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SPACE SIMULATING DEVICE AND METHOD

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FIG. 1

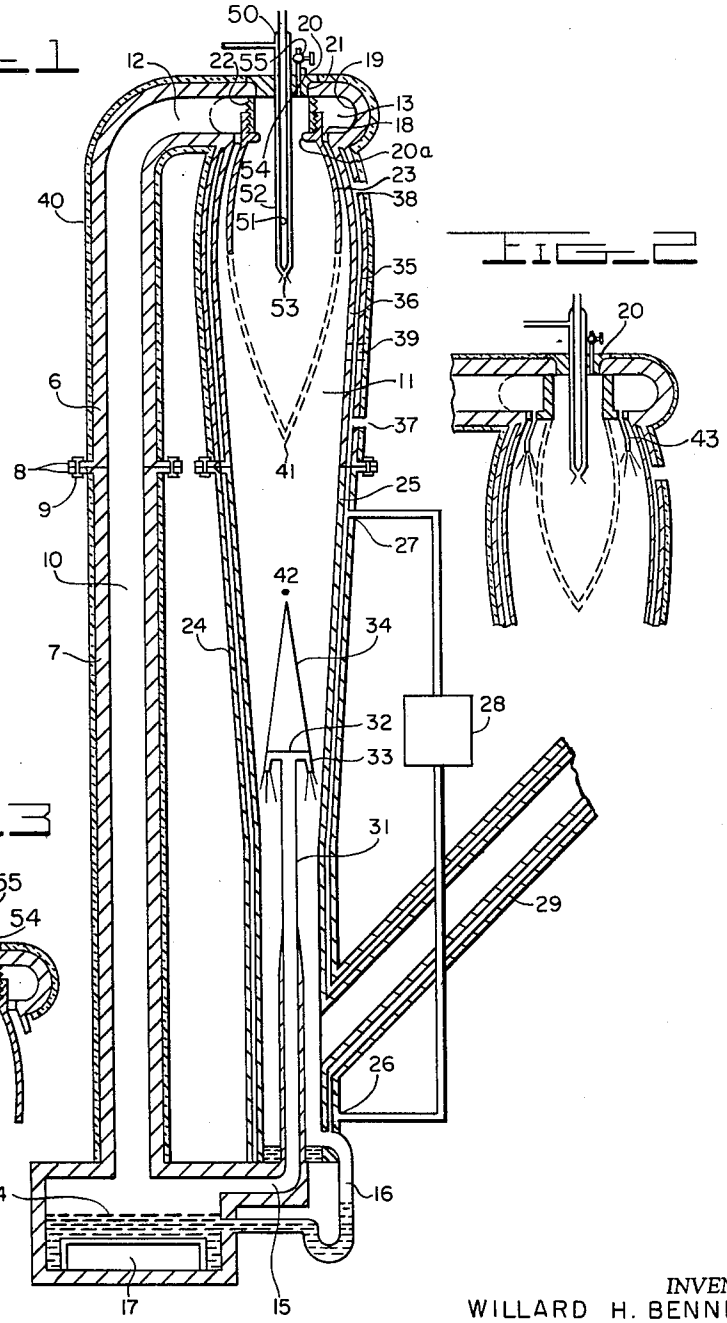
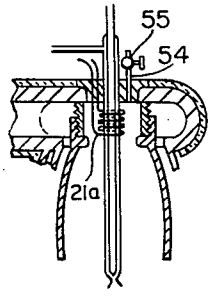


FIG. 2

FIG. 3



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SPACE SIMULATING DEVICE AND METHOD

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to space simulating devices and more particularly to a device for producing and maintaining conditions resembling those in space for investigating the performance of certain devices or phenomena under space conditions.

Heretofore investigations in a high vacuum simulating space conditions have not been carried out with satisfaction because of the difficulty in maintaining a continuous high vacuum around gassy devices. Further prior art devices permit back-flow of the gases from the surrounding walls and are restricted to use with condensible gases.

It is therefore an object of the present invention to provide a device for producing and maintaining suitable high vacuum space conditions to conduct investigations therein.

Another object of the invention is to provide a device suitable for studying thermal propulsion means involving jets of fuel and electric propulsion systems involving ion and electron jets.

Still another object is to provide a device which is an ideal means for coping with cesium ion devices and other ionic propulsion devices.

While still another object is to prevent back-flow gases in the high vacuum chamber.

Yet another object is to provide a device which is operative to simulate space conditions in a relatively short period of time and which will operate to simulate space conditions for indefinitely long periods of time.

Other and more specific objects of the invention will become apparent upon a careful consideration of the following detailed description when taken together with the accompanying drawing in which:

FIG. 1 illustrates a cross-sectional view of the device;

FIG. 2 illustrates a modification of the device shown in FIG. 1; and

FIG. 3 illustrates another modification of the device shown in FIG. 1.

The present invention is directed to a device for simulating conditions in space and for maintaining a high vacuum around gassy devices. The high vacuum space simulating condition is carried out by use of a boiler that produces gaseous vapor which passes through a tubular section into a header at the upper end of the device. The header surrounds an adjustable mechanical element which in combination with an annular opening into a chamber forms a nozzle between the header and the chamber. The mechanical element is adjustable with respect to the annular opening in order to regulate the vapor flow through the nozzle for different experiments. It is noted that for a particular experiment the mechanical element will be set for a particular opening and where the device is used for the same purposes at all times the mechanical element could be fixed. The vapors are drawn by separate fore or diffusion pumps from the header into the chamber through the nozzle and flow between the walls of the chamber and the mechanical element positioned within the annular opening. Because of the small area between the mechanical element and the wall of the chamber the gaseous vapor is drawn through the nozzle at high

velocities and forms a movable gaseous wall between the wall of the chamber and the area just below the end of the mechanical element. The vapors recombine at a point below the mechanical element into a uniform stream of vapors across the entire cross-section of the chamber. The vapors are then drawn down through the chamber and are pumped through an area between the wall of the chamber and a diffusion pumping mechanism. After passing through the diffusion stage the vapors condense on the wall surface of the chamber and any air molecules and/or test gases are pumped out of the chamber by the attached prevacuum fore or diffusion pumps.

Now referring to the drawing, there is shown by illustration a suitable device for carrying out investigations in a high vacuum simulating space conditions. The device includes a housing having an upper section 6 and a lower section 7 with matching flanges 8 which are secured together by any suitable means such as bolts 9. When the housing is secured together, the housing forms a tubular vapor passage 10 and a high vacuum space simulating compartment 11 joined together such that there is a passage 12 from the vapor tube 10 to a circular vapor reservoir or cavity 13 at the top of the compartment 11. The vapor passage 10 also joins at the bottom with a boiler reservoir 14 which has passages 15 and 16 connecting the boiler with compartment 11 at the bottom of the housing. Within the housing and lying within the boiler region above the bottom wall of the housing is an electric heater 17 which is provided to heat any fluid placed in the boiler.

The passage 12 meets with the vapor reservoir 13 which has semi-circular walls 19 to provide a "header" for the compartment 11 that opens into the compartment through an annular opening 18. The housing has an opening 21 at the top coaxial with the circular cavity and the compartment 11 which opens into the cavity to provide an opening through which the elements to be investigated can be inserted. The opening is closed by a suitable cover 20, through which the test device 50 is inserted. The test device as shown includes coaxial tubular members 51 and 52. A suitable fuel is injected through the inner tube 51 and outlet 53 and a suitable fluid such as air is injected through tube 52 to form a combustible mixture with the fuel at the outlet end. The outlet end 53 of tube 51 is adjustable with respect to the outlet of the tube 52 in order to adjust the air mixture of the combustible products. The cover is provided with a tubular passage 54 therein through which a suitable fluid under pressure such as hydrogen or helium may be forced. The hydrogen may also be ionized as an electrically neutral ionized hydrogen gas by any suitable ionizing means well known in the art such as a radio-frequency coil 21*a*, shown surrounding the test device in FIG. 3. The RF coil may be included in the structure but will only be used to provide the ionized gas when desired. A suitable valve 55 is installed in the incoming gas line for the purpose of controlling the pressure and speed of the gas added through the cover wherein the pressure and speed depends on the pressure of the vapors passing along the outside of the funnel-shaped member. The inner wall of the housing at the opening at the top has a cylindrically threaded member 22 secured thereto coaxial with the opening 21 and the annular opening 18. A section of a somewhat funnel shaped member 23 is inserted through the annular opening 18 with the small end toward the housing opening 21 and screw threaded onto the cylindrical member 22 secured about the opening 21. The member 23 may be adjustable relative to the annular opening 18 in order to adjust the passage opening between the annular opening and the member 23. For this purpose lugs 20*a* are added to the inner surface thereof. The member 23 in combination with the annular opening 18 and the walls of compartment 11

provides effectively a nozzle through which a fluid can flow.

The lower portion of the compartment **11** is made with spaced walls **24** and **25** through which a coolant may be forced through inlet **26** and outlet **27** by a refrigeration compressor **28** to condense the vapors hitting the wall surface of the chamber. In all cases it is not necessary to cool the lower section of the chamber therefore in those cases where a cooled lower section is not necessary the refrigerant will not be used. The lower portion is also provided with an arm **29** to which one or more diffusion pumps or forepumps are connected as needed to evacuate chamber **11** and to aid in maintaining a suitable low pressure in the chamber **11**. The passage **15** connects with an axially aligned tubular member or conduit **31** which extends upwardly into the compartment **11**. The conduit has a top portion or cap **32** with a deflector skirt **33** secured thereto which deflects downwardly a fluid passing through the conduit upwardly. The combination of the cap and skirt forms a nozzle through which fluid will pass. The passage **16** connects into a side of the compartment slightly above the bottom thereof such that fluid formed by condensation of the vapor hitting the wall surface will stand in the bottom of the compartment any excess will drain through passage **16** to the reservoir or boiler **14** of the housing. The cap **32** has connected thereto a conical member **34** which extends with the point of the cone facing toward the upper end of the compartment and the lower end connected with the cap forms a constriction with the walls of the compartment.

The upper portion of compartment **11** is made with a double wall **25—36** and is provided with an inlet **37** and an outlet **38** through which a hot fluid is forced to maintain the upper portion of compartment **11** at a much higher temperature than the bottom portion. The temperature of the upper portion should approximate the temperature of the mercury vapor passing through that portion of the compartment. A double glass window **39** is made in the wall surface to provide an inspection opening and the hot fluid passing within the double walls of the upper section of the housing prevents fogging of the window and maintains the mercury vapor at a constant temperature. The housing is also provided with an in-insulating material **40** along the vapor tube and the hot double walled section to prevent any loss of heat. Likewise the cold section could be protected to prevent loss of the cooling effect.

In operation of the device, for example, in investigating simulated flames of jets in a vacuum simulating space conditions and using mercury as the gaseous vapors in the chamber, the flame making device **50** is inserted into the chamber **11** through the opening in the top of the housing such that the flame when started will be positioned below the end of the adjustable member **23** and the opening is sealed by any appropriate means. The refrigeration unit is started to cool the lower section of chamber **11** and the hot fluid is forced through the double walled section of the upper section of the chamber. The chamber **11** is then evacuated by operation of the prevacuum, fore or diffusion pump connected to arm **29** and the heater **17** put into operation to vaporize the mercury in the boiler. Operation of the evacuating means and heater is continued for continuous operation. When the chamber has been evacuated and the mercury vaporized, the mercury vapor gases will flow through the tube **10** and passage **12** into the "header" **13**, where the vapors will be drawn into the evacuated chamber **11** through the annular passage about the funnel-shaped element. Since the vapor gases going from the "header" into the evacuated chamber pass through a confined area between the chamber wall and the funnel shaped element, the velocity of the vapor gases will increase with reduced pressure due to the smaller area in the passage. As the vapor gases pass by the funnel-shaped element into the chamber **11** the velocity will be less and the pressure higher. The mercury vapors will then flow together at a point **41** below the member **23** and will then be drawn on out of the chamber **11** by the action of a diffusion pump at **33** in the chamber and the forepumps connected to the arm **29**. The mercury vapor will receive an additional velocity from the action of the diffusion pump built into the chamber **11** by the mercury vapors being drawn downwardly about the conical member secured to the cap of the diffusion pump. Once the chamber has been evacuated and space conditions obtained, the jet flame is started into operation. The molecules of the jet flame operating just below the funnel shaped member will be surrounded by the mercury vapor gases and the molecules of the flame will hit the molecules of the mercury vapor to increase the velocities of the molecules of the mercury vapor. The mercury vapor thus forms a gaseous moving wall about the flame. It has been determined that some of the mercury vapor moving along the wall of the funnel-shaped member has a tendency to curve around the edge of the funnel-shaped member and to get into the area between the test device and the inner walls of the member **23**. Any backflow of gases into this area has a deleterious effect on the efficiency of the device. Thus a gas such as hydrogen or helium is forced into the area within the funnel-shaped member and surrounding the test device. This gas must be admitted through the cover at a speed such that, at the pressure of admittance, the molecular mean free path of the gas is appreciably shorter than the distance from the end of the test device to the bottom edge of the funnel-shaped member and also the distance from the end of the test device on a horizontal line to the edge of the vapor steam flow.

The gas being admitted through the cover to the area within the funnel-shaped member has the effect of holding back any pump vapors passing between the chamber wall and the outer surface of the funnel-shaped member because of the pumping action of the diffusion pump. The diffusion pump will pump the gas admitted through the cover the same as the mercury gases about the funnel-shaped member. The hot fluid passing through the walls of the upper section of the chamber maintains a constant temperature about the mercury vapor and since the gas flame molecules strike a moving wall of mercury vapor there will be no condensation of gases in the vicinity of the test device **50**, consequently there will be no backflow of the molecules. The gases of the flame and gas admitted through the cover will mix with the mercury vapors at a point below **41** and will be carried together downwardly through the chamber. The walls of the chamber below the point **41** are maintained at a temperature of about —30° C., thus the gases striking the chamber walls in this area will condense and those gases passing through the chamber will be forced toward the chamber walls at a point **42** by the cone-shaped member **34** secured to the diffusion pump in the lower portion of the chamber. The diffusion pump will draw the gaseous mixture downwardly through the chamber in the normal operation of a diffusion pump. Since the conical member and the walls of the chamber restrict the area therebetween, the velocity of the gaseous mixture will again be increased and drawn from the chamber at an increased rate.

It is to be noted that the mercury vapor forms a moving gaseous wall about the flame and this moving wall prevents the gases from condensing in the vicinity of the flame and hence there is no molecular back-flow. The diffusion pump in the lower portion of the chamber maintains a vacuum in the area of the upper chamber section above the pump except for the vapor pressure of mercury at the temperature of the walls. The mercury vapor is drawn downward at the pressure required to hold gases ahead of the flame jets at point **41** in the chamber and the flow of mercury vapor **15** adjusted by adjusting the member relative to the annular opening at the upper end of the chamber. The greater the flow

from the gas source from the device being tested, the greater the flow of mercury vapor required to be drawn downwardly from the header 13.

In an alternative arrangement the annular opening into the chamber can be made with an annular arrangement of gas jets 43 so the mercury vapors can be drawn downwardly through the jets. In this device there is no funnel-shaped element and the jets of gases will be directed downwardly somewhat parallel to the wall of the chamber surrounding the test gases. The effect of the jets of mercury vapor are the same as described for the device having the annular passage and funnel-shaped element. Each of the species shown are provided with an appropriate cap to seal the housing opening about the test device.

For some test devices it will not be necessary to include a diffusion pump in the space simulating device wherein the pumping action relied on would be furnished by diffusion pumps connected to the arm 29 of the device. Further there may be instances where more than one diffusion pumping stage will be required in the space simulating device. Any combination of diffusion and/or forepumps may be used where the diffusion pumps are integral with the space simulating device or separate pumps connected to the outlet arm.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A method of simulating space conditions for investigating gaseous devices under space conditions which comprises inserting and sealing said gassy device to be investigated into a chamber, evacuating said chamber about said gassy device, heating a fluid to form a gaseous medium and directing said gaseous medium to a header about said gassy device, pumping said gaseous medium at a high velocity along and surrounding said gassy device between the walls of said chamber and a mechanical element positioned about said gassy device, continuously vacuum pumping said chamber and pumping said gaseous medium between said chamber wall and the gassy device being investigated.

2. A method of simulating space conditions for investigating gassy devices under space conditions which comprises inserting and sealing said gassy device to be investigated into a chamber, evacuating said chamber about said gassy device, forming a first gaseous medium and directing said gaseous medium to a header about said gassy device, pumping said first gaseous medium at a high velocity along and surrounding said gassy device between the walls of said chamber and a mechanical element positioned about said gassy device, forcing a second gaseous medium about said gassy device and within the area confined by said mechanical element positioned about said gassy device, continuously vacuum-pumping said chamber and maintaining said first gaseous medium between said chamber walls and the gassy device being investigated and continuously forcing said second gaseous medium about said gassy device.

3. A device for simulating space conditions which comprises a housing, a chamber in said housing within which space conditions are simulated, an opening in said housing in axial alingment with said chamber, an annular opening into said chamber in spaced relationship with said opening in said housing, a reservoir in said housing between sad opening in said housing and said annular opening into said chamber, means connected about said housing opening and extending through said annular opening into said chamber in spaced relationship with said annular opening in said chamber and the adjacent wall of said chamber, means connected with said reservoir between said annular opening in said chamber and said housing opening for admitting a gaseous medium into said reservoir, and means associated with said chamber for evacuating said chamber and pumping said gaseous medium through said annular opening into said chamber.

4. A device for simulating space conditions which comprises a housing, a chamber within which space conditions are simulated, an opening in the top of said housing in axial alignment with said chamber, an annular opening in said chamber spaced from said opening in said housing, a reservoir in said housing in the vicinity of said opening at the top thereof and the annular opening in said chamber, a funnel-shaped means connected to said housing about said housing opening and extending through said reservoir into said chamber in spaced relationship with said annular opening in said chamber and the adjacent wall of the chamber, said funnel-shaped means being adjustable relative to said opening in said chamber, means connected with said reservoir for admitting a gaseous medium into said reservoir about said chamber, and means associated with said chamber for continuously vacuum-pumping said chamber and forcing said gaseous medium through said annular opening through the spacing between said funnel-shaped means and the wall of said chamber and through said chamber.

5. A device for simulating space conditions which comprises a housing, said housing including a space simulating compartment and a vapor passage adjacent thereto and parallel therewith, a vapor reservoir at the top of said housing, said reservoir interconnecting said simulating compartment with said vapor passage, an opening in said housing axially aligned with said compartment, said compartment having an annular opening into said reservoir and in alignment with said opening in said housing, a funnel-shaped element secured about said housing opening and extending through said reservoir and through said annular opening into said compartment in spaced relationship with the adjacent walls of said compartment, a boiler means connected with said vapor passage and adapted to supply a gaseous medium to said reservoir above said compartment, and means for vacuum-pumping said compartment and pumping said gaseous medium from said reservoir between said funnel-shaped element and the compartment wall and on to the compartment at a high velocity.

6. A device for simulating conditions for investigating gassy devices under space conditions which comprises a housing, a chamber within said housing in which space conditions are maintained, an annular opening in the top of said chamber, an opening in said housing in axial alignment with said opening in said chamber through which a device to be investigated is inserted into said chamber, a funnel-shaped means secured about said opening in said housing, said funnel-shaped means extending into said chamber in spaced relationship with the wall of said chamber and surrounding said device to be investigated, means for supplying a continuous flow of a gaseous medium to said chamber at the top thereof, means connected with said chamber for continuously vacuum-pumping said chamber, and pumping said gaseous medium about said funnel-shaped means and around said gaseous device, said gaseous medium providing a moving gaseous wall between said gassy device and the wall of said chamber.

7. A device for simulating space conditions for investigating gassy devices under space conditions which comprises a housing, a chamber within said housing in which space conditions are maintained, an annular opening in the top of said chamber, an opening in said housing in axial alignment with said annular opening in said chamber through which the device to be investigated is inserted into said chamber, a funnel-shaped means secured about said opening in said housing and extending into said chamber through said annular opening therein in spaced relationship with the wall of said chamber, said funnel-shaped means surrounding said device to be investigated, means for supplying a continuous flow of a

gaseous medium through said opening in said housing and into the area confined by said funnel-shaped member, means for supplying a continuous flow of the gaseous medium into said chamber at the top thereof and surrounding said funnel-shaped member, means connected with said chamber for continuously vacuum-pumping said chamber and pumping said gaseous medium along said funnel-shaped means and around said gassy device to provide a moving wall of a gaseous medium between said gassy device and the wall of said chamber.

8. A device as claimed in claim 7 wherein said chamber is made of double walls and has a heating means connected to the top portion thereof and a cooling means connected to the bottom portion thereof.

9. A device as claimed in claim 8 in which a diffusion pump means is arranged in the lower section of said chamber.

10. A device for simulating space conditions which comprises a housing, a chamber within said housing within which space conditions are simulated, an annular opening in the top of said chamber, an opening in said housing in axial alignment with said annular opening in said chamber through which a device to be investigated is inserted into said chamber, an annular array of jet openings extending into said chamber and spaced axially from said opening in said housing, a reservoir in said housing in the spacing between said opening in said housing and said annular array of jets, said reservoir adapted to admit a gaseous medium into said chamber, means for admitting a gaseous medium into said reservoir, said reservoir adapted to admit said gaseous medium into said chamber through said jets and means associated with said chamber for vacuum-pumping said chamber and pumping said gaseous medium through said annular array of jets and through said chamber.

11. A device for simulating space conditions which comprises a housing, a chamber in said housing within which space conditions are simulated, a diffusion pump assembled in said chamber, an opening in the top of said housing in axial alignment with said chamber, a vapor reservoir positioned between said opening in said housing and said chamber, a cylindrical member in axial alignment with said chamber connected about said opening in the top of said housing and passing through said reservoir and connecting to said chamber, an annular array of jets extending into said chamber from said vapor reservoir to form a passage from said reservoir into said chamber about said cylindrical member, means connected with said reservoir for admitting a gaseous medium into said reservoir, said diffusion pump in said chamber continuously vacuum-pumping said chamber and pumping said gaseous medium through said annular jets and through said chamber.

12. A device as claimed in claim 11 in which said chamber means is heated along the upper portion thereof and cooled along the lower portion thereof.

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