June 8, 1943. E. J. HAEDIKE 2,321,483

PROPORTIONAL MIXER

Filed Jan. 6, 1941 2 Sheets-Sheet 1

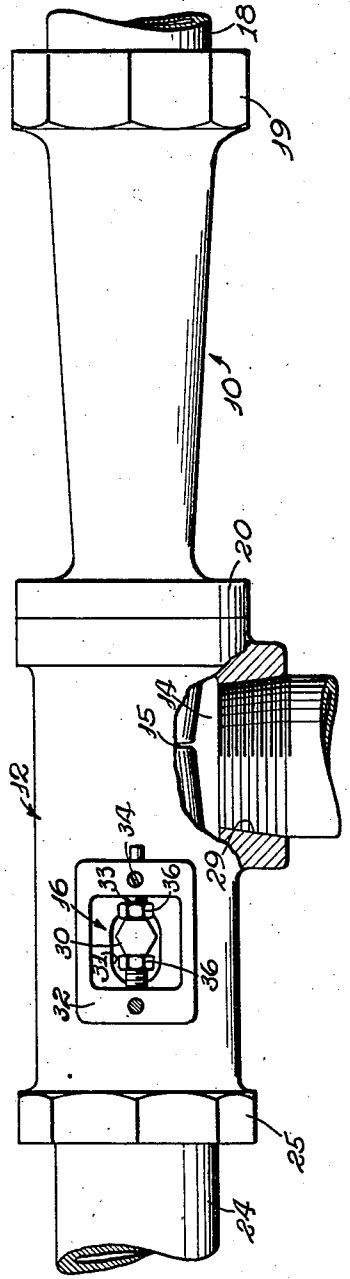


Fig. 1

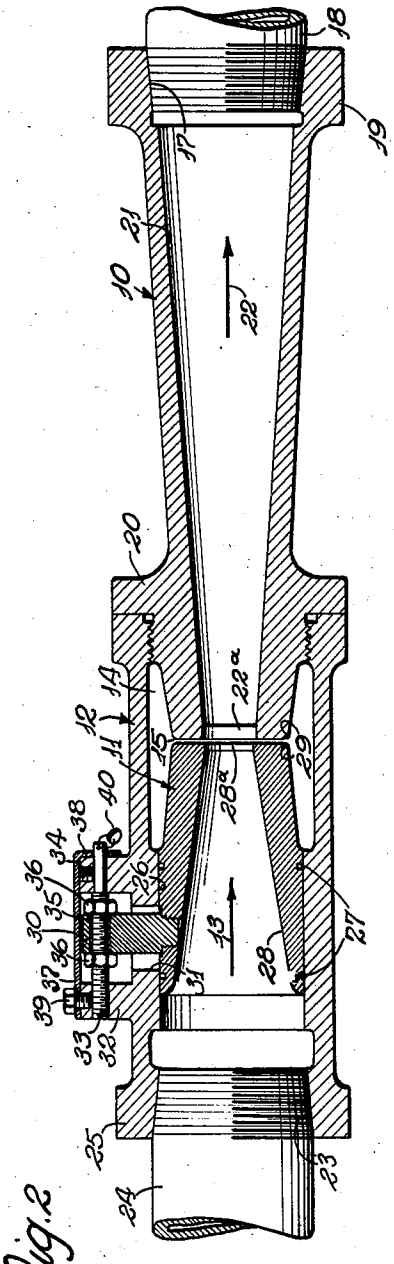


Fig. 2

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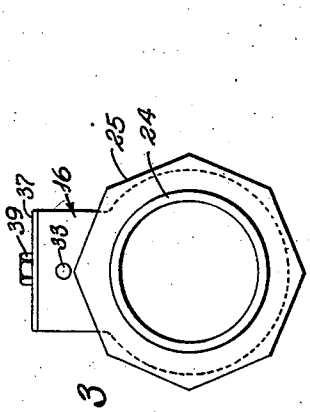


Fig. 3

Fig. 4

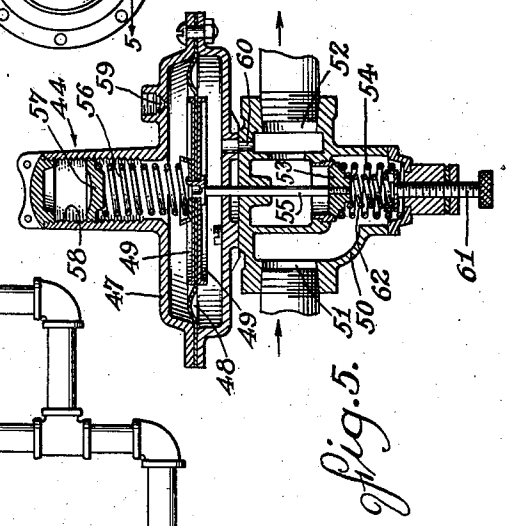


Fig. 5.

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2,321,483

PROPORTIONAL MIXER

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Application January 6, 1941, Serial No. 373,217

10 Claims. (Cl. 48—180)

The invention relates to mixer apparatus of the general type commonly used in effecting a proportioned mixture of combustible gas and air in the supply system of a blast burner. The function of the mixer apparatus is to retain automatically a predetermined ratio of gas to air so that by simply controlling the quantity of air supplied, the quantity of combustible mixture passing to the burner will be similarly controlled and the gas-air ratio for most efficient operation retained. Customarily, the air is supplied under substantial pressure and this pressure is varied to effect the desired control of the quantity of air, and hence mixture, which is fed to the burner. In order to obtain precision of results the arrangement must be such that the proportion of gas to air is maintained substantially constant throughout a wide turndown range for the air pressure, i. e., variation in air pressure. Moreover, the retention of such fixed ratio must obtain whether the changes in air pressure result from a deliberate control operation or from some inadvertent change in supply pressure.

One object of the invention is to provide a mixer apparatus of the type set forth embodying a novel arrangement for maintaining a substantially uniform ratio of gas to air throughout an extremely wide turndown ratio for the air pressure.

Another object is to provide a mixer of the type set forth in which a novel and simplified arrangement is provided for adjusting the air-gas ratio at will and without the use of auxiliary or supplementary adjusting apparatus or connections.

Still another object is to provide a novel proportional mixer for multiple gases, such as combustible gas and air, which is characterized particularly by its ruggedness and simplicity of construction as well as by the precision of gas-air ratio adjustment which may be effected.

Another object is to provide a proportional mixer apparatus of the type in which one gas is fed at high velocity through the throat of a Venturi type flow-way and entrains a second gas supplied at constant low pressure to an opening in the throat from a suitable regulator, and which apparatus is particularly characterized by the fact that the flow-way has a substantially unity coefficient of discharge and the opening in the throat also constitutes an adjustable orifice having a substantially unity coefficient of discharge, the line from the regulator to the orifice being free of any other orifices, so that a virtually constant proportionality of the second gas entrained by the first at the throat will be obtained throughout a wide range of pressures for the first gas.

The invention also resides in the novel arrangement for sealing the mixer to prevent tampering with its adjustment.

Further objects and advantages of the invention will become apparent as the following description proceeds, taken in connection with the accompanying drawings in which:

Figure 1 is a plan view, partially broken away, of a proportional mixer of novel form and which is a key element of the mixer apparatus herein disclosed, embodying the invention.

Fig. 2 is a longitudinal sectional view of the mixer.

Fig. 3 is an end elevation of the mixer.

Fig. 4 is a generally diagrammatic plan view of a fuel supply system for a blast burner incorporating as one of its elements the proportional mixer herein disclosed.

Fig. 5 is a sectional view of the zero governor, taken substantially along the line 5—5 in Fig. 4.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

In the instant embodiment, the mixer system shown (Fig. 1) is of a form particularly adapted for mixing combustible gas and air, preparatory to feeding the mixture through suitable manifolding to the burner of a furnace or the like. The illustrated system includes a mixer proper which comprises (see Fig. 2) three major structural elements, namely, a Venturi mixer member 10, a nozzle or jet member 11 and a body 12, the latter being fixed to the end of the member 10 and telescoped over the member 11. All three of these parts are, for the sake of durability and economy, made of heavy cast metal. In brief, axially alined and oppositely tapering flow-ways in the members 10 and 11 coact to define a Venturi type passageway through which air under pressure flows in the direction of the arrow 13. Fuel gas is supplied to an annular chamber 14 defined within the body 12 and is inspirated, by the stream of air noted, being drawn into the latter through an annular orifice in the form of a clearance gap 15 between the

opposed ends of the members 10 and 11. The width of this gap 15 determines the gas-air ratio, and a suitable adjustment mechanism, designated generally as 16 is provided for adjusting the member 11 endwise in the body 12, to thereby adjust the size of the gap or orifice to effect a desired ratio.

Turning now to the details of the various parts, it will be observed (see Fig. 2) that the mouth or outlet end of the member 10 is tapped as indicated at 17 to receive a discharge pipe 18. This end of the member 10 comprises an enlarged octagonal head 19 shaped to be readily engaged by a wrench. Intermediate its ends, but adjacent the inner one, the member 10 is formed with an encircling, integral enlargement 20 upon which is threaded the body 12, to fix the parts 10 and 12 rigidly together. The member 10 tapers, as a whole, toward its inner end and an axially extending passage or flow-way 21 in its interior is shaped to form a smoothly tapering, accurately dimensioned flow-way for the gas-air mixture, which flows through it in the direction of the arrow 22.

The body 12 is generally tubular in form and is tapped at its outer end, as indicated at 23, to receive an air supply pipe 24. This outer end of the body is shaped in the form of an enlarged, wrench-engageable, octagonal head 25. The interior of the body 12 is shaped to form an annular seat 26 of substantial length in a direction longitudinally of the body, and in which the inner nozzle member 11 is slidably mounted. In assembling the device, the member 11 is first slipped into the body 12, then the latter is screwed onto the member 10.

As to the adjustable nozzle member 11, it will be observed (see Fig. 2) that it comprises a cylindrical body portion slidable in the seat 26, as well as an end portion which tapers longitudinally toward the inner nose of the Venturi mixer member 10. The nozzle member 11 has a sliding fit within the body 12 with a clearance of preferably only about 0.003 inch in the seat 26. Annular grooves 27 at spaced points in the seat 26 form a labyrinthine passage to baffle and restrict any possible air leakage along the exterior of the nozzle 11. In this way any objectionable air leakage along the exterior of the nozzle is obviated. An axially extending passage 28 within the nozzle member 11 is shaped to form a smoothly tapering flow-way for the entering air and which converges toward the alined small end of the flow-way 21 in the member 10.

Combustible gas is supplied to the chamber 14 through a conduit connected to a tapped hole 29 (Fig. 2) in the side of the body 12. As indicated generally above, the gas from this chamber 14 is entrained by the stream of air passing through the flow-ways 28, 21. During this inspirating operation, the gas passes through the adjustable gap 15 between the ends of the members 10 and 11. With such an arrangement the shapes of the adjacent portions of the members 10 and 11 are important in obtaining precision results, it being especially necessary to guard against the creation of eddy currents or turbulence at this point in the system. In this connection, it has been found desirable to form the flow-ways 28 and 21 with adjacent end portions of round or cylindrical cross section as indicated at 28^a and 22^a. Also the cylindrical terminal portion 28^a of the nozzle flow-way 28 is made slightly smaller in diameter than the entry portion 21^a of the flow-way 21. Furthermore, the terminal portion 28^a is slightly less in width than the cylindrical entry portion 22^a of the flow-way 21. The opposed end faces of the members 10 and 11 are machined flat and precisely parallel, and their peripheries are chamfered as indicated at 29.

Also notable are the flow characteristics of the parts mentioned. The Venturi type flow-way for the air has a substantially unity discharge factor and so does the annular orifice 15 for the gas. Consequently, the ratio of gas to air remains virtually constant through a wide range of air pressure since, as will hereinafter appear in further detail, there are no other orifices or the like in the gas line from the gas supply regulator to the orifice 15 so that the characteristics of the gas and air paths remain perfectly matched, as noted.

For accurate adjustment of the gap 15 it will be seen that the motion of the member 11 must be rigidly guided so as to maintain parallelism, throughout the range of adjustment, between the opposed faces of the members 10 and 11. The long bearing seat 26 within the body 12, in which the member 11 is telescoped, affords precisely this type of guide. This accurate guiding of the adjusting motion of the member 11 also assures maintenance of alinement between the flow-ways 28 and 21.

The adjustment mechanism 16 for shifting the nozzle member 11 axially is capable of very exact positioning of the latter member. It should be understood that the size of the gap 15 has been somewhat exaggerated in the drawings. In actual practice it is ordinarily of the order of magnitude of 0.015 to 0.025 inch in width. The particular adjustment mechanism shown comprises a stud 30 projecting into a hole in the member 11 and rigidly secured thereto by a tapered thread. The stud 30 projects outward through a slot 31 in the body 12, this slot being bordered by a rectangular housing 32 integral with the body 12. A lead screw 33 projects through opposite side walls of this housing 32 and is fixed against rotation by a set screw 34. The lead screw also projects through a transverse hole 35 in the stud 30. A pair of adjusting nuts 36 are threaded on the lead screw and by rotating these nuts the stud 30, and hence the nozzle member 11 fixed to it, can be shifted endwise of the body 12. The threads on the lead screw 33 have quite a short lead so as to afford a very fine adjustment for the nozzle member 11.

The adjusting mechanism 16 described above is of a form which can be readily sealed to prevent tampering by unauthorized persons after the nozzle member 11 has been adjusted to effect a desired gas-air ratio. The sealing arrangement comprises a sheet metal cover member 37, dimensioned to overlie the top of the rectangular housing 32, and having a depending end flange 38 with a hole in it to receive the projecting end of the lead screw 33. A screw 39 holds the cover removably in place and a sealing wire 40 led through a hole in the projecting end of the lead screw 33 prevents removal of the cover.

In use, the mixer described above may, for example, be incorporated in a system of the general form indicated in Fig. 4. In this system air under pressure is supplied from a suitable source (not shown) through the pipe 24 under the control of a single valve or blast gate 41. On the other hand, the combustible gas is supplied from a pipe 42 under the control of a manual shut-off valve 43 and a zero pressure gas governor 44.

The latter device is, aside from an adjustment arrangement hereinafter described, of well known construction and serves, in general, to maintain the gas entering the mixer at substantially constant and low pressure such, for example, as at so-called zero or atmospheric pressure. The gas-air mixture leaving the mixer through the pipe 18 enters a system of manifold piping 45 through which it is supplied to a plurality of burners of any suitable form such, for example, as the blast line burners 46 illustrated.

In the operation of the system as so far described, the valve 43 is normally left full on and only closed when it is desired to shut down the furnace completely. The gas-air ratio desired is initially set up by adjusting the width of the clearance gap or orifice 15 in the mixer through the medium of the adjustment mechanism 16. Thereafter, the mechanism 16 is sealed up and full control of the system is effected through manipulation of the single valve 41. The system is thus particularly well accommodated for use with automatic controls since the latter need only vary the setting of the single valve 41 to vary the delivery of both fuel and air in accordance with heating demands.

The incoming air is supplied under pressure as, for example, with a maximum available pressure head of seventy inches W. C., this pressure being varied as desired by the valve 41 and ordinarily maintained within a range of from three to thirty inches W. C. For operation outside this latter range, adjustment of the zero governor 44, in the manner later described, is desirable and for the present it will be assumed that the system is operating with an air pressure within the range noted. The incoming high pressure air streams through the entrance flow-way 28 of the mixer (see Fig. 2), its pressure head being converted to velocity head as the flow-way converges. Finally, the stream of air attains a maximum velocity substantially at the point at which it passes across the gap or orifice 15. The gas, at approximately atmospheric pressure in the chamber 14, is thus entrained by the high velocity stream of air, and enters it, being thoroughly mixed with the latter as the gas and air move through the mixer's exit flow-way 21. During the passage of the mixture through the expanding exit flow-way 21, the velocity head of the mixture is reconverted to pressure head. The high pressure mixture, on leaving the mixer, passes through the manifolding (see Fig. 4) and is burned in the usual manner.

As the heat requirements of the installation change from time to time the setting of the blast gate or valve 41 is varied accordingly. As a result the pressure of the air entering the mixer is correspondingly changed, and a commensurate change effected in its velocity as it crosses the orifice 15. The amount of gas entrained is, however, dependent, in the present arrangement, on this velocity and so the ratio of gas to air remains substantially constant. In fact, in actual test it has been found that with the illustrated apparatus the gas-air ratio is maintained within a tolerance of plus or minus five percent throughout a turn-down ratio of seven-to-one for the air. This represents a change in the analysis of the products of combustion of less than one percent of carbon dioxide. Such accurate control of gas-air ratio throughout such a wide range of air pressures is so notable as to be unique in the field of commercial proportional mixers.

Relative to the constancy of the gas-air ratio it should be observed that there is no control valve or other orificing or restricting device between the pressure regulator or governor 44 and the orifice 15.

Such freedom from orifices or valves is made possible by the adjustment of the orifice 15 itself to get desired changes in ratio. But since there are no other orifices or the like to introduce another and disturbing coefficient of discharge in the gas line, the coefficient of discharge for the orifice 15 can be, and is, made to match that of the air supply flow-way. Accordingly, a change in air pressure, and hence velocity, is reflected in an almost precisely proportionate change in gas flow and, thereby, a high degree of uniformity preserved in the gas-air ratio.

Not only does the disclosed arrangement accomplish extreme accuracy of maintenance of gas-air ratio, but it also affords maximum efficiency with respect to the ratio of intake air pressure to discharge mixture pressure. As a generalization, it may be noted that there is an energy exchange between the air and the gas which it entrains, this being necessary to raise the static potential energy of the gas to manifold pressure. The mixer exit or manifold pressure will always be less than the intake air pressure by an amount necessary to compensate for the kinetic and potential energy imparted to the gas plus friction and heat losses. In the present mixer a very high percentage of the initial potential energy of the air is recoverable as useful pressure in the manifold. In fact it is possible to attain a manifold pressure of twenty-five inches W. C., with an input pressure of seventy inches W. C. This represents a gain of at least seventy percent over proportional mixers of older and less efficient design.

When operating outside the usual range of air pressures indicated above, that is, below three inches W. C., or above thirty inches W. C., it is sometimes desirable to make some further adjustment of the system to retain the gas-air proportionality with the requisite exactitude. Thus at very low pressures the air velocity is so far diminished as to entrain insufficient gas, which at very high air pressures the gas delivery tends to be excessive. I have found that the range of usable air pressures can be very substantially increased by incorporating in the system described a simple adjusting arrangement for the zero governor 44.

In the illustrated governor (see Fig. 5) the usual, generally disk shaped casing 47 is provided and across the interior of which extends a flexible diaphragm 48. Fixed to opposite sides of the diaphragm are reenforcing disks 49. Bolted on the lower side of the casing 48 is a valve body 50 having an inlet 51 and an outlet 52 and cored out of to form a passage therebetween with a valve disk 53 interposed in the passage. This valve disk 53 is normally urged to closed position by a helical compression spring 54 seated in the bottom of the valve body. A thrust pin 55, fixed to the valve disk 53, contacts the center of the diaphragm and operatively connects the two. On the opposite side of the diaphragm a loading spring 56 bears against the diaphragm and its pressure is adjustable by a plug 57 threaded in a bore 58. Atmospheric pressure is admitted to the upper side of the diaphragm 48 through a port 59, while gas pressure is applied to the lower side through a port 60. The opposed springs are so balanced, rela-

tive to the pressures involved, that the diaphragm will open the valve disk **53** when the outlet gas pressure from the regulator drops to a predetermined point relative to atmospheric pressure.

In the event that very high air pressures are applied to the mixer, the latter will, as heretofore noted, tend to draw too much gas. To obviate this difficulty provision is made for yieldably, and adjustably, limiting the opening of the regulator valve **53** so as to throttle the gas in it under the condition noted. For this purpose an adjusting screw **61** is threaded in the lower end of the valve body **50** and connected to the valve disk by a compression spring **62**, disposed within the spring **54**. The spring **62** thus forms a yieldable stop for the valve disk and the latter's travel can be adjusted by the screw **61**. By thus limiting the opening of the valve disk **53** a substantial orificing effect can be introduced for large gas flows, accompanying high air pressures, so that the rationing of gas and air is retained quite uniform even at high air pressures.

At the other extreme of air pressures, that is, with very low pressures, it is desirable to adjust the spring **56** in the governor (by the plug **57**) so that the regulator valve will open to maintain a pressure in the mixer's chamber **14** slightly above atmospheric pressure. For example, if the gas pressure in the chamber **14** is run up to 0.5 to 0.75 inch W. C. the gas-air ratio will be retained substantially uniform when the air pressure is brought down to only one inch W. C. or, in some instances, as little as 0.5 inch W. C. Extreme range of air pressures is thus made possible.

From the foregoing it will be seen that a very efficient and high precision instrumentality has been provided. Nevertheless it is extremely simple and rugged in construction so that low cost and long life are assured.

I claim as my invention:

1. In a proportional mixer of the type set forth, the combination of first and second members having respectively entrance and exit flow-ways formed therein, said flow-ways being axially alined and tapered toward each other, a generally tubular body fixed to one of said members and telescoped over the other for guided endwise rectilinear sliding movement of the latter, means operable from the exterior of said body for adjusting the position of said member within it, whereby to position the latter with a clearance gap of preselected width between it and the other member, and said body being shaped interiorly to provide a chamber for a gaseous medium substantially encircling said gap, whereby when gas is supplied to said chamber and a second gas passed through said flow-ways the first mentioned gas will be inspirated through said gap into the gas passing through said flow-ways and with a ratio to the second gas fixed by the width of said clearance gap.

2. In a proportional mixer of the type set forth, the combination with two members arranged end-to-end with a small clearance gap between their adjacent ends and having axially alined flow-ways therethrough tapered toward each other to points of minimum diameter for each on opposite sides of said gap, of a generally tubular body rigid with one of said members and telescoped over the other, said other member having limited rectilinear endwise adjusting movement within the body, and said body being shaped interiorly to form a gas supply passage embracing the gap between the adjacent ends of said members, whereby one gaseous medium may be inspirated from said chamber through said gap and into a stream of a second gaseous medium passing through said flow-ways, such stream reaching its maximum velocity adjacent the juncture of said flow-ways at said gap.

3. In a proportional mixer of the type set forth, the combination of two members arranged end-to-end and having axially alined flow-ways therein fashioned to form a Venturi type passage comprising entrance and exit passages tapered axially toward a throat which joins them and which constitutes the minimum diameter portion of the Venturi passage, the plane of juncture of said members being adjacent said throat, a generally tubular body rigid with the one of said members in which the said exit passage is formed and telescoped over the other of said members, means within said body guiding said other member for rectilinear endwise adjusting movement therein while maintaining the same rigidly against side play, and said body being shaped interiorly to form a gas supply passage embracing a clearance gap between the opposed ends of said members.

4. In a proportional mixer of the type set forth, the combination of two members arranged end-to-end with a small clearance gap between their ends and having axially alined flow-ways therethrough tapered toward each other, said flow-ways terminating at their adjacent minimum-diameter ends in short portions of cylindrical contour, a generally tubular body rigid with one of said members and telescoped over the other, said other member being guided and supported by said body for axial sliding movement toward and away from said one member to adjust the width of the clearance gap between them, adjusting means for shifting said other member endwise, and said body being shaped interiorly to form a gas supply passage embracing the clearance gap between the opposed ends of said members.

5. In a proportional mixer of the type set forth, the combination of two members arranged end-to-end with a small clearance gap between their adjacent ends and having, respectively, entrance and exit flow-ways therethrough disposed in axial alinement and tapered toward each other, said flow-ways terminating at their adjacent minimum-diameter ends in short portions of cylindrical rather than tapered contour, the cylindrical portion of said entrance flow-way being of slightly smaller diameter, and also of slightly less axial length, than the cylindrical portion of said exit flow-way which lies on the opposite side of said clearance gap therefrom, a generally tubular body rigid with one of said members and telescoped over the other to guide and support the latter for endwise movement, said body being shaped interiorly to form a gas supply chamber embracing the periphery of said gap, and adjusting means for shifting said other member endwise to adjust the width of said clearance gap.

6. A proportional mixer of the type described comprising, in combination, a generally tubular body having a mixer member rigid with one end thereof, said body and mixer member having inlet and outlet openings in their respective outer ends, said mixer member having an axially extending mixer passage therein tapered away from said outlet opening into which it leads, a nozzle member telescoped within said tubular body and guided therein for endwise sliding adjusting movement, said nozzle member having a passage

therein tapered toward that in said mixer member and extending between said inlet and the adjacent end of said mixer passage, manually operable means for adjusting said nozzle member endwise within said body to vary the clearance between the opposed ends of said nozzle and mixer members, and said body having a gas inlet in the side thereof for supplying gas to flow through such clearance into the mixer passage at its point of juncture with the passage of said nozzle member.

7. A proportional mixer comprising, in combination, a pair of elongated generally frusto conical members disposed in axial alinement with their small ends toward each other, said members having alined flow-ways therethrough tapering toward each other, a generally tubular body telescoped over one of said members and fixed to a portion of the other intermediate the latter's ends, the exterior of said one member and the interior of said body presenting mating surfaces supporting and guding said one member for rectilinear endwise movement in said body and forming a seal peripherally about said one member, means for adjusting said one member endwise to vary the width of a gap between its inner end and the opposed end of the other member, and said body having a gas inlet communicating with a chamber encircling the periphery of said gap and formed within said body, between said seal and the line of juncture of said body with said other member, by the clearance between the tapered noses of said member and the interior wall of said tubular body into which they project.

8. In a proportional mixer of the type set forth, the combination of two members arranged end-to-end with a small clearance gap between their adjacent ends and having axially alined flow-ways therethrough tapered toward each other to points of minimum diameter for each on opposite sides of said gap, a generally tubular body rigid with one of said members and telescoped over the other, said other member having limited endwise movement within the body, said body being shaped interiorly to form a gas supply passage embracing the gap between the adjacent ends of said members, whereby one gaseous medium may be inspirated from said chamber through said gap and into a stream of a second gaseous medium passing through said flow-ways, such stream reaching its maximum velocity adjacent the juncture of said flow-ways at said gap, a stud fixed to said other member and projecting through a slot in the side of said body, and means including a lead screw on the exterior of said body and cooperating with said stud for shifting said other member endwise within said body to vary the width of said clearance gap.

9. In a proportional mixer of the type set forth, the combination of two members arranged end-to-end with a small clearance gap between their opposed ends and having axially alined flow-ways therethrough tapered toward each other to points of minimum diameter for each on opposite sides of said gap, a generally tubular body rigid with one of said members and telescoped over the other, said other member being guided and supported by said body for rectilinear axial sliding movement toward and away from said one member, adjusting means including a threaded member operable from the exterior of said body for shifting said other member endwise to adjust the width of said clearance gap, said body being shaped interiorly to form a gas supply passage embracing the gap between the adjacent ends of said members, and means for sealing said adjusting means against movement, to prevent tampering therewith.

10. An apparatus for mixing gases in predetermined proportion comprising, in combination, two members arranged end-to-end and having axially alined flow-ways therein fashioned to form a Venturi type passage comprising entrance and exit portions tapered axially toward a throat which joins them and which constitutes the minimum diameter portion of the Venturi passage, the plane of juncture of said members being adjacent said throat, means supporting said members for relative movement toward and away from each other in order adjustably to vary the clearance between their adjacent ends, means for supplying one gas to said Venturi passage, whereby a high velocity flow of the same through said throat results, means including a conduit for supplying a second gas to the clearance gap between said members for entry into the stream of said one gas in said throat, the width of said adjustable clearance serving to control the ratio of said gases one to the other, said clearance gap forming an orifice having a coefficient of discharge substantially equal to that of said Venturi passage, and pressure control means interposed in said conduit for maintaining the pressure of said second gas at a low and relatively constant value, the portion of said conduit between said control means and said clearance gap being free of any orifice or similar restriction.

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