Bendix
Aerospace Systems Division

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Results of the Thermal Mapping Test on the ALSEP Power Conditioning Unit

This ATM presents the results of the Thermal Mapping Test performed on the GE PCU. The test was performed between 4/9/68 and 4/11/68.

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INTRODUCTION

Results of the Proto "A" Thermal Vacuum Test indicated that it would be beneficial to obtain more detailed information concerning internal dissipation of the PCU as a function of input and output power. Other beneficial data would include maximum temperature rise of regulator power transistor with dynamic power ranges of 33 and 55 watts.

A packaged unit was required to obtain meaningful data. The unit sent to General Electric on 1 August 1967 for use on AEC Contract AT (30-1)-3535 was made available for these tests. The unit (P/N 2330000-2, S/N 1) was returned to Bendix on 2 February 1968.

The results of a thermal mapping test are presented in this report.

Internal Dissipation

The theoretical internal dissipation of the PCU as a function of input power, output power and voltage regulator dynamic range of 55 watts is shown in Figure 1. The dissipation above the sloping line represents the regulator transistor dissipation. The sloping line represents the dissipation of the converter and all other circuits in the PCU. These other circuits include voltage regulator sensing, over-under voltage sensing, input current and voltage sensing, temperature sensing, and regulator status monitoring circuits.

The family of curves shown on Figure 1 were plotted by use of the following equation:

$$P_T = \frac{\left(P_{in} - \frac{53.6}{50} P_o - 5\right)\left(P_R + \frac{53.6}{50} P_o + 5 - P_{in}\right)}{P_R} + \frac{3.6}{50} P_o + 5$$

where:
P_T = Total PCU internal loss in watts
P_{in} = Input Power in watts
P_o = PCU Output Power in watts
P_R = $\frac{16}{15}$ x Dynamic power range of the voltage regulator (assumes the regulator transistor collector saturation voltage approaches zero when "full on")

Note that the equation is valid only when the quantities in parenthesis are greater than zero.

Figures 2 and 3 are the actual graphs of internal dissipation with a regulator dynamic range of 33 and 55 watts respectively. These regulator ranges correspond to regulator resistances of 7.37 and 4.27 ohms including .7 ohms manganin wire resistance of the harness. Note that the conversion losses differ for each power conditioner and that they are not exactly linear as assumed. The difference in losses between power conditioners is caused by differences in printed circuit resistances (lengths). The conversion losses are linear with output power of 30 watts and up.

Another significant difference between the actual and theoretical curves is that the actual regulator dissipation curves do not meet the conversion loss curves in the lower left hand corner. This gap is a result of the darlington connected transistor pair in the power circuit of the regulator. The saturation voltage of that pair is approximately 1.1 volts with the 33 watt regulator and 1.4 volts with the 55 watt regulator. This results in a gap of approximately 2.2 and 5 watts for the two regulator ranges. These saturation voltages were considered when the regulator resistors were selected. The actual dynamic range of the regulators were very close to 33 and 55 watts.

Efficiency

The conversion efficiency of the PCU as a function of output power is shown in Figure 4. The PCU efficiency is greater than 85% for output power of 35 watts and up. These curves were derived from the conversion loss lines shown in Figures 2 and 3.

Regulator Transistor Temperature Rise

The maximum temperature rise of the regulator transistors as a function of the dynamic range of the regulator is shown in Figure 5. The slope of the line is very close to one.

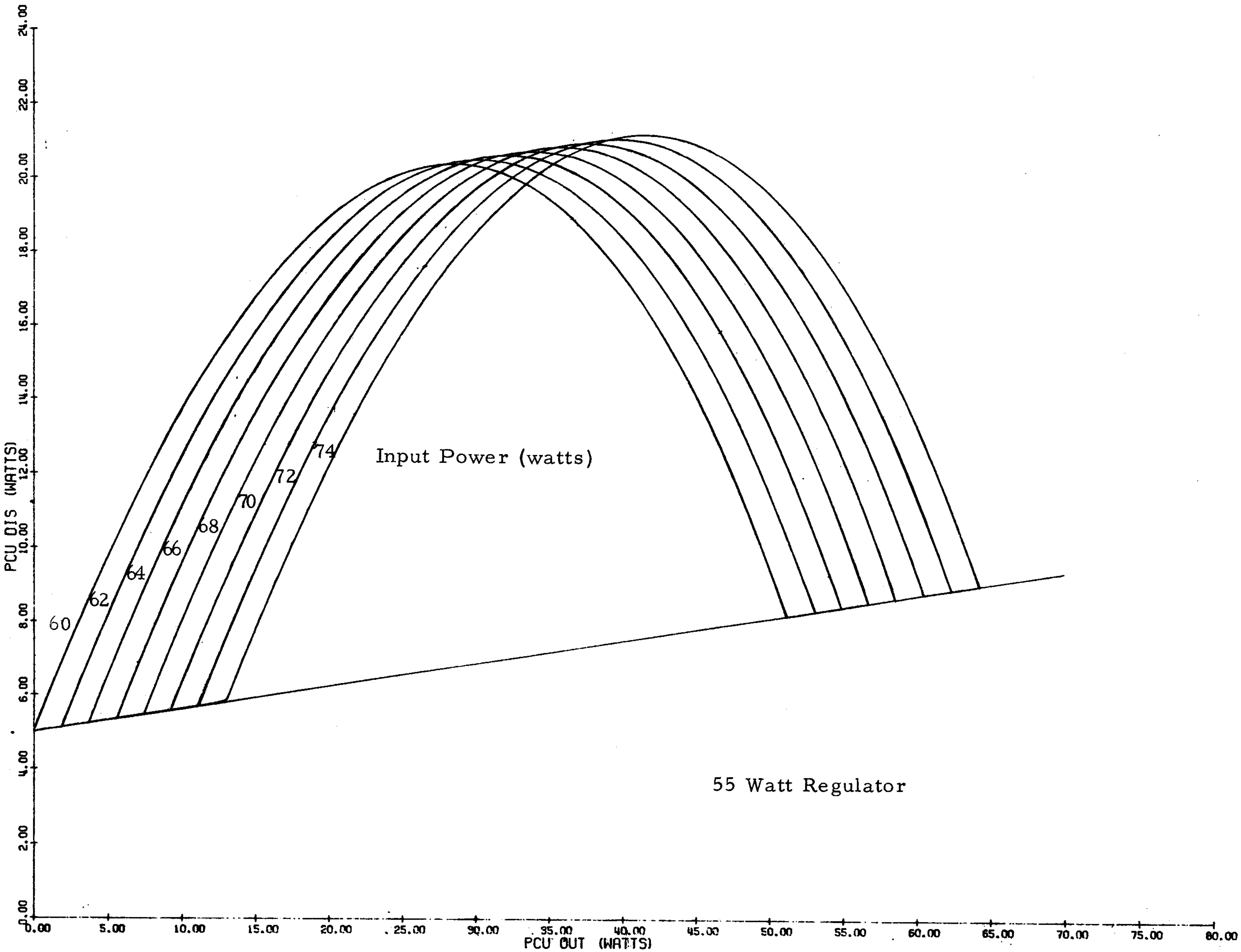
These data were obtained with the voltage regulator module unpotted, then potted. No measurable difference was observed with potted versus unpotted modules. Qual and up units have the power transistors potted in a thermally conductive epoxy compound.

Regulator Current TM Signal

The regulator current telemetry signal (input to the Data Processor) as a function of actual regulator current is shown in Figure 6 for the two regulator ranges. The curves are linear as expected.

FIGURE 1

PCU DISIPATION VS PCU OUTPUT (IN WATTS)



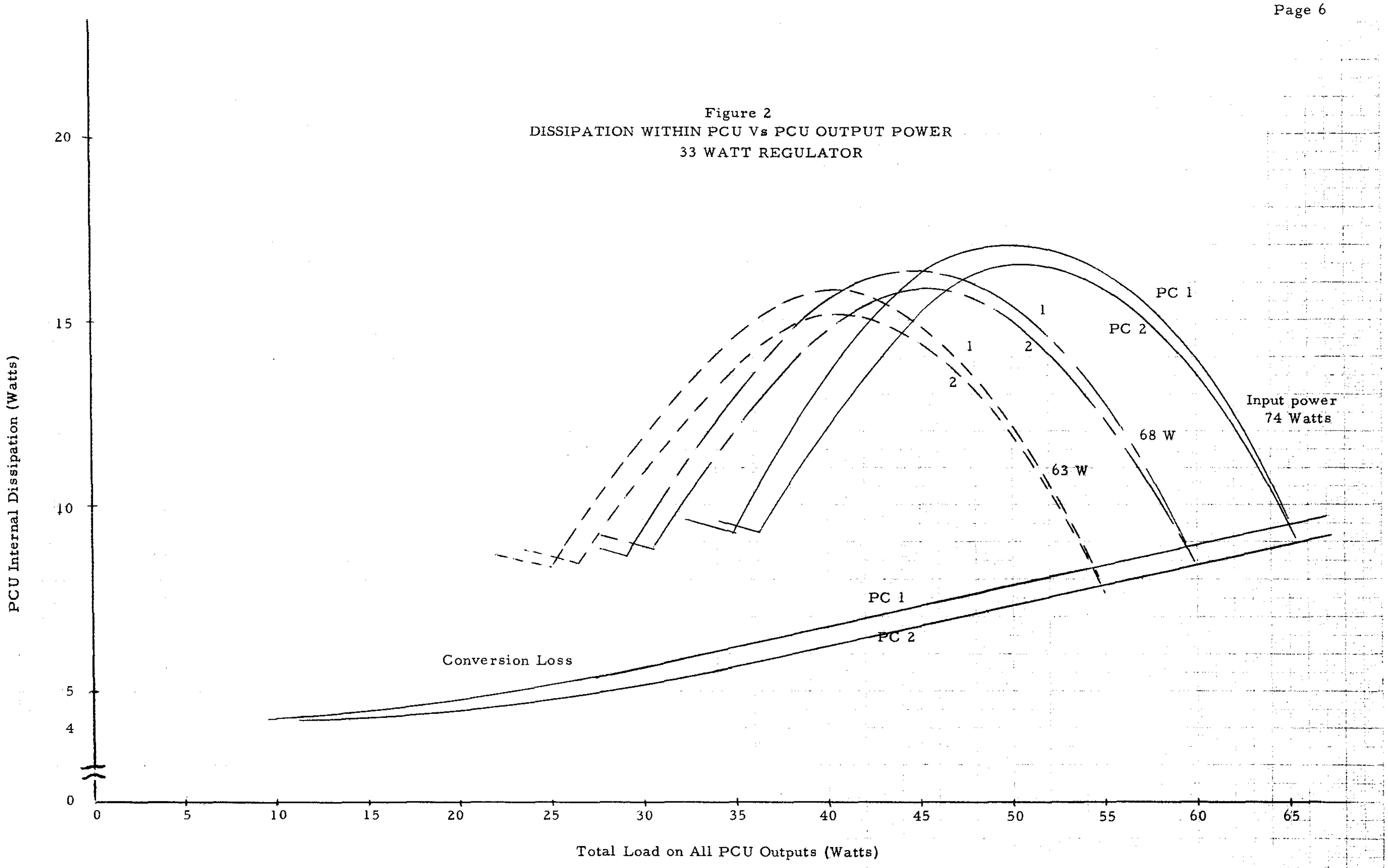
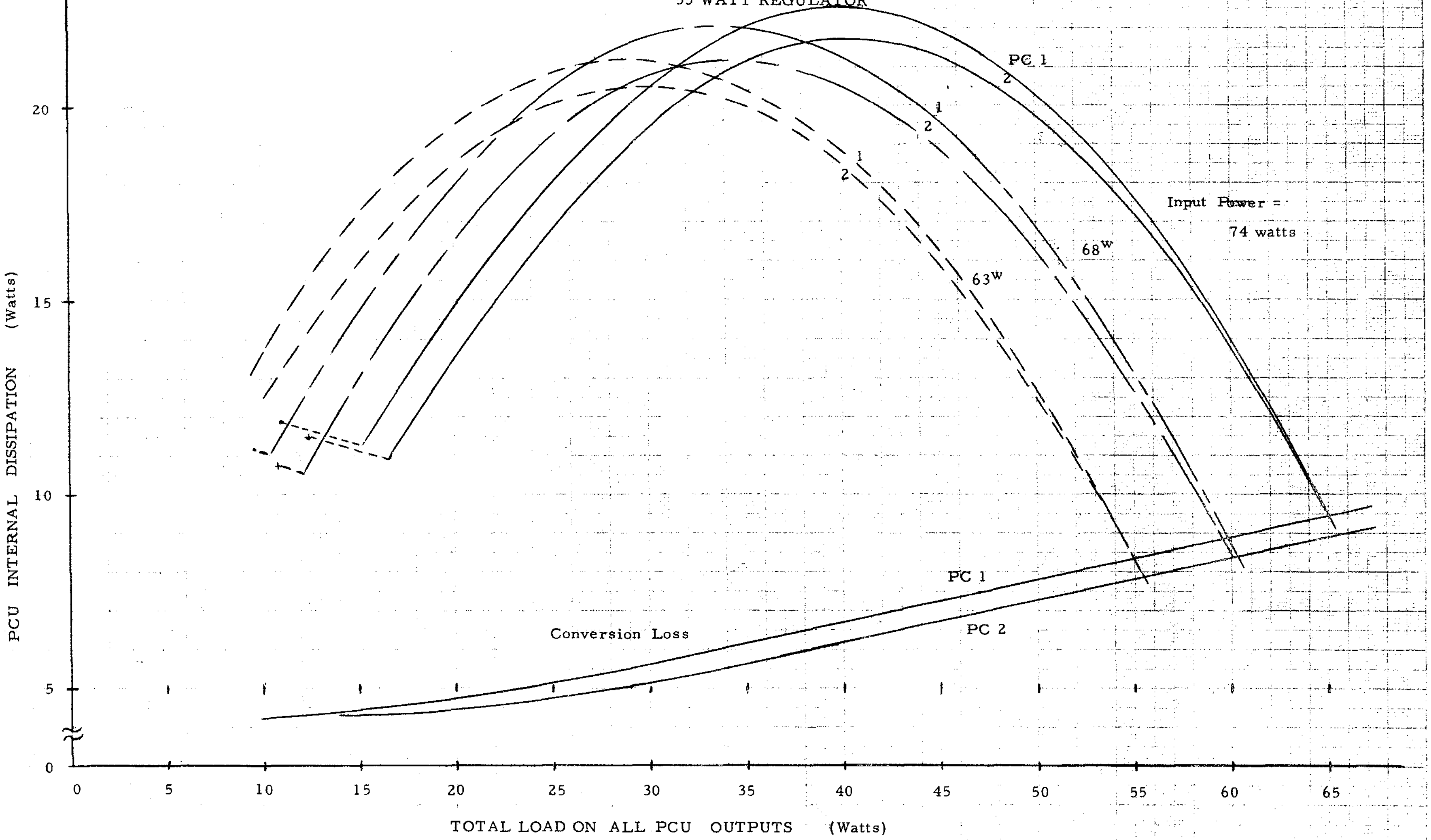


Figure 2
DISSIPATION WITHIN PCU Vs PCU OUTPUT POWER
33 WATT REGULATOR
PCU Internal Dissipation (Watts)
20
15
10
5
4
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Total Load on All PCU Outputs (Watts)
PC 1
PC 2
1
2
1
2
Input power
74 Watts
68 W
63 W
PC 1
PC 2
Conversion Loss

Figure 3

DISSIPATION WITHIN PCU vs PCU OUTPUT POWER

55 WATT REGULATOR



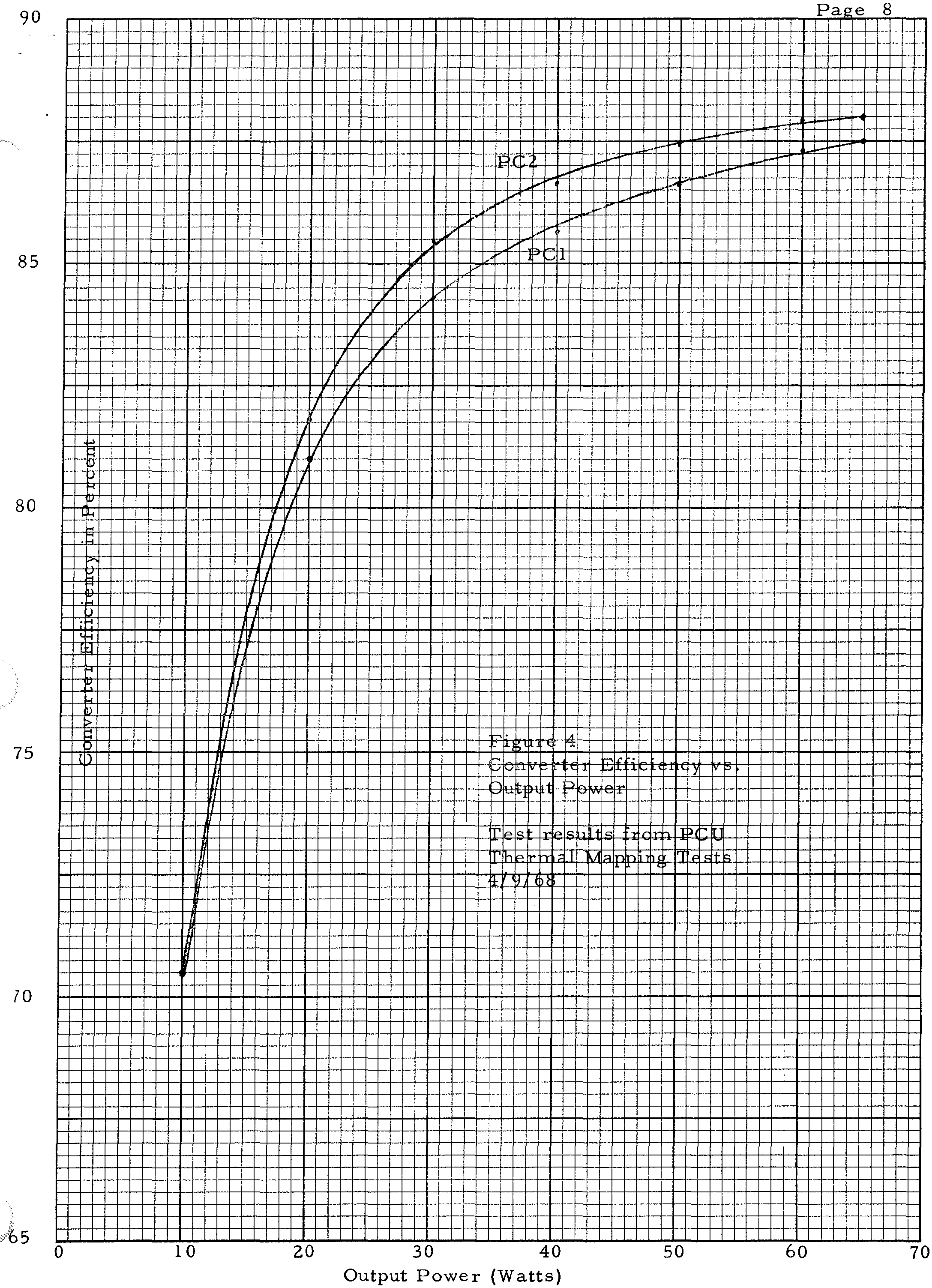


Figure 4
Converter Efficiency vs. Output Power

Test results from PCU Thermal Mapping Tests
4/9/68

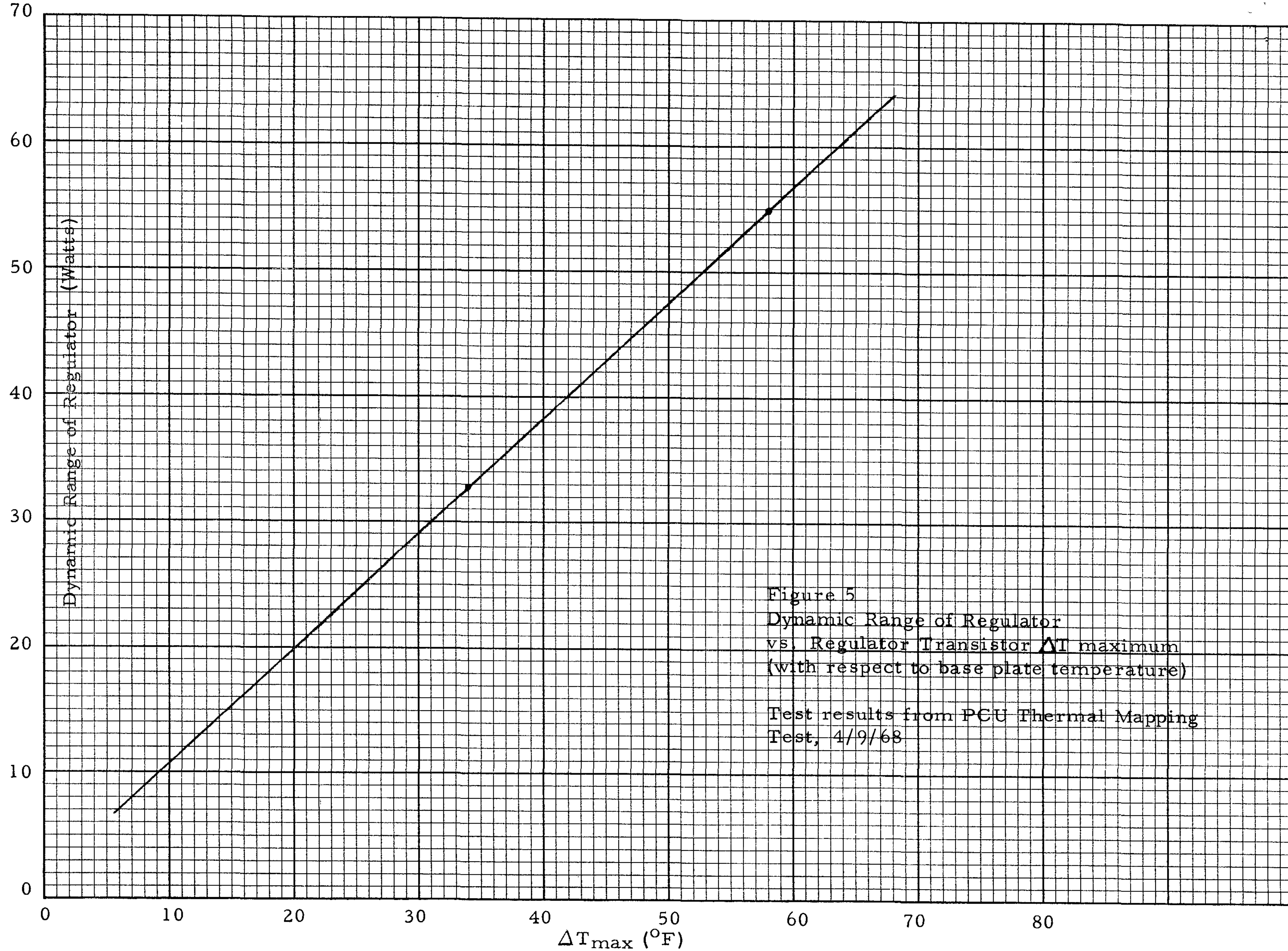


Figure 5
Dynamic Range of Regulator
vs. Regulator Transistor ΔT maximum
(with respect to base plate temperature)

Test results from PCU Thermal Mapping
Test, 4/9/68

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