Sept. 20, 1971 N. R. WRIGHT 3,606,611

AFTERBURNER

Filed Oct. 24, 1968 2 Sheets-Sheet 1

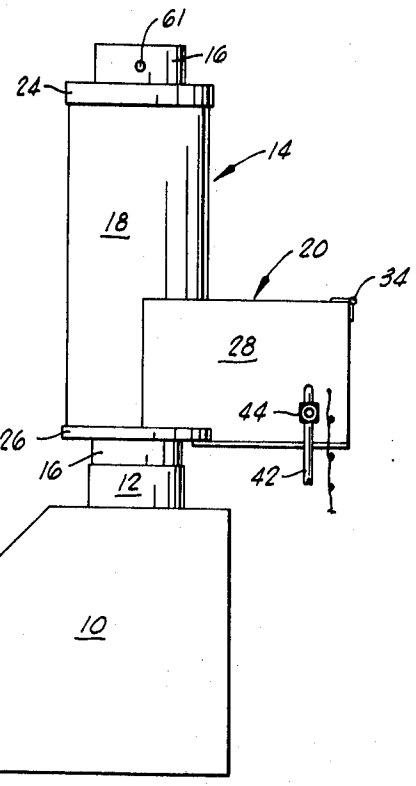


Fig. 1

Fig. 2

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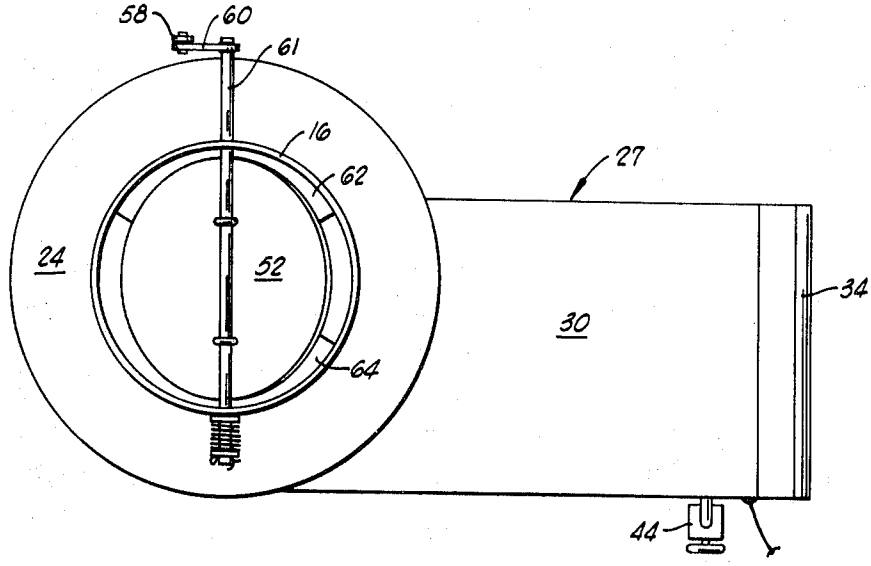


Fig. 3

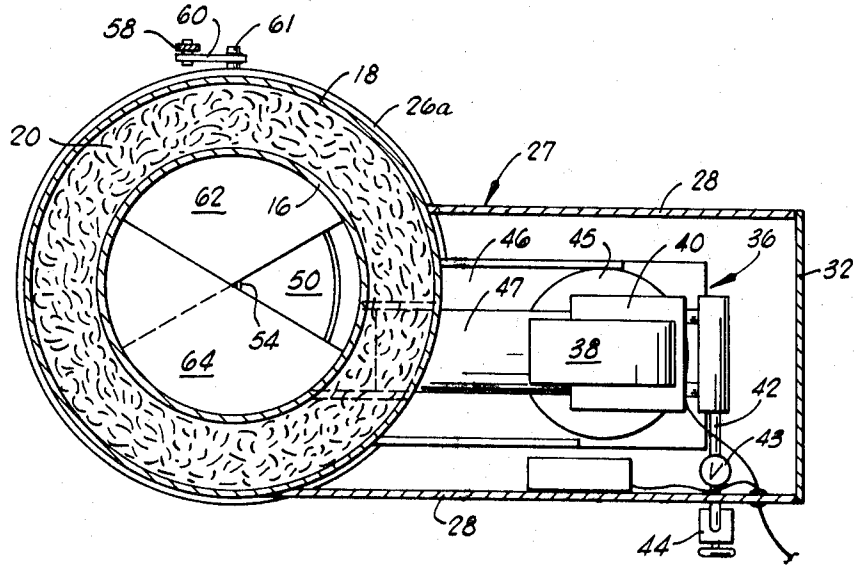


Fig. 4

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AFTERBURNER

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ABSTRACT OF THE DISCLOSURE

An afterburner for attachment to stacks and flues for the purpose of burning residual products of incomplete combustion, the afterburner including an elongated titanium inner sleeve concentrically surrounded by a shorter metallic outer sleeve with a thermal insulating material positioned between the inner and outer sleeves. A pair of damper plates are located in the upper and lower ends of the inner sleeve, and are movable to selected positions of closure within the inner sleeve. A burner is secured to the side of the inner sleeve at a location above the lower damper plate, and is constructed to burn a mixture of fuel and air and direct the flame in a generally tangential direction into the lower end of the inner sleeve. A pair of vertically spaced, circumferentially staggered, semicircular baffle plates are secured within the inner sleeve at a location above the burner and function to impart a spiralling or helical motion to gases moving upwardly in the inner sleeve.

Background of the invention

Field of the invention.—This invention relates to combustion apparatus, and more particularly, to an afterburner device which can be used for converting noxious and odiferous products of incomplete combustion of organic materials to simpler, invisible and non-odorous products suitable for discharge to the atmosphere.

Brief description of the prior art and problem solved

As is well known, the pollution of the air by the discharge of the products of incomplete combustion thereto from stacks, flues and exhaust ducts constitutes a continuing problem which faces society. One solution to this problem which has previously been proposed entails charging the products of the incomplete combustion to some type of afterburner or secondary combustion device where such products are heated to a high temperature in an effort to achieve further, and hopefully complete, combustion of the carbonaceous materials in the effluent discharged from the locus of the incomplete combustion. Afterburners used for this purpose have often included a tubular member into which the gaseous and solid products of incomplete combustion have been charged. In such tubular members, these products have been subjected to high temperatures and contact with a flame so that further combustion is effected within the tubular member.

A problem which has continued to characterize afterburner systems of this type is the inability of the inner surface of the tubular member to withstand the elevated temperatures necessary to achieve complete and total combustion of the effluent from the primary combustion zone. Steel has frequently been used as a surface contact material for constructing the interior surface or wall of such afterburners, and on other occasions, a fire brick material has been employed. I have found that the steel or iron surfaced afterburners will not, however, withstand temperatures exceeding about 1600° F. over extended periods of time without the metal softening to an undesirable extent and weakening the structural strength

of the afterburner. Moreover, at the elevated temperatures which I have found to be required in order to achieve complete combustion of the products in the effluent, iron and steel undergo chemical reactions with some of the products formed during the incomplete primary combustion with the result that these ferrous materials are attacked by the chemicals formed in such reactions and the effective service life of the afterburner is thereby decreased. Fire brick, when employed as an interior liner of the tubular member, withstands high temperatures well, but must be protected from moisture to avoid fracture or physical breakdown. Moreover, the use of fire brick adds greatly to the weight of the afterburner. In the case of some tubular afterburner systems used for the purpose of attempting to achieve more complete combustion of residual hydrocarbon materials, the design of such afterburner systems has not provided a sufficient residence time of the gases and effluent products within the combustion zone of the tubular portion of the afterburner for the secondary or final combustion to reach a stage of completeness necessary to avoid discharging solid particles and odiferous materials from the top of the tubular afterburner.

Brief description of the present invention

The present invention provides an improved afterburner which functions to substantially completely burn the products contained in the gaseous effluent from a furnace or other primary combustion system. The afterburner of the present invention is of relatively light weight and is portable so that it can be easily secured to existing stacks, flues and other discharge ducts used to discharge to the atmosphere the products of incomplete combustion occurring in most industrial combustion processes. Broadly described, the afterburner of the present invention comprises an elongated inner sleeve constructed of titanium and concentrically surrounded by a shorter metallic outer sleeve. A solid thermal insulating material is positioned in the annulus between the inner and outer sleeves, and a pair of titanium damper plates are located in the upper and lower ends of the inner sleeve and are movable to selected positions of closure within the inner sleeve for the purpose of controlling the rate of flow of gaseous materials from the bottom to the top of the inner sleeve. A high temperature burner is secured to the side of the inner and outer sleeves at a location above the lower damper plate, and is constructed to burn a mixture of fuel and air, and to direct the resulting flame in a generally tangential direction into the lower end of the inner sleeve. The burner is necessarily one which is capable of propagating into the inner sleeve, a flame in which the temperature is at least 1600° F., and which is preferably sufficiently hot to yield a minimum temperature at any location within the inner sleeve and between the damper plates of 1600° F. The burner has the further characteristic of including means for blowing air into the inner sleeve in an amount sufficient to assure that no unburned solid residue is discharged from the afterburner. A pair of vertically spaced, circumferentially staggered, semicircular titanium baffle plates are secured within the inner sleeve at a location above the burner and function to impart a spiralling or helical motion to gases moving upwardly in the inner sleeve.

An important object of the invention is to provide an afterburner which is capable of completely burning the effluent from a stack or flue of a furnace or other combustion system utilized for burning organic materials.

An additional object of the present invention is to provide an afterburner which is relatively light weight, and is economically constructed and which can be easily transported from one location to the other and installed on an existing stack or flue used to convey the products of

combustion from a furnace or similar apparatus to the atmosphere.

Yet another object of the present invention is to provide an afterburner which can withstand without malfunction or detriment, temperatures in the vicinity of 2000° F. over extended periods of time.

In addition to the foregoing described objects and advantages, additional objects and advantages will become apparent as the following detailed description of the invention is read in conjunction with the accompanying drawings.

Brief description of the drawings

FIG. 1 is a view in elevation of the afterburner of the present invention as it appears when attached to the stack or flue of a furnace.

FIG. 2 is a vertical sectional view through the afterburner of the present invention.

FIG. 3 is a top plan view of the afterburner of the invention.

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2.

Detailed description of a preferred embodiment of the invention

Referring initially to FIG. 1 of the drawings, shown therein is a furnace **10** having a stack or flue **12** projecting from the upper side thereof. The afterburner device of the present invention is designated generally by reference character **14**, and is shown mounted on the stack **12** by means of securement of the lower end of an inner shell **16** to the stack. Securement may be made in any suitable manner. The afterburner **14** includes an outer shell **18** which extends concentrically around the inner shell **16**, and has secured thereto a burner housing designated generally by reference numeral **20**.

The details of construction of the afterburner **14** are illustrated in FIG. 2. Referring to FIG. 2, it will be noted that the inner shell **16** comprises an elongated, metallic tubular member. The inner shell **16** is constructed of titanium for a purpose hereinafter to be more fully explained. It will be noted that the opposite ends of the inner shell **16** project beyond the ends of the concentric outer shell **18**, which outer shell can suitably be constructed of stainless steel. In the annulus defined between the inner shell **16** and the outer shell **18**, a thermal insulating material of relatively low thermal conductivity is positioned, and in the illustrated preferred embodiment of the invention constitutes a ceramic material sold under the trade name Fiberfrax. This material can be used continuously at temperatures up to 2300° F. and for intermittent periods at higher temperatures. The upper and lower ends of the annulus between the inner shell **16** and the outer shell **18** are closed by means of end plates **24** and **26** which each include annular flanges **24***a* and **26***a*, respectively, extending around the outer shell **18**.

At the lower end of the outer shell **18**, the burner housing **20** is secured to the outer shell and includes a pair of substantially parallel side plates **28**, a top plate **30** and an access plate **32** which is secured by a suitable hinge **34** to the top plate. The burner housing **20** functions to enclose and to protect from the weather and from access by unauthorized persons, a fuel burner assembly **36**. The fuel burner assembly **36** includes a centrifugal blower **38** and a mixing chamber **40** where a hydrocarbon fuel is mixed with air delivered to the mixing chamber by the blower. The fuel is delivered to the mixing chamber **40** via a fuel intake conduit **42** containing control valves **43** and **44**, and is fired by electrical ignition. The mixing chamber **40** and blower **38** are mounted upon a suitable supporting pedestal **45** which is secured to a plate **46** extending from the end plate **26**. The flame from the burner is forced by the blower **38** through a titanium duct **47**. The duct **47** extends through the outer shell **18** through a titanium sleeve **48** and opens through the inner shell **16** in a generally tangential direction (see FIG. 4). The blower **38** also blows an additional supply of air through the duct **47** into the inner shell **16**, and the volumetric input of this additional or excessive air is adjustably controlled to assure that no unburned, solid residue is discharged from the afterburner to the atmosphere. The fuel burner assembly **36** can be any suitable burner capable of burning a mixture of air and a hydrocarbon fuel to produce a flame in which the temperature exceeds 1600° F., and which preferably can be made to attain, by proper adjustment of the burner, temperatures as high as 2400° F. in order to achieve a minimum temperature within the inner shell **16** between the damper plates hereinafter described of at least 1600° F. Under some conditions, it may be necessary to use several of the burners to achieve the latter condition. One burner which has been found suitable is the Webster Inshot Burner marketed by the Webster Inshot Burner Company of Tulsa, Okla.

Certain structure is located within the inner shell **16** for controlling the flow of gases to effect substantially complete combustion of carbonaceous effluent materials introduced to the afterburner from the stack to which it is attached. This effluent control structure includes a pair of vertically spaced, generally circular baffle plates **50** and **52**. The lower baffle plate **50** is mounted on a shaft **54** which extends transversely and diametrically through the inner shell **16** at a location below the inlet opening of the duct **47** in the inner shell. The shaft **54** extends to the outside of the outer shell **18** where it is attached to a crank arm **56** which may be used to control the extent to which the baffle plate **50** extends across and obstructs the opening through the inner shell **16**. In a preferred embodiment of the invention, a control linkage **58** connects the crank arm **56** to a crank arm **60** which is connected to a shaft **61** which extends diametrically through the inner and outer shells **16** and **18** and is keyed to the upper damper plate **52** for controlling the rotational movement of the upper damper plate. It will be noted that the upper damper plate is located near the upper end of the inner shell **16**, and that, when the control linkage **58** is included in the structure, the damper plates **50** and **52** are moved in synchronism with each other. The damper plates **50** and **52** are preferably constructed of titanium.

Positioned between the lower and upper damper plates **50** and **52**, and above the inlet opening of the duct **47** in the inner shell **16** are a pair of baffle plates **62** and **64**. The baffle plates **62** and **64** are each of semicircular configuration, and are spaced vertically from each other and extend horizontally a portion of the way across the interior of the inner shell **16**. The lowermost baffle plate **62** is positioned a slight distance above the location at which the burning fuel-air mixture enters the inner shell **16** from the duct **47**, and it will be noted in referring to FIG. 4 that the lower baffle plate **62** is oriented so that its straight edge intersects the inner shell at a location which is just above the point of impingement on the inner shell of flame and gases passing at a high velocity from the duct **47** into and across the inner shell. It will further be noted that the upper semicircular baffle plate **64** is positioned in the inner shell **16** so that the projection of its straight transverse edge extends at an angle of about 60° with respect to the transverse edge of the lower baffle plate **62**. The baffle plates **62** and **64** are also preferably constructed of titanium.

Operation

The afterburner of the invention is relatively lightweight and is portable, and its relatively simple construction makes it economical to fabricate. The afterburner can be quickly and easily attached to a stack or flue, similar to the stack or flue **12** of the furnace **10** shown in FIG. 1, with such stack or flue being connected either directly or through a suitable adapter to the lower end of the inner shell **16**. The fuel burner assembly **36** is then ignited and adjusted so that a flame is directed into the inner shell **16** sufficient to raise the temperature at the point of entry into the shell to above at least 1600° F. Prefer-

ably, the temperature is at least 1800° F. and may be as high as about 2200° F. Additional air is also introduced by the blower **38** as may be required.

The gaseous and solid products of the incomplete combustion occurring in the furnace move upwardly through the stack or flue **12** and into the lower end of the inner shell **16**. Here they are contacted by the flame being directed into the inner shell **16** from the burner assembly **36**. Final combustion of the effluent from the furnace commences at the point of contact with the flame from the fuel burner assembly **36**, and is completed in the course of the transiting of the inner shell **16** by the mixed gases in the course of combustion. In order for combustion to be complete, a temperature of at least 1600° F. must obtain at the point of introduction of the flame to the inner shell **16**, and the residence time of the burning gases within the inner shell must be at least 0.3 second. This desired residence time is obtained in part as a result of the retarding action which arises due to the swirling or helical motion imparted to the gases by the baffle plates **62** and **64**. These plates are arranged so that, as the flame from the fuel burner assembly **36** strikes the back wall of the inner shell **16**, it is deflected in a circumferential direction by the lower baffle plate **62** and commences to spin upwardly within the inner shell **16**. The upper baffle plate **64** furthers the spinning action and continues to confine the flame and burning gases in a helical or spiraling movement. After the burning gases and residual products of incomplete combustion pass the upper baffle plate **64**, the characteristic helical or spiraling motion has been imparted to them and they continue in this movement to the top of the inner shell **16**.

Since the velocity of input of the products from the furnace below will vary with the type of furnace, and with the flue or stack construction, it is further desirable to be able to control the rate at which these materials enter the inner shell **16** and ascend from the bottom to the top thereof. To this end, the damper plates **50** and **52** are provided. It will be observed in referring to FIGS. 2 and 3 that the damper plates **50** and **52** may be varied in their position so as to effect any degree of closure of the inner shell **16** which may be desired. This in turn retards or accelerates the movement of the gases through the inner shell **16** to yield the desired residence time most suited to particular furnace and stack conditions.

I have found through considerable experimentation that the fabrication from titanium of the inner shell **16** and the baffle plates **62** and **64**, as well as the damper plates **50** and **52**, greatly prolongs the life of the afterburner, and enables the high temperatures necessary to complete combustion to be carried out in the inner shell **16** without damage to the metallic portions of the afterburner contacted by the burning gases. Moreover, titanium is substantially inert to any of the chemical products in the effluent introduced to the inner shell **16**, and to any of the products produced in the course of effecting complete combustion therein.

Although a preferred embodiment of the invention has been herein described, it will be apparent that some variations in the form and arrangement of structure can be made without departure from the basic principles of the invention. Changes of this type which continue to rely on such basic principles are therefore deemed to be circumscribed by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

What is claimed is:

1. An afterburner comprising:
- an elongated, titanium inner sleeve having an upper end and a lower end;
- a rigid outer sleeve positioned concentrically around the inner sleeve, and having an upper end and a lower end;
- a thermal insulating material positioned between the inner and outer sleeves;

- a burner secured to the lower end of the outer sleeve and having a flame duct communicating with the interior of the inner sleeve;
- baffle plate means positioned in the inner sleeve above the flame duct for imparting a spiraling motion to gases moving upwardly in the inner sleeve;
- a first damper plate positioned in the lower end of the inner sleeve below said flame duct, and movably mounted in said inner sleeve to control the flow of gases therethrough;
- a second damper plate positioned in the upper end of said inner sleeve and movably mounted in said inner sleeve to control the flow of gases therethrough; and
- a control linkage interconnecting said first and second damper plates for synchronizing the movements thereof.

2. An afterburner comprising:
- an elongated, titanium inner sleeve having an upper end and a lower end;
- a rigid outer sleeve positioned concentrically around the inner sleeve and having an upper end and a lower end;
- a thermal insulating material positioned between the inner and outer sleeve;
- a burner housing secured to said outer sleeve, said burner housing including:
  - a pair of opposed, parallel, spaced side plates;
  - a top plate extending horizontally between the upper edges of said side plates; and
  - an access plate hinged to said top plate and extending vertically between said side plates;
- a burner secured to the lower end of the outer sleeve and having a flame duct communicating with the interior of the inner sleeve, said burner being disposed within, and surrounded by, said burner housing; and
- baffle plate means positioned in the inner sleeve above the flame duct for imparting a spiraling motion to gases moving upwardly in the inner sleeve.

3. An afterburner comprising:
- an elongated, titanium inner sleeve having an upper end and a lower end;
- a rigid outer sleeve positioned concentrically around the inner sleeve, and having an upper end and a lower end;
- a thermal insulating material positioned between the inner and outer sleeves;
- a burner secured to the lower end of the outer sleeve and having a flame duct communicating with the interior of the inner sleeve;
- a first damper plate positioned in the lower end of said inner sleeve below said flame duct and movably mounted in said inner sleeve to control the flow of gases therethrough;
- a second damper plate positioned in the upper end of said inner sleeve and movably mounted in said inner sleeve to control the flow of gases therethrough; and
- baffle plate means positioned in the inner sleeve above the flame duct for imparting a spiral motion to gases moving upwardly in the inner sleeve.

4. An afterburner comprising:
- an elongated, titanium inner sleeve, having an upper end and a lower end;
- a rigid outer sleeve positioned concentrically around the inner sleeve, and having an upper end and a lower end;
- a thermal insulating material positioned between the inner and outer sleeves;
- a burner secured to the lower end of the outer sleeve and having a flame duct communicating with the interior of the inner sleeve;
- a first baffle plate positioned horizontally in said inner sleeve at a vertical level immediately above said flame duct and across said inner sleeve from the opening thereinto of said flame duct, said first baffle plate

closing a portion less than the whole of the open space defined within said inner sleeve; and

a second baffle plate positioned horizontally in said inner sleeve above said first baffle plate and circumferentially offset in said inner sleeve from said first baffle plate, said second baffle plate closing a portion less than the whole of the open space within said inner sleeve.

5. An afterburner device as defined in claim **4** wherein said first and second baffle plates are titanium.

6. An afterburner comprising:

an elongated titanium inner sleeve having an upper end and a lower end;

a rigid outer sleeve positioned concentrically around the inner sleeve, and having an upper end and a lower end;

a thermal insulating material positioned between the inner and outer sleeves;

a burner secured to the lower end of the outer sleeve and having a flame duct communicating with the interior of the inner sleeve, said flame duct extending substantially tangentially with respect to the inner periphery of said inner sleeve;

a first baffle plate of semicircular configuration positioned horizontally in said inner sleeve at a vertical level immediately above said flame duct and across said inner sleeve from the opening thereinto of said flame duct; and

a second baffle plate of semicircular configuration positioned horizontally in said inner sleeve above said first baffle plate and circumferentially offset in said inner sleeve from said first baffle plate.

7. An afterburner as defined in claim **6** and further characterized as including:

a first damper plate positioned in the lower end of said inner sleeve below said flame duct and movably mounted in said inner sleeve to control the flow of gases therethrough; and

a second damper plate positioned in the upper end of said inner sleeve and movably mounted in said inner sleeve to control the flow of gases therethrough.

8. An afterburner as defined in claim **7** and further characterized to include

a control linkage interconnecting said first and second damper plates for synchronizing the movement thereof.

9. An afterburner as defined in claim **8** wherein said first and second baffle plates and said first and second damper plates are titanium.

10. An afterburner as defined in claim **9** and further characterized to include a burner housing secured to said outer shell and surrounding said burner, said burner housing including:

a pair of opposed, parallel, spaced side plates;

a top plate extending between the upper edges of said side plates; and

an access plate hinged to said top plate and extending between said side plates.

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23—277; 431—5