

May 21, 1946.

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2,400,719

APPARATUS FOR FILTERING GAS

Filed Oct. 28, 1939

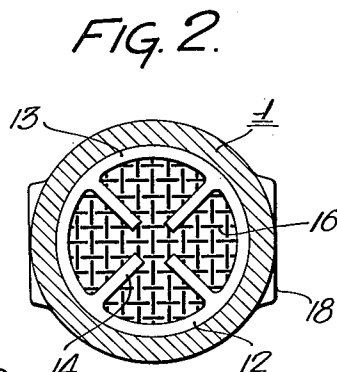
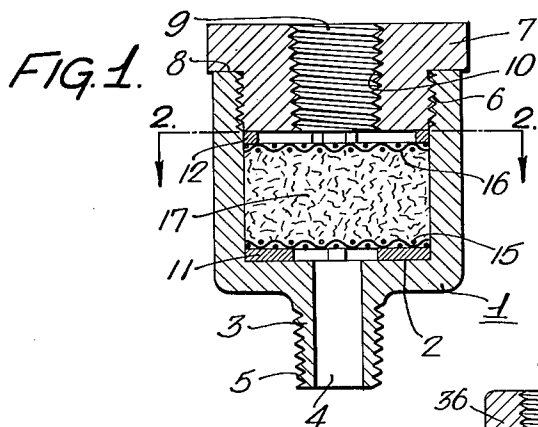


FIG. 3.

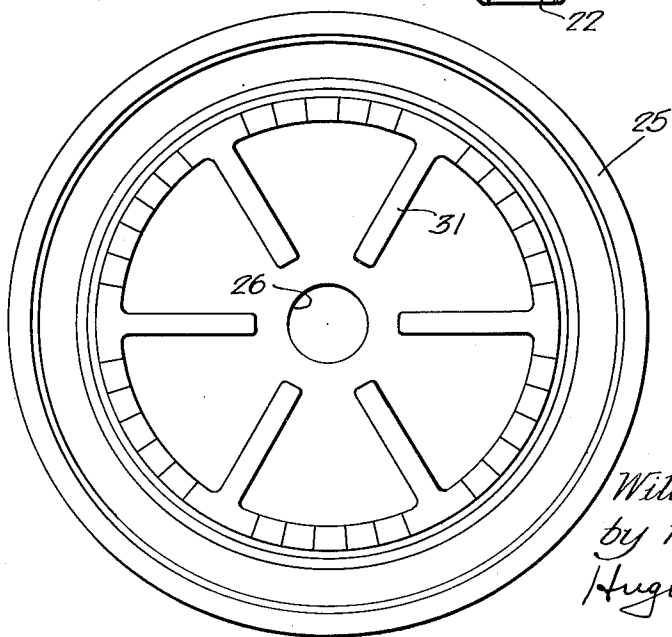
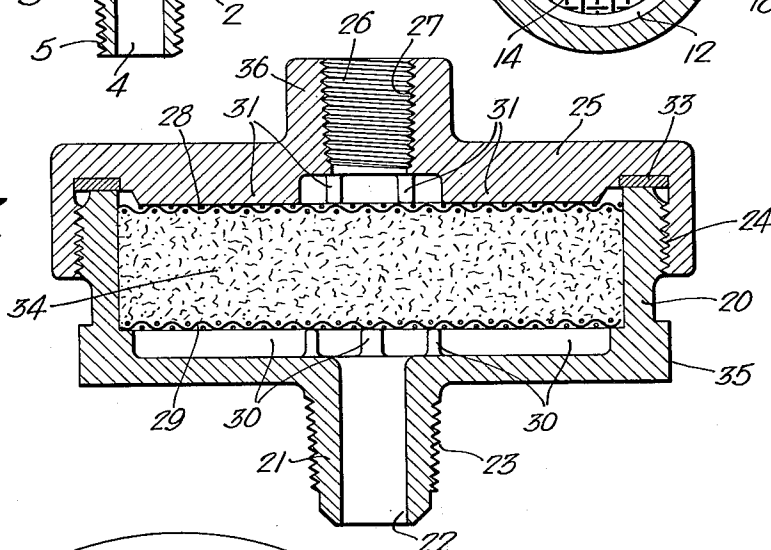


FIG. 4.

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UNITED STATES PATENT OFFICE

2,400,719

APPARATUS FOR FILTERING GAS

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Application October 28, 1939, Serial No. 301,678

7 Claims. (Cl. 183—45)

This application is a continuation in part of and replaces my copending application Serial Number 190,371, filed February 14, 1938, the latter having since been formally abandoned in favor of this application.

The invention pertains more particularly to apparatus for treating gas.

The invention pertains more particularly to apparatus for the treatment of combustible gas containing impurities suspended therein.

The invention pertains still more particularly to apparatus for filtering combustible gas containing particles of vapor phase gum.

In the distribution and utilization of manufactured combustible gas, such as coal gas, coke oven gas, oil gas, carburetted water gas and the like, considerable trouble is encountered due to the presence in the gas of particles of gum (the so-called "vapor phase gum"). These particles are generally formed in suspension by reactions between minute concentrations of oxides of nitrogen and certain hydrocarbons found in the gas. For a general discussion of vapor phase gum, reference may be had to Industrial and Engineering Chemistry, 26, 947 and 1028 (1934).

The gum particles are very small. They range upward from the threshold of visibility with the aid of the ultramicroscope to particles of a diameter of 3 μ , though those larger than 1 μ tend to settle out of the gas.

The formation of the particles takes place throughout the distribution system as long as there remain any nitric oxides present in the gas.

These gum particles block the small orifices of the control valves of low rate appliance burners, such as the needle valves of gas range and water heater pilots, and needle valves controlling the flow of gas to gas refrigerator burners. The consequent stoppage of the valves causes extinction of the burners associated therewith so that the vapor phase gum problem, generally, constitutes not only a nuisance and a source of expense, but also in the case of automatic gas appliances, a possible source of danger to life and property.

To avoid pilot trouble it is necessary to remove these gum particles completely, as only an extremely small quantity of gum is required to block the needle valves of commonly used pilot burners, such for instance as the lighter known commercially as the "Rutz" lighter, which in heavily gummed gas may be extinguished in four hours by as little as 0.000025 gram of gum. This is of the order of 1 pound of gum for 18 million pilot valves. The small quantity of gum upon the valve promotes the further deposition of dirt, iron oxide, grease, and fat, which in the absence of gum rarely cause pilot trouble in manufactured gas systems.

It is, therefore, necessary to remove the gum completely from the gas. That is, the gas enter-

ing the pilot burner for combustion should show no vapor phase particles visible in the Tyndall beam (i. e., by ultramicroscopic examination) and microscopic examination of valve needles and seats should reveal no gum deposits thereon.

The ideal solution would be to remove at least one of the gum-forming constituents (e. g., the oxides of nitrogen) from the freshly generated gas at the gas plant. But while this is done to some extent, and aids in combatting the trouble to that extent, unfortunately complete removal of the oxides of nitrogen is very difficult of attainment. Accordingly, due to the previously mentioned tendency to form gum particles continuously throughout the distribution system so long as any nitric oxides remain in the gas, it is not enough to treat the gas merely at the gas plant. The gas must be treated at the appliances as well, to remove any last traces of vapor phase gum particles before they can enter the pilot valves.

Due to the low pressure of the gas at the appliances, the drop in pressure across any filter for the removal of gum must be very low. This is because pressures in gas services and piping to domestic appliances are quite low as compared with pressures frequently employed in transmission mains. For instance, transmission main pressures may be as high as 100 pounds per square inch, but distribution main pressures are of the order of from 3 to 8 inches of water column. With such low pressures only a very low pressure drop through any filter may be tolerated. A pressure drop of 1 inch of water column is all that may be allowed in most cases.

Another problem of extreme importance in this field is that of obtaining a reasonable filter life. For gum filtration purposes it is conceivable that a diaphragm might be chosen or a fibrous material sufficiently compressed to substantially completely prevent the passage of even the smallest gum particles while at the same time permitting the flow of gas. However, experience has shown that filters of this type are necessarily very large to permit a reasonable flow of gas. Furthermore, such filters are of very short useful life. This is because the gum particles build up rapidly on the face of the filter to form a lacquer-like film which rapidly becomes substantially impervious to the gas.

To overcome the latter difficulty and in accordance with my invention, I arrange a fibrous mass having the required specificity, in a manner such that the interstices between the fibers are sufficiently large to permit the gum particles to penetrate the mass. In other words, the interstices must not be so small as to filter by means of a sieving action whereby the gum particles would build up on the face of the filter.

Filtration is accomplished in accordance with

my invention by bringing the gum particles into contact with fibers having suitable selective surface conditions by turbulence, by Brownian movement, and in the case of the larger particles by gravitational fall.

However, the interstices between the fibers must not be so large as to permit the gas to flow there-through without the required turbulence.

The necessary surface conditions for good filtration are shared by very few fibrous materials, among which is the material known as rock wool.

I have discovered that these requirements may be met by arranging the rock wool fibers, usually by compression, in filter masses of definite density characteristics.

The term "density" is used here and throughout the specification and in the claims to mean apparent density as distinguished from absolute density, apparent density being equal to the weight in grams of a given fibrous mass divided by the volume in cubic inches of the space occupied by it. Because of variations within the material itself this density is obviously average.

I have discovered that in the case of rock wool a minimum density of 3 grams per cubic inch provides interstices sufficiently small for my purposes provided the filter path is sufficiently deep, the latter being a consideration which will be hereinafter treated in connection with pressure drop.

I have also discovered that in the case of rock wool a maximum density of 16 grams per cubic inch provides interstices approximately just sufficiently large to permit the desired penetration by the gum particles of the fibrous mass.

A maximum range in densities therefore, assuming of course, that the fibers are not too variable in distribution and size is from 3 grams per cubic inch to 16 grams per cubic inch. A preferred range is between 5 grams per cubic inch and 14 grams per cubic inch, since such range is less susceptible to possible wide variations.

It will be recognized that for a fixed rate of gas flow the depth of penetration of gum particles will be greatest in the case of a filter mass having a density of 3 grams per cubic inch and will be least in the case of a filter mass having a density of 16 grams per cubic inch. Good average densities from this standpoint are between 5 grams per cubic inch and 10 grams per cubic inch, which range has the added advantage of being even less susceptible to wide variations in rock wool, since the effect of variations in uniformity of rock wool can be minimized by decreasing the density and increasing the depth.

The depth of penetration is to some extent dependent upon the rate of gas flow, it being natural to assume that the higher the rate of gas flow the deeper the penetration.

The rate of gas flow, however, through any filter mass suitable for my purposes is limited by the permissible maximum pressure drop of one inch of water column.

Accordingly, I have found that when employing rock wool having a density of from 16 grams per cubic inch down to about 13 or 14 grams per cubic inch, the minimum filter mass depth is preferably 0.25 inch and that the filter mass should generally speaking increase in depth as the density of the rock wool decreases by a function which does not depart greatly from a straight line. In other words, with a fixed pressure drop not greatly exceeding one inch of water column and other conditions fixed in each case the required mass of rock wool to efficiently filter out

gum particles is approximately a constant within the density ranges given.

Since the permissible maximum pressure drop is one inch of water column, a depth of 1½ inches is sufficient when the density of rock wool is 3 grams per cubic inch and a depth of one inch when the density is 5 grams per cubic inch.

If desired, greater depths may be employed with a corresponding decrease in gas flow with any given pressure drop which should not greatly exceed one inch of water column.

Depths lower than 0.25 inch should be avoided.

The above observations with respect to depth are necessarily general in view of variations in rock wool. Thus, a depth of 0.25 inch is generally suitable with the 14 gram material up to a pressure drop of one inch of water column. With material of considerably lower density a depth as low as 0.25 inch is suitable up to pressure drops somewhat lower than one inch of water column. Conceivably the 3 gram material might be used in depths of the order of 0.25 inch with very low pressure drops, that is, with very low rates of gas flow.

Even though rock wool as commercially produced at the present time varies considerably in fiber diameter and general uniformity, not only in different lots but also within the same lot which naturally reflects itself in differences in the sizes and arrangement of interstices when compressed to my range densities, highly satisfactory filtration of the gas may be obtained provided the filter masses are arranged to meet the following test:

The test gas is passed through a given filter mass having a density within any range above given at a rate to produce a pressure drop across the filter mass of one inch of water column. Under such circumstances, to insure against passage of gum, the filter mass should be of a depth to restrict the flow in cubic feet per hour of the test gas to below

$$4\sqrt{\frac{0.60}{\text{specific gravity of test gas}}}$$

per square inch of filter cross-section. Upon simplification this mathematical expression becomes 3.1 divided by the square root of the specific gravity of the test gas. To insure good capacity with filter compactness, the filter mass is preferably not made of a depth sufficient to restrict the flow in cubic feet per hour of test gas to below

$$1.7\sqrt{\frac{0.60}{\text{specific gravity of test gas}}}$$

Upon simplification this latter mathematical expression becomes 1.3 divided by the square root of the specific gravity of the test gas.

When using a test gas having a specific gravity of 0.60 the limits become 1.7 and 4.0 cubic feet per hour per square inch of filter cross section.

Examples of gases which may be employed as a test gas are any of the manufactured gases, or atmospheric air. Carburetted water gas is an example of a gas which may be made with a specific gravity of 0.60.

Filters meeting this test, which is not based on filtering efficiency but merely on gas flow, will efficiently filter gum particles from the gas at all rates of gas flow provided the pressure drop through the filter does not substantially exceed one inch of water column and provided the filter

mass is of a density within any of the above ranges.

Accordingly, it is readily seen that the given values are essentially critical as particularly defining a filter which will cause the effective removal of vapor phase gum particles from manufactured gas.

The invention will be further described in connection with the attached figures which form a part of this specification and which are chosen for illustration and in which:

Figure 1 shows a vertical cross-section of a filter for domestic gas range pilots.

Figure 2 shows a horizontal cross-section along the line 2—2 in Figure 1.

Figure 3 shows a vertical cross-section of a filter for gas refrigerator burners.

Figure 4 shows a plan view of the underside of the cover in Figure 3.

Referring now to Figures 1 and 2, 1 indicates a generally cylindrical filter chamber member, provided with an interior bore which constitutes the filter chamber. The member 1 is provided with the seat or shoulder 2 and with the lug 3, which is provided with the passage 4 communicating with the filter chamber. The lug 3 is further provided with pipe threads as indicated at 5. The interior bore of member 1 is threaded at 6 to engage the screw plug 7 which is adapted to be screwed into the bore and to seat in gas tight manner against the end of member 1 as indicated at 8. The screw plug is provided with the passage 9 which is furnished with pipe threads as shown at 10, and which communicates with the filter chamber. 11 and 12 are spiders provided with rims as 13 and arms as 14 and adapted to furnish support for screens 15 and 16. 17 is a filter pad of compressed rock wool. For convenience in assembly and connection, the member 1 may be provided with wrench grips, as at 18, and the head of the screw plug 7 may be formed as a nut.

All metal parts are preferably of a material or materials which do not corrode in the presence of manufactured gas. As an example, the filter chamber member 1, the screw plug 7, and spiders 11 and 12 may be of brass which preferably has a copper content not greater than 68% and still more preferably not substantially greater than 63%, and screens 15 and 16 may be of stainless steel. 16-mesh screen is very satisfactory, although other suitable mesh screen may be employed.

The interior bore is preferably accurately dimensioned in diameter and length, as is also the screw plug. The screws and spiders are preferably accurately formed in thickness. Such accurate dimensioning facilitates the securing of the desired rock wool arrangement in assembling the filter, as in such case a predetermined quantity of rock wool may be merely compressed to the desired cross-sectional area, depth and density.

In so assembling the filter, the spider 11 is positioned against the seat 2 and the screen 15 placed abutting the spider. A weighed or otherwise previously determined quantity of rock wool is then placed in the filter chamber and the screen 16 and spider 12 positioned on the other side of it. The screw plug 7 is then introduced and tightened until it seats in gas tight contact with the end of member 1 as at 8, compressing the rock wool within the chamber.

The filter pad, if desired, may be stamped, punched or otherwise formed from a rock wool

blanket of the required thickness to give the desired weight of rock wool, or a plurality of blankets may be superimposed to give the required thickness for the purposes indicated. In this case it is convenient to have the diameter of the filter pad slightly larger than the diameter of the inner bore of the filter chamber member 1 to insure a tight fit and thus avoid possibilities of channeling about the wall of said inner bore. As an example, the filter pad may have a diameter $\frac{1}{8}$ inch larger.

Rock wool blankets such as used commercially for heat insulation purposes may be employed, with or without the customary binding materials, if desired, particularly if irregularities in fiber distribution and fiber size are not too great, and the blanket is not too full of the usual beads which at present are apparently unavoidably formed during the manufacture of rock wool commercially.

Accurate dimensioning of the parts predetermines the cross section, density and depth of the rock wool after compression. The quantity of rock wool selected by weighing or punching from a mass of predetermined thickness is that which will give the density appropriate to the predetermined depth after compression to the predetermined volume.

The filter may be connected at either end to the pipe leading from the gas supply and at the opposite end to the pipe leading to the pilot or other low rate gas consuming device.

In use, the gas flows through the filter pad depositing therein the gum particles and other suspended solids, the screens and spiders serving to retain the rock wool without unduly impeding the flow of the gas.

The spiders with their arms 14 serve to support the screens and prevent their bulging while transmitting the pressure for compressing the filter pad and further serve to provide gas spaces which distribute the gas across the area of the pad.

As an example, a filter similar to that shown in Figure 1 having a chamber bore of 0.75 inch diameter and an overall chamber length of 0.75 inch is provided with a screw plug, screens and spiders dimensioned to provide a space for rock wool 0.50 inch deep after compression. The filter is filled with 1.8 grams of rock wool and, after assembly and installation, will filter heavily gummed gas, and is suitable for filtering, for example 0.75 cubic feet of gas per hour, without exceeding a pressure drop of one inch of water column through the filter. The density of the rock wool after compression is approximately 8.15 grams per cubic inch.

The degree of compression of rock wool from a form typical of that used commercially for other purposes is shown by the following. Filter pads for filters of the size and construction of the above example are formed commercially by punching from a blanket mass six inches in thickness. These punched pads when compressed in the filter chamber to a depth of $\frac{1}{2}$ inch have a density of approximately 8 grams per cubic inch.

Referring to Figures 3 and 4.

These figures illustrate a larger filter differing in some details from that in Figures 1 and 2.

20 indicates a filter chamber member having an interior bore, providing the filter chamber. Member 20 is provided with the lug 21 having the passage 22 communicating with the filter chamber. Lug 21 is provided with the pipe threads 23.

The member 20 is provided with threads 24, adapted to engage the threads of the cover 25. The cover 25 is provided with the passage 26,

which communicates with the interior of the chamber and which is provided with pipe threads as at 27. 28 and 29 are screens similar to those of Figures 1 and 2.

Instead of discrete spiders for supporting the screens and for providing gas distributing spaces, spiders are shown formed in the base of member 20, as indicated at 30 and on the inside of the cover 25, as indicated at 31. The latter is shown more clearly in Figure 4. 33 is a gasket to provide gas tight contact between the cover 25 and the chamber member 20. 34 is a filter pad of compressed rock wool.

As in Figures 1 and 2, the parts are preferably accurately dimensioned to provide a space for compressed rock wool of accurately predetermined area and depth to facilitate the securing of the proper density and depth in the compressed filter pad.

The assembly of the apparatus of Figures 3 and 4 is similar to that described in connection with Figures 1 and 2, except for the changes due to the fact that the spiders are integral with the filter chamber member and cover, and that a gasket is employed. As in Figures 1 and 2, a convenient method of assembly includes the compression of a weighed quantity of rock wool, or a punching from a blanket of predetermined thickness and thus desired weight, to an accurately predetermined cross-sectional area and depth and thus predetermined density.

As an example of a filter similar to that shown in Figures 3 and 4, a filter having a bore of 2.3 inches in diameter, 0.75 inch deep and having its spiders and screens dimensioned to give a space for compressed rock wool, 0.50 inch deep, and provided with 16.9 grams of rock wool is suitable for filtering, for example 7.0 cubic feet of gas per hour, without exceeding a pressure drop of one inch of water column. The density of the rock wool in the above example when compressed is approximately 8.15 grams per cubic inch.

In all cases care should be exercised when inserting the rock wool into a filter chamber to avoid undue unevenness in density throughout the body of the material, and to avoid channeling at the side walls.

The rock wool employed may be of the type used for heat insulation. Preferably, it is free from relatively excessive quantities of beads customarily formed during the manufacture of such material. Rock wool is usually made from slag and is ordinarily composed of oxides of calcium, magnesium, aluminum, iron and silicon. As an example, the fibers of rock wool may have average diameters between 3 and 4 microns, with some fibers ranging between 1 and 8 microns and may be of all lengths up to 80 millimeters. In the case of blankets, an organic binder is frequently employed to cause the fibers to adhere.

Typical samples of commercial rock wool gave the following analyses.

	Sample 1	Sample 2
	Percent	Percent
SiO ₂	31	40
Al ₂ O ₃	14	15
CaO.....	29	27
MgO.....	15	15
Impurities.....	11	3

Uniform packing of the rock wool is highly desirable and the filter pads are preferably formed by cutting or punching out discs from a blanket or superimposed blankets of rock wool

of substantially uniform and desired thickness. This method better insures uniform packing than introducing the rock wool in balls or tufts, although the latter method may be employed satisfactorily especially if care is taken to avoid undue unevenness in density.

It is to be understood that after extended use the pressure drop through the filter will increase due to the collection of gum in the interstices of the filter element which may eventually necessitate renewal. The life of the element, of course, depends somewhat on the quantity of gum in the gas it is required to filter. The characteristics of the filter pad made in accordance with this invention, however, permit considerable penetration in depth by the gum particles, so that filtration is not confined to a narrow zone on the entrance side of the element, a factor influential in securing a low pressure drop along with a long filter element life. The filter will, in most cases, outlive the appliance to which it is attached. This is of greatest importance commercially since the filter after being installed will in by far the larger number of cases require no servicing whatsoever.

The apparatus of the invention has been described particularly in connection with the filtering of vapor phase gum particles from gas. It may, however, have use in other applications. For instance, it is an excellent filter for dust laden combustible gas. The figures illustrate forms of the invention chosen for illustration.

It is to be understood that the foregoing is by way of illustration and that changes, omissions, additions, substitutions, and/or modifications might be made within the scope of the claims without departing from the spirit of the invention.

I claim:

1. A gas filter adapted to remove from a gas suspended particles of ultramicroscopic dimensions and of less than 1 mu in diameter, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of said gas therethrough, said filter element having a depth in the direction of gas flow of at least 0.25 inch and said rock wool having a density between 3 grams per cubic inch and 16 grams per cubic inch.

2. A gas filter adapted to remove extremely minute vapor phase gum particles of less than 1 mu in diameter suspended in combustible gas flowing to a low rate appliance burner, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of said gas therethrough, said filter element having a depth in the direction of gas flow of at least 0.25 inch and said rock wool having a density between 5 grams per cubic inch and 14 grams per cubic inch.

3. A gas filter adapted to remove from a gas suspended particles of ultramicroscopic dimensions and of less than 1 mu in diameter, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of said gas therethrough, said rock wool having a density between 3 grams per cubic inch and 16 grams per cubic inch, and said filter element having a depth in the direction of gas flow such that when subjected to test with a test gas flowing through said filter element at a rate sufficient to cause a pressure drop of one inch of water column the flow of said test gas per square inch of filter element cross-section taken at right angles to the direc-

tion of gas flow is restricted in cubic feet per hour to below 3.1 divided by the square root of the specific gravity of the test gas.

4. A gas filter adapted to remove extremely minute vapor phase gum particles of less than 1 μ in diameter suspended in combustible gas flowing to a low rate appliance burner, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of said combustible gas therethrough, said rock wool having a density between 5 grams per cubic inch and 14 grams per cubic inch, and said filter element having a depth in the direction of gas flow such that when subjected to test with a test gas flowing through said filter element at a rate sufficient to cause a pressure drop of one inch of water column the flow of said test gas per square inch of filter element cross-section taken at right angles to the direction of gas flow is restricted in cubic feet per hour to below 3.1 divided by the square root of the specific gravity of the test gas.

5. A gas filter adapted to remove extremely minute vapor phase gum particles of less than 1 μ in diameter suspended in combustible gas flowing to a low rate appliance burner, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of said combustible gas therethrough, said rock wool having a density between 3 grams per cubic inch and 10 grams per cubic inch, and said filter element having a depth in the direction of gas flow such that when subjected to test with a test gas flowing through said filter element at a rate sufficient to cause a pressure drop of one inch of water column the flow of said test gas per square inch of filter element cross-section taken at right angles to the direction of gas flow is restricted in cubic feet per hour to below 3.1 divided by the square root of the specific gravity of the test gas.

6. A gas filter for the removal of extremely min-

ute vapor phase gum particles of less than 1 μ in diameter from combustible gas flowing to a low rate appliance burner, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool in said casing between said inlet and outlet openings and in close contact with the side walls thereof, said rock wool having a density between 3 grams per cubic inch and 16 grams per cubic inch, and said filter element having a depth between said inlet and outlet openings such that when subjected to test with a test gas flowing through said filter element at a rate sufficient to cause a pressure drop of one inch of water column the flow of said test gas per square inch of filter element cross section is restricted in cubic feet per hour to below 3.1 divided by the square root of the specific gravity of the test gas, said filter element being of insufficient depth to restrict the flow in cubic feet per hour of said test gas per square inch of filter element cross section to below 1.3 divided by the square root of the specific gravity of the test gas.

7. A gas filter adapted to remove from combustible gas flowing to a low rate appliance burner vapor phase gum particles of ultramicroscopic dimensions and of less than 1 μ in diameter, comprising a filter casing having inlet and outlet openings, and a filter element of rock wool arranged in said casing for the flow of combustible gas therethrough, the fibers of said rock wool being relatively evenly distributed, said filter element having a depth in the direction of gas flow of at least 0.25 inch and said rock wool having a density between 3 grams per cubic inch and 16 grams per cubic inch to provide interstices between said fibers sufficiently large to permit said gum particles to penetrate into the body of said filter element but insufficiently large to prevent substantially complete removal of said gum particles from said gas.

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