United States Patent [19]

Desty et al.

[11] **3,833,337**

[45] **Sept. 3, 1974**

[54] **FLARESTACKS**

[75] Inventors: **Denis Henry Desty**, Weybridge; **Christopher John Young**, Horton, both of England

[73] Assignee: **The British Petroleum Company Limited,** London, England

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[21] Appl. No.: **245,223**

[30] **Foreign Application Priority Data**

Apr. 29, 1971 Great Britain 12069/71

[52] **U.S. Cl.** **431/284,** 431/202, 239/424, 239/505, 239/571, 239/DIG. 7

[51] **Int. Cl.** **F23q 9/00**

[58] **Field of Search** .... 431/4, 5, 354, 202, 284; 239/416.5, 423, 424, 505, 506, 571, DIG. 7

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Primary Examiner—Carroll B. Dority, Jr.
Attorney, Agent, or Firm—Morgan, Finnegan, Durham & Pine

[57] **ABSTRACT**

A flare stack burner tip using the Coanda effect, the bore of the Coanda body is used as a feed line for high pressure gas and the Coanda director surface is positioned across the outlet of the high pressure gas line so as to cause entrainment of air into the fuel gas stream. The feature of the invention is a self adjusting slot between the Coanda surface and gas inlet which adjusts itself automatically to the flow rate of high pressure gas so that a substantially constant pressure is maintained.

5 Claims, 6 Drawing Figures

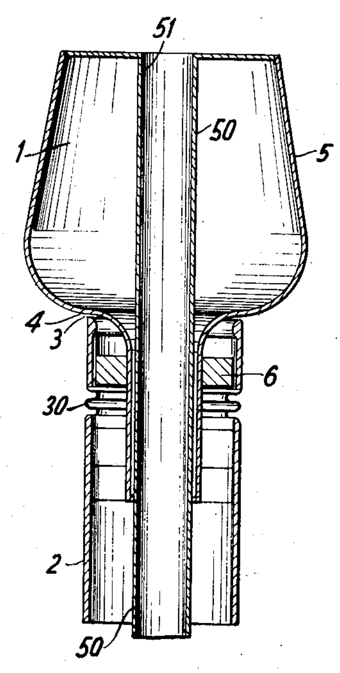
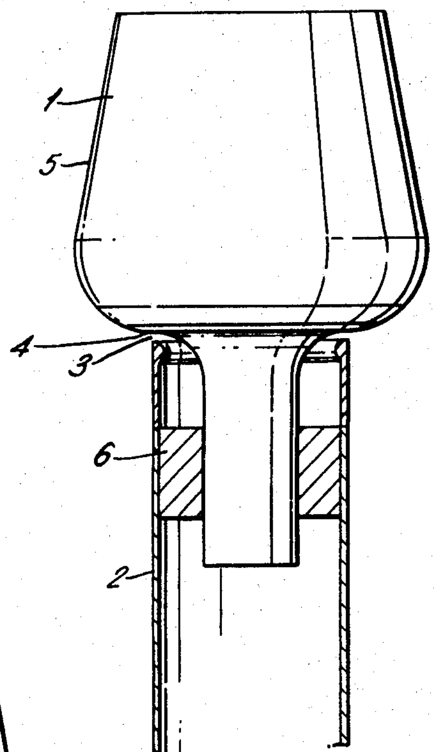


FIG. 1.



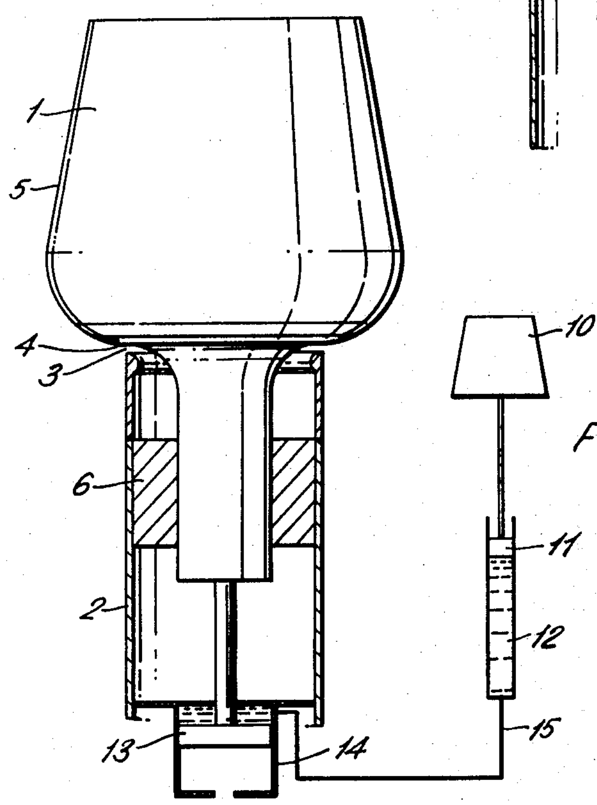


FIG. 2.

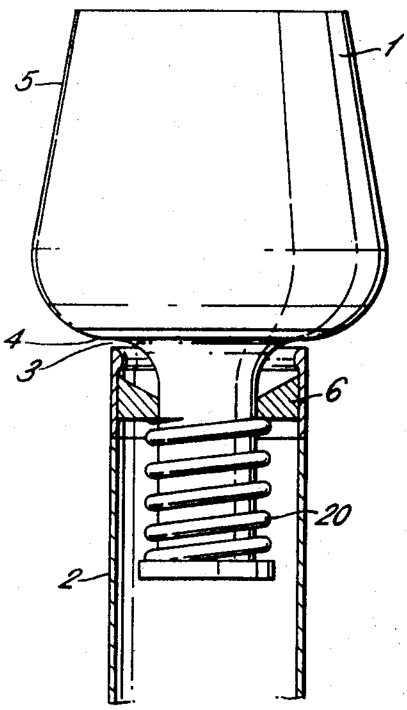


FIG. 3.

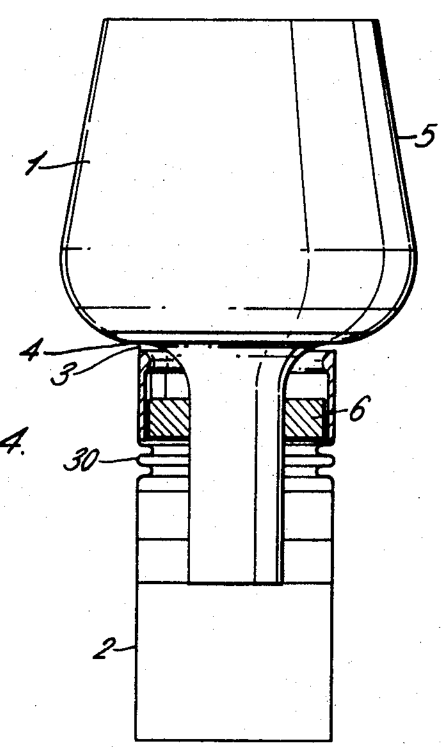
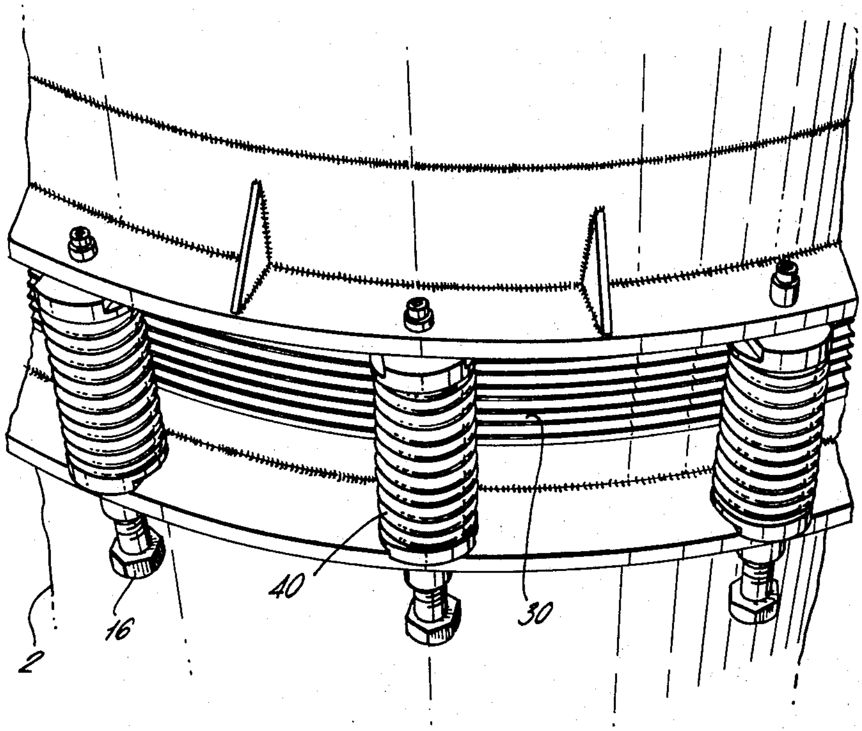


FIG. 4.

FIG. 5.



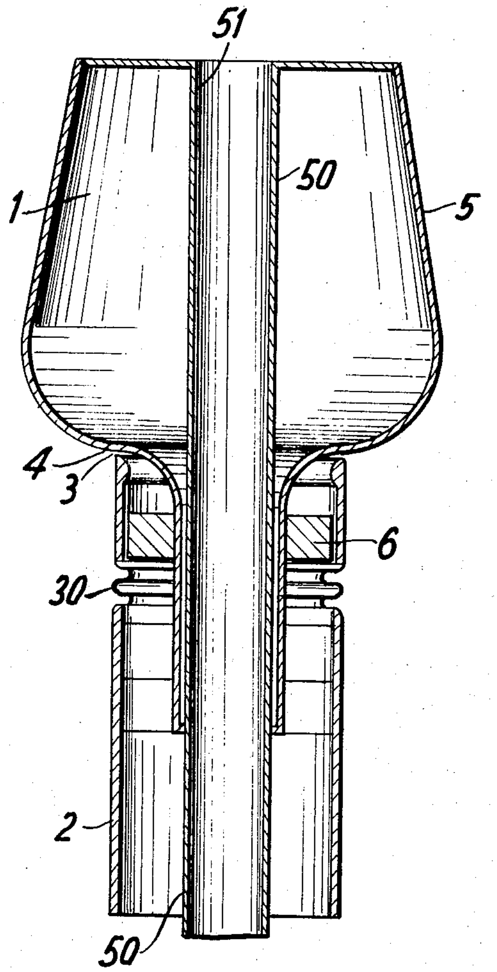


FIG.6

FLARESTACKS

This invention relates to a burner for disposing of waste combustible gas, and in particular it relates to the disposal of waste petroleum gas.

There are many occasions when the oil industry has to handle a crude petroleum or fraction thereof which has an unacceptably high vapour pressure by reason of the concentration of low molecular weight hydrocarbons, e.g., methane, ethane, propane and butane. It is common practice to reduce the vapour pressure by reducing the concentration of the volatile components and the combustible gas so produced usually has a pressure below 6 kN/m^2. (The pressures represent excess over atmospheric).

It is not always possible to sell or otherwise make use of combustible gases at low pressure and on occasions they have to be sent to waste. This often gives rise to smoky flames, particularly with butane at pressures below 1.5 kN/m^2.

Our copending U.S. patent application Ser. No. 78,479, now U.S. Pat. No. 3,709,654 and Ser. No. 245,369, filed Apr. 19, 1972 disclose burners for disposing of low pressure waste gases comprising an inlet adapted to direct a high pressure gas to flow over a director surface which is curved to initiate flow of gas and air towards a fuel inlet which is adapted to supply fuel (originally at low pressure) into the flow of high pressure gas and air. The director body is known as a Coanda body and the director surface as a Coanda surface.

Such burners are very useful in situations where the volume of gas to be burned does not fluctuate over wide limits. However, in many operations, flarestacks require a wide turn down range to allow for varying operating conditions.

The term turndown range is the ratio of the maximum achievable heat input to the burner without loss of combustion divided by the minimum heat input thereto.

The low throughput limit of a Coanda flare with a fixed slot occurs at about 70 kN/m^2, and so, normally, turn down is obtained by using a high maximum pressure (say 550–650 kN/m^2 giving a turn down of about 3:1). However, high maximum operating pressures have two disadvantages — sometimes the gas is not available at sufficient pressure to give the necessary turn down, and also the noise from the flare increases with the applied pressure.

We have now discovered that the presence of a self adjusting slot enables the operating pressure to be kept constant or nearly so over a wide range of flows, thus giving a wider turn down than normally possible, and also doing away with the difficulties associated with high pressure operation.

Thus according to the present invention there is provided a flarestack burner tip comprising a feed line for a high pressure gas and a Coanda body as hereinbefore defined having a Coanda surface as hereinbefore defined positioned across the outlet of the high pressure gas line the curved director surface Of the Coanda body initiating flow of gas and air along the surface of the Coanda body, there being a self-adjusting slot between the Coanda surface and the high pressure gas line.

By self adjusting slot we mean a slot which adjusts itself automatically to the flow rate of high pressure gas so that the pressure of the high pressure gas remains approximately constant on the emerging from the slot.

The high pressure gas may be a fuel gas or it may be steam. Preferably it emerges from the feed line at a pressure in the range 70 to 300 kN/m^2.

If the high pressure gas is fuel gas then preferably the Coanda body includes an internal passage adapted to supply fuel gas at a low pressure into the flow of high pressure gas and air.

If the high pressure gas is steam then the Coanda body must contain such a passageway.

According to one aspect of the present invention the Coanda body is allowed to "float" on the gas stream, as in an air bearing. The slot will then open up to pass any required flow at constant pressure. However, this system only allows low operating pressures unless the body is ballasted to a high all up weight.

According to another aspect of the invention an external load acts on the Coanda body through a mechanical advantage inserted between the load and the Coanda body, thus allowing the load necessary to be reduced by the appropriate ratio. The connection may be hydraulic, pneumatic or mechanical. This has the double advantage of removing the dead weight from the top of the flarestack and reducing the load required. In the case of remote hydraulic or pneumatic control, the pressure/flow characteristics of the flare could be altered as required.

According to a further aspect of the present invention the load on the Coanda body may be increased by fitting a spring which urges the Coanda surface against the high pressure gas inlet. The properties of the spring must be such that the Coanda surface is lifted off the inlet to form the slot when high pressure fuel gas or steam is introduced.

Although the use of a spring loaded system rather than a free floating one means that the pressure is no longer constant for all flows, the flow increases as the square of the pressure, giving a very steep characteristic and good turn down.

All the above involve movement of the flare tip, with a consequent requirement for suitable guides and flexible connections in the case of a central low pressure feed.

According to a still further aspect of the present invention the adjustable slot is provided by fitting a bellows joint in the feed pipe just below the slot. This allows gas adjustment to be made simply without movement of the tip itself, since the pressure on the lip of the slot can be made to open this slot to the required width.

Preferably springs are used in parallel with the bellows. This use of additional springs is a convenient way of obtaining the required slot closure pressure for a particular application and has the advantages that —

i. The bellows are working at lower stress levels making possible a longer working life.
ii. Manufacturing variations in the bellows can be allowed for by suitable choice of spring strength.
iii. The same bellows can be used for flares of different specification by appropriate spring selection.

It is known that a stream of gas will "stick" to a suitably shaped surface and a curved surface can deflect a stream of gas and thereby produce a low pressure zone. In the burner according to the invention, the initial portion of the director surface is the surface of revolution formed by the rotation of a quadrant of a circle about the longitudinal axis of the Coanda body, the curved section of the quadrant being tangential to the slot. This produces a zone of low pressure into which surrounding atmospheric air flows.

During the use of the burner, the low pressure zone contains gas with high kinetic energy. In order to improve the flow pattern away from the low pressure zone, the final portion of the director body is shaped so as to reduce the kinetic energy and increase the pressure of the gas, e.g., the final portion of the director body is tapered.

The invention also includes a method for disposing of waste combustible gas by use of a flarestack burner tip as hereinbefore described.

The invention is illustrated with reference to FIGS. 1 – 4 of the drawing accompanying the provisional specification and FIG. 5 of the complete specification.

OF THE DRAWINGS:

FIG. 1 is a fragmentary vertical sectional view, partly in elevation, of a flarestack burner tip constructed in accordance with the invention, illustrating the Coanda body portion thereof in a free floating position over a high pressure fuel gas outlet to provide a fuel gas outlet slot that is self-adjustable according to the flow rate of the gas;

FIG. 2 is a view similar to that of FIG. 1, illustrating a first alternative embodiment of a flarestack burner tip constructed in accordance with the invention, the view illustrating a hydraulic system for applying an additional load to the Coanda body portion of the burner tip;

FIG. 3 is a view similar to FIG. 1, illustrating a second alternative embodiment of a flarestack burner tip constructed in accordance with the invention, the view illustrating a spring member applying an additional load to the Coanda body portion of the burner tip;

FIG. 4 is a vertical sectional view, partly in elevation, of a third alternative embodiment of a flarestack burner constructed in accordance with the invention, illustrating the Coanda body portion of the burner mounted in a fixed position while a bellows section provided in the gas outlet line permits the gas outlet slot to be self-adjustable responsive to the gas flow-rate;

FIG. 5 is a fragmentary view in side elevation of a fourth alternative embodiment of a flarestack burner tip constructed in accordance with the invention illustrating a fuel gas line containing both a bellows section providing self-regulation of the gas outlet slot and a plurality of springs for assisting movement of the bellows; and

FIG. 6 is a vertical sectional view, partly in elevation, of a fifth alternative embodiment of a flarestack burner tip constructed in accordance with the invention, illustrating a fixed Coanda body portion and a high pressure gas line containing a bellows section, all similarly to that shown in FIG. 4, and including a low pressure fuel gas line extending through the Coanda body.

The flarestack tip comprises a Coanda body **1** and a line **2** for the supply of high pressure fuel gas. When gas is flowing, a slot **3** opens up between the body **1** and the line **2.**

The body **1** has a director surface comprising two portions **4** and **5** which merge into one another. **4** is a deflector portion which turns the direction of the high pressure gas from horizontal to vertical and **5** is a tapered portion which modifies the flow between the deflector portion **4** and the top of the body **1.**

The shape of the deflector portion **4** is most conveniently specified as the surface of revolution formed by the rotation of a quadrant of a circle about the longitudinal axis of the Coanda body, the curved section of the quadrant being tangential to the slot; as shown in the drawings the distance between the axis of rotation and the centre of the quadrant is equal of the radius of the quadrant. The shape of the tapered portion **5** is that of a frustum of a cone.

As the high pressure fuel gas flows round the deflector portion **4** its direction of flow is changed from (initially) horizontal to vertical. This induces a low pressure zone in the surrounding air and hence it induces movement of air as well as fuel towards the top of the body **1.**

The body **1** is positioned within the line **2** by a guide **6.**

In FIG. **1**, the body **1** is free floating.

At the balance point $PA = W$, where P is the pressure of the gas in the seat pipe, A is the cross section of the pipe and W is the weight of the body **1.**

Hence, since A and W are constant, P is constant and regardless of the gas flow, the gap merely opens to accomodate it.

In FIG. **2**, additional loading is applied to the body **1** by means of a hydraulic system.

A load **10** is applied to the piston **11** of a narrow hydraulic cylinder **12.** The body **1** is connected to the piston **13** of a wide hydraulic cylinder **14.** A line **15** transfers hydraulic pressure between the cylinders **12** and **14.**

In this case the mechanical advantage of the hydraulic system $W_2/W_1 = A_2/A_1$ wherein W_1 is the weight of the applied load **10,** W_2 is the weight of the body **1,** A_1 is the area of the cylinder **12** and A_2 is the area of the cylinder **14.**

With reference to FIG. **3**, a spring **20** urges the body **1** towards the line **2** and opposes the lifting action of the high pressure gas.

At equilibrium, $W_3 = A_3$, $P = Rd$, wherein W_3 is the weight of the body **1,** A_3 is the area of the line **2,** P_3 is the pressure in the line **2,** R is the spring rate and d is the spring deflection.

With reference to FIG. **4**, the line **2** contains a spring bellows section **30** just below its outlet. If the pressure of emerging gas increases, then the slot **3** widens, i.e., relative motion between the body **1** and the line **2** takes place. However, in the embodiments described with reference to FIGS. **1–3**, it is the body which has moved and the line which has remained fixed. In the FIG. **4** embodiment, the body remains fixed, almost all of the line **2** remains fixed and the relative motion is accomodated by contraction of the bellows **30.** Conversely, a diminution of pressure results in an expansion of the bellows. Using this method, the diameter of the outer tube **2** at the gas exit slot **3** must exceed the diameter of the bellows **30** so the force due to the gas pressure on the slot **3** exceeds the force opening the bellows **30** by internal pressure.

At equilibrium, $A^1_4P_4 = R_2d_2$ wherein A^1_4 is the net effective area, P_4 is the pressure of the gas in the line **2,** R_2 is the spring rate of the spring bellows and d_2 is the deflection.

With reference to FIG. **5**, additional springs **40** assist the bellows **30** in its slot closure action. They act in parallel with the bellows **30** and are attached to the line **2** above and below the bellows **30.** By appropriate adjustment of the strength of the springs **40,** variations in flare specification and bellows manufacture may be allowed for. The large screws **16** allow spring compression and adjustment.

Referring now to FIG. **6** of the accompanying drawings, there is illustrated a fixed Coanda body **1** and a high pressure gas line **2** containing a bellows section **30,** all in a similar manner to that shown in the embodiment illustrated in FIG. **4,** and including a low pressure fuel gas conduit line **50** extending internally through the Coanda body **1.** It will be understood from the preceding discussion that a low pressure fuel gas flowing through the internal conduit **50** exits at **51** to be subsequently mixed with the flow of high pressure gas and entrained atmospheric air exiting from the Coanda body for combustion.

What we claim is:

1. A flarestack burner tip, comprising:

a high pressure gas conduit line terminating in a generally vertical portion;

a Coanda body positioned over the upper end of said high pressure gas conduit line,

said Coanda body having an external deflector surface positioned adjacent to and extending completely across the upper end of said high pressure gas conduit line,

said deflector surface including a substantially horizontal portion adapted to form a circumferentially extending slot with the upper end of said high pressure gas conduit upon said Coanda body being spaced therefrom and a curved portion extending outwardly from said high pressure gas conduit line and tangentially to said horizontal portion,

said slot adapted to direct high pressure gas over said curved portion of said Coanda deflector surface; and

wherein said Coanda body is fixedly mounted with respect to said high pressure gas conduit line and the latter includes a flexible bellows section pemitting the upper end of said high pressure gas conduit line to freely move toward and away from said Coanda body responsive to the pressure of the flow of said high pressure gas to thereby maintain a substantially constant pressure on the gas passing through said slot.

2. A flarestack burner tip, comprising:

a high pressure gas conduit line terminating in a generally vertical portion;

a Coanda body positioned over the upper end of said high pressure gas conduit line,

said Coanda body having an external deflector surface positioned adjacent to and extending completely across the upper end of said high pressure gas conduit line,

said deflector surface including a substantially horizontal portion adapted to form a circumferentially extending slot with the upper end of said high pressure gas conduit upon said Coanda body being spaced therefrom, a curved portion extending outwardly from said high pressure gas conduit line and tangentially to said horizontal portion, and terminating in a tapered portion extending in a general vertical direction tangentially to said curved deflector surface portion,

said slot adapted to direct high pressure gas over said curved portion of said Coanda deflector surface;

said Coanda body further including a low pressure fuel gas conduit line extending internally through said Coanda body adapted to supply a low pressure fuel gas into the flow of high pressure fuel gas and entrained atmospheric air from the external surface of said Coanda body; and

means mounting said Coanda body for free vertical movement with respect to the upper end of said high pressure gas conduit line responsive to the pressure of the flow of said high pressure gas to thereby maintain a substantially constant pressure on the gas passing through the slot.

3. A flarestack burner tip as claimed in claim **1,** wherein said curved portion of said Coanda deflector surface comprises a surface of revolution formed by the rotation of a quadrant of a circle about the longitudinal axis of the Coanda body.

4. A flarestack burner tip as claimed in claim **1,** wherein said Coanda body includes a generally centrally disposed spindle member extending downwardly from said horizontal portion of said deflector surface into telescoping freely slidable movement with guide means fixedly mounted within said high pressure gas conduit line.

5. A flarestack burner tip as claimed in claim **1,** including spring means adapted to provide an external load to said flexible bellows section of said high pressure gas conduit line.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,833,337 Dated September 3, 1974

Inventor(s) Denis Henry Desty and Christopher John Young

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 48, change "gas" to -- gap --.

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents