Nov. 25, 1969 W. KRAUSE 3,480,264

METALLURGICAL WALKING BEAM FURNACE

Filed Jan. 25, 1968 5 Sheets-Sheet 1

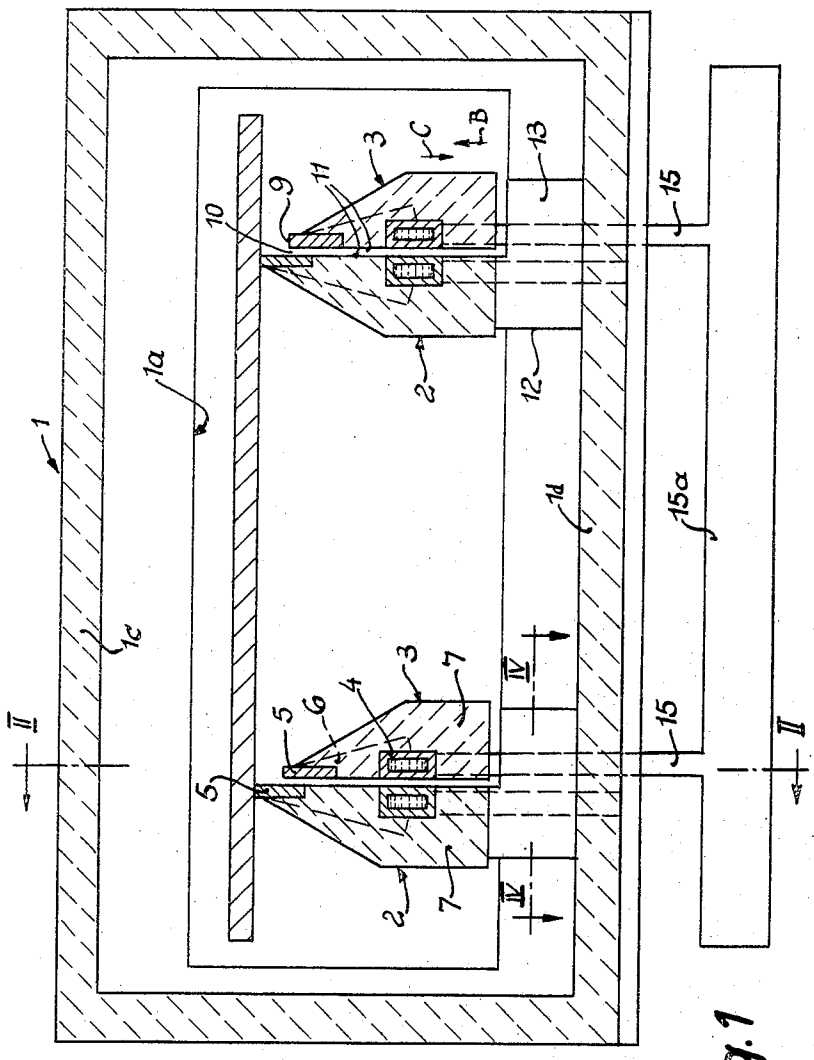


Fig. 1

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METALLURGICAL WALKING BEAM FURNACE

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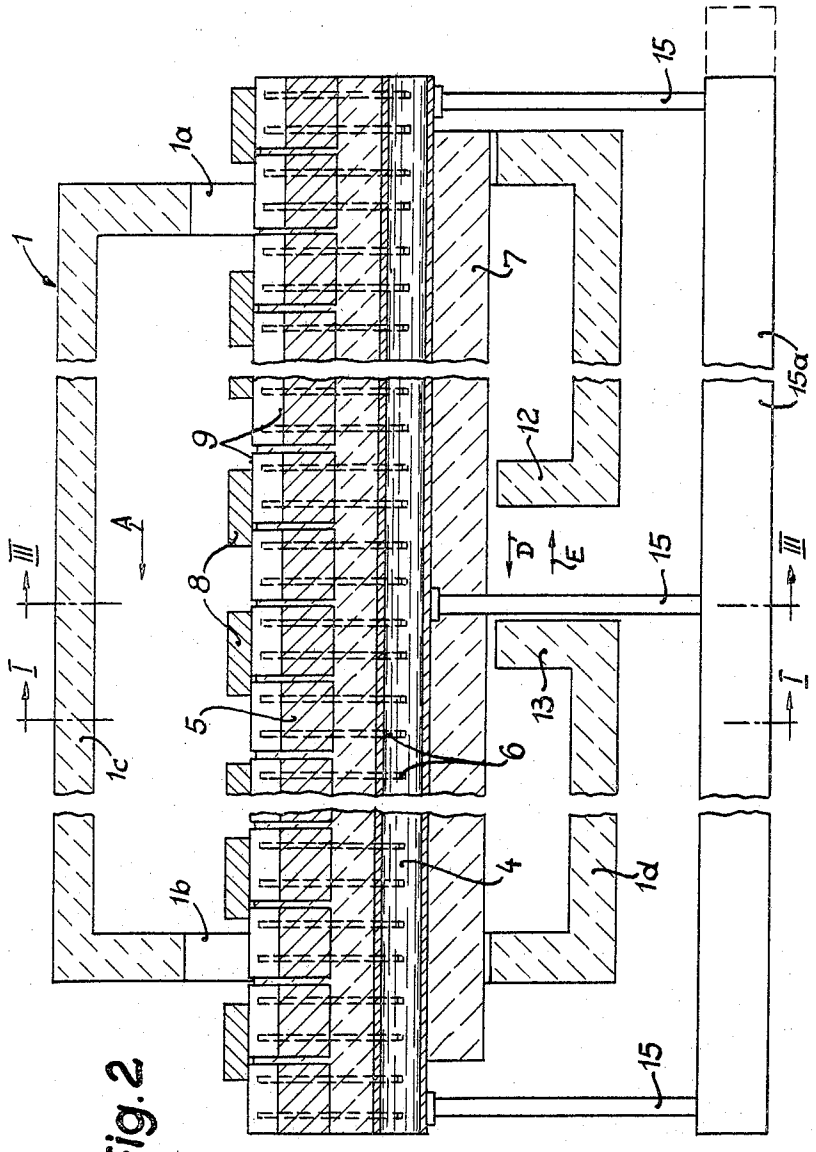


Fig. 2

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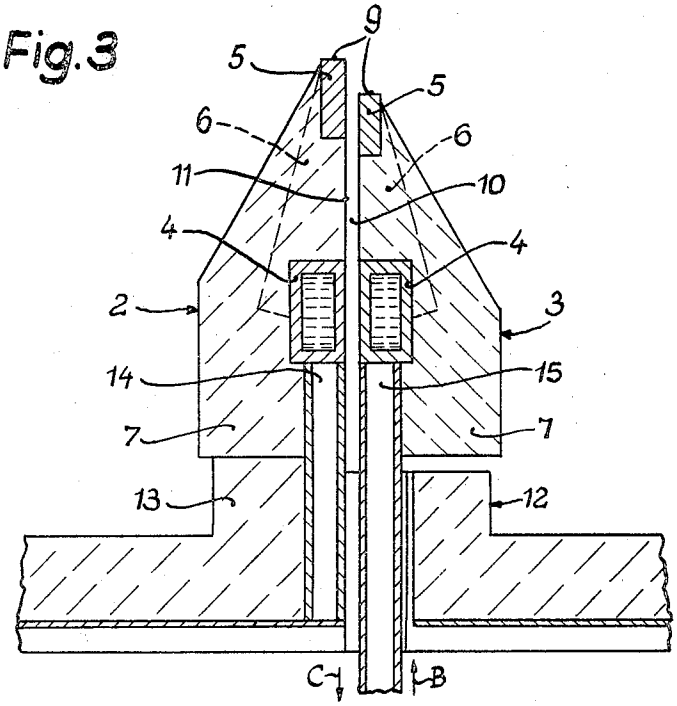
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METALLURGICAL WALKING BEAM FURNACE

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Fig. 3



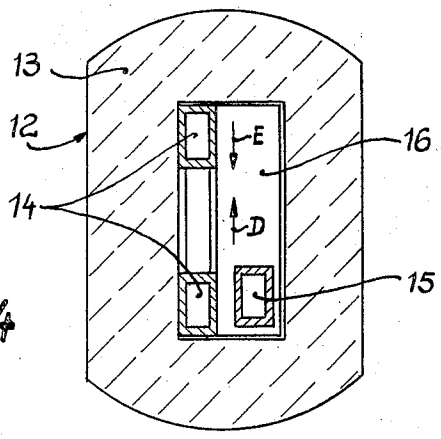


Fig. 4

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METALLURGICAL WALKING BEAM FURNACE

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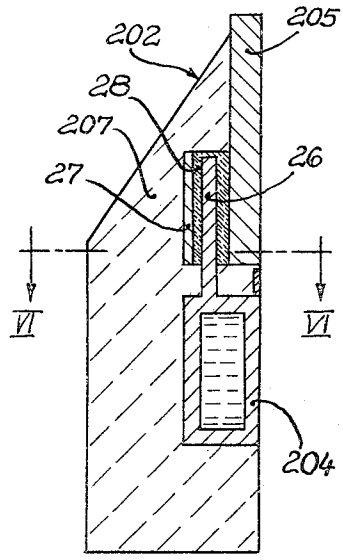


Fig. 5

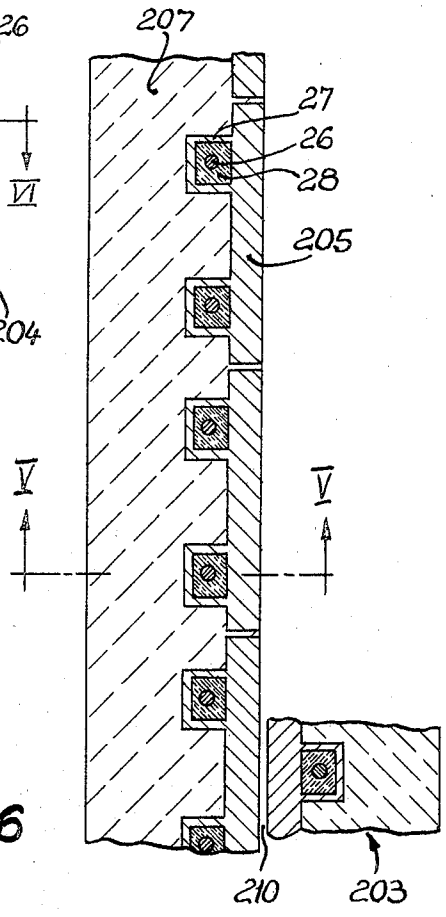


Fig. 6

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METALLURGICAL WALKING BEAM FURNACE

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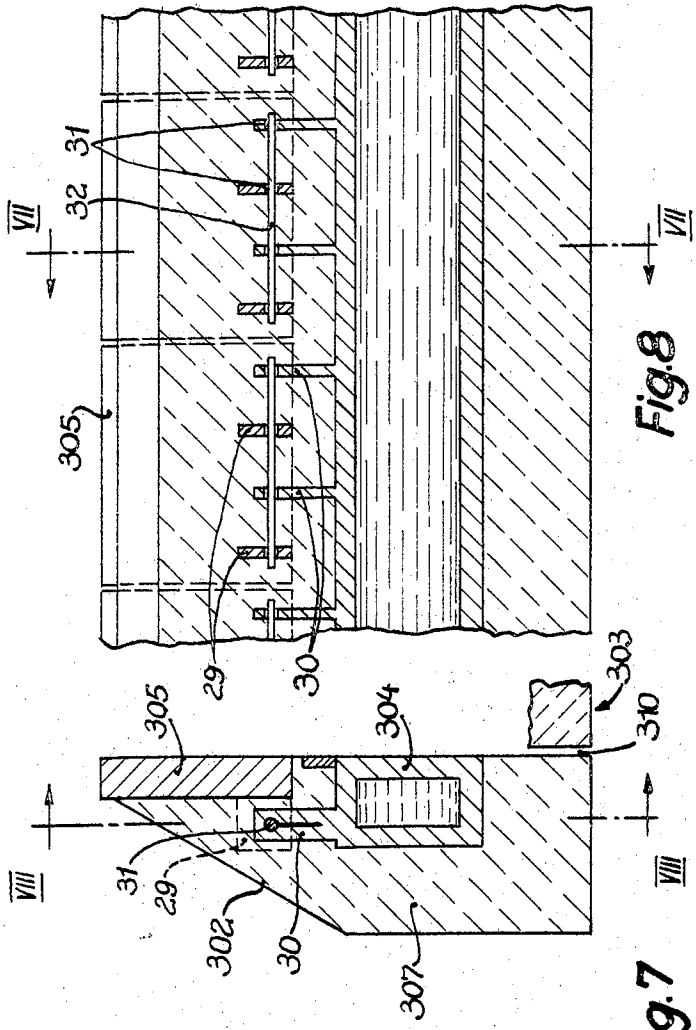


Fig.8

Fig.7

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United States Patent Office 3,480,264 Patented Nov. 25, 1969

3,480,264

METALLURGICAL WALKING BEAM FURNACE

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Claims priority, application Germany, Jan. 31, 1967, K 61,311; May 23, 1967, K 62,346
Int. Cl. C21d 9/00
U.S. Cl. 263—6 14 Claims

ABSTRACT OF THE DISCLOSURE

A metallurgical furnace wherein the workpieces are transported intermittently through a heating chamber and rest on stationary holders during intervals between stepwise advances. Each holder is adjacent to a walking beam which is movable up and down as well as forwardly and backwards to transport workpieces forwardly when in raised position and while moving forwardly and to thereupon deposit the workpieces on the holders during downward movement and prior to backward movement to retracted position. The holders and the associated walking beams are surrounded by jackets of heat-insulating material and are separated from each other by narrow vertical gaps through which scale and like solids can descend but which admit little heat to the respective holders and walking beams. The holders and walking beams are internally cooled by a circulating fluid and have rows of plate-like work-engaging portions which extend upwardly and consist of highly heat-resistant metallic material.

CROSS-REFERENCE TO RELATED APPLICATION

The present invention relates to improvements in metallurgical furnaces of the class described in my co-pending application Ser. No. 651,051, filed July 3, 1967, now U.S. Patent No. 3,434,702, and assigned to the same assignee.

BACKGROUND OF THE INVENTION

The present invention relates to metallurgical furnaces in general, and more particularly to improvements in so-called walking beam furnaces wherein ingots, slabs, rods, bars or like bulky metallic workpieces are transported through a heating chamber. The walking beams of such furnaces are movable up and down as well as forwardly and backwards to transport workpieces stepwise from the inlet toward and through the outlet of the heating chamber. As a rule, walking beam furnaces are over firing furnaces, i.e., the workpieces are heated from above but not from below. This is due to the fact that the stationary supports and motion transmitting devices for the walking beams occupy too much room in the lower zones of heating chambers. Absence of underfiring often causes serious problems, particularly when the workpieces are bulky, because the material of workpieces is heated unevenly which leads to excessive thermal stresses.

SUMMARY OF THE INVENTION

It is an object of my invention to provide a metallurgical furnace wherein the workpieces can be heated from above and from below, wherein the surfaces of workpieces are not scratched or otherwise damaged during stepwise travel through the heating chamber, and which can accommodate and transport with equal facility very large and heavy as well as relatively small workpieces.

Another object of the invention is to provide a walking beam furnace wherein the workpieces are not subjected to undesirable thermal stresses, wherein the workpieces can be heated from all sides with a desired degree of intensity, which can heat different types of workpieces to desired temperature, and wherein the workpieces cannot pile up in the interior of the heating chamber.

A further object of the invention is to provide a walking beam furnace wherein the mechanisms which move the walking beams occupy little room to leave ample space for underfiring and wherein the supporting units which carry the workpieces during travel through the heating chamber are constructed and assembled with a view to permit free descent of scale and convenient removal of scale from the heating chamber.

An additional object of the invention is to provide a furnace wherein the stationary supports for the workpieces as well as the walking beams are properly cooled and wherein the cooling system for such parts occupies little room.

Still another object of the invention is to provide a walking beam furnace wherein the temperature in the heating chamber can be raised to a desired level prior to introduction of workpieces (dry run) so that the temperature in the heating chamber can be maintained at a desired optimum value at the very moment when the workpieces enter the furnace.

A concomitant object of the invention is to provide a furnace wherein the temperature can be varied prior and/or during transport of workpieces through the heating chamber.

An ancillary object of the invention is to provide compact, rugged and long-lasting stationary and mobile supports for workpieces which are transported through the heating chamber of a walking beam furnace.

A further object of the invention is to provide a furnace wherein the parts which come into supporting engagement with workpieces in the heating chamber are thermally insulated from such parts which are cooled so as to prevent excessive losses in heat energy and to avoid undesirable differences in temperature of various parts of workpieces.

The improved metallurgical furnace comprises a heating chamber having an inlet, an outlet, a top wall and a bottom wall, a plurality of stationary supporting means provided in the chamber and extending between the inlet and the outlet to support at intervals workpieces which are fed through the inlet and advance intermittently toward and through the outlet, a plurality of mobile supporting means or walking beams, each associated with one of the stationary supporting means and each movable between raised and lowered positions and between advanced and retracted positions to lift workpieces off the stationary supporting means during movement to raised positions, to transport the thus lifted workpieces toward the outlet during forward movement to advanced positions, to deposit workpieces on the stationary supporting means during movement to lowered positions, and to thereupon return to retracted positions prior to start of a fresh cycle and while the workpieces rest on the stationary supporting means, and heat-insulating jacket means surrounding the supporting means by leaving a relatively narrow gap between each stationary supporting means and the associated mobile supporting means so that scale and other solid matter can drop through the gaps but the gaps permit little heat to penetrate between the cooled parts of the stationary and adjoining mobile supporting means. The top and bottom walls of the heating chamber are spaced from the supporting means so that the workpieces can be heated from above and from below. Each supporting means comprises one or more internally cooled elongated carriers which take up all stresses arising when the workpieces rest thereon, and each supporting means

further comprises rows of preferably plate-like work-engaging portions of highly heat-resistant metallic material which come into immediate contact with workpieces and are coupled to the respective carriers to be held against tilting, lengthwise and/or other displacement.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved furnace itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a transverse vertical sectional view of a metallurgical walking beam furnace which embodies one form of my invention, the section being taken in the direction of arrows as seen from the line I—I of FIG. 2;

FIG. 2 is a fragmentary longitudinal vertical sectional view of the furnace as seen in the direction of arrows from the line II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary transverse vertical sectional view of two associated suporting means as seen in the direction of arrows from the line III—III of FIG. 2;

FIG. 4 is an enlarged horizontal sectional view as seen in the direction of arrows from the line IV—IV of FIG. 1;

FIG. 5 is a transverse vertical sectional view of a supporting means in a second metallurgical furnace, substantially as seen in the direction of arrows from the line V—V of FIG. 6;

FIG. 6 is a horizontal sectional view as seen in the direction of arrows from the line VI—VI of FIG. 5;

FIG. 7 is a transverse vertical sectional view of a supporting means in a third metallurgical furnace, substantially as seen in the direction of arrows from the line VII–VII of FIG. 8; and

FIG. 8 is a longitudinal vertical sectional view as seen in the direction of arrows from the line VIII—VIII of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 and 2, there is shown a metallurgical walking beam furnace which comprises a heating chamber **1** having an inlet **1***a*, an outlet **1***b*, a top wall or roof **1***c*, and a bottom wall or floor **1***d*. The workpieces **8** are transported intermittently and sideways in the direction indicated by arrow A, i.e., from the inlet **1***a*, through the interior of the chamber **1**, and toward and through the outlet **1***b*. The interior of the chamber **1** accommodates two stationary horizontal supporting units or beams **2** which extend across the interior of the chamber and through and beyond the inlet **1***a* and outlet **1***b*. For convenience, the stationary units **2** will be called holders. Each of these holders is associated with a mobile supporting unit or walking beam **3** (hereinafter called conveyor). The purpose of the conveyors **3** is to intermittently advance the workpieces **8** in the direction of arrow A. To this end, the conveyors **3** are movable up and down between raised and lowered positions as indicated by arrows B and C, as well as forwardly and backwards between advanced and retracted positions as indicated by arrows D and E. In order to transport the workpieces **8** by a step, the conveyors **3** are moved upwardly (arrow B) in their retracted positions to thereby lift the workpieces **8** off the holders **2**, thereupon forwardly (arrow D) in their raised positions to advance all of the workpieces by a step of predetermined length, thereupon downwardly (arrow C) to deposit the workpieces on the holders **2**, and then in rearward direction (arrow E) in their lowered positions to return to retracted positions prior to start of a fresh cycle. The same operation is repeated as often as necessary to transport a batch or a continuous succession of workpieces **8** through the chamber **1** where the workpieces are heated from above and from below. Workpieces are loaded onto the holders **2** at a loading station which is outwardly adjacent to the inlet **1***a*.

Each holder **2** and each conveyor **3** comprises a preferably horizontal elongated tubular carrier **4** of rectangular cross-sectional outline which is cooled internally by circulating water or other suitable cooling fluid and which serves to take up all bending and compressive stresses which are due to the weight of the workpieces **8** and to the weight of other parts of the respective holder or conveyor. Each holder and each conveyor further comprises a series or row of aligned vertical plate-like work-engaging portions **5** of rectangular cross-sectional outline which consist of highly heat-resistant metallic material and whose horizontal top surfaces **9** come into direct supporting engagement with the undersides of the workpieces **8**. The means for connecting the plates or portions **5** with the respective carriers **4** comprises connectors or ribs **6** which transmit bending and other stresses to the carriers when the surfaces **9** of the plates **5** carry the weight of the workpieces. The parts **4**, **5**, **6** of each holder **2** and of the associated conveyor **3** are surrounded by a jacket **7** of heat-insulating material which exposes only the top parts of plates **5** and allows the holders and associated conveyors to define between themselves a relatively narrow and preferably vertical clearance or gap **10**. This gap is bounded by a vertical side face **11** of the holder **2** and by a vertical side face **11** of the adjoining conveyor **3**. As shown in FIG. 2, the holders **2** are mirror symmetrical to the associated conveyors **3** with reference to vertical planes which extend through the corresponding gaps **10**. The carriers **4** of the holders **2** and conveyors **3** are adjacent to the respective surfaces **11**.

The holders **2** are mounted on internally cooled upright column **12** which are rigid with or extend downwardly beyond the bottom wall **1***d* of the chamber **1** and are provided with shells or envelopes **13** of heat-insulating material. The shells **13** accommodate hollow metallic frames **14** for the carriers **4** of the respective holders **2** (see FIGS. 3 and 4) and reciprocable and vertically movable hollow frames **15** for the carriers **4** of the conveyors **3**. The interior of each frame is preferably cooled by circulating coolant. The envelopes or shells **13** define internal compartments **16** (FIG. 4) which accommodate the fixed frames **14** and the movable frames **15**. The means **15***a* for moving the frames **15** up and down as well as forwardly and backwards may be constructed and assembled in a number of ways and their exact design forms no part of the present invention. For example, the frames **15** can be moved up and down by hydraulic jacks and may be moved forwardly and backwards by double acting hydraulic cylinder and piston assemblies which are pivoted to the columns **12** and to the respective conveyors **3**. The means **15***a* for moving the conveyors **3** is indicated in FIGS. 1 and 2 at a level below the bottom wall **1***d* of the chamber **1**. Such means moves the conveyors **3** by way of the hollow frames **15**. The compartments **16** in the shells **13** are large enough to accommodate sturdy frames **14**, **15** and to permit requisite movements of frames **15** in order to raise and lower the conveyors **3** as well as to move them forwardly and backwards.

Each work-engaging plate **5** is rigid with at least two downwardly extending connectors **6** to form therewith an inverted U-shaped body. Furthermore, only two sides of each plate **5** are in contact with the material of the respective jacket **7** and these two sides of each plate **5** are in contact with the respective connectors **6**. In some instances, the outer side of each plate **5** can be fully exposed. Also, the furnace of FIGS. 1–4 may comprise three or more holders **2** and an equal number of conveyors **3**.

Since the connectors **6** are rather narrow, a large quantity of heat insulating material of the jackets **7** extends between the rows of work-engaging plates **5** and the associated carriers **4**. Therefore, losses in heat energy are rather low because the plates **5** are almost completely insulated from the carriers.

FIGS. 1 and 3 show that the height of conveyors **3** is less than the height of holders **2**. Therefore, when the conveyors **3** are moved to their lower end positions (arrows C), their plates **5** are sufficiently spaced from the undersides of workpieces **8** to allow for requisite heating of workpieces from below (under firing). In contrast to so-called pusher furnaces, the plates **5** merely take up compressive stresses; therefore, these plates can be simply embedded in the material of the jackets **7** and the connectors **6** can be dispensed with. Thus, the connectors **6** are optional. In pusher furnaces, the work-engaging members (also called riders) are subjected to compressive as well as to substantial shearing stresses and must be strongly connected with the remaining parts of the furnace. If employed, the connectors **6** can be welded, bolted, screwer or otherwise permanently or detachably secured to the plates **5** and carriers **4**.

The surfaces **11** of the holders **2** and conveyors **3** can be coated with sheets of metallic material. The carrier **4** of each holder **2** and the carrier of each conveyor **3** is surrounded by heat-insulating material from below and at that side which faces away from the respective gap **10**. The width of the gaps **10** is preferably so small that they permit entry of negligible amounts of heat but allow free passage of dirt, dust, scale or like solids. Since the gaps are so narrow, the surfaces **11** need not be insulated so that the holders **2** and conveyors **3** can be made compact and occupy little room in the lower zone of the heating chamber **1**. Therefore, such lower zone can accommodate necessary under firing equipment and, furthermore, the compact holders and conveyors permit very satisfactory heating of workpieces from below. That part of a jacket **7** which surrounds the respective holder **2** also serves as a heat-insulating shield for the surface **11** of the adjoining conveyor **3**, and vice versa.

All of the conveyors **3** are preferably moved by common moving means **15***a* so that they perform simultaneous movements in directions indicated by arrows B, C, D and E.

In conventional walking beam furnaces without under firing, the vertical strokes of walking beams are rather long in order to insure that each portion of each workpiece is lifted above the stationary supporting structure prior to a forward stroke. Such long lifting strokes are necessary because a heated workpiece tends to sag in the regions between the walking beams. Furthermore, scale accumulates on the stationary support and the walking beams must lift the workpieces sufficiently to prevent them from sliding along the accumulations of scale when the walking beams perform a forward stroke.

In my furnace, the conveyors **3** need not perform long upward strokes, i.e., they need not lift the workpieces well above the surfaces **9** of work-engaging plates **5** of the holders **2**, because the conveyors are immediately or very closely adjacent to the associated holders and, therefore, the flexing or sagging of workpieces in the regions above the gaps **10** is negligible. Moreover, and since the gaps permit evacuation of scale by gravity, accumulations of scale on the surfaces **9** of work-engaging portions **5** in the holders **2** are negligible.

As stated before, it is often desirable to move the conveyors **3** well below the holders **2** when the conveyors move downwardly toward their lower end positions. This allows for more intensive heating of workpieces from below during the intervals when the conveyors **3** dwell in their lower end positions.

The material of the jackets **7** can be held against separation from the respective carriers **4** by resorting to suitable retaining bars of metal or the like. Such arrangement is quite satisfactory for the jackets on the holders **2** and columns **12** because these parts are not subjected to excessive shaking or like stresses. In order to avoid separation of insulating material from the carriers **4** of the conveyors **3**, such material can be encased, either completely or in part, in outer envelopes of sheet metal or the like.

FIGS. 5 and 6 illustrate a portion of a second metallurgical furnace, namely a holder **202**. This holder comprises a tubular carrier **204** which is cooled internally by circulating fluid and is surrounded by an insulating jacket **207**. The work-engaging portions **205** resemble vertical plates and are arranged to transmit stresses to the carrier **204** by way of rod-like connectors **26** which are rigid with the carrier and are surrounded with clearance by sleeve-like annuli **27** which are rigid with the plates **205**. The clearances between the connectors **26** and annuli **27** contain fillers **28** of heat-insulating material which is tamped into the clearances. The annuli **27** are surrounded by the material of the jacket **207** and do not come in contact with the workpieces, i.e., they need not take up any compressive stresses.

The construction of the associated conveyor **203** is identical with that of the holder **202**, with the exception that the conveyor **203** is movable up and down as well as forwardly and preferably backwards. The holder **202** is separated from the conveyor **203** by a relatively narrow gap **210**. The vertical surfaces which are adjacent to the gap **210** are not lined with insulating material excepting in the region below the carriers **204**.

An important advantage of the connections between the work-engaging portions **205** and carriers **204** is that the portions **205** are thermally insulated from the carriers (partly by the material of the jacket **207** and partly by the material of the fillers **28**). Therefore, the portions **205** can be heated to optimum temperature and do not conduct heat from the workpieces to the carrier. The annuli **27** are not subjected to compressive stresses because such stresses are transmitted from work-engaging portions **205** directly to the jacket **207** and thence to the carrier **204**.

Referring finally to FIGS. 7 and 8, there is shown a further holder **302** having a tubular carrier **304**, a jacket **307**, a series of plate-like material-engaging portions **305** and different connections between the portions **305** and carrier **304**. The portions **305** have lugs or projections **29** which extend in a direction away from the gap **310** and alternate with upwardly extending connectors or projections **30** of the carrier **304**. Horizontal coupling rods **32** extend through registering apertures **31** provided in the lugs **29** and connectors **30** to hold the portions **305** against upward movement with reference to the carrier.

The associated conveyor **303** is a mirror symmetrical replica of the holder **302** but is movable with reference to the holder up and down as well as forward and preferably backwards to effect stepwise movements of workpieces through the heating chamber.

Each portion **305** preferably comprises at least two lugs **29** and its lugs are preferably connected with at least two projections **30** of the corresponding carrier **304**.

Certain important advantages of my furnace can be summarized as follows:

The holders and conveyors can be readily insulated to withstand temperatures of at least 1,000° C. which are produced by under firing in the heating chamber **1**. Since the inner sides of the conveyors and holders (i.e., those sides which are adjacent to the gaps) need not be insulated, and since the gaps are narrow, the conveyors and the holders occupy little room to insure a very satisfactory ratio of total chamber volume to the volume which is available for under firing. In fact, such ratio can approach or even exceeds the ratio in conventional pusher type furnaces with under firing. The conveyors can be moved well below the work-engaging portions of the holders to insure satisfactory heating of workpieces from

below. Finally, the conveyors are subjected to relatively low thermal stresses and can stand long periods of use. This is due to the fact that the conveyors need not leave the interior of the heating chamber and that they are almost completely encased in heat-insulating material.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. A metallurgical furnace comprising a heating chamber having an inlet and an outlet; at least two pairs of elongated supporting units provided in said chamber extending spaced in transverse direction a considerable distance from each other between said inlet and said outlet, each of said pairs of supporting units comprising a stationary supporting means having upper work-supporting portions to support at intervals metallic work pieces which are fed through said inlet and advance intermittently toward and through said outlet, and a mobile supporting means also having upper work-supporting portions and being movable between raised and lowered positions and in the direction towards said outlet to lift work pieces off said work-supporting portions of said stationary supporting means during movement to said raised position, to transport the thus-lifted work pieces towards said outlet during movement towards said outlet in said raised position, and to deposit work pieces on said stationary support means during movement to said lowered position, each of said supporting means having a side face facing and separated by a small distance from the side face of the other supporting means of the respective unit so as to define a narrow gap between said side faces, said upper work-supporting portions bordering on said gap; and heat-insulating means for each supporting means bounded in part by the respective side face and extending from the latter away from said gap.

2. A furnace as defined in claim **1**, wherein said heating chamber comprises top and bottom walls spaced from said supporting means so as to permit heating of work-pieces from above and from below.

3. A furnace as defined in claim **1**, further comprising means for internally cooling said stationary and said mobile supporting means.

4. A furnace as defined in claim **1**, wherein the side faces of the supporting means of each unit are located in parallel substantially vertical planes, and wherein each of said supporting means comprises further elongated hollow fluid-cooled carrier means bordering on the respective gap and arranged to support the full weight of work pieces resting on said upper work-engaging portions.

5. A furnace as defined in claim **4**, wherein said upper work-engaging portions of each supporting means are arranged in a row along the respective supporting means and each consisting of heat-resistant metallic material and connected to the respective carrier means to transmit stresses thereto.

6. A furnace as defined in claim **5**, wherein each of said work-engaging portions has an upper narrow edge face and wherein said heat-insulating means has opposite said side face a face extending from the region of said edge face downwardly and outwardly and outwardly inclined.

7. A furnace as defined in claim **5**, wherein the height of work-engaging portions of said stationary supporting means exceeds the height of work-engaging portions of said mobile supporting means.

8. A furnace as defined in claim **5**, wherein said carrier means comprise upwardly extending connectors and said material-engaging portions comprise annular members surrounding with clearance the connectors of the respective carrier means, and fillers of heat-insulating material accommodated in said clearances.

9. A furnace as defined in claim **5**, wherein said carrier means comprise upwardly extending connectors received in complementary recesses provided therefor in the respective work-engaging portions to hold said portions against tilting and against lengthwise displacement with reference to said carrier means.

10. A furnace as defined in claim **5**, further comprising mechanical coupling means connecting said work-engaging portions with the respective carrier means.

11. A furnace as defined in claim **5**, wherein said heat insulation means comprises portions disposed between said carrier means and the respective work-engaging portions and further comprising substantially vertical connector means provided on said carrier means to hold the respective work-engaging portions against movement with reference to the respective carrier means, said connector means being surrounded by heat-insulating material.

12. A furnace as defined in claim **5**, wherein said carrier means are provided with upwardly extending projections and said work-engaging portions are provided with projections alternating with the projections of the respective carrier means, said projections having registering apertures and further comprising elongated coupling members extending through said apertures to mechanically connect the projections of said carrier means with the projections of the respective work-engaging portions.

13. A metallic furnace comprising a heating chamber having an inlet and an outlet; a plurality of stationary supporting means provided in said chamber and extending between said inlet and said outlet to support at intervals metallic work pieces which are fed through said inlet and advance intermittently toward and through said outlet; a plurality of mobile supporting means, each associated with one of said stationary supporting means and each movable between raised and lowered positions and in the direction towards said outlet to lift work pieces off said stationary supporting means during movement to said raised position, to transport the thus-lifted work pieces towards said outlet during movement towards outlet in said raised position, and to deposit work pieces on said stationary supporting means during movement toward said lowered position; heat-insulating jacket means surrounding said supporting means but leaving a relatively narrow gap between each stationary supporting means and the associated mobile supporting means; and fluid-cooled columns comprising stationary frames for supporting said stationary supporting means and heat-insulating shells surrounding said frames, said shells defining internal compartments and said mobile supporting means comprising frames received in said compartments with requisite clearance to permit movements of said mobile supporting means with reference to the associated stationary supporting means.

14. A furnace as defined in claim **13**, further comprising means for moving the frames of said mobile supporting means, said moving means being disposed below said chamber.

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