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The diagram shows a cross-section of a dam with a horizontal base. The base is divided into four segments with lengths 22, 23, 24, and 25. The dam profile is defined by a curved upstream face, a rectangular middle section, and a trapezoidal downstream face.

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ANNEALING FURNACE

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My invention relates to annealing furnaces and has a particular reference to furnaces for annealing metal articles and castings.

The object of my invention is to provide a furnace in which the annealing process can be carried in accordance with a definite temperature curve. For this purpose I provide a furnace composed of different sections, each section especially suitable for one particular portion of the temperature curve. For instance, when annealing cast iron castings for converting them into malleable iron, it is necessary to subject them to four successive heat treatments as follows:

1. Gradually raising the temperature to a maximum at which disintegration of the cementite takes place.
2. Maintaining the maximum temperature for a certain length of time until the cementite disintegration is completed.
3. More or less rapid cooling until a suitable temperature is reached for disintegrating perlite into a more uniform structure.
4. Maintaining this temperature for a certain length of time.

There are two principal types of malleable iron furnaces: tunnel or continuous furnaces, and periodic furnaces, preferably with electric heating. In the latter type of furnace the work is loaded in a batch and is subjected to the heat treatment until the process is completed, when the work is withdrawn.

The tunnel furnaces or kilns are very economical, the fuel consumption being low, in case of coal equal to about 20% by weight of castings. These furnaces are well adapted for various temperature curves, although it is difficult to maintain the desired temperatures very accurately and uniformly throughout the sections of the furnace. For this reason these furnaces are not so well adapted for production of very high grade castings for which an exact temperature control is necessary. Another disadvantage of these furnaces is that their efficiency becomes considerably reduced for light load on the kiln cars and it becomes more difficult to maintain a uniform temperature curve with only partly filled cars. Besides, they occupy a large amount of space in the plant, the time

of treatment being controlled by the length of the furnace.

Periodic furnaces, mainly of the electric type, are very well adapted for maintaining very accurately the required temperature curve, with a uniform heating throughout the furnace, so that it is possible to obtain in such furnaces the highest grades of malleable iron. The exact temperature control can be easily adjusted for various loads, and the furnace itself occupies very little room in the plant. Its fuel consumption is, however, rather high, reaching 400 kilowatt hours per ton of castings, or, expressing in terms of coal, about 1000 lbs. of coal per ton, or 50%.

The actual experience has shown that for the production of the highest grades of malleable iron it is necessary to maintain a very accurate temperature only during the last period of annealing, when perlite becomes disintegrated and a granular structure of metal develops. The other three periods do not require such an exact temperature control. It appears therefore that it is possible to build a composite furnace so as to combine the advantages of the two types of furnaces and to eliminate their disadvantages.

I found that for this purpose the best results are obtained if the first two stages of the annealing process are carried in a correspondingly shortened tunnel furnace, of a sufficient length only to complete the disintegration of cementite. The subsequent cooling can be carried rapidly and it does not require any furnace, as the work can be simply exposed to the air draft until its temperature reaches the point when perlite begins to disintegrate. Then the work can be placed in a periodic or additional (separate) electric furnace where the temperature is maintained constant all the time and within required limits to obtain the fine granular structure of the metal. The work remains in the furnace until the process is completed.

My arrangement permits to use a tunnel furnace for the greatest part of the thermal process, thereby obtaining the benefit of the economic operation of such a furnace, saving, however, in its cost and space requirements; the final annealing, at the same time,

is carried in the separate furnace under the most exact temperature control.

My invention is more fully described in the accompanying specification and drawings in which—

Fig. 1 is a plan view of my composite furnace, Fig. 2 is a sectional elevation of same, and Fig. 3 is a temperature curve for malleable iron.

My furnace comprises a tunnel portion 1 of an ordinary construction except that it is shortened and terminates with the firing zone 2 where burners 3 are located. The hot gases flow through the preheating portion 1 into a stack 4. Rails 5 pass through the tunnel for cars 6 carrying castings or other articles to be annealed. A hydraulic plunger 7 is used to push the cars through the tunnel. Any other suitable device, of course, can be employed for this purpose.

The rails 5 extend beyond the tunnel and pass under a cooling hood 8 with a stack 9 through which the air is drawn by any suitable means, for instance, by a fan or by natural draft. The rails terminate at a pit 10 of an electric furnace 11 and are in alignment with rails 12 on a lift table 13 and with extension rails 14 on the other side of the pit.

The electric furnace may have one or several compartments 15 lined with a suitable refractory material and provided with electric heating elements 16 connected by cables 17 with a source of electric current. The number of compartments 15 is selected so as to provide for a continuous operation of the furnace in accordance with the operation of the tunnel kiln.

The lift table 13 is mounted on a ram 18 operated hydraulically in a cylinder 19 and is adapted to raise the cars into the furnaces 15 where they are retained in a suspended position by retaining lugs 20 of an ordinary construction.

The operation of my furnace is as follows. In the preheating portion 1 of the tunnel furnace the castings 21 on the cars 6 are brought to a temperature of about 1700° F. during from 24 to 36 hours, following the portion 22 of the temperature curve Fig. 3. In the firing zone the castings are maintained at this temperature for about 24 hours.

This period corresponds to the portion 23 of the temperature curve. The castings are then removed from the furnace and are placed under the cooling hood 8 where they are cooled following the curve 24. This cooling may be quite rapid as it does not affect the quality of the product.

The cars are then brought one at a time on the table 13 and raised into the corresponding furnace compartment 15, being held in a raised position by lugs or latches 20. Here the temperature is maintained at from 1200 to 1450 degrees F. for a length of time depending on the kind of castings and

the grade of the product (see curve 25, Fig. 3).

With this arrangement it is possible to reduce the total length of the tunnel furnace by about $\frac{3}{5}$ times, with corresponding reduction of the first cost and maintenance expenses. The number of electric furnaces will be reduced, and the total power consumption, expressing in terms of coal, will be about 25% of the weight of metal to be annealed. The whole installation will be considerably shorter than it would be required if a tunnel furnace alone was used (about 200 feet instead of 350 for 50 tons of castings in 24 hours).

I claim as my invention:

1. In an annealing furnace, the combination with a tunnel kiln, cars for work adapted to pass through said tunnel kiln, said kiln containing preheating and high temperature zones and terminating at the end of said high temperature zone, and a separate furnace adapted to maintain a constant temperature and containing several cells for said cars, the number of said cells being proportioned according to the time required for final heat treatment and to the time interval between successive arrivals of said cars from said tunnel kiln.

2. In an annealing furnace, the combination with a tunnel kiln, rails passing through said kiln, cars for work to be annealed adapted to pass through said kiln on said rails, said kiln containing preheating and high temperature zones and terminating at the end of said high temperature zone, a cooling arrangement for cars coming from said kiln, said rails extending through said cooling arrangement, a separate furnace in a coordination with said kiln and said cooling arrangement, said separate furnace containing compartments for said cars and adapted to maintain a constant temperature, and means to selectively place said cars in said compartments.

In testimony whereof I affix my signature.
NAUM G. GIRSHOWITCH.