

DEVELOPMENT OF A LOW-PROFILE RESCUE BREATHING APPARATUS AND A MINE RESCUE TEAM HELMET

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ABSTRACT

The Bureau of Mines has funded the development of two items of mine rescue team equipment in order to make mine rescue missions safer and more efficient. A 2-h breathing apparatus was developed with the goals of low profile, light weight, positive pressure, cooler breathing air, and low breathing resistance. These goals were achieved through the use of efficient design, proper choice of

materials, dual spring-loaded breathing bags, and an internal heat exchanger. The apparatus, the LP-120, has a profile of 10 cm, weights 10 kg, and contains 240 L O₂. A rescue team helmet was also developed that combines the functions of full head protection, breathing apparatus facepiece, communications, and lighting. This helmet was designed to be used with the LP-120.

INTRODUCTION

Since mine rescue teams constitute a small market in the view of equipment manufacturers, their needs remain unfulfilled when they are unique. At present, mine rescue teams utilize equipment that largely has been designed for other purposes and are hampered in their duties by being forced to use safety equipment that only marginally serves their needs. Simply stated, the problem is that the more general the need, the more likely it is

to be satisfied; whereas the more unique the need, the more likely it is to be unsatisfied.

The Bureau is attempting to solve the problem of how to advance technology in mine rescue team equipment through subsidizing its development costs. At present, the Bureau is involved with two such developments: a low-profile rescue breathing apparatus and a mine rescue team helmet.

DESCRIPTION OF APPARATUS

The low-profile rescue breathing apparatus is being developed by U.S.D. Corp. through contract H0123008. The mine rescue team helmet is being developed by Gentex Corp. through contract H0252050. Both pieces of equipment are being developed to improve the efficiency, safety, and comfort of mine rescue team members involved in mine rescue and recovery missions.

LOW-PROFILE RESCUE BREATHING APPARATUS

Four agencies are cofunding the low-profile rescue breathing apparatus (LPRBA) contract - the U.S. Bureau of

Mines, for use by mine rescue teams on rescue and recovery missions in underground coal mines; the U.S. Air Force, for use by Air Force firefighters in chemical warfare firefighting; the U.S. Federal Emergency Management Agency (subgroup - U.S. Fire Administration), for use by firefighters in situations when long-duration apparatus are needed, such as in high-rise buildings, tunnels, and subways; and the U.S. Coast Guard, for use in cleaning up chemical spills or toxic waste dumps.

The LPRBA is a closed-circuit apparatus and has a rated duration of 120 min, hence its name, the LP-120. Figure 1 shows the LP-120 in its present configuration; figure 2 is a schematic of the apparatus. Since duration is dependent upon O₂ use rate, the apparatus is better

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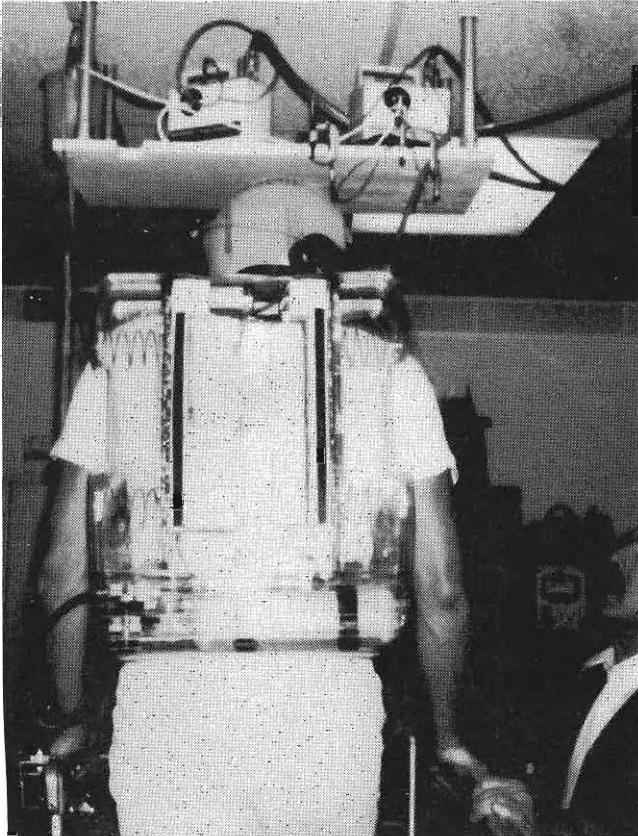


FIGURE 1.—The LP-120.

described as containing 240 L O₂. The apparatus has a number of features that make it unique among closed-circuit RBA's:

1. The most significant feature is the low profile of the apparatus, which is effectively 10 cm from the farthest projection of the back. The actual thickness will be greater than 10 cm, but use of the contour of the human back keeps the 10-cm profile. The most widely used RBA, the Draeger BG-174A, has a thickness of 16 cm and contains 400 L O₂. This is considered a 4-h device but is not usually used for more than 2 h.

2. The weight of the LP-120 is also a significant improvement over that of present apparatus. It is projected to weigh approximately 10 kg compared to 16 kg for the Draeger BG-174A.

3. The apparatus is a positive-pressure system, which means that, in most circumstances, the pressure in the face-piece remains positive compared to ambient. This ensures that any inadvertent

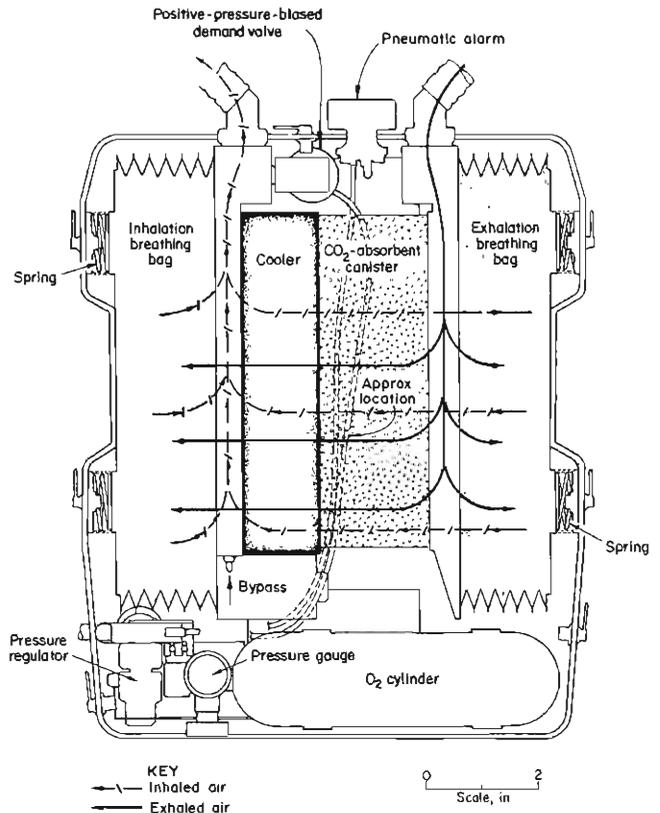


FIGURE 2.—LP-120 schematic.

leaks will be outward and will not result in any inward leakage that could contaminate the breathing air and endanger the wearer. The positive pressure is maintained through the use of a biased demand valve and two spring-loaded bags.

4. Dual breathing bags enable the breathing resistance to be split between inhalation and exhalation, unlike other closed-circuit RBA's in which most of the effort is placed on exhalation. This is because other apparatus place their single breathing bag in the breathing loop after the CO₂-absorbent canister, or CO₂-scrubber, so that the user must force the air through the chemical bed on exhalation. The use of two breathing bags splits the work of breathing, and, because of the pressure gradient between the bags on either side of the CO₂-scrubber, some of the air flows through the scrubbers by itself.

5. A lithium nitrate, phase-change, heat exchanger is utilized to cool the air after it is heated by the LiOH in the scrubber.

MINE RESCUE TEAM HELMET

The major improvement offered by the mine rescue team helmet (MRTH) (figs. 3-6) is that it consolidates a number of separate pieces of equipment produced by different manufacturers: the hardhat, the facepiece of the breathing apparatus, the cap lamp, and the communications system. All of the separate items have been designed to be compatible with each other, and the MRTH has been designed to be compatible with the LP-120. Following are listed the benefits of the MRTH:

1. The new helmet increases head protection through the use of impact- and penetration-resistant materials and increased coverage at the back and sides of the head.
2. Unlike a hardhat, it will not fall off if you lower your head.
3. It offers a lower profile than hard hats. This will result in hitting the roof less often.
4. The MRTH utilizes a new, smaller light source designed and sold by MSA.
5. The faceplate is removable and attaches to the chest straps of the

breathing apparatus when breathing protection is not needed. See figure 6 for a concept drawing.

6. A three-position switch in the communications system enables the wearer to speak to ambient, or the fresh air base, if connected to the lifeline, or to turn off the communications system.

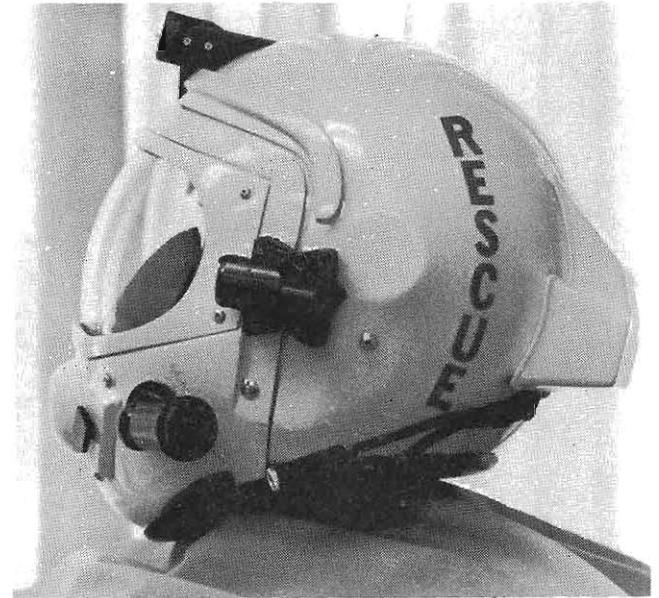


FIGURE 4.—MRTH, side view.



FIGURE 3.—MRTH, front view.

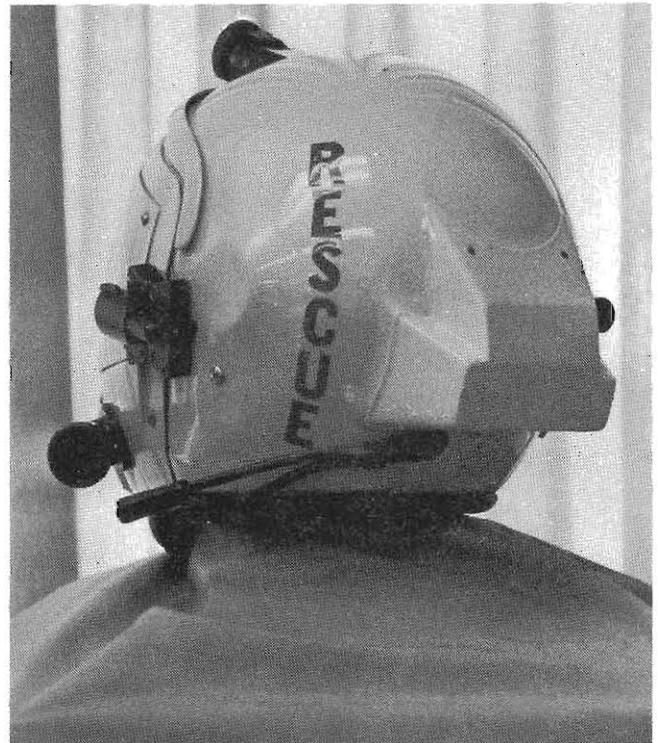


FIGURE 5.—MRTH, back view.



**FACEPIECE HARD SHELL
IN DONNED POSITION**



**FACEPIECE HARD SHELL
IN DOFFED POSITION**

FIGURE 6.—MRTH concept drawing.