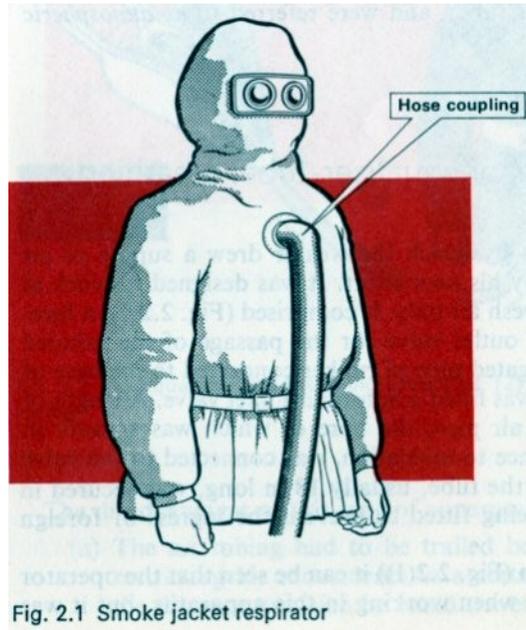


Chapter 2 - Early types of breathing apparatus

1 The evolution of breathing apparatus

The function of breathing apparatus is to enable the wearer to work in an atmosphere which would not otherwise support life. The necessity of such an apparatus has long been appreciated, and primitive devices of various kinds were in use as long as 100 years ago. The earliest types consisted of a muzzle fitting to the mouth with valves connected to which were tubes, the ends of which remained in the outer air. This type was used for a considerable period, in default of anything better, but suffered from the disadvantage that the energy required to overcome the friction of the air passing through the pipe had to be provided by the respiratory efforts of the wearer and breathing was consequently extremely difficult.

A more complex apparatus consisted of an airtight helmet and jacket of cowhide fitted with a hose-coupling to which air was pumped through delivery hose (Fig. 2.1). In this type the exhaled air escaped down under the skirt of the jacket and helped to keep the wearer cool in hot atmospheres.



A real attempt to master the problem was made in 1875 when Professor Tyndall, in conjunction with Sir Eyre Massey Shaw, devised and introduced a 'smoke cap', which was in fact the first respirator. This was similar in essentials to modern respirators, consisting of an airtight hood into which air was drawn from the atmosphere via a canister containing filtering elements.

All the early types of breathing apparatus were dependent upon a supply of oxygen from the atmosphere for their success. It was originally thought, from an insufficient understanding of the principles of respiration, that a respirator which would filter smoke and other gases would be effective under all conditions.

It was not realised that the greatest danger at a fire was due to oxygen deficiency, which nothing but a supplementary supply of air or oxygen could remedy. At least 16 per cent of oxygen is necessary to support life, and where due to combustion the percentage in the air is reduced below this figure, only apparatus which will provide its own supply of air (or oxygen) will enable the wearer to continue at work.

Apparatus depending on a self-contained supply of oxygen was produced for use in mines as early as 1881, but this type of breathing apparatus was not widely adopted for fire brigade use until after World War I.

The following are typical examples of early types of breathing apparatus which relied on a supply of air from the atmosphere, usually by means of air tubes, and were referred to as *atmospheric breathing apparatus*.

2 Short-distance, or equaliser-tube, breathing apparatus

This was an apparatus by which the wearer drew a supply of air from the atmosphere by his own effort. It was designed to work at a short distance from fresh air only. It comprised (Fig. 2.2(1)) a face-piece, with non-return outlet valve for the passage of the exhaled air and a flexible corrugated tube of rubber connected to the base of the face-piece to which was fitted a non-return inlet valve.

A length of strong wire-embedded air pipe, the bore of which was smooth in order to reduce resistance to inhalation, was connected to the valve inlet. The free end of the tube, usually 18 m long, was secured in fresh air, a strainer being fitted to prevent the ingress of foreign matter.

From the illustration (Fig. 2.2(1)) it can be seen that the operator required no assistance when working in this apparatus, but it was of paramount importance that the free end of the pipeline was in fresh air, and a man was always left in attendance at the free end to ensure that it was not tampered with or moved into an impure atmosphere.

The disadvantages of this type of apparatus were:

- a) The air tubing had to be trailed behind the wearer, thus restricting his movements to a certain extent and limiting the distance to which he could travel.
- b) The air tube could be cut or damaged by falling debris or other causes.
- c) The supply of air was dependent on the respiratory efforts of the wearer and involved considerable exertion.

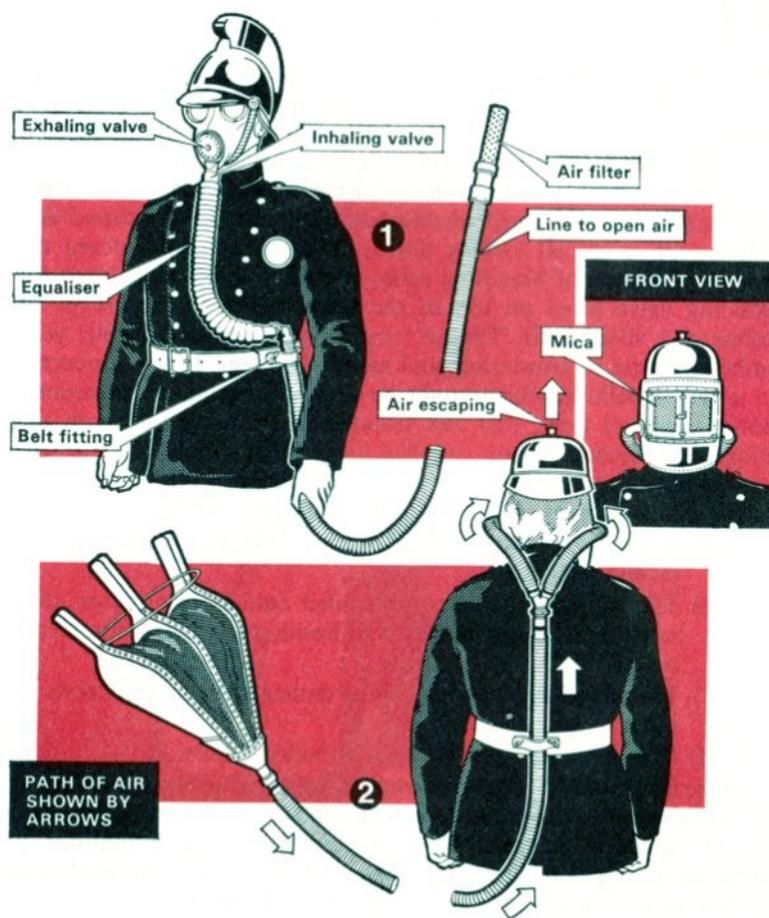


Fig. 2.2 (1) Equaliser tube breathing apparatus. (2) Bellows type smoke helmet

3 Bellows smoke helmets

A popular type of this apparatus consisted of a simple headgear blocked out of hide which fitted over the head of the wearer, hood fashion. A piece of soft leather attached to the base of the helmet, tucked in under the wearer's tunic or coat, sealed the lower part of the helmet from surrounding air. Small clear mica windows in hinged frames giving a wide field of vision could be instantly opened and closed with a special locking device (Fig. 2.2(2)). Air entered the helmet by means of breathing tubes at each side of the helmet. An exhaling valve fitted on top of the helmet allowed the escape of excess and vitiated air. The air pipeline was non-collapsible, with embedded wire or armouring, and metal couplings. It was connected to a set of bellows which could be of pedal, hand, or sometimes power-operated type; this was situated in fresh air and with the efforts of a second person supplied a continuous flow of air to the wearer of the apparatus.

The disadvantages of this type of apparatus were:

- a) A constant supply of air was always dependent upon a second person.
- b) The air tubing had to be trailed behind the wearer, thus restricting his movements and limiting the distance he could travel.
- c) The air tubing could be cut or damaged by falling debris or other causes.
- d) The apparatus as a whole was bulky to stow.

More and more brigades discarded this type of apparatus in favour of 'self-contained' apparatus in which the wearer carried his own supply of air or oxygen. Nevertheless, despite the limitations of atmospheric types of breathing apparatus, their use continued on a diminishing scale until the beginning of World War II.

4 Self-contained self-generating breathing apparatus

This type of apparatus consisted of a respirator type of face-piece, breathing tube and canister. The canister was filled with chemicals (the peroxides of sodium and potassium) which both generated oxygen and absorbed carbon dioxide exhaled by the wearer. The warmth and moisture of the exhaled breath started the reaction, but this process took a little time. Other disadvantages were that the apparatus could not respond to a sudden demand for oxygen and, owing to the fact that the reaction of the peroxides was exothermic considerable heat was generated, which added to the discomfort of the wearer.

This type of apparatus was never widely used in this country, but it was developed and improved in the United States of America.

5 Self-contained oxygen breathing apparatus

The forerunner of the self-contained oxygen breathing apparatus now widely used in this country was introduced into fire brigades in about 1912. This apparatus was a development of that used in the mines and was of self-contained closed circuit type (Fig. 2.3). A cylinder of oxygen was carried sufficient for a duration of up to 1 hour. The exhaled breath was returned to a breathing bag containing an absorbent which removed the carbon dioxide; it was then mixed with a fresh supply of oxygen and used again. The wearer inhaled and exhaled through breathing tubes fitted with non-return valves and connected to a mouthpiece. Goggles were worn for protection of the eyes.

The carbon dioxide absorbent used in the early apparatus consisted of sticks of caustic soda, which assumed a brown sticky state in use. Later the caustic sticks were replaced by coke soda, a form of coke impregnated with caustic soda. Both these absorbents were difficult to remove from the bag, and it was essential to wash out the breathing bag with warm water after each time of use. Carbon dioxide absorbents of this type are no longer used in the United Kingdom, and have been replaced in modern breathing apparatus by a substance known as soda lime.

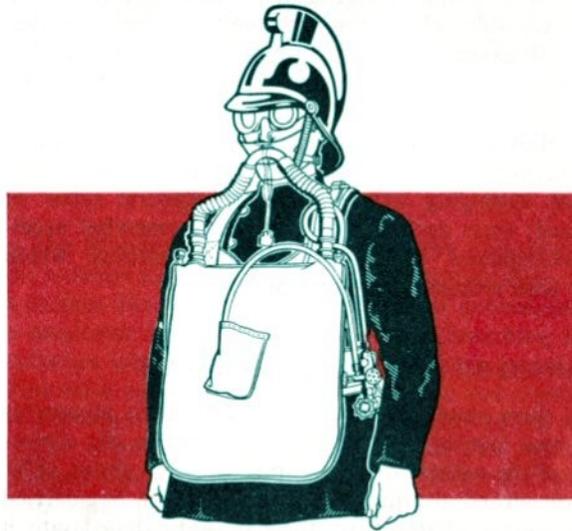


Fig. 2.3 Early type of self-contained oxygen breathing apparatus

In the closed circuit types of oxygen breathing apparatus no outside air is taken into the set, nor is the exhaled breath discharged to atmosphere. The exhaled breath is regenerated by removal of the CO₂, and the substitution of fresh oxygen, and the amount of oxygen to be carried is only that actually consumed by the wearer, so that the cylinder into which the oxygen is compressed (usually at a pressure of 120 or 132 atmospheres (bar)) is comparatively small.

To prevent a shortage of oxygen for a man walking at 5.6 km/h, a constant supply of 2 litres per minute should be available. This figure was the minimum provided in the early types of oxygen breathing apparatus, and is still the minimum provided in some modern types of apparatus.

The self-contained oxygen regenerative type of breathing apparatus gradually gained favour. Since some brigades preferred appliances using air to those supplying oxygen, the atmospheric types of apparatus died hard ; their decline, however, was somewhat accelerated by the development of compressed-air apparatus, which appealed to those who retained a preference for air.

6 Self-contained air breathing apparatus

Various attempts were made to produce a breathing apparatus which carried its own supply of air as an alternative to the atmospheric types. One of the earliest made its appearance in about 1870. In this type, air was stored at atmospheric pressure in a bag carried on the back; the wearer inhaled from the bag and exhaled into it through a mouthpiece and breathing tubes.

The intake was from the bottom of the bag where the air was cooler, and the exhaled breath was returned to the top. The air in the container quickly became deficient in oxygen, and the duration of the apparatus was only about 2-3 minutes. Fig. 2.4 is an illustration typical of this type of apparatus.

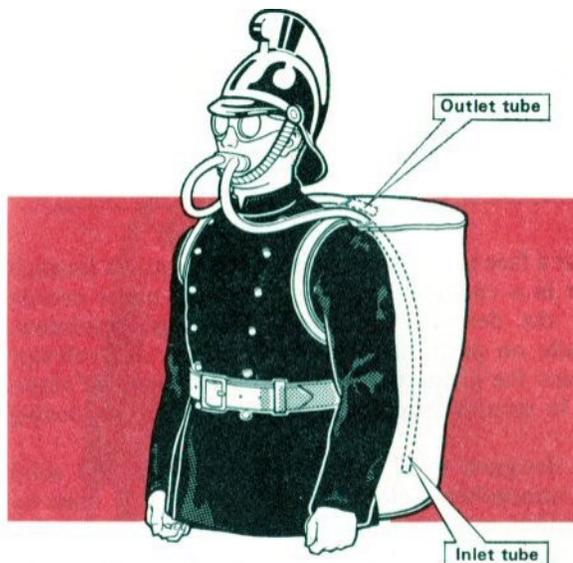


Fig. 2.4 Air breathing bag

In about the middle 1920s the Mandet apparatus of French design came into use. The apparatus was self-contained, having air at high pressure stored in two cylinders carried on the wearer's back. The apparatus was marketed in this country by Messrs. Roberts, McLean and Co. Ltd. Later this firm developed their own set, on similar lines, which was known as the 'Roberts Compressed-Air Breathing Apparatus, Mark 41.

The Mandet breathing set was of the open-circuit type in which the exhaled air is discharged into the atmosphere, and provision for a carbon dioxide absorbent is therefore unnecessary. It consisted of a respirator type of face mask with a breathing tube, and the two cylinders which discharged through a lung-governed demand valve. This valve operated according to the rate and depth of breathing and so provided the quantity of air demanded by the wearer.

The quantity of air carried in the two cylinders when fully charged was about 950 litres. A man walking at 6.4 km/h breathes about 37 litres per minute. At this rate of work the apparatus had a nominal duration of about 25 minutes.