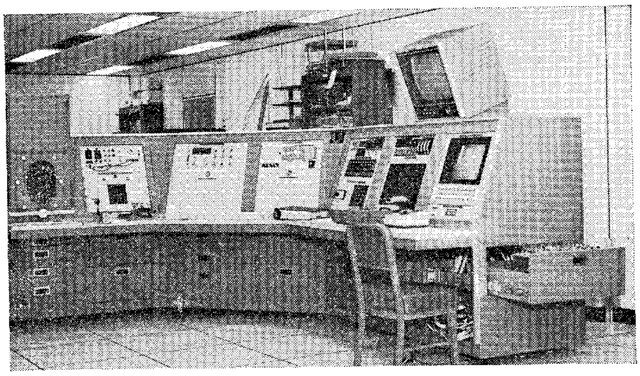

Fig. 3 Breadboard 2 physiological, behavioral, and data management station.

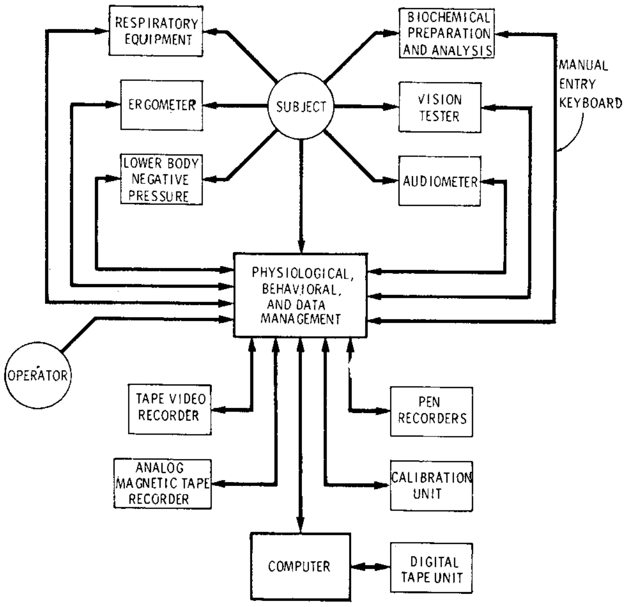

Fig. 4 The IMBLMS breadboard 2 block diagram.

Potential Applications

Although the primary purpose of the IMBLMS development is a flight system, the program may have other potential applications, such as to provide for some relief of the remote health services problems that exist in the United States today. Although the application of this technology obviously could not cure all the problems, it could be adapted for use on Earth as a health services access system with the following features: 1) the use of an integrated medical, communications, and data management facility manned by physicians' assistants to provide points of entry into the health care establishment for people in medically deprived areas; 2) the provision for outpatient services on a local level, coupled with the use of communications technology to provide the consultation support and supervision of the physicians' assistant; 3) the use of appropriate combinations of fixed and mobile facilities to meet the varying needs dictated by different sites; and 4) the use of information processing to relieve personnel of burdensome recordkeeping and administrative functions and to enhance the availability of statistics for more effective planning, features which permit efficient use of the physicians' time and are essential for support and supervision of the physicians' assistants.

Conceptually, a national network of health services units could be developed, although initially a demonstration program would be a cost-effective method to establish the feasibility of the basic approach.[2] The exact configuration of the demonstration program units would depend on the site or sites selected, but the system may be described basically as follows. Remotely located field units would be supported by a control center located adjacent to a large hospital emergency facility. The control center would be in constant communication (voice, data, television) with the remotely located elements of the system. The local center, which would be a fixed facility typically located in a town without a medical clinic or hospital, would offer outpatient and emergency health services, and would serve as a relay point for communications with other more remotely located facilities. The mobile facility, which would be a scaled-down version of the local center, would be capable of offering health services to fewer people and would have the advantage of being transportable over major roads, on a scheduled basis, to cover a wider area. Ambulances and hand-carried equipment would further extend the system so that isolated areas would be offered some regular health services coverage.

Conclusions

The IMBLMS is being developed as a medical system that integrates medical and data management facilities for space application. The modular design of the system will provide the technological tools for onboard medical support to perform projected medical experiments and to permit changes in measurement capability both during and between missions. Thus, the IMBLMS will not only be suitable for use during early extended space flights but also will be able to accommodate measurement and diagnostic apparatus as well as treatment and surgical facilities developed for later missions. Major elements of the IMBLMS also could be adapted for use on earth as a health services unit.

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Electrophilic Property of Uranium Hexafluoride

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Introduction

In recent years a sizable effort has been in progress to develop reactors employing nuclear fission fuels in the gaseous state. This effort has been motivated by the much higher temperatures (12,000—50,000°K) permissible in this new type of reactor, known as the gas core or cavity reactor, than in the present reactors employing solid fuel elements. There are two major applications for which the gas core reactor promises

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great advantages—nuclear rocket propulsion and the generation of electric power.

For the generation of electric power, the Carnot efficiency, which represents the maximum possible thermal efficiency of power plants, is increased by using higher temperature heat sources. Consequently both the fuel consumption and the waste heat per unit of electrical energy generated are reduced. For land based power plants, the reduction in waste heat alleviates the problem of thermal pollution. For space power systems, the availability of a higher temperature heat source permits the employment of higher temperature radiators for the release of waste heat and thus lessens the weight penalty imposed by the radiators. Conventional types of energy conversion devices cannot operate at temperatures higher than about 2500°K. Current literature therefore emphasizes the use of MHD generators with the gas core reactor. It has been pointed out[1] that, while both the gas core reactor and the MHD generator are relatively new concepts each with its own unresolved problems, the coupling of the two concepts does not mean that the existing problems are compounded. On the contrary, in a combined gas core reactor—MHD system, the major outstanding problem in MHD power generation, that of achieving high electrical conductivity, is thought to be resolved since the working medium can be heated in the gas core reactor to a sufficiently high temperature. Furthermore, many constraints on the gas core reactor that are inherent in the rocket propulsion application are relaxed. For example, the working medium leaving the reactor may contain a higher concentration of fuel since it can be reclaimed; the working fluid can be an inert gas instead of hydrogen, and the over-all weight of the system is not of critical importance.

Several investigators[2,3] have performed preliminary design studies for gas core reactor—MHD power plants. Encouraging prospects in both space and land based applications have been reported and full-scale experiments have been recommended. Thus it becomes appropriate now to inquire whether the coupling of the gas core reactor and the MHD generator may lead to new problems that were not experienced in either of the component systems. In the present investigation, one such problem which could arise in a system using uranium hexafluoride (UF_6) as nuclear fuel is studied. In such a system the working medium in the MHD generator may be an argon plasma containing UF_6 either in substantial quantity or as an impurity.

It is known that halogen compounds often possess relatively large molecular cross section for electron attachment and therefore are electrophilic. The injection of minute quantities of sulfur hexafluoride (SF_6) into a flowing plasma under conditions of interest to spacecraft re-entry is known to deplete substantially the free electrons in the plasma[4] through the attachment of free electrons to the SF_6 molecules, forming negative ions. The injection of SF_6 into the re-entry plasma sheath is therefore considered an effective method of alleviating the re-entry communications problem. It is well-known that under conditions of practical interest to MHD generators, the working medium is a plasma whose electrical conductivity is attributable to the presence of free electrons. The presence of UF_6 in the working medium may therefore drastically lower the electrical conductivity of the medium and result in inefficient performance of the MHD generator. Although the thermodynamic and chemical properties of UF_6 under normal conditions have received considerable attention in the past, little is known about the properties of UF_6 under plasma conditions. Under normal conditions, the chemical properties of UF_6 differ considerably from those of SF_6. Whether or not UF_6 is electrophilic, as is SF_6, must be established through detailed experimental investigation.

Stagnation-Point Electrostatic Probe

A stagnation-point electrostatic probe was constructed for the present investigation. The existing probe theories were extended and used to relate the measured probe characteristics to the free electron number density, the negative ion temperature, the positive ion temperature, the electron temperature, and the ion temperature. The detailed analysis accompanying the theory for a stagnation-point probe in a continuum, partially ionized plasma containing negative ions is involved. The essential features of the extended theory are summarized in this paper together with the simplifying assumptions used.

A simple theory for an infinite planar electrostatic probe in a nonflowing collisionless plasma in the absence of negative ion was developed by Langmuir and Mott-Smith.[5] Hung and Paquette[6] presented an analysis accounting for the presence of negative ions. Each of the constituent species is considered to have a Maxwellian velocity distribution. The temperatures of the various species present are considered to be identical. In the present investigation, the formation of negative ions preferentially depletes free electrons possessing lower kinetic energies. Since collisional exchange of kinetic energies between the electrons and the more massive species is inefficient, the electron temperature is greater than the ion temperature. Consequently a theory which differentiates the electron temperature from the ion temperature is needed. Such a theory is presented in Ref. 4.

The basic probe theory is valid for a plasma whose charged particle mean free path is much greater than the thickness of the probe sheath, within which the effect of probe bias is felt by the plasma. The plasma of interest in the present application is a continuum and the sheath thickness is generally several times the mean free path. Collisions within the sheath can influence the charged particle flux. Based on the works of Talbot,[7] however, it is concluded that under the conditions of the present experiments the probe current density is not greatly affected by these collisions. The basic theory,[4] which neglects the collisional effects, therefore relates the measured probe characteristics to the properties of the plasma at the sheath edge. Collisions within the sheath, however, cause an increase in the sheath thickness, and hence also the effective collecting area of a finite probe, with increasing probe bias. Consequently, the total saturation currents possess positive slopes, as shown in Fig. 1.

To relate the properties of the plasma at the sheath edge to the freestream condition of the plasma (i.e., the plasma condition in the absence of the probe), the theory of Talbot[7] was

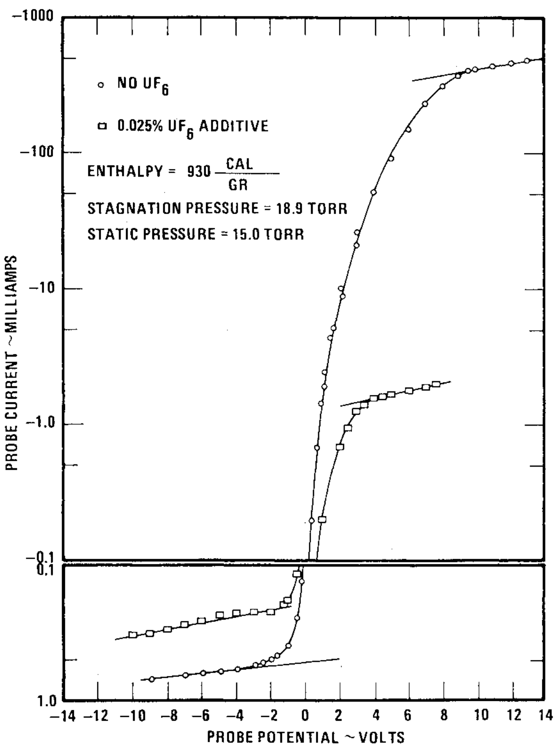

Fig. 1 Probe characteristics showing effect of UF_6.

modified and used. The basic assumptions of the Talbot theory are that completely frozen flow exists throughout the boundary layer and that ambipolar diffusion exists outside of the sheath. The validity of both assumptions are discussed by Talbot.[7] Talbot did not take into account the presence of negative ions. However, when the presence of negative ions is included, the basic analysis remains virtually unchanged.

Apparatus and Experimental Procedure

A plasma torch was used to generate a 3-in.-diam subsonic stream of argon plasma, exhausting into a water cooled vacuum tank which is 3 ft diam and 4 ft long. The tank was evacuated by a mechanical vacuum pump. A gate valve was placed between the pump and the tank to regulate the tank pressure. The electrostatic probe was housed in a $\frac{3}{8}$ in. outside diam copper tubing and was water cooled. The collecting electrode was steel, 0.060 in. diam and was insulated from the remainder of the probe by a glass insulator. The probe was shaped like a flat ended cylinder and the collecting electrode was located at the center of the flat end. During the experiments, the probe was placed in the center of the plasma stream with the flat end perpendicular to the flow direction.

A mixture of UF_6 and argon was injected into the plasma stream through two $\frac{1}{32}$-in.-o.d. stainless steel tubes placed at the nozzle exit perpendicular to the plasma flow. The UF_6 feed rate was controlled by valves between the UF_6 feed tank and the tubes. The argon flow rate and the torch current were set to predetermined values to produce desired plasma enthalpies. Before each run, argon was added to a UF_6 feed vessel to pressurize the vessel to 15 psia. The UF_6 feed rate were calculated using the recorded rate of pressure drop in the feed tank during each run and the concentration of UF_6 in the feed mixture.

Results and Discussions

The current-voltage characteristics of the electrostatic probe were obtained at static pressures of 15 and 30 torr and enthalpies up to 1.5×10^3 cal/g for the argon plasma with and without the addition of UF_6. For each set of experimental conditions, the ion temperature of the plasma was evaluated from the probe characteristics independently. The results were within 5% of each other. The typical probe characteristics given in Fig. 1 demonstrate that a small addition of UF_6 suppresses the electron saturation current by more than a factor of 100. The reduction in electron number density as a function of the ratio of UF_6 concentration to free electron concentration prior to UF_6 addition is shown in Fig. 2. It is seen that the addition of UF_6 in a number density equal to the free electron number density prior to UF_6 addition reduces the electron concentration by as much as 98%. Further reductions in electron concentration require much larger additions of UF_6.

During some experimental runs, a deterioration of the probe collecting electrode was detected. This deterioration was traced to the dissociation of some of the UF_6 molecules, resulting in chemically reactive products. These products react with the collecting electrode and cover the electrode with a resistive film. By lowering the effective collecting area of the probe, the resistive film led to erroneous number density results. In general, this deterioration is important only when the probe is strongly positively biased and the plasma enthalpy and the UF_6 feed rate are both high. Under these conditions, a large negative ion current (on the order of 50 ma) reaches the collecting electrode and the probe deteriorate rapidly after a relatively short period (on the order of 10 sec). To insure that the coating action does not significantly influence the probe characteristics, the probe traces were taken rapidly, the positive voltage ranges were swept in less than $\frac{1}{2}$ sec. For cases where some coating action were suspected, several traces were taken consecutively and compared with one another so as to ascertain that no significant deterioration of the collecting electrode had taken place during a given run.

The experimental data obtained in the present investigation show that uranium hexafluoride is electrophilic. In view of this finding, the use of uranium hexafluoride as the nuclear fuel in the gas core reactor–MHD generator system is probably impractical. In particular, the electron attachment and the possible subsequent detachment are known to depend on the electron energy as well as the pressure and the temperature of the plasma. Further experiments at temperatures and pressures appropriate to the gaseous nuclear core as well as to the MHD generator would be useful.

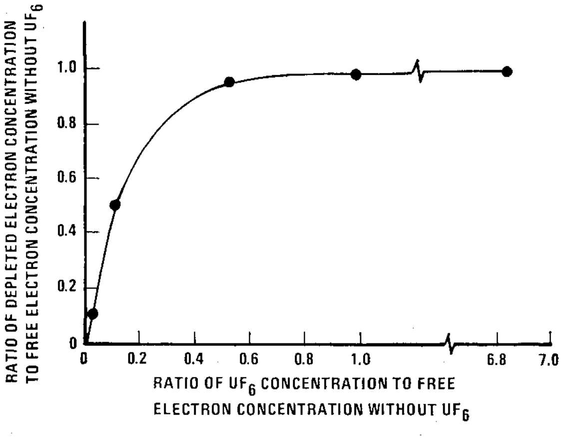

Fig. 2 Effectiveness of UF_6 as an electrophilic compound.

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Detection of Crystals in CO_2 Jet Plumes

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APPLICATION of jet systems for attitude control and propulsion of spacecraft is the primary reason for investigation of freejets exhausting into vacuum. Since the jet

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