Jan. 28, 1969 M. W. PATRICK ETAL 3,424,146

INFRARED HEATERS AND GENERATORS

Filed March 23, 1967 Sheet 1 of 7

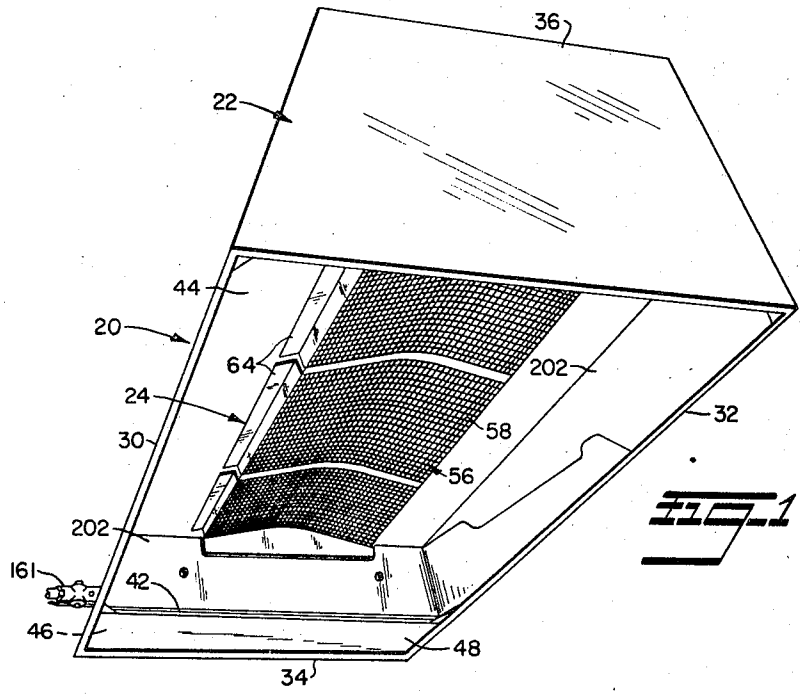


FIG. 1

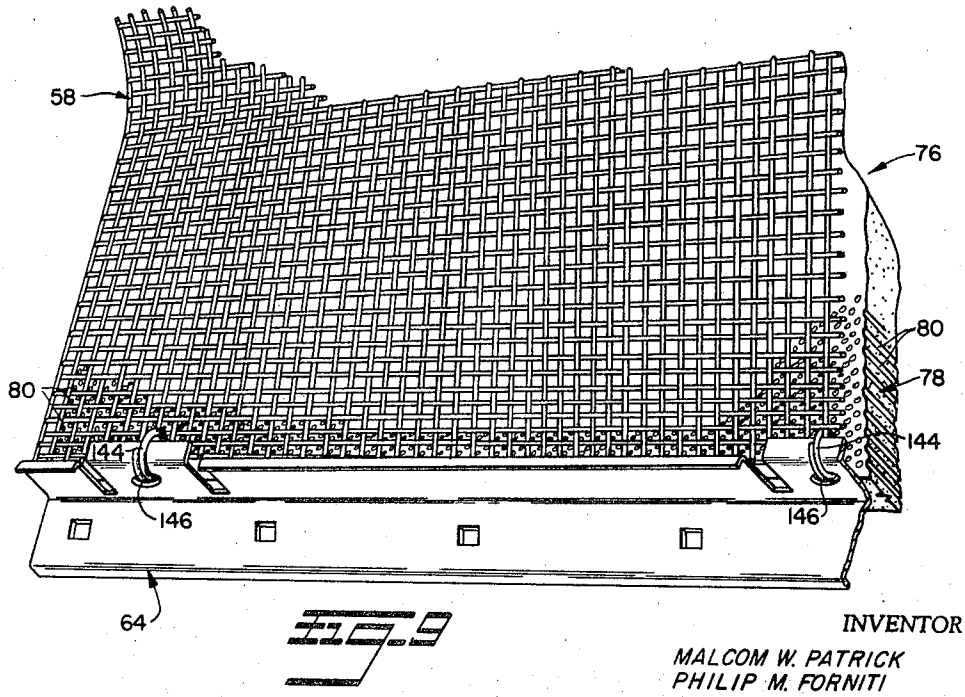


FIG. 9

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INFRARED HEATERS AND GENERATORS

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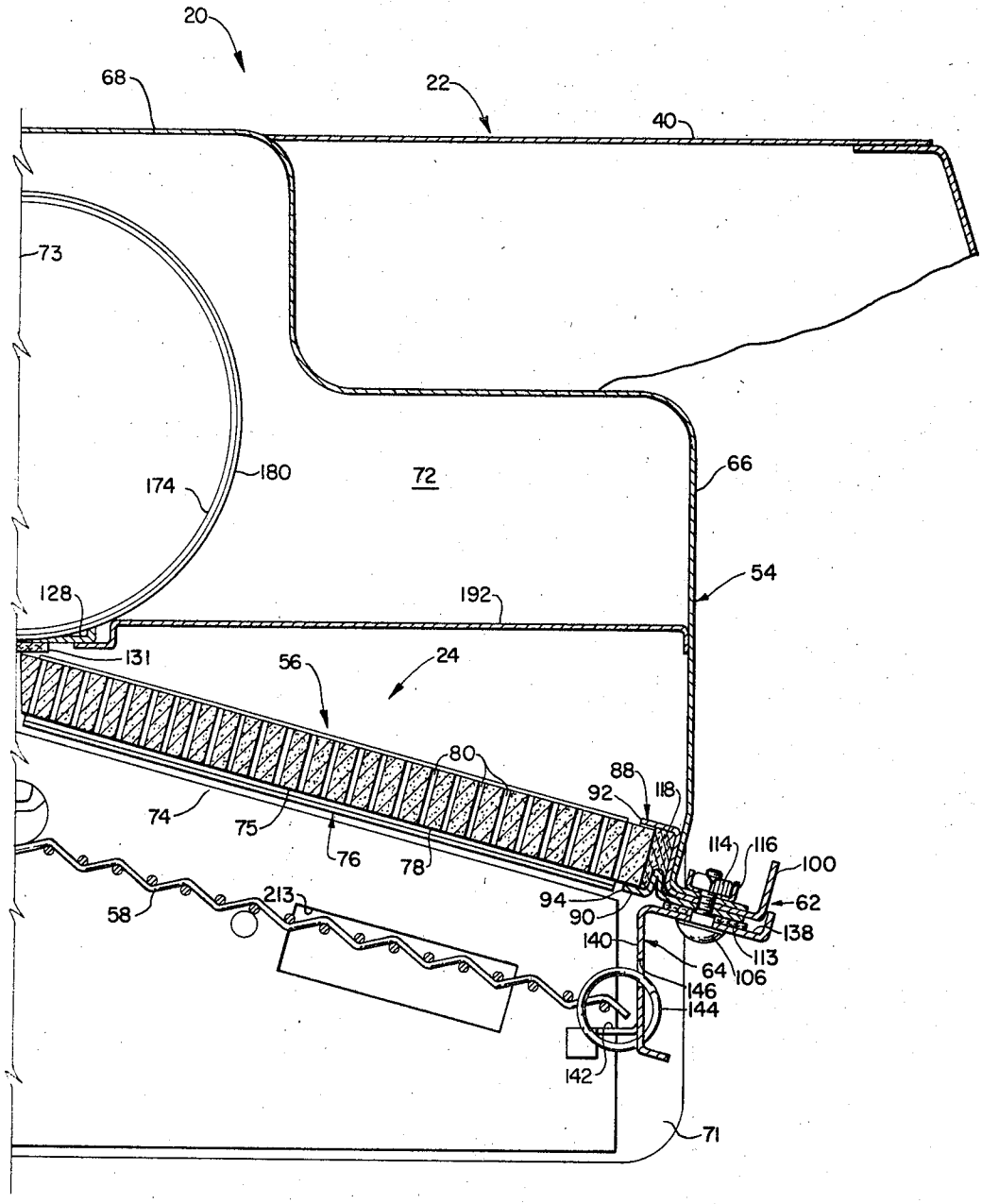


FIG. 2

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INFRARED HEATERS AND GENERATORS

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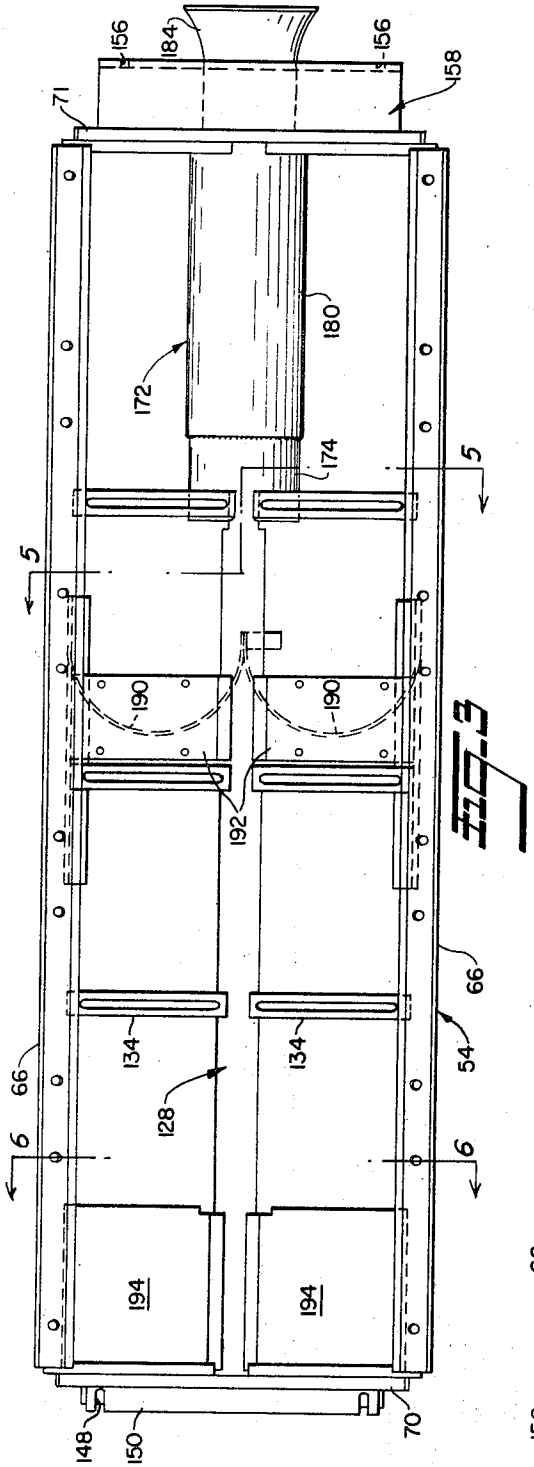


FIG. 3

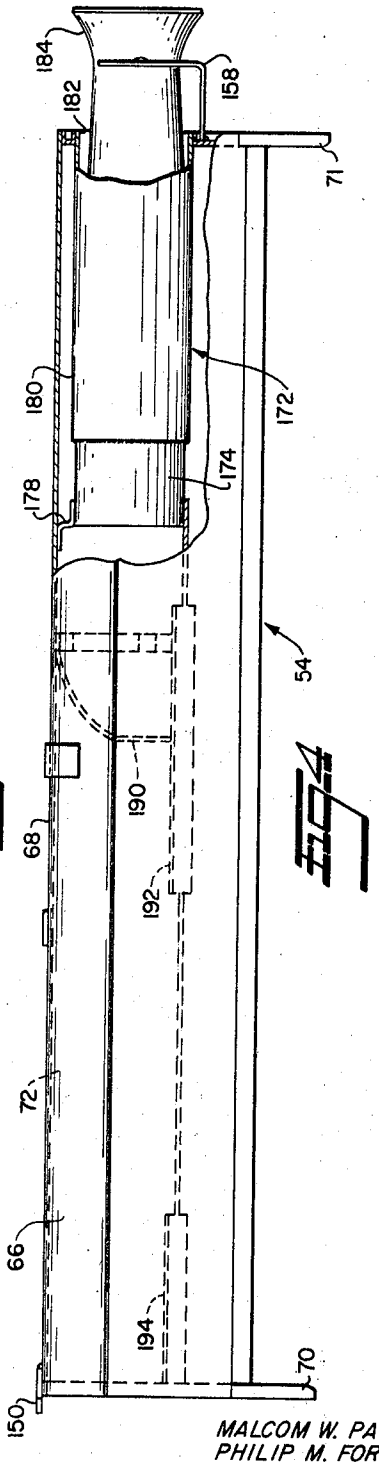


FIG. 4

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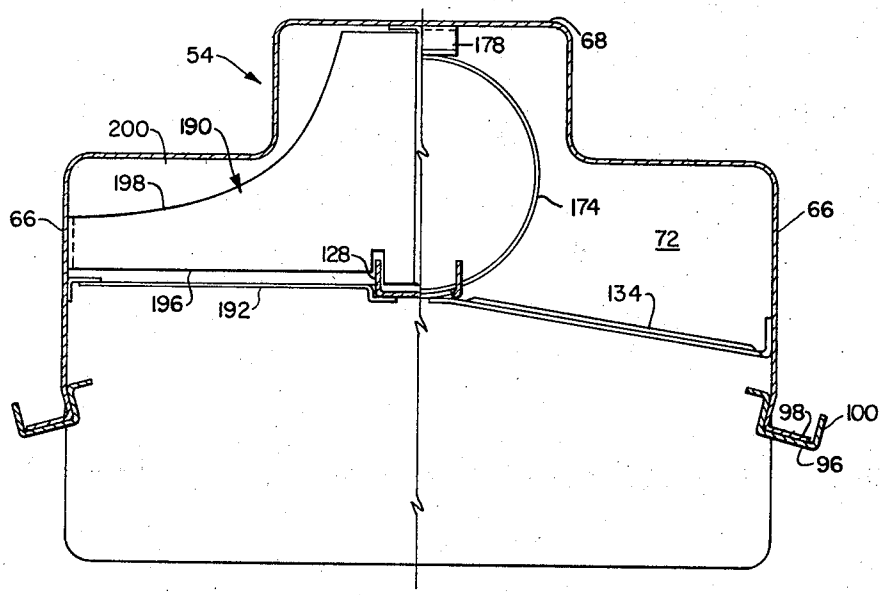


FIG. 5

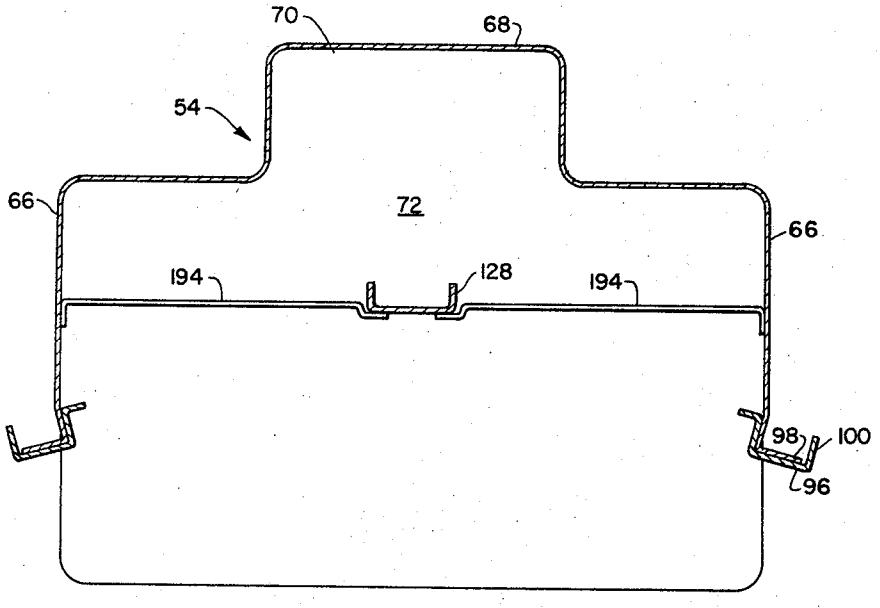


FIG. 6

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INFRARED HEATERS AND GENERATORS

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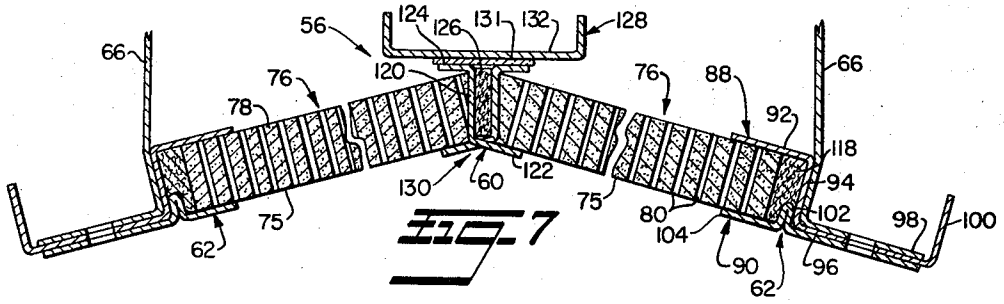


FIG. 7

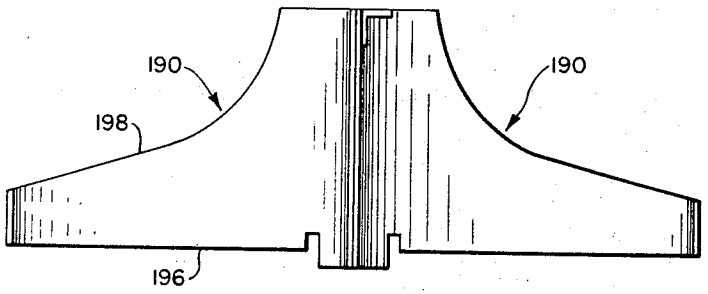


FIG. 12

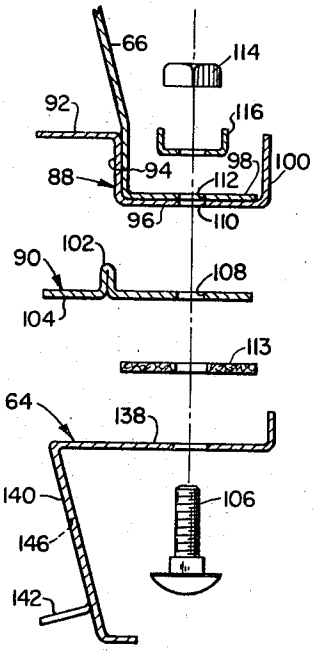


FIG. 8

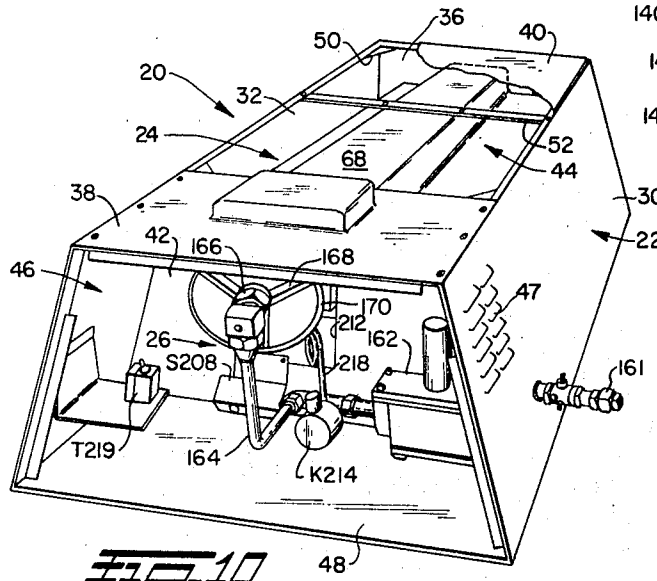


FIG. 10

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INFRARED HEATERS AND GENERATORS

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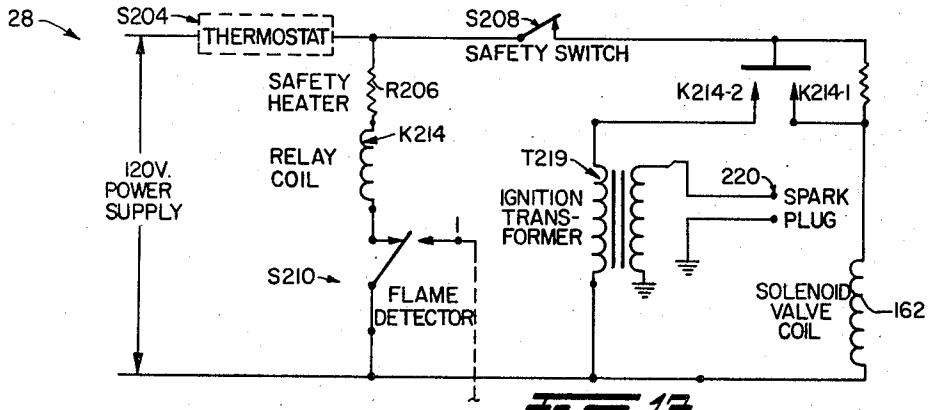


FIG. 13

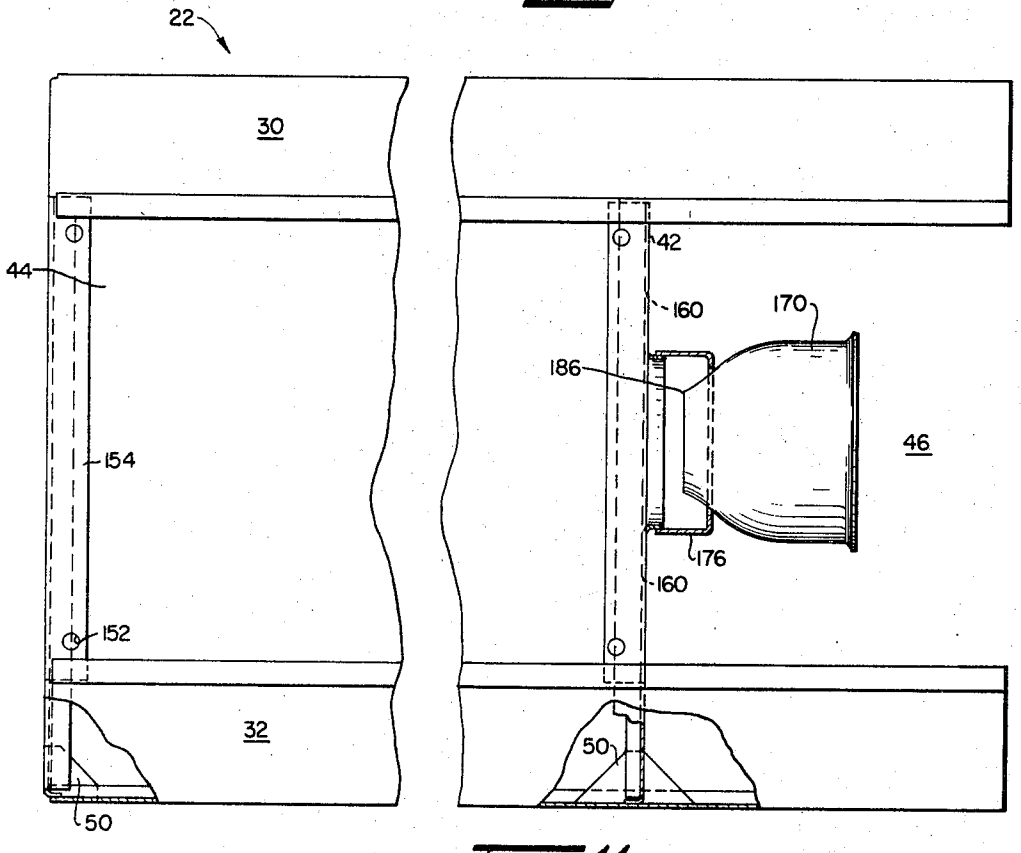


FIG. 11

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INFRARED HEATERS AND GENERATORS

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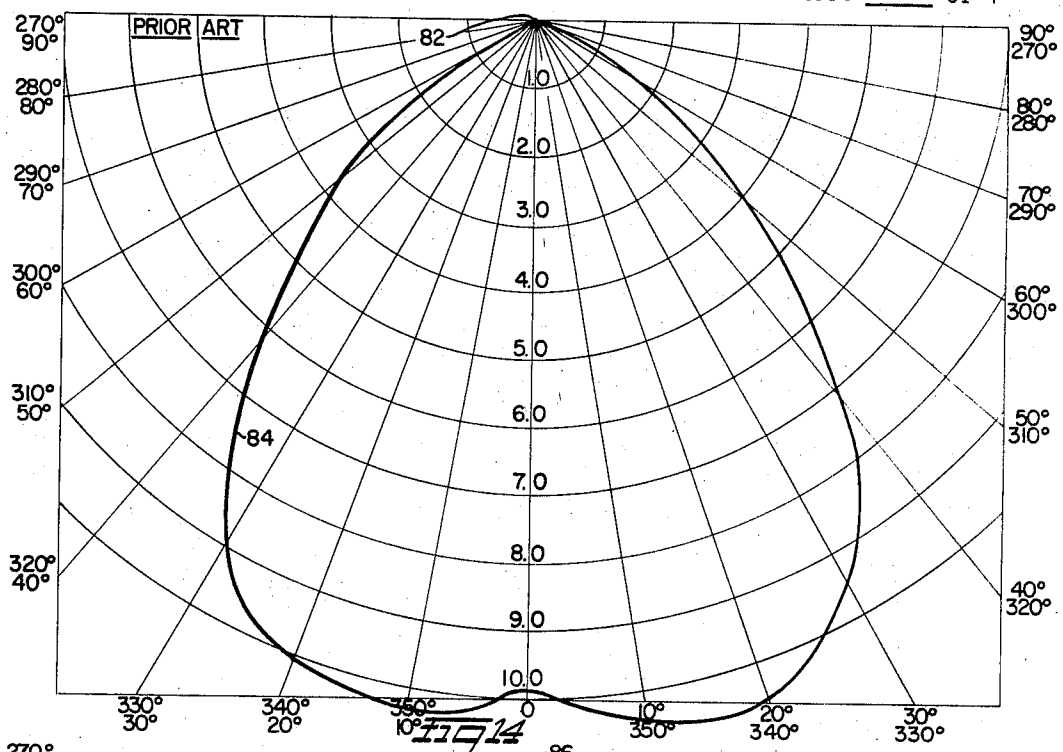


FIG 14

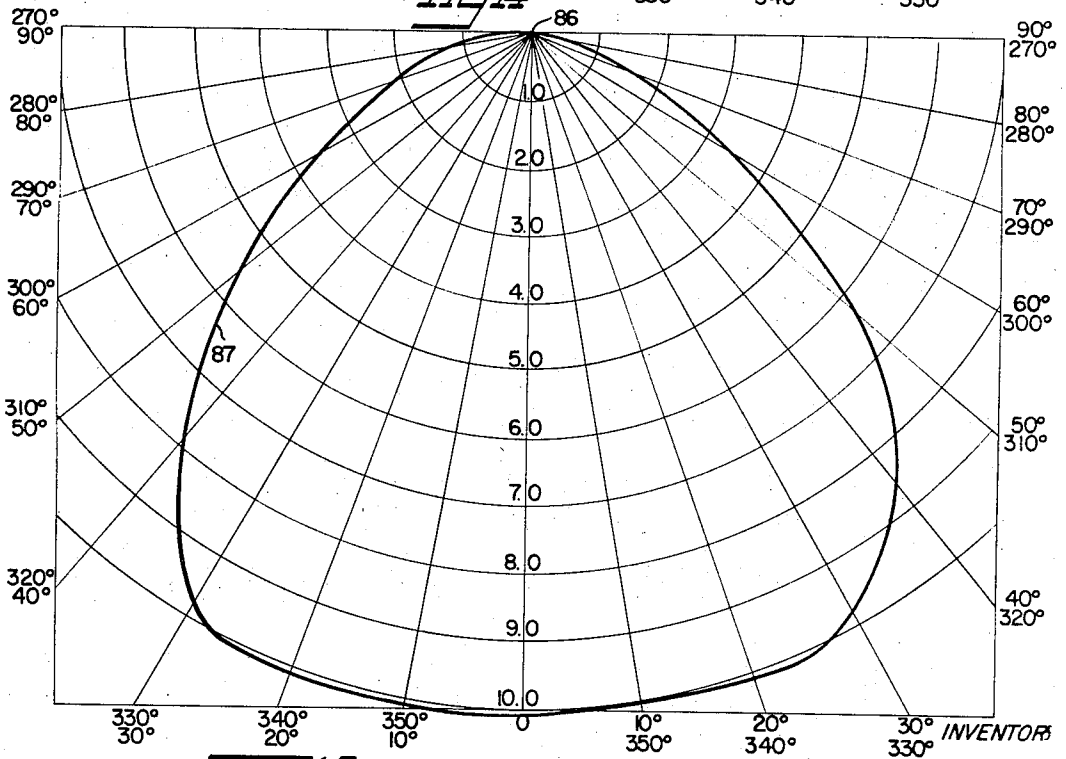


FIG 15

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United States Patent Office 3,424,146
Patented Jan. 28, 1969

3,424,146

INFRARED HEATERS AND GENERATORS

Malcom W. Patrick, Chagrin Falls, and Philip M. Forniti, Cleveland, Ohio, assignors, by mesne assignments, to White Consolidated Industries, Inc., a corporation of Delaware

Filed Mar. 23, 1967, Ser. No. 625,334
U.S. Cl. 126—92 15 Claims
Int. Cl. F23d *13/14;* F24c *3/04*

ABSTRACT OF THE DISCLOSURE

Combustion type infrared generators having two relatively inclined rows of radiants providing a V-shaped radiant surface; retainers for mounting the radiants in the burner housing, which preferably has stepped sides and internal combustible mixture distributing baffles; and a curved reradiator adjacent the radiant surface. Radiant heaters having infrared generators removable through a normally open side of a heater casing and without other access to the casing exterior, a fuel-air supply arrangement and ignition and control systems.

Background and summary of the invention

This invention relates to infrared generators and, more specifically, to infrared generators of the combustion type and to radiant heaters in which combustion type infrared generators are incorporated. In particular, the present invention is concerned with improved infrared generators of the type described in Patent No. 2,775,294 to Gunther Schwank and with radiant heaters for space heating and similar uses in which such infrared generators are used as the radiant energy source.

Generally speaking, the type of infrared generator with which the present invention is concerned includes a housing providing a plenum chamber for a combustible fuel-air mixture and an open side which is spanned by an assembly of refractory radiants having passages for the combustible mixture therethrough. The combustible mixture is generated and flows under pressure from a premixer or aspirating type mixer into the plenum chamber and then through the radiants to a combustion zone adjacent the outer surface of the radiant assembly, heating this surface to incandescence and causing it to emit radiant energy which is primarily in the upper part of the infrared portion of the electromagnetic spectrum. In many cases a reradiator (typically a coasre mesh screen of heat resistant metal) is mounted adjacent the radiant surface to increase the efficiency of the infrared generator.

In those heretofore known infrared generators of the type just described of larger capacities there are typically two rows of radiants arranged in a planar array having a flat radiant surface. It has now been discovered that there are significant advantages in inclining the rows of radiants relative to each other to produce a V-shaped radiant assembly with a similarly configured radiant surface. One advantage is a substantially more uniform and significantly wider distribution of the energy emitted from the radiant surface with respect to the major and minor axes of the generator. Another advantage is a surprising reduction in the size of an infrared generator of given capacity. Further advantages are a reduction in the per radiant heat load, which increases the useful service life of the radiants, improvement of the cross-lighting ability, and an increase in efficiency.

Yet another important advantage of the novel V-shaped tile arrangement described above is that it materially simplifies the task of mounting multiple rows of radiants in the generator housing. In the infrared generators of the present invention the mounting problem is even further

resolved by the use of novel retainers between the rows of tiles, which lock the adjacent rows together by a "keystone" type effect. These retainers are completely free of mechanical connection to the generator housing and accordingly effectively accommodate contraction and expansion-induced relative movement between the rows of tiles as the infrared generator is cycled as does the V-shaped configuration of the radiant assembly, which eliminates the "buckling" problem appurtenant to planar arrays of multiple radiants.

Co-operating retainers of novel construction for the free edges of the radiant assembly combine with the retainers described in the preceding paragraph to fix the radiant assembly relative to the generator housing. These retainers have readily detachable radiant supporting components. Accordingly, since there is no mechanical connection between the first-described retainers and the radiants, the radiants can be easily and quickly removed from the generator housing for cleaning or replacement.

Another important feature of the present invention is a novel rerediator of curved configuration which is prefably employed to even further increase the efficiency of the infrared generators disclosed herein. Unexpectedly, it has been found that this configuration eliminates the destructive hot spots which would form along the bend of a V-shaped reradiator and, at the same time, has no adverse effect on the uniformity of radiant energy emission which was heretofore thought to require a reradiator exactly parallel to the radiant surface of the generator.

The reradiator is mounted in spaced relationship to the radiant assembly by novel brackets which accommodate expansion and contraction of the reradiator as the infrared generator is cycled. These brackets are preferably attached to the generator housing by removable fasteners so that the reradiator may be easily and quickly removed and serviced or replaced when necessary.

Other significant features of the present invention are a novel generator housing configuration, which significantly reduces the transfer of heat from combustion products to the housing and a baffle arrangement which insures a uniform flow of combustible mixture over the entire radiant assembly without creating an unacceptable back pressure in the plenum chamber. These features therefore also make worthwhile contributions to the operation and efficiency of the infrared generators described herein.

As mentioned above, the present invention resides, in another aspect, in the provision of novel, improved radiant heaters in which the radiant energy is supplied by combustion type infrared generators. Perhaps the most salient feature of these novel heaters is a novel, improved arrangement for mounting the infrared generator in more-or-less conventionally configurated heater casing having an open bottom through which the radiant energy emitted by the infrared generator passes to the space or objects to be heated. This arrangement permits the infrared generator to be removed through the open bottom of the casing and eliminates the need for access to any other part of the casing exterior. This feature is especially important in applications such as high bay heating where banks of heaters may be mounted adjacent the roof of a building so that neither the sides nor the top of the heater are accessible without lowering the entire heater.

From the foregoing it will be apparent than one important and primary object of the present invention is the provision of novel, improved combustion type infrared generators and novel, improved radiant heaters in which combustion type infrared generators are employed as the source of radiant energy.

Other related and important but more specific objects of the present invention reside in the provision of combustion type infrared generators;

(1) which are capable of providing a more uniform and wider distrbiution of emitted radiant energy than those of the same general type heretofore known.

(2) which are substantially smaller for a given capacity than those heretofore available.

(3) which have a lower heat load per radiant than those heretofore known and in which the radiants accordingly have a longer service life.

(4) in which the radiants are more effectively mounted in the generator housing than in heretofore available infrared generators of the same general type and in which the radiants are easily and quickly removable from the generator housing.

(5) in which, in conjunction with the preceding objects, the radiant energy is emitted from a radiant assembly in which adjacent rows of radiants are inclined relative to each other to provide a generally V-shaped configuration.

(6) which have a novel reradiator that is free from sharp bends and appertenant destructive hot spots and which have a novel reradiator mounting arrangement to accommodate temperature change—induced distortions of the reradiator.

(7) in which the generator housing has a novel configuration capable of significantly reducing heating of the housing.

(8) which have a novel internal baffling arrangement for effecting uniform distribution of a combustible fuel-air mixture.

Another important but specific object of the present invention resides in the provisions of novel, improved radiant heaters in which the source of radiant energy is a combustion type infrared generator and in which the infrared generator can be removed through one normally open side of a heater casing in which it is mounted without the necessity of gaining acces to the rest of the heater exterior.

Other objects, further novel features, and additional advantages of the present invention will become apparent from the appended claims and as the ensuing detailed description and discussion proceeds in conjunction with the accompanying drawing.

Brief description of the drawing

In the drawing:

FIGURE 1 is a pictorial view of a radiant heater embodying the principles of the present invention in which the source of radiant energy is a novel improved combustion type infrared generator similarly constructed in accord with the principles of this invention;

FIGURE 2 is a partial, vertical section through the radiant heater of FIGURE 1;

FIGURE 3 is a bottom view of the combustion type infrared incorporated in the radiant heater of FIGURE 1;

FIGURE 4 is a side view of the infrared generator;

FIGURES 5 and 6 are sections through the infrared generator taken substantially along lines **5—5** and **6—6** of FIGURE 3;

FIGURE 7 is a partial vertical section through the infrared generator, showing in detail the novel retainers employed to support the radiants of infrared generator from the generator housing;

FIGURE 8 is an exploded view of the generator housing, the retainers employed to fix the free edges of the radiants to the housing, and a bracket employed to support a reradiator in spaced relationship to the radiants;

FIGURE 9 is a pictorial view of the reradiator and one of the reradiator supporting brackets;

FIGURE 10 is a pictorial view of the radiant heater showing the arrangement of the major components in its control compartment and the configuration of the infrared generator housing;

FIGURE 11 is a plan view of the radiant heater casing with certain top panels removed and parts broken away to show the arrangement of components in the housing;

FIGURE 12 is an end view of a combustible mixture deflecting assembly employed in the infrared generator;

FIGURE 13 is a schematic of a control system for the infrared generator;

FIGURE 14 is a chart showing the radiant energy distribution from a conventional infrared generator of the same general type as that contemplated by the present invention; and

FIGURE 15 is a graphical illustration of the radiant energy distribution from infrared generators constructed in accord with the principles of the present invention.

Detailed description of a preferred embodiment

Referring now to the drawing, FIGURE 1 depicts a novel radiant heater **20** constructed in accord with the principles of the present invention. The major components of infrared generator **20** are a casing **22** housing a novel combustion type infrared generator 24 also constructed in accord with the principles of the present invention, a combustible mixture supply system **26** (see FIGURE 10) for the infrared generator, and a control and ignition system **28** (see FIGURE 13).

The details of casing **22** are unimportant and may be varied as necessary for particular applications of the present invention. Generally speaking, however, this casing includes side walls **30** and **32**, removable end walls **34** and **36**, and removable top panels **38** and **40** (see FIGURE 10). A partition **42** divides casing **22** into an infrared generator compartment **44** and a systems compartment **46**, which communicates with the ambient atmosphere through louvers **47** in side walls **30** and **32**. The bottom side of infrared generator compartment **44** is open for the passage of the radiant energy emitted from infrared generator **24**, while the bottom of compartment **46** is closed by a panel **48**.

In addition to the components described in the preceding paragraph, casing **22** includes various reinforcing members such as the gussets **50** shown in FIGURE 11 and the tie strap **52** shown in FIGURE 10. The details of these reinforcing members are not part of the present invention, which may be understood without reference to them. They will accordingly not be described further herein.

Referring now to FIGURES 1–8, the major components of the novel infrared generator **24** incorporated in radiant heater **20** are an infrared generator housing **54**, a radiant assembly **56**, and a reradiator **58**. Radiant assembly **56** is retained in housing **54** by novel clips **60** and retainer assemblies **62**; and reradiator **58** is fixed to the housing by elongated support brackets **64**.

As shown in FIGURES 2–6, infrared generator housing **54** has parallel, opposed side walls **66**, a top wall **68**, and end walls **70** and **71** defining a combustible mixture plenum chamber **72**. Also, with the infrared generator oriented as shown in FIGURES 2, 5 and 6, its lower or bottom side is open. Side walls **66** are stepped toward a vertical, longitudinal plane **73** through the midpoint of the infrared generator. This is an important practical feature of the present invention. Specifically, in infrared generator **24**, combustion occurs in a zone **74** adjacent the outer radiant surfaces **75** of radiant assembly **56**. The combustion products flow from combustion zone **74** downwardly around the lower edges of and then upwardly along side walls **66**. By stepping the side walls toward the center of the infrared generator, they are to a considerable extent isolated from the combustion products, minimizing the transfer of heat from the combustion products to the generator housing. This is important in that it minimizes the heating of the combustible fuel-air mixture which, as will be explained in more detail later, flows through plenum chamber **72** to combustion zone **74**.

Housing **54** has another important practical advantage in that it is of sheet metal construction, thus making it materially less expensive to fabricate than the cast-type housings heretofore typically employed in infrared gener-

ators of the same general type as that contemplated by the present invention. Any appropriate sheet material may be employed with one suitable material being sheet steel coated with a conventional, high temperature resistant, procelain enamel.

As in the case of radiant heater casing **22**, there are various structure details of housing **54** which are not considered part of the present invention. Therefore, to the extent that these details are not necessary to an understanding of the present invention, they will not be discussed herein.

Referring now specifically to FIGURES 2 and 7, radiant assembly **56** is mounted across and spans the open side of housing **54**. Assembly **56** includes two rows or arrays **76** of radiants **78** which are substantially equal in length to housing **54** and which may be one, two, or more radiants wide. Radiants **78** may but do not necessarily have to be ceramic tile of the type disclosed in U.S. Patent No. 2,775,294 to Gunther Schwank. In any event, they will be provided with passages **80** for the flow of combustible fuel-air mixture from the interior of housing **54** to combusion zone **74**.

One of the important features of the present invention is the mounting of the two radiant arrays **76** in mutually inclined, abutting relationship so that radiant assembly **56** has the V-shaped configuration shown in FIGURES 2 and 7. One advantage of this configuration, mentioned briefly above, is a significant improvement in the uniformity of radiant energy distribution over that obtainable from the heretofore known infrared generators of the general type contemplated by the present invention in which flat or planar radiant assemblies are employed.

In conjunction with the foregoing, FIGURE 14 shows the distribution pattern along the major or longitudinal axis of the conventional planar radiant assembly. The distribution pattern shown in this figure is for an infrared generator oriented so that the planar radiant emitting surface of the generator faces downwardly. Reference characters **82** and **84** respectively identify the location of the major burner axis, which extends at a right angle to the figure, and the curve tracing the distribution pattern in a plane normal to the major axis of the infrared generator of the emitted radiation.

FIGURE 15 shows a typical pattern for infrared generators constructed in accord with the principles of the present invention, reference characters **86** and **87** respectively identifying the major or longitudinal axis of the infrared generator, which extends at a right angle to the figure, and a curve showing the distribution pattern of the emitted radiation in a plane normal to the major or longitudinal axis of the infrared generator.

A comparison of FIGURES 14 and 15 shows that the distribution pattern of the infrared generators of the present invention are substantially more uniform than those of heretofore available generators of the same general type. Curves **84** and **87** also show that the infrared generators of the present invention produce a wider distribution pattern than those heretofore available, which is another significant advantage.

FIGURE 14 does not show the distribution pattern of radiant energy along the minor or transverse axis of infrared generators according to the present invention i.e., over a vertical plane including the major axis of the generator or lines parallel to the major axis. Such patterns have however been ascertained. These show that the same high degree of uniformity obtained along the major axis is also present along the minor axis, which is also a significant advantage.

The novel V-shaped radiant assembly described in the preceding paragraphs has a number of other important advantages. These have previously been discussed in considerable detail.

Referring now to FIGURES 2, 7, and 8, each of the radiants **78** is mounted in generator housing **54** in the novel V-shaped configuration just described by the clips **60** and retainer assemblies **62** mentioned above. Retainer assemblies **62** include a pair of co-operating retainer members **88** and **90** adapted to clamp a radiant therebetween. As shown in FIGURES 7 and 8, members **88** have a retaining portion **92** adapted to engage or abut the upper or inner surface of the associated radiant **78**, a leg **94** adjacent the side wall **66** of housing **54** with which the retainer is associated, a leg **96** abutting an outwardly extending flange **98** at the lower edge of the housing side wall, and an upstanding flange **100**. Retainer members **88** are fixed to the side walls of housing **54** as by tack welding.

The co-operating retainer members **90** have a generally flat configuration except that they are folded intermediate their ends to provide an abutment **102** adapted to be juxtaposed to the leg **94** of the co-operating retainer member **88**. As shown in FIGURE 7, members **90** have legs **104** adapted to engage the outer or lower side of radiants **78** so that they co-operate with the legs **92** of retainer members **88** to clamp the radiants **78** therebetween. Retainer members **90** are detachably fixed to the flanges **98** of generator housing side walls **66** by bolts **106**, which extend upwardly through aligned apertures **108**, **110**, and **112** in retainer members **90** and **88** and flange **98** and an insulating washer **113** between bracket **64** and retainer member **90**, by nuts **114**, and by nut retainers **116**.

The method of fixing the outer edges of the radiants to the generator housing just described is also considered an important feature of the present invention because an individual radiant can be easily and quickly removed from the infrared generator for cleaning, replacement, etc. This is done simply by removing the detachable component **90** of the retainer assembly **62** fastening the radiants to the housing.

An insulating strip **118** of Fiberfrax or other temperature resistant insulation is interposed between the edge of the radiants **78** and the leg **94** of retainer member **88**. This insulation reduces the transfer of heat from the radiant to the burner housing, minimizing the possibility of overheating.

Another important feature of the present invention is the novel clips **60** which connect or joint the two radiant arrays **76**. These clips have a generally Z-shaped configuration and a web **120** between oppositely directed legs **122** and **124**. Clips **60** are disposed at intervals along radiant assembly **56** at the intersections of adjacent radiants and in the center of each radiant.

Successive clips **60** are oriented with corresponding legs extending in opposite directions. The downward force exerted by a radiant **78** on the leg **122** of a specific clip **60** results in a corresponding downward force being exerted on the oppositely disposed radiant **78**. Therefore, with radiant assembly **56** oriented as shown in FIGURE 7, clips **60** exert a "keystone" type locking effect on the radiants in the mutually inclined arrays **76** to retain them in the V-shaped arrangement shown in FIGURE 7.

Clips **60** are not connected to any components of infrared generator **24** except for radiants **78**. Accordingly, they freely accommodate temperature-induced expansions and contractions in radiant assembly **56** caused by cycling of infrared generator **24**.

As is also shown in FIGURE 7, an insulating member **126** of Fiberfrax or other heat resistant material is interposed between the two radiant arrays **76** to seal the joint therebetween and prevent the formation of hot spots. Also, because of it resiliency the Fiberfrax material acts as a cushion between the mitered faces of the radiants as they expand during heating to minimize the abrasive action between the mitered faces.

The precise angle between the two radiant arrays **76** is not critical and may vary from installation to installation. This is not to be understood, however, as meaning that there are no limits on this angle. Specifically, if the included angle between the two rows of radiants is too

large, making the V more shallow, the desired uniformity of radiant energy distribution will not be obtained; and, moreover, the "keystone" type of lock between the two rows of radiants will be lost, producing the same mounting problems encountered in conventional, multiple row radiant assemblies. Conversely, if the angle between the two rows of radiants is made too small and the V becomes too steep, the distribution of radiant energy will not be uniform; and, in addition, there will be an undesirably high interchange of heat between the two rows of radiants, resulting in over-heating of the radiants.

In practice, included angles on the order of 150° have been found acceptable [1] in that the desired pattern of radiation is obtained; and, at the same time, structural integrity of the radiant assembly is obtained. Different angles can of course be employed, if desired.

Referring now to FIGURES 3–7, a channel **128** is fixed to generator housing **54** on the back or inner side of radiant assembly **56** along the intersection **130** of the two radiant arrays **76**. Channel **128**, which is free of mechanical connections to radiants **78**, supports the radiants and maintains them in the configuration of FIGURE 7 during shipping and at other times when the radiant is not in the downwardly facing orientation shown in FIGURE 7 and in which the "keystone" locking effect obtained with the radiant assembly in this position is not present.

A strip **131** of asbestos or other insulation fixed to the web **132** of channel **128** minimizes the transfer of heat from the radiant assembly by conduction through clips **60** and the channel **128** to housing **54**. This is also helpful in preventing overheating of the housing.

In addition to performing the function just described, channel **128** is connected by braces **134** (see FIGURE 3) to the walls **66** of housing **54** at intervals along the housing. This arrangement adds rigidity to the generator housing.

Referring now to FIGURES 1, 2, and 9, reradiator **58** is mounted in spaced relationship to radiant assembly **56** to increase the efficiency of infrared generator **24** in a known manner. Reradiator **58**, which will typically consist of one or more sections of coarse mesh screen of temperature resistant metal such as Nichrome or Inconel (three sections are employed in the illustrated embodiment to minimize distortion), has a continuously curved configuration in the vicinity of the intersection **130** between the two radiant arrays **76**. This eliminates the sharp bend which would be necessary at this point if the heretofore deemed necessary practice of maintaining precise parallelism between the radiant surfaces and reradiator of an infrared generator were to be followed. By eliminating such a bend, the destructive hot points which form along such bends are also eliminated, materially increasing the service life of the reradiator. At the same time, it has been found that the lack of parallelism in this vicinity surprisingly does not adversely affect the uniformity of emission from radiant surfaces **75** of radiant assembly **56** to a significant extent.

Referring now to FIGURES 2 and 7–9, the brackets **64** by which reradiator **58** is supported from generator housing **54** are eleongated, sheet metal members having integral mounting legs **138** and reradiator supporting legs **140**. Brackets **64** are detachably fixed to the flanges **98** of generator housing **54** by the same bolts **106** securing retainer members **90** to these flanges. This permits the reradiator to be readily removed from infrared generator **24** when necessary.

As is best shown in FIGURES 8 and 9, inwardly directed flanges or lugs **142** are struck from legs **140** at intervals therealong. The reradiator **58** rests on lugs **142** and is loosely secured to the lugs by pig rings **144** which are fastened through the reradiator and apertures **146** in bracket legs **140**.

The mounting arrangement just described maintains reradiator **58** in the proper position relative to radiant assembly **56**. At the same time, this mounting arrangement, together with the reradiator configuration described above, accommodates temperature change induced distortion and movement of the reradiator as infrared generator **24** is cycled.

Referring now to FIGURES 1, 2, and 11, infrared generator **24** is removably mounted in radiant heater casing **22** by four bolts (not shown). Two of these extend vertically through slots **148** in a bracket **150** attached to generator housing end wall **70** and apertures **152** in a bracket **154** fixed to radiant heater casing end wall **36**. These bolts fix bracket **150** to bracket **154**, supporting end **70** of infrared generator **24** from end wall **36** and are accessible from the bottom of the casing **22** through the generator compartment **44**.

The second set of bolts extend horizontally through openings **156** in an L-shaped bracket **158** fixed to generator housing end wall **71** and aligned apertures **160** in radiant heater casing partition **42**. The bolts accordingly fix the opposite end of infrared generator **24** to the partition **42** and are accessible from the bottom of the casing **22** through the systems compartment **46** by removing the panel **48**.

In conjunction with the generator mounting arrangement just described, the overall plan dimensions of the infrared generator are smaller than the corresponding dimensions of the open bottom side of casing **22**. Accordingly, when desired, infrared generator may be easily and simply removed from casing **22** by removing the two bolts attaching the infrared generator to partition **42** and loosening the two by which it is fixed to bracket **154** and then removing the infrared generator through the bottom of the casing.

Moreover, since all four bolts are accessible through the bottom of casing **22**, infrared generator **24** can be removed without the necessity of gaining access to the remainder of casing **22**. This is particularly important in applications such as high bay heating where radiant heaters **20** may be arranged in closely spaced side-by-side relationship and in juxtaposition to the roof of a building or other structure in which case access to the sides and top of the heater could be obtained only by lowering it. Accordingly, the novel method of mounting the infrared generator in casing **22** just described is considered an important feature of this invention.

Referring now to FIGURE 10, the combustible mixture supply system **26** of radiant heater **20**, which is mainly conventional, includes a fuel supply line **161** extending through casing side wall **30** into compartment **46**, where it is connected to a solenoid valve **162**. The latter is, in turn, connected through line **164** to a conventional orifice member **166**. The later is mounted by a spider **168** in the bell **170** of a venturi assembly **172**, which also includes a venturi tube **174** extending through the end wall **71** of infrared generator **24** into the interior of generator housing **54** and through partition **42** into systems compartment **46**.

Venturi bell **170** is fixed to heater casing partition **42** by a U-shaped bracket **176** and is free of mechanical connections to infrared generator **24**. Venturi tube **174** is fixed to infrared generator housing **54** by the L-shaped bracket **158** mounted on housing end wall **71** and by a bracket **178** which is attached to the top wall **68** of generator housing **54**. A tube **180** sealed to venturi tube **174** and the opening **182** for the venturi tube in end wall **71** isolates plenum chambetr **72** from systems compartment **46**.

From the foregoing, it will be apparent that venturi tube **174** is fixed only to infrared generator **24** and is free of attachment to casing **22**. The flared inlet end **184** of the venturi merely has a sliding fit over the outlet end **186**

[1] With the radiant surfaces 75 facing downwardly, each radiant array 76 would be accordingly inclined at an angle on the order of 15° to the horizontal.

of the entrance bell mounted in the casing. This arrangement further facilitates the removal of the infrared generator from casing **22** since no dismantling of the combustible mixture supply system is required when the infrared generator is removed.

The aspirator type fuel-air supply system thus far described operates in the conventional manner with the flow of gas under pressure through orifice member **166** inducing a flow of air into venturi assembly **172**. As the gas and air flow through venturi tube **174**, they are mixed; and the combustible fuel-air mixture is discharged from the venturi tube into the pletnum chamber **72** in the interior of generator housing **54**.

Referring now to FIGURES 3 and 4, turning vanes **190** and baffles **192** and **194** are employed to obtain a uniform distribution of the combustible mixture throughout plenum chamber **72**. Baffles **192** and **194** are generally flat sheet metal members extending between channel **128** and the side walls **66** of housing **54** at a level generally coincident with the bottom of venturi tube **174**. Baffles **194** are located at the end of housing **54** opposite venturi assembly **172**, and baffles **192** are located in spaced relation to the outlet end of venturi tube **174** approximately midway between the ends of housing **54**.

As best shown in FIGURES 3, 4, and 12, turning vanes **190** are arcuately sectioned sheet metal members having a straight lower edge **196** and a curved upper edge **198**. The turning vanes are mounted in side-by-side relation in plenum chamber **72** with their concave surfaces spanning chamber **72** and facing the outlet end of venturi tube **174**. The bottom edges of the turning vanes rest on the laterally extending baffles **192** just described and extend upwardly from these baffles to the top wall **68** of housing **54**. Due to the configuration of the upper edges **198** of the turning vanes, there are openings **200** between the turning vanes and housing **54** through which the combustible mixture can flow toward the end of the infrared generator opposite the venturi assembly.

As indicated above, the baffling arrangement just described is effective to provide a uniform distribution of the combustible mixture throughout the plenum chamber. At the same time, this particular baffling arrangement does not create an objectional back pressure in the plenum chamber so it is considered an important practical feature of this invention.

From plenum chamber **72**, the combustible mixture flows through the apertures **80** in radiants **78** to combustion zone **74**. Here the fuel-air mixture burns, heating radiants **78** and reradiator **58** to incandescence, causing them to emit radiant energy which is primarily in the infrared portion of the spectrum.

Reflectors **202** (part of which are shown in FIGURE 1) attached to the side walls **30** and **32** of casing **22**, to partition **42**, and to end wall **36** may be provided to direct the radiant energy emitted from radiant surfaces **75** and impinging on them back through the open bottom of the casing into the area or onto the objects being heated. Reflectors **202** are fixed to the associated casing components by appropriate brackets (not shown) which position them at the desired inclination relative to the components on which they are mounted. Preferably, detachable fasteners are employed to fasten the reflectors to these brackets so that they can be removed when necessary.

The remaining major components of radiant heater **20** is the control and ignition system **28** mentioned briefly above. This may be of any desired construction with one suitable system being the DSAN-DSAL model available from the assignee of the present invention.

The details of this system are not part of the present invention; and they will, accordingly, not be described in detail herein. Generally speaking, however, this system (see FIGURES 10 and 13) includes a thermostat or other switch **S204** which, when closed, initiates operation of infrared generator **24** by completing a circuit through the heater **R206** of a safety switch **S208** located in generator compartment **44** and incorporated in the system to shut it down on ignition failure. A second circuit is simultaneously completed through a flame detector **S210** extending through openings **212** in partition **42** and **213** in infrared generator end wall **71** to a position adjacent one of the radiant surfaces **75** of radiant assembly **56**. The flame detector is incorporated in the system to shut down the heater if the supply of power or fuel fails while the system is in operation.

A third circuit is completed at the same time as the two just described. This is through the coil of relay **K214**, which is also mounted in compartment **46**.

Energization of relay **K214** causes relay contacts **K214–1** and **K214–2** to close, energizing the solenoid of and opening valve **162**. The opening of valve **162** allows fuel to flow from line **161** through the valve and line **164** to plenum chamber **72** and, also, through a line **218** extending through opening **212** to a pilot burner (not shown) disposed beside flame detector **S210** adjacent radiant assembly **56**.

The closing of the relay contacts also energizes ignition transformer **T219**, providing a spark across the gap of sparkplug **220**, which is located adjacent the pilot burner to ignite the latter. The pilot burner then ignites the main burner; and, thereafter, the flame detector operates to de-energize relay **K214**, shutting off the ignition transformer and the flow of current through the safety switch heater **R206**. At this point, the control system is in the normal "on" configuration.

Unless there is a fuel or power failure, the system will remain in this "on" configuration until the demand for heat is satisfied. At this time switch **S204** will open, interrupting the flow of current through the solenoid of valve **162** which will close, interrupting the flow of fuel to infrared generator **24**.

In the foregoing discussion, infrared generator **24** has been described by reference to one exemplary application; viz, its utilization in a radiant type space heater. It will, however, be readily apparent to those skilled in the arts to which the present invention pertains that the type of infrared generator disclosed herein is not limited to this particular application. On the contrary it may readily be employed in any other application for which infrared generators of the same general type are useful.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description; and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. An infrared generator of the combustion type comprising a housing having an open side and defining a fuel-air plenum chamber; an assembly of radiants spanning the open side of said housing, said radiants having fuel-air flow passages therethrough; and means for effecting a flow of combustible fuel-air mixture from said plenum chamber through said flow passages to a combustion zone adjacent the exposed side of said radiant assembly to heat said radiants to temperatures at which they will emit radiant energy which is primarily in the infrared portion of the electromagnetic spectrum; said radiants being arranged in two separate arrays each having a generally planar radiant face and said infrared generator further including means for mounting said radiant assembly in said casing with the two arrays of radiants in side-by-side relationship and abutted along a line extending longitudinally of said housing and with the two arrays of radiants outwardly diverging relative to each other to form a generally V-shaped assembly in cross-section,

whereby the radiant energy emitted from the radiants in said assembly and transferred therefrom will be substantially uniformly distributed with respect to the major and minor axes of the infrared generator.

2. The infrared generator of claim 1, together with at least one reradiator of heat resistant metal fixed to said housing in spaced relation to said radiant assembly, said reradiator spanning said radiant faces and having a concave, smoothly curved configuration to thereby eliminate sharp bends and the destructive hot spots associated with such bends while retaining a substantially uniform exchange of energy between said reradiator and the radiant faces of the radiant assembly.

3. The infrared generator of claim 2, wherein the means for fixing said reradiator to said casing comprises reradiator-supporting brackets fixed to said housing on opposite sides thereof and adapted to have the opposite edges of said reradiator rested thereon and retainer means for loosely fastening the reradiator to said brackets to thereby retain said reradiator on said brackets while accommodating expansion- and contraction-induced movement of said reradiator relative to said brackets during the cycling of the infrared generator.

4. The infrared generator of claim 1, wherein the included angle between the radiant faces of the two arrays of radiants is on the order of 150°.

5. The infrared generator of claim 1, wherein said flow effecting means comprises means for supplying the combustible fuel-air mixture to said plenum chamber and communicating with said chamber through an inlet opening in one end of said housing and including mixture distribution means in said housing and extending laterally across said plenum chamber for effecting a generally even distribution of the fuel-air mixture along the length of the plenum chamber.

6. The infrared generator of claim 5, wherein said mixture distribution means comprises arcuately sectioned baffles disposed in side-by-side relationship across said plenum chamber and extending from the inner faces of said radiant assembly toward the side of the housing opposite the radiant assembly, the concave sides of said baffles facing the inlet opening in said housing.

7. The infrared generator of claim 1, wherein said housing has side walls extending normally from the open side thereof and wherein each of said side walls is stepped toward a longitudinal midplane through said housing normal to the open side of said housing to reduce the transfer of heat to said housing from combustion products flowing from the combustion zone around the edges of the side walls at the open side of said housing and upwardly along said side walls.

8. An infrared generator of the combustion type comprising a housing having an open side and defining a fuel-air plenum chamber; an assembly of radiants spanning the open side of said housing, said radiants having fuel-air flow passages therethrough; and means for effecting a flow of combustible fuel-air mixture from said plenum chamber through said flow passages to a combustion zone adjacent the exposed side of said radiant assembly to heat said radiants to temperatures at which they will emit radiant energy which is primarily in the infrared portion of the electromagnetic spectrum; said radiants being arranged in two separate arrays each having a generally planar radiant face and said infrared generator further including means for mounting said radiant assembly in said casing with the two arrays of radiants in side-by-side relationship and abutted along a line extending longitudinally of said housing and with the two arrays of radiants inclined relative to each other to form a generally V-shaped assembly, whereby the radiant energy emitted from the radiants in said assembly and transferred therefrom will be substantially uniformly distributed with respect to the major and minor axes of the infrared generator and means for mounting said infrared generator with the open side of the generator facing in a generally downward direction and wherein the two arrays of radiants in the radiant assembly slope downwardly from the center of said housing toward the sides thereof with the infrared generator thus oriented, the means for mounting said radiant arrays in said housing including first radiant retaining means fixed to the side walls of said housing at intervals therealong for supporting the opposite side edges of said radiant assembly relative to said housing and second radiant retaining means between said radiant arrays at intervals along said assembly for positioning the abutted edges of the two radiant arrays relative to each other, each said second retaining means having a first portion adapted to engage the inner side of a radiant in one array and the exterior side of a radiant in the other array, each said second radiant retaining means being free of attachment to said housing.

9. The infrared generator of claim 8, together with high temperature resistant insulation between and separating the juxtaposed edges of the two arrays of radiants.

10. The infrared generator of claim 8, together with a stop member mounted in the generator housing and extending generally the length of the plenum chamber closely adjacent the radiants and along the intersection of the two radiant arrays for supporting the radiants at their juxtaposed edges when said generator is oriented so that the radiant faces of the assembly are facing in any but a generally downward direction.

11. The infrared generator of claim 8, wherein each said first radiant retaining means comprises a pair of cooperating retainer members having portions adapted to engage opposite sides of a radiant to retain it therebetween, with said first retainer members being permanently fixed to said housing, and means for detachably fixing the second retainer members to the associated first retainer members to thereby facilitate the removal of the radiant assembly from the generator housing.

12. The infrared generator of claim 11, together with high temperature resistant insulation between the retainer members in each said first radiant retaining means for thermally isolating the edges of said radiant assembly from the generator housing.

13. The infrared generator of claim 11, together with reradiator-supporting brackets for supporting a reradiator from the generator housing in spaced relation to the radiant faces of the radiant assembly, said brackets being detachably fixed to the first retainer members of said first radiant retaining means by the means fixing the cooperating second retainer members thereto.

14. The infrared generator of claim 8, wherein each said second radiant retaining means is a generally Z-shaped member of heat resistant metal having a web adapted to be disposed between the two radiant arrays and legs on the opposite ends of said web providing said first and second radiant engaging portions.

15. A radiant heater for space heating and the like comprising a casing having an open side, an infrared generator of the combustion type in said casing and oriented to project the radiation emitted from its radiant surfaces through the open side of said casing, said infrared generator comprising a housing having an open side and defining a fuel-air plenum chamber; an assembly of radiants spanning the open side of said housing; said radiants having fuel-air flow passages therethrough; and means for effecting a flow of combustible fuel-air mixture from said plenum chamber through said flow passages to a combustion zone adjacent the exposed side of said radiant assembly to heat said radiants to temperatures at which they will emit radiant energy which is primarily in the infrared portion of the electromagnetic spectrum; said radiants being arranged in two separate arrays each having a generally planar radiant face and said infrared generator further including means for mounting said radiant assembly in said casing with the two arrays of radiants in side-by-side relationship and abutted along a line extending longitudinally of said housing and with the two arrays

of radiants outwardly diverging relative to each other to form a generally V-shaped assembly in cross-section, whereby the radiant energy emitted from the radiants in said assembly and transferred therefrom will be substantially uniformly distributed with respect to the major and minor axes of the infrared generator, and means in said casing for supplying a fuel-air mixture to the infrared generator, the overall dimensions of the opening in the casing being larger than the corresponding dimensions of the infrared generator, said infrared generator being fixed to said casing solely by fasteners accessible through the open side of the casing and the infrared generator being free of mechanical connections to the combustible mixture supply means whereby said infrared generator can be removed from said casing through the open side thereof and without access to the remainder of the exterior of the casing.

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