United States Patent

[11] **3,575,395**

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[21] Appl. No. **876,667**
[22] Filed **Nov. 14, 1969**
[45] Patented **Apr. 20, 1971**
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[54] **BILLET HEATING FURNACE AND CONVEYOR THEREFOR**
13 Claims, 7 Drawing Figs.

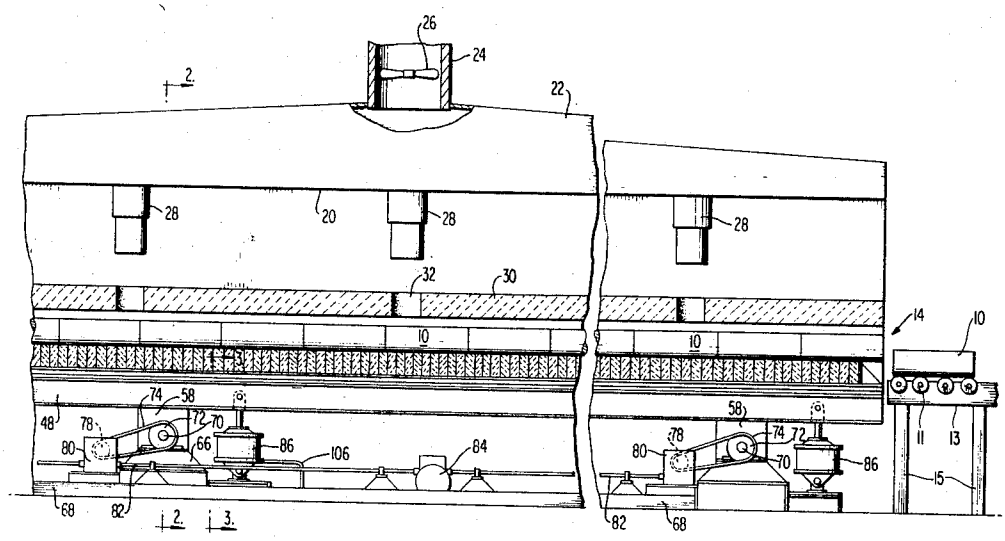
[52] **U.S. Cl.** **263/6,** 198/219
[51] **Int. Cl.** **B65g 25/04,** F27b 9/14
[50] **Field of Search** ..... 263/6, 6 (A); 198/218, 219

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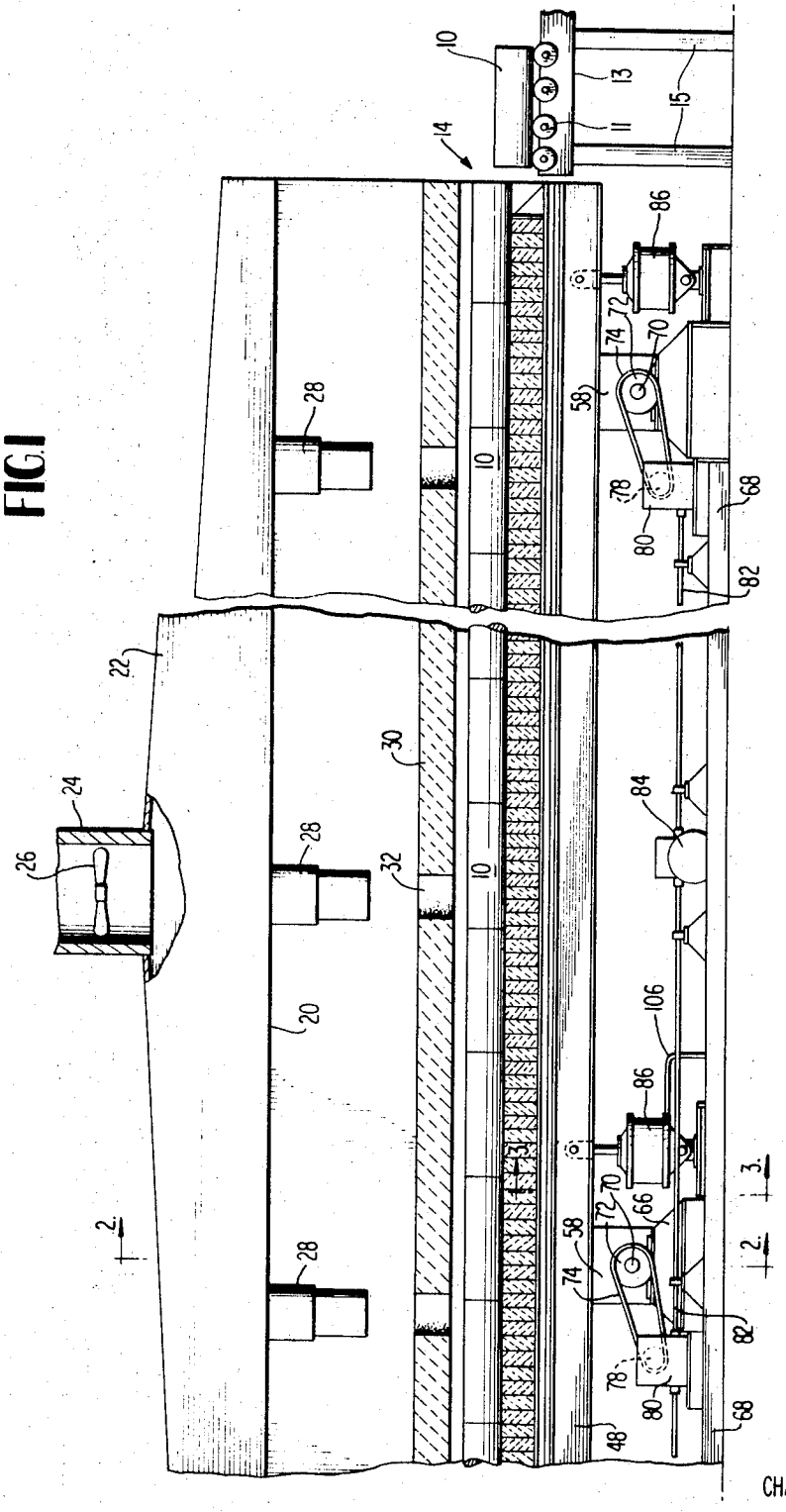
ABSTRACT: This disclosure relates to a walking beam furnace for heating billets and the like in which the billets are conveyed by a central beam through a furnace chamber. Power means are provided to impart circular motion in a vertical plane to the central beam and an independent pneumatic force biases the beam upwardly to assist the power means in the movement of the beam, to minimize power requirements and to minimize wear on the power equipment.



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4 Sheets-Sheet 1

FIG. 1

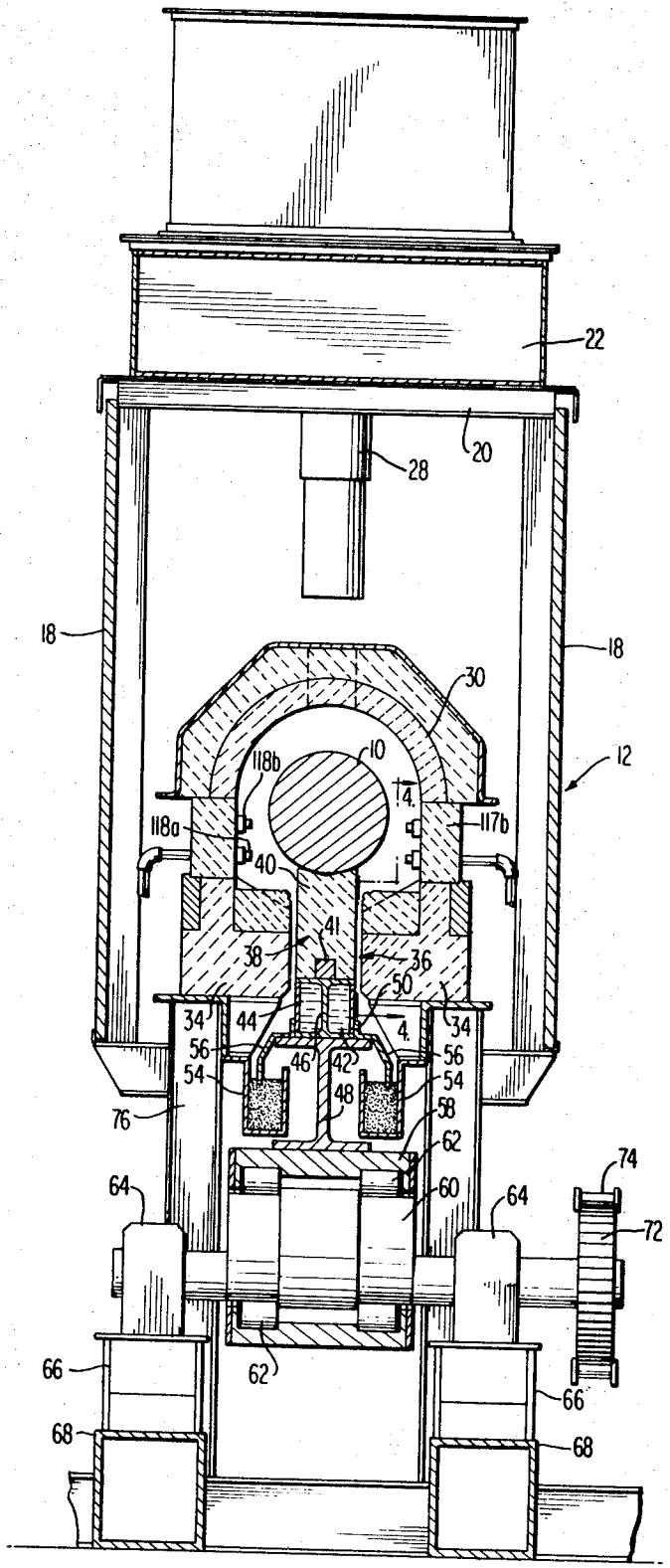


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FIG2


22
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118b
10
14
118a
117b
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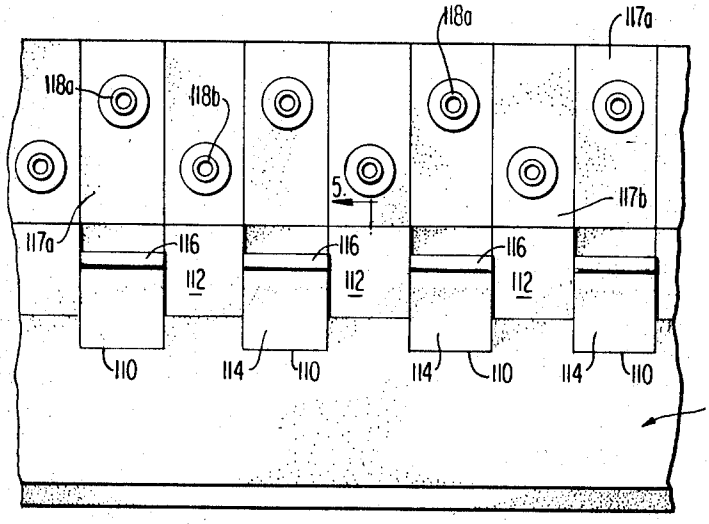


FIG.4

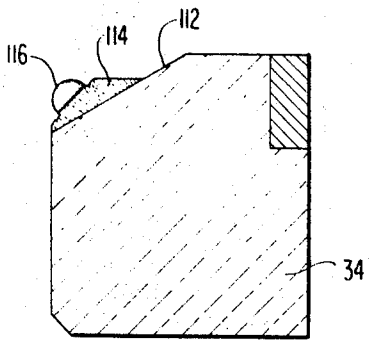


FIG5

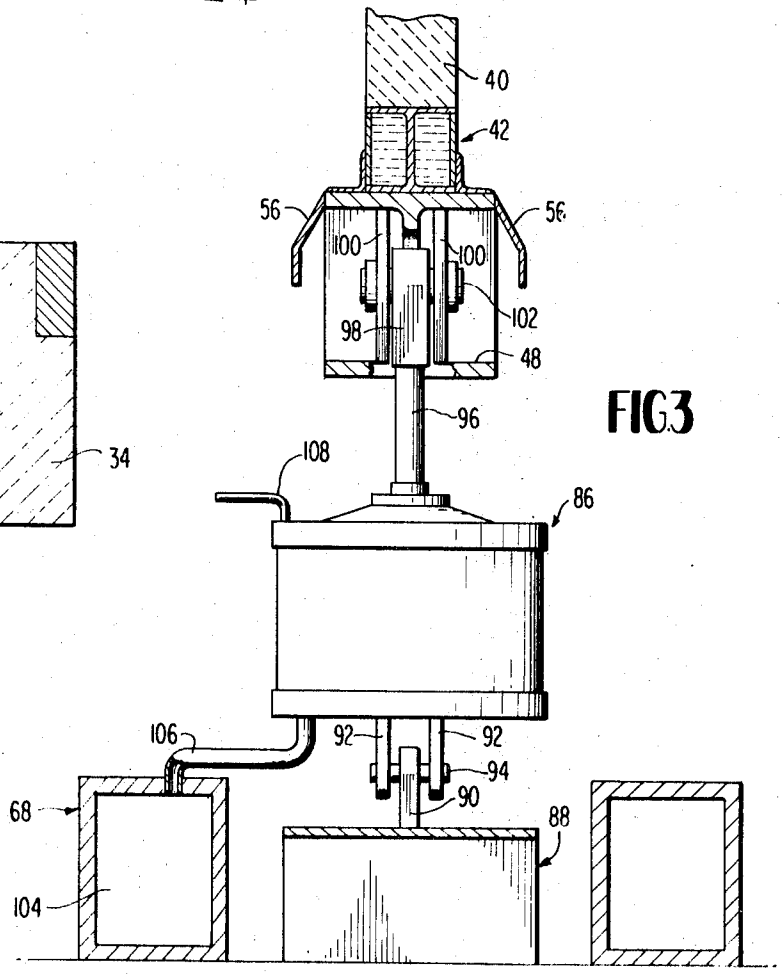
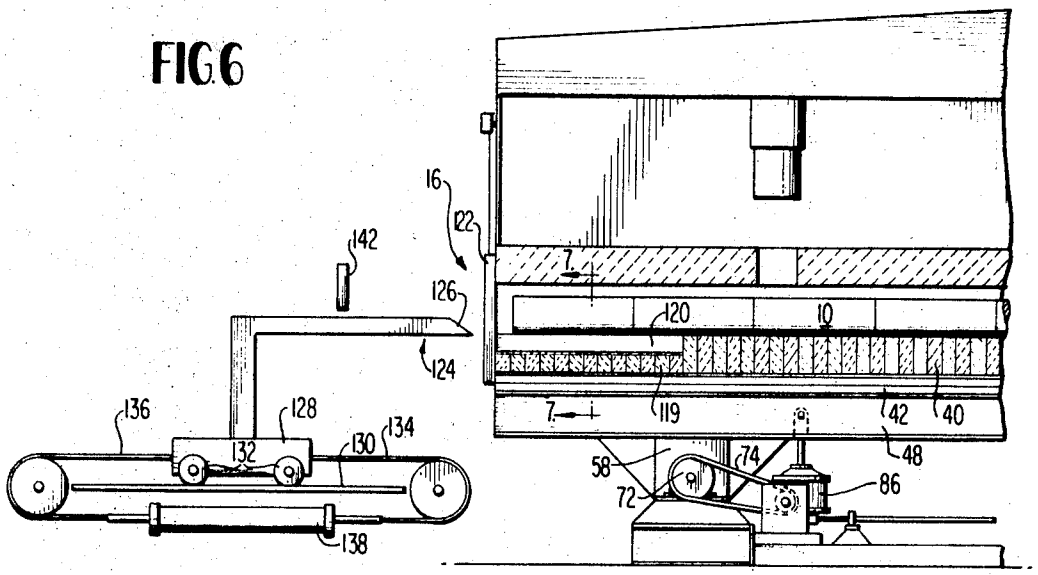


FIG3

FIG. 6



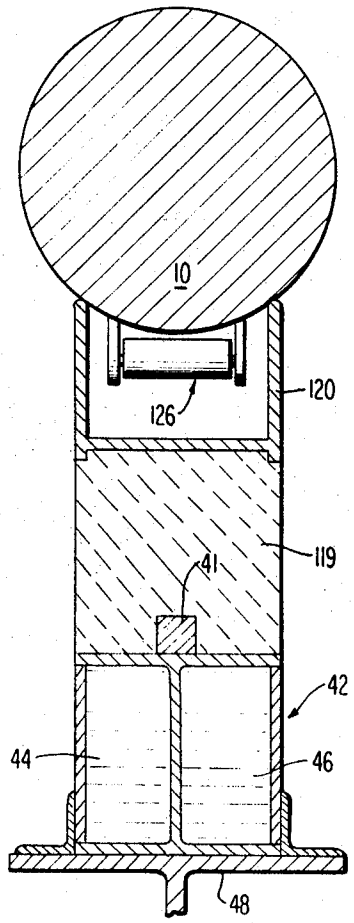


FIG. 7

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BILLET HEATING FURNACE AND CONVEYOR THEREFOR

This invention relates to furnace construction. In one of its aspects it relates to a walking beam construction for a furnace in which the movement of the beam through its orbital motion is assisted by a pneumatic biasing means.

In another of its aspects the invention relates to a furnace for heating billets in which the billets are moved through the furnace with a walking beam having an eccentric drive mechanism which imparts an orbital motion to the beam, and wherein an auxiliary, resilient means is provided to bias the beam upwardly to assist the eccentric drive mechanism.

Walking beams are well-known for conveying articles through furnaces. Many different mechanisms have been devised to cause orbital or circular movement to the walking beams in a vertical plane. One such mechanism employs an eccentric hub which is journaled in the frame and eccentrically journaled in the beam supports. As the hub rotates, the beam follows an orbital or circular path in a vertical plane. A power source, such as a motor, rotates the hub. The power requirements for the movement of the beam increase as the beam is raised and increase still more as the beam picks up the articles to be conveyed from their support. As the beam begins its downward descent, the weight of the article and the weight of the beam produces an opposite torque on the motor tending to hasten rotation of the hub. The motor must then apply an opposite torque to restrain the movement of the beam downwardly. The motor requirements therefore go from maximum torque in one direction to a maximum torque in an opposite direction in a relatively short period of time. This large torque reversal shortens the motor life as well as the life of the other moving parts. When the beam components are of substantial magnitude and the load carried by the beam is great, the power requirements for the motor are enormous.

I have now discovered that the power requirements of a motor in a walking beam as described above can be greatly diminished and the wear on the motor and power drive equipment can be minimized by providing a yielding force, preferably pneumatic, for the beam to bias the beam upwardly.

By various aspects of this invention, one or more of the following, or other, objects can be obtained.

It is an object of this invention to provide an improved walking beam furnace for large metal billets wherein power requirements for the beam are minimized.

It is a further object of this invention to provide a walking beam construction wherein an eccentric drive means is provided and wear on the drive means is minimized.

It is a further object of this invention to provide a walking beam for conveying substantial weight of metal billets wherein movements of the billets on the beam is cushioned for a smooth operation and less wear on the moving parts.

It is yet another object of this invention to provide an improved furnace for heating metal billets to temperatures in excess of 2,000° F. wherein the billets are conveyed through the furnace smoothly without the need for high-temperature alloy metals as structural components within the furnace.

It is still another object of this invention to provide a high-temperature furnace in which billets are quickly brought up to temperature and moved through the furnace with a minimum of oxidizing air entering the furnace.

It is yet another object of this invention to provide a walking beam furnace in which heavy articles are easily and smoothly conveyed through the furnace with a minimum of wear on the furnace parts which contact the articles.

It is another object of this invention to provide a walking beam furnace for heating metal billets to high temperatures wherein the support beam has a high degree of dimensional stability.

Other aspects, objects, and the several advantages of this invention are apparent to one skilled in the art from a study of this disclosure, the drawings, and the appended claims.

According to the invention there is provided a billet heating furnace for rapidly heating metal billets and there is also provided a walking beam conveyor for a billet heating furnace. The billet heating furnace has walls forming a longitudinal passage for the billets and has an entrance end and an exit end. The furnace walls form a longitudinal opening in the bottom thereof between the exit and entrance ends. Means are provided to support billets within the longitudinal passage at opposite sides of the longitudinal opening. A walking beam is positioned in the opening and means are provided to drive the walking beam through an orbital path whereby the top surface of the walking beam passes above and below the billet support means to move the billets through the furnace from the entrance to the exit end. High intensity burners are spaced along the sides of the longitudinal passage for heating the billets as they are moved from the entrance end to the exit end. An auxiliary resilient biasing means, preferably pneumatic in nature, is provided for the walking beam to aid in the raising and support of the beam.

The drive means is preferably an eccentric drive-type mechanism and the auxiliary biasing means is independent of this drive means.

The invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a partial side elevational view in section illustrating a furnace according to the invention;

FIG. 2 is a front elevational view in section taken along lines 2–2 of FIG. 1;

FIG. 3 is a partial front elevational view in section taken along lines 3–3 of FIG. 1;

FIG. 4 is a partial sectional view seen along lines 4–4 of FIG. 2;

FIG. 5 is a partial sectional view along lines 5–5 of FIG. 4;

FIG. 6 is a side elevational view in section of an end portion of the furnace, schematically illustrating a retriever device; and

FIG. 7 is a partial sectional view taken along lines 7–7 of FIG. 6 showing the relationship between the retriever device and the end of the furnace.

Referring now to the drawings, and to FIGS. 1 through 3 in particular, there is illustrated a furnace 12 for heating a plurality of cylindrical billets 10. The furnace has an entrance end 14 and an exit end 16 (FIG. 6). Sidewall panels 18 and a top wall panel 20 encase the furnace. An exhaust manifold 22 and an exhaust conduit 24 have a fan 26 which draws exhaust gases through adjustable exhaust pipes 28 from the furnace.

The furnace is formed from a top refractory member 30 having vertical exhaust holes 32 which communicate with the exhaust pipes 28 for removing gases from the furnace. Bottom refractory members 34 form the bottom portion of the furnace and are spaced from each other to provide a longitudinal opening 36. A walking beam 38 is positioned for circular or orbital movement within the longitudinal opening 36. The walking beam 38 is formed from a plurality of refractory blocks 40 having a wide V-shaped upper surface, a cooled support member 42 and a support I beam 48. The cooled support 42 has water passages 44 and 46 through which water is circulated to provide a cooled barrier between the support I beam 48 and the refractory block 40. The refractory blocks 40 have a recess 41 at the bottom. A spline bar 52 fits within the recess 41 and positions the refractory block 40 on the support 42. Means (not shown) are provided at either end of the walking beam to resiliently compress the refractory blocks 40 to hold them in place.

Angle irons 50 secure the cooling block 40 on the I beam 48.

A bottom heat seal for the furnace is formed by troughs 54, which are secured to the bottom of the furnace, and by sealing flanges 56, which depend from the top of the I beam 48 and extend into the trough 54. Water or sand or other suitable sealing material can be provided in the troughs to prevent air from entering the furnace through the longitudinal opening 36.

The walking beam is supported by an eccentric drive comprising an annular support member **58** which journals an eccentric hub **60** through bearings **62**. The eccentric hub **60** is supported at the sides by side holder **64**, upright supports **66** and horizontal, hollow tubular beam **68**. The outboard end **70** of the eccentric hub **60** has a sprocket wheel **72** fixed thereto. A chain **74** engages the sprocket **72** and a sprocket wheel **78** to drive the eccentric hubs **60**. The sprocket wheel **78** is driven through a motor **84**, a drive shaft **82** and gear box **80**.

The furnace refractory sections **34** are supported by the hollow beams **68** and upright support beams **76**.

The walking beam is biased upwardly by a gas cylinder **86**. A box beam **88** having an upright flange **90** pivotally supports the gas cylinder **86** through depending ears **92** and pin **94**. The piston rod **96** from the gas cylinder **86** extends upwardly through an aperture in the support I beam **48** and pivotably engages the I beam **48** through collar **98**, plates **100** and pin **102**. A constant gas pressure is supplied to cylinder **86** through air supply manifolds **104** and flexible conduit **106**. The manifold **104** is formed from the tubular beams **68**. A manifold (not shown) is provided between the beams to equalize the pressure in the manifolds **104**. A vent **108** is provided at the upper portion of the gas cylinder to permit the upper part of the cylinder to breathe as the piston moves within the cylinder with the vertical movement of the walking beam **38**.

A billet loading device is schematically illustrated in FIG. **1** at the entrance end **14** of the furnace. The loading device has rollers **11** which are journaled in a horizontal support **13**. Vertical supports **15** are fixed to the horizontal support **13**. The rollers can be powered by a motor (not shown) or a simple pusher mechanism (not shown) can be used to push the billets into the furnace when the walking beam is in its lowermost position. Rollers can be provided at the sides of the furnace adjacent the walking beam at the very front of the furnace to aid in moving the billet into the furnace.

Referring now to FIGS. **4** and **5**, the bottom refractory members **34** are formed from a plurality of sections approximately 2 feet long extending the length of the furnace. Each section contains a plurality of spaced openings **110** which are juxtaposed to sections having sloping inner corners **112**. Separate and removable pier blocks **114** fit into the openings **110** and extend out into the furnace above the sloping inner corners **112** for supporting the billets **10**. Each pier block **114** has a rounded corner and a support corner cap **116** thereon. The support corner cap **116** is made out of a high-temperature alloy metal and the pier blocks **114** are made out of a refractory material. The billets **10** are supported by and contact the caps **116**.

The furnace is fired by a plurality of burner tiles forming an upper row **117***a* having nozzles **118***a* and a lower row **117***b* having nozzles **118***b*. The burners direct a flame into the center of the furnace to envelop the billets with a reducing portion of the flame. The upper row **117***a* is directly above the pier blocks and the lower row **117***b* is above the sloping corners **112**. The flames from the lower row **117***b* of burner tiles will extend down along the sloping corner **112** and envelop the bottom of the billets when the billets are heated on the pier blocks **114** and will pass beneath the billets when the billets are raised off the pier blocks. The flames from the upper row **117***a* will tend to pass over the tops of the billets regardless of whether the billets are resting on the pier blocks or are raised in the position shown.

As an alternate embodiment, the refractory blocks **40** can comprise juxtaposed sections of higher and lower refractory blocks to permit the flame to pass beneath portions of the billets when the billets are supported by the walking beam. The higher refractory blocks will support the billets and the flame will pass between the lower refractory blocks and the billets.

Reference is now made to FIGS. **6** and **7** which illustrate the means for removing the heated billets from the end of the furnace. Adjacent the exit end **16** of the furnace there are provided special refractory support blocks **119** which are shorter than the refractory support blocks **40**. A U-shaped channel **120** is supported by the blocks **119**, the channel **120** forming a support for the billets **10**. At this end of the furnace, the billets are fully heated and there is no need to provide high intensity burners. Thus the U-shaped channels can be made of high-temperature alloy metal and will not be severely affected by the high heat used to heat the billets in the heating sections of the furnace.

The means for removing the heated billets from the furnace is illustrated schematically in FIG. **6**. This billet retriever per se is more fully described and is claimed in U.S. Pat. No. 3,415,393 and forms no part of this invention. This patent is incorporated herein by reference.

Briefly, the billet retriever enters the furnace when the door **120** is raised. The retriever device **124** has a forward wedging means **126** which is supported on a car **128**. A track **130** guides and supports the wheels **132** of the car **128**. Pulley ropes **136** are affixed to either end of the car **128** and are driven by a hydraulic cylinder **138**.

Suitable means for removing the billet from the retriever device **124** are disclosed in said Pat. 3,415,393. Other suitable means for removing the billet from the retriever device **124** are disclosed and claimed in copending Ser. No. 747,685, filed Jul. 25, 1968.

In operation, a billet **10** is moved into the furnace from the loading rollers **11** onto the side support members while the beam is at its lowermost position. The billet rests on the wide U-shaped upper surface of the refractory blocks **40** as the walking beam is raised. All billets are generally in end to end contact on the walking beam refractory members **40** for maximum space utilization. The billets are moved through the furnace on the walking beam and are removed by the billet retriever illustrated in FIGS. **5** and **6**.

As a billet is moved into the exit end of the furnace onto the channel **120**, a new billet can be pushed into the furnace. The billets are moved from the entrance end to the exit end of the furnace by the walking beam **38**. The beam moves in an orbital motion in a vertical plane (as viewed in (FIGS. **1** and **6**) with the top of the refractory blocks **40** rising above the top of the pier blocks **114** as the beam moves towards the exit end of the furnace. After the top of the refractory blocks **40** has fallen below the top of the pier blocks, the beam then moves back towards the front end of the furnace. In the drawings, the walking beam is shown in its uppermost position. When a billet reaches the very end of the furnace, its presence is sensed, and the walking beam is stopped, leaving the billets to rest on the pier blocks.

The billets are supported by the pier blocks **114** during that time in which the beam **38** moves back towards the front end of the furnace and when the beam **38** is stopped in the lowermost position. The billets are supported by the refractory blocks **40** as the beam **38** moves towards the exit end of the furnace. In this manner, the billets are moved from the entrance end of the furnace to the exit end thereof in incremental steps.

The billets are heated in the heating section of the furnace as they move therethrough by direct impingement of the flame from the burners on the billets. Preferably, the billets are enveloped by a reducing portion of the flame to minimize oxidation on the outer surface of the billets. This is accomplished by placing the burner tiles in close proximity to the billets and by adjusting the velocity and mixture of the combustible fuel entering the burners. The products of combustion are exhausted from the furnace through the vertical exhaust holes **32**, exhaust pipes **28**, manifold **22** and exhaust conduit **24**.

Movement of the beam **38** is caused by eccentric hub **60** which rotates by sprocket wheel **72** and chain **74**. A plurality of such hub-containing mechanisms are spaced along the length of the furnace. Each such mechanism is driven by motor **84** at a constant speed through drive shaft **82**, gear box **80** and chain **74**. Thus, the hub **60** rotates at a constant speed, thereby moving the walking beam **38** at a constant rate.

In order to facilitate the removal of the heated billets from the exit end of the furnace, the motor has a variable speed control so that it can be operated at a lower speed than normal to move the billets through the furnace. The slower speed is used to position the billets for removal from the furnace with the retriever device. When it is desirable to remove the end billet from the furnace, the motor **84** is switched to the low speed, and the beam moves to the uppermost position of its travel and stops. The exit door **122** opens and the retriever device enters the furnace to remove the end billets from the furnace. The forward wedging means **126** of the retriever device is advanced into the furnace until the end billet drops onto the retriever device. The wedging means pushes the forward end of the billet upwardly until it becomes so unstable that it drops onto the retriever device. The retriever device fits between the U-shaped channel as illustrated in FIG. **7**. The billet and the retriever device are then withdrawn from the furnace until the forward portion of the retriever device strikes a switch at **142** whereupon the retriever mechanism stops and the billets are removed therefrom. The heated billets can then be taken to an extrusion press for fabrication into metal parts.

In the movement of the walking beam described in the drawings, the greatest power for the system is required to raise the walking beam **38** above the pier blocks so as to lift the billets up and carry them forward toward the exit end of the furnace. For large copper or brass billets, for example, the weight of the walking beam and the billets can be as much as 1,000 pounds per foot of walking beam. The length of the furnace can vary from 30 to 100 feet and thus the total weight to be raised by the motor would be 30,000 to 100,000 pounds. The motor must therefore be geared to the maximum amount of force required to raise the beam and the load of billets.

According to the invention, the movement of the walking beam is aided and cushioned by the application of air pressure through cylinders **86** and piston rod **96**. The cylinders are also disposed along the length of the furnace. Each cylinder is filled with a predetermined pressure from manifold **104**. This air pressure is transmitted through the piston rod **96** to the beam **38**. The air pressure in the cylinder can be adjusted to minimize the power requirements or current draw of the motor. This can be done manually or automatically through suitable instruments.

The air pressure assists the motor in raising the beam and in lifting the billets off the pier blocks. As the beam starts to move downwardly from its uppermost position, the air pressure continues to apply an upward force to the beam, thereby acting against the weight of the billets and the beam. In this manner, the reverse torque caused by the weight of the billets and the walking beam can be minimized. Further, the torque reversal on the motor due to the change from upward to downward motion of the walking beam is severely cushioned. The air pressure can be adjusted to substantially eliminate the torque reversal effect by adjusting the air pressure so that the force on the beam from the gas cylinders is equal to or greater than the weight of the beam. In such a case, the motor will be working against the air pressure in the downward cycle.

The effect of the air cylinder is to minimize the force required for operating the walking beam and to decrease the wear on the motor drive and its associated moving parts. Therefore, smaller motors can be used to operate the walking beam and these smaller motors will have longer life.

The gas cylinders **86** have an open connection to the manifold **104**. The pressure in the manifold remains substantially constant, and therefore the pressure in the gas cylinders remain substantially constant. The force from the gas cylinders is thus substantially constant but yieldable with the movement of the walking beam. The billets have a floating or cushioned ride on the walking beam with the use of the gas cylinders **86**.

This floating ride of the walking beam avoids banging of the support parts due to torque reversal and permits more accurate control of the beam. The billets can be raised and lowered onto the supporting pier blocks much more gently to thereby minimize wear on these parts. Further, this floating action minimizes the surface scratches and defects in the billets as a result of the contact between the billets and their stationary supports.

Whereas the cylinders **86** have been described as having air pressure supplied to them, other gases, or even liquids could be used as desired.

The furnace of the invention finds particular utility in heating high copper alloys for extrusion wherein the required temperature is in the range of 2,000° F. to 2,200° F. At such temperatures most metals and their alloys have little or no strength and oxidize rapidly. Thus, conventional billet heating furnaces in which metal is used for structural parts within the furnace are not suitable. By the construction of the novel furnace according to the invention, refractory parts are used exclusively within the furnace for structural purposes, except at the exit end where the high-temperature burners are not present. The structural metal beam parts are protected from heat by the refractory walls and by the water cooled portions of the beam. The cooling of the beam gives a high degree of dimensional stability to the support I beam **48**. This dimensional stability is desirable in minimizing the stress on the refractory blocks **40** as the temperature within the furnace changes.

The single walking beam structure facilitates sealing the furnace from ambient air. At the high temperatures at which the furnace operates, significant amount of oxidation can take place on the billets if the furnace is not properly sealed. The illustrated heat and air seal between the sidewalls and the walking beam is just one such seal which can be provided in the furnace between the walking beam and the walls. Many other types of heat seals will be suggested to those skilled in the art.

The slow movement of the billets upwardly as well as horizontally facilitates more accurate temperature measurement of the billets. The temperature of the billets are usually sensed by fixed optical pyrometers which read only a small area of any given billet within the furnace. With the slow movement of the billets in their undulating motion, the pyrometer can take an average reading over a larger surface area than on a stationary billet. Erroneous errors due to surface irregularities are thereby minimized.

Whereas the invention has been described with reference to a furnace having upper and lower rows of burners spaced along the sides, it is within the scope of the invention to employ only a single row of burners in a furnace. A single row of burners would be more appropriate in such a walking beam furnace in which smaller billets were to be heated.

Whereas the invention has been described with reference to a particular billet retriever or remover, other types of retrievers or removal devices are possible within the scope of the invention.

Reasonable variation and modification are possible within the scope of the foregoing disclosure and the drawings without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

I claim:

1. In a billet heating furnace for rapidly heating metal billets, said furnace comprising:

furnace walls forming a longitudinal passage for billets and having an entrance end and an exit end, said furnace walls forming a longitudinal opening at the bottom thereof from said entrance end to said exit end;

means to support billets within said longitudinal passage at opposite sides of said longitudinal opening;

a walking beam in said opening;

an eccentric drive means supporting said walking beam to drive said walking beam through an orbital path whereby the top surface of said walking beam passes above and below said billet support means to move said billets through said furnace from said entrance end to said exit end;

burner means spaced along the sides of said longitudinal passage for heating said billets as they are moved from said entrance end to said exit end;

the improvement which comprises:

an auxiliary resilient biasing means independent of said eccentric drive means for said walking beam to aid in the raising of said walking beam and to cushion the travel of said walking beam.

2. A billet heating furnace according to claim 1 wherein said biasing means includes a plurality of pneumatic cylinders and means to supply a substantially constant fluid pressure to said pneumatic cylinders.

3. A billet heating furnace according to claim 1 wherein a plurality of annular cylinders are fixed to a bottom portion of said walking beam and said eccentric drive means comprises an eccentric hub journaled in each of said annular cylinders, and means to drive said eccentric hubs at a constant speed.

4. A billet heating furnace according to claim 3 further comprising a frame supporting said furnace walls and said eccentric hub is journaled in said frame.

5. A billet heating furnace according to claim 4 wherein said biasing means is supported by said frame.

6. A billet heating furnace according to claim 1 wherein said walking beam includes an upper refractory member, a longitudinal support beam, and a cooled support member fixed between said upper refractory member and said longitudinal support beam to maintain the temperature of said longitudinal support beam relatively cool compared to said upper refractory member.

7. A billet heating furnace according to claim 6 further comprising means for providing a heat seal for said longitudinal passage between said walking beam and said furnace walls.

8. A billet heating furnace according to claim 1 wherein said billet support means comprises spaced refractory members having outer corners for supporting said billets, said sidewalls supporting said refractory members and having portions adjacent said refractory members sloping beneath said corners so that said billets are supported by said refractory members.

9. A billet heating furnace according to claim 8 wherein said burners comprise upper and lower burners, said lower burners being at said sloping wall portions and said upper burners being at said refractory members and positioned above the plane of said lower burners.

10. In a billet heating furnace for rapidly heating metal billets, said furnace comprising:

furnace walls forming a longitudinal passage for billets and having an entrance end and an exit end, said furnace walls forming a longitudinal opening at the bottom thereof from said entrance end to said exit end;

means to support billets within said longitudinal passage at opposite sides of said longitudinal opening;

a walking beam in said opening;

means to drive said walking beam through an orbital path whereby the top surface of said walking beam passes above and below said billet support means to move said billets through said furnace from said entrance end to said exit end;

burner means spaced along the sides of said longitudinal passage for heating said billets as they are moved from said entrance end to said exit end;

the improvement which comprises:

a pneumatic biasing means for said walking beam to aid in the raising of said beam and to cushion the travel of said walking beam.

11. A billet heating furnace according to claim 10 wherein said drive means includes a motor and the pressure in said pneumatic biasing means is adjusted to minimize the power requirements for said motor.

12. A billet heating furnace according to claim 10 wherein said drive means includes an electric motor and the pressure in said pneumatic biasing means is adjusted to minimize the current draw on said motor.

13. A walking beam assembly comprising:

a pair of fixed support means forming a longitudinal opening therebetween;

a longitudinal support means having a top support surface in said longitudinal openings;

means to support and drive said longitudinal support means through an orbital path whereby said top surface is raised above and is lowered below the top surface of said fixed support means;

the improvement comprises:

a pneumatic auxiliary support for said longitudinal support means biasing said longitudinal support means upwardly with a substantially constant, yielding force.