

[54] **ROCKET BURNER WITH FLAME
PATTERN CONTROL**

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239/430**

[51] Int. Cl. **B05b 7/10**

[58] Field of Search...239/399, 402.5, 403, 405, 432,
239/400, 422 X, 430 X, 433, 428, 132.3;
266/34, DIG. 3

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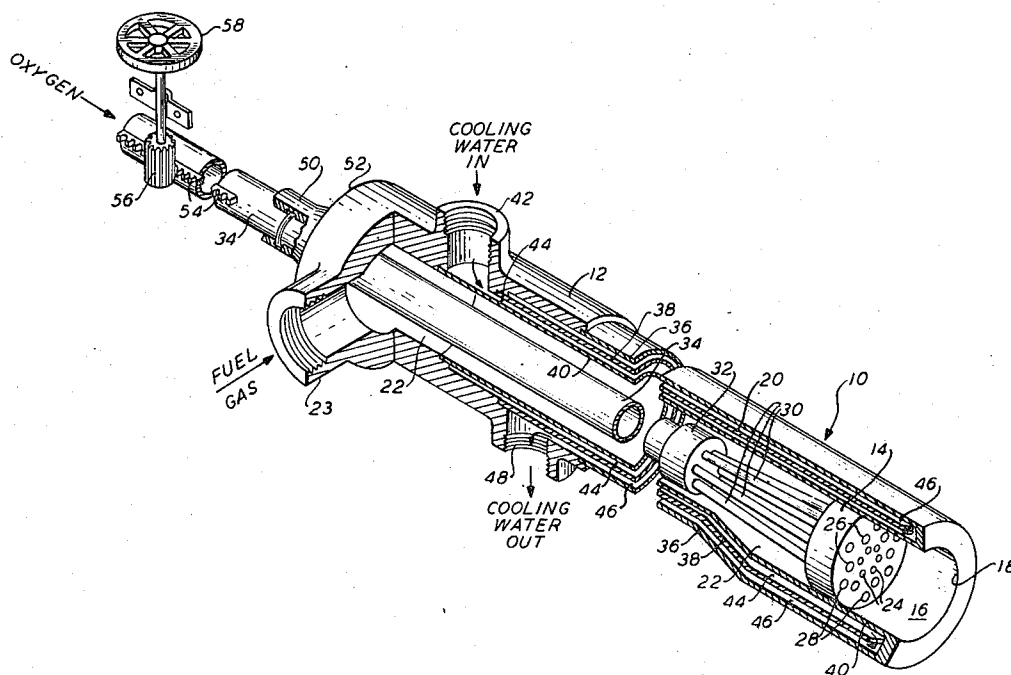
Primary Examiner—Lloyd L. King

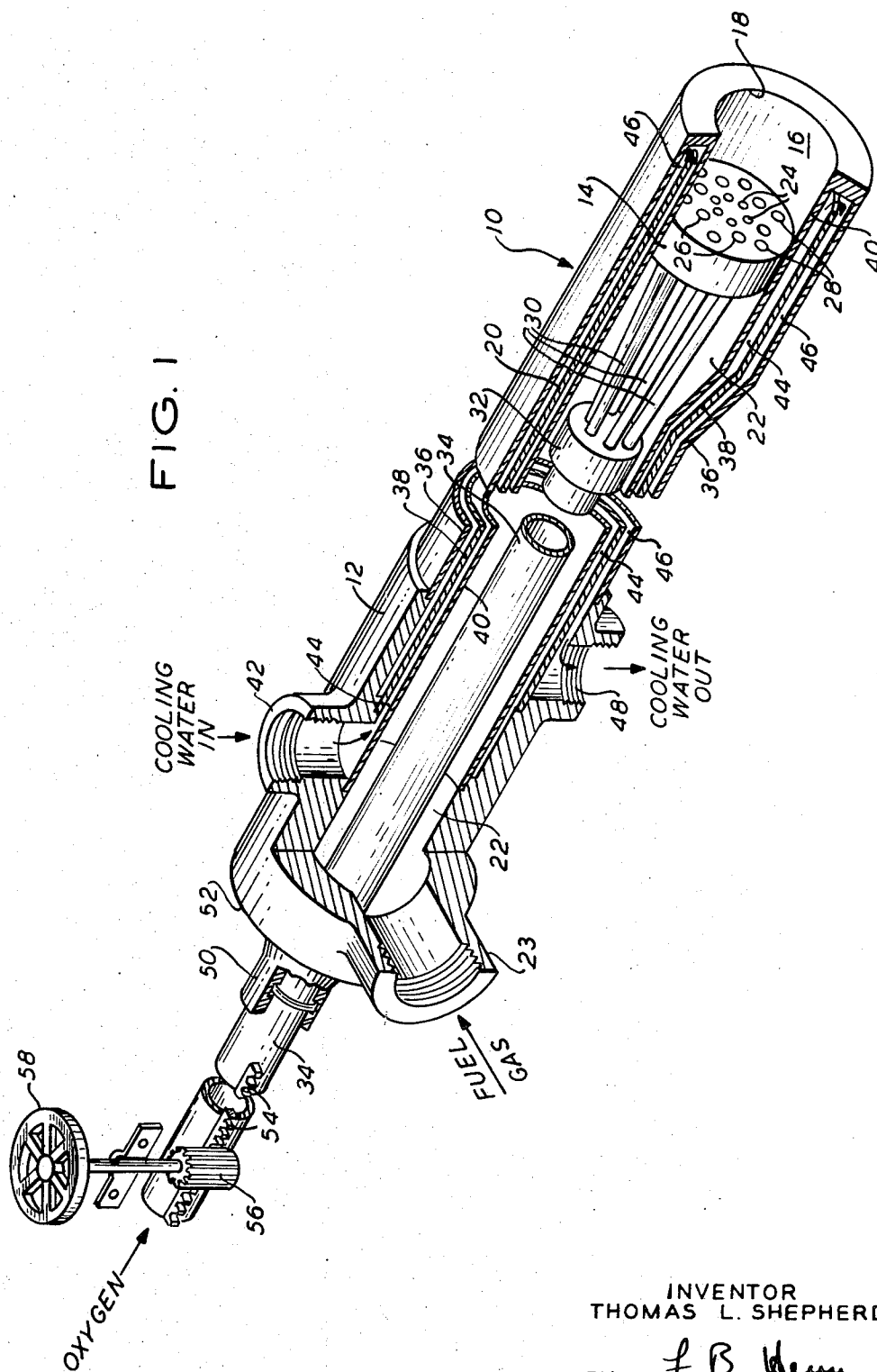
Attorney—Edmund W. Bopp and H. Hume Mathews

[57] **ABSTRACT**

An oxygen-fuel burner of the rocker burner type comprising a cylindrical combustion chamber having an open discharge end and a burner plate with separate oxygen and fuel ports constituting the opposite end of the chamber; the projected longitudinal axes of the oxygen ports extending in converging directions towards the longitudinal axis of the chamber but in off-set, non-intersecting relation thereto, so that points on the respective axis that most closely approach the chamber axis define a transversely positioned plane between the burner plate and the chamber exhaust; the projected longitudinal axes of the fuel ports being projected substantially parallel to the chamber axis for mixing of oxygen and fuel at and beyond the plane of closest approach, and means for adjusting the longitudinal position of the burner plate on the chamber axis and thereby locating the plane of closest approach in relation to the chamber exhaust for determining the pattern of the burner discharge flames.

15 Claims, 8 Drawing Figures





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FIG. 2

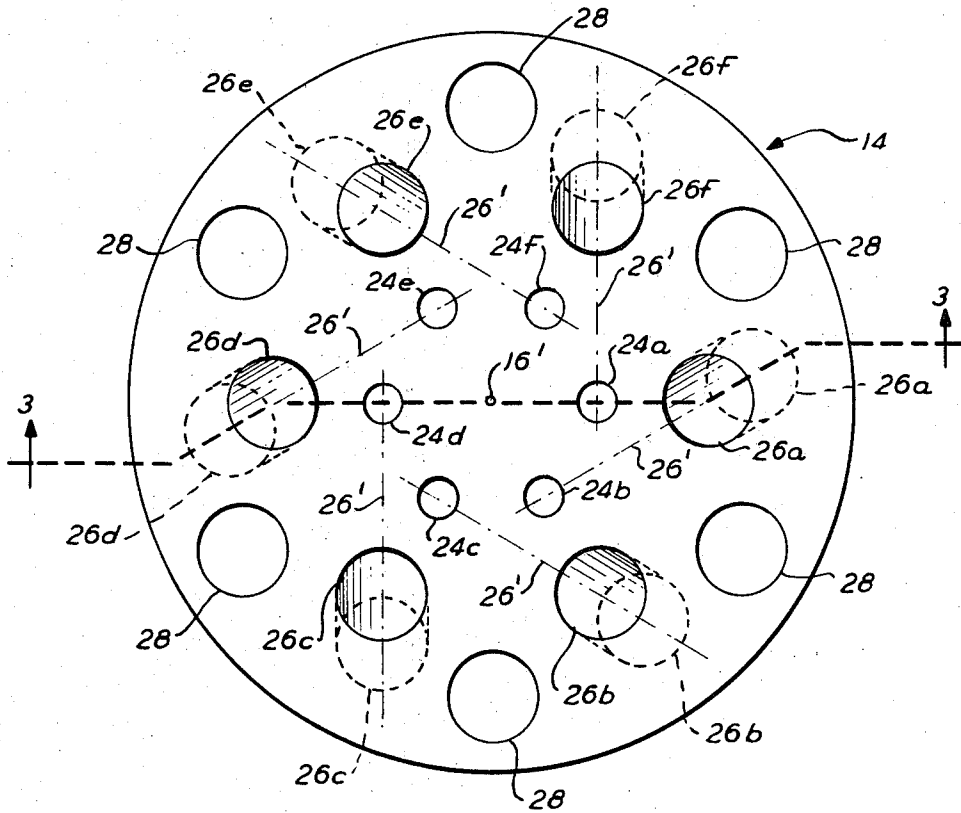
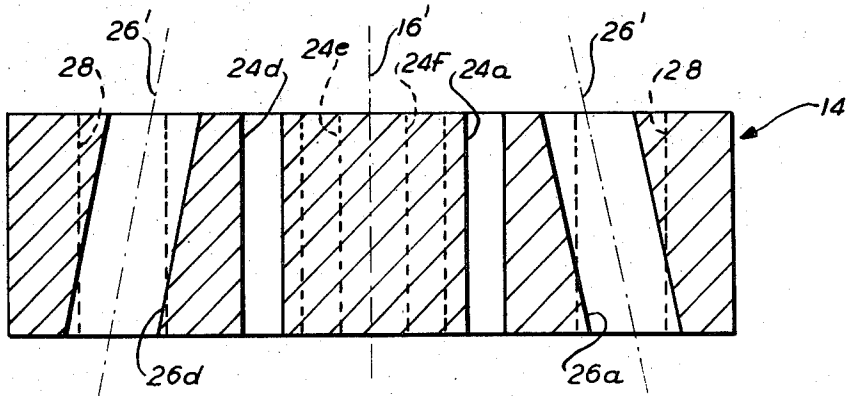


FIG. 3



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FIG. 4

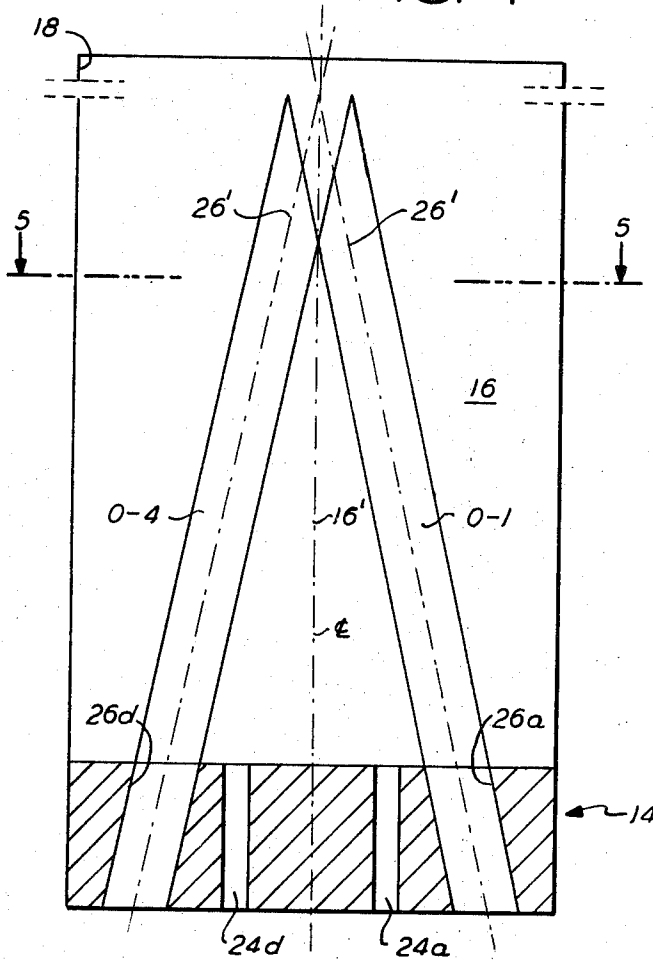


FIG. 5

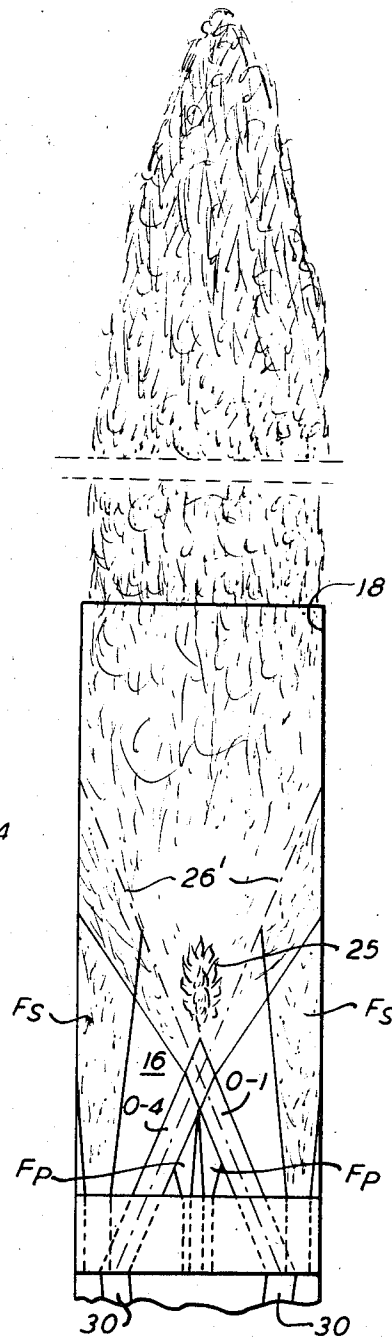
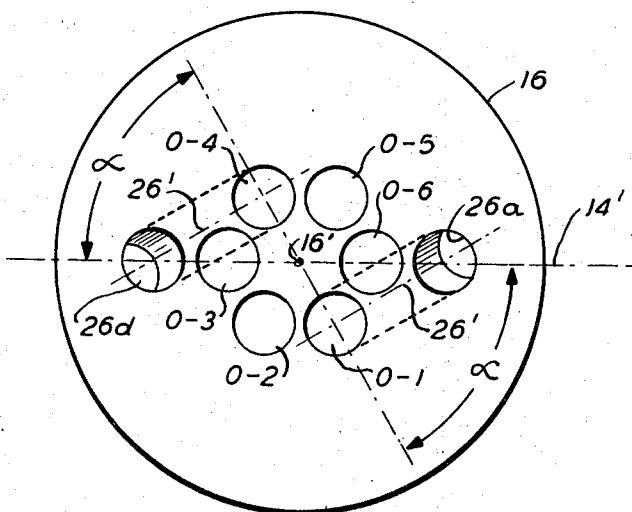


FIG. 7

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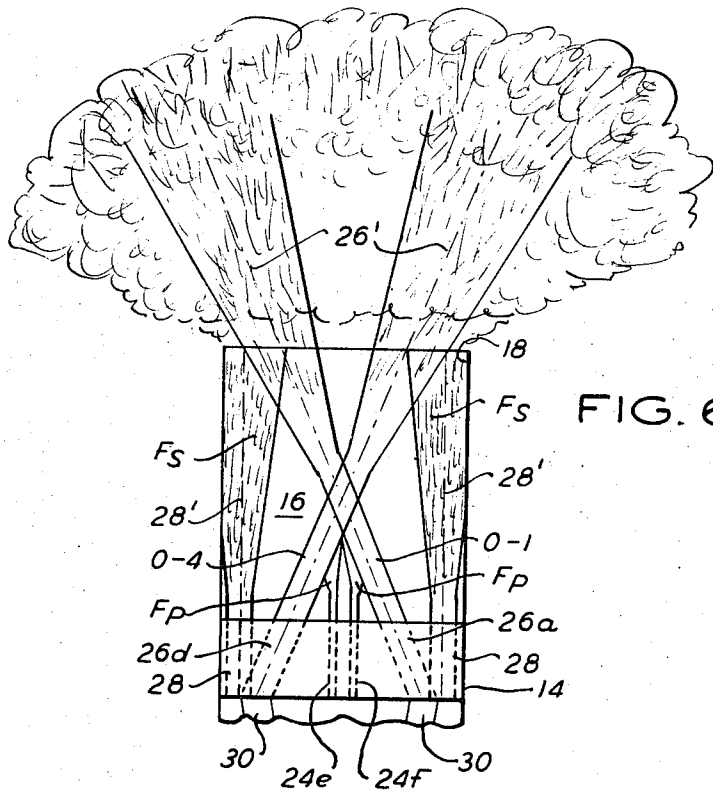


FIG. 6

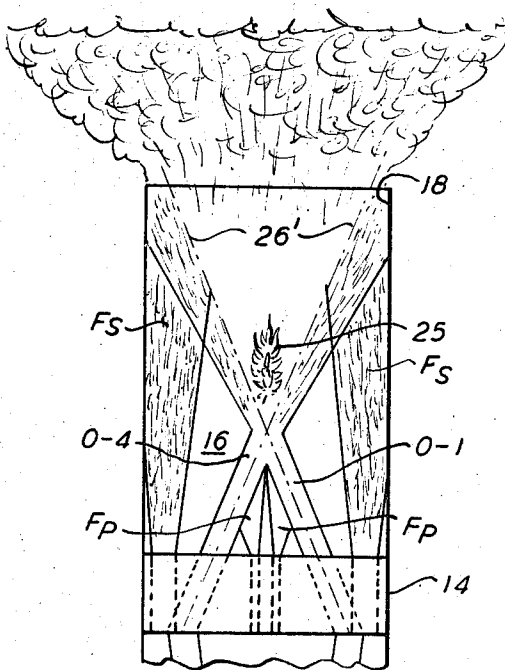


FIG. 8

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ROCKET BURNER WITH FLAME PATTERN CONTROL

BACKGROUND OF THE INVENTION

The invention concerns burners for space heating, heat working, and the like, and especially burners of the oxygen-fuel type wherein oxygen and fuel respectively are fed as required to the burner for combustion and projection of heating flames. Control of the physical size and shape, i.e. pattern or configuration, of the burner flames is essential for many applications, such as for example where short, bushy or spreading flames best serve the heating purpose; in other applications, a long slender, needle-type flame may be indicated.

Although flame pattern control for oxygen-fuel burners has heretofore been proposed and practiced, it has not been satisfactorily achieved insofar as known, in modern acceptable burner equipment. For example, a prior art device known as the "shell-type" burner utilized the needle valve principle for changing the flame pattern. In this burner the oxygen is fed through a cylindrical housing or shell and mixed with fuel gas from a feeder that is axially adjustable in the shell for defining an annular nozzle type opening, constituting the adjustable burner passage. The burner also includes a so-called "bluff body" flame stabilizer and spreader that is in direct contact with the oxygen-fuel flame at the point of mixing. As indicated above, control of the flame pattern of the shell burner is accomplished by axial movement of the central fuel feeder for varying in the manner of needle valve control, the annular passage for directing an oxygen-fuel mixture into the combustion region at the bluff body.

Serious difficulties and disadvantages were encountered in the operation of the shell burner. Premature ignition of the highly combustible oxygen-fuel mixtures within the burner itself created a dangerous explosion hazard; also excessive maintenance was involved due to the difficulty of properly cooling the burner parts in direct contact with the hot oxygen-fuel flames. For these reasons general use of the shell type oxygen-fuel burner has greatly declined.

A more acceptable oxygen-fuel burner now in common use is known as the "rocket burner," a typical example being shown by U.S. Pat. No. 3,135,626 granted June 2, 1964 to Moen and Shepherd. Briefly, the rocket burner comprises a cylindrical combustion chamber open at the discharge end and having a multi-port burner plate forming the opposite end of the chamber. Fuel gas and oxygen are separately fed in closely grouped parallel streams through respective ports in the burner plate for mixing and burning in the combustion chamber. Initially, this is accompanied by establishment of low velocity anchoring flames as gases along the peripheries of adjacent fuel and oxygen streams mingle after passing through the burner plate ports.

In the rocket burner, a limited degree of flame pattern control can of course, be achieved by valve regulation of the amounts, pressures and ratios of the oxygen and fuel fed to the burner; also by locating the burner plate selected distances from the burner exhaust, an elongated "stiff" flame or a comparatively short, fat flame can be produced. However, regulation of the oxygen and fuel burner input does not provide for flexi-

bility in varying the flame pattern for a given BTU burner output. Location of the burner plate at different distances from the burner exhaust also does not achieve the desired control of flame pattern as the closely grouped parallel gas streams from the conventional burner plate ordinarily start mixing and burning well within the combustion chamber near the burner plate and tend to diverge downstream. Where the burner plate is comparatively close to the exhaust of the combustion chamber, bushy type flames naturally result; however, a widespreading umbrella-shaped flame is not possible with the conventional rocket burner.

The invention therefore is concerned with providing an improved rocket burner having flexible flame pattern control over a wide range for a given BTU burner output.

SUMMARY OF THE INVENTION

In accordance with the invention in its broader aspects, a rocket type oxygen-fuel burner is provided with a specially designed multiple-port burner plate for so directing respective streams of fuel gas and oxygen into the cylindrical combustion chamber of the burner, that initial mixing of the gases for combustion occurs within a region spaced from the burner plate; furthermore for a given BTU output of the burner, this region can be shifted toward or away from the exhaust end of the combustion chamber by corresponding relative longitudinal movement of the burner plate with respect to the combustion chamber for changing throughout a wide range the pattern of the discharge flames.

In a preferred form of the invention, the region of initial gas mixing is determined by interaction of a plurality of the fuel gas streams that flow from the burner plate generally parallel to the longitudinal or central axis of the chamber, with a plurality of oxygen streams that flow angularly from the burner plate so as to converge toward the chamber axis, but in off-set or tangential, non-intersecting relation thereto. Accordingly, the points on the respective converging axes that are closest to the chamber axis define a plane that is transverse to this axis. The plane, herein called the "plane of closest approach," is the general locator of the region of gas mixing and primary combustion.

Since the projected longitudinal axes of the oxygen ports start to diverge beyond the plane of closest approach, the momentum of high velocity oxygen streams tends to produce bushy, wide-spreading flames where the burner is adjusted for axes divergence beyond the chamber exhaust; conversely where the adjustment is such that the diverging streams are confined by the chamber walls, an elongated sharp and jet-like high velocity flame is produced. Variation of the flame discharge pattern within the limits indicated above is achieved in accordance with the invention by relative longitudinal movement between the burner plate and the combustion chamber, and hence variation of the position of the plane of closest approach with respect to the chamber exhaust for controlling divergence of the mixed combustion gases.

A principal object of the invention therefore is to provide an improved oxygen-fuel burner of the rocket burner type with flame pattern control wherein the mixing of oxygen and fuel gas occurs within a region of

the combustion chamber remote from the burner plate, and the distance between the mixing region and the chamber exhaust is made variable for varying within a wide range the pattern of the chamber exhaust flames.

A further and related object is to provide an improved burner of the character described above wherein the projected longitudinal axes of the oxygen and fuel ports of the burner plate are angularly related for defining the remotely spaced gas mixing region, and the burner plate is movable relative to the chamber exhaust for varying the location of the mixing region and so controlling the pattern of the exhaust flames.

A further object of the invention is to provide an improved burner of the type described above that achieves efficient use of heat output for variable flame pattern control, that is easily adjustable for a given BTU burner output within a wide range of flame pattern control, and that has low maintenance cost and is free of preignition hazard.

Other objects, features and advantages will appear from the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view, partly in section, of a rocket type oxygen-fuel burner embodying the invention;

FIG. 2 is a plan view of the multi-port burner element of the rocket burner shown in FIG. 1;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a diagrammatic view of the burner element and combustion chamber indicating convergence of two oxygen streams toward the chamber axis;

FIG. 5 is a diagrammatic plan view indicating the relation of the oxygen streams to the chamber axis at the plane of closest approach along line 5—5 of FIG. 4; and

FIGS. 6, 7, and 8 are diagrammatic views illustrating respectively, different positions of the burner plate with respect to the combustion chamber exhaust for achieving different patterns of the exhaust flames.

DESCRIPTION OF PREFERRED EMBODIMENT

The oxygen-fuel rocket burner 10 shown by way of example in FIG. 1, comprises a tubular or cylindrical housing 12 within which a burner element 14 defines one end of a combustion chamber 16. The open end of the housing at 18 defines the opposite or discharge end of the chamber from which heating flames are projected for heat working, space heating, etc. As the combustion chamber is subject to the high temperatures encountered in the operation of oxygen-fuel burners, the housing 12 includes a water-cooled jacket 20 that extends throughout the length of the combustion chamber and most of the housing for effective heat dissipation.

The burner element 14, herein for convenience termed "burner plate," constitutes in effect a flow divider for separately feeding a plurality of oxygen and fuel-gas streams respectively into the combustion chamber. In the present example, the burner plate is formed as an apertured disc-like cylinder that is concentrically mounted within the combustion chamber and serves as a partition between the combustion

chamber and an elongated plenum chamber 22 for the fuel gas. The plenum chamber extends from the burner plate to the opposite end of the housing where it is connected to a fuel gas supply conduit at 23, that conveniently may be utility natural gas.

Certain of the burner plate apertures or ports are centered as at 24 for example, and extend through the burner plate for directly communicating with the fuel gas plenum chamber 22. A plurality of other ports 26 for supplying oxygen to the combustion chamber are arranged in a circle, preferably concentric with the longitudinal axis of the combustion chamber (and burner plate), around the smaller centrally grouped fuel ports 24. Additional fuel ports 28 in the burner plate, also communicating with the fuel chamber 22, are disposed in a circle around the outer peripheral area of the oxygen ports 26. The central fuel ports 24, shown as 6 in number, and the outer fuel ports 28, also 6 in number, extend transversely through the burner plate; i.e., the axes of the respective ports extend generally parallel to the longitudinal axis of the combustion chamber. The oxygen ports 26, however, are angularly disposed with respect to the chamber axis, the projected longitudinal axes of which converge toward the chamber exhaust in off-set, tangential relation to the chamber axis so as to be in non-intersecting relation therewith. That is, the longitudinal axes of the oxygen ports are inclined toward and skewed somewhat with respect to the chamber axis as indicated in FIG. 2 for establishing the geometric relation described above.

The oxygen ports 26 are connected to an oxygen supply through a manifold arrangement that comprises a plurality of tubes 30 interconnecting the corresponding oxygen ports and a header 32. The header in turn, is fed by a conduit 34 that extends longitudinally through the chamber 22 and the housing to the exterior for connection as indicated with a source of pressurized oxygen.

It will be apparent that in the apparatus so far described, separate supplies of oxygen and fuel-gas are fed to the corresponding ports in the burner plate, the oxygen from the conduit 34 and manifold to the ports 26, and the fuel-gas from the supply line at 23 and plenum chamber 22 directly to the burner plate ports 24 and 28. Accordingly, the burner plate ports direct as indicated above, separate streams of oxygen and fuel-gas respectively into the combustion chamber 16 for mixture beyond the burner plate and subsequent burning as more fully described below.

The combustion chamber walls as mentioned above are protected from overheating by a water-cooled jacket 20 constituting part of the housing 12 and consisting of concentric tubular walls 36, 38, and 40 that are spaced in the usual manner for defining annular, reverse-flow cooling paths. As shown, the cooling path extends from the cooling water inlet 42 through the annular passage 44 defined by walls 38 and 40 to the burner exhaust end, where the flow reverses into the annular passage 46 formed between the walls 36 and 38, and thence to the cooling water outlet 48.

The materials of construction for the present burner may conform in general to those used in previous rocket burners; i.e., the burner plate may be made of copper or tellurium copper, and the cylinders of the housing, cooling jacket and combustion chamber made

of brass or stainless steel, according to required thermal conductivity, flame-corrosion resistance, etc.

In practicing the invention, the position of the burner plate 14 is adjustable along the longitudinal axis of the combustion chamber with respect to the chamber exhaust; i.e., the burner plate can be moved toward or away from the chamber exhaust for in effect changing the length of the combustion chamber, and thereby the pattern of the exhaust flames. To this end, the burner plate 14, manifold 30-32, and conduit 34 are integrated as a structural unit for relative movement with respect to the housing 12. The burner plate has a sliding fit with the inner cylinder wall 40 constituting the combustion chamber wall, and the conduit 34 is guided for longitudinal movement by a sealing bushing 50 through the end wall 52 of the housing. Relative movement between the burner plate assembly and the housing can be achieved in any suitable manner; for example, a gear rack 54 that is connected to the conduit, is engaged by a coaxing pinion 56 that in turn is manually operated at 58 for moving the conduit (and the burner plate) longitudinally in either direction.

Reference is now made to FIGS. 2 and 3 for illustrating the specific arrangement of the burner plate ports for directing interacting streams of oxygen and fuel-gas respectively into the combustion chamber. Taking for example the oxygen port 26a, it will be noted that the longitudinal axis 26' thereof is skewed with respect to the center of the burner plate, i.e., the longitudinal axis of the combustion chamber, so that intersection of the port axis 26' with the chamber axis 16' is not possible. It will also be noted that the oxygen port axis 26' intersects with the longitudinal axis of one of the centrally located small fuel ports 24b, hereinafter referred to as "primary fuel" ports, for ensuring mixing of these two streams. Moving clockwise, it will also be seen that the other oxygen ports 26b, 26c, etc., are similarly skewed with respect to the chamber axis and have their respective longitudinal axes oriented for intersecting with corresponding axes of primary fuel ports 24c, 24d, etc.

FIG. 3 illustrates the angular direction of the oxygen ports 26a and 26d for directing oxygen streams in converging direction toward the chamber axis 16', but in tangential off-set, non-intersecting relation thereto as best illustrated in FIG. 2. The oxygen streams from the 6 ports shown in FIG. 2 therefore tend to form a clockwise vortex around the chamber axis at a region remote from the burner plate.

FIGS. 4 and 5 which diagrammatically supplement FIGS. 2 and 3, indicate the relationship between the projected longitudinal axes of the oxygen ports and the extension of the chamber axis 16'. In the partly sectional view of the combustion chamber and burner plate shown by FIG. 4, the burner plate is in a similar position to that shown in FIG. 3. The oxygen streams from the ports 26a and 26d are represented for convenience in illustration, as straight high velocity jets or stream cores 0-1 and 0-4, disregarding for the moment any modifying effects of the fuel-gas streams (not shown) from the primary fuel ports 24a and 24d, etc. Although the axes of the two skewed streams appear in FIG. 4 to intersect each other and the chamber axis 16' at some point beyond the section line 5-5, their closest approach to the axis actually occurs at the section line. Accordingly, the transverse plane or region

determined by the section line 5-5 is referred to herein as the "plane of closest approach." FIG. 5 taken along this section line shows the skewing angle α of the oxygen streams 0-1 and 0-4 as about 60° in clockwise direction from the initial positions of FIG. 3 as represented by the horizontal or transverse burner plate axis 14'. The other oxygen streams 0-2 and 0-3, etc., are assumed to be skewed uniformly in the same direction as best shown in FIG. 2.

Between the plane of closest approach and the chamber exhaust, the oxygen streams begin to diverge toward the combustion chamber wall. FIG. 6 illustrates schematically this divergence for a given advanced position of the burner plate wherein the combustion chamber is comparatively short. In this example, divergence of the oxygen port axes extends beyond the chamber exhaust.

Returning briefly to FIG. 2, it will be seen that the additional or secondary fuel gas ports 28 along the peripheral area of the burner plate are designed to supply the main volume of comparatively low velocity fuel to the combustion chamber. As the axes of these ports, as in the case of the central or primary fuel-gas ports 24a, 24b, etc., extend generally parallel to the chamber axis, the secondary fuel gas streams form in effect a low velocity gas envelope at the chamber periphery surrounding the oxygen and the primary fuel streams.

In FIG. 6, the sectional view is intended to indicate the interaction of the oxygen and fuel streams in and beyond the combustion chamber, rather than the precise scalar relationship of the axes in FIGS. 2, 3, and 4. It was found in developing the present invention that a wide spreading, bushy or "umbrella" type flame for the rocket burner as represented by FIG. 6 is best achieved by using the momentum of high velocity oxygen streams directed in both converging and tangential (or skewed) directions with respect to the combustion chamber axis for locating the plane of closest approach sufficiently near the chamber exhaust that the divergence of the high velocity stream is not confined by the chamber walls. By avoiding convergence carried to actual intersection of the oxygen stream axes, as at some common point on the chamber axis, serious problems involving limitation of flame length, combustion chamber cooling, etc., are avoided and the advantages of free gas and flame divergence beyond the plane of closest approach for producing the desired umbrella-type flame are retained.

Referring more specifically to the burner operation, the primary combustion mechanism in the present invention, while somewhat similar to that described in the Moen and Shepherd patent above, wherein holding flames for stabilizing the main combustion chamber flames are established in a low velocity region near the discharge side of the burner plate, actually differs materially therefrom by establishing primary combustion for the stabilizing flames in a chamber-centered region a material distance from the burner plate. This is achieved by feeding the comparatively small primary supply of fuel gas from the burner ports 24a, 24b, etc., directly into the converging oxygen streams entering the region of closest approach, FIGS. 2 and 6. As the oxygen and primary fuel streams gradually converge, the respective streams mix and provide as schematically indicated at 25 low velocity holding flames.

This introduction of a comparatively small amount of fuel into the oxygen streams at the plane of closest approach, produces a transversely extending region for the primary and stabilizing combustion. This region is in a gas mixture zone of relatively low velocity, extending to the enveloping fuel streams F_s . Secondary combustion is therefore effectively stabilized by direct communication with the primary combustion zone. The size and spread of this zone, referring to FIG. 5, is readily controlled in the design, according to the convergence and skewing angles of the oxygen port axes. As the diverging oxygen streams from the region of closest approach continue to diverge toward the chamber exhaust and mix with the enveloping main supply of secondary fuel gas from the ports 28, combustion of the mixed gases is ensured by the primary combustion or holding flames at the region of closest approach as indicated in FIG. 6.

The secondary combustion region, i.e., where combustion of the spreading mixed oxygen and fuel gases is completed, extends beyond the chamber exhaust as indicated and is determined generally by the velocity and divergence of the oxygen streams with respect to the chamber exhaust and the amount of fuel gas from the ports 28. It will be seen from FIG. 6 that the main or secondary fuel supply envelope from the ports 28 is traversed by and mixed with the stronger high velocity diverging oxygen streams 0-1 and 0-4, etc., with consequent spreading or mushrooming of the mixed burning gases beyond the chamber exhaust. Accordingly, a secondary combustion or flame region having the desired wide-spreading umbrella type pattern is established.

The degree of flame spread for a given burner plate adjustment can of course be further varied by empirical adjustment of the supply pressures for the oxygen and fuel gas streams. Variation of the oxygen-fuel ratio affects flame spread to the extent that a ratio giving an optimum fuel supply for producing combustible mixtures for the main combustion flame system, results in a larger secondary combustion region. Although the term "oxygen" as used herein generally refers to the preferred use of commercially pure oxygen, it is also intended to include oxygen enriched gases in applications where the higher combustion temperatures obtainable by pure oxygen are not required.

Where the burner plate and plane of closest approach are located as illustrated in FIG. 7, so that the projected diverging axes 26' of the oxygen stream cores intersect the combustion chamber wall, as distinguished from FIG. 6 wherein divergence of the axes beyond the plane of closest approach is not restricted by the chamber wall, mixing and initial secondary combustion of the enveloping fuel streams F_s and the oxygen streams 0-1 and 0-4, etc., are confined to a greater extent within the now elongated combustion chamber 16. That is, as the chamber wall is now effective to deflect the oxygen streams generally along and into the enveloping fuel stream, mixing of the oxygen and secondary fuel tends to take place mainly within the combustion chamber. The momentum of the oxygen streams, combined with the chamber pressure incident to secondary combustion, produces a stiff, sharp and elongated flame at the combustion chamber exhaust. It is believed that this effect is due in part to the energy of the deflected oxygen cores, that tend to

reconverge, somewhat as a tapering cone, on the chamber axis. Secondary fuel is during this process mixed with the oxygen and carried along toward the central axis of the chamber, where secondary combustion continues as the mixed gases and combustion flames are discharged at high velocity from the burner exhaust to form a long, needle-type flame.

FIG. 8 illustrates an intermediate adjustment of the burner plate for obtaining a flame pattern that represents a moderately bushy flame, materially longer than the umbrella type flame of FIG. 6. In this flame pattern adjustment the projected longitudinal axes 26' of the oxygen stream cores barely clear the chamber exhaust so that part of the oxygen stream is deflected inwardly by the chamber wall. Accordingly, but part of the oxygen stream energy is available to spread the mixed gases and flame in divergent directions at the exhaust so that a modified bushy flame of moderate length is produced. It will be apparent from the descriptions of FIGS. 6-8, that a wide range of graduated flame pattern control can be achieved by corresponding adjustment of the burner plate (and plane of closest approach) with respect to the chamber exhaust.

Summarizing briefly, it will be seen that the invention avoids certain prior art difficulties by the use of aerodynamic flame-holding for establishing an oxygen-fuel mixing region remote from any part of the burner plate, thereby isolating the movable burner plate from any contact with flame or combustible oxygen-fuel mixtures.

In practice, the rocket burner of the invention is flexible in scope of operation; all gaseous, atomizable or vaporizable fuels can be burned at high efficiency without major design changes, and optimum conditions for a given fuel can be obtained by adjustment of design parameters. Basic variable factors of the burner include the burner BTU output that is determined by the amounts of oxygen and fuel supplied, the angle of exhaust flame divergence determined by the position of the burner plate (and the diverging and skewing angles of the oxygen stream cores), and the "turn-down ratio." The latter is defined in terms of the full range of burner operation for a stable flame situation. This can be quantitatively expressed as a ratio

$$\frac{\text{B.t.u. hr. (max.)}}{\text{B.t.u. hr. (min.)}}$$

Conventional commercial burners have in general a narrow range within which stable flame operation can be obtained, whereas rocket burners of the present invention may have, for example, a turn-down ratio of about 1,000:1, that is determined by the burner dimensions, principally the diameters of the respective oxygen and fuel ports, and the angular relation of the port axes to the chamber axis.

Practical advantages of the invention also include improved flame stability by reason of the low velocity, centered primary combustion region, improved turn-down ratio, simplicity of design wherein a flame stabilizing bluff body or the like, in the flame is not needed, and greatly improved safety with practical elimination of preignition and explosion hazard.

Having set forth the invention in what is considered to be the best embodiment thereof, it will be understood that changes may be made in the system and

apparatus as above set forth without departing from the spirit of the invention or exceeding the scope thereof as defined in the following claims.

I claim:

1. An oxygen-fuel burner of the rocket-burner type 5
having a combustion chamber wherein a plurality of oxygen and fuel streams are fed into one end of the chamber and the opposite end is open for combustion flame discharge, comprising:
 - a. means for directing separate streams of fuel into 10
the chamber and toward the discharge end,
 - b. means for directing separate streams of oxygen into the chamber for converging flow, the respective projected axes of the oxygen streams being in off-set, non-intersecting relation to the longitudinal axis of the chamber, 15
 - c. means for directing a comparatively small amount of the fuel flow into the converging oxygen flow for establishing a primary stabilizing combustion region, 20
 - d. the diverging oxygen flow beyond the primary combustion region traversing and mixing with the main amount of the fuel flow for establishing a secondary combustion region,
 - e. and means for varying the traversing location of 25
the oxygen and fuel with respect to the discharge end of the combustion chamber for controlling the discharge pattern of the secondary combustion flames.
2. An oxygen-fuel burner as specified in claim 1 30
wherein the oxygen and fuel stream directing means consists of a burner plate having a plurality of ports for the respective streams, and control means produce relative movement between the burner plate and combustion chamber along the longitudinal axis of the chamber for varying the traversing location of the oxygen and fuel. 35
3. An oxygen-fuel burner as specified in claim 2
wherein the oxygen ports are radially spaced from the center of the burner plate, and the projected longitudinal axes thereof are inclined in generally converging, non-intersecting relation to the longitudinal axis of the chamber. 40
4. An oxygen-fuel burner as specified in claim 2
wherein ports for the main fuel flow are located along the peripheral portion of the burner plate, and ports for the primary fuel are located centrally of the burner plate in general alignment with the primary combustion region. 45
5. An oxygen-fuel burner as specified in claim 4 50
wherein the projected longitudinal axes of the fuel ports are generally parallel to the longitudinal axis of the chamber.
6. An oxygen-fuel burner as specified in claim 3 55
wherein the projected longitudinal axes of the oxygen ports at the respective points closest to the chamber axis define a transverse plane determining the location of the primary gas mixing zone.
7. An oxygen-fuel burner as specified in claim 2
wherein the main fuel streams form a secondary fuel envelope within the combustion chamber in surrounding relation to the oxygen and primary fuel streams. 60
8. An oxygen-fuel burner as specified in claim 7
wherein the projected axes of the oxygen ports diverge

beyond the primary combustion region toward the side wall of the combustion chamber for traversing and mixing with the enveloping fuel flow.

9. An oxygen-fuel burner as specified in claim 8 having an adjusted position of the burner plate representing divergence of the oxygen port axes beyond the discharge end of the chamber, wherein a radially expanding flame region is formed for producing short, spreading flames in a generally mushrooming pattern.

10. An oxygen-fuel burner as specified in claim 8 having an adjusted position of the burner plate representing intersection of the diverging axes with the chamber side wall in a comparatively long combustion chamber, wherein confined mixing and interaction of the oxygen and fuel streams produce an elongated, needle-type flame discharge from the combustion chamber.

11. An oxygen-fuel burner of the rocket-burner type having a combustion chamber wherein a plurality of oxygen and fuel streams are fed into one end of the chamber and the opposite end is open for combustion flame discharge, comprising:

- a. means for directing separate streams of oxygen into the chamber for converging flow, the respective projected axes of the oxygen streams being in off-set, non-intersecting relation to the longitudinal axis of the chamber,
- b. means for directing a portion of the fuel flow into the converging oxygen flow for establishing a primary stabilizing combustion region remote from the feed end of the chamber,
- c. and means for directing the main portion fuel flow along the chamber wall so as to envelop the oxygen streams and primary combustion region,
- d. the diverging oxygen streams beyond the primary combustion region traversing and mixing with the fuel envelope for establishing a secondary combustion region.

12. An oxygen-fuel burner comprising housing means having a discharge end for projecting an oxygen-fuel flame, a burner element in said housing means, said element including a plurality of fuel gas ports for projecting a plurality of streams of fuel gas from said element, said element further including a plurality of oxygen ports for projecting separate streams of oxygen for converging flow about a longitudinal axis, the respective projected axes of the said oxygen ports being in off-set, non-intersecting relation with respect to the longitudinal axis, certain of the fuel gas ports being positioned centrally with respect to the oxygen ports for establishing with said oxygen streams a primary stabilizing combustion region, other of said fuel gas ports being positioned to form a fuel gas envelope surrounding the oxygen streams.

13. A burner as set forth in claim 12 further including means to adjust the position of said burner element relative to the discharge end of the burner.

14. A burner as set forth in claim 12 wherein the longitudinal axis of each certain fuel gas port intersects with the projected axis of a respective oxygen port for insuring mixing of the respective streams.

15. A burner as set forth in claim 12 wherein the oxygen ports form a vortex about said longitudinal axis.

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