**APOLLO NEWS REFERENCE**

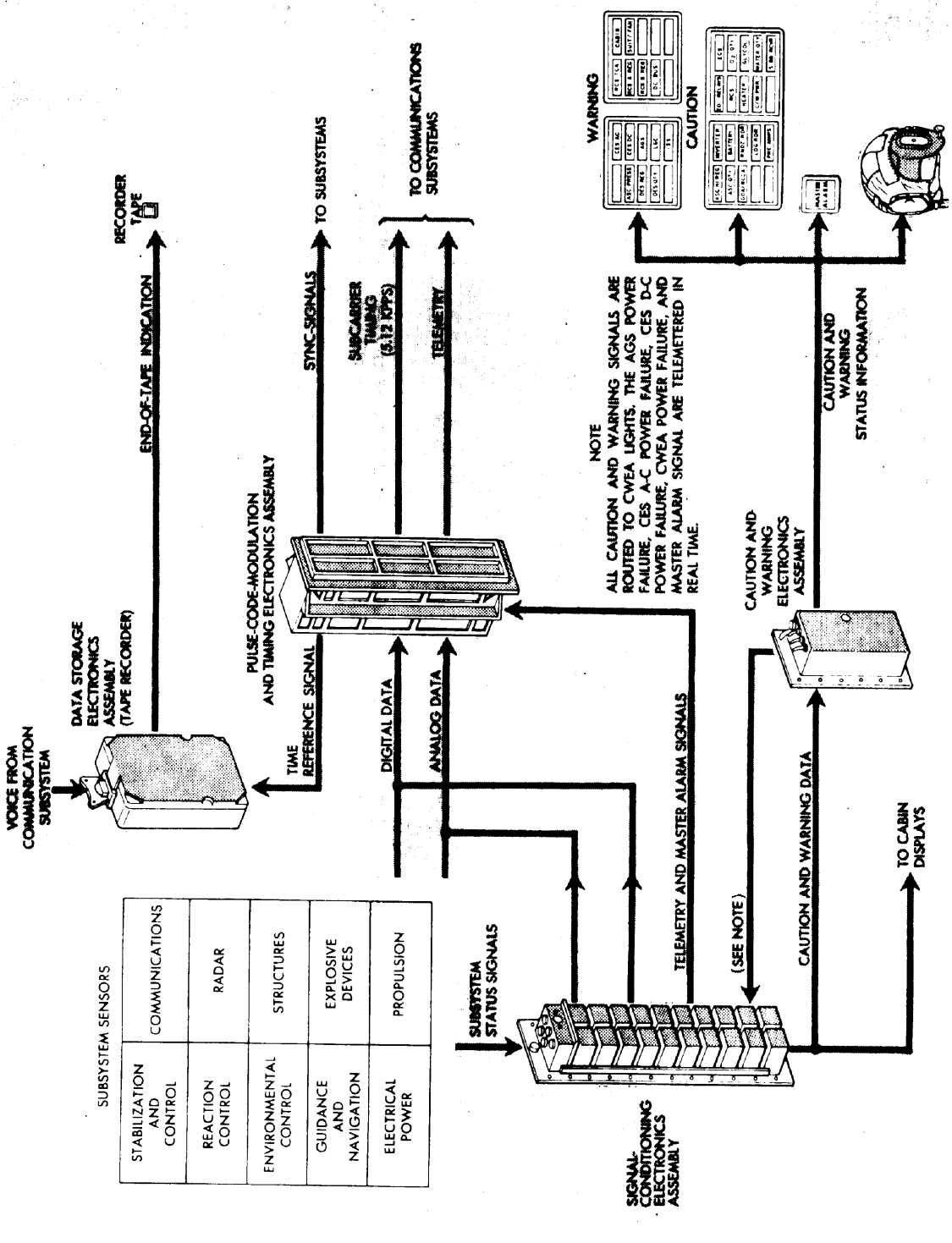
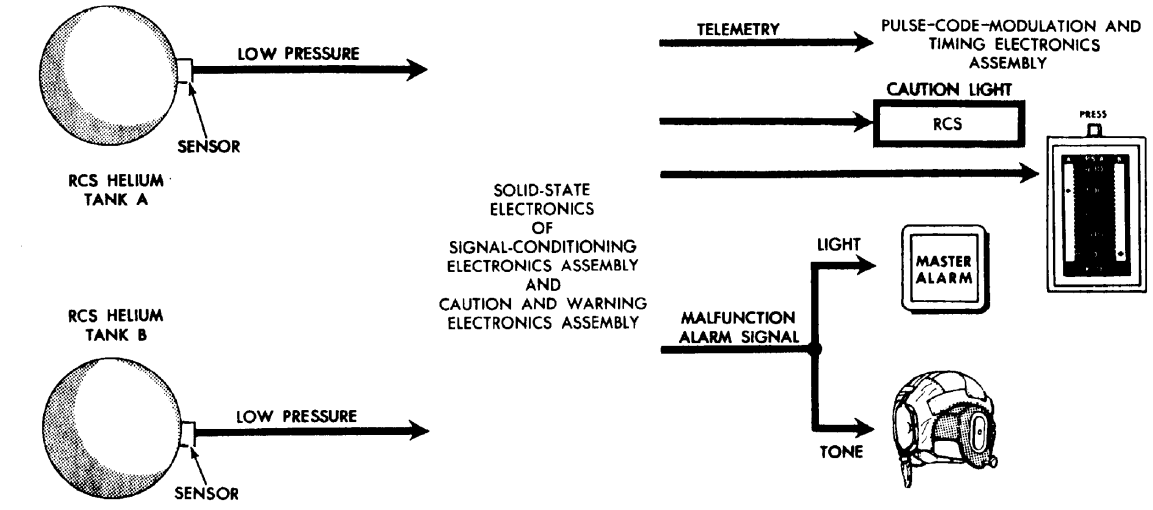



*Diagram of Instrumentation Subsystem*



Grumman




R-104

*RCS Failure Detection*

The data storage electronics assembly is a tape recorder that records voice and time-correlation data (mission elapsed time). The voice and data inputs are multiplexed and recorded. The recorder can be operated manually or semiautomatically. In the manual mode, an astronaut closes a push-to-talk switch on his attitude controller assembly or electrical umbilical and speaks into his microphone. In the semiautomatic mode, CS equipment senses voice inputs from within the cabin or from the communications receivers and activates the recorder. Voice signals from the CS intercom bus are also recorded, together with mission elapsed time.

## EQUIPMENT

### SUBSYSTEM SENSORS

The sensors fall into four general categories: mechanical, resistive, variable reluctance, and electrical. They are located throughout the various LM subsystems and structure and are used to change physical data into electrical signals.

### SIGNAL CONDITIONING ELECTRONICS ASSEMBLY

This assembly consists of two electronic replaceable assemblies, each capable of housing up to 22 plug-in subassemblies of 11 different types (converters, amplifiers, etc.). Each subassembly contains its own power supply, which is isolated from the other subassemblies. Loss of one subassembly, due to a power supply failure does not affect operation of the other subassemblies. The subassemblies perform one or more of the following seven functions: amplify d-c voltages, attenuate d-c voltages, convert ac to dc, convert frequency to dc, phase-modulate ac to dc, convert resistance variations to d-c voltages, and isolate signals.



"ApolloNewsRef LM M.I05.PICT" 240 KB 1999-02-07 dpi: 360h x 367v pix: 2698h x 3824v

### Pulse-Code-Modulation and Timing Electronics Assembly

This assembly comprises two sections: timing electronics and pulse code modulation. The timing electronics section develops timing signals for the pulse code modulation section, and the LM subsystems including the mission elapsed timer. The pulse-code-modulation section converts analog and digital signals to one of two formats, normal and reduced, for telemetering: 51,200 bits per second and 1600 bits per second.

### Data Storage Electronics Assembly

This assembly is a single-speed, four-track, magnetic tape recorder that stores voice and time-correlation data. A maximum of 10 hours of recording time is provided (2.5 hours on each track) by driving the tape, at 0.6 inch per second, over the record head and, on completion of a pass, automatically switching to the next track and reversing tape direction. One tape (450 feet) is supplied in a magazine.

### Caution and Warning Electronics Assembly

This assembly compares analog signals (between 0 and 5 volts dc), from the signal-conditioning electronics assembly, with preselected internally generated limits supplied by the caution and warning power supply as reference voltages. In addition to analog inputs, it receives discrete on-off and contact closure signals. All inputs are routed to detectors; the detected signals are routed through logic circuitry, enabling relay contacts that cause caution or warning lights to go on or causing talkbacks to change state. Simultaneously, the detected signal energizes a master relay driver, enabling relay contacts. These contacts route a signal to light the master alarm lights and trigger the 3-kHz tone to the headsets.





"ApolloNewsRef LM M.I06.PICT" 193 KB 1999-02-07 dpi: 360h x 367v pix: 2691h x 3824v

**APOLLO NEWS REFERENCE**

# LIGHTING

## QUICK REFERENCE DATA

| | |
|---|---|
| Exterior tracking light | |
| Type | High-intensity, flashing |
| Intensity | 9,000 beam candlepower (minimum) |
| Visibility | Cone centered on LM +Z-axis, with semivertex angle of 30° |
| | Visual: 10 to 130 nautical miles |
| | CSM sextant: 30 to 400 nautical miles |
| Docking lights | |
| Type | Incandescent |
| Intensity | Fixed |
| Visibility | 1,000 feet |
| Interior | |
| Control panels and pushbuttons | White |
| Circuit breakers | White |
| Numeric readouts | Green |
| Lunar contact lights | Blue |
| Caution annunciators | Yellow |
| Warning annunciators | Red |
| Master alarm pushbutton/lights | Red |
| Component caution lights | Yellow |
| Engine start and stop pushbutton/lights | Red |
| Computer status condition indicators | White |
| Self-luminous devices | Green |
| Talkbacks (two- and three-position) | White background |
| Displays | |
| Characters and indicia | White |
| Labels and multipliers | Green |
| Range markings | Green |
| Immediate-action or emergency controls | Yellow |
| Indicator power failure lights | Red |
| Floodlights | White |

Exterior and interior lighting aids in the performance of crew visual tasks and lessens astronaut fatigue and interior-exterior glare effects. Exterior lighting is used for LM and CSM tracking and docking maneuvers. Interior lighting illuminates the cabin and the controls and displays on the Commander's and LM Pilot's panels.

## FUNCTIONAL DESCRIPTION

LM lighting is provided by exterior and interior lights and lighting control equipment. The exterior lighting enables the astronauts to guide and orient the LM visually to the CSM visually to achieve successful tracking and docking. Interior lighting is divided into seven categories: incandescent annunciators, component caution lights, floodlights, computer condition lights, integral electroluminescent lighting, numeric electroluminescent lighting, and incandescently illuminated pushbuttons.

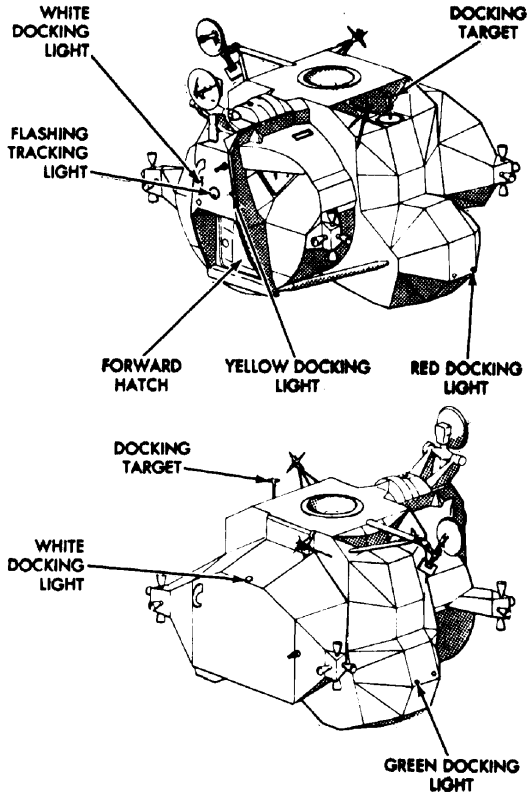
### EXTERIOR LIGHTING

Exterior lighting includes five docking lights, and a high-intensity tracking light.



"ApolloNewsRef LM N.L01.PICT" 207 KB 1999-02-07 dpi: 360h x 367v pix: 2648h x 3817v

**APOLLO NEWS REFERENCE**




R-105

*Ascent Stage Exterior Lighting*

## DOCKING LIGHTS

Five docking lights mounted on the exterior of the LM provide visual orientation and permit gross attitude determination relative to a line of sight through the CSM windows during rendezvous and docking. For transposition and docking, the docking lights are turned on by a switch located at spacecraft Lunar Module adapter attachment points. This switch is automatically closed upon deployment of the adapter panels. At completion of the docking maneuver, LM power is turned off and the docking lights go off. The lights are visible, and their color recognizable, at a maximum distance of 1,000 feet.

## TRACKING LIGHT

The tracking light permits visual tracking of the LM by the CSM. A flash tube in the tracking light electronics assembly causes the light, which has a 60° beam spread, to flash at a rate of 60 flashes per minute.

## INTERIOR LIGHTING

Interior lighting consists of integral panel and display lighting, backup floodlighting, and electroluminescent lighting. Electroluminescence is light emitted from a crystalline phosphor ($Z_NS$) placed as a thin layer between two closely spaced electrodes of an electrical capacitor; one of the electrodes must be transparent. The light output varies with voltage. Advantageous characteristics are an "afterglow" of less than 1 second, low power consumption, and negligible heat dissipation.

## INTEGRALLY LIGHTED COMPONENTS

There are three types of integrally lighted components: panel areas, displays, and caution and warning annunciators. The integrally lighted components use electroluminescent or incandescent devices that are controlled by on-off switches and potentiometer-type dimming controls. All panel placards are integrally lighted by white electroluminescent lamps with overlays. The displays have electroluminescent lamps within their enclosures. The numeric displays show green or white illuminated digits on a nonilluminated background; displays with pointers have a nonilluminated pointer travelling over an illuminated background. The brightness of the electroluminescent displays is varied with dimming controls which can be bypassed by a related override switch, so that full brightness will be maintained should a dimming control fail.

## LUNAR CONTACT LIGHTS

Two Lunar Contact lights go on when one or more of the four lunar-surface sensing probes contact the lunar surface. A probe is mounted beneath each of the landing gear footpads.

## FLOODLIGHTING

Floodlighting is used for general cabin illumination and as a secondary source of illumination for

the control and display panels. Floodlighting is provided by the Commander's overhead and forward floodlights, the LM Pilot's overhead and forward floodlights, and recessed floodlights in the bottom of extending side panels. These floodlight fixtures provide an even distribution of light with minimum reflection. Every panel area has more than one lamp.

### PORTABLE UTILITY LIGHTS

Two portable utility lights are used, when necessary, to supplement the cabin interior lighting. The lights, when removed from the flight data file container, connect to the overhead utility light panel. Switches provide one-step dimming for light-intensity control.

### OPTICAL SIGHT RETICLE LIGHT

The crewman's optical alignment sight, used to sight the docking target on the CSM, has a reticle that is illuminated by a 28-volt d-c lamp.

### ALIGNMENT OPTICAL TELESCOPE LIGHTS

A thumbwheel on the computer control and reticle dimmer assembly controls the brightness of the telescope reticle. The lamps edge-light the reticle with incandescent red light.



"ApolloNewsRef LM N.L03.PICT" 138 KB 1999-02-07 dpi: 360h x 367v pix: 2698h x 3824v

**APOLLO NEWS REFERENCE**

# PORTABLE LIFE SUPPORT SYSTEM

The portable life support system provides an astronaut with a livable atmosphere inside his space suit during excursions on the lunar surface and in space. Worn on the back and connected to the suit's waist by umbilicals, it permits up to four hours of extravehicular activity.

The backpack supplies oxygen for breathing and suit ventilation, and refrigerated water and oxygen for body cooling. It pressurizes the suit to 3.9 psi and removes contaminants from the oxygen circulating through the suit. It also has a communication-telemetry set, controls to operate it, and devices to monitor its functions.

For the lunar mission, the LM will have two of these life support packs. The LM will carry enough supplies to refill each pack's oxygen tank and water reservoir, and replace its battery and two lithium hydroxide cannisters three times. This will allow a total of four extravehicular trips.

R-113

*Portable Life Support System*

The life support pack, with its controls, weighs 84 pounds; it is 26 inches high, 17.8 inches wide, and 10.5 inches deep. It is powered by a 16.8-volt silver-zinc battery. A fiberglass cover protects the pack against micrometeoroids.

Five subsystems make up the portable life support system: primary oxygen supply, oxygen-ventilating circuit, water transport loop, feedwater loop, and space suit communication system. An oxygen purge system with an additional 30-minute supply of oxygen for emergency or backup use is mounted on the pack, but operates separately.

A thermal insulator made of fire-resistant Beta cloth and aluminized Kapton covers the pack and its shell to restrict heat leakage in or out, depending on the moon's temperature. A similar insulator covers the oxygen purge system.

A remote control unit, which is attached to the suit chest, has switches for the life support pack's water pump and oxygen fan, five-position communication selector switch, a radio volume control, an oxygen quantity gage, and an oxygen purge system lever.

## FUNCTIONAL DESCRIPTION

### PRIMARY OXYGEN SUPPLY

This subsystem supplies oxygen for breathing and pressurizes the space suit and helmet. The oxygen is automatically fed into the suit to maintain a pressure of 3.9 psi. Slightly more than 1 pound (1.06) of gaseous oxygen is stored at between 850 and 950 psi in a tank nearly 6 inches in diameter and slightly more than 17 inches long. The tank is replenished from the LM oxygen supply.

### OXYGEN-VENTILATING CIRCUIT

This subsystem circulates oxygen through the space-suit pressure garment and purifies recirculating oxygen. It also helps cool the astronaut by evaporating moisture that accumulates on his skin.



"ApolloNewsRef LM O.P01.PICT" 372 KB 1999-02-07 dpi: 360h x 367v pix: 2740h x 3775v

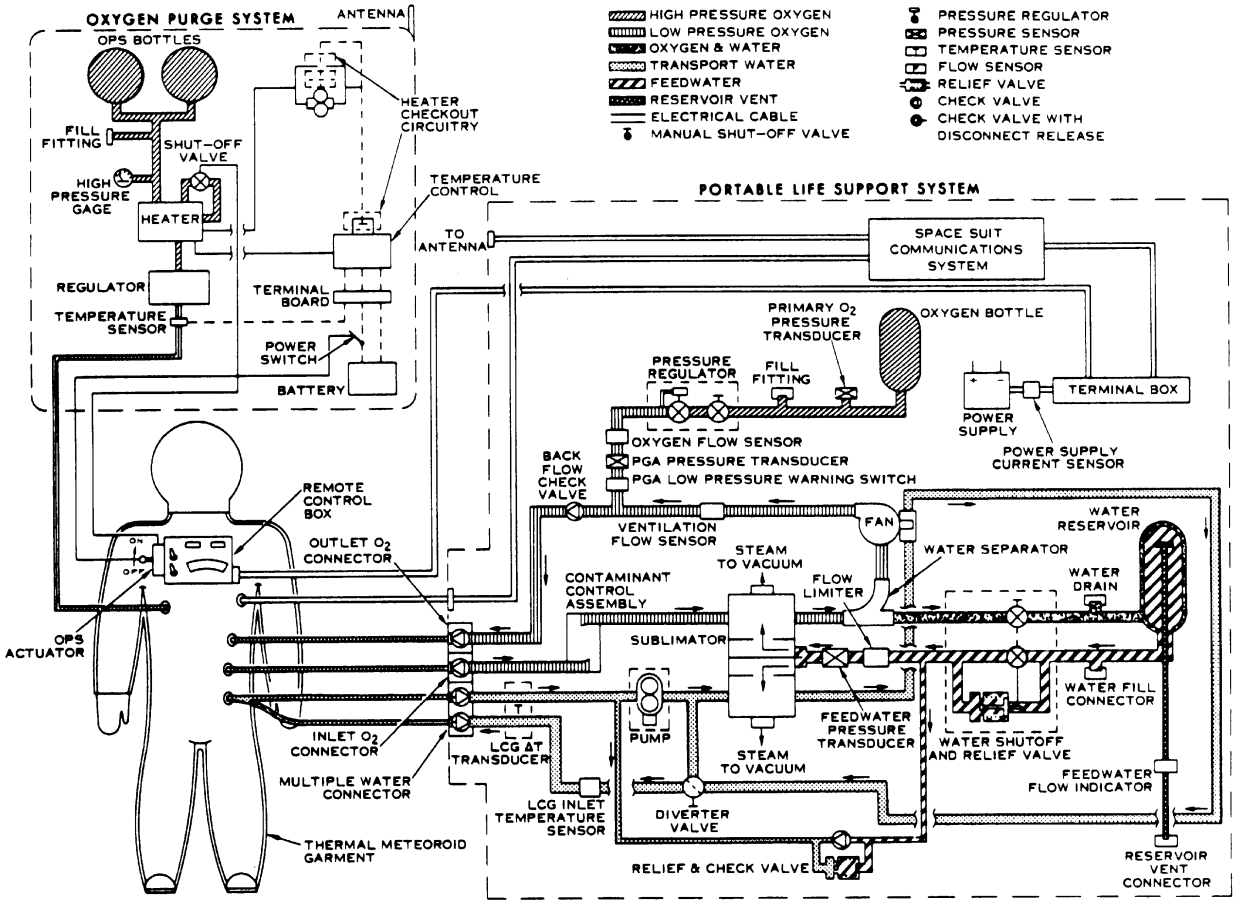
Oxygen entering the backpack from the suit passes through a lithium hydroxide cartridge, where chemicals trap carbon dioxide exhaled by the astronaut. It then goes through an activated-charcoal bed that removes trace contaminants, including body odors. The oxygen flow is cooled by a porous-plate sublimator, a self-regulating heat-rejection device developed by Hamilton Standard. Water in the sublimator absorbs the heat and seeps through the pores of the sublimator's sintered-nickel plates exposed to a passageway where space vacuum enters. The water freezes, forms an ice layer across the plates, then turns from ice to vapor. The rate of this sublimating process is governed by the amount of heat being rejected.

Excess water entering the oxygen flow, mainly from astronaut respiration and perspiration, is removed by a water separator and stored outside the bladder section of the water reservoir. A fan recirculates oxygen to the space suit at a rate of 6 cubic feet per minute.

Six extra lithium hydroxide cartridges are carried in the LM to replace used cartridges.

## WATER TRANSPORT LOOP

This loop cools the astronaut by removing his metabolic heat and any heat that leaks into the suit from the hot lunar surface. A battery-operated pump continuously circulates 1.35 pounds of chilled water at a rate of 4 pounds per minute through a network of plastic tubing integrated in the liquid cooling garment worn under the space suit. The pack dissipates metabolic heat at an average of 1,600 Btu per hour and can handle peak rates up to 2,000 Btu.

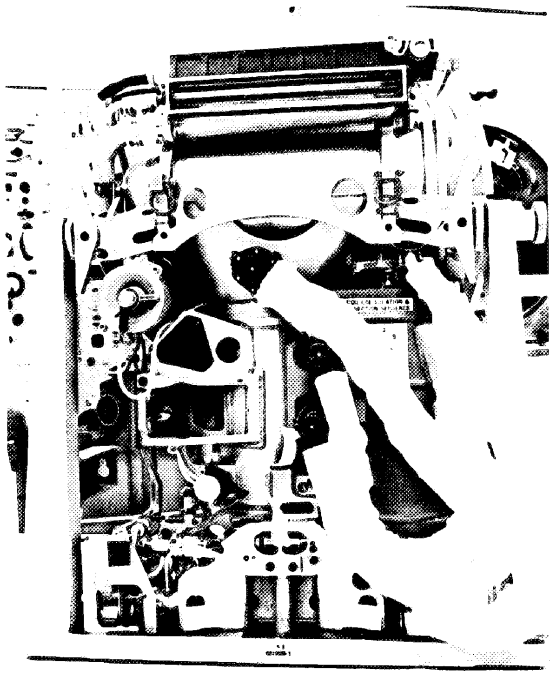



R-114

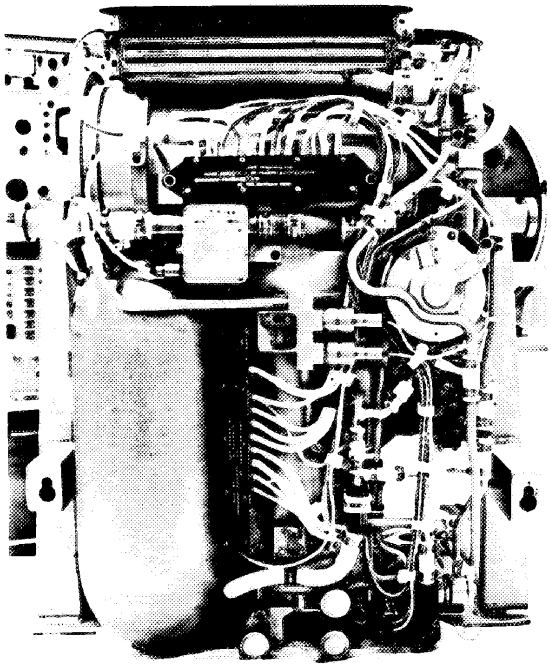
*Portable Life Support System Schematic*



"ApolloNewsRef LM O.P02.PICT" 609 KB 1999-02-07 dpi: 480h x 490v pix: 3552h x 4955v



R-115 *Front View of PLSS*



R-116 *Rear View of PLSS*

The sublimator that cools the oxygen flow extracts heat from the circulating water, which normally leaves the pack at 45° F. To control cooling, the astronaut uses a valve on the pack to select any one of three water temperature ranges (45° to 50°, 60° to 65°, or 75° to 80°). This valve diverts water past the sublimator.

## FEEDWATER LOOP

This subsystem supplies 8.5 pounds of expendable water, stored in a rubber bladder reservoir, to the heat-rejecting porous-plate sublimator. Suit pressure against the bladder forces water into passages between the sublimator's heat transport fluid passages and its metal plates, which are exposed to space vacuum. The ice layer formed on the porous plates during sublimation prevents the slightly pressurized water from flowing through the metal pores.

Condensed water from the oxygen-ventilating circuit is collected outside the reservoir bladder. Feedwater is replenished from the LM supply. Refilling the bladder forces water condensed from the oxygen flow into the LM waste management system.

## SPACE SUIT COMMUNICATION SYSTEM

This system provides primary and backup duplex voice transmission and reception, telemetering of physiological and suit environmental data, and audible warning signals. It also regulates the voltage and electrical current used by various transducers and the oxygen supply indicator.

The duplex systems enable the astronaut to transmit and receive radio communications simultaneously; a potentiometer controls sound volume. The transceiver control station aboard the LM is used as a relay station between crewmen on the lunar surface. It also relays radio-telemetry data to earth monitors and to the CM when it is in line of sight of the LM.

Telemetry channels are manually selected without interrupting or interfering with voice communication. The primary voice communication system is used for telemetry. Six of the seven telemetry channels transmit suit operational and environmental data – oxygen supply pressure, water inlet temperature, suit pressure, feedwater pressure, suit



"ApolloNewsRef LM O.P03.PICT" 430 KB 1999-02-07 dpi: 360h x 367v pix: 2719h x 3768v

water temperature rise, and backpack battery current – to the LM. The remaining channel transmits an electrocardiogram signal.

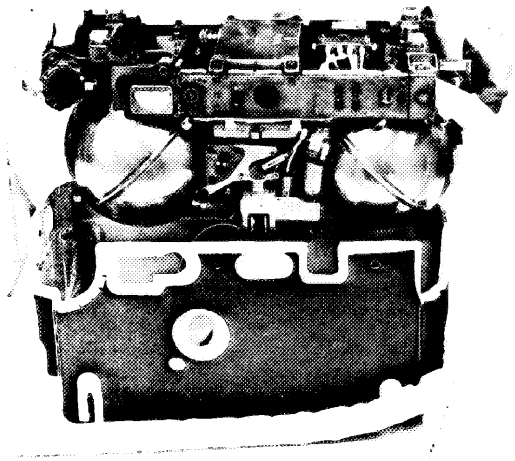
Audible tones warn the astronaut of low suit pressure, high oxygen flow, low ventilation flow, and low feedwater pressure conditions.

## OXYGEN PURGE SYSTEM

The oxygen purge system, connected to the suit by a separate umbilical, is designed for backup use in the event of emergencies such as loss of suit pressure or depleted oxygen supply. However, an astronaut can use it independently as a life support chest pack during extravehicular transfer between the LM and CM.

The system supplies either an open-loop purge flow or makeup flow directly to the suit. In both cases, it maintains suit pressure at 3.7 psi. In the purge mode, it provides a 30-minute flow at a rate of 8 pounds of oxygen an hour, fulfilling breathing requirements, flushing out carbon dioxide, and defogging the helmet visor. This emergency system, mounted separately on top of the backpack, is operated by a lever, attached to the pack's remote control unit. The system umbilical is attached to the suit connector that connects the suit to the LM Environmental Control Subsystem when the astronaut is inside the LM.

The purge unit weighs 40.7 pounds; is 18.4 inches long, 10 inches high, and 8 inches deep. Two spherical containers hold a total of 5.7 pounds of oxygen stored at 6,950 psi. A battery-powered, temperature-controlled heater warms the rapidly expanding oxygen to prevent subzero oxygen temperatures at the space-suit flow inlet.



R-117 *Oxygen Purge System*

*Information in this section relative to the Portable Life Support System was provided by Hamilton Standard, Division of United Aircraft. Complete details on the Portable Life Support System can be obtained from Hamilton Standard.*

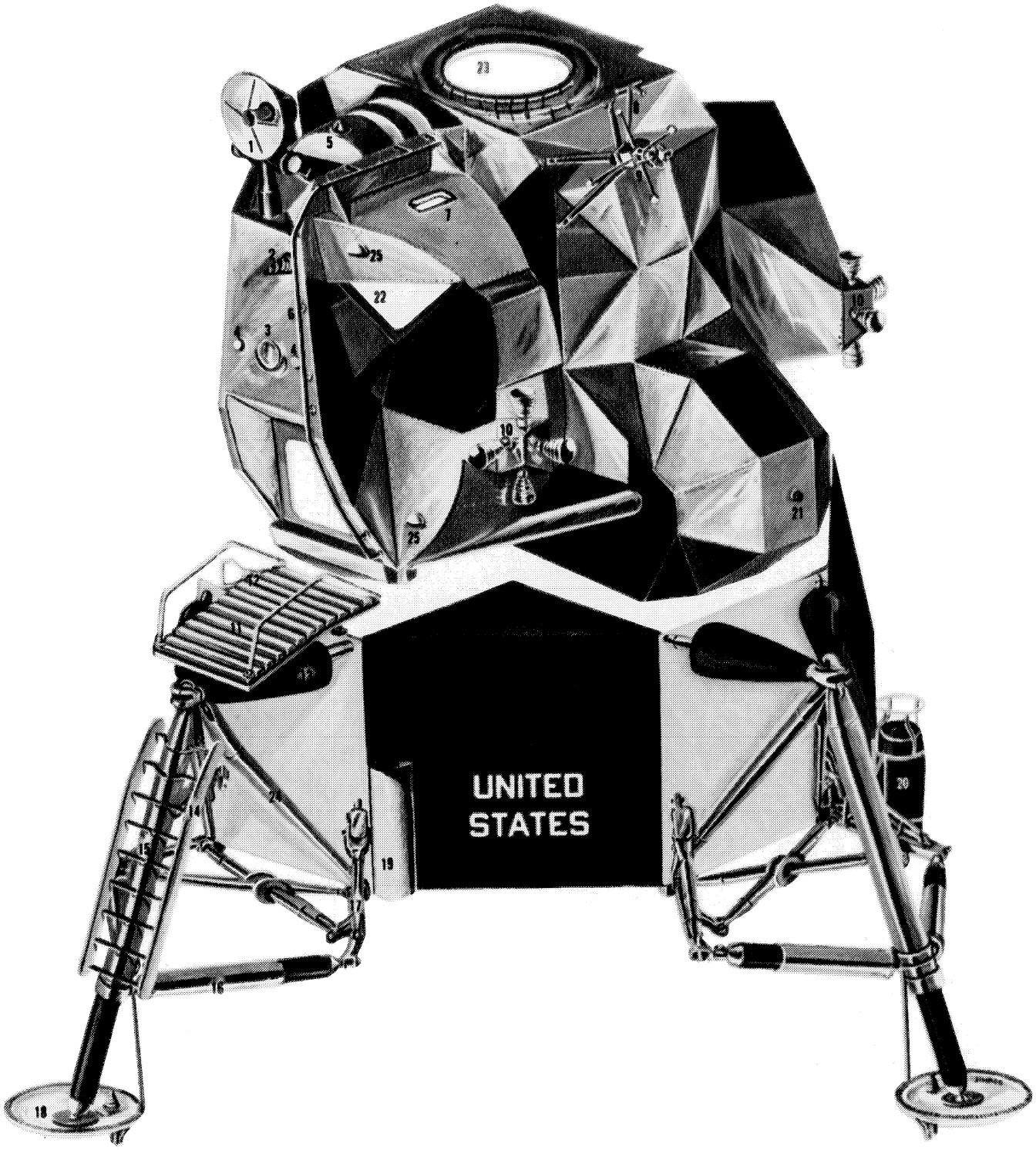


"ApolloNewsRef LM O.P04.PICT" 272 KB 1999-02-07 dpi: 360h x 367v pix: 2684h x 3767v

# ANATOMY OF THE NASA / GRUMMAN APOLLO LUNAR MODULE

The enclosed acetate overlays supplement the Apollo Spacecraft News Reference. The Apollo lunar landing spacecraft—the Lunar Module — comprises more than a million separate parts, interconnected by miles of wiring and plumbing. The overlays show the major Lunar Module components and their interrelationship. The number codes identify each component, and complement the "Index" of the News Reference book.

Grumman Aerospace Corporation

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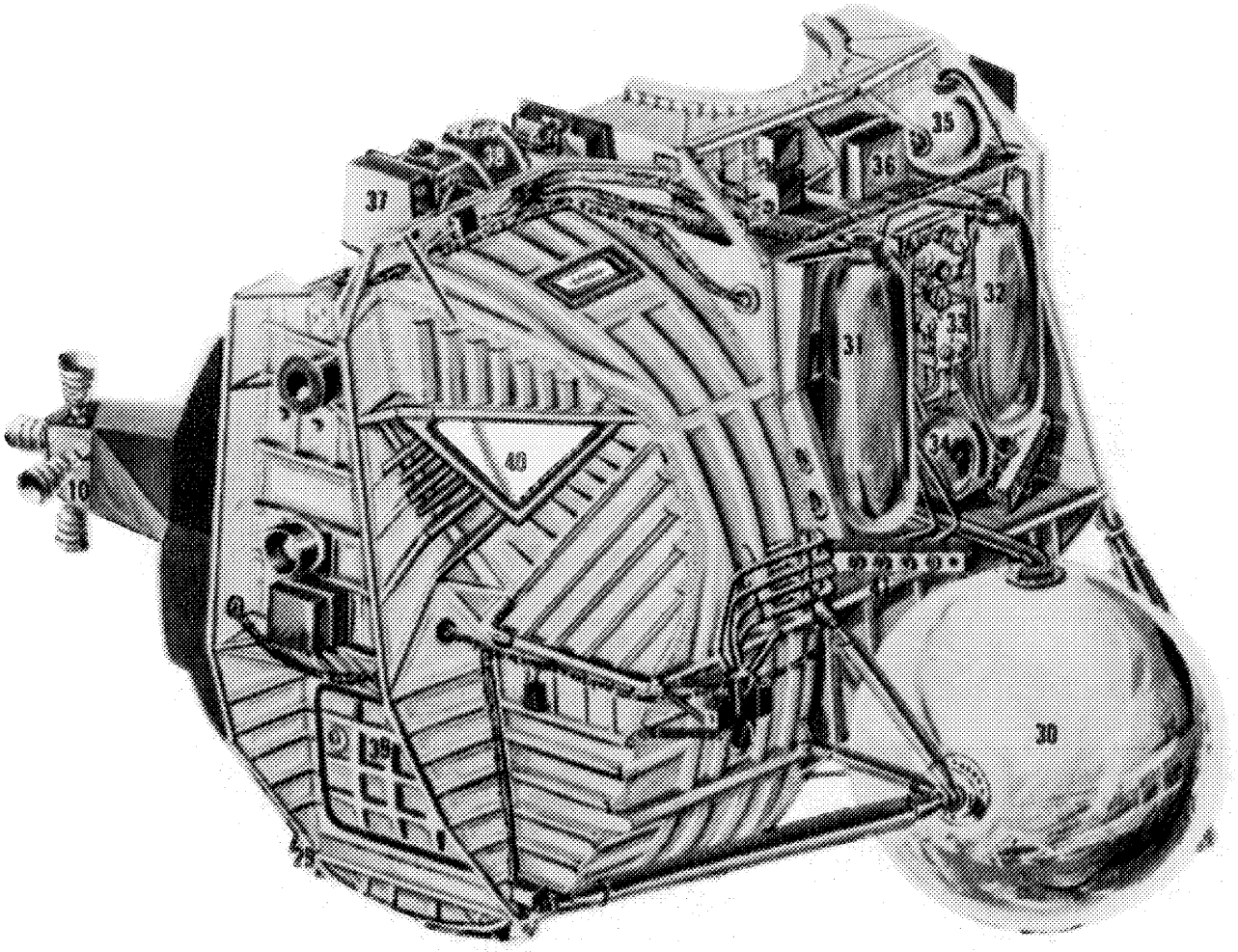


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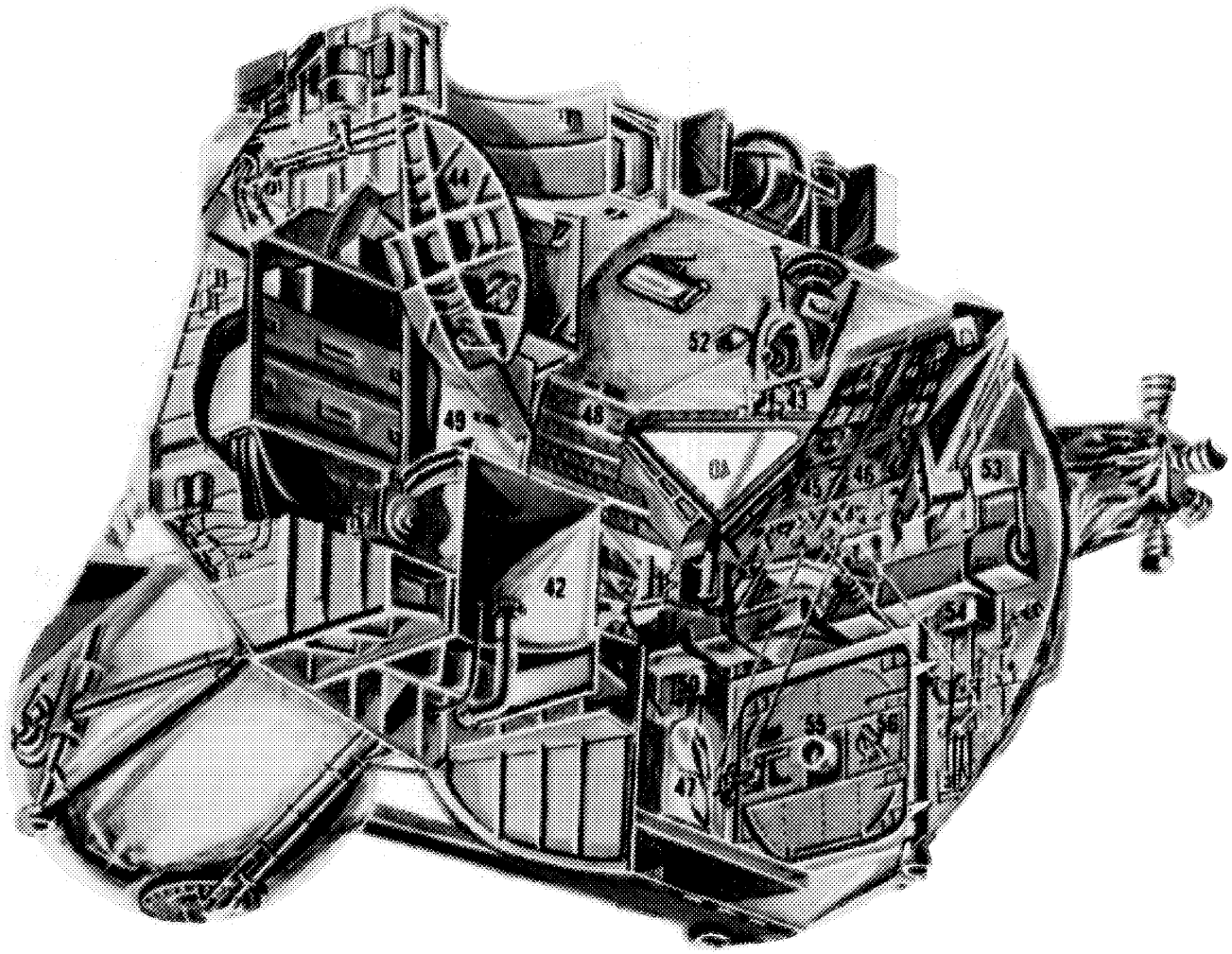


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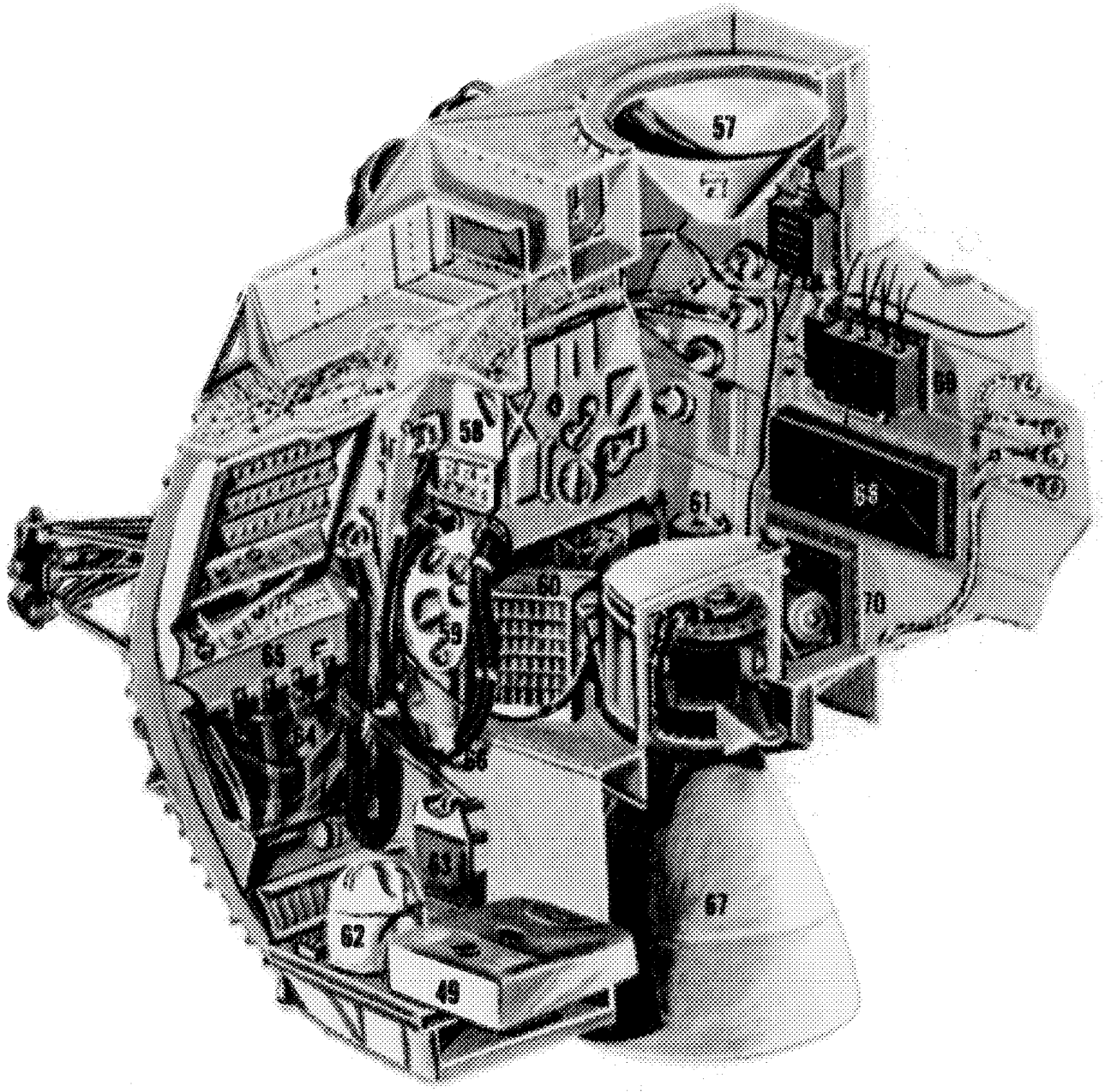


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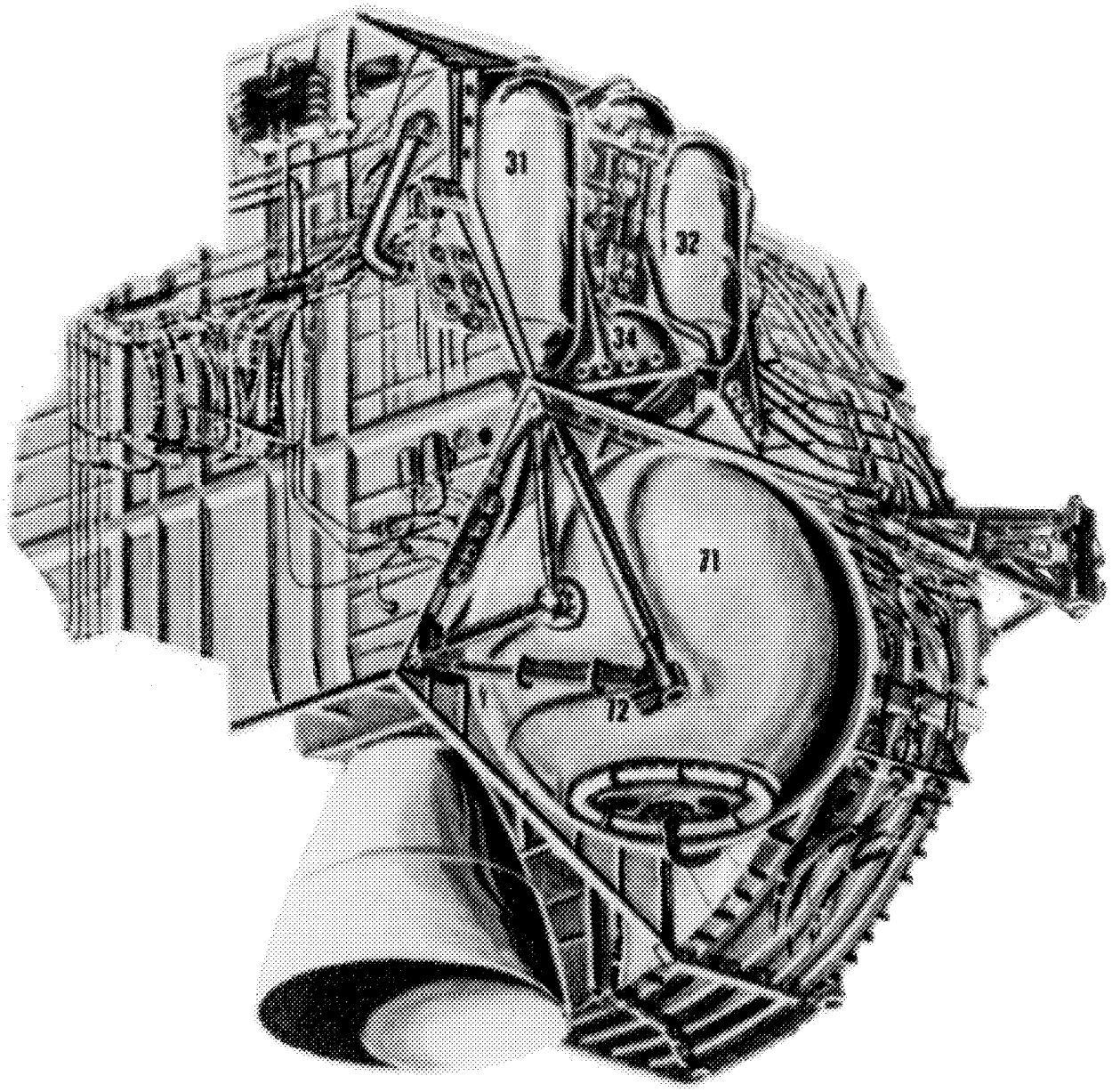


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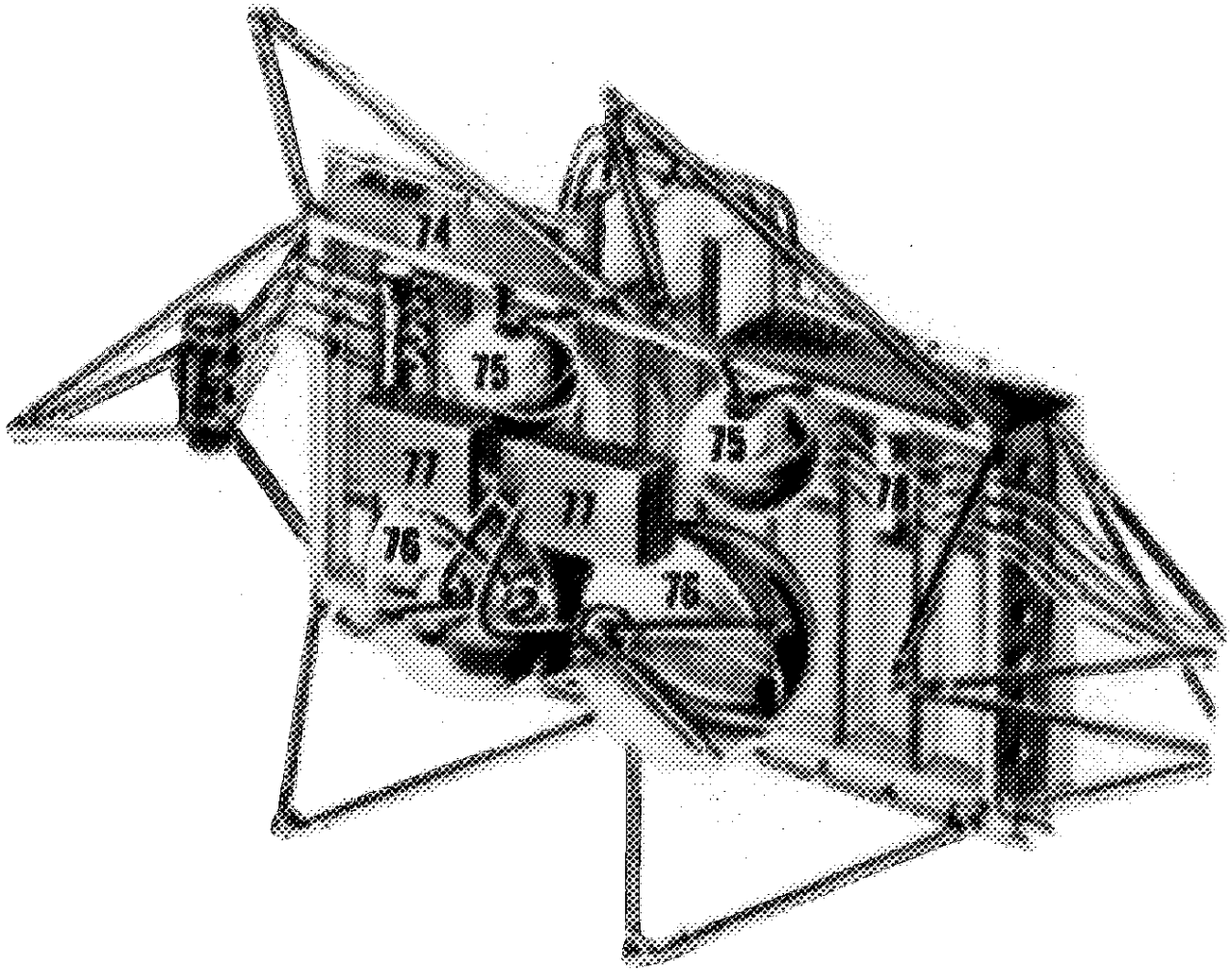


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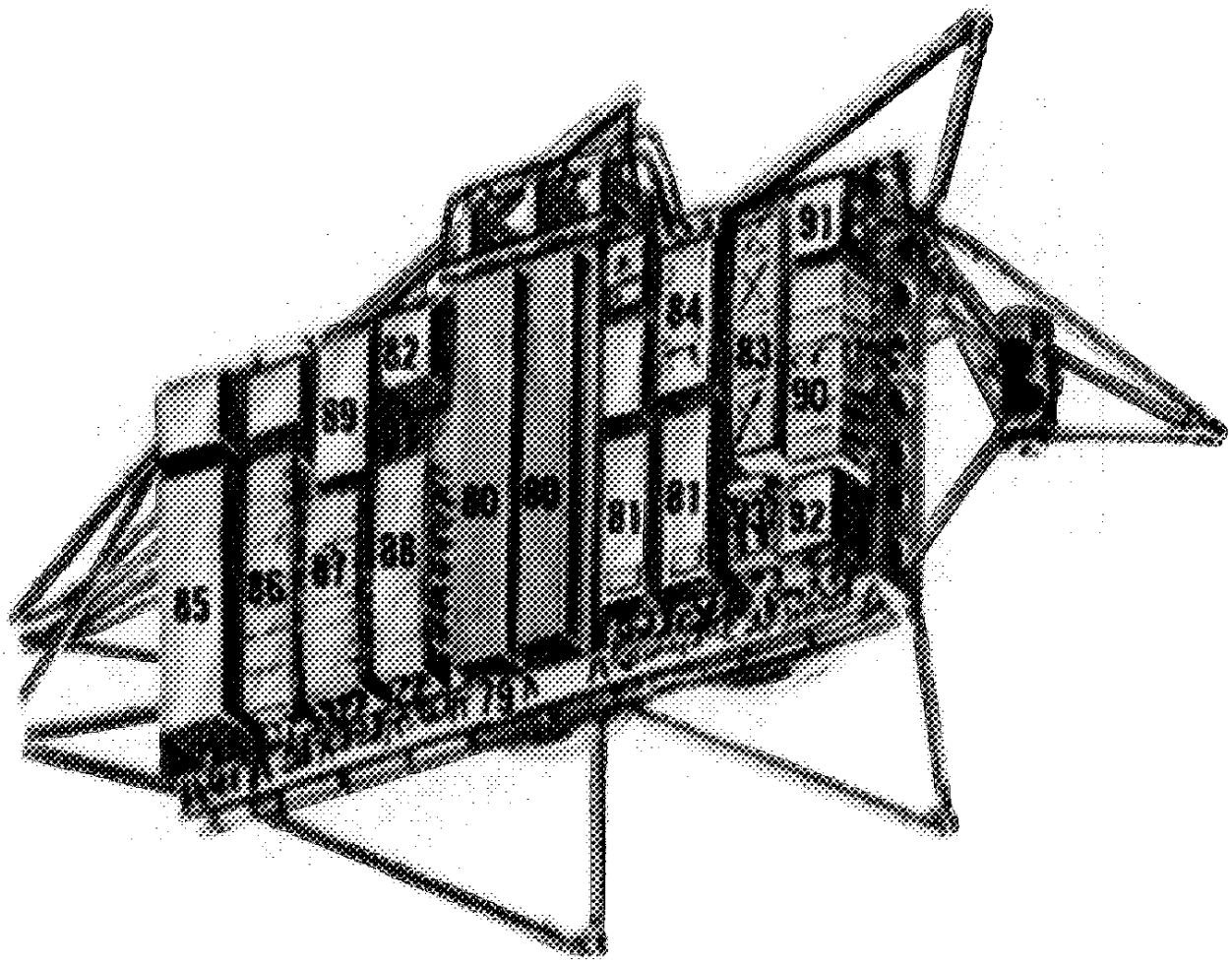


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