CHAPTER 1

AIRCRAFT OXYGEN EQUIPMENT AND ASSEMBLIES

CONTENTS

Introduction

1. Oxygen systems in one form or another are fitted to all those RAF aircraft which operate at actual or cabin altitudes in excess of 8,000 feet. They are therefore to be found in all aircraft except helicopters and the Bulldog and Chipmunk basic trainers.

2. The desirable physiological and operational requirements for aircraft oxygen systems may be summarized thus:

a. *Prevention of Hypoxia.* Breathing ambient air on ascent to altitude produces a progressive fall in the partial pressure of oxygen in the lungs (PO_2). Above 8,000 feet the PO_2 will be at levels which are insufficient to meet the body's requirements for oxygen and hypoxia will develop. This most serious of hazards must be prevented in flight and one method of so doing is to provide an artificial pressure invironment, ie a pressurized cabin. The alternative method is to provide a source of added oxygen so as to maintain the PO_2 at ground level equivalent at all altitudes. In most military flying a highly pressurized cabin (High Differential Cabin) is inappropriate for several reasons and so both methods are combined. The cabin is pressurized to a certain degree (Low Differential Cabin) and any short-fall in oxygen required is met by a supplement source in the aircraft.

(1) *100% Oxygen.* Oxygen would be most simply and conveniently delivered as 100% oxygen at all altitudes. This, however, has several disadvantages not least of which are those of cost, weight and bulk; particularly since 100% oxygen is not required physiologically until a cabin altitude of 34,000 feet is reached. Furthermore, ear discomfort and deafness may develop as a result of reabsorption of oxygen from the middle ear cavity, frequently some time after landing (Delayed Otitic Barotrauma or 'Oxygen Ear'). Difficulty in breathing, chest discomfort and cough may occur after flights in high performance aircraft during which high g manoeuvres have been performed while breathing 100% oxygen and wearing G-trousers, (Acceleration Atelectasis or 'Oxygen Lung'). Also, breathing 100% oxygen for long periods (12-16 hours) so irritates the respiratory tract that chest discomfort may result. Finally, there is an increased risk of fire if 100% oxygen is used.

(2) *Airmix.* For the reasons given above present aircraft oxygen systems aim to provide a progressive increase in oxygen concentration (Airmix) in the inspired gas which is directly proportional to the fall in PO_2 experienced during ascent and which maintains the lung PO_2 at the ground level equivalent of approximately 100mm Hg. Figure 1 illustrates the concentration of oxygen required to achieve this.

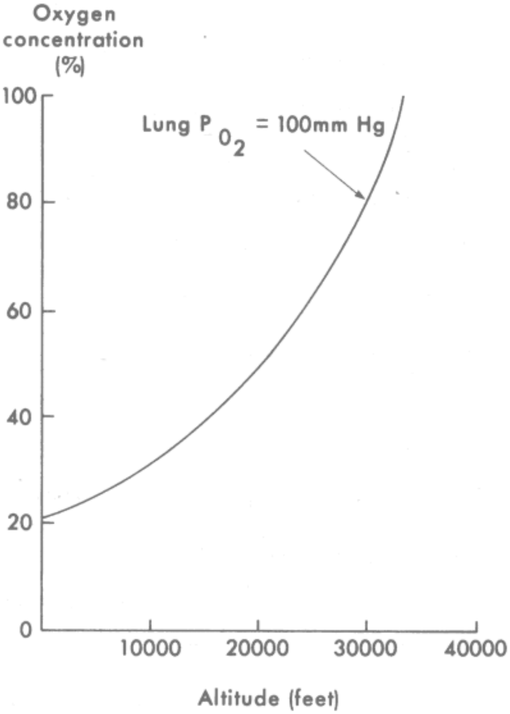


Fig 1 Relationship between Altitude and the Concentration of Oxygen required to maintain Ground Level Equivalent.

In practice this aim is achieved by providing an increase in inspired oxygen concentration from ground level until at about 30,000 feet most oxygen systems are delivering 100% oxygen. The delivery of 100% at 30,000 feet, rather than at

33,700 feet as theoretically required, allows a considerable safety margin. 100% oxygen will continue to prevent hypoxia up to 40,000 feet but above this altitude pressure breathing is required to provide continued protection (Para 29 a (3)).

b. *Adequate Nitrogen Concentration.* Nitrogen must be present in sufficient quantity to prevent the occurrence of Oxygen Ear or Oxygen Lung. Thus 40% nitrogen or more is normally required in a breathing system unless oxygen requirements dictate otherwise.

c. *Adequate Ventilation and Flow.* The system must be capable of delivering a sufficient quantity of gas to meet the individual's requirements. Thus, up to 60 litres per minute must be attainable along with instantaneous peak inspiratory flows of 200 litres per minute.

d. *Minimal Resistance to Breathing.* Resistance due to valves and turbulent flow throughout the system (the latter derived from uneven surfaces, branches and changes in internal diameters) must be minimized to prevent disturbances to respiratory rhythm. Ideally, the flow characteristics should be such as to produce no noticeable resistance to breathing.

e. *Temperature.* The inspired gas should be neither too warm nor too cool for comfort. Its temperature should be within ± 5°C of cockpit ambient.

f. *Safety Pressure.* Inward leaks around the face mask seal or from hose connections must be countered. This is accomplished by providing a small positive overpressure in the mask to ensure that any leaks are outbound (Para 29a (2)).

g. *Protection against Toxic Fumes and Decompression Sickness.* A facility for selecting 100% oxygen at any time and at any altitude is necessary in the event of toxic fumes appearing in the cabin or when decompression sickness is liable to develop or has done so (cabin altitudes above 18,000 feet), (Para 29a (7)).

h. *Indication of Supply and Flow.* Indications of both supply and flow must be available to the user at all times as a check of correct function, (Para 29a (4) and (5)).

i. *Evaluation of Integrity.* Where possible fail-safe methods of operation should be used (eg the crew member should be unable to breathe through the mask until it is correctly connected to the rest of the system) together with the means to check emergency functions (eg manual test of mask seal and pressure breathing facilities), (Para 29a (8)).

j. *Convenience.* As much of the system as possible should be automatic and the drills to cope with a failure should be simple. Failures must be immediately and clearly indicated.

k. *Duplication.* In aircraft with low differential pressure cabins there should be a back-up system in the event of main system failure. There is no need for such an Emergency Oxygen supply in aircraft with high differential cabins where the cabin itself provides the primary protection against hypoxia and the oxygen equipment is only used if cabin pressurization fails, or toxic fumes contaminate the cabin.

l. *Provision for High Altitude Escape.* A separate emergency oxygen supply is needed in aircraft fitted with ejection seats or from which bale-out is possible. This supply, fitted either to the seat or to the personal parachute pack, is usually the same as the back-up supply referred to at k above.

m. *Independence from Environment.* The environment extremes sustained in flight must not impair the performance of the oxygen equipment. This is particularly so in regard to low temperatures, accelerations (aircraft manoeuvres and windblast on escape) and atmospheric pressure changes.

3. The oxygen systems in RAF aircraft have been progressively refined over the years. The subject has become increasingly complex and aircraft specific. Because of this the following account is necessarily of a general nature but Annex A summarises the details of systems found in individual aircraft types.

4. In broad terms any aircraft oxygen system

consists of two parts: a store of oxygen and a means of its delivery to the man (regulator hose and face mask).

AIRCRAFT OXYGEN STORAGE

General

5. In all present RAF aircraft oxygen is obtained from an on-board store which is replenished whilst the aircraft is on the ground. Future systems may employ the on-board generation of oxygen. Oxygen is stored either as a gas at high pressure or as a liquid at low temperature.

6. Whatever the source, the gas supplied to the man must be of a certain high standard. Thus, it must contain at least 99.5% oxygen, be odourless and virtually free of any toxic substances (eg the carbon monoxide concentration must be less than 0.002%). The maximum allowable levels for various hydrocarbons are specified in relation to the type of storage system used since this will influence the potential contamination hazard (*see* Para 22). To avoid the risk of ice formation at low temperatures the water content must not exceed 0.005mg per litre of oxygen at Standard Temperature and Pressure (STP : 0°C, 760mm Hg).

Gaseous Storage

7. In most gaseous oxygen storage systems the oxygen is held in cylinders of 750 and/or 2250 litres capacity, (at Normal Temperature and Pressure (NTP : 15°C, 760mm Hg)), according to the size of aircraft and the requirements of the crew/passengers. Table 1 indicates the oxygen available from the two common sizes of cylinder.

Nominal Cylinder Size (Litres)	Litres of Gas Available at NTP
750	710
2250	2130

Table 1 Oxygen Cylinder Contents

The cylinders are mounted outside the pressure cabin. They are specially strengthened and wire-wound to prevent fragmentation or explosion if punctured. (NB In the Hawk aircraft the cylinders are of 1400 litres (NTP) capacity and are not wire-wound).

8. The gas is stored at a pressure of 1800 pounds per square inch (psi); the pressure is stepped down by reducing valves before entering the next part of the system and there is usually a duplication of pipework and non-return valves as protection against a single leak emptying the whole system. A typical gaseous storage system is shown at Fig 2.

9. The advantages of such a system are that it is relatively simple, oxygen is not lost by venting when not in use and it can be used immediately after filling. In addition, availability is not usually a problem.

10. The disadvantages are that the cylinders are bulky and heavy. Consequently, this system is used when weight and space are not at a premium, or when the supply is only for use in emergencies and is therefore small (Paras 42 and 43) or when the supply is portable (Para 51).

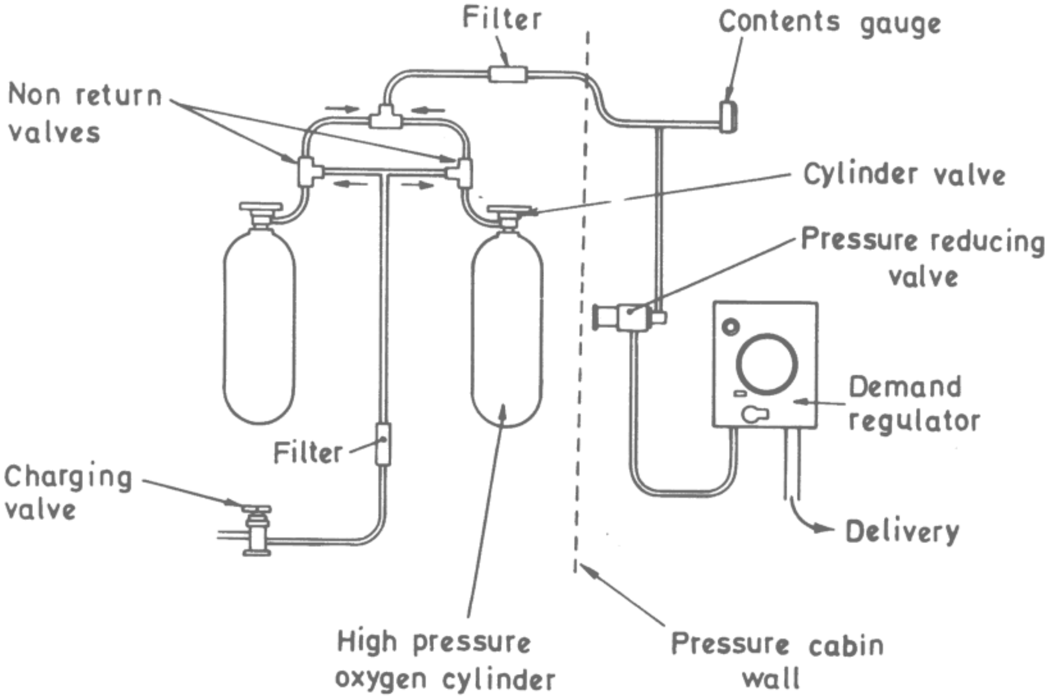


Fig 2 A Typical Gaseous Oxygen Storage System.

Liquid Storage

11. The problems of weight and bulk are greatly reduced by storing oxygen as a liquid under low pressure. Such systems occupy about half the space and are half as heavy as the high pressure gaseous systems as can be seen in the comparison at Table 2.

12. Liquid Oxygen (LOX) vaporizes at –183°C at normal atmospheric pressure, each litre of liquid yielding 840 litres of gaseous oxygen (NTP). This expansion ratio for LOX is almost seven times greater than that for gaseous oxygen stored at 1800 psi.

13. Between 3.5 and 25 litres of LOX are carried depending upon aircraft type and crew requirements. Table 3 lists the capacities of current systems and their yields.

Storage System	Weight of Charged System (Kg)	Space Occupied by System L
High Pressure Cylinder containing gas at 1800 psi	19	52
Liquid Oxygen Converter containing 3.5 litres	8	25

Table 2 Comparison of Gaseous and Liquid Storage Systems each yielding 3000 litres (NTP) Oxygen.

Capacity (L)	Available Gaseous Yield (L NTP)		
	Immediately (10 mins) After Filling	12 hours After Filling	24 hours After Filling
3.5	2800	2660	2520
5	4000	3800	3600
10	8000	7600	7200
25	20000	19000	18000

Table 3 : Capacities and Yields of Current LOX Systems.

Note: The yields shown are those used for Service assessments and are based upon a conversion factor of 800 L (NTP) gas per one L LOX. This figure incorporates a safety margin for gauging and filling errors and also for that gas unavailable for use within stabilization systems, where fitted. 5% is assumed to be lost in 12 hours and 10% in 24 hours.

14. The double-walled insulated container, essentially a stainless steel vacuum flask, its control valves and connecting pipework are collectively known as a LOX Converter. It is basically divided into two parts: one is insulated and contains the liquid, the other is uninsulated and contains the gas. A typical LOX Converter is pictured at Fig 3.

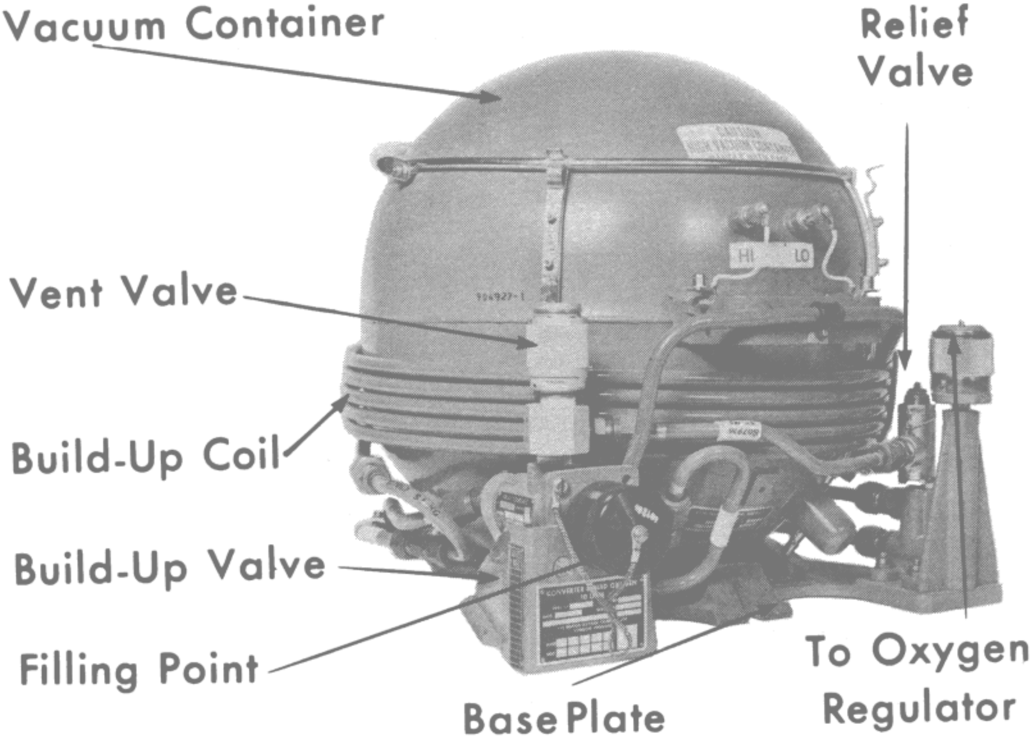


Fig 3 A Typical LOX Converter.

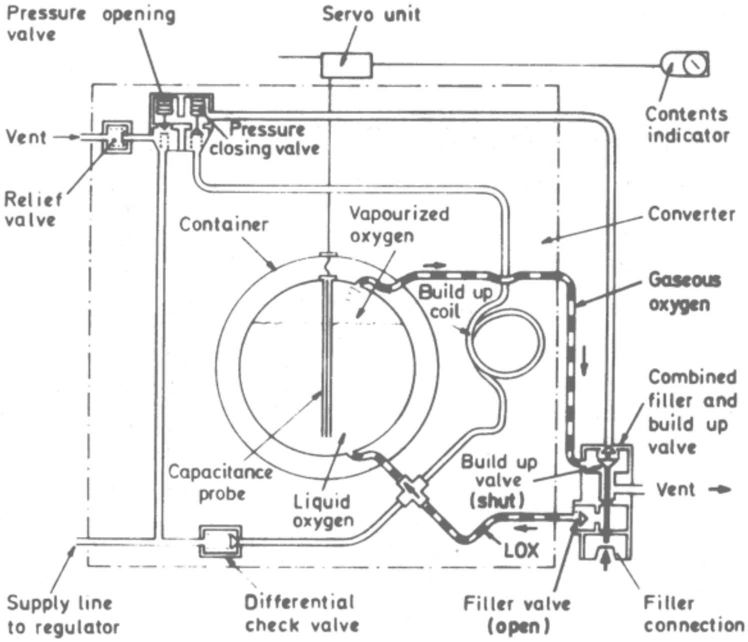


Fig 4a LOX System — Filling.

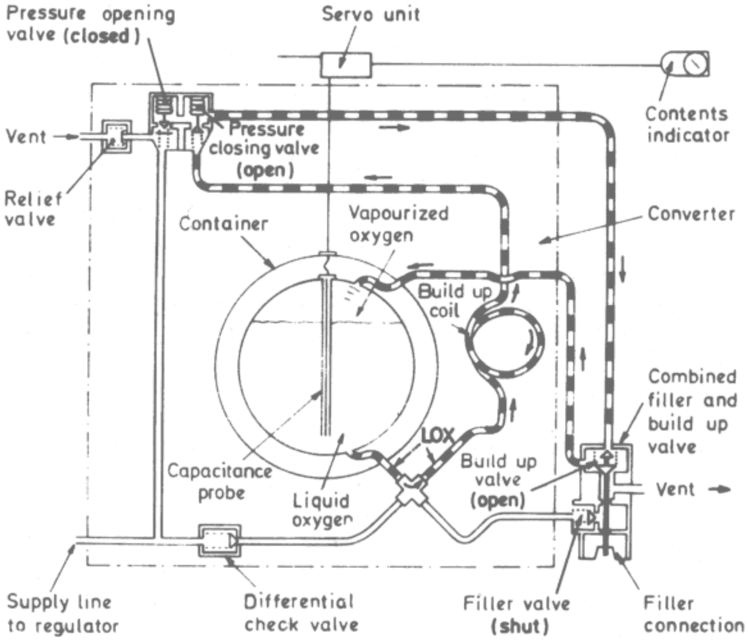


Fig 4b LOX System — Build-up.

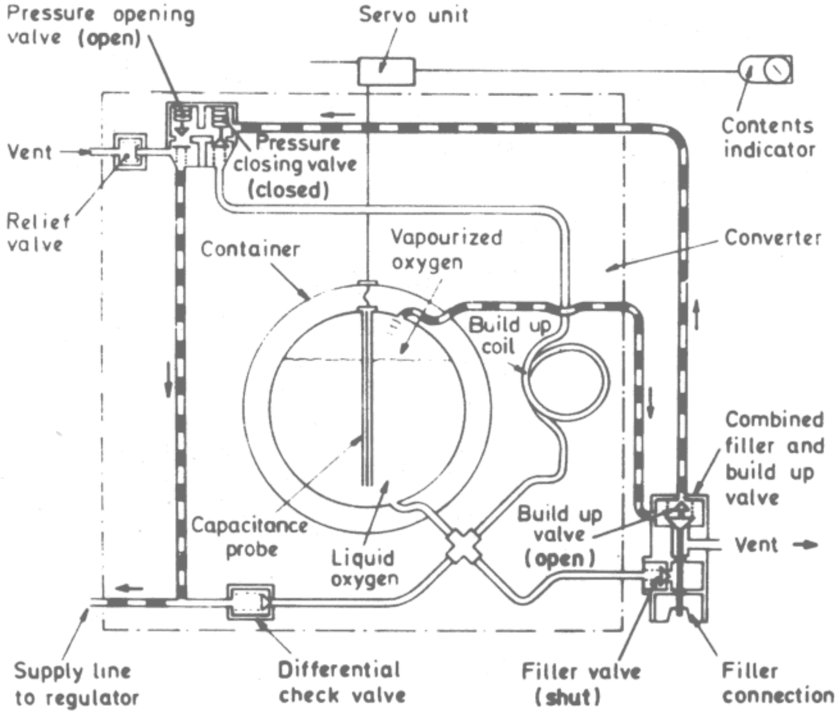


Fig 4c LOX System – Delivery.

Fig 4 Layout of a Typical Liquid Oxygen System.

The converter may be permanently mounted in the aircraft or be removable for rapid replacement. The layout of a typical liquid oxygen converter is shown at Fig 4.

15. The converter is charged from a ground LOX dispenser via a filling inlet and vent valve. This allows LOX to flow freely into and out of the converter (Fig 4a). As liquid passes into the container it evaporates and eventually cools the internal walls to –183°C when evaporation ceases. The container then rapidly fills with liquid.

16. When the charging hose is disconnected the filling and vent valve closes and joins the bottom and top of the container through a length of uninsulated pipe (the pressure build-up coil) and a pressure closing valve. Liquid oxygen flows from the bottom of the container, vaporises into the pressure build-up coil and passes as gas back into the top. The heat carried in by the gas warms the surface layer of the liquid so that its vapour pressure rises. This process continues until the pressure in the container reaches the operating pressure of the converter (between 70 and 300 psi) when the pressure closing valve shuts and flow of liquid into the pressure build-up coil ceases, (Fig 4b). Fluctuations outside this normal operating range are guarded against by pressure relief valves.

17. The inherent heat leak into the container raises the pressure in the converter until the level is reached at which the pressure opening valve opens. The gas phase is then in communication with the delivery pipe and any demand by the user is met by a flow of gas from the top of the container in preference to a flow from the liquid phase, (Fig 4c). This is ensured by the differential check valve which allows the passage of liquid only when the pressure in the delivery line falls below the converter pressure by a pre-determined value.

18. The liquid content of the container is monitored continuously by measurement of electrical capacitance between the inner of the two containing shells and a third perforated shell immersed in the liquid and gaseous oxygen. The output of the capacitance gauge is presented in the cockpit for aircrew use and also near the charging point for use by the ground crew. The pressure at which the gaseous oxygen is delivered is usually also displayed in the cockpit.

19. The advantages of the LOX system are that it is compact, comparatively light and a small quantity of liquid yields a large quantity of gas. An additional bonus is that the container will not explode if damaged.

20. The disadvantages are that evaporation and venting takes place relatively quickly since the insulation cannot be absolute. This means that the converter has to be recharged at frequent intervals. The expense of this is compounded by the loss of liquid during transfer both to the converters themselves and to the dispensers from the place of manufacture: less than one eighth of the liquid produced by the manufacturing plant reaches an aircraft converter.

21. In addition, LOX takes a long time to stabilize once in the converter and then its stability may be upset if the container is agitated, as for example, by aerobatics. The warm layer of liquid at the liquid/gas interface is disturbed and cold liquid comes into contact with the gas, which condenses and causes a fall in pressure. This 'Temperature Stratification' is overcome in combat aircraft by a stabilizing chamber, connected to the converter, from which gaseous oxygen is bubbled through the LOX container during charging. These bubbles, in condensing, heat all the liquid in the container to the temperature at which its vapour pressure equals the normal operating pressure.

22. A further potential disadvantage of liquid oxygen is that of contamination by toxic materials such as nitrogen oxides, carbon dioxide, carbon monoxide and the hydrocarbons methane, ethane, ethylene and acetylene. The sources of contamination include the air from which the oxygen is produced, plant compression, refrigeration, storage, transport and handling equipment. Most contaminants have boiling points higher than that of liquid oxygen so that they do not evaporate along with it and thus they will accumulate within the container. A build-up of contaminant can therefore occur and eventually particles or 'slugs' of pure contaminant may pass from the container into the warming coils, evaporate and be inhaled by the user in relatively high concentrations. Strict control must be exercised to ensure that such a build-up does not occur. Frequent analysis by infra-red spectroscopy is used to monitor the level of contaminants in the LOX supplies. In addition, great care must be taken to prevent contaminants entering the transport containers and charging hoses.

23. These considerable disadvantages make liquid oxygen the preferred method of storage only when weight and bulk are at an absolute premium, and oxygen is essential throughout a flight, as is the case with combat aircraft.

OXYGEN DELIVERY

General

24. From whichever source the oxygen derives, the easiest way in which it can reach the aircrew is by a Continuous Flow System. Since the flow does not vary with the demand of the user, such a system tends to be inefficient and wasteful. However, it is simple and was used to provide the earliest method of oxygen delivery. Continuous flow systems are still often used to provide a bale-out and emergency oxygen supply, (Para 42).

25. Historically, the next development was the use of a reservoir interposed between the regulating device and the face mask and designed to prevent too much wastage of gas. Examples are still in service with some RAF aircraft in the form of the British Economizer System, (Para 47), but this, like the continuous flow system is unable to vary its output with the inspiratory demand of the user.

26. The disadvantages of the above methods are overcome by Pressure Demand Systems in which the flow of gas from the regulator

varies directly with the inspiratory demand of the user. In addition, the extra facilities required (Airmix, Safety Pressure, Pressure Breathing etc) can be provided.

27. Therefore, in the RAF most aircraft are now fitted with Demand Oxygen Systems consisting of a Regulator, Delivery Hoses and Mask.

PRESSURE DEMAND SYSTEMS

Pressure Demand Regulators

28. The principles underlying the design and function of regulators are essentially the same whether the regulators be Panel-Mounted, Man-Mounted or Seat-Mounted. The detailed description below is of the Panel-Mounted Mark 17 Regulator. Other Panel-Mounted, Man-Mounted and Seat-Mounted Regulators are also described. A summary of the features of regulators in current service is at Annex B.

29. **The Panel-Mounted Pressure Demand Regulators.** Those in use are:

a. *Mark 17 Panel Mounted Demand Regulator.* The mark 17F version of this regulator is illustrated at Fig 5.

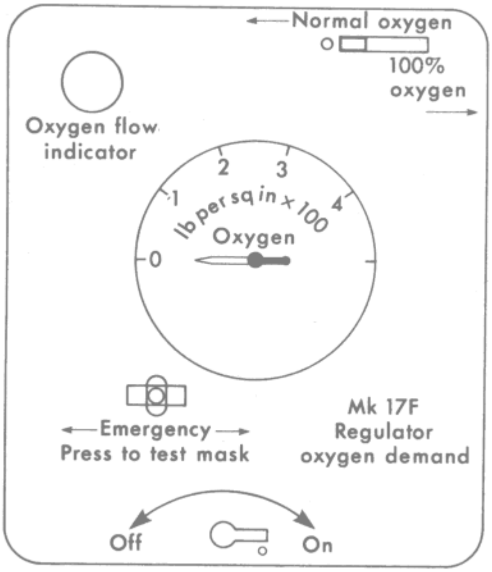


Fig 5 Mark 17F Demand Regulator.

The regulator consists basically of a demand valve, which incorporates a pressure reducing valve, a breathing diaphragm and a lever mechanism. This is shown diagramatically at Fig 6.

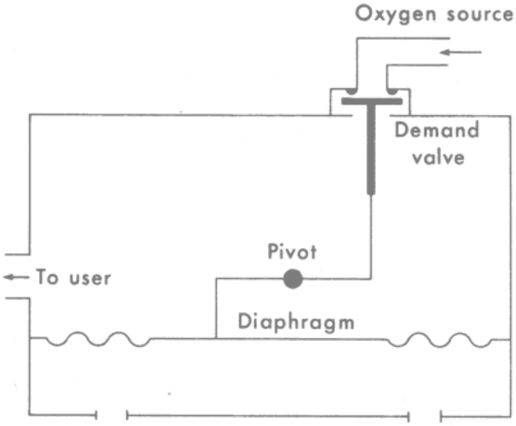


Fig 6 Mark 17 Regulator : Basic Mechanism.

When the user breathes in, a fall in pressure in the mask is transmitted to the regulator where the reduction is sensed by the breathing diaphragm. The diaphragm moves inwards and causes the lever mechanism to open the demand valve. When the user breathes out, pressure builds up in the regulator as oxygen continues to flow into it but is not demanded, the diaphragm moves back and the demand valve closes. The regulator also includes refinements in the form of Automatic Functions and Manual Selections. The Automatic Functions are:

(1) *Airmix.* In order to deliver air which is progressively enriched with oxygen on ascent, a venturi tube is fitted downstream of the demand valve. Opening into the venturi is a passage linked to a chamber which incorporates an aneroid capsule and a non-return valve. This is shown diagramatically at Fig 7.

As oxygen flows through the venturi at high velocity a fall in pressure is produced and cabin air is sucked through the chamber and passage. Air, mixed with oxygen, is thus delivered to the user: (Airmix). As altitude increases the aneroid capsule expands, gradually closing off the

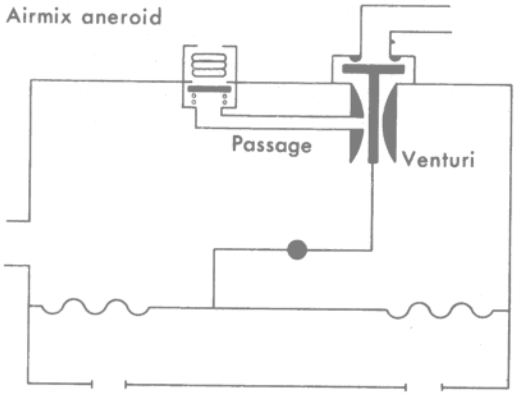


Fig 7 Mark 17 Regulator : Airmix Facility.

orifice and so reducing the amount of air mixing with the oxygen. There is a progressive increase in the concentration of oxygen reaching the user until, at about 30,000 feet, 100% oxygen passes to the mask, the orifice being completely shut.

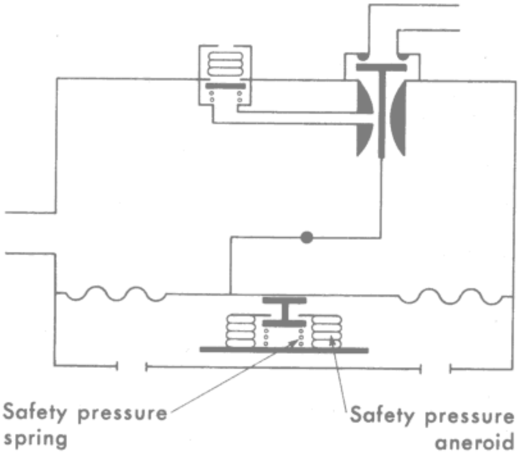


Fig 8 Mark 17 Regulator : Safety Pressure Facility.

(2) *Safety Pressure.* At cabin altitudes above 8,000 feet the risk of hypoxia as a result of inward leaks in the system (especially with an ill-fitting mask) is prevented by Safety Pressure. This is produced by applying a spring force of 2mm Hg to the underside of the breathing diaphragm. This opens the demand valve until an equal pressure is built up within the system to overcome the spring. The pressure within the mask is thus kept above ambient throughout inspiration. The spring is prevented from acting on the breathing diaphragm by an aneroid until the cabin altitude exceeds safety pressure height, a height which varies from regulator to regulator (see Annex B) but for the Mark 17 is at 10,000-12,000 feet. The arrangement is shown diagramatically at Fig 8.

(3) *Pressure Breathing.* Positive pressure breathing above cabin altitude of 40,000 feet is achieved by applying a spring force to the underside of the breathing diaphragm. It is prevented from acting below 40,000 feet by a pressure breathing aneroid which encloses the safety pressure capsule. The arrangement is shown diagramatically at Fig 9.

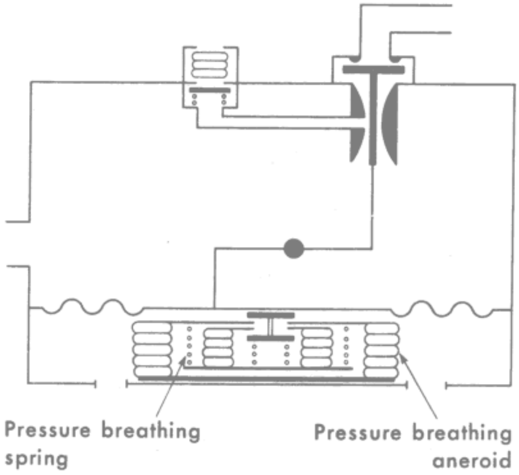


Fig 9 Mark 17 Regulator : Pressure Breathing Facility.

At 40,000 feet the pressure breathing aneroid allows further expansion of the inner aneroid and so a larger force is applied to the diaphragm. This force is related to cabin altitude by further gradual expansion of the pressure breathing aneroid. The regulator will provide protection to an altitude of 50,000 feet at which time it will be delivering 30mm Hg positive pressure to the user.

(4) *Flow Indication.* Tappings taken from both sides of the venturi (upstream

and downstream) allow the variations in pressure which result from flow to deflect a small (blinker) diaphragm. The deflection completes an electro-magnetic circuit which turns the flow indicator (see Fig 5) so that it appears as a vertical white bar on the face of the regulator. When the flow ceases there is no pressure difference across the diaphragm, the electromagnet is de-energised and the Magnetic Indicator (MI or 'Dolls Eye') goes black, indicating no flow.

(5) *Contents Indications.* A remote oxygen contents gauge is connected to the output line of the cylinders and, although operated by pressure, is calibrated in quantities: ie fractions of FULL. A pressure gauge is mounted in the centre of the regulator face and indicates the inlet pressure to the regulator face and indicates the inlet pressure to the regulator (see Fig 5). It should read between 250-400 psi when supplied by gas and between 150-200 psi when supplied by LOX.

The manual switches on the regulator (Fig 5) are:

(6) **On/Off** *Lever.* The On/Off lever is green and located at the bottom of the regulator face. It is usually wire-locked in the 'On' position.

(7) **Normal/100%** *Lever.* The Normal/100% lever is located at the top right hand corner of the regulator face. It allows 100% oxygen to be selected for delivery at any altitude by blanking off the air entry port of the airmix facility.

(8) **Emergency/Press To Test Mask** *Toggle.* The Emergency/Press to Test Mask toggle is located just below and to the left of the regulator pressure gauge. When deflected to the right or left it allows the delivery of an additional 4mm Hg pressure at all altitudes, thus providing safety pressure (eg when toxic fumes are present in the cabin) or a low pressure test of the mask seal, (mask toggle "up": *see* Para 36a (1)). When pressed in it delivers oxygen under a pressure of approximately 30mm Hg and so provides a high pressure test of connections and mask seal, (mask toggle "down": *see* Para 36a (1)). This facility can also be used in flight in an attempt to blow debris off the mask inlet valve since debris lodged in this valve leads to difficulty in breathing out, (*see* Para 36a (3)).

b. *Mark 21 Panel Mounted Demand Regulator.* The Mark 21 regulator is similar in appearance to, and has the same performance characteristics up to 40,000 feet as, the Mark 17F regulator. It has all the automatic functions and manual selections described above for the Mark 17F. However, when used with the appropriate items of aircrew protective clothing it is able to provide pressure breathing protection up to altitudes of 56,000 feet. Above 40,000 feet it delivers a higher pressure at any given height then the Mark 17F: at 45,000 feet the delivery pressure is 30mm Hg and at 56,000 feet it is approximately 70mm Hg. To enable the mask seal and integrity of the delivery system to be checked the Emergency/Press to Test Mask toggle of the Mark 17F is replaced in the Mark 21 by a four-position sweep lever. The Mark 21 regulator is illustrated at Fig 10. The sweep lever has four labelled positions:

(1) **Normal.** The Normal position is that for routine use of the regulator, which thus provides the correct flow and pressure according to cabin altitude.

(2) **Emergency.** The Emergency position provides a manual selection of 4mm Hg safety pressure and is therefore equivalent to deflecting the Emergency/Press to Test Mask toggle on the Mark 17 regulator. It provides a means of carrying out a low pressure check of mask seal. In flight it is selected, together with 100% oxygen, should the cabin air become contaminated with toxic fumes.

(3) **Mask Test.** The Mask Test position, achieved only by withdrawing the knurled knob at the end of the sweep lever, provides a high pressure check of connections and mask seal by delivering a posi-

tive pressure of 30mm Hg to the mask (mask toggle "down": *see* Para 36a (1)). It is therefore equivalent to pressing in the Emergency/Press to Test Mask toggle of the Mark 17 regulator and it similarly provides a possible means of clearing the mask inlet valve in flight.

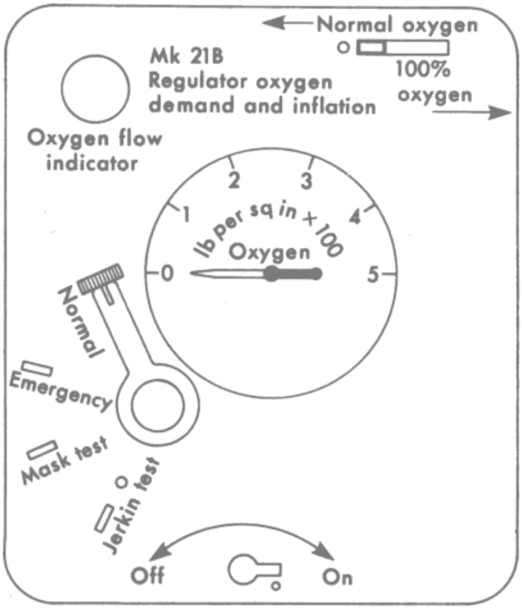


Fig 10 Mark 21B Demand Regulator.

(4) **Jerkin Test**. The Jerkin Test position, also only achieved by withdrawing the knurled knob at the end of the sweep lever, provides a delivery pressure of 60mm Hg. It is used to assess the integrity of partial pressure assemblies: ie mask (P/Q type) and pressure jerkin (PJ) plus G-trousers, if worn. This position must ONLY be used when such assemblies are worn and only in the presence of another person able to release the pressure if necessary. It is NEVER used in flight.

Note: The sweep lever is returned to the Normal position on completion of the pre-flight checks.

When operated by aircrew wearing a P/Q mask, PJ and G-trousers the Mark 21 regulator will provide pressure breathing protection, in the event of rapid decompression, up to altitudes of 56,000 feet: provided that no more than 30 seconds are spent at that altitude and that descent to below 40,000 feet can be achieved within a further 90 seconds. When a P/Q mask is worn with a PJ alone, protection is provided up to 52,000 feet, at which altitude a pressure of 60mm Hg is delivered to the system. The protection afforded by the Mark 21 regulator, when combined with various Aircrew Equipment Assemblies, is summarized at Table 4.

c. *CRU–68A (Bendix) Panel Mounted Demand Regulator.* The CRU-68A Regulator (Fig 11) is fitted to the Hercules aircraft and its principle of operation is similar to that of the Mark 17 regulator described above. Thus, it is capable of providing the automatic functions of Airmix, Safety Pressure (1-2mm Hg but not delivered until a cabin altitude of 28,000 feet is reached), Pressure Breathing (to a maximum altitude of 50,000

Aircrew Equipment Assembly (AEA)	Maximum Altitude (feet)	Mark 21 Delivery Pressure (mmHg)	Maximum Time at Altitude on Rapid Decompression (seconds)	Minimum Rate of Descent to 40,000 feet (feet/min)
P/Q mask	45,000	30	60	10,000
P/Q mask + PJ	52,000	60	30	10,000
P/Q mask + PJ + G-trousers	56,000	70	30	10,000

Table 4 Protection provided by Mark 21 Regulator when combined with various AEAs.

feet when the delivery pressure is approximately 28mm Hg) and Flow and Contents Indication. It also has the following facilities for manual selection:

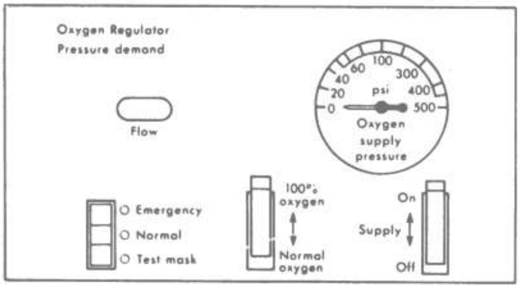


Fig 11 CRU-68A Demand Regulator.

(1) **Supply On/Off.** The Supply On/Off toggle lever is coloured green and is located at the bottom right corner of the regulator.

(2) **100% Oxygen/Normal Oxygen.** The 100% Oxygen/Normal Oxygen toggle lever is coloured white and is located at the bottom centre of the regulator. It provides a manual selection of 100% oxygen at any altitude and is thus used should toxic fumes contaminate the cabin.

(3) **Emergency/Normal/Test Mask.** The three position Emergency/Normal/Test Mask toggle lever is coloured red and is located at the bottom left corner of the regulator. When in the Normal position, the regulator functions normally. When in the Test Mask position, 20-30mm Hg pressure is delivered to provide a check of mask seal. From this position the lever is spring-loaded to return to Normal: it therefore has to be held deflected when testing the mask. The Emergency position provides a continuous over-pressure of 7mm Hg and is used in conjunction with selection of 100% oxygen when toxic fumes are present.

d. *Type A-12A Panel Mounted Demand Regulator.* The Type A-12A regulator is fitted at each crew station in Jetstream aircraft. It is illustrated at Figure 12.

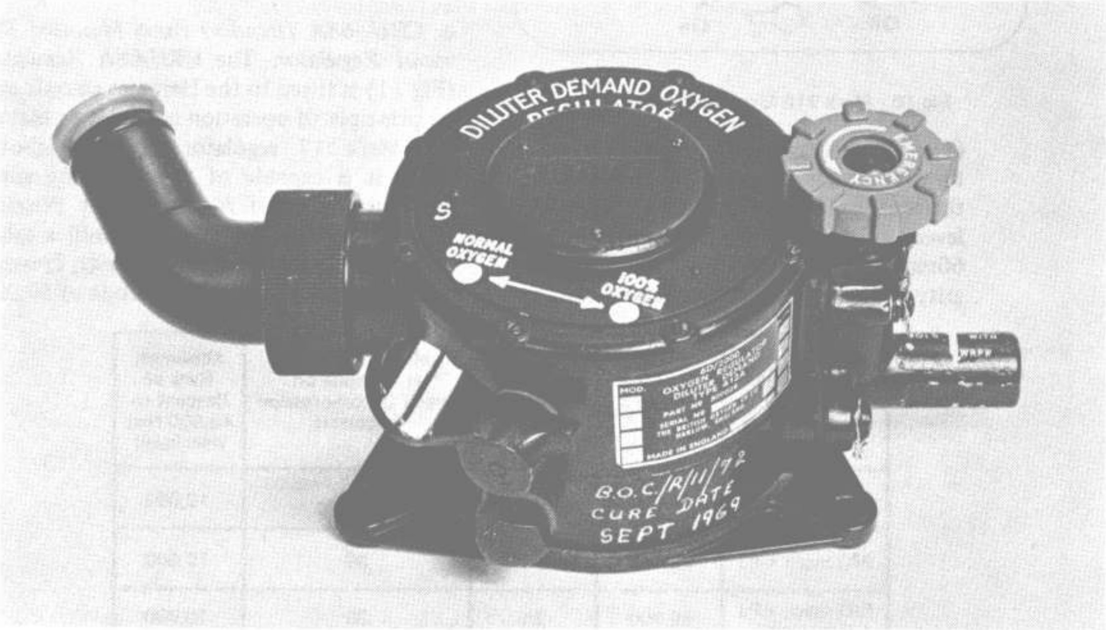


Fig 12 Type A-12A Oxygen Regulator.

The regulator is a simple demand type with no facilities for Safety Pressure or Pressure Breathing. From sea level to 5,000 feet it provides air alone on demand. Airmix is then delivered automatically to an altitude of 30,000 feet. Thereafter, 100% oxygen is supplied to a maximum altitude of 34,000 feet. Flow is signalled by a magnetic indicator and a contents gauge is positioned in the left console panel. It is possible to select 100% oxygen manually at any altitude in the event of toxic fumes in the cabin or if hypoxia is suspected, but for normal flight conditions the Diluter Control Lever is set to the Normal Oxygen position. In the event of a sudden or suspected leak in the system or a failure of the regulator, a continuous flow of oxygen can be initiated by operating the Emergency Oxygen Control Valve. This, however, exhausts the oxygen supply very rapidly and the valve is normally wire-locked in the closed position to prevent accidental operation. The A-12A Regulator is used in conjunction with a Type R mask, (para 36 d). It cannot be used with any other type of mask.

30. **Man-Mounted Pressure Demand Regulators.** Many aircraft currently operated by the RAF incorporate oxygen systems in which the regulator is mounted on the man. This was made possible by miniaturization of regulator design, in turn feasible as a result of making the regulator function on pneumatic principles. The forces required to operate the mechanical linkage between the demand valve and control diaphragm of a panel-mounted regulator are such that the regulator must necessarily be large in order to accommodate the large diaphragm needed to minimize resistance to inspiration. An alternative method is to make the link between the demand valve and diaphragm a pneumatic one in which the flexible demand valve is controlled by gas pressure applied to its opposite (back) side. A typical servo-controlled regulator of this type is shown at Fig 13.

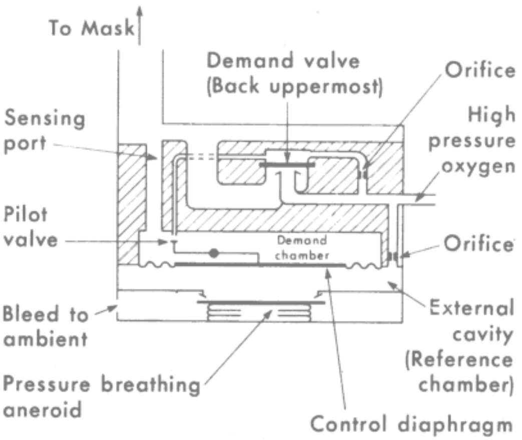


Fig 13 A Typical Servo-Controlled Demand Regulator.

The controlling pressure is determined by a second (pilot) valve itself controlled by a diaphragm and mechanical link. Pressure transmitted from the mask cavity to the demand chamber on inspiration displaces the control diaphragm and opens the pilot valve. The pressure on the back of the demand valve (upper surface in Fig 13) falls and it opens, so allowing oxygen to flow to the user. Safety Pressure and Pressure Breathing can be achieved by gas loading the control diaphragm to increase the pressure in the cavity surrounding its external surface. The loading is accomplished by means of a bleed flow into the cavity from the high pressure supply. The external cavity pressure is raised by means of an aneroid the expansion of which, with altitude, increases the resistance of flow to ambient. The great advantage of these servo-controlled regulators is the magnification of the control link made possible by the gas linkage. As a result, the size of the control diaphragm can be greatly reduced (typically to a diameter of 2-3 cm compared with the 8-10 cm diameter needed in purely mechanical regulators) so allowing an overall reduction in the size of the regulator. Mounting the regulator on the man has several other advantages over panel-mounted regulators, including ease of servicing and ready accessibility. The miniature man-mounted regulators in current service are described below and their features are summarized at Annex B.

a. *Type 317A Miniature Man-Mounted Demand Regulator.* Type 317A regulators are used in Phantom and Harrier aircraft and are designated 317A Mk 1 and 317A Mk 2 respectively. The only difference is the angle at which the inlet fitting is mounted

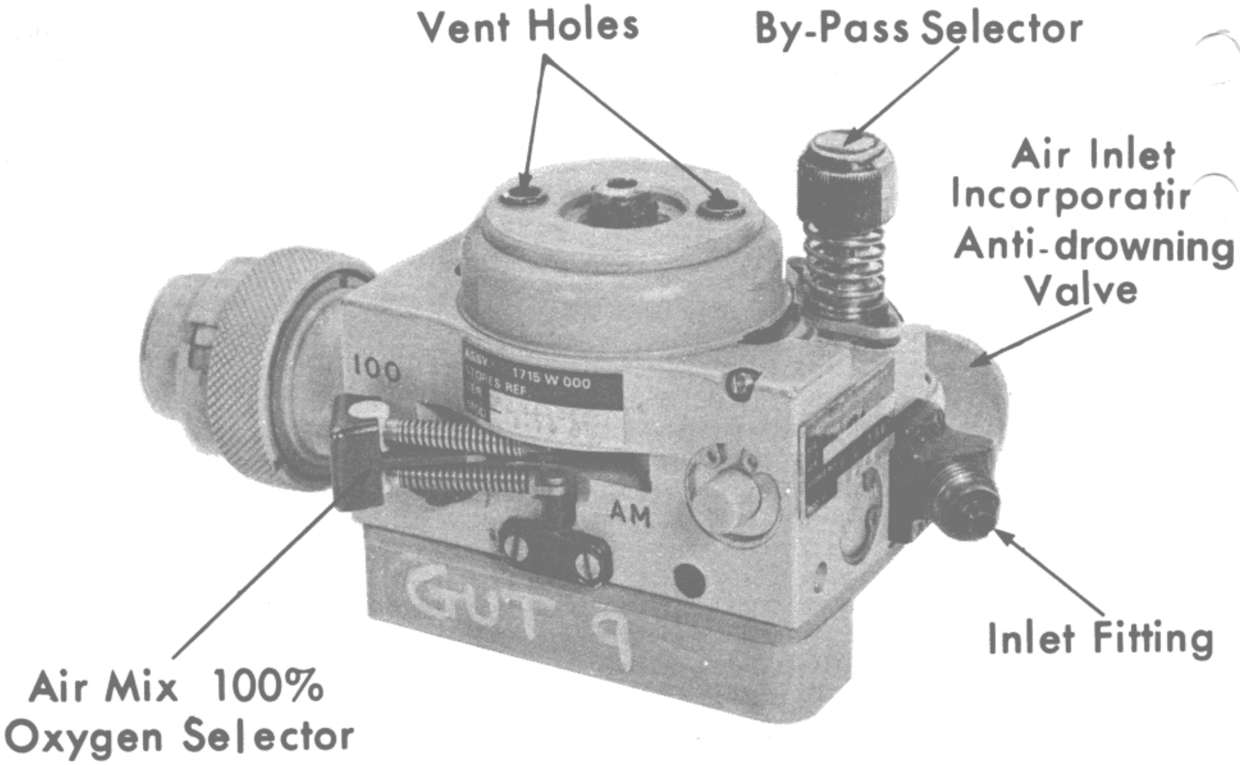
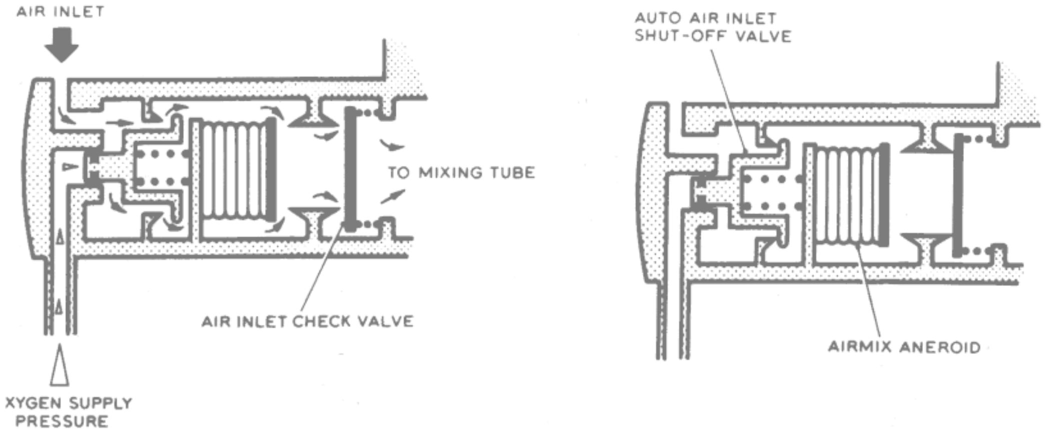


Fig 14 Type 317A Mk 2 Regulator.

at the bottom of the regulator. This fitting accommodates the high pressure oxygen hose which is routed from the left in the Phantom and from the right in the Harrier. An illustration of the Type 317A Mk 2 regulator is at Fig 14.

The regulator is mounted on the chest plate of the life-preserver with a connection for the mask hose at the top. The regulator provides the usual automatic functions of Airmix (with 100% oxygen supplied above 34,000 feet), Safety Pressure (operating at altitudes above 15,000-18,000 feet) and Pressure Breathing (to a maximum altitude of 50,000 feet). Since the regulator is man-mounted, contents and flow indications are remoted to positions elsewhere in the cockpit. A further complication, that of still being connected to the regulator on water entry after ejection, is countered by the addition of an Automatic Air Inlet Shut-Off (or Anti-Drowning) assembly. This is incorporated within the air inlet and shuts automatically under a spring load should the oxygen supply cease – as it would on man-seat separation after ejection - or fall below a predetermined level in flight. Inspiration is then only possible through the mask anti-suffocation valve and requires a greater effort than usual; thus serving to warn the user of failure should it occur at altitude (see also para 40c). The configuration of the shut-off valve under normal and failed conditions is shown at Fig 15.



a. Normal Oxygen Supply. b. Oxygen Supply Failed.

Fig 15 Configuration of Automatic Shut-Off Valve.

The following manual selections are available:

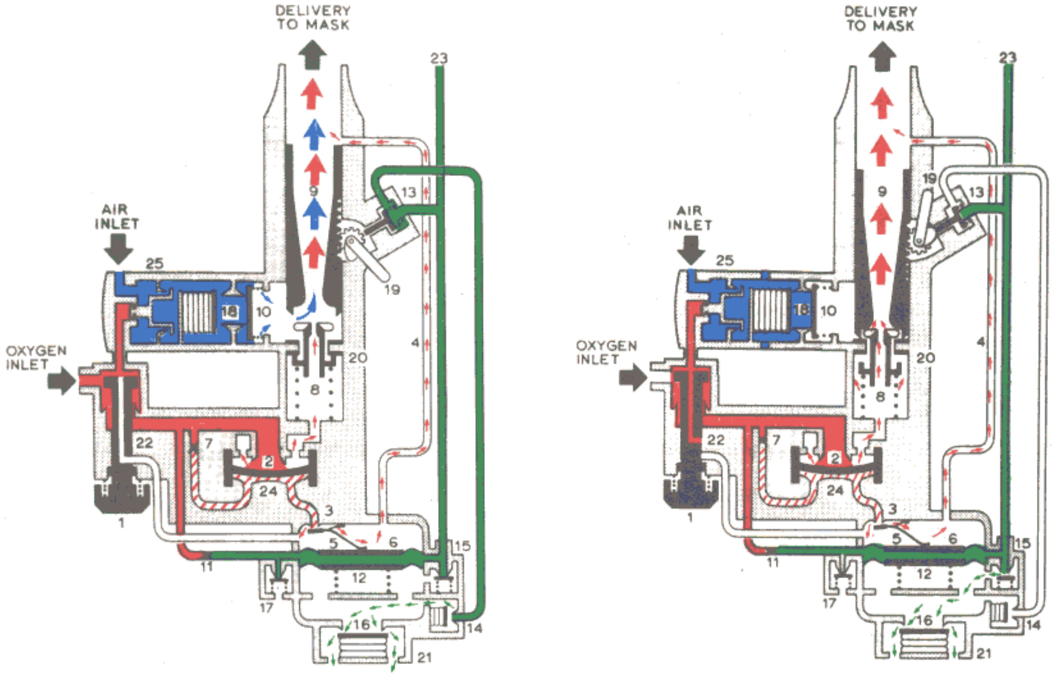
(1) **AM/100.** A two-position Airmix/100% Oxygen selector switch is located on the side of the regulator. Airmix (AM) selection provides normal regulator function. Selection of 100 provides 100% oxygen at any altitude by closing the air inlet. It is used should a toxic hazard arise in the cockpit and automatically delivers safety pressure at all altitudes as well. Diagrams illustrating regulator operation when AM and 100 are selected at Figs 16a and b respectively.

(2) **Bypass.** A yellow, spring-loaded By-pass selector knob is mounted on the front of the regulator. The by-pass control is normally in the depressed position, the knob being pushed in and rotated counter-clockwise to accomplish this. In this position the main regulator operates normally: the by-pass valve being held shut under a spring pressure (as in Figs 16a and b). Should the automatic function of the regulator fail or become suspect, a metered (11-14 litres per minute) continuous flow of oxygen direct to the mask is established by pressing the by-pass knob in, rotating it clockwise and releasing. The control then rises under spring pressure, opens the by-pass route and shuts off the supply to the main regulator. This is illustrated at Fig 16c. Note that the continuous flow will be reflected in the cockpit by the appearance of a continuous white magnetic indicator.

(3) *Vent Holes.* Two Vent Holes are also located on the front of the regulator through which an integral aneroid capsule senses cabin altitude. The integrity of the delivery system and adequacy of the mask seal can be tested by covering the two holes with the finger-tips and checking that there is an increase in delivery pressure and that the magnetic indicator alternates black/white through several breathing cycles.

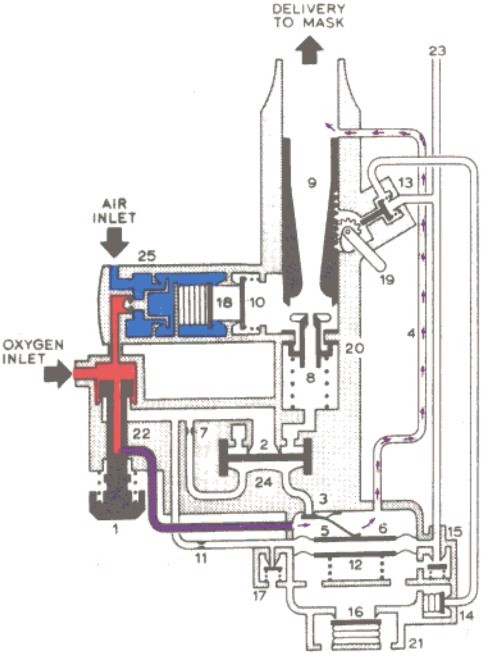
A V1 type oxygen mask must be used with the 317A regulator. Other types of mask are not compatible since control of the mask expiratory valve compensation is from the reference chamber of the regulator and the connection between the two requires a special tube, (see Para 36b).

b. *Type 417A Mk 2 Miniature Man-Mounted Demand Regulator.* Type 417A Mk 1 regulators are used in Jaguar aircraft. An illustration of such a regulator is at Fig 17. (NB) The Mk 1 designation refers soley to an alteration in the material used for the pressure breathing aneroid). The regulator assembly comprises a main regulator and a standby regulator both of which are of the



'AM' SELECTED

'100' SELECTED



BY-PASS VALVE OPERATED

KEY

1. BY-PASS VALVE
2. DEMAND VALVE
3. PILOT VALVE (CLOSED BY SPRING-LOADED PADDLE
4. SENSING LINE
5. PADDLE
6. SENSING DIAPHRAGM
7. ORIFICE - DEMAND VALVE CONTROL
8. INJECTOR NOZZLE
9. MIXING TUBE
10. AIR INLET VALVE
11. ORIFICE - PRESSURE BREATHING CONTROL
12. FOLLOWER DIAPHRAGM
13. SHUT-OFF VALVE
14. SAFETY PRESSURE ANEROID
15. SAFETY PRESSURE RELIEF VALVE
16. PRESSURE BREATHING ANEROID
17. MAXIMUM PRESSURE RELIEF VALVE
18. AIRMIX ANEROID
19. AIRMIX SELECTOR LEVER
20. INJECTOR NOZZLE SEAT
21. BLEED VENTS (PRESS-TO-TEST)
22. ORIFICE - BY-PASS FLOW
23. EXPIRATORY VALVE COMPENSATION CONNECTION
24. MONITOR CHAMBER
25. AUTOMATIC AIR INLET CLOSING VALVE

🟥	OXYGEN - SUPPLY PRESSURE
▨	OXYGEN - SERVO PRESSURE
🟩	MANIFOLD PRESSURE
🟦	AIR
🟪	EMERGENCY BY-PASS

Fig 16 Type 317A Regulator: Function.

demand type and are pneumatic in principle of operation. The assembly is mounted on the chest plate of the user's life-preserver with a connection for the mask hose at the top and an angled inlet connection at the bottom. The main regulator provides the usual automatic functions of Airmix (with 100% oxygen being supplied above 27,500-33,000 feet), Safety Pressure (operating at altitudes above 14,000-15,000 feet) and Pressure Breathing (to a maximum altitude of 50,000 feet).

Contents and flow indications are remoted to positions elsewhere in the cockpit. The main regulator also incorporates an anti-drowning device which shuts off the air inlet to the regulator whenever supply pressure falls; as in selection of the standby regulator or following ejection. The following manual selections are available:

(1) **Airmix/100%.** A two position, spring-loaded, snap-over lever is located on the face of the regulator. Selection of Airmix provides normal main regulator function. Selection of 100% overrides the dilution mechanism by closing the air-inlet valve and the safety pressure/pressure breathing valve. Thus, with the lever in this position, the regulator provides 100% oxygen, together with safety pressure, at all altitudes. It is used should a toxic hazard arise in the cockpit or when an in-flight emergency occurs. Diagrams illustrating regulator operation

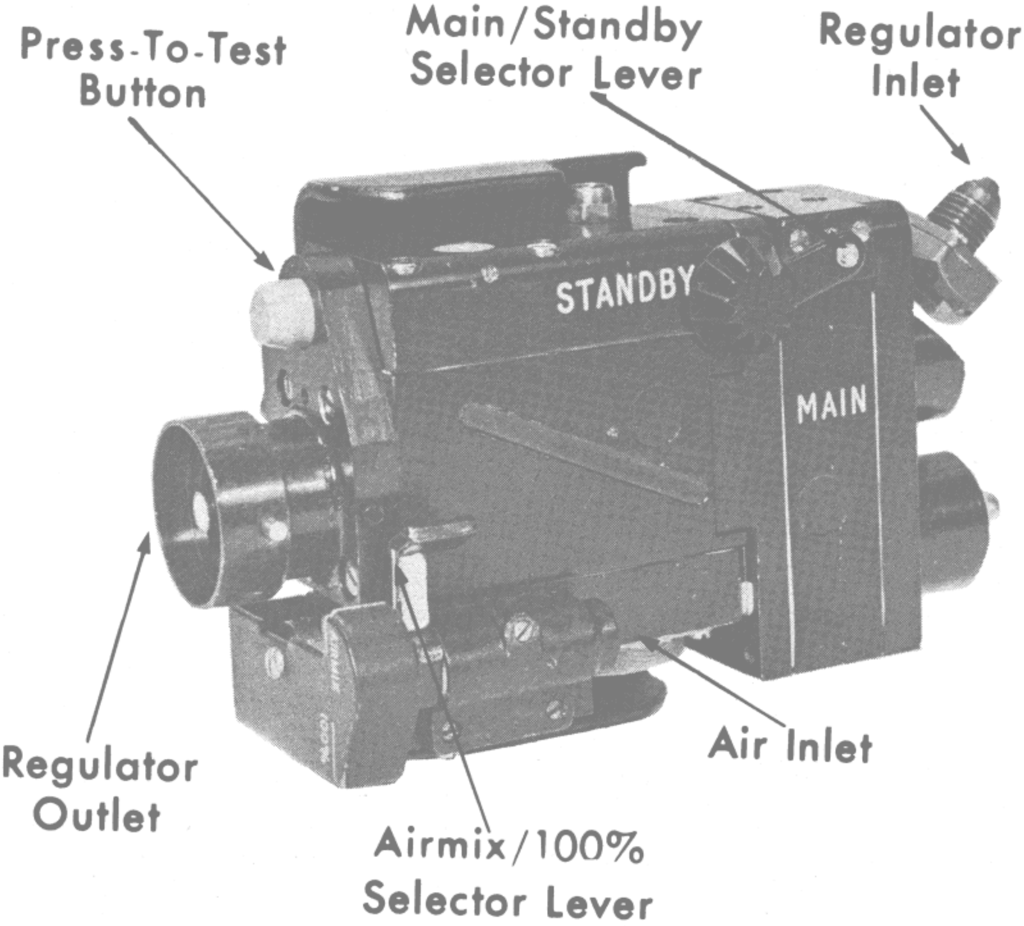


Fig 17 Type 417A Mk 1 Regulator.

when Airmix and 100% are selected are at Figs 18a and b respectively.

(2) **Press-to-Test**. A Press-to-Test button, located on the top of the regulator, closes the bleed-to-atmosphere vent when depressed. This directs the bleed through a relief valve incorporated within the button and produces a stabilised pressure build-up when a mask is fitted and connected correctly. It thus provides a ground level check of the mask seal and integrity of the system.

(3) **Main/Standby**. A two position Main/Standby selector lever is located at the bottom of the regulator face. Selection of Standby operates a changeover valve, so cutting off the oxygen supply to the main regulator and directing it to the standby regulator. Only 100% oxygen, with safety pressure from sea level, is delivered by the standby regulator. It also provides pressure breathing above 39,000 feet. Operation of the Standby regulator is illustrated at Fig 18c.

A V2 type oxygen mask must be used with the 417A regulator. Other types of mask are not compatible since control of the mask expiratory valve compensation is from the reference chamber of the regulator and the connection between the two requires a special tube, (*see* Para 36b).

c. *Type 417 Mk 2 Miniature Man-Mounted Demand Regulator.* The Type 417 Mk 2 regulator is used in Nimrod aircraft where it forms part of the emergency oxygen system for the aircrew: the primary protection against oxygen lack being provided by the high differential pressure cabin. It is also used when toxic fumes contaminate the cabin. The regulator is illustrated at Fig 19.

The regulator is similar in operation to the Type 417A regulator described above in that it provides Airmix/100% Oxygen and Safety Pressure facilities. However, since it is essentially an emergency system, there is no standby regulator in the assembly and there are no Pressure Breathing or Press-to-Test. facilities. (NB The latter were incorporated in the earlier Type 417 and 417 Mk 1 regulators: the redundant ports and threaded holes are sealed off in the Type 417 Mk 2). In addition, the mounting plate found on the Type 417A regulator is replaced in the Type 417 by a purpose built regulated holder, illustrated at Fig 20, into which the regulator clips. The holder connects the oxygen supply to the regulator and the regulator to the oxygen mask hose. It also incorporates a spring-loaded clothing attachment clip to allow easy man-mounting of the complete assembly. The holder was introduced to allow for rapid change to a spare regulator should the need arise. A T1 type oxygen mask must be used with the 417 regulator (*see* Para 36c). Other types of mask are not compatible.

31. **Seat-Mounted Pressure Demand Regulators.** As a result of a review of available sites for mounting demand regulators within the cockpit, a seat mounting has been re-introduced for the Hawk and Tornado. (A seat-mounted Type 120 regulator has always equipped the T Mk 5 Lightning aircraft). Seat-mounted regulators offer several important advantages over other sites. These advantages include:

– *Less Susceptibility to Damage.* Miniature man-mounted regulators are vulnerable to damage: a high proportion of associated unserviceability has been attributed to blows sustained by the regulators during donning/doffing and during cockpit entry/exit.

– *Reduction in Amount of Equipment Carried on the Man.* Any reduction in the amount of equipment carried in an already bulky assembly is helpful, particularly since there is so little space available on the man when compared with the seat.

– *Larger Regulator Assembly.* Since more space is available on the seat, the regulator can be made large enough to provide more comprehensive protection against component failures.

– *Duplication of Regulators.* Duplication of regulators increases the flexibility and operational capability of the system (eg main or emergency oxygen supplies can be used through either of the regulators).

– *Fewer Regulators Required.* The total number of regulators required for an aircraft

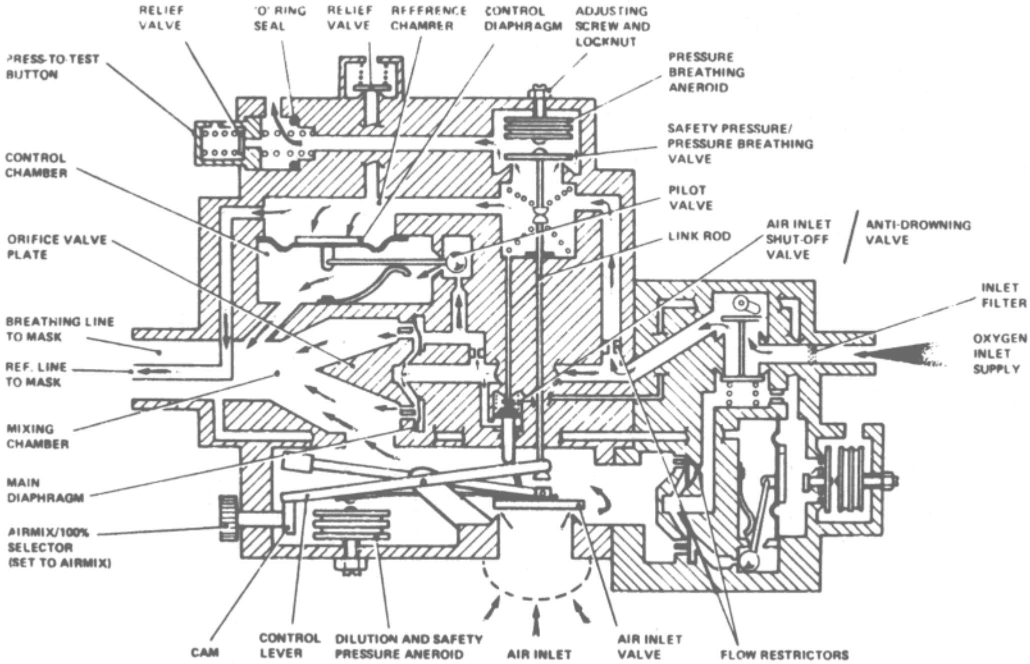


Fig 18a 417A Regulator - Airmix Selected.

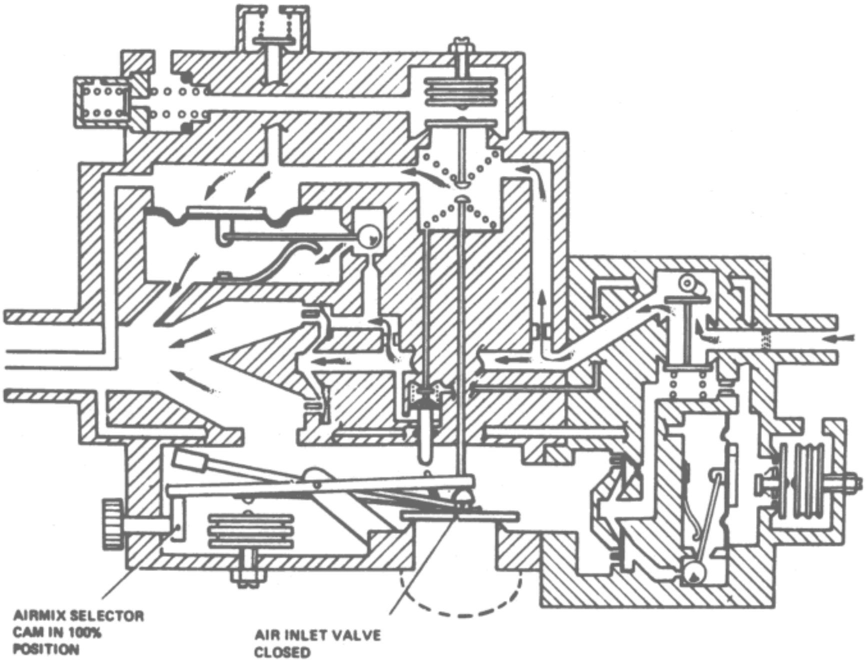


Fig 18b 417A Regulator - 100% Oxygen Selected.

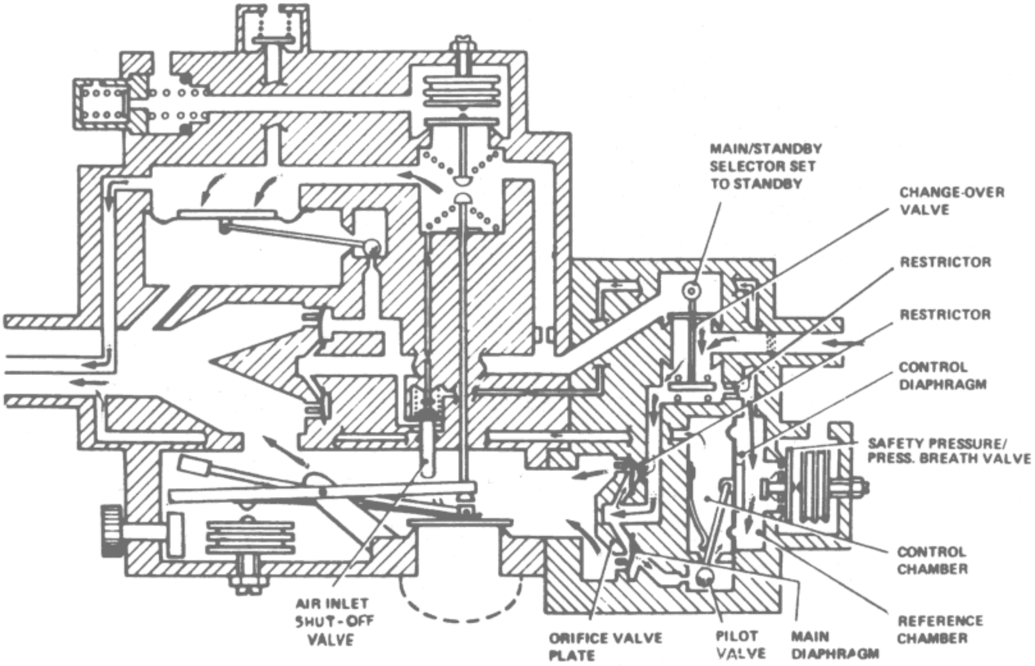


Fig 18c 417A Regulator - Standby Selected.

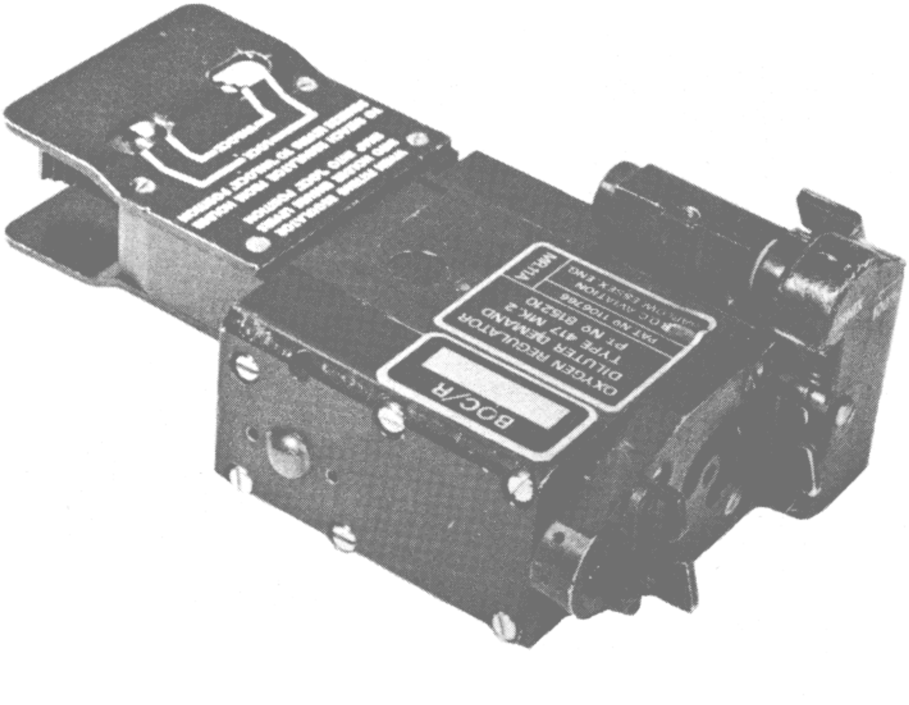


Fig 19 Type 417 Mk 2 Regulator.

fleet is considerably less than the number required when demand regulators are issued personally to all aircrew.

Seat-Mounted Pressure Demand Regulators in current use are:

a. *Type 517 Seat-Mounted Demand Regulator.* Type 517 regulators are mounted on the seat portions of the Personal Equipment Connectors (PECs) of the Mark 10 series Martin Baker ejection seats fitted to the Hawk and Tornado aircraft. Respectively, the regulators are located on the left- and right- hand sides of the seats in these aircraft. A Type 517 regulator is illustrated at Fig 21. The principle of its operation is pneumatic servo-control (*see* Para 30). The regulator assembly consists of a demand airmix regulator and a separate 100% oxygen demand regulator together with a change-over valve and associated relief valves. The Airmix regulator provides the usual automatic functions of Airmix (to an altitude of 34,000 feet above which 100% oxygen is delivered), Safety Pressure (applied at altitudes above 15,000 feet) and Pressure Breathing (operating at altitudes above 39,000 feet to a maximum of 50,000 feet). There is also a facility for automatic closure of the air inlet in the event of oxygen supply failure or if the supply pressure drops below a pre-determined level. Contents and flow indications are remoted to positions elsewhere in the

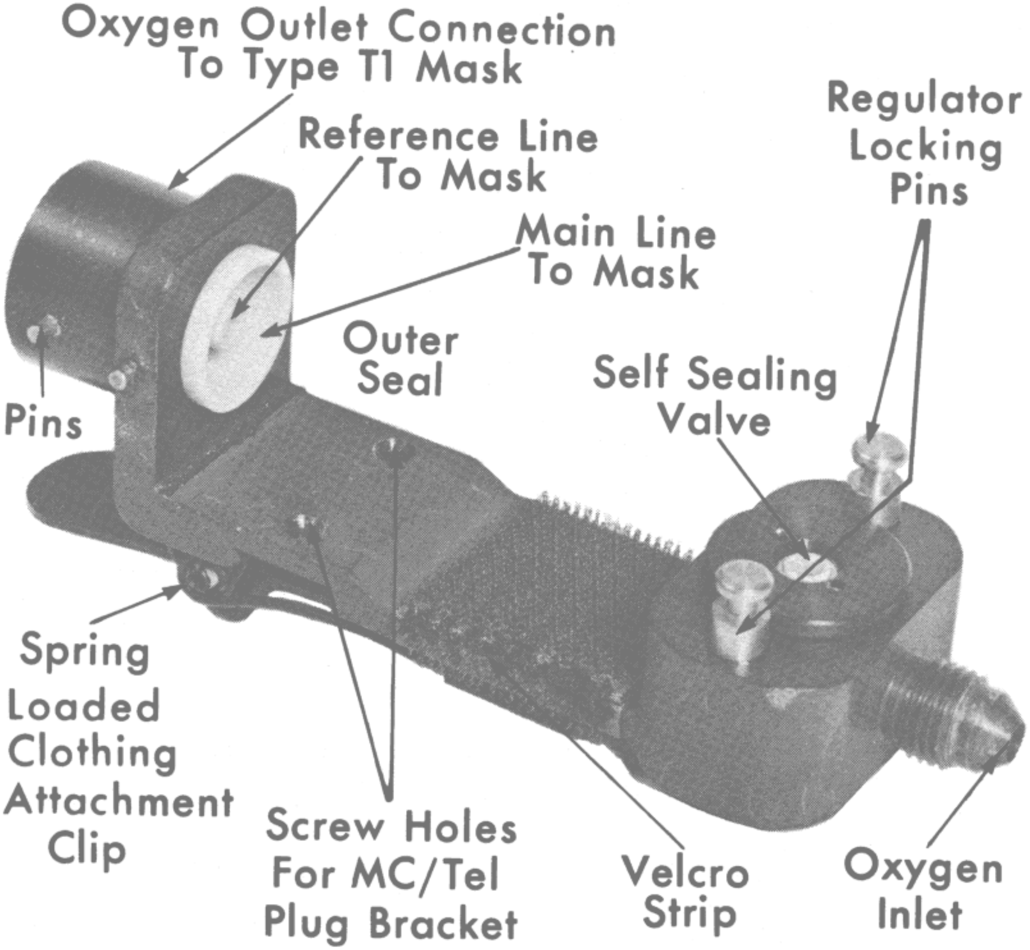


Fig 20 Oxygen Regulator Holder.

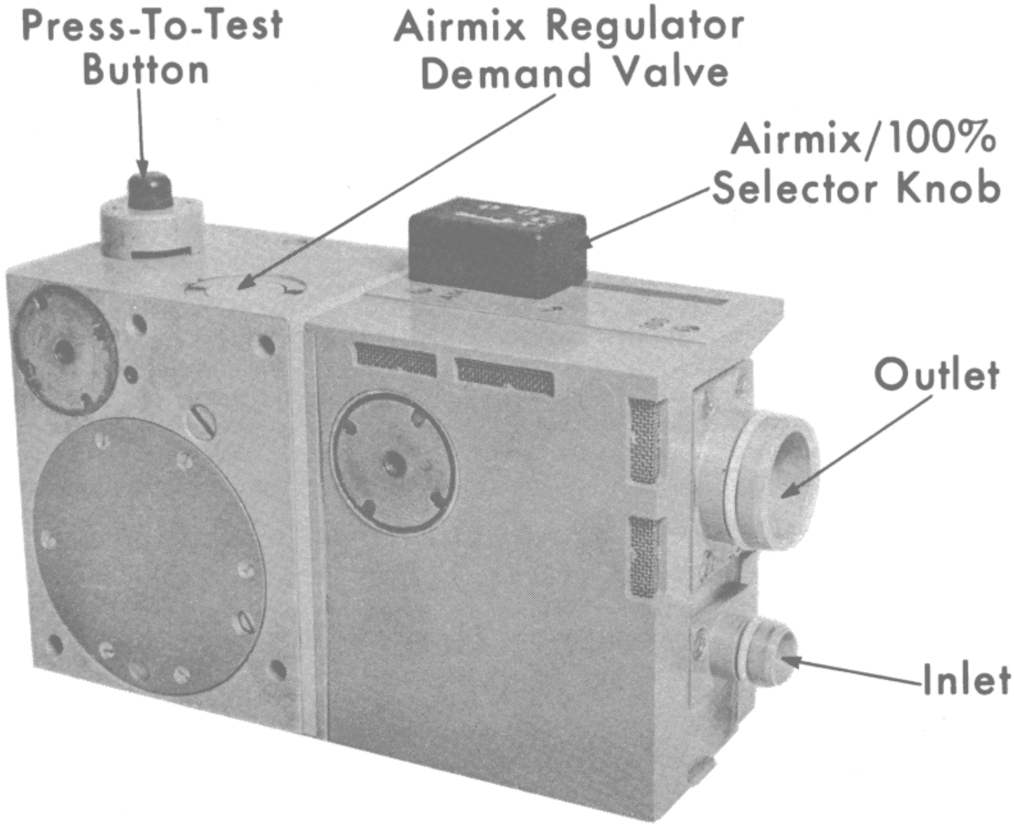


Fig 21 Type 517 Regulator.

cockpit. Finally, a pressure-compensated relief (dump) valve serves to vent any sudden increase in delivery pressure at the regulator outlet (eg on rapid decompression or on failure of the regulator). The valve is normally held closed by pressure from the control chamber. In addition there are two manual controls:

(1) **Press-To-Test.** A Press-to-Test button is located on the top of the regulator. When this is pressed in the aneroid bleed vent is closed, allowing pressure to build up in the pressure breathing control chamber and opening the servo valve so that pressure is delivered to the mask. This enables the user to check the fit of his oxygen mask and the delivery system for leaks. Excessive build-up of pressure is prevented by relief valves.

(2) **AM/100.** A two position spring-loaded lever is mounted on top of the regulator. When AM (Airmix) is selected the airmix regulator functions normally as described above. When 100 is selected the oxygen supply is diverted to the 100% regulator. The mechanism of this regulator is similar to that of the airmix one except that a safety pressure aneroid is not fitted. Safety pressure is delivered at all altitudes when 100% oxygen is selected. Also, in the 100% configuration, oxygen is fed directly to the regulator outlet so by-passing the injector. Oxygen loss via the air inlet is prevented by the check valve. Finally, the Press-to-Test facility is not available. An extension of

the AM/100 operating lever is connected to the emergency oxygen system so that should the latter be operated manually, the 100% regulator is automatically selected as well. The operation of the Type 517 regulator when in the Airmix and 100% oxygen configuration is shown diagramatically at Fig 22a and b respectively.

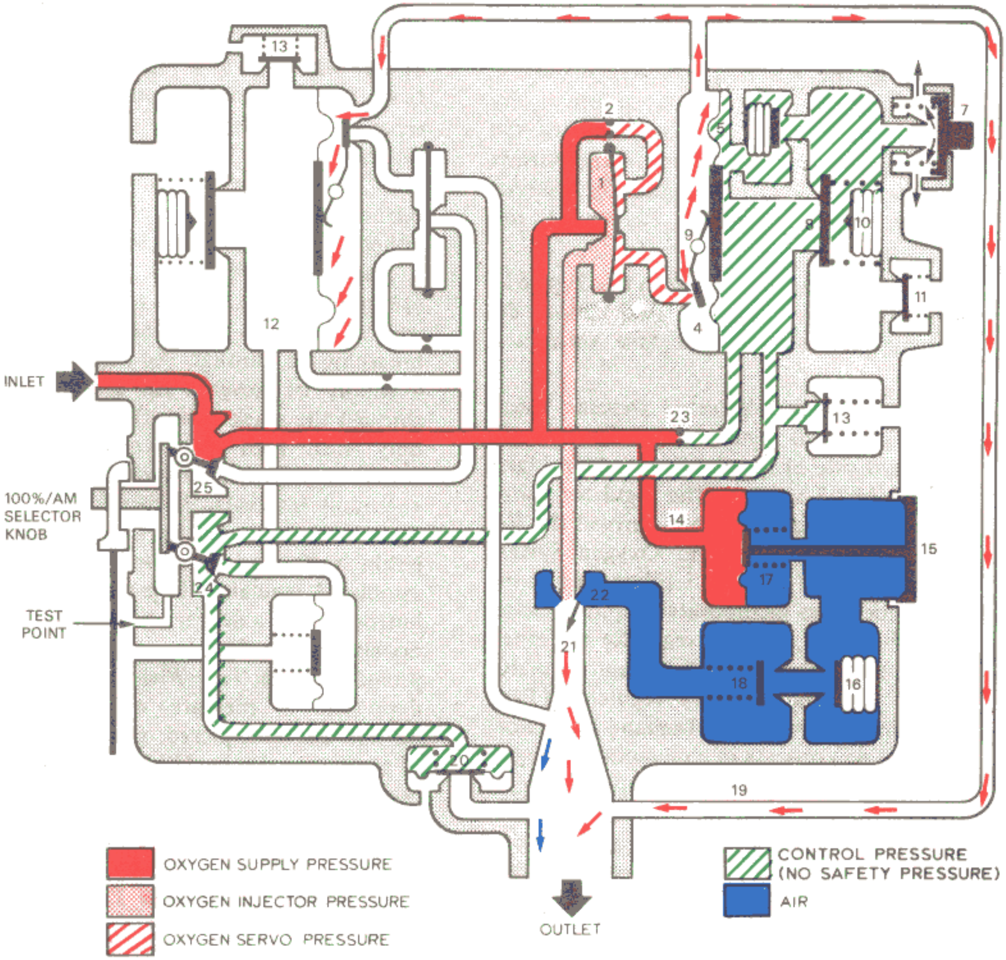
P/Q series masks are used with the Type 517 regulator: the numerical designation depending upon aircraft type, (*see* Annexes A and C).

b. *Type 120 Seat-Mounted Demand Regulator.* Type 120 regulators are fitted to the starboard side of the ejection seats in Lightning T Mk 5 aircraft. The regulator forms part of a bolt-on assembly, termed the Remote Controlled Demand Oxygen System Assembly Type 120 Mk 1 (illustrated at Fig 23), which also incorporates a quick disconnect plug, PEC, standby regulator and emergency oxygen bottle. The main regulator (Type 120) and standby regulator (Type 220 Emergency Oxygen Demand Regulator: *see* Para 45) operate in conjunction with the main and emergency oxygen supplies respectively: there are no facilities for selective changeover (compare with Type 517). The Type 120 regulator is illustrated at Fig 24.

The regulator operates on the pneumatic servo-control principle (*see* Para 30) and provides the usual automatic functions. Airmix is provided up to 34,000 feet: thereafter 100% oxygen is delivered. Safety Pressure is applied at altitudes above 14,000-15,000 feet and from ground level if 100% oxygen is selected. Pressure Breathing commences at 39,000 feet and the regulator can provide protection to a maximum altitude of 70,000 feet (the correct aircrew protective clothing must of course be worn when operating at such altitudes: the regulator was originally designed for use with the Partial Pressure Helmet). Contents, pressure and flow indications are remoted around the cockpit as are the manual controls. Thus, selection of 100% oxygen is accomplished by operation of an Airmix/100% oxygen switch mounted on a panel in the cabin. Such a selection also delivers safety pressure at any altitude. It is used in the event of toxic fumes in the cockpit or if an in-flight emergency develops. The air inlet is closed on selection of 100% oxygen but there is also an automatic facility by which the inlet shuts if there is loss of oxygen pressure, either as a result of main supply failure or as a result of deliberately shutting off the source of supply. This is a 'fail safe' feature which prevents the user inadvertently breathing air through the regulator without a supply of oxygen. Air can be breathed through the mask anti-suffocation valve, but only with high inspiratory effect which would be sufficient to warn the user. Finally, a ground test valve is fitted at the end of each PEC. It is used for applying mask and jerkin tests during ground checks of the associated regulator. Depression of the port button allows a delivery pressure of approximately 26 mm Hg through the system and provides a Mask Test. When both buttons are depressed a pressure of approximately 52 mm Hg is delivered: this provides a test of the jerkin. Under NO circumstances must both test buttons be depressed unless a pressure jerkin is being worn.

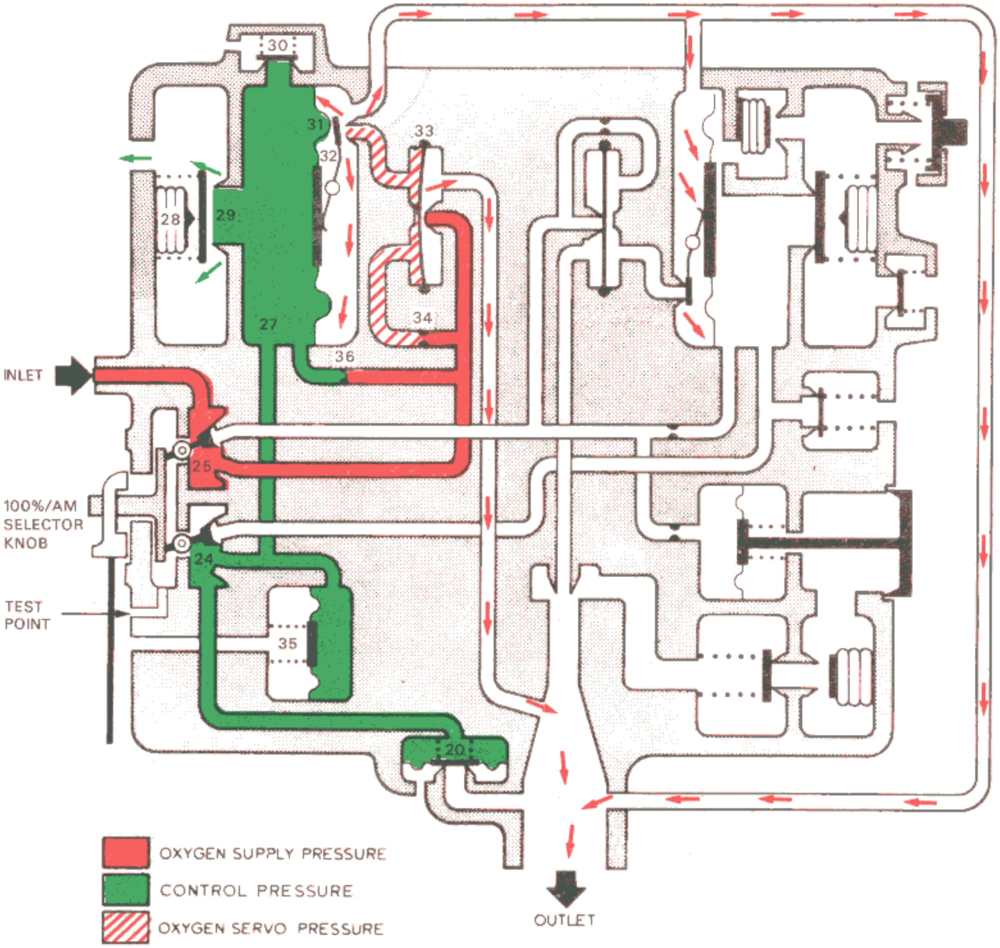
Oxygen Hoses and Personal Equipment Connectors.

32. From the oxygen source the delivery pipework is routed, via the regulator where this is panel-mounted, onto the seat. Here the hoses may be guide-mounted directly onto the seat side, or may pass to the seat-mounted regulator where fitted, or may plug into the seat portion of a Personal Equipment Connector (PEC). In the first situation (panel-mounted regulator) the inlet hose then plugs directly into the mask hose. In the second situation (seat-mounted regulator) the oxygen hose passes to the mask hose via the man portion of a PEC. In the third situation the man portion of the PEC may connect directly to the mask hose or, in the case of man-mounted devices, it must first pass through the regulator to which the mask hose is directly attached. The possible routings are summarized at Fig 25.



1	Demand valve	13	Maximum pressure relief valve
2	Servo bleed orifice	14	Flow limiting orifice
3	Demand valve control chamber	15	Air inlet valve
4	Servo valve	16	Airmix aneroid
5	Sensing diaphragm	17	Air inlet valve diaphragm
6	Safety pressure aneroid	18	Check valve
7	Press-to-test button	19	Sensing passage
8	Safety pressure control valve	20	Dump valve
9	Servo valve lever	21	Mixing tube
10	Pressure breathing aneroid	22	Injector nozzle
11	Press-to-test relief valve	23	Aneroid bleed orifice
12	Pressure breathing control chamber	24	Dump valve changeover valve
		25	Oxygen supply changeover valve

Fig 22a Type 517 Regulator – Airmix Selected.



20	Dump valve
24	Dump valve changeover valve
25	Oxygen supply changeover valve
27	Pressure breathing control chamber
28	Pressure breathing aneroid
29	Safety pressure control valve
30	Maximum pressure relief valve
31	Sensing diaphragm
32	Servo valve lever
33	Demand valve
34	Servo bleed orifice
35	Follower diaphragm assembly
36	Aneroid bleed orifice

Fig 22b Type 517 Regulator – 100% Oxygen Selected.

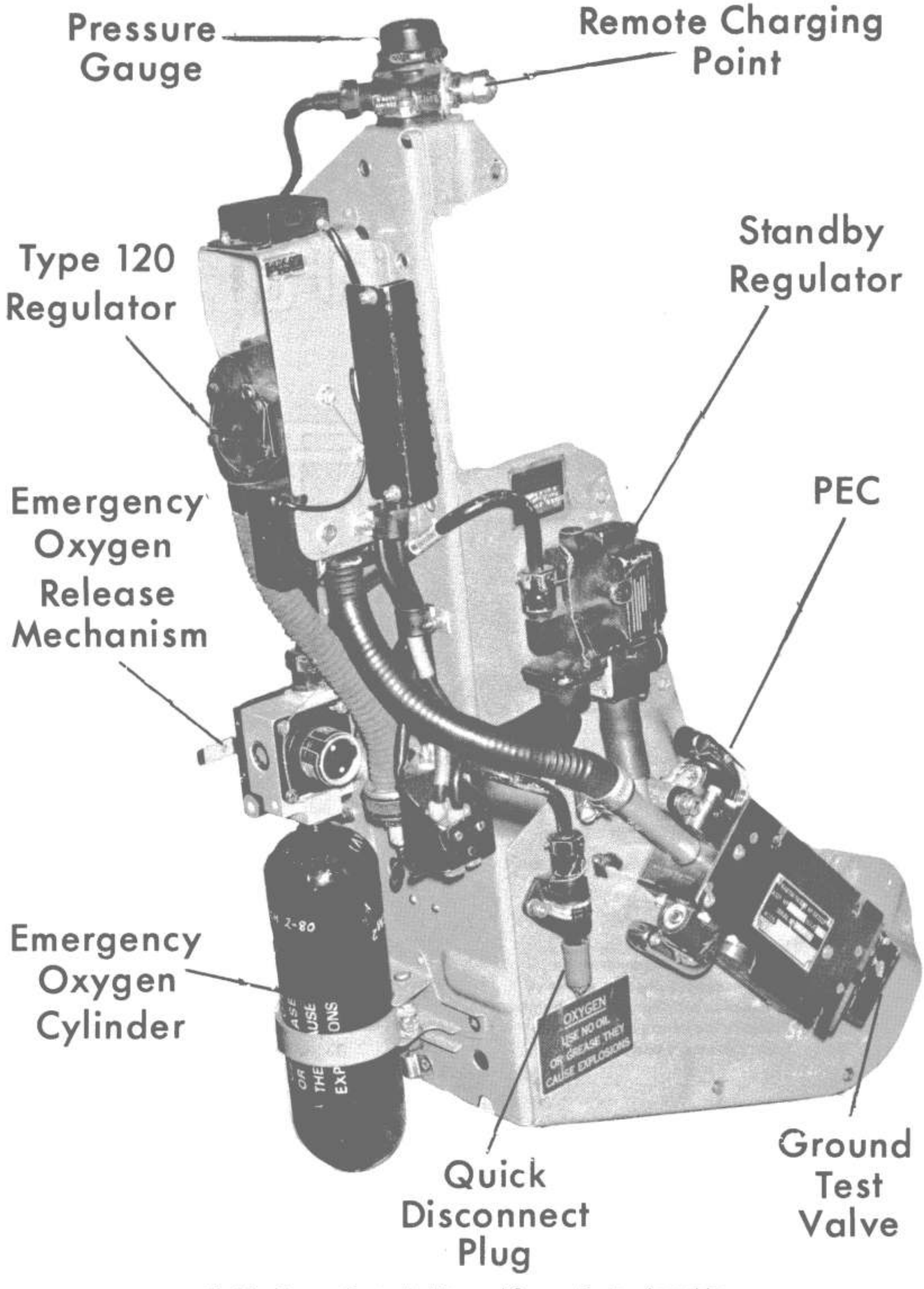


Fig 23 Remote Controlled Demand Oxygen System Assembly.

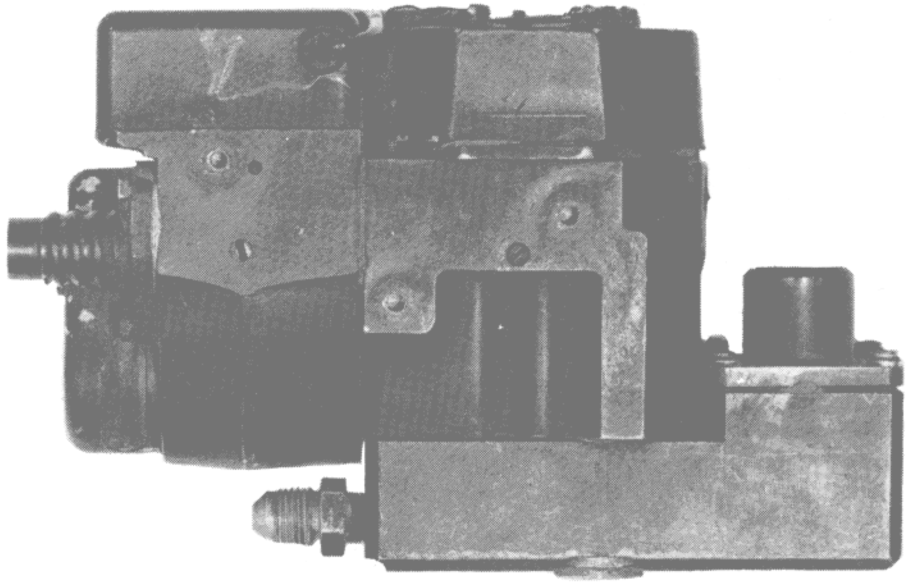


Fig 24 Type 20 Regulator.

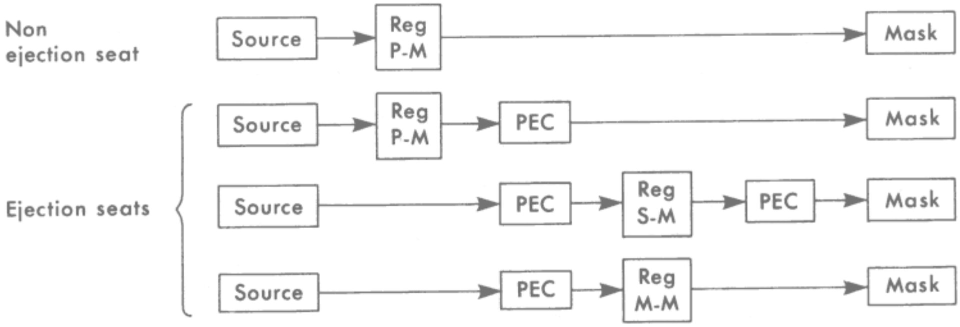


Fig 25 Routes of Delivery Systems
(P–M = Panel Mounted, S–M = Seat Mounted, M–M = Man Mounted)

33. Wide-bore oxygen hoses are only used after the regulator has stepped down the gas delivery pressure. They are made of extruded liners of natural or vulcanized rubber, reinforced by spirally-wound galvanised steel wire and covered with rubberized gauze or stockinette. They are anti-kink and incorporate various end-connectors to suit different aircraft oxygen systems.

34. The high pressure hoses (70 psi) used in conjunction with the servo-controlled regulators are made of narrow-bore anti-kink reinforced rubber.

35. A PEC is the usual means by which a user is connected to his services in an ejection seat aircraft. It is designed to couple and uncouple

these services by a single action. In addition to the main oxygen supply the PEC provides the channel by which the emergency oxygen supply, the G-trousers supply (if worn), the air-ventilated suit supply (if worn), the filtered air supply to the aircrew respirator (if worn) and the mic-tel are connected. On ejection, all service lines, except the emergency oxygen, are disconnected and sealed off automatically. A PEC consists of three, interlocking, main parts: the aircraft, seat and man portions.

a. *Aircraft Portion.* The aircraft portion is attached to the supply services from the airframe by anti-kink hose and remains in the aircraft at all times. All services in this portion are provided with valves which close automatically on disconnection, so preventing wastage of air and oxygen supplies. On ejection, a short static line unlocks the operating lever to allow the aircraft portion to fall away.

b. *Seat Portion.* The seat portion is bolted to the side of the ejection seat. Most services are provided with inner and outer connecting valves which close when either the aircraft or the man portion is removed. Mic-tel contacts are sunk beneath the surface to minimize the risk of damage to them when the man portion is connected or disconnected. A dust cover is provided to prevent damage to the valves and contacts when the seat is unoccupied.

c. *Man Portion.* The man portion forms part of the Oxygen Mask Hose Assembly which is issued as flying clothing to the individual. It is connected to the seat portion prior to flight. The G-trouser and air-ventilated suit connectors are detachable should these services not be required during flight. Dressing is also facilitated by their detachment. After flight the man portion is disconnected manually by use of the operating handle. On ejection, the man portion remains attached to the seat until man-seat separation when it is unlocked automatically either by the seat mechanics or by means of a pre-adjusted pull-off lanyard connecting the PEC to the user's lifepreserver.

In aircraft which use panel-mounted or seat-mounted regulators the oxygen hose connected to the man portion of the PEC is of wide bore (ie low pressure). In those aircraft which may require the use of a pressure jerkin, the oxygen hose incorporates a chest connector for attachment to the jerkin. A typical PEC and low pressure oxygen mask hose assembly is shown at Fig 26a. In aircraft which use man-mounted regulators the overall dimensions of the PEC are smaller, because of the cockpit configuration, and high pressure oxygen hose is used for connection to the regulators. In addition, the use of high pressure emergency oxygen in these systems has necessitated a change in the position of various valves and connections. Service ports not required are blanked off. A typical PEC and high pressure oxygen mask hose assembly is shown at Fig 26b. Details of PECs and oxygen mask hose assemblies in current service are summarized at Annex C.

Pressure Demand Masks and Mask Hoses.

36. Pressure demand oxygen systems require an oxygen mask which will maintain a face seal under raised breathing pressures. Those in RAF service at present are the P/Q series masks, for use with panel-mounted or seat-mounted regulators, and V (and T) series masks for use with man-mounted regulators. Details of these masks are given below and their features are summarized at Annex D.

a. **P/Q** *Masks.* P and Q masks are identical except for size, the latter being smaller. Numerical suffixes (eg P2/Q2) serve to distinguish masks used with different aircraft systems: these distinctions are shown at Annex D. A typical type P/Q mask is illustrated at Fig 27.

The mask consists of a hard fibre-glass exoskeleton containing a soft rubber moulded face-piece with a reflected edge which provides the self-sealing property: as pressure builds up in the mask, the seal is pressed harder onto the face. Moulded into the bridge of the hose is a strip of malleable metal which can be shaped to improve the fit around the wearer's nose. The mask incorporates several features:

(1) *Chain Toggle Harness and Toggle Lever.* A chain type harness is mounted

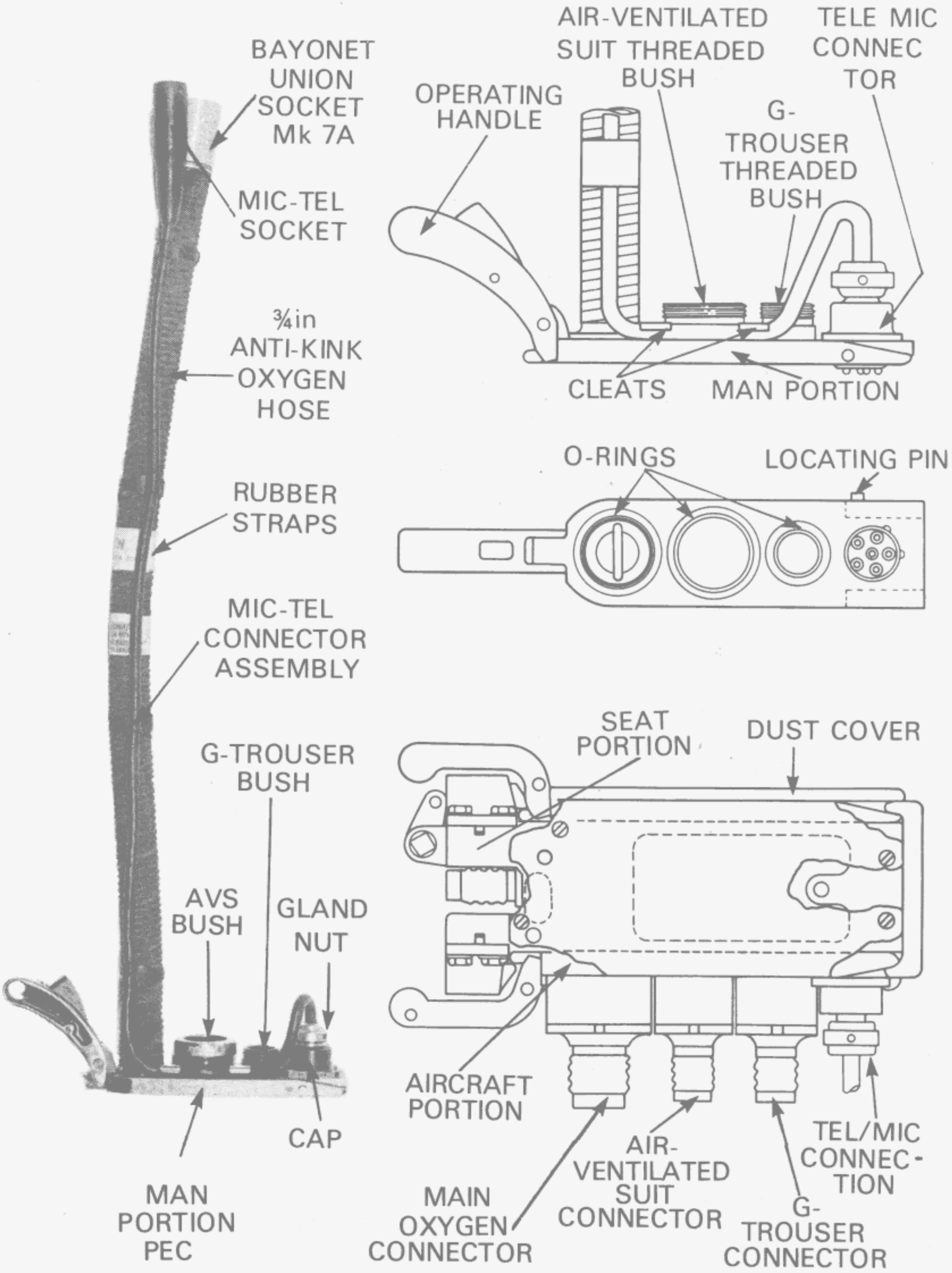


Fig 26a Typical PEC and Low Pressure Oxygen Mask Hose Assembly.
(eg Lightning F Mks 3 and 6)

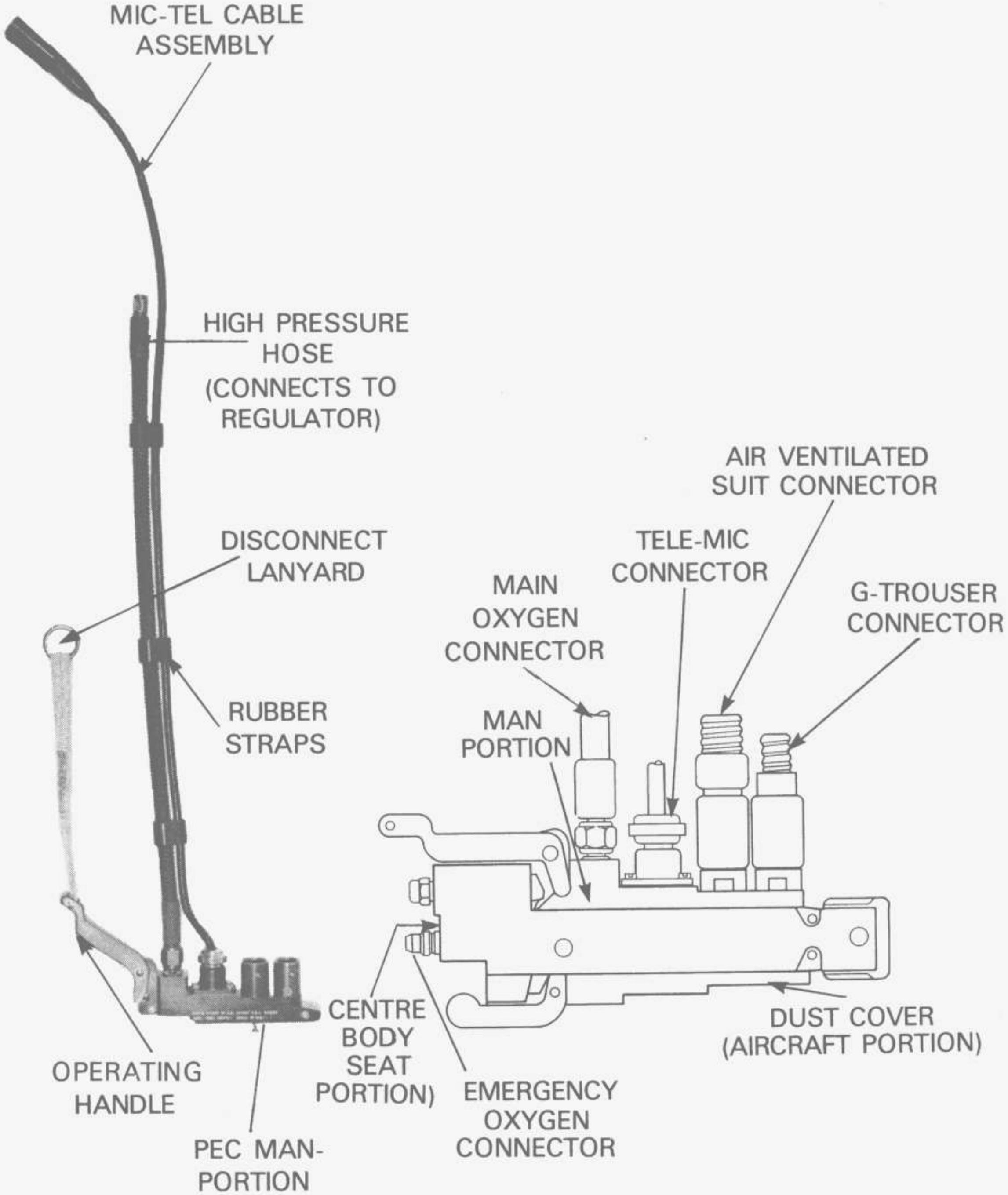


Fig 26b A Typical PEC and High Pressure Oxygen Mask Hose Assembly.

(Phantom)

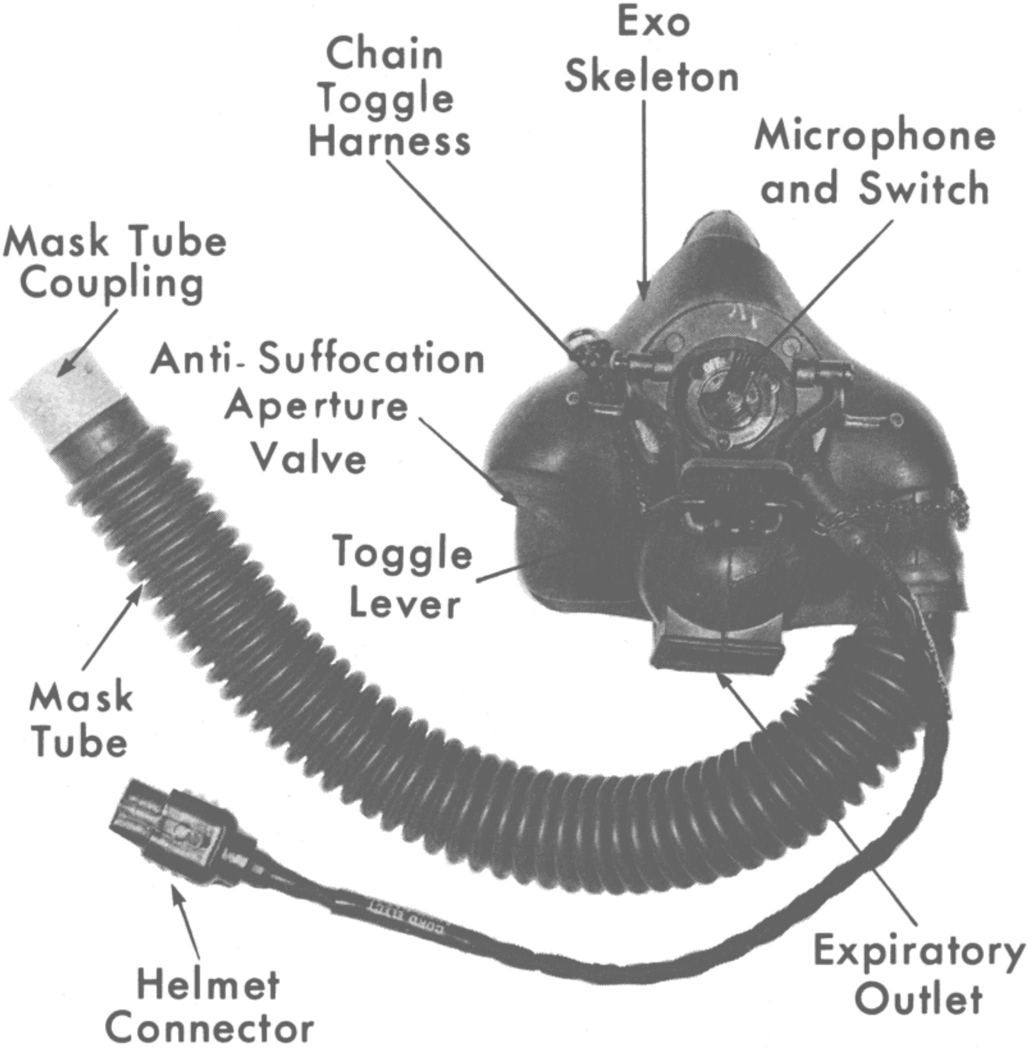


Fig 27 Typical Oxygen Mask of the Types P and Q Series.

on the front of the exoskeleton. On each side it then runs over a shaped metal bow (also mounted on the exoskeleton) which ensures correct routing. At each free end the chain has an oval link by which it can be attached to the aircrew protective helmet, thus securing the mask to the wearer's face. The chain may be further tensioned by rotation of the mask toggle lever: under normal conditions the toggle is said to be "up" (wide-ribbed extension uppermost) with the two chains bearing on the arms of the bow. When pressure breathing is undertaken the wearer rotates the toggle downwards so tightening the chains over the bow and clamping the mask against the face. It may also be used in this way to enhance the seal if toxic fumes are present in the cockpit although this is strictly unnecessary provided that safety pressure is being delivered.

(2) *Inspiratory valve.* An inspiratory valve is mounted in the left-hand side of

the mask. It is made of soft rubber and acts as a simple non-return valve, allowing oxygen to be breathed in but preventing expired gas from passing back down the oxygen inlet hose. A plastic mesh cover is fitted over the valve inside the mask as an ice-guard. This prevents any accumulation of moisture from coming into direct contact with the valve and so any ice formation does not compromise the function of the valve. In addition, the guard encourages formation of hoar frost, through which it is still possible to breathe, rather than solid ice.

(3) *Expiratory Valve.* The expiratory valve is mounted in the base of the mask to allow drainage of any moisture collecting within the mask cavity. It is protected by a thermal insulating, flexible rubber, outlet snout. The valve plate itself is metal and is held onto a metal seating by a very light spring which is overcome on expiration. In fact, this spring is too weak to hold the valve shut against even the small rise in mask cavity pressure generated by safety pressure from the regulator. It is therefore assisted by a compensating tube which feeds gas pressure from the inlet port to a diaphragm and piston on the reverse side of the expiratory valve. Such an arrangement is termed a Compensated Expiratory Valve and it ensures that the valve remains shut until expiration. However, should pressure in the inlet port be reduced for any reason the valve in this configuation would once again tend to open. For this reason the valve plate above is separated from the piston below by a second spring: this final arrangement is termed a Split Compensated Expiratory Valve. The system of valves is shown diagramatically at Fig 28.

Clearly, the correct functioning of a compensated expiratory valve is dependent upon the presence of a functioning

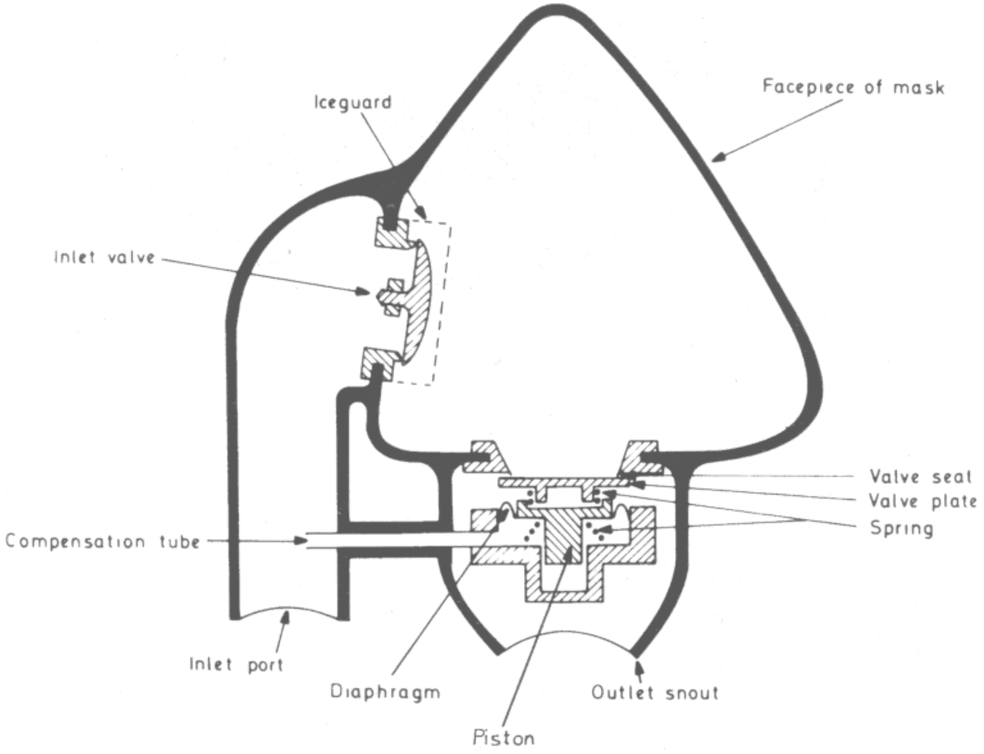


Fig 28 Valve System of a Pressure Demand Mask.

inspiratory valve since if the latter was absent or was to become wedged open by debris from within the mask cavity, expiratory effort by the user would be transmitted back down the inlet port and along the compensating tube to the back of the expiratory valve. Thus the expiratory valve would be held shut and expiration would be impossible.

(4) *Anti-Suffocation Valve.* An anti-suffocation valve is mounted in the right-hand side of those P/Q series masks which are used with a personal hose assembly incorporating a self-sealing 'prop' valve in the man portion of the PEC. (Such masks are distinguished by the additional suffix 'C'). A 'prop' valve is a device which closes the oxygen entry of the personal hose assembly automatically when the assembly is detached from the seat. The wearer then breathes air through the anti-suffocation valve. Closure of the 'prop' valve prevents water entering the breathing hose should ejection be followed by immersion. The anti-suffocation valve itself is an inward relief valve which opens when the pressure within the mask cavity falls to 9-13mm Hg below ambient pressure.

(5) *Microphone and Microphone Switch.* A miniature dynamic microphone and switch assembly is mounted above the expiratory valve in the front centre of the mask. An electrical cord assembly is attached to the microphone and connects it to the aircrew helmet via a plocket on the left-hand side of the latter.

The mask hose is secured at one end to the inlet connector of the mask and has at its distal end either a Mark 7 Bayonet Connector or an MC3A Inlet Warning Connector, (*see* Para 42). It is made of soft corrugated rubber tubing to allow for maximum movement. Some types are available in both standard and longer length versions; the latter are distinguished by the suffix 'A'. Additionally, in those aircraft from which high speed ejection is a possibility, the hose is strengthened by a straining cord passing through the mask tube from the bayonet connector to a ring located in the inlet connector. (The cord also reduces volume changes within the hose and hence minimizes pressure swings at the inlet port, which might otherwise cause difficulty in breathing out). The oxygen mask for these aircraft is further strengthened by replacing the link chain with a pin-type chain harness: kinking is prevented by locating a sleeve of rubber tubing over each chain.

b. *V Masks.* The V series masks are used with miniature man-mounted regulators: V1 masks with Type 317A (Phantom/Harrier) regulators and V2 masks with Type 417A (Jaguar) regulators. Both types of mask are available in large and small sizes and are essentially the same in design and construction as the P/Q series. A V1 mask is illustrated at Fig 29.

The V1 mask consists of an exoskeleton, to which is attached a chain toggle harness assembly, and a soft rubber face-piece which mounts the inspiratory and compensated expiratory valves, the anti-suffocation valve and the microphone assembly. These features are similar to those described above for the P/Q series masks except for the following differences:

(1) *Chain Toggle Harness Assembly.* Since high speed ejection is a possibility from aircraft in which the V1 mask is worn, the chain is of the bicycle pin-type (Peripin) for increased strength. A rubber sleeve over the chain prevents kinking.

(2) *Anti-Suffocation Valve.* The anti-suffocation valve in V masks works in conjunction with the anti-drowning facility incorporated in the man-mounted regulators, allowing the wearer to breathe when the latter operates (eg on water entry following man-seat separation after ejection or if oxygen delivery pressure falls), (*see* Paras 30a and b).

In addition, the mask hose is designed to attenuate regulator or cabin noise which might otherwise be transmitted to the microphone. It is made of an inner layer of Terylene fabric and an outer layer of silicone rubber with a layer of foam between. An integral wire coil supports the hose which is non-extendible and incompressible. At its

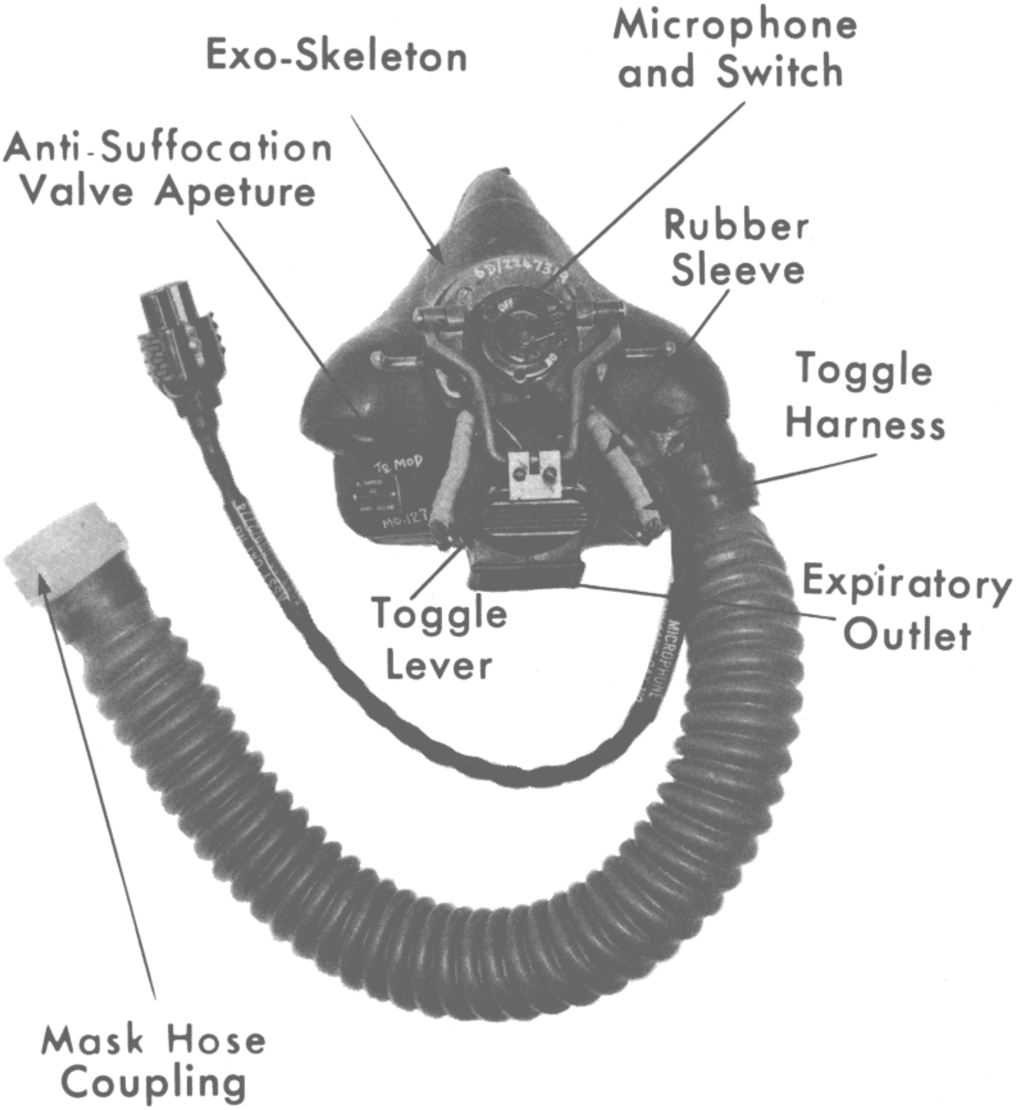


Fig 29 Type V1 Oxygen Mask.

distal end a mask hose coupling is attached which is designed to mate with the outlet of the type 317A regulator. Two connections must be made; one is the main breathing supply and the other is the compensation pressure supply from the reference chamber of the regulator to the expiratory valve. Located within the main coupling is another smaller coupling from which extends a pipe connector. A narrow bore silicone rubber tube (the Compensation Tube) connects this inner coupling with the back of the compensated expiratory valve. Thus, compensation of the expiratory valve is accomplished, via a closed system, by the regulator rather than by direct exposure of the valve to inlet pressure as in masks of the P/Q series. This latter system (described at Para 36a (3)) has several disadvantages:

– Changes in the length of the mask hose by head movement can cause a rise in the pressure within the hose which is transmitted to the back of the expiratory valve. The consequent increase in resistance to expiration may cause breathing difficulties and interrupt speech.

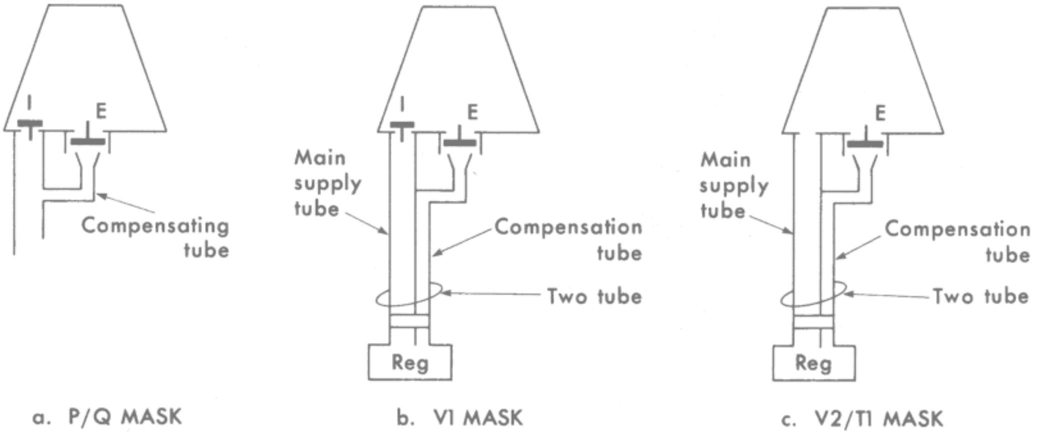
– A failure of the regulator demand valve to shut off immediately the inspiratory demand ceases causes a rise in mask hose pressure, which is again transmitted to the back of the expiratory valve, and hence expiratory difficulty.

– Failure of the demand valve in the open position will result in a very high pressure throughout the system and make expiration very difficult. Such a high flow failure could lead to lung damage.

– Difficulty in breathing out is also experienced during high rates of ascent with the accompanying fall in environmental pressure. Since gas between the regulator and inspiratory valve cannot escape or expand the differential pressure rises within the mask hose and hence within the compensation line. An extreme example of this phenomenon may cause lung damage on rapid decompression when expanding gas cannot escape from the lungs because the expiratory valve is being held shut.

The system of control of the expiratory valve by the pressure in the reference chamber of the regulator used in man-mounted regulators overcomes all these drawbacks. The system employs two seperate pneumatic connections between the regulator and the mask and works well when the distance between the two is relatively short. It is colloquially called the 'Two Tube' system and is shown diagramatically at Fig 30. It should be noted that, in a type V1 mask, a broken or badly connected compensation tube (so called 'two tube failure') will only be revealed by correct pre-flight checks: with such a fault selection of BYPASS will produce restriction on breathing out, whilst the two finger check will give only a slow build up of pressure, if any, (*see* Para 30a (2) and (3)). The V2 mask is identical to the V1 mask except for the following:

(1) An inspiratory valve is not fitted. The presence of a compensation tube renders the need for a non-return inspiratory valve redundant since expired gas cannot affect the compensation of the expiratory valve by applying back pressure to it, (compare with Para 36a (3)). However, this is only the case as long as the compensating tube is intact. If it is broken or connected wrongly then



a. P/Q MASK b. V1 MASK c. V2/T1 MASK

Fig 30 Expiratory Valve Compensation in Pressure Demand Masks.
(I = Inspiratory Valve, E = Expiratory Valve)

expired gas can be applied through the leak to the back of the expiratory valve and so make expiration impossible. Two Tube failure in the V2 mask is therefore instantly recognised by the user. (Compare with Two Tube failure in the V1 mask which may go un-noticed in flight). In fact, the presence of an inspiratory valve in the V1 mask is unnecessary. Its retention is a legacy of the original high altitude requirement of the mask which, when combined with the use of a pressure jerkin, did require such a valve to ensure that re-breathing could not occur.

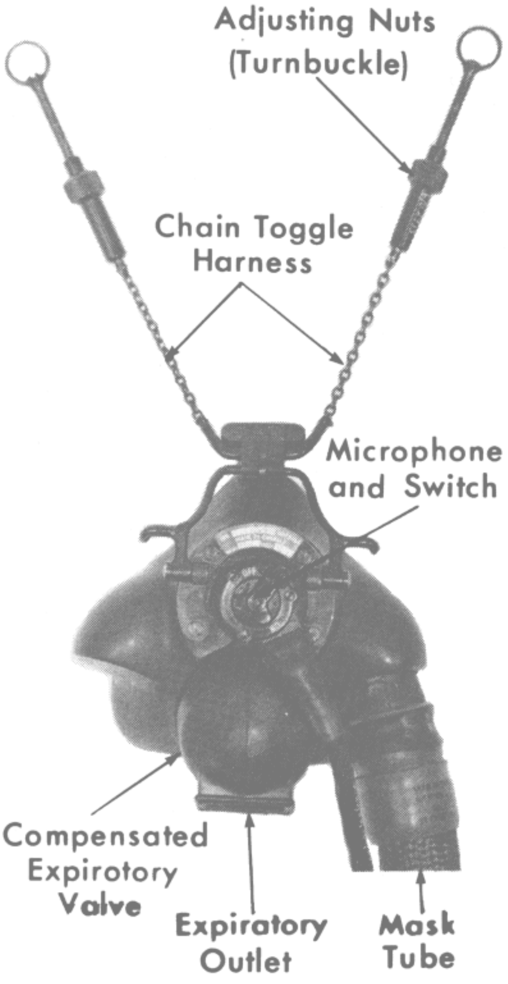


Fig 31 Type T1 Oxygen Mask.

(2) A bayonet type mask hose coupling is fitted for connection to the type 417A regulator. It incorporates a smaller coupling for the compensation tube.

c. *T1 Mask.* The T1 mask is used with the type 417 miniature man-mounted regulator in Nimrod aircraft and is worn in conjunction with a headset. The mask is available in a large and small size. A T1 mask is illustrated at Fig 31. The design and function of the mask is similar to that of the V2 mask described above. Thus, the normal exoskeleton and face-piece mount a toggle harness, a compensated expiratory valve and a microphone assembly. There is no inspiratory valve and expiratory compensation is from the reference chamber of the regulator via a two tube mask hose. This is shown diagramatically at Figure 30c. The chain toggle harness incorporates adjusting nuts which adjust the length and tension of the harness. The chains themselves are prevented from twisting whilst being tensioned

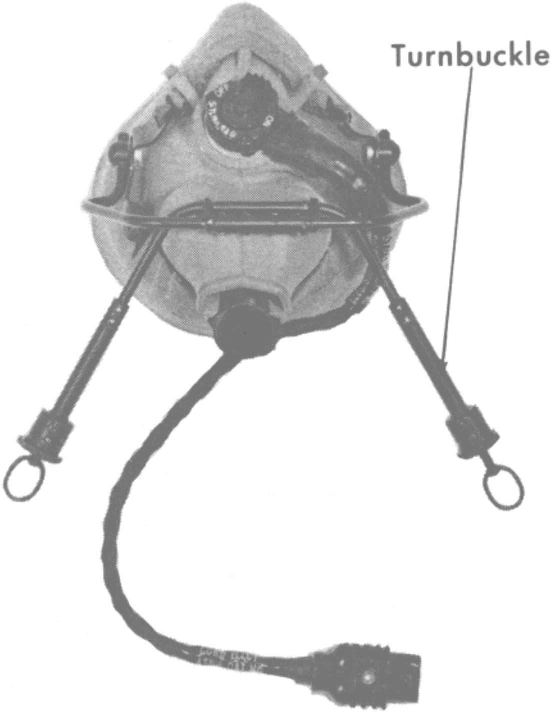


Fig 32 Type R Oxygen Mask.

by swivel links.

d. *R Mask.* The Type R mask is used in conjunction with the Type A-12A oxygen regulator in Jetstream aircraft, (*see* Para 29d). It is illustrated at Fig 32. The mask is identical to the Type H series masks (see Para 47d) except that it has no inspiratory valve and its mask hose assembly is different.

37. Special masks are available, on the recommendation of a medical officer, for personnel who are sensitive to the standard black rubber mix used in face pieces. Such 'medical' masks are made from silicone rubber and are either off-white or green in colour.

Faults and Corrective Drills

38. Malfunctions in the oxygen system are best understood and dealt with in the air by dividing them into modes of presentation to the user and then providing a table or flow chart detailing the corrective action to be taken. Such tables or charts form part of the Flight Reference Cards (FRCs) carried by each crew member.

39. Some malfunctions have been mentioned above when describing individual components. However, in flight, the precise cause of such failures is of much less importance to the user, who may be in considerable danger, than the need for a rapid and accurate response. Thus, any failure must be immediately and clearly obvious either as an objective indication in the cockpit or as a subjective effect on the man himself. The mode of presentation is then identified in the FRC and the required action taken.

40. The descriptions below expand upon the FRCs which apply to systems based on typical panel-mounted, seat-mounted and man-mounted regulators. The latter is the most complex since separation of the regulator from direct contact with the aircraft or seat services complicates the whole system considerably (eg Emergency Oxygen routing), increases the likelihood of problems within it and lengthens the drills necessary to correct such problems.

a. *Panel-Mounted System.* The 'Oxygen' Flight Reference Card (FRC) for a typical system (Buccaneer) based on a panel-mounted regulator is shown at Fig 33. The card is straight-forward and self-explanatory. Although it properly makes no mention of the causes of the faults, or of the reasons for the indicated actions, these may be worked out from a knowledge of the system. The following in particular should be noted:

(1) Whatever the problem, the first priority is to re-establish an oxygen supply. (NB A rapid descent to below 10,000 feet is not the way to combat hypoxia). The card always leads to operation of the Emergency Oxygen (EO) knob if the problem is not resolved very quickly. However, even the EO will be useless unless the hose connections are correctly made and hence the instruction to check connections comes before all else.

(2) Since the EO system has a finite duration, the aircraft is committed to a descent to 10,000 feet cabin altitude or below as soon as possible once the EO system has been operated.

(3) The commonest cause of a persistent black magnetic indicator is an electrical failure of the indicator itself, whilst that of a persistent white magnetic indicator is a leak in the system, usually from around the face mask seal.

(4) A restriction on breathing out is an indication of inspiratory valve malfunctions: the valve is held open by mask debris so that expired gas pressure acts on the expiratory valve from behind, via the compensating tube, and prevents it opening, (*see* para 36a (3)).

(5) Selection of 100% oxygen is used as a diagnostic test in that normal breathing thereafter indicates that the system is functioning, provided that all connections are intact and the mask is sealed.

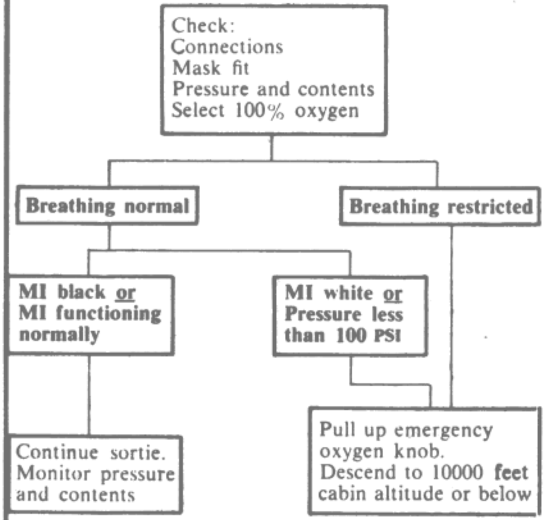
b. *Seat-Mounted System.* The 'Oxygen' failures FRC for a typical system (Hawk) based on a seat-mounted regulator is shown at Fig 34. The simplicity of the FRC is a reflection of the simplicity of the system to which it relates. The supplementary notes listed above for the panel-mounted system

OXYGEN FAILURES — P/Q MASK

Suspected Hypoxia or Contaminated Supply

Check connections, contents, flow and mask fit
Pull up the emergency oxygen knob
Descend to 10,000 feet cabin altitude or below
If oxygen contamination suspected — Regulators OFF

Difficulty in Breathing In *or*
MI Malfunction *or*
Oxygen Pressure Less Than 100 PSI



Difficulty in Breathing Out

Lift mask off face
Operate P to T EMERGY switch (to dislodge dirt under inlet non-return valve)

If Difficulty Persists

Ease edge of mask off face
Descend to 10,000 feet cabin altitude or below

SMOKE OR FUMES

100% OXYGEN
EMERGENCY switch sideways
Pressurisation OFF
Ram-air valve ON
Descend to below 25,000 feet ASAP

Fig 33. Typical FRC for System based on Panel-Mounted Regulator (Buccaneer).

apply equally to the seat-mounted. In addition, it should be noted that operation of the Emergency Oxygen system, whether manually or automatically on ejection, automatically selects the 100% oxygen regulator if this has not been done already, (*see* Para 31a (2)).

c. *Man-Mounted System.* The 'oxygen' failures FRC for a typical system (Phantom) based on a man-mounted regulator is shown at Figure 35. The complexity of such regulators is reflected in the increased complexity of the card which, while still being easy to follow, has more instructions than its counterparts described above. The following points should be noted in particular:

(1) Operation of the EO system is followed by subsequent selection of By-pass and Airmix. Selection of By-pass ensures that any fault within the main regulator is avoided, while selection of the Airmix makes inspiration easier. This is because, on By-pass, the EO supply alone cannot meet the users needs and, with the air inlet shut (ie with '100'

OXYGEN MALFUNCTIONS

WARNING: When emergency oxygen is manually operated no cockpit indications are available to show system is operating or contents remaining. The OXY MI remains black.

Suspected Hypoxia or Oxygen Contamination

Check connections, contents and flow
Operate emergency oxygen control
Set main oxygen supply OFF
Descend below 10,000 feet cabin altitude

OXY on CWP, or MI Continuous White or Black, or Difficulty in Breathing In

Check contents, connections, mask fit and main supply ON
Select 100%
If fault or warning persists:

Breathing normal	Breathing restricted
Continue sortie Monitor contents and MI	Select emergency oxygen Set main supply OFF Descend to 10,000 feet cabin altitude

Fig 34. Typical FRC for System based on Seat-Mounted Regulator (Hawk).

selected), it must be supplemented with air drawn in through the mask anti-suffocation valve. The suction required to open this valve (9-13mm Hg) is such that inspiration is noticeably restricted. With 'AM' (airmix) selected the extra air required is drawn in through the air inlet port and the anti-suffocation valve is not used: any restriction imposed by the airmix aneroid decreases as altitude is reduced.

OXYGEN FAILURES

SUSPECTED HYPOXIA

Check	**Contents, connections, flow**
EMERG O_2	**Pull**
Regulator	BY-PASS
Altitude	<10,000 ft

If O_2 contamination suspected

Main O_2 system ... **OFF**
When below 6000 ft cabin alt
Regulator ... ... AIR MIX

DIFFICULTY IN BREATHING OUT

Regulator	BY-PASS and AIR MIX
Altitude	<35,000 ft
O_2	Monitor contents/pressure
MI	Check continuous white

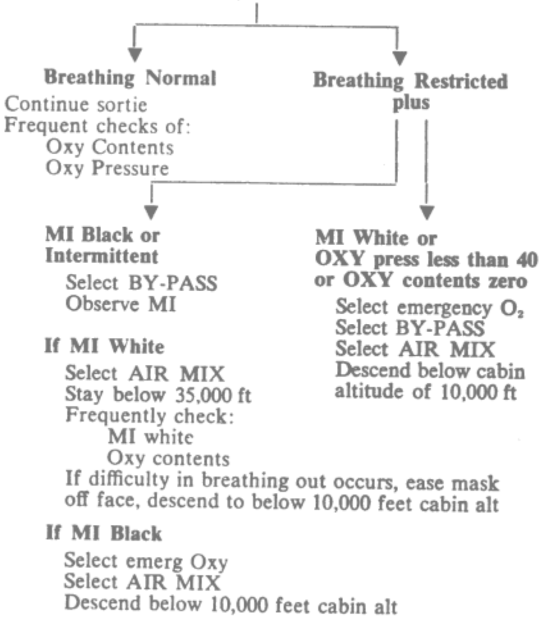
If fault persists

Ease mask off face to breathe out
Descend below 10,000 ft cabin alt

DIFFICULTY IN BREATHING IN
or MI CONTINUOUS WHITE OR BLACK
or OXY CONTENTS ZERO
or OXY PRESSURE LESS THAN 40 PSI

Check:
- PEC connection
- Mask hose to regulator
- Mask fit
- Main Oxy ON contents

Select 100%, then:



Breathing Normal

Continue sortie
Frequent checks of:
- Oxy Contents
- Oxy Pressure

Breathing Restricted plus

MI Black or Intermittent

Select BY-PASS
Observe MI

If MI White

Select AIR MIX
Stay below 35,000 ft
Frequently check:
- MI white
- Oxy contents

If difficulty in breathing out occurs, ease mask off face, descend to below 10,000 feet cabin alt

If MI Black

Select emerg Oxy
Select AIR MIX
Descend below 10,000 feet cabin alt

MI White or OXY press less than 40 or OXY contents zero

Select emergency O_2
Select BY-PASS
Select AIR MIX
Descend below cabin altitude of 10,000 ft

Fig 35. Typical FRC for System based on Man-Mounted Regulator (Type 317A) (Phantom).

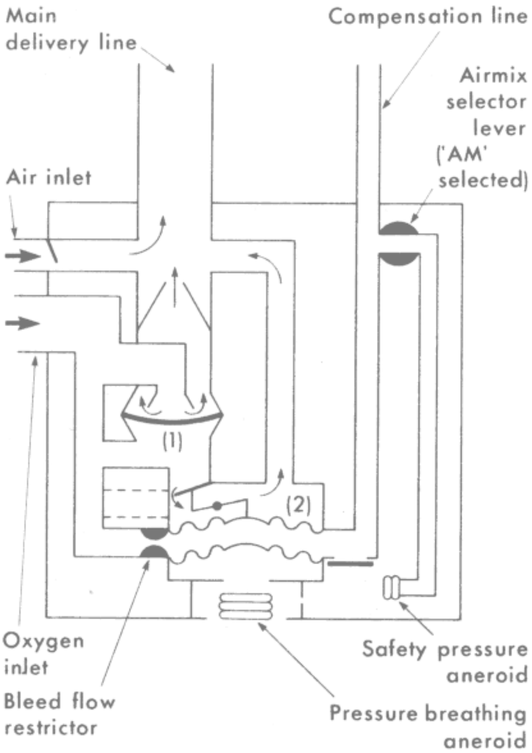


Fig 36a Type 317A Regulator – Normal Operation with Intact Compensation Line, Airmix selected and Safety Pressure delivered.
(Negative pressure of inspiration deviates monitor (1) and (2) diaphragms to allow flow of oxygen and air as shown).

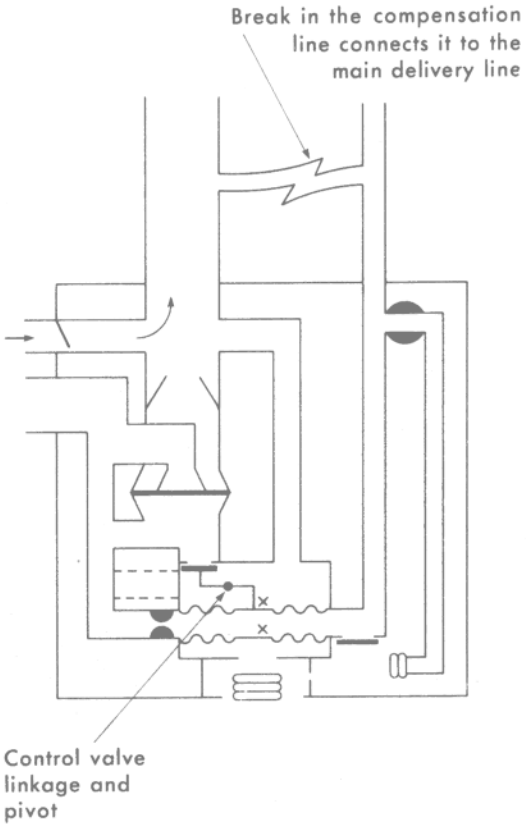


Fig 36b Type 317A Regulator – Operation with Broken Compensation Line, Airmix selected and Safety Pressure delivered.
(Negative pressure of inspiration is transmitted to both sides (X) of the follower diaphragm which therefore does not move and there is no flow of oxygen. Air is drawn in via the air inlet port and hypoxia develops).

(2) Compensation Line failure (*see* also para 36b) will manifest itself immediately as a difficulty in breathing out if the mask inspiratory valve is held open by mask debris. The required actions are then as expected. However, such a failure may also be covert and come to light only as the result of a subsequent problem. Hypoxia is the most serious of these and the sequence of possible events in the regulator when the compensation line has failed covertly is shown at Figs 36a, b, c and d. This figure should be studied in conjunction with Fig 16. When Airmix is selected and the altitude is such that safety pressure is being delivered (ie above 15,000-18,000 feet) and there is a break in the compensation line, equal inspiratory pressures are transmitted to both sides of the regulator follower diaphragm. The diaphragm will not move under such circumstances and no oxygen will flow. The user will be unaware of this since his respiratory demands are met by air drawn in via the air inlet port (Fig 36b). Hypoxia will develop and its correct diagnosis will require the selection of By-pass, in accordance with the FRC. (Selection of 100% oxygen (as a diagnostic step: see Para 40a (5) above), and hence closure of the air inlet port, in these circumstances results in difficulty breathing in as the regulator air inlet route is denied

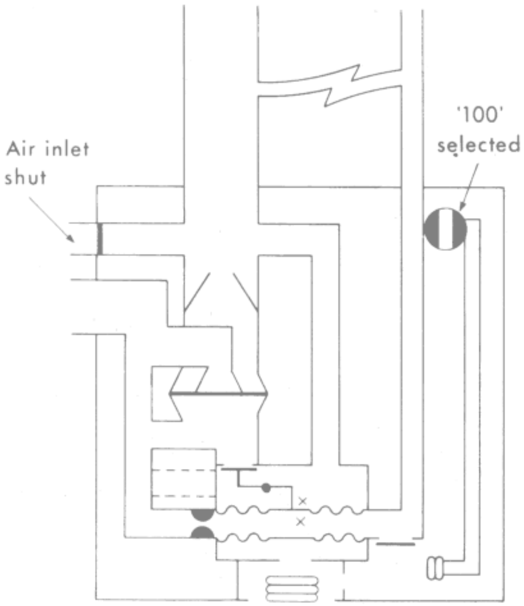


Fig 36c Type 317A Regulator – Operation with Broken Compensation Line and 100% Oxygen selected. (Selection of 100% oxygen closes the Air Inlet port. Negative pressure of inspiration acts on both sides (X) of the follower diaphragm and splints it as in b above. No oxygen flows and no air is available until the mask anti-suffocation valve opens).

to the user and the flow of oxygen is prevented, as before, by splinting of the follower diaphragm on inspiration (Fig 36c). Increased inspiratory effort on the part of the user will open the mask anti-suffocation valve and so supply some air but the hypoxic state will be perpetuated). The continuous flow of oxygen as a result of selection of By-pass will be delivered not only up the main delivery line but also up the broken compensation line where it will act on the back of the mask expiratory valve and so prevent it from opening. The user is then unable to breath out (Fig 36d). A similar sequence of events is seen when hypoxia is suspected when using the 417A (Jaguar) regulator. However, selection of the standby oxygen regulator, in accordance with the FRC, in this case results in an immediate inability to breathe both in and out should the underlying problem be a broken compensation line. The user is unable to breathe in because inspiratory effort is transmitted to both sides of the control diaphragm in this regulator, even when Standby is selected. Such air as is inspired enters via the mask anti-suffocation valve. (A similar predicament arises if, instead of selecting the Standby regulator, 100% oxygen is selected on the main regulator; and for the same reasons, ie the control diaphragm is splinted by the inspiratory effort). Difficulty breathing out is simply the result of expiratory effort being transmitted down the main delivery line, since there is no inspiratory valve fitted to the V2 mask, and back up the compensation line, through the break, to the back of the expiratory valve.

(3) Whenever By-pass is selected the magnetic indicator should be white continuously.

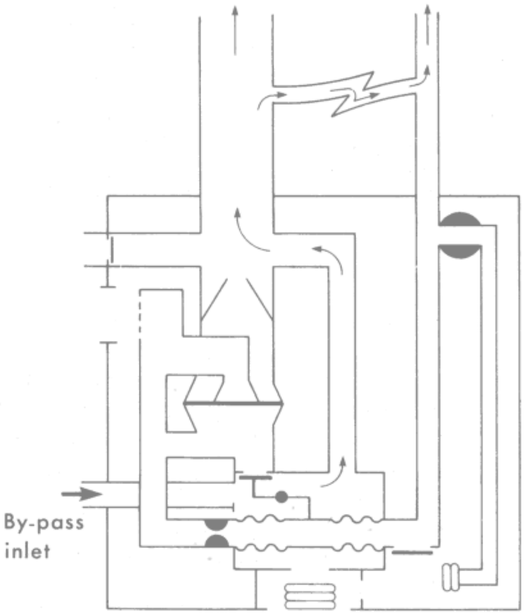


Fig 36d Type 317A Regulator – Operation with Broken Compensation Line and By-Pass selected. (Selection of By-Pass produces a continuous flow of oxygen to the mask but it also passes up the broken Compensation Line to the back of the mask expiratory valve and makes expiration difficult).

EMERGENCY OXYGEN (EO) SYSTEMS

General

41. A supply of emergency oxygen is available to each crew member should the main supply fail (the EO is then operated manually) or should ejection or bale-out be necessary (the EO is then operated automatically). Details of the EO systems to be found in individual aircraft types are summarized at Annex A and the two principal forms of EO assembly in current service are described below.

Continuous Flow Emergency Oxygen Assemblies

42. In Continuous Flow EO Assemblies oxygen is stored as a gas in a cylinder of 55 litres (NTP) capacity charged to 2000 psi. The cylinder is mounted on the ejection seat. It is connected to the user via an oxygen flow regulator mounted on its head and a soft rubber delivery tube. Once operated, the oxygen is supplied continuously at a rate of approximately 12 litres (NTP) per minute initially, thereafter declining exponentially, and provides a useful duration of about 10 minutes. The flow is modified by a piece of associated equipment: the Inlet Warning Connector (MC3A Connector). This device is fitted to the end of P1/Q1 mask hoses. It is illustrated at Fig 37. The Inlet Warning Connector serves to warn the user of a disconnect in the main oxygen supply line. This it does by causing a restriction to inspiration since a suction of 16-20mm Hg is needed to open the disconnect warning assembly. In addition, it incorporates an excess pressure relief valve which, when used with the continuous flow EO system, prevents the build up of uncomfortably high pressures; the valve opens at a pressure of 20mm Hg (Setting the valve to open at 20mm Hg allows for pressure breathing). However, to allow this blow-off valve to operate the main oxygen supply hose must be disconnected when the EO is operated: this is accomplished by simply pulling the inlet warning connector straight out from the oxygen hose. If it is not disconnected then oxygen from the EO cylinder will flow back down the hose as far as the regulator and high pressure will build up until the regulator relief valve operating pressure is reached. The function of the inlet warning connector is shown diagramatically at Fig 38. A self-sealing valve also guards the EO inlet. It is held open when the EO supply is connected but until that time it will prevent any loss of oxygen from the main supply, via the EO inlet. It should be noted that moderately high inspiratory and expiratory efforts are required when this EO system is used, but that such resistances are normal. As the EO supply is exhausted ventilatory requirements are met by lifting the edge of the mask away from the face and breathing external air; (there is no anti-suffocation valve in masks used with systems incorporating an inlet warning connector).

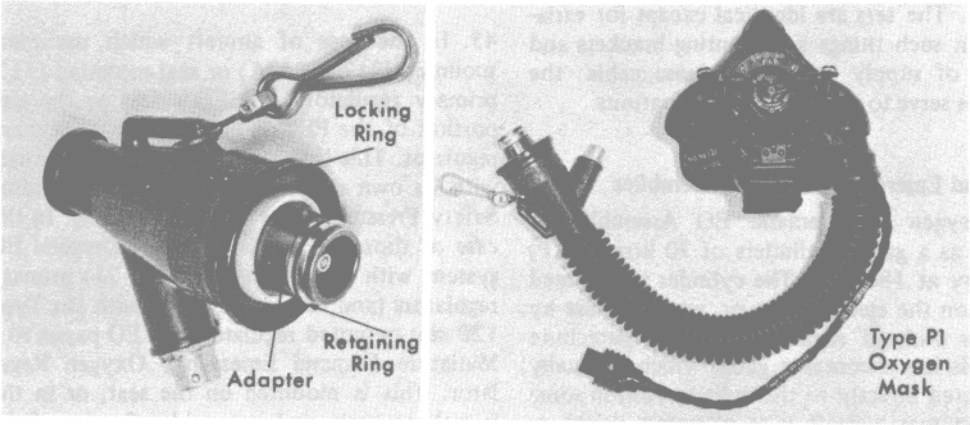
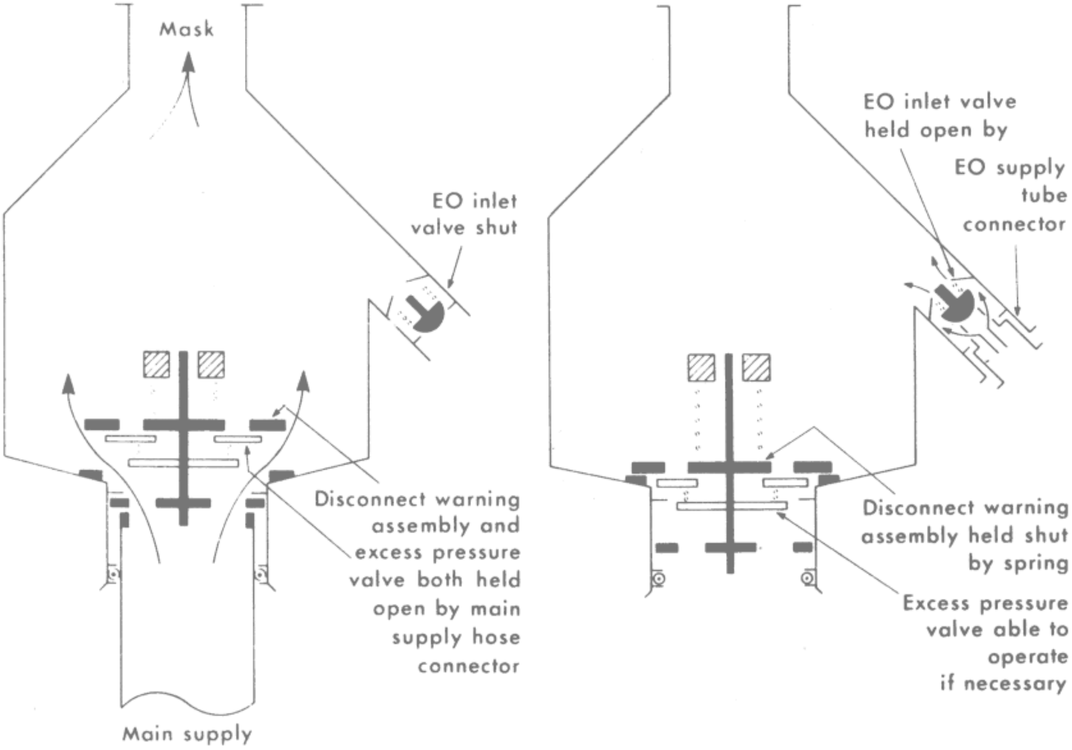


Fig 37. Inlet Warning Connector.



a. Main Supply Connected, EO Supply Disconnected.

b. Main Supply Disconnected, EO Supply Connected.

Fig 38 Inlet Warning Connector: Function.

43. The continuous flow EO sets in current service are designated Emergency Oxygen Sets Mk 7 A-J, depending upon aircraft type (see Annex A). An EO Set Mk 7D is illustrated at Fig 39. The sets are identical except for variations in such things as mounting brackets and length of supply hose and release cable: the suffixes serve to distinguish the variations.

Demand Emergency Oxygen Assemblies

44. Oxygen for Demand EO Assemblies is stored as a gas in cylinders of 70 litres (NTP) capacity at 1800 psi. The cylinder is mounted either on the ejection seat or, when for use by aircrew without such seats, in the parachute pack. It has a contents gauge which is usually connected directly to the cylinder, but in some ejection seat aircraft it is mounted elsewhere on the seat in a position where it is more easily seen by the occupant. Once initiated by the release mechanism, the oxygen flows through a pressure-reducing head on the top of the cylinder and thence, at a nominal pressure of 50 psi, to a regulator.

45. In the case of aircraft which use man-mounted (317A, 417A) or seat-mounted (517) primary regulators, the EO passes to the seat portion of the PEC and thence to the primary regulator. This then controls a flow to the user with its own delivery characteristics, including Safety Pressure and Pressure Breathing. In the case of those aircraft which use a Demand EO system with panel-mounted (17, 21) primary regulators (and of aircraft fitted with the Type 120 seat-mounted regulator) the EO passes to a Miniature Demand Emergency Oxygen Regulator. This is mounted on the seat, or in the parachute pack, and is capable of some of the delivery characteristics of the primary regulator: both safety pressure from ground level

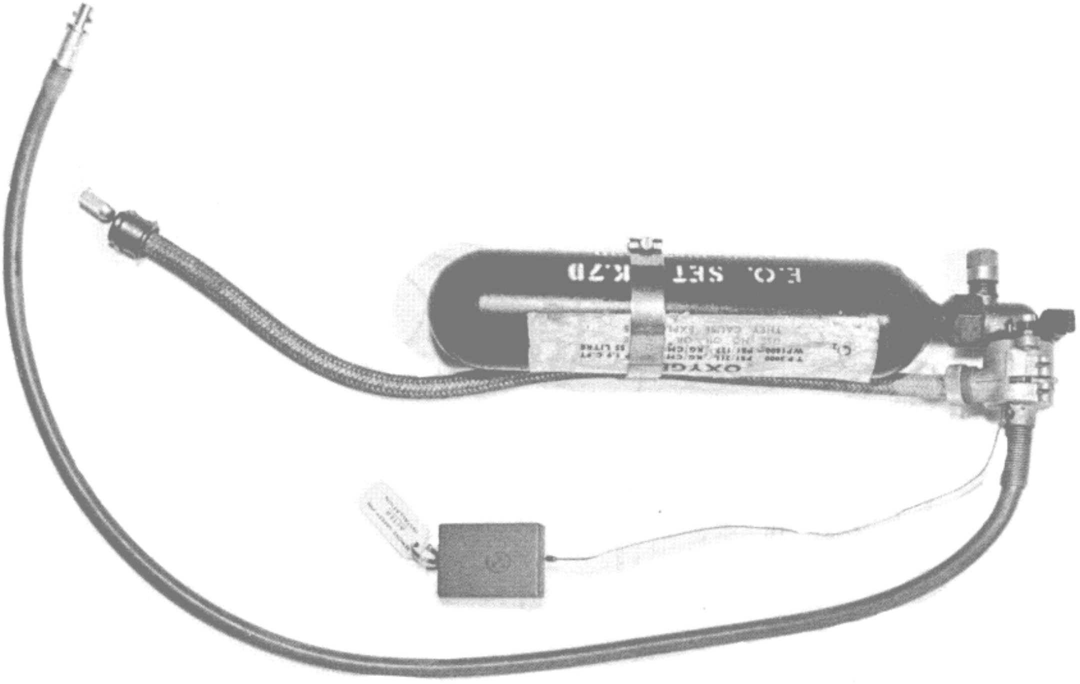


Fig 39 Emergency Oxygen Set Mk 7D.

and pressure breathing are provided but Airmix is not. The designations of these emergency regulators reflect their relationship to the primary regulators and the characteristics of those in current service are given at Table 5.

A Mk 3A Miniature Demand EO Regulator is shown at Fig 40. The Mk 2/2A and Type 220 regulators are similar in appearance and operation.

Primary Regulator	Miniature Demand EO Regulator	Safety Pressure	Pressure Breathing	Notes
Mk 17	Mk 3/3A*	Ground Level to 40,000 ft.	Up to 50,000 ft.	
Mk 21	Mk 2/2A*	"	Up to 56,000 ft.	Will also inflate pressure clothing
Type 120	Mk 220	"	"	"

Table 5 Characteristics of Miniature Demand Emergency Oxygen Regulators in Current Service.

(*The 'A' Suffix denotes a straight, compared with the original angled, inlet.)

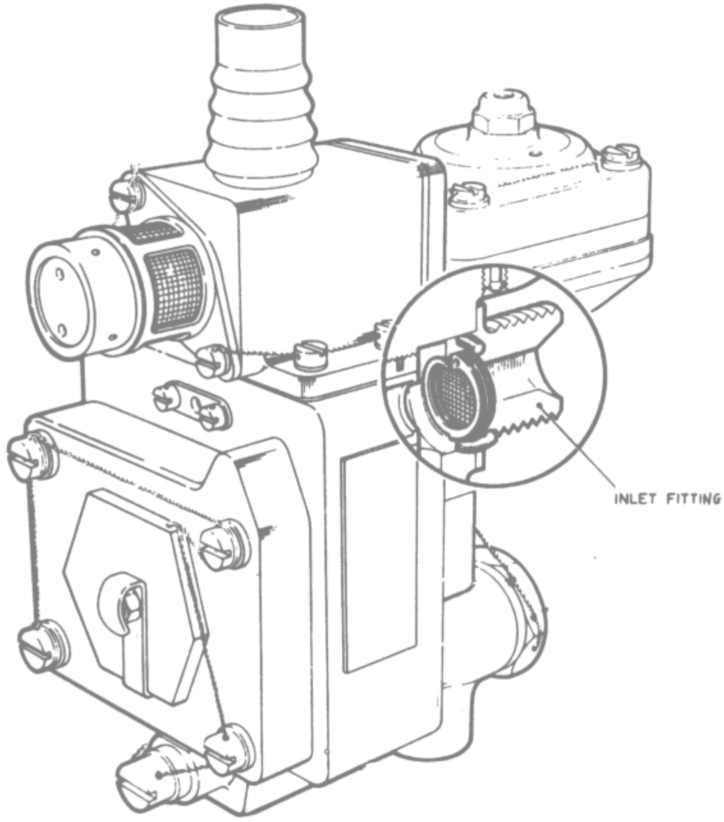


Fig 40 Mk 3A Miniature Demand Emergency Oxygen Regulator.

46. The operation of miniature demand EO regulators is based on pneumatic servo-controlled principles, (see Para 30). The mechanism is shown diagramatically at Fig 41. On inhalation, reduction of pressure in the sensing chamber is transmitted via the sensing diaphragm and servo lever to open the servo valve. This allows oxygen to enter the servo chamber, deflect the servo diaphragm, move the demand valve lever and open the demand valve. Oxygen then passes from the inlet passage direct to the regulator outlet. When inhalation stops, pressure builds up in the sensing chamber and the movement of valves and levers is reversed so preventing further flow of oxygen. Safety Pressure and Pressure Breathing are delivered automatically at the appropriate altitudes. However, there is no facility for Airmix and exhaustion of the oxygen supply requires the user to breathe in via the mask anti-suffocation valve. The duration of demand EO systems depends upon the altitude at which it is operating and the breathing rate of the user: usually its duration is of the order of 10 minutes.

OTHER DELIVERY SYSTEMS

The British Economizer System

47. The British Economizer System is a modified continuous flow system in which the oxygen is fed from a gaseous source, via a regulator, to the economizer and thence to the face mask. The system is illustrated at Fig 42. Although it is simple, reliable and comfortable, this system does not cater for changes in breathing rate, gives no indication of function other than low or high flow rates (at the regulator but not beyond) and cannot conveniently integrate with pressure breathing equipment. The details

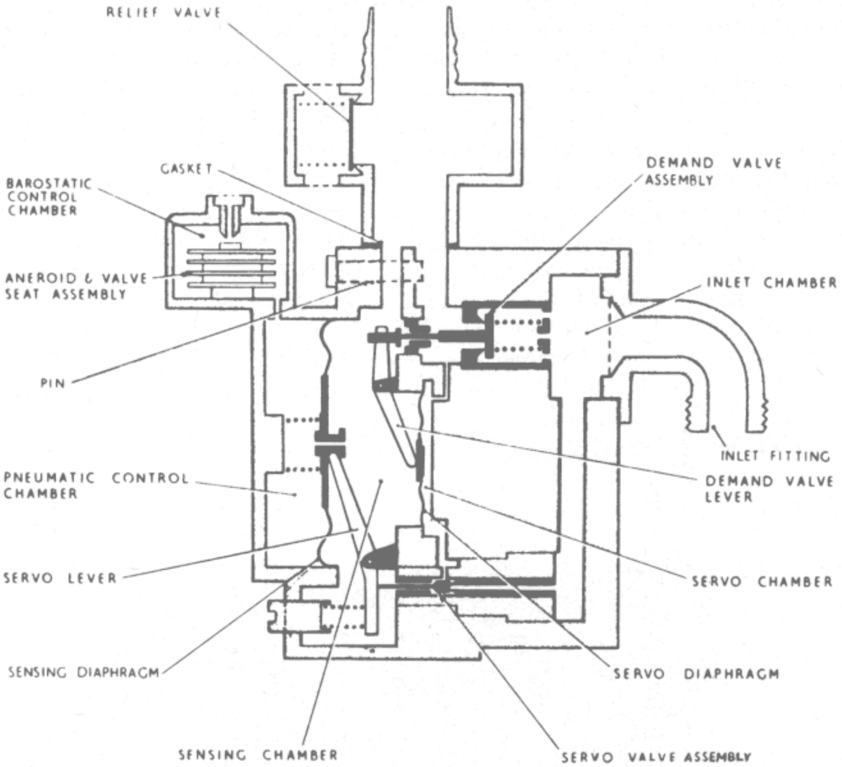


Fig 41 Miniature Demand EO Regulator: Function.

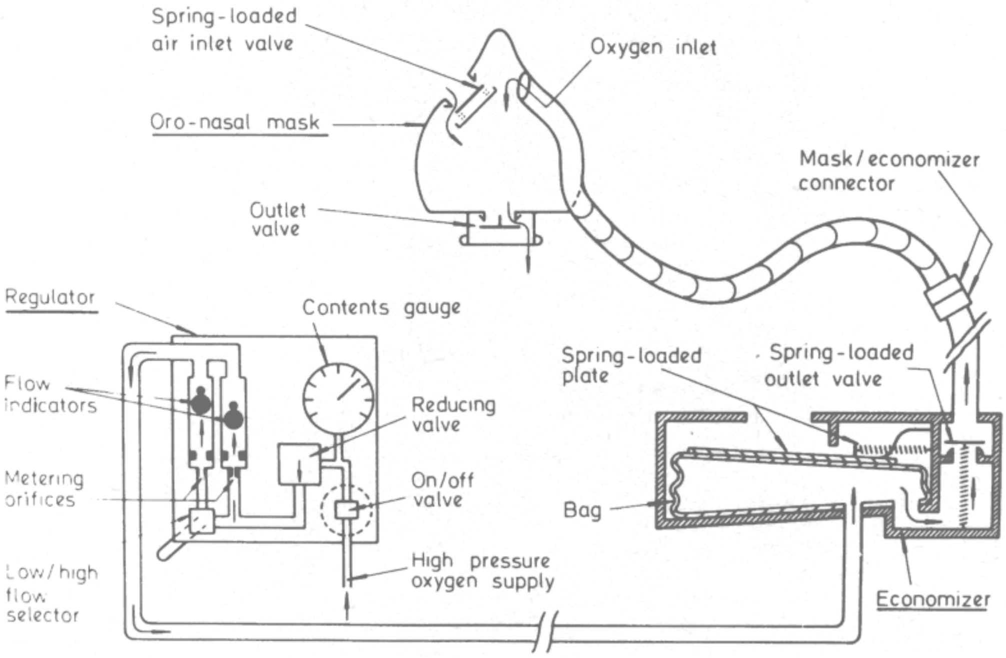


Fig 42 The British Economizer System.

of the systems fitted in aircraft still using the economizer are summarized at Annex A. The main components of the British Economizer System are:

a. *Automatic Line Valve.* An automatic line valve is fitted to the high pressure supply line. It ensures that the oxygen supply is always on whenever the aircraft is flying at altitudes where oxygen is required. The guarded On/Off valve is normally turned on before flight, but should this not happen, an aneroid capsule automatically trips the switch to On when the aircraft reaches 8,000 feet. Thereafter it can only be turned off again manually and only when the aircraft is below 8,000 feet. To avoid depletion of the gas supply, the valve must be turned off after the flight.

b. *Regulators.* As with pressure demand regulators, the regulators used in the economizer system serve to reduce the oxygen pressure and control the flow before the gas is passed to the user. In this case, however, a suitable constant flow is provided. Two Marks of regulator are in current service:

(1) *Mark 16 Oxygen Regulators.* Mark

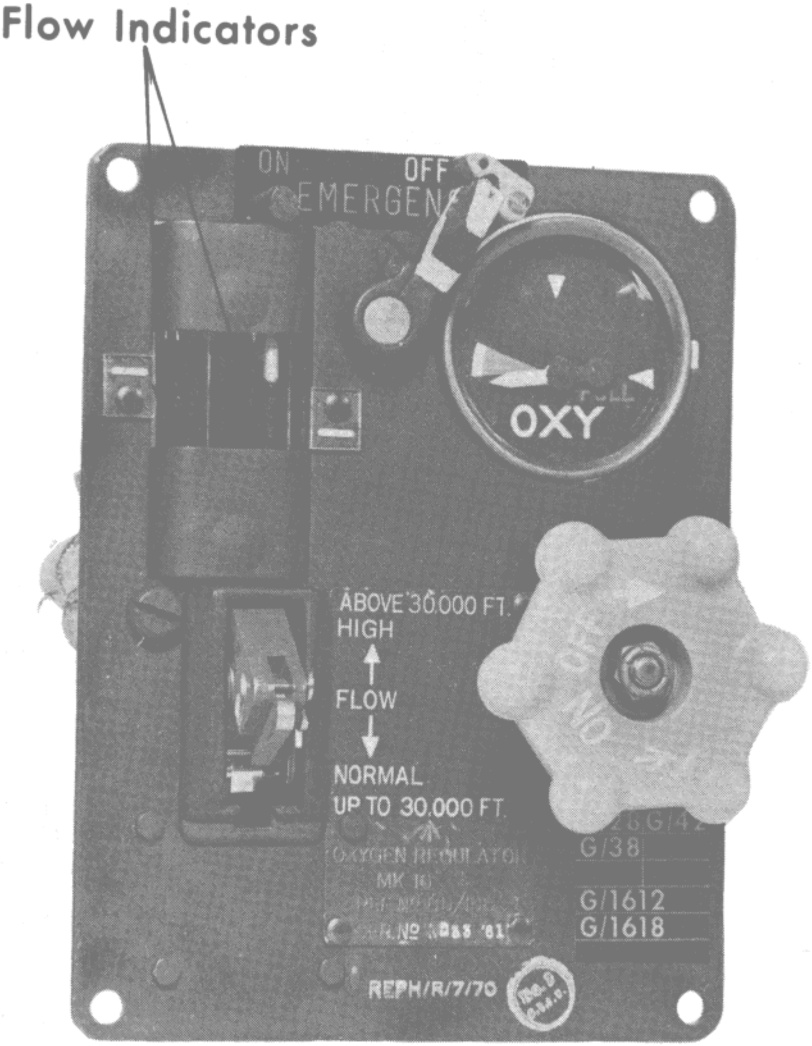


Fig 43 Mark 16A Oxygen Regulator.

16 series regulators are fitted to Jet Provost Mks 3 and 4 aircraft. A Mk 16A regulator is illustrated at Fig 43. The Mk 16B differs from this only in that it has a second outlet which supplies oxygen at reduced pressure, to a second regulator, the Mk 16C. The Mks 16B and C are used together in two-seat aircraft: the 16B is located on the port (student's) side, the 16C on the starboard (instructor's) side. Both the Mk 16A regulator and the Mk 16B comprise a high pressure ON/OFF valve, a reducing valve, an automatic flow increase attachment, twin flow indicators, an emergency flow valve, a relief valve and a high pressure contents gauge. The regulator is usually wire-locked on. A normal flow (3.4-4.6 litres (NTP) per minute) is provided by the regulator up to a cabin altitude of 30,000 feet. Above this level the automatic flow increase attachment, which consists of a capsule-controlled valve, increases the flow to High (5.1-7.4 litres (NTP) per minute). This change-over can also be made manually at any altitude by setting the toggle switch to High Flow. The twin flow indicators show which flow condition is selected. The indicators themselves consist of two perspex tubes with bobbin-shaped floats inside. The correct position for the bobbins when flow is present is marked on the regulator face: one bobbin is visible when Normal Flow is selected, while both are seen when the regulator is delivering High flow. The Emergency Flow valve increases the total flow to 27 litres (NTP) per minute when selected to On. This is done, in accordance with the aircraft FRCs, if hypoxia is suspected, or if toxic fumes contaminate the cockpit, or if there is a failure of normal oxygen delivery. The Emergency selector lever is normally retained in the Off position by a spring catch. The function of the regulator is illustrated diagramatically at Fig 44. The Mk 16C regulator is similar in operation but does not have its own On/Off valve, reducing valve, relief valve or contents gauge.

(2) *Mark 10 Oxygen Regulators.* Mark 10 series regulators are fitted to Shackleton aircraft, (and, as a special removeable console for paratroops, in Hercules aircraft). They are also fitted in the Jetstream aircraft but in this case provide only an emergency system for the passengers and are not used in conjunction with an economizer. The Mk 10A* and Mk 10B regulators differ only in that the latter has larger outlet connectors to accommodate a higher output flow. The Mk 10A* is illustrated at Fig 45 and can supply up to 10 aircrew/passenger stations. The MK 10B can supply a total of 50 stations in aircraft fitted with large-bore piping installation. Mark 10 series regulators consist of a high pressure On/Off valve, a high pressure contents gauge, a reducing valve and manual control mechanism and a low-pressure flow gauge. Selection of the On/Off valve to On allows high pressure oxygen to enter the regulator where it passes to the contents gauge and to a high pressure chamber surrounding the reducing valve. The flow of gas through this valve is governed by the reduced pressure setting obtained by means of the variable low-pressure flow control. Rotation of this control varies the spring loading on the reducing valve diaphragm and so alters the reduced pressure. The required pressure for a specific altitude is obtained by adjusting the low-pressure control until the pointer on the low-pressure flow gauge indicates that altitude. Oxygen at this selected pressure then leaves the regulator through two outlet connectors. Should an increased flow be needed in an emergency the flow control is rotated counter-clockwise (Increase) until the gauge pointer moves into the emergency sector. The low pressure flow gauge is calibrated from zero to 40,000 feet in addition to this emergency sector.

c. *Economizer.* The economizer itself (*see* Fig 42) consists of an inflatable bag into which oxygen flows from the regulator. The out-flow is guarded by a trip valve. During expiration, the trip valve closes and the

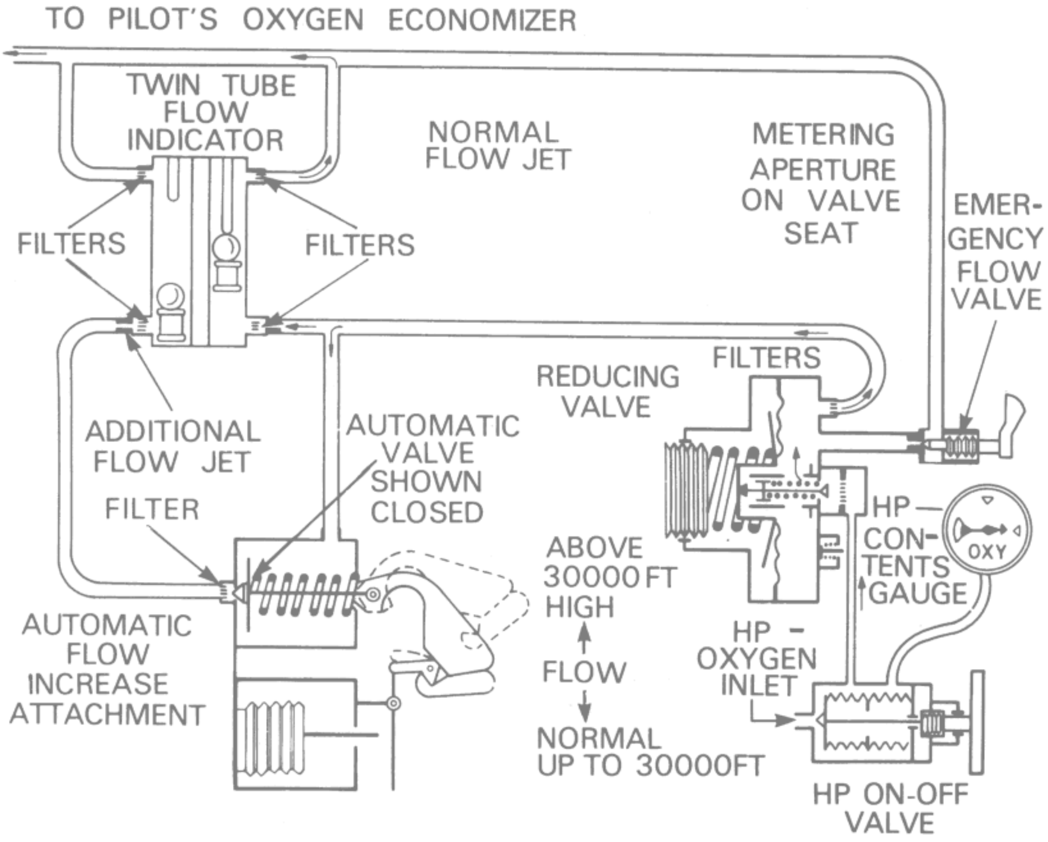


Fig 44 Mark 16 Oxygen Regulator — Function.

oxygen, which would otherwise flow to waste, inflates the bag. During inspiration, the valve lifts and the bag deflates with the assistance of a spring-loaded plate and oxygen is delivered to the mask. When the bag is fully inflated the valve lifts anyway and oxygen is discharged into the mask. The use of an economizer enables the duration of the oxygen store to be doubled. When more than one economizer is supplied from a regulator, a Cut-Off valve is used to prevent wastage from those crew stations which are not in use. The valve is so designed that the action of stowing the end of the economizer tube in a clip, which forms part of the valve, automatically cuts off the supply to that economizer.

d. *H Masks.* The Type H series masks are for use with the economizer system and must not be used with any pressure demand system or with pressure breathing equipment. The variants in the series allow for their use with a range of flying headgear. Thus, the Type H mask is used with a Type G or similar helment, the Type H1A with a headset and the Type H2 with Mars 2, 3 and 4 protective helmets. These three types of mask are illustrated at Figs 46a, b and c respectively. They are each available in three sizes: large, medium and small. The mask facepiece is made of moulded rubber and lined with suede for comfort. It incorporates ports for an inlet connector, two expiratory valves, a non-return air inlet (inspiratory) valve and a microphone aseembly. Ducts for the flow of oxygen from the inlet are also formed during the moulding process.

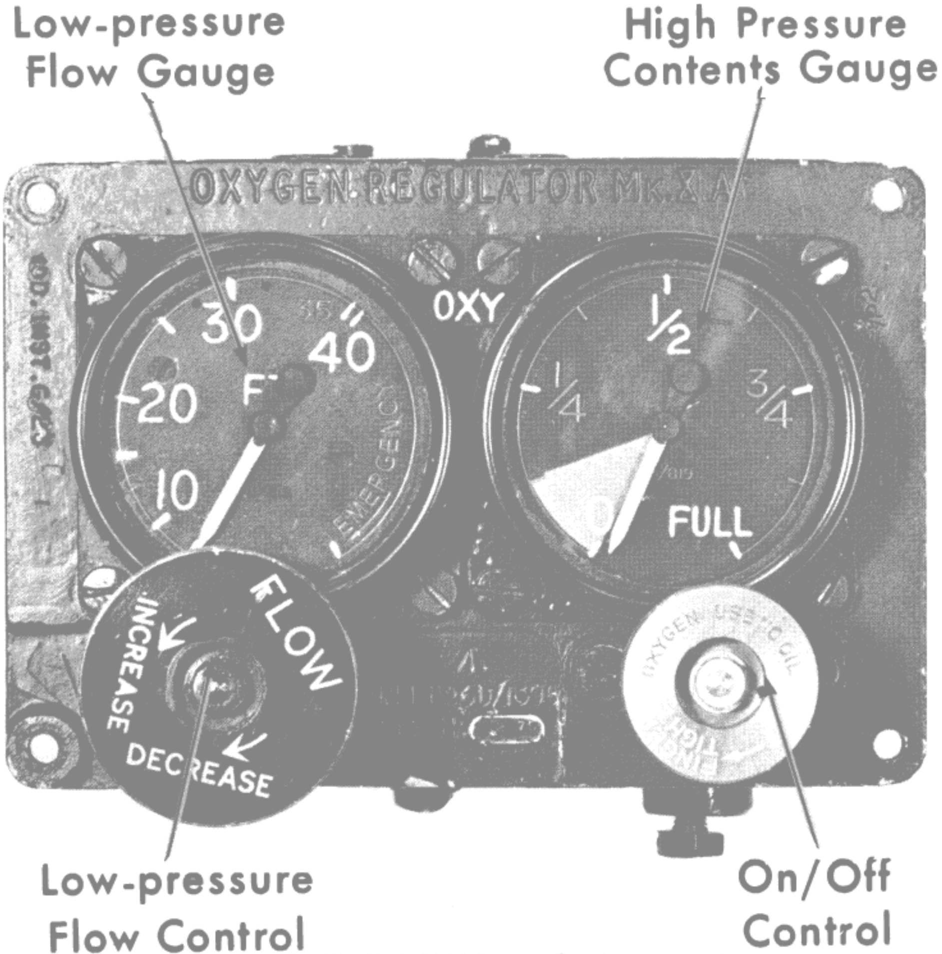
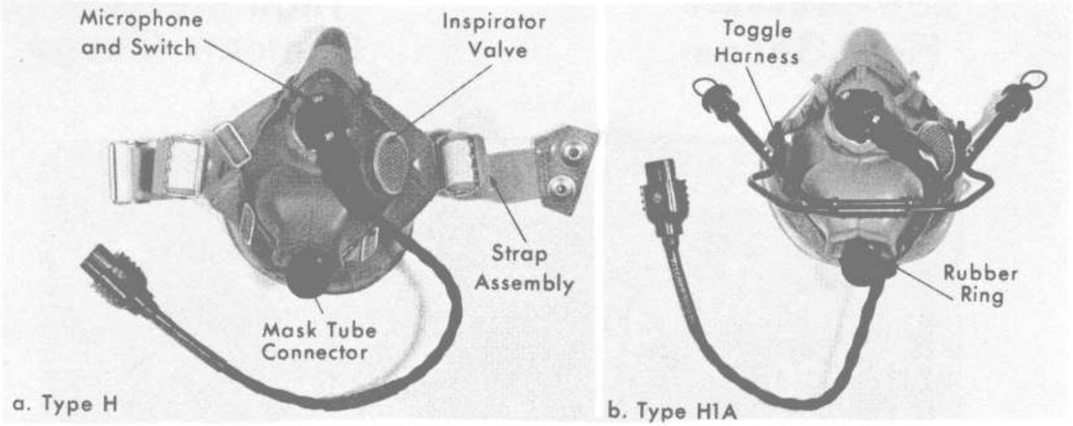


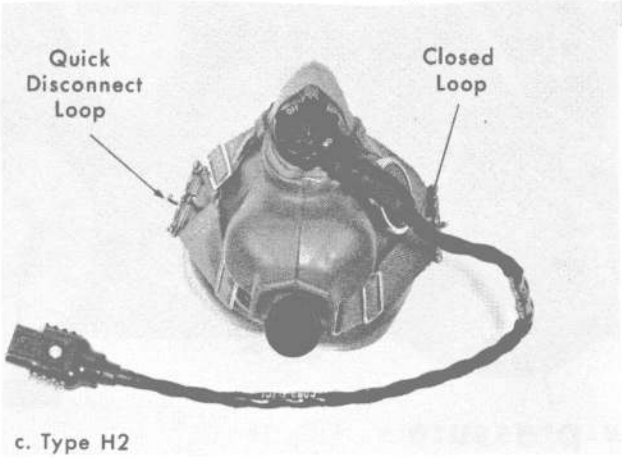
Fig 45 Mark 10A* Oxygen Regulator.

A typical facepiece is shown at Fig 47. The facepiece is held in position by three adjustable webbing straps fastened to it and to which are attached the various fittings for connection to different headgear. The non-return inlet valve allows controlled air dilution of oxygen to take place. The valve is lightly spring-loaded in the closed position. During inspiration, when the regulator is delivering normal flow, the first part of the breath consists of oxygen from the economizer storage bag. When the bag is deflated, continued inspiration causes a suction within the mask which opens the inlet valve, so allowing air to be breathed in, together with a certain amount of oxygen straight through the economizer. Oxygen flow increases with altitude, and air dilution is further reduced at altitude when High flow is being delivered, so achieving the required increase in inspired oxygen concentration. Mask hose assemblies, made of corrugated rubber tubing, are available in various lengths and with different end connectors. Some also incorporate a second tube to which the EO system is connected. Type H series medical masks are available manufactured from silicone rubber, to personnel who are sensitive to the materials used in the standard H masks. These masks consist of a P or Q type facepiece and exoskeleton (*see* Para 36a) in which is mounted a standard H type air inlet valve, a single expiratory valve and a microphone assembly. A medical H mask is shown at Fig 48. It should be noted that although the facepieces



a. Type H

b. Type H1A



c. Type H2

Fig 46 Type H Series Masks.

are of the P/Q type they are not P/Q series masks. There is no non-return valve fitted at the oxygen inlet (although an ice-guard is fitted) and the compensation line between the expiratory valve housing and the mask hose is blanked off.

With the economizer system, when used with the Mk 16 regulator, it must be remembered that the regulator flow indicators show that flow is occurring but not its magnitude nor whether oxygen is reaching the mask. Therefore, to confirm the integrity of the whole system, it is essential for the user to feel puffs of oxygen coming into the mask, (at the rate of 6 per minute on Normal setting and 9 per minute on High Flow setting). This 'Puff Check' is best carried out before engine start-up and it is often easier to feel the gas flow if the mask is held over the eyes.

Passenger Oxygen Systems.

48. In passenger-carrying aircraft the primary protection against hypoxia is cabin pressurization. The oxygen systems installed in such aircraft are designed to provide emergency oxygen for the passengers and crew in the event of pressurization failure, or for therapeutic purposes. Oxygen for these systems is usually stored as gas although liquid oxygen is used in some aircraft. The high pressure supply is reduced by valves in the normal way before passing to a main ring circuit for passenger supply or to the presssure demand systems usually fitted on the flight deck for crew

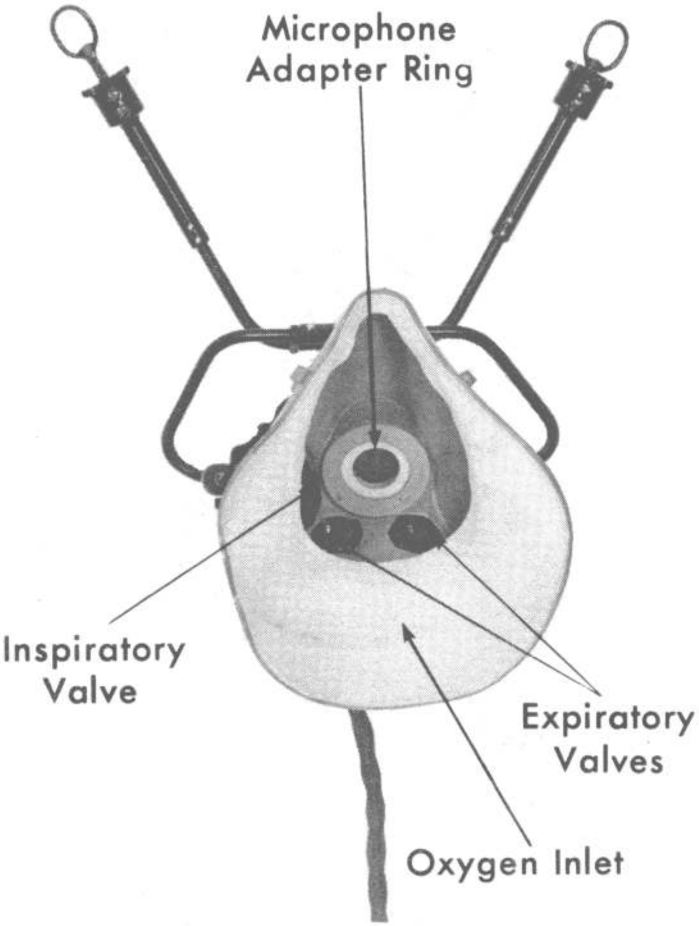


Fig 47 H Mask Typical Facepiece.

use. A Ring Main system is shown diagramatically at Fig 49.

49. During normal flight, oxygen is supplied from the aircraft storage system to the passenger oxygen regulator which reduces the input pressure to approximately 40 psi. Depending upon aircraft type, the passenger oxygen regulator may be either a Mk 10 series regulator (Jetstream – *see* Para 47b (2)) or may comprise an automatic pressure regulator control unit (VC 10, Nimrod). The former requires manual control of the system from the flight deck while the latter is automatic but can be operated manually. Details of the systems to be found in individual aircraft types are summarized at Annex A. The automatic pressure regulator control unit comprises an interconnected double pressure regulator, a barometric control valve and a time-delay reservoir. It is located on the flight deck at the engineer's Oxygen Control Panel. From this station,

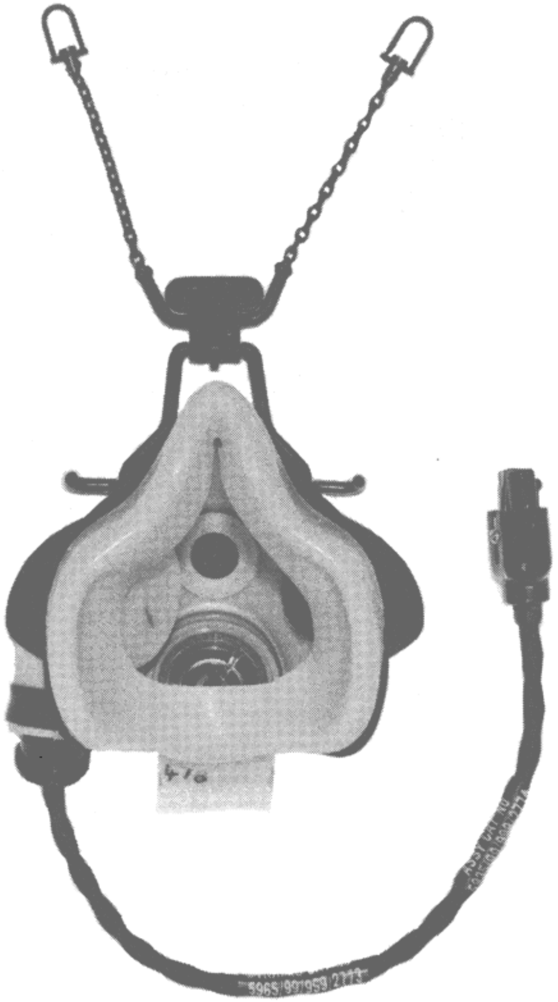


Fig 48 Type H Series Medical Mask.

oxygen can be delivered to the passengers manually at Normal (40 psi) pressure for therapeutic purposes or at Emergency (80 psi) pressure to present the passenger masks. In the event of cabin pressurization failure, and when the cabin altitude exceeds a pre-set level (usually 10,000-14,000 feet) the regulator automatically ~~rises~~ raises the supply pressure to approximately 80 psi (Emergency). This increased pressure activates a warning horn and its delivery to the ring main operates an actuator in each mask presentation unit, causing the masks to 'drop down' in front of the passengers to a position from which they can be applied to the face. A continuous flow of oxygen at emergency pressure emanates from each mask,

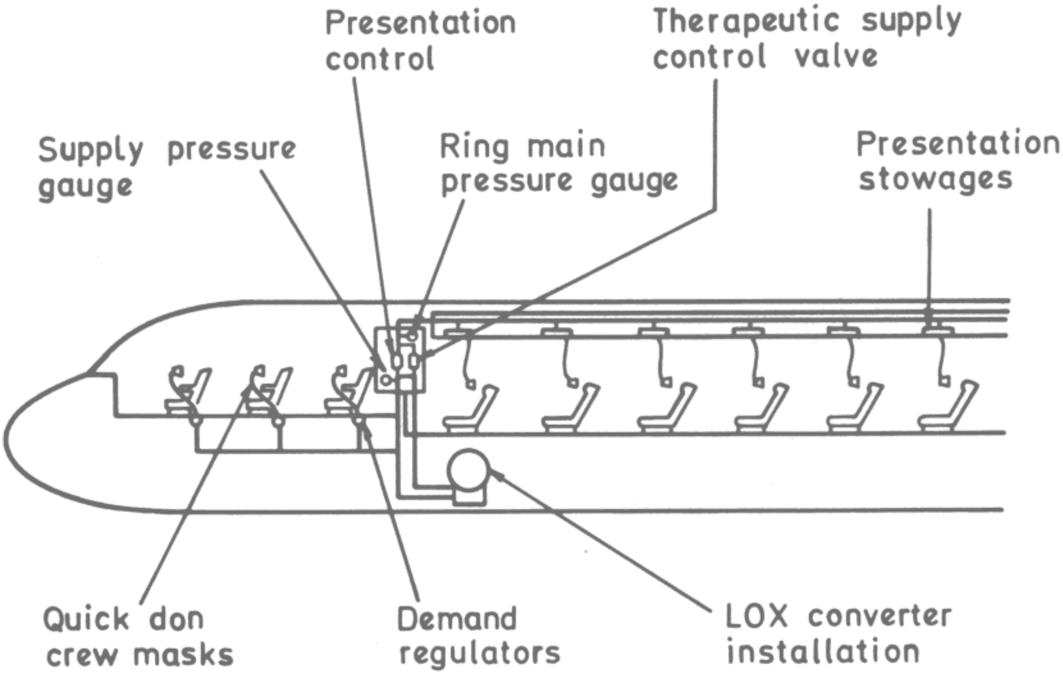


Fig 49 Passenger Ring Main System.

once its check valve is released (see below), and is maintained as long as the cabin altitude remains above 17,000 feet. When the aircraft has descended to a cabin altitude of less than 17,000 feet the control unit reduces the delivery pressure to Normal. Flow is maintained at a reduced level and each mask then functions as a demand type.

a. *Passenger Drop Down Masks.* Drop down masks are stowed in two-mask or three-mask presentation units. Each mask comprises a soft rubber facepiece complete with headband, expiratory valve and an oxygen inlet valve. The mask hose connects the mask to the oxygen supply and incorporates a combined flow indicator and check valve which consists of a tubular body with a transparent window. This houses a green, spring-loaded flow indicator, which is invisible when there is no flow of gas, and a spring-loaded telescopic check valve. While it is telescoped this valve prevents oxygen flow. Some units release the valve when they drop down while in others flow is initiated when the user pulls the mask to his face.

b. *Therapeutic Masks.* Provided that the mask has a bayonet connector which fits the therapeutic outlet on the presentation unit, and it has a probe which can open the unit's self-sealing valve, any oxygen mask can be used for therapeutic purposes. In some aircraft a suitably modified drop down mask is used. In most cases, however, the Type L oxygen mask is used. It is illustrated at Fig 50. The mask is of the reservoir type with a flexible, latex breathing bag suspended from the facepiece which is itself made of thin, moulded polythene. The facepiece incorporates a gauze-covered ventilation hole and is held in position by a single elastic headband. In use, a continuous flow of oxygen is fed into the bag through a pipe from the oxygen supply point. During inspiration, air is drawn in through the vent hole after the oxygen accumulated in the bag has been exhausted. During expiration, a part of the expired breath, that part which is exhaled first and so is relatively rich in oxygen, re-enters the

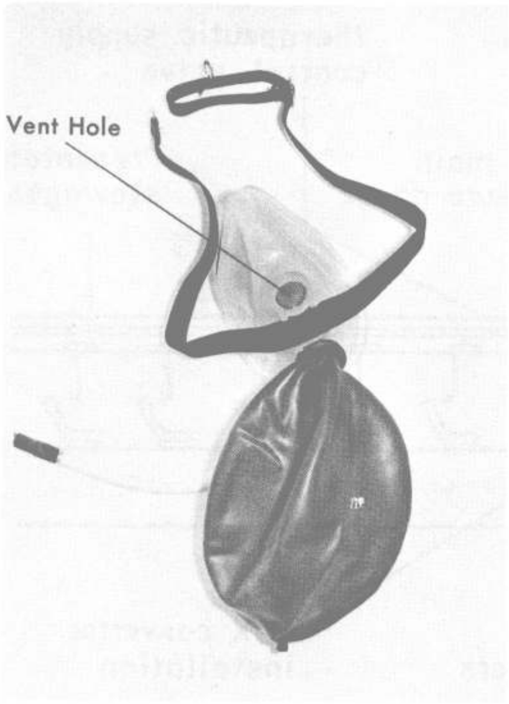


Fig 50 Type L Oxygen Mask.

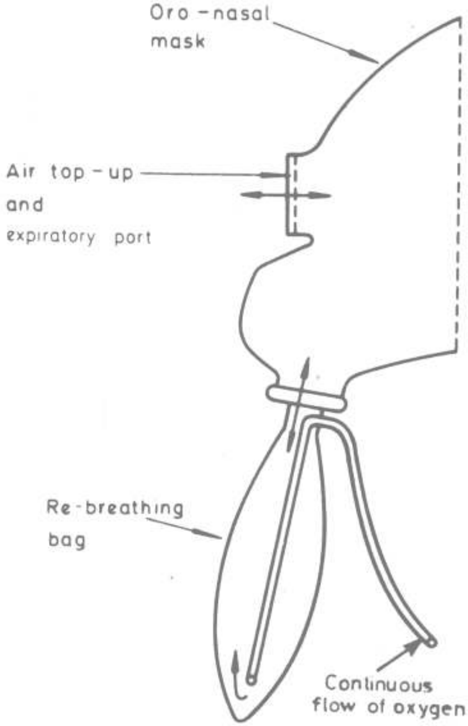


Fig 51 Re-breathing Reservoir Oxygen Mask.

surized aircraft not fitted with an oxygen suppl
supply for passengers have allowed to operate d

bag and is mixed with fresh oxygen which has been flowing in continuously. The remainder of the expirate passes out through the vent hole. This is an example of a Re-breathing Reservoir system and is shown diagramatically at Fig 51. Besides its therapeutic role, the Type L mask is used as the emergency mask for passengers in those aircraft which employ the Mk 10 series as passenger regulators (*see* Para 47b (2) and above). In these cases the masks are attached via bayonet connectors to the low pressure outlet points in the cabin. Type L masks are also used in conjunction with Mk 8 Walk-Around Sets, (*see* Para 51b).

50. The maximum altitude at which pressurized aircraft not fitted with an oxygen supply for passengers are allowed to operate depends upon the rate of descent which can be achieved following a decompression. RAF regulations are specific on this matter and the maximum operating altitudes of such aircraft must not exceed 25,000 feet.

Walk-Around Oxygen Sets.

51. Walk-around sets provide a controlled oxygen supply for aircrew whose duties may require them to move about the aircraft during flight at cabin altitudes above 10,000 feet. There are 3 such sets in current service: designated Marks 4, 8 and 9. The Mk 8 set provides a continuous flow of oxygen to the user, while the Mks 4 and 9 are pressure demand systems. The applicability of each of these sets to individual aircraft types is detailed at Annex A.

a. *Mark 4 Walk-Around Oxygen Set.* The Mk 4 walk-around set consists of an oxygen cylinder (Mk 13) of 150 litres (NTP) capacity to which is attached a demand type regulator (Mk 19). The set can be used with oxygen masks of the P/Q series, special adaptors being available to connect the various types of mask hose to the regulator.

AL 14

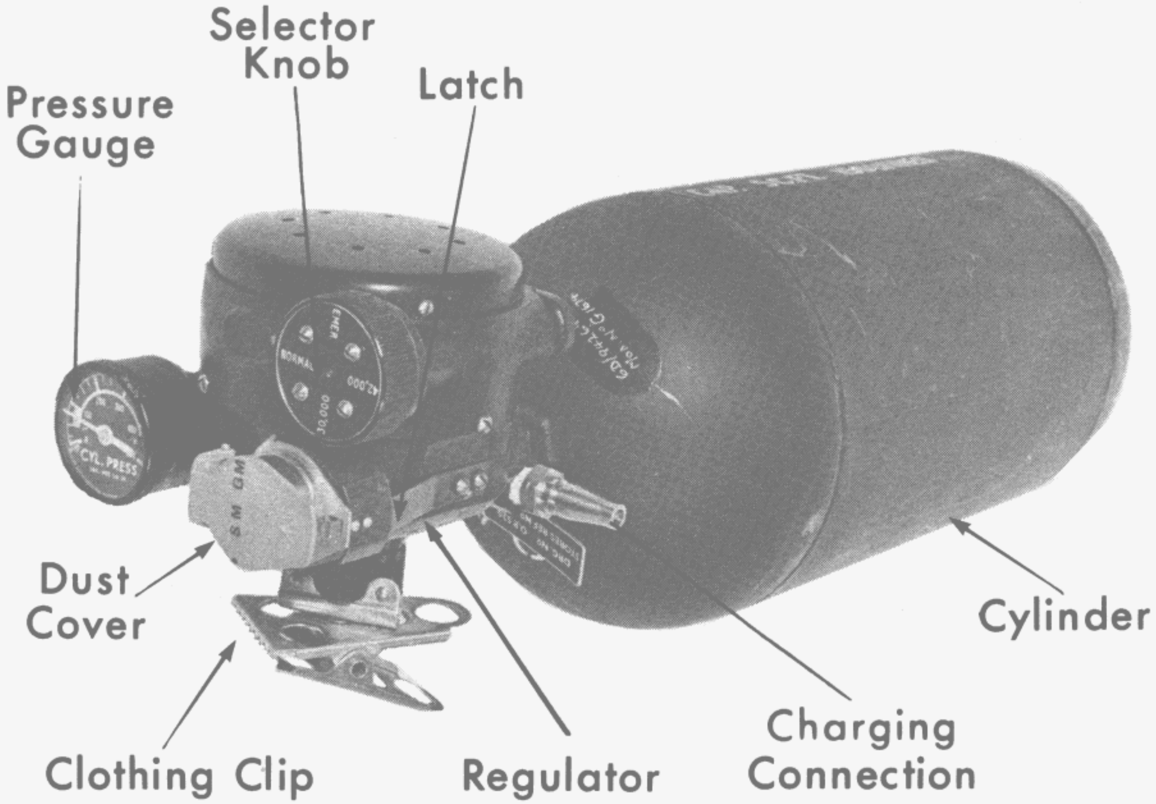


Fig 52 Mk 4 Walk-Around Oxygen Set.

A Mk 4 set is illustrated at Fig 52. Oxygen from the cylinder is supplied to the regulator at a pressure of 450 psi. This is reduced to 40 psi by the regulator which also incorporates a contents gauge, a selector dial and a mask hose socket. The regulator works on the demand valve lever principle, shown diagramatically at Fig 53 (and *see* Para 29a), and supplies oxygen at pressures dependent upon the position of the selector dial. The different pressures are accomplished by varying the spring-loading on the regulator diaphragm. The delivery pressures are approximately zero, 4mm Hg, 11mm Hg and 24mm Hg when the dial is set to Normal, 30,000 (feet), 42,000 and Emergency respectively. When the set is to be used, the clothing clip is secured to the carrying harness, and the selector is positioned as appropriate. A deep breath must be taken before disconnecting the mask hose from the main supply and connecting it to the socket on the regulator. For an average flight under normal conditions, a fully-charged set has a duration of about 20-34 minutes, depending upon cabin altitude and the user's workload. In some aircraft the set can be recharged in flight by connecting it to the aircraft main supply.

b. *Mark 8 Walk-Around Oxygen Set.* The Mk 8 walk-around set consists of an oxygen cylinder of 120 litres (NTP) capacity, stored at 1800 psi, and fitted with a check valve, a control head assembly, a carrying bag and a Type L breathing mask (*see* Para 49b) with a connecting tube. The set is illustrated at Fig 54. The check valve incorporates a contents gauge and a needle valve. This valve is

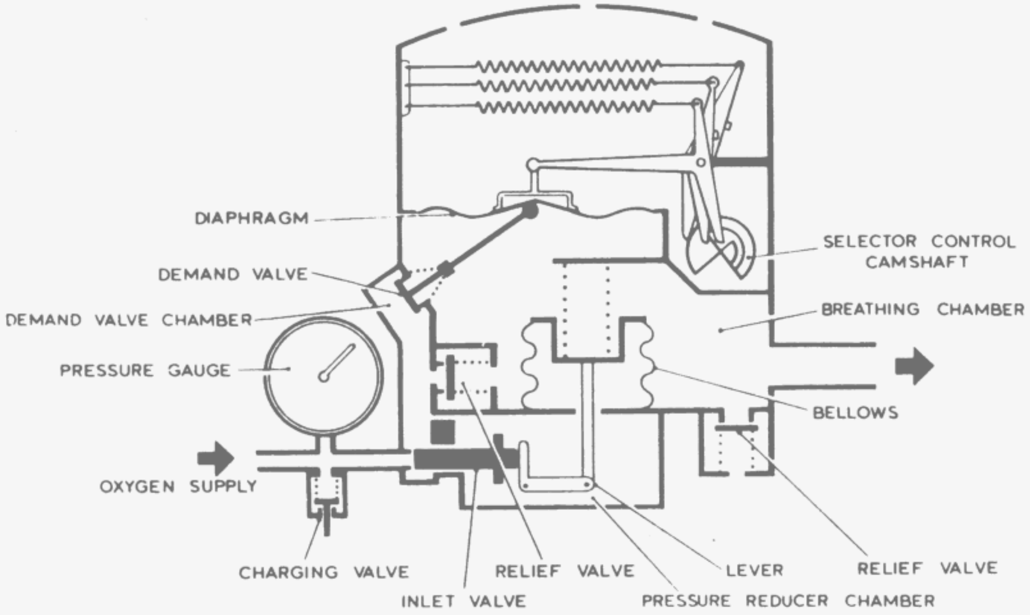


Fig 53 Mk 19 Regulator: Function.

normally held shut by a spring-loading which may be released by rotating a dial, mounted on the control head assembly, from the Off position to either the Medium or the High flow position. The former delivers a nominal 2 litres (NTP) per minute continuous flow of oxygen to the user while the latter delivers a nominal 4 litres (NTP) per minute. A steady flow is achieved by a metering orifice in the outlet port. The medium flow position should be selected for use at cabin altitudes below 18,000 feet while the high flow position should be selected when the set is being used above 18,000 feet.

c. *Mark 9 Portable Oxygen Set.* Mk 9 portable oxygen sets are not only used by crew members whose normal duties require them to move about the aircraft in flight, but also by those crew members who may have to undertake their duties, or to investigate and remedy faults, in a non-respirable atmosphere. The set provides the user with 100% oxygen on demand and affords protection against smoke, fumes and decompression up to an altitude of 30,000 feet. It comprises a mask and regulator assembly, a 2-cylinder pack assembly with a total storage capacity of 400 litres (NTP) at 1800 psi and strap assemblies which clip onto the pack. The set in normal use is shown at Fig 55.

(1) *Mask and Regulator Assembly.* The mask and regulator assembly consists of a moulded-rubber facepiece fitted with an inner mask assembly, a perspex visor, a speech transmitter incorporating an expiratory valve and a demand regulator to which is connected a 4 foot long delivery hose, (some sets have hoses 15 feet long: these are designated Mk 9A Portable Oxygen Sets). The assembly is illustrated at Fig 56. The mask is held in position by a headstrap with 6 adjustable tongues. A cushion-type face seal is incorporated in the facepiece and is filled with a 45:55 glycerine:water mixture via a filler tube. The visor is bonded to the facepiece and has mounting orifices for the regulator and the speech assemblies. The inner mask is made of moulded rubber shaped to fit over the nose and mouth. It incorporates a non-return inspiratory valve in the right cheek. The demand regulator is fully automatic provided that the inlet

AL 14

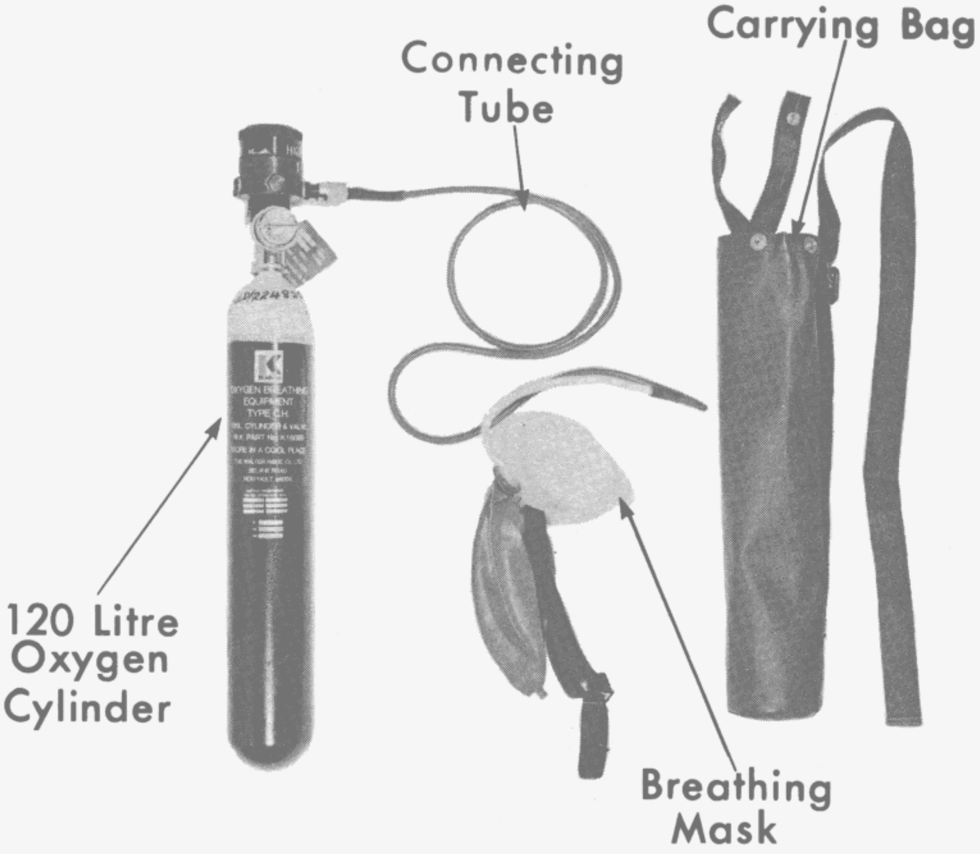


Fig 54 Mk 8 Walk-Around Oxygen Set.

supply pressure is adequate and requires no adjustment in service. If necessary it can be operated manually by depressing a rubber diaphragm through a hole in the cover.

(2) *Cylinder Pack Assembly*. The cylinder pack assembly consists of two, 200 litre (NTP) oxygen cylinders connected together by means of a pressure reducing assembly. The latter incorporates a shut-off valve, a pressure gauge, a relief valve and an outlet. The entire system is shown diagramatically at Fig 57. When the shut-off valve is opened, oxygen flows from the cylinders to the pressure reducing chamber. Deflection of the chamber diaphragm by this gas under pressure shuts the inlet valve at between 65 and 100 psi. Connection of the mask hose to the pressure reducer outlet opens the outlet valve and allows oxygen at reduced pressure to pass to the demand regulator. Inspiration deflects the regulator diaphragm and oxygen is drawn in until inspiration stops, when the diaphragm reseats the valve and stops the flow of gas. Oxygen passes to the inner mask through the non-return inspiratory valve. The system does not provide safety pressure and so a good seal is essential if inward leaks are to be avoided.

Closed Circuit Systems.

52. Considerable economy in the rate of consumption of any oxygen supply is achieved if the expired air is re-breathed after the removal of carbon dioxide. This is the principle of closed circuit systems. However, freezing and the accumulation of nitrogen are serious potential dangers of such systems so they are

employed very little in conventional aviation. On the other hand, in space, where the astronaut is obliged to carry his entire oxygen supply with him from earth, the advantages of closed circuits have been amply demonstrated. They are also used extensively in anaesthetic, fire-fighting and under-water breathing equipment.

Fig 55 Mk 9 Portable Oxygen Set in Normal Use.

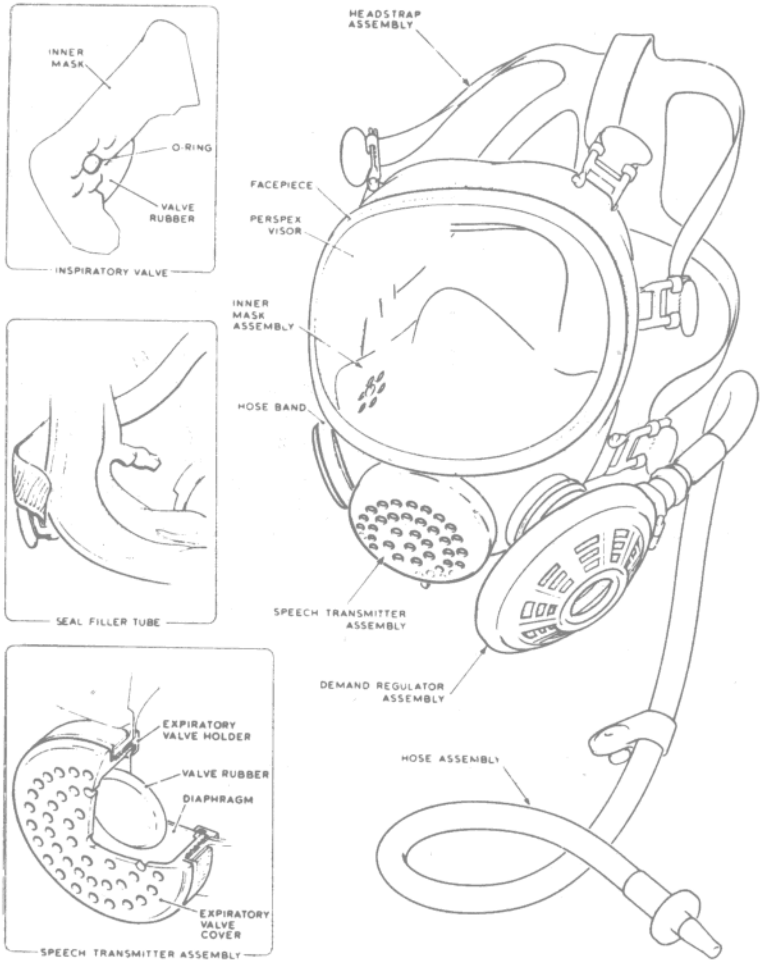


Fig 56 Mk 9 Set: Mask and Regulator Assembly.

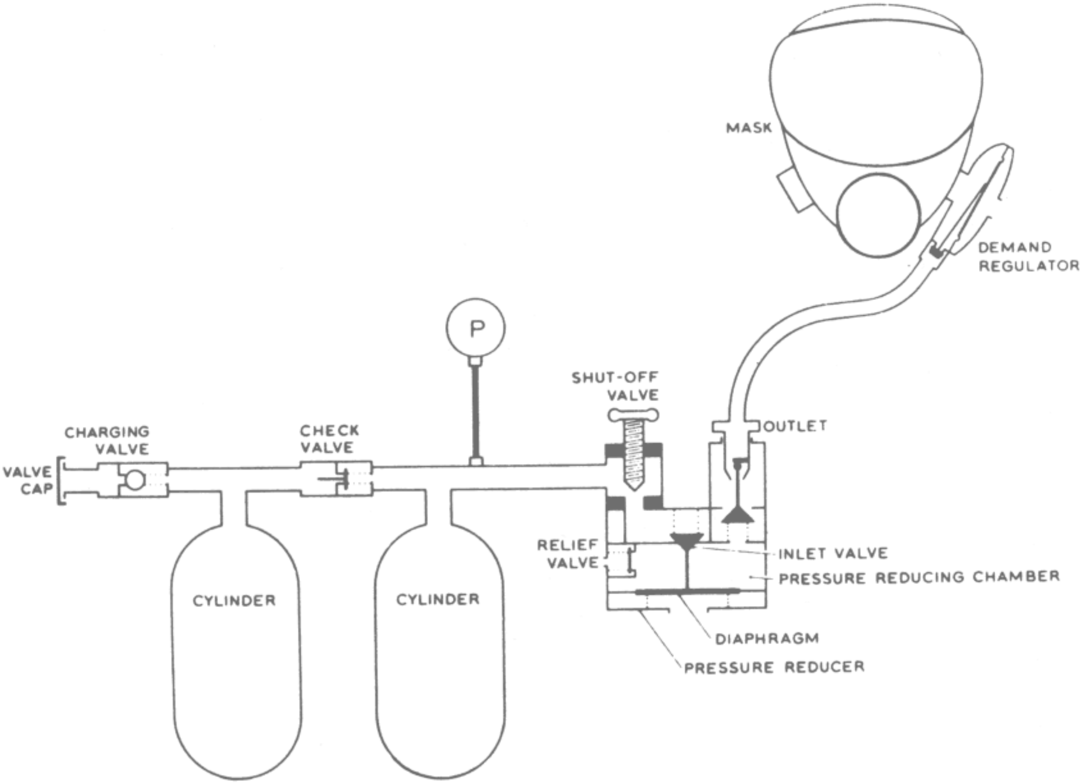


Fig 57 Mk 9 Set: Function.

SUMMARY OF OXYGEN SYSTEMS IN INDIVIDUAL AIRCRAFT TYPES.

No (a)	Aircraft (b)	Oxygen Storage: Type and Capacity (c)	Primary Regulator (d)	EO System (e)	PEC (f)	Mask (g)	Notes (h)
1	ANDOVER	Mk 1: LOX 1 x 10 L Mk 2: LOX 1 x 10 L + Gas 2 x 2250 L	17F x 4	←*	No	P2/Q2 P6/Q6	Mk 4 Walk-Around (w/a) x 2 Mk 8 w/a x 3 + L Mask
2	BUCCANEER	LOX 1 x 10 L	17F x 2	Demand: Mk 3 EO Reg	Yes	P8C/Q8C+ 'A' Option	
3	CANBERRA Low Level	Gas 1-2 x 2250 L ± 1-11 x 750 L Depending on Mk	17F	Continuous Mk 7J or K	No	P1/Q1	
4	CANBERRA PR 9	Gas 10 x 750 L	21B	Demand Mk 2 EO Reg	Yes	P2C/Q2C	Pressure breathing garments may be worn
5	DOMINIE	LOX 1 x 10 L	17F x 6	←*	No	P2/Q2 P6/Q6	Mk 4 w/a x 3
6	HARRIER (All Mks)	LOX 1 x 5 L	317A Mk 2	Demand: through primary Reg	Yes	V1	
7	HAWK	Gas 2 x 1400 L	517	Demand: through primary Reg	Yes	P8C/Q8C P9C/Q9C + 'A' Option	

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
8	HERCULES	LOX 1 x 25 L	CRU-68A	← *	No	P2/Q2	Mk 4 w/a x 4 Mk 9 w/a x 1 Para-Herc uses Mk 10A Reg feeding up to 12 economizers on a console
9	HUNTER	Gas 2-6 x 750 L depending on Mk	17F	Continuous Mk 7A	No	P1/Q1	
10	JAGUAR (All Mks)	LOX 1 x 10 L	417A	Demand: through primary Reg	Yes	V2	
11	JP 3/4	Gas 1 x 2250 L	16B x 1 16C x 1	Continuous Mk 7E	No	H	Economizer system
12	JP 5	Gas 3 x 750 L	17F x 2	Continuous Mk 7E	No	P1/Q1	
13	JETSTREAM	Gas 1 x 2250 L	A-12A	← * +10A* reg for pax. No economizer	No	R + drop down for pax	
14	LIGHTNING F Mk 3 & 6	LOX 1 x 3½ L	17F	Demand: Mk 3 EO reg	Yes	P2C/Q2C	
15	LIGHTNING T Mk 5	LOX 2 x 3½ L	120	Demand: Mk 220 EO reg	Yes	P2C/Q2C	

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
16	NIMROD	LOX 1 x 25 L	417 x 13	← * + ring main system for pax	No	T1 + drop down for pax	Mk 9/9A w/a x 3
17	PHANTOM	LOX 1 x 10 L	317A Mk 1	Demand: Through primary reg	Yes	V1	
18	SHACKLETON	Gas 10 x 2250 L		10A*feeding economizers	No	H	
19	TORNADO	LOX 1 x 10 L	517	Demand: through primary reg	Yes	P8C/Q8C P9C/Q9C	
20	VC 10	Gas 6 x 3220 L	17F x 5	← * + ring main system for pax	No	P6/Q6 + drop down for pax	Mk 8 w/a x 6 Mk 9 w/a x 1
21	VICTOR	Gas 10 x 2250 L	17F x 7	Demand: Mk 3 EO reg	Pilots Yes Rear-Crew No	P2C/Q2C	
22	VULCAN B2	Gas 10 x 2250 L	17F x 8	Demand: Mk 3 EO reg	–"–	P2C/Q2C	

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
23	VULCAN SR II	Gas 12 x 2250 L	21B x 8	Demand: Mk 2 EO reg	—"—	P2C/Q2C	Pressure breathing garments may be worn

← * : In those aircraft with high differential pressure cabins, the primary protection against hypoxia is the pressure cabin itself. The oxygen system fitted provides the Emergency Oxygen system.

SUMMARY OF OXYGEN REGULATORS IN SERVICE

No (a)	Regulator (b)	Mounting (c)	Safety Pressure (d)	Cabin Altitude Limit (e)	Notes (f)
DEMAND REGULATORS					
1	17F	Panel	Above 10,000-12,000 feet	50,000 ft at which height 30mm Hg pressure given	
2	21B	Panel	Above 10,000-12,000 feet	56,000 ft at which height 70mm Hg pressure given	Requires the use of pressure breathing garments: jerkin ± G-trousers
3	120	Seat	Above 14,000 feet	45,000 ft at which height 30mm Hg pressure given	Controls located remotely around cockpit. Originally designed for use with Partial Pressure Helmet.
4	317A	Man	Above 16,000-18,000 feet	50,000 ft at which height 30mm Hg pressure given	Has By-pass facility and anti-drowning shut-off valve.
5	417A	Man	Above 14,000-15,000 feet	50,000 ft at which height 30mm Hg pressure given	Has built-in Standby regulator and anti-drowning shut-off valve
6	417	Man	Above 14,000-15,000 feet	43,000 ft	As for 417 but NO pressure breathing facility. It is the emergency oxygen regulator In Nimrod aircraft.
7	517	Man	Above 15,000 feet	50,000 ft at which height 30mm Hg pressure given	
8	CRU-68A	Panel	Above 28,000 feet	48,000 ft at which height 28mm Hg pressure given	

(a)	(b)	(c)	(d)	(e)	(f)
9	A-12A	Panel	No	34,000 ft	No safety pressure or pressure breathing facilities.
OTHER REGULATORS					
10	16	Panel	No	43,000 ft	High flow delivered automatically at 30,000 ft ± 1500 ft but 100% oxygen not guaranteed because of H mask inlet valve. Used with Automatic Line Valve and Economizer.
11	10A*	Panel	No	43,000 ft	Used as an Emergency Oxygen regulator ± Economizer.

SUMMARY OF OXYGEN MASK HOSE ASSEMBLIES IN SERVICE

No (a)	Hose Assembly (Mk) (b)	PEC (c)	Aircraft (d)	Notes (e)
LOW PRESSURE HOSES				
1	1	Yes	Lightning, Canberra PR9, Victor	Has G-trouser connection
2	2	Yes	Vulcan	No G-trouser connection
3	9	Yes	Buccaneer	Air-ventilated Suit (AVS) port blanked off
4	10	Yes	Hawk, (Sea Harrier)	No AVS port
5	11	No	Victor, Vulcan	Rear crew. Connection to oxygen supply by means of Personal Hose Coupling
6	12	Yes	Tornado	Has AVS port
HIGH PRESSURE HOSES				
7	1	Yes	Phantom	Tailored disconnect lanyard connected by metal ring to clip on lifepreserver
8	2	Yes	Harrier	Automatic mechanical unlock of PEC on man-seat separation. Has lanyard (stitched to lifepreserver) to aid normal or emergency ground exit. Zipped sheath restrains service lines. AVS port blanked off.
9	3	Yes	Jaguar	Automatic mechanical unlock of PEC on man-seat separation. Has lanyard (stitched to lifepreserver) to aid normal or emergency ground exit.

SUMMARY OF OXYGEN MASKS IN SERVICE

No (a)	Mask Type (b)	Aircraft (c)	Suspension Harness (1) (d)	Hose (e)	Connector (f)	Notes (g)
PRESSURE DEMAND MASKS						
1	P1/Q1	Canberra (low level) Hunter JP 5	Link-Chain		Inlet Warning (MC3A)	No anti-suffocation valve
2	P2/Q2	Canberra PR9 Dominie Hercules Lightning (all Mks) Victor Vulcan (all Mks)	Link-Chain		Mk 7 bayonet	Anti-suffocation valve in Canberra PR9, Vulcan SR 11, Victor and Lightning P2C/Q2C
3	P3/Q3					NOT IN USE
4	P4/Q4					NOT IN USE
5	P5/Q5					NOT IN USE
6	P6/Q6	Andover VC 10 Dominie	Turnbuckle		Mk 7 bayonet	Used on flight deck. Same as P2/Q2 but for attachment to headset
7	P7/Q7					NOT IN USE

(a)	(b)	(c)	(d)	(e)	(f)	(g)
8	P8/Q8	Buccaneer Hawk Tornado	Peripin and Sleeve	Restraint Cord		May have 'A' and 'C' suffixes (2)
9	P9/Q9	Tornado	Peripin and Sleeve			Microphone plug for use with Mk 4 protective helmet
10	P10/Q10	Tornado	Peripin and Sleeve			Has new lead for use with the Mk 4 protective helmet
11	V1	Harrier Phantom	Peripin and Sleeve	Silenced 2-tube	L Adam	Has non-return inspiratory and anti-suffocation valves
12	V2	Jaguar	Peripin and Sleeve	Silenced 2-tube	Bayonet	Has an anti-suffocation valve but not a non-return inspiratory valve (iceguard is fitted)
13	V3, V5, V7, V8					These variants are identical to V1 but incorporate progressively improved microphone assemblies
14	V4, V6					These variants are identical to V2 but incorporate progressively improved microphone assemblies
15	T1	Nimrod	Turnbuckle	Silenced 2-tube		P/Q type mask with V type hose and no inspiratory valve

(a)	(b)	(c)	(d)	(e)	(f)	(g)
OTHER MASKS						
16	R	Jetstream	Turnbuckle			Similar to H type mask but no inspiratory valve. Used with A-12A regulator. No pressure breathing
17	H, H1A, H2	JP 3/4 Shackleton	Elastic/Hook or Turnbuckle			Used with Economizer System. No pressure breathing
18	L		Elastic			Therapeutic mask. Used in continuous flow systems both aircraft mounted and portable

Notes: (1) There is a need in some cases for a longer than usual suspension harness on the masks worn with the Mk 4 series protective helmets. When fitted with lengthened harnesses, such masks have the additional suffix 'L'.

(2) In the P/Q series masks, suffix 'A' designates a long mask hose (6 inches longer than normal), and suffix 'C' designates the presence of an anti-suffocation valve.