Mark IV Gulliver – An In Situ Instrument for Extraterrestrial Life Detection

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The space age has raised the curtain on man's most momentous era of exploration. Perhaps the foremost question which may be answered through this exploration is whether life exists on other planets. The best way to resolve this age-old enigma would be to send biologists to the planets. This, however, probably will not be possible until the latter part of this century. Meanwhile, unmanned landings on Mars are being planned for the 1970's by the U. S. National Aeronautics and Space Administration. Mars has been selected as the first target because it seems the most likely, accessible abode of extraterrestrial life. Thus, if our generation of scientists is to glimpse the answer to the fascinating question of life beyond the Earth, that glimpse must be revealed through bioengineering instrumentation and telemetry.

Instruments for this task face many challenges. Because of the tremendous cost of delivering payloads to space destinations, they must be small, of minimum weight, and demand little electric power. Nonetheless, they must be rugged enough to withstand the vibration, shock, and acceleration of spacecraft launchings and planetary landings. The instruments, necessary reagents, and other ancillary systems must survive the rigors of the eight-month trip through the space environment to Mars. Prior to launch, the entire experimental payload will be cycled several times through sterilization temperatures. This is to prevent Earth microorganisms from being carried to Mars where they might invalidate the experiment and contaminate the planet. Once it arrives on Mars, the instrument package must operate in the severe environment of that planet for periods of up to several weeks or months. Finally, in a foreign environment amongst unknown compounds and conditions where organisms, if they exist, may be very different from those on Earth, the instruments will be expected to provide unambiguous data.

Gulliver (1, 2, 3, 4) is an instrument devised to detect microorganisms living in the soil of Mars. Previous reported models of the instrument such as that in Figure No. 1 (figure unavailable) were designed to function essentially alike. After the soft-landed space capsule rolls to a halt on the planetary surface, small projectiles are launched to deploy approximately 25 feet of silicone-greased string across the Soil. Immediately thereafter, a small electric motor reels the strings and the adhering soil particles into the incubation chamber for the experiment.

A major research activity of the Gulliver program has been the development of the nutrient medium. The objective is to produce a medium in which many widely varying species of terrestrial microorganisms grow or metabolize. It is hoped that extraterrestrial organisms will be somewhat similar biochemically and utilize one or more of the nutrients with the production of gas. The medium is to contain various radioactive compounds labeled such that the organisms assimilating them will produce radioactive gas. Two such media have been developed (5). All types of microorganisms tested, including aerobes, anaerobes, heterotrophs, and autotrophs, of both photo- and chemo- varieties, utilize the media to produce $C^{14}O_2$. Other labels, such as S^{35} and H^3, may be added to the media as the work proceeds.

The experiment calls for the simultaneous use of two identical units. One injects an antimetabolite into the soil culture in addition to the nutrient medium as an experimental control. The antimetabolite has been under development concurrently with the medium and, similarly, is based upon tests on a wide variety of terrestrial microorganisms. A negative, or attenuated, response produced by the control unit compared to a positive response from the test unit strongly indicates the biological nature of the latter response.

An experimental result such as that shown in Figure No. 2 would provide positive evidence for life. Numerous field tests performed on mountaintops, deserts, saline flats, and open fields have demonstrated the feasibility of the experiment and instrument (1). With medium containing a total activity of 10 microcuries, positive results have been obtained in the laboratory within several hours when as little as 1.0 mg. of soil containing several hundred cells was tested.

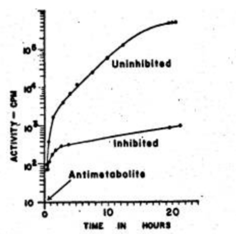

Fig.2. Typical result of Gulliver test.

Recently, analysis of several problems confronting extraterrestrial life detection systems suggested field tests in which the radioactive medium was applied directly to the soil surface. The responses were considerably stronger and the response times shorter than those obtained with the instrument.

Mark IV Gulliver, Figure No. 3, was designed to incorporate these advantages. It differs from previous models primarily in that it operates <u>in situ</u> and does not require the retrieval of a soil sample from a surface of unknown composition and texture.

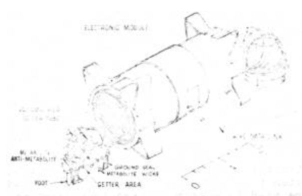

Fig.3. Mark IV Gulliver.

A significant biological advantage results from this new technique. In the retrieval of a soil sample, the sample is disturbed to a degree depending upon the sampler. As a consequence, the microenvironment is altered to the disadvantage of any microorganisms present. For example, if the microorganisms are photosynthetic, they will be growing on the surface. In soil retrieval, probably most of the surface organisms would be mixed through the depth of the sample and no longer be able to receive sunlight. Similarly, water vapor and gases in the microenvironment would be disturbed.

The second major change incorporated into the new instrument is miniaturization. The advantages gained are greater redundancy through the use of multiple units, greater statistical significance, more representative sampling, and the ability to conduct experiments with a variety of nutrient media.

The new model measures 3-1/4 inches long and 1-1/4 inches in diameter, and weighs approximately five ounces. Each unit will operate with an average power demand of approximately one-third watt and a several-second peak demand of approximately four watts. The central electronics contained in the capsule, excluding data handling and telemetry systems, will weigh approximately one pound. Still further miniaturization of all compounds is contemplated.

In a visualized planetary experiment, a volley of the Mark IV units is fired from the landed capsule. Electric umbilical cords connect each unit to the capsule-housed power supplies, programmer, data handling, and telemetry systems. After each unit comes to rest, the extensible, cylindrical ends are ejected and fall to the ground. The flexible seal conforms to the ground contour, thus effecting a closed volume to serve as an incubation chamber. The radioactive nutrient medium is then discharged directly onto the ground surface within the confined volume at each end of the unit. Normally both extensible ends should reach the ground surface but, even in circumstances of unusually difficult terrain, at least one end should find a surface. The enclosure reduces evaporation of the water in the medium, and a radiant heater protects the liquid medium on the enclosed ground surface against freezing. Any nonmetabolically-derived gases released from the medium are collected on the exposed surface of the chemical getter. After several minutes, this getter surface is sealed and fresh material is exposed to collect the gas evolved by the experiment. A small geiger tube contained in each extensible end of the unit counts the activity collected and transmits the data over the cable to the central capsule for processing and radio relay to Earth. A baffle prevents the geiger tube from "seeing" the radioactivity in the medium, but permits the passage of the gas. Each sensor unit also contains an ampul of antimetabolite which can be released by preset program or by a logic system. In this manner, any of the units can be planned or selected as controls for the experiment.

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<u>References</u>

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