Dec. 28, 1965 R. G. CHOWN ETAL 3,225,829

APPARATUS FOR BURNING A COMBUSTIBLE MIXTURE IN A WELL

Filed Oct. 24, 1962 2 Sheets-Sheet 1

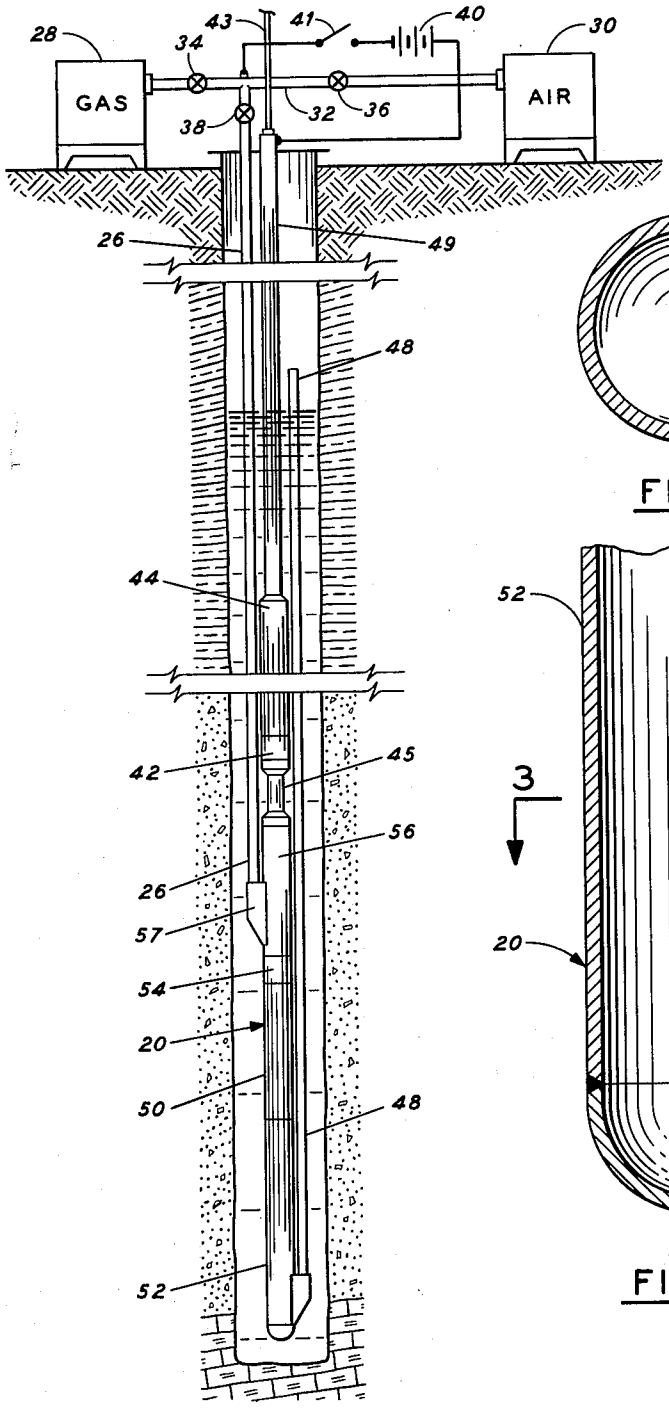

FIG. 1

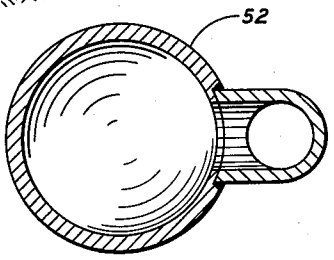

FIG. 3

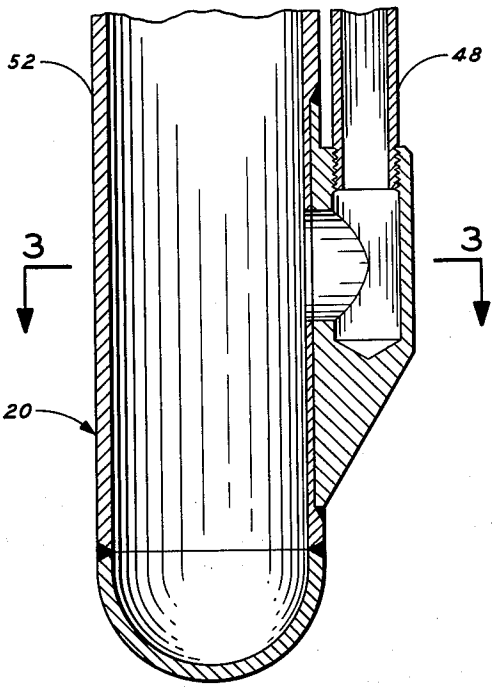

FIG. 2B

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Filed Oct. 24, 1962 2 Sheets-Sheet 2

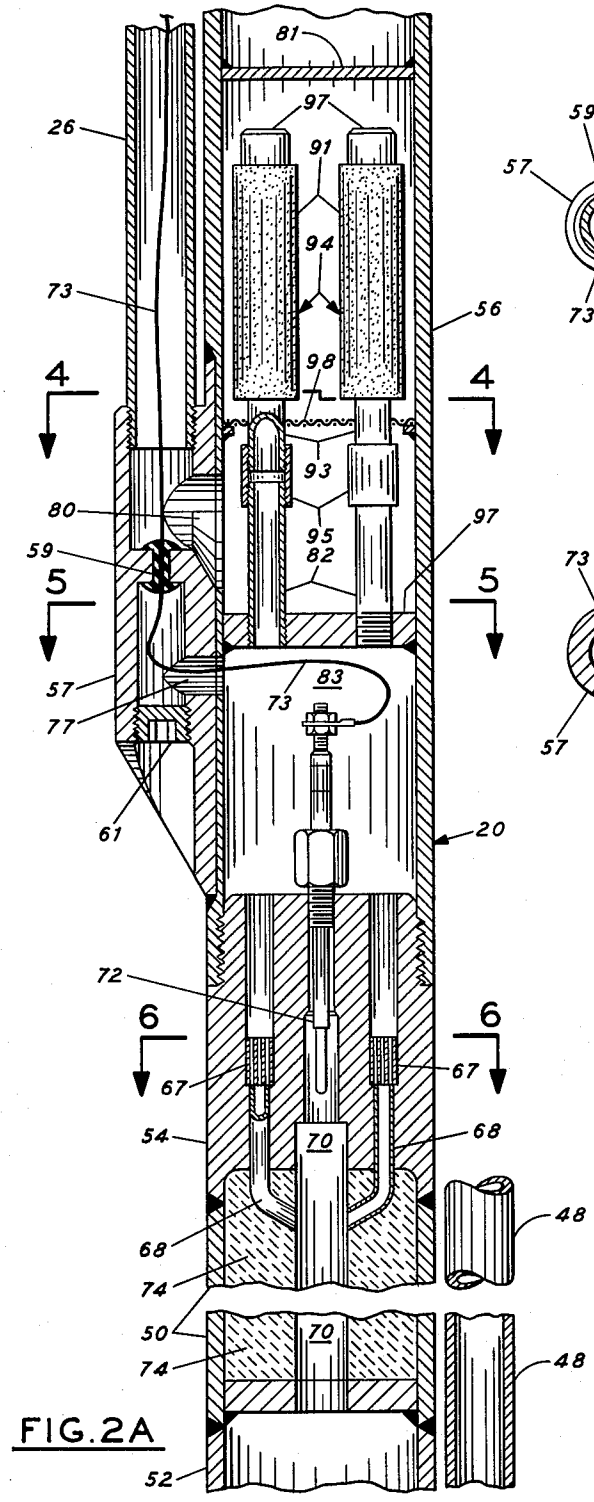

FIG. 2A

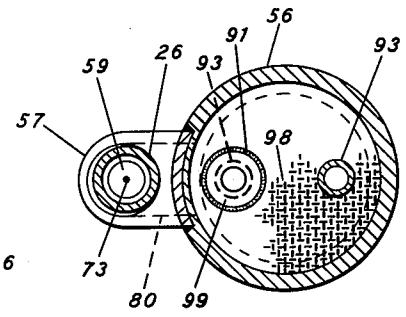

FIG. 4

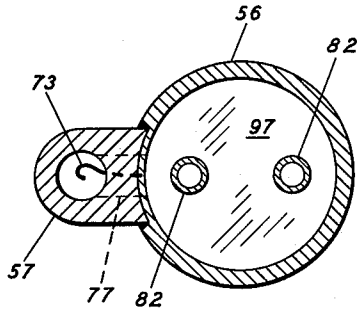

FIG. 5

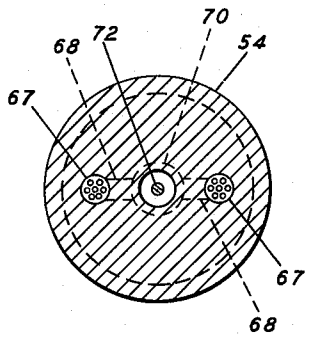

FIG. 6

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APPARATUS FOR BURNING A COMBUSTIBLE MIXTURE IN A WELL

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This invention relates to improved methods and apparatus for burning a combustible mixture in a well, and more particularly, this invention relates to improved methods and apparatus for filtering a combustible gas prior to flowing the gas to a combustion chamber of a downhole burner for combustion therein.

It is known that oil production from a well penetrating an oil-bearing formation can be improved by heating the oil in the well and in the formation. The most successful method of applying heat to the oil is by burning a combustible mixture in a downhole burner located in a well near the producing formation. An example of a downhole burner is shown in U.S. Patent 2,887,160. As is generally described in U.S. Patent 2,887,160, a gaseous combustible mixture is flowed from the surface in a supply conduit to a downhole burner. The combustible gas is directed to the combustion chamber of the burner and burned. Because of the danger of the combustion flashing back up the supply conduit, flash back preventers are provided in the inlet passages into the combustion chamber. The flash back preventers usually comprise some type of a flow restricting material through which the gas must flow. Further, the inlet passage into the combustion chamber often has a small diameter. Therefore, both the flash back preventers and the inlet passage are susceptible to being plugged by foreign matter entrained in the gas stream which flows through them.

In field applications of downhole burners, plugging of the small openings of the burners has been a serious problem. This is particularly true when compressors are used to pump the gaseous mixture to the burners. Grease and dirt from the compressors become entrained in the gas and are carried to the burner and plugging results. Rust and pipe scale and dirt may also be knocked loose in the tubing when running the burner in the hole. When gas is flowed to the burner, there is likelihood that these particles may plug the flow passages to the combustion chamber of the burner.

Heretofore, attempts have been made to filter the combustible mixture as it passed down the supply conduit from the surface to the burner. One means of filtering the gas stream as disclosed in U.S. Patent 2,887,160, comprised flowing the gas through a set of slots in the supply conduit. This method is not always satisfactory because if the slots are narrow enough to adequately filter the foreign matter from the gas, the larger particles entrained in the gas flow accumulate on the slots and plug them. If on the other hand the slots are spaced so as not to be plugged, much of the foreign matter passes the slots and plug the flash back preventors or the delivery nozzle of the burner itself.

The present invention is directed to overcoming this problem and provides an improved filter section for filtering a combustible gas flowing into a burner from a supply conduit prior to passing it to the combustion chamber of the downhole burner. In one aspect this invention comprises a combustion chamber having an exhaust section at its lower end and an inlet for gas in the upper portion. Ignition means are located in the combustion chamber in operable relationship with the gas inlet to ignite combustible gas passing therethrough. A filter section is located above the combustion chamber. Porous

filter means are positioned in the filter section and said filter means are operably connected with the inlet for gas into the combustion chamber to form therewith the only passageway for gas flow from said filter section into said combustion chamber. The filter section is provided with an entry port means for the flow of gas from the supply conduit into the filter section. The entry port means is the only entry for combustible gas from the supply conduit into the filter section. The entry port means or the terminal portion of the supply conduit into the filter section is located at a level below the level of the porous filter means whereby the gas flowing into said filter section is caused to flow up to said porous filter means for flow to said combustion chamber. In this manner much of the larger foreign matter entrained in the gas is deposited in the filter section below the porous filter means and, therefore, will not be available to plug the porous filter means.

It is a particular object of the present invention to provide an improved filtering arrangement for filtering gas flowing to the combustion chamber of a downhole burner. Further objects and advantages of the present invention will become apparent from the following detailed description read in light of the accompanying drawings which are made a part of this specification and in which:

FIG. 1 is a schematic view showing a downhole gas and air burner operably positioned in a well;

FIG. 2*a* is a view, partially in section, of the upper portion of the preferred embodiment of apparatus of the present invention;

FIG. 2*b* is a continuation of FIG. 2*a* and is a view of the lower portion of the preferred embodiment of apparatus of the present invention;

FIG. 3 is section 3—3 of FIG. 2*b*;

FIG. 4 is section 4—4 of FIG. 2*a*;

FIG. 5 is section 5—5 of FIG. 2*a*;

FIG. 6 is section 6—6 of FIG. 2*a*.

With reference to the drawings and to FIG. 1 in particular, a downhole gas and air burner according to this invention is generally designated by the numeral **20** and is used for burning a combustible mixture in a borehole. Apparatus of this general type are called downhole burners or gas and air burners. Downhole burner **20** includes an exhaust section **52** connected to the lower end of a combustion chamber section **50**. The exhaust gases resulting from combustion in section **50** are exhausted through exhaust section **52**. As shown, an exhaust pipe **48** is connected to receive the exhaust gases from exhaust section **52** and convey them to a desired level in the well. Alternatively, the exhaust gases may be expelled directly into the well from exhaust section **52** without the use of an exhaust pipe.

A burner head section **54** and a filter section **56** are connected above combustion chamber section **50**. In the preferred embodiment of this invention, the downhole burner **20** is connected to and concentric with a production pump **44**. As shown in FIG. 1, a production pump **44** and a gas anchor **42** are located in the well on production tubing **49**. The pump is a conventional production pump, and it is operated by means of sucker rod **43**. The downhole burner **20** is attached to the production string below the production pump **44** and gas anchor **42** by means of connecting nipple **45**.

With reference now to all the drawings, it is one aspect of this invention to provide a burner **20** which includes a combustion chamber **70** having an inlet **68** at its upper end and a filter section **56** communicating with said inlet **68** through a porous fluid filter means **94**, which chamber and filter section are mounted in concentric relationship with a production pump **44**. Nipple **45**, by means of appropriate threaded connections, mounts burner **20** con-

centric with pump 44. In this manner the burner is run in the well on production tubing 49 and supported by the production tubing 49. If sandup of the well should occur the burner 20 may be pulled with the pump 44 on the heavy production tubing 49. Heretofore, burners were hung in the well on the combustible mixture supply conduits. If a sandup occurred, the burner had to be pulled out of the hole on the relatively weak supply conduit alone rather than the production tubing and loss of the burner could result if the supply conduit broke. The side entry connection 57 in filter section 56 provides an entry port for combustible mixture into the filter section of the burner while the burner is mounted concentrically with pump 44. The supply conduit 26 of the preferred embodiment is run eccentric with the burner 20 and the pump 44 and production tubing 49.

A combustible gaseous mixture is supplied to burner 20 by means of supply conduit 26 which communicates with burner 20 through side entry connection 57 into filter section 56. A combustible mixture is supplied by mixing a gas such as methane or fuel gas for example, and air at the surface. For example, gas from gas source 28 and air from air source 30 are mixed in appropriate proportions in tubing 32 by means of valve 34 and valve 36. Flow of the combustible gas to burner 20 is controlled by valve 38. A control system for supplying a combustible mixture to a downhole burner is disclosed in U.S. Patent No. 3,012,607. A source of current for igniting the mixture in the borehole is represented schematically by battery 40, connected by suitable conductors through switch 41 to the ignition means 72 in the burner 20.

It is a particular feature of the present invention to provide an improved filter section for removing foreign matter entrained in the gas flowing to a downhole heater. The filter section 56 has a relatively large cross-sectional flow area compared to the cross-sectional flow area of the conduit 26 terminating in the filter section 56. It is preferred that the cross-sectional area of the filter section be at least twice that of the supply conduit. The filter section 56 contains porous filter means 94 positioned above the floor 97 of the filter section 56. The porous gas filtering elements 91 are elevated above the bottom of the filter section 56 and above the entry port 80 for gas flow into the filter section 56 so that any foreign matter coming off the gas stream due to the change in velocity and direction of the gas will fall to the bottom of the filter section 56 and will, therefore, not plug the porous filter elements 91.

With particular reference now to FIG. 2*a* and FIG. 2*b* and FIG. 3, FIG. 4, FIG. 5 and FIG. 6 which are sectional views taken at the indicated locations on FIG. 2*a* and FIG. 2*b*, a preferred embodiment of apparatus according to the present invention, is shown. A combustible mixture supplied to burner 20 is burned in combustion chamber 70, which is located in combustion chamber section 50. The combustion chamber 70 is preferably formed by a ceramic lining 74 to provide suitable heat transfer to the well fluids around the burner. The exhaust gases from the combustion chamber 70 are passed to exhaust section 52 and to the exhaust conduit 48.

The combustion chamber 70 has an inlet 68 for gas in its upper end. Ignition means 72 is operably positioned with respect to combustion chamber 70 and inlet 68 to ignite the gas passing therethrough. The ignition means is supplied with suitable electrical conductors to connect it with a source of electricity. For example, the production tubing and metal connecting parts may serve as one conductor, and insulated wire 73 connected with the surface through supply conduit 26 as the other. Wire 73 is operably connected to ignition means 72. The insulated wire 73 may be run through supply conduit 26 and passed to the ignition means through port 77. Seal 59 prevents gas flow through port 57. Plug 61 serves to give access to the seal 59 and wire 73.

In order to prevent combustion from flashing back up the combustible gas supply conduit 26 in the event of a pressure surge in the well, flash back prevention means 67 are formed in inlets 68. The flash back prevention means 67 have restricted passageways through which the gas must pass. FIG. 6 is a sectional view showing a form of flash back prevention means useful in this invention. The flash back prevention means, which may have holes of only .004 of an inch for example, and the small opening forming inlets 68 will become plugged if foreign matter is not filtered from the gas stream that is supplied to the burner.

In accordance with the present invention, a combustible gas is supplied to the burner 20 from the surface by means of supply conduit 26. Conduit 26 has an entry port mean means 80 into the filter section 56 of burner 20. Entry port means 80 of conduit 26 is the only entry for the combustible gas into filter section 56. The upper end of the filter section 56 is closed off to prevent gas flow up the filter section by any suitable means such as for example bulkhead 81.

Porous filter means indicated generally by numeral 94 located in the filter section 56 are operably connected to the inlets 68 into the combustion chamber 70 by means of conduit 82 and chamber 83. In order for gas to flow into the combustion chamber 70 from the supply conduit 26, it must pass through the porous filter means 94 in filter section 56. The porous filter means 94 are preferably formed from a porous material such as sintered bronze or a similar porous metal. It is preferred that the pore size of the porous filter means be in the range of from about 20 to 60 microns in diameter.

With reference to FIG. 4, a suitable form of porous filter means 94 is shown. A porous filter element, for example, a cylinder 91 of porous metal, is provided with a base plate 99. The connection between the porous metal cylinder 91 and the base plate 99 is made gas tight. A gas-tight removable plug 97 seals the other end of the cylinder 91 and provides access to the interior of the cylinder 91 for cleaning. Gas, therefore, flows through the porous surface of cylinder 91 which provides for filtering the gas. It is contemplated that any suitable filter means may be used with the present invention, provided it is positioned in accordance with this invention. The porous filter element 91 is mounted on tubular conduit 93. A threaded joint 95 is provided to connect conduits 93 and conduits 82 for ease in insertion and removal of the porous filter element 91. The floor 97 of filter section 56 is provided with appropriate passageways for conduits 82 for flowing gas to combustion chamber 70. FIG. 5 is a sectional view showing plate 97 provided with passageways for conduits 82.

It is a particular feature of this invention to position the porous filter means 94 in the filter section 56 above the entry port means 80 for gas flow into the filter section 56. The flowing gas stream is caused to change direction when entering the relatively large filter section 56 from conduit 26 in order to assist in precipitating the foreign particles entrained in the gas. In this manner foreign matter will be removed from the gas stream and will collect on plate 97.

FIG. 4, which is section 4—4 of FIG. 2*a*, also shows more clearly screen 98 which is desirably positioned in the flow path of filter section 56 between entry port means 80 of conduit 26 and the porous filter means 94. Gas is caused to flow through the screen 98 to aid in removing foreign matter from the gas stream as it flows in an upwardly direction in the filter section 56 prior to entering the porous filter means 94 for flow to the combustion chamber 70. Screen 98 preferably has relatively large openings compared to the porous filter means. Screens of from at least about 50 to 200 mesh are preferred for use in the present embodiment of the invention.

The important features of this invention have been illustrated and described. The scope of the invention is not to be limited to the specific embodiments described herein but only by the scope of the appended claims.

We claim:

1. Apparatus for burning a combustible gas in a borehole comprising a combustion chamber having an exhaust section at its lower end, an inlet into the upper portion of said combustion chamber, ignition means in operable relationship with said inlet to ignite the gas passing through said inlet into said combustion chamber, a filter section above said inlet, entry port means in said filter section, a plate in said filter section forming a floor in said filter section, porous filter means in said filter section, said porous filter means comprising a porous filter element and conduit means supporting said porous filter element above said plate, said conduit means operably connected with said inlet through said plate to form therewith the only passage for gas flow out of said filter section into said combustion chamber and supply conduit means operably connected with said entry port means of said filter section for flowing the combustible gas to said filter section from the surface.

2. The apparatus of claim 1 where the cross-sectional flow area of the filter section is large compared to the cross-sectional flow area of the supply conduit means.

3. Apparatus for burning a combustible gas in a borehole comprising a combustion chamber having an exhaust section at its lower end, an inlet into the upper portion of said combustion chamber, ignition means in operable relationship with said inlet to ignite the gas passing through said inlet into said combustion chamber, a filter section above said inlet, porous filter means in said filter section operably connected with said inlet to form therewith the only passage for gas flow out of said filter section into said combustion chamber and entry port means in said filter section as the only entry for the gas into said filter section, said entry port means positioned in said filter section below said porous filter means whereby the gas which flows into said filter section through said entry port means is caused to flow up to said porous filter means for flow to said combustion chamber.

4. The apparatus of claim 3 where the cross-sectional flow area of the filter section is large compared to the cross-sectional flow area of the entry port means.

5. The apparatus of claim 3 where a gas supply conduit is operably connected to said entry port means.

6. The apparatus of claim 3 where a screen is placed across the gas flow path in said filter section between the entry port means and the porous filter means.

7. The apparatus of claim 3 further characterized in that the filter section has at least one side and the entry port means is located at the side of the filter section.

8. Apparatus for burning a combustible gas and air mixture in a well comprising a combustion chamber having an inlet for said mixture in its upper portion and an exhaust at its lower portion, ignition means in said combustion chamber in operable position to ignite the combustible mixture passing into said chamber, a filter section above said combustion chamber, porous filter means in said filter section operably connected to said inlet to form therewith the only passage for combustible mixture from said filter section into said combustion chamber, and supply conduit means for flowing the combustible mixture into said filter section as the only flow passage for the combustible mixture into said filter section, said conduit means directing the combustible mixture into said filtering section at a level below the level of said porous filter means whereby the mixture is caused to flow in an upwardly direction in said filter section prior to entering the porous filtering means for flow to said combustion chamber.

9. The apparatus of claim 8 where a screen is placed across said filter section between said entry port means and said porous filter means.

10. Apparatus for burning a combustible gas in a well comprising a combustion chamber having an exhaust section at its lower end, a flow inlet in the upper portion of said combustion chamber for passage of the combustible gas into said combustion chamber, ignition means in said combustion chamber in operable relationship with said inlet to ignite the gas passing therethrough, a filter section having one end closed to fluid flow up said section and the other end connection with the upper portion of said combustion chamber, entry port means in the side of said filter section for gas flow into said section, supply conduit means operably connected to said entry port means for supplying gas to said filter section, porous filter means in said section, said filter means operably connected with said inlet to provide therewith the only flow path for gas from said entry port means through said filter section into said combustion chamber, said filter means positioned in said section to have the porous filter element located above said entry port means whereby the gas entering said filter section through said entry port means is caused to flow up to said porous filter element for flow to said combustion chamber and means connecting said filter section in concentric relationship with a production pump.

11. Apparatus for burning a combustible gas in a well comprising means defining a combustion chamber having an exhaust means at its lower end, an inlet into the upper portion of said combustion chamber, ignition means for igniting the gas in said combustion chamber, a filter section above said inlet, entry port means in said filter section, a floor in said filter section, porous filter means in said filter section, said porous filter means positioned above and out of direct contact with said floor and conduit means operably connecting said porous filter means with said inlet, said conduit means forming the only passageway through said floor for gas flow out of said filter section through said inlet and into said combustion chamber.

12. Apparatus for burning a combustible gas in a well comprising means defining a combustion chamber having an exhaust means at its lower end, an inlet in the upper portion of said combustion chamber, ignition means to ignite the gas in said combustion chamber, a fitler section above said inlet, porous filter means in said filter section, entry port means in said filter section for flowing a combustible gas into said filter section below said porous filter means and conduit means connecting said porous filter means with said inlet to form therewith the only passage for gas flow out of said filter section into said combustion chamber.

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