



(51) International Patent Classification:

F02K 5/02 (2006.01) F02K 7/18 (2006.01)
F02K 7/10 (2006.01)

(21) International Application Number:

PCT/GB2015/000148

(22) International Filing Date:

22 May 2015 (22.05.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1409600.2 30 May 2014 (30.05.2014) GB

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,

HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

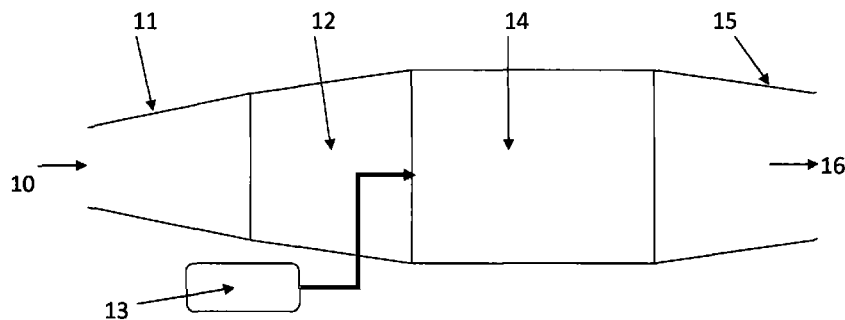
Published:

— with international search report (Art. 21(3))

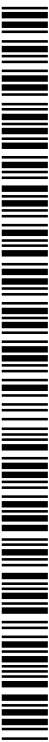
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: A NEW RAMJET ENGINE

Figure 1



(57) Abstract: This new ramjet consists of an air intake port (11), a diffuser stage (12), a fuel source (13), a combustion stage (14), and an exhaust nozzle (15). There are impellers in the diffuser stage that draw air into the engine when the aircraft is stationary or moving at any speed below the maximum cruising speed. The impellers are driven by electric motors, which require an electrical power source such as a battery, or are fed from an alternative source such as a fuel cell system. There are control systems for the impellers, for the fuel supply, and overall engine control. The new ramjet is a hybrid engine as it uses a combination of an electrical or another power source in addition to at least one combustible liquid or gaseous fuel. The engine can also operate in a way where it uses only one power source or fuel.



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A New Ramjet Engine

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Glossary

New Ramjet, Hybrid Ramjet, New Hybrid Ramjet – all refer to the same new aero-engine.

Conventional Ramjet – refers to designs of ramjet engine other than the new ramjet described herein.

Diffuser – A part of a jet engine air intake. Its usual function is to allow the air speed to decrease by volume expansion, and, in effect, the air pressure to increase.

Passive Diffuser – This has the same description as a diffuser, but to distinguish it from an active diffuser as described below.

Active Diffuser – A diffuser that contains an array of impellers (to enhance the functionality of the diffuser).

1. INTRODUCTION

Advancements and improvements in jet engine design have plateaued in the last twenty years or so. Typically there have been improvements in the use of new materials, blade design, combustion techniques and other features for improved efficiency. However, there has been no step change in the fundamentals of engine design since about the 1950's. The recent technological developments in electronics have led to the 'more electric aircraft', where much of the aircraft auxiliary systems are now electrically operated including the flight control surfaces, replacing most of the hydraulic systems, and leading to a significant weight saving. Another major area where mass can be removed is in the engine, which is a very complex and weighty mechanical component despite the use of lightweight titanium and superalloy components.

Compared to the widely used gas turbine engine, a conventional ramjet has several major advantages in terms of weight and fuel saving. In a conventional ramjet the compressor, shafts and turbines are absent, and thus there are almost no moving parts. It is therefore, a very simple and much lighter engine, typically only a fraction of the weight of a gas turbine. These features result in an engine with a much lower production cost and in ease of manufacture. However, conventional ramjet engines are not self-starting; they do not operate until a secondary engine, or a propellant, has driven the aircraft to the high air ramming speed required to trigger the operation of the ramjet motor, and solely operate at supersonic speeds. These are severe limitations, and at present restrict the use of ramjets almost exclusively to military applications e.g. the high speed interception of hostile craft. Little use of ramjets can occur in the much wider field of commercial aircraft, until these strict limitations are overcome.

This Patent Application concerns a new design of hybrid ramjet aero-engine for use in both civil and military aircraft. The new ramjet proposed here has the critical addition of an active diffuser¹, containing impellers, to increase the air flow through the engine when the incident air at the intake port is moving slowly due to the slow or stationary speed of the aircraft. When the incident air is moving very fast, the diffuser assumes its usual role of allowing the air speed to decelerate, and in effect, the air pressure to build up, as in the case of a conventional (passive) ramjet diffuser with no impellers inside. Although the active diffuser and its power source make the new engine heavier than a conventional ramjet, it is still a very much lighter unit than a gas turbine. Thus the new engine retains the advantages of light weight, fuel saving and low manufacturing cost.

The points raised above, supported by technical information, are discussed in more detail in the Application below.

¹ Throughout this Application and in relation to the new engine, the terms "diffuser" and "active diffuser" are of the same meaning and relate to the diffuser section of the engine where one or more impellers are present.

2. CURRENT TECHNOLOGIES

i. Ramjets

Compared to a gas turbine engine, a ramjet is a very simple and much lighter jet engine where all of the rotating compressor, shafts and turbines are absent. In essence there are no moving parts at all, apart from auxiliary fuel feeding pumps and any moveable variable geometry parts for guiding the air flow within the engine.

As the name suggests, air is rammed into the front opening of the engine by the forward velocity of the aircraft. The efficiency of this ram-air effect varies according to the forward velocity, and to the shape of the opening: a convergent opening may collect more air and increase the mass flow rate of the air into the engine. Inside the engine the air speed is decelerated in the diffuser and pressure is allowed to build up. After the diffuser is the combustion section, where the fuel is injected and burnt. Within the combustion section is a device called a flame holder, which prevents the flame from extinguishing in the high speed air flow. A detailed description of the flame holder and its function is given in Appendix A.

The internal geometry of the ramjet engine can significantly affect its efficiency. So the optimum design needs to be determined through suitable thermo- and aero-dynamic and/or CFD modelling for the required speed and operating conditions. Ramjet engines follow the combustion cycle called the Brayton Cycle. Energy is also absorbed from the thrust to make the ramjet engine work, as the ram-air compression presents a drag effect on the aircraft in which the engine is contained. The operating speed range for a ramjet is typically between mach 0.5 and mach 6. The most efficient range is between mach 1 and mach 3. Below mach 0.5 there is insufficient ram-air compression to enable the engine to produce usable thrust, and above mach 6 the air inlet temperature is far too high, causing compression problems and potential engine meltdown in the combustion stage.

ii. Air-Turbo Ramjets

The basic ramjet is not a self starting engine. In order to use a ramjet in a missile or aircraft there must be another method for launching the vehicle. Usually, in military aircraft, the ramjet is in addition to another engine such as a gas turbine. This secondary engine is used to launch the aircraft, and above a certain speed and altitude the ramjet takes over. This integrated gas turbine and ramjet combination is known as an air-turbo ramjet. The SR71 supersonic aircraft has two air-turbo ramjet engines, each based on a Pratt and Whitney J58 gas turbine secondary engine. The obvious disadvantage with the air-turbo ramjet is that depending on the flight phase one or the other engine is usually not functioning and is, therefore, dead weight.

iii. Rocket Engines

A rocket engine is another type of reaction engine. In terms of the main components only, a rocket engine is also relatively simple in construction in comparison with a gas turbine engine. Liquid fuel and a liquid oxidising agent are both injected into a combustion chamber, mixed and ignited in a continuous process. An opening at one end of the combustion chamber allows the rapidly expanding hot gases to exit as a high velocity jet. Obviously, this engine does not require atmospheric oxygen to function, and therefore, readily presents itself as the ideal engine for the vacuum of space.

3. THE PROBLEMS TO BE SOLVED

Essentially the problems to be solved concern the design of a ramjet motor capable of allowing a civil or military aircraft to take-off, cruise and land without the assistance of another engine. These problems include those of engine weight and of associated fuel savings, and concomitantly of airframe weight and shape. The tables in Appendix B give the weight and thrust of typical reaction (jet and rocket) engines, and it can be seen that large jet engines typically weigh around five to six tonnes. The engines are a significant weight component of any aircraft. Fuel has to be burnt in order to carry the weight of the engines in addition to the remainder of the aircraft's weight. The weight not only affects fuel efficiency, but it also affects the design of the aircraft. For example, a heavy aircraft must have larger wings, which in turn increases the drag on the airframe, which is another factor affecting fuel efficiency. However, if several tonnes could be removed from the weight of the aircraft by employing considerably lighter engines, then there would be a significant fuel saving for the same airframe size. Or, for the same fuel consumption, the aircraft could fly higher and faster.

4. THE INVENTION

4a. TECHNICAL DESCRIPTION

An example of the invention will now be described by referring to the accompanying drawings:

- figure 1 shows a basic sketch of the main components of the invention.
- figure 2 shows one arrangement of the diffuser section with two impellers and electric motors, and
- figure 3 shows the movable extent of the variable geometries for the air intake port and the exhaust nozzle.

The basic components of the new ramjet consists of a variable geometry air intake port (11), a diffuser (12), a number of impellers in the diffuser (21), a fuel source (13), a combustion section (14) and a variable geometry exhaust nozzle (15).

The variable geometry air intake port presents a variable cross sectional opening or aperture to the incident air (10) depending on the (relative) air speed, or speed of the aircraft. For example, when the air speed is low the air intake port is opened to its maximum extent (31) to capture as much air as possible. Very little or no diffusion of the air takes place in the air intake port when it is opened to its maximum extent. Conversely when the air speed is very high, i.e. approaching or above mach 1, the air intake port is retracted or narrowed to present a minimum aperture (32) to the on-coming air. In this position the air intake port is diverging, and significant diffusion takes place in this space (i.e. passive diffusion) between the air intake port and the entrance of the active diffuser, to allow the air to slow down and the pressure to build up.

The air entering the diffuser (12) is sub-sonic either because the aircraft is stationary or flying slowly, or because the air intake port has a small aperture allowing the natural diffusion of high speed incoming air in the intake port before entering the diffuser. The diffuser section allows the air to slow further and the pressure to increase before entering the combustion section. Because the air in the diffuser is moving at a speed well below the speed of sound, a number of motorised impellers (21) can

be mounted in this section. The sub-sonic air speed will allow the impellers to operate efficiently without the problems of wave drag² or any other transonic effects.

The impellers (21) mounted in the diffuser can be driven by electric motors (22) and powered by either a battery pack or by another energy source, or, driven by another non-electrical motor, i.e. a) an electrically driven diffuser powered by a battery, with (e.g.) one or more fuel cells to assist recharging, and with (e.g.) the possible use of supercapacitors; or b) an active diffuser driven by a non-electrical motor e.g. a separate internal combustion engine. However, it is the intention in this invention to drive the impellers by electric motors. (See Note)³. The impeller diameters increase with the diverging cross section of the diffuser. At slow air speeds each impeller is controlled so that all impellers do the same amount of (fluid dynamic) work on the air flow. So the smallest diameter impeller rotates the fastest, and the largest diameter impeller rotates the slowest. Consequently the air slows and the pressure builds up. The presence of the impellers, therefore, reinforces this slowing of the air speed and the building of the air pressure compared with what would naturally occur in an open or passive diffuser (without any impellers). This enhances the effectiveness of the diffuser due to the pressure difference across each impeller. Hence the back pressure can be significantly greater compared with an open diffuser of the same size and volume. This impeller loaded diffuser can be referred to as an active diffuser in this case.

The role of the impellers are four fold:

- i) To force an air flow through the engine when the aircraft is stationary or moving slowly.
- ii) To enhance a negative air speed gradient within the diffuser with a positive pressure difference especially when the aircraft is flying slowly or below the critical ramjet cruising speed.
- iii) To allow electrical regeneration to take place, where one or more impellers are controlled to generate electrical power when the aircraft is flying at its cruising speed, which may be above or below mach 1 depending on the design of the engine.
- iv) To provide reverse thrust after touch-down by reversing the direction of rotation, to force air out of the front of the engine.

Between each impeller there should be stator vanes (23) which remove the swirl of the air due to the impellers and to aid in the diffusion of the air. Another technique to remove the swirl between impellers is to utilise counter-rotation for every other impeller. A further improvement in the design of the impellers is to employ swept blades to offset the problems of wave drag, so the tips of the impeller blades can run close to the speed of sound.

After the diffuser is the combustion section (14). In its simplest form the combustion section consists of a fuel injector, a flame holder and an igniter. The flame holder may be a simple gauze as present in a conventional ramjet, or a single combustion chamber and flame holder combined, or multiple combustion chambers or cans and flame holders combined. However, in the absence of any central shaft, there is complete flexibility with the style of combustor and fuel injection system that can be employed.

² **Wave drag** is a component of the drag on aircraft, blade tips and projectiles moving at transonic and supersonic speeds, due to the presence of shock waves.

³ **Note:** To avoid the frequent repetition of both systems i.e a) and b) in the Application, a), the electrically powered method, is the focus. However, it is recognised that b) is also a valid method.

After the combustion section is the exhaust nozzle (15). This is intended to increase the velocity of the gases leaving the combustor into a high velocity jet (16) at the exit. The velocity and mass flow of the jet gases provides the thrust from the engine. The nozzle may have a fixed converging geometry. However, for a wide speed range the exhaust nozzle may have a variable geometry, providing a narrow aperture (33) for slow flying conditions and a wide aperture (34) for high speed conditions. For supersonic speeds the exhaust nozzle requires a converging-diverging geometry.

4b. ENGINE SYSTEM DESIGN AND DESIGN VARIATIONS

The new engine must have a suitable control system that regulates the fuel supply with the air flow to maintain the correct air-fuel ratio. A stoichiometric air-fuel ratio can be used, where there is a perfect balance in the combustion equation between the fuel and the oxygen in the air; neither too rich nor too lean. However, at the stoichiometric ratio, the combustion temperature is at its highest. To counter this heat, in a ramjet there must be a layer of cool air over the combustion can and the inside surface of the exhaust nozzle (15). This is easily engineered. However, if the internal air by-pass around the combustion chamber is substantial, then this will provide an envelope of cold air around the hot gaseous jet in the exhaust nozzle for noise reduction.

In addition to the fuel control system, there must be a suitable control system (24) for the impellers, so that the electrical power consumption by each motor is balanced. This is to prevent any one motor working harder than the others. Also, it is to prevent a situation where one motor-impeller combination is absorbing power from the air flow set up by another such combination, effectively wasting energy. When the airflow into the engine is sufficiently fast caused by the forward velocity of the aircraft so that it is operating as a ramjet, the central control system can allow all the impellers and the electrical machines to absorb energy from the velocity of the incoming air, thus recharging the batteries (25) in sustained flight. If the impellers try to absorb too much power from the incoming air, then this will create a substantial drag on the engine, the aircraft will slow down, which in turn will affect the performance of the ramjet engine. Alternatively, this would be useful in decelerating the aircraft. It is envisaged that the central control system would also control the variable geometry inlet and exhaust nozzles, to regulate the air flow through the engine, depending on air speed and flight conditions.

The performance of the ramjet engine is dependent on sufficient compression of the incoming air either by the active diffuser system and/or by the ram air effect. Extra thrust can be achieved by injecting additional fluids into different sections of the ramjet engine. For example, water can be injected into the air stream in or after the diffuser section, which has the effect of cooling the air and allowing an increase in the pressure. A mix of water and alcohol would be an alternative fluid to inject, to enhance the cooling effect, and the alcohol component would burn in the combustion chamber to provide a further thrust boost. After-burning is also possible, where fuel is injected into the hot exhaust stream in the exhaust nozzle. A fuel and fluids control system is employed to regulate both the fuel supply and additional liquids and gases for thrust augmentation.

The usual fuel for this engine is likely to be kerosene, although other fuels (liquid or gaseous) could be used. Alternative fuels may include a blend, such as a hydrocarbon and an oxygen rich fuel when the engine is being used at very high altitudes and the air is substantially rarefied. Taking this idea to the extreme, where a mix of fuel and an oxidising agent are both injected into the combustion chamber the engine may transform into a rocket type of engine. Furthermore, if a wall barrier closes down

behind the combustion chamber effectively isolating the diffuser stage from the combustion stage, then the engine is completely transformed into a rocket engine, assuming appropriate cooling of the combustion and rear sections of the engine have been considered to prevent overheating.

The construction and operation of the new hybrid ramjet engine has been described. The use of the word 'hybrid' has two justifications: 1) The combination of a high electrical power source supplying the impellers (to produce thrust), and a fuel for combustion in the engine (also to produce thrust), provides one definition of the word 'hybrid'. 2) The engine may function in a mode in which there is a combination of impellor driven and ramjet processes for producing thrust. This is the second definition of the word 'hybrid' used to describe the new ramjet engine. Thus equipped, the new engine has four different modes of operation i.e. using only the electrical power source with the electric motor driven impellers, or the non-electrical motor driven impellers, or only a liquid (or gaseous) fuel source applied to the ramjet burner, or in a hybrid mode in which a certain number of these sources of energy are combined. These different modes will enable the aircraft to taxi onto the runway, to take off under its own power without secondary assistance, and to reach and maintain ramjet operating speeds. For the first time, therefore, a hybrid ramjet engine equipped with impellers could be used to power commercial aircraft, while retaining many military applications.

4c. THE INVENTION IN OPERATION:- THE STAGES DURING TAKE-OFF, AT CRUISING SPEED AND IN LANDING

- i. As the engine is run up from standstill, the electrically driven impellers, which require an electrical power source such as a battery, provide an air flow through the engine. The impellers alone are able to produce thrust without the engine burning fuel. This may be useful when an aircraft is moving slowly on the taxi-way for example.
- ii. For greater thrust, gaseous or liquid fuel is burnt and the engine produces thrust due to the combination of the air drawn in and (pushed) through the engine by the impellers, and due to the jet of hot gases exiting the exhaust nozzle. At this stage the ramjet engine behaves like a simply designed gas turbine engine; in that it can produce thrust whilst stationary.
- iii. Once in motion the increasing forward velocity of the aircraft starts to allow incoming air to be progressively forced into the air intake scoop, providing additional compression. Here, at take-off and in climb, the engine functions in a dual or hybrid mode, combining impellor driven and ramjet characteristics to produce thrust.
- iv. Once cruising speed has been reached, air is being rammed into the air intake. This ram effect increases the efficiency of the engine. The ram effect mode of operation of the engine completely takes over when ramjet operating speed is reached. At this stage the electrically powered impellers are able to recharge the battery system.
- v. At this high cruising speed, the geometry of the air scoop is important, because if it has a frontal area that is too large, the air intake will become choked. Also, a large frontal area may present a large drag force on the engine, hindering its performance. Likewise, the geometry of the exhaust nozzle should be matched to the desired operating speeds and conditions. It is envisaged that for a range of cruising speeds, from subsonic to supersonic, the air intake port

and the exhaust nozzle should each have a variable geometry. Ideally, the new engine will be designed for a speed range that encompasses both civil and military applications.

- vi. Just before coming into land, the aircraft slows down and loses altitude. During this slowing down process the new ramjet engine can act as an air brake by continuing to recharge the battery system. However, there may arise a situation where the aircraft may have to sustain a low level, low speed flight by circling over the airport for say up to 30 minutes due to air traffic congestion or a problem at the airport. In which case the ramjet engines may not be able to recharge the battery system due to the low air-speed. An alternative electrical power source may be required to maintain a supply of electrical energy to the electrically driven impellers. This alternative electrical power source may come from a fuel cell system, powered by hydrogen for example. So in the event of sustained slow speed flying for a protracted period of, say, a number of hours, the fuel cell system is able to recharge the batteries in order to maintain sustained operation of the new ramjet engine below the ramjet operating speed, and to prevent over-depletion of the battery bank.
- vii. Upon final approach and landing the engine reverts back to its hybrid mode, behaving more like a simple gas turbine than a ramjet engine. At touch-down, the fuel supply is switched off and the rotational direction of the impellers is reversed and the speed increased to maximum to provide reverse thrust to decelerate the aircraft. Once parked up on the apron and during refuelling, as with many other types of aircraft, a rapid recharge facility may be used to restore the partially depleted battery bank.

5. ADVANTAGES

ADVANTAGES A1

The advantages of the new ramjet engine compared 1) with conventional gas turbine and turbo-fan engines are claimed as follows:

1. Much lighter weight for the same cubic volume of the engine, including the additional battery pack.
2. Cheaper to produce: fewer components, and much simpler construction, leading to significant cost reductions in manufacture.
3. Can produce thrust using the impellers alone, saving fuel when the aircraft is moving slowly on the taxi-way on the ground, and when coming in to land.
4. Higher altitude and cruising speeds can be achieved.
5. Fuel can be burnt at the stoichiometric ratio for maximum fuel burn efficiency, because there is no turbine that could otherwise melt.
6. The new hybrid ramjet is based on a conventional ramjet, which has a speed range extending from about mach 0.5 to mach 6. Therefore, the hybrid ramjet engine can achieve a higher operating speed than a turbo-fan engine.
7. For the same power and weight of engine, an airframe with a new ramjet engine could have smaller wings and less drag.

ADVANTAGES A2

The advantages of the new hybrid ramjet engine compared 2) with a conventional ramjet are claimed as follows:

8. The new hybrid ramjet is self starting, and there is no need for an additional engine or propellant for take-off and climb.
9. The new hybrid ramjet engine can operate as a simple rotary jet engine, or as a ramjet, or in transition between these two modes.
10. The speed range of the new ramjet engine is capable of both subsonic and supersonic cruising speeds with the same engine design.
11. The new ramjet engine recharges its batteries, or another reversible electrical power source, at a suitable cruising speed and in aircraft deceleration.
12. The new ramjet engine is able to provide a reverse thrust for deceleration after landing, by reversing the rotational direction of the impellers, thus pushing air out of the front of the engine.

6. APPENDICES

APPENDIX A

THE FLAME HOLDER

There have been different designs of flame holder, the simplest being a flat gauze, where the compressed air is forced through small holes in the gauze, but on the downstream side of the gauze bluff body and re-circulatory air flows cause the flame to remain in the wake behind the solid parts of the gauze. Sometimes the flame holder is a can that has an opening or exit at one end, and it also has a multitude of air entry holes throughout the closed surface for air to pass into the can. Bluff body or re-circulating air flow in the can keeps the flame in the can. There may also be advantages in having a number of small combustion cans arranged in a ring, for example, so that there are multiple injectors with multiple flame sources, should there be a problem with a single injector and a single flame source. Once the fuel is ignited the flame propagates towards the exhaust nozzle, which is usually converging to increase the exit velocity of the exhaust gases.

APPENDIX B

DATA REGARDING JET AND ROCKET ENGINES

Table 1.

Jet or Rocket engine	Mass (kg)	Mass (lb)	Thrust (kN)	Thrust (lbf)	Thrust-to-weight ratio
RD-0410 nuclear rocket engine	2,000	4,400	35.2	7,900	1.8
J58 jet engine (SR-71 Blackbird)	2,722	6,001	150	34,000	5.2
Rolls-Royce/Snecma Olympus 593 turbojet with reheat (Concorde)	3,175	7,000	169.2	38,000	5.4
Pratt & Whitney F119	1,800	3,900	91	20,500	7.95
RD-0750 rocket engine, three-propellant mode	4,621	10,188	1,413	318,000	31.2
RD-0146 rocket engine	260	570	98	22,000	38.4
SSME rocket engine (Space Shuttle)	3,177	7,004	2,278	512,000	73.1
RD-180 rocket engine	5,393	11,890	4,152	933,000	78.5
RD-170 rocket engine	9,750	21,500	7,887	1,773,000	82.5
F-1 (Saturn V first stage)	8,391	18,499	7,740.5	1,740,100	94.1
NK-33 rocket engine	1,222	2,694	1,638	368,000	136.7
Merlin 1D rocket engine	440	970	690	160,000	159.9

Data source: Wikipedia web page on turbo-jet engines, http://en.wikipedia.org/wiki/Jet_engine

Table 2.

Rolls Royce Trent Series Specification Table

Trent Engine Family: Leading Particulars							
Engine	Static Thrust (lbf)	Basic Engine Weight (lb)	Thrust to Weight Ratio	Length (in)	Fan Diameter (in)	Entry Into Service	Applications
Trent 553	53,000	10,400	5.1	154	97.4	2003	Airbus A340-500
Trent 560	60,000	10,400	5.76	154	97.4	2002	Airbus A340-600
Trent 768	67,500	10,550	6.4	154	97.4	1996	Airbus A330-200, 300
Trent 772C	71,100	10,550	6.7	154	97.4	2007	Airbus A330-200, 300
Trent 875	75,000	13,100	5.7	172	110	1995	Boeing 777-200
Trent 895	93,400	13,100	7.1	172	110	1999	Boeing 777-200ER
Trent 970	75,152	13,842	5.4	179	116	2007	Airbus A380-841
Trent 980-84	84,098	13,842	6.0	179	116	TBA	Airbus A380-941
Trent 1000-A	63,800	11,924	5.4	160	112	2009	Boeing 787-8
Trent 1000-K	73,800	11,924	6.2	160	112	2010	Boeing 787-9

Data source: Abbreviated from Wikipedia, http://en.wikipedia.org/wiki/Rolls-Royce_Trent

CLAIMS

The technical features and embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A new hybrid ramjet engine incorporating an active diffuser stage, where said stage consists of at least one rotary impellor.
2. A new hybrid ramjet engine as recited in claim 1, and where the active diffuser stage consists of at least one impellor, said impellor or impellors are operated by an electrical machine, where said electrical machine is defined as a reversible motor-generator, depending on the rotational direction of the shaft torque.
3. A new hybrid ramjet engine as described in claims 1 and 2 involving an active diffuser stage, shown in Drawings, figure 2, with multiple impellors (21) and multiple electrical machines (22), where each said impellor or impellors are connected to a reversible electrical machine.
4. A new hybrid ramjet engine as described in claim 1, having an active diffuser stage with at least one impellor that is powered by a machine as described in claims 2 and 3, such that after each impellor there should be stator vanes (23) which remove the swirl of the air due to the impellor and which aid in the diffusion of the air.
5. A new hybrid ramjet engine as described in claim 2 containing a number of individually motorised impellors, where the net input power to the machines raises the power of the air (the air-power) inside the engine, which in turn may allow the air pressure or the air flow or both to increase inside the engine, and where each impellor is allowed to run at the same or different speeds relative to the other impellors.
6. A new hybrid ramjet engine containing a number of motorised impellors, where regenerative power can be removed from the forward motion of the engine by the impellor(s), operating within the air flow inside the engine and presenting a decelerating force on the engine, and where that net power is extracted from the motorised impellors, preferably as electrical power.
7. A new hybrid ramjet engine as described in claim 1, involving an active diffuser stage as described in claim 2, where said diffuser stage may have a non-diverging volume to enable the new ramjet to operate more efficiently at subsonic speeds.
8. A new hybrid ramjet engine as described in claim 1, where the exhaust nozzle (15) has a variable geometry, between converging and diverging, including both converging and diverging together, in order to optimise the exhaust gas flow out of the engine, for a range of aircraft speeds and flight conditions.
9. A new hybrid ramjet engine described in claim 1 and with a variable exhaust nozzle geometry described in claim 8, which has a closable wall between the diffuser and combustion sections to transform the new ramjet engine into a non-air-breathing rocket engine.

10. A new hybrid ramjet engine as described in claim 1 in which the new ramjet engine can operate as a simple jet engine, or as a ramjet, or in transition between these two modes.
11. A new hybrid ramjet engine as described in claim 1, which is designed to allow an aircraft to take-off, climb, cruise, and land without a secondary engine or propulsion system.
12. A new hybrid ramjet engine as described in claim 1, with a diffuser stage as described in claims 2 and 3, where the electrical machines in the diffuser stage require a rechargeable electrical power source such as a battery system, and/or a super-capacitor system, and/or a non-rechargeable electrical power source such as a fuel cell system, or a combination of any two or all three such electrical power sources, thereby allowing an interchange of electrical energy between these devices or sources.
13. A new hybrid ramjet engine as described in claim 1 which is self starting, and there is no need for an additional engine or propellant for take-off and climb.
14. A new hybrid ramjet engine as described in claim 1, which has a speed range that is capable of both subsonic speed, e.g. in commercial flights, and supersonic cruising speeds, with the same engine design
15. A new hybrid ramjet engine as described in claim 1 which is able to recharge a battery bank, or another reversible electrical power source, at a suitable cruising speed and in aircraft deceleration.
16. A new hybrid ramjet engine as described in claim 1 which is able to provide a reverse thrust for deceleration after landing, by reversing the rotational direction of the impellers, thus pushing air out of the front of the engine.
17. A new hybrid ramjet engine as described in claim 1 which can produce thrust using the impellers alone to maintain flight, or to save fuel when the aircraft is moving slowly on the taxi-way on the ground, and when coming in to land.
18. A new hybrid ramjet engine as described in claim 1 where the fuel supplied to it can be burnt at the stoichiometric ratio for maximum fuel burn efficiency for commercial aircraft applications, because there is no turbine that could otherwise be heat damaged.

Figure 1

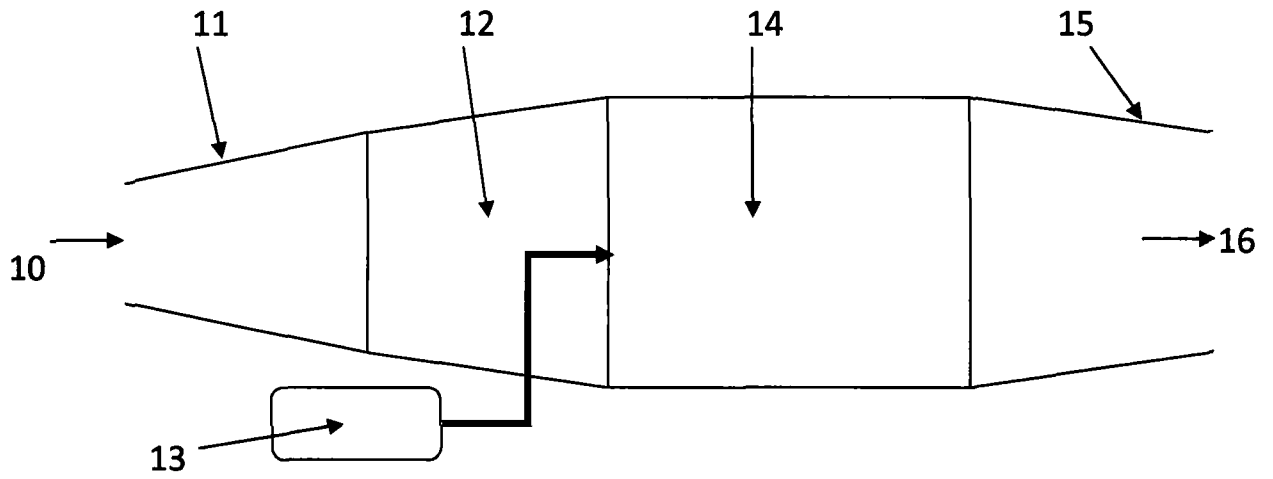


Figure 2

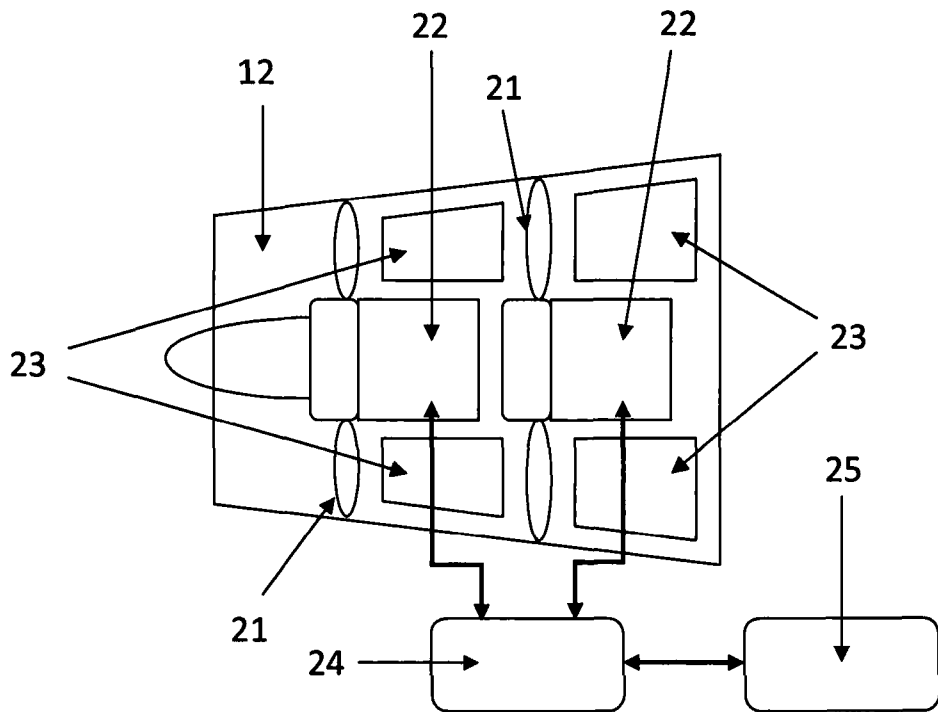
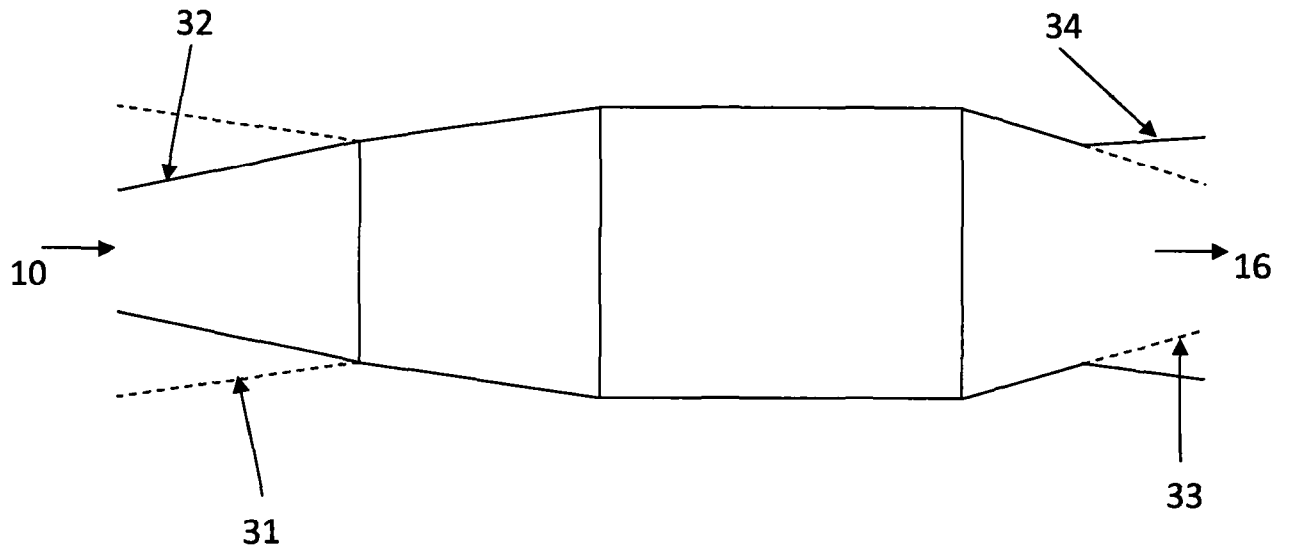


Figure 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2015/000148

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02K5/02 F02K7/10 F02K7/18
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
F02K B64D F02C
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 368 620 A (GILES JR HARRY L [US]) 18 January 1983 (1983-01-18) figures 3a-3d,4 column 2, line 48 - column 2, line 50 column 2, line 67 - column 3, line 2 -----	1,4,6,9, 10,15 2,3,5,7
X Y	GB 2 230 820 A (KERSHAW H A) 31 October 1990 (1990-10-31) figure 1 page 2, paragraph 7 -----	1,10,13, 14,16-18 2,3,5,7
X	US 3 719 428 A (DETTMERING W) 6 March 1973 (1973-03-06) abstract figures 1,2,5 column 2, line 63 - column 2, line 68 column 3, line 23 - column 3, line 32 column 3, line 54 - column 3, line 56 column 5, line 34 - column 5, line 43 -----	1,4,6,8, 10-18

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 18 September 2015	Date of mailing of the international search report 28/09/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Herbiet, J
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2015/000148

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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