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ДВИГАТЕЛИ ЗАРУБЕЖНЫХ САМОЛЕТОВ

Учебные задания по английскому языку

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Данные учебные задания предназначены для студентов 1-2-го курсов II факультета и содержат оригинальные тексты по теме "Авиационные двигатели" из журналов "Антеравиа" и "Спейсфлайт" 1990 г.

Цель - совершенствование навыков чтения и понимания прочитанного по вышеназванной тематике, а также контроль сформированности лексико-грамматических навыков (умений) студентов. Выполнены на кафедре иностранных языков.

Рецензент Е.М.Безрукова

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## ДВИГАТЕЛИ ЗАРУБЕЖНЫХ САМОЛЕТОВ

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## P A R T II

### UNIT 1

1. Просмотрите следующие слова, они помогут вам в работе над текстом "Gas Turbine Engine Rotor Dynamics":

advent - приход(появление), tend - стремиться(иметь тенденцию), appropriate - подходящий (соответствующий), roll - вращать(ся), intershaft - межвальный, approach - подход( к проблеме), involve - включать в себя(подразумевать), mention - упоминать, seal - уплотнитель(сальник), lubrication-смазка, incorporate - объединять (включать).

2. Прочтите текст, найдите и переведите предложения, в которых содержатся ответы на вопросы:

1. How are vibration amplitudes maintained?
2. What worsens further difficult bearing lubrication and cooling problems?
3. Why is it becoming difficult to achieve adequate control of the inner rotor dynamics?
4. What do alternate approaches to inner spool rotor dynamic problems result in?

### T e x t

#### Gas Turbine Rotor Dynamics .

1. With the advent of higher performance, more compact two-spool gas-turbine engines which employ higher rotational speeds and higher temperatures, adequate control of the dynamics of the inner rotor is becoming more difficult to achieve. This is because inner shafts supported on two bearings tend to have one more flexible critical speeds within the engine operating speed range.

2. This problem has been traditionally solved by either increasing the shaft diameter, adding bearings, or by utilizing an appropriate number of rolling - element intershaft bearings. By proper placement of these bearings, the flexibility of the inner shaft is controlled and vibration amplitudes are maintained.

3. Alternate approaches to inner spool rotor dynamic problems often involve changes in design speed and number of turbine or compressor stages. These approaches, however, result in increased engine size and weight, not to mention increased costs due to the additional bearing supports, seals, and lubrication.
4. As the speed of the inner shaft increases to achieve increasingly higher engine performance, dynamic control becomes more difficult. In the smaller two-shaft engines the limited inter-shaft space is making it more and more difficult to incorporate the necessary bearing lubrication and seal systems. Furthermore, the continuing increase in operating temperatures further worsens difficult bearing lubrication and cooling problems.

III. Закончите данное предложение, выбрав фразу, отображающую одну из мыслей текста:

If the continuing increase in operating temperatures were solved ...

1. ... it would mean new possibilities for gas turbine engine development.
2. ... there would be no difficult bearing lubrication and controlling problems.
3. ... the design would be balanced to get higher engine reliability and maintainability.

IV. Подберите английские эквиваленты:

- |  |                          |
|--|--------------------------|
| 1. характеристика                          | 1. inner shaft           |
| 2. скорость вращения (частота)             | 2. dynamic control       |
| 3. ступень компрессора                     | 3. placement             |
| 4. внутренний вал                          | 4. operating speed range |
| 5. динамическое регулирование              | 5. performance           |
| 6. расположение                            | 6. design speed          |
| 7. диапазоны рабочих режимов               | 7. rotational speed      |
| 8. расчётная скорость                      | 8. two-shaft gas turbine |
| 9. двухкаскадный газотурбинный (двигатель) | 9. compressor stage      |

V. Переведите текст "T700 Engine Dynamic Design" письменно со словарём (30 мин).

## T 700 Engine Dynamic Design

1. The following major requirements controlled the design of the T 700 engine from the point of view of engine dynamics: a) The number of bearings and frames necessary to support the rotors should be minimized to have a low cost, lightweight engine; b) The design should be balanced to achieve high engine reliability and maintainability, field replacement of modules, clearance control during maneuvers and heavy unbalance situations, high life requirement of bearings, high engine integrity under situations due to loss of blades, etc; c) Rotor criticals sensitive to unbalance in the low pressure or high pressure rotors should be outside the steady-state operating range with good margin.
2. The T700 gas generator has two bearings mounted on cages with squeeze films in parallel. The gas generator has three criticals below the idle of approximately 30.000 rpm. No rotor criticals exist in the operating range, which has a maximum speed of 44.700 rpm.
3. Since the gas generator and power shaft operate at supercritical speeds, they have excellent tolerance to unbalance.
4. The T700 engine has excellent dynamic characteristics, it serves to illustrate the squeeze film, soft-mounting concept of design. The T700 is a unique engine whose gas generator rotor is solely mounted on two squeeze film damped bearings. These design features were selected as a result of extensive analysis and rig and full-scale engine test. The T700 has excellent vibration characteristics with less than 5 g's acceleration on casings under normal operating conditions.

## UNIT 2

- I. Просмотрите следующие слова, они помогут Вам в работе над текстом "Propfan Now Moving to Full-Scale Development and Testing"

saving - экономия(зд.), propfan - тяговый вентилятор (двигателя),  
advances - улучшения, wind tunnel - аэродинамическая труба,

full-scale - натуральная величина; swept tip - стреловидная законцовка(лопастей); to hold promise - сдержать обещание; link - соединить; nacelle - гондола(двигателя); evaluate - оценивать; schedule - планировать; aft - в хвостовой части; introduce - внедрить (зд.) impact - влияние.

II. Какие слова образуют терминологические словосочетания:

- |                     |                |
|---------------------|----------------|
| a) fuselage-mounted | a) saving      |
| b) fuel             | b) testing     |
| c) acoustic         | c) tunnel      |
| d) wind             | d) consumption |
| e) full-scale       | e) tip         |
| f) fuel             | f) development |
| g) swept            | g) speed       |
| h) subsonic         | h) engine      |

#### Propfan Now Moving to Full-Scale Development and Testing

( Data provided by Lockheed-Georgia Company USA)

1. Great fuel savings are seen possible in the future through use of the so-called propfan, an advanced turboprop design. Based on the success of wind tunnel testing which had indicated savings in fuel consumption by as much as 30 per cent, a major follow-on contract has been awarded to the firm by the National Aeronautics and Space Administration to carry out full-scale development and ground test of the propfan system.

2. Propfan system tests were at speed up to Mach 0.8 and up to 35,000 feet (10,670 metres) in altitude.

3. The eight-blade propfan propeller has thin-profile blades with highly swept tips (2.74 metres in diameters). It holds the promise of linking propfan fuel-efficiency with subsonic jet speeds. The design has excellent acoustic characteristics. A new nacelle system has been designed and fabricated to house the Allison Model 501-M78 gas turbine engine. It is designed so that the propfan propulsion system can be mounted on the left wing.

4. The complete propfan system has first been evaluated in outdoor static tests. Then it was mounted on one wing of a

Gulfstream-11 which had undergone acoustic testing in the 12X24 metre low speed wind tunnel at NASA's Research Center in California.

5. For the flight-test phase now scheduled for mid-1990's, the propfan propulsion system will be mounted on the left wing of the Gulfstream-11. Its two aft fuselage-mounted engines will provide the main power during flight.

6. Some aerospace industry analyses have shown that up to 227 billion litres of fuels could be saved by the year 2000 if propfan can be introduced. Thus, successful propfan development will have a major impact on the Short-to-medium range aeroplane market.

III. Какое слово по значению выпадает из данной группы слов:

- a) advance; b) progress; c) success; d) profile.
- a) link; b) connect; c) combine; d) carry.
- a) altitude; b) speed; c) rate; d) velocity.
- a) propulsion; b) design; c) engine; d) power plant.
- a) examine; b) mount; c) test; d) try.

IV. Выберите правильный ответ в соответствии с содержанием текста:

- 1) The eight-blade propfan propeller has thick-profile blades with highly swept-back tips.  
a) It is right; b) It is wrong; c) It is not mentioned in the text.
- 2) Great fuel savings are seen possible in the future through use of the so-called propfan.  
a) It is right; b) It is wrong; c) It is not mentioned in the text.
- 3) The design has excellent combustion characteristics.  
a) It is right; b) It is wrong; c) It is not mentioned in the text.
- 4) Its two in-wing mounted engines will provide the main power during flight.  
a) It is right; b) It is wrong; c) It is not mentioned in the text.

5) A ramjet is a very simple, light weight engine for supersonic aeroplanes and missiles.

a) It is right; b) It is wrong; c) It is not mentioned in the text.

V. Переведите текст "Ramjet and Scramjet" письменно (в классе) за 25 мин. Смотрите примечания после текста.

### Ramjet and Scramjet<sup>1</sup>

(described by engineer Alan Bond, inventor of the revolutionary Hotol engine)

"A ramjet is a very simple, lightweight engine for supersonic aeroplanes and missiles. It consists of a specially shaped duct, which slows down the air which is entering. That causes<sup>2</sup> its energy to be turned into heat and high pressure. Fuel is burnt in the flowing air which is then reaccelerated by the shape of the rear of the duct. This hot air, having higher energy than the inlet air, travels much faster so it causes the thrust from the escaping<sup>3</sup> jet to be higher than the drag caused by slowing down the air.

When the aeroplane or missile is travelling above Mach 5, the fuel is burnt at supersonic speeds. Hence, Supersonic Combustion Ramjet, or Scramjet. Both Ramjet and Scramjet will operate only at high speed and need to be accelerated by some other type of engine. They may lead to aeroplanes that can fly straight into space or half way around the world in about one hour."

#### Notes:

- 1) scramjet - воздушно-реактивный двигатель со сверхзвуковым сгоранием топлива;
- 2) cause - служить причиной ч.-л.
- 3) escape - покидать, выходить из...

### UNIT 3

I. Просмотрите следующие слова, они помогут вам в работе над текстом "General Electric's Engines":

sale(s) - продажа; sell(sold) - продавать(торговать чем-л.);  
customer - покупатель; face competition - сталкиваться с конкуренцией;  
run - работать (о двигат); set rules - устанавливать,



(определять) правила ; fixed-pitch - неизменяемый шаг; emission - эмиссия (выброс газов) от двигателей; counter-rotating - обратного вращения; hole - окно (в облачности), воздушная яма, отверстие.

II. Отметьте, какие пары образуют синонимы:

- |                |             |
|----------------|-------------|
| a) operate     | a) revolve  |
| b) project     | b) show     |
| c) demonstrate | c) burner   |
| d) combustor   | d) decrease |
| e) reduce      | e) run      |
| f) rotate      | f) design   |

### T e x t

#### General Electric's Engines

1. In civil as in military engines, General Electric has grown greatly over the past two decades. The GE CF 6-80C is still the sales leader among engines for widebody aircraft. "GE could sell 200 big engines a year through 1994 without a single new customer", says Brian Rowe, senior vice-president of General Electric Aircraft Engines. GE has always faced competition in nearly all its markets and has usually sold to customers who operate other engines as airlines have always mixed engines in their fleets. GE engine reliability is essential and is being achieved. The first CF-6-80C has passed four years and 15,000hr in service and has never been removed from the aircraft. Of the 23 engines that are above 8,000hr, 21 have never been removed.
2. GE's last planned new engine was the GE36 Unducted Fan (UDF). The decision that faces GE now is whether to launch the biggest new commercial engine program ever, the GE90. The existing CF6-80C/E family can run to 75,000 lb. "Above 75,000lb," says Rowe, "we need an engine at least 10% better in specific fuel consumption." But GE has set some rules for the project. The Company doesn't want to push component efficiency, but to put in as much from the CF6-80C as possible that works well.
3. Without pushing component technology, the way to improved efficiency lies through cycle changes. The fan, which must logically be much bigger than that of any current engine, will be

fixed-pitch and directly driven. The compressor will be based on technology demonstrated under the NASA - sponsored Energy Efficient Engine (E3) program, and turbine temperatures will be 110-165K below levels that have been demonstrated on GE's military engines.

4. The GE90 will also have a new combustor design, another result of E3 work, which will reduce nitrogen-oxide emissions. The basic GE90 will have thrust potential to 90,000 - 92,000lb. "Beyond the year 2000," Rows says, "you could use a counter-rotating fan and get 100,000lb in the same hole". The engine will cost \$1,5 - 2 billion to develop. The management at GE Aircraft engines is in the happy position and has enough money to do this.

III. Укажите, какое из высказываний даёт правильный ответ на вопрос:

Why will General Electric be able to get 100,000lb of its engines beyond the year 2000?

- because G.E. has always faced competition in nearly all its markets.
- because the fan, which must logically be much bigger than that of any current engine, will be fixed-pitch.
- because G.E. will use a counter-rotating fan.
- because the management at GE Aircraft engines is in the happy position.

IV. Поставьте вопросы в правильной последовательности, соответствующей содержанию текста:

- How much will the GE90 cost?
- General Electric has grown greatly over the past two decades, hasn't it?
- What decision does G.E. face now?
- G.E. engine reliability is essential and is being achieved, isn't it?
- Where does the way to improved efficiency lie?
- What type of engines is still the sales leader among engines for widebody aircraft?

V. Переведите текст "Zoeche Diesel Engine Advances" устно (в классе). Смотрите примечания после текста.

## Zoche Diesel Engine Advances<sup>1</sup>

Munich-based Zoche's light aircraft diesel engines should be available<sup>2</sup> for flight testing in two years time, according to the company's founder Michael Zoche. The Zoche engines, which include the four-cylinder Zo O1A and the eight-cylinder ZO O2A, represent one of the most recent attempts to develop a new powerplant family for light fixed-wing aircraft. Interest has been expressed by many manufacturers, especially those of unmanned air vehicles.

The 220 kw Zoche engine will weigh less than equivalent turboprop engines while using less fuel.

Current reciprocating engines mostly offer modest power/weight ratios, are more complex to handle<sup>3</sup> than turbines, and use aviation gasoline fuel which is generally expensive<sup>4</sup>, and in some areas, difficult to obtain. Small turbines are expensive, fuel-thirsty<sup>5</sup> at idle settings<sup>6</sup>, and weighed down by the gearboxes<sup>7</sup> required to reduce their high shaft speeds to propeller speeds.

The Zoche engines incorporate the latest cylinder technology as well as such refinements<sup>8</sup> as tungsten<sup>9</sup> counterweights and full aerobatic pressure lubrication.<sup>10</sup> Recent improvements include a patented air starting system, using the rotor of the mechanical air at 30 bar to bring the engine to full speed in 0,6 seconds.

The reservoir can be refilled in flight from a piston pump driven by manifold<sup>11</sup> air. Low-pressure mechanical and high-pressure turbochargers<sup>12</sup> work in tandem, and the engine is flat-rated to 2,750 metres.

### Notes:

1. advance - прогресс, успех
2. available - имеющийся в распоряжении, доступный
3. handle - обращаться, управлять
4. expensive - дорогостоящий
5. to be fuel-thirsty - быть неэкономичным (двиг.) по расходу топлива (зд.)
6. idle setting - положение РУД "малый газ"
7. gearbox - редуктор, коробка передач
8. refinement - улучшение, доводка, усовершенствование

9. tungsten - вольфрам  
 10. lubrication - смазка  
 11. manifold - система трубопроводов  
 12. turbocharger - турбозарядный агрегат(устройство).

#### U N I T 4

I. Просмотрите следующие слова, они помогут вам в работе над текстом "Rolls-Royce Company":

airframe - корпус(каркас); option - выбор; exercise - осуществлять(применять), проявлять; triple - утраивать(ся);  
 retire - снимать с обслуживания (эд.); twin - двухмоторный самолёт; count - иметь значение; core - ядро(течения)эд.;  
 eventually - в итоге; соu - недоступный; recession - спад;  
 kn - узел,(мера скорости), (knot).

II. Подберите определения к существительным:

- |              |                |
|--------------|----------------|
| a) ratio     | a) strong      |
| b) emphasis  | b) real        |
| c) thrust    | c) bypass      |
| d) engine    | d) special     |
| e) recession | e) static      |
| f) position  | f) three-shaft |

III. Замените подчеркнутые слова противоположными по значению:

1. Firm orders are solid in the short term and will continue to be very strong for 2 to 3 years.
2. The big three-shaft engine will always be better than the two-shaft.
3. 400-450 seat twins at the top of the climb could well need the equivalent of 355 KN static.

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descend, worse, weak, stop, long, liquid.

#### Rolls-Royce Company

1. Rolls-Royce gives special emphasis to 1989's double achievement of getting a Rolls-Royce jet, the new Trent, launched on

both McDonnell Douglas and Airbus Industrie airframes for the first time.

2. Rolls-Royce has come a long hard way in 10 years or so, from offering engines covering only 20 % of the airframes available a decade ago to 70% today. Firm orders are solid in the short term and will not be a surprise if some options are not exercised after 1992-93

3. The airlines are expected to get nearly 8,400 new aircraft in the period up to 2003, although nearly a sixth of these are 150-seaters to be delivered before 1994, the large majority of which have already been ordered.

4. The replacement market, rather than that for expanded fleets, is expected to triple, compared with the past 15 years 2,500 aircraft are to be retired or re-engined. Total requirements up to 2003 are more likely to be in the region of 3,800 aircraft "It is the big twins that are driving the thrust requirements", says Robins, Deputy Chairman of Rolls-Royce. What counts these days is not static thrust but thrust at the top of the climb. 400-450-seat twins at the top of the climb could well need the equivalent of 355kN static, but we are still talking of bypass ratios of five or six to one", he says.

5. The Trent has already been sold on the A 330 at a thrust of 320kN and (with an increased-flow core and the fan diameter increased from some 246 cm to 254 cm) is being offered at 338 kN for the 767X. Rolls-Royce says the engine is capable of more than 355 kN eventually, even if it is staying coy about core modifications and fan diameters at this point.

6. What about thrusts beyond? "What for?" asks Robins. "I can't see what need arises. I can see nothing in the next decade that will require a start-again engine. The big three-shaft engine will always be better than the two-shaft. And the higher the thrust and pressure ratio go, the better the three shafts look. This is a very strong technical position. Nobody sees a real recession in the industry over the next 15 years".

IV. Прочтите текст, укажите номера абзацев, к которым данные предложения могут служить заголовками:

- A three-shaft engine is a strong technical position.
- Rolls-Royce orders continue to be strong.

- The replacement market tendency is to triple up to 2003.

V. Укажите вопрос, на который нельзя найти ответ в содержании текста:

1. Who sees a real recession in the industry over the next 15 years?
2. Where was the new Trent launched on for the first time?
3. Does Rolls-Royce regard the Trent as an evolutionary hybrid engine?
4. In what region are total requirements more likely to be up to 2003?
5. What bypass ratios does the firm expect to get?

VI. Сделайте грамматический анализ предложения 3 абзаца (инфинитив, инф. конструкция). Предложение переведите.

VII. Переведите письменно текст "R-R Plans Hybrid Engine" с помощью словаря.

#### R - R Plans Hybrid Engine

Rolls-Royce is proposing a new vectored-thrust engine to power advanced STOVL aircraft.

The company plans to combine the thrust-vectoring qualities of the Pegasus with the high specific thrust of an engine under development for the European Fighter Aircraft. The aim is to produce a supersonic aircraft capable of vertical landing, rather than a STOVL aircraft with Mach 1 capability.

Rolls-Royce regards the new engine as an evolutionary hybrid, combining the fundamental elements of the Pegasus with the advantages of a modern conventional fighter engine.

If the engine exit streams are mixed for STOVL operations, the resultant flow can be divided in any proportion to achieve aircraft balance. The choice of engine bypass ratio is therefore not critical to balance, as it is with Pegasus, although mixed exhaust temperature increases as bypass ratio is reduced. The company believes that mixed flow should be avoided in the front lift system if possible, and defends the use of low-temperature flow. An ejector could overcome this objection to mixed flow, but at the expense of increased volume, possible transition.

difficulties, and reduced flexibility.

The philosophy of "cold" front nozzles means that the engine is designed to be unmixed in the lift mode. Although thrust generated by the bypass flow of a mixed engine is low for satisfactory aircraft balance, an unmixed engine provides the flexibility to resolve this difficulty.

## UNIT 5

I. Просмотрите следующие слова, они помогут вам в работе над текстом "Pratt and Whitney's Engine Family":  
ride - участвовать в ч.-либо(зд); abrupt - резкий, внезапный;  
foreseeable - предстоящий; take for granted - принимать как должное (само собой разумеющееся); entertain - поддерживать (предложения) зд.; doubt - сомнение(ться); shroudless - без бандажного обода (о воздушном винте) зд.; rival - соперник(конкурент); prediction - предсказание (утверждение); emerge - появляться, возникать (неожиданно); gear(ed) - двигатель с редуктором; variable - pitch - изменяемый шаг; hollow - полый (пустотелый),

II. Прочтите текст, найдите и переведите предложения со следующими словосочетаниями:

- to concentrate on fuel burn
- to ride the boom in sales
- hollow-bladed shroudless fan
- to be forced into new modified engines
- a geared, variable-pitch engine
- to put an abrupt end to the situation

### Pratt and Whitney's Engine Family

1. Like other companies, P&W has been riding the boom in sales of commercial aircraft. Peter Chapman, executive vice-president of P&W's commercial engine business, doesn't see anything that will put an abrupt end to this situation in the foreseeable future. An example that Chapman says is Northwest's recent order for 40 firm 757s and 40 options. Once, such an order would have been taken for granted by P&W because Northwest already has

33 757s with P&W engines, but Northwest seriously entertained proposals from Airbus for A321s and from Rolls-Royce for RB211-535E4s.

2. Other areas of the business are changing. "We used to concentrate on fuel burn, but now reliability is much more important," says Chapman.

3. The 767X, now virtually an all-new aircraft, becomes reality. P&W believes that the existing PW4000 family will produce enough power for the new turn. "I have no doubt that Rolls-Royce, General Electric and Pratt & Whitney can build an 85,000lb engine, but we don't see a requirement for one," says Chapman.

4. So, the theory goes, a 75,000lb-thrust PW4000 family member, with a new 264cm shroudless fan but no fundamental changes to the core, can handle the new Boeing, but the smaller-cored Trent and CP6-80 cannot. The rivals are forced into new or radically modified engines.

5. P&W's prediction is that if much more than 75,000lb is required, the need will come later in the decade. Emerging as the company's answer is the Advanced Ducted Propeller (ADP), a geared variable-pitch engine with a BPR of more than 10:1, capable of delivering GE90 thrust from a PW 4000 hot section.

6. Physically identical PW4000 engines can deliver from 222kW to 289kW. The Step 2 growth version, intended for the A330, is designed to deliver 302kW. The Step 3 PW4000 incorporates Pratt & Whitney's first hollow-bladed shroudless fan.

III. Определите, соответствует ли следующее предложение содержанию текста:

Pratt and Whitney expects to deliver an auxiliary power unit (APU) to Boeing in 1990's.

IV. Выберите наиболее подходящий заголовок к абзацу I:

- The business areas are changing.
- Pratt and Whitney and the rivals.
- ADP is a geared, variable-pitch engine.
- P&W's family members.

V. Переведите текст "Auxiliary Power Unit Choice Widens Again" устно (на занятии) за 20-25 мин. Смотрите примечания после текста.



## Auxiliary Power Unit Choice<sup>1</sup> Widens Again

1. Pratt & Whitney has already opened the first front by introducing a competitive<sup>2</sup> auxiliary power unit (APU) for the Boeing in 1990's and see the first delivery of a new APS 2000-equipped 737 the following October, 1990.
2. The APS 2000 is an entirely<sup>3</sup> different approach from that offered by Garrett, placing an integral bleed system<sup>4</sup> up against the Garrett load compressor that has been flying on the 737 and MD-80. The firm decided to make the APS 2000 an integral system after surveying<sup>5</sup> the airlines and aircraft manufacturers, who said that was what they needed.
3. A bleed-in system offers lower weight and greater efficiency with only half the number of parts, "so it has fewer things to go wrong". A load compressor is slightly more efficient at higher loads, but at low loads the less expensive and more reliable integral system has the efficiency edge<sup>6</sup>. The single-rotor engine has a compression ratio of 4:1.
4. The APS 2000 also has a different structure to reduce maintenance problems. Both bearings<sup>7</sup> are located in front of the compressor, at the cold end, running at cooler temperatures with less oil break down and longer bearing life than APUs with one bearing in front and one in the middle, next to the turbine rotor.
5. There is no need in a de-oiling system<sup>8</sup> on the APS 2000. Lockheed laboratory began tests in June 1990. These tests indicated no de-oiling requirement.
6. The APS 2000 also offers in-place bore scope<sup>9</sup> inspections, fault<sup>10</sup> isolation and display, in-place access<sup>11</sup> to line-replaceable units, a two-stage fuel pump and full-authority<sup>12</sup> digital electronic control.

### Notes:

1. choice - выбор
2. competitive - соперничающий, конкурирующий
3. entirely - совершенно, вполне, целиком
4. bleed system - система отбора воздуха (от двигателя)
5. survey - наблюдение, обзор, контроль

6. edge - граница, край, конец
7. bearing - подшипник
8. de-oiling system - система обезмасливания (обезжиривания)
9. borescope - бороскоп
10. fault - ошибка, повреждение, отказ
11. access - доступ, подход
12. full-authority - эффективный, максимальный

## U N I T 6

I. Просмотрите следующие слова, они помогут вам в работе над текстом "P & W Plans for the 1990's" (Part I):

Derivative - модификация (вариант); refan - реventиляторный (двиг.); uprated - с повышенной тягой (мощностью); certificate - удостоверить (свидетельствовать) подтверждать commitment - обязательство (поддержка); thread - нить (связующая линия); retention - сохранение; durability - продолжительность работы (длительность) core mounted - расположенный на основном контуре (двиг) account for - объяснять (ч.-либо); shut-down - выключение, отсечка (двиг.); fairly - довольно; measure - измерять; retain - сохранять (удерживать); avoid - избегать; tip speed - окружная скорость; torque - крутящий момент; capacity - рабочий объём; cowling - капот; mismatch - рассогласование (несовпадение) eliminate - уничтожать; adjustable - регулируемый; ADP - усовершенствованный двигатель с винтом в кольцевом канале.

II. Отметьте, какие пары образуют антонимы:

- |             |             |
|-------------|-------------|
| a) cooling  | a) outside  |
| b) decrease | b) long     |
| c) low      | c) warming  |
| d) thick    | d) increase |
| e) short    | e) thin     |
| f) inside   | f) high     |

## P & W Plans for the 1990s

### Part I)

1. In the 1980s, Pratt & Whitney launched two-and-one-third new large commercial engines - the PW2000, PW4000 and V2500 - the only all-new programs in their class. Now, derivatives and refans should carry the company beyond the year 2000. Upgraded versions are available. The PW2041, rated at 194,5 kN, was offered to America and is being certificated. The company has made an internal commitment to the Pw2043, a 196,5 kN engine with a new fan, 4,2cm larger in diameter, which will be available in 1992. It will offer more thrust and open the way to a more powerful engine. The larger fan will fit inside the contours of the existing nacelle.

2. The connecting thread in PW2000 developments is that two parts of the engine do not change: the high-pressure spool, which is the most expensive part of the engine and drives performance retention and durability, and the coremounted accessories, which account for most inflight shut-downs. Reliability and durability ought to remain fairly stable.

3. The Step 1 engine is a higher-temperature version of the engine with improved materials and more cooling in the high-temperature turbine. It is mainly intended to provide more power for MD-11 growth versions without requiring physical changes to the inlet duct. Thrust could reach 289 kN.

4. The Step 2 engine is designed for the A330 and it is in the 302kN class and will be certificated by June 1992. The primary difference is a new 254 cm fan (the current fan measures 238cm). The fan pressure ratio is also increased, from 1.6:1 to 1,75:1, composite fan-exit guide vanes save weight.

5. To retain efficiency and to avoid a noise increase the fan tip speed is kept the same as in the other PW4000s, and this means that the rotational speed is reduced. One stage is added to each end of the low pressure spool to maintain its performance at the reduced speed. Because the speed is lower but the power is greater the torque required to drive the fan is substantially increased; the shaft wall is made thicker and, for the first time, cooling air is introduced into the hottest part

- of the shaft, increasing its torque capacity by 35%.
6. The Step 3 engine has the same low-pressure system and core as the PW 4168, running at the same core temperatures, but has a shroudless hollow titanium fan. Because of the removal of the shroud it has a higher airflow and P&W has now raised the diameter to 264cm. The first engine could be tested in the second quarter of 1991.
7. All the P&W engines have short separate - flow cowlings. If more power is required, P&W believes, the best solution is the Advanced Ducted Propeller (ADP). The ADP has a bypass ratio higher than 11:1, roughly twice as high as today's engines. Its low fan pressure ratio leads to nozzle area mismatches at different speeds, so the fan pitch (and hence airflow) must be adjustable. Providing the fan with a reverse position eliminates the thrust reverser and reduces the overall diameter and weight of the engine.

III. Закончите данные предложения, выбрав фразу, отображающую одну из мыслей текста.

If the fan were provided with a reverse position...

1. ... it would change the jetflow with the axial centreline of the engine.
2. ... the gearbox could be much smaller than one might expect.
3. ... it would reduce the overall diameter and weight of the engine.

IV. Выберите правильный ответ на следующие вопросы, ответ переведите на русский язык:

- a) What parameters of PW 2000 ought to remain fairly stable?
  - b) What cowlings have all the P&W engines?
  - c) How is the engine torque capacity increased?
  - d) When could the first engine with 264cm diameter be tested?
  - e) Why is one stage added to each end of the low pressure spool of PW 4000?
- a) The fan pressure ratio and diameter ought to remain fairly stable.
- Reliability and durability ought to remain fairly stable.

The fan pitch and the weight of PW 2000 ought to remain fairly stable.

- b) All the P&W engines have the same cowlings.  
All the P&W engines have uprated cowlings.  
All the P&W engines have short separate-flow cowlings.
- c) It is increased by cooling air introduction into the hot-test part of the shaft.  
It is increased by the raised diameter of the engine.  
It is increased by physical changes in the inlet duct.
- d) Such engine could be tested in the 1990s.  
Such engine could be tested in the second quarter in 1991.  
The first engine with 264 cm diameter could be tested in June 1992.
- e) One stage is added to PW 4000 each end of the low pressure spool to have a bypass ratio higher than 11:1.  
... to open the way to a more powerful engine.  
... to maintain its performance at the reduced speed.

V. Переведите текст "Boeing Tests Improved RB,211" письменно со словарём.

#### Boeing Tests Improved RB,211

Boeing begins performance tests of an improved version of the RB.211-524 G. The engine has several improvements aimed at producing a better specific fuel consumption and consequent payload/range benefits.

Revised nacelle aerodynamics, reduced blade-tip clearances, and improved annulus and high-pressure (HP) turbine sealing have been achieved in "Package One"(P1) improvements aimed at reducing s.f.c. by 1 to 1.6 per cent. A further improvement aimed at a further 2 per cent saving, is embodied in "Package Two"(P2) which includes an improved efficiency fan and intermediate-pressure compressor, coupled with a high-efficiency HP compressor and full electronic control of bleed valves and variable-geometry guide vanes.

The major element of the Package Two improvements is a re-profiled spinner, which offers "substantial reductions in turbine gas temperature"(TGT). The spinner, which is supported by a newly designed make-up piece, changes the profile into the fan, giving extra efficiency.

The company has also changed the final exit angle of the nozzle, to re-align the jetflow with the axial centreline of the engine R-R expects RB - 524G flight time to top 0,5 million hours. Flight-testing of the engine has been completed after 166 flights.

## U N I T 7

I. Просмотрите следующие слова, они помогут вам в работе над текстом "P&W Plans for the 1990s" (Part II):

rev/min(revolutions per minute) - оборотов в мин.; versus-против(относительно); gearbox - редуктор (коробка передач); invention - изобретение; modest - умеренный; planetary - планетарный; impact - удар (столкновение); cost - стоимость (цена); rig test - испытание на стенде; root - комель (корневая часть) лопасти; twisted - закрученный (о лопасти); feed - питать(подавать); computer-aided - автоматически (с помощью вычислительной машины); tremendous - огромный; couple - пара (два).

II. Какое из предложенных слов имеет значение:

- a) конструкция - 1)designer;2)design; 3)designed; 4)designful;
- b) таким образом- 1)thus; 2)therefore; 3)thereby; 4)thereafter;
- c) отделение(фирмы) - 1)divide; 2)divider; 3)divided; 4) division.

### P & W Plans for the 1990s

#### ( Part II)

1. The Advanced Ducted Propeller (ADP) has a lower tip speed than a conventional fan, to maintain efficiency at its low pressure ratio, and it is also larger, so the rotational speed is less than half as great: in the region of 1,500 rev/min versus 3,200 rev/min for current engines. At this point, direct drive from low-pressure turbine begins to be impractical. Because the low-pressure spool is turning slowly, more stages must be added at both ends to maintain performance; at the same time,

the torque load on the shaft increases. In the ADP, the low-pressure spool runs faster than it does in current engines (in the 4,500-5,000 rev/min range) and the fan is driven by a gearbox with a ratio between 3:1 and 4:1.

2. The ADP, says P&W, is not as difficult, as complex or as risky as it looks, and it requires no new materials or new inventions. On a large engine, the gearbox may be rated at about 45,000kw. But the ratio is modest and naturally suited to a single-stage planetary gearbox. The gearbox is free from accessory drives and the engine is designed so that flight loads are not carried into the transmission. Design studies carried out by P&W (in association with gearbox experts at sister divisions Sikorsky and P&W Canada, and at partner Fiat) show that the ADP gearbox could be much smaller than one might expect.

3. The ADP's tip speed, and hence the impact energy of birds, ice or rain, is mid-way between propeller and turbofan levels. The blades might, therefore, be made of composites. The higher bypass ratio improves efficiency and reduces noise; the low-pressure compressor and turbine are simpler and lighter; and because the engine is more efficient it can use a smaller high-pressure spool.

4. In manufacturing, the cost of the extra moving parts is at least partly balanced by fewer stages and parts in the low-pressure spool and core. Some demonstration work on the ADP has already been carried out. A rig test has shown that the reversing principle works. With the fan in the reverse position, the roots of the twisted blades form a solid wall. This blocks part of the reversed airflow, which can then feed the core inlet.

5. Gearbox technology is being explored. Computer-aided design is a tremendous help in gearbox engineering. In the next couple of years, P&W is likely to demonstrate the ADP at almost full scale, possibly on a PW 2000 core. Thus, these cores could meet the need of any likely commercial aircraft for some years into the next century.

III. Из данных для выбора слов укажите то, которое лучше и полнее закончит предложение, предложение переведите:

1. Because the low-pressure spool is ... slowly, more stages

must be added to maintain performance.

- a) requiring                      c) transmitting
- b) revolving                        d) studying

2. The higher bypass ratio improves ... and reduces noise.

a) flight; b) gearbox; c) efficiency; d) technology.

3. With the fan in the reverse position, the roots of the twisted blades ... a solid wall.

a) design; b) add; c) suit; d) form.

IV. Укажите номер абзаца, в котором находится предложение с субъектным инфинитивным оборотом, предложение переведите.

V. Определите, есть ли в тексте ответы на следующие вопросы:

1). How does the low-pressure spool run in the ADP?

2). Does the ADP require new materials or inventions?

3). The ADP turbine fan system comprises a heat exchanger, doesn't it?

4). What technology is being explored nowadays?

5). The ADP gearbox is free from accessory drives, isn't it?

6). What bypass ratio has the ADP?

VI. Переведите текст "Cooling Systems" устно. Смотрите примечания после текста.

### Cooling Systems

1. With progress from piston to turbine engines there is usually sufficient air available<sup>1</sup> from the engine at a high enough pressure not only to pressurize the cabin but to provide the energy for cooling.

2. The turbine fan system comprises a heat exchanger which provides the initial cooling of the air from the engine compressor. The air passes from the heat exchanger to the air turbine, and the refrigeration is provided by making the turbine drive a fan or ejector-pump<sup>2</sup> compressor, either of which can be made to boost<sup>3</sup> the flow of coolant ram<sup>4</sup> air through the heat exchanger.

3. Owing<sup>5</sup> to the fear of air contamination<sup>6</sup> by oil, etc., it is possible to use a cabin compressor which takes the air from the wing leading edge, and passes it through a centrifugal compressor and into the cabin. The engine-compressor bleed<sup>7</sup> method



of cabin pressurization and the turbine fan cold air unit are the lightest and simplest ways of cabin pressurization and cooling.

4. The boot -strap<sup>8</sup> and jet-pump cold air unit are suitable for aircraft operating up to Mach 1, but with the speeds which are being considered today it is obvious<sup>9</sup> that heat exchangers will cause considerable<sup>10</sup> drag if they are to be ram-cooled. At altitudes above 25,000ft there is not much air available for cooling in any case. These factors have led to the development of the regenerative systems which can employ either fan or bootstrap types of unit.

5. In the regenerative system, cabin air is led from the engine compressor, passes through an air-to-air heat exchanger, and then goes through the turbine of the particular<sup>11</sup> type of cold-air unit chosen before finally entering the aircraft cabin.

#### Notes:

- 1) available - пригодный, доступный, используемый
- 2) ejector - компрессор со струйным насосом
- 3) boost - увеличивать, повышать
- 4) ram(air) - воздух, сжатый за счёт скоростного напора
- 5) owing to - благодаря, вследствие
- 6) contamination - загрязнение, заражение
- 7) bleed - отбор (давления); отвод, слив, перепуск
- 8) boot-strap(unit)- узел(двиг.) с нарастанием тяги после пере-  
хода на турбонасосную подачу топлива;
- 9) obvious - очевидный, ясный
- 10) considerable - значительный
- 11) particular - особый

#### UNIT 8

I. Просмотрите следующие слова, они помогут вам в работе над текстом "FiatAvio Takes a New Turn":

licence - лицензия; share - доля, пай, акция; be responsible for - быть ответственным за ...; involve - включать в ...;

pursue - проводить (программу зд.); SHP - мощность на валу (в лощ. силах); update - модернизированный (зд.); concerning - относительно; exclude - исключать; fortunate - удачливый, счастливый; content - довольствоваться (удовлетворять); minor - меньший (младший).

II. Сгруппируйте следующие слова по частям речи: I - существительные; 2 - прилагательные; 3 - наречия; 4 - глаголы:

a) definitely; b) afterburner; c) accessory; d) continue; e) development; f) industrial; g) want; h) already; i) consortium; j) privately; k) commercial.

III. Отметьте, какие пары образуют синонимы:

- |                  |                |
|------------------|----------------|
| a) use           | a) require     |
| b) account for   | b) aim         |
| c) involve       | c) utilize     |
| d) collaboration | d) explain     |
| e) goal          | e) cooperation |
| f) need          | f) include     |

#### FiatAvio Takes a New Turn

1. FiatAvio is definitely moving towards civil engines in 1990's. At present, governmental engine orders account for some 60% of sales, civil engines represent 30% and industrial gas turbines used for electrical power generation have the remaining 10%.

2. FiatAvio continues to build components under licence from Rolls -Royce. It has a similar agreement with General Electric. In Eurojet, the consortium building the EJ200 for the European Fighter Aircraft (EFA), in which Italy has a 21% share, FiatAvio is responsible for design and construction of the low-pressure turbine and shaft, afterburner and accessory gearbox of this engine.

3. As regards commercial engines, FiatAvio has a long history of collaboration with General Electric and Pratt & Whitney. FiatAvio's 5% share in the General Electric CF-80C involves manufacture of the accessory gearbox and low-pressure turbine nozzles and discs. Its respective 4% and 2% shares in Pratt & Whitney's PW2037/40 and PW4000 engines again include the accessory gearbox.

4. FiatAvio also has a 6% share in the International Aero Engines (IAE) V 2500 program, which in its initial versions involves design, development and production of the accessory gearbox and exhaust cone. FiatAvio is also involved in the Light Helicopter Turbine Engine Company T800 program being pursued by Allison and Garrett.

5. A speciality of FiatAvio has long been helicopter gearboxes. The Company is now designing and will build a new 13,000SHP transmission for the CH-53 Super Stallion update program, under subcontract to Sikorsky.

6. FiatAvio's goal over the coming years is to increase its participation in the high-technology part of programs concerning new civil engines. It is now time to become more involved in small engines, while FiatAvio doesn't exclude development of the IAE V2500 family.

7. FiatAvio sees a need for a modern turbofan in the 10,000lb - thrust class to power the new range of 50-passenger regional jets. This type has a bright future and FiatAvio wants to be part of it.

8. FiatAvio is already fortunate to belong to a financially strong and privately held group well used to the industrial decision-making process. Until now, the company has been content to be a relatively minor player in world engine business, but it looks as if it is ready to fight for a bigger share.

IV. Выберите наиболее подходящий заголовок к абзацу 8:

- a) FiatAvio's components under Rolls-Royce licence.
- b) FiatAvio's helicopter gearboxes.
- c) FiatAvio - a minor player in world engine business.
- d) FiatAvio is in need of a modern turbofan class.

V. Укажите, какие из следующих утверждений соответствуют содержанию текста:

- 1. a) FiatAvio's task over the coming years is to design a new 13,000SHP transmission for the CH-53 Super Stallion update program.
- b) FiatAvio's goal over the coming years is to move towards civil engines in 1990's.

c) FiatAvio's purpose over the coming years is to increase its participation in the high-technology part of programs concerning new civil engines.

- 2). a) A speciality of FiatAvio has long been components under licence from General Electric.
- b) A speciality of FiatAvio has long been low-pressure turbine nozzles and discs.
- c) A speciality of FiatAvio has long been helicopter gearboxes.

VI. Назовите номер абзаца, в котором вы найдёте ответы на вопросы:

1. По лицензии какой фирмы ФиатаВиво продолжает разрабатывать компоненты двигателей?
2. В каком направлении будет работать фирма ФиатаВиво в 90-е годы?
3. За каким самолётом фирмы ФиатаВиво будущее?
4. В содружестве с какой фирмой ФиатаВиво разрабатывает вспомогательный редуктор и выключное сопло?

VII. Переведите письменно текст "BAe 1000 Business Airliner" с помощью словаря(контрольный перевод).

#### BAe 1000 Business Airliner

1. The British Aerospace 125 business jet has had a long and, in many ways, remarkable career. The first Series 1 machine, fitted with Rolls-Royce turbojets, had a maximum weight of 20,000lb and a range of 1,110n.m. The eleventh production version (including the three major turbofan-retrofit versions of earlier series) is the 800-fitted with Garrett TFE 731 turbofans, weighing in at a maximum 27,300 lb and with a range under the same conditions of 3,000n.m. BAe wanted the new aeroplane in service no later than 1991. The Series 800 was approaching six years of age, and other products such as the Dassault Falcon 2000 were looming.

2. An alternative might have seemed to be the General Electric Garrett GE738, but that engine was growing even as it was designed, and turned out to be too big for the 125. P & W Canada produced the PW305 turbofan, a modern, fuel-efficient engine using derivative, rather than breakthrough, technology.
3. The PW305 in this first production application is a 4,5:1 bypass ratio two-shaft turbofan with a four-stage axial, single-stage HP turbine, and a three-stage LP turbine. The core has a pressure ratio of 15:1, and the first two compressor stages have variable guide vanes. It develops 5,200lb static thrust at sea level and has a claimed specific fuel consumption of 0.675lb st/h at 40,000ft at Mach 0.8. That should give the 1000 fuel burn of just 1,165 lb/h.
4. The engines will be fitted with thrust reversers as standard reverse thrust is an option on the 800. The 1000 will fly initially without the thrust reversers, but with dummy cowls. The new engine is considerably heavier than the Garrett. The extra weight, and different pick-up points, demanded a completely different pylon design, although the fuselage structure to which the pylon is attached is largely unchanged. The engines are installed with 2° of toe-out, and the thrust reversers are tilted at 10° above the horizontal.

## U N I T 9

I. Просмотрите следующие слова, они помогут вам в работе над текстом "New Aircraft, New Engine":

combat - боевой; attempt - пытаться (пробовать); be under way - вести работу (зд.); facilities - оборудование; set up - построено (зд.); integrity - целостность; impose - налагать (прикладывать); airfoil shape - аэродинамический профиль (конфигурация); flat-rated - плоский (по расчёту); drop - падать; ambient - окружающий; sustain - поддерживать (выдерживать); vortex - вихрь; multi-mission capability - возможность совершения многих полётов; silicon carbide - карбид кремния; carbon - углерод.

II. Какие слова образуют терминологические словосочетания:

a) combat

a) technology

b) full-scale	b)temperature
c) supersonic	c)ratio -
d) test	d)acceleration
e)transonic	e)velocity
f) bypass	f)facilities
g) ambient	g)development
h) advanced	h) aircraft

### New Aircraft, New Engine

1. The one thing more difficult than designing an advanced new combat aircraft, is to design an equally advanced, new engine for it. But this is what India is attempting to do.
2. Work on various versions of the GTX engine - the GTX - 37 turbojet, GTX-37 UB turbofan - have been way now for over five years. The design stage of the GTX-35 VS is over, and it is in full-scale development.
3. Extensive test facilities have been set up, including a 6,000KW multi-stage compressor test facility and various air supply facilities, as well as a high mass-flow, high-pressure unit. There are also numerous component test facilities. A ferris wheel facility was set to test the integrity of the engine compressor disc, in which blade centrifugal loads are imposed on the disc while keeping it stationary under test.
4. The GTX-35 VS has three-stage LP(low pressure) compressor with a fan pressure ratio of 3.22:1 and five-stage wide-chord high-flow transonic HP (high pressure) compressor with variable stators, a pressure ratio of 6.5:1 and efficiency of 0.85. Overall pressure ratio is thus 21:1. Furthermore new airfoil shapes have helped to improve blade tip efficiency at supersonic air velocities relative to the rotor.
5. The single-stage HP turbine is heavily loaded, with an imp-ressive turbine loading factor of 1.90 and an efficiency of 0.85.
6. A mixed-flow, fully-modulated low-bypass ratio augmented-type afterburner has been selected for the GTX-35VS. It will have a fully-variable exhaust nozzle, even in the dry mode.
7. Designed to operate under +30°C conditions, the engine is flat-rated to restore the performance, which drops at such high ambient temperatures, by varying the maximum cycle temperature.

its high pressure ratio and low bypass ratio lead to high re-  
cent thrust and moderate low dry specific fuel consumption.  
These will help to meet such performance requirements as high  
specific excess power, sustained turn rate and transonic accele-  
ration at altitude.

8. A further 20% thrust increase has also been built into the  
design of the GTX-35VS. Among the changes required would be a  
new combustor with vortex-controlled diffuser and advanced  
cooling.

9. The GTX-35VS is expected to be the first of a family of new  
advanced-technology engines. There could also be further devel-  
opments of the basic GTX-35VS. These engines would have very  
high thrust/weight ratios, and high specific thrust, giving their  
aircraft multi-mission capability. Exotic, very-high-tempera-  
ture materials like silicon carbide and carbon composites are  
likely to be used.

III. Найдите и переведите предложения, в которых содержатся  
ответы на вопросы:

1. What is India trying to do in the sphere of engine designing?
2. What has helped the GTX-35 VS to improve blade tip efficiency  
at supersonic velocities?
3. For what purpose was a ferris wheel facility set up?
4. Is the GTX-35 VS expected to be the first of a family of new  
advanced-technology engines?
5. The GTX-35 VS will have a fully-variable exhausted nozzle,  
won't it?

IV. Выберите правильный ответ в соответствии с содержанием  
текста:

- 1) Further developments of the basic GTX-35 VS would have very  
low thrust/weight ratios.
- 2) The design stage of the GTX-35 VS is over, and it is in full-  
scale development.
- 3) The GTX-35 VS has a two-stage LP compressor with a fan pressure  
ratio of 2.21:1.
- 4) The GTX-35 VS is rated to produce a minimum 768 lb thrust  
carbon at 2101°F turbine inlet temperature.

5) The GTX-35 VS meets such performance requirements as high specific excess power, sustained turn rate and transonic acceleration at altitude.

a) it is right; b) it is wrong; c) it is not mentioned in the text.

V. Переведите письменно текст "The F109" с помощью словаря (контрольный перевод).

#### The F109 (Garret Turbine Engine/Allison)

1. The F109 engine design for a jet trainer has a sea level thrust of 1330 lb, specific weight of 426 lb, and an SFC (specific fuel consumption) of 0.392 at 1976°F turbine inlet temperature. It has an emergency rating so that if the plane loses one engine on takeoff it can still climb out on a hot day from a 5000-ft altitude airfield. Under those conditions, the engine is rated to produce a minimum 768 lb thrust with an SFC of 0.543 at 2101°F turbine inlet temperature.

2. It's a twin spool engine design with a counter-rotating shaft system. The outer shaft, to which a turbofan is attached, powers a 2-stage low pressure turbine. The inner high-pressure core consists of a 2-stage centrifugal compressor, annular reverse flow combustor, and 2-stage high-pressure turbine. Both the stator and 1st stage turbine blades are air cooled: air comes up through the fir tree, into internal passages, and then after passing through the blades is discharged from the blade tips into the engine flow.

3. Overall, the F109 engine is 44in. long, 22in. wide (at the front) and 28in. high. The LP (low pressure) shaft turns at 16,000 rp.m. and the HP (high pressure) shaft at 45,000 rpm. According to the project, it represents a considerable advance (in performance) over the engines used in the current T-37 jet trainer - with 30% lower SFC and an estimated 4.25 man - hrs per flight hour maintenance level versus 6.5 man - hrs for the present engine.

4. The design life goal for cold section components is 18,000h and for hot section components 9,000hr. Once the engines go into operational service, the program calls for every tenth aircraft to have a recorder to monitor the system and see if the engine is operating as it's supposed to.