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HITCHHIKER-G, A NEW CARRIER SYSTEM FOR ATTACHED SHUTTLE PAYLOADS

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ABSTRACT:

A new carrier system has been developed for economical and quick response flight of small attached payloads on the space shuttle. Hitchhiker-G can accommodate up to 750 lb. of customer payloads in canisters or mounted to an exposed plate. The carrier connects to the orbiter's electrical systems and provides up to six customers with standard electrical services including power, real time telemetry, and commands. A "transparent" data and command system concept is employed to allow the customer to easily use his own ground support equipment and personnel to control his payload during integration and flight operations. The first Hitchhiker-G was successfully flown in January 1986 on STS 61C.

HITCHHIKER PROGRAM

The Hitchhiker Program was initiated in early 1984 by the NASA Office of Space Flight with the objectives of providing a quick reaction and low cost capability for flying small payloads that required somewhat more services than Get Away Special (GAS) experiments but did not require the extensive, custom, services of a Spacelab. The Hitchhikers are to be flyable as little as six months after being manifested and will be flown four times a year on an opportunity basis. Two versions of Hitchhiker were selected: Hitchhiker-G, developed by Goddard, can carry up to six customer payloads weighing a total of up to 750 lbs.; Hitchhiker-M, to be developed by Marshall, will carry up to three payloads for a total customer weight of up to 1170 lbs. The electrical and mechanical interfaces of the two Hitchhiker carriers are different but the program management and manifesting will be done in a similar manner.

Hitchhikers and their payloads are provided with power, command, and data services from the orbiter using a new special harness in each orbiter which allows a Hitchhiker to be flown without interfering with up to four primary payloads on the same flight. Hitchhikers are carried in "bays" 2 and 3 near the forward end of the payload bay. Hitchhiker-G is side mounted on the starboard side to avoid interference from the RMS which is normally carried on the port side. In order to meet the requirement for quick reaction Hitchhiker-G is designed with standard pre-defined electrical interfaces and also has special transparent data system features to reduce the time required to perform electrical integration and checkout of the customer hardware to the carrier. Mechanical interfaces are also simple and consist of a flat vertical plate with a 70 mm. grid hole pattern or a canister similar to GAS with or without a motorized door.

Hitchhikers are considered secondary payloads and may not interfere with primary payload requirements on the same mission. Unique crew activity and attitude (pointing) requirements of a limited nature (eg. several hours) can usually be accommodated but may extend the lead time requirement.

SHUTTLE PAYLOAD OF OPPORTUNITY CARRIER (SPOC)

The Hitchhiker-G was implemented using the Shuttle Payload of Opportunity Carrier (SPOC). In addition to Hitchhiker-G, SPOC is being used to support non-Hitchhiker programs which are manifested as primary payloads and are therefore not limited with regard to payload weight, crew activity, pointing requirements, etc. within the normal STS capability. Currently the largest of these is the Shuttle High Energy Astrophysics Laboratory -2 (SHEAL-2) which weighs over 12000 lbs. and is over 20 feet long.

The SPOC system is designed to be modular and expandable in accordance with payload requirements to allow maximum efficiency in utilizing orbiter resources and thereby increase the potential for early manifesting on the Shuttle. Various SPOC configurations starting at 500 lbs. total weight are shown in fig. 1. (Hitchhiker-G is confined to configurations occupying only two bays.)

The SPOC system consists of the following elements:

The avionics unit provides standard electrical interfaces for up to six customer payloads. It contains a microprocessor control unit, relay switching equipment, medium-rate multiplexer, and other hardware necessary to interface with the customer hardware and orbiter. A small hand controller in the cabin allows the crew to activate and de-activate the payload and provides an independent command path to control inhibits to any hazardous functions.

The SPOC plate provides a 50 by 60 inch mounting surface for the avionics and customer hardware. The plate accepts 3/8 inch bolts on 70 mm. centers and is equipped with heaters, thermostats and thermistors for maintaining and measuring thermal control of the plate and mounted hardware as well as thermal blankets and surfaces for the back and unused portions of the front of the plate. Plate mounted customer hardware may need additional customer provided blankets, heaters, or other thermal control provisions.

The SPOC motorized door canister has mechanical interfaces nearly identical to a GAS canister and can accommodate a customer payload of up to 170 lbs., 19.75 inches in diameter and 28 inches deep. A sealed canister (no door) can also be chosen and can accommodate 200 lbs. of payload in an atmosphere of nitrogen or air. The canisters are not insulated and can radiate somewhat more heat than GAS canisters. The customer's payload must contain heaters and thermostats to maintain the desired temperature.

The standard electrical interface or "port" consists of a signal cable and a separate power cable which provide the following:

o Two 28 V (+/- 4 V) 10 Amp. power lines which can be turned on (together) by ground command. Customer power and energy are monitored by the carrier system. The maximum simultaneous total customer power for a Hitchhiker is 1300 W and the nominal maximum total customer energy is 6 KWH/ day with additional energy negotiable.

o Four 28V bi-level or pulse commands (10 ma max) which can be used with relay drivers and relays to control additional power switching within a payload. (For canister payloads one command is reserved for control of the door.)

o An asynchronous 1200 baud uplink command channel.

o An asynchronous 1200 baud low-rate downlink data channel. This data is available over Ku-band service or S-band service and can also be recorded on the orbiter's tape recorder.

o A medium-rate downlink channel 1-1400 KB/s for use with the real-time-only Ku-band TDRS service. The total simultaneous customer data rate for the Hitchhiker-G cannot exceed 1400 KB/s.

o IRIG-B serial time code and a one pulse per minute square wave signal which can be complemented by a time command via the above asynchronous uplink channel.

o Three channels for temperature sensors to allow measurement of payload temperatures even when the payload power is off (for canister payloads these channels are reserved for door position, canister pressure, and temperature).

o An analog channel, 0-5V, 8 bit quantizing, 10 hertz sample rate. An index pulse is also supplied which can be used to advance a user supplied analog multiplexer to allow measuring a large number of parameters.

In order to provide low cost, quick reaction, and increased autonomy for the customer, SPOC has been implemented with a transparent data system concept (fig. 3). The Customer provided Ground Support Equipment (CGSE), associated software, and personnel can be used to generate commands to the customer's payload and display data from the payload during payload to carrier integration and verification testing and also during flight operations. The asynchronous data and command interfaces, and medium-rate data interface are transparent in that the interface between the customer's flight hardware and the carrier is identical in electrical characteristics and protocols to the corresponding interface between the SPOC GSE and the CGSE thus the GSE the customer used during development of his instrument may be used without modification during carrier integration and flight. The remaining interfaces (bi-level commands, analog channel, etc.) can also be connected but require conversion to asynchronous format at the CGSE. If desired the CGSE can also be provided with orbiter attitude and position data. These interfaces operate in real-time with transmission delays of 5-15 seconds during flight. Simpler experiments with minimal command and data display requirements can be accommodated without customer delivered GSE. All of the data is available on magnetic tape within one month after the flight.

HITCHHIKER-G MANIFESTING SCENARIO

Prospective Hitchhiker-G customers first discuss their requirements with the Goddard Project Office to determine feasibility and compatibility with the Hitchhiker-G capabilities. They then submit a Customer Payload Requirements (CPR) document to GSFC and a Request for Flight (NASA form 100) through NASA Headquarters. When accepted by Headquarters, payloads are placed in a queue system (currently being developed) and then selected for flight on a specific Hitchhiker-G mission. Sources of payloads are expected to include NASA sponsored, DoD sponsored, participants in NASA Joint Endeavor Agreements or Foreign cooperative agreements, and (when pricing policy is completed) other customers. Prices for commercial use of Hitchhiker-G haven't been finalized but are expected to be on the order of several hundred thousand dollars for a one port payload.

Approximately 8 months before flight the customer delivers complete documentation on his payload to GSFC. The safety data package requirements are similar to GAS in the case of canister payloads but are somewhat more complex if the customer's equipment will be plate mounted. About 4 months before flight the customer's hardware is delivered to GSFC and with the help of the customer and his CGSE the payload is integrated to the carrier, and system functional tests and EMI tests are performed. Prior to delivery the customer is responsible for performing any necessary tests required for safety certification (such as static load tests) as well as any tests required by the customer to confirm proper operation (such as vacuum or vibration tests). Following tests at GSFC the integrated payload is shipped to Kennedy Space Center and integrated into the orbiter where only interface verification tests are performed. Launch occurs typically about 8 weeks after orbiter integration. During flight the Hitchhiker-G is operated from a control center at GSFC with participation of the customers and their CGSE. Displays of orbit position, attitude, ancillary data, and any downlink TV are provided along with access to crew voice transmissions. Following landing the Hitchhiker-G is removed and de-integrated and the customer hardware is returned to the customer at GSFC.

HITCHHIKER-G MISSIONS

The Hitchhiker-G1 payload (fig. 4) flew on STS 61C in January 1986. The customer payloads were: The USAF Particle Analysis Cameras for Shuttle (PACS) which was designed to make photographs of particle contamination in the vicinity of the orbiter; The NASA/GSFC Capillary Pump Loop (CPL) experiment which determined the zero-gravity performance of a proposed Space Station thermal system; and the NASA/Perkin Elmer Shuttle Environmental Effects on Coated Mirrors (SEECM) experiment which studied the effects of residual atmosphere on telescope mirror contamination. The PACS consisted of a stereo camera and flash assembly mounted on the upper portion of the plate. The CPL instrument was carried in a sealed canister and was connected to multiple power ports to allow over 1000 W of power to be used. The mission was successful and the experimenters are currently studying their data. The carrier operated nominally with over 800 commands being sent and over 120 hours of data obtained. A number of minor ground system problems are being corrected for the subsequent flights.

Hitchhiker-G2 will carry a USAF/NRL Ultraviolet Limb Imaging Experiment (UVLIM) which will scan the horizon to obtain data on the constituents of the atmosphere; the NASA/GSFC Pumped Two-Phase (PTP) experiment which will test Space Station thermal control equipment; and a NASA/JSC Plasma Motor Generator experiment which contains a probe to be ejected from a canister during the flight.

FUTURE ENHANCEMENTS UNDER STUDY

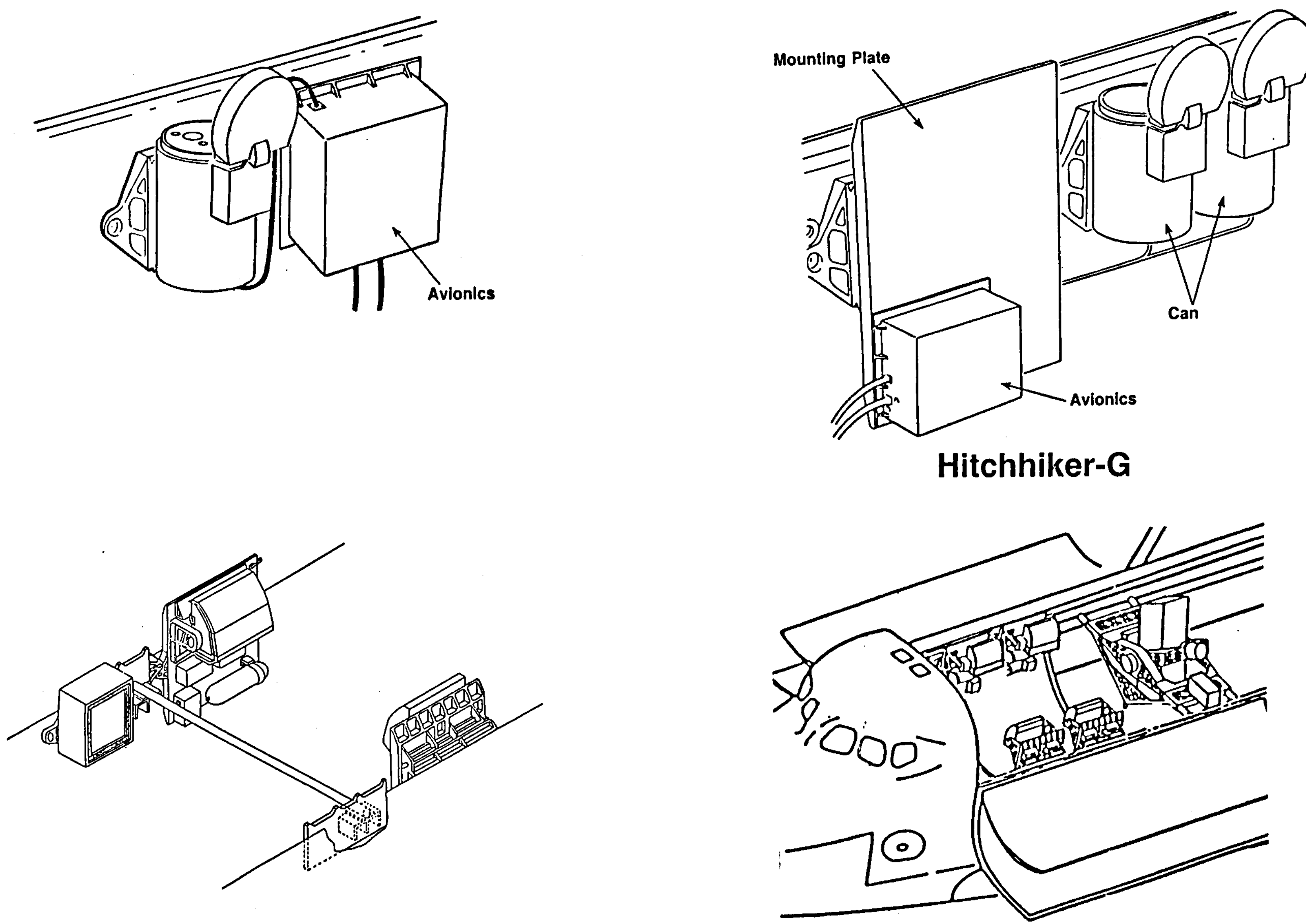
The following are enhancements which may be added to the SPOC system in the future depending on demand and feasibility:

o An ejection mechanism to allow deployment of small probes or spacecraft from the canister. This would be similar to the existing GAS system except that power and electrical services could be obtained prior to launch via an umbilical connector. Spin-up capability is also being studied. Payloads up to 150 lbs. could be accommodated.

o A larger canister with ejection mechanism for larger attached or ejected payloads up to approximately 350 lbs. and 30 inches in diameter.

o A method for late installation of payloads into motorized door canisters on the launch pad to reduce the time-to-launch from 8 weeks to 2-3 days.

o A probe bus for ejectable experiments is being considered. This bus would be ejected from a canister, contain batteries, data system, transmitter, and receiver and would carry a customer's instruments for a brief mission in the vicinity of the orbiter while communicating to an antenna and SPOC port on the attached carrier.



SHEAL I

SHEAL II

Fig. 1 SHUTTLE PAYLOAD OF OPPORTUNITY CARRIER CONFIGURATIONS

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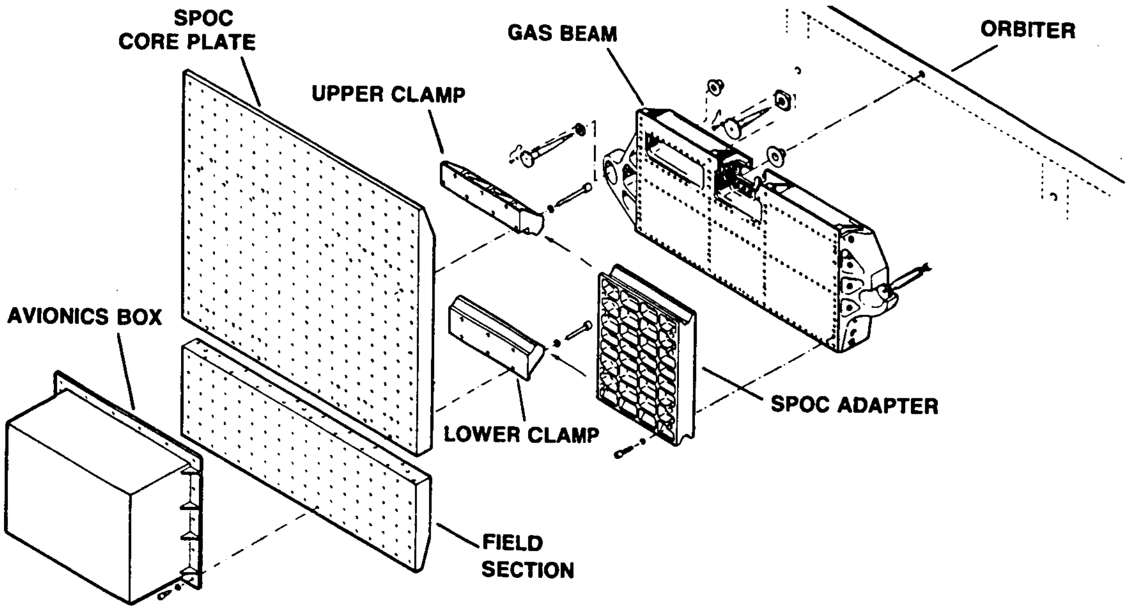

Fig. 2 SPOC PLATE

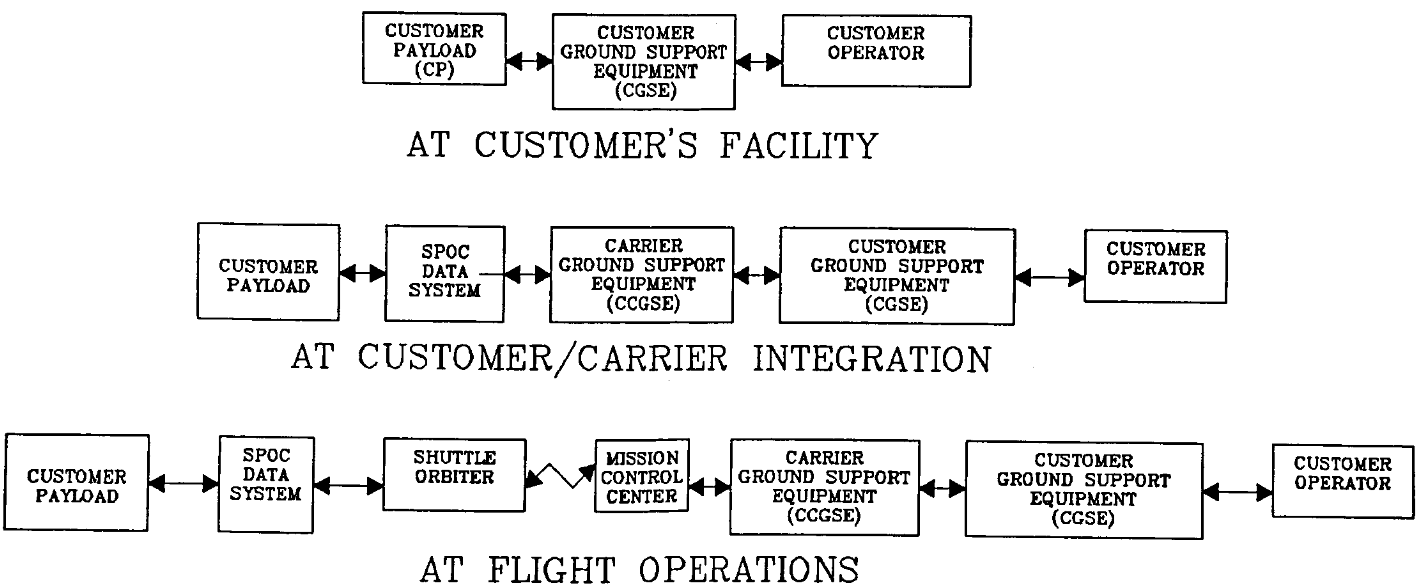

Fig. 3 SPOC TRANSPARENT DATA SYSTEM COMMUNICATIONS

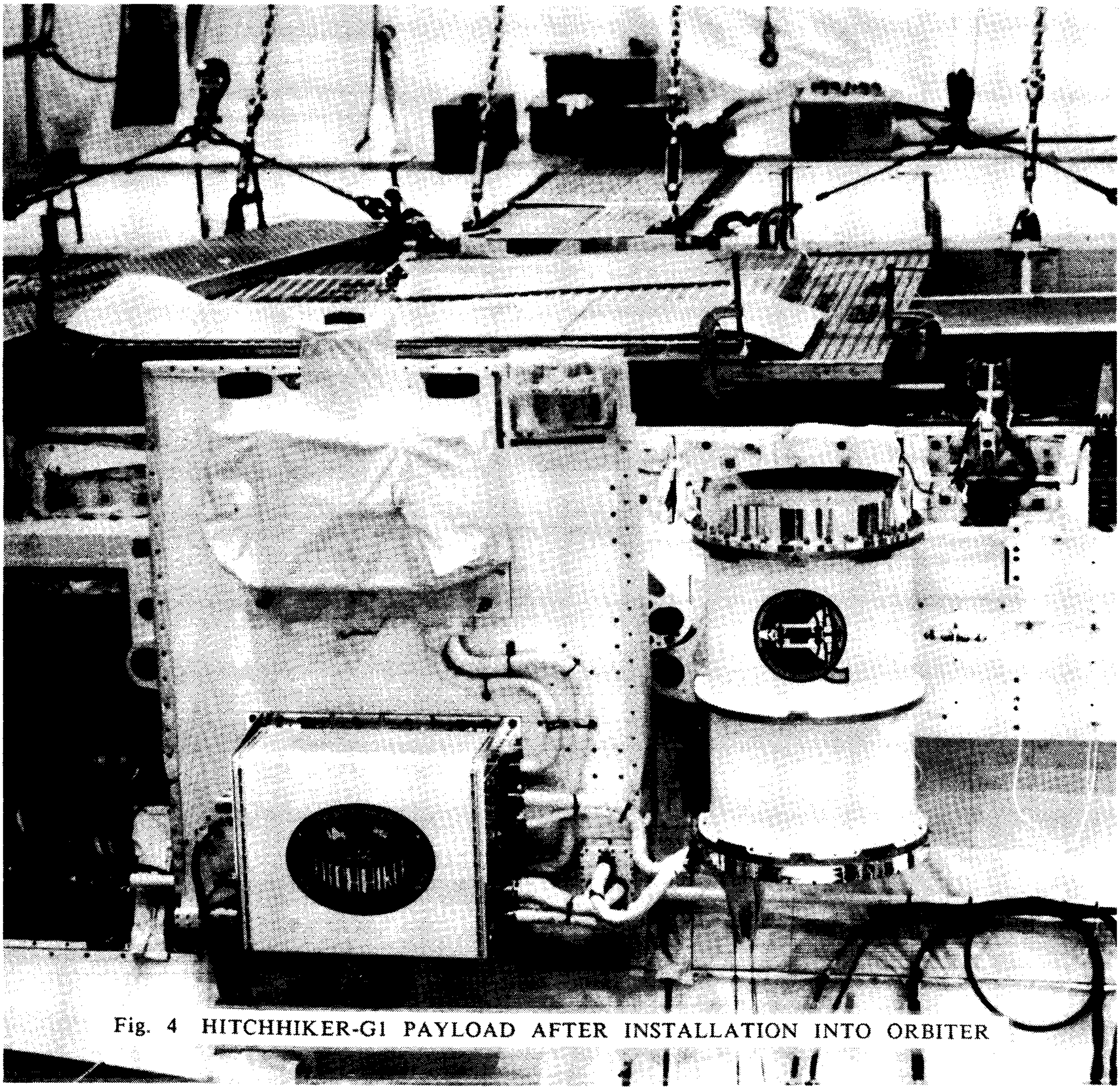

Fig. 4 HITCHHIKER-G1 PAYLOAD AFTER INSTALLATION INTO ORBITER