A V/STOL aircraft includes an aft by-pass powerplant 28 having an aft, rearwardly directed nozzle 30 and twin transverse vectorable nozzles 32. A duct 29 extends forwardly of the powerplant and terminates in a vectorable nozzle 16. The duct supplies relatively cool by-pass air to the nozzle.

Fig.5.
"Jet Propulsion Efflux Outlets"

This invention relates to jet propulsion efflux outlet assemblies and to aircraft incorporating such assemblies.

V/STOL aircraft have been proposed which incorporate a RALS (remote augmented lift system). Such aircraft include a downwardly directed outlet assembly located forwardly of the powerplant which is supplied with reheated fan air during V/STOL modes of flight. Reheat has been essential in earlier RALS proposals because, without reheat, the flow delivered to the outlet assembly would be insufficient to develop the required thrust. It will be understood that the reheat system means that the outlet assembly is of large diameter and bulky to accommodate the reheat equipment, fuel supply and burner arrangements and to withstand the reheat temperatures (typically in excess of 1000°C). In a modern fighter aircraft space and weight are at a premium, and the additional space and weight demands of a system incorporating a vectorable RALS nozzle mean that such a system is difficult to install. In existing RALS proposals, it is thus not practical to vary the direction in which efflux exhausts from the outlet assembly.
With the new generation of variable by-pass ratio engines the mass-flow of by-pass air that can be delivered is substantially increased and studies by the applicants have shown that such engines may be adapted to provide a remote lift system which does not require reheat to provide the desired remote thrust. The applicants have designed an arrangement which allows a smooth transition to or from fully wing supported flight and which contributes minimally to the drag of the aircraft, whilst occupying a small volume in the aircraft body.

According to one aspect of this invention, there is provided a jet propulsion efflux outlet assembly, comprising delivery duct means and an outlet nozzle means mounted for telescopic movement with respect to said delivery duct means between a retracted and an extended position.

According to another aspect of this invention, there is provided an aircraft of at least one of the vertical and short take-off type, which includes a powerplant, longitudinally spaced forward and rearward outlet assemblies for receiving at least a part of the efflux from said powerplant, wherein said forward outlet assembly is spaced generally forwardly of said powerplant and comprises delivery duct means, an outlet nozzle means for generating at least a component
- 3 -

of lift and means for varying the direction in which efflux exhausts from said outlet nozzle means.

The invention will now be described by way of non-limiting example, reference being made to the accompanying drawings, in which:-

Figure 1 is a side view of an example of a jet propulsion efflux outlet assembly in accordance with the invention;

Figure 2 is a section view on the outlet assembly taken on lines II-II of Figure 1;

Figure 3 is a section view taken on lines III-III of Figure 1;

Figure 4 is a side view of the forward part of a V/STOL aircraft incorporating the outlet assembly of Figures 1 and 2;

Figure 5 is a side view of the complete aircraft of Figure 4, and

Figure 6 is a composite plan view of the aircraft of Figure 4, with upper and lower halves of the Figure showing bottom plan and top plan views respectively.

Referring initially to Figures 1 to 4, the jet propulsion efflux outlet assembly 10 includes a delivery duct 11 which delivers propulsion fluid to the assembly during V/STOL modes, the duct being of generally circular cross-section and having a
curved downstream portion 12 which terminates inboard of the lower surface 14 of the aircraft. An outlet nozzle 16 of slightly larger generally circular cross-section and having a similar curvature to that of the downstream portion 12 is telescopically mounted with respect to the downstream portion by a bracket 18 pivotally mounted on an extension 20 of the duct 10 for movement about a pivotal axis generally concentric with the centres of curvature of said outlet nozzle 16 and said downstream portion 12. The outlet nozzle 16 is sealed to said downstream portion by a sliding seal 20. The outlet nozzle 16 is movable between a retracted position in which it does not protrude from the lower aircraft surface (illustrated in full lines in Figure 1) and an extended position (illustrated in dotted lines in Figure 1) in which it protrudes from an aperture 21 in the aircraft lower surface by a ram 22 having one end attached to the aircraft structure and the other end pivotally attached to a crank arm 24 connected to the bracket 18. In the retracted position the outlet nozzle exhausts substantially vertically downwards and in the extended position it exhausts in a direction at about 20° to the horizontal.

The V/STOL aircraft 24 illustrated in Figures 4 to 6 incorporates an outlet assembly of the type illustrated in Figures 1 to 3 for exhausting
by-pass air in a generally downwards vectorable direction
at a position spaced well forward of the centre of
gravity 26 of the aircraft when the aircraft is in a
vertical/short take off or landing mode.

The aircraft 24 includes a powerplant 28
located in an aft body portion and the powerplant is
of the variable by-pass type, including variable
camber, variable incidence blades.

The powerplant 28 includes a collar assembly
29 for receiving relatively cool by-pass air direct
from the fan of the powerplant. The collar assembly
includes two outlet ports 31 each controlled by a
valve (not shown) e.g. a simple vane valve, and
each delivering air into the bifurcated upstream
portion of the delivery duct 11. The powerplant 28
also includes a conventional rearwardly directed
nozzle 30 and a pair of transverse vectorable nozzles
32. The nozzles 32 may be of the rotating vane type
and be capable of exhausting between a vertically
downwards direction and a direction at about 20°
to the horizontal.

In use, the powerplant may be controlled
so that, for normal cruise flight, the cool by-pass
air and hot core efflux are mixed and exhaust through
the rearwardly directed nozzle 30. In this mode, the
aperture 21 in the aircraft lower surface is closed
by a flap or door (not shown).
For vertical/short take off or landing, the powerplant is controlled so that all of the hot core efflux is exhausted through the transverse vectorable nozzles 32, and the cool by-pass air is exhausted through the forward outlet nozzle 16 which is positioned in its retracted position to generate a vertical lift component with the associated flap or door open.

A typical design of powerplant 28 may be a variable by-pass and pressure ratio engine with a fan section having variable camber, variable incidence blades capable of delivering about 400 lb/sec of air (fan pressure ratio of about 4½:1) in normal flight and 550 lb/sec of air (fan pressure ratio of about 5½:1) in lift mode. The relatively cool by-pass air may have a temperature of about 200°C, so that the outlet nozzle 16 and the delivery duct 10 may be uncooled and formed of lightweight, small diameter non-metallic ducting. Because of the low fan air temperature and high pressure ratio, the duct may be smaller than that required for conventional RALS systems, whilst still providing a sufficient flow of unreheated air to generate the required lift thrust.

The efflux outlet assembly 10 provides a simple, lightweight, small diameter, compact arrangement which allows the efflux direction to be
vectored but which does not protrude from the aircraft surface during normal forward flight. This allows the efflux to be vectored with minimal fuselage ablation, and the low mass of the movable part of the nozzle 16 and the absence of reheat equipment mean that the nozzle may easily be vectored.

It will be understood that the efflux outlet assembly 10 may be used in configurations of aircraft other than that illustrated, and that the powerplant 28 may be configured or operated differently from the ways described herein. For example, the outlet nozzle 16 and the nozzles 32 may be vectored asynchronously. Also, the vectoring angle of 20° may be different dependent on the particular application and geometry of the aircraft.
CLAIMS

1. A jet propulsion efflux outlet assembly, comprising delivery duct means and an outlet nozzle means mounted for telescopic movement with respect to said delivery duct means between a retracted and an extended position.

2. A jet propulsion efflux outlet assembly according to Claim 1, wherein said delivery duct means has a curved downstream portion, said outlet nozzle means includes an upstream portion of complementarily curved shape, and said outlet nozzle means is mounted for pivotting movement between said retracted and stowed positions, whereby the direction in which said efflux exhausts may be angularly adjusted.

3. An aircraft of at least one of the vertical and short take-off type, which includes a powerplant, longitudinally spaced forward and rearward outlet assemblies each for receiving at least a part of the efflux from said powerplant, wherein said forward outlet assembly is spaced generally forwardly of said powerplant and comprises delivery duct means, an outlet nozzle means for generating at least a component of lift, and means for varying the direction in which efflux exhausts from said outlet nozzle means.

4. An aircraft according to Claim 3, wherein said delivery duct means has a curved downstream portion,
said outlet nozzle means includes an upstream portion of complementarily curved shape, and said outlet nozzle means is mounted for pivoting movement between said retracted and stowed positions whereby the direction in which said efflux exhausts may be angularly adjusted.

5. An aircraft according to Claim 3 or 4, whereby the rearward outlet assembly includes means for angularly adjusting the direction in which the efflux exhausts therethrough.

6. An aircraft according to any of Claims 3 to 5, which further includes a rearwardly directed outlet nozzle for generating thrust for forward flight.

7. An aircraft according to Claim 6, wherein said powerplant is operable to provide a flow of relatively cool efflux and a flow of relatively hot efflux, and control means are provided for directing said cool efflux to mix with said hot efflux and thence to said rearwardly directed outlet nozzle for cruise flight and for directing said cool efflux to said forward outlet assembly for vertical and/or short take off or landing.

8. A jet propulsion outlet assembly substantially as hereinbefore described with reference to, and as illustrated in, any of the accompanying drawings.

9. An aircraft substantially as hereinbefore described with reference to, and as illustrated in, any of the accompanying drawings.
Amendments to the claims have been filed as follows

1. An aircraft of at least one of the vertical and short take-off type including:
   a by-pass powerplant for generating relatively hot core efflux and relatively cool by-pass air;
   a rearward efflux outlet assembly for receiving and exhausting core efflux;
   a forward outlet assembly spaced forwardly of the powerplant and comprising an outlet nozzle means for receiving and exhausting by-pass air to generate at least a component of lift, and means for varying the direction in which said by-pass air exhausts from said outlet assembly.

2. An aircraft according to Claim 1, wherein said forward outlet assembly includes a delivery duct means for receiving by-pass air from said powerplant and having a curved downstream portion, said outlet nozzle means includes an upstream portion of complementarily curved shape, and said outlet nozzle means is pivotally mounted for telescop ing movement between a retracted position and a stowed position, whereby the direction in which said efflux exhausts may be angularly adjusted.

3. An aircraft according to Claim 1 or 2, whereby the rearward efflux outlet assembly includes means for angularly adjusting the direction in which the efflux exhausts therethrough.

4. An aircraft according to any preceding claim, which
further includes an aft, rearwardly directed, outlet nozzle for generating thrust for forward flight.

5. An aircraft according to Claim 4, including control means operable in cruise flight to direct said by-pass air to mix with said hot core flux and thence to said aft, rearwardly directed outlet nozzle, and operable for vertical and/or short take-off or landing to direct said cool by-pass air to said forward outlet assembly.

6. An aircraft according to any preceding claim, wherein said powerplant is located generally aft of the centre of gravity of the aircraft.

7. An aircraft of at least one of the vertical and short take-off type, including a by-pass powerplant disposed in a rearward region of the aircraft and arranged to generate relatively hot core efflux and relatively cool by-pass air, an aft propulsion nozzle for exhausting hot or mixed propulsion efflux generally rearwardly, at least one transverse vectorable nozzle for exhausting hot or mixed propulsion efflux, and a forward, vectorable nozzle spaced forwardly of said powerplant for directing relatively cool by-pass air in a vectorable downwards direction, for providing a significant proportion of the lift required for vertical or short take-off.

8. An aircraft substantially as hereinbefore described with reference to, and as illustrated in, any of the accompanying drawing.
FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:

UK Classification B7G (GJVN)
Int. Cl. B64C

(Collections other than UK, EP & PCT:)
Selected US specifications from Int. Cl. sub-class B64C

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

<table>
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<th>Category</th>
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<th>Relevant to claim(s)</th>
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<td>X</td>
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CATEGORY OF CITED DOCUMENTS
X relevant if taken alone
Y relevant if combined with another cited document
P document published on or after the declared priority date but before the filing date of the present application
E patent document published on or after, but with priority date earlier than, the filing date of the present application

Search examiner K E WILLIAMS
Date of search 21 August 1989
Relevant Technical fields

(i) UK Cl (Edition K)  B7G GJVN B7W WPF611

(ii) Int Cl (Edition 5)  B64C 15/all, 29/all

Databases (see over)

(i) UK Patent Office

(ii)

Documents considered relevant following a search in respect of claims 1 to 6 and 9

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