Jan. 21, 1969 E. E. STRAND 3,422,811

HIGH TEMPERATURE SURFACE-COMBUSTION RADIANT HEATER

Filed Feb. 8, 1968

FIG. 1

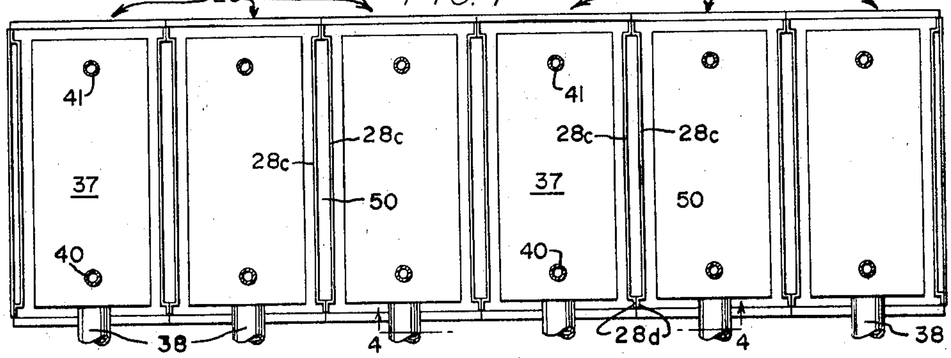
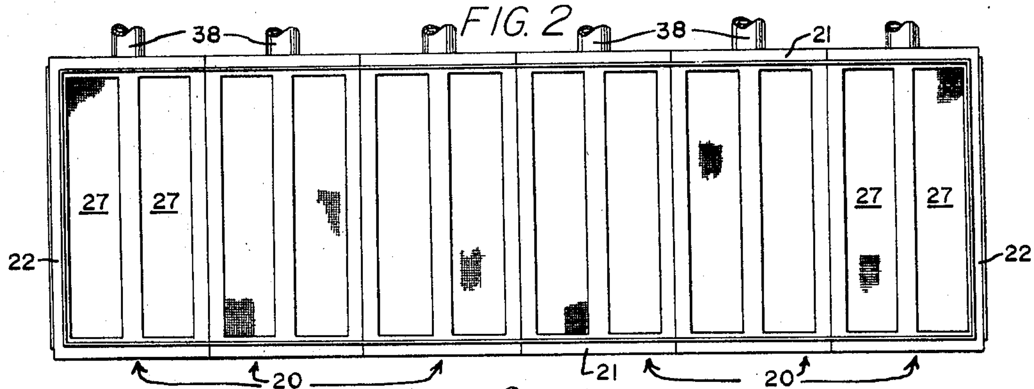


FIG. 2



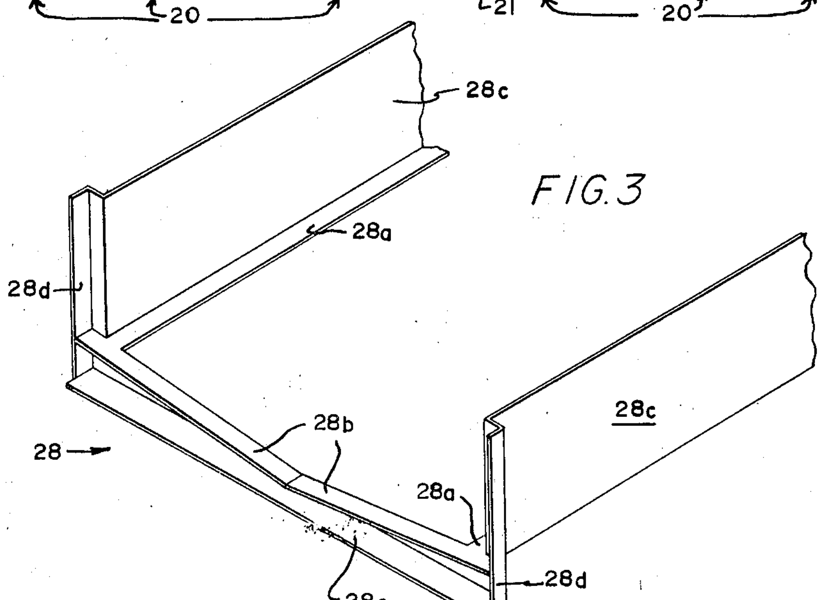


FIG. 3

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FIG. 4

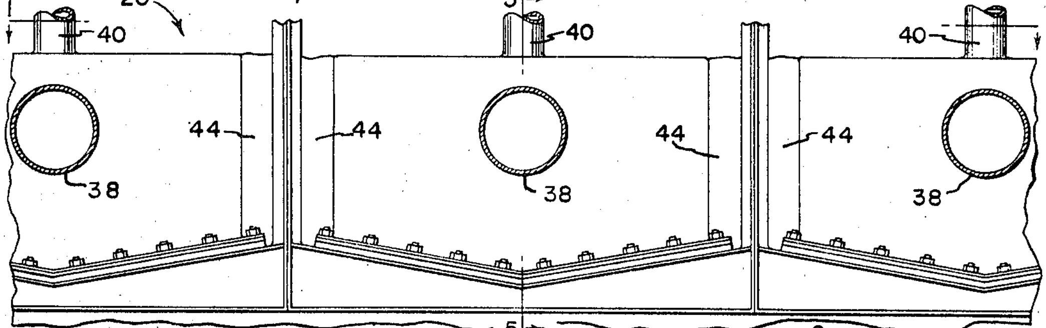

FIG. 5

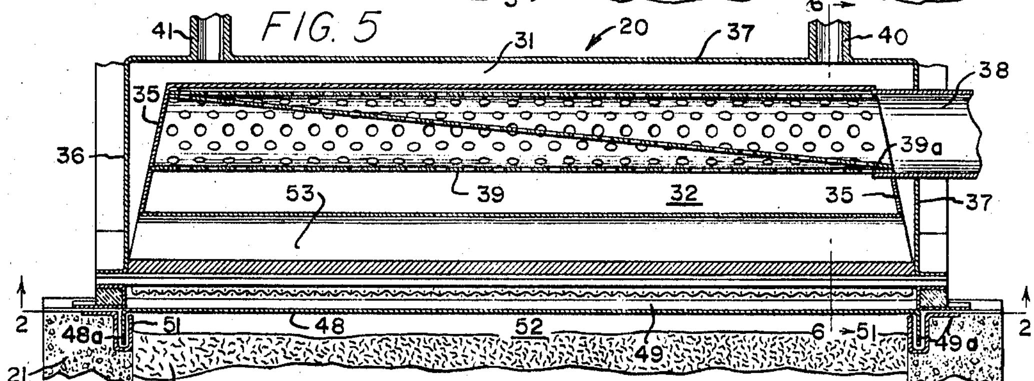

FIG. 6

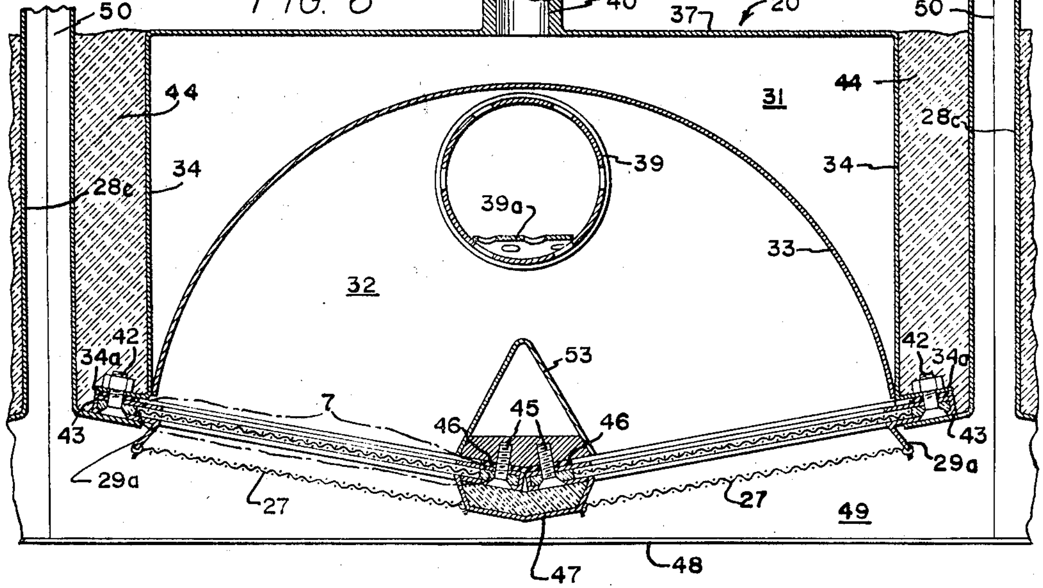

FIG. 7

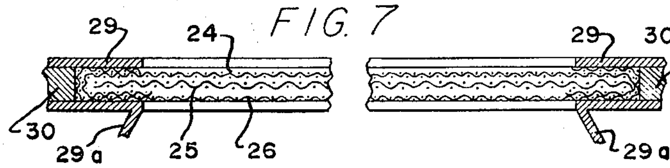

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FIG 8

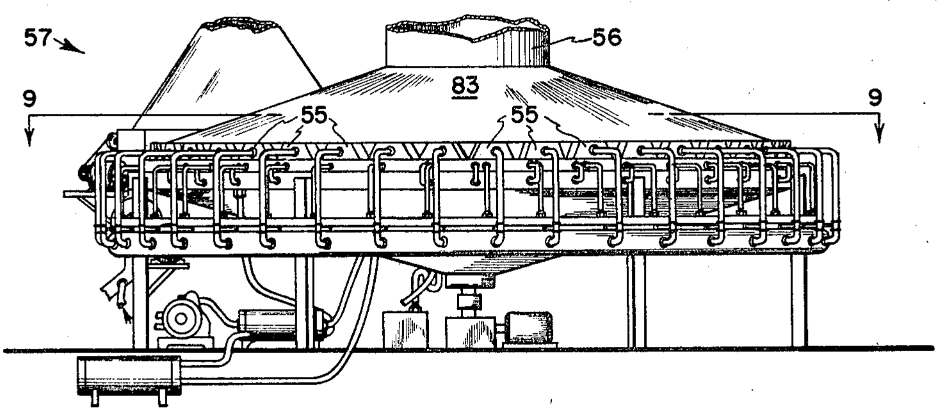
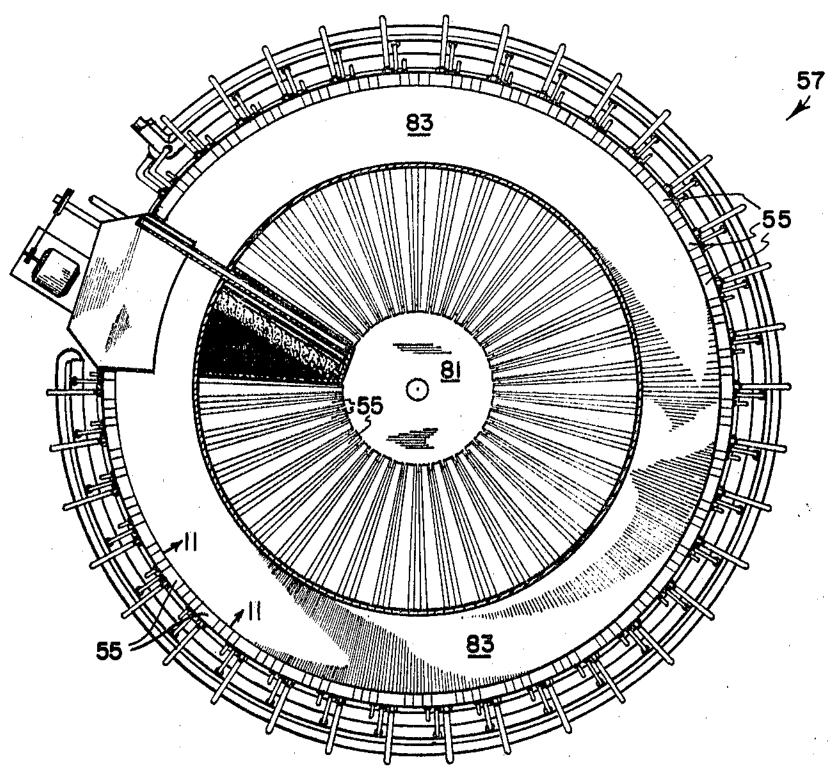


FIG 9



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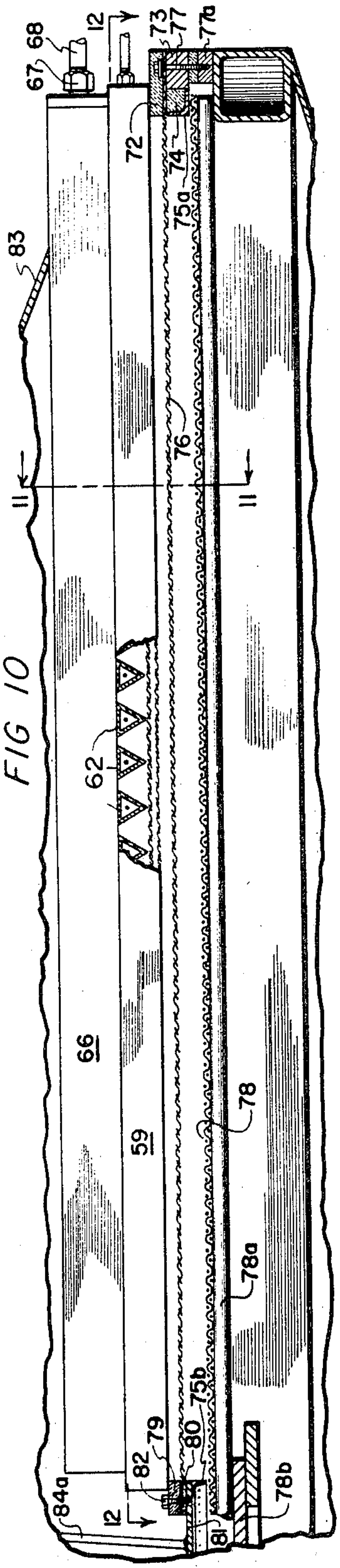

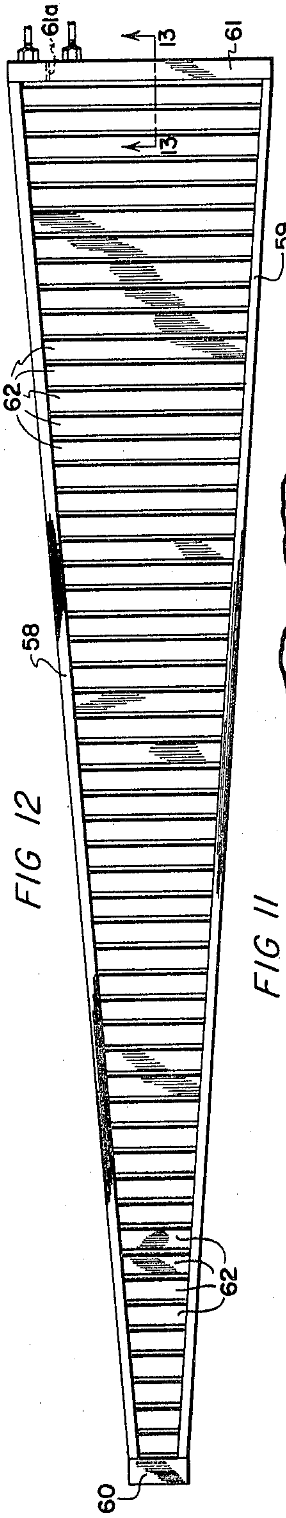

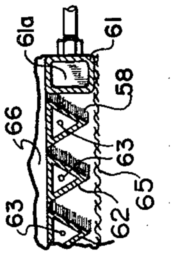

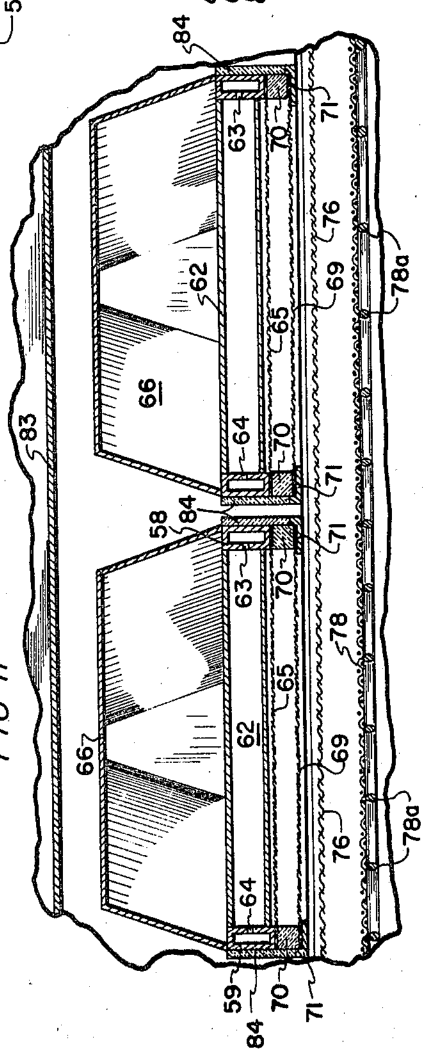

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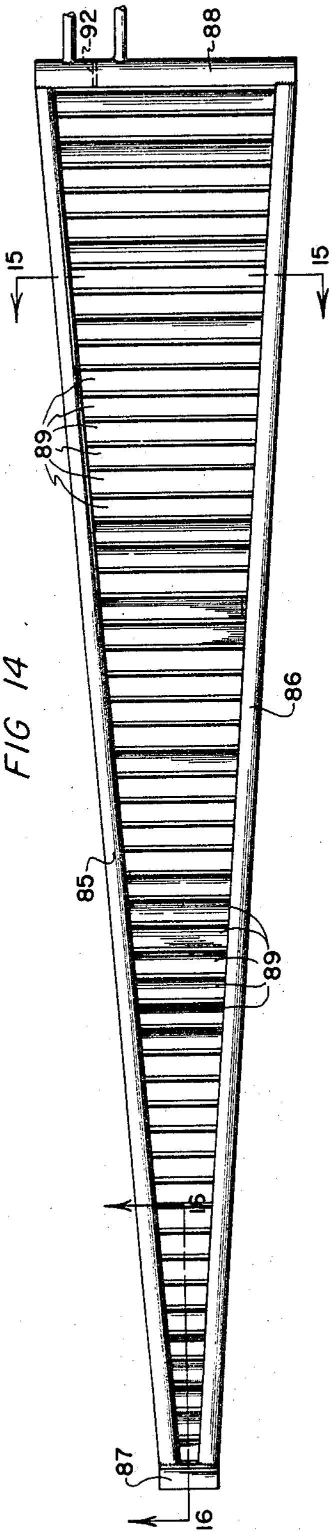

FIG 14

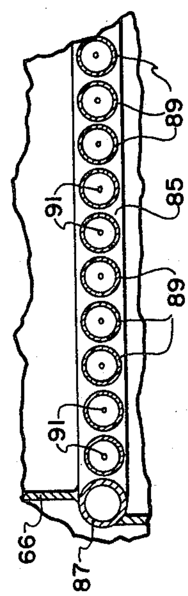

FIG 16

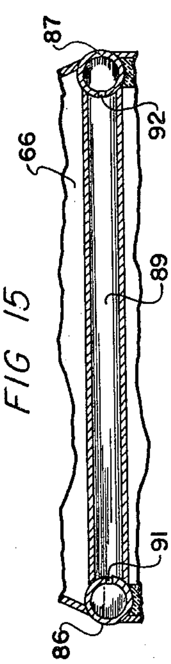

FIG 15

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United States Patent Office

3,422,811
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3,422,811
HIGH TEMPERATURE SURFACE-COMBUSTION RADIANT HEATER

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Continuation-in-part of application Ser. No. 555,570, June 6, 1966. This application Feb. 8, 1968, Ser. No. 704,018
U.S. Cl. 126—92 13 Claims
Int. Cl. F33d *11/44;* F24c *3/04;* F23d *13/12*

ABSTRACT OF THE DISCLOSURE

A surface combustion type, radiant gas heater, having a burner and reverberatory screen assembly, is provided with a reflector that is spaced backwardly from the screen assembly. The reflector is backed by a cooling jacket through which a coolant is forced. Higher than usual burner screen temperatures can be obtained, and the screen assembly is fabricated of materials capable of withstanding such high temperatures. In the industrial treatment of materials, an impermeable, but thermal energy absorbing and radiating member is spaced forwardly of the screen assembly to seal the material being treated from the products of combustion generated by the heater. A plurality of the heaters can be combined in mutually spaced side-by-side relationship to provide progressive heating of the material being heated or heating of a larger expanse of material. Offtake ducts formed between the heaters can then form passages through which the products of combustion can be removed.

This application is a continuation-in-part of my application Ser. No. 555,570, filed June 6, 1966, now abandoned.

This invention is concerned with the generation of heat of exceptionally high temperature (e.g. in the neighborhood of 3000° F.) and with the application of such heat to useful purpose. It provides a gas-fired radiant heater that can be constructed and operated economically to produce the desired heat and to apply such heat to a variety of purposes, especially the treatment of materials industrially.

Use is made of various concepts and features shown by the Mentel et al. U.S. Patent 3,084,736 granted Apr. 9, 1963, entitled "Gas-Fueled Infrared Generator," but considerably higher temperatures are achieved with correspondingly increased intensity of radiated energy and without contamination of the materials being treated by the accompanying products of combustion. Moreover, a series of the heaters can be advantageously utilized for the overall treatment of a broad surface area or for progressive heating of a material. Danger of flame flash back into the fuel feed system is greatly minimized if not completely eliminated.

The Mentel et al. infrared generator is known as a surface combustion type of gas burner. It utilizes a fine mesh burner screen unit, through which the fuel gas is forced from a plenum chamber for combustion at the outer face of such screen in a manner that heats the screen to incandescense. A reverberator screen of relatively course mesh is spaced outwardly from the burner screen unit, so as to act as a damper to prevent hot gases from being wiped away too rapidly and also as a reflector to reverberate infrared rays back onto the burner screen, thereby building up its temperature to incandescence. A reflective, safety screen may be spaced in back of the burner screen to help prevent flash back of flame into the plenum chamber and combustion of fuel gas therewithin at the relatively low temperature specified, i.e. 900° F. to 1800° F.

Features of the present invention are the utilization of

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a reflector of radiant energy rays, as the back of the plenum chamber, the provision of a forced cooling system for such reflector, the provision of an impermeable and imperforate thermal energy absorptive and radiating plate spaced forwardly of the reverberator screen, and the provision for leading off and venting products of combustion from between the burner screen and the impermeable radiating plate.

For the extremely high temperatures that are preferred with heaters of the invention, although not necessarily employed, the screens and radiating plate must be of a material, such as silicon-carbide or ceramic coated Fiberchrome, manufactured by the Johns-Manville Corporation, capable of withstanding the extremely high temperatures involved, but the reflector can be of any heat-conductive material having a reflective surface, e.g. polished stainless steel or polished aluminum.

One highly useful application of the radiant heaters of this invention is in connection with the method and apparatus of Storrs U.S. Patent No. 2,809,154, granted Oct. 8, 1957, entitled, "Heat Treatment of Substances for the Recovery of Decomposition Products." As so applied, high intensity radiant energy is projected downwardly onto material passing therebeneath from a radiating plate shared in common by a series of the heaters. Other uses will become apparent. For example, the heaters of the invention can be used to dry materials, in calcined operations, or in the roasting of metallurgical ores in accordance with methods other than that taught by the said Storrs patent.

Some representative applications of the invention are shown in the accompanying drawings, which illustrate the best modes presently contemplated of practicing the invention. Further objects and features of the invention will become apparent from the accompanying drawings and detailed description that follows:

The drawings

FIG. 1 represents a fragmentary top plan view, partly in horizontal section, taken from the standpoint of the line **1—1** of FIG. 4, and showing a series of the radiant heaters of this invention serving as the heating means for a material-processing retort;

FIG. 2, a corresponding bottom plan view taken from the standpoint of the line **2—2** of FIG. 5;

FIG. 3, a fragmentary perspective view, drawn to a considerably larger scale, of supporting framework forming a component of one of the heaters of the series;

FIG. 4, a fragmentary end elevation drawn to a considerably larger scale than are FIGS. 1 and 2;

FIG. 5, a longitudinal vertical section taken on the line **5—5** of FIG. 4;

FIG. 6, a transverse vertical section taken on the line **6—6** of FIG. 5 and drawn to a still larger scale;

FIG. 7, an enlarged fragmentary view of that portion of FIG. 6 encircled by the line **7**, an intermediate portion being broken out for convenience of illustration;

FIG. 8, a side elevation view of a thermal reactor utilizing another embodiment of the heater of the invention;

FIG. 9, a horizontal section, taken on the line **9—9** of FIG. 8;

FIG. 10, a fragmentary, enlarged vertical section, taken on the line **10—10** of FIG. 9;

FIG. 11, a fragmentary, vertical section, drawn to an even larger scale than is FIG. 10, and taken on the line **11—11** of FIGS. 9 and 10;

FIG. 12, a horizontal section, taken on the line **12—12** of FIG. 10;

FIG. 13, a vertical section, taken on the line **13—13** of FIG. 12;

FIG. 14, a view like FIG. 12, but showing still another form of the invention; and

FIGS. 15 and 16, vertical sections taken on the line 15—15 and 16—16, respectively, of FIG. 14.

Detailed description

Referring to the drawings:

In the particular embodiment illustrated in FIGS. 1–7, a series of six radiant heater units **20**, constructed in accordance with the invention, are arranged side-by-side on longitudinal, end supporting walls **21** and **22**, respectively, FIG. 2, above a mass **23**, FIG. 5, of material to be treated. Such material is placed on any suitable support or in any suitable container (not shown), which may be stationary or in the nature of a conveyor. The material may be and usually is either massed discrete solids, liquid, or semi-liquid. If it is of a flowable nature, it may be made to flow under and past such heater units in any suitable manner, by gravity or otherwise. The purpose in any event is to subject a material to be heat-treated to the radiant heating effect of the heater units **20**. It is to be understood, however, that one or more of such heater units can be employed in other ways for various industrial, commercial, or domestic heating purposes.

Each heater unit **20** comprises a dual assembly of respective sets of screens **24**, **25**, and **26**, FIG. 7, and **27**, FIG. 6, providing a surface-combustion type of gas burner, such as shown by the afore-referred-to Mentel et al. Patent No. 3,084,736. Screen **24** is a safety screen, screens **25** and **26** together form a burner or generator screen unit, and the screen **27** is a so-called reverberator screen, all in substantial accord with the infrared generator of such patent, the commercial form of which is manufactured by the C. A. Olsen Manufacturing Co., Elyria, Ohio, under the trade designation "Infralux." However, other surface-combustion types of burner screen construction can be employed. For example, where the excessively high temperatures noted above are involved, it will be necessary to utilize perforate cloth of graphite, silicon carbide, or ceramic coated Fiberchrome, instead of the customary metal screen. One satisfactory, fine mesh carbon cloth, is that produced by the Carborundum Company under the trademark "Carbotex."

The two sets of screens forming the dual assembly of each heater unit **20** are mounted in a supporting frame **28**, see especially FIG. 3, and, for this purpose, each set is advantageously framed by stainless steel stripping **29** that encloses the edges of the screens **24**, **25**, and **26** together with an interposed spaced strip **30** of mild steel, and that has a depending flange **29*a*** to which a longitudinal edge of screen **27** is secured.

The frame **28** has longitudinal side members **28*a***, FIG. 3, which seat and support outer longitudinal edge margins of adjoining sets of screens, and transverse end members **28*b***, which similarly seat and support ends of such sets of screens. Otherwise, the frame **28** has flue-forming side and end members **28*c*** and **28*d***, respectively, joined to and upstanding from the outer lateral edges of the respective side members **28*a*** and end members **28*b***, respectively, and has lower transverse end members **28*e***, joined at their opposite ends to depending portions of respective flue-forming end members **28*d***.

The inner longitudinal edge margins of adjoining sets of screens are secured to and serve to support an open-ended conduit **53**, FIGS. 5 and 6, that provides circulation for a coolant fluid in a cooling chamber **31**.

Such cooling chamber **31** and a plenum chamber **32** for the distribution of a gaseous fuel, such as natural gas or packaged LPG, are formed above the sets of screens by means of and at opposite faces of a reflector plate **33**, which is concave and preferably curved as a parabolic reflector and has its longitudinal edges connected in fluid-tight relationship with the side walls **34** of an inverted tank. The plate is preferably stainless steel, with its reflector surface highly polished. Connections with the mild steel tank walls **34** are preferably made by welding. Plates **35** close opposite ends of the plenum chamber **32**, and the cooling tank has end walls **36** and a top wall **37**, which, together with side walls **34**, completely enclose the cooling chamber **31**.

A fuel gas and air mixture is introduced into plenum chamber **32** from any suitable source by way of a supply pipe **38** and perforate distributor header **39**, which advantageously has a perforate divider plate **39*a*** extending diagonally along its length. This makes for uniform burning conditions at the burner screens. A coolant fluid, usually and preferably water, is introduced to cooling chamber **31** through a pipe **40** and discharged through a pipe **41**. Although most of the heat energy is reflected by reflector **43**, the provision for forced cooling, especially by a liquid coolant, enables operation at ultra-high temperatures.

The screen sets are anchored to respective flanges **44*a*** of walls **44** by means of bolts **42**, with heat resistant gaskets **43** interposed. Following installation of the assembled screens and tank in supporting frame **28**, heat insulation **44** is packed into the spaced between walls **34** and flue-forming walls **28*c***. Opposite margins of the framed screens are secured to the bottom of conduit **30** by screws **45**, with heat resistant gaskets **46** interposed and an insulated, protective shield **47** applied therebelow for supporting inner longitudinal edges of the screens **27**.

As is usual with surface combustion types of gas burners, the gas from plenum chamber **32** burns on the outer surface of each of the screens **26**. Spaced below the screens is a heat absorbing and radiating plate **48** that, with the reflector **33**, has the effect of intensifying the radiant energy generated by the burner screens. Screens **24**, **25**, and **26** are preferably 40, 10, and 60 mesh, U.S. Standard, respectively, and screen **27** preferably has openings 3⁄16 inch square.

Leading from the combustion chamber **49**, formed between the screens and plate **48**, are flues **50** for conducting gases of combustion to disposal through any suitable stack (not shown). Adjoining end members **28*d*** of side-by-side frames **28**, see FIG. 1, provide for formation of the flues **50** between upstanding side wall members **28*c*** of such frame.

The combustion chambers **49**, which are in communication side-by-side along the length of the retort served by the several heater units **20**, are preferably sealed from the outside atmosphere by liquid trap seals **51**, FIG. 5, utilizing depending flanges **48*a*** of plate **48**. Plate **48** acts as a black body in absorbing, with great efficiency, the radiant energy directed to it from the burner screens and reflector **33**, until the plate **48**, itself, becomes intensely hot. Since the plenum chamber is insulated and insulation is provided around the combustion chamber, the radiant energy absorbed by plate **48** can only be emitted downwardly from the plate **48** to the material **23**. The retort chamber **52** containing the material **23** thus receives maximum radiant heat energy from the intensely hot plate **48**, while being completely separated from gases of combustion which are conducted away without contacting such material. Because the gases of combustion are of low density, they are virtually unaffected by the reverberating thermal energy and they are relatively cool as they are conducted away, in comparison to the more intense temperatures of the burner screen and plate **48**.

In the embodiment of FIGS. 8–13, the heaters of the invention are shown generally at **55**. They are wedge-shaped and are mounted like spokes beneath a central exhaust stack **56** of a thermal reactor, shown generally at **57**. A reactor of this type is fully shown and described in my co-pending application for U.S. Patent, Ser. No. 704,067 filed Feb. 8, 1968.

Each heater includes a lower frame that includes a coolant circulating system made up of hollow side members **58** and **59**, that converge to be connected at one of their ends by a hollow end member **60**. The other ends of the side members are more widely spaced and are connected by a hollow member **61** that has a partition **61*a*** intermediate its length.

Spaced between end members **60** and **61** and interconnecting the side members **58** and **59** are a series of intermediate, elongate, hollow members **62** of triangular crosssection. Each intermediate member has its ends welded to the side members **58** and **59** such that orifices **63** and **64**, through the respective side members, interconnect the interiors of the side members with the interior of the intermediate member. The members **62** are arranged with their apexes downwardly and their bases spaced just slightly apart. The side walls of the triangular intermediate members thus form reflectors to reflect radiant energy towards and through a burner screen **65**, that is stretched tautly below the apexes. The burner screen is ceramically bonded to the bottoms of side members **58** and **59** and end members **60** and **61**. Although other materials can be used, a fine mesh, ceramic coated, Fiberchrome screen has been found suitable for use as the burner screen.

A closed hood **66** is fixed to the side and end members and a fitting **67** in the large end of the hood overlying end member **61** is adapted to have a fuel line **68** connected thereto. A controlled ratio of gas and air can be supplied as a fuel gas through line **68** and fitting **67** to hood **66**, in any convenient manner.

The fuel gas entering the hood moves downwardly through the small openings between the bases of intermediate members **62** and through the burner screen where it is ignited at the face of the burner screen and behind a reverberator screen **69**. The reverberator screen is like that heretofore described and has larger openings therethrough than does the burner screen. As illustrated, the reverberator screen in clamped between an insulating member **70** that is affixed to the bottom of the burner screen beneath the end and side members, and an angle member **71**. In a reactor such as that illustrated, and shown more in detail in my aforementioned co-pending application for patent, Ser. No. 555,570, the angle member **71**, at the large end of the heater, rests on a ring of insulation **72**, FIG. 10, that is supported by a ring member **73**, having insulation **74** on the inside thereof and an outer ore guide **75*a*** that serves as a facing.

A circular, impermeable and imperforate membrane member **76**, corresponding to the plate **48** previously described, and made of a material or materials capable of absorbing and radiating heat energy but impervious to gases of combustion, is clamped at its outer edge between ring of insulation **72** and ring member **73** by bolts **77** that are passed through the ring of insulation to be threaded into a ring member **77*a***. Material to be heat treated, using the heaters of the invention, is spread on a screen **78** that is rotated beneath the impermeable membrane, and after it has been so treated the residue is removed. Screen **78** is stretched tautly over rods **78*a*** that radiate out from and that rotate with a central plate **78*b***. The inner edge of impermeable membrane **76** is clamped between a ring of insulation **79**, on which the small end of the heater rests, and an insulating ring member **80** that is positioned on a support plate **81**, by bolts **82**. An inner ore guide **75*b*** depends from support plate **81** to a point just above screen **78**, so that it holds material to be heat treated on the screen.

The details of the screen **78**, the drive means therefor, the feed means for feeding material onto the screen, the means for removing residue from the screen, and the inner and outer ore guides are all shown in detail in my co-pending application for U.S. patent Ser. No. 704,067 filed February 8, 1968.

Gases of combustion formed by operation of the heaters cannot pass through the impermeable membrane and are discharged upwardly through flues or ducts defined by the outside walls of the hoods of adjacent heaters to be directed into exhaust stack **56** by a hood **83** that fits over the heaters and that is sealed to them and to the ring of insulation **72** throughout the space between the heaters. Because the gases are not very dense, they are not significantly affected by the radiant energy reverberation between the burner screen assembly, the reflector, and membrane **76** and since they are carried away quickly after combustion takes place they remain relatively cool. The hood **83** is sealingly connected to the lower end of the exhaust stack. The outer walls of the side members and hoods of adjacent heaters thus form flue-walls to direct the gases of combustion into the exhaust stack **56**. If found necessary, to prevent heating of the coolant water, insulation **84**, can be placed against the lower frame, adjacent to the side members. Brackets **84*a***, suspended from the hood holds support plate **81** and the heaters resting thereon.

In practice, fuel is supplied to the interior of hood **66** through fitting **67** and is thereafter distributed through the narrow spaces between the bases of intermediate members **62** and the burner screen to the combustion chamber formed between the front face of the burner screen and the reverberator screen. The adjacent, inclined faces of the intermediate members cooperate to form a reflective surface, corresponding to that previously described, and with the burner screen to form a plenum chamber at the back side of the burner screen. As the fuel is passed through the narrow openings formed between the intermediate members **62** it is cooled, or maintained cool, by the contact with the intermediate members through which water is being circulated as a coolant. Thus, there is very little, if any, danger of the fuel in the plenum chamber being hot enough to support flash back and the safety screen heretofore described is not necessarily required.

In FIGS. 14–16, there is shown another type of coolant system that can be used in lieu of the coolant system of the lower frame shown in the embodiment of FIGS. 8–13. The coolant circulating system of the lower frame of FIGS. 14–16, is made up entirely of pipe members and, in some cases, may be more economical to construct than coolant circulating system of the lower frame heretofore described. As illustrated, pipes **85** and **86** serve as the side members of the frame and with pipes **87** and **88**, connected at the ends thereof as the long and short end members, respectively. Intermediate, pipes **89** extend between the side members and are closely spaced so that fuel supplied through the hood will be evenly distributed as it passes between them. The intermediate pipes are made of a material that will carry the coolant water and that will provide good reflective surfaces that will cooperate with the reverberator screen **89** in heating the burner screen to incandescence and in radiating energy through the burner screen to the impermeable membrane **90**. The mounting of the reverberator screen **89** and if impermeable membrane **90** are the same as previously described in connection with the heater of FIGS. 8–13.

Openings **91**, through the wall of pipes **85** and **86**, into each of the intermediate pipes **89**, are designed to insure continuous flow of water as a coolant, through each intermediate pipe.

Water is supplied to pipe **87** at one side of a plug **92**, and is passed through pipes **85**, **88** and **86** and each of the intermediate pipes **89**, before being returned to pipe **87** to be discharged at the opposite side of plug **92**.

When the coolant system, shown in FIGS. 14–16, is used, the exterior surfaces of curved walls of adjacent intermediate pipes cooperate to form a reflective surface that functions to reflect heat energy in the same manner as do the reflective surfaces heretofore described.

Obviously, a lower frame utilizing a combination of pipes and other specially designed members, such as are shown in FIGS. 8–13, could also be used.

It should also be apparent that the overall shape of the heaters can be changed, as required for a heating operation. For example, they can be made rectangular or circular rather than wedge-shaped, as disclosed. Also, a plurality of heaters can be arranged other than as shown, so that material to be heat treated can be passed beneath them, or so that they can be moved into position to heat such material. If only one heater is required for an operation, it can be made of any desired size or shape.

Experience with the radiant heaters of this invention has shown that an exceptionally high conversion of available B.t.u. input to radiant energy output that can easily be put to useful purpose, is accomplished.

Although preferred forms of my apparatus have been herein disclosed, it is to be understood that the present disclosure is made by way of example and that variations are possible without departing from the hereinafter claimed subject matter I regard as my invention.

I claim:

1. A gas-fired, high temperature radiant heater, comprising

an assembly of screens forming a surface combustion type of gas burner;

means including a reflector having a substantially concave forward face forming with said screens a plenum chamber behind and in operative communication with said assembly of screens;

means for introducing fuel gas into said plenum chamber, so fuel gas will pass into the screen for surface combustion forwardly and outside of said chamber; and

means including a chamber behind said reflector for forcing a coolant in intimate contact with the back of said reflector.

2. A radiant heater in accordance with claim **1**, wherein the coolant is a liquid.

3. A radiant heater in accordance with claim **1**, wherein the screens are of a highly heat resistant material, such as silicon carbide, for ultra high temperature operation.

4. A radiant heater in accordance with claim **1**, wherein there is additionally provided an imperforate, heat-radiating member spaced forwardly of the assembly of screens, so as to separate the combustion area of the heater from an area of heat application.

5. A radiant heater in accordance with claim **4**, wherein the heat-radiating member has an area substantially commensurate wth the screen area, so as to define a combustion chamber between it and the screens.

6. A radiant heater in accordance with claim **5**, wherein flues for products of combustion lead from the combustion chamber and said chamber is otherwise closed.

7. A radiant heater in accordance with claim **5**, wherein there are additionally provided walls defining a retort chamber within the area of heat application, for the treatment of materials.

8. A radiant heater in accordance with claim **1**, wherein a perforate tube is provided in the plenum chamber in communication with the means for introducing fuel gas thereinto, as a distributor for said fuel gas.

9. A gas-fired, high temperature radiant heater, comprising

an assembly of screens forming a surface combustion type of gas burner;

a reflector having at least one reflective surface spaced behind the assembly of screens and arranged to reflect energy back toward the said screens, said reflector surface forming with the screens a plenum chamber;

means for introducing fuel gas into said plenum chamber whereby fuel gas will pass into the screens for surface combustion forwardly and outside of said chamber; and

means for forcing a coolant into intimate contact with the back of said reflective surface.

10. A gas-fired, high temperature, radiant heater according to claim **9**, further including

an impermeable, heat-absorbing and radiating member spaced forwardly of the assembly of screens and forming with the said assembly of screens, at one side of the impermeable member, a combustion chamber wherein the fuel gas is burned, the opposite side of the impermeable member being adapted to have heat radiate therefrom to an area of heat application.

11. A gas-fired, high temperature, radiant heater according to claim **10**, further including

flue means connected into the combustion chamber to carry away gases of combustion formed during the burning of the fuel gas.

12. A gas-fired, high temperature, radiant heater, according to claim **1**, wherein the reflector comprises

closely spaced, hollow elements through which the coolant is adapted to be circulated, each said element having a reflective surface; and

means for circulating said coolant through the said hollow elements.

13. A gas-fired, high temperature, radiant heater according to claim **12**, wherein the means for introducing fuel gas into the plenum chamber comprises

a hood, extending over the hollow elements; and

conduit means for directing said fuel gas into the hood, whereby it is distributed through the spaces between the hollow elements to the plenum chamber.

No references cited.

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