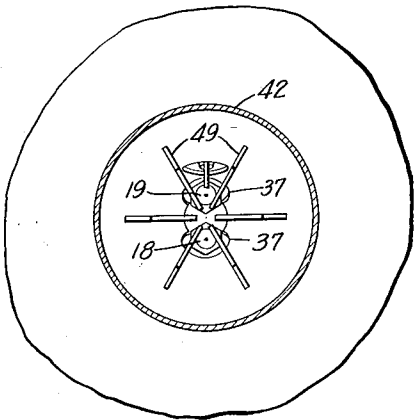
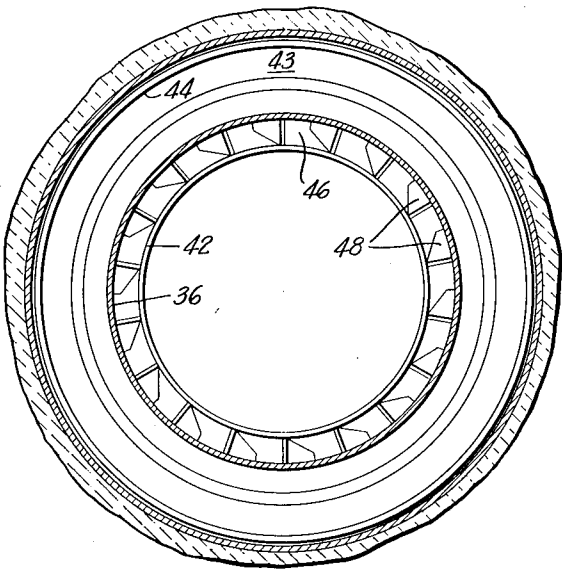
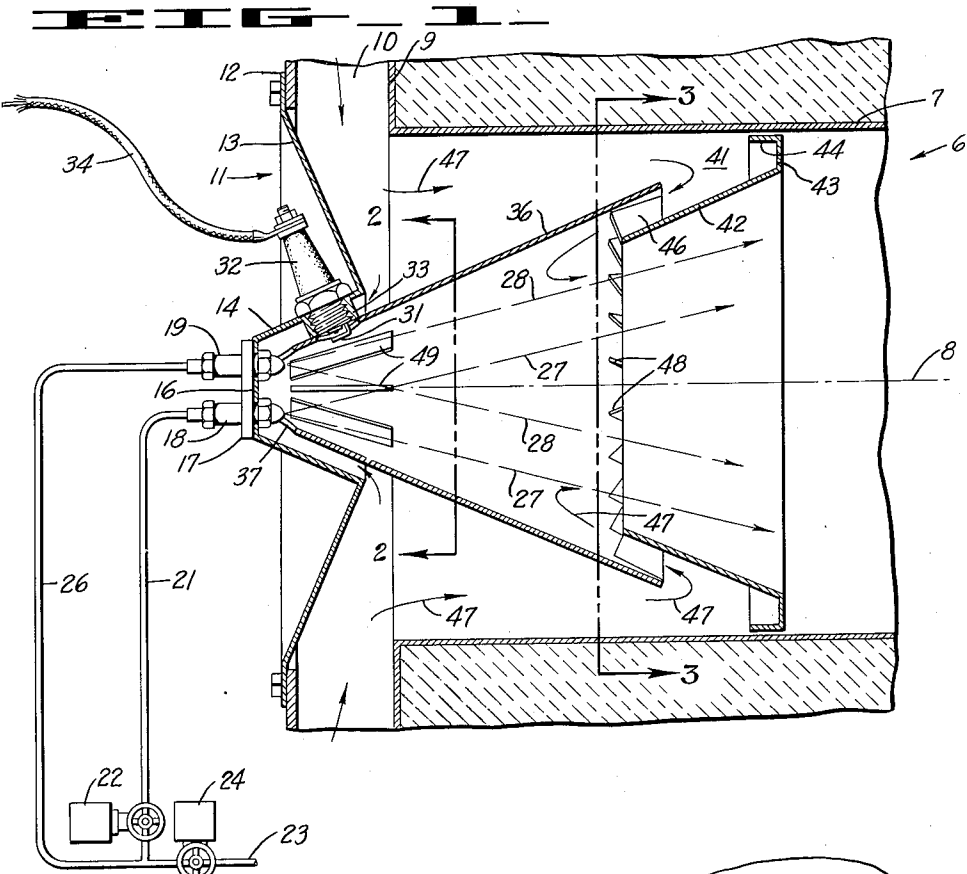


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BURNER AND COMBUSTION SYSTEM

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## BURNER AND COMBUSTION SYSTEM

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Our invention relates to apparatus primarily for use in connection with mobile steam power plants and of a type useful in connection with a steam generator as disclosed in our co-pending application Serial No. 28,548, now Patent No. 2,645,210, issued July 14, 1953, filed May 22, 1948, and utilizing a fuel burner system of the sort disclosed in our co-pending application Serial No. 27,374, filed May 17, 1948, now Patent No. 2,589,224, issued February 19, 1952.

In mobile power plants of the type indicated, it is desirable to have spark ignition of the fuel for combustion and to have the fire operate intermittently and also to vary substantially in quantity from a very small amount to a very large amount. While the ignition of the fire initially at a relatively low rate when the structure is being started from cold is readily accomplished by the usual spark ignition device, it is sometimes difficult, even after the structure has been operating for some time, to ignite a very large quantity of fuel suddenly discharged into the combustion system. It has also been found that to provide satisfactory relatively smoke free and efficient combustion over a very wide range, for example a range of eight to one, is difficult in a single combustion chamber. That is, it is easy to design a combustion chamber which operates well with a given amount of fuel but it is not easy to arrange a structure which operates well with greatly different quantities of fuel.

Despite the availability of materials resistant to relatively high temperatures, it is difficult to afford a combustion chamber having a relatively long life in an environment in which a very large quantity of fuel is burned in a relatively small volume.

It is therefore an object of our invention to provide a burner and combustion system effective to burn a relatively small quantity or a relatively large quantity of fuel in substantially the same combustion chamber.

Another object of our invention is to provide a burner and combustion system in which ignition of an intermittently operating flame is successful at very large volumes of fuel.

Another object of our invention is to provide a burner and combustion system effective over a long period of time without substantial deterioration even though the quantity of fuel burned varies rapidly and somewhat at random from a relatively small amount to a relatively great amount.

A still further object of our invention is in general to improve burner and combustion systems.

A still further object of the invention is to provide a burner and combustion system which utilizes ordinary materials and simple structures to produce a satisfactory combustion, particularly a satisfactory intermittent combustion over a very wide range of quantities.

Other objects, together with the foregoing, are attained in the embodiment of the invention described in the accompanying description and illustrated in the accompanying drawing, in which:

Figure 1 is a cross section on a longitudinal vertical

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plane through a burner and combustion system constructed in accordance with our invention and illustrated in part diagrammatically.

Figure 2 is a detail shown in cross section on the line 2—2 of Figure 1.

Figure 3 is a detail shown in cross section on the line 3—3 of Figure 1.

While the burner and combustion system is susceptible to wide variation depending upon numerous design factors and particularly upon the associated mechanism with which it is to operate, it has successfully been embodied as illustrated herein in connection with a steam generator 6, within which is disposed a circular cylindrical combustion tube 7, having a central axis 8. The tube is preferably fabricated of combustion resistant metal or other suitable material. The combustion tube 7 adjacent one end is spaced from the wall 9 of the generator to leave an intervening annular air inlet opening 10 connected to suitable source of combustion air under pressure such as a blower, not shown.

Spanning the end of the combustion tube 7 and removably fastened to the wall 9 is a face plate 11 serving as a support for additional structure. The face plate is preferably made up of an outer ring 12 of light metal joined to a dished plate 13 itself connected to an outer cone 14 truncated and spanned by a disc 16, the plane of which is somewhat beyond the general plane of the ring 12. The dished and conical contour of the face plate 11 is to avoid severe warpage under intermittent high temperature.

The disc 16 is symmetrical with the axis 8, being perpendicular thereto, and is effective to carry a burner plate 17 on which a main burner nozzle 18 and an auxiliary burner nozzle 19 are mounted. Upon removal of the plate 17 the two nozzles can be removed, but when the plate is in position the axes of the nozzles are substantially parallel to the axis 8 and are as close to it as is mechanically feasible. The main nozzle 18 is connected by a conduit 21 through a control valve 22 to a supply conduit 23 leading to any suitable source of fuel oil. An additional control valve 24 not only controls the principal supply of oil to the main nozzle 18 but likewise controls supply through a conduit 26 to the auxiliary nozzle 19.

The nozzles 18 and 19 discharge hollow cones of fuel spray approximately indicated by envelope lines 27 and 28. This showing is at best an approximation as the envelope is not sharply defined and also varies under different operating conditions, but is intended to afford a substantially correct showing. The envelope lines 27 extend in the general direction of the axis 8 diverging as they proceed away from the nozzle 18 and do not intersect or interfere with the envelope lines 28 of the nozzle 19 until a substantial axial distance has been traversed, although at a greater distance the two envelopes approximately merge into quite similar patterns.

The envelope lines 28 of the spray cone from the nozzle 19 are approximately intercepted by the electrodes 31 of a spark igniter 32. This is conveniently a standard automobile type grounded spark plug screwed into an appropriate boss 33 in the outer cone 14 and provided with an ignition lead 34 in the usual way. The location of the electrodes 31 is adjacent the auxiliary nozzle 19 but remote from the main nozzle 18.

Situated coaxially within the tube 7 is a combustion cone 36, preferably fabricated of relatively inexpensive sheet metal. This is feasible since the outer portion of the combustion cone 36 is subjected to and kept from excessive temperature by substantially all of the relatively cool combustion air entering through the passageway 10. The cone 36 is arranged with its small end adjacent the nozzles 18 and 19 and in some cases is actually fastened to the disc 16 and in other cases is disposed in close prox-

imity thereto. Cut out portions 37 are provided in the combustion cone not only to avoid mechanical interference with the nozzles 18 and 19 but likewise to admit some air in the immediate vicinity of the nozzles although the cut out portions are protected from a direct blast of entering air by the truncated outer cone 14.

The angle of divergence of the combustion cone 36 is somewhat greater than the angle of divergence of the spray envelopes 27 and 28. The larger end of the combustion cone terminates in an annular pocket 41 defined in part and on the outside by the combustion tube 7 and in part and on the inside by a deflector cone 42, preferably fabricated also of sheet metal and provided with a rim flange 42 having, if desired, an inturned portion 44 in rather close engagement with the combustion tube 7. Preferably the combustion cone 42 has a frictional sliding fit within the combustion tube 7 in order to preclude the passage of any substantial amount of combustion air around the deflector cone. In some instances, the flange 43 is either a sufficiently loose fit within the combustion tube 7 or is actually cut away or apertured to permit some of the combustion air to pass by the deflector cone 42.

In the preferred instance as shown, the size of the pocket 41 is such and the dimensions of the deflecting cone 42 are such that the smaller end of the deflector cone is nested within the larger end of the combustion cone 36. Both cones are well outside the fuel spray envelopes. There is an axial amount of overlap to define an annular passage 46 between the two cones. This passage is shaped to be effective to control the direction of flow of air. Incoming air, indicated by arrows 47 flows generally radially inward from the opening 10 and in most instances is also possessed of some rotational swirl about the axis 8 as a center, either due to the operation of the blower mechanism or due to the provision of auxiliary swirl vanes in the opening 10, or due to unavoidably unsymmetrical flow.

In any case, the inflowing air following the path 47 and travelling into the pocket 41 reverses its direction in flowing through the opening 46 so that it has a substantial component of flow opposite to the direction of flow of fuel from the nozzles 18 and 19. This is believed to be important as it produces a large relative travel between the fuel and the air to assist in obtaining a maximum admixture.

It has been observed in practice that air passing through the passageway 46 and entering the combustion cone 36 is possessed of sufficient asymmetry to have a swirl component and forms a vortex within the cone 36. It is believed that ideally it would be possible to introduce air into the large end of the combustion cone 36 without any vortical motion. But in practice there seems always to be swirl, and it seems not to be necessary to provide specific swirl inducing means. However, for purposes of illustration herein and for convenience in fabrication and to insure that a large amount of swirl of a vortical nature is provided, the passage 46 is spanned by a number of small vanes 48, interposed between and in most instances fastened to the combustion cone 36 and deflector cone 46.

The air stream has a vortical swirl as it discharges from between the vanes 48 and as it travels in a direction toward the left in Figure 1 along the axis 8 and around the inside of the combustion cone 36. The swirling air encounters smaller and smaller cone diameters as it approaches the burner nozzles. The rate of rotational velocity of the vortical air swirl increases very markedly, and the violence of the rotary air movement increases greatly toward the small end of the combustion cone 36.

While the countercurrent direction of motion is helpful and while the violent vortical motion is productive of excellent combustion in the region of the large part of the combustion cone and of the deflector cone 42 and even within the combustion tube 7 toward the right in Figure 1, it has been determined that such vortical swirl is entirely too violent and acts too much as a centrifugal separator

in the small end of the combustion cone 36 near the nozzles. The centrifugal force instead of merely providing desirable turbulence apparently tends to form concentric zones of material too rich for combustion and too poor for combustion. It has been noted that the violent swirl tends to disrupt the fuel envelopes and in many instances interferes substantially with ignition.

Consequently, adjacent the small end of the combustion cone 36 near the burner nozzles 18 and 19 and in the vicinity of the spark plug electrodes 31, and also in a region where the spray envelopes 27 and 28 and have not yet merged, there are disposed a number of arresting vanes 49. These are strips of metal secured to the combustion cone 36 extending in the general direction of the axis 8 and also extending a substantial amount radially toward the center of the cone. They are preferably disposed so as not to interfere with but rather to shield the electrodes 31 and so as not to intercept any of the liquid spray from the nozzles 18 and 19. The vanes 49 have the effect, in general, of preventing rapid swirls about the axis 8 in the small end of the combustion cone 36 and afford what is relatively a quiescent zone. There are some eddies and turbulence in the vicinity of the arresting vanes 49, but in part they come also from air entering through the relieved portions 37.

To initiate operation of this structure, the spark plug 32 is energized in the usual way and a continuous spark is afforded at the electrodes 31. The control valve 24 is suitably opened but the valve 22 remains closed. There is a flow of fuel through the conduit 26 to the auxiliary nozzle 19. In one representative instance this nozzle has a capacity of spraying one gallon of fuel per hour, a relatively minor amount of oil. The small quantity of fuel emerging from the auxiliary nozzle 19 hasn't much penetration and is relatively protected within the small end of the combustion cone 36, a sort of protected cove, despite the fact that combustion air in quite large quantity is entering through the opening or annulus 10. Most of the combustion air passing rather violently through the swirl vanes 46, reverses itself and passes then through the interior of the deflector cone 42 into the combustion tube 7 toward the right in Figure 1. Only some mildly turbulent air passes the arresting vanes 49 and may be augmented by a small amount of low velocity air entering through the cutaway portions 37. The relatively quiescent conditions in the small end of the combustion cone facilitate the immediate spark ignition of the relatively small quantity of vaporized fuel within the envelope 28. A moderately small flame then burns within the combustion cone 36, mostly in the small end thereof, and the products of combustion mix with the main portion of air traveling into the combustion tube 7.

Simultaneously with or preferably slightly after the primary ignition has taken place, the valve 22 is opened and a larger supply of oil issues from the main nozzle 18. This quantity of oil, in a representative instance, ranges from say four gallons per hour to say thirty two gallons per hour. Occasionally, nozzles in addition to the nozzles 18 are utilized, several at a time being cut into or out of operation simultaneously or sequentially but for illustration herein the nozzle 18 represents a variable main fuel supply. This main supply enters the small end of the combustion cone 36 and does not immediately mix with the supply from the auxiliary nozzle.

The main supply need not be directly ignited by the spark plug 31 since the electrodes are relatively far away and the proportions of the air and fuel may not be appropriate, although sometimes direct ignition appears to occur. In any case, there is luminous combustion or flame from the auxiliary nozzle in the vicinity of the mid point of the combustion cone 36 and somewhere in that zone the fuel from the main nozzle, as represented by the envelope 27, is mixed into the auxiliary flame. Ignition of the main quantity of fuel therefore, is designed to

take place from the auxiliary flame rather than directly from the spark plug itself.

As the main quantity of fuel travels toward the right in Figure 1 it encounters a very violent vortical swirl of air having a substantial component toward the left in Figure 1. The resulting turbulence admixes the air and oil in a very short space of travel and in a relatively small chamber volume. Combustion of the entire quantity thereupon ensues partly in the combustion cone and partly as the mixture travels from the interior of the deflecting cone 32 out into the combustion tube 7. This tube is relatively long and combustion is entirely completed within it.

The operation of the main nozzle 18 is interrupted quite abruptly from time to time by closure of the valve 22 although the supply of air through the opening 10 may not be changed at all. If the proportions of air and oil are proper for combustion before the interruption of operation of the main nozzle 18, they are improper after the fuel has been interrupted. However, the auxiliary nozzle is well enough protected from the main air flow so that its combustion continues properly without interruption. When the main nozzle 18 is again effective, upon abrupt opening of the valve 22 to discharge oil at the rate of say thirty-two gallons an hour into the combustion cone 36 (which immediately theretofore has been supporting combustion at the rate of only one gallon per hour), the ignition of this large quantity of relatively cold fuel nevertheless is positive and immediate because the auxiliary flame is sufficient to insure that result, and sufficient air is available toward the larger portion of the combustion cone.

The description of combustion events and locations is as accurate as possible but due to difficulty or observation in practice only approximations can be given.

We claim:

1. A burner and combustion system comprising a smooth substantially imperforate combustion cone having an axis, a nozzle disposed at the small end of said combustion cone and directed in a predetermined direction along said axis toward the large end of said combustion cone, means for directing an air stream into the large end of said combustion cone in an opposite direction and toward the small end of said combustion cone, means adjacent the large end of said combustion cone for imparting to said air stream a vortical swirl about said axis and along the inner surface of said cone, and means only adjacent the small end of said combustion cone and axially between said nozzles and the large end said cone for arresting said vortical swirl only in the vicinity of the small end of said combustion cone.

2. A burner and combustion system comprising a smooth combustion cone having an axis, a nozzle disposed at the small end of said combustion cone and directed along said axis toward the large end of said combustion cone, a detector cone nested within the large end only of said combustion cone to leave an annular opening therebetween, swirl vanes spanning said opening for imparting a single unidirectional swirl about said axis to air flowing through said opening along the inside of said combustion cone toward the small end thereof,

and axially disposed arresting vanes within the small end only of said combustion cone and located axially between said nozzle and said annular opening for arresting said unidirectional swirl adjacent the small end only of said combustion cone.

3. A burner and combustion system comprising a combustion cone having an axis, a pair of nozzles directed into the small end of said combustion cone to discharge spray in a predetermined direction along said axis toward the large end of said combustion cone, a spark igniter projecting into said combustion cone in a position to ignite said spray from one of said nozzles, means for directing an air stream into the large end of said combustion cone in a direction opposite to said predetermined direction, means within the large end of said combustion cone for inducing a single unidirectional swirl of said air stream within said combustion cone and flowing along the inner wall thereof toward said nozzles, and means for arresting said swirl of said air stream within said combustion cone but only adjacent the small end thereof on the spray side of said nozzles.

4. A burner and combustion system comprising a substantially smooth combustion cone symmetrical about an axis and having a small end and a large end, a fuel nozzle disposed adjacent said small end and effective to discharge fuel in a conical stream along said axis toward said large end, a deflector cone symmetrical about said axis and telescoped within the large end of said combustion cone to provide an axial overlap of a portion of the large end of said combustion cone and a portion of the small end of said deflector cone, said portions being radially spaced apart to leave a passageway therebetween, a single set of vanes in said passageway for imparting a unidirectional swirl to air flowing through said passageway toward said small end of said combustion cone and for discharging said air with a unidirectional swirl onto said smooth combustion cone with an axial flow component toward said small end of said smooth combustion cone, and swirl arresting vanes within said combustion cone only in said small end thereof adjacent the fuel discharge side of said fuel nozzle for arresting said swirl of only that portion of said air adjacent the fuel discharge side of said nozzle.

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