May 9, 1961 R. E. McCLURE, JR 2,983,502

METHOD AND APPARATUS FOR ANNEALING COILS OF METAL STRIP

Filed Oct. 21, 1953 3 Sheets-Sheet 1

FIG. 1.

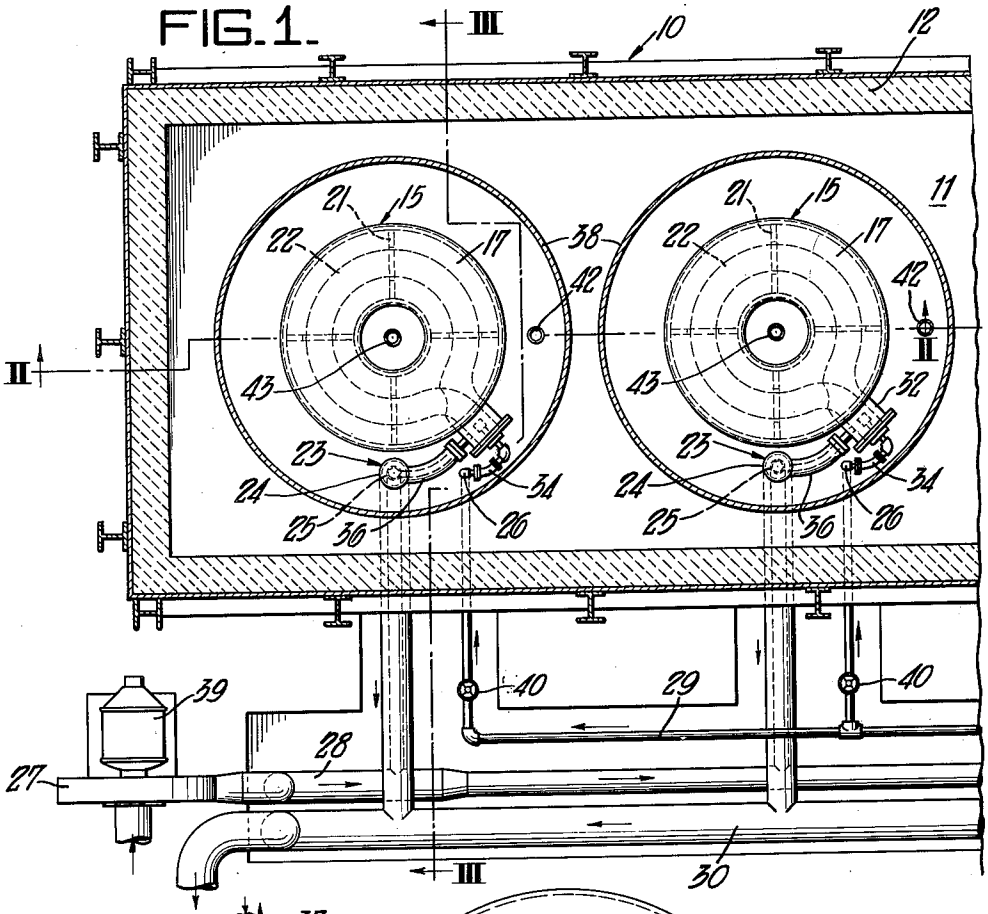
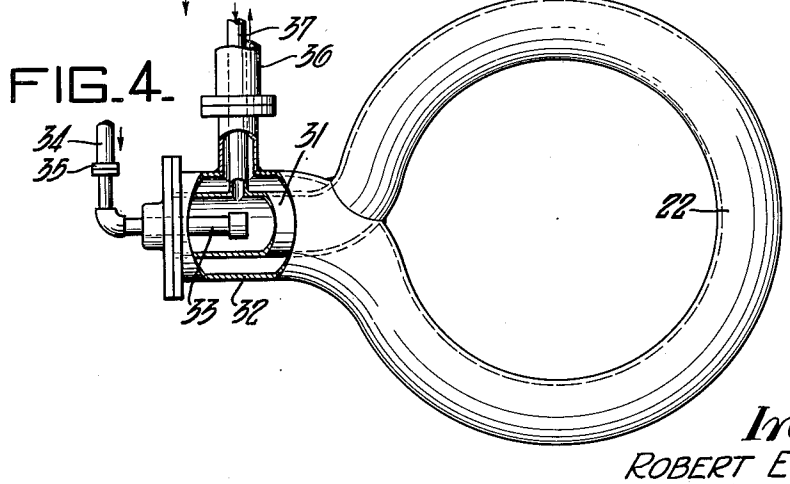


FIG. 4.



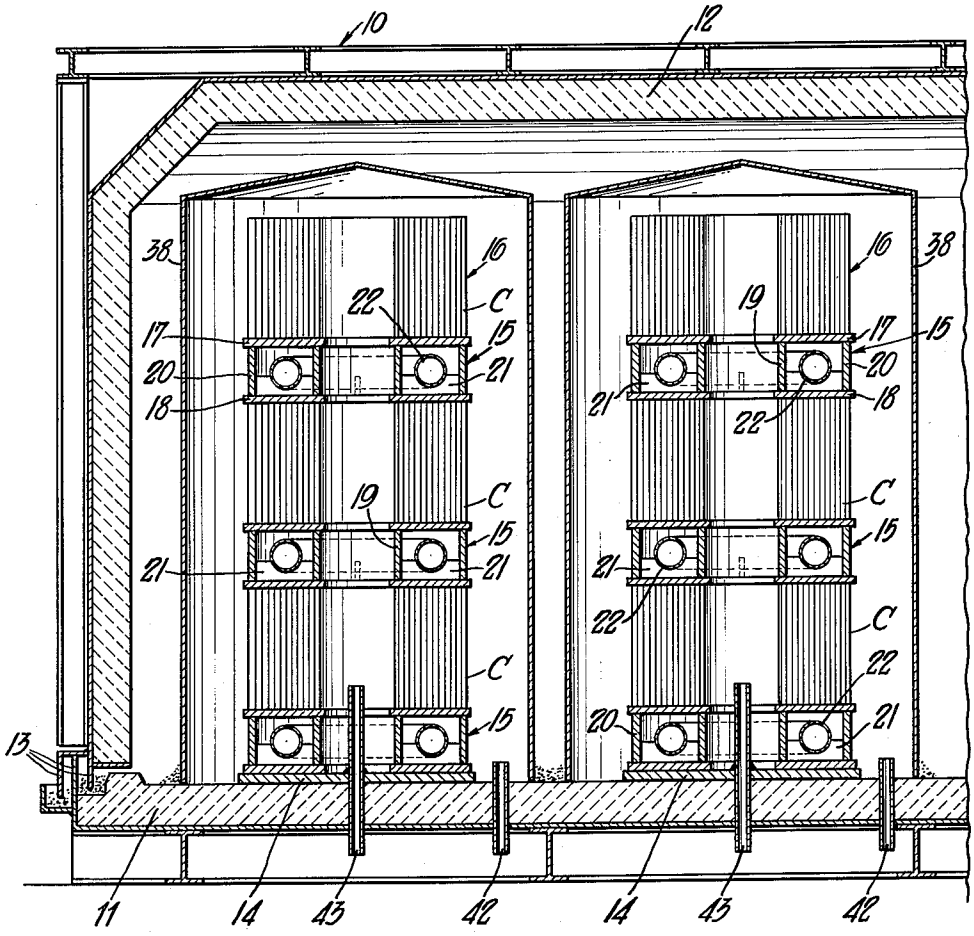
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METHOD AND APPARATUS FOR ANNEALING COILS OF METAL STRIP

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FIG. 2.



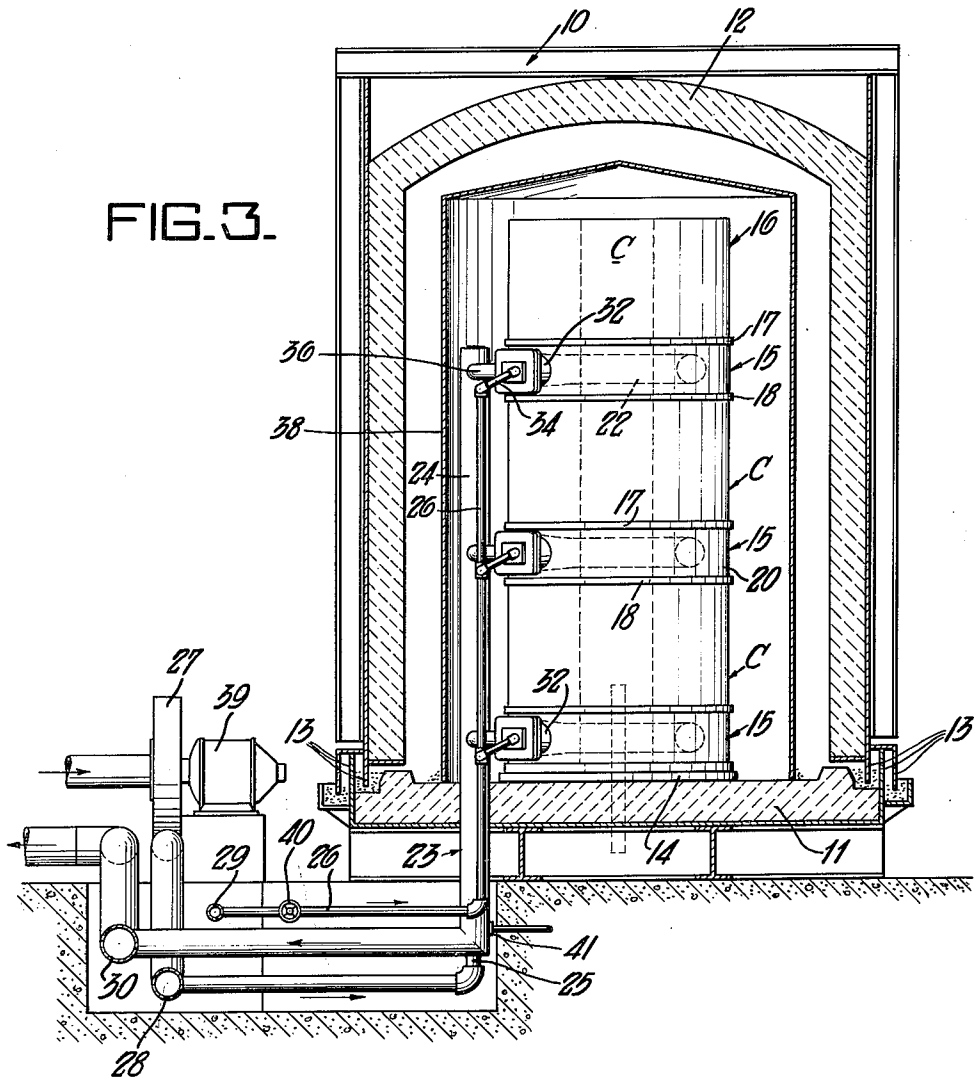
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METHOD AND APPARATUS FOR ANNEALING COILS OF METAL STRIP

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FIG. 3.



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METHOD AND APPARATUS FOR ANNEALING COILS OF METAL STRIP

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10 Claims. (Cl. 263—40)

This invention relates to a metallurgical furnace and method. In particular, it is concerned with the heating of metal strip in coils for the purpose of annealing.

In modern steel-mill practice, cold-reduced steel strip in coils is annealed in furnaces of the hood or cover type having a refractory lining with radiant heaters installed therein, usually gas-fired combustion tubes. The coils are stacked on end on a base and the hood or cover is lowered over the charge after it has been enclosed in an inner cover of steel plate. This type of heating has been widely adopted and used in recent years despite a serious objection thereto, viz., the relatively slow rate at which heat penetrates to the center of the charge through the wall of the inner cover and the successive plies or thicknesses of the strip making up the coils. As a result, both heating and cooling stages of the annealing cycle are quite long and the production from a single hood is limited, even though it is used successively with several bases. What is more serious, there is a large temperature differential between different parts of the charge as it heats up, causing non-uniformity in the characteristics of the finished product.

Many attempts have been made to remedy the above difficulties. Fans have been installed in the base supporting the charge, for circulating at high velocity the protective atmosphere usually introduced into the inner cover, to increase convection heating of the charge. In addition, convector spacers have been used between coils to permit some circulation of the atmosphere across the ends of the coil turns and thereby increase the rate of heat absorption. Even with these expedients, all the heat delivered to the charge must still be absorbed first by the inner cover and then transmitted from it to the charge by radiation or convection.

I have invented a novel system of heating a charge of stacked coils enclosed within an insulating cover and an inner metal cover. In accordance with my invention I generate heat within the inner cover in immediate proximity to the ends of the coils thereby effecting a rapid penetration of heat into the interior of the charge. More particularly, the invention contemplates portable, "pancake" heating plates or chambers fitted with heat-generating means, adapted to be placed on one coil and to support another coil thereon. Connections for supplying heat-generating media to the plates extend upwardly through the base on which the charge is stacked. Heating plates and coils are preferably stacked alternately on the base and enclosed by lowering the inner cover and insulating cover thereover. Heat is then generated in the space between the coils and transmitted directly thereto by radiation and conduction. At the conclusion of the heating and cooling stages, the coils are removed from the base and the heating plates are taken off and piled alternately with the next batch of coils.

A complete understanding of the invention may be obtained from the following detailed description and explanation which refer to the accompanying drawings illustrating the present preferred embodiment. In the drawings,

Fig. 1 is a plan view showing in horizontal section a portion of a cover-type furnace equipped according to the invention;

Figure 2 is a longitudinal section taken along the plane of line II—II of Figure 1;

Figure 3 is a transverse section taken along the plane of line III—III of Figure 1; and

Figure 4 is a plan view of an element for heating the portable plates or chambers.

Referring now in detail to the drawings, a furnace **10** comprises a base or hearth **11** and a hood or cover **12** adapted to be placed over a charge deposited thereon making a tight seal with the base by virtue of interfitting channels and flanges **13**. The base and cover are fabricated from steel plate and rolled sections and each has a refractory lining. Charge supports or hearth plates **14** of heat-resistant steel are laid on the base and each is adapted to receive a stack of coils C of metal strip disposed with their axes vertical and substantially coinciding.

In accordance with my invention, I intersperse heat-generating means with the coils C stacked on supports **14**. Preferably, I place a heating plate or chamber **15** on each support, then deposit a coil C on the plate. A second plate is set on the coil and a second coil on the second plate and so on until each stack **16** of the furnace charge has been built up to the desired height. The heating plate **15** as illustrated is in the form of an annular chamber or fire-box comprising a pair of vertically spaced bearing plates **17** and **18** having coaxial cylindrical spacers **19** and **20** therebetween. The top plate **17** is removable from the spacers. Radial webs **21** spaced circumferentially of each chamber support an annular combustion tube **22** in a plane parallel to plates **17** and **18**.

In order to supply heat-generating media to the tubes **22** between the bearing plates of the fire boxes, I provide a riser **23** adjacent each stack **16** extending upwardly through base **11** and secured thereto. Each riser includes an outlet main **24** for waste combustion gases, an air-inlet main **25** extending therethrough, and a fuel-supply main **26** adjacent thereto. Air is supplied to mains **25** from a blower **27** through a header **28**. The fuel-supply mains are connected to a header **29** from any convenient source of gas. Outlet mains **24** are connected to an exhaust header **30** extending to a stack (not shown). Mains **24** and **25** are in heat-exchange relation whereby the outflowing waste gases preheat the incoming combustion air.

As shown in Figure 4, the ends of each tube **22** extend radially thereof at a common point, one end **31** extending laterally into and thence through the other **32** which is enlarged to accommodate it. A burner nozzle **33** is mounted on a fitting which closes tube end **31** and is connected to fuel-supply main **26** by flexible metallic-hose **34** equipped with quickly detachable couplings **35**. A similar flexible metallic-hose **36** fitted with similar couplings connects the outlet end **32** of tube **22** to outlet main **24**. A flexible metallic-hose **37** also fitted with quickly detachable couplings (not shown) extends through hose **36** and connects air main **25** to the inlet end **31** of tube **22**. The hoses **34**, **36** and **37** are of heat-resistant steel. They permit the heating plates to be piled with coils of various widths.

After the heating chambers **15** and coils have been stacked alternately on charge supports **14** and connections made between the ends of tubes **22** and the outlet, air and fuel mains **24**, **25** and **26**, an inner cover **38** is lowered over each stack **16** and the insulating cover is low-

ered onto base 11. Blower 27 is then driven as by a motor 39 and valves 40 in the lines leading to fuel mains 26 are opened. As a result, a combustible mixture is delivered to tubes 22 and circulated therethrough. A spark-gap igniter 41 at the lower end of each outlet main 24 initiates combustion of the mixture whereupon the flame travels back along the course of the gases to the tips of burners 33. Thus heat is generated in the tubes 22 by combustion of the gases fired therethrough and the heat is radiated from the tubes to plates 17 and 18. The latter conduct the heat directly to the edges of the coil turns exposed to contact with the plates. A protective atmosphere may be maintained in the inner covers by inlet 42 and outlets 43 extending through the base 11.

The supply of fuel is controlled as the charge temperature rises, to prevent overheating when the final temperature is reached. It is also graduated downwardly as by orifice plates, from the bottom heating plate to the uppermost one to prevent overheating the upper coils of the stack. When the charge has been brought up to the desired temperature and held thereat for the required time, valves 40 are closed to terminate the generation of heat in tubes 22 and cover 12 is removed from base 11. Operation of blower 27 may be continued thereafter, if desired, to cool the charge by circulation of atmospheric air through the tubes. This, of course, shortens the cooling stage of the annealing cycle. When the charge has been cooled to the proper temperature, usually that at which the strip does not oxidize readily in air (about 300° F.), covers 38 are removed and the coils are unloaded from the stacks 16. This involves laying the heating plates or chambers 15 aside temporarily, after breaking the couplings 35. As soon as one charge has been unloaded from the base, another may be loaded on and the heating thereof started without delay, the heating plates being placed alternately with the coils and their tubes 22 reconnected to the mains before the inner covers 38 and insulating cover 12 are replaced.

It will be evident that the invention is characterized by many important advantages. The principal one is the time saving made possible by the increased rate at which heat is absorbed by the charge. The forced cooling also effects a further shortening of the annealing cycle. As a result of the time thus saved, a furnace according to my invention has a greater capacity per week than conventional radiant-tube furnaces. There is also less difference between the temperatures of the hottest and coolest portions of the charge thus improving the uniformity of the product. The combustion air is heated by the outflowing waste gases thereby increasing combustion efficiency and fuel economy.

My portable heating elements afford better support for the combustion tubes 22 than is possible for the tubes in conventional furnace construction. The aggregate length of the tubes, furthermore, is less. This decreases the cost of the equipment. Contributing further to the latter is the omission of the atmospheric-circulating fan and spacers found necessary in conventional radiant-tube furnaces.

Although I have disclosed herein but a preferred embodiment of my practice, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. In a method of heating coils of metal strip, the steps including placing a coil with its axis vertical on a bearing surface, placing on said coil a pair of bearing plates spaced apart, one overlying the other, placing a second coil on the upper of said last-mentioned plates, enclosing the resulting stack, discharging and igniting a combustible mixture of gases around the space between said pair of plates and exhausting burned gases from said space thereby heating said coils principally by conduction through said plates directly into the edges of the coil plies in contact therewith.

2. In a method of heating coils of metal strip, the steps including stacking coils in vertically spaced relation with their axes substantially in vertical alinement, disposing an annular radiant tube in the space between each pair of adjacent coils, enclosing the stacked coils, discharging and igniting a combustible mixture of gases through said tubes thereby supplying heat to the coils principally through the edges of the plies thereof, and exhausting burned gases from said tubes.

3. In apparatus for heating coils of metal strip including a hearth, a cover disposable thereon to enclose a stack of coils built up on the hearth, the combination therewith of a plurality of independent annular fire boxes disposed one beneath each coil, fuel and air mains extending through said hearth and detachable connections between said mains and each fire box.

4. The apparatus defined by claim 3 characterized by an exhaust main extending upwardly through said base for conducting waste gases from the fire boxes and detachable connections from said exhaust main to each fire box.

5. The apparatus defined by claim 3 characterized by each fire box having an annular radiant tube therein, said connections extending to said tubes.

6. The apparatus defined by claim 5 characterized by said tubes having entering and exit end portions extending radially through said fire boxes.

7. In apparatus for heating coils of metal strip including a hearth, a cover disposable thereon to enclose a stack of coils built up on the hearth, the combination therewith of a plurality of pairs of vertically spaced bearing plates adapted to be disposed one pair beneath each coil, fuel and air mains extending upwardly through said hearth and a burner firing into the space between each pair of plates, said burners being connected to said mains.

8. The apparatus defined by claim 7 characterized by an annular radiant tube disposed in a horizontal plane between the plates of each pair, said burners firing into said tubes, respectively.

9. A portable heater adapted to be placed horizontally between adjacent coils piled one on another to form a stack, said heater comprising a chamber having a central passage therethrough, said chamber being defined by spaced upper and lower bearing plates, and spaced inner and outer tubular load-transmitting walls extending between said plates, an annular radiant tube disposed coaxially in said chamber in a plane parallel to said plates and spaced vertically from each of said plates, and a burner mounted to fire gases through the tube around the axis of the chamber.

10. The apparatus defined by claim 9, characterized by radial webs in said chamber spaced circumferentially thereof and normal to said plates, said webs supporting said tube at a level intermediate said plates.

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