Dec. 27, 1938. W. N. McCUTCHEON 2,141,192

APPARATUS FOR ANNEALING

Filed Jan. 2, 1937 2 Sheets-Sheet 1

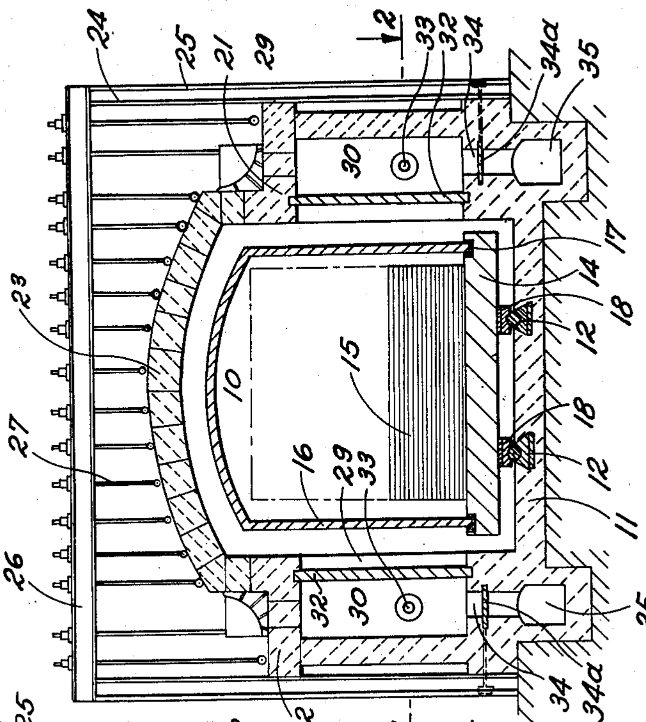

Fig. 1

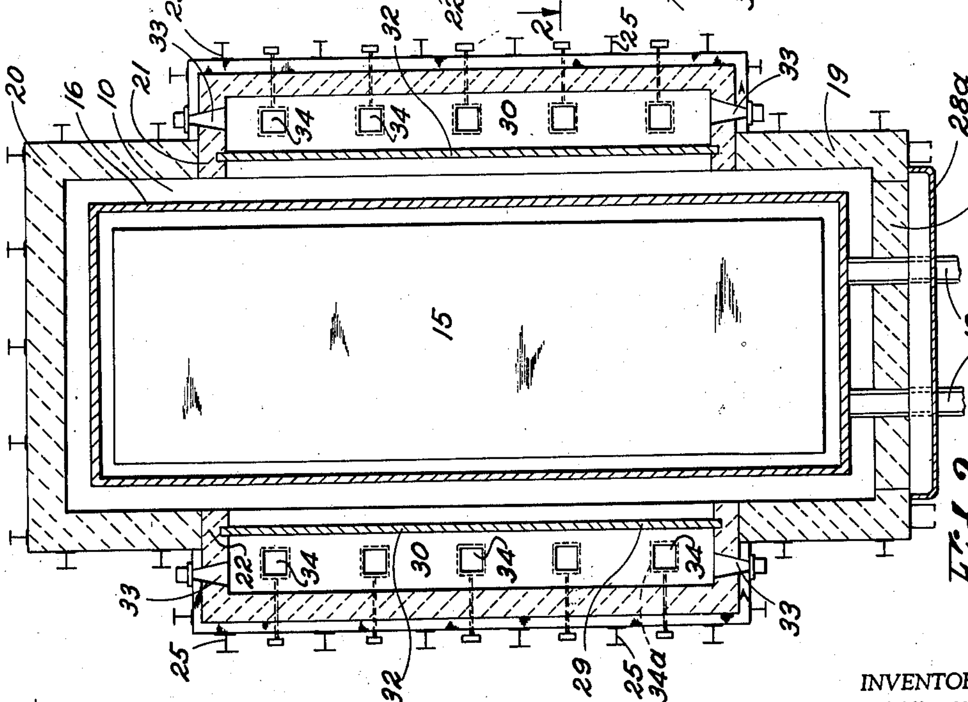

Fig. 2

INVENTOR.
WILLIAM N. McCUTCHEON

BY Richey & Watts

ATTORNEYS

APPARATUS FOR ANNEALING

Filed Jan. 2, 1937 2 Sheets-Sheet 2

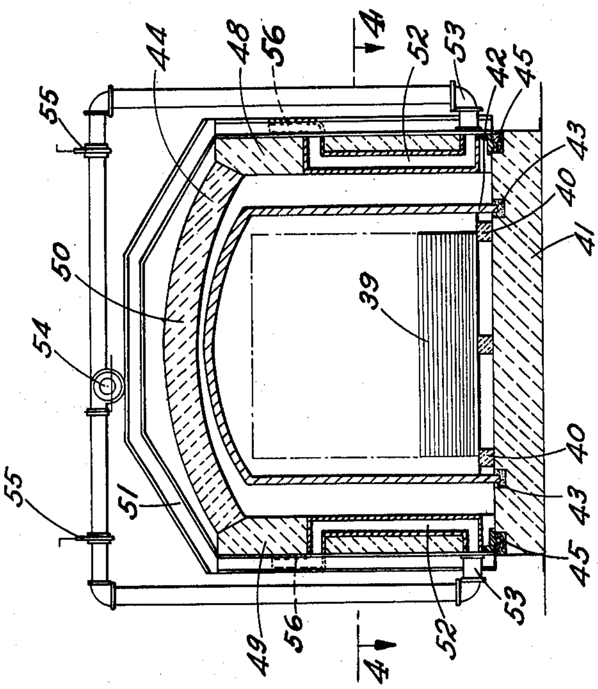

Fig. 3

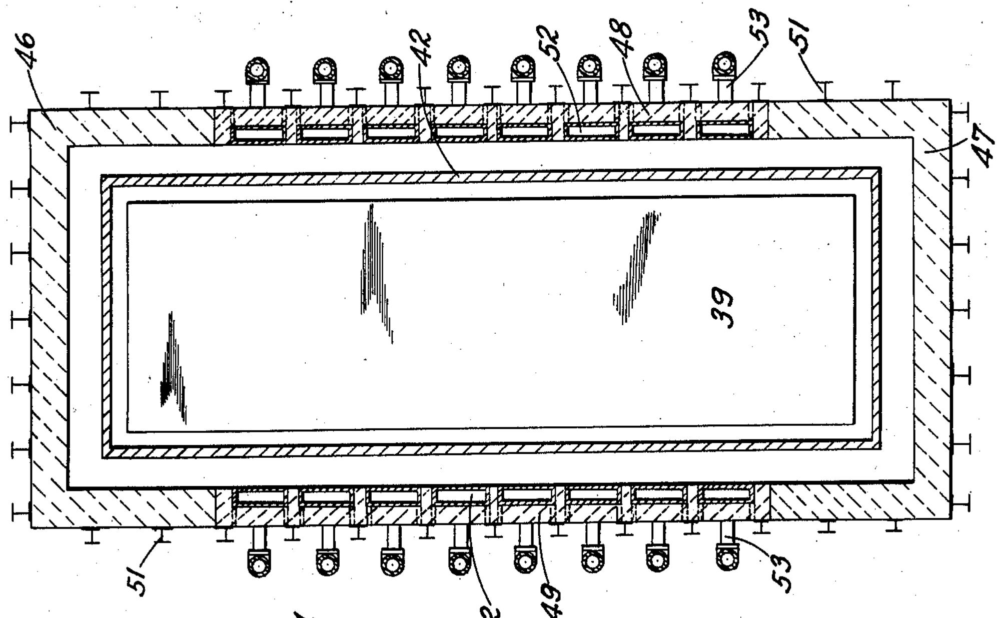

Fig. 4

INVENTOR.
WILLIAM N. McCUTCHEON
BY Richey & Watts
ATTORNEYS

Patented Dec. 27, 1938 2,141,192

UNITED STATES PATENT OFFICE

2,141,192

APPARATUS FOR ANNEALING

William N. McCutcheon, Thornburg, Pa.

Application January 2, 1937, Serial No. 118,738

3 Claims. (Cl. 266—5)

This invention relates to the art of annealing and/or heat treating metals, and more specifically to a method of box annealing ferrous metal sheets, plates and coils, and to apparatus to effectuate such method.

Heretofore, it has been the practice in box annealing to stack a plurality of sheets, plates or coils on a suitable base, lower a cover over the entire charge of metal, secure the same to the base and then place the box with the metal disposed therein in a suitable heating furnace. The furnace was fired by the introduction of a combustible mixture into the furnace chamber, the flame produced thereby being directed upon the annealing box. Unless the furnace was heated at a relatively slow rate, it was found that certain zones in the charge of metal would reach the desired temperature sooner than other portions of the metal and in some instances such zones in the charge of metal would become overheated or burned. For example, in firing the furnace, the greatest intensity of heat would be concentrated or localized within the upper regions of the furnace chamber. The material disposed in such regions would be subjected to this intense heat, resulting in such material becoming overheated or attaining the required temperature for annealing before those portions of the charge of metal disposed adjacent the bottom of the annealing box. As a result, it was found that it was impossible under such practices to obtain a product which had been uniformly heat treated throughout the extent of the charge. Also it was difficult to obtain a product which was uniform in grain structure and possessed uniform physical properties. It was found that a single sheet of metal would possess highly variable characteristics throughout its extent, which metal would not only react differently but would give totally different results throughout the extent of a sheet of such metal when subjected to fabrication. The cost of box annealing was, therefore, excessive not only from the standpoint of furnace operation but also from the standpoint of scrap loss. Those portions of the charge of metal which had become overheated or burned because of excessive heating, or had been underheated, had either to be scrapped or be subjected to a subsequent heat treatment.

It has been recognized that to obtain a box annealed product having uniform characteristics, the product must be uniformly heated and that the failure to obtain such product was due to an uneven heating of the charge of metal disposed within the annealing box.

Various methods of firing furnaces have been proposed in an effort to obtain uniform heating of the products. Efforts have been made to obtain uniform heating of the metal by maintaining a uniform temperature within the furnace chamber. But a uniform furnace temperature does not produce a uniform product because the rate at which a unit of metal absorbs heat is in direct ratio to the amount of surface area of such volume exposed to the heat. For example, in a charge of metal, a unit volume of the metal at one of the corners of the charge absorbs heat three times as rapidly as an equal volume on the side mid-way between the ends and the top and bottom of the charge. If therefore, the two volumes are subjected to the same temperature, the one at the corner of the charge having the greater exposed area will reach the desired temperature sooner than the volume having the lesser exposed area. Even if the volume first reaching the desired temperature is held at that temperature while the remainder of the metal is being heated to the desired point, a uniform heat treatment cannot result because the length of time during which the metal is held at the desired temperature is a factor in producing the grain structure in the metal by the heat treatment.

By the present invention, I have provided a method of box annealing which produces a product which does not possess any of the undesirable characteristics which have characterized products produced by prior methods of box annealing. The resultant product under this present invention is fully annealed, has substantially uniform grain structure throughout the charge of metal, has substantially uniform physical properties and gives uniform results when subjected to fabrication. The time during which the charge of metal is in the furnace, subjected to treatment, is greatly reduced and the cost of annealing is thereby less for a specified volume of metal. A further reduction in cost is also realized through the avoidance of re-annealing and scrapping the portions of a heat which, heretofore, had become overheated or had been held at annealing temperature for too great a length of time.

By the present invention, the furnace is so heated that all portions of the charge of metal placed within the heating chamber will be brought to the desired annealing temperature at substantially the same time; no portion of the charge of metal will be subjected to this temperature for an appreciably greater length of time than any other portion. Also by the present invention, the heating and cooling cycles of the metal may be so controlled that during these cycles all portions of the charge are subjected to the same heat treatment.

I have found that to obtain a uniform heat treatment of a charge of metal, heat must be introduced unevenly into the charge. In heat treating metal, it is desirable to maintain the input of heat at a rate equal to the maximum rate at which heat can be efficiently absorbed by the entire volume of the charge of metal. The maximum rate of absorption cannot be increased. I have discovered that a uniform heating of the entire charge in the minimum time may be obtained by maintaining the heat input into those volumes of the charge of metal having the least amount of exposed area at the maximum rate of absorption for the material, and the heat input in those portions having a greater exposed area at a rate proportionately lower.

In carrying out my invention, I have found that a uniform heating of a charge of metal may be obtained by directing all of the heat at the charge from the sides and none from the top and ends, and, because of the volume of the base on which the charge is stacked, directing the maximum amount of heat to the lower regions of the charge and somewhat less, progressively, to the regions above.

The invention also includes new and improved apparatus for practicing the foregoing method. The apparatus comprises an annealing furnace having heating means so disposed along the side walls of the furnace as to radiate heat directly to the desired portions of the charge of metal positioned within the furnace chamber. The heating means can be so controlled and operated that varying amounts of heat can be radiated to the charge of metal. The furnace may be so constructed that portions of the charge of metal disposed within the furnace chamber and having the lowest rate of heat absorption is subjected to radiated heat whereas the rate of heating of other portions of the charge is limited by the influence of the furnace walls adjacent such portions.

The foregoing and other advantages of the invention and the invention itself will become more apparent from the following detailed description thereof taken in conjunction with the accompanying drawings wherein similar reference characters denote corresponding parts and wherein:

Figure 1 is a transverse sectional elevation of an annealing furnace embodying the present invention,

Figure 2 is a horizontal sectional view taken on the line 2—2 of Figure 1,

Figure 3 is a transverse sectional view of another form of furnace for practicing the present invention, and

Figure 4 is a horizontal sectional view taken on the line 4—4 of Figure 3.

With reference to the accompanying drawings and particularly Figures 1 and 2, there is illustrated one embodiment of an apparatus for carrying out my invention, comprising an annealing furnace of the box annealing type, designated in its entirety by the numeral **10** and including a bottom **11** preferably made of a heat insulating refractory. The furnace bottom **11** is provided with parallel rails **12** upon which an annealing box is moved into and out of the heating chamber of the furnace **10**. The annealing box includes an insulating refractory base **14** upon which the metal **15** is stacked, and a cover **16** which is adapted to be lowered over the metal **15** and sealed within groove **17** of the base **14**, in any suitable manner as by means of sand. Suitable skids **18** are provided along the bottom of the base **14** to engage the rails **12** on the bottom of the furnace **10**.

The furnace **10** comprises end walls **19** and **20**, side walls **21** and **22**, and an arched roof **23**, preferably disposed within a frame work **24** consisting of vertical buckstays **25** and horizontal cross members **26**. The roof **23** is suspended from the cross members **26** by means of hangers **27**. The end walls **19** and **20**, and the roof **23** may be constructed of a heat absorbing refractory, whereas, the side walls **21** and **22** are made of a heat insulating refractory. The advantages and purpose of the use of these particular types of refractories for different portions of the furnace will become more apparent as the description of this invention progresses. The end wall **19** is provided with a doorway **28** through which the annealing box is moved into the furnace which is sealed by a door **28**a.

The opposed side walls **21** and **22** of the furnace are provided with elongated openings **29** extending therethrough which openings are spaced from the ends and top of the side walls and are so positioned with respect to the charge of metal disposed in the furnace chamber as to be adjacent that portion of the charge which has the least amount of exposed surface area per unit volume of metal. These openings **29** connect with firing chambers **30** defined by offsets or bays formed along the side walls **21** and **22**, coextensive with the openings. A radiant panel **32** having its peripheral edges extending into the side walls separates the furnace chamber from the firing chamber. As illustrated in the drawings, the plane of the radiant panel **32** is spaced outwardly from the inner surface of the side walls. but if desired the radiating surface of this panel may be coincident with the inner surface of the side walls. Each firing chamber **30** is provided at its opposed ends with firing ports **33** through which extend suitable nozzles for introducing combustible mixtures into the firing chamber. The products of combustion are conveyed from the firing chamber through a plurality of flues **34** extending through the bottom of the firing chamber **30**. Each of the flues **34** is provided with a slide valve **34**a for controlling the amount of gases conveyed from the chamber **30** through any particular flue **34**. These flues connect with a longitudinally extending duct **35** which leads to a stack (not shown).

By controlling the length of the flame projected into the firing chamber through the firing ports **33** and the effective area of flues **34**, the amount of heat radiated from any particular area of the panel **32** to the charge of metal **15** may be regulated. Since it is desirable to have the maximum heat radiated to portions of the charge adjacent the bottom thereof, the firing chamber is preferably so fired that the bottom portion of the panel is subjected to the hottest flame. The ends of the furnace **19** and **20** and the roof portion **23**, when constructed of a heat absorbing refractory, are not effective in imparting any heat to the charge through radiation, but rather tend to absorb heat from the heated gas which circulates in that portion of the furnace chamber. The ends of the charge and top portion thereof are in effect blanketed or shielded from direct radiated heat through the construction of the furnace adjacent such portions and the arrangement of the radiant panels which direct substantially all of the radiated heat against those portions of the stack having the minimum amount of exposed area per unit volume of metal.

In the cooling cycle of the metal, it is desirable to maintain the cooling rate of all portions of the charge uniform, for, as has been said hereinbefore, the length of time during which a charge of metal is maintained at a certain temperature is a factor in the grain structure of the finished product. The subject furnace is preferably so operated that during the cooling cycle all portions of the charge cool at substantially equal rates. At the conclusion of the heating cycle, the operation of the furnace may be reversed and cool air introduced into the firing chambers 30, which cool air will be effective in causing a more rapid cooling of those portions of the charge which are slowest to cool, such portions being the ones which have the minimum amount of exposed area per unit volume of metal. The refractory of the furnace adjacent the ends and top of the charge, being of a heat absorbing character, gives off heat during the cooling cycle and prevents too rapid a cooling of the ends and the top of the charge.

It will be seen, therefore, that in the operation of a furnace as illustrated hereinabove, it is possible during the heating cycle to so fire the furnace that all portions of the charge will reach the desired annealing temperature at or about the same time, and that during the cooling cycle all portions of the charge are uniformly cooled. Firing the furnace as above described results in the product having substantially uniform characteristics such as grain structure and physical properties throughout all portions of the charge of metal.

With reference to Figures 3 and 4, there is illustrated a bell type annealing furnace embodying the present invention. The metal 39 to be heat treated is stacked on a plurality of skids 40 which rest upon the furnace base 41. A cover 42 is lowered over the charge of metal and the edges thereof inserted within the groove 43 which may be filled with sand to effect a seal. The furnace 44 is adapted to be lowered over the charge of metal and sealed to the base 41 as at 45.

The bell type furnace 44 comprises end walls 46 and 47, side walls 48 and 49 and a roof 50 suitably constructed within a frame work 51. In this construction, the end walls 46 and 47 and the roof 50 may be constructed of a heat absorbing refractory whereas the side walls 48 and 49 may be constructed of a heat insulating refractory in a manner similar to that disclosed in Figures 1 and 2. The side walls 48 and 49 are provided with a plurality of spaced recesses in which are disposed rectangular metallic firing chambers 52. These firing chambers are of relatively small depth as compared with their width and are disposed adjacent those portions of the charge of metal which have the least amount of exposed area per unit volume of metal. The outer surface of the firing chambers constitute rectangular radiant panels which are coincident with the plane of the side walls. Each of the firing chambers 52 are fired by projecting a combustible mixture into the bottom of the chambers from pipes 53 which are connected to a suitable supply line 54. A suitable valve 55 in each of the pipes 53 controls the amount of combustible mixtures introduced into each firing chamber 52. The products of combustion are conveyed from the firing chamber 52 through the exhaust flues 56 extending through the side walls of the furnace chamber.

Each of the firing chambers 52 is separately fired and the amount of combustible mixtures introduced into these firing chambers is so controlled that the amount of heat radiated from the radiating panels 52 may be correspondingly controlled. In other words, the firing chambers adjacent those portions of the charge to which the greatest amount of heat is to be directed may be fired at the maximum rate and other chambers may be fired at a rate in accordance with the amount of heat it is desired to radiate from the respective panels to the particular portion of the charge of metal opposite each radiating surface. The operation of this type of furnace may be carried on in a manner similar to that followed in the furnace disclosed in Figures 1 and 2 so that a substantially uniform heating and cooling cycle may be maintained throughout the charge of metal.

Having thus described my invention, what I desire to obtain by Letters Patent is defined in what is claimed.

I claim:

1. A muffle type furnace, for heating stacked sheet metal, having vertical end and side walls and a roof defining a heating chamber, the side walls having recesses opening into the heating chamber along the lower middle portion of said walls, said recesses stopping short of the ends and tops of the side walls, heat radiating means closing the heating chamber side of said recesses, and means for conducting heat to said radiating means.

2. A muffle type furnace, for heating stacked sheet metal, having vertical end and side walls and a roof defining a heating chamber, the side walls having recesses opening into the heating chamber along the lower middle portion of said walls, said recesses stopping short of the ends and tops of the side walls, heat radiating means closing the heating chamber side of said recesses, said radiating means comprising rectangular tubes carrying heated gases.

3. A muffle type furnace, for heating stacked sheet metal, having vertical end and side walls and a roof defining a heating chamber, the side walls having recesses opening into the heating chamber along the lower middle portion of said walls, said recesses stopping short of the ends and tops of the side walls, heat radiating panels closing the heating chamber side of said recesses, and means for conducting heat to said radiating means.

WILLIAM N. McCUTCHEON.