AD 267 347

AIRCRAFT ARMAMENTS, Inc.
COCKEYSVILLE, MARYLAND

AIRCRAFT ARMAMENTS, Inc.

ENGINEERING PROGRESS REPORT
E41R1 POINT SOURCE GAS ALARM
Contract Number
DA-18-108-CWL-6553

for

ARMY CHEMICAL CENTER
Edgewood, Maryland

Period of 22 July 1961
Through 2 September 1961

ER-2490
REPORT NO.

September 1961
DATE

Prepared by: E. B. Tyler
E. B. Tyler - Project Engineer

Approved by: C. A. Bartenfelder
C. A. Bartenfelder - Project Manager

Copy #28

AAINC E 135A

AIRCRAFT ARMAMENTS, Inc.

TABLE OF CONTENTS

AIRCRAFT ARMAMENTS, Inc.

I. INTRODUCTION

This report describes the engineering and manufacturing efforts at AAI on the E41R1 Point Source Gas Alarm Program from 22 July 1961 to 2 September 1961 performed under Contract II DA-18-108-CWL-6553. Included herein is a summary of the CONARC testing of the alarms now in progress at Ft. Benning, Georgia and the combined effort development program with CRDL for the design and fabrication of the E41R1 alarm and associated equipment.

During this reporting period the scope of effort has been directed to the manufacture of three (3) alarms (Nos. 35-36 and 37) which will be used as replacements for the alarms which have been undergoing Service Tests at Ft. Benning; the procurement and fabrication of components and the assembly of six (6) additional alarms (Nos. 38 through 43), and the retro-fitting of the three (3) alarms from Service Test at Ft. Benning (Nos. 14-21 and 26).

The manufacture and retro-fitting of the operational alarms has been based on a design which has incorporated the recommended (with subsequent approval) changes as determined by Final Engineering Test Division, CRDL, Research and Development Testing at AAI, and Service Tests at Ft. Benning, Georgia. In addition, based on this design, the procurement and fabrication of components for fifteen (15) additional alarms is in progress. One (1) Master alarm will be manufactured from the final Class I drawings (as approved by CRDL).

II. SUMMARY OF WORK PERFORMED

The Research, Development, Test and Evaluation of the E41R1 Point Source Gas Alarm has progressed as scheduled in accordance with a test plan promulgated by AAI. This program has been directed toward the improvement of alarm performance and reliability and has included continued efforts in the following areas.

a. Testing of original and experimental design in air pumps

b. Investigation of improved alarm horn performance and reliability

c. Continued efforts to improve the sensitivity and stability of the photometer including the inherent problems associated with the photocell.

d. Investigation of engineering feasibility consideration in a redesign of a remote warning unit.

e. Investigation of condensation (air lines).

With the exception of the spares for the Ft. Benning alarms, all contractual commitments of the Phase II program have been completed.

Delivery of Phase III units has begun and to date all aspects are on schedule.

III. DETAILED DISCUSSION OF PROGRAM

A. Phase II Program

During this report period the following actions were completed.

a. Alarm Nos. 17-19 and 22 were refurbished, tested and delivered.

b. Alarm Nos. 35-36 and 37 were assembled, tested and delivered.

c. The Class II tracings (which represent the 15 alarms to be delivered under Phase III, were loaned to CRDL. After making the copies they required, CRDL returned the tracings to AAI.

With the completion of the above listed items all contractual commitments for Phase II have been completed with the exception of the spare parts for the Ft. Benning alarms which are scheduled for delivery.

B. Phase III Program

The preparation of the final Phase III Class I drawings is progressing with a present completion factor of approximately 50 percent and an anticipated completion date of 1 October 1961 (on schedule). These drawings represent a design which has incorporated the recommended (and approved) changes as determined by Final Engineering Test Division, CRDL; Research and Development Testing at AAI; and Service Tests at Ft. Benning.

The procurement of material, fabrication of parts and assembly of six (6) 1 August 1961 delivery and fifteen (15) 1 December 1961 delivery Phase III alarms is progressing satisfactorily. These alarms are in accordance with AAI drawing 3862-040299-10. A detailed discussion of delivery and schedules for these units is contained in the following section.

C. Fabrication, Testing and Delivery

Under the scope of the existing contract, three (3) alarms (Nos. 35-36 and 37) were delivered approximately 1 August 1961 to CRDL and were subsequently shipped to Ft. Benning for Service Tests. Shortly after the start of these tests, technical difficulties were encountered; therefore, the tests were suspended and the three (3) alarms returned to AAI to determine and correct these difficulties. At approximately the same time three (3) previous alarms (Nos. 14-21 and 26) were also returned to AAI for retro-fitting so that six (6) alarms could be returned to Ft. Benning for resumption of the Service Tests.

In order to accomplish this retro-fitting program and since it was not specifically covered under the existing contract, it was agreed by CRDL technical personnel that AAI would cannibalize parts from three (3) of the first six (6) units required as the first delivery in Phase III which were due on 1 September 1961. It was further agreed that AAI would then cannibalize parts from three (3) of the fifteen (15) units under Phase III required for delivery by 15 December 1961 in order to complete the six (6) units required as the first delivery in Phase III.

This change has necessitated a revision in schedule in that delivery of six (6) units under Phase III originally scheduled for 1 September 1961 be modified to deliver three (3) units on 8 September 1961 and three (3) units on 1 October 1961. As a result, three (3) of the fifteen (15) Phase III units scheduled for delivery on 15 December 1961 will be short parts will not be delivered. However, this matter has been discussed with the CRDL Project Manager and it has been tentatively agreed that if the parts utilized in the retro-fit are useable and made available at a later date, they will be used to complete the delivery of the fifteen (15) Phase III units. Otherwise, authorization will be required to fabricate the additional parts required.

When initially delivered to Ft. Benning, units Nos. 14-21 and 26 were standard Phase II alarms. However, by the aforementioned retro-fit, the transport assembly has been removed and replaced by new, redesigned assemblies.

In the previous reporting period, alarms Nos. 17-19 and 22 were refurbished and delivered to CRDL for test purposes. These were originally standard Phase II units which were refurbished to include the latest improvement changes which are outlined below for purposes of clarity.

a. Existing air motor replaced with new (identical) motor

* b. Low torque timer motor replaced with high torque motor

* c. Low torque transport motor replaced with high torque motor

d. Transport mechanisms overhauled

* e. Air inlet heater replaced with new redesigned assembly

* f. Exit air heater replaced with new redesigned assembly

g. All tubing replaced

* h. New photometer head installed with new type thermister

i. Printed Circuit Board modified as follows:

(1) R34 from 24V to 18V regulated (inlet heater control)

(2) Heat sink in Q5 removed - not replaced

(3) R28 changed to 180 Ω

(4) R27, R29 and K1 to 18V regulated (flasher)

(5) Removed CR4, CR5 and CR8

(6) Low voltage cutoff:

(a) R31 changed to 390 Ω, 1/2 watt ± 5%

(b) R23 changed to 2K Ω

(c) CR11 changed to IN748A

(d) Diode type IN457 added in series with CR11

(e) Ground K3

* j. Added K5 relay for transport motor control

* k. Paralleled S1 and S2 for transport motor control

* l. Replaced prefilter lever support with aluminum part

* m. Replaced gaskets with new types

* n. Replaced nylatron fluid pump bearings with stainless steel ball bearings

o. Replaced all switches

* p. Replaced drum latch with new design

* q. Replaced drum spring with new design

* r. Added fluid nozzle return spring

* s. Replaced 'phone jack with new design

* t. Added "D" rings

* u. Added fluid pot guide

* v. Replaced primer knob seal with new design

* w. Replaced null knob with new design

x. Replaced wire harness

* y. Waterproofed printed circuit board

* z. Added RFI suppressors

aa. Added baro switch

bb. Replaced decals

* cc. Added detent to air inlet

* dd. Added instruction plate

* ee. Waterproofed alarm

* ff. Replaced thermostats with new type

gg. Encapsulated horn (can)

* hh. Added bar to fluid pot holder

* ii. Replaced alarm handle with redesigned part

* jj. Replaced fluid pot gasket with new design

Alarms Nos. 35-36 and 37 were standard Phase III alarms which have incorporated the above asterisked changes (*) in addition to the following changes at the time of initial delivery to Ft. Benning.

a. New horn, diaphragm and can

b. New, redesigned transport mechanism assembly

c. New machined photometer head with new thermister

d. Eliminated front cover interlock striker plate

e. Increased drum needle length

f. Added spacers to air pump body

g. Removed primer detent

h. Improved surface quality of fluid pump pulleys

i. Replaced all dust covers and chains with redesigned units

j. Improved stand-off mounting technique

k. Interchanged null knob and reset switch

l. Interchanged power and remote alarm receptacle

m. Modified nomenclature

n. Improved case design

o. Replaced exit heater cap with new design

p. Replaced pre-filter lever with new design

q. Modified air pump bracket

r. Added null pot stop

When units Nos. 35-36 and 37 were returned to AAI for corrective action the following changes were made prior to returning to Ft. Benning.

a. R12 -5K, 1 watt changed to 5K, 5 watt

b. Increased depth of pre-filter holder

c. Increased length of drum needles

d. Added printed circuit board splash guard

e. Added glyptol to C1 on printed circuit board

f. Removed alarm light from flasher circuit

g. Removed the following RFI suppressors

(1) Timing motor capacitor

(2) Transport motor capacitor

(3) K1 contact capacitor

(4) Horn suppressors

(5) Air pump filter assembly

Testing was completed on alarms Nos. 35-36 and 37 with a total time logged of 163, 153 and 142 hours respectively. Each alarm completed each test satisfactorily with no major discrepancies. The test plan followed is the one reported in AAI ER-2473 of August 1961.

Testing of the first three (3) Phase III alarms (Nos. 38-39 and 40) is underway. The only major discrepancy noted to date has been with tape #60-74. There have been several instances where the tape has been approximately 1/16 too wide which has resulted in malfunction of several variations that are discussed elsewhere in this report.

The test description for units Nos. 38-39 and 40 is as follows:

Test No.	Date	Time	Description
A	8/24	00:00-12:00	Break-in Run - Detail Alarm Inspection, Checkout and Adjustment
A		12:00-24:00	Break-in Run
A	8/25	00:00-12:00	Change Motors and Check Switch Adjustments
1		12:00-24:00	Debugging: Vary Temp every 3 hours (Room, +115°F, Room, -40°F). During each 3 hour period, vary Voltages (21, 24, 28V) hourly. Record all data required by Electrical and Mechanical Check Lists
2	8/28	08:00-20:00	*Bench Test: Room Temp with Battery
3		20:00-08:00	*Oven Test: +115 F with Battery
4	8/29	08:00-20:00	Bench Test: Room Temp, vary Voltage in 2 hour steps from 21 to 28 Volts
5		20:00-08:00	*Oven Test: +115°F, vary Voltage in 2 hour steps from 21 to 28 Volts
6	8/30	08:00-20:00	*Outdoor Test: Operate in Direct Sunlight with Batteries
7		20:00-08:00	*Outdoor Test: Operate in Unprotected Area with Batteries
8	8/31	08:00-20:00	*Cold Test: -40°F with Batteries (Alarm Operating when Placed in Box)
9		20:00-08:00	*Cold Test: -40°F with Batteries - Cold Soak for 2 hours in Chamber without Power, Solution Pot Removed and Covers Open; then Start Operation
	9/1	08:00-20:00 20:00-08:00	Alarm Check and Pressure Test

* During Tests so symbolled, Temperatures were monitored at the following locations:

- Top Panel Skin
- Front Door Skin (Center)
- Rear Door Skin (Center)
- Adjacent to Liquid Nozzle (Air Temp)
- Adjacent to Manual Priming Knob (Air Temp)
- Adjacent to P.C.B. @ Center (Air Temp)
- Adjacent to Air Pump (Air Temp)

D. Research and Development Program

1. Air Pump Assembly

In accordance with the coordinated AAI/CRDL test plan, bench testing of two types of air pumps has continued. A detailed description of the two air pumps and the test procedure being followed is contained in paragraph C.1 of AAI ER-2473.

As of the end of this reporting period the standard pump has been operated 1326 hours (1312 hours on the air motor) and the experimental configuration has been operated 1136 hours (1116 hours on the air motor). There has been no significant difference in the accumulation of deposits.

STANDARD PUMP

PART	Original	500 hrs w/Filters	800 hrs w/o Filters	Change	Percent
Diaphragm	1.0161	1.0171	1.0226	.0065	.006
Inlet Fitting	1.0131	1.0180	1.0238	.0097	.009
Exhaust Fitting	1.2940	1.2979	1.3201	0.0261	.020
Inlet Valve	0.1679	0.1678	.1712	.0033	.019
Exhaust Valve	0.1684	0.1699	.1747	.0063	.037

EXPERIMENTAL PUMP

PART	Original	500 hrs w/Filters	800 hrs w/o Filters	Change	Percent
Diaphragm	1.0279	1.0282	1.0301	.0022	.002
Inlet Fitting	0.9522	0.9519	0.9575	.0053	.004
Exhaust Fitting	0.6917	0.6902	0.7001	.0084	.012
Inlet Valve	0.1646	0.1662	0.1668	.0022	.013
Exhaust Valve	0.1667	0.1667	0.1678	.0011	.006

2. Motors

a. Transport and Timing Motors

The practice of testing all transport and timing motors as they are received at AAI has continued. This testing consists of placing the motors on a test jig and running them at 18V under a load of 60 in/oz for two hours and at 18V under a load of 80 in/oz for fifteen minutes. During the test, measurements are made of the input current and cycle time on a measured time basis. Figures 1 and 2 are the results of the latest tests.

b. Air Pump Motor

In general, the air pump motors have performed very well and have fulfilled the requirements of 1000 hours minimum operating time. There have been occasions, however, in recent months wherein motor failures have occurred after approximately 100 hours of operation. Several units have been returned to Globe Industries, Inc., fabricators of the motor, who have disassembled and inspected these samples. Their report indicates that the grease in the gearbox displayed evidence that it had broken down due to what appeared to be high temperature operation. There was also evidence that the grease fill may not have been adequate for this motor application.

Globe has since reassembled the motors with a larger quantity of Aeroshell No. 7 grease and another sample with Unitemp No. 500 grease. These two motors are now undergoing life testing and to date have accumulated more than 350 hours of operation without any sign of failure.

Motor Test Haydon 2 rpm

C - Current in milliamperes
CT - Cycle time in minutes

	Time	#2 C	#2 CT	#3 C	#3 CT	#4 C	#4 CT	#5 C	#5 CT	#6 C	#6 CT	#7 C	#7 CT
60 in/oz	0	16	.68	18	.76	15	.68	14	.67	19	.75	18	.69
	0+30	18	.68	15	.64	15	.68	13	.66	18	.74	17	.67
	0+60	19	.66	15	.64	13	.64	16	.66	19	.76	16	.67
	0+90	17	.67	15	.64	13	.64	13	.66	18	.77	17	.67
	0+120	17	.67	15	.62	13	.64	13	.66	18	.77	17	.67
80 in/oz	0	19	.75	18	.72	17	.75	18	.75	21	.80	19	.74
	0+15	18	.76	17.5	.72	17	.73	17	.75	20	.80	18	.75

	Time	#8 C	#8 CT	#9 C	#9 CT	#10 C	#10 CT	#11 C	#11 CT	#12 C	#12 CT	#13 C	#13 CT
60 in/oz	0	13	.72	14	.73	14	.69	18	.57	15	.69	14	.68
	0+30	15	.72	15	.73	15	.70	16.5	.60	14	.69	14	.68
	0+60	14	.70	13	.75	15	.70	16.5	.61	14	.70	15	.68
	0+90	13	.71	15	.74	15	.71	16	.60	15.5	.72	14	.68
	0+120	14	.71	15	.72	14	.68	16	.60	16	.71	14	.67
80 in/oz	0	16	.76	12	.69	20	.80	21	.78	18	.72	17	.75
	0+15	15	.75	13	.70	17	.77	18.5	.66	17.5	.72	17	.73

	Time	#14 C	#14 CT	#15 C	#15 CT	#16 C	#16 CT	#17 C	#17 CT	#18 C	#18 CT	#19 C	#19 CT
60 in/oz	0	14.5	.72	18	.80	15	.69	17	68.5	14	.71	16	.68
	0+30	14	.72	15	.79	15	.69	16	.67	18	.74	15	.68
	0+60	14	.72	15	.79	14	.69	16	.66	18	.75	15	.70
	0+90	14.5	.72	15	.79	14	.69	15.5	.66	18	.74	15	.71
	0+120	14	.71	15	.79	14.5	.70	16	.66	17.5	.75	15	.69
80 in/oz	0	15.5	.73	15.5	.76	15	.64	16	.73	14	.72	15	.70
	0+15	15	.72	14	.73	13	.64	15	.67	15	.70	15	.68

Note: Serial #1 issued for installation in Unit #38

Figure 1.

Motor Test Haydon 1/3 rpm

C - Current in milliamperes
CT - Cycle time in minutes

	Time	#1 C	#1 CT	#2 C	#2 CT	#3 C	#3 CT	#4 C	#4 CT	#5 C	#5 CT	#6 C	#6 CT
60 in/oz	0	9.0	3.05	9.0	3.01	7.0	3.20	8.0	3.11	8.0	.12	8.5	3.10
	0+30	9.0	3.05	9.0	3.01	7.0	3.20	8.0	3.11	8.0	.12	8.5	3.10
	0+60	8.5	3.01	8.5	2.97	6.0	3.19	7.5	3.10	8.0	.12	9.0	3.11
	0+90	8.5	3.03	8.0	2.97	6.0	3.19	8.0	3.11	8.0	.12	8.5	3.10
	0+120	8.0	3.03	8.0	2.98	6.0	3.20	8.0	3.11	8.0	.12	8.5	3.09
80 in/oz	0	8.0	3.11	9.0	3.02	7.5	3.20	10.0	3.20	9.5	.13	9.0	3.10
	0+15	8.0	3.11	9.0	3.02	7.5	3.19	10.0	3.23	9.0	.12	9.0	3.10

	Time	#7 C	#7 CT	#8 C	#8 CT	#9 C	#9 CT	#10 C	#10 CT	#11 C	#11 CT	#12 C	#12 CT
60 in/oz	0	9.2	3.07	9.0	3.03	9.5	3.00	8.0	3.03	9.9	3.07	9.0	3.00
	0+30	8.0	3.00	8.0	3.03	9.5	3.01	8.6	3.03	7.6	2.93	9.0	2.99
	0+60	8.0	3.00	8.0	3.04	9.5	3.00	8.5	3.01	7.5	2.94	9.0	3.00
	0+90	8.0	3.06	8.2	3.03	9.5	3.00	8.0	3.03	7.0	2.92	9.1	3.00
	0+120	8.0	3.02	8.0	3.02	9.5	3.01	8.0	3.03	7.0	2.92	9.0	3.01
80 in/oz	0	8.0	2.99	9.0	3.09	9.5	3.00	8.5	3.02	9.2	3.02	9.0	2.93
	0+15	9.0	3.04	9.0	3.12	9.5	3.00	8.5	3.02	11.0	3.05	9.0	2.90

	Time	#13 C	#13 CT	#14 C	#14 CT	#15 C	#15 CT	#16 C	#16 CT	#17 C	#17 CT	#18 C	#18 CT
60 in/oz	0	10.0	2.89	8.5	2.99	10.0	2.93	10.0	2.85	8.0	2.93	8.0	3.16
	0+30	10.0	2.83	9.0	3.00	10.0	2.99	10.0	2.86	9.0	2.88	7.5	3.11
	0+60	9.5	2.83	9.0	3.01	10.0	3.00	10.0	2.86	9.0	2.[illegible]4	7.5	3.14
	0+90	9.5	2.85	9.0	2.99	10.0	3.01	9.5	2.86	9.0	2.[illegible]5	7.5	3.11
	0+120	9.0	2.80	9.0	2.98	10.0	3.01	9.5	2.86	9.0	2.[illegible]6	7.5	3.13
80 in/oz	0	10.0	2.90	9.0	3.00	10.0	3.00	10.5	2.86	9.0	3.[illegible]2	10.0	2.91
	0+15	10.0	2.91	9.0	3.01	10.0	2.99	9.0	2.85	9.0	3.[illegible]6	9.5	2.92

Figure 2.

Motor Test Haydon 1/3 rpm, cont'd

	Time	#19 C	#19 CT	#20 C	#20 CT	#21 C	#21 CT
60 in/oz	0	8.5	3.14	8.0	3.27	8.0	3.12
	0+30	8.0	3.14	8.0	3.26	8.0	3.11
	0+60	7.5	3.10	7.5	3.26	8.0	3.11
	0+90	7.5	3.10	7.5	3.26	7.5	3.10
	0+120	7.5	3.10	7.5	3.26	8.0	3.11
80 in/oz	0	8.0	3.00	8.0	3.28	8.0	3.13
	0+15	8.0	2.99	8.0	3.27	8.0	3.12

Figure 2, cont'd

AIRCRAFT ARMAMENTS, Inc.

During the testing of alarm No. 36 a high torque 1/3 rpm motor failed after 23 hours of operation. The motor was returned to the Haydon Company where the failure was diagnosed as a shorted winding. This motor has been repaired, returned and retested by AAI.

On alarm No. 37 a high torque 2 rpm motor failed after 10[illegible] hours of operation. The motor was returned to the Haydon Company where the failure was diagnosed as an improperly staked gear train. The Haydon Division of the General Time Corporation attributes this failure to the fact that these motors are fabricated in their model shop where their normal quality control measures cannot be as rigidly enforced as is the case with full production components.

During the testing of alarm No. 38, a high torque 2 rpm motor failed after 101 hours of operation. When the failure was noted the back of the motor was removed and it was observed that the armature was not turning. Upon tapping the brushes the motor then started to operate, however, the motor was removed from the alarm as a precautionary measure. Subsequent testing of this motor has indicated a very erratic and intermittent operation. The motor has been returned to the Haydon Company for a complete analysis.

During the service tests on unit No. 21 at Ft. Benning, a high torque 2 rpm motor failed after approximately 100 hours of operation. A preliminary investigation indicates the following:

a. Intermittent Stalls

b. Shaft eccentricity with hole in Delrin back

c. Shaft appears to be corroded

d. Lower brush failed in the brush assembly

Shortly after the above failure, the transport motor on alarm No. 26 failed. Subsequent inspection revealed that the gear train in this motor has failed but the exact point of failure is unknown. All motors are to be returned to Haydon for repair and a laboratory report has been requested describing the cause of these failures.

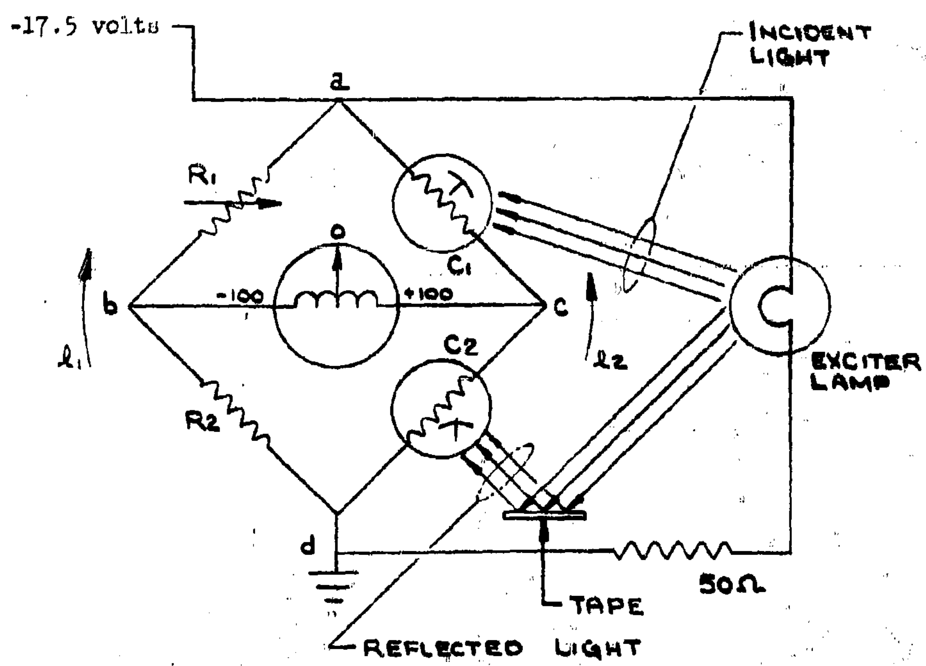
3. Electronics

a. Photometer Head

A continuing program of studies has been maintained to determine if the photometer as used in the alarm could be increased in sensitivity and also stabilized for temperature changes.

The present photometer head has unavoidable drift due to variation in light level, bias voltage, and operating temperature, thus the drift in the current through the photocell is as high as twenty micro amps which can cause false alarms. Therefore, some other arrangement of the existing head seems to be necessary.

A possible solution to the drift problem is through the use of a balanced bridge circuit. The electrical operation of the bridge circuit is as follows.



When the bridge circuit is balanced:

$$V_{ab} = V_{ac}$$

therefore $i_1R_1 = i_2C_1$

also $V_{bd} = V_{cd}$

so $i_1R_2 = i_2C_2$

$$\frac{i_1R_1}{i_2R_2} \quad \frac{i_2C_1}{i_2C_2}$$

$$\therefore \quad R_1 = \frac{R_2C_1}{C_2}$$

When the circuit becomes unbalanced due to a change in the resistance of photocell $\#C_2$, current must pass through the meter relay. The sensitivity of the bridge circuit is $f\left(\frac{C_1}{C_2}\right)$, therefore, small resistance values are needed for each photocell. The CL602 photocell has a light resistance of 150,000 ohms. Since the sensitivity is $s = f\left(\frac{C_1}{C_2}\right)$ and $s = f\left(\frac{150,000}{150,000 \pm C_1}\right)$ the CL602 photocell would have to have changes in resistance on the order of 75,000 ohms, whereas a photocell with lower resistance would give more deflection in the meter relay reading for equal amounts of light change. Therefore, the CL605L photocell with an operating light resistance of 1,000 ohms would be more effective for a bridge circuit.

During this report period a bridge circuit consisting of two (2) CL602 photocells was constructed and placed in an alarm for testing. After 232 hours of testing it was confirmed that the CL602 photocell has an operating light resistance of 150,000 ohms which is too high for the desired sensitivity.

AIRCRAFT ARMAMENTS, Inc.

Subsequently another bridge circuit consisting of two (2) CL605L photocells was constructed and installed in alarm No. 9. A sensitivity test was performed using a Munsell Neutral Scale with the following results:

MUNSELL NEUTRAL SCALE VALUE	METER RELAY READINGS IN amps UNIT #9 CL605L		UNIT #9 CL602	UNIT #30 STANDARD HEAD		UNIT #19 STANDARD HEAD
9.5	0	100	0	100	120	100
9.0	-20	80	-5	95	116	95
8.5	-75	20	-14	87.5	104	86.5
8.0	-100	-35	-22	80	96	78
7.5		-80	-27	77	88	
7.0		-100	-36		77	
6.5			-43			

From the results of the Munsell Neutral Scale Test, it can be seen that the CL602 bridge circuit and CL602 standard photometer head are equally sensitive to light changes, whereas, the bridge circuit with the CL605L photocells is much more sensitive to light changes in the area of gas alarm use. See Figure 3. For two steps in the Munsell scale the standard changed 20 μamps where the CL605L bridge circuit changed 120 amps. This means that the bridge circuit is 6 times more sensitive to light level changes than the standard photometer circuit. The CL602 bridge circuit is also 6 times less sensitive to light level changes than CL605L bridge circuit.

The CL605L bridge circuit is presently being tested to determine its operational stability during changes in light, temperature, and bias voltage. The maximum air blank recorded for this circuit is 35 μamps.

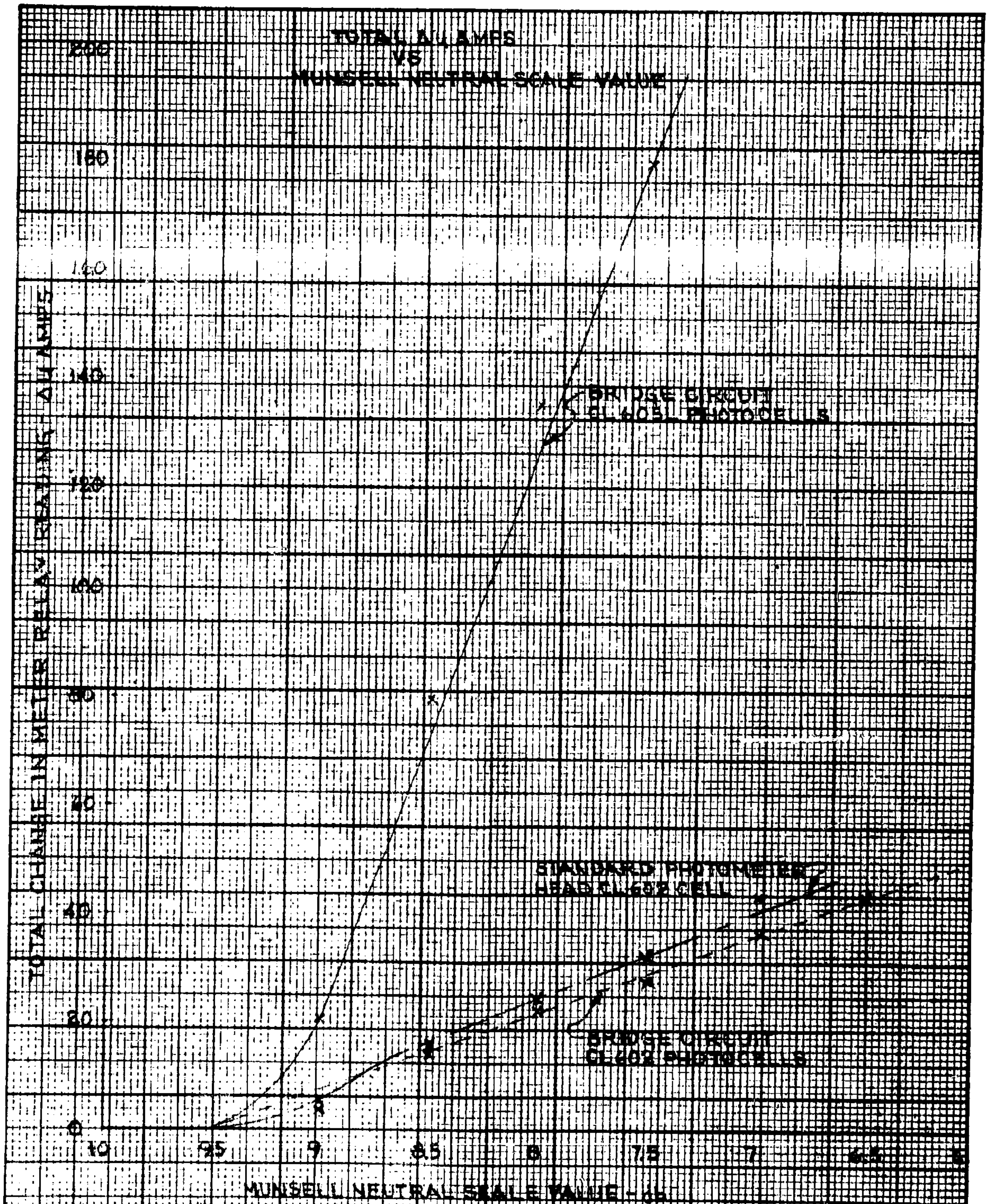

TOTAL Δμ AMPS
VS
MUNSELL NEUTRAL SCALE VALUE
TOTAL CHANGE IN METER RELAY READING Δμ AMPS
BRIDGE CIRCUIT
CL 605L PHOTOCELLS
STANDARD PHOTOMETER
HEAD CL 602 CELL
BRIDGE CIRCUIT
CL 602 PHOTOCELLS
MUNSELL NEUTRAL SCALE VALUE - 6b

FIGURE 13

AIRCRAFT ARMAMENTS, Inc.

This 35 amps seems high but it is only 35 percent of null to alarm scale value. On the standard gas alarm's photometer head, an air blank of 12 amps would be 60 percent of null to alarm scale value. After 277 hours of testing, the maximum combined airblank and null drift was 55 micro amps. This 55 percent of null to alarm scale value is small compared to the drift of the standard photometer head. Therefore, the bridge detection head warrants continued testing.

b. Results of Photocell Testing - Type 605L

The testing was performed on a batch of eleven (11) photocells selected at random from a single purchase lot of Type 605L Clairex photocells.

The photocell test rig impresses a fixed voltage across each photocell in series with a 180K resistor. For changes in photocell resistance, normally ranging from 1K to 4K, the cell current remains essentially constant since this change is small in comparison to 180K. Hence, with constant current the voltage across a photocell is proportional to its resistance. An automatic stepper switch is used to connect each cell in sequence to a chart recorder in order to follow the changes of any particular cell during the course of a test.

Complete data were obtained for all eleven (11) cells of the test batch; however, for the sake of clarity data from only four (4) cells were graphed. The four (4) cells selected for graphic presentation are the two cells at the extremes of the test batch, i.e., highest and lowest resistances, and two others of the batch. The first test consisted

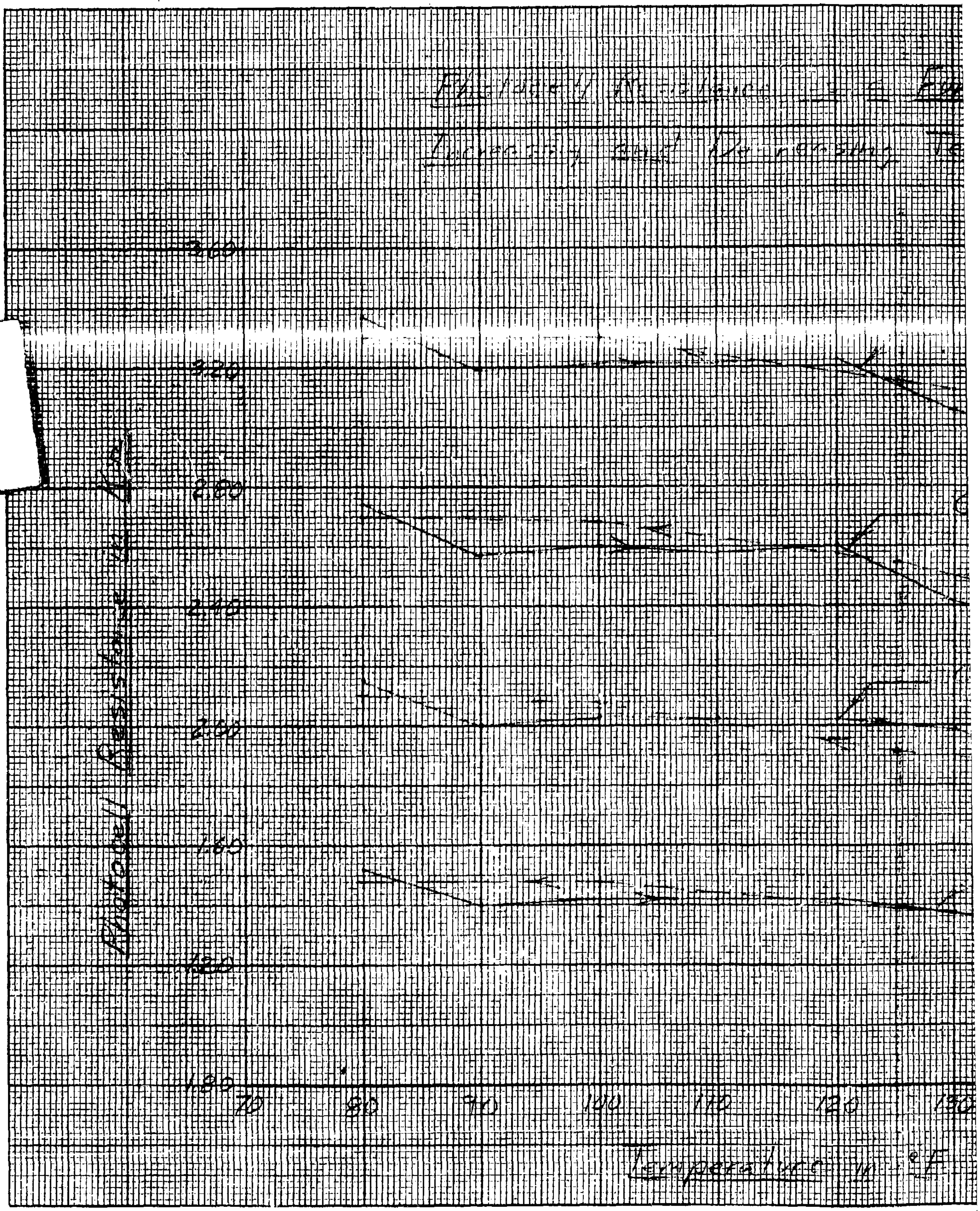
AAINC E 138A

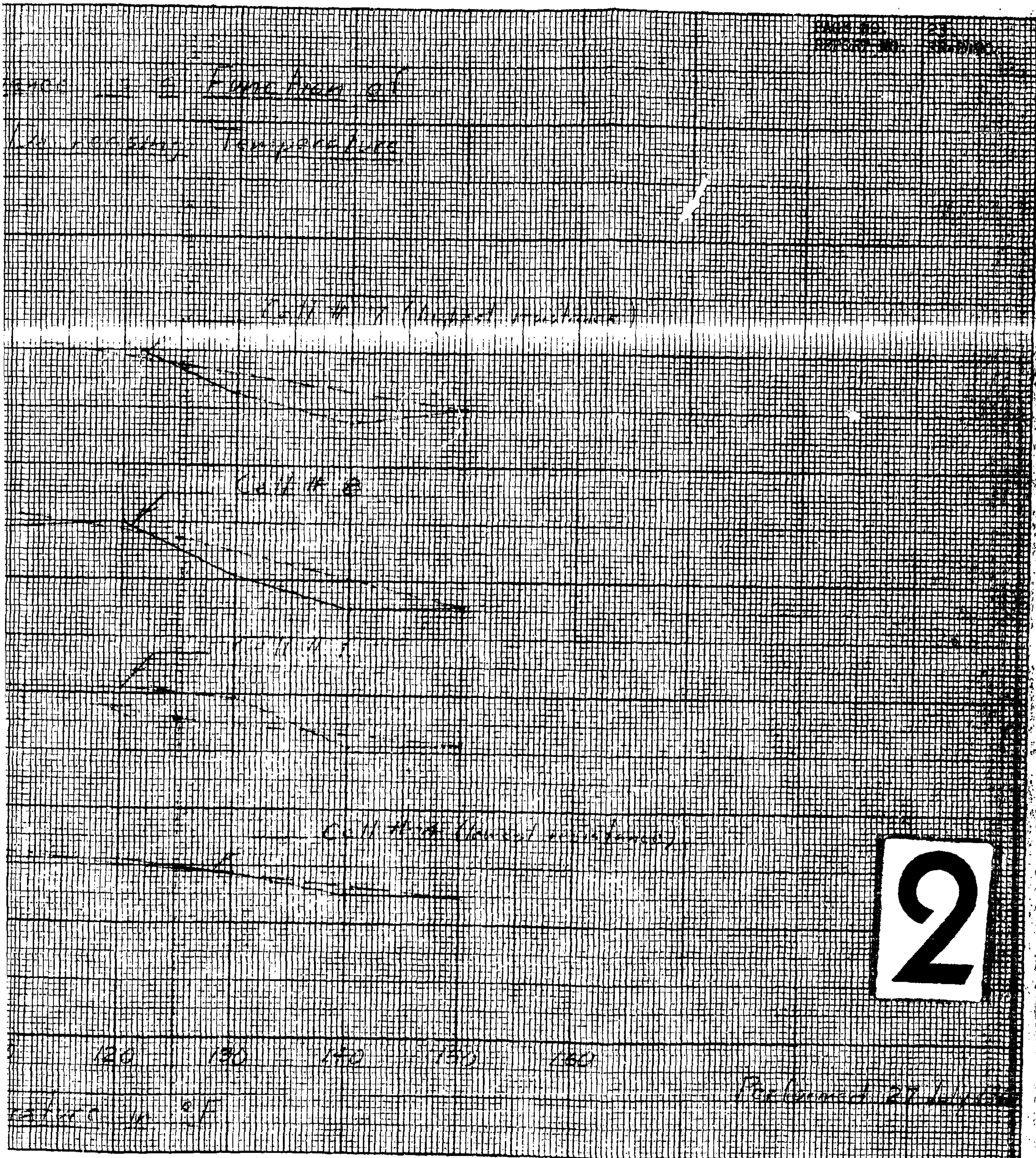
of holding light level constant and varying the temperature. Graphs #1 and #2 illustrate the effects of temperature variation upon the cells. The temperature sensitivity ranged from a high of -6.1Ω/°F for cell #8 to a low of -3.3Ω/°F for cell #4. Expressed as a percentage change, however, the temperature sensitivity of the cells is nearly constant, falling between the values of -0.19%/°F and -0.23%/°F. Graphs #1A and #2A portray the same curves as graphs #1 and #2, but the invarience of temperature coefficient is more evident when the curves are plotted on semi-log paper.

One is unable to draw quantative conclusions here regarding temperature hysteresis effects since very close control over the temperature could not be maintained. Crossovers of the "out" and "return" paths on graphs #1 and #2 invite suspicions that different temperature were produced between the up and down excursions of the temperature. Graphs #3 through #8 illustrate the light response of the test cells. Since no method was immediately available for measuring light levels, the lamp voltage was varied and then responses of the various photocells were compared for given differences in lamp voltage.

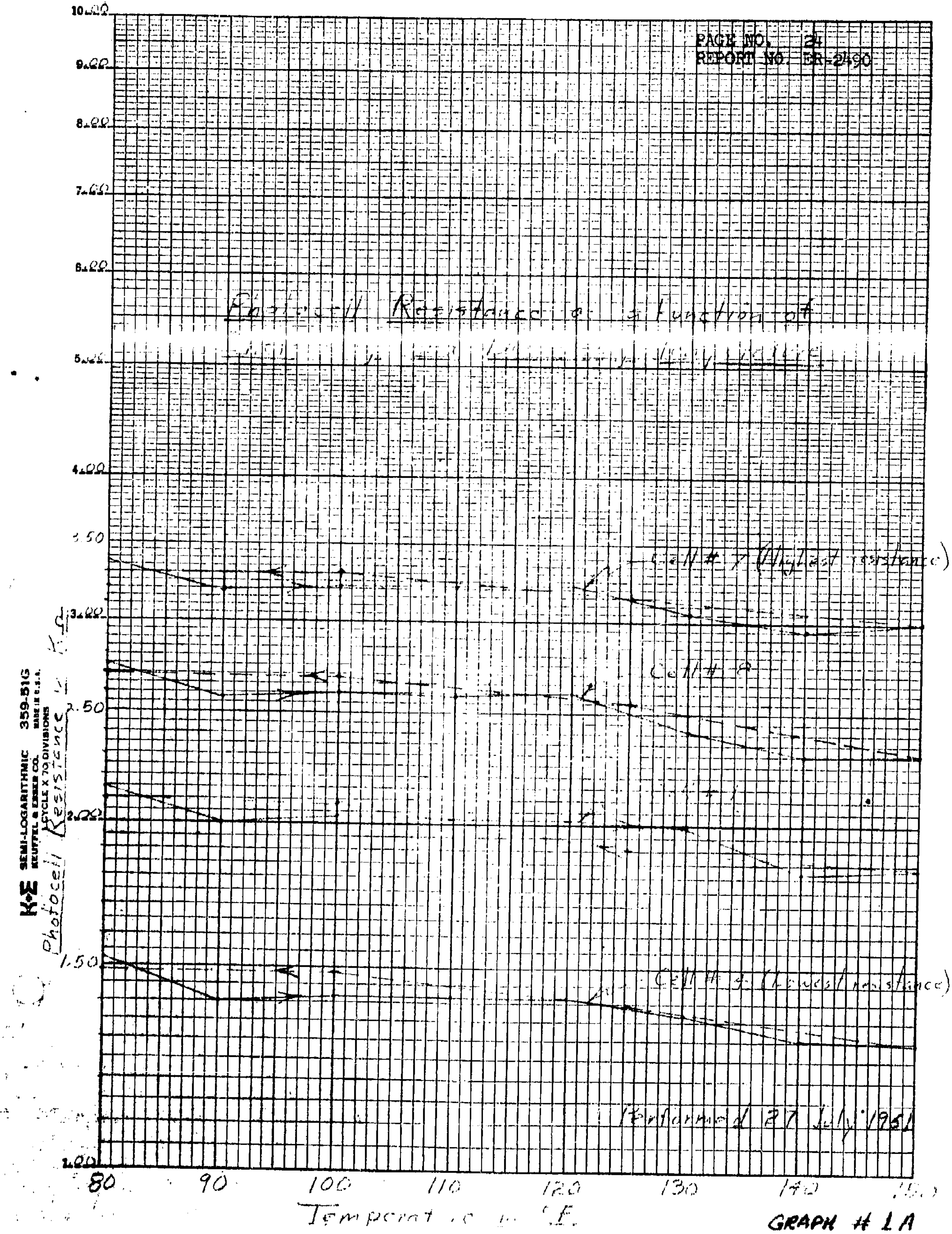
In general the graphs reveal that photocells with higher resistance have a greater rate of change of resistance with light. Cell #4 has the lowest resistance among the test batch, consequently its curve has the lowest slope. Similarly cell #7 has the highest values for resistance and rate of change (slope). The percentage change in resistance, however, is very nearly constant as shown on the semi-log plot #3A. For

1

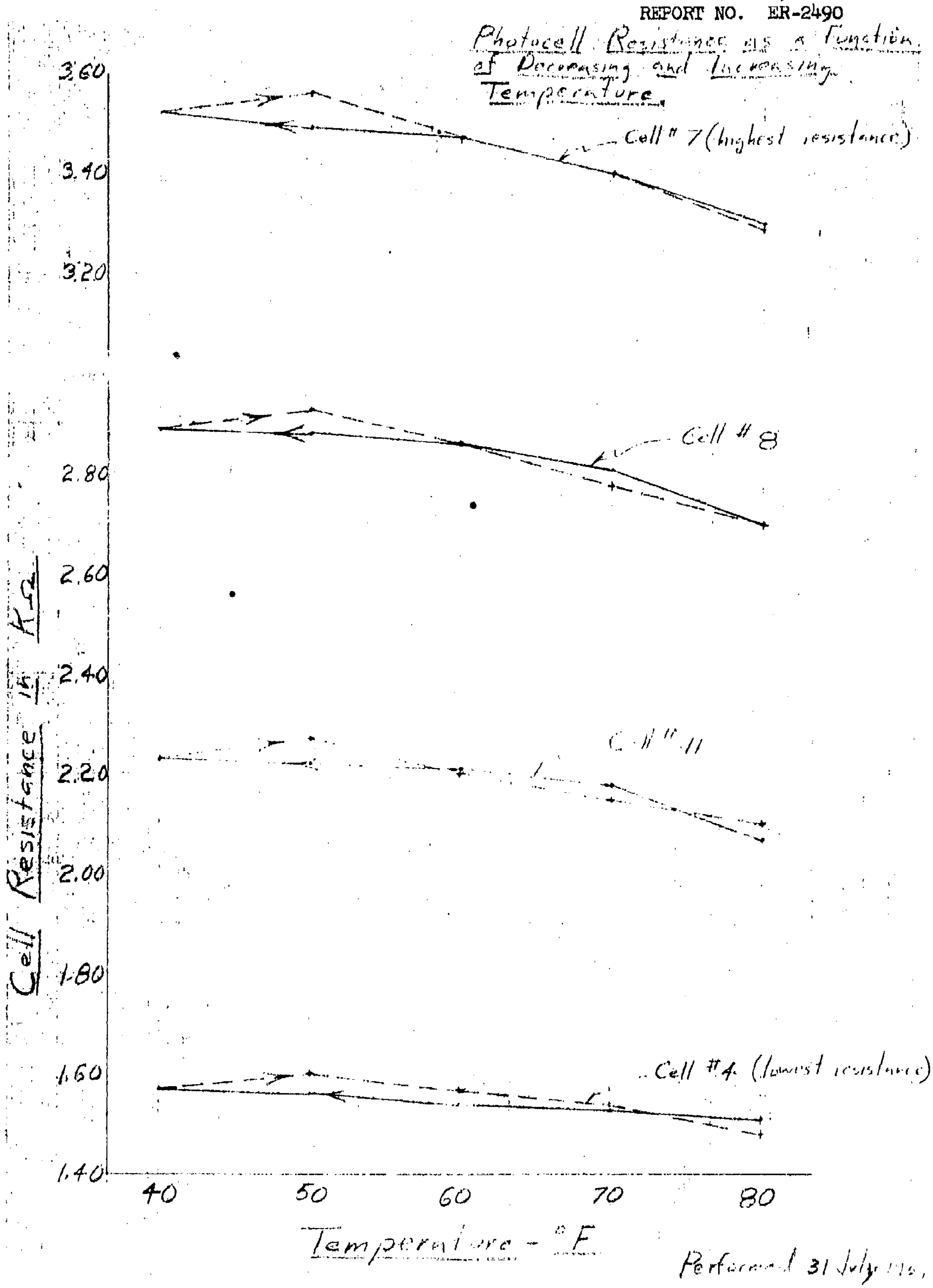

Photocell Resistance in
70
80
90
100
110
120
130
Temperature in °F



GRAPH #1

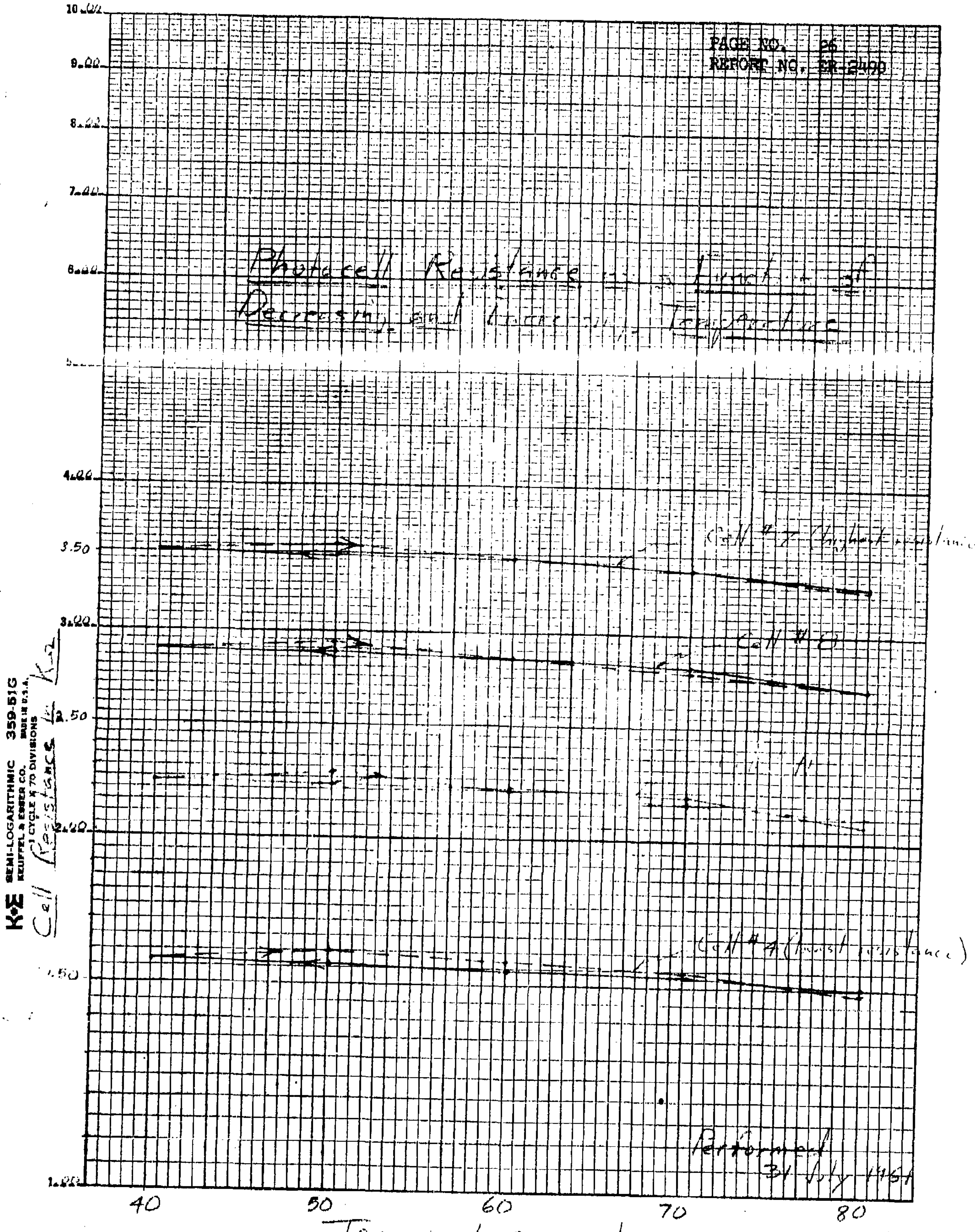

Photocell Resistance as a function of
Cell # 7 (Highest resistance)
Cell # 8
Cell # 4 (Lowest resistance)
Performed 27 July 1951
Photocell Resistance in KΩ
Temperature in °F.
10.ΩΩ
9.ΩΩ
8.ΩΩ
7.ΩΩ
6.ΩΩ
5.ΩΩ
4.ΩΩ
3.50
3.ΩΩ
2.50
2.ΩΩ
1.50
1.ΩΩ
80
90
100
110
120
130
140
150
K+E SEMI-LOGARITHMIC 359-51G
KEUFFEL & ESSER CO. 1 CYCLE X 70 DIVISIONS MADE IN U.S.A.

GRAPH # 1A

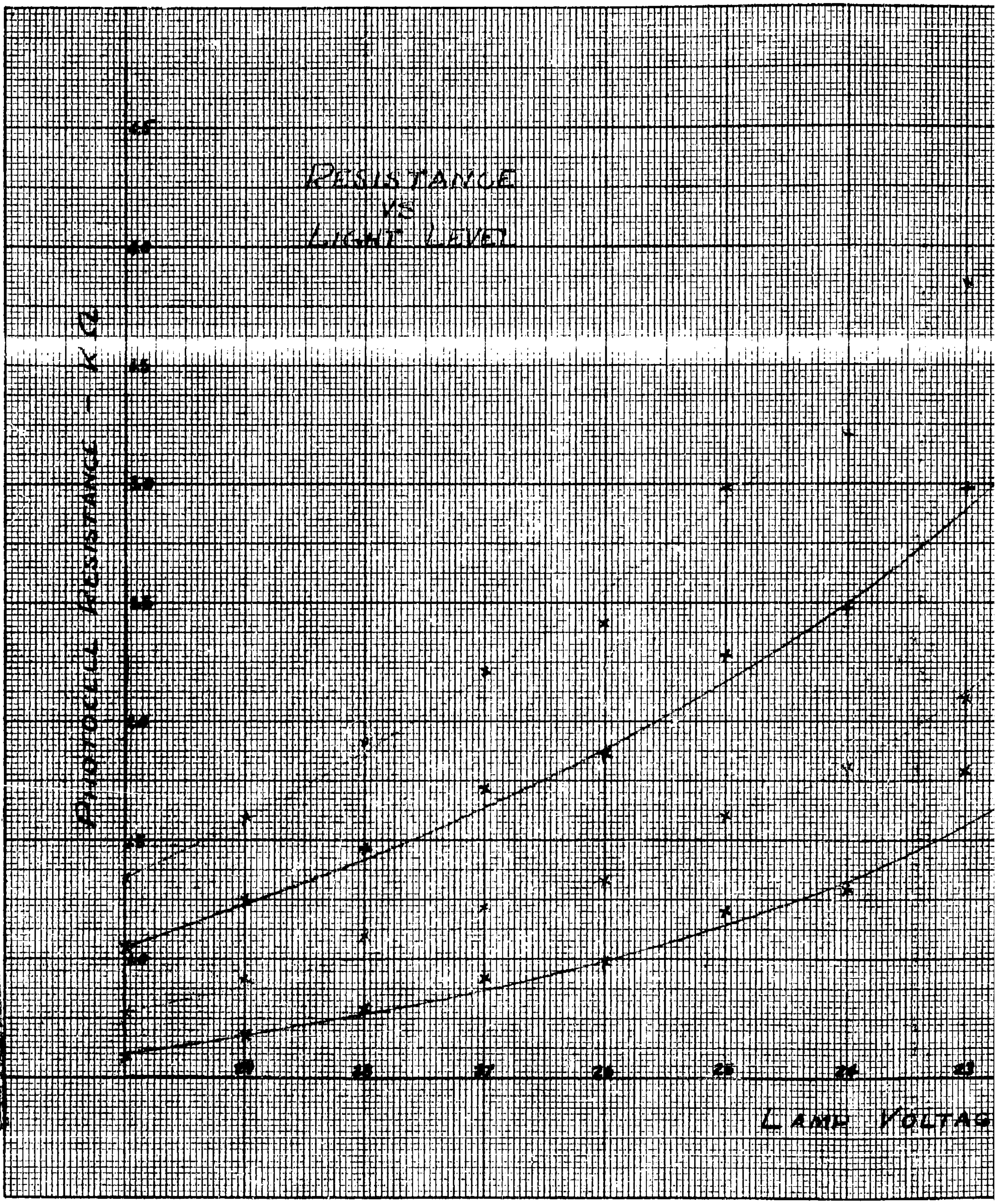


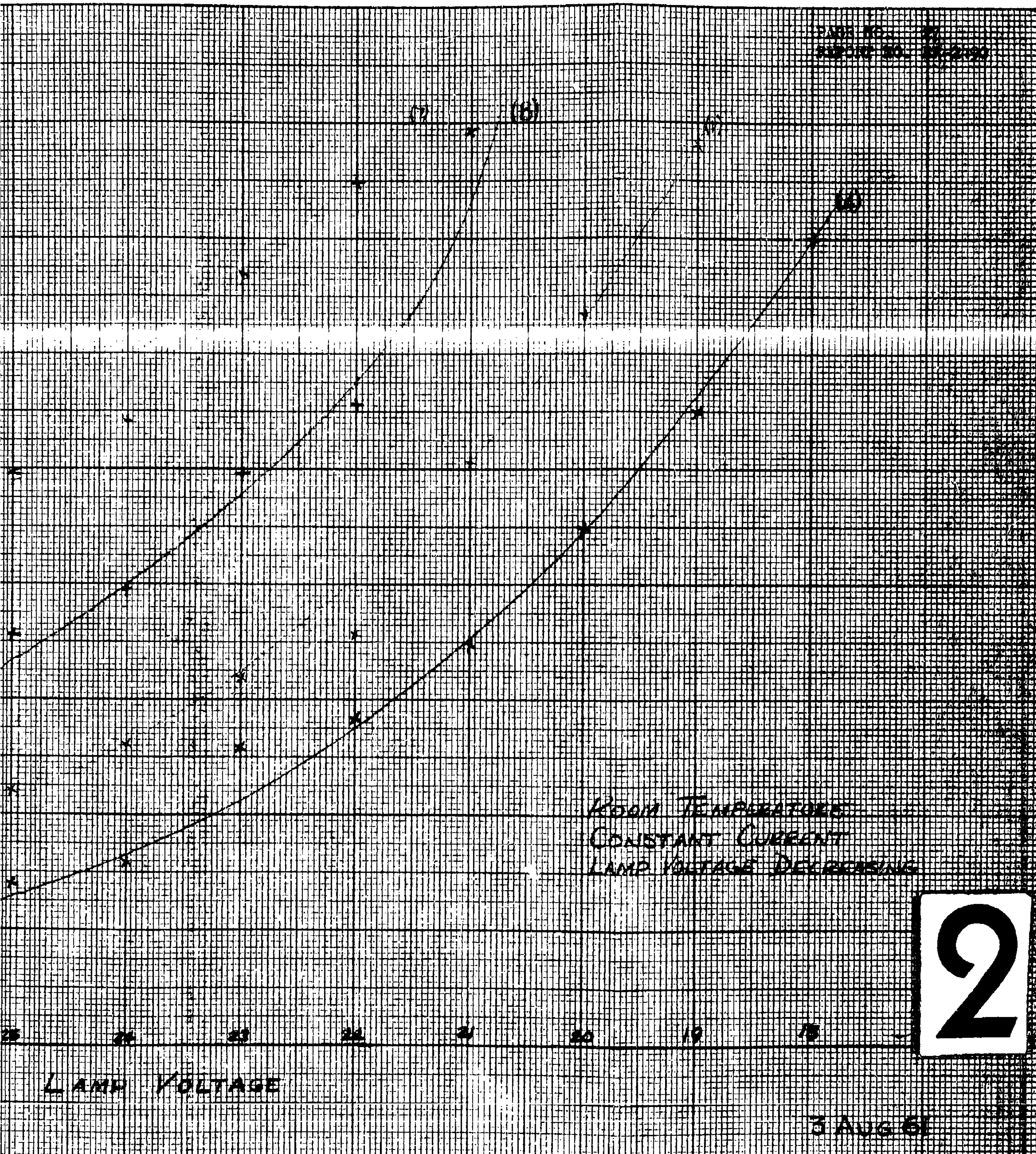
Performed 31 July

GRAPH #2

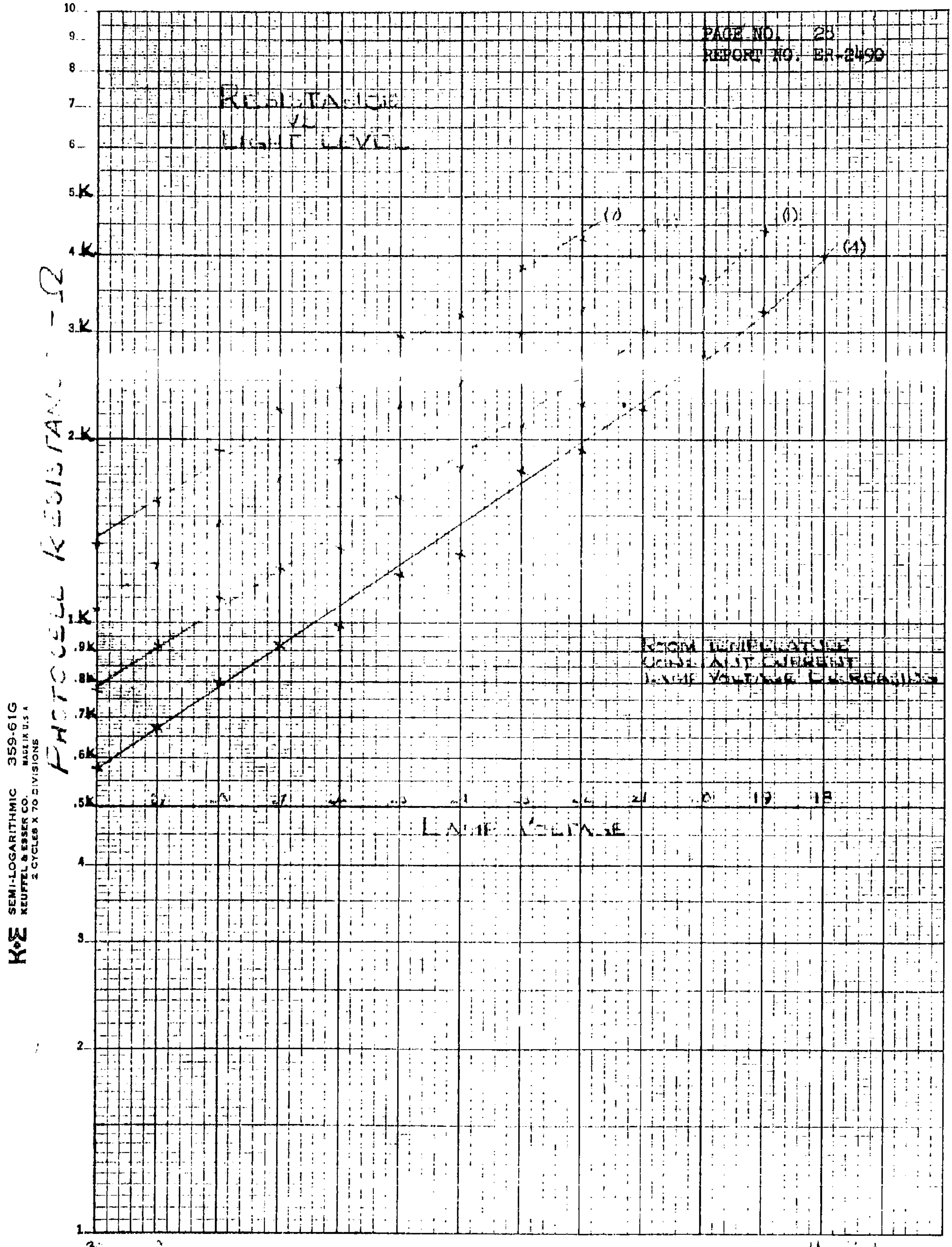

10.00
9.00
8.00
7.00
6.00
4.00
3.50
3.00
2.50
2.00
1.50
1.00
40
50
60
70
80
K+E SEMI-LOGARITHMIC 359-51G
KEUFFEL & ESSER CO.
1 CYCLE X 70 DIVISIONS
Performed
31 July 1961

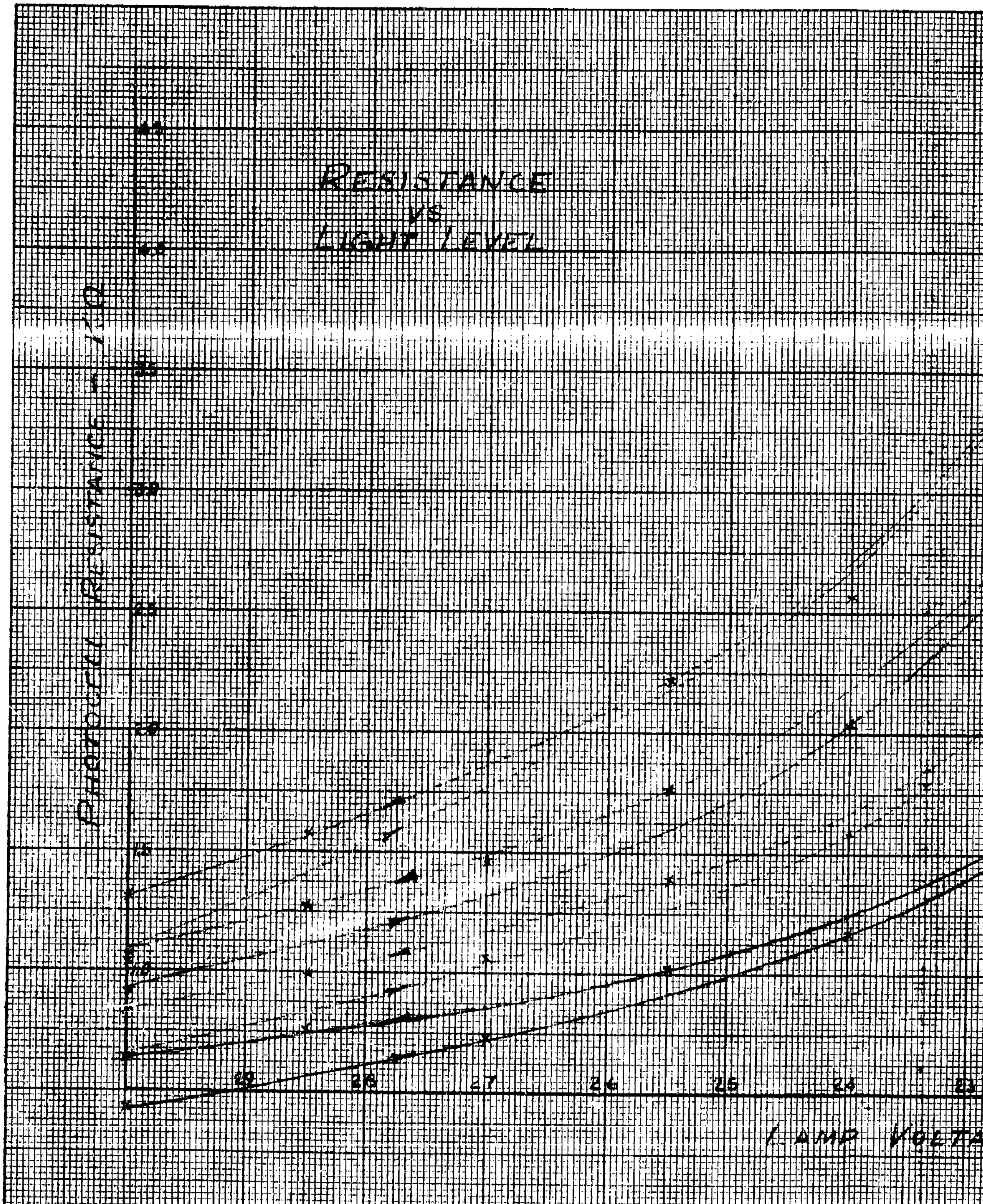
GRAPH #2A


RESISTANCE
VS
LIGHT LEVEL
PHOTOCELL RESISTANCE - KΩ
LAMP VOLTAG

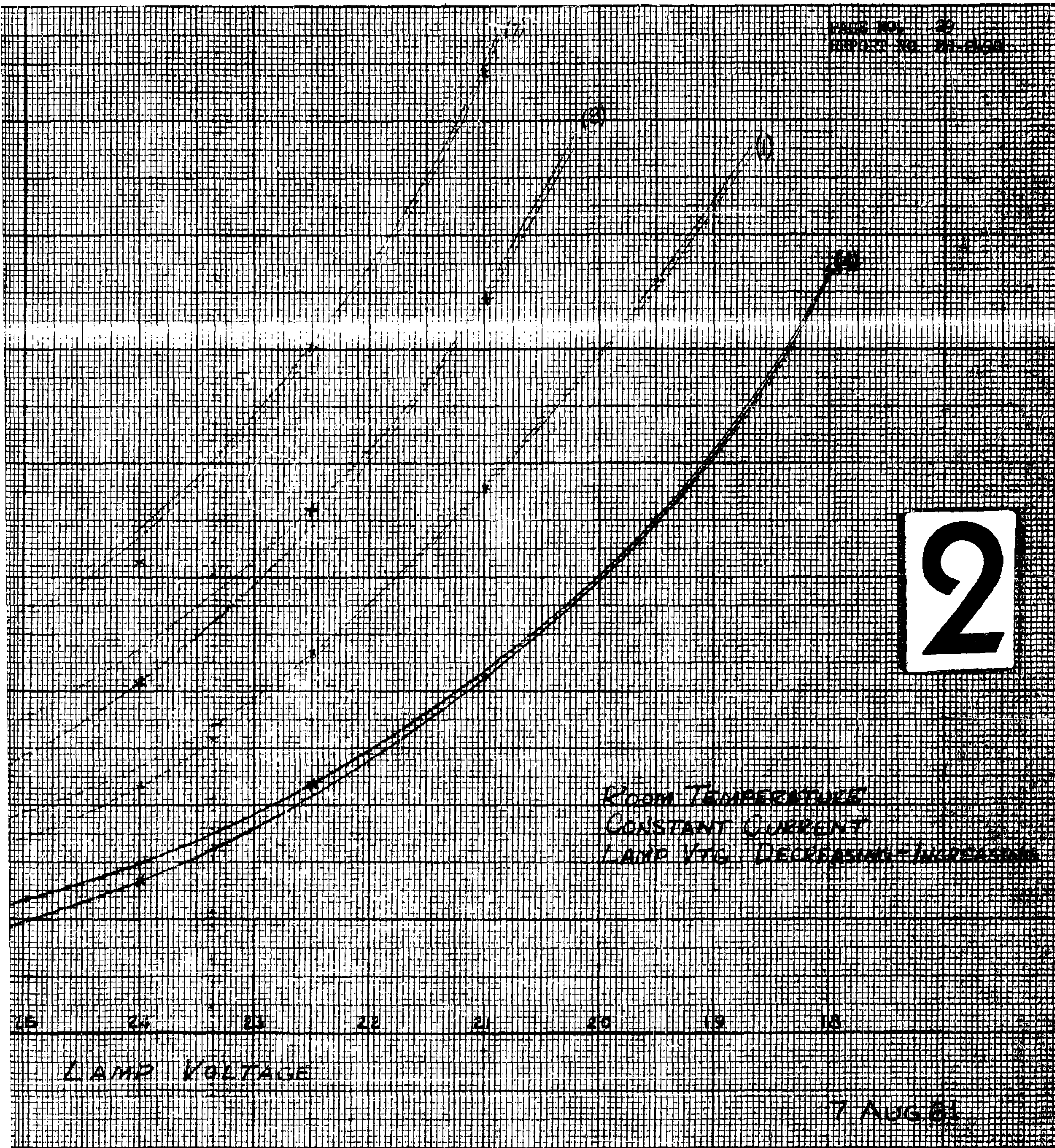

(7)
(6)
(8)
25
24
23
22
21
20
19
18
ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VOLTAGE DECREASING
2
LAMP VOLTAGE
3 AUG 61

GRAPH #3


RESISTANCE
vs
LIGHT LEVEL
PHOTOCELL RESISTANCE - Ω
LAMP VOLTAGE
ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VOLTAGE DECREASING
SEMI-LOGARITHMIC 359-61G
KEUFFEL & ESSER CO.
2 CYCLES X 70 DIVISIONS

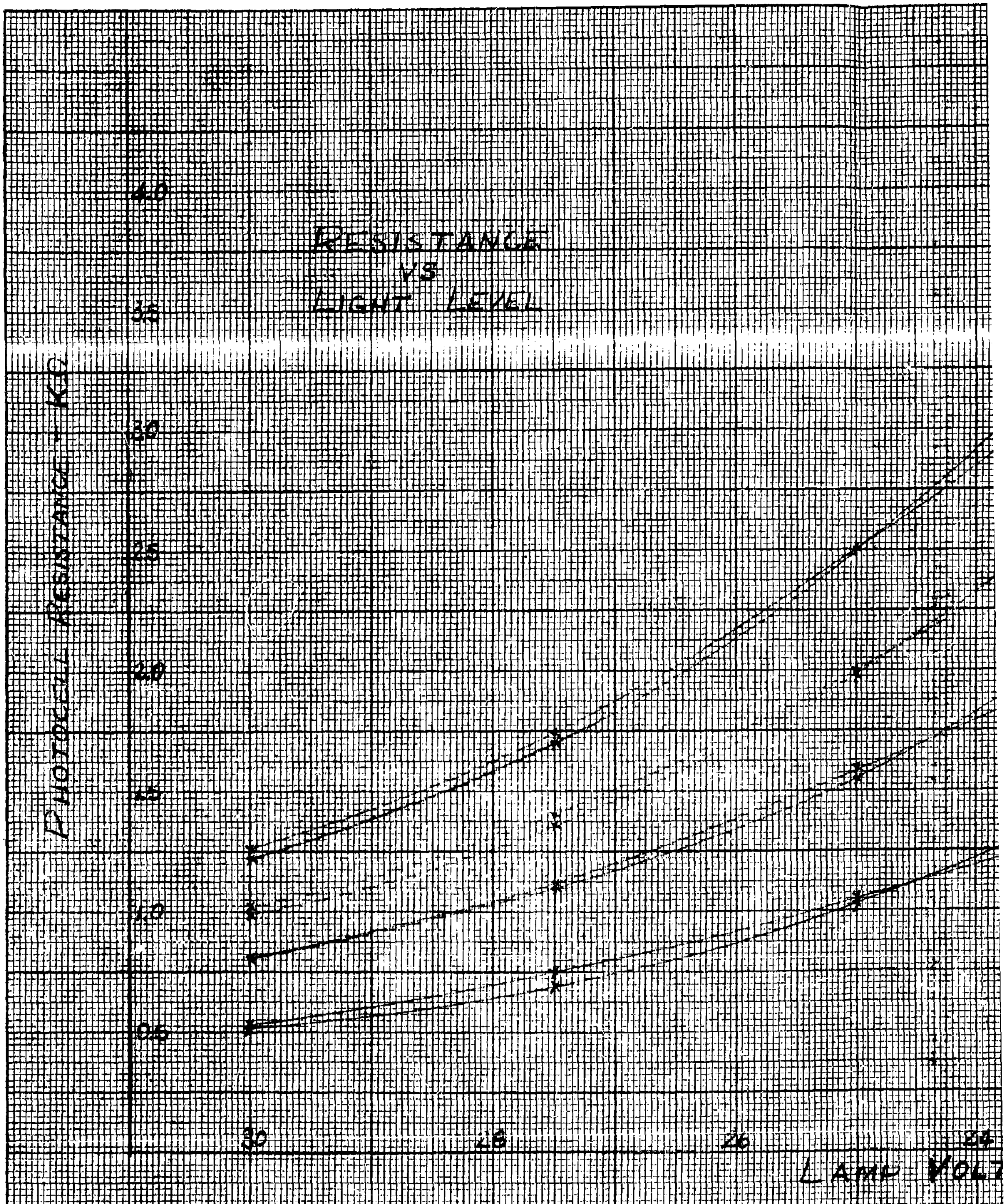

RESISTANCE
VS
LIGHT LEVEL
PHOTOCELL RESISTANCE - KΩ
29
28
27
26
25
24
23
LAMP VOLTA

1

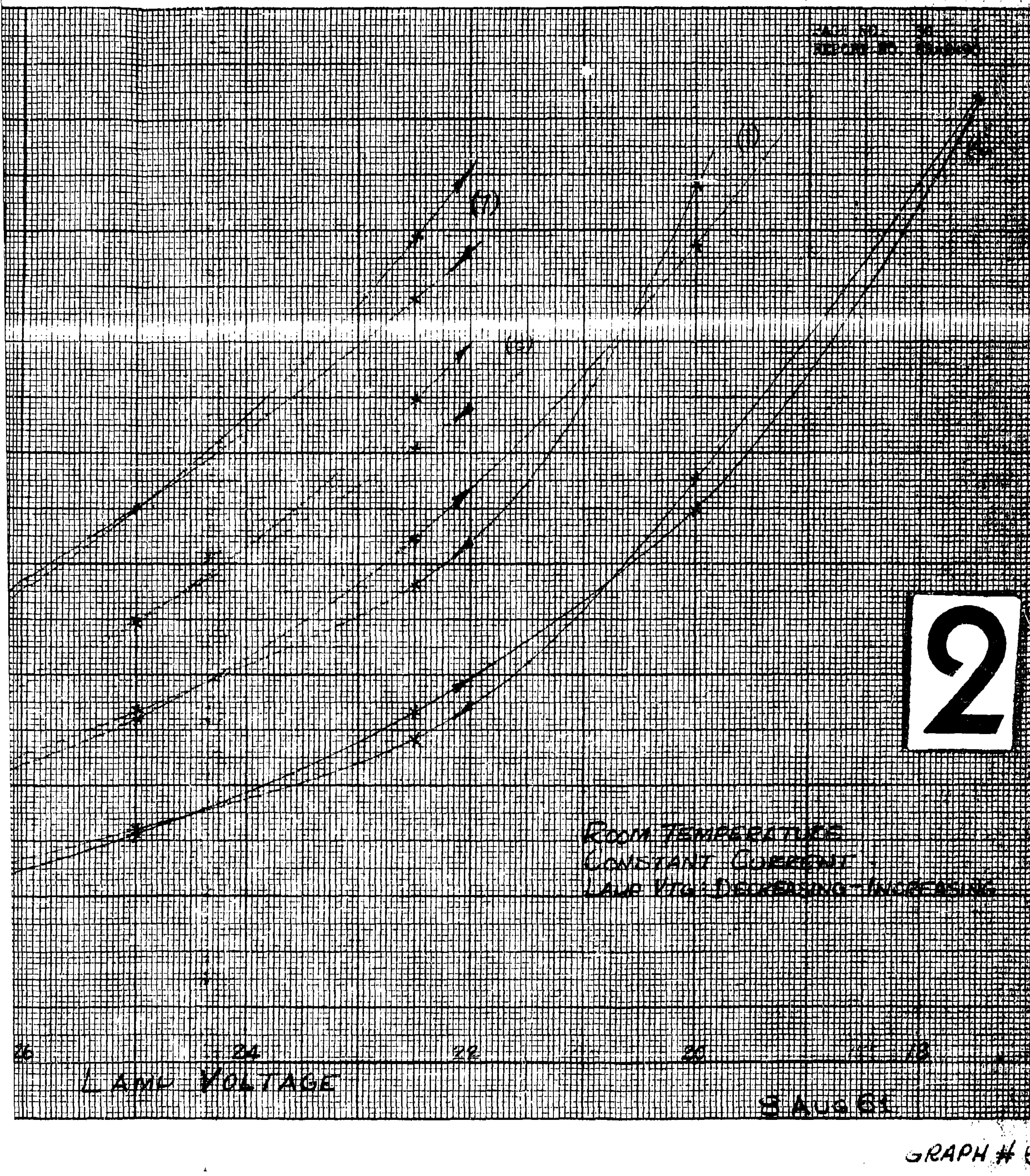


PAGE NO.
REPORT NO.
(1)
(2)
(3)
(4)
2
ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VTG. DECREASING - INCREASING
25
24
23
22
21
20
19
18
LAMP VOLTAGE
7 AUG 61

GRAPH # 4

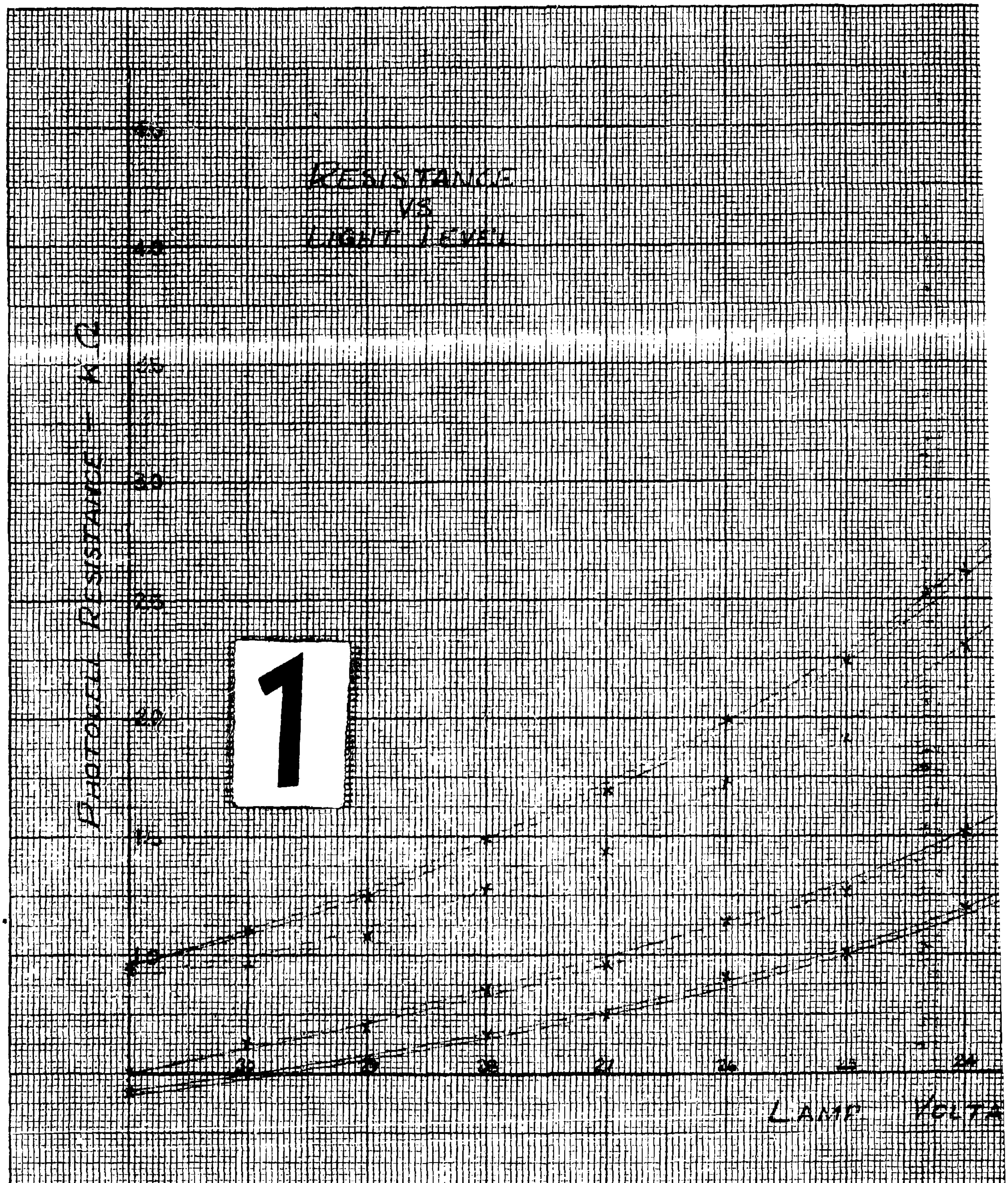

RESISTANCE
VS
LIGHT LEVEL
PHOTOCELL RESISTANCE - KΩ
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
30
28
26
24
LAMP VOLT

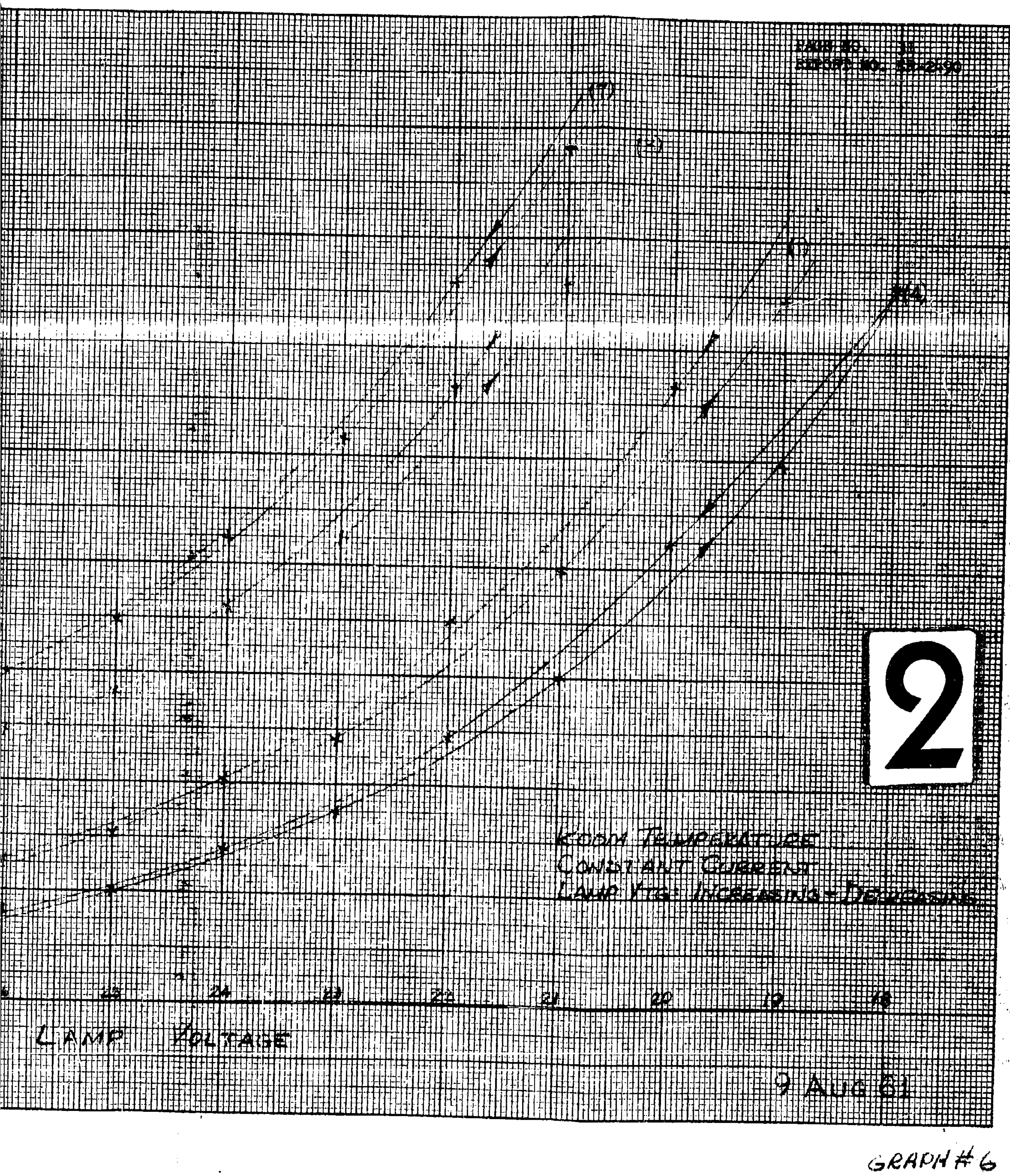
1


(1)
(7)
(6)
2
ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VTG: DECREASING-INCREASING
26
24
22
20
18
LAMP VOLTAGE
8 AUG 61

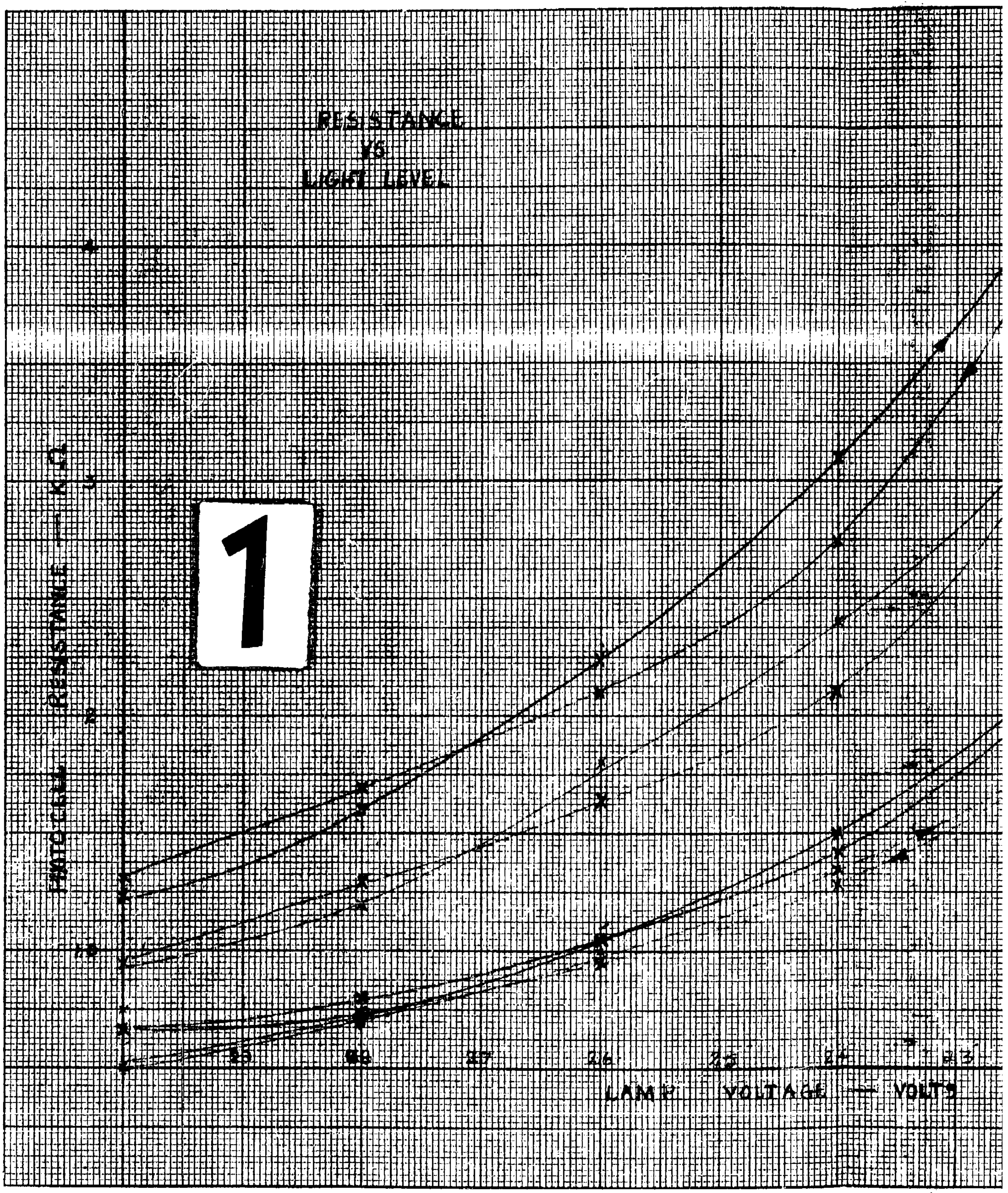
GRAPH # 5

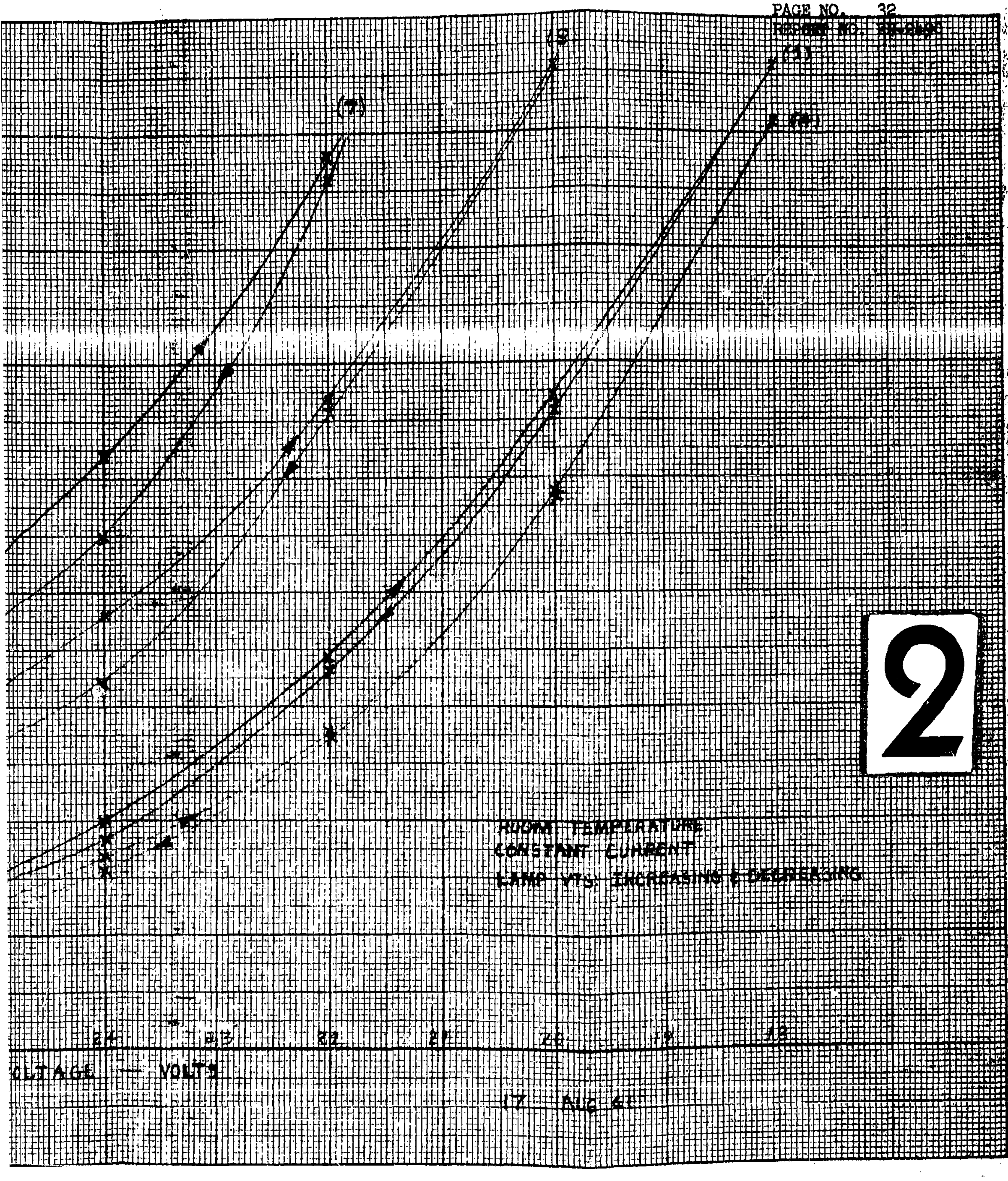
1


RESISTANCE
VS
LIGHT LEVEL
PHOTOCELL RESISTANCE – KΩ
LAMP VOLTA

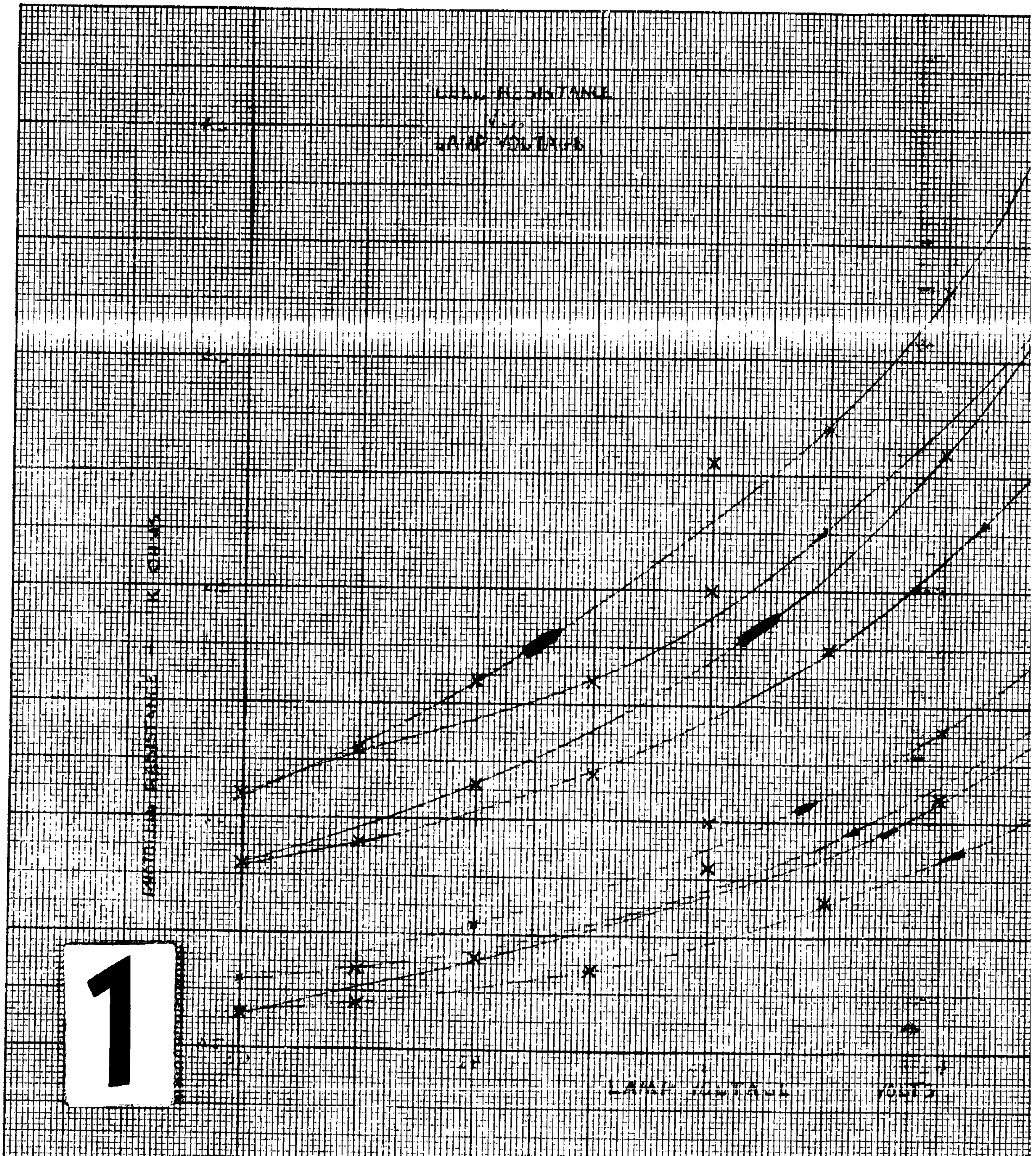

ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VTG: INCREASING + DECREASING
25
24
23
22
21
20
19
18
LAMP VOLTAGE
9 AUG 61

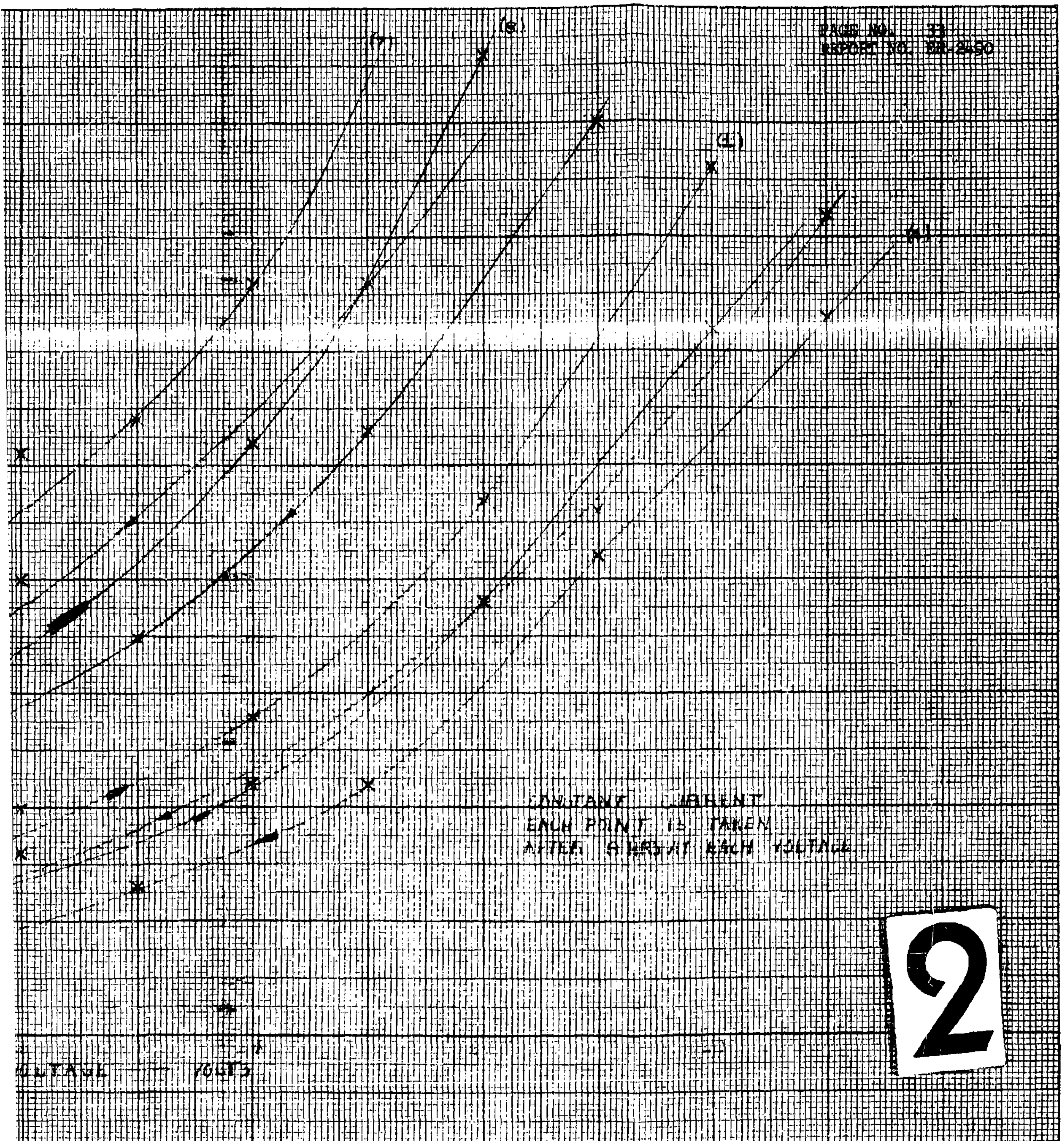
GRAPH #6


RESISTANCE
VS
LIGHT LEVEL
FOTO CELL RESISTANCE — K Ω
LAMP VOLTAGE — VOLTS
1


(5)
(1)
(7)
2
ROOM TEMPERATURE
CONSTANT CURRENT
LAMP VTS. INCREASING & DECREASING
24
23
22
21
20
19
18
OLTAGE — VOLTS
17 AUG 61

GRAPH #7


RESISTANCE
LAMP VOLTAGE
K OHMS
VOLTS



GRAPH # 8

the various conditions of light level and temperature, photocell #7 (maximum) remained at 2-1/4 to 2-1/2 times the value of the resistance of photocell #4 (minimum). Temperature and light level sensitivities of the photocells were compared in an effort to discover whether photocells having greater light sensitivities also tend to have greater temperature sensitivity. While such a relationship appears to exist, it seems inadvisable to conclude that such is the case because of inaccuracy in the testing techniques.

Graphs #3 through #8 illustrate the hysteresis effect which is experienced when the light level is changed in one direction and then returned to its original value. The wide variation in the magnitude of the difference between beginning and end values is most likely the result of inaccuracy of lamp voltage adjustments. In particular the cross-overs of the "up" and "down" curves on graph #5 suggest false settings of lamp voltage at 22.5 volts since these pairs of points are inverted with respect to those plotted at other lamp voltages. The data obtained in these tests reveals an exceedingly great variation among cells from a single batch. The cell with the highest resistance had a value of about 250 percent of the value of the cell with lowest resistance. On the other hand, calculations show the percentage change in resistance with either light or temperature variation to be very nearly the same for all cells. It can be seen from the semi-log plots on graphs #1A, #2A, and #3A that while there is a considerable spread between cells, they change in the same proportions.

The conclusion, then, is that two cells of the same resistance under the same conditions would perform quite suitably in a bridge circuit where we wish temperature drifts and variation due to common light level changes to compensate for one another. In such a manner it may be possible to prevent the above effects from interferring with the alarm detection circuitry.

4. Condensation

Recently alarm Nos. 35, 36 and 37 were rendered inoperable at Ft. Benning due to condensation forming on the air line connecting the tape transport drum pick-up fitting to the knockout portion of the solution pot. This condensation dripped onto the printed circuit board and shorted capacitor C_1 by filling the gap between the lead and the case, thus shorting the capacitor and causing a temporary failure to the voltage regulator on its printed circuit board.

The immediate solution to this problem was to insulate the lead from the case of the capacitor with the application of a coat of Glyptol. This was done on all existing boards but on any new boards, the capacitor will be reorientated so that the grounded end will point towards the condensation source. An additional protection was also afforded by placing a "splash guard" between the condensation source and the printed circuit board. This guard consists of a phenolic sheet fastened to the top of the printed circuit board by three (3) stainless steel clips. Its purpose is to divert the excessive condensation away from the component side of the board to the waterproofed track side where the presence of moisture will not affect alarm performance.

Since both the insulation and the above mentioned "splash guard" are interim measures, further Research and Development is underway to either eliminate the problem and/or provide absolute protection to this vital part. Various concepts are being investigated.

a. The design of an extruded rubber 'L' angle (112° included angle) which will be secured to the printed circuit board and supported by the PC board mounting point. It will extend from the end of the heat sink to the area of the air motor and protrude approximately 1/4" over the printed circuit board.

b. An investigation of materials in an effort to obtain a suitable insulation which may be applied to the entire printed circuit board rather than only the rear (track side) portion. Samples are to be subjected to hot and cold testing as well as completely immersed in the reagent solution of sodium pyrophosphate and ODN.

c. An investigation of several new types of rubber tubing, both thin and thick walled, and a teflon impregnated asbestos tubing which may be used as a jacket over the main air line.

When the desired configuration has been tested and approved, replacement parts will be provided for the Phase III alarms.

AIRCRAFT ARMAMENTS, Inc.

5. Endurance Testing

ALARM #	TOTAL TIME	ALARM #	TOTAL TIME
9	1202	26	349
11	558	27	1016
12	172	28	272
13	782	29	199
14	338	30	819
15	1225	31	197
16	182	32	86
17	576		
* 17	203	33	396
18	221	34	36
19	33		
* 19	315	35	327
20	175	36	326
21	421	37	332
22	341		
* 22	290	38	104
23	950	39	116
24	36	40	115
25	36		

* Total time after refurbishing

6. Vacuum Sensor Switch

Tests have been performed on several alarms at AAI in an effort to determine points of maximum pressure differential in order to design a more reliable baro switch than that previously installed on the alarm. Static pressures were measured at the point where the flow meter connects to the air inlet. The small section of tubing at this point was removed and a monometer inserted into the air system to measure static air pressure under varying conditions. Air flow was varied between .7 to 1.2 liters per minute and input voltages were adjusted to 21, 24 and 28 volts. On alarms 11, 21, 30, 39 and 40 measurements were taken and it was found that the static pressure varied between .1 to .2 inch of water. These measurements were taken with the alarm operating at room temperature.

Pressure measurements were also taken between the air pump outlet and the alarm exit heater. Again a monometer was inserted into the air line and the voltages and air flow varied as indicated above. Again it was found that such changes produced only an insignificant change in static pressure at this point. It was noted that the air pressure varied approximately .2 inch of water as the air flow was changed from .8 liters a minute to 1.2 liters per minute. Alarm 11 measurements were taken to measure the pressure differential between the inlet and outlet as the air flow was varied between .8 liters per minute to 1.3 liters per minute. It was observed that under these conditions the pressure differential varied between .4 to .95 inch of water. At the end of this report period alarm 10 was used to attempt to restrict the air inlet so that a major change in static pressure would occur as the air flow was varied. Insufficient time was available to record enough data for an evaluation of this set up.

The purpose of this investigation is to locate a point or points where sufficient pressure changes are produced in order that a pressure sensing device may be designed which will give a reliable indication when air flow drops below a predetermined value. If possible commercial components will be selected in order to minimize the amount of testing required.

7. Tape Studies

Earlier in this report it was mentioned that problems were encountered during alarm testing due to tape which was .062 inch too wide. This increase in the tape width usually does not allow the tape spool to be completely seated onto the pay-out spindle. When this condition exists, the tape spool will frequently "ride" off the spindle until it is retained by the front cover. The tape path is no longer in alignment with the transport drum and there is, therefore, a tendency for the tape to gradually "walk" off the drum. The increased drag of the spool binding on the front cover occasionally results in tape breakage between the spool and the drum.

When tape breakage is not experienced at this point other factors come into play which are equally as disasterous with respect to alarm performance. Assuming operation continues with the spool improperly seated in the spindle, as already pointed out, the tape begins to "walk" off the drum. When the drum is seated under the photometer head, the outer edge of the tape is stretched (or ruffled) due to the larger diameter of the tape guide flange on the drum. As the ruffled tape is wound onto the take-up spindle, the outside diameter of the expended tape is greatly increased over the normal condition and eventually will begin to scrub against the bottom can panel. At this point the take-up spindle locks in place but the garter spring continues to be pulled over the pulley. On several occasions this phenomena has resulted in a permanent elongation of this spring and requiring replacement of same.

A more frequent result of the stalled take-up spindle is that the tape will wrap around the transport drum. Since all tension on the take-up side of the drum has been lost, a force no longer exists which will pull the tape free of the drum needles. The tape consequently is carried around the drum until several layers of tape are accumulated. No specific failure pattern has been determined under this condition but the problem has usually resulted in one or more of the following:

a. Stalled transport motor

b. Burned out transport motor

c. Damaged air pump

d. False alarm

The reason for (a) and/or (b) is that with the accumulation of tape between the drum and head, drag is increased to the point where either the motor stalls or the gear train fails. Air pump damage may result because of the additional tape thickness between the drum and head and the corresponding increase in restrictions in the air system. False alarm occurs after the transport motor has stalled but the alarm continues to operate. Excessive air blank occurs and after several "transports", spot development is sufficient to produce a false alarm. On one occasion the tape build up produced tape breakage when the tape snagged the fluid nozzle. It should also be pointed out that when tape wrap-around occurs, the tape is pulled from the take up spindle causing this component to reverse its direction thereby producing an even greater overload on the garter spring.

No alarm changes are proposed or recommended to offset the problem discussed above. Rather, the recommendation has been made to Chemical Corps personnel that tape width be controlled to 0.625 ± 0.03 inch.

IV. FUTURE PROGRAM

Future program on the E41R1 Gas Alarm will be directed towards the fabrication of the additional alarms required by the contract and a continuation of R&D studies. Efforts under the latter will be primarily concerned with photocell and photometer studies, automatic nulling, inlet heater design, the remote alarm and correction of difficulties that are encountered at Ft. Benning during CONARC testing.