gas carries away any vapors evolved from oil left on the strip from the rolling process. Sealing rolls 45 at the entrance and exit ends of the apparatus prevent excessive loss of the protective atmosphere at these points.

After passing over the drums 35 and 36 in the chamber 31, the strip passes between cooling tubes 46 of hairpin or V-shape disposed with their vertex upward and located at about the middle of the strip S. Any suitable cooling fluid may be circulated through the tubes 46 to absorb heat from the strip. Because of the shape and arrangement of the tubes, the advancing strip is cooled first at the center thereof and then progressively toward each edge. This prevents buckling which might result from an attempt to cool the strip across its entire width at one point along its path. A shroud or jacket 47 of thermal insulation is disposed above the tubes 46 of the upper set, to prevent excessive cooling of the strip before it passes between these tubes. After passing between the sets of tubes 46, the strip continues through the chutes or ducts 32, 33 and 34, thereby losing additional heat to the walls thereof and eventually cooling to a temperature at which atmospheric oxidation does not proceed rapidly, by the time it reaches the lower end of the chute 34. On emerging from the latter, the strip may be drawn around the drum 41 to a coiling device or may be advanced in strand form for further processing such as coating, stamping, or the like. If the strip is coiled, the coiler will provide the tension necessary to advance the strip through the heating and cooling chambers. Otherwise, this tension may be applied by suitable pinch rolls adjacent the guide drum 41.

The cooling apparatus described above is disclosed and claimed in Wean Patent 2,199,472 and Wean et al. Patent 2,205,915 granted on applications copending herewith.

It will be apparent from the foregoing description that the invention provides a relatively simple, yet highly effective method and apparatus for annealing strip, which are not subject to the objections to the conventional annealing practice. According to the invention, each unit length of strip is subjected to precisely the same

conditions so that a high degree of uniformity in the finished product is assured. The apparatus may be operated, furthermore, at relatively high speed as the heating and cooling of the strip may be effected fairly rapidly since it is handled in single thickness or strand form at all times. It will also be evident that the cost of the apparatus disclosed is less than that of conventional annealing equipment of the same capacity.

Among other advantages may be mentioned the fact that since the muffles are suspended from their upper ends, they are maintained straight by their own weight. The increased life of the muffles resulting from the non-oxidizing character of the flame in the lower zones and the fairly uniform and relatively low temperature therein and the fact that the heating to the maximum temperature in the topmost zone is effected largely by radiation and with little or no direct impingement of the gases on the muffles, have already been pointed out. The burners of the several zones can be regulated for the greatest economy at any particular operating rate. The muffles can be removed sidewise from the heating chamber so that no extra head room is required. The two muffles shown, furthermore, can be replaced by other muffles of different widths depending on the width of strip to be handled.

Although I have illustrated and described herein but a preferred embodiment and practice of the invention, it will be understood that changes in the construction and operation disclosed may be made without departing from the spirit of the invention or the scope of the appended claims. A single muffle, for example, may be used to treat wide strip, instead of the two muffles shown.

I claim:

1. Apparatus for treating strip comprising an elongated, vertical heating chamber, a muffle suspended therein, means for guiding strip through the muffle, and transverse baffles dividing said chamber into successive zones, the topmost zone having walls converging toward said muffle, burners in said topmost zone, and means deflecting combustion gases flowing upwardly from said burners toward said walls whereby the walls radiate heat to said muffle.

2. Apparatus for treating strip comprising an elongated heating chamber, a muffle extending therethrough, means for guiding strip through the muffle, means dividing said chamber into a plurality of zones, burners positioned to deliver combustion gases circumferentially of the muffle in the initial zones, and a plurality of independently controlled burners in the final zone spaced apart across the width of the muffle.

3. In a method of treating strip, the steps including drawing the strip upwardly through a substantially vertical muffle, heating the lower portion of the muffle substantially exclusively by convection to a temperature below the desired maximum temperature to which the strip is to be heated, maintaining a reducing atmosphere about the lower portion of said muffle, and heating the upper portion of the muffle substantially to said desired maximum temperature, substantially exclusively by radiation, and maintaining the temperature of the strip substantially uniform across the width thereof as it traverses said upper portion.

4. Apparatus for treating strip comprising an elongated, vertical heating chamber, a muffle therein and extending substantially the full height thereof, means suspending the muffle from its upper end for sidewise movement, means for guiding strip through the muffle, means for heating said muffle, and a slot in a side wall of said chamber having a removable closure, whereby said muffle may be removed sidewise from the chamber in one piece.

5. In a method of heating a tall, vertical muffle through which strip is drawn for annealing, the steps including discharging into a muffle-enclosing chamber, at points spaced along its length, along a circumferential path around it, combustion gases in a state of freedom for direct contact with the muffle, and substantially confining said gases against unrestrained upward flow under natural draft, thereby defining zones of substantially constant gas pressure and causing repeated circumfluence of the muffle by said gases.

6. Apparatus for treating strip comprising an elongated heating chamber, a muffle extending therethrough, means dividing the chamber into successive zones, means for guiding strip through the muffle, means for heating the portions of the muffle in the initial zones including burners firing into the chamber circumferentially of the muffle, and means for heating the portion of the muffle in the final zone including burners distributed across the width of the chamber and firing toward the muffle, and means directing the combustion gases flowing from said last-mentioned burners longitudinally of the muffle.

7. Apparatus for treating strip comprising an elongated, vertical heating chamber, a muffle depending through said chamber, means for guiding strip through said muffle in strand form, means supporting said muffle substantially exclusively from the upper end thereof, whereby the weight of the muffle keeps it in tension and prevents buckling, and means effective to confine the lower end of the muffle against horizontal movement in one direction while permitting movement thereof vertically and horizontally in a direction at right angles to said first-mentioned direction.

8. Apparatus for treating strip comprising an elongated, vertical heating chamber, a muffle suspended therein, means for guiding strip through the muffle, burners positioned adjacent the muffle firing into the space between the muffle and the chamber wall, combustion gases free for direct contact with the former, so as to circulate a heating flame around the muffle, burners positioned near the exit end of the muffle adapted to heat the chamber wall to radiant temperature whereby the exit end of the muffle is heated principally by radiation, said last-mentioned burners being spaced across the width of the muffle, and means for separately controlling them whereby the temperatures at points spaced across the width of the muffle may be maintained at the desired value.

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