Nov. 11, 1947. W. A. MORTON 2,430,477

METHOD AND APPARATUS FOR HEATING STEEL

Filed Nov. 6, 1941 2 Sheets-Sheet 1

Fig. 1.

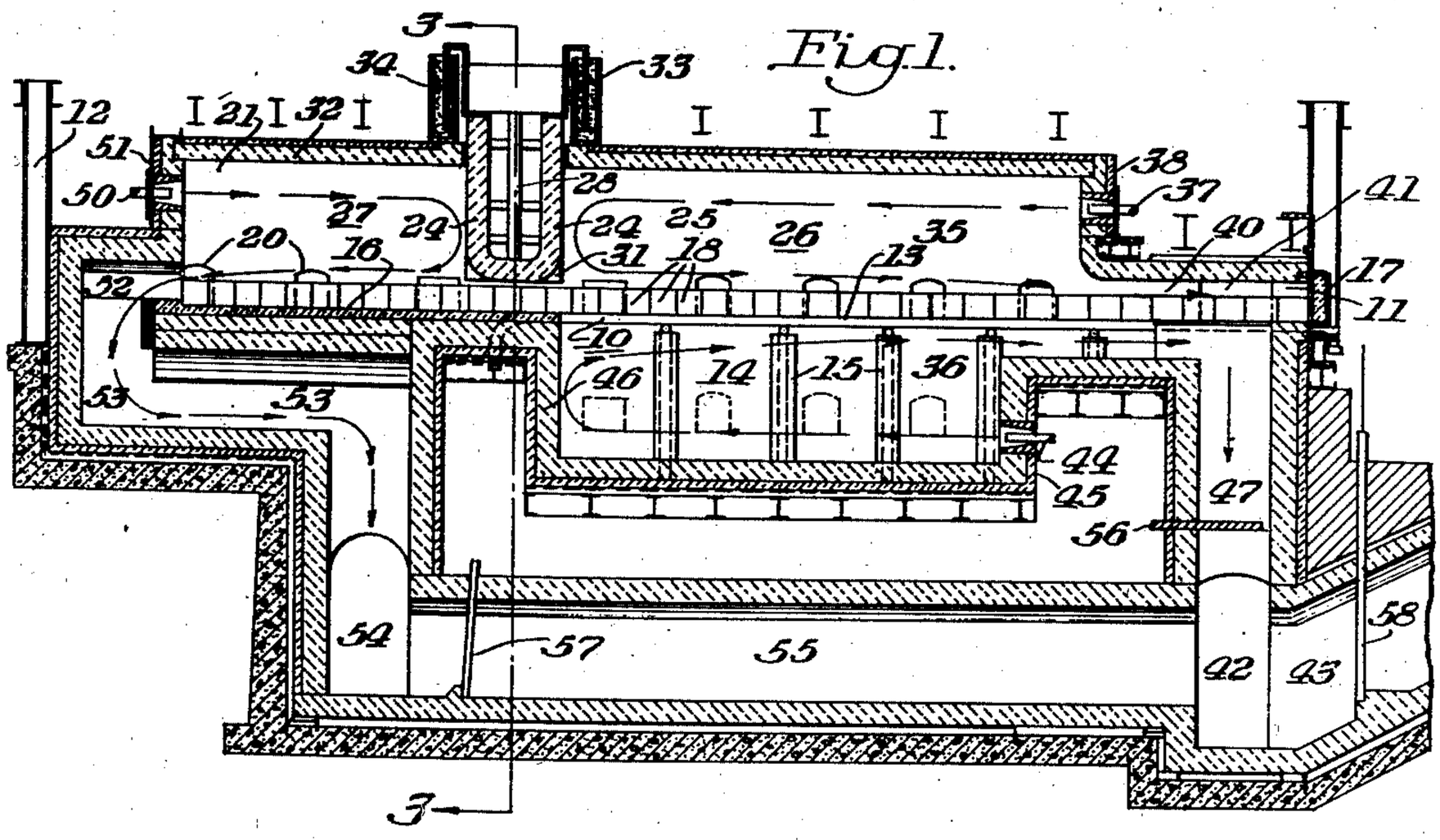

Fig. 2.

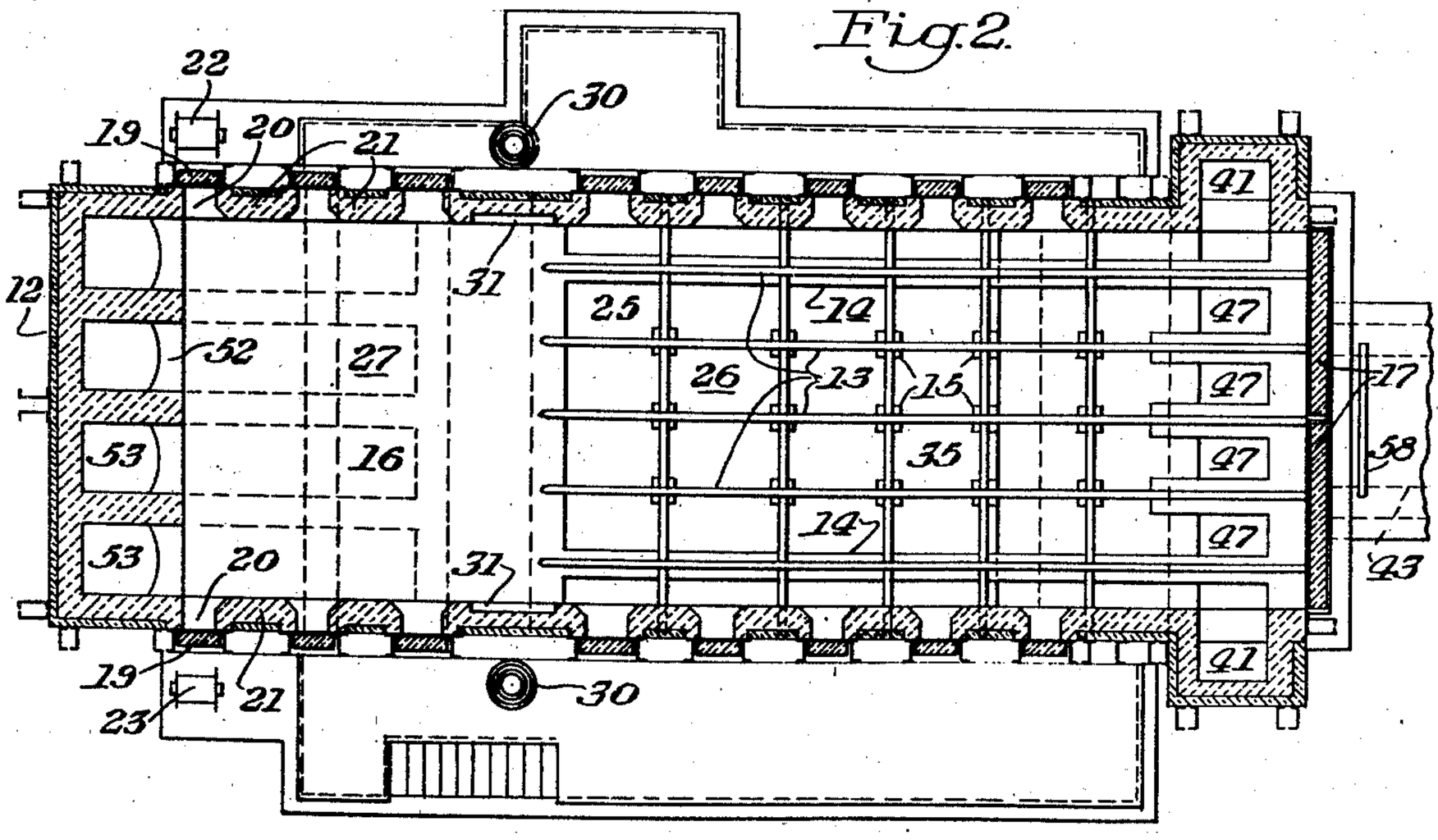

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Fig. 3.

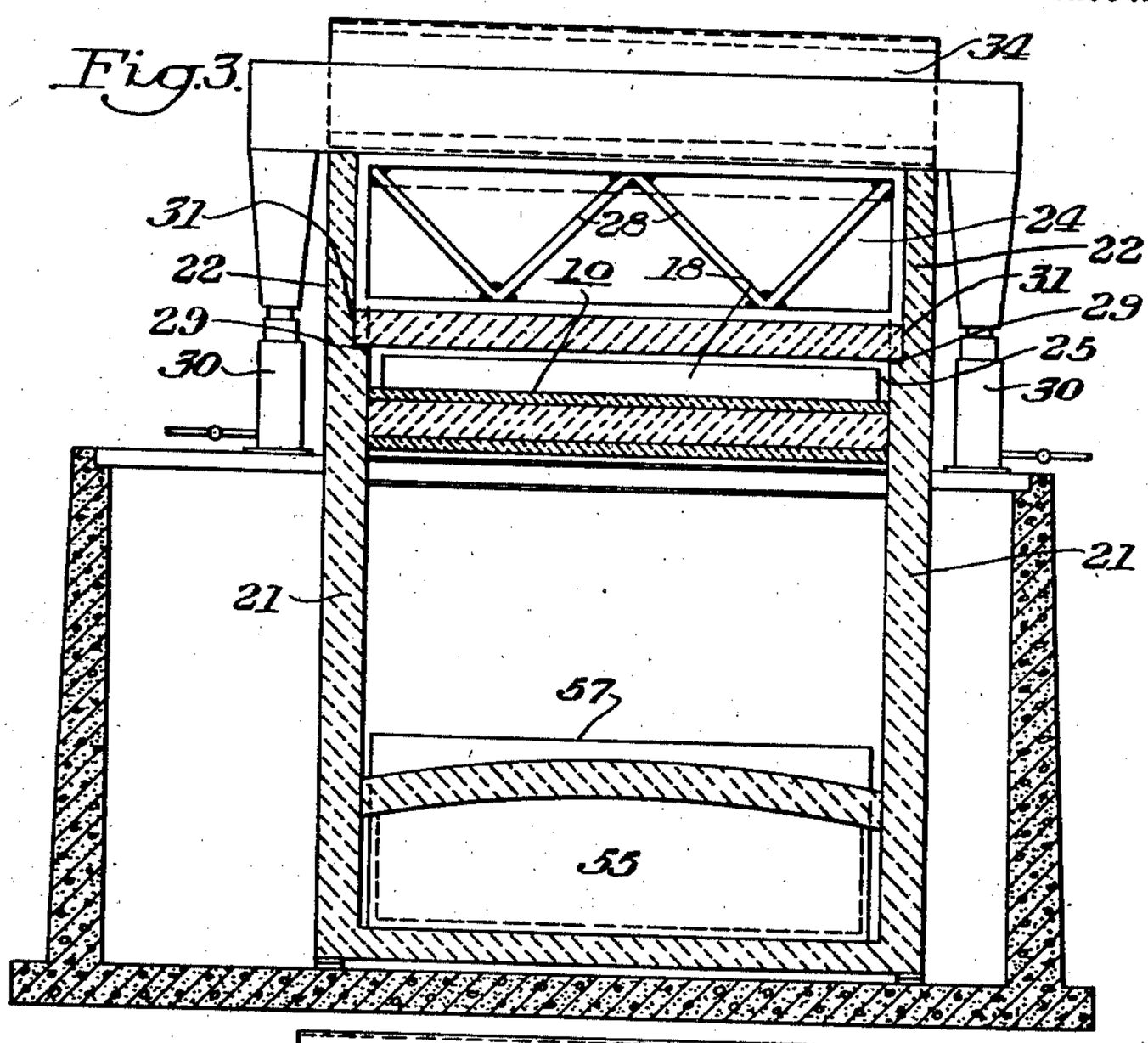
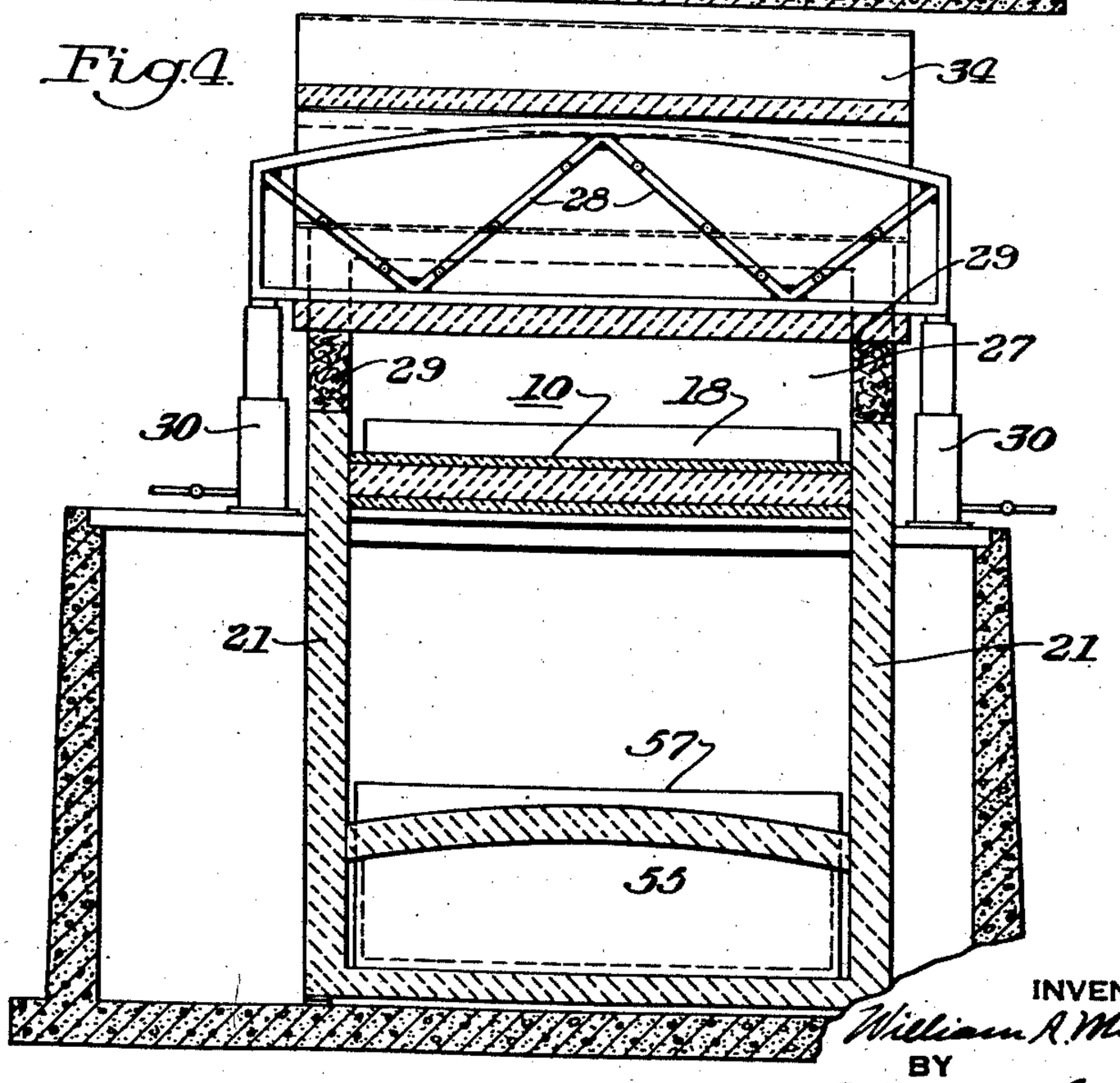


Fig. 4.



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METHOD AND APPARATUS FOR HEATING STEEL

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22 Claims. (Cl. 263—39)

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This invention relates generally to methods for heating steel and alloys and more particularly to such methods wherein articles of steel and steel alloys are heated as they are continuously moved through the furnace, and to heating furnaces for accomplishing the same.

A continuous type heating furnace is employed in the steel industry to uniformly heat or reheat billets, ingots, blooms, slabs, rails and the like, which vary not only in size but in metallurgical characteristics. Thus each grade or analysis of steel or alloy must be heated to a predetermined temperature and at a predetermined rate to preserve the metallurgical characteristics and properly prepare it for rolling or performing other operations thereon.

In the present practice of heating high carbon and various other special steels it is usually customary to employ at least two independent furnaces to properly heat the articles before they can be worked in their heated state. The furnaces required may be of the continuous type or the soaking pit type in and out or a combination of both. The use of two or more furnaces for properly heating the articles involves certain extra fuel, labor and equipment which this method will avoid. This method also avoids material losses and the waste which occurs if these steels are heated in conventional single compartment furnaces.

The principal object of this invention is the provision of a continuous heating furnace which overcomes these disadvantages, by providing a preheating, slow heating and final heating zone, each of variable thermal potential as to quantity and temperature of the heat applied.

Another object is the provision of a continuous heating furnace having a plurality of heating zones through which the articles being heated pass in succession and in which the temperature is independently regulated.

Another object is the provision of a continuous furnace structure having a preheating chamber, a primary heating chamber, and a secondary heating chamber through which the articles to be heated travel in succession.

Another object is the provision of a continuous furnace structure, the main heating chamber of which is divided transversely by a partition which is adjustable relative to the hearth to admit the travel of different size articles from one section to the other.

Another object is the provision of a continuous heating furnace having two heating chambers through which the articles being heated pass in

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succession and which are fired independently of one another.

Another object is the provision for introducing and withdrawing the heating medium at both ends in the main heating chamber of a continuous furnace and having an intermediate transverse wall which is adjustable vertically to divide the main furnace chamber into two independent chambers.

Another object is the provision of a transverse adjustable partition wall structure in a continuous heating furnace having a seal with the permanent wall structure thereof.

Another object is the provision of a continuous heating furnace provided with a transversely disposed and vertically movable partition wall arranged when in one position to permit the furnace to operate as a single chambered furnace and when in another position to operate as a double chambered furnace wherein the temperatures are independently controlled and through which the articles pass in succession.

The means for controlling the temperatures and regulating furnace pressure, etc. are similar to those described in my copending application Serial Number 337,987, filed May 31, 1940, now Patent No. 2,329,211.

The furnace atmosphere adjacent the steel is composed of the products of combustion. The products of combustion being free of oxygen are caused to circulate in a protective blanket between the steel and the incomplete combustion of the heating flames to protect the steel from decarburization.

While the design of these furnaces as to the relative size of the compartments is generally fixed by the quantity of steel to be heated per hour, it is readily apparent that the rate of heating in the several compartments may be varied to some reasonable extent by varying the quantity of heat supplied, the temperature at which the heat is liberated, or both, without departing from the intent of the design.

Other objects and advantages appear hereinafter in the following description and claims.

In the accompanying drawings a practical embodiment illustrating the principles of this invention is shown wherein:

Fig. 1 is a diagrammatic sectional view taken longitudinally of the furnace showing the partition wall in a lowered position.

Fig. 2 is a diagrammatic horizontal sectional view taken along the plane of the hearth of the furnace illustrated in Fig. 1.

Fig. 3 is a vertical sectional view of the furnace showing the adjustable divisional wall.

Fig. 4 is a view similar to Fig. 3 showing the partition wall in a raised position.

Referring to the drawings, the furnace illustrated is provided with a continuous hearth 10 extending from the charge end 11 to the discharge end 12. The first portion of the hearth comprises a series of parallel water cooled skids 13 extending longtudinally of the hearth from the charging end 11. The outermost skids 13 are supported on the vertically and longitudinally disposed walls 14, whereas the intermediate skids are supported by the ordinary piers 15. The skids 13 extend to the solid monolithic hearth section 16 which extends to the discharge end 12 of the furnace.

The charging end 11 of the furnace is provided with a suitable door 17 which when elevated permits the entry of transversely disposed steel articles 18. These articles move into and through the furnace in the conventional manner by means of a pusher, not shown. Suitable doors 19 are provided for closing oppositely disposed openings 20 in the side walls 21 at the discharge end 12 of the furnace through which the steel articles 18 are ejected. A pusher bar, not shown, is operated by the motor driven pinch roll 22 and engages the ends of a steel article, shoving it longitudinally through the opening 20 onto the motor driven discharge roll 23 which delivers the heated article from the furnace. The steel articles 18 are heated to their proper temperature when they arrive at the discharge end of the furnace and are ejected when they successively become aligned with the openings 20.

A transverse vertically disposed partition wall 24 divides the main furnace chamber 25 into two independent heating chambers 26 and 27. This partition wall is preferably constructed to have a U-shaped cross section as indicated in Fig. 1 so that it may be properly cooled. This wall is built up of refractory blocks supported by the transversely disposed metal bridge structure 28 which extends beyond the side walls 21 of the furnace structure and is arranged to be supported at its ends by the hydraulic jack structures 30. Thus by actuating the hydraulic jack structures the partition wall 24 may be raised or lowered to any suitable height relative to the plane of the hearth 10 of the furnace. The refractory material on the ends of the wall 24 may extend into a recess 31 in the side walls 21 as illustrated in Figs. 1 and 2, thus forming a labyrinth seal between the furnace chambers 26 and 27. The roof 32 of the furnace may be sealed with the adjustable partition wall 24 by means of the depending flanges 33 which are integral with the partition wall and extend into the sand filled troughs 34 lying transversely across the roof on each side of the U-shaped partition wall. The depending flange 33 and the troughs 34 are of sufficient depth to permit vertical adjustment of the wall 24 without breaking the seal when the wall is raised to its uppermost position as illustrated in Fig. 4.

Again the bridge structure and the refractory material of the partition wall 24 may extend through the side walls 21 and the roof 32 as shown in Fig. 4 and be sealed therewith by the application of mud and firebrick 29 in the gap formed in the side walls and between the roof, after the partition wall 24 has been adjusted to the proper elevation with respect to the hearth 10.

The furnace chamber 26 is divided into upper and lower independent chambers 35 and 36 by

the skid supporting walls 14 and the continuous series of steel articles 18 lying on the hearth. The upper chamber 35 is fired by means of a row of burners 37 placed in the rear wall 38 of the furnace above the hearth. The flames issuing from these burners travel out over the steel articles and parallel therewith toward the partition wall 24 and reverse, as indicated by arrows in Fig. 1, flowing back over and immediately above the steel articles to the charging end 11 of the furnace, passing through the preheating chamber 40 from whence the products are discharged through the flues 41 leading to the common passageway 42, and thence through the passageway 43 to the recuperator or stack as the case may be.

The lower chamber 36 is fired by a row of burners 44 in the lower wall 45. The flames issuing from these burners travel, as indicated by arrows in Fig. 1, toward the intermediate wall 46, and then reverse, traveling immediately adjacent the under side of the steel articles to the lower portion of the preheating chamber 40 and are discharged through the vertically disposed flues 47 which lead into the common passageway 42.

The chamber 27 at the discharge end of the furnace is heated by the burners 50 in the end wall 51. The flames from these burners travel horizontally through the chamber 27 toward the partition wall 24 substantially parallel with the steel articles and are then redirected back over the steel to the discharge openings 52 and are then carried through the flues 53 to the common passageway 54. The products of combustion at this end of the furnace may be carried through the passageway 55 to the passageways 43 and thence to the stack, or they may be transferred by other passageways not shown to suitable heat exchange apparatus. The temperature and operation of the furnace may be controlled by the temperature of the products of combustion measured in the flues immediately after the gases have passed over the steel or by means of a thermal responsive element in the bottom of the partition wall 24 where it is not affected by the direct heat of the flames.

It will be noted that the rows of burners 37, 44 and 50 supplying the chambers 35, 36 and 27, respectively, are arranged to produce heating flame substantially horizontal and parallel to the steel articles 18 lying on the hearth and they are spaced farther from the plane of the hearth than from the roof or the floor of the furnace. The reason for this arrangement is to provide flames that travel outwardly from the burners in a path substantially parallel with the steel articles until the velocity of the flames are reduced to such an extent that the draft created by the independent discharge openings of each chamber redirects the path of movement of the products of combustion of the flame, causing it to travel in a reverse direction parallel and adjacent to the steel articles being heated.

The combustion is substantially complete in each of the flames before the path of the flame is redirected by the draft effect. The hottest or initial portion of the flames do not directly impinge on the steel articles being heated and the inert products of combustion, which travel intermediate of the steel and the initial flame, thus blanket the steel on its return path of movement to the flues. In this manner the atmosphere surrounding the steel articles may be controlled to prevent localized overheating, excess oxidation and decarburization of the steel. The hottest portion of the heating flames is along the initial

path of the flame propagation and the heat is diffused in passing through the blanketing layer to the steel.

Thus the steel is heated by radiation from the initial portion of the flame and by convection from the products of combustion which blanket the steel while passing back through the combustion chamber. The radiant heat reflected from the roof and the walls must also pass through the blanketing layer of the products of combustion in traveling to the steel. Thus the direct and reflected radiant heat energy is diffused as it passes through the products of combustion blanketing the steel, thereby uniformly heating the steel. Control of the discharge of these products of combustion is obtained in the flues **41** and **47** by the adjustable dampers **56** and the flues **53** by the adjustable dampers **57**. A stack damper **58** is provided in the passageway **43** for regulating the total discharge of the products of combustion.

Thus the three combustion chambers **27**, **35** and **36** are independently fired by the burners **50**, **37** and **44** respectively. These burners are each provided with an independent automatic temperature combustion control which regulates the air-gas ratio, the rate of combustion, and the temperature of each chamber independently of each other. Ordinarily the combustion chambers **35** and **36** are regulated to provide the same air-gas ratio, thereby exposing the upper and the lower sides of the steel articles to the same degree of temperature. The removal of the waste gases from any one of the three combustion chambers in no way affects the removal of the waste gases in any other of the combustion chambers as the partition wall **24** is adjusted relative to the steel article **18** to prevent the flow of gases to either side thereof and the vertical skid supporting walls **14** prevent commingling of the gases between the combustion chambers **35** and **36**. The furnace pressure control may be operated by the stack damper **58** to maintain the common pressure throughout the entire furnace. Thus the desired rate of heating may be produced in each combustion chamber without affecting the rate of heating in an adjacent combustion chamber.

High carbon and various special steels may thus be slowly heated to approximately 1600° F. as they pass through the combustion chamber **26**. After the steel passes under the partition wall **24** it is subjected to the heating flames in the combustion chamber **27** which raises the temperature of this steel to approximately 1900° F. or 2300° F. at a comparatively rapid rate. In heating the high carbon and special alloy steels in this manner and by blanketing them with the products of combustion of the heating flame, decarburization of the steel is reduced to a minimum, thereby greatly increasing the percentage of the steel that is available for rolling or other hot working operations and without materially changing the metallurgical characteristics of the steel due to the heating process. This is a material advantage of this invention and in conventional furnaces it is not practical to set up two distinct temperature cycles in which the heat from one combustion chamber is distributed or controlled independently of the other.

Under certain conditions it may be necessary to use only the combustion chamber **27** for heating the material. Thus all of the heating takes place in this chamber, and the chambers **35** and **36** are shut down. However the operation of the furnace in this manner would only be desirable under specific circumstances wherein the desired heating could be obtained in a short time by very high temperature. The size of the steel article and its metallurgical characteristics are of course of prime consideration and determine whether or not the furnace may be operated in this way.

Again the partition wall **24** may be raised, thus combining the chambers **26** and **27** in a large single combustion chamber **25**. Under these conditions the furnace would be operated by the independent controls to function in the manner of the present type of continuous heating furnace of this character. Thus the continuous furnace comprising this invention may be operated to function as three different types of furnaces yet involves the expense of only one furnace, which is a material advantage in the art of heating or reheating steel.

By independently regulating the heating zones in the preheating chamber **40** and the heating chambers **35** and **36**, and in the final heating stage in the chamber **27**, the rate of heating the steel articles may be accurately controlled at each stage in the heating cycle, which is a material advantage of this invention in the heat treating process of the present high carbon and special alloy steels. This advantage can only be obtained by segregating and independently controlling each of the three combustion systems within the chambers **27**, **35** and **36** and results in less decarburization of the high carbon steels and alloys.

By operating the hydraulic jack structures **30** the partition wall may be quickly raised or lowered without shutting down the furnace, and if this wall is not within the furnace the seal between the walls and the roof for the furnace may be quickly made by the application of clay with a mud gun.

I claim:

1. The process of heating steel and steel-alloy billets, ingots and other shapes which comprises causing the same to travel uninterruptedly through two separate heating zones, thermally isolating the heating zones by firing and withdrawing all of the products of combustion from each heating zone independently, slowly heating the steel in the first zone to a predetermined temperature, heating the steel in the second zone to a higher predetermined temperature and at a faster rate, and independently controlling the temperature of the respective zones.

2. The process of heating steel and steel-alloy billets, ingots and other shapes which comprises causing the same to travel uninterruptedly through two separate and independently heated zones, and heating the same both from above and below in the first zone and from above in the second zone, thermally isolating the heating zones by firing and withdrawing all of the products of combustion from each part of each heating zone independently.

3. The process of heating steel and steel-alloy billets, ingots and other shapes which comprises causing the same to travel uninterruptedly through two separate and independent heating zones substantially thermally isolated from one another, heating the same both from above and below in the first zone to a temperature below the final desired temperature and from above in the second zone, and maintaining an accelerated furnace temperature in the second zone in which the steel is raised to the final desired temperature.

4. In a heating furnace for the purposes de-

scribed, the combination of two heating chambers arranged in seqpence, means for causing the articles to travel uninterruptedly through the chambers in turn, independently controlled means for heating each of said chambers, separate means for withdrawing the products of combustion from each chamber, and a depending partition wall interposed between said chambers, and means to adjust the wall to provide an opening of predetermined fixed height relative to the hearth to pass a selected size of steel articles from one chamber to the other.

5. In a heating furnace for the purposes described, the combination of two heating chambers arranged in sequence, means for causing the articles to be heated to travel in the form of a substantially continuous row or rows through said chambers in sequence, means for individually controlling the temperature in each of said zones, separate means for withdrawing the products of combustion from each chamber, a depending partition wall interposed between the chambers, and means for raising and lowering said wall to different fixed elevations to cause the selected size of articles being heated to seal the opening between the chambers.

6. In a heating furnace for the purposes described, the combination of two heating chambers arranged in sequence, means for causing the articles to travel uninterruptedly through the chambers in sequence, independently controlled means for heating each of said chambers, separate means for withdrawing the products of combustion from each chamber, a depending partition wall interposed between said chambers, means for raising and lowering said wall to different fixed elevations to cause the selected size of articles being heated to seal the opening between the chambers, means for heating the articles from above and below in the first chamber, and means for heating the articles from above in the second chamber.

7. In a heating furnace for the purposes described, the combination of two heating chambers arranged in sequence, means for causing the articles to be heated to travel in the form of a substantially continuous row through said chambers in sequence, means for individually controlling the temperature in each of said zones, separate means for withdrawing the products of combustion from each chamber, a depending partition wall interposed between the chambers, means for raising and lowering said wall to different fixed elevations to cause the selected size of articles being heated to seal the opening between the chambers, means for heating the articles from above and below in the first chamber, and means for heating the articles from above in the second chamber.

8. In a continuous heating furnace for the purposes described, the combination with two heating chambers arranged in sequence, of a communicating aperture between the chambers and at the bottom of the chambers for the passage of the materials from one chamber to the other chamber, and means to adjust the aperture to provide a fixed height that is substantially sealed by the material selected to pass from one chamber to the other, independent heating means for each chamber, and independent exhaust means for each chamber.

9. In a continuous heating furnace for the purposes described, the combination with two heating chambers arranged in sequence, of a charging opening at the end of the first chamber at the

floor level thereof, independent heating means above and below the floor level of the said chamber, a communicating aperture between the chambers and at the floor level of the chambers for the passage of the materials from one chamber to the other chamber, and means to adjust the aperture to provide a fixed height that is substantially sealed by the material selected to pass from one chamber to the other, independent heating means for the second chamber, and independent exhaust means for each chamber remote of said aperture.

10. In a continuous heating furnace for the purposes described, the combination with two heating chambers arranged in sequence, of a charging opening at the end of the first chamber at the floor level thereof, independent heating means above and below the floor level of the said chamber, a communicating aperture between the chambers and at the floor level of the chambers for the passage of the materials from one chamber to the other chamber, and means to adjust the aperture to provide a fixed height that is substantially sealed by the material selected to pass from one chamber to the other, independent heating means for the second chamber, independent exhaust means for each chamber, and a discharging opening at the extreme opposite end of the second heating chamber at the floor level thereof, said exhaust means being adjacent the charging and discharging openings respectively.

11. In a continuous heating furnace, a depending partition means interposed in the furnace to divide it into separate heating chambers, means for independently heating the said chambers and independently discharging the products of combustion therefrom, and means for varying the height of the partition to provide a fixed aperture to permit the passage of materials of different thickness beneath the partition whereby substantial atmospheric isolation is maintained between the chambers.

12. In a longitudinally extending continuous heating furnace adapted for the controlled heating of special steels moved along its longitudinal axis, a depending partition member interposed across the longitudinal axis of the furnace and spaced above the hearth of the furnace for the passage of steel units therebeneath, means for moving the partition member vertically to provide clearance for steel units of different height, separate heating chambers formed in the furnace by the said member, separate means for withdrawing the products of combustion from each chamber, and a seal means across the top of the furnace which remains effective during any vertical adjustment of the said member.

13. In a furnace for heating high carbon steels and the like which comprises a continuous furnace having heating zones substantially isolated atmospherically from each other when the furnace is operating, means for moving the steel from one zone to the other while maintaining such isolation, individual outlet flues connected to the several heating zones, separate heating means and controls for regulating the temperature of each of the zones whereby the steel is slowly heated to the critical or recalescence point in the first zone and rapidly heated to the final desired temperature in the final zone.

14. A method of heating high carbon and alloy steels which comprises the steps of preheating the steel in a zone of low thermal potential, passing the steel into a second zone of higher thermal potential, slowly adding most of the sensible heat

to be finally contained in the steel in the second zone, and sharply accelerating the rate of heating the steel by passing it through a third zone of higher thermal potential wherein the final desired temperature is attained.

15. The process of heating steel and steel alloy billets and the like which comprises the steps of causing the same to travel uninterruptedly along a common hearth through separately flame heated and exhausted furnace chambers, heating the steel in the first chamber to a predetermined temperature, sharply accelerating the heating to the final desired temperature in the second chamber, and discharging the steel at the end of the second chamber.

16. The process of claim 15 which also includes the step of initially heating the steel in a preheating chamber connected with the first chamber.

17. The process of claim 15 which also includes the step of heating the steel both from above and below in the first chamber and from above in the second chamber.

18. The process of claim 15 which also includes the step of protecting the steel in both chambers from the direct action of the flames of combustion by passing waste gases between the steel and the heating flames.

19. The process of claim 15 which also includes the step of slowly heating the steel in the first chamber for a materially longer period of time than the accelerated heating in the second chamber.

20. In a continuous steel heating furnace, the combination of a furnace chamber, a common hearth extending through the furnace chamber from the charging to the discharge end to support the steel moving continuously therethrough, a movable transverse wall dividing the furnace chamber into two heating chambers, independent flame heating and exhaust means for each heating chamber, means to adjust the wall to different fixed heights relative to the hearth for the passage of varied sizes of steel articles, and means to seal the wall at a fixed height to pass a selected size of steel articles from one heating chamber to the other.

21. In a continuous steel heating furnace, the combination of a furnace chamber, a hearth extending through the furnace chamber from the charging end to the discharge end to support the steel moving continuously therethrough, a movable transverse wall dividing the furnace chamber into a long heating chamber adjacent the charging end and a relatively short isolated heating chamber adjacent the discharge end, means to adjust the wall to different fixed heights relative to the hearth for the passage of varied sizes of steel articles, and independent flame heating and exhaust means for each heating chamber.

22. In a continuous steel furnace, the combination of a furnace chamber, a hearth extending through the chamber from the charging end to the discharge end to support the steel moving continuously therethrough, a vertically adjustable transverse wall sealed with the walls and roof of the furnace chamber to divide the latter longitudinally, upper and lower heating chambers extending from the charging end to the movable wall, an upper heating chamber extending from the movable wall to the discharge and separate heating and exhaust means for each of said heating chambers adjacent the furnace ends remote of the movable wall.

WILLIAM A. MORTON.

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Certificate of Correction

Patent No. 2,430,477. **November 11, 1947.**

WILLIAM A. MORTON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 6, lines 68 and 69, claim 3, strike out the words "substantially thermally isolated from one another"; line 72, same claim, after "zone" and before the comma insert *thermally isolating the heating zones by firing and withdrawing all of the products of combustion from each part of each heating zone independently*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 10th day of February, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.