Содержание

ПРЕДИСЛОВИЕ

По тематическому признаку пособие разделено на две главные части – “General Aviation” и “Computer Science”. Все сведения, излагаемые в пособии, соответствуют главным направлениям специализации МГТУ ГА. Следуя тематическому принципу, пособие разделено на отдельные топики для письменного и устного общения по специальности. Учебный текст топика вводится преподавателем в виде лекции, которая содержит комментарии его содержания с целью соблюдения точности перевода на русский язык. По завершении ввода, учебный материал активируется в вопросно-ответной форме.

Более высоким уровнем активации материала являются выступления студентов с сообщениями и докладами на английском языке.

Завершающим этапом может стать участие студентов в мини спектаклях, сценарии которых разрабатываются на дидактической основе “Aviation Talk”.

Работа с учебными материалами этого уровня ориентирована на развитие у студентов творческого инженерного мышления, умения дискутировать на научно-технические темы, извлекая необходимую перспективную информацию.

Учебный мини спектакль может проводиться в форме научно-практического семинара, учебного симпозиума или конференции, заседания комиссии по расследованию причин летного происшествия или катастрофы.

Дидактическая эффективность учебного занятия повышается с успешным использованием материалов “Aviation Talk” при работе в паре, где роль инструктора исполняет наиболее подготовленный студент.

Вводные разделы курса постановки произношения являются наиболее ответственными, часто требующими корректирующих занятий для отстающих студентов. Поэтому при использовании всех возможностей современных технических средств обеспечения учебного процесса, они могут служить лишь помощниками преподавателя, расширяющими его дидактические возможности и повышающими эффективность его труда.

INTRODUCTION:
PRACTICAL APPLICATIONS OF NEWTON'S THIRD LAW OF MOTION

Nature of a Force

The word force is a general term for any push or pull. A force is always exerted on a body by another body, or on a part of a body by another part.

The gravitational force exerted on a body by the earth acts toward the earth's center. It is a concentrated force acting at a point called the center of gravity of the body.

The gravitational attraction or earth pull on a body is commonly called the weight of the body.

Composition and Resolution of a Forces

A force is an action exerted by one body on another that tends to change the state of motion of the body acted upon. To specify a force, it is necessary to know its direction, magnitude, and sense. Hence, forces are vector quantities. They must be added, subtracted, multiplied, and divided vectorially. The ordinary arithmetical rules of addition, subtraction, multiplication, and division, which are valid for scalar quantities, cannot be used except in special cases. Forces like other vector quantities can be represented by straight lines. The direction of the line represents the direction in which the force acts. And the head of an arrow on the line shows whether the force acts up or down, to the right or to the left, east or west, etc.

Motion

The commonest phenomena which we observe are those involving the movement of subject from one point to another. Walking, riding, flying, dancing, climbing and sailing are all familiar examples of motion.

Motion is the continuous change in position of an object or a particle. The line along which a moving particle travels is called the path of the particle or the path of the motion. If the path is a straight line the motion is *rectilinear*; if it is a curved line the motion is *curvilinear*.

Plane Motion

Plane motion is motion in which each point of the moving body remains at a constant distance from a fixed plane. Each point of the body moves in a plane, and that plane in which the center of gravity of the body moves is called the plane of the motion. A translation may or may not be a plane motion; a rotation about a fixed axis is always a plane motion.

Newton's Laws of Motion

Thus far we have studied the laws of motion, without asking, "What is it that causes a body to move?" We know that a force is needed in order to change the motion of a body, that is, in order to accelerate it or decelerate it, or to change its direction. In the absence of a force, a body will either remain at rest, or continue to move with constant speed in a straight line. These conclusions are summed up in three statements known as laws of motion.

The first law

The statement of the first law of motion is as follows:

A body at rest remains at rest and a body in motion remains in motion at a constant speed in a straight line, unless acted upon by an external force.

Thus the first law involves the idea of motion and the idea of force. It explains what is to be understood by force: it is that which tends to change the state of rest of a body, or of uniform motion in a straight line.

The second law

The second law deals with the change in motion of a body when force is applied to it. This law is stated as follows:

Rate of change of motion of a body is proportional to the applied force and is in the direction in which the force acts.

The expression *change of motion* requires explanation. By motion is here meant quantity of motion or momentum. It is defined as the product of the velocity and a quantity called the mass of the body.

The Third Law

The third law of motion may be stated as follows.

To every action there is always an equal and opposite reaction. It is matter of common observation that a body A cannot exert force on a second body B without B at the same time exerting force on A. Thus all forces occur in pairs, which may conveniently be spoken of as action and reaction. The third law of motion tells us that the two forces which constitute such a pair are equal in magnitude and opposite in direction.

For example, when we stretch a rubber band, holding one and in each hand, you must pull as hard with your left hand as you do with your right hand.

Practical applications of Newton's Laws of Motion Forces opposite in direction

There are four main forces exerted on an aircraft: they are lift and gravitational force, which exert along its vertical axis.

Next pair of forces is thrust and frontal drag which exert along longitudinal axis.

Lift (the sum of all upward forces or supporting force of the air) is developed by wings of the airplane.

The gravitational force or the weight of the airplane (the sum of downward acting forces) acts at the center of gravity of the airplane. Lift and gravitation forces are always opposite in direction. When they are equal in magnitude the aircraft doesn't climb or dive, altitude doesn't change. Such kind of airplane's motion may be called plane motion because the altitude doesn't change.

Thrust (the sum of all forward forces) or propulsive force is a force making the airplane move forward. To remain in level unaccelerated flight, a thrust must be equal and opposite in direction to the aircraft drag. The propulsion force is obtained by the displacement of the air flowing through the get engine in a direction opposite to that in which the airplane is propelled. This is an application of Newton's Third Law of motion.

Drag and **weight** are forces inherent in anything lifted from the earth and moved through the air. **Thrust** and **lift** are artificially created forces used to overcome the forces of nature and enable an airplane to fly.
The engines combination is designed to produce thrust to overcome drag. The wing is designed to produce lift to overcome the weight (gravity).

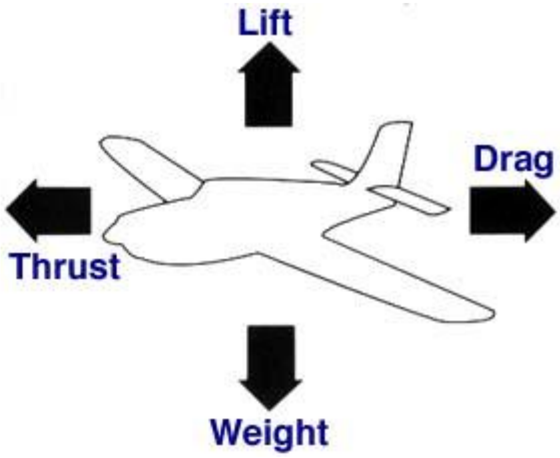


Fig.1 Relationship of forces in flight

VTOL

At present much attention is paid to the development of vertical and short take-off and landing airplanes (VTOL) through their ability to fly fast as well to take-off and land vertically. The possibility to land on any surface and to take off vertically is very important for civil aviation aircraft and for military airplanes. In airplane “rise and landing” vertical have at all eliminated both-start and run. Landing demands from the pilot of jeweler work: it is necessary smoothly increase an angle of attack of the wing to pass the plane from horizontal in vertical position to be hooked by a hook for a cable, to bring the machine to a stage and to join with it.

On hovering the pilot manipulate gas rudders. It’s important to understand the general laws of “trailing” flight, landing in the view of influence of the ground, the management without any aerodynamic rudders. For these purposes in our country is constructed flying stand “turbo fly”, flying TRD with a cabin mounted on it, the chassis and wisely located cross-bars of gas rudders.

As the range of flight on such plane is limited, the engines for vertically flying up are with small length of start of the plane, should chosen TVRD (turbofan engines) with easy elevating engines.

The part of a jet is allocated from the engine and thrown out vertically downwards. Depending on capacity of the allocated stream the airplane will start vertically or runs before taking off about 90 meters.

Part 1
GENERAL AVIATION
Topic 1
Why Airplanes Fly

Airplanes are power-driven, heavier-than-air craft, which drive their lift i.e. a support in the air from the dynamic reaction of the air flow over a system of fixed surfaces or wings. Wings develop lift when they move through the air with sufficiently high speed. According Bernoulli's Principle, wings and tail surfaces (the airfoils) are designed to increase the velocity of the air-flow above their surface, thereby decreasing pressure above the airfoil and increasing lift.

Simultaneously, the impact of the air on the lower surface of the airfoil increases the pressure below (i.e. lift)

This high speed of the air is imparted to airplane by its power plant. The power plan consists of one or several jet engines. The jet engines develop thrust.

The amount of lift can be calculated as the difference of air pressures below the wing and above the wing. This difference depends on air speed of the airplane and on the angle of attack of the wing. Generally the higher is the air speed of the airplane the higher is the developed lift.

The amount of thrust can be calculated as the product of the mass of air flowing through the jet engine by its acceleration. As a rule, thrust is created whenever there are divergent passages which convert velocity, or kinetic energy, into pressure energy.

Comprehensive Text-Related Glossary

why [waɪ] - почему
airplane ['ɛəpleɪn] – самолет; aircraft ['ɛəkrɑ:ft] – летательный аппарат вообще
to fly; flew; flown [flaɪ; flu; floun] - летать
heavier than ['hevɪə] – тяжелее чем
to fall; fell; fallen [fɔ:l; fel; fɔ:lən] - падать
to support [sə'pɔ:t] - поддерживать
supporting force [fɔ:s] – поддерживающая сила
lift [lɪft] – подъемная сила (напр. крыла)
to develop [dɪ'veləp] – развивать (напр. подъемную силу)
wing [wɪŋ] – крыло, аэродинамическая поверхность
sufficiently [sə'fɪʃəntlɪ] – достаточно
speed [spi:d] – скалярная (не имеющая направления) скорость; **velocity** [vɪ'lɔsɪtɪ] – векторная скорость изменения (параметра)
to impart [ɪm'pɑ:t] – сообщать, передавать (усилие)
power plant; also: **power plant** ['pauəplɑ:nt] – силовая установка (состоящая из нескольких реактивных двигателей)
several ['sevrəl] - несколько
thrust [θrʌst] – тяга двигателя (в Ньютонах или тоннах)

air speed [ɛə spi:d] – воздушная скорость самолета**; ground speed** [graund] – путевая скорость самолета; **indicated air speed** – приборная скорость самолета
angle of attack of the wing – угол атаки крыла (угол между хордой крыла и направлением движения крыла относительно воздушной массы)
develop lift – развиваемая подъемная сила
amount [ə'maunt] – величина (тяги, подъемной силы)
product ['prɔdʌkt] – произведение (результат умножения)
acceleration [əkˌselə'reɪʃən] - ускорение
rule [ru:l] - правило
to create [kri:'eɪt] - создавать
whenever [wen'evə] – всякий раз
divergent [daɪ'və:dʒənt] - расширяющийся
passage [pæsɪdʒ] - канал
to convert [kən'vɜːt] - преобразовывать
pressure ['preʃə] – давление

1.1. Questions for Argument and Discussion

1. Why don’t airplanes fall?
2. What is lift?
3. What flight parameters does lift depend on?
4. When is lift developed?
5. What are wings for?
6. How do we call the device which imparts high speed to the airplane?
7. What part does the powerplant consist of?
8. What does the jet engine do?
9. How can we calculate the amount of lift?
10. Why air pressure below the wing is higher than air pressure above the wing?
11. What is thrust?
12. How can we calculate the amount of thrust?
13. What does the mass of air flowing through the engine depend on?
14. How do we call the difference between the input speed of the air and its output speed?
15. What air passages are called divergent?
16. What air passages are called convergent?
17. Why all exhaust nozzles are convergent?
18. Is there any connection between velocity and pressure of air in a passage?
19. How do we call devices which convert velocity into pressure?
20. In what units do we measure lift and thrust?

1.2. Suggested Topics for Presentations and Reports

1. General principles of lift development
2. General principles of thrust development
3. Flow of air through divergent and convergent passages

4. Practical applications of Newton’s third law of motion
5. Classical and modern Gas Dynamics
6. Aviation periodicals – “Flight”, “Flying”, “Aerospace America”, “Interavia”, “Interavia Air Letters” (whom and what are they for?)
7. Home appliances and devices which I have repaired.

1.3. Aviation Talk

Instructor: Peter, what in your opinion, comes first, lift or thrust?
Peter: First the airplane is on the ground, supported by its landing gear.
Instructor: And what is next?
Peter: Next the pilot switches the engines on, and they start developing thrust.
Helen: And where are the passengers?
Instructor: They have already boarded the plane and are waiting for the airplane to take off.
Peter: And what does the pilot do next?
Instructor: Next the pilot asks the flight dispatcher for permission to take off.
Helen: What is this permission for?
Instructor: The runway must be free, and the dispatcher knows for sure if it is free or not.
Peter: Is the plane already moving or not?
Instructor: Not yet. But having obtained the permission, the pilot applies the throttles and the plane starts moving.
Helen: And the air hostess tells the passengers to fasten their belts.
Instructor: She had to do this much earlier, when the airplane was stationary.
Peter: And off we go?
Instructor: Yes. Having developed sufficient speed, the airplane leaves the ground and the pilot tells the flight dispatcher: “Route zero zero ten, airborne!”
Helen: So we understand that thrust comes first.
Instructor: Quite so. And this has a much wider meaning. Young people must also develop sufficient thrust to go into their life orbits.

Topic 2
Main Parts of the Airplane

All airplanes consist of two main parts – airframe and powerplant. The airframe consists of cockpit, fuselage, wings, landing gear and tail unit. The powerplant consists of one of several jet engines.

The cockpit houses the pilots, instrument panel and forward-looking, or weather, radar. The main structural body of all airplanes is the fuselage, which houses passengers and cargo. The cockpit is in that portion of the fuselage which is occupied by the pilot (or the pilot and copilot). From this cockpit radiate all controls used if flying and landing the airplane. To the fuselage are attached wings, engine mounts, tail unit and landing gear.

Wings are structural parts supporting the airplane in the air by developing lift. Wings and tail surfaces are airfoils. According Bernoulli’s principle airfoils are designed to increase the velocity of the airflow above its surface, thereby decreasing pressure above the airfoil. Simultaneously, the import of the air on the lower surface of the airfoil increases the pressure (i.e. lift) below this surface. The part of the drag induced by the lift is called induced drag.

The wing is a system of fixed surfaces, the chief structural means of obtaining lift to support the airplane in the air. Lift and supporting force drive from the useful dynamic reaction of airflow moving through the wing. The forward part of an aircraft is rounded and called leading edge. Tapered aft part of the wing is called trailing edge. The wing chord or chord line is a reference line, an imaging straight line joining the extremetees of the leading and trailing edges.

Lift can be calculated as the difference of pressures below the wing and above the wing. The angle between the chord of a wing and the direction of the flow of air- is. called the angle of attack. The wing chord, or chord line, is the reference line from the tip of the leading edge to the tip of the trailing edge of the wing. Small, nearly vertical aerodynamic surfaces mounted at the tips of airplane wings are called winglets. Winglets produce large side forces even at low angles of attack, which, combined with the perpendicular local flow, provide a forward thrust component. This reduces the airplane induced drag, i.e. that part of the drag, induced by the lift. Induced drag is the resistance which would be encountered if the air had no viscosity.

Landing gear are those components of the airplane that support and provide mobility on land, or any surface. The landing gear consist of wheels, struts, bracing, shock absorbers and other associated devices. Landing gear notion also includes all supporting components, such as tail wheel, nose wheel and others.

Tail unit is the combination of stabilizing and controlling surfaces, situated at the rear of the airplane. The vertical stabilizing surface is called the fin, the horizontal stabilizing surface is called the horizontal stabilizer.

Comprehensive Text-Related Glossary

airframe [ˈɛəfreɪm] – планер самолета
power plant [ˈpauə , plɑ:nt] – силовая установка
cockpit [ˈkɔkpɪt] - кабина лётчиков

landing gear ['lændɪŋ gɪə] – шасси самолёта
tail unit [teɪl 'ju:nɪt] – хвостовое оперение
instrument panel ['pænəl]- приборная доска
forward-looking radar ['fɔ:wəd, lukɪŋ 'reɪdə] - радиолокатор переднего обзора
weather ['weðə] - погодный, для определения метеоусловий по маршруту
structural body ['strʌktʃərəl] - несущая конструкция
cargo ['ka:gou] - груз
engine mounts - моторами двигателя
difference - разность (давлений)
chord of a wing [kɔ:d] – хорда крыла
tip of the leading edge - крайняя часть (законцовка) передней кромки крыла
tip of the trailing edge - крайняя часть (законцовка) задней кромки крыла
reference plane ['refrəns] - опорная плоскость
winglets - концевые "крылышки"
induced drag [' dræg] - присоединённое лобовое сопротивление самолёта, вызываемое развиваемой подьёмной силой
resistance [rɪ'zɪstəns] - сопротивление
to encounter [ɪn'kauntə] - встречать
viscosity [vɪs'kɔsɪtɪ] - вязкость (воздуха)
to provide [prə'vaɪd] - обеспечивать
wheels [wi:l z] - колёса шасси
struts [strʌts] - стойки шасси
bracings ['breɪsɪŋ] - расчалки шасси
shock absorbers [ab'sorbsz] - амортизаторы, амортизационные стойки
tail wheel [wi:l] - хвостовое колесо
nose wheel - носовое колесо
fin - вертикальный стабилизатор

2.1 .Questions for Argument and Discussion

1. What main parts do all airplanes consist of?
2. What are the main components of the airframe?
3. How do we call the compartment, which houses the pilots?
4. Where is the forward - looking radar located?
5. What components does the cockpit house?
6. What components are attached to the fuselage?
7. How do we define wings? Why wings develop lift?
8. Why air pressures below the wing and above the wing are different?
9. What is the angle of attack?
10. How does the angle of attack influence lift?
11. How do we define the wing chord?
12. Where is the leading edge of the wing located?
13. Where is the trailng edge of the wing located?
14. What are winglets?
15. What are winglets for?

16. Why do winglets deminish drag and provide a forward thrust component?
17. What is drag?
18. How is the forward thrust component developed by winglets?
19. What is landing gear for? What parts does it consist of?
20. What is tail unit?
21. What controls are located on the tail unit?
22. How do we call the vertical stabilizing surface?
23. How do we call the horizontal stabilizing surface?

2.2. Suggested Topics for Presentations and Reports

1. Design and interior of a modern cockpit
2. Instrument panels and big picture displays in a modem cockpit
3. Fuselage compartments of wide-body airplanes
4. Cargo loading and unloading devices of modem transports
5. Criterial complexes applicable for wing quality evaluation
6. Tail unit control surfaces
7. Modem undercarriage design and controls
8. Vertically moving undercarriage designs.

2.3. Aviation Talk

Instructor: Helen, can you name two main parts of all aircraft?
Helen: These are airframe and powerplant.
Instructor: Can you imagine an airframe without its powerplant?
Helen: I think they can not exist separately, one without the other.
Peter But I can imagine such an airframe very well!
Helen: But it won't fly!
Peter: I have actually seen such a flying airframe and it is called glider! Gliders have no powerplants, but they fly!
Instructor: You are quite right, but gliders are very special flying machines, needing upcoming flow of air for flight.
Peter: The terms "airframe" and "glider" mean very different things, but, unfortunately, in Russian are not differenciated.
Instructor: Now, Helen, are wings absolutely necessary? Can we fly without them?
Helen: The wings are used for developing lift. What else can support an airplane in the air?
Peter: I've heard about airplanes with vectored thrust of their engines. The pilot can make the engines blow downwards and the airplane moves vertically, or hovers in the air.
Instructor: Such airplanes are called vertical take-off and landing (VTOL) airplanes, but they still use wings for level flight. It is much more economical.
Helen: I think that personal VTOL airplanes can be sited on roofs or on very small strips of land, can't they?
Instructor: They can. But the lift which is developed by thrust alone is very expensive. Very few people can afford VTOL airplanes oh their roofs.

Topic 3
Flight Controls

Airplane, or flight, controls are those aerodynamic or mechanical devices which are used by the pilot to control direction, altitude, and speed of an airplane. The mostly frequently used flight control is the rudder, which is a hinged vertical control, used to induce or overcome yawing movements of the airplane about its vertical axis. In this way, the rudder turns the airplane to the left or to the right.

But to do its job efficiently the rudder must be assisted by another flight control, called ailerons. The ailerons are pairs of control surfaces, normally hinged along the wing span and designed to control the airplane in roll by their differential movement. In so doing the ailerons make the airplanes bank to the left or to the right. So, before executing any turn, the pilot first banks the airplane and only then uses pedals to rotate the rudder in the needed direction.

To change altitude of flight the pilot uses elevator, which is the control for making the airplane climb or dive. The elevator is a hinged horizontal control surface used to make the airplane change its altitude by raising or lowering the tail. The elevator is usually electrically connected to the pilot’s control wheel or side stick.

All flight controls are big and heavy aerodynamic surfaces, requiring considerable efforts for their operation. Tabs, or trimmers, are small auxiliary airfoils, attached to the trailing edge of a movable control surface to decrease the rotational effort and also to trim the airplane for varying conditions of power, load and air speed. Properly trimmed, flight controls feature very low, or near-zero, rotational efforts.

Actuators, actuating systems, or actuating motors are those electric, electro-hydraulic, or hydraulic devices which actually rotate flight controls of an airplane. Actuators get their commands from autopilots, flight controllers, or from on-board computers.

Comprehensive Text-Related Glossary

flight controls [' flaɪt kən'trəulz] - органы управления полётом, включая аэродинамические рули самолёта и секторы газа
control surfaces ['sə:fɪsz] - аэродинамические рули самолёта
altitude ['æltɪtju:d] - высота полёта
frequently ['fri:kwəntlɪ] - часто (используемый)
rudder ['rʌdə] - руль направления
hinged vertical control [hɪndʒ] - вертикальный орган управления на шарнирной подвеске
to induce [ɪn'dju:s] - вызывать, инициировать
to overcome [ˌəuvə'kʌm] - преодолевать, препятствовать
yawing movements [' jɔ:ɪŋ] - рысканье самолёта, незначительные отклонения влево или вправо от курса, имеющие случайный характер
ailerons ['eɪlərɔn] - элероны, подвижные аэродинамические поверхности для создания правого или левого крена самолета. Внешние элероны работают при малых скоростях, внутренние - при высоких скоростях

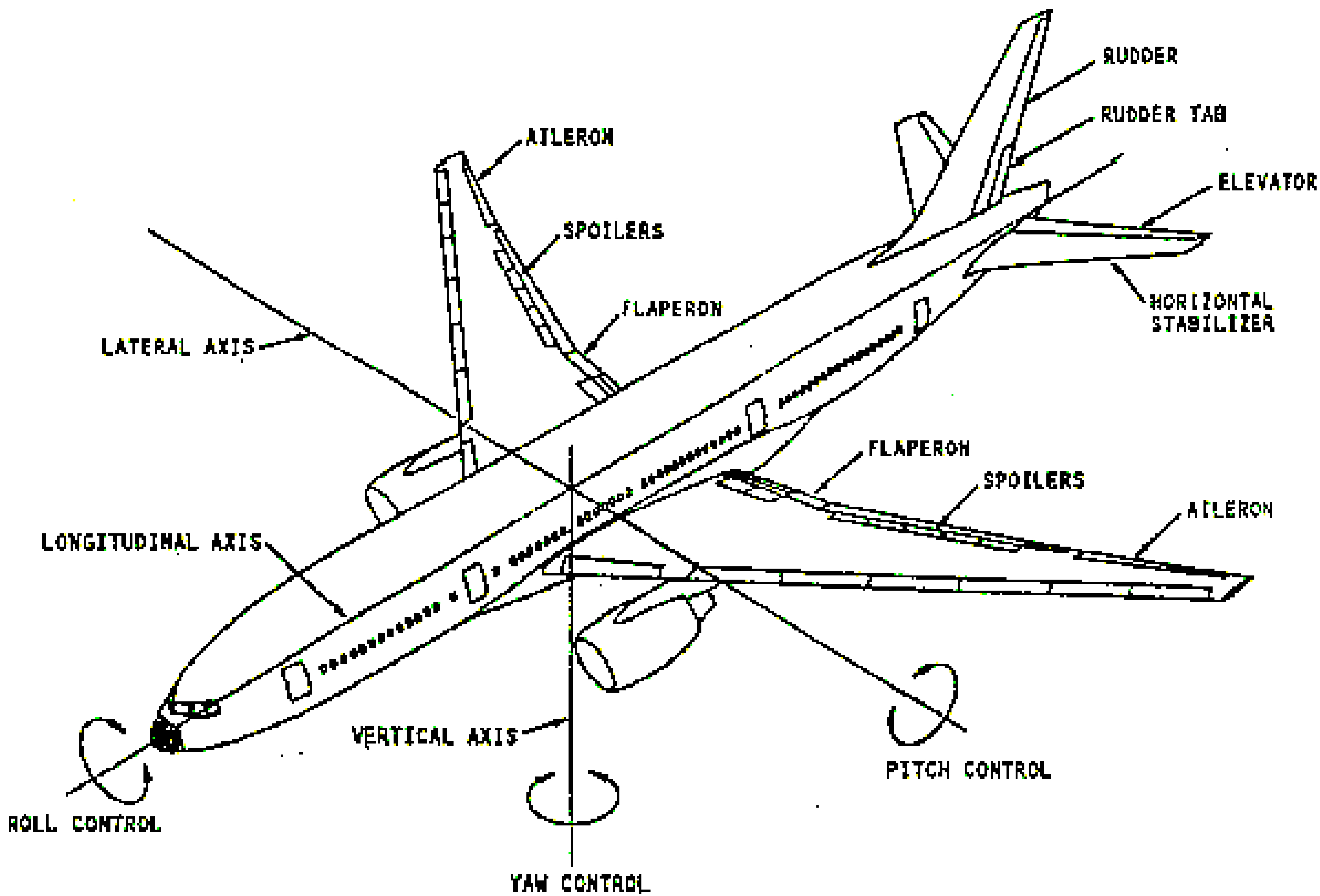
in roll ['roul] - по крену
to bank [bæŋk] - выполнять крен (левый или правый)
to execute ['eksıkju:t] - выполнять (маневр, команду)
turn [tə:n] -поворот (налево или направо)
elevator ['elıveıtə] - руль высоты
control wheel [wi:l] - штурвал (управления самолётом)
side stick ['said'stik] - боковая ручка управления (самолётом)
tabs [tæbz] - триммеры (рулей самолёта)
trimmers ['trımə z] - триммеры, вспомогательные поверхности управления, предназначенные для балансировки самолёта и снятия нагрузки с рычага управления
auxiliary [ɔ:g'zıljərı] - вспомогательный
actuator ['æktjueıtə] - рулевая машинка, приводящая в движение рули самолёта
flight controller [flaıt kən'trəulə] - командно-пилотажный прибор, выполняющий полёт по заданному маршруту

3.1. Questions for Argument and Discussion

1. What are flight controls used for?
2. What flight parameters can be controlled by the pilot?
3. What does the rudder do in flight?
4. Why does the pilot use the rudder so often?
5. Can the rudder do its job alone? For what reasons?
6. What factors does efficiency of the rudder operation depend on?
7. What are ailerons? What are their functions in flight?
8. Why ailerons are called differential controls
9. What kind of movement is rolling?
10. When does the pilot use pedals?
11. What does the pilot use elevator for?
12. How does altitude change during climbing?
13. How does altitude change during diving?
14. What do tabs do in flight?
15. What do tabs actually compensate?
16. What is the aim of trimming flight controls?
17. What is the job of actuators? Where do they get their commands from?
18. How does the pilot control roll of the airplane?
19. How does the pilot control yaw of the airplane?
20. What deflection of the elevator (up or down) induces diving movement? Why?
21. What deflection of the elevator (up or down) induces climbing movement? Why?

3.2. Suggested Topics for Presentations and Reports

1. Roll, pitch and yaw control systems of modern aircraft
2. Criteria for estimating efficiency of airplane controls
3. Fly-by-wire airplane controls
4. Criteria of stability of digital control systems
5. The problem of reliability vs. redundancy in on-board control systems



Frame of Reference and Flight Control System

6. Length of fuselage and efficiency of tail unit controls
7. Autopilot, flight-director, on-board computer. What is next?
8. Vectored thrust control systems
9. Hydraulic, electro-hydraulic and hydraulic actuators
10. Choice of sampling frequency in digital control systems.

3.3. Aviation Talk

Instructor: Today we are going to discuss some fundamental notions and ideas, pertaining to airplane controls and to control theory in general...
Helen: I don’t understand why should we delve into such complex matters as control theory. We already understand that to turn the airplane to the right the pilot pushes the right pedal and the plane turns. Why should we complicate things?
Peter: Things become complex and messy when there are too many inbetweens. I understand that between the leg of the pilot and the rudder there are such go-betweens as autopilot, flight director, on-board computer and the rudder actuator.
Helen: Are these devices really necessary?
Instructor Pilots are only humans and sometimes commit piloting mistakes. The commands they issue are not always the best solutions of the given piloting problem. In flight pilots may get tired and inattentive. All these problems are successfully solved by back-up piloting devices.
Peter What is primary flight control system?
Instructor: The primary flight control system, or PFCS, controls the airplane flight attitude in relation to the three basic axes:
- Longitudinal
- Lateral
- Vertical.

Helen: Presently we often speak about system s and systemic approach. What is meant, for instance, by the roll control system?
Instructor: The roll control system in modem airplanes, such as Boeing 777, uses the ailerons, flaperons, and spoilers to control the airplane attitude about the longitudinal axis. During a bank of the airplane, the aileron and flaperon on one wing move in an opposite direction from the aileron and fleperon on the other wing.
Peter You have just introduced a new term "flaperon”. What does it actually mean?
Instructor: Flaperons are differential flaps used on Boeing 777 and some other new wide-body airplanes. When one flaperon is up, another flaperon is down.
Helen: Do spoilers assist in any way the operations of flaperons? Instructor: They do. The spoilers move up only on the down wing and do not move on the up wing.
Peter. In modem technical manuals we also come across another system, called the pitch control system. Is it in any way particular?
Instructor It usually refers to all devices involved in controlling movements of the airplane about its lateral axis. The airplane may climb, dive, or may maintain straight and level flight.
Helen: I understand that the words "straight and level" have some special meaning for all pilots. What is it?
Instructor They simply mean that everything is in perfect order, no deviations are taking place.

Topic 4

High Lift Devices (HLD)

HLD are special mechanical appliances used by the pilot for developing additional lift at very low air speeds during take-off stage of the flight.

Flaps are big aerodynamic surfaces, located at wing and extended by the pilot for developing additional lift during taking off and for braking during landing stages' of the flight. Differentially operating flaps are called flaperons. When one flaperon is up, another flaperon is down.

Slats are slotted aerodynamic surfaces located at the leading edge of the wing and used by the pilot for developing additional lift at very low air speeds during take-off. As opposed to flaps, slats are never used for braking the airplane during landing.

Spoilers are aerodynamic devices which break up or spoil laminar flow of the air about the wing, giving an increased drag and a decreased lift. They deploy on both wings and act as speedbrakes in the air and on the ground. Modern airplanes have up to seven spoilers on each wing.

The high lift control system (HLCS) receives commands from the flight crew and increases the wing lift so the airplane can take off and land at lower speed and higher weight. Typically, the high lift devices operated by the HLCS are:

- Seven leading edge slats on each wing
- One Krueger (leading edge, inboard) flap on each wing
- One single slotted outboard flap on each wing -One double slotted inboard flap on each wing.

Operation of the HLCS also causes the ailerons and the flaperons to move. They droop on both wings when the high lift devices extend.

Comprehensive Text-Related Glossary

high lift devices [dɪˈvaɪsɪz] - средства механизации крыла; механизация
appliances [ə'plaɪənsz] - устройства, приспособления
additional [ə'dɪʃənl] - дополнительный
take-off stage [,teɪk ' ɔf ' steɪdʒ] – взлётный этап полета
flaps [flæps] – закрылки
slats [' slæt s] - предкрылки
spoilers ['spɔiləz] - интерцепторы или спойлеры (пластины на поверхности крыла, отклоняемые для создания срыва потока воздуха и уменьшения подъёмной силы)
trailing edge of the wing [' treɪlɪŋ] - задняя кромка крыла
to extend [ɪks'tend] - выпускать
braking [' breɪkɪŋ] - торможение
landing stage [lændɪŋ] - этап приземления; посадочный этап полёта
differentially operated flaps ['dɪfrənʃəlɪ] - щитки с дифференциальным управлением (когда один щиток опускается, другой поднимается)

flaperon [,flæpə'rɔn] - дифференциально-управляемый щиток
slotted aerodynamic surface ['sə:fɪs] - снабжённая щелями аэродинамическая плоскость
leading edge of the wing ['liːdɪŋ] - передняя кромка крыла
to break up [breɪk ' ʌp] - нарушать, срывать
laminar flow ['læmɪnə] - ламинарное или бестурбулентное обтекание крыла
increased drag [ɪn'kriːse ' dræg] - возросшее лобовое сопротивление **decreased lift** [dɪ'kriːst 'lɪft] - уменьшенная подъёмная сила
to deploy [dɪ'plɔɪ] - выдвигать
speedbrakes [' spi:d, breɪks] - работающие в зависимости от скорости тормоза (чем выше скорость, тем сильнее торможение)
High Lift Control System - система управления средствами механизации крыла (на самолёте Боинг 777)
high weight [weɪt] - более высокий взлётный вес
Krueger flap - щиток Крюгера. На самолёте Боинг 777 щитки Крюгера располагаются на внутренней передней кромке крыла
single-slotted outboard flap [aut'bo:d] - однощелевой закрылок на внешней задней кромке крыла
double-slotted inboard flap [ɪn'bord] - двухщелевой закрылок на внутренней задней кромке крыла
to droop ['dru:p] – выпускаться

4.1. Questions for Argument and Discussion

1. What are high lift devices?
2. At what stage of the flight are they used?
3. What are flaps?
4. What for are flaps used during take-off?
5. What for are flaps used during landing?
6. How do we call differentially operating flaps?
7. What are slats?
8. Where are slats located?
9. Which high lift devices are used for braking?
10. In what cases lift becomes unnecessary?
11. What does the pilot do to decrease lift?
12. What is the difference between laminar and turbulent flows of air?
13. What does the pilot do to increase drag? When is it necessary?
14. What number of spoilers is typical for modern wide-body airplanes?
15. How many leading edge slats are normally located along the wing span?
16. What specific types of flaps do you know?
17. What is the HLCS for? Where does it get its commands from?
18. What means can be used by the pilot to make the taking-off run as short as possible?
19. Why short taking-off run is preferable?
20. What is the difference between a single-slotted flap and a double-slotted flap?

4.2. Suggested Topics for Presentations and Reports

1. Primary flight control system and high lift control system
2. Cost analysis of high lift vs augmented thrust
3. Other solutions of the shorter taking-off run problem
4. Short, very short and vertical taking-off and landing airplanes
5. HLCS, autopilot and flight director interaction
6. Criteria for estimating efficiency of high lift devices
7. **High lift devices of Tu-334 and Boeing 777.**

4.3. Aviation Talk

Instructor: Glad to see you all! Today we are going to discuss high lift devices - special aerodynamic appliances, which make wings behave the way we want.
Helen: Do wings misbehave? ’
Instructor: It’s common knowledge that wings are devices for developing lift. They behave properly and develop their nominal lift, but only at their cruising air speed, for which they were designed.
Helen: And what's bad about this?
Instructor: The airplane is big and heavy, and it takes hundreds of meters of runway to accelerate it to its taking-off speed.
Peter: We understand here that the pilot wants to make his taking-off run as short as possible.
Helen: And for this he needs a lot of lift, and quickly!
Instructor: And here our high lift devices come in. They just develop a lot of additional lift at low air speeds!
Peter: The pilot just switches them on, and off he goes!
Instructor: A lot of additional lift means a lot of additional thrust because overall drag of the airplane increases.
Helen: Which of the high lift devices makes the highest contribution to additional lift?
Instructor: It’s flaps and flaperons on Boeing 777. They are really big and heavy and it takes up to 4 minutes to move the flaps from the retracted position to the 30-unit position (fully extended).
Peter: Are flaps and slats controlled collectively?
Instructor: Not quite. During extension, the flaps and slats extend at the same time. During retraction, the flaps retract before the slats. When the flaps are fully retracted, the slats retract.
Helen: How does the pilot know the positions of flaps and slats at the moment?
Instructor: On Boeing 777 and on other wide-body transports there are three different displays for flaps and slats.

The primary mode display is black when the flaps and slats are fully retracted. When the flaps or slats extend, a white tape fills the display from the top down.

The secondary mode display has separate indications for

The left wing flaps
The right wing flaps
The left wing slats
The right wing slats

The alternate mode display is even more informative and has tick marks and reference detent numbers to identify the flap and slat positions separately.

Helen: What's the use of these three modes?

Instructor: The pilot must not be distracted or overloaded with data he does not need.

Peter: We already know, that spoilers help the pilot in getting rid of the lift when it is no longer needed. What do spoilers do in flight?

Instructor: In flight, the spoilers help the ailerons and flaperons control airplane roll about the longitudinal axis. They also supply speedbrake control to reduce lift and increase drag for descent and landing.

Helen: How many separate spoilers are there on each wing?

Instructor: Typically there are seven spoilers on each wing, but the numbers may vary. The five outboard spoilers are forward of the outboard flap. The two inboard spoilers are forward of the inboard flap. Each spoiler has its assigned number.

Peter: How are spoilers commanded?

Instructor*:* In roll control, the pilots manually command the spoilers, and, if engaged, the autopilot automatically commands them.

Topic 5

The Jet Engine Fundamentals

Thrust or force required to propel the airplane through the air is provided by the propulsion system to overcome the resistance resulting from the compression of the air through which the airplane fly.

Thrust or propulsion force is provided by the engine.

All engines have in common the ability to convert heat energy into mechanical energy by the flow of the air through the engine. The heat energy is released at a point in the cycle where the pressure is higher relative to atmospheric.

The jet engine and the power plant are means of creating thrust, necessary for the movement of an airplane through the air and on the ground.

The power plant is bolted to an engine mount i.e. a frame, which supports engine and connects it with the wing. Immediately behind the engine mount is the fire wall to protect the airplane from any heat liquids, gases or flame from the engine.

The jet engine is a device for developing thrust. All jet-engines operate on the principle of developing thrust by throwing back large masses of hot air. The amount of thrust can be calculated as the product of the mass of air, flowing through the engine, by its acceleration. To understand the principle of internal reaction we must remember Newton's third law of motion: "For every force acting upon a body, there is an equal and opposite reaction". The jet engine is throwing back large masses of hot exhaust air, the opposite reaction to which is thrust.

All modern aviation jet engines consist of the following main parts:

1. Air intake unit and the fan
2. Low pressure stages of the axial compressor
3. Intermediate pressure stages of the axial compressor
4. High pressure stages of the axial compressor
5. The combustion chamber
6. High pressure stages of the gas turbine
7. Intermediate pressure stages of the gas turbine
8. Low pressure stages of the gas turbine
9. Exhaust nozzle, afterburner or thrust augmenter, and thrust reverser.

Low pressure stages of the gas turbine rotate the fan and low pressure stages of the axial compressor, forming one mechanical unit, called low pressure spool. Intermediate pressure stages of the gas turbine rotate intermediate pressure stages of the axial compressor, forming another mechanical unit, called intermediate pressure spool High pressure stages of the gas turbine rotate high pressure stages of the axial compressor, forming the third mechanical unit, called high pressure spool.

All three spools rotate at their optimal speeds. Modern triple-spool jet engines feature very large diameter fan, minimum number of stages and very low level of noise.

Comprehensive Text-Rated Glossary

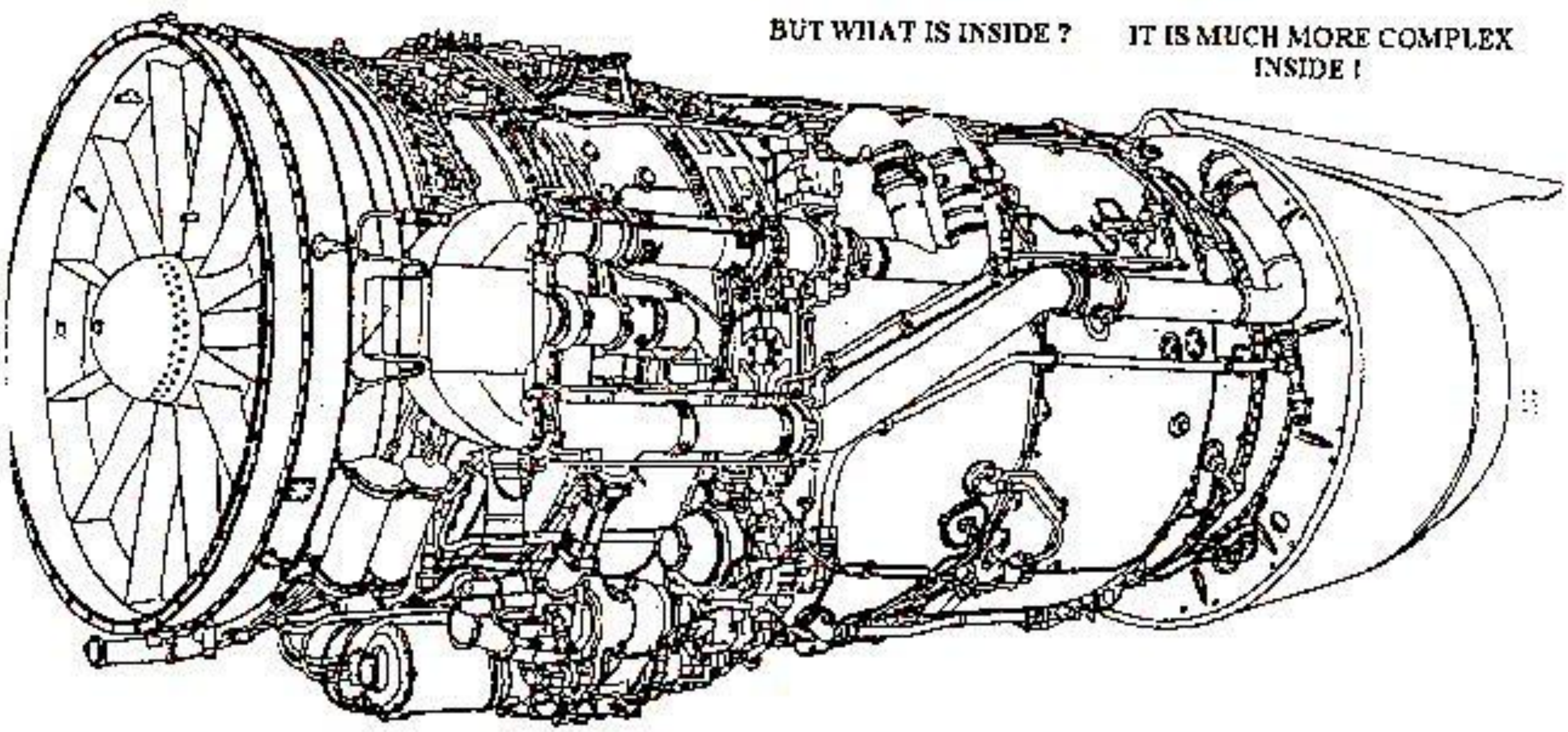
jet engine ['dʒet 'endʒɪn] - реактивный двигатель
fundamentals [ˌfʌndə'mentlz] - основные сведения
throwing back [' θrəuɪŋ ' bæk] - отбрасывание назад
amount [ə'maunt] - величина (напр. тяги)
to calculate ['kælkjuleɪt] - рассчитывать, вычислять
product ['prɔdʌkt] - произведение (как результат умножения)
acceleration [əkˌselə'reɪʃən] - ускорение
internal reaction [ɪn'tə:nl] - внутренняя реакция масс воздуха (на отбрасывание назад больших масс воздуха)
equal and opposite ['i:kwəl] - равная и противоположно направленная (реакция)
exhaust air [ɪg'zɔ:st] - выхлопные газы
thrust [θrʌst] - тяга (реактивного двигателя)
air intake unit [,ɛə ' ɪnteɪk ' ju:nɪt] - воздухозаборник (реактивного двигателя)
fan [fæn] -вентилятор
low pressure stages ['lou , 'preʃə ' steɪdʒɪz] - ступени низкого давления (компрессора)
axial compressor ['æksɪəl , kəm'presə] - осевой компрессор
intermediate [ˌɪntə'mi:djət] - промежуточный
combustion chamber [,kəm'bʌstʃən 'tʃəɪmbə] - камера сгорания
gas turbine [gæs 'tə:bɪn] - газовая турбина
exhaust nozzle [,ɪg'zɔ:st 'nɔzl) - выхлопное сопло
afterburner [, a:fta'bə:nə] - устройство дожига топливе
thrust augmenter [.̈n.'ɔ:gmənta] - форсажная камера
thrust reverser [, ri'və:sə] - устройство реверса тяги (с целью торможения)
low pressure spool [spu:l] - ротор низкого давления
mechanical unit [mɪ'kænɪkəl 'ju:nɪt] - механический агрегат
triple-spool jet engine ['trɪpl] - трехвальный реактивный двигатель
to feature ['fi:tʃə] - характеризоваться; иметь особенности
low level of noise [' nɔɪz] - низкий уровень шумов

5.1 .Questions for Argument and Discussion

1. On what principle do all jet engines operate?
2. How can we calculate the amount of thrust?
3. What does the third law of motion say?
4. What is thrust? In what units is it measured?
5. To obtain more thrust from your jet engine, which component of the thrust formula would you increase?
6. What parts does the modern jet engine consist of?
7. What does the axial compressor do?
8. How many stages does the axial compressor consist of?
9. Where is air-fuel mixture burnt?
10. What does the gas turbine do?

Aviation Talk:

BUT WHAT IS INSIDE ? IT IS MUCH MORE COMPLEX INSIDE !



General Jet Engine Layout

11. How do we call the stages, which the gas turbine consists of?
12. What do these stages of the gas turbine do?
13. What parts does a spool consist of?
14. How many spools does a modern jet engine consist of? What are their names?
15. What are the main features of a triple-spool jet engine?

5.2. Suggested Topics for Presentations and Reports

1. General principles of thrust development at low subsonic, high subsonic, and supersonic air speeds
2. Divergent and convergent passages in jet engine designs
3. Axial and centrifugal compressors
4. Cannular and annular combustion chambers
5. Basic principles of gas turbine design
6. Creep, corrosion, fatigue and thermal shock in gas turbine blades
7. Methods of gas turbine blades cooling
8. Multi-spool jet engines.

5.3. Aviation Talk

Instructor: Today we are going to discuss aviation jet engines, which are actually turbo-jet engines, having a compressor at the front to force the air in.
Peter: What drives the compressor?
Instructor: There's plenty of energy at the back, where the hot gases leave the combustion chamber. If you put a turbine there and connect it to the compressor by a shaft, that would solve the problem, wouldn't it?
Helen: What's about the other types of jet engines?
Instructor They're all variations on the turbo-jet principle. There's the turbo-prop, for example, where the turbines rotate both the compressor and an ordinary propeller.
Helen: What are the advantages of this type of engine?
Instructor: At very low flying speeds propellers are more efficient form of propulsion that jet engines. Pure jet engines are very efficient at high subsonic speeds, but at medium and low subsonic speeds their efficiency sharply decreases.
Peter: And this was the reason for development of by-pass engines.
Instructor Right you are, this was the reason. But the development of by-pass engines was only the first step.
Helen: Are by-pass engines still used?
Instructor They are, but in a modified form. In **a** by-pass engine only some of the air goes straight through; the remainder is passed through ducts, round the combustion chamber and turbine, but later rejoins the main stream at the rear.
Peter: And what was the second step?
Instructor: The second step was development of fan engines. The first set of rotor blades of the axial compressor was enlarged to form a sort of multi-blade propeller, known as the fan.

Helen: Modern jet engines look so big and impressive. Is it because of their large diameter fans?
Instructor The diameter of modern high by-pass ratio jet engines is up to three meters, and they are pilon-mounted.
Helen: Does the term "high by-pass ratio" imply large diameter fan?
Instructor It does. High by-pass ratio means the ratio of outer, or cold flow of air to inner, or hot flow of air, passing through the gas generating part of the engine. Typical values of practically used by-pass ratios are 1.7-3.1
Peter Some modern jet engines are described as ducted fans. What does it mean?
Instructor It usually means that these engines have large diameter fan within an annular shroud.

Topic 6

Axial Compressor

Axial compressor is a mechanical device for causing a pressure rise in the air, delivered to the combustion chamber. There is a constant relationship between the volume, the temperature, and the pressure of the air as it passes through the axial compressor. The temperature of the air at any point of the duct is the product of the pressure and the volume of that air.

When the volume of the air is being reduced in an axial compressor, there is a rise in both pressure and temperature The more efficient is the design of the compressor, the higher will be the rise in pressure. The efficiency of an axial-flow compressor depends primarily upon the design of its rotor and stator blades.

Rotor blades have airfoil cross-sections and are made of aluminum alloy, steel or titanium. They can operate with maximum efficiency only within a limited range of operating conditions. Outside this range the smooth flow of air in the compressor is usually upset by unwanted turbulence. When one stage of the compressor is upset by turbulence, it is said that the compressor stalls. The stalling compressor usually develops severe vibrations or coughing. Sometimes it may even produce shot-like sounds. When all stages of the compressor are upset by turbulence, it is said that the compressor surges. The surging compressor produces powerful bangs, the temperature of the exhaust gases rapidly rises and the engine may be partially or wholly damaged. Stator blades may be attached directly to the casing of the compressor, with connecting shrouding at the tips to give them greater stability.

Comprehensive Text - Related Glossary

axial compressor ['æksıəl] - осевой компрессор
to cause [kɔ:z] - создавать
pressure rise ['preʃə raız] - повышение давления
to deliver [dı'lıvə] - подавать
constant relationship [rı'leıʃənʃıp] - постоянное соотношение
volume ['vɔljum] - объем (воздуха)
duct [dʌkt] - канал; контур
to reduce [rı'dju:s] - сокращать, уменьшать
axial flow compressor [fləu] - компрессор с течением воздуха вдоль оси, осевой компрессор (в отличие от центробежного компрессора с поперечным течением воздуха)
efficient [ı'fıʃənt] - эффективный, с высоким КПД
rise in pressure ['raız] - подъем давления
primarily ['praımərılı] - в основном, в первую очередь
design [dı'zaın] - конструкция
blades ['bleıdz] - лопатки (ротора и статора осевого компрессора)
airfoil cross-section ['ɛəfɔıl] - профилированное поперечное сечение (типа поперечного сечения крыла)
alloy [ə'lɔi] - сплав

titanium [tai’teɪnjəm]-титан (металл)
range [reɪndʒ] - диапазон
operating conditions [kən'dɪʃənz] - условия эксплуатации
smooth flow of air [smu:ð] - невозмущенное течение воздуха
to upset - нарушать, срывать ламинарый поток
unwanted turbulence ['tə:bjuləns] - нежелательная турбулентность
to stall [stɔ:l] - работать в режиме срыва потока в одной ступени компрессора
severe vibrations [sɪ'vɪə] - сильные вибрации
coughing [kɔfɪŋ] - издаваемые похожие на кашель звуки
to produce shot-like sounds [ʃu:t laɪk] - издавать звуки, похожие на выстрелы
to surge [sə:dʒ] - работать в режиме помпажа, при котором срыв потока происходит во всех ступенях компрессора
powerful bangs [bæŋz] - мощные взрывоподобные звуки rapidly ['raepidli] - быстро
partially or wholly ['pɑ:ʃəlɪ] - частично или полностью
to damage [’dæmɪdʒ] – повреждать
to attach [ə’tætʃ] - устанавливать, закреплять
casing [keɪsiŋ] - корпус; кожух
shrouding [ʃraudɪŋ] - бандажирование законцовок лопаток (для повышения жесткости)

6.1. Questions for Argument and Discussion

1. What does the axial compressor do in a jet engine?
2. How can we calculate the temperature of the air at any point of the duct of the compressor?
3. What happens when the volume of the air in the compressor is reduced?
4. What docs the efficiency of the compressor depend on?
5. What material are the blades of the compressor made of?
6. What happens, when one stage of the compressor is upset by turbulence?
7. What is the axial compressor stall?
8. How does the axial compressor stall manifest itself?
9. What happens when all stages of the axial compressor are upset by turbulence?
10. What is the axial compressor surge?
11. How does the axial compressor surge manifest itself?
12. What are the results of the compressor surging?
13. What is the difference between stalling and surging conditions?
14. Where does the axial compressor take its energy from?
15. What are stator blades (vanes) for?
16. Where are stator blades attached to?
17. What measures are taken to ensure greater stability of the stator blades?

6.2. Suggested Topics for Presentations and Reports

1. Gas dynamic processes in a convergent duct
2. Criteria complexes for estimating efficiency of axial compressors

3. Comparative analysis of axial, centrifugal and hybrid compressors
4. Stall conditions in axial compressors
5. Surge conditions in axjal compressors
6. Optimum rotation speeds of low pressure, intermediate pressure, and high pressure compressor stages.

6.3. Aviation Talk

Instructor: Historically, there are three types of compressors, used in aviation jet engines. These are centrifugal compressors, axiaul flow compressors and hybrid compressors. Each of these types has its own advantages and disadvantages.
Helen: Up to now we have discussed only axial flow compressors. Does it mean that they are the most efficient type?
Instructor: Yes, it does. Axial flow compressors are the most efficient and the most complex type of compressors, and they are used in most jet engines. On the other hand, centrifugal compressors are very simple and robust.
Peter: Does the term "centrifugal” mean that the air in a centrifugal compressor is moving radially outwards?
Instructor: It does. A vaned disk, called the impeller, is attached to the turbine shaft near the air intake. As the disk rotates, it spins all contact with it. Centrifugal force flings the air outwards at high velocity.
Helen: But we need to increase the pressure of the air, not its velocity!
Instructor: I haven’t finished yet! The air is flung off the impeller into divergent passages formed by diffuser vanes, attached to the outer casing.
Helen: Oh, now I see. When the air enters these passages, it slows down, and the lost kinetic energy reappears as pressure energy. Am I right?
Instructor: You are absolutely right. From there, of course, the compressed air is ducted to the combustion chamber.
Peter: It sounds so simple in theory!
Instructor: In practice this type of compressor is both robust and very easy to manufacture, but, unfortunately, its efficiency is low. It appears that instead of driving the air outwards it would be preferable to drive it backward, without any change of direction of movement.
Peter: It seems to be a more efficient arrangement!
Instructor: It is. The compressors of this type are called axial flow compressors.
Helen: Are these compressors mounted on the turbine shaft too?
Instructor: Yes. The axial compressors force the air straight backward by means of a series of multi-blade fans, mounted one behind the other.
Peter: As far as I understand, we can choose the number of these multi-blade discs in accordance with our needs.
Instructor: That's it! Between each set of rotor blades are similar sets of stationary blades, attached to the outer casing. These stationary blades redirect the air to the correct angle for the next set of rotor blades. Each set of rotor blades with its set of stator blades is known as a stage.

Topic 7

The Combustion Chamber

Combustion chambers are mechanical devices for burning air-fuel mixture. They may be installed in the engine in a number of different ways. The multiple combustion chamber layout is used with engines having centrifugal compressors. In this layout a number of flame tubes are disposed radially round the engine. Annular and tubo-annular designs of combustion chambers are more often used presently.

The flame tube of annular combustion chambers is in the form of a double ring which in turn is fitted into an annular casing of two more rings. Tubo-annular combustion chambers have flame tubes grouped round the engine, as in the multiple layout, but instead of each having a separate outer casing, they are all disposed in a common annular casing, shaped like two broad rings, one inside the other.

Tubo-annular chambers are easier to manufacture and overhaul, while annular chambers, besides possessing these advantages, are also more compact. Annular chambers are more fuel-efficient and reduce many of the problems of air pollution. All combustion chambers must be capable to withstand very high temperatures, rapid changes of temperature and corrosive effects produced by the products of combustion.

Comprehensive Text-Related Glossary

air-fuel mixture ['mɪkstʃə] - топливно-воздушная смесь
to install [ɪn'stɔ:l] - устанавливать
multiple combustion chamber layout ['mʌltɪpl 'leɪaut] - камера сгорания с отдельными жаровыми трубами
centrifugal compressor [,sentri'fjugəl] - центробежный компрессор
flame tube [' fleɪm 'tju:b] - жаровая труба
layout [, lei'aut j - планировка, расположение
annular combustion chamber ['ænjulə] - кольцевая камера сгорания
double ring *['* 'dʌbl rɪŋ] - двойное кольцо
tubo-annular combustion chamber - трубчато-кольцевая камера сгорания
separate outer casing ['keisiŋ] - отдельный внешний кожух
shaped [ʃeɪpt] - имеющие форму
one inside the other [ɪn'saɪd] - один внутри другого
to manufacture [ˌmænju'fæktʃə] - изготовлять, производить
advantage [əd'vɑ:ntɪdʒ] - преимущество
more fuel-efficient [fjuəl ə'fɪʃənt] - с более высокой топливной эффективностью
to reduce [rɪ'dju:s] - сокращать, частично решать (проблемы)
air pollution [ɛə , pə'lu:ʃən] - загрязнение воздушной среды
capable to withstand [wɪð'stænd] - в состоянии выдерживать, противостоять
corrosive effects [kə'rəusɪv] - коррозионные воздействия
products of combustion ['prɔdʌkts] - продукты сгорания

7.1. Questions for Argument and Discussion

1. What are combustion chambers for?
2. What part of the jet engine is before the combustion chamber?
3. How many layouts of the combustion chambers are known?
4. With what type of compressors is the multiple combustion chamber layout used?
5. What is the flame tubes disposition in the multiple combustion chamber layout?
6. What designs of combustion chambers are more often used presently?
7. What is the form of the flame tube of annular combustion chambers?
8. What is the disposition of flame tubes in tubo-annular combustion chambers?
9. In what do tubo-annular combustion chambers differ from annular combustion chambers?
10. Which combustion chambers are easier to manufacture?
11. Which combustion chambers are more compact?
12. If you are interested in higher fuel efficiency and lesser air pollution, which type of combustion chambers would you choose?
13. What are operating conditions of combustion chambers?
14. What requirements must all combustion chambers comply with?

7.2. Suggested Tonics for Presentations and Reports

1. Criterial complexes used for combustion chambers evaluation
2. EEE (Energy - Efficient Engine) and other research and development programs in the field of combustion chambers
3. Two-zone combustion in modern combustion chambers
4. Combustion chamber in a fuel-effiicient jet engine
5. Thrust augmentation combustors
6. Plenum combustion chambers of VTOL airplanes
7. Combustion chambers of vectored-thrust jet engines.

7.3. Aviation Talk

Instructor: This time we are going to discuss the central part of the jet engine - its combustion chamber. This is the place where fuel is mixed with the air from the compressor and ignited.
Peter: It must be quite complex!
Instructor: On the contrary, you'll be surprised by its simplicity! Just imagine two tubes, one inside the other. The inside one, called the flame tube, is fitted at the front with a perforated flare, located behind an entry snout. In the center of the flare there are a number of swirl vanes.
Helen: Up to now, it's quite simple.
Instructor: The air comes from the compressor at high velocity of one or two hundred meters per second...

Peter: It can surely blow out the flame.
Instructor: Very definitely it can. Besides, there is more available air than is needed for combustion. And this is the reason why there are two tubes: only the quantity of air needed for combustion goes into the inner tube, the rest passes outside it.
Helen: The flare clearly helps to decrease the velocity of the air entering the flame tube...
Peter: And also to raise its temperature and pressure.
Instructor: You're both right!
Peter: *I* don't see why the compressor should be made to deliver so much air when only part of it is needed for combustion.
Instructor: The temperature of the gases leaving the combustion zone may be as high as 2000 degrees Centigrade. This is too hot to feed into the turbine. About half of the excess air is needed to dilute and cool these exhaust gases.

Topic 8

The Gas Turbine

The gas turbine provides the power to drive the compressor and accessories. It does this by extracting energy from the hot gases released from the combustion chamber and expanding them to lower pressure and temperature. High stresses are involved in this process, and for efficient operation, the turbine blade tips may rotate at speeds up to 500 meters per second The continuous flow of gas, to which the turbine is exposed may have an entry temperature of up to 1400 C. and may reach a velocity up to 700 meters per second in some parts of the turbine.

To produce the driving torque, the turbine may consist of several stages, each employing one row of stationary nozzle guide vanes and one row of moving blades. The number of stages depends on whether the engine has one shaft or two and also on the relation between the power required from the gas flow, the rotational speed at which it must be produced and the diameter of turbine permitted.

The number of shafts varies with the type of engine. High compression ratio engines usually have two shafts, driving high and low pressure compressors. On high by-pass ratio fan engines another turbine is interposed between the high and low pressure turbines, thus forming a triple-spool system.

The by-pass engine enables a smaller turbine to be used than in a pure jet engine for a given thrust output and it operates at a higher gas inlet temperature, thereby obtaining improved thermal efficiency and power to weight ratio.

The balancing of a turbine is an extremely important operation in its manufacture and maintenance. In view of the high rotational speeds and the mass of materials, any unbalance could seriously affect the rotating assembly bearings and engine operation. Balancing is effected on a special balancing machine and is conducted after each maintenance operation connected with replacements of blades, discs and bearings.

Comprehensive Text-Related Glossary

power ['pauə] - мощность
to drive ['draiv] - приводить во вращение
accessories [ək'sesərɪ] - вспомогательные агрегаты
to extract [ɪk'strækt] - извлекать (энергию)
to expand [ɪks'pænd] - расширять (газ)
high stresses ['stresiz] - высокие нагрузки
to involve [ɪn'vɔlv] - связывать, сопрягать
continuous flow of gas [kən'tɪnjuəs] - непрерывный поток газа
to expose [eks'pəuz] - подвергать
entry temperature ['entrɪ] - температура на входе турбины
driving torque [tɔ:k] - вращающий момент
row ['rou] - ряд
stationary nozzle guide ['gaid] - неподвижная направляющая лопатка соплового аппарата

moving blades ['bleidz] - вращающиеся лопатки турбины
one shaft or two [ʃɑ:ft] - один вал или два
diameter of turbine permitted [pə'mɪtəd] - допустимый диаметр турбины
compression ratio ['reɪʃɪou] - коэффициент сжатия
high by-pass ratio fan engines [baipa:s] - вентиляторные двигатели с высоким коэффициентом двухконтурности
to interpose [ˌɪntə:'pəuz] - встраивать; устанавливать (между)
triple-spool system - трехвальная система
for a given thrust output - для данной развиваемой тяги
thermal efficiency ['θə:məl] - тепловая эффективность
power/weight ratio - удельная мощность
balancing ['bælənsiŋ] - балансировка
to effect [ɪ'fekt] - производить, осуществлять
unbalance - разбалансировка
bearing ['bɛərɪŋ] - подшипник
replacements [rɪ'pleɪsmənt] - замены

8.1 . Questions for Argument and Discussion

1. What is the gas turbine for?
2. Where does the turbine obtain its energy from?
3. At what speeds may the turbine blade tips rotate for efficient operation?
4. What is the entry temperature of the flow of gas to which the turbine is exposed?
5. What velocity this flow of gas may reach?
6. What number of stages may the turbine consist of?
7. What rows does each stage of the turbine consist of?
8. What is the difference between blades and vanes?
9. On what factors does the number of stages depend?
10. How many shafts do high compression ratio engines have?
11. What do these shafts do?
12. On what types of engines are triple-spool systems used?
13. What parts does a spool consist of?
14. What are the advantages of by-pass engines?
15. What is meant by the by-pass ratio?
16. Why balancing of a gas turbine is considered as an extremely important operation?
17. What are the results of any unbalance of the gas turbine?

8.2. Suggested Topics for Presentations and Reports

1. Gas dynamic processes in gas turbine stages
2. Energy transfer from gas flow to turbine
3. Compressor-turbine matching
4. Criteria for evaluating performance of a gas turbine
5. Impulse-type turbines for cartridge and air starters
6. The problem of higher turbine entry temperatures.

8.3. Aviation Talk

Instructor: The basic principles of gas turbine design are easy to understand, but their practical application is very complicated, to say the least. First, what does the turbine do?

Peter: It drives the compressor, of course.

Instructor: Anything else?

Helen: I suppose it drives various accessories, too. Fuel pumps, electric generators, and things like that.

Peter: In turbo-prop aircraft it drives the propeller shaft, in helicopters it drives the rotor shaft, both through reduction gears.

Instructor: You're both well in the picture! I am very impressed!

Helen: Don’t be misled! We've read all this from a booklet!

Instructor: Very good. Now let's see how a turbine operates. The hot exhaust gases from the combustion chamber first pass fixed nozzle guide vanes.

Peter: They look like stator vanes in a compressor, don't they?

Instructor: Yes, in a way. But actually they are quite different. Firstly, they have complex cooling ducts inside. Secondly, they are monocrystallic, that is produced from a piece of metal, grown as a single crystal.

Helen: What substance is used as a cooling agent?

Instructor: As a cooling agent is used common air, bled from a compressor stage. Immediately behind the fixed nozzle guide vanes are the rotating blades of the turbine. These are the most critical items of the whole jet engine. In modern jet engines they have to withstand temperatures of up to 1400 degrees Centigrade and strains of up to three or four tons.

Peter: I think that design and manufacture of such blades must be quite a problem!

Instructor: This is the field of what is known as very high technologies and top secret know-how. Now let's see once more the principles upon which the gas turbine operates...

Peter: I can see on this diagram that the nozzle guide vanes form convergent passages. Are they really convergent?

Instructor: They are. These convergent passages cause the gases to accelerate just before they strike the blades of the turbine.

Peter: The turbine blades also seem to be twisted. What is this twist for? **Instructor:** Yes, their stragger angle is greater at the tip than at the root. This ensures that the gases do equal work throughout the length of the blade, and that they leave the turbine at a uniform axial velocity.

Helen: How many turbines may have modern high by-pass ratio engines?

Instructor: Modern high by-pass ratio jet engines may have three gas turbines, and three concentric shafts, running independently. This forms a triple spool system.

Helen: What are the advantages of triple spool jet engines?

Instructor: Such engines are very fuel efficient and also extremely quiet.

Topic 9

The Exhaust System

The exhaust system of a jet engine passes the turbine discharge gases to atmosphere at a velocity, and in the required direction, to provide the resultant thrust. Great care must be taken in the design of the exhaust system at the rear of the engine. If the flow of exhaust gases is impeded by too small an exit, temperatures and pressures will be built up inside the engine, while too large an exit will make them fall, and create a loss of thrust.

When afterburning is in operation, the area of the exhaust nozzle can be increased by opening two eyelids that partially obstruct the nozzle aperture when closed. The pilot actuates these eyelids by pneumatic rams, which in turn are linked to the fuel supply system. As they are open the supply of fuel is increased.

By-pass engines can benefit spectacularly from the use of afterburning. Thrust can be increased by 70% or more for short periods of time. This enables the airplanes to reach an economical cruising height far more quickly than planes not fitted with afterburners.

As a rule, it can be said that forward thrust is created wherever there are divergent passages which convert velocity into pressure energy. Following the air as it passes through the engine, we see that considerable thrust is developed in the compressor because of the rise in pressure there.

Comprehensive Text-Related Glossary

exhaust system [ɪɡ'zɔ:st 'sɪstɪm] - выхлопная система
discharge gases ['dɪsʧɑːʤ] - газы на выходе турбины
to provide [prə'vaɪd] - обеспечивать; создавать
to take great care [kɛə] - обращать особо большое внимание
at the rear [rɪə] - в задней части
to impede [im'pi:d] - препятствовать
exit [’eksit] - выходное отверстие
to build up - нарастать
to make fall [fɔ:l] - приводить к падению
loss of thrust - потеря тяги двигателя
afterburning ['ɑ:ftəˌbə:nɪŋ] - дожиг топлива
to be in operation [ˌɔpə'reɪʃən] - быть включённым, при включённом
area ['ɛərɪə] - площадь
eyelids ['aɪlɪd z] - створка, заслонка
partially ['pɑ:ʃəli] - частично
to obstruct [əb'strʌkt] - перекрывать, загораживать
nozzle aperture ['æpətʃə] - отверстие сопла
to actuate ['æktjueɪt] - приводить в действие
pneumatic rams [nju:'mætɪk] - пневматические толкатели

in turn [in'tə:n] - в свою очередь
link [lıŋk] -связаны (с топливной системой)
supply of fuel [sə'plaı] - подача топлива
by-pass engines - двухконтурные двигатели
to benefit ['benıfıt] - существенно улучшать (свои показатели)
to enable [in'eibl] - давать возможность
to reach [ri:tʃ] - достигать
economical cruising height ['kru:zıŋ 'haıt] - высота экономичного крейсерского полета
not fitted - не оборудованные
divergent [daı'və:dʒənt] - расходящийся (канал)
to convert [kən'vɜːt] - преобразовать
considerable [kən'sıdərəbl] - значительный, существенный
rise ['raiz] - увеличение, рост (давления)

9.1. Questions for Arguments and Discussion

1. What does the exhaust system do to provide the resultant thrust?
2. Why the design of the exhaust system must be taken very carefully?
3. What are the consequences of choosing too small an exit for the flow of exhaust gases?
4. What are the consequences of choosing too large an exit for the flow of exhaust gases?
5. What can be done with the area of the exhaust nozzle when afterburning is in operation?
6. What do two eyelids do with the nozzle aperture?
7. By what device does the pilot actuate the eyelids?
8. To what system are pneumatic rams linked?
9. When is the supply of fuel increased?
10. From what can by-pass engines benefit?
11. By what amount does the use of afterburning increase thrust?
12. Why afterburning is used only for short periods of time?
13. What does the short application of afterburning enable the airplanes to reach far more quickly?
14. In comparison with what does the short application of afterburning enable the airplanes to reach an economical cruising height for more quickly?
15. When is forward thrust created?
16. What do divergent passages do?
17. Where is considerable thrust developed?
18. or what reason is considerable thrust developed in the compressor?

9.2. Suggested Topics for Presentations and Reports

1. Criteria applicable for exhaust system evaluation
2. Design and construction of modern exhaust systems

3. Afterburners in high by-pass ratio jet engines
4. Thrust reversal systems
5. Exhaust systems of vectored thrust jet engines
6. Environmentally clean and quiet exhaust systems

9.3. Aviation Talk

Instructor: This is our final Aviation Talk in the present series. We have discussed Airframe and Powerplant, but. for obvious considerations of space and time, we have omitted some important items, such as:

- Fuel, Oil, Air, and Hydraulic systems
- Electric systems, Starting and Ignition
- Controls and Instrumentation
- **-**Installation and Maintenance

Peter: But we can discuss them very briefly, just to get an idea of what they are for!
Instructor: This is what I have just planned to do, but at the end of our present sessions. But presently we have to return to our final talk on Exhaust Systems. And our first item for discussion will be quite obvious: What are these systems for?
Helen: The answer is just as obvious: The exhaust systems are the devices for passing the turbine discharge gases to atmosphere to provide the resultant thrust.
Instructor: What will be the results of choosing too small or too large ал exit for the flow of exhaust gases?
Peter: When the exhaust gases are flowing through too small an exit, temperatures and pressures inside the engine will be gradually building up, and disastrous results become more and more possible.
Helen: What do you mean by disastrous results?
Instructor: The very first result will be the surge in the axial compressor.
Peter: But I have not completed yet! When the exhaust gases are flowing through too large an exit, temperatures and pressures inside the turbine will be lower than nominal with the resultant loss of thrust.
Helen: And this is just the case for switching the afterburner on!
Instructor: Switching the afterburner on is a very expensive operation and must be justified by actual requirements of flight. How does the pilot switch the afterburner on when it is really necessary?
Peter: When the plane is climbing, the pilot switches the afterburner on by pneumatic rams, which open the eyelids and at the same time open up the supply of fuel.
Instructor: Which jet engines can benefit most from the use of afterburners?
Helen: These are by-pass engines. Some of them can increase thrust by more than 70% for short periods of time needed for climbing.
Instructor: Now our final question. When is forward thrust created?
Peter: Forward thrust is created in all cases when the air flows through divergent passages or when the pressure of that air increases.
Helen: But we have not discussed on-board systems yet!

Peter: And the first question to this effect will be about fuel systems. How does the pilot control speed? Does he vary the flow of fuel?

Instructor: Yes, in a way. But things are actually more complicated. An engine's thrust depends upon the weight of air passing through it, and this weight varies according to the aircraft's speed, its altitude and the temperature of the air itself.

Helen: You mean that if any of these alter, then the speed of the plane will alter too?

Instructor: Precisely.

Peter: That could be dangerous!

Instructor: Yes, but in fact every engine is fitted with an automatic control unit that senses these variable and applies the necessary corrections.

Helen: Our next question will be connected with oil systems. How does the pilot know oil temperature?

Instructor: Oil temperature is sensed by temperature-sensitive element fitted in the oil system. A change in temperature causes a change in the resistance value and a corresponding change in the current flow at the indicator.

Peter: Now we would like to know something about air systems. Cabins and deicing systems must be supplied with some hot air. Where does it come from?

Instructor: The hot air for different needs is usually taken from the last stage of the compressor.

Helen: Our next question is connected with the hydraulic system. What is this system for?

Instructor: The hydraulic system provides *a* very simple and efficient method of transmitting power by means of liquid under pressure. Hydraulic actuators operate all airplane controls - rudders, elevators, and ailerons.

Peter: Next we have the electric system, starting and ignition.

Instructor: The electric system operates on alternating current, produced by on-board AC generators. Aviation standards of AC are: frequency of the current - 400 cycles per second, voltage - 117 volts.

Peter: But you have not said anything about starting and ignition!

Instructor: Starting and ignition come separately. Two separate systems are required to start a jet engine: a low-voltage electrical starting system, and igniting system. During engine starting the two systems must operate simultaneously.

Helen: Controls and instrumentation is our last but one problem.

Instructor: The controls are designed to make the handling of the engines as simple as possible. It means that the plane flies at the right speed for a given throttle setting, whatever the actual operating conditions.

Peter: But what does the instrumentation system do?

Instructor: It shows to the pilot the actual power output of the engines, temperature of the gases, entering the turbines and jet pipe temperatures.

Helen: Our final item for discussion is installation and maintenance. But clearly this item is only the last, but not the least in importance.

Instructor: Modern jet engines can be placed almost anywhere, provided they remain accessible for maintenance and repairs. Presently almost all jet engines are made in modular form to facilitate the rapid replacement of worn assemblies.

The adoption of on-board computers, modular construction, and on- condition maintenance has stimulated the development of monitoring instruments, sensors, and early warning systems, improving overall reliability of air transportation.

Peter: What does modem on-condition maintenance come to?

Instructor: For all of us modem on-condition maintenance means transition from old, on-time types of maintenance, to new and progressive types, based on exact information about actual conditions of all components. This information is supplied to the on-board computer by numerous sensors, monitoring actual operating conditions of all critical components of the airplane.

Peter, Helen: We all thank you for answering our questions and for clear presentation of new and sometimes quite complex material Thank you!

Part 2

Computer Science Fundamentals

Topic 10

Electric Current

Electric current is traditionally defined as the ordered flow of electrons in a conductor. As conductors we can use all metals. Metals are good conductors because they have free electrons. The best conductors are metals silver, gold, copper, and aluminum.

There are two types of electric current. The first type is called direct current (DC), the second type is called alternating current (AC). Direct current is the current which always flows in one direction. There are two directions of DC flow. One direction is from positive potential (+) to negative potential (-), and it is called technical direction of DC flow. The second direction is from negative potential (-) to positive potential (+) and it is called scientific direction of DC. Negative potential corresponds to excess of electrons, positive potential corresponds to their deficit. The technical direction of DC flow appeared when people started using DC for practical applications without knowing anything about electrons.

Alternating current (AC) is the current which changes its direction many times per second. The number of changes of direction per second is called frequency of AC. Frequency of AC in the mains in Russia is 50 (fifty) cycles per second, voltage, is 220 (two hundred and twenty) volts. Frequency of AC in the mains in the USA is 60 (sixty) cycles per second. Frequency of AC in the mains on board of aircraft is 400 (four hundred) cycles per second, voltage is 117 (one hundred and seventeen) volts. Frequencies of AC are different because there is a design rule, which reads: "The higher is the frequency of AC the smaller and lighter are all power transformers on board".

Electric current is measured in amperes (A). One ampere is defined as one coulomb per second. One coulomb of electricity is the amount of electrons, which, flowing through a solution of nitrate of silver, deposits 1.118 milligrams of silver on the electrode. Practically used units for measuring electric current are milliamperes (mA) and microamperes (μA).

Comprehensive Text-Related Glossary

electric current ['kʌrənt] - электрический ток
conductor [kən'dʌktə] - проводник (электрического тока)
silver ['sɪlvə] - серебро
gold [gould] - золото
copper ['kɔpə] - медь
direct current [di'rekt] - постоянный ток
alternating current ['ɔ:ltəneɪtɪŋ] - переменный ток
scientific [, saiən'tifik] - научный
excess [ik'ses] - избыток
deficit ['defisit] - недостаток

application [ˌæplɪ'keɪʃən] - применение, приложение
frequency ['fri:kwənsɪ] - частота
in the mains ['meinz] - в сети (переменного тока)
on board [bɔ:d] - на борту (самолета)
design rule [dɪ'zaɪn ru:l] - правило проектирования
power transformer ['pauə , træns'fɔ:mə] - силовой трансформатор
to measure ['meʒə] - измерять
amount [a'maunt] - количество
solution [sə'lu:ʃən] - раствор
to deposit [dɪ'pɔzɪt] - откладывать (из раствора)
units ['ju:nɪt] - единицы измерения
microamperes [,maikrɔuəm'pi: əz] - микроамперы

10.1. Questions for Argument and Discussion

1. What is electric current?
2. What substances can be used as conductors?
3. Why all metals are good conductors?
4. Which metals arc the best conductors?
5. What types of electric current do you know?
6. What is direct current?
7. How many directions of direct current flow do we know?
8. In what direction does direct current actually flow?
9. What is the meaning of positive potential?
10. What is the meaning of negative potential?
11. What is alternating current?
12. What is frequency of alternating current?
13. What is frequency of AC in the mains in Russia?
14. What is frequency of AC in the mains in the USA?
15. What is frequency of AC in the mains on board of Civil Aviation airplanes?
16. Why frequencies of AC are different?
17. What units are used for measuring electric current?
18. How do we define one ampere?
19. What values do we measure in coulombs?
20. What is one coulomb of electricity?
21. What units for measuring electric current are used practically?

10.2. Suggested Topics for Presentations and Reports

1. Principles of generation ,of alternating current
2. Principles of generation of direct current
3. Conductors and superconductors of electric current
4. Frequency of alternating current
5. Measurements of current and voltage
6. AC and DC generators on board of Civil Aviation airplanes.

10.3. Aviation Talk

Instructor: Presently we are starting Part Two of our series of topics, called "Computer Science Fundamentals". These topics are aimed at promoting understanding of general principles of operation of on-board, or flight, computers. Our first topic in this series is called "Electric Current".
Peter: I understand that all power supply units of computers require alternating current for their operation. As we all know, to alternate means to change.
Instructor: By definition, alternating current is the current that changes its direction of flow many times per second.
Helen: But what does alternating current have to do with computers?
Instructor: All computers take their power from the mains. And in the mains we have alternating current which must be converted into direct current, used by all computers.
Peter: Why do we always and everywhere have alternating current in the mams?
Instructor: AC is so popular because of its very important advantage - transform ability.
Helen: And what does it mean?
Instructor: It means that we can change its voltage according to our needs by using stepping-up or stepping-down transformers.
Helen: But AC has another parameter, which can be changed - frequency.
Peter: I've never heard anything about changing frequency of AC. Up to now, at least.
Instructor: We do not change frequency, we choose it from the very beginning.
Helen: We've already heard that the higher is the frequency in the mains the smaller and lighter ere all power transformers. Why not to have in our mains alternating current of a higher frequency?
Peter: Yes, why not to have in our mams 400 cycles per second AC, as in aviation? Our home TV sets would be twice as light.
Instructor: We must not forget about radiation losses involved. The higher is the frequency in the mams, the higher are radiation losses in transmission lines. And distances in our country are really great The present value of 50 cycles per second is optimum.
Helen: How do we measure AC?
Instructor: Current is measured by connecting the meter in series. That means that we have to disrupt the circuit first, then we have to connect the meter so that all current would flow through the meter.
Helen: And in what units do we measure current?
Instructor: Current is measured in amperes, milliamperes, or microamperes, depending on strength of the current.
Peter: What kind of meters do we use for measuring current?
Instructor: For measuring current we use meters with very low inner resistance.
Helen: Sometimes we have to measure voltage. What kind of meters do we use in this case?
Instructor: For measuring voltage we use meters with very high inner resistance. And we must not forget what in this case we connect the meter in parallel.
Peter, Helen: We both thank you for answering our questions. Thank you!

Topic 11

Transformer

Transformer is an electro-mechanical device for changing the ratio between current and voltage. All transformers operate on the principle of electromagnetic induction, which means crossing the conductor by magnetic lines of force. All transformers consist of three main parts: (1) Primary winding, which is connected to the mains; (2) Iron core, which concentrates magnetic lines of force and makes all of them cross the secondary winding; (3) Secondary winding, which is connected to the load of the transformer.

There are two practically used types of electrical transformers: (1) Stepping-up transformers, in which the number of turns in the secondary winding is higher than the number of turns in the primary winding of the transformer, and (2) Stepping-down transformers, in which the number of turns in the secondary winding is lower than the number of turns in the primary winding. Transformers are described by their operating power, operating frequency, and transformation ratio. Operating power of a transformer is calculated as the product of current by voltage in its secondary winding under conditions of maximum loading. By operating frequency is usually understood the frequency in the mains for which the specific transformer is designed. Power transformers, designed for 60 cycles per second operation will not operate in the 50 cycles per second mains because of overheating and ultimate failure. Encapsulated on-board transformers, designed for operation in the 400 cycles per second mains, in the 50 cycles per second mains quickly overheat and in some cases explode. Transformation ratio of a transformer is the ratio of the number of turns in its primary winding to the number of turns in its secondary winding.

The operating of ideal, or lossless transformers is described by the rule of transformation, which reads: 'The product of current by voltage in the primary winding is always equal to the product of current by voltage in the secondary winding". All real transformers have losses and beat during operation. The common source of losses is low-quality iron in the iron core of the transformers.

Comprehensive Text-Related Glossary

device[di'vais] -устройство
ratio ['reɪʃɪou] - отношение (величин)
magnetic lines of force [' fɔ:s] - магнитные силовые линии
primary winding ['praɪmərɪ waɪnd] - первичная обмотка (трансформатора)
the mains ['meinz] - сеть (переменного тока)
iron core ['aɪən 'ko:] - железный сердечник
secondary winding ['sekəndərɪ] - вторичная обмотка (трансформатора)
stepping-up transformer [,stepiŋ'ʌp, træns'fɔ:mə] - повышающий трансформатор
number of turns [tə:nz] - число витков
operating power [,ɔpə'reɪtiŋ] - рабочая (номинальная) мощность

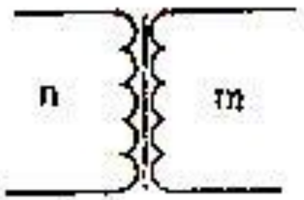
operating frequency ['fri:kwənsı] - рабочая частота
transformation ratio [ˌtrænsfə'meıʃən] - коэффициент трансформации
under conditions ['ʌndə , kən'dıʃənz] - в условиях; при работе в режиме
loading ['ləudıŋ] - нагрузка; под нагрузкой
is designed [, iz di'zaind] - спроектирован
overheating ['əuvə'hi:tiŋ] - перегрев
ultimate ['ʌltımıt] - завершающий, конечный
failure ['feıljə] - отказ, авария
encapsulated [in, 'kæpsju: 'leitid] - герметизированный
to explode [ıks'ploud] - взрываться
lossless ['lɔslis] - без потерь
rule [ru:l] - правило
which reads ['ri:dz] - которое гласит
product ['prɔdʌkt] - произведение
is equal ['i:kwəl] - равно
to heat ['hi:t] - нагреваться
common source ['kɔmən ' sɔ:s] - обычная, распространенная причина
low-quality [, lou 'kwɔliti] - низкокачественное (железо).

11.1 . Questions for Argument and Discussion

1. What do we use transformers for?
2. On what principle do all transformers operate?
3. What does electromagnetic induction mean?
4. What parts do all transformers consist of?
5. Where is primary winding connected to?
6. Where is secondary winding connected to?
7. What does the iron core of a transformer do?
8. How many types of transformers do we know?
9. In what cases do we use stepping-up transformers? What are they?
10. In what cases do we use stepping-down transformers? What are they?
11. Can you think of a transformer. which is neither stepping-up nor stepping down?
12. What parameters are used for describing all transformers?
13. What is operating, or nominal, power of a transformer?
14. What is operating, or nominal, frequency of a transformer?
15. Will 60 cycles per second transformers operate in a 50 cycles per second mains? For what reason?
16. What will be the result of connecting a 400 cycles per second aviation transformer to the 50 cycles per second mains?
17. What is transformation ratio of a transformer?
18. What does the rule of transformation read?
19. To which transformers is the rule of transformation applicable?
20. What is the most common source of losses in all transformers?

(1) TRANSFORMER

General View

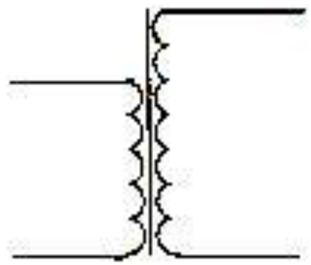


Iron core

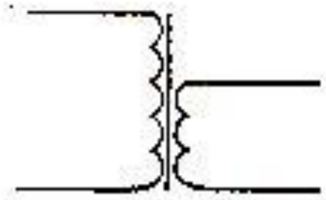
Primary winding,
n – number of turns
in the primary
winding

Secondary winding,
m – number of turns
in the secondary
winding

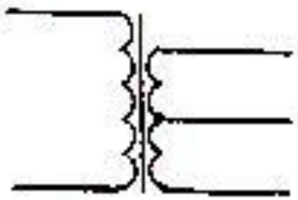
(2) STEPPING-UP
TRANSFORMER
$n<m$



(3) STEPPING-DOWN
TRANSFORMER
$n>m$

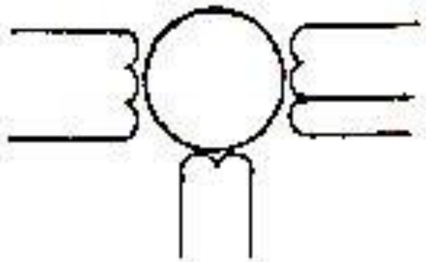


(4) STEPPING-DOWN
TRANSFORMER,
the secondary winding
of which has a center tap



(5) AUTOTRANSFORMER

(6) TOROIDAL TRANSFORMER



11.2. Suggested Topics for Presentations and Reports

1. 50-cycles per second, 60-cycles per second, and universal power transformers
2. 400-cycles per second aviation transformers
3. Variable transformation ratio autotransformers
4. Low-losses power transformers
5. Special applications transformers.

11.3. Aviation talk

Instructor: On board of modern airplanes there are up to eight hundred of different transformers and great care is taken to reduce their weight and number to an absolute minimum. But do we have any reserves?

Peter: What do these transformers do? Why not to get rid of them altogether?

Instructor: Almost all on-board transformers are of a stepping-down type. All on-board electronic devices and their integrated circuits require + 12 volts DC for their operation. We have to step down the AC voltage from the mains up to this value and then to convert it into DC.

Helen: Can’t we get round this problem end reduce the weight of iron? I’ve heard about practically lossless toroidal magnetic circuits.

Instructor: This is a doughnut-shaped piece of magnetic material, together with several coils of current-carrying wire wound about the toroid. If the permeability of the magnetic material is high enough, the magnetic flux is completely confined within it.

Peter: Does the word "completely" mean that there are no losses?

Instructor: It does mean exactly this.

Helen: Then why not to use toroidal transformers everywhere?

Instructor: There is one snag about toroidal transformers: they are difficult to manufacture and very expensive.

Peter: Do we have any other devices in the primary winding circuit of a transformer?

Instructor: In the primary winding circuit of a power transformer we also find such devices as an on-off switch and a fuse.

Helen: We know something about them. The on-off switch switches the computer on or off. I can see this switch on the front panel of my computer. I am not so sure about the fuse. Does it protect the computer from overloads?

Instructor: It does. It is a small device which disrupts the primary winding circuit when the current exceeds the nominal value. Usually you can find it on the back panel of your computer.

Topic 12

Rectifier

Rectifier is an electronic device for converting alternating current from the mains into direct current, necessary for computer circuits. All rectifiers operate on the principle 6f one-way conductivity of a rectifying diode. One-way conductivity means that the rectifying diode conducts current in one direction and does not conduct current in the opposite direction.

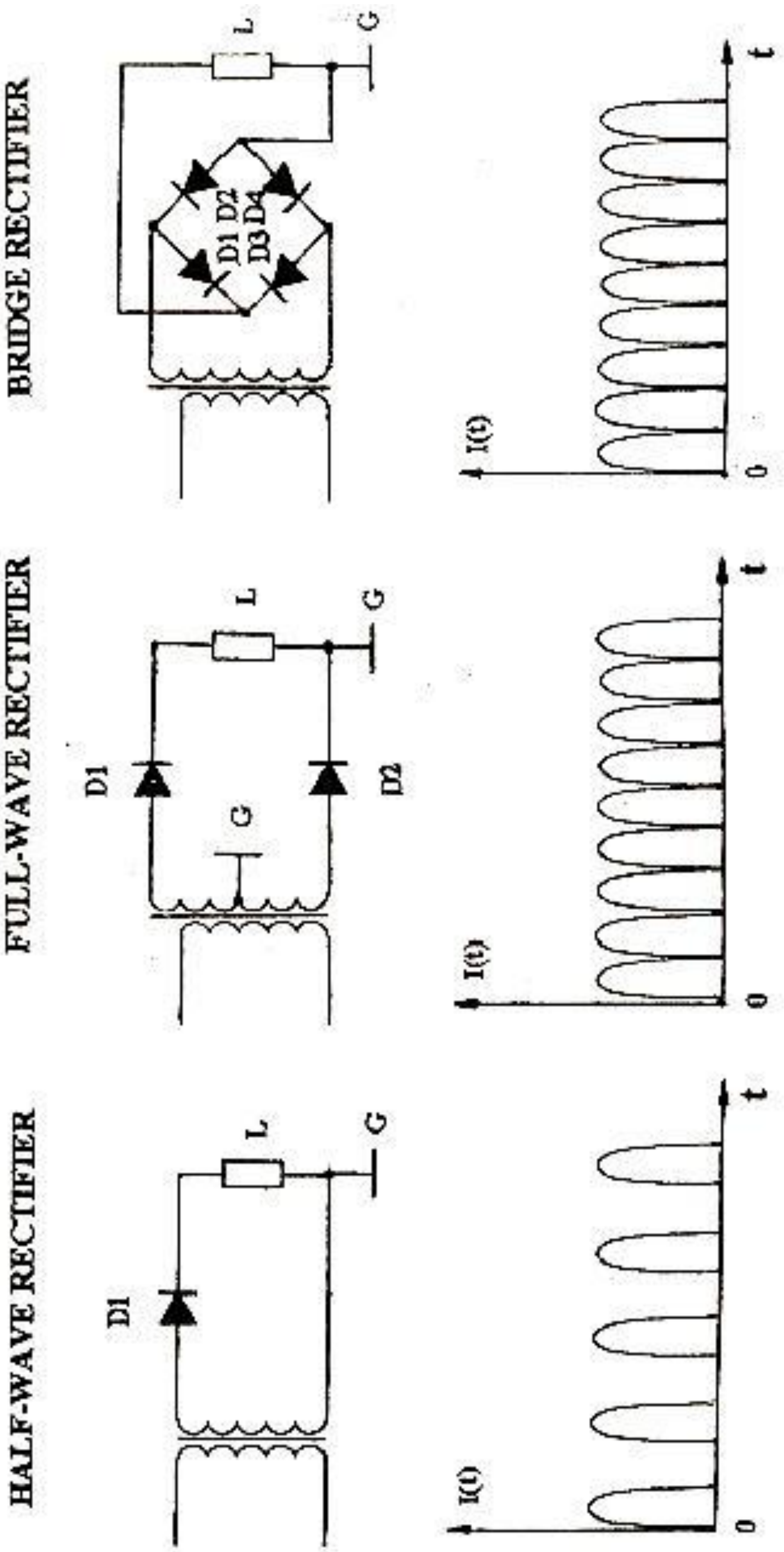
All rectifiers consist of three main parts: (1) Power transformer, which is connected to the mains, (2) Rectifying diode, (.t)Load. There are two mam types of rectifiers. The first type is called half-wave rectifier, the second type is called full-wave rectifier. In a half-wave rectifier the secondary winding of the power transform er does not have any center tap and the frequency of pulsations at the output is fifty cycles per second. In a full-wave rectifier the secondary winding of the power transformer has a center tap, which is grounded, and there are two rectifying diodes The pulsations frequency at the output of a full-wave rectifier is one hundred cycles per second, which is much easier to filter out.

During the first half-cycle of the AC voltage, the electro-motive force (EMF), developed in the secondary winding of the power transformer, drives the current from the ground to the rectifying diode. In this direction the diode conducts and the current flows through the load. During the second half-cycle the electro-motive force changes for the opposite and drives the current from the diode to the ground. In this direction the diode does not conduct and no current flows through the load

The frame of reference, used for plotting the functional dependence of current from times called the rectangular frame of reference. It consists of the origin and two axis - the axis of the variable (horizontal) and the axis of the function (vertical).

Text-Related Glossary

rectifier ['rektıfaıə] - выпрямитель
necessary [**necessary**] - необходимый, нужный
circuits ['sə:kıt s] - схемы, электронные устройства
one-way conductivity [,wʌn ' weı , kɔndʌk'tıvıtı] – односторонняя проводимость
load ['loud] - нагрузка (устройство, питаемое от выпрямителя)
half-wave rectifier [' hɑ:f weiv] - однополупериодный выпрямитель
full wave rectifier ['fulweiv] - двухполупериодный выпрямитель
center tap ['sentə ' tæp] - отвод от центральной части вторичной обмотки трансформатора
is grounded ['graundid] - заземлен
pulsations frequency [,pʌl'seıʃənz 'fri:kwənsı] – частота пульсаций (на выходе выпрямителя)


HALF-WAVE RECTIFIER
D1
L
G
I(t)
0
t
FULL-WAVE RECTIFIER
D1
G
L
D2
G
I(t)
0
t
BRIDGE RECTIFIER
D1 D2
D3 D4
L
G
I(t)
0
t

to filter out [, flitə 'aut] - отфильтровать, удалить с помощью сглаживающего конденсатора
electro-motive force [,ɪ'lektrəu 'moutiv ' fɔ:s] - электродвижущая сила, ЭДС
to drive ['draiv] - заставлять двигаться, заставлять протекать
ground ['graund] - заземление, земля (схемы)
rectifying diode [,'rektɪfaɪŋ dai'oud] - выпрямляющий диод
frame of reference [' freɪm ɔv 'refərəns] -система координат
to plot [' plɔt] - строить (кривую)
functional dependence ['fʌŋkʃənl dɪ'pendəns] - функциональная зависимость
rectangular [rek'tæŋgjulə] - прямоугольный
origin ['ɔrɪdʒɪn] - начало (системы координат)
axes [' æks si:z] - оси (pi.); **axis** [' æks siz] - ось (sing.)

12.1. Questions for Argument and Discussion

1. What are rectifiers for? Where are they used?
2. What is the principle of their operation?
3. What parts does a rectifier consist of?
4. How do we understand one-way conductivity?
5. What types of rectifiers do we know?
6. How do we call the first type of rectifiers?
7. Why these rectifiers are called half-wave?
8. What is the pulsation frequency at the output of these rectifiers?
9. What are advantages and drawbacks of half-wave rectifiers?
10. How do we call the second type of rectifiers?
11. Why these rectifiers are called full-wave?
12. What parts does a full-wave rectifier consist of?
13. How many diodes does a full-wave rectifier use?
14. What is the pulsation frequency at the output of a full-wave rectifier?
15. What are advantages and drawbacks of full-wave rectifiers?
16. How can we convert pulsating current into direct current?
17. What must we use for visual presentation of functional dependence of rectified current from time?
18. What are the main parts of the rectangular frame of reference?
19. What do we usually plot along the horizontal axis of the rectangular frame of reference?

12.2. Suggested Topics for Presentations and Reports

1. General principles of rectification
2. Half-wave, full-wave, and bridge rectifiers
3. Conversion of pulsating current into direct current
4. General principles of filtering of pulsating currents
5. Criteria, applicable for evaluating quality of DC supplies
6. Sources of on-board DC power.

12.3. Aviation Talk

Instructor: Our present discussion is devoted to rectification and rectifiers. We know that rectification means conversion of AC (Alternating Current) into DC (Direct current).
Peter: Why not to have DC in the mains from the very beginning?
Instructor: There is one trouble with direct current - it is not transformable, which means that we can not step it down or step it up, according to our needs.
Peter: All car drivers know that there are devices called choppers, which do just this.
Helen: You mean that these choppers change the ratio between DC current and DC voltage?
Peter: They do just this. They transform direct current.
Instructor: But here we must not forget that choppers first convert DC into AC, then they change the ratio between current and voltage of the obtained AC, and finally the convert AC into DC, but with the ratio between current and voltage which we need.
Helen: There is one snag about rectifiers which I do not understand. After rectification we obtain pulsating current, but we need direct current. How do we solve this problem?
Instructor: The solution is very simple. We connect a condenser across the load. The higher the capacity of this condenser, the more direct, more smooth will become our direct current.
Peter: The operation of getting rid of all AC components out of our DC is called filtering or smoothing. Is it possible to obtain DC which does not contain any AC components?
Instructor: This type of DC can be obtained with the help of accumulators, batteries, cells and other chemical sources of current.
Helen: Once you have mentioned frames of reference and said something about the polar frame of reference. What is it for?
Instructor: The choice of the most suitable frame of reference depends on your variable. If you have to rotate something and observe what happens after each 10, 20, 30, and so on degrees of rotation, then your obvious choice will be the polar frame of reference.
Peter: It is very suitable for adjusting ignition moments of reciprocating engines.
Instructor: It is a very good example. Another example is directivity patterns of on-board radar antennas.

Topic 13

Amplifier

Amplifier is an electronic device or stepping up power of the signal. All amplifiers operate on the principle of controlling very large amounts of output power by very small amounts of input power, applied to the control electrode. Amplification factor of an amplifier is calculated as the ratio of its output power to input power. There are two main types of amplifiers: (1) Vacuum tube amplifier, and (2) Transistor, or solid state, amplifier,

Vacuum tube amplifier consists of plate, control grid, cathode, and filaments. Plate collects electrons, flying from cathode. Control grid controls current, flowing through the tube. Cathode emits electrons. Filaments heat the cathode, enabling the process of electronic emission. By their nature vacuum tubes are high voltage devices because voltages are high, but currents are low.

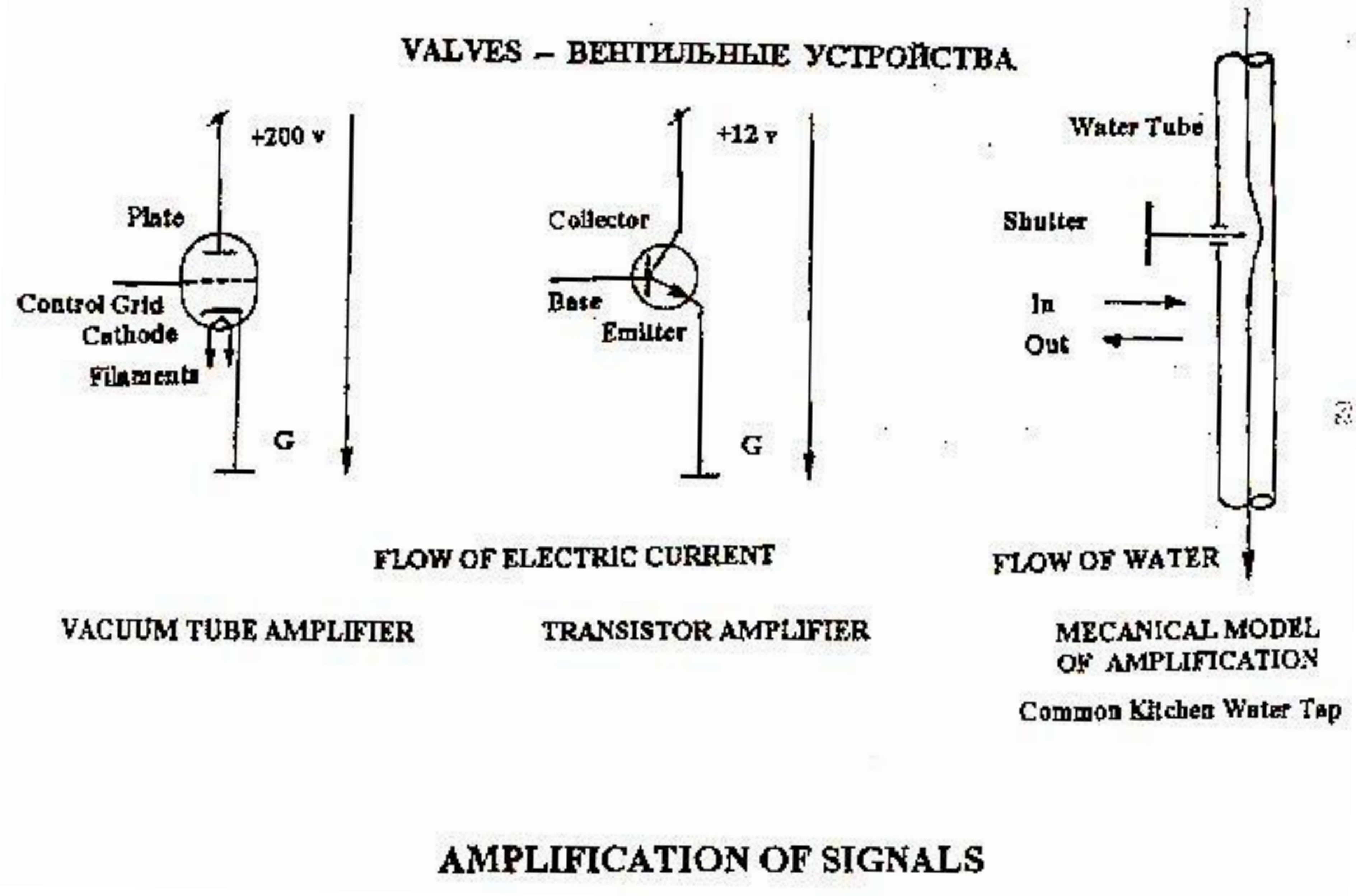
Transistor amplifier consists of collector, base, and emitter. Base controls current flowing through the transistor. Emitter emits electrons. Collector collects electrons, arriving from emitter. By their nature transistors are current devices because currents are high, but voltages are low.

Mechanical, electric, and electronic devices, controlling very large amounts of output power by means of very small amounts of input power, applied to the control organ, are defined as valves. In this respect common kitchen water taps are typical valves because they control very large water flows practically effortlessly. Vacuum tubes and transistors do the same, but with flows of electrons.

Feedback in amplifiers is defined as application of a part of output signal to the input Feedback is positive when the phases of input signal and of feedback signal are the same. Positive feedback turns amplifiers into generators. Feedback is negative when the feedback signal is out of phase with the input signal. Negative feedback amplifiers feature low distortion and high stability.

Comprehensive Text-Related Glossary

amplifier ['æmplɪfaɪə] – усилитель
to apply [ə'plaɪ] - прикладывать к … , подавать на...
amplification factor [ˌæmplɪfɪ'keɪʃən] - коэффициент усиления
ratio ['reɪʃɪəu] - отношение (величин)
output power ['autput 'pauə] - выходная мощность
input power ['input] - мощность сигнала на входе, входная мощность
vacuum tube amplifier ['vækjuəm 'tju:b] - усилитель на электронных лампах, ламповый усилитель
solid state ['solid 'steit] - (усилитель) на интегральных схемах, твёрдотельный (усилитель)
plate ['pleit] - анод (электронной лампы)


VALVES – ВЕНТИЛЬНЫЕ УСТРОЙСТВА
+200 v
Plate
Control Grid
Cathode
Filaments
G
+12 v
Collector
Base
Emitter
G
Water Tube
Shutter
In
Out
FLOW OF ELECTRIC CURRENT
FLOW OF WATER
VACUUM TUBE AMPLIFIER
TRANSISTOR AMPLIFIER
MECANICAL MODEL
OF AMPLIFICATION
Common Kitchen Water Tap
AMPLIFICATION OF SIGNALS

control grid ['grid] - управляющая сетка
cathode ['kæθəud] - катод
filaments ['fɪləmənts] - нити накала (катода)
base ['beis] - база, управляющий электрод транзистора
collector [kə'lektə] - коллектор транзистора
emitter [ɪ'mɪtə] - эмиттер транзистора
to flow through [' fləu ' θru:] - протекать через (электронную лампу)
to heat [hi:t] - нагревать (катод)
to enable [ɪ'neɪbl] - делать возможным
by their nature ['neɪtʃə] - по своей природе
high voltage devices [' haɪ ' vəultɪdʒ dɪ'vaɪsiz] – высоковольтные приборы, приборы с высоким внутренним сопротивлением
current devices ['kʌrənt] - токовые приборы (с низким внутренним сопротивлением)
amounts [ə'maunts] - величины
in this respect [ri'spekt] - в этом отношении
common kitchen water taps ['kɪtʃɪn] - обычные кухонные водопроводные краны
valves [vælvz] - вентили, вентильные приборы
effortlessly ['efətlɪslɪ] - без видимых усилий, без затраты мощности
to do the same [seɪm] - делать то же самое
feedback ['fi:dbæk] - обратная связь (в усилителях)
application [ˌæplɪ'keɪʃən] - подача (сигнала)
to turn into [tə:n] - превращать (в генераторы)
to be out of phase ['aut ɔv feiz] - быть в противофазе, изменяться в противоположных направлениях
to feature ['fi:tʃə] - характеризоваться, демонстрировать
low distortion [dɪs'tɔ:ʃən] - низкие искажения
high stability [stə'bɪlɪtɪ] - высокая устойчивость

13.1. <u>Questions for Argument and Discussion</u>

1. What are amplifiers used for?
2. What is the principle of their operation?
3. What does the control electrode of an amplifier do?
4. How is the amplification factor of an amplifier defined?
5. How many types of amplifiers do we know?
6. What are the main components of a vacuum tube amplifier?
7. What does the control grid of a vacuum tube amplifier do?
8. Why is it necessary to heat the cathode?
9. Why vacuum tubes are called high voltage devices?
10. What parts does a transistor amplifier consist of?
11. Why transistors are called current devices?
12. What does the base electrode of a transistor amplifier do?

13. What does the emitter electrode of a transistor amplifier do?
14. What does the collector electrode of a transistor amplifier do?
15. Is there anything in common between the base electrode of a transistor and the control grid of a vacuum tube?
16. How do we generally call devices controlling large amounts of output power by means of small amounts of input power?
17. What is feedback?
18. What types of feedback do we know?
19. What is positive feedback? What do we use it for?
20. What is negative feedback?
21. What are the results of negative feedback application?
22. What parameters of amplifiers are considered as most critical?

13.2. Suggested Topic for Presentations and Reports

1. General principles of amplification
2. Current and voltage amplifiers
3. Audio and video amplifiers
4. Most critical parameters of amplifiers
5. Criteria, applicable for evaluation of amplifiers
6. Negative and positive feedback in amplifiers
7. Phase relationships in amplifiers
8. Stability of amplifiers.

13.3. Aviation Talk

Instructor: Presently it is really very difficult to find an on-board device without a built-in amplifier. This is especially true respective avionic equipment and on-board computers.
Peter: What requirements must these amplifiers satisfy?
Instructor: They must only amplify, that is they must step up only the amplitude of the signal, all other parameters must be left intact.
Peter: What are these parameters?
Instructor: They are phase and frequency characteristics, or responses. All modern amplifiers are negative feedback amplifiers, that is they use negative feedback to improve their quality
Helen: Does quality mean high fidelity sound?
Instructor: It does, but this terra is commercial and is not suitable for our purposes. In science sound quality is measured in percentages of distortion and in signal-to-noise ratios.
Helen: What is meant by distortion?
Instructor: By low or zero distortion amplifier we understand amplifier which increases only amplitude of the signal without adding or removing anything.
Peter: In other words, the amplifier must be absolutely impartial and amplify all

frequency components of the signal equally well.
Instructor: But all real amplifiers distort, that is they add some new frequencies of their own and remove or diminish some frequencies of the signal. The summary percentage of such changes is called distortion.
Helen: You have also mentioned that signal-to-noise ratio influences sound quality. What is meant by this?
Instructor: By noise we mean low frequency hum due to bad filtering and high frequency hiss due to low quality transistors of the amplifier.
Peter: How can we expose a noisy amplifier?
Instructor: It's very simple. Just turn your volume control to the maximum and listen.
Helen: And what will we hear?
Instructor: You'll hear your amplifier at its worst.

Topic 14

Trigger

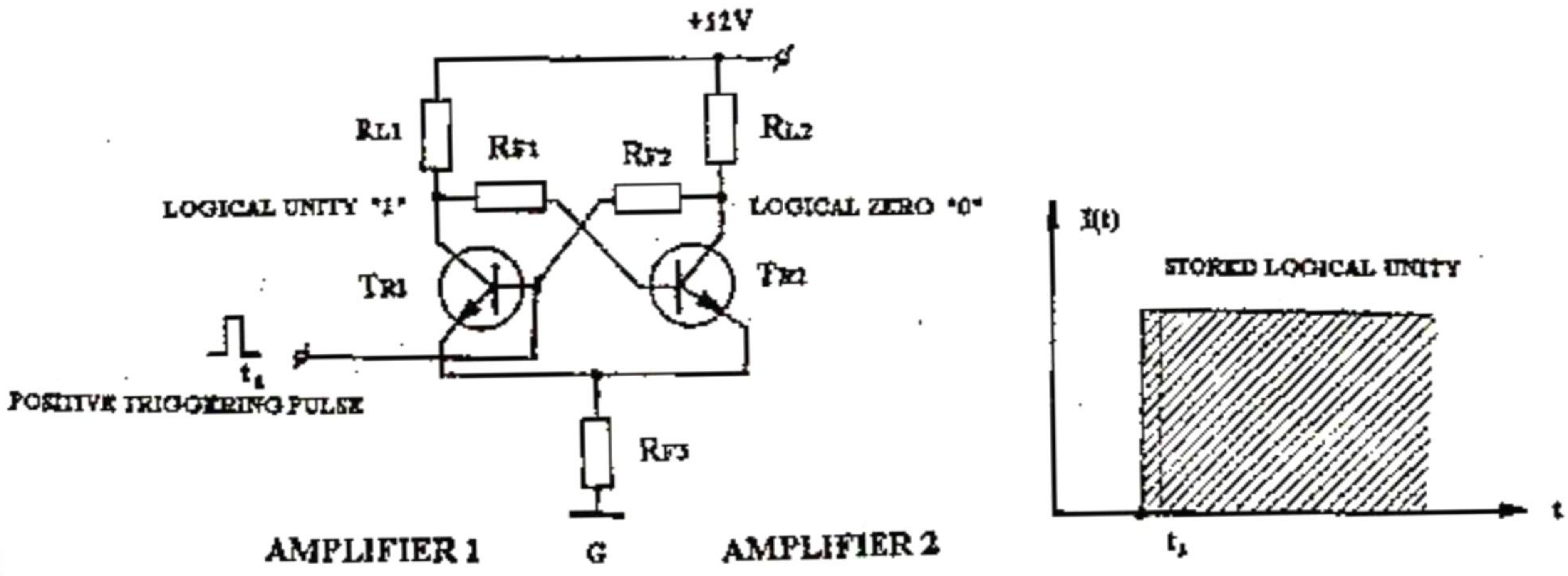
Trigger, or flip-flop, is an electronic device for storing one bit of data. Triggers consist of two amplifiers with feedback. All triggers operate on the principle of feedback, maintaining one amplifier open when the other amplifier is closed. Random access memories (RAMs) of all computers are nothing more but combinations of triggers. Single-in-line memory modules (SIMMs) and double-in-line memory modules (DIMMs) are just examples of random access memory units of modern computers.

Operation of a trigger begins with positive triggering pulse, applied to the base of the first amplifier. The amplifier opens, and its collector voltage drops because negatively - charged electrons arrive to it. This low collector voltage through feedback resistor is applied to base of the second transistor and closes it. The collector voltage of the second amplifier increases and through another feedback resistor maintains the open state of the first amplifier. The first amplifier remains open after the triggering pulse is over. *If* we agree that the open state of the first amplifier corresponds to logical unity (I), then we say that the collector current of the first amplifier stores the logical unity, while the collector current of the second amplifier stores the logical zero (0).

One bit of data, equivalent to saying yes or no, is the smallest unit for measuring data. One byte corresponds to eight bits of data. One megabyte corresponds to one million bytes. One gigabyte corresponds to one thousand megabytes. Modem computers feature random access memories of up to 10 or even 50 gigabytes.

Comprehensive Text-Related Glossary

trigger ['trɪɡə] - триггер, устройство для хранения одного бита информации
to store [stɔ:] - хранить (информацию)
feedback ['fi:dbæk] - обратная связь (в усилителях)
to maintain [meɪn'teɪn] - поддерживать, сохранять
random access memory ['rændəm 'ækses] - память со случайным доступом, оперативная память компьютера
single-in-line memory modules (SIMMs) ['sɪŋgl ɪn 'laɪn] - симмы, модули оперативной памяти с односторонним расположением блоков микросхем
double-in-line memory modules (DIMMs) ['dʌbl ɪn 'laɪn] - диммы, модули оперативной памяти с двусторонним расположением блоков микросхем (используются в современных компьютерах)
example [ɪg'zɑ:mpl] - пример
triggering pulse ['trɪɡərɪŋ ' pʌls] - запускающий импульс
to apply [a'plai] - прилагать, подавать
to drop [drɔp] - падать
arrival [ə'raɪvəl] - прибытие, поступление



TRIGGER (FLIP-FLOP)

STORING OF DATA

through feedback resistor [θru:] - через резистор обратной связи
remains open [ri'memz oupn] - остается открытым
after the triggering pulse is over ['iz 'ouvo] - после окончания запускающего импульса
to agree [ə'gri:] - приходить к соглашению; договориться
logical unity ['ju:nıtı] - логическая единица
logical zero ['zıərəu] - логический нуль
data ['deıtə] - информация
megabyte ['megəbait] - мегабайт, один миллион байтов
gigabyte ['gaigəbait] - гигабайт, одна тысяча миллионов байтов

14.1. Questions for Argument and discussion

1. What are triggers?
2. What parts do triggers consist of?
3. On what principle do all triggers operate?
4. What does feedback maintain?
5. How do we call devices which constitute random access memories of all computers?
6. What are SIMMs and where are they used?
7. What are DIMMs and in what they differ from SIMMs?
8. What type of computer memory is called random access memory?
9. What type of data does read-only memory (ROM) contain?
10. How is one bit of data stored by a trigger? What is the result of application of a positive triggering pulse to the base of the first transistor? What is the reason of closing of the second transistor? Why the first transistor of the trigger remains open after the positive triggering pulse is over?
11. To what state of the transistor does storing of a logical unity correspond?
12. To what state of the transistor does storing of a logical zero correspond?
13. What amount of data do you use when you say yes or no?
14. How many bits of data does one byte contain?
15. How many bytes of data does one megabyte contain?
16. How many bytes of data does one gigabyte contain?

14.2. Suggested Topics for Presentations and Reports

1. High-speed triggers for computers with 500-700 megacycles per second clock frequencies
2. Volatile and non-volatile memories of modern computers
3. Sub-molecular triggers in parallel artificial intelligence computers
4. Molecular triggers and the problem of infinite memory
5. Education of parallel (“Occam”) computers.

14.3. Aviation Talk

Instructor: In our present topic we are going to discuss triggers – electronic devices for storing one bit of data. Triggers are the most frequently used and also the cheapest elements of all integrated circuits. Electronic designers know, that the cost of manufacturing one resistor of the medium high denomination, say 47k, is equivalent to the cost of manufacturing five transistors.
Peter: We already know that triggers are electronic devices with two stable states. The open state of the first transistor corresponds to storing a logical unity in its collector circuit. But what if we want to store a logical zero?
Instructor: There is a number of ways to do this. The most obvious way is to apply a negative triggering pulse to the base of the first transistor, or to apply a positive triggering pulse to the base of the second transistor, or to reset the computer.
Helen: What does feedback do in all these processes?
Instructor: Feedback insures the open state of one transistor when the other transistor is closed, and vice versa.
Peter: This device, I mean the trigger, has two stable states. The first stable state corresponds to the first transistor being open while the second transistor is closed; the second stable state corresponds to the first transistor being closed while the second transistor is open. It is not clear, for how long the trigger will remain in the first or in the second stable state?
Instructor: The trigger will remain in one of these stable states for as long as the power is on. When you switch off the power, all data is lost. This type of power-dependent memory is called volatile memory.
Helen: Does all this mean that we must save the results of our work as often as we can?
Instructor: You must not forget to save the results of your work every ten-fifteen minutes, to be on the safe side. Some operating system can do this automatically.
Helen: And where are the results saved, if the end user is so absent- minded?
Instructor: The results are saved on your current floppy disc, or on your hard disc, if your floppy disc is write-protected.

Topic 15

Number Systems

Number systems are defined as the ways of presenting numerical values as powers of a certain base number, specific for each number system. For historical reasons humans used decimal number system because their ten fingers were suitable for counting. Computers use binary number system because their triggers have two stable states. The main drawback of the binary number system is too long notation of numbers, which means that too many triggers are required for their presentation. Much more economical are octal number system, the base number of which is eight, and hexadecimal number system, the base number of which is sixteen.

Of all number systems, the hexadecimal number system is the most economical and requires the least number of digits and the least number of triggers. To represent numerical values, this system uses Arabic digits 0,1,2,3,4,5,6,7,8,9, and also the upper-case letters of the Latin alphabet A,B,C,D,E,F. Here two hexadecimal digits can be used to specify a byte of data.

Special conversion tables can be used to convert numbers from one number system into another. For example, using Binary to Decimal Conversion Table, we can see that the weight of a binary unity in a binary number depends on its position and may be 1, 2, 4, 8, 16, 32, 64, and so on. Examining Binary to Decimal, Binary to Octal, and Binary to Hexadecimal Conversion Tables, we come to the conclusion that the most economical number system is hexadecimal.

Comprehensive Text-Related Glossary

number systems ['nʌmbə] - системы счисления
numerical values [nju:'merıkəl 'vælju:s] - численные величины
power ['pauə] - степень, результат возведения в степень
base number [beıs 'nʌmbə] - основание системы счисления
suitable ['sju:təbl] - подходящий, удобный
counting [kauntıŋ] - счет, подсчеты
binary number system ['baınərı] - двоичная система счисления (основание - два)
stable states ['steıbl] - устойчивые состояния (триггера)
drawback ['drɔ:bæk] - недостаток
notation [nəu'teıʃən] - запись (чисел)
presentation [ˌprezen'teıʃən] - представление (чисел)
octal number system ['ɔktəl] - восьмеричная система счисления (основание – 8)
hexadecimal number system [, heksə'desimel] - шестнадцатеричная система счисления (основание - шестнадцать)
the least number of triggers [li:st] - наименьшее число триггеров
Arabic digits ['dıdʒıt] - арабские цифры
upper-case letters ['letəz] - заглавные буквы

to specify [spesi'fai] - задавать, конкретизировать
conversion tables [kən'və:ʃn] -таблицы преобразования; таблицы перевода
in comparison [kəm'pærɪsn] - по сравнению
equivalent [ɪ'kwɪvələnt] - эквивалент (эквивалентная запись в другой системе счисления)

15.1. Questions for Arguments and Discussion

1. What are number systems?
2. How do we define base numbers of different number systems?
3. What number system is used by humans? What were the reasons for using this number system?
4. What number system is need by computers? What were the reasons for using this number system?
5. Why binary number system is considered as inefficient from the point of view of the required number of triggers?
6. What is octal number system? What is its base number?
7. Why hexadecimal number system is considered as the most economical from the point of view of the required number of triggers?
8. What is meant by one digit?
9. What are conversion tables used for?
10. On what does the weight of the stored logical unity depend?
11. When do we have to convert numbers from one number system into another?
12. On what does the choice of a specific number system depend?

15.2. Suggested Topics for Presentations and Reports

1. Criteria for evaluation and choice of number systems
2. Advantages and drawbacks of binary number system
3. Decimal number system in computers
4. Hexadecimal number system in office and on-board computers
5. Number systems data converters

15.3. Aviation Talk

Instructor: Number Systems is the concluding installment in our present series of Aviation Talks. We are going to discuss the most important and generally used systems.
Peter: As for as we know, there are only two systems which can be considered as such. One of them is used by humans, another is used by computers.
Helen: The system which is used by humans is called decimal number system. And the reason for its appearance is very simple - our ancestors used their ten fingers for counting.
Instructor: Can you think of any drawback of this system?
Helen: The first drawback is obvious - it needs special converters to be run on binary

computers.
Peter: I can think of the second - it is not as economical on space and numbers of triggers as, say, hexadecimal system.
Helen: The second generally used number system is, of course, binary.
Its main drawback is also generally known - it's too long notation of numbers, and, consequently, too many triggers needed for storing data.
Instructor: Which number system is free from all these drawbacks?
Helen: Oh, it's common knowledge! It is, of course, hexadecimal number system. It is used nowadays practically in all home, office, and on-board computers.
Peter: Which computers are most promising for the future?
Instructor: These are high-speed parallel computers. But the arrival of sub-molecular and molecular level memories is capable to change the whole computer scene. And this concludes our present installment on Computer Science Fundamentals.

ПРИЛОЖЕНИЕ
ПРАВИЛА ЧТЕНИЯ ЗНАКОВ МЕЖДУНАРОДНОЙ ФОНЕТИЧЕСКОЙ ТРАНСКРИПЦИИ, ПРИНЯТЫХ IPA /INTERNATIONAL PHONETIC ASSOCIATION, GR. BRITAIN/

Приводимые ниже общие правила чтения знаков Международной Фонетической Транскрипции помогут недостаточно знакомому с фонетикой английского языка студенту, программисту или инженеру правильно произносить приводимые в толковых притекстовых словарях транскрипции слов, терминов и иной лексики, используемой в учебных материалах данного пособия. При чтении транскрипции лексики следует обращать особое внимание на долгие звуки [i:], [a:], [ɔ:], [u:], [ə:], [æ]. Общее представление о разнице фонетического строя двух языков дают известные графические модели алгоритмов языка JOVIAL: - jogging (бег трусцой) - для русского языка и skiing (бег на лыжах) - для английского:

Russian speaker……………………jogging model of speech

English speaker…___...___...___...skiing model of speech

Черточки в модели бега на лыжах соответствуют долгим звукам, а точки - коротким звукам и укороченным интервалам между ними, весьма характерным для фонетики современного английского языка.

Произносительные нормы английского языка не являются жестко фиксированными и могут меняться, например, от университета к университету или даже от лектора к лектору. Так, оставаясь в рамках произносительных норм, которым следует Лингафонный Институт Великобритании и дикторы BBC и CNN, можно отметить, что в некоторых случаях такие звуки, как [ə], [d], [t] могут быть факультативными, т.е. необязательными для произношения, и иногда выделяться в современных словарях с помощью курсива либо круглых скобок.

(а) ГЛАСНЫЕ ЗВУКИ

В разделе приводятся русские аналоги английских звуков и после точки с запятой - английские примеры.

[i] - долгий звук u; tree

[ɪ] - краткий, открытый звук u; bit

[e] - как э в словах этот, экий; get

[æ]- более открытый звук, чем э (занимает промежуточное положение между русскими а и я; map

[a:] - долгий, глубокий звук а; car

[ɔ] - краткий, открытый звук о; pot

[ɔ:] - долгий звук о; walk

[o] - закрытый, короткий звук о, большей частью встречающийся в дифтонгах, занимает промежуточное положение между русскими о и у; low

[u] - короткий звук "у" в дифтонгах, произносится со слабым округлением губ; tone

[u:]-долгий звук у; move

[ʌ] - краткий гласный звук, приближающийся к русскому а в словах варить, бранить. Этот английский звук всегда стоит под ударением; cut

[ə:] - долгий гласный звук, напоминающий долгий звук э; work
[ə]- безударный гласный звук, примерно соответствующий безударной гласной в словах нужен, комната; worker

(б) ДВУГЛАСНЫЕ ЗВУКИ - ДИФТОНГИ

Приводятся русские аналоги произношения и после точки с запятой - английские примеры:
[eɪ] - эй; take
[ou] - оу; phone
[aɪ] - ай; write
[au] - ау; round
[ɔɪ] - ой; boy
[ɪə] - иа; here
[ɛə] - эа; there
[uə] - уа; poor

(в) СОГЛАСНЫЕ ЗВУКИ

Приводятся русские аналоги произношения и после точки с запятой - английские примеры:
[p] - п; poor
[b] - б; bit
[m]- м; map
[w] – звук, занимающий промежуточное положение между “уи” и “в”; wind
[a] - ф; five
[v] - в; vector
[θ] [ð] - оба этих звука образуются простым продуванием воздуха между передними зубами при прижатом к ним кончике языка, причем первый звук воспроизводится без голоса, второй - с голосом; think, that
[s] - с; sell
[z] - з; zero
[t] - т, произнесенное не у зубов, а у десен; take
[d] - д, произнесенное не у зубов, а у десен; dot
[n] - н, произнесенное не у зубов, а у десен; now
[l] - л; load
[r] - р, произнесенное без вибрации кончика языка; wrong
[ʃ] - ш, произнесенное мягко; push
[dʒ]- дж; job
[tʃ] - ч; child
[k] - к; keep
[g] - г, gold
[ŋ] - н(г), произнесенное задней частью языка; wrong
[h] - простой выдох; hot
[j]] - й; year