МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
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П.П. АЛЬМУРЗИН

AIRCRAFT ELECTRICAL AND ELECTRONIC SYSTEMS

Рекомендовано редакционно-издательским советом федерального государственного автономного образовательного учреждения высшего образования «Самарский национальный исследовательский университет имени академика С. П. Королева» в качестве учебного пособия для обучающихся по основным образовательным программам высшего образования по направлениям подготовки 15.03.05 Конструкторско-технологическое обеспечение машиностроительных производств, 24.03.04 Авиастроение, 25.03.02 Техническая эксплуатация авиационных электросистем и пилотажно-навигационных комплексов, 27.03.02 Управление качеством и специальности 24.05.07 Самолёто- и вертолётостроение

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В данное пособие включены тексты для чтения, пересказа, реферирования и аннотирования, лексико-грамматические упражнения, тестовые задания. Использована оригинальная литература по авиации.

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UNIT 1. Electric Charge and Electrostatics

1. Discuss the following questions.

- What is electricity used for in everyday life?

- What are the possible uses of electricity in an aircraft?

- What happens when you rub a plastic stick on a piece of wool and put it close to strips of paper?

- Can an electrostatic charge be dangerous to a human? What can a person do to avoid its negative effects?

2. Read the text to find the answers to the previous questions.

Electric charge is all around us. Indeed, many of the everyday items that we use in the home and at work rely for their operation on the existence of electric charge and the ability to make that charge do something useful. Electric charge is also present in the natural world and anyone who has experienced an electrical storm cannot fail to have been awed by its effects. In this section we begin by explaining what electric charge is and how it can be used to produce conduction in solids, liquids and gases.

It is well-known that if a conductor has a deficit of electrons, it will exhibit a net positive charge. If, on the other hand, it has a surplus of electrons, it will exhibit a net positive charge. An imbalance in charge can be produced by friction (removing or depositing electrons using materials such as silk and fur, respectively) or induction (by attracting or repelling electrons using a second body which is respectively positively or negatively charged).

If two bodies have charges with the same polarity (i.e. either both positively or both negatively charged) the two bodies will move apart, indicating that a force of repulsion exists between them. If, on the other hand, the charges on the two bodies are unlike (i.e. one positively charged and one negatively charged) the two bodies will move together, indicating that a force of attraction exists between them. From this we can conclude that like charges repel and unlike charges attract.

Static charges can be produced by friction. In this case, electrons and protons in an insulator are separated from each other by rubbing two materials together in order to produce opposite charges. These charges will remain separated for some time until they eventually leak away due to losses in the insulating dielectric material or in the air surrounding the materials. Note that more charge will be lost in a given time if the air is damp.

Static electricity is something that can cause particular problems in an aircraft and special measures are taken to ensure that excessive charges do not build up on the aircraft's structure. The aim is that of equalizing the potential of all points on the aircraft's external surfaces. The static charge that builds up during normal flight can be dissipated into the atmosphere surrounding the aircraft by means of small conductive rods connected to the aircraft's trailing surfaces. These are known as **static dischargers** or **static wicks** – see Fig. 1.

Fig. 1. Static discharging devices

A significant amount of charge can build up between conducting surfaces when they are insulated from one another. Where this might be a problem steps are taken to dissipate the charge instead of allowing it to accumulate uncontrolled.

Stray static charges can very easily damage static- sensitive devices such as semiconductors, mem- ory devices and other integrated circuits. Damage can be prevented by adopting the appropriate electrostatic sensitive device (ESD) precautions (described in the aircraft maintenance manual) when handling such devices. Precautions usually involve using wrist straps and grounding leads as well as using static-dissipative packaging materials.

3. Are these statements true or false?

1) If a conductor has a deficit of electrons, it will exhibit a net positive charge.

2) Friction produces attracting or repelling electrons using a second body which is respectively positively or negatively charged.

3) Induction is removing or depositing electrons using materials such as silk and fur.

4) If two bodies have charges with the same polarity - the two bodies will move apart.

5) Excessive charges might build up on the aircraft's structure as a result of an electrostatic charge.

6) More charge will be lost in a given time if the air is dry and hot.

7) **Static dischargers** or **static wicks** help dissipate an electrostatic charge into the atmosphere.

8) Stray static charges can very easily damage static- sensitive devices such as semiconductors, memory devices and other integrated circuits.

4. Match the following words with their translation.

1. Electric charge	**a.** Накапливать
2. Conductor	**b.** Изолирующий материал
3. Positive charge	**c.** Блуждающий статический заряд
4. Induction	**d.** Отталкивать
5. To repel	**e.** Индукция
6. To attract	**f.** Электрический заряд
7. Insulating material	**g.** Статический разрядник
8. Static wicks	**h.** Положительный заряд
9. To build up	**i.** Притягивать
10. Stray static charge	**j.** Проводник

UNIT 2. Electric Field and Capacitors

1. Discuss the following questions.

- Is electric field visible or not?

- What are the possible ways to visualize it?

- What is inside the field?

- What is the main device to store a charge?

2. Match the following basic mathematic actions to their symbols.

1. Equals to	**a.** +
2. Divided by	**b.** x
3. Multiplied by	**c.** ÷
4. Minus |ˈmʌɪnəs|	**d. -**
5. Plus	**f.** =

3. Read the text and check your answers to the questions in activity 1.

The force exerted on a charged particle is a manifestation of the existence of an electric field. The electric field defines the direction and magnitude of a force on a charged object. The field itself is invisible to the human eye but can be drawn by constructing lines which indicate the motion of a free positive charge within the field; the number of field lines in a particular region being used to indicate the relative strength of the field at the point in question.

Figures 2 and 3 show the electric fields between isolated unlike and like charges whilst fig. 4 shows the field that exists between two charged parallel metal plates which forms a charge storage device known as a **capacitor**.

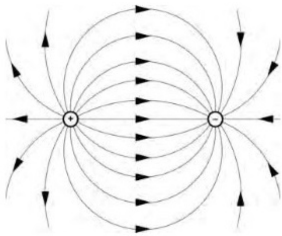


Fig. 2. Electric field between isolated unlike charges

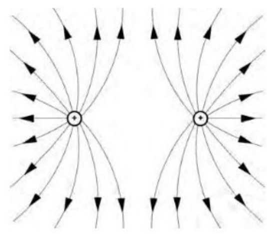


Fig. 3. Electric field between isolated like charges

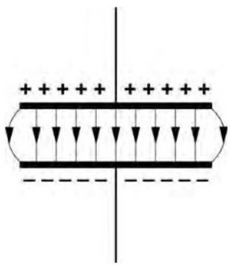


Fig. 4. Electric field between the two isolated charged parallel metal plates of a capacitor

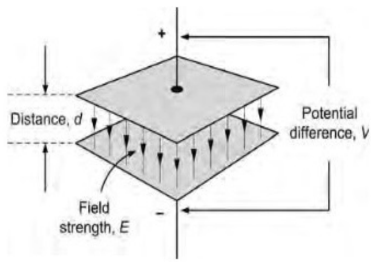


Fig. 5. Electric field strength between two charged conducting surfaces

The strength of an electric field (E) is proportional to the applied **potential difference** and inversely proportional to the distance between the two conducting surfaces (see fig. 5). The electric field strength is given by:

$$E = \frac{V}{d} \; ,$$

where E is the electric field strength (in V/m), V is the applied potential difference (in V) and d is the distance (in m).

The amount of charge that can be stored by a capacitor is given by the relationship:

$$Q = C \times V \quad ,$$

where Q is the charge in coulomb, C is the capacitance in farads, F, and V is the voltage in volts, V. This relationship can be re-arranged to make C or V the subject as follows:

$$C = \frac{Q}{V} \text{ and } V = \frac{Q}{C} \quad .$$

Example:

A 68 µF capacitor is required to store of 170 µC. What voltage should be applied to the capacitor?

The voltage can be calculated from:

$$V = \frac{Q}{C} \quad ,$$

where $Q = 170\mu\text{C}$ and $C = 68\mu\text{F}$; thus:

$$V = \frac{3.4\,\text{mC}}{6.8\mu\text{F}} = \frac{3,400\ \mu\text{C}}{6.8\mu\text{F}} = 500\,\text{V} \quad .$$

When replacing a capacitor it is essential to ensure that the replacement component is correctly rated in terms of type, value, working voltage and temperature. Capacitors are prone to failure if their maximum working voltage is exceeded and they should be de-rated when operated at a relatively high ambient temperature according to manufacturers' specifications. It is also essential to observe the correct polarity when replacing an electro- lytic (polarized) component. This is usually clearly marked on the external casing.

When working with high-voltage capacitors it is essential to ensure that the capacitor is fully dis- charged before attempting to replace the component. In most cases, any accumulated charge will safely drain away within a few seconds after removal of power. However, this should not be relied upon and a safe discharge path through a high-value resistor (say 1MΩ) fitted with appropriate probes will ensure that capacitor is safe to work on.

4. Answer the following questions to the contents of the text.

1) What defines the direction and magnitude of a force on a charged object?

2) What is a capacitor?

3) The strength of an electric field (E) is proportional to the applied potential difference and inversely proportional to the distance between the two conducting surfaces, isn't it?

4) Give the formula to receive the amount of charge that can be stored by a capacitor.

5) Under which conditions are capacitors prone to failure?

6) What is the main safety rule when working with high-voltage capacitors?

5. Underline 7 terms related to the topic and translate them using a dictionary.

UNIT 3. Direct Current and Alternating Current

1. Discuss the following questions.

- Is current a flow of electricity which results from the ordered directional movement of electrically charged particles?

- What is electric current mainly used for in technology?

- What do DC and AC stand for?

- How is direct current produced?

- What is a transormer in the context of current?

2. Read the text and check your answers to the questions in activity 1.

Direct current

Direct current (DC) is current that flows in one direction only. DC circuits are found in every aircraft. An understanding of how and why these circuits work is an essential prerequisite to understanding more complex circuits. Because of their negative charge, electrons will flow from a point of negative potential to a point with more positive potential (recall that like charges attract and unlike charges repel). However, when we indicate the direction of current in a circuit we show it as moving from a point that has the greatest positive potential to a point that has the most negative potential. We call this conventional current and, although it may seem odd, you just need to remember that it flows in the opposite direction to that of the motion of electrons!

The most commonly used method of generating direct current is the electrochemical cell. A cell is a device that produces a charge when a chemical reaction takes place. When several cells are connected together they form a battery.

There are two types of cell: primary and secondary. Primary cells produce electrical energy at the expense of the chemicals from which they are made and once these chemicals are used up, no more electricity can be obtained from the cell. In secondary cells, the chemical action is reversible. This means that the chemical energy is converted into electrical energy when the cell is discharged whereas electrical energy is converted into chemical energy when the cell is being charged. You will find more information on aircraft batteries in Chapter 5.

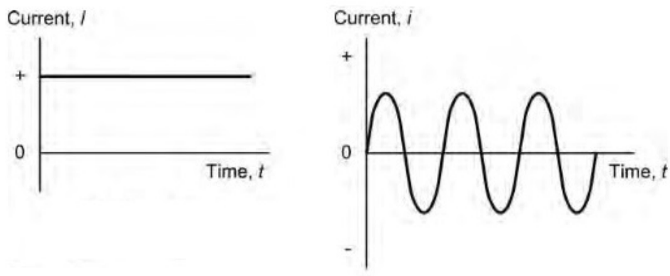
Conventional current flows from positive to negative whilst electrons travel in the opposite direction, from negative to positive.

In a primary cell the conversion of chemical energy to electrical energy is irreversible and so these cells cannot be recharged. In secondary cells, the conversion of chemical energy to electrical energy is reversible. Thus these cells can be recharged and reused many times.

Alternating current and transformers

Direct currents are currents which, even though their magnitude may vary, essentially flow only in one direction. In other words, direct currents are unidirectional. Alternating currents, on the other hand, are bi-directional and continuously reversing their direction of flow, as shown in fig. 6. Most modern jets and turboprops use both DC and AC, and the reasons are practical, if not immediately obvious. AC current is more efficient to make and distribute. Alternators can provide electricity at lower rpms than DC generators.

A graph showing the variation of voltage or current present in a circuit is known as a waveform.



a *b*

Fig. 6. Comparison of direct and alternating current:
a – direct current; *b* – alternating current

Transformers provide us with a means of stepping- up or stepping down an AC voltage. For a step-up transformer, the output (or secondary) voltage will be greater than the input (or primary) whilst for a step-down transformer the secondary voltage will be less than the primary voltage. Since the primary and secondary power must be the same (no increase in power is possible), an increase in secondary voltage can only be achieved at the expense of a corresponding reduction in secondary current, and vice versa (in fact, the secondary power will be very slightly less than the primary power due to losses within the transformer).

When replacing a transformer it is essential to ensure that the replacement component is correctly rated. The specifications for a transformer usually include the rated primary and secondary voltage and current, the power rating expressed in volt-amperes, VA (this is the maximum power that the transformer can deliver under a given set of conditions), the frequency range for the transformer (note that a transformer designed for operation at 400Hz will not work at 50Hz or 60Hz), and the per-unit regulation of the transformer (this is the ability of the transformer to maintain its rated output when under load).

3. Are these statements true or false?

1) Direct current (DC) is current that flows in many directions.

2) Because of their negative charge, electrons will flow from a point of negative potential to a point with more positive potential.

3) The most commonly used method of generating direct current is the electric socket in a wall.

4) Conventional current flows from positive to negative.

5) Electrons travel rom positive to negative.

6) Alternating currents are bi-directional and continuously reversing their direction of flow.

7) Transformers provide us with a means of remaining an AC voltage constant.

4. Match the following words with their translation.

1. Direct current	**a.** Напряжение
2. Alternating current	**b.** Генератор переменного тока
3. Transformer	**c.** Цепь, схема
4. Circuit	**d.** Двунаправленный
5. Electrochemical cell	**e.** Постоянный ток
6. Battery	**f.** Электрохимическая ячейка
7. Uni-directional	**g.** Аккумулятор
8. Bi-directional	**h.** Трансформатор
9. Altenator	**i.** Переменный ток
10. Boltage	**j.** Однонапрвленный

UNIT 4. Safety

1. Discuss the following questions.

- Is safety the condition of being protected from or unlikely to cause danger, risk, or injury?

- What common means of safety do you know?

- What basic means of safety in aviation are known to you?

- Do you know any situations where negligence of safety rules resulted in an accident?

2. Read the text and do the activities that follow.

When working on aircraft electrical and electronic systems, personal safety (both yours and of those around you) should be paramount in everything that you do. Hazards can exist within many circuits – even those that, on the face of it, may appear to be totally safe. Inadvertent misconnection of a supply, incorrect earthing, reverse connection of components, and incorrect fitting can all result in serious hazards to personal safety as a consequence of fire, explosion or the generation of toxic fumes. In addition, there is a need to ensure that your work will not compromise the safety and integrity of the aircraft and not endanger the passengers and crew that will fly in it.

Potential hazards can be easily recognized and it is well worth making yourself familiar with them but perhaps the most important point to make is that electricity acts very quickly and you should always think carefully before working on circuits where mains or high voltages (i.e. those over

50V or so) are present. Failure to observe this simple precaution can result in the very real risk of electric shock.

Voltages in many items of electronic equipment, including all items which derive their power from the aircraft's 400 Hz AC supply, are at a level which can cause sufficient current flow in the body to disrupt normal operation of the heart. The threshold will be even lower for anyone with a defective heart. Bodily contact with AC supplies and other high-voltage cir- cuits can thus be lethal.

The most critical path for electric current within the body (i.e. the one that is most likely to stop the heart) is that which exists from one hand to the other. The hand-to-foot path is also dangerous but somewhat less dangerous than the hand-to-hand path. So, before you start to work on an item of electronic equipment, it is essential not only to switch off but to disconnect the equipment at the mains by removing the mains plug. If you have to make measurements or carry out adjustments on a piece of working (or 'live') equipment, a useful precaution is that of using one hand only to perform the adjustment or to make the measurement. Your 'spare' hand should be placed safely away from contact with anything metal (including the chassis of the equipment which may, or may not, be earthed).

The severity of electric shock depends upon several factors including the magnitude of the current, whether it is alternating or direct current, and its precise path through the body. The magnitude of the current depends upon the voltage which is applied and the resistance of the body. The electrical energy developed in the body will depend upon the time for which the current flows. The duration of contact is also crucial in determining the eventual physiological effects of the shock. As a rough guide, and assuming that the voltage applied is from the aircraft's 400Hz AC supply, the following effects are typical:

- Current: less than 1mA; Physiological effect: Not usually noticeable.

- Current: 1mA to 2mA; Physiological effect: Threshold of perception (a slight tingle may be felt).

- Current: 2mA to 4mA; Physiological effect: Mild shock (effects of current flow are felt).

- Current: 4mA to 10mA; Physiological effect: Serious shock (shock is felt as pain).

- Current: 10mA to 20mA; Physiological effect: Motor nerve paralysis may occur (unable to let go).

- Current: 20mA to 50mA; Physiological effect: Respiratory control inhibited (breathing may stop).

- Current: more than 50mA; Physiological effect: Ventricular fibrillation of heart muscle (heart failure).

The figures quoted in the list are provided as a guide – there have been cases of lethal shocks resulting from contact with much lower voltages and at relatively small values of current. The upshot of all this is simply that any potential in excess of 50V should be considered dangerous. Lesser potentials may, under unusual circumstances, also be dangerous. As such, it is wise to get into the habit of treating all electrical and electronic systems with great care.

Other hazards

Various other hazards, apart from electric shock, exist within the environment of an aircraft when work is being carried out on electrical and electronic systems. For example, accidental movement of the aircraft's spoilers can result in injury and/or damage to equipment. Whenever power sources are changed or when switches or circuit-breakers are opened that may cause movement of spoilers it is essential to ensure that the spoilers are deactivated or that all persons and equipment are removed from the vicinity.

It is essential to remove electrical power from an aircraft before removing or installing components in the power panels. Failure to observe this precaution can result in electric shock as well as damage to components and equipment.

3. Are these statements true or false?

1) Hazards may appear only in unsafe circuits.

2) Inadvertent misconnection of a supply, incorrect earthing, reverse connection of components, and incorrect fitting can all result in serious hazards to personal safety.

3) However, all the above-mentioned will never result in fire, explosion or the generation of toxic fumes.

4) Electricity does not act very quickly and you should always think carefully before working on circuits where mains or high voltages.

5) Voltages in many items of electronic equipment are at a level which can cause sufficient current flow in the body to disrupt normal operation of the heart.

6) The most critical path for electric current within the body is that which exists from one hand to the other, while the hand-to-foot path is totally safe.

7) Accidental movement of the aircraft's spoilers can result in injury and/or damage to equipment,

8) Open circuit-breakers will never cause movement of spoilers.

4. Complete these safety explanations, use the correct form of the modals and the passive form of the passive form of the verbs in brackets.

Example: This electrical unit needs to be handled carefully.

1) This electrical unit ___________________________ (need / handle carefully). It ____________________________ (must not / drop or throw).

2) This box ________________ (need / carry this way up). It __________________________ (must not / turn) upside down).

3) This circuit ___________________ (should / keep) in a dry place. It __________________________ (have to / protect) from rain.

4) Persons and equipment ______________________ (must / remove) from the vicinity. Nobody unauthorized _____________________ (should / allow) in the area.

5) All electrical and electronic systems _____________________ (have to / treat) with great care. They ___________________ (must not / neglect).

UNIT 5. Auxiliary power unit (APU)

1. Discuss the following questions.

- How are modern aircraft started when they are on the ground?

- Why is an auxiliary power unit used? What are its functions — what units does it supply power with?

- Can it be used in flight?

- What role do the aircraft electric and electronic systems play in its operation?

- What can a pilot do if all the electric systems failed and the aircraft lost all power and its controls?

2. Read the text and check your answers to the questions in activity 1.

An APU is a relatively small gas turbine engine, typically located in the tail cone of the aircraft. The APU is a two-stage centrifugal compressor with a single turbine. Bleed air is tapped from the compressor and connected into the aircraft's air distribution system. Once started (see Chapter 10) the APU runs at constant speed, i.e. there is no throttle control. The APU shuts down automatically in the event of malfunction.

APUs are used for starting the aircraft's main engines via the air distribution system. While the air- craft is on the ground, the APU can also provide:

- electrical power;

- hydraulic pressure;

- air conditioning.

The APU (see fig. 7) itself is started from the main aircraft battery. In some aircraft, the APU can also provide electrical power in the air in the event of main generator failure. The Boeing 787 aircraft has more electrical systems and less pneumatic systems than aircraft it is replacing. In this case the APU delivers only electrical power.

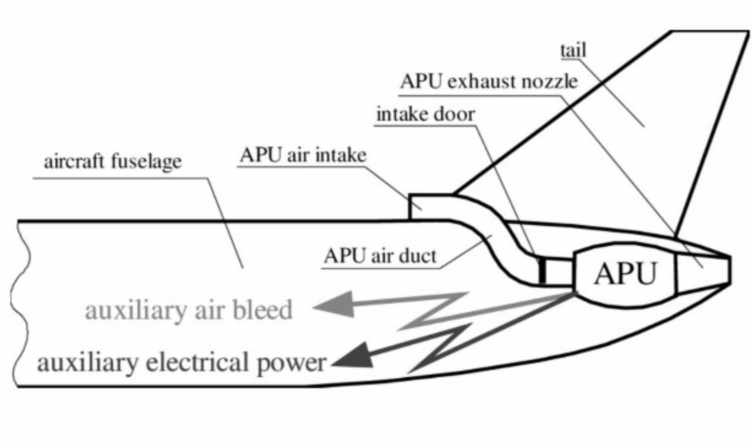


Fig. 7. Auxiliary power unit (APU)

APUs fitted to extended-range twin-engine operations aircraft (ETOPS) are critical to the continued safe flight of the aircraft since they supply electrical power, hydraulic pressure and an air supply in the event of a failed main engine generator or engine.

Some APUs on larger four-engined aircraft are not certified for use while the aircraft is in flight.

It is essential to remove electrical power from the relevant busbar (or in some cases the entire aircraft) before removing or installing electrical components. Failure to observe this precaution can result in electric shock as well as damage to components and equipment.

It is essential that electrical power is removed from an external power cable before connecting the cable to the aircraft. Failure to observe this precaution can result in electric shock as well as damage to components and equipment.

In the event of generator failure, continuous power can be provided by a ram air turbine (RAT). Also referred to as an air-driven generator, this is an emergency source of power that can be called upon when normal power sources are not available. The RAT is an air-driven device that is stowed in the wing or fuselage and deployed in the event that the aircraft loses normal power. When deployed, it derives energy from the airflow, see fig. 8. RATs typically comprises a two-bladed fan, or propeller that drives the generator shaft via a governor unit and gearbox; the gear ratios increase the generator shaft speed.

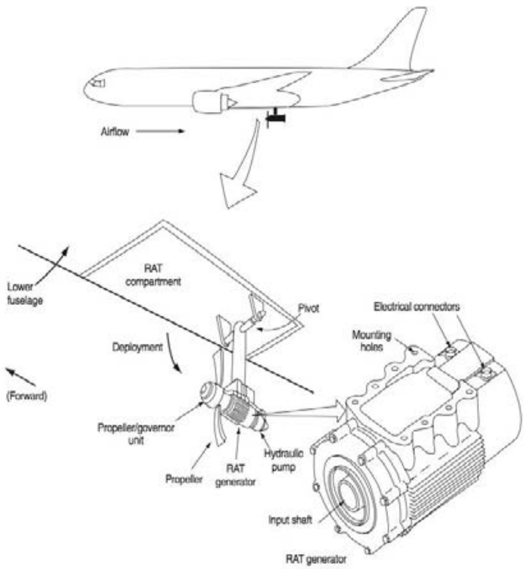


Fig. 8. Ram air turbine

The RAT can be deployed between aircraft speeds of 120 to 430 knots; some RATs feature variable pitch blades operated by a hydraulic motor to maintain the device at typical speeds of 4,800r.p.m. Typical RAT generators produces an AC output of 7.5kVA to a TRU. Heaters are installed in the RAT generator to prevent ice formation. RATs can weigh up to 400lbs on very large transport aircraft, with blade diameters of between 40 and 60 inches depending on power requirements.

3. Are these statements true or false?

1) An APU is a relatively small piston engine, typically located in the tail cone of the aircraft.

2) The APU runs at constant speed, i.e. there is no throttle control.

3) The APU itself is started from the on-ground battery.

4) The Boeing 787 aircraft has both electrical systems and pneumatic systems.

5) It is impossible to use the APU while the aircraft is in flight.

6) It is essential that electrical power is removed from an external power cable before connecting the cable to the aircraft.

4. Answer the following questions to the contents of the text.

1) What is RAT?

2) When is it activated?

3) Where is it located?

4) Where does it derive its power from?

5) Why does it have a gearbox?

6) What speeds is the RAT deployed at?

7) What is its AC output?

8) Does the RAT have a heater?

5. Label the main components of a RAT in fig. 9 below.

Fig. 9. Photo of a ram air turbine

UNIT 6. Computers

1. Discuss the following questions.

- What is the origin of the word «computer»?

- When did they first appear and what were their first uses?

- What kind of technologies are used in computers today?

- What roles do computers play in aviation?

2. Read the text and do the activities that follow.

Modern aircraft use increasingly sophisticated avionic systems which involve the use of microprocessor-based computer systems. These systems combine hardware and software and are capable of processing large amounts of data in a very small time.

The main components are:

(a) a central processing unit (CPU)

(b) a memory, comprising both ‘ read/write ’ and ‘ read only’ devices (commonly called RAM and ROM respectively)

(c) a means of providing input and output (I/O).

For example, a keypad for input and a display for output. In a microprocessor system the functions of the CPU are provided by a single very large scale integrated (VLSI) microprocessor chip. This chip is equivalent to many thousands of individual transistors.

Semiconductor devices are also used to provide the read/write and read-only memory. Strictly speaking, both types of memory permit ‘random access’ since any item of data can be retrieved with equal ease regardless of its actual location within the memory. Despite this, the term ‘RAM’ has become synonymous with semiconductor read/write memory.

The basic components of the system (CPU, RAM, ROM and I/O) are linked together using a multiple- wire connecting system know as a bus (see fig. 10).

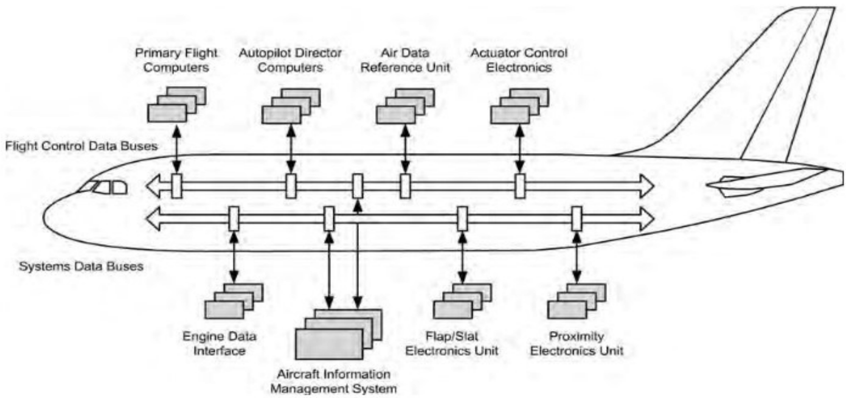


Fig. 10. Bus systems implemented on a modern passenger aircraft

A computer system consists of a central processing unit (CPU), a read-only memory (ROM), a read/ write (random access) memory (RAM), and one or more input/output (I/O) devices. These elements are linked together using a local bus system that comprises an address bus, a data bus, and a control bus.

Depending on the size of their internal data bus, avionic computer systems usually manipulate data in groups of 8, 16 or 32 bits. When this data is obtained from an external serial bus this data must first be assembled into parallel form in order to facilitate internal processing.

Stray static charges can very easily damage static-sensitive devices such as microprocessors and memory chips. Damage can be prevented by adopting the appropriate ESD procedures which usually involve using grounded wrist straps when handling chips and boards and using specially treated conductive packaging for transport and storage of component parts.

3. Describe the diagram (fig. 11) of a computer system layout and operation using the correct form of the passive of these verbs: *to feed, to input, to process, to control, to store, to output, to display*.

Example: Initial data from different sensors and gauges of the aircraft is fed through an input unit into the storage unit which consists of ...

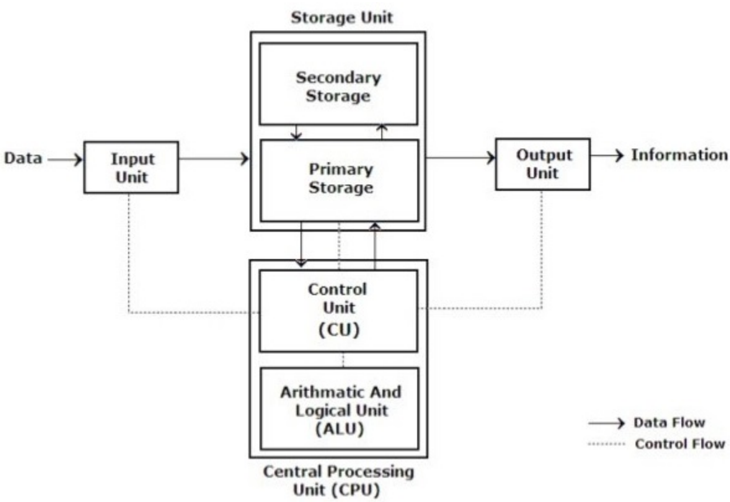


Fig. 11. Block diagram of computer

4. Answer the following questions to the text.

1) Do modern aircraft use increasingly sophisticated avionic systems which involve the use of microprocessor-based computer systems?

2) What do these systems combine?

3) What are the most common I/O devices?

4) What is VLSI?

5) What are its advantages?

6) Which unit links CPU, RAM, ROM and I/O?

7) Do avionic computer systems usually manipulate data in groups of 8, 16 or 32 bits?

8) What can damage an aircraft computer and what precautions must be taken by a maintenance engineer?

UNIT 7. Continuing Airworthiness. Wires and Cables

1. Discuss the following questions.

- What are the three main duties of a maintenance engineer? What is airworthiness?

- What kind of special knowledge does a maintenance engineer have to have?

2. Read the text to find out more details to your answers.

Continuing Airworthiness

Airworthiness is the measure of an aircraft's suitability for safe flight. Certification of airworthiness is granted by a certificate of airworthiness from the state of aircraft registry national aviation authority, and is maintained by performing the required maintenance actions.

Certification is based on standards applied by national aviation authorities. Interoperability is served when national benchmarks adopt standards from international civil and military organizations such as International Civil Aviation Organization (ICAO), European Aviation Safety Agency (EASA), NATO and European Defence Agency (EDA).

https://en.wikipedia.org/wiki/Airworthiness#Additional_airworthiness_specifications

A job description of an aircraft maintenance engineer

An aircraft maintenance engineer is responsible for ensuring that an aircraft operates properly and safely. A maintenance engineer may make repairs, troubleshoot problems, conduct inspections and make upgrades to aircrafts. Daily duties may include keeping records of and performing scheduled maintenance, making emergency repairs, or preparing for Federal Aviation Administration (FAA) inspections.

An aircraft maintenance engineer works with specialized aviation and power tools, computers, diagnostic equipment and x-ray machines. While working, he or she may climb ladders or stand on scaffolds, manage other maintenance staff or spend long hours on emergency repairs. Maintenance engineers must carefully observe all FAA rules and regulations when performing any job duty.

https://study.com/articles/Aircraft_Maintenance_Engineer_Job_Description_and_Requirements.html

3. Discuss the following questions before reading the text in 4.

- What is avionics? What are the main functions of avionics?

- What roles do cables and wires play in the operation of avionics? Read the text and do the activities that follow.

4. Read the text to find out more details to your answers.

This chapter reviews some practical installation requirements, documentation and test equipment required by the avionics engineer to ensure the continued airworthiness of aircraft electrical and electronic systems.

Continuing airworthiness

Many processes are required throughout the aircraft's operating life to ensure that it complies with the applicable airworthiness requirements and can be safely operated. The generic term for this range of processes is continuing airworthiness. The term ‘maintenance’ is used for any combination of overhaul, repair, inspection, replacement, modification or defect rectification of an aircraft or component, with the exception of the pre-flight inspection.

Persons responsible for the release of an aircraft or a component after maintenance are the certifying staff. Maintenance of an aircraft and its associated systems requires a variety of test equipment and documentation; these are required by certifying staff to fulfil their obligations in ensuring continued airworthiness.

Aircraft wiring cannot be considered as ‘fit and forget’. Legislation is being proposed to introduce a new term: **electrical wire interconnection system** (EWIS); this will acknowledge the fact that wiring is just one of many components installed on the aircraft. EWIS relates to any wire, wiring device, or combination of these, including termination devices, installed in the air- craft for transmitting electrical energy between two or more termination points.

Wire and cable installation

The importance of aircraft wire and cable selection, installation and maintenance cannot be overstated. Modern aircraft (or upgraded older aircraft) are installed with more wiring, carrying more current than earlier generations of aircraft; much of this wiring carries digital signals. Wiring and cables must be treated as integral components of the aircraft; they are not to be treated as ‘fit and forget’. Wires are formed from a single solid conductor or stranded conductors, contained within insulation and protective sheath materials. Cables can be defined as:

- two or more separate wires within the same insulation and protective sheath

- two or more wires twisted together

- any number of wires covered by a metallic braid, or sheath

- a single insulated conductor covered by a metallic outer conductor (co-axial cable).

The terms wires and cables are often interchanged. In this chapter, reference will be made to ‘wiring’ in the all-embracing generic sense; cables will be referred to in specific terms as and when required. Surveys and inspections of aircraft have revealed a number of issues and problems that require the close attention of system design and maintenance to ensure continuing airworthiness. Wire insulation can deteriorate over time (typically over ten years); exposed conductors create the environ-ment for potential faults, spurious signals and **arcing**.

Wires are vulnerable to their installed environment, e.g. changes in temperature, exposure to moisture and vibration that can lead to **open circuits** and/or **chafing**. In certain areas of the aircraft, e.g. the leading/trailing edges of the wing and wheel wells, the physical environment is harsher than protected areas, e.g. the flight compartment or passenger cabin. The installation of wire and cable is very important; the following must be avoided:

- sharp bend radii

- unsupported wires

- routing high and low power circuits in the same bundle, or loom.

It is essential that older standards of wiring are inspected in accordance with maintenance schedule; the wiring should be replaced if there are any signs of deterioration. Care must be taken not to disturb or damage wiring during maintenance or inspection of nearby equipment.

5. Are these statements true or false?

1) The term ‘maintenance’ is used for repair, inspection or defect rectification

2) The pre-flight inspection does not include maintenance.

3) Maintenance of an aircraft and its associated systems requires a variety of test equipment and documentation.

4) ‘Fit and forget’ is the main rule of aviation.

5) Aircraft wiring carries pulling and pushing loads.

6) Cables have 1 definition.

7) Exposed conductors create the environ-ment for potential faults, spurious signals and arcing.

8) Some areas of an aircraft make wiring vulnerable to damage.

6. Visit an English version of a web-site of an airline or international airport, go to Careers section and prepare a short report about different positions in aviation and requirements for them.

UNIT 8. Cable and Wire Looms

1. Discuss the following questions.

- Where are the cables used?
- What is the main difference between the wires and cables?
- Why are cables and wires arranged into looms?
- What are their functions and requirements for their performance?
- Can you suggest any means of their protection?

2. Read the text and check your answers.

Cable and wire looms

Grouping individual wires and cables into bundles forms a loom (or harness); these bundles are tied, or strapped together to form a secure assembly. Wire looms must be installed and maintained to ensure maximum integrity. The loom should be formed without twisting or overlapping the cables/wires. They can be tied together with waxed string, lacing cord or nylon straps. These ties are made at regular intervals, equally spaced along the loom; the loom is then secured to the airframe with clamps. The current-carrying capacity of wires reduces in looms since the inner wires are not able to radiate heat efficiently. To illustrate this point, a single 20-gauge wire in free circulating air is rated at 14A; this reduces depending on the number of wires in the loom:

- single wire, 14 A
- three wires, 9 A

- seven wires, 7 A

- twelve wires, 5 A.

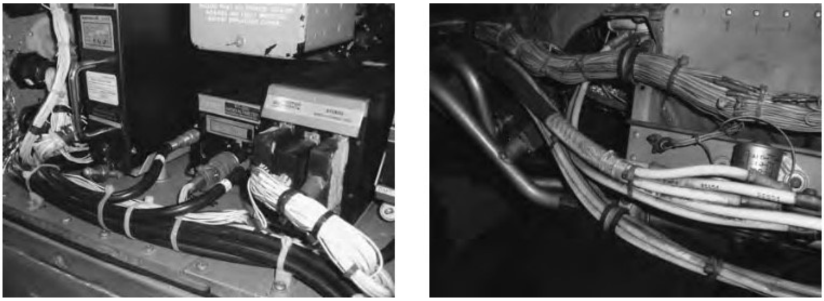


Fig. 12. Examples of installed wire looms

Figure 12 provides some examples of installed wire looms. The loom will follow a path through the aircraft dictated by existing structure and obstacles; additional support and protection is provided where required. Any bends or branches in the loom must not be so sharp that the loom becomes kinked (never bend or form wires or cables with pliers or any sharp edge). Looms must be installed such that they are supported with clamps and protected from chaffing through con-tact with sharp edges, pipes and other wiring.

Cable clamps and grommets are used throughout the aircraft to provide this protection.

3. Match the terms and definitions.

1. A wire	**a.** Pincers with parallel, flat, and typically serrated surfaces, used chiefly for gripping small objects or bending wire

2. A cable strengthening	**b.** A brace, band, or clasp for or holding things together
3. A loom	**c.** An eyelet placed in a hole to protect or insulate a rope or cable passed through it or to reinforce the hole
4. To secure	**d.** An insulated wire or wires having a protective casing and used for transmitting electricity or telecommunication signals
5. A clamp	**e.** To fix or attach (something) firmly so that it cannot be moved or lost
6. To radiate	**f.** Metal drawn out into the form of a thin flexible thread or rod
7. An obstacle	**g.** Emit (energy, especially light or heat) in the form of rays or waves
8. Pliers	**h.** A collection of cables tied together
9. A grommet	**i.** A thing that blocks one's way or prevents or hinders progress

4. Read the guidelines and do the activities that follow.

General guidelines for the installation of wire looms are as follows:

- Install with a downward slope away from equipment to prevent moisture running into the equipment

- Do not install below fuel pipes

- Avoid areas of high temperature

- Install to minimize EMI

- Make provision for at least one remake of the wire

- Take care not to crush coaxial cables

- Areas of high vibration require additional loom support

- Breakout should not cross over the main loom.

Open looms are formed with bound wires in a bundle; these are supported by p-clips and protected by grommets. The use of open looms is dictated by temperature and length of loom, together with any EMI considerations. **Conduits** (fig. 13) are used in specific areas, e.g. wing leading edges to protect wiring loom from rain and other fluids; these conduits are made from plastic or metal.

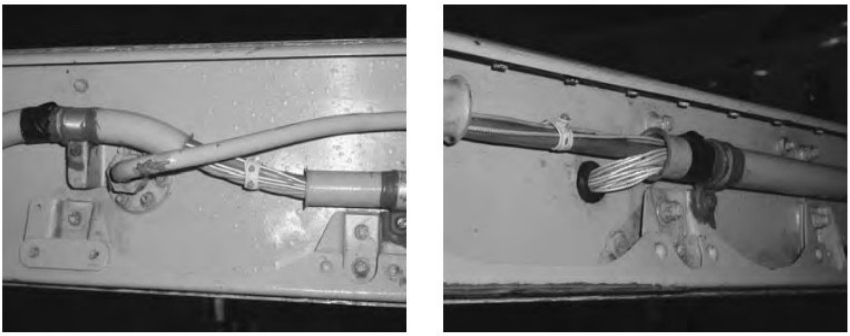


Fig. 13. Examples of cable-loom conduct

When looms can be passed through bulkheads, they must be prevented from chaffing; this can be achieved by clamping or potting, see fig. 14. **Ducted looms** are formed in channels made from a suitable material, e.g. aluminium alloy or composite. They provide more support and are used to guide the looms through and around specific areas of the aircraft.

When the loom passes through bulkheads, they are often sealed with a rubber bung, see fig. 14.

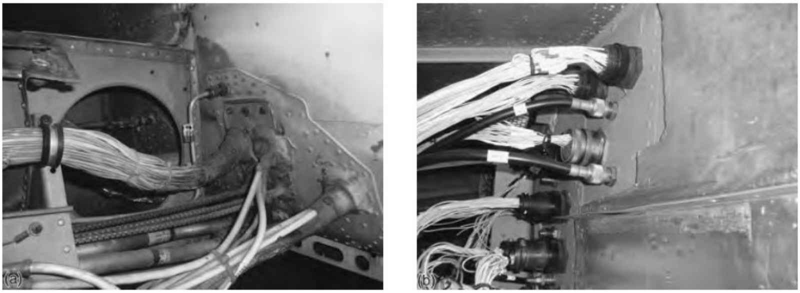


Fig. 14. Bulkhead wire looms: sealant/potting and connectors

5. Match the parts of the sentences.

1. Do not install ...	**a.** over the main loom.
2. Avoid areas of ...	**b.** below fuel pipes
3. Install to minimize ...	**c.** crush coaxial cables
4. Make provision for at least one remake of the wire ...	**d.** EMI
5. Take care not to ...	**e.** additional loom support
6. Areas of high vibration require ...	**f.** high temperature
7. Areas of high vibration require ...	**g.** additional loom support
8. Breakout should not cross ...	**h.** at least one remake of the wire

UNIT 9. The ways to provide protection for cables and wires

1. Discuss the following questions.

- What weather conditions are known to be disruptive to an aircraft systems?

- What other conditions can be harmful and unwanted?

- Which parts of aircraft have cables and wires inside?

- Which parts of the aircraft are subjected to stresses?

- What types of metal treatment processes are popular in aviation and electronics?

2. Read the text and the activities that follow.

Certain areas of the aircraft will experience high vibration (fig. 15); wiring in these areas will be subjected to a harsher environment.

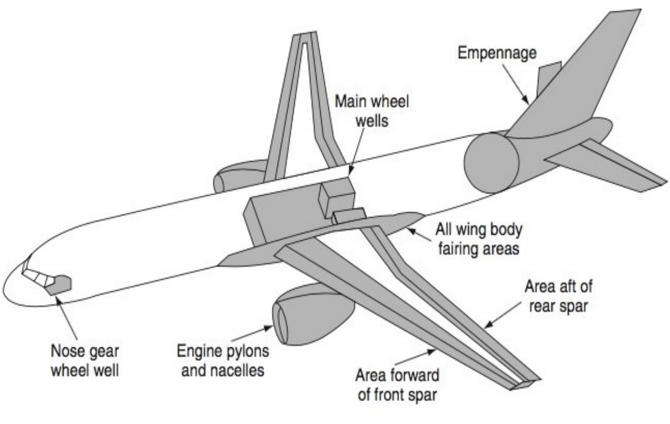


Fig. 15. High vibration areas

These areas include:

- wheels wells
- empennage
- wing roots
- wing trailing edges
- wing leading edges
- engine pylons and nacelles.

The wiring in these areas will be exposed to severe wind and moisture problems (**SWAMP**); wiring specifications and inspection requirements must be adhered to.

Wire terminations and connections

It is highly unlikely that a single wire or cable will be routed from the power source directly to the load – it will invariably pass through bulkheads via connectors. Certain areas in the aircraft are not suitable for the routing of wires (e.g. zones exposed to high temperature or EMI). Wiring is invariably installed in sections and joined at intervals. Terminations and connection types used will depend on a number of factors driven by cost and continued airworthiness requirements. The size and configuration of the aircraft will determine where connectors are needed and located.

Other considerations are when aircraft sections (wings, fuselage, etc.) are manufactured at various geographical locations and come together at a different place for final assembly. Finally, the need for inspection, removal and installation of equipment needs to be considered; quick-release connectors are used for most **line- replaceable units (LRU)**.

Wires can be joined by soldering, although this is normally only used within equipment. (Soldering aircraft wires reduces their flexibility and can lead to premature failure.) The majority of cable and wire terminations in the airframe are made by attaching crimp tags for use with terminal blocks or pin and sockets within connectors. There are two types of crimp: dimple and confined; the latter is the type normally used on aircraft.

The confined crimp is formed by compressing the crimp's shank onto the conductor. This results in the **cold flow** of metal between shank and conductor forming a homogeneous mass. The crimping operation also causes the crimp to form over the insulating and sheath materials. The crimping operation is performed with crimping pliers that contain two dies to form the crimp in a controlled and preset way. For larger-diameter cables and wires, power tools are required. Connections can be made to terminate a cable with a ring-tag, or join two cables together with a splice. These can be used for repairs or as permanent installations. They can also be used to form junctions, e.g. when modifying an aircraft to 'tap' into a signal line.

Terminal blocks with connections must be withdrawn and the strands straightened. Excessive twisting will increase the diameter of the conductor, making it difficult to insert into the barrel. Once formed, the tag can be attached to terminal blocks with connections made to respective circuits. Some terminations benefit from a heat-shrink sleeve; this provides extra mechanical protection and support. Heat-shrink material is polythene based and reduces to a pre-determined diameter (but not length) when heated. The advantages of crimping are:

- good conductivity

- consistent operation

- good strength

- resistance to corrosion.

3. Answer the questions to the text.

1) What areas of the aircraft experience much stress?

2) What does it result in?

3) How does the wiring go through bulkheads?

4) What unit is used for connecting parts of wiring?

5) What types of connectors are used for line- replaceable units?

6) Why isn't soldering the proper method for connecting cables?

7) What is crimping?

8) How is tag connected to terminal blocks?

UNIT 10. Indicating systems overview

1. Discuss the following questions.

- Does a pilot need to control in-flight parameters?

- How does he do it?

- How does an indicating system collect data to display the readings?

- Which aircraft systems require indicating of their parameters on the instruments in the pilot's cabin?

2. Read the text to find out more details to your answers.

Engine indications can be broadly divided into primary and secondary systems. Some indication systems are unique to gas turbine, turboprop or piston engines, some are common to all types. Primary indicators include:

- speed

- temperature

- thrust

- fuel flow.

Secondary indicators include (but are not limited to):

- oil temperature

- oil quantity

- oil pressure

- vibration.

Measurements are made by a variety of transducers; these are devices used to convert the desired parameter, e.g. pressure, temperature, displacement etc. into electrical energy. The locations of engine instruments is normally between the two pilot's panels, see fig. 16.

Fig. 16. Typical engine instruments

Engine temperature

In this unit let us overview an exhaust gas temperature indication alone as one of the primary gas turbine engine indication. Engine temperature is closely monitored at all times, particularly during start and take- off, to make sure that engine limits are not exceeded. It is sometimes referred to as:

- turbine inlet temperature (TIT)

- inter-turbine temperature (ITT)

- turbine outlet temperature (TOT)

- exhaust gas temperature (EGT)

- turbine gas temperature (TGT)

- jet pipe temperature (JPT).

The type of measurement depends on where the probe is located and according to individual engine manufacturer's terminology; fig. 17 illustrates some of these locations. The turbine section runs at very high temperatures, typically 1000ºC; the transducer used in this application is the **thermocouple** (sometimes referred to as a 'temperature probe').

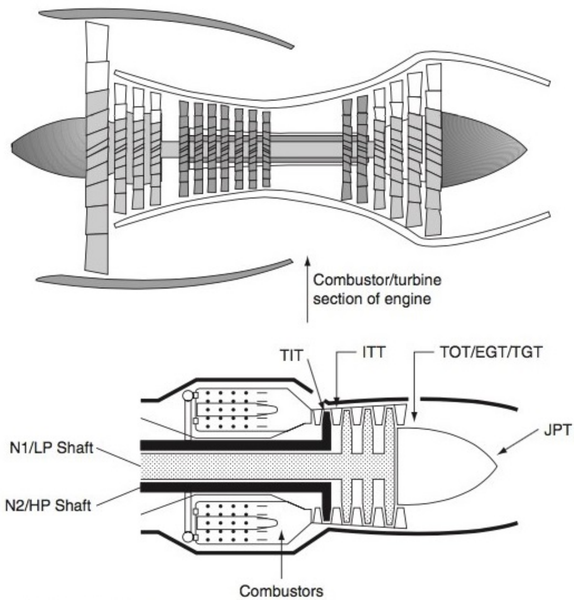


Fig. 17. Engine temperature measurement

A typical engine temperature measurement system is illustrated in fig. 18. On larger engines, it is possible to have a range of temperatures in the exhaust zone due to the turbulence of gases.

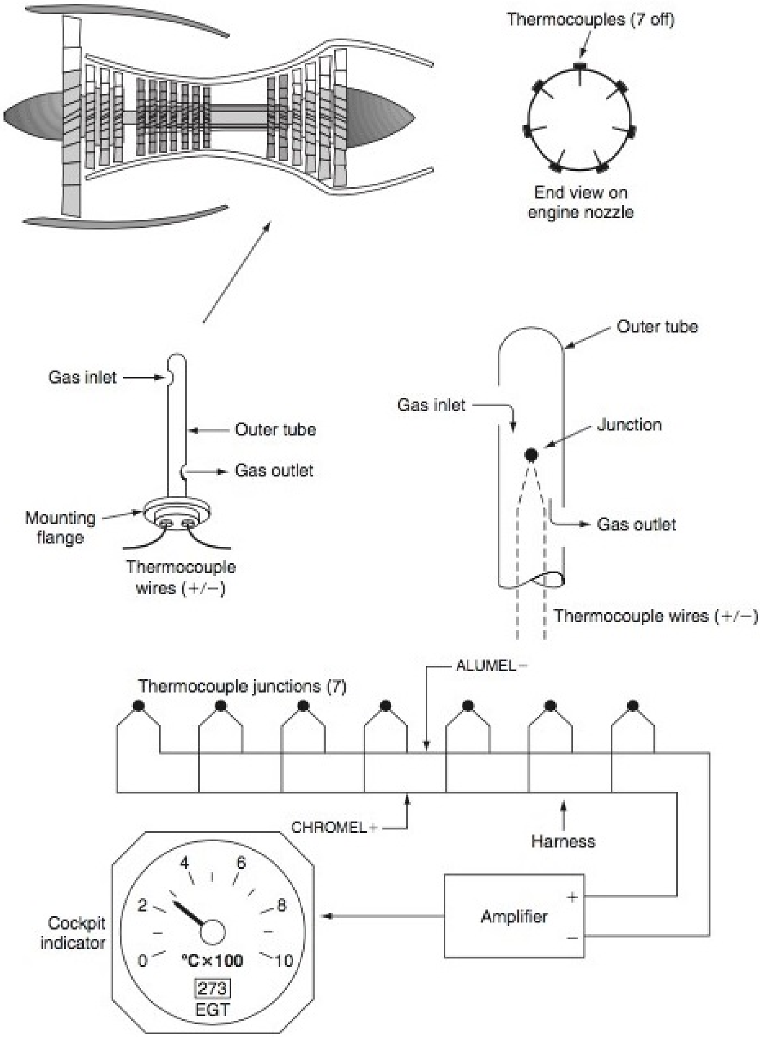


Fig. 18. Engine temperature system

Some installations feature a thermocouple that has two or even three hot junctions within the same outer tube. This arrangement provides an average of temperature within the zone to provide an average temperature at different immersion distances in the engine.

Thermocouple cables are colour-coded to reduce the likelihood of different materials being cross-connected, or mixed in the same installation (note that these codes vary in some countries; always refer to the maintenance manual).

Small gas turbine engines are normally fitted with several thermocouples to provide an average temperature and some redundancy in case of failure. Larger engines can be fitted with up to 21 thermo- couples; these are connected in parallel to provide an average reading of the gas temperature in the exhaust zone. The interconnecting cables between the thermocouple(s) and indicator have to be the same material throughout the system otherwise addition junctions will be formed, thereby generating unwanted voltages.

3. Answer the following questions.

1) How many indications can engine indications be broadly divided into?

2) What are primary indicators?

3) How are measurement made?

4) Is engine temperature closely monitored at all times?

5) What temperatures does the turbine section typically run at?

6) Why do some installations feature a thermocouple that has two or even three hot junctions within the same outer tube?

7) Why are thermocouple cables colour-coded?

8) Under which conditions are unwanted voltages generated?

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