Sept. 3, 1957 J. E. KINNISON 2,804,919

VOLUMETRIC COMBUSTION METHOD AND APPARATUS

Filed July 20, 1949 3 Sheets-Sheet 1

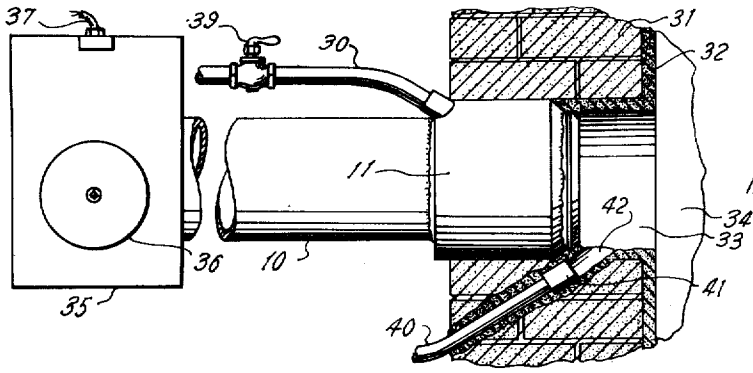
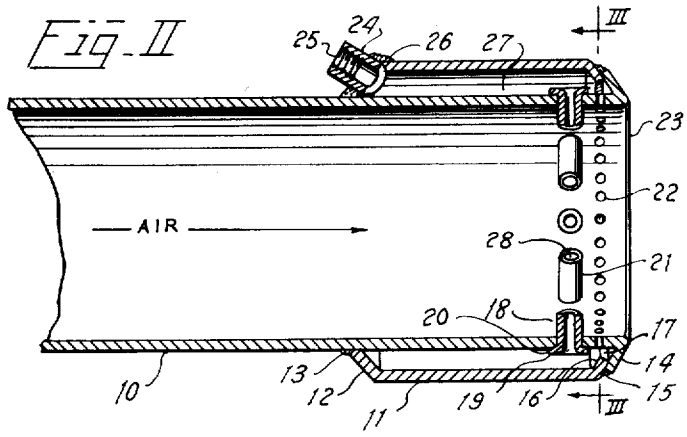


Fig. I

Fig. II



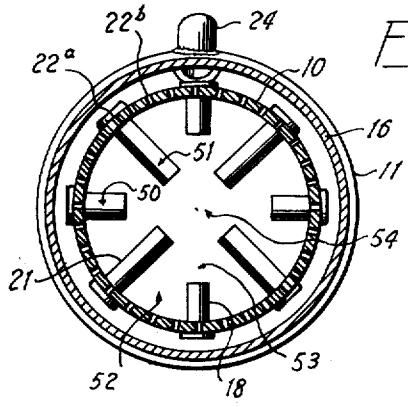


Fig. III

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VOLUMETRIC COMBUSTION METHOD AND APPARATUS

Filed July 20, 1949 3 Sheets-Sheet 2

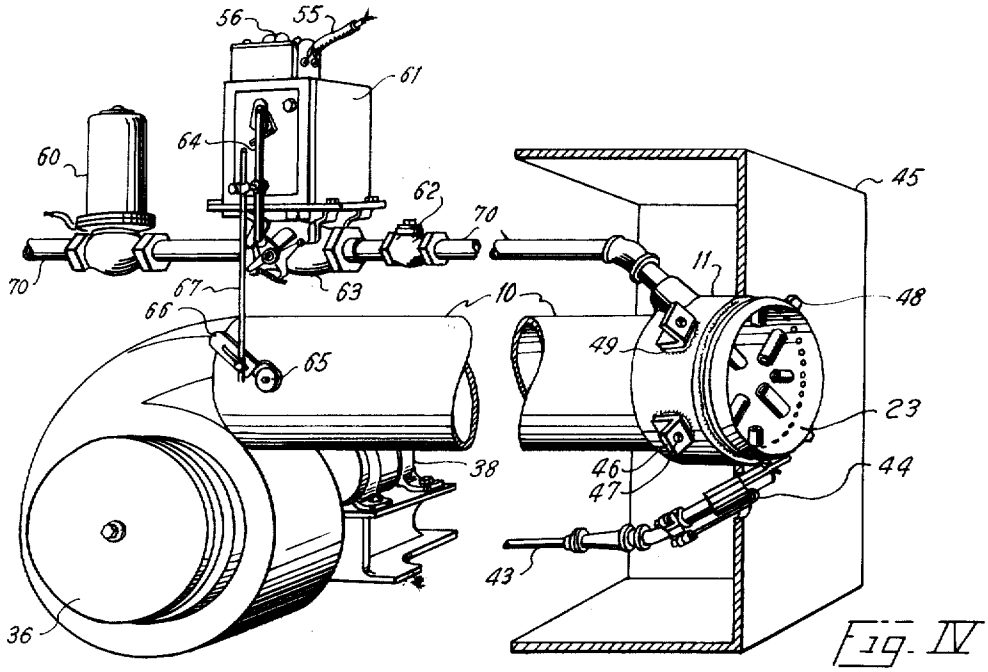


Fig. IV

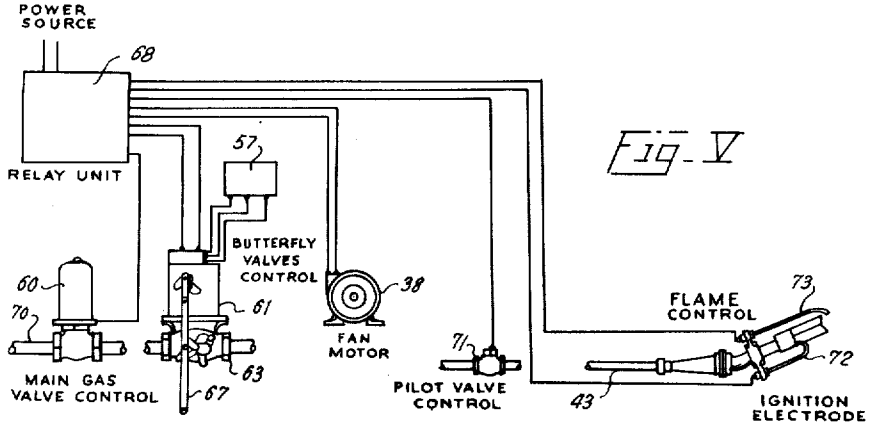


Fig. V

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VOLUMETRIC COMBUSTION METHOD AND APPARATUS

Filed July 20, 1949 3 Sheets-Sheet 3

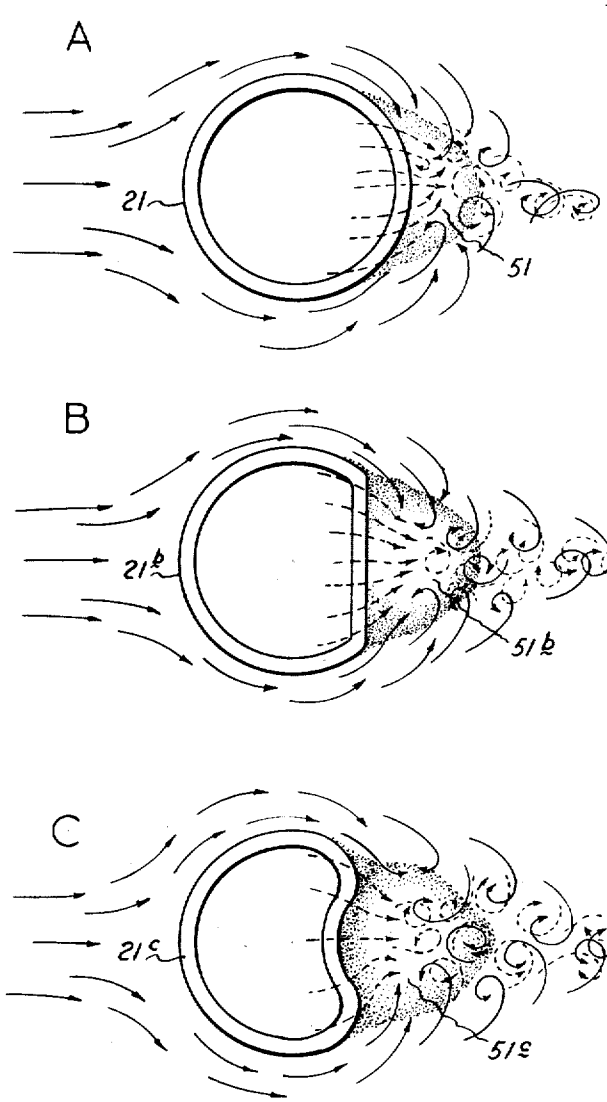


Fig. VI

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2,804,919

VOLUMETRIC COMBUSTION METHOD AND APPARATUS

John Emmett Kinnison, Tucson, Ariz.

Application July 20, 1949, Serial No. 105,683

8 Claims. (Cl. 158—109)

This invention concerns a method for effecting efficient fluid fuel combustion. It involves the automatic self-regulation of the proper proportioning of fuel and air for more complete combustion.

A moving stream of air properly distributes a suitable volume of fuel into itself; and the fuel thus distributed is received into the body of the air stream at different depths therein.

The air stream moves in a plurality of zones of differing velocities into which it is divided; and into segments of such zones fuel is introduced in amounts which are responsive to the mass of air moving therein, the segments and/or zones of greater mass and velocity receiving more fuel than those of less.

The method of this invention and suitable apparatus employing it represents a complete reversal of method and apparatus heretofore used. A burner employing my method may be said to be "turned inside out" as compared to old style burners. In earlier devices, particularly in conventional gas burners, fluid fuel was forced, under pressure (usually from a centrally located gas supply pipe) through a number of small jets at considerable velocity. These jets had relatively small orifices or openings through which the gas was discharged; and an orifice of a special size was necessarily provided for use with a particular kind of gas and for use with a particular gas pressure. For instance, manufactured gas required a certain small orifice, natural gas required a still smaller orifice, and liquefied petroleum gases (such as butane) required a very minute orifice; and in each burner the orifices were sized according to the gas pressure provided therefor, and the capacity thereof.

Also, in the conventional burner, air at atmospheric pressure was allowed to flow into the area surrounding the gas discharge orifices, there to mix. Sufficient air for proper combustion was rarely ever secured by this means, and usually there was provided another source of air, also flowing into the region of the gas and/or the flame, at atmospheric pressure. The well known Bunsen burner illustrates this principle.

Conventional burners employ a jet of gas in connection with a supply of air which is allowed and/or induced to flow in response to the velocity of the gas and/or the movement occasioned by the flame itself. Supplies of air, conventionally employed, frequently were spoken of as primary air supply, secondary air supply, and even tertiary air supply. In any case, the movement and/or burning of gas caused the flowing of the air into the region of the gas or the flame, or both.

All such conventional methods, apparatuses and operations, thus described, have been completely abandoned in this invention, as they have been found wholly useless therein. All available data on conventional burners, such as gas pressure as related to orifice sizes and air (oxygen) consumed, have been found to have no application in constructing my invention, which has very large orifices, no "jetting" of gas, and gas of little, if any, pressure.

In this invention a stream of air is supplied, as with a blower or fan, or it may be set in motion and kept moving my induced draft or natural draft in a stack of proper height. However, the use of the usual tall stack is unnecessary, and a simple vent is advised. No more is required. Thus, the expensive smoke stack is eliminated. Such elimination results in great savings in initial costs and in maintenance costs.

The central theme of the method here disclosed is to be found in a moving stream of air, into which gas is not forced but is allowed to flow and automatically distributed and therein enmixed. No conventional mixing chamber is employed. None is necessary.

However, a nominal pressure is maintained on the gas, especially when offered initially into the air stream. The gas therefore may well be said to flow into the air stream.

Whether the gas be drawn into the air by the movement of the latter or flow therein by reason of a nominal gas pressure, the automatic distribution of the gas throughout the air air stream is occasioned by the activity of the air stream itself. Such activity must be understood to comprehend movement and flow in the air stream, occasioned by mass and velocity thereof, and the creation of definitely located and related areas of turbulence therein, these being especially pronounced in regions where partial vacuum is induced, as will be hereinafter explained.

The method herein contemplated comprehends the enmixing, for combustion, of varying volumes of gas (even of gases varying in B. t. u. content), with volumes of air which vary as the volume of the gas varies, and which also may vary as the B. t. u. content of the gas varies, the variations in the volumes of gas and air thus enmixed being automatically induced by the continuing capacity of this method for effecting complete combustion.

When desired, automatic mechanical controls may also be employed and operated in response to completeness in combustion (or the lack of it) measured in the products of combustion.

An outstanding and unusual value of the method here presented and the apparatus employing it is found in the remarkable capacity of the invention for effecting complete and thorough mixing and high combustion efficiency in the use of fuel, notwithstanding the very pronounced variation in the volumes of gas and air which are enmixed from time to time, and notwithstanding the varying B. t. u. content in the gases enmixed with air.

The capacity of my burner for utilizing all kinds of combustible gases and causing their proper mixture with the right amounts of air for best combustion is indeed extreme. It is a truly flexible burner. It is a really universal burner. It readily burns any gaseous fuel. There are no changes to be made in it when a different kind of gas is fed to it, or when gas pressure is drastically modified. Yet efficient combustion results.

It is truly revolutionary to provide, in a gas burner of high efficiency, the relatively enormous gas openings which I provide to pass from a gas reservoir into a stream of air defined by a centrally located large air duct.

In this invention the several orifices from which gas is delivered into the air stream are uncommonly large. The orifices or outlets at the ends of the several fingers which deliver gas into the body of the air stream are many times larger than usual gas orifices on the conventional burner; and the surface orifices employed in this invention (explained hereinafter) are also larger than usual. This precludes the "jetting" of gas from these openings, as in conventional burners.

My construction and arrangement allows the "leakage" of gas into the air stream at several depths therein, and

also around the outer wall of such air stream. Therefore, any volume of gas, any kind of gas, is deliverable into the air stream as the movement and volume and quantity of that air may demand for complete mixing. This is a most unusual departure from conventional methods and apparatuses.

In this invention, the hollow fingers which extend into the air stream and part way across the body thereof, perform a double function. First, they admit gas into the air stream at varying depths therein; and, second, they form obstructions which deflect the air stream in such ways as to cause strong eddy currents on the sides of these projecting fingers opposite the source of the air. In fact, they create regions of partial vacuum and/or turbulence into which gas rushes to enmix with air; and such regions are variously located throughout the air stream, so as to divide its total body into sections of more or less defined patterns.

The divisions of the air stream into sections or zones are of two interrelated characters. One is a division of the stream as though it were cut into from its long sides to form smaller streams spaced slightly from one another by the projecting fingers themselves; and the other is a division into a plurality of layers of air, as though they were cut longitudinally from end to end of the air stream, so as to form a central core of fast moving air surrounded by layers of air moving at a less rate, each outward layer being slower than the next inner layer, because of the greater number of projections in the outer layers and because of the friction of the air duct itself. The "central core" of the air stream is free of projections, moves fastest, and is relatively small; and even parts thereof eddy about in answer to the requirements of the respective areas of turbulence created by the zones of partial vacuum.

The method employing structures of the general character hereinabove indicated results in a completely thorough enmixing of gas and air, thus promoting efficient combustion. The gas is delivered into the various segments, sections and zones of the air stream (which vary in velocity and turbulence) in accordance with the demands therein occasioned by variations in their respective movements.

Thus, relatively more gas may be fed into a specific segment of the air stream from one hollow delivery finger than from another finger. The result is what I choose to call automatic balancing of the gas flow into the air stream, with the result that a more complete and thorough mixing of the air and gas comes about; and with a further result that any kind of gas, B. t. u. considered or pressure considered, may be delivered into the air stream with completely satisfactory results; and, furthermore, the unusually large openings for delivery of the gas into the air stream permit the automatic balancing of the quantity of gas fed into the respective segments of the air stream, regardless of the nature of the gas and its properties or pressure. This is a true innovation in gas burners and methods for effecting mixture between fuel and air. It results in a fuel-entrained air stream.

Succinctly stated, one important result of this invention is that both fuel and air are metered together volumetrically. We may properly speak of the burner exemplified in this invention as being a volumetric burner.

The primary objects of this invention may be collected from the foregoing statements and from the remaining part of this specification and attached claims. Among such objects are the following:

(*a*) The provision of a moving stream of air for supplying oxygen for combustion, and the introduction of gas into such air stream from a gas reservoir arranged outwardly of the air conduit, and hollow gas delivery fingers leading from the reservoir and projecting inwardly of the air stream.

(*b*) Construction and arrangements as indicated in

paragraph (*a*) above, with the addition of a series of longer hollow fingers alternating with a series of shorter hollow fingers, so that gas may be delivered into the air stream at different depths.

(*c*) Construction and arrangements as in paragraph (*b*) above with the addition of a multiplicity of surface orifices arranged about the inner face of the air stream duct and in positions anterior to the hollow fingers.

(*d*) Combustion mechanism made in accordance with the provisions of any of the paragraphs (*a*) to (*c*) above and having air forced therein through the use of suitable mechanism, the burner and/or firebox being operated without the necessity of a conventional smoke stack.

(*e*) The arrangement and construction of a gas burner following the requirements of one or more of the lettered paragraphs above in which the air stream is divided into various smaller streams, and the smaller streams further divided into segments, such streams and segments being fed from variously located orifices provided for such purpose.

(*f*) A gas burner, made as indicated above, in which the hollow gas delivery fingers are arranged substantially at right angles to the axis of the air stream (or approximately so), allowing the air flow to strike these fingers and divide thereabout, the fingers being so positioned and constructed as to result in areas of partial vacuum and/or turbulence anteriorly thereof, into which areas gas may be fed from the several sources indicated above.

(*g*) The provision of a gas burner of the character indicated above in which the gas delivery fingers terminate in relatively large orifices, from which gas may be allowed to move in response to the conditions of movement in the air stream.

(*h*) The provision of a gas burner of the character described herein and its operation by being supplied with gas of relatively low pressure value, the gas being delivered into air streams of relatively high velocity, having therein areas of substantial turbulence, the amount of gas thus enmixed with air being automatically induced by the movements in the latter.

(*i*) Automatically inducing and maintaining uniformity and proper balance of gas and air mixing to such a degree as to prevent "flutter" in firebox and stack throughout the entire range of the amount of fuel consumption.

(*j*) The provision of a burner of such flexibility as to be capable of employing gas of widely varying B. t. u. content and/or widely varying pressure, under conditions of extremely variable fuel demands, and maintaining highly efficient combustion at all times.

(*k*) The eliminaation of the necessity for the conventional mixing chamber and of the conventional smoke stack, and the elimination of "flash back."

(*l*) The process of maintaining proper mixtures of gas and air regardless of extreme conditions of super heat in the pre-heating of gas and air for combustion.

(*m*) The turbulent segmentation of an air stream into which fluid fuel is gently and automatically distributed and enmixed.

(*n*) The saving of materials, labor and costs in gas supply lines and fittings and control apparatus by reason of the fact that these may be unusually small, notwithstanding the increase of friction on the gas passing through small conduits. This is so, because I require little or no pressure in the gas as it is fed to the burner.

One satisfactory form of a typical device employing my method is illustrated in the accompanying drawings, in which:

Fig. I is an elevational view of a typical burner set in a sectionalized wall of the firebox.

Fig. II is a sectionalized elevation of the anterior or open end of a typical burner.

Fig. III is a cross-section taken along the line III—III of Fig. II.

Fig. IV is a perspective view of a burner equipped with blower and control mechanism.

Fig. V is a diagrammatic view of the electrical operation of control mechanisms.

Fig. VI is a schematic view of areas of turbulence in the air flow.

In the drawings illustrating one suitable form of a typical device employing my method, each part has been indicated by a numeral; and therein the numeral **10** indicates an air duct, of any desired shape. It may be cylindrical, square or polysided, as desired. A gas chamber **11** is arranged outside of the air duct; and this chamber may take any shape suitable. If desired, the gas chamber may completely enclose a section of the air duct, as indicated in the drawings.

The rear wall of the gas chamber may be provided with the return **12** to facilitate the union of the chamber with the outside of the duct through the use of fused material, such as the welding shown as at **13**. Any other suitable form of union between these members may be employed to seal against gas leaks.

I usually provide a return **14** on the forward or anterior end of the duct **10**, against which the anterior return **16** of the chamber **11** may be placed, so that these members may be joined by fusing, as indicated by the welding material **15**, or otherwise united to seal against the escape of gas.

It is preferred that the return **16** be shorter than the return **12**, so that the shorter return may be passed over the flared inner end **19** of the gas supply finger **18**, while the burner is being assembled.

Short finger **18**, as well as the other gas delivery fingers in the burner, may be welded to the duct **10** by fusing as at **20**. Spot welding may be employed. However, these fingers may be placed and secured in any manner suitable, such as through the use of threads.

In addition to short delivery fingers, a series of longer gas delivery fingers, such as those shown as at **21** may be employed. A series consists of any desired number of fingers of equal length. Two or three or more series of fingers, each of a different length, may be employed, as the size of the burner and the demands of the job require. Small burners may use only one series of fingers.

The free ends of all of the gas delivery fingers, both long and short, terminate in the relatively large orifices **28**, through which gas passes into the air stream defined by the duct **10**.

I also provide surface orifices **22**, which are arranged about the inner side of the open end of conduit **10**. The region in which these surface orifices are placed may be considered as the lip region **23**, at the mouth of conduit **10**.

For convenience in supplying gas to the chamber **11**, there may be arranged the internally threaded coupling **24**, communicating with the chamber, the internal threads of the coupling being shown as at **25**, and welding, securing the coupling in place, being shown as at **26**. Of course, the gas chamber may be cast (with the air duct) and it may be provided with a boss which may be tapped and threaded to receive a gas supply pipe **30**. The manner in which connection is made between a gas supply pipe and the chamber is not material.

In a preferred form of my burner, I have arranged a space **27** which lies between the outer wall of duct **10** and the inner face of the chamber **11**. This space is filled with gas, from which the orifices (indicated above) are supplied with gas for delivery into the air stream moving through duct **10**.

My burner may be mounted and supported in any suitable manner adjacent to a firebox or chamber to be heated. Usually, the wall of the firebox is made of fire brick, as at **31**, and plastered with refractory material or fire clay, as at **32**.

It is recommended that the lip or open end **23** of the gas burner be recessed within the wall of the firebox leaving a space anterior to the burner, which is shown as at **33**. This space may be lined with refractory material, and the overhanging or surrounding walls of the space will serve to prevent unnecessary heating or burning of the open end or lip of the burner.

The firebox **34** may be any form of fire chamber that the situation requires, and it may be constructed in any manner suitable to the purposes to be served. It is to be noted, however, that when my burner is used, and my method is practiced, that this fire chamber need not be supplied with a conventional stack. Only a vent of suitable and proper size is required for the escape of products of combustion. The operation of my burner does not depend on the draft from a conventional smoke stack or flue, as is the case with conventional burners.

One end of the air duct extends out of the wall of the fire chamber, and such part of the duct may have attached thereto a suitable air supply unit **35**, which may consist of a blower fan or any other suitable type of air mover. The fan may be driven with any form of motive power desired. Usually an electric motor **38** is employed for this purpose, and the electrical lead **37** furnishes power to the motor.

An adjustable damper **36** may be provided on the housing of the air supply unit **35**. This damper may be used in regulating the amount of air moved inwardly by the blower.

Gas may be supplied to the gas chamber **11** through gas supply pipe **30** by manipulating the gas cock **39**. Manual control of the gas supply is optional, however. Mechanical controls may be supplied as desired, and these may be operated electrically if desired.

A gas pilot **40** may be employed with my burner, to facilitate ignition when the main gas supply is turned on. The mouth **41** of the gas pilot is usually placed in the protected passage **42**, so as to remove it (as far as reasonably possible) from the corrosive effect of flame. The gas pilot shown as at **40** is a simple form of pilot, which may carry a manually operated gas cock. However, any suitable pilot device may be employed.

Another form of gas pilot is shown as at **43**, which may be provided with the electrode **44** for igniting the pilot.

A special type of burner mounting box **45** may be arranged to support the burner when installed in any type of firebox. Other types of mounting may be employed, as is found suitable. A simple steel plate may be built into the wall of the firebox, or attached thereto, and the burner supported thereon through an opening or hole made therein to receive the mouth of the burner.

One may provide mounting lugs **46** to be bolted to whatever form of burner mounting is employed. Holes **47** may be provided through the free legs of the lugs to receive bolts or cap screws **48**. Such bolts or screws also may pass through the wall of the mounting box **45**. Any other form of fastening may be employed.

When lugs **46** are provided on the burner, they are usually mounted on the outer wall thereof, as on the outer wall of the gas chamber, and secured thereto with any suitable means, such as welding **49**.

An electric lead **55** may be arranged to the gas control unit, which may be made responsive to switch **56**; and the main controller unit **57** may have any number of different circuits leading thereto to effect whatever controls are desired.

The main gas valve control is shown as at **60**, and the gas supply control unit as at **61**, while the throttle valve is shown as at **62**.

Gas flutter valve **63** is provided with an operating arm **64**; and air flutter valve **65** is provided with an operating arm **66**; and both of these arms have common linkage **67** (connected between members **64** and **66**).

The main relay unit is shown as at **68**, the main gas supply line as at **70**; and the pilot valve **71** is provided with ignition electrode **72** and flame control **73**.

The items of gas and air control thus briefly mentioned

are more clearly set forth in the diagrammatic sketch making up Fig. V. Such arrangement is conventional.

Surface orifices **22***a* lead directly into vacuum areas; and surface orifices **22***b* lead into segments of the air stream located between the gas supply fingers.

Vacuum areas **50** are induced on the anterior faces of the shorter gas supply fingers; and like areas **51** are induced on the anterior faces of the longer gas supply fingers. There are no differences in these vacuum areas, except that the area is slightly more elongated on the anterior face of the longer fingers.

These fingers may take any suitable form, typical of which three forms have been set out in Fig. VI. Finger A is a round hollow tube; finger B has an arcuate face receiving the force of the air flow, and its opposite or anterior face is substantially flat; and finger C may be arcuate on its backside and may have a crease or trough on its anterior face. The anterior faces of all of the fingers mark the region where intense turbulence is found. Hollow fingers may be so shaped as to create any turbulence desired.

Segments of the air stream defined by spaced gas supply fingers are shown as at **52**; while segments **53** of the air stream are those defined by spaced gas supply fingers of equal length, and further defined by a gas supply finger of shorter length arranged between a pair of longer fingers.

From the foregoing, it will be seen that all regions of the air stream are fed with gas, the orifices delivering which are so spaced and located as to effect the best possible distribution of gas within the air stream; and the areas of turbulence cause the complete mixing of these intermingled streams of gas and air.

For purpose of illustration only, and for no other purpose, I set out herewith some relative measurements as to one form of suitable air duct and the gas ports supplying gas thereto, which are illustrated in Fig. III. In a burner having an air duct of the size of a standard six inch pipe, there would be provided four relatively long hollow gas delivery fingers, approximately two inches in length (though they may be substantially longer or shorter); and between each of them a relatively short hollow finger, approximately one inch in length, more or less, so that there would be four of these shorter fingers, or a total of eight fingers. Then, these hollow fingers could well be made of standard one-half inch pipe, thus providing relatively great orifices.

The peripheral surface orifices, consisting of holes drilled through the wall of the air duct so as to communicate with the gas chamber, may consist of anywhere from three to seven holes or more in each arcuate segment of the air duct comprising one-eighth of its circumference. These surface orifices may be made with drills ranging from one-eighth to three-sixteenths inch in diameter (although they may be made with slightly larger or smaller drills).

Therefore, in a burner as illustrated in Fig. III, the total area of all the gas delivery ports may range approximately from one-fifth to one-third of the total cross-sectional area of the air duct, considering that the surface orifices provided between any two fingers have a total cross-sectional area amounting to approximately that of one finger.

Thus, it will be seen that when my burner is compared to the standards established by conventional burners, I provide a tremendous gas orifice area as it is related to the area of the air stream; and when it is considered that the mass of air in relation to the area of the air stream may vary greatly, and the volume of gas may also vary in proportion thereto, it is to be realized that the area of the gas orifices has no apparent relation to the capacity of the burner, or to the volume of gas that may be employed in combustion. This is explained by three factors, present in my burner, which are absent in conventional burners. They are the practical absence of gas pressure as a factor, and the presence of a moving stream of air of appreciable velocity, and the turbulence resulting from the peculiar construction of the burner. The modus operandi of my burner is the moving air stream.

The practure of my method of efficient combustion and the operation of my burner is simplicity itself. Assuming that the burner is properly installed, the operator will see to it that the pilot is lit. Usually the pilot remains lighted at all times, even when the burner is shut down. The pilot is adjusted to maintain the flame required for lighting the main burner, and it is usually left that way. The pilot must be fairly substantial in its flame size in order that the draft of the main burner does not extinguish it at any time.

The operator would open the air damper **36** to that position which is proper for a normal supply of air, and thereafter he would operate the switch on the motor to start the blower and create a flow of air through the burner. Usually this flow is maintained momentarily to start movement in the firebox and clear out the stack. Then the main gas cock **39** is manually operated, usually to a predetermined degree of opening, which may be marked.

The train of air flowing through the burner is then impregnated with gas flowing from the gas chamber into the main air duct. Thereupon the gas thus supplied becomes co-mingled with air in the proper mixture to support efficient combustion. The burner then is left with the gas cock and air damper in operating position; and the manual operation of this burner is thus completed.

As the load demand makes necessary, gas may be increased or decreased, and likewise the air supply.

The air stream leaving the blower proceeds to flow unobstructedly along its very central core **54**, but the greater part of the air is moved against obstructions consisting of gas delivery fingers projecting into the air stream. These fingers break the stream up into smaller streams which divide about the fingers and converge on their anterior sides in an area of turbulence resulting from these obstructions. On the anterior faces of all of these fingers there is a region of partial vacuum.

Into all of the areas of turbulence and partial vacuum gas is fed, from the gas reservoir or chamber. Some hollow gas delivery fingers, being longer than others, deliver gas deeper into the air stream, than do the shorter fingers. Gas is thus delivered into various layers of air throughout the entire stream of air.

Gas flows into the space along the anterior face of each finger from two sources. At the root of each finger there is a surface orifice from which gas flows. At the free end of each finger there is an open orifice through which gas pours into the air stream. From both of these sources gas is whipped around before the anterior face of the fingers and projected into the area of turbulence in that region, where it is thoroughly mixed with air. Surface orifices immediately adjacent the root of these fingers also allow gas to flow into the turbulent areas.

Even the peripheral areas of the air stream, moving to pass between spaced fingers, receive a supply of gas from surface orifices.

Therefore, it will be seen, that all areas of air stream, from its periphery to its core, is supplied with gas, the core receiving its supply of gas from the relatively large openings at the free ends of the longer fingers.

The movement of gas entering the air stream is largely controlled by the mass of air moving about, across and around the several gas ports, whether they be surface ports or ports in the free ends of the fingers.

Experience soon teaches the proper gross adjustment of the air intake damper adjacent the blower and of the primary gas cock on the gas supply line, so that there is sufficient air and sufficient fuel to be co-mingled to meet all conditions and requirements of heat.

Three different systems of control may be employed to regulate gas and air admitted into my burner. One is the manual control, which is selfevident, though explained briefly above.

Another system is called automatic control, by the use of which the gas and air supplies are turned off and on electrically in response to physical factors which may be used to determine the need for change, as for instance, temperature. Another factor may be time. The automatic electrical control system may be made as simple or elaborate as desired. Such systems are well known and need no further explanation.

The third method of control is the automatic modulating control, whereby the gas and air are varied, in a dual valve control, as indicated herein. Diagrammatically, such a system is shown in Fig. V. Such a system is well known in the art.

Adjustment of air may be had through the operation of the flutter valve **65** in the air duct. This valve may consist of a disc attached to a pin arranged across its median line, so that it may be operated exteriorly of the air duct. This arrangement can be made to open the air duct entirely by having the disc lay parallel to the flow of air, or it may be interposed transversely of the air duct, so as to close off the flow entirely. When the burner is operated with automatic modulating controls, this air flutter valve is installed. See Fig. V.

Also, there is a somewhat like flutter valve **63** arranged in the main gas supply pipe; and these two valves are linked together, so that they operate in unison. Electrical controls responsive to heat and/or other factors may cause the joint regulation of the gas and air supplies by the operation of the gas flutter valve and the operation of the air flutter valve. Thus a constant air-gas ratio may be maintained, to vary with heat demands.

Notwithstanding the showing of a motor driven blower for moving air through the burner, it is to be understood that any form or device for moving air may be employed in this invention.

I desire to make quite clear that the hollow fingers which feed gas into the air stream are quite distinctive in at least five particulars:

(1) They afford the relatively enormous channels and outlets through which gas may be fed into the air stream from a body of gas maintained at negligible or near-atmospheric pressure;

(2) These gas fingers may be made in any length desired, to penetrate the air stream. The penetration is not required to be of uniform depth, notwithstanding that I find it convenient to make the burner with several fingers of one depth or length and several of another;

(3) The hollow fingers are required to penetrate the air stream, so as to discharge gas inwardly of such stream. They therefore project laterally and inwardly from the walls of the duct through which air is moved. Although the burner works perfectly when the fingers are arranged at approximately a right angle relation to the axis of the air stream, it will work equally well when the open ends of the fingers are turned slightly toward the mouth of the burner;

(4) These fingers may be of any desired shape. They may be round (as shown at A in Fig. VI), polysided, elliptical, arcuate, arcuate on one side and flat on the other (as shown at B in Fig. VI), deformed, or provided with a trough-like recess on their anterior faces (as shown at C in Fig. VI); and

(5) These fingers perform the very important function of obstructing, deflecting and otherwise conditioning the air stream to create turbulence and/or vacuum-like areas therein for the purpose of effecting a more thorough mixture between gas and air.

A few typical forms of suitable fingers are shown diagrammatically in Fig. VI, wherein A discloses a very usual form of finger, it being round, and indicated as at **21**. The solid arrows show the path and progress of air which flows against the back side of the finger, passes around it, and seeks to rush, in more or less violent manner, into the area of partial vacuum **51***a*, occurring on the anterior face of the finger. Gas, indicated by broken arrows, pours out of the open end of the finger to be churned, in a turbulent manner, into thorough mixture with the agitated air.

As at B, in Fig. VI, we find a form of finger **21***b* which is arcuate on its back side and flat upon its anterior face, allowing the creation of the turbulent area **51***b*.

As at C, in Fig. VI, we find another finger, **21***c*, wherein the anterior face is recessed, and the field of turbulence and semi-vacuity **51***c* is produced.

I have disclosed method and apparatus whereby gas, offered at little or no pressure, is fed into a defined air stream, the latter being propelled or drawn to effect necessary movement, the gas moving through hollow delivery channels of relatively great size, which introduce the gas to various depths in the air stream, so that it may be drawn into areas of turbulence, provided by obstructions placed in the path of the moving air, the distribution of the gas being responsive to air movements around the conduits through which the gas is introduced to the air stream. Apparatus made in keeping with the disclosures hereinabove offered develops a high combustion efficiency, regardless of variations in gas pressure and in the character of the gas, especially the heat content thereof.

I claim:

1. The method of mixing gas and air, comprising: the provision of a flowing air stream; the provision of a body of gas arranged adjacent thereto; so dividing such air stream as to produce therein juxtaposed areas of unequal movement; creating in each of a plurality of such areas a zone of semi-vacuity adjacent an area of faster flowing air; and simultaneously feeding separate streams of gas into each such zone from a plurality of spaced discharge orifices arranged in said zone.

2. The method of mixing gas and air, comprising: the provision of a flowing air stream; creating an area of semi-vacuity so arranged in said air stream as to define a laterally disposed and elongated zone therein; simultaneously feeding a separate stream of gas into each end of said zone from a separate source immediately adjacent each such end; and the flowing of air into said zone along its elongated sides; and unobstructively flowing the gas and air together from the place of initial commingling to a place of ignition.

3. In a gas burner, a conduit adapted for the passage of an air stream therethrough; a gas chamber arranged externally of such conduit; a plurality of hollow members carried by the walls of such conduit and directed toward the axis of such air stream, the said members being adapted to allow the flow of gas from said chamber to points interiorly of said conduit in the proximity of the discharge end of said conduit; and a multiplicity of orifices so arranged through the wall of said conduit adjacent said members as to allow the flow of gas from said chamber into said conduit between said members and said discharge end, and immediately adjacent the former.

4. In a gas burner, an air conduit; a gas chamber; a plurality of hollow gas delivery fingers extending into the conduit and adapted to conduct gas from the chamber into the conduit in a common transverse plane defined within its mouth; and a plurality of orifices arranged through the wall of the conduit and adapted for the passages of gas from the chamber to the conduit anteriorly of the fingers and immediately adjacent thereto.

5. The method of mixing fluid fuel with air and burning the same, comprising: flowing a stream of air through a duct; creating a plurality of areas of semi-vacuity within said stream, in the proximity of the discharge end of said duct, said areas being in spaced relation and extending inwardly of said stream from its perimeter along a line substantially at a right angle to the longitudinal axis of said stream; simultaneously feeding plural streams of fluid fuel into each such area along such line, one such fuel stream entering each such area at the perimeter of the air stream, and another such fuel system entering that end of such area which is nearest the longitudinal axis of the air stream; discharging the resulting mixture of

fuel and air from the duct; and igniting the mixture as discharged.

6. In a fluid fuel burner, an air duct; means for moving air through said duct; a plurality of nipples arranged to extend inwardly of said duct near its discharge end; a plurality of orifices passing through the wall of the duct immediately adjacent the forward faces of said nipples; and means for supplying fuel to said nipples and said orifices.

7. In a fluid fuel burner, an air duct; a plurality of turbulence-producing diverting members arranged on a common transverse plane and extending inwardly of said duct near its discharge mouth; a plurality of fuel passageways arranged to discharge fuel anteriorly of each of said members, one such passageway being arranged in said duct immediately adjacent each of said members, and one such passageway opening from the most inward extremity of each of said members; and means for supplying each such passageway with fuel.

8. The method of mixing fluid fuel with air, comprising: laterally confining and forwardly flowing a stream

of air from such confinement; creating an area of semi-vacuity within said stream in the immediate proximity of the zone of its escape from such confinement, said area extending inwardly of said stream; simultaneously feeding plural streams of fluid fuel into such area, each such stream being fed through a separate aperture positioned within such area; and discharging the resulting mixture of fuel and air through said zone.

References Cited in the file of this patent

UNITED STATES PATENTS

1,395,139	Porter	Oct. 25, 1921
1,547,381	Golsan	July 28, 1925
2,113,426	Engels	Apr. 5, 1938
2,116,096	Caldwell	May 3, 1938
2,222,822	Nordensson	Nov. 26, 1940
2,269,699	Stoecker	Jan. 13, 1942
2,353,865	Armstrong	July 18, 1944

FOREIGN PATENTS

23,350	Great Britain	Oct. 15, 1914