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SMOKE GENERATING DEVICE

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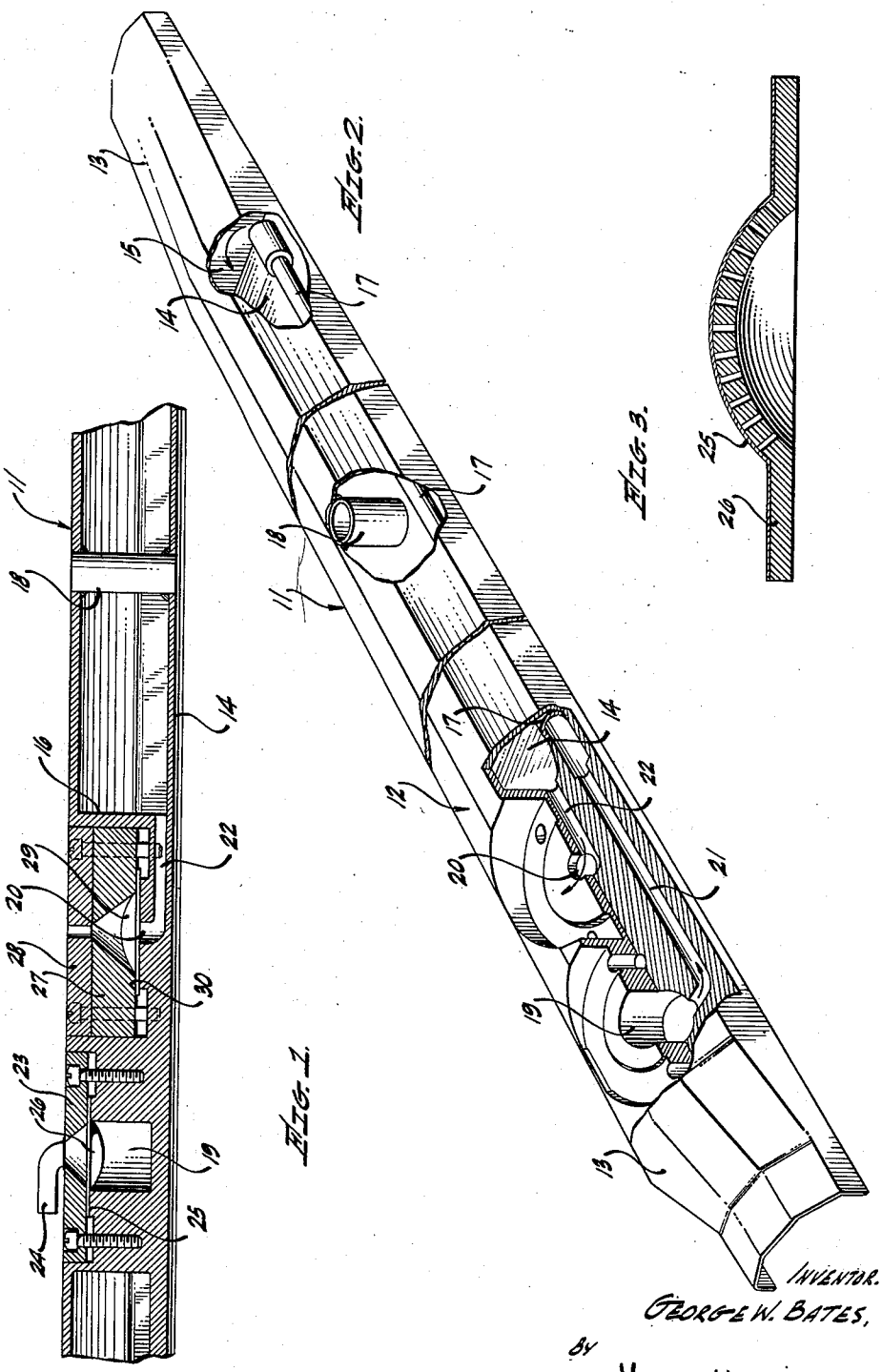


FIG. 2.

FIG. 3.

FIG. 1.

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SMOKE GENERATING DEVICE

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This invention relates to a smoke generating device, and more particularly to a smoke generating device adapted to be used on high speed bodies which produces a smoke trail to aid in the visual observation of such bodies.

To aid in the visual observation of high speed objects such as projectiles and self-propelled missiles, which are normally difficult to observe due to their speed, size or distant location, it is advantageous to provide a means affixed to such a high speed body which will produce a visible trail such as a smoke trail. Various materials which will hydrolize in the presence of moist air to produce particles which form a dense cloud are well known to the art. These materials include liquids such as titanium tetrachloride ($TiCl_4$), stannic chloride ($SnCl_4$), and various solid chemical compounds which contain sulphur and the double chloride of a metal such as titanium. Oil, which atomizes when discharged at high velocity, thus forming a visible trail is also used.

In the state of the art prior to the present invention, however, various difficulties have been encountered when smoke generating devices known to the prior art have been used on high speed missiles or projectiles having a high rate of acceleration and subject to violent maneuvers. Difficulty has been encountered in discharging the fluid during rapid acceleration or maneuvers, and in maintaining a steady rate of flow. Further, it has been difficult in the state of the art prior to the present invention to control the origination point at which a smoke trail will be produced in missiles or projectiles.

Accordingly, it is an object of the present invention to provide a smoke generating device adapted for use with a high speed body which provides a means for ejecting a smoke producing material from said generator at a predetermined velocity of said object.

It is another object of the present invention to provide a smoke generating device adapted for use with a high speed body which provides a means for ejecting a smoke producing material from said generator to produce a smoke trail of substantially uniform density.

It is another object of the present invention to provide a smoke generating device adapted for use with a high speed body which provides a means for ejecting smoke producing material during acceleration, deceleration, or maneuvers of said body.

It is a further object of the present invention to provide a smoke generating device adapted for use with a high speed body which is self contained and in which the smoke producing material is isolated within the smoke generator while being transported or handled.

It is a still further object of the present invention to provide a smoke generating device adapted for use with a high speed body which is efficient and reliable while light in weight and small in volume.

Other objects and advantages of the present invention will be apparent to those skilled in the art from the following description of a presently preferred embodiment

of the present invention as illustrated in the accompanying drawing made a part of this specification in which:

Fig. 1 is a cross-sectional view in elevation of the device of the present invention, taken substantially along the longitudinal center line of the assembled device in which, for purposes of clarity and ease of illustration, the air inlet and fluid outlet of the assembled device are shown positioned on the centerline.

Fig. 2 is a perspective view of the present invention with partial sections taken to show the internal construction of the device of the present invention; and

Fig. 3 is an enlarged view of a rupturable diaphragm used in the present invention.

The smoke generating device described herein utilizes a container having smoke producing material enclosed therein, a sealed air pressure inlet to the container with means for admitting air under pressure into the container when the air reaches a predetermined pressure, and a means for ejecting the smoke producing material from the container when the internal pressure of the container reaches a predetermined level.

Referring to the drawing a presently preferred embodiment of the present invention adapted for use on a self-propelled air borne body is shown.

The present invention comprises a housing defining a container **11** which encloses the smoke producing material to be discharged, an inlet and outlet housing section **12**, and fairings **13** which provide airflow configuration for the smoke generating device of the present invention. In the present embodiment described herein, the container **11** is an elongated hollow metallic body whose overall dimensions are determined by the quantity of smoke producing material which is to be discharged by the smoke generating device. The inner surface **14** of the container **11** and inlet-outlet housing **12** is determined by the shape of the surface of the body to which the smoke generating device is to be affixed. In the embodiment shown, the inner surface **14** has a slight concavity which adapts it to be affixed to a cylindrical body. The hollow container **11** is closed at its ends by a back wall **15** and a front wall **16** which is a common wall formed by the inlet-outlet housing **12** as described hereinafter. In the presently preferred embodiment the container **11** is filled with liquid titanium tetrachloride ($TiCl_4$) which is used as the smoke producing material.

An air conduit **17** extends from the front wall **16** of the container to a position proximate the back wall **15** of the container. In the present embodiment the air conduit **17** is a cylindrical tube open at both ends. As a means for affixing the smoke generating device of the present invention to the high speed body for which it is adapted, spacers **18** open at both ends are provided between the inner and outer wall of the cylinder for the insertion of a bolt or similar fastening means between the smoke generating device and the surface of the body to which it is affixed.

The inlet-outlet housing **12** is longitudinally juxtaposed and coextensive with the container **11** at the forward end of the container and defines the common wall **16** between the inlet-outlet housing **12** and the container **11** of the assembled smoke generating device. The inlet-outlet housing **12** is a metallic body defining an air inlet chamber **19** and a fluid outlet chamber **20**, which are cylindrical in shape. The housing section **12** also defines an air inlet path **21** and fluid outlet path **22** extending longitudinally through the inlet-outlet housing to communicate the air inlet chamber **19** and fluid outlet chamber **20** respectively, with the container **11**.

At the common wall **16** means are provided for connecting the air conduit **17** of the container **11** to the air inlet path **21** of the housing section **12**. The air inlet cover **23** having an air inlet opening therethrough sub-

stantially symmetrical with the air inlet chamber **19** and coextensive therewith, is recessed flush within the upper surface of the inlet-outlet housing **12**. An air inlet nozzle **24** extending above the upper surface of the air inlet cover **23** and coextensive with the air inlet opening therethrough, is positioned substantially parallel to the direction of motion of the body to which the smoke generating device is affixed, with the air inlet of the nozzle **24** facing the direction of motion. For ease of illustration, the air inlet nozzle and fluid outlet have been rotated to the centerline of Fig. 1, however, in operation the air inlet nozzle and fluid outlet are radially displaced as in Fig. 2 to avoid any interference between the airstreams impinging on the inlet or outlet. A continuous air inlet path is thus provided from the inlet opening of the air inlet nozzle **24**, through the air inlet chamber **19**, the air inlet path **21**, and the air conduit **17**, into the container **11**. Interposed between the air inlet chamber **19** and the opening of the air inlet cover **23** is a first rupturable diaphragm **25**. The rupturable diaphragm has dimensions substantially greater than the dimensions of the air inlet chamber **19** and acts as a seal between the air inlet cover **23** and the air inlet chamber. In the present embodiment a rupturable diaphragm of soft metal foil, such as lead foil (Fig. 3), having a thickness of approximately 0.00085 inch with a rupture strength of approximately fourteen pounds per square inch is used. A backup plate **26** is positioned juxtaposed to the surface of the rupturable diaphragm **25** between the diaphragm and the air inlet cover **23**, and is substantially equal in area and configuration to the rupturable diaphragm. The backup plate **26**, having multiple perforations to allow the passage of air therethrough, is substantially rigid and avoids working of the flexible rupturable diaphragm when variations in air pressure would otherwise cause the diaphragm to flex. Fastening means are provided through the air inlet cover **23** into the housing **12** in order to exert compressive force between the contact portion of the rupturable diaphragm and the contact surface of the inlet-outlet housing **12**. In the presently preferred embodiment, the contact surface of the housing **12** proximate the air inlet chamber **19** is lapped smooth to allow better contact with the rupturable diaphragm. The rupturable diaphragm **25** being of soft metal provides an efficient seal between the inlet nozzle side and the container side of the continuous air inlet path to the container.

Positioned above the fluid outlet chamber **20** is the fluid outlet cover **27** having a fluid outlet opening therethrough substantially symmetrical with the fluid outlet chamber **20** and coextensive therewith. A fluid outlet orifice plate **28** is recessed flush with the outer surface of the fluid outlet cover **27**, and defines an orifice outlet extending from the fluid outlet opening of the fluid outlet cover **27**. The outlet orifice plate **28** may be interchanged to provide an orifice of required diameter to obtain the discharge rate of smoke producing material desired in any given application of the smoke generating device. Thus, a continuous fluid outlet path is provided from the container **11** for the discharge of the smoke producing material within the container **11** through the orifice of the fluid outlet orifice plate **28**. Interposed in the fluid outlet path between the fluid outlet chamber **20** and the opening of the fluid outlet cover **27** is a second rupturable diaphragm **29**. The rupturable diaphragm **29** has dimensions substantially greater than the dimensions of the fluid outlet chamber **20** and acts as a seal between the outlet side and the container side of the continuous fluid outlet path. In the present embodiment a rupturable diaphragm of lead foil similar to that of the first rupturable diaphragm **24** is used, having a thickness, however, of approximately 0.0012 inch and a rupture strength of approximately twenty pounds per square inch. A back-up plate **30** similar to the backup plate

described hereinbefore is positioned proximate the surface of the rupturable diaphragm **29** between the diaphragm and the fluid outlet chamber **20** to avoid working of the diaphragm due to pressure variations. Fastening means are again provided through the fluid outlet cover **27** into housing section **12** in order to exert compressive force between the contact portion of the rupturable diaphragm and the contact surface of the inlet-outlet housing **12**, to accomplish an efficient fluid seal.

Thus, in operation with the smoke generating device disclosed herein affixed to a high speed body, air is admitted through the air-inlet nozzle **24** but is sealed from the container **11** until the air inlet pressure, due to the speed of the body to which the device is affixed, reaches a predetermined pressure. At that time the first rupture diaphragm **25** is ruptured and air under pressure is admitted through the air conduit **17** into the container **11** proximate the end of the container opposed to the fluid outlet. As the air under pressure is admitted into the container, the fluid pressure within the fluid outlet chamber **20** accordingly increases to the predetermined pressure at which the second rupture diaphragm **29** ruptures, and the smoke producing material is discharged through the fluid outlet orifice. If greater speed is attained by the body to which the smoke generating device is affixed a greater air pressure is built up within the container **11** and the smoke producing material is discharged at an increased rate. Thus, the rate of discharge is proportional to the speed of the body, and the density of the smoke trail is substantially constant. The thickness of the rupturable diaphragms may be varied to provide for the discharge of the smoke producing material at various rates of speed of the body. The rupture strength of the rupturable diaphragms which will cause the diaphragms to rupture at a given air pressure and thus a given velocity may be readily determined by one skilled in the art. The inlet and outlet diaphragms have different rupture strengths according to whether the pressure head of the fluid in the container will be additive or subtractive in the application of the smoke generating device. Thus, in the embodiment described herein, the outlet rupturable diaphragm is located forward of the fluid container and a smoke trail is desired after acceleration is completed. At the point where deceleration commences, an additional initial pressure due to the fluid head will be exerted on the outlet diaphragm. The outlet diaphragm, therefore, has a slightly higher rupture strength than the inlet diaphragm to allow discharge of the fluid at the point of maximum velocity of the body when acceleration is completed. If discharge of the fluid is desired at a given velocity during acceleration, utilizing the described embodiment of the present invention, the smoke generating device may be positioned with the container section forward of the inlet-outlet housing section to provide a positive fluid head on the outlet diaphragm during acceleration of the body. In such an application the air inlet nozzle is reversed with respect to the assembled device shown, to direct the air inlet opening of the nozzle in the direction of motion of the body.

For use at extremely high altitudes where there is insufficient moisture in the air to hydrolize the smoke producing material as it is discharged, a second assembly similar to the one described herein, may be positioned adjacent the smoke generating device, with the second assembly containing a moisture forming material such as aqueous ammonia. The outlet orifices are then positioned to intersect outside of the surface of the smoke generating device. Thus, as the smoke producing material and the ammonia are discharged their discharge paths intersect, and the smoke producing material is hydrolized by the atomized fluid being discharged from the companion device.

While a preferred embodiment of the smoke generating device of the present invention as adapted to high

velocity airborne bodies has been described, it is to be understood that this is given by way of example only. Various modifications and applications of the smoke generating device of the present application will be apparent to those skilled in the art, and the scope of the invention is to be determined by the objects and the claims.

What is claimed is:

1. A smoke generating device adapted for use on a high speed body comprising a closed container, said container being filled with smoke producing fluid, a housing juxtaposed to said container, said housing defining an air inlet path and fluid outlet path therethrough, said air inlet path and said fluid outlet path communicating with said container, an air inlet nozzle affixed to said housing defining an air inlet opening to said air inlet path, said nozzle being directed in the direction of motion of said body, a first pressure sensitive rupture diaphragm interposed in and sealing said air inlet path, and a second pressure sensitive rupture diaphragm interposed in and sealing said fluid outlet path, said second rupture diaphragm having a rupture strength in excess of a rupture strength of said first rupture diaphragm.

2. A smoke generating device adapted for use on a high speed body comprising an elongated metallic container, said container being filled with smoke producing fluid, a housing longitudinally juxtaposed to said container, said housing defining an air inlet path and fluid outlet path therethrough, said air inlet path and said fluid outlet path communicating with said container, an air inlet nozzle affixed to said housing defining an air inlet opening to said air inlet path, said nozzle being directed in the direction of motion of said body, a first pressure sensitive rupture diaphragm interposed in and sealing said air inlet path, a second pressure sensitive rupture diaphragm interposed in and sealing said fluid outlet path, and perforated back-up plates for each of said rupture diaphragms.

3. A smoke generating device adapted for use on a high speed body comprising a closed container, said container being filled with smoke producing fluid, a housing longitudinally juxtaposed to said container at a first end of said container, said housing defining an air inlet path and a fluid outlet path therethrough, an air inlet conduit communicating with said air inlet path extending within said container from said housing to a position proximate the second end of said container, said container communicating with said fluid outlet path, a first rupturable diaphragm interposed in said inlet path, said first rupturable diaphragm being a metallic diaphragm of finite thickness and having a predetermined rupture strength, a second rupturable diaphragm interposed in said outlet path in said housing, said second rupturable diaphragm being a metallic diaphragm of finite thickness and having a predetermined rupture strength in excess of said rupture strength of said first rupturable diaphragm, and perforated back-up plates for each of said rupturable diaphragms.

4. A smoke generating device adapted for use on a high speed body comprising a closed container, said container being filled with a fluid smoke producing material, a housing longitudinally juxtaposed to said container at a first end of said container, said housing defining an air inlet path and a fluid outlet path therethrough, an air inlet nozzle affixed to said housing defining an air inlet opening to said air inlet path, said nozzle being directed in the direction of motion of said body, an air inlet conduit communicating with said air inlet path extending within said container from said housing to a position proximate the second end of said container, said container communicating with said fluid outlet path, a first rupturable diaphragm interposed in said inlet path, said first rupturable diaphragm being a metallic diaphragm of finite thickness and having a predetermined rupture strength to rupture at a given air pressure corresponding to a predetermined air velocity, a second rupturable diaphragm interposed in said outlet path, said second rupturable diaphragm being a metallic diaphragm of finite thickness and having a predetermined rupture strength in excess of said rupture strength of said first rupturable diaphragm to rupture at a predetermined fluid pressure and perforated semispherical back-up plates for each of said rupturable diaphragms.

5. A smoke generating device adapted for use on a high speed body comprising; a closed container, said container being filled with smoke producing fluid; a housing longitudinally juxtaposed to said container at a first end of said container, said housing defining an air inlet path and fluid outlet path therethrough; an air inlet nozzle affixed to said housing defining an air inlet opening to said air inlet path, said nozzle being directed in the direction of motion of said body; an air inlet conduit communicating with said air inlet path extending within said container from said housing to a position proximate the second end of said container; said container communicating with said fluid outlet path; a first rupturable diaphragm interposed in said air inlet path, said first rupturable diaphragm being a lead diaphragm of finite thickness and having a predetermined rupture strength to rupture at a predetermined air inlet pressure; a second rupturable diaphragm interposed in said fluid outlet path, said second rupturable diaphragm being a lead diaphragm of finite thickness and having a predetermined rupture strength to rupture at a predetermined fluid pressure within said container, said rupture strength of said second rupturable diaphragm being substantially equal to or greater than said rupture strength of said first rupturable diaphragm; a substantially rigid plate of finite thickness juxtaposed to the air inlet surface of said first rupturable diaphragm, said rigid plate having multiple perforations therein; and a substantially rigid plate of finite thickness juxtaposed to said second rupturable diaphragm at the surface of said rupturable diaphragm nearest said container, said rigid plate having multiple perforations therein.

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