PATENT SPECIFICATION

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(54) FLARE STACK APPARATUS

(71) We, JOHN ZINK COMPANY, of 4401 South Peoria, Tulsa, Oklahoma, United States of America; a corporation organized and existing under the laws of the State of Delaware, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention lies in the field of flaring of waste fuel gases. More particularly it concerns a flare for the complete smokeless combustion of smoke-prone waste fuel gases. Still more particularly it concerns the admixture of a second waste gas or liquid fuel as well as atomized water droplets with the combustion air prior to entering the burning zone above the burner device.

In the prior art, it is well known that steam injected into the flame zone will promote the complete combustion of the carbon supplied by the smoke-prone gaseous fuels, which might be burned in the flare. It is also known that atomized droplets of water can be injected into the flame zone to promote by their chemistry the complete combustion of the carbon in the fuel gas.

It is an object of this invention to provide a flare stack apparatus for smokeless combustion of smoke-prone hydrocarbon fuel by premixing with the pressurized combustion air, atomized droplets of water, so that the premixed water-air as it passes through the combustion zone at the outlet of the burner device, will vaporize and promote smoke-free combustion.

According to the present invention there is provided a flare sack apparatus comprising:

(a) a flare stack comprising a normally vertical cylindrical conduit;

(b) a burner device supported inside said conduit at the discharge end thereof whereby combustion occurs above said discharge end;

(c) means to supply waste fuel gas co-axially with said burner device for combustion;

(d) means to supply a normally vertical co-axial flow of combustion supporting air in said conduit past said burner device;

(e) means above said discharge end to ignite said waste fuel gas-air mixture as it is discharged from said conduit;

said apparatus additionally comprising:

(f) compressor means axially supportive within the stack to increase the flow velocity of said combustion air in said conduit;

whereby there will be turbulent mixing of said compressed combustion air with said waste fuel gas issuing from said burner device; and

(g) means to inject atomized water droplets into said conduit means upstream of said burner.

Combustion air is supplied at the bottom of the flare stack through air compressor means, so as to create sufficient velocity of air, to provide energy for complete and turbulent mixing of the air with the fuel gas issuing from the burner device, as the air passes the burner device, thereby providing an intimate mixture of air and fuel gas for smokeless combustion.

Means are provided also for injecting into the flare stack upstream of the burner device, for intimate mixing with the flowing combustion air, minute droplets of water or water vapor to be carried by the air stream into the flame zone above the combustion burner device.

Means are provided also for injecting into the flare upstream of the burner device of a second waste fuel gas, for combustion, providing an opportunity for intimate mixing of additional waste fuel gas or liquid fuel and atomized water droplets, and the combustion air, so that in passing through the flame zone there will be complete combustion of all carbon.

Means are provided also for injecting a liquid fuel in the form of fine droplets, either alternatively or simultaneously with water in the form of fine droplets injected into the air upstream of the burner device.

These and other objects and advantages of this invention and a better understanding of the principles and details of the invention will be evident from the following description taken in conjunction with the appended drawing which illustrates one embodiment of the invention, in the form of a partial cross-section.

In fuel burning devices such as flares for waste gas, the capacity of the device, or the relative ability of the device to prevent smoke emission, is governed by the effectiveness of turbulent air-gas mixture achieved by the device. Turbulence of mixture results from the expression of kinetic energy as the combustion air and gas meet, where turbulent energy is supplied by both the velocity of the gas stream at discharge for burning, and the velocity at which the air stream is moving as it meets the gas. Separate energies are additive for production of a required energy level as a total of the two. The separate energies are, according to the standard kinetic formula, $MV^2/2$, and since total energy is required for satisfactory performance, high gas pressure energy requires lesser air flow energy for production of required total energy.

Requirement for less air flow energy is more economical because less power is used for elevation of air supply pressure adequately above atmospheric pressure, in order to cause its discharge to atmospheric pressure at needed velocity, for its contribution to a required total energy state.

Discharge velocity for air is according to the square root of the pressure drop. Thus doubling velocity of discharge, requires four-times as much pressure drop. Gases burned in devices typical of this invention are generally supplied to the flare at pressures best measured as "inches water-column". One pound psi is equal to 27.7 inches of water, and one ounce pressure is equal to 1.7 inches water column. It is to be seen that, with low gas pressure, the velocity-energy of the gas stream is quite low, and in order to obtain a sufficiently great total velocity energy for smoke suppression, through properly turbulent burning, the air discharge velocity must be greater. The source of greater air discharge velocity is greater air discharge pressure, which is obtained at the cost of greatly increased air compression energy, or power cost. The prior art offers no escape from this power cost if smoke is to be suppressed. However, the apparatus of this invention provides relief to a substantial degree from power costs.

Referring now to the drawing, there is shown in partial cross-section one embodiment of the invention. A flare stack comprises typically a vertical conduit 12, which can be of any cross-section, but is preferably of circular cross-section, is provided with a burner device 16, which is supported from the flare stack 12 by means not shown, but well known in the art, such that the top of the burner is substantially at the top edge 14 of the stack 12. The stack is provided with means to support it on the ground, not shown but well known in the art. Air supply is provided through a conduit 22 which leads to a compressor device 24 which may be of conventional design. The purpose of the compressor is to provide sufficient pressure of the air, and consequently sufficient velocity of the air downstream of the compressor 24, indicated by arrows 28 issuing from the compressor, such that when the air stream reaches the burner device 16 its velocity around and through the burner elements, will be sufficiently high as to intimately mix with the gas issuing from the burner elements 16, into the flame zone 10, above the burner.

There is a device for ignition of the gas issuing from the burner device 16, which is of conventional design and is not shown but is well known in the art.

Waste fuel gases flowing in accordance with arrow 20 are carried by pipe 18 into the bottom of the burner device, and the gas issues therefrom through a plurality of small orifices, at relatively high velocity, to mix with the air as shown by arrows 30, progressing in the stack past the burner device 16. With sufficient energy in the air 30, and sufficient velocity of the gas issuing from the burner orifices in the device 16, there will be adequate mixing of the waste fuel gas 20 in the air 30 to provide smokeless combustion.

If the pressure and therefore the energy of the gas 20 is low, then additional air velocity 30 will be required to provide a sufficient total energy to get intimate mixing. Consequently, a compressor device 24 is shown in the drawing. No particular requirement as to the type of compressor is needed, except that there be sufficient exit velocity 28 to provide the mixing energy at the burner which is required for the smokeless combustion.

An auxiliary inlet pipe 31 is shown in the wall of the flare stack 12, through which water, as shown by arrow 32, is provided under pressure, so that atomization indicated by arrows 34, into small droplets of water, takes place. These small droplets will be picked up by the air stream 28, 30, and carried into the flame zone 10 where the droplets are evaporated and the water vapor content chemically enters into the combustion, to facilitate the complete and smokeless combustion of the carbon.

The location of the inlet pipe 31 can be at any point in the column of the stack 12 such as is indicated at point 36, or it can even be inserted into the air stream 26 prior to compression in the compressor 24 at point 38. In general, the point of injection of the water would be preferred at point 36 in that it would allow a longer period of turbulent mixing of the atomized water and the air prior to reaching the flame zone 10.

It is possible also under conditions where a second combustible waste gas or liquid is provided, to inject such gas or liquid as shown at 40, with or without atomized water droplets into the flare stack 12, to mix with the high velocity air 28, and be thoroughly mixed prior to passage, as shown by arrows 30, into the flame zone 10 above the burner device. Further, atomized droplets of water, can be mixed with the air supplied from the bottom of the stack 12 through conduit 38.

It will be clear also, that a third fluid such as gaseous or liquid (atomized) fuel may be supplied, such as at 36, and atomized water may also be supplied.

If the second fluid 32 or 40 is a noxious gas, or a gas for disposal by burning, it is burned as it passes through the combustion zone 10, which is caused to exist because of a pilot which is not shown, but which is located at the periphery of and immediately downstream of the top of the flare, or in any suitable location to assure ignition of the mixture of 20 and 30, immediately downstream of the burner device. Such operation increases the utility of the device through addition of this service to the otherwise normal function of smokeless burning of the waste gas 20.

If the second fluid 32 or 40 is as water droplets, or as water vapor, there is a beneficial effect in that, because of the presence of H_2O in the combustion zone, the burning of 20 is greatly accelerated, and the normal smoke emission of 20 is significantly reduced, to allow smokeless operation with less air-derived turbulence. This means less requirement for air discharge velocity 28 through compression in 24. Also smokeless operation in the burning of 20 is provided with less expenditure of power. In this case, the reduced smoking tendency is due to the endothermal chemistry of water vapor-hydrocarbon which is well known in the art of smokeless flaring of hydrocarbons.

Thus, it can be seen that the flare stack of the present invention is designed to pass air through compressor 24, to be mixed with waste gases flowing into the stack at 20, and to have water supplied at 32 to be atomized by the air, the mixture of water, air and waste gases then passing to the burner, whilst at the same time having the option of supplying a second waste gas or liquid and a third gaseous or liquid fuel as well as the required atomized water droplets.

WHAT WE CLAIM IS:—

1. A flare stack apparatus comprising:

(a) a flare stack comprising a normally vertical cylindrical conduit;

(b) a burner device supported inside said conduit at the discharge end thereof whereby combustion occurs above said discharge end;

(c) means to supply waste fuel gas coaxially with said burner device for combustion;

(d) means to supply a normally vertical coaxial flow of combustion supporting air in said conduit past said burner device;

(e) means above said discharge end to ignite said waste fuel gas-air mixture as it is discharged from said conduit;

said apparatus additionally comprising:

(f) compressor means axially supportive within the stack to increase the flow velocity of said combustion air in said conduit; whereby there will be turbulent mixing of said compressed combustion air with said waste fuel gas issuing from said burner device; and

(g) means to inject atomized water droplets into said conduit means upstream of said burner.

2. An apparatus as claimed in claim 1, including means to atomize a combustible liquid and to inject atomized droplets of said combustible liquid into said conduit upstream of said burner device.

3. An apparatus as claimed in claim 2 in which said atomized droplets are injected at the outlet of said compressor means.

4. An apparatus as claimed in claim 1 including means to simultaneously inject a combustible gas into said conduit upstream of said burner device.

5. A flare stack apparatus, substantially as herein before described with reference to and as illustrated in the accompanying drawing.

POTTS, KERR & CO.,
Chartered Patent Agents,
27 Sheet Street,
Windsor,
Berkshire SL4 1BY
— and —
15, Hamilton Square,
Birkenhead,
Merseyside L41 6BR.

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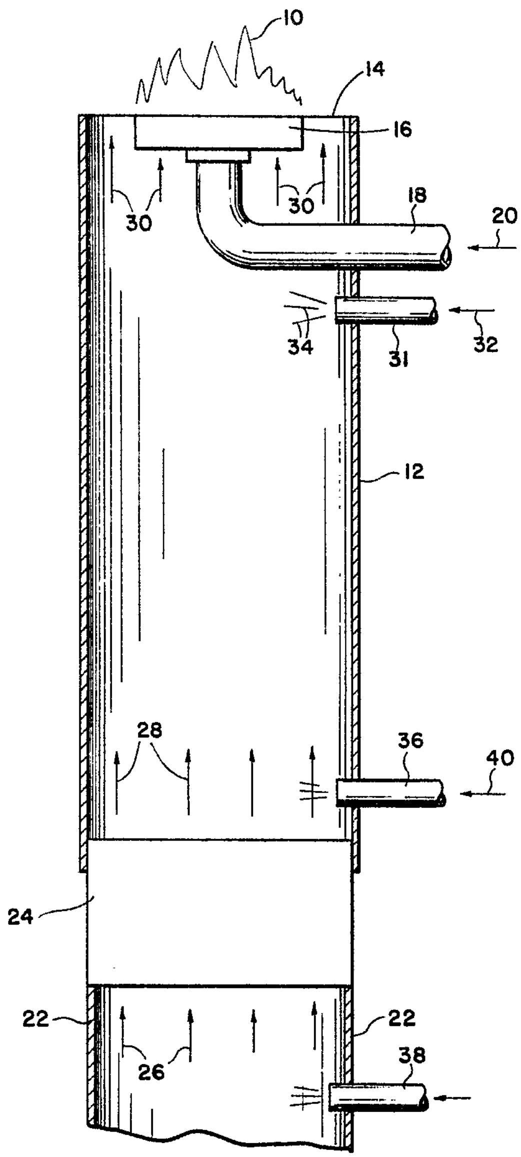
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