

March 16, 1954

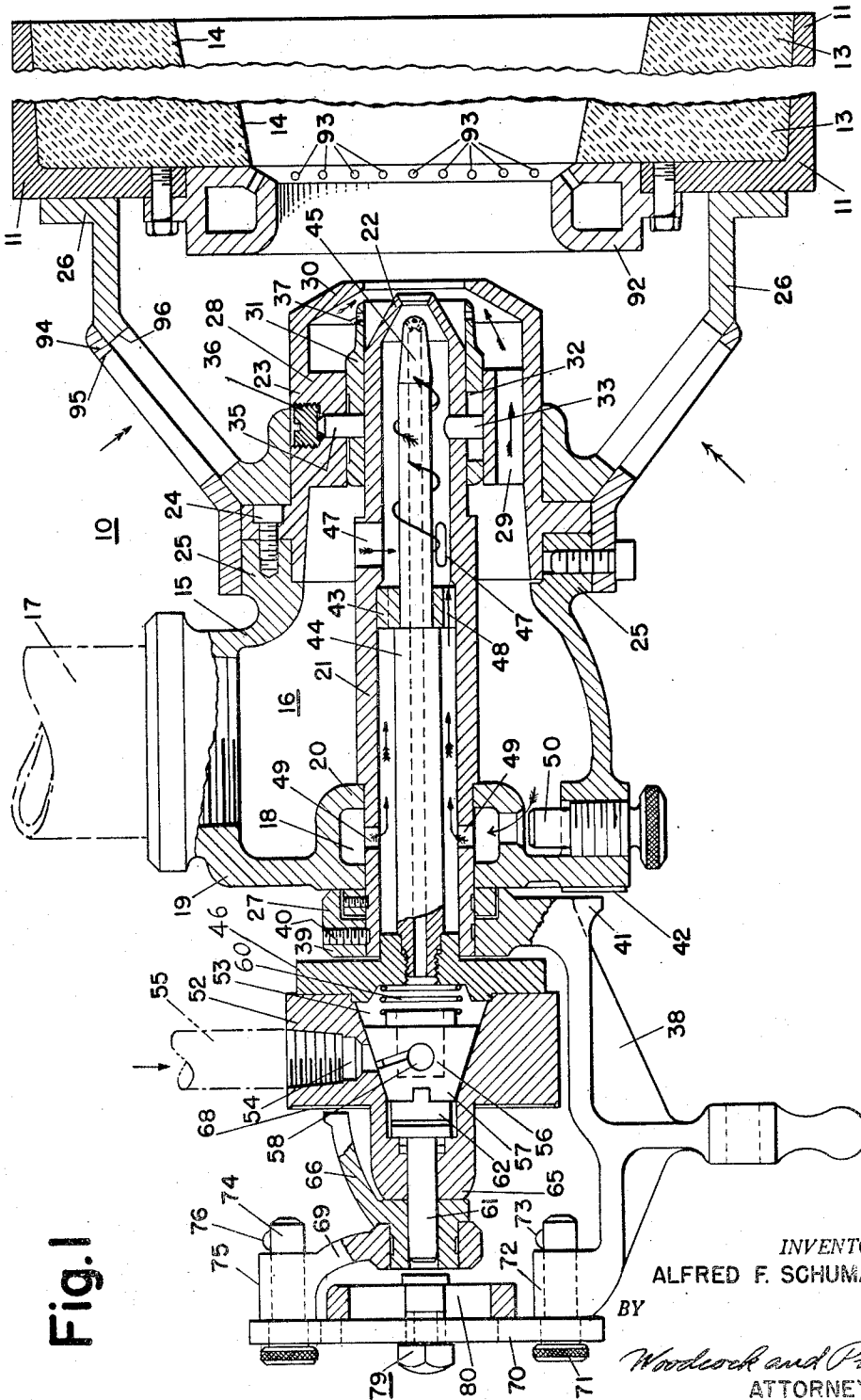
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2,672,190

MIXING VALVE FOR SPRAY TYPE OIL BURNERS

Filed Aug. 12, 1949

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MIXING VALVE FOR SPRAY TYPE OIL BURNERS

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Fig. 2

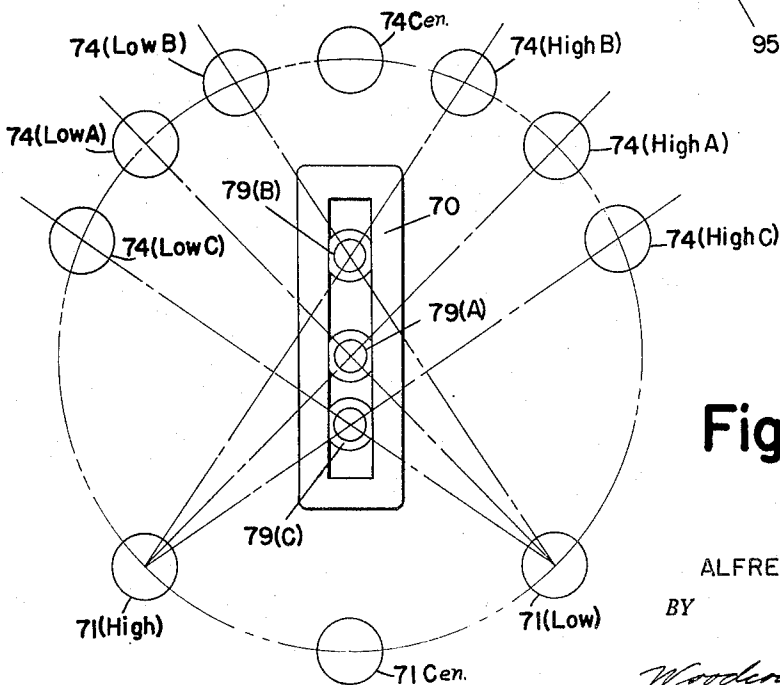
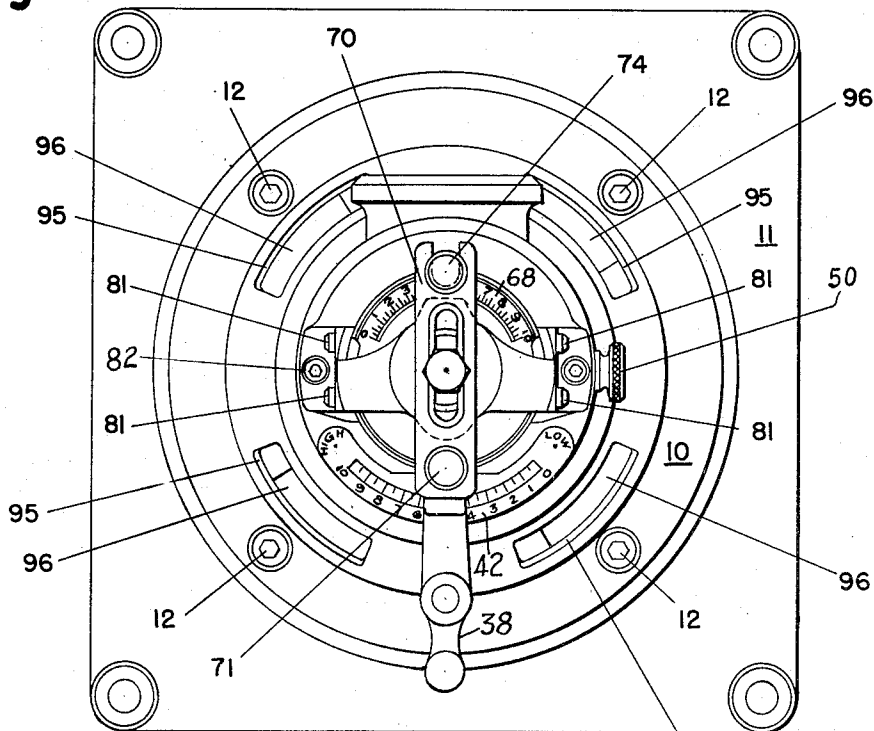


Fig. 9

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Fig.6

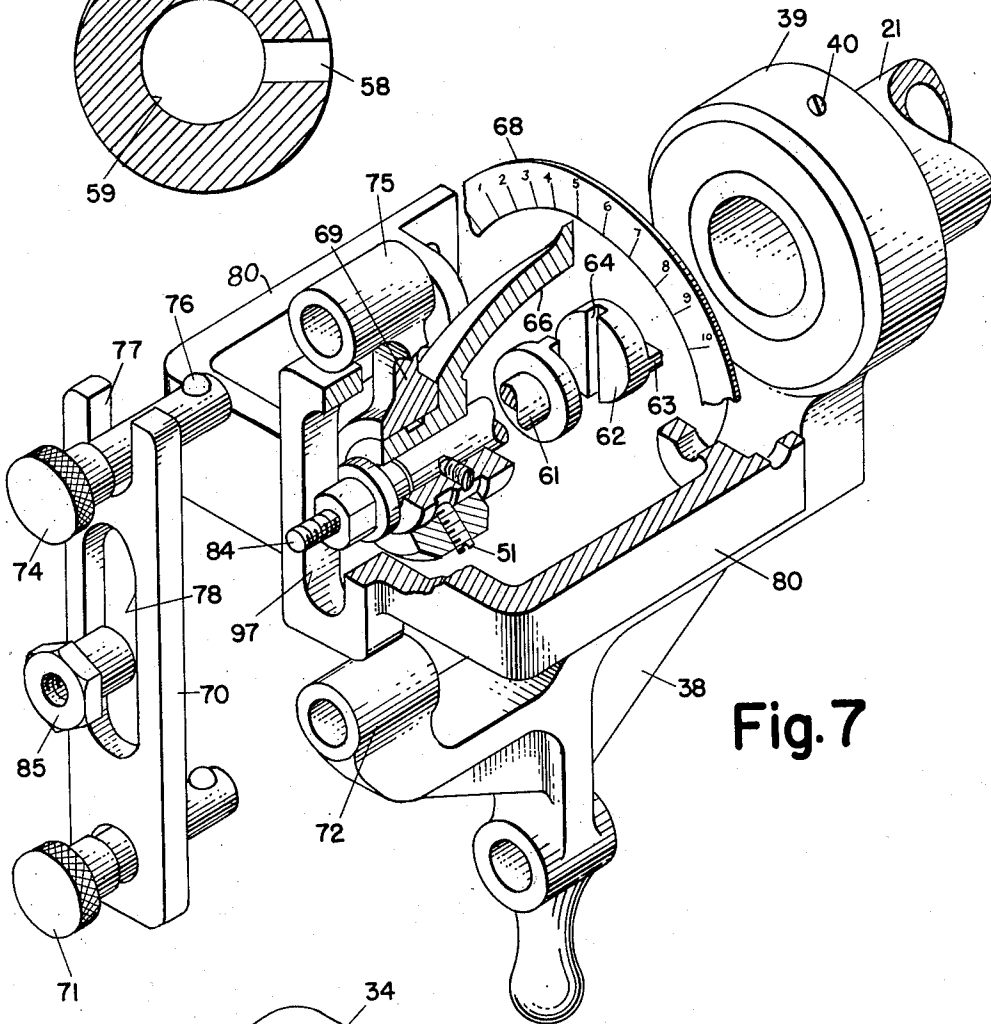
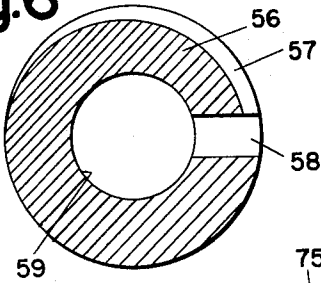
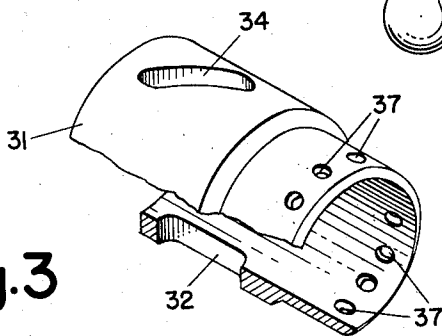


Fig.7

Fig.3



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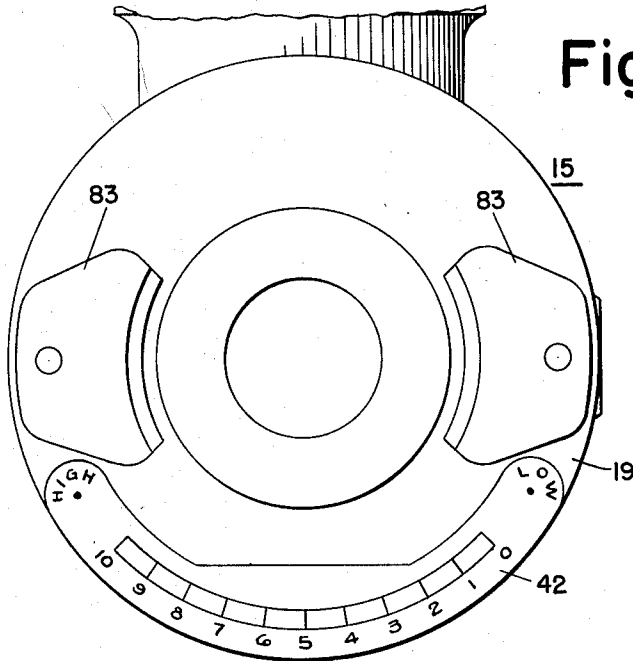


Fig. 5

Fig. 4

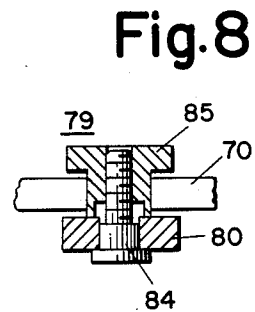
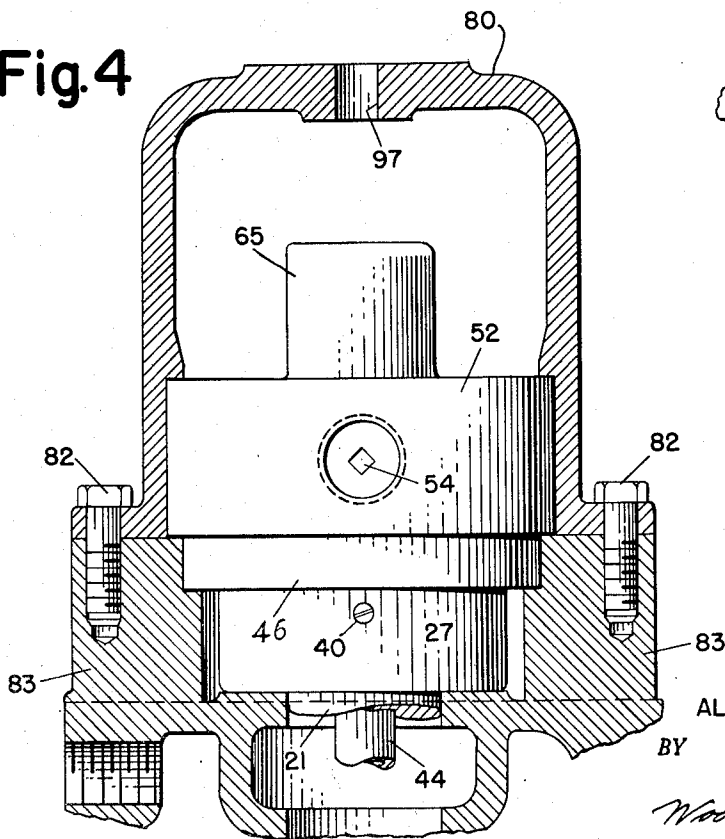


Fig. 8

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MIXING VALVE FOR SPRAY TYPE OIL BURNERS

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Fig.12

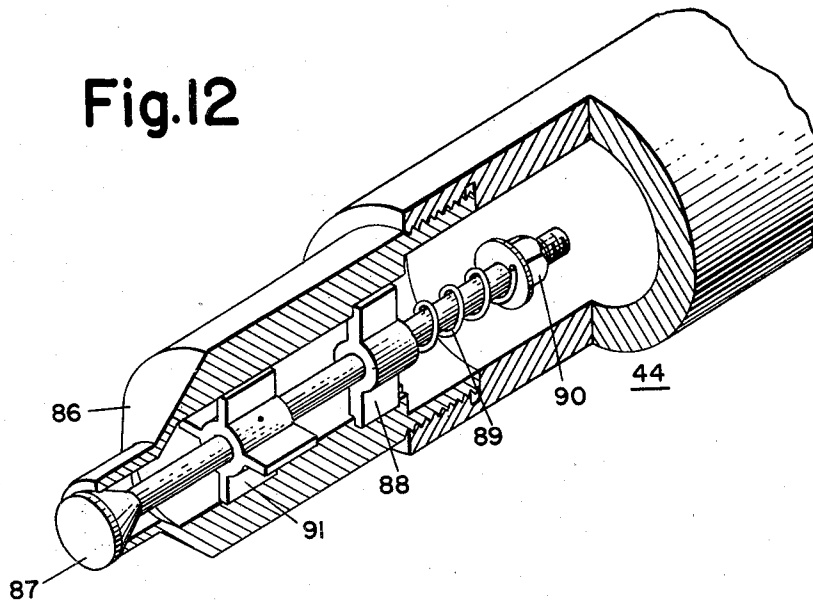


Fig.11

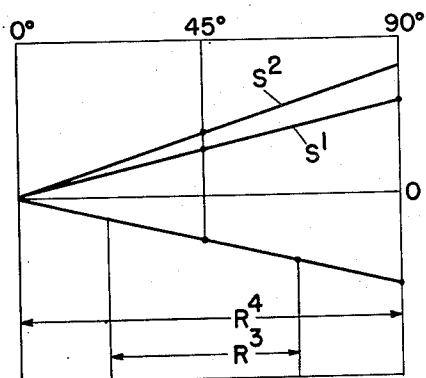
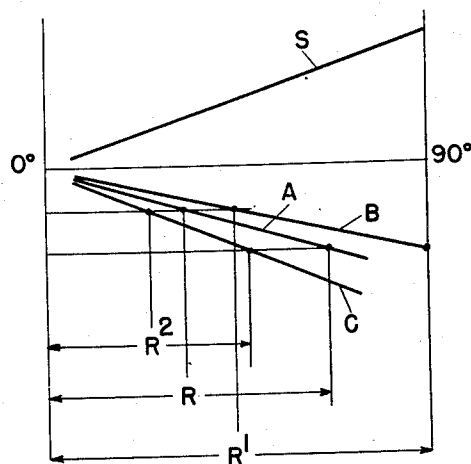


Fig.10



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UNITED STATES PATENT OFFICE

2,672,190

MIXING VALVE FOR SPRAY TYPE OIL
BURNERS

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Application August 12, 1949, Serial No. 109,983

14 Claims. (Cl. 158—76)

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This invention relates to mixing valves and particularly to burners in which the components of a combustible mixture, for example air and oil, are intimately mixed for discharge into a burner tile.

In the conventional types of burners, the inner or outer air nozzle is moved to vary the amount of secondary air with the disadvantages that the shape of the burner flame is undesirably changed, that the control of the secondary air is inaccurate and that the efficiency of the induction of ambient air through the burner tile opening is impaired.

In accordance with one aspect of the present invention, the spacing of the discharge tips of the nozzles with respect to each other and to the burner tile opening remains fixed and the amount of secondary air is adjusted by varying the area of the discharge orifice of the outer nozzle: specifically, this change in area is effected by adjustment of a sleeve along the inner nozzle toward and from the discharge end of the outer nozzle. With such arrangement, the secondary air may be accurately varied over a wide range with but insubstantial effect upon the shape of the flame or upon the air induction efficiency of the nozzle-tile combination. More specifically, the inner air nozzle is rotatable and is so coupled to the slidable sleeve that there is provided a linear relationship between the angular positions of the inner nozzle and the amount of air discharged by the outer nozzle per unit of time at a given pressure.

In accordance with another aspect of the invention the supply of liquid to a fuel nozzle within the inner air nozzle is controlled by rotatable valve member having a peripheral groove of rectangular cross section and of progressively increasing depth to provide a linear relationship between the angular position of the fuel valve member and the amount of liquid discharged from the fuel nozzle per unit of time at a given pressure.

Further in accordance with the invention, the relationship between the linear and angular velocities of primary air moving helically within the inner air nozzle toward the discharge tip of the fuel nozzle may be varied to change the angle of the cone of the fuel-air mixture discharged from the burner.

The invention further resides in features of construction, combination and arrangement hereinafter described and claimed.

For a more detailed understanding of the invention and for illustration of a preferred em-

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bodiment thereof reference is made to the accompanying drawings in which:

Fig. 1 is a sectional view, in side elevation, of a burner mounted for use;

Fig. 2 is a front elevational view, on reduced scale, of the burner-tile arrangement shown in Fig. 1;

Fig. 3 is a perspective view, on enlarged scale and in part broken away, of a nozzle-sleeve shown in Fig. 1;

Fig. 4 is a plan view of parts appearing in Figs. 1 and 2;

Fig. 5 is a front elevation view of a valve housing shown in Figs. 1, 2 and 4;

Fig. 6 is a cross-sectional view, on enlarged scale, of a fuel-control valve shown in Fig. 1;

Fig. 7 is an exploded view, in perspective, of the actuating arms and interconnecting linkage for air and fuel control members shown in Fig. 1;

Fig. 8 is a detail view, in section, of an adjustable fulcrum device shown in Figs. 1, 2 and 7;

Figs. 9, 10 and 11 are the explanatory figures referred to in discussion of adjustment of link mechanism shown in Figs. 1, 2 and 7; and

Fig. 12 is a perspective view, partly in section, of a preferred form of fuel-nozzle tip.

Referring to Figs. 1 and 2, the burner assembly 16 is shown attached to the front face of a burner-tile plate 11, as by bolts 12. The burner tile 13, of suitable refractory material, extends from the rear face of tile plate 11 and has an opening 14 diverging from the tile plate 11 to form an ignition or combustion chamber.

The housing member 15 of burner 10 is provided with a main chamber 16 which receives air at constant pressure from an air supply line 17 and is also provided with an auxiliary air chamber 18 in part defined by the front wall 19 of housing 15 and by an internal wall 20. The inner air nozzle 21 is rotatably received by aligned openings in the walls 19 and 20 of housing 15 and extends through the main air chamber 16 with its discharge tip 22 within the outer air nozzle 23.

The outer air nozzle 23 extends from the rear wall 25 of housing 15 and is attached thereto as by bolts 24. The housing member 15 is mounted upon the front end of a conical bracket or housing 26 attached to the front face of the tile plate 11. As the outer nozzle 23 is attached to the burner housing 15 which in turn is attached by bracket 26 to the tile plate 11, the spacing between the tip of the outer air nozzle and the throat of tile opening 14 is fixed or invariable.

The distance from the discharge end of the inner nozzle to the discharge end of the outer nozzle and to the throat of the tile opening 14 is also invariable: specifically, collar 27 secured to the inner nozzle 21 bears against the outer face of the front wall 19 of the valve housing 15 and a shoulder of the inner nozzle bears against the rear face of the internal wall 20 thus to preclude any axial or longitudinal movement of inner nozzle 21.

The forward part of the inner nozzle 21 passes through a spider bearing member 28 within the outer air nozzle 23 at suitable distance from the discharge tip 30 thereof. Air from the main chamber 16 flows through the passages 29 provided in the spider 28 to the space between the discharge tips 22 and 30 of the inner and outer air nozzles. The effective cross sectional area of the discharge orifice at the end of the air passage between the tips is variable by a sleeve 31 (Figs. 1 and 3) slidable along the inner nozzle 21 and within the spider bearing 28. As shown more clearly in Fig. 3 the sleeve 31 is provided with a longitudinally extending slot 32 which receives a pin 33 (Fig. 1) extending from the inner nozzle 21. The sleeve 31 is also provided with an angularly extending slot 34, Fig. 3, which receives pin 35 (Fig. 1) projecting from the spider 28 and retained therein by a plug 36 or equivalent.

Thus as the inner nozzle 21 is rotated in one direction or the other, the sleeve 31 is moved axially along the nozzle 21 to vary the width of the annular air passage terminating at the aforesaid discharge orifice formed by the stationary tips 22, 30 of the inner and outer nozzles. The angle of the slot 34 is so chosen, in the particular valve illustrated, that 90° rotation of the inner nozzle 21 corresponds with full travel of the sleeve 31. Furthermore with the arrangement shown, the relationship between the angular position of air nozzle 21 and the amount of air discharged by the outer air nozzle is substantially linear. As previously stated, the air in chamber 16 is at constant pressure and the pressure drop across the discharge orifice for the secondary air is substantially constant and low throughout the entire range of adjustments of sleeve 31; otherwise stated, throughout the range of burner adjustment the fuel-air pressure is maintained at the tip of the burner for efficient atomization of the fuel oil. Preferably, the forward end of sleeve 31 is provided with a peripheral series of small ports 37, Fig. 3, which preserve this linearity at low through-puts of air and insure intimate mixture of the secondary air with the fuel-air mixture issuing from the discharge tip 22 of the inner air nozzle. At very low burner settings, the air through ports 37 is more effective to prevent undue spread of the flame than the air passed by the narrow orifice between the end of the sleeve and tip 30.

As the aforesaid adjustment of secondary air is obtained without changing the positions of tips 22 and 30 of the air nozzles with respect to the throat of the tile opening 14, the efficiency of the induction of atmospheric air by the jet action of the burner discharge is not impaired by control of the secondary air to obtain different combustion rates.

To permit adjustment of sleeve 31 to its various positions, there is provided an air control lever 38 (Figs. 1, 2 and 7) having a hub 39 (Fig. 1) which receives the external end of inner nozzle 21 and is attached thereto as by set screw 40. 75

The index member 41 attached to or integral with arm 38 cooperates with an "Air" scale 42 (Figs. 1, 2, 5) attached to the front face 19 of the valve housing 15. The scale 42 is linear and may be calibrated in arbitrary numerical units or may, for a particular installation using a predetermined fixed air pressure, be calibrated in units of weight of air per minute, the burner shown being of low pressure type using for example a supply source pressure of from 8 ounces to 32 ounces for atomizing.

Within and intermediate the ends of the inner air nozzle 21, there is provided a ported bearing or spider 43 (Fig. 1) which supports a fuel nozzle 44 having its discharge end or tip 45 within the discharge tip 22 of the inner air nozzle for atomization of the oil by the primary air. The opposite end of the fuel nozzle 44 is attached to and received by a stationary member 46 which is part of the fuel valve housing later described. The inner air nozzle 21, intermediate the spider 43 and discharge tip 22, is provided with tangential ports 47 for admission of primary air from the main air chamber 16. The air passing through these ports advances axially of the inner air nozzle in a helical path for intimate admixture with or atomization of the liquid fuel issuing as spray from the discharge tip of the fuel nozzle. The preferred form of fuel nozzle tip is shown in detail in Fig. 12 and is later herein specifically described. Because of the aforesaid rotation of the primary air, the fuel-air mixture discharged from the burner is in the form of a cone, the pitch of the cone depending upon the relation between the linear and angular velocities of the primary air within the inner air nozzle. To control the angle of this cone, and therefore to control the length and shape of the burner flame, there is provided an arrangement for controlling additional primary air flowing longitudinally within the inner air nozzle through the ports 43 of the bearing spider 43. As the positions of the fuel nozzle and air nozzles remain fixed with respect to each other for all settings of the burner, the shape of the flame as effected by adjustment of valve 50 is not appreciably affected by the changing of the secondary air adjustment.

Specifically, and in the particular arrangement shown, the inner nozzle 21 is provided with a second, circular series of ports 49 (Fig. 1) which provide for communication with the auxiliary air chamber 18. With valve 50 (Fig. 1) closed, there is no passage of air from the main chamber 16 through the auxiliary chamber 18 to the inner air nozzle and consequently the ratio of angular to linear velocity of the primary air is high resulting in a flame which is short and broad. As valve 50 is progressively opened, more and more air passes through the auxiliary chamber 18 and ports 49 to increase the amount of air moving linearly or longitudinally of the nozzle through ports 48; consequently the pitch of the primary air spiral is increased with consequent lengthening and narrowing of the flame. (For purposes of illustration, the control knob of valve 50 is shown in Fig. 1 as displaced 90° from the preferred actual position shown in Fig. 2.)

The valve for controlling admission of fuel to nozzle 44 includes a housing member 52 having a conical chamber 53 (Fig. 1) in communication through inlet port 54 with the fuel line 55 which supplies the liquid fuel at constant pressure to the burner. The recess 53 receives a conical valve

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member 56 having a peripheral groove 57 of rectangular cross-section which, as shown in Fig. 6, progressively increases in depth from the periphery of member 56 and terminates in a radial passage 58 of substantially larger cross-sectional area. The passage 58 extends to the bore 59 of the valve member and so provides for passage of fluid from the supply line 55 to the axial bore of the fuel nozzle 44 in amount dependent upon the angular setting of valve member 56. For reasons which later appear, the arcuate length of groove 57 is substantially in excess of 90° and in initial machining of valve member 56 may approximate 180°.

As the passage 57 is of rectangular cross section, the relationship between the angular position of valve member 56 and the amount of liquid passed by the valve is linear. A further advantage of the rectangular, peripheral groove is that this linear relationship is true of valve members so constructed even though in machining or honing of them to final dimensions there are inevitable slight differences in the arcuate length of rectangular groove 57. Also to accommodate slight inevitable differences in machining of the valves and seats, the width of port 54 axially of member 56 is made somewhat greater than the width of groove 57. Furthermore, as shown in Fig. 1, the valve member 56 is free or floating to insure it is always properly seated. Specifically, valve member 56 is biased into seating engagement by spring 60 and is connected to the valve stem 61 through a floating coupling 62 which insures angular correspondence between the positions of valve stem and valve member while permitting relative axial movement. The floating coupling member 62 (Figs. 1 and 7) may be of a type having a ridge 63 received by a groove in the forward face of valve 56 and having a groove 64 in its opposite face to receive the projecting end of a coupling member attached to or formed at the rear end of the valve stem 61. To the forward end of stem 61 which projects through the boss 65 of valve housing 52 is attached, as by set screw 67, a pointer or index 66. The "Fuel" scale 68 for cooperating with index 66 may be attached to or inscribed upon the front wall of the valve housing 52. The arm 69 for actuating the valve member 56 may be securely fastened as by a set-screw 67a to the valve stem 61 or to the hub of the index member 66.

As thus far described, the sleeve 31 may be adjusted by arm 38 to effect linear control of the area of the air orifice and the arm 69 may be actuated to effect linear control of the area of the fuel orifice. There is now described a proportioning coupling or linkage which provides for concurrent actuation of these two arms with proper proportionality of their individual adjustments as required to maintain a fuel-air ratio corresponding with a neutral, a reducing or an oxidizing flame: such proportioning linkage is not herein claimed, but is claimed in copending application Serial No. 269,739, filed February 4, 1952. As best shown in Figs. 1 and 7, the two arms 38 and 69 for respectively adjusting the air and fuel are coupled by a link 70 which, in the preferred arrangement shown, is pivotally connected to arm 38 by a pin 71 which extends through the boss 72 of arm 38. A similar pivot pin 74 which extends through boss 75 of arm 69 is slidably received by a slot 77 at the opposite end of link 70. The link 70 is also provided with a central slot 78 extending longitudinally thereof to receive a fulcrum device 79 adjust-

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able to vary the ratio between concurrent movements of arms 38 and 69. The fixed bracket member 80 (Figs. 1, 4 and 7) to which the fulcrum is adjustably secured is attached by screws 81 (Fig. 2) to the housing member 52 and this sub-assembly is in turn secured, as by screws 82, to the main housing member 15 of the burner. The projections 83 (Figs. 4 and 5) extending from the front wall 19 of housing 15 are stepped to center the elements 46 and 52 of the fuel valve housing with respect to the common axis of rotation of the fuel valve and the inner air nozzle.

As most clearly shown in Figs. 7 and 8 the fulcrum device 79 for link 70 comprises a special bolt 84 and nut 85. The shank of the bolt 84 is slidably received by the slot 97 in the stationary bracket 80 and the shank portion of nut 85 is snugly slidably received by central slot 78 of the link 70. The length of the shank of nut 85 is somewhat greater than the thickness of link 70 so that when nut 85 is tightened the nut and bolt assembly is firmly clamped to the bracket 80 with the link 70 free to pivot about the fulcrum.

Assuming the fulcrum is secured to bracket 80 in position "A," Fig. 9, in alignment with the axis of rotation of arms 38 and 69, the ratio between the angular movements of the fuel and air controls is 1 to 1. More specifically, as the air-control arm 38 is moved from "Low" to "High" the pivot pin 71 moves from right to left through an angle of 90° and pivot pin 74 of the fuel-control arm 69 is moved from left to right through an angle of 90° from position "Low A" to position "High A". Assuming that for any of various reasons, including those later discussed, it is desired to obtain a higher or lower ratio, it is only necessary to loosen nut 85 of the fulcrum, shift it to the new position and then tighten it. Assuming, for example, the fulcrum 79 is moved to position 79B, Fig. 9, movement of air lever 38 through an angle of 90° from "Low" to "High" effects adjustment of the fuel valve 56 through an angle of only 45° from the position "Low B" to "High B." Thus for each one degree movement of the fuel-control arm 69 there is a two degree movement of the air-control arm 38. Conversely, if it is desired to increase the fuel-air ratio, the fulcrum 79 is moved to the other side of the axis of rotation of the arms 38 and 69 to, for example, the position 79C for which the adjustment of the air-control lever from "Low" to "High" through an angle of 90° effects adjustment of the fuel valve member 56, over a substantially larger angle, for example 120°. For this fulcrum setting, for each 1° movement of the air-control arm 38 there is a 1½° movement of the fuel control arm 69 as indicated by the position 74 "Low C" and 74 "High C".

Referring to Fig. 10 by way of supplemental explanation, the relationship between the amount of secondary air and the position of the air-control arm 38, for any given fixed supply pressure, is represented by straight line S. It will also be assumed, for a particular fuel the fuel valve should be concurrently adjusted over a range "R" of 90°. In such event, the fulcrum pin 79 is secured to the bracket 80 in alignment with the common axes of rotation of the inner air nozzle 21 and the fuel valve 56. With the fulcrum so adjusted, a 1° movement of the air-control lever 38 corresponds with a 1° movement of the fuel-control lever 69; this relationship exists throughout the entire range of adjustment of the control lever attached to arm 38.

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If a fuel having less B. t. u.'s per unit volume is used, the proper relation between the range of adjustment R' of the fuel valve and the amount of fuel passed by it may correspond with curve B (Fig. 10): It is apparent that a much wider range of adjustment of the fuel valve is required for the same range of adjustment of the air valve. In such case, the fulcrum 79 is moved below the axis of rotation of the arms (Fig. 9) to position 79C affording the increased range of adjustment of the fuel valve and maintaining the proper ratio between the concurrent adjustments of the fuel and air levers. Conversely, if a richer fuel is used the range of adjustment R₂ (Fig. 10) of the fuel valve is contracted by shifting the fulcrum point of lever 70 to a position above the axis of rotation of the arms 38 and 69.

When both the link 70 and the bracket 80 are slotted, the range of adjustment of fulcrum 79 is continuous and not limited to the three settings specifically illustrated and discussed by way of example.

The position of fulcrum 79 may be shifted to adapt a given valve installation for use with different air source pressures. Assume for example, that the air pressure is such that the secondary air varies with change in position of arm 38 as indicated as curve S₁ of Fig. 11, and that complete combustion is obtained from minimum to maximum burner settings when the fuel valve is adjusted through an angle of 90° through a range R₃. If now the air pressure is increased so that the secondary air curve becomes S₂, the fulcrum point 79 should be relocated to effect adjustment of the fuel valve over the extended range R₄, of say, about 120° for 90° movement of the air-control arm 38.

Thus the provision of the adjustable fulcrum permits a valve of given size and construction to be used with different fuels, with different available air supplies and to obtain a flame which to any desired extent is oxidizing, reducing or neutral. This feature is also of advantage when several ganged valves of a furnace require different proportional movements of the air and oil control elements to obtain flames of similar characteristic (neutral, reducing or oxidizing). For all of fuel ranges obtainable by shifting of fulcrum 79, the mid-range setting of fuel arm 69 is the same. To change the setting of the valve 56 which corresponds with the mid-setting of arm 69, the set-screw 51, Fig. 7, is loosened, pointer 66 attached to the valve stem is moved to the new position and the set-screw 51 retightened.

The fuel nozzle 44 (Fig. 12), instead of having the usual tip with a plurality of tiny orifices which readily clog has an annular discharge orifice between a spring-biased valve 87 and its seat formed by the end of the nozzle tip of sleeve 86. The stem of the valve 87 passes through a spider bearing 88 within the sleeve 86 and, beyond the bearing, extends through the biasing spring 89 which is compressed between the bearing 88 and the retaining nut 90 on the valve stem. Preferably, the valve stem is centered within the sleeve 86 by the slidable spider 91. In normal operation of the burner, the liquid passed by the control valve groove 57 issues as a fine cone of spray about the tip of the valve 87 which yields to the pressure of the liquid within the nozzle and maintains a constant pressure drop across the fuel valve measuring orifice 57; such configuration of the discharge is maintained even at low valve settings so affording effective atomization.

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This is in contrast with the operation of tips having tiny fixed orifices: at low pressures, most of the oil drips out of the lowermost orifices. The improved type of tip has the further advantage that the fuel line may be cleared of sludge without removal of the fuel valve or the nozzle from the burner; to clear the fuel line the fuel valve 56 is turned to bring the large radial passage 58 into alignment with the correspondingly large inlet port 54. Any sludge or solid matter in the line passes freely through the valve into the fuel nozzle where however instead of clogging the ports as heretofore, it forces the valve 87 to yield to substantially greater extent than normally, the resulting wide annular orifices freely passing the extraneous undesired accumulation of sludge, dirt or other foreign matter.

The gas burner ring 92 (Fig. 1) attached to the tile plate 11 need not be used when the furnace is fired exclusively from the burner 10; if provided for alternative use of gas or liquid fuel it serves as the throat of the tile opening when the furnace is oil fired. As indicated, the space between the discharge tip of the outer nozzle and ring 92 defines an orifice through which atmospheric air is drawn by jet action of the discharge from the burner nozzle through the ring 92. As previously herein stated, with the burner arrangement shown the secondary air adjustment is effected without disturbance of the shape or dimensions of the orifice through which atmospheric air is induced into the burner tile. The amount of air induced may be controlled to suit various sub-atmospheric furnace pressures by varying the alignment between the arcuate slots 95 in the damper-disc 94 and the arcuate slots 96 in the burner bracket support 23.

It shall be understood that all features of the invention, though jointly and individually of particular advantage in burner construction, are not limited thereto: for example, the link arrangement between the fuel and air control arms may to advantage be used in other types of mixing valves or proportioning devices and the fuel valve with its peripheral rectangular groove may be used for accurate linear regulation of the flow of liquids other than fuel oil.

What is claimed is:

1. A burner comprising inner and outer air nozzles concentrically disposed and having converging tips at their discharge ends which define a secondary air passage converging to an annular orifice whose position is the same for all settings of the burner, said nozzles being fixed in regard to relative linear movement, a fuel nozzle within said inner air nozzle with its discharge end at the same fixed distance from the discharge end of each of said air nozzles for all burner settings, said inner air nozzle discharging an atomized mixture of fuel and primary air through an orifice in substantially the same plane as said annular orifice, and a sleeve slidable on said inner air nozzle toward and from the discharge end of the outer nozzle to vary the effective cross-sectional area of said passage so to vary the secondary air discharged through said annular orifice for fixed positional relation of said fuel nozzle to both of said orifices to minimize change in shape of the flame as the secondary air is varied.

2. A burner comprising an outer air nozzle, an inner air nozzle rotatably mounted within said outer air nozzle, said nozzles having converging tips at their discharge ends which define a secondary air passage converging to an

annular orifice, a fuel nozzle mounted within said inner air nozzle with its discharge end at fixed distance from the discharge end of each of said air nozzles, a sleeve rotatable with and movable longitudinally of said inner nozzle toward and from the discharge end of the outer air nozzle, structure operable externally of the burner to effect rotation of said inner air nozzle, structure precluding longitudinal movement of said inner air nozzle during its rotation to maintain a fixed distance between the discharge ends of said inner and outer air nozzles, and coupling means between said inner nozzle and said sleeve and between said sleeve and fixed structure of said burner to effect longitudinal movement of said sleeve upon rotation of said inner nozzle and so vary the effective cross-sectional area of said passage, the relative position of the discharge ends of all of said nozzles remaining fixed.

3. A burner comprising an outer air nozzle, an inner air nozzle terminating within said outer air nozzle, said outer air nozzle having a tip tapered toward the discharge end of said inner air nozzle and therewith defining a converging air passage, a fuel nozzle terminating within said inner air nozzle, and a sleeve slidable externally of said inner air nozzle toward and from engagement with the discharge end of said outer air nozzle to vary the effective cross-sectional area of said passage, said sleeve having small openings therethrough to insure effective atomization of the fuel discharged from said fuel nozzle when said sleeve closely approaches engagement with the discharge end of said outer air nozzle.

4. A burner comprising an air nozzle, a fuel nozzle within said air nozzle, said air nozzle having tangential inlet ports to impart angular motion to the air moving toward the discharge end of the fuel nozzle and having other inlet ports more remote from its discharge end which are non-tangential for admitting air which has straight-line motion toward said tangential inlet ports, and valve means for controlling the amount of air supplied to said other ports in adjustment of the relationship between the angular and linear velocities of air moving toward the discharge ends of said nozzles.

5. A burner comprising an air chamber, an air nozzle within said chamber and having tangential inlet ports providing for passage of air from said chamber into said nozzle and for imparting angular motion thereto during passage to the discharge end of the nozzle, a fuel nozzle within said air nozzle for discharging fuel into the air moving therein, structure within said air nozzle through which said fuel nozzle extends and having non-tangential ports directing air linearly of said air nozzle toward said tangential ports, and valve means controlling the amount of air passing through said non-tangential ports for varying the relationship between the angular and linear velocities of air moving within said air nozzle toward the discharge ends of said nozzles.

6. A burner comprising an air chamber, an outer air nozzle extending from said chamber, an inner air nozzle extending through said chamber into said outer air nozzle and having tangential ports to impart angular motion to air during passage thereof from said chamber into said inner air nozzle for flow toward the discharge end of said inner nozzle, a fuel nozzle within said inner air nozzle, and valve means more remote than said tangential ports from the

discharge end of the inner nozzle controlling admission of air from said chamber for flow longitudinally of said inner nozzle toward said tangential ports to vary the angle of the cone of discharge of admixed fuel and air from the burner.

7. A burner comprising an air chamber, an outer air nozzle extending from said chamber, an inner air nozzle extending through said chamber into said outer air nozzle and having tangential ports to impart angular motion to air during passage thereof from said chamber into said inner air nozzle for flow toward the discharge end of said inner nozzle, said nozzles having at their discharge ends converging tips which define a converging air passage, a fuel valve within said inner air nozzle, a sleeve movable longitudinally of said inner air nozzle to vary the effective cross-sectional area of said air passage, and valve means controlling admission of auxiliary air from said chamber to said inner nozzle at a region more remote than said tangential ports from the discharge end of said inner nozzle, said auxiliary air having straight-line movement toward said tangential ports to vary the angle of the cone of discharge of admixed fuel and air from the burner.

8. A burner comprising an outer air nozzle having a bearing member disposed therein, an inner nozzle terminating within said outer nozzle and having its discharge end fixedly spaced from the discharge end of said outer nozzle, said nozzles having converging tips at their discharge ends which define an air passage converging to an annular orifice, a sleeve slidable in said bearing member along said inner nozzle to vary the effective cross-sectional area of said passage for said fixed spacing of the discharge ends of said nozzles, and mechanism for adjusting the position of said sleeve along said inner nozzle to vary the discharge of air from said outer nozzle without shifting the position of said orifice.

9. A burner comprising a fixed air chamber, an outer air nozzle extending therefrom, a bearing member disposed therein and having ports for flow of air from said chamber to said outer air nozzle, an inner nozzle extending through said chamber and said bearing member into said outer nozzle with its discharge end fixedly spaced from the discharge end of said outer nozzle, said nozzles having converging tips at their discharge ends which define an air passage converging to an annular orifice, a sleeve slidable through said bearing member along said inner nozzle to vary the effective cross-sectional area of said passage, and mechanism for adjusting the position of said sleeve to vary the amount of air flowing through said ported bearing member from said chamber for discharge by the outer nozzle without shifting the position of said annular orifice.

10. A burner comprising an outer air nozzle, a bearing member disposed therein and having ports for passage of air to the discharge end thereof, a rotatable inner air nozzle extending through said bearing member, having its discharge end at fixed distance from the discharge end of said outer air nozzle and having tangential inlet ports to impart angular velocity to incoming air, a second multi-ported bearing member disposed within said inner air nozzle, said nozzles having converging tips at their discharge ends which define a converging air passage, a fuel nozzle extending through said second bearing member with its discharge end at fixed distance from the discharge ends of said inner

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and outer air nozzles, a sleeve slidable in said first bearing member and rotatable with and movable longitudinally of said inner air nozzle, means for rotating said inner nozzle, a structure precluding longitudinal movement of said inner nozzle during its rotation, structure coacting with said sleeve and said inner nozzle effective upon rotation of said inner nozzle to adjust the position of said sleeve in control of the effective cross-sectional area of said converging air passage for control of air passed by said first bearing member, and valve means controlling the amount of air passed by said second ported bearing member for movement linearly of said inner nozzle toward and beyond said tangential inlet ports to vary the relationship between the linear and angular velocities of the air moving within said inner air nozzle toward the tip of the fuel nozzle.

11. A burner comprising a housing defining a main chamber and an auxiliary chamber, an outer air nozzle extending from said housing and receiving air from said main chamber, a rotatable inner air nozzle extending through said chambers into said outer nozzle and having tangential ports for passage of air from said main chamber and other ports for passage of air from said auxiliary chamber into said inner nozzle for linear flow, said outer nozzle having at its discharge end a tip tapered toward the discharge end of said inner air nozzle and therewith defining a converging air passage, a sleeve slidably mounted on said inner nozzle for movement toward and from the discharge end of said outer nozzle to vary the discharge of air from said outer nozzle, and a valve operable externally of said housing and positioned to control passage of air from said main chamber through said auxiliary chamber to said inner nozzle so to vary the angle of the cone of admixed fuel and air discharged from the burner.

12. A burner comprising a housing defining a main chamber and an auxiliary chamber, an outer air nozzle extending from said housing and receiving air from said main chamber, a rotatable inner air nozzle extending through said chambers into said outer nozzle and having tangential ports for air from said main chamber and having other ports for air from said auxiliary chamber positioned to effect linear flow, said outer nozzle having at its discharge end a tip tapered toward the discharge end of said inner air nozzle and therewith defining a converging air passage, a sleeve rotatable with and slidable along said inner nozzle toward and from the discharge end of said outer nozzle to vary the effective cross-sectional area of said converging passage, a fuel nozzle for discharge of fuel near the discharge end of said inner nozzle, means for rotating said inner nozzle, structure for precluding longitudinal movement of said inner nozzle during its rotation, coupling means including a pin-slot connection between said inner nozzle and said sleeve effective upon rotation of said inner nozzle to effect sliding movement of said sleeve in adjustment of the air discharged by the outer nozzle into the fuel-air mixture discharged by the inner nozzle, and a valve for controlling the air from said main chamber to said auxiliary

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chamber for linear movement toward said tangential ports in adjustment of the relationship of the angular and linear velocities of air mixed within the inner nozzle with fuel discharged by said fuel nozzle.

13. The combination with an ignition tile having a divergent passage of a burner having a fuel nozzle and inner and outer air nozzles whose discharge ends are at fixed distance from the throat of said divergent passage and define an annular discharge orifice, said nozzles having converging tips at their discharge ends which define an air passage converging to said annular orifice, a sleeve slidable along said inner air nozzle toward and from the discharge end of said outer air nozzle, and means operable externally of the burner for varying the position of said sleeve in adjustment of the air from said discharge orifice which remains at fixed distance from the throat of said tile passage.

14. A burner comprising a hollow member terminating in an outer air nozzle, a rotatable inner nozzle extending through said hollow member and having its discharge end at a fixed distance from the discharge end of said outer air nozzle, said nozzles having converging tips at their discharge ends which define an air passage terminating in an annular discharge orifice at the burner tip, a sleeve slidably engaging said inner nozzle for rotation therewith and for movement longitudinally thereof, means external of the burner for rotating said inner nozzle, structure for precluding longitudinal movement of said inner nozzle during its rotation, and pin-slot coupling means between said sleeve and said inner nozzle and between said sleeve and said hollow member effective upon rotation of said inner nozzle to effect longitudinal movement of said sleeve so to effect change in the cross-sectional area of said passage and so to vary the air discharged from the burner without change in the relative position of the discharge ends of said air nozzles.

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