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PERFORMANCE PARAMETER MEASUREMENTS ON THE INTERPLANETARY MONITORING PLATFORM IMP I

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PERFORMANCE PARAMETER MEASUREMENTS
ON THE
INTERPLANETARY MONITORING PLATFORM
IMP I

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SUMMARY

The IMP Spacecraft includes instrumentation to monitor 15 separate performance parameters - 4 voltages, 3 currents and 8 temperatures. These measurements provide important information on the operational status of the primary power system as well as the thermal environment of critical experiments and subsystems.

Each of the 15 parameters are described in detail - including their relationship to the overall spacecraft system. Temperature measurement locations are shown and the method of calibration of the temperature parameters is outlined.

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INTRODUCTION

The Interplanetary Monitoring Platform (IMP) is a series of GSFC spacecraft designed to investigate energetic particle phenomena and magnetic fields at altitudes up to approximately 150,000 N. miles.

In addition to the scientific experiments, telemetry system, power system, etc, IMP carries on-board instrumentation designed to relay certain information concerning its own performance. This information consists of telemetered data of 15 "performance parameter (PP)" measurements. These measurements include 4 voltages, 3 currents and 8 temperatures.* In addition, two temperature measurements are "dual level" which permit the verification of spacecraft separation from the third stage motor and the extension of the Rb Magnetometer. Approximately 33 measurements of each PP are transmitted for each one hour of spacecraft operation.

This report describes each of the fifteen parameters - their function, relationship to the spacecraft system and, in the case of temperature parameters, their physical location within the spacecraft.

The design of the electronic instrumentation (Performance Parameter Card, S-74-IH1 and temperature sensors) was the responsibility of the Flight Data Systems and Thermal Systems Branches of the Spacecraft Technology Division. It is anticipated that the details of these designs, omitted from this report, will be presented in forthcoming reports from that Division.

The following brief description of the PP design has been summarized from Ref 1:

The 15 performance parameters present an output voltage of 0 to 5 vdc to the spacecraft Encoder. The first seven are encoded through Analog Oscillator No. 1 (A.O. 1) and the remaining eight through A.O. 2. The voltage divider network for the

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* See Figures 1 and 2

PP1,* PP2 and PP8 monitors is contained in the Performance Parameter card while that for PP12 is located on the Battery connector. The current parameters are obtained from magnetic amplifiers having an output voltage of 0 to 5 vdc, dependent upon sensor current. The temperature measurements are made by calibrated thermistors within voltage divider networks. The +7 vdc necessary for operation of the thermistors is obtained from the Multi-converter.

VOLTAGE AND CURRENT MEASUREMENTS

These measurements include the following four voltages and three currents:

PP1	Solar Array - Battery Voltage
PP2	Prime Converter, +50v output
PP8	Prime Converter, +12v line (A) output
PP12	Multi-converter, +7v output
PP3	Battery Current
PP4	Spacecraft Current
PP9	Solar Array Current

Some of the important aspects of each of these parameters in relation to the spacecraft power system** are as follows:

PP1 (Solar Array - Battery Voltage) - This monitor indicates the input voltage to the Prime Converter which in turn, supplies regulated voltages to nearly all experimentation and instrumentation. The nominal operating value of PP1 is +19.5 volts which is governed by the Solar Array Regulator. When the Battery operates the spacecraft (i.e., during shadow periods) this voltage can be as low as +12 volts. However, if it drops below +12 volts, the programmer will turn the spacecraft off for eight hours, allowing the Battery to recharge.

PP2 (Prime Converter, +50v Output) - This is one of the two voltages (+12v is the other) supplied to the Telemetry Transmitter.

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* The fifteen parameters are designated PP1 thru PP15 and correspond to channels 1 thru 15, frame 2 of the IMP telemetry format.

** Figure 3.

PP8 (Prime Converter, +12v (line A) Output) - This output of the Prime Converter supplies most experiments and spacecraft subsystems either directly or thru additional converters.

PP12 (Multi-converter, +7v Output) - The eight temperature measurement circuits are supplied by this +7v output. This voltage is regulated to better than ±1%, but to guard against possible ambiguities after launch and to assure the accuracy of the temperature measurements, the PP12 monitor was incorporated in the spacecraft design.

PP3 (Battery Current) - This sensor indicates current flow to or from the Battery (without regard to direction). The direction, i.e., charge or discharge mode must be determined from the data of PP4 and 9 below. The sensor is designed for a full scale reading of only 500 milliamps to provide better resolution of current levels under "trickle" charge conditions. This results in the loss of quantitative data during periods of high (> 500 ma) charging rates (e.g., after shadow exit) or high discharging rates (during shadow).

PP4 (Spacecraft Current) - This parameter indicates the total spacecraft load current except that used for Battery charging (PP3) and the small current drain of the Solar Array Regulator. PP4 multiplied by PP1 gives the total spacecraft power requirement.

PP9 (Solar Array Current) - The total amount of current supplied by the four Solar Paddles is indicated by this sensor. This current multiplied by PP1 is the total Solar Array power output.

The amount of current being "dumped" or dissipated (PPX) as heat by dumping transistors and resistors can be determined by: PPX = PP9 - (PP3 + PP4).

(Data processing of IMP PP data is programmed to include each of the above calculations.)

Spacecraft calibrations of the voltage and current sensors are done in accordance with Ref 2.

TEMPERATURE MEASUREMENTS

Each thermistor assembly* (i.e., one or more thermistors plus fixed resistors) is calibrated in a well-stirred oil bath. The spacecraft circuitry is simulated during calibrations for increased accuracy. Low range temperature sensors such as used on the solar paddles are mounted on a block of high thermal mass which is cooled by a liquid nitrogen "bath". Readings are taken at specified intervals as the mass slowly warms to room temperature.

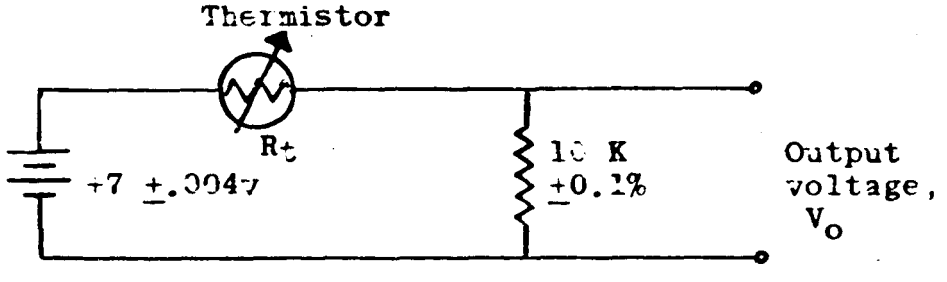
Figure 1 includes some pertinent data on the eight temperature sensors while the general location of each sensor is shown on the spacecraft drawings of Figures 5a and 5b. Figures 6 thru 10 illustrate the exact location of each of the sensors.

Two of the temperature measurement circuits include provisions to confirm, via telemetry, two mechanical events: separation of the spacecraft from the third stage motor (PP10) and secondly, extension and lock-in of the Rb Magnetometer (PP13). This is accomplished by paralleling a 10 K ohm resistor with the nominal 10 K output impedance of the Performance Parameter card while in the "pre-event" configuration. At event time a micro-switch removes the 10 K resistor from the circuit causing a step function change of the output frequency of the PP (approximately 130 cps).

CALIBRATION OF TEMPERATURE PARAMETERS

Calibration of the temperature measurement parameters is as follows (complete and detailed procedures and explanations are contained in Ref 2):

(1) THERMISTOR - Each temperature sensor is precisely calibrated (in an oil-bath) prior to physical installation in the spacecraft assembly (Battery, Transmitter, etc). This calibration yields temperature (^{o}C) versus voltage according to the following circuit:**



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* Figures 4a and b.

** This circuit simulates the circuitry in the spacecraft and permits thermistor "self heating".

R_t is then calculated from ohms law by

$$R_t = 10\ K \left[\frac{7.00}{V_o} - 1 \right] \quad \text{(K ohms)},$$

which is used to plot the thermistor resistance versus temperature curve.

(2) SPACECRAFT - Spacecraft calibrations are done by substituting accurately known resistance values for each temperature parameter. This results in encoder output frequency as a function of input resistance.

This procedure is normally done at room temperature, cold and hot to take into account the shift, if any, of the analog oscillators with temperature. (However, tests have proven that actually there is no significant shift over the 0°C to +40°C range. Therefore, final calibrations were done at room temperature only.)

(3) COMBINATION - The data from (1) above (temperature vs thermistor resistance) is combined with that from (2) above (simulated resistance versus output frequency) to yield temperature versus output frequency (or period) which is the final overall calibration curve for a particular temperature performance parameter.

CONCLUDING REMARKS

After launch, telemetered data from Performance Parameter in-flight measurements will be available in basically two formats. The first will tabulate each PP versus time but the data will be represented by a comb filter number (by hand operation, this can be translated to a frequency and then, from the appropriate calibration curve, to engineering units (e.g., volts, amps, or °C)).

The second format type will include PP data printed out directly in engineering units. In addition, time averages, calculations, and curve plotting will be computer programmed.

A complete set of the aforementioned data will be kept on file by the IMP Project Office, GSFC. Summary status sheets, based on this data will be forwarded periodically to cognizant project personnel.

It is hoped that IMP experimenters, instrumenters and others will be able to use this report to gain a more complete understanding of the IMP Performance Parameter system so that in-flight data will be more meaningful and useful to them.

REFERENCES

1. S-74 (IMP) Experiment and Instrument, Technical Description. EMR, 23 July 1963.

2. S-74 (IMP) Performance Parameter Calibration Procedure, Revision A. EMR, 19 July 1963.

LIST OF ILLUSTRATIONS

PERFORMANCE PARAMETER MEASUREMENTS
INTERPLANETARY MONITORING PLATFORM (S-74/IMP I)

PP	MEASUREMENT	(1) CALIBRATION	(2) NOMINAL SPACECRAFT OPERATING RANGE
1.	SOLAR ARRAY / BATTERY VOLTAGE	+10.5 TO +21V.	+11.8 TO 19.6 V
2.	PRIME CONVERTER, +50V OUTPUT	+20 TO +60V	+50.0V ± 1%
3.	BATTERY CURRENT	0 TO 500 ma	≷ 50 ma
4.	SPACECRAFT CURRENT	0 TO 4 AMP.	~2 AMP.
5.	SKIN TEMP. NO.1 (TOP OF FACET D)	-34°C TO +73°C	
6.	Rb GAS CELL TEMP.	+6°C TO +82°C	+42° ± 5°C
7.	BATTERY TEMP.	-17°C TO +87°C	+10° TO +30°C
8.	PRIME CONVERTER, +12V OUTPUT	+9.5V TO +13V.	+12V ± 1%
9.	SOLAR ARRAY CURRENT	0 TO 5 AMP.	~2 TO 4 AMP.
10.	SOLAR PADDLE (ARM #1) TEMP. (1)	-138°C TO +80°C	
11.	SKIN TEMP. NO.2 (SIDE FACET 'D')	-34°C TO +73°C	
12.	MULTI CONVERTER, +7V OUTPUT	+4.0 TO +8.5V	+7.0V ± 1%
13.	Rb LAMP TEMP. (2)	+53°C TO +148°C	+100° TO +115°C
14.	PRIME CONVERTER TEMP.	-39°C TO +79°C	+45° TO +60°C
15.	TRANSMITTER TEMP.	-38°C TO +80°C	+40° TO +55°C

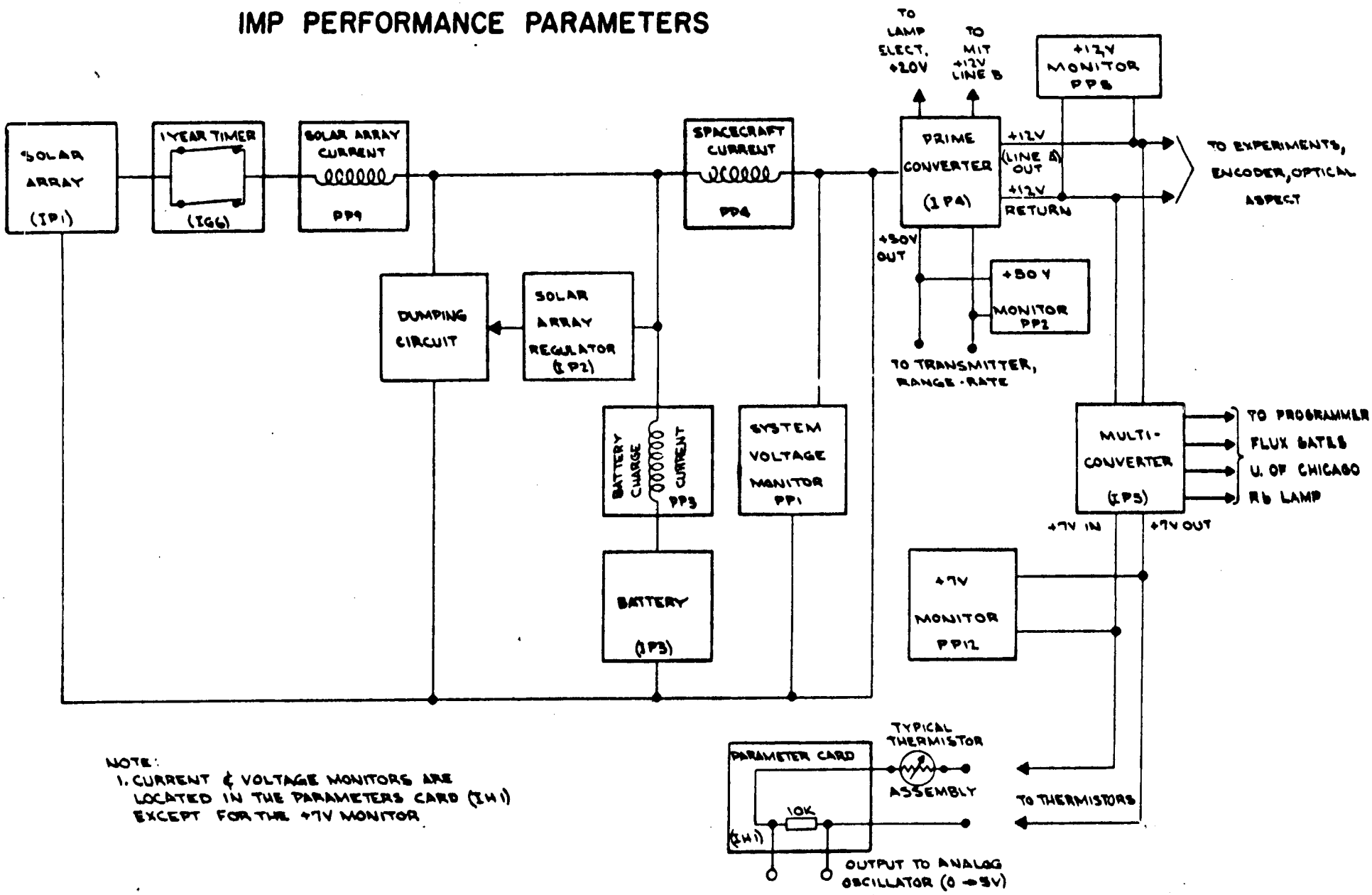
(1) ALSO INDICATES SPACECRAFT SEPARATION FROM X-258 THIRD STAGE MOTOR.

(2) ALSO INDICATES Rb MAGNETOMETER EXTENSION.

(3) DATA FROM MIT EXPERIMENT WILL CONFIRM SOLAR PADDLE NO.3 ERRECTION.

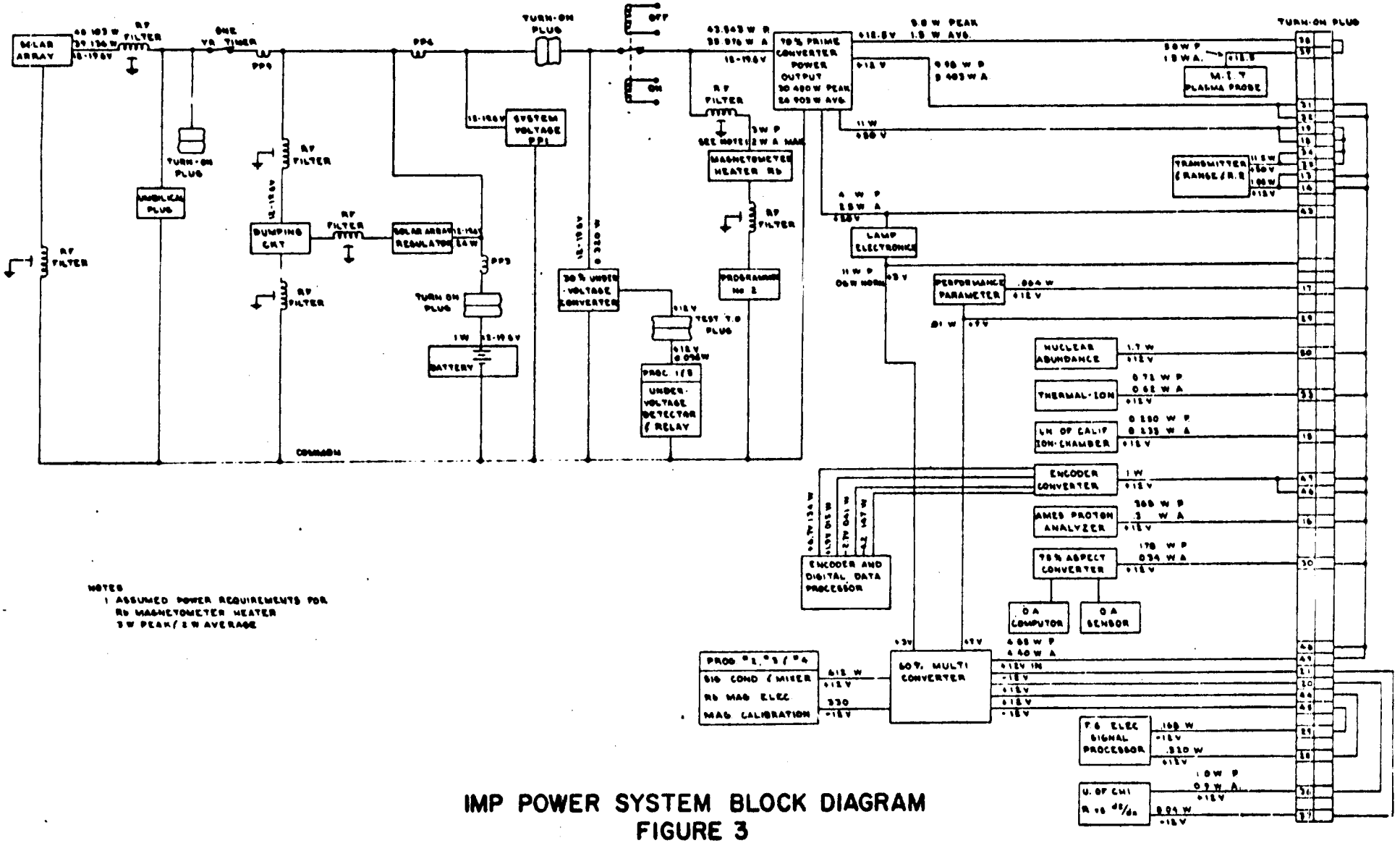
FIGURE 1

IMP PERFORMANCE PARAMETERS



NOTE:
1. CURRENT & VOLTAGE MONITORS ARE LOCATED IN THE PARAMETERS CARD (1H1) EXCEPT FOR THE +7V MONITOR

PP BLOCK DIAGRAM
FIGURE 2



NOTES
1 ASSUMED POWER REQUIREMENTS FOR Rb MAGNETOMETER HEATER 3 W PEAK / 2 W AVERAGE

IMP POWER SYSTEM BLOCK DIAGRAM
FIGURE 3

IMP THERMISTOR ASSEMBLY EXAMPLES

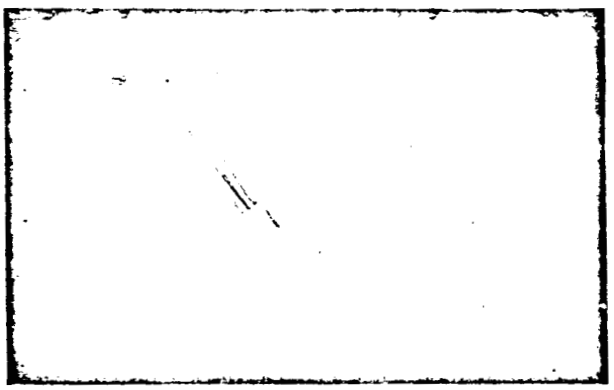


FIGURE 4a
IMP THERMISTOR ASSEMBLY-TYPE "E"
SHOWN 1/2 ACTUAL SIZE

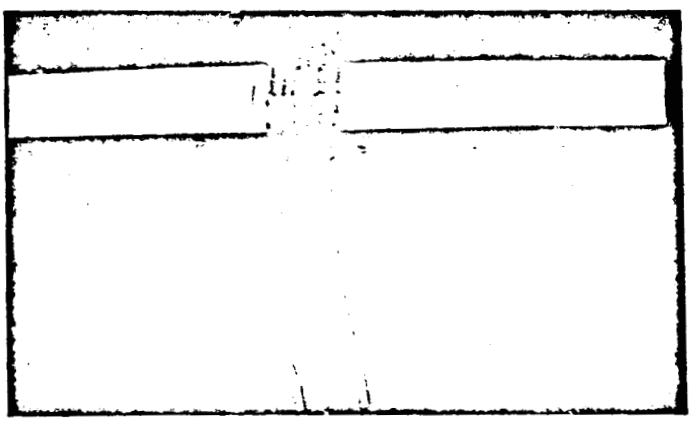


FIGURE 4b
IMP THERMISTOR ASSEMBLY-TYPE "C"
SHOWN TWICE ACTUAL SIZE

TEMPERATURE MEASUREMENT LOCATIONS
S-74 INTERPLANETARY MONITORING PLATFORM

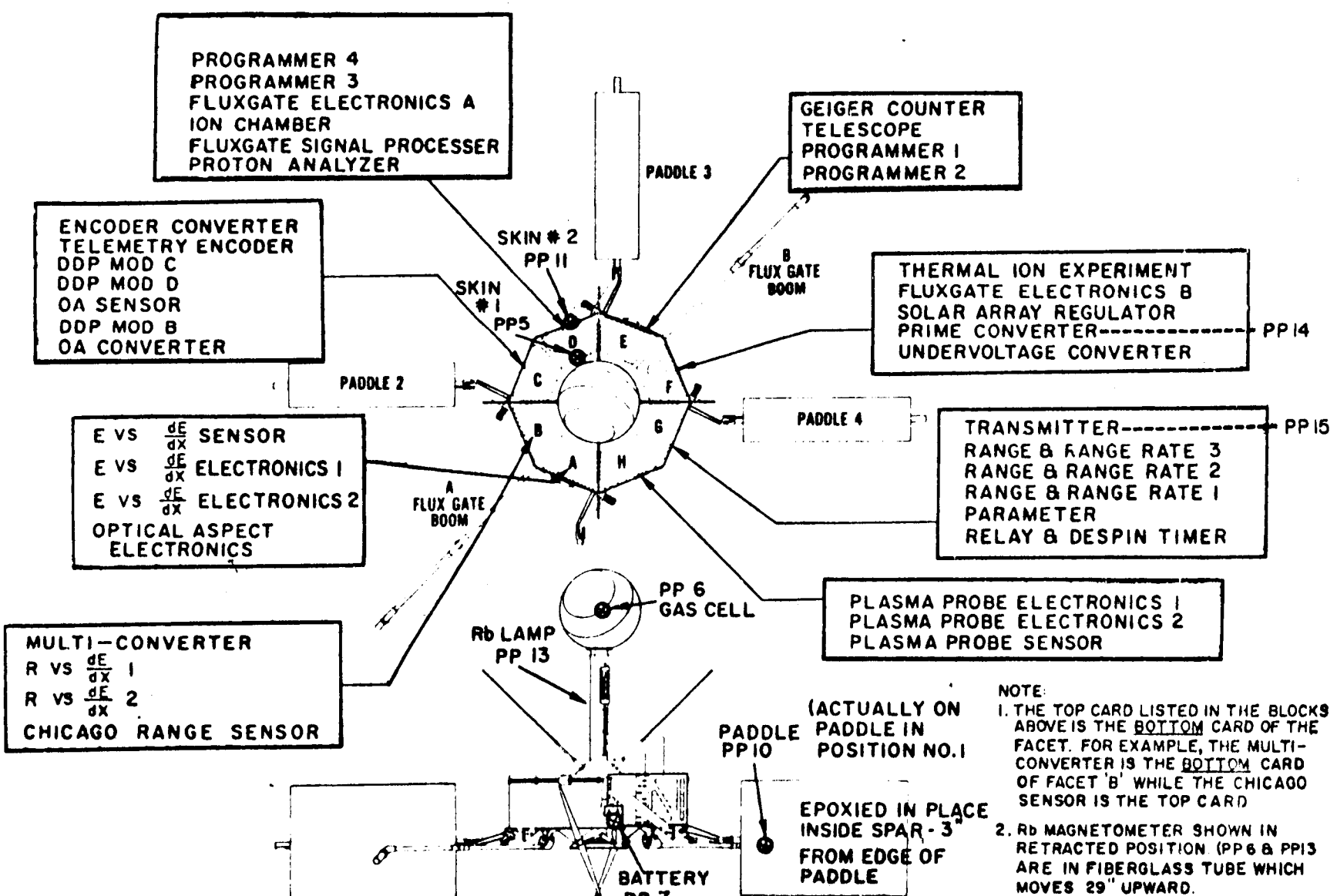


FIGURE 5a

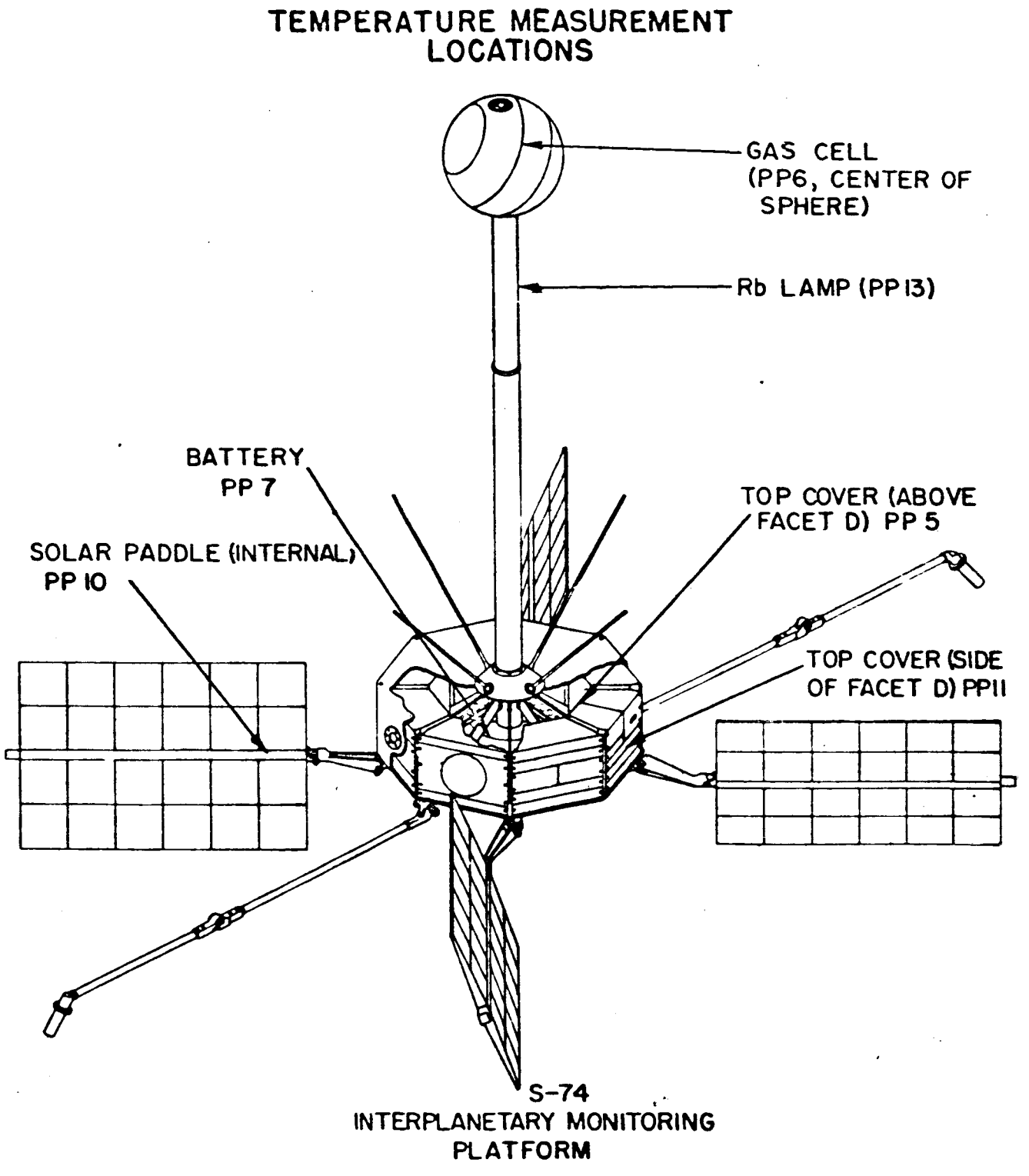
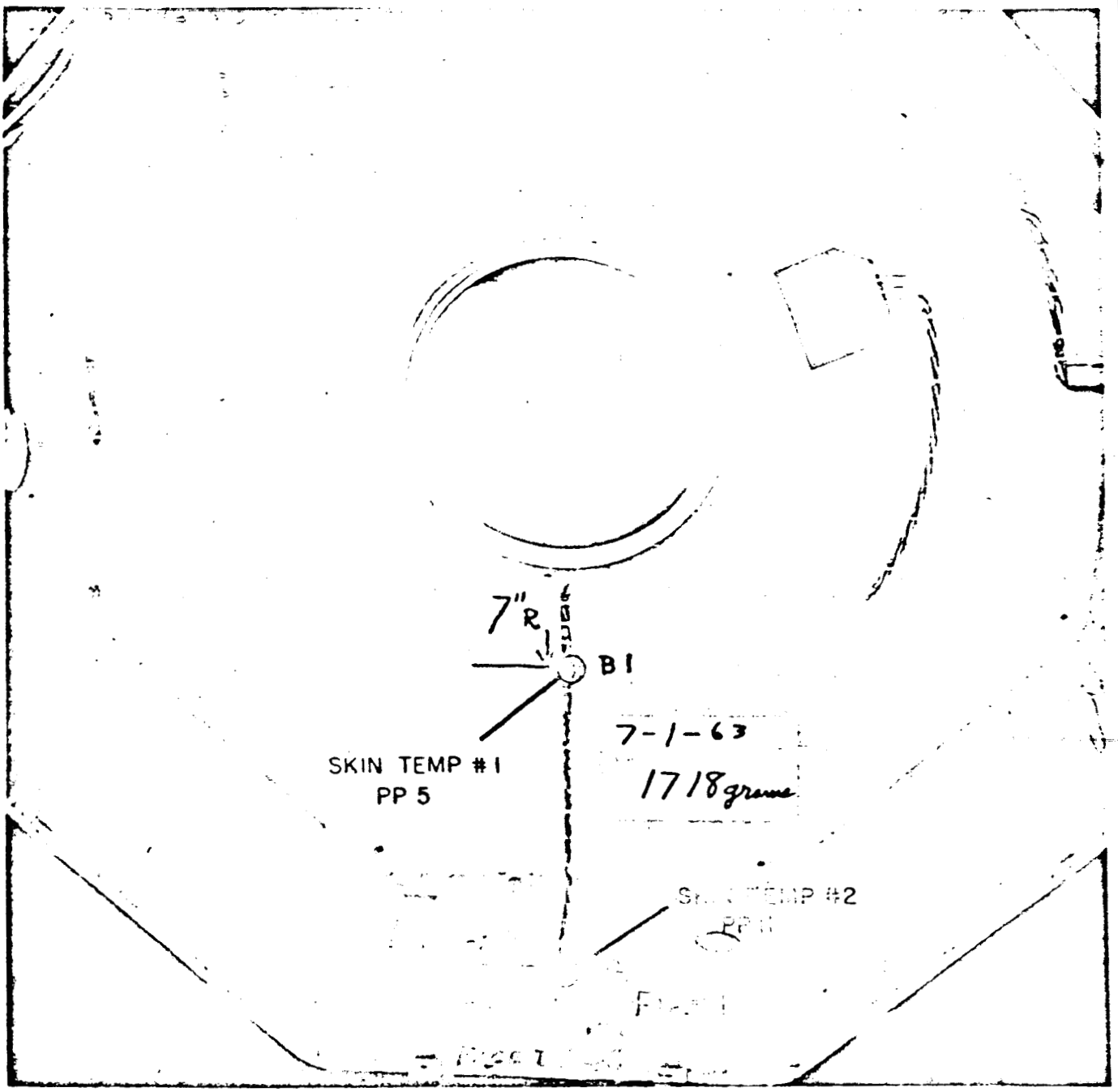

TEMPERATURE MEASUREMENT LOCATIONS
GAS CELL (PP6, CENTER OF SPHERE)
Rb LAMP (PP13)
BATTERY PP 7
TOP COVER (ABOVE FACET D) PP 5
SOLAR PADDLE (INTERNAL) PP 10
TOP COVER (SIDE OF FACET D) PP11
S-74
INTERPLANETARY MONITORING PLATFORM

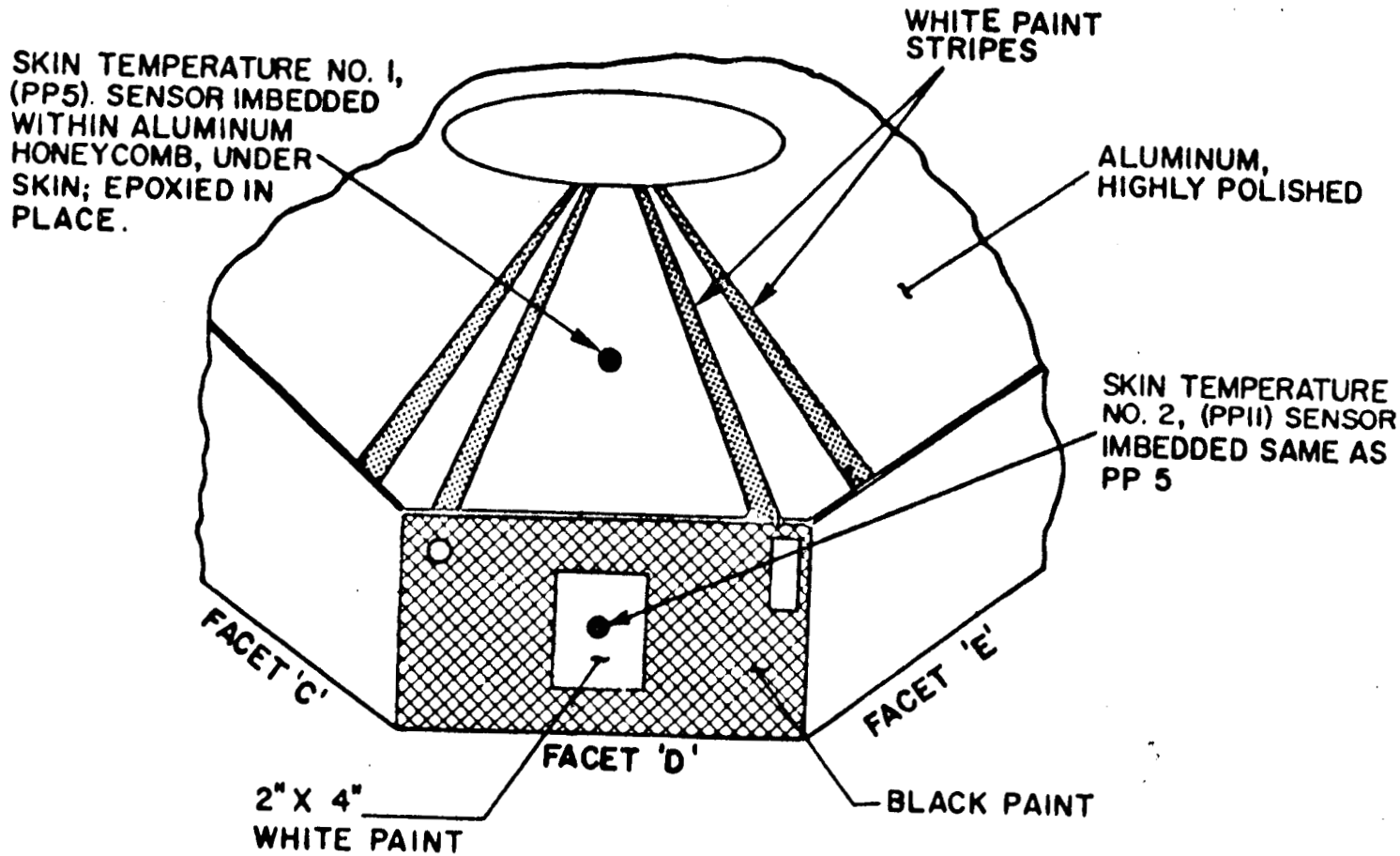
FIGURE 5B

SKIN TEMPERATURE MEASUREMENTS (PP 5 & PP11)



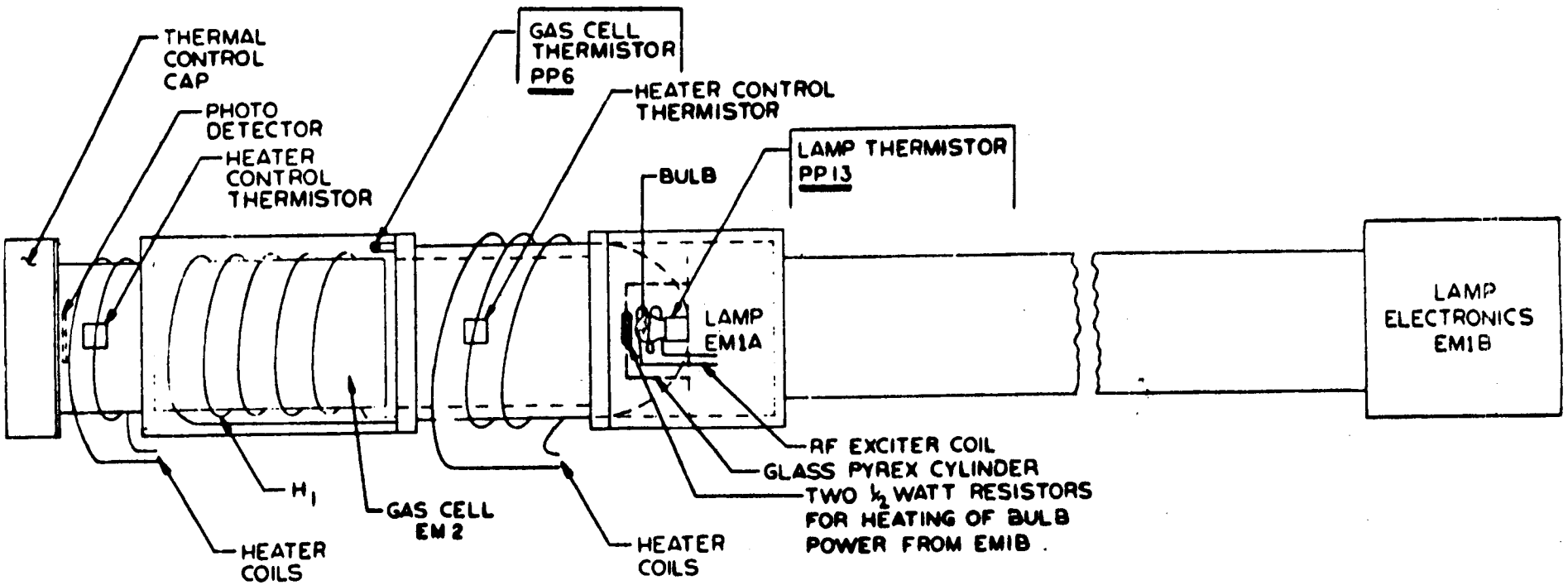
LOCATION OF SKIN TEMPERATURE SENORS – Inside view of IMP Top Cover showing thermistors (B1 & B2) epoxied in place on top and side of facet "D". Five mill Aluminum sheet added over all surfaces of inside of cover.

FIGURE 6a



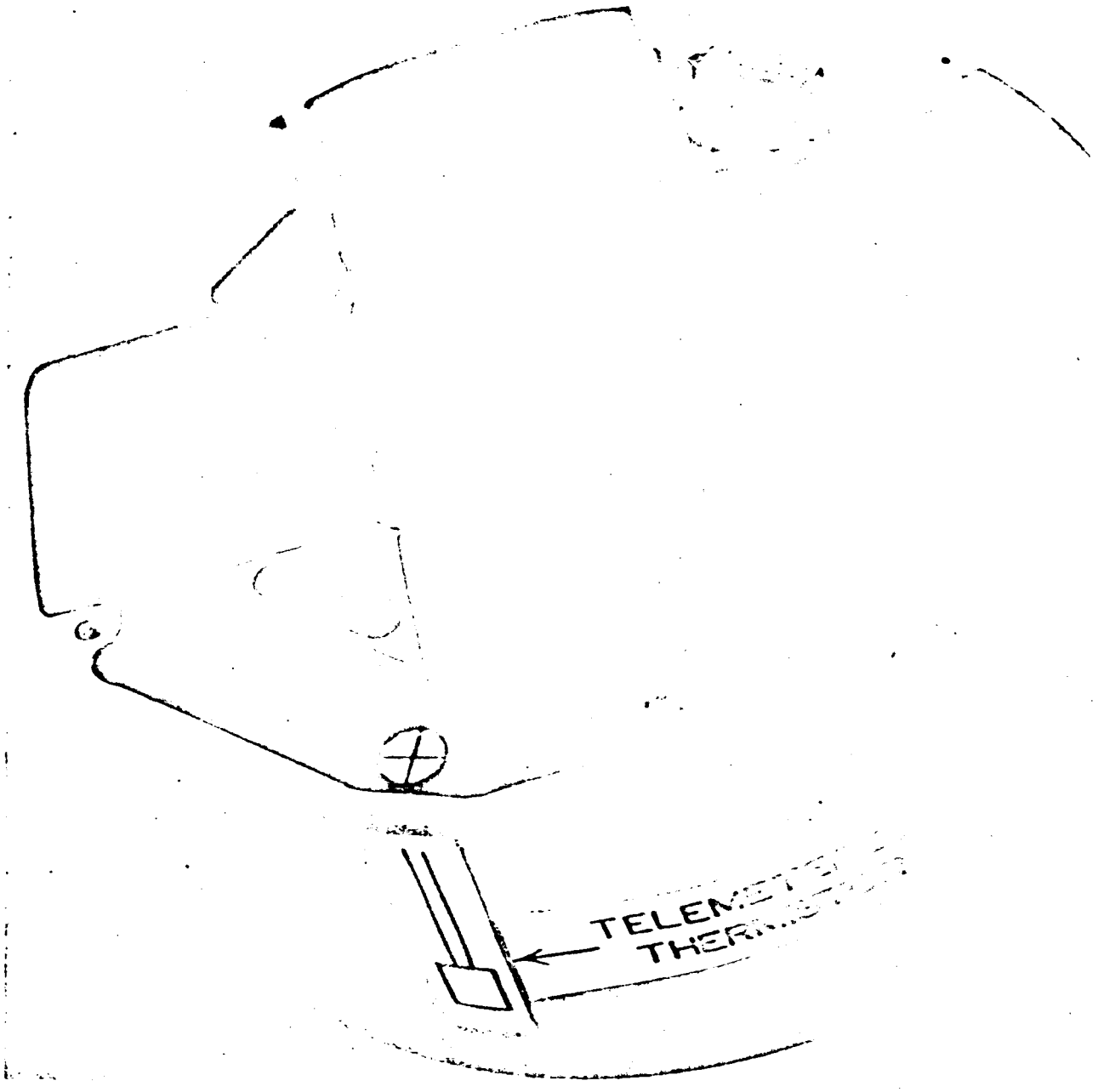
TOP COVER (EXTERNAL VIEW)
SKIN TEMPERATURE SENSOR LOCATIONS
FIGURE 6b

IMP Rb MAGNETOMETER ASSEMBIY



LOCATION OF THERMISTORS ON Rb MAGNETOMETER
(PP 6 & PP 13)
FIGURE 7

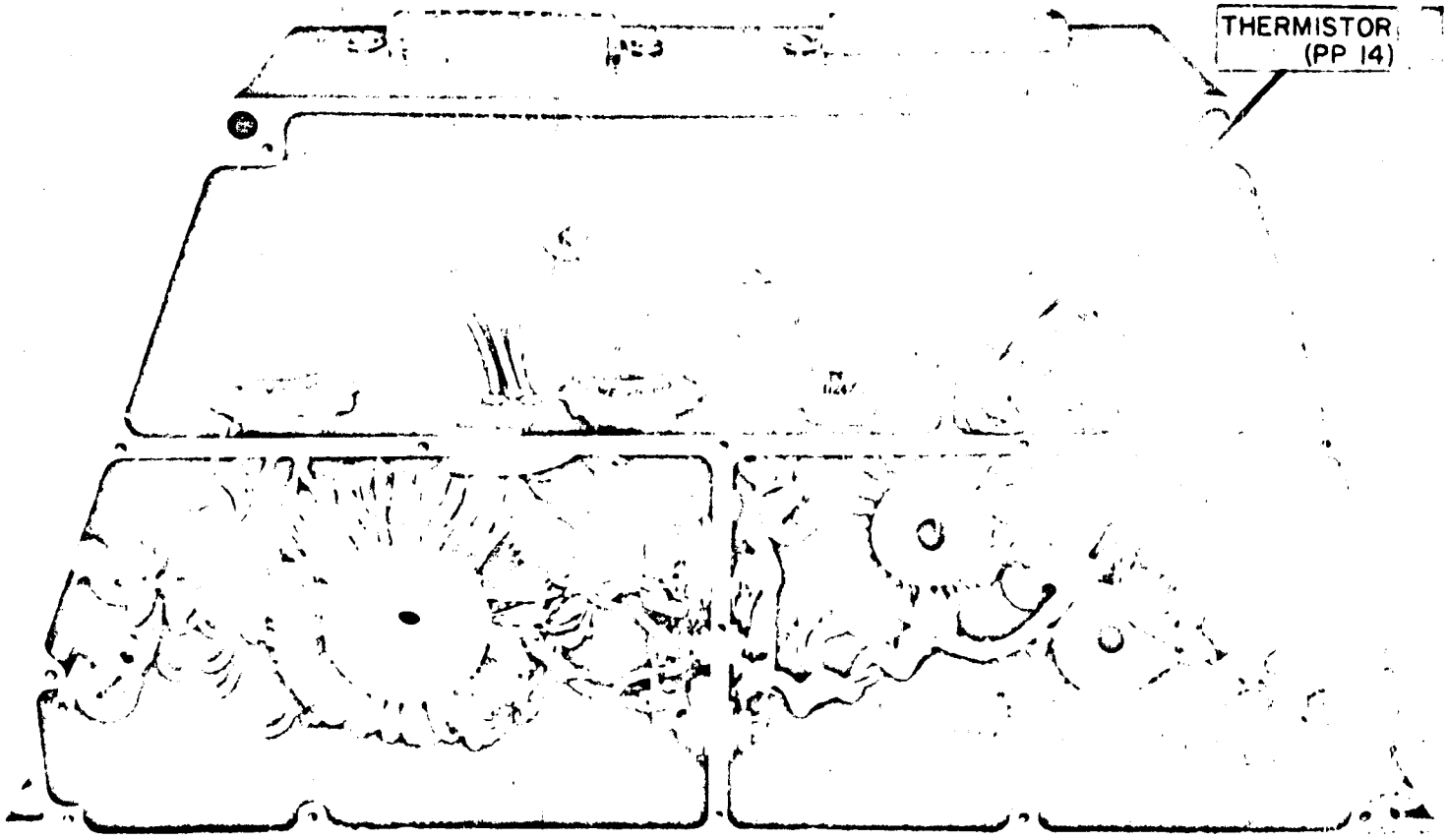
IMP SILVER CADMIUM BATTERY
(PP 7)



LOCATION OF BATTERY THERMISTOR—
THERMISTOR IS "FLOATING" IN EPON 834
EPOXY IN POSITION SHOWN

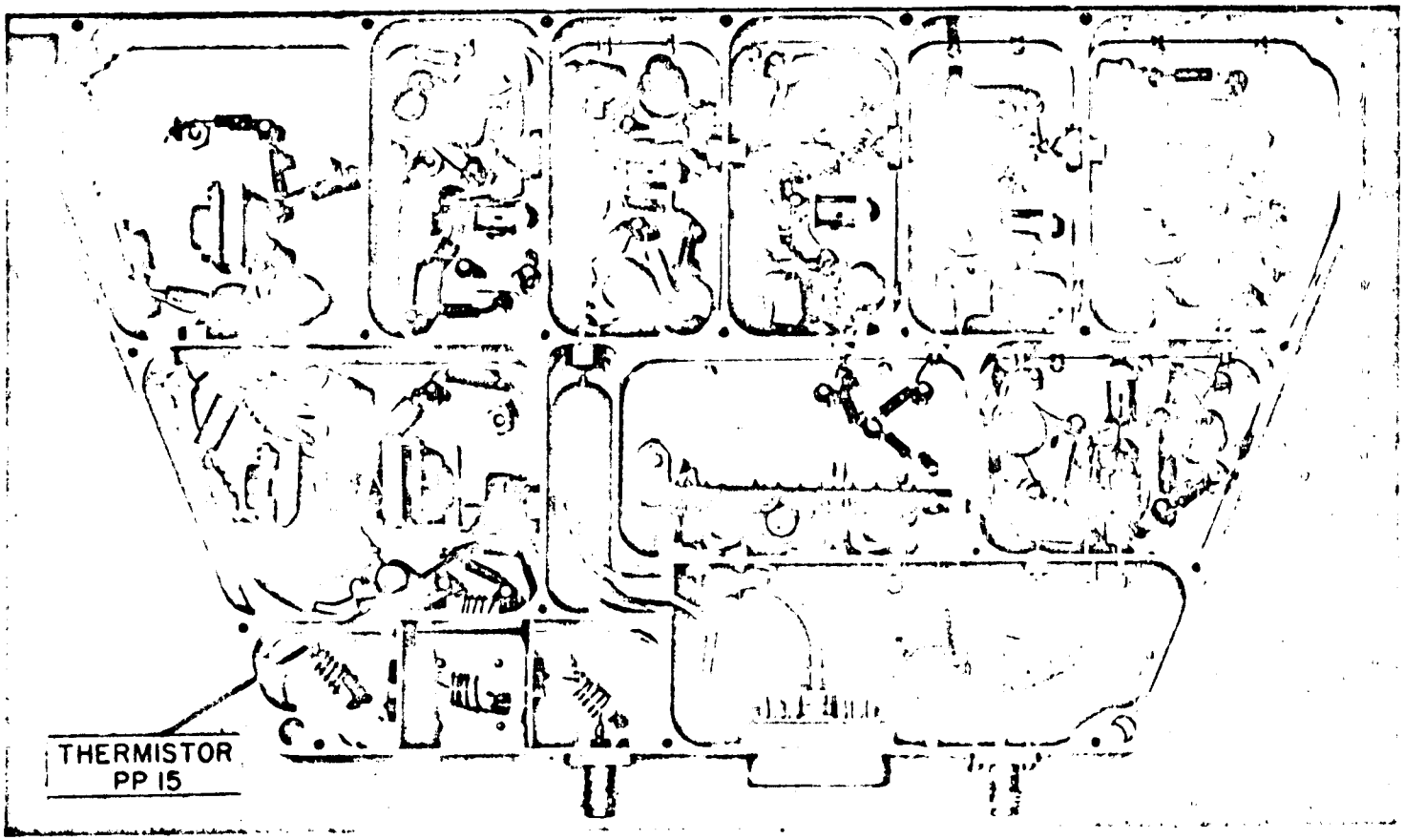
FIGURE 8

IMP PRIME CONVERTER (IP4-06)



LOCATION OF PP 14 THERMISTOR
FIGURE 9

IMP TRANSMITTER (IT7-07)



LOCATION OF PP 15 THERMISTOR
FIGURE 10