United States Patent [19]

Beck

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[54] **MODULAR HEATER FURNACE**

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[51] **Int. Cl.**.....**F27b 9/36,** H05b 3/06

[58] **Field of Search**.....13/20, 22, 25; 219/388, 395, 402, 403, 409, 424, 553

[56] **References Cited**

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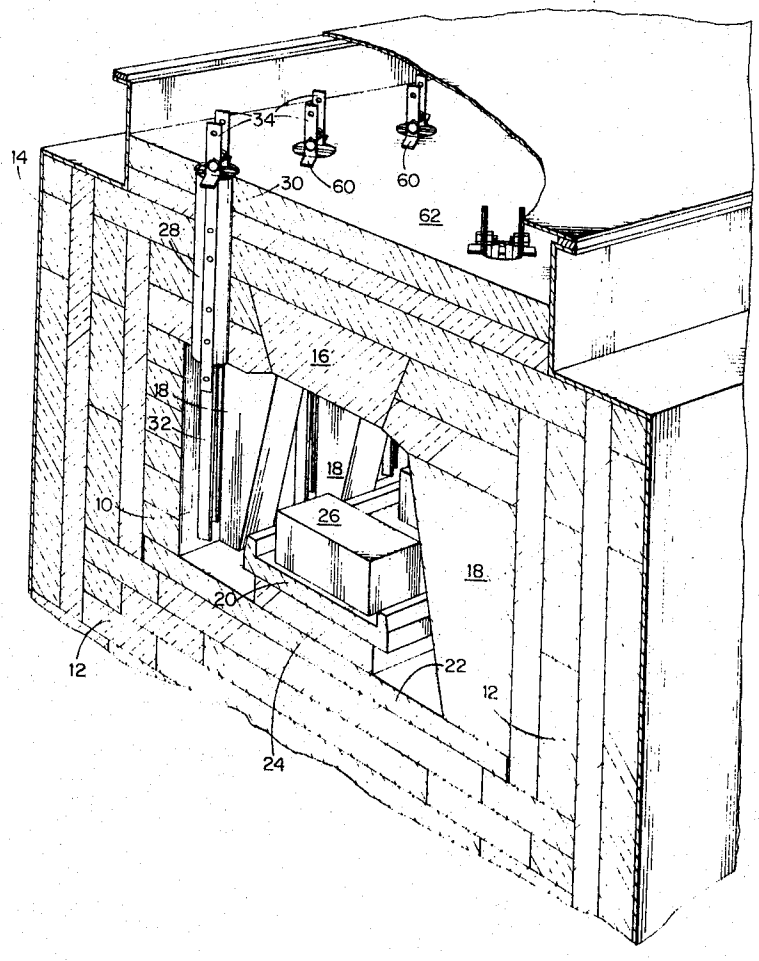
[57] **ABSTRACT**

A heat treating furnace having distinct easily replaceable modular heating elements disposed in an effectively continuous array along the furnace for efficient high temperature operation. Each heating element is in the form of a sinuous ribbon of high temperature metal and is supported within the furnace in a manner to permit easy removability without furnace disassembly.

9 Claims, 4 Drawing Figures



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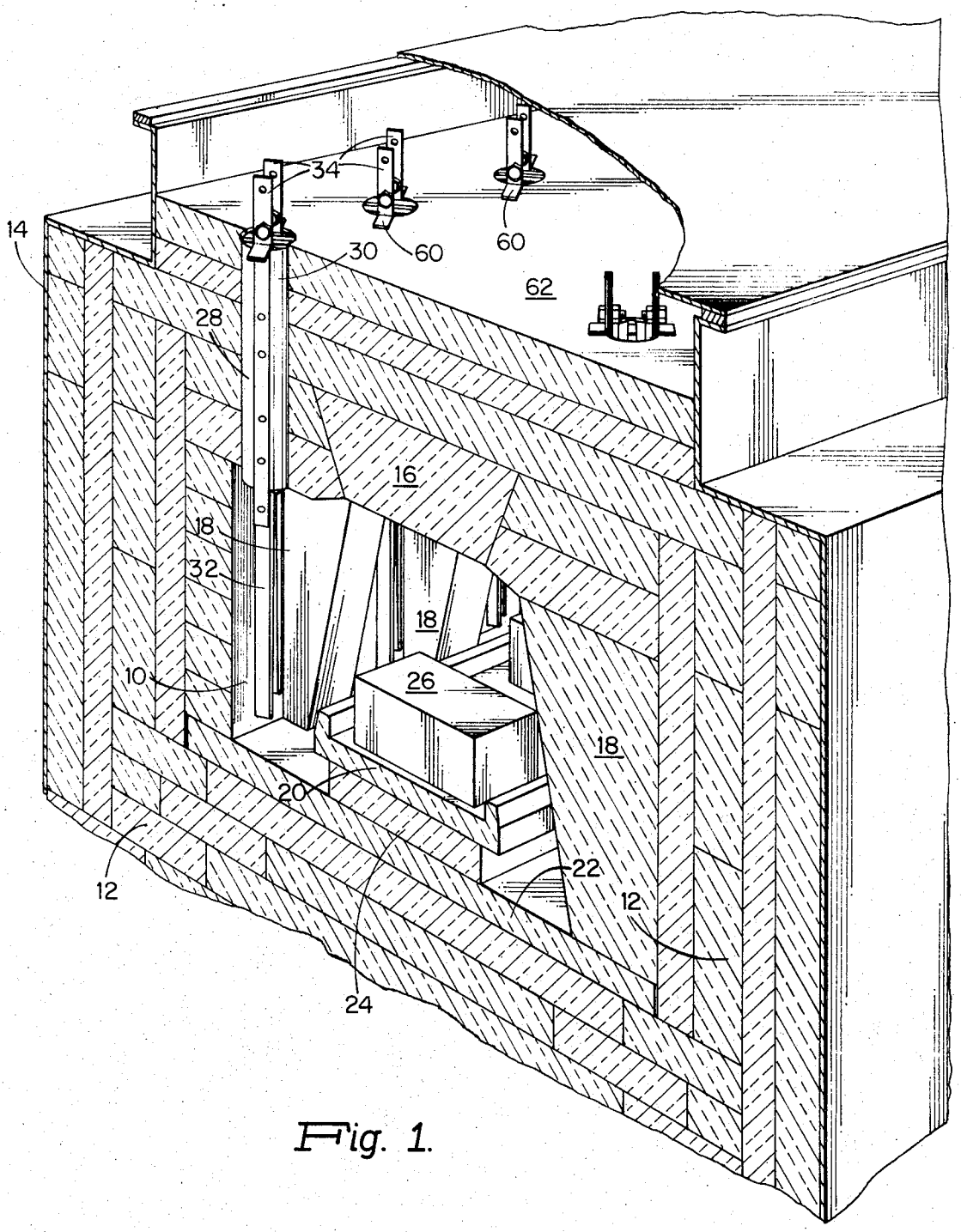

Fig. 1.

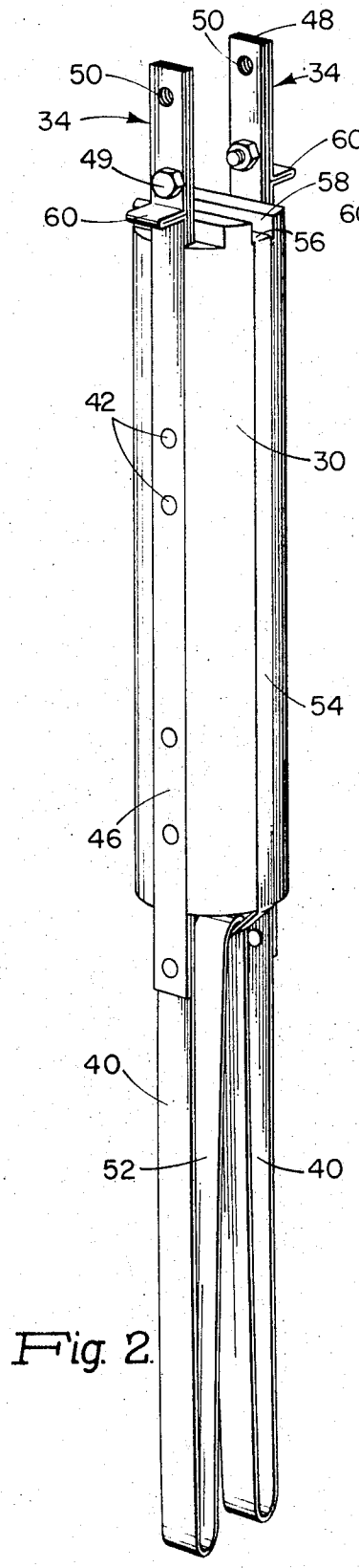

Fig. 2.

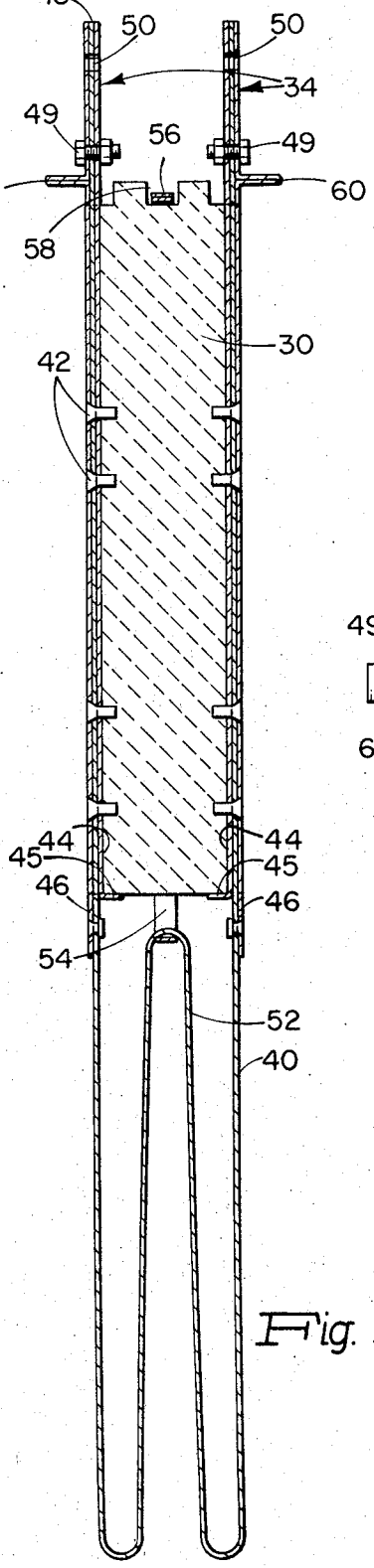

Fig. 3.

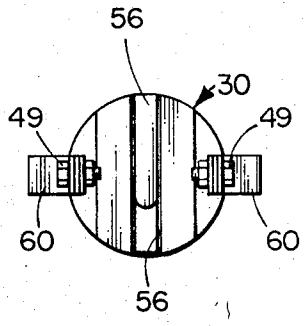

Fig. 4.

MODULAR HEATER FURNACE

FIELD OF THE INVENTION

This invention relates to heat treating furnaces and more particularly to a furnace having an array of easily removable modular heating elements disposed along the active length of the furnace.

BACKGROUND OF THE INVENTION

In precision furnaces employed in the heat processing of materials and products, it is often necessary to replace the heating elements therein which can periodically fail by reason of the extremely high temperatures at which such furnaces operate. In many furnaces of conventional construction, the design of the heating elements and their disposition within the furnace is such to require dismantling of the furnace structure in order to gain access to the heating elements for repair or replacement. Such disassembly requires considerable time and labor and results in a decrease in the time the furnace is operative. In addition, in certain operating environments disassembly of the furnace to gain access to the heating elements is completely impractical. For example, where a furnace contains a contaminating environment, disassembly of the furnace structure can cause release of contaminants into the surrounding environment, and decontaminating procedures must be undertaken before any such disassembly is possible. Various furnaces have been proposed in which heating elements are removably disposed within the furnace. However, such furnaces have generally been of rather simple construction unsuitable for many modern heat processes and have usually been operative at only relatively low temperatures.

SUMMARY OF THE INVENTION

In accordance with the present invention, a furnace is provided in which an array of easily replaceable modular heating elements is disposed therein to provide efficient high temperature operation and which can be removed without material affect on the strength and integrity of the furnace. Each heating element includes a ribbon of high temperature metal such as molybdenum formed in a folded or sinuous configuration and supported by a collar of electrically and thermally insulative material. The heating elements are each disposed within a furnace chamber by means of the mounting collar cooperative with a receptacle portion provided in the roof of the furnace, and are readily removable from the furnace without requiring furnace disassembly and without affecting the structural strength of the furnace. The roof of the furnace chamber can be supported along its length by a plurality of piers each constructed to provide intended structural support without detracting from the thermal transmission between respective heating elements. Electrical connection to the array of elements is provided externally of the furnace by means of bus bars or other suitable connecting means. Preferably, each heating element is disposed within the chamber with the metal ribbon angularly disposed such that a major portion of the heating surface thereof confronts the chamber for efficient heating radiation therein.

DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cutaway pictorial view of a furnace constructed according to the invention;

FIG. 2 is a pictorial view of a modular heating element embodying the present invention;

FIG. 3 is a cutaway elevation view of the modular heating element of FIG. 2; and

FIG. 4 is a top view of the modular heating element of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

A heat treating furnace for providing efficient high temperature operation and having modular and easily removable and replaceable heating elements according to the invention is illustrated in FIG. 1. An elongated furnace chamber **10** is defined by thermal insulation usually in the form of refractory brick **12**. The brick work is contained within a sheet metal housing **14** and includes a roof portion **16** supported along the length thereof by a plurality of piers **18** also formed of refractory material and disposed in spaced relationship along each side of the furnace chamber **10**. A channel shaped hearth plate **20**, also of refractory material, is supported on the floor **22** of the furnace chamber by members **24** and extends along the active length of the chamber **10**. A work product **26** is supported on hearth **20** and is conveyed through the furnace by a suitable conveyor mechanism, such as a push rod assembly operative to incrementally advance the work product through the furnace. The conveyor mechanism could alternatively be embodied within the furnace structure itself and can be for example of the movable hearth type wherein the hearth is disposed within the floor of the furnace chamber and is supported by a cooperative beam structure to provide cyclic movement of the hearth to convey a work product therealong.

An array of modular and easily removable heaters **28** is provided along each side of furnace chamber **10**. Each heater is supported by a collar **30** disposed within an opening provided in roof portion **16**, with the active element **32** disposed within the chamber **10** between an adjacent pair of piers **18**. The electrical leads **34** of each heater **28** extend from the roof of the furnace and, in operation, are connected to bus bars or other suitable means to which electrical energy is applied for activation.

The piers **18** supporting roof portion **16** of the furnace are each of tapered configuration having a wider upper end confronting the furnace roof and a narrower lower end confronting the floor **22** of the furnace chamber, the taper being dimensioned and configured to permit adjacent ribbon elements **32** to be in thermal radiating relationship with each other. The physically distinct heating elements within an array along a side of the furnace chamber, as well as each array of elements are thermally communicative to achieve an effectively continuous source of heat within the chamber and having a uniform heating capacity along the furnace. Heating efficiency is further enhanced by the angular disposition of ribbon elements **32** within furnace chamber **10**, as will be further described hereinbelow,

to permit radiation into the chamber from a plurality of heating surfaces of element **32**.

It is a particular feature of the invention that the heaters **28** are each easily removable from the furnace without affect on the furnace strength and without furnace disassembly. The roof portion **16** is supported along its length by piers **18**, and removal of one or more heaters **28** does not materialiy detract from the strength of the roof structure. To remove a heater **28**, it is only necessary to disconnect the leads **34** from the associated electrical bus bar and to lift the heater out of its mounting opening in roof **16**. A new heater is replaced just as readily by insertion through the mounting opening and connection of the leads thereof to an electrical energy source. It should be noted that since physically distinct heaters are employed in the novel furnace, failure of a single heating element will not cause degradation of the overall heating capacity of the heater array, as can occur in a furnace having a physically continuous heat source.

The heater **28** is illustrated in greater detail in FIGS. **2** through **4**. Referring to these figures, a ribbon **40** of high temperature metal such as molybdenum is formed in a sinuous shape as illustrated and is supported at the upper end thereof by a collar **30** of electrically and thermally insulative material such as a high temperature ceramic. The collar **30** is of generally cylindrical configuration and has a portion of the ribbon **40** affixed thereto by means of a plurality of fasteners **42**. The portions of ribbon **40** attached to collar **30** are sandwiched between first and second metal straps **44** and **46** which extend from below the lower end of collar **30** to he upper extremities of ribbon **40**. The inner straps **44** each have a lower end **45** bent inward on the bottom end of collar **30** for support. The upper ends **48** of straps **44** and **46** and the interposed portion of ribbon **40** can be welded to provide a unitary electrical lead structure. Fasteners **49** can also be provided to further secure the electrical leads. Typically, an opening **50** is provided through each lead for electrical connection to associated bus bars or other electrical connection means.

The interior loop **52** of ribbon **40** is supported by a metal strap **54** which extends beneath this loop and along respective opposite sides of collar **30** in a position approximately orthogonal to the position of the respective straps **44**, the upper ends **56** of strap **54** being bent inward on the top of collar **30** within a channel **58** provided thereacross to mechanically secure strap **54** in position. It is seen that the straps **44** and strap **54** extend outwardly by a small amount from the surface of collar **30**. Upon installation of the heater within the mounting opening in roof portion **16**, the metal straps are in contact with the surrounding refractory material of the furnace roof, rather than the refractory material of collar **30**, and serve to prevent fusion of the mounting collar **30** to the furnace roof, which can occur at extremely high operating temperatures.

In the illustrated embodiment, each heater **28** is supported within an associated opening of the furnace roof **16** by flanges **60** provided at the upper end of the heater and extending substantially orthogonally outward from the axis of the electrical leads **34**. The flanges **60** are supported on the upper surface **62** of the furnace structure for suspension of the respective heaters within furnace chamber **10**. It will be appreciated that the heaters can be suspended within the furnace by a variety of mounting means which may include a keying element for predetermined angular disposition thereof within the furnace chamber.

It is a particular feature of the invention that each heater **28** is disposed within the furnace chamber with the heating element **32** angularly disposed, as depicted in FIG. **1**, such that a major portion of the heated surfaces of element **32** confront the furnace chamber for efficient heat radiation. If the heaters were arranged such that the elements **32** were disposed with their edges facing across the furnace chamber **10**, radiation would occur primarily from these edge surfaces. The heat being radiated from the broader surfaces of the ribbon elements would not be efficiently employed, as the adjacent heating elements would be radiating toward one another. Similarly, if the heaters were disposed with the broad surfaces of elements **32** facing orthogonally across the furnace chamber, radiation from the broader surfaces of the sinuous ribbon elements would be inefficient as the confronting heated surfaces of each ribbon element would be radiating toward one another. By angular disposition of the heating elements within the furnace chamber, the broad surfaces of the ribbon elements confront the furnace chamber to a greater extent than other dispositions, with the result of achieving a more optimum heat efficiency.

It will be evident that the invention can be embodied in a variety of furnace structures to suit particular heat processing requirements and that various modifications and alternative implementations of the invention will occur to those versed in the art. Accordingly, it is not intended to limit the invention by what has been particularly shown and described except as indicated in the appended claims.

What is claimed is:

1. A heat treating furnace comprising:

an elongated furnace of insulative material defining a furnace chamber and having a hearth in said chamber along which a work product is conveyed, a roof, and a plurality of piers spaced along the length of said chamber on respective opposite sides thereof for support of said roof;

an array of modular easily replaceable heating elements disposed in said furnace chamber along the active length thereof, each heating element being disposed between adjacent ones of said piers;

each of said heating elements including:

a sinuous ribbon of high temperature metal adapted to be electrically heated to an operating temperature and for disposition in said furnace chamber;

a mounting collar of electrically and thermally insulative material supporting said ribbon and cooperative with a receptacle portion of said roof for maintaining said ribbon in said furnace chamber for radiation into said chamber; and

first and second leads integrally formed with said sinuous ribbon and disposed outside of said chamber and adapted for connection to a source of electrical energy;

each of said piers being tapered from said roof to said hearth to permit radiation by said heating elements

to adjacent ones to provide an effectively continuous array.

2. A heat treating furnace according to claim 1 wherein said sinuous ribbon is supported on said mounting collar by metal straps extending along the length of said collar, said straps being in contact with the receptacle portion of said furnace roof to maintain said receptacle portion and the confronting surface of said mounting collar in spaced relationship.

3. A heat treating furnace according to claim 1 wherein each of said heating elements is disposed with said sinuous ribbon angularly disposed within said furnace chamber to permit efficient radiation from the broad surfaces thereof into said chamber.

4. A heat treating furnace according to claim 1 wherein each of said heating elements further includes:

at least one elongated metal strap secured along the portions of said sinuous ribbon supported by said mounting collar and along said integrally formed leads and rigidly attached to said ribbon and to said mounting collar to provide a unitary structure.

5. A heat treating furnace according to claim 4 wherein said sinuous ribbon is of recurvate configuration having two outer loops disposed away from said mounting collar and an inner loop confronting said mounting collar; and

a metal strap supporting said inner loop and secured to said mounting collar.

6. A heat treating furnace according to claim 1 wherein each of said heating elements includes:

at least one metal strap in contact with and rigidly attached to the portions of said sinuous ribbon supported by said mounting collar and to said integrally formed leads, said metal straps being operative to provide structural support for said heating element and efficient electrical leads.

7. A heat treating furnace comprising an elongated furnace of insulative material defining a furnace chamber and having a hearth in said chamber along which a work product is conveyed, and a roof;

an array of modular easily replaceable heating elements disposed in said furnace chamber along the active length thereof;

each of said heating elements including:

an elongated mounting collar of electrically and thermally insulative material;

a sinuous ribbon of high temperature metal adapted to be electrically heated to an operating temperature and axially extending from and supported by said mounting collar; and

first and second leads integrally formed with said sinuous ribbon and extending from said collar in a position opposite to that of said sinuous ribbon;

said mounting collar being cooperative with a receptacle portion of said roof for maintaining said ribbon in said furnace chamber for radiation therein, said first and second leads being in a position, with said sinuous ribbon in said furnace chamber, outside of said chamber and adapted for connection to a source of electrical energy;

a plurality of piers spaced along the length of said chamber on respective opposite sides thereof for support of said roof, each adjacent pair of piers being disposed on respective sides of a heating element;

each of said piers being tapered from a broader portion at said roof to a narrower portion at said hearth, with said taper being such to permit thermal radiation between adjacent ones of said heating elements and provide an effectively continuous array.

8. A heat treating furnace according to claim 7 wherein said sinuous ribbon includes first and second portions longitudinally confronting said elongated mounting collar;

and wherein each of said heating elements further includes:

at least one elongated metal strap confronting each portion of said sinuous ribbon confronting said mounting collar and also confronting said first and second leads; and

means for rigidly securing each of said elongated straps to the associated portion of said ribbon and leads and to said mounting collar to provide a unitary structure.

9. A heat treating furnace comprising an elongated furnace of insulative material defining a furnace chamber and having a hearth in said chamber along which a work product is conveyed, and a roof;

an array of modular easily replaceable heating elements disposed in said furnace chamber along the active length thereof;

each of said heating elements including:

an elongated mounting collar of electrically and thermally insulative material;

a sinuous ribbon of high temperature metal adapted to be electrically heated to an operating temperature and axially extending from and supported by said mounting collar;

said sinuous ribbon having a plurality of substantially parallel flat surfaces angularly disposed within and confronting said furnace chamber to permit efficient radiation from said flat surfaces into said chamber; and

first and second leads integrally formed with said sinuous ribbon and extending from said collar in a position opposite to that of said sinuous ribbon; said mounting collar being cooperative with a receptacle portion of said roof for maintaining said ribbon in said furnace chamber for radiation therein, said first and second leads being in a position, with said sinuous ribbon in said furnace chamber, outside of said chamber and adapted for connection to a source of electrical energy;

a plurality of supports spaced along the length of said chamber on respective opposite sides thereof for support of said roof, said supports being configured to permit thermal radiation between adjacent ones of said heating elements and provide an effectively continuous heater array.

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