Oct. 18, 1960 R. D. LEMMERMAN 2,956,637

SOUND ATTENUATING DEVICE

Filed April 23, 1959 2 Sheets-Sheet 1

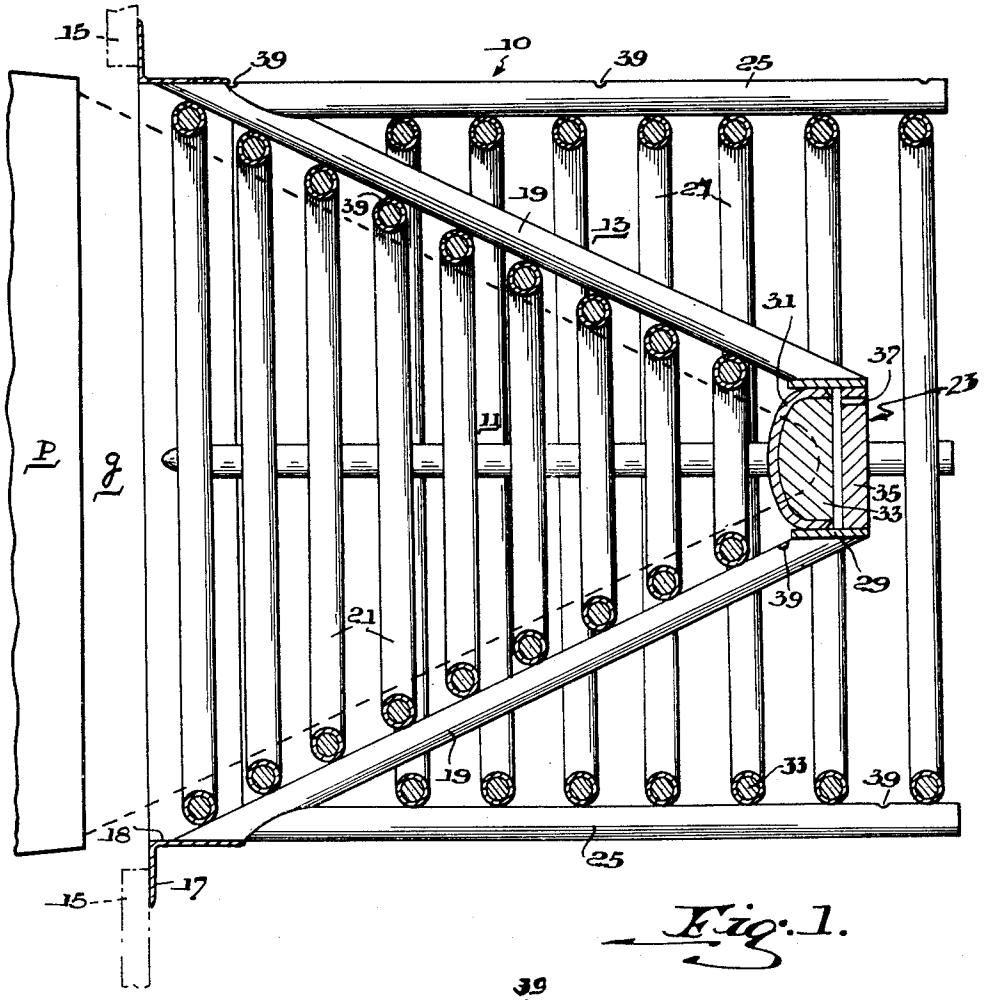


Fig. 1.

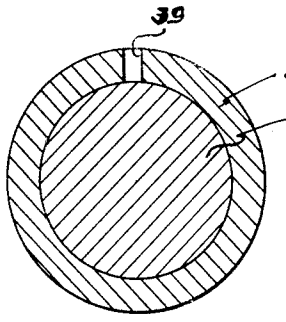


Fig. 2.

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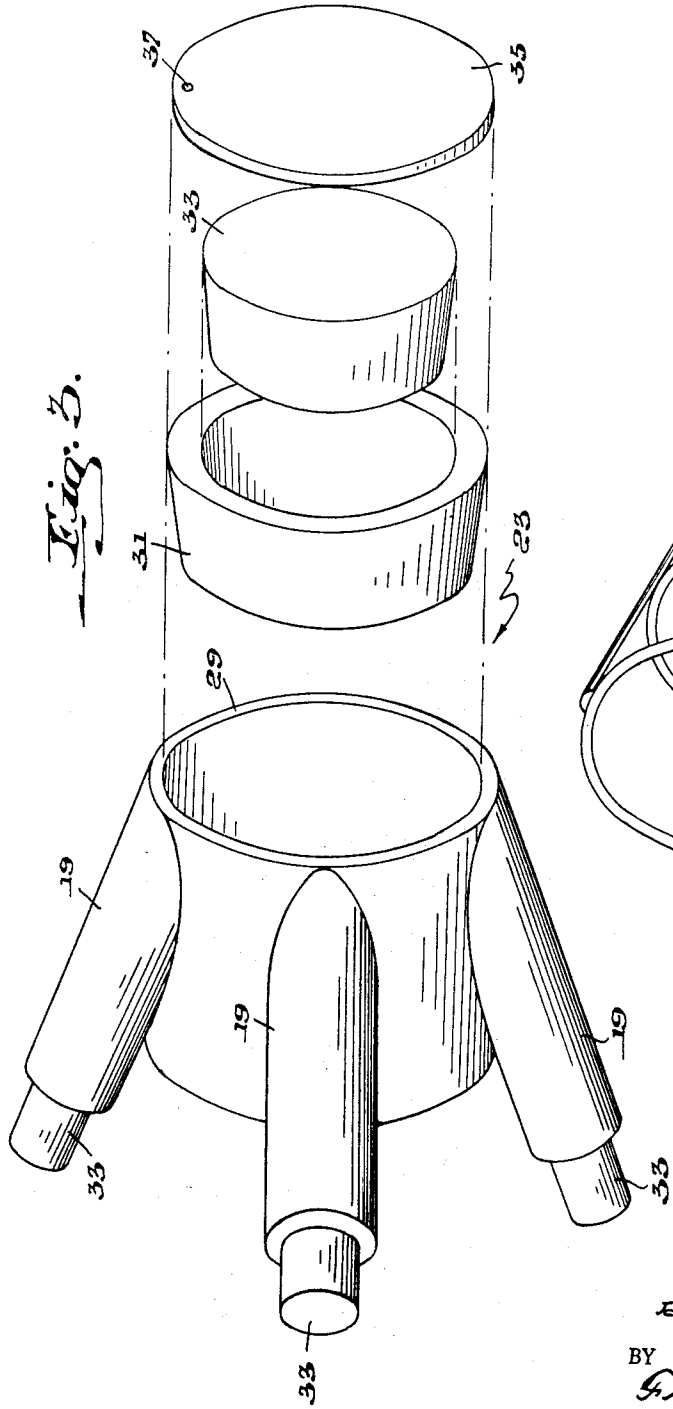


Fig. 3.

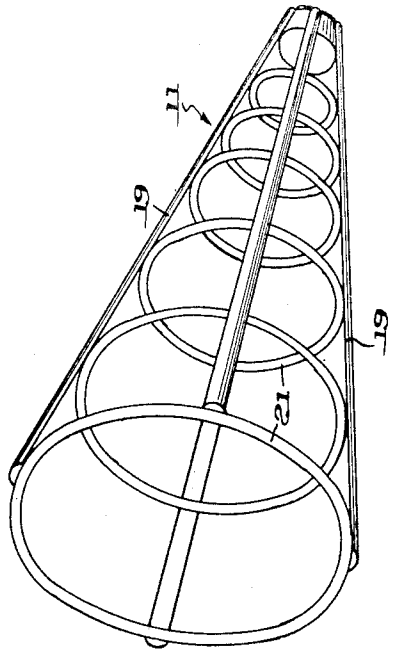


Fig. 4.

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SOUND ATTENUATING DEVICE

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10 Claims. (Cl. 181—35)

This invention relates to sound attenuating devices and more particularly to a sound attenuating device adapted to be employed with reactive propulsion engines which discharge high heat exhaust gases.

To increase the power output of reactive propulsion engines such as the turbo-jet, ram-jet and turbo propeller engines the fuel combustion may be such that the exhaust gases discharge as a high heat exhaust having temperatures exceeding 2600° F. In jet aircraft engines this increase in power is accomplished by an afterburner incorporated in the engine and the operation is generally designated as afterburner operation.

This afterburner operation has caused difficulties in efforts to reduce the sound level of these flaming jet exhausts over extended periods of engine operation. Heretofore sound attenuating devices to reduce the sound level of the exhaust gas have been employed at the exhaust port of the jet engine. Incorporated in these devices is a diffuser element which is adapted to be placed in the stream of high velocity gases so as to intercept and redirect the latter thereby to change the velocity frequency distribution and reduce the sound level.

To employ the diffuser in the presence of the high temperatures encountered with afterburner operation the above mentioned diffuser is provided with liquid cooling means. However, because the source of liquid coolant is not always readily available at the site where the reactive propulsion engine is to be operated the liquid coolant means has not always been satisfactory. It is also readily apparent that since the exhaust temperature emitting from the engine during such afterburner operation normally exceeds 2600° F. that the metallic members forming the diffuser under exposure thereto yield under the load of the exhaust gases and fail.

To overcome these difficulties it has heretofore been proposed to construct the members forming the diffuser of metals capable of withstanding these high afterburner flame temperatures. However, this proposal has been discarded as not being feasible since metals having such characteristics have many detriments, particularly with respect to difficulty in fabrication, the limited availability of these metals on the open market, and the increased cost thereof.

It is accordingly an object of the present invention to provide a sound attenuating diffuser constructed in a manner to alter the normal aerodynamic flow characteristics of the exhaust gases of reactive propulsive engines so as to minimize the formation of sounds and to withstand temperatures exceeding 2600° F.

It is a further object to provide a sound attenuating diffuser constructed of materials which are easily fabricated, readily available on the open market, and are of reasonable cost.

It is a further object to provide a sound attenuation diffuser constructed from structural members comprising a plurality of materials of which at least one of said materials is resistant to break down under the load of the exhaust gases at normal operating temperatures of the reactive propulsion engine and at least one of the other of said materials is a heat absorbing material having a fusion temperature below the temperature at

which the structural member breaks down under the continuous application of gas streams having temperatures in excess of 2600° F.

It is still a further object to provide a diffuser having means incorporated in the downstream end thereof for intercepting the tip of the flame so as to absorb and disperse the heat present at said tip.

A feature of the invention is the provision of a heat absorbing material within the structural strength member of the diffuser which heat absorbing material serves to absorb and transmit the heat away from the structural strength material at a rapid rate and over a prolonged period so as to extend the period during which the structural members may be exposed to the load of the exhaust gases at high temperatures before breakdown.

By the present invention, it is proposed to construct a sound attenuating device in the form of a diffuser for substantially diminishing the sound created by the discharge of the exhaust gases, particularly the sounds in the low frequencies, and which is capable of withstanding gas stream temperatures above 2600° F. by the selection and arrangement of the materials, at least one of which is a material imparting strength to the diffuser structure under the load of the exhaust stream and a second material which has a high latent heat of fusion and a fusion temperature substantially below the temperature at which the rigid member tends to deform upon the application of the gas stream temperatures. In this manner the second material having the high latent heat of fusion serves to absorb heat from the load resistant strength material so as to maintain the temperature of the load resistant strength member at a substantially constant level until the second material has completely changed its phase from solid to liquid.

The above principle of the invention may be applied selectively to the diffuser structure. This follows since the exhaust gases emitted by the jet engines discharge in an outwardly converging cone, the apex of which contains the greatest concentration of heat at temperatures in excess of 2600° F. Accordingly, it is at this location where the heat of the gases must be dispersed or absorbed. However, under certain circumstances it may be desirable to construct the entire or only portions of the diffuser structure in accordance with the above principle.

In carrying out the invention, at least some of the members forming the diffuser comprise a rigid sheath-like member forming an enclosure in which there is housed a core of heat absorbent material which has the high-latent heat of fusion and the fusion temperature described above.

Further objects and features will hereinafter appear.

In the drawings:

Fig. 1 is a cross sectional side elevational view of a diffuser embodying the present invention.

Fig. 2 is an enlarged cross-sectional view of one of the bars forming the diffuser and embodying the principle of the invention.

Fig. 3 is an enlarged exploded view of the apex of the diffuser.

Fig. 4 is a perspective view of the primary diffuser only.

Referring now to the drawings there is shown one embodiment of a diffuser 10 embodying the invention. The diffuser 10 may be used as a portable sound attenuating means for use in run-up testing of jet aircraft engines, but it is to be understood that the diffuser has many applications such as, for example, in permanent test cell units, or the testing of rocket engines and the like.

As shown the diffuser arrangement 10 comprises a primary diffuser 11 and a secondary diffuser 13 which are adapted to be positioned in the path of the flow of exhaust

gas streams being emitted from the exhaust port P of a reactive propulsive engine. The diffuser may be located in an enclosure provided with additional sound attenuating means or under some circumstances it may be used alone and mounted on a convenient supporting frame 15.

The primary diffuser comprises generally annular supporting rim 17 forming a circular inlet 18 through which the exhaust gases *g* pass. Attached to the supporting rim 17 are a plurality of rearwardly converging supporting bars 19 which are connected along their lengths by welding or the like by longitudinally spaced circular, hoop-like bars 21. Located at the apex of the cone-like primary diffuser is a heat absorbing member 23 which for convenience is hereinafter designated as a flame splitter.

The secondary diffuser 13 comprises generally a plurality of spaced horizontally and longitudinally extending bars 25, of which one end of each is fixed to the supporting bars 19. Attached to the horizontal bars 25 are a plurality of longitudinally spaced circular sound diffusing bars 27 which are bent into hoops of substantially uniform diameter so that the secondary diffuser comprises an open ended cylindrical frame concentrically mounted about the primary diffuser. It is to be noted that the secondary diffuser serves to further eliminate the formation of sound by the exhaust gases as more fully described in the previously identified application. Under some circumstances such further treatment of the exhaust gas may not be required such that the secondary diffuser may be omitted.

As shown, the core of the exhaust gases *g* is substantially conical and under normal operating conditions of reactive propulsion engines such as jet aircraft engines the temperature of the gases at the apex are such that the material from which the components of the diffuser are formed must be capable of withstanding prolonged periods of exposure to the exhaust stream and the temperatures without breakdown. To this end satisfactory results have been obtained from materials such as cast iron and iron alloys such as steel. Preferably these metals are characterized by being resistant to breakdown under the load of the gas stream at temperatures ranging from 1000 to 2000° F. These materials are readily available on the open market and easily fabricated into the above described diffuser structure.

It has been found, however, that when the diffuser is used to attenuate the sounds created by exhaust streams having temperatures exceeding 2600° F., as in afterburner operation of jet engines, that these metals tend to fail such that the attenuation effect thereof is lost before the test or run-up period of the engine is completed.

By the present invention, there are means incorporated into the diffuser for absorbing the heat from the structural components such that they are capable of withstanding temperatures exceeding 2600° F. In the embodiment shown one such means comprises the flame splitter 23.

As shown, the flame splitter 23 comprises a housing having a metallic open ended cylinder 29 to the outer periphery of which the converging ends of the bars 19 are fastened by suitable means such as by welding or the like. Inserted into and fastened to the interior side walls of the cylinder 29 is a metallic cap 31. Thereafter a heat absorbent or dissipating material 33 is inserted into the open end of the cylinder and the open end is then sealed by a face plate 35 having a vent 37 located at a high point.

The metal components of the diffuser, i.e. the bars 19, 21, 25, 27 and the housing of the flame splitter 23 are preferably formed from metals capable of withstanding the load stresses created by the high velocity flow of the exhaust gas over the full range of temperatures of the exhaust gas for at least a short period. These metals are characterized by a slow loss of strength up to a given temperature whereupon they rapidly lose their strength characteristics. Further, the metal components are constructed sufficiently thick such that they are capable of transferring heat therethrough to effect the function of the heat absorbent material, as will be explained below, without breakdown of the diffuser structure at the elevated temperatures at which the metal starts to rapidly lose its strength under load.

The heat absorbent material is characterized by having a fusion temperature substantially lower than the temperature at which the metal member forming the housing breaks down in the presence of the high velocity and high heat content gases. It is apparent that when the fusion temperature of the heat absorbent material is lower than the temperature at which the load resistant strength components of the diffuser break down under the load at the elevated temperatures of the gas stream, the resulting change of state of the material from a solid to a liquid absorbs considerable heat directly from the strength members and accordingly maintains the temperature of the latter below their breakdown temperatures so that they are capable of retaining their strength when exposed to elevated temperatures. The period during which the heat is absorbed is, of course, dependent upon the latent heat of fusion of the heat absorbent material. Accordingly if prolonged exposure to temperatures exceeding 2600° F. is desirable the heat absorbent material is selected to have a high latent heat of fusion and a fusion temperature below that at which the strength material breaks down under the load of the exhaust stream.

It is clear from the foregoing that since the heat absorbent material 33 changes state substantially below the temperature at which the strength components of the diffuser breaks down, the heat is absorbed by the flame splitter until the change of state is completed. In some applications this period may not be sufficient and under these conditions it may be preferable to provide additional heat absorbing structure. To this end, as shown in Figs. 1 and 2 one or more of the circular bars 21 and 27 and braces 19 and 25 forming the primary and secondary diffuser 11 and 13 may comprise tubes of cylindrical cross-section and the interior thereof filled with a heat absorbent material 33 similar to that used in the flame splitter. To permit the escape of gas and the overflow of the material during the change of state the top sides of the tubes are provided with vents 39. Of course, the greater the number of components constructed with the heat absorbing material the greater quantities of heat are absorbed and the greater will be the period to which the diffuser may be subjected to temperatures and loads of the exhaust gas before breakdown of the strength member occurs.

In one satisfactory combination of materials to effect prolonged life of the sound attenuating device at elevated temperatures according to the present invention, the outer rigid components 19, 21, 25 and 27 and the housing of the flame splitter are constructed of stainless steel of the 300 Series preferably No. 304 stainless steel and the internal heat absorbent components are formed from industrial pure aluminum preferable in the extruded form. The stainless steel has a fusion temperature of about 2500° F. and does not lose significant strength characteristics until the temperature therein is above about 1500° F. The aluminum has a fusion temperature of approximately 1200° F. and a latent heat of fusion of 96.4 calories per gram. This combination of materials has resulted in permitting exposure of the diffuser without destruction in temperatures exceeding 2600° F. for a period of 45 seconds up to 2 minutes depending on the mass of the heat absorbent material incorporated in the load resistant strength members of the diffuser.

Prolonged life of the sound attenuating device in exhaust gases having temperatures in excess of 2600° F.

has also been obtained by employing fusible salts, such as sodium chloride and the like, for the heat absorbing material.

Although the foregoing has illustrated and described the invention in detail it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as will now be understood by those skilled in the art.

What I claim is:

1. A sound attenuating device adapted for use in the presence of a high velocity exhaust gas stream having a high heat concentration at temperatures ranging above 2600° F. comprising a metallic frame means terminating in a substantially conical portion, said conical portion being provided with openings to permit the flow of exhaust gases therethrough and having an apex, metallic housing means in said apex, said metallic means being capable of resisting breakdown under the load of said gas streams at said temperatures for a limited period, and a core within said housing means and formed from a material having a fusion temperature below the temperature at which said metallic means break down under the load of said gas streams, so that said heat is absorbed in said core during its change of state thereby to increase the period during which said device may be exposed to said temperatures.

2. A sound attenuating device adapted for use in the presence of high velocity exhaust gases having temperatures ranging above 2600° F. comprising a frame of substantially circular cross section and having an open end to receive said exhaust gases and terminating at its other end in a substantially conical portion, said conical portion being provided with openings to permit the flow of said exhaust gases therethrough and having an apex including a housing, said frame and housing being capable of resisting breakdown under the load of said gases at said temperatures for a limited period, and a core in said housing formed from a material having a fusion temperature below the temperature at which said frame and housing break down, so that said heat is absorbed in said core during its change of state thereby to increase the period during which said device may be exposed to said temperatures.

3. A sound attenuating device adapted for use in the presence of high velocity gas streams having temperatures ranging above 2600° F. comprising a frame terminating in a substantially conical portion, said conical portion being provided with openings to permit the flow of exhaust gases therethrough and having an apex comprising a bi-material structure having an outer load resistant member to impart strength to said device, and a core within said load resistant member formed from a material having a fusion temperature substantially below the temperature at which said load resistant member tends to break down.

4. A sound attenuating device adapted to be used in the presence of exhaust gases having temperatures in excess of 2600° F. originating from reactive propulsive engines, said device comprising a frame having a series of circular members of graduated size disposed transversely in longitudinally spaced relation to the flow of said exhaust gases, said circular members being made of a plurality of materials at least one of which is a load resistant material capable of resisting breakdown under the load of said gas streams at said temperatures for a limited period, and at least one other material having a fusion temperature below the temperature at which said load resistant material breaks down under the load of said exhaust gases.

5. A sound attenuating device adapted for use in the presence of a high velocity and high temperature gas stream comprising frame means for attenuating the sound generated by said gas stream and having an inlet and an outlet to permit the flow of gas therethrough, a member mounted in said frame transversely to the flow of said gas stream and having a metallic housing, said frame and housing being capable of resisting breakdown under the load created by the high velocity and high temperature gas stream for a limited period only, and a core within said housing formed from a heat sink material so that said heat of said gas stream is absorbed in said core and thereby to increase the period during which said frame means may be exposed to said high velocity and high temperatures.

6. A sound attenuating device adapted for use in the presence of a high velocity and high temperature gas stream comprising a load resistant frame for attenuating the sound generated by said gas stream and having an inlet and an outlet, a member mounted in said frame transversely to the flow of said gas stream and having a load resistant housing, said frame and housing being capable of resisting breakdown under the load created by the high velocity and high temperature gas stream for a limited period only, and a core within said housing formed from a heat sink material so that said heat of said gas stream is absorbed in said core and thereby to increase the period during which said frame may be exposed to said high velocity and high temperatures.

7. A sound attenuating device adapted for use in the presence of a high velocity and high temperature gas stream comprising a frame of substantially circular cross section and having an inlet and an outlet, a member mounted in said frame transversely to the flow of said gas stream and having a housing, said frame and housing being capable of resisting breakdown under the load created by the high velocity and high temperature gas stream for a limited period only, and a core within said housing formed from a heat sink material so that said heat of said gas stream is absorbed in said core and thereby to increase the period during which said frame may be exposed to said high velocity and high temperatures.

8. A sound attenuating device adapted for use in the presence of a high velocity and high temperature gas stream comprising a stainless steel frame for attenuating the sound generated by said gas stream and having an inlet and an outlet to permit the flow of gas therethrough, a member mounted in said frame transversely to the flow of said gas stream and having a stainless steel housing, said frame and housing being capable of resisting breakdown under the load created by the high velocity and high temperature gas stream for a limited period only, and a core within said housing formed from a heat sink material so that said heat of said gas stream is absorbed in said core and thereby to increase the period during which said frame may be exposed to said high velocity and high temperatures.

9. The invention as defined in claim 8 in which said heat sink material is aluminum.

10. A sound attenuating device adapted for use in the presence of a high velocity and high temperature gas stream comprising a plurality of bars connected to form a frame having a gas inlet and a gas outlet for attenuating the sound generated by said stream, at least one of said bars including a closed end and hollow stainless steel casing and a heat sink material in said hollow casing, a member mounted on said frame transversely to the flow of said gas and having a stainless steel housing, and a core formed of a heat sink material.

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