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R. J. RUFF

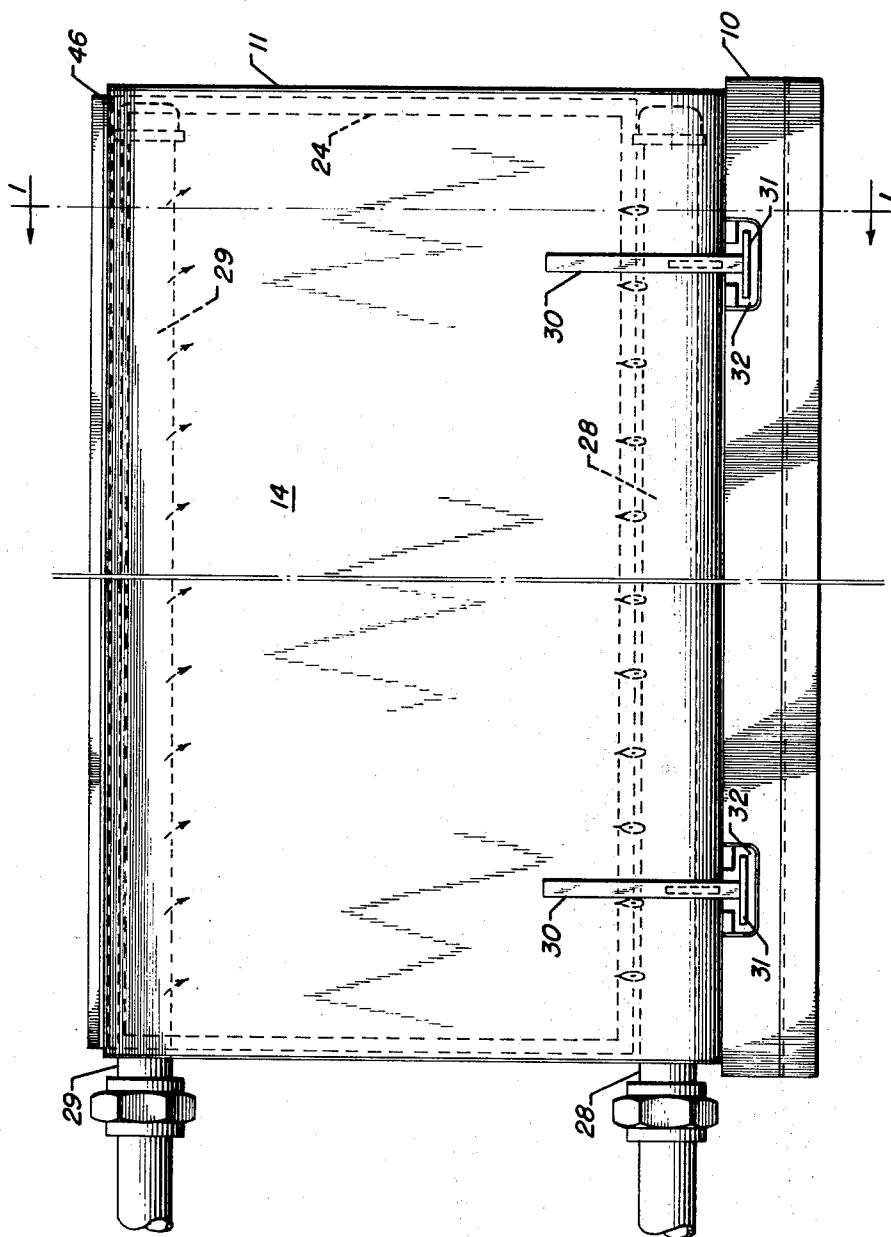
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CATALYTIC RADIANT HEAT TREATING APPARATUS

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2 Sheets-Sheet 2

Figure 2



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CATALYTIC RADIANT HEAT TREATING APPARATUS

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9 Claims. (Cl. 263—43)

This application is a division of my present application Serial No. 139,226 filed September 19, 1961, which in turn is a continuation-in-part of application Serial No. 797,935 filed March 9, 1959, now abandoned.

The present invention relates to improved means for effecting the infra-red heat treating of articles or materials and more particularly to an improved type of heat treating unit which utilizes a metallic catalytic element as a source of high temperature radiant heat and is readily adapted to many uses.

Radiant heat has found wide application in space heating as well as the heat treatment of articles and materials, and also in cooking operations, for example broiling. In most cases, the source of such radiant heat has been electrically energized infra-red lamps or Calrod type heaters or in some instances gas fired burners in which the heat developed by combustion of the gas fuel is converted to radiant heat.

In the use of infra-red lamps as a source of radiant energy, it has been common practice to utilize a large number of such lamps together with suitable reflectors grouped closely together along the walls of an oven through which the work passes and the same type of apparatus is commonly utilized with Calrod heaters which also utilize reflectors to direct the radiant heat in a desired pattern. Electrically energized radiant heat sources are relatively convenient to use and are quite effective on certain types of work but there are several disadvantages to this type of heater in that the surface of the heater itself must be at relatively high temperature in order to produce the desired radiant energy and furthermore, the reflectors must be so designed and the work must be so positioned as to eliminate the possibility of producing hot spots on the work. Furthermore, the wave length of the infra-red energy is determined by the source temperature and since a relatively high source temperature is utilized in electrical units in order to produce a relatively large quantity of infra-red energy in a reasonably small space, it is sometimes difficult to provide the optimum wave length for the particular work being treated. Also, high surface temperatures for the heat sources result in reduced heater life and in the event a single heating unit fails, the quality of the work is adversely affected.

Electrically energized heaters are not readily adaptable to proportional control since such heaters are either "On" or "Off" and where it is desired to secure an intermediate range of radiant energy, the control of electrically energized heaters is extremely difficult. Furthermore, the reflectors utilized with electrically energized heaters gradually become covered with dirt deposits thereby reducing the efficiency of the reflectors and since less energy is reflected, more energy is absorbed with a consequent increase in heat losses and furthermore, the heat treatment of the work passing through the oven is adversely affected by changes in heating conditions caused by dirty reflectors and even under the best conditions, a substantial portion of the heat released by an electrically energized heating element is transmitted through the reflector and absorbed in the insulation or in the room containing the oven. A further disadvantage

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tage of the electrically energized type of heater for use in radiant heating is the fact that electricity usually costs from three to seven times the cost of other fuels. As a result, it will be seen that other forms of radiant heat sources would be desirable for many applications.

Where gas is utilized as a fuel for radiant heating apparatus, it has been common practice to burn such gas in such a way that a flame impinges upon a ceramic which is capable of withstanding exceedingly high temperature and such ceramic may be of the cup type or line type where the source of high temperature consequently takes the appearance of either a circle or a line. The source temperature of such radiant energy is extremely high, ordinarily above 1700° F. and with proper adjustment of the air and gas mixture to the burner there is no visible evidence of a flame, the only apparent heat source being a white hot ceramic. Since with this type radiant source, also known as incandescent radiator, the source temperature must be exceedingly high, there is no possibility of controlling the actual wave length of the radiant energy reaching the work.

Where gas fired incandescent radiators are utilized, it has hitherto been necessary to position the work being treated at a relatively great distance from the burner in order to provide a desired degree of heat distribution and to avoid excessive heating or hot spots, and furthermore, furnaces utilizing gas fired radiant heat burners are of necessity relatively large and heavy and consequently quite costly to manufacture and install.

Gas fired burners providing radiant heat may be proportionately controlled so that high or low or any intermediate energy release is possible, but in order to accomplish this result, the source of radiant heat remains at substantially the same temperature and only the size of the source increases or decreases. This results in non-uniform diffusion of the radiant energy where the energy released is varied and consequently some difficulty may be experienced in properly treating the work subjected thereto.

Another type of radiant heating apparatus which has been developed more recently is the catalytic oxidation burner which relies on the catalyzed oxidation of fuel gas at the exposed or radiant heat-emitting side of a gas-permeable combustion element. However, heretofore, the designs have been such that emission surface temperatures are in the range of from 400° to 850° F. The previously known construction and arrangements have used porous beds of catalyst particles or catalytically impregnated fabric such that their infra-red radiation or heat output has necessarily been in the low range. In still other designs the temperature variations are obtained by controlling the supply of fuel gas, by means of a valve, to gas distributing member extending across the back side of the catalytic element and permitting oxygen for supporting the combustion to reach the exposed side of the catalytic radiator by diffusion from the surrounding area backwardly to the catalyst surfaces. It has been found, however, that in approaching a maximum surface temperature of about 750° F. complete oxidation of the fuel gas is not achieved, apparently due to the increasing unreliability of sufficient oxygen diffusing to the catalyst surface against increased velocity of fuel gas passing through the catalytic combustion element. Moreover, an electric ignition device built into the catalytic combustion element is usually required for starting the combustion and attaining radiation temperature and this complicates both the manufacture and the use of such catalytic radiators.

It is an object of the invention to provide a radiant heating apparatus which is easy to manufacture and in which the source of radiant heat is a catalytic combus-

tion element from which radiant energy will be released substantially uniformly over its entire surface.

A further object of the invention is the provision of a catalytic radiant heater which is highly resistant to mechanical as well as thermal shock and in which a thin catalytic combustion element or each of a plurality of catalytic combustion elements functions without visible flame and in which substantially the entire radiant heat output is directed to a desired location or area without the use of conventional reflectors.

A further object of the invention is the provision of a radiant heating apparatus in which a catalytic combustion element is utilized as the source of radiant heat in a manner which prevents back flow of heat from the catalytic combustion element thereby permitting utilization of substantially the entire heat output of the element.

A still further object of the invention is the provision of a radiant heating apparatus in which a catalytic combustion element or a plurality of such elements, utilized as the source of radiant heat, is adapted to being supplied uniformly with a mixture of fuel and air and can be brought to ignition temperature without the need of heating devices built into the catalytic element or elements.

The present improved designs make use of one or more specifically plated and treated metal alloy gauze (screen) as the catalytic element to affect the catalytic oxidation of the fuel stream and provide an infra-red radiant heating surface. The screen is electro-plated with a noble metal, preferably platinum or palladium, or with mixture thereof, to provide an oxidizing catalyst surface uniformly thereover. In some applications, other platinum group metals, or such metals as titanium, cobalt, etc., may be composited with the platinum during the coating step to give improved oxidation characteristics. The metallic catalytic coatings on high temperature resistant alloy screens provide means for obtaining highly efficient oxidation surfaces as well as high temperature emissions. Various metal alloy screens may be used as a gas pervious base, however, as will be set forth in greater detail hereinafter, a chromium-nickel gauze (such as those known as Chromel or Nichrome) of a fine mesh is the preferred base material for the catalytic coating. Also, as will be set forth hereinafter in greater detail, it has been found desirable to use thin catalyst elements comprising generally only one or two activated screens.

In a broad aspect, the catalytic radiation heater of the present invention provides for high temperature radiant heating in the infra-red range above about 850° F. and up to about 1800° F., comprising in combination a relatively thin metallic element of at least one gas pervious metal alloy gauze having a noble metal catalytic surface of substantially uniform thickness thereover to form a front heat radiating surface, at least one pervious gas distributing and heat reflective metal alloy gauze mounted in back of and co-extensive with said catalytic element, and confined manifold means having air and fuel supply inlet means thereto encompassing the backside of said gas distributing gauze.

The present invention utilizes in combination with the catalytic element a heat reflective layer in back thereof in order to return, as far as possible, radiant heat from the catalytic element back to the emitting surface of the unit. Preferably, a porous fine mesh, heat resistant metal gauze or screen is utilized to "reflect" the heat back to the emitting surface. The term "reflect" as used herein refers to the ability to either effect the actual reflection of the heat back to the emitting surface or, alternatively, have the ability to absorb radiant heat and in turn give up such heat to a stream passing therethrough. Thus, as used in the present improved heating apparatus, a heat resistant alloy metal screen is used whereby to reflect infra-red heat, as well as readily give up heat to the gaseous fuel stream which is distributed to the backside

of the screen and flows toward the catalytic element. Other types of materials such as glass-wool or certain clean slag or mineral wools may have reflective abilities, but not necessarily with equivalent results, in that the individual strands are reflective and have the ability to readily give up any absorbed heat to a gaseous stream.

In one embodiment of a radiation heating apparatus according to the present invention, a heat wall of one or more heating units, each individual radiation unit contains a wool-like heat reflective gas distribution layer and a catalytic combustion element of equally large rectangular shape which are adapted to be held between suitable protective large mesh screens or gratings between marginal flanges in a rectangular frame, such heating wall together with an enclosed gas distribution space therebehind assuring the simultaneous distribution of fuel-air mixture onto the backside of all radiation units of said wall.

In another embodiment, the radiation element may comprise at least one metallic screen-like combustion element catalytically activated by a noble metal, at least one underlying reflective metal screen member and at least one layer of wool-like fireproof material which is a multiple of the thickness of the catalytic combustion element.

In still another modified embodiment, the catalytic radiation heater of this invention comprises a plurality of the radiation units within a heater housing which has in combination therewith, a gas burner for the simultaneous preheating of the catalytic elements in said plurality of units to ignition temperature.

The catalytically activated heat radiating surface is formed of at least one, and preferably of two coated alloy screens or gauze members which are of a relatively fine mesh, such as in the 30 to 50 mesh range. The individual wire size should be relatively large for the mesh size, as for example in the range of 0.010 inch in diameter for 40 mesh gauze, of the order of 0.015 inch in diameter for 30 mesh gauze, and say .0089 inch in diameter for 50 mesh gauze, so as to be able to withstand movement from thermal expansion and thermal stresses. The metal or alloy of the base material and the catalytic coating of noble metal thereof may be in accordance with that set forth in U.S. Patent No. 2,658,742 issued November 10, 1953 to H. R. Suter and R. J. Ruff. Reference is made to this patent for a showing and description of the method for effecting the coating itself, and in view thereof, it is not believed necessary to specifically describe herein the coating procedure.

A preferred form of catalytic element for radiation of infra-red heat is, however, provided to be relatively thin as compared with an element suitable for the oxidation of exhaust fumes and as described in the aforesaid patent. The catalytic combustion element is a relatively thin metallic element which has noble metal surfaces and is permeable to both air and fuel gas. This element may comprise one or more metal screens or metal gauzes fabricated of alloy of high thermal resistance and coated with palladium, platinum or any other of the noble metals such as osmium, ruthenium, rhodium and iridium, or a mixture of several of the noble metals, preferably with palladium or a mixture of platinum and palladium. The catalytic element is of such nature that upon heating the same to ignition temperature and supplying a suitable mixture of fuel and air thereto, catalysts will take place along and over the entire surface resulting in the liberation of heat in the form of radiant energy.

The term "gauze" as used herein refers to the fine mesh metal screens, typically referred to in the trade as metal gauzes. Also, the term "thin," as used herein with respect to the catalytically activated element comprising the heat emitting surface of the unit which effects flameless catalytic oxidation of the fuel stream passing therethrough, refers to the actual physical thickness of element itself. Such element shall comprise at least one coated fine mesh metallic gauze, but generally will comprise two, or perhaps three, fine mesh metallic gauzes suitably activ-

ated with an oxidizing catalytic coating and placed together.

On the exterior of the wall section, over the catalytic surface, is a protective covering or guard screen which is relatively stiff and capable of generally preventing damage or deformation to the catalyzed screens, without causing the blocking of heat radiation therefrom. The guard screen may be of relatively large gage heat resistant alloy wire and may have openings in the range of from about 1/4 inch by 1/4 inch to 1/2 inch by 1/2 inch, however, other meshes may well be used to serve in the function of a protective layer.

In the utilization of the improved metallic catalytic unit, a mixture of fuel and air is supplied through manifold means to the backside of the unit and passed through the diffusing media to be uniformly distributed to the catalytically active metal gauze, where flameless combustion of the fuel occurs. The initial ignition may be effected by applying a flame from a torch, or where desired by burner means built into the fuel supplying manifold means.

Velocities through the diffuser-reflector media are generally low ranging from the order of about 2 to 5 feet per minute. The fuel-air mixture is fed to the gauze below the flammable range, and consequently no flame appears from the unit as the fuel is consumed on the catalytic surface of the active element after catalytic combustion takes over. The gauze heats to a dull red, or a bright red, or an intermediate glow, with temperature depending only on the ratio of the air-gas mixture to the unit. The fuel is generally supplied from liquefied petroleum gases, however, methane or natural gas may be utilized for the higher temperature operations. It may be pointed out that the diffusing media are also of advantage in effecting the preheating of the fuel mixture flowing to the catalytic gauze.

Further features of the invention will be apparent from the following more detailed description taken in conjunction with the accompanying drawings.

FIGURE 1 is a sectional view taken substantially on the line 1—1 of FIGURE 2 and showing one commercial embodiment of a catalytic radiant heating apparatus constructed in accordance with this invention.

FIGURE 2 is a side elevational view of the radiant heating apparatus shown in FIGURE 1.

FIGURE 3 is a sectional view showing diagrammatically a radiation unit which may be used as a wall or panel in the apparatus of FIGURES 1 and 2.

FIGURE 4 is a diagrammatic sectional elevational view indicating an externally mounted preheating burner in combination with a catalytic radiant heating unit.

Referring now to FIGURES 1 to 3 there is shown a radiant heat treating apparatus constructed to utilize the improved form of catalytic element in accordance with this invention. Vertically disposed, spaced, opposed radiation units or radiant heating units 11 and 12 are mounted upon a base 10 for slidable movement toward and away from each other. The radiant heating unit 11 may well comprise a generally rectangular hollow housing 13 having an outer wall 14, a top wall 15, a curved bottom wall 16 and the inner side of the housing 13 is closed by an inner wall 17 which serves to provide a radiant heat source.

With particular reference to the diagrammatic FIGURE 3, the inner wall 17 may comprise a generally rectangular shell or frame 18 having marginal inwardly extending flanges 19 and 20 positioned within the flange 19 and forming the radiation face of the wall 17 is a catalytic combustion element 21 which is permeable to air and fuel gas. In any event the catalytic combustion element 21 is a metallic element which has noble metal surfaces and is permeable to both air and fuel gas. This element may comprise one or more screens or gauzes fabricated of alloy of high thermal resistance and coated with palladium, platinum or any other of the noble metals such as osmium,

ruthenium, rhodium, and iridium, or a mixture of several of the noble metals, preferably with platinum or a mixture of platinum and palladium. The resulting catalytic element 21 is of course of such nature that upon heating the same to ignition temperature and supplying a suitable mixture of fuel and air thereto, catalysis will take place resulting in liberation of heat in the form of radiant energy. Rearwardly of the catalytic combustion element 21 there is provided at least one reflective screen 22a and a layer of wool-like material which may take the form of the aforementioned types of ceramic wool, or the silica-alumina wools. In order to maintain the layer 22 of wool-like material in place, there is provided a net or grating such as the screen 23 covering the rear surface of the layer 22, the screen 23 being retained in place by the flanges 20 on the shell or frame 18. The screen 22a is preferably of a fine mesh, heat resistant metal alloy, of the type described hereinbefore. It is to be noted that the layer 22 of wool-like material is air pervious and of considerably greater thickness than that of the catalytic element 21 and serves to diffuse the stream of air and fuel gas flowing therethrough during use of the apparatus. Generally, during flow of gas through the radiant heating unit, the pressure drop through the layers 22 and 22a is greater than the pressure drop through the catalytic combustion element or screen 21. Furthermore, the material composing the layer 22 should also possess suitable heat reflective flame-proof characteristics and be of a strandlike nature that it is substantially dust and particle free. Actually, a diffusing material with entrained particulate material which can absorb heat and glow has been found to provide ready means for undesirably effecting a back-flashing to the fuel inlet. On the other hand, by using a heat reflective metal screen in combination with a diffusing layer has been found to substantially preclude any back-flashing, particularly where the non-active screen is spaced from the catalytically active screens.

A downwardly and outwardly inclined partition 24 extends from the top wall 15 of the housing 13 downwardly to a lower edge 25 which is spaced inwardly from the outer wall 14 of the housing 13 and above the bottom wall 16 of such housing. Partition 24 serves to divide the housing 13 into an inner compartment 26 which communicates with the catalytic combustion element 21 through the screen 23 and layer 22 and the partition 24 also serves to provide an outer compartment 27. It will be seen from an inspection of FIGURE 1 that the outer compartment 27 communicates with the inner compartment 26 only around the lower edge 25 of the partition 24.

In the embodiment shown, a preheating burner 28 of any suitable type but extending substantially throughout the length of the housing 13 is disposed in the lower part of such housing adjacent the bottom wall 16 and in the path of flow of air from the compartment 27 around the lower edge 25 of the partition 24 into the compartment 26. An elongated perforated tube 29 is disposed in the top of compartment 27 and the tube 29 extends substantially throughout the length of the housing 13 and serves to supply a suitable mixture of fuel and air to the compartment 27.

The radiant heating unit 11 may be mounted on the base 10 for sliding movement thereon by suitable brackets 30 secured to the housing 13 and provided with flanges 31 slidably received in T-slots 32 in the upper surface of the base 10.

In a similar manner the radiant heating unit 12 may well comprise a generally rectangular housing 33 having an outer wall 34, a top wall 35, a curved bottom wall 36 and an inner wall 37. The inner wall 37 is of the same structure as the inner wall 17 of the radiant heating unit 11 and consequently need not be described in further detail, it being noted, however, that a catalytic combustion element is incorporated in the radiant heating unit 12 for providing a source of radiant energy in the same manner, as described for the radiant heating unit 11.

A downwardly and outwardly inclined partition 38 is provided in the housing 33 and the partition 38 extends downwardly from the top wall 35 to a lower edge 39 spaced from the outer wall 34 and the bottom wall 36 of the housing 33. The partition 38 serves to provide an inner compartment 40 and an outer compartment 41, the outer compartment 41 communicating around the lower edge 39 of the partition 38 with the compartment 40 and the latter compartment communicating with the catalytic combustion element on the inner surface of the inner wall 37 through the screen and layer of wool-like material constituting such inner wall.

An elongated preheating burner 42 is provided in the lower portion of the compartment 40 and an elongated air and fuel supply tube 43 having perforations therein is provided in the compartment 41 adjacent the top wall 35 of the housing 33. The radiant heating unit 12 is also provided with brackets 30 for slidably mounting the same in the slots 32 of the base 10.

The radiant heating units 11 and 12 may be provided with suitable cooperation shields 44 and 45 adjacent the lower portions thereof and at the top may be provided with adjustable shields 46 and 47. The shields 44 and 45 together with the shields 46 and 47 serve to provide a heat treating chamber 48 between the inner walls 17 and 37 of the heating units 11 and 12 and an article 49 to be heat treated may be suspended in the chamber 48 by means of a hook or other suitable engaging means 50 extending upwardly through a slot 51 between the inner edges of the shields 46 and 47 if desired, the hook 50 may be carried by a suitable conveyor for transporting the article 49 through the chamber 48.

In the operation of the above described form of the invention and assuming that an article 49 to be heat treated is positioned in the chamber 48 and that the radiant heating units 11 and 12 have been adjusted on the base 10 to provide the proper spacing between the inner walls 17 and 37 and the article 49 to be heat treated, a supply of air is introduced to the compartments 27 and 41 through the tubes 29 and 43 and the preheating burners 28 and 42 are ignited and adjusted to provide a proper heat output for heating the catalytic combustion elements 21 in the inner walls 17 and 37 to ignition temperature. Upon the catalytic elements 21 reaching ignition temperature, a suitable mixture of fuel and air is supplied to the compartments 27 and 41 through the tubes 29 and 43 and such mixture passes downwardly and around the lower edges 25 and 39 of the partitions 24 and 28 and into the compartments 26 and 40 where such fuel mixture flows through the screens 23 and layers 22 to the catalytic elements 21 where such mixture is burned by catalytic action and without the production of actual flames. The wool-like layer 22 operates to diffuse the flow of fuel and air in such a manner that the same is supplied uniformly over the entire surface of the catalyst elements 21 and furthermore, the wool-like layer 22 together with screen 22a operates to prevent a back flow of heat from the catalytic elements 21, thereby ensuring that the entire heat output of the catalytic elements 21 is directed inwardly to the heat treating chamber 48 and the article 49 therein to be heat treated. Where the apparatus is being operated in such a manner that the catalytic elements 21 are maintained above ignition temperature by the catalytic action, then the preheating burners 28 and 42 may be shut off during operation.

The heat output of the catalytic elements 21 is uniform over the entire surface thereof, and as a result of providing the screen 22a and the wool-like layer 22, the entire heat output of the catalytic elements is liberated in the form of useable heat and consequently the efficiency of the apparatus of this invention is relatively high. Furthermore, in view of the even and uniform dissipation of heat, there will be no hot spots on the article 49 to be heat treated and the heat radiated thereto may be controlled within relatively narrow limits. It is assumed, of

course, that suitable control will be provided to control the operation of the preheating burners 28 and 42 and that also suitable controls will be employed for controlling the supply of fuel and air to the tubes 29 and 43.

FIGURE 4 of the drawing shows a modification in the preheating arrangement in that a burner 52 is mounted exteriorly of the gas air-distribution chambers of the housing. The burner 52 is used in lieu of an interior burner, such as burner 28, or the burner 42, to provide an initial heating of the catalytic combustion elements to a temperature sufficient for starting catalytic combustion of the air-fuel mixture. In this modified design, the gas-air mixture is supplied through line 29' directly to a gas-air manifold or distribution section 26' of the housing to the gas distribution and reflective layers in the panels of the radiant heating walls and thence uniformly through these layers to the catalytic combustion elements or catalyst screens. As the catalyst screens heat up the catalytic ignition takes over and all flames die out, leaving the catalyst screens to effect the desired conversion of gaseous fuel energy to infra-red energy which radiates directly from the surface of the elements.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof, and therefore the invention is not intended to be limited to all the details shown in the drawings and described in the specification.

I claim as my invention:

1. A catalytic radiant heat treating apparatus comprising a base, a pair of vertically disposed spaced opposed radiant heating units mounted on said base, each unit including an inner wall, the inner face of said wall comprising a gas pervious thin catalytic element providing a source of radiant heat, a layer of gas diffusing heat reflective material covering the outer surface of said catalytic element, a closed chamber disposed outwardly of said wall and having communicating inner and outer compartments, a preheating burner disposed in said inner compartment for preheating said catalytic element to ignition temperature and means for supplying a fuel and air mixture to said outer compartment under sufficient pressure to cause said mixture to flow to said inner compartment and through said layer to said catalytic element, said units providing a space between said inner walls to receive an article to be treated by radiant heat emanating from said catalytic elements.

2. A catalytic radiant heat treating apparatus comprising a base, a pair of vertically disposed spaced opposed radiant heating units mounted on said base, each unit including an inner wall, the inner face of said wall comprising an air pervious catalytic element providing a source of radiant heat and a layer of air diffusing material covering the outer surface of said catalytic element, a closed chamber disposed outwardly of said wall and communicating with said catalytic element through said layer, a partition disposed in said chamber and dividing the same into inner and outer compartments, said partition terminating in spaced relation to the bottom of said chamber whereby said outer compartment communicates with said inner compartment only around the lower edge of said partition, a preheating burner disposed in said inner compartment for preheating said catalytic element to ignition temperature and means for supplying a fuel and air mixture to said outer compartment, under sufficient pressure to cause said mixture to flow around the lower edge of said partition to said inner compartment and through said layer to said catalytic element, said units providing a space between said inner walls to receive an article to be treated by radiant heat emanating from said catalytic elements.

3. A catalytic radiant heat treating apparatus comprising a base, a pair of vertically disposed spaced opposed radiant heating units mounted on said base, each unit including an inner wall, the inner face of said wall comprising an air pervious catalytic element providing a

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around the lower edge of said partition to said inner compartment and through said screen and said layer to

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said catalytic element and cooperating shields on said units to provide a heat treating chamber between said inner walls to receive an article to be treated by radiant heat emanating from said catalytic elements.

9. A catalytic radiant heat treating apparatus comprising a base, a pair of vertically disposed spaced opposed radiant heating units slidably mounted on said base for movement toward and away from each other, each unit including an inner wall, the inner face of said wall comprising an air pervious catalytic element providing a source of radiant heat, a layer of air diffusing wool-like flameproof material covering the outer surface of said catalytic element and a screen covering the outer surface of said layer to retain the same in place, a closed chamber disposed outwardly of said wall and communicating with said catalytic element through said screen and said layer, a downwardly and outwardly inclined partition disposed in said chamber and dividing the same into inner and outer compartments, said partition terminating in spaced relation to the bottom of said chamber whereby said outer compartment communicates with said inner compartment only around the lower edge of said partition,

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a preheating burner disposed in said inner compartment adjacent the bottom for preheating said catalytic element to ignition temperature and a perforated tube disposed in the top of said outer compartment for supplying a fuel and air mixture to said outer compartment, under sufficient pressure to cause said mixture to flow around the lower edge of said partition to said inner compartment and through said screen and said layer to said catalytic element and cooperating shields on said units to provide a heat treating chamber between said inner walls to receive an article to be treated by radiant heat emanating from said catalytic elements.

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