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Bauer et al.

[11] **3,823,875**

[45] **July 16, 1974**

[54] **BURNER NOZZLE TIP FOR PULVERIZED COAL AND METHOD FOR ITS PRODUCTION**

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[52] **U.S. Cl.** **239/419.5,** 29/455, 239/424.5, 239/553.5, 239/590.5

[51] **Int. Cl.** **F23d 13/36**

[58] **Field of Search** ..... 239/419.5, 423, 424, 424.5, 239/552, 553, 553.5, 590, 590.5; 29/157 C, 455, DIG. 5, DIG. 8; 122/333

[56] **References Cited**

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1,919,591	7/1933	Irish et al.	239/552 X
2,697,422	12/1954	Armacost	122/333
2,895,435	7/1959	Bogot et al.	239/424 X

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Assistant Examiner—Andres Kashnikow
Attorney, Agent, or Firm—Arnstein, Bluck, weitzenfeld & Minow

[57] **ABSTRACT**

A burner nozzle tip for a pulverized solid fuel combustion furnace is formed of a stainless steel, hollow, open ended cast outer shell and a replaceable stainless steel, weld-free, hollow, open-ended cast inner shell wherein at least one integrally cast, weld-free internal rib of the former engages at least one integrally cast, weld-free elongated rib of the latter to form a unitary concentric body. The nozzle tip is adapted for the projection of pulverized solid fuel and air through the inner shell, and air through the space between the inner and outer shells. A method for the production of a heat and erosion resistant tangential burner nozzle tip for a pulverized solid fuel combustion furnace is provided which includes casting the said shells and positioning the inner shell within the outer shell with each rib of the former engaging a rib of the latter whereby a unitary weld-free, concentric shelled burner nozzle tip is obtained.

10 Claims, 9 Drawing Figures

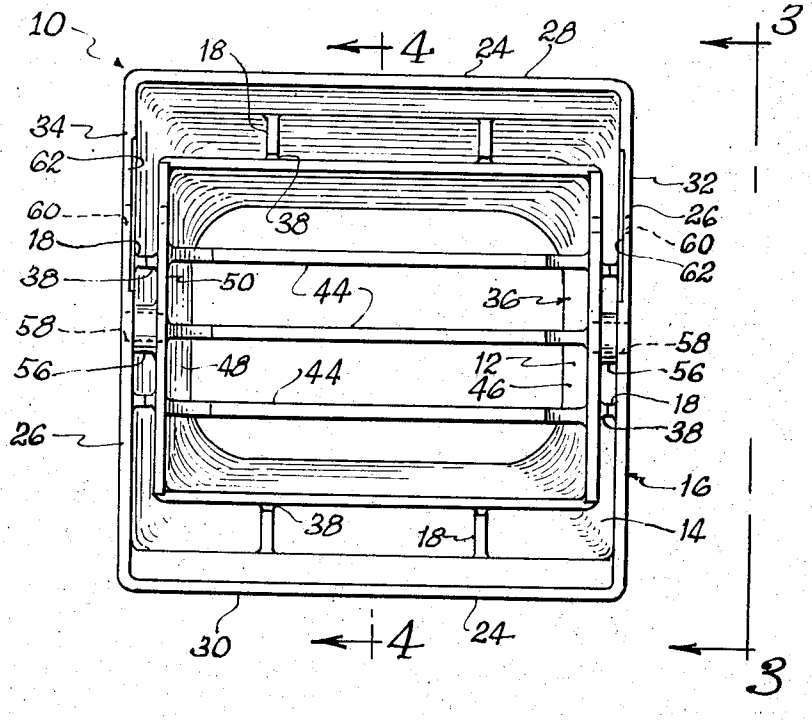


FIG. 1

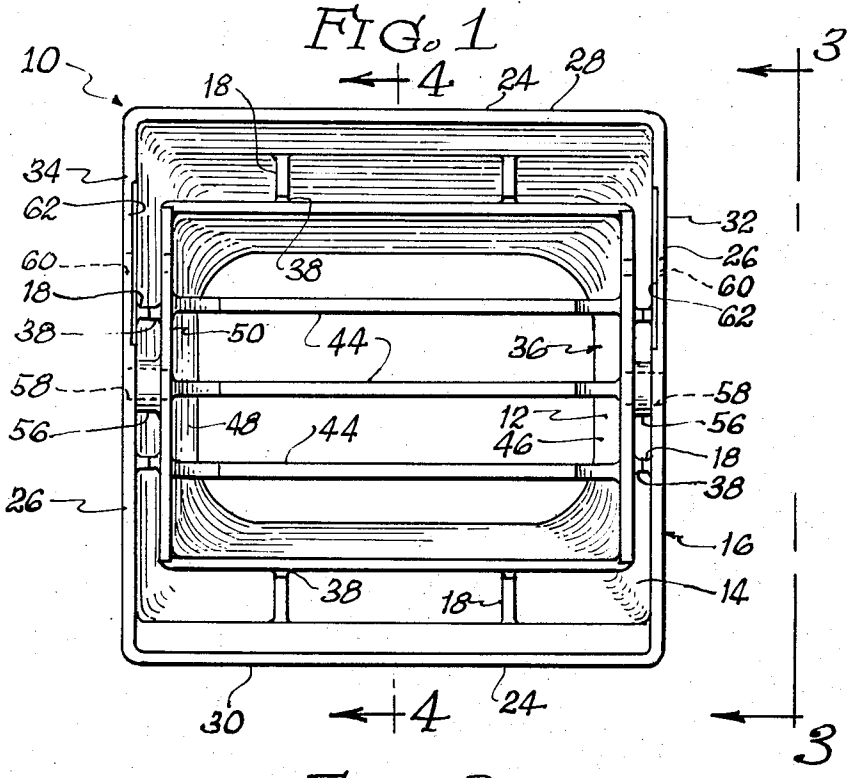

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FIG. 2

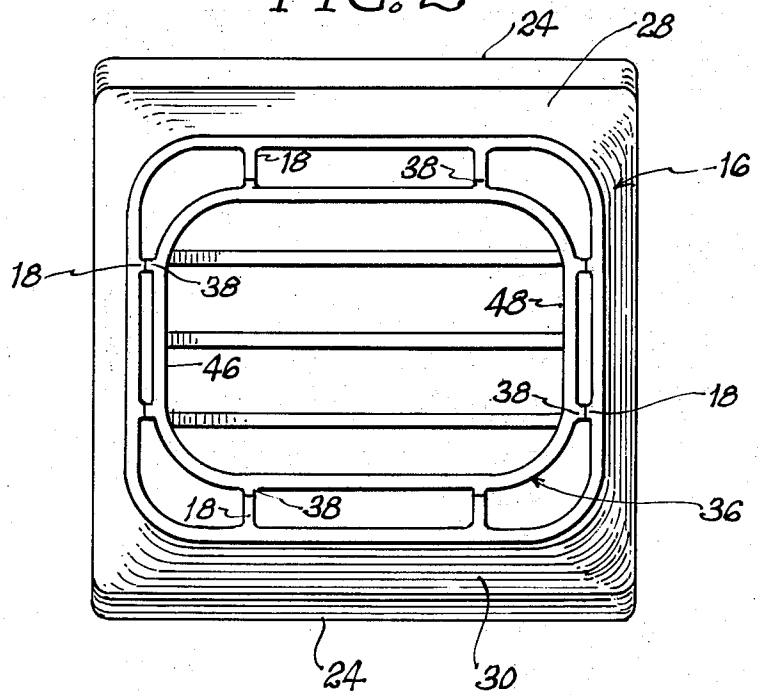

24
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FIG. 3

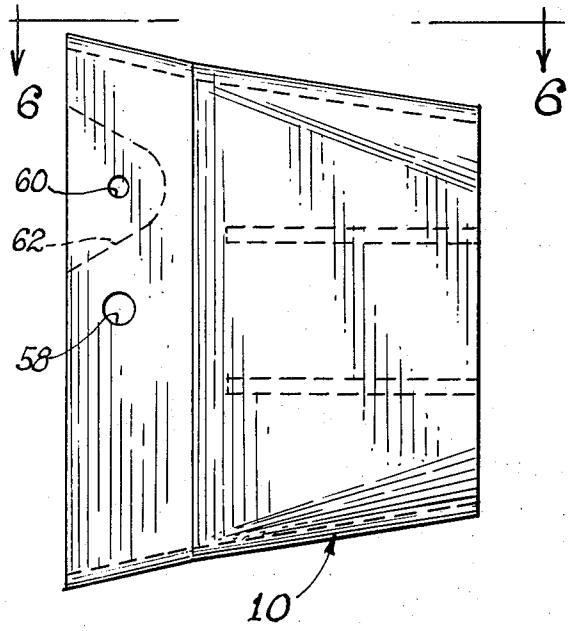


FIG. 4

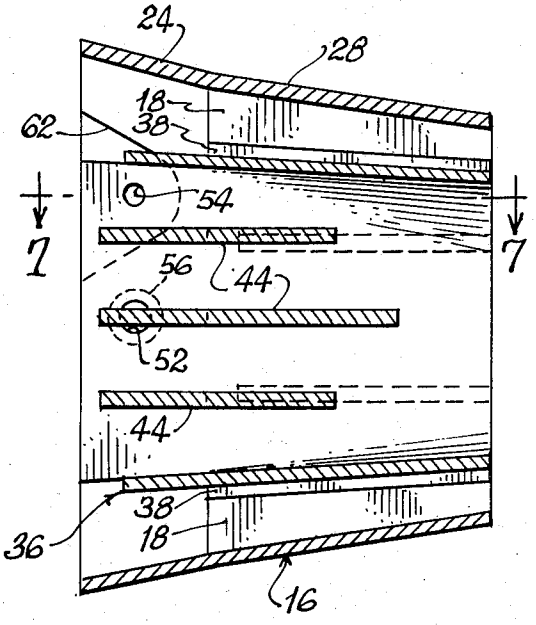


FIG. 5

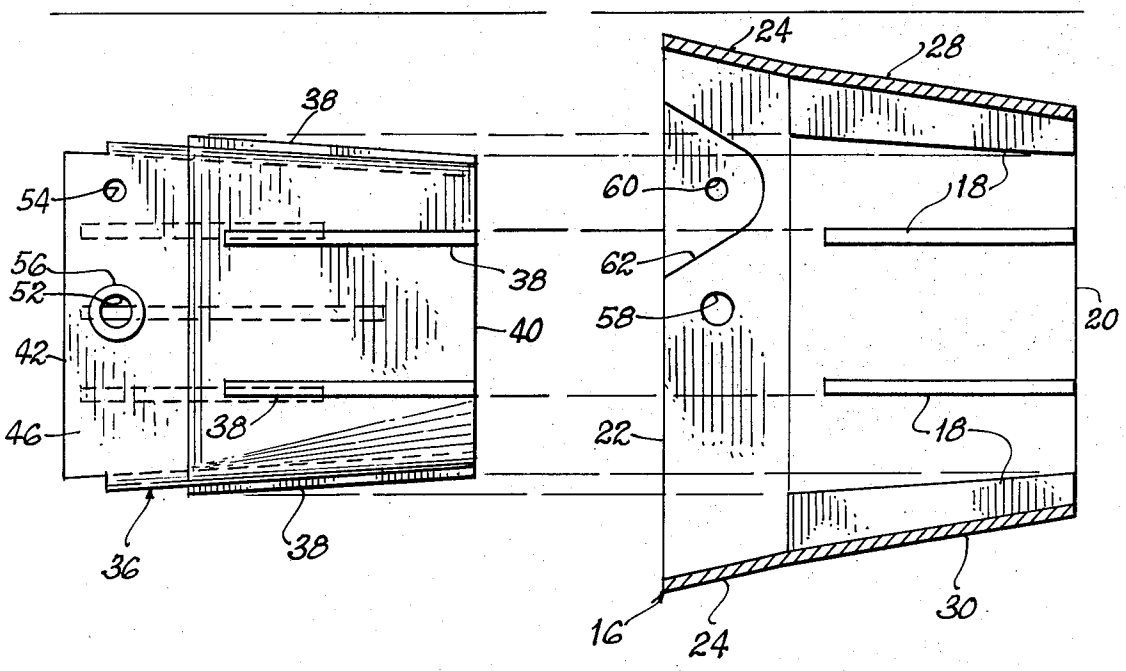


FIG. 6

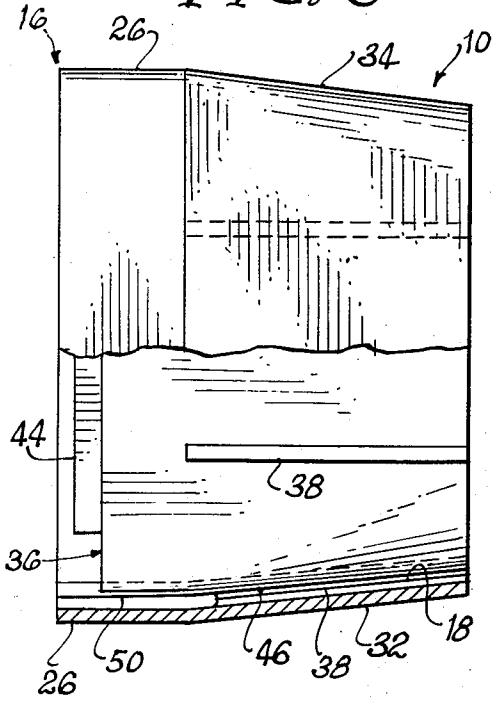


FIG. 7

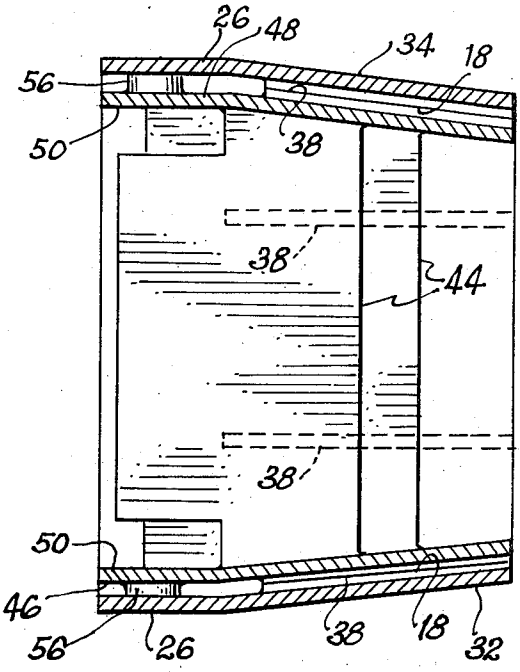


FIG. 8

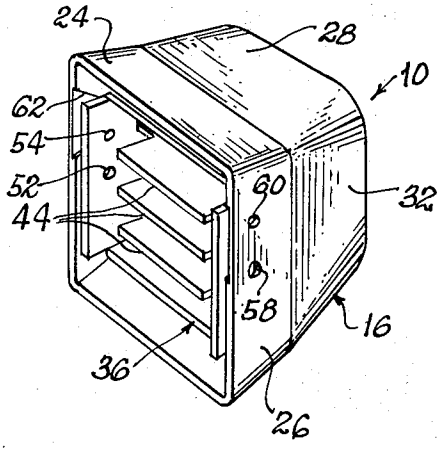
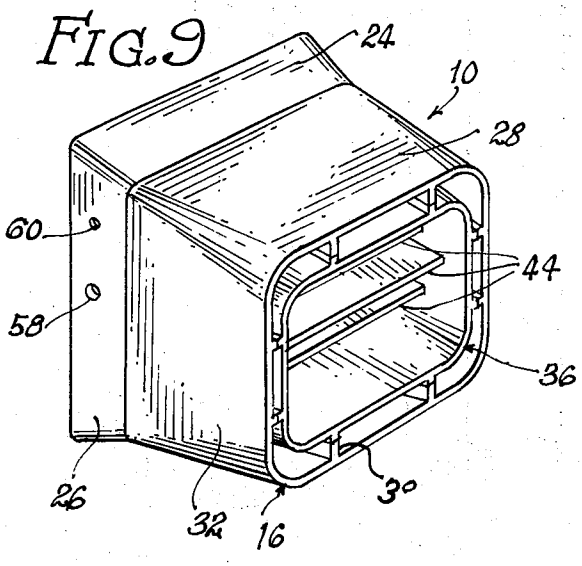


FIG. 9



BURNER NOZZLE TIP FOR PULVERIZED COAL AND METHOD FOR ITS PRODUCTION

BACKGROUND OF THE INVENTION

This invention relates to a burner nozzle tip particularly adapted for use in a pulverized solid fuel combustion furnace utilizing tangential firing. This invention also relates to a unique method for the production of a heat and erosion resistant burner nozzle tip.

Boiler furnaces, particularly steam generating boiler furnaces, utilizing tangential firing systems have been employed for many years. One such boiler furnace utilizing a tilting tangential firing arrangement is described in U.S. Pat. No. 2,697,422 issued Dec. 21, 1954. In such furnaces, fuel, most commonly pulverized coal suspended in air, and air are introduced into a vertically elongated burning zone from burner assemblies in a direction to impart a horizontally circular flame pattern. The burner assemblies include burner nozzles having burner nozzle tips which are adjusted to project the fuel and air in a direction tangent to the circular flame pattern. This arrangement is known as tangential firing. In a commercial boiler furnace, for example, in a steam generator, tiers of burner assemblies including burner nozzle tips are vertically spaced throughout the height of the burning or combustion zone. Means are provided for tilting the burner nozzle tips to provide control of the firing of the fuel and to raise or lower the body of flame as described in U.S. Pat. No. 2,697,422.

Although boiler furnaces heretofore described, utilizing nozzle tips of steel have been successfully employed, the tips must be frequently replaced. The burner nozzle tips are subject to highly deleterious conditions due to erosion by the solid fuel, e.g. pulverized coal, in air passing through the tip and due to the extreme temperatures encountered in the burning or combustion zone of the furnace. In the construction of nozzle tips, baffle or splitter plates are disposed within the tip to provide directional force to the solid fuel and air mixture, particularly upon the tilting of the nozzle. These plates, and the box-like structure supporting them are rapidly eroded by the solid fuel mixture projected through the tips under pressure. In addition, these elements of the tip as well as the outer box-like portion of the tip through which air is passed under pressure is subject to the heat of the flame as the nozzle necessarily is positioned, at least in part, in the burning or combustion zone. The latter described elements warp and crack from the heat encountered even in normal operation of the furnace. Recently, burner nozzle tips have been fabricated from stainless steel, for example, No. 304 stainless steel, by welding panels or plates of the stainless steel into burner nozzle tips containing baffle plates in an inner chamber through which fuel and air are projected and in an annular chamber through which air is projected. Although the useful life of these burner nozzle tips is considerably longer than the formerly used tips, the outer portions of the tips are still often destroyed by cracking, burning and melting due to the heat encountered in the furnace, and all of the components of the tip are subject to extreme cracking in heat affected zones adjacent the welds required in fabrication. The problem is particularly severe in portions of the stainless steel plates which are in the sigma phase range due to the welding of the stainless steel.

Therefore, it is one object of the present invention to provide a burner nozzle tip which is formed of heat and erosion resistant stainless steel which is not fabricated by welding.

It is another object of the present invention to provide a burner nozzle tip for a tangential firing arrangement in a solid fuel furnace which is formed of cast stainless steel and is weld-free.

It is another object of the present invention to provide a burner nozzle tip for a tangentially fired solid fuel furnace which includes a heat resistant outer shell and an abrasion resistant replaceable inner shell which can be readily assembled with little or no heat-stressing welding.

Still another object of this invention is the provision of a method of producing a heat and erosion resistant tangential burner nozzle tip of cast stainless steel which can be assembled without welding.

These and other objects and advantages of the present invention will become apparent from the following description when the same is considered in connection with the accompanying drawings.

SUMMARY OF THE INVENTION

In accordance with the present invention a tangential burner nozzle tip for a pulverized solid fuel combustion furnace is provided of cast stainless steel components which can be assembled without welding. The nozzle tip includes a stainless steel, hollow open-ended cast outer shell having at least one integrally cast, weld-free elongated rib extending internally from each side thereof from one open end toward its other open end. The tip further includes a replaceable stainless steel, weld-free hollow, open-ended cast inner shell positioned within the outer shell and adapted to conduct and project pulverized solid fuel and air therethrough. The inner shell has at least one integrally cast, weld-free elongated rib extending externally from each side for each rib of the outer shell, with the ribs of the inner shell engaging the ribs of the outer shell when the inner shell is positioned within the outer shell. The inner shell preferably has at least one transverse baffle plate integrally cast therein which is adapted to provide direction to the pulverized solid fuel and air mixture being projected therethrough. The annular space between the inner and outer shells is adapted for the projection of air therethrough and a rib of one shell engaging with a corresponding rib of the other shell together provide a baffle or splitter plate in the annular space to provide direction to the stream of air passing therethrough corresponding to the direction provided to the fuel and air mixture by the baffle plate integrally located within the inner shell. The burner nozzle tip thus provided comprises two shells which are each integrally cast and are fitted together without the necessity of welding as required in the presently used tips. The absence of fabrication welding eliminates heat-weakened zones which are subject to cracking in the normal use of the burner nozzle tips. In addition, the cast inner shell which is subject to erosion due to the abrasive action of the solid fuel and air mixture being projected therethrough, can be cast of an abrasion-resistant material and can be readily removed from the outer shell without cutting or de-welding and replaced without welding. As the shells of the tip of the present invention are separately cast,

the inner shell can be readily replaced without replacing the entire tip, thus resulting in a saving of material and labor costs since the inner portion of the tip receives the severest wear, and, although the inner shell is more resistant, it still must be replaced more frequently than the outer portion of the tip.

The method of production of the burner nozzle tip in accordance with the present invention includes casting an inner shell of stainless steel, and casting a hollow, open-ended outer shell of stainless steel. The outer shell is cast so as to include at least one inwardly projecting, weld-free elongated rib positioned interiorly oeach side of the shell. Similarly, the inner shell is cast with at least one outwardly projecting integrally cast, weld-free elongated rib positioned exteriorly on each side of the shell. Each of the ribs of the outer shell are adapted to engage one of the ribs of the inner shell upon the latter being positioned within the outer shell. The method includes positioning the inner shell within the outer shell with each rib of the inner shell engaging a rib of the outer shell to form a unitary weld-free, concentric shelled burner nozzle tip. The tip thus formed has the advantages described in the preceding paragraph resulting from its construction of cast stainless steel and the absence of fabrication welds which result in cracking in areas adjacent to the welds.

The method of the present invention can further desirably include providing cored pairs of apertures in the shells to receive supporting and tilting members, and can further include casting at least the outer shell of stainless steel, such as 309, No. 25–12 stainless steel, which has a substantially greater resistance to heat than the stainless steel of the inner shell and casting the inner shell of stainless steel, such as 410 stainless steel alloy, which has a substantially greater resistance to erosion from a moving solid fuel in air suspension than the stainless steel of which the outer shell is cast. Particularly in the latter described method, which is preferred, a burner nozzle tip is provided having an inner portion which is particularly resistant to the erosive action encountered in the use of burner nozzle tips and further having an outer portion, which is normally subject to greater heat deterioration than the inner portion, which is substantially more resistant to the heat encountered both in normal use and in furnaces employing hotter flame temperatures than in burner nozzle tips presently utilized.

In the improved method and apparatus of the present invention in which both or at least the outer shell is cast of stainless steel having improved heat resistance, such as 309, No. 25–12 stainless steel increased furnace operating temperatures can be employed. For example, where temperatures in the furnace now must be held to 900°–1,000° Fahrenheit, or more recently to 1,500°–1,700° Fahrenheit, the use of cast, weld-free shells, or at least the outer shell, produced of 309, No. 25–12 stainless steel in accordance with this invention permits the use of operating temperatures in the order of 2,000°–2,200° Fahrenheit, with concommitent increases in efficiencies of the furnace.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of the burner nozzle tip of the present invention taken from the inlet end of the tip.

FIG. 2 is an elevational view similar to FIG. 1 taken from the outlet end of the tip.

FIG. 3 is a side elevational view of the tip shown in FIGS. 1 and 2 taken along line 3—3 of FIG. 1.

FIG. 4 is a vertical section taken along line 4—4 of FIG. 1.

FIG. 5 is an exploded, partly sectional, and partly elevational view of the tip shown in FIGS. 1–4.

FIG. 6 is a plan view, partly in section, taken along line 6—6 of FIG. 3.

FIG. 7 is a plan sectional view taken along line 7—7 of FIG. 4.

FIG. 8 is a perspective view showing the inlet side of the burner nozzle tip.

FIG. 9 is a perspective view of the tip showing the outlet end hereof.

BRIEF DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings, the numeral **10** indicates generally a burner nozzle tip in accordance with the present invention. Burner nozzle tip **10** functionally features a duct or chamber **12** through which pulverized solid fuel, preferably coal, suspended in air is projected, and an annular duct or chamber **14** through which air is projected.

The outer portion of tip **10** is defined by a hollow, open-ended cast outer shell **16.** In accordance with the present invention shell **16** is integrally cast of heat-resistant stainless steel and includes elongated ribs **18** extending interiorly from each side of the shell extending from the outlet end **20** of the shell toward the inlet end **22** of the shell. In the embodiment shown, ribs **18** extend only partially toward inlet end **22** to provide additional clearance for assembly and for connecting to tilting and supporting mechanisms as will be hereinafter described. The sides of outer shell **16** are substantially isosceles trapezoidal in shape with the edges of the sides defining the open ends **20** and **22** of the shells being parallel. In addition, the sides can include a flared portion **24** or **26** adjacent and including the edge constituting inlet end **22** in each of the top **28,** bottom **30,** right side **32,** and left side **34** of the shell. More particularly, flared portions **24** of top **28** and bottom **30** flare outwardly with respect to the remainder of each of top **28** and bottom **30** culminating at their widest points in their edges defining end **22.** Conversely, flared portions **26** of right side **32** and left side **34** flare inwardly with respect to the remainder of the respective side so as to be substantially parallel to each other. Having the portions **26** substantially parallel facilitates the installation of tip **10** in a boiler furnace and the connection of the tip with supporting and tilting mechanisms as will be hereinafter described.

Burner nozzle tip **10** further includes a replaceable hollow, open-ended cast inner shell **36** which is adapted to be replaceably and removably positioned within outer shell **16.** Shell **36** is integrally cast of stainless steel with a plurality of elongated ribs **38** extending externally from each side of shell **36** from the outlet end **40** toward the inlet end **42** of the shell. In the embodiment shown, ribs **38** extend only partially toward inlet end **42** to provide clearance for the connecting members of supporting and tilting mechanisms of a boiler furnace, although ribs **38** could extend to the edges constituting inlet end **42.** There is no need for ribs **38** to extend further toward inlet end **42** in the embodiment shown as they function only in conjunction with ribs **18** as will be hereinafter described. Inner shell

36 is further integrally cast with a plurality of splitter or baffle plates 44 extending laterally between the right side 46 and the left side 48 of shell 36. Plates 44 can be of any desired shape, but preferably are substantially T-shaped as shown. Plates 44 extend less than the full distance to outlet end 40 to permit mixing of the portions of the fuel in air mixture into which the mixture is split by the plates. Thus, the streams will have an opportunity to intermix prior to reaching outlet end 40 of the shell.

The sides of inner shell 36 are substantially isosceles trapezoidal in shape with the edges of the sides defining the open ends of the shell being parallel. In addition, the sides of the shell constituting right side 46 and left side 48 can include a flared portion 50 which is flared inwardly with respect to the remainder of the sides so as to be substantially parallel to each other and to flared portions 26 of the corresponding sides of outer shell 16. Having the portions 50 substantially parallel facilitates the assembly of shell 36 within shell 16 and the connection of the tip with the supporting and tilting mechanisms of a furnace.

The preferred method of production of a burner nozzle tip in accordance with the present invention includes the step of casting inner shell 36 integrally with at least one, and preferably two elongated outwardly projecting ribs 38 positioned exteriorly on each side of shell 36 extending from outward end 40 toward inlet end 42 of the shell, and further including in the step of integrally casting the shell the casting of a plurality of baffle or splitter plates 44 as heretofore described. The most favorable results of the casting step are obtained when the entire inner shell 36 with its ribs 38 and baffle or splitter plates 44 are cast in one operation, preferably by sand molding. Other foundry methods suitable for casting stainless steel can be used in this step. Shell 36 is cast to include flared portions 50 at the sides of the shell constituting right side 46 and left side 48 for the purpose heretofore described. In the most preferred embodiment of the method of the present invention, inner shell 36 is cast of stainless steel which is highly resistant to abrasion and particle erosion. In the latter method, inner shell 36 will thus have increased resistance to the erosion effects of a pulverized solid fuel in air mixture which is projected therethrough under pressure in normal operation of the tip.

The step of casting inner shell 36 preferably further includes providing cored pairs of apertures 52 and 54 in the sides 46 and 48 of the shell. In addition, the exterior surface of shell 36 at sides 46 and 48 is cast with a boss 56 surrounding apertures 52 to maintain the spacing between shells 36 and 16 and to prevent movement and vibration therebetween after installation of the nozzle tip as hereinafter described.

Another step of the preferred method of the present invention is the integral casting of stainless steel of outer shell 16 with an inwardly projecting elongated rib 18 positioned interiorly on each side of the shell positioned to engage one of the ribs 38 of shell 36 upon assembly of inner shell 36 within shell 16. Shell 16 is cast, preferably by sand molding, although other methods of casting stainless steel can be used, to include flared portions 24 and 26 as heretofore described. Flared portions 26 include a pair of cored apertures 58 and 60 positioned so that upon assembly of shell 36 within shell 16 apertures 58 and 60 are in alignment with apertures 52 and 54, respectively. Ribs 18 extend interiorly and longitudinally to the extent required to snugly fit with the corresponding ribs 38 to form unitary splitter or baffle plates therewith within annular duct or chamber 14 upon assembly of the shells. In the most preferred method of this invention, shell 16 is cast of stainless steel which is highly resistant to heat. In the latter method, outer shell 16 being the component of the nozzle tip which is subjected to the highest temperatures in either normal or high temperature usage consequently has the greatest resistance to the effects of the temperatures encountered.

Still another step in the preferred method of the present invention is the assembly of shell 16 and 36 into a unitary weld-free, concentric shelled burner nozzle tip 10. Assembly is accomplished by positioning inner shell 36 within outer shell 16 by inserting outlet end 40 of the former into the inlet end 22 of the latter until each rib 38 of the former frictionally and firmly engages a rib 18 of the latter. At this point, shell 36 is firmly positioned concentrically within shell 16 to the full extent of the ribs 18 and 38. In addition, boss 56 of shell 36 almost touches the flared portions 26 of sides 32 and 34 of shell 16, but preferably is closely spaced therefrom, preferably with a gap therebetween in the order of one-sixteenth-one-eighth inch. Spacing of the boss in this manner permits the shells to be readily assembled without binding. Although it is preferred to assemble shells 16 and 36 as above without welding, the shells can be tack-welded at one or several convenient points about the periphery of the outlet end 40 of inner shell 36. Tack-welding of the assembly is not required, particularly where the assembly can be installed in the furnace as hereinafter described. Tack-welding, if desired, is preferably restricted to the inlet end of the nozzle tip as this end is subjected to less heat than the outlet end and is cooled by the streams of air and solid fuel in air entering the nozzle tip.

In the assembled unitary, concentric shelled nozzle tip, bosses 56 and apertures 52 are or can readily be aligned with apertures 58 in shell 16. Bosses 58 serve as trunnion bushings for nozzle tip supporting rods (not shown) which are commonly utilized in tangentially fired boiler furnaces. Apertures 52 which extend through boss 56 and apertures 58 are adapted to receive the nozzle tip supporting rods and to permit the nozzle tip to be rotated thereabout. In this manner, nozzle tip 10 can be readily installed in a tangentially fired boiler furnace by inserting the nozzle tip supporting rods of the furnace through apertures 58 and 52 of tip 10.

Similarly, aligned apertures 60 and 54 of outer shell 16 and inner shell 36, respectively, are adapted to receive nozzle tip tilting members (not shown) which are commonly utilized in tangentially fired boiler furnaces. In the customary manner, the vertical direction imparted to the fuel and air mixture by the burner nozzle tip is controlled by the nozzle tip tilting members being extended or withdrawn in a generally horizontally direction with respect to the position of the nozzle tip supporting rods. In addition, the preferred method of the present invention includes casting outer shell 16 with a relief 62 in the inner surface of shell 16 surrounding each aperture 60 and extending to the adjacent edge of the respective sides 32 and 34. Interior relief 62, which preferably has a depth of about one-eighth inch provides clearance for the portion of the nozzle tip tilting member which extends into the annu-

lar space between shells **16** and **36** and for the movement thereof.

In accordance with the method thus described, a burner nozzle tip is provided which is formed of heat and erosion resistant stainless steel which is not fabricated by welding. The burner nozzle tip is produced by casting two integral portions which are cast and can be readily assembled without undesirable heat-stressing welding. In the most preferred method of the invention, the inner portion or shell **36** is cast of stainless steel which is particularly resistant to abrasion, or other material so resistant, while the outer portion or shell **16** is cast of stainless steel which is highly heat-resistant, or other material so resistant. Burner nozzle tips assembled from these parts are extraodinarily useful and long lasting, since the outer shell which is of highly heat-resistant material can withstand the extremely high temperatures, often in the order of 1,500°–1,700° Fahrenheit, in the furnace; while the inner shell, which is cooled by the flow of air therethrough, can withstand the harsh erosion conditions due to the pulverized solid fuel mixture impinging upon the interior surfaces of the burner nozzle tip.

In addition, the inner surfaces of inner shell **36** are subjected to the most deleterious conditions to which the nozzle tip is subjected, and consequently, more frequently require replacement than the outer portions of the tip. Prior to the present invention, replacement of the inner surfaces of the nozzle tips required complete removal of the tips and replacement of the entire tips or laborious refabrication of the worn surfaces of the tips. In accordance with the present invention, worn inner shells **38** are merely replaced with replaceable cast inner shells with the saving and continued use of the still usable outer shells. In both the production of the desired nozzle tips and their assembly and installation, and in the replacing of an inner shell of a tip, heat-stressing welding is not required, thus eliminating a major source of failure of the heretofore known burner nozzle tips.

Various changes coming within the spirit of my invention may suggest themselves to those skilled in the art; hence I do not wish to be limited to the specific embodiments shown and described or uses mentioned but intend the same to be merely exemplary, the scope of my invention being limited only by the appended claims.

I claim:

1. A tangential burner nozzle tip for a pulverized solid fuel combustion furnace comprising

a. a stainless steel, hollow, open ended cast outer shell having at least one integrally cast, weld-free elongated rib extending internally from each side thereof from one open end toward the other open end thereof, and

b. a replaceable stainless steel, weld-free, hollow, open-ended cast inner shell positioned within said outer shell and adapted to conduct and project pulverized solid fuel and air therethrough from one open end thereof to and out its other end, said inner shell having at least one integrally cast, weld-free elongated rib-extending externally from each side thereof for each rib of said outer shell, said ribs of said inner shell engaging said ribs of said outer shell whereby said shells are inter-engaged so as to form a unitary concentric body for projecting pulverized solid fuel and air through said inner shell and air through the space between said inner and outer shells.

2. The nozzle tip defined in claim **1** wherein the sides of the inner and outer shells are substantially isosceles trapezoidal in shape with the edges of said sides thereof defining the open ends of said shells being parallel.

3. The nozzle tip defined in claim **2** wherein one of said open ends is defined by the shorter parallel edges of said sides of said shells and constitutes the outlet end of each shell and said nozzle tip and said other parallel edges of said sides defining the other open end constituting the inlet end of each shell and said nozzle tip.

4. The nozzle tip of claim **1** wherein at least one side of each of said shells has a marginal portion adjacent one end thereof defining a pair of apertures adapted for receiving nozzle tip supporting and tilting members, said marginal portions of said inner and outer shells defining at least an aligned pair of apertures.

5. The nozzle tip of claim **1** wherein said outer shell has a substantially greater resistance to heat than said inner shell and said inner shell has a substantially greater resistance to erosion from a moving solid fuel in air suspension than said outer shell.

6. A method for the production of a heat and erosion resistant tangential burner nozzle tip for a pulverized solid fuel combustion furnace comprising

a. casting a one-piece, weld-free stainless steel hollow open-ended inner shell having at least one transverse baffle plate integrally, interiorly cast therein, and having at least one outwardly projecting integrally cast, weld-free elongated rib positioned exteriorly on each side of said shell and extending from one open end of said shell toward the other open end, said cast inner shell being adapted to conduct and project pulverized solid fuel and air therethrough,

b. casting a one-piece, weld-free stainless steel hollow, open-ended outer shell having at least one inwardly projecting integrally cast, weld-free elongated rib positioned interiorly on each side of said shell and extending from one open end of said shell toward the other open end, each of said ribs being adapted to engage one of said ribs of said inner shell upon said inner shell being positioned within said outer shell, said cast outer shell being adapted to conduct and project air therethrough, and

c. positioning said inner shell within said outer shell with each rib of the former engaging a rib of the latter whereby a unitary weld-free, concentric shelled burner nozzle tip is formed.

7. The method defined in claim **6** wherein said casting steps include providing at least one cored pair of apertures aligned in superposed sides of said inner and outer shells adjacent one end thereof adapted to receive nozzle tip supporting and tilting members.

8. The method defined in claim **7** wherein said step of casting said inner shell includes integrally casting an enlarged boss adjacent one of said pair of apertures in said side.

9. The method defined in claim **7** wherein said step of casting said outer shell includes casting said side thereof with a portion of reduced thickness about one of said pair of apertures, said portion of reduced thickness extending from about said aperture to said adjacent end of said shell.

10. The method defined in claim **6** wherein said step of casting said outer shell includes casting said shell of

stainless steel which has a substantially greater resistance to heat than the stainless steel of which said inner shell is cast, and said step of casting said inner shell includes casting said shell of stainless steel which has a substantially greater resistance to erosion from a moving solid fuel in air suspension than the stainless steel of which said outer shell is cast.

* * * * *