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AN ALTITUDE CHAMBER RESCUE ENSEMBLE

Russell P. Lloyd, Engineering Division
Support Operations Directorate, KSC, NASA

INTRODUCTION

The John F. Kennedy Space Center of the National Aeronautics and Space Administration is responsible for the launching of the Apollo space vehicles. One phase of the preflight checkout of these vehicles is the altitude chamber testing of the command/service modules (CSM) and the lunar module (LM). A portion of the altitude chamber tests are accomplished with the astronaut crews in the spacecraft. The fact that the astronauts are in the spacecraft at a simulated altitude of above 200,000 ft requires that a rescue team be provided in the event of an accident in the spacecraft. The rescue crew is stationed in an airlock maintained at an altitude of 18,000 ft. A protective ensemble therefore is needed that will provide the rescue crew with life support capabilities, communications, and protection in the event of an emergency. In the event of an emergency, repressurization of the chamber is initiated; as the chamber descends, the airlock ascends and the two meet at 25,000 ft. This phase of the emergency repressurization takes less than 30 sec. Each rescue team is allowed to remain at the 18,000 ft altitude for only 4 hr; therefore, 2 or 3 rescue teams may be utilized during the usual 10 to 12 hr spacecraft test.

HISTORY

At the initiation of the Apollo program the only equipment KSC had for the rescue ensemble consisted of some gear from the Mercury program; all Gemini program altitude testing had been done at the manufacturer's plant. The first manned altitude testing of Apollo hardware was CSM-012, which was to have flown on Apollo 1—the flight that was prevented by the disastrous fire on Launch Complex 34 in January 1967. When the chamber testing was accomplished on this spacecraft, a final ensemble configuration had not been selected; however, the following equipment was to be used (fig. 27.1):

1. Helmet, mask, regulator assembly.
2. Liquid oxygen backpack, ELSA.
3. Dacron coverall with conventional underwear.
4. Safety boots.
5. FM Handi Talki.

THE ELSA

The backpack shown in figure 27.1 is an early ELSA (environmental life support assembly), not yet fully qualified, which was used only as backup to a hose-line breathing system. This early ELSA, which uses a 3.5 liter dewar and provides 80 psig to a mask, was developed at KSC as an alternate to a similar backpack, which was too bulky and heavy owing to the use of a larger liquid oxygen dewar. This unit is essentially the same as that now used at KSC with some changes to reduce flammability and to increase reliability.

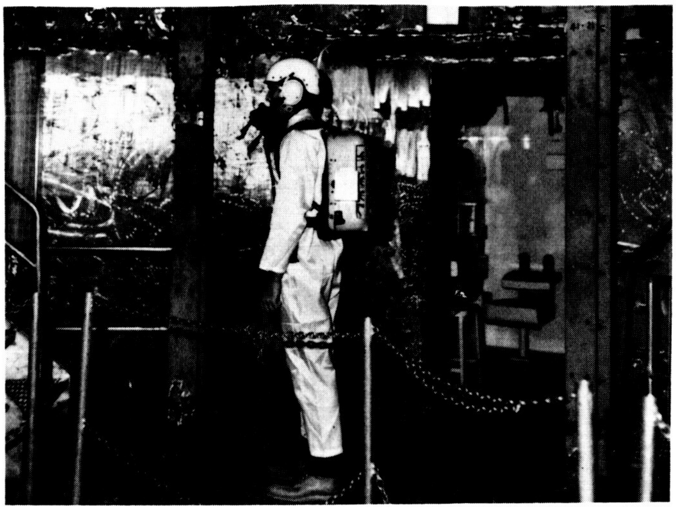

Figure 27.1 *The original rescue ensemble.*

The performance specifications for the ELSA are:

1. Liquid oxygen service.
2. Full weight not to exceed 25 lb.
3. Liquid oxygen capacity of 3.5 liters.
4. Ambient operating temperature of 50° to 90° F.
5. Gaseous oxygen temperature at the mask of 70° F ±20° F.
6. Normal operating pressure of 100 ±5 psig.
7. The unit must be operational through an operating pressure range of 50 to 155 psig.
8. Relief valve setting at 150 ±5 psig.
9. Standby time of 16 hr.
10. Operating altitude from sea level to 30,000 ft.
11. Oxygen flow rate to meet the following conditions:

Liters/ min	*Mask inlet temperature (°F)*	*Minimum time*	*System psig*	*Altitude ft*
15	70 ± 5	2.5 hr	80 ± 10	Sea level
25	60 ±5	30 min	80 ± 10	Sea level
45	50 (minimum)	5 min	70 ± 20	Sea level
15	70 ± 5	5 hr	80 ± 10	18,000
25	60 ± 5	1 hr	80 ± 10	18,000
45	50 (minimum)	15 min	70 ± 20	18,000

ELSA performance specifications today are the same as those originally given except that standby time has been reduced from 16 hr to 8 hr. The spacecraft tests at altitude are not as long as they were originally, thereby reducing the standby time required; furthermore, only new or newly overhauled dewars are suitable for the longer standby time—normal degradation of the dewar causes too great a loss of heat to maintain pressure below the relief valve setting.

The normal operating profile of the ELSA is 10 min at sea level, an ascent to 18,000 ft, and a normal stay time of just under 4 hr at that altitude, and a descent to sea level at 5,000 fpm. The activity of the personnel during this profile would be light. The heaviest demand on the ELSA would be during a rescue operation, which could take place at any time during the 4-hr stay at

18,000 ft. Under rescue conditions, the airlock is ascended to 25,000 ft in approximately 5 sec, after which there would be a high demand on the ELSA through the rescue, which takes 1-1/2 to 2 min, followed by, or in parallel with, a descent to sea level possibly as fast as 17,000 fpm.

The ELSA was qualified for operational use in early 1968 through a qualification program designed to demonstrate the units capabilities under both normal and extreme operating conditions. The qualification program included tests at altitudes up to 43,000 ft, tests at attitudes from 0 to 180° from vertical, and tests at flow rates of 15, 25, and 45 liters/min. Numerous tests combined the above variables under various planned and unplanned situations. These unmanned qualification tests were followed by a man-rating test in the altitude chamber, including a test to determine the actual useful capacity under normal operating conditions. The units lasted the required 5 hr with liquid to spare. It was extrapolated that the ELSA would last over 7 hr at 18,000 ft. Note that these tests were made with dewars capable of passing the 16-hr standby test; the overall operating time is reduced somewhat by a dewar having less efficient insulation.

Simplicity is a major factor in the reliability of the ELSA, which consists of a 3-1/2 liter dewar, heat exchanger coils, pressure control valves, and valves for filling and venting (fig. 27.2). The unit is filled by introducing liquid through the fill valve and out the vent valve; a minimum of 8.5 lb of liquid is put in the dewar. To put the ELSA into service, one simply opens the build-up valve, allowing the high pressure PCV (pressure closing valve) to maintain 100 psig on the liquid in the dewar. This pressure in turn forces liquid into the primary coil, and the low pressure PCV then controls the pressure in the secondary coil at 80 psig, which is the pressure supplied to the pressure-demand regulator in the helmet assembly. Figures 27.3, 27.4, and 27.5 show the ELSA construction.

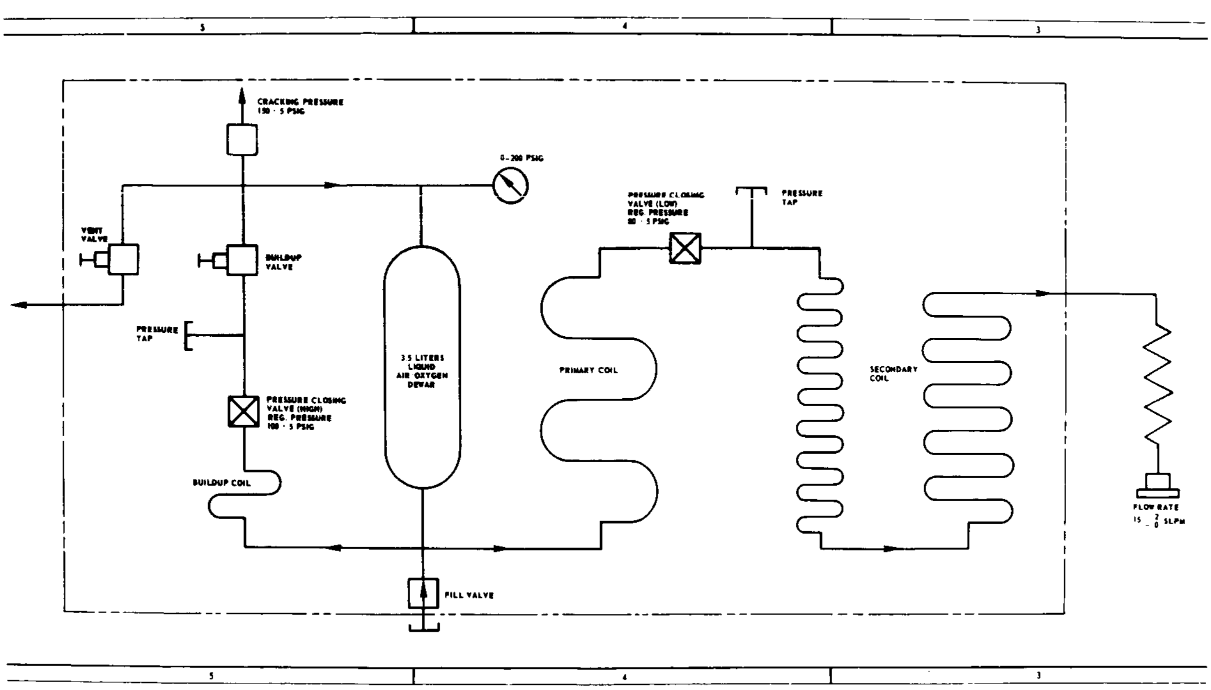

Figure 27.2 *ELSA schematic.*

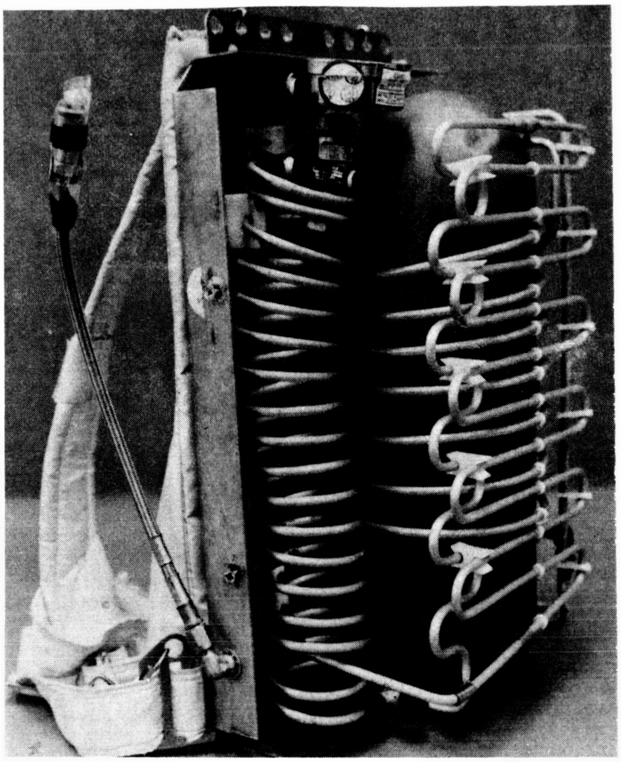

Figure 27.3 *Left side view of ELSA with cover removed.*

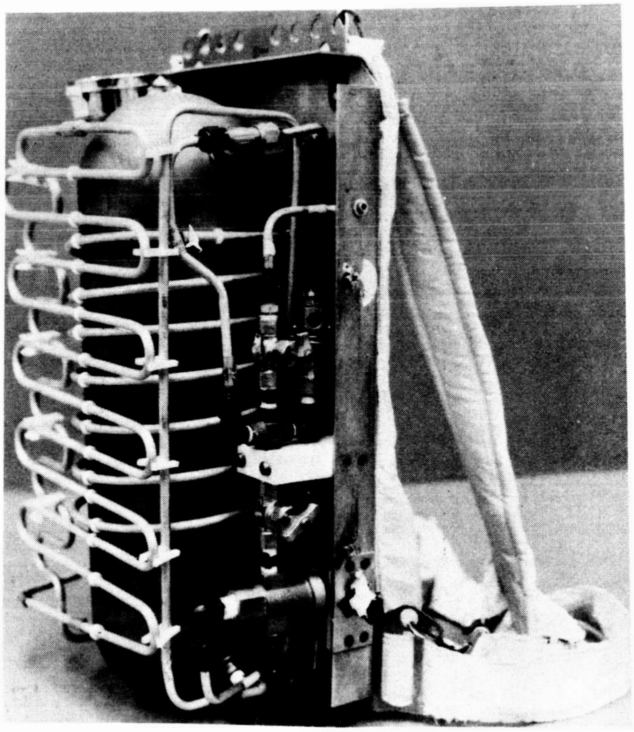

Figure 27.4 *Front view of ELSA with cover removed.*

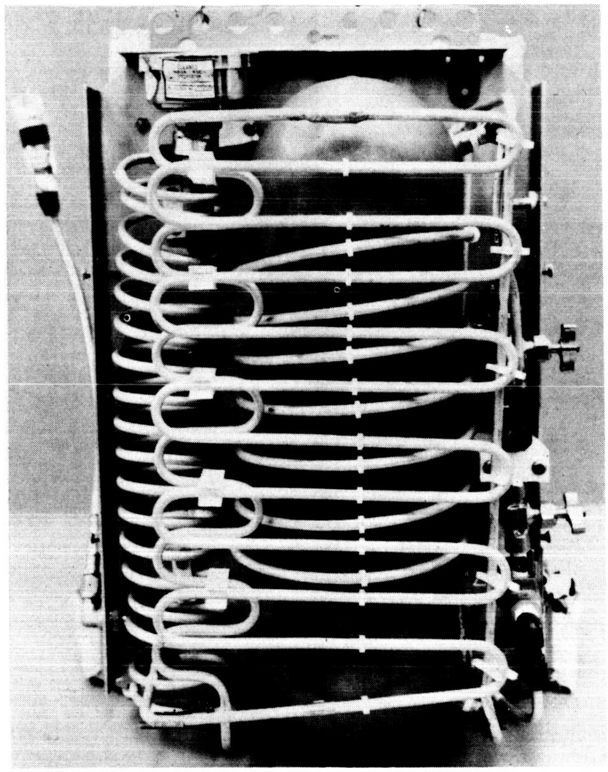

Figure 27.5 *Right side view of ELSA with cover removed.*

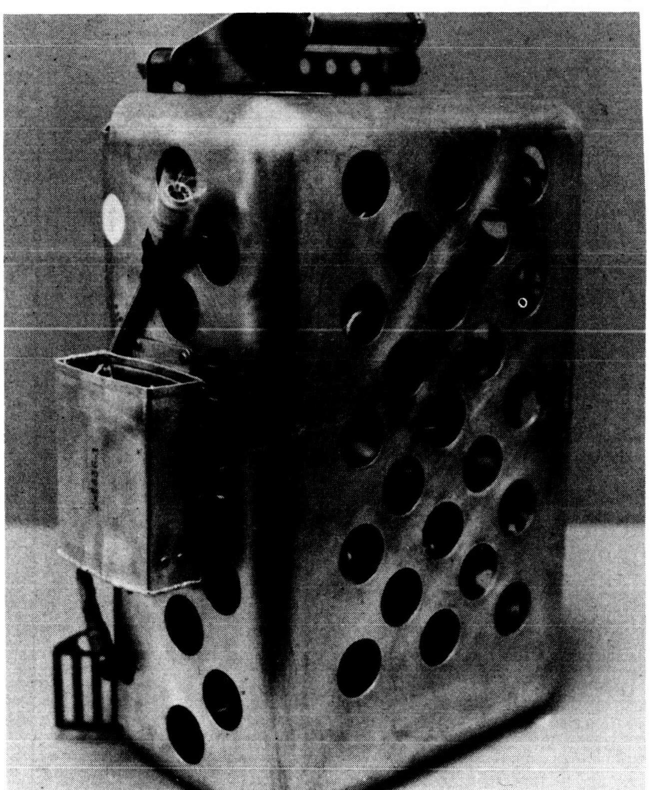

Figure 27.6 *ELSA*

THE PRESENT ENSEMBLE

Since 1966, the ELSA has been modified to remove the flammables, the case is now aluminum instead of plastic (fig. 27.6), and the harness is Beta cloth rather than nylon (fig. 27.7). The original dewars were replaced with dewars designed with superinsulation as a means of maintaining the 16 hr standby time. A problem with outgassing of the superinsulation, however, forced a return to dewars similar to the original ones.

The dacron coveralls have been replaced with a two-piece Beta cloth suit (fig. 27.8) over Roxel treated cotton long underwear. The original plan to use a Beta hood under the helmet proved unsatisfactory due to Beta fibers and any wrinkle in the hood caused discomfort.

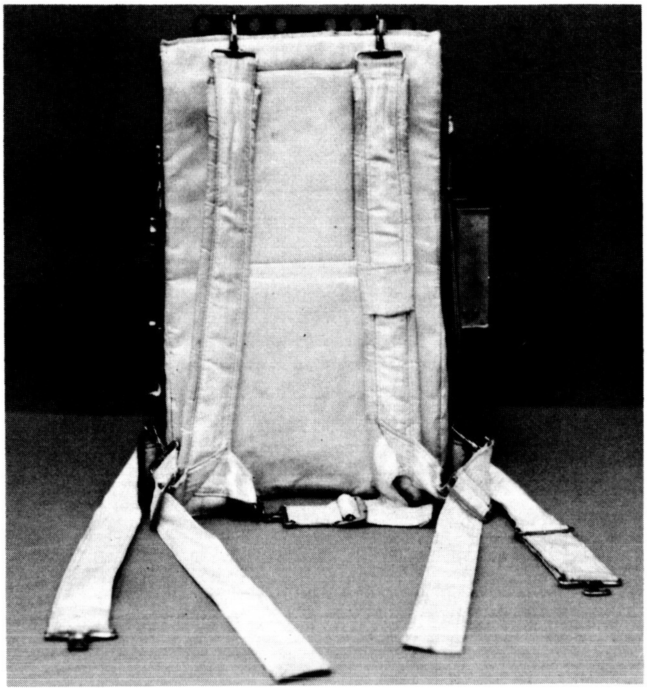

Figure 27.7 *ELSA Beta cloth harness.*

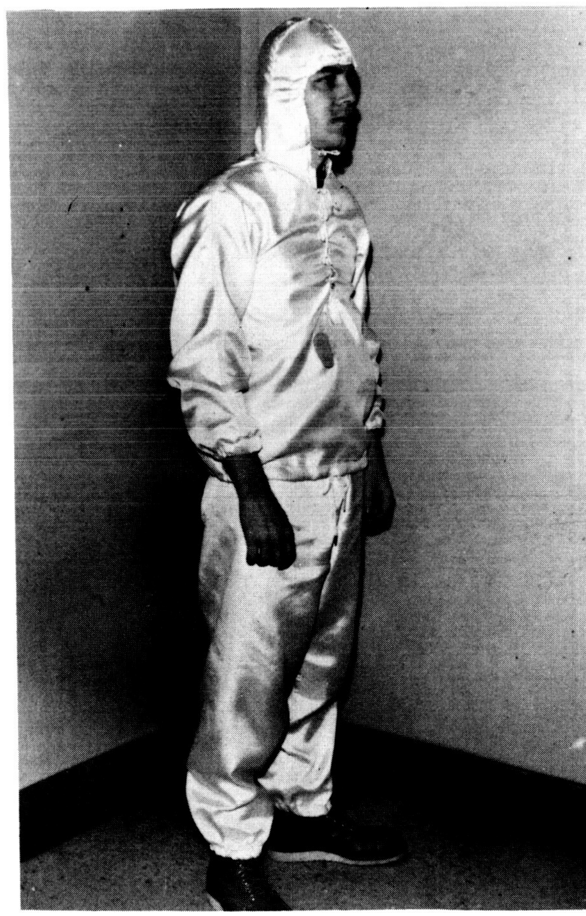

Figure 27.8 *Beta cloth rescue garment.*

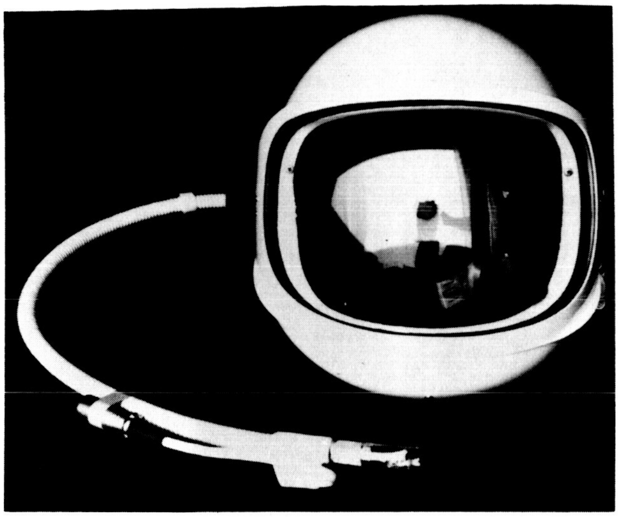

Figure 27.9 *Side view of Robertshaw helmet.*

The most recent change has been the replacement of the helmet, mask, and regulator assembly with a helmet (fig. 27.9 and 27.10) that incorporates all three into a single unit and provides eye protection from smoke and water in the event of fire in the chamber. Efforts to find goggles that would provide a smoke-tight seal with the old helmet and mask were unsuccessful.

The present ensemble consists of the following: (fig. 27.11, 27.12, and 27.13):

1. Full head helmet.
2. ELSA Mark II.
3. Beta cloth suit.
4, Safety boots.
5. FM Handi Talki.

The Kennedy Space Center's philosophy in equipping the altitude chamber rescue team has always been to give them total mobility and flexibility by eliminating the need for a link to the airlock facility itself for any life support function. Thus, they do not have to worry about dragging a long flex hose or having to disconnect from facility oxygen and work with a small, less reliable portable source. The rescue ensemble described here is believed to fulfill these objectives well.

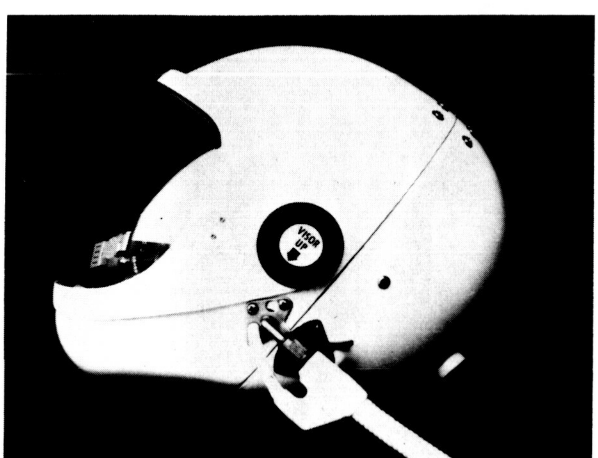

Figure 27.10 *Front view of Robertshaw helmet.*

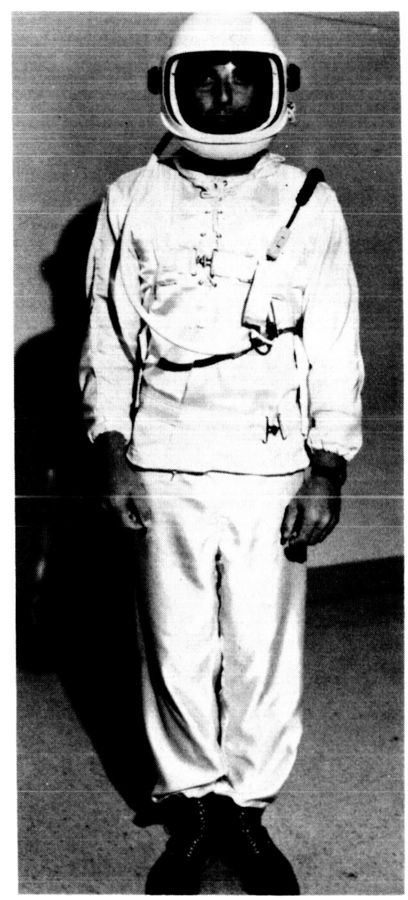

Figure 27.11 *Front view of present rescue ensemble.*

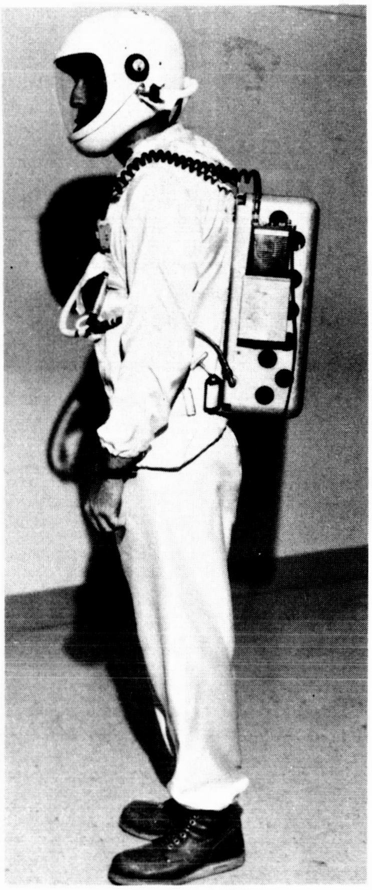

Figure 27.12 *Side view of present rescue ensemble.*

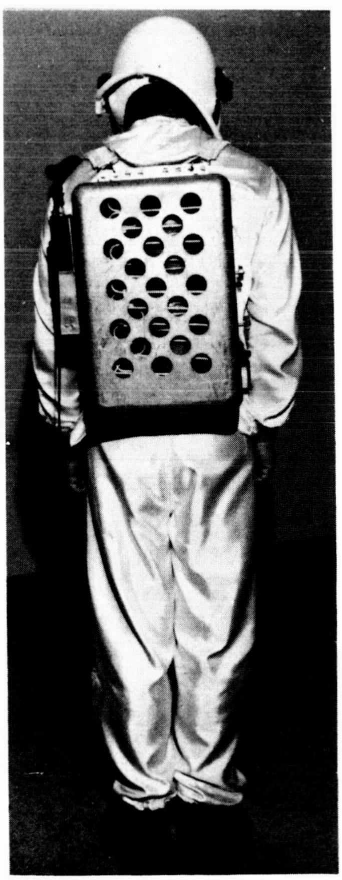

Figure 27.13 *Back view of present rescue ensemble.*