March 21, 1967 L. C. HARDISON 3,310,098

CATALYTIC INFRA-RED HEATER

Filed Aug. 12, 1966

Figure 1

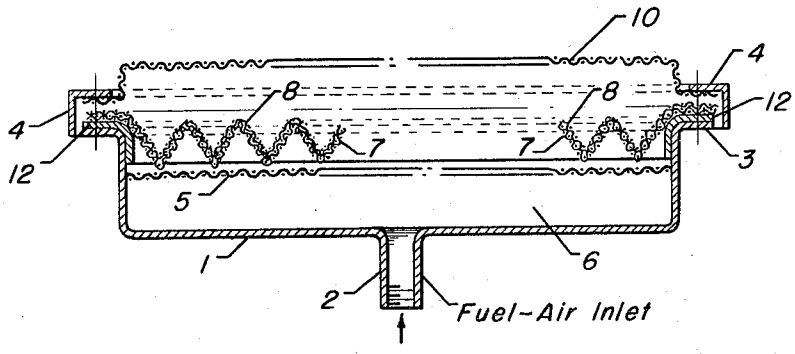


Figure 2

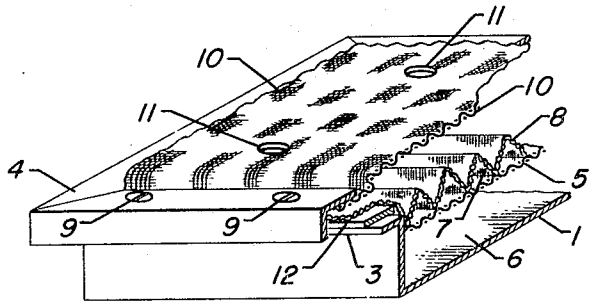


Figure 4

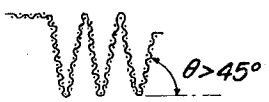


Figure 3



Figure 5

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CATALYTIC INFRA-RED HEATER

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This application is a continuation-in-part of my previously filed application Ser. No. 375,043, filed June 15, 1964, now abandoned.

The invention relates to an improved form of catalytic infra-red heater and specifically to a heater unit which utilizes a pleated or corrugated form of catalytically coated all-metal screen member for emitting high temperature infra-red heat therefrom.

There are now many types and forms of infra-red heating units which burn fuel-air mixtures over a metal gauze member which may or may not be catalytically coated. Most units have been used in connection with fuel supplied from bottled gases of butane or propane or mixtures thereof, although some installations have been made for burning methane or natural gas as the fuel. Certain of these earlier designed units did not operate satisfactorily because of back-flashing of the fuel-air mixture into the inlet manifold section or plenum of the housing, particularly after there has been a gradual heat build-up in the distributor screens or the diffusion packing upstream from the infra-red heat emitting surface. Small cinder-like particles within the mineral wool distribution layers frequently provided the hot spots which in turn initiated flash backs into the fuel inlet zone. Also, in connection with the use of one or more alloy distribution screens positioned back of or upstream from the catalytically coated infra-red heat emitting screen, there has been a step-wise back-flashing of the fuel-air mixture into the inlet zone. In other words, where the temperature build-up was sufficiently high on the surface of the alloy screen because of low flow rates, or because of improper reflecting ability in the distributing member, there was heat absorption and "catalytic" oxidation of the fuel-air mixture by virtue of the alloy metal acting as a catalyst, even though the screen had not been specially catalytically coated. This latter type of back-flashing appeared to be particularly true in the burning of propane, since the latter has a low temperature ignition as compared with methane. Heater unit surfaces which have a U-shape such that there are opposing sections permitting cross-heating, or cross-radiation, also provide problems in connection with the burning of propane, since there tends to be a more rapid build-up of interior heat and a resulting more rapid back-flashing.

The higher ignition temperature for methane permits its use in certain types of infra-red heating units; however, in effecting methane burning there have been problems in obtaining low temperature ignition of adequate preheating to the fuel-air stream. Actually, it appears that a unit adapted for the burning of methane shall have a high flow rate and low pressure drop through the catalytic screen(s) as compared with propane burning in order to obtain a lower space velocity and resulting good combustion, as well as the elimination of back-flashing problems. It may be further pointed out that where it is desired to increase catalytic surface in a unit for the burning of methane, that the use of multiple layers of coated gauze is not entirely satisfactory since there will be an increase in the pressure drop of the gas flow through each additional layer. On the other hand, an increased screen area in a single layer will lower the pressure drop without changing wire size or the overall size of the unit.

It is thus a principal object of the present invention

to provide an infra-red heater which is designed and constructed to have a pleated or corrugated catalytic screen and radiant surface that in turn provides a large surface area and reduced pressure drop for a given sized unit.

It is also an object of the present invention to provide an accompanying large surface area uncoated distributing screen upstream from and in direct combination with a catalytically coated radiant screen whereby there may be an adequate uniform preheating to the fuel-air charge stream and such that the unit may accommodate the burning of a methane rich fuel.

In one embodiment, the improved construction and arrangement provides a catalytic infra-red heater unit for supplying high temperature radiant heat that comprises in combination, a housing section having an inlet port for a fuel-air stream thereto and an unenclosed face for heat radiation and flue gas flow therefrom, at least one corrugated-form metal alloy screen member across said housing and said unenclosed face thereof and at least one corrugated form all-metal alloy screen member coated with a metallic oxidizing catalyst coating positioned externally over and extending into corrugations of said first corrugated form screen whereby the fuel-air stream passing outwardly from the interior of said housing and through said screen members will be both preheated and catalytically oxidized as it leaves the surface of the coated screen and provide flameless infra-red heat emission therefrom with a minimum of back-heating.

Various types of corrugations or pleated configurations may be utilized for the catalytically activated radiant screen member; however, a preferred form utilizes a shape or configuration that precludes direct cross-radiation and heat absorption by the element itself, particularly where the unit is to utilize propane or butane as the fuel to be burned. As will hereinafter be set forth more clearly, full "U" shaped pleats or opposing wall sections are thus eliminated from preferred designs. Generally, pleats or corrugations providing a slope of less than 45° and greater than 30° with respect to the plane of the unit will give extended surface area without direct cross-radiation effects. On the other hand, where a heat producing unit is to be utilized in supplying convective heat to a rapidly flowing gas stream, then a tightly pleated configuration with sections having opposing surfaces may be used satisfactorily without any undue danger of heat build-up in the unit and back-flashing problems.

A preferred design and construction for a preferred form of unit also utilizes a guard screen member superimposed externally over or in downstream position with respect to the expensive catalytically coated fine mesh infra-red radiant heating member whereby there is protection to such fine mesh catalyst member, as well as the provision of a re-radiating surface for emitted radiant heat.

Reference to the accompanying drawing and the following description thereof will serve to more clearly point out the improvements and advantageous features in connection with the enlarged surface area radiant heating unit of this invention.

FIGURE 1 of the drawing is a sectional elevational view through one embodiment of the improved infra-red heater and shows a corrugated-form heat radiating catalytic member.

FIGURE 2 of the drawing shows a diagrammatic and sectional isometric type of view of the heat unit indicated in FIGURE 1.

FIGURES 3, 4 and 5 of the drawing show diagrammatically variations in the form or design of the pleated or corrugated form of configuration for the catalytically coated heat radiating member to provide an extended area.

Referring now particularly to FIGURES 1 and 2 of the drawing, there is indicated a rectangular form housing 1 having a fuel-air inlet connection 2 on the back or upstream portion thereof with respect to an open unenclosed face for heat radiation and flue gas flow therefrom. The unenclosed face of housing 1 is provided with a flange section 3 which is adapted for supporting screen members and accommodating an external clamping ring 4. Traversing the inside portion of the housing 1 there is provided an open perforate support screen member 5 which in turn defines an internal manifold zone 6 as well as provide support means for one or more transverse screen members 7 and catalytically coated members 8. The support screen member 5 may be welded or otherwise attached around its periphery to the interior of the housing 1 and is preferably an open large mesh type of screen, or perforate plate member, permitting little or no pressure drop on the fuel-air supply.

In the present embodiment, there is indicated a single V pleated and catalytically coated screen 8 extending across the entire open face portion of the housing 1 and adapted to be held in place by the clamping ring 4 with suitable bolt means 9. In a similar V form design and construction, there is shown a single uncoated heating screen 7 that is directly adjacent to and upstream from the catalytically activated screen member, with corrugations matching into one another. The screen members are, as previously indicated, in contact with and supported by the interior transverse screen member 5.

With respect to the infra-red heat radiating member 8, there are various types of catalytic coatings that may be utilized to provide a fuel oxidizing surface, as well as high temperature resistant infra-red heat radiation surface; however, in a preferable construction an all-metal catalytic coating is applied directly to a heat resistant alloy metal screen of relatively fine mesh. In some instances, a single layer of activated screen provides an efficient effective oxidation of the fuel-air mixture although in other instances better results may be obtained with the use of two or more catalytically activated alloy screen members lying together across the heater opening to serve as the radiating surface. The catalytic coating may comprise platinum, palladium or a combination thereof, either alone or in combination with one or more of the other members of the platinum group of metals, such as ruthenium, iridium, rhodium, etc. Also some percentages of other activating components, such as thorium, tungsten, and the like may be applied in combination with the one or more platinum group metals. Deposition of the coating may be carried out in the manner similar to that set forth in the Suter et al. U.S. Patent No. 2,720,494, issued Oct. 11, 1955, where alloy metal wire or ribbon is catalytically activated to provide a desirable form of gas oxidizing or incinerating element. It is believed unnecessary to provide detail herein as to the means for applying and activating the coating in connection with the infra-red heat generating member of this invention, since reference may be made to such patent for preparation and coating methods.

Positioned externally of the screen members 7 and 8 of the present unit, there is provided a guard screen 10 which in turn may be provided with one or more lighting holes 11. The guard screen 10 may be made of a relatively large mesh screen as compared with the catalytic and distributing screen members 8 and 7 such that there is not too much blocking or back radiaiton of infra-red heat to the interior of the unit. The flange potrion of the guard screen 10 is shown in connection with the present embodiment as being clamped with the edges of the other transverse screen members between the housing flange 3 and the removable clamping ring 4. For example, the guard screen 10 may be formed of a 16 mesh or larger opening screen while the catalytically coated screen 8, as well as the heating screen 7, are formed of a fine mesh

alloy, i.e., about 40 mesh, or perhaps smaller and in the 50 to 70 mesh range. In all cases, the alloy utilized shall be of chrome-nickel alloys such as Nichrome and Chromel and the like, capable of withstanding high temperature ranges of the order of about 1600° F. or more. The present embodiment also indicates the use of a layer of insulating material 12 in the form of a gasket along the outer periphery of the housing 1 as well as between the flange 3 and the external edges of the screen members. The insulating material may be of an alumina fiber material or high temperature resistant matting such as "Fiberfrax" and the like. The insulating gasket material 12 is of particular advantage in preventing direct heat transfer to the housing 1. It has also been found that the external guard screen 10 provides a surface which permits the high temperature coated screen 8 and internal heater screen 7 to move and expand under high temperature heating conditions with a minimum of internal buckling.

In the actual operation of the unit the fuel-air mixture entering through inlet port 2 is distributed into the manifold section 6 and redistributed through the latter by way of support screen 5 and heating screen 7 to the catalytically coated screen member 8. By virtue of the catalyst oxidizing coating, the latter effects a substantially complete oxidation of the fuel in the presence of the air across the entire surface of the screen member in a substantially flameless manner. At the time of the initial lighting or igniting of the unit, there may be a torch inserted through the holes 11 of the guard screen 10 to provide an initial flaming of the fuel-air mixture on the outer surface of the catalyst member 8; however, as the latter heats up, there is a gradual catalytic oxidation of the fuel taking place such that the flame dies down and there is a resulting flameless catalytic oxidation across the entire surface of the element 8. Normally, adjustment of the fuel-air flow will permit varying infra-red heat output from the outer surface of the catalytic member 8, with actual variations from almost black or dark-red to a bright light red coloration for the catalyst member 8. The heating screen 7, being uncoated, will generally stay relatively cool by virtue of the flow therethrough to the catalytic screen 8. However, there will be a certain amount of back radiation of heat to screen 7 and in turn a release of heat therefrom to the fuel-air stream passing outwardly to the coated screen 8. In all cases the screen 7 is constructed to follow the same matching configuration as the coated screen and is touching or substantially touching so that there is uniformity of heat transfer with the flowing fuel-air stream to the coated surface for catalytic oxidation. With certain fuels and with fairly high flow rates, it some times is possible to have a very slight spacing between the coated and uncoated screens, such as 1/32" or so. However, experience and tests have shown that the touching of the screens gives the best reflective action and is the preferred design and construction.

As indicated briefly hereinbefore, particularly in connection with propane or butane burning, there is desired a minimization of cross-radiation and heat buildup within the unit so as to preclude black-flashing into the manifold or fuel inlet areas, although in connection with methane burning there is not the same danger of back-flashing since methane has a high ignition temperature. It is therefore desirable to modify the configuration of the corrugations or pleating arrangements to comply with the type of fuel being supplied. For direct infra-red heating from a high temperature source, the V form pleat or corrugation shall be sufficiently widespread to preclude cross-radiation. The term "cross-radiation," as used in this application, means direct maximum intensity radiation between adjacent sloping section of the V-pleat or corrugation of the outer catalytic screen and which occurs outwardly in a direction normal to the plane of the emitting surface, and it does not include the much lower intensity radiation along other directions or upstream

toward the heating screen 7. For example, in FIGURE 4 of the drawing, there is shown diagrammatically a sloping section of mesh having the angle θ equal to about 45° with respect to the horizontal plane of the screen member. Where the angle θ is equal to 45° or less, there will be little or no cross-radiation of the infra-red heat generation between sloping sections. On the other hand, where the angle θ is greater than 45°, such as shown in FIGURE 3, there will be a substantial amount of the cross-radiation between sections of the pleated screen member which can lead to excessively high temperatures developing in the region between adjacent sloping sections, particularly at low fuel flow. However, the latter configuration may be used satisfactorily when placed in a service where there is considerable flow of a gas of vapor stream around the unit such that there is imparted a large heat output into the stream in the form of convected heat. Lacking means for convecting the heat rapidly away from the unit, then cross-radiation will in turn provide high internal heat within the unit and resulting problems of back-flash and loss of efficiency in output.

It is, of course, not intended to limit the present invention to a V form of pleat or corrugation for it is obvious that various modifications may be formed in an extended area surface coated member. For example, FIGURE 5 of the drawing shows an open corrugated form of pleating with curved or rounded crests and valleys to the surface of the coated screen member; however, the sloping portions of the pleating or corrugated sections shall provide an angle θ which is less than 45° so as to preclude cross-radiation of sections when it is desired to provide infra-red radiant surfaces emitting outwardly to a heat receiving object. It may again be noted that the pleated design is of particular advantage, since in a given sized unit it is possible to get an extended surface area with a minimum of pressure drop and low space velocity, all of which enhances the oxidation of a methane rich fuel stream for infra-red heat generating purposes. For example, as indicated in FIGURE 5, where θ is greater than 30° but less than 45°, there will be a substantial increase in surface area but a minimization of cross-radiation. Such design also precludes the need of multiple layers of coated screen to obtain desired increased coated surface areas for methane burning.

I claim as my invention:

1. A catalytic infra-red heater unit for supplying high temperature radiant heat which comprises in combination, a housing section having an inlet port for a fuel-air stream thereto and an unenclosed face for heat radiation and flue gas flow therefrom, at least one corrugated-form non-catalytic metal alloy screen member across said housing and said unenclosed face thereof, at least one corrugated-form all-metal alloy screen member coated with an all-metal oxidizing catalyst and positioned externally over and directly adjacent to said non-catalytic screen, the corrugations of said non-catalytic screen extending into matching corrugations of said coated screen, whereby the fuel-air stream passing outwardly from the interior of said housing and through said screen members will be preheated by said non-catalytic screen and catalytically oxidized as it leaves the surface of the coated screen and provide flameless infra-red heat emission therefrom.

2. The heater unit of claim 1 further characterized in that said corrugated form screen members have a pleated V shape and sections thereof are sloped to provide an angle of greater than 30° and less than about 45° with the plane of the screen members.

3. A catalytic infra-red heater unit for supplying high temperature radiant heat which comprises in combination, a housing section having an inlet port for a fuel-air stream thereto and an unenclosed face for heat radiation and flue gas flow therefrom, a transverse perforate support screen across said housing and said unenclosed face thereof, at least one corrugated form non-catalytic metal alloy screen member positioned externally adjacent said support screen and at least one corrugated-form all-metal alloy screen member coated with a metal oxidizing catalyst and positioned externally over and directly adjacent to said first corrugated-form screen, the corrugations of said non-catalytic screen extending into said coated screen member so as to match and touch corrugations of the latter whereby the fuel-air stream passing outwardly from the interior of said housing and through said screen members will be preheated by said non-catalytic screen and catalytically oxidized as it leaves the surface of the coated corrugated screen and provide flameless infra-red heat emission therefrom.

4. A catalytic infra-red heater unit for supplying high temperature radiant heat which comprises in combination, a housing section having an inlet port for a fuel-air stream thereto and an unenclosed face for heat rediation and flue gas flow therefrom, a traverse perforate support screen across said housing and said unenclosed face thereof, at least one corrugated form non-catalytic metal alloy screen member positioned externally adjacent said support screen and at least one corruagted-form all-metal alloy screen member coated with a metal oxidizing catalyst and positioned externally over and directly adjacent to said first corrugated-form screen, the corrugations of said non-catalytic screen extending into said coated screen member so as to match and touch corrugations of the latter, whereby the fuel-air stream passing outwardly from the interior of said housing and through said screen will be preheated by said non-catalytic screen and catalytically oxidized as it leaves the surface of the coated corrugated screen and provide flameless infra-red heat emission therefrom, and a high temperature resistant alloy metal guard screen spaced from the extending over said external coated infra-red emitting screen member with said guard screen having a substantially open mesh as compared with said coated screen member to preclude heat absorption and heat reflection from the latter.

5. The heater unit of claim 4 further characterized in that said guard screen has at least one lighting hole in the face thereof and said coated screen member is a chrome-nickel alloy mesh with an all-metal catalyst deposition having a major portion thereof being a metal selected from the group consisting of platinum and palladium.

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