

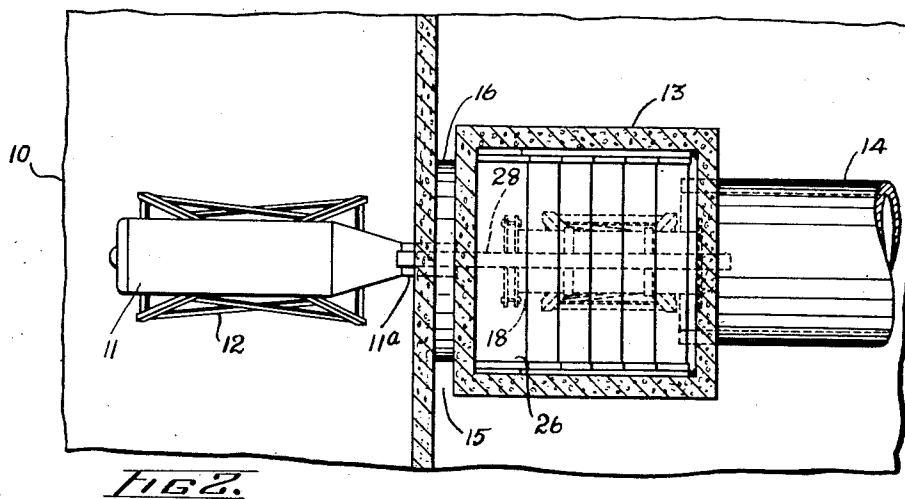
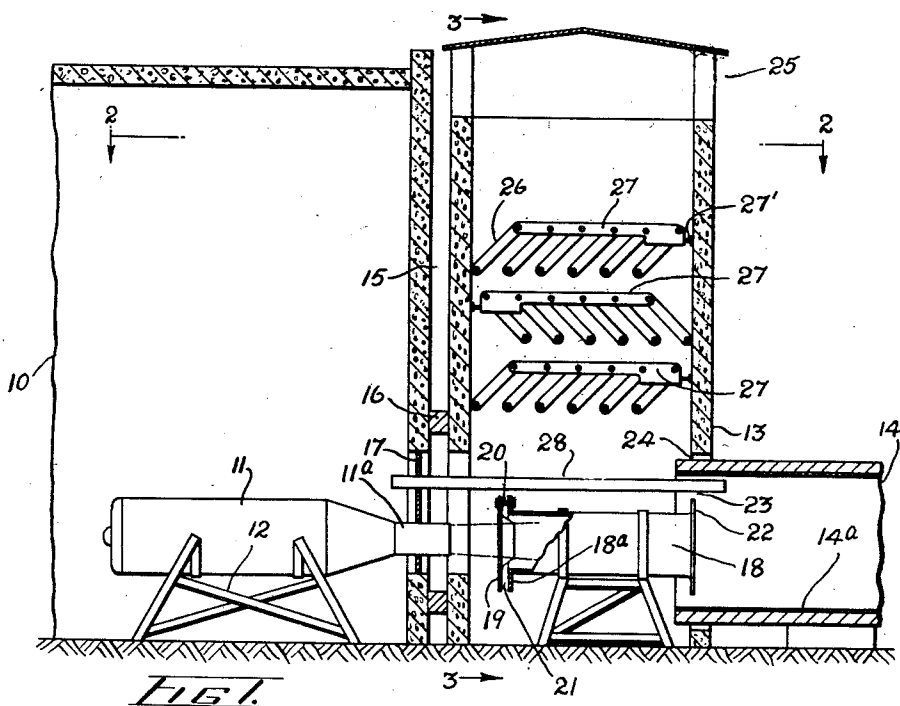
April 12, 1955

L. G. WIGLE
SILENCING MEANS

2,706,013

Filed Aug. 30, 1951

2 Sheets-Sheet 1



INVENTOR
L. G. WIGLE
PER

Smith E. Mayhew
ATTORNEY

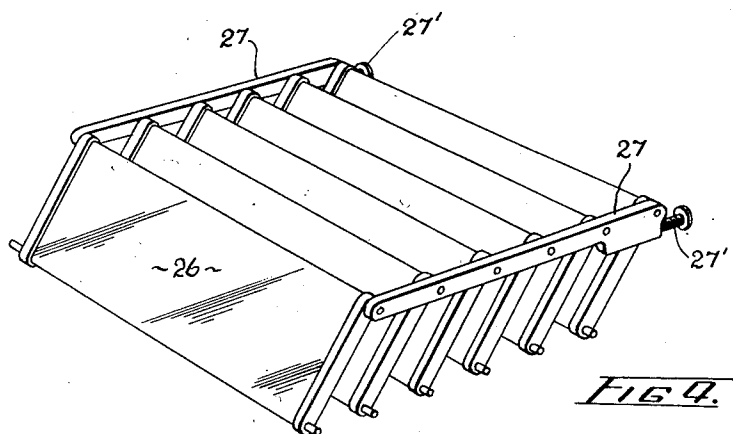
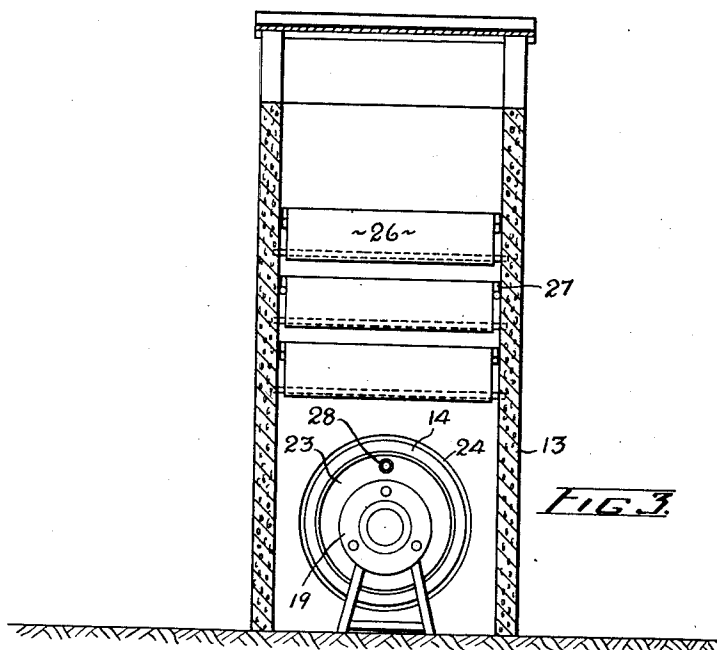
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INVENTOR
L. G. WIGLE
PER

Bert E. Mayhew
ATTORNEY

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SILENCING MEANS

Lloyd Grant Wigle, Islington, Ontario, Canada, assignor to A. V. Roe Canada Limited, Malton, Ontario, Canada, a corporation

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9 Claims. (Cl. 181—43)

This invention relates to silencing means and particularly to means for silencing a discharge of gases from gas turbine engines, rocket motors and the like.

Various constructions of silencing means, such as mufflers and sound absorbent structures, have been used for silencing the discharge of gases but in the past great difficulty has been experienced in constructing silencing means which will not affect the indicated performance of the device from which the gases are discharged. In the silencing of test cells for gas turbine engines, for example, it is of great importance that the pressure at the inlet of the engine should be substantially equal to the pressure at the outlet or discharge nozzle; otherwise misleading readings of the engine thrust will be obtained on the test equipment.

Furthermore the gases discharged from reaction propulsion motors are usually at a very high temperature and conventional silencing means are likely to deteriorate rapidly under such conditions.

The main object of this invention is the provision of a silencing means which will have substantially no effect upon the indicated performance of the gas turbine engine or other reaction propulsion device to which it is applied.

Another object of the invention is the cooling of the discharged gases so that they will not destroy the means provided for silencing them. Other objects and advantages will become apparent during the course of the following description of a preferred application of the invention.

In the attached drawings forming a part of this application and in which like characters of reference are used to denote like parts throughout the same:

Fig. 1 is a sectional side elevation of a gas turbine test cell and silencing device according to this invention, showing an engine under test therein;

Fig. 2 is a sectional plan view of the test cell and silencing device taken on the line 2—2 in Fig. 1;

Fig. 3 is a sectional end elevation of the test cell and silencing device taken on the line 3—3 in Fig. 1; and

Fig. 4 is a perspective view of the sound absorbing vanes in the silencing house.

In the drawings the test cell 10 is shown cut away at its inlet end since the silencing of the inlet is the subject of my copending application No. 224,080, dated May 2, 1951, now abandoned, and has no bearing upon this invention. The engine 11 is shown mounted on the usual balances 12 in the test cell and its discharge nozzle 11^a protrudes into the silencer which comprises principally the silencing house 13 and the conduit 14. The house 13 is insulated from the adjacent wall of the test cell by the air gap 15 and the sponge rubber sealing ring 16. The discharge nozzle 11^a is surrounded by a bulkhead 17 in the wall of the test cell and it will be understood that, to obtain accurate readings of the performance of the engine, the pressures on both sides of this baffle must be substantially equal.

A mixing tube 18 is mounted in the house 13 so that the distance between the plane of its inlet and the said nozzle is about 1½ times the diameter of the discharge nozzle and its outlet is arranged to discharge into the larger conduit 14. The mixing tube 18 is a tube of heavy steel plate or similar material while the inner walls 14^a of the conduit 14, in accordance with known sound control practice, are made of relatively light gauge sheet metal lined with a sound absorbing medium such as wire wool with an inner lining of a suitable perforated sheet to hold the sound absorbing medium in place; the walls of

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the conduit 14 are therefore necessarily subject to damage from excessive heat.

The inlet of the mixing tube is specially constructed and embodies a flanged frusto-conical inlet-defining member 19 supported by spacers 20 in spaced relationship to a flange 18^a on the periphery of the tube, so that an air passage 21 exists between the orifice member 19 and the forward edge of the tube. The smaller diameter of the conical frustum, which forms the orifice, is arranged so that it is substantially equal to the diameter in the plane of the orifice of the diverging cone of discharged exhaust gases from the engine; the orifice therefore conforms to the perimeter of the stream of gases which it is to accommodate.

Peripherally arranged around the outlet end of the mixing tube 18 is a flange 22, restricting the annular space between the outlet terminal portion of the mixing tube and the overlapping inlet terminal portion of the conduit 14, and leaving an air gap 23.

As will be seen from Fig. 1, the conduit 14 protrudes inwardly through the wall of the house 13 and a narrow annular air gap 24 is provided between the inlet terminal portion of the conduit and the surrounding wall of the house. The dimensions of this air gap are chosen so that its axial length is many times greater than its radial thickness.

The principal inlet of air to the house 13 is effected through an air gap 25 under the eaves of the roof of the house. To control and silence the flow of air from this gap through the inlet passage provided by the house 13, three sets of inclined rectangular vanes 26 of sound absorbing construction, in accordance with known practice, are situated in series in the upper part of the structure, the vanes in each set extending the full width of the house and being hinged to its walls at their lower edges. The upper edges of the vanes in each set are interconnected by connecting links 27 each embodying a jack screw 27' bearing against the wall of the house 13 and whereby the incidence of the vanes may be set to control the pressure in the lower part of the house 13, as will be explained hereinafter, by reducing or increasing the rate of flow of air through the air inlet passage provided by the house 13.

A duct 28 penetrating the bulkhead 17 above the discharge nozzle 11^a of the engine is led across the house 13 and into the conduit 14 through the annular gap 23 between the inner surface of the conduit and the outer peripheral rim of the flange 22. In some installations this annular gap 23 may be so narrow as to necessitate two or more ducts 28 annularly arranged around the upper part of the bulkhead 17 in order to provide sufficient capacity; however, in certain cases, orifices in the bulkhead 17 will provide sufficient ventilation to allow the duct or ducts to be dispensed with.

In operation the engine 11 under test discharges a conical jet of exhaust gases which substantially fills the orifice of the member 19. These gases are travelling across the discontinuity between the discharge nozzle and the mixing tube at a very high velocity and are at high temperature. Since the jet substantially fills the orifice, no air can be entrained and carried into the mixing tube through the orifice so that the ambient air between the nozzle and the mixing tube is not seriously disturbed. It has been found that if such conditions exist over a distance approximately 1½ times the diameter of the nozzle the effective thrust of the jet is substantially unmodified. Cooling air is introduced into the mixing tube annularly through the air passage 21 immediately downstream of the orifice and this cooling air is mixed with the exhaust gases in the mixing tube 18. The cooling air tends to adhere to some extent to the walls of the mixing tube thereby protecting the mixing tube from overheating, though in any case the tube is made of such heavy plate that it can withstand considerable heat without ill effects. The cooling of the exhaust gases causes them to contract so that both their speed and temperature are materially reduced as they are discharged from the mixing tube into the conduit 14. Additional air is drawn into this conduit, at the discontinuity between the mixing tube and the conduit, through the annular air gap 23, and this additional air

further cools the exhaust gases and again tends to adhere as a cooling film to the walls of the conduit to protect them against overheating. In consequence the exhaust gases, after the two stage introduction of cooling air, are greatly decelerated before their eventual discharge to atmosphere from the conduit 14.

It will be recognized by those skilled in the art that the cooling and deceleration of the exhaust gases by the introduction of air may be augmented by the introduction of water sprayed into the gas stream, but in general, with the proper control of the admission of cooling air, the conventional water sprays, with their piping and other undesirable complications, may be dispensed with. According to this invention the sound absorbing walls of the conduit 14 are protected against overheating by the pre-cooling of the hot gases in the mixing tube 18 and by the film cooling effect of the additional air introduced through the annular gap 23, and this combination is adequate without the recourse to liquid cooling media.

Air for cooling is admitted into the house 13 through the air gaps 25 and the sets of vanes 26, which are arranged obliquely to baffle and restrict sound waves and their sound absorbing construction assists in silencing any noise arising from the discharge of gases from the engine and the introduction of cooling air through the air passages 21 and 23. It is of great importance that the pressure in the lower part of the silencing house 13 should be substantially the same as the pressure in the test cell 10 in order to avoid interference with the indications of performance of the propulsive jet. The vanes 26 are therefore adjustable about the hinges at their lower edges and by variation of their incidence, through the medium of the adjustable links 27, the pressure in the lower part of the house 13 can be increased or decreased. In actual practice it is desirable that the pressure in the neighbourhood of the discharge nozzle 11^a in the house 13 should be slightly lower (by one or two inches of water) than the pressure in the test house in order to insure that no gases from the silencer house 13 tend to enter the test house 10.

The performance of the engine may also be affected by the circulation of hot gases in the test cell; these gases may be heated simply by contact with the hot parts of the engine under test. The duct 28 is therefore provided to ventilate the test cell and to carry away any hot gases which may arise from around the engine. A depression of the order of 100 inches of water exists between the pressure in the test cell and the extractor pressure at the outlet end of the duct 28, in the conduit 14, and the diameter of the duct must therefore be chosen, in accordance with the dimensions of the test cell, to insure adequate ventilation thereof. In a typical example the quantity of air extracted through the duct was found to be of the order of $\frac{1}{3}$ of the mass flow of the engine. If a single circular duct cannot be accommodated, a plurality of ducts may be annularly arranged around the upper part of the bulkhead 17 as mentioned previously in this specification.

It will be noted that care is taken to insulate the various components of the silencer from one another; the house 13 is insulated from the test cell by the air gap 15 and the conduit 14 is insulated from the house 13 by the air gap 24. Although the gap 15 is reinforced by the sound absorbing sealing ring 16, both the air gaps 15 and 24 are relatively narrow so that any sound waves tending to escape through them are reflected between the adjacent surfaces and considerably absorbed before they can escape.

It will be understood that the width of the air gap 21 controlled by the spacers 20, the width of the air gap 23 controlled by the flange 22, the incidence of the vanes 26 adjustable by the links 27, and the capacity of the duct 28 must be determined empirically to produce the best results for the particular type of engine under test. It has been found that for an engine discharge of W pounds per second, satisfactory results can be obtained by the introduction of cooling air at W/2 pounds per second through each of the gaps 21 and 23 and through the duct 28, so that a flow of 3W/2 pounds per second passes through the mixing tube and 5W/2 passes through the conduit. However experiment has indicated that none of these quantities is particularly critical. It will be understood therefore that the form of the invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of the parts may

be resorted to without departing from the spirit of the invention or the scope of the claims.

What I claim as my invention is:

1. A silencer comprising, a nozzle through which a stream of hot gases is discharged at high velocity, an open-ended tube having one end axially spaced from the outlet of the nozzle and into which the stream of gases is discharged, an open-ended conduit discontinuous with the tube and having one end adjacent the other end of the tube to receive gases discharged from the tube, the conduit having a sound absorbing lining, a housing enclosing and extending between the outlet of the nozzle and the said end of the conduit, an inlet opening in the housing remote from the nozzle, the housing providing an air inlet passage leading inward from the opening, and sound absorbing vanes obliquely disposed in the said passage.

2. A silencer comprising, a nozzle through which a stream of hot gases is discharged at high velocity, an open-ended tube having one end facing and axially spaced from the outlet of the nozzle and into which the stream of gases is discharged, an open-ended conduit into which the other end of the tube extends in spaced relationship therewith, a sound absorbing lining in the conduit, a housing enclosing the tube and having openings receiving the nozzle and the conduit, the edges of the openings being spaced from the nozzle and the conduit to provide sound insulating air gaps between the said edges and the nozzle and conduit, an inlet opening in the housing, the housing providing an air inlet passage leading inwardly from the opening, and sound absorbing surfaces disposed in the said passage.

3. A test cell installation for a reaction propulsion motor comprising a test cell having a port for the ejection nozzle of the motor, a silencing house adjacent the port and spaced from the test cell and having an opening facing the port in the test cell, an open-ended tube in the silencing house and having one end axially spaced from and facing the port in the test cell to receive gases discharged from the nozzle, an open-ended conduit discontinuous with and extending from the other end of the tube through one wall of the silencing house to receive gases discharged from the tube, the conduit having sound absorbing inner walls and having its outer periphery spaced from the said wall of the silencing house, an inlet opening in the silencing house, the silencing house providing an air inlet passage leading inwardly from the inlet opening, and sound absorbing means disposed in the said passage.

4. A test cell installation as claimed in claim 3 including means placing the interior of the test cell in communication with the interior of the conduit to ventilate the test cell into the conduit.

5. A test cell installation as claimed in claim 3 including a duct connecting the interior of the test cell with the interior of the conduit to ventilate the test cell into the conduit.

6. A silencer comprising, a nozzle through which a stream of hot gases is discharged at high velocity, an open-ended tube having an inlet end facing the outlet of the nozzle and into which the stream of gases is discharged, an orifice-defining member axially spaced from the outlet of the nozzle and from the inlet end of the tube and having an orifice for the stream of gases substantially conforming to the cross-sectional perimeter of the said stream in the plane of the orifice, the space between the orifice-defining member and the inlet end of the tube providing an inlet for air to cool the stream of gases in the tube, an open-ended conduit disposed co-axially with respect to the said other end of the tube, one end of the conduit surrounding and being annularly spaced from said other end of the tube to provide an inlet for air between the tube and the conduit to cool the stream of gases in the conduit, a housing enclosing the tube and having openings in oppositely facing walls through which pass the nozzle and the conduit, an inlet opening in the housing, the housing providing an air inlet passage leading inwardly from the opening, and sound absorbing surfaces disposed in the said passage.

7. A silencer comprising, a nozzle of a reaction propulsion motor through which a stream of hot gases is discharged at high velocity, an open-ended tube having an inlet end facing the outlet of the nozzle and into which the stream of gases is discharged, an orifice-defining member axially spaced from the outlet of the nozzle and from the inlet end of the tube and having an orifice for the

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stream of gases substantially conforming to the cross-sectional perimeter of the said stream in the plane of the orifice, the space between the orifice-defining member and the inlet end of the tube providing an inlet for air to cool the stream of gases in the tube, an open-ended conduit disposed co-axially with respect to the said other end of the tube, one end of the conduit surrounding and being annularly spaced from said other end of the tube to provide an inlet for air between the tube and the conduit to cool the stream of gases in the conduit, an annular flange surrounding the said other end of the tube, the flange being mounted on one and spaced from the other of the said other end of the tube and the inner periphery of the said one end of the conduit to restrict the size of the said inlet for air, a housing enclosing the tube and having openings in oppositely facing walls through which pass the nozzle and the conduit, an inlet opening in the housing, the housing providing an air inlet passage leading inwardly from the inlet opening, and sound absorbing surfaces disposed in the said passage.

8. A test cell installation for a reaction propulsion motor comprising a test cell enclosing the motor and having a port for the ejection nozzle of the motor, a silencing house adjacent the port and having an opening providing communication with the test cell, and an open-ended tube in the silencing house and having one end axially spaced from and facing the port in the test cell to receive gases discharged from the nozzle through the opening in the silencing house, and an open-ended conduit discontinuous with and extending from the other end of the tube through one wall of the silencing house to receive gases discharged from the tube, an inlet opening in the silencing house walls defining an air inlet passage leading inwardly from the inlet opening, and sound absorbing vanes disposed in the said passage for silencing it, the vanes being disposed obliquely with respect to the

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flow of air through the said passage and being pivoted to the said walls for adjustment of the angle of incidence of the vanes with respect to the said flow of air.

9. In a silencer, a nozzle through which a stream of gases is discharged, an open-ended tube having an inlet end axially spaced from the outlet of the nozzle and into which the stream of gases is discharged, the cross-sectional area of the said inlet end being materially greater than the cross-sectional area of the stream of gases in the plane of the said inlet end, an orifice-defining member at the inlet end of the tube having a generally radially inwardly extending flange defining an orifice substantially conforming to the cross-sectional perimeter of the stream of gases in the plane of the orifice, and a side inlet leading into the tube downstream of the orifice defining-member to permit the entry of air into the tube to cool the stream of gases in the tube.

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