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Andersen

[11] **3,833,208**

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[54] **MUFFLE FURNACE**

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[52] **U.S. Cl.** ..... **266/3 R,** 432/210

[51] **Int. Cl.** **C21d 9/56**

[58] **Field of Search** ..... 266/3 R; 432/210, 120, 432/194

[56] **References Cited**

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Assistant Examiner—DeWalden W. Jones
Attorney, Agent, or Firm—Vincent G. Gioia; Robert F. Dropkin

[57] **ABSTRACT**

A muffle furnace is disclosed which includes an elongated furnace having an elongated chamber or muffle contained therein with the muffle constructed of upper and lower segments connected at their sides to an elongated support which in turn is supported within the furnace by vertical supports spaced along its length. The upper and lower segments of the muffle are catenary-shape in cross section.

6 Claims, 4 Drawing Figures

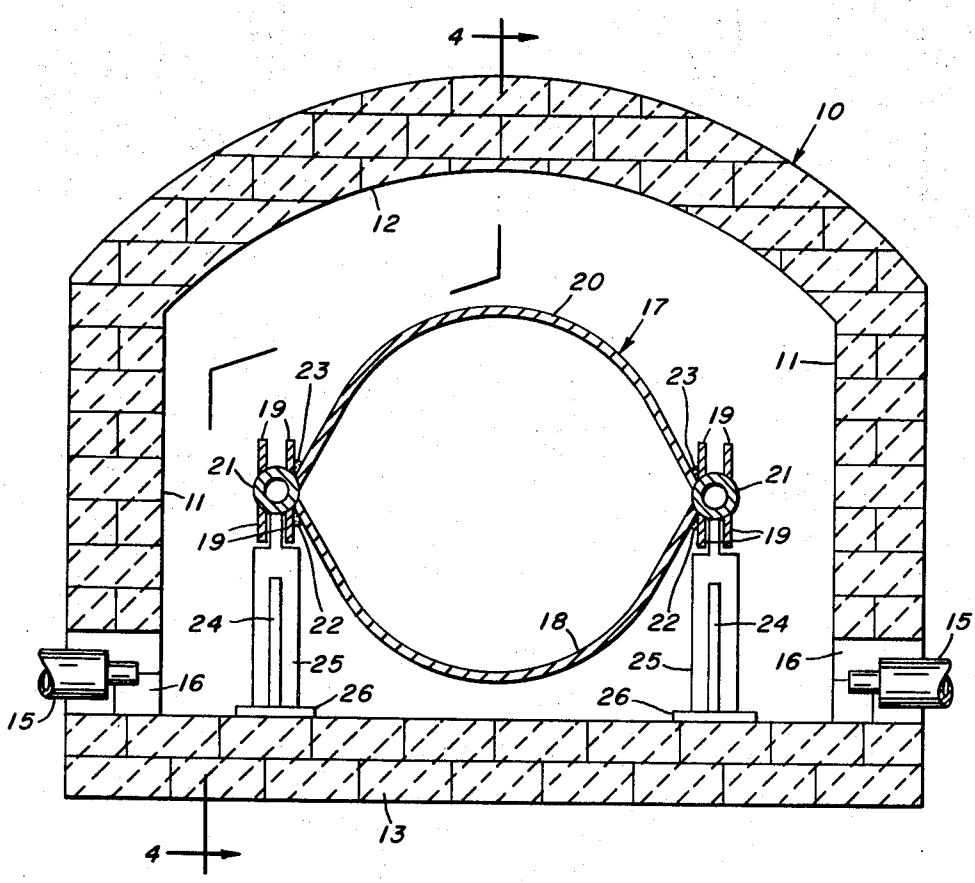


FIG. 1.

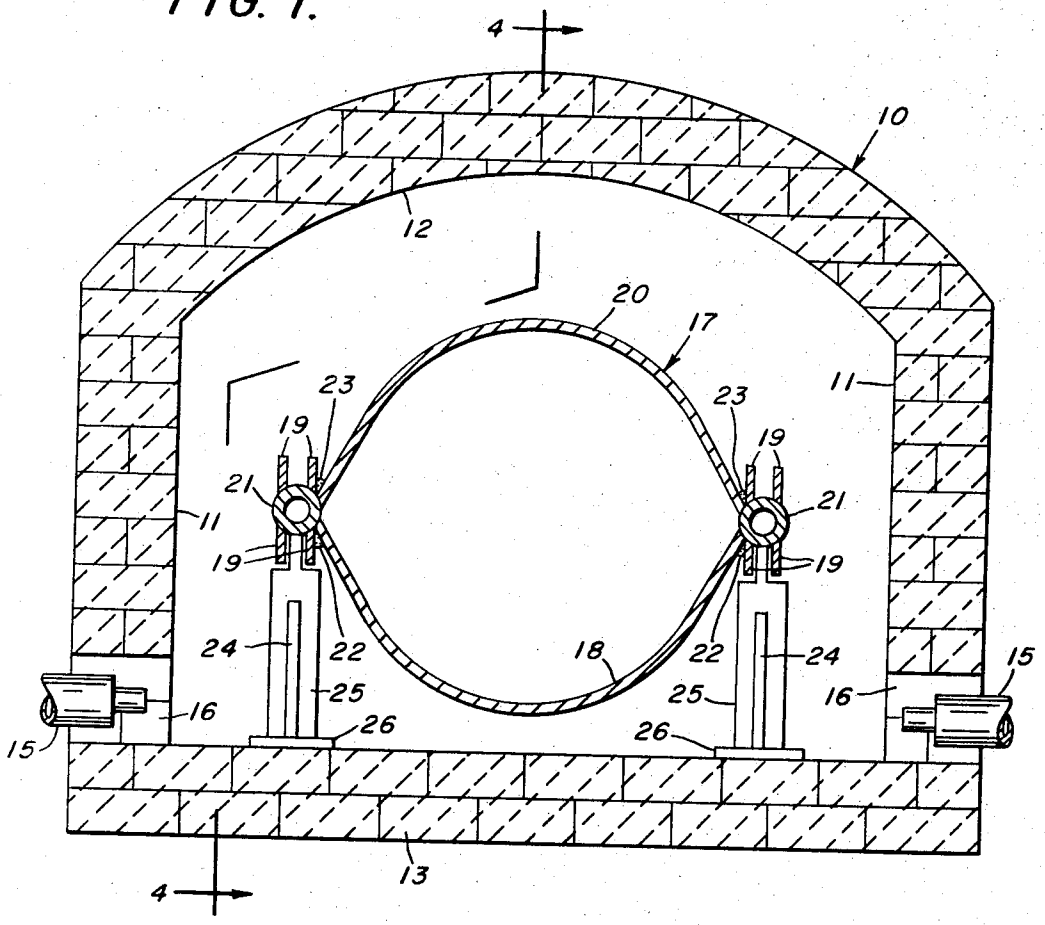

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FIG. 4.

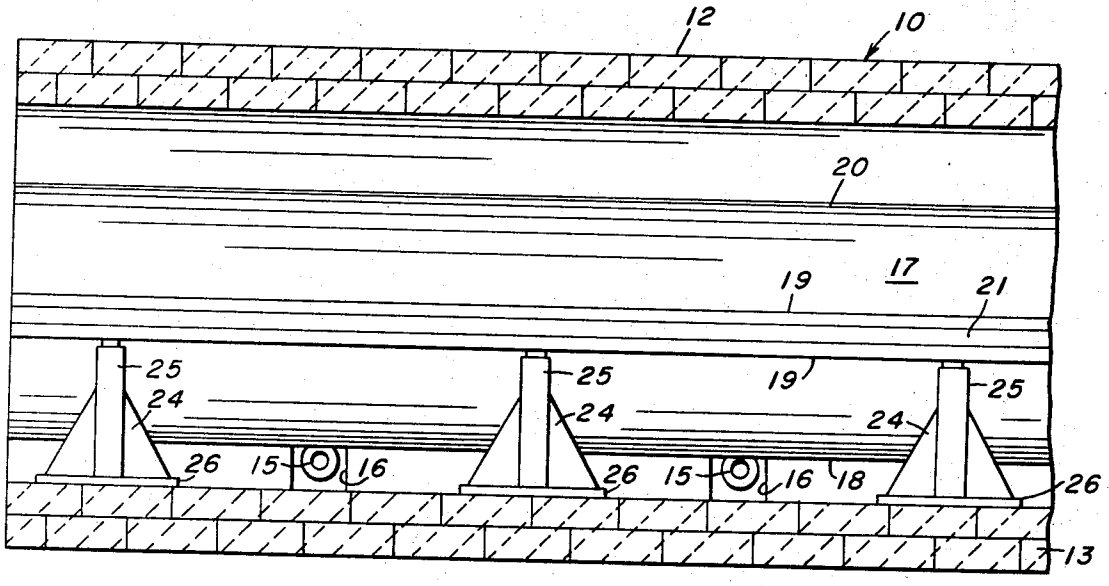

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FIG. 2.

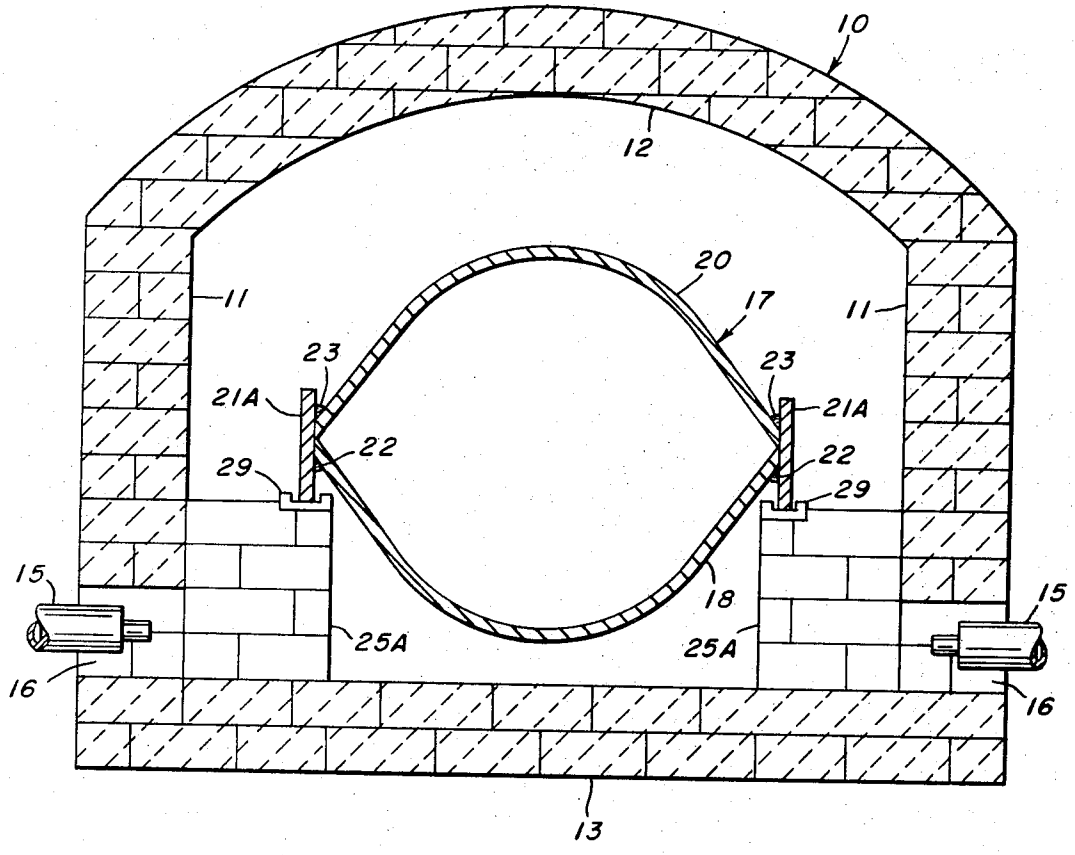
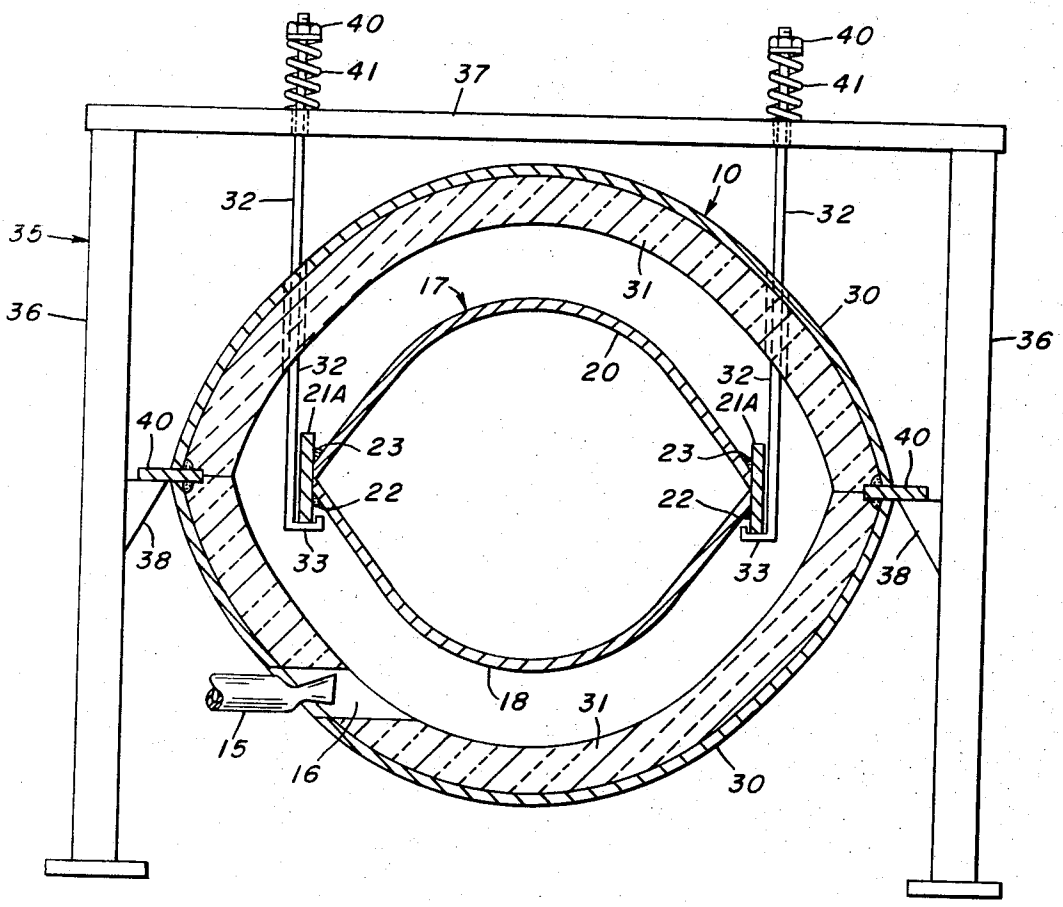


FIG. 3.


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21A
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MUFFLE FURNACE

BACKGROUND OF THE INVENTION

Muffle furnaces are furnaces constructed so that the materials being heated within them are shielded from flames and in some cases from oxidizing gases. Most muffle furnaces are constructed with compartments or baffles within a fired furnace so that the flue gases may heat the interior portion of the muffle without actually entering it.

Muffle furnaces for continuous processes or for processes wherein the heated piece is very long present special problems. Typical of these processes is bright annealing of metal strip. To bright anneal a metal strip, a shielded chamber must be provided that is long enough for an annealing process to occur while the strip is in transit through the muffle, or if it is not a continuous strip, the muffle must be long enough to contain the strip. Bright annealing of ferrous metals is generally effected at temperatures in the neighborhood of 2,000°F.

Presently muffle furnaces for strips are constructed of long tubular muffles supported within elongated furnaces that are suitably fired and suitably insulated. It is essential that the muffles be fabricated of metals having adequate tensile strength at the annealing temperatures, such as the alloy known as INCONEL 600. However, even metals with adequate tensile strength have dimished creep resistance at the high temperature. Creep resistance is the slow distortion of metal when subjected to stresses for a long period of time. Muffles for continuous processing generally must be made of metal to obtain good heat transfer and gas sealing characteristics to provide a reasonably inexpensive structure.

Muffles made of long tubes of INCONEL with circular cross section are supported by saddle-like supports spaced appropriately to maintain the muffles with minimum sagging. The saddles in turn are supported from the floor of the furnace by support legs. The muffles are usually circumferentially corregated for rigidity and provided with interior devices for conveying a strip through them. It is important to have a muffle spaced from the furnace in order to obtain circulation of hot gas around it so that adequate and even heat transfer through the wall may be maintained.

Two serious problems have been encountered in the structures of muffle furnaces for bright annealing. Both of these problems have to do with the diminished creep resistance of the muffle at annealing temperatures. One problem is the tendency of the muffle shell to distort around the saddles in the form of indentations into the muffle shell, caused by localized high stresses on the muffle shell where the saddles support it. The other problem is the tendency of the upper part of the muffle to flatten from a circular to an eliptical shape caused by bending forces introduced into the circular muffle wall by its own weight. Operation of muffle furnaces that are so constructed usually requires rotation of the muffle about its longitudinal axis periodically to permit creep in opposite directions to effect some straightening and thereby to keep the muffle operative.

THE INVENTION

This invention is a muffle furnace that is constructed to avoid or greatly mitigate the above noted problems. The muffle furnace of this invention, as in the prior art, includes an elongated furnace, usually of a refractory brick material having heat generating means such as one or more burners maintained within it. Also within the furnace is an elongated metal muffle constructed of a lower segment of catenary cross section, an upper segment of catenary cross section and two rigid side support elements, all of which are connected together to form an enclosed chamber. In addition, this invention includes vertical supports within the furnace for holding the muffle above the furnace floor by engaging and supporting the rigid side support elements.

The term *catenary* is used in this specification and the appended claims in its usual sense. A catenary is a curve that would be made by a free hanging chain suspended at both ends. It is of course obvious that reasonable departures from perfection are intended to be included within the scope of the claims herein and that the term *catenary* is intended to have some latitude. The upper segment of catenary cross section and the lower segment of catenary cross section may also be corregated with circumferential corregations to provide a stiffer wall, although such corregations are less needed than in prior art muffles.

The longitudinal side support elements may be any rigid member that runs substantially the length of the muffle, one on each side, preferably diametrically opposed. The simplest side support member is a tubular member which may form part of the muffle by being welded separately to the top catenary segment and the bottom catenary segment. The supports may also be plate-like elements, I-beams, angles or of any other shape. The criterion for the size and shape of the side support elements is that they must have sufficient rigidity to support the muffle when the side support elements themselves are supported by a series of spaced vertical supports within the furnace.

The vertical supports within the furnace generally are discontinuous in order to promote good circulation of hot gas around the muffle. In simplest form the vertical supports will be short metal pieces of appropriate square, round or I-beam cross section; however, brick columns or shelves built out from the furnace wall or built onto the furnace floor may also be employed. The vertical supports may be hangers suspended from the top of the furnace. The vertical supports must engage the side supports in a manner that allows for thermal expansion of the muffle.

The structure described above is resistant to creep distortion at high temperatures because its shape conforms to the direction in which the metal is stressed: in this case pure tension in the lower segment and pure compression in the upper segment, with no bending moments introduced at any points of the catenary segment. Supporting the bottom catenary section by its edges instead of by a saddle beneath it provides that all strain on the bottom segment that would cause distortion will resolve itself into a component of force substantially tangential to the cross section at any point. Thus, with the bottom segment made in the curve in which it would hang if it were absolutely flexible, adding increments of flexibility by such means as diminished wall stiffness will not cause its shape to change. Also, removing saddles as supports avoids local stresses that are different than those created by the weight of the bottom section of the muffle shell and avoids distortion of the muffle at its point of support.

Similarly, it has been found that the stresses on the upper segment due to its own weight are such that resolution of these forces results in a component that approximately follows the tangent to the catenary-shaped cross section at all points. Thus, the furnace of this invention may be constructed of material with adequate tensile strength to resist the strains imposed on it, and after long periods of use there will be very little or no distortion of the muffle due to diminished creep resistance at the high temperature of use.

DETAILED DESCRIPTION OF THE INVENTION

The invention may be better described with reference to the accompanying drawings illustrating several useful embodiments of it.

FIG. **1** is an elevation end view of a furnace embodying this invention in cross section.

FIG. **2** is an elevation end view of another furnace embodying this invention in cross section.

FIG. **3** is an end elevation view of another furnace embodying this invention.

FIG. **4** is a partial elevation side view of the furnace illustrated in FIG. **1** taken along the line **4—4.**

Referring first to FIGS. **1** and **4,** there is illustrated a furnace generally designated **10** and constructed of conventional brickwork. The furnace is illustrated in simplified form and is not intended to illustrate wall thicknesses, linings or any other of the conventional construction features of a furnace. The furnace **10** includes a wall **11,** a roof **12** and a floor **13** to form a complete enclosure. The furnace is provided with burners **15** positioned in ports **16** so that air-fuel mixtures may be burned within the interior of the furnace **10.**

Within furnace **10** a muffle generally designated as **17** is supported. The muffle comprises a lower segment **18** and an upper segment **20,** both of which are catenary-shape in cross section. A side support element **21** in the form of a thick-walled tube is connected to the lower segment **18** by weld **22** and to the upper segment **20** by weld **23.** The upper and lower segments of the muffle and the portion of the side support **21** between them form a closed chamber that shields material within it from the flames or the hot oxidizing gases within the confines of the furnace **10.**

The muffle **17** is supported within the furnace **10** so that there is open space above it, beneath it and around both sides of it. Supporting the muffle **17** is accomplished by vertical supports **25** which engage side support elements **21** between holding elements **19** and maintain them above the floor **13** of the furnace. A suitable plate **26** is illustrated to hold the vertical support **25** and plate **26** may be adapted to be fixed to the furnace floor **13** and is welded to the base of vertical support **25.** Side elements **24** are employed to hold vertical supports **25** upright when the muffle **20** elongates due to thermal expansion and slides along the top of vertical supports **25.**

From FIGS. **1** and **4** it is evident that lower segment **18** is a free hanging segment of the muffle **17** suspended between opposing side supports **21,** and since its cross section is in the shape of a catenary, it is already in the shape toward which it would move if under sufficient stress to creep, and as such the use of muffle **17** at high temperature should not affect the shape of lower segment **18.** Although it is not as evident from inspection, the catenary-shaped cross section of upper segment **20** is also a shape which normal stresses would cause it to assume by creep.

It is also evident from FIGS. **1** and **4** that the manner of supporting muffle **17** on vertical supports **25** does not involve a fixed connection between the two. Since thermal expansion of the muffle may exceed one foot, the arrangement shown where the muffle may slide on the vertical supports will accommodate to such expansion.

FIGS. **2** and **3** illustrate other embodiments of the invention which may be employed. In FIG. **2** lower segment **18** and upper segment **20** of the muffle **17** are connected to a plate-like side support element **21A** by welds **22** and **23.** As with the embodiment of FIG. **1,** welds **22** and **23** participate in sealing the interior of muffle **17** from the gases within furnace **10.** Support element **21A** is made rigid with respect to horizontal forces by being connected to muffle **17** and its vertical dimension is sufficient to support the muffle **17.** FIG. **2** also illustrates that vertical support **25A** which supports the muffle **17** may be constructed of brick. It is contemplated that supports **25A** will be small, spaced columns protruding from side wall **11** of the furnace **10** rather than a continuous shelf so that free circulation of hot gases around the muffle **17** is insured. A skid plate **29** is also employed on each column **25A** to provide a suitable surface on which side supports **21A** can slide when the muffle expands.

FIG. **3** illustrates another embodiment of this invention. In FIG. **3** a lightweight furnace is constructed of a metal shell **30** that is lined with lightweight insulation **31** such as mineral wool. A muffle constructed like the muffle shown in FIG. **2** is maintained, but it is supported from hangers **32.** Hangers **32** are illustrated with hook-like bottom elements **33** so that no direct connection between the side supports **21A** and the hangers **32** is required. Thus, muffle **17** may expand and slide with respect to hangers **32.**

Exterior supports **35** may be employed to support the furnace **10** and the muffle **17.** The exterior support includes vertical columns **36,** a beam **37** and brackets **38.** As illustrated, flanges **40** extend from the furnace and rest on brackets **38** whereby the furnace **10** is supported above grade. The muffle **17** is supported independently of the furnace **10** by hanging from beam **37.** The height of muffle **17** with respect to furnace **10** may be regulated by nuts **40** operating through springs **41** which operate to absorb shocks in the vertical loading of muffle **17.**

An advantage of the embodiment of FIG. **3** is that substantially all of the supporting structure is cool, and accordingly it need not be made of special material or of large cross section. Columns **36,** brackets **38** and beam **37** are all much cooler than furnace temperature. Metal shell **30** and flanges **40** are likewise cool. Even hangers **32** are cool except for the very short length within furnace **10.**

A particular advantage to the embodiments shown herein is that the muffles are symmetrical about a horizontal plane through the intersection lines of the upper and lower catenary segments. This symmetry permits the muffles to be turned upside down occasionally which substantially increases their effective lives. Even though the catenary shape of lower segment **18** will be maintained throughout its life, there is a tendency for the lower segment to become longer. It is evident that the useful life of muffle **17** could be about doubled if

each of segments **18** and **20** could act as the bottom segment for about the same length of time.

What is claimed is:

1. A muffle furnace comprising:

A. an elongated furnace having heat generating means therein,

B. an elongated metal muffle constructed of a lower segment of catenary cross section, an upper segment of catenary cross section and opposed rigid side support elements with said upper segment, lower segment and support elements connected to form an enclosed chamber within said furnace, and

C. vertical supports within said furnace adapted for supporting the rigid side support elements.

2. The muffle furnace of claim **1** wherein each of the side support elements is a tube.

3. The muffle furnace of claim **1** wherein continuous welds connect the upper segment and the lower segment to the support elements.

4. The muffle furnace of claim **1** wherein each of the side support elements is a plate.

5. The muffle furnace of claim **1** wherein said vertical supports are hangers.

6. The muffle furnace of claim **1** wherein said muffle is symmetrical about a horizontal plane through the intersection lines of the upper and lower segments.

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