

Nov. 19, 1957

E. R. FISHER ET AL

2,813,397

THERMAL EXPANSION MEANS FOR COMBUSTION CHAMBERS

Filed Jan. 2, 1957

3 Sheets-Sheet 1

FIG. 1

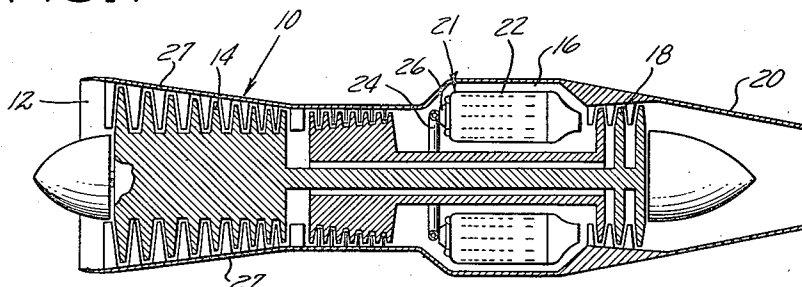
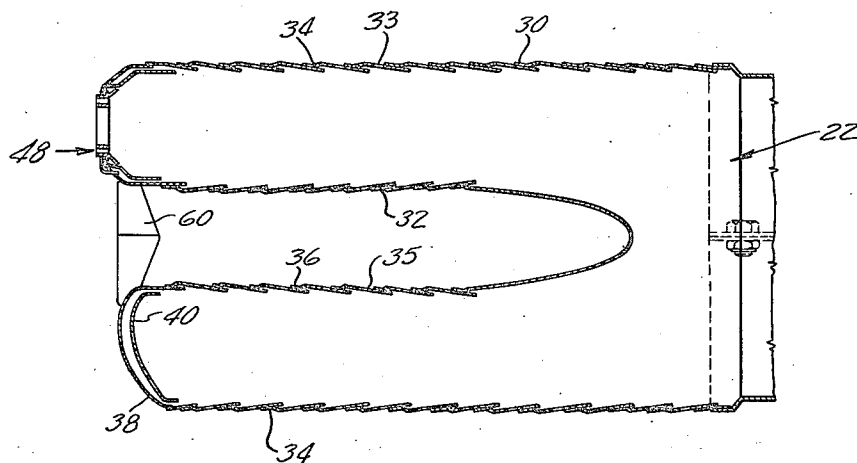


FIG. 2



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FIG. 3

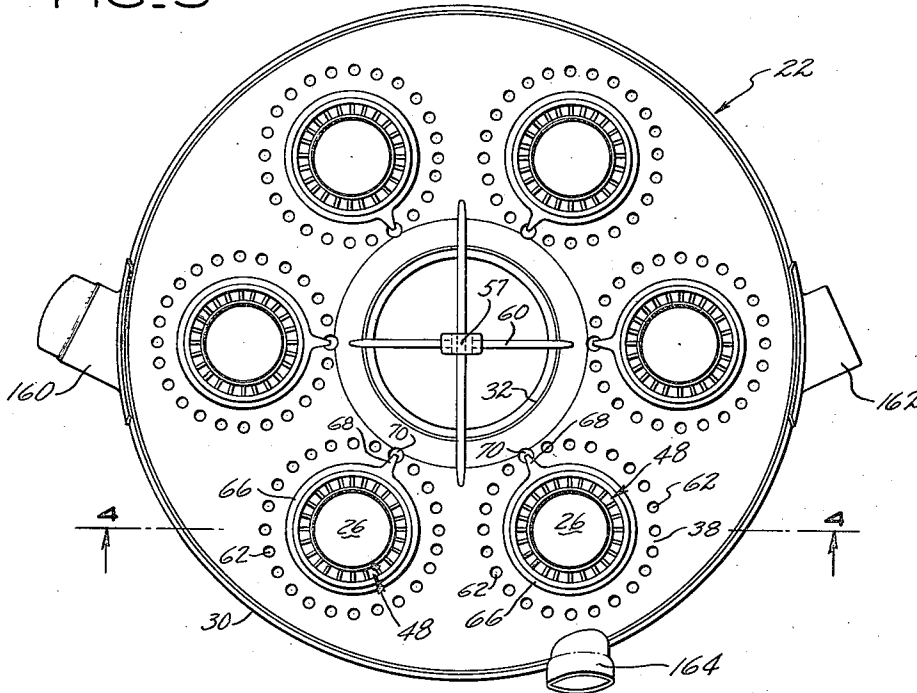
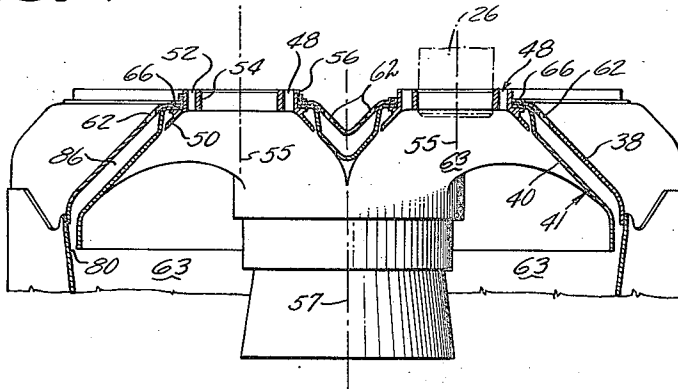


FIG. 4



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FIG. 5

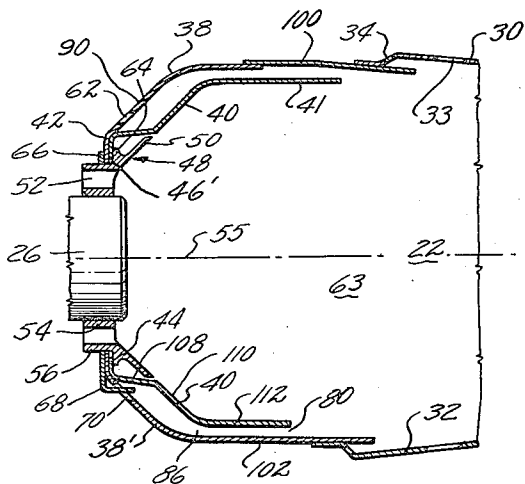


FIG. 6

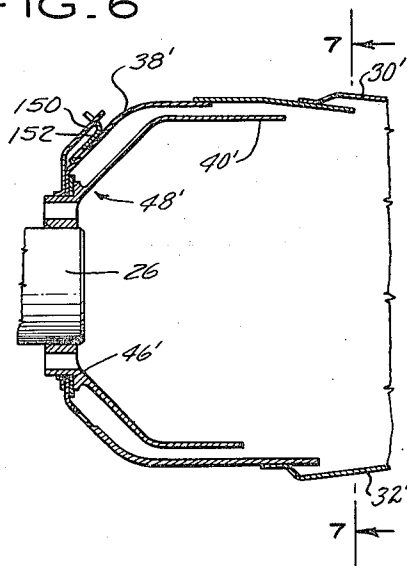


FIG. 7

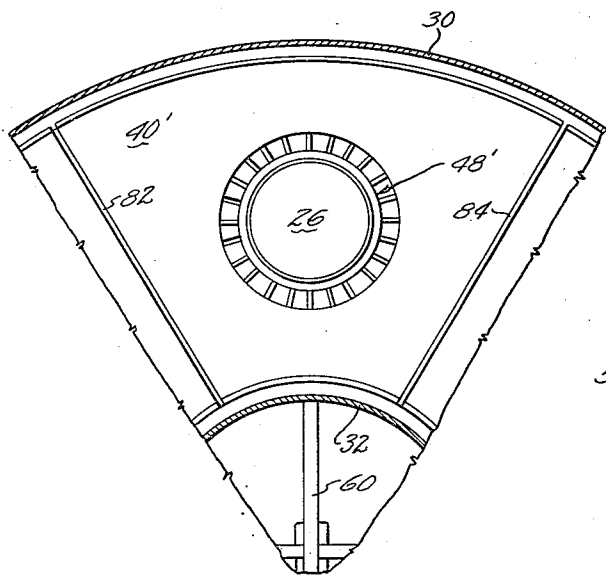
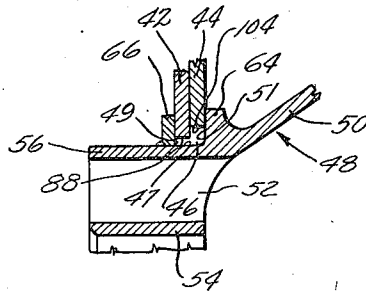


FIG. 8



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THERMAL EXPANSION MEANS FOR COMBUSTION CHAMBERS

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Application January 2, 1957, Serial No. 632,188

8 Claims. (Cl. 60—39.32)

This invention relates to combustion chambers and, more particularly, to the support and attachment between the fuel nozzles, air swirlers and the front ends of combustion chambers.

It is an object of this invention to provide a combustion chamber construction which will permit relative thermal expansion between combustion chamber parts as they operate in their areas of substantially different temperatures.

It is a further object of this invention to provide a combustion chamber construction which is light in weight, simple yet rugged in construction, and provides optimum combustion chamber efficiency.

Other aspects and advantages of our invention will become apparent upon the reading of the following detailed description taken in conjunction with our drawings which are:

Fig. 1 is a cross-sectional view of a typical aircraft turbine engine.

Fig. 2 is a cross-sectional view of the combustion chamber used in such an engine showing our invention at its forward end.

Fig. 3 is a front view of a combustion chamber utilizing our invention.

Fig. 4 is a view taken along line 4—4 of Fig. 3.

Fig. 5 is an enlarged fragmentary view of the front end combustion chamber construction shown in Fig. 2.

Fig. 6 is a fragmentary cross-sectional view of an alternate burner construction.

Fig. 7 is a view along line 7—7 of Fig. 6.

Fig. 8 is an enlarged fragmentary cross-sectional view of the front end of the combustion chamber construction shown in Fig. 2 to illustrate in great detail the attachment between the combustion chamber and the air swirler.

Referring to Fig. 1 we see a turbojet aircraft powerplant 10 comprising air inlet section 12, compressor section 14, combustion chamber cavity 16, turbine 18 and exhaust duct 20. Combustion unit 21 comprises a plurality of combustion chambers 22 which are located within combustion chamber 16 and between compressor 14 and turbine 18 and further comprises a fuel manifold 24 and fuel nozzles 26. Combustion chambers or burners 22 are fed fuel by fuel manifold 24 and fuel nozzles 26. Combustion chamber 22 is of the so-called "can" type for it is of sheet metal construction, is of roughly cylindrical structure and its axial dimension is greater than its radial dimension. The various components of engine 10 are contained within engine case 27 which may be of one-piece construction or which may be composed of a plurality of abutting cases attached to one another in any well known fashion such as bolted flanges.

Air enters powerplant 10 thru air inlet section 12, is compressed as it passes thru compressor 14, is heated in a power generating function by combustion unit 21 and then passes thru turbine 18 in a power extraction function and thence is exhausted in jet exhaust fashion thru exhaust duct 20.

While not necessarily so limited, powerplant 10 may

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use eight combustion chambers or burners 22 each of which is positioned and supported from engine case 27 as shown, described and claimed in co-pending U. S. application Serial No. 556,733 entitled, "Combustion Chamber Support Means," and filed in the names of Charles D. Robin and Philip G. Dooley as co-inventors.

Combustion chambers 22 are equally spaced circumferentially about the centerline of engine 10 and equidistant radially therefrom.

Now referring to Figs. 2 and 3 we see that combustion chamber 22 comprises louvred outer wall 30 and louvred center tube 32, both of which are of circular cross-section and concentric. Air from compressor 14 passes over the sheet metal skin of outer wall 30 and center tube 32 and passes into combustion chamber 22 thru cooling louvres 34 and combustion holes 33 of outer wall 30 and cooling louvres 36 and combustion holes 35 of center tube 32. At its forward end combustion chamber 22, in Figs. 2 and 3, comprises a plurality of joined outer cups 38 which surround concentrically an equal number of joined inner cups 40. While not necessarily so limited, combustion chamber 22 in Figs. 2 and 3 is shown to have six inner and outer joined cups units 40 and 38. The outer cup 38 and the inner cup 40 terminate at their forward ends in abutting inwardly directed circular flanges 42 and 44 (Fig. 5). Flanges 42 and 44 engage annular groove or recess 46 of air swirler unit 48 with substantial radial clearance. Air swirler unit 48, in addition to outwardly extending groove 46, also includes conical section 50, and a plurality of angular swirler vanes 52 extending from inner wall or cylindrical sleeve 54 to outer wall or cylindrical sleeve 56. It will be noted in Figs. 5 and 8 that the axis or centerline 55 of cups 38 and 40 and clearance holes 104 and 88 therein for the reception of air swirler unit 48 are common and said axis or centerlines are also parallel to the axis or centerline 57 of burner 22. Air swirlers 48 are equally spaced circumferentially about the axis of burner 22 and equidistant radially therefrom.

Fuel manifold 24 feeds fuel to the plurality of fuel nozzles 26. Each fuel nozzle 26 is of substantially circular cross-section and engages in telescoping fashion and in an axial sliding fit inner cylindrical sleeve 54 of air swirler unit 48. Fuel nozzle 26, thru fuel manifold 24, and the six air swirler units 48 serves to radially and circumferentially position combustion chamber 22 while the axial positioning of combustion chamber 22 is accomplished thru the combustion chamber support unit taught in U. S. application Serial No. 556,733 referred to supra. Support means 60 attaches combustion chamber 22 to fuel manifold 24, which is attached to engine case 27.

It will be noted that combustion chamber outer cup 38 has a plurality of cooling air holes 62 in its forward conical surface which permit cooling air to pass between outer cup 38 and inner cup 40.

One purpose of inner cup 40 is to provide a barrier for the hot combustion zone 63 formed by the burning of atomized fuel which has been introduced thru fuel nozzle 26 and mixes with the air which passes thru air swirler units 48 and combustion holes 33 and 35. Since inner cup 40 is loosely supported by air swirler 48, only, it is free to expand thermally with respect to outer cup 38 without adversely affecting these parts as would be the case if the inner and outer cups were joined rigidly. Inner cup 40 further serves to form an annular passage 86 with outer cup 38 including outlet 80 thru which cooling air which enters thru cooling air holes 62 passes to cool both inner cup 40 and outer cup 38 and then is discharged downstream thru outlet 80 to scrub against and cool the surfaces of walls 30 and 32.

As best shown in Figs. 8 and 5 annular cavity 46 with

base 47 and walls 49 and 51 is formed by outer surface 56 of air swirler unit 48, outwardly extending flange 64 which may be an integral part of air swirler unit 48 and outwardly directed flange 66 which is spaced from flange 64 and attached to air swirler unit 48 by any convenient means such as welding, brazing or the like. Outwardly directed flange 66 has tab 68 projecting therefrom which may be bent and received in hole 70 of outer cup 38 to prevent air swirler unit 48 from being rotated with respect to fuel nozzle 26 and combustion chamber 22 by the force of the swirler air being passed thru the angular vanes thereof. Other suitable retention means may be used to perform this function.

Considerable difficulty has been encountered in burner or combustion chamber construction in the past in that the various parts of the burner run at greatly different and varying temperatures and therefore substantial thermal relative expansion exists within and between the various parts. For example, the fuel manifold 24 and fuel nozzles 26 might run in the vicinity of 200° to 300° F. while the burner outer and inner walls 30 and 32, respectively, together with outer cup units 38 might run at temperatures of about 1000° F. Inner cups 40, in the same construction, might run at temperatures as high as 2000° F. Obviously, substantial relative thermal expansion will exist between parts running at these operating temperatures. In burner construction it is essential to have the burner sufficiently rugged that parts will not fail and pass downstream destroying engine efficiency and other engine parts and yet the burner must be constructed such that this ruggedness of design does not bring about substantial loads and stresses in the burner parts and other associated parts if these parts attempt to expand due to thermal expansion.

As best shown in Figs. 5 and 8, air swirler units are supported in position by fuel nozzles 26 while outer cups 38 and inner cups 40 are supported slidably radially within annular groove 46 of air swirler unit 48. It will be noted that both outer cone 38 and inner cone 40 are received in groove 46 with substantial radial clearance and, due to the fact, while not necessarily so limited, the metal used to manufacture inner cup 40 has a higher coefficient of thermal expansion and operates at higher temperature than does outer cup 38, the radial clearance of inner cup 40 with respect to air swirler unit 48 is greater than that of outer cup 38. It will be noted that the plurality of inner cups 40 which form the inner cup unit 41 are supported solely by air swirler units 48. An advantage gained by having unit 41 of one-piece construction is that failure in any one of the inner cups 40 will not necessarily be harmful to other engine parts for unit 41 will continue to be supported by the other air swirler units 48 and not pass downstream. Outer cups 38 and inner and outer walls 30 and 32, respectively, run cooler than inner cups 40 because cooling air which is discharged from compressor 14 passes over these sheet metal pieces performing a cooling function.

It is a feature of our invention that our air swirler units 48 are "floating" and therefore, can be machined on their inner diameter with close clearance over the outer diameter of fuel nozzles 26. This minimum clearance between fuel nozzles 26 and air swirlers 48 is very important to reduce the amount of air leakage between these two parts, for air leakage in this area adversely affects combustion flame length and temperature distribution. In conventional burner construction, where the air swirlers are welded in fixed relation to the burner cans 22, an excessive clearance must exist between fuel nozzles 26 and air swirlers 48. This excessive clearance is made necessary by the fact that fuel nozzles 26 are part of furnace brazed assembly fuel manifold 24, and the center-to-center distance between fuel nozzles 26 cannot be closely held. Since the nozzles are usually out of true position in the conventional assembly by several thousandths of an inch, the inner diameter of air swirlers

48 had to be machined over-sized by double this amount to permit assembly of parts.

In our combustion chamber construction, this excessive clearance between fuel nozzles and air swirlers which is detrimental to combustion efficiency is eliminated.

It is a feature of our invention that cooling provision is provided to the metal of inner cups 40 by permitting cooling air to pass thru cooling air metering holes 62 and thence thru discharge orifice 80 which is formed between the downstream edge of inner cups 40 and outer cups 38. The distribution and amount of air flow thru holes 62 is governed by the area of orifice or outlet 80 which is in turn governed by the relative thermal expansion between outer cup 38 and inner cup 40. The metal to be used in inner cup 40 is chosen not only such that it will withstand the operating temperatures but also such that it will reach such a size at operating temperatures that it will form proper sized cooling air orifice 80 along with lip or inwardly directed circular flange 44 of inner cone 40 such that relative expansion may take place between outer cup 38 and inner cup 40 and also between either outer or inner cup and air swirler unit 48.

Since fuel nozzles 26 are supported by fuel manifold 24 and in turn support and position air swirler units 48, due to the correlation between outwardly opening annular groove 46 and inwardly directed circular flanges 42 and 44, fuel manifold 24 and fuel nozzle 26 support, in addition to air swirler unit 48, outer cups 38 and inner cups 40. In this arrangement, air swirler unit 48 may be directly supported by fuel nozzles 26 and fuel manifold 24, and since these parts operate at roughly the same temperature, there is but a small degree of relative thermal expansion therebetween. As outer cup 38 and inner cups 40 expand thermally to a greater extent than the fuel manifold clusters which may be roughly seven inches in diameter, and air swirler unit 48, both sets of cups 38 and 40 continue to be securely supported in position and yet, due to the fact that they slidably engage groove 46, they are capable of attaining thermal growth within groove 46 so as not to lose support therefrom and yet this thermal growth can be attained without imparting stresses and strains to the thermally expanding parts or the parts associated therewith.

Outer cup 38 is so shaped that at its forward end it is in the form of an inwardly directed flange 42 which has circular hole 88 substantially centrally located therein. The diameter of hole 88 is greater than the dimension of base 47 of annular cavity 46. Outer cup 38 smoothly blends from inwardly directed flange 42 into an outwardly extending conical section 90 and then smoothly blends into spaced cylindrical sleeves 100 and 102. Inner cup is so shaped as to form an outwardly directed flange 44 at its forward end which has substantially centrally located circular hole 104 located therein such that the diameter of hole 104 is greater than the diameter of hole 88 and is also greater than the dimension of base 47 of annular recess 46. It will be noted that diameters of both holes 88 and 104 are less than the greatest dimensions of walls 49 and 51 of annular recess 46. Inner cup 40 blends smoothly from outwardly directed flanges 44 into an axially extending sleeve 108 and then smoothly blends into an outwardly extending conical section 110 and then smoothly blends into and terminates in an axially extending sleeve 112 such that outlet 80 is formed between inner cup 40 and outer cup 38. Inner cup 40 is so shaped and of such dimension that when it expands to its operating position conical section 110 of inner cup 40 blends smoothly with conical section 50 of air swirler unit 48 to form a single smooth conical wall and this expansion of inner cup 40 also brings cooling air outlet 80 to its proper area such that the selected amount of

cooling air passes thru cooling air holes 62, annular cooling passage 86 and thru outlet 80.

Figs. 6 and 7 show an alternate construction to our invention in which inner cups 40' are welded or in other fashion attached to air swirler units 48' whereas outer cups 38' only, slidably engage annular groove 46'. This is best shown in Fig. 6 whereas Fig. 7 shows that in this alternate embodiment inner cup 40' is made separate from all other inner cups such that there are as many inner cups 40' as there are air swirler units 48'. This permits growth between the various inner cups 40' without affecting other inner cups. Inner cup 40' engages adjacent inner cups 40' along radially extending walls 82 and 84. To prevent the rotation of air swirler 48' relative to outer cup 38', tab 150 which projects from and is attached to 48' engages a recess in tab 152 which is attached to outer cup 38'.

In Fig. 3 we see that combustion chamber 22 is provided with cross-over tube connections 160 and 162 which engage similar connections, in adjacent combustion chambers 22 so that when one combustion chamber is lit, the flame therefrom passes through cross-over tubes 160 and 162 to ignite adjacent combustion chambers. Ferrule 164 is provided to receive a spark plug to ignite the atomized fuel within combustion chamber 22 for starting purposes.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

We claim:

1. A combustion unit comprising a fuel manifold having at least one fuel nozzle of substantially cylindrical exterior attached thereto, an air swirler unit comprising an inner cylindrical sleeve which is telescoped in sliding fit onto said fuel nozzle exterior and an outer cylindrical sleeve spaced externally from said inner sleeve and further having a plurality of equally spaced angular vanes projecting between and attached to said inner and outer sleeves thru which swirler air passes and also having an outwardly opening radially extending annular recess projecting from the outer sleeve, a combustion chamber having at its forward end at least one outer cup and at least one inner cup concentric within said outer cup, each of said cups having inwardly directed circular flanges juxtapositioned and slidably received radially within said annular recess with substantial radial clearance such that said outer and inner cups are supported in said annular recess yet said inner cup, said outer cup and said annular recess are free to expand relative to one another without stress to the parts.

2. A combustion unit comprising a fuel manifold having at least one fuel nozzle of substantially cylindrical exterior attached thereto, an air swirler unit comprising an inner cylindrical sleeve which is telescoped in sliding fit onto said fuel nozzle exterior and an outer cylindrical sleeve spaced externally from said inner sleeve and further having a plurality of equally spaced angular vanes projecting between and attached to said inner and outer sleeves thru which swirler air passes and also having an outwardly opening radially extending annular recess projecting from the outer sleeve, a combustion chamber having at its forward end at least one outer cup and at least one inner cup concentric within said outer cup, each of said cups having inwardly directed circular flanges juxtapositioned and slidably received radially within said annular recess with substantial radial clearance such that said outer and inner cups are supported in said annular recess yet said inner cup, said outer cup and said annular recess are free to expand relative to one another without stress to the parts, and cooling air holes in said outer cup to admit cooling air between said outer cup and said inner cup.

3. A combustion unit comprising a fuel manifold having at least one fuel nozzle of substantially cylindrical

exterior attached thereto, an air swirler unit comprising an inner cylindrical sleeve which is telescoped in sliding fit onto said fuel nozzle exterior and an outer cylindrical sleeve spaced externally from said inner sleeve and further having a plurality of equally spaced angular vanes projecting between and attached to said inner and outer sleeves thru which swirler air passes and also having an outwardly opening radially extending annular recess projecting from the outer sleeve and further having a conical projection from one end of said inner sleeve, a combustion chamber having at its forward end at least one outer cup and at least one inner cup concentric within said outer cup and having a common axis which is also common to the axis of said air swirler unit, each of said cups having inwardly directed circular flanges juxtapositioned and slideably received radially within said annular recess with substantial radial clearance such that said outer and inner cups are supported in said annular recess yet said inner cup, said outer cup and said annular recess are free to expand relative to one another without stress to the parts, cooling air holes in said outer cup to admit cooling air between said outer cup and said inner cup, a cooling air discharge orifice formed between said inner and outer cone, said inner cone and said outer cone made of such metal that said inner cone forms a smooth projection from said conical projection and further such that said orifice is of preselected area at operating temperatures.

4. A combustion unit comprising a fuel manifold having at least one fuel nozzle of substantially cylindrical exterior attached thereto, an air swirler unit comprising an inner cylindrical sleeve which is telescoped in sliding fit onto said fuel nozzle exterior and an outer cylindrical sleeve spaced externally from said inner sleeve and further having a plurality of equally spaced angular vanes projecting between and attached to said inner and outer sleeves thru which swirler air passes and also having an outwardly opening radially extending annular recess projecting from the outer sleeve, a combustion chamber having at its forward end at least one outer cup and at least one inner cup concentric within said outer cup, each of said cups engaging said swirler unit such that relative thermal expansion can occur between said cups and swirler unit.

5. An aircraft engine with an outer case having a combustion unit comprising a plurality of can-type burners equally spaced circumferentially about the centerline of said engine and each equidistant radially therefrom, each of said burners having a plurality of air swirlers at the forward end thereof equally spaced circumferentially about the axis of said burner and equidistant radially therefrom and each having an outwardly opening annular recess, a fuel manifold supported by said engine case and having a plurality of fuel nozzles each of which telescopically engage in an axial sliding fit one of the air swirlers to position same, the front end of each of said burners comprising a plurality of outer and a plurality of inner cups with each of said inner cups located concentrically within one of said outer cups, said outer and said inner cups terminating at their forward ends in abutting inwardly directed circular flanges which are received in a sliding fit and with substantial radial clearance in said annular recess.

6. An aircraft engine with an outer case having a combustion unit comprising a plurality of can-type burners equally spaced circumferentially about the centerline of said engine and each having axially extending centerlines parallel to and equidistant radially from the engine centerline, each of said burners having a plurality of air swirlers at the forward end thereof equally spaced circumferentially about the centerline of said burner and equidistant radially therefrom and each having an outwardly opening annular recess and further having spaced inner and outer sleeves with a plurality of angular vanes extending therebetween and also having an outwardly projecting conical section extending from said inner sleeve, a fuel manifold

supported by said engine case and having a plurality of fuel nozzles each of which telescopically engages in an axial sliding fit, one of said inner sleeves to position air swirlers, the front end of each of said burners comprising a plurality of outer and a plurality of inner cups with each of said inner cups located concentrically within one of said outer cups, said outer and said inner cups terminating at their forward ends in abutting radially directed circular flanges which are received with substantial radial clearance in said annular recess such that there is greater radial clearance between said inner cup and said recess than between said outer cup and said recess, said inner cups being so shaped as to commence at their forward ends as said radially directed circular flanges which engage said annular recess then blending smoothly into a first axially extending sleeve and then blending smoothly into an outwardly extending conical section and then blending into and terminating in a second axially extending sleeve such that an annular passage is formed between said outer and inner cups which terminates in an outlet between said outer cup and said second axially extending sleeve of said inner cup and further such that as said inner cup expands with respect to said air swirler at operating temperatures said air swirler conical section and said inner cup conical section align to become a smooth conical section and further such that the area of said outlet reduces to a predetermined value, and a plurality of cooling air holes in said outer cup located outboard of said first axially extending sleeve of said inner cup such that cooling air will be admitted thru said holes and pass thru said annular passage to be discharged thru and metered by said outlet area.

7. A combustion unit comprising a fuel manifold having at least one fuel nozzle attached thereto, an air swirler telescopically sleeved onto said fuel nozzle having an annular recess with a base and outwardly extending walls on its outer surface and also having a conical projection therefrom, a combustion chamber having at its forward end at least one outer cup and at least one inner cup which inner cup is located concentrically within said outer cup, said outer cup so shaped as to commence at its forward end in an outwardly directed flange with a circular hole centrally located therein of greater diameter than the base dimension of said annular recess but of less diameter than the largest wall dimension of said annular recess then smoothly blending into an outwardly extending conical section then smoothly blending into spaced cylindrical sleeves, said inner cup being so shaped as to commence at its forward end in an outwardly directed flange with a circular hole centrally located therein of greater diameter than the diameter of said outer cup

centrally located hole and greater diameter than the base dimension of said annular recess but of less diameter than the largest wall dimension of said annular recess, then smoothly blending into a first axially extending sleeve and then smoothly blending into an outwardly extending conical section and then smoothly blending into and terminating in a second axially extending sleeve such that an annular passage is formed between said outer and inner cup which terminates in an outlet between said outer cup spaced cylindrical sleeves and said second axially extending sleeve of said inner cup and further such that as said cups expand with respect to said air swirler at operating temperatures, said air swirler conical section and said inner cup conical section align to become a smooth conical section and further such that the area of said outlet reduces to a predetermined value, a plurality of cooling air holes in said outer cup located outboard of said first axially extending sleeve of said inner cup such that cooling air will be admitted thru said holes and pass thru said annular passage to be discharged thru and metered by said outlet area, said outwardly directed flanges in said outer and inner cups aligned juxtapositioned and received in a sliding fit between the walls of said annular recess such that said outer and inner cups are positioned by said annular recess but may expand relative to each other and said annular recess.

8. An aircraft engine with an outer case having a combustion unit comprising a plurality of can-type burners equally spaced circumferentially about the centerline of said engine and each equidistant radially therefrom, each of said burners having a plurality of air swirlers at the forward end thereof equally spaced circumferentially about the axis of said burner and equidistant radially therefrom and each having an annular recess, and further having a conical projection extending therefrom, a fuel manifold suspended from said engine case and having a plurality of fuel nozzles each of which telescopically engages in an axial sliding fit one of said air swirlers to position same, the front end of each of said burners comprising a plurality of outer and a plurality of inner cups with each of said inner cups located concentrically within one of said outer cups, said outer cups terminating at their forward ends in circular flanges which are received with substantial radial clearance in said annular recess, and said inner cups attached to said air swirler conical projection so as to form a smooth wall therewith.

No references cited.