Parker Aircraft Co.
5827 WEST CENTURY BOULEVARD • LOS ANGELES 45, CALIFORNIA • SPRING 6-1221

29 January 1965

Letter No. S121-5-558

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Attention: Mr. J. V. Dunlap, PR-RC

Subject: Transmittal of Technical Progress Report

Reference: Contract NAS8-11662

Gentlemen:

In accordance with the reports requirements of the contract, we attach one (1) reproducible and seven (7) copies of the ~~sixth~~ 7th Monthly Technical Progress Report for the Electro-Pneumatic Actuation System.

Very truly yours,

PARKER AIRCRAFT CO.

J. E. Blaney
Project Administrator

FACILITY FORM 602
N66-10930 (ACCESSION NUMBER)
(THRU)
34 (PAGES)
1 (CODE)
CR 67921 (NASA CR OR TMX OR AD NUMBER)
15 (CATEGORY)

JEB:ek
Enclosures

cc: Mr. J. Marks, Resident Engineer

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ff 653 July 65

Sp/30729

PROGRESS REPORT

NASA CONTRACT NAS8-11662

1.0 INTRODUCTION

1.1 This is the seventh of the narrative progress reports required by Contract NAS8-11662 calling for the design, development, fabrication, and test of two electro-pneumatic actuation systems per NASA specification 50M35026.

2.0 GENERAL

2.1 Component fabrication is approximately 90% complete. Nearly all of the parts for the actuator and servo valve are in-house in an unassembled condition.

2.2 The first of the servo valve second stage flexures is through the E.D.M. phase with the slits in. The metering edges are now being ground and will be plated on the ends to establish the operational clearance. The second flexure is following closely.

2.3 Small amounts of test fixture adaptors and valve covers are yet to be made.

2.4 No work has been done on the gas manifolding and valving in this report period. This is also true of the test panel.

3.0 ANALYTICAL

3.1 Analytical work this period was limited to the study of test data for the valve first stage.

4.0 DESIGN

4.1 No activity needed or performed other than drawing maintenance.

5.0 MANUFACTURE AND TEST

5.1 The two first stage jet pipe and torque motor assemblies have been received, and considerable successful testing has been accomplished as evidenced by the raw data sheets and computations attached.

5.2 Testing so far has been performed on one torque motor assembly to insure consistency of data. The following observations are considered of interest.

5.2.1 The first test consisted of dead ended operation of the first stage only, mounted on a test manifold. The attached data sheet and pressure gain curve shows excellent linearity in the operating region and a higher pressure gain than anticipated. The arbitrary null shows that some adjustment of null is needed to make the performance synmetrical, but to insure data consistency the first stage setting as received from the manufacturer will not be distrubed. The torque motor will be properly nulled on the final valve assembly.

5.2.2 Note the reasonable hysteresis evidenced by the cluster of data points.

5.2.3 The manufacturer's test data specs is included with the data for reference.

5.2.4 Several sheets of computations and conversion factors are included to aid in following Parker's interpretation of test results.

5.2.5 Calibration curves of the flowmeters used are included for reference.

5.2.6 The jet pipe flow gain data accumulated using flowmeter 3625 is included but subject to some question because of later observed flowmeter malfunctions.

5.2.7 Further runs made using Parker flowmeter 3626 and plotted on the curve of 1/27/65 are of considerable interest.

5.2.7 (continued)
The most important factor here is evidence that the assumptions made in the computer analysis for jet pipe characteristics have been substantiated.

Other factors of major importance and evidence of potentially good second stage performance as shown by tests are:

a. Flow from one diaphragm chamber does not materially affect the pressure gain of the other chamber.

b. For a given setting (input to the torque motor) pressure as a function of servo flow is predictable.

c. The effect of supply pressure variation on servo pressure and/or flow is also predictable.

6.0 PROBLEM AREAS

6.1 There have been no major technical problems uncovered in this report period. The valve nulling and pressure recovery characteristics will be explored more fully and may need some final trimming for optimization. We can operate a system using a torque motor of the demonstrated performance.

PARKER AIRCRAFT SYSTEMS & ADVANCED COMPONENTS DIVISION.

DATE 1/2/[illegible] PROJECT 121

ENGINEERING DATA / INSTRUCTIONS

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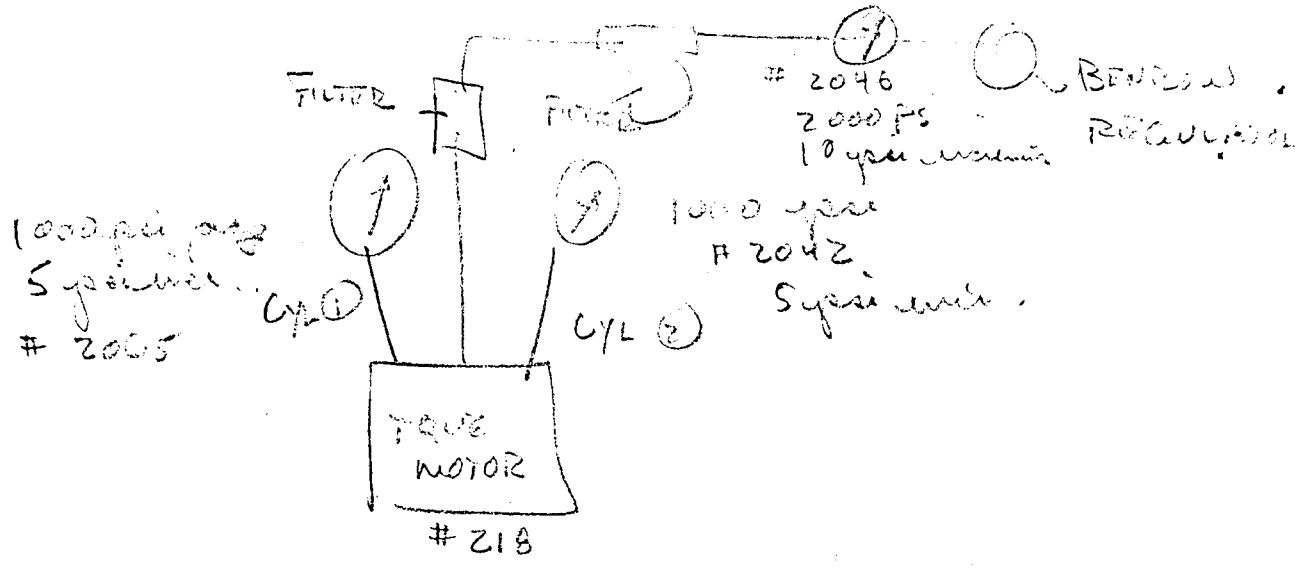

Read ended

15 milliamps scale - Simpson - Millammeter

Parker Amplifier for 121 Project

PR-300 Philbrick Power supply

Mounted on Parker Plate

Only one feedback spring

NOTE: FILE ORIGINAL IN PROJECT ENGINEERING NOTEBOOK.

PAGE OF

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S / to [illegible] psi supply

Millimp.	① Diaphragm	② Diaphragm
3.75	365	382
3.5	383	370
3.7	375	375
3.0	413	343
2.5	455	305
2.0	400	270
1.5	539	225
1.0	573	173
0.0	6	110
-1.0	[illegible]30	50
-1.5	[illegible]37	43
-2.0	650	38
-2.5	650	38
-1.3	645	38
-1.0	638	40
0.0	621	80
1.0	573	170
1.7	543	210
2.3	[illegible]00	256
3.0	[illegible]34	320
3.5	[illegible]75	373
2.0	[illegible]45	260
0.0	[illegible]00	115
2.0	[illegible]04	250
2.0	508	260
1.0	575	187
3.0	426	348
4.0	345	418
5.0	[illegible]60	495
6.2	160	570

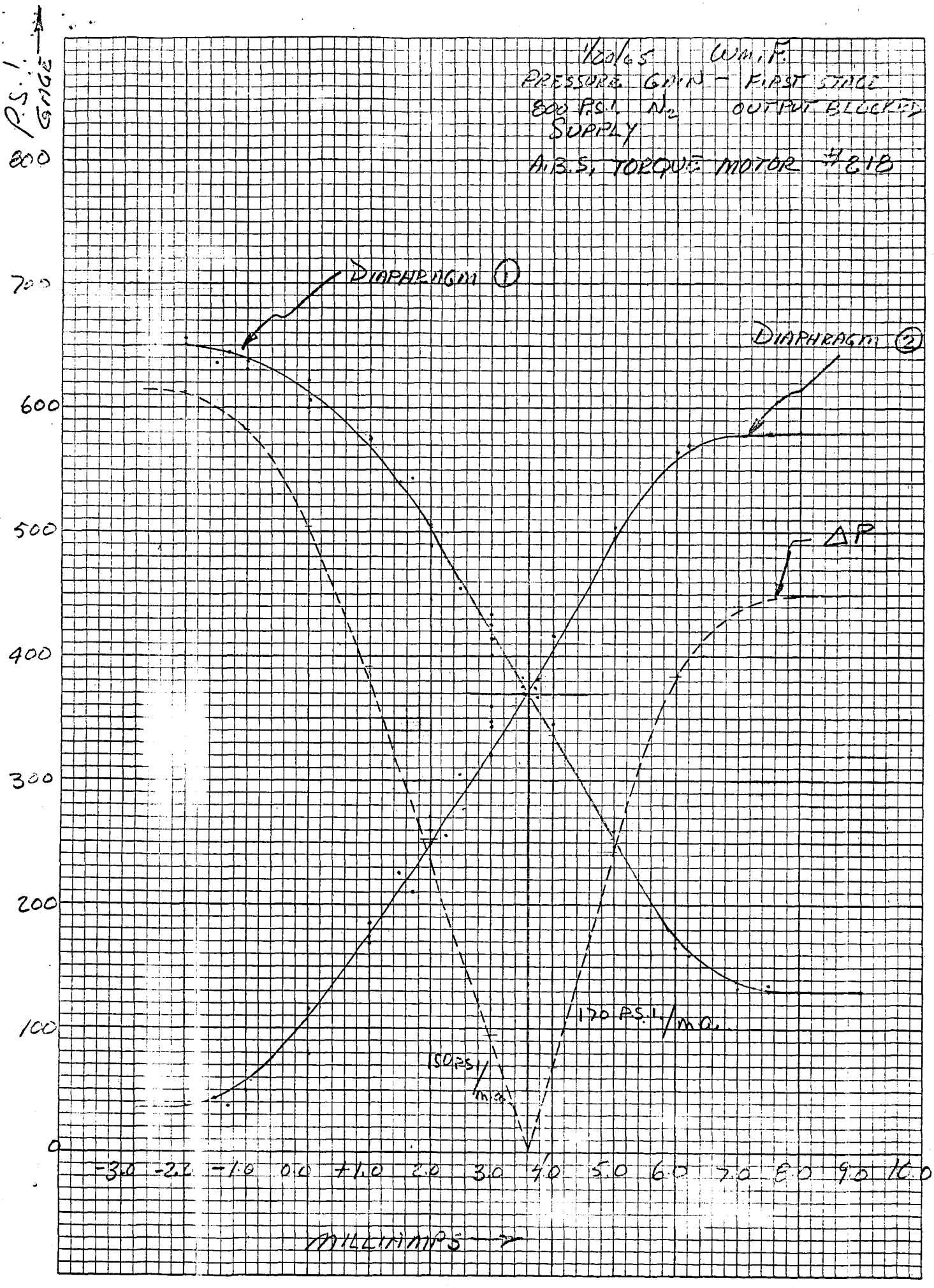
m.a.	①	②
7.5	131	580
8.0	130	580
9.0	130	580
9.0	130	580
8.0	130	580
7.0	132	580
6.0	165	565
5.0	248	503
3.0	400	3[illegible]
2.0	505	260
-2.0	656	3[illegible]
7.5	136	580 INFLECTION

OSCILLATORY INPUTS TO CHECK HYSTERISIS

NOTE: FILE ORIGINAL IN PROJECT ENGINEERING NOTEBOOK.

PAIRCO U21

PAGE OF



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A.B.S. DATA

TEST DATA, 605-1226 SERVOVALVE

CUSTOMER	PARKER AIRCRAFT
TORQUE MOTOR SERIAL NO.	217
SUPPLY PRESSURE	800 PSI
MAX RECOVERY PRESS.	750 PSI
NEUTRAL PRESS	475 PSI
RATED CURRENT	48 MA
PRESSURE GAIN	110 PSI/MA
HYSTERESIS	1.0 MA

Re Tye on Vellum

JAN 22 1965

TEST DATA, 605-1226 SERVOVALVE

CUSTOMER	PARKER AIRCRAFT CO.
TORQUE MOTOR SERIAL No.	218
SUPPLY PRESSURE	800 PSI
MAX. RECOVERY PRESS.	700 PSI
NEUTRAL PRESS.	46 MA
RATED CURRENT	45
PRESSURE GAIN	100
HYSTERESIS	1.4 MA

JAN 22 1965

Handbook

condition $P = 800$ psi gage $= 815$ psi absolute

$T = -250°F$ (460 − 250 = 210° RANKINE)

FROM CHART 210° RANKINE = 117° K (See p 74) plotted on NSA

THEN FOR PRESSURE OF $\frac{815}{15} = 54.3$ ATMOSPHERES.

$Z = \frac{PV}{RT} = \cong 1.00$ p. 71 of handbook

FROM $Z = \frac{PV}{RT} = 1.00 = \frac{(54.3)(V)}{0.6526 \times 117° K}$ p. 69

where $V = FT^3/\#$

$\frac{(1.00)(0.6526)(117)}{54.3} = V = 1.405 \ FT^3/\#$

@ 3.0 #/MIN = 3 × 1.405
= 4.22 FT^3/MIN @ {815 psi absolute, 117° K}

at standard conditions

P = 1.0 atmosphere
V = ?
Z = 0.6526
T = 289° K {page 2A}

then $1.00 = \frac{(1.0)(V)}{(0.6526)(289)}$

or $V = (1.00)(0.6526)(289)$

$= 188.3 \ FT^3/\#$

FOR 3 #/MIN
= (188.3)(3.0)
= 565 FT^3/MIN – STD

FOR .08 #/MIN
= (.08)(188.3)
= 15.1 [illegible]/MIN

1/07/65

Check computation for obtaining mat. flow

3.0 lbs/min of H_2 mat. flow per hr. S.T.C. spec

$$\frac{\frac{\#}{MIN}}{\frac{SEC}{MIN}} \times 1.15 \times 10^4$$

$$\left(\frac{3.0}{60}\right)(1.15) \times 10^4 = 575 \text{ FT}^3/\text{MIN OF } H_2$$

$$\text{S.C.F.M. } N_2 = (575)(.269)$$

$$= 214 \text{ FT}^3/\text{MIN OF } N_2$$

EQUIVALENT FLOW AND FLOW UNIT CONVERSIONS FOR GASES

MULTIPLY NUMBER OF → / BY / TO OBTAIN ↓	SCFM N_2	SCFM He	SCFM H_2	#/SEC N_2	#/SEC He	#/SEC H_2	SCC/SEC N_2	SCC/SEC He	SCC/SEC H_2	SCIM N_2	SCIM He	SCIM H_2
SCFM N_2	1	3.79×10^{-1}	2.69×10^{-1}	8.28×10^{2}	2.2×10^{3}	3.1×10^{3}	2.12×10^{-3}	8.04×10^{-4}	5.71×10^{-4}	5.79×10^{-4}	2.19×10^{-4}	1.56×10^{-4}
SCFM He	2.64	1	7.1×10^{-1}	2.19×10^{3}	5.8×10^{3}	8.18×10^{3}	5.6×10^{-3}	2.12×10^{-3}	1.51×10^{-3}	1.53×10^{-3}	5.79×10^{-4}	4.11×10^{-4}
SCFM H_2	3.72	1.41	1	3.08×10^{3}	8.18×10^{3}	1.15×10^{4}	7.89×10^{-3}	2.99×10^{-3}	2.12×10^{-3}	2.16×10^{-3}	8.16×10^{-4}	5.79×10^{-4}
#/SEC N_2	1.21×10^{-3}	4.54×10^{-4}	3.22×10^{-4}	1	2.64	3.72	2.56×10^{-6}	9.74×10^{-7}	6.9×10^{-7}	7.0×10^{-7}	2.65×10^{-7}	1.89×10^{-7}
#/SEC He	4.57×10^{-4}	1.73×10^{-4}	1.22×10^{-4}	3.79×10^{-1}	1	1.41	9.68×10^{-7}	3.67×10^{-7}	2.61×10^{-7}	2.64×10^{-7}	1.0×10^{-7}	7.1×10^{-8}
#/SEC H_2	3.25×10^{-4}	1.23×10^{-4}	8.7×10^{-5}	2.69×10^{-1}	7.1×10^{-1}	1	6.86×10^{-7}	2.6×10^{-7}	1.85×10^{-7}	1.88×10^{-7}	7.1×10^{-8}	5.04×10^{-8}
SCC/SEC N_2	4.72×10^{2}	1.78×10^{2}	1.27×10^{2}	3.9×10^{5}	1.028×10^{6}	1.45×10^{6}	1	3.79×10^{-1}	2.69×10^{-1}	2.73×10^{-1}	1.04×10^{1}	7.35×10^{-2}
SCC/SEC He	1.24×10^{3}	4.72×10^{2}	3.34×10^{2}	1.032×10^{6}	2.73×10^{6}	3.83×10^{6}	2.64	1	7.1×10^{-1}	7.20×10^{-1}	2.73×10^{-1}	1.95×10^{-1}
SCC/SEC H_2	1.75×10^{3}	6.63×10^{2}	4.72×10^{2}	1.46×10^{6}	3.84×10^{6}	5.44×10^{6}	3.72	1.41	1	1.02	3.83×10^{-1}	2.73×10^{-1}
SCIM N_2	1.728×10^{3}	6.55×10^{2}	4.65×10^{2}	1.43×10^{6}	3.80×10^{6}	5.35×10^{6}	3.66	1.39	9.85×10^{-1}	1	3.79×10^{-1}	2.69×10^{-1}
SCIM He	4.56×10^{3}	1.728×10^{3}	1.23×10^{3}	3.79×10^{6}	1.0×10^{7}	1.41×10^{7}	9.66	3.66	2.6	2.64	1	7.1×10^{-1}
SCIM H_2	6.43×10^{3}	2.44×10^{3}	1.728×10^{3}	5.32×10^{6}	1.41×10^{7}	1.98×10^{7}	1.36×10	5.14	3.66	3.72	1.41	1

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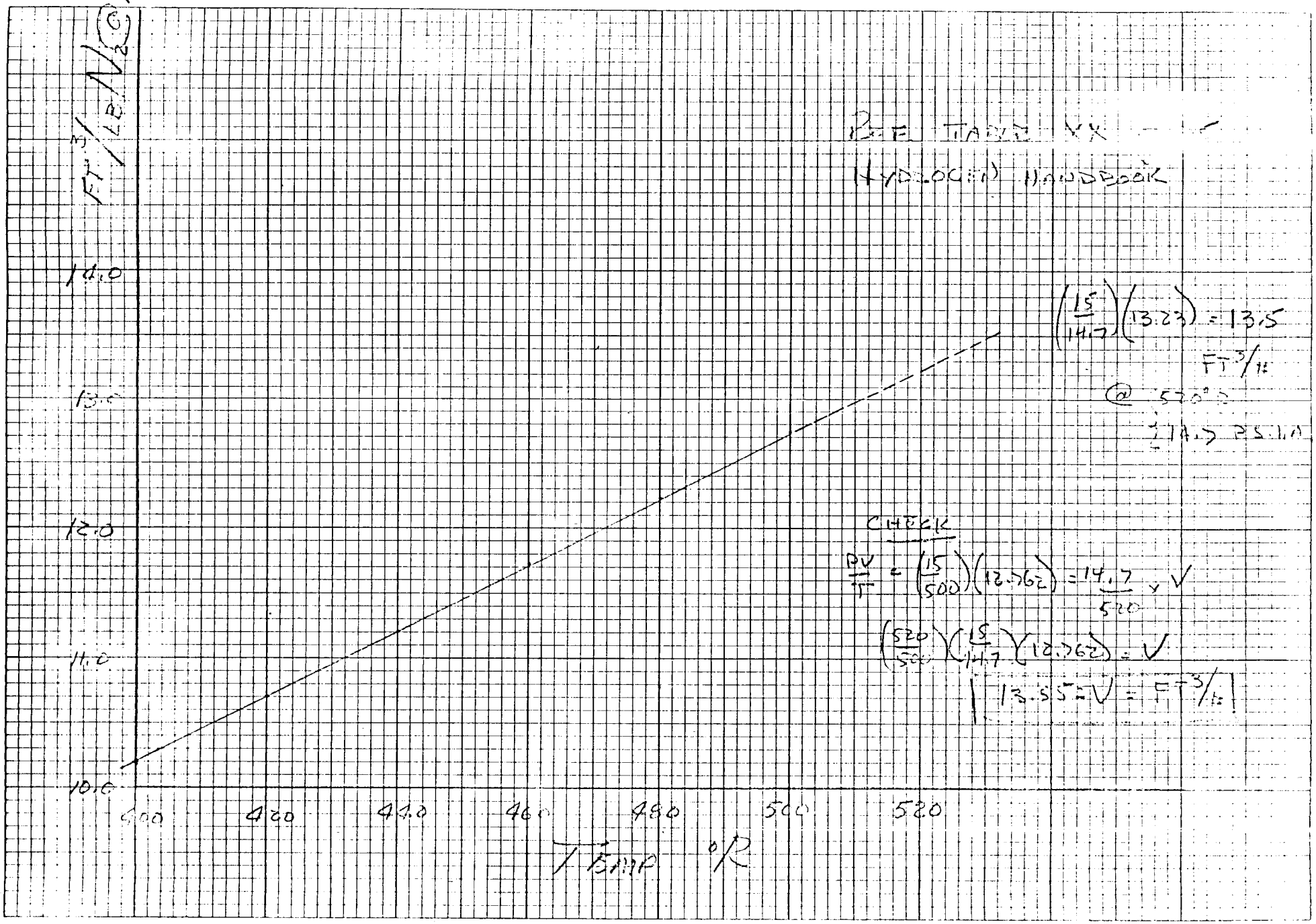

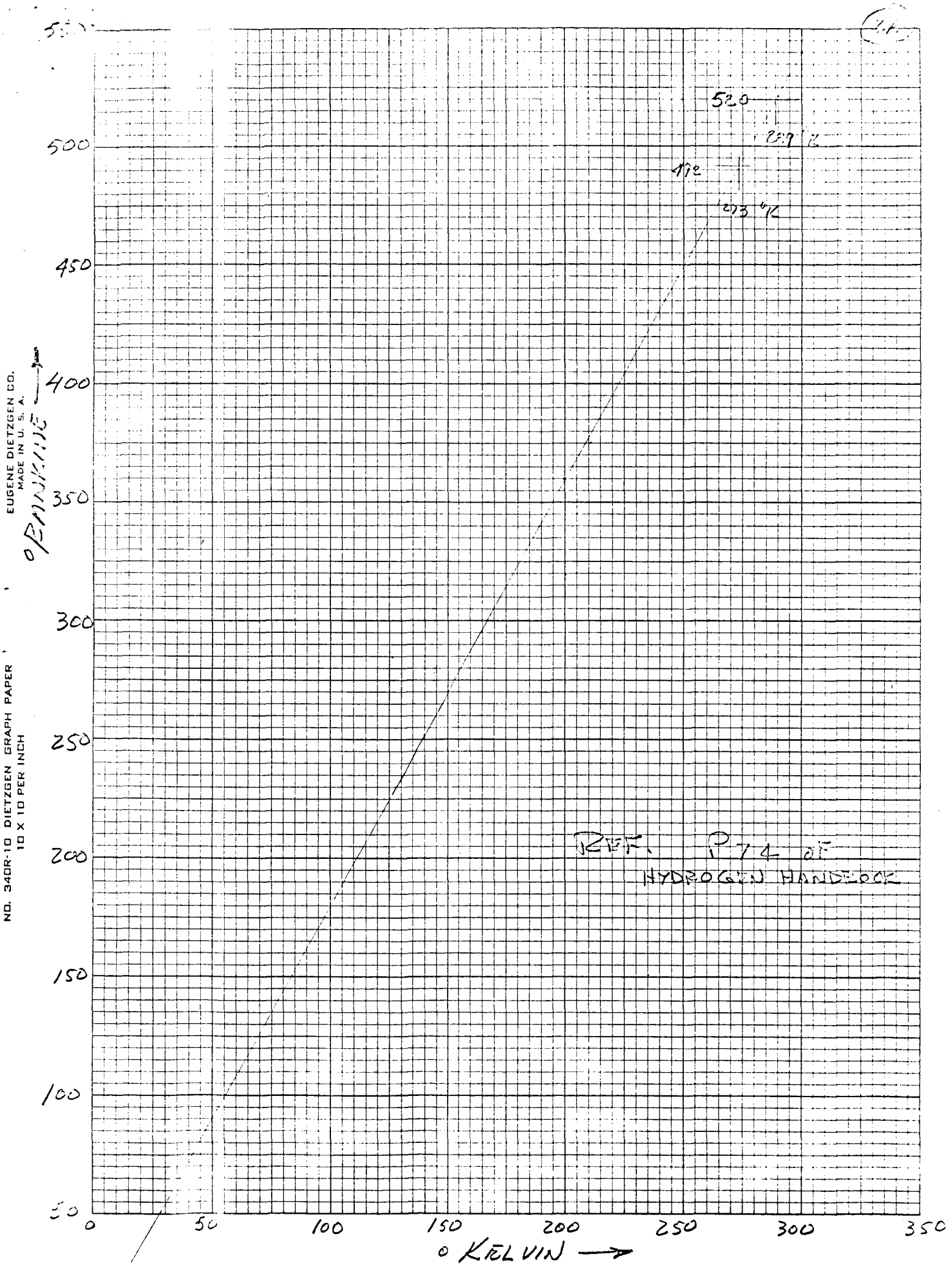

520
500
450
400
350
300
250
200
150
100
50
0
50
100
150
200
250
300
350
° RANKINE
° KELVIN
REF. P74 OF
HYDROGEN HANDBOOK
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at 1[illegible]3 $FT^3/\#$ for Hydrogen.

and 13.55 $FT^3/\#$ for N_2

$\{.08\}\{188.33\} = 15.1$

$\frac{\#}{MIN} \times \frac{FT^3}{\#} = \frac{FT^3}{MIN}$

quiescent flow $= \left\{\frac{13.55}{188.33}\right\}\{15.1\}$

$= 1.085\ FT^3/MIN$ of N_2

for each side $q = \frac{1.085}{2} = .543\ FT^3/MIN$

$1\ c.c. = .061023\ IN^3$

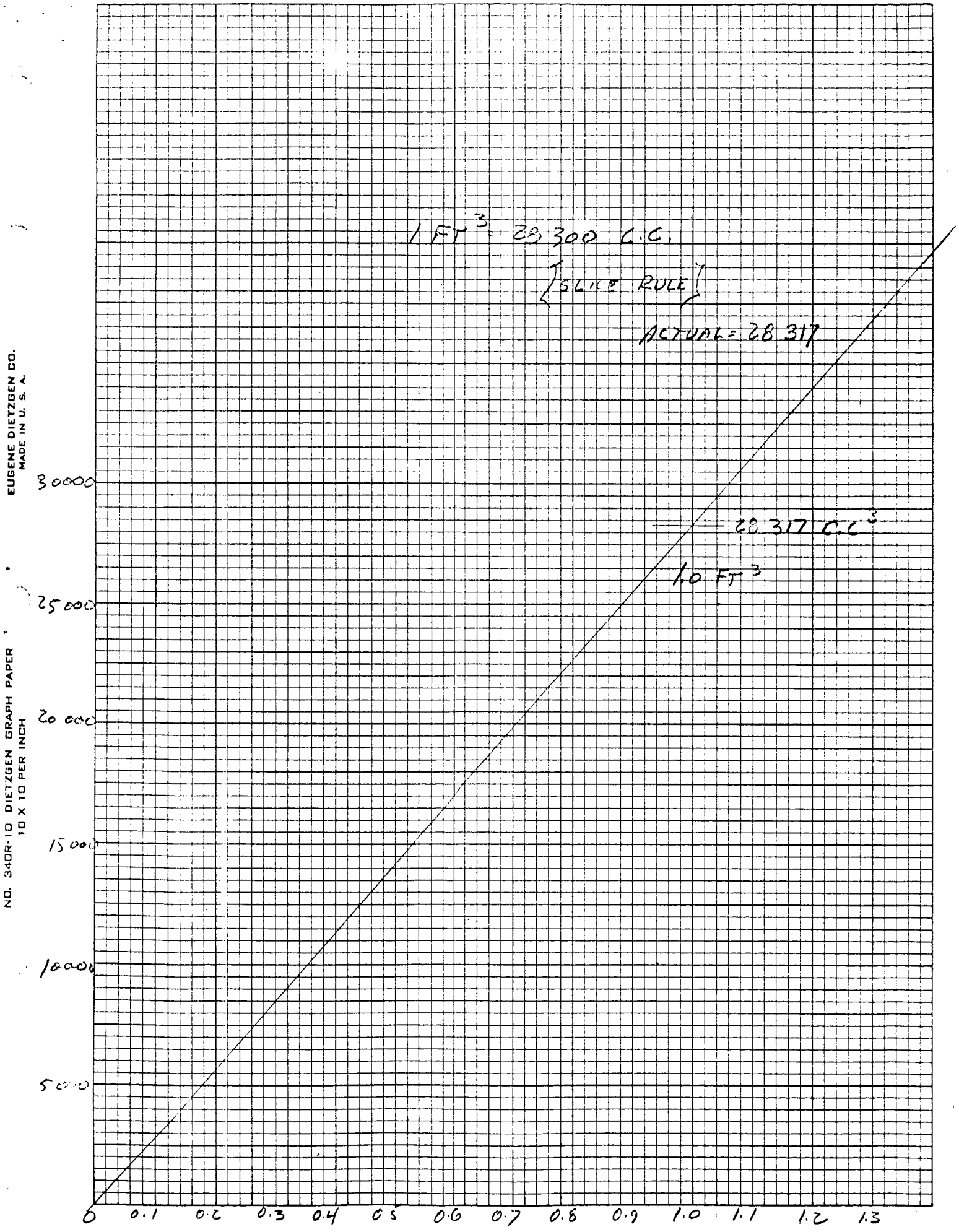
$1\ c.c. = \frac{.061023}{1728} = .00003535\ FT^3$ $\{.0[illegible]\}$

$\therefore 28300\ c.c. = 1\ FT^3$

(28,317)

therefore flowmeter should read max. of

$\boxed{1(.543)(28300) = 15400\ c.c./MIN}$ per side


1 FT³ = 28 300 C.C.
SLIDE RULE
ACTUAL = 28 317
28 317 C.C³
1.0 FT³
30000
25000
20000
15000
10000
5000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
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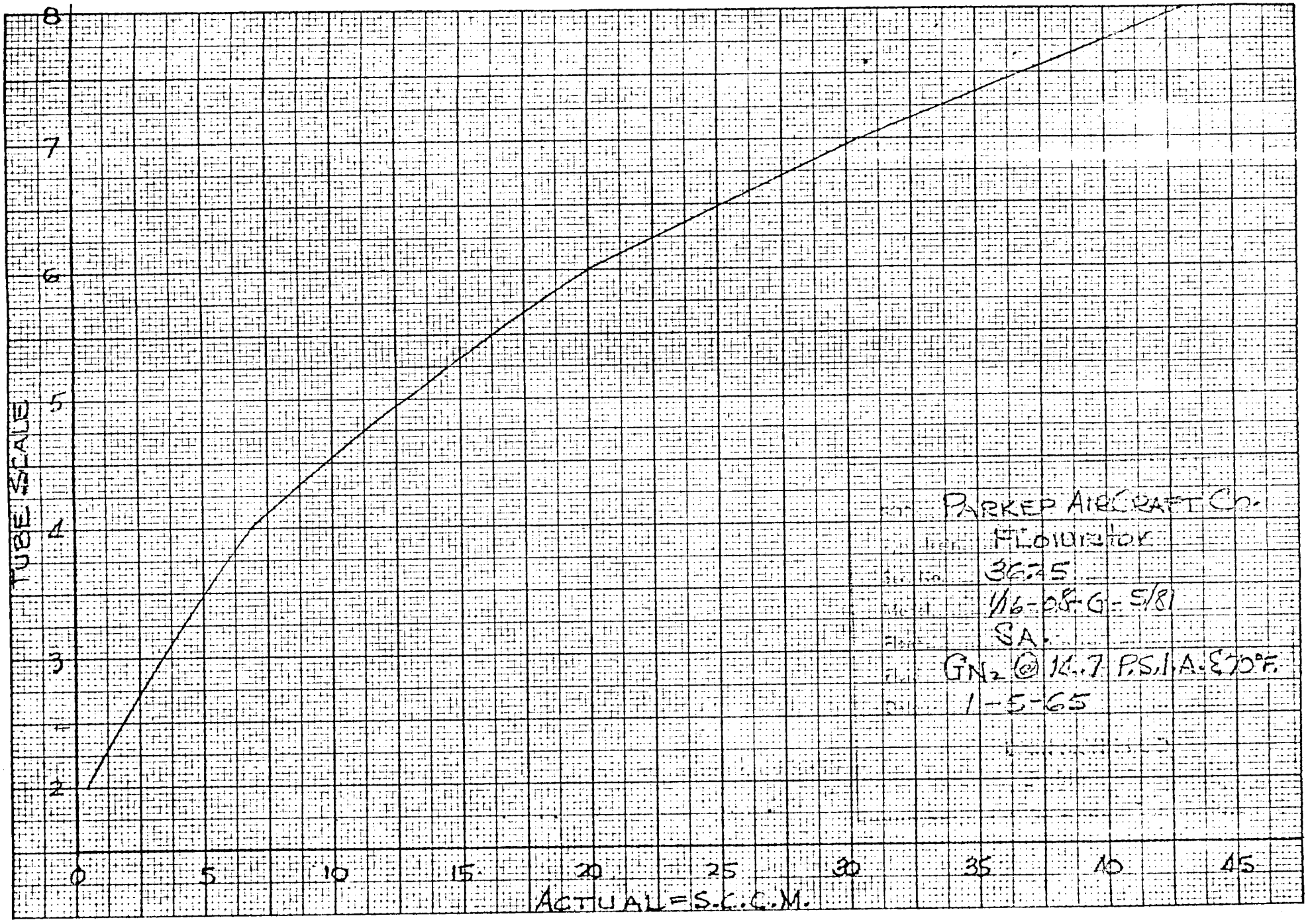

3625

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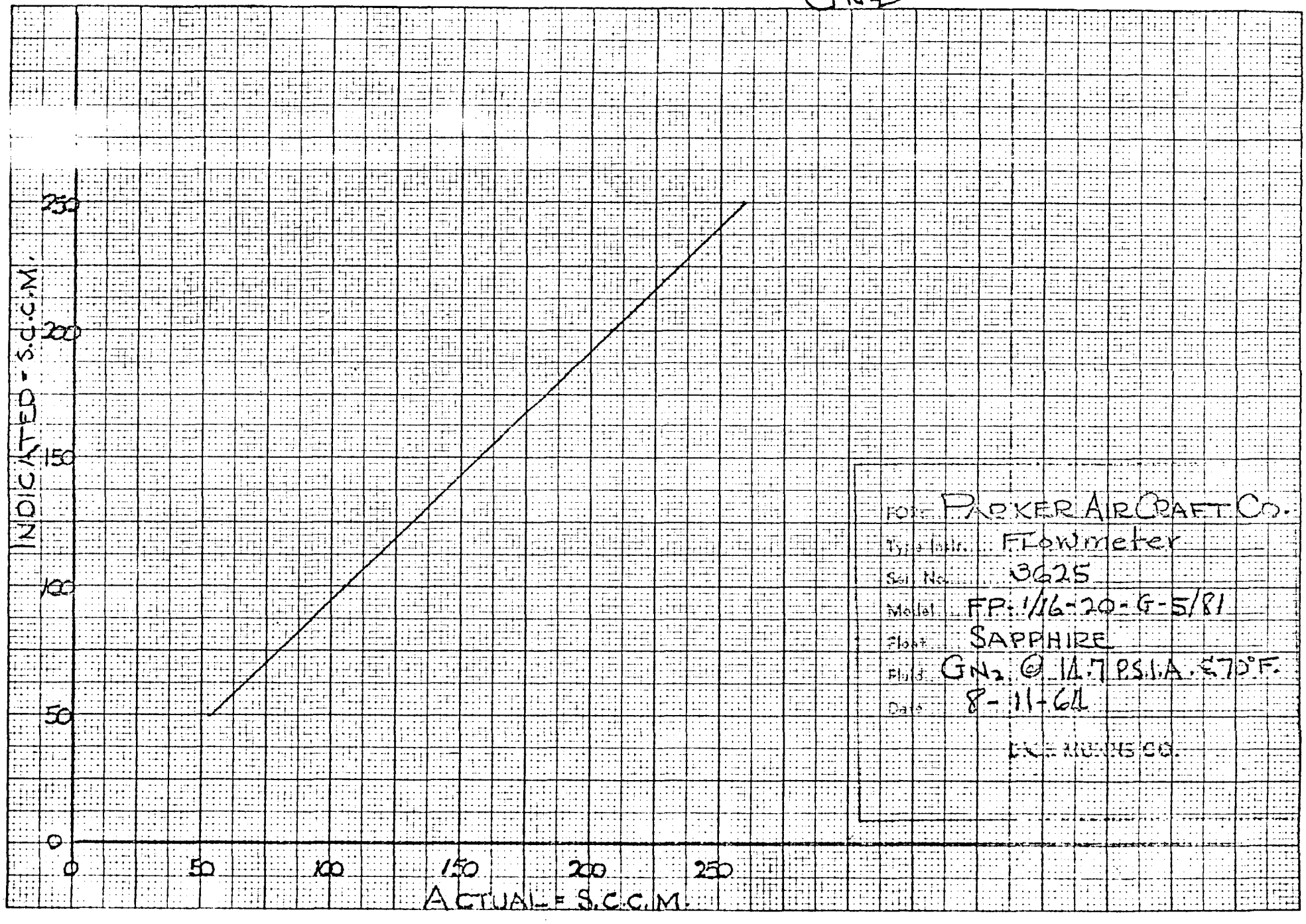
7 X 10 INCHES
KEUFFEL & ESSER CO.

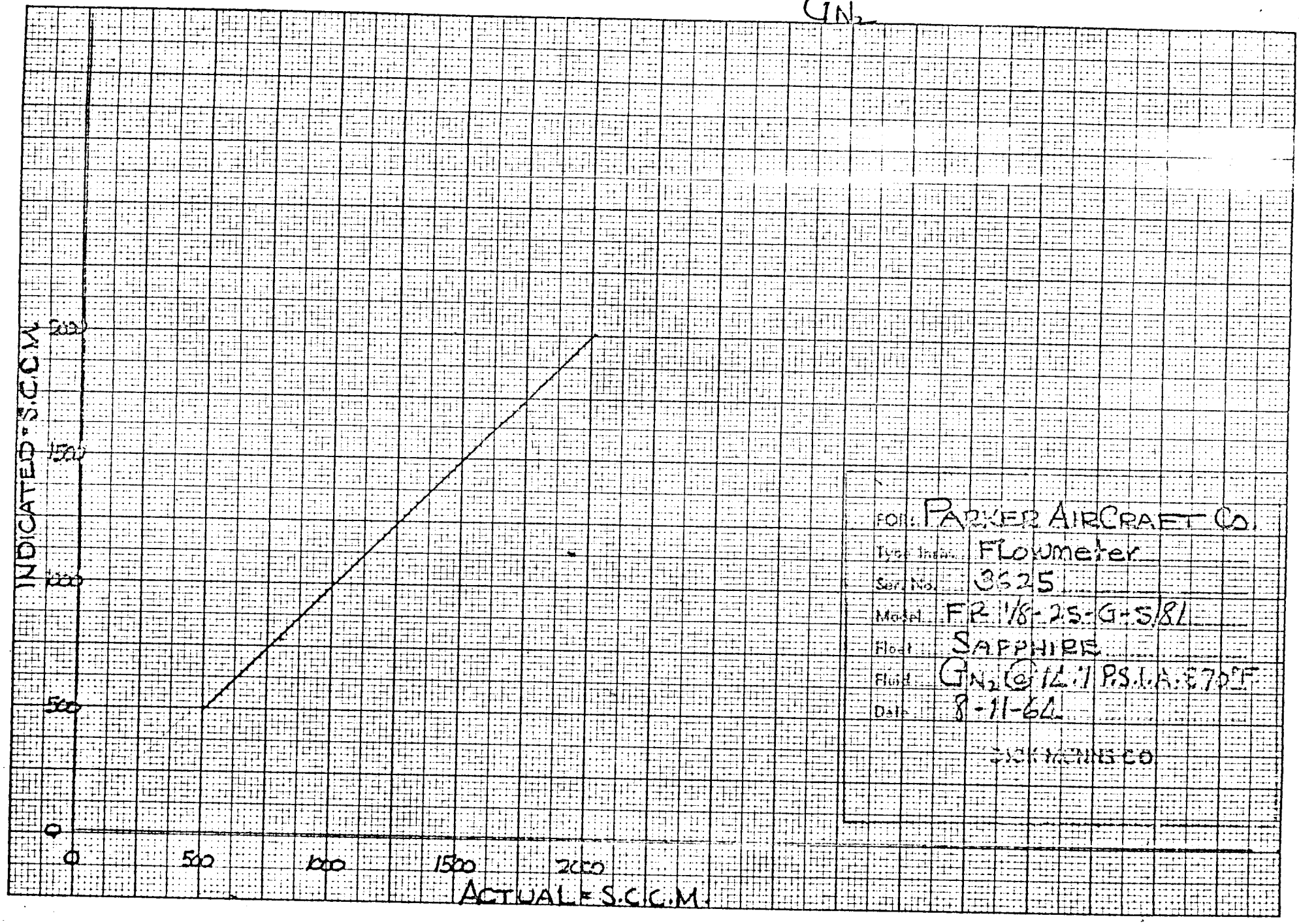
GN_2



K+E 46 1323
KEUFFEL & ESSER CO.

3625

GN_2



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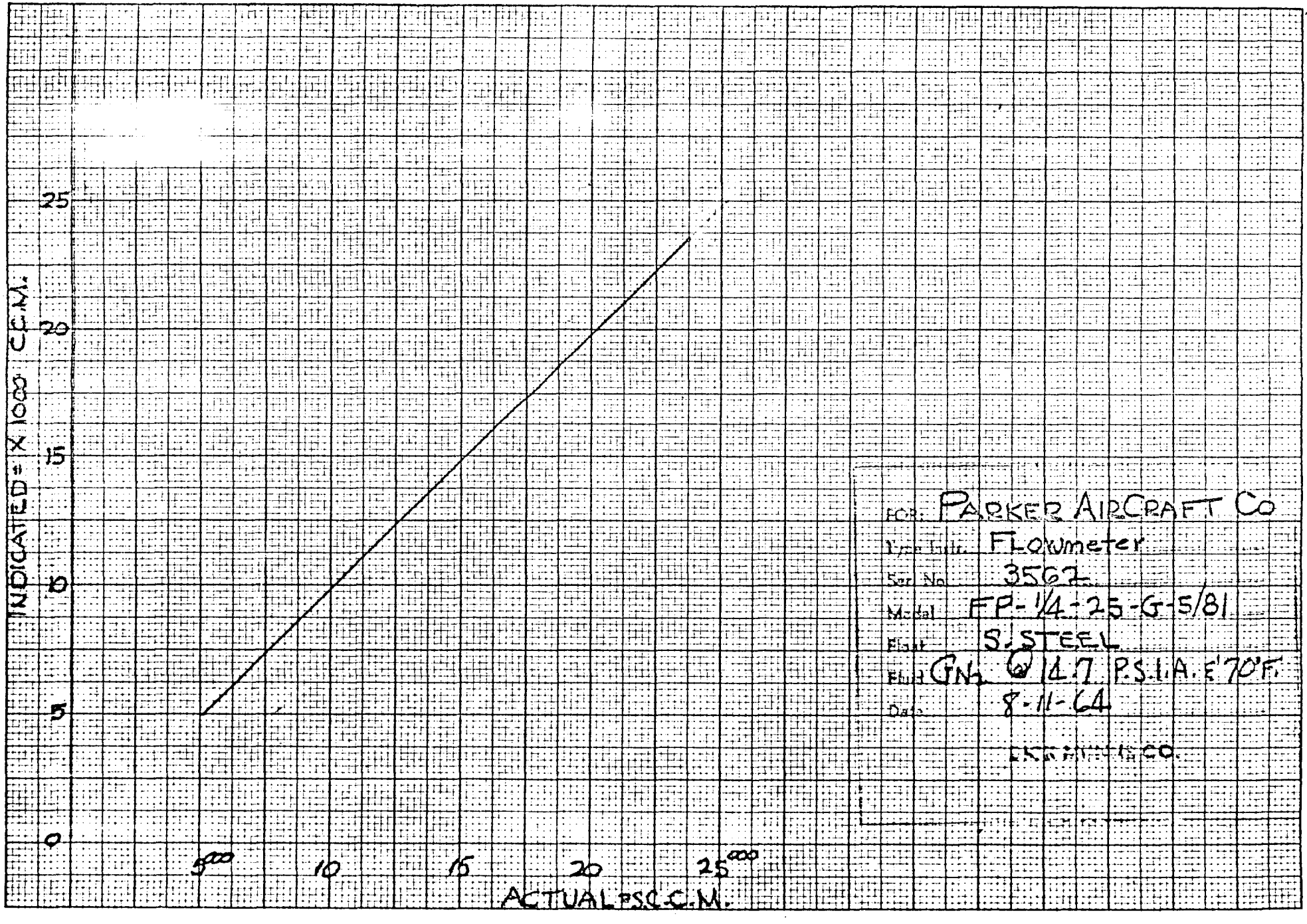

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DATE 1/25/65

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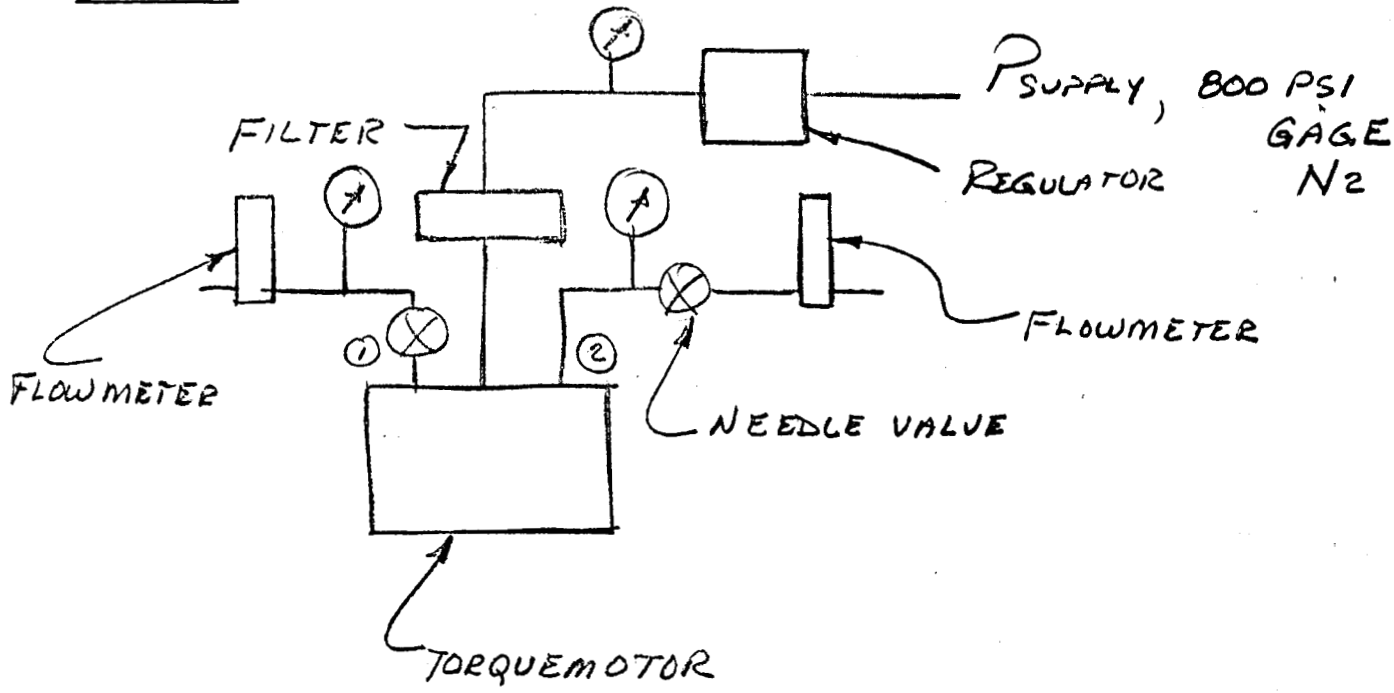

REFER TO TEST OF 1/20/65 FOR STATIC GAIN

TORQUE MOTOR A.B.S. #218

SUPPLY GAGE 2046 2000 P.S.I., 10 P.S.I. DIVISIONS
GAGE ① 2065 1000 PSI 5 PSI DIVISIONS
GAGE ② 2042 1000 PSI 5 PSI DIVISIONS
TORQUE MOTOR 605-1226 SERIAL # 218
FLOWMETER - SERIAL NO 3625, CALIBRATION ATTACHED
SIMPSON 1[illegible] M.A. AMMETER
BENBOW [illegible]ULATOR

FIRST STAGE
FLOW GAIN TESTS

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SERVO VALVE

FIRST STAGE FLOW GAIN

FLOW METER #3625

RUN	PRESSURE ①	PRESSURE ②	INDICATED FLOW ①	INDICATED FLOW ②	NOTES	CORRECTED FLOW ①	CORRECTED FLOW ②	PRESSURE ①	PRESSURE ②	INDICATED FLOW ①	INDICATED FLOW ②	NOTES	CORRECTED FLOW ①	CORRECTED FLOW ②
	370	360	—	—	3.75 m.A.	—	—	590	155	—	—	1.0 m.A.		s.c.c.m.
	303	415	—	—	4.50 m.A.			590	150	—	2	Scale #1		0.5
	508	210	—	—	3.00 m.A.			590	150		3	#1		3.5
	348	375	—	—	4.00 m.A.		s.c.c.m	586	150		5	#1		13.0
	345	382	—	3.0	SCALE #1		3.5	585	150		8	#1		43.0
	345	382	—	4.0			7.0	583	30		3	#4		~
	340	395	—	5.0			13.0	580	80		23	#3		~
	348	383	—	4.5	RESET * AMMETER		9.75	580	95		20	#3		2000
	348	380	—	4.0			7.0	580	105		17	#3		1700
	348	380	—	5.0			13.0	580	110		15	#3		1500
	345	380	—	6.0			20.0	580	125		10	#3		1000
	345	380	—	7.0			30.5	585	155		2	#3		~
	343	380	—	8.0			43.0							
	320	35	—	8.0	SCALE #4		8500							
	320	100	—	7.3	#4		8000							
	320	160	—	6.3	#4		7000							
	320	210	—	5.0	#4		5000							
	330	225	—	3.0	#4		~							
	335	320	—	2.0	#4		~							
	315	315	—	23	Scale #3		~							
	337	322	—	17.5	Scale #3		1750							
	340	324	—	12.5	#3		1250							
	340	350	—	10.0	#3		1000							

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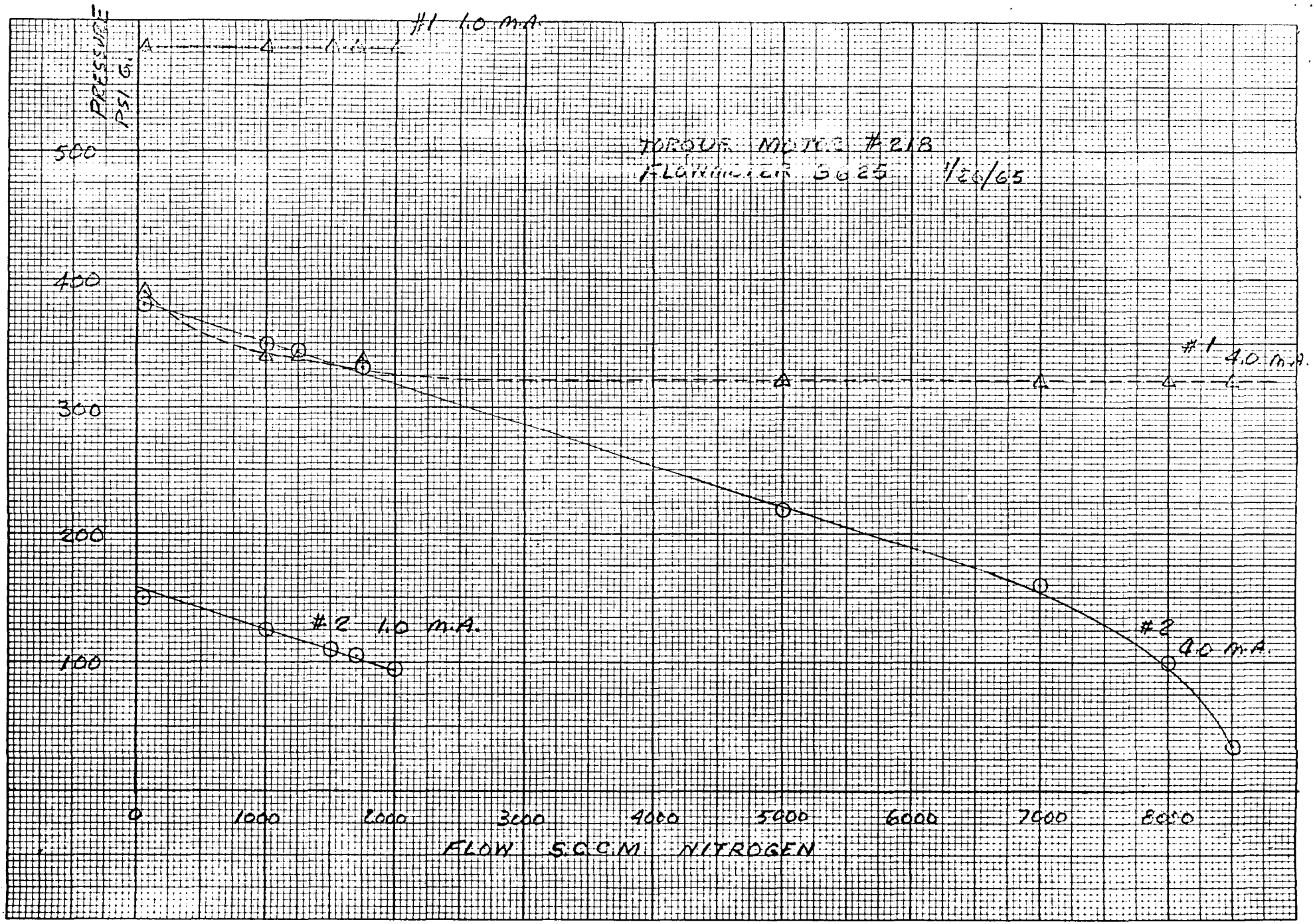


121 PROGRAM

SERVO VALVE FLOW GAIN - FIRST STAGE

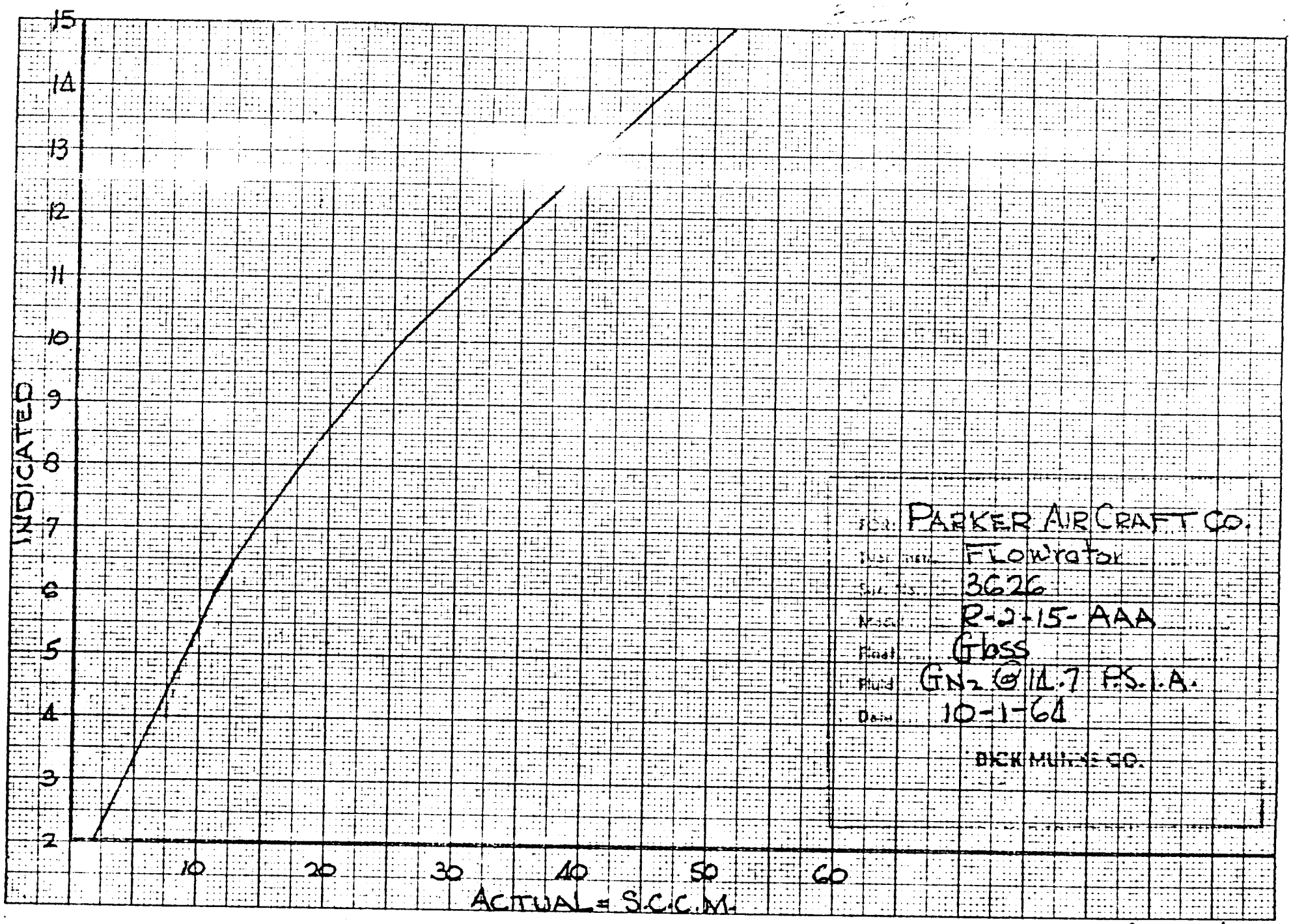
VALVE 605-1226 SERIAL # 218 FLOW METER #3626

RUN	M.A.	① PRESSURE	② PRESSURE	METER SCALE	INDICATED FLOW	CORR. FLOW	M.A.	① PRESSURE	② PRESSURE	METER SCALE	INDICATED FLOW	CORR. FLOW
	3.75	365	370	—		—	-2.0	683	30	—	—	—
	3.75	345	380	FIRST SC. SECOND BALL	4.0	42 S.C.C.M		683	30	#2 #1	1.0	—
	3.75	355	365	—	—	—		685	28	#1	2.0	—
	3.75	370	350	#2 FIRST BALL #2	2.0	—		675	25	#1	3.0	450
	3.75	365	355	BALL #1 #2				675	20		4.0	750
		357	352	#1	2.5	—	-2.0	670	15	#1	5.0	1050
		355	355	#1	3.5	600 SCCM						
		348	340	#1	6.0	1325						
		345	340	#1	6.0	1325	+8.0	128	532	—	—	—
		340	330	#1	9.0	1975		128	528	#2 #1	1.0	
METER SHIFTED		~~355~~	~~328~~	~~#1~~	~~10.0~~			128	525	#1	2.0	—
		350	320	#1	9.0	1975		128	516	#1	3.0	450
		345	305	#1	12.0	2225		127	510	#1	4.0	750
		340	200	#1	14.0	2350		125	500	#1	6.0	1325
		340	180	#2	4.8	3050		125	495	#1	7.0	1525
		330	165	#2	5.0	3150		125	483	#1	9.0	1875
		350	238		7.0	4150		125	480	#1	11.5	2175
		346	220		8.0	4550		125	477	#1	13.0	2300
		345	200		9.0	5000		125	465	#2	4.0	2600
		340	180		10.5	5600		123	440	#2	5.5	3225
		338	155		12.0	6200		122	410	#2	7.5	4175
		335	135		13.0	6550		118	380	#2	10.0	5450
		335	115		14.0	6925		117	365	#2	11.0	5900
		335	105	#2	? 15.0	7250		117	350	#2	12.5	6450
								117	335	#2	14.0	6975
	+1.0	595	155	—	—	—		125	532	#3 —	—	Check
		595	150	#2 #1	1.0	—		120	473	#3 #1	2.0	—
		595	143	#2 #1	2.0	—		115	320	#1	5.0	.265 SCFM 7500 SCCM
		596	135		3.0	450		110	270		6.0	325 SCFM 9200 SCCM
		595	128		4.0	750		105	185		7.0	.38 SCFM 10730 SCCM
		595	117		7.0	1525		100	105		7.8	.43 SCFM 12150 SCCM
			100		10.0	2050		98	60		8.0	.47 SCFM 12420 SCCM
			87		12.5	2250						
			76	#2	3.5	2300						
			62	#2	4.0	2600						
			40	#2	5.0	3150						
			30	#2	5.3	3350						

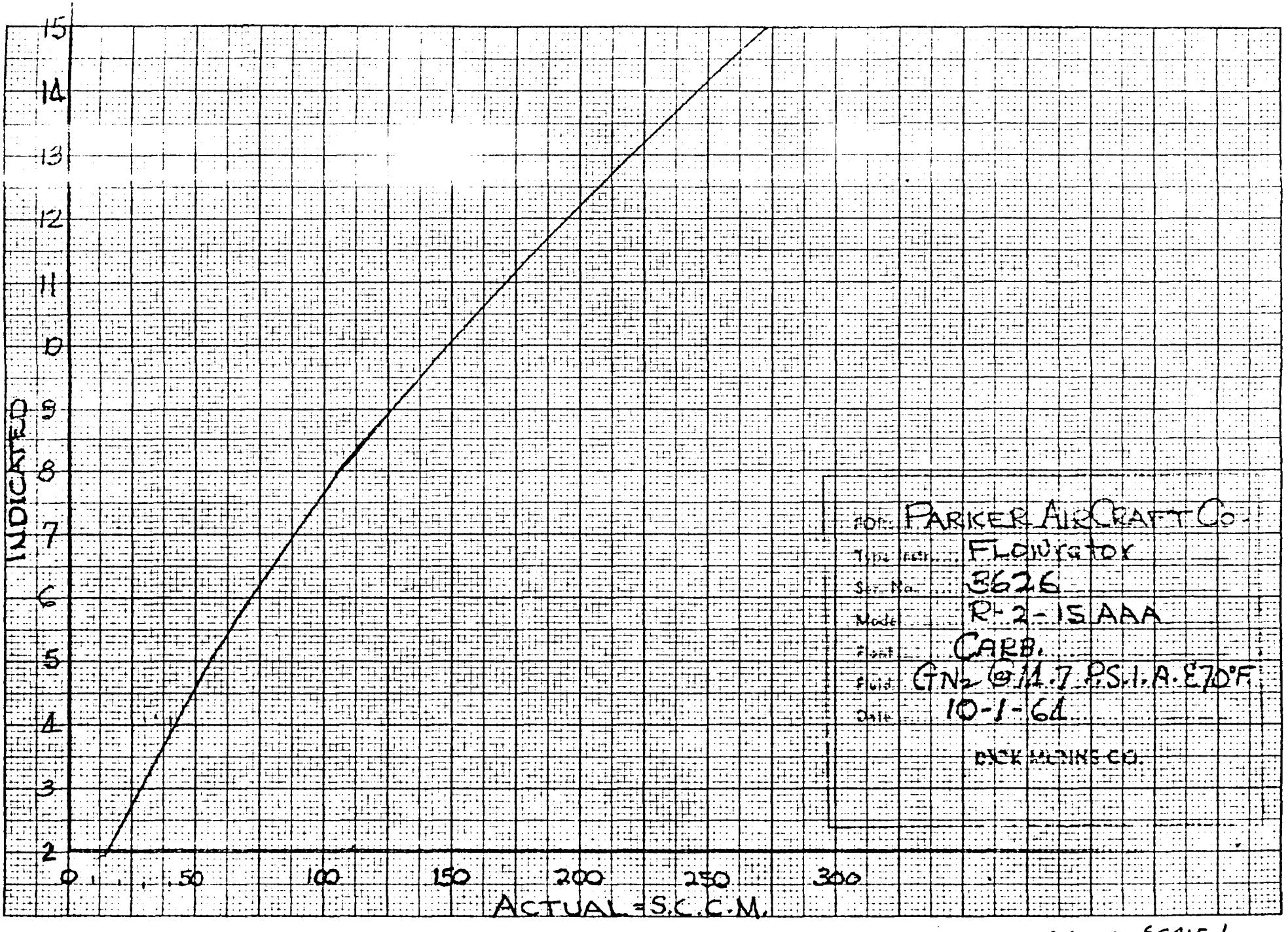
$(4.72)(10^2)(60) \times SCFM = SCCM$

$\boxed{28320 \times SCFM = SCCM}$

KEUFFEL & ESSER CO.

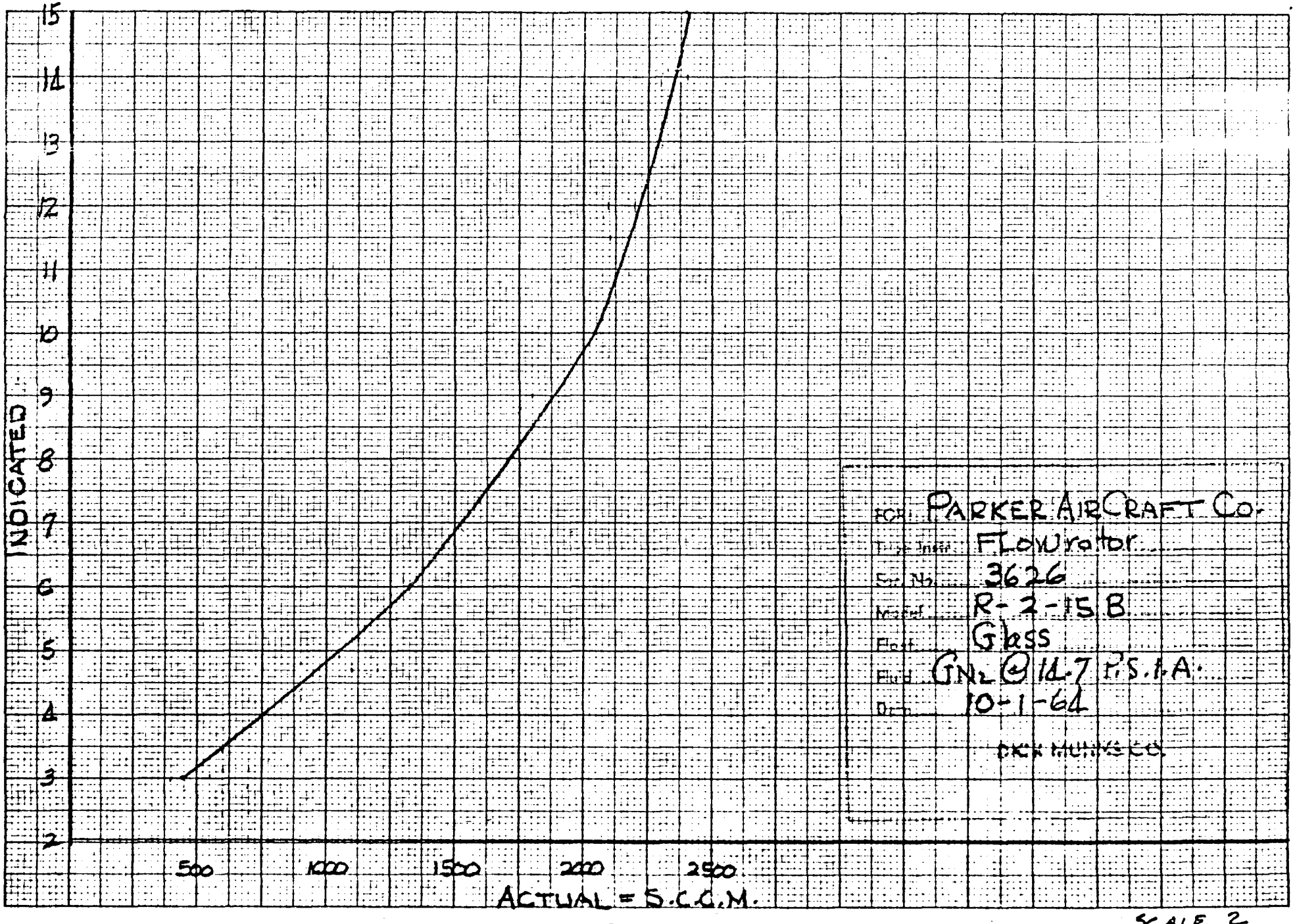


SCALE 1
3626 BALL 1



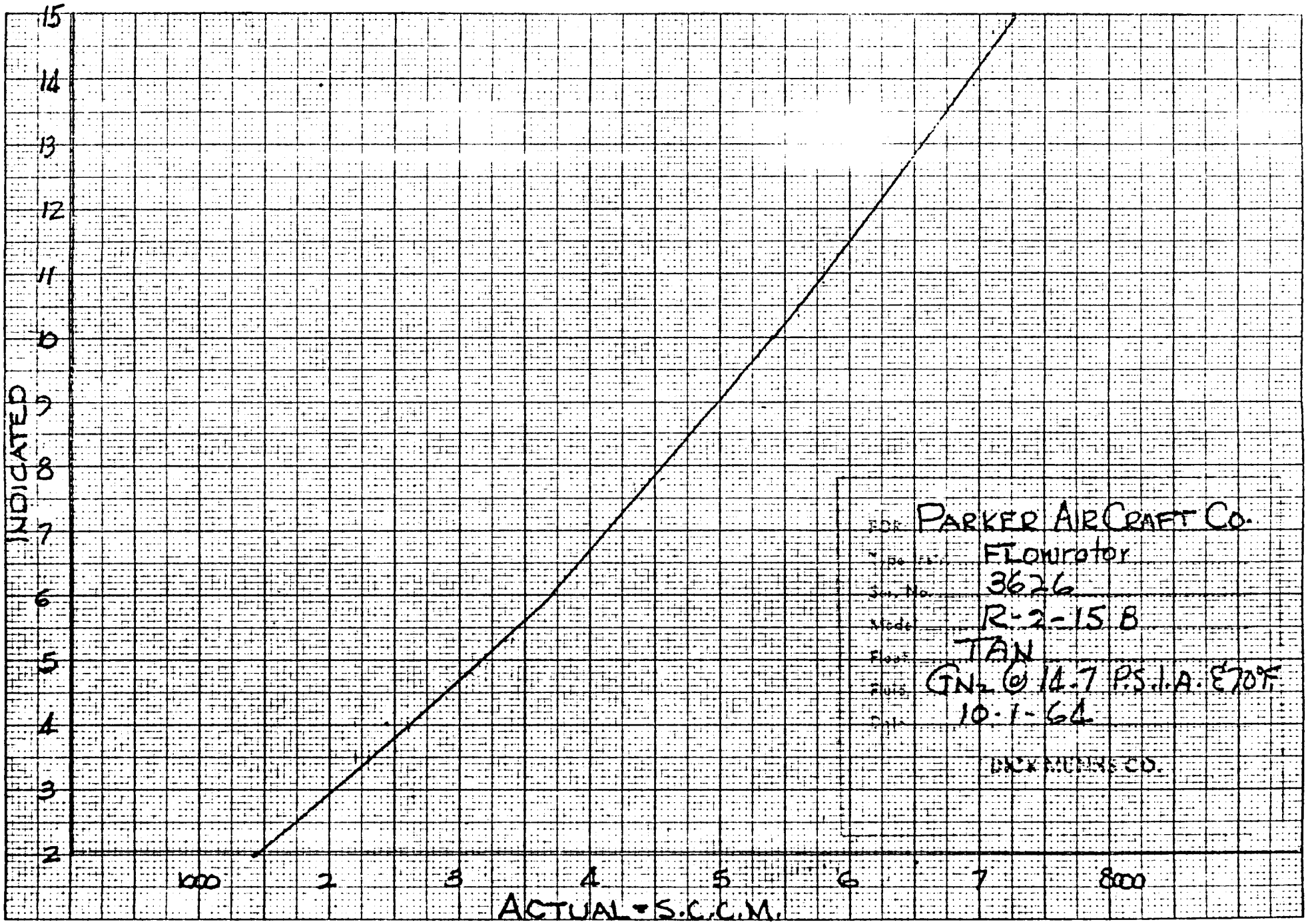
3626 SCALE 1
BALL 2

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



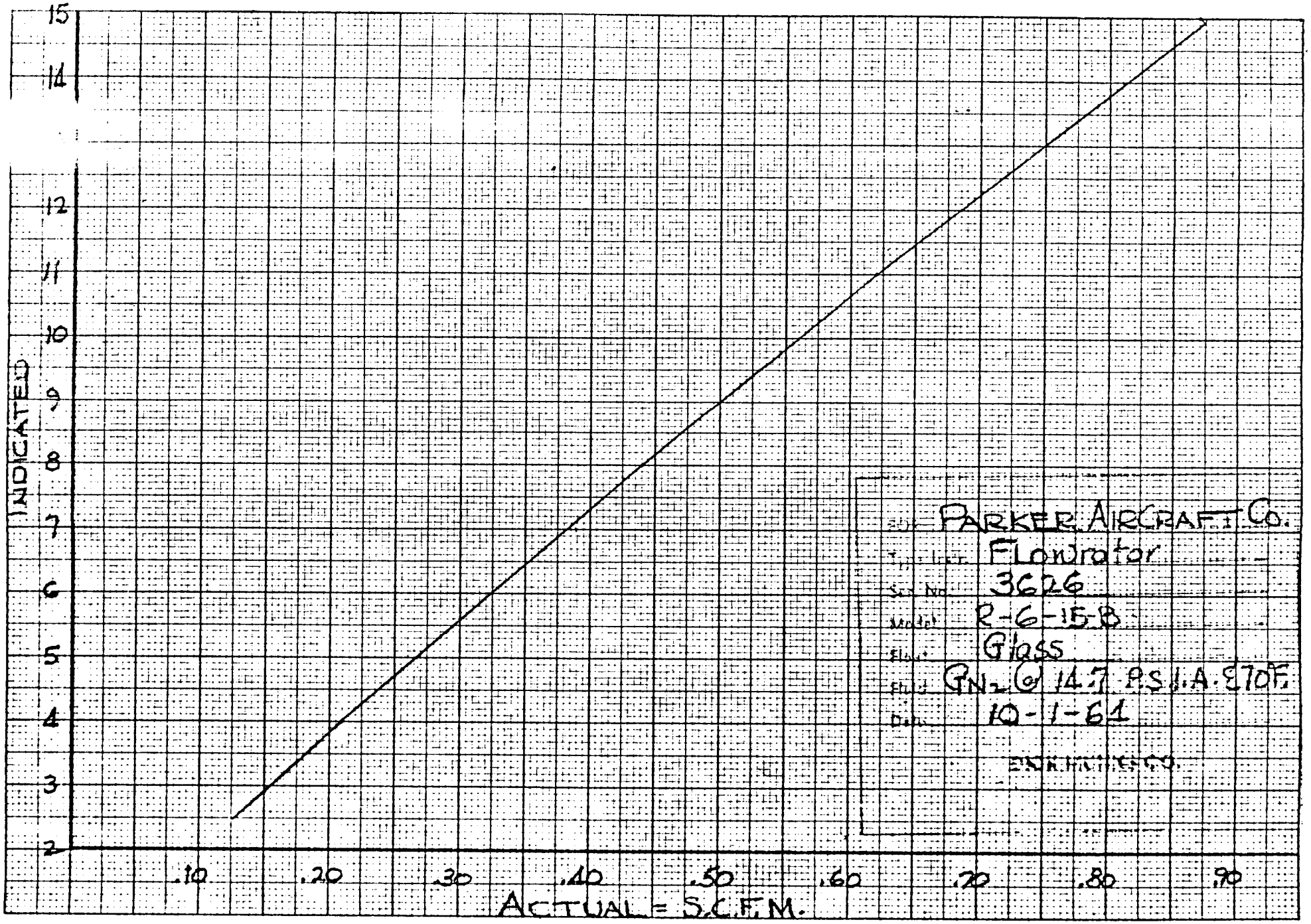
3626 SCALE 2
BALL 1

K+E 10 X 10 TO THE INCH 7 X 10 INCHES
KEUFFEL & ESSER CO.

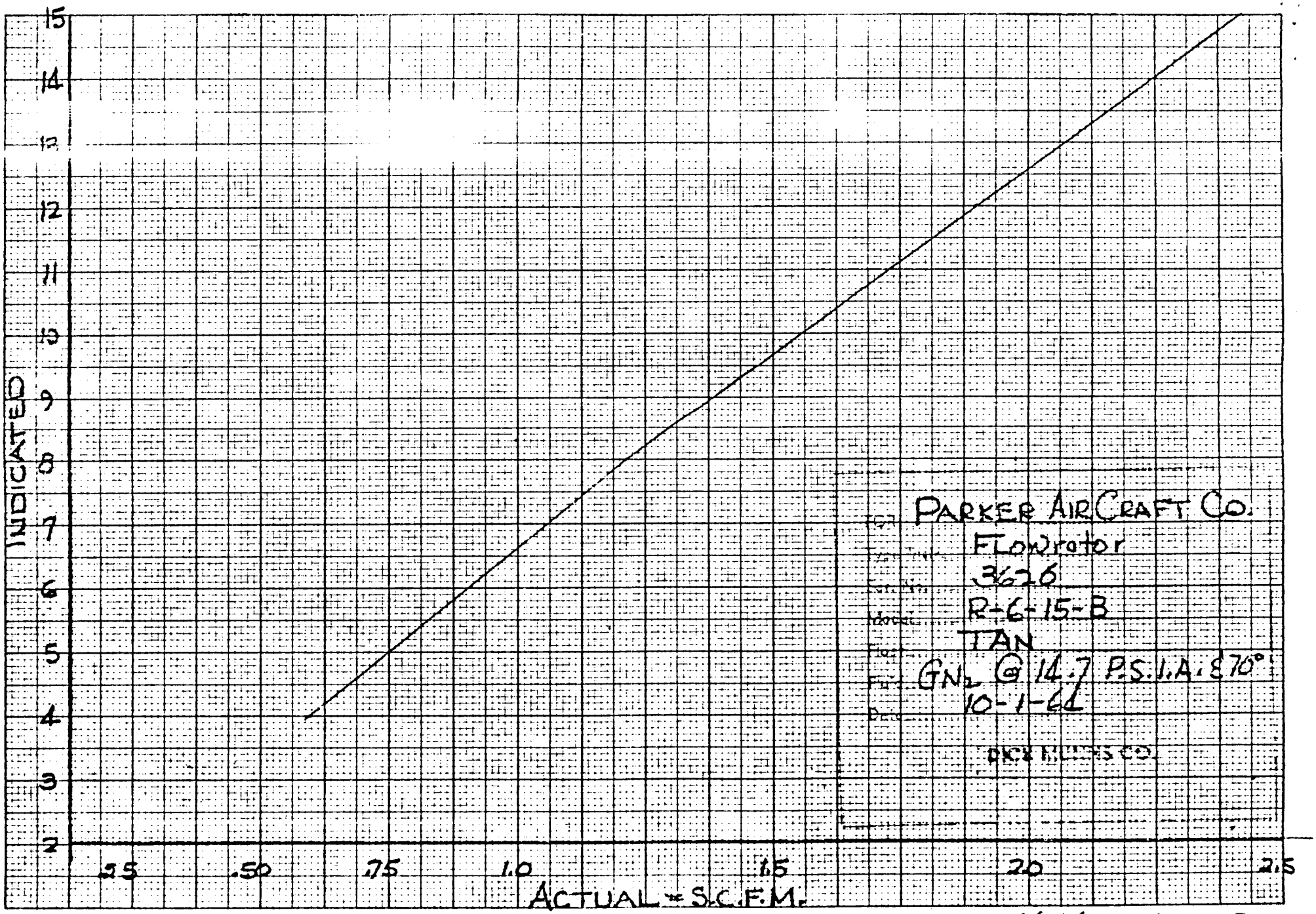


3626 SCALE 2
BALL 2

K+E 10 X 10 7 X 10
KEUFFEL & ESSER CO.



3626 SCALE 3 BALL 1

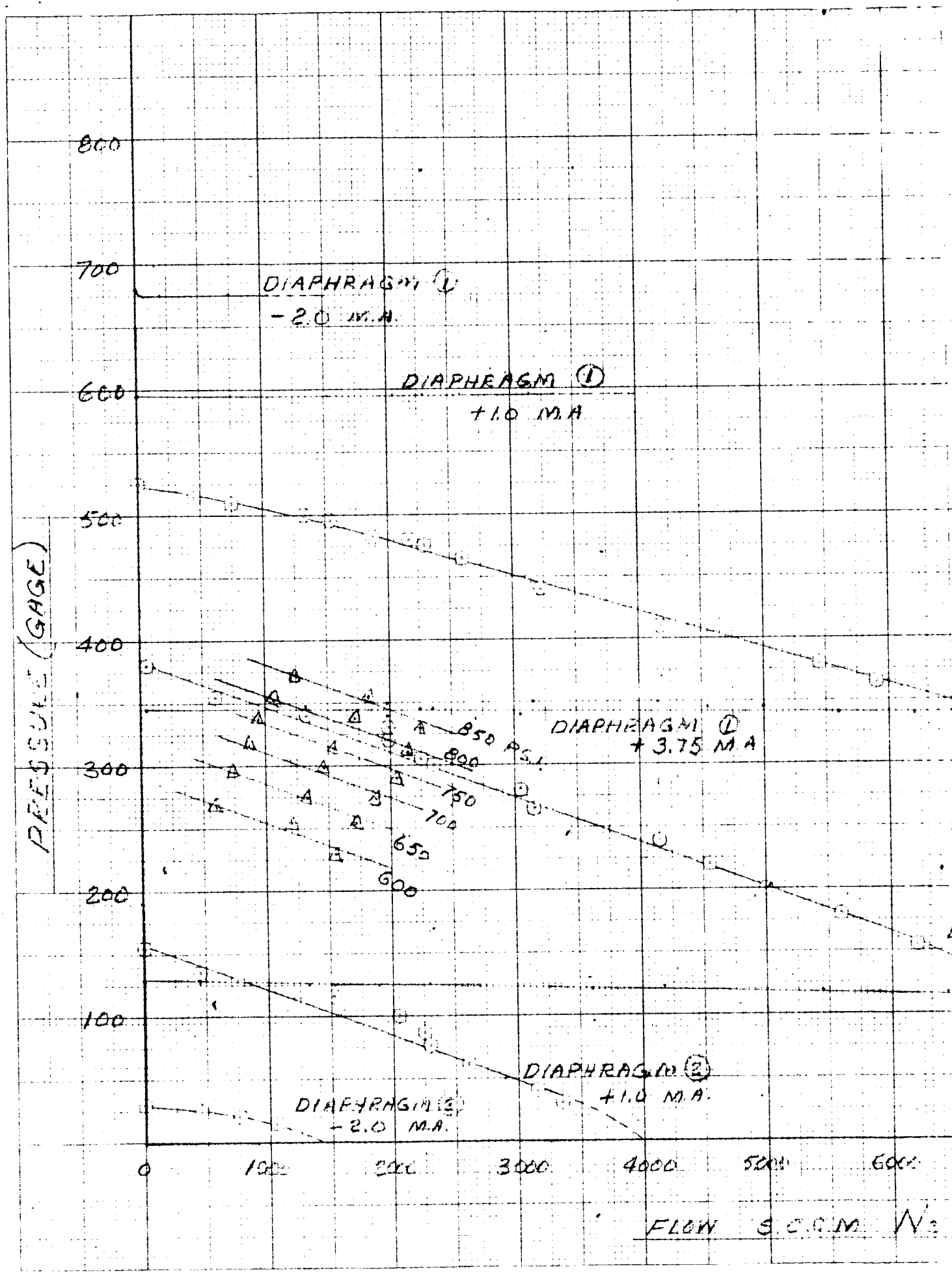


3626 SCALE 3
BALL 2

EFFECT OF SYSTEM PRESSURE VARIATION @ 3.75 [illegible] INPUT

FLOW METER #3626
SCALE #2

SYSTEM PRESSURE	①	②	O		FLOW IND ACTUAL	~~FLOWS INDICATED ACTUAL~~						
800	360	365	—	① 360	#1 5.1	353	#1 8.0	365	[illegible] 11.5	335	#2 9.3	DISREGARD
			—	② 353	1075 GPM	347	1725	[illegible]	[illegible]	[illegible]		
750	334	350	—	① 320	#1 4.8	326	#1 7.1	340	#1 10.0	315	#2 8.4	IRREGULARITIES
				② 338	950	315	1550	290	2050	295		
700	310	334	—	① 295	#1 4.4	303	#1 6.7	314	#1 8.9	295	7.5	
				② 318	875	300	1475	270	1875	158		
650	283	310	—	① 268	#1 4.0	280	#1 6.0	290	#1 8.0	273	6.5	
				② 295	750	275	1325	254	1725	177		
600	255	286		240	#1 3.5	255	#1 5.5	265	#1 7.1	255	5.8	
				268	600	255	1200	230	1550	167		
550	235	266										
500	210	243										
700	312	320		306	#1 4.2	290	#1 6.7	308	#1 9.0	290	6.8	
				310	825	290	1475	273	1875	200		
500	215	225										
800	362	365		358	#1 5.0	338	#1 8.0	350	#1 11.1	330	8.0	
				348	1050	338	1725	310	2150	230		
850	383	393		364	#1 5.6	355	#1 8.6	370	#1 12.3	345	8.2	
				373	1225	355	1825	330	2250	240		
										335	8.5	800
										237		
										333	7.5	
										240		


800
700
600
500
400
300
200
100
0
1000
2000
3000
4000
5000
6000
PRESSURE (GAGE)
FLOW S.C.F.M. N2
DIAPHRAGM ①
-2.0 M.A.
DIAPHRAGM ①
+1.0 M.A
DIAPHRAGM ①
+3.75 M.A
850 P.S.I.
800
750
700
650
600
DIAPHRAGM ②
+1.0 M.A.
DIAPHRAGM ②
-2.0 M.A.

2

SERVO MOTOR - FIRST STAGE - FLOW CHARACTERISTICS

A.B.S. JET PIPE 604-1226 SERIAL # 216

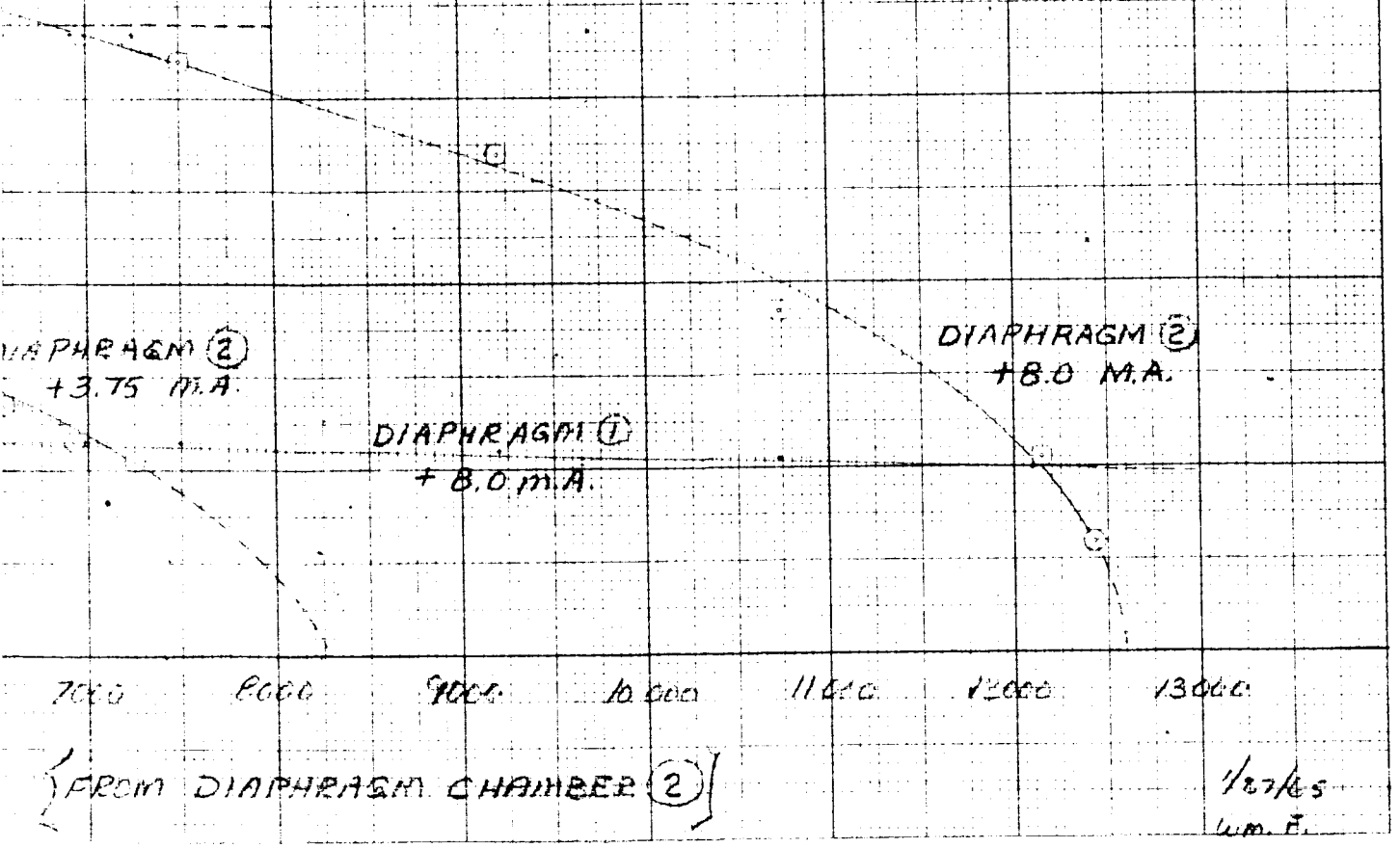
ONE FEEDBACK SPRING ON TEST MANIFOLD

SET AT MEDIAN POSITION

FLOW METER # 3626

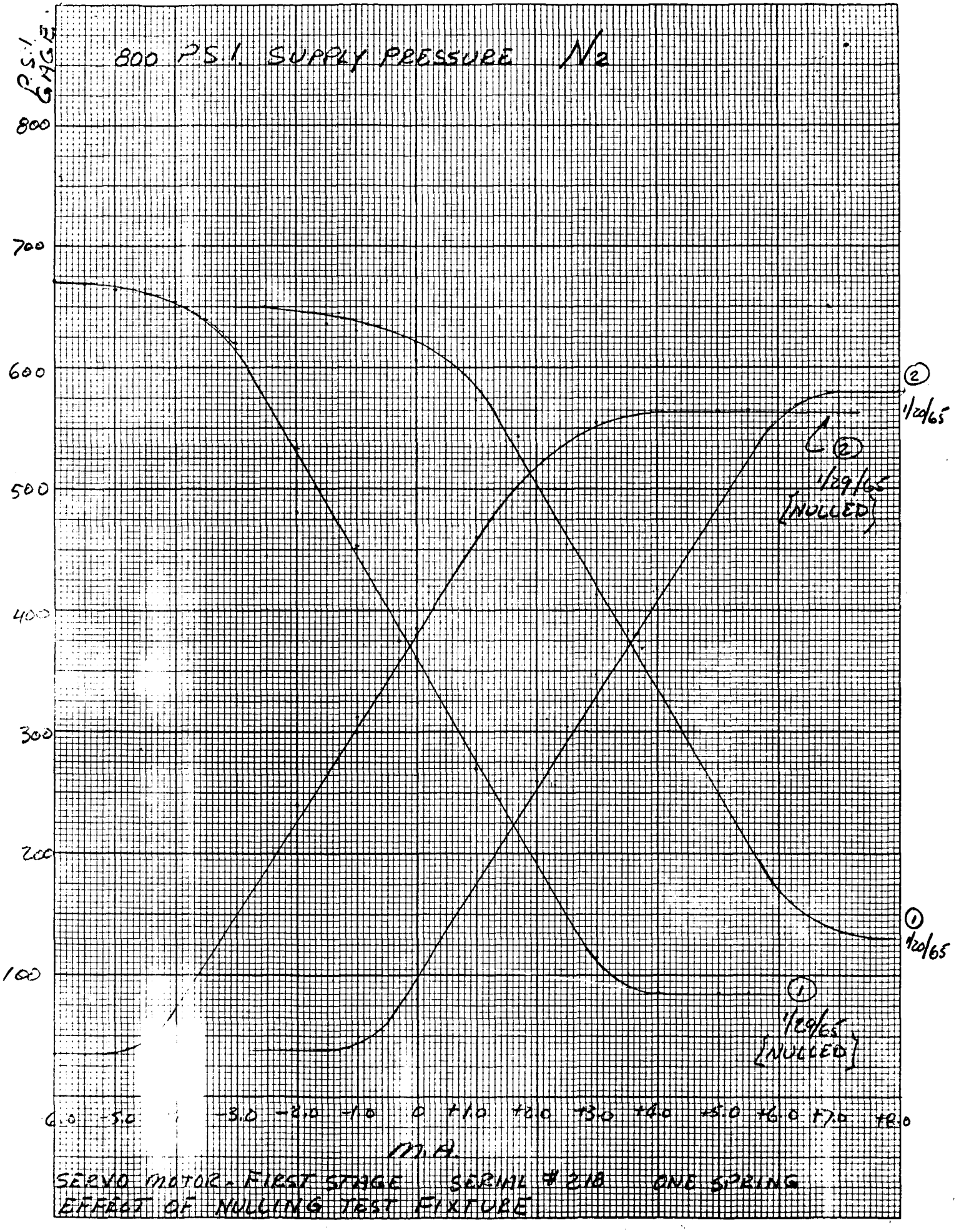
REFER TO PRESSURE GAIN CURVE OF 1/20/65

300 P.S.I.G. SUPPLY PRESSURE



(FROM DIAPHRAGM CHAMBER (2))

1/27/65
W.M.F.



EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340R-20 DIETZGEN GRAPH
20 X 20 PER INCH

PARKER AIRCRAFT SYSTEMS & ADVANCED COMPONENTS DIVISION.

DATE 1/29/65 PROJECT 126

ENGINEERING DATA / INSTRUCTIONS

BY FRANTZ FOR PARKER INTERNAL USE ONLY DISTRIBUTION

SERVO VALVE 605-1226 SERIAL # 218
NULLED MECHANICALLY

M.A.	DIAPH (1)	DIAPH (2)
0	355	383
0	361	385
-1.0	454	313
-2.0	537	240
-3.0	620	140
-4.0	650	75
-5.0	665	35
-5.5	668	35
-6.0	670	35
-4.0	653	60
-1.0	451	300
0.0	360	385
+1.0	270	460
+2.0	200	507
+3.0	115	556
+4.0	86	565
+5.0	86	565
+5.5	86	565
+3.0	115	555
0.0	360	380
-0.2	375	375

NOMINAL ADJUSTMENT
ON TEST FIXTURE
X-1226-5T
800 PSI SUPPLY

MIN. SETTING OF ADJ.

M.A.	DIAPH (1)	DIAPH (2)
0	30	555
-1.0	30	555
-2.0	30	555
+1.0	30	555
+5.0	35	550

DISCONTINUED RUN

MAX. SETTING OF ADJ.
0 665 33

DISCONTINUED RUN - CLEAR OVER TO OTHER SIDE BEYOND CAPABILITY OF AMMETER OR USEFUL OPERATING RANGE OF MOTOR ANYHOW.

CHECK - RESET TO NOMINAL ADJUSTMENT

	DIAPH (1)	DIAPH (2)
0 M.A.	375	380

THEREFORE SETTING HAS NOT CHANGED AND RUNS ARE VALID.

NOTE: FILE ORIGINAL IN PROJECT ENGINEERING NOTEBOOK.
PAIRCO 113