

Reed et al.

- [54] SMOKELESS FLARE PIT BURNER AND METHOD
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- [22] Filed: Sept. 20, 1971
- [21] Appl. No.: 182,008
- [52] U.S. Cl..... 431/5, 431/12, 431/89, 431/202, 431/285
- [51] Int. Cl..... F23d 13/20
- [58] Field of Search 431/5, 12, 61, 89, 431/202, 278, 285

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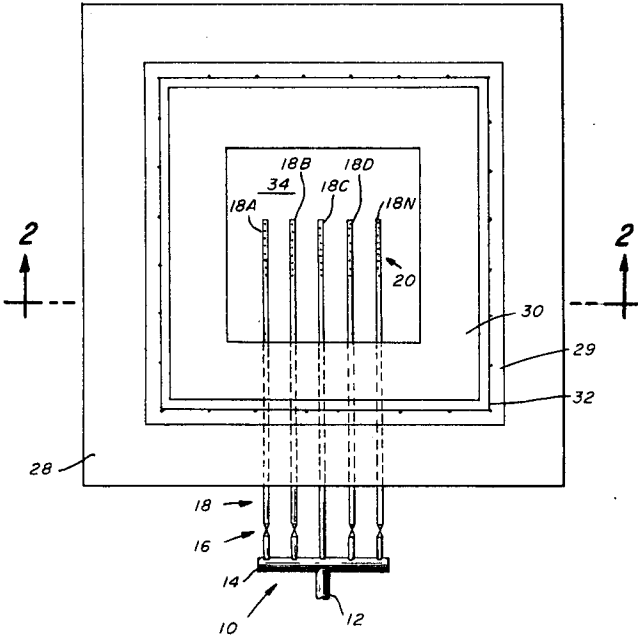
Primary Examiner—Carroll B. Dority, Jr.

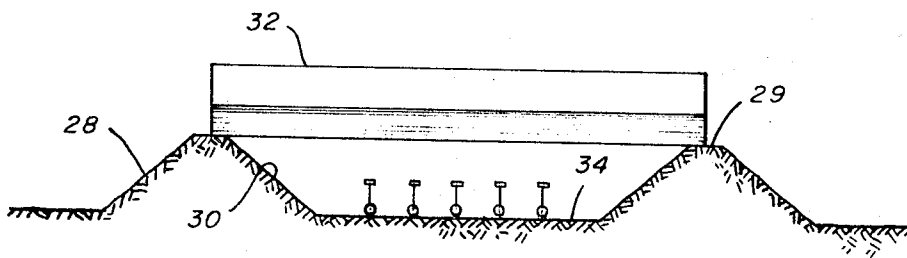
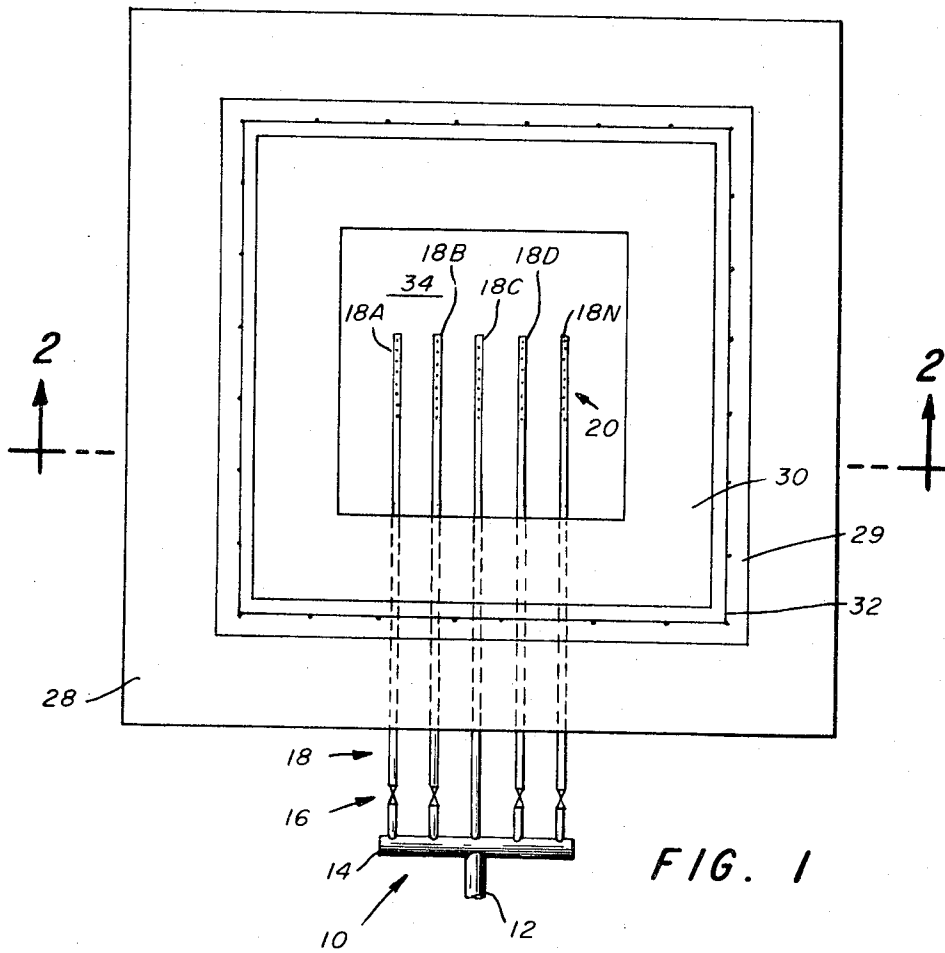
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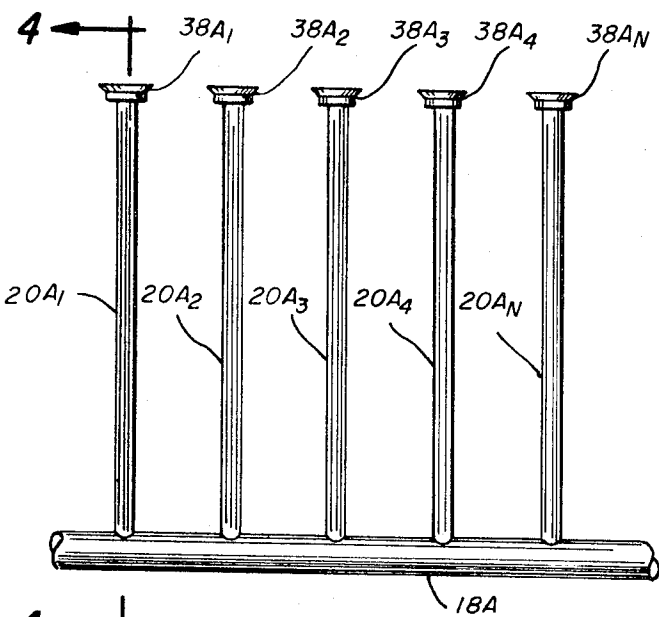
[57] ABSTRACT

This invention involves a method and apparatus for smokeless combustion of a combustible gas, which is supplied at a flow rate which varies widely from a low to a high value. It involves dividing the total flow rate through a manifold into a plurality of flow lines with each flow line providing gas to a plurality of burners. The pressure of the gas in the manifold is measured and valves in each of the flow lines are controlled as a function of the manifold pressure, so that they open, one at a time, as the flow increases, thereby supplying gas to each flow line and to its burners at a much narrower range in flow rate. Thus the velocity of the gas is always high enough to get proper air mixing and smokeless combustion.

13 Claims, 9 Drawing Figures







4 ← FIG. 3

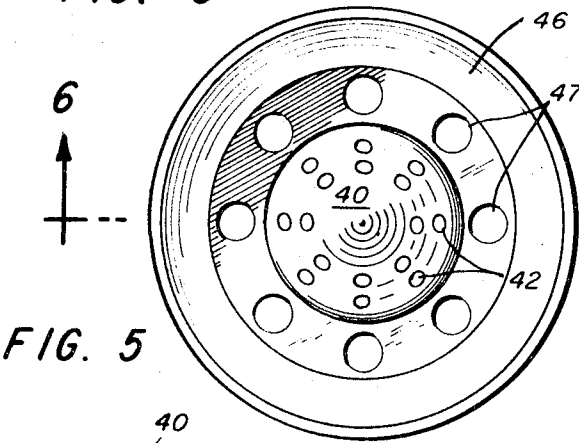


FIG. 5

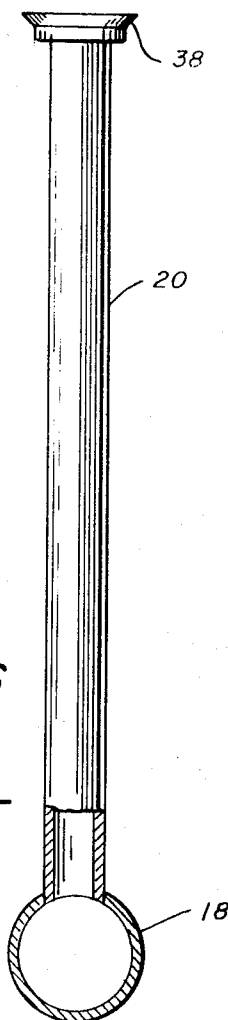


FIG. 4

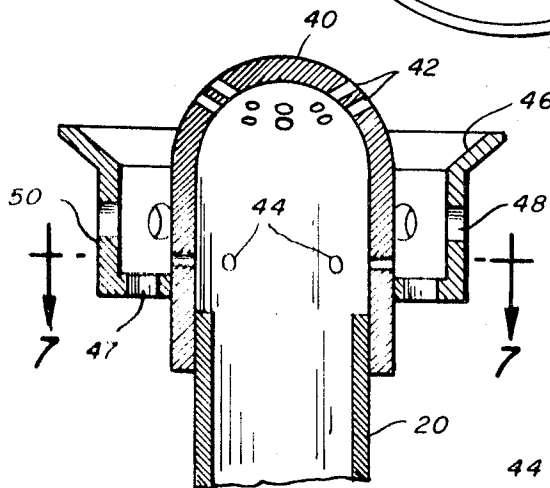


FIG. 6

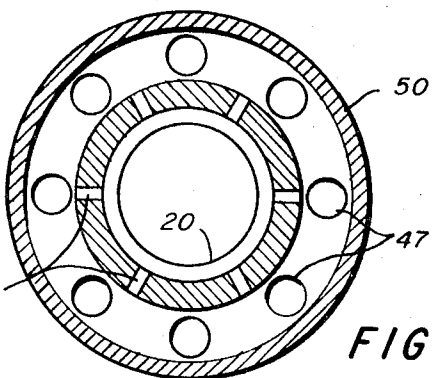
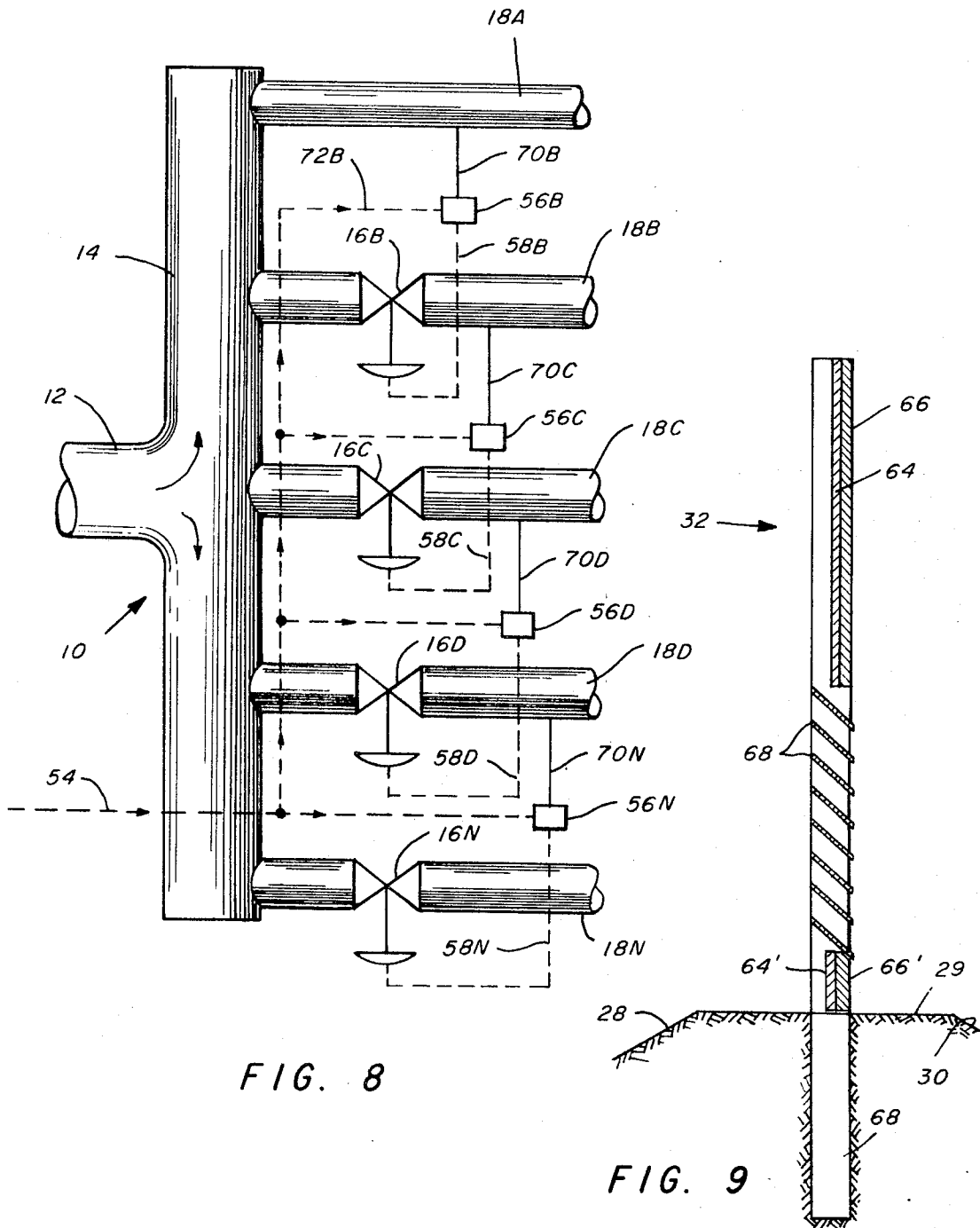


FIG. 7



SMOKELESS FLARE PIT BURNER AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention lies in the field of gas combustion and is directed specifically to the burning or flaring of huge quantities of emergency-vented, and smoke-prone hydrocarbons, so as to avoid smoke production of widely variable supply rates, from a low to a very high rate.

2. Description of the Prior Art

It has been found that hydrocarbons, when burned tend to produce black smoke as a function of the hydrogen to carbon ratio. For instance, propane will tend to produce about 8 percent carbon escaping as black smoke while the acetylenes will produce about 50 percent. In the art of burners and the burning of gases to avoid smoky flames it is necessary to have an adequate velocity of gas, so that proper induction and mixing of air will be obtained. In other words there is an optimum minimal velocity for a particular hydrocarbon and air demand which is governed by but not proportional to the weight ratio of hydrogen to carbon in the particular hydrocarbon. Although the optimum is usually at the critical (sonic) velocity state, i.e., when the absolute pressure upstream of a burner orifice is twice the value of the absolute pressure downstream, that is not limiting in this invention as substantial smoke suppression occurs at values less than critical depending upon the particular hydrocarbon. As used herein "optimum velocity" means that velocity of flow across a burner orifice for a given hydrocarbon's hydrogen to carbon weight ratio that will produce sufficient turbulence mixture with air, or other combustion supporting gases, for smokeless combustion. If the gas is supplied at such a low rate that this mixing cannot take place, then there will be smoke produced, unless a smoke suppressant such as steam is supplied. Conventionally, it takes about one-half pound of steam to burn, without smoke, one pound hydrocarbons, and in cases where the hydrocarbons burned may be as great as two hundred thousand pounds, as an example, the steam demand at 100,000 pounds represents a cost figure averaging about \$80.00. There may be as many as 500 of these relief periods per year, for example, so the annual cost of steam can be as great as \$40,000.00. It becomes important, therefore, to find a means of burning this gas without smoke in compliance with air-pollution regulations and without or at least minimal use of a smoke suppressant.

In most prior art flow systems, the huge volume of gases is vented from a single point and typically at pressures ranging from a fraction of an inch of water to just under one pound gauge. The low venting pressures are often the result of limitations in the processing system from which these gases are derived. Where a severe pressure limitation, such as this, exists there is no escape from the use of smoke suppressant. However, where venting pressures can be significantly higher, say 30 p.s.i. as an example, there is no longer need for smoke suppressant. With these pressures a high velocity flow of gas can be derived (approaching and including critical or sonic velocity) with its attendant turbulence, which permits discharge from a relatively large plurality of points in the presence of adequate air mixture with the vented hydrocarbons. Thus, burning departs from the smoke-prone, low-pressure discharge

from a single point, with very slow burning, to the extremely rapid, turbulent, combustion typical of burner practice, with lesser volumes of hydrocarbons, from a relatively large number of discharge points. Under these conditions a suppressant is not required.

However, in the case just described, there is a secondary problem of considerable magnitude in that great quantities of heat are radiated from the burning gases and means for interception of the radiation to adjacent areas, people and plant life, as well as structures, is demanded. To accomplish this, the area of burning must be largely enclosed.

The calorific value of hydrocarbon gases varies considerably. For example, methane has a heat value of 910 BTU per cubic foot, ethane has 1,620; propane: 2319; butane: 3,014; pentane: 3,714 and so on up to octane with 5,802 BTU per cubic foot. Hence, burning millions of cubic feet per hour involves a tremendous amount of heat. There is a further problem in that from 5 to 40 per cent of this heat is emitted as infrared radiation, which can travel considerable distances and still heat objects upon which it falls.

SUMMARY OF THE INVENTION

The weaknesses of the prior art and the objectives of this invention are accomplished by having a plurality of burners, some of which are burning continuously and others of which are switched in to the gas supply as the flow rate increases. Thus there is maintained at each burner a flow rate sufficient to burn the gas without smoke. The gas goes to a manifold from which a plurality of flow lines carry the gas, each to one or a plurality of burner pipes, which rise up from the flow lines and terminate in burners at their top.

One flow line is connected permanently to the manifold. The other flow lines are connected to controlled valves. The pressure in the manifold is measured and control means are provided, which selectively open one or more of these valves in accordance with the pressure measured in the manifold. Thus, as the flow rate, and therefore the pressure, increases in the manifold, a first valve is opened and there are now two flow lines carrying gas to two pluralities of burners. As the flow rate increases further, a second valve will open carrying gas to a third flow line and to its burners, and so on.

As the flow rate decreases, these valves are selectively closed and thus the number of flow lines are reduced providing sufficient flow rate for each of the burners.

The flow system is placed in the bottom of a pit surrounded by a dike. On the ridge of the dike is a metal fence adapted to shield the area around the fence from the direct luminous and heat radiation from the flames. Louvers are provided in the bottom portion of the fence in order to permit air flow into the interior of the fence, for the combustion of the gas.

It is an object of this invention to provide a system of manifold, flow lines, controlled valves, and control means for burning or flaring a large and variable quantity of hydrocarbon gases. It is a further object of this invention to efficiently burn the gas in a smokeless manner by controlling the number of burners receiving gas in accordance with the pressure of the gas in the supply line, so that a specific range of flow rates will be available for each burner. Thus, proper combustion can take place and so minimize the smoke formed.

These and other objects of this invention and a better understanding of the principles of the invention will be

evident from the following description, taken in conjunction with the appended drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 show top elevational and cross-sectional views respectively, of the burner system, the pit, the dike, and the protective heat shield.

FIGS. 3 and 4 show some detail of the vertical burner lines and burners.

FIG. 5 shows a top plan view of the burner assembly.

FIG. 6 shows a vertical section through the burner along line 6—6 of FIG. 5.

FIG. 7 shows a horizontal section through the burner along line 7—7 of FIG. 6.

FIG. 8 shows a general assembly, plan view of the supply line, the manifold, flow lines, control valves, and control means.

FIG. 9 shows a vertical section through the dike and the anti-radiation fence.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, and in particular to FIGS. 1 and 2, there are shown the overall assembly of manifold, flow lines, burners, pit, dike, and fence.

The numeral 10 generally indicates the manifold system, numeral 16 the valves, numeral 18 the flow lines to the burners.

The gas to be flared enters the supply line 12, branches into the manifold 14, and into the flow lines 18, through the dike and into the pit 34. The dike is preferably made of earth and has a crown 29 (on which a fence 32 stands) with an outer slope 28 and an inner slope 30.

The dike itself forms a very good heat and light shield, however, it is important that air be available to the burners and there is, therefore, a limit to the elevation of the dike, beyond which, it is desirable to provide a metal fence, illustrated generally as 32. The upper part carries a metal plate which will be described in more detail, and the lower portion of the fence provides louvers that will shield against direct visible and infrared radiation, but will permit air flow into the pit for the burning of the gas.

The flow lines going into the burning pit are horizontal pipes from which there are a plurality of risers 20A1, 20A2... 20AN, as shown in FIG. 3.

A burner pipe is shown in more detail in FIG. 4, which is a section taken along line 4—4 of FIG. 3. The burner pipes 20 are capped with a burner 38 which is shown in greater detail in FIGS. 5, 6, and 7.

The whole purpose of this system is to provide a plurality of points at which gas issues and at which it mixes with air in order to be burned without smoke. Therefore, the single inlet flow line 12 goes to a plurality of flow lines 18, each of the flow lines carries a plurality of burner lines. As shown in FIGS. 5, 6, and 7, each burner has a plurality of small openings through which the gas can issue at a velocity dependent upon its pressure, and so in a turbulent mixture with the air supply, will burn without smoke.

Referring to FIGS. 5, 6, and 7 the burner is in the form of a pipe cap 40 mounted on the top (as by welding) of a gas burner pipe 20. There are a plurality of openings 42 circumferentially arranged around the top of the burner and another plurality of openings 44 arranged around the side of the burner where the streams

of gas issuing from the openings 44 impinge upon the wall 50 of a burner flange which has openings 47 in its horizontal surface and a plurality of openings 48 in its vertical surface. The flange 50 flares out, 46 at the top end of the burner. FIG. 5 shows a top view while FIG. 7 shows a sectional view taken along the line 7—7 of FIG. 6.

While the particular details of the burner are not critical in this invention, it is desirable to have a flange such as 50 surrounding the burner in order to provide turbulent mixing of the gas with the air. The burners are also raised to a considerable height above the bottom of the pit, on pipes 20, so that there will be a continuing supply of air from beneath the burners, that can flow up through the openings in and around the flange 50, to mix with the gas issuing from the orifices 42 and 44 in the burner. Because of the large amount of heat which is provided by the combustion of the gas, there will be a strong rising current of air over the flame and correspondingly a large inflow of outside air through the louvers, down the inside slope of the dike, and into the pit in the area of the burners.

While not shown in the drawings, it would be clear that pilot lights will be needed that will burn continuously at each of the burners so that as the flow valves (shown in more detail in FIG. 8) are turned on, and the gas issues from the burner, there will be instant ignition and burning.

FIG. 8 shows in plan, a general view of the piping. It comprises an inlet flow supply line 12 which contains the gas to be flared. This branches into a gas manifold 14 from which a plurality of flow lines 18A, 18B...18N are connected. One of these flow lines 18A is permanently connected to the manifold without a valve, and there is a continual flow of gas through flow line 18A and into the burners lines 20. Each of the other flow lines 18B, 18C...18N have a valve 16B, 16C...16N. These are the type that can be remotely controlled by means of a pressure controller, indicated by numbers 56B, 56C, 56D, 56N.

The pressure controllers 56 are devices which are well known in the art and are available on the market. They comprise devices which have a pipe such as 70B leading into the flow line, or gas manifold, to measure the pressure in the manifold. They have an input line such as 72B which comprises a compressed air supply for the operation of the valves, and they have an outlet pipe such as 58B which is the air supply to operate the valve 16B, for example.

The controller 56B works on the basis that when the pressure as measured by line 70B indicates that the valve should open, the control air pressure in line 72B is switched to line 58B and presented to the valve 16B and this pressure causes the valve to open. Thereafter, gas will flow from the manifold 14 through flow line 18A and through flow line 18B. In the same way the controller 56C controls the valve 16C and so on.

The operation of this control system is as follows. When the gas flow rate is low, then the number of burners which share this gas should be reduced to a minimum in order that there may be sufficient gas supply to each burner to get sufficient turbulence for clean burning.

As the flow rate (or flow pressure) increases, it soon gets to the point that there is more flow than can be handled by one flow line and one corresponding set of burners. When this condition is reached, the pressure

measured by the first controller reaches a preset limit and that controller, 56B for example, switches in the valve 16B.

There are now two flow lines carrying gas from the manifold. The pressure in the manifold originally measured by the controller 56B will drop, in view of the two flow lines carrying gas. The controller is designed so that it has a drop-out or valve-closing action at a much lower pressure than its valve opening pressure so that even though the pressure in the manifold drops when the second flow line is connected, the valve will still stay open until the pressure and flow rate drop considerably. When this pressure condition arises, the controller will then close valve 16B and the remaining flow then will issue only through the flow line 18A.

Typically, the control pressures might be set, for example, as follows: For pressures of gas supply from just above atmospheric up to 10 p.s.i. gauge there is only one flow line 18A in operation. On further increase in the flow rate, or flow pressure, the controller 56B switches in flow line 18B by opening valve 16B. This doubled the flow rate out of the manifold and will drop the manifold pressure from the ten pounds per square inch at which the valve 16B opens to a value of 2.5 p.s.i.

Now as the gas flow rate increases the pressure will rise and when it increases to a value of 15 p.s.i. controller 56C will cause valve 16C to open and switch in flow line 18C. This increase of outflow will drop the manifold pressure from a value of 15 p.s.i. to a value of 6.7 p.s.i. Then as the pressure rises further, say to 20 p.s.i. the fourth valve is switched in. At this time with four flow lines the pressure will drop back to 11.3 p.s.i. approximately, and then as it increases further to 25 p.s.i., flow line 5 is connected in by opening valve 16N and the manifold pressure will drop back to 16 p.s.i.

The reason for this sequence of control is to maintain manifold pressure at a minimum of 2.5 p.s.i. At this pressure approximately 13 percent of the volume for venting at 25 p.s.i. is being discharged, in order to maintain the state of air turbulence for avoidance of smoke production. The pressures are higher in all other cases.

The velocity of discharge from pressure at 2.5 p.s.i. is essentially 17 percent of critical (or sonic) velocity for the gas being discharged. For propane, this is essentially 140 feet per second, for methane, 256 f.p.s. and for ethane, 173 f.p.s.

The pressure sensing instruments 56 will cause the valve to remain open despite the drop in pressure as they operate. When the supply volume and pressure starts to drop, the various valves will close in reverse sequence as they did in opening in sequence. The decrease and increase in flow rate may be quite rapid or it may occur over a period of approximately 20 to 30 minutes. There must be no smoking at any flow stage, therefore the controllers and the valves must operate promptly as the pressure changes.

In FIG. 9 is shown a detail of the fence and louvers mounted on the top of the dike. The fence is constructed of a plurality of pipe units 68 set into the earth, connected by vertical walls of steel 64 from the top down to an intermediate level and 64 ft. at the bottom. The bottom portion of the fence comprises a group of louvers 68 set so as to admit air into the pit. They are slightly overlapping so that there is no opportunity from the burner and flame area for luminous or infrared radiation to pass through the louver openings.

The inner surface 66 of the wall comprises refractory material which is attached to the sheet 64 and serves to protect it from the direct thermal radiation from the flame. All other parts are generally painted with aluminum paint or other reflecting coating, in order to minimize the heat absorption.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components. It is understood that the invention is not to be limited to the specific embodiment set forth herein by way of exemplifying the invention, but the invention is to be limited only by the scope of the attached claim or claims, including the full range of equivalency, to which each element or step thereof is entitled.

What is claimed is:

1. A method for smokelessly flaring a combustible gas at or above ground level which gas is supplied at a variable flow rate from a manifold into a plurality of flow lines, each flow line providing gas to at least one burner comprising the steps of:

- passing gas uncontrolled directly into a first flow line to at least one burner;
- controlling the gas flow into each of said subsequent flow lines by means of mechanical valves, each of said valves pre-settable to desired opening and closing pressures;
- separately measuring the pressure in said first flow line and in each succeeding flow line at a point downstream of each of said valves;
- sequentially controlling the gas flow into a subsequent flow line as a function of said measured pressure in its preceding flow line to maintain optimum gas velocity at each burner for proper air-gas mixing to provide smokeless combustion.

2. The method as in claim 1 including opening each of said valves when the gas pressure in said preceding flow line reaches a selected pressure P₁; and

closing each of said valves when said gas pressure in said preceding flow line drops to a selected pressure P₂, where P₂ is less than P₁.

3. A system for smokelessly flaring a combustible gas at or above ground level which is supplied through a supply line at a variable flow rate, comprising:

- manifold means for connecting said supply line to a plurality of flow lines, each flow line having a plurality of vertical burner lines, burners at the top of each burner line, said burners comprising a conduit having at least one orifice for jetting said gas into the surrounding air;
- valve means in each flow line except the first;
- means to measure the gas pressure in said manifold; and
- control means responsive to said manifold pressure to open said valves, each at a different selected pressure in said manifold to maintain optimum gas velocity at said burners for proper air-gas mixing to provide smokeless combustion.

4. The system as in claim 3 in which said control means opens a first valve at a manifold pressure P₁ and closes said first valve at a pressure P₂ and P₁ is greater than P₂.

5. The system as in claim 4 in which said control means is adapted to open a second valve to a third flow line at a manifold pressure P₃ where P₃ is greater than

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P1, and to close said second valve at a pressure P4 where P4 is less than P3 and greater than P2.

6. The system as in claim 3 including a pit in the earth into which the manifold, valves and flow lines are placed and including an earthen dike surrounding said pit;

7. The system as in claim 3 including a metal fence surrounding said burners, said fence including louvers for air flow into the burner space, said burners and said fence constructed in such a manner as to cut off luminous and heat radiation to selected areas around said fence.

8. The system as in claim 3 including at least five flow lines.

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9. The system as in claim 3 including from two to five flow lines.

10. The system as in claim 3 including at least eight burners per flow line.

11. The system as in claim 3 including from one to eight burners per flow line.

12. The system as in claim 7 including a refractory coating on at least part of the surface of said fence exposed to the radiation from said burners.

13. The method of claim 1 wherein said optimum gas velocity substantially approaches or is of critical or sonic.

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