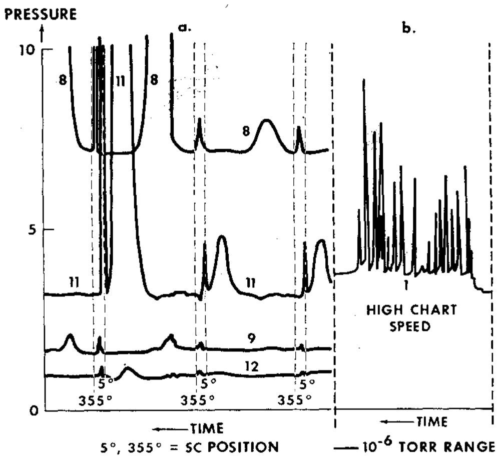

Fig. 6 Gage response in Chamber A (2TV-1), a) during water boiler operation, b) during waste-water dumping, no spacecraft rotation.

protective panels caused the cold wall panels to release part of the adsorbed or cryopumped gas load. Release resulting from higher surface temperatures of gases by the spacecraft may also have occurred. Figures 3 and 4 show the existence of good space simulation during the tests. These figures also indicate that the GSE caused the gases released locally to diffuse throughout the chamber lowering the achievable quality of space simulation to some degree.

Results of Chamber A Measurements

As in Chamber B, the gage readings generally indicated quasiequilibrium condition with average chamber pressure in the lower 10^{-6} torr range. Figure 5a, for instance, shows typical pressure readings during pumpdown of Chamber A from the 10^{-4} torr range to the 10^{-6} torr range. During spacecraft activities, various events causing directional gas flow within the chamber were recorded. Unlike the situation in Chamber B previously described, the gas flow pattern in Chamber A rotated with the spacecraft and created characteristic gage readings that depend on the phase of rotation. This rotation starts at approximately 5° and reverses at approximately 355° or at any intermediate angle. The typical gage response to nearly unidirectional gas flow ($X/Y < \frac{1}{10}$) during spacecraft rotation and continuous water boiler operation (at two different rates) is shown in Fig. 6a. Another type of nearly unidirectional gas flow occurred, when, at various times during the testing, water droplets were ejected from a waste water dump nozzle into the chamber and evaporated several feet from the spacecraft. The gages

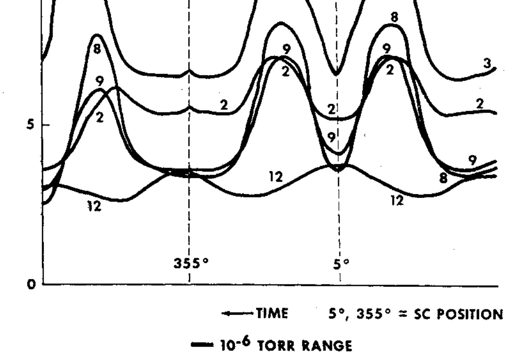

Fig. 7 Gage response in Chamber A (2TV-1) during Bay 4 leak.

directed toward the vent reacted with high pressure spikes (shown for one gage in Fig. 6b). Figure 5b depicts the gage response when the forward hatch of the command module was opened briefly during one of the tests. The angle of the spacecraft changed three times. The reaction of the gages is typical for nearly unidirectional flow of a "condensible" gas. A different type of directional gas flow caused by a leaking GSE connection to the spacecraft near Bay 4 is shown during spacecraft rotation in Fig. 7. Gage reaction indicates leaking of a "noncondensible" gas. Here the original directional gas flow resulted in a localized higher gas concentration. Figures 5–7 show that space simulation was good during the tests, and they indicate the effect of GSE.

Concluding Remarks

The described measuring system proved to be valuable not only for verifying required test conditions, but also for detecting abnormal and characteristic test article or chamber conditions by assisting in leak detection, leak localizing, simple gas analysis (condensibles and noncondensibles), analysis of pumping system performance, and analysis of events (operations of valves, doors, life support systems, water boilers, and waste water dumping). Improvements could be made by the use of: a) pairs of gages supported by rotatable mounts which would permit the same gage to read, in short sequences, the gas flows in one and then in the opposite direction; b) metal-tubulated ion gages provided with instruments to measure gage temperatures; c) small mass spectrometer tubes (replacing some of the ion gages) for measuring partial pressures and for analyzing gas types; and d) power supplies for the gages providing automatic range switching and range recording.

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Emissive Probes for Plasma Potential Measurements on the Sert II Spacecraft

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TWO emissive probe (hot wire) systems having different measurement requirements have been designed, fabricated, tested, and delivered for use on the SERT II spacecraft. With emissive probes, emitted electrons are drawn

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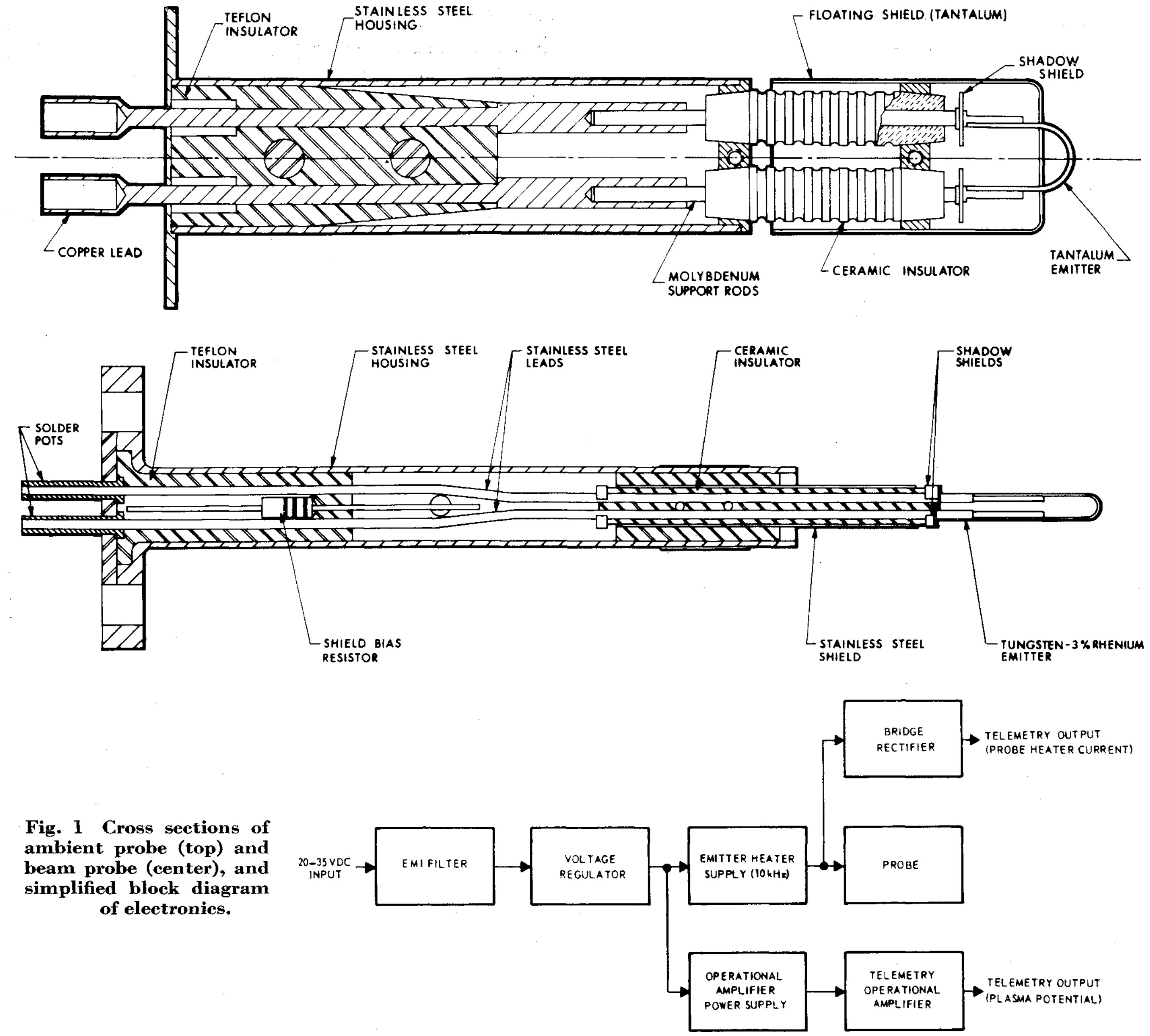

Fig. 1 Cross sections of ambient probe (top) and beam probe (center), and simplified block diagram of electronics.

back to the probe when the probe is positive (with respect to space potential at the probe location) and the collected electron current from the plasma should be unaffected by the emission. When the probe is negative, electrons are emitted from the probe, and by measuring the space-charge-limited current flow, the value of space potential can be determined. For the beam probe, the particle densities are sufficient to insure adequate electron collection by the emitter when the probe is positive with respect to the plasma. For the ambient probe, however, when the probe is positive with respect to plasma potential, measurements can be dependent upon plasma densities. As a result, a bias voltage of -50 v with respect to the spacecraft was incorporated into the ambient probe system to insure that the probe is always negative with respect to the space plasma (i.e., always emitting electrons).

Tungsten-3% rhenium was chosen for the emitter for the ambient probe (Fig. 1, top), because grain growth data supported its ability to satisfy the lifetime requirements. The essential elements of this probe are a directly-heated emitter and a shield electrode which is connected by a resistive divider to the emitter, so that the shield is held at the mean emitter potential. The configuration is such that the emitter and electronics are connected to the spacecraft through a 10-megohm resistance. This introduces an additional current which is proportional to the probe voltage with respect to spacecraft and the resulting voltage offset is assimilated in the calibration.

Tantalum was chosen as the emitter material for the beam probes (Fig. 1, center) because of low power requirements for a given electron emission, and a favorable sputtering yield. The design point for the emitter was chosen so that sputtering would not greatly alter the emission capability or the heating power required. Sputtering of the tantalum emitter by 250-ma, 3-kev mercury ions for 30 min was expected to result in a small decrease in the average diameter of the emitter. However, during the calibration procedure, the emitter diameter was not measurably reduced by sputtering at the operational level. Since the emitter power is current-regulated, any decrease in the size of the emitter by sputtering will increase the emitter temperature, hence a favorable increase in emission capability will result. Deposition of sputtered material from the shield will tend to oppose this increase in temperature and should not appreciably affect the characteristics of the emitter since both are made of tantalum. The essential elements of the beam probe are the directly-heated emitter and the "floating" guard electrode or shield. Since sheath thicknesses in the beam plasma are considerably

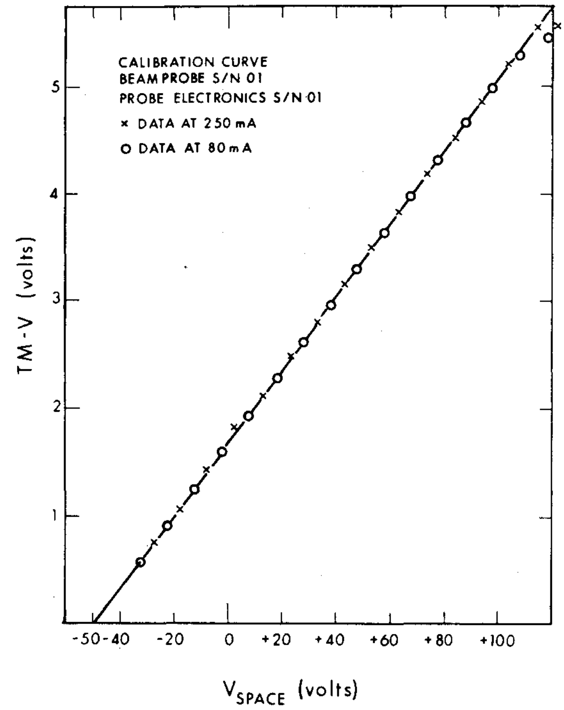

Fig. 2 Beam probe calibration curve.

smaller than those in the ionospheric plasma, the shield can operate up to several volts negative with respect to the emitter without introducing appreciable error. A slightly negative potential on the shield is desirable to prevent "stripping" electrons from the beam plasma, since it automatically limits the electron current collected to the ion current striking the shield.

The probe systems (Fig. 1, bottom) are designed to supply a constant current to heat the probe emitter and provide a means of determining the potential developed between the probe filament and spacecraft ground. The processed data from this potential measurement and the probe heater current are supplied to the spacecraft telemetry. The electronic configurations for the two probe systems are similar, but the beam probe system has an added transformer near the probe, and the ambient probe system has an added negative voltage power supply to provide the necessary bias voltage. The only other differences in the two systems are values of resistors and transformer windings due to the differences in heating requirements of the two different emitter designs. The calibration procedures for the two probe systems basically consisted of 1) stabilizing a plasma source at a desired ion density, 2) measuring the plasma potential at the "probe location" using a reference probe, 3) positioning the probe to be calibrated at the probe location, 4) recording the telemetry output voltage (TM-V) to establish the relationship between plasma potential and TM-V, and 5) recording TM-V for ambient probe bias voltages of +50v to −100v.

The ambient probe calibration was performed in a 5-ft-diam by 12-ft-long vacuum system, so that a low-energy argon ion source developed to calibrate plasma spectrometers such as the ALSEP and OGO instruments could be used to provide the low-density plasma necessary. From this calibration, the bias voltage of −50v was chosen.

The beam probe calibration was performed in a 2-ft-diam by 6-ft-long vacuum system. A 10-cm-diam mercury ion engine (supplied by NASA-Lewis Research Center) was used to generate the 3-kv ion beam. The 250-ma design current corrsponded to a density of $\sim 10^9$ ions/cm^3.

Typical calibration results for the beam probe system are shown in Fig. 2 and are accurate throughout the ion density and potential range of interest. The results for the ambient probe system are very similar but are subject to more doubt than for the beam probe because of sheath considerations in this density range. The validity of the calibration of the ambient probe may be demonstrated during the SERT-II flight when the spacecraft is forced to potential differences with respect to the space plasma.

An Improved High-Power Xenon Short-Arc Lamp

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Introduction

In Japan the development of xenon short-arc lamps was initiated in 1957. By use of forced-air cooling, a 5-kw lamp was developed and put to use as a light source for large Cinelama projectors, solar simulators and arc-image furnaces. This Note describes development of 25-kw and 30-kw short-arc (12-mm gap) xenon lamps with liquid cooled electrodes (Fig. 1). The 20-kw xenon short-arc lamps with liquid-cooled electrodes have been introduced by Thouret, Lienhard, etc.[1–3]

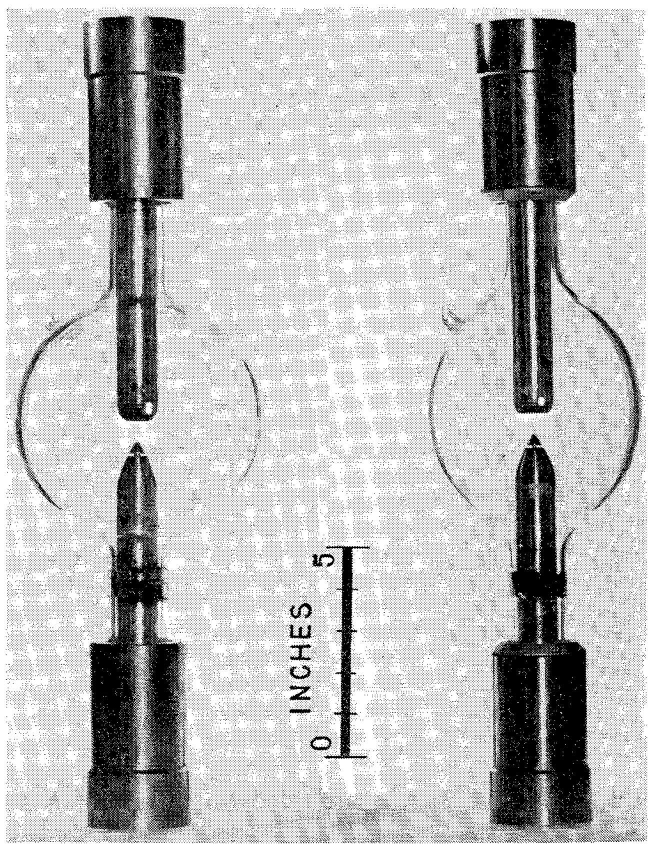

Fig. 1 Xenon 30-kw (left) and 25-kw (right) lamps.

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