https://ntrs.nasa.gov/search.jsp?R=19740003574 2020-03-23T12:25:46+00:00Z

20. THE VIKING SURFACE SAMPLER

By Robert B. Seger, Martin Marietta Aerospace
and Vernon P. Gillespie, Langley Research Center

INTRODUCTION

During the 45 day launch window starting August, 1975, twin Viking Spacecraft will be launched from Kennedy Space Center toward the planet Mars. The second craft will follow the first by about 30 days, being launched in series from the same complex. The 3400 kilogram (7500 lb) Viking Spacecraft, consisting of both an Orbiter and a Lander, is encapsulated in a fairing above the Titan III E/Centaur Launch vehicle. Nearly a year later and 330 million kilometers (206 million miles) from Earth, Viking will approach and orbit the Red Planet. The Spacecraft then separates into an Orbiter and a Lander. The Orbiter performs visual mapping and upper atmospheric investigation. The Lander descends to the surface of the planet, depending upon its ablative aeroshell, its 16.8 meter (55 foot) diameter disc gap band parachute, and finally its three descent engines. Once safely down, the Lander Science Instruments will collect data for transmission to Earth, including panoramic stereo color pictures; organic, inorganic, magnetic and physical analyses of the surface; and seismic and meteorological characteristics. Also the Mars surface material will be investigated for evidence of biological activity. The subject of this paper is the Surface Sampler Subsystem which will help make possible the investigation of the Martian surface.

THE SURFACE SAMPLER SUBSYSTEM

Figure 1 is a photograph of a prototype Viking Lander, taken near the Martin Marietta plant. Figure 2 shows the relative placement of the Surface Sampler Subsystem to some other subsystems on the vehicle. The Surface Sampler Subsystem consists of the acquisition assembly, the biology processing and distribution assembly (Biology PDA), the gas chromatograph/mass spectrometer processing and distribution assembly (GCMS PDA), and the electronics control assembly. The system interfaces with the Biology PDA, the GCMS PDA, and the X-Ray Fluorescence instruments. It also supports many Physical Properties experiments. (The mirrors mounted on the side of the acquisition assembly support some of the Physical Properties experiments.) The magnets mounted on the collector head backhoe, the magnet cleaning brush, and the magnet magnification mirror support the Magnetic Properties Investigations. The primary sample field is made up of an 120° arc with a minimum radius of three feet and a maximum radius of ten feet, a total area of approximately 90 square feet. It is designed to acquire a sample from a variety of soil models as specified in the Viking Mars Engineering Model. The Surface Sampler transports, processes, meters, and delivers the samples to the science instruments in accordance with strict scientific requirements such as cleanliness and cross-contamination. Digital commands are received by the Surface Sampler Control Assembly (SSCA) from the lander Guidance Control and Sequencing Computer (GCSC) for controlling the operations of the subsystem. Position, temperature and other data are collected by the Surface Sampler and transferred to the lander data acquisition unit for transmission to Earth. It should be emphasized that all operations of the Surface Sampler must be performed by onboard sequences and logic because of the transmission time from Earth to Mars.

TYPICAL SEQUENCE

Before the individual components of the subsystem are discussed, a typical acquisition cycle is presented. This will aid in the understanding of the purpose and requirements of the individual assemblies.

Shortly after landing, the pyros fire, and release the covers on the two PDA's. Automatically the wind spoilers deploy and the PDA's are ready to accept their first sample. Sometime later the furlable boom is extended about 1-1/2 inches, releasing the boom mechanism from the support post. The boom mechanism then elevates about 45° and rotates about 180° in azimuth. At this point, the collector head is rotated 45° inside the protective cover (shroud), and the boom element is extended approximately 4 inches. This additional extension mechanically releases the shroud and four springs propel the shroud through the thin atmosphere about eight feet. The collector head is returned to the upright position and is ready for its first digging sequence.

Although it can be completely changed or altered through a ground update capability, the first sequence is stored in the Lander GCSC. It must be emphasized that the sequence presented here is a typical sequence anticipated for acquiring the first samples for the biology and GCMS experiments. First, the boom unit rotates in azimuth to a predetermined position, elevates "down" to a position approximately horizontal and then extends to a length of approximately nine feet. Note that each motion is performed singularly; that is, it does not rotate and extend at the same time. This is done to improve the system accuracy and to increase the system safety. After extending, the boom unit elevates "down" until it is stopped by the actuation of the ground contact switch located in the gimbal mechanism of the collector head. At this point in time, the jaw opens and the connector head is extended forward with a force of thirty pounds, gathering a scoop full of surface material. If the desire would have been to acquire sub-surface material, upon ground contact the furlable boom would be retracted a short distance. The backhoe would have positioned itself and would have made a furrow about three inches wide and a foot long. The collector head would then open and the forward movement of the collector head would have obtained a scoop full of material from the bottom of the furrow. After the jaw closes to retain the sample, the boom is again elevated to the horizontal position and retracted. The collector head is now rotated to the inverted position, in which position most surface material lodged in the "nooks and crannies" will fall off. The inverted collector head is rotated in azimuth to a position over the GCMS PDA. It is extended so as to center over the PDA screen, and is lowered to a position over the screen that allows adequate room for collector head vibration (one-half inch) but is well protected from the Martian winds by the spoilers atop the processor. After activation of the processor a delivery sequence is initiated. The collector head is vibrated; that is, the lid is pulsed in very short strokes at 8.8 hertz. The sharp teeth inside the cover break up any loosely bound clods and the 2000-micron holes sift the material onto the primary screen of the PDA. The PDA grinds, sieves and meters the material. A level sensor in the metering tube indicates whether or not an adequate sample has been obtained. If an adequate sample has not been obtained, the collector head will vibrate again for a few seconds and, after permitting time for grinding and sieving, the level sensor will again check for adequate material.

When adequate material is obtained, the acquisition assembly will elevate to clear the spoilers, rotate in azimuth, retract and lower itself to be correctly positioned over the Biology PDA. A similar delivery sequence will ensue.

In the ninety day lander mission, this will be repeated four times for the Biology PDA and three times for the GCMS PDA. (All Biology samples should be common to GCMS samples.) If insufficient material is obtained, however, it is permissible to collect a second sample at the same sampling site to complete the sampling cycle.

THE ACQUISITION ASSEMBLY

The acquisition assembly consists of a furlable articulated boom and the collector head. This boom shown in figure 3 stands about 14 inches high, 8-1/2 inches wide, and 24 inches long and weighs about 28 pounds.

Wound around a single six-inch-diameter drum is about twelve feet of furlable boom. It is forced flat when it is wound on the boom through guides and forms a column when it is extended. Attached to the tip of the boom element is the collector head, shown in figure 4. It was primarily designed to dig or scoop material. The rotation motor is located in the cylindrical section immediately behind the jaw. The lower jaw housing is the largest single piece and makes up the primary structure. The upper jaw can be opened and shut by the solenoid attached to the housing directly behind the upper jaw. This solenoid can be used to open and close the jaw and also to vibrate the jaw. The solenoid is energized by a square wave signal of 8.8 hertz.

The switch adjacent to the jaw monitors the jaw movement and "chops" the signal. This creates a short sharp vibration conducive to passage of material. If, however, the jaw hangs open due to excess load or material causing it to stick, the full square wave is exercised and the jaw motion is much more violent. As a secondary function, the collector head is involved in many physical properties and magnetic properties experiments.

The backhoe, which was designed primarily to get a sub-surface sample, can also make trenches. These trenches, placed at different positions, can be used to study the effects of the wind on the soil and the angles of repose which are of major interest to the physical properties scientists. The backhoe also contains two magnet arrays. These samarium-cobalt magnets may be viewed from the back with the cameras directly. Also, there is a magnifying mirror which allows a close look of the front side of magnet arrays.

The lower surface of the jaw has a temperature probe to record the temperature of a jaw. With the aid of the grid pattern painted on the upper surface of the lander, onto which material will be deposited, color, size, angle of repose and wind action may be observed.

GCMS PDA

It was mentioned earlier that GCMS PDA was opened by a pyrotechnic device soon after landing. This device allows the lid of the pressurized instrument to swing open, freeing the wind spoilers and allowing them to "pop" in place. The processor is now ready to accept its first sample.

The collector head sifts 2000-micron size material onto the primary screen, as shown in figure 5. An agitator vibrates the underside of the screen to increase the acceptance of this material. The agitator is basically a spring wire shaped like a question mark. The top of the agitator rubs the underside of the 2000-micron primary screen. The stem of the agitator extends down the funnel and into the grinder. A lobe on the grinder severely agitates the spring. This keeps the material flowing and prevents compaction in the funnel. The material flows through the funnel and collects in the comminutor. The comminutor acts much like an auger and a grinder. Allowed to position itself freely within the housing, its eccentric action tends to grind the material. At the same time the flutes tend to reject the material, much the same action as the flutes on a drill forcing the chips back away from the cutting surface. The material then circulates until it is ground down to a size that permits it to fall through the 600-micron "gap" around the periphery of the auger. As the material falls into a plenum chamber, it is stirred over a sieve covering a one cubic centimeter metering tube. Most of the material falls through the 300-micron sieve and collects in the metering tube.

A level sensor, easily a symposium subject within itself, is electrically pulsed and it is determined whether or not the metering tube is full. As mentioned earlier, this sequence can be repeated as many times as desired. The metering tube is located in a sliding shuttle. Once it is determined that the metering tube is "full" the material is transferred to the GCMS experiment. The shuttle then is translated to the "dump" position. The vibrator on the shuttle is activated and the comminutor is run in reverse. A linear cam causes the auger to lower, increasing the gap to 4000 microns. The flutes then force the excess and oversized material into the plenum chamber, through the dump tube, and into a self contained dump box. The PDA is now ready to accept the next sample.

BIOLOGY PDA

The Biology PDA (figure 6) is functionally similar to the GCMS PDA. The Biology PDA, however, does not have a grinding unit; rather it utilizes the material directly as it is sifted through the 1000-micron primary screen. The volume processed for the Biology experiment is seven cubic centimeters. Unlike the GCMS PDA, the Biology PDA is not pressurized. Rather this component has a bio-filter in the upper cover which allows the Biology experiment to "breathe" through the PDA. The Biology PDA also has an integral dump box for excess material.

CLEANING

After manufacturing and acceptance testing, the Biology PDA is organically cleaned to 1 ppm of total organics at the Martin Marietta plant. The GCMS PDA and the collector head/shroud assemblies are sent to the NASA White Sands Test Facility (WSTF) to be organically cleaned to less than 1 nanogram per square cm with the procedures developed for the Apollo Moon Missions. This is required by the extreme sensitivity of the GCMS instrument. After the assemblies are broken down as far as possible, each and every part is cleaned and flushed. The parts are then reassembled and vacuum baked. The parts are so clean that a screw will not thread into an insert and new screws using a silver plating for their lubricant are used for the reassembly procedure. The motors are hermetically sealed to maintain their lubricants. The assembly is now pressurized to protect it from the ingress of contaminants prior to flight. The assemblies will remain pressurized during any further testing, transportation and assembly onto the spacecraft. Prior to the final "buttoning up" procedures, the auxiliary tanks used to maintain positive internal pressure will be removed and the pressurized system will depend upon its own sealed construction to maintain cleanliness until landing on Mars.

CONTROL ASSEMBLY

The Surface Sampler Control Assembly (SSCA) located inside the lander body receives 16-bit digital commands from the Viking lander computer (GCSC), decodes the command, and activates the appropriate motor or solenoid to perform the commanded function. In the case of boom movements, the command word contains 9-bit position information. As the boom moves, potentiometers inside the boom send analog information to the SSCA and, after an A/D conversion, the position words are compared. When comparisons of the commanded position and actual position agree, power is removed from the boom. Each command is timed to assure completion prior to performing the next command.

A block diagram of the software required to operate the Surface Sampler is shown in Figure 7. Each table contains a group of detailed digital commands for specific operations. Features of the software are the decision elements associated with level detectors, and the flexibility to deliver a sample to support any investigation, or any combination thereof.

SUBSYSTEM PERFORMANCE

A Surface Sampler Subsystem for the Viking lander has been designed, fabricated, cleaned, and successfully tested. To date, testing has included component level tests to qualification environment and subsystem level tests. This development hardware has also been integrated into a System Test Bed (STB) for the lander system. In addition to the normal dynamic and thermal environments the Surface Sampler hardware has been tested in the NASA/USAF KC-135 aircraft to simulate the effects of the reduced Martian gravity. Although problems have been encountered with the "first-build" and integration, the basic design appears to be sound and hardware qualification is scheduled for late 1973.

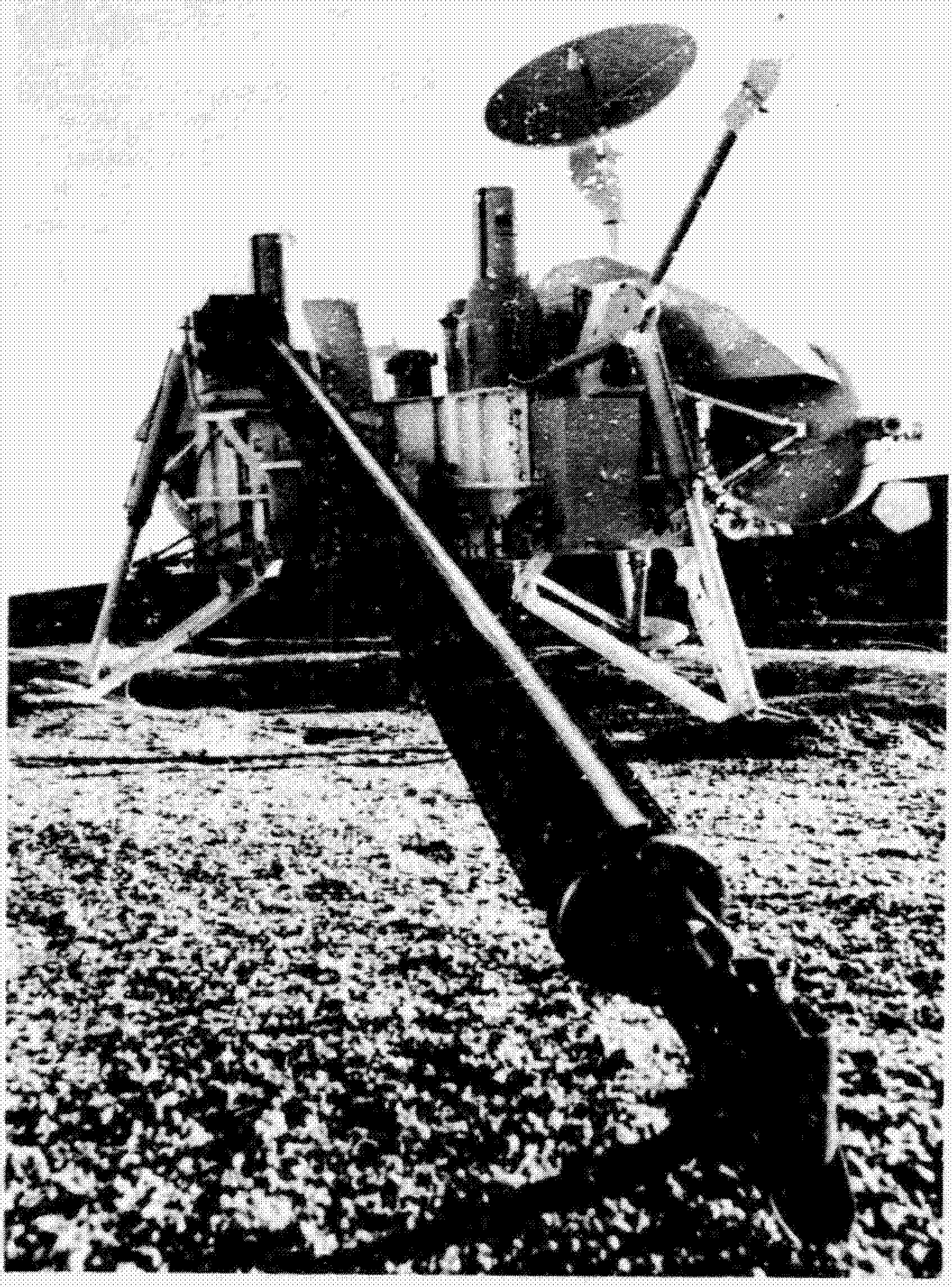

Figure 1.- Viking lander.

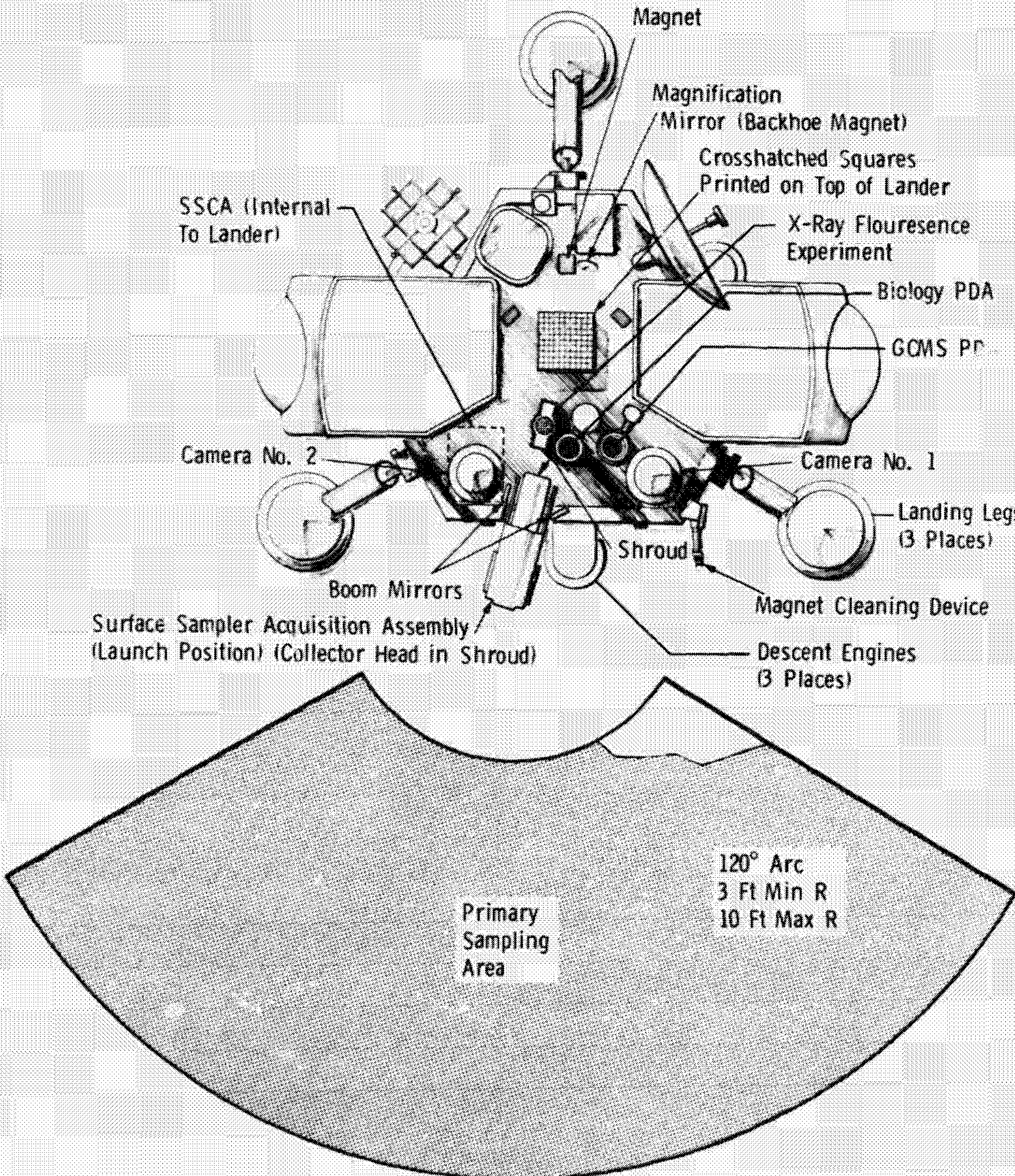

Figure 2.- Lander configuration.

Figure 3.- Acquisition assembly.

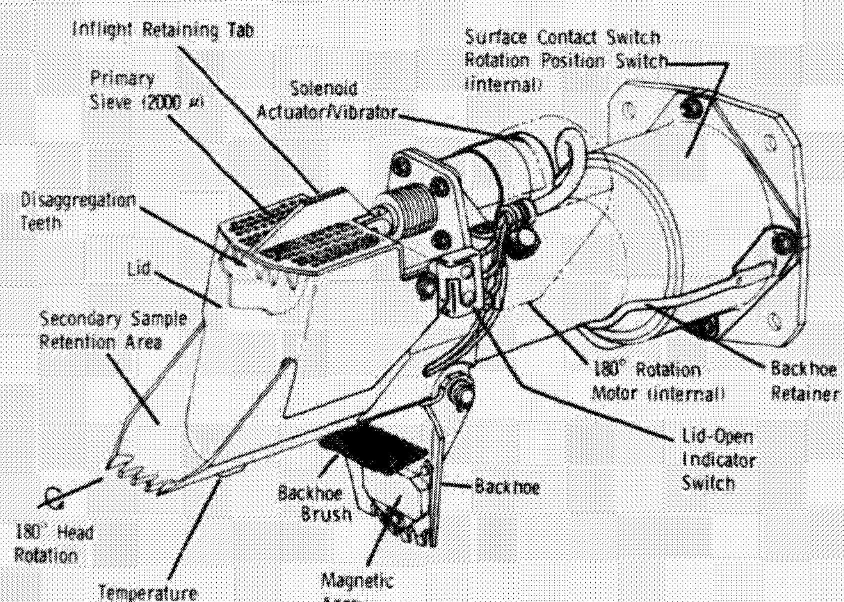

Figure 4.- Collector head.

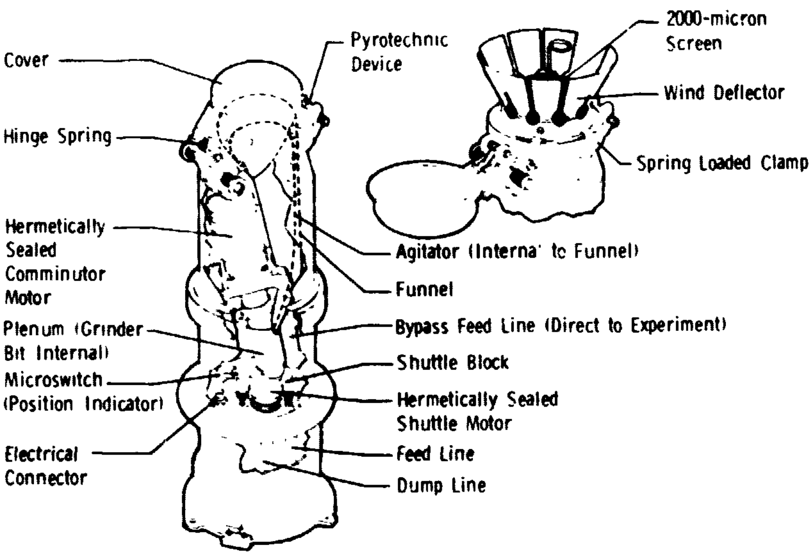

Figure 5.- GCMS PDA.

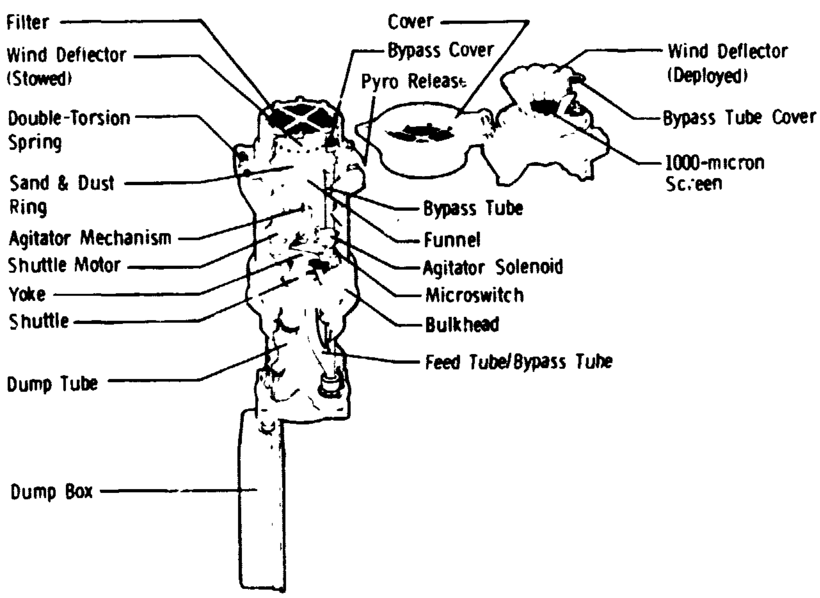

Figure 6.- Biology PDA.

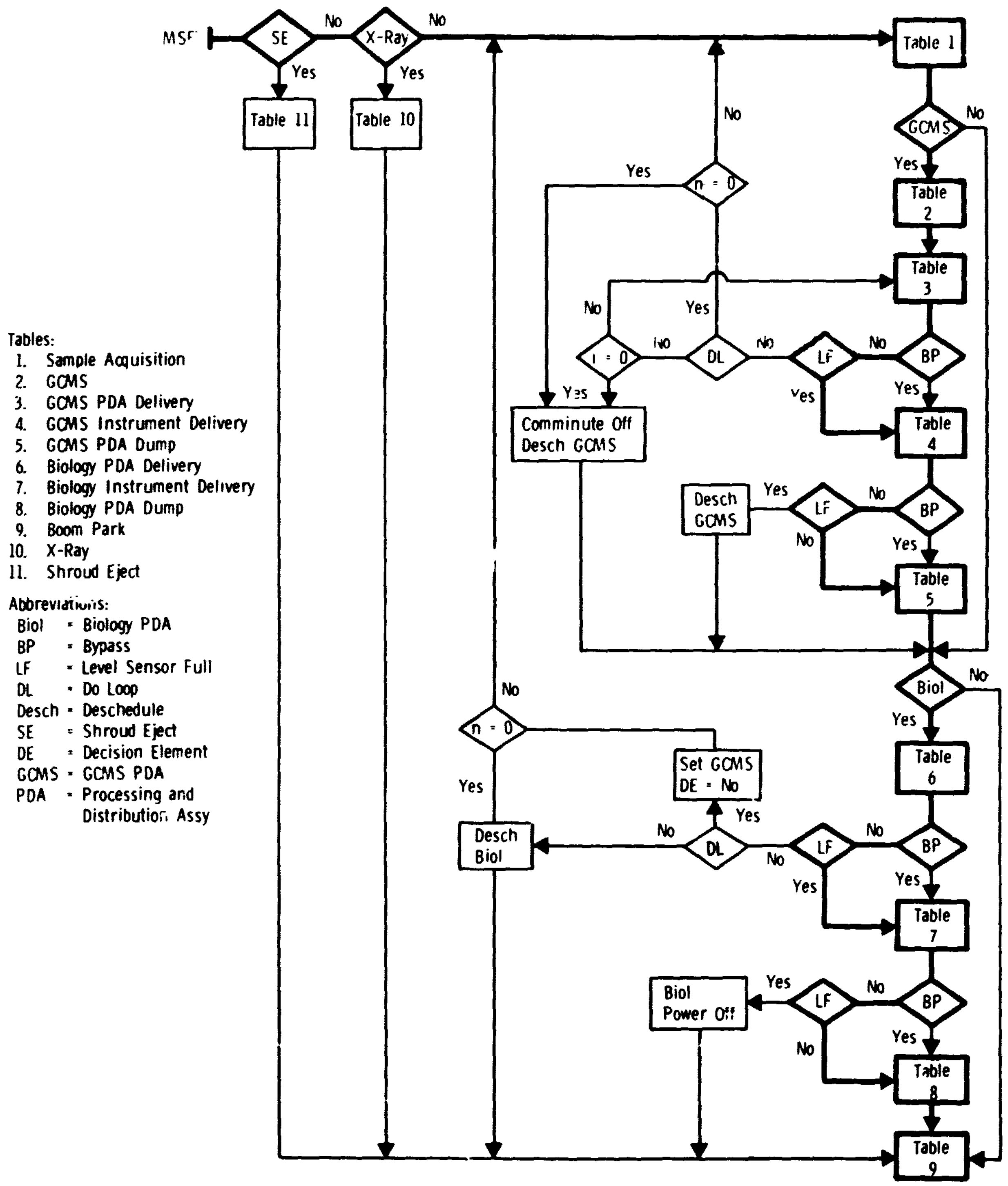

Figure 7.- Surface sampler operational capability diagram.