

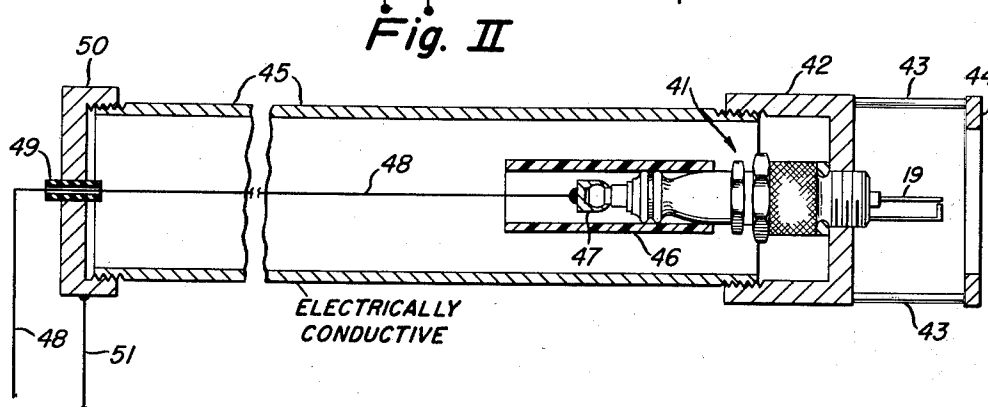
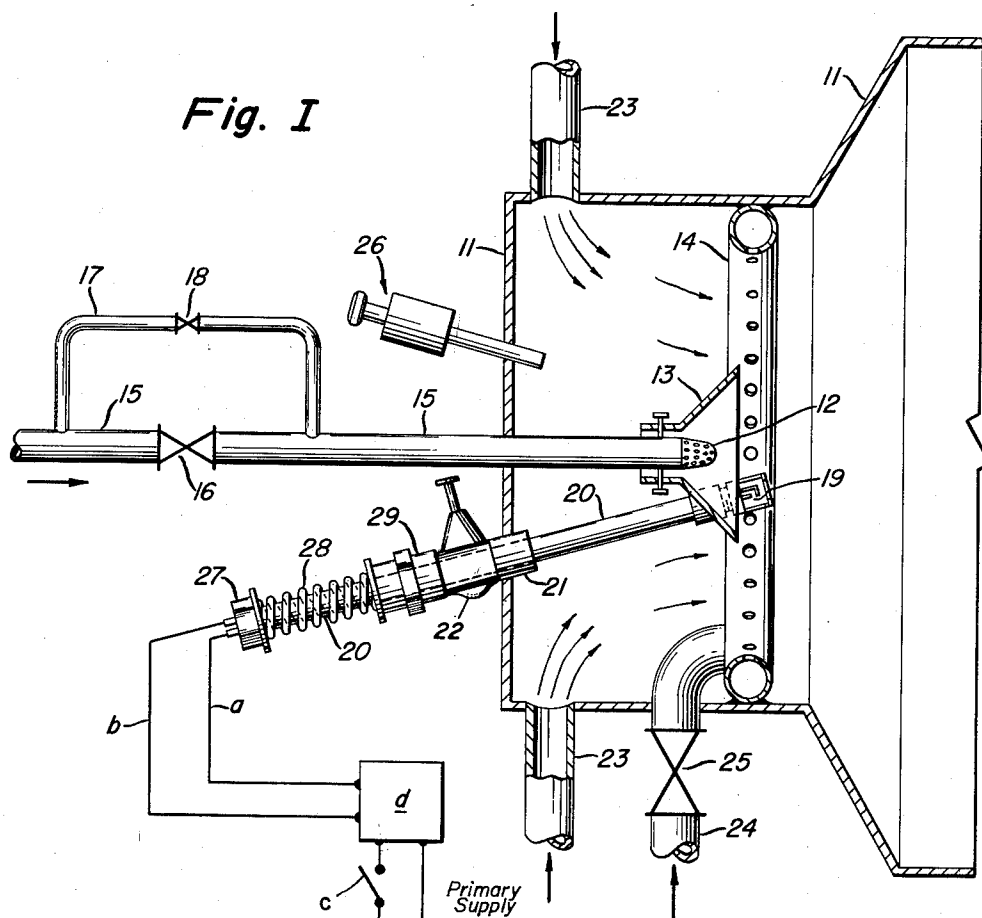
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BURNER IGNITER SYSTEM

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BURNER IGNITER SYSTEM

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This invention relates to a process and apparatus for the ignition of fuels at burners in furnace enclosures. More particularly, this invention relates to the ignition of fluid fuels fed to burners in enclosed air-heater furnaces in the presence of a high velocity air stream.

Furnaces employing fuel burners positioned in enclosures are widely used in petroleum refineries and throughout other industries. The burners of such furnaces are fed by fluid fuels which are burned in the presence of air and often must be ignited in the presence of a high velocity air stream. For example, direct-fired air heaters are provided on fluid catalytic cracking units in petroleum refinery operations for use during start-ups to heat the cracking unit regenerator vessel and catalyst bed. The heaters generally operate at pressures in the range of 10-25 p.s.i.g. above atmospheric pressure. The pressures are created by an air stream flowing at high velocity from an air compressor into the heater. The hot gases from the combustion zone of the heater combine with another stream of air and the mixed stream is used to heat regenerator vessels and/or catalyst beds. In such operations it is important that combustion is maintained at all times when the fluid fuel, e.g. fuel gas, is entering through the burners; otherwise the unburned mixtures of fuel gas and air could quickly create an explosion hazard in the air heater, regenerator vessel and connecting piping. Costly delays of one or more shifts and the risk of filling the air heater with an explosive mixture have been encountered during start-ups because of difficulty in lighting the air heaters. The normal procedure for lighting the air heaters is to use an ignition device to ignite a pilot burner which in turn ignites the main burner. The pilot burner and the main burner are often positioned in the high velocity air stream to assure heating of the air stream particularly by the main burner. Although the pilot burner is generally sufficient to ignite the main burner much difficulty has been encountered in igniting the pilot burner. Increasing the amount of fuel to the pilot burner results in increased fuel to air ratio in the enclosure and the fuel to air ratio may approach or exceed the lowest combustible fuel to air ratio in the furnace enclosure. Such conditions may readily result in explosion, e.g. as from attempting ignition of the pilot burner under such conditions, endangering lives of personnel. Such explosions are also very harmful to equipment, often necessitating complete replacement of the furnace and nearby process equipment.

Heretofore, various methods and devices have been proposed for igniting such burners. One of these, now in commercial use, employs a flame front traveling in a conduit from a point of ignition of fuel outside the furnace to within the furnace for the purpose of igniting the pilot burner. In such a system it is intended that a flame, obtained by ignition of a small amount of gas-air mixture, within the tube, be propagated into the vicinity of the burner by traveling through the tube from outside the furnace and would result in a small flame at the outlet end of the tube located close to the pilot burner. The small flame is intended to ignite the pilot burner. However, the small flame, or igniter flame, has been difficult if not impossible to establish and fuel to the pilot burner has sometimes been turned on at the same time that an attempt is made to propagate the small flame in the tube so that a single flash of flame might ignite the pilot burner adjacent the end of the tube. A number of ignition trials

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have often been necessary. With only a short delay between trials, fuel from the pilot burner mixing with the air flowing into the furnace, even though generally maintained at a low rate during such ignition, can result in a combustible or explosive mixture throughout most of the heater. If such fuel mixture is not purged from the heater between ignition trials, dangerous conditions exist. In addition to explosion hazards, the lack of dependability of such prior art systems makes them unsatisfactory in many uses.

Other devices also have disadvantages in addition to lack of dependability. Ignition elements positioned close to burner ports often are damaged by debris from combustion or by over heating and also may not ignite properly until a dangerously explosive mixture of gases is formed in the heater in the furnace enclosure.

I have now provided a furnace ignition system which is dependable even in igniting burners in the presence of a high velocity air stream. The igniter system of this invention comprises a furnace of the type which uses a fluid fuel charged to a burner in a furnace enclosure in the presence of an air stream flowing at a high velocity or rate of flow, through a burner feed line which is provided with a valve means; in combination with the feed line and burner, there is provided a conduit for charging fluid fuel to the burner, the conduit having sufficient restriction to maintain a ratio of fuel to air in the furnace enclosure below the minimum combustible fuel to air ratio when the valve means of the burner feed line is in closed position; and in combination with the conduit and burner, an electrically operated ignition element adapted for continuous activation is positioned adjacent ports provided on the pilot burner.

I have also provided an improved electrically operated igniter device comprising an electrically operated igniter element capable of continuous activation or energization, a heat resistant elongated tubular mounting means adapted for carrying the igniter element, shield means carried by the mounting means and positioned to protect the igniter element from falling debris or the like, and means for continuously energizing or activating the ignition element.

In the method of using the igniter system provided herein, while air is charged to the furnace at a high velocity, the igniter element is positioned adjacent the fuel ports of the pilot burner and the flow of fuel to the pilot burner is directed through and restricted in a by-pass conduit so that a fuel-air mixture, having a ratio of fuel to air below the lowest combustible ratio, is fed into the furnace enclosure; the igniter element is then energized for continuous operation until the ignition of the fuel at the burner is effected.

My invention will be more fully understood with reference to the following description.

FIGURE I is an elevational view, partially in cross-section, showing an embodiment of the igniter system of this invention.

FIGURE II is an elevational view, partially in cross-section, showing an electrically operated igniter device in accordance with one embodiment of this invention.

With reference to FIGURE I, mounted through wall 11, the wall of a furnace enclosure or furnace chamber of an air heater, is burner feed line 15. Pilot burner 12, having fuel ports, is mounted at the end of burner feed line 15 and within the furnace enclosure or furnace chamber defined by wall 11. Diffuser 13 is provided adjacent to burner 12 for diffusing the flame of burner 12 toward the fuel ports of main ring burner 14. Diffuser 13 should permit flow of air, entering the furnace chamber through air ports 23, to pass over burner 12. This may be accomplished, for example, by perforations in the diffuser or by spacing the diffuser from fuel feed line 15. Fuel feed

line 15 is equipped with feed line valve 16 which is capable of closing to stop flow of fuel through fuel line 15. Fuel line 15 is also provided with by-pass conduit 17 which is preferably of smaller diameter than fuel feed line 15. Conduit 17 is equipped with a means for regulating flow therethrough, such as for example by-pass conduit valve 18. By-pass conduit valve 18 is adjustable to restrict flow through conduit 17 as will hereinafter be more particularly discussed.

Electrically operated igniter element 19 is attached at one end of heat resistant elongated tube 20. Tube 20 is a mounting means for the igniter element. The igniter element is preferably either a spark igniter or a glow coil. Tube 20 contains electric leads *a* and *b* from igniter element 19. Tube 20 may be electrically conductive and may form part of one of the leads *a* and *b*. The igniter element is energized or activated by means of an electrical source such as ignition transformer *d* supplying electrical energy through leads *a* and *b* when switch *c* is in closed position. Tube 20 is mounted through wall 11 by a mounting means such as tubular receptacle 21 in which tube 20 is slide fitted. Gate valve 22 is provided on receptacle 21 to permit insertion and withdrawal of the igniter device, including tube 20 and element 19 through the furnace wall. Receptacle 21 is also provided with packing gland 29 to provide a seal around tube 20 for prevention of gas leakage from the furnace enclosure. At the other end of tube 20, cap 27 is provided, through which leads *a* and *b* protrude. Between cap 27 and receptacle 21, there is provided spring means 28 urging cap 27 away from receptacle 21. Spring 28 constitutes a means for retracting element 19 from the vicinity of burner 12 after ignition to prevent damage by overheating. Gate valve 22 is closed down on tube 20 and, with packing gland 29, holds the igniter device, including tube 20, igniter element 19 and the leads, in place during the ignition process; simply by opening gate valve 22, the igniter element is urged away from the burner and gate valve 22 may again be closed to clamp tube 20 and hold the ignition device away from the combustion area. Where spring 28 is omitted, the ignition device may be withdrawn manually. Hydraulic means or other means may also be employed for inserting and withdrawing the ignition device.

Additional means for holding the igniter device in position may be provided in lieu of gate valve 22.

Further, a lensed observation tube 26 may be provided in wall 11 and used to observe the ignition process during operation of the ignition device. Such observation tubes are commonly known as "peep holes" and are well known in the art.

Now turning to FIGURE II, the igniter device therein illustrated is a device capable of insertion and withdrawal through the packing gland, gate valve and receptacle illustrated in FIGURE I. The igniter device is constructed of an elongated heat resistant tube 45 having cap 42 on one end and cap 50 on the other end. Cap 42 constitutes the mounting means for the igniter element and carries spark plug 41 which is the igniter element in this embodiment. Spark plug 41 may be for example, an internal combustion engine spark plug such as Champion No. 45, mounted with gasket. Cap 42 also carries projections 43 which support ring 44 and the projections and ring constitute the shield protecting the electrodes of spark plug 41 from debris and the like. Spark plug 41 is provided with terminal cover 46. The terminal cover may be composed of silicon-neoprene, porcelain or other material having good electrical insulating properties, to prevent shorting the spark plug. The silicone-neoprene materials useable as terminal covers are available commercially, for example as a double layer material having one layer of silicone rubber-covered glass fiber covered with another layer consisting of neoprene (polychlorobutadiene). The terminal cover is advantageously composed of such an electrical insulating

material which is also heat resistant. Spark plug 41 is also provided with spark plug lead cap 47 for completing an electrical contact between lead 48 and the inner connection of the spark plug. Lead 48 is attached to spark plug lead cap 47 and protrudes through cap 50. At its protrusion through cap 50, lead 48 is carried by insulator 49 to electrically insulate the lead from cap 50. If cap 50 is non-conductive, insulator 49 is not necessary. Lead 48 is suspended away from the walls of tube 45 within tube 45 by slight tension, or packing or the like may be provided to insulate the lead from the wall of the tube. Lead 48 may be an insulated electrically conductive wire and the electrical insulation provided throughout should be heat resistant. Lead 51 is attached in electrical connection to cap 50. Cap 50, tube 49 and cap 42 are all composed of electrically conductive material and constitute a part of the electrical lead from one electrode of spark plug 41. Leads 48 and 51 are placed in circuit with a switch and electrically energizing means such as a power source (not shown). Lead 51 may be attached to cap 50 by any means known to the art, i.e. screw clamp, weld or the like. A convenient method of attaching lead 51 is to place the lead within cap 50 before screwing cap 50 onto tube 45. As cap 50 is then screwed onto tube 45, lead 51 becomes compressed within the threaded joint and completes electrical contact. Other means for attaching leads are well known in the art.

In operation with reference to FIGURE I, pilot burner 12 is ignited by positioning igniter element 19 adjacent to the fuel ports of burner 12 in a position corresponding to a fuel and air mixture having a ratio above the lowest combustible fuel to air ratio. Such a mixture is obtained close to the ports of burner 12 by closing valve 16 and lessening the flow of fuel to the burner via valve 18 and/or conduit 17. Switch *c* is closed and igniter element 19 is thereby continuously energized igniting the fuel and air mixture adjacent burner 12. After burner 12 is thereby ignited, burner feed line valve 16 is opened for full flow of fuel to the burner. Pilot burner 12 may then be used to ignite main ring burner 14 which is supplied with fuel through supply line 24 and valve 25. During the ignition process, air is flowed through port 23 into the furnace enclosure at a high rate of flow. The operation of the igniter device employing the spark plug as illustrated in FIGURE II is evident from the above disclosures, i.e. the spark plug is continuously actuated by closing an electric circuit during the ignition procedure. After ignition of the burner, the igniter device may be deactivated by breaking the electric circuit.

The fuel which may be used to supply the pilot burner during the ignition process may be any fluid fuel and is preferably the fuel which is to be burned at the main burner. Such fuel may include liquids such as oil, kerosene, etc., pulverized coal, hydrocarbon gases, or the like. Where normally liquid or pulverized solid fuels are used, the fuel may be atomized prior to its introduction through the burner ports and such atomization may conveniently be achieved with steam. Normally gaseous hydrocarbon fuels are preferred. The amount and rate of flow of fuel used during the ignition procedure depends upon the amount of air flowing through the furnace and further depends upon the lowest combustible fuel to air ratio of the particular fuel used. The fuel should be used in amounts below the amount necessary to provide a combustible fuel to air ratio throughout the furnace enclosure with reference to the amount of air flowing through the furnace enclosure within a given amount of time. For example, if a 2 volume percent mixture of a fuel with air is the lowest amount of fuel which will provide a combustible mixture of fuel with air, then the rate of fuel flow should be regulated below 2 volume percent, based on the amount of air entering the furnace chamber.

Even with the below minimum combustion ratio of fuel to air entering the furnace chamber, there is an

area of combustible fuel and air mixture near the burner ports. The reason for the existence of this area is that the fuel is not immediately dispersed or carried throughout the furnace but the concentration of fuel within the furnace chamber is greater at the burner ports. The igniter element is positioned within this area of combustible air and fuel mixture, preferably within an area defined by a diffuser, during ignition procedure and may be withdrawn after ignition is complete. During the ignition procedure, the ignition element is continuously energized and is continuously capable of igniting a combustible fuel and air mixture. As more fuel is introduced through the burner at a very low rate, the area of combustibility proceeds slowly outward from the burner. The area of combustibility is advantageously partially enlarged by the diffuser and it is therefore preferred to employ a diffuser adjacent the burner ports. In a short time, the area of combustibility coincide with the position of the igniter element and ignition occurs. It is important to note, in order that the process may be more fully understood, that the area of combustible fuel and air mixture, where ignition does not occur, proceeds beyond the igniter element and the mixture adjacent the igniter element may become too rich for effective ignition. However, because the igniter element is capable of continual operation, the combustible mixture is ignited without failure. Also, the lower flow-rate through the by-pass conduit maintains a combustible mixture at the burner for a longer time, aiding ignition.

Hereinabove and hereinafter, the terminology "lowest combustible fuel to air ratio" or similar terminology is used. Such fuel to air ratios may readily be determined by means known to the art for each individual fuel. The ratio defines the minimum amount of fuel mixed with a volume of air, which mixture will support or permit combustion. Such ratio varies from fuel to fuel, varies under pressure, varies with temperature, etc. In the present invention sufficiently small amounts of fuel are used during the ignition of the pilot burner so that the fuel air mixture throughout the furnace enclosure is maintained below the lowest combustible fuel to air ratio.

The by-pass conduit, such as is illustrated in FIGURE I is provided with a valve to regulate flow to the burner during ignition of the burner. The valve has proven very satisfactory in that it provides variance in the amount of flow obtained. The desired rate of flow may depend on the fuel used, different fuels forming different ratios in combustible mixtures with air. However, the valve in the by-pass line may be eliminated and the size of the by-pass line alone may be used to regulate flow to the burner during ignition. Also the by-pass line may be replaced with an orifice, such as a fixed orifice. Other means for restricting flow are well known. The valve is preferred because it permits use of fuels having broader ranges of lowest combustible fuel to air ratios in that the flow of fuel can be controlled, resulting in control of the fuel to air ratio in the furnace enclosure or chamber.

The igniter element may be any electrically operated igniter or ignition element adapted for continuous activation. Such elements are capable of continuous energization when positioned adjacent the ports of the pilot burner in the presence of high velocity air stream and in the area of combustible fuel and air mixture. The igniter element is preferably of sturdy construction and should be removable from its mounting so that it may be cleaned, replaced, or tested as necessary. Although a spark-producing element e.g. a spark plug, is the preferred igniter element, almost equally advantageous is an electric glow coil or glow wire. When using an electric glow coil such as a 6 volt cigarette lighter the ignition transformer is replaced with a 6 volt power source, e.g. a 6 volt storage battery capable of activating or energizing the glow coil. Such low voltage glow coils have one advantage in that they may greatly lessen the tendencies

of electrical break down of insulation of lead wires from the igniter element.

The igniter element may conveniently be tested by removing it from its mounting and, in turn, mounting it in a small enclosure under pressures of 10 to 50 p.s.i.g. above atmospheric pressure. The igniter element is then energized and is observed through a translucent window of the enclosure to visually determine its ability to function.

The shield used to protect the igniter element should be permeable to the passage of gases, but should be of sturdy construction to protect the igniter element from damage by falling debris. It is also advantageous to construct the shield in such a manner as to permit viewing of the igniter element through a "peep hole" when the igniter element is in place and functioning adjacent the burner ports.

The ignition transformer used with a spark ignition igniter has an output of at least 2000 volts and preferably from about 8,000 to about 20,000 volts. The gap of the spark plug depends somewhat on the ignition transformer output and should be between about $\frac{1}{32}$ " and $\frac{1}{8}$ " and is preferably about $\frac{1}{16}$ ". The ignition transformer, or the battery in case of a glow coil or any other power source used, should be capable of continuously energizing the ignition element.

In the preferred embodiment, the igniter element is positioned within the conical area defined by extending the diffuser plate and adjacent the burner ports and is retractable therefrom after ignition is complete. The means for retracting the igniter element are not intended to be restricted to the spring means described above. The igniter element and mounting therefor may be manually retractable, may be retracted by gear arrangements, hydraulic means, solenoid means or the like. Other means for retracting the igniter element will be obvious to those skilled in the art. It is not necessary that the igniter element be completely withdrawn from the furnace enclosure and the igniter element may be retracted only from the combustion area to prevent damage and may still be retained within the furnace enclosure. However, the igniter element should be capable of withdrawal from the enclosure for purposes of cleaning, replacement, testing or the like.

The igniter system, electrically operating device and method of this invention were tested in a pilot burner of an in-line air heater used on a fluidized catalytic cracking unit. A prior art igniter device was replaced with the system of this invention for testing. As a preliminary observation, the prior art device employed an external spark plug to establish a flame front which it was intended would rise through a tube to the pilot burner and ignite the burner. About 1.2 volume percent of a propane pilot burner gas based on total air flow was found necessary for start-up using the prior art device. Performance of the prior art system was generally unsatisfactory in that long delays in achieving ignition, sometimes created due to the inability to maintain the rising flame front throughout the length of the tube and due to inability to co-regulate flame front reaching the burner end of the tube with a combustible mixture near the burner. Each time a new attempt at ignition was made, a new flame front had to be established. Also, for the purpose of assuring safety in ignition, it was often necessary to purge the furnace of propane gas to lessen explosion tendencies established by accumulation of near-combustible mixtures within the furnace.

After installation of the present ignition device, a start-up was accomplished using only 0.4 volume percent of the propane pilot burner gas based on volumes of air entering the furnace enclosure. The lower explosive limit of the propane pilot gas was estimated at about 2.0 volume percent at 300° F. and 10 p.s.i. above atmospheric and about 1.0 to 1.7 volume percent at 600° F. and 10 p.s.i.

above atmospheric. Thus it is evident that the 1.2 volume percent necessary for start-up of the prior art device dangerously approaches the lower explosive limit of the propane gas and, at 600° F. and 10 p.s.i. above atmospheric, actually falls within the range of the lower explosive limits for the gas. Because the device of this invention operates using sufficiently low rate of fuel flow so that the fuel to air ratio falls below the lower explosive limit in the furnace enclosure, a greatly increased degree of safety is achieved.

In addition to improved safety, the present system provides increased accuracy in ignition. Actual plant start-ups were attempted with the system and each one was immediately successful. In each start-up the system of this invention permitted the elimination of the use of excessive gas rates to the pilot burner during ignition of the pilot burner but also permitted use of full pilot flow after ignition. In the start-ups, the furnace ignition system provided herein was found to be effective under pressures as high as about 50 p.s.i.g. above atmospheric, created by a high velocity air stream of about 118,000 s.c.f.h. of air flowing through the combustion chamber. In one successful start-up, the propane fuel gas flowed through the by-pass line and into the pilot burner at 500 s.c.f.h. (about 0.4 volume percent based on the air flowing at about 118,000 s.c.f.h.) and the lower flammability limit of the fuel was 2% by volume in air.

Using a refinery fuel gas having a lower combustible limit of about 4.0% in air as a pilot burner fuel it was found that less than 0.2% by volume based on air can be used when employing the present ignition system.

In view of the start-ups discussed above and in view of experimentation on fuel-air mixtures in the presence of high velocity air streams and pressures created thereby it has been found that the ratio of fuel to air used during start-up with the herein described device should be from about 2% to about 90% and preferably from about 5% to about 50% of the lowest combustible fuel to air ratio. Air rates of flow are usually greater than about 50,000 s.c.f.h. and may be as great as about 2,000,000 s.c.f.h. or greater and although pressures created within air heaters are generally in the range of from about 10-50 p.s.i.g. above atmospheric, higher and lower rates of air flow are intended when using this invention. The system, device, and process of this invention are particularly useful for ignition of burners in the presence of air flowing at rates of from about 2 to about 200 feet per second or greater, and even more advantageously at rates above about 10 feet per second.

It is evident from the foregoing that I have provided an improved system and method for ignition of fuel and air mixtures in furnace enclosures, and particularly under pressure in the presence of high velocity air streams.

I claim:

1. In an air heater furnace chamber in which the pilot burner is positioned in a current of a large volume of air charged to the heater furnace at a fast rate of flow suf-

ficient to inhibit ignition of fluid fuel adjacent to the ports of said pilot burner and which includes a fluid feed line to said burner and a valve means in the feed line capable of closing to prohibit flow of fluid fuel through said feed line and capable of opening to permit a sufficient amount of fluid fuel to flow through said feed line and from said ports into said chamber to form throughout said chamber a mixture of said fluid fuel and air in an explosive fuel-to-air ratio, the combination with said fuel feed line of a restricted conduit in parallel flow relation to said valve and adaptable to by-pass said valve means, said restricted conduit adapted to decrease the volume rate of flow of fuel to said burner to a volume rate of flow based on said large volume of air to from about 2 to about 90% of the lowest combustible fuel to air ratio, an electrically energizable igniter element capable of continuous energization and positioned adjacent the ports of said pilot burner and within the area of said chamber containing a combustible fuel and air mixture, shield means attached to said igniter element for protecting said igniter element from the deposition of products of combustion thereon, and means whereby said igniter element may be continuously energized when said valve means is closed and fluid fuel feed is flowing to said pilot burner through said restricted conduit, whereby said pilot burner may be ignited.

2. The combination of claim 1 including igniter element mounting means attached to a wall of said chamber and carrying said ignition element and spring means attached to said mounting means for removing said igniter element from adjacent said burner ports.

3. The combination of claim 2 wherein said mounting means is an elongated tube carried by a packing gland at the wall of said chamber and a valve means for retaining in position said elongated tube and igniter element in respect to said burner ports.

References Cited in the file of this patent

UNITED STATES PATENTS

1,625,796	Denison	Apr. 26, 1927
2,153,598	Steward	Apr. 11, 1939
2,173,766	Ramsay	Sept. 19, 1939
2,443,259	Martin	June 15, 1948
2,507,277	Smits	May 9, 1950
2,596,729	See	May 13, 1952
2,659,200	Thompson	Nov. 17, 1953
2,715,200	Flynn	Aug. 9, 1955
2,777,512	Johnson et al.	Jan. 15, 1957
2,780,062	Barrett et al.	Feb. 5, 1957
2,806,518	Poole et al.	Sept. 17, 1957
2,905,236	Wright	Sept. 22, 1959

FOREIGN PATENTS

574,674	Canada	Apr. 28, 1959
780,653	Great Britain	Aug. 7, 1957
819,256	Great Britain	Sept. 7, 1959