Aug. 19, 1969 M. JACOBS ET AL 3,461,847

AUTOMATIC FURNACE TEMPERATURE CONTROL

Filed Dec. 22, 1967 2 Sheets-Sheet 1

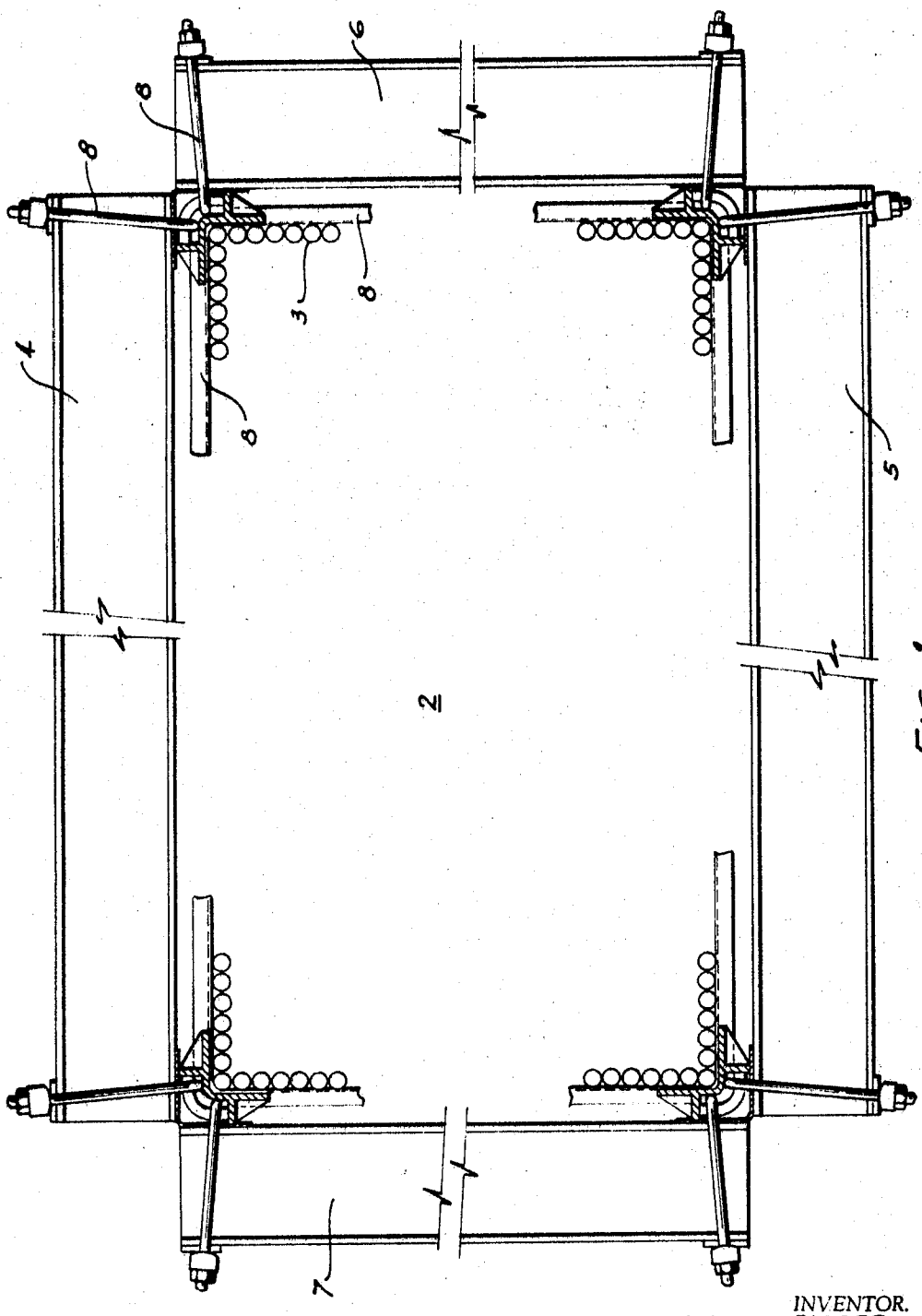


FIG-1

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AUTOMATIC FURNACE TEMPERATURE CONTROL

Filed Dec. 22, 1967 2 Sheets-Sheet 2

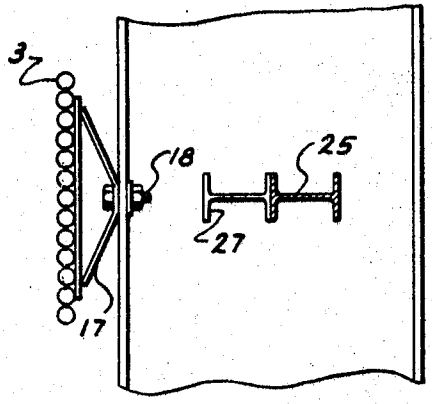


FIG-3

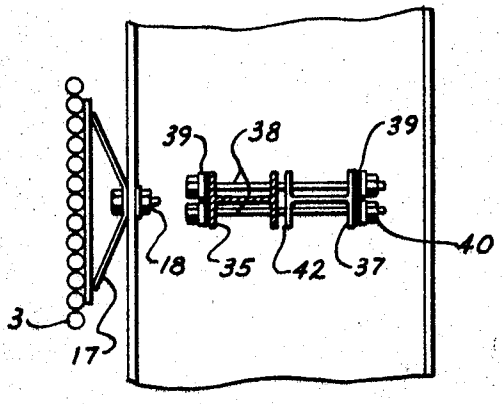


FIG-5

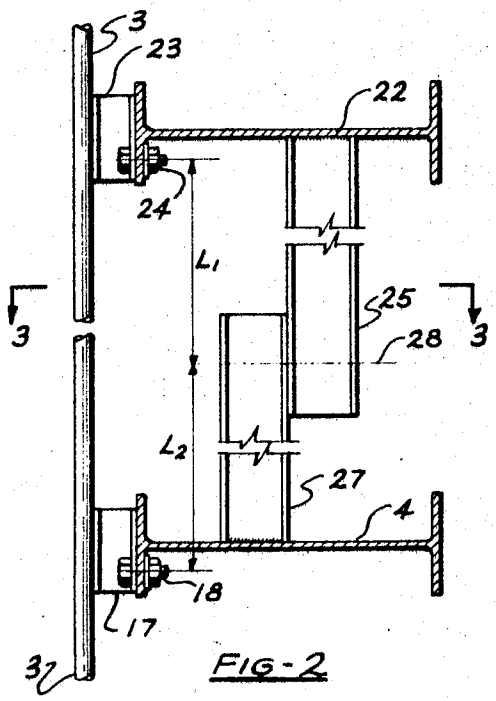


FIG-2

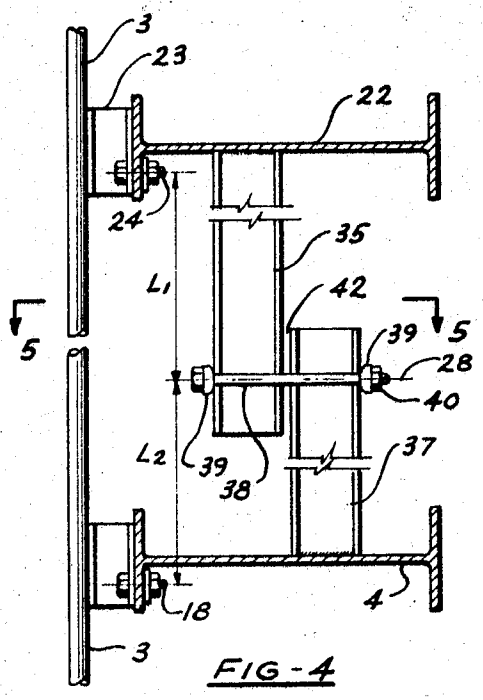


FIG-4

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3,461,847

AUTOMATIC FURNACE TEMPERATURE CONTROL

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Int. Cl. F22b 37/24
U.S. Cl. 122—510 6 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for maintaining the buckstays of a steam generator level. Upper and lower buckstays are eccentrically supported from vertically expanding steam generator furnace walls. A first rigid member extends vertically downward from the upper buckstay and a second rigid member extends vertically upward from the lower buckstay. The bending moment of each buckstay around its support is resisted by the horizontal force acting between the two vertical members. This force may be transmitted by having the members in sliding contact or by the use of a sliding, bending or preferably rotating bolt.

Background of the invention

This invention relates to steam generators and in particular to an apparatus for maintaining the buckstays thereof level without excessive bending forces on the buckstay supports. Large steam generators generally have furnaces which are lined with steam generating tubes and which are supported from the top of the unit. As the unit approaches operating temperature, the furnace structure expands vertically downward as well as horizontally. Some units operate with pressure in the furnace at all times while others operate with negative furnace pressure. In either case provision must be made for temporary high pressure excursions within the furnace due to minor furnace explosions or pressure increases due to the lighting of an additional burner. These pressures would tend to distort the furnace structure causing high stresses at various points and breaking insulation were not some means provided to stiffen the furnace structure. Therefore buckstays are generally used. These buckstays are stiff members located outside the furnace structure and supported from it thus limiting furnace wall distortion. Since furnace pressure acts on all furnace walls, the buckstays on opposite walls must be connected through buckstay ties so that the reactions of one buckstay are resisted by the reactions of the opposing buckstay.

The vertical expansion of a large steam generator is in the order of 12 inches throughout its height. Horizontal expansion of the furnace walls also occurs. The buckstays being positioned outside the furnace are at lower temperatures and do not expand to the same extent as the furnace walls. Therefore it has become accepted practice to support these buckstays from the furnace wall tubes at various elevations so that each buckstay moves vertically with the furnace wall tubes an amount depending on the vertical expansion of the steam generator for the particular buckstay elevation. Horizontally the buckstay is fixed to the furnace wall at one location and permitted to slide with respect to the furnace wall at other supports. The tie between opposing buckstays is arranged in close proximity with the furnace wall so that the tie rod structure approaches the furnace wall temperature. In this fashion, horizontal movement of opposing buckstays approximates the furnace expansion.

The support of these large buckstays from the furnace wall is an eccentric support with the buckstay weight causing a bending moment around the support. Additional forces may be imposed on the buckstays, as for example, where they are used for supporting pipes or other members. Resisting the bending moment at the support would lead to high forces on the support members. This would interfere with the sliding action which is required due to the relative expansion between the furnace wall structure and the buckstays, and would also put a very high localized bending moment, and therefore high stresses, in the furnace wall tubes.

It has therefore been conventional to supply other means to resist this bending moment. Generally a vertical member extends downwardly from the upper buckstay to a lower buckstay leaving a few inches clearance from the lower buckstay. A clip on this lower buckstay interacts with the vertical member from above so as to resist the bending moment of the upper buckstay and resolve it into a force normal to the furnace wall. This is repeated throughout the height of the unit with three or four vertical members being positioned between each pair of buckstays. The lowest buckstay has vertical members extending upwardly as well as downwardly from the buckstay above. In this fashion, the bending moment of the lower buckstay is resolved into a normal force at the buckstay elevation above and vice versa.

With such an arrangement, vertical buckstay levelers must pass through the entire height of the unit in segments, therefore producing a general clutter and limited access throughout the entire height of the unit. Considerable material is also required since these vertical members must pass through the entire height of the unit.

Summary of the invention

Our invention comprises an arrangement of members to resist the bending moment due to the buckstay weight. The bending moments of an upper and lower buckstay are each used to counteract each other through vertically extending members. Horizontal forces are transmitted between these vertical members at a location where the bending moment for each buckstay supplies the proper resisting force for the other buckstay. This arrangement is repeated throughout the elevation of the steam generator with the buckstays operating in pairs thereby limiting the need for vertical members to one-half the height of the unit.

It is an object of our invention to resist the bending moment of a buckstay around its support without excessive forces on the support.

It is a further object to minimize the material requirement to accomplish buckstay leveling.

It is a still further object to avoid clutter and limited access to the steam generator.

Brief description of the drawings

FIGURE 1 is a plan view through a steam generator furnace showing the general arrangement of buckstays;

FIGURE 2 is a side elevation of a buckstay leveler;

FIGURE 3 is a sectional view through the buckstay leveler of FIGURE 2;

FIGURE 4 is a side elevation of a buckstay leveler using a tension bolt; and

FIGURE 5 is a sectional plan view through the buckstay leveler of FIGURE 4.

Description of the preferred embodiments

FIGURE 1 being a sectional plan view of a steam generator shows furnace 2 which has its walls lined by a plurality of vertical steam generating tubes 3. These tubes extend throughout the height of the steam generator and expand longitudinally as the unit comes up to temperature. Since the parallel furnace wall tubes are interconnected laterally by welding adjacent tubes together,

the furnace will also expand horizontally. To retain the square furnace shape under internal furnace pressure, opposing buckstays 4 and 5 are positioned on opposing walls while opposing buckstays 6 and 7 are positioned on the adjacent pair of opposing walls. These buckstays are supplied at a number of elevations and are supported in the manner illustrated in FIGURES 2 and 4. An increased furnace pressure tends to force the tubes outwardly against buckstay 4, and this buckstay remaining rigid prevents the tubes from moving outwardly. Buckstay 5 performs the same function on the opposing wall. Buckstay ties 8 are connected to each end of each buckstay so that the force tending to move buckstay 5 to the right is opposed by the force tending to move buckstay 4 to the left. These buckstay ties 8 are formed in several parts with one part maintained in close relationship with the furnace wall so that it approaches tube temperature through their co-extensive portion, and the buckstay tie expands to the same extent that the furnace expands horizontally. This permits the buckstays to move outwardly from each other as the furnace expands whereby the buckstays maintain the same spaced relationship with their adjacent furnace wall tubes.

Referring to FIGURE 2, lower buckstay 4 is supported from the furnace wall tube 3 by stirrup 17 and bolt 18. A fixed connection is provided near the centerline of the furnace while at other locations a slotted hole is provided so that the furnace may expand horizontally with relation to the buckstay. The weight of the buckstay 4 produces a bending moment to the right around the supporting bolt 18. Use of an additional bolt above support 18 could conceivably resist this bending moment but would produce substantial forces in the support connections. A considerable concentrated bending moment would be put on the tubes 3; and since these tubes contain high pressure water and steam and are exposed to furnace radiation, such high stresses are intolerable.

An upper buckstay 22 is similarly supported from tubes 3 through stirrup 23 and bolt 24. This buckstay 22 similarly has a bending moment to the right caused by its own weight. A vertical I beam 25 is welded to the upper buckstay 22 and extends vertically downward. A vertical I beam 27 is welded to the lower buckstay 4 extending vertically upward with this I beam being parallel to I beam 25. These beams are so located that they are in sliding contact at an intermediate elevation 28.

The bending moment due to the weight of the upper buckstay 22 is opposed by a horizontal force imposed on I beam 25 at elevation 28. This force is imposed by I beam 27 at an inboard location with respect to the furnace acting on I beam 25 with a force having a vector to the right. An equal and opposite horizontal force vector to the left is imposed on vertical I beam 27 by the vertical I beam 25. This force resists the bending moment caused by the weight of lower buckstay 4.

Since I beams 25 and 27 remain at ambient temperature while furnace wall tubes 3 are heated to some 700° F., provision must be made for vertical expansion difference between the lower and upper buckstays. Therefore I beams 25 and 27 are in sliding contact. The point of contact at elevation 28 is selected so that the horizontal force imposed is sufficient to counteract the bending moments of each buckstay. Where the buckstays are of equal weight and have equal bending moments, the difference between the support elevation of the upper buckstay and the intermediate elevation designated by L_1 is equal to the vertical distance between the intermediate elevation 28 and the support elevation of the lower buckstay as designated by L_2. Where different bending moments exist in the two buckstays, the vertical differences L_1 and L_2 should be in inverse proportion to the bending moment of each buckstay around their respective supports. If additional loads are imposed on the buckstays, such as piping supports, these loads should be considered in determining L_1 and L_2 so as to arrive at the proper intermediate elevation 28 such that the force transmitted horizontally is proper for opposing the bending moments of each of the buckstays.

Similarly buckstays 5, 6 and 7 are coupled with corresponding buckstays at an upper elevation and use a construction similar to that illustrated in FIGURES 2 and 3. The remaining buckstays on the steam generator at various elevations are treated in pairs in the same manner as buckstays 4 and 22.

The horizontal force to the right imposed on I beam 25 results in a force away from the furnace walls on the upper buckstay 22. The same force acting in the other direction from I beam 27 imposes a force towards the furnace walls on lower buckstay 4. In order to avoid any necessity of the furnace wall structure taking these horizontal loads, the identical arrangement, as shown in FIGURE 2, is used on the opposite side of the unit with buckstay 5 being directly opposite buckstay 4 and with another buckstay being directly opposite buckstay 22. The horizontal force thus imposed on the upper and lower buckstays is therefore transmitted through tie rods 8 precluding any need for the introduction of these horizontal forces into the furnace wall tubes 3.

FIGURES 4 and 5 illustrate an alternate arrangement wherein lower buckstay 4 is again supported from the furnace wall tubes 3 through stirrups 17 and support bolts 18. Upper buckstay 22 is also supported from the furnace wall tubes 3 through stirrups 23 and support bolts 24. A vertical member 35 is rigidly welded to the upper buckstay 22 and extends vertically downward. A vertical member 37 is rigidly welded to the lower buckstay 4 and passes vertically upward being generally parallel with the upper member 35 and being on the outboard side of member 35 with respect to the furnace. Holes are drilled in each of the vertical members at the intermediate elevation 28 with this elevation being selected as previously described to properly counteract the bending moments of each buckstay around its respective support. Tie bolt 38 passes through the two vertical members and operates in tension. Rocker washers 39 are supplied and nut 40 is tightened approximately hand-tight and spot welded in place to prevent loosening. A slight clearance 42 is provided between the two vertical members. As the steam generating unit reaches temperature, the lower and upper buckstays 4 and 22 tend to move vertically apart from one another. Bolt 38 being connected to each of these members rocks on washers 39 thereby maintaining its ability to transmit horizontal forces while permitting free relative movement in the vertical direction. While this arrangement using rocker washers is preferred, the same result could be achieved by using a slotted opening permitting sliding movement or by using a long enough bolt so that that flexibility within the bolt would permit the vertical movement.

While we have illustrated and described a preferred embodiment of our invention it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. We therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of our invention.

What is claimed is:

1. An apparatus for maintaining level the buckstays of a steam generator having a vertically expanding furnace structure, said steam generator having a first buckstay at an upper elevation, a first support eccentrically supporting said first buckstay from the furnace structure; said steam generator also having a second buckstay at a lower elevation, and a second support eccentrically supporting said second buckstay from said furnace structure comprising: a first member rigidly fastened to said first buckstay and extending downwardly; a second member rigidly fastened to said second buckstay and extending upwardly; means for mounting said first and second

members for transmitting horizontal force between said first and second members at an intermediate elevation between said first and second buckstay elevations, said intermediate elevation being a vertical distance from said first and second supports in inverse proportion to the bending moment of said first and second buckstays around their respective supports.

2. An apparatus as in claim 1 wherein the bending moment of each buckstay around its respective support is equal and the horizontal force is transmitted at an elevation equidistant from said first and second support elevations.

3 An apparatus as in claim 2 wherein the bending moment of each buckstay around its support is due only to the weight of the buckstay and each buckstay is of equal weight.

4. An apparatus as in claim 1 wherein said first member comprises a vertical beam welded to said first buckstay and extending vertically downward; said second member comprises a vertical beam welded to said second buckstay and extending vertically upward; said first and second members being parallel and in sliding contact with said first member being outboard from the furnace structure of said second member.

5. An apparatus as in claim 1 wherein said first member comprises a vertical beam welded to said first buckstay and extending vertically downward; said second

member comprises a vertical beam welded to said second buckstay and extending vertically upward, said first and second members being parallel and in slightly spaced relationship, with said first member being inboard toward the furnace of said second member; and a rotatable bolt passing through said first and second members.

6. An apparatus as in claim 1 wherein said first and second buckstays, said first and second supports, and said first and second members comprise a buckstay structure; having also an identical buckstay structure on the opposite side of the furnace structure; buckstay ties connecting each end of the upper buckstay on one side of the furnace to the corresponding end of the upper buckstay on the other side of the furnace; and buckstay ties connecting each end of the lower buckstay on one side of the furnace to the corresponding ends of the buckstay on the opposite side of the furnace.

References Cited

UNITED STATES PATENTS

2,655,238	10/1953	Langvand.	
2,773,487	12/1956	Walter et al.	
3,301,225	1/1967	Boe et al.	122—510

KENNETH W. SPRAGUE, Primary Examiner

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,461,847 Dated August 19, 1969

Inventor(s) Martin Jacobs and Raul J. Roccatagliata

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, lines 2 and 3, of the patent, (Title Page, line 7 of the application), change "Automatic Furnace Temperature Control" to --Buckstay Leveler--.

Drawing sheets 1 and 2 change "Automatic Furnace Temperature Control" to --Buckstay Leveler--.

Column 4, line 53, of the patent, (Page 8, line 5 of the application), omit the second occurrence of "that".

SIGNED AND
SEALED
MAY 26 1970

(SEAL)
Attest:

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Commissioner of Patents