

Feb. 9, 1937.

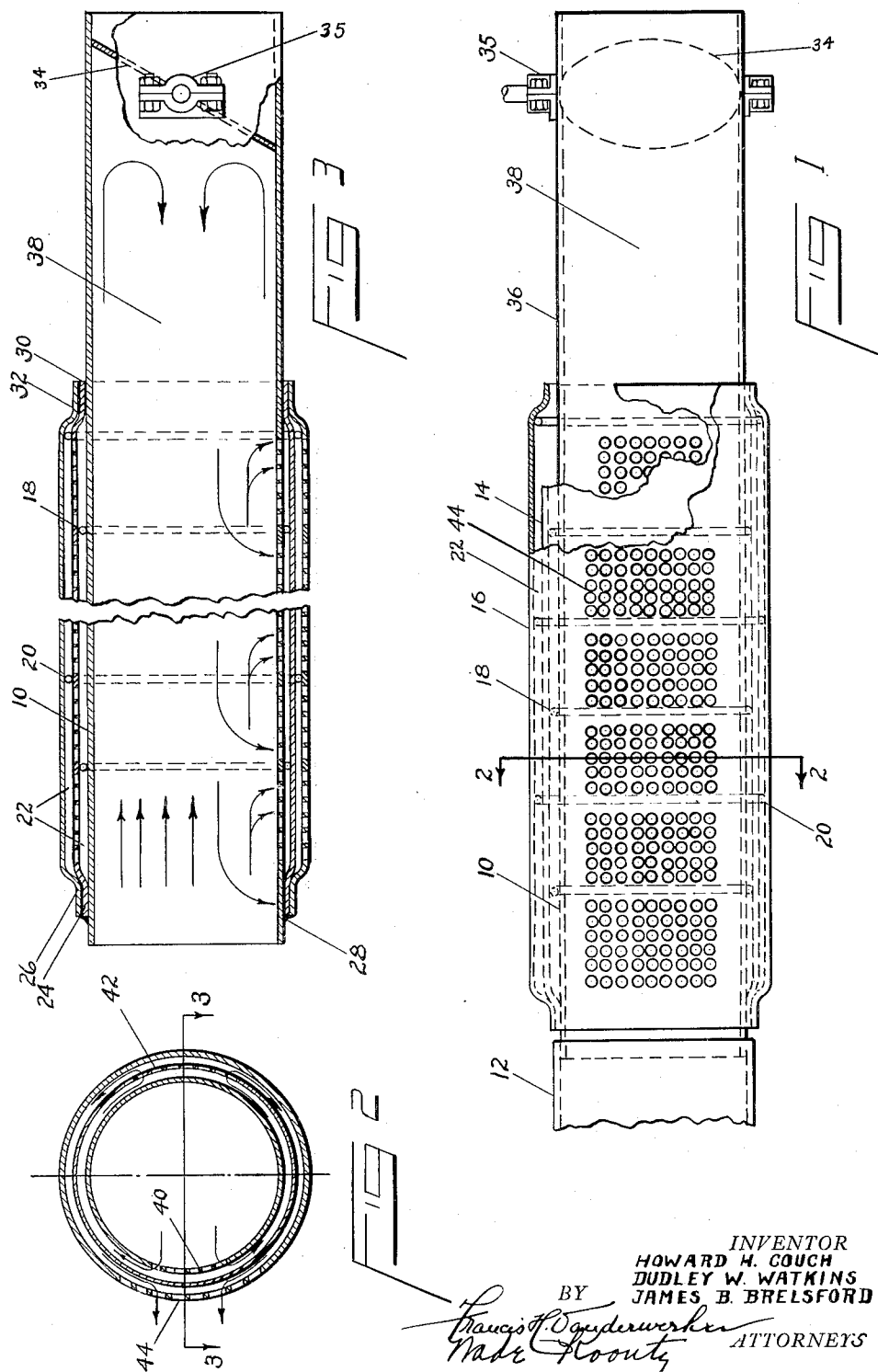
H. H. COUCH ET AL

2,069,751

EXHAUST SILENCER

Filed May 15, 1933

2 Sheets-Sheet 1



INVENTOR  
HOWARD H. COUCH  
DUDLEY W. WATKINS  
JAMES B. BRELSFORD  
BY  
*Francis T. Ogden*  
Attorneys

Feb. 9, 1937.

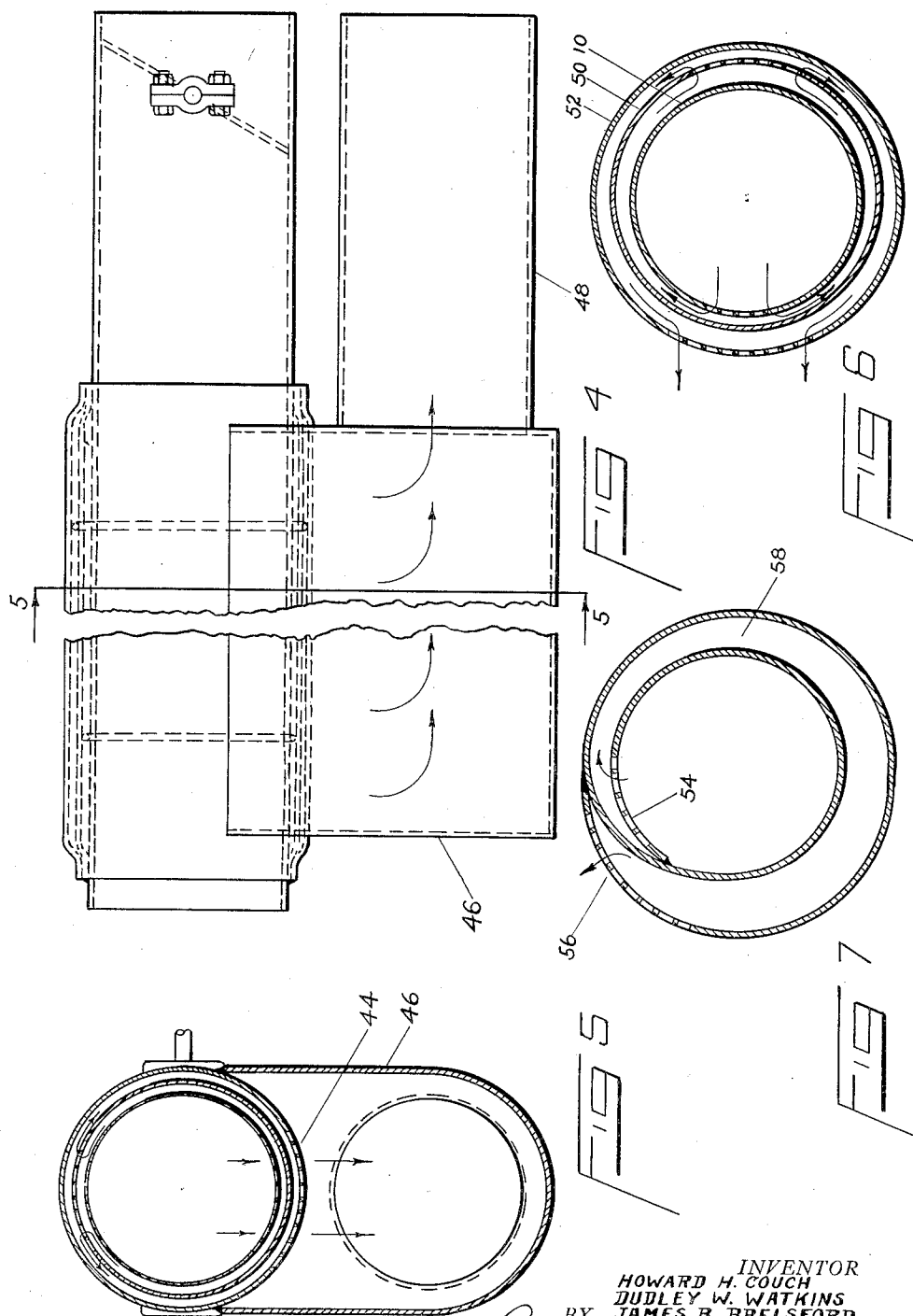
H. H. COUCH ET AL

2,069,751

EXHAUST SILENCER

Filed May 15, 1933

2 Sheets-Sheet 2



INVENTOR  
HOWARD H. COUCH  
DUDLEY W. WATKINS  
BY JAMES B. BRELSFORD

*Francis P. Vanderwerker*  
*Madison, N.Y.* ATTORNEYS

## UNITED STATES PATENT OFFICE

2,069,751

## EXHAUST SILENCER

Howard H. Couch, Oakwood, Dudley W. Watkins,  
Patterson Field, and James B. Brelsford, Day-  
ton, Ohio,

Application May 15, 1933, Serial No. 671,184

12 Claims. (Cl. 181—55)

(Granted under the act of March 3, 1883, as  
amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manu-  
factured and used by or for the Government of  
the United States for governmental purposes  
without the payment to me of any royalty thereon.

This invention relates to devices for silencing  
pressure pulsations of gaseous mediums passing  
therethrough. More particularly, this invention  
relates to exhaust silencers for explosive engines  
and is especially designed for use in connection  
with aircraft engines.

The exhaust gases coming from an internal  
combustion engine flow in pulsation and the  
noises incident thereto are essentially due to the  
explosion in the engine cylinders, the vibrations  
of the conductor of these gases from the en-  
gine, and the impacts of the gases against the  
atmosphere as it leaves the conductor.

This invention has for one of its objects the  
provision of a silencer in which a passageway or  
channel is surrounded by a series of side  
branches disposed successively along the length  
thereof. These side branches are connected with  
the passageway and are so constructed and ar-  
ranged as to reduce the noises to a minimum and  
to alternate the pulsations of the exhaust of the  
internal combustion engine to which the sil-  
encer is connected.

It is a further object of this invention to pro-  
vide a silencer that is small in size and low in  
weight for a given horsepower, the cross-  
sectional area of which is slightly greater than  
that of the exhaust pipe, resulting in a silencer  
which has but very little more drag than the  
regular exhaust pipe.

Certain other objects and advantages will ap-  
pear and be appreciated from the detailed de-  
scription of the invention taken in connection  
with the accompanying drawings which show  
several embodiments of this invention.

Referring to the drawings:

Fig. 1 is a bottom plan view of a silencer em-  
bodying our invention with parts broken away;

Fig. 2 is a sectional view taken on line 2—2 of  
Fig. 1;

Fig. 3 is a longitudinal sectional view taken on  
the line 3—3 of Fig. 2;

Fig. 4 is a side elevational view showing a  
further embodiment of this invention;

Fig. 5 is a sectional view taken on the line 5—5  
of Fig. 4;

Figs. 6 and 7 are cross-sectional views similar  
to Fig. 3 showing further embodiments of this in-  
vention.

The silencer comprises an unimpeded or un-  
restricted channel or passageway for the exhaust

gases and one or more series of chambers dis-  
tributed lengthwise of said channel and sur-  
rounding the same to provide a series of sections  
that have communication with the channel and  
with the atmosphere. The innermost chambers  
of each section are in direct communication with  
the channel and the outer or superimposed  
chambers have communication with the channel  
indirectly through correspondingly annular pas-  
sages positioned lengthwise, but the chambers  
of each series are preferably not in communica-  
tion with one another.

The communicating orifices of the chambers  
of each section progressively increase in number  
in the direction of the gas flow. Although, as  
illustrated herein, each section has substantially  
the same progressive increase in effective ex-  
haust area, it will be obvious that the communi-  
cating orifices along the channel, as well as the  
chambers of each series, may be progressively  
increased either from the same number of open-  
ings as that shown at the inner portion of the  
channel or from progressively increasing num-  
ber of openings so that there will be a progressive  
increase in the effective exhaust area of the  
silencer substantially throughout the length  
thereof and also for each section.

The number of communicating orifices and the  
rate of increase in the effective opening of each  
section will depend to a great extent upon the  
relative rate of flow, rate of expansion of the  
gaseous medium and the limiting back pressure.

The silencer also provides for the gaseous  
medium to be divided in each section into two  
branches that are caused to abut one another  
immediately prior to passing through the com-  
municating orifices between the chambers thereof  
and to flow through each section in a sinuous path  
by arranging the communicating orifices only  
along one side of each chamber wall or jacket  
and by having the orifices of adjacent jackets  
substantially diametrically disposed.

The silencer may be further modified by pro-  
viding a back pressure chamber wherein a pres-  
sure of the gaseous medium is built up such that  
it will tend to effect a smooth flow of the gaseous  
medium to atmosphere rather than a pulsating  
flow. This variation is not always necessary but  
is applied where maximum efficiency of silencing  
is desirable. The results of tests made at the  
Material Division of the U. S. Army Air Corps  
with a silencer embodying this invention have  
shown that substantially 97 per cent of the total  
sound energy of an airplane with a 2:1 geared  
engine was dissipated by the silencer. Tests of

the engine as a separate unit would show a greater reduction.

Referring to Fig. 1 of the drawings, which shows a preferred form of this invention, the numeral 10 designates a circular tube or channel of substantially the same cross-section as the exhaust tube 12 of the engine. Two cylinders 14 and 16 are mounted on the tube 10 in concentric relation therewith and in spaced relation with the tube and with one another. The distance between the walls of the several cylinders is small so as to provide narrow passages as well as to produce a silencer the overall cross-sectional area of which is slightly greater than the cross-sectional area of the exhaust tube. A series of spacer rings 18 are mounted on tube 10 between the outer wall of tube 10 and the inner wall of cylinder 14. The number of these spacer rings will depend upon the number of side branches that may be desired. There are also provided a series of spacer rings 20 between the outer wall of cylinder 16 and the inner wall of cylinder 14. These spacer rings serve to prevent the walls of the cylinder from buckling inward as well as in the capacity of bulkheads which determine the several side branches 22. By having each spacer connected to only one of its adjacent walls and the corresponding ends 24 and 26 of the cylinders 14 and 16 respectively welded to each other and to the tube 10 by a weld 28 with the respective opposite ends 30 and 32 of these tubes free to slide relative to one another and to the tube 10, the tubes will not be stressed under expansion and contraction with changes in temperature.

The tube or channel 10 extends beyond the sections 22 and a baffle plate or cut-out 34 is pivotally supported therein by bearings 35 that are welded on opposite sides of the tube 10. The baffle plate is positioned at a predetermined point beyond the sections 22 so that the extension 36 and the baffle plate provide a chamber of predetermined capacity. The location and volume of the chamber 38 are experimentally determined from the total volume and length of the silencer and exhaust tube and bear a definite relation thereto.

The operation of the silencer is as follows:

The exhaust gases coming from the engine enter through 12 to tube 10. These gases flow in pulsations which result from the explosions in the engine cylinders.

These pulsating gases flow along tube 10 and partially escape through holes or ports 40 into the space between tubes 10 and 14. This partial escape of gas through holes or ports 40 tends to reduce the peak pressure of that individual gas pulsation.

The gases passing through holes or ports 40 into the space between 10 and 14 divide into approximately equal parts and flow in both directions around tube 14 and meet at 42, which are on the opposite side of the silencer from ports 40. The speed of these separate gas streams is converted at impact into a local pressure, which increases the volume of their flow through ports 42 into the space between tubes 14 and 16 resulting in a further decrease in pressure between tubes 14 and 16 than would normally result.

The gases flowing through ports 42 into the space between tubes 14 and 16 again divide into approximately equal parts and flow in both directions around tube 16, meeting at ports 44. These ports are similar to ports 40 and 42, but greater in number. The increase in the number of ports 44 over ports 42 and of ports 42 over ports 40 is

employed to take care of the increased volume of the exhaust gases due to expansion. The total cross-sectional area of all the ports in either 10, 14 or 16 is such as to provide for a gas flow of sufficient volume to prevent back pressure building up due to expansion of gases and which would result in excessive loss of engine power. Ports 40, 42 and 44, and the tortuous path of the exhaust gases through the silencer with the abutting of the gas streams as described and the interferences due to passing through ports 40, 42 and 44, the changing of direction in passing through the curved passages between the jackets and the narrow chambers of each section, have the particular function of destroying the higher sound frequencies generated by the rapid combustion of fuel in the engine cylinders.

The lower sound frequency produced by the volume and pressure of the engine pulsations of the exhaust gases are dampened out by use of chamber 38.

Gases from one exhaust pulsation, which have not passed out to the atmosphere through ports 40, 42 and 44, as described above, continue their flight into chamber 38, strike baffle plate 34 and rebound back into the body of the silencer, escaping through ports 40, 42 and 44 in the manner described above before the next exhaust pulsation can interfere with this action. Although there is a loss of pressure in a particular pulsation due to escape of a part of its volume through ports 40, 42 and 44, the expansion of the gases maintains a speed sufficient to complete the above cycle. To control the completion of the cycle of flow of one pulsation, as described above, baffle plate 34 of chamber 38 is so located with respect to the body of the silencer that each pulsation may complete this cycle of flow without interference from the preceding or the following one.

When the baffle plate 34 of chamber 38 is in closed position, the chamber 38 may be regarded as operating similar to an electrical condenser in parallel with the channel or tube 10 and the side branches 22. When, however, the baffle plate is open, the main flow of the gas is through the baffle plate opening and the side branches may be regarded as operating similar to electrical filters that eliminate certain undesired frequencies.

Chamber 38 may be omitted and the silencer closed off flush with the ends of the outer tubes 14 and 16 where more complete silencing is unimportant. If the chamber 38 is not used tubes 10, 14 and 16 should be lengthened so as to allow practically all of the exhaust gas to escape in increments along the length of the silencers leaving but very little high pressure gas to strike the end of the silencer.

Fig. 4 shows another embodiment of this invention. The construction shown in this view is the same as in Fig. 1, except that there is provided a U-shaped deflector 46 that is open at one end only and surrounds the bottom portion of the tube 16 containing the exhaust openings or ports 44 for the entire length of the silencer. The open end of this deflector is provided with an extension tube 48 to direct the gases as desired.

Fig. 6 shows a further embodiment of this invention. The construction of the silencer in this view is the same as in Fig. 1 except that the cylinders 50 and 52 surrounding tube 10 are eccentrically disposed with respect to the latter tube, and to each other. The arrangement of the ports is identical with the correspondingly positioned ports of the silencer shown in Fig. 2.

A still further variation of this invention is

shown in Fig. 7, in which the silencer is made from one continuous sheet of metal. The sheet is wound in such a manner and the ports 54 and 56 so arranged that the gases passing through

ports 54 are directed circumferentially around through the sectional chambers 58 of the silencer to ports 56 whence they escape to atmosphere.

Various changes may be made in the design and construction shown and illustrated herein without departing from the spirit of this invention.

We claim:

1. A device for conducting a flow of gas and limiting the transmission of wave pulsations therethrough, comprising, a conducting channel closed at one end and open at the other to receive said gas having a plurality of longitudinally disposed ports, a perforated tube of greater diameter than said channel surrounding the same to enclose said ports and spaced therefrom, said tube being rigidly connected with the channel at one end but free at the other to prevent stressing of the walls of said channel and tube under expansion and contraction thereof and radial partitions between the walls of said tubes to provide a plurality of separate axially arranged chambers, each chamber having direct communication with atmosphere.

2. A device for conducting a flow of gas and limiting the transmission of wave pulsations therethrough, comprising, a conducting channel that is closed at one end and having a plurality of longitudinally disposed ports, a plurality of tubes of increasing diameter greater than said channel surrounding said channel and spaced therefrom and from one another, said tubes being perforated along their lengths and being rigidly connected with the channel at one of their ends but free at the other to prevent stressing of the walls of said channel and tube under expansion and contraction thereof and radial partitions between adjacent walls of said tubes to provide a plurality of separate axially arranged side branches, each branch having direct communication with atmosphere.

3. A device for conducting a flow of gas and limiting the transmission of wave pulsations therethrough, comprising, a conducting channel that is closed at one end and having a plurality of longitudinally disposed ports, a plurality of perforated tubes of increasing diameter greater than said channel surrounding said channel and spaced therefrom and from one another radial partitions between adjacent walls of said tubes to provide a series of separate gas conducting branches laterally disposed with respect to and surrounding said tubes, said channel being rigidly connected with the channel at one of their ends but free at the other to prevent stressing of the walls of said channel and tube under expansion and contraction thereof.

4. A device for conducting a flow of gas and limiting the transmission of wave pulsations therethrough, comprising a conducting tube having closure means at one end and being open at the other to receive said gas, and a plurality of gas conducting branches laterally disposed and adjacent said tube, each of said branches being provided with inlet and outlet openings to establish separate communication between said tube and atmosphere, the said branches extending from the open end of said tube toward the closed end thereof for a given length of said conducting tube to provide a gas containing reservoir extending substantially beyond said branches and having a

capacity such that the pressure variation in the flow of gas through said branches is reduced to a maximum consistent with minimum back pressure.

5. A device for conducting a flow of gas and limiting the transmission of pulsations therethrough, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations, and a plurality of gas conducting branches laterally disposed and adjacent said tube, each of said branches including a plurality of chambers in communication with each other, the effective open areas of said inlet and outlet openings of said chambers progressively increasing in the direction of travel of said gases from conducting tube to atmosphere.

6. A device for conducting a flow of gas and limiting the transmission of pulsations therethrough, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed will cause a material reduction in the sound energy of said pulsations, and a plurality of gas conducting branches laterally disposed and adjacent said tube, each of said branches being provided with inlet and outlet openings consisting respectively of a plurality of relatively small ports arranged longitudinally of said branches to establish communication between said tube and atmosphere, the dimensions of said branches and their respective openings being such that the acoustic length of said tube is negligibly affected thereby.

7. A device for conducting a flow of gas and limiting the transmission of pulsations therethrough, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations, and a plurality of gas conducting branches laterally disposed and adjacent said tube, each of said branches establishing substantially separate communication between said channel and atmosphere and including at least one or more chambers, said chamber or chambers having relatively small ports longitudinally arranged in the walls thereof, the ports of one wall being oppositely disposed with respect to the ports of another so that the gas flow is divided upon entering through the ports of one wall and caused to abut before passing through the ports of another.

8. A device for conducting a flow of gas and limiting the transmission of pulsations therethrough, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations, and a plurality of gas conducting branches laterally disposed and adjacent said tube, said branches being respectively provided with inlet and outlet openings to establish substantially separate communications between said

tube and atmosphere and having such dimensions that the acoustic length of said tube is negligibly affected thereby, said non-dissipative portion having a capacity such that the pressure built-up therein by the gas flow will smoothen out the pressure variations of said pulsations and thereby obtain a substantially uniform flow of gas through said branches.

9. A device for conducting a flow of gas and limiting the transmission of pulsations there-through, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations consistent with obtaining a minimum of back pressure, and a plurality of gas conducting branches laterally disposed and adjacent said tube, said branches being respectively provided with inlet and outlet openings to establish substantially separate communications between said tube and atmosphere and having such dimensions that the acoustic length of said tube is negligibly affected thereby.

10. A device for conducting a flow of gas and limiting the transmission of pulsations there-through, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations consistent with obtaining a minimum of back pressure, and a plurality of gas conducting branches laterally disposed and adjacent said tube, each of said branches being provided with inlet and outlet openings to establish separate communication between said tube and atmosphere, the dimensions of said branches and their respective openings being such as to

dissipate the energy of the high frequency sound waves of the direct and reflected wave pulsations and such that the acoustic effect of said tube is negligibly affected thereby.

11. A device for conducting a flow of gas and limiting the transmission of pulsations there-through, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations, and a plurality of gas conducting branches of different acoustic lengths laterally disposed and adjacent said tube, said branches being respectively provided with inlet and outlet openings to establish substantially separate communications between said tube and atmosphere and having such dimensions that the acoustic length of said tube is negligibly affected thereby.

12. A device for conducting a flow of gas and limiting the transmission of pulsations there-through, comprising a conducting tube having means for closing one end to provide a non-dissipative portion and being open at the other and along a length thereof to provide a dissipative portion, said non-dissipative portion being adjusted to such a length that, when closed, will cause a material reduction in the sound energy of said pulsations consistent with obtaining a minimum of back pressure, and one or more branches laterally disposed and adjacent said tube for conducting said gases to atmosphere, said branch or branches having communication with said tube in the region of a nodal point or points along said tube and having the communicating openings thereof of such dimensions as to negligibly affect the acoustic length of said conducting tube.

HOWARD H. COUCH.  
DUDLEY W. WATKINS.  
JAMES B. BRELSFORD.