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SYSTEM COMPARISON C_m 15 AND C_m 17

The quality of the photography obtained by system Cm-17 was reportedly far superior to that obtained by system Cm-15. Vehicle attitude, stability, orbit parameters, system performance, temperature, internal pressure, FMC error and exposure are some of the possible contributing factors that may have caused the marked difference in the results of these two systems.

A comparison of the two systems is included to aid in determining the reason(s) for the difference in quality of the photography obtained.

Orbital Parameters

The orbital parameters achieved were very near the predicted nominals and were as follows:

	Parameter	Nominal	Actual
Cm-15	Period (Min.)	89.93	89.98
	Apogee (N.M.)	183.88	184.00
	Perigee (N.M.)	113.11	114.00
	Eccentricity	0.0099	.010
	Inclination (Deg.)	64.87	65.17
	Argument of Perigee	155.71	151.08
Cm-17	Period (Min.)	90.46	90.49
	Apogee (N.M.)	212.4	215
	Perigee (N.M.)	111.6	108
	Eccentricity	0.0140	.0148
	Inclination (Deg.)	69.88	70.95
	Argument of Perigee	160.01	162.34

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System Performance

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Cm-15 Panoramic instrument operation as determined by telemetry data was satisfactory with the slave instrument running 1 to 2% slower than the master instrument thru day 4 of the mission. The slave instrument ran 3 to 5% slower than the master on the fifth day of the mission. This was the only variation between the two instruments evident in the telemetry data.

One real time command was available for selecting V/H ramp and instrument on/off functions.

Cm-17 Both panoramic instruments operated satisfactorily throughout the flight with the in-flight cycle periods being very close to the pre-flight nominals. The slave instrument ran approximately 2% slower than the master on several passes.

Instrument operation was monitored on 4 passes over [redacted] Three of these passes were stereoscopic and one was monoscopic. The slave instrument was used for the monoscopic operation.

The master instrument lens rotation monitor was intermittent on all operations acquired by telemetry. This problem appeared to be a maladjustment or failure of the monitor switch and did not impair the instrument operation. There were no other instrument problems evident in the telemetry data.

Five real time commands were used to control the following payload functions.

1 - RTC 8 - V/H ramp selection

2 - RTC 9 - Instrument and mode selection

3 - RTC 10 - V/H ramp start delay

 [redacted]

4 - RTC 11 - Instrument on/off (Intermix Mode)

5 - RTC 12 - Intermix selection

Temperature Environment

Cm-15 The 65 degree orbit inclination flown on this flight caused the largest on-orbit thermal variability yet encountered on a Cm mission. The relatively early launch window provided additional large variabilities in the space thermal environment. The combination of launch window and thermal control mosaic was designed to give a minimum stovepipe temperature of 70 degrees.

The launch window was from 2:00 to 2:40 PM. During this time the Beta angle was increasing 1¼ degrees per hour. The launch time of 2:00 P.M. which was the beginning of the launch window gave a first orbit Beta Angle of 5¼ degrees decreasing to 3¼ degrees by orbit 81, thus providing the lowest possible design temperatures.

The thermal control mosaic was a basic DOW 17-Gold stripe configuration with while Kemacryl Lacquer applied as follows:

1. Twenty-five (25) 0.9 inch wide stripes covering 95 degrees of the vehicle circumference on the sun side. Seven (7) of these stripes were on each barrel with 11 stripes on the fairing.
2. Seven (7) stripes 0.9 inch wide under the clock.

   Note: Three of the paint stripes on barrel No. 2 and two of the stripes on barrel No. 1 were covered with 2 inch wide aluminized glass cloth over 280 degrees of the vehicle circumference.

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[redacted]

The average stovepipe temperatures observed during the flight were 71 degrees and 67 degrees for instruments 1 and 2 respectively. A plot of temp sensors 11 and 13 temperature for the flight is included.

The main instrument temperatures had stabilized by Orbit 9 and changed very little throughout the flight. A tabulation of the in-flight temperatures is enclosed.

Cm 17 The temperature control design for Cm-17 was for the master and slave instrument stovepipes to be maintained at 80°F ± 10°. The desired thermal control was achieved through nominal orbital parameters and launch time. The original Cm thermal control mosaic was utilized to achieve the desired temperature environment.

During ascent, the temperatures encountered were considerably cooler than on previous "Cm" flights, resulting in the stabilization of instrument temperatures by Orbit 2 [redacted] This temperature environment was maintained throughout the remainder of the flight with little or no change encountered.

The average stovepipe temperatures observed during the flight were 80°F and 78°F for the master and slave instruments respectively. A plot of temperature sensors 11 and 13 is included. Temperature sensors 11 and 13 on the master instrument were recorded during the flight for readout on selected orbits and are representative of the temperatures encountered during complete orbits.

Plots of this data and a tabulation of [redacted] are included.

[redacted]

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Internal Pressure

Cm-15 A pirani gage was used to monitor the internal pressure of the system. At the time of acquisition at [redacted] on orbit 1 the instruments had just turned off after operating for 2½ cycles each. A plot of the pressure during this pass as well as other passes and the pirani gage calibration are included.

Cm-17 Plots of the internal pressure of the system during the flight and the pirani gage calibration are included in this report. This data indicates the pressure of the system followed the same general characteristics noted on previous flights.

FMC Error (V/H Match)

Cm-15 A total of 10 V/H ramps, 5 of which had repeat V/H characteristics of the other 5 were available for V/H match on this system. Ramps 5 and 10 were used on all passes except pass 30. Ramp 3 was used on this pass.

The FMC error or V/H match between the tangent point (65°N) and 40°N was within 2% as obtained by using data from the "Best Guess" Ephemeris for a nominal orbit, orbit 32, and the instrument cycle periods. For latitudes below 40°N the error increased rapidly. A plot of this data is included in this report.

Cm-17 On this system 10 ramps with separate slopes for each were available. Each ramp was programmed to compensate, in either direction about a nominal point, a total of 250 seconds in 5, 50 second steps. This gives a total of 121 individual V/H ramp configurations. As a result of the near nominal orbit achieved and the added V/H ramps a FMC or V/H match within 2% was obtained on all passes except passes 50 thru 53, between 70°N and 15°N latitude for the master instrument. The slave instrument had an error of about 3%. These figures are obtained by using the "Best Guess" Ephemeris data for a nominal orbit, orbit 32, and the instrument cycle period data. Ramp 3 and a programmer delay of 50 seconds was used for the major portion of the mission. Ramp 8 with a delay of 50 seconds was used on passes 50 thru 53. Ramp 3 and a delay of 100 seconds was used on passes 6 thru 10. This data is plotted and is enclosed.

Exposure Settings and Film

Cm-15 A 0.200 inch slit and a Wratten 21 (orange) filter was used on each panoramic instrument. All horizon optics were set at F6.8 and 1/100th of a second exposure time with Wratten 25 filters.

Film type SO-132 was used in both instruments with the following identification:

	Master	Slave
Type and Length	7J23-7800	7J23-7800
Emulsion Data	34-11-8-2	34-11-10-8-2
Wt., No of Splices & Spool No.	43.5-39.4-1S-475	43.5-39.4-2S-472
Box No.	1021	1084

The film in the slave instrument was threaded incorrectly which would adversely affect the imagery on this instrument.

The exposure tolerance charts included indicate the exposure should have been adequate at all target latitudes.

Cm-17 A slit width of 0.250 inch was used on both panoramic instruments. A Wratten 21 (orange) filter was used on the master instrument and a Wratten 12 (yellow) filter was used on the slave instrument. The horizon optics had an aperture setting of F8.0 for the master instrument and F6.8 for the slave instrument. Wratten 25 filters and an exposure time of 1/100th of a second were used on all horizon optics.

The film used was type SO-132 with the following identification:

	Master	Slave
Type and Length	7J23-7800	7J23-7800
Emulsion Data	7-12-10-2	7-13-10-2
Wt., No. of splices & Spool No.	44.0-39.7-28-497	44.0-39.6-18-480
Box No.	1033	2016

The exposure tolerance plots included indicate the exposure at all target latitudes should have been adequate. The exposure on the slave instrument should have been slightly greater than that of the master instrument.

Vehicle Attitude and Stability

Cm-15 The orbital vehicle for this mission was FTV 1135, the last Agena B vehicle to be used on this program.. The Agena B vehicle flies with a nominal 1 1/2 degree nose up pitch which is not compensated for in the FMC system.

Attitude data from the master instrument payload was reviewed for orbits 1 thru 30 to get representative attitude data for the flight.

[redacted]

The first 15 frames of each operation were not included because of the high pitch and roll rates noted on most passes during the first 10 to 15 frames. This data is included in tabular form showing the average rates and maximum excursion angles observed. Though this data indicates the vehicle was pitching and rolling at relatively high rates, these rates do not exceed the allowable rates for 10 foot ground resolution.

Plots of vehicle attitude versus frame number for passes 30, 39, and 55 are included to show representative vehicle attitude during the flight.

Cm-17 An Agena "D", FTV 1156, orbital stage was used on this mission. Data from the processed payload was reviewed for pitch and roll attitudes rate. The average attitude rates for the flight was approximately 6 to 10 degrees per hour. A tabulation of this data is enclosed. Plots of vehicle attitude versus frame number are included for passes 30, 39 and 56. These plots give representative data for the flight.

<u>Summary</u>

A review of the data for orbit, vehicle stability, system performance, temperature, internal pressure, FMC error, and exposure does not support the fact that the results of Cm-17 were superior by any degree of magnitude to those obtained by Cm-15.

The orbits achieved were nearly nominal on both flights and should not have affected one flight more than the other.

The vehicle, though more stable on the Cm-17 flight did not introduce attitude rate errors in excess of the design requirements for 10 foot ground resolution for either flight.

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Yaw data is not currently available for either flight. Therefore, the effects of yaw attitude is not known at this time.

The system dynamic operation for both systems was satisfactory with the slave instrument running slower than the master on both flights. The added real time commands used on Cm-17 provided more versatility and better control of the program execution than was available on Cm-15.

From empirical data it appears that instruments having stovepipe temperatures in excess of 70°F have produced higher resolution photography than instruments with stovepipe temperatures less than 70°F.

The stovepipe temperatures observed on Cm-15 averaged 69°F while the stovepipe temperatures on Cm-17 averaged 80°F.

Since the lens system is focussed at 68 to 72°F it would appear that the stovepipe temperatures encountered on Cm-15 were more ideal than those of Cm-17.

More adequate tests should be formulated to determine the effect temperature has on resolution as there has not been sufficient ground testing in this area to substantiate this effect.

The internal pressure as determined by telemetry data was approximately the same for both systems.

The FMC error was within 2 to 3% on both missions between 65 and 40 degrees North latitude with the error increasing rapidly below 40 degrees for Cm-15. Due to the near nominal orbit achieved on both missions the FMC match was within the allowable error for 10 foot ground resolution on both flights.

The exposure should have been adequate on both missions with the exposure on the Cm-17 mission being greater due to the wider slits used on the instruments.

Conclusions

The vehicle attitude, V/H match and temperature environment (as derived from empirical data) indicates the photography obtained by Cm-17 should have been of higher quality than that obtained by Cm-15.

While the above supports the fact that the results of Cm-17 were superior to those obtained by Cm-15 the data does not provide a basis for the "poor" quality of Cm-15 photography. All factors considered indicate system Cm-15 was well within the design requirements for 10 foot ground resolution.

Two items of importance that have not been considered in this report are processing of the exposed payload and the atmospheric conditions during the flight. Further investigation may be warranted in these areas.

It is recommended that tests be formulated and conducted on a Cm or J system, possibly Cm-22, to determine more fully the effects temperature and attitude deviations have on resolution.

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CM 15 1135 TEMPERATURE SUMMARY [redacted]

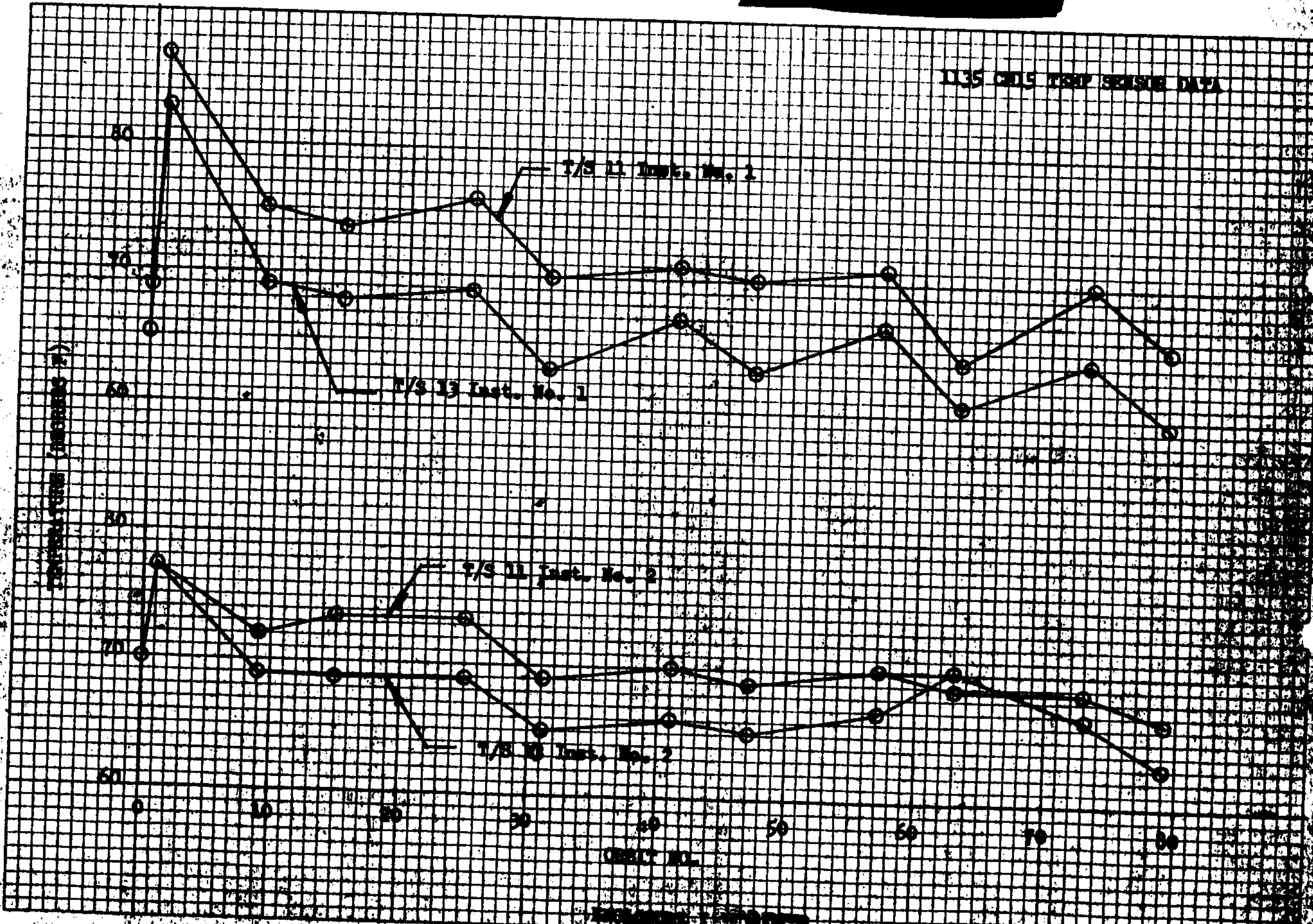
TEMP SENSOR	LAUNCH LIFTOFF	+480 SEC.	ORBIT 1	9	15	25	31	41	47	57	63	73	79
Inst. No. 1													
2	66.5	69	82.0	76	78.3	77.1	71	74	73.6	74.9	71.1	71.1	71.1
5	64.1	75	82.0	69	68.9	68.9	66.5	69	66.5	66.5	64.1	66.5	63
7	65.2	70	98.9	83	84.2	84.2	77	81	78.3	80.7	78.3	77.1	76
11	65.2	103	86.8	75	73.6	76.0	70	71	70.0	71.1	64.1	70.0	65.2
12	66.5	83.1	82.0	57	54.9	57.2	52	55	52.6	54.9	50.2	55	50.2
13	68.9	66.5	83.1	69	67.8	68.9	63	67	63.0	66.5	60.7	64.1	59.5
Inst. No. 2													
2	68.9	70	78.3	78	79.6	79.6	75	76	76.0	76.0	73.6	74	72.4
5	68.9	69	74.9	71	73.6	73.6	70	70	71.1	70.0	67.8	69	66.5
7	67.8	70	83.1	81	83.1	82.0	76	78	78.3	78.3	76.0	75	74.9
11	70.0	71	77.1	69	68.9	68.9	65	66	65.2	67.8	70.0	66.5	63
12	-	70	89.1	93	85.5	87.9	81	83	79.6	83.1	76.0	78	72.4
13	68.9	65	77.1	72	73.6	73.6	69	70	68.9	70.1	68.9	68.9	66.5
S/I Unit													
1	61.9	85.5	92.8	65	59.5	64.1	56	61	58.3	60.7	54.9	60	53.8
2	54.9	93	94.0	64	59.5	63	55	60	54.9	59.5	54.9	59	53.8
Fairing													
4	68.9	200	84.0	69	69.2	58.5	60	54	56.0	56	53.8	48	53.8
Clock													
1	67.8	93	90.2	57	52.6	57.2	51	54	50.2	56	50.2	54	50.2
Thrust Cone													
1	66	74	126	64	58	63	56	60	54.6	60.5	52.3	56	50

ENCLOSURE II

SECRET [redacted]

K+E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO. MADE IN U.S.A.

SECRET [redacted]



SECRET

[redacted]

SECRET

[redacted]

T/S No.	Pin No.	Function	LAUNC. +490	1	2	9	16	25	31	41	48	/	63
[redacted]													
2	30	Inst. No. 1	69.0	89.3	90.2	90.2	87.9	87.9	82.0	86.0	83.1	86.8	81.1
5	32	Inst. No. 1	73.5	87.7	83.1	83.1	80.7	80.7	75.5	80.7	76.0	80.7	74.9
7	34	Inst. No. 1	66.5	89.5	91.5	91.5	90.2	90.2	83.5	88.0	83.1	87.9	82.0
11	36	Inst. No. 1	93.0	89.3	80.7	85.5	80.7	85.5	76.4	82.0	74.9	80.7	72.6
12	38	Inst. No. 1	88.0	89.3	76.0	76.0	68.9	74.9	77.7	74.0	67.8	74.9	66.0
13	40	Inst. No. 1	57.2	87.0	82.6	82.0	76.0	79.6	75.5	77.0	72.4	76.0	69.5
2	42	Inst. No. 2	62.0	80.5	83.1	86.6	85.5	85.5	81.1	84.0	80.7	83.1	79.6
4	44	Inst. No. 2	63.0	83.1	81.6	92.8	84.2	92.8	78.9	90.0	78.3	87.9	76.1
6	46	Inst. No. 2	64.0	80.7	78.5	79.6	78.3	78.3	73.6	77.0	73.6	76.4	73.6
7	49	Inst. No. 2	62.0	81.5	83.5	85.5	83.1	84.2	78.3	83.0	80.7	83.1	78.3
11	51	Inst. No. 2	66.5	81.7	85.7	82.0	78.3	78.3	71.3	78.0	79.6	78.3	73.6
12	54	Inst. No. 2	70.0	82.9	83.8	91.5	83.1	92.8	78.1	88.0	77.1	87.9	76.0
13	57	Inst. No. 2	57.2	76.9	79.2	80.7	78.3	78.3	75.1	77.0	76.0	76.0	73.6
1	31	Clock No. 1	85.5	95.6	80.7	70.6	66.5	68.9	69.5	69.0	64.1	68.9	63.0
2	33	Clock No. 2	98.0	90.2	76.0	66.5	61.9	64.1	60.7	64.0	59.5	64.1	58.1
1	45	Thrust Cone	81.7	95.2	88.6	91.0	86.2	91.0	77.0	87.0	82.8	86.2	81.6
1	50	Fairing No. 1	-	-	-	-	-	-	-	-	-	-	-
3	52	Fairing No. 3	-	-	-	-	-	-	-	-	-	-	-
4	55	Fairing No. 4	-	81.9	82.9	76.8	69.2	76.8	53.8	72.0	58.5	74.2	55.6

1156 TEMPERATURE ENVIRONMENT

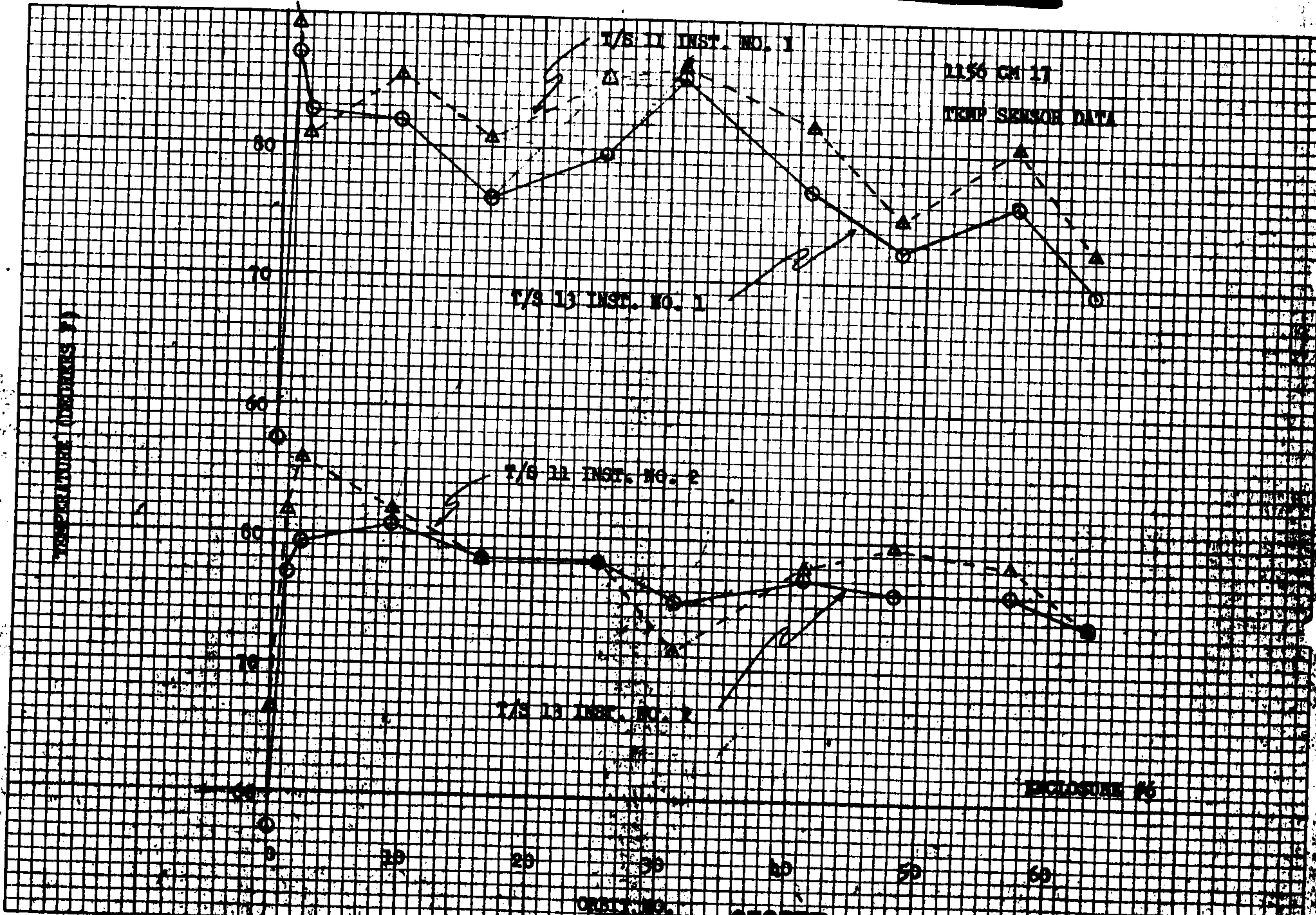
ENCLOSURE #5

SECRET

[redacted]

K+E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 359-5 MADE IN U.S.A.

SECRET [redacted]



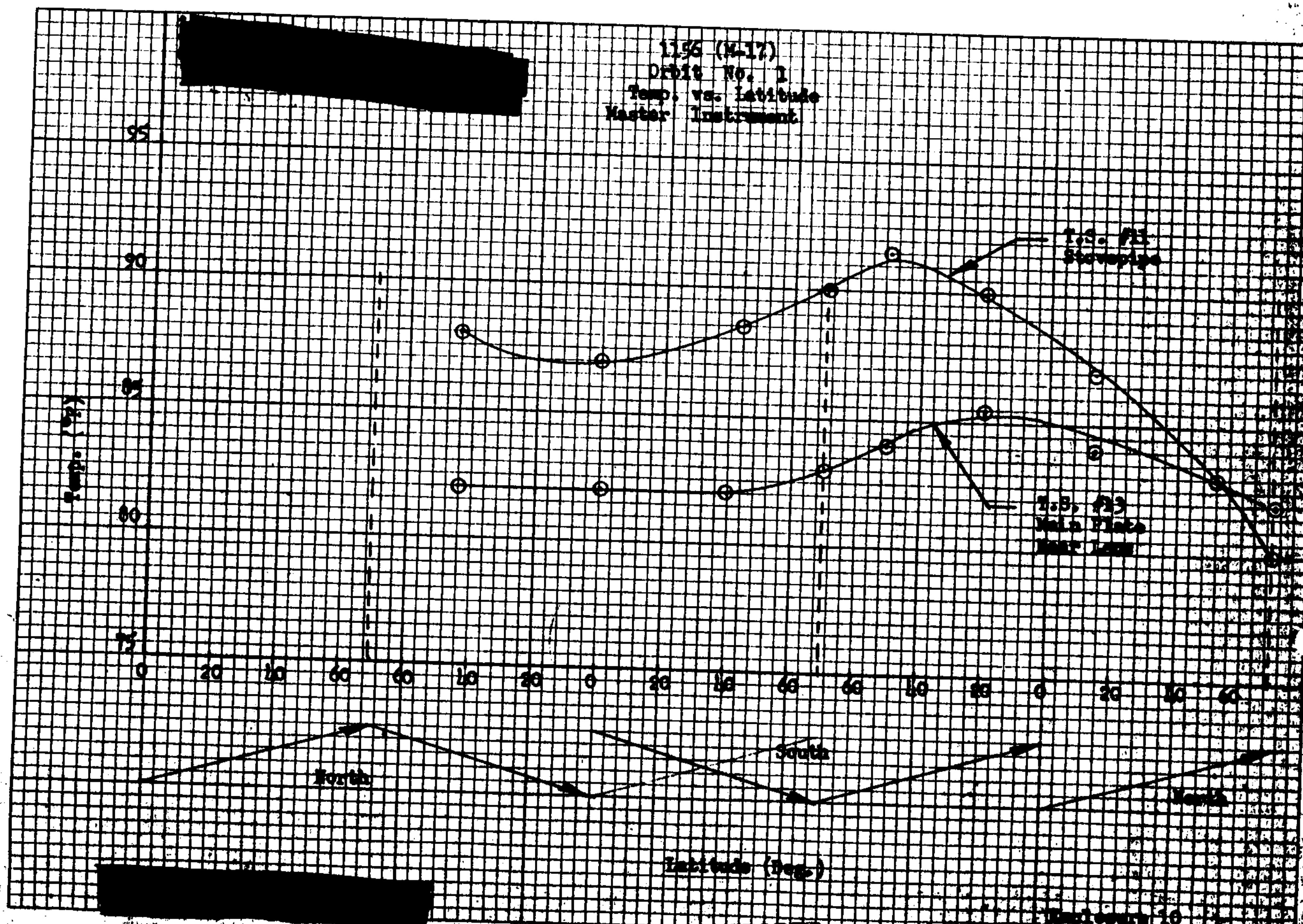
ENCLOSURE #6

SECRET [redacted]

K+E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 359-5 MADE IN U.S.A.

SECRET

[redacted]



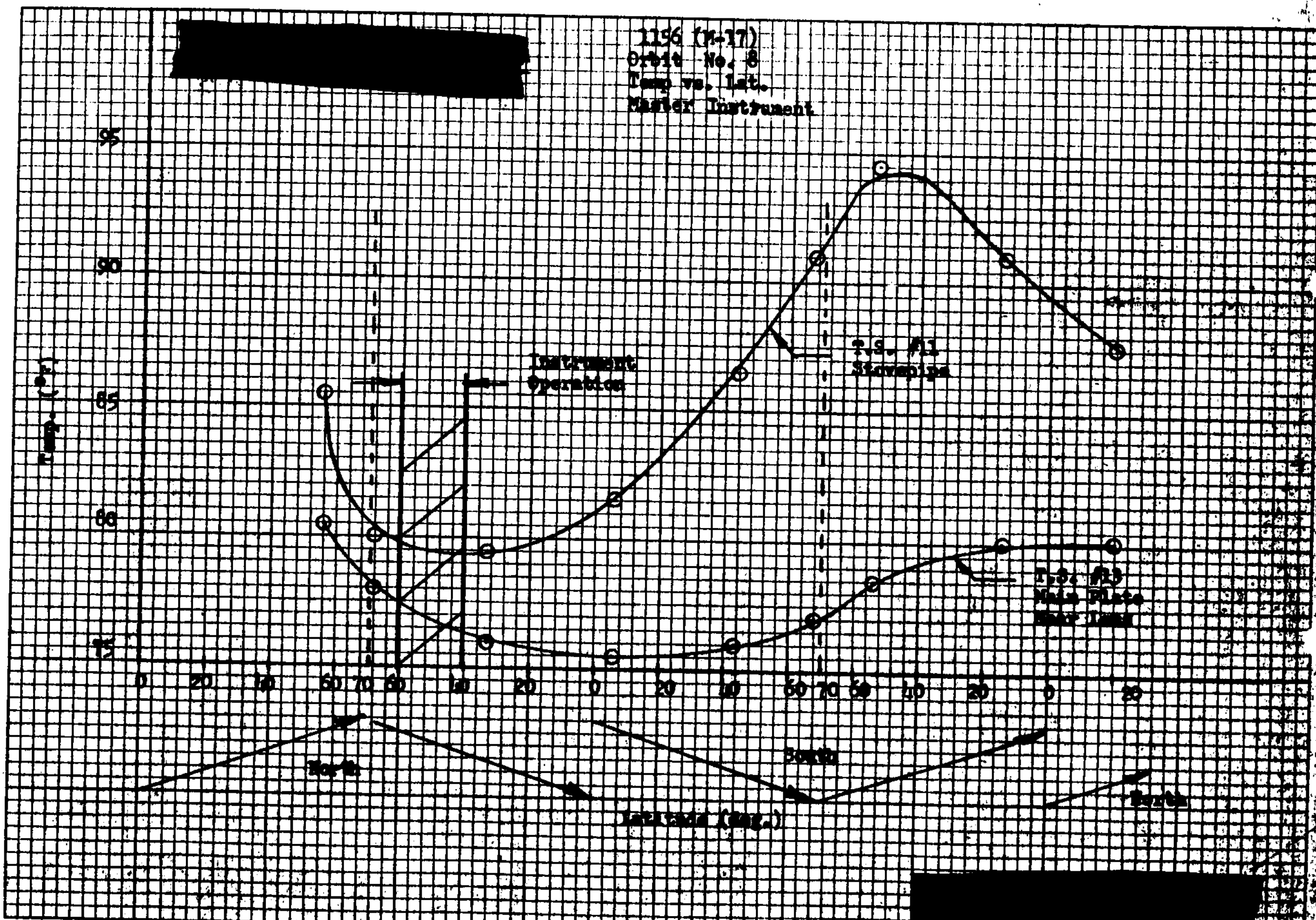
[redacted]

Enclosure 10

SECRET

K+E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 359-5 MADE IN U.S.A.

SECRET



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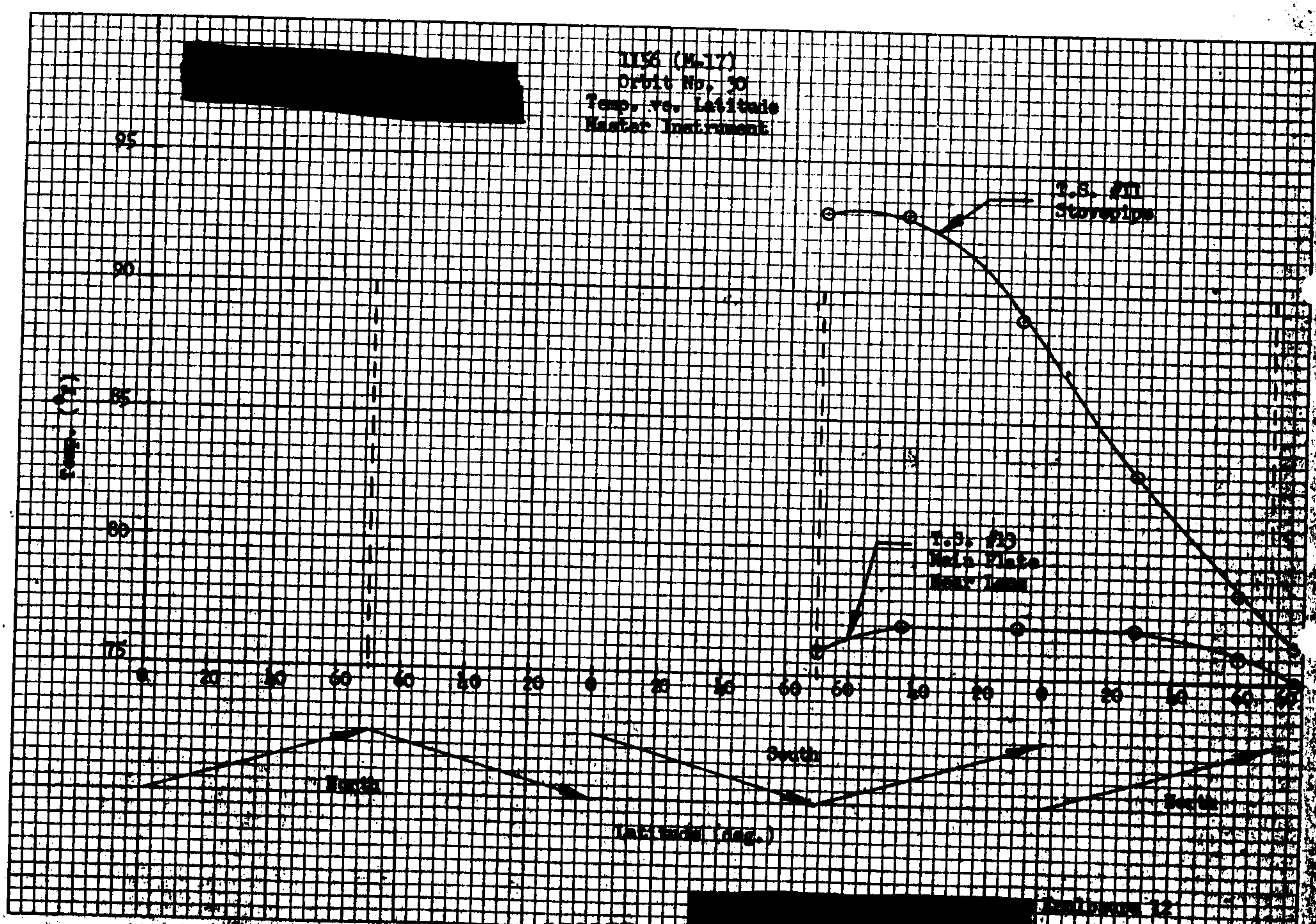
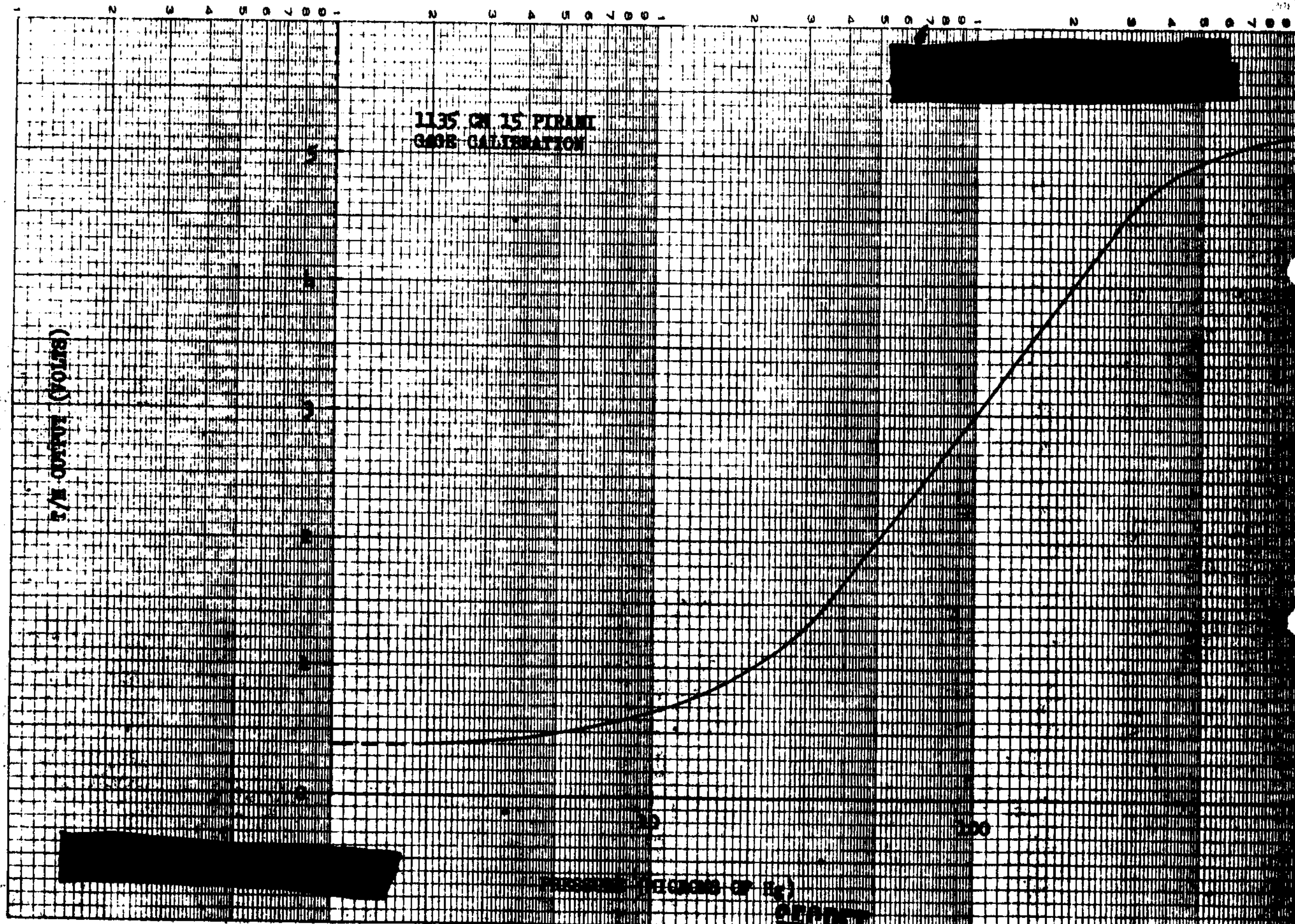


[redacted] Enclosure 12

SECRET



SECRET

ENCLOSURE VI