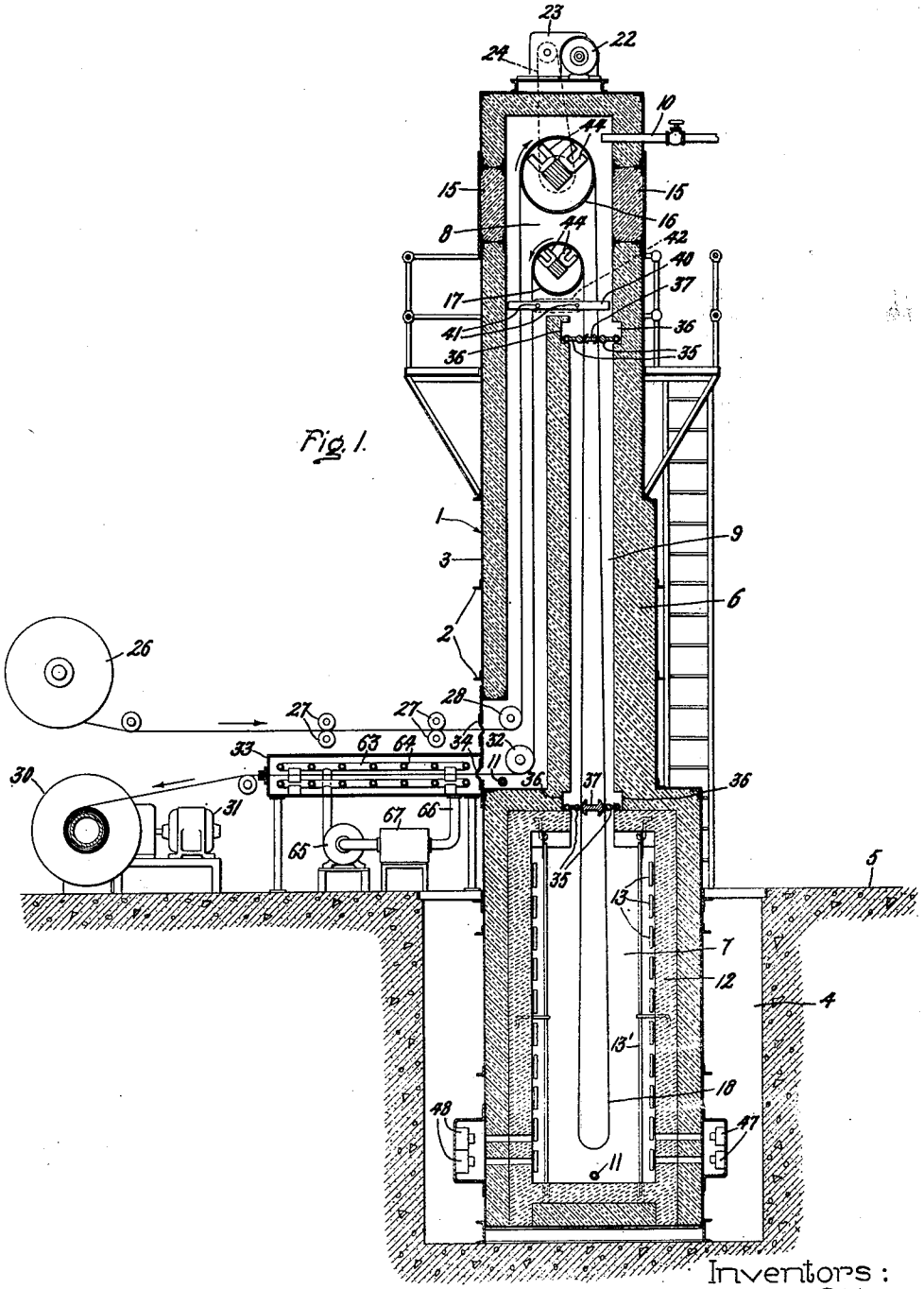
July 30, 1935. A. N. OTIS ET AL 2,009,856

ANNEALING FURNACE

Filed March 21, 1934 2 Sheets-Sheet 1

Fig. 1.




Inventors:
Albert N. Otis;
James L. McFarland,
by Harry E. Dunham
Their Attorney.

July 30, 1935. A. N. OTIS ET AL 2,009,856

ANNEALING FURNACE

Filed March 21, 1934 2 Sheets-Sheet 2

Fig. 2.

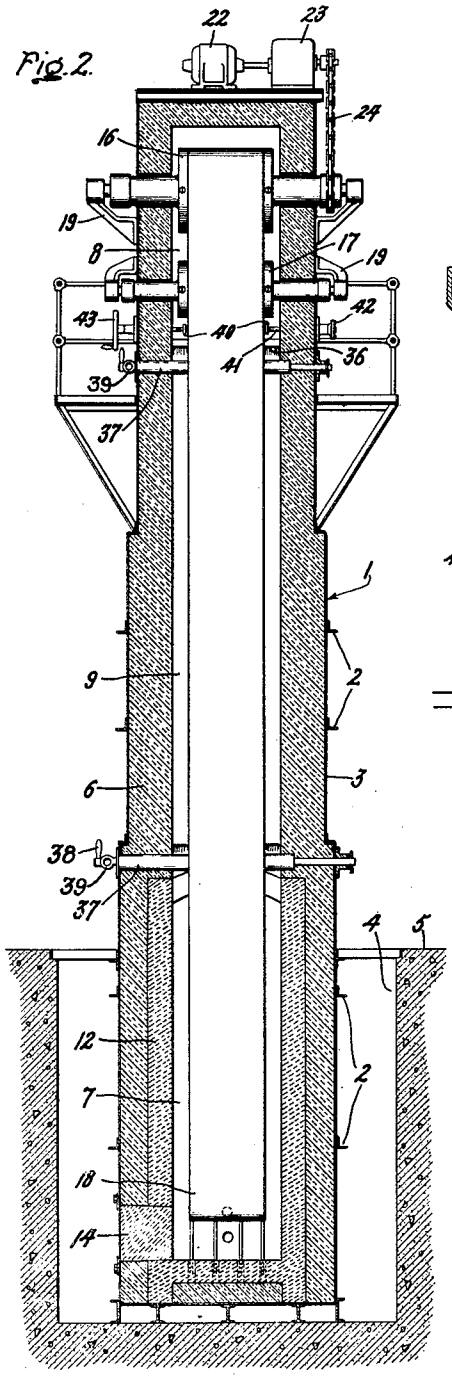
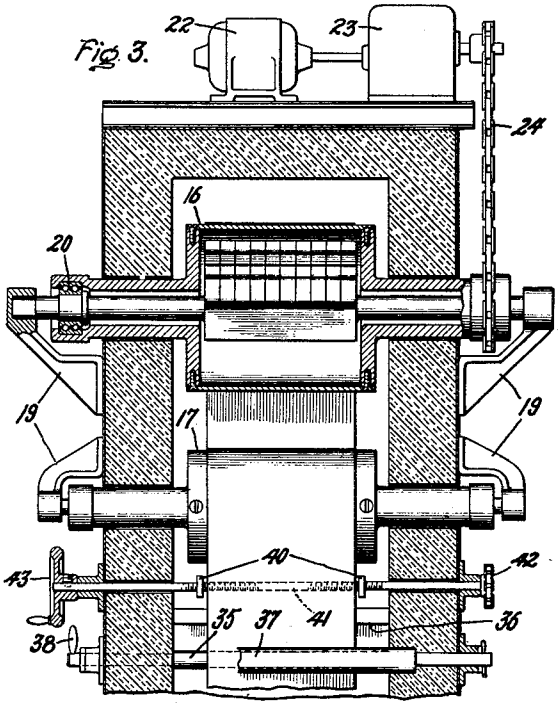



Fig. 3.



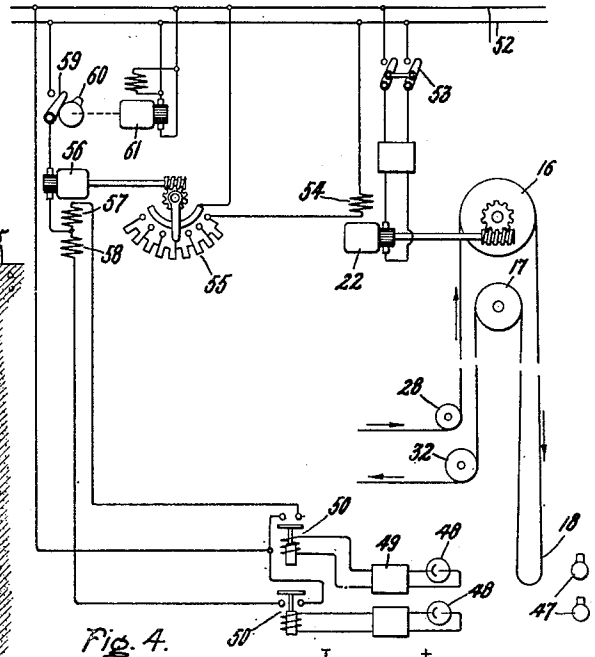




Fig. 4.

Inventors:
Albert N. Otis;
James L. McFarland,
by Harry E. Dunham
Their Attorney.

Patented July 30, 1935 2,009,856

# UNITED STATES PATENT OFFICE

2,009,856

## ANNEALING FURNACE

Albert N. Otis and James L. McFarland, Schenectady, N. Y., assignors to General Electric Company, a corporation of New York

Application March 21, 1934, Serial No. 716,629

21 Claims. (Cl. 263—3)

Our invention relates to annealing furnaces of the type which provides for the continuous movement of the material to be annealed through the furnace. It relates particularly to annealing furnaces adapted for use in annealing material in strip form, such for example as steel strip.

One object of our invention is the provision of an annealing furnace which in consideration of its output capacity has relatively small cubical contents and requires relatively small floor space and head room. Another object of our invention is that the furnace shall provide for a maximum heat recovery from the material being annealed, hence reducing the heat requirements and giving to the furnace a high heat efficiency. A further object of our invention is the provision of an annealing furnace of the continuous type wherein the material being annealed is supported and moved while heated to the proper temperature without danger of having the surface thereof scratched or otherwise damaged. A still further object of our invention is the provision of means for regulating the passage of the material through the furnace.

Our invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a vertical sectional view of an annealing furnace comprising an embodiment of our invention; Fig. 2 is a similar vertical sectional view at right angles to that of Fig. 1; Fig. 3 is an enlarged detail view corresponding to Fig. 2 showing the upper portion of the furnace; and Fig. 4 is a circuit diagram of the drive and control apparatus of the furnace.

In Fig. 1 we have shown the furnace comprising an outer housing 1 which may be built up of structural steel parts 2 to which are secured steel plates 3. The housing preferably is supported with its lower end in a pit 4 arranged below the level of the floor 5 thereby effecting economy in the necessary head room required. The housing which is provided with a lining 6 of heat insulating material forms three vertically aligned chambers, a lower heating chamber 7, an upper drum chamber 8 and an intermediate heat exchange chamber 9. These chambers preferably are maintained full of a suitable non-oxidizing gas such, for example, as hydrogen, or a mixture of hydrogen and nitrogen, the furnace being shown provided with the gas supply pipe 10 located near the top thereof and with the outlet openings 11, of which one is located at the bottom of the heating chamber and the other near the roll 32. In accordance with the usual practice the heating chamber 7 is provided with an additional lining 12 of refractory material and on the walls are located series of heating elements shown at 13 in front of which are suitable guards 13'. These elements are preferably electric resistance elements and suitable temperature controlling devices, not shown, are employed for regulating the heating elements whereby the desired temperature is maintained in the heating chamber. As shown in Fig. 2, the heating chamber is provided at one side with the door 14 whereby access may be had to this chamber for the installation and subsequent maintenance of the heating units, etc.

The drum chamber 8 in the upper portion of the housing is likewise provided with doors 15, one being shown in this case on each side of the chamber, in order to give access to the chamber, such for example, as when a new strip of material to be annealed is to be threaded through the furnace. Supported in the chamber 8 are the two hollow drums 16 and 17 by which the material to be annealed is suspended in a loop 18, which hangs with its two sides in close space relation and approximately parallel through the heat exchange chamber 9 and into the heating chamber 7. Both drums 16 and 17 are rotatably mounted on shafts which, as shown in Fig. 3, are non-rotatably supported by the brackets 19 secured to the outer face of the housing. The drums are each mounted on hollow trunnions encircling their respective shafts and passing through apertures in the opposite walls of the furnace. The trunnions are in turn mounted at their ends on their respective shafts by bearings 20 which as shown in Fig. 3 are mounted outside of the housing whereby they operate in a cooler atmosphere than if arranged within a drum chamber. The lower and smaller drum 17 is arranged to run freely on its shaft. The upper or larger drum 16 is arranged to be driven by the motor 22 through a suitable worm reduction gearing 23 and the chain connection 24. By this means drum 16 is rotated to feed the material to be annealed into the loop at the proper speed under the control of apparatus which will be described hereinafter. The material to be annealed is withdrawn by the drum 16 from the coil 26 through the rider rolls 27 and under the roll 28. Obviously suitable protective means including a drop bar arranged to engage the material between the groups of rolls 27 may be provided if desired to stop motor 22 in case a free end of the material should pass

the first group of rolls. From the drum 17 the material after annealing is withdrawn from the furnace by the reel 30, which for example is shown driven by the motor 31, the material passing under the roll 32 and through the cooling chamber 33 in which the temperature of the material is reduced to such a point that oxidation will not occur when the material is exposed to the air. Where the strip enters and leaves the furnace it passes through the seals shown at 34 which, for example, may comprise thin steel plates covered with asbestos fabric. Between these seals and the drums 16 and 17 the strip is shown extending through a passage or chamber which connects at its upper end with the drum chamber 8.

At the opposite ends of the heat exchange chamber 9 we have shown seals for restricting the transfer of hot gas from the heating chamber into the heat exchange chamber and also from the latter chamber into the drum chamber. These seals are represented as comprising the two outer vane-like members 35 which are pivotally mounted in the small recesses 36 in the lining of the housing and have operating handles 38 at the outside whereby they may be turned upwardly so as to occupy the recesses. The seals also comprise the central members 37 which are arranged so that they may be withdrawn bodily from the side of the furnace by the rings 39. The seals 35 and 37 are spaced from each other only sufficient to allow the strip material to pass freely therebetween. They are provided with rounded faces adjacent the strip and are constructed or at least the adjacent faces thereof are constructed preferably of a suitable soft metal such as copper so as to avoid any possible scratching of the strip material should it have a polished face and rub against one or more of the seals. With the members 35 turned up into the recesses and the members 37 withdrawn, a free path is provided for the threading of a strip of material to be annealed through the furnace.

For guiding the material laterally, we have provided the two bars 40 through which are threaded the shafts 41 having righthand and lefthand threads. These shafts are connected at one side of the furnace by chain gearing 42 and at the other side of the furnace one of the shafts is provided with the hand wheel 43, so that the bars may be separated or brought closer together as may be required for different widths of strip which it may be required to anneal. The position of both bars 40 may be simultaneously adjusted by turning the hand wheel.

In order to cause the material being annealed to cling without slippage to the drums 16 and 17, which slippage might produce objectionable scratches on the material, particularly in the case where the material being annealed is bright, we have provided both drums with magnetic means arranged therein. Such magnetic means comprise magnets represented at 44, the same being secured to the fixed shafts on which the drums rotate, and in positions opposite the upper portion of the surfaces of the drums which are engaged by the strip of material as it passes over the drums. Where magnets are employed within the drums the faces of the drums are constructed of non-magnetic material, such as copper, whereby the flux from the magnets may readily reach the material being annealed, such as sheet steel, to cause it to cling firmly to the faces of the drum.

For the regulation of the speed of motor 22 by which the upper drum 16 is rotated we have provided a control apparatus responsive to the length of the loop 18. For this purpose we have provided two aligning transverse openings in the lower portion of the furnace opposite the end of the loop 18. In a suitable housing arranged at one side of the furnace opposite these openings are the light sources 47 and correspondingly positioned in other suitable housings at the opposite side of the furnace are the photoelectric devices 48 which devices connect through suitable amplifiers 49 with the relays 50. These relays are similar to each other and so arranged that the upper relay or that connected with the upper photoelectric device is arranged to close its contacts when light to its photoelectric device is unobstructed by the loop 18, while the lower relay 50 or that one connected with the lower photoelectric device is arranged to close the circuit of its contacts when light to its photoelectric device is obstructed by the loop. Motor 22 which drives drum 16 is shown having its armature circuit energized from the source of current 52 through the switch 53. Its field winding 54 is also connected to the same source 52 through the rheostat 55. The position of the arm of this rheostat is moved by the motor 56 which is also connected to be supplied from the source 52 and is provided with the two reversely wound series field windings 57 and 58. These windings are connected in circuit through the contacts of the relays 50 whereby the motor 56 is energized through one or the other of the windings in accordance with the position of the end of the loop 18 of material to be annealed. In circuit with the motor 56 we have shown the switch 59 arranged to be intermittently closed and opened by the cam 60 which is driven at slow speed by the motor 61 whereby motor 56 is rendered operative at intervals and for only a portion of the total time.

It will be seen that with the above-described apparatus as long as the material to be annealed is being fed into the loop 18 at the same speed as that at which it is being withdrawn from the loop, the length of the loop will not change and the rheostat 55 will not change in value. Should the loop become too short, as would occur if the feed-in speed should become too slow, the upper photo device will be exposed to its light source causing the energization of the upper relay 50 which will close the circuit to motor 56 through the field winding 57 which in turn will cause motor 56 to run in such a direction as to shift the rheostat so as to weaken the field produced by winding 54 of motor 22 thus increasing its speed. Conversely if the loop becomes too long the lower photoelectric device 48 will be shadowed by the loop and the lower relay 50 by being deenergized will close the circuit of motor 56 through field winding 58 causing motor 56 to run in the opposite direction and so changing rheostat 55 that the field produced by winding 54 is strengthened whereby the drum 16 is rotated at decreased speed.

The cooling chamber 33 in which the strip is cooled below the point at which oxidation would occur were the strip to be exposed to the air is shown as including the headers 63 with which connect the transverse pipes 64 having jets therein from which a suitable non-oxidizing cooling gas is blown toward the hot strip. The cooling gas is recirculated through the chamber by means of the blower 65 which is connected with the headers 63 and with the return pipe 66 and the temperature of the gas as it is drawn from the

chamber is reduced by the cooler 67. Cooling apparatus such as described above is disclosed and claimed in the copending application by Albert N. Otis, Serial No. 742,132 filed Aug. 30, 1934, and assigned to the same assignee as the present application.

We have chosen the particular embodiment described above as illustrative of our invention and it will be apparent that various modifications may be made without departing from the spirit and scope of our invention which modifications we aim to cover by the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An annealing furnace comprising a heating chamber, means for supporting therein a loop of material to be annealed, a heat exchange chamber connecting with said heating chamber and means for feeding the material through the heat exchange chamber into the heating chamber and for withdrawing the material through the heat exchange chamber from the heating chamber, the material approaching and leaving the heating chamber being arranged to move in adjacent paths in said heat exchange chamber.

2. An annealing furnace comprising a heating chamber, means for suspending therein a loop of flexible material to be annealed, a heat exchange chamber having one end connecting with said heating chamber and means for feeding the material into the heating chamber and for withdrawing it therefrom, said material in approaching and leaving said heating chamber being passed through said heat exchange chamber in closely adjacent paths whereby a rapid exchange of heat may take place.

3. An annealing furnace comprising a heating chamber, a heat exchange chamber arranged thereover, means for suspending a loop of material to be annealed with its lower end portion in said heating chamber and with the opposite sides of another portion thereof adjacent to each other in said heat exchange chamber and means for feeding the material into one side of the loop and for withdrawing it from the other side thereof.

4. An annealing furnace comprising a heating chamber, a heat exchange chamber arranged thereover, means arranged above said heat exchange chamber for suspending a loop of material to be annealed with its lower end in said heating chamber and with the opposite sides of an intermediate portion of the loop adjacent to each other in said heat exchange chamber and means for feeding the material into one side of the loop and for withdrawing it from the other side thereof.

5. An annealing furnace comprising a heating chamber, a heat insulated heat exchange chamber arranged thereover, rotatable means for suspending a loop of material to be annealed with its lower end portion in said heating chamber and with the opposite sides of another portion thereof in close heat exchange relation with each other in said heat exchange chamber and means for continuously feeding the material into one side of the loop and for withdrawing it from the other side thereof.

6. An annealing furnace comprising an upper chamber, a lower heating chamber, an intermediate heat exchange chamber, rotatable means in said upper chamber for suspending a loop of material to be annealed with the lower end of the loop in said heating chamber and with both sides of an intermediate portion of the loop in said heat exchange chamber.

7. An annealing furnace comprising an upper relatively cool chamber, a lower heating chamber, an intermediate heat exchange chamber, drums in said upper chamber for suspending a loop of material to be annealed with the lower end of the loop in said heating chamber and with both sides of an intermediate portion of the loop in said heat exchange chamber, the relative position of said drums being such that the two sides of the loop in the heat exchange chamber are close to and in good heat exchange relation with each other.

8. An annealing furnace comprising a heating chamber, means for suspending a loop of moving material to be annealed in said chamber, driving means for moving said material through said chamber and means responsive to the length of the loop for controlling said driving means to maintain the length of said loop at a predetermined value.

9. An annealing furnace comprising a heating chamber, a heat exchange chamber arranged thereover, means for suspending a loop of material to be annealed with its lower end portion in said heating chamber and with the opposite sides of another portion thereof adjacent to each other in said heat exchange chamber, material-moving means for feeding the material into one side of the loop, material-moving means for withdrawing the material from the other side of the loop and means responsive to the length of the loop for controlling one of said material-moving means so as to maintain the length of said loop at a predetermined value.

10. An annealing furnace comprising a heating chamber, means for suspending a free loop of moving material to be annealed in said chamber, means for directing a light beam across said chamber, a photoelectric device arranged to receive said beam, the beam being arranged to be intercepted by the loop when the latter reaches a predetermined length and means responsive to said device for controlling the length of the loop.

11. An annealing furnace comprising a heating chamber, means for suspending a free loop of moving material to be annealed in said chamber, feed control means for the material forming said loop responsive to the length of the loop comprising means for projecting a plurality of light beams across said chamber at different heights and arranged to be intercepted by the lower end of said free loop in accordance with the length thereof and a photoelectric device arranged to receive each of said beams when not intercepted by the loop.

12. An annealing furnace comprising a heating chamber, a heat exchange chamber above the heating chamber, a drum for suspending each side of a free loop of material to be annealed in said chambers, means for withdrawing the material from one side of the loop over one drum, means for rotating the other drum to feed the material to the other side of the loop, means for directing a light beam across said chamber and positioned to be intercepted by the end of said loop, a photoelectric device arranged to receive said beam and means responsive to said device for regulating the speed of said other drum.

13. An annealing furnace comprising a heating furnace having walls of heat refractory material and having heating units arranged on the walls thereof, a heat exchange chamber arranged above the heating chamber and having walls of heat insulating material, a drum chamber arranged above the heat exchange chamber, ad-

justable seals between said chambers, drums in said drum chamber for supporting a loop of material to be annealed in the heating and heat exchange chambers, said drums being so arranged that the two sides of said loop hang in close space relation with each other.

14. An annealing furnace comprising a vertical housing having a lining of heat insulating material, the lower portion of said housing comprising a heating chamber having heating means therein, an intermediate portion of the housing comprising a heat exchange chamber and the upper portion of said housing comprising a relatively cool drum chamber, seals operable from the exterior of the housing at each end of the heat exchange chamber, drums in the drum chamber arranged to suspend the two sides of a loop of material to be annealed in the heat exchange and the heating chambers, means for withdrawing the material from one side of the loop and means for rotating one of the drums to supply material to the other side of the loop.

15. An annealing furnace having a hollow drum therein for supporting the material to be annealed and provided with a hollow shaft at each end thereof, a fixed shaft extending through said drum and hollow shaft and a magnet secured to the fixed shaft within the drum.

16. An annealing furnace having a hollow drum therein for supporting the material to be annealed and provided with a hollow shaft at each end thereof extending through the walls of the furnace, bearings for said hollow shaft at the exterior of said furnace, a fixed shaft extending through the drum and hollow shaft and a magnet within said drum secured to the fixed shaft.

17. In a furnace having a chamber provided with an opening therein through which material is adapted to pass simultaneously into and out of the chamber in adjacent paths, sealing means for said opening comprising members arranged to cooperate with the material at opposite sides of the opening and a removably mounted intermediate member.

18. In a furnace having a chamber provided with an opening therein through which material is adapted to pass simultaneously into and out of the chamber in adjacent paths, sealing means for said opening comprising a member intermediate said paths arranged to cooperate at opposite sides with said material and a movable member at each side of said opening arranged to cooperate with said material.

19. In a furnace having a chamber provided with an opening therein through which material is adapted to pass simultaneously into and out of the chamber in adjacent paths, sealing means for said opening comprising a plurality of outer pivotally mounted members and an intermediate member, means for moving the outer members to an inoperative position and means for withdrawing the intermediate member.

20. An annealing furnace comprising a heating chamber having heating elements therein, a heat exchange chamber arranged thereover and in communication therewith, a drum chamber arranged over the heat exchange chamber and communicating therewith, drums in said drum chamber from which strip material to be annealed is adapted to be suspended in a loop in the heating and heat exchange chambers, seals between the heating and heat exchange chambers and between the heat exchange chamber and the drum chamber, means for driving one of said drums, means for controlling said driving means including a photoelectric device arranged to respond to the length of the loop and means for supplying a non-oxidizing gas to said furnace.

21. An annealing furnace comprising a heating chamber having heating elements therein, a heat exchange chamber arranged thereover and in communication therewith, seals between said chambers, a drum chamber over said heat exchange chamber, seals therebetween, a plurality of drums in said drum chamber from which a continuously moving strip of material is adapted to be suspended in a loop in said heat exchange and heating chambers, a motor mounted on the furnace for moving one of said drums, magnets in said drums for causing the material to cling thereto, said furnace having an opening provided with seals through which the strip is adapted to enter and leave, photoelectric devices arranged to be affected by the length of said loop, control apparatus for said motor responsive to said devices and means for admitting a non-oxidizing gas to the drum chamber of said furnace.

ALBERT N. OTIS.
JAMES L. McFARLAND.