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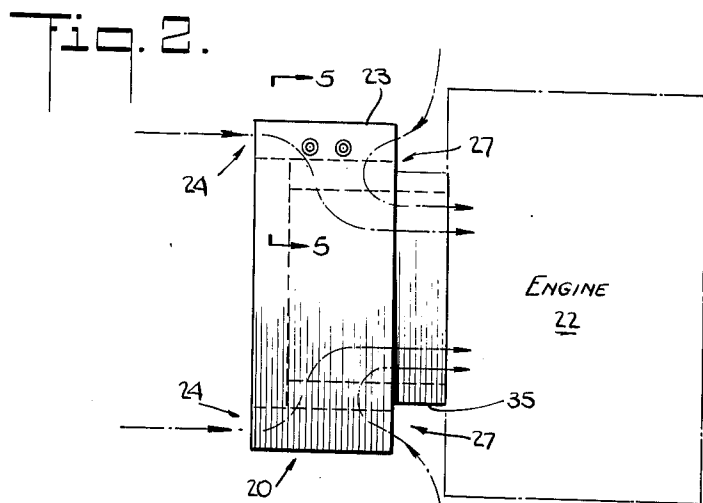
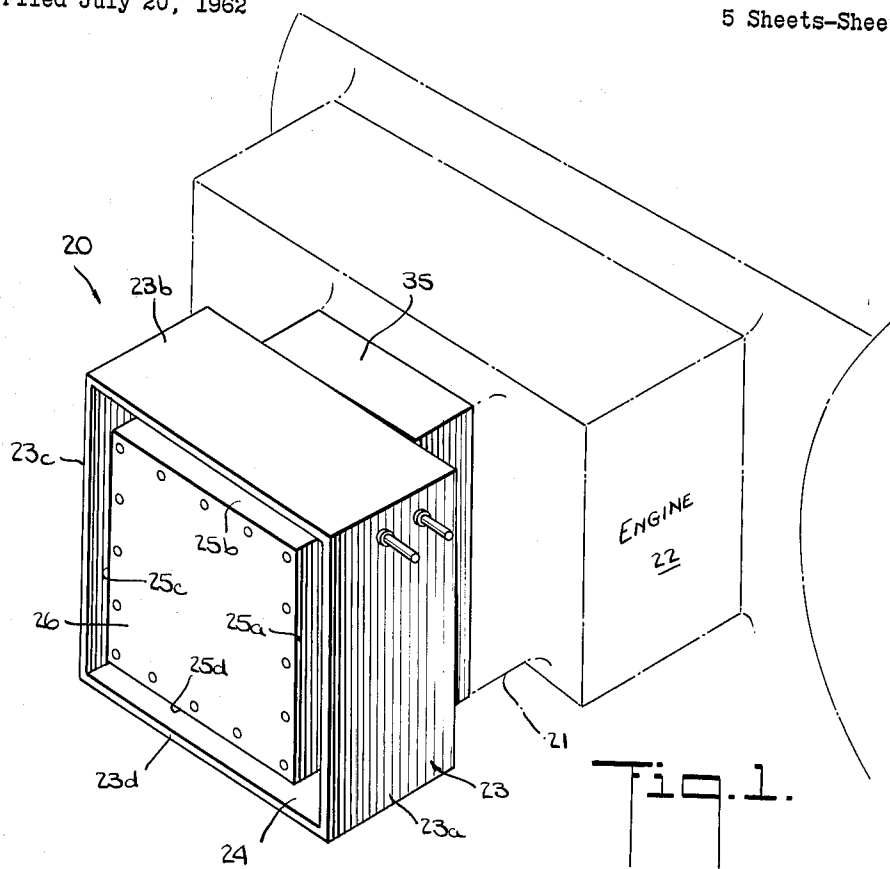
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3,235,001

SILENCER AND HEAT EXCHANGER DEVICE

Filed July 20, 1962

5 Sheets-Sheet 1



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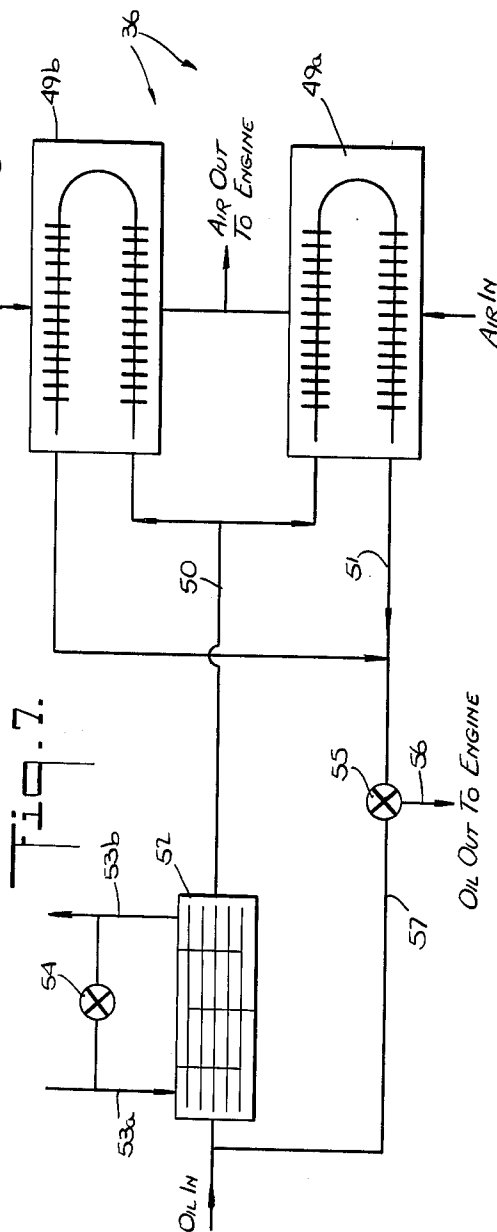
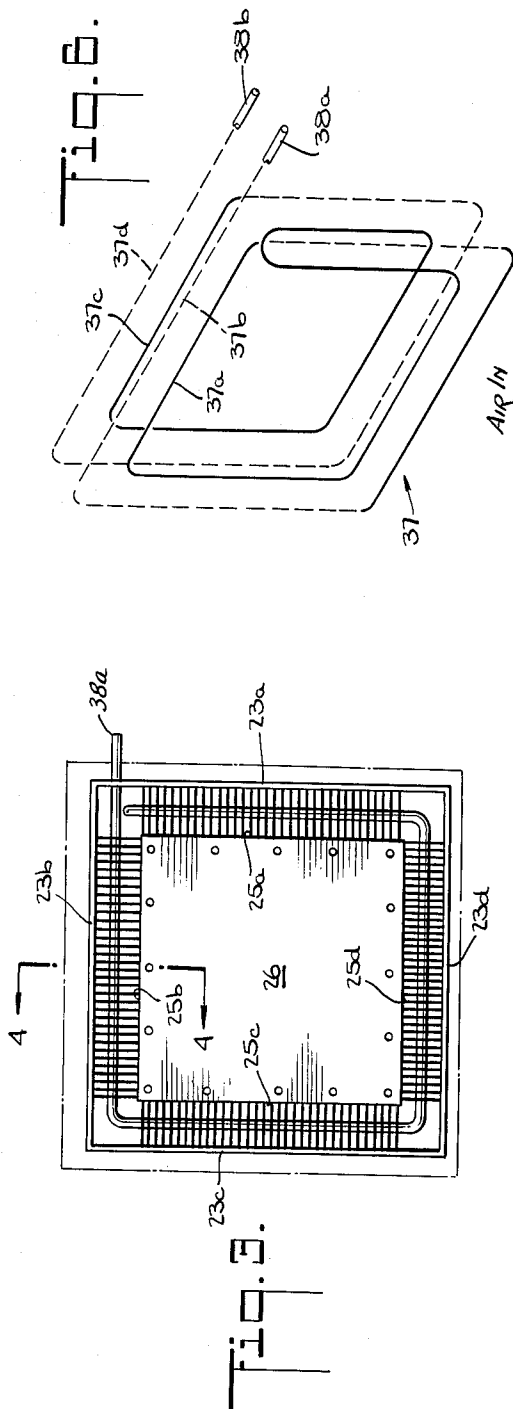
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SILENCER AND HEAT EXCHANGER DEVICE

Filed July 20, 1962

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Feb. 15, 1966

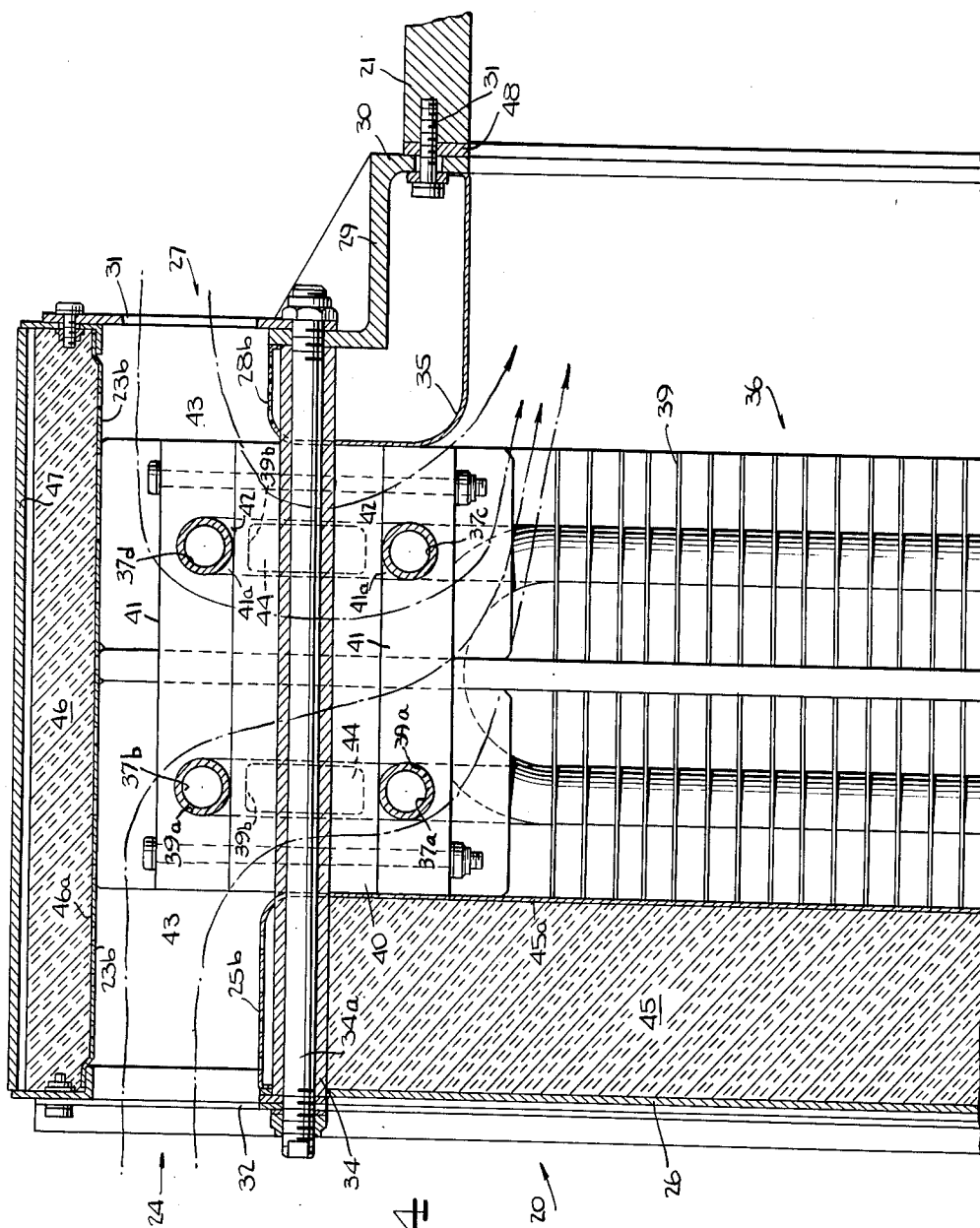
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SILENCER AND HEAT EXCHANGER DEVICE

Filed July 20, 1962

5 Sheets-Sheet 3



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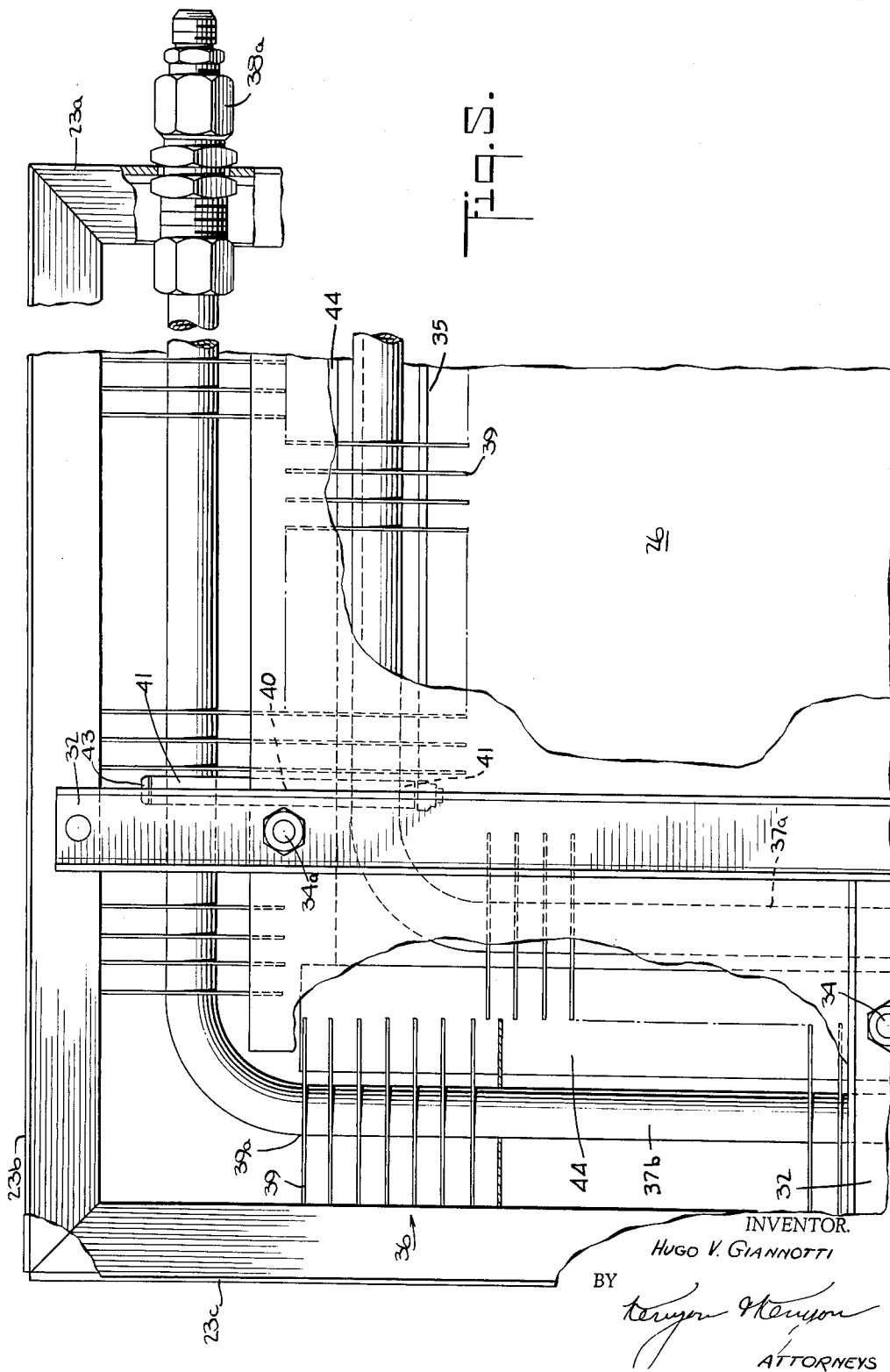
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3,235,001

SILENCER AND HEAT EXCHANGER DEVICE

Filed July 20, 1962

5 Sheets-Sheet 4



Feb. 15, 1966

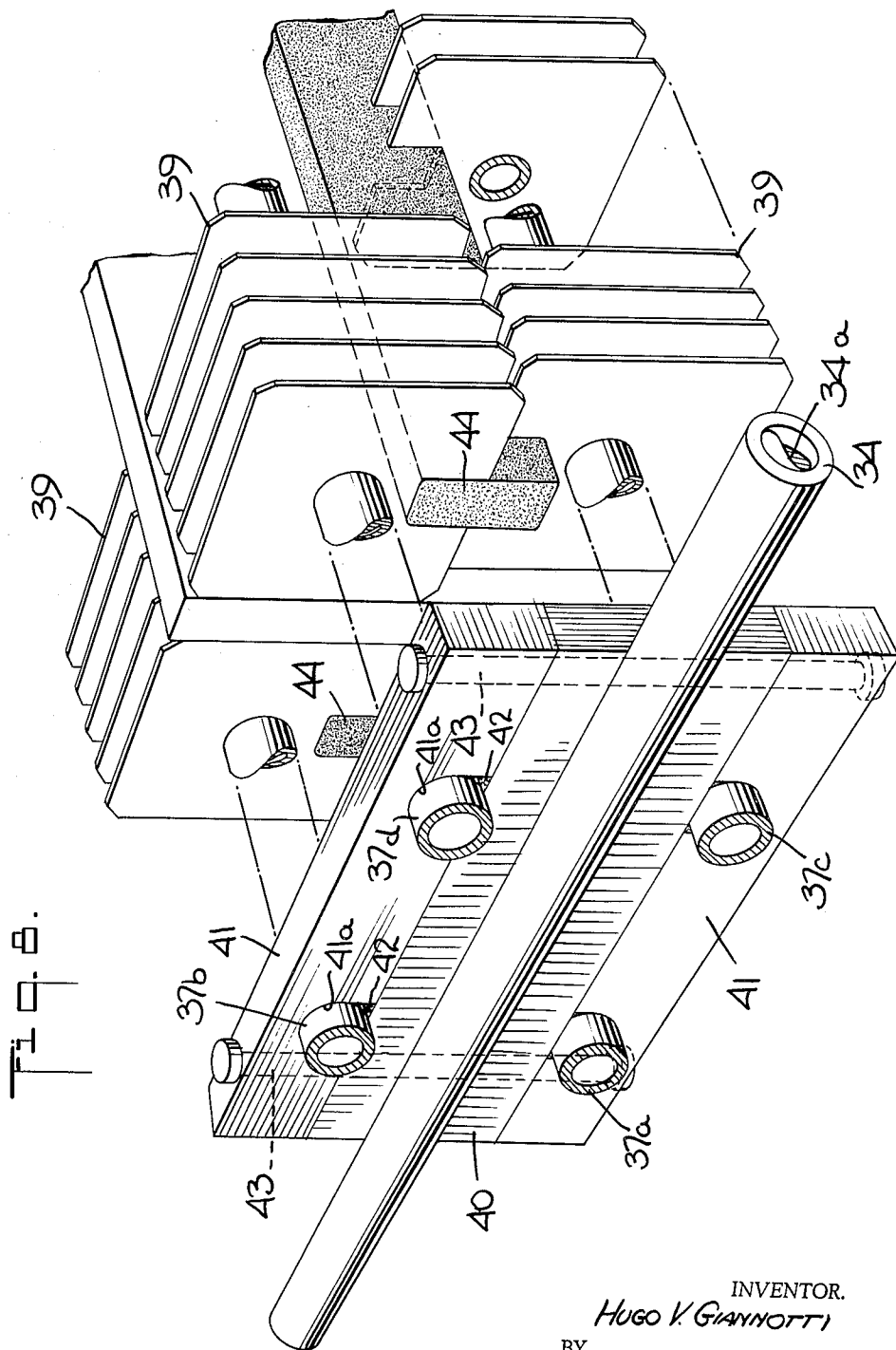
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SILENCER AND HEAT EXCHANGER DEVICE

Filed July 20, 1962

5 Sheets-Sheet 5



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SILENCER AND HEAT EXCHANGER DEVICE

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Filed July 20, 1962, Ser. No. 211,292

8 Claims. (Cl. 165-51)

The present invention relates generally to a silencer for equipment having a flow of fluid and more particularly to an improved apparatus in which the silencer contains a heat exchanger adapted both to transfer heat and to retard the propagation of noise.

The air inlet as well as the exhaust outlet of an internal combustion engine can be the source of troublesome noise conditions. The inlet of a reciprocating engine emits a hissing noise caused by the high velocity of the air flow through venturis and past throttle plates of the carburetor. With this type of engine the energy level of the noise may not be high and consequently effective silencers have been provided. On the other hand in the case of gas turbine engines, noise of an exceptionally high energy level can be emitted from the inlet. One of the reasons that the energy level is high is the great weight flow of air that passes through gas turbine engines as compared to reciprocating engines of related power output. In addition the presence of a high speed compressor adjacent to the inlet serves as the source of high energy noise extending across a broad frequency spectrum. Such a compressor employs a plurality of blade or vane members whether the compressor is of the centrifugal or axial flow type and the plurality of blades or vanes in conjunction with the high rotational speeds can emit high energy noise at frequencies which extend into the ultrasonic frequency range.

In addition to the air inlet, the exhaust outlet presents a difficult silencing or muffling problem. In reciprocating engines, the noise at the exhaust outlet is of a pulsating type at low speed and it blends into a steady roar at higher speeds. For stationary and surface transportation equipment, very effective mufflers have been developed. But due to the size and weight of muffler systems they normally are not used on high powered aircraft since the penalty of size and weight are not justified by noise reduction alone.

As with the inlet of gas turbine engines, the exhaust outlet is the source of extremely high levels of noise. Here the high noise level is due to the great weight of gas flow and its high velocity. Devices to reduce the noise at the exhaust outlet or nozzle have been only partially successful since again, the amount of bulk and weight that can be written off to noise suppression alone is limited.

In the case of aircraft gas turbines, engines of high horsepower or thrust ratings are commonly used and these engines can emit sound levels which can actually be damaging to the human ear. Beyond the consideration of possible physical injury to the hearing of the observer, noise emitted from the engine inlet can be a source of distraction and annoyance to operating personnel, ground personnel, and the public in general in the area of an airport or adjacent an engine manufacturing plant.

Any attempt to provide a silencer for an internal combustion engine such as a gas turbine encounters the problem of providing a structure which is compatible with the high weight flows of air which must pass through it. Thus with respect to ground installations, the size and cost of a silencer device are important considerations while in aircraft installations, the size, weight and complexity of the silencer are the paramount factors.

With many types of internal combustion engines it is commonly necessary to provide heat exchanger equipment for transferring heat with respect to fluids such as lubricat-

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ing oil, fuel, hydraulic fluid, and the like. Heat exchangers for these purposes can add to the general envelope of the equipment and thereby present a space problem. In aircraft installations, the heat exchanger not only can cause a space and weight problem but in addition can interfere with the otherwise clean aerodynamic design of the craft. If an effort is made to integrate the heat exchanger into the engine itself, the weight problem and the problem of complexity may be aggravated by the requirement of duct work to deliver a heat transfer fluid to the heat exchanger and also the need of fans and the like to induce the flow of heat transfer fluid.

In addition to engine inlets and outlets, noise conditions requiring silencing occur at the apertures or passages of fan inlets and outlets, heat transfer equipment, incorporating fans, and other equipment having a flow of gas. In each of these cases, the associated equipment often-times requires heat exchanger equipment.

Accordingly, it is the primary object of the present invention to provide a silencer for an aperture of a fluid flow device in which a heat exchanger within the silencer cooperates therewith in retarding the propagation of noise from the device.

More particularly, it is an object of the invention to provide a silencer containing a heat exchanger which transfers heat with respect to the flow of fluid of a unit of equipment and at the same time retards the propagation of noise from the equipment.

Another object of the invention is to provide a silencer for a fluid flow device in which sound absorbing material as well as a heat exchanger disposed within the silencer are adapted to retard the propagation of noise from the device.

An additional object of the invention is to provide a silencer for an engine inlet in which a heat exchanger within the silencer assists in retarding the propagation of noise from the inlet.

A further object of the invention is to provide an engine inlet system in which a heat exchanger within the silencer transfers heat between fluids related to the engine and the flow of air to the inlet.

In one embodiment of the invention the silencer for an aperture of a device through which a flow of gas passes comprises a housing having a pair of openings with one connected to the aperture. The housing is adapted to receive a flow of gas moving with respect to the openings and the aperture. Means disposed within the housing transfer heat with respect to the flow of gas. In this way, the housing and the heat exchanger means retard the propagation of noise from said aperture.

In another embodiment of the invention, the silencer for the engine air inlet comprises a housing having a pair of openings one of which is adapted for connection to the aperture. The housing is adapted to receive a flow of air through the other of the pair of openings to the opening connected to the inlet and thus into the inlet of the engine. Within the housing there is disposed a heat transferring device which is adapted to transfer heat with respect to the flow air to the engine inlet. In this way both the housing and the heat transfer device retard the propagation of noise from the engine inlet.

In still another embodiment of the invention the silencer includes a housing having spaced apart wall portions one of which has an opening adapted for connection to the engine air inlet. At least one of the wall portions has an additional opening disposed therein at a predetermined distance from an axis extending through the first opening. The housing also contains a unit for transferring heat with respect to the flow of air to the inlet. With this arrangement both the additional opening disposed at a predetermined distance from

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the axis of the opening connected to the inlet and the heat transferring means serve to retard the propagation of noise from the inlet.

In still another embodiment of the invention the housing of the silencer is provided with sound absorbing material.

In an additional embodiment of the invention the housing includes spaced apart wall portions which have openings disposed about their periphery for admitting the flow of air into the housing and onto the inlet.

In a further embodiment of the invention the housing of the silencer includes a heat exchanger device adapted for connection to a supply of fluid related to the engine in order that heat can be transferred between the fluid and the flow of air to the inlet.

Other objects and features of the invention will become apparent in the following specification and claims and in the drawings in which:

FIG. 1 is a perspective view of the silencer of the invention;

FIG. 2 is a side elevational view of the silencer;

FIG. 3 is a front elevational view of the silencer;

FIG. 4 is an enlarged fragmentary section view of the heat exchanger within the silencer taken along the line 4—4 in FIG. 3;

FIG. 5 is an enlarged fragmentary section view of the heat exchanger taken along the line 5—5 in FIG. 2;

FIG. 6 is a perspective view of the heat exchanger tubing;

FIG. 7 is a schematic representation of the silencer and heat exchanger connected to the engine oil system;

FIG. 8 is a fragmentary exploded perspective view of the heat exchanger and the sound absorbing material adjacent thereto.

In FIG. 1 silencer 20 of the invention is shown connected to an aperture such as inlet 21 of engine 22. Housing 23 of the silencer having a substantially square form includes side panels 23a-d. Front inlet 24 of the silencer is an opening formed adjacent the periphery of the silencer between the inner surfaces of side panels 23a-d and the outer surfaces of inner side panels 25a-d, respectively. Front panel 26 extends across the front edge portions of inner side panels 25a-d and covers the opening formed by the inner side panels. Similarly as in the front portion of the silencer, the rear portion is provided with rear inlet 27 extending about adjacent to the periphery of housing 23 (FIGS. 2 and 5). Rear inlet 27 is an opening formed between the inner surface of side panels 23a-d and the outer surface of inner side panels 28a-d, respectively.

Silencer 20 is mounted on engine 22 adjacent the inlet thereof by means of support ring 29 which extends from adjacent inner side panels 28a-d at rear inlet 27 to attaching flange 30. The silencer is connected to the engine inlet by means of screws 31. At the forward portion of the silencer, channels 32 support the side panels of housing 23 with respect to the inner side panels while at the rear of the silencer, straps 33 position the housing with respect to inner side panels 28a-d. Tie rods 34 and bolts 34a (FIGS. 4 and 5) retain the silencer in assembly along its central axis by positioning front panel 26 and the inner side panels 25a-d with respect to inner side panels 28a-d and support ring 29.

As shown in FIGS. 2 and 4 air flow passes through both front inlet 24 and rear inlet 27 into engine inlet 21. The air flow through front inlet 24 has an S-shaped path due to the fact that the openings of the front inlet are spaced at a greater distance from the central axis of the silencer than is the outer portions of engine inlet 21. On the other hand air flow into rear inlet 27 passes along a substantially U-shaped path as it approaches the engine inlet. The trailing portions of inner side panels 28a-d are curved inwardly with respect to the central axis of the silencer in order to facilitate the entry of the air into the inner portion of the silencer (FIG. 4). For a similar

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reason the forward portions of inner side panels 28a-d are curved inwardly. Fairing 35 extends from adjacent the inner side panels 28a-d to attaching flange 30 in order to guide the air flow toward the engine inlet.

Heat exchanger 36 (FIGS. 3-5) is disposed within housing 23 in the path of flow from both front and rear inlets 24 and 27, respectively. The heat exchanger has a substantially square shape and its outer portions are adapted to fit within side panels 23a-d at a distance rearwardly from front panel 26. The heat exchanger can be of the extended-surface type comprising pipe or tubing 37 which consists of a U-shaped portion of tubing formed into squares fitted within one another (FIG. 6). Thus heat exchanger tubing 37 (FIGS. 6 and 8) includes forward inner and outer tubing portions 37a and b, respectively and rearward inner and outer tubing portions 37c and d, respectively. Fittings 38a and b of tubing portions 37b and 37d, respectively are adapted for connection to a source of fluid. The extended surface for the heat exchanger consists of a plurality of substantially square fins 39 having openings 39a through which the tubing extends. The spaced apart fins on one row of tubing can be staggered with respect to the fins on the adjacent row of tubing as shown in FIG. 5. The tubing of the heat exchanger is supported by mounting bars 40 attached to tie rods 34 (FIGS. 4, 5 and 8). The tubing is urged against and secured in place with respect to mounting bars 40 by means of clamps 41 which contain slots 41a having semicircular base portions substantially in conformity with the diameter of the tubing. The semicircular portions of the slot as well as the slot itself can be made sufficiently oversize in order to permit expansion of the tubing upon a temperature increase. Inserts 42 of elastomer material can be inserted in the slots in order to cushion the tubing from the clamping action of clamps 41 and also to prevent fretting corrosion at the points of clamping. In addition the inserts can prevent the transmission of high frequency vibration from the engine to the silencer structure. Inserts 42 also can be positioned to cushion the tubing with respect to mounting bars 40. During assembly clamps 41 are urged against the tubing by the application of force due to the installation of bolts 43 which extend through the clamps as well as the mounting bars. In this way heat exchanger 36 is rigidly supported within housing 23 of the silencer.

Since fins 39 are disposed in a direction substantially parallel to the central axis of the silencer and because of the spaced intervals between the fins, the heat exchanger provides a plurality of slots or channels through which air flow passes after entering the silencer at the front and rear inlets. The disposition of the fins results in the path of flow from either inlet being divided into a plurality of channels in communication with the engine inlet. This arrangement provides an effective barrier to sound propagating from the engine inlet, since each reflection can absorb a portion of the noise energy. In order to further retard the propagation of noise through the fin assemblies, sound absorbing pads 44 having a substantially rectangular cross section are installed in slots 39b which are disposed between the inner and outer portions of tubing when the heat exchanger is assembled. Consequently pads 44 extend across the paths of flow and are capable of intercepting noise that would otherwise be projected between the fins in the direction of the inlets. The sound absorbing pads which are fabricated from felt, fiber material, and the like can be encased in plastic film material in order to protect the pad against erosion from the high velocity air stream.

The propagation of noise from the engine inlet can be further retarded by conditioning housing 23 to act as a reverberating chamber. This is accomplished by selecting the volume and dimensions of the housing in accordance with the low frequencies which are to be attenuated. In order to absorb the high noise frequencies more effectively, blanket 45 is disposed in the cavity between front

panel 26 and the front heat exchanger assembly. Sound absorbing blanket 45 can be fabricated from material similar to that of pads 44 and can also be encased with plastic film 45a to protect the blanket from erosion by the air flow. Inner side panels 25a-d are perforated so that noise in the vicinity of the front inlet is absorbed by the blanket. Inner side panels 28a-d are similarly perforated in order to condition the cavity between support ring 29 and fairing 35 to act as a reverberating sound absorbing chamber. Further sound absorption is obtained by placing sound absorbing blanket 46 about side panels 23a-d of the housing. Here again the side panels are perforated to increase the sound absorbing effect. Blanket 46 can also be protected with plastic film 46a.

The exterior of the silencer is completed by forming casing 47 about blankets 46. In order further to prevent the transmission of engine vibration to the silencer, gasket 48 of elastomer material disposed between flange 30 and the flange adjacent the engine inlet.

With this arrangement the silencer retards the propagation of noise from the engine inlet by means of reverberating chamber effect of the housing, the multiple reflecting and sound absorbing of the heat exchanger assembly, the sound absorption of the pads disposed within the heat exchanger, and the sound absorption of the blankets within the housing. In this manner, the silencer provides a device for introducing air flow into the engine inlet, for retarding noise and for serving as a structure both to contain the heat exchanger and to cause a flow of air with respect to it. In this way a single device combines the functions of silencing and heat exchanging.

FIG. 7 is a schematic representation of silencer 20 having heat exchanger 36 connected to the lubricating oil system of the engine. The system includes front and rear heat exchangers 49a and 49b connected in parallel to lines 50 and 51. Lubricating oil at elevated temperature from the engine is delivered to the heat exchangers along line 50. In certain applications the oil from the lubricating system may be employed as a heat source for the engine fuel supply by passing the oil through fuel heater 52 prior to admitting the oil to heat exchangers 49a and b. Fuel inlet and outlet lines 53a and b, respectively, are connected to the fuel heater and can be shunted by pressure relief valve 54 in order that fuel flow may be maintained if an excessive pressure drop occurs within the fuel heater. The lubricating oil after being cooled within the heat exchanger passes through temperature control valve 55 and into line 56 returning to the engine. Temperature control valve 55 is adapted to blend oil returning from the heat exchanger through line 51 with oil approaching the fuel heater by means of line 57 in order to deliver oil at a predetermined temperature to line 56. Thus if the oil returning from the engine is of a low enough temperature substantially all flow will pass through line 57. On the other hand if the oil is of an excessively high temperature, substantially all oil will be delivered through line 51 back to the engine.

It should be understood that the heat exchanger within the housing of the silencer is adaptable for transferring heat with respect to the air passing into the engine inlet for fluids other than engine lubricating oil such as helicopter transmission oil, air conditioning refrigerants, and hydraulic fluid. Furthermore, the extended surface of the heat exchanger may be of forms other than flat fins such as helical fins, and the like.

In addition it should be further understood that the silencer arrangement as well as the combined silencer and heat exchanger can be adapted for use at the exhaust section of an engine or in conjunction with an aperture, that is an inlet or an outlet of a variety of gas flow devices whenever there is a noise suppression problem.

While there has been disposed what at present are considered to be preferred embodiments of the invention, it is to be understood that changes and modifications can be made therein without departing from the essential spirit of

the invention. It is intended therefore in the appended claims to cover all such changes and modifications within the true scope of the invention.

What is claimed:

1. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having spaced wall portions, one of said wall portions having an opening for connection to the aperture, at least one of said wall portions having an additional opening disposed therein, said housing in its operative condition forming a passage for receiving a flow of gas moving along flow lines between said openings, a heat exchanger disposed within said housing, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface dividing said passage into a plurality of additional passages through which the flow lines extend, and sound absorbing material disposed within said housing adjacent the inlet and the outlet portions of said additional passages for absorbing sound travelling parallel to at least a portion of the flow lines, whereby the additional passages formed by said extended surface direct the noise from the aperture towards said sound absorbing material in order to retard the propagation of the noise from said aperture.

2. A silencer for an aperture of a device through which a flow of gas passes comprising structure forming a housing having spaced wall portions, one of said wall portions having an opening for connection to the aperture, at least one of said wall portions having an additional opening disposed therein in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said openings, a heat exchanger disposed within said housing, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface dividing said passage into a plurality of additional passages through which the curved flow lines extend, and sound absorbing material disposed within said housing adjacent the inlet and outlet portions of said additional passages for absorbing sound travelling parallel to at least a portion of said flow lines, whereby the additional passages formed by said extended surface direct the noise from the aperture towards said sound absorbing material in order to retard the propagation of the noise from said aperture.

3. A silencer for an aperture of a device through which a flow of gas passes comprising structure forming a housing having a pair of spaced wall portions disposed in a facing relationship, one of said pair of wall portions having an opening disposed in the central portion thereof for connection to the aperture, at least one of said pair of wall portions having an additional opening disposed therein, said additional opening being annular in form and extending adjacent the periphery of said one wall portion in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said openings, a heat exchanger disposed within said housing adjacent said additional opening, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface dividing said passage into a plurality of additional passages through which the curved flow lines extend, and sound absorbing material disposed within said housing adjacent the inlet and outlet portions of said additional passages for absorbing sound travelling parallel to at least a portion of said flow lines, whereby the additional passages formed by said extended surface direct the noise from the aperture

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towards said sound absorbing material in order to retard the propagation of the noise from said aperture.

4. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having a pair of end walls disposed in a facing relationship and a side wall portion extending between the end walls, one of said pair of end walls having an opening disposed in the central portion thereof for connection to the aperture, at least one of said pair of end walls having an additional opening annular in form and extending about the periphery of said one end wall in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said openings, a heat exchanger disposed within said housing adjacent said additional opening, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and a plurality of fins on said member for transferring heat between said fluid and the flow of gas, said fins dividing said passage into a plurality of additional passages through which the curved flow lines extend, and sound absorbing material disposed within said housing adjacent the inlet and outlet portions of said additional passages and overlying the portions of the other of said end walls and said side wall portion adjacent said additional passages for absorbing sound travelling parallel to at least a portion of said flow lines, whereby the additional passages formed by said plurality of fins, direct the noise from the aperture towards said sound absorbing material in order to retard the propagation of the noise from said aperture.

5. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having spaced wall portions, one of said wall portions having an opening for connection to the aperture, at least one of said wall portions having an additional opening disposed therein in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said openings, a heat exchanger disposed within said housing and having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface dividing said passage into a plurality of additional passages through which the curved flow lines extend, sound absorbing material disposed within said housing and overlying the inner surface thereof adjacent the inlet and the outlet portions of said additional passages for absorbing sound travelling parallel to at least a portion of said flow lines, and additional sound absorbing material intersecting the plurality of additional passages formed by said extended surface for absorbing sound travelling directly from said aperture toward said additional opening, whereby the additional passages formed by said extended surface direct the noise from the aperture towards said sound absorbing material and said additional sound absorbing material in order to retard the propagation of the noise from said aperture.

6. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having a pair of end walls disposed in a facing relationship and a side wall portion extending between the end walls, one of said pair of end walls having an opening disposed in the central portion thereof for connection to the aperture, each of said pair of end walls having an additional opening disposed therein adjacent the periphery thereof in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said opening and said additional openings, a heat exchanger wholly disposed within said housing and extending between said end wall adjacent said additional openings, said heat exchanger having a member for conducting a fluid with respect to which heat is to be trans-

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ferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface dividing said passage into a plurality of additional passages through which the curved flow lines extend, and sound absorbing material disposed within said housing and overlying the portions of the other of said end walls and said side wall portion adjacent said additional passages for absorbing sound travelling parallel to at least a portion of said flow lines, whereby the additional passages formed by said extended surface direct the noise from the aperture towards said sound absorbing material in order to retard propagation of the noise from said aperture.

7. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having a pair of end walls disposed in a facing relationship and a side wall portion extending between the end walls, one of said pair of end walls having an opening disposed in the central portion thereof for connection to the aperture, each of said pairs of end walls having an additional opening extending about the periphery thereof in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said opening said additional openings, a heat exchanger disposed within said housing and extending between said end walls adjacent said additional opening, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface including a plurality of fins spaced apart substantially parallel to one another and extending outwardly toward said side wall portion, said fins dividing said passage into a plurality of additional passages through which the curved flow lines extend, sound absorbing material disposed within said housing and overlying the portions of the other of said end walls and said side wall portion adjacent said passages for absorbing sound travelling parallel to at least a portion of said flow lines, and at least one elongated member of sound absorbing material extending adjacent said fins and intersecting said additional passages formed thereby, said member absorbing sound travelling directly toward said additional openings, whereby the additional passages formed by said fins direct the noise from the aperture towards said sound absorbing material and said sound absorbing member in order to retard the propagation of the noise from said aperture.

8. A silencer for an aperture of a device through which a flow of gas passes comprising a structure forming a housing having a pair of substantially parallel end walls disposed in a facing relationship and a side wall portion extending between the end walls substantially perpendicular thereto, one of said pair of end walls having an opening disposed in the central portion thereof for connection to the aperture, each of said pairs of end walls having an additional opening extending about the periphery thereof in a position offset from the axis of said opening, said housing in its operative condition forming a passage for receiving a flow of gas moving along curved flow lines between said opening and said additional openings, a heat exchanger disposed within said housing and extending between said end walls adjacent said additional opening, said heat exchanger having a member for conducting a fluid with respect to which heat is to be transferred and an extended surface on said member for transferring heat between said fluid and the flow of gas, said extended surface including a plurality of fins spaced apart from one another and extending substantially perpendicular toward said side wall portion, said fins dividing said passages into a plurality of additional passages through which the curved flow lines extend, sound absorbing material disposed within said housing and overlying the portions of the other of said end walls and said side wall portion adjacent said passages for absorbing sound travelling paral-

lel to at least a portion of said flow lines, and at least on elongated member of sound absorbing material extending adjacent said fins substantially parallel to said side wall portion and intersecting said passages formed by said fins, said member absorbing sound travelling directly toward said additional openings, whereby the additional passages formed by said fins direct the noise from the aperture towards said sound absorbing material in order to retard the propagation of the noise from said aperture.

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