

April 29, 1958

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2,832,402

ANNULAR PILOT BURNER FOR COMBUSTION HEATERS

Filed April 14, 1952

3 Sheets-Sheet 1

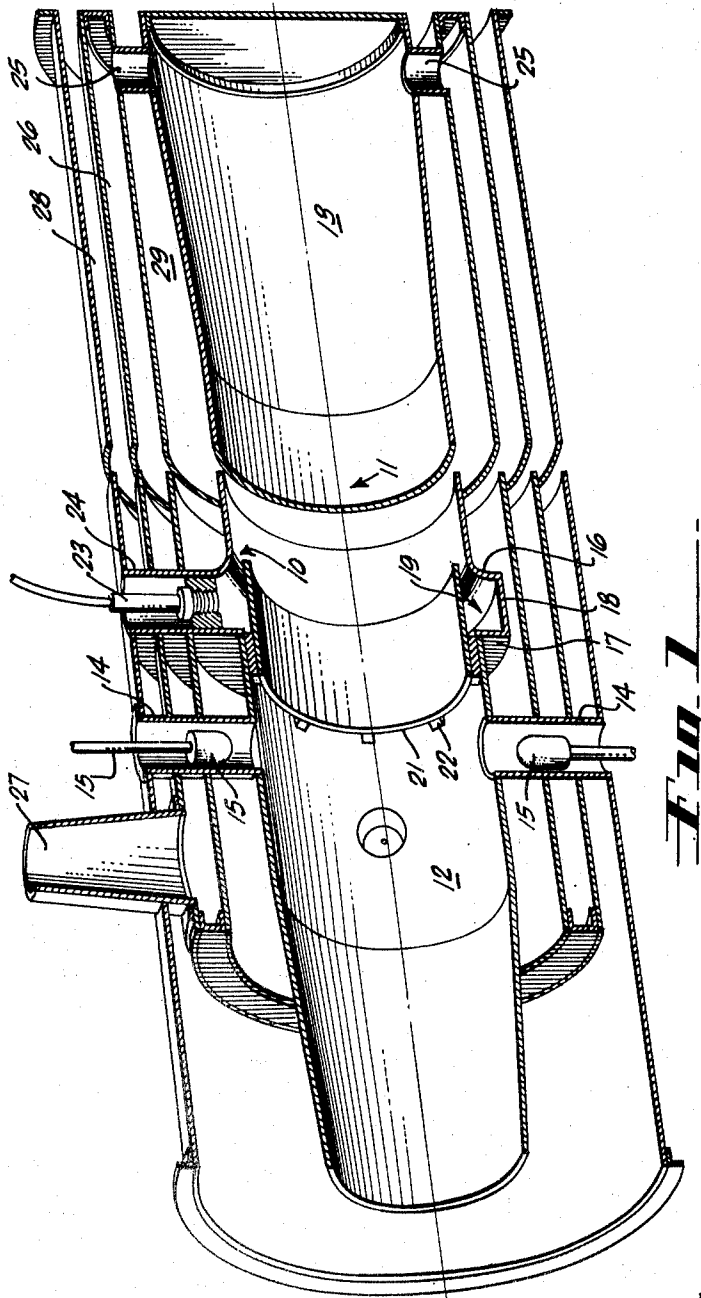


Fig. 1

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3 Sheets-Sheet 2

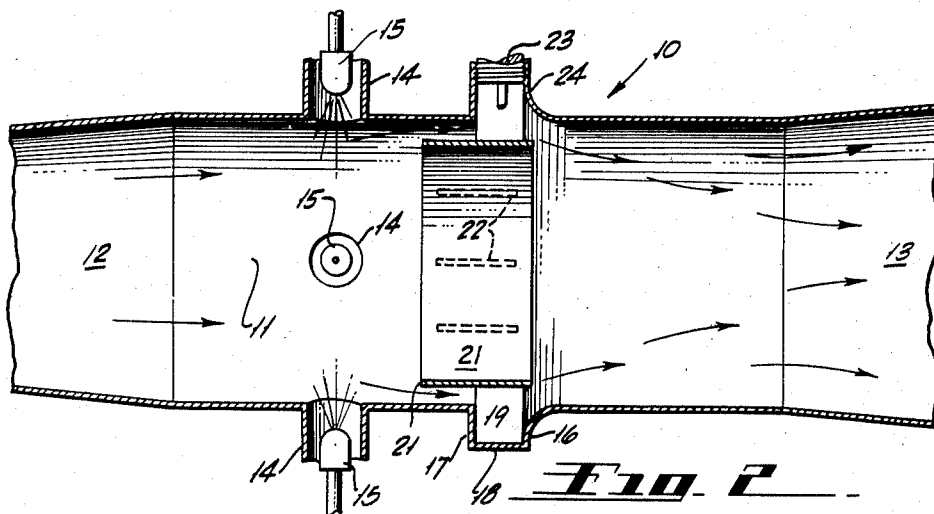


Fig. 2

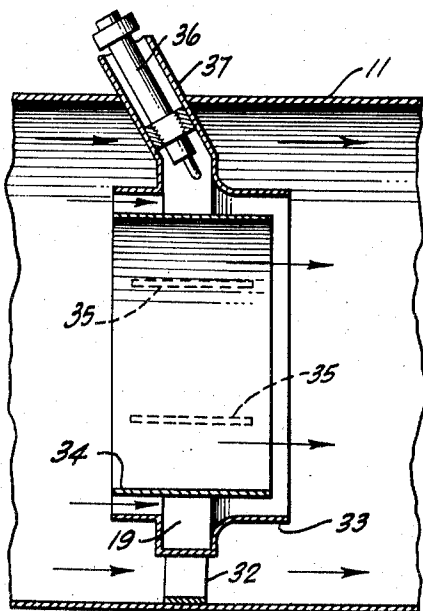


Fig. 3

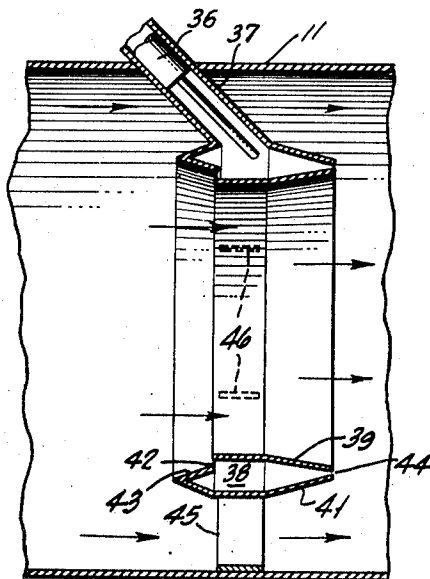


Fig. 4

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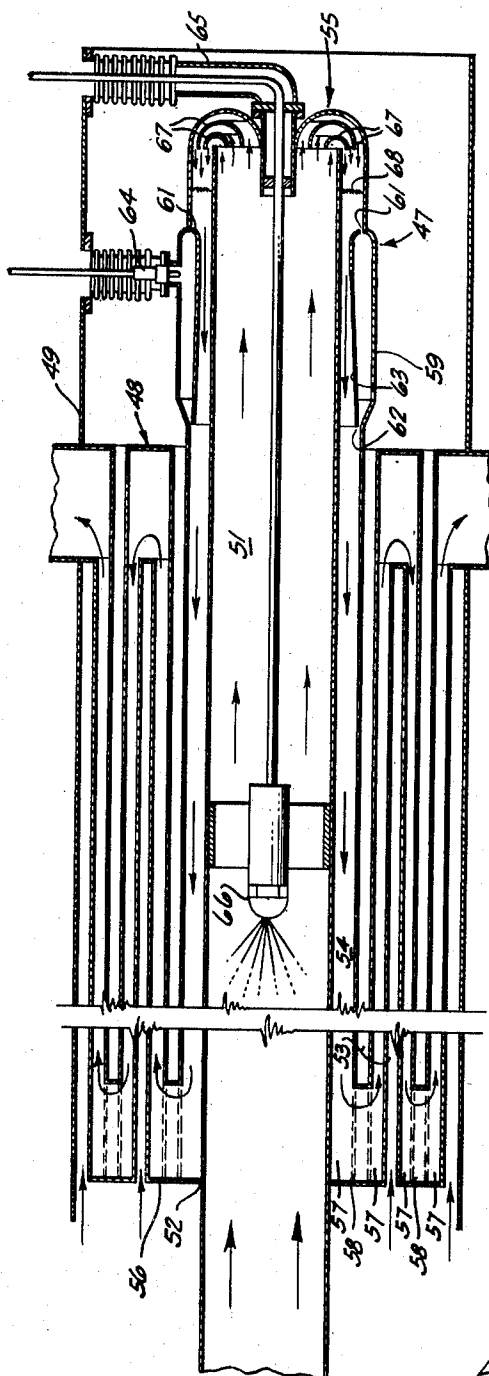


Fig. 5

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ANNULAR PILOT BURNER FOR COMBUSTION HEATERS

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2 Claims. (Cl. 158-28)

This invention relates to combustion devices, such as combustion heaters; primary and secondary burners for turbo, and ram, jet engines and the like and is particularly concerned with the combustion initiating and maintaining means, or burners, thereof.

This invention improves the starting and performance of such devices by providing a built-in pilot-burner therefor which, contrary to the usual such burner, is radially and longitudinally compact and, at least in one embodiment, forms a substantially integral part of the main conduit for the combustible mixture burned in the combustion chamber of the combustion device. The burner is so constructed that, instead of, as is conventional, necessitating the employment of an independent source of fuel and air for its starting and operation, it utilizes a small portion of the main fuel-air mixture flowing longitudinally past it in the main, or central, conduit of the heat-exchanger.

In one form of the invention, the burner radially diverts outwardly of the periphery of the main fuel-air conductor, a peripheral portion of the main fuel-air mixture, ignites it, and discharges flaming gases radially and longitudinally from its downstream face and into contact with the periphery of the main stream.

In another form of the invention, the device is an annulus mounted coaxially of the main path more nearly centrally in the main stream; traps off an annular portion of the stream which is located nearer the longitudinal center line than as above; ignites it; and discharges two separate rearwardly directed cones of flaming gases from its rear annular edge, these cones moving respectively outwardly and inwardly of the path in contact with the main stream.

In still another form of the invention, the device consists in effect of an annular, streamlined combustion chamber occupying a substantially central portion of the fuel-air stream, the chamber having a small annular inlet opening at its upstream annular edge and a still smaller annular outlet opening at its annular downstream edge. The trapped-off, or diverted, portion of the fuel-air stream is ignited in this chamber and the flaming gas is discharged in annular form from the rear opening.

In all forms of the invention, the compact, simple, self-feeding and self-piloting burner effects surer starting of the combustion-apparatus of which it forms a built-in part, than do contemporary burners by, among other things, trapping off and decelerating a portion of a relatively rapidly moving fuel-air mixture. The ensuing externally applied compression of this portion enables the mixture to achieve the proper velocity for flame-propagation before the spark-plug or the like is actuated, thus conferring surer starting characteristics upon the device utilizing the burner. Detonation is somewhat reduced by virtue of the fact that the burner effects a better mixture of the fuel with the air and sends no unmixed, "pure" fuel into the main chamber. The self-feeding feature renders the burner self-piloting.

Resonant, or buzz, burning is reduced substantially,

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since the ignition of the main fuel-air mixture occurs at the outlet portion of the present burner, where there is but little turbulence or other flow-disturbance in the main fuel-air stream.

The aforementioned embodiments of the invention are, by way of example only, illustrated in the accompanying drawings and described hereinafter in conjunction therewith.

In these drawings,

Figure 1 is a longitudinal substantially central section of a combustion heater arranged in perspective attitude and provided with the burner of the invention;

Figure 2 is a fragmentary longitudinal section of that portion of the conductor-path for the fuel-air mixture which includes the present burner, this portion having been removed from the exchanger;

Figure 3 is a fragmentary longitudinal section of the main conduit of a device which includes another form of the invention;

Figure 4 is a similar view of still another form of the invention; and

Figure 5 is a longitudinal sectional view of a heat-exchanger provided with yet another form of the invention.

In the construction shown in Figures 1 and 2, the burner 10 is arranged at the periphery of the fluid-conductor means 11 which constitutes the main fuel-air inlet 12 in its left-hand portion and constitutes the main combustion-chamber 13 in its right-hand portion.

The fluid-conductor means 11 is here shown as defined by two coaxial conduit-sections longitudinally spaced apart at their adjacent ends a distance determined by the designed flow-conditions of the heater. In the portion of the conduit 12 that lies upstream of the burner 10 are mounted four circumferentially equidistant tubes 14 in each of which is coaxially mounted a suitable fuel-injector 15.

The upstream end of the downstream section containing chamber 13 is outwardly flared peripherally as at 16, while the adjacent end of the other section bears an annular flange 17. The flange and the flare are connected peripherally by an annular band 18, the three surfaces thus defining an annular chamber 19 which is radially offset from the outermost surface of the main path 11. If desired, chamber 19 may be beaded outwardly into the wall of the path 11, instead of being constructed as afore-described.

Roughly, the entire chamber 19 is screened off in effect from the path of the main body of the fuel-air mixture by means of an annular "plate" 21 disposed concentrically inwardly of the conduit sections at the chamber-region and having its respective edges located respectively upstream and downstream of the axial boundaries of the chamber 19. Member 21 is united to, and spaced radially inwardly from, the upstream conduit-section 12 by means of a plurality of lugs or bars 22, the lugs being circumferentially spaced around the periphery of the plate and being of relatively small width circumferentially thereof.

The outer surface of the upstream portion of the annular plate, together with the inner adjacent surface of the upstream conduit section, serve to separate or divert laterally from the main stream, a predetermined portion thereof and to direct it into the peripherally located radially extending annular flame-initiating chamber 19. The downstream edge of the annular plate lies longitudinally upstream of the adjacent conduit wall and hence enables the flaming gases to move radially inwardly and longitudinally of chamber 13. The outer surface of the intermediate portion of the annular plate serves to confine the portion of the main stream segregated and trapped in the igniting chamber 19 while it is being ignited.

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A suitable ignition device 23 is conventionally mounted in a suitably thermally insulated tube 24 extending radially of the main conduit 11 and opening thereinto and is operated only at the inception of the utilization of the combustion-apparatus, and only to initiate ignition in the pilot-burner chamber 19 of the segment of the relatively high velocity fuel-air mixture which has been trapped and slowed down therein to a velocity enabling certainty of ignition and thermally complete combustion thereof. Thereafter, the fuel-air segments continuously entering chamber 19 are automatically ignited as soon as they enter this chamber, rendering the burner self-piloting as well as self-feeding.

It is to be particularly noted that the flaming gases issuing from the downstream opening of the chamber 19 initially flow in close laminarity to the inner surface of the wall of the conduit section 13. In this region, the velocity of the main fuel-air mixture is relatively low and its flow-path is substantially non-turbulent. Consequently, the flame-front produced by the union of these flaming gases and the main fuel-air mixture is substantially non-turbulent and detonationless. This annular flame-front gradually enlarges or expands radially inwardly as it passes downstream. This flame-front is also possessed of remarkable stability, since resonance of pulsations, a cause of "buzz-burning," is obviated.

By properly proportioning the annular cross-section of the igniter chamber 19 and its inlet and outlet to that of the main fuel-air path, the velocity of the flow in the annular chamber 19 may be slowed down any desired amount and to suit any given conditions of the fuel-air mixture, such as the fuel-air ratio and the atmospheric conditions.

The aforedescribed parts that constitute the fuel-air mixture entraining, igniting and combustng unit are here shown as combined with a heat-exchanger, the conductor path for the now completely burning mixture opening at its downstream end, by means of radial conduits 25 into a coaxially outwardly arranged hot-pass 26, from the opposite end of which combustion gases emerge and pass through a flue 27. Substantially coaxially surrounding pass 26, and lying respectively inwardly and outwardly thereof are cold passes 28 and 29 each pass being connected at each of its ends to the air to be heated. Thus, the heat exchanger per se is more or less conventional.

For use in turbo, and ram, jet engines, and for large combustion heaters, the pilot burner takes the forms shown in Figures 3 and 4. Essentially, in these forms, the outermost periphery of the pilot burner is located closer to the longitudinal centerline of the main conduit and the burner is supported by, and spaced radially inwardly from, the inner surface of the wall of the main conduit by means of struts 32 or the like.

By way of example, the species depicted in Figure 3 comprises a short section of conduit 33 mounted coaxially inwardly of main conduit 11 on which it is supported and from which it is radially spaced by means of the struts 32. A toroidal chamber 19 substantially identical with that of Figure 1 is formed radially and peripherally in a portion of the wall of conduit section 33, as, and for the purposes, heretofore described. An annular wall, or screen, or baffle, such as a solid cylindrical plate 34, is provided as and for the reasons already given, and is radially inwardly spaced from, and supported by, the inner wall of conduit 33 by means such as struts 35. An elongate igniter, such as a spark-plug 36, is coaxially mounted in a thermally insulated tube 37 extending into the chamber 19.

In this species of the invention, the flaming-gas front, initiated at the downstream, radially separated edges of the cylinders 33 and 34, spreads both outwardly and inwardly in the main fuel-air stream at a propagation rate determined by the main burner conditions. Also, in this inventive form, substantially the same functional ad-

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vances which are achieved by the invention in connection with the burner described hereinbefore in use with relatively small internal combustion heaters, such as the one shown in Figure 1, are effected when the invention is applied to turbo-compressor jet engines and ram jet engines and for large industrial burners.

In Figure 4, essentially the same principles as those inherent in the device of Figure 3 are employed, the cylinders of Figure 3 being conformed together radially and longitudinally to define an annular, substantially centrally disposed streamlined combustion chamber 38 which is substantially streamlined in the direction of the flow of the main fuel-air stream. The chamber defined by the members 39 and 41 has an annular opening 42 near its upstream edge, the opening being defined by a radially inward offset of the member 39 and an incurved lip 43. This chamber 38 also has an annular opening 44 at its downstream edge, defined by radially separating the members 39 and 41 thereat. The cross-sectional area of opening 42 is preferably of the order of 7½% of the maximum cross-sectional area of the chamber 38, whereas the cross-sectional area of opening 44 is only of the order of 2% of this area. Thus, the combination of deceleration and externally applied compression on the pilot burner flow at the pilot burner inlet, improves pilot burner performance. The streamlined conformation of the pilot burner, in connection with its very small outlet area relative to the maximum cross-sectional area of the burner, minimizes flow disturbances at the flame front rear edges of the burner, enabling stable burning. The pilot burner is positioned centrally of the conduit 11 and supported thereon, by means of radially extending struts or braces such as those designated 45 and 46 in Figure 4.

In Figure 5, an annular pilot-burner group 47 of improved characteristics is constructionally combined with a heat exchanger 48, here in order to provide, in one of its fields of uses, an improved aircraft type internal combustion heater of radially compact nature yet of high capacity and performance.

The construction comprises an open-ended shell 49 which spaced surrounds the pilot-burner 47 and also surrounds and forms a part of the heat exchanger 48, defining one surface thereof. The central pass 51 of the heat exchanger communicates at the one end 52 with a source of combustion-supporting air and at the opposite end it is flow-associated with the pilot-burner and burner stabilizing group, later particularized. Generally, alternate ones of the cold-passes 53 lying radially between the central pass and the shell communicate at their upstream end with the ventilating air source and communicate at their opposite ends with the compartment to be heated and ventilated.

An annular combustion chamber 54 outwardly surrounds the central pass, is substantially coextensive with same, and communicates at its outer end 55 with the central pass, its inner end portions 56 communicating with the hot passes 57 which lie between alternate ones of the cold passes and are connected to each other at their upstream ends by passages 58.

The combined pilot-burner, combustion initiating chamber and flame-holder group 47 is located quite near the downstream end of the central pass and is preferably integrally built into the outer wall of the annular combustion chamber. In any case, it comprises a pair of generally co-axial, or "nested," annular sheets 59 and 63 which are separated radially and are substantially coextensive. The sheets 59 and 63 are juxtaposed at their upstream ends by means of the recurved portions defining apertures 61. The configuration thus constituted is a streamlined critically proportioned hollow annulus open at its upstream edge 61 and at its downstream edge 62. The upstream opening 61 has an area of the order of 7½% the maximum cross-sectional area of the annular burner, while the downstream opening 62 has an area of the order of 2-4% of said maximum area.

Both the length of the chamber defined by the walls 59, and the said maximum area, depend upon the pressure and velocity of the combustion supporting air and upon the capacity rating of the heat exchanger but in any event, combined with the relative proportions of the inlet and outlet openings therein, are such as to decelerate and slightly compress the combustion-supporting air that enters the upstream opening thereof sufficiently to enable complete combustion in the burner of a proper mixture of fuel and said air. The fuel-air mixture entering the burner is preferably ignited in the burner near its upstream end 61 by means of an insulated spark-plug 64. The inner wall 63 of the burner preferably angles outwardly towards the outer wall thereof in order to confer the desired turbulence-reducing streamlining upon the fuel-air mixture entering the combustion chamber upstream of the burner and to locate the exit of flaming gases and the annular flame-holder defined by the flaming gas-exit of the burner near the outer wall of the combustion chamber where there is substantially laminar flow and low turbulence.

A main fuel injector unit 65 for supplying the combustible for operating the heat exchanger in mixture with the combustion-supporting air is mounted coaxially in the central pass 51 and supported therein with its nozzle 66 disposed a sufficient distance upstream of the downstream end of the central pass to enable proper mixing of fuel and air before the mixture emerges from said downstream end, near the burner. At said end, a plurality of spacedly nested, semi-annular turning vanes 67 close off the gap between the central pass and the immediately outwardly adjacent combustion-chamber and deflect the fuel-air mixture into the downstream end of the combustion-chamber and into the annular burner. A damping-screen 68 is disposed transversely in the upstream end of the annular combustion chamber and serves to suppress the resonant amplitude of pulsations in the fuel-air mixture and to eliminate turbulences therein before same reaches the pilot-burner.

Although several species of the physical forms which the inventive concepts can assume have been described hereinabove in some detail, it is to be understood that this has been done merely to clarify the inventive principles and to enable physical reproduction of at least one form thereof. The invention is therefore by no means limited by such, being in fact and in law susceptible of embodiment in any form lying within the scope of the subjoined claims.

I claim:

1. A pilot burner for a combustible fuel-gas mixture flowing in a confined path therefor, comprising: a conduit for said mixture, said conduit comprising two substantially coaxial, longitudinally spaced sections; an annular flare on the upstream end of the downstream conduit-section; an annular flange on the downstream end

of the upstream conduit-section; a surface joining the outer peripheries of the flare and the flange to thereby define an annular chamber lying radially outside the body of said conduit; an igniter extending into operative relationship with said chamber; and an annular wall mounted coaxially inwardly of said chamber and longitudinally at least coextensive therewith, said annular wall having a portion defining with the radially adjacent portion of the upstream conduit section an annular, upstream located inlet space for the admission of fuel-air mixture into said annular chamber thereby to substantially turbulently segregate a small portion of the main fuel-air mixture from the main body thereof so as to effect trapping of same in said annular chamber and to decelerate the trapped-off portion to optimum ignition velocity.

2. A self-piloting pilot-burner for igniting a main body of combustible fluid outside the main body of a combustible mixture flowing in a confined path therefor, comprising: a pair of coaxial, longitudinally spaced apart conduit sections, and an annular sink disposed coaxially of said sections and radially beyond the peripheries thereof; said sink comprising an annular flare extending outwardly from the upstream end of the downstream conduit section, an annular flange extending outwardly from the downstream end of the upstream conduit section; a longitudinally extending surface joining the outer edges of the flare and the flange, thereby to form a rectangular-section fluid-trapping annulus having substantially a fluid-damming effect on said trapped portion at its downstream face; single-shot igniting means extending operatively into said annulus; and a separate cylindrical wall mounted coaxially inwardly of said annulus and extending longitudinally at least coextensively therewith so as to direct a portion of said main body thereinto, and substantially radially confine same therein, thereby to facilitate initiation of ignition therein.

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