UNIVERSITY OF TECHNOLOGY

MACHINES AND EQUIPMENT DEPARTMENT

AIRCRAFT ENGINEERING BRANCH

AIRCRAFT SYSTEMS AND MAINTENANCE 4TH YEAR

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Chapter One

Basic Information

1.1- **Pumps** :-

Pumps are mechanical tools which increase energy levels of different types of liquid by converting movement energy into mechanical energy.

1. **Types of pumps** :-

Pumps are generally divided into two major types which are:

a. **centrifugal pump** :- see figure (1)

b. **positive displacement**:- see figure (2)

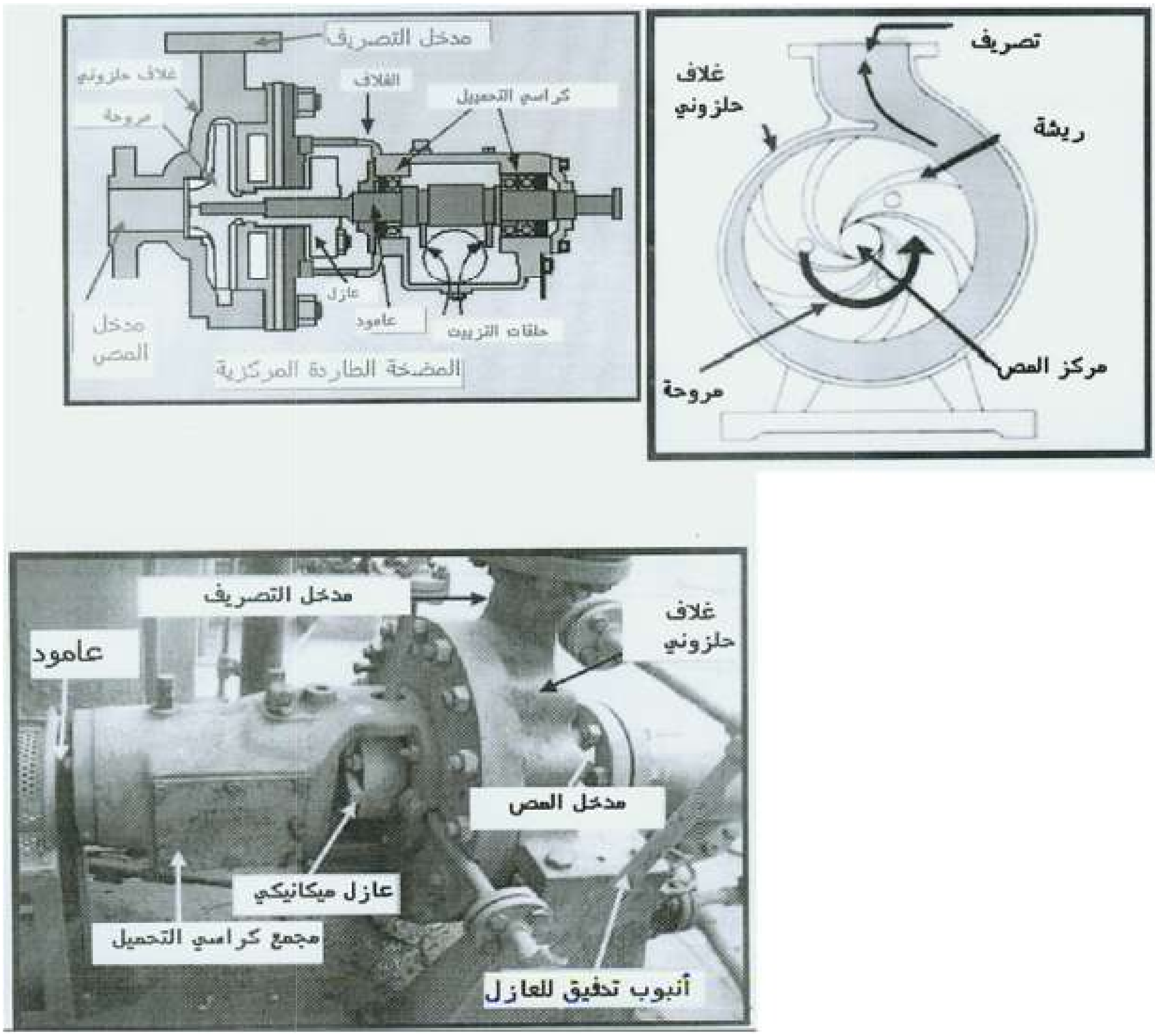


Figure No.(1) Centrifugal Pumps

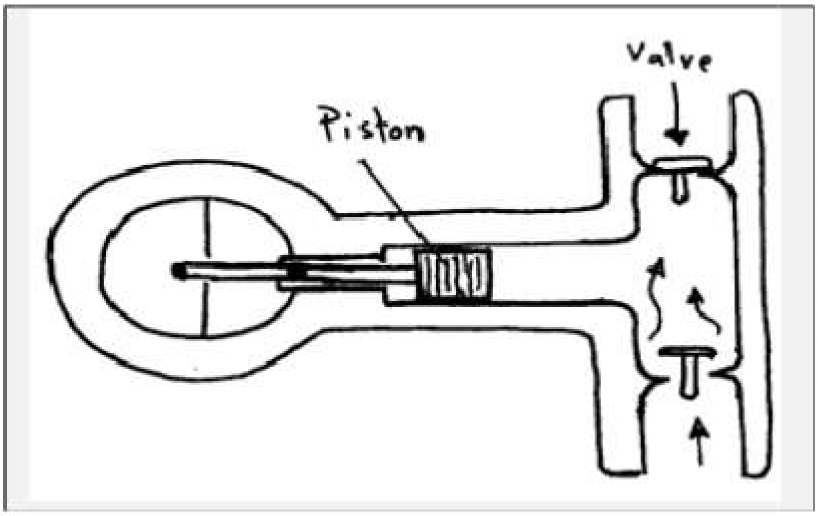


Figure No.(2) Positive Displacement Pump

Positive Displacement Pump	Centrifugal Pumps
Less Pressure	Generate fluids with high pressure
Used for ground levels splays	The ability of lifting fluids for high altitude
Easy and simple of components	Complicated of components
Cheap	Expensive
Low Efficiency 30 – 60 %	High Efficiency 60 – 80 %
Deals only with fluids of low viscosity	Deals with low and high fluids viscosity
Work with low energy	Consume high energy
Small and Simple	Large and Complex
Maintenance is easy	Maintenance is complicated

2. Pumps Maintenance :-

a. Always investigate the exit fluids outflow.
b. Checking valves safety verification.
c. Checkup the pump plume periodically.
d. Checkup the sound of the pumps works and ensures if there is noisy sound after the pump works.
e. Never to leave pumps working for very long time continually.
f. Checkup the pump piston periodically.

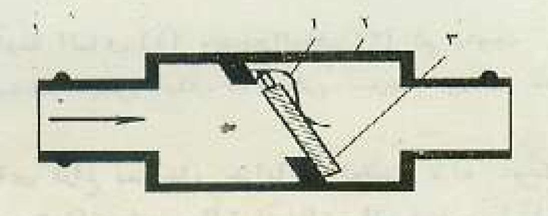
1.2- <u>Valves and Pipes</u> :-

1.2.1- <u>Valves</u> :-

A valve in general isan instrument that allows fluids moves into one direction only, and never to return in back direction. And it has another gob in some kind of valves.

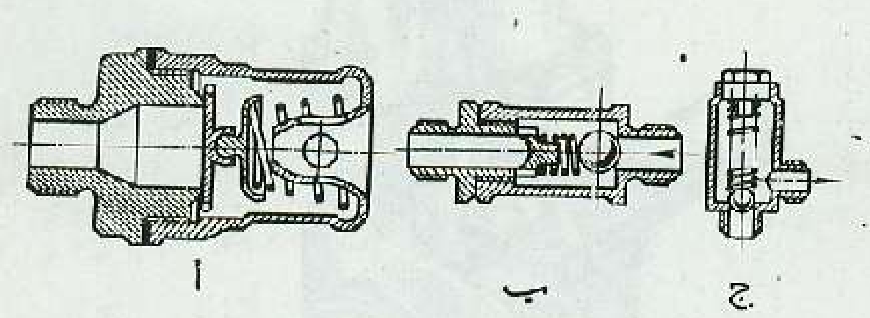
1.2.2- <u>Valves Types</u> :-

a. None return valves.



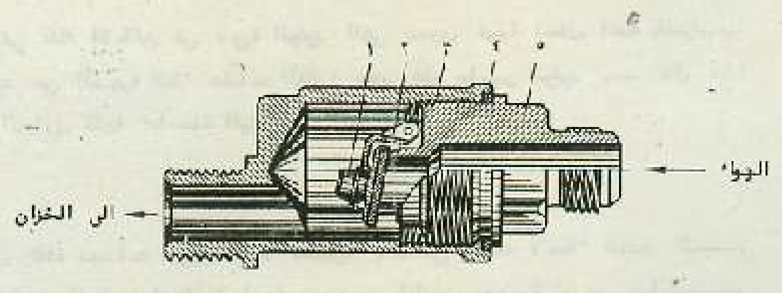
شكل (١٠ — ١٤) رسم تخطيطي لبيان تصميم صمام عدم الرجوع:
١ — ياي ، ٢ — بدن ، ٣ — بلف

b. Safety valves.



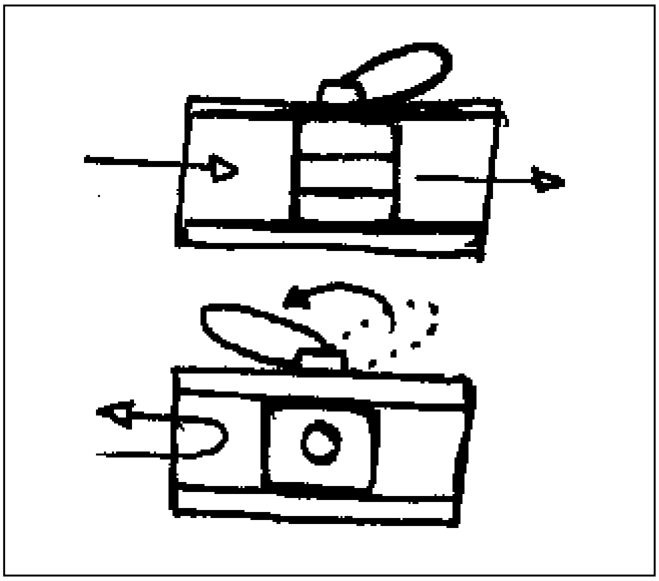
شكل (١٠ — ١٢) رسم تخطيطي لبيان تصميم صمامات الامان:
أ — صمام ذو قرص ، ب ، ج — صمام ذو كرة

c. Vacuum Valves.



شكل (١٠ — ١٥) صمام الفرار:
١ — بلف ، ٢ — مشبك ، ٣ — بدن ، ٤ — جوان ، ٥ — انبوب التوصيل

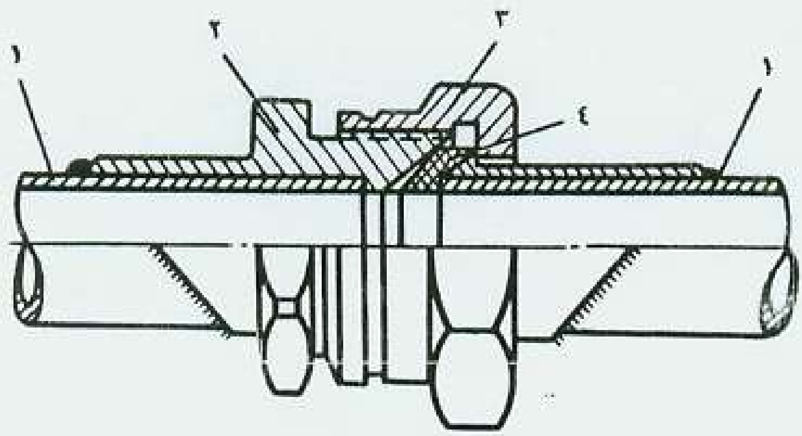
d. Blockage valves.



1.2.3- Pipes :-

Pipes are used enlarge numbers in aircraft and airplane systems and in many types such as:

a. Rubber pipes.
b. Plastic pipes.
c. Metal pipes.
d. Compound type pipes (rubber plus metal net).



شكل (٨ — ١٥) توصيل المواسير مع بعضها البعض

١ — مواسير ، ٢ — انبوب التوصيل ، ٣ — صامولة الشد ، ٤ — نيبيل (nipple)

1.3- **Filters :-**

Filters are used for clarification air, fuel, oil, and hydraulic in aircraft and airplane systems.

1.3.1- **Types of filters :-**filter are generally can be classified into :

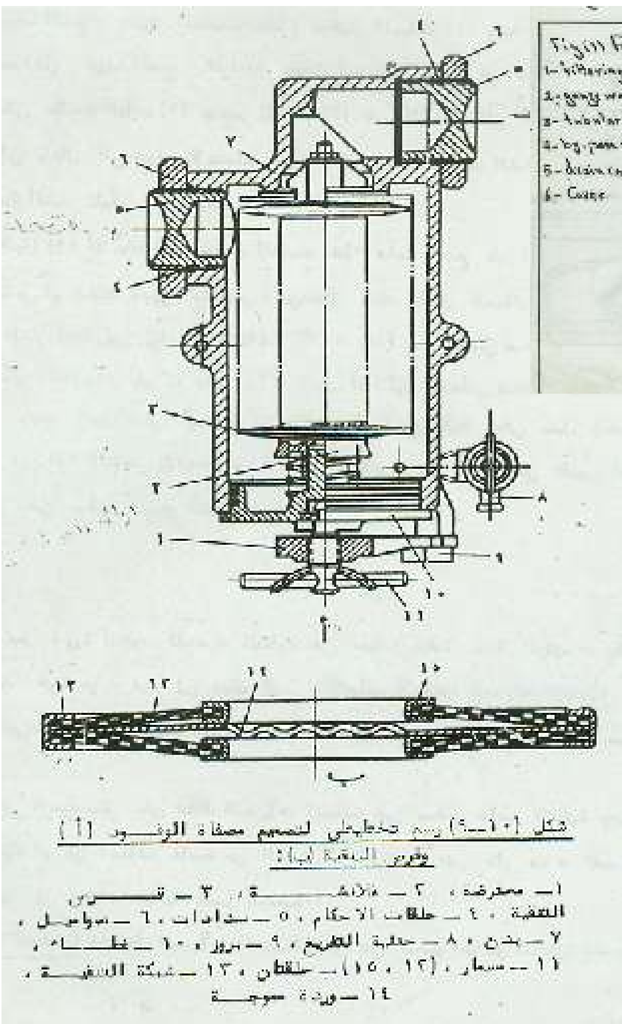
a. Metal filters.
b. Fabric filters.
c. Leaves filters.
d. Compound filters of the above.

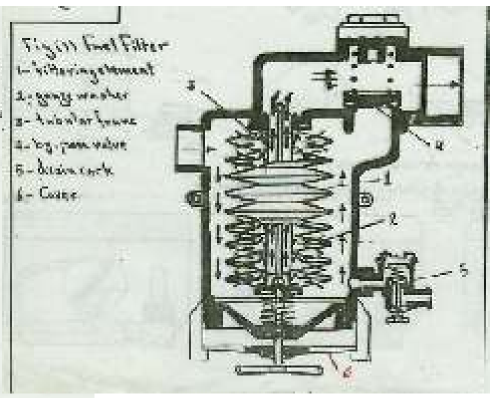
1.3.2- **Some of the filters types were used in aircraft systems :-**

1.3.2.a- **Fuel system filters :-**

The quality of the fuel clarification delivered for the aircraft engines are shows the quality of the filter itself. And it can be classified into:

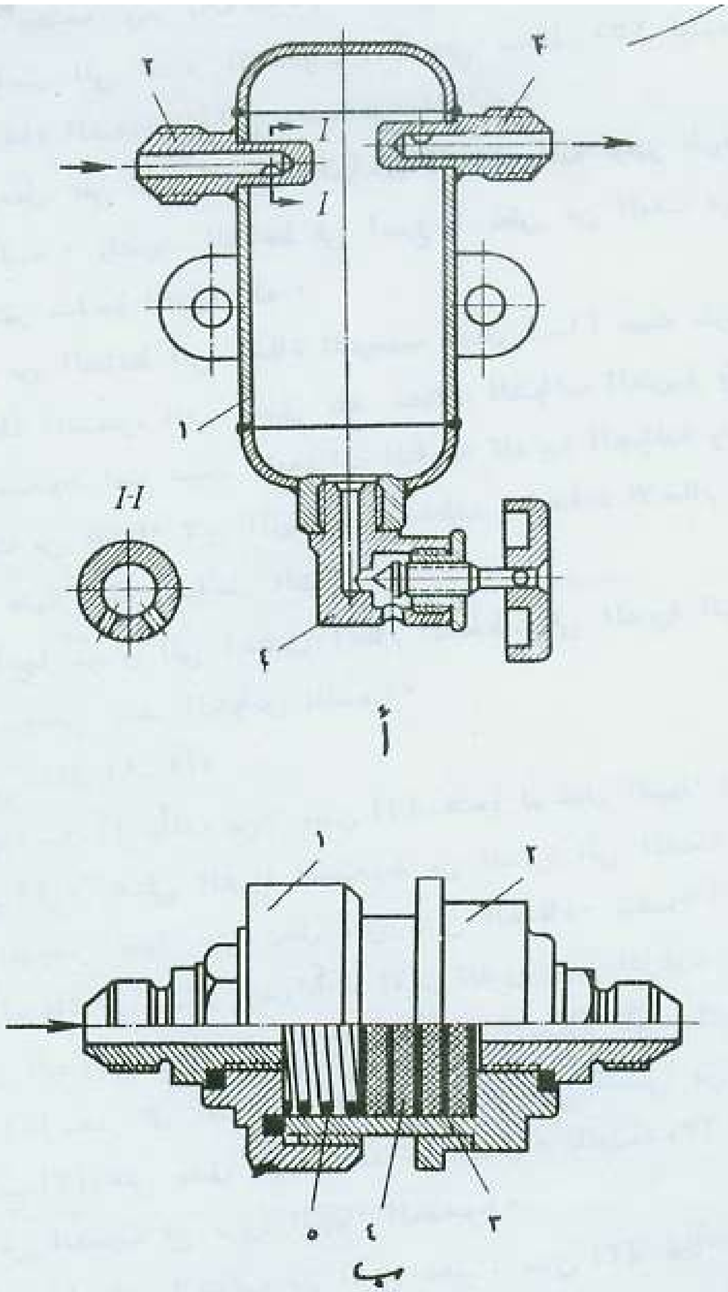
i. Primary shallow filters for large stain size >100 micron.
ii. Secondary capacitive filters for stain < 25 micron.





1.3.2.b- <u>Air Compressed system filters</u> :-

i. Precipitation filters.(clarification air from humidity and oil drops)
ii. Chronic filters.(used for clarification air from stain and to ensuring dry air delivered)



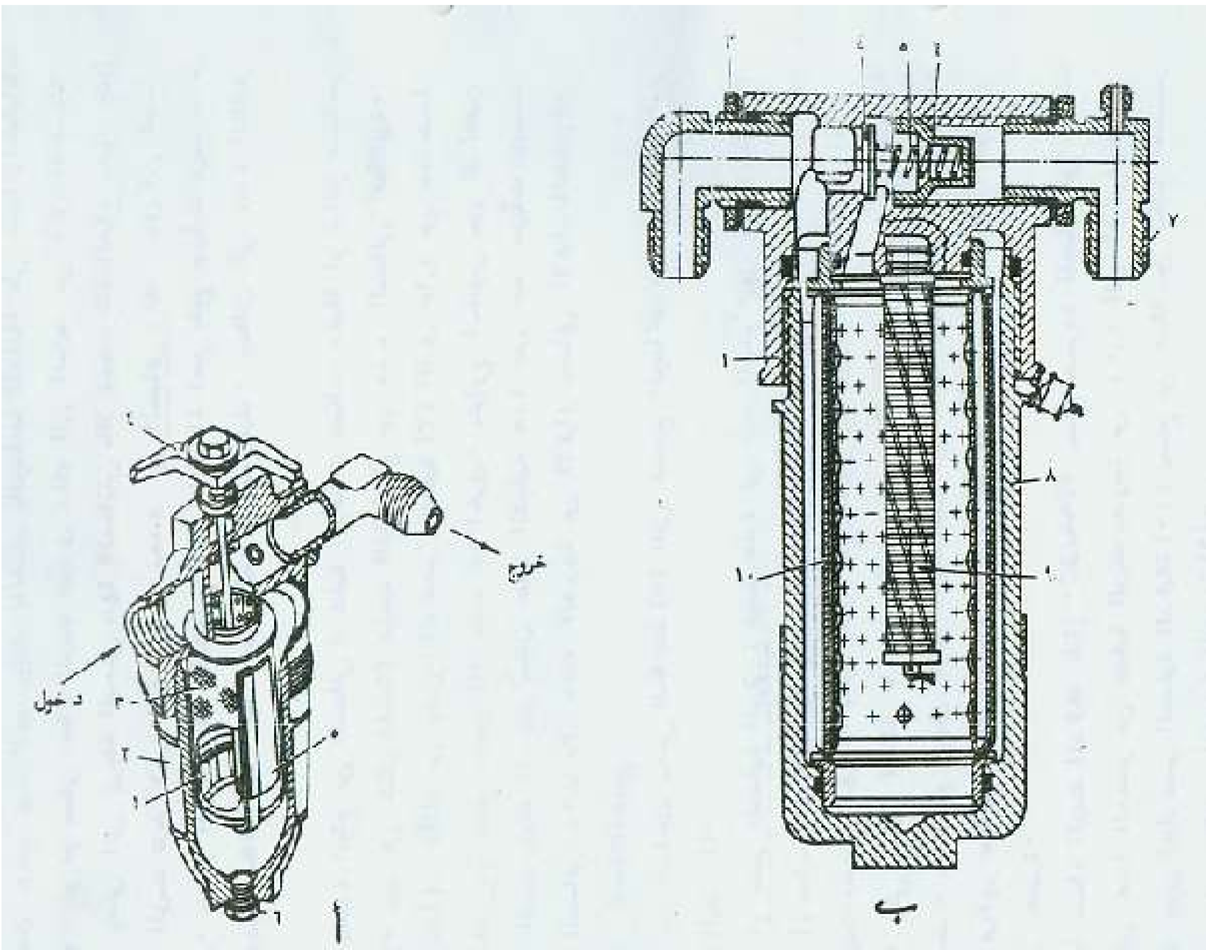
(٩-٣)
شكل [redacted] : مصافي دورة الهواء المضغوط:
أ ـ مصفاة الترسيب : ١ ـ بدن المصفاة ، ٢ ـ فتحة دخول الهواء ، ٣ ـ فتحة خروج الهواء ، ٤ ـ حنفية تفريغ المصفاة من الرسوب ، ب ـ مصفاة مستمرة : ١ ـ غطاء ، ٢ ـ بدن ، ٣ ـ شبكة من نحاس اصفر ، ٤ ـ جوان لبادى ، ٥ ـ يـاى

1.3.2.c- <u>Hydraulic system filters</u> :-

Through the continues use of hydraulic in the hydraulic systems it soil with stains which effects on it's performance, so it's need to be filtered.

There are many types of filters were used in hydraulic systems but generally they can be classified into two types.

i. Purification filters.(used for large size of stains in low hydraulic pressure)
ii. High pressure filters:-
   1. Cleave filters.
   2. Accurate net filters.
   3. Paper filters.



شكل (٨ ـ ٤) مصافي تستخدم في دورة الهيدروليك

أ ـ مصفاة شقية: ١ ـ هيكل، ٢ ـ بدن، ٣ ـ عنصر التصفية، ٤ ـ يد، ٥ ـ مقشط، ٦ ـ سدادة، ب ـ مصفاة دقيقة: ١ ـ رأس، ٢ ـ فتحة دخول الزيت، ٣ ـ صامولة، ٤ ـ صمام، ٥ ـ باي، ٦ ـ غطاء السد، ٧ ـ فتحة خروج الزيت، ٨ ـ بدن، ٩ ـ عنصر التصفية الخشنة، ١٠ ـ عنصر التصفية الدقيقة

1.4- Cocks :-

Cocks are used to control the amount of air or fluids went through it.

And they can be classified by application into :

a. Blockage cocks.
b. Transmission cocks.
c. Evacuation cocks.

But by design classification :

a. Plug cocks.
b. Disk cocks.
c. Grebe Cocks
d. Bluff cocks.

Chapter Two

Aircraft Fuel System

The main cause of fuel system is to deliver fuel to engines in most clarification case and different types of flights without break. So the god fuel system must ensure:

1. Continuity of fuel delivered to the engine in different flight altitudes and whatever was the airplane condition.
2. Guaranty of fuel consumption outflow without effecting on airplane stability or controllability.
3. Guaranty of fuel delivered in different environment conditions.
4. Never to contain a large amount of fuel without needs and to ensure consume all of it in a single flight.
5. Safety against fire as god as possible.
6. The fuel delivered to the engine must be in higher clarification.
7. The design of fuel system must be simple and not complicated.
8. The maintenance of fuel system should be easy and not expensive.

2.1 <u>Constituents of fuel system</u> :-

a. Fuel Tanks.
b. Pumps
c. Fuel filters.
d. Fuel valves.
e. Fuel cocks.
f. Fuel pipes and tubes.
g. Fuel Gauges (measuring fuel consumption, fuelflow and fuel amount).

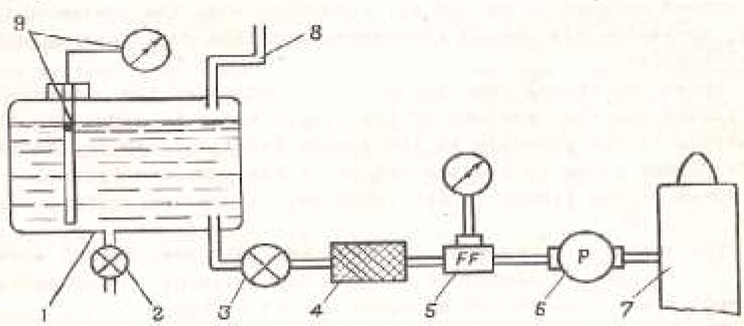


FIG. 23.1. SCHEMATIC DIAGRAM OF ELEMENTARY FUEL SYSTEM
1 – tank; 2 – drain cock; 3 – shut-off valve; 4 – fuel filter; 5 – fuel flowmeter, 6 – high-pressure pump; 7 – aircraft engine; 8 – venting system; 9 – fuel quantity gauge

Figure No.1 Fuel system constituents

2.2- Types of fuel tanks :-

1. **Rubber tanks** :- Consist of several reinforced and non-reinforced corrosion resistant rubber layers, it could be potted in every available size in the airplane.
2. **Semi-stiffen tanks** :- Different from the rubber tanks by containing metal reinforced net and it potted in specific places in airplane.
3. **Metal tanks** :- They used with high speed high altitude airplanes where the temperature of the airplane outside walls might reaches ($200^oc \sim 250^oc$) and due to the decrement in pressure the fuel boil in lower degrees so the thickness of the tanks wall will be (0.5 ~ 2mm) according to flights conditions. This type of tanks are the common used these days in airplane it fixed in airplane wings and body by welding or rivets, the basic disadvantages of this type of tanks are its weight and maintenance complexity.
4. **Vacuum full tanks** :- In some small low speed airplane usually older types they benefit from some spaces in a wings and by glue it with resisted glue then used it as a fuel tank, clearly this is a very dangerous to use but also cheap.
5. **Containers fuel tanks** :- It's an external fiberglass fuel tanks used generally with military warcraft at the long-term flights were they usually used at the beginning instead of the primary tanks then they drop it. Generally they connected under the wings of the warcraft and they were supplies with fins so that they will not hit the body or tell of the warcraft when they drop it. This kind of tanks came with large of disadvantages such as big weight, large drag force and reduces both stability and controllability of the warcraft.

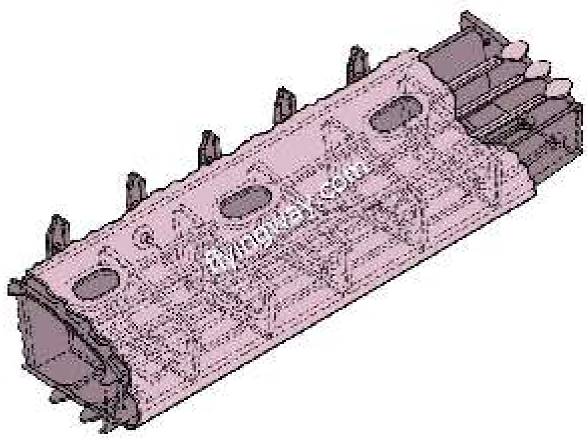



Figure No.2 Some of Fuel Tanks

2.3- <u>Airplane Fuel Types</u> :- In general there are two types of airplane fuel (gasoline and Kerosene) the 1st one used generally with piston-engine type which used in training or fields sprinkling, there are many kinds of this fuel such as (G80 – Red color, G100 – Green color and G100LL Blue color).

The 2nd type used in all types of jet-engine airplanes its less viscose higher octane and more quality than the gasoline, there are many kinds of this fuel such as (Jet B , Jet A and Jet A-1) the most popular one in our days is (Jet B). It also used with warplanes.

2.4- <u>Control of Fuel Consumption</u>:-The stability of the airplane is very important during the flight condition ,therefore consuming a large amount of fuel effects on airplane stability, so we should take that into consideration during fuel consumption by designing a consumption method never effect on the airplane stability even in emergency conditions. In general there are two methods of fuel consumption which are :

1. The 1st method consumes fuel from primary tanks at the airplane body and wings in the same time without disturbing airplane stability. Figure No.3

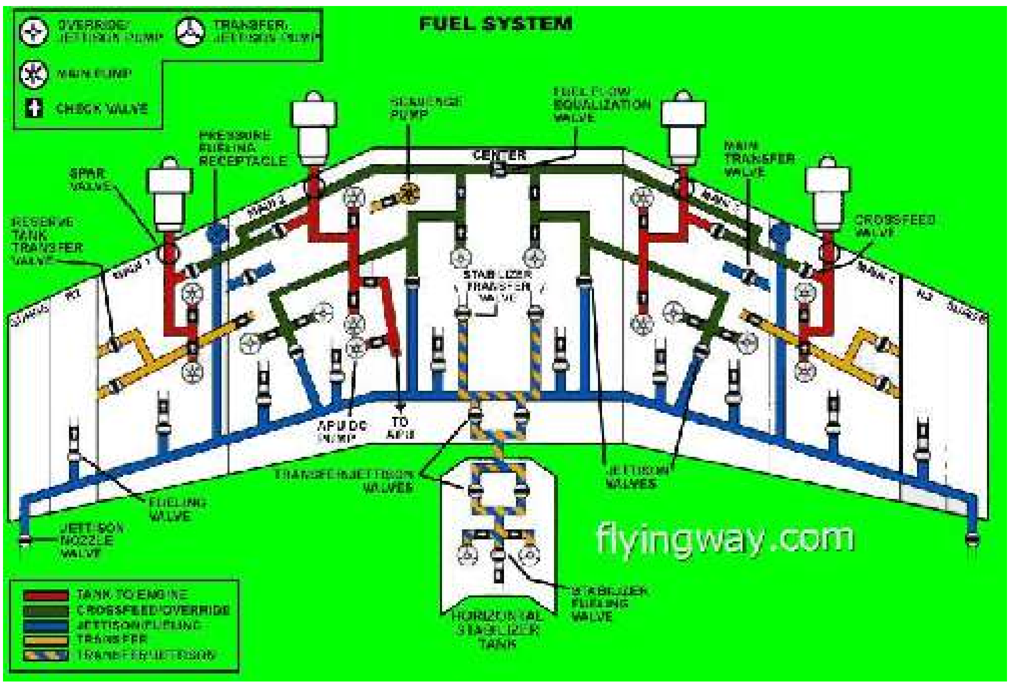


Figure No.3 1st Method of fuel consumption

2. The 2nd method consumes fuel from mini-tanks into major tank supplies directory to the jet engine and they used generally in warplanes. Figure No.4

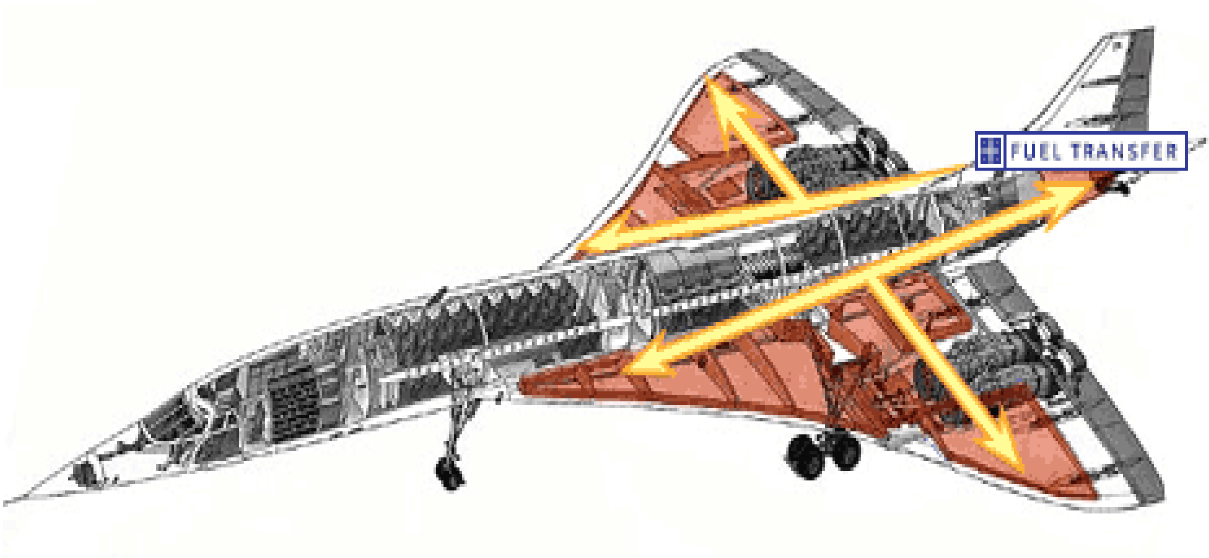


Figure No.4 2nd Method of fuel consumption

2.5- Fuel Cargo cycle :-

The fuel cargo cycle is a very important process also it should occur with higher degree of safety and short time limit also exact amount of fuel.

Usually they don’t cargo each tank in the airplane at ones because it will take long time and needs a bigger group, so usually the fuel tanks are connected to each other's by tubs and when the 1st tank are full the 2nd tank began and so until all the tanks are completely full with fuel.

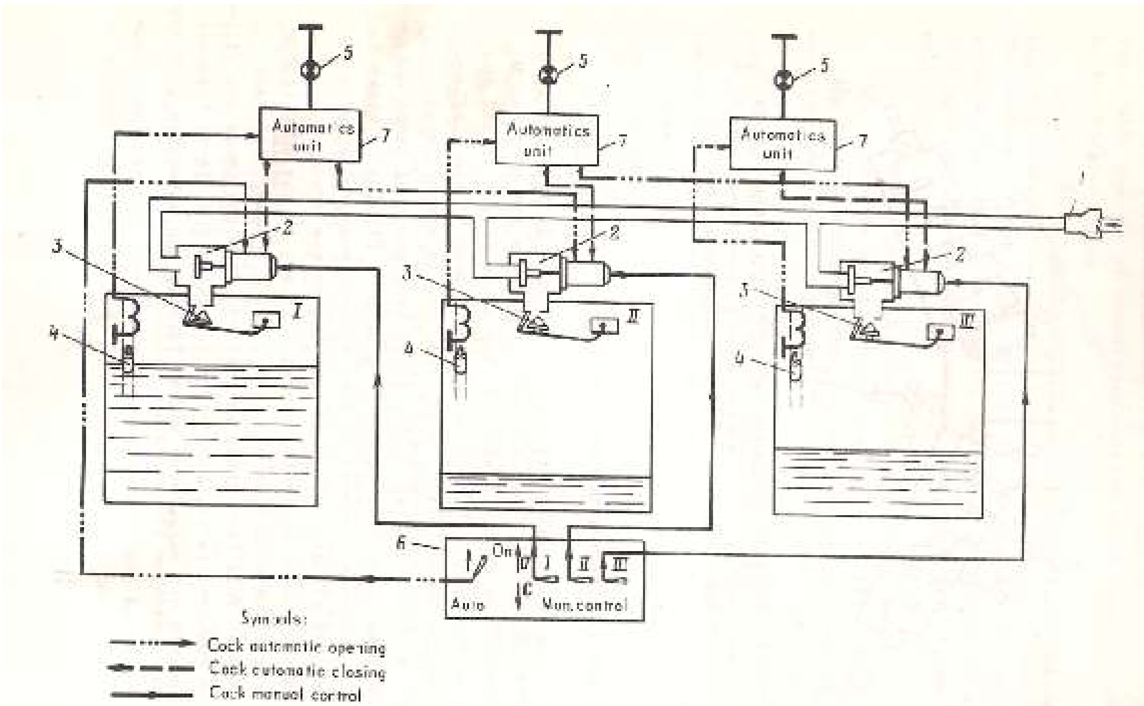


FIG. 23.8. SCHEMATIC DIAGRAM OF SINGLE-POINT FUELLING SYSTEM
1 – central filter; 2 – filling cocks; 3 – float shut-off valves; 4 – induction fuel level transmitters; 5 – warning lamps; 6 – control panel; 7 – automatic unit

2.6- Fuel cycle efficiency at different altitude :-

Meant by high-altitude operation of the fuel system is the maximum altitude to which normal (without cavitation of fuel) supply of fuel to the engines is ensured.Cavitation is boiling vaporization of the fluid moving in the pipeline owing to the local reduction of the pressure up to the liquid vapor saturation pressure.The physical mechanism of cavitation is as follows. The liquid having a free surface evaporates. Separate particles (liquid molecules) separate from its surface and fly to the ambient space. The rate of the movement (evaporation) of molecules increases with the increase of the liquid temperature and with the reduction of the vapor (gas) pressure over the liquid surface. In a closed vessel at a particular moment the amount of molecules thrown from the liquid becomes equal to that absorbed by the liquid, i.e. movableequilibrium between the liquid and vapor occurs. Such vaporis called the saturated vapor while the pressure in the vessel is the pressure of saturated vapors at a given temperature. When the local pressure in the pipeline becomes equal to the saturated vapor pressure, the liquid boils intensively with liberation of vapor.Besides, the aircraft fuel is capable of dissolving a particular amount of air. The amount of air dissolved in the fuel is in the direct proportion to the air pressure. When the pressure drops down, excessive air starts liberating from the fuel forming gas (air) bubbles.Under the actual conditions the reduction of the pressure in the liquid and fuel systems of the aircraft may be caused by the reduction of the pressure in the system (venting one) as the aircraft climbs owing to suction action of the pump and hydraulic resistances of the liquid in different main lines and units(Fig. 23.2, b).The vapor-air cavities disrupt the fuel flow. Normal operation of the pump is disturbed and the reduction of fuel supply to the engine may lead to the stoppage of the latter.Besides, cavitation leads to mechanical destruction (erosion) of the pipeline and especially pump metal. Erosion stems from microscopic hydraulic shocks of the liquid particles.The modern jet aircraft have ceilings of 12,000 to 35,000 m and flight speeds of 2000 to 3500 km/h. With the altitude, the barometric air pressure drops down considerably (at an altitude of 0, 10, 25 km the pressure is respectively equal to 1, 0.26,0.025 kgf/cm^2). Besides, the high-speed flight is accompanied by high aerodynamic heating of the aircraft structure. In this case, the temperature of the fuel may reach 100 - 150^{O}C and above.At a temperature of 100^{o}C the pressure of saturated vapors of aviation kerosene's used in the air jet engines (T-l, TC-l and T-5) is approximately equal to 0.2, 0.3 and 0.08 kgf/cm^2, respectively. When climbing, fuel T-l in the tank communicated by a vent with the atmosphere will cavitate at an altitude of about 12 km, fuel T-5, at an altitude of about 18 km. The pressure drop in the fuel system leads to cavitation at considerably lower altitudes.The elementary system considered above (Fig. 23.1) cannot ensure altitude operation required for the modern aircraft. The following design measures are used for increasing high-altitude operation of the aircraft fuel systems: creation of tile excessive pressure in the tank owing to the use of the ram pressure (at lowaltitudes) or use of forced pressurization of the tanks from the foreign source (at high altitude); installation of additional booster pumps directly near the tanks and in the suction pipeline.Creation of the excessive pressure in the tank (tank pressurization) is the simplest method of increasing the altitude of fuel system operation (the fuel pressure curve moves-upwards).The pressurization resides in that air or neutral gas with a certain excessive pressure is fed to the over-fuel space of the tanks. To supply air, use is made either of the ram pressure through the vent system (Fig. 23.2, a) or the forced pressurization system. When cock 8 is open, air from the engine compressor (bottle) is fed through reducer 10 and non-return valve 9 to the vent system. Additional non-return valve IJ shuts off the pipeline which connects the vent system to the atmosphere.It should be pointed out that in spite of the fact that the tank pressurization is very simple, it cannot be used as a main method of fighting cavitation owing to the increase of the weight of the construction which is necessitated by excessive loads on the tank walls and its container. Therefore, a relatively low pressure (Δp = 0.1 - 0.3 kgf/cm^2) is used, and this ensures cavitation-free operation of the booster pumps installed at the tanks at high altitudes, i.e. high altitude of operation is ensured at the section between the tank and the booster pump.The most effective way of preventing cavitation is the booster pumps. They create an excessive pressure of 0.5 - 2 kgf/cm^2 (depending on the type and operation mode of the pump) in the system.The pressure ram created by the pump is so selected that in the most critical section (a-a) of the system (before the high pressure pump of the engine) the pressure exceeds the fuel vapor saturation pressure, under the heaviest flight conditions (V_{max} at ceiling). On the aircraft with long fuel pipelines and high flow rates the pressure ram of one booster pump 2 may prove insufficient. In this case second booster pump 5 is, installed in the system in series with the first one.Thus, the booster pumps ensure high altitude of operation of the system at the section between the booster pump and the highpressure pump. A combined method of increasing high altitude of, operation of the fuel system (pressurization plus booster pumps) is widely used in the modern aircraft

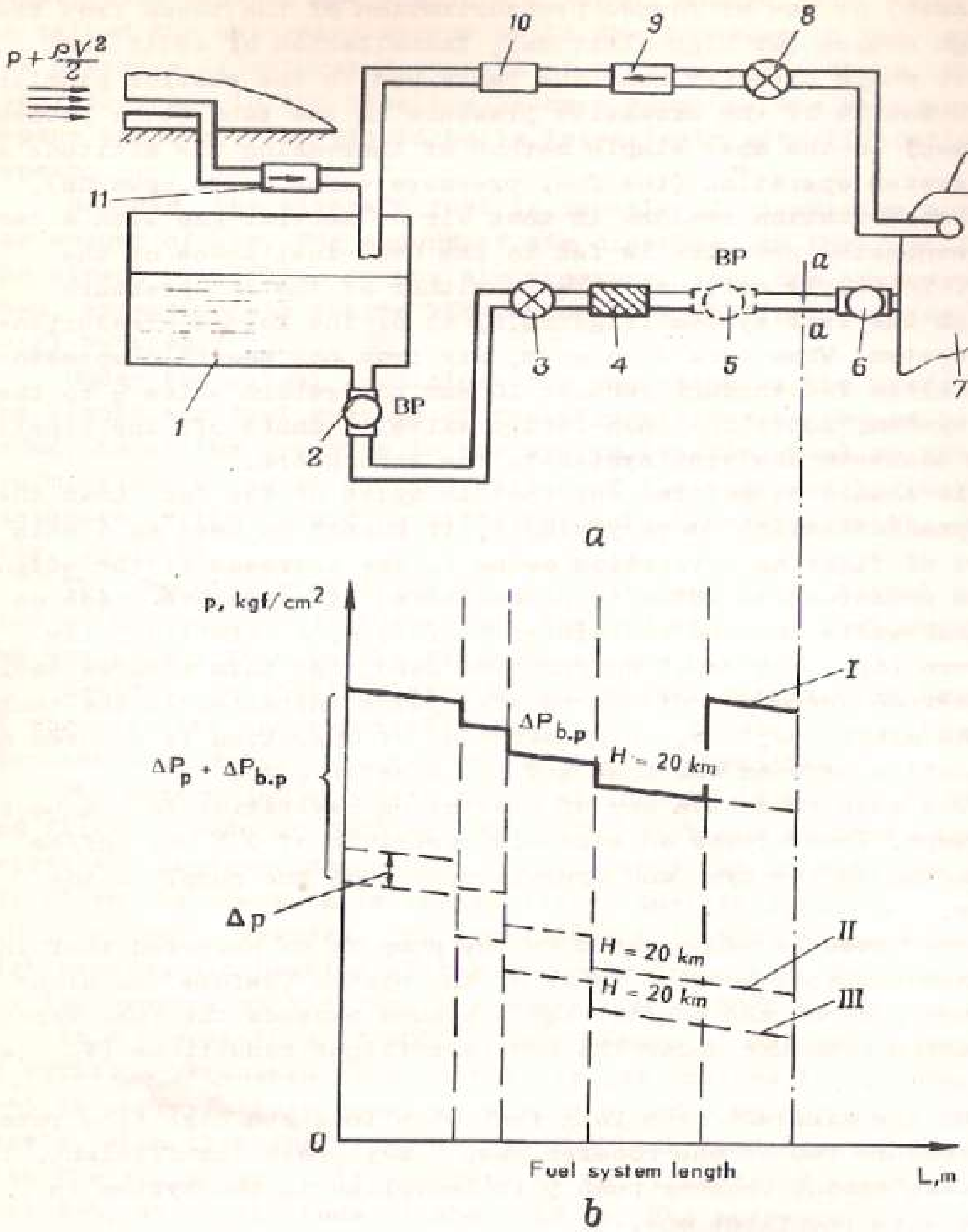


FIG. 23.2. MEANS FOR INCREASING ALTITUDE OF OPERATION OF FUEL SYSTEM
a – schematic diagram of fuel system with means for increasing altitude of operation; b – dependence of fuel pressure on fuel system length and flight altitude; 1 – tank; 2, 5 – booster pumps; 3 – shut-off valve; 4 – filter; 6 – high-pressure pump; 7 engine; 8 – cock; 9, 11 – non-return valves; 10 – air reducer of pressurization system; I – with booster pump and pressurization; II – with pressurization; III – without pressurization

2.7- Fuel System Behavior At Different Flight Conditions :-

Generally there are three basic flight conditions which are :

1. **Pitching up or down**.
2. **Yawing left or right**.
3. **Rolling left or right**.(plus revers flight)

In some flight conditions the airplane movement is a combination of two or three of the above flight conditions especially the warplanes, there for a god fuel system should assure fuel consumption whatever were the conditions of flight.Many solutions were put for such problem we will take the simplest one.

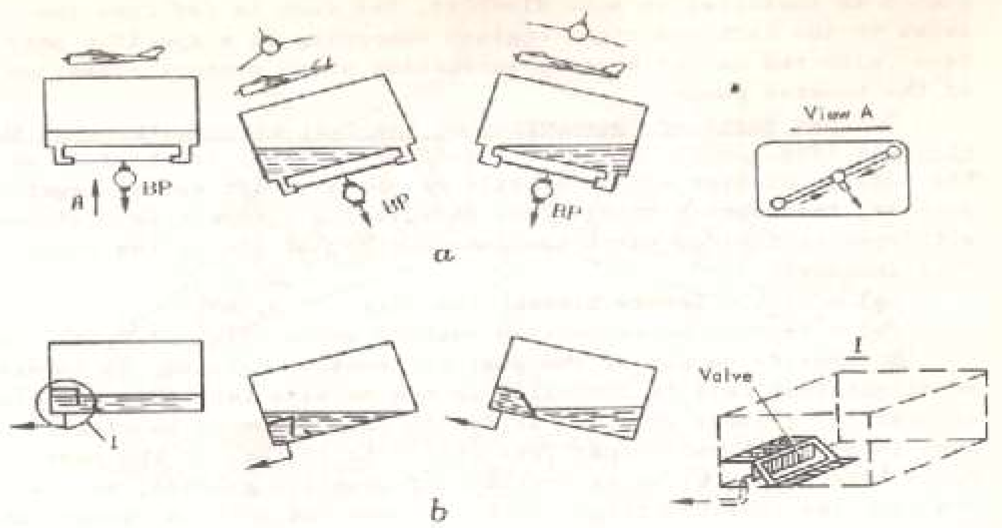


FIG. 23.5. DEVICES ENSURING CONSUMPTION OF FUEL AT EVOLUTIONS OF AIRCRAFT
a – operating principle of twin intake branch pipe; b – operating principle of service pocket with rocking valve

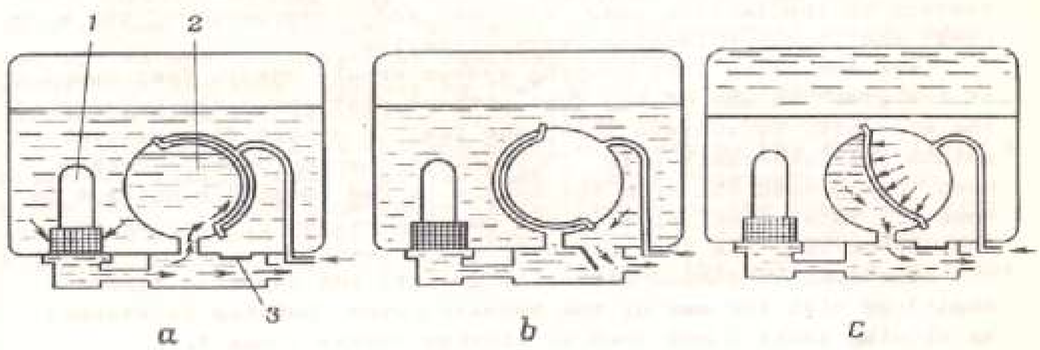


FIG. 23.6. OPERATING PRINCIPLE OF INVERTED-FLIGHT FUEL CELL
a – at action of positive g-loads; b – in case of pump failure; c – at action of negative g-loads; 1 – booster pump; 2 – inverted-flight fuel cell; 3 – valve

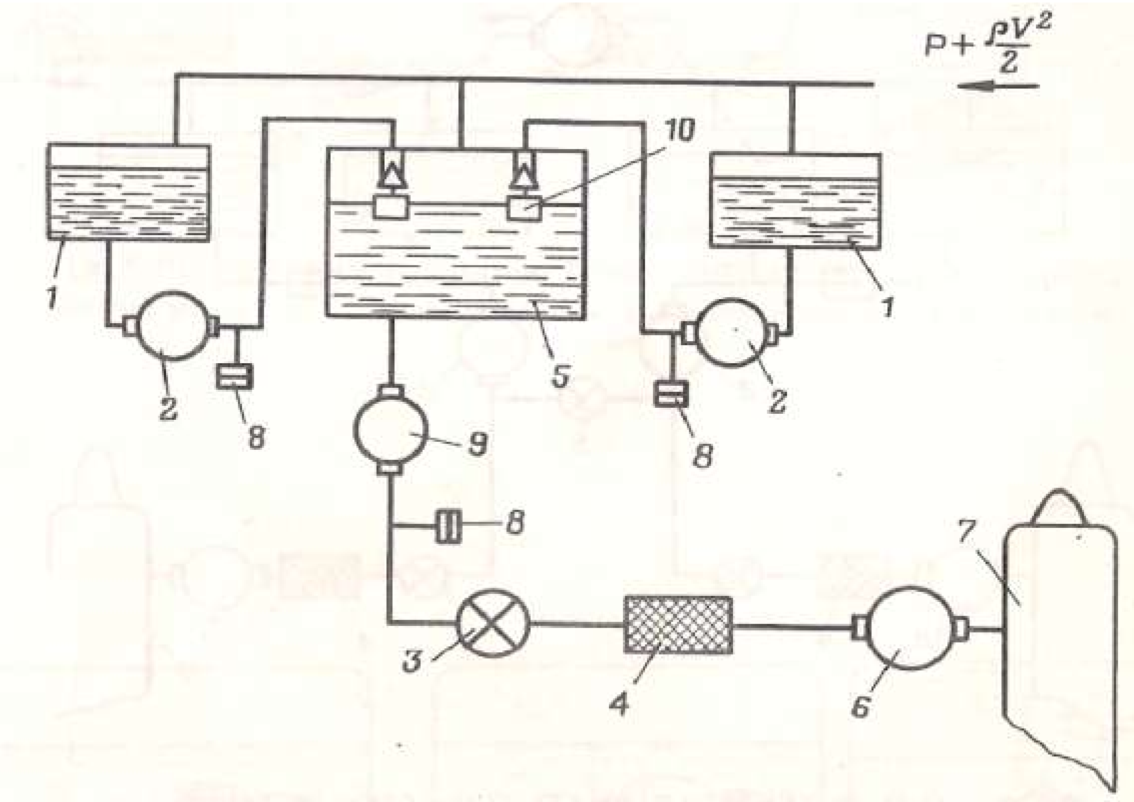


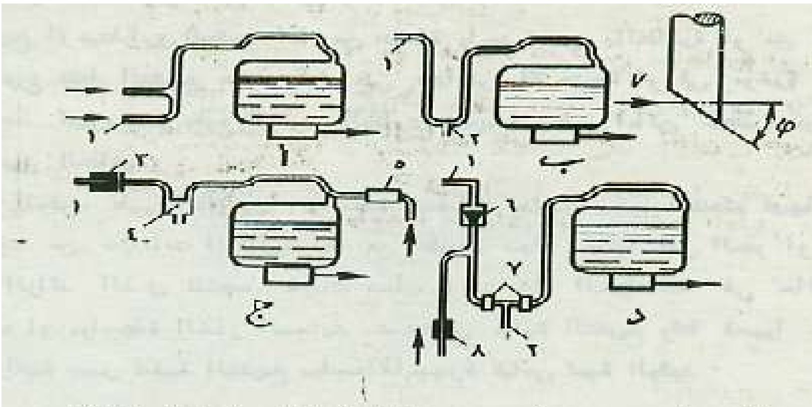
FIG. 23.3. FUEL SYSTEM WITH SERVICE TANK

1 – tanks; 2 – transfer pumps; 3 – shut-off valve; 4 – filter; 5 – service tank; 6 – high-pressure pump; 7 – engine; 8 – pressure switch sensors; 9 – booster pump; 10 – float valves

2.8- <u>Controlling Excessive pressure on Fuel Cycle</u> :-

It's very important to control the excessive pressure on fuel cycle to ensure fuel delivery to the engine and to do that there are three major cycles of excessive pressure which are :

1. Open Cycle.
2. Closed Cycle.
3. Compound Cycle.



شكل (١٠ — ٢١) رسوم تخطيطية لبيان دورات تصريف خزانات المصرف :

أ — دورة مفتوحة مزودة بانبوبي مص الهواء ، ب — دورة مغلوقة مزودة بانبوب واحد لمص الهواء وماسورة على شكل حرف U ، جـ — دورة مفتوحة مزودة بجهاز ازالة الجليد ، د — دورة مشتركة تعتمد على الضغط الناتج من ضاغط المحرك النفاث ، ١ — انبوب ماص الهواء ، ٢ — انابيب التفريغ ذات ثقب معير ، ٣ — جهاز ازالة الجليد من انبوب ماص الهواء ، ٤ — خزان لجمع رواسب الوقود في دورة التصريف ، ٥ — صمام فراغي ، ٦ — صمام عدم الرجوع ، ٧ — صمامات الامان ، ٨ — ثقب معير

2.9- Fuel System Safety Handling :-

As any successful system in the airplane fuel system should have a safety handling to reduce the dangers might occurs during flight to the system, the basic breakdowns of the fuel system were due to :

1. Breakdown the fuel pumps.
2. Fuel filters blockage.
3. Breakdown the fuel valves.
4. Fire close to the system or by it.
5. Pipes or tubes leakage due to bad maintenance.

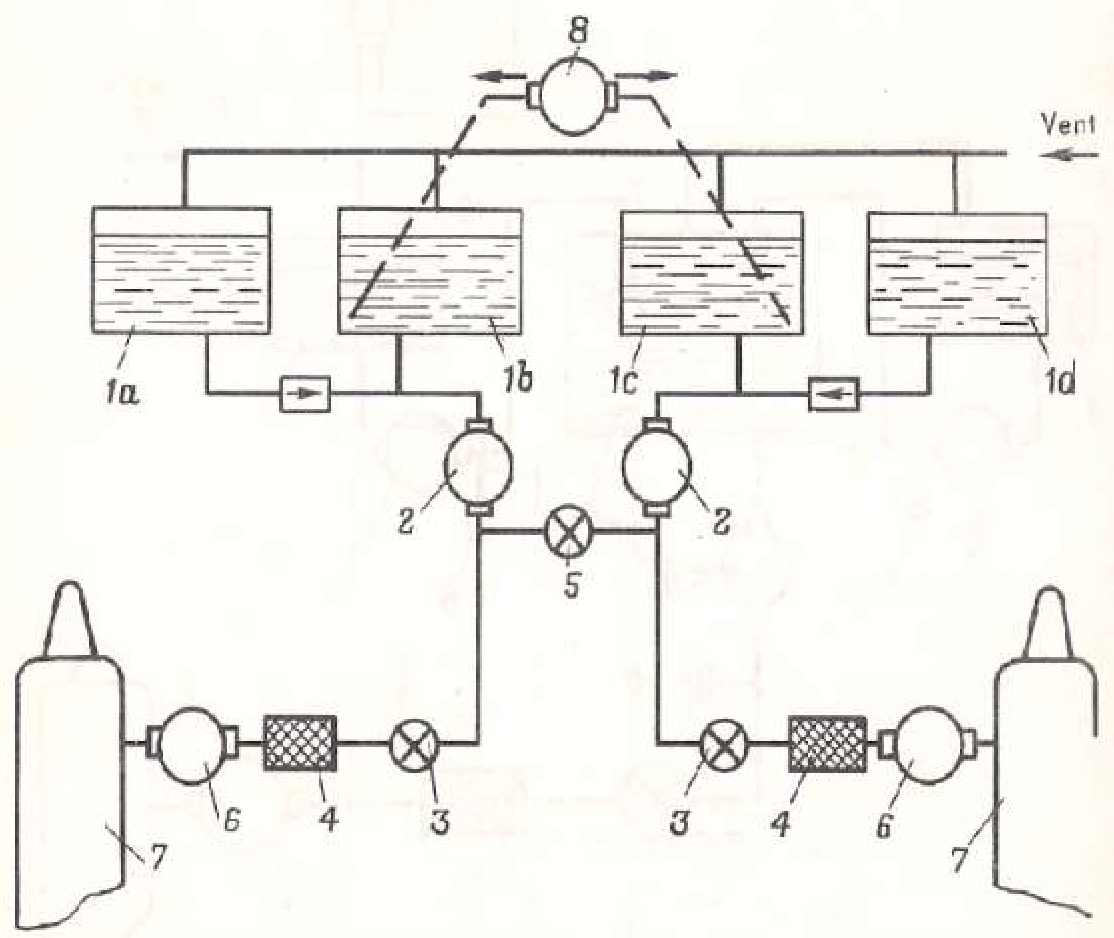
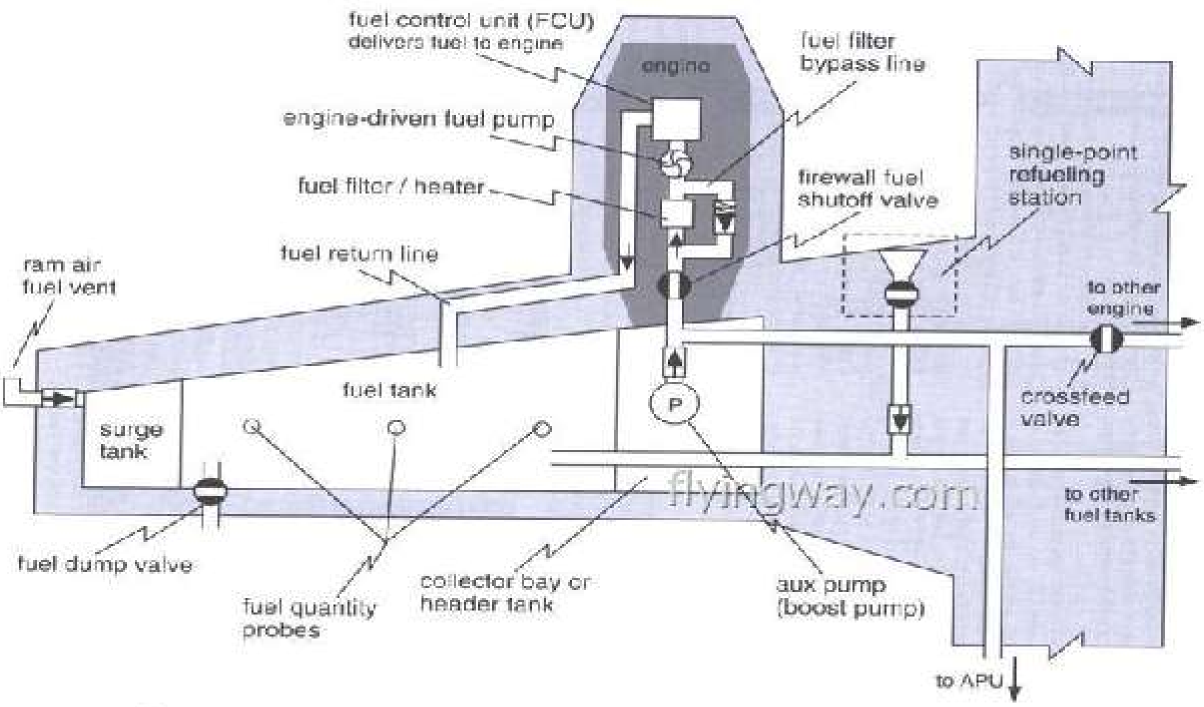


FIG. 23.4. FUEL SYSTEM WITH PARALLEL CONNECTION OF TANKS
1a, 1b, 1c, 1d – fuel tanks; 2 – booster pumps; 3 – shut-off valves; 4 – filters; 5 – cross-feed valve; 6 – high-pressure pumps; 7 – engines; 8 – transfer pump

2.10- Evacuation Cycle of Fuel System at Emergency Cases :-

In some emergency cases we need to evacuate or drop the fuel from the airplane especially at the cases when the landing gear locks in the body of the airplane or if the engine was burn. A god evacuation cycle should ensure

1. Evacuate fuel as fast as possible.
2. Evacuate fuel as much as possible.
3. The fuel evacuation could be happened from one point or many points.
4. These evacuation points should be as far as possible from the engine.
5. The evacuation of fuel is one side very risky operation so we must be assuring from it.



2.11- <u>Flight Feeding</u> :-

Simply it's a re-charging airplane with fuel at the atmosphere during flight usually occurs with military warplane long flights or in some transporting airplane, below some figures of flight feeding.

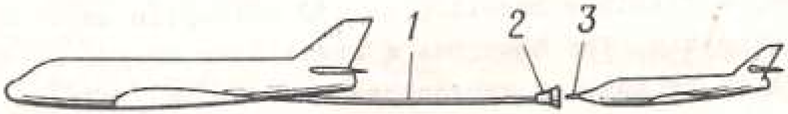


FIG. 23.9. IN-FLIGHT FUELLING WITH USE OF CONE
1 – flexible hose; 2 – cone; 3 – intake pipe

Such a refuelling system provides for simultaneous servicing of a number of the aircraft from one tanker and does not require skilled operators at contacting.

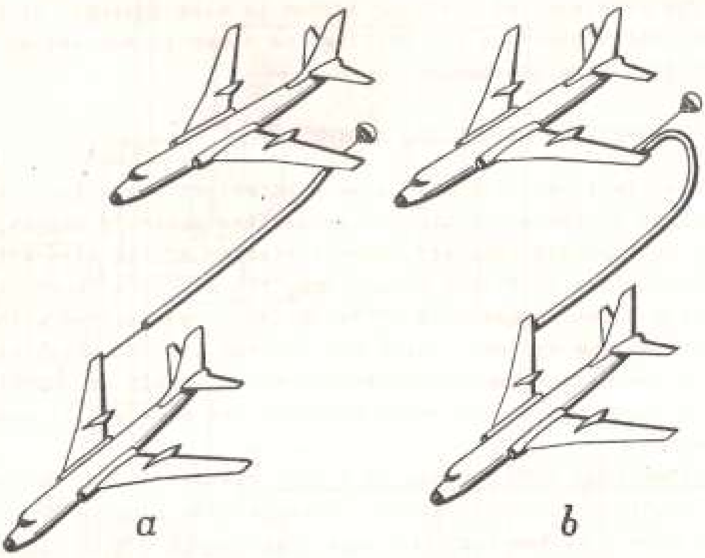


FIG. 23.10. IN-FLIGHT WING-TO-WING FUELLING
a – beginning of contact; b – transfer of fuel

2.12- Bacteria and Microbes Dangers on Fuel Tanks :-

Bacteria known as **(Microorganisms)** is very danger on fuel tanks if we know there were more than 100 species of this bacteria which have the ability to live in the little drops of water collected in the bottom of the fuel tank due to bad maintenance leads to major problem such as :

1. Blockage the fuel filters.
2. Reduce the fuel property and efficiency.
3. If its left for long time it could cause tank rusty.

2.13- Fuel System Maintenance :-

1. Connect the fuel van and the airplane to the ground during fuel cargo.
2. After any fuel cargo operation we have to be shore from system sealing.
3. Checkup fuel filters and pumps periodically.
4. Checkup fuel consumption.
5. Checkup the delivered fuel to the engine and the engine thrust which gives an indication on fuel clarification.
6. Checkup the fuel amount on the fuel tanks.
7. Always take general safety principals into consideration.
8. Applied maintenance periodically according to system logbook.
9. Checkup fuel tubs and pipes.
10. Checkup the excessive pressure and its cycles.

Chapter Three

Aircraft Hydraulic System

The Hydraulic system is one of aircraft major systems and it's used in many places in aircrafts such as:

1. Take off and fall of under carriage (Landing Gear).
2. Airplanes Tiers break down.
3. Flaps movement.
4. Airplanes controller's movements.
5. Airplane doors movement.

The Hydraulic system surpass from other airplane systems are:

1. The ability of generating huge power according to the other systems.
2. The perfect exact movement controlling of airplane flaps and controllers at any position with short time period.
3. Softness performance activity.
4. Any leakage in the system could easily be notice by eyes only.

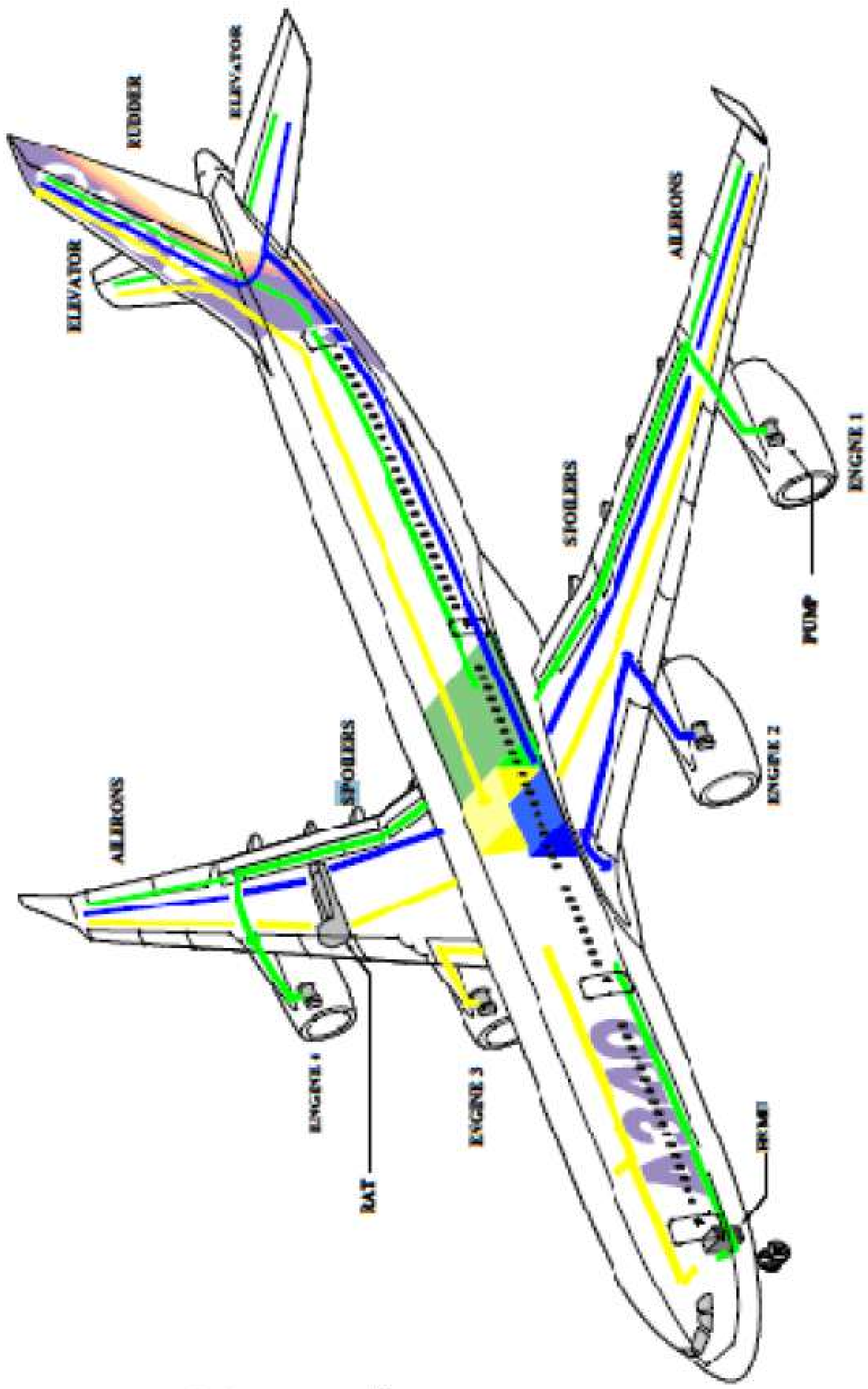
While the major defects of the Hydraulic system are:

1. Heavy weight usually.
2. The complexity of hydraulic feeding.
3. Not safe against fire.
4. Maintenance of the system is complicated and expensive.

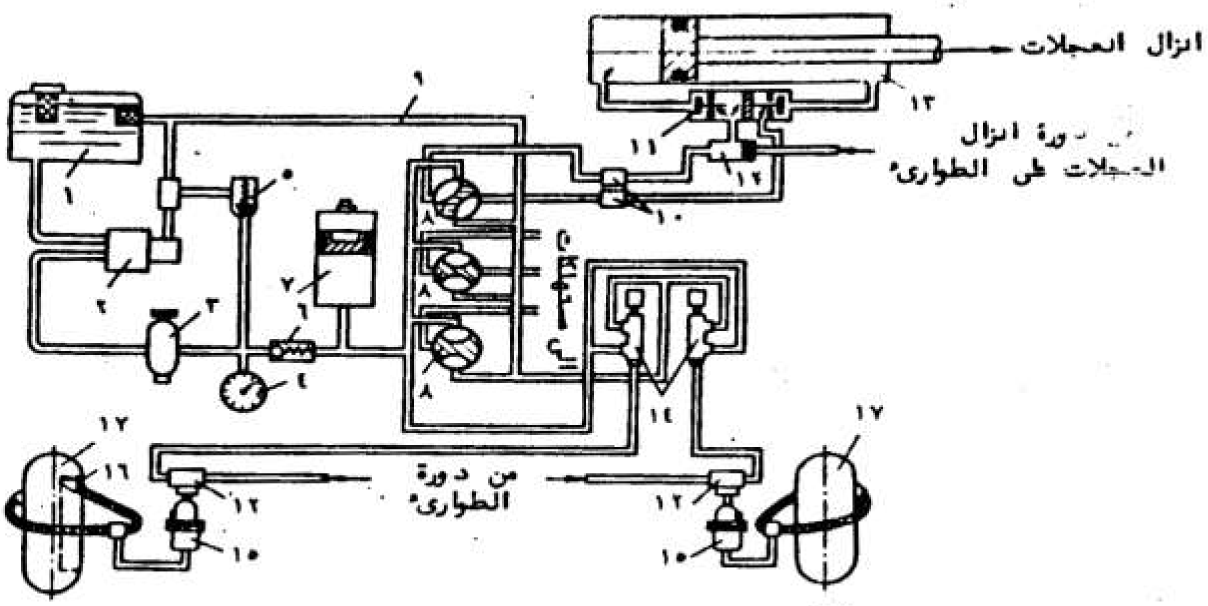
3.1- <u>Hydraulic System Construction</u> :-

In general the Hydraulic system can be sub-divided into basic Hydraulic system and the Consumers cycle system, the basic Hydraulic system are consist of :

1. Hydraulic tanks.
2. Hydraulic Pumps (including high presser pumps).
3. Valves such as safety valves, non-return valve …etc.
4. Pipes and tubs.
5. Hydraulic accumulators.
6. Gauges (Hydraulic amount gauge and pressure gauge).

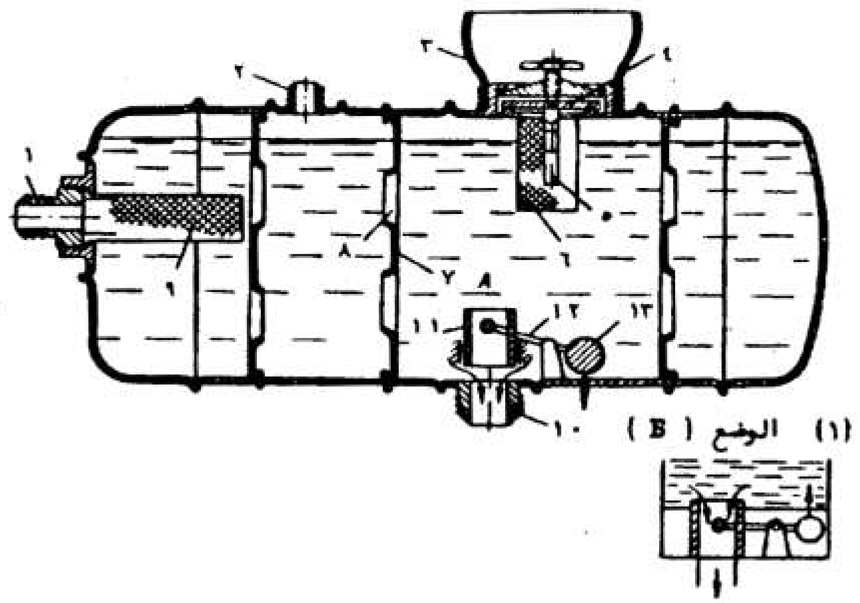

ELEVATOR
RUDDER
ELEVATOR
AILERONS
SPOILERS
ENGINE 1
PUMP
ENGINE 2
SPOILERS
AILERONS
ENGINE 4
ENGINE 3
RAT
A340

Hydraulic System Diagram in Modern Airplanes



شكل (١) رسم تخطيطى لبيان مكونات دورة الهيدروليك :

١ ـ خزان الزيت ، ٢ ـ طلمبة الزيت ، ٣ ـ مصفاة الضغط العالى ، ٤ ـ مقياس الضغط ، ٥ ـ صمام الامان ، ٦ ـ صمام عدم الرجوع ، ٧ ـ مدخرة هيدروليكية ، ٨ ـ حنفيات توزيع الزيت ، ٩ ـ قناة صب الزيت فى الخزان ، ١٠ ـ صمامان قابلان للانفصال السريع ، ١١ ـ قفل هيدروليكى ، ١٢ ـ صمامات الطوارئ ، ١٣ ـ اسطوانة التشغيل ، ١٤ ـ صمامات فرامل العجلات ، ١٥ ـ مسرع هيدروليكى ، ١٦ ـ قميص الفرملة ، ١٧ ـ عجلة



شكل (٢) رسم تخطيطى لمقطع خزان زيت الهيدروليك :

١ ـ فتحة لصب الزيت فى الخزان ، ٢ ـ فتحة التصريف ، ٣ ـ قمع ، ٤ ـ عنق الملء ، ٥ ـ مسطرة القياس ، (٦ ، ٩) ـ مصفاة ، ٧ ـ جدار ، ٨ ـ فتحة ، ١٠ ـ فتحة قناة المص ،

3.2- <u>Hydraulic Tanks</u> :-

For airplanes an organic hydraulic derived from petrol were used and sometimes they named it (Airplane Hydraulic Oil) and in some cases accessories improvers were includes to improve hydraulic viscosity or to prevent it from oxidation easily distinguished by its red color, this hydraulic resist heat from (60 ~ 90 ^{o}C) and its inflammation temperature is 92 ^{o}C ,after this temperature the hydraulic lose its viscosity and quality and no longer be useful. According to its low inflammation the system fitness should be taken in higher order especially at warmer places such as engines, also this hydraulic flame if it's contacted with compressed air so we should take that into consideration by isolating hydraulic pipes from air-pressed pipes. The hydraulic used in the system have to be conforming to the specification technics and should be tested before and after every flight to insure of its viscosity and other specifications.

The hydraulic tanks are usually mead by metals of (1 ~ 2 mm) thickness and reinforced to stand the pressure of hydraulic inside. Each tank should have a filling neck with filters fits with indicator cover to show the amount of hydraulic in the tank.

In the bottom of the tank there are two vents, one to the cycle and the other one from it. Both vents were equipped with filters to prevent hydraulic spume. See figure 2.

3.3- <u>Hydraulic System Performance at Different flight Conditions</u>

1. <u>At high altitude</u>:-

At high altitude flights the atmospheric pressure decreased and to insure of hydraulic pressure an **azote gas** were supplies to the hydraulic at pressure of (0.2 ~ 2.5 kg/cm^2) to stabilize its pressure according to its need.

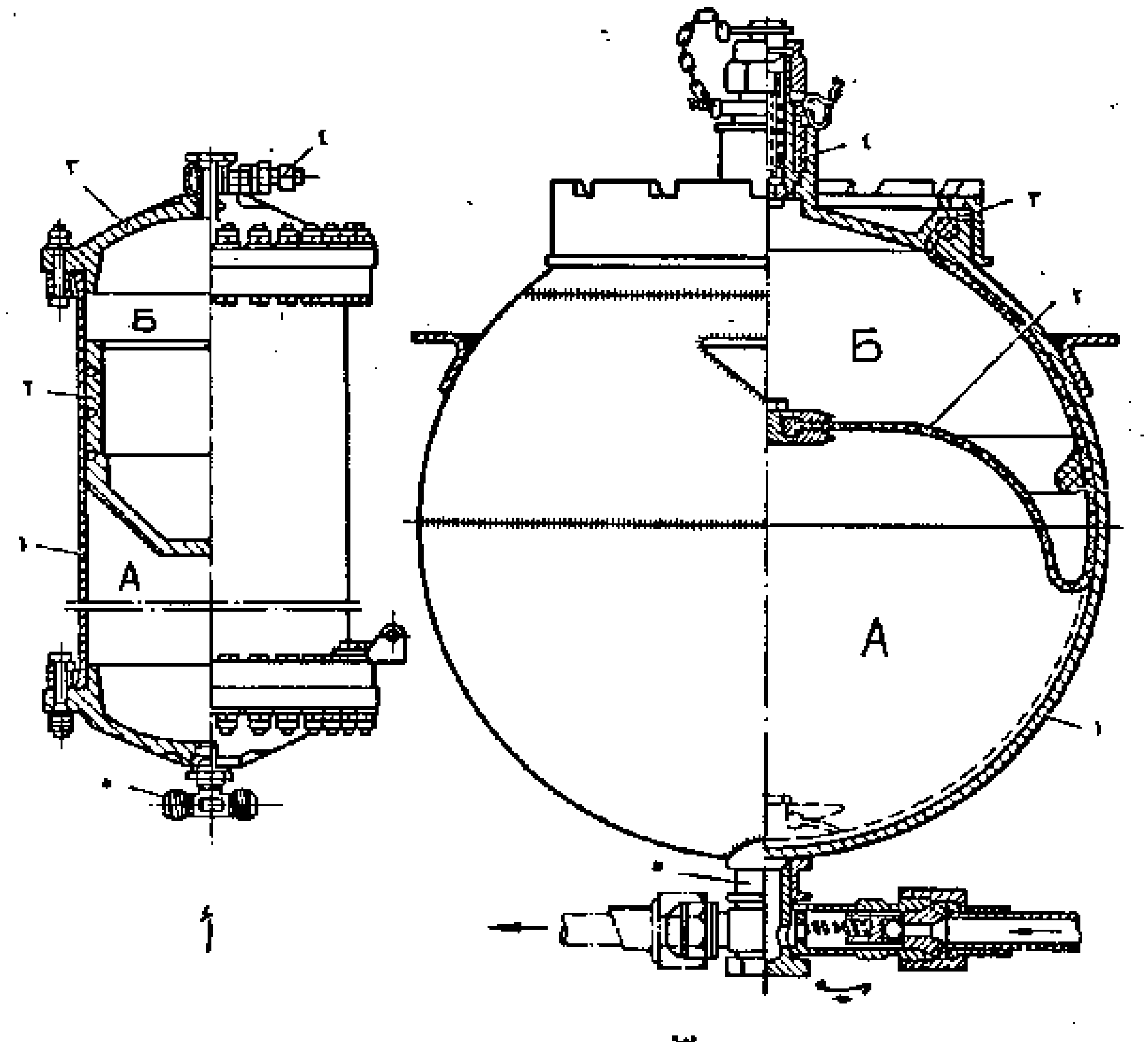
2. <u>At reverse flight</u>:-

For reverse flight condition the hydraulic tank supplies with reverse flight valve figure 2, this valve depends on the balancing principles to work where in the revers flight the valve touches the exchange vents to ensure of hydraulic supplies. In some airplanes they used a revers flight tank or hydraulic accumulators for reversing flights.

3.4- Hydraulic Accumulators :-

The hydraulic accumulators are used to perform the following functions':

1. To effect a short-time increase of the system power (this provides for decrease of the power of the pumps).
2. To increase idle time of the pumps in the systems with theconstant displacement pumps and unloading units and to increase a pause period in the systems with the pump switch.
3. To ensure operation of separate consumers at failure or the pumps.
4. To decrease the fluid pressure pulsation and damping of hydraulic shocks.



شكل ٣ مدخرات هيدروليكية

أ ـ ذات مكبس عائم ، ب ـ ذات رق ، ١ ـ بدن ، ٢ ـ مكبس عائم ، ٣ ـ غطاء ، ٤ ـ فتحة لملء الغاز ، ٥ ـ فتحة توصيل وصرف الزيت ، أ ـ جوف مملوء بالزيت ، ب ـ جوف مملوء بالغاز

In general there are two types of hydraulic accumulators the piston hydraulic accumulators and the spherical hydraulic accumulators.

Piston Hydraulic Accumulators	Spherical Hydraulic Accumulators
1. Floating Piston 2. Cylindrical Shape 3. Simple Assembling 4. Piston are fixed by Rings 5. High friction between piston and cylinder 6. Probability of Rings damage 7. Heavy Weight 8. Used with Heavy Equipment 9. Stresses at cylinder inner surface are less 10. Relatively Big Volume	1. Flexible Diaphragm 2. Spherical Shape 3. Complex Assembling 4. Hard Maintenance 5. No Friction with spherical walls 6. Probability of Puncture 7. Lighter weight 8. Used with light Equipment 9. High Stresses on Spherical Surface 10. Relatively Small Volume

3.5- Hydraulic Power Consumer Circuits :-

3.5.1- Purpose and components of consumer circuits :-

The consumer circuits serve to supply the hydraulic energy from the supply circuit through control devices to actuating devices and to convert it into the mechanical energy of the control object movement. The consumer circuit comprises a control device (valve), actuating device (actuating cylinder, hydro motor) and pipelines.

In addition to the above obligatory devices, the consumer drive circuits comprise various additional units. They are installed in order to:

a. Increase reliability and survivability of the system;
b. Adjust the speed of the movement of the actuating devices and the pressure in front of them;

c. Fix, synchronize and ensure a required sequence of operation of the actuating devices.

Depending on the controlled object operating principle, the consumer circuits are divided into discrete (intermittent) and continuous control systems.

The discrete control systems include the landing gear retraction/extension control systems, the flap, cargo hatch door, air brakes control systems, etc., i.e., the systems featuring two or several fixed displacements, for instance, from the extended to the retracted position and vice versa.

The continuous action systems include the systems for controlling hydraulic boosters, variable sweep wing, nose wheels steering, the system for adjusting air intakes, etc., i.e., the systems which fix the controlled object at any required position (the variable sweep wing control system may be of the discrete type also.

3.5.2- Hydraulic Valves :-

The hydraulic valves are the control members of hydraulic system. They control a flow of the fluid to the actuating mechanisms. They might be classified according to the following features:

a. Type of the distribution device; slide-valve, valve and plug.
b. Number of fixed positions of the wing; two- and three- position valves.
c. Drive type; manual and electrically controlled.
d. Control method; direct control, servo-control.

The slide valve – type valves with electric (remote) control are most widely used at present.

3.5.3- Some Types of Hydraulic Valves :-

1.Two – Position Direct – Action valve with electric drive:-

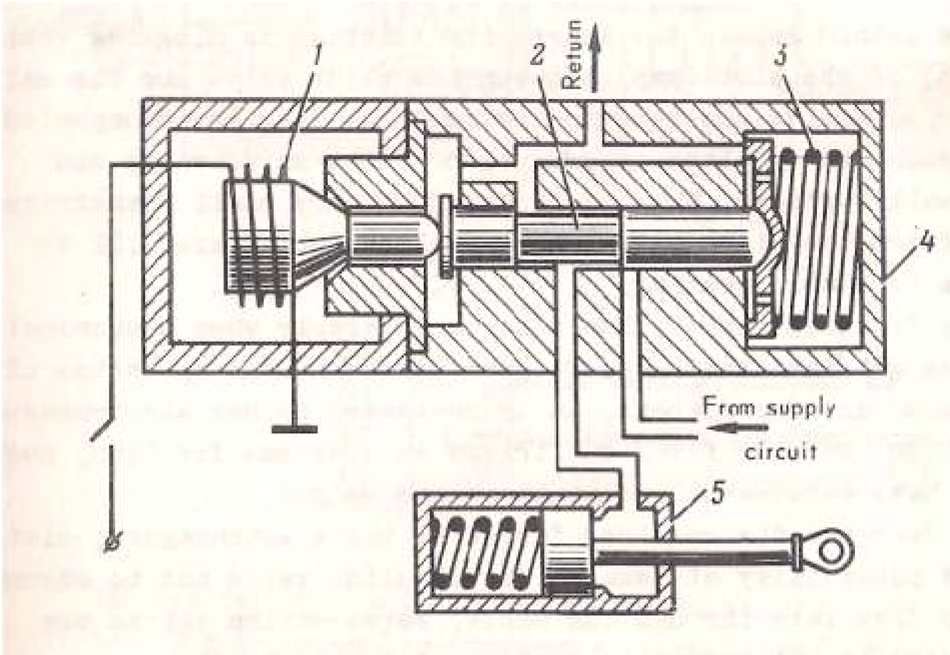


FIG. 19.1. TWO-POSITION DIRECT-ACTION VALVE WITH ELECTRIC DRIVE

1 – electromagnet; 2 – slide valve; 3 – spring; 4 – body; 5 – actuating device

2. Two – Position Slide Valve – Type Servo – Action valve with

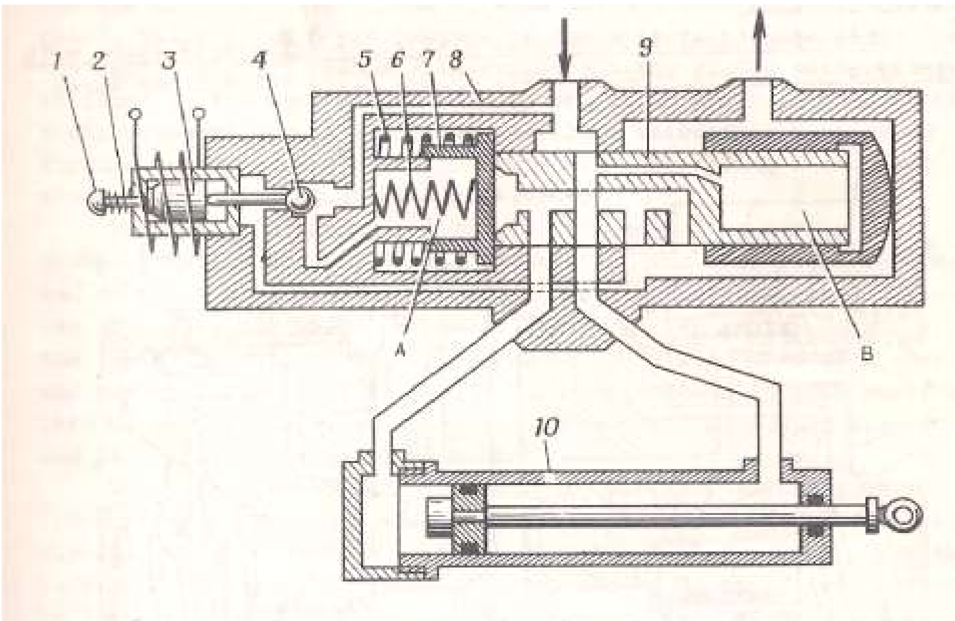


FIG. 19.2. TWO-POSITION SERVO-ACTION SLIDE VALVE-TYPE VALVE

1 – button; 2, 5, 6 – springs; 3 – electromagnet; 4 – valve; 7 – cup; 8 – body; 9 – slide valve; 10 – actuating device

electric and manual control:-

3. **Three – Position Servo – Action flat slide Valve – Type valve with electric and manual control:-**

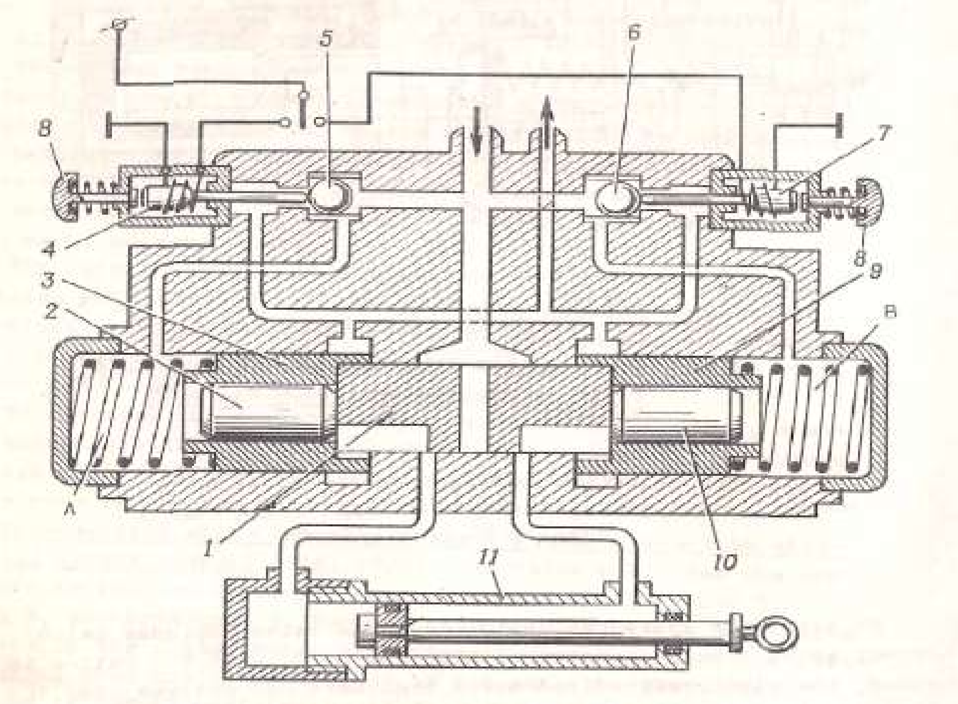


FIG. 19.3. THREE-POSITION SERVO-ACTION VALVE
1 – slide valve; 2, 10 – pushers; 3, 9 – sleeves; 4, 7 – electromagnets; 5, 6 – ball valves, 8 – button; 11 – actuating device

4. **Direct – Action Valve – Type valve with electric and manual control:-**

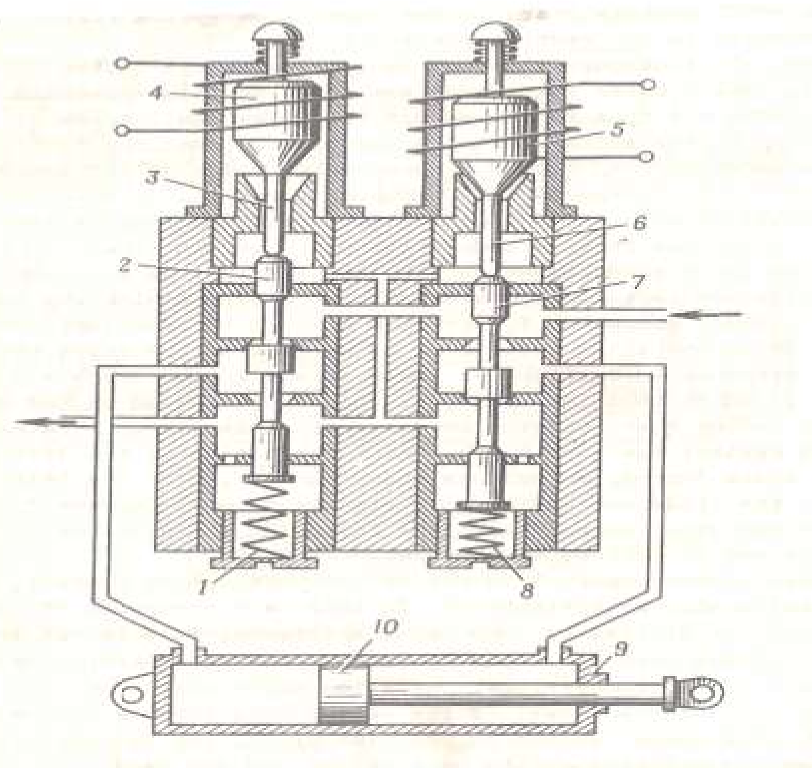


FIG. 19.4. DIRECT-ACTION VALVE
1, 8 – springs; 2, 7 – slide valves; 3, 6 – pushers; 4, 5 – electromagnets; 9 – actuating device body; 10 – actuating device piston

3.6- Actuating Devices :-

The hydraulic systems use various types of actuating devises, the actuating cylinders and hydro-motors are most widely used nowadays. Generally it consist of :

1. Rod.
2. Cylinder.
3. Fixed Cover from sides.
4. Piston fixed by rings.

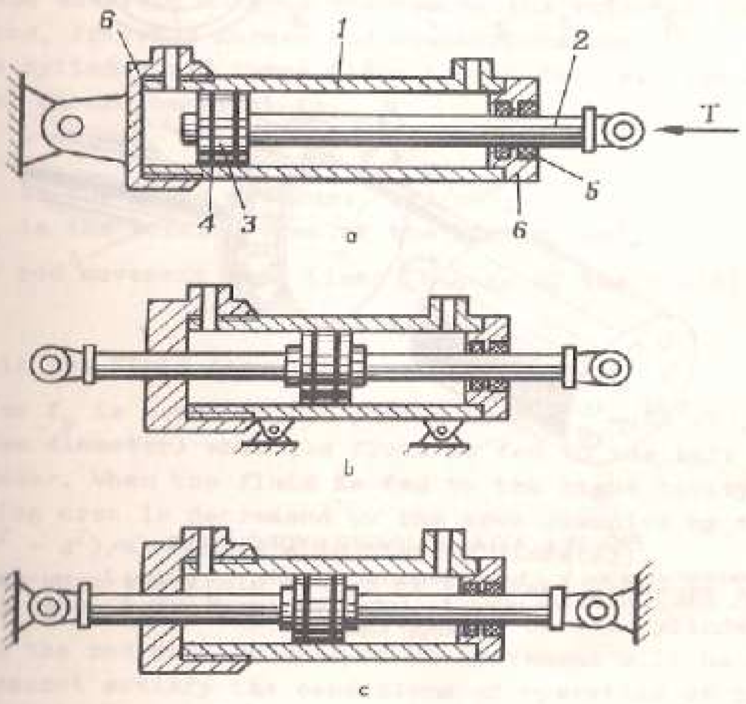


FIG. 19.5. ACTUATING CYLINDER
a – reciprocating; b with two-side rod; c – with movable cylinder; 1 – cylinder; 2 – rod; 3 – piston; 4 – sealing ring; 5 – felt gland; 6 – covers

This figure shows three types of actuating cylinders:

a. Reciprocating Actuating Cylinder.
b. Actuating Cylinder with two – side rod.
c. Actuating Cylinder with movable cylinder.

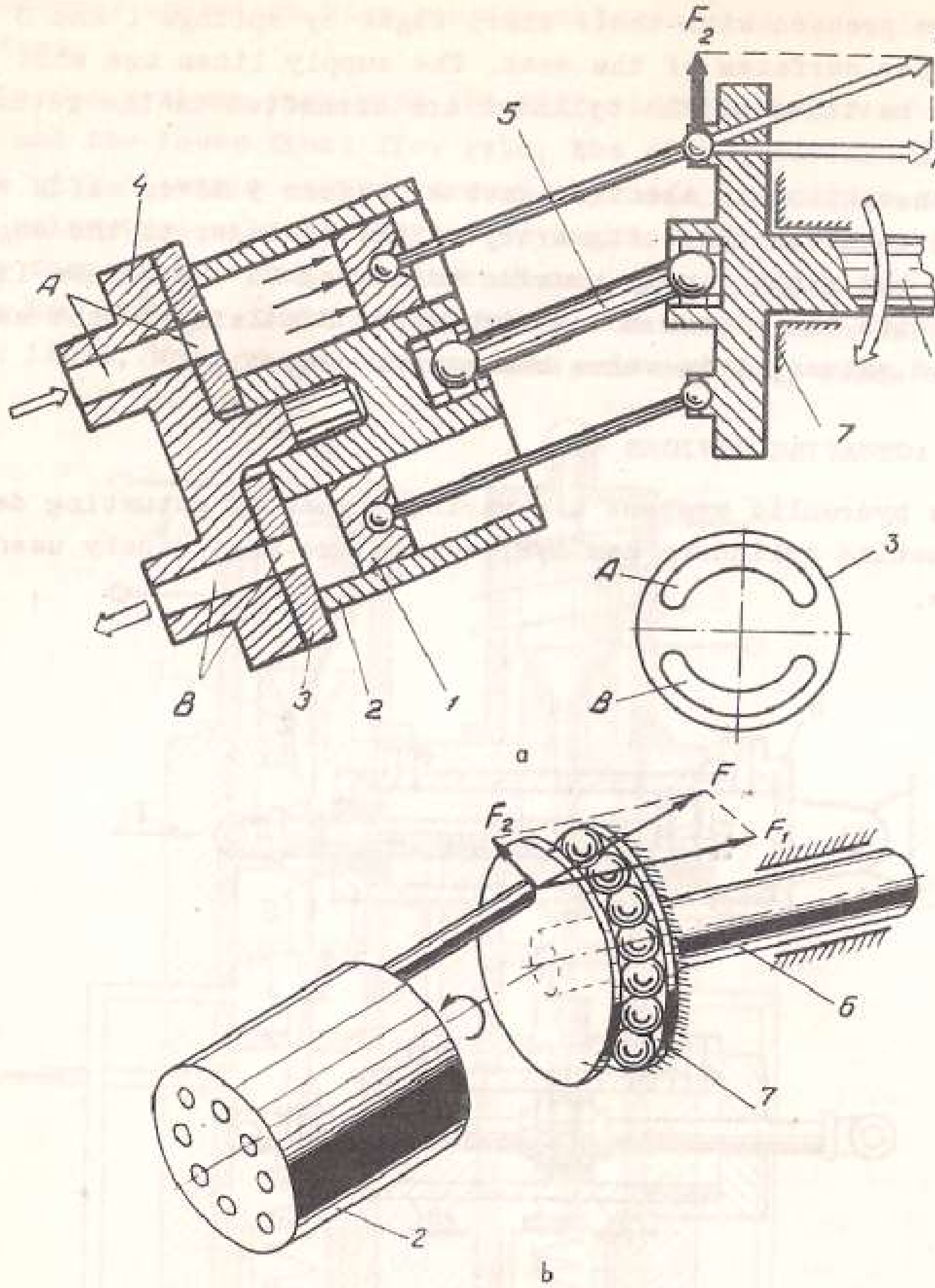
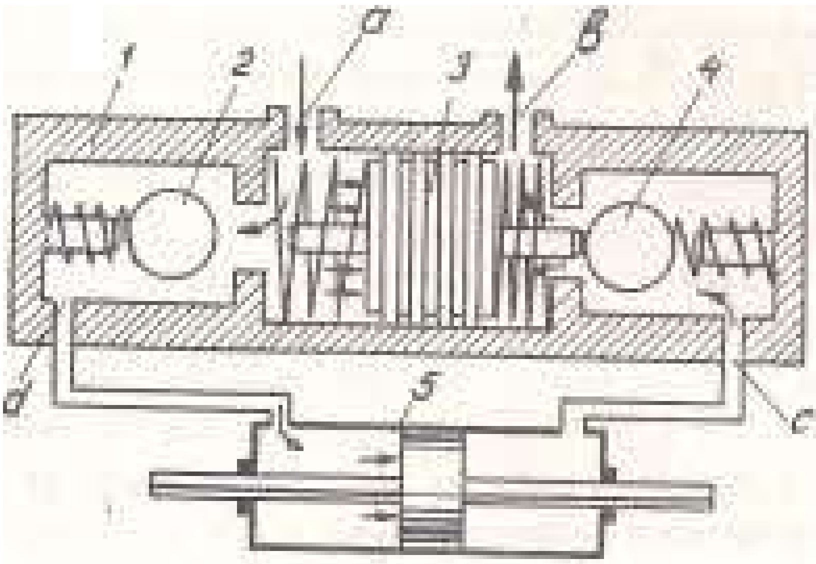


FIG. 19.6. AXIAL-PLUNGER HYDROMOTOR

a – hydromotor diagram; b – torque formation principle; 1 – piston; 2 – cylinder block; 3 – distribution slide valve; 4 – body; 5 – universal joint; 6 – output shaft; 7 – thrust bearing



This figure shows an Axial – Plunger Hydro – Motor

3.7- <u>Fixation of Actuating Devices</u> :-

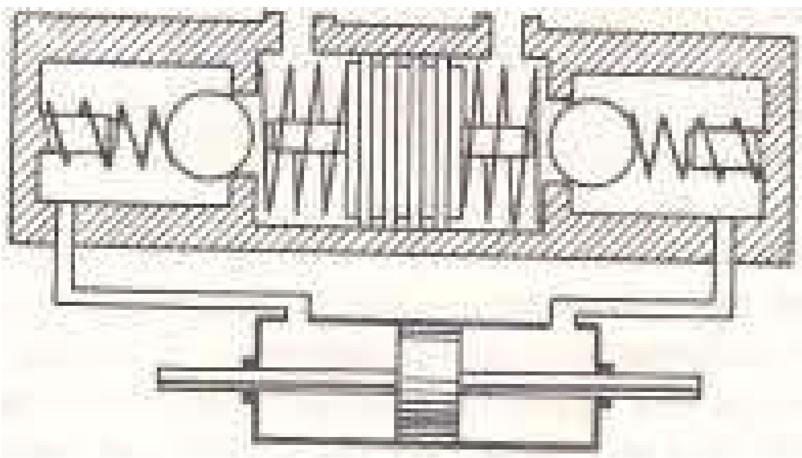
To fix the actuating devices in definite positions, uses made of hydraulic and mechanical locks.

<u>The hydraulic lock</u> automatically locks the fluid in the actuating device in preset positions, thus fixing the device.

The schematic diagram of the **two-side hydraulic lock** is shown in Fig. below, a. Body 1 of the lock houses two non-return ball

TWO·WAY HYDRAULIC LOCK

a - work of lock at supply of liquid to cylinder; b _ fixation of actuating mechanism; 1 - body; 2, 4 - valves; 3 - floating piston; 5, - actuating mechanism



Valves 2 and 4 with floating piston 3 arranged in between. The fluid from the cock is fed to the lock through connections a, b and from the lock to mechanism 5 through connections c and d.When the fluid under pressure is fed to connection a, left valve 2 opens and the fluid passes through channel d to the left cavity of mechanism 5. In this case, piston 3 is moved rightward under the action of the fluid pressure and right valve 4 is opened by the rod ensuring return of the fluid from the right cavity of the cylinder to the tank through connections c and b and through the cock.When supplying the fluid to connection b, the lock operates similarly as when the fluid is fed to connection a, but in the opposite direction.If connections a and b are connected to the return line, piston 3 is in the middle position (Fig. 19.7, b), non-return valves 2 and 4 lock the fluid in both cavities of the hydraulic cylinder fixing the piston and retaining the controlled unit in the desired position. The lock which locks the fluid only in one cavity of the hydraulic cylinder is called a single-side hydro lock. Its operating principle is similar to that described above.The main disadvantage of the hydraulic locks is impossibility to retain the unit in the present position for a long time .Even minor leaks of the fluid (through non-return valves), which cannot be practically avoided, lead to the displacement of the unit. Therefore, the hydraulic locks are used where non-prolonged fixation of the unit in a desired position is required.To ensure a prolonged fixation of the piston, mechanical locks (ball, ring and collet ones) are used.

The schematic diagram of **the ball lock** is shown in Fig. 19.8.Balls 3 are arranged in piston 1 of actuating cylinder 2 in a special holder. When the piston moves, the balls move with the former. When the piston approaches plunger 4 (Fig. 19.8, a), the balls thrust against the plunger and move it rightward compressing spring 5. Due to this, the piston can keep on moving rightward. As soon as the balls are opposite annular recess 6 of the cylinder (Fig. 19.8, b), the plunger under the action of the spring will rush the balls into the annular recess. The lock is closed and the rod is fixed relative to the cylinder by the balls.The lock is open only when the fluid under pressure is fed to the opposite cavity of the cylinder. In this case, plunger 4 moves rightward compressing spring 5. The balls leave the annular recessunder the action of the cylinder force created during the movement of the piston releasing piston 1.

The disadvantage of this lock is a considerable specific pressure of the balls on the bearing surface of the recess. This considerably decreases reliability of the lock at high loads. Therefore, the ring and collet locks are used in the actuating cylinders. A round-sectioning is installed in the ring lock instead of the balls. This increases the bearing area and decreases the contact pressure. In the collet lock (Fig. 19.9) split bush 1 (collet) rigidly secured to piston 5 serves the function of the balls. When the lock is closed, the collets grips are separated by plunger 3 loaded by spring 4 and engage with their projections the end face of support bush 2 secured in the cylinder. The lock is opened by supplying the pressure to its cavity. In this case, plunger 3 is forced by the fluid to move rightward compressing spring 4.

The collet grips bend inward under the action of the force applied from the side of the support bush and. disengage from the support bush.

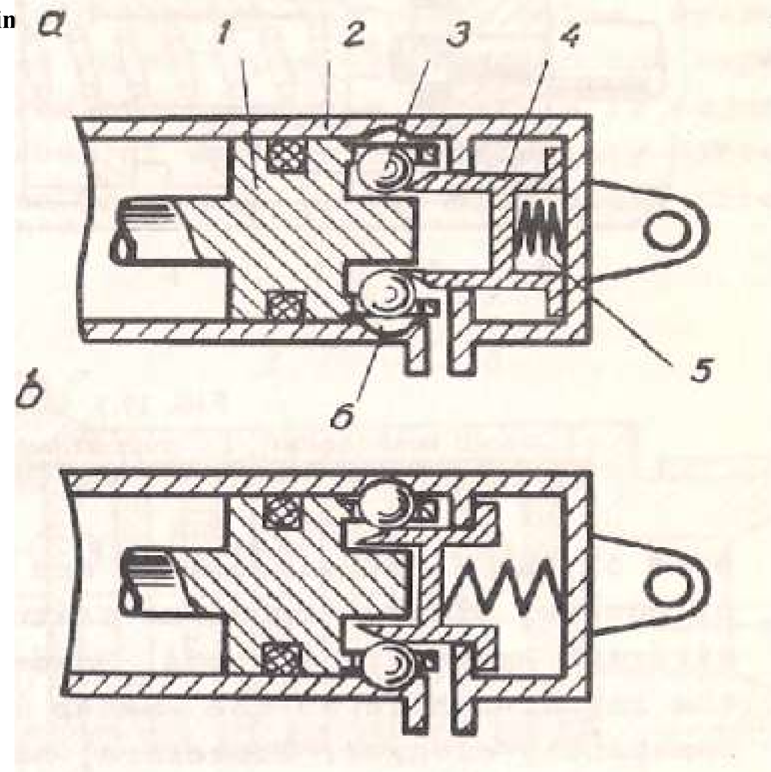


FIG. 19.8. BALL LOCK
a – lock open; b – lock closed; 1 – piston; 2 – actuating cylinder; 3 – balls; 4 – plunger; 5 – spring; 6 – annular recess

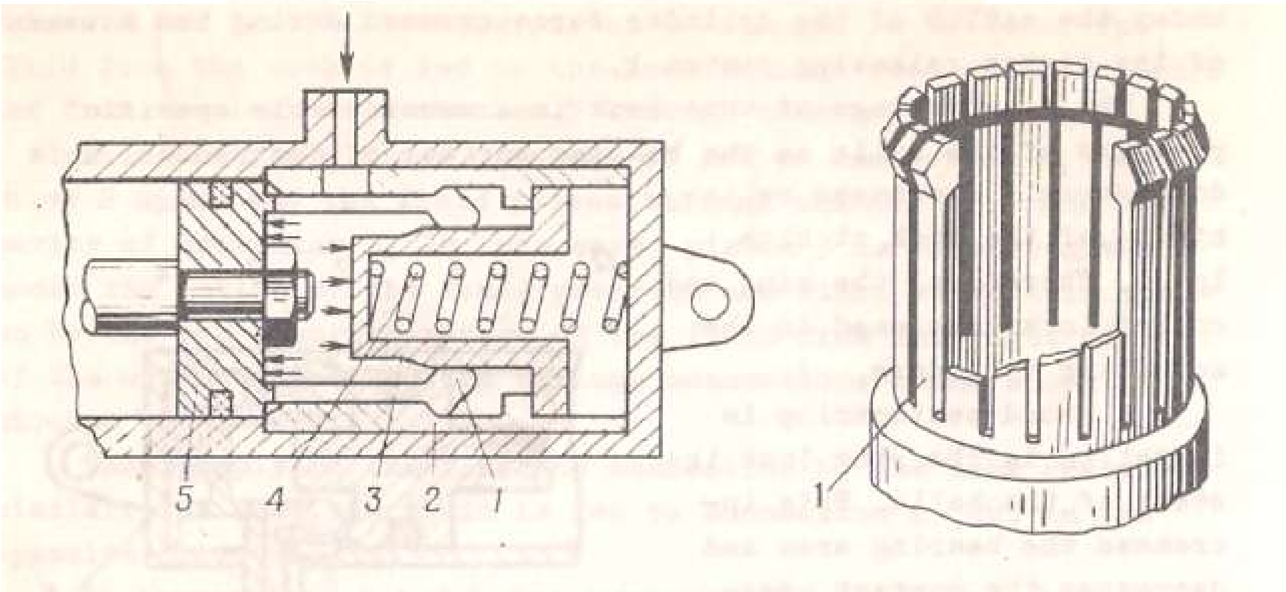


FIG. 19.9. COLLET LOCK
1 – split bush (collet); 2 – support bush; 3 – plunger; 4 – spring; 5 – piston

3.8- <u>Throttling Devices</u> :-

A throttle creates the hydraulic resistance on the fluid path to restrict its flow. It is intended to decrease the movement speed of the actuating device.

An elementary throttle is a washer with a hole (Fig. 19.10).The resistance of this throttle is mainly determined by the fluid flow rate and by the throttle hole area. The channel length is so small here that fluid friction against the throttle walls is negligible. Therefore, the throttle resistance does not practically depend on the fluid viscosity, and hence, on its temperature. It is, of course, a very important feature for the throttles of the modern aircraft hydraulic systems. However, to create a high resistance, the required hole in the washer may appear so small that it may be constantly clogged. Therefore, such throttles have not found wide application in the hydraulic systems of the modern aircraft. The throttle reliability may be increased only by increasing the diameter of the throttling hole.

To obtain the low, Flow rate throttles (with a high diameter of the hole), it is necessary eitherto increase the length of the throttling channel or to use a stack of washers.

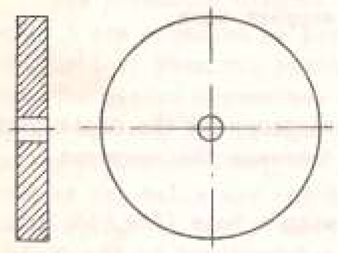


FIG. 19.10. ELEMENTARY THROTTLE

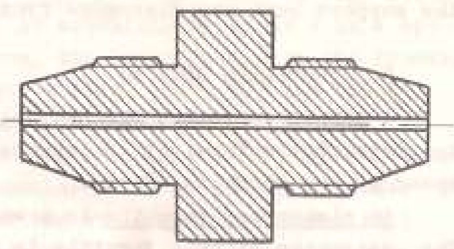


FIG. 19.11. LOW RATE THROTTLE WITH ELONGATED CHANNEL

The elongated channel throttle (Fig. 19.11) is simple to construct but its resistance depends on the fluid viscosity, and hence, its temperature.

A throttle with a stack of washers (Fig. 19.12) .comprises, washer 1 with holes mounted in body 3. Distance rings are arranged in-between to admit the fluid through the plate holes. Operation of this throttle is based on multiple compression and expan-sion of the fluid flow. The resistance of the throttle is adjusted by selecting the required number of washers and is mainly dictated by losses in the hole (similar to losses in the elementary throttle considered above).The resistance of the throttle being discussed does not practically depend on the fluid viscosity, and hence, on its temperature. Therefore, the throttles of this type are mainly used in the hydraulic systems.The above throttles retard the movement of the actuating mechanisms in both directions. Therefore, they are called two-side throttles. When the actuating device is to be retarded in one direction only, use is made of a single-side throttle (Fig.

19.13).The single-side throttle comprises body 1 with two connections, valve 3 with throttling hole 2 and spring 4. When the fluid moves in the direction shown by the arrow, valve 3 is pressed to its seat and the fluid flows through throttling hole 2.

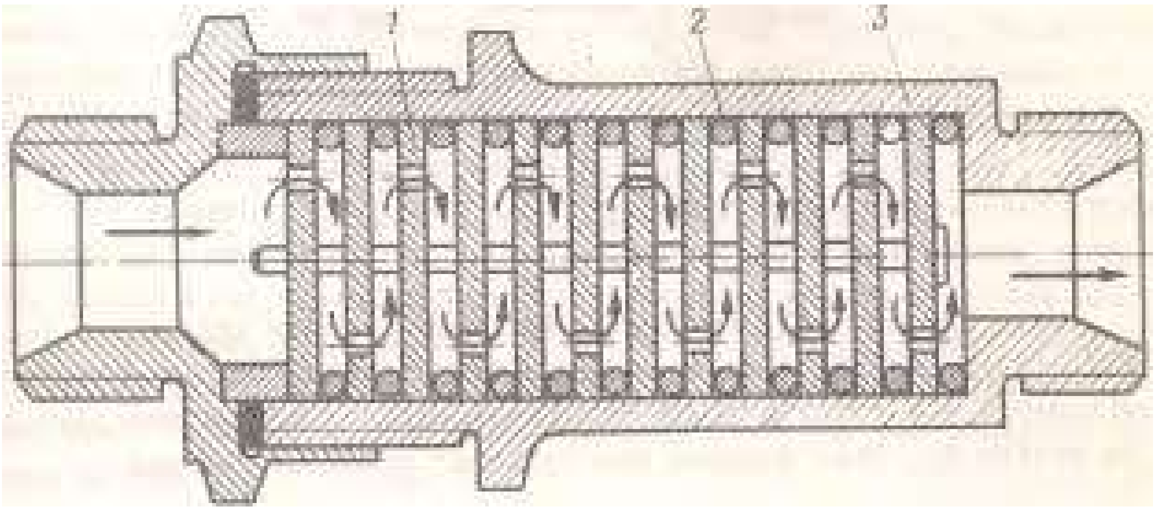


Fig. 19.12, Low rate throttle with stack of washers
1 - Washer; 2 - distance rings; 3 – body

During the reverse flow the fluid opens the valve and flows substantially without the resistance, since spring 4 is soft and pre-tightened slightly.The throttles may be installed both in the actuating device supply and return lines.When the throttle is installed in the supply line (Fig. 19.14, a), it decreases the amount of the fluid fed to the cylinder for a time unit and the pressure in front of the piston (in cavity A). This ensures the retarded speed of the rod. However, if a load creating an acceleration directed to the side of the rod movement is applied to the actuating device rod, the throttle may fail. In this case, the rod speed may considerably increase since the throttle does not counteract this.

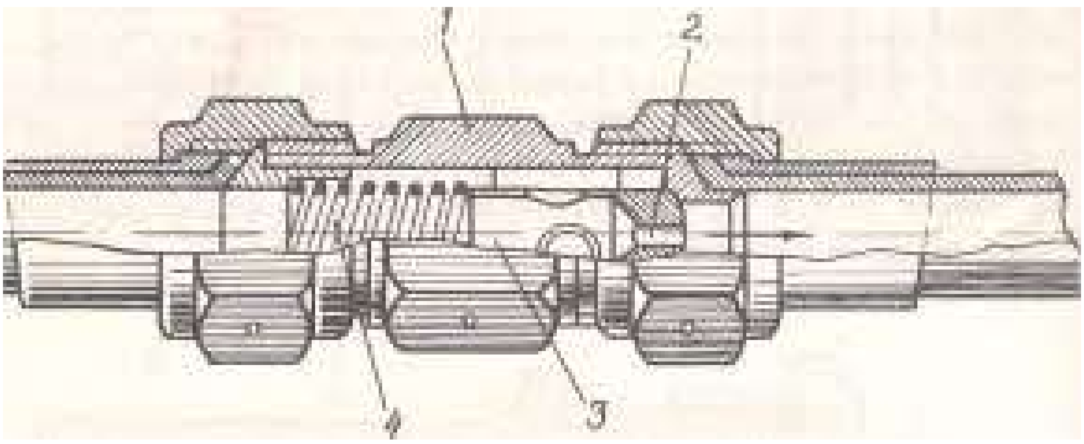


FIG. 19.13, SINGLE.SIDE THROTTLE
1 -body; 2 - throttling hole; 3 - valve; 4 - spring

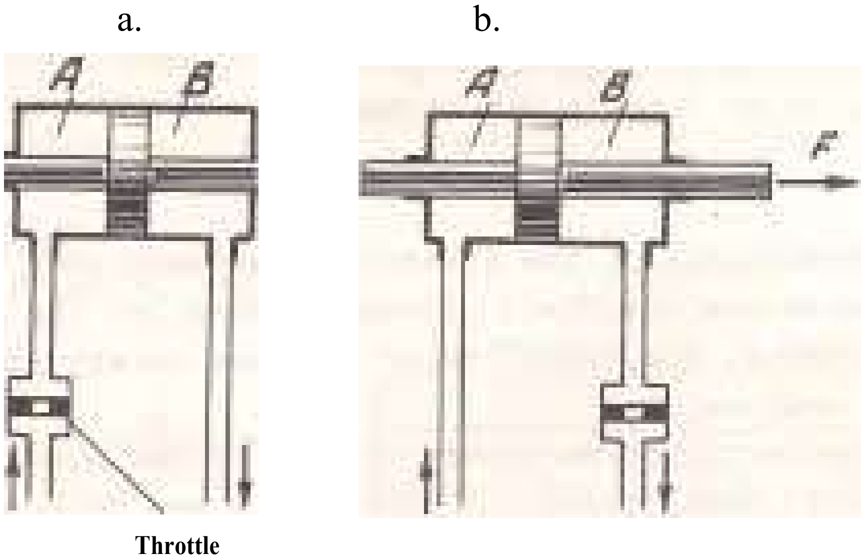


FIG. 19.14, THROTTLE INSTALLATION DIAGRAM
a - in supply line; b - in return line

Installation of the throttle in the actuating cylinder return line (Fig. 19.14, b) decreases the flow rate of the fluid from return cavity B when the rod moves rightward. As a result, the pressure in cavity B (counter pressure) increases and the. Rod movement speed decreases. Thus, irrespective of the reasons for increaseof the speed of the rod, the throttle counteracts such an increase. Among the advantages of the hydraulic' system with the throttle installed in the return line is also the fact that the heat liberated at throttling is removed to the tank (and not to the actuating device as in the case of the throttle installed in the supplyline).It is known that the flow rate of the fluid through the throttle is directly proportional to the pressure difference, and hence, to the fluid pressure in front of the throttle. Therefore, when the fluid pressure in the system changes, the flow rate of the fluid through the throttle, and hence, the cylinder rod movement speed (the hydro-motor shaft speed) change also.To ensure a constant actuation speed whenever necessary from the design considerations irrespective of the fluid pressure in the supply line, special throttling devices are used in the hydraulic systems. They consist of a control device (reducer) and a throttle. The control device maintains the constant pressure of the fluid in front of the throttle thus ensuring the constant flow rate of the fluid through it.The throttles are widely used in the aircraft hydraulic systems that is:

1. In the landing gear, door and hatch cover control systems to decrease inertia loads at opening (extension) and closing (retraction), as well as to ensure a specific sequence of operation of the system elements;
2. In the flap and air brake control systems for ensuring the smooth extension to preclude an intensive change of the longitudinal aerodynamic moment;
3. In the variable-sweep wing control system for adjusting the angular rate of wing deflection and in other systems.

3.9- Reducing Devices :-

The hydraulic reducers are intended to decrease the fluid pressure on separate portions of the system to the required value. They are necessitated owing to the fact that the aircraft hydraulic systems use a number of actuating devices which are operable according to the specifications on lower pressure than the working pressure in the supply line.The hydraulic reducers are divided into the constant-pressure reducers which maintain a definite fluid pressure and variable pressure reducers in which the pressure is set in the course of control.

A constant-pressure reducer (Fig. 19.17) comprises body 1, slide valve 2, reducer spring 3, spring 6 of the slide valve and adjustment screw 4. In the initial position when no fluid is fed to connection 5, the slide valve is in the left position under the action of the spring force difference, communicating the reduced pressure cavity with high-pressure cavity. When the fluid under pressure is fed to connection 5, it flows through the throttling channel to the actuating device acting simultaneously upon the end face of slide valve 2. The slide valve is forced by the fluid pressure to compress spring 3, moves rightward and decreases the passage area of the throttling channel, and hence, the pressure. When the required pressure is reached, the slide valve partially or fully discontinues the fluid flow to the actuating mechanism, thus precluding an excess of the preset pressure. The fluid pressure maintained by the reducer may be adjusted by adjustment screw 4. If the screw is driven in (moved leftward), spring 3 and slide valve 2 will move leftward too, thus increasing the passage area of the throttling channel. To shut off fluid supply to the actuating mechanism in this case, the slide valve should be moved through a distance longer than in the first case (before adjustment) by the screw displacement value, and hence, spring 3 should be compressed to a higher degree. However, the spring can be compressed to a higher degree only if the pressure aft of the reducer is increased. Thus at such an adjustment ofthe reducer fluid supply will be shut off at a higher pressure. Therefore, the pressure aft of the reducer will rise.

A variable-pressure reducer (Fig. 19.18) features pusher 4 instead of the adjustment screw. When depressing the. Pusher, the reducer is readjusted. The higher is the rightward displacementof the pusher, the higher is the pressure at which the slide valve will stop supply of the fluid to the actuating cylinder (the reduced pressure will raise) and the higher will be the force which is to be applied to the pusher for preventing the slide valve against the leftward displacement.

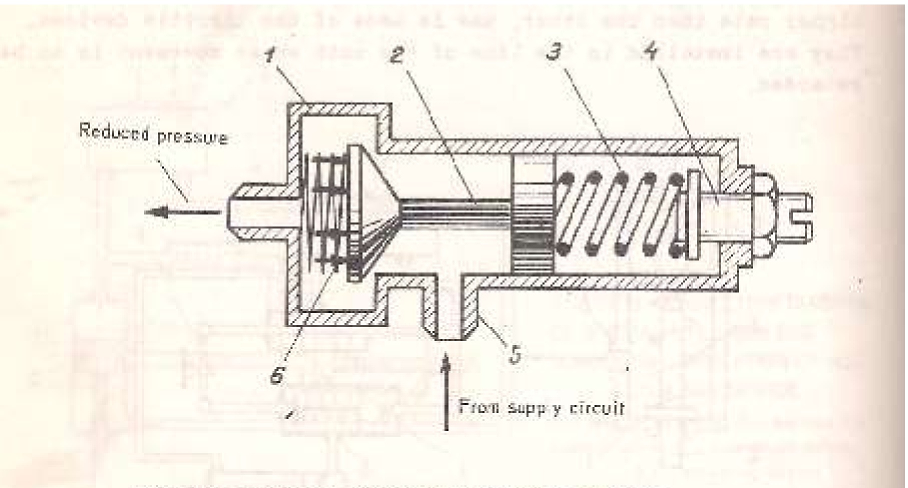


FIG. 19.17. CONSTANT-PRESSURE HYDRAULIC REDUCER
1 – body; 2 – slide valve; 3 – reducer spring; 4 – adjustment screw; 5 – connection; 6 – spring

The variable pressure reducers are widely used as braking valves. These valves are intended not only to supply the fluid at the required pressure to the braking devices but also to ensure a rapid decrease of the pressure therein. Therefore, the schematic diagram of the braking valve (Fig. 19.19) is somewhat different from the schematic diagram of the elementary variable-pressure reducer considered above. The main components of the braking valve are body I, slide valve 2 serving as an inlet valve with spring 7, outlet valve 5 with spring 6, reducer spring 3 and pusher 4.If no force is applied to the pusher (Fig. 19.19, a), the reducer spring is released. Inlet valve 2 is closed by spring 7, outlet valve 5 is opened by spring 6 and the braking devices communicate with the return line.When pusher 4 is depressed (Fig. 19.19, b), it lowers down transmitting the force through spring 3 and closes outlet valve 5. As a result, the braking devices are disconnected from the return line. During a further travel of the pusher, inlet valve 2 opensand the fluid from the pressure line flows to the braking

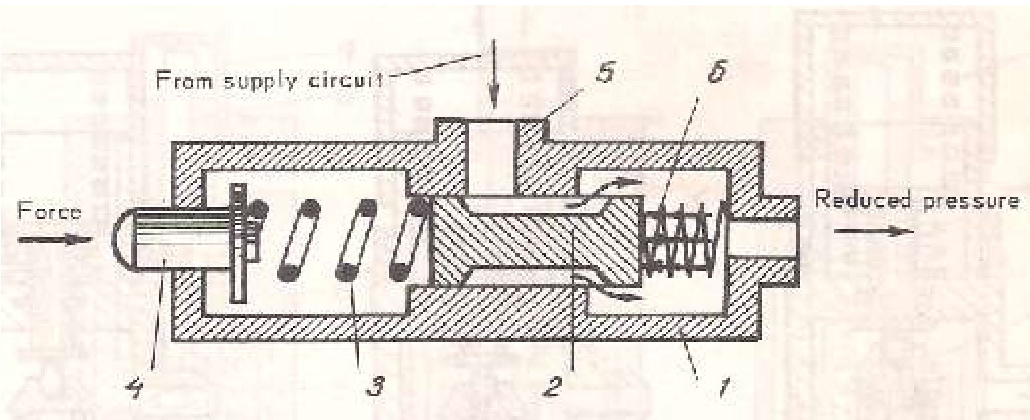
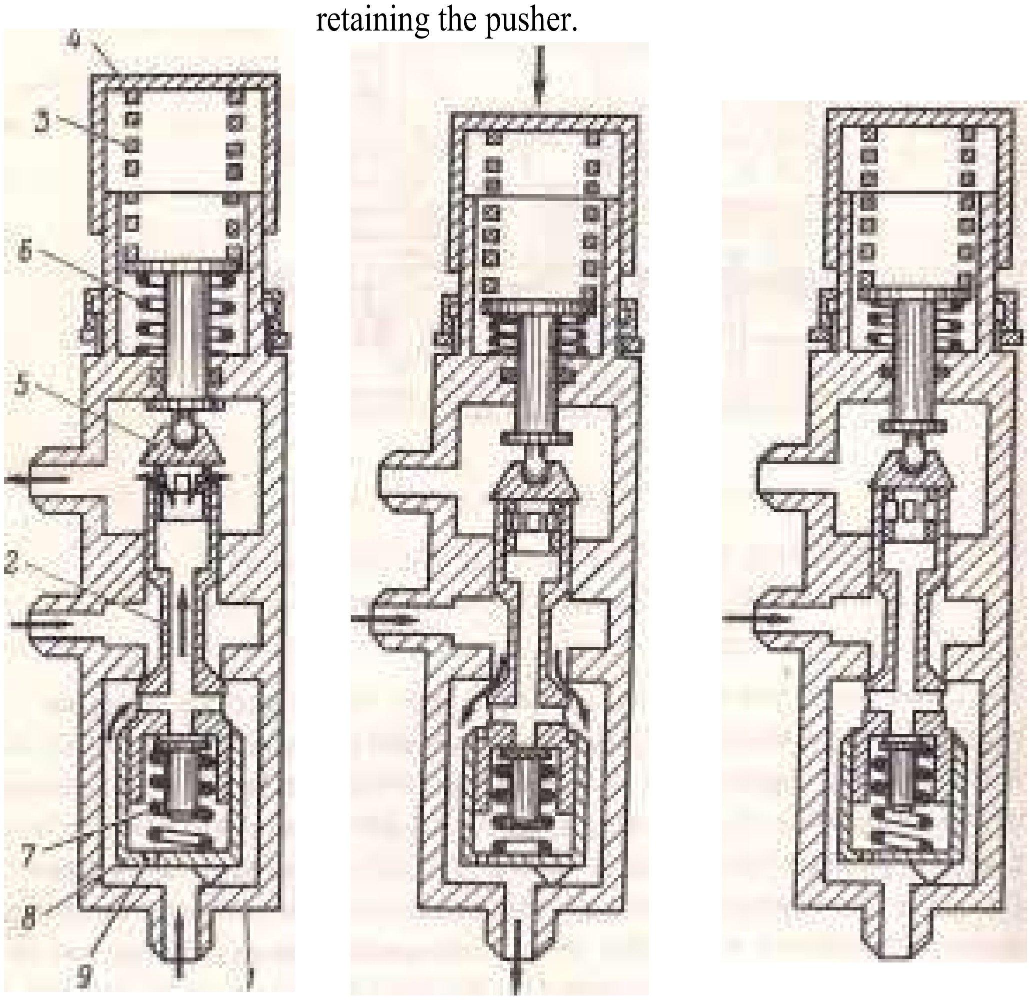


FIG. 19.18. ELEMENTARY VARIABLE-PRESSURE REDUCER
1 – body; 2 – slide valve; 3, 6 – springs; 4 – pusher; 5 – connection

devices. As the pressure rises, the pressure force acting on the end face of inlet valve 2 increases, Under the action of this force valve 2 moves upward compressing spring 3. The force acting on the pusher increases. When a specific pressure is reached in the braking devices, the inlet valve closes with the seat shutting off the fluid flow to the brakes. Outlet valve 5 remains closed thus maintaining the required pressure in the brakes (Fig. 19.19. c), Similar to the elementary variable-pressure reducer. The pressure in the braking devices depends on the pusher travel. The increase of the pusher travel increases the pressure in the braking devices and the force required for retaining the pusher.



a. b. c.

FIG. 19.19, BRAKING VALVE
a - zero force on pusher; b - beginning of braking; c - fixation of preset pressure in brakes; 1 - body; 2 - inlet valve; 3 - reducer spring; 4 _ pusher; 5 _ outlet valve; 6, 7 - springs; 8 - damper body; 9 _ throttle

The brakes are released by relieving the pusher. In this case, reducer spring 3 is released and outlet valve 5 is forced by the fluid pressure and spring 6 to open. As a result, the braking devices are connected to the return line.To decrease the loads required for retaining the pushers at braking of the aircraft, use is made of servo-action braking valves. These valves ensure a smoother and uniform variation ofpressure in the braking devices.

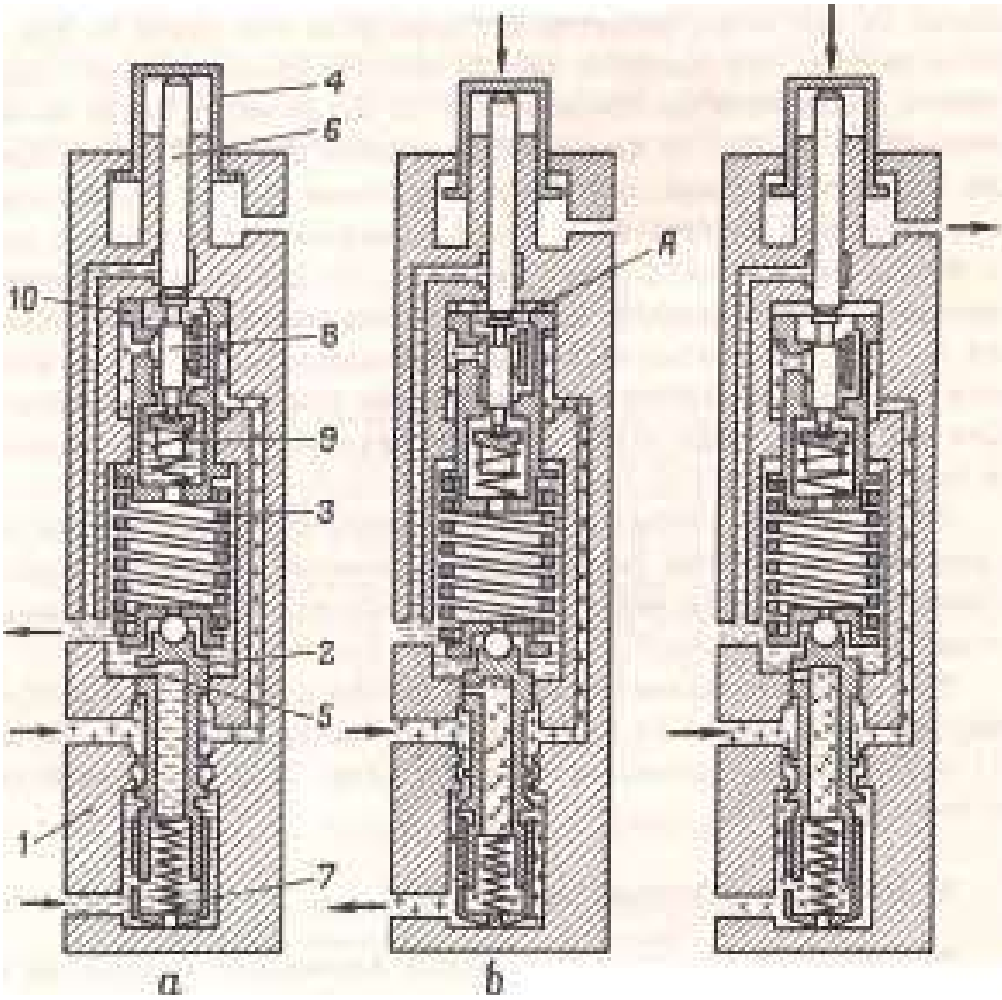


FIG. 19.20, SERVO·ACTION BRAKING VALVE
a - zero force on pusher; b - beginning of braking; c - fixation of preset pressure in brakes; 1 - body; 2 - slide valve; 3 - reducer spring; 4, 6 - pusher; 5 - Slide valve return hole; 7 - spring; 8 - booster slide valve; 9 - spring; 10 - piston

Such a braking valve(Fig. 19.20. a) has a booster which comprises slide valve 8 with spring 9 and piston 10.When depressing the pusher (Fig. 19.20. b). Slide valve 8 overcomes the force of spring 9, moves down and connects cavity A over piston 10 with the pressure line. Under the fluid pressure the piston moves down and moves slide valve 2 through reducer spring 3. As a result,the brakes are disconnected from the return line and are connected to the pressure line.As the pusher movement ceases. Slide valve 8 stops. Pistol reaches it and stops shutting off supply of the fluid to the over piston cavity. The pressure in the braking devices rises. The pressure force acts on the end face of slide valve 2 and moves it upward (Fig. 19.20. c) compressing reducer spring 3 which thrusts with its upper end against the piston fixed by the fluid locked in the over-piston cavity. At a preset pressure, slide valve 2 cuts off supply of the fluid from the brake,to increase the reduced pressure. It is necessary to increase the pusher travel. This will lead to that the piston will lower through a higher value and again admit the fluid to the brakes. The fluid pressure after the valve will rise until slide valve 2 again shuts off the fluid from the brakes.Thus.In this pattern also the pressure reduced by the valve is proportional to the pusher travel. However, the force applied to the pusher of this valve is spent only for compressing weak spring 9.The reducing valves similar to safety ones tend to self-oscillate. And this should be borne in mind during operation,to damp self-oscillations, hydraulic damper 8 (Fig. 19.19) is installed in the braking valves.

3.10- Control of Undercarriage (Retraction And Extension) :-

All modern high-speed aircraft have landing gear retractable in flight to decrease high drag and improve flight performance.For this purpose, the aircraft includes a mechanism for retraction and extension of the landing gear which ensures the movement of the legs from the position in which they are found during taxiing to the retracted position and back. The landing gear is retracted and extended with the use of a hydraulic or pneumatic actuator.The direction and kinematics of the retraction/extension of the landing gear are determined by presence of the free volumesand location of the legs.

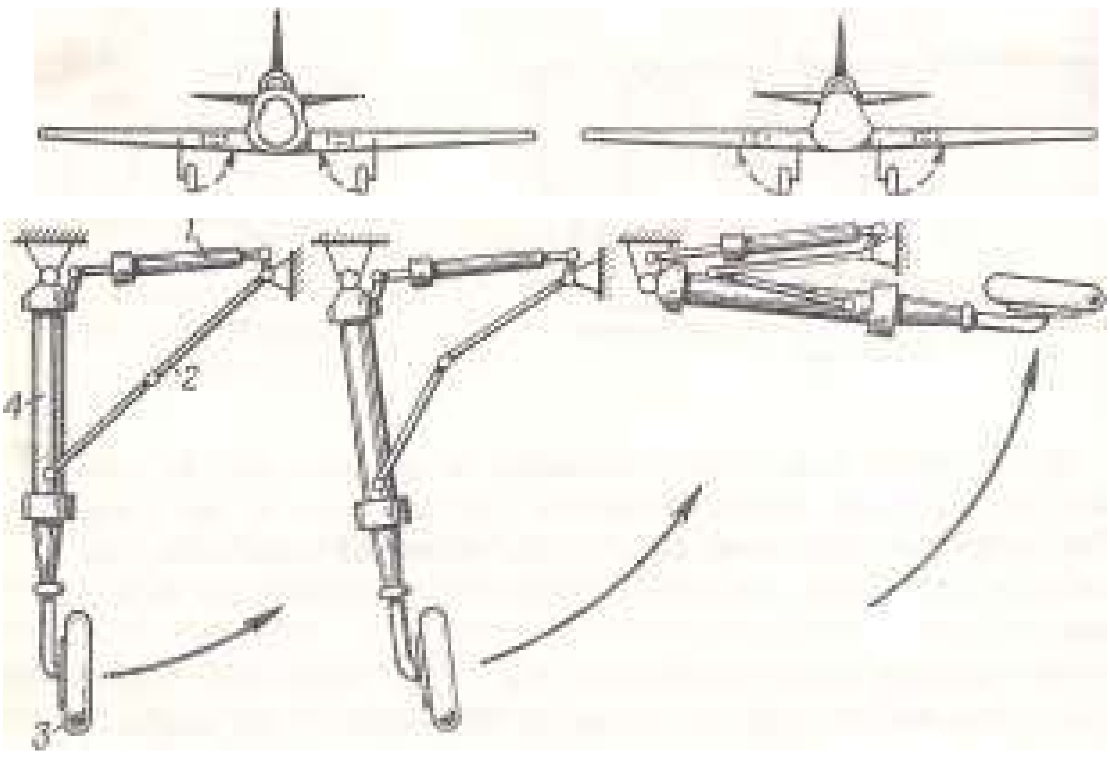


Fig. 12.16, Landing gear span wise retraction (extension kinematics)

1- actuator: 2 - brace 3 - wheel 4 - leg

The landing gears are usually retracted normally to the air stream or along it.

<u>Span wise retraction of the landing gear legs</u> (normally to the stream) is shown in Fig. 12.16. Retraction of the legs towardsthe fuselage (with the wheels accommodated in a thicker part of the wing) is most widely employed today.When thickness and arrangement of the wing prevent accommodation of the wheels in the inner cavity of the wing, the wheels are arranged in the fuselage (Fig. 12.17).

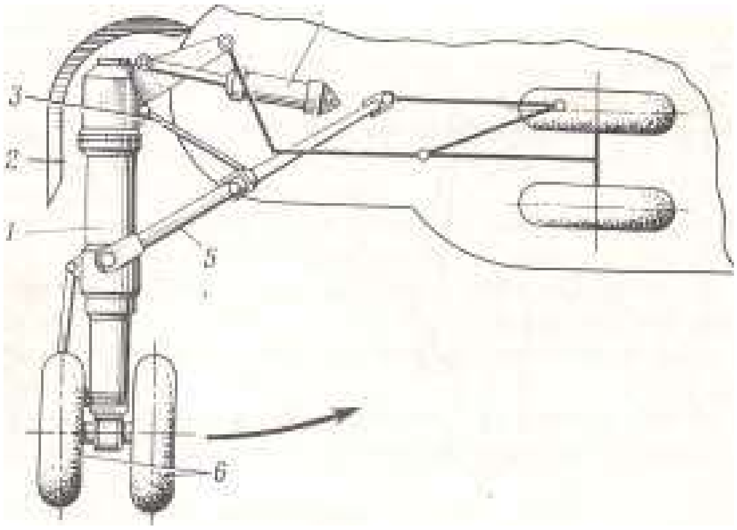


Fig. 12.17, Kinematics of extension and retraction of landing gear into fuselage

1 - leg 2 - door 3 - spacer 4 - actuator 5 - folding brace 6 - wheels

To more advantageously use the inner volumes of the fuselage, patterns with turning of the wheels during retraction are used (Fig. 12.18).When the landing gear is retracted slantwise of the wing, the air stream influences but slightly the extension and retraction. However, such a retraction pattern disrupts the closed contour of the skin on a considerable area near the wing root, which decreases torsional stiffness of the wing.

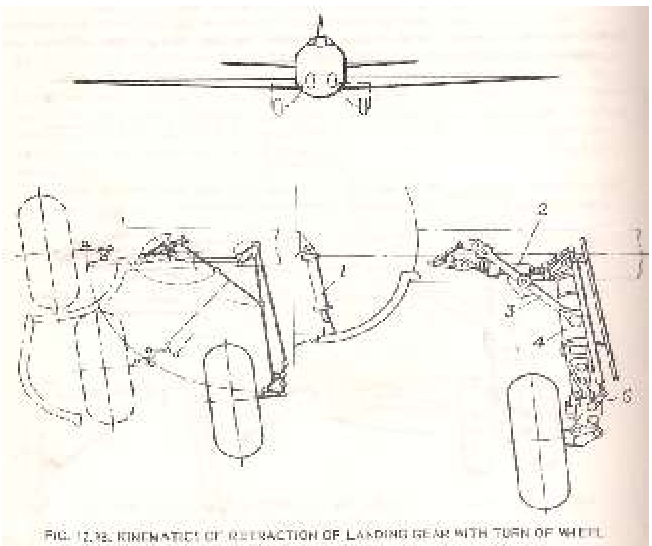
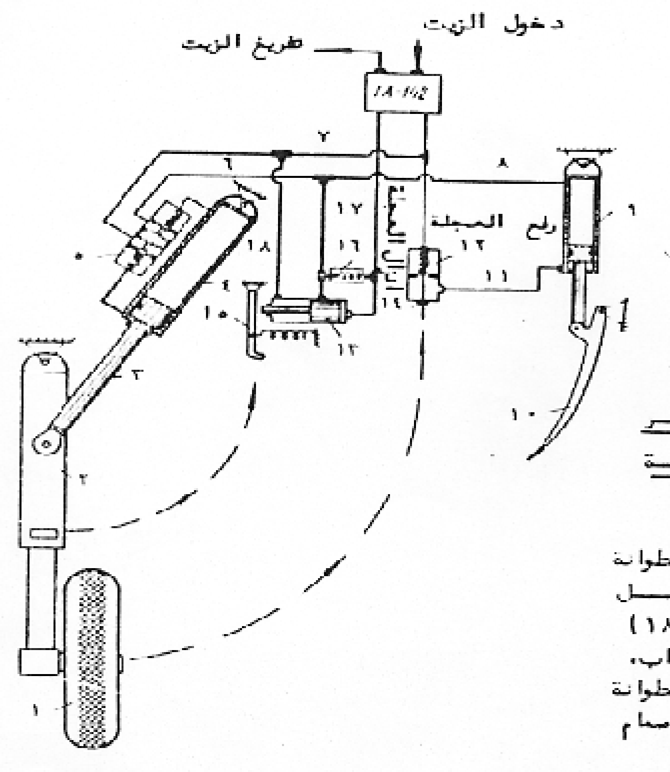


FIG. 12.18. KINEMATICS OF RETRACTION OF LANDING GEAR WITH TURN OF WHEEL
1 – door cylinder; 2 – actuator; 3 – [illegible] 4 – leg; 5 – wheel turning mechanism

This necessitates introduction of the additional strengthening members into the wing structure to increase its weight.

Chord wise retraction of the landing gear (downstream) is used on the aircraft with two and more engines arranged on the wing. In this case, the legs are retracted into, the nacelles (Fig. 12.19) downstream and upstream. To decrease overall dimensions of the nacelle, the bogie is made turning (Fig. 12.20). To accommodate the long legs (especially the wing ones) within small volumes, use is made of the legs which shorten at retraction. Retraction of the main legs into the fuselage forward or backward along the longitudinal axis is employed on the bicycle pattern aircraft. The nose leg of the three-point landing gear is retracted according to the same pattern.In retracting the landing gear forward, ram pressure exerts a considerable resistance but provides for extension of the landing gear.To preclude retraction of the legs during the ground movement of the aircraft and inadvertent extension at g-loads acting inflight, the legs are fixed inthe extreme positions (retracted and extended). The legs are fixed inthe extended position by the folding brace locks or by actuators.The legs are fixed inthe retracted positions by special locks mounted on the load-bearing members of the airframe. The lock fastens the eye secured to the leg. The leg is attached to the constant-length part of the leg which is the shock absorber cylinder. This ensures closing of the lock even if the shock absorber fails to extend fully.To check closing of the locks when the landing gear is extended or retracted, the special indication system is provided.



شكل (٧) رسم تخطيطي يبين سير الحركة في دورة التحكم في ساق العجلة بالحرية السفلى

١ ــ عجلة ، ٢ ــ ساق العجلة ، ٣ ــ ساق اسطوانة التشغيل ، ٤ ــ اسطوانة التشغيل ، ٥ ــ قفل هيدروليكي ، (٦ ، ٧ ، ٨ ، ١١ ، ١٣ ، ١٧ ، ١٨) ــ مواسير الزيت ، ٩ ــ اسطوانة تشغيل الباب ، ١٠ ــ باب ، ١٢ ــ صمام التسبق ، ١٤ ــ اسطوانة تشغيل القفل ، ١٥ ــ قفل ميكانيكي ، ١٦ ــ صمام عدم الرجوع

3.11- Hydraulic Power Drive :-

The hydraulic boosters which are hydraulic servo drives are most widely used in the control systems.The hydraulic booster is intended to boost the control signals and deflect the aircraft control surfaces in accordance with displacements of the control levers.The hydraulic booster (Fig. 15.2) comprises actuating cylinder 4 and distributing slide valve 1 which directs a fluid flow through channels c and d to either cavity of the cylinder. The feedback is affected by arranging body 2 of the slide valve on the rod of piston 3 of actuating cylinder 4.When the pilot pulls the control stick backwardchannel c (and chamber B of the actuating cylinder) isconnected to the pressure line of the hydraulic system, while channel d (hence,chamber A of the actuating cylinder), with the return line.

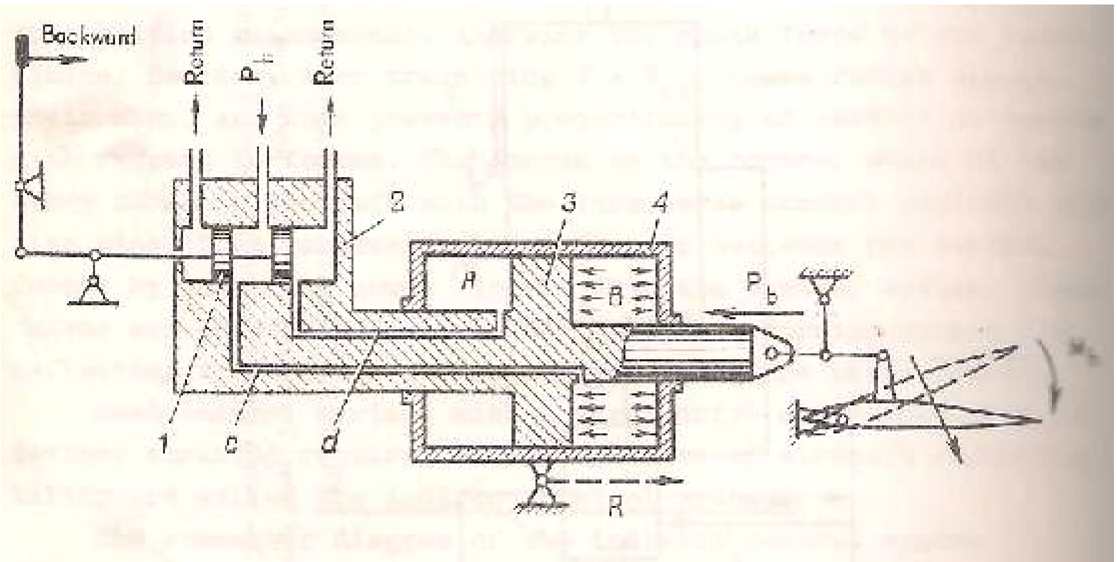


FIG. 15.2. HYDRAULIC BOOSTER SCHEMATIC DIAGRAM

1 – slide valve device; 2 – body; 3 – piston; 4 – actuating cylinder

Owingto the pressure difference in chambers B and A the piston, and hence, the rod and tie rod connected to the control surface start moving leftward deflecting the control surface. The continuous movement of the rod (displacement of the control surface) is possible only when channels c and d are open. If the pilot stops the control stick (and hence, the slide valve), the rod, while moving· leftward, will shift body 2 of the slide valve onto the slide valve. As channels c and d are closed, the rate of the movement of the rod starts to decrease and the latter will stop as soon as the channels are fully closed. The control surface becomes deflected through a certain angle corresponding to the position of the control stick (slide valve).

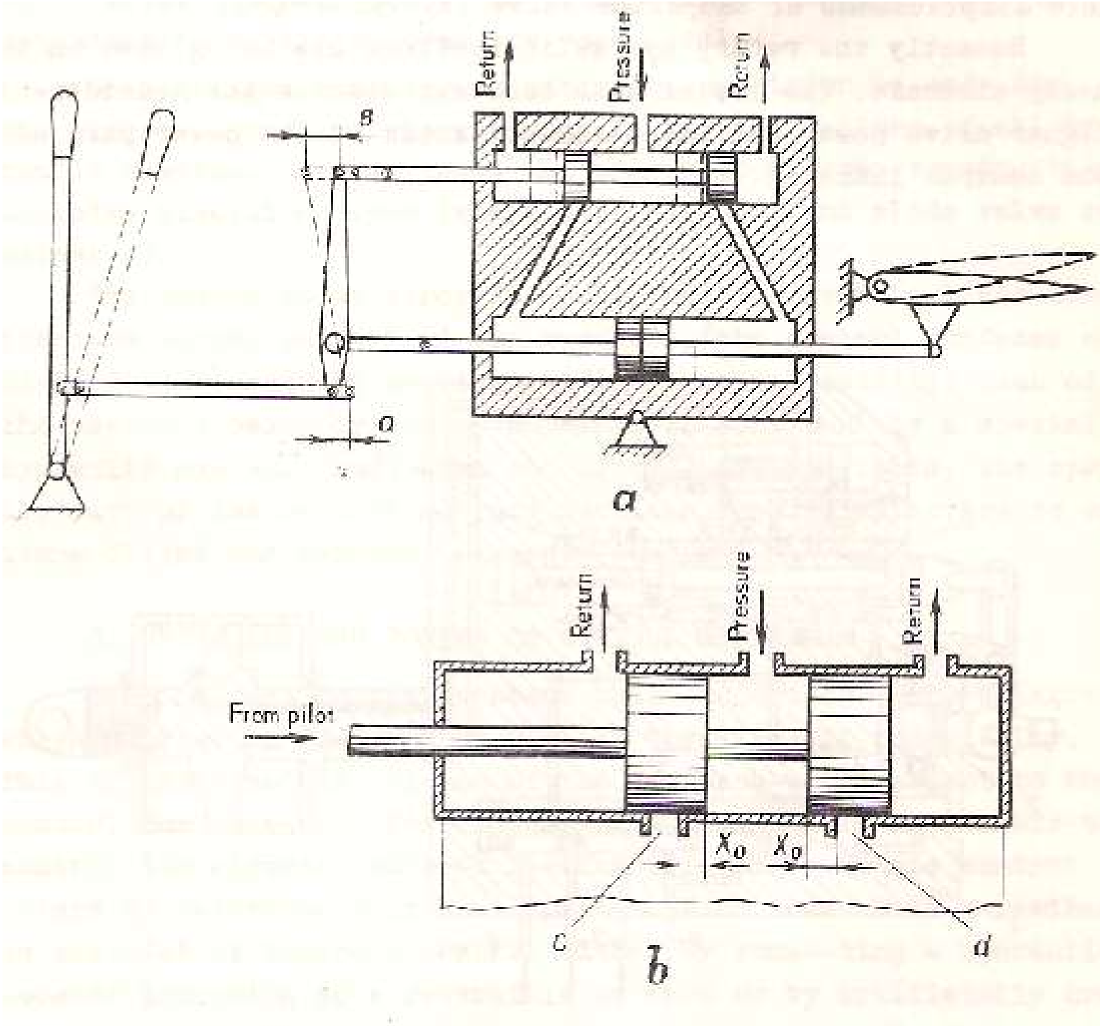


FIG. 15.3. MEANS FOR RELIABLE LOCKING OF HYDRAULIC SYSTEM CHANNELS
a – control system with differential lever; b – slide valve hole sealing-off

A great number of the hydraulic boosters are being used nowadays. There are hydraulic boosters with a movable rod or movable body, with cylindrical and flat slide valves, valve distributor,etc.To ensure reliable locking of the hydraulic system channelsby the control slide valve and to ensure decrease of leakage ofthe fluid, provision is made constructional for certain overlap (x_0) of the edges of the hydraulic line holes by the slide valve (Fig. 15.3, b). This overlap determines the control system dead zone, i.e. deflection of the control lever does not cause immediate deflection of the control surfaces. To decrease the dead zone, the hydraulic boosters use differential levers (Fig. l5.3, a). Small deflection of the control lever by value "a" will cause a considerable displacement of the slide valve (by value "b").Recently the rotary hydraulic boosters are being used on the heavy aircraft. The use of such boosters ensures the considerably higher drive power and increased stiffness of the power part of the control linkage.

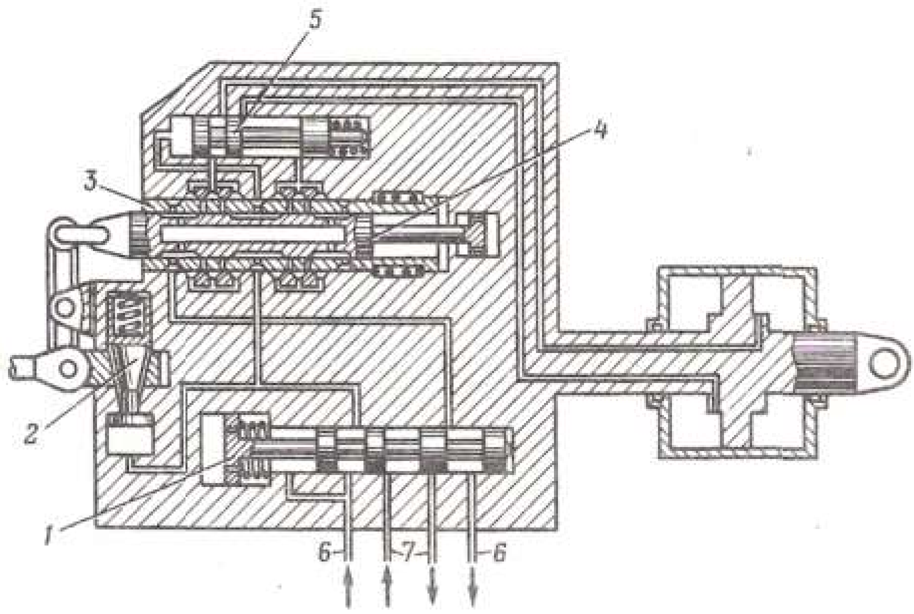


FIG. 15.4. MEANS FOR INCREASING RELIABILITY OF HYDRAULIC BOOSTER
1 – slide valve for engagement of duplicating hydraulic systems; 2 – slide valve retainer; 3 – duplicating slide valve; 4 – control slide valve; 5 – cross-feed valve; 6 – main hydraulic system; 7 – duplicating hydraulic system

The disadvantage of the booster control system resides in its intricate design and lower reliability as compared with the direct control system. The most unreliable element of the boosters is control slide valve 4 (Fig. 15.4). To increase its reliability,use is made of stand-by slide valve 3 (in case of probable jamming). The boosters are provided with additional filters for superfine cleaning of the hydraulic fluid. The most efficient way to increase reliability of the control system is duplication of separate units and lines, as well as duplication of the entire system. For instance, the modern aircraft widely use duplication of the supply hydraulic system with the aid of slide valve 1. Besides the main hydraulic system, one or even two emergency hydraulic systems are provided, including a stand-by system operating from an autonomous drive (e.g. windmill drive). Two-chamber boosters fed from the independent hydraulic systems are used widely.On the light maneuvering aircraft, provision is made forthe direct control of the surfaces in case of failure of all hydraulic systems. In this case, the hydraulic booster construction includes special devices (cross feed valves 5 and slide valve retainer 2).The modern heavy aircraft where the considerable hinge moments preclude manual control of the surfaces, the control surfaces are divided into separate sections to increase reliability; each ofthe sections being driven by separate booster and. by a special hydraulic system. Thus when one of the boosters fails, the operating part of the control surface sections remains effective to continue flight and perform emergency landing.

3.12- Sealing Devices of Hydraulic System :-

Seals are used to prevent leakage of the fluid being under excessive pressure through the gap in the joint of two fixed or movable surfaces.Reliability of the hydraulic system depends greatly on the condition of the sealing devices. The requirements to be met by the sealing devices have increased owing to use of high pressure and owing to widening of the hydraulic system operation temperature range.

Sealing of fixed joints which are not disassembled in the course of operation and repair is affected by welding or soldering. However, this method is seldom used. The fixed joints are usually sealed by means of easily deformable gaskets and rubber rings. Depending on the fluid working pressure and its temperature, sealing gaskets of various materials are used:

1. Pronate gaskets, at a pressure of 75 - 100 kgf/cm^2 and at a temperature of up to 100^{o}C
2. Aluminum and Copper gaskets, at a pressure of up to 260 kgf/cm^2,
3. Steel gaskets, at higher pressures.

To create reliable sealing of the movable joints is considerably more difficult than of the fixed joints. It is most difficult to seal the high-pressure rotary joints.To seal the movable joints, use is made of the following types of sealing:

1. Slot seal in which sealing is effected by tight fitting ofone part to another,
2. Collar seal
3. Rubber ring seal,
4. Metal and non-metal (flour-plastic and text-lite) ring seals.

The rubber ring seals are most widely used in the hydraulic systems. The sealing action is based on the compression force created in the rubber ring during assembly of the seal; this force is further increased under the action of the fluid pressure. The ring is compressed from all sides and can withstand high pressures.

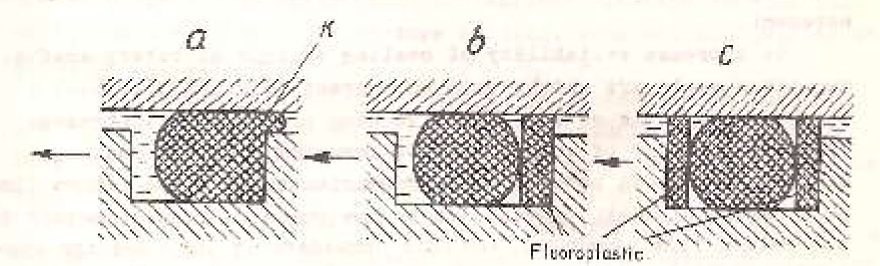


FIG. 19.31. SEAL WITH RUBBER RINGS
a – seal operating principle; b – installation of protective ring at one-side supply of liquid;
c – installation of protective rings at two-side supply of liquid

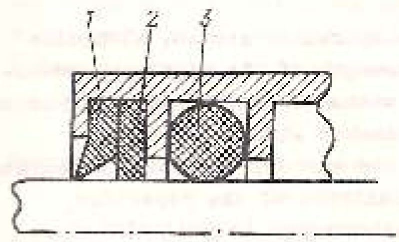


FIG. 19.32. SEALING ASSEMBLY
1 – scraping ring; 2 – felt ring; 3 – rubber ring

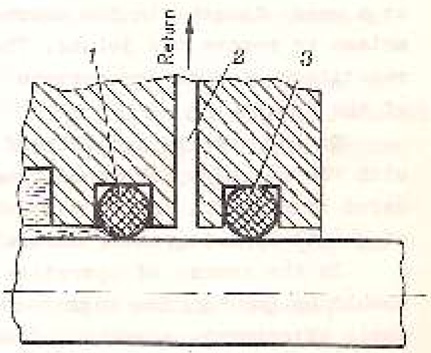


FIG. 19.33. TWO-STAGE SEALS
1, 3 – rubber rings; 2 – return chamber

3.13- <u>Maintenance of Hydraulic System</u> :-

When maintenance was occurs for hydraulic system some points should be taken into consideration:

1. Sealing the system components is much recommended to prevent leakage.
2. It's strongly recommended to isolate hydraulic pipes than air-compressed one because any leakage between them causes fire.
3. Periodically system component checks according to system log-book.
4. We have to be sure that the pipes were not damages or leakage, and if so it has to replace immediately with new one.
5. Checking the type and amount of hydraulic in the hydraulic tanks.
6. Checking the system works in the ground before airplane takeoff.
7. In some countries where changing in the environment is great some excessive improvers were delivered to the hydraulic to improve its performance.
8. For the hydraulic system parts its mostly recommended to be replaced at the precise time expire due to flight time or by time.

Chapter Fore

Aircraft Pneumatic System

Pneumatic system is one of the important systems in aircraft which used for many applications such as:

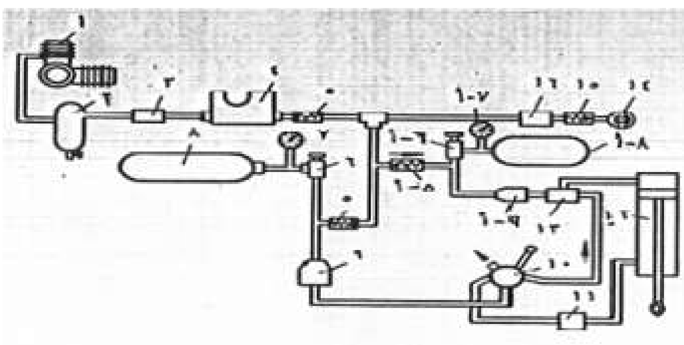
1. Rise and revelation of airplane undercarriage.
2. Movement of controlling flaps.
3. Braking wheels.
4. Used as auxiliary system for other systems.
5. Plug of the cabin cover of airplane.
6. Activate some equipment in airplane.

The privilege of pneumatic system upon other system is:

1. Little Effect by fire.
2. Light weight considering other systems.
3. The ability of supplying huge amount of power in short time.
4. Easy to recharge with air.

While the main disadvantages of the pneumatic system is:

1. It difficult to make the system completely and tightly blocked due to air high pressure.
2. The movement transmitting in this system is not quite smooth as its in hydraulic one.
3. The effect of humidity of air on the system and its performance in different environmental conditions.
4. The compressed air is not recycling into the system.

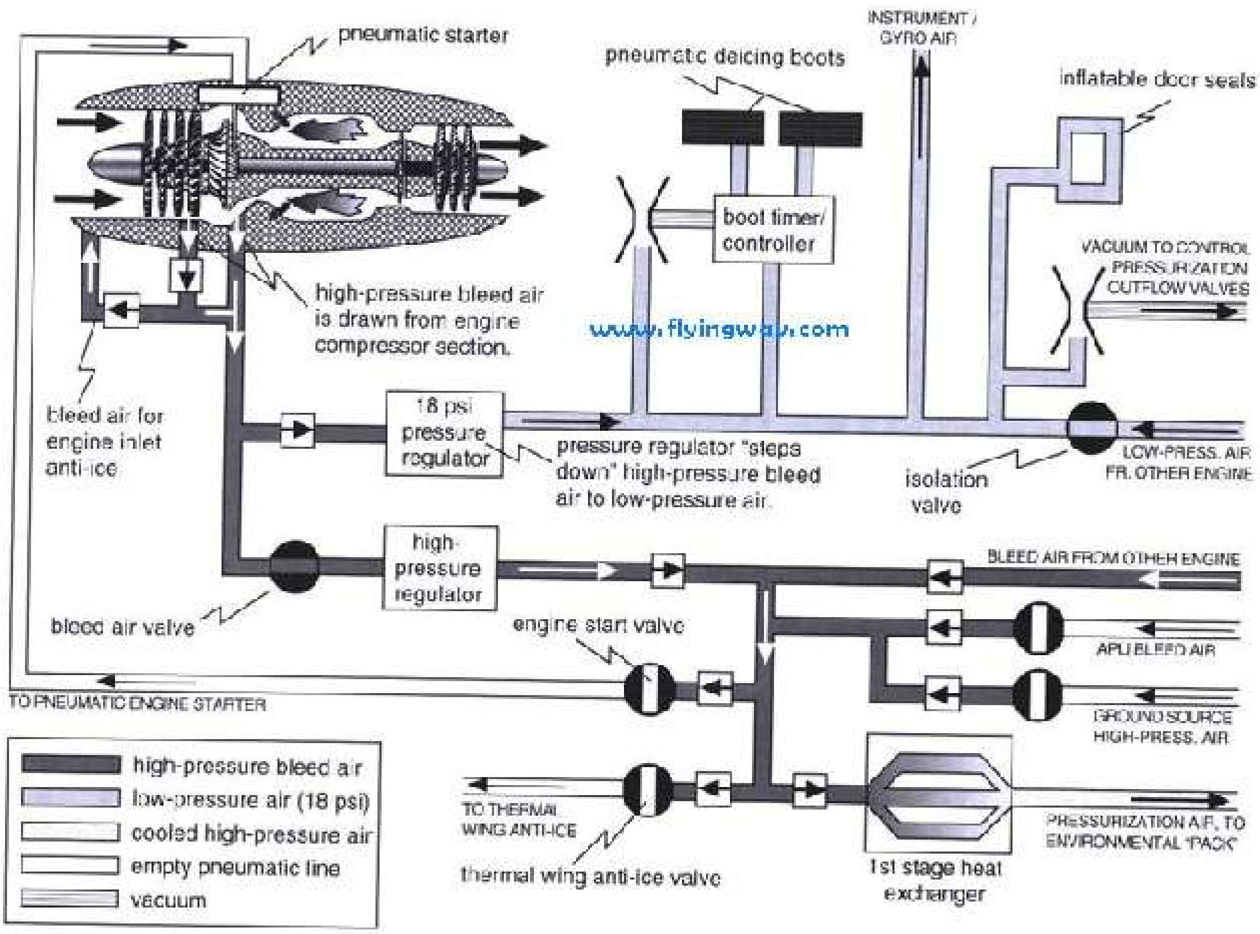


شكل (٤ – ١) رسم تخطيطي يبين مكونات دورة الهواء المضغوط :
١ – ضاغط ، ٢ – مصفاة الترسيب ، ٣ – مصفاة مستمرة ، ٤ – آلية الضغط ، (٥ ، ٥ – أ) – صماما عدم الرجوع ، (٦ ، ٦ – أ) – حنفية السد ، (٧ ، ٧ – أ) – مقياسا الضغط ، (٨ ، ٨ – أ) – بالونان ، (٩ ، ٩ – أ) – مخفضا الضغط ، ١٠ – حنفية توزيع الهواء ، ١١ – صمام خانق ، ١٢ – اسطوانة التشغيل ، ١٣ – صمام الطوارئ ، ١٤ – فتحة الملء ، ١٥ – صمام عدم الرجوع ، ١٦ – مصفاة مستمرة

4.1-Constitute of Pneumatic System:-

Like the Hydraulic system Pneumatic system can be sub-divided into basic system and the Pneumatic consumer's cycle system, the basic systems are consisting of:

1. Air Compressor.
2. Air tanks (balloons).
3. Air pipes.
4. Air pressure regulator.
5. Air pressure reducer.
6. Blockage taps.
7. Pressure gauge (Manometers).
8. Filling vent.
9. Precipitation filters and continues filters.
10. Valves such as safety valves, non-return valve …etc.

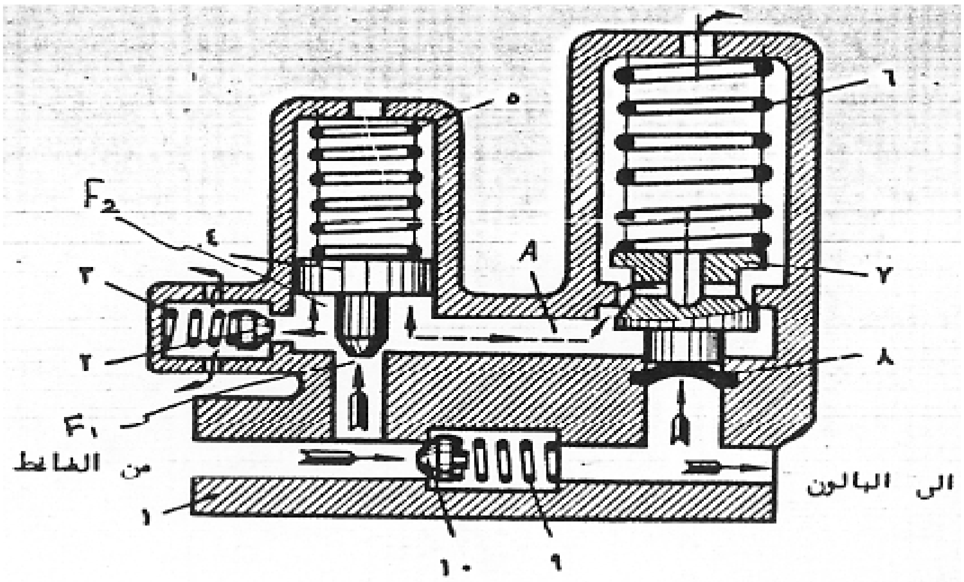


Pneumatic System Cycle

4.2-**Pressure Regulator** :-

Pressure regulator is a device that usually puts after the air compressors which controls and regulates the air pressure in the pneumatic system.

The figure below shows an air pressure regulator which regulate air pressure between (140 ~ 150 kg/cm^2).the pressure regulator reduce the loads on the compressor due to high pressure leads to keep the system safe and elongate the life-time of the compressor.



شكل (٢) رسم تخطيطي لبيان سير الحركة في
آلية الضغط طراز АД-150

١ ـ بدن الآلية ، ٢ ـ صمام التفريغ ، (٣ ، ٥ ، ٦ ،
٩) ـ يايات ، ٤ ـ صمام الغلق ، ٧ ـ صمام الفتح ،
٨ ـ رق ، ١٠ ـ صمام عدم الرجوع

$P_1=F_1/A_1$ where $A_1= \pi/4\ D_1^2$ area of the lower disc

$P_2=F_2/A_2$ where $A_2= \pi/4\ D_2^2$ area of the upper disc

$F_{spring}=kx$ where k : stiffness of spring

x : the distance that the springs moves

$P_{max}=150$ kg/cm^2 , $P_{min}=140$ kg/cm^2 , $P_{max}-P_{min}=10$ kg/cm^2

4.3-Pressure Reducer :-

The constant- and variable -pressure reducers are used in the pneumatic systems.

The constant-pressure reducer (Fig. 21.9) is installed for reducing pressure in the Consumer lines.

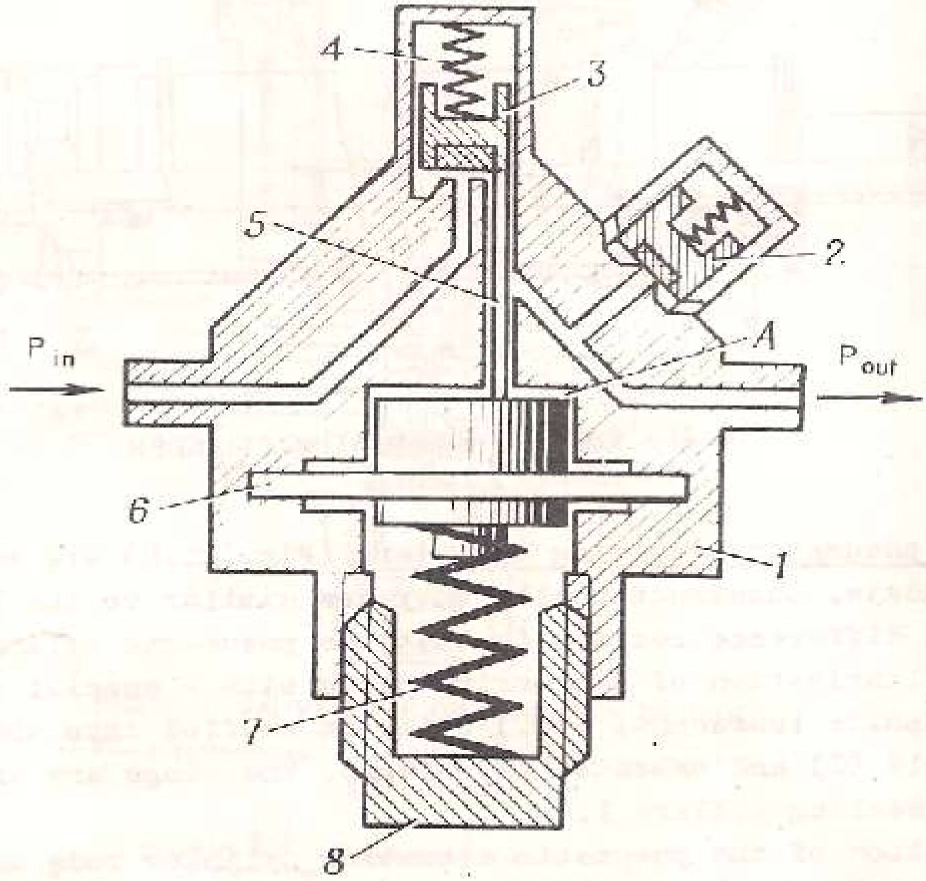


FIG. 21.9. CONSTANT-PRESSURE REDUCER
1 – body; 2 – safety valve; 3 – valve; 4, 7 – springs; 5 – pusher; 6 – diaphragm; 8 – adjustment screw

At a zero pressure in front of the reducer, valve 3 gets open under the action of the force difference of springs 7 and 4.When air (nitrogen) is supplied to the reducer, it passes through the split between the valve and the seat into cavity A and through the outlet connection to the system.

The pressure in the system and cavity (A) increases, under the action of the pressure to be increased diaphragm 6 compresses spring 7 and bends down. Pusher 5 moves with the diaphragm and allows the valve to move and the latter is closed by spring 4. When the estimated pressure in cavity A (system) is attained. The valvecloses fully shutting off the air flow from the high-pressure line to the aft-of-reducing valve line. Thus, a particular (estimated) reduced pressure is set aft of the reducer.

If air is consumed in the consumer line, the valvewill not close fully but will stop at an intermediate position which ensures maintenance of the estimated reduced pressure in cavity A. and hence in the system.

If the pressure increases in cavity A for some reasons and exceeds the estimated one, the pressure force acting on the diaphragm will increase compression of the reducing spring and the valve will open partially. The passage area between the valve and the seat, and hence, the pressure after the valve will decrease.

If the pressure decreases in cavity A below the estimated reduced pressure, the reducing spring will overcome the force of pressure on the diaphragm and spring 4 to increase the passage area of the reducing valve through the pusher and hence, the pressure after the valve.

The reduced pressure may be changed by changing tension of the reducing spring by means of adjustment screw 8.

The increase of the pressure in the system above the estimated one is possible owing to leakage of reducing valve 3 to protect the consumer line against overpressure. Safety valve 2 is installed in the reducer. It opens when the pressure exceeds the estimated reduced pressure by 20 – 25%.

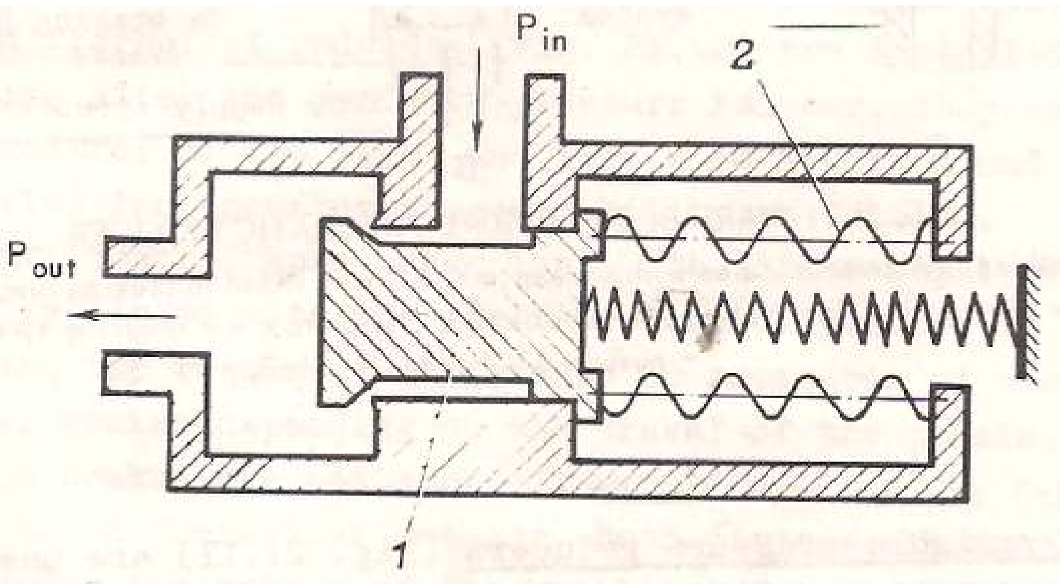


FIG. 21.10. CONSTANT-PRESSURE REDUCER WITH SYLPHON
1 – valve; 2 – sylphon

One of the shortcomings of such a reducer is the dependence of the reduced pressure on the reducer inlet pressure. Actually, the air (nitrogen) pressure at inlet to the reducer continuously acts on the lower surface of the valvepreventing closing of the latter. If the inlet pressure drops down, the valvemay obviously close at lower pressure in cavity A (after the reducing valve). Therefore, the decrease of the inlet pressure will somewhat decrease the reduced pressure.

If it is impermissible from the design requirements to be met by the consumer, another type of the reducer is used (Fig. 21.10). In this reducer the forces acting on the slide *valve* from the inlet pressure are mutually balanced and exert the zero effect on the reduced pressure.

4.4-Pneumatic system consumer circuits :-

The pneumatic systems ensure operation of various mechanisms and devices of the aircraft. Main control of wheel brakes, by-pass bands, drag chute release, de-icing and high-altitude system valves, fuel emergency drainage, seat movement, hand wheel mechanism disengagement, sealing of hatches, emergency control of the landing gear, doors and hatch covers, brakes comprises the incomplete list of the pneumatic system consumers. The consumer lines serve to supply the energy to these mechanisms from the supply line.

The elementary consumer line of the pneumatic system is shown in Fig. 21.1. Air (nitrogen) from the supply line isfed to reducer 1 which decreases pressure at the inlet to the distributing device (control valve 2). The valve directs the compressed air flow to one of the cavities of the actuating device (actuating cylinder 3), the second cavity of it being connected in this case to the atmosphere. Owing to the difference of pressures, the piston with the rod moves the mechanism being controlled.

In the case when the pneumatic system is used as an emergency one (in addition to the main hydraulic system), air (nitrogen) from valve 1 (Fig. 21.2) rushes to shuttle switch 2 which disconnects actuating cylinder 4 from the hydraulic system and ensures supply of compressed air to it.

After the emergency system is used, air (nitrogen) is released through special devices 3 and the working fluid fills the pipelines running from the shuttle valve to the cylinder.

The control device of the pneumatic braking system (Fig. 21.3) is pneumatic variable pressure reducer 2 (similar to the hydraulic braking system), which is controlled by a special lever. To ensure separate braking, differential reduce1- 3 is connected in the circuit. The lever of reducer 3 is linked with the control pedals,when the pedals are pushed, the differential reducer supplies air (nitrogen) to the braking devices of the left and right wheels at different pressures.

In the emergency braking system (Fig. 21.4) gas is not fed directly to the braking devices. It acts on the fluid being in separating tank 4. The fluid is fed under the gas pressure through shuttle switches 5 to the braking devices. In addition to reducers, distribution and actuating mechanisms, the consumer lines also comprise throttles, slaving valves, non-return valves and other auxiliary devices.

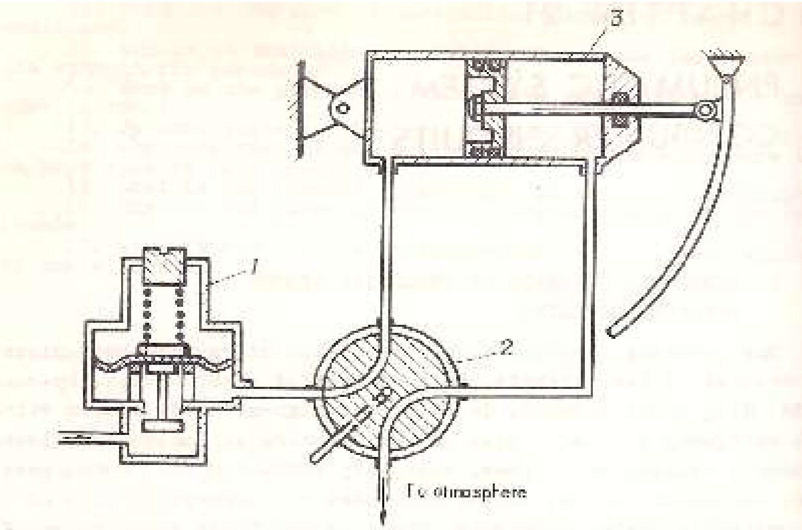


FIG. 21.1. SCHEMATIC DIAGRAM OF ELEMENTARY LINE OF PNEUMATIC SYSTEM CONSUMERS
1 – reducer; 2 – control valve; 3 – actuating cylinder

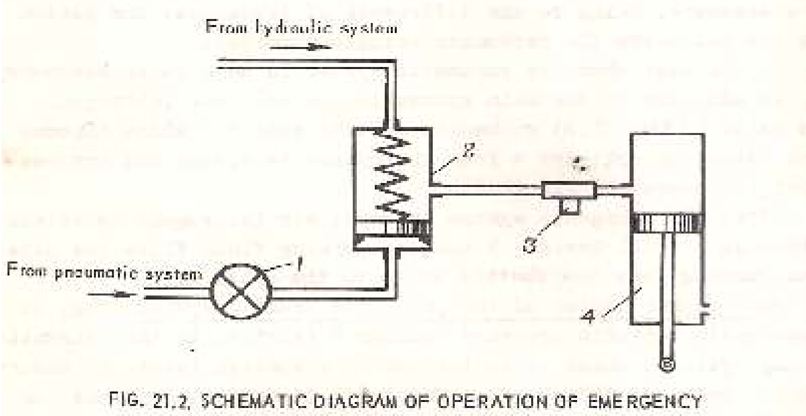


FIG. 21.2. SCHEMATIC DIAGRAM OF OPERATION OF EMERGENCY PNEUMATIC SYSTEM CONSUMERS
1 – valve; 2 – shuttle switch; 3 – air release device; 4 – actuating cylinder

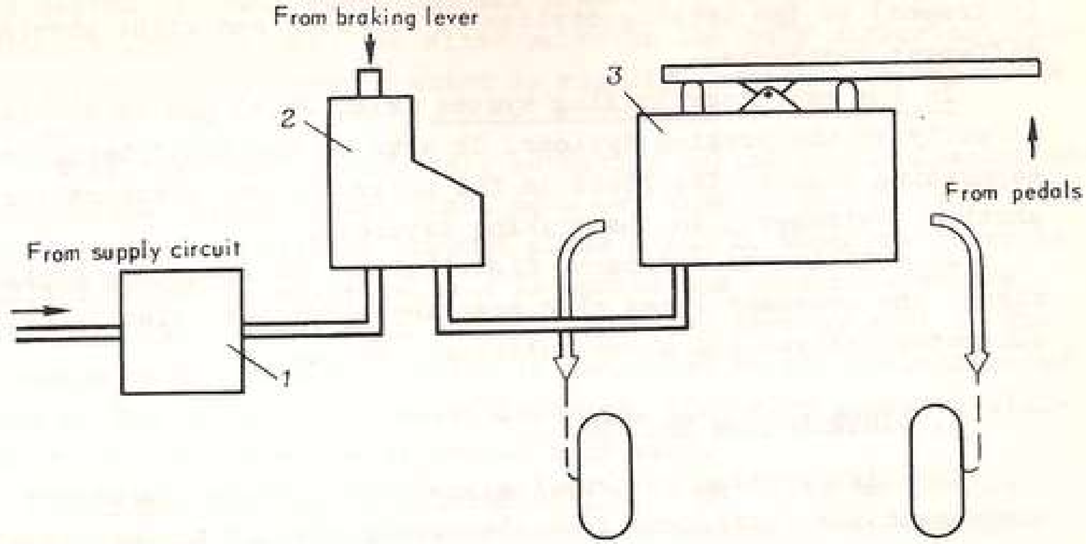


FIG. 21.3. SCHEMATIC DIAGRAM OF PNEUMATIC BRAKING SYSTEM
1 – reducer; 2 – variable pressure reducer; 3 – differential reducer

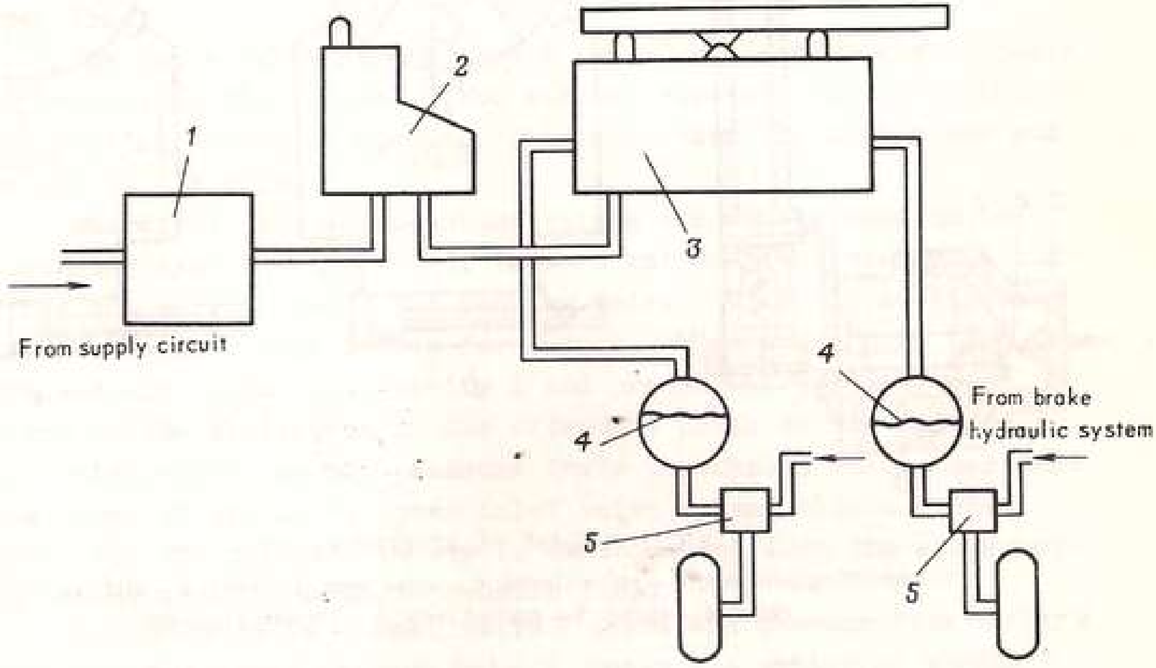


FIG. 21.4. SCHEMATIC DIAGRAM OF EMERGENCY BRAKING PNEUMATIC SYSTEM
1 – reducer; 2 – variable pressure reducer; 3 – differential reducer; 4 – separating tank; 5 – shuttle switches

4.5-Pneumatic Actuating Device :-

The actuating devices of the pneumatic systems are actuating cylinders and pneumatic motors (pneumatic rotary drives).The actuating devices of the pneumatic system are intended for converting the compressed air (nitrogen) energy into the mechanical energy of the aircraft mechanism movement.

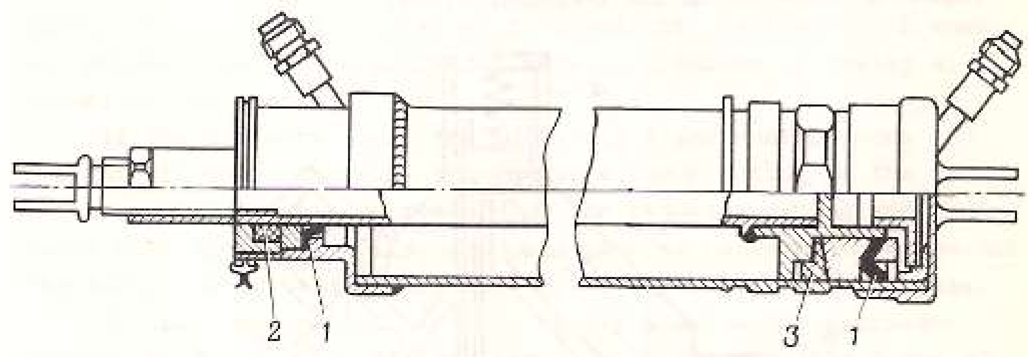


FIG. 21.8. PNEUMATIC ACTUATING CYLINDER
1 – collars; 2,3 – rings

The pneumatic actuating cylinders (Fig. 21.8) are most widely used nowadays. Constructional they are similar to the hydraulic ones. The difference resides in that the pneumatic cylinders provide for lubrication of the moving parts with a special composition (graphite lubricant, etc.) which is stuffed into the gland rings (felt (2) and asbestos (3) rings). The rings are installed near the sealing collars **1.**

Fixation of the pneumatic actuating cylinder rods may be effected only by mechanical locks. Ball locks are most widely used at present. Their construction is similar to the hydraulic ball locks considered above.

The pneumatic motors are divided into displacement and **tur**bine. The displacement pneumatic motors are similar to the hydro-motors. In the turbine motors the kinetic energy of gas is directly converted into the mechanical energy. In this case, gas is fed to the nozzle hole from which it escapes at a considerable speed and gets onto the rotor blades.

Employment of the pneumatic motors is restricted by high consumption of **air.** However, they are used when the aircraft is on the ground to drive high-power mechanisms: to start the engine, lower the cargo plane for embarkation of troops, etc. The hydro-motors cannot be used in this case owing to a high temperature of the fluid.

4.6- **Maintenance of Pneumatic System** :-

1. Insurance of making the system completely and tightly blocked due to air high pressure.
2. Observing the amount of compressed air leakage continuously to insure that the system works efficiently.
3. At the environment of very low temperature (Below 0 ^{o}C) the maintenance grope should double check the pneumatic cylinder annuals rubber rings from losing its elasticity due to freezing leads to air leakage.
4. While at the reverse environment of high temperature and humidity there is a problem of water vapor concentrating in the systems and pipes leading to rusty risks should be taken into consideration.
5. Excessive vibration in aircraft during flight effects on all aircraft system especially on the pneumatic system cussing breaking it down or high compressed air leakage thus reducing its performance, therefore the system must be fitted after every maintenance cycle.
6. After every flight the precipitation filters must be evacuated from water and dust.
7. The maintenance operations must be occurs precisely due to system logo book periodically.

Chapter Five

Aircraft Fire System

5.1- Purpose of Fire Safety Systems on Aircraft and requirements to be met by them

Fire on the aircraft is one of the main reasons for disastrous flight accidents in peaceful time and destruction of the aircraft under combat conditions.

The most probable reasons for fire on the aircraft are as follows'

1. Leakage of the aircraft fuel, oil and hydraulic systems.
2. Abnormal engine operation and destruction of its parts.
3. Defects of aircraft electrical equipment.
4. Forced landing with the landing gear retracted, which leads to destruction of aircraft parts.
5. Effect of enemy fire in combat.

Fire Safety System in Boing 737

The most fire-hazardous places on the aircraft are ***fuel tankcompartments***, ***engine nacelles***, ***cabins*** where a multitude of electrical equipment units and ***hydraulic system pipelines*** is located.

The fire safety system serves to ***warn***,***detect*** and ***extinguish*** fire in the most fire-hazardous places of the aircraft.

The fire safety system comprises

1. The fire-extinguishing system serving tor detection and extinguishment of fire at the most fire-hazardous places of the aircraft.
2. The neutral gas system serving to fill a free space of the fuel tanks with neutral gas to preclude ignition of the fuel vapors.
3. Portable fire-extinguishers arranged in the aircraft cabins.
4. Fire bulkheads installed in the engine nacelles.

The fire safety systems should meet the following specific requirements

1. Well-timed detection of fire or its symptoms in the assigned compartment of the aircraft
2. Discrimination of actual symptoms of fire from the false ones to prevent unnecessary operation of the system - high efficiency of fire-fighting means,
3. Multiple action of the fire-fighting means,
4. Absence of toxic gas liberation at extinguishing of fire.

5.2- Fire-Extinguishing Principle and Fire Extinguishments

All the modern aircraft use one method of extinguishing (warning) of fire. It is based on properties of neutral gases and vapors of fire-extinguishing fluids to create a medium which does not support burning around fire location.

The extinguishment should meet the following main requirements:

1. The minimum possible fire-extinguishing concentration (i.e. minimum per cent content of fire-extinguishing gases and vapors in the air medium sufficient for creating the medium which doesnot support burning),
2. Sufficiently high rate of evaporation of liquid agents at low temperatures;
3. Chemical neutrality to structural and equipment materials of the aircraft'
4. Non-toxicity.
5. Possibility of use of fire extinguishments in all flight conditions within a wide ambient temperature range.

The fire extinguishments listed below are used on the aircraft.

Carbon dioxide CO_2 has relatively low efficiency as a fire extinguishing agent. Its fire-extinguishing concentration is 25%.

The advantages of carbon dioxide are stability at storage, corrosion prevention, ability to decrease the ambient temperature.

The disadvantages of carbon dioxide are a loss of efficiency at low temperatures causing the reduction of pressure in the bottles. At a temperature of -78 ^{0}C (200 K) and atmospheric pressure carbon dioxide solidifies. Therefore, the use of carbon dioxide requires special heating of the fire safety system portions. With the temperature rise, the pressure of carbon dioxide in bottles increases. This necessitates installation of special safety valves on the bottles with CO_2, Carbon dioxide is widely used both in the neutral gas and in the fire-extinguishing systems.

Fire extinguishment "3.5" has fire-extinguishing efficiency 3.5 times as much as that of carbon dioxide. Its fire-extinguishing concentration is 6.6%. This composition includes the following ingredients, per cent by weight ethyl bromide (C_2H_5Br) - 70% and carbon dioxide ($C0_2$) 30%. This liquid is toxic and causes corrosion of aluminum and magnesium alloys. The advantage of extinguishment "3.5" is preservation of the efficiency throughout the whole operating temperature range. The composition is used only for extinguishing fire but owing to chemical activity, in a limited scale.

Fire extinguishment "7" has the fire-extinguishing efficiency 7 times as much as carbon dioxide and two times as much as liquid "3.5". Its fire-extinguishing concentration is 3.3%. Extinguishment"7" is based on methylene bromide (CH_2Br_2) - 80% and ethyl bromide (C_2H_5Br) - 20% by weight. Extinguishment"7" is still more toxic and chemically active than extinguishment "3.5". All operations with this extinguishment should be performed with the use of protective clothing and gas masks. It is used on the modern aircraft in a limited scale and only for extinguishing- fire.

Freon 114 B2 is a halogenated hydrocarbon of the ethane row.It is heavy colorless liquid operating within a wide temperature range from -110 to +45°C (163 - 320 K). The liquid is very efficient; its fire-extinguishing concentration is 3.47%, i.e. almost the same as of extinguishment "7". Freon 114 B2 does not react with aluminum and magnesium alloys and is low toxic (does not require the use of the gas mask). This explains its wide application as fire-extinguishing liquid on the modern aircraft.

5.3- Schematic Diagram of Fire-Extinguishing System

The fire-extinguishing system (Fig. 25.1) is ready for operation when switch 6 is cut in. When fire breaks, thermal warning device 5 operates and closes the circuit of the starting devices of distribution valve 3 and discharge bonnet 2 of bottle 1. Under the pressure of air or its vapors the extinguishment is rapidly expelled through the syphon pipe of the bottle to the system to sprayer 4. The liquid evaporates quickly, mixes with air andforms a medium which does not support burning. Simultaneously the temperature in the fire zone decreases owing to evaporation ofthe liquid. This leads to liquidation of fire. When thermal warning device 5 is cut in, lamp 7 illuminates on the pilot's console to warn of fire in the given compartment of the aircraft.

The system for extinguishing fire in the engine is built according to the same principle. If the temperature inside theengine exceeds 15000 the thermal detectors installed in the casings of the engines and oil cavities of the compressor and turbine bearings operate.

5.4- Schematic Diagram of Neutral Gas System

The neutral gas system (Fig. 25.2) is intended for creation of the explosion-proof medium in the air spaces of the fuel tanks and between the tanks and the skin by supplying gaseous carbon dioxide to them during flight. The tanks are filled with neutral gas only under the combat conditions when they can be fired through by incendiary projectiles of the enemy.

When switch 3 is cut in. the actuating device of discharge bonnet 2 of bottle 1 operates. Gas rushes to the pipelines of the neutral gas system (sometimes. doubling as the pipelines of the venting system) and further through jet 6 to the overfuel space of the tanks. The jet ensures a definite flow rate of the neutral gas while reducer 5 decreases the pressure of gas to 1.1 - 3.5 kgf/cm^2. Filter 4 is installed in the neutral gas system to preclude clogging of jet 6.

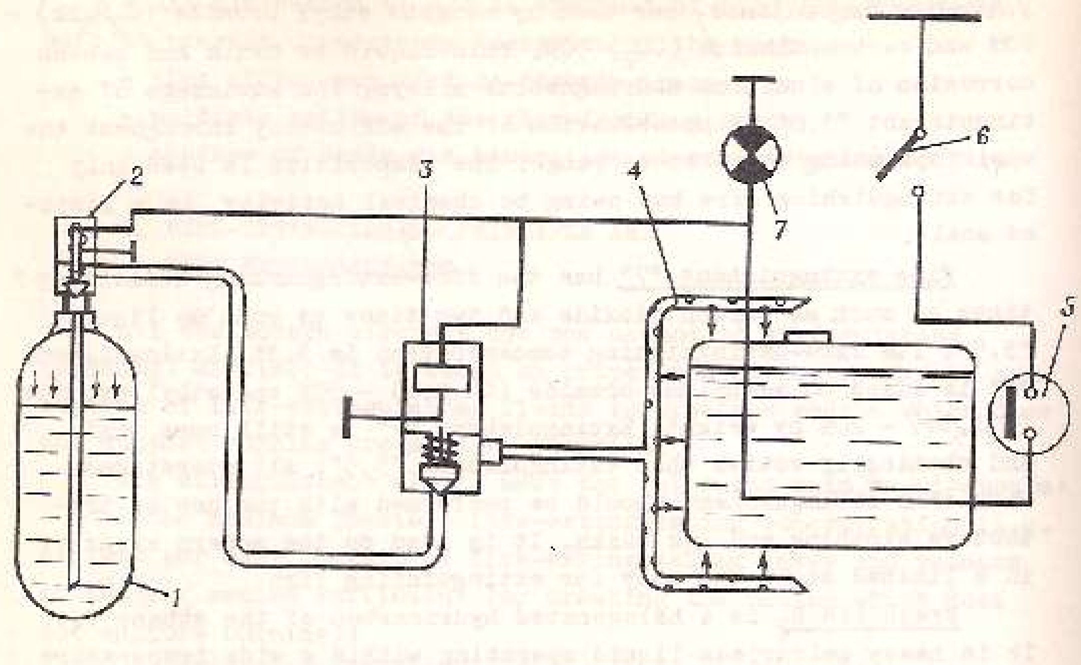


FIG. 25.1. SCHEMATIC DIAGRAM OF FIRE-EXTINGUISHING SYSTEM
1 – bottle; 2 – discharge bonnet; 3 – distribution valve; 4 – sprayer; 5 – thermal warning device; 6 – switch; 7 – FIRE warning lamp

While filling the tanks, carbon dioxide, as being heavier, expels a part of fuel vapors and air from the tank through the venting system. Mixing with the remaining part of air and vapors of fuel, carbon dioxide forms an explosion-proof medium.

The fire-extinguishing systems and neutral gas systems differ from the schematic diagrams considered above in the presence of several compartments (areas of possible fire) with their detectors and distribution valves. The neutral gas system is a part of the fire-extinguishing system.When -all the fire extinguishment bottles are empty, it is possible to open the discharge bonnet of the neutral gas bottle and supply carbon dioxide to the fire-extinguishing system. The system involves several shots of bottle engagement. Besides, the neutral gas system on the modern aircraft automatically supplies carbon dioxide not to all tanks but to the tanks from which the fuel is consumed.

In the course of operation of the aircraft, after using the system for extinguishing fire it is necessary to charge the bottles with extinguishment. The aircraft construction provides for charging of the bottles both with and without removal of them from the aircraft.

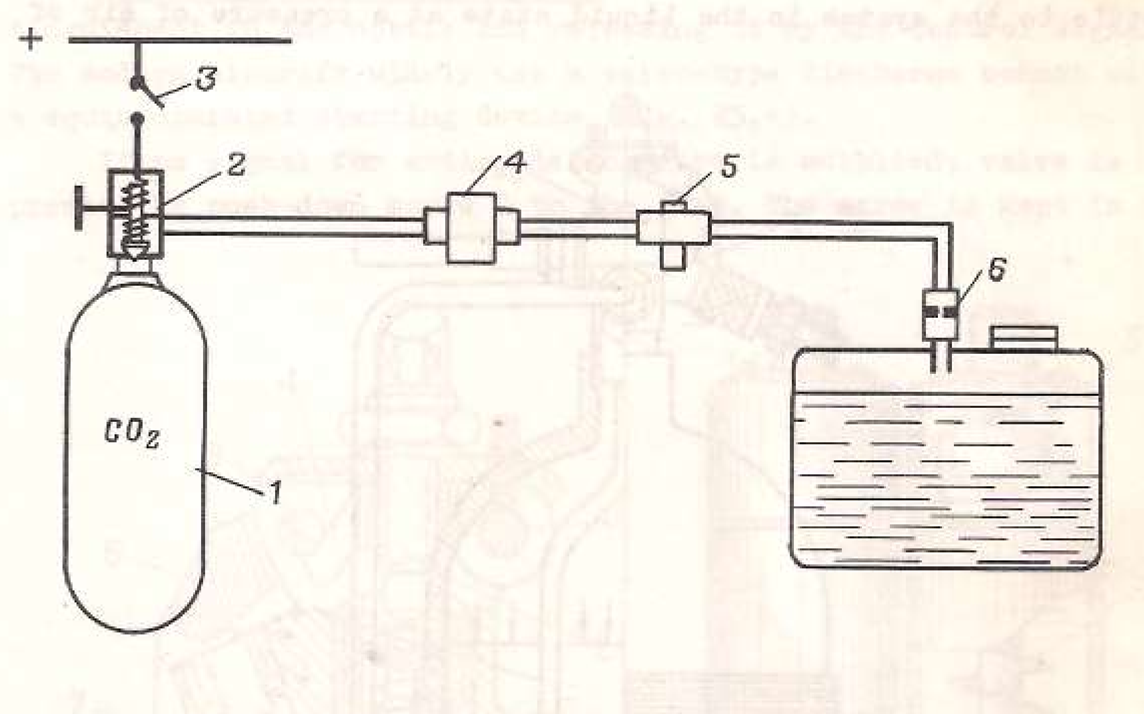


FIG. 25.2. SCHEMATIC DIAGRAM OF NEUTRAL GAS SYSTEM
1 – bottle; 2 – discharge bonnet; 3 – switch; 4 – filter; 5 – reducer; 6 – jet

5.5- Fire Safety System Unit

The fire-extinguishing bottles (fire extinguishers) serve as containers for the required reserve of extinguishthe fire-extinguishing bottles (fire extinguishers) serve as containers for the required reserve of extinguishment and for supply of the latter in the gaseous or liquid state to the required compartment. Cylindrical bottles of 2, 4 and 8 lit in capacity(Fig. 25.3) and spherical bottles are usually used. The bottlesare reinforced by double wire soldered braid 1.

Syphon pipe 4 is installed inside the bottle intended for extinguishing fire. It censures supply of fire extinguishment from the bottle to the system in the liquid state at a pressure of air of(70 to 170 kgf/cm^2) which is in the bottle above the liquid and is intended to expel it.The bottles which are used only in the neutral gas system do not include syphon pipes. Carbon dioxide is supplied to the system in the gaseous state owing to continuous evaporation from the liquid phase surface.On the modern aircraft bottles with neutral gas are used also for extinguishing fire when there is shortage of fire extinguishment. Therefore, they have the syphon pipes and double bonnets.

The bottle discharge bonnets serve for shutting off fire extinguishment in the bottle and releasing it by the control signal. The modern aircraft widely use a valve-type discharge bonnet with a squib-operated starting device (Fig. 25.4).

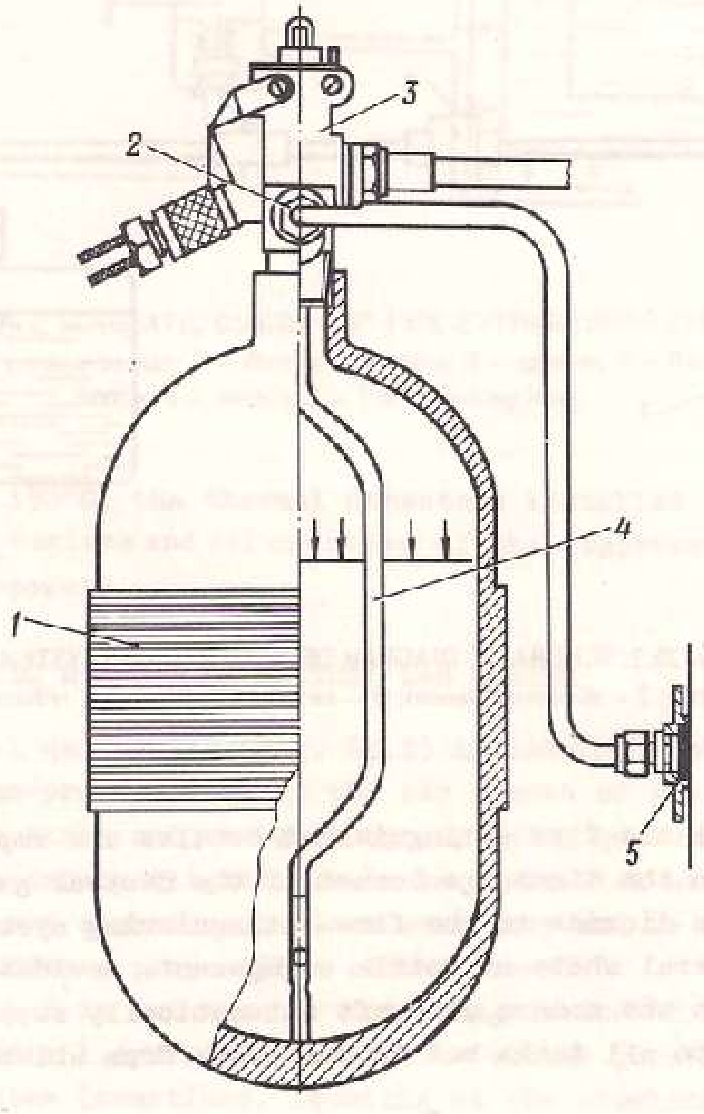


FIG. 25.3. FIRE EXTINGUISHER
1 – reinforcing braid; 2 – safety valve; 3 – discharge bonnet; 4 – syphon pipe; 5 – check diafragm

If no signal for extinguishing fire is supplied, valve is pressed by push-down screw 2 to the seat. The screw is kept in the closed position by lever 4 which is fixed by axle latch 5. When a signal (voltage) is applied to squib 8, powder ignites and powder gases rush under starting piston 7. Piston 7 moves upward and turns starting lever 6, and hence, axle latch 5, then hinged lever 4 is withdrawn from the stop. Under the action of the spring and gas pressure, the upper part of the discharge bonnet rotates about axle 3 and releases valve 1 which opens and releases fire extinguishment from the bottle to the system. One of the discharge bonnets of the neutral gas bottles is of a diaphragm type. When the squib circuit is closed, powder ignites. Pressure of powder gases forces the piston with a needle to puncture the diaphragm which cuts off the outlet instead of the valve and releases carbon dioxide from the bottle.

The electromagnetic distribution valve (Fig. 25.5) serves for directing fire extinguishment fed from the centralized source to the respective compartment, to the fire location. The .number of distribution valves corresponds to the number of the fire-fighting compartments. When the bottle discharge bonnet is open, the fire extinguishment rushes to all the valves but is released only through the open valve, i.e. the distribution valve ensures selection of fire extinguishing. The operating principle of

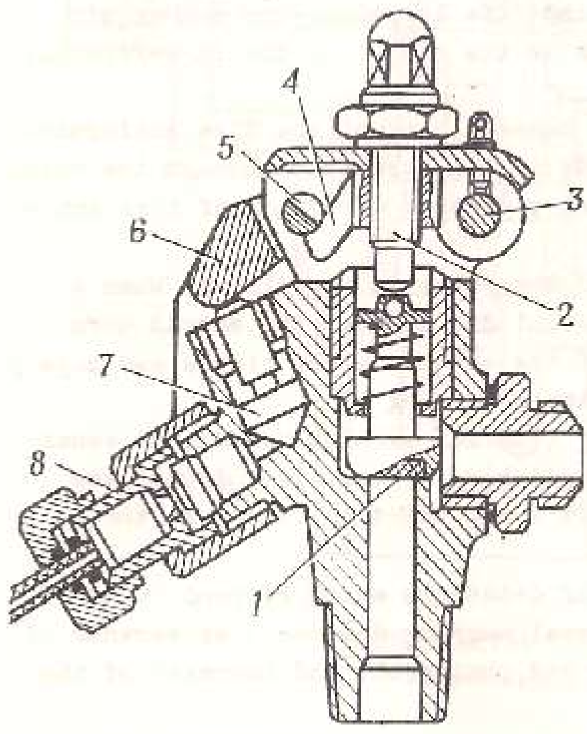


FIG. 25.4. BOTTLE SQUIB-OPERATED DISCHARGE BONNET

1 – valve; 2 – push-down screw; 3 – axle; 4 – hinged lever; 5 – axle latch; 6 – starting lever; 7 – starting piston; 8 – squib

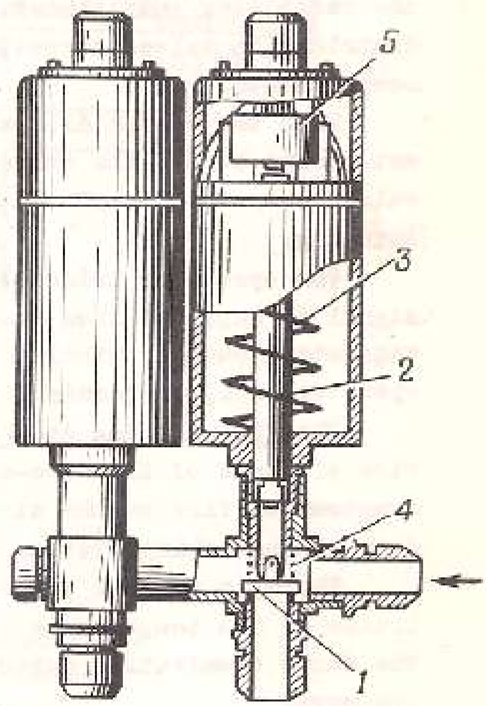


FIG. 25.5. DISTRIBUTION ELECTROMAGNETIC VALVE

1 – valve; 2 – electromagnet core; 3 – electromagnet winding; 4 – spring; 5 – limit switch

the valve is as follows, when a signal is supplied from the thermal detector or the second turn engagement button, winding 3 of the electromagnet .closes and core 2 opens valve 1, overcoming tension of spring 4.

<u>The fire warning detectors</u> (thermal warning units) are sensitive elements of the fire-extinguishing system. They detect the symptoms of fire on the aircraft and automatically cut in the fire-extinguishing system. There is a great variety of detectors which respond to increase of the temperature (thermal warning devices), appearance of the flame (ionization detector and photocell) and increase of the pressure. The thermal warning devices responsive to temperature increase are most widely used on the modern aircraft nowadays. Constructional the thermal warning devices are divided into bimetal thermal, thermo battery detectors made of differential thermocouples, ionization detectors and continuous-action semiconductor detectors.

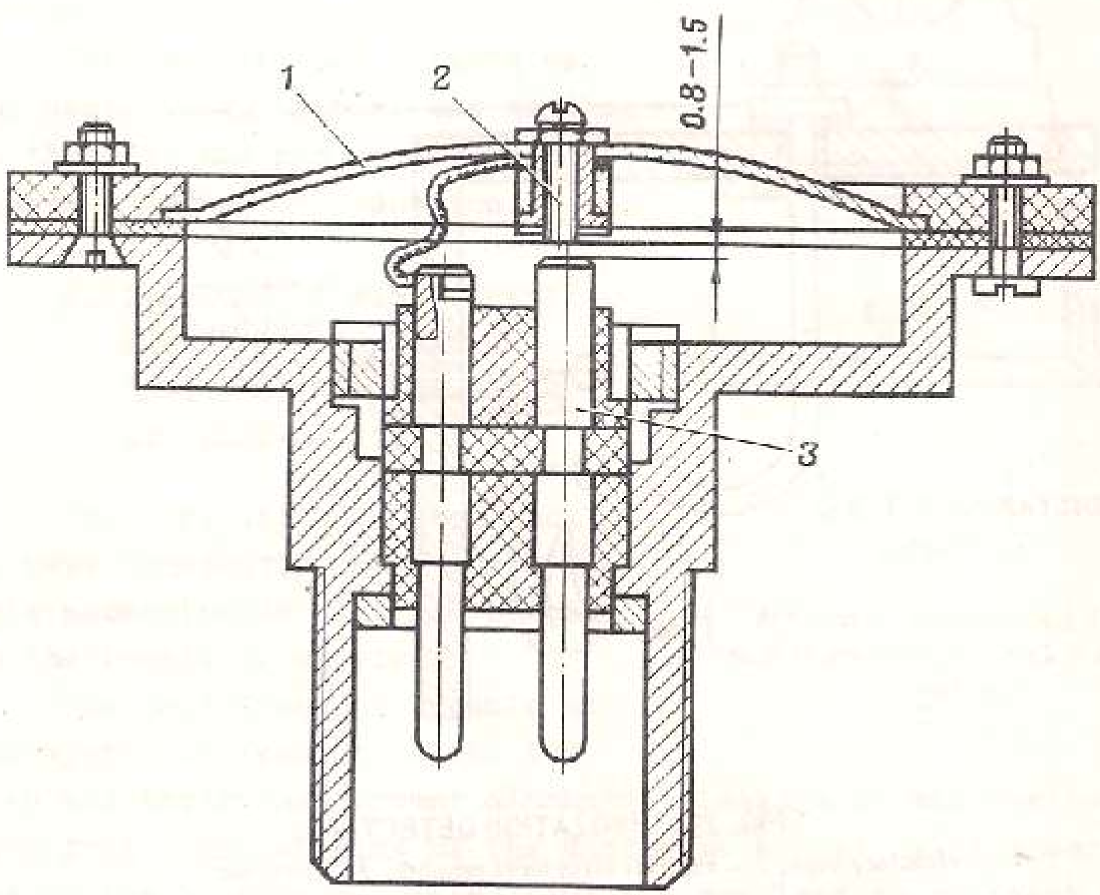


FIG. 25.6. BIMETAL THERMAL DETECTOR
1 – bimetal spring; 2, 3 – contacts

In the bimetal thermal detector (Fig. 25.6) bimetal spring 1 is a heat sensitive element. It is soldered of two plates with different thermal expansion coefficients. The upper plate is made of alloy with the lesser thermal linear expansion coefficient while the lower one is made of alloy with the higher thermal expansion coefficient. When the temperature increases, the stresses appear in the plates which form the moments bending down the bimetal plate. Now contacts 2 and 3 of the thermal detector will close and supply a signal for operation of the fire-extinguishing system (Fig. 25.1). The bimetal thermal detector with normally open contacts operates similarly. The grave disadvantage of the bimetal thermal detectors is the possibility of false operation. This.is dictated by cut-out (cut-in) of the thermal detectors within a definite temperature range. However, these temperatures are not always reliable symptoms of fire. There may be no fire at an elevated temperature and fire may occur at a decreased temperature. This often causes false operation of the fire-extinguishing system in the course of operation.

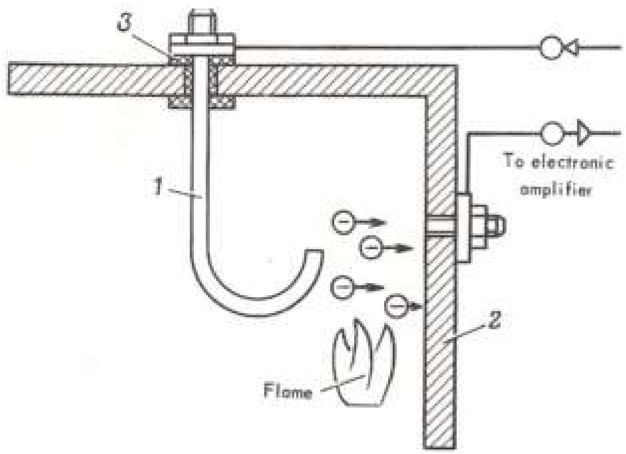


FIG. 25.7. IONIZATION DETECTOR
1 – refractory pipe; 2 – aircraft structural member; 3 – insulator

The ionization detectors are responsive to a more reliable symptom presence of the flame. The ionization detector (Fig. 25.7) is stainless refractory pipe I secured through insulator 3 to the aircraft structural member. In case of the flame, the space between pipe 1 and structure 2 is ionized and the current starts flowing from the pipe to the structure to trigger a special electronic amplifier which supplies a signal for operation of the fire-extinguishing system. However, such a principle of fire detection (by flame) fails to ensure well-timed detection and is not used widely nowadays. The main requirements for the thermal detectors are most fully met by thermo-battery detectors.

<u>The Thermo-battery detector</u>:(Fig. 25.8) compr1ses d1fferent1al thermocouples 1 which respond not to the absolute value of the temperature but to the rate of its growth. This is a true symptom of fire and provides for well-timed detection of it. One junction of **the** thermocouple electrodes is riveted as thin disc 2 (about 0.16 mm thick) other junction 3 is thicker. Since both junctions **are** close to each other,at a steady temperature the contact (electro-magnetic-field) e.m.f. of both junctions will be equal and oppositely directed and the thermocouple e.m.f. will be equal to zero. As the temperature rises, the thin junction will heat faster thanthe thick one, the contact e.m.f. difference will appear and the thermocouple e.m.f. will develop. The thermocouple e.m.f. will be proportional to, the rate of increase of the temperature, i.e. the difference of temporaries between the thin and thick junctions. At a definite rate of temperature rise the thermocouple e.m.f. will cause operation of a high-sensitive relay for cutting-in the fire-extinguishing system.

The reducers and filters of the neutral gas systems are similar to those of the air system with the constant degree of reduction.

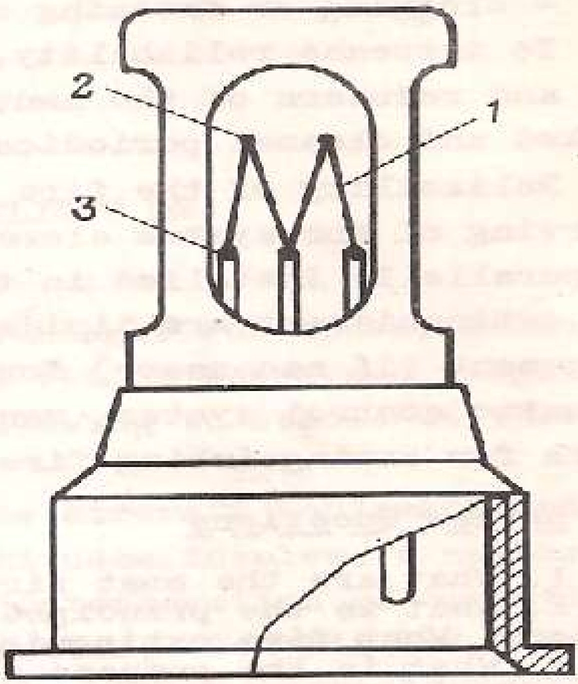


FIG. 25.8. THERMOBATTERY DETECTOR

1 – differential thermocouples; 2 – thin disc (hot junction); 3 – thick disc (cold junction)

5.6- Troubles of Fire Safety System on Aircraft and Measures for Increasing Its Reliability

The fire safety system should be kept constantly ready for use. This necessitates care and checks in the course of service. The most frequent trouble of the system is leakage of the bottles and their inadvertent discharge. Leakage-of the bottles may stem from loose closing of the discharge bonnet valve, Poor sealing at the bonnet-to-bottle joint and may lead to constant discharge of the bottles. Tightness of the charged bottles is checked by weighing or by readings of the pressure gauge installed on the discharge bonnet.

In case of drastic rise of the pressure in the bottle (at an increase of the temperature), inadvertent discharge may occur through safety valve 2 installed on the discharge bonnet (fig. 25.3). The discharge pressure from valve 2 rushes to check diaphragm 5 to force it out. It is necessary to check the presence of warning diaphragms before flight.

In the course of operation of the neutral gas system, discontinuation of neutral gas supply to the fuel tanks takes place. This may stem from

- failure of the neutral gas bottle heating system, hence, decrease of the gas pressure in the bottles.

- clogging or freezing of jets and reducers.

To increase reliability, the filters are installed before the jets and reducers of the neutral gas system.' The filters should be checked and cleaned periodically.

Reliability of the fire safety system is ensured by multiple reserving of the system elements. Two and more thermal detectors are parallel installed in the compartments. The bottles with fire extinguishment are divided into several groups with alternate engagement (if necessary) for operation. In case of failure of the automatic control system, manual control is used for engaging the system for extinguishing fire.

5.7- Aircraft Fire Zones

For fire detection aircraft were divided into zones according to amountof air in that zone these zonesis:

1. **A Zone:**for the places of plenty amount of air such as combustion chamber,engine compressor and turbine. These zones used automatic fire system and suitable extinguishment.
2. **B Zone:** for the places of plenty amount of air but went through barrier aerodynamic places such as Exhaust and Engine Cowl. These zones used both smoke and fire censors' with automatic fire system and suitable extinguishment.
3. **C Zone:**for the places of little amount of air such as electrical and power units.
4. **D Zone:**for the closed places where no amount of air exists such as systems unit Undercarriage and storage area and so.

5.8- Fire System Maintenance

1. The maintenance operations must be occurs precisely due to system logo book periodically.
2. Assurance of Thermo-couples cleaning no dust over it because it might cause error reading or false warning.
3. Secure the system pipes and bottles from excessive vibration and high shakes.
4. Observing the measurements of the bottles periodically and assure of its reliability to work perfectly.
5. After extinguishing fire we have to assurance of throw-out the extinguishment remaining through suitable vents.
6. We should not replace the extinguishment in the bottles unless there is leakage or it's expired.
7. Assurance of System works before every flight through the system lights.
8. When the system bottles recharged we should check the fitness of the system to be assure there are no leakage in it.

Chapter Six

Aircraft Crew Life-Support System (Oxygen System)

6.1- Influence of High-Altitude Flight onHumanOrganisme

High-altitude flights offer advantages for accomplishing a great number of combat missions. The flight speed and range are increased, navigation is facilitated owing to stable weather conditions, etc.

Ensuring normal operation of the aircraft equipment and normal conditions for crews at high altitudes involves a number of problems. A part of them stems from deterioration of operation of such units as engines, generators, motors, electric and radio equipment with decrease in air density. These technological difficulties are solved during designing of the units.

A considerable difficulty lies in overcoming of high altitude influence on the human organism. The main high-altitudes effects on human organisms are as follows:

1. Reduction of the partial pressure of oxygen
2. Drastic variation of the atmospheric pressure at climbing and descent.
3. Decrease of the air temperature and humidity.

6.1.1- <u>Reduction of partial pressure of oxygen</u>.

To sustain life of a man, it is necessary, to have oxygen which is contained in the ambient air. The air is a mixture of different gases (nitrogen, oxygen, argon, carbon dioxide, etc.) and water vapors. None of the gases combines with other gases and fully preserves its properties. With increase of the altitude, the per cent content of gases remains approximately constant. In accordance with the volume each gas has its partial pressure, i.e. the pressure, it would have if the entire volume would be occupied by it. The partial pressure of a gas in the mixture is determined from the formulas ($P_g = P_H G/100$)

Where P_g : Partial pressure of gas mm Hg.

G : percent (by volume) content of a given gas in the mixture.

P_H : total pressure of the gas mixture, mm Hg.

As the altitude increase, the atmospheric pressure drops, and hence, the partial pressure of each gas including oxygen drops too. Oxygen is fed to the human organism with the air inhaled. Oxygen liberated from air is transferred in the lung alveoli to the blood and during contraction of the heart muscle is directed to all the parts of the body. As a result of metabolism, oxygen is spent in cells and carbon dioxide is formed. Carbon dioxide flows with the venous blood to the heart, then to the lungs where it is diffused through the alveoli walls to the alveolar air and removed during exhalation to the ambient atmosphere. The organism will be saturated with oxygen only if its partial pressure in the alveolar air exceeds that in the blood, and the partial pressure in the blood, exceeds that in tissues. To remove carbon dioxide, its partial pressure ratio should be reverse to that described above.

When the oxygen partial pressure decreases, its diffusion to the blood through alveolar walls decreases too, the blood is not saturated with oxygen to a sufficient degree, and oxygen starvation results.

Oxygen starvation manifests itself as follows depending on the altitude:

1. At an altitude of 2000 – 3000 m, vision and attention are decreased.
2. At an altitude of 4000 – 5000 m, dyspnea, muscle weakness and vertigo appear.
3. At an altitude of 6000 – 7000 m, the pilot almost fully loses capacity for work and he is on the edge of losing consciousness. This stage of oxygen starvation is called critical stage.

Prolonged oxygen starvation leads to faint and finally to death of a man. It is essential that the pilot does not feel oxygen starvation and often does not understand his grave conditions.

Intensity of oxygen starvation increases when the pilot performs any work and when the altitude increases. The flight altitude of 4 - 5 km is a physiological altitude limit for flying in an open cabin.

6.1.2- Drastic variations of atmospheric pressure at climb and descent.

In addition to oxygen starvation developing with Climb, the human organism is very sensitive to drastic variations of the atmospheric pressure which occur in high-rate climb and descent of the aircraft. In this case, the pressure in the closed and semi closed cavities of the organism (middle ear cavity', abdominal cavity) does not equalize with, the ambient pressure. This leads to a considerable pressure differential which causes the expansion or contraction of the closed and semi-closed cavities of the organism accompanied by pain.

Another effect of high-rate climb at altitudes above 8000 m *is* the decreased ability of nitrogen to dissolve in the blood and tissues. Nitrogen liberating in the form of bubbles exerts the mechanical effect on tissues, ganglions 5, and blood vessels. This causes itch, rash, pain in joints and muscles and, in graver cases, temporal local paralysis. During low-rate climb the nitrogen excess transferred from the blood to the alveolar air and then to the ambient medium.

6.1.3- <u>Decrease of air temperature and humidity</u>.

The air temperature at high altitudes decreases down to -60^0C and below. The pilot loses its regular capacity for work. Prolonged action of cold results in overcooling of separate parts of the body and freezing.

The decrease of air humidity with a climb to an altitude also exerts an adverse effect on the human organism. Decreased humidity is accompanied by dryness in the nasopharynx and eye mucous membrane, the skin becomes rough and susceptible to infection diseases.

6.2- Need for Oxygen Feed and Conditioning Systems

The low partial pressure of oxygen, low absolute pressure, low temperature and humidity of air at high altitudes necessitate the use of technical means for supporting life and capacity for work.

The problem of physiological support of high-altitude flights is mainly confined to creation of the required partial pressure of oxygen in the air being inhaled. This is achieved by increasing the volumetric content of oxygen in the air inhaled in the course of climbing with the aid of the oxygen equipment. To perform flights at altitudes above 12,000 - 13,000 m, it is necessary to use the oxygen equipment with the excessive pressure created under the mask.

The value of the oxygen excessive pressure created in the mask depends on the flight altitude (Fig. 26.1) Breathing at the increased pressure under the mask increases the arterial pressure and peripheral blood pressure, the venous blood reaches the heart with difficulty. The, normal activity of the blood system and saturation of the organism with oxygen are disturbed.

The time of continuous use of such instruments at maximum altitudes of flight does not exceed several minutes.

To ensure normal activity of the blood system during breathing at the increased pressure and facilitate the breathing process, use *is* made of special jackets and suits. When the pneumatic chambers of the suit are filled with air a compensating pressure is applied to the chest, abdominal cavityextremities. Breathing is facilitated and stagnation of the venous blood in extreme ties is eliminated.Using inflatable jacket and trousers, it is possible to increase the excessive pressure in the oxygen regulator by correspondingly increasing the flight altitude up to 18,000 m. Further rise of the excessive pressure of oxygen cannot increase the flight altitude of the aircraft, since the ambient pressure decreases to about 47 mm Hg at an altitude of 19.000 m. At this pressure water boils at a temperature below +37°C, i.e. at the temperature of a human body. Since there is about 70% of water in the human organism, at altitudes above 19.000 m it will boil in tissues and liquid media of the body. Thus as regards breathing use of the oxygen equipment provides far increasing the flight altitude up to 18,000 m, However, other problems such as influence of decreasing absolute pressure and temperature of the ambient media, are not solved.The most advisable way for solving the complex of the above problems *is* the use of sealed cabins with creating a microclimate therein. The parameters of microclimate of the sealed cabins are called physiological parameters. This main physiological-hygienic parameters are the following physical parameters of the cabin air medium I barometric pressure, pressure variation rate temperature, humidity and composition of air and its purity. Life activity and capacity for work of the pilot depend on these parameters. The most favorable conditions (as regards the atmospheric pressure) for normal life activity of the pilot would be the conditions approaching the earth ones. However, in this case the considerable pressure differential between the cabin and ambient air would take place at high altitudes, for instance at an altitude of 20 km the pressure differential will reach 719 mm Hg. At such excessive pressure the loads of up to 9800 kgf/cm^2 will act on the walls of the pressurized cabin. The increase of strength of the cabin will increase its weight, and this deteriorates flight characteristics of the aircraft. Besides, if such pressurized cabin is damaged at a high altitude, the pilot will immediately get into surroundings unsuitable for life. The higher is the pressure difference, the more difficult is it for a pilot to withstand depressurization.

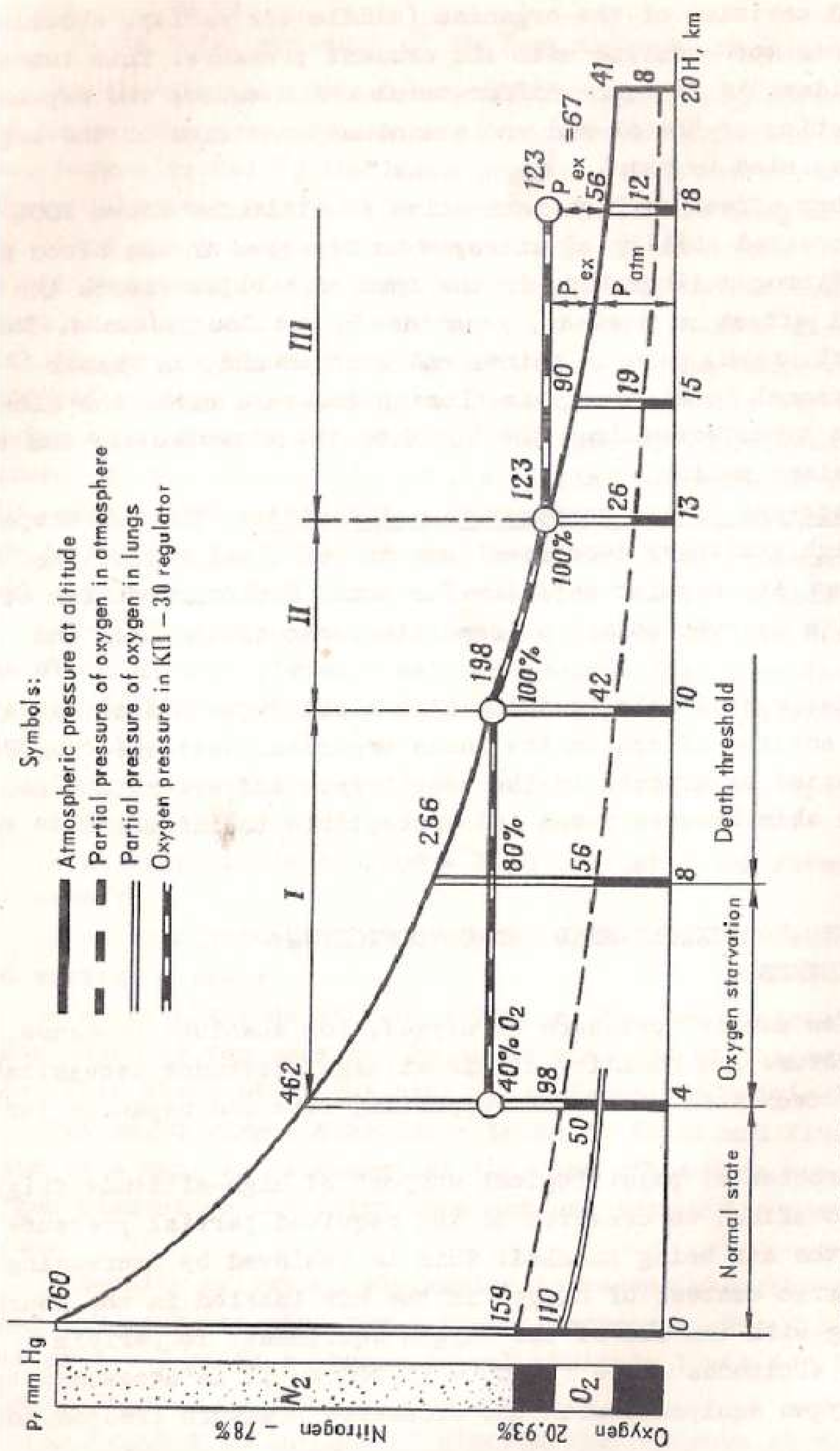


FIG. 26.1. RELATIONSHIP BETWEEN AIR PRESSURE AND OXYGEN EXCESSIVE PRESSURE AND FLIGHT ALTITUDE

I – supply of air-oxygen mixture to mask; II – supply of pure oxygen at atmospheric pressure to mask; III – supply of pure oxygen at excessive pressure to mask

6.3- Types of Pressurized Cabins

General requirements for all pressurized cabins are maintenance of the excessive pressure and preservation of other preset parameters of air. Despite a wide diversity of embodiments, it is possible to discriminate the following possible patterns of pressurized cabins (Fig. 26.2):

a. with pressurization of compressed atmospheric air,
b. with pressurization from bottles or gas-fire (in case of employment of liquefied air), installed on the aircraft;
c. with regeneration of cabin air in this pattern compressed air is used only in the amounts required to compensate for air leakage from the cabin.
d. combined type.

The sphere of application of the cabin types is determined mainly by the flight altitude. In this case the concentration of ozone (03) in the ambient medium is taken into account in addition to the air absolute pressure value. The maximum permissible concentration of ozone in inhaled air is 0.0001 mg/lit. The higher concentration of ozone causes irritation of the mucous membrane of the nose, throat, eyes, coughing, fatigue, headache and feeling of burn in stomach. The ozone concentration of 0.02 kg/lit leads to pneumonia and pulmonary edema.

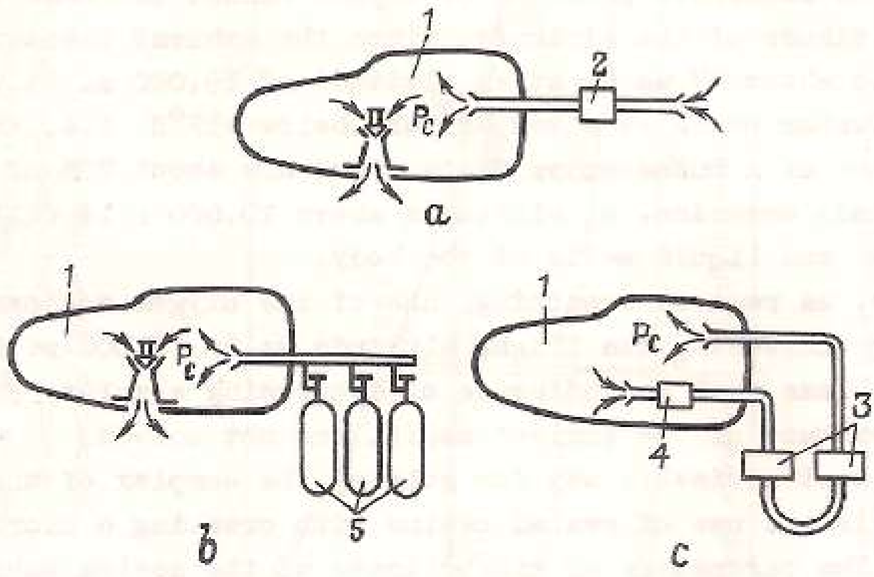
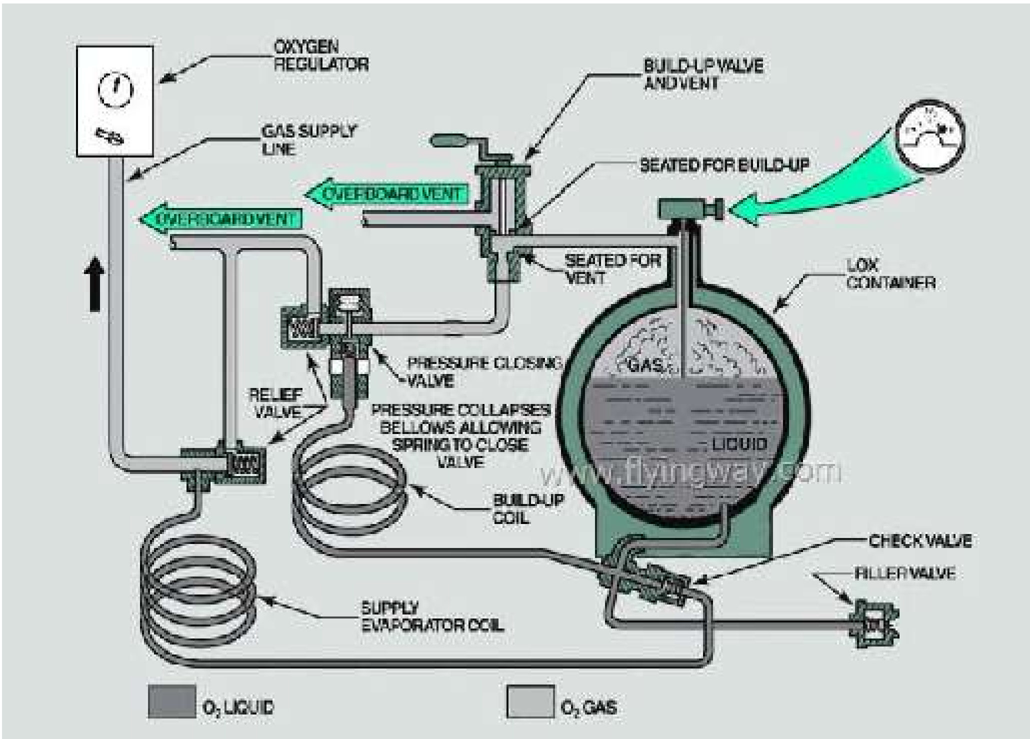
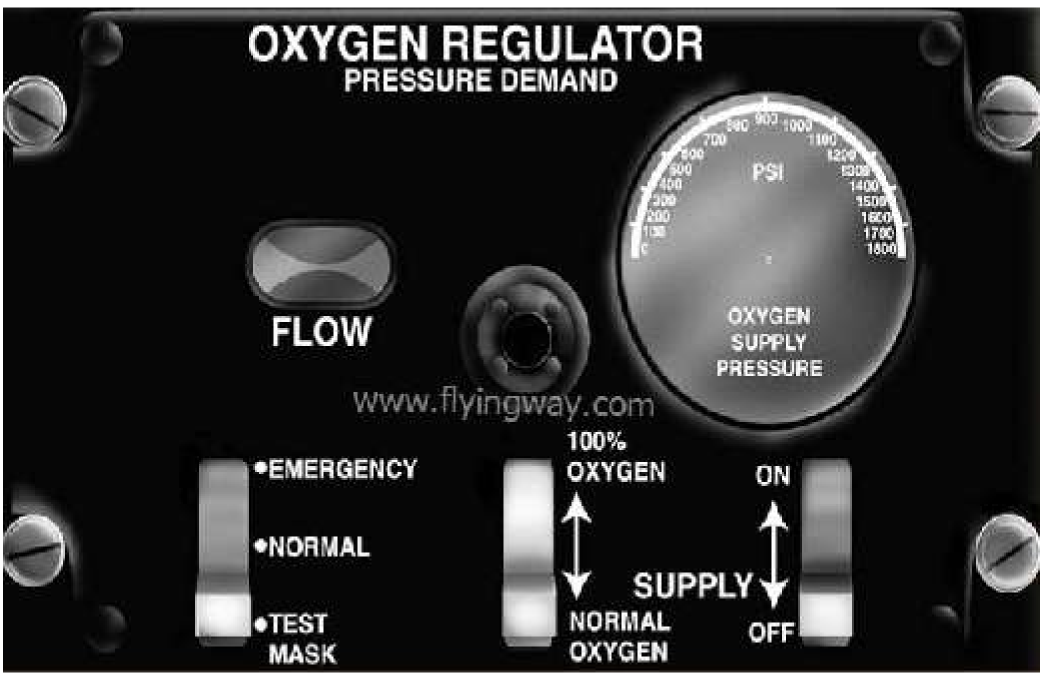
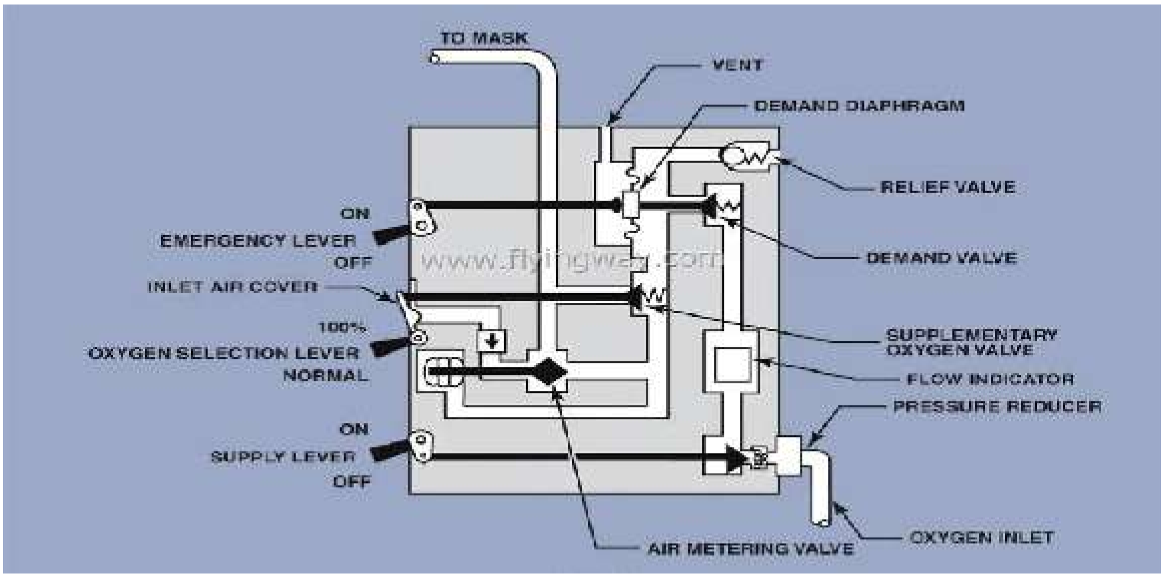


FIG. 26.2. TYPES OF PRESSURIZED CABINS
a – with atmospheric air pressurization; b – with bottle pressurization; c – with regeneration of cabin air; 1 – cabin; 2 – compressor; 3 – absorption cartridges; 4 – fan; 5 – bottles with air

Besides detrimental effects on a man, ozone oxidizes intensively rubber articles decreasing their service life, and this is also to be taken into account when selecting the cabin type and its equipment.The maximum concentration of ozone is found at altitudes of 20 to 30 km. All this restricts application of atmospheric air for pressurization of the cabin or necessitates the use of special installations for decomposing ozone into oxygen.

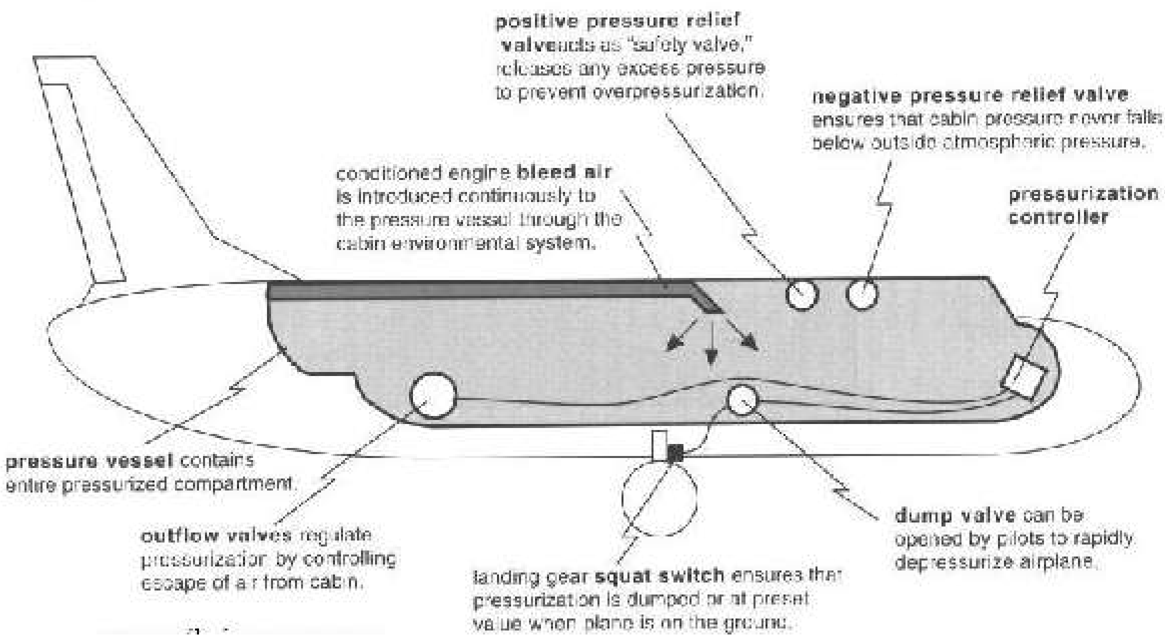


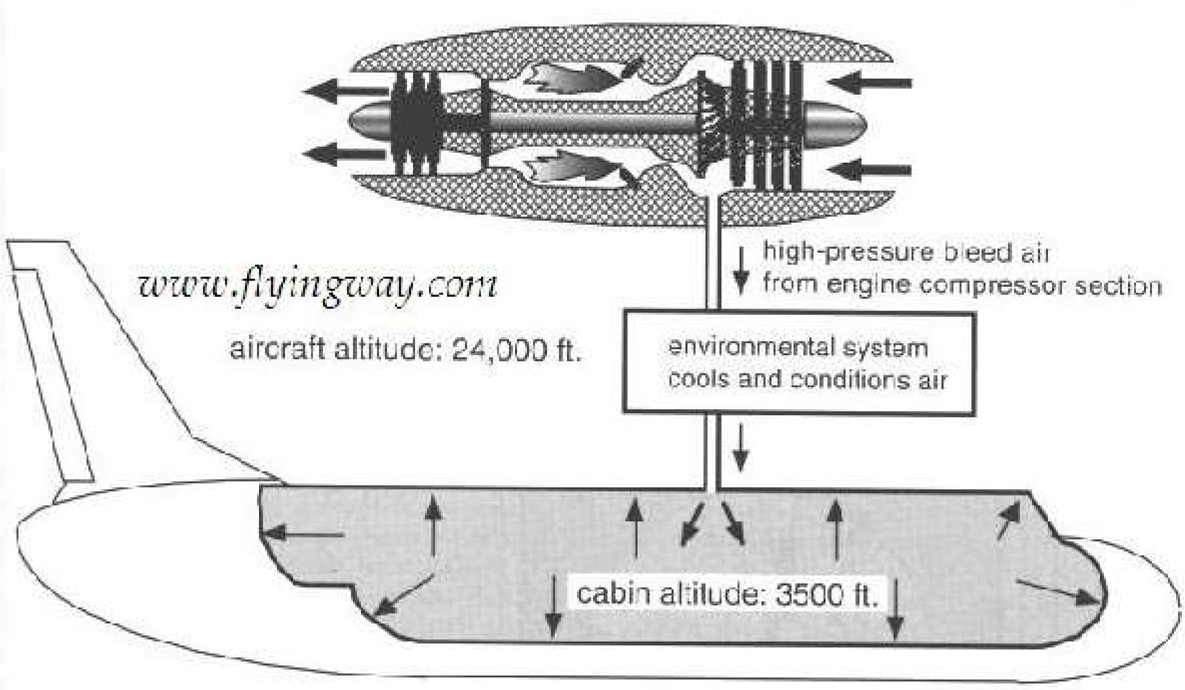




Flight Altitude (ft)	Cabin Pressure Differential		Cabin Pressure Altitude	
	Min (psi)	Max (psi)	Min (ft)	Max (ft)
0	0	0.25	−500	0
5,000	0	0.30	4,350	5,000
10,000	2.12	2.42	4,350	5,000
15,000	3.94	4.24	4,350	5,000
20,000	5.48	5.78	4,350	5,000
*24,300	6.60	6.80	4,500	5,000
25,000	6.60	6.80	5,000	5,380
30,000	6.60	6.80	7,400	7,870
35,000	6.60	6.80	9,600	10,100
40,000	6.60	6.80	11,520	12,050

*Maximum flight altitude for a 5,000 ft cabin altitude   *www.flyingway.com*





6.4- Aircraft Crew Life-Support System (Oxygen System) Maintenance

1. The maintenance operations must be occurs precisely due to system logo book periodically.

2. Check the fitness of the airplane cabin and the system to be assure there are no leakage in it.

3.Check the air supplied to the cabin is conforming the specification quality and environment.

4. Check the air filters periodically.

5. Check the oxygen supply emergency system before every flight.

6. Before the flight air supplies to the cabin and then checked after 5-10 min so if the difference in air pressure of the cabin was large than the average that mean there is leakage in the airplane ,not necessarily due to the system itself.

Chapter Seven

Aircraft Conditioning System

7.1- Components of Aircraft Conditioning System

1. Regulators of (Air supply, Pressure, Temperature and Ventilation).
2. Thermal Exchangers.
3. Valves Such as (Closed, Non-return and Safety).
4. Different Size and Types of Pipes.
5. Filters for air dust and humidity.
6. Detectors for Temperature, Humidity, Pressure and Airflow rate.
7. Turbo-Cooler.

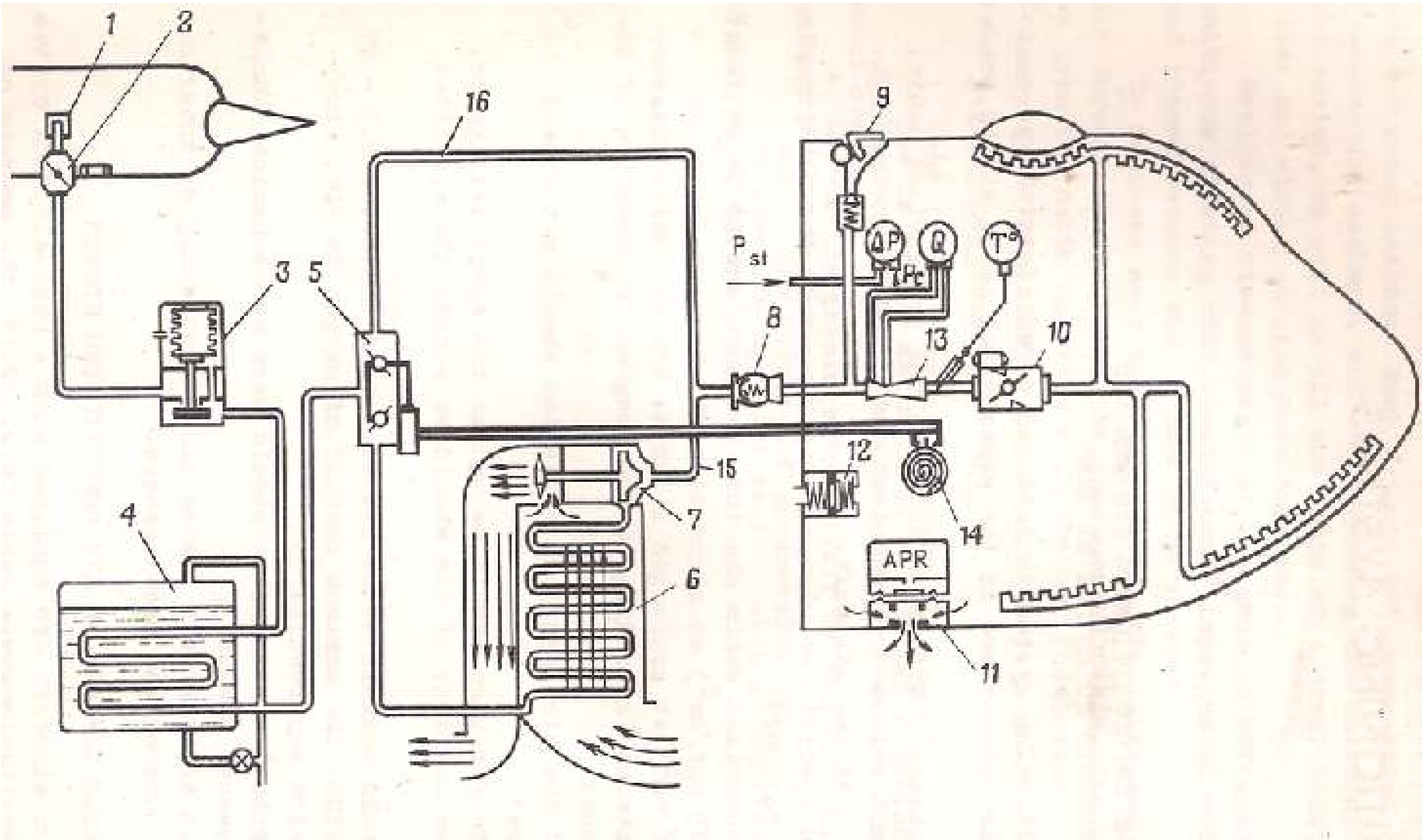


FIG. 27.1. SCHEMATIC DIAGRAM OF CONDITIONING SYSTEM OF VENTILATION-TYPE CABIN
1 – engine air intake; 2 – shut-off valve; 3 – absolute pressure regulator; 4 – heat exchanger; 5 – distribution valve; 6 – air-to-air heat exchanger; 7 – turbocooler; 8 – non-return valve; 9 – shutter; 10 – air supply regulator; 11 – pressure regulator; 12 – safety valve; 13 – flow rate detector; 14 – thermoregulator; 15 – cold line; 16 – hot line

7.2- Purpose of Conditioning Systems and Requirements to be met by them:

1. The conditioning system is intended to maintain the parameters of the air atmosphere in the pressurized cabin at the present level .
2. The conditioning system in set with the pressurized cabin, oxygen equipment and control and test units comprises the high-altitude system of the aircraft .
3. The basic specific requirements to be met by the conditioning system are as follows :

   a. The pressurized cabin absolute pressure should be at least• 268mm Hg (0.35 kgf/cm2) at short-time flights and 300 mm Hg (about 0.4 kgf/cm2) at prolonged flights; the excessive pressure should be maintained according to the program irrespective of the aircraft purpose.
   b. Rate of the air pressure variation should not exceed the specified norms.
   c. Cabin temperature should be within the specified limits.
   d. Relative humidity of air should be within the specifiedlimits.
   e. Air should contain about 21% of oxygen and about 0.5 - 1% of carbon dioxide, the maximum content of oxygen is 40%, otherwise an explosion may result.
   f. Air supplied to the cabin should have no mechanical admixtures or unpleasant smells.
   g. Noise in the aircraft cabins should not annoy or interfere with conversations of the crew members.

7.3- Schematic Diagram of Air-conditioning System

The modern aircraft are equipped with a high-altitude system including a ventilation-type cabin (Fig. 27.1). The sources of compressed air for pressurization of the cabin may be special blowers or compressors of the aircraft engines. Air intake, 1 is installed at the last stages of the engine compressor. To supply air to the cabin with particular parameters, the pressurization system includes a number of units which control the pressure, temperature, amount, and. if necessary humidity of air. Besides, air cleaners and noise suppressors may be installed in the system.

Air from the pressurization source is fed to gate-type shutoff valve 2 with an electric drive which is controlled from the cabin.When the shut-off valve is open, air is fed to absolute pressure rector 3. The regulator automatically maintains a definite pressure in the system pipelines irrespective of the engine power rating and flight altitude, after the regulator, air is supplied to heat exchanger 4 where it is subject to initial cooling. Partially cooled air may be directed by distribution valve 5 to the cabin through two lines. Air directed through a line which includes air-to-air heat exchanger 6 and turbo-cooler 7 will be cooled additionally. This line is called a cold line. The line through which air is fed to the cabin without further cooling is called a hot one.The distribution valve directs air through a cold or hot line or through both lines in any ratio. Thus, air may be fed to the cabin with a temperature the minimum and maximum of which are determined by the capacity of the heat exchanger and air-to-air heat exchanger with the turbo-cooler. The distribution valves are of the shutter or plug type with an electric drive. The valve is controlled automatically by thermo-regulator 14 installed in the cabin. The pilot can control the valve manually to adjust the cabin temperature at his will.Air fed through the cold and hot lines is combined and passing non-return valve 8 reaches the airline which is run in the pressurized cabin. The need for installing a non-return valve in the air line before the cabin stems from the possibility of failure of the pressurization sources or destruction of the pressurization system components outside the cabin. In these cases the non-return valve will ensure relatively slow depressurization of the cabin.

To regulate supply of air to the cabin, the system includes air supply regulator 10 which is a valve with a throttle shutter which is driven electrically (sometimes mechanically) from the pilot's station. This valve is used to adjust the amount of air fed to the cabin (from zero to maximum possible) at the pilot's will. To measure the amount of air fed to the cabin, flow rate detector 13 is installed in the pressurization airline. The indicator is mounted on the pilot's instrument board. To ensure the additional ventilation of the cabin at low altitudes with the cabin depressurized (summer circling flight), a low-altitude cabin ventilation system is included in the air supply line. The system inc1ud an airline and shutter 9. The shutter has an electric drive and is controlled by the pilot. The shutter opens upstream of air. The cabin pressurization line terminates with nozzles at the crew stations for supplying air to feet of the crew members and to the glazing of the cabin.

In addition to the units listed in the schematic diagram, the pressurization systems may include filters, heaters, moisture separators, humidifiers, noise suppressors which ensure the respective treatment of air.Separate units of the conditioning system are installed outside the pressurization pipeline, e.g., pressure regulator 11 and safety valve 12. The pressure regulator releases a part of air from the cabin to adjust the pressure in the pressurized cabin according to the preset law. This also provides for constant exchange of the cabin air.The safety valve restricts the rise of the excessive pressure in the cabin in case of failure of pressure regulator 11 and prevents the negative pressure differential in the cabin. Besides, this valve may be used for emergency depressurization of the cabin.

To check operation of the cabin conditioning system, the following devices are provided in addition to the air flow rate indicator:

1. Temperature indicators of air fed to the cabin and cabin air indicators.
2. Cabin altitude and differential-pressure indicator.
3. Critical cabin altitude warning unit intended to warn the crew on the necessity to switch over for pure oxygen supply.

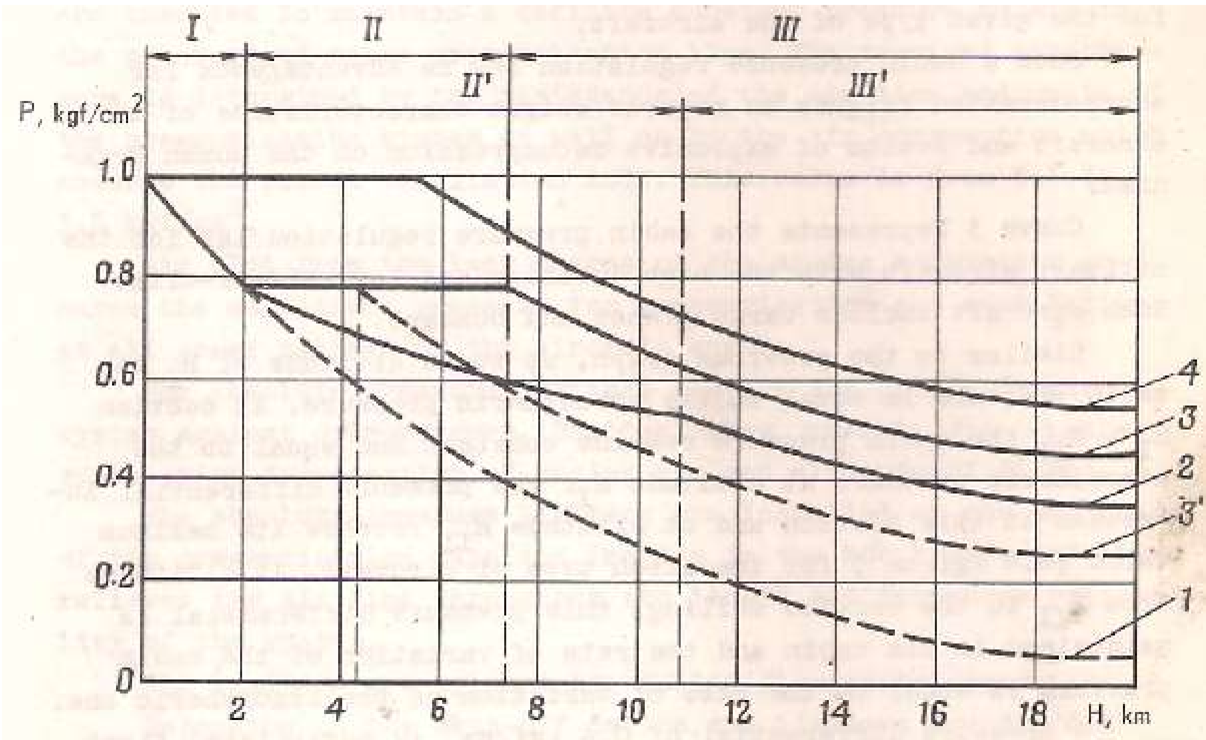
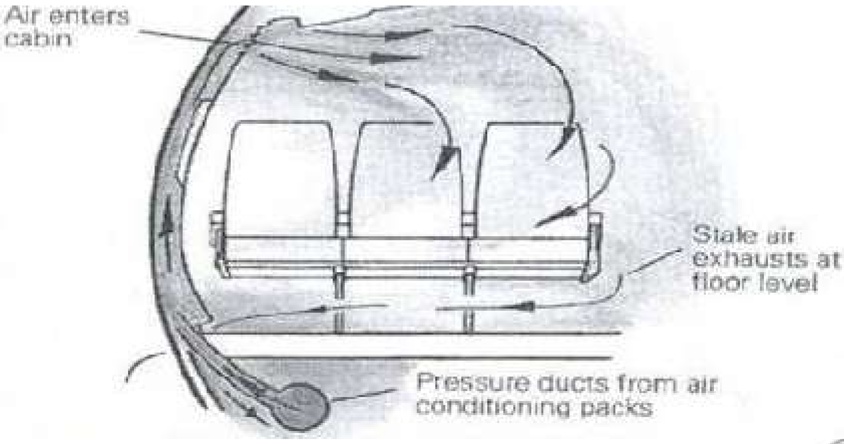
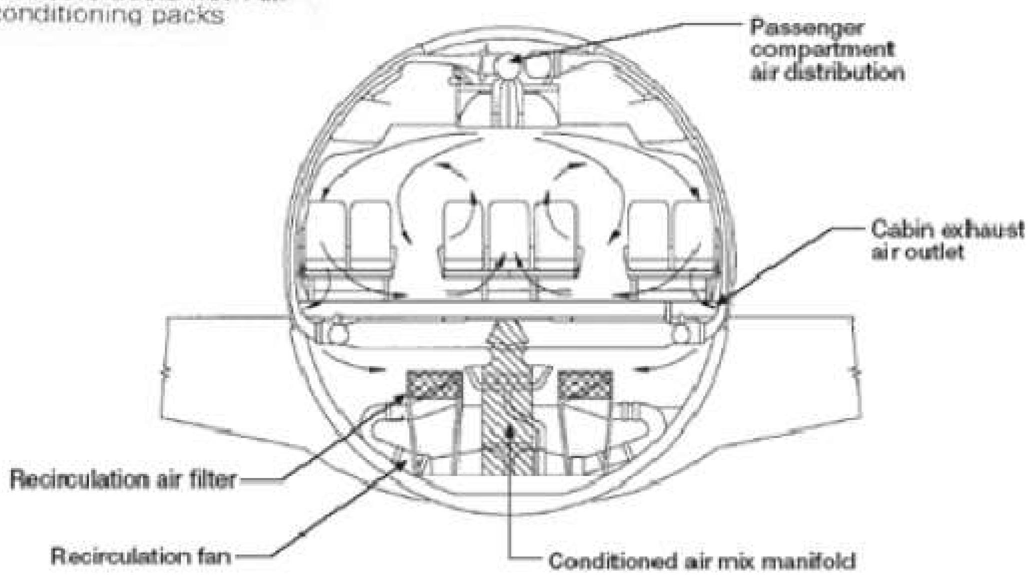


FIG. 27.2. CABIN PRESSURE REGULATION LAWS

1 – atmospheric pressure variation nature; 2 – for aircraft with high rate of climb; 3 – for aircraft with long duration of flight and low rate of climb; 3 – in combat mode; 4 – for civil aircraft






To air Turbo-cooler

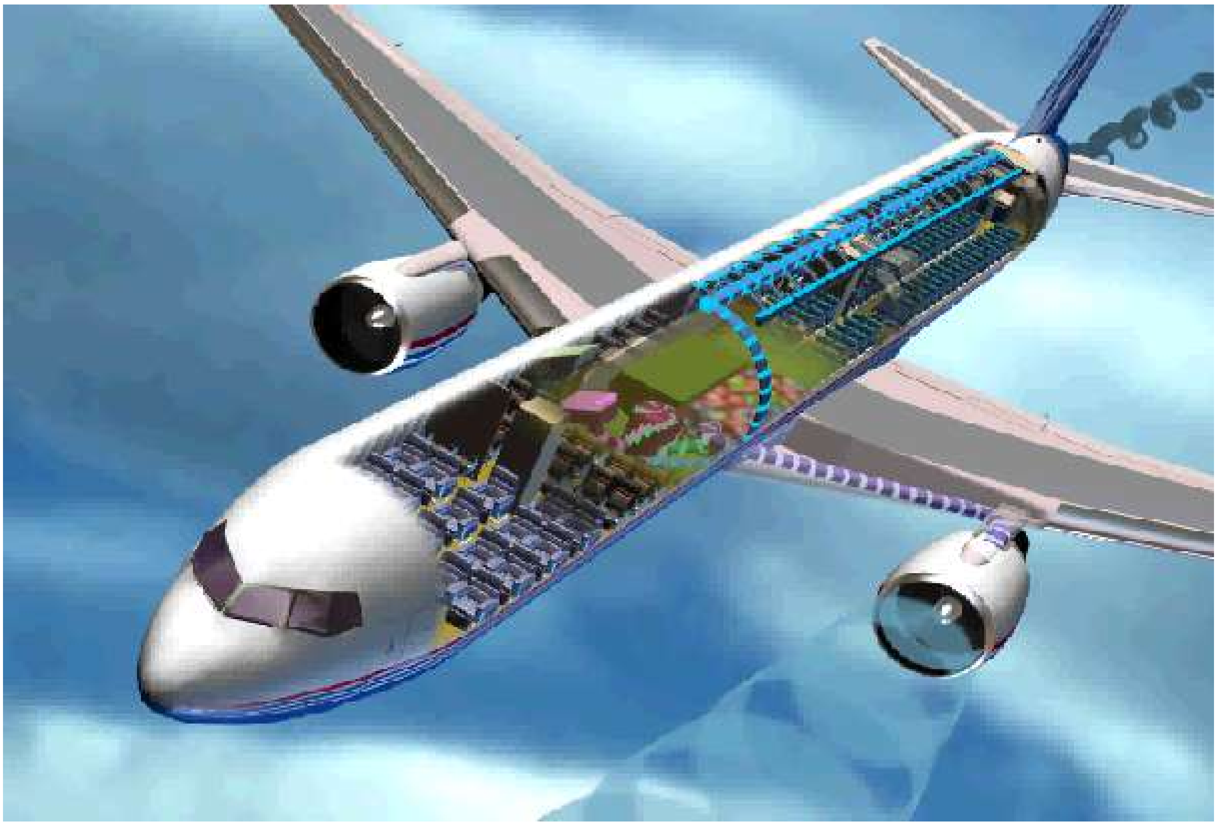

Changing Ozone Condition


Air from engine intake


Delivered to the cabin


Mixed with Oxygen


Filtering the air

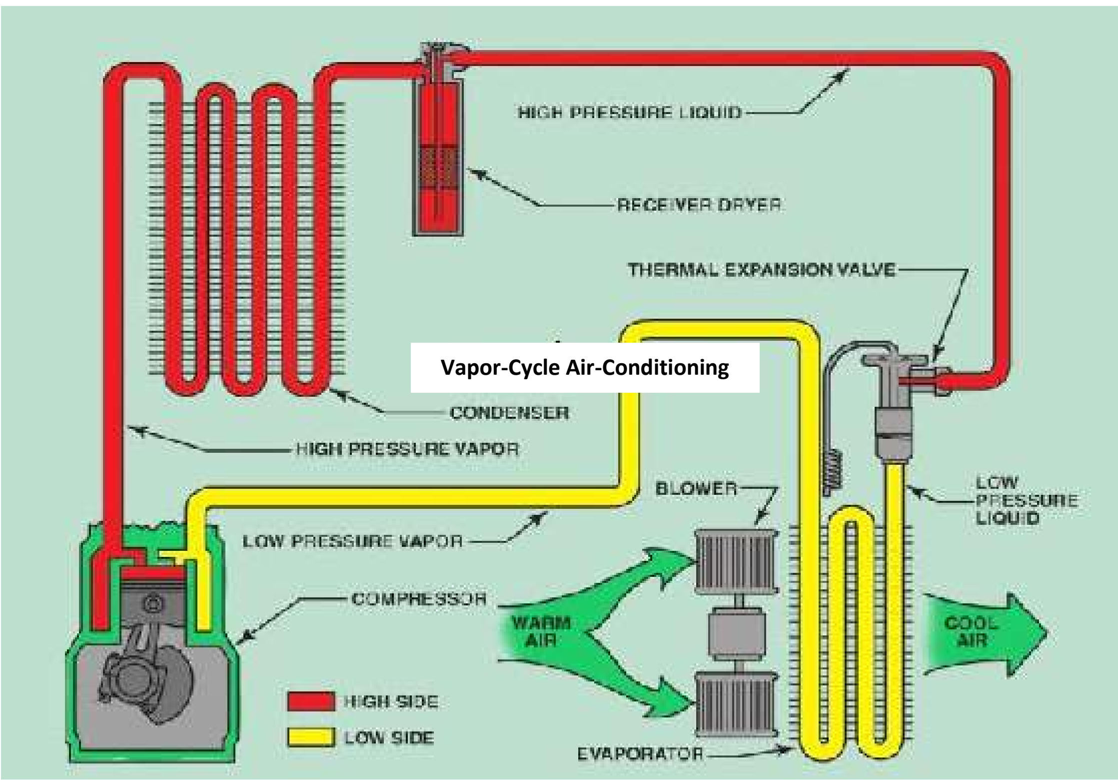


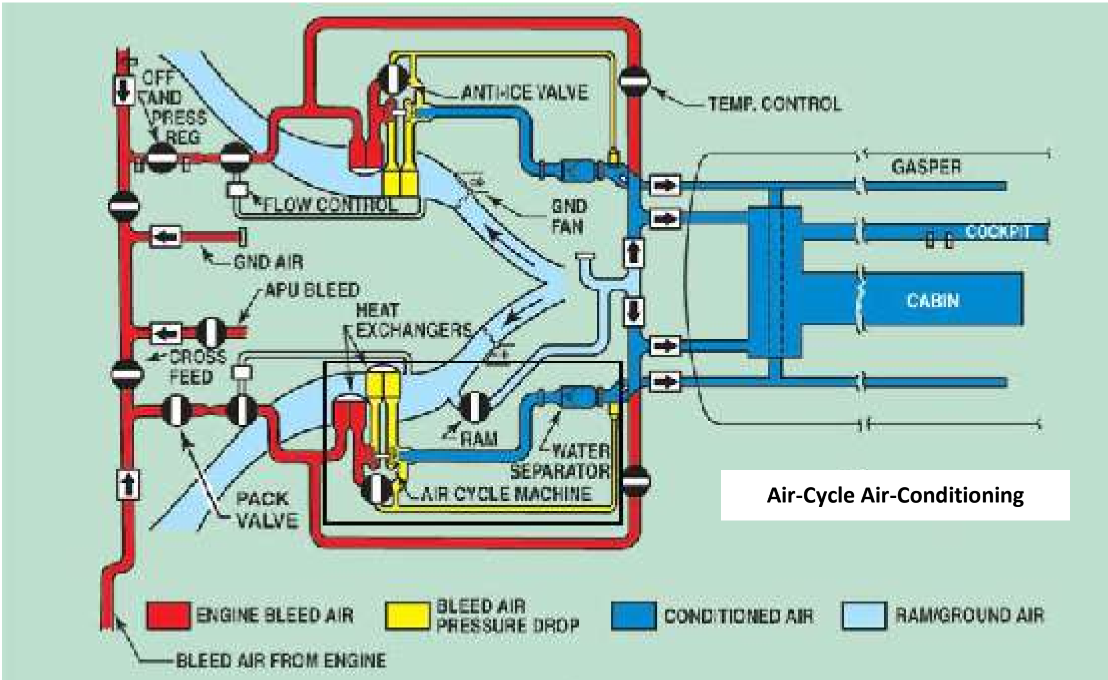
The whole process for cooling air from the engine intake

7.4- Types of Air-conditioning System

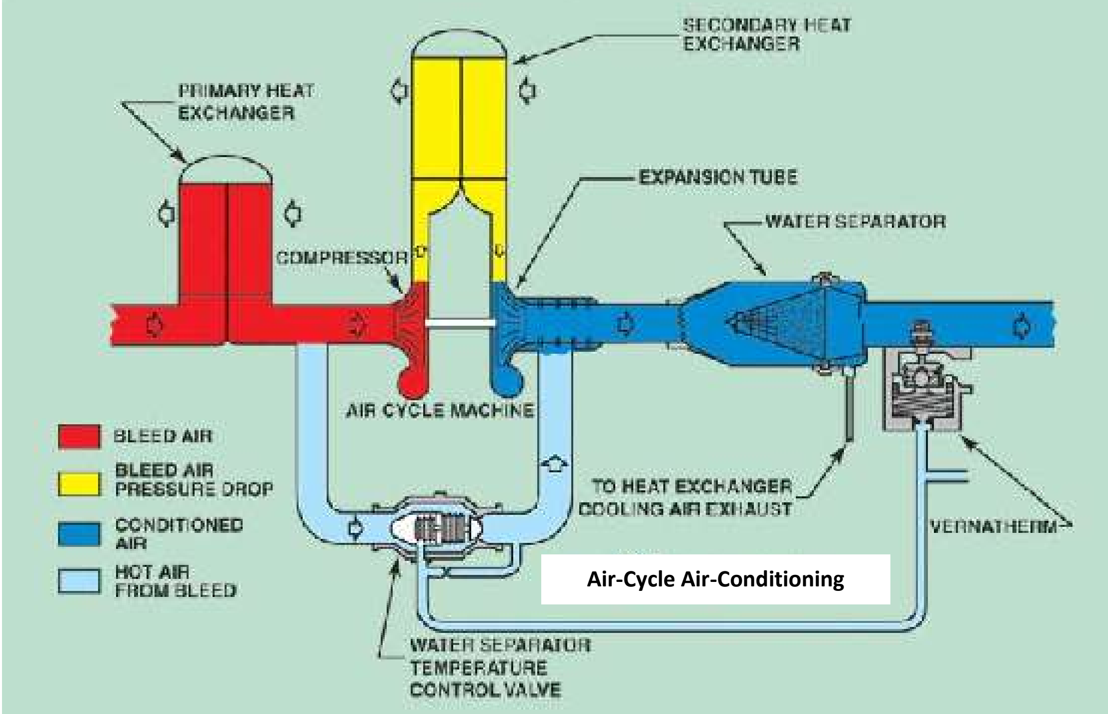
1. Vapor-cycle Air conditioning.

2.Air-cycle Air conditioning.

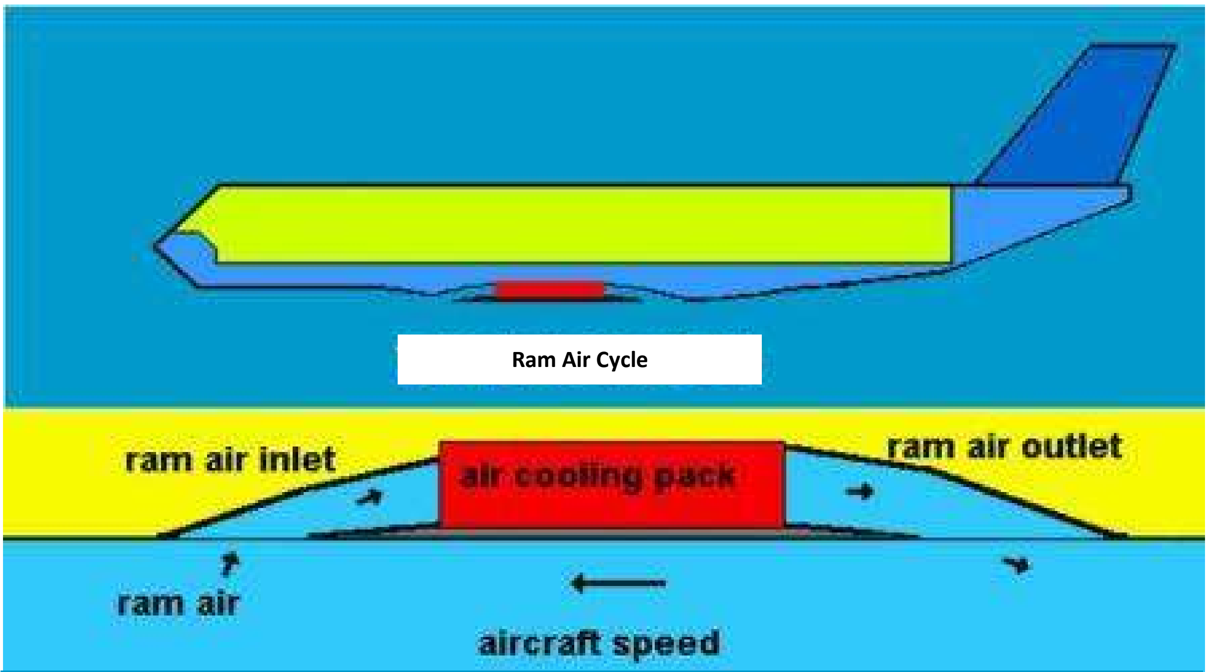




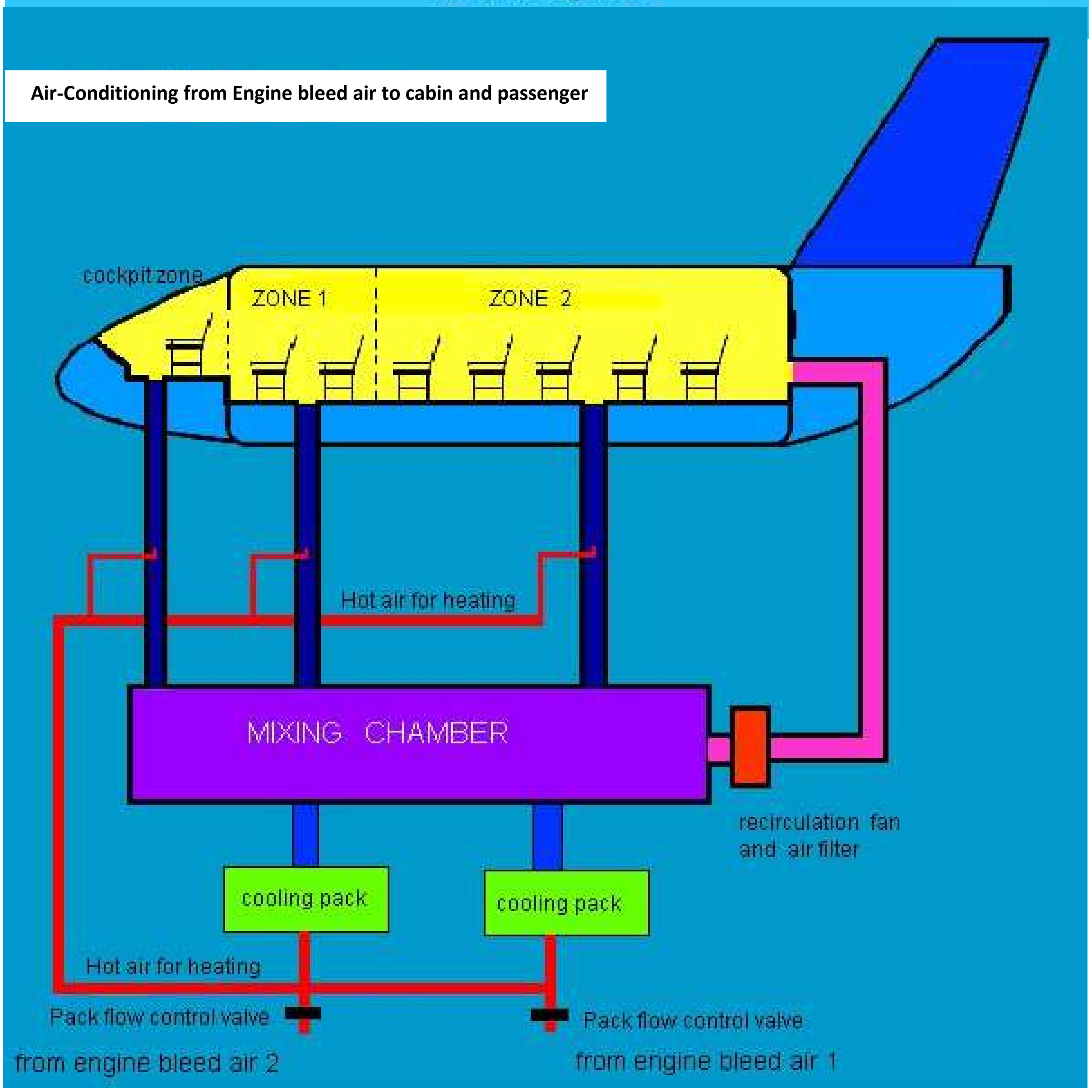
Air-Cycle Air-Conditioning



Air-Cycle Air-Conditioning



Ram Air Cycle



Air-Conditioning from Engine bleed air to cabin and passenger

7.5- Maintenance of Air-conditioning System

1. The maintenance operations must be occurs precisely due to system logo book periodically.
2. Check the fitness of the whole airplane and cabin and the system to be assure there is no leakage in it.
3. Check the air supplied to the passenger and cabin conforming the specification quality and environment.
4. Checkup the system before every flight.
5. Check the air filters and Ventilation Vent periodically.
6. Checking up if there is smell in the air delivered.

Chapter Eight

Aircraft Movement Controlling Systems

8.1- Aircraft Basic Movement conditions:

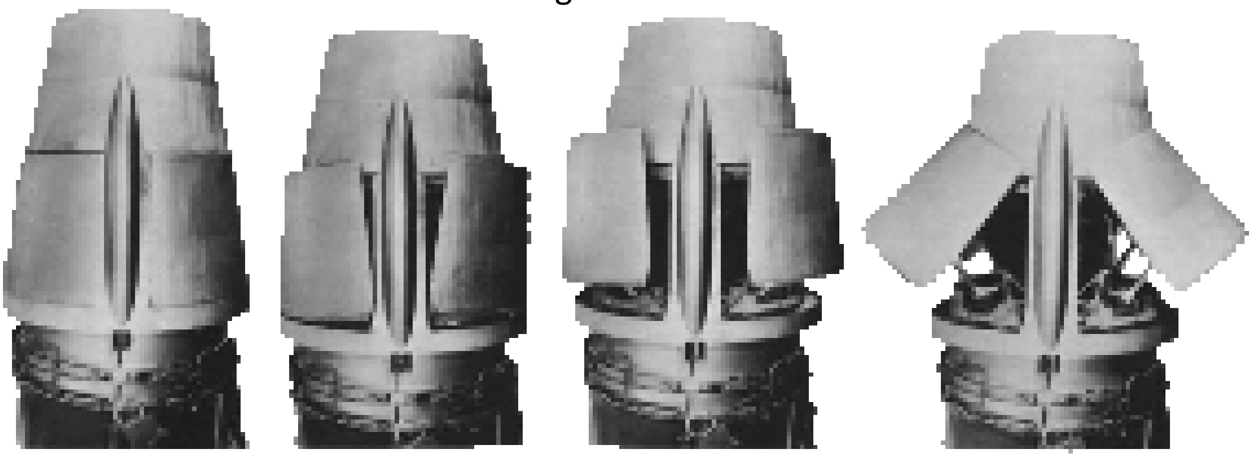
1.Pitching condition
  a. Pitching up.
  b. Pitching down.
2. Yawing condition
  a. Yawing left.
  b. Yawing right.
3. Rolling condition
  a. Rolling left.
  b. Rolling right.

8.2- Types of Flight Control Mechanism:

1. Wing flight control mechanism.
2. Tel unit flight control mechanism.
3. Engine Revers thrust control mechanism.
4. Special flight control mechanism for special aircraft.

Wing flight control mechanism.

Tel unit flight control mechanism



Engine Revers thrust control mechanism

Special flight control mechanism for special aircraft

8.3- Flight Conditions Controlling Methods:

1. The Electro-mechanical methods.
2. The Hydro-mechanical methods.
3. The Manual-mechanical methods.
4. The combined method (Automatic flight control).

8.3.1- The electro-Mechanical methods:

This methods depends upon the conjunction between electrical circuit and mechanical machine and its advantages are:

1. Most popular used in modern aircraft for flight control movements.
2. Gives the pilot the sense of movement by his hand movements.
3. The design is simple not complicated and easy to maintain.

While the disadvantages are:

1. Consume large power.
2. Lot of brake down cases.
3. Before and After flight tests.

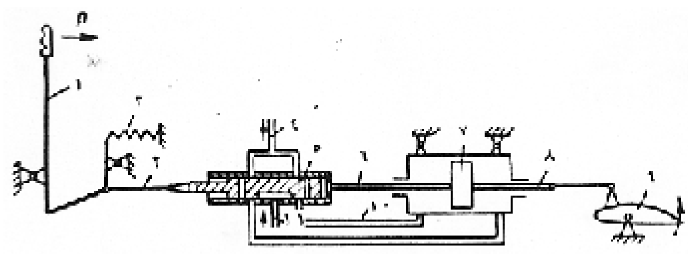
8.3.2- The Hydro-Mechanical methods:

This methods depends on converting the hydraulic pressure in the hydraulic equipment into mechanical movement and its advantages are:

1. Used a lot in modern aircraft for flight control movements.
2. Movement transmitted smoothly and perfectly almost insensible movements.
3. Ability of moving very large parts in the aircraft.

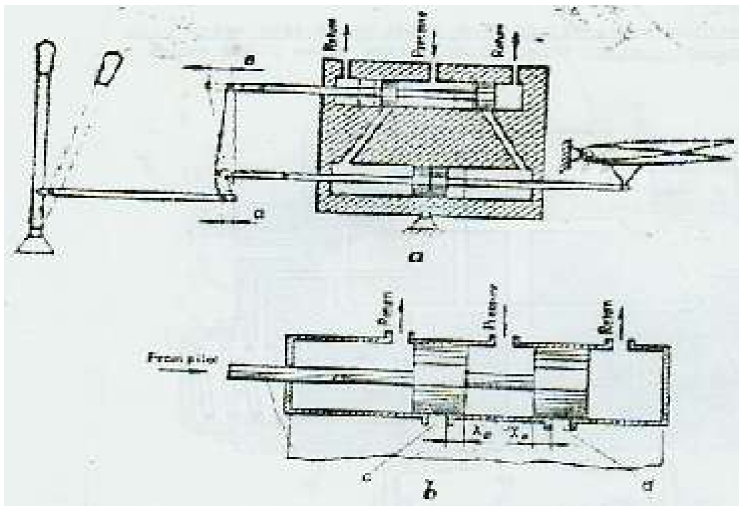
While the disadvantages are:

1. The design is complicated and hard to maintain.
2. Heavy weight.
3. Consume large power.
4. Needs a large space in the aircraft.
5. The maintenance are complicated and expensive.



شكل (٩) رسم تخطيطي لبيان سير الحركة في دورة التحكم في سطح الاتزان الأفقي بواسطة البوستر

١ ـ عصا القيادة ، ٢ ـ شداد ، ٣ ـ جهاز التحميل ، ٤ ـ ماسورة الطريق ، ٥ ـ محبس ، (٦ ، ٨) ـ قائم البوستر ، ٧ ـ مكبس البوستر ، ٩ ـ سطح الاتزان الأفقي ، ١٠ ـ ماسورة ، ١١ ـ ماسورة اعطاء الزيت



8.3.3- The Manual-Mechanical methods:

In this methods the movement were transmit by pilot hands through cables, chains and machines the advantages are:

1. Used a lot in sportcanvas aircraft to control flight movements.
2. Might use as emergency system at emergency conditions.
3. Very simple design light weight easy to maintain .

While the disadvantages are:

1. Needs high skills and consume a lot of human power.
2. Percentage of error very high.

8.3.4- The Combined methods(Automatic Control Flight):

This methods also conjunct between electrical circuit, mechanical machine and Hydraulic equipment's to control the movement of the aircraft, its advantages are:

1. Must be Exist in every modern aircraft.
2. Un-sensible automatic handless movements.
3. Gives the pilot the ability and time to solve another problems if there were any.

While the disadvantages are:

1. Effected by flight vibration.
2. Complicated design an edible to repair if break down.
3. Effected by the Electro-magnetic disturbance.

8.4- Aircraft Movement Controlling Systems Maintenance

1. The maintenance operations must be occurs precisely due to system logo book periodically.
2. Never Try to handle or fixing the system during the flight.
3. Assurance of fixing the system after every check-up to reduce the vibration as much us possible.
4. Checkup the system before every flight.

Chapter Nine

Aircraft ElectricalAnd Communication Systems

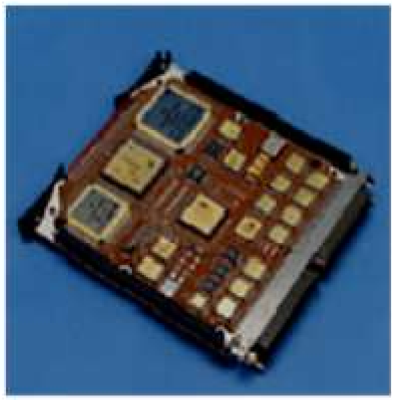
9.1- Components of Aircraft Electrical Systems:

1. Electrical boards and electronics equipment's.
2. Communication equipment's.
3. Guiding and Radars equipment's.
4. Airplanes Light equipment's.
5. Flight measurements and equipment's.

9.1.1- Electrical boards and electronics equipment's:

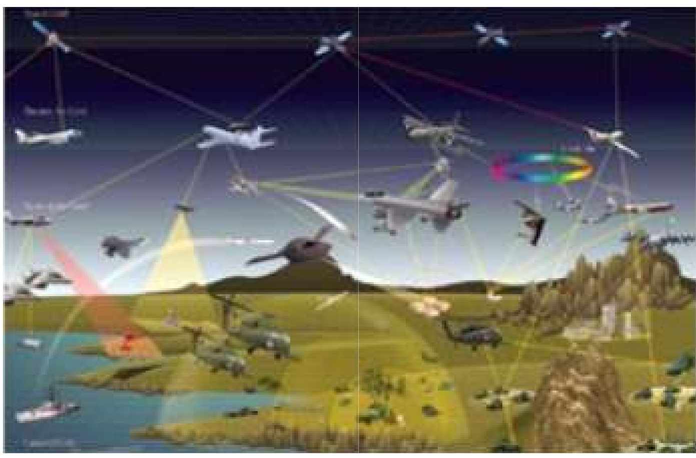
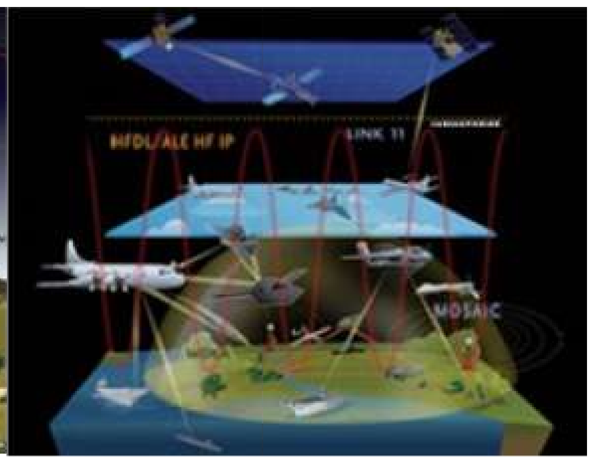
In each modern aircrafts there are many of electrical boards and electronics equipment's each board controls specific job in aircraft, these boards are fixed tightly well isolated in aircraft structure so that no one try to fixed it.



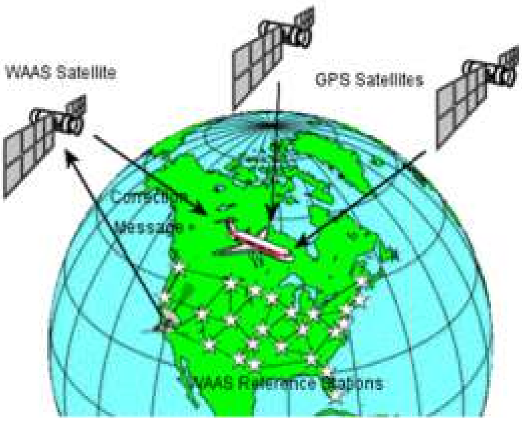


9.1.2- Communication equipment's:

The communication equipment's in aircraft is very important because it supplies the aircraft exact conditions between the pilots and airports control giddiness.

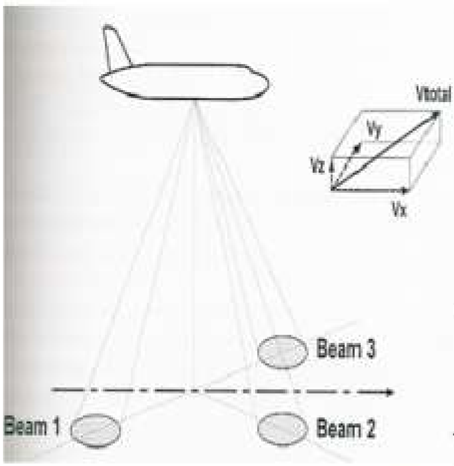
Now the modern aircrafts usually used GPS and Satellites for communicating the figures up and below shows how were this system works.

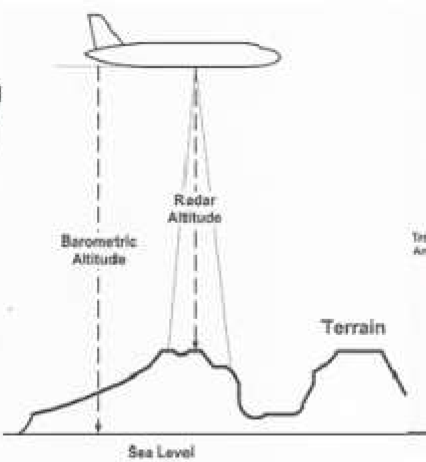


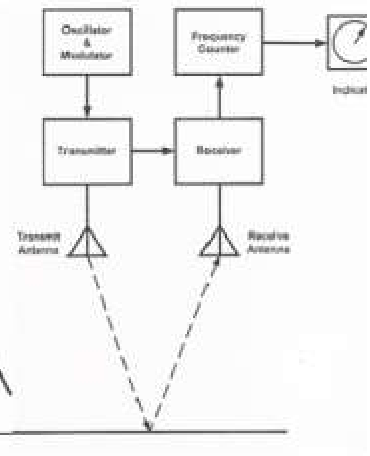
9.1.3- Guiding and Radars equipment's:

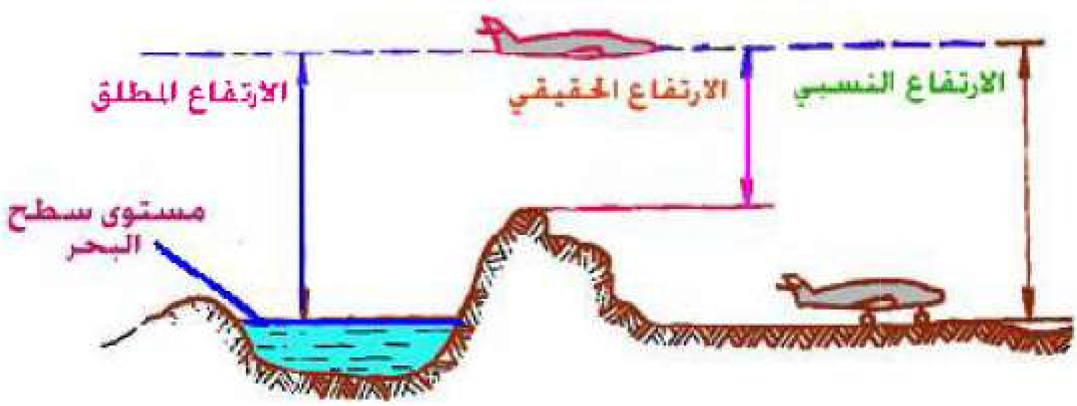
There are different types of aircraft Guiding and Radars in modern aircrafts such as:

1. **Altitude Radars:** In each airplane at every flight point there are three altitudes:
   - **a.** True altitude.
   - **b.** Relative altitude.
   - **c.** Absolute or Barometric (Sea-level) altitude.





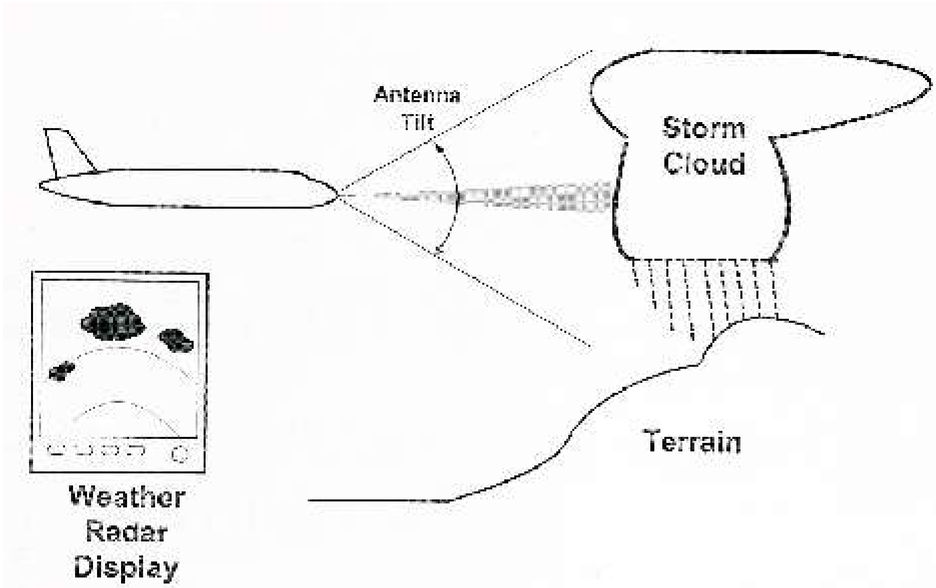




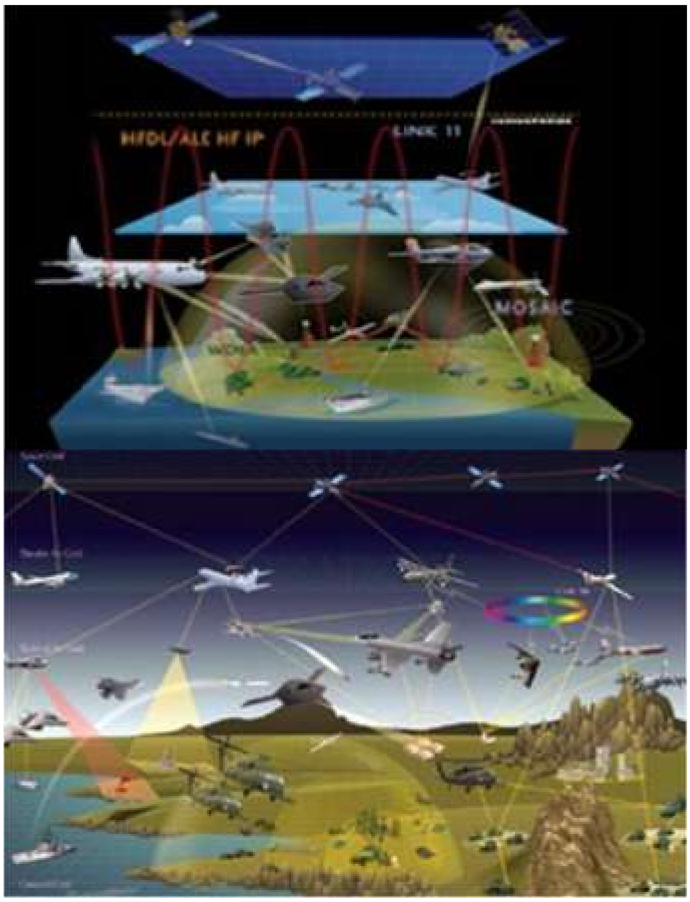
2. **Flight Guiding Radars:** One of the most important radars in modern aircraft actually no airplane in these days flight without flight guiding radars. It used the GPS maps and satellites communications.

3. **Localizer and Positioner Radars:** Theses radars shows the exact international position and conditions of the airplanes during any flight

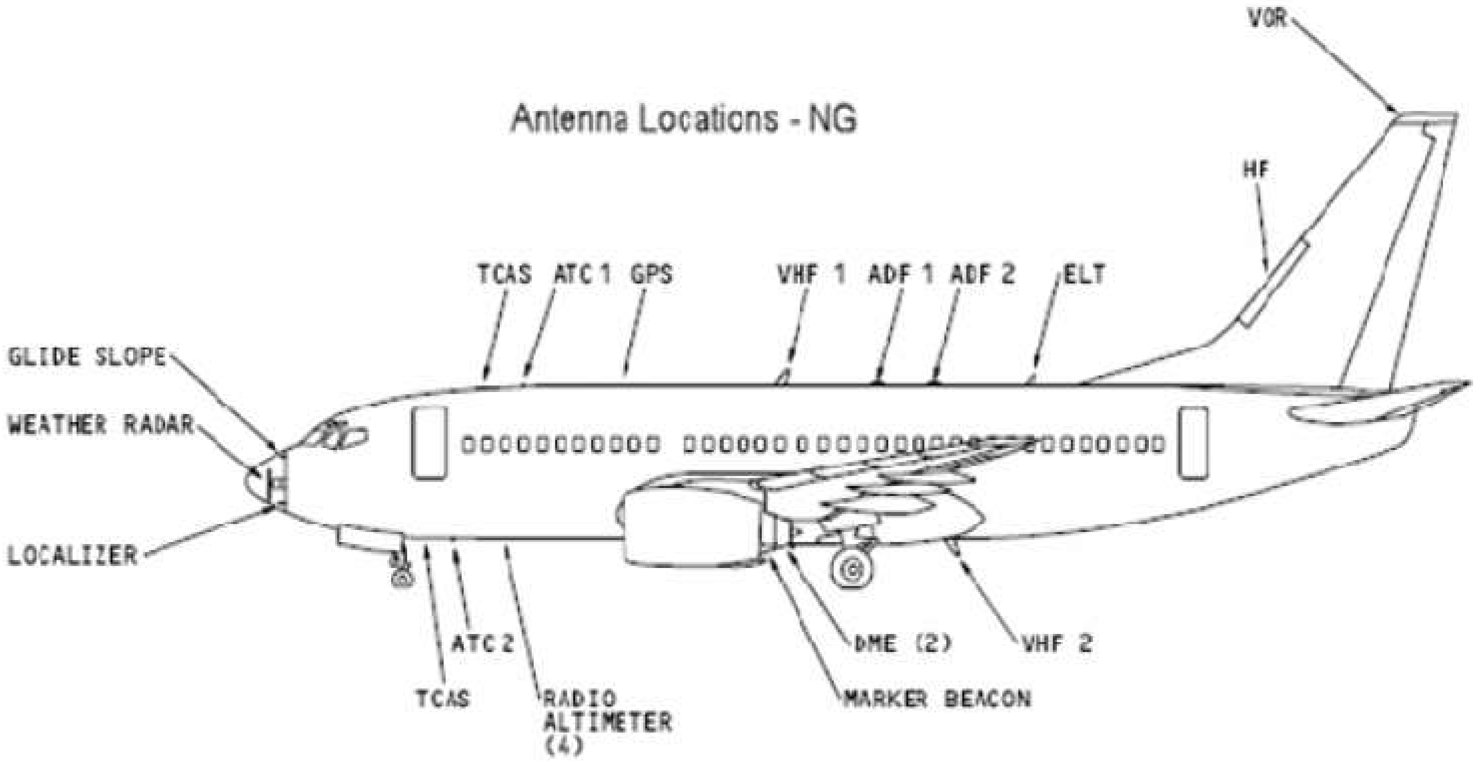
4. **Weather Radars:** This radar shows the environmental and weather conditions during the flight at each second.

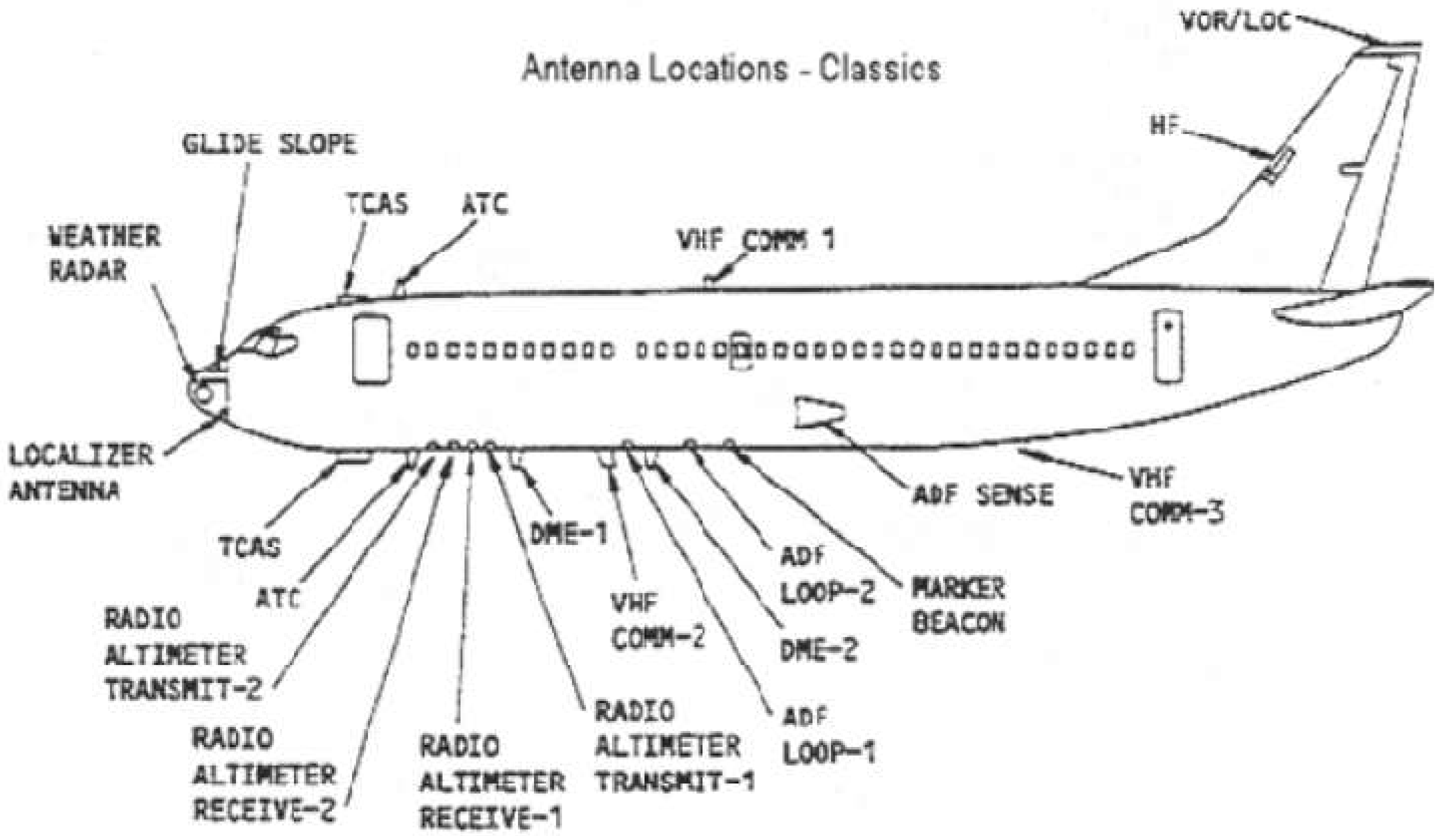


5. **Distinguishing Radars:** The purpose of this radar is to distinguish any flight body near the airplane to eliminate the probability of air impacts.



6. **Communications radars:** The airplanes communicate between each other's airplanes and the airports guiding control tower.

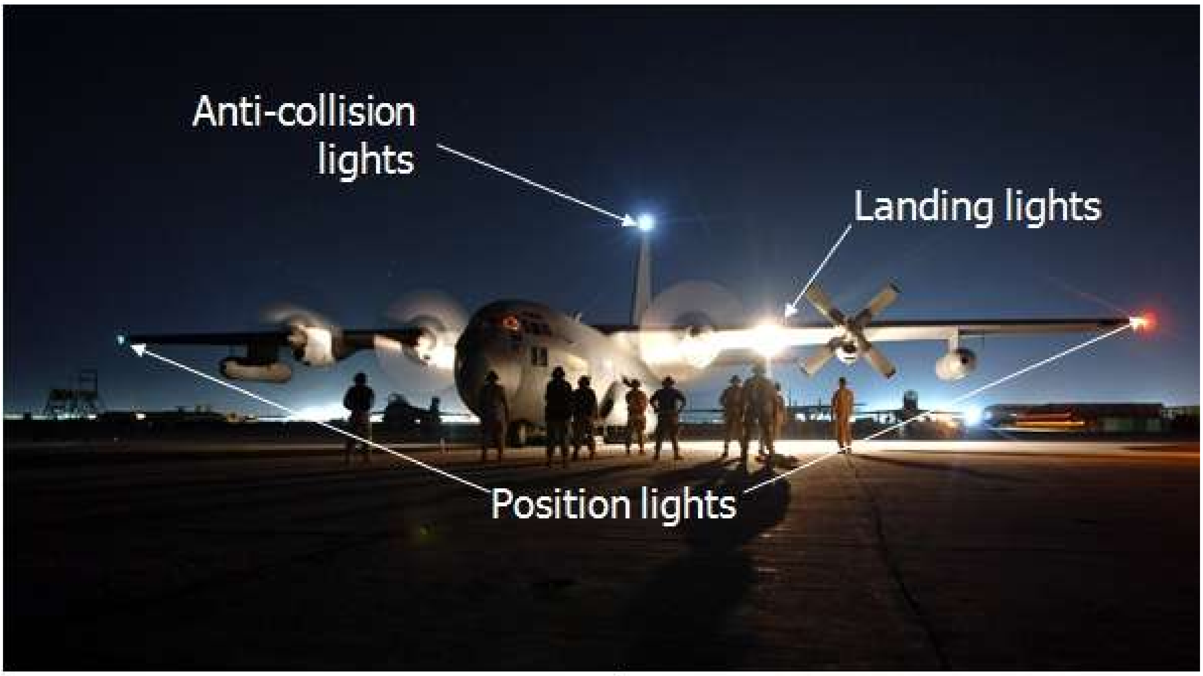

Antenna Locations - NG
VOR
HF
TCAS
ATC 1
GPS
VHF 1
ADF 1
ADF 2
ELT
GLIDE SLOPE
WEATHER RADAR
LOCALIZER
ATC 2
TCAS
RADIO ALTIMETER (4)
DME (2)
VHF 2
MARKER BEACON


Antenna Locations - Classics
VOR/LOC
HF
GLIDE SLOPE
TCAS
ATC
WEATHER RADAR
VHF COMM 1
LOCALIZER ANTENNA
ADF SENSE
VHF COMM-3
TCAS
DME-1
ATC
ADF LOOP-2
MARKER BEACON
RADIO ALTIMETER TRANSMIT-2
VHF COMM-2
DME-2
RADIO ALTIMETER TRANSMIT-1
ADF LOOP-1
RADIO ALTIMETER RECEIVE-2
RADIO ALTIMETER RECEIVE-1

9.1.4- Airplanes Light equipment's:

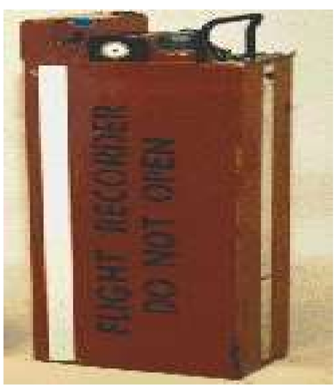
In each airplane there are three types of lightening Internal ,External and Emergency lightening.

1. **Internal light:** this include the crew light cabin light and equipment's light.
2. **External Light:** this types of lightening includes:
   a. Landing Lights: Powerful White or Yellow lights at the wings and/or on the airplane nose.
   b. Positions Lights: Red light at the left wing Green at the right and White at the tell.
   c. Indicating Lights: Rotating powerful red and/or yellow lights at the top and bottom of the airplane.
3. **Emergency Light:** In the emergency conditions a low power red light consume very little power were used.



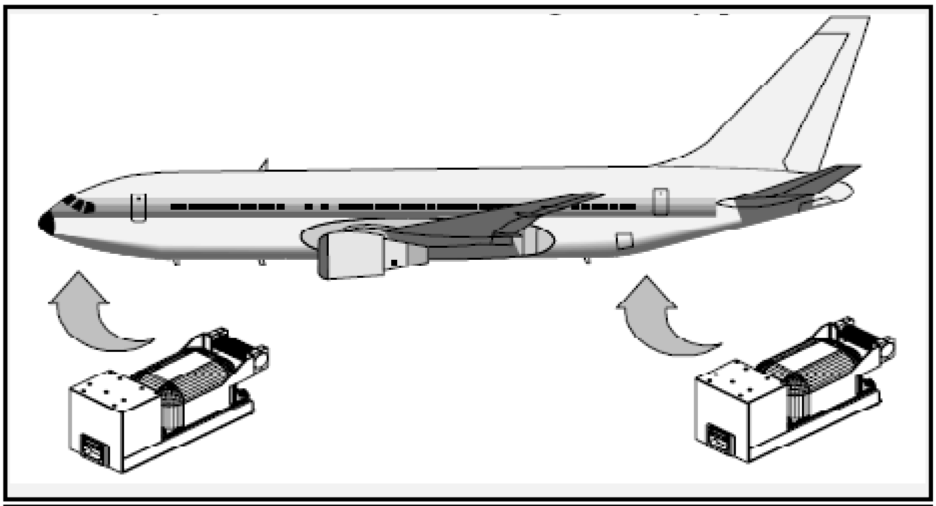


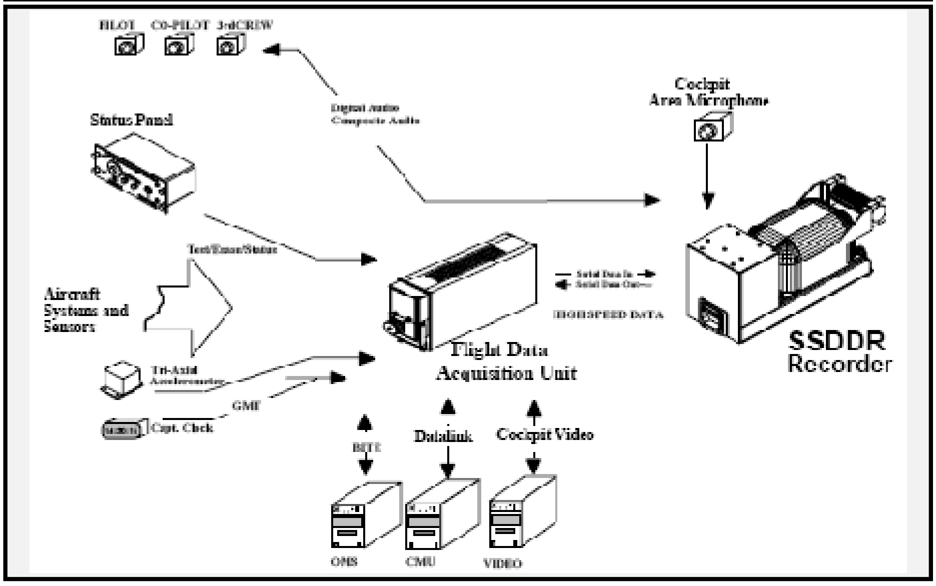

9.1.5- Flight Measurements equipment's: Each modern airplanes contains many flight measurements equipment's these equipment's were used for different uses to help pilots during any flight. One of the most important flight measuring equipment are the both Flight Recorder (Black Box).

9.2- The Flight Recorders:

In each modern airplane there are two flight recorders, the cabin voice recorder and the whole flight conditions recorder. Each box record the pilots behaviors and decisions during the whole flight for different conditions. Their positions in the airplane were in the most squire places and tights places one on the airplane nose the other at the end of the airplane.





9.3- Aircraft ElectricalAnd Communication SystemsMaintenance:

1. The maintenance operations must be occurs precisely due to system logo book periodically.
2. Never Try to handle or fixing the system during the flight.
3. Assurance of fixing the system after every check-up to reduce the vibration as much as possible.
4. Checkup the system before every flight.

Chapter Ten

Aircraft De - Icing Systems

10.1- Need For De-Icing Systems And Requirements To Be Met - By Them:

1. Ice formation on the wing and tail unit exerts a considerable effect on flight performance, stability and controllability of the aircraft. Ice formation distorts the shape and results in irregularities on the leading portion of the profile Fig. 10.1 the entire profile of the wing causes turbulence of the steam which considerably increases friction coefficient of the wing and tail unit and decreases C_L and critical angle-of attack α_{cr} Owing to local stalls. This is especially manifested at formation of trough shaped ice.

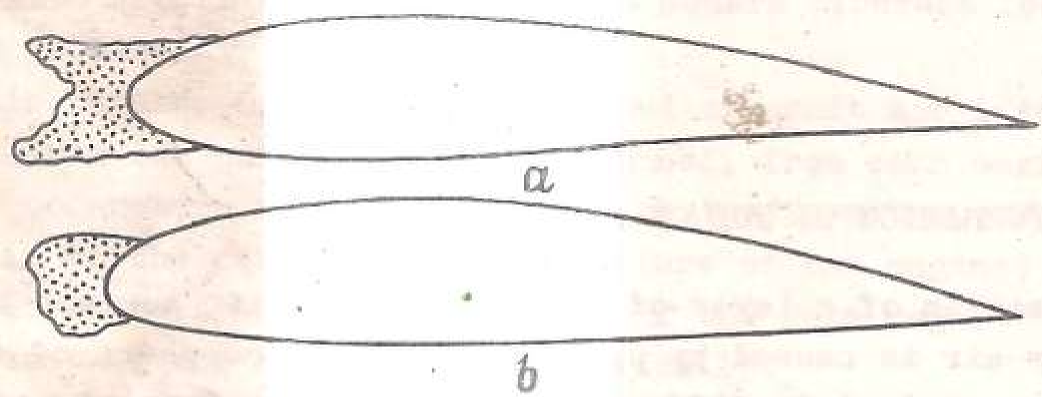


FIG. 28.1. TYPES OF ICE FORMATION
a – trough-shaped ice; b – wedge-shaped ice

2. Ice formation on the inlet devices of the engine (propeller blades) decreases the available thrust. This decreases the maximum speed of flight (V_{max}) the vertical rate of climb (V_y) and the ceiling of the - aircraft, the duration and range of flight.
3. Decrease of critical angles of attack of the wing and tail unit at ice formation is extremely dangerous at low speeds of flight and especially at landing. Stalling disturbs normal operation of the surface controls and ailerons. Their hinge moments, and hence, control sensitivity are decreased drastically. This may bring the aircraft to dangerous angles of attack, roll and yaw. Besides, decreased efficiency of the control surfaces may cause complete loss of controllability.
4. Ice formation on glasses obstructs vision of the pilot.

5. Ice formation on pickup devices of the airspeed, altitude, angle of attack indicators may lead to their failure and unintentional entry into dangerous conditions of flight.

10.2- De – Icing System Positions in the Aircraft:

To prevent in-flight ice formation, the aircraft are provided with special de-icing systems which are installed in places which are most subject to icing:

1. In leading edges of the wing and tail unit.
2. In leading edges of engine intakes.
3. In windshields of cabins؛
4. In pitot-tubes, etc.

10.3- De – Icing System Specific Requirements:

The de-icing systems of the aircraft should meet a number of specific requirements:

1. The system should have an ice warning detector؛
2. Prevent ice formation or eliminate it under all flight conditions and any weather.
3. Ensure sufficient multiplicity of use.
4. Preclude damage to and destruction of the equipment andelements of the construction during operation of the deicers.

10.4- Methods of Fighting De–Icing Formation:

Known at present are the following methods of fighting ice formation are:

1. Mechanical.
2. Physical.
3. Chemical.
4. Thermal.
5. Combinations of the above.

10.4.1- Mechanical De – Icing:

Mechanical methods of fighting ice formation are based only on removal of ice with the aid of some mechanical action (deformation or vibration of surfaces, aerodynamic, centrifugal or other external forces).

The pneumatic ice removers were widely used on the wing and tail unit of the low-speed aircraft in 1935-1960.

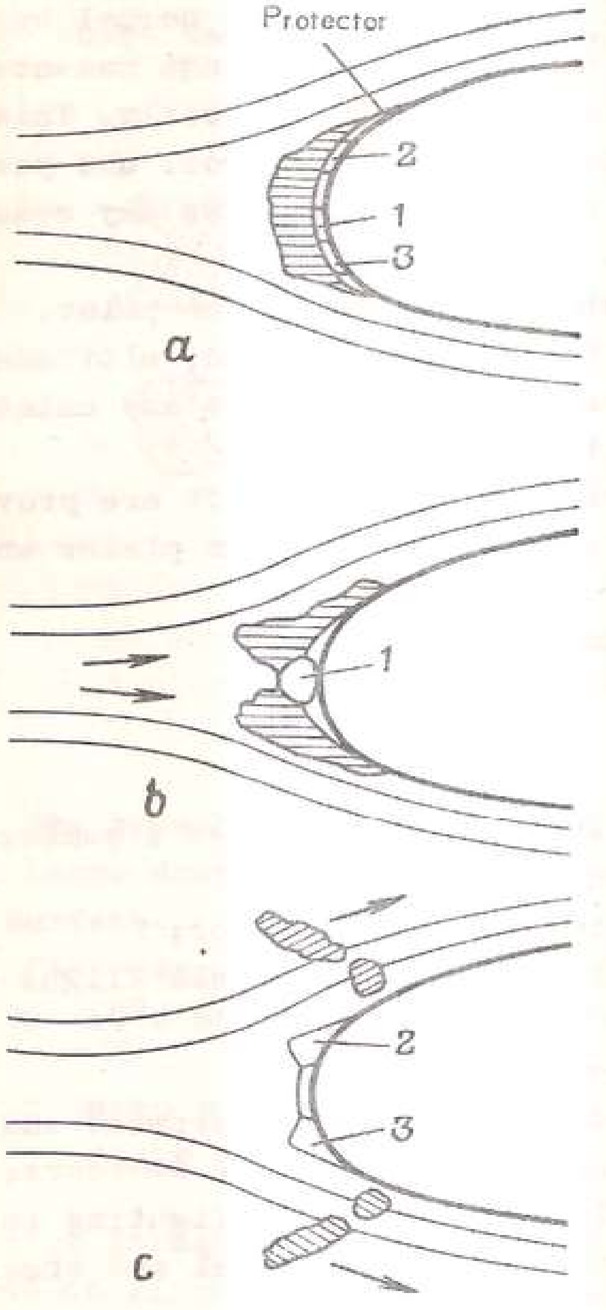


FIG. 28.2. PNEUMATIC DE-ICER
a – protector is not cut in; b – air is fed to central chamber 1; c – air is fed to chambers 2 and 3

A thin rubber protector (Fig. 10.2) having a number of elastic longitudinal or lateral chambers is applied to the wing (tail unit) leading edge surface to be protected. When the deicer is cut in, the chambers are periodically inflated by the compressed air (Fig. 10.2, b and c) and crush ice formed on them.The oncoming air stream throws ice away from the aircraft sur-face. Such systems require the low energy consumption (air flow rate of 0.4 kgf/min) and have a small specific gravity.The radical disadvantage of this system is deterioration of aerodynamic quality of the wing and tail unit caused by a change of the shape of the profile leading edge at inflation of the protector. Besides, there is danger of puncturing the protector in the course of service.

The pneumatic deicersmay be used for radio transparent readmes where it is impossible or difficult to use the thermal methods while the physical and chemical methods are not efficient.At present constructions of vibration deicers are under development. Such deicers periodically shake separate sections of the wing by high-frequency vibrators, thus destroying ice crust.

10.4.2- Physical and Chemical De – Icing:

The physical and chemical methods of fighting ice formation are based on two principles:

a.Decrease of adhesion of ice to the aircraft surface؛

b.Decrease of the water freezing temperature by providing an intermediate layer of the non-freezing solution.

When the first principle is used, a coating which does not adhere to ice is applied to the aircraft surface. Such a coatingdoes not require the energy in flight. However, the coating substance is intensively used in the course of ice formation and besides, it is destroyed by rain. Therefore, such a method may be used on the short-time or single-use aircraft where other methods are not expedient.The liquid deicers (Fig. 10.3) using the second principle of chemical and physical fighting ice formation are widely used at present.
Non-freezing liquid (glycol composition, ethyl or isopropyl alcohol, alcohol-glycerin mixtures, etc.) are fed to sprayers 1 of blades of the propellers or to the windshields of the canopy. Liquid is stored in special tanks 4 from which it is fed to the pipelines of the system through filter 2 by booster pump 3 or by pressurization. Liquid flowing from the sprayers is spread over the surface under the action of the centrifugal forces.

The disadvantages of such systems are:

a. Non-uniform wetting of the protected surface.

b. Considerable consumption of liquid.

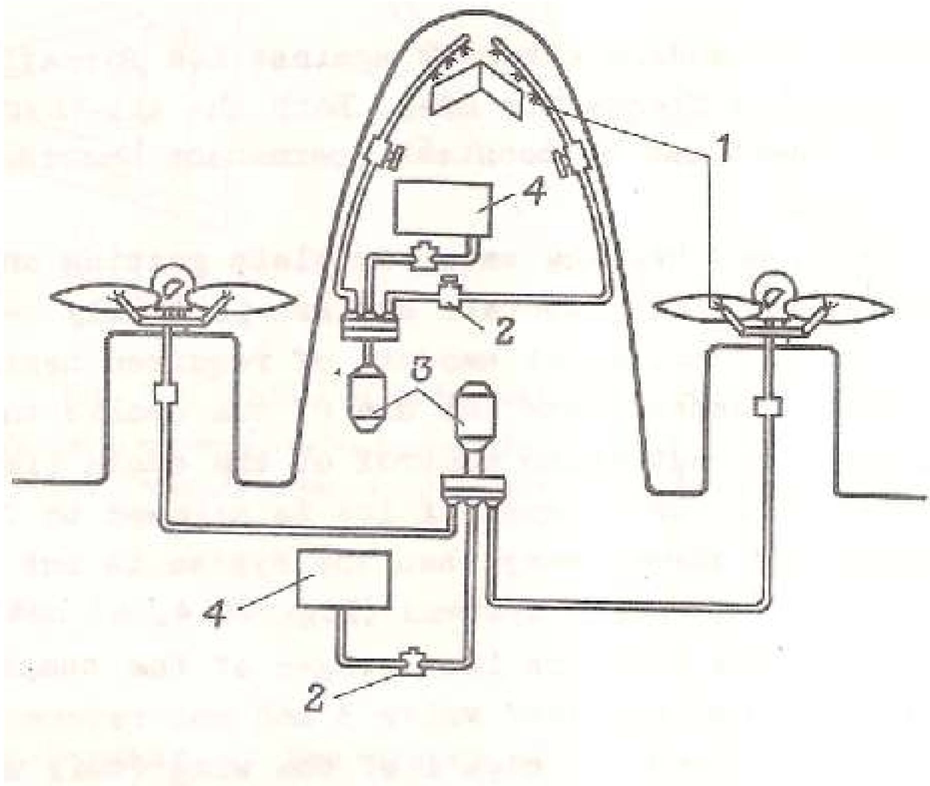


FIG. 28.3. LIQUID DE-ICER SCHEMATIC DIAGRAM
1 – sprayers; 2 – filter; 3 – booster pump; 4 – tanks with liquid

Some modern aircraft use the liquid deicers on the wing and tailunit. Liquid is fed through a porous surface of the leading edges (porous bronze or stainless steel). This decreases consumption of liquid (1.5-2.5 lit/m^2per hour).The liquid systems are more efficient as means for preventing ice formation, rather than removing ice crust. If the system is engaged after formation of ice, considerable time is needed for de-icing. Besides, the liquid systems require great amounts of liquid for the period of flight. The pipelines, sprayers and especially porous skin may be clogged.

10.4.3- Thermal De – Icing:

To protect the modern aircraft against ice formation, the thermal deicers are frequently used. Both the air-thermal and electro-thermal deicers can be constant (permanent heating of surface) and cyclic action.

During permanent heating water droplets getting on the heated surface spread over it, evaporate and are partially removed by the air stream. However, great amounts of required heat (hot air or electric power) necessitate the use of the cyclic thermal deicers with manual or automatic control of the cycle time. During cyclic heating a thin safe layer of ice is allowed to form which is melted and thrown away when the system is cut in.

In the hot-air de-icing systems (Fig. 10.4, a) hot air (100 – 250 ^oC)is bled from the last stages of the compressor and is fed through shut-off valve 3 and non-return valve 4 along pipelines 2 to leading edge 1 of the wing (tail unit). Non-return valve 4 prevents leakage of hot air towards the engine in case of its failure. Air circulates in the wing leading edge (Fig. 10.4, b) through channels defined by corrugations (special guide partitions). The circulation patterns vary and are so selected as to ensure maximum supply of heat to the leading part of the wing skin. Cooled air is released through slits 5 in the wing tips to the atmosphere.

The disadvantages of the hot-air de-icing systems are as follows:

a. Difficulty of supplying the energy (hot air) to the surfaceto be protected (special pipelines and volumes inside the aircraft are needed).
b. Decrease of the available engine power owing to bleeding of air from the compressors,and this may impede engagement of the system at takeoff-time-lagging of the system which starts operating witha delay required for heating the wing (stabilizer) leading edges.

It is more convenient to supply the energy to the heating place by using the electro-thermal deicers. During operation they rely upon heating of conductors when the electric current is passed through them. A typical electro-thermal deiceris a multi-layer structure. Two electric insulation glass cloth sheets are placed between two thin sheets of the skin; heaters are placed between the glass fabric sheets. The external glass cloth layer

should have good thermal conductivity and the internal one should be thermal and electro insulated.The constant heating elements are made as chromo nickel steel bands, 0.3 mm thick. The cyclic heating elements are made in the form of wire constantan screens or in the form of a conductinglayer of metal sprayed over the surface (copper, manganese and magnesium alloy).The electro-thermal de-icers are widely used for heating the tail unit or wing when the engines are arranged far from them,as well as for heating the blades and cones of propellers, pitot tubes, different air intakes and windshields of the cabins. Electric heating of glasses is effected with the aid of film heating elements built in the glass throughout its area. The film electric heater is a transparent current conducting film (gold, dismuth, oxide-tin, etc.) arranged between two silica glases and applied by spraying.
The glass temperature is controlled automatically.
In addition to convenient supply of the energy, the electro-thermal de-icers provide for easy automation of heat control. and this dictates their wide application though reliability of such de-icers is somewhat lower than that of the air-thermal ones.

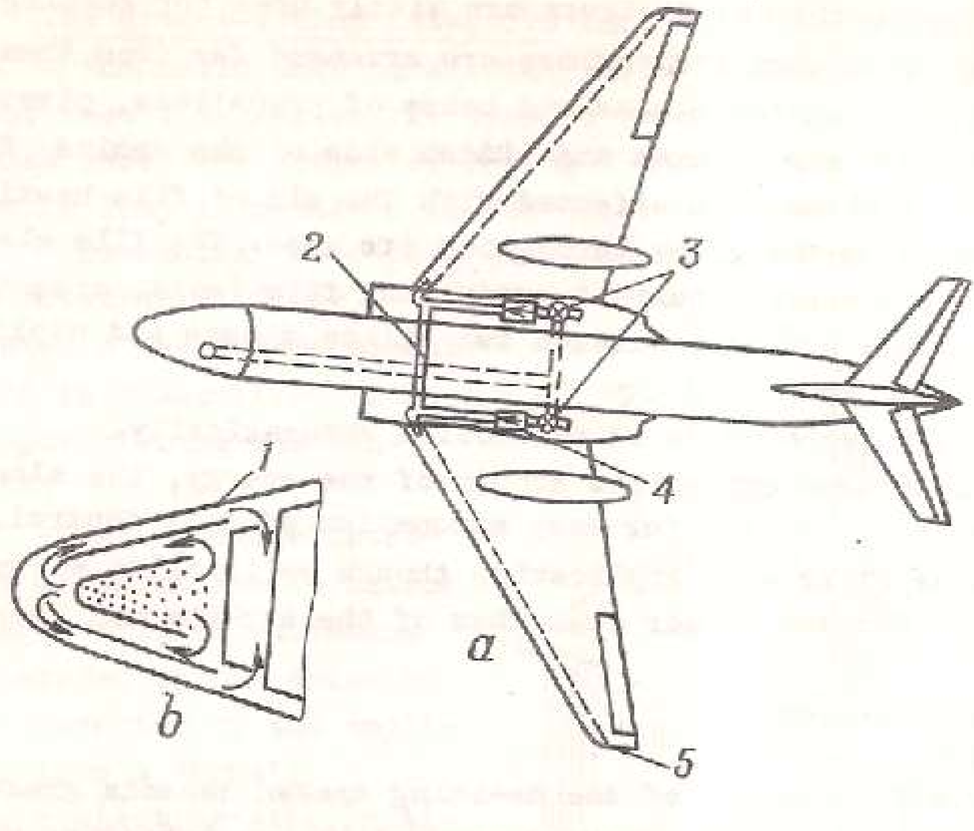


FIG. 28.4. SCHEMATIC DIAGRAM OF AIR-THERMAL DE-ICER
a – hot-air de-iceing system; b – wing leading edge; 1 – leading edge skin; 2 – pipelines; 3 – shut-off valves; 4 – non-return valves; 5 – air release slit

10.5- IceDetectors:

Efficient operation of the de-icing system depends greatlyon its well-timed cut-ins which is ensured by ice detectors which warns the pilot of the beginning of ice formation or automatically cuts in the system for operation.There are a lot of types and constructions of the ice detectors. **They may be conventionally divided into two main groups:**

a. Direct-action detectors which respond to presence of ice on them.

b.Indirect-action detectors which respond to presence of water droplets in the atmosphere.

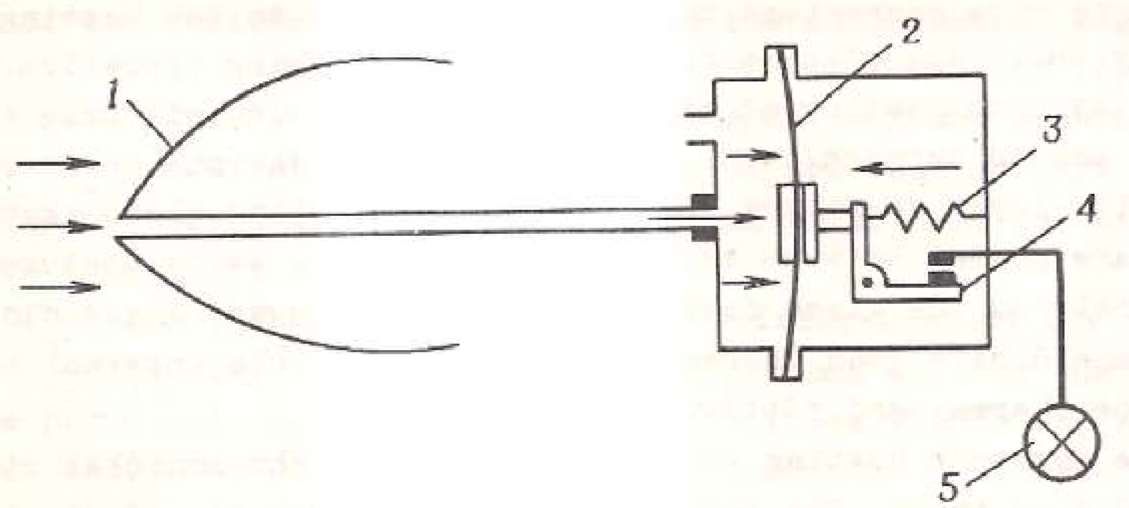


FIG. 28.5. PNEUMATIC ICE DETECTOR

1 – pitot tube; 2 – diaphragm; 3 – spring; 4 – contacts; 5 – warning lamp

The direct-action detectors include:

- pneumatic detectors (Fig. 10.5) in which ice formation on pitot tube 1 decreases the dynamic pressure and diaphragm 2 is bended under the action of spring J and closes contacts 4, and then warning lamp illuminates in the pilot's cabin.
- mechanical detectors (Fig. 10.6)in which ice formation onthe rotating cylinder creates a resistance moment which is transmitted to a scraper closing the contacts.
- radioisotope detectors in which ice formation changes flux of radiation registered by the detector and converted by the amplifier into a signal.
- electrostatic, optical, etc.

The main shortcoming of the direct-action detectors is that they supply a signal after ice formation has begun.

The indirect-action detectors include:

- electric inductiondetectors which respond to change of electric conductivity of the atmosphere in the presence of water and ice.
- thermal detectors which respond to the difference between the temperatures of the wetted front surface (in the atmosphere with overcooled water) and dry rear surface of the detector.
- radar detectors which respond to presence of droplets of water (ice) in clouds in front of the aircraft.

The sensitivity of such detectors is considerably higher and they supply signals simultaneously with the beginning of ice formation; when combined with the thermometers, they can provide accurate and well-timed indication of beginning of ice formationon the aircraft.

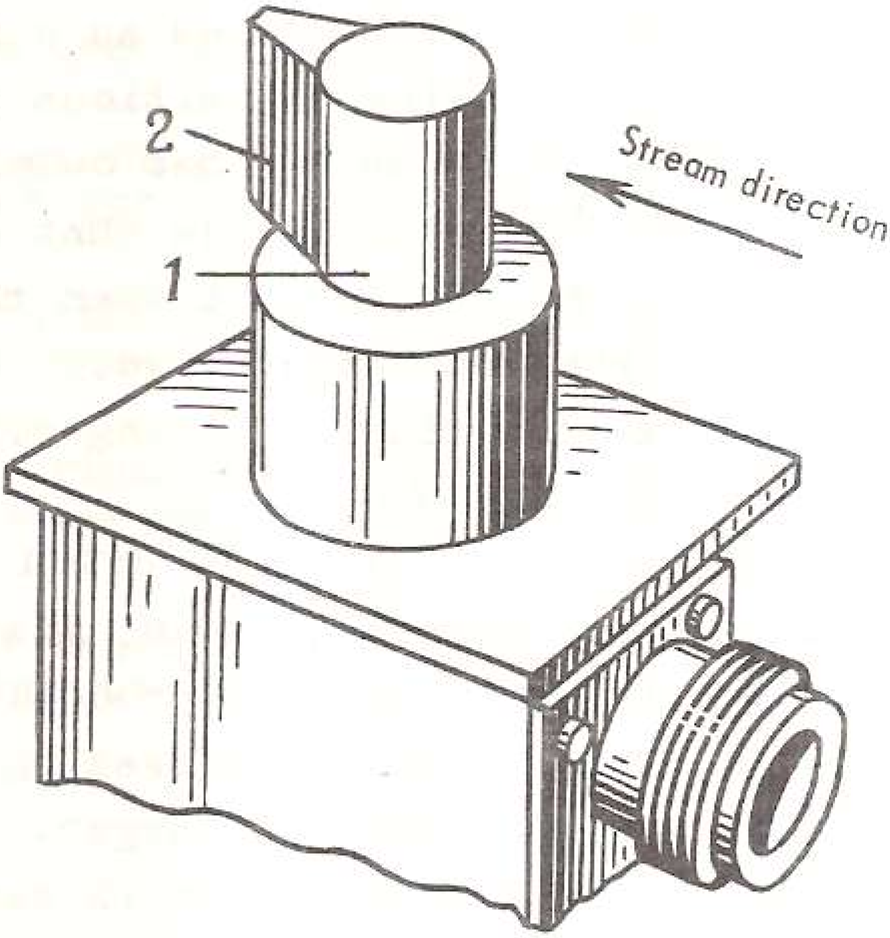
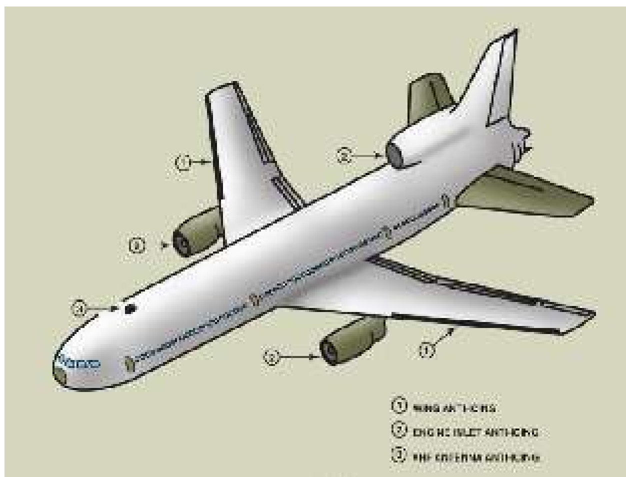
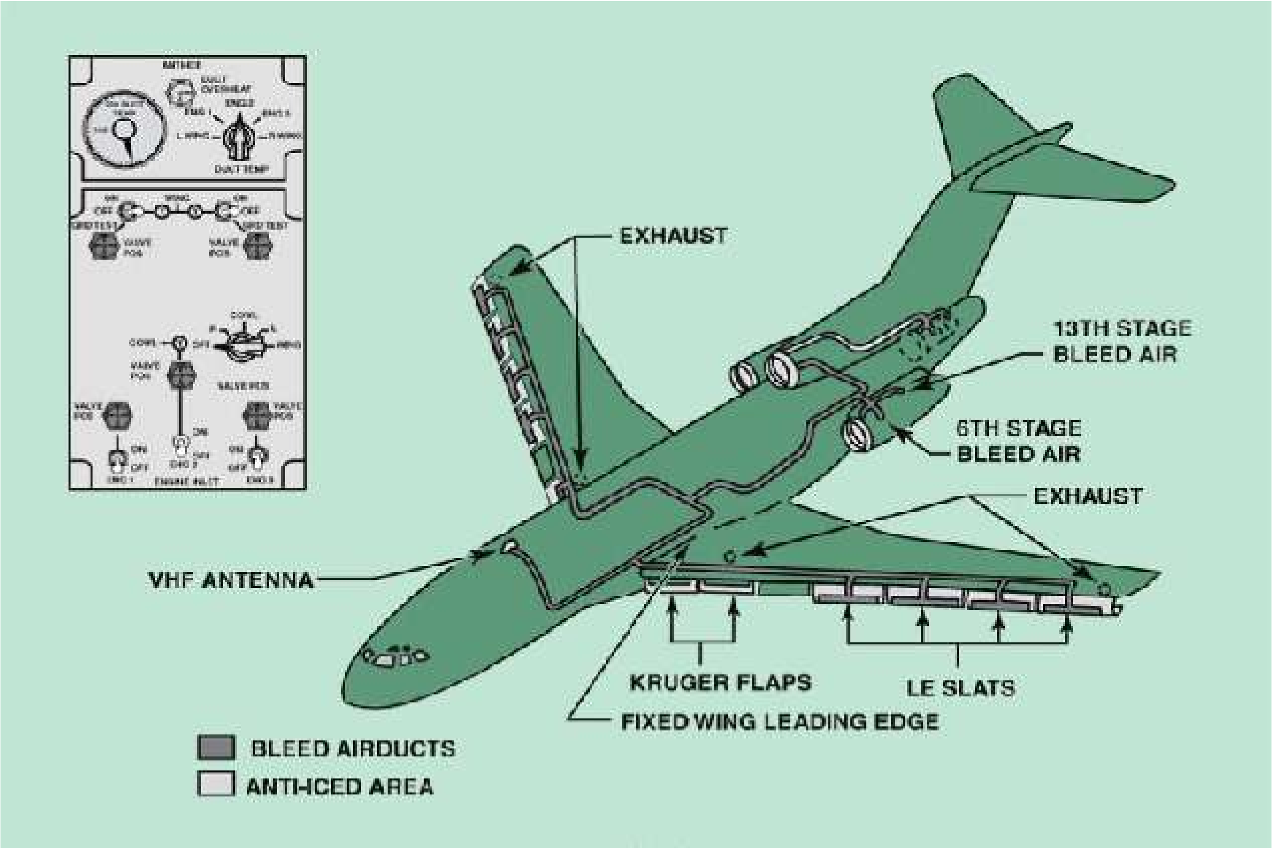
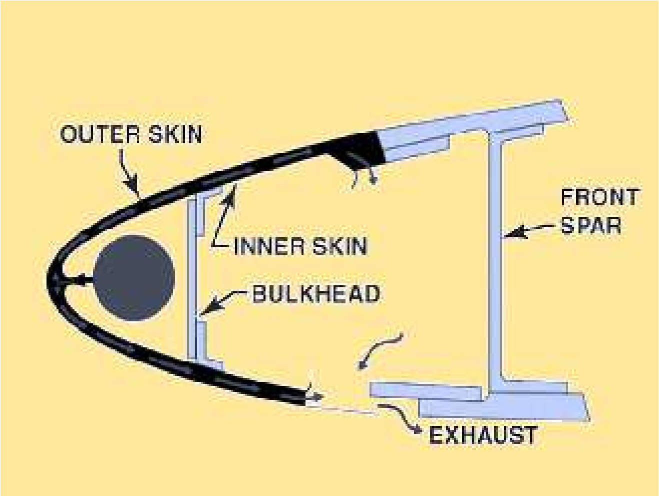
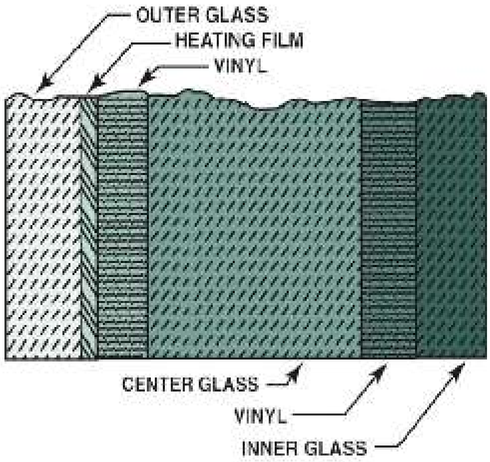


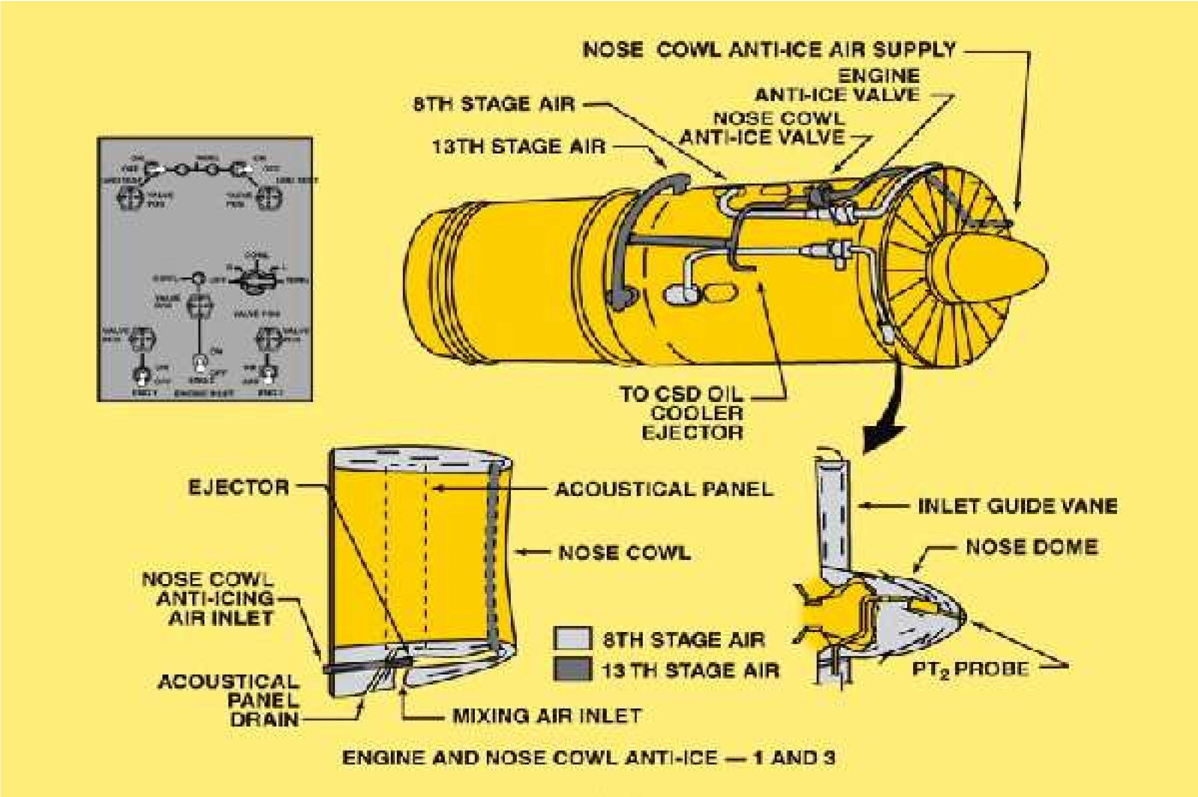
FIG. 28.6. MECHANICAL ICE DETECTOR
1 – rotating cylinder; 2 – scraper

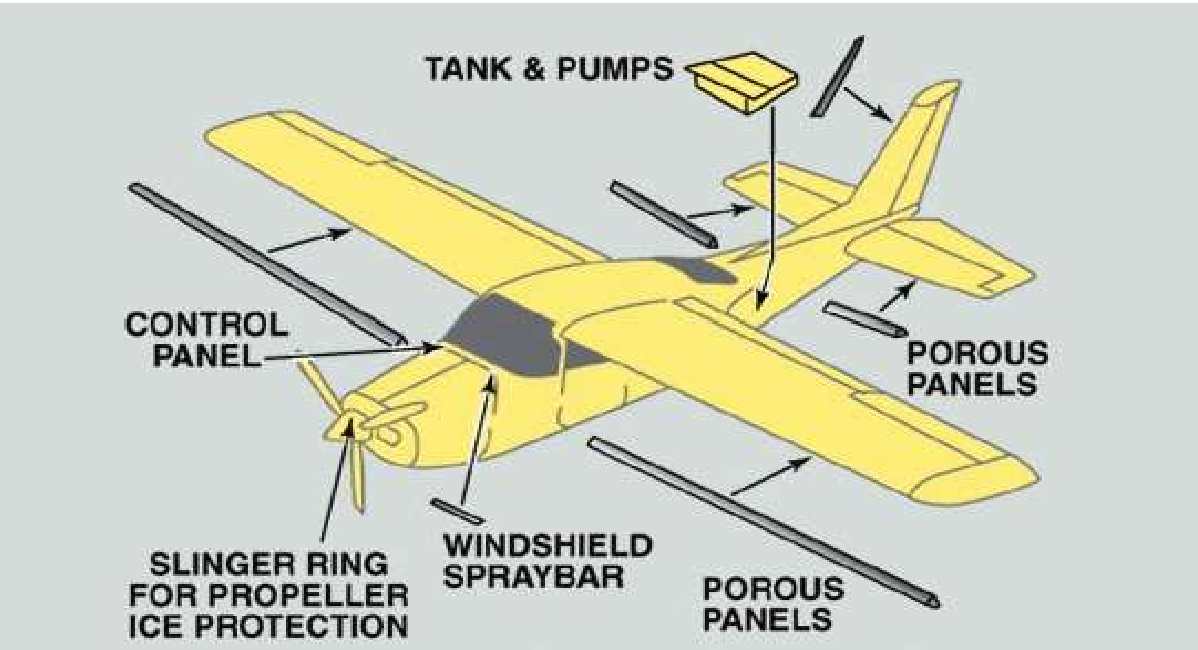


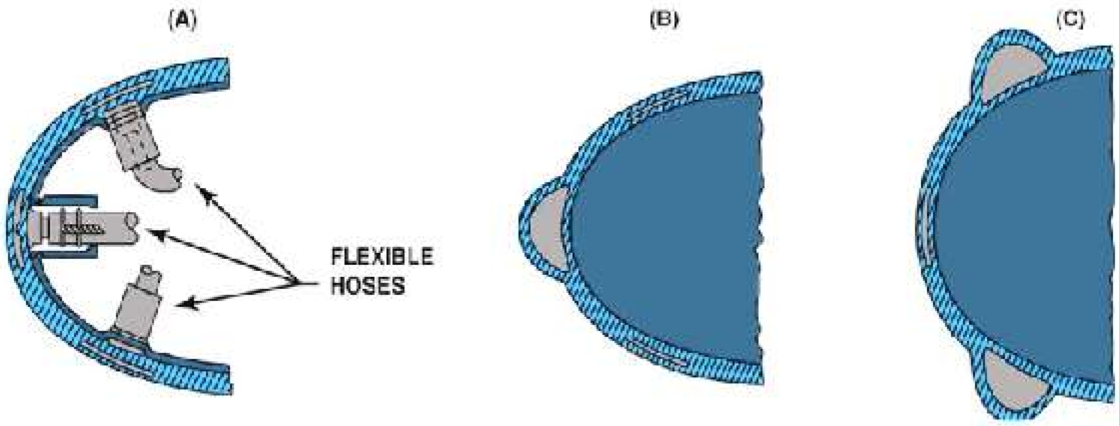

EXHAUST
13TH STAGE
BLEED AIR
6TH STAGE
BLEED AIR
EXHAUST
VHF ANTENNA
KRUGER FLAPS
LE SLATS
FIXED WING LEADING EDGE
BLEED AIRDUCTS
ANTI-ICED AREA

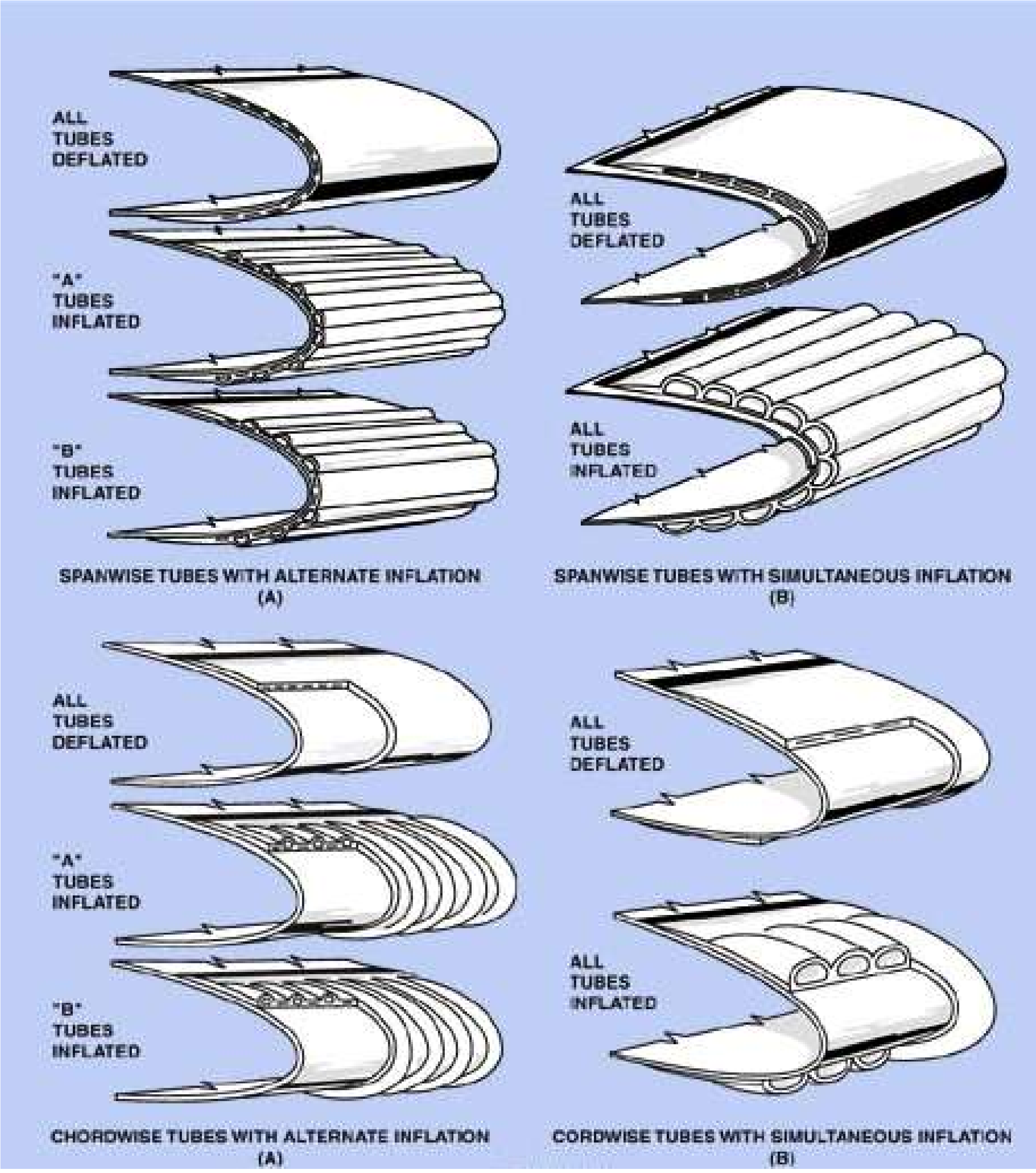

OUTER SKIN
INNER SKIN
BULKHEAD
FRONT
SPAR
EXHAUST

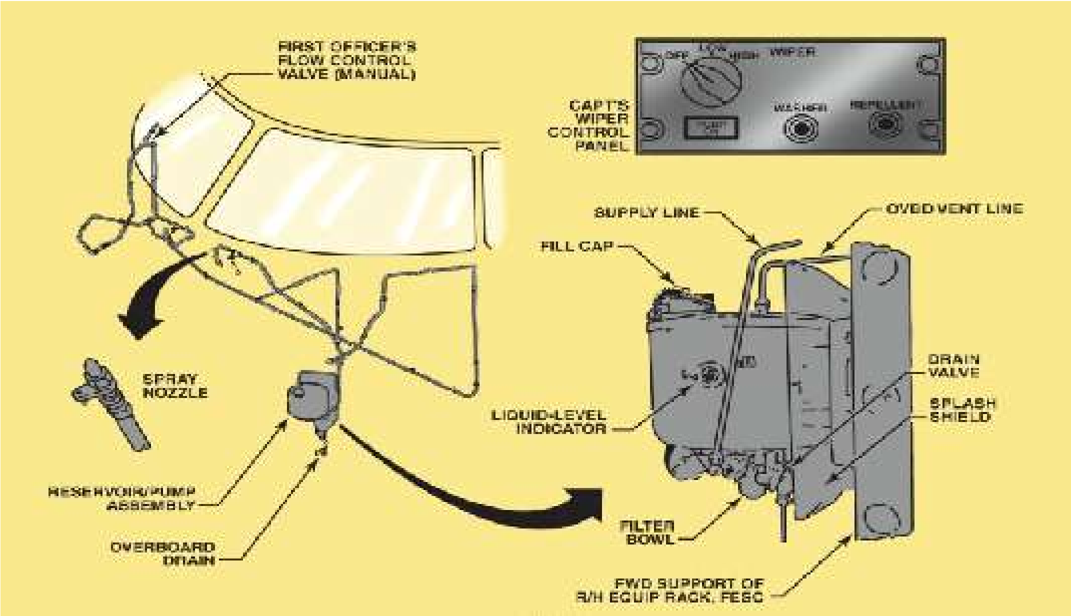

OUTER GLASS
HEATING FILM
VINYL
CENTER GLASS
VINYL
INNER GLASS

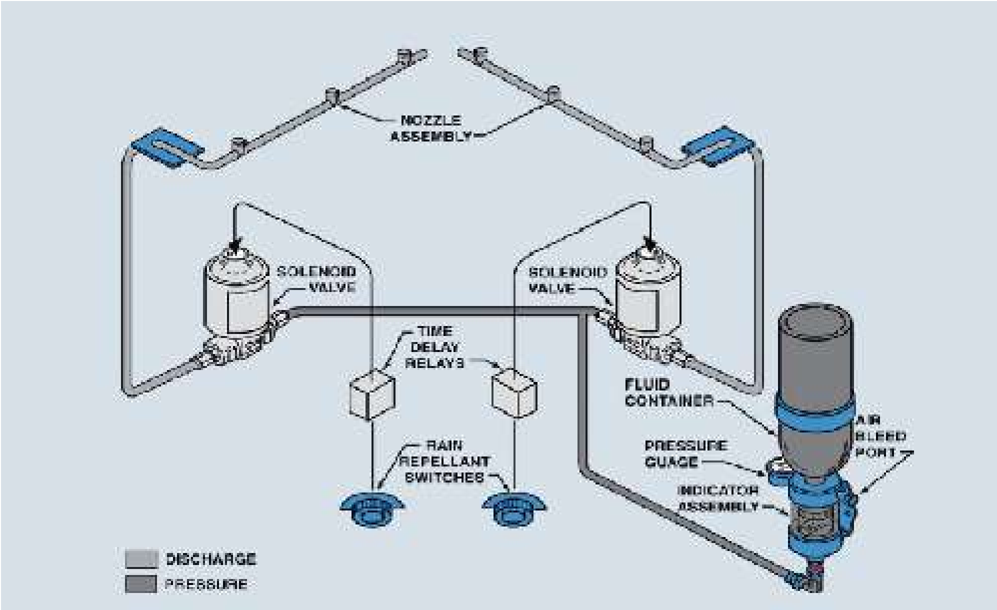

NOSE COWL ANTI-ICE AIR SUPPLY
ENGINE ANTI-ICE VALVE
8TH STAGE AIR
NOSE COWL ANTI-ICE VALVE
13TH STAGE AIR
TO CSD OIL COOLER EJECTOR
EJECTOR
ACOUSTICAL PANEL
NOSE COWL
NOSE COWL ANTI-ICING AIR INLET
ACOUSTICAL PANEL DRAIN
MIXING AIR INLET
8TH STAGE AIR
13 TH STAGE AIR
INLET GUIDE VANE
NOSE DOME
PT2 PROBE
ENGINE AND NOSE COWL ANTI-ICE — 1 AND 3

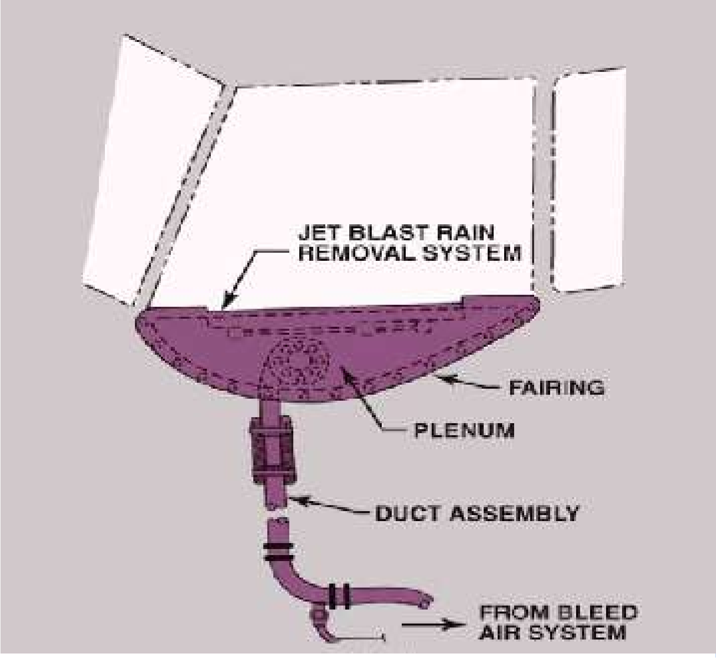

TANK & PUMPS
CONTROL PANEL
POROUS PANELS
SLINGER RING FOR PROPELLER ICE PROTECTION
WINDSHIELD SPRAYBAR
POROUS PANELS


(A)
(B)
(C)
FLEXIBLE
HOSES


ALL
TUBES
DEFLATED
"A"
TUBES
INFLATED
"B"
TUBES
INFLATED
SPANWISE TUBES WITH ALTERNATE INFLATION
(A)
ALL
TUBES
DEFLATED
ALL
TUBES
INFLATED
SPANWISE TUBES WITH SIMULTANEOUS INFLATION
(B)
ALL
TUBES
DEFLATED
"A"
TUBES
INFLATED
"B"
TUBES
INFLATED
CHORDWISE TUBES WITH ALTERNATE INFLATION
(A)
ALL
TUBES
DEFLATED
ALL
TUBES
INFLATED
CORDWISE TUBES WITH SIMULTANEOUS INFLATION
(B)


FIRST OFFICER'S
FLOW CONTROL
VALVE (MANUAL)
CAPT'S
WIPER
CONTROL
PANEL
WIPER
WASHER
REPELLENT
SUPPLY LINE
OVBD VENT LINE
FILL CAP
SPRAY
NOZZLE
DRAIN
VALVE
SPLASH
SHIELD
LIQUID-LEVEL
INDICATOR
RESERVOIR/PUMP
ASSEMBLY
OVERBOARD
DRAIN
FILTER
BOWL
FWD SUPPORT OF
R/H EQUIP RACK, FESC


NOZZLE
ASSEMBLY
SOLENOID
VALVE
SOLENOID
VALVE
TIME
DELAY
RELAYS
FLUID
CONTAINER
AIR
BLEED
PORT
PRESSURE
GUAGE
INDICATOR
ASSEMBLY
RAIN
REPELLANT
SWITCHES
DISCHARGE
PRESSURE


JET BLAST RAIN
REMOVAL SYSTEM
FAIRING
PLENUM
DUCT ASSEMBLY
FROM BLEED
AIR SYSTEM

10.6- Ice Formation on Parked Aircraft and Measures, To Fight It

Aircraft icing frequently occurs on the ground during parking.

It greatly influences safe takeoff of the aircraft and, it not counteracted efficiently, considerably decreases combat readiness of a military unit owing to delayed aircraft departure.

When the aircraft freezes as a result of Sublimation of steam into ice, the following depositions take place:

1. Frost - in clear weather owing to cooling of the aircraft surface to a temperature below that of air؛
2. Hard (crystal) deposit when the air temperature exceeds the aircraft surface temperature.
3. Crystalline rime in strong cold owing to oversaturation of air with water vapors.
4. Freezing of the aircraft often stems from overcooled water present in the atmosphere (rain, mist or drizzle).
5. Transparent vitreous ice or dull ice is formed on the aircraft surface in this case. Such freezing is more dangerous since ice formations are stronger and larger.
6. Take-off of iced aircraft is dangerous first of allowing to premature and sharp stall (aw and C_L max decrease which leads to a heavy accident).
7. It is necessary to carefully remove ice, frost or snow from the aircraft, especially from the wing and tail unit. The condition of the aircraft surface should be checked up before taxiing to the start line.
8. Ice formation on the parked aircraft is counteracted both by protecting them against freezing and by removing ice formed on the aircraft surface.
9. The most efficient way is to store aircraft in hangars.
10. However, this is an expensive method and hardly suitable forheavy aircraft. The most frequent method of protecting the aircraft against freezing is covering of the aircraft. The disadvantage of such method is high labor consummation and difficulty involved in placing and removing covers, especially on large aircraft, as well as possibility of ice formation on the covers.
11. Removal of ice from the aircraft by warm air fed under pressure from special engine heaters is widely used today. This method combines heat and mechanical effects; heated mixture of water and antifreeze (alcohols or ethylene glycols).
12. **lighting arrester and its made of composted carbon with 2 end negative and positive lead connected to the frame and main electric power the location for lighting arrester by the end of both wing edge plus front aircraft left and right electronic door the size of this part is almost alkaline battery size 2A.**