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2,990,905

JET NOISE SUPPRESSION MEANS

Filed May 8, 1958

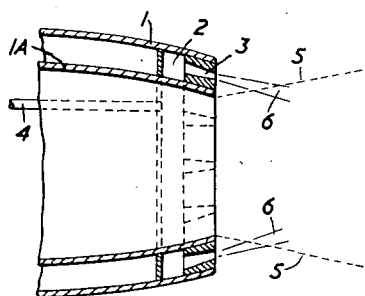


FIG. 1.

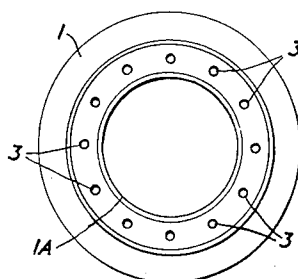


FIG. 2.

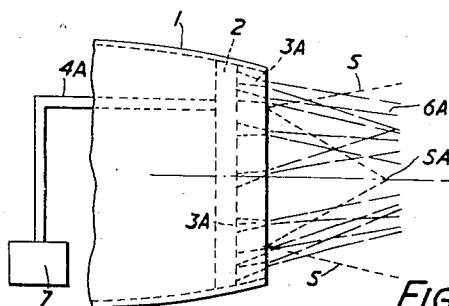


FIG. 3.

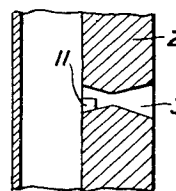


FIG. 6.

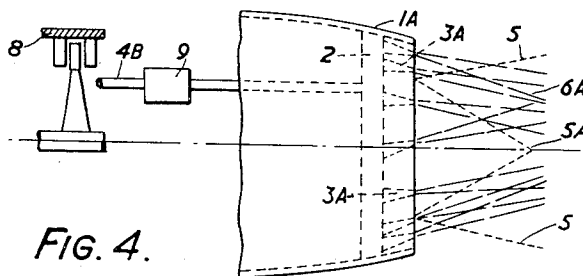


FIG. 4.

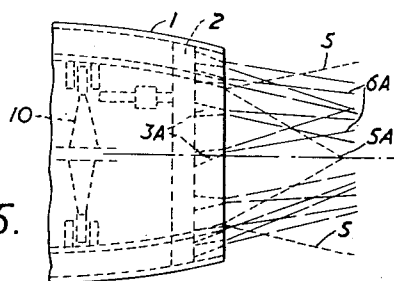


FIG. 5.

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JET NOISE SUPPRESSION MEANS

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3 Claims. (Cl. 181-43)

This invention relates to a method of and apparatus for suppressing part of the noise created by a high velocity jet issuing into the atmosphere. The problem which has given rise to the invention is that of noise suppression for aircraft jet engines.

In the British specifications Nos. 766,985 and 766,986 proposals have been made for dealing with this same problem and it has been demonstrated that the sound field produced when a jet issues into the atmosphere is largely caused by the action of the intense turbulence in the region of steep velocity gradients existing in the jet flow near to and beyond the nozzle exit. The proposals previously made were mainly concerned with altering the geometry of the nozzle away from the conventional plain circular nozzle. As a result, some appreciable reduction in noise has been attained in practice especially in frequency bands which are generally more distressing to human beings, which frequency bands are potentially more dangerous when the noise level is sufficiently high and less readily attenuated with distance. In some cases it is worth achieving a noise reduction in some frequency bands even at the expense of an increase in noise in some other frequency bands.

The present invention provides a method of suppressing part of the noise created by a jet issuing into the atmosphere by the interaction of the main jet with auxiliary jets which are separate from and emitted at spaced positions around the periphery of the jet and in a generally downstream direction.

The auxiliary jets may be emitted in a direction skewed in relation to the longitudinal axis of the main jet but not all auxiliary jets need be skewed to the same extent or even in the same sense. The auxiliary jets may be emitted initially in a direction with a component substantially tangential to the periphery of the jet. The axes of the auxiliary jets may be inclined towards or away from the axis of the main jet. Preferably the auxiliary jets emerge at spaced intervals around the periphery of the main jet.

In order to obtain high velocity auxiliary jets it may be desirable to employ a low density gas, for example helium. Auxiliary nozzles of convergent form may be used but in cases where the jet velocity is very high it may be desirable to use supersonic nozzles of convergent form. Fluid for the auxiliary jets may be tapped from a working or exhaust fluid stream. In the latter example, compression means may be incorporated between the tapping point and the auxiliary nozzles. In all examples the auxiliary nozzles may be provided with swirlers.

The invention further provides apparatus for suppressing part of the noise created by a jet issuing into the atmosphere including a jet pipe nozzle ending and a plurality of nozzles arranged around the periphery of said ending, said nozzles being separately supplied, and emitting a plurality of auxiliary jets which promote mixing between the surrounding atmosphere and the jet and restrict the formation of large eddies in the mixing region of the jet.

Certain embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

FIGURE 1 shows a cross section of an end part of

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a jet pipe taken along the longitudinal axis thereof and showing main and auxiliary jets.

FIGURE 2 shows an end elevation of a jet pipe.

FIGURE 3 shows a plan view of an end part of a jet pipe, main and auxiliary jets and a supply arrangement for these jets.

FIGURES 4 and 5 show an arrangement similar to that shown in FIGURE 3 with different supply arrangements.

FIGURE 6 shows an enlarged view of one of the auxiliary nozzles with a swirler incorporated therewith.

Referring now to FIGURES 1 and 2 the jet pipe nozzle ending comprises co-axial outer and inner walls 1 and 1A respectively. Between these walls is positioned an annular duct 2 which is connected to a supply pipe 4. In the downstream wall of the annular duct is a series of nozzles 3, shown for example as convergent nozzles. These nozzles are in fact small and in FIGURE 1 only a few are shown very much enlarged for the purpose of clarity. These nozzles are positioned to emit auxiliary jets 6 in a direction so that they penetrate an outer envelope 5 of the main jet. In this example the nozzles are inclined in the direction of flow towards the longitudinal axis of the jet pipe nozzle. The ratio of the diameter of the jet pipe nozzle ending to the diameter of the auxiliary nozzles may be for example of the order of 25:1.

FIGURE 3 shows nozzles 3A inclined with respect to the longitudinal axis of the jet pipe nozzle ending and also inclined in another sense. The auxiliary jets 6A in the arrangement shown in FIGURE 3 are thus emitted with a component of motion substantially tangential to the outer envelope 5 of the main jet as well as with a radially inward component as shown in FIGURE 1 with respect to the main jet. As shown in FIGURE 3 the component of tangential inclination may be different for each of the auxiliary jets and the radially inward inclination of some jets may be different from that of other auxiliary jets. A container 7 is connected to a pipe 4A, this container being charged with helium under pressure. This may be a conventional helium bottle.

FIGURES 4 and 5 show a modified arrangement for supplying fluid to the auxiliary nozzles 3. In FIGURE 4 a pipe 4B is positioned to tap air from a compressor 8 of the aircraft engine, this air being further compressed by a compressor 9 in the pipe 4B. FIGURE 5 shows a similar arrangement in which gases are tapped from the exhaust gases from a turbine 10 of the aircraft engine.

FIGURE 6 shows an enlarged view of a convergent divergent supersonic nozzle which in cases where the velocity of the main jet is very high can be substituted for the convergent nozzles shown in FIGURES 1 and 3. Any of these nozzles may also incorporate swirlers as shown diagrammatically at 11 in FIGURE 6 to modify the noise suppression performance.

The operation of the noise suppression device will now be considered with reference in particular to FIGURE 3 of the drawings. The auxiliary jets 6A by virtue of their interaction with the main jet and their tangential component of motion follow a substantially helical path or in the form of spiral vortices which penetrates the envelope 5 of the main jet. It has been found that turbulence of a nature which gives rise to intense relatively low frequency noise occurs in the region of the apex of the inner cone 5A. This point has been found to be at a distance approximately five jet pipe diameters downstream of the jet pipe nozzle orifice. It is therefore necessary that the auxiliary jets 6A should penetrate the main jet up to and somewhat beyond this point. The effect of the small auxiliary jets following their respective helical paths into the main jet is to restrict the formation of large eddies which would otherwise form in the

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region previously specified. In other words the auxiliary jets set the pattern of the turbulence and are in some ways analogous to the effect of teeth or corrugations which have been previously proposed for noise suppression. The noise level associated with the main jet issuing from a nozzle into the atmosphere is a function of the intensity of turbulence in the jet stream particularly in the region previously specified.

If the growth of the large eddies in this turbulence can be restricted some measure of noise suppression will be effected. The frequency of the noise created is dependent among other parameters on the scale of the eddies; therefore if large eddies are restricted, the lower range of frequencies of the noise created will be suppressed. Furthermore the auxiliary jet vortices will entrain air from the atmosphere and promote mixing of the jet 6 and the atmosphere. The auxiliary jets themselves will only create relatively high frequency noise which will be rapidly attenuated with distance.

What I claim is:

1. Apparatus for reducing the noise generated from the exhaust gas of a jet engine which comprises a jet type nozzle ending and at least one auxiliary jet, the axis of said auxiliary jet being inclined with respect to the main jet so that the auxiliary jet stream is directed towards and penetrates the main jet in a region at a distance of substantially five diameters of said main jet downstream of the jet pipe nozzle and which auxiliary jet has at the same time a component of motion substantially tangential to the outer envelope of the main jet.

2. Apparatus for partially inhibiting the generation of noise created by a main jet issuing into the atmosphere comprising a jet pipe nozzle ending and a plurality of nozzles spaced around the periphery of said ending, fluid supply means for said nozzles, the nozzles being directed downstream of the jet pipe nozzle ending and towards a region at least five diameters from the nozzle ending, and operable to emit auxiliary jets of fluid in a direction with a component of motion tangential to the periphery of the main jet, said nozzles being spaced around the periphery of the main jet so as to form an interrupted

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fluid layer between the main jet and the atmosphere, the auxiliary fluid layer being operable to interact with the main jet by means of said tangential component to form vortices in the auxiliary jets and modify the cross-sectional configuration of the main jet to restrict the formation of large eddies in the mixing region of the main jet and to entrain atmosphere between consecutive auxiliary jets to promote mixing between the atmosphere and the main jet.

3. A turbo-jet engine incorporating apparatus for partially inhibiting the generation of noise created by a main jet issuing into the atmosphere, said apparatus comprising a plurality of nozzles spaced around the periphery of the jet pipe nozzle ending, ducting to convey fluid tapped from the jet engine to said nozzles, the nozzles being directed downstream of the jet pipe nozzle ending and towards a region at least five diameters from the nozzle ending to emit auxiliary jets of fluid in a direction with a component of motion tangential to the periphery of the main jet, the auxiliary jets being spaced from one another around the periphery of the main jet to form an interrupted fluid layer between the main jet and the atmosphere, the auxiliary fluid layer being operable to interact with the main jet by means of said tangential component to form vortices in the auxiliary jets and to modify the cross-sectional configuration of the main jet to restrict the formation of large eddies in the mixing region of the main jet and to entrain atmosphere between consecutive auxiliary jets to promote mixing between the atmosphere and the main jet.

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	(2nd addition to No. 1,057,271)	

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,990,905

July 4, 1961

Geoffrey Michael Lilley

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 23, for "type" read -- pipe --.

Signed and sealed this 3rd day of April 1962.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

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