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PROJECT APOLLO
TASK MSC/TRW A-97

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INDEPENDENT FLIGHT SOFTWARE VALIDATION
TEST RESULTS FOR MISSION AS-204A

13 DECEMBER 1966

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JAN 22 1969

Prepared for
MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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HOUSTON, TEXAS
NAS 9-4810

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The coordination and review of this effort at MSC was performed by J. Williams of MPAD with the cooperation of M. Keathley of CAD concerning the capabilities of the MSC Bit-by-Bit Simulation Program.

Final Report - Apollo 11 Mission

ABSTRACT

This report is submitted to the NASA Manned Spacecraft Center by TRW Systems in partial fulfillment of Task MSC/TRW A-97, contract NAS 9-4810. The AS-204A Mission has been simulated on the MSC Block I interpretive computer simulation using the Apollo Guidance Computer (AGC) A-Release Program Sunspot 247. The software tests have been analyzed by TRW Systems and are summarized in this document. The nominal AS-204A deorbit burn and entry as defined by the "AS-204A Spacecraft 012 Reference Trajectory" and four off-nominal entry cases comprise the major portion of the results within this document.

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1. INTRODUCTION

The purpose of the testing described within this document was to provide MSC with added confidence in the AS-204 AGC program using an independent simulation of the guidance computer and spacecraft environment, while providing useful experience in the application of an independent verification capability at MSC, for later flights.

The performance of this independent verification testing is in accordance with the MSC/TRW Task A-97 agreement.

The testing used the A-release and the B-release programs, but the results contained within this document pertain only to the A-Release program for Mission AS-204A.

This test results document supersedes the Preliminary Test Results for Mission AS-204 (Reference 1) in that the information contained within the preliminary results was obtained with several significant errors within the Block I simulator, which have since been corrected.

The independent verification testing for AS-204A was based on the test plan issued (Reference 2). However, a number of changes to the planned tests have been made in performing the runs; for this reason, this document contains a description of those tests performed.

2. SUMMARY

The simulation results obtained during independent verification testing of the Mission AS-204 AGC flight program are summarized in this section. These results must be qualified on two points. First, the scope of the simulation results is considerably less than defined in the test plan (Reference 2) due to simulator and editor program development problems. In using the Block I bit-by-bit simulation to perform testing on the AS-204 AGC flight program, much effort was expended on isolating simulator problems and rerunning test cases. In addition, development of editor programs which provide simulation results suitable for analysis was not completed until late in the verification testing effort. This delayed complete analysis of the simulation runs until that time. Second, the simulation results presented in this document were obtained with errors in the simulation of the spacecraft autopilot. These errors lead to inaccuracies in the simulation results. However, the results are sufficiently meaningful and valid to warrant presentation of the results.

The nominal AS-204A deorbit burn and entry as defined by the "AS-204A Spacecraft 012 Reference Trajectory" (Reference 3) and four off-nominal entry cases comprise the major portion of the results described within this document.

The following is a description of the results of the nominal deorbit burn and entry simulation. The simulation results have been compared with an MIT nominal test run (Reference 4) for presentation in this document. The MIT test run was not initialized with the state vector from the MSC Spacecraft 012 Reference Trajectory and, therefore, the descriptions made are limited to valid comparisons.

The targeting calculations for the nominal deorbit burn and entry test run required approximately the same amount of flight time as the MIT nominal run. Because of a difference in the initial state vectors between the MIT run and the "nominal deorbit run," the calculated times for ignition of the service propulsion system (SPS) engine were different. The predicted target miss for the state vector at entry interface determined by the burn ΔV , and the calculated burn attitude was -5.9 nautical miles.

The ullage maneuver was initiated by the astronaut 17 seconds prior to SPS ignition and was terminated two seconds after SPS ignition.

The torques exerted on the vehicle at SPS ignition due to the difference between the predicted center of gravity (c. g.) offset and the actual offset were minimal.

AGC operation in thrust vector control (TVC) was as expected. The angular excursions during thrusting were small as illustrated by MIT's run. The duration of the burn was consistent with the acceleration and the total intended ΔV imparted to the spacecraft.

Command module/service module (CM/SM) separation attitude was attained, and staging was performed as expected. The attitude rates at separation were within the expected range.

The nominal entry profile was close to the expected trajectory. The maximum acceleration on the spacecraft (SC) due to atmospheric lift was 4.68 g's during the first pulse and 3.95 g's during the second pulse. The steering during final phase behaved as expected.

An engineering simulation has been performed from entry interface (input data from nominal deorbit run) to splash using an N-stage program developed under Task A-9. The results of this simulation closely parallel the results of the Block I bit-by-bit simulation of the AGC. The appendixes contain plotted results of both the bit-by-bit simulation and the engineering simulation for the nominal AS-204A trajectory.

Three off-nominal entry runs were performed to determine the effectiveness of the AGC adaption to overshoot and undershoot entry conditions.

In the overshoot entry condition, the g-limiter logic was exercised. The maximum acceleration that the vehicle encountered was 11.92 g's. This is approximately 2 g's greater than the 10-g limit. The SC was unable to steer to the intended target. The target miss was increased, in payment for a reduced acceleration loading. This increase in target miss is caused by the lift vector up-roll command required to decrease the acceleration load and, therefore, increases the down range translation away from the intended target.

In the undershoot entry condition, which caused a 100-second increase in flight time from entry interface to splash, the trajectory was as expected. The maximum acceleration loading was 6.54 g's. Steering to the target was accomplished.

An off-nominal entry run was performed with a 200 percent increase in c.g. offset in the command module. The SC trajectory from entry interface to splash was not significantly affected. However, the fuel consumption was increased by 400 percent because of the excess steering required.

An off-nominal deorbit burn run was performed. The SPS gimbal trim setting was input 5 degrees from the actual SC c.g. position. An initial torque was encountered of about 600 foot-pounds. This torque created an attitude error and, therefore, a velocity error which the TVC attempted to correct. The state vector errors with respect to the nominal run at entry interface were 54,400 feet in position and 66 feet per second in velocity.

Additional minor test results were obtained:

- 1) A program alarm was exercised by creating a stable member alignment sufficiently out of the plane of the trajectory to approach gimbal lock.
- 2) A CDU fail alarm was exercised by creating an error between the actual coupling display unit (CDU) value and the desired CDU value which was greater than the maximum allowable.
- 3) An error code (1405), "5 minutes to desired ignition time," was created when initiating P32 without sufficient time before the desired time of ignition.
- 4) An error code (1411), "Target latitude exceeds declination of orbit," was exercised.
- 5) An error code (1426) "IMU orientation unsatisfactory for entry," was exercised.

In addition to numerical results, the AS-204A testing has provided valuable data on the Block I simulator capabilities as well as deficiencies. This information is valuable in that it is directly applicable to the Block II development requirements. For instance, the reduction of data required

for incorporation into this report requires organization of information and hand calculations which can all be performed in a computerized editing operation. The need for better tools within the simulator for debugging problem areas has been illustrated during testing for AS-204A. The need for a more direct communication with the environment for making parameter changes without starting from an input deck has been found. These requirements should be incorporated into the Block II development.

3. TEST DESCRIPTION

The purpose of the following is to describe the independent software validation tests that were performed for the AS-204A Mission.

The scope of the AS-204A AGC software validation testing was to exercise approximately one-third of the flight programs used in the AS-204A Mission. The MSC Block I simulator provided the capability for simulating three primary mission phases: 1) deorbit boost, 2) coast, and 3) entry. Therefore, the following programs were exercised during the AS-204A independent software validation testing:

P00 AGC Idling

P32 AGC Return-to-Earth Prethrust

P42 AGC Return-to-Earth Thrusting

P61 Maneuver to CM/SM Separation Attitude

P62 CM/SM Separation and Entry Attitude Maneuver

P63 Entry Initialization

P64 Post 0.05 g

P67 Final Phase

3.1 TEST CASES

The following describes each of the independent software validation test cases performed for the AS-204A Mission.

a) Nominal Deorbit and Entry
(AS-204A1-02-019)

This nominal run was designed to provide a reference for comparison with test runs including mission anomalies, to provide an overall check of the program sequencing and normal operation, to verify the targeting capability of the AGC, and to provide a means of initializing the flight simulation at a point prior to entry interface for off-nominal perturbations.

This test case was initialized in the pre-deorbit phase prior to the initiation of the Return-to-Earth Prethrusting Program (P32). The point of initialization was sufficiently early in the flight to allow the pretargeting calculations to be completed 5 minutes before SPS ignition.

This nominal deorbit test run was continued through the deorbit burn, CM/SM separation, and entry to Mach 0.5 (chute deployment) at which time the simulation was automatically terminated.

b) Off-nominal Overshoot Entry Condition
(AS-204A1-20-003)

This off-nominal test case was performed to exercise the entry steering capability of the command module. A target location was specified by MSC as laying within the entry footprint and, therefore, within the capability of the guidance system. A checkpoint during the nominal run (AS-204A1-02-019) was employed to obtain the nominal state vector at entry interface. The new target location was input to the AGC. The movement of the target, in effect, simulated a perturbation of the initial state vector at entry interface.

For this case, the target location was moved to simulate an overshoot condition at entry interface.

c) Off-nominal Undershoot Entry Condition
(AS-204A1-21-003)

This off-nominal case was designed to increase the entry flight time by 100 seconds. For this case, the target location was changed to simulate an undershoot condition at entry interface. The target location was specified by MSC. The nominal state vector at entry interface was obtained using a checkpoint on the nominal run (AS-204A1-02-019).

d) Off-nominal Overshoot Entry g-Limiting Condition
(AS-204A1-22-003)

This off-nominal case was designed to exercise the g-limiting logic within the AGC during an entry in an extreme overshoot condition. The target location was specified by MSC as laying outside of the entry footprint. The nominal state vector at entry interface was obtained using a checkpoint on the nominal run (AS-204A1-02-019).

e) Off-nominal Entry With Command Module c.g. Offset
(AS-204A1-01-019)

This run was performed with an excessive c.g. offset in the command module. The test run was initialized immediately after the SPS deorbit burn as defined by the RT. The test run was performed through the CM/SM separation attitude maneuver, CM/SM separation, the entry attitude maneuver, and entry. The nominal target location was used.

3.2 INITIALIZATION

The source of the initialization values for the validation test runs described in this document is the AS-204A RT (Reference 3). Many of the values of the parameters in the simulation environment and the AGC were not directly available in the RT, and for this reason, an initialization processor was developed (Reference 5).

With the aid of the initialization processor and information obtained from the RT, all of the parameters in the environment and the AGC were initialized at two places along the nominal (RT) trajectory: a) deorbit prethrusting calculations, and b) coast to entry.

a) Nominal Deorbit and Entry Initialization
(AS-204A1-02-019)

time	1183745.078 sec
altitude	643,404.50 ft
latitude	-11.908873 deg
longitude	-174.10010 deg
inertial velocity	25,561.410 ft/sec
inertial flight-path angle	-0.017717101 deg
inertial azimuth	59.94442 deg
SC pitch	104.53719 deg
SC yaw	-52.883335 deg
SC roll	74.400132 deg
target latitude	30.989641 deg
target longitude	-54.961656 deg

b) Off-nominal Entry With a CM c.g. Offset Initialization
(AS-204A1-01-019)

time	1184806.094 sec
altitude	637,470.75 ft
latitude	23.922343 deg
longitude	-114.37244 deg
inertial velocity	25,132.091 ft/sec
inertial flight-path angle	-0.79419087 deg
inertial azimuth	67.812639 deg
SC pitch	-129.44224 deg

SC yaw	0.71567174 deg
SC roll	178.799999 deg
target latitude	30.989641 deg
target longitude	-54.961656 deg
c. g. offset ΔX	0.1 m
ΔY	0.2 m
ΔZ	0.3 m

c) Off-nominal Overshoot Entry Condition Initialization
(AS-204A1-20-003)

Checkpoint at entry interface on nominal run
(AS-204A1-02-019) with a new target location:

target latitude	30.9000 deg
target longitude	59.5000 deg

d) Off-nominal Undershoot Entry Condition Initialization
(AS-204A1-21-003)

Checkpoint at entry interface on nominal run
(AS-204A1-02-019) with a new target location:

target latitude	30.5000 deg
target longitude	47.7000 deg

e) Off-nominal Overshoot Entry g-Limiting Condition
Initialization (AS-204A1-22-003)

Checkpoint at entry interface on nominal run
(AS-204A1-02-019) with a new target location:

target latitude	32.0000 deg
target longitude	65.0000 deg

Appendix A contains the complete initialization as outlined in the "User's Guide for Apollo Guidance Computer Block I Simulator," (Reference 6).

3.3 MASS PROPERTIES AND SIMULATION VARIABLES

The AS-204A mass properties and simulation variables were defined using the "Guidance and Navigation Operations Plan R-507" (Reference 7) and the "AS-204A Data Specifications D" (Reference 8).

The data are described in TRW 66-7224-8" Data Variable Update for AS-204A."

3. 4 ASTRONAUT INPUTS

Appendix B lists the astronaut inputs required for the AS-204A simulation from the initiation of the Return-to-Earth Prethrusting Program (P32) through entry to splash.

4. TEST RESULTS

The following test results are presented in two forms. The test results summary contains information pertaining to specific phases of the mission (e. g., the separation attitude maneuver). The time line results present data at discrete times throughout the mission (e. g., time of initiation separation attitude maneuver).

4.1 NOMINAL DEORBIT AND ENTRY (AS-204A1-02-019)

Table 1 presents a nominal entry comparison for the AS-204A mission.

Table 2 contains the test results summary for the nominal AS-204A test run.

Table 3 contains the time line results for the nominal test run.

The targeting calculations performed in program P32, AGC Return-to-Earth Prethrust, required 118 seconds of flight time. The calculated time of SPS ignition provided a predicted inertial velocity and flight-path angle at entry interface. This condition at entry interface produces a predicted target miss of -5.9 nautical miles.

The simulation of the control system for the SC was not correctly performed. An error in the units of the deadband within the simulator coupled with an incorrect simulation of the logic in the autopilot, produced an error in the SC attitude rates and fuel consumption for the stabilization and control system (SCS) and the command module reaction control system (RCS). This error in the simulation of the control system will be reflected in all of the test runs.

The attitude maneuver for the deorbit burn was performed correctly in that the final attitude was correctly attained. However, the attitude rates and the fuel consumption were incorrect, due to the errors defined above.

The ullage maneuver was initiated 17 seconds prior to the SPS ignition and was terminated 2 seconds after ignition. The ΔV imparted to the vehicle was 9.77 feet per second.

At SPS ignition, the c. g. offset coincided with the SPS gimbal trim settings, so there was a minimum torque exerted on the vehicle. The angular excursions in pitch and yaw during the burn were 2.24 degrees and 0.19 degrees, respectively. The ΔV of the SPS burn was 578 feet per second as intended. The SPS thrust was nominal, producing an acceleration and burn time consistent with the ΔV of the burn.

The state vector after the burn differed from the RT by 18,000 feet in position and 62 feet per second in velocity. The velocity error was in the vertical direction toward the earth. Since the state vector was different from the RT after the burn, this run was continued to splash.

The separation attitude was attained correctly. The attitude rates at CM/SM separation, even with the error in the autopilot, were less than 0.15 degrees per second.

The entry attitude maneuver after CM/SM separation was performed with the autopilot simulation error. The ΔV imparted to the SC from the non-coupled RCS attitude thrusters was consistent with the autopilot simulation error.

The predicted target miss at entrance into program P67 (Final Phase) was approximately -130 nautical miles.

The maximum acceleration loading on the SC reached 4.86 g's and 3.95 g's for the first and second pulses, respectively.

The environment target miss at Mach 0.5 (chute deployment) was 45,000 feet downrange and 60,000 feet crossrange. The AGC state vector error at splash was less than 12,700 feet downrange and 22,000 feet crossrange. The difference between the AGC and environment altitude at the same flight time (splash) was 33,000 feet.

The nominal simulation run was compared with an MIT run No. 11 (Reference 4) and with a run using an engineering simulation of AS-204A entry developed under MSC/TRW Task A-9. The results during entry are compared in the following table. The entry profiles from entry interface to splash compared favorably in the runs. In addition, the steering commands in roll were very similar in their time profile.

However, because of the autopilot simulation error in the bit-by-bit simulation during the final entry phase, the attitude rates, fuel consumption and steering accuracy are in error.

Table 1. AS-204A Nominal Entry Comparison

<u>Parameter</u>	<u>Bit-By-Bit</u>	<u>MIT</u>	<u>Engineering</u>
Predicted target miss at entrance to P67	-130.8 n mi	-137.2 n mi	Not available
Maximum acceleration (first pulse)	4.86 g	4.34 g	4.09 g
Maximum acceleration (second pulse)	3.95 g	3.03 g	2.91 g
Environment downrange target miss	43,000 ft	2918 ft	8500 ft
Environment crossrange target miss	60,000 ft	1824 ft	4000 ft
AGC downrange target miss estimate	12,700 ft	Not available	Not available
AGC crossrange target miss estimate	22,000 ft	Not available	Not available

Appendix C contains detailed computer plots of AGC and environment variables for the nominal deorbit run AS-204A1-02-019.

Appendix I contains the computer plots of the engineering simulation for comparison. The engineering simulation was initialized with the nominal deorbit state vector from run AS-204A1-02-019 at entry interface.

Table 2. Test Results Summary, Nominal Deorbit Burn and Entry
(AS-204A1-02-019)

Targeting

Time of targeting initiation	1183751.08 sec
Elapsed time required for pretargeting calculations	118 sec
Predicted time of ignition (g. e. t)	329 hr 7 min 1.5 sec
Predicted inertial flight-path angle	-1.81 deg
Predicted target miss	-5.9 n mi
Inertial velocity at entry	25,589 ft/sec
ICDU values before attitude maneuver	CDUX 80.01 deg CDUY 113.53 deg CDUZ 339.38 deg
Final desired ICDU values after attitude maneuver	CDUX +179.33 deg CDUY +189.05 deg CDUZ +359.06 deg

Attitude Maneuver for Deorbit Burn

Time of maneuver initiation	1183941 sec g. e. t.
Total time of maneuver	242 sec
Final ICDU values after maneuver	CDUX +179.30 deg CDUY +189.00 deg CDUZ -0.39 deg
Angular excursions	pitch 111.70 deg yaw 46.79 deg roll 91.08 deg
Maximum angular rates	pitch 0.12 deg/sec yaw 0.75 deg/sec roll 0.15 deg/sec

Table 2. Test Results Summary, Nominal Deorbit Burn and Entry
(AS-204A1-02-019) (Continued)

Deorbit SPS Burn

Time of SPS ignition		1184823.1 sec
Delta velocity		578 ft/sec
SPS fuel expended		1383.367 lb
SPS tailoff		0.53 sec
Position deviation from RT (after cutoff)		18,850 ft
Velocity deviation from RT (after cutoff)		61.9 ft/sec
Angular excursions during steering in TVC	pitch	2.24 deg
	yaw	0.19 deg
Burn time		20.50 sec

Attitude Maneuver to CM/SM Separation Attitude

Time of maneuver initiation		1184881.09 sec
Total time of maneuver		63 sec
ICDU values before attitude maneuver		CDUX 180.86 deg
		CDUY 185.84 deg
		CDUZ 1.94 deg
Final desired ICDU values		CDUX 180.60 deg
		CDUY 18.63 deg
		CDUZ 0.45 deg
Final ICDU values achieved after the maneuver		CDUX 180.66 deg
		CDUY 18.68 deg
		CDUZ 0.49 deg
Angular excursions	pitch	167.19 deg
	yaw	2.09 deg
	roll	8.53 deg
Maximum angular rates	pitch	0.15 deg/sec
	yaw	0.15 deg/sec
	roll	0.12 deg/sec

Table 2. Test Results Summary, Nominal Deorbit Burn and Entry
(AS-204A1-02-019) (Continued)

CM/SM Separation

Time		1184985.09 sec
Attitude	pitch	45.65 deg
	yaw	3.81 deg
	roll	187.56 deg
Attitude rates	pitch	+0.15 deg/sec
	yaw	-0.15 deg/sec
	roll	-0.05 deg/sec

Maneuver to Entry Attitude

Time of maneuver initiation		1184995.09 sec
Total time of maneuver		110 sec
ICDU values before maneuver		CDUX 188.69 deg
		CDUY 24.94 deg
		CDUZ 0.62 deg
Final desired ICPU values		CDUX 359.38 deg
		CDUY 173.40 deg
		CDUZ 0.68 deg
Final ICPU values achieved after the maneuver		CDUX 359.20 deg
		CDUY 173.38 deg
		CDUZ 0.58 deg
Inertial flight-path angle at completion of maneuver		-1.49137 deg
Inertial velocity		25339.8 ft/sec
Inertial azimuth		77.6603 deg
Angular excursions	pitch	85.98 deg
	yaw	3.28 deg
	roll	178.53 deg
Maximum angle rates	pitch	5.16 deg/sec
	yaw	1.80 deg/sec
	roll	8.25 deg/sec
ΔV imparted during maneuver		25.48 ft/sec

Table 2. Test Results Summary, Nominal Deorbit Burn and Entry
(AS-204A1-02-019)(Continued)

Entry

Maximum g loading (first pulse)	4.68 g
Maximum g loading (second pulse)	3.95 g
Initial roll command	0.01 deg
AGC predicted target miss at entrance to final phase	-130.8 n mi
RCS fuel expended from entry interface (400,000 ft) to splash	66.6 lb
AGC predicted target miss at splash	0.6 n mi
AGC state vector position miss from intended target	$\Delta X = 12,751$ ft $\Delta Y = 33,706$ ft $\Delta Z = 27,080$ ft $\Delta R = 42,263$ ft
Environment state vector position miss from intended target	$\Delta X = 33,702$ ft $\Delta Y = 27,269$ ft $\Delta Z = 60,046$ ft $\Delta R = 74,060$ ft
Target latitude	30.9896 deg
Target longitude	-54.9616 deg
Splash latitude	31.1629 deg
Splash longitude	-55.1497 deg

Table 3a. Nominal AS-204A Deorbit and Entry Time Line

<u>Mission Phase</u>	<u>Time</u>	<u>CDU Mode</u>	<u>SCS Mode</u>
Begin targeting calculations	1183751.080	Fine alignment	G&N ΔV
End targeting, begin attitude maneuver	1183923.080	Attitude control	G&N attitude control
End deorbit attitude maneuver	1184187.080	Attitude control	G&N attitude control
Begin ullage maneuver	1184805.080	Attitude control	G&N ΔV
SPS ignition	1184823.080	Attitude control	G&N ΔV
End ullage maneuver	1184825.080	Attitude control	G&N ΔV
SPS engine-off	1184843.067	Attitude control	G&N ΔV
Begin CM/SM separation attitude maneuver	1184881.080	Attitude control	G&N attitude control
End CM/SM separation attitude maneuver	1184941.080	Attitude control	G&N attitude control
CM/SM separation	1184985.080	Entry	G&N entry
Begin entry attitude maneuver	1184993.067	Entry	G&N entry
End entry attitude maneuver	1185105.080	Entry	G&N entry
Entry interface	1185249.080	Entry	G&N entry
0.05g	1185399.080	Entry	G&N entry
0.20g	1185429.080	Entry	G&N entry
Splash	1185801.080	Entry	G&N entry

Table 3b. Nominal AS-204A Deorbit and Entry Time Line; Environment Inertial State Vector

Mission Phase	RSTATE X(ft)	RSTATE Y(ft)	RSTATE Z(ft)	VSTATE X(ft/sec)	VSTATE Y(ft/sec)	VSTATE Z(ft/sec)
Begin targeting calculations	14786434.73	-15085155.98	-4347331.310	17593.38612	13634.22162	12568.80381
End targeting, begin attitude maneuver	17485261.29	-12443788.92	-2110161.114	13679.21892	16973.10630	13354.38942
End deorbit attitude maneuver	20188161.57	-7430995.510	1450776.326	6629.311088	20692.23346	13476.21443
Begin ullage maneuver	18744612.11	6150358.917	8684962.700	-11089.19828	21275.34127	8844.119986
SPS ignition	18540732.88	6531834.364	8842120.475	-11563.32560	21108.78447	8616.953985
End ullage maneuver	18517542.54	6574004.456	8859311.760	-11629.28385	21055.64771	8571.178450
SPS engine -off	18302886.46	6947656.875	9009148.409	-12232.33034	20487.54937	8079.390568
Begin CM/SM separation attitude maneuver	17819204.28	7718371.890	9306474.946	-13205.89043	20075.22345	7574.302194
End CM/SM separation attitude maneuver	16982263.88	8902261.083	9736836.985	-14681.26398	19370.56428	6764.470156
CM/SM separation	16313297.68	9741969.364	10020944.86	-157198.8349	18788.95732	6146.234874
Begin entry attitude maneuver	16187007.85	9891590.752	10069577.95	-1590.422958	18677.58090	6031.921230
End entry attitude maneuver	14265816.24	11888094.59	10652621.35	-18350.76278	16919.80912	4367.507997
Entry interface	11423821.61	14135549.82	11119353.97	-21029.09336	14209.90029	2092.868736
0.05g	8100031.966	16023377.20	11248826.79	-23144.95052	10878.01498	-371.7534212
0.20g	7401765.038	16338779.06	11230551.52	-23377.25354	10145.66831	-841.0826967
Splash	2551162.143	17771757.19	10784619.56	-1345.570789	-295.7125705	-28.85161740

Table 3c. Nominal AS-204A Deorbit and Entry Time Line; AGC State Vector in Inertial Coordinates

Mission Phase	R _X Inertial(ft)	R _Y Inertial(ft)	R _Z Inertial(ft)	V _X Inertial(ft/sec)	V _Y Inertial(ft/sec)	V _Z Inertial(ft/sec)
	Not available	Not available	Not available	Not available	Not available	Not available
Begin targeting calculations	Not available	Not available	Not available	Not available	Not available	Not available
End targeting, begin attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
End deorbit attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
Begin ullage maneuver	18739553.0	6159901.7	8688902.2	-11101.05	21271.37	8838.57
SPS ignition	18535459.0	6541295.1	8845956.4	-11576.67	21100.64	8609.12
End ullage maneuver	18512238.0	6583436.8	8863125.6	-11645.53	21041.08	8560.02
SPS engine - off	18297106.0	6957080.7	9012867.6	-12252.95	20472.05	8069.07
Begin CM/SM separation attitude maneuver	17812941.0	7727357.1	9309979.0	-13222.47	20070.17	7571.20
End CM/SM separation attitude maneuver	16975019.0	8910920.4	9740145.2	-14697.38	19364.72	6761.02
CM/SM separation	16305352.0	9750358.4	10024096.0	-15735.63	18782.52	6142.53
Begin entry attitude maneuver	16178727.0	9900173.0	10072779.0	-15919.95	18670.75	6028.00
End entry attitude maneuver	14256045.0	11895608.0	10655301.0	-18365.22	16911.68	4363.27
Entry interface	11412091.0	14141772.0	11121367.0	-21041.69	14200.13	2087.87
0.05g	8086606.0	16027980.2	11250020.7	-23154.08	10866.16	-377.80
0.20g	7388099.5	16343022.7	11231544.1	-23383.05	10133.40	-848.71
Splash	2568227.3	17770928.9	10709675.2	-1248.24	-333.53	-450.88

Table 3d. Nominal AS-204A Deorbit and Entry Time Line; AGC State Vector in Platform Coordinates

Mission Phase	R _X Platform(ft)	R _Y Platform(ft)	R _Z Platform(ft)	V _X Platform(ft/sec)	V _Y Platform(ft/sec)	V _Z Platform(ft/sec)
Begin targeting calculations	Not available	Not available	Not available	Not available	Not available	Not available
End targeting, begin attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
End deorbit attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
Begin ullage maneuver	982052.07	270629.10	-21530782.95	25542.82	86.32	1175.50
SPS ignition	1441505.04	272128.23	-21504668.36	25502.50	80.02	1728.99
End ullage maneuver	1492469.50	272283.87	-21501115.43	25461.49	75.67	1823.85
SPS engine - off	1947066.39	273483.43	-21460452.21	25041.70	64.94	2694.17
Begin CM/SM separation attitude maneuver	2896027.80	275696.14	-21336017.92	24903.08	51.50	3847.40
End CM/SM separation attitude maneuver	4381564.87	278145.49	-21051451.91	24593.58	30.11	5645.50
CM/SM separation	5457164.27	279122.15	-20773972.78	24285.92	14.32	6951.09
Begin entry attitude maneuver	5651200.15	279225.08	-20717420.29	24222.48	11.44	7186.78
End entry attitude maneuver	8304636.82	277933.26	-19728950.91	23094.80	-37.68	10438.07
Entry interface	11490117.70	268781.59	-17939210.78	21031.91	-89.09	14366.85
0.05g	14438595.72	251489.15	-15502129.67	18152.29	-141.65	18022.26
0.20g	14972858.59	247018.20	-14952541.02	17452.58	-155.04	18589.15
Splash	17886847.09	187135.47	-1082362.53	46.20	-88.58	1364.79

Table 3e. Nominal AS-204A Deorbit and Entry Time Line: Environment Inertial State Vector

<u>Mission Phase</u>	<u>Altitude(ft)</u>	<u>Inertial Velocity(ft/sec)</u>	<u>Inertial Flight-Path Angle(deg)</u>	<u>Inertial Azimuth(deg)</u>
Begin targeting calculations	642848.0847	25561.57397	-0.01784133194	59.87101856
End targeting, begin attitude maneuver	639140.9058	25564.56697	-0.02130030727	58.34108822
End deorbit attitude maneuver	636014.0110	25568.03955	-0.02541649752	58.10821632
Begin ullage maneuver	640255.1626	25570.07867	-0.02088272980	68.34527678
SPS ignition	640461.0090	25564.49054	-0.03340844023	68.29310458
End ullage maneuver	640451.5963	25535.18442	-0.1031709132	68.34527678
SPS engine - off	636828.4136	25192.18404	-0.9243221026	68.86848480
Begin CM/SM separation attitude maneuver	620908.9111	25194.84456	-1.043483945	69.99181821
End CM/SM separation attitude maneuver	593057.7505	25229.27524	-1.163289230	71.87548087
CM/SM separation	570581.7863	25256.99620	-1.247342657	73.34154999
Begin entry attitude maneuver	566320.0658	25262.23705	-1.262275292	73.61514571
End entry attitude maneuver	499719.1589	25339.80193	-1.491371537	77.66038766
Entry interface	399373.0310	25466.13699	-1.699994025	83.42270629
0.05g	280917.0918	25576.51550	-1.835206366	89.83305138
0.20g	256618.0988	25497.80361	-1.774638370	91.11954456
Splash	36601.58573	1377.983704	-18.16888362	80.12921246

Table 3f. Nominal AS-204A Deorbit and Entry Time Line;
AGC Latitude, Longitude, and Acceleration

<u>Mission Phase</u>	<u>Latitude (deg)¹</u>	<u>Longitude (deg)¹</u>	<u>GMAX(g)</u>
Begin targeting calculations	Not available	Not available	Not available
End targeting, begin attitude maneuver	Not available	Not available	Not available
End deorbit attitude maneuver	Not available	Not available	Not available
Begin ullage maneuver	Not available	Not available	Not available
SPS ignition	Not available	Not available	Not available
End ullage maneuver	Not available	Not available	Not available
SPS engine - off	Not available	Not available	Not available
Begin CM/SM separation attitude maneuver	Not available	Not available	Not available
End CM/SM separation attitude maneuver	Not available	Not available	Not available
CM/SM separation	Not available	Not available	Not available
Begin entry attitude maneuver	Not available	Not available	Not available
End entry attitude maneuver	30.0449	-93.8654	0.000000
Entry interface	31.6221	-83.6590	0.0029797
0.05g	32.2469	-72.1629	0.0510137
0.20g	32.2322	-69.6868	0.194494
Splash	30.9886	-54.9669	1.193271

¹ By convention, positive latitude is north and positive longitude is east.

Table 3g. Nominal AS-204A Deorbit and Entry Time Line: Environment CDU
Shaft Angles and Rates

<u>Mission Phase</u>	<u>CDUX (deg)</u>	<u>CDUY (deg)</u>	<u>CDUZ (deg)</u>	<u>CDUDOTX (deg/sec)</u>	<u>CDUDOTY (deg/sec)</u>	<u>CDUDOTZ (deg/sec)</u>
Begin targeting calculations	80.0152428	113.5404691	-20.62271452	0.0000000000	0.0000000000	0.0000000000
End targeting, begin attitude maneuver	80.13740098	113.6650895	-20.66770889	0.3013143769	0.2277887464	-0.0445902108
End deorbit attitude maneuver	179.2859271	189.0089452	-0.395220392	0.0266704482	-0.0080089791	0.0099643765
Begin ullage maneuver	179.2857717	189.0088405	-0.395350244	-0.0073332251	0.0282344410	0.0324549139
SPS ignition	179.2857963	189.0087453	-0.395741070	-0.0285922824	-0.0292204706	0.0046279283
End ullage	179.4242950	188.7184696	-0.141017679	0.2318692017	-0.3562850695	0.3935465031
SPS engine-off	180.9115149	185.8348798	2.030067100	-0.0926101000	0.0219175888	-0.0532849624
Begin SM/CM separation attitude maneuver	180.8601422	185.8448910	1.944409131	0.0000000000	-0.0056716569	0.0058433284
End CM/SM separation attitude maneuver	180.7908081	18.76981957	0.551383398	-0.1312449791	-0.1406615797	-0.0782604376
CM/SM separation	191.2390029	18.68743858	0.494184273	0.0182840814	0.0072430867	0.0053827533
Begin entry attitude maneuver	191.2391812	19.31364164	0.499509414	0.0348240182	1.640794405	0.0173076236
End entry attitude maneuver	180.0221015	173.3862975	0.584594891	-0.0053035209	-0.0227179600	-0.0623350856
Entry interface	180.8347602	158.0462858	3.713345637	0.0306400523	-0.0512899650	-0.0171359358
0.05g	180.8350043	147.6986627	3.493837334	-0.0359000443	-0.0080086742	0.0188497334
0.20g	180.8350431	145.6456988	3.473173390	0.0199942488	0.0294293194	0.0000000000
Splash	210.7738343	34.06333218	-14.35470087	0.0000000000	-0.1330605522	-0.3847415471

Table 3h. Nominal AS-204A Deorbit and Entry Time Line; AGC CDU and Desired CDU Values

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	THETAD (deg)	THETAD+1 (deg)	THETAD+2 (deg)
Begin targeting calculations	Not available	Not available	Not available	Not available	Not available	Not available
End targeting, begin attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
End deorbit attitude maneuver	Not available	Not available	Not available	Not available	Not available	Not available
Begin ullage maneuver	179.2859	-170.9912	-0.37353	179.3298	-170.9363	-0.32958
SPS ignition	179.2859	-170.9912	-0.38452	179.3298	-170.9363	-0.32958
End ullage	179.5386	-171.5076	0.03295	179.6814	-171.7712	0.21972
SPS engine - off	-179.1211	-174.1443	1.98852	-179.1870	-174.1003	1.90063
Begin CM/SM separation attitude maneuver	-179.1321	-174.1553	1.94458	-179.1321	-174.1443	1.95556
End CM/SM separation attitude maneuver	-179.2749	18.72070	0.51635	-179.3848	18.63281	0.45043
CM/SM separation	-168.7500	18.68774	0.50537	-168.7061	18.63281	0.45043
Begin entry attitude maneuver	-168.7500	21.43433	0.53833	-168.7061	26.58691	0.670166
End entry attitude maneuver	-179.9780	173.3862	0.56030	179.9341	173.3972	0.68115
Entry interface	-179.1541	157.9614	3.71337	-179.1211	157.8296	3.66943
0.05g	-179.1541	147.5684	3.49365	-179.1211	147.3486	3.44970
0.20g	-179.1650	145.5908	3.46069	-179.1211	145.4590	3.40576
Splash	-149.2163	34.54102	-13.50220	-149.1943	33.83789	-14.72168

Table 3i. Nominal AS-204A Deorbit and Entry Time Line:
Inertial Acceleration

<u>Mission Phase</u>	<u>Inertial Acceleration X (ft/sec²)</u>	<u>Inertial Acceleration Y (ft/sec²)</u>	<u>Inertial Acceleration Z (ft/sec²)</u>
Begin targeting calculations	0.000000000	0.000000000	0.000000000
End targeting, begin attitude maneuver	0.000000000	0.000000000	0.000000000
End deorbit attitude maneuver	0.000000000	0.000000000	0.000000000
Begin ullage maneuver	0.000000000	0.000000000	0.000000000
SPS ignition	-0.143172900	-0.387520936	-0.281384115
End ullage maneuver	-8.786920560	-21.83327355	-12.79427979
SPS engine-off	-7.602627168	-22.68584691	-15.16197744
Begin CM/SM separation attitude maneuver	0.000000000	0.000000000	0.000000000
End CM/SM separation attitude maneuver	0.000000000	0.000000000	0.000000000
CM/SM separation	0.000000000	0.000000000	0.000000000
Begin entry attitude maneuver	0.000000000	0.000000000	0.000000000
End entry attitude maneuver	0.000399598	-0.000204332	-0.000010112
Entry interface	0.005150728	-0.001983888	-0.000215288
0.05g	1.722177995	-0.321068587	0.584855607
0.20g	6.540653097	-0.582403463	1.957349915
Splash	7.492750745	32.88717972	15.87550501

Table 3j. Nominal AS-204A Deorbit and Entry Time Line; Gimbal Angles and Gimbal Rates

Mission Phase	GIMO (deg)	GIMI (deg)	GIMM (deg)	GIMRATEO (deg/sec)	GIMRATEI (deg/sec)	GIMRATEM (deg/sec)
Begin targeting calculations	-80.01524049	-113.5404681	20.62271474	0.0000000000	0.0000000000	0.0000000000
End targeting, begin attitude maneuvers	-80.01523460	-113.5404749	20.62270047	0.0000000000	0.0000000000	0.0000000000
End deorbit attitude maneuvers	-164.4921319	175.6324887	-2.678903198	-0.1977444112	-0.0054632799	-0.1229191336
Begin ullage maneuvers	171.2815883	169.0785691	0.142445227	0.2088521772	0.0690630940	0.1160921351
SPS ignition	175.3124899	170.7065119	1.477157084	0.2336029895	0.0733976411	0.0624164488
End ullage maneuvers	178.4443751	170.0467039	4.544393108	-0.5521691035	-0.9633868711	0.5047690871
SPS engine - off	178.0590621	173.0539749	-0.064503679	0.1964453466	0.1178067032	-0.0430521684
Begin CM/SM separation attitude maneuvers	-179.4134663	172.8847748	-1.036712382	0.0649286561	-0.0273715578	-0.0043564725
End CM/SM separation	172.8228253	-20.54419759	6.794128630	-0.0209167718	-0.1367135658	0.1700150902
CM/SM separation	171.5837810	-12.98687779	0.909135509	-0.0354680203	-0.1306474131	0.1743518642
Begin entry attitude maneuvers	171.2594375	-11.56049634	-0.166203800	-0.0419406239	-0.1334522573	0.1778667057
End entry attitude maneuvers	2.094586371	-169.1709816	-0.732556914	2.4624122820	-0.6274186842	0.8311839573
Entry interface	-0.503603910	-165.4283121	-8.048091255	-0.5336578381	-2.3190545860	-0.8088680690
0.05g	-20.67750197	-0.014210152	-4.885415007	-1.9010010540	0.5403245787	-1.0578365490
0.20g	-14.60284486	-139.3436963	-6.749551242	-1.0901291540	-1.2280581730	-1.3727199250
Splash	-126.0804041	-17.33174356	-32.19185903	0.01137086873	-0.9168221646	0.7000905462

Table 3k. Nominal AS-204A Deorbit and Entry Time Line; Body Roll, Pitch, and Yaw Angles and Rates

Mission Phase	Roll (deg)	Pitch (deg)	Yaw (deg)	Roll Rate (deg/sec)	Pitch Rate (deg/sec)	Yaw Rate (deg/sec)
Begin targeting calculation	74.40013191	104.5371901	-52.883333512	0.000000000	0.000000000	0.000000000
End targeting, begin attitude maneuver	74.40012659	104.5371948	-52.88332017	0.000000000	0.000000000	0.000000000
End deorbit attitude maneuver	165.4801697	216.2325031	-6.094037529	0.1051521826	-0.1048747646	-0.1856299490
Begin ullage maneuver	187.3982733	223.6060396	4.606329034	-0.1424293865	0.1212247619	0.1635879749
SPS ignition	184.7282109	222.1759233	1.300753014	-0.1423763618	0.1685288511	0.1201109541
End ullage maneuver	183.7803527	222.9859210	-2.957089079	0.8908923049	-0.6547373487	0.5559621914
SPS engine - off	181.5927558	219.9317230	1.110841747	-0.1540706742	0.1728288873	0.0035212413
Begin CM/SM separation attitude maneuver	178.9410974	220.1151218	0.549605877	0.0072686932	0.0614397005	0.0338525603
End CM/SM separation attitude maneuver	189.7034886	53.26923648	-1.811923353	-0.1780215320	-0.0555045615	0.1187518313
CM/SM separation	187.5637292	45.65882391	3.814127708	-0.1760219132	-0.0593046713	0.1200801803
Begin entry attitude maneuver	187.2571658	44.26288827	4.887450501	-0.1809684823	-0.0580784974	0.1226338671
End entry attitude maneuver	-1.451452575	136.1344684	1.856250812	-1.109214881	1.756510330	1.699137791
Entry interface	4.890653959	132.2178238	6.533948470	2.289930512	1.060298292	0.2669646982
0.05g	20.17009829	111.2731206	-6.959369566	1.696613535	-0.773672592	-1.374054342
0.20g	15.97432503	107.5721687	-2.146896071	1.837773149	1.099288564	-0.5885070535
Splash	479.9724299	36.06958380	4.294820729	-1.058157205	-0.3307346881	0.3224479832

Table 31. Nominal AS-204A Deorbit and Entry Time Line; SC Mass, RCS Fuel Mass, RCS Fuel Mass, SPS Engine Thrust, Inertial Contact Acceleration and Total Inertial Acceleration

Mission Phase	SC Mass (lb)	RCS Fuel Mass (lb)	Thrust (lb)	Contact Acceleration (ft/sec/sec)	Total Acceleration (ft/sec/sec)
Begin targeting calculations	25831.96761	571.6097221	0.000000000	0.000000000	30.30637959
End targeting, begin attitude maneuver	25831.96761	571.6097221	0.000000000	0.000000000	30.31491087
End deorbit attitude maneuver	25720.04786	459.6908295	0.000000000	0.000000000	30.32335469
Begin ullage maneuver	25718.98002	458.0229845	0.000000000	0.000000000	30.32080412
SPS ignition	25698.77766	438.4205838	0.000000000	0.499847952	30.67876788
End ullage maneuver	25590.99590	438.1791719	21364.77770	26.78797122	53.08269016
SPS engine - off	24374.23461	438.1478664	21499.90097	28.32548587	54.24660401
Begin CM/SM separation attitude maneuver	24315.41002	438.1478664	0.000000000	0.000000000	30.37681134
End CM/SM separation attitude maneuver	24300.94816	403.6867168	0.000000000	0.000000000	30.45668653
CM/SM separation	24300.94861	403.6867168	0.000000000	0.000000000	30.52124619
Begin entry attitude maneuver	11506.10235	319.1126667	0.000000000	0.000000000	30.53349804
End entry attitude maneuver	11456.26511	221.1654451	0.000000000	0.000448924	30.72537592
Entry interface	11445.18197	210.0823131	0.000000000	0.005523781	31.01587463
0.05g	11436.61344	201.5137832	0.000000000	1.846899609	30.68624992
0.20g	11436.09023	200.9905764	0.000000000	6.852047535	29.22951189
Splash	11378.12624	143.0265969	0.000000000	37.27921087	6.746092407

4.2 OFF-NOMINAL OVERSHOOT ENTRY CONDITION (AS-204A1-20-003)

Table 4 contains the test results summary for the off-nominal overshoot entry condition in which the target has been moved westward within the target footprint boundary. The target location, defined by MSC (Appendix H), was selected to be within the entry footprint and therefore within the steering capability of the SC.

Table 5 contains the time line results for this off-nominal test run.

The latitude and longitude of splashdown were defined as 30.9 and -59.5 degrees, respectively. The nominal state vector (at entry interface) for a latitude and longitude of 30.989 and -54.9616 degrees were employed for this run. The maximum acceleration loading on the vehicle was 8.44 g's. The g-limiting logic was not exercised. The environment target miss was approximately 35,000 feet in cross range and 79,000 feet down range.

Appendix D contains detailed computer plots of the AGC and environment variables for this test case AS-204A1-20-003.

Table 4. Test Results Summary; Off-nominal Overshoot Condition (AS-204A1-20-003)

<u>Entry</u>	
Maximum g loading (1st pulse)	8.44 g
Maximum g loading (2nd pulse)	Does not exist
Initial roll command	-104.38 deg
AGC predicted target miss at entrance to final phase	+110.5 n mi
AGC predicted target miss at Mach 0.5 or (~35,000 feet)	-0.9 n mi
Target latitude	30.9000 deg
Target longitude	-59.5000 deg
Splash latitude	30.990 deg
Splash longitude	-59.7186 deg

Table 5a. Time Line; AS-204A Overshoot Entry Condition

<u>Mission Phase</u>	<u>Time</u>	<u>CDU Mode</u>	<u>SCS Mode</u>
Entry interface (400, 000 feet)	1185247.080	ENTRY	G&N ENTRY
0.05g switch set	1185395.080	ENTRY	G&N ENTRY
0.02g	1185427.080	ENTRY	G&N ENTRY
Splash (less than Mach 0.5)	1185701.080	ENTRY	G&N ENTRY

Table 5b. Time Line; Environment Inertial State Vector

<u>Mission Phase</u>	<u>RSTATEX (ft)</u>	<u>RSTATEY (ft)</u>	<u>RSTATEZ (ft)</u>	<u>VSTATEX (ft/sec)</u>	<u>VSTATEY (ft/sec)</u>	<u>VSTATEZ (ft/sec)</u>
Entry interface (400, 000 feet)	11465837.54	14107060.58	11115040.68	-20995.91495	14250.92134	2124.328138
0.05g switch set	8192555.708	15979706.48	11249786.81	-23101.47976	10975.70970	-313.4347270
0.02g	7448643.771	16318653.81	11231414.41	-23361.27941	10204.93628	-832.3692388
Splash (less than Mach 0.5)	4093185.342	17512095.44	10733100.91	-1321.440501	-186.8835420	-109.0117830

Table 5c. Time Line; AGC State Vector in Inertial Coordinates

Mission Phase	R_X Inertial (ft)	R_Y Inertial (ft)	R_Z Inertial (ft)	V_X Inertial (ft/sec)	V_Y Inertial (ft/sec)	V_Z Inertial (ft/sec)
Entry interface	11454126.42	14113314.87	11117065.37	-21008.60953	14241.12050	2119.298127
0.05g	8179156.66	15984352.70	11251005.30	-23111.020376	11039.87264	-319.749940
0.02g	7434983.94	16322922.86	11232412.57	-23367.535001	10193.00616	-840.604657
Splash	4096753.66	17511206.94	10676321.31	-1250.206011	-206.63783	-537.416581

Table 5d. Time Line; AGC Latitude, Longitude, Contact Acceleration

Mission Phase	Latitude (deg)	Longitude (deg)	GMAX (g)
Entry interface	31.6060	-83.6591	0.004214
0.05g	32.2452	-72.1629	0.04559
0.20g	32.2326	-69.8414	0.1993
Splash	30.8661	-59.5008	1.3098

Table 5e. Time Line; AGC State Vector in Platform Coordinates

Mission Phase	R _X Platform (ft)	R _Y Platform (ft)	R _Z Platform (ft)	V _X Platform (ft/sec)	V _Y Platform (ft/sec)	V _Z Platform (ft/sec)
Entry interface	11447964.77	269018.01	-17967834.38	21064.92	-87.63	14315.17
0.05g	14365682.97	252404.91	-15573912.59	18239.07	-132.70	17937.42
0.02g	14937743.25	248135.94	-14989535.05	17499.64	-129.32	18557.79
Splash	17052004.22	467262.37	-12100431.02	122.09	44.86	1370.26

Table 5f. Time Line; AGC CDU and Desired CDU Values

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	THETADX (deg)	THETADY (deg)	THETADZ (deg)
Entry interface	179.0662	157.9285	-2.8125	179.0222	157.8735	-2.8564
0.05g	179.0552	147.6233	-3.0432	179.0222	147.3926	-3.0981
0.20g	179.0662	145.4260	-3.1201	179.0222	145.3711	-3.1641
Splash	-170.1782	32.2778	-5.1636	-170.1233	3.1157	-6.2183

Table 5g. Time Line; Environment Inertial State Vector

Mission Phase	Altitude (ft)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle (deg)	Inertial Azimuth (deg)
Entry interface (400, 000 feet)	400792.0146	25464.28820	-1.698802311	83.34108144
0.05 g switch set	284016.5869	25578.17061	-1.839422011	89.67618627
0.02 g	257999.3393	25506.52738	-1.786338739	91.08834478
Splash (less than Mach 0.5)	35834.22673	1339.034736	-20.56643324	82.95397687

Table 5h. Time Line; Inertial Acceleration

Mission Phase	Inertial Acceleration X (ft/sec ²)	Inertial Acceleration Y (ft/sec ²)	Inertial Acceleration Z (ft/sec ²)
Entry interface (400, 000 feet)	0.004865336901	-0.001883398833	-0.0003578918249
0.05 g switch set	1.551418265	-0.07667231247	-0.02682713020
0.02 g	6.519698844	-0.2322503785	0.4721501925
Splash (less than Mach 0.5)	12.75129357	33.16532854	20.54096370

Table 5i. Time Line; CDU Shaft Angles and Rates

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	CDUDOTX (deg/sec)	CDUDOTY (deg/sec)	CDUDOTZ (deg/sec)
Entry interface (400, 000 feet)	179.0660482	158.0913620	-2.823754862	-0.03281590	-0.0510447668	0.001778120
0.05g switch set	179.0660678	147.7753278	-3.063124281	-0.03094365	-0.0406790724	0.000000000
0.02g	179.0663160	145.5871903	-3.131338871	-0.00116958	-0.0628863268	-0.00049836
Splash (less than Mach 0.5)	189.8217328	32.85989104	-4.547167481	0.000000000	-0.1900775534	-0.14808616

Table 5j. Time Line; Gimbal Angles and Rates

Mission Phase	GIMO (deg)	GIMI (deg)	GIMM (deg)	GIMRATEO (deg/sec)	GIMRATEM (deg/sec)	GIMRAEI (deg/sec)
Entry interface (400, 000 feet)	26.10343459	-162.9535812	6.692999108	2.616728212	1.404418897	-1.223526178
0.05g switch set	22.03887261	-146.8119509	-5.205228438	-2.397208171	1.102756903	0.5056302174
0.02g	22.01933896	-142.6490351	0.1398826408	1.691109152	0.06004207362	-0.4429413084
Splash (less than Mach 0.5)	-148.5378125	-17.02990320	-19.78829871	-1.268789935	2.042210171	0.3475690448

Table 5k. Time Line; Body Roll, Pitch, and Yaw Angles and Rates

Mission Phase	Roll (deg)	Pitch (deg)	Yaw (deg)	Roll Rate (deg/sec)	Pitch Rate (deg/sec)	Yaw Rate (deg/sec)
Entry interface (400,000 feet)	-25.76088970	133.3401822	8.094187796	-1.79408552	-1.791255985	1.742063922
0.05g switch set	-15.93331786	115.0689624	16.21318256	1.447241658	-0.828758728	-1.98945252
0.02g	-18.82596619	111.6171398	11.67929536	-1.20683100	-0.221869142	1.246365589
Splash (less than Mach 0.5)	143.4084337	44.69309584	0.945789980	1.191840570	1.457555516	0.774404049

Table 5l. Time Line; SC Mass, RCS Fuel Mass, Inertial Contact Acceleration and Total Inertial Acceleration

Mission Phase	SC Mass (lb)	RCS Fuel Mass (lb)	Contact Acceleration (ft/sec/sec)	Total Acceleration (ft/sec/sec)
Entry interface (400,000 feet)	11446.77862	211.6789594	0.005229414	31.01187620
0.05g switch set	11438.36816	203.2685002	1.553543360	30.86387611
0.02g	11438.15551	203.0558512	6.540897420	29.7017251
Splash (less than Mach 0.5)	11368.10161	133.0019689	41.04224281	9.933587922

Table 5m. Time Line; Relative Velocity, Flight-path Angle, Azimuth, and Angle of Attack

Mission Phase	Relative Velocity (ft/sec)	Relative Flight-path Angle (deg)	Relative Azimuth (deg)	Angle of Attack (deg)
Entry interface (400,000 feet)	25464.28820	-1.698802311	83.34108144	165.4313462
0.05g switch set	24148.69966	-1.791380156	82.97618500	165.4313462
0.02g	24269.42795	-1.938650789	89.65870474	154.4914306
Splash (less than Mach 0.5)	24199.36831	-1.882863913	91.14720265	155.5885752

4.3 OFF-NOMINAL UNDERSHOOT ENTRY CONDITION (AS-204A1-21-003)

Table 6 contains the test results summary for an off-nominal undershoot entry condition in which the target was intended to lay within the life support time limit boundary. The target was defined by MSC (Appendix H) as latitude 30.5 degrees and longitude -47.7 degrees.

Table 7 contains the time line results for this off-nominal test run.

The maximum acceleration loading on the vehicle was 6.54 g's. The flight time from entry interface to Mach 0.5 was 100 seconds greater than nominal. The target miss was approximately 58,500 feet crossrange and 42,000 feet downrange.

Appendix E contains detailed computer plots of the AGC and environment variables for this test case AS-204A1-21-003.

Table 6. Test Results Summary; Off-nominal Undershoot Entry Condition (AS-204A1-21-003)

<u>Entry</u>	
Maximum g loading (1st pulse)	6.54 g
Maximum g loading (2nd pulse)	Does not exist
Initial roll command	-15.20 deg
AGC predicted target miss at entrance to final phase	+525.7 n mi
AGC predicted target miss at Mach 0.5	-0.9 n mi
Target latitude	30.5000 deg
Target longitude	-47.7000 deg
Splash latitude	30.6623 deg
Splash longitude	-47.8148 deg

Table 7a. Time Line; Off-nominal Undershoot Entry Condition

<u>Mission Phase</u>	<u>Time</u>	<u>CDU Mode</u>	<u>SCS Mode</u>
Entry interface (400, 000 feet)	1185249.080	ENTRY	G&N ENTRY
0.05g switch set	1185395.080	ENTRY	G&N ENTRY
0.02g	1185427.080	ENTRY	G&N ENTRY
Splash (less than Mach 0.5)	1185899.080	ENTRY	G&N ENTRY

Table 7b. Time Line; Environment Inertial State Vector

<u>Mission Phase</u>	<u>RSTATEX (ft)</u>	<u>RSTATEY (ft)</u>	<u>RSTATEZ (ft)</u>	<u>VSTATEX (ft/sec)</u>	<u>VSTATEY (ft/sec)</u>	<u>VSTATEZ (ft/sec)</u>
Entry interface (400, 000 feet)	11423816.10	14135554.53	11119353.04	-21029.20554	14209.98915	2092.850796
0.05g switch set	81925037.48	15979666.53	11250176.24	-23103.24774	10973.41783	-306.8952020
0.02g	7448462.480	16318403.57	11232222.93	-23369.09774	10192.79076	-808.178267.
Splash (less than Mach 0.5)	133822.6659	18048552.93	10628963.24	-1449.222758	-463.4611591	-38.66650650

Table 7c. Time Line; AGC State Vector in Inertial Coordinates

Mission Phase	R_X Inertial (ft)	R_Y Inertial (ft)	R_Z Inertial (ft)	V_X Inertial (ft/sec)	V_Y Inertial (ft/sec)	V_Z Inertial (ft/sec)
Entry interface	11412077.36724	14141705.38353	11121283.903316	-21041.988629	14199.461974	2086.9494924
0.05g	8132890.223751	16006097.01819	11250466.997268	-23132.336630	10914.659694	-384.9684866
0.02g	7528365.863103	16281737.16214	11235940.089337	-23349.423793	10285.635407	-765.3236897
Splash	4480513.473268	17249902.55542	10964368.855531	-1217.9355434	-191.1375368	-496.8846615

Table 7d. Time Line; AGC Latitude, Longitude, Contact Acceleration

Mission Phase	Latitude (deg)	Longitude (deg)	GMAX (g)
Entry interface	31.6378	-83.3570	0.0000
0.05g	32.2464	-72.0083	0.0489
0.20g	32.2359	-69.9961	0.1708
Splash	31.7731	-60.6105	1.3868

Table 7e. Time Line; AGC State Vector in Platform Coordinates

Mission Phase	R _X Platform (ft)	R _Y Platform (ft)	R _Z Platform (ft)	V _X Platform (ft/sec)	V _Y Platform (ft/sec)	V _Z Platform (ft/sec)
Entry interface	11490036.91	268816.24	-17939149.68	21031.13	-88.71	14367.64
0.05g	14402059.99	251954.00	-15537993.65	18195.14	-137.18	17979.84
0.02g	14867491.45	248292.39	-15063653.71	17598.15	-143.54	18489.46
Splash	16786207.57	193495.77	-12491490.17	137.29	26.18	1321.84

Table 7f. Time Line; Actual and Desired CDU Values

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	THETADX (deg)	THETADY (deg)	THETADZ (deg)
Entry interface	179.9780	158.3240	0.4724	179.9451	158.2031	0.4175
0.05g	179.9890	147.9419	0.2307	179.9451	147.7222	0.1758
0.20g	179.9780	146.1951	0.1868	179.9451	145.9644	0.1318
Splash	-171.0022	32.3218	-4.2517	-171.0461	31.5527	-5.2075

Table 7g. Time Line; Environment Inertial State Vector

Mission Phase	Altitude (ft)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle (deg)	Inertial Azimuth (deg)
Entry interface (400,000 feet)	399372.7188	25466.27774	-1.699989305	83.42278783
0.05g switch set	284174.2161	25578.70481	-1.836926551	89.66040310
0.2g	258174.2209	25508.05490	-1.784486756	91.02517416
Splash (less than Mach 0.5)	38237.69122	1522.01722	-16.34108280	81.83992748

Table 7h. Time Line; Inertial Acceleration

Mission Phase	Inertial Acceleration X (ft/sec ²)	Inertial Acceleration Y (ft/sec ²)	Inertial Acceleration Z (ft/sec ²)
Entry interface (400,000 feet)	0.004949394	-0.00140492	0.000208444
0.05g switch set	1.508100903	-0.12456886	0.277911158
0.02g	6.195054331	-0.44486106	1.552720546
Splash (less than Mach 0.5)	2.331375394	32.19097360	14.68731208

Table 7i. Time Line; CDU Shaft Angles and Rates

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	CDUDOTX (deg/sec)	CDUDOTY (deg/sec)	CDUDOTZ (deg/sec)
Entry interface (400, 000 feet)	180.8349674	158.0571395	3.713573631	0.000000000	-0.0535634410	0.02171306676
0.05g switch set	180.8349674	147.9602871	3.493720776	0.000000000	-0.0447278131	-0.0002197233
0.02g	180.8349674	145.6853649	3.473142443	0.000000000	-0.0664475572	0.000000000
Splash (less than Mach 0.5)	185.2294756	30.54104402	-22.4900548	-0.02453437	-0.1250010019	-0.4004100136

Table 7j. Time Line; Gimbal Angles and Rates

Mission Phase	GIMO (deg)	GIMI (deg)	GIMM (deg)	GIMRATEO (deg/sec)	GIMRATEM (deg/sec)	GIMRATEI (deg/sec)
Entry interface (400, 000 feet)	-0.978319534	-157.6894835	-6.925608890	-0.5671047138	-0.588150437	-2.338562147
0.05g switch set	-7.541424125	-143.2015623	-9.726117187	-2.083826928	-0.616131703	0.7493202215
0.02g	-5.626018306	-140.8959795	-4.657049541	1.9805054270	-1.415490216	-0.84540978
Splash (less than Mach 0.5)	-72.46444135	-35.34536778	-35.15441102	0.4458699494	0.8912767646	-0.97082108

Table 7k. Time Line; Body Roll, Pitch, and Yaw Angles and Rates

Mission Phase	Roll (deg)	Pitch (deg)	Yaw (deg)	Roll Rate (deg/sec)	Pitch Rate (deg/sec)	Yaw Rate (deg/sec)
Entry interface (400, 000 feet)	4. 670121052	124. 5559769	5. 336958542	2. 112284095	1. 199574323	0. 5631747306
0. 05g switch set	11. 61477587	110. 4415803	4. 060045408	1. 645112645	-1. 14480861	-1. 303737101
0. 02g	7. 235267617	108. 0854798	0. 872713684	-1. 01805340	2. 201636487	-0. 548314401
Splash (less than Mach 0. 5)	75. 71118049	25. 86833325	3. 355653120	-1. 28541010	-0. 57304951	0. 6414798712

Table 7l. Time Line; SC Mass, RCS Fuel Mass, Inertial Contact Acceleration and Total Inertial Acceleration

Mission Phase	SC Mass (lb)	RCS Fuel Mass (lb)	Contact Acceleration (ft/sec/sec)	Total Acceleration (ft/sec/sec)
Entry interface (400, 000 feet)	11444. 93144	209. 8317730	0. 005149153	31. 01537788
0. 05 switch set	11436. 75000	201. 6503347	1. 538544881	30. 75138179
0. 02g	11436. 56316	201. 4634899	6. 402151249	29. 35487016
Splash (less than Mach 0. 5)	11414. 83906	179. 7393928	35. 45999476	5. 290354642

Table 7m. Time Line; Relative Velocity, Flight-path Angle, Azimuth, and Angle of Attack

Mission Phase	Relative Velocity (ft/sec)	Relative Flight-path Angle (deg)	Relative Azimuth (deg)	Angle of Attack (deg)
Entry interface (400,000 feet)	24150.77305	-1.792618018	83.06246539	158.1061914
0.05 g switch set	24269.96673	-1.936018063	89.64206999	154.3936975
0.02g	24200.88849	-1.880906271	91.08061165	154.3418983
Splash (less than Mach 0.5)	493.1003512	-60.27762438	32.00982576	154.1437873

4.4 OFF-NOMINAL OVERSHOOT ENTRY g-LIMITING CONDITION (AS-204A1-22-003)

Table 8 contains the test results summary for the off-nominal extreme overshoot entry condition. This test was intended to exercise the g-limiting capability within the AGC. The target location was defined by MSC (Appendix H) as latitude +32.0 degrees and longitude -65.0 degrees.

Table 9 contains the time line results for this off-nominal test run.

The g-limiter logic was exercised for this test case. The maximum acceleration loading experienced was 11.92 g's. This is approximately 2 g's greater than the intended limit of 10 g's.

The spacecraft was unable to steer to the intended target. The target miss of 55,000 feet crossrange and 1,500,000 feet downrange was payment for a reduced acceleration loading. In order to have reduced the acceleration, a "heads-up" roll command was issued. This roll command reduced the acceleration, but increased the downrange translation away from the intended target.

Appendix F contains detailed computer plots of the AGC and environment variables for this test case AS-204A1-22-003.

Table 8. Test Results Summary; Off-nominal Overshoot g-Limiting Condition (AS-204A1-22-003)

Entry

Maximum g loading (1st pulse)	11.92 g
Maximum g loading (2nd pulse)	8.00 g
Initial roll command	179.99 deg
AGC predicted target miss at entrance to final phase	-424.0 n mi
AGC predicted target miss at Mach 0.5	-223.7 n mi
Target latitude	32.0000 deg
Target longitude	-65.0000 deg
Splash latitude	31.8511 deg
Splash longitude	-60.8294 deg

Table 9a. Time Line; AS-204A Overshoot Outside of Entry Footprint

<u>Mission Phase</u>	<u>Time</u>	<u>CDU Mode</u>	<u>SCS Mode</u>
Entry interface (400, 000 feet)	1185249.080	ENTRY	G&N ENTRY
0.05g switch set	1185397.080	ENTRY	G&N ENTRY
0.02g	1185423.080	ENTRY	G&N ENTRY
Splash (less than Mach 0.5)	1185633.080	ENTRY	G&N ENTRY

Table 9b. Time Line; Environment Inertial State Vector

<u>Mission Phase</u>	<u>RSTATEX (ft)</u>	<u>RSTATEY (ft)</u>	<u>RSTATEZ (ft)</u>	<u>VSTATEX (ft/sec)</u>	<u>VSTATEY (ft/sec)</u>	<u>VSTATEZ (ft/sec)</u>
Entry interface (400, 000 feet)	11465835.44	14107026.74	11115052.98	-20996.08797	14250.48590	2124.515866
0.05g switch set	8146301.236	16001473.77	11249261.53	-23133.03097	10926.27424	-342.696761
0.02g	7541990.071	16277422.15	11234907.41	-23342.79926	10297.63963	-757.824052
Splash (less than Mach 0.5)	4477541.162	17250350.26	10997899.08	-1282.476229	-171.136115	-73.6862350

Table 9c. Time Line; AGC State Vector in Platform Coordinates

Mission Phase	R _X Platform (ft)	R _Y Platform (ft)	R _Z Platform (ft)	V _X Platform (ft/sec)	V _Y Platform (ft/sec)	V _Z Platform (ft/sec)
Entry interface	11490123.03	268780.97	-17939206.06	21031.91	-89.09	14367.04
0.05g	14365808.87	252044.64	-15574020.45	18240.25	-139.76	17936.78
0.02g	14937895.60	247279.44	-14989651.52	17501.42	-158.04	18557.53
Splash	19012380.73	-140469.56	-8694647.74	-59.62	-178.96	1463.19

Table 9d. Time Line; AGC CDU and Desired CDU Values

Mission Phase	CDUX (deg)	CDUY (deg)	CDUZ (deg)	THETADX (deg)	THETADY (deg)	THETADZ (deg)
Entry interface	-179.1541	157.9614	3.7224	-179.1211	157.8296	3.6694
0.05g	-179.1541	147.6892	3.5046	-179.1211	147.6343	3.4497
0.20g	-179.1541	145.5359	3.4827	-179.1211	145.3271	3.4277
Splash	-174.7705	30.4651	-22.6977	-174.8145	30.3662	-22.9614

Table 9e. Time Line; AGC State Vector in Inertial Coordinates

<u>Mission Phase</u>	<u>R X Inertial (ft)</u>	<u>R Y Inertial (ft)</u>	<u>R Z Inertial (ft)</u>	<u>V X Inertial (ft/sec)</u>	<u>V Y Inertial (ft/sec)</u>	<u>V Z Inertial (ft/sec)</u>
Entry interface	11412084.61174	14141774.54613	11121367.58953	-21041.858804	14200.080799	2087.793886
0.05g	8179114.19806	15981312.59496	11251397.20900	-23112.656203	10961.815291	-313.124904
0.02g	7434816.41128	16322667.27151	11233234.43406	-23375.072101	10180.728603	-815.694257
Splash	158463.85348	18046591.28902	10553799.85044	-1315.8106608	-489.9942733	-452.829005

Table 9f. Time Line; AGC Latitude, Longitude, Contact Acceleration

<u>Mission Phase</u>	<u>Latitude (deg)</u>	<u>Longitude (deg)</u>	<u>GMAX (g)</u>
Entry interface	31.6380	-83.3569	0.0000
0.05g	32.2454	-72.3177	0.0457
0.20g	32.2323	-69.6867	0.1943
Splash	30.4890	-47.6641	1.1097

Table 9g. Time Line; CDU Shaft Angles and Rates

<u>Mission Phase</u>	<u>CDUX</u> <u>(deg)</u>	<u>CDUY</u> <u>(deg)</u>	<u>CDUZ</u> <u>(deg)</u>	<u>CDUDOTX</u> <u>(deg/sec)</u>	<u>CDUDOTY</u> <u>(deg/sec)</u>	<u>CDUDOTZ</u> <u>(deg/sec)</u>
Entry interface (400,000 feet)	179.9887511	158.6757468	0.4647459448	-0.01733006987	-0.00192568602	0.0000000000
0.05g switch set	179.9891066	148.1068019	0.2443062468	-0.03078226666	-0.07064353598	0.0000000000
0.02g	179.9891312	146.3364806	0.2002422275	0.01934999756	-0.01864205009	0.0000000000
Splash (less than Mach 0.5)	188.9976085	32.65551612	-3.809984412	-0.02241701596	-0.05068612381	-0.047637393

Table 9h. Time Line; Environment Inertial State Vector

<u>Mission Phase</u>	<u>Altitude</u> <u>(ft)</u>	<u>Inertial</u> <u>Velocity</u> <u>(ft/sec)</u>	<u>Inertial</u> <u>Flight-path</u> <u>Angle (deg)</u>	<u>Inertial</u> <u>Azimuth</u> <u>(deg)</u>
Entry interface (400,000 feet)	400774.9704	25464.20284	-1.699490999	83.34013074
0.05g switch set	282332.6334	25579.34215	-1.838410266	89.75421485
0.02g	261166.6406	25508.05490	-1.797384631	90.88219696
Splash (less than Mach 0.5)	35562.67588	1295.940782	-20.50068697	80.82792443

Table 9i. Time Line; Inertial Acceleration

<u>Mission Phase</u>	<u>Inertial Acceleration X (ft/sec²)</u>	<u>Inertial Acceleration Y (ft/sec²)</u>	<u>Inertial Acceleration Z (ft/sec²)</u>
Entry interface (400,000 feet)	0.004565284	-0.0019808847	-0.00068041
0.05g switch set	1.645777397	-0.0056849485	0.133922805
0.02g	5.523518614	-0.2793186688	0.839145411
Splash (less than Mach 0.5)	5.866669859	35.9358231000	21.42231555

Table 9j. Time Line; Gimbal Angles and Rates

<u>Mission Phase</u>	<u>GIMO (deg)</u>	<u>GIMI (deg)</u>	<u>GIMM (deg)</u>	<u>GIMRATEO (deg/sec)</u>	<u>GIMRATEM (deg/sec)</u>	<u>GIMRATEI (deg/sec)</u>
Entry interface (400,000 feet)	-0.77245275	-16.14318563	4.9210460110	2.3663049250	-0.990640818	-0.553080246
0.05g switch set	11.26790550	142.3455644	-7.238354107	-1.914783527	0.5309399119	-0.329340258
0.02g	8.067159293	-142.7477274	-2.915113655	1.4447244070	-1.310204794	1.631991670
Splash (less than Mach 0.5)	-129.892200	-13.57627614	-25.58443618	-1.285643890	1.2873993210	0.4606667988

Table 9k. Time Line; Body Roll, Pitch, and Yaw Angles and Rates

	<u>Roll</u> (deg)	<u>Pitch</u> (deg)	<u>Yaw</u> (deg)	<u>Roll Rate</u> (deg/sec)	<u>Pitch Rate</u> (deg/sec)	<u>Yaw Rate</u> (deg/sec)
Entry interface (400,000 feet)	180.8785575	19.46790637	5.883852151	-0.8535947713	2.551301332	-0.2220790832
0.05g switch set	169.2907994	28.05776015		1.695274666	-0.8926200769	0.3596481496
0.02g	172.6444484	25.91751852	25524.53637	-1.650299832	0.2089816817	-1.8733036150
Splash (less than Mach 0.5)	98.21392554	86.47492362	94.59110794	0.03180133247	0.6812721434	1.2740975920

Table 9l. Time Line; SC Mass, RCS Fuel Mass, Inertial Contact Acceleration and Total Inertial Acceleration

<u>Mission Phase</u>	<u>SC Mass</u> (lb)	<u>RCS Fuel Mass</u> (lb)	<u>Contact Acceleration</u> (ft/sec/sec)	<u>Total Acceleration</u> (ft/sec/sec)
Entry interface (400,000 feet)	11447.18104	212.0807953	0.005022817	31.01160878
0.05g switch set	11438.68975	203.5900879	1.651226888	30.69874713
0.02g	11438.38723	203.2875633	5.593900758	29.67528273
Splash (less than Mach 0.5)	11389.58955	154.4898984	42.24544867	10.58077798

Table 9m. Time Line; Relative Velocity, Flight-path Angle, Azimuth, and Angle of Attack

<u>Mission Phase</u>	<u>Relative Velocity (ft/sec)</u>	<u>Relative Flight-path Angle (deg)</u>	<u>Relative Azimuth (deg)</u>	<u>Angle of Attack (deg)</u>
Entry interface (400,000 feet)	24148.61947	-1.792106341	82.97518164	161.2464818
0.05g switch set	24268.22237	-1.937580951	89.74094634	151.4154836
0.02g	24217.18794	-1.894449688	90.92987661	155.2882594
Splash (less than Mach 0.5)	503.6685619	-64.30483080	80.82792443	154.5702711

4.5 PLOTTED TEST RESULTS

Appendix C contains the plotted results of the nominal deorbit burn and entry for the AS-204A reference trajectory initialization. These results contain AGC and environment parameter plots.

Appendixes D, E, and F contain the plotted results of the off-nominal overshoot entry condition (within the entry footprint), the undershoot entry condition (inside the entry footprint), the g-limiting overshoot entry condition (outside of the entry footprint), respectively.

Appendix G contains the plotted results of the off-nominal command module c. g. offset during entry.

Appendix I contains the plotted results of the nominal entry case using the engineering simulation developed under Task A-9.

4.6 ADDITIONAL TEST RESULTS

The following results were obtained during testing which were not described or required in the test plan (Reference 1).

a) Program Alarm

In the event the stable member should be aligned during entry with the X_{sm}/Z_{sm} plane out of the trajectory plane more than ± 20 degrees, a program alarm is displayed. This function was simulated, and the program alarm was correctly displayed.

b) CDU Fail

An error between the actual CDU value and the initial desired CDU value was initialized creating an error greater than the maximum allowable, and a CDU Fail was correctly displayed.

c) Error Codes

1) The deorbit burn nominal run was initialized at a time that would not allow the completion of the targeting calculations before the message, "5 minutes to desired ignition time." The Noun 31 error code 1405 was correctly displayed.

- 2) A target latitude which exceeded the declination of the orbit was input correctly causing a Noun 31 error code 1411, message "target latitude exceeds declination of orbit."
- 3) A stable member misalignment during entry correctly caused a Noun 31 error code 1426, message "IMU orientation unsatisfactory for entry."

d) Command Module c. g. Offset

A simulation run was made with a large c. g. offset (200 percent greater than nominal) in the command module during entry. The offset was as follows:

$$\Delta X = 0.1 \text{ m}$$

$$\Delta Y = 0.2 \text{ m}$$

$$\Delta Z = 0.3 \text{ m}$$

The run results showed little difference in the trajectory. However, the final phase steering was considerably affected. Table 10 illustrates the fuel consumption as opposed to the nominal consumption. (These should only be considered to be qualitative results because of the inaccuracies in the simulation of the CM RCS.) Appendix G contains plots illustrating the excess steering created by the c. g. offset. Of particular interest are the graphs of ROLLC versus time and TFUEL versus time.

e) Service Module SPS Gimbal Trim Setting

Prior to entrance into program 32, for the deorbit burn calculations, the values of the pitch and yaw trim settings for the SPS engine are required as inputs for targeting calculations. A simulation run was made starting with the nominal deorbit burn and entry initial conditions and with a SC Y-axis c. g. offset error causing an effective error of 5 degrees in the nominal pitch trim setting. An initial torque of 599.6 foot-pounds was placed on the SC due to the incorrect trim

setting. The following position and velocity errors were recorded with respect to the nominal at entry interface (400,000-foot altitude):

$$\Delta X = +45,606 \text{ ft}$$

$$\Delta Y = -30,284 \text{ ft}$$

$$\Delta Z = -6,493 \text{ ft}$$

$$\Delta \dot{X} = +44.742 \text{ ft/sec}$$

$$\Delta \dot{Y} = +44.707 \text{ ft/sec}$$

$$\Delta \dot{Z} = +21.907 \text{ ft/sec}$$

f) REFSMMAT Error

A simulation run was made with an error in the reference inertial to stable member transformation matrix (REFSMMAT) in the AGC erasable memory. The matrix was non-orthonormal to the extent that the value of the determinant of the matrix was 0.99727 and the dot product of two columns of the matrix was as large as 0.009529.

The results of the simulation run show that an error in the AGC state vector position, increasing at 300 feet per second, occurs.

Table 10. Fuel Consumption for Command Module c. g. Offset

<u>Phase</u>	<u>Nominal RCS Fuel Consumption (lb)</u>	<u>RCS Fuel Consumption with c. g. Offset (ft)</u>
CM/SM separation to entry attitude maneuver	48.84	54.34
Attitude hold until entry interface (400,000 feet)	11.48	14.24
Entry interface to start of final phase steering (257,000 feet)	8.69	35.40
Final phase steering to splash (35,000 feet)	57.97	269.37

APPENDIX A

AS-204A REFERENCE TRAJECTORY INITIALIZATION

NOMINAL DEORBIT AND ENTRY INITIALIZATION

(AS-204A1-02-019)

*N1 = I0,
*N2 = I1,
*N3 = A, J1=HMS3B204A,
* J2=H00020019,
* J3=H00000000,
* J4=H NONEF,
*N4=H11/02/66,
*N6=I0,
*N7=I0,
*N8=I0,
*N9=I0\$
*N1=I1966,
*N2=D24803345.078,
*N3=I1967,
*N4=D0.0,
*N5=O6740300540317.
*N6=O04240,
*N7=A, J1=D4474616.8,
* J2=D-4622773.3,
* J3=D-1348018.6,
* J4=D5400.3237,
* J5=D4116.8428,
* J6=D3819.6692F,
*N8=D0.05,

*N9=D0. 01,
*N10=D2,
*N11=D2,
*N12=D20,
*N14=D0. 0,
*N15=D2. 0,
*N18=D0. 0,
*N19=A, J1=D0. 0,
* J2=D0. 0,
* J3=D0. 0F,
*N21= I3,
*N22=A, J1=D80. 015238,
* J2=D114. 54109,
* J3=D-20. 622714F,
*N23=A, J1=D26. 63,
* J2=D-138. 07,
* J3=D57. 38F,
*N24=A, J1=D0. 0,
* J2=D0. 0,
* J3=D0. 0F,
*N25=A, J1=D0. 0,
* J2=D0. 0,
* J3=D0. 0F,
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*N29=A, J1=D122.727,
* J2=D0.0,
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* J4=D0.0F,
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* J2=D0.0,
* J3=D0.0,
* J4=D0.0F,
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* J2=D0.0,
* J3=D0.0F,
*N34=A, J1=D0.0,
* J2=D0.0,
* J3=D0.0F,
*N35=D0.0115,
*N36=A, J1=D104.53719,
* J2=D-52.883335,
* J3=D74.400132F,
*N38=D0.0,
*N39=D0.0,
*N40=D0.0,
*N41=D0.0,
*N42=A, J1=D0.0,
* J2=D0.0,

* J3=D0.0F,

*N43=D10000.0,

*N44=D1.0,

*N45=I5,

*N46=I1,

*N47=I1,

*N48=I1,

*N49=I0,

*N58=I3\$

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\$REQ+	S	RRECT + 4	DDEC	-1348.0186	B-14	=
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OFF-NOMINAL ENTRY WITH CG OFFSET INITIALIZATION

(AS-204A1-01-019)

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*N2=I1,
*N3=A, J1=HMS3B204A,
* J2=H00010021,
* J3=H00000000,
* J4=H NONEF,
*N4=H11/03/66,
*N6=I0,
*N7=I0,
*N8=I0,
*N9=I0\$
*N1=I1966,
*N2=D24804406.09,
*N3=I1967,
*N4=D0.0,
*N5=O4700300551757,
*N6=O04240,
*N7=A, J1=D5709462.355,
* J2=D1880219.803,
* J3=D2649231.107,
* J4=D-3418.72582,
* J5=D6341.22408,
* J6=D2604.04259F,
*N8=D0.05,

*N9=D0.01,
*N10=D2,
*N11=D2,
*N12=D20,
*N14=D0.0,
*N15=D2.0,
*N18=D0.0,
*N19=A, J1=D0.1,
* J2=D0.2,
* J3=D0.3F,
*N21=I4,
*N22=A, J1=D179.3833599,
* J2=D-162.30363,
* J3=D1.253765699F,
*N23=A, J1=D26.630000,
* J2=D-138.07,
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*N24=A, J1=D0.0,
* J2=D0.0,
* J3=D0.0F,
*N25=A, J1=D0.0,
* J2=D0.0,
* J3=D0.0F,
*N26=D.0025,
*N27=D11207.00,
*N28=D5240.9,
*N29=A, J1=D144.747,

* J2=D0.0,
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* J2=D0.0,
* J3=D0.0F,
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* J2=D0.0,
* J3=D0.0F,
*N35=D0.0115,
*N36=A, J1=D-129.44224,
* J2=D.7156717458,
* J3=D178.7999994F,
*N37=A, J1=D-4.672144296,
* J2=D-108.7807749,
* J3=D67.63745743F,
*N38=D0.0,
*N39=D0.0,
*N40=D0.0,
*N41=D0.0,

*N42=A, J1=D0. 0,
 * J2=D0. 0,
 * J3=D0. 0F,
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 *N44=D1. 0,
 *N45=I5,
 *N46=I1,
 *N47=I0,
 *N48=I1,
 *N49=I0,
 *N58=I4\$

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\$REQ+	S	ADVAN	+0	ADVAN		=
\$REQ+	S	STARTSW	+0	TC	ESTART	=
\$REQ+	S	ESTART	+2	CADR	ENDREENS	=
\$REQ+	S	SLAP 1	+4	XCH	A	=
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\$REQ+	S	ENDREENS	+0	TC	PHASCHNG	=
\$REQ+	S	ENDREENS	+1	OCT	C00105	=
\$REQ+	S	ENDREENS	+2	INDEX	INHINT	=
\$REQ+	S	ENDREENS	+3	CAF	100DEC	=
\$REQ+	S	ENDREENS	+4	TC	WAITLIST	=
\$REQ+	S	ENDREENS	+5	CADR	READACCS	=
\$REQ+	S	ENDREENS	+6	TC	ENDOFJOB	=
\$REQ+	S	MODREG	+0	OCT	C00042	=
\$REQ+	S	SWINIT	+1	OCT	C01001	=

\$REQ+	S	PIPAX	+0	OCT	C00000	=
\$REQ+	S	PIPAY	+0	OCT	C00000	=
\$REQ+	S	PIPAZ	+0	OCT	C00000	=
\$REQ+	S	GBIASX	+0	DEC	0.0	=
\$REQ+	S	GBIASX	+1	DEC	0.0	=
\$REQ+	S	GBIASX	+2	DEC	0.0	=
\$REQ+	S	ADIAX	+0	DEC	0.0	=
\$REQ+	S	ADIAX	+1	DEC	0.0	=
\$REQ+	S	ADIAX	+2	DEC	0.0	=
\$REQ+	S	ADSRAX	+0	DDEC	0.0	=
\$REQ+	S	ADSRAX	+2	DDEC	0.0	=
\$REQ+	S	PBIASX	+0	DDEC	0.0	=
\$REQ+	S	PBIASX	+2	DDEC	0.0	=
\$REQ+	S	PBIASX	+4	DDEC	0.0	=
\$REQ+	S	TIME 2	+0	DDEC	+118480609	=
\$REQ+	A	000756		DEC	200 B-8	=
\$REQ+	S	CDUX	+0	OCT	C37710	=
\$REQ+	S	CDUY	+0	OCT	C43113	=
\$REQ+	S	CDUZ	+0	OCT	C02165	=
\$REQ+	S	THETAD	+0	OCT	C37710	=
\$REQ+	S	THETAD	+1	OCT	C43113	=
\$REQ+	S	THETAD	+2	OCT	C02165	=
\$REQ+	S	ROLLC	+0	DDEC	.5	=
\$REQ+	S	K1ROLL	+0	DEC	0.0	=
\$REQ+	A	001132		DDEC	0.0	=
\$REQ+	S	AXO	+0	DDEC	.00003271354	=
\$REQ+	S	AYO	+0	DDEC	-.00005009514	=

\$REQ+	S	UNITWREF	+4	OCT	C37777	=
\$REQ+	S	UNITWREF	+5	OCT	C37777	=
\$REQ+	S	UNITW	+0	DDEC	+. 36719181528	B-1 =
\$REQ+	S	UNITW	+2	DDEC	-. 84099031746	B-1 =
\$REQ+	S	UNITW	+4	DDEC	-. 397373194936	B-1 =
\$REQ+	S	RN	+0	DDEC	+302830. 56356	B-24 =
\$REQ+	S	RN	+2	DDEC	+82483. 135236	B-24 =
\$REQ+	S	RN	+4	DDEC	-6561486. 29570	B-24 =
\$REQ+	S	VN	+0	DDEC	+76. 4644233128	B-7 =
\$REQ+	S	VN	+2	DDEC	+00. 24753790023	B-7 =
\$REQ+	S	VN	+4	DDEC	+04. 59514616584	B-7 =
\$REQ+	S	UNITR	+0	DDEC	+. 0461000282	B-1 =
\$REQ+	S	UNITR	+2	DDEC	+. 01255644351	B-1 =
\$REQ+	S	UNITR	+4	DDEC	-. 998857910	B-1 =
\$REQ+	S	GDT	+0	DDEC	+. 008603218	B-8 =
\$REQ+	S	GDT	+2	DDEC	+. 0021279706	B-8 =
\$REQ+	S	GDT	+4	DDEC	-. 18467812692	B-8 =
\$REQ+	S	AZO	+0	DDEC	-. 01014875	=
\$REQ+	S	TEPHEM	+0	OCT	C00002	=
\$REQ+	S	TEPHEM	+1	OCT	C37111	=
\$REQ+	S	TEPHEM	+2	OCT	C14100	=
\$REQ+	S	LAT(SPL)	+0	DDEC	. 086083333	=
\$REQ+	S	LNG(SPL)	+0	DDEC	-. 152666667	=
\$REQ+	S	ENDFRESH	+0	ENVSUM		=
\$REQ+	S	ENDFRESH	+0	CFDUMP		=
\$REQ+	S	COPYGRAV	+14	CFDUMP		=
\$REQ+	S	COPYGRAV	+14	ENVSUM		=

\$REQ+	S	COPYGRAV	+14	EDUMP A+0	A+1777		=
\$REQ+	S	CDU DRIVE	+7	EDUMP A+0	A+1777		=
\$REQ+	S	REFSMMAT	+0	DDEC	-. 39469591793	B-1	=
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\$REQ+	S	REFSMMAT	+14	DDEC	-. 88527177946	B-1	=
\$REQ+	S	REFSMMAT	+16	DDEC	-. 24162351865	B-1	=
\$REQ+	S	REFSMMAT	+20	DDEC	-. 39738136603	B-1	=

\$REPORT+ NEXTTYPE=03

\$/

APPENDIX B

ASTRONAUT INPUTS

APPENDIX B
ASTRONAUT INPUTS

This appendix describes the astronaut inputs required during the 204 simulation runs. These inputs are manually inserted through the command and data handling console typewriter during the run.

The method used is as follows:

- 1) Visually monitor the DSKY DUMPS being printed on-line on the CDC printer until a message from COLUMN A appears.
- 2) Wait until this message has appeared in at least two more consecutive DSKY DUMPS and then press the manual interrupt button found to the right of the typewriter.
- 3) When the interrupt occurs (as indicated by the TYPE IN light immediately below the interrupt button being lighted), type in the appropriate message from COLUMN B.
- 4) If the DSKY DUMP display remains completely unchanged for more than 8-10 seconds following an astronaut input, repeat the message.

The astronaut inputs are given in Table B-1. Table B-2 provides a definition of the displayed data in R1 through R3 of the DSKY corresponding to the associated noun-verb codes.

The character "... " as used in this appendix is defined by the three periods followed by a carriage return. This is done in order to put the simulator into the mode to accept typewriter inputs when a manual typewriter interrupt has occurred.

Following the insertion of "... " a message is typed out to the user and is concluded with the comment

START INPUT

The appropriate message from COLUMN B is then typed in.

Table B-1. AS-204 Astronaut Input List

<u>Column A</u>					<u>Column B</u>	
DSKY DUMPS - Look for:					Astronaut Input - Type in:	
Program	Noun	Verb	Register	1		
1)	00	---	---	-----	1)	... DSKY: VERB 37 ENTER 32 ENTER;/
2)	32	44*	06*	-----	2)	... DSKY: VERB 33 ENTER;/
3)	32	74*	06*	-----	3)	(same as above)
4)	32	70*	06*	-----	4)	(same as above)
5)	32	34*	06*	-----	5)	(same as above)
6)	32	33*	06*	-----	6)	(same as above)
7)	32	47*	06*	-----	7)	(same as above)
8)	32	35*	06*	-----	8)	(same as above)
9)	32	17*	06*	-----	9)	(same as above)
10)	32	25*	50*	00001	10)	... MANUAL: SCS NEWMODE=6; DSKY: ENTER;/
11)	32	20*	16*	-----	11)	... DSKY: VERB 33 ENTER;/
12)	32	17*	06*	-----	12)	(same as above)
13)	32	07*	50*	00042	13)	... DSKY: VERB 37 ENTER 42 ENTER;/
14)	42	20*	16*	-----	14)	... DSKY: VERB 33 ENTER;/
15)	42	14*	06*	-----	15)	(same as above)
16)	42	25*	50*	00002	16)	... MANUAL: SCS NEWMODE=5; DSKY: ENTER;/
17)	42	11*	50*	-----	17)	... DSKY: ENTER;/
18)	42	52*	16*	-----	18)	... DSKY: VERB 33 ENTER;/
19)	42	47*	06*	-----	19)	(same as above)

Table B-1. AS-204 Astronaut Input List (Continued)

<u>Column A</u>					<u>Column B</u>	
DSKY DUMPS - Look for:					Astronaut Input - Type in:	
Program	Noun	Verb	Register	1		
20)	42	07*	50*	00061	20)	... DSKY: VERB 37 ENTER 61 ENTER;/
21)	61	53*	16*	-----	21)	... DSKY: VERB 33 ENTER;/
22)	61	25*	50*	00001	22)	... MANUAL: SCS NEWMODE=6; DSKY: ENTER;/
23)	61	17*	06*	-----	23)	... DSKY: VERB 33 ENTER;/
24)	62	25*	50*	00004	24)	... MANUAL: SCS NEWMODE=3; DSKY: ENTER;/
25)	62	25*	50*	00003	25)	... MANUAL: SCS NEWMODE=7; DSKY: ENTER;/
26)	62	25*	50*	00041	26)	... MANUAL: STAGE SERVICE;/ An automatic return to the typewriter occurs 3 seconds after the above message. At that time, you type in - DSKY: VERB 33 ENTER;/
27)	62	62*	06*	-----	27)	... DSKY: VERB 33 ENTER;/
28)	64	---	---	-----	28)	... MANUAL: GSWITCH ON;/
(as soon as Program 64 is entered, insert message 9)						

Table B-2. Displayed Data

<u>Noun</u>	<u>Display</u>	<u>Unit</u>	<u>Register</u>	<u>Definition</u>
07	N/A			Change program request
11	N/A			Engine on enable
14	XXXXX.	fps	R1	ΔV counter set
17	XXX. XX	deg	R1	Final ICPU angles
20	XXX. XX	deg	R1	Present ICPU angles
25	XXXXX.		R1	Checklist code
33	XXXXX. XXXXX XXX. XX	hr min sec		Time of ignition
34	XXXXX. XXXXX. XXX. XX	hr min sec		Event time
35	XXXXX. XXXXX. XXX. XX	hr min sec		Time to event
44	XXX. XX XXX. XX XXXX. X	deg deg n mi		Target latitude Target longitude Altitude
47	XXX. XX XXXX. X XXXXX.	deg n mi fps		Gamma at entry Miss distance Inertial velocity at entry
32	XX0XX XXXX. XXXX.	min sec fps fps		Time to event Velocity to be gained Measured velocity change
53	XXX. XX XXX. XX XX0XX	g deg min sec		Max acceleration Gamma at entry Free fall time
62	XXX. XX XXX. XX XXXXX.	deg deg		Impact latitude Impact longitude Heads up/down

Table B-2. Displayed Data (Continued)

<u>Noun</u>	<u>Display</u>	<u>Unit</u>	<u>Register</u>	<u>Definition</u>
70	XXX.XX	deg		Pitch trim
	XXX.XX	deg		Yaw trim
	XXX.XX	sec		Tailoff time
71	XXX.XX	deg		Commanded roll angle
	XXX.XX	g		Present accel- eration
	XXXX.X	n mi		Predicted range minus range to go

Note:

Verb Definitions

<u>Verb</u>	<u>Description</u>
06	Decimal display
16	Monitor decimal
50	Please perform

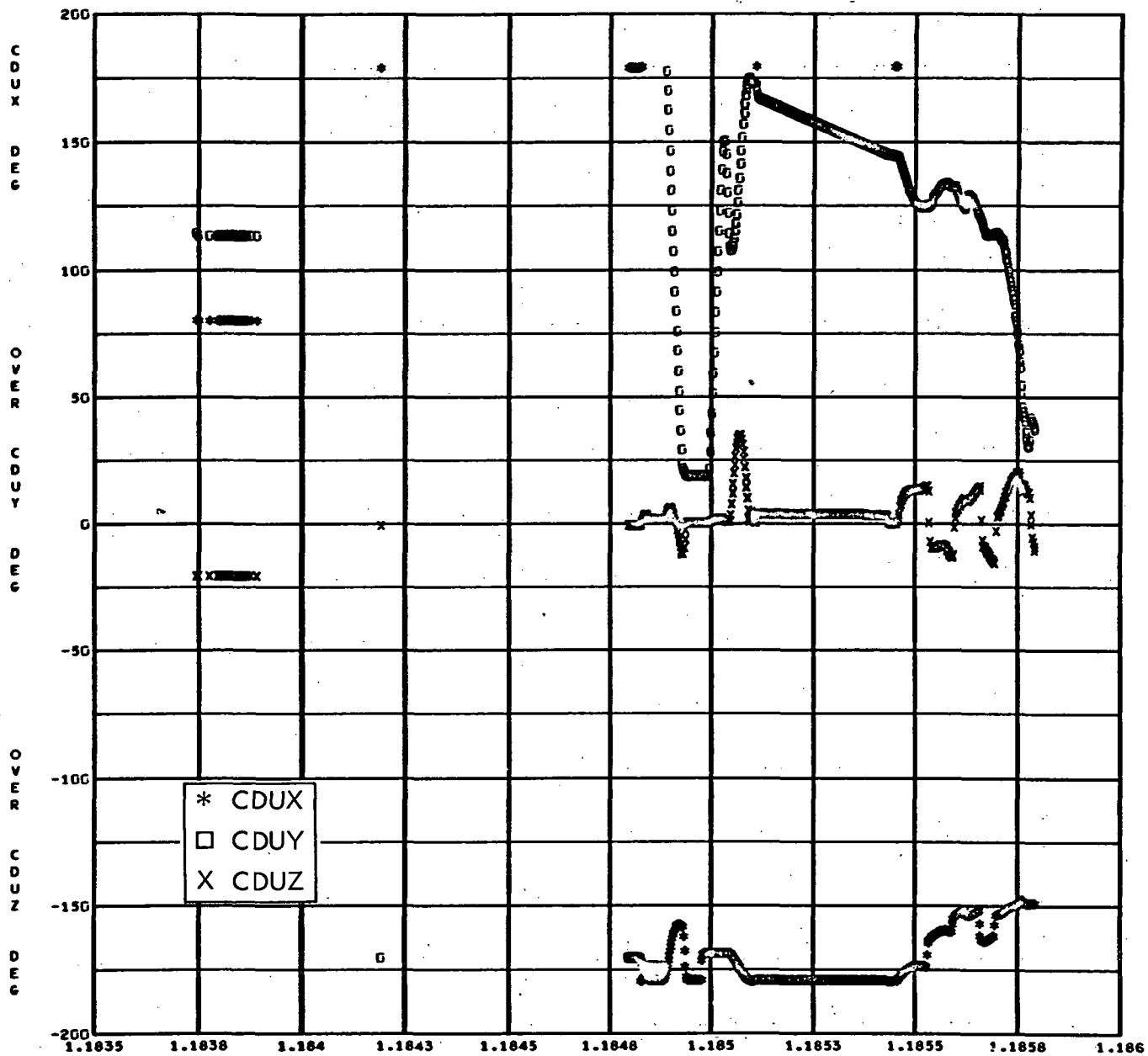
APPENDIX C

PLOTS OF NOMINAL DEORBIT TEST RUN*

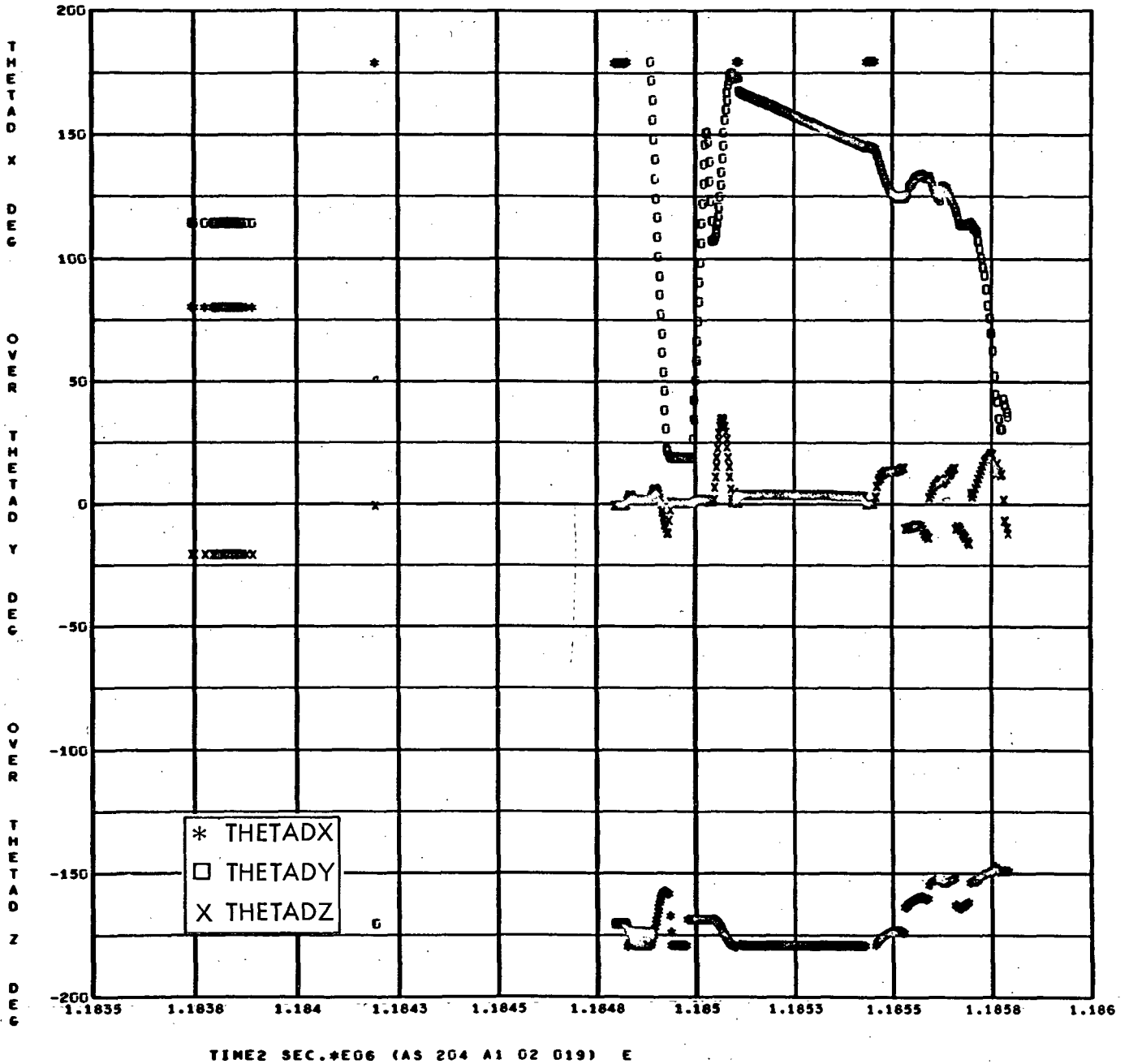
AS-204A1-02-019

AGC PLOTS

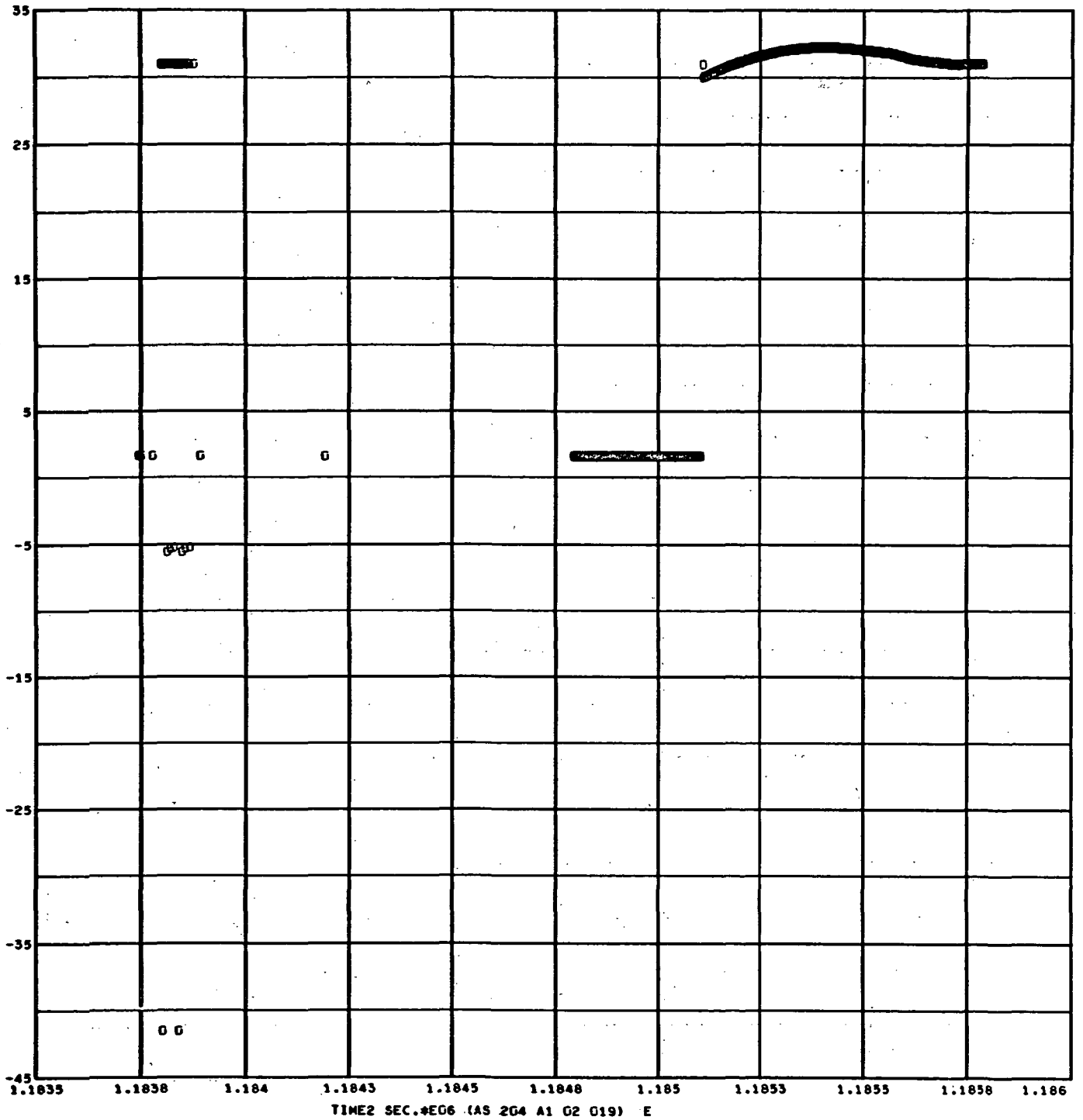
AS-204A1-02-019



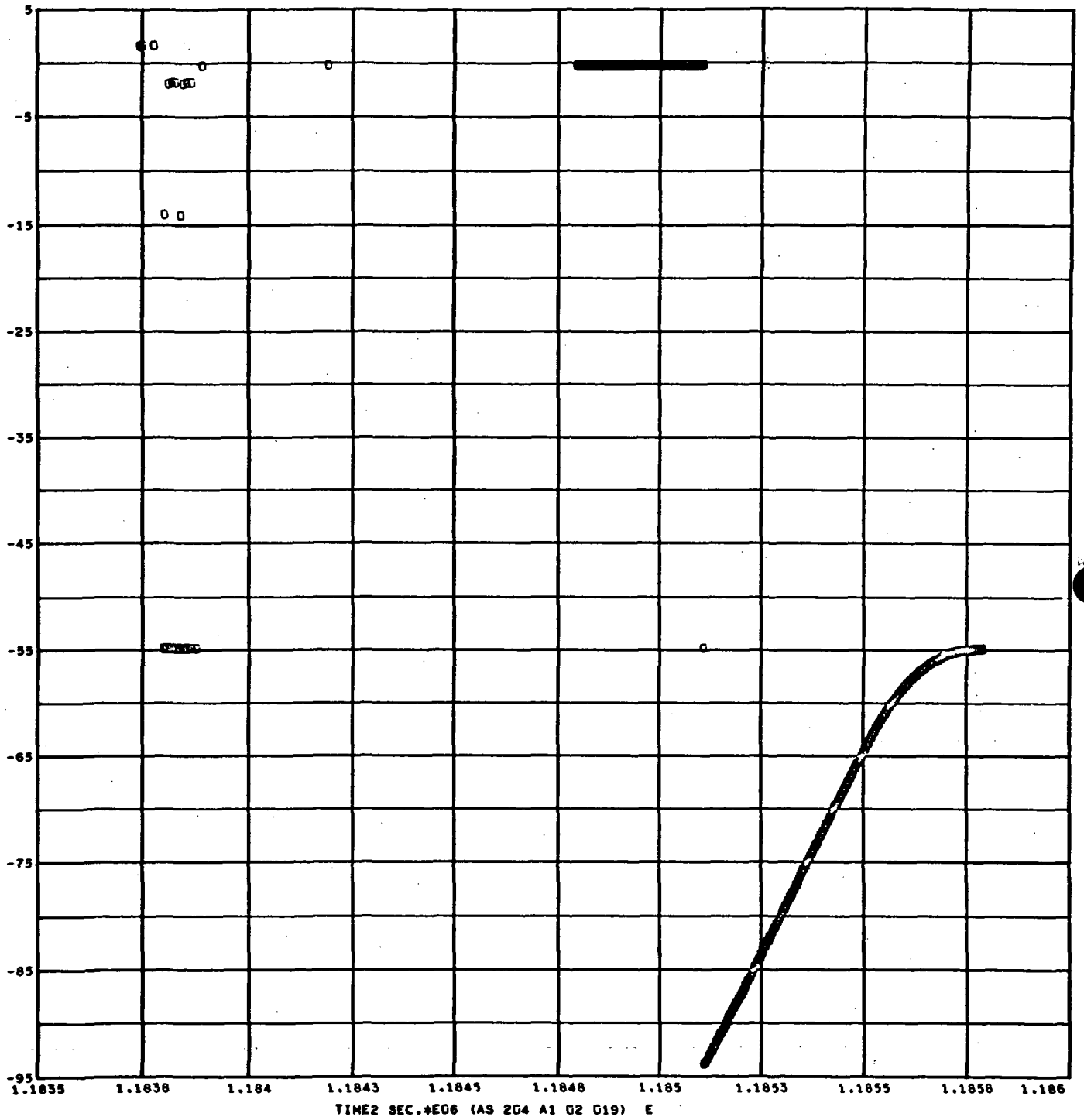
TIME2 SEC.#E06 (AS 204 A1 02 019) E



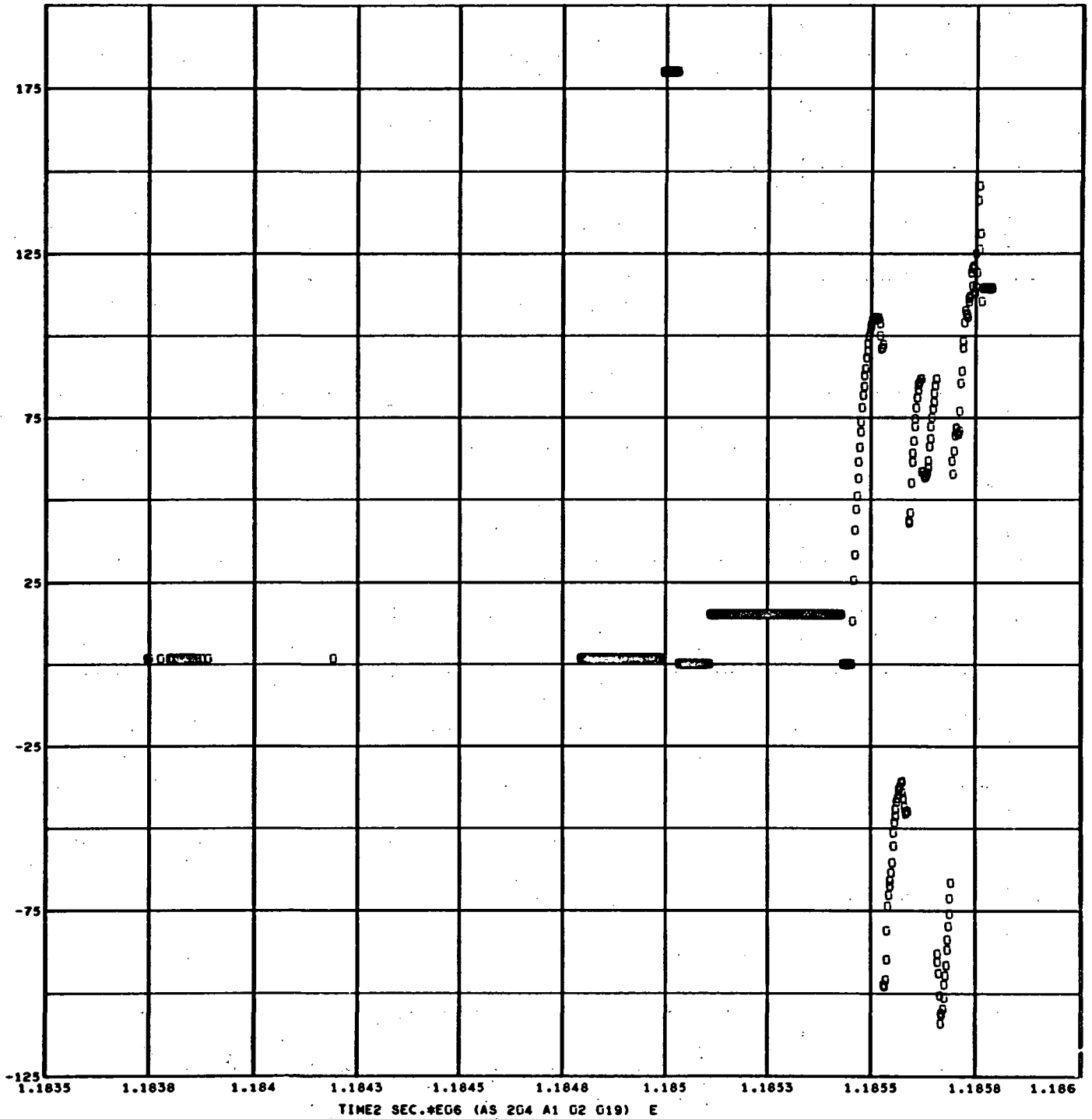
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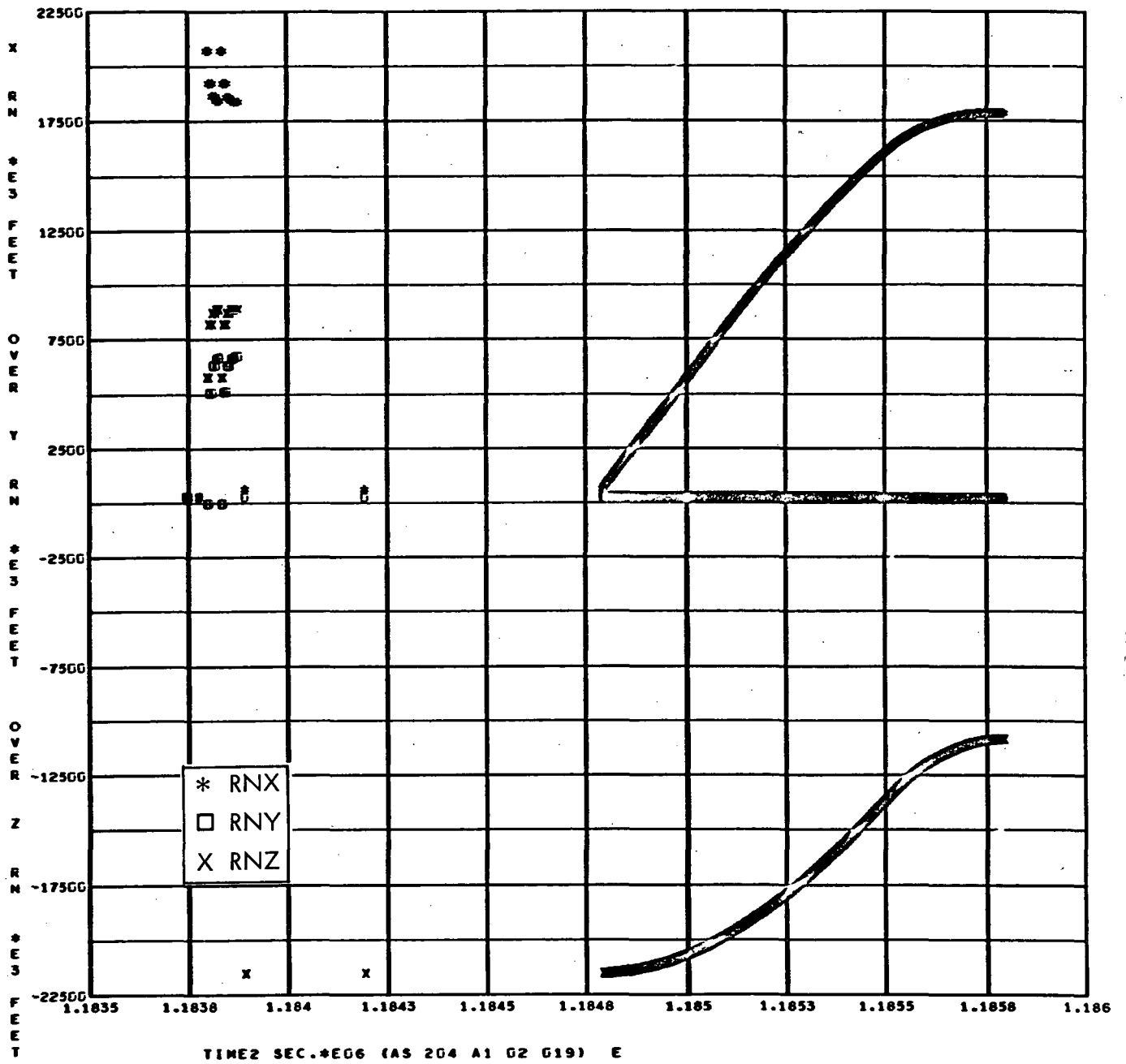


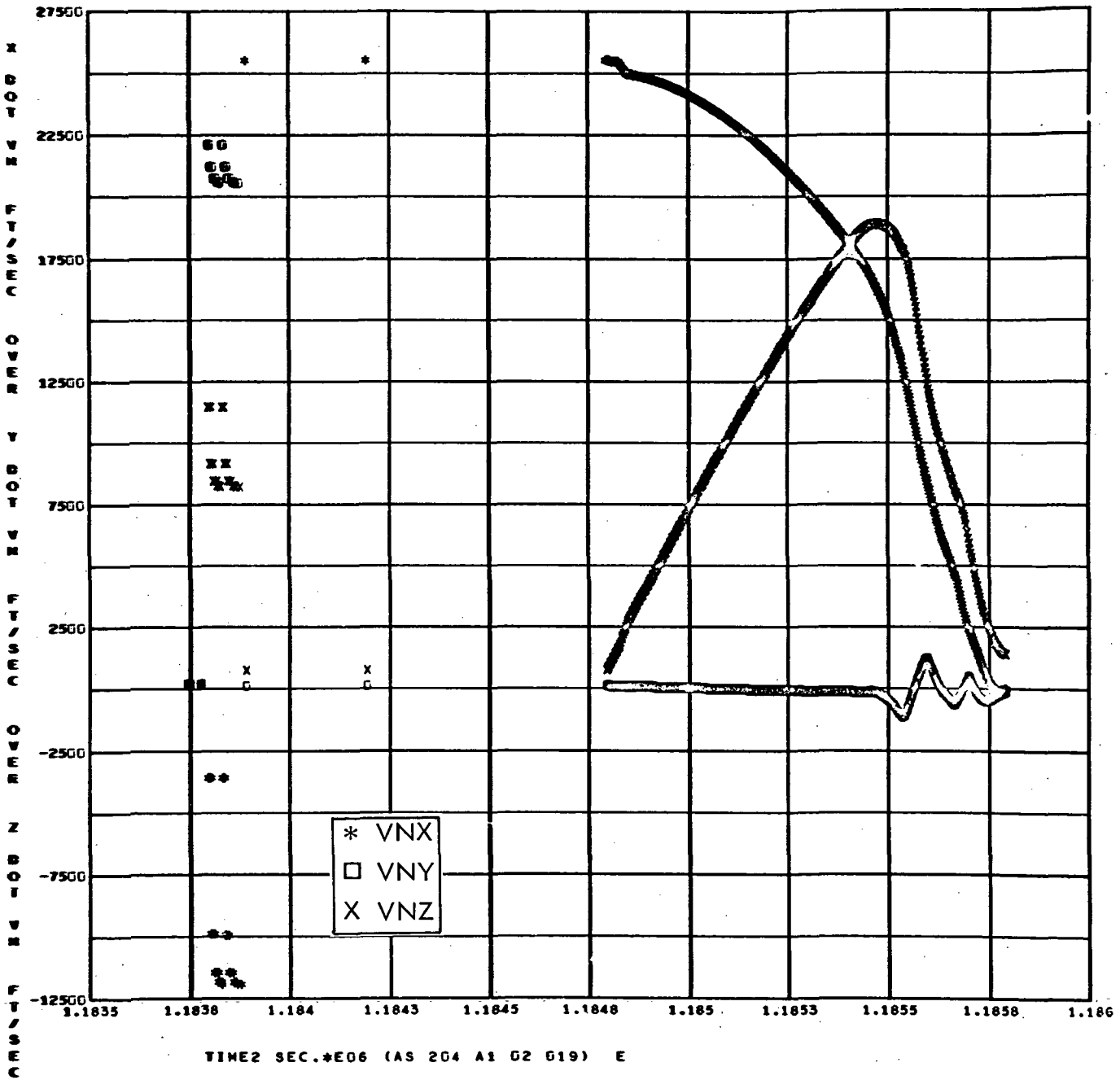
D I Z O C F L O R



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ACCELERATION
G MAX



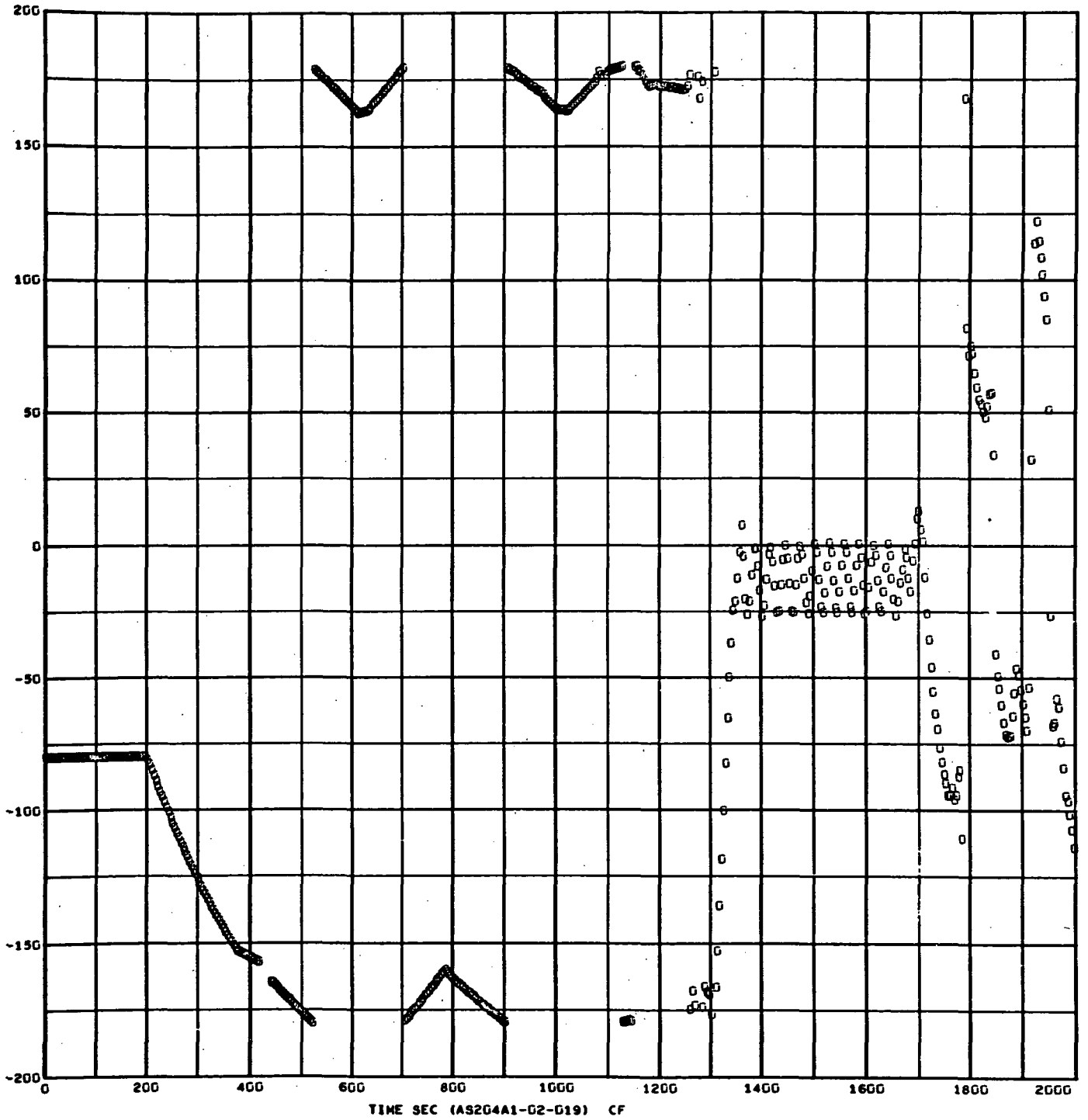




ENVIRONMENT PLOTS

AS-204A1-02-019

OUTER GIMBAL ANGLE IN DEGREES



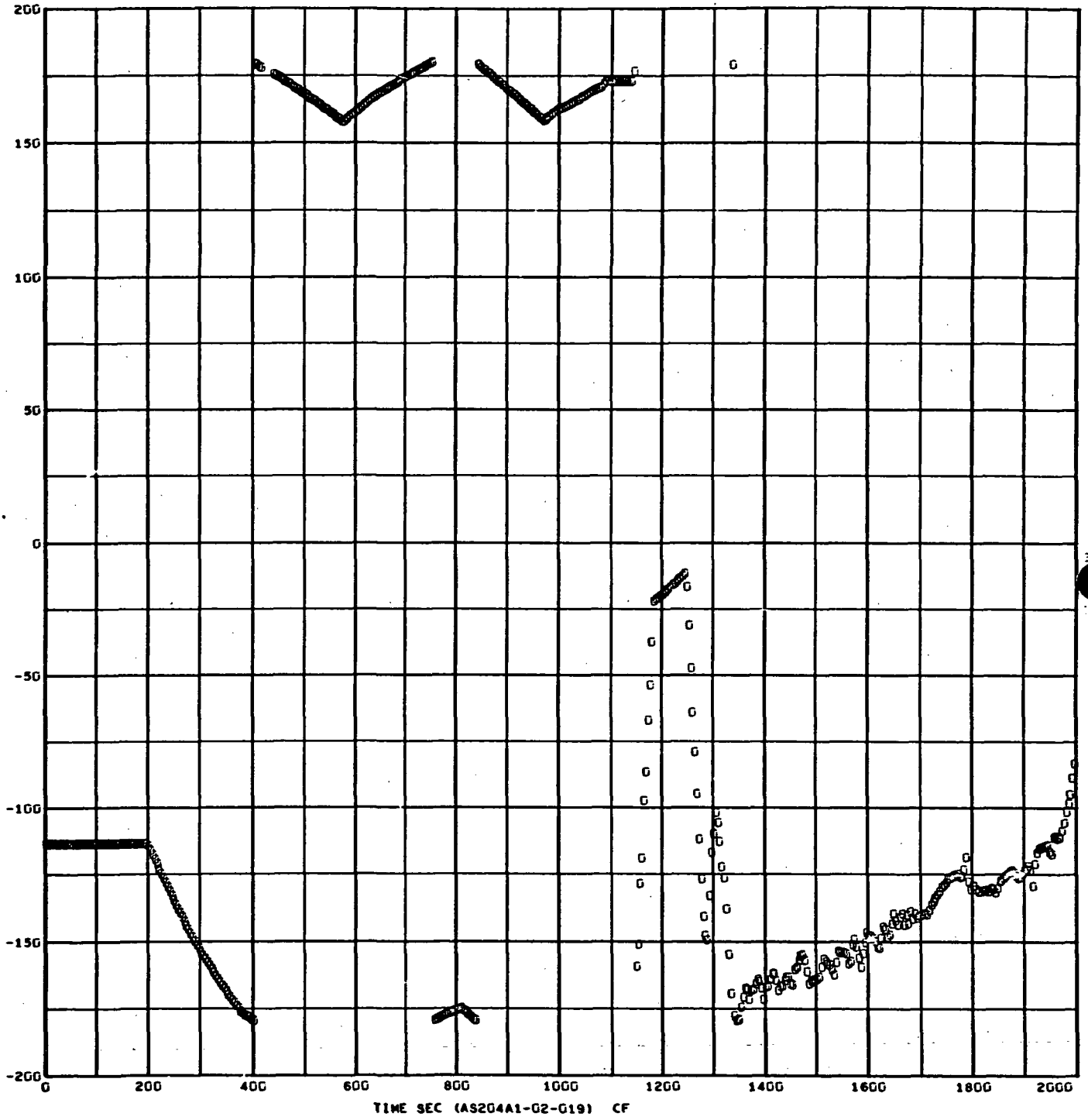
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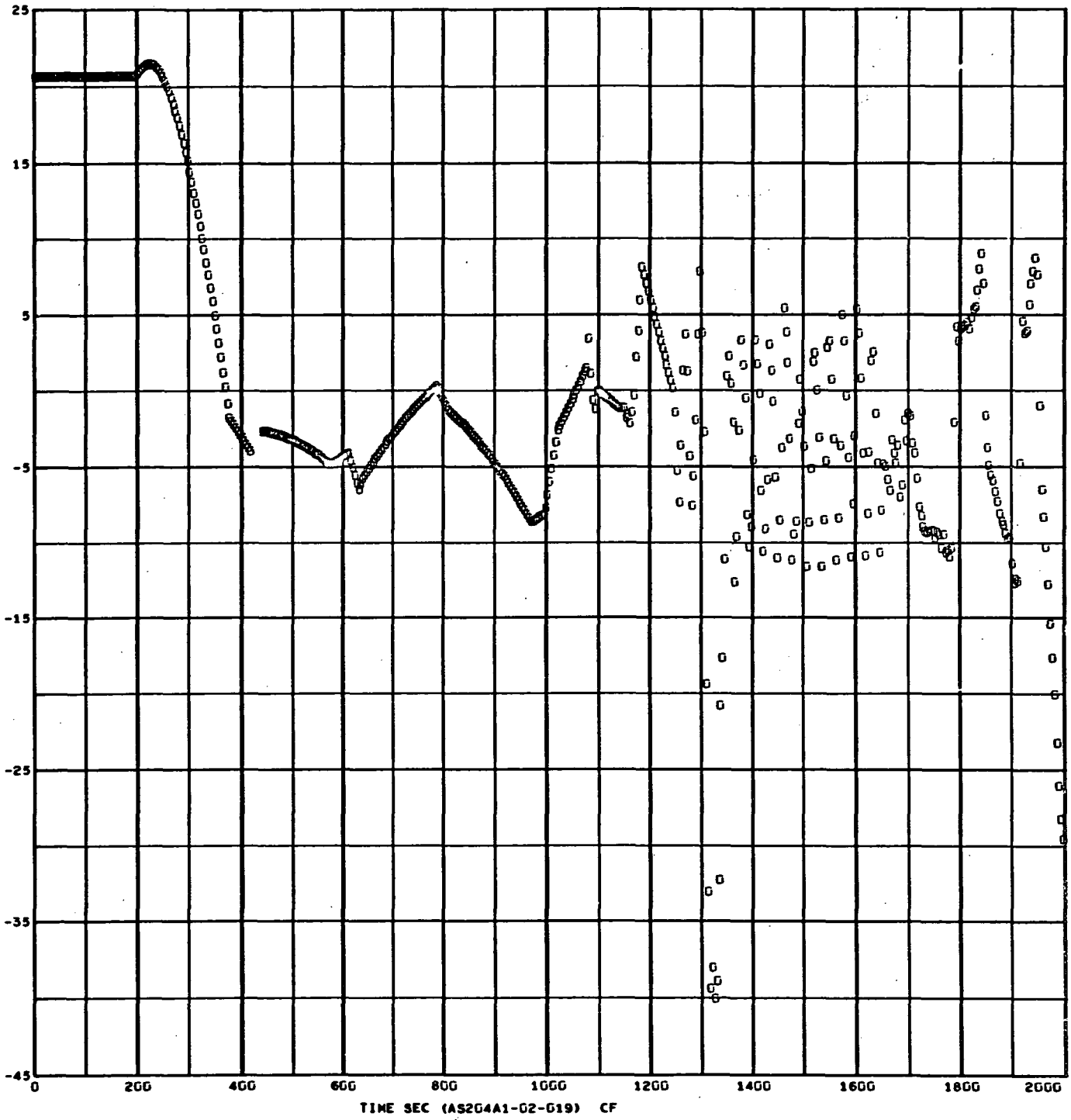
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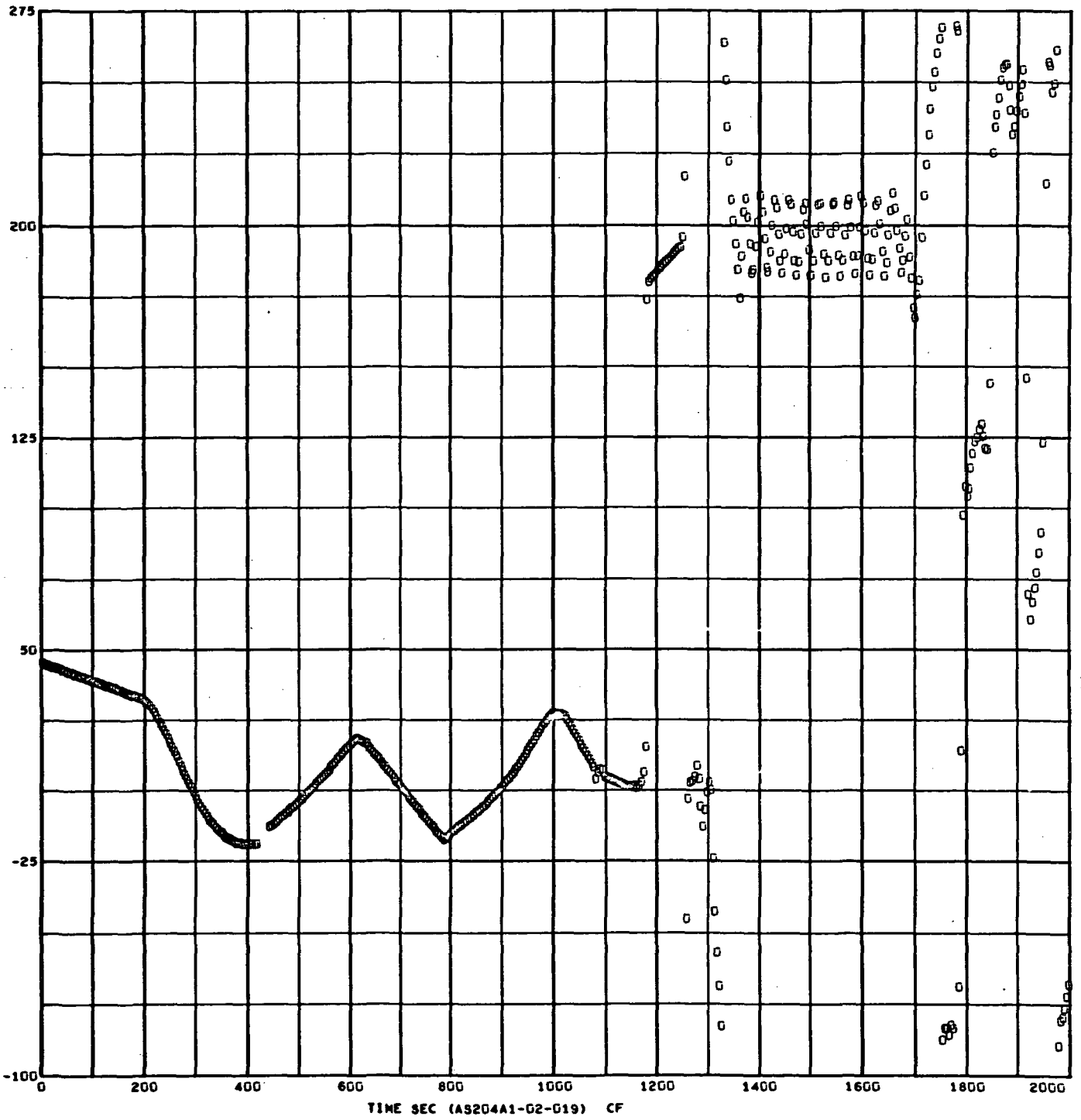
MIDDLE GEAR ANGLE IN DEGREES



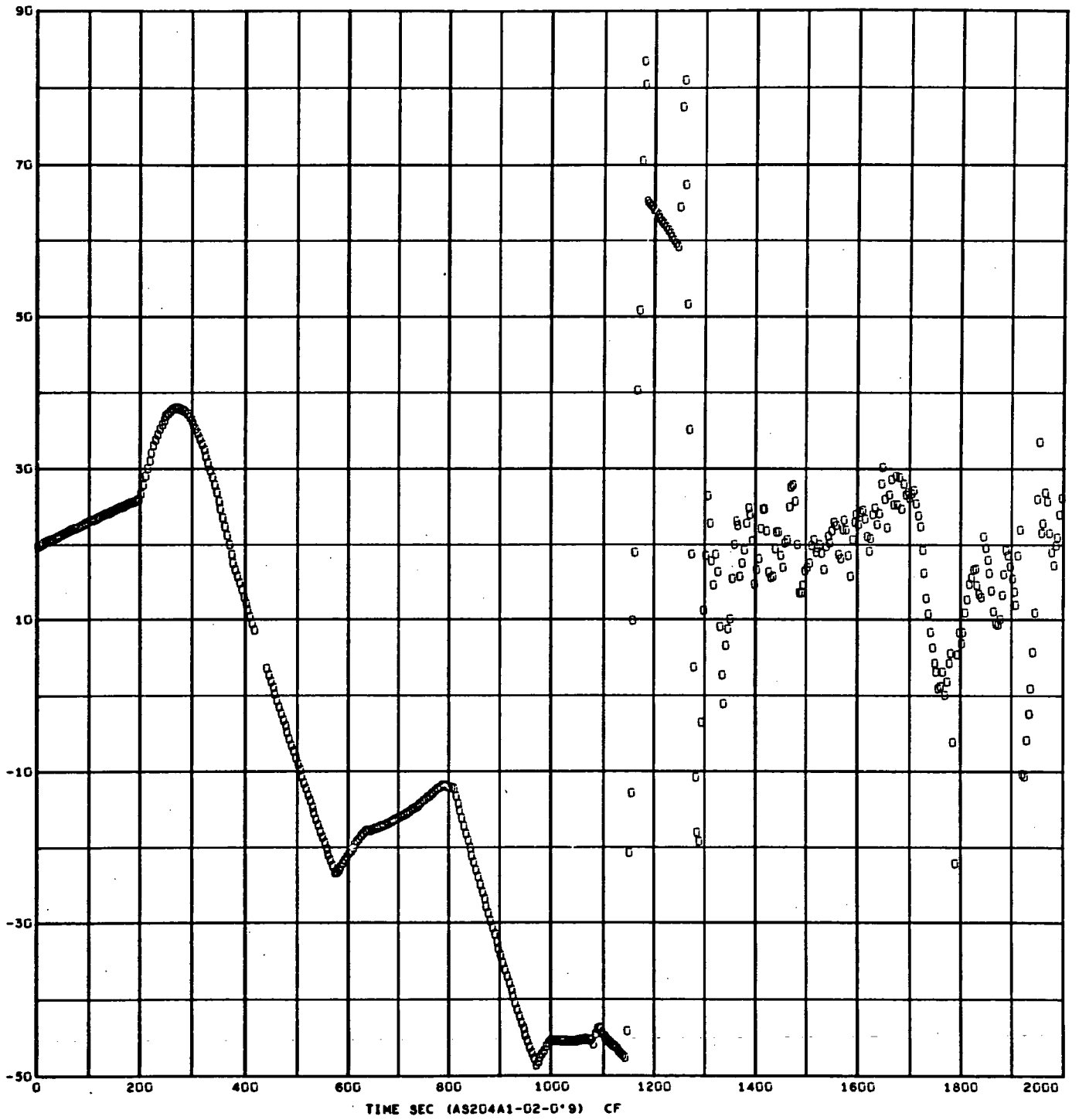
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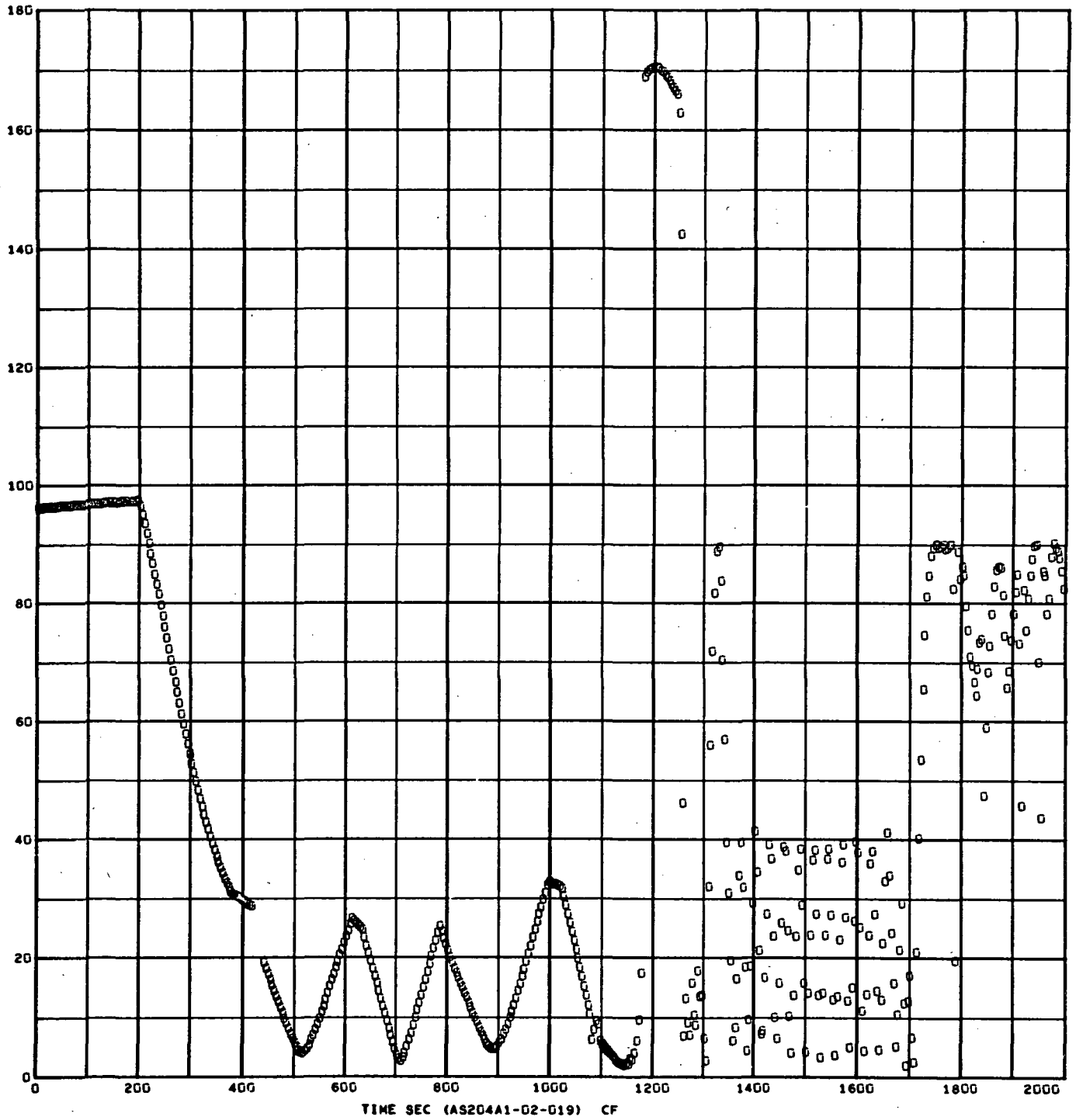
66DD FOR 400B



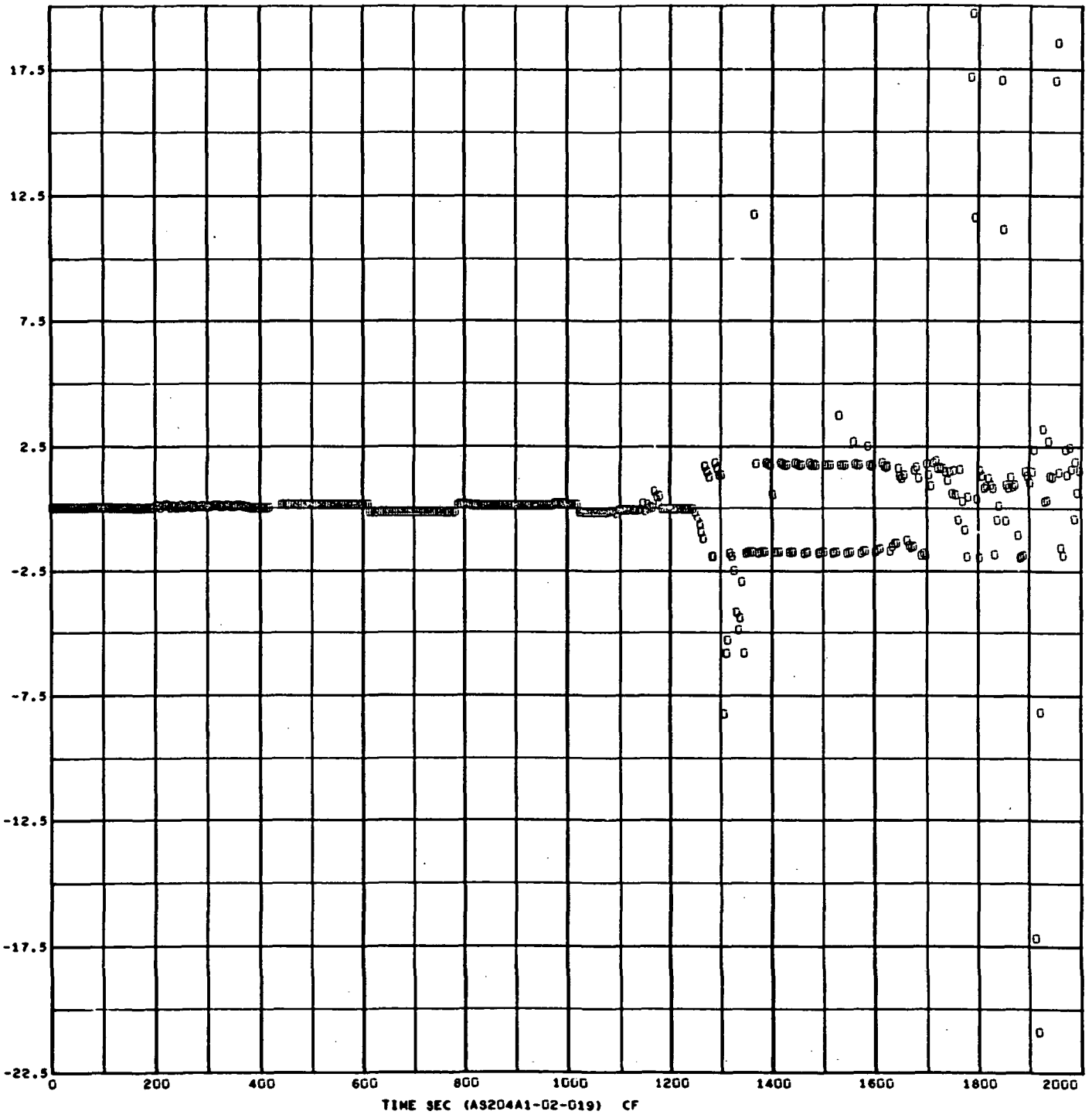
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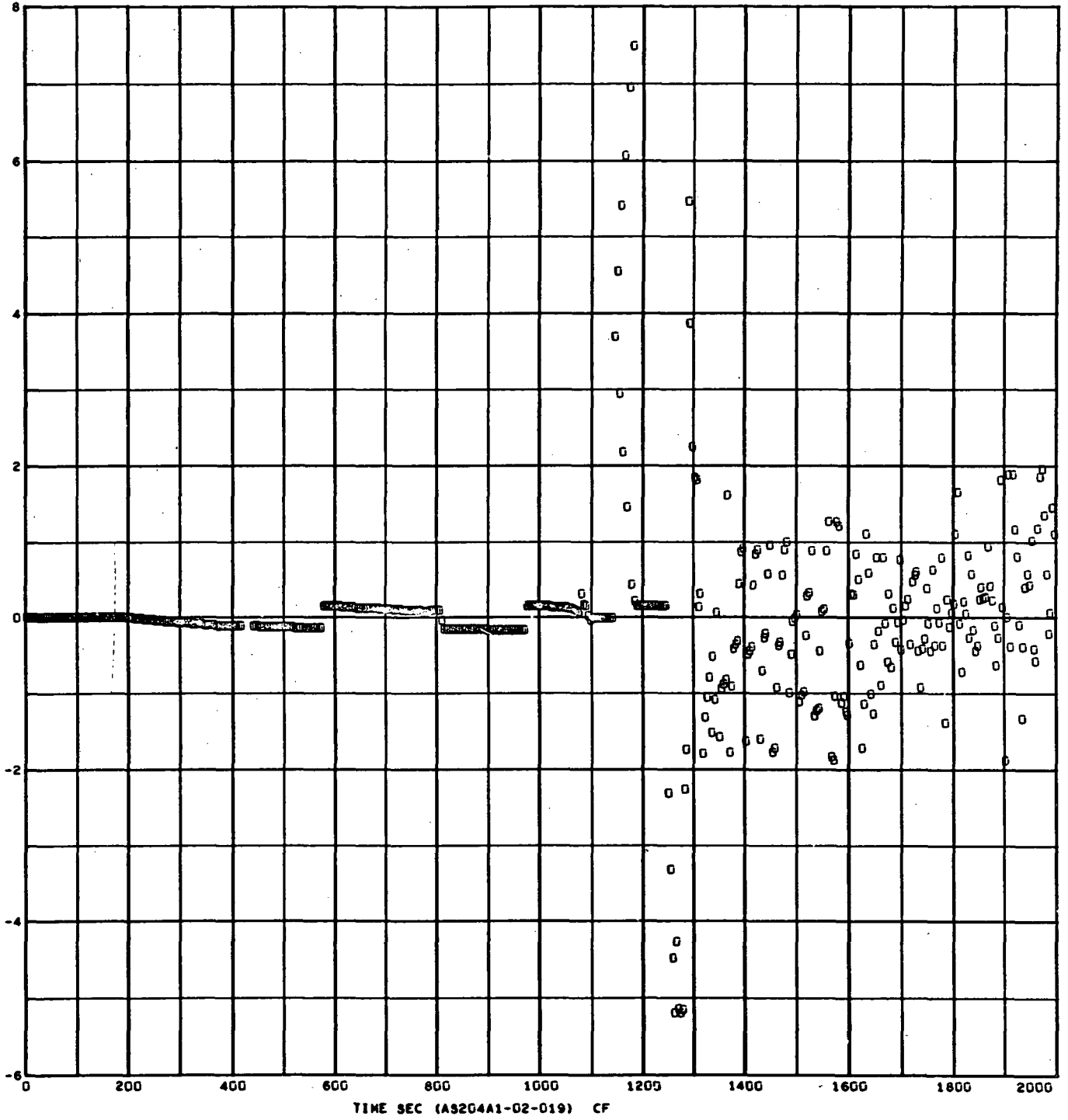


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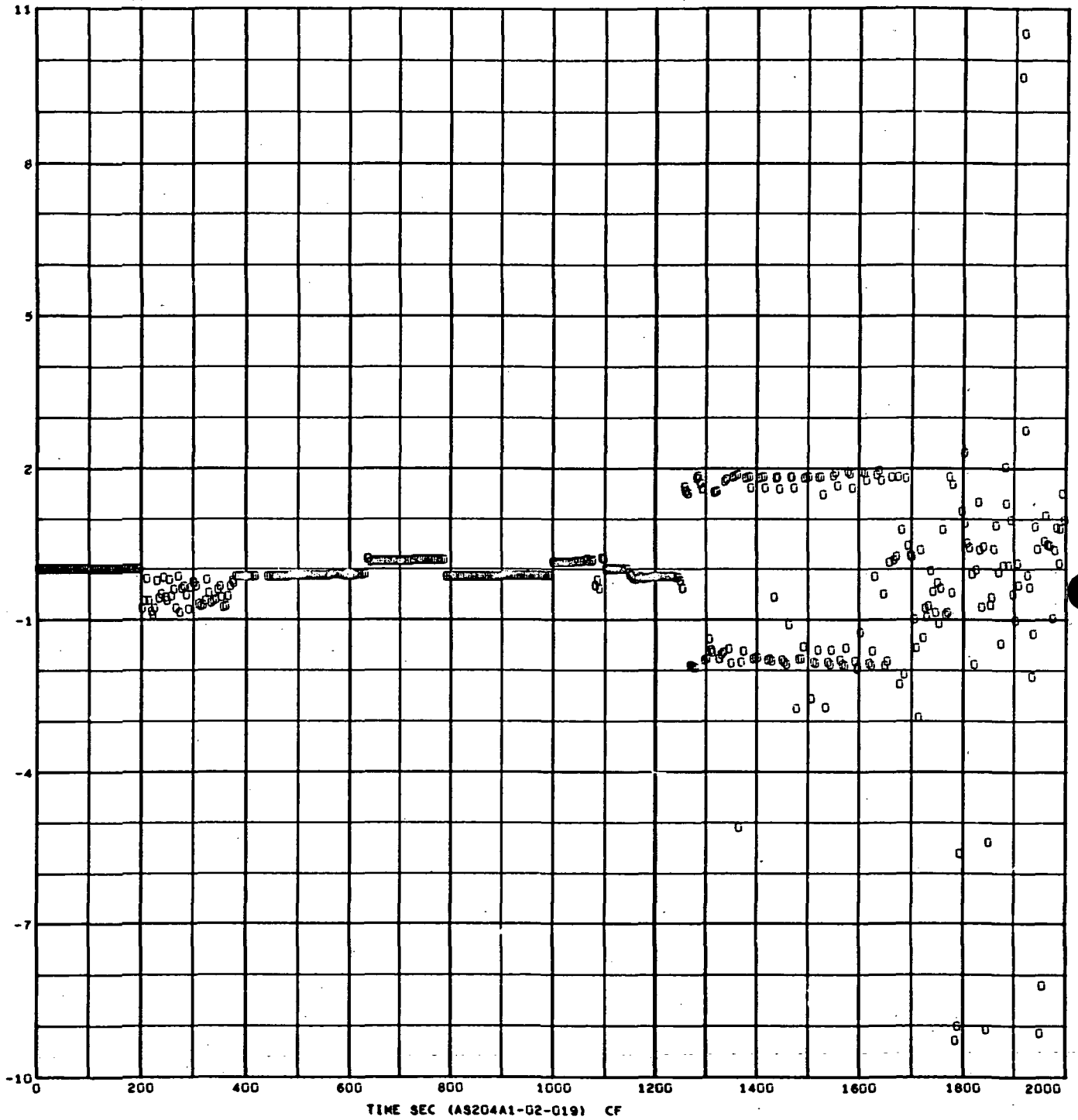


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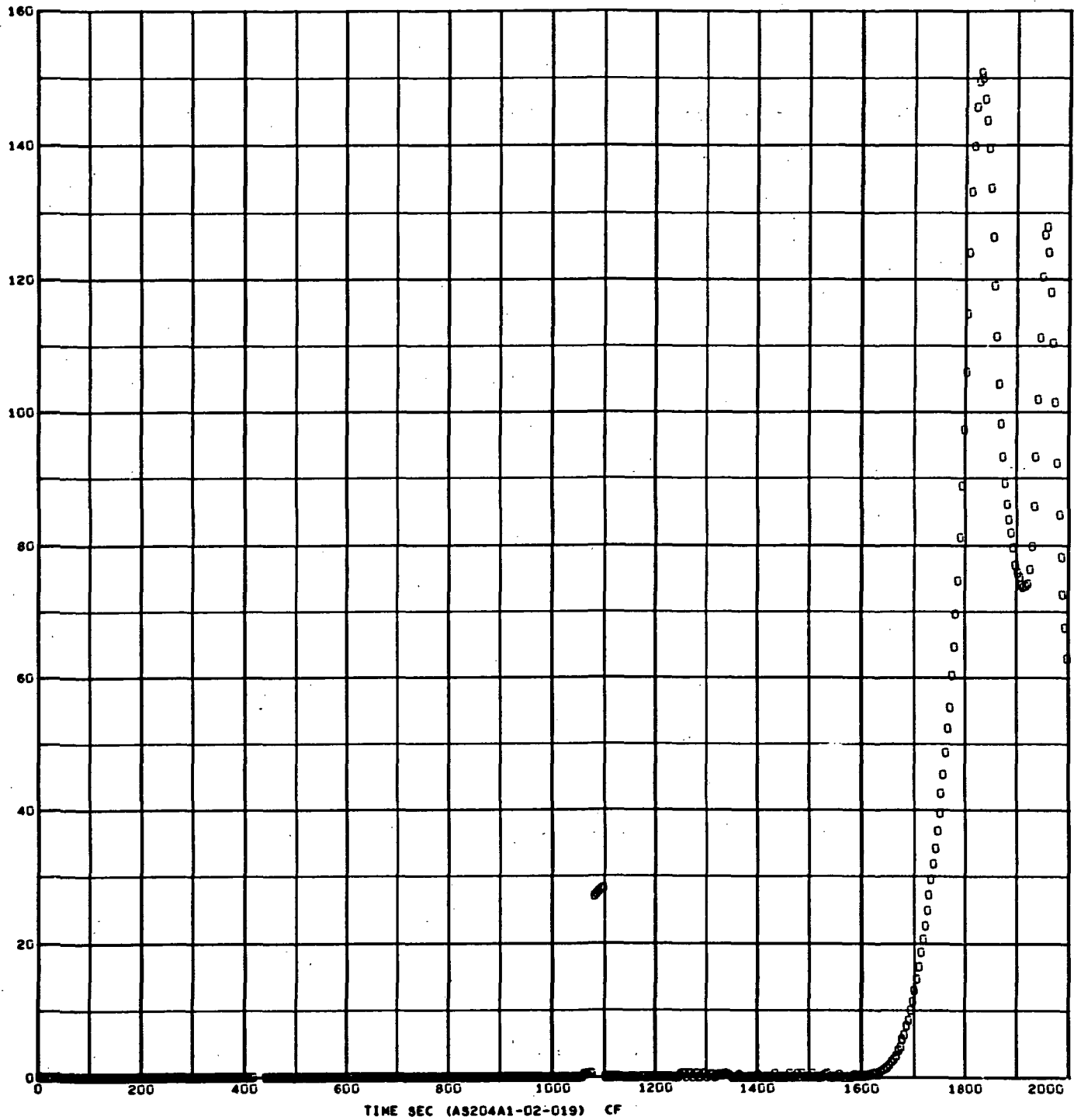
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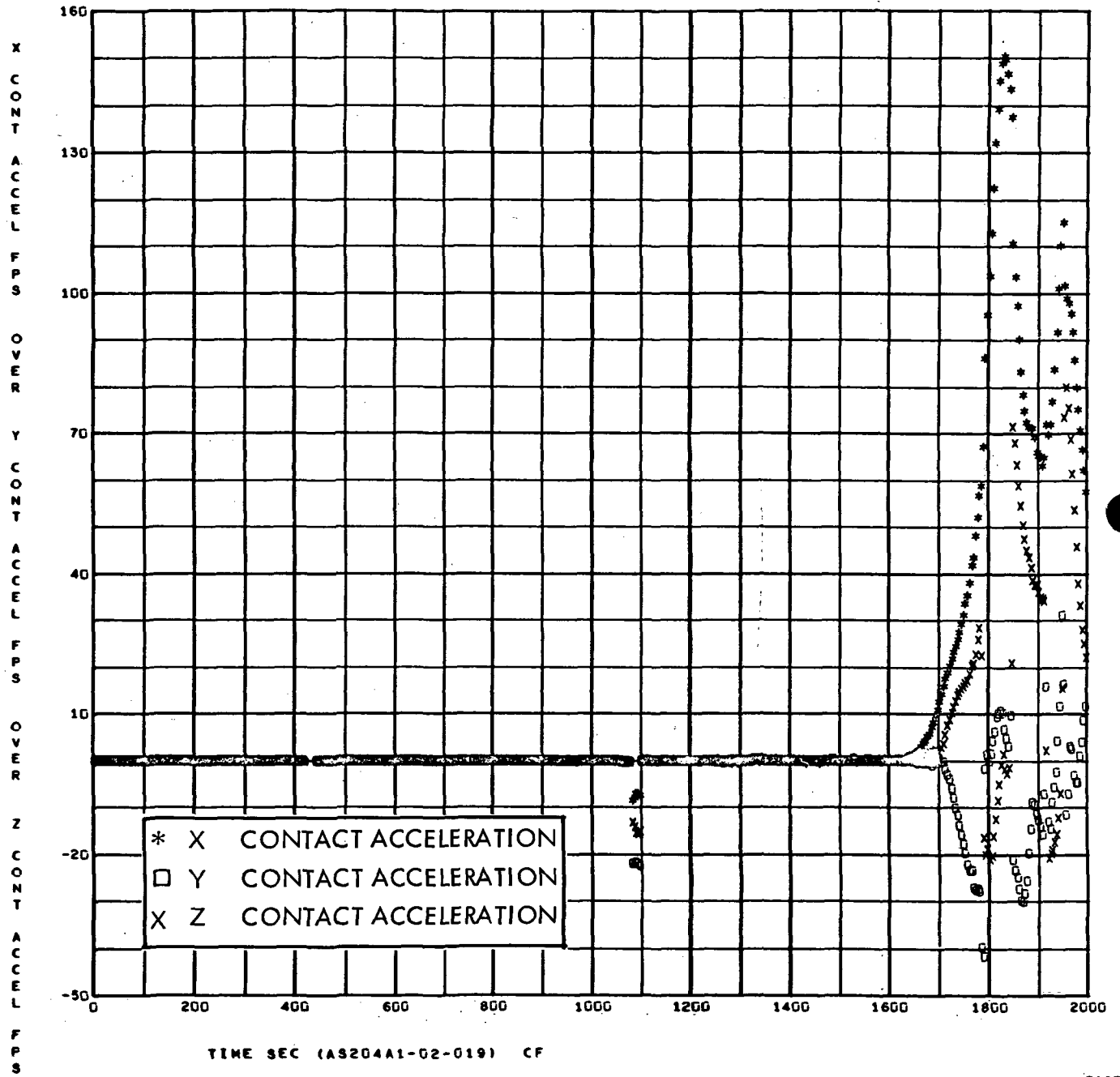


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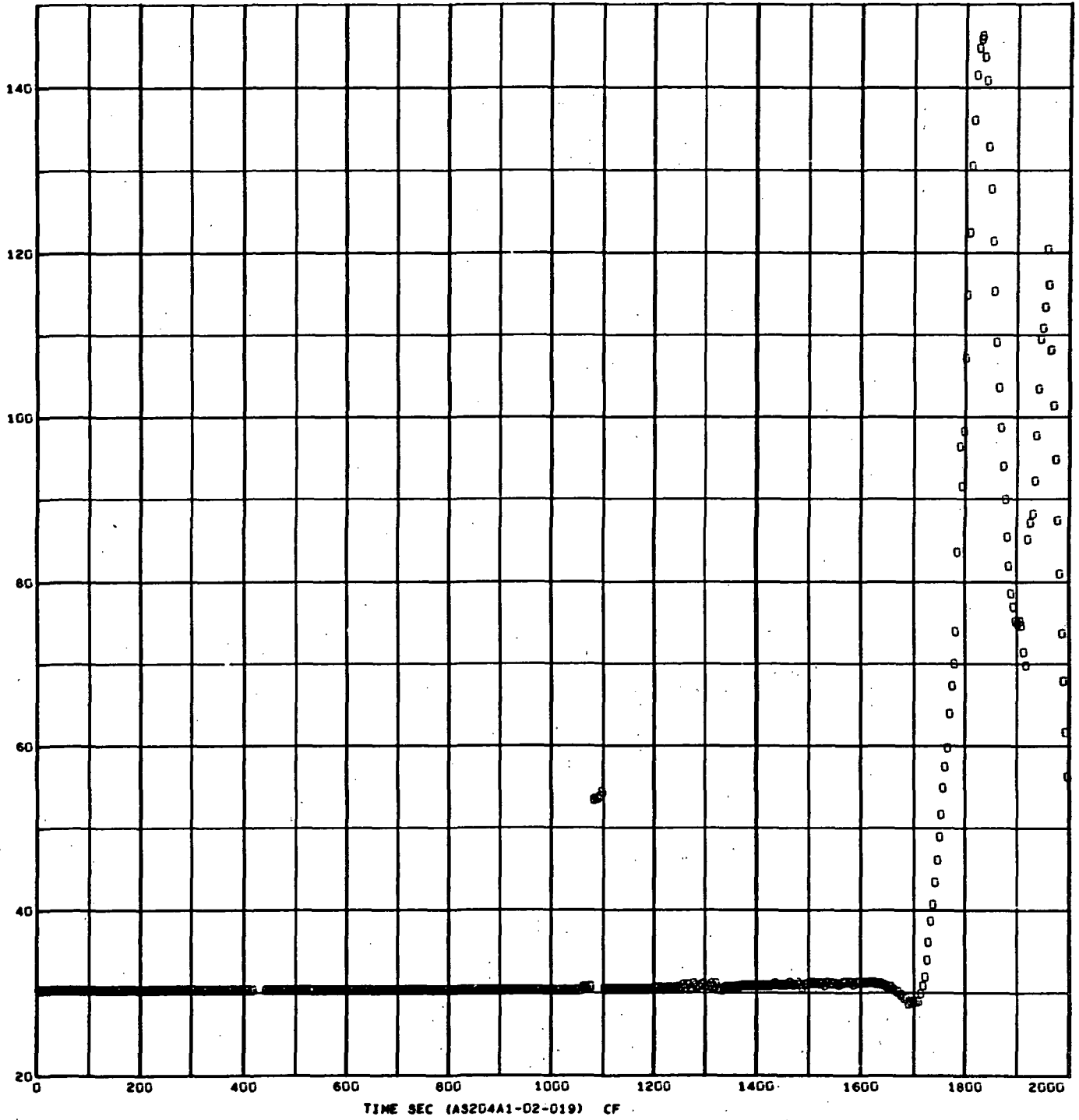
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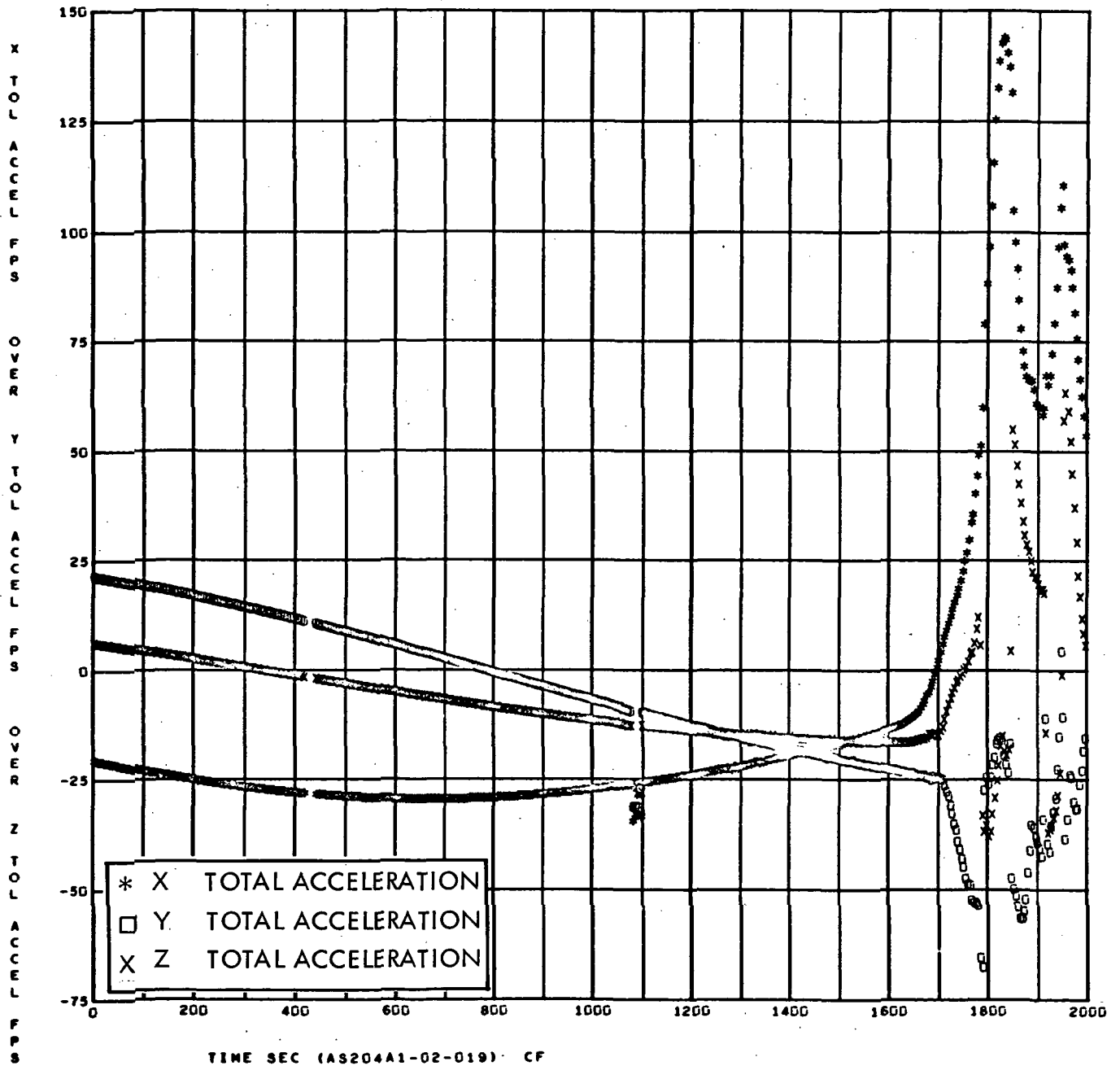
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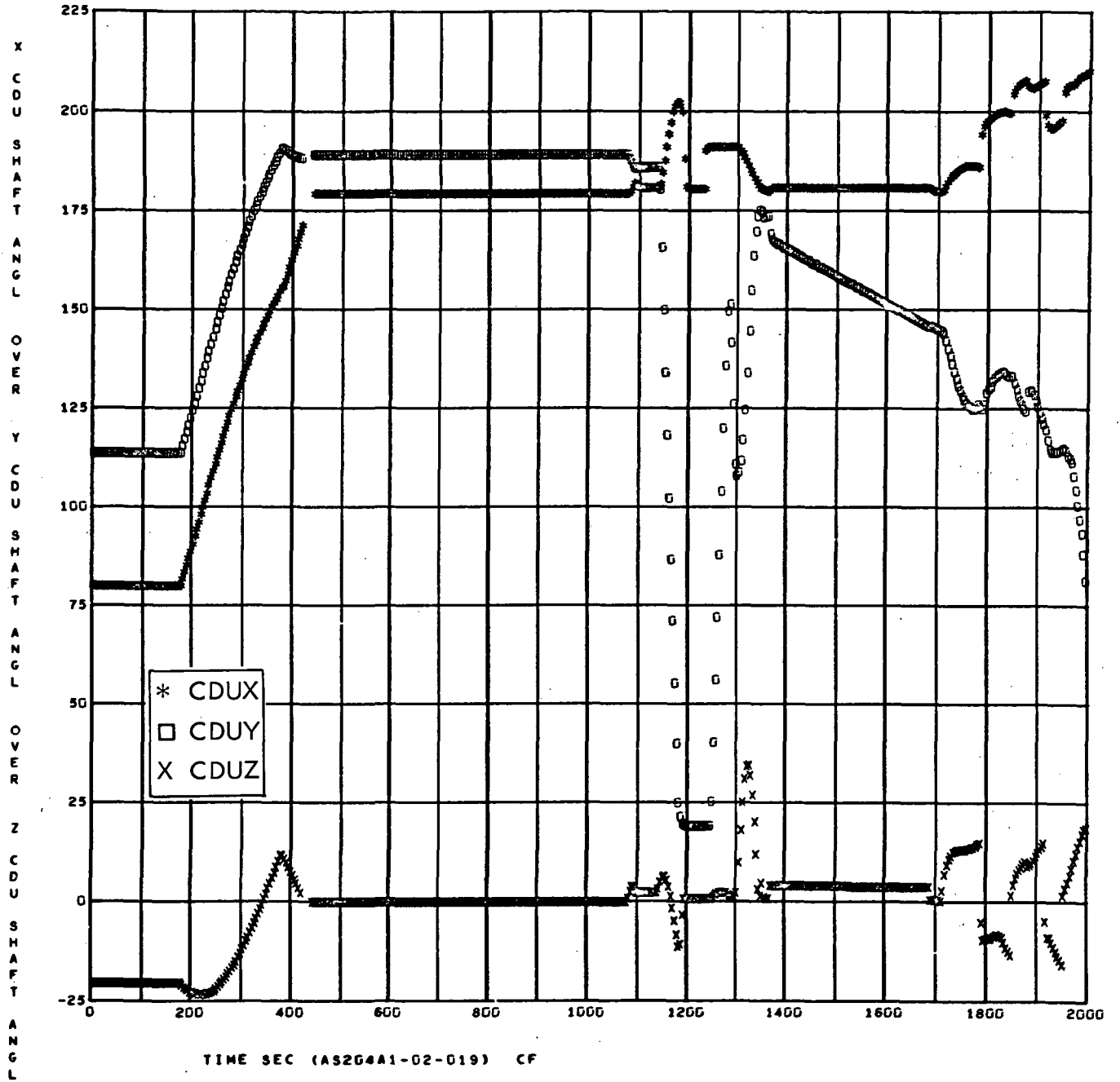


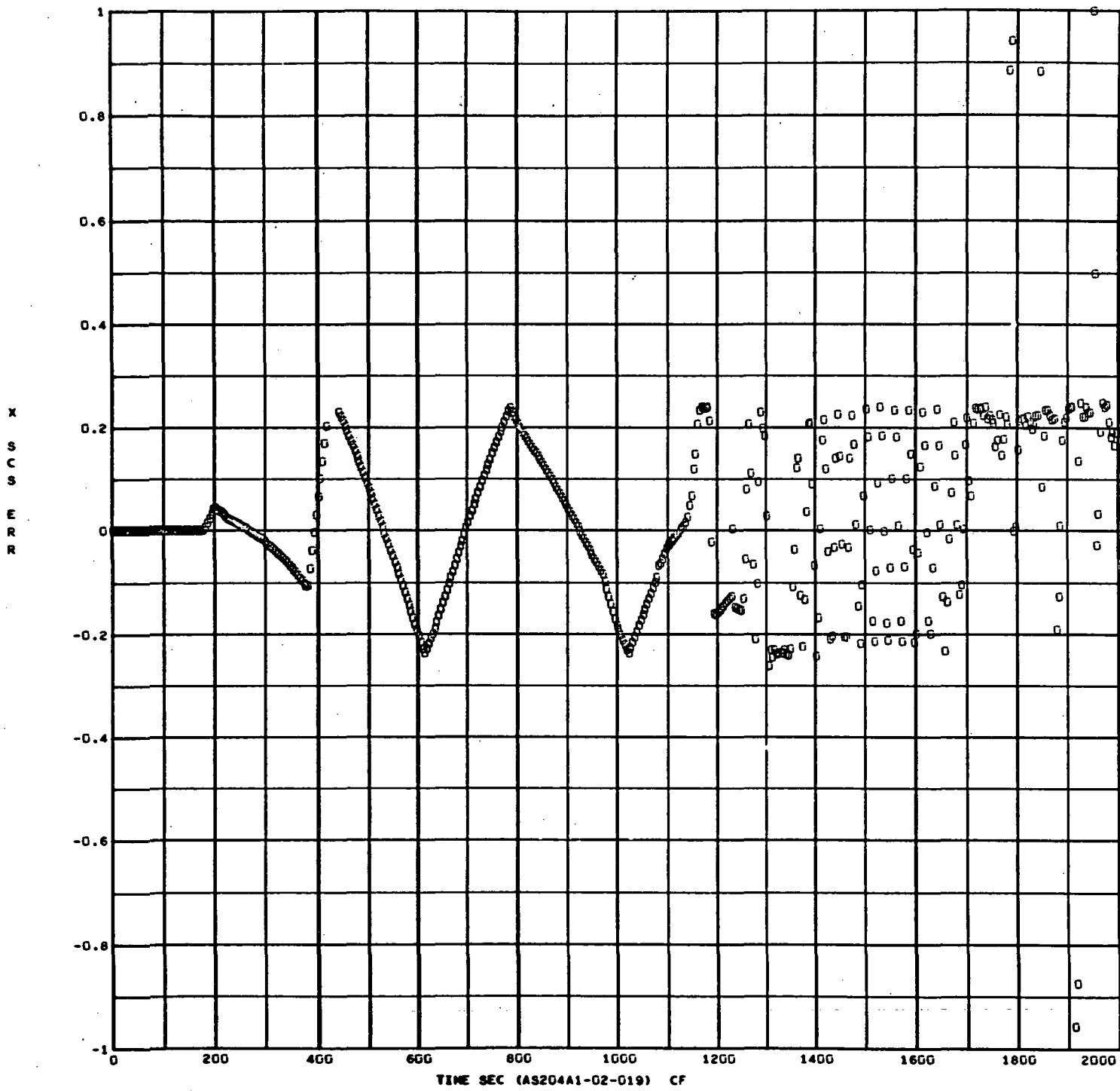


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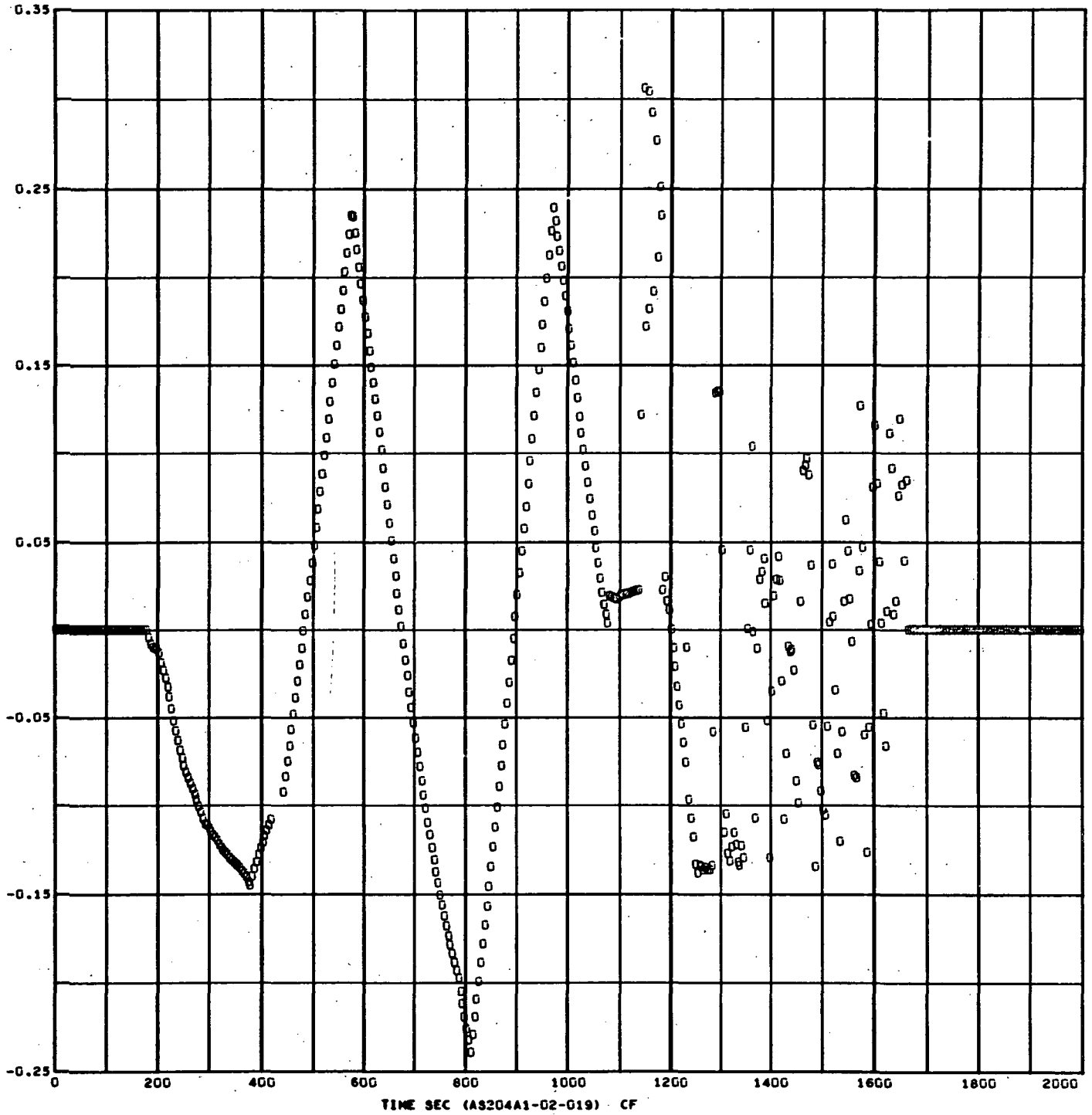




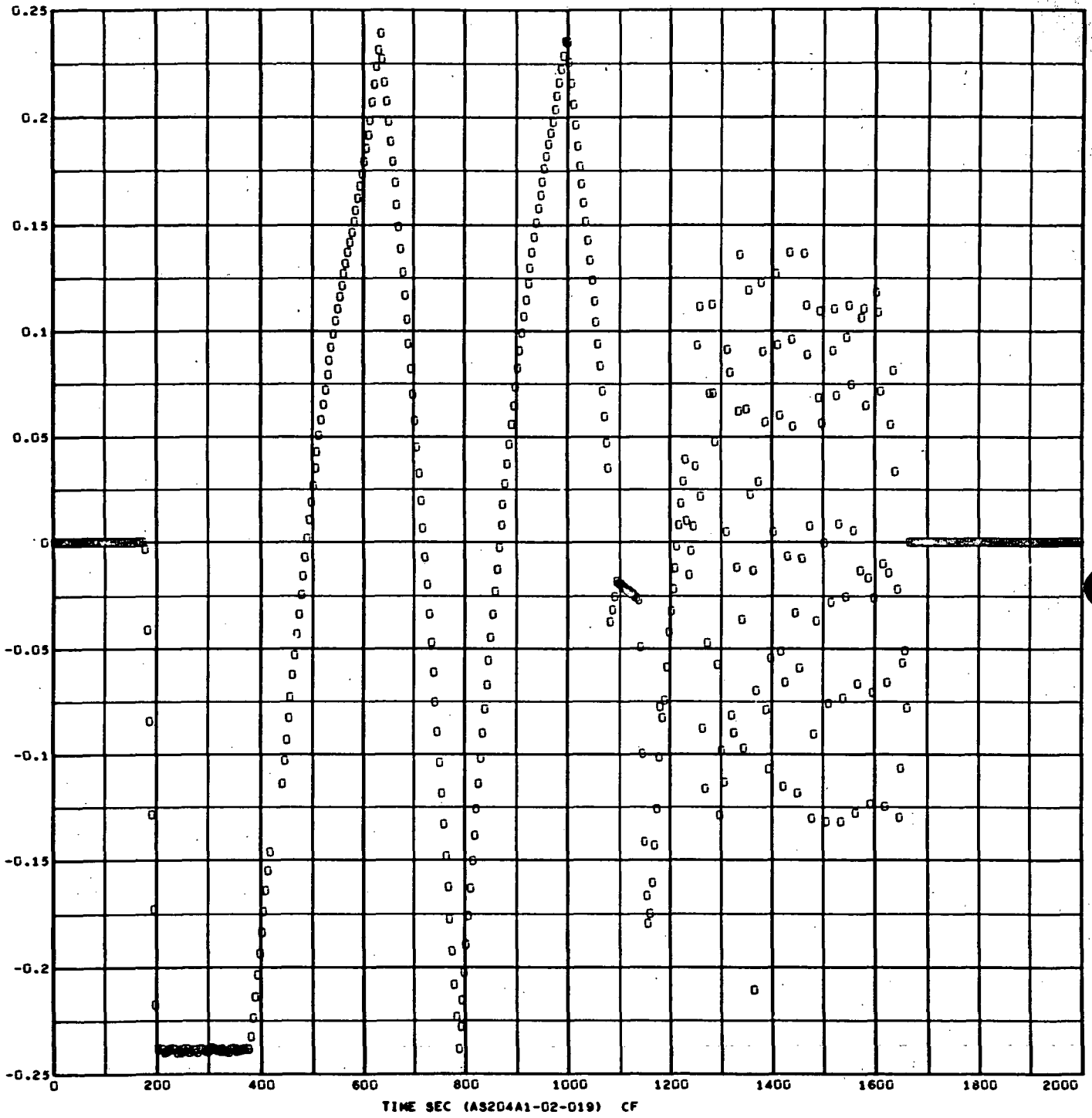




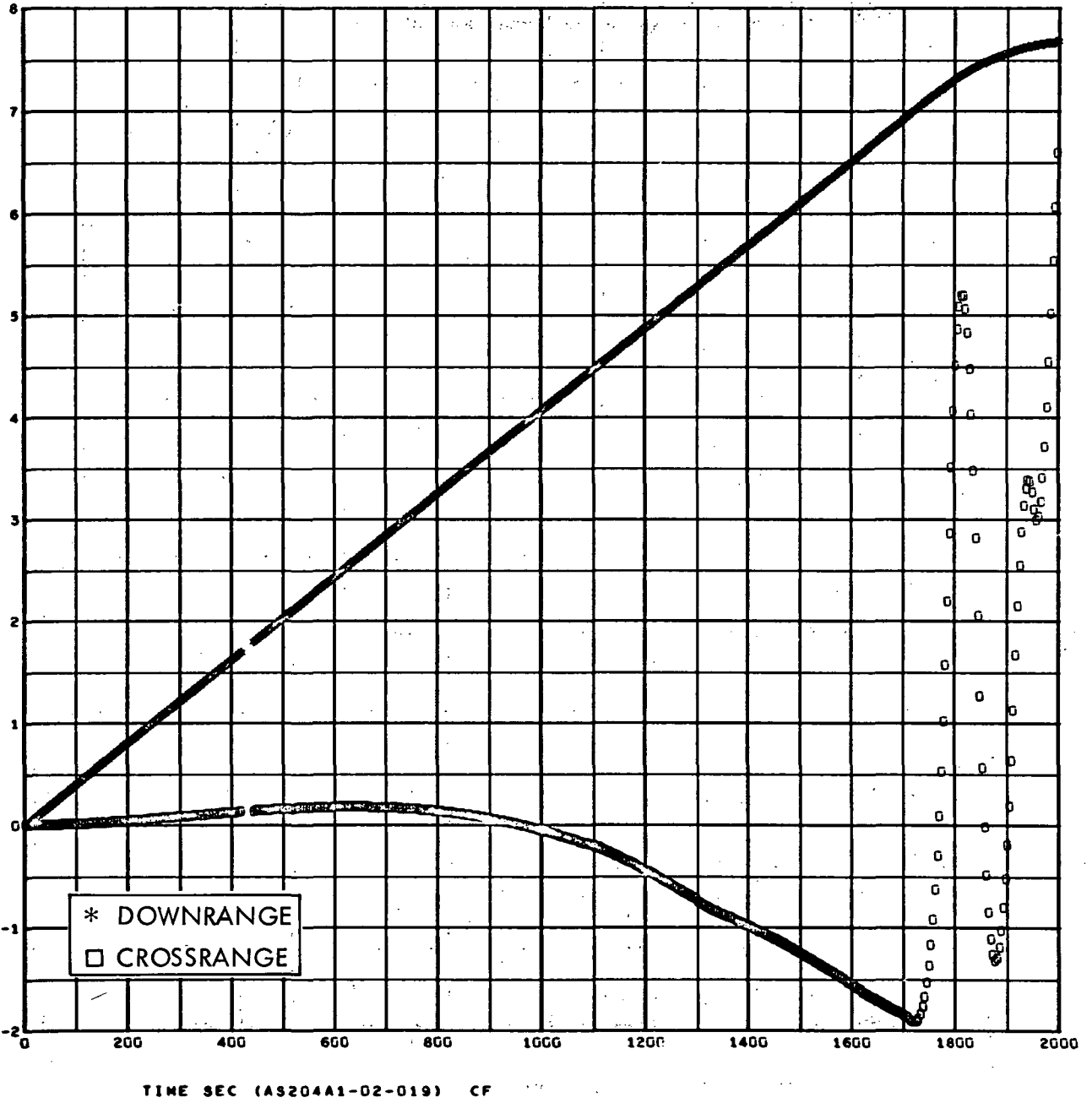
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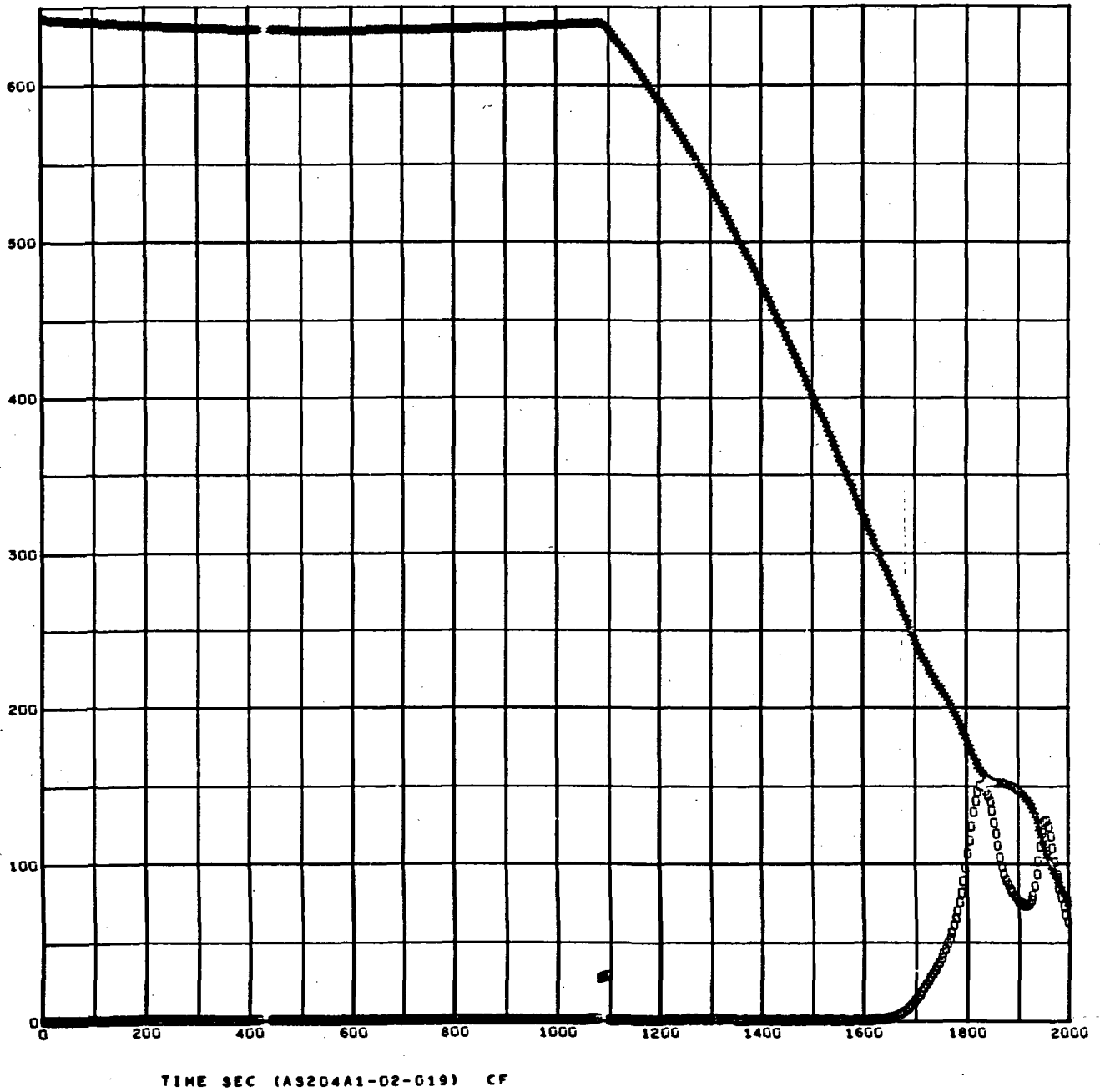
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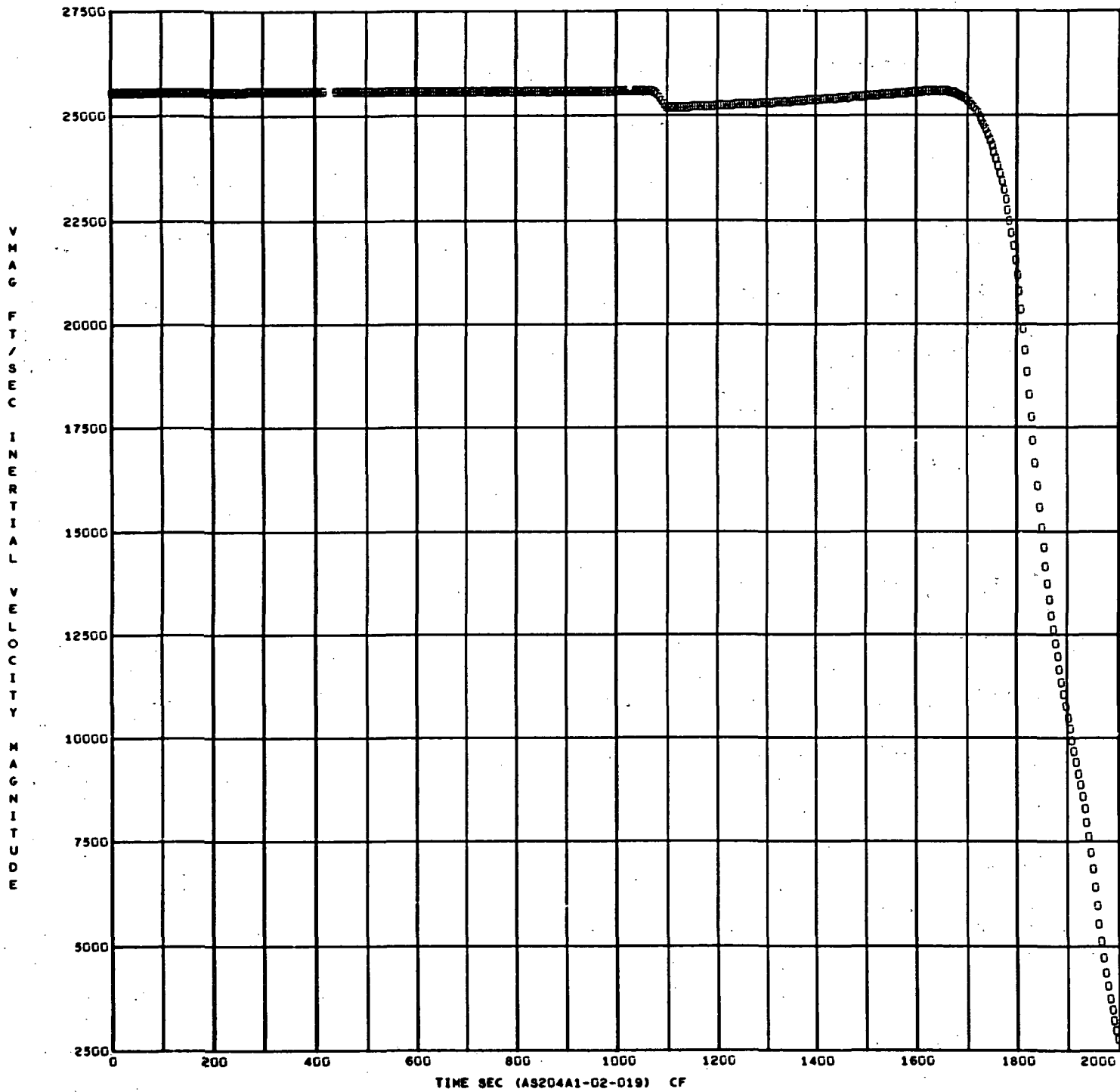
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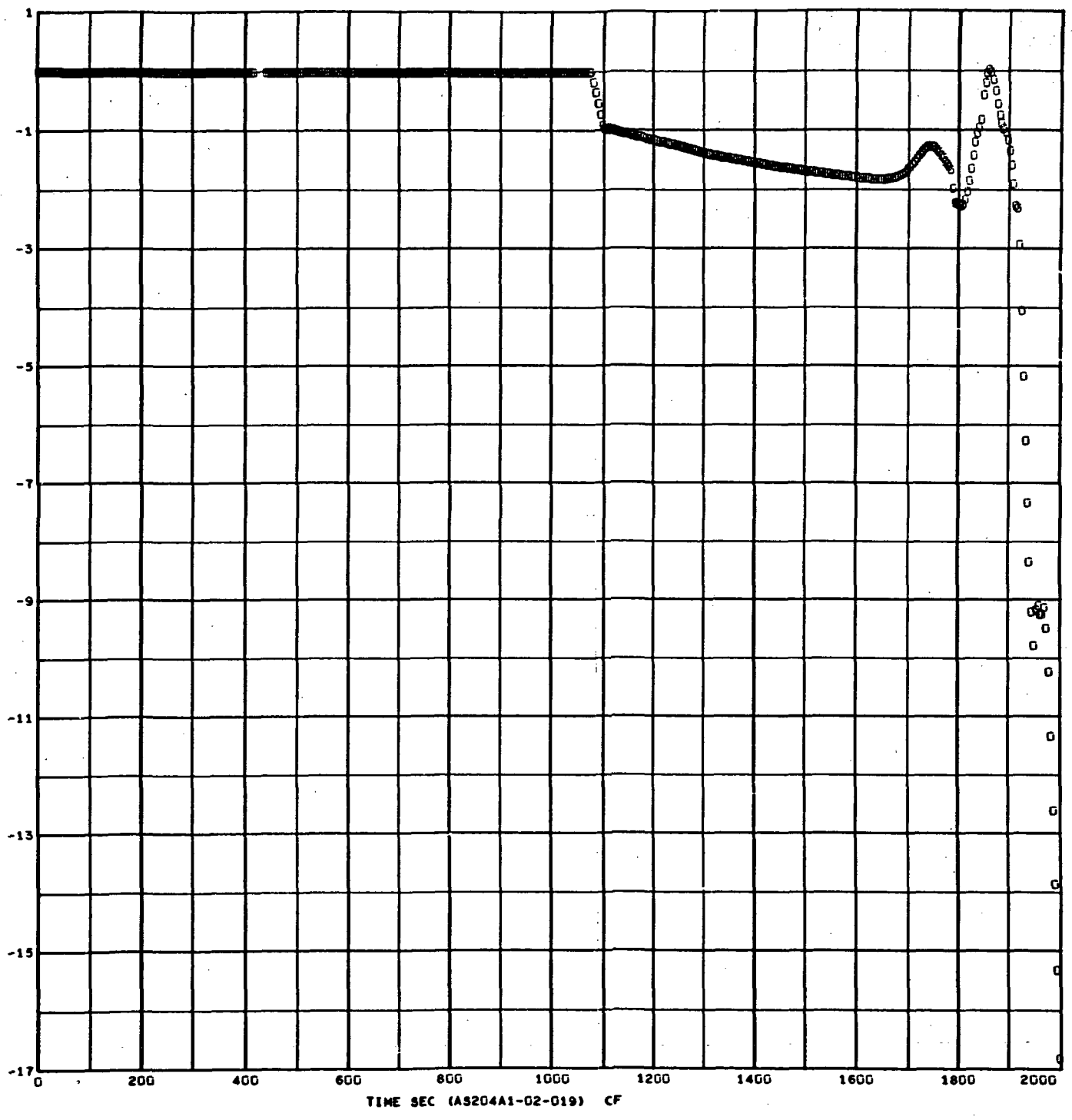
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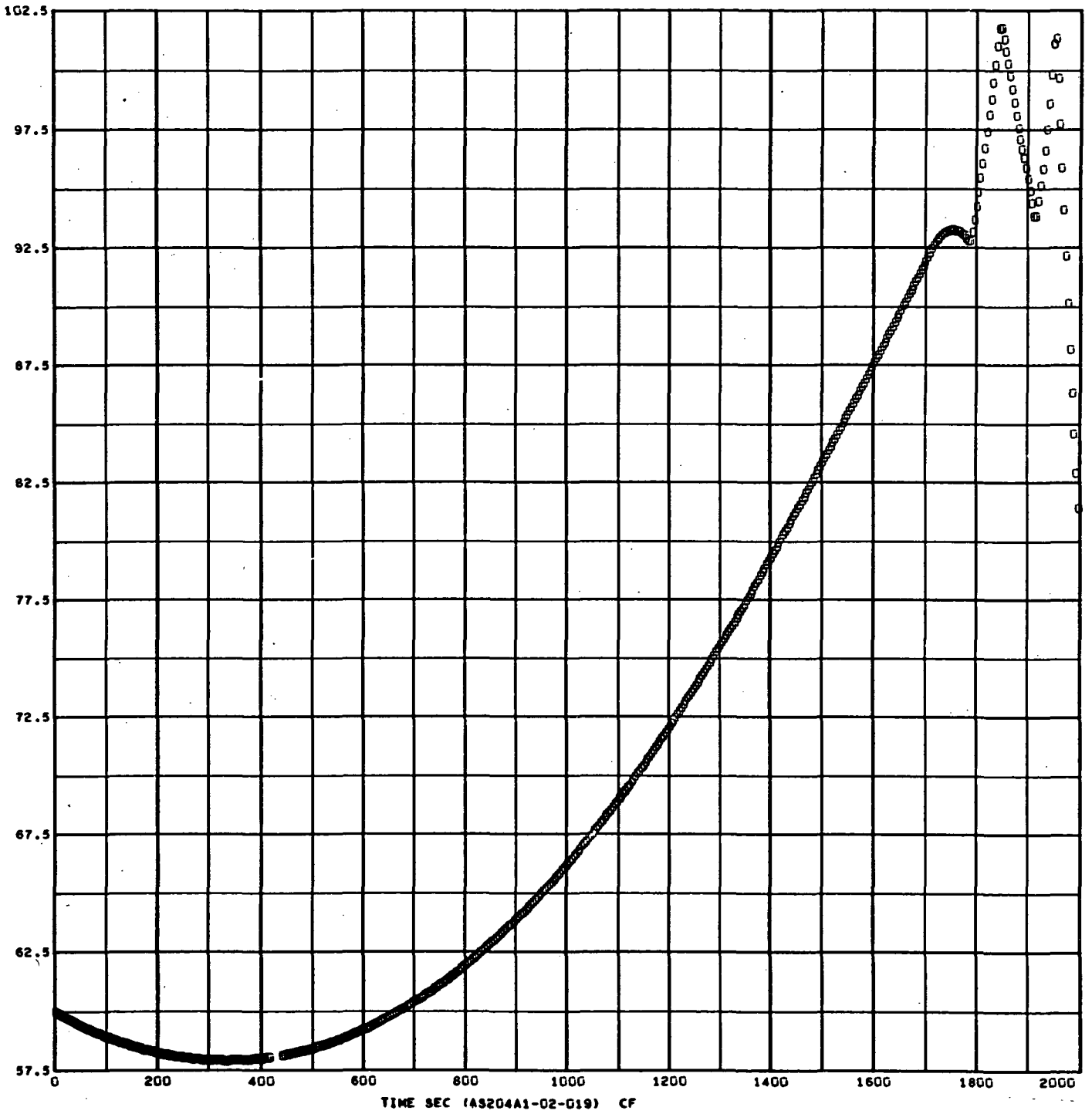


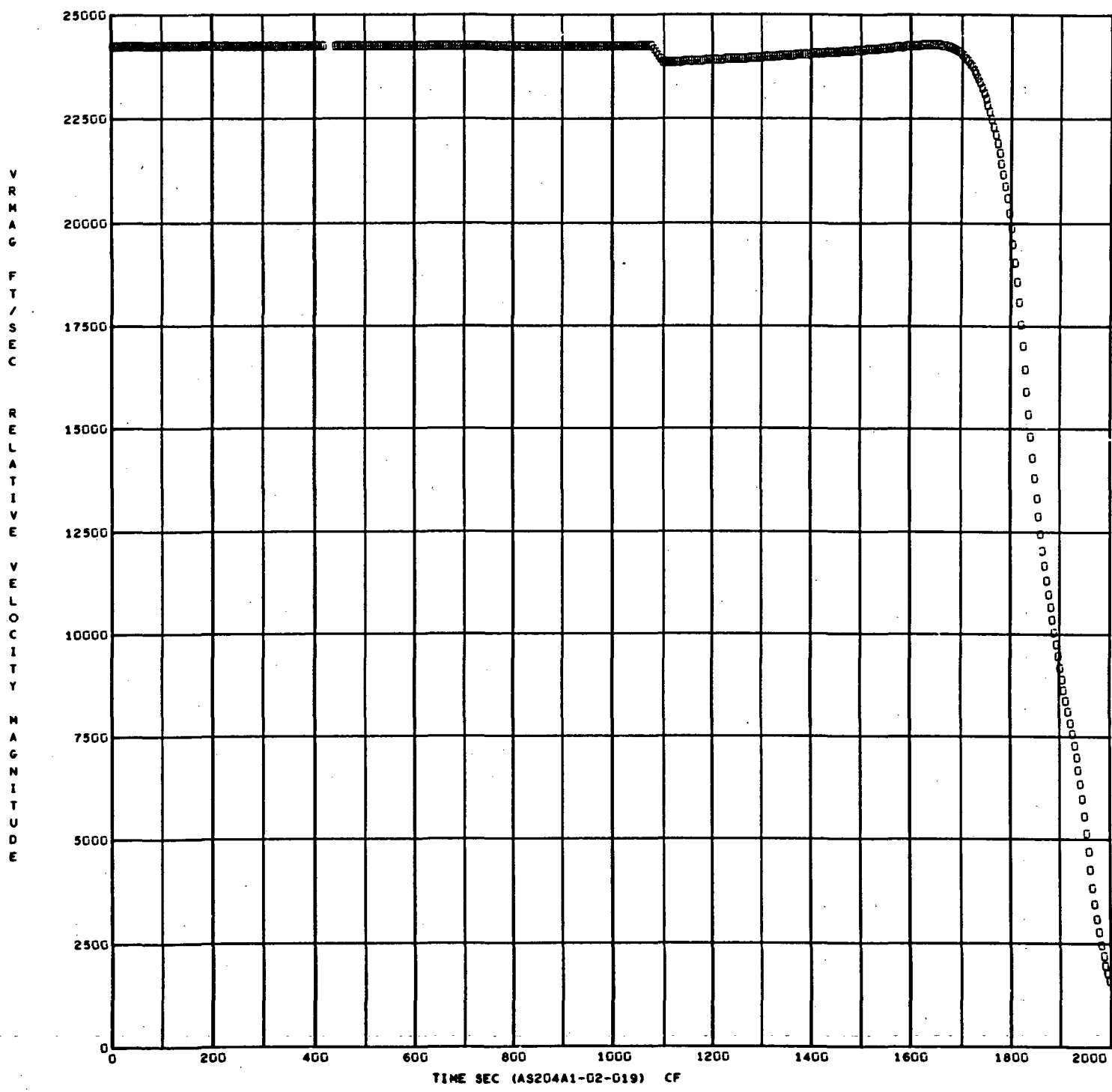
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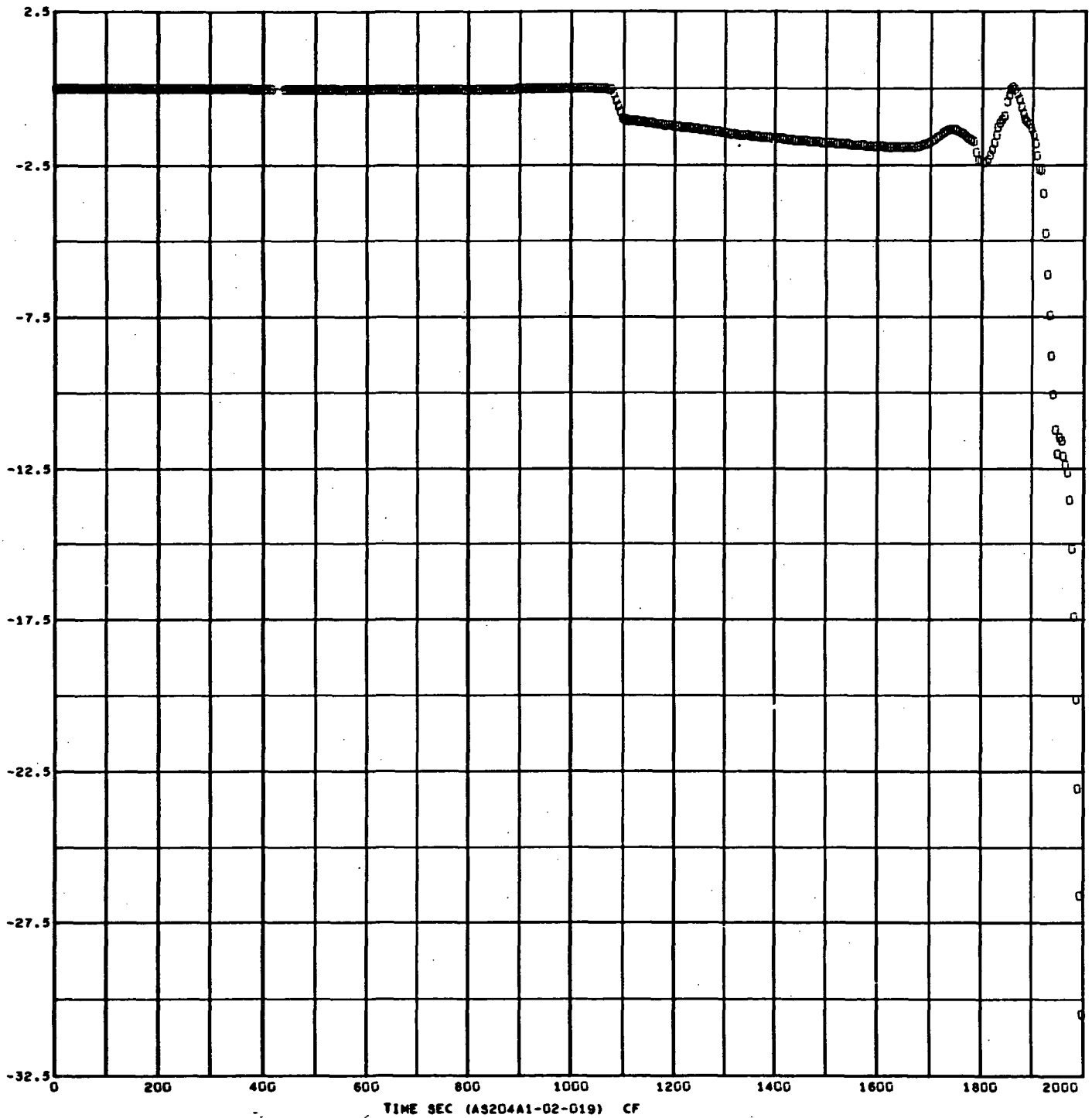
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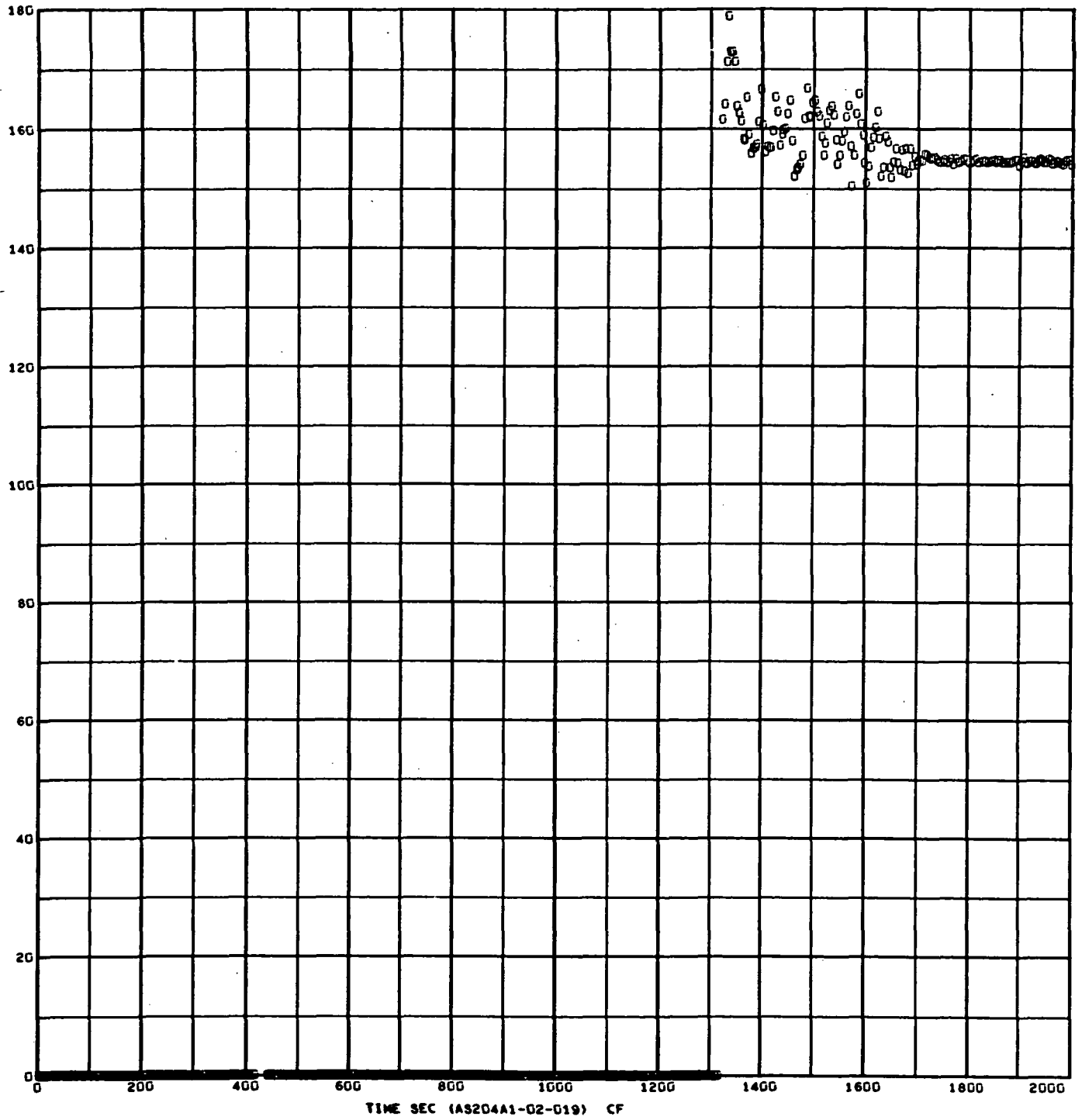
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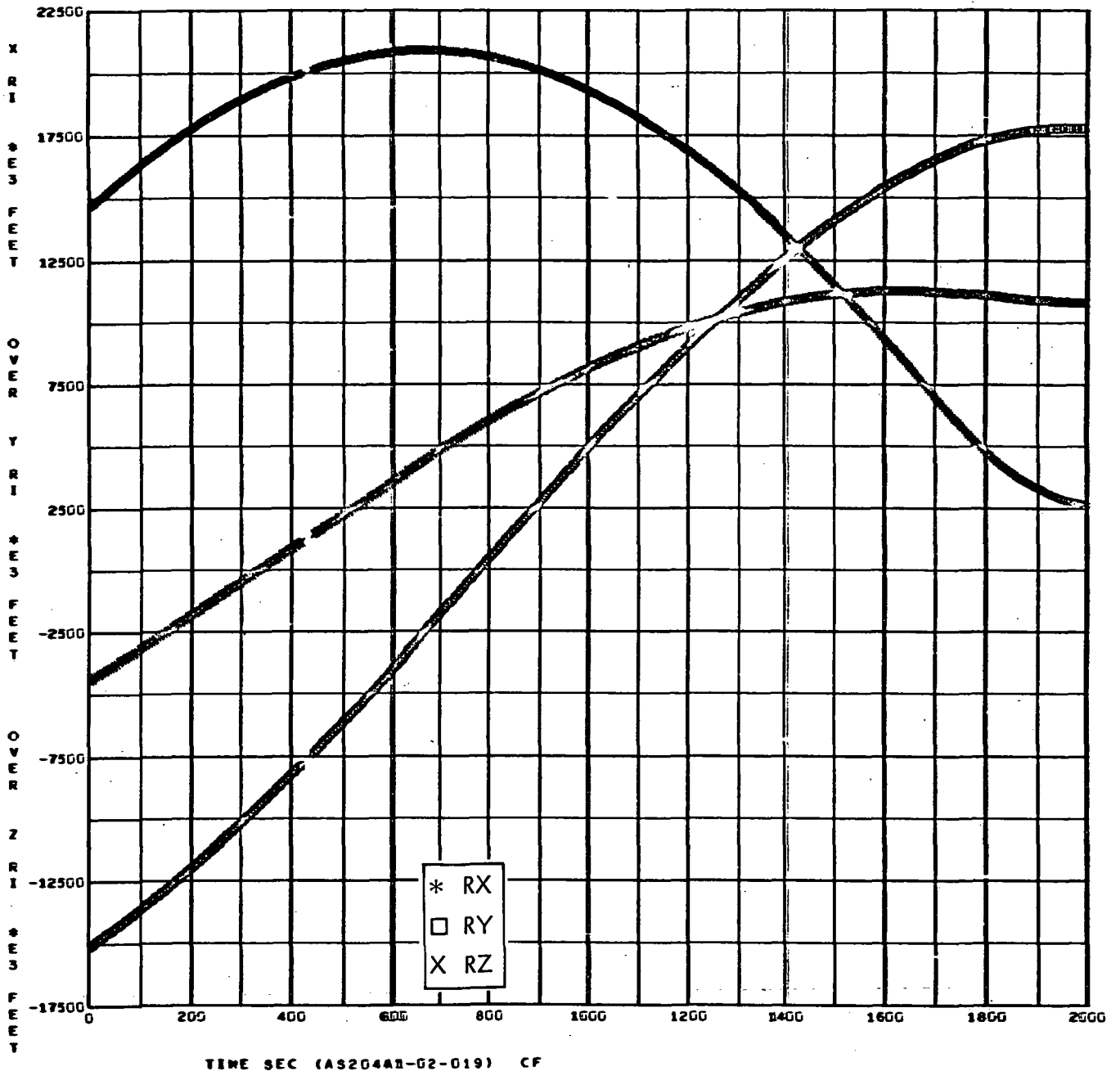
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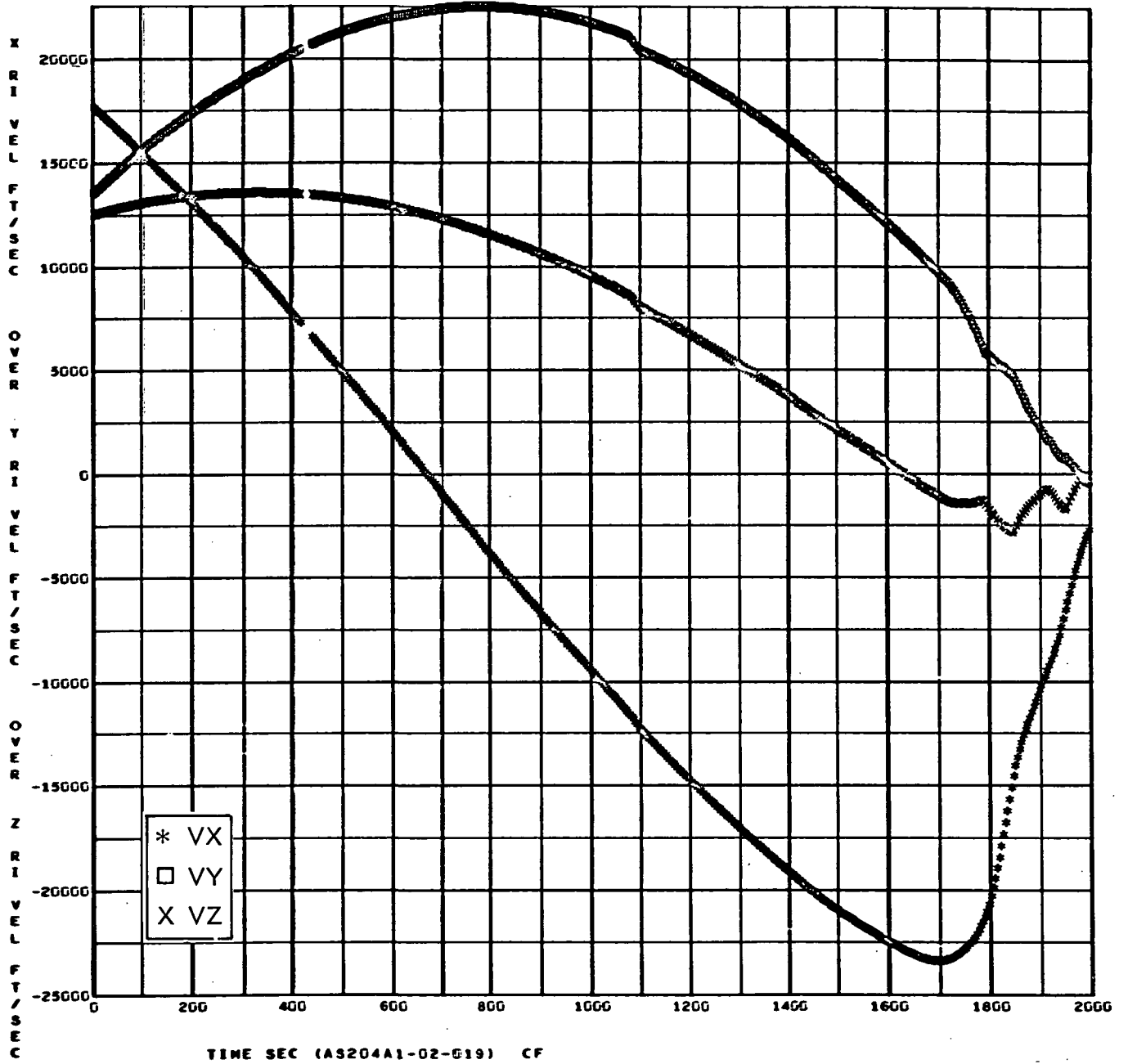
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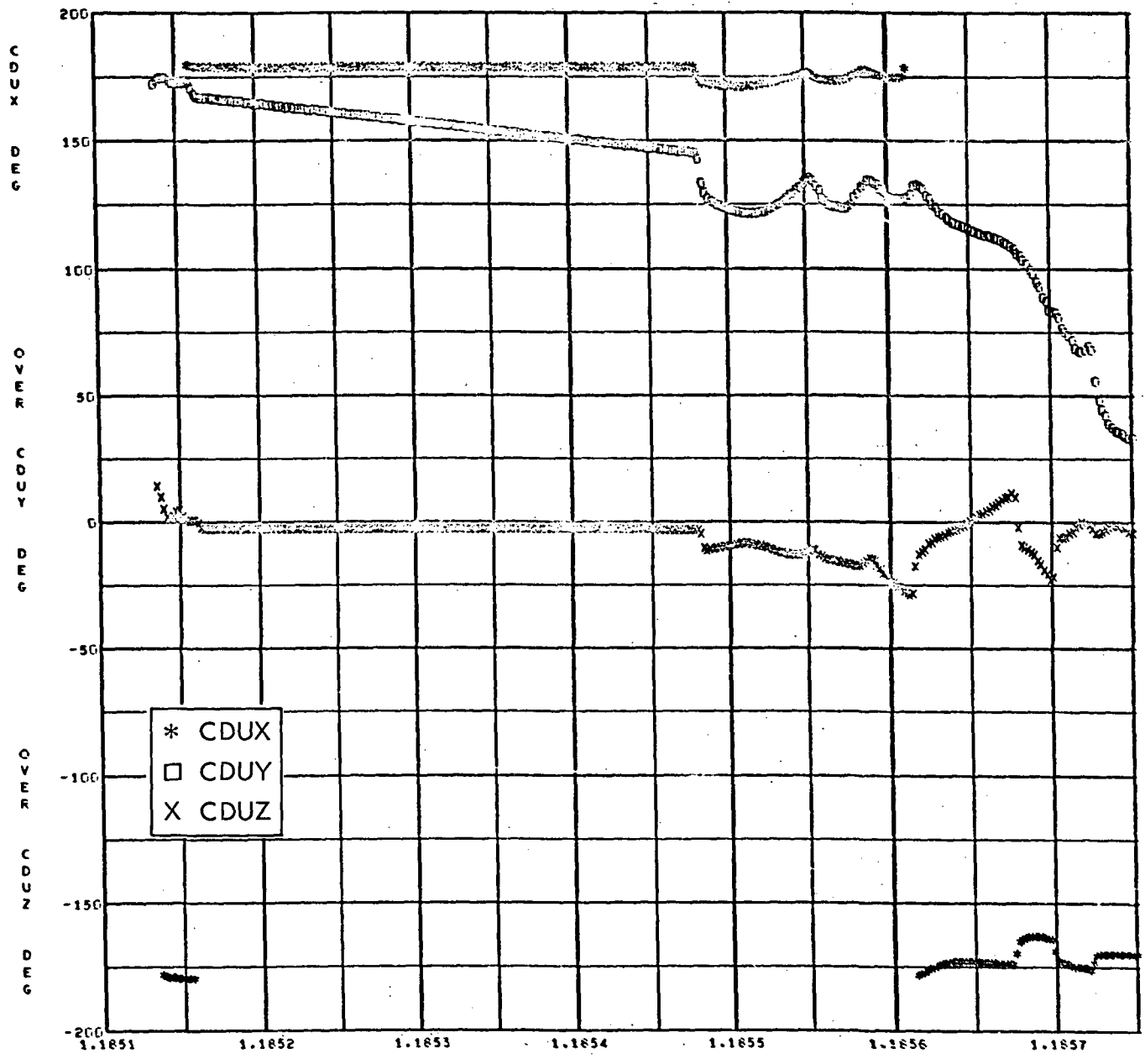


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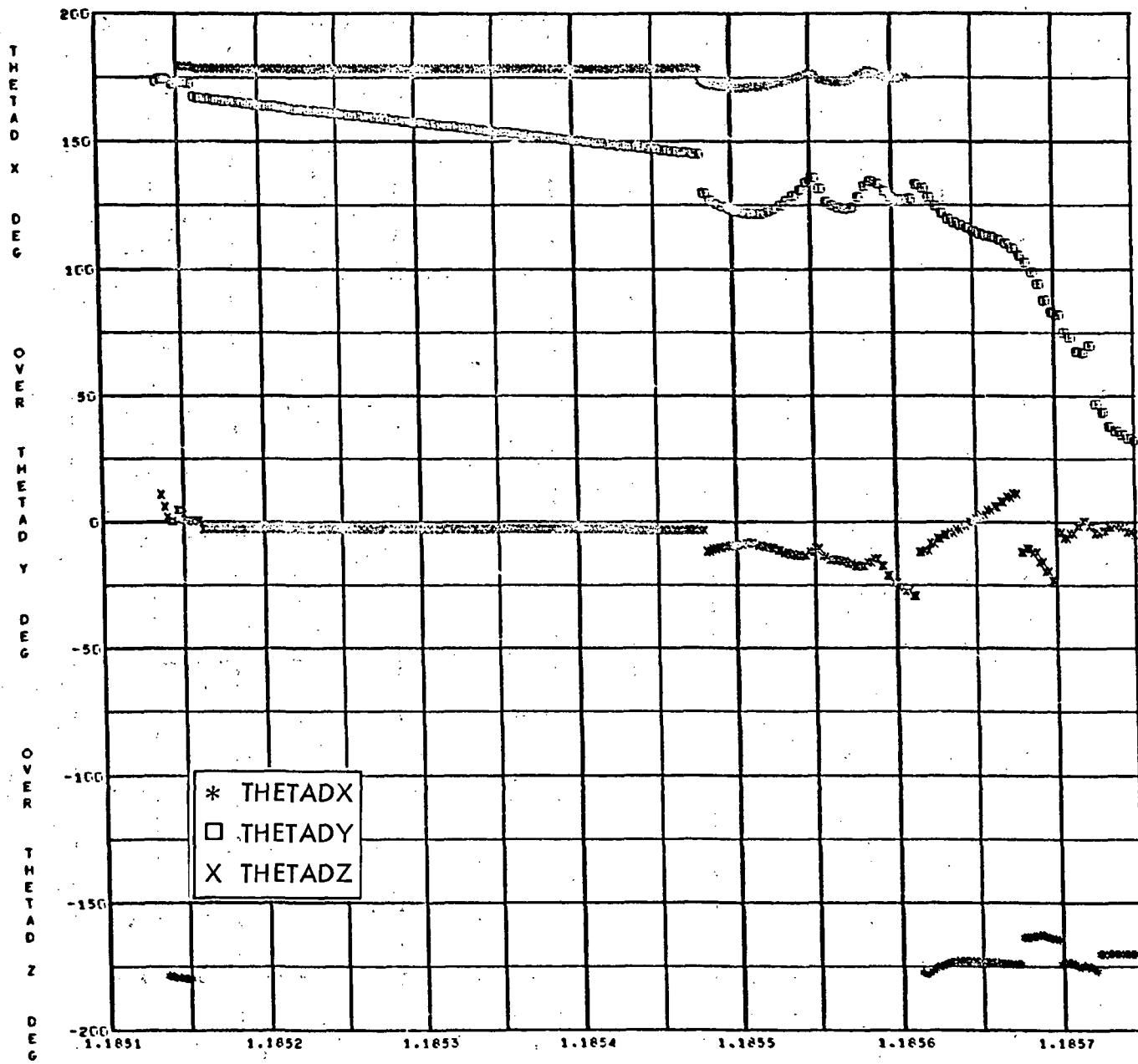








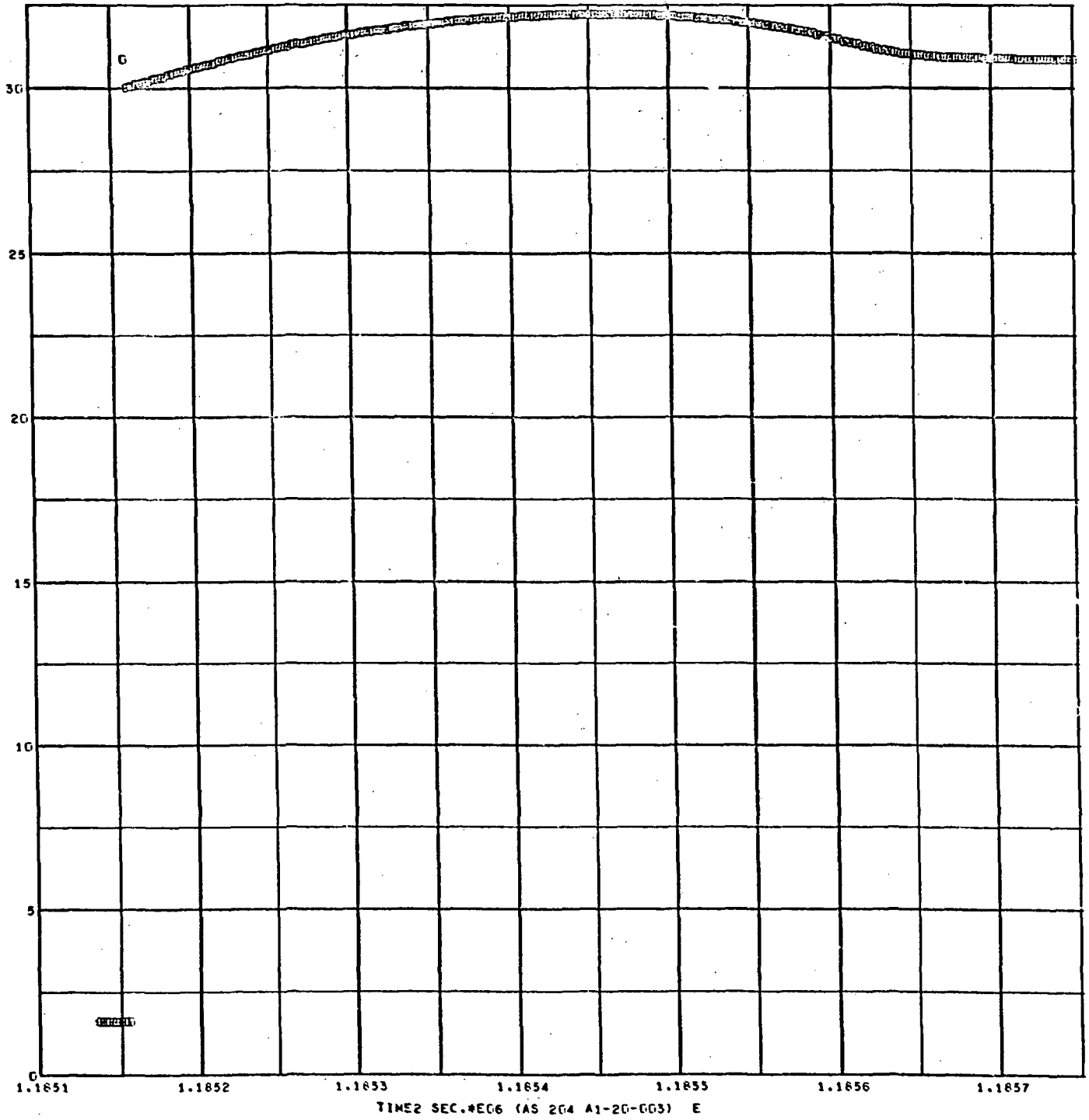
TIME2 SEC.#EG6 (AS 204 A1-20-003) E



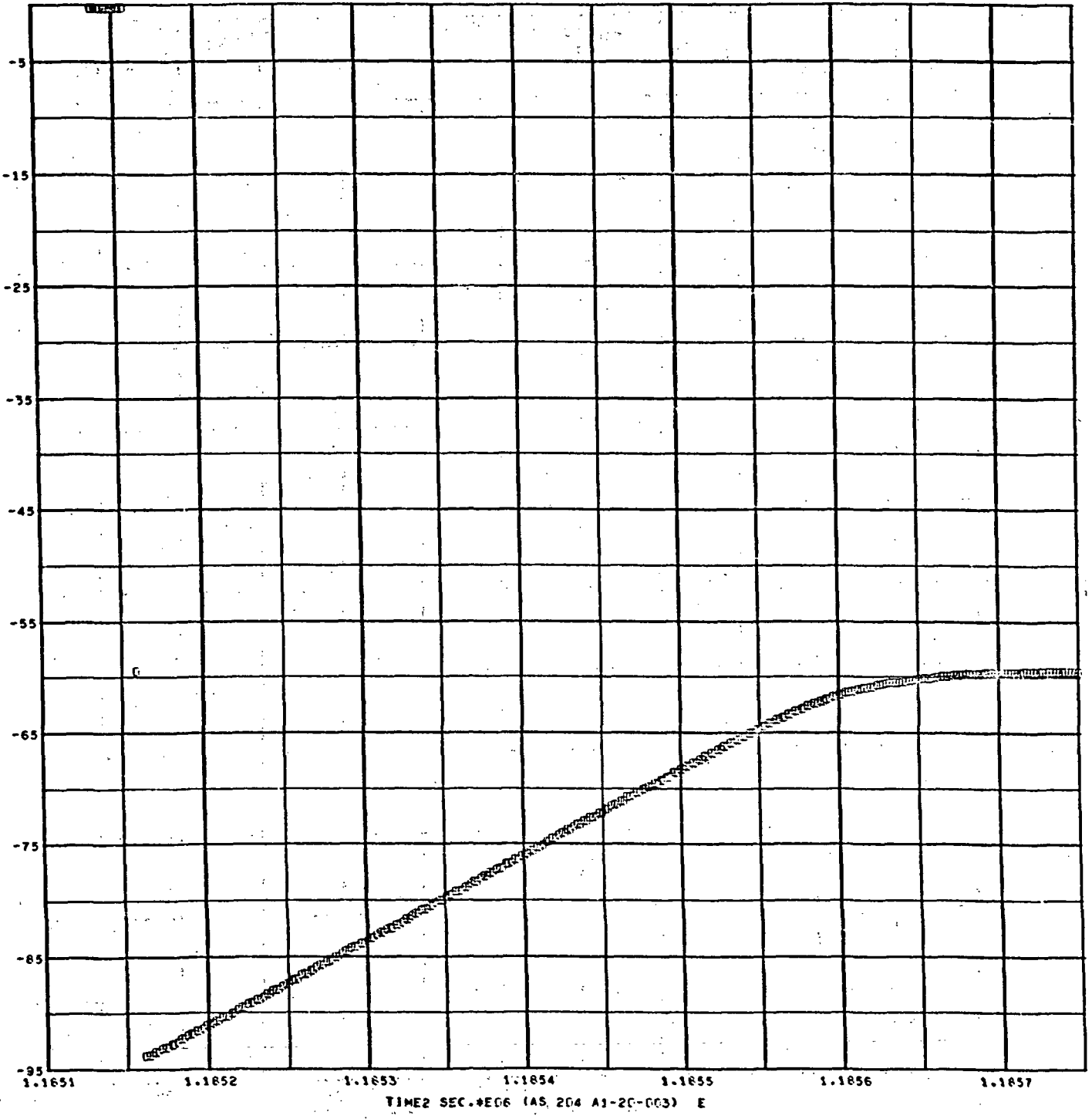
TIME2 SEC.*E06 (AS 204 A1-20-003) E

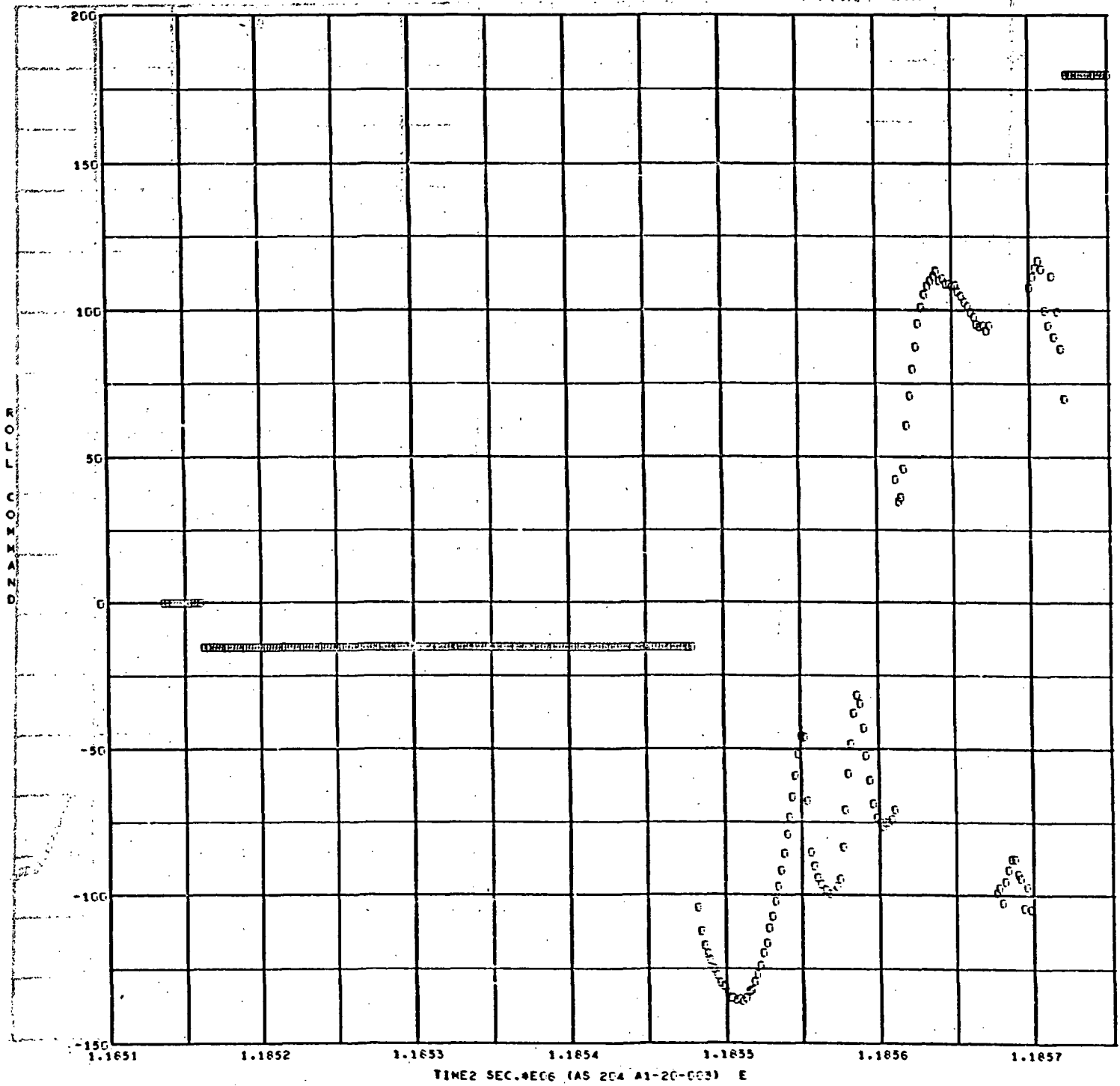
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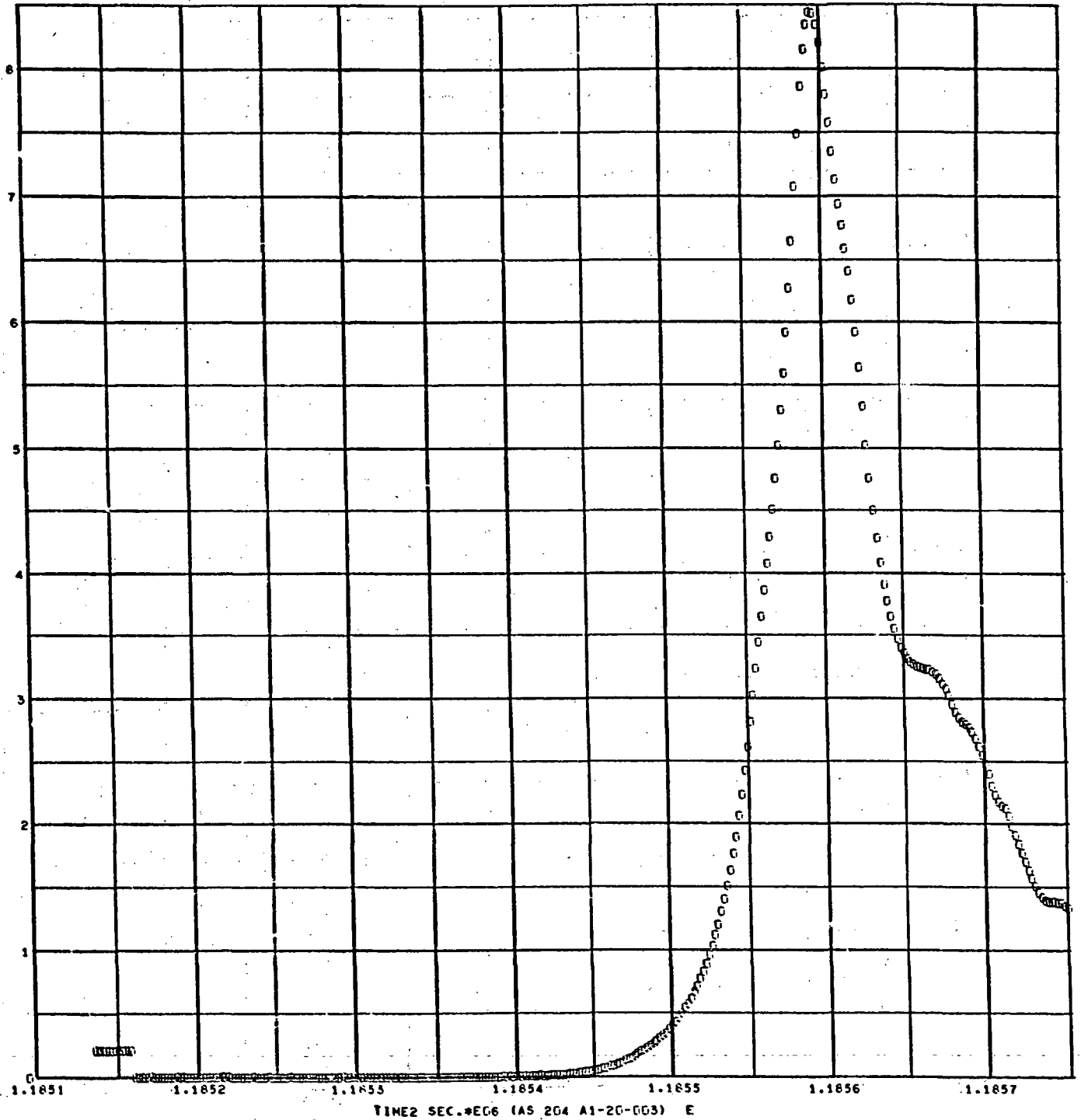


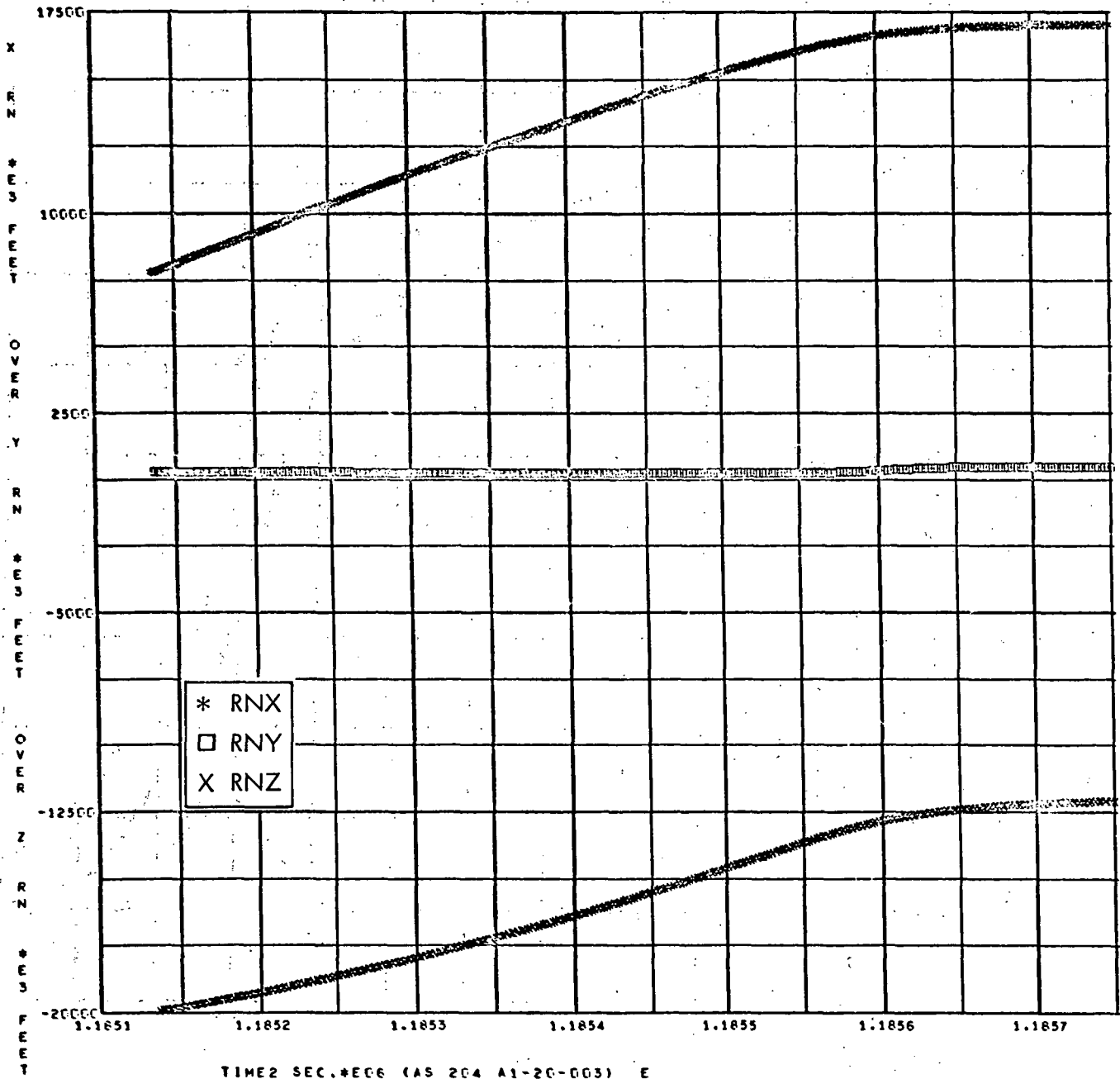
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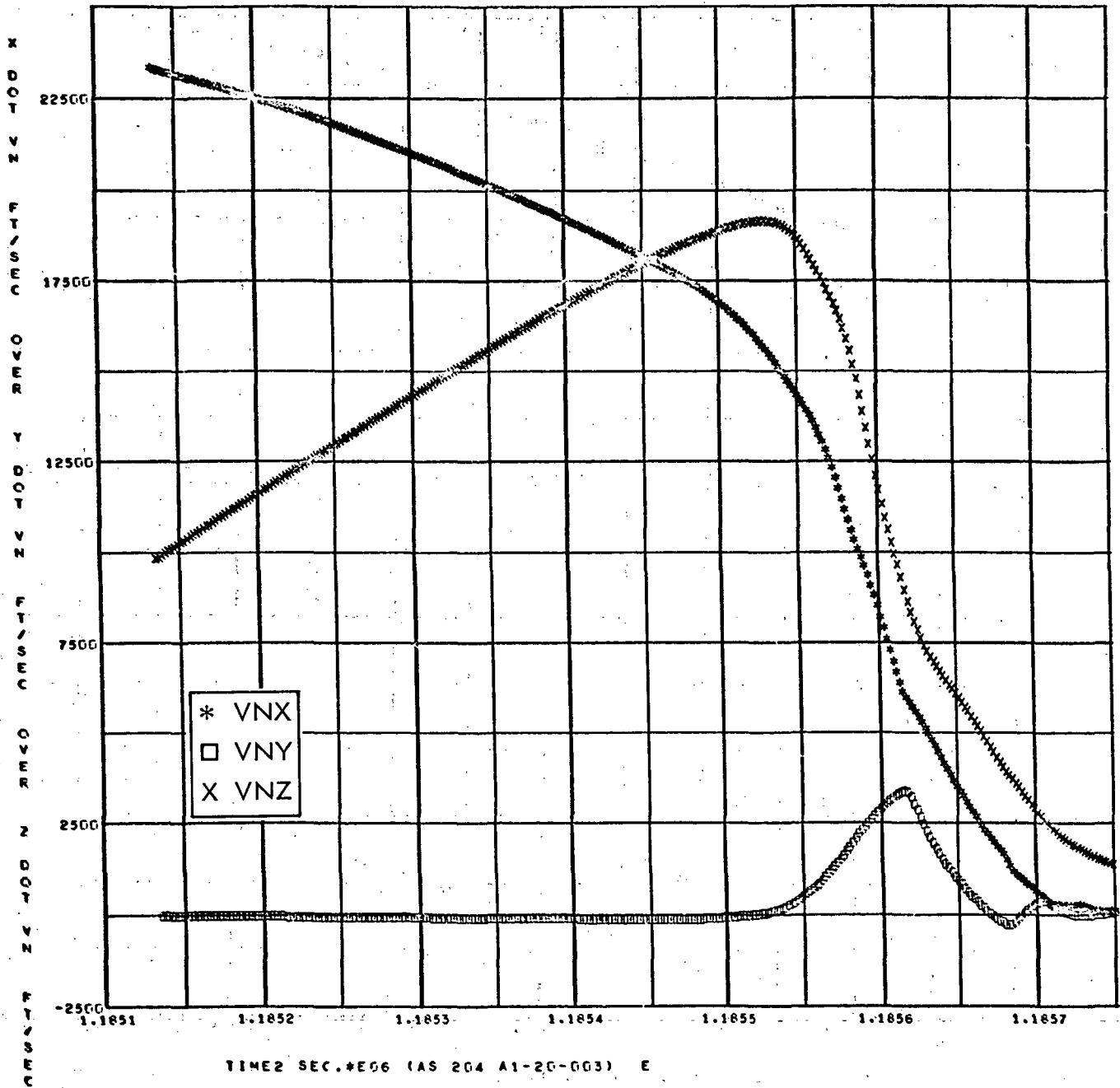




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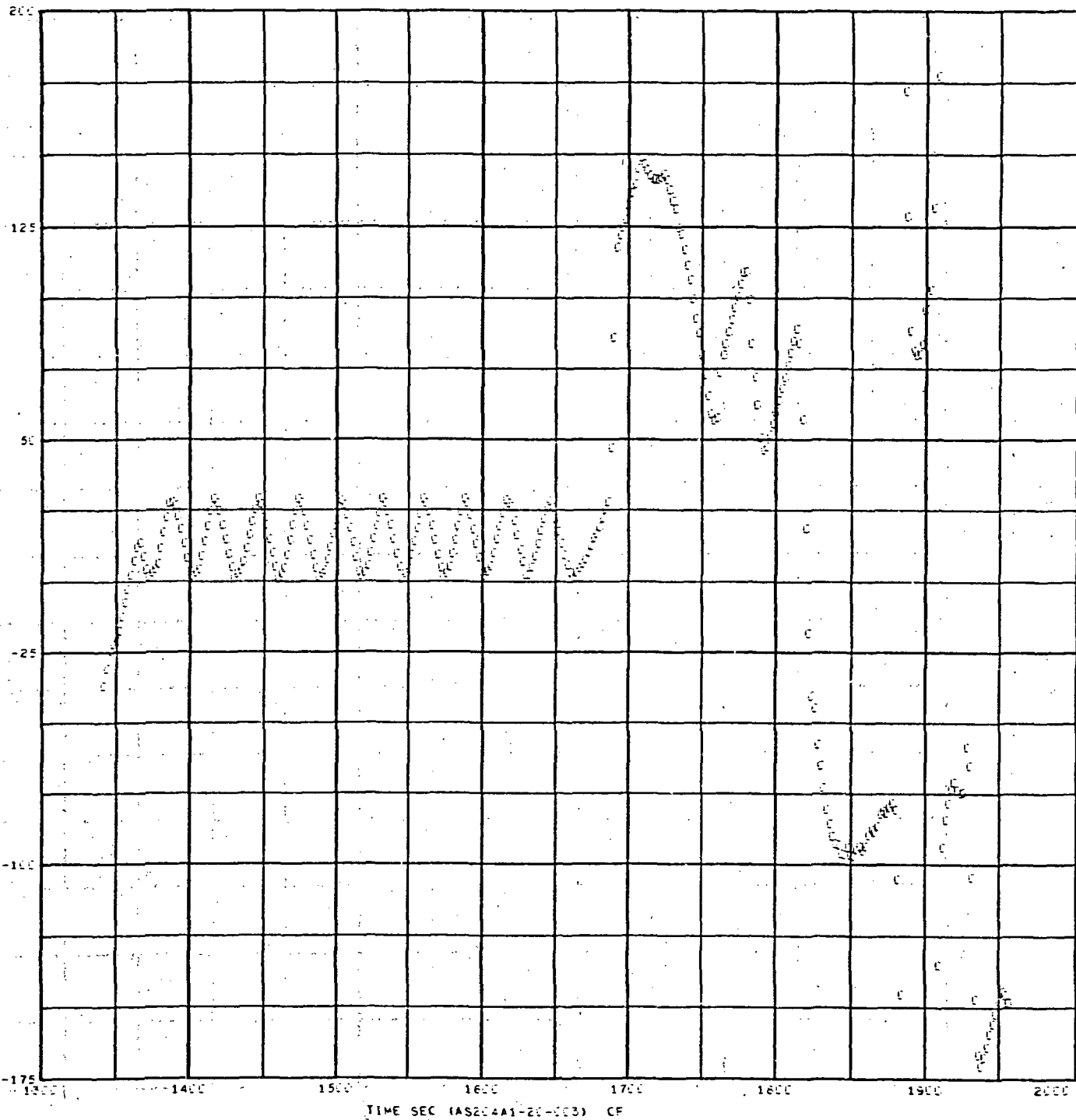




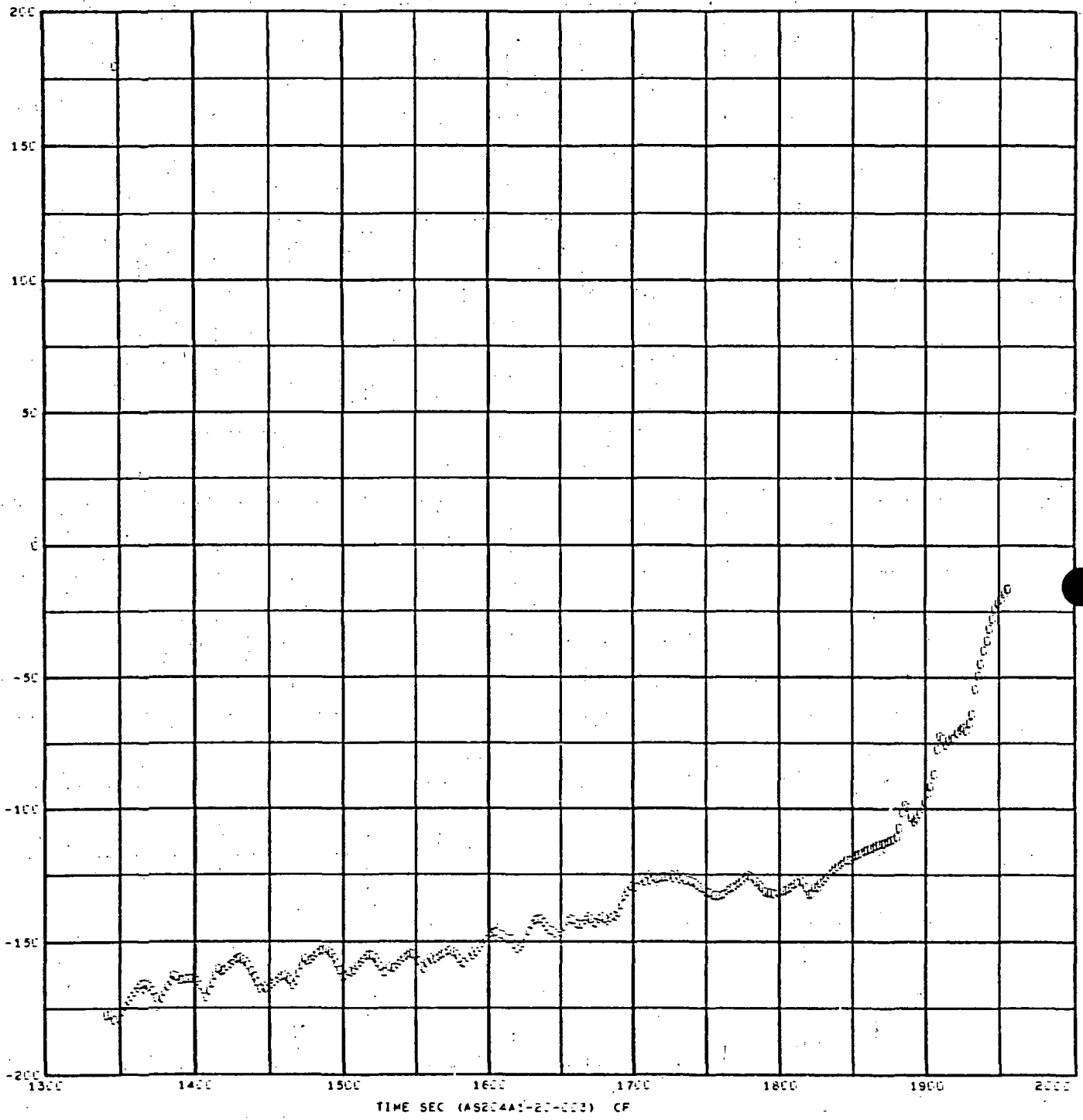
ENVIRONMENT PLOTS

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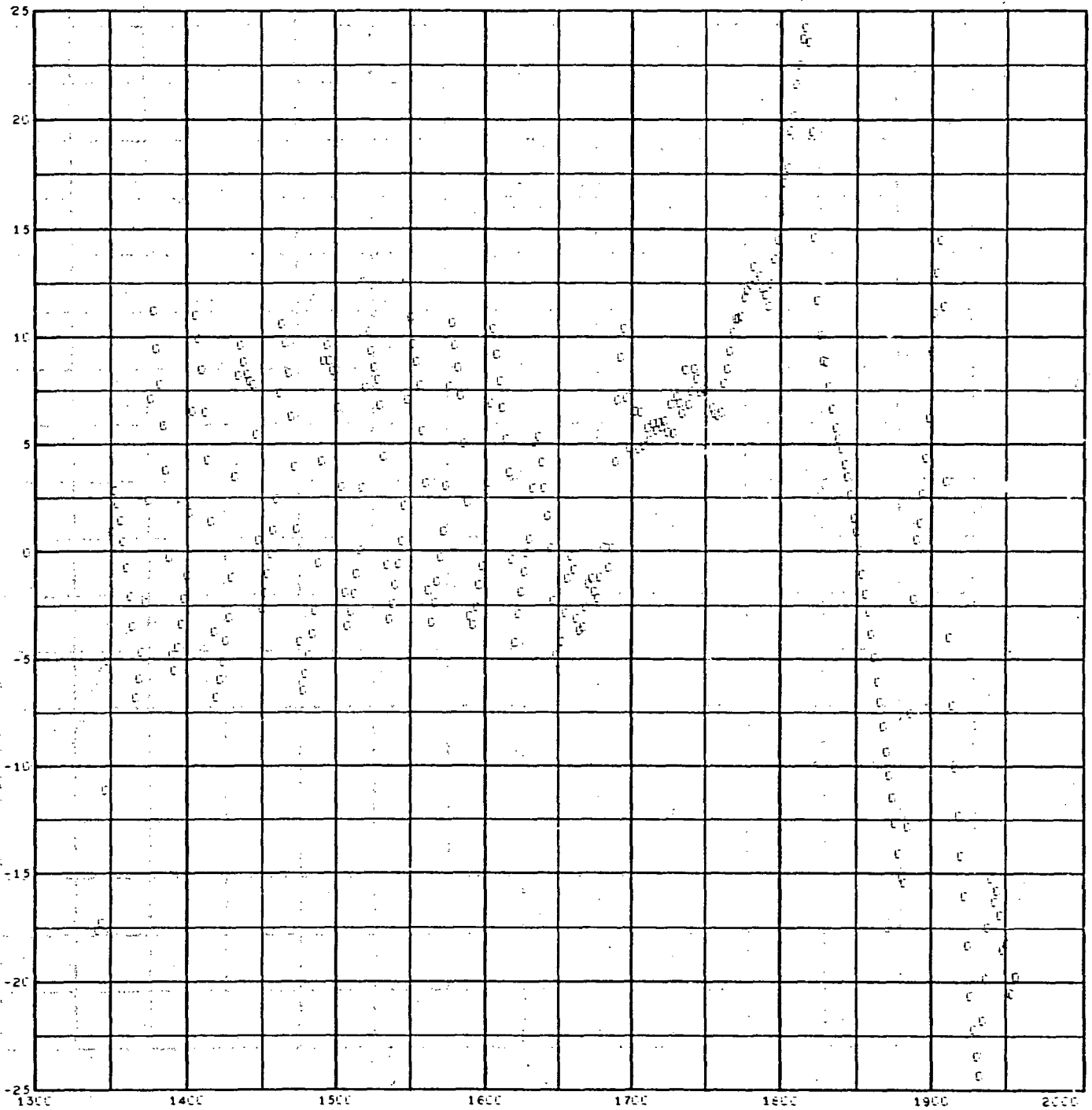
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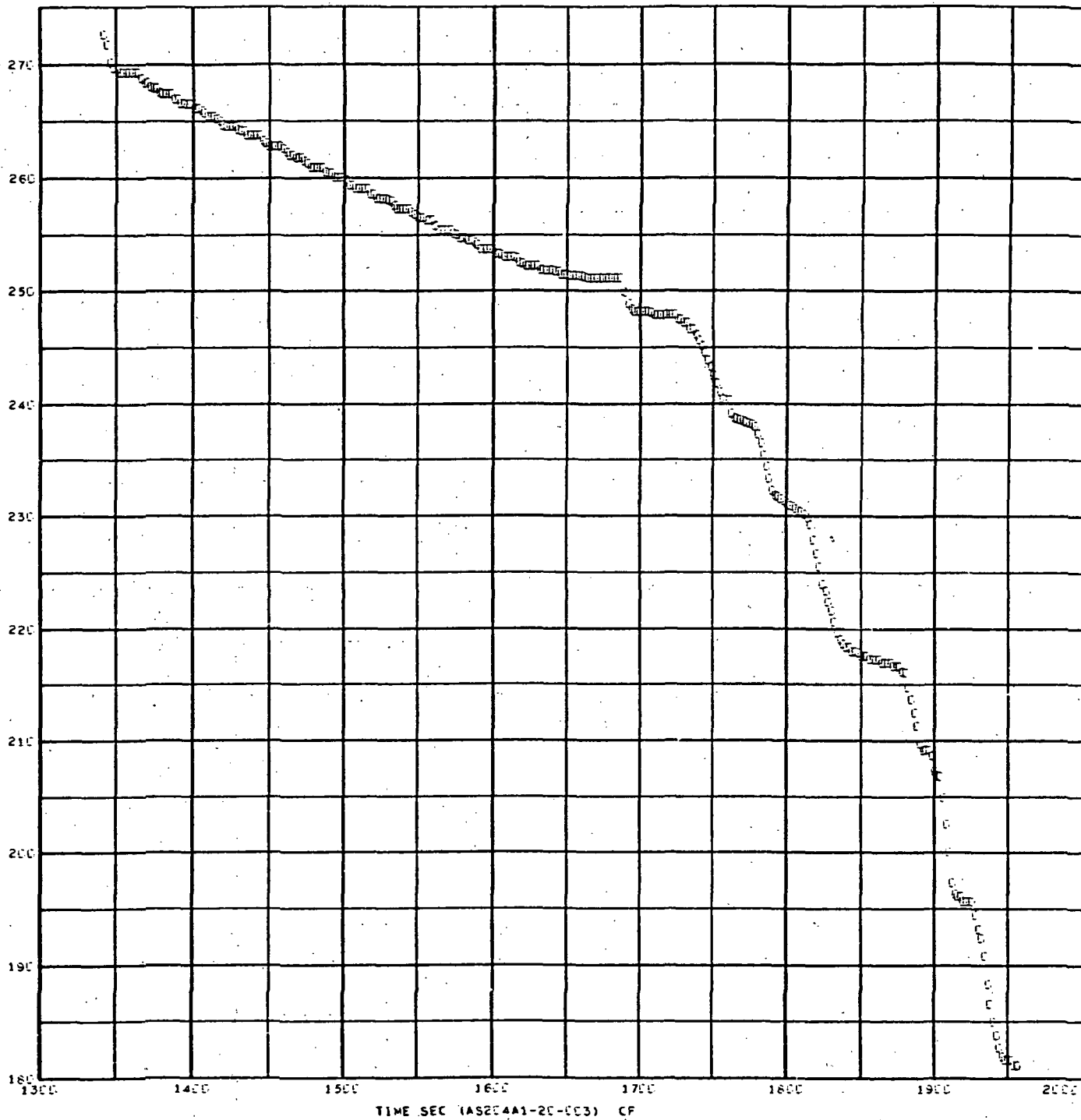
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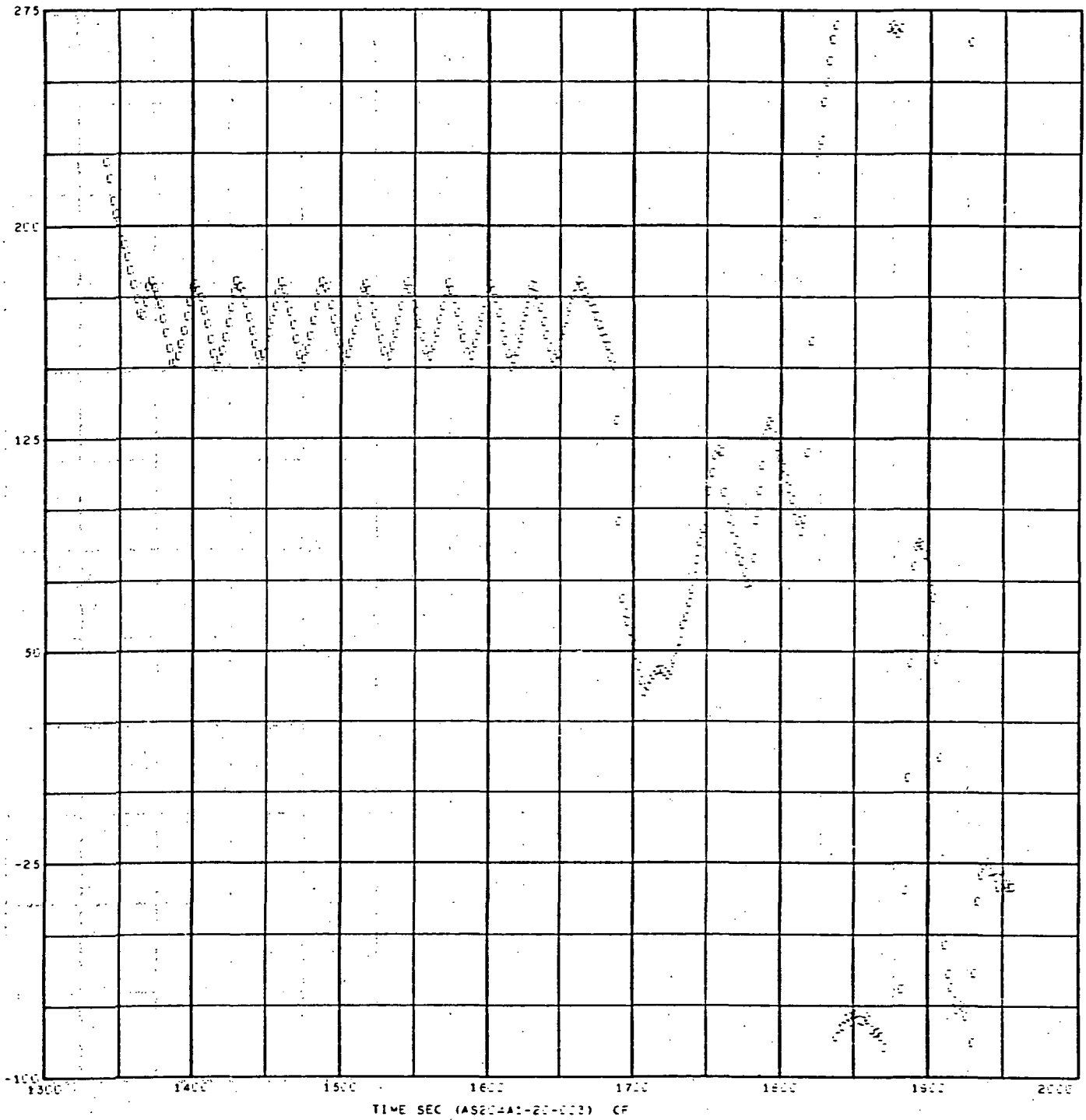
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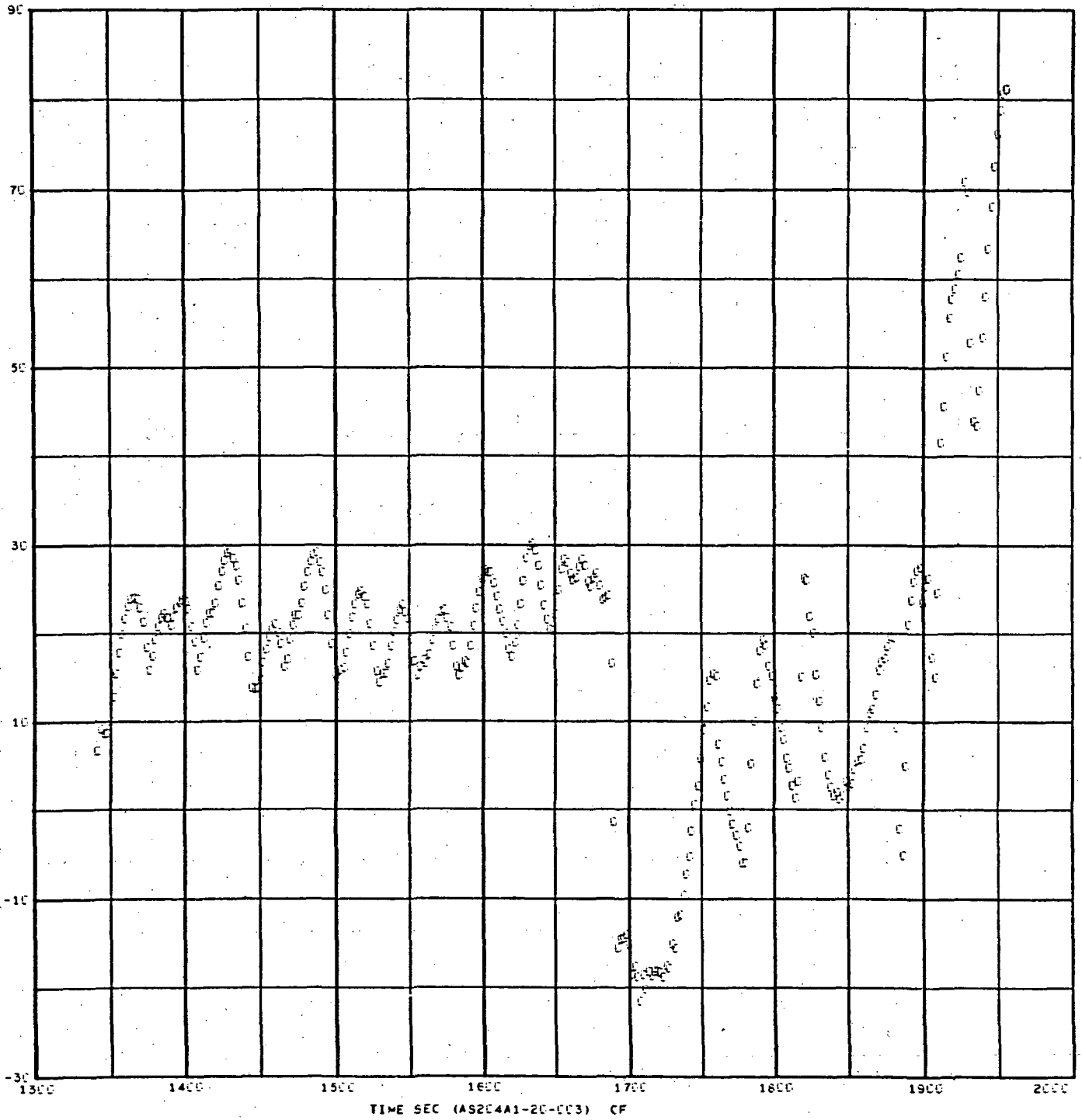
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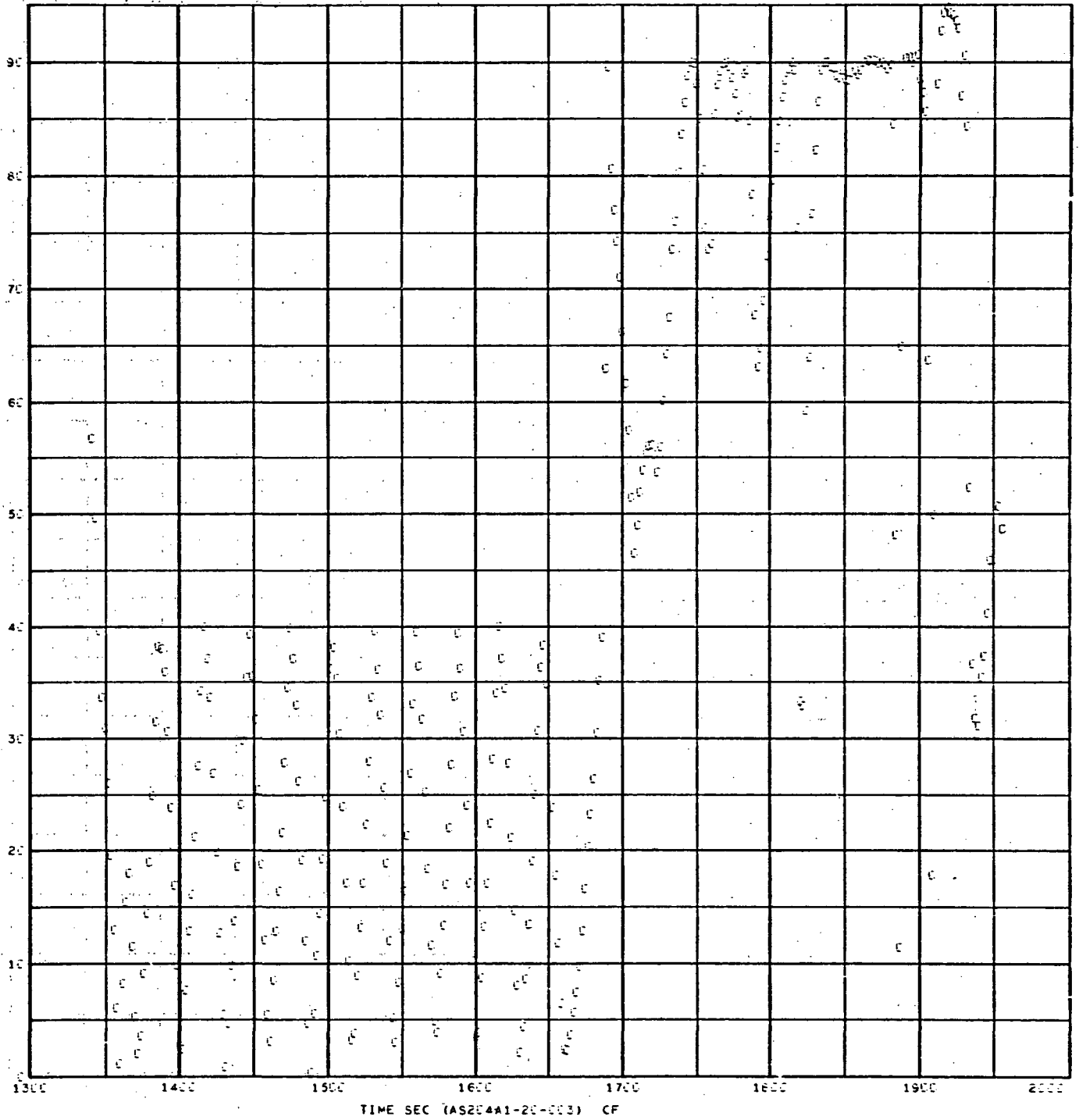
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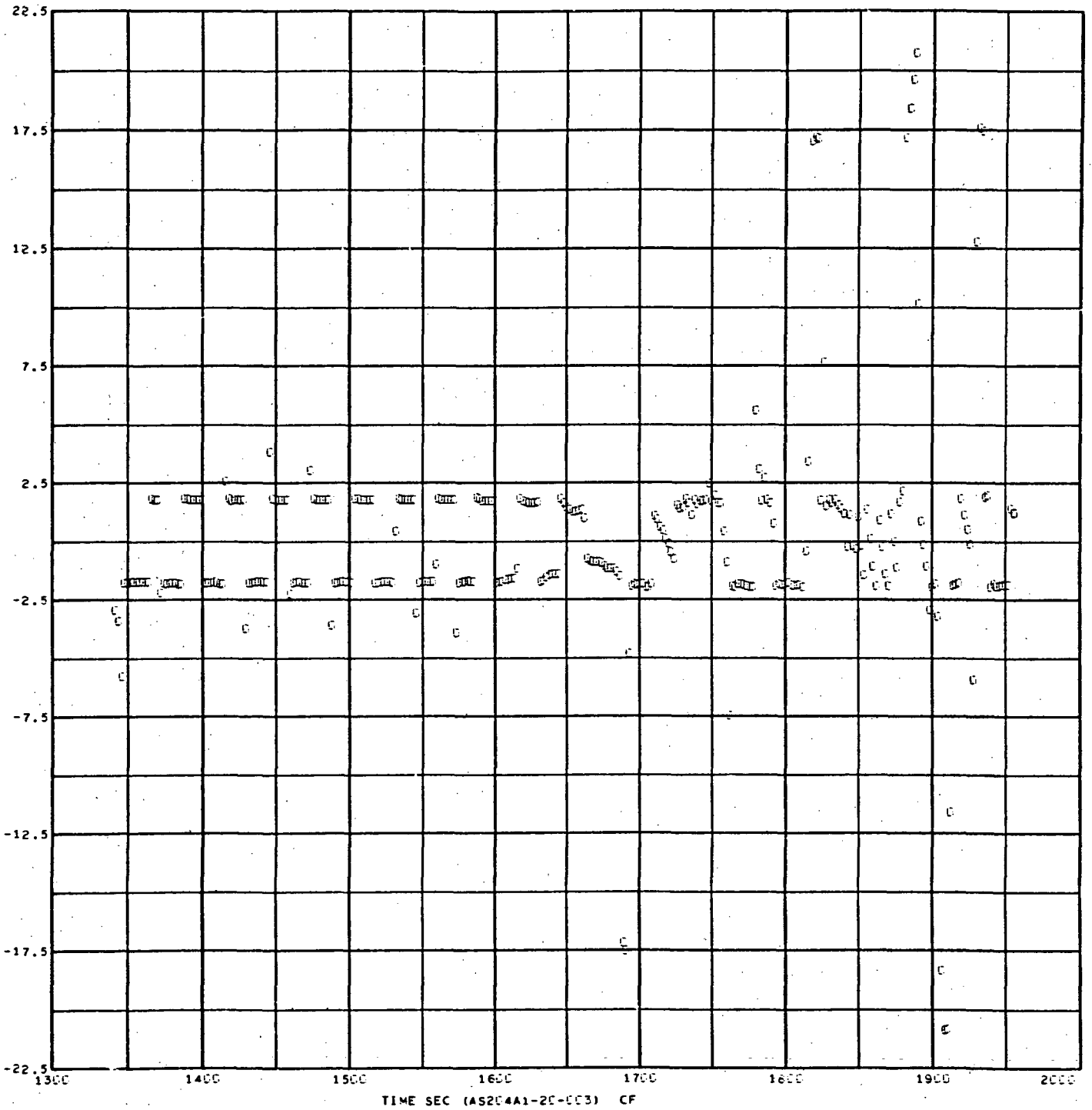
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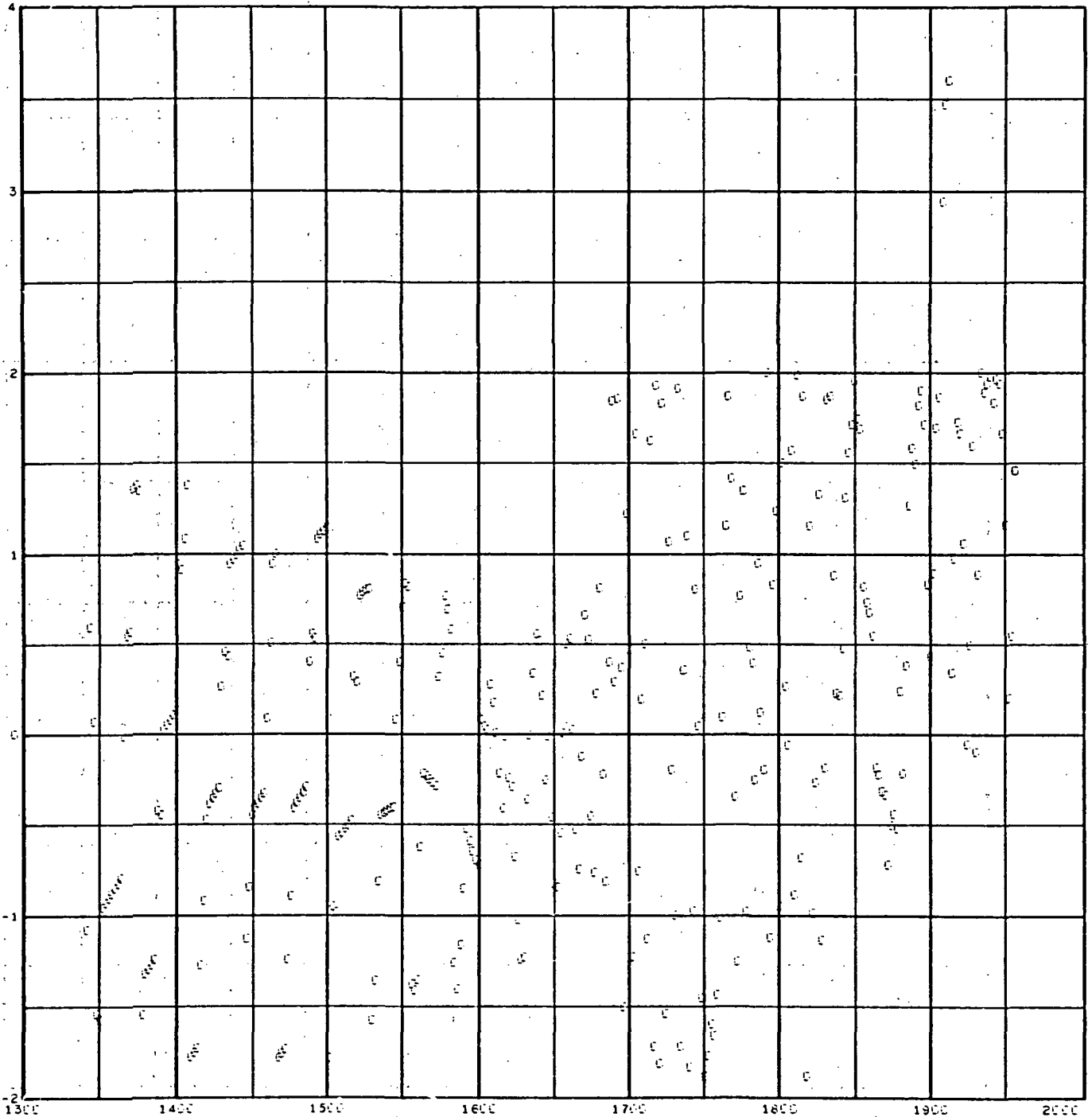
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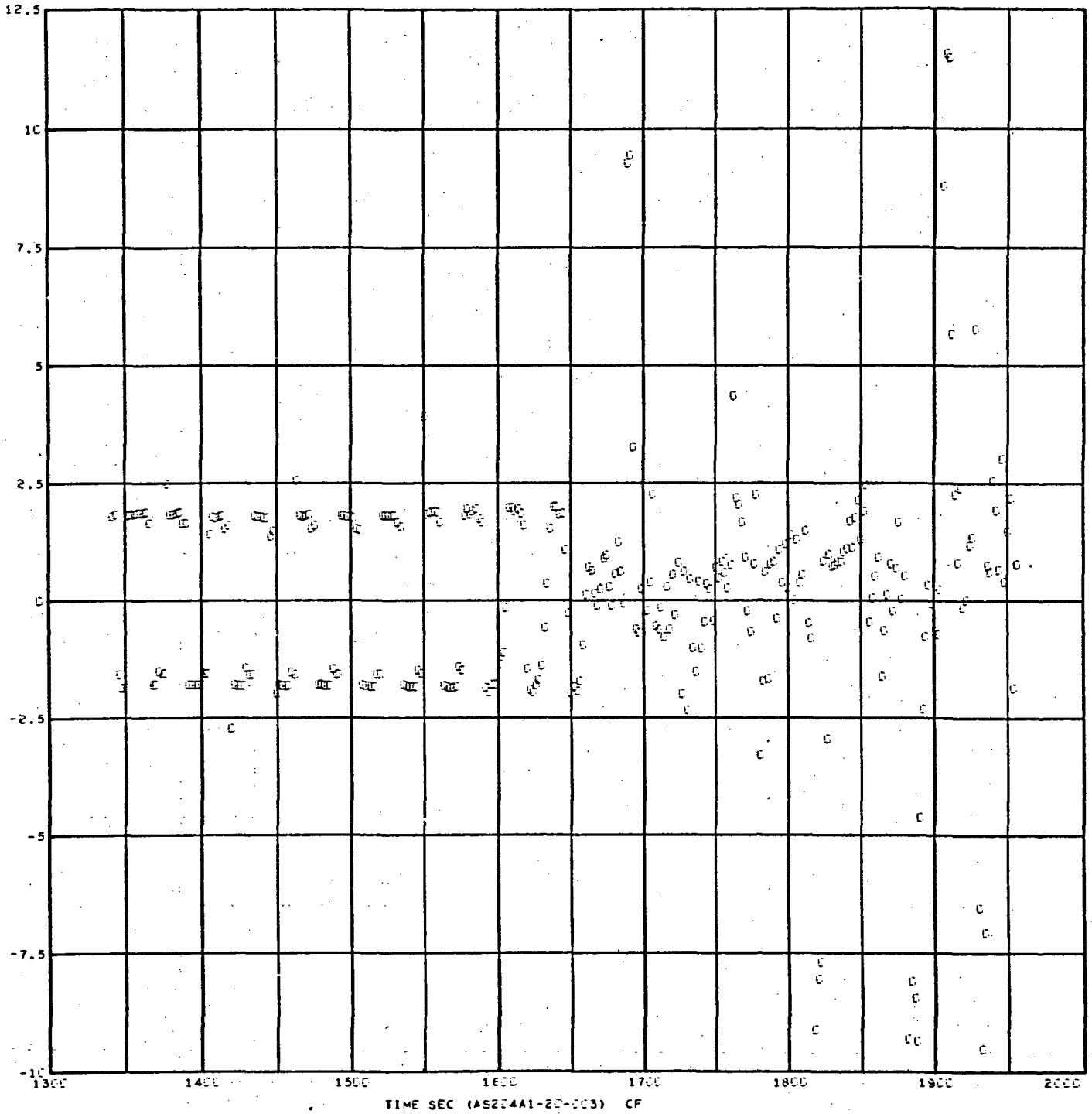
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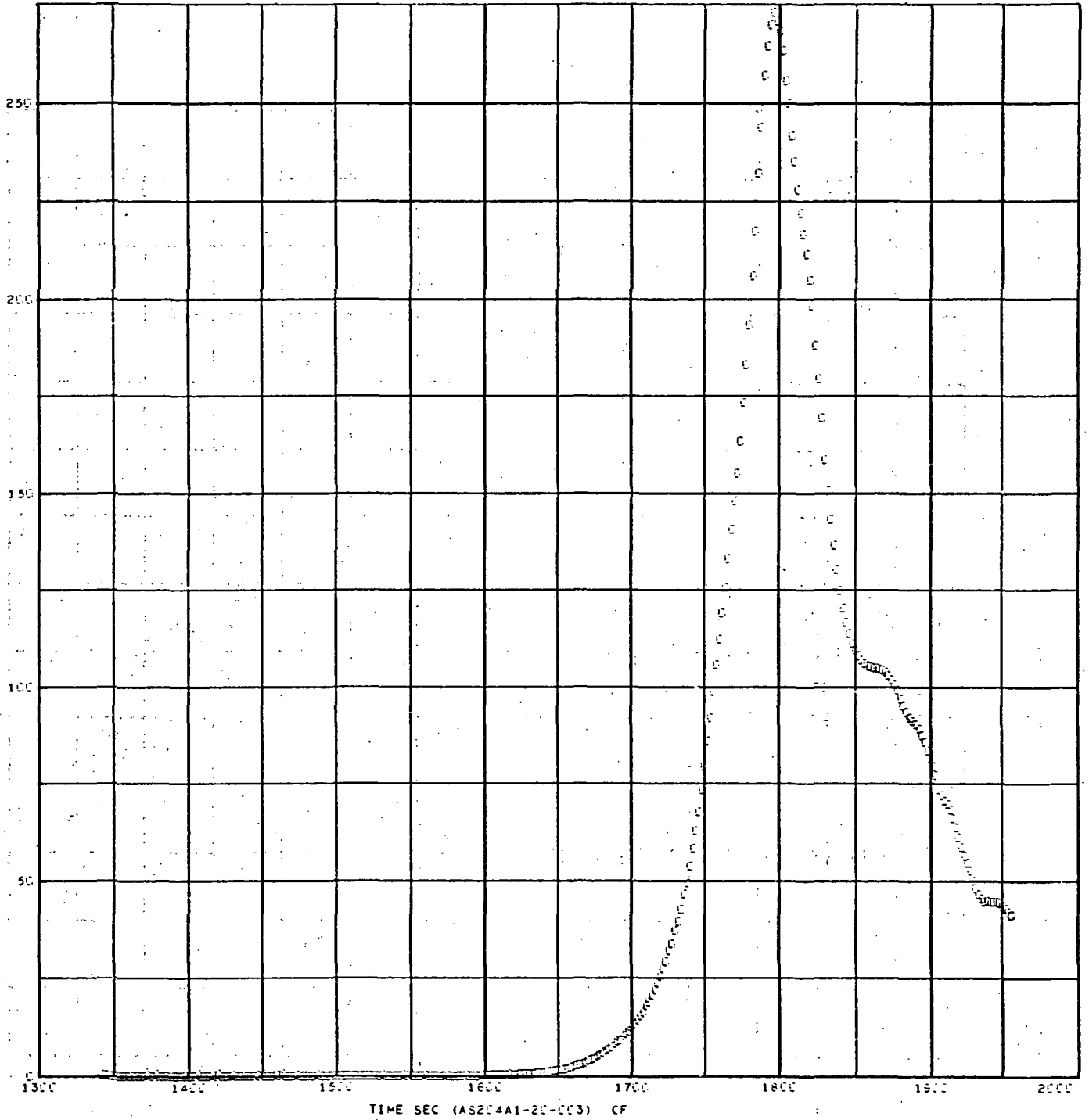
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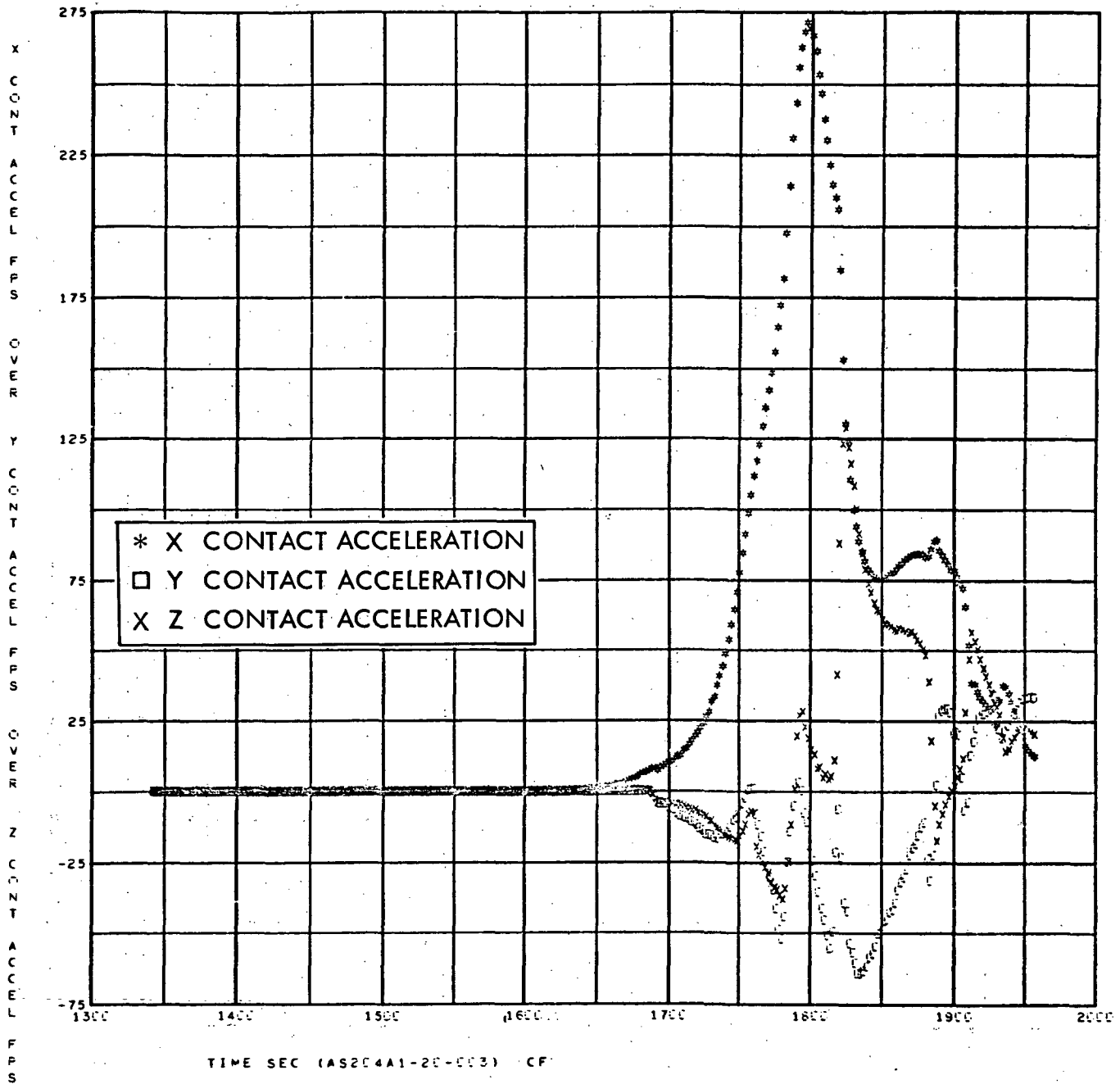


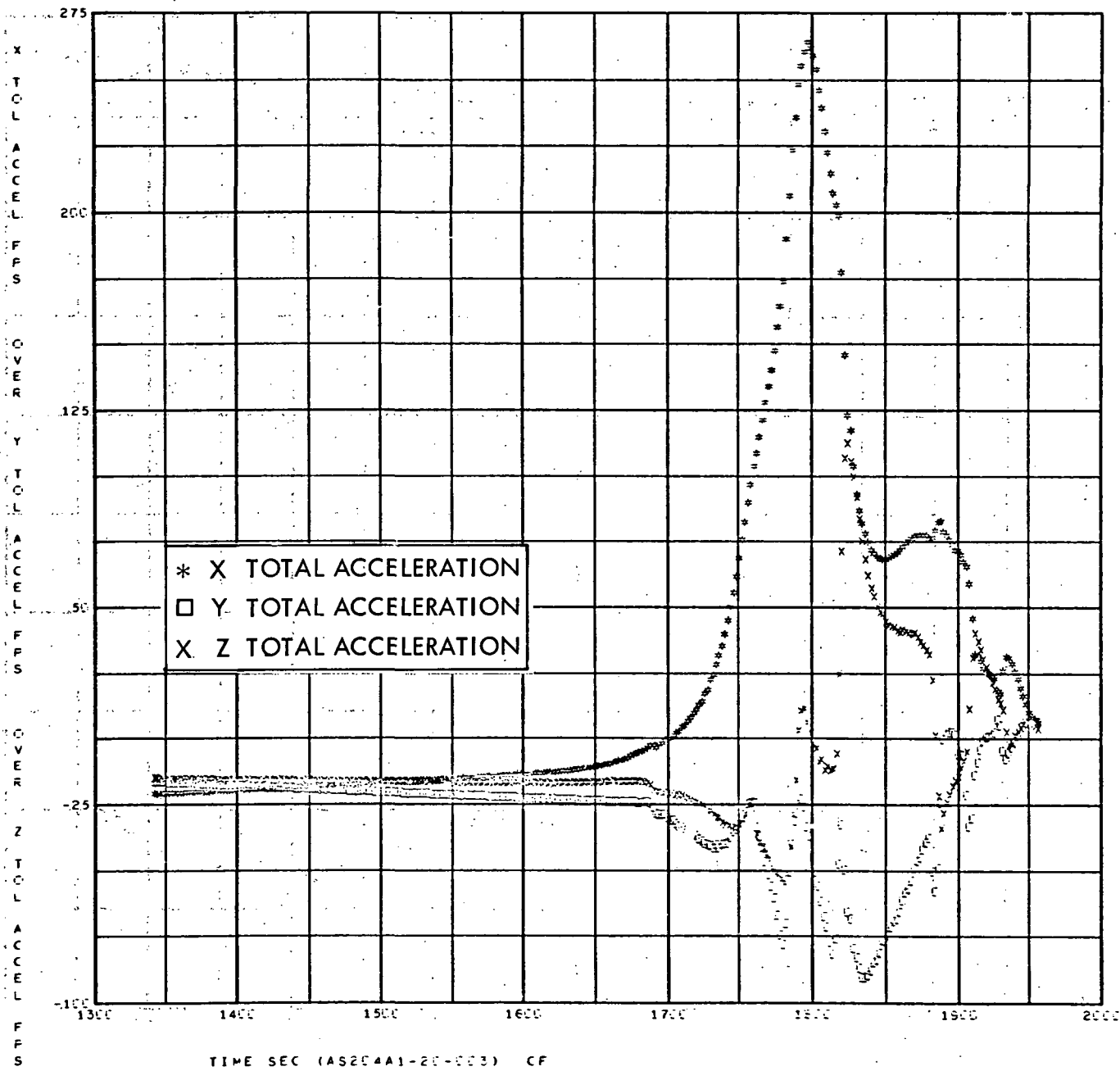
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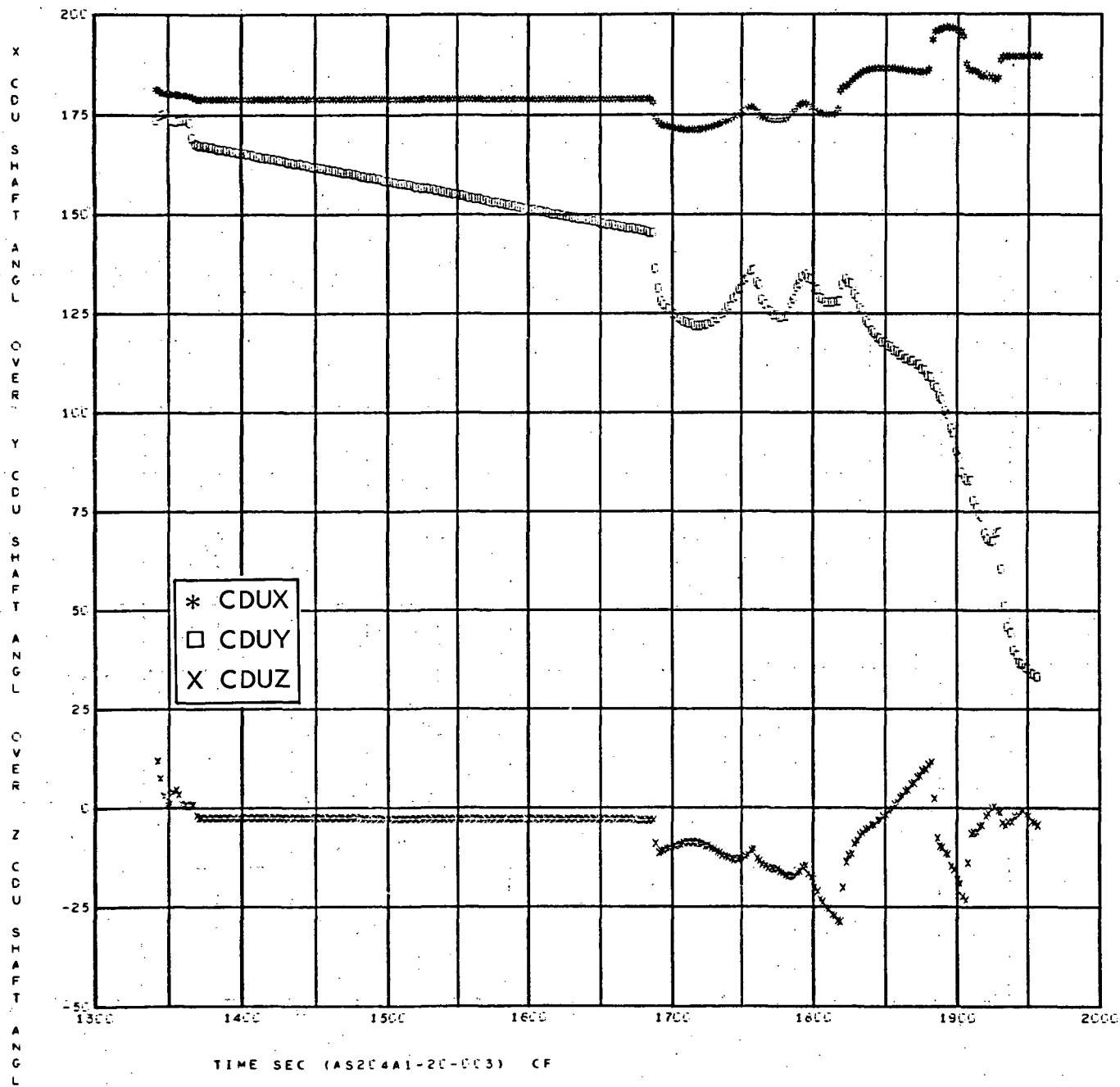
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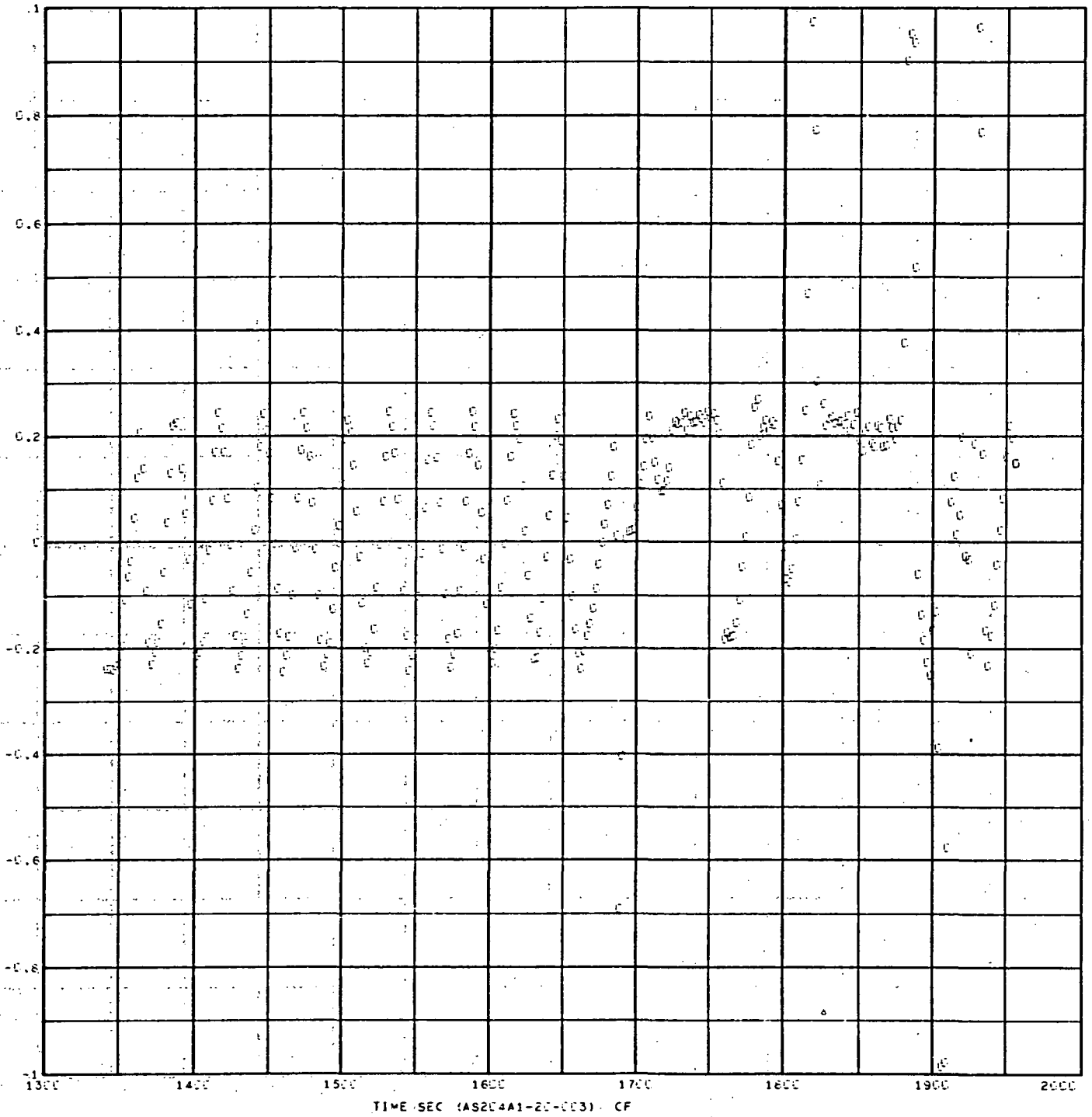




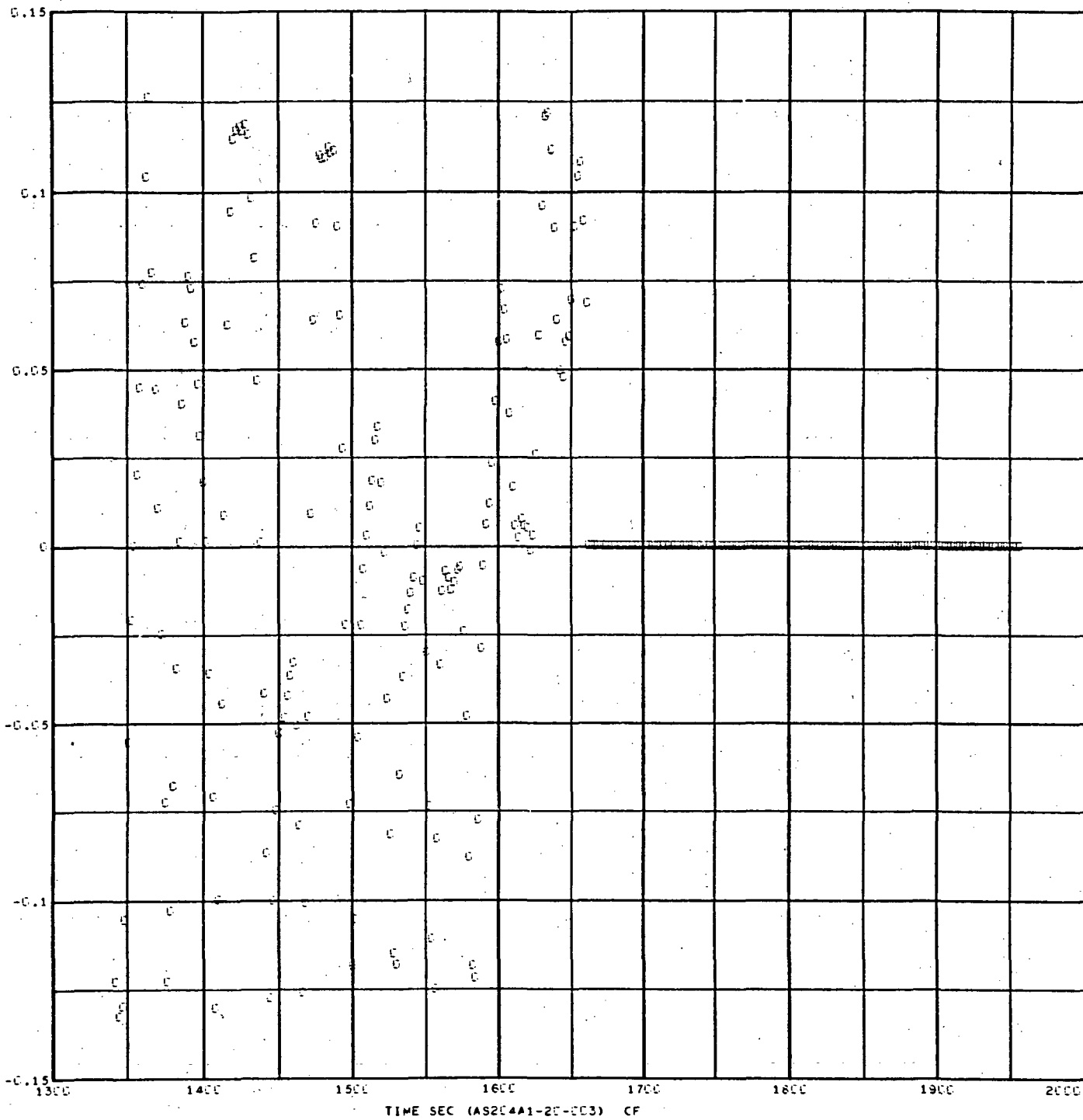




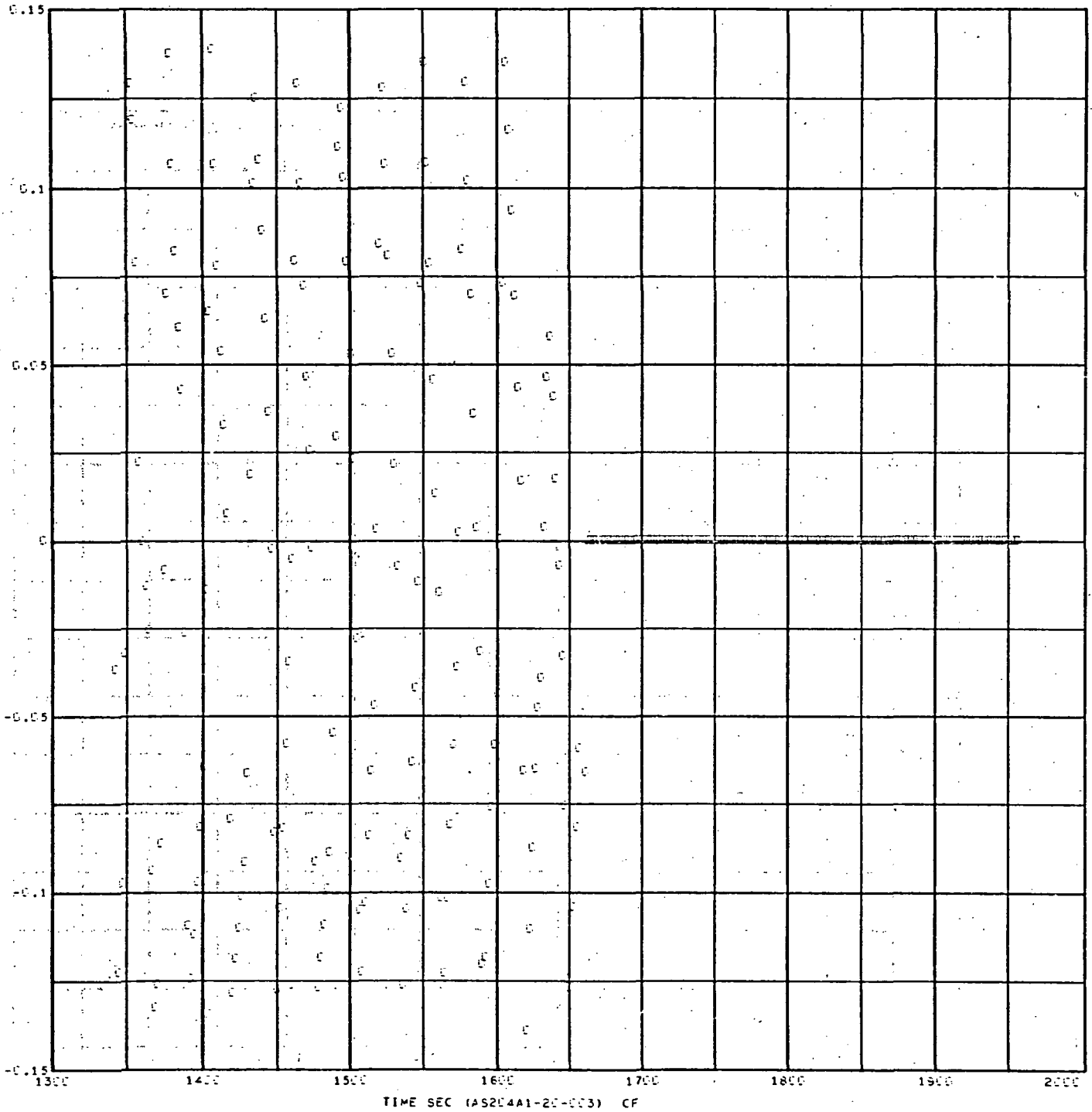
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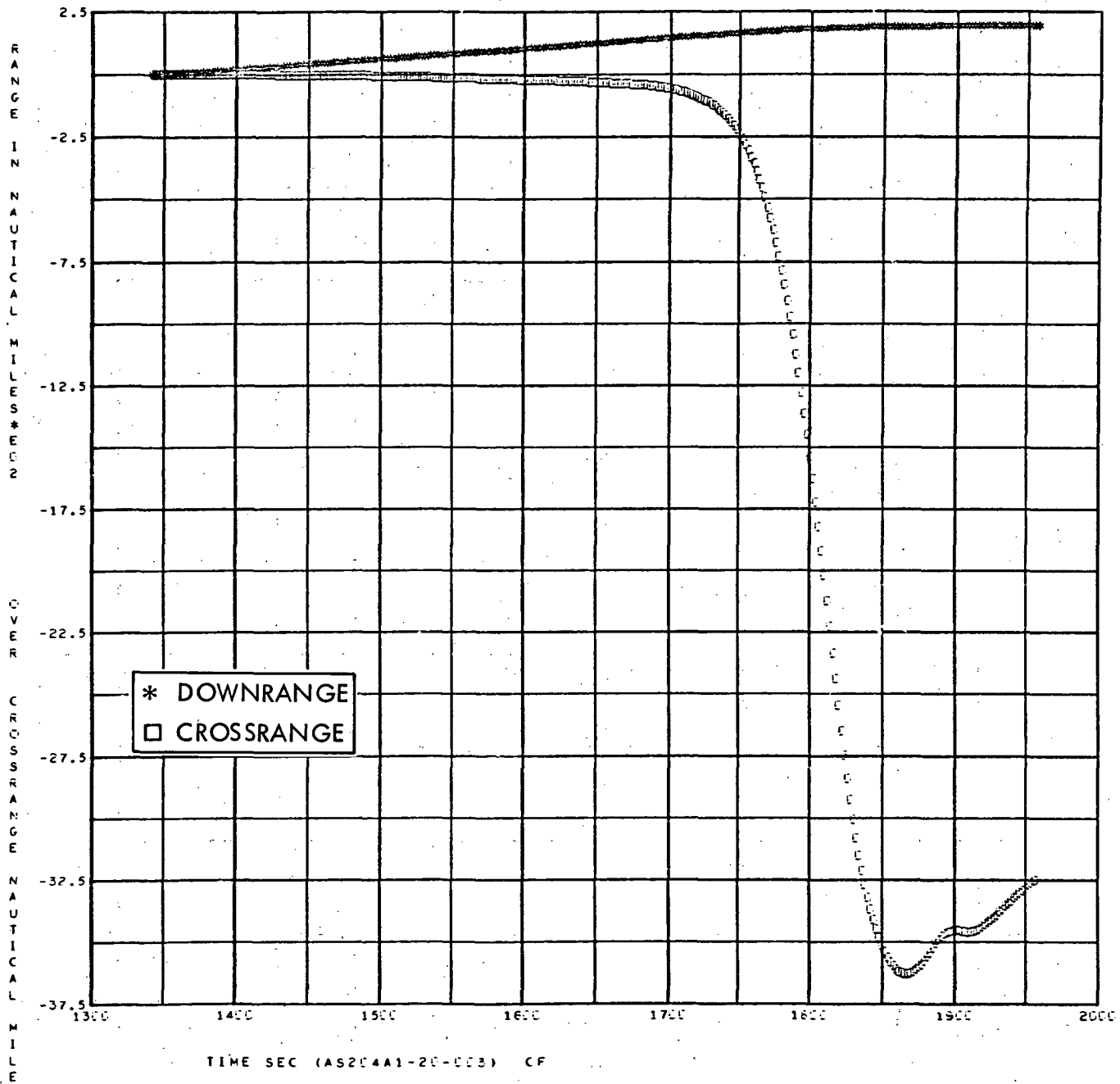


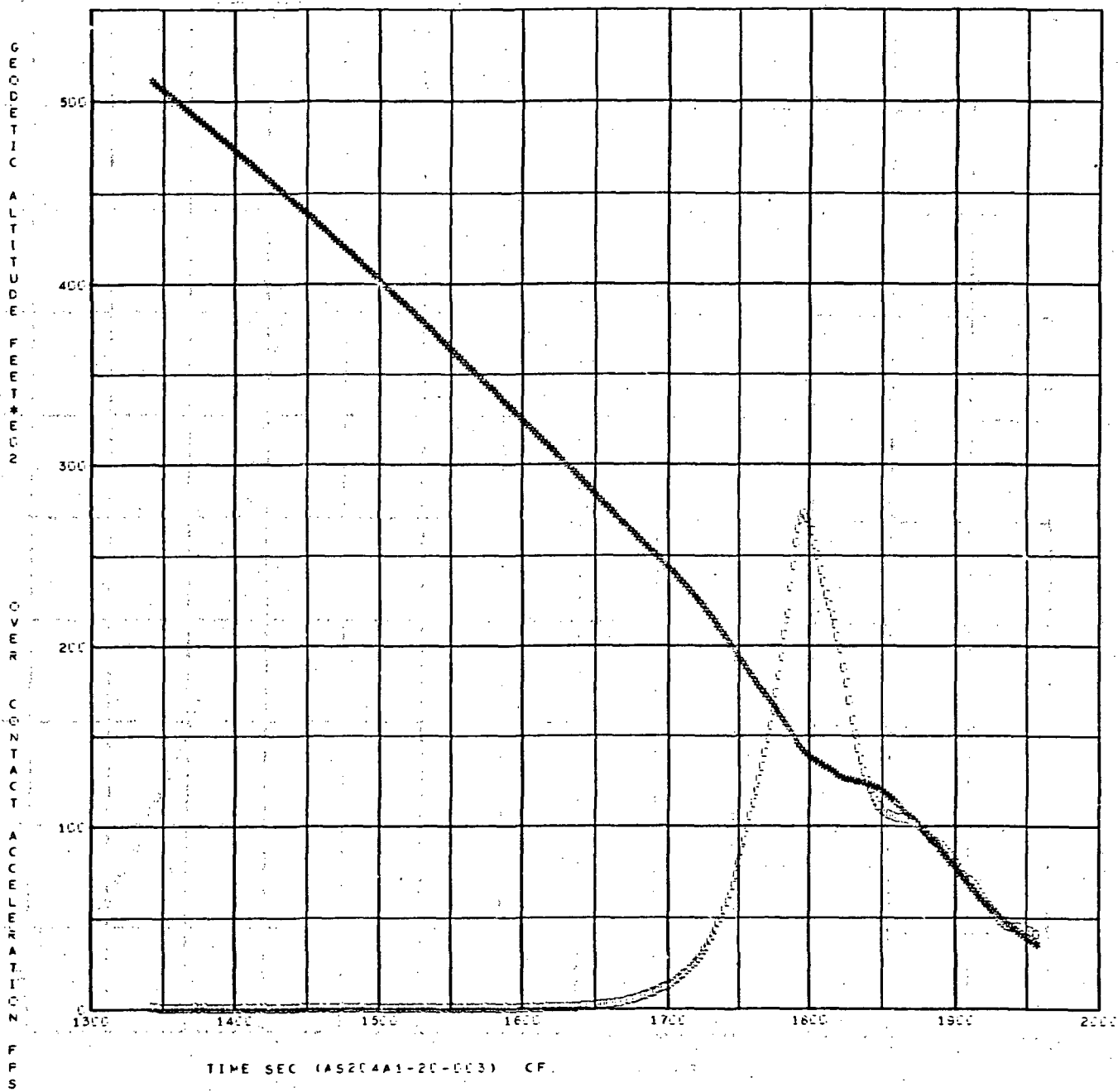
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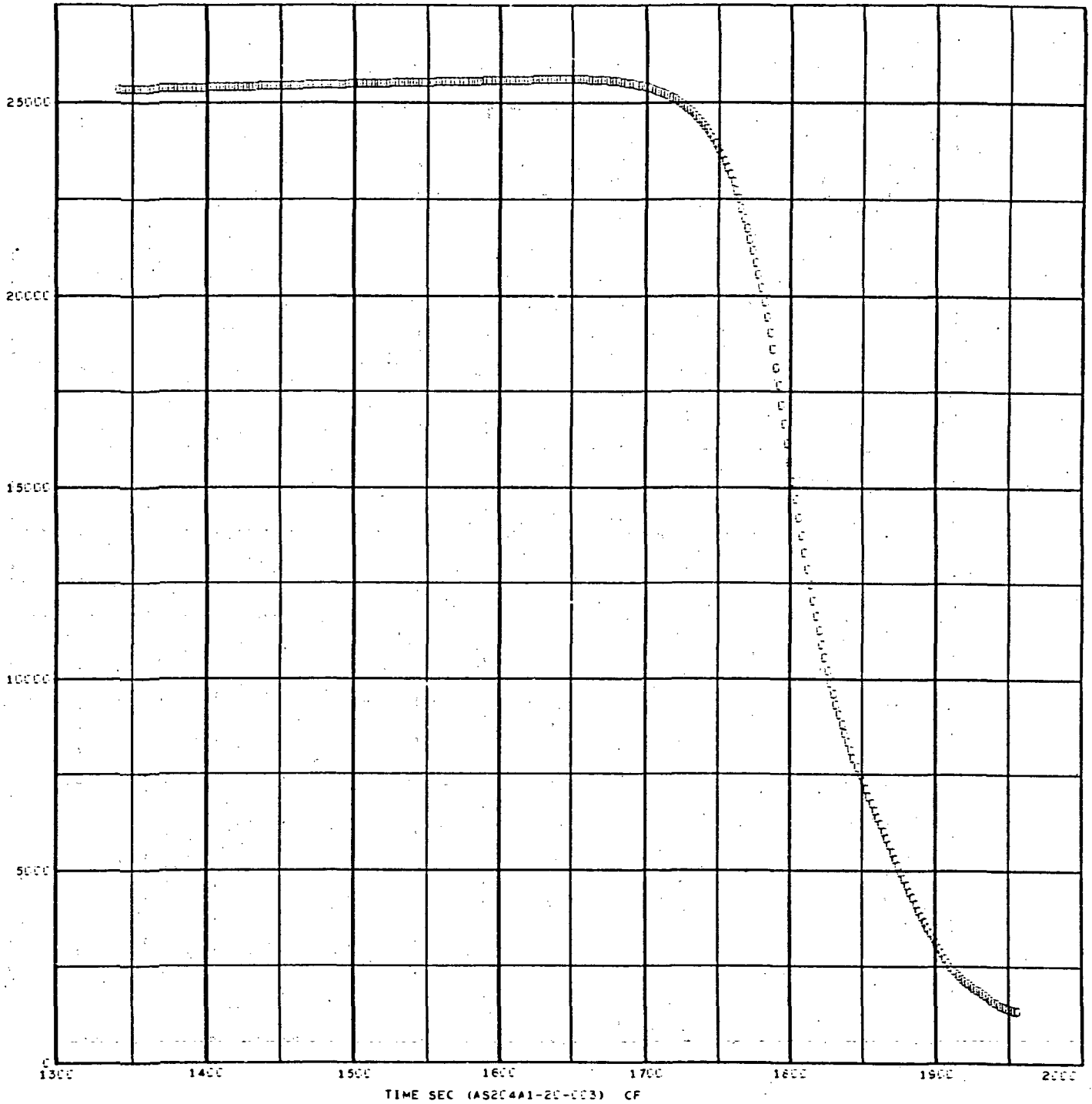
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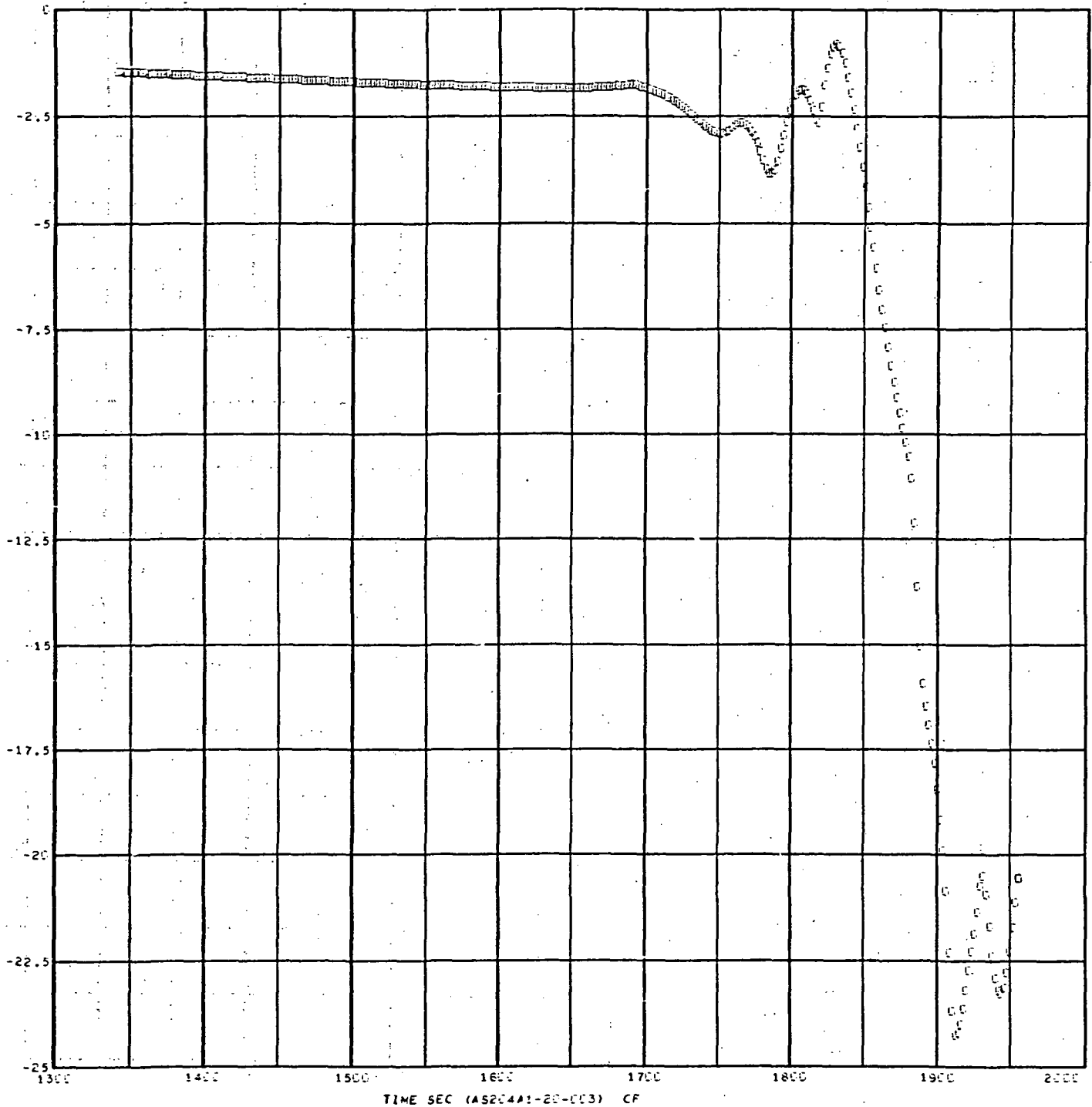




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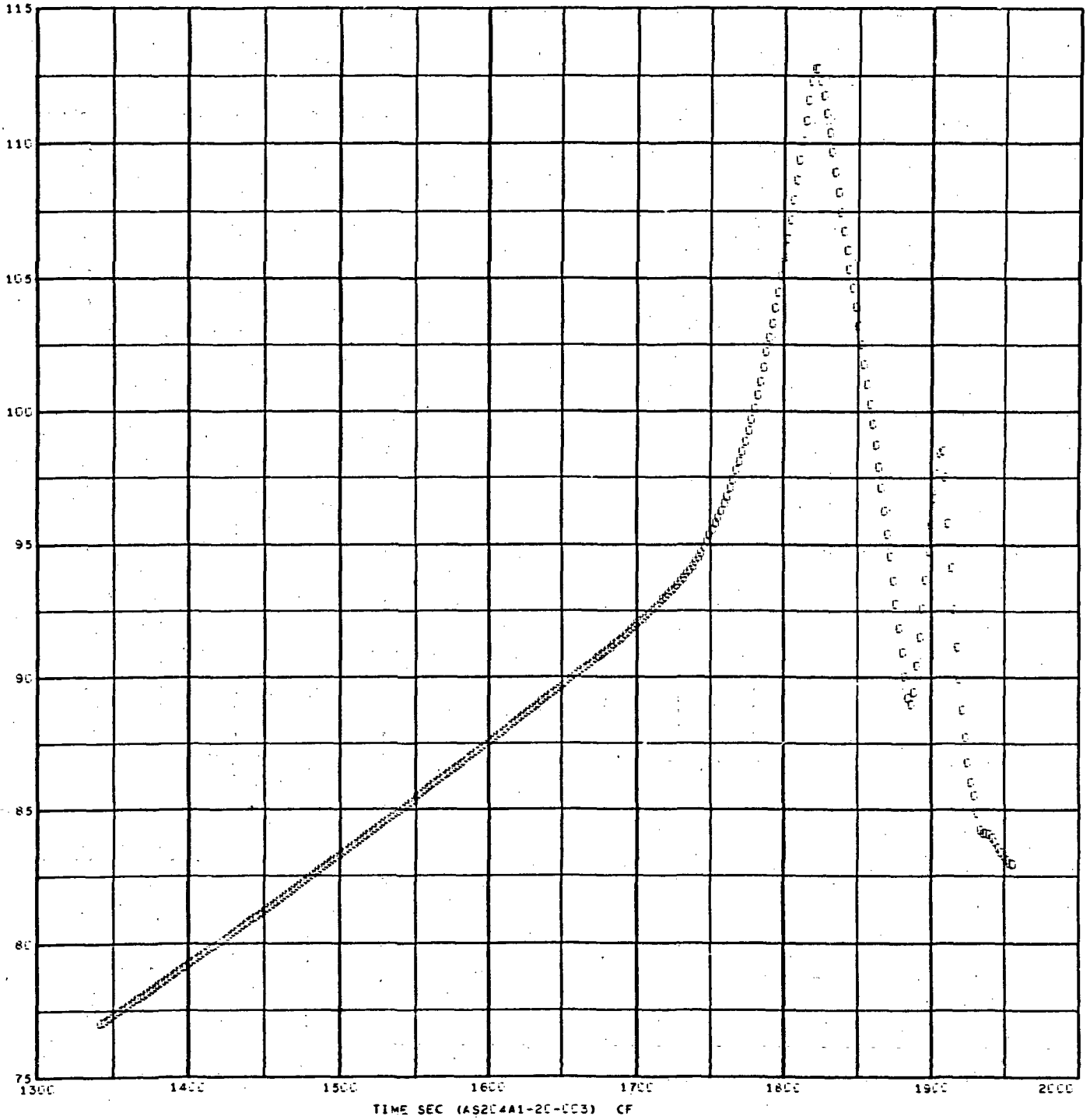
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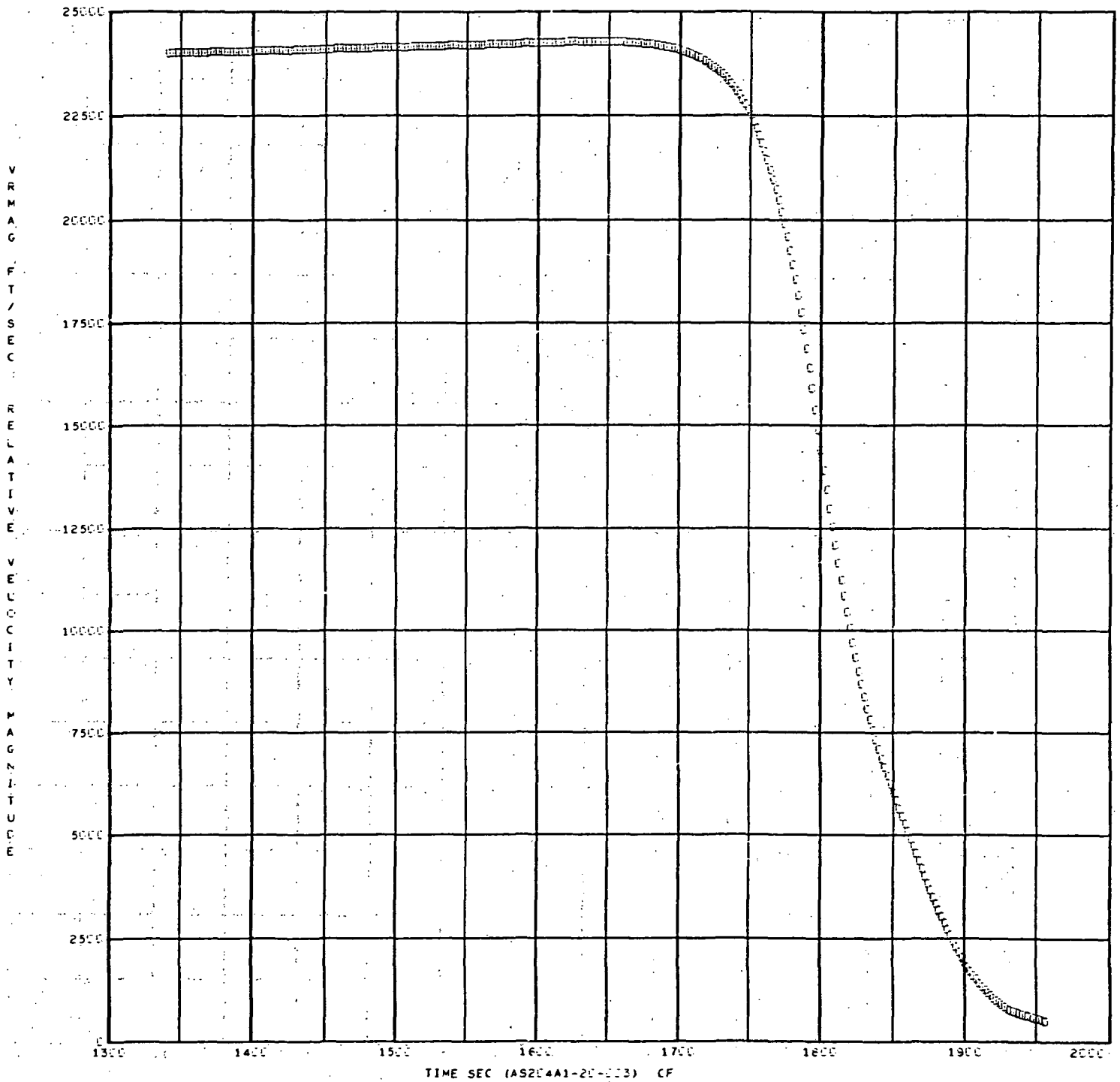


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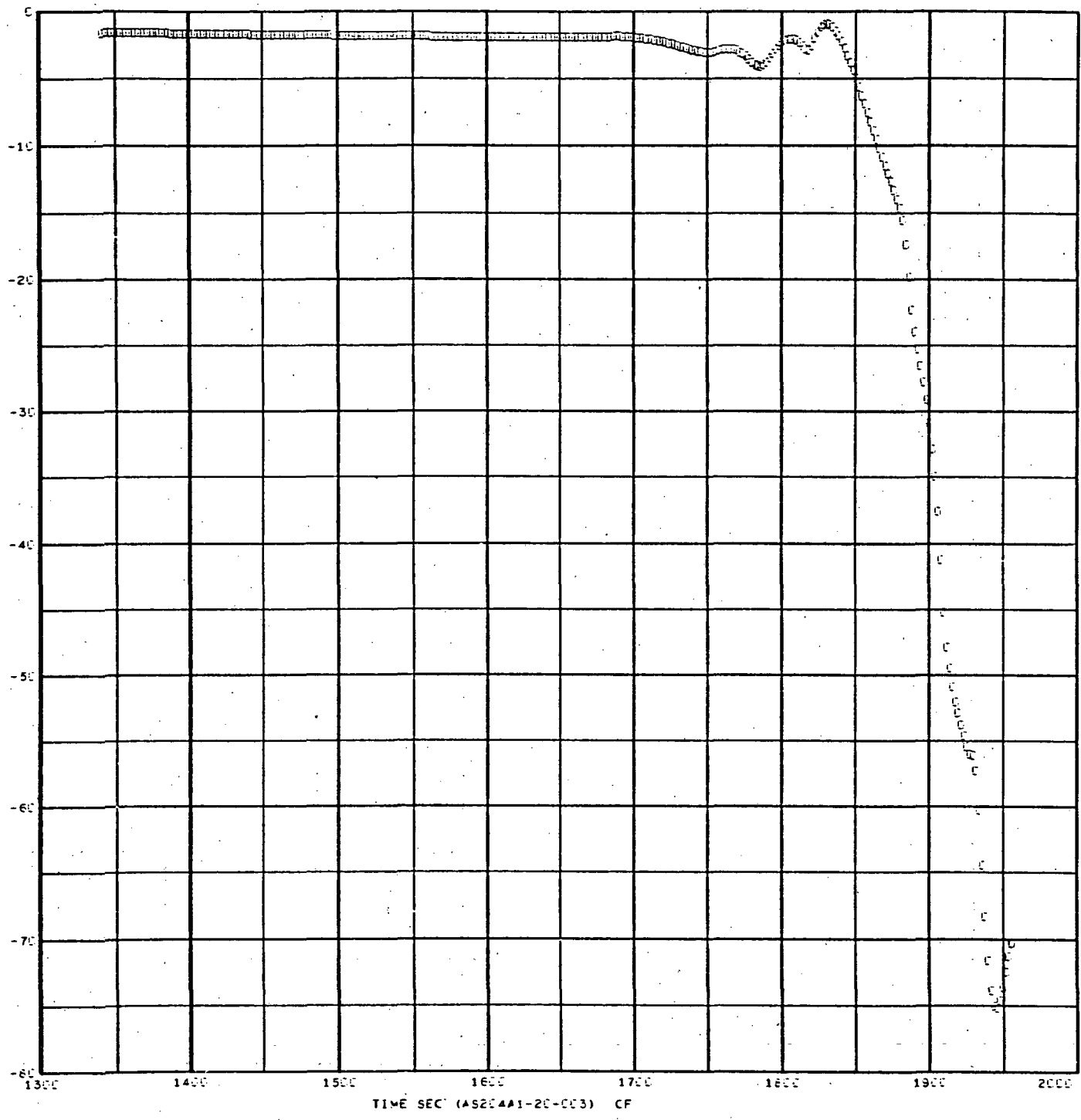
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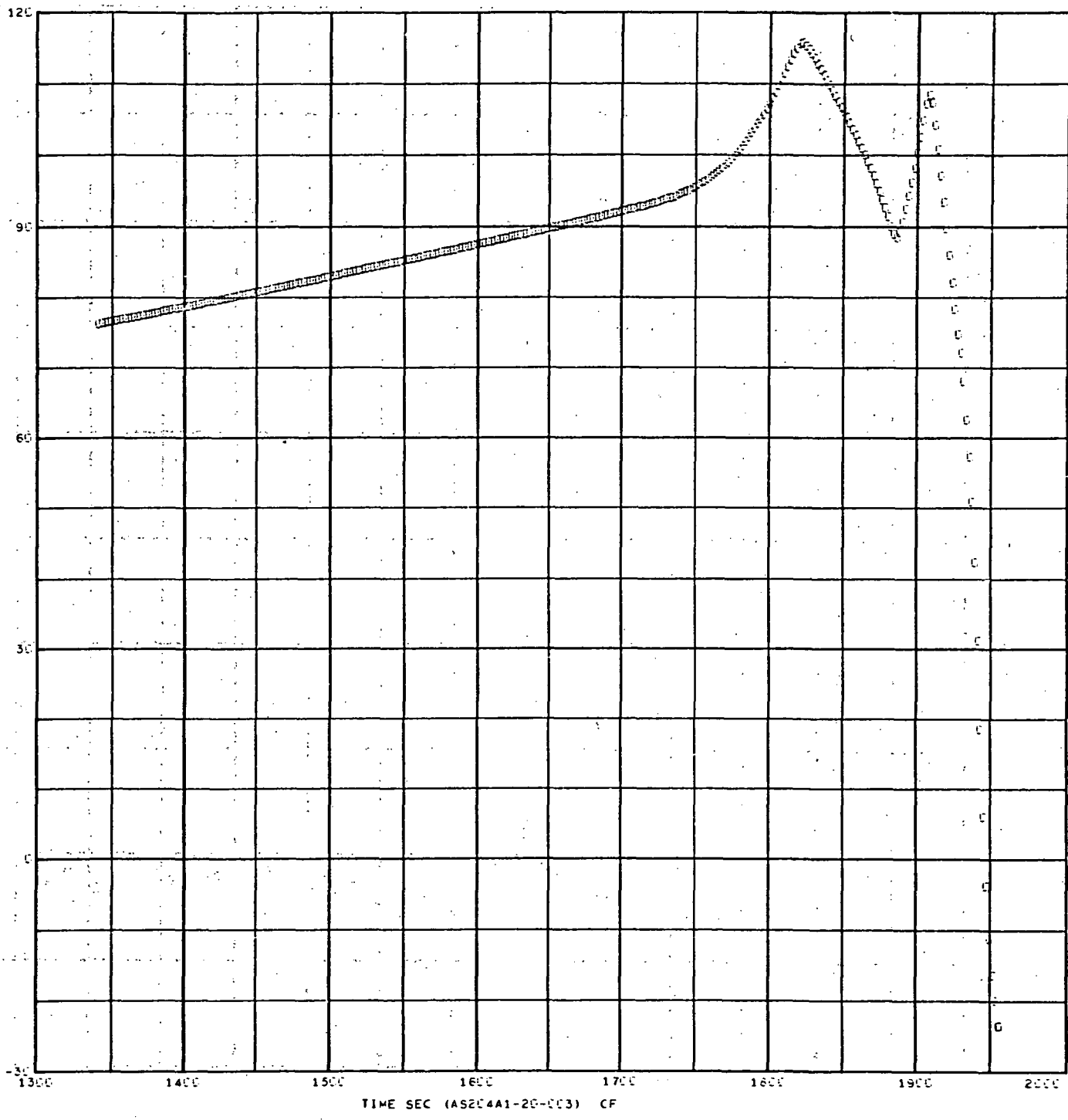
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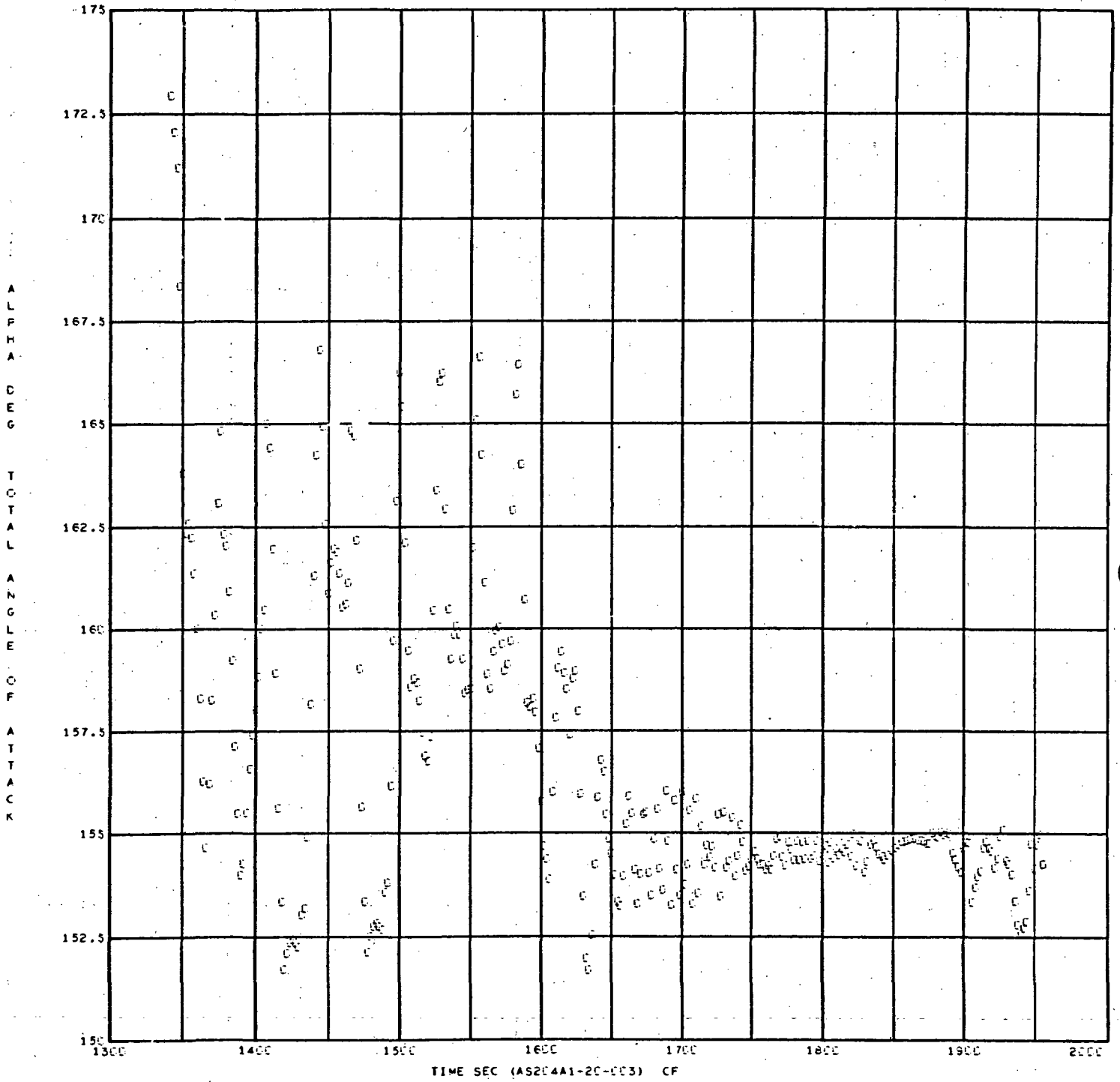
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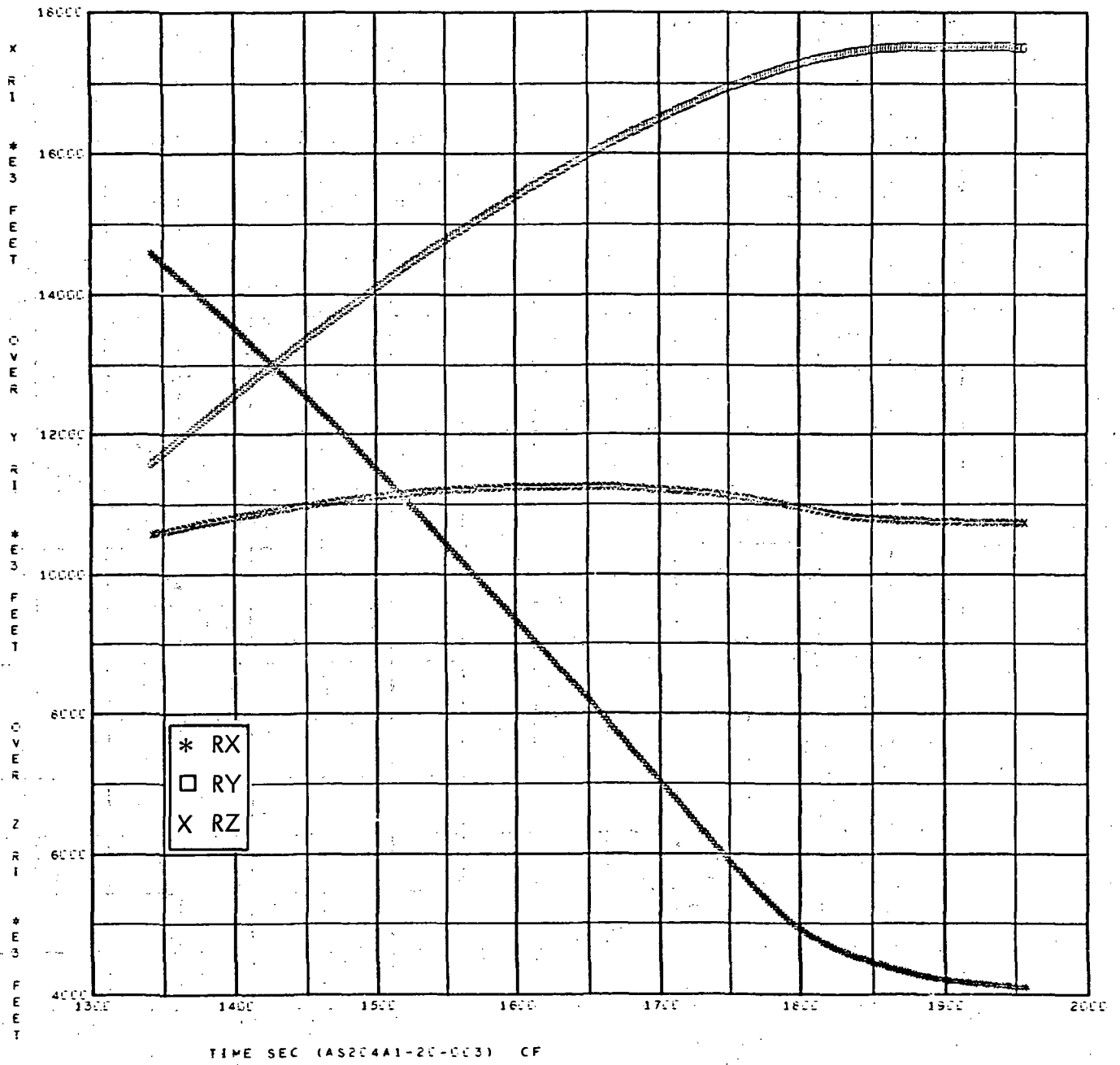
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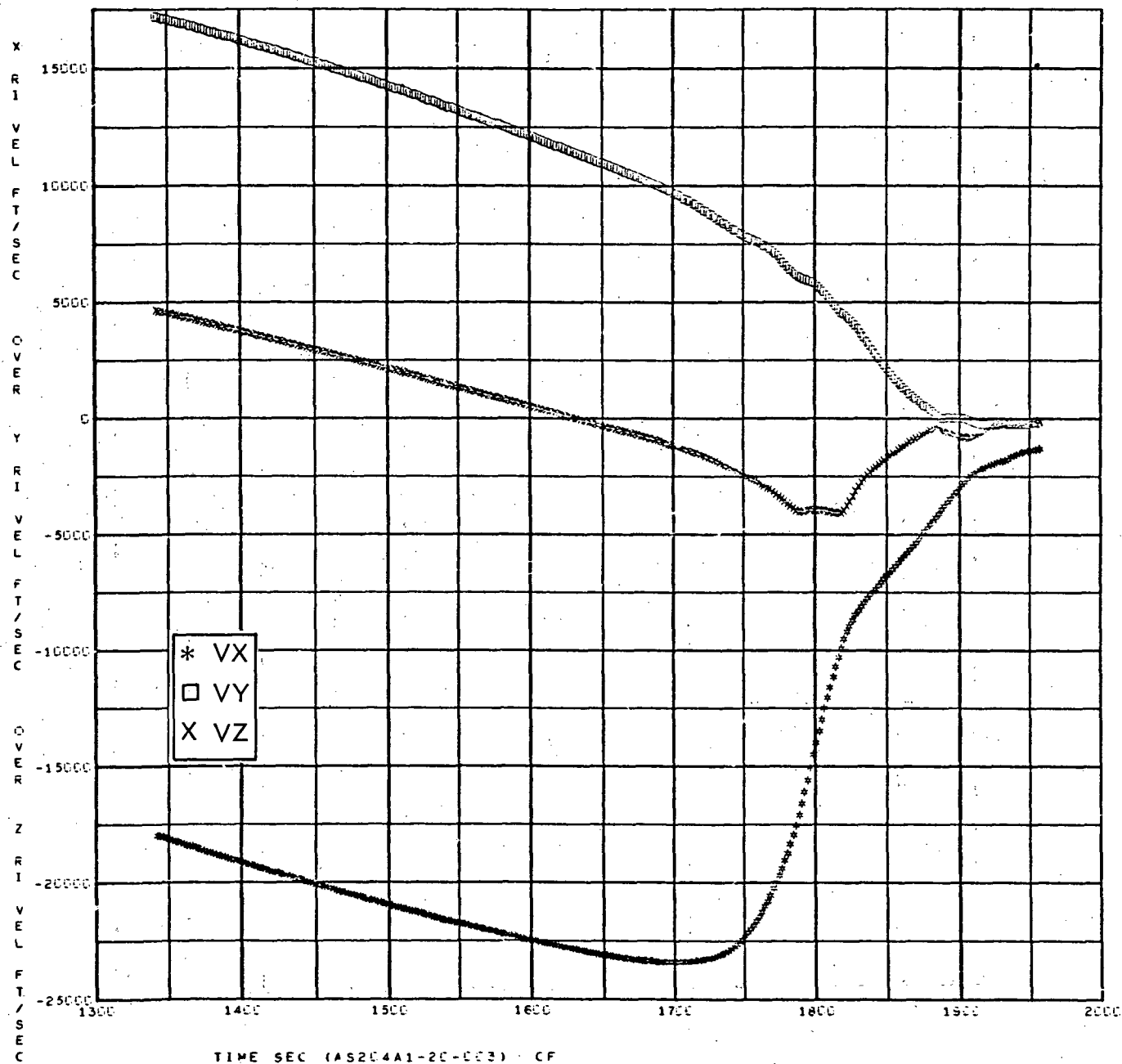


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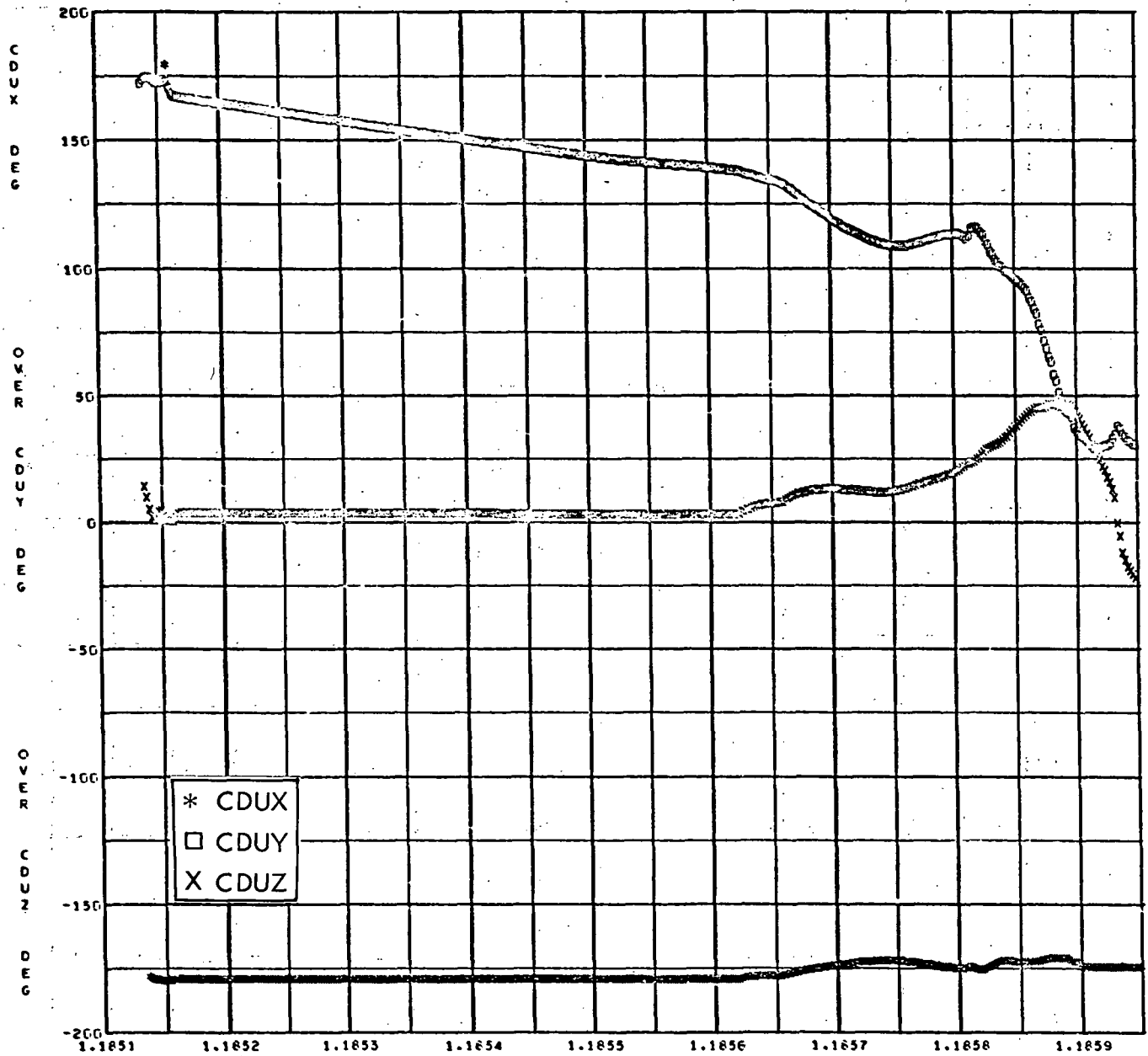
APPENDIX E

PLOTS OF OFF-NOMINAL UNDERSHOOT ENTRY CONDITION

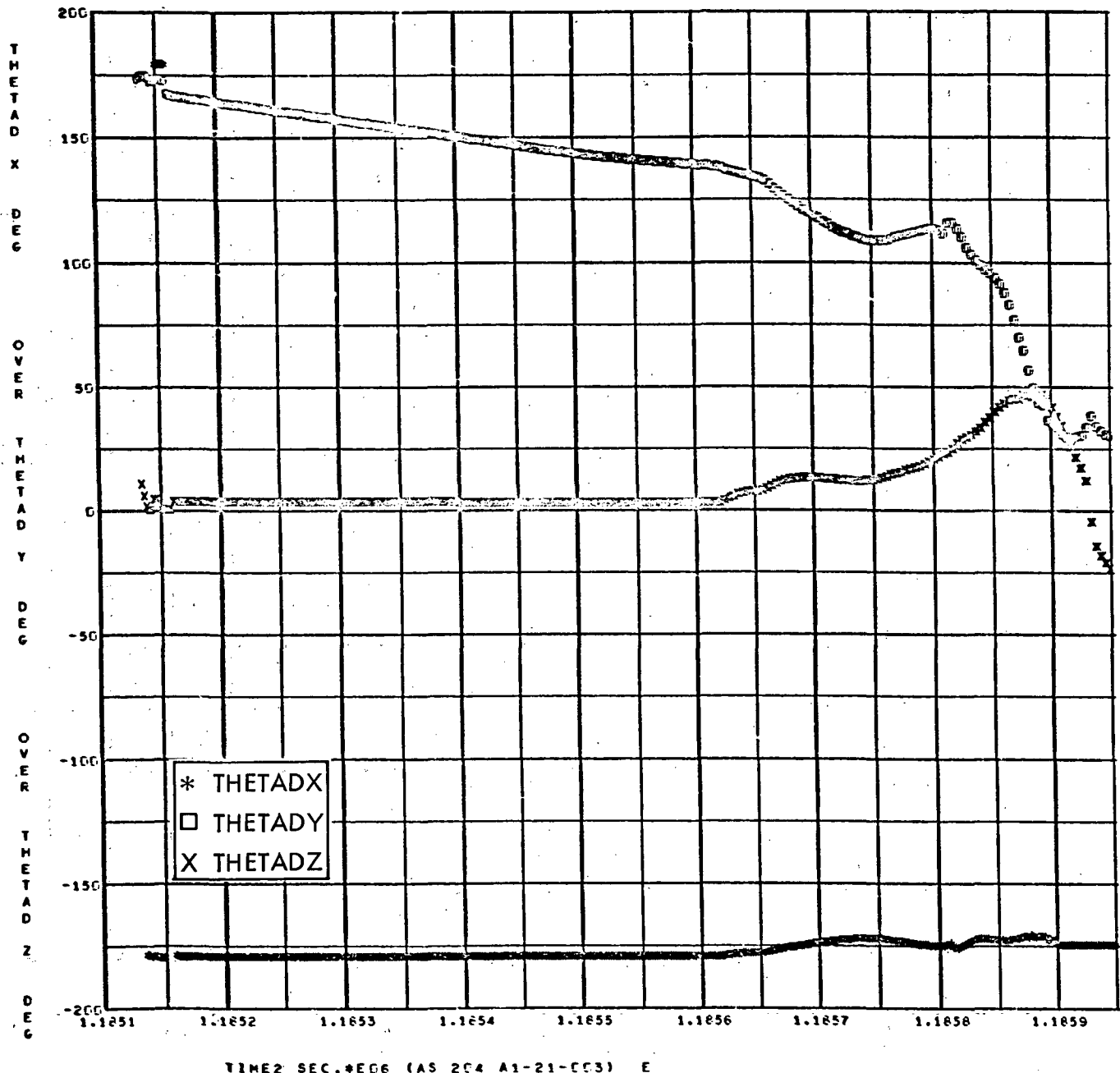
AS-204A1-21-003

AGC PLOTS

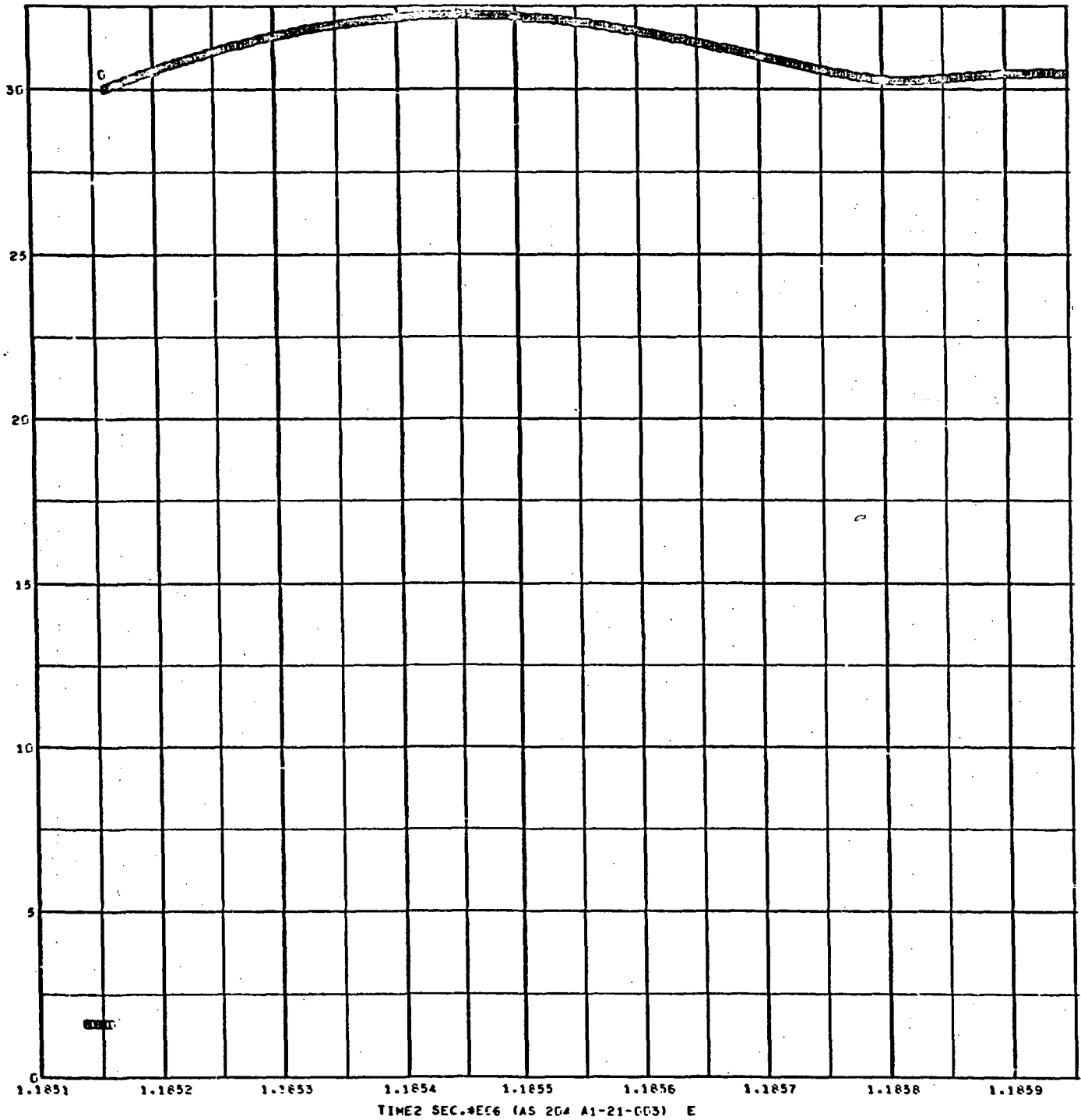
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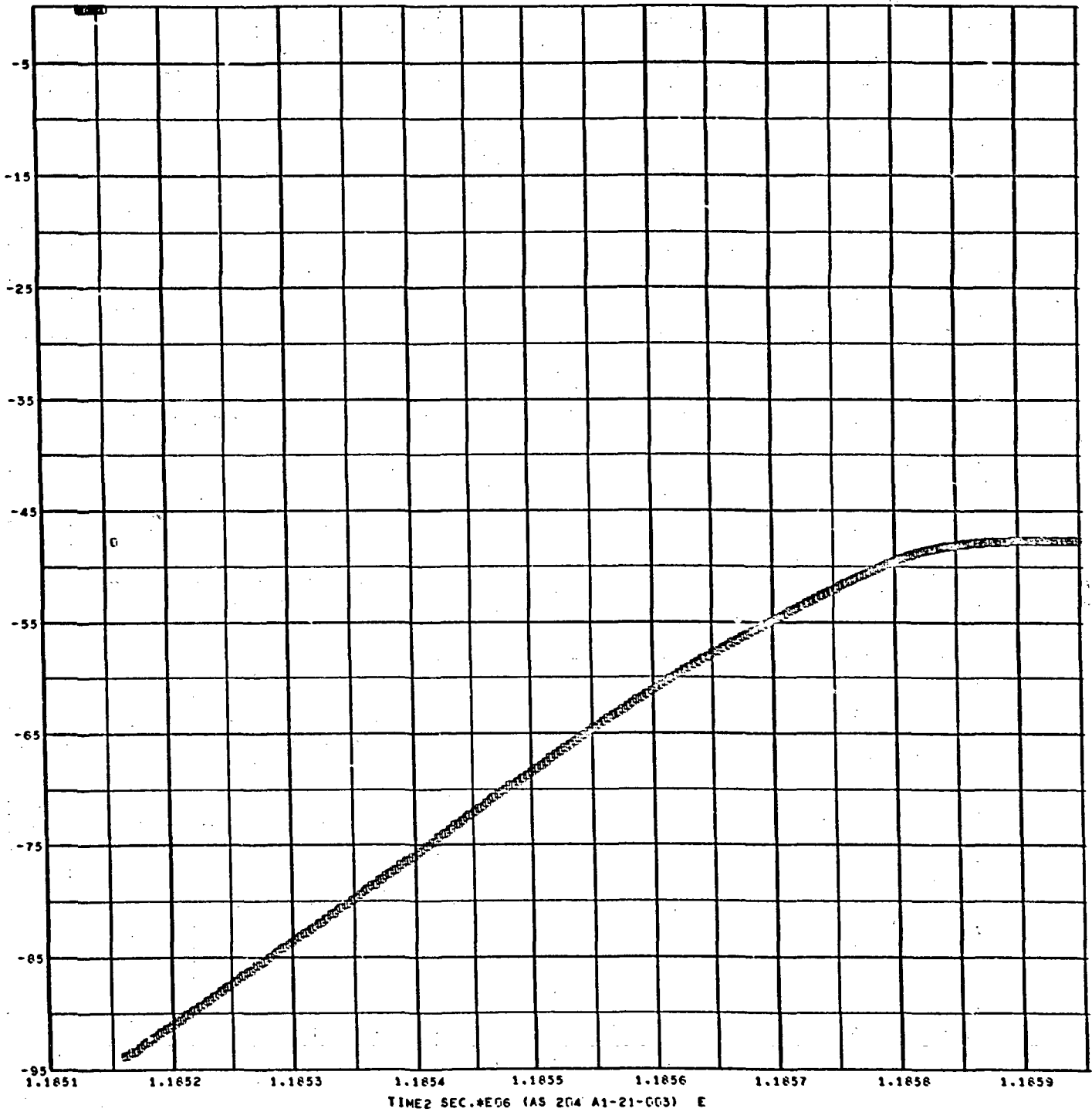
TIME2 SEC.*EG6 (AS 204 A1-21-003) E



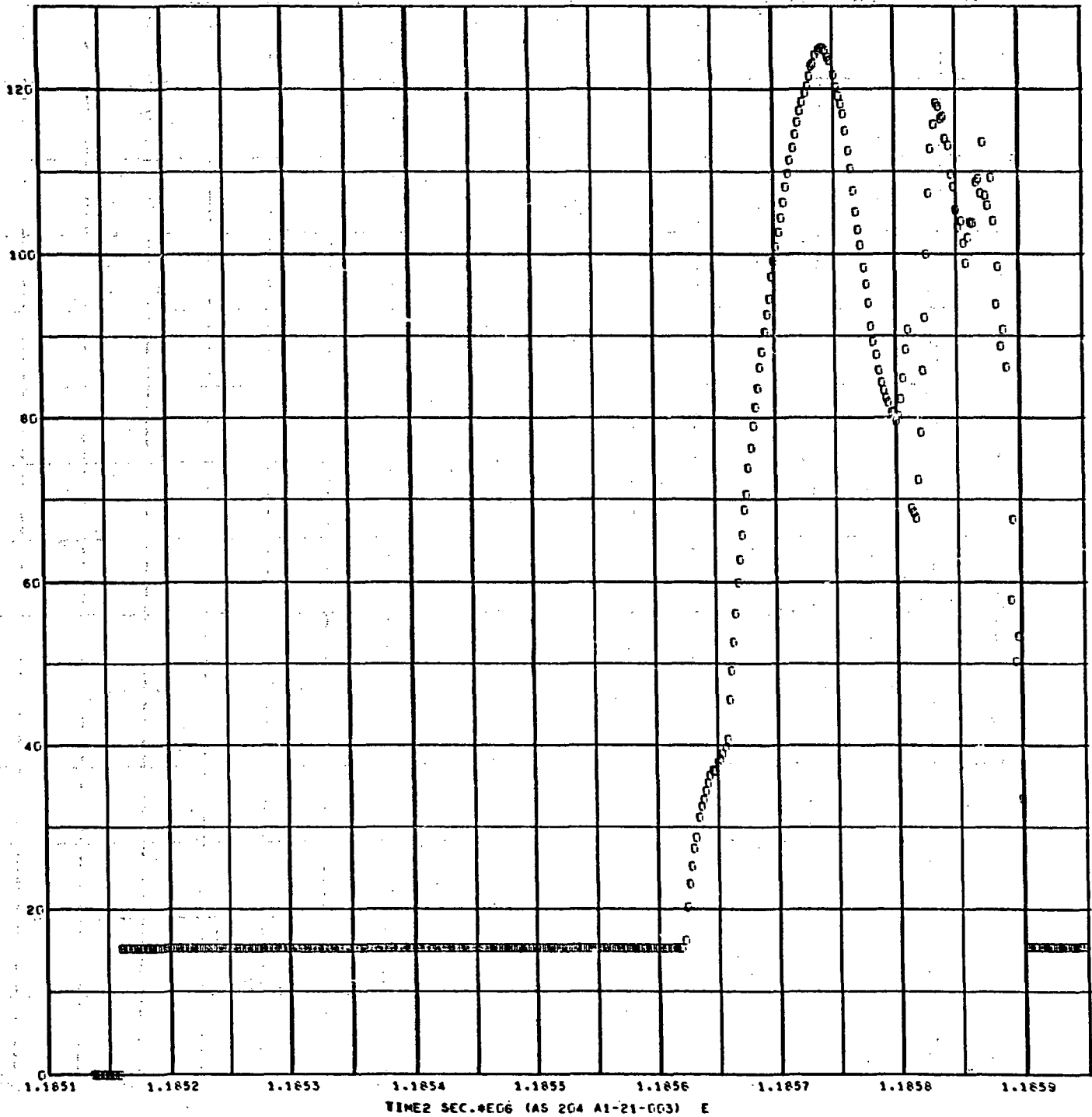
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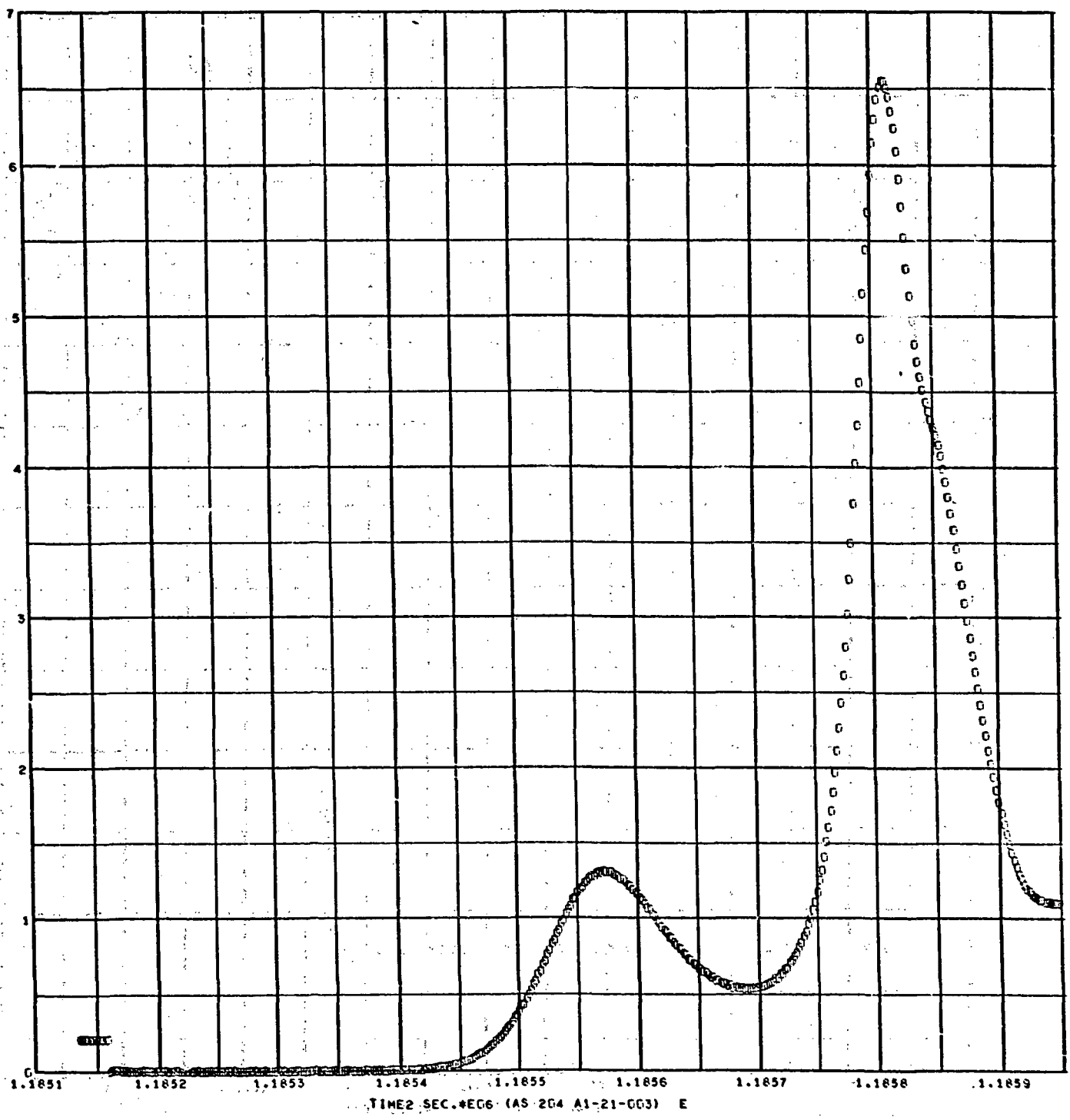
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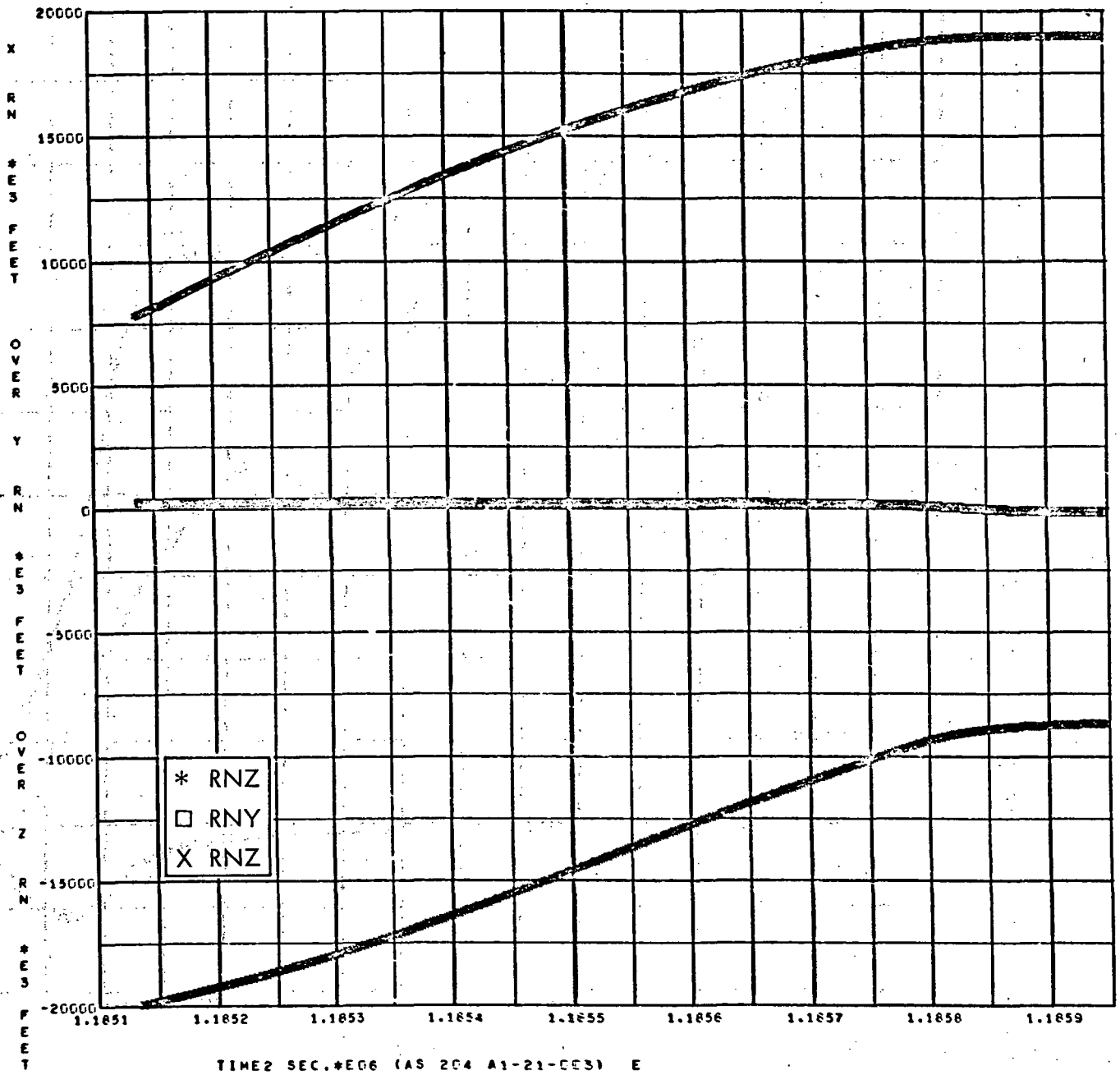


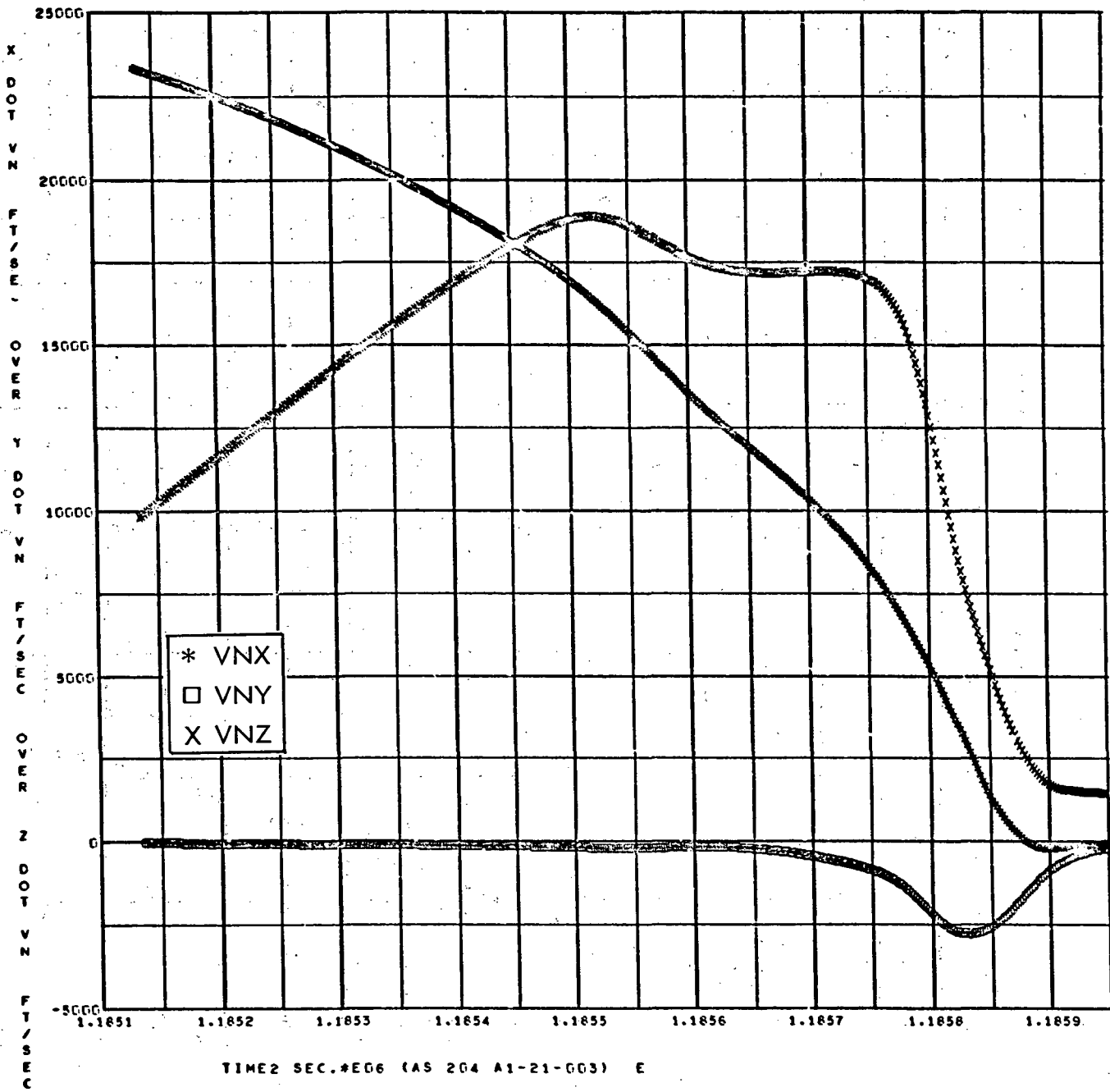
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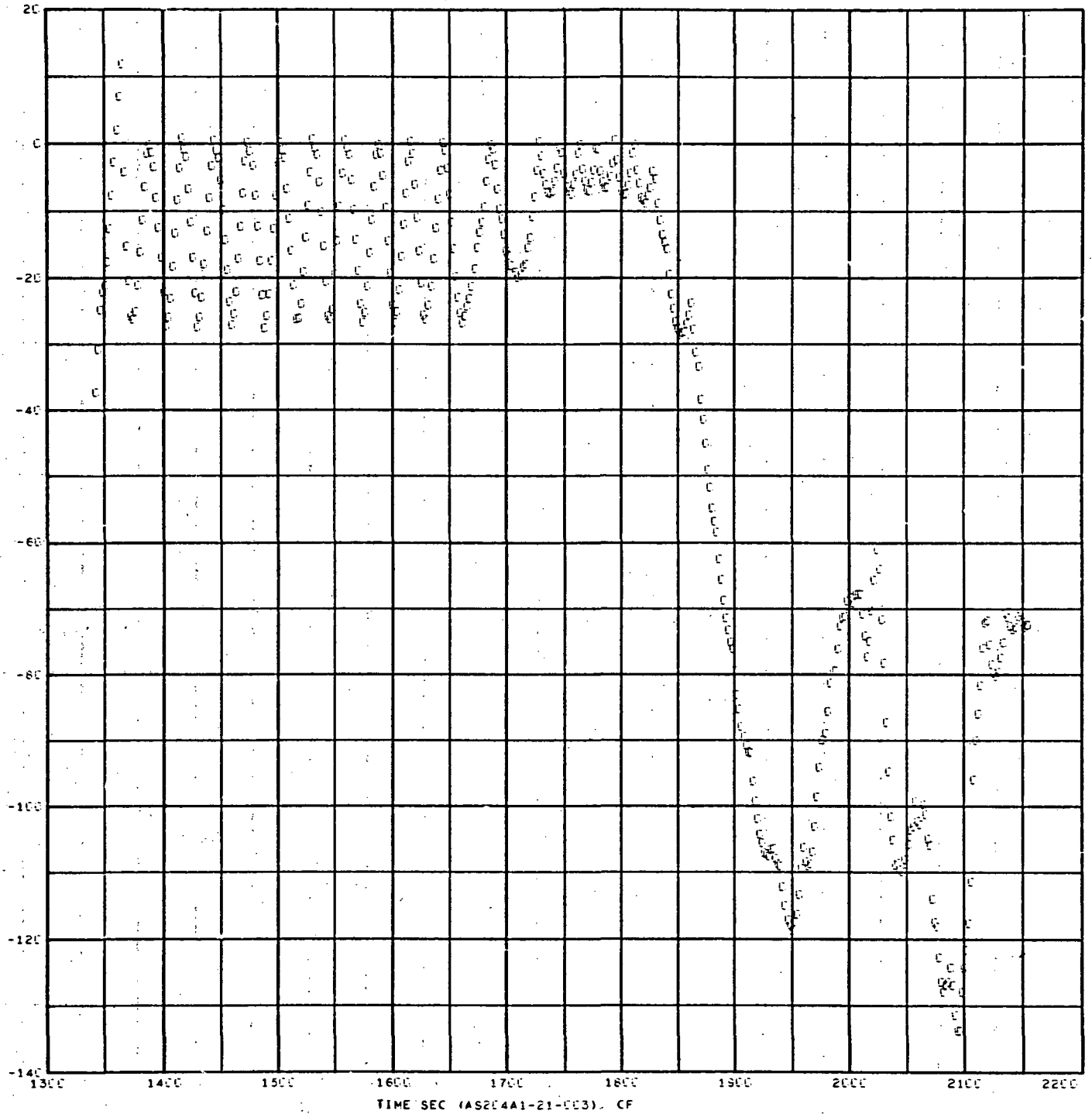




ENVIRONMENT PLOTS

AS-204A1-21-003

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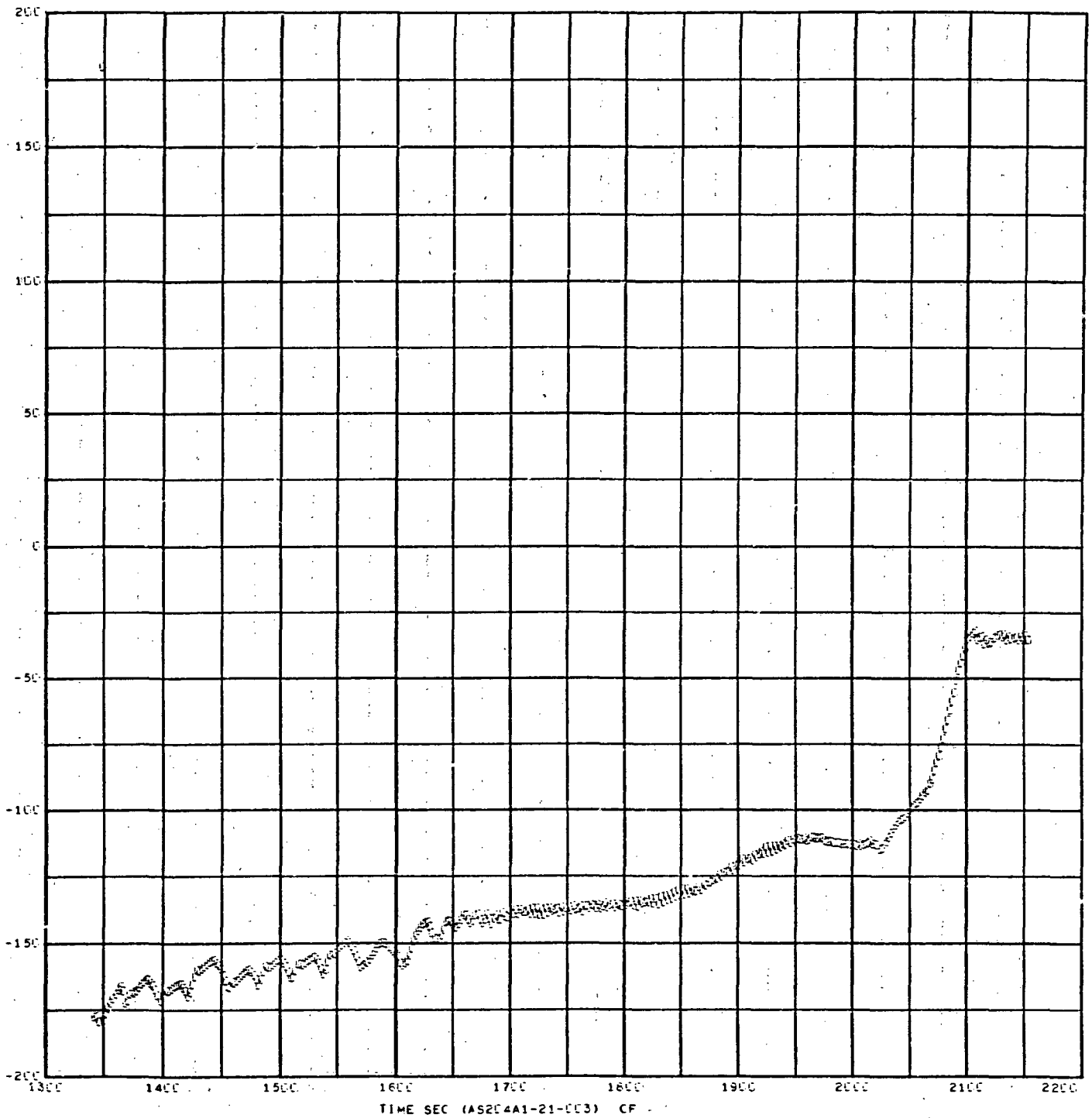
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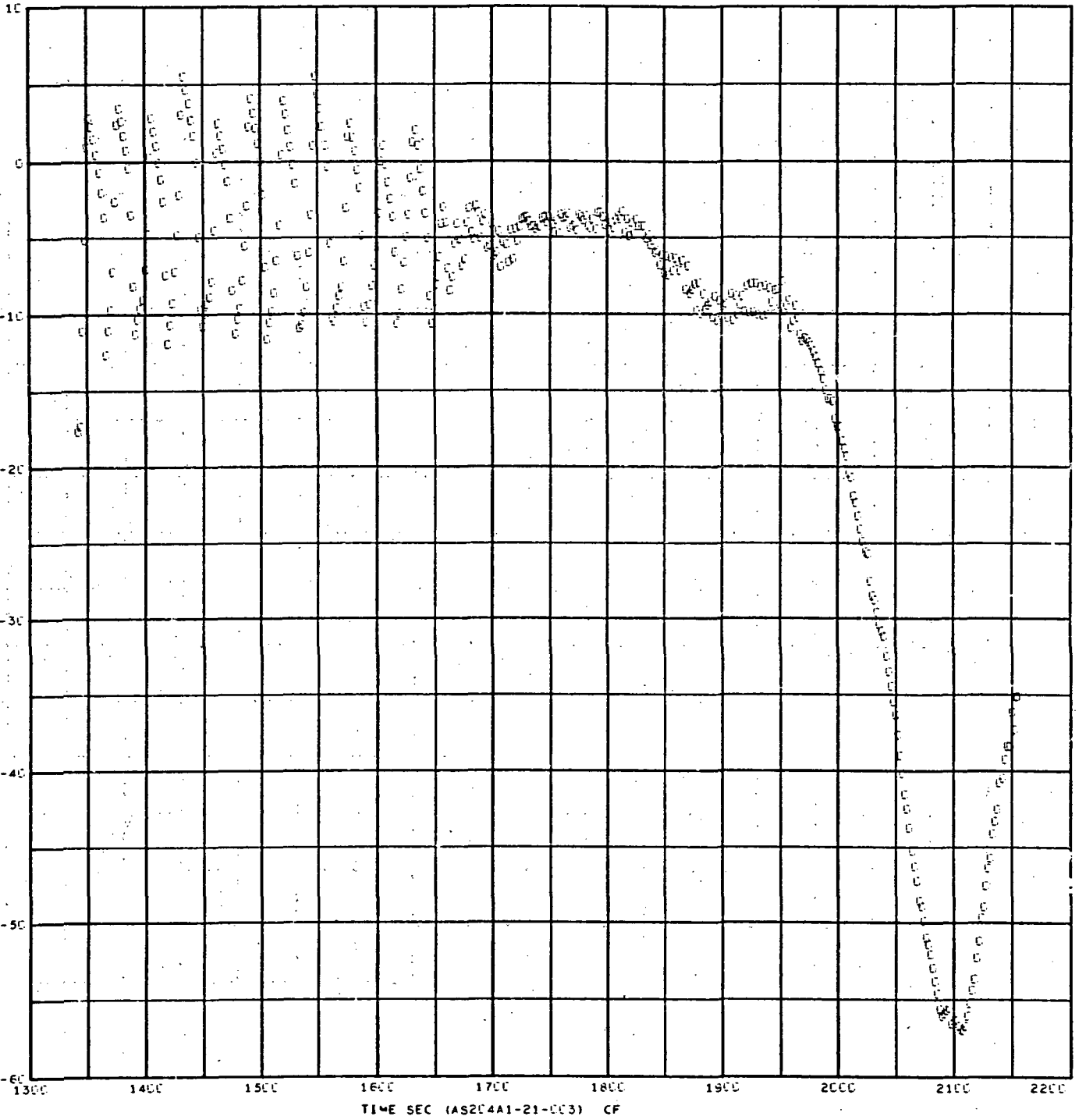
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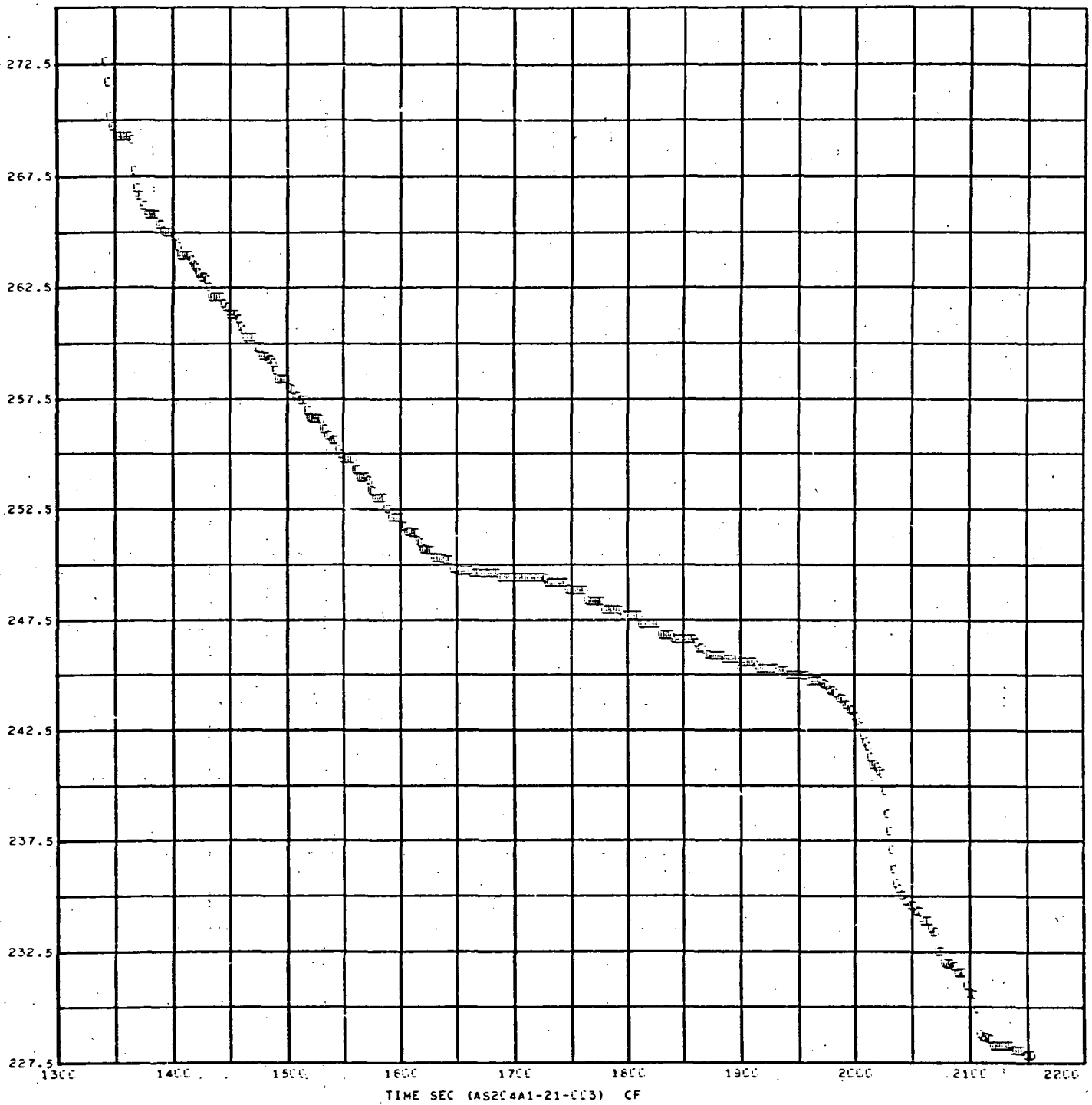
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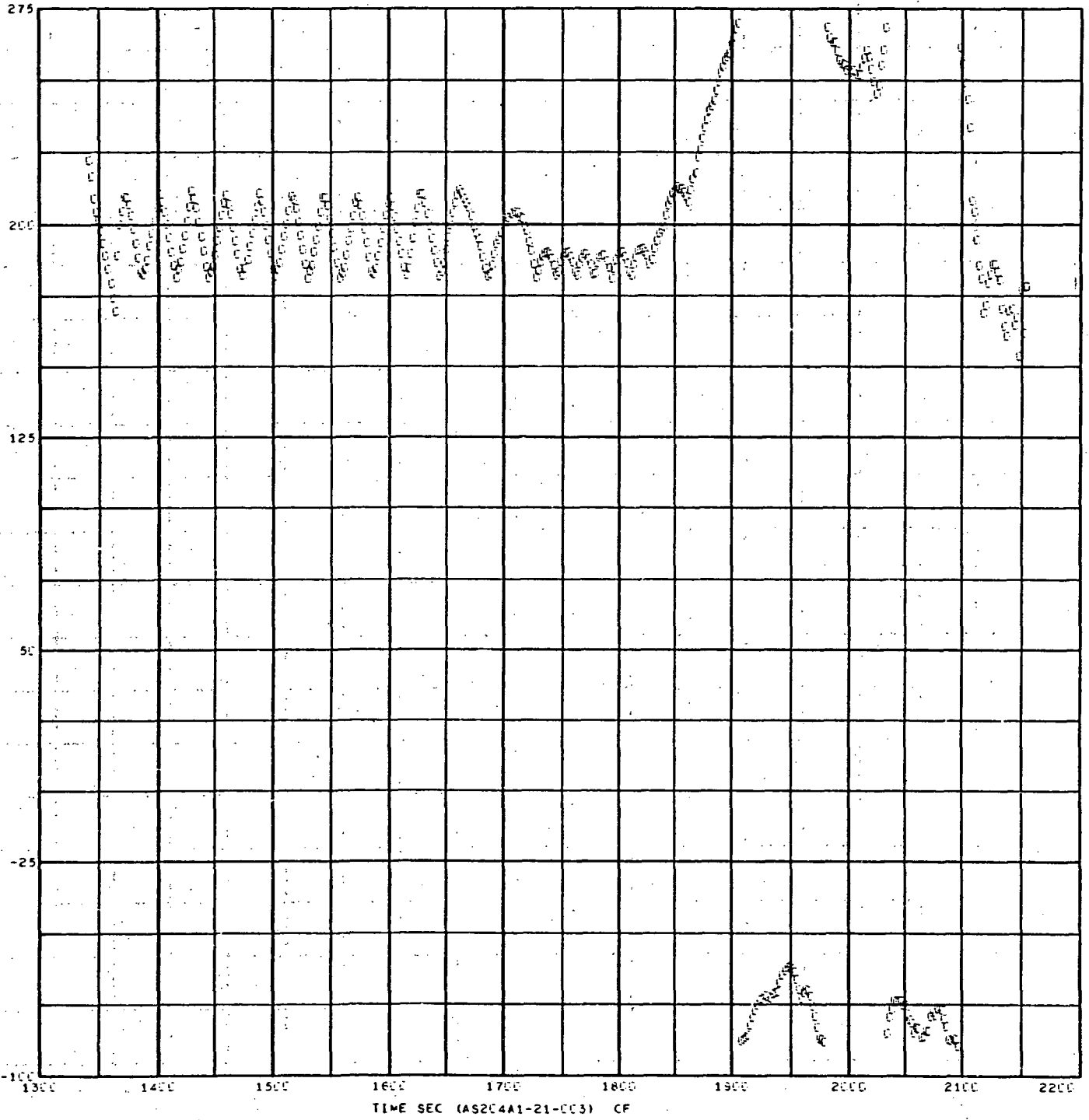
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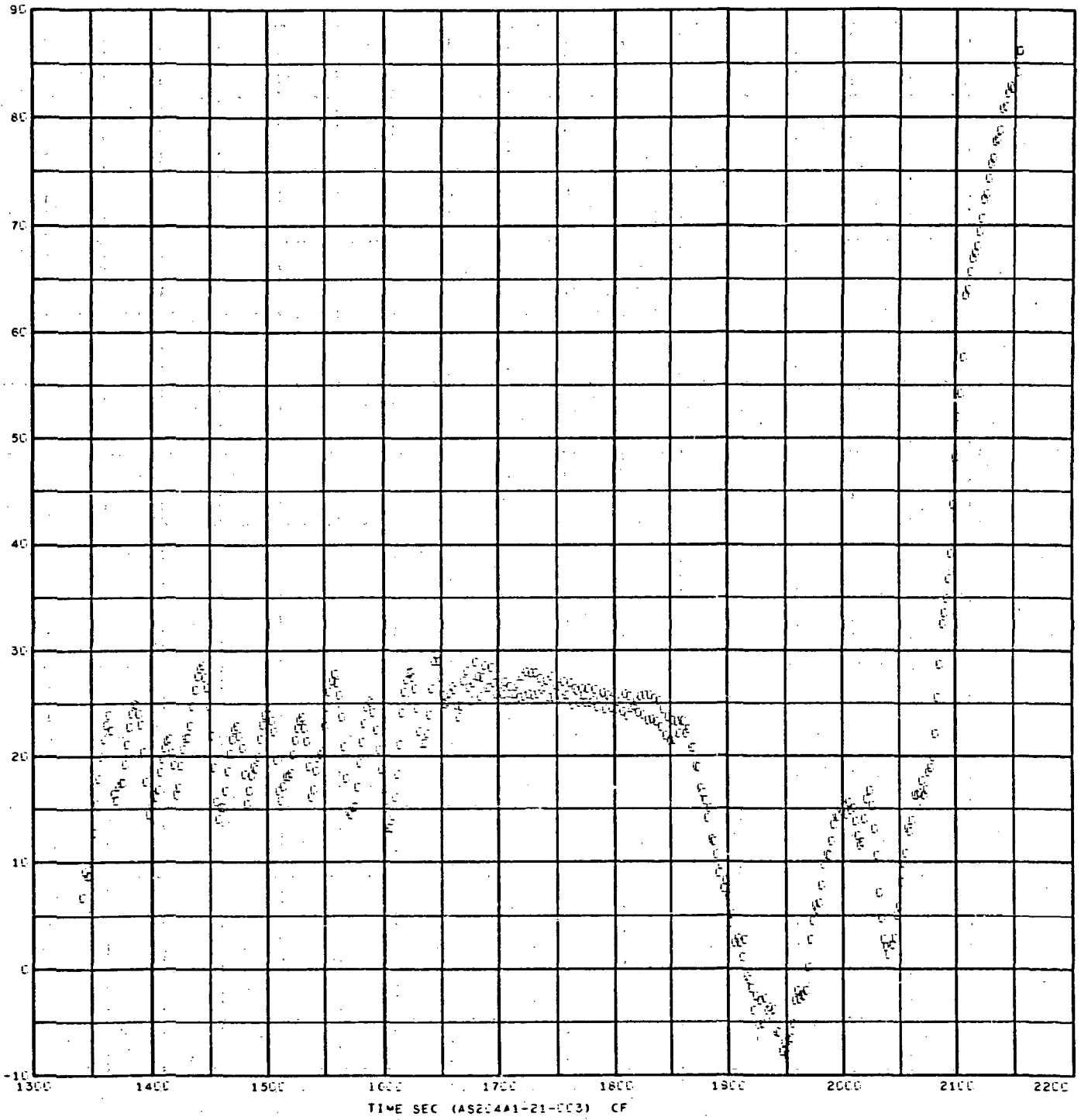
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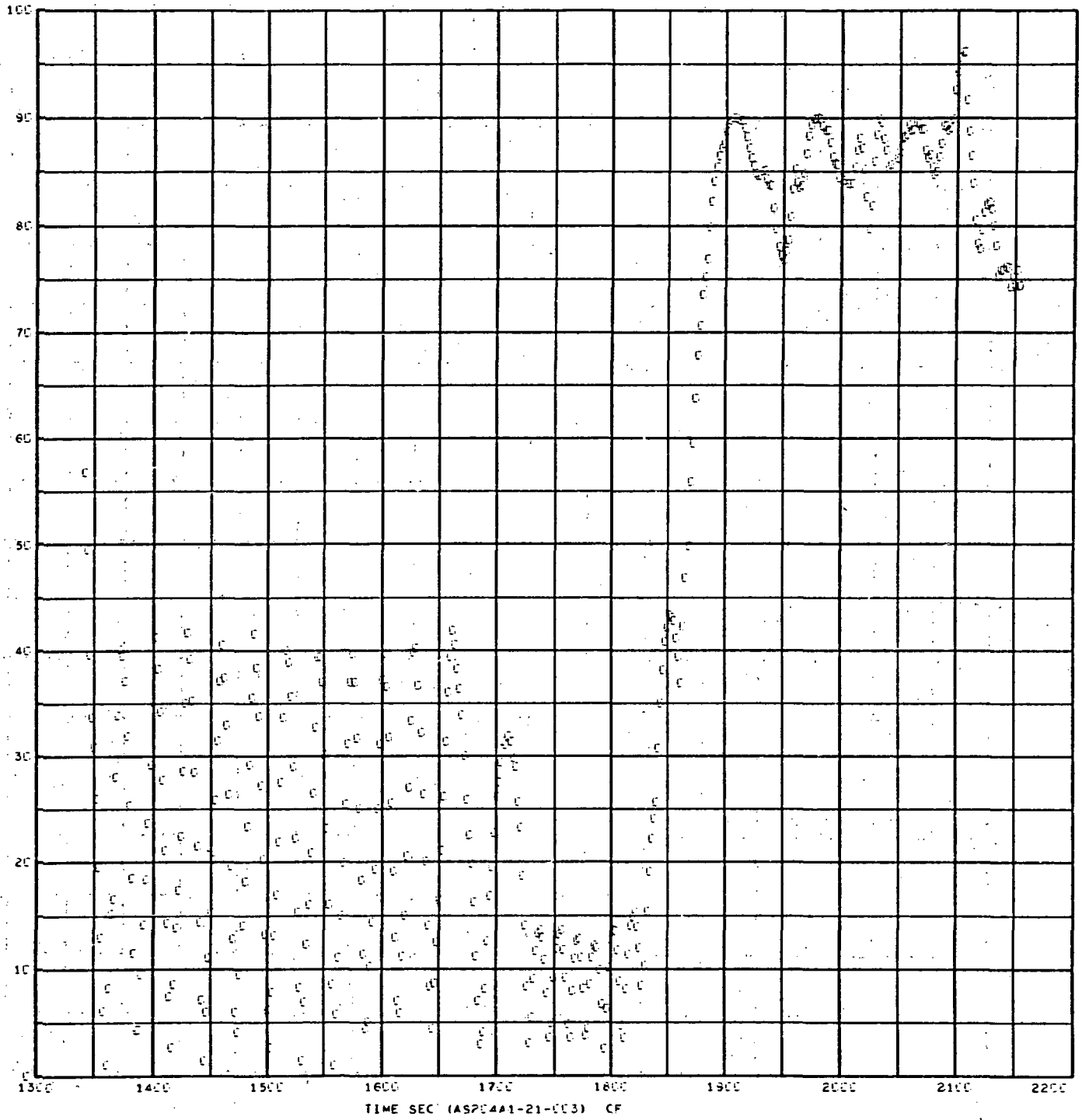
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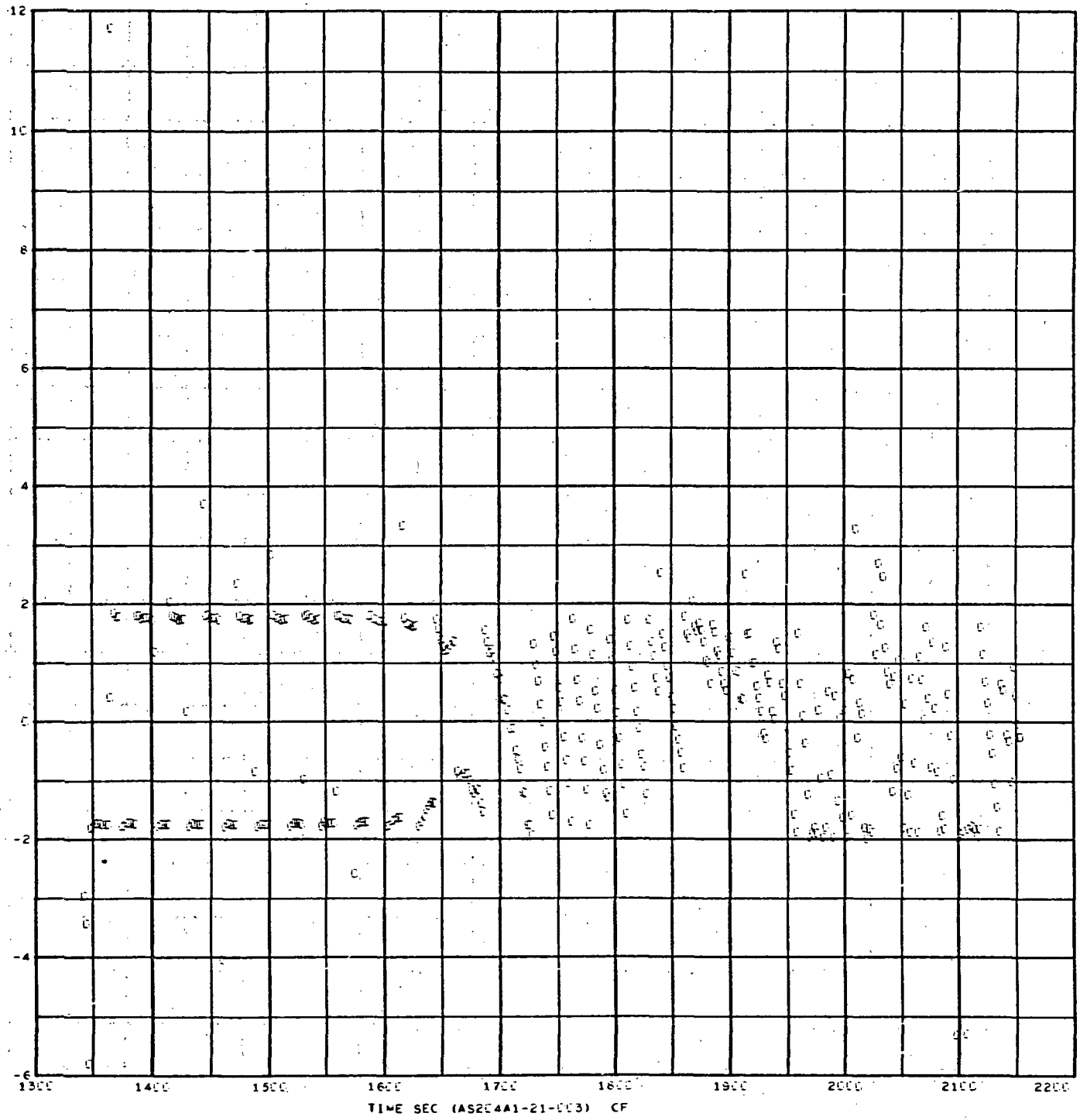
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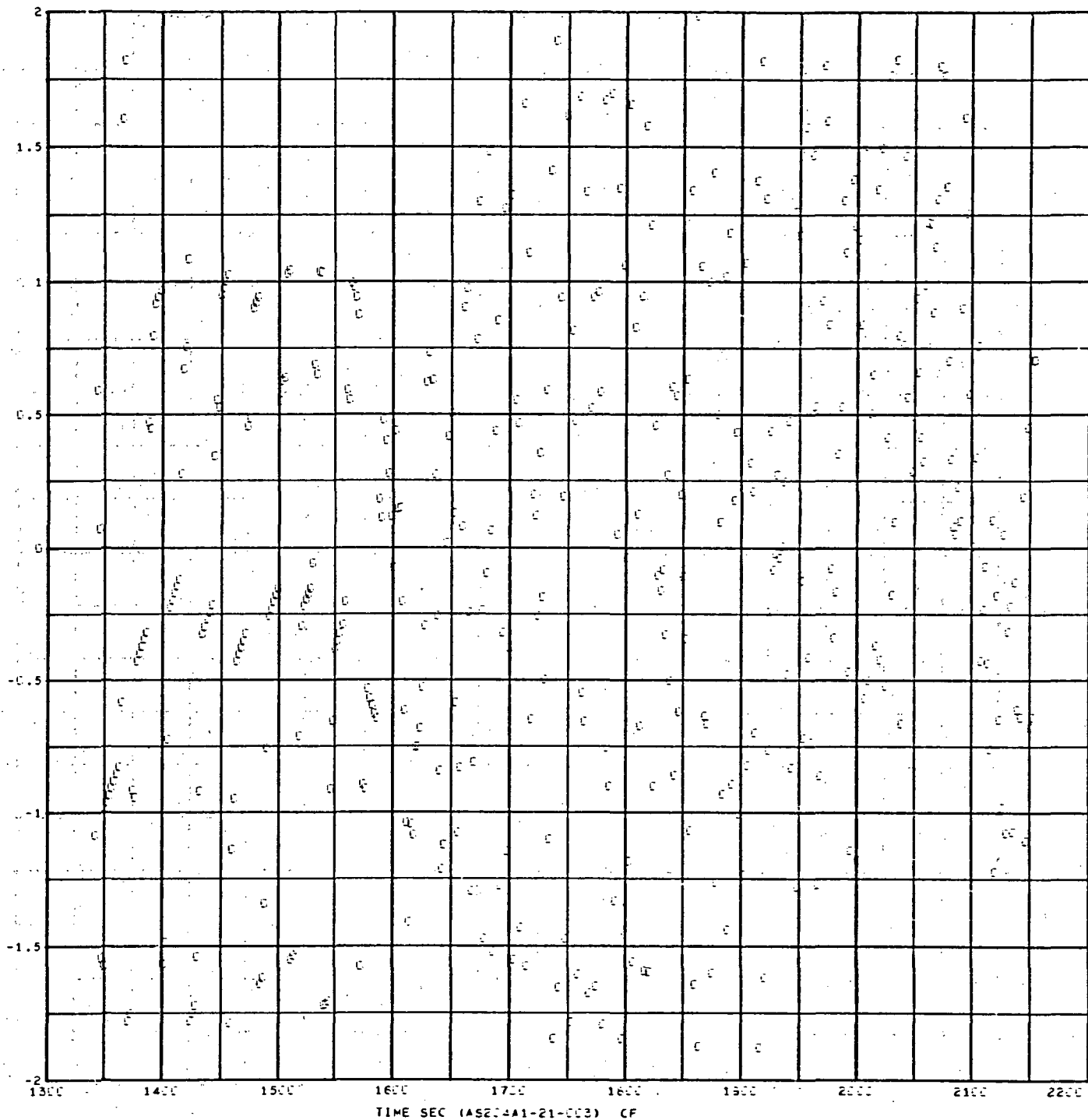
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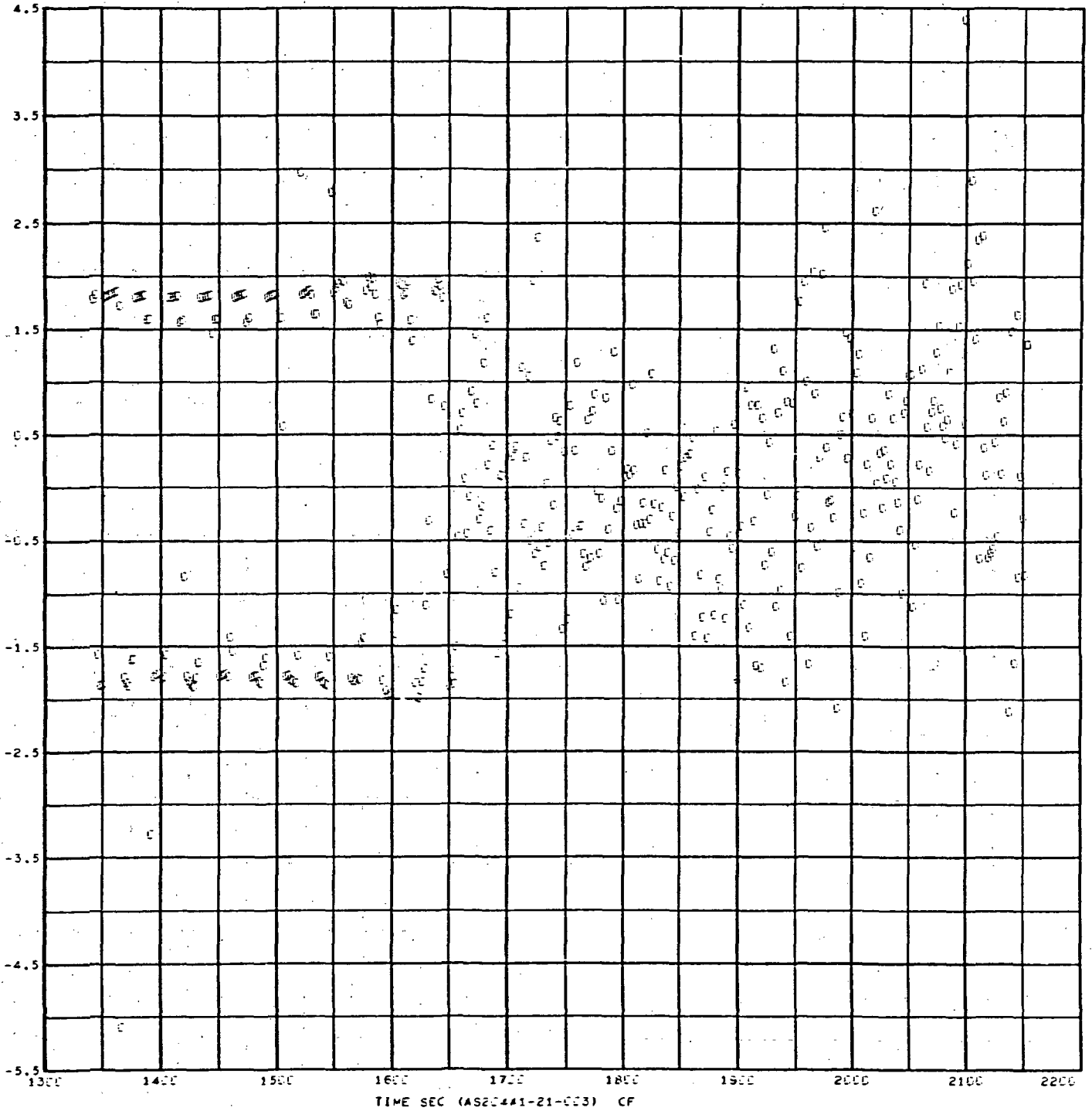
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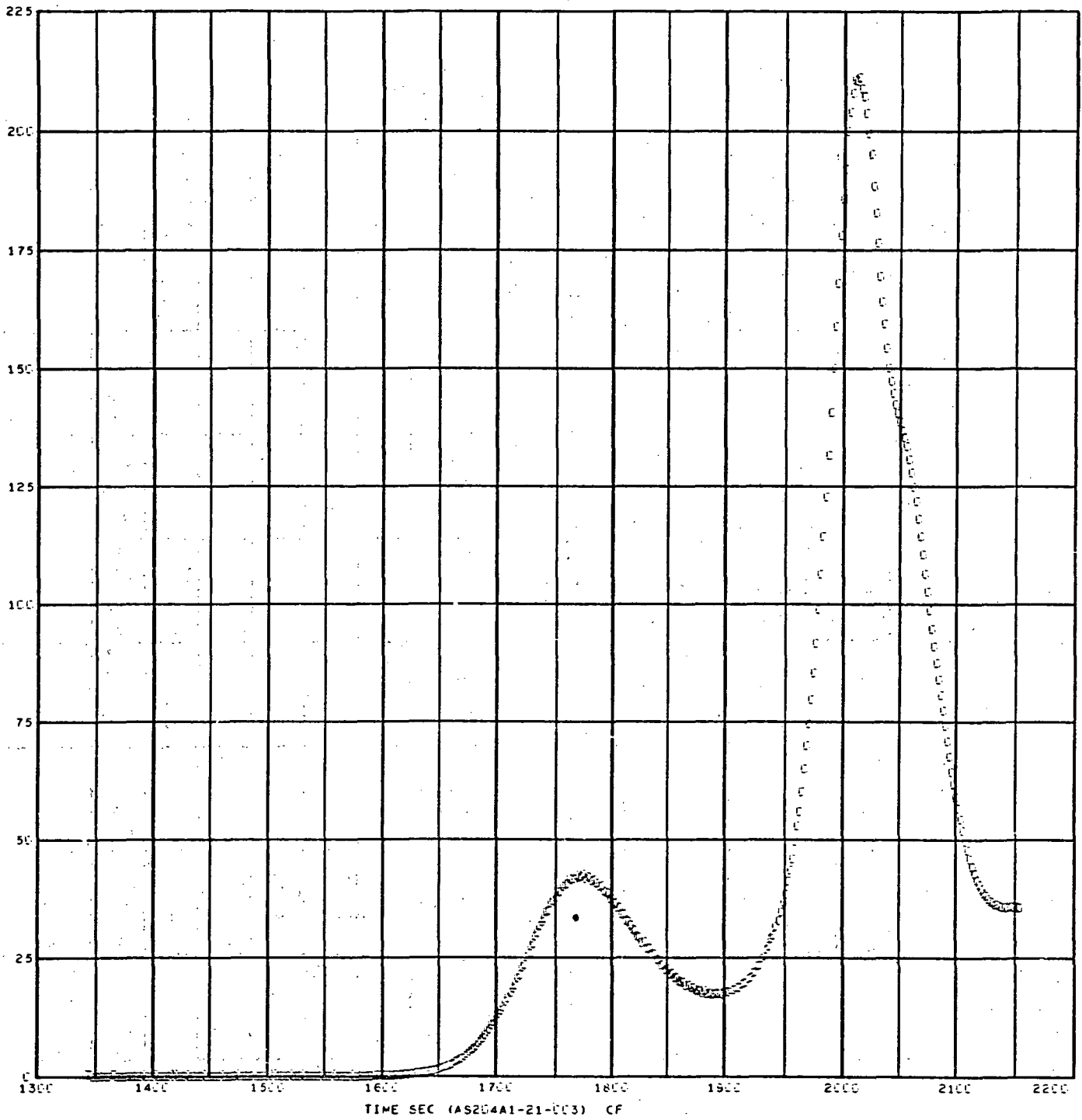
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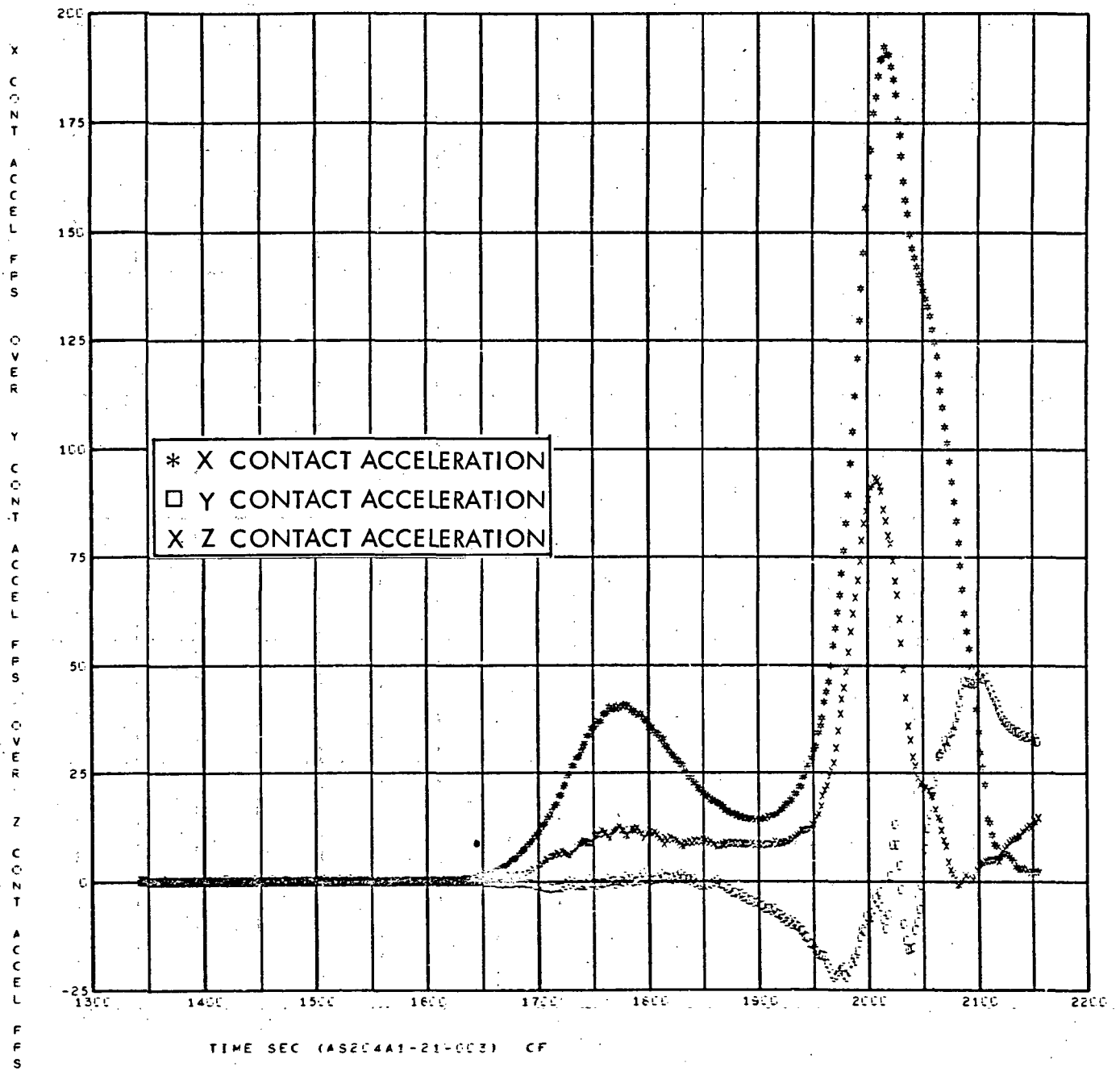


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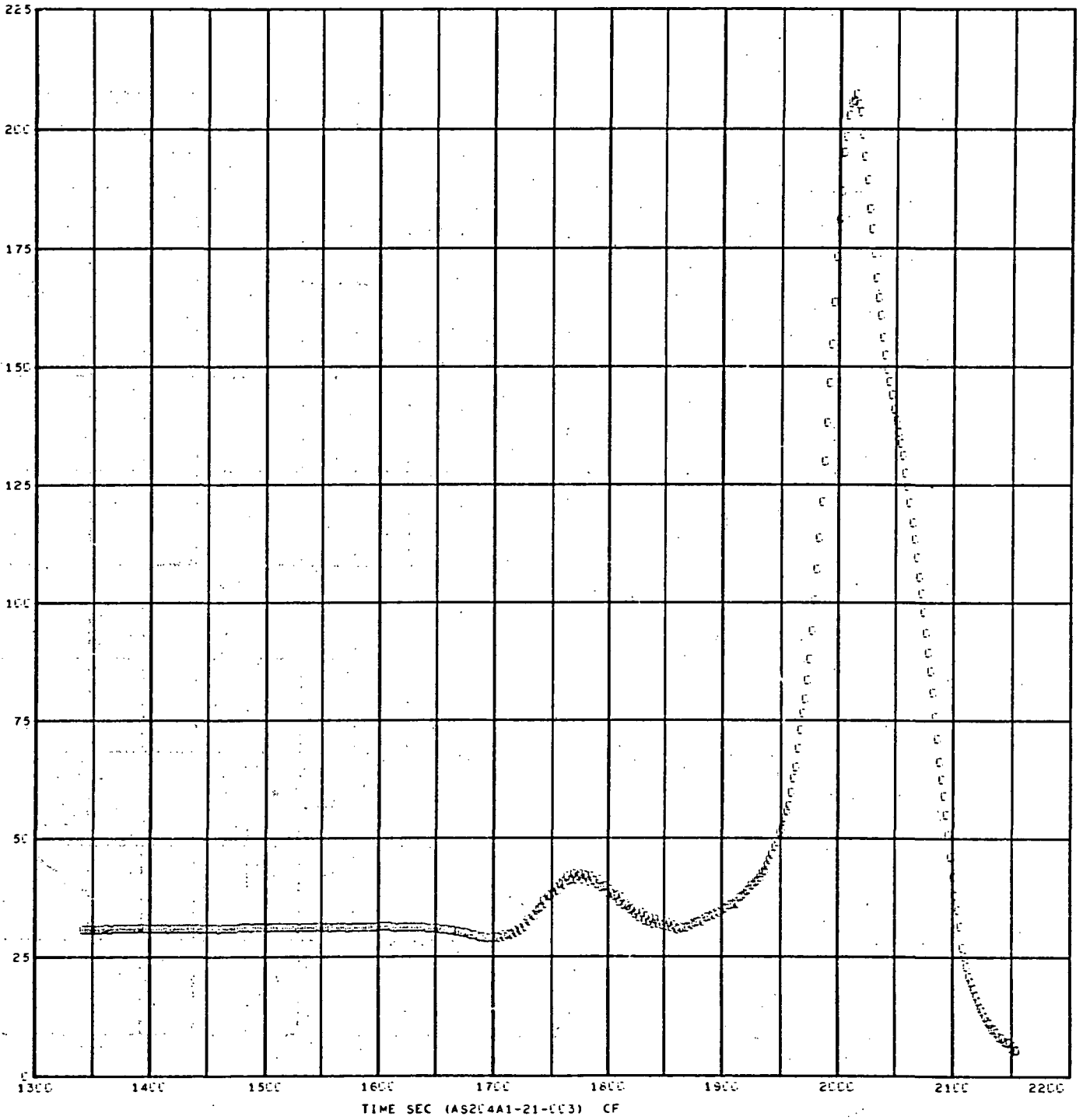


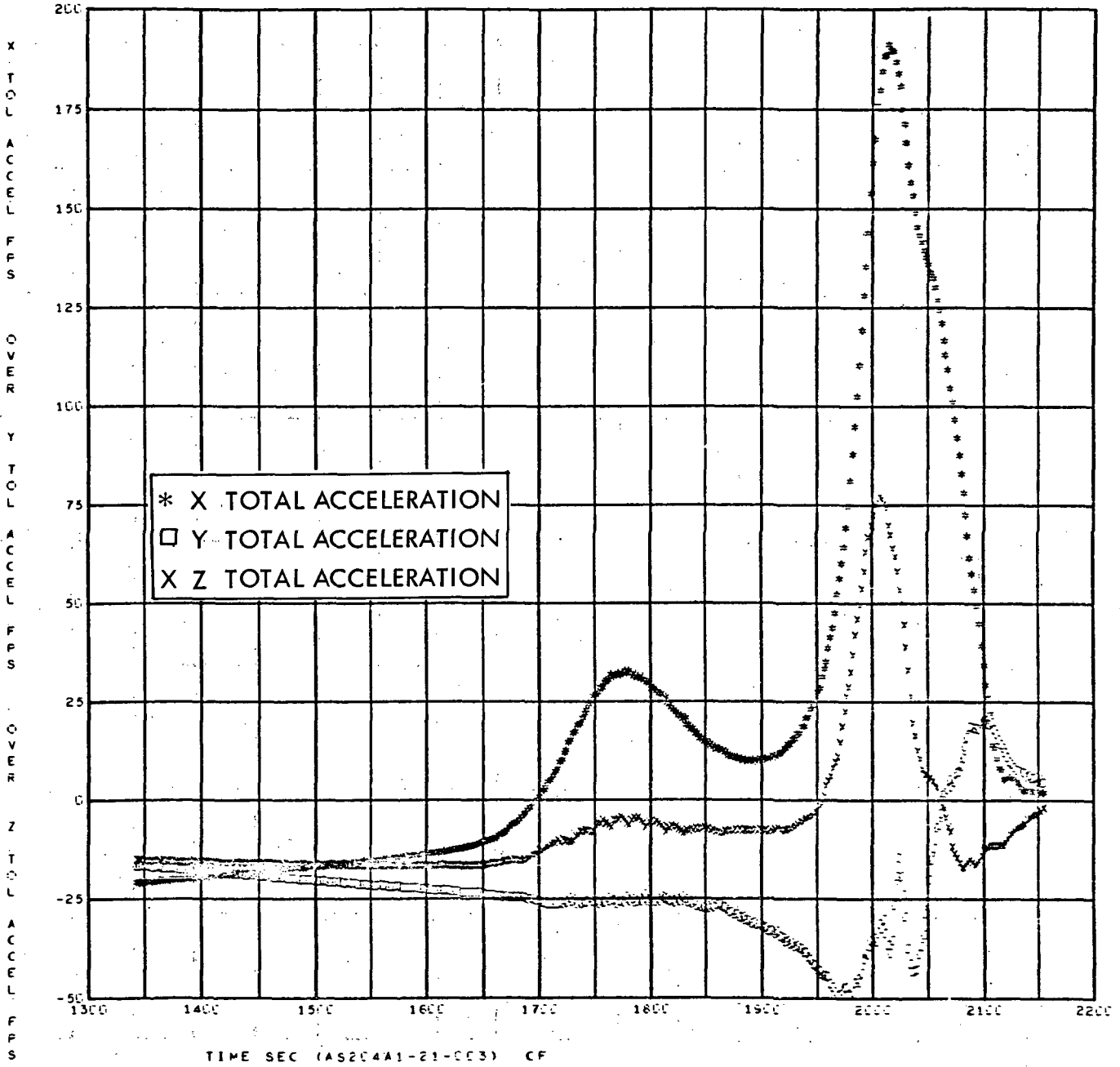
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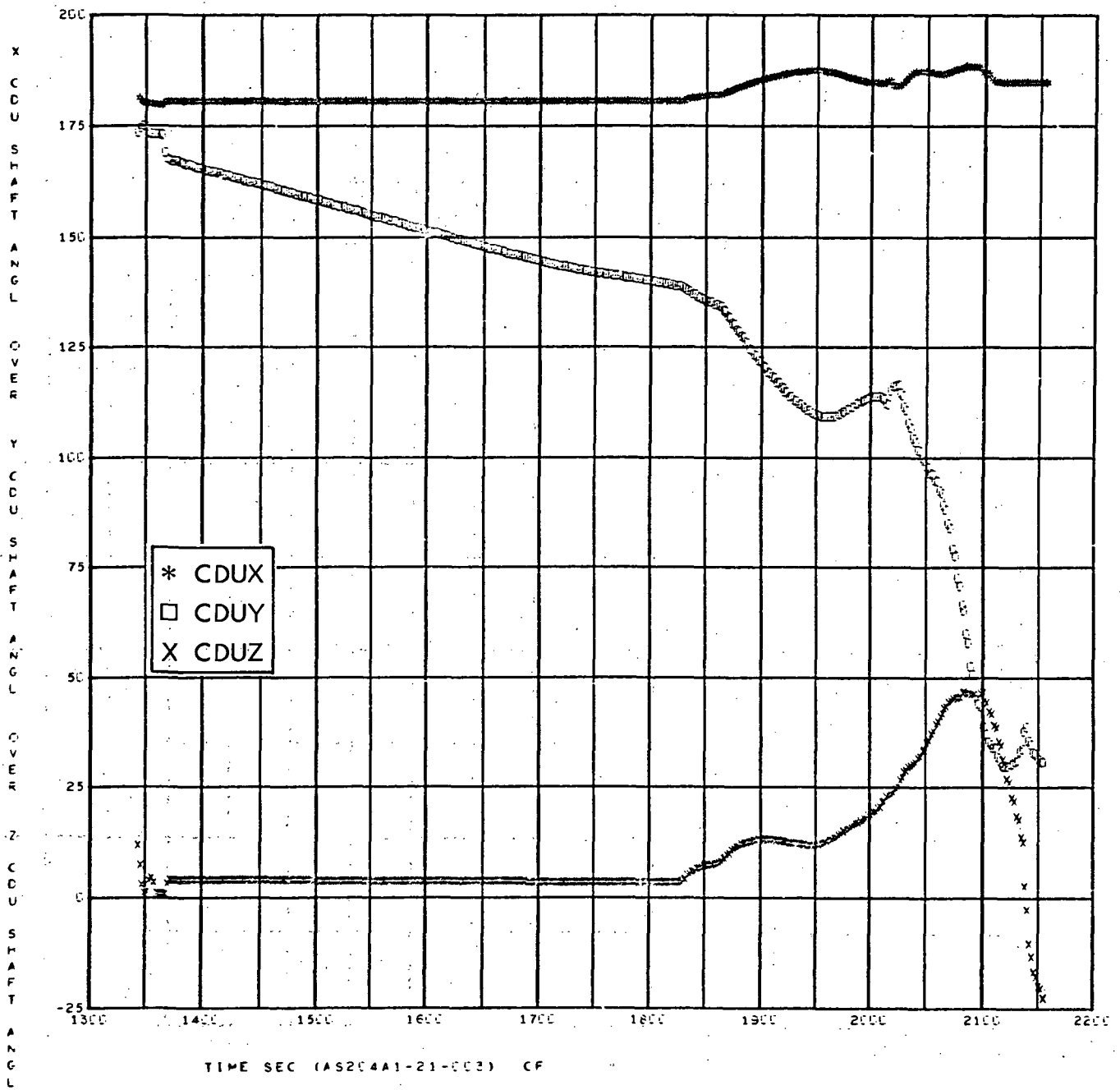
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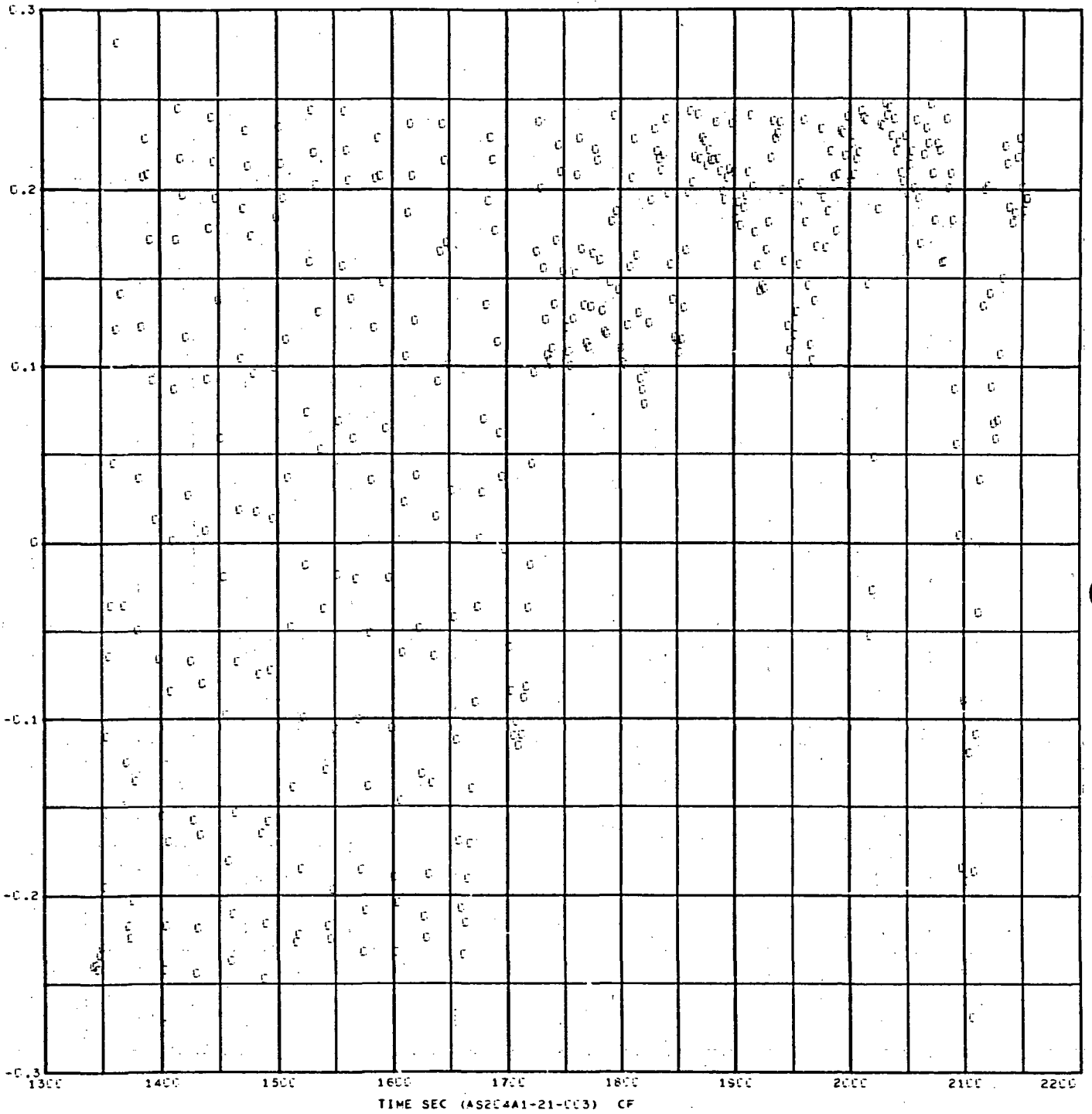
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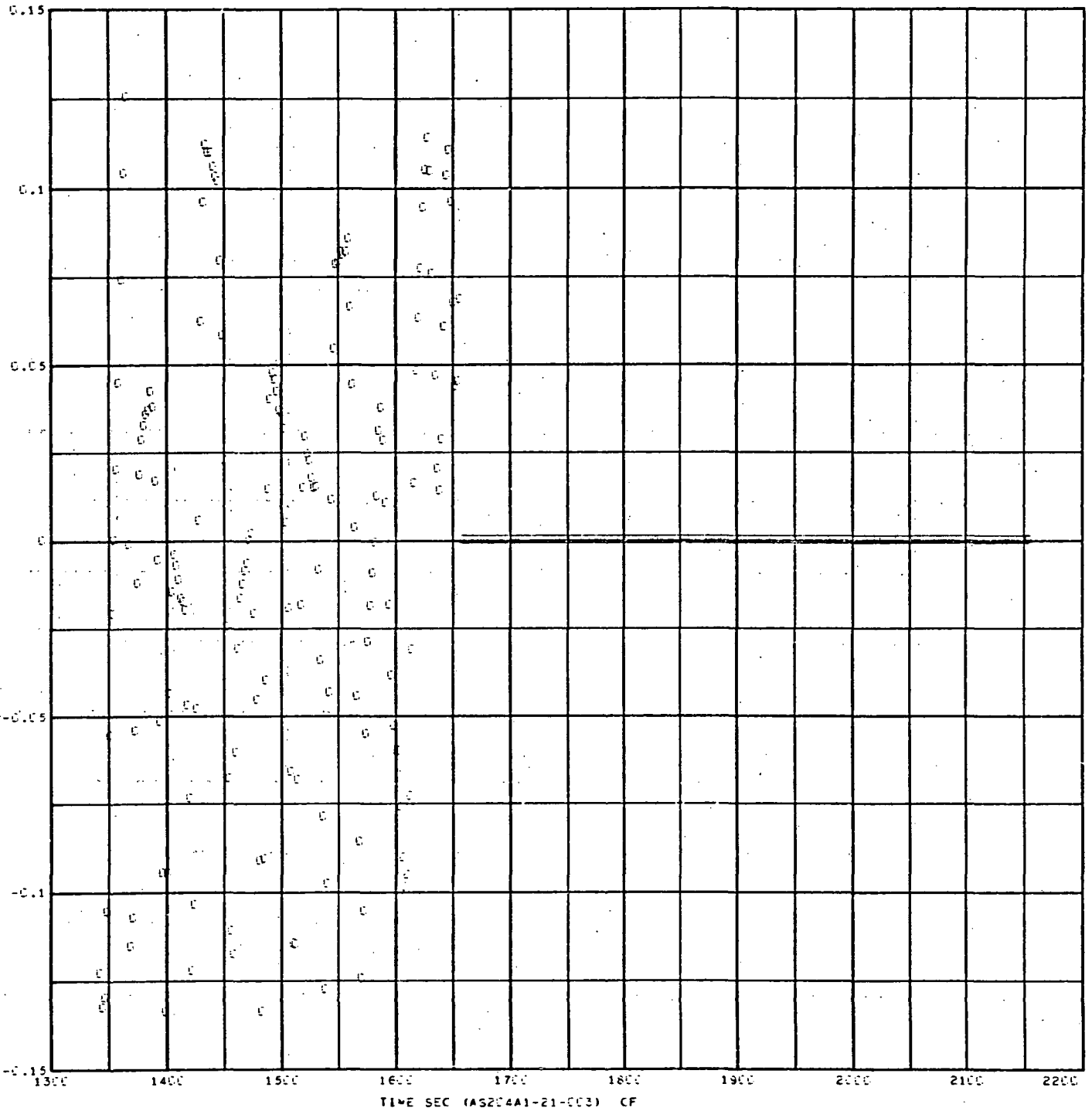


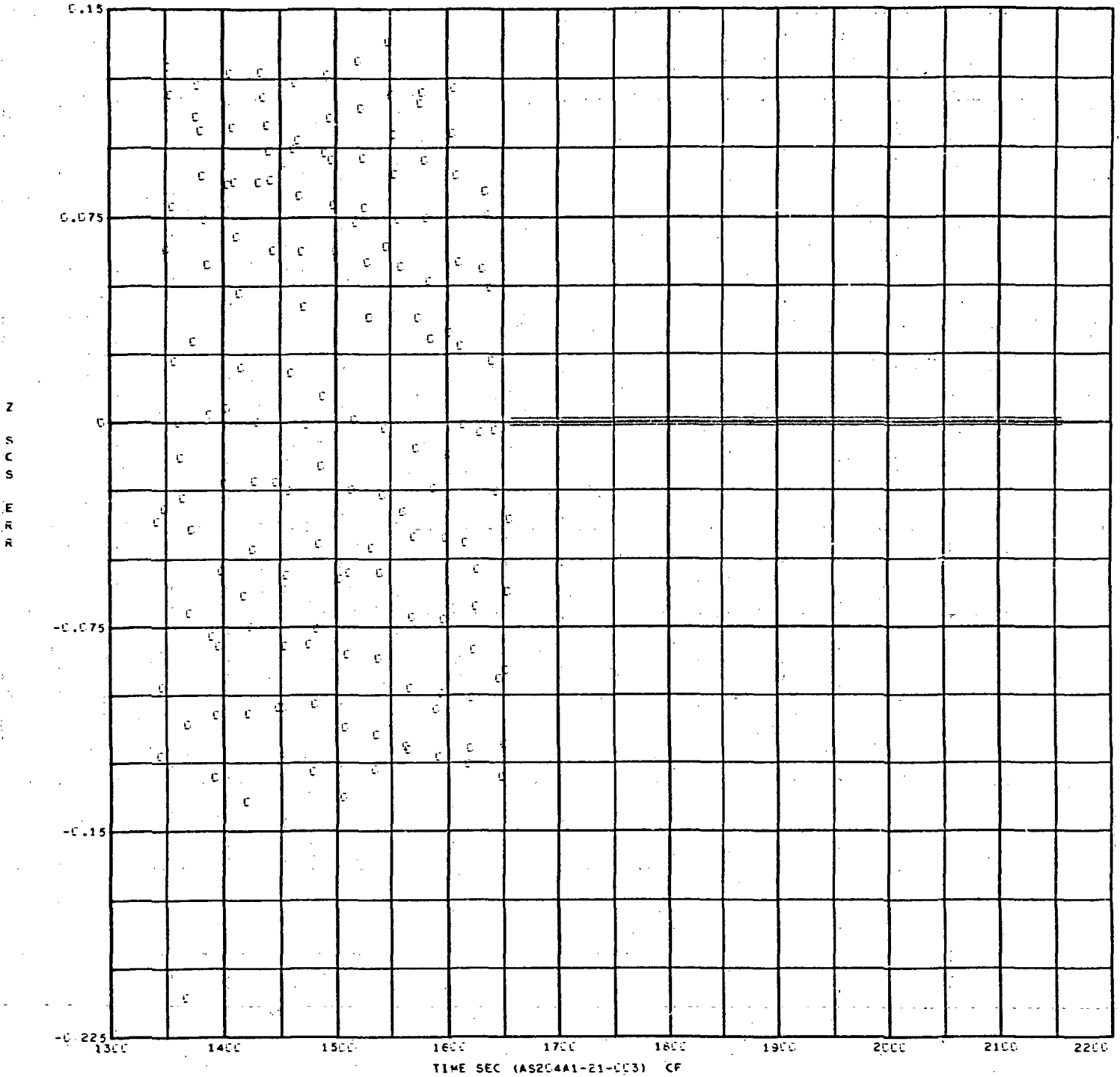




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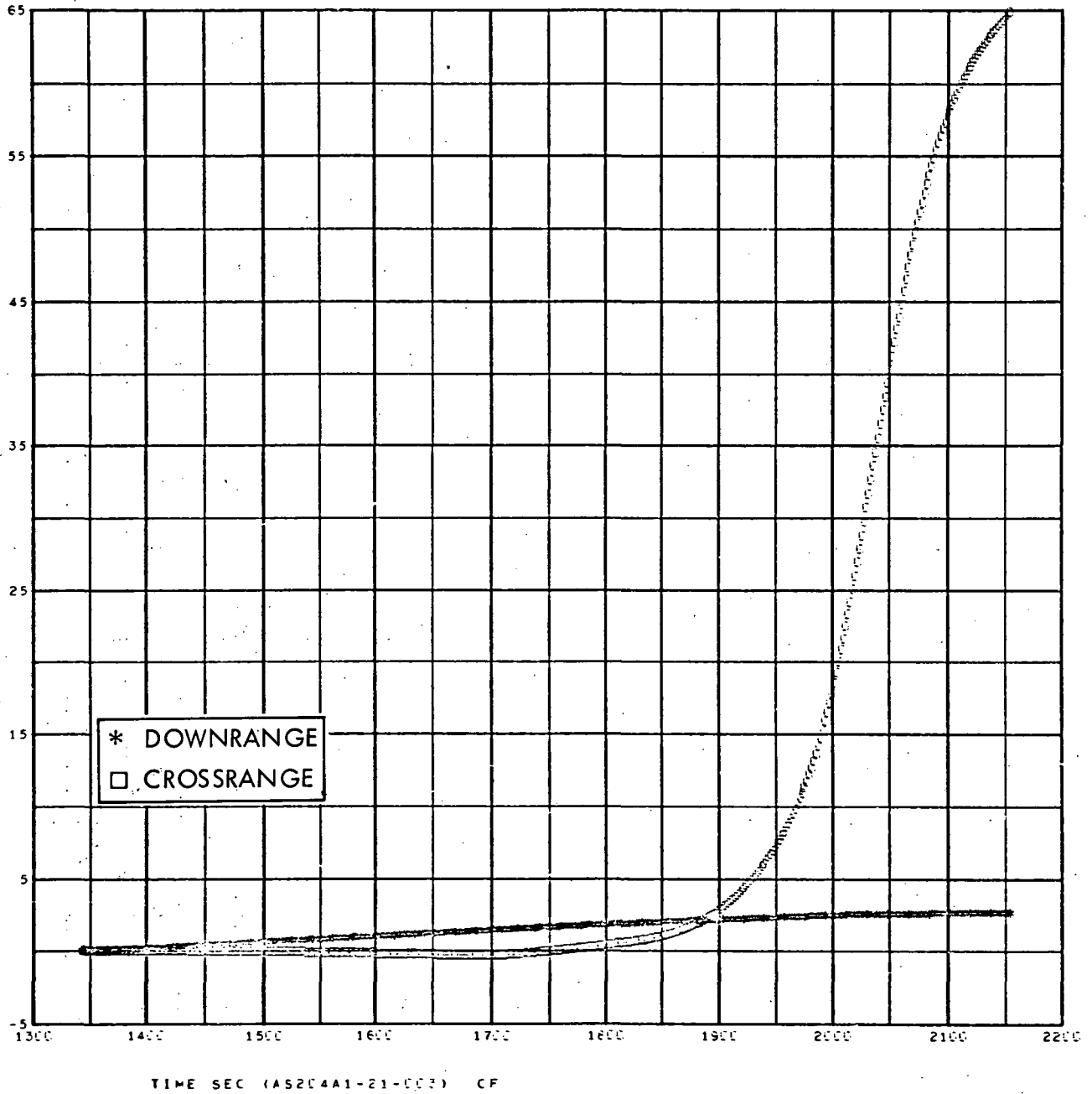
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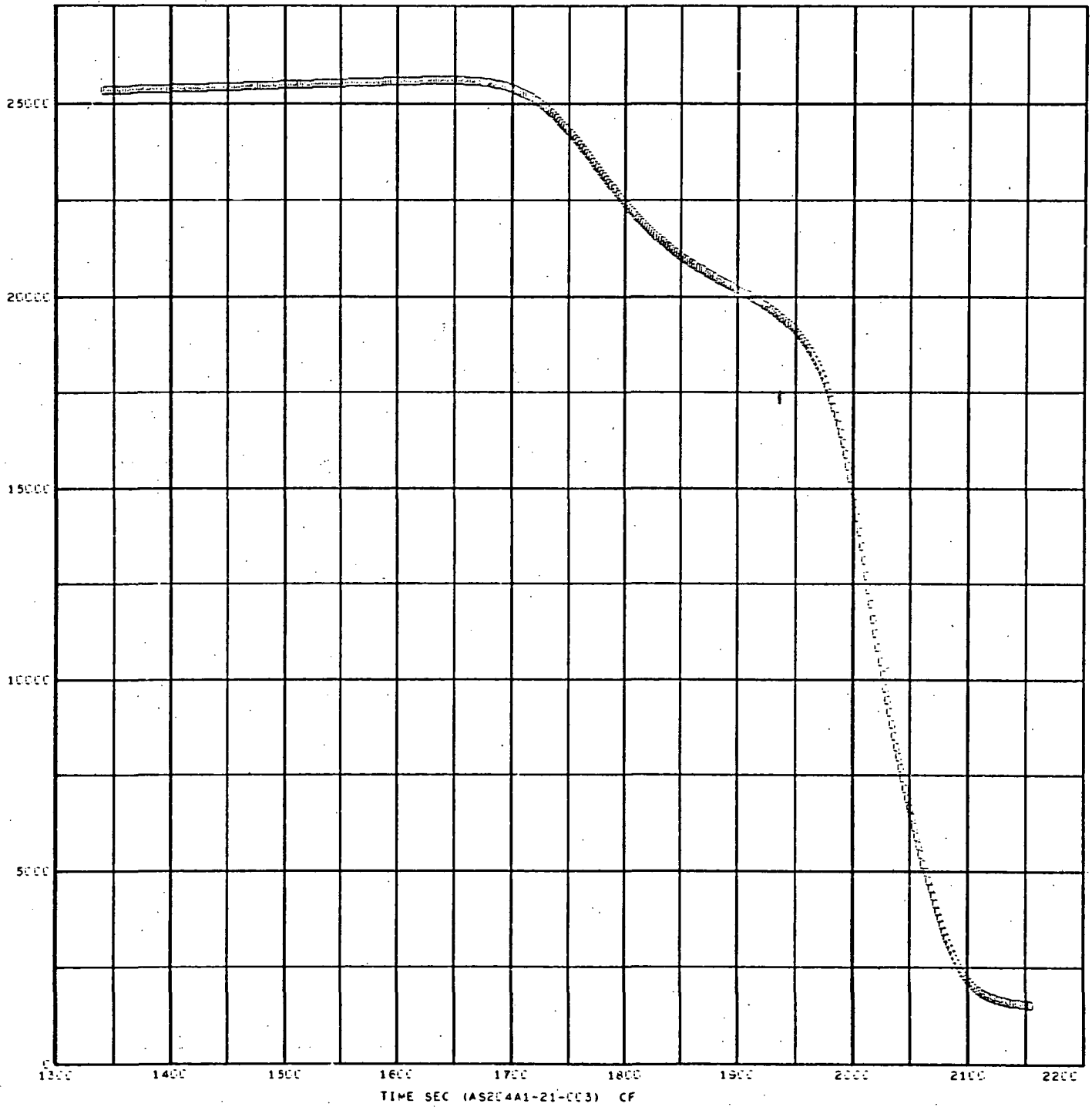
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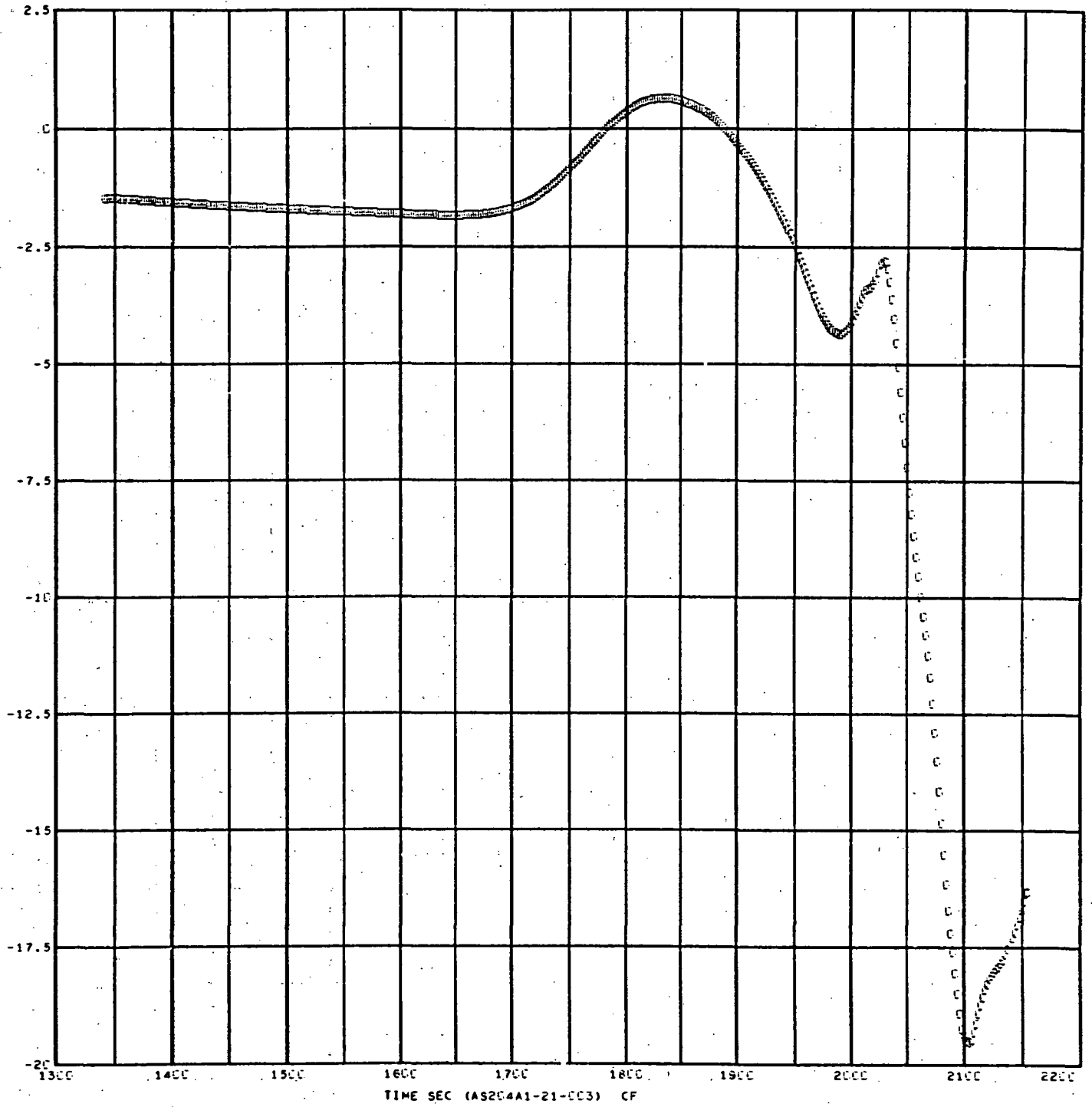
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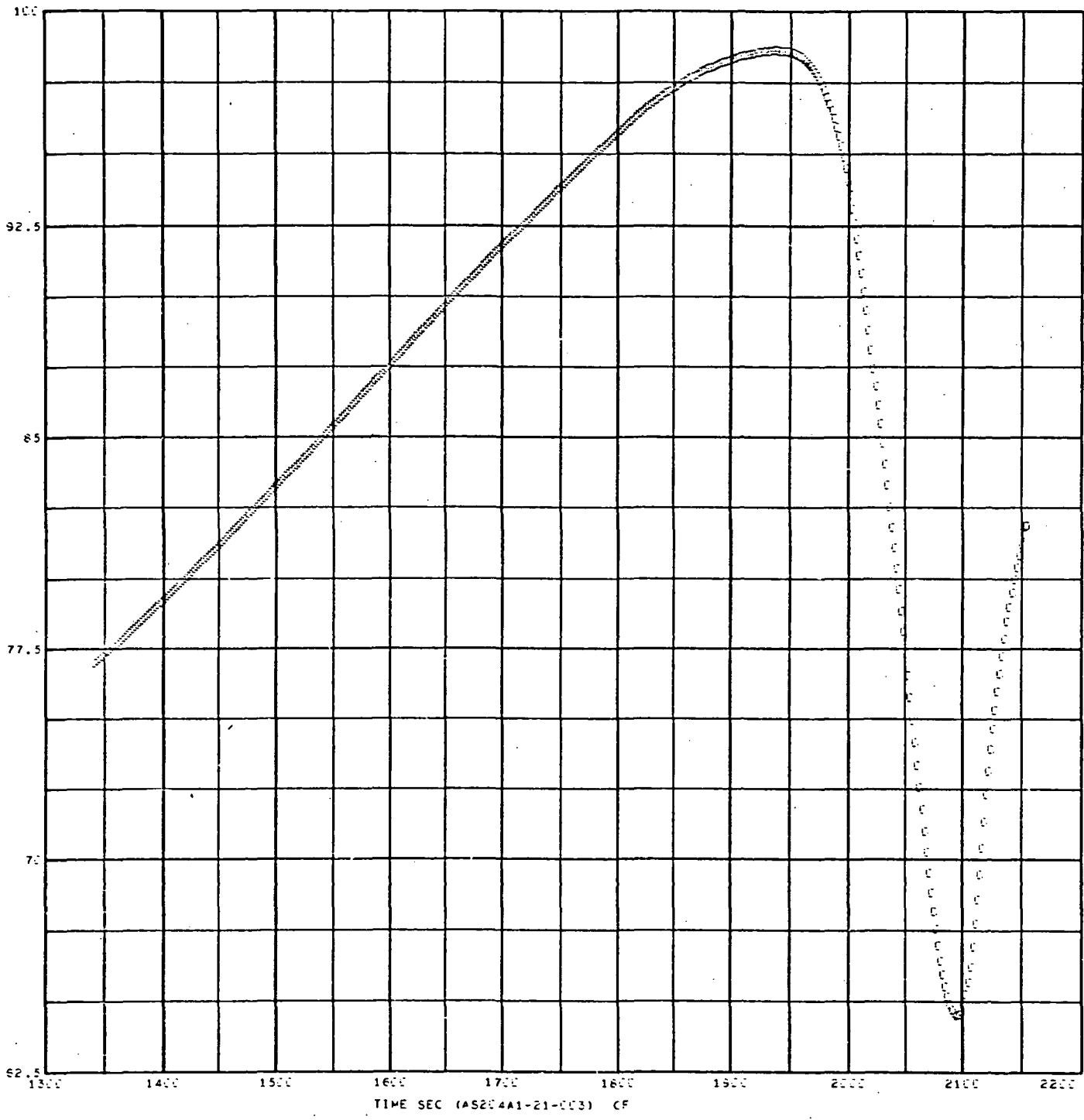


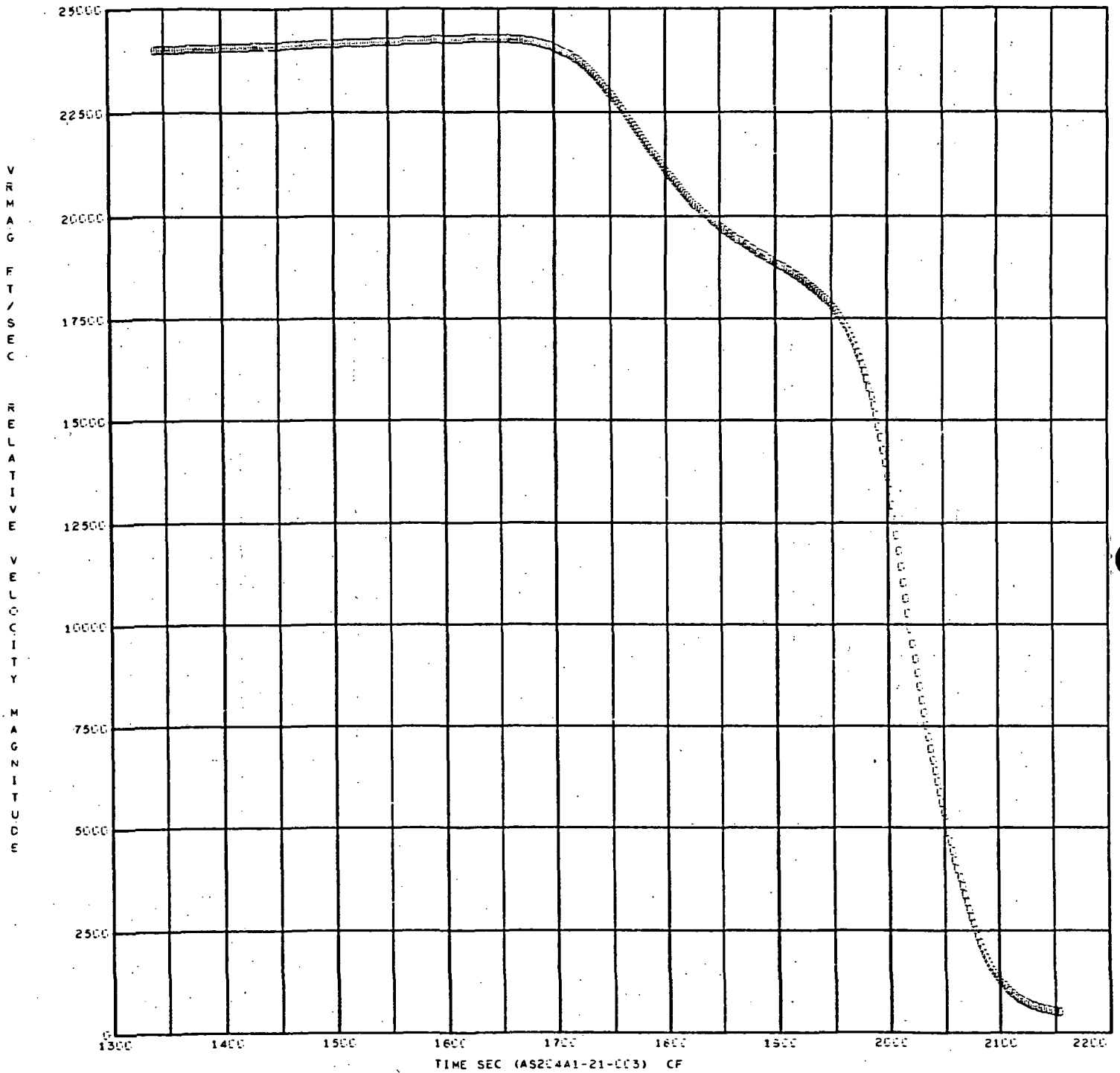
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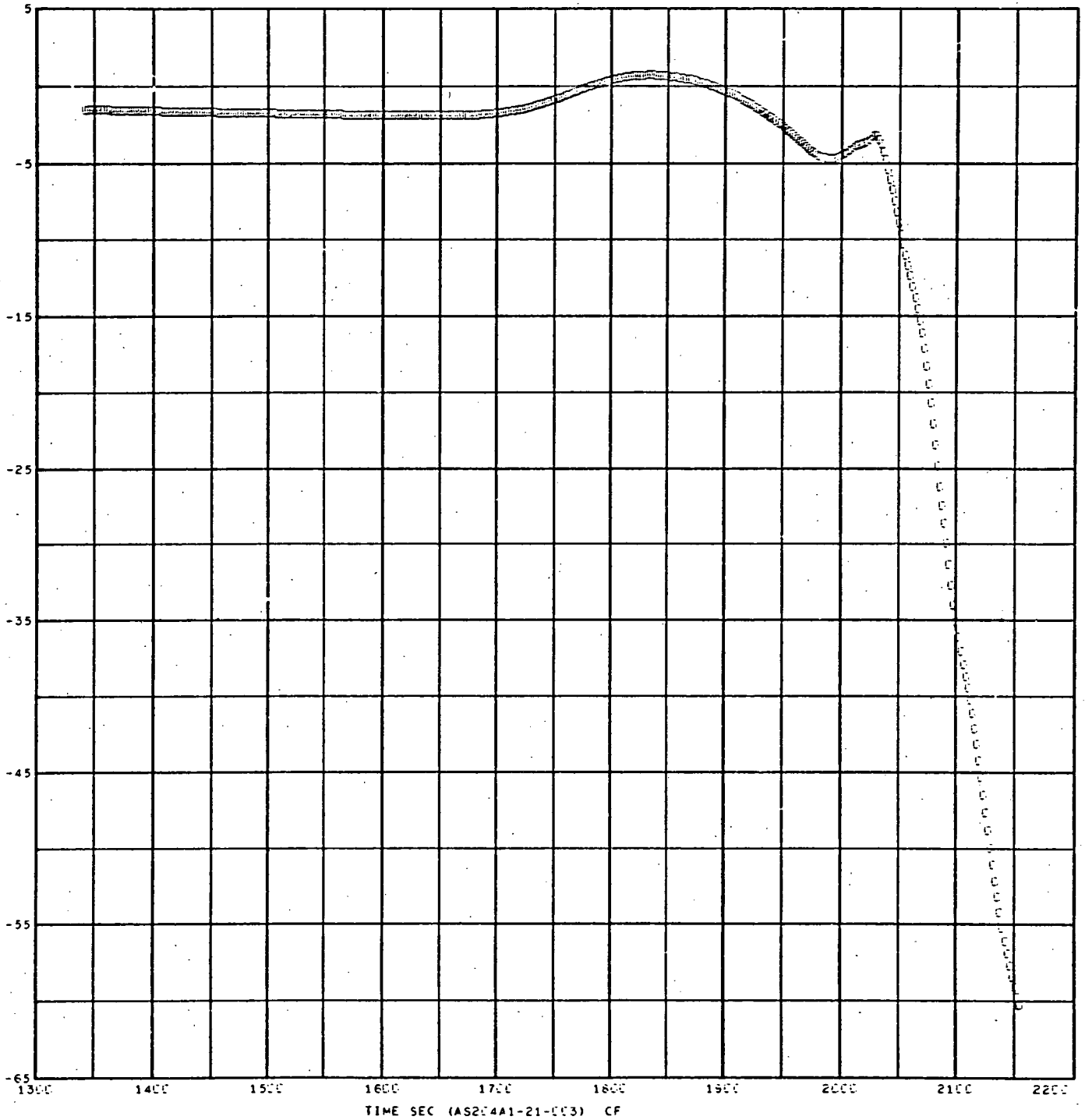
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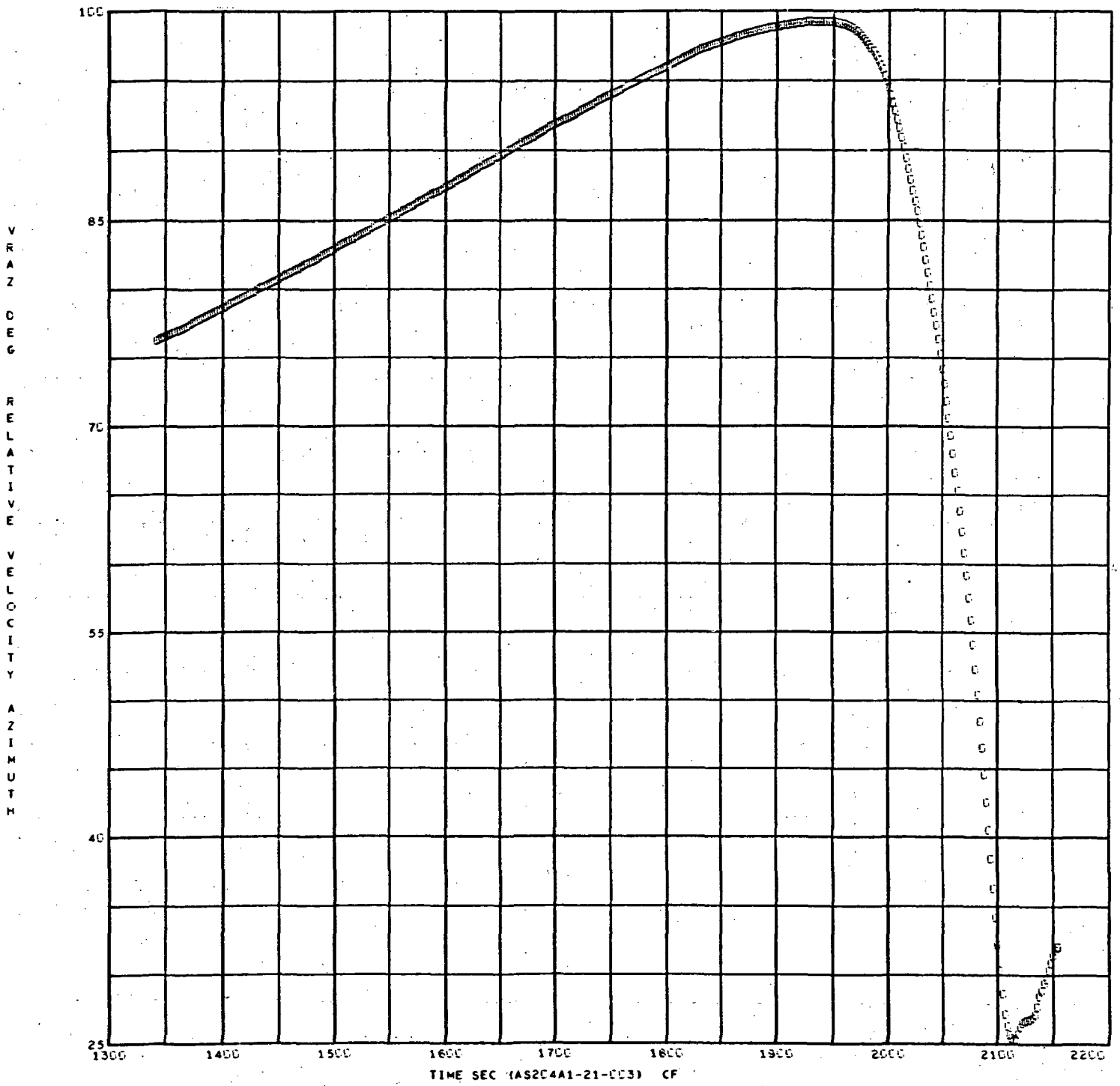
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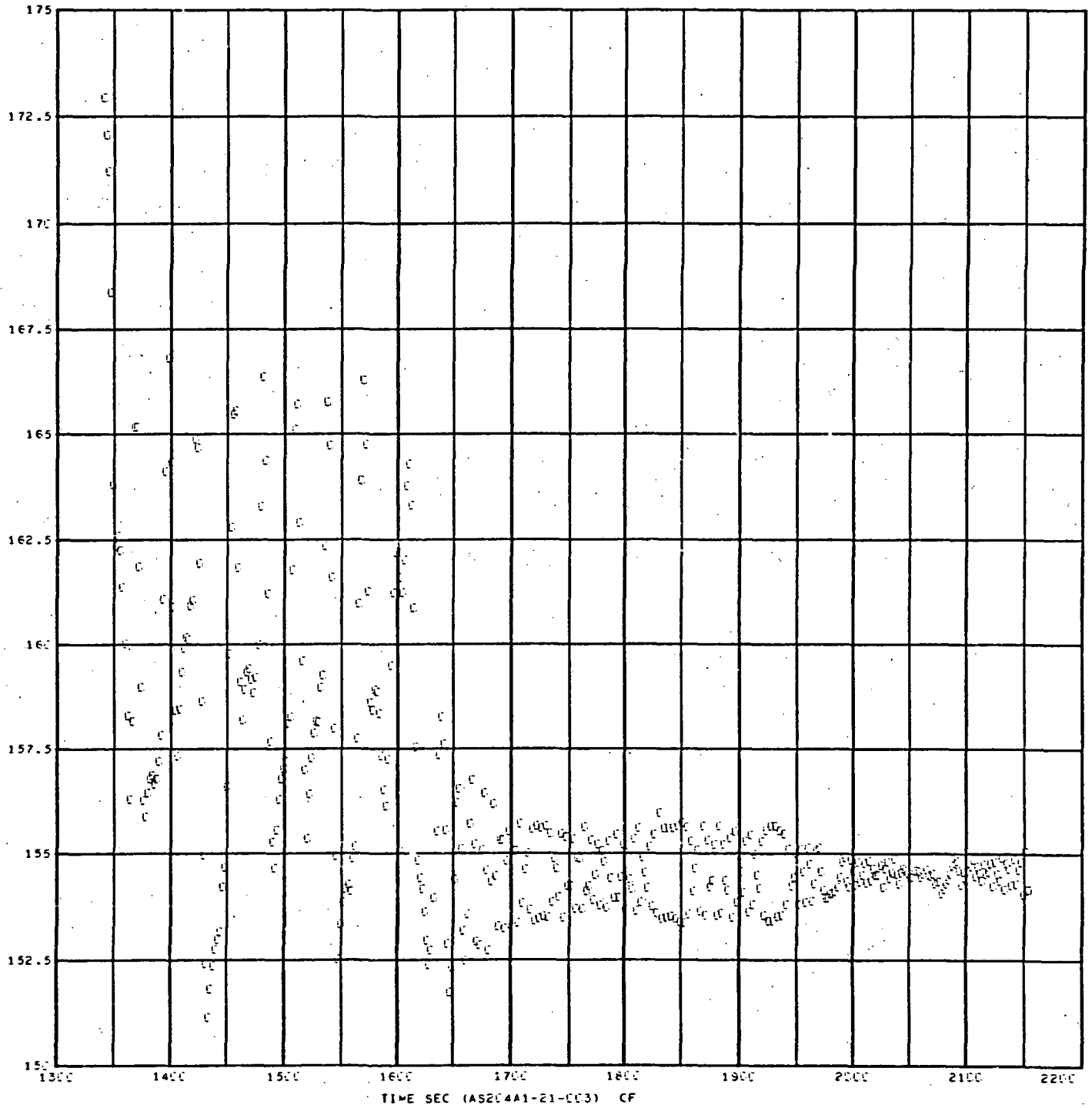
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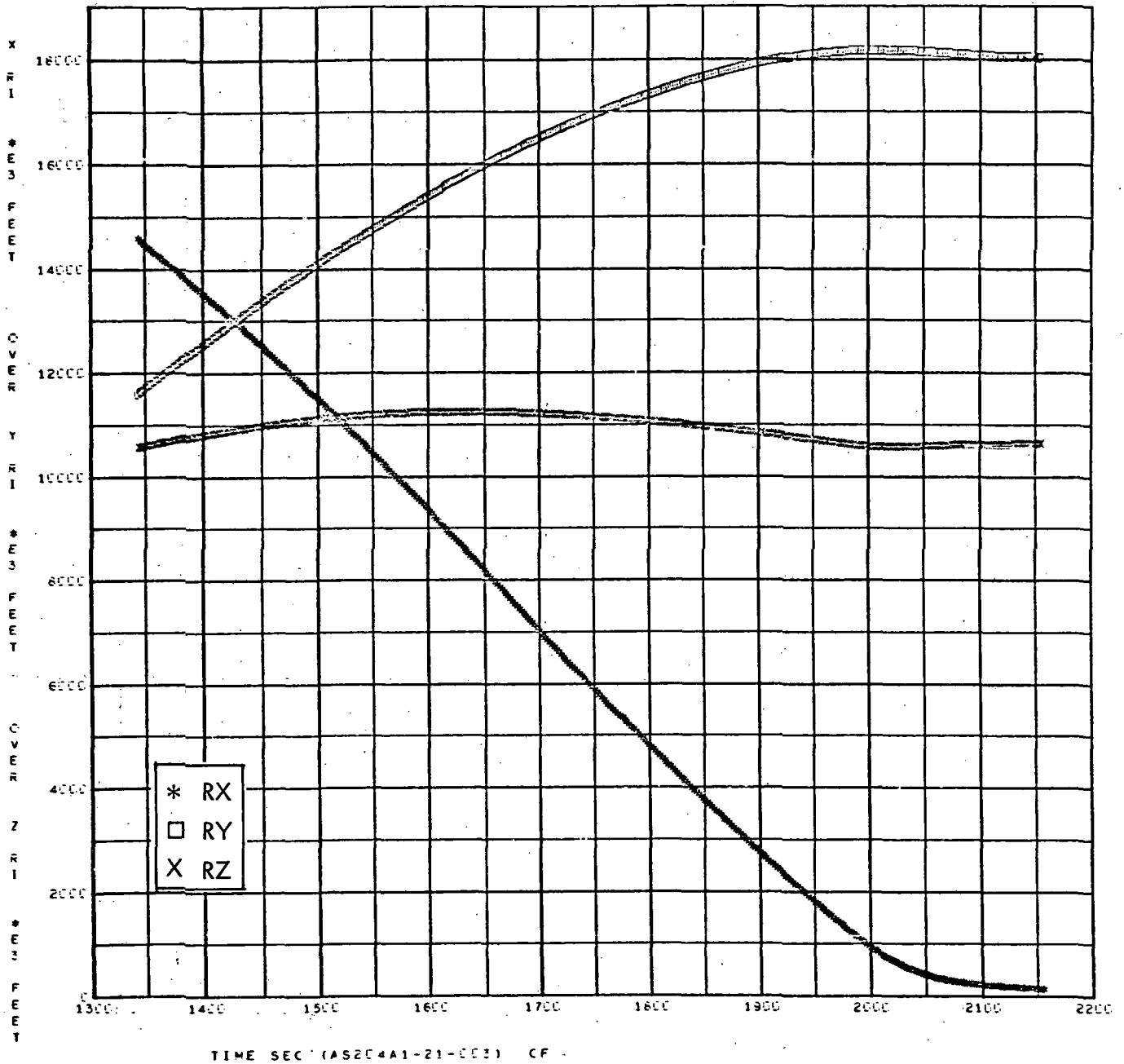


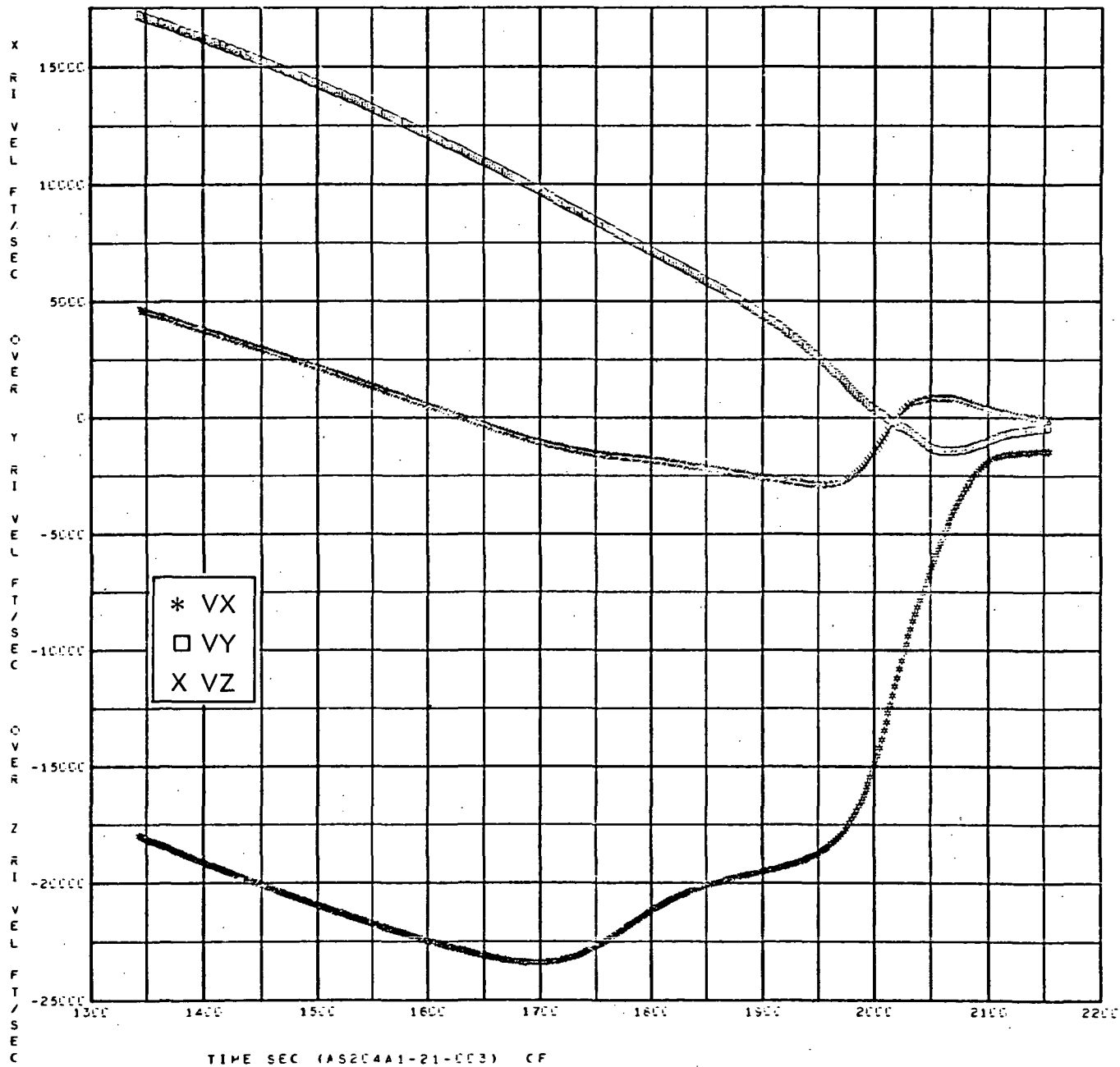


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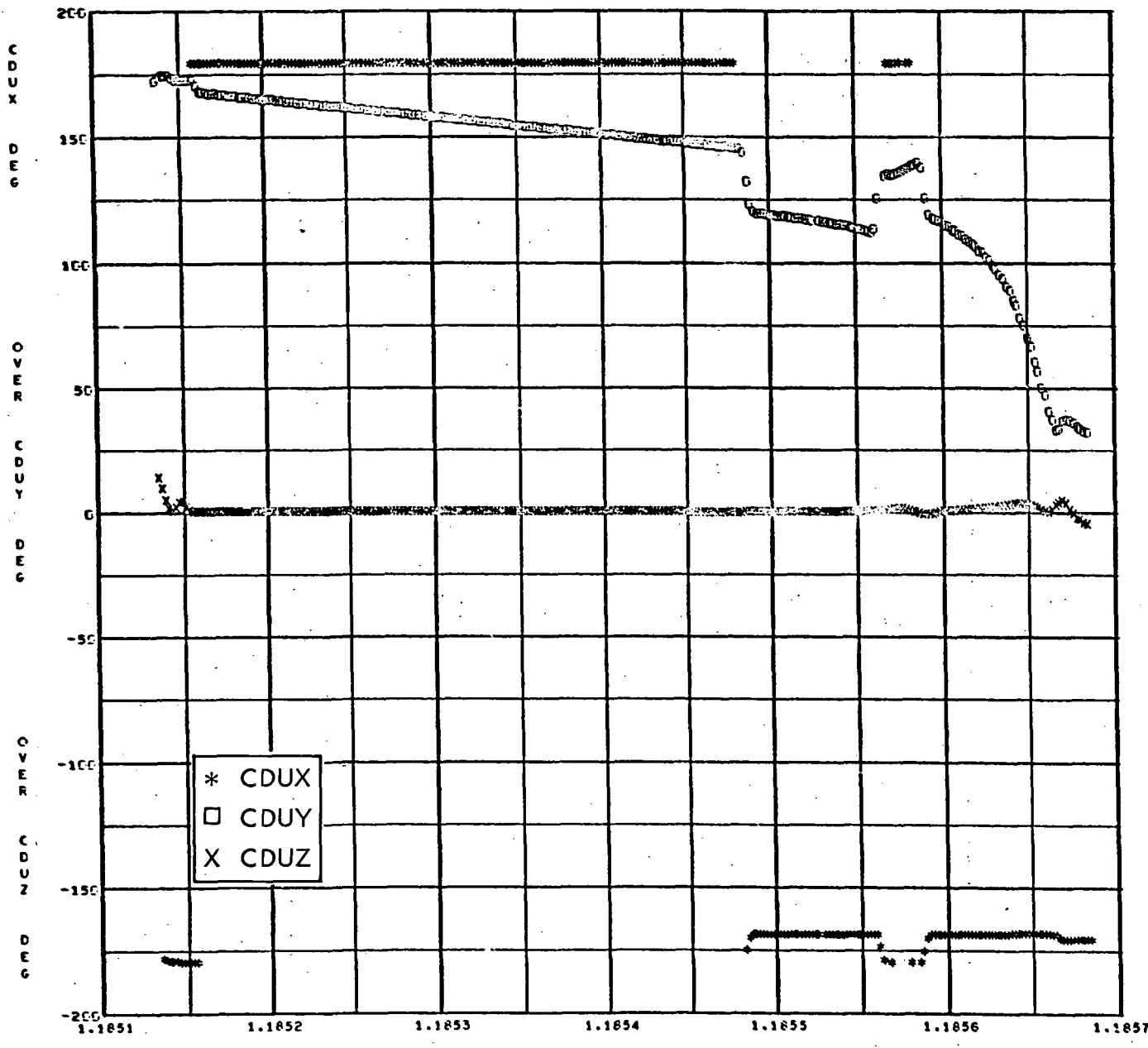
APPENDIX F

PLOTS OF OFF-NOMINAL OVERSHOOT ENTRY G-LIMITING CONDITION

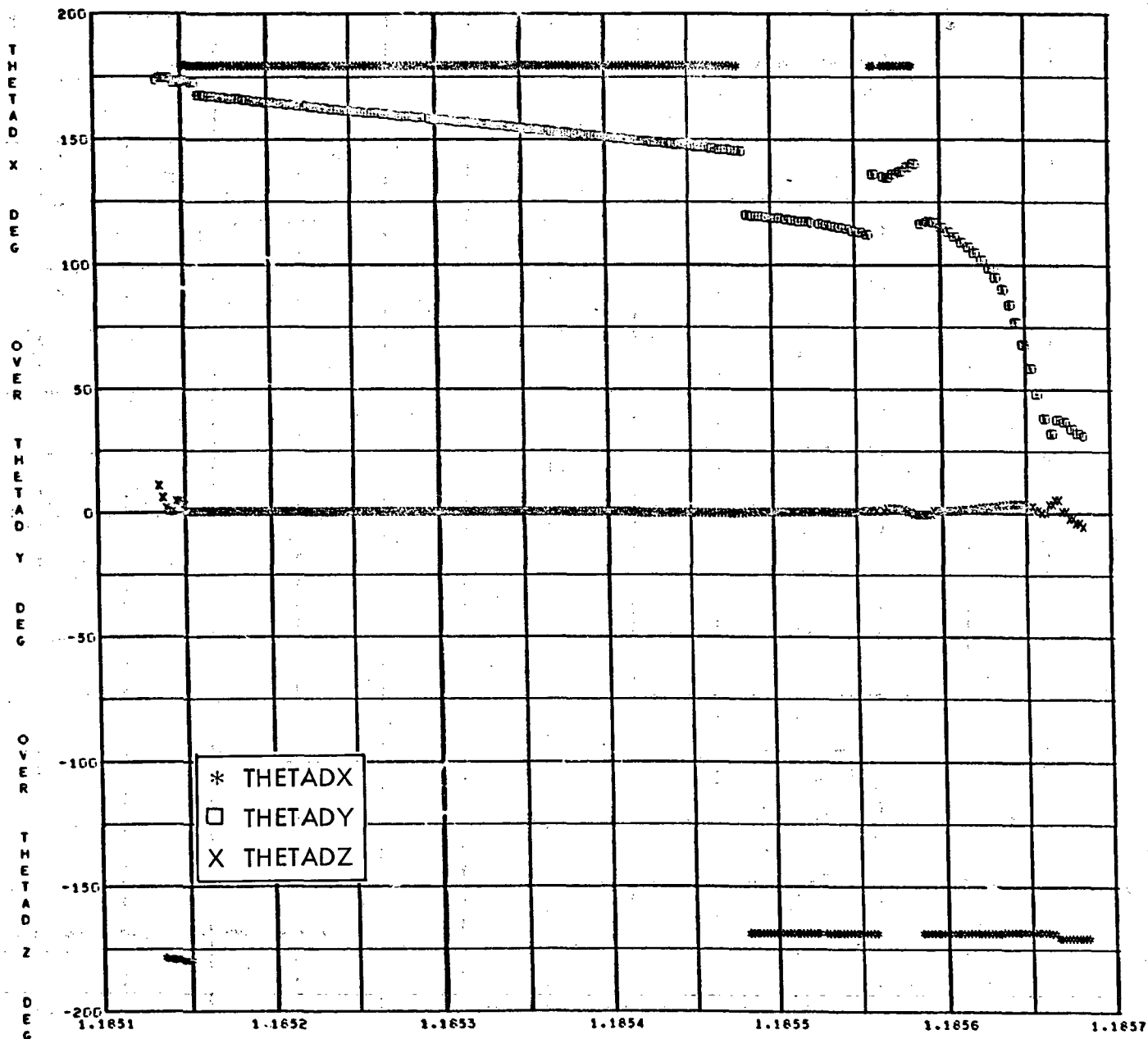
AS-204A1-22-003

AGC PLOTS

AS-204A1-22-003



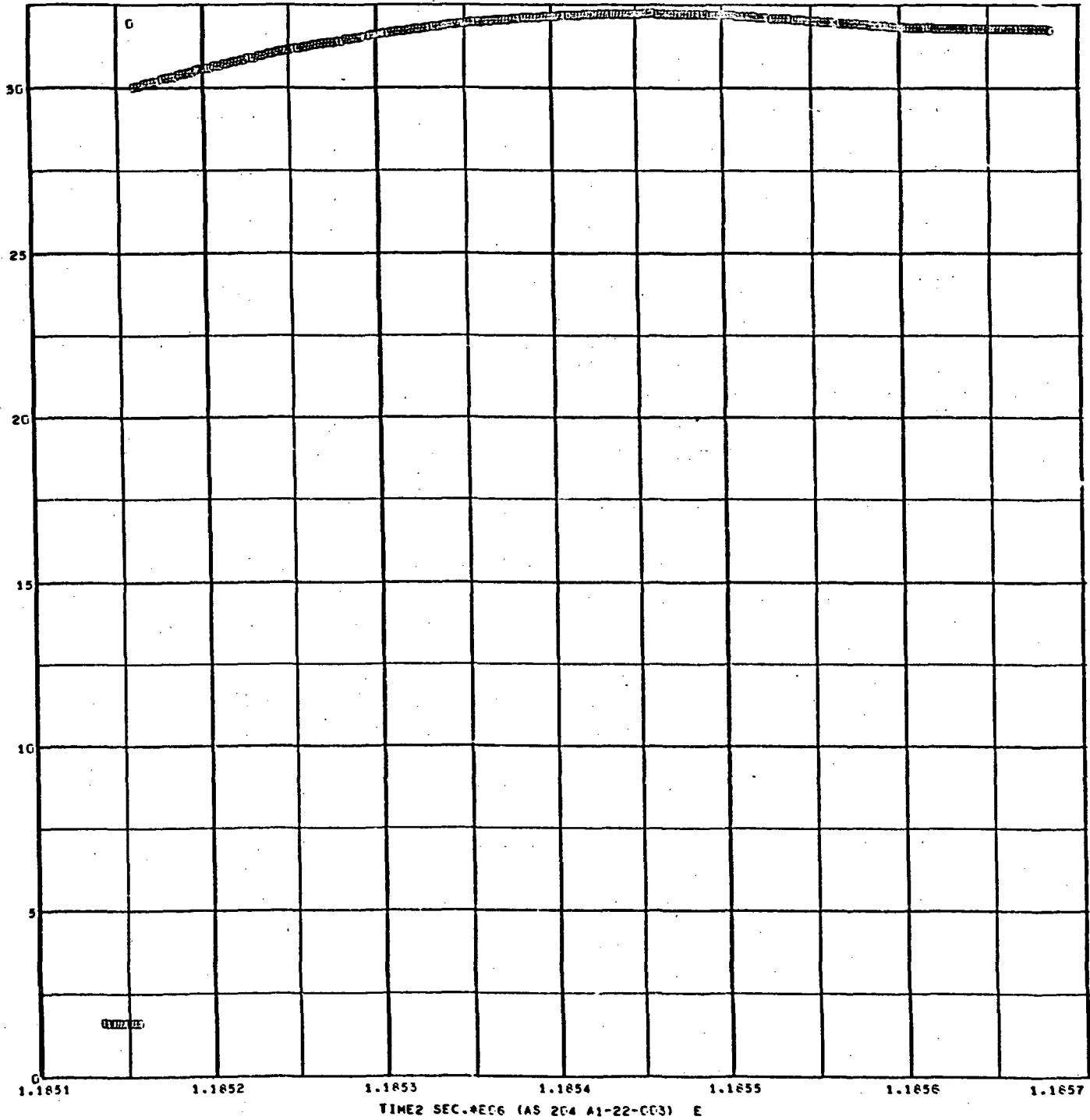
TIME2 SEC.*E06 (AS 204 A1-22-003) E



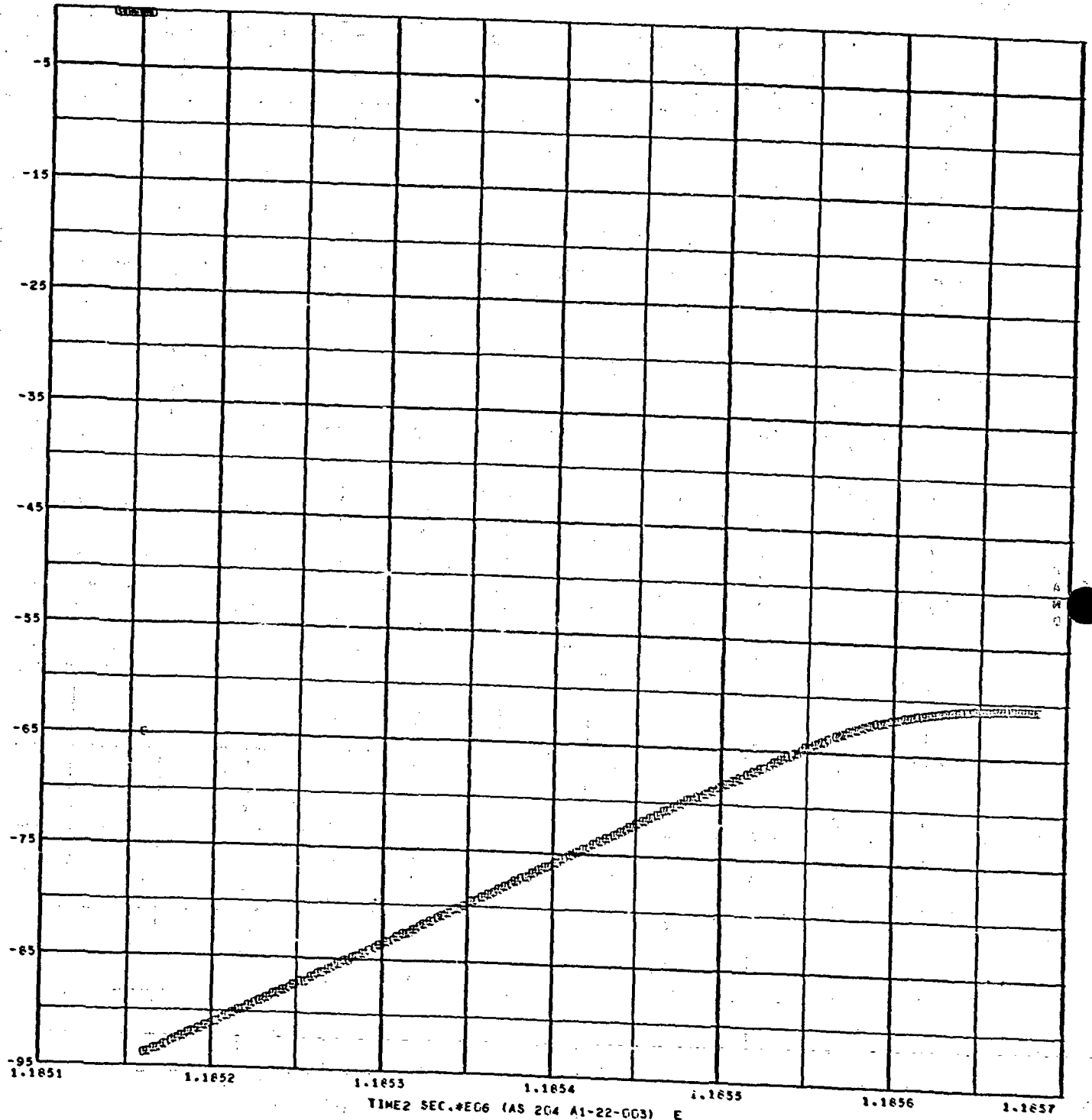
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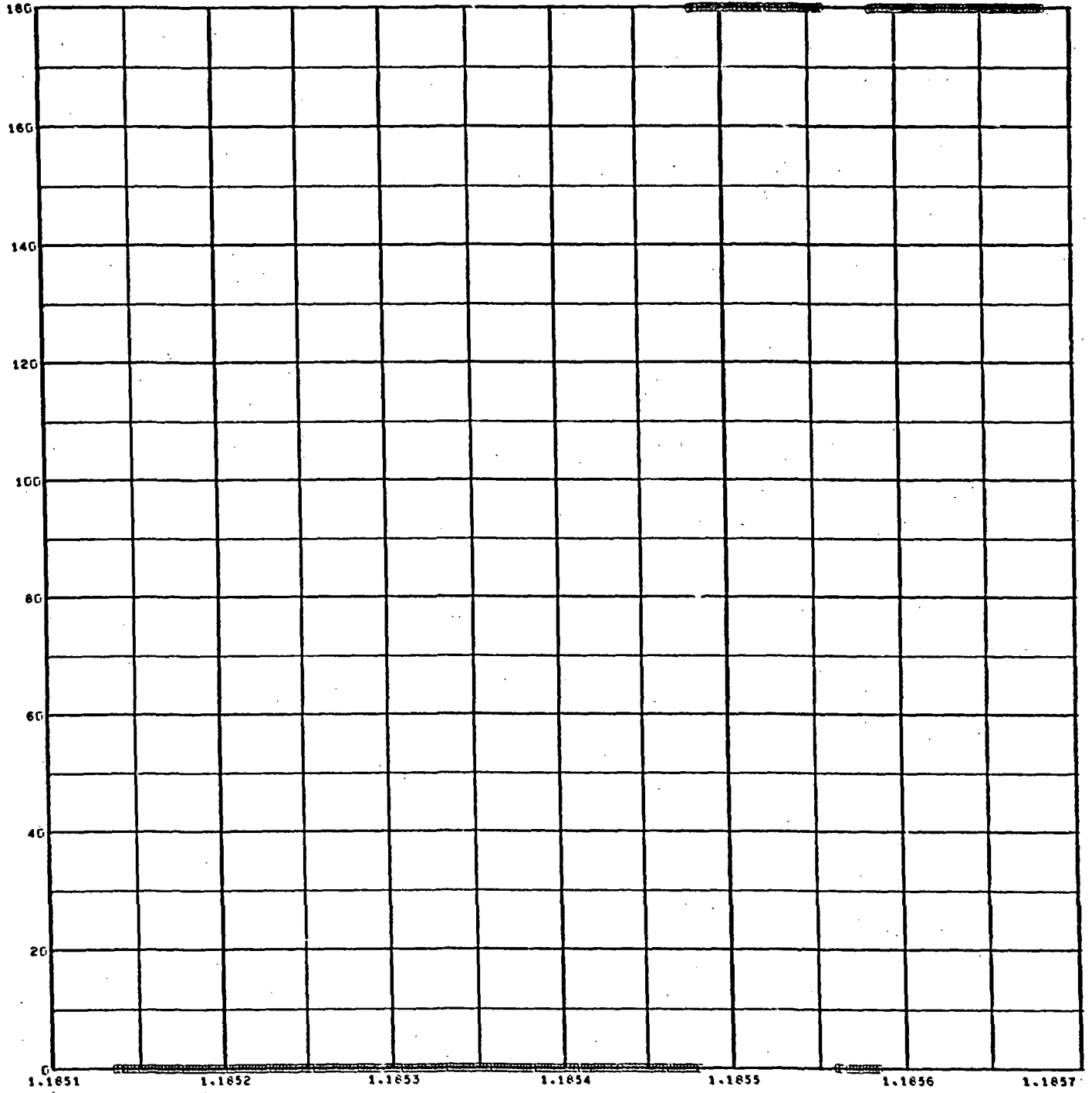
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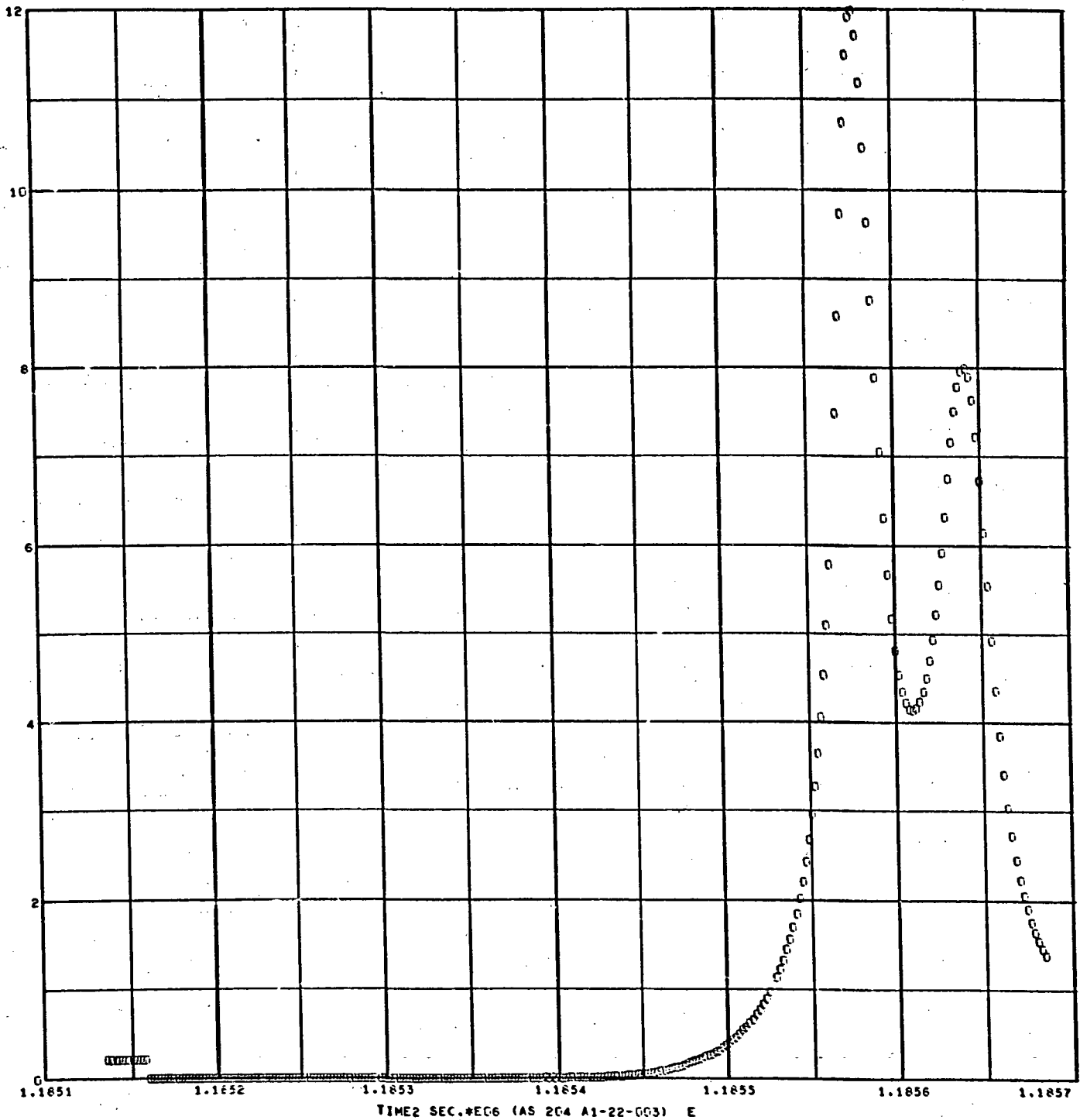
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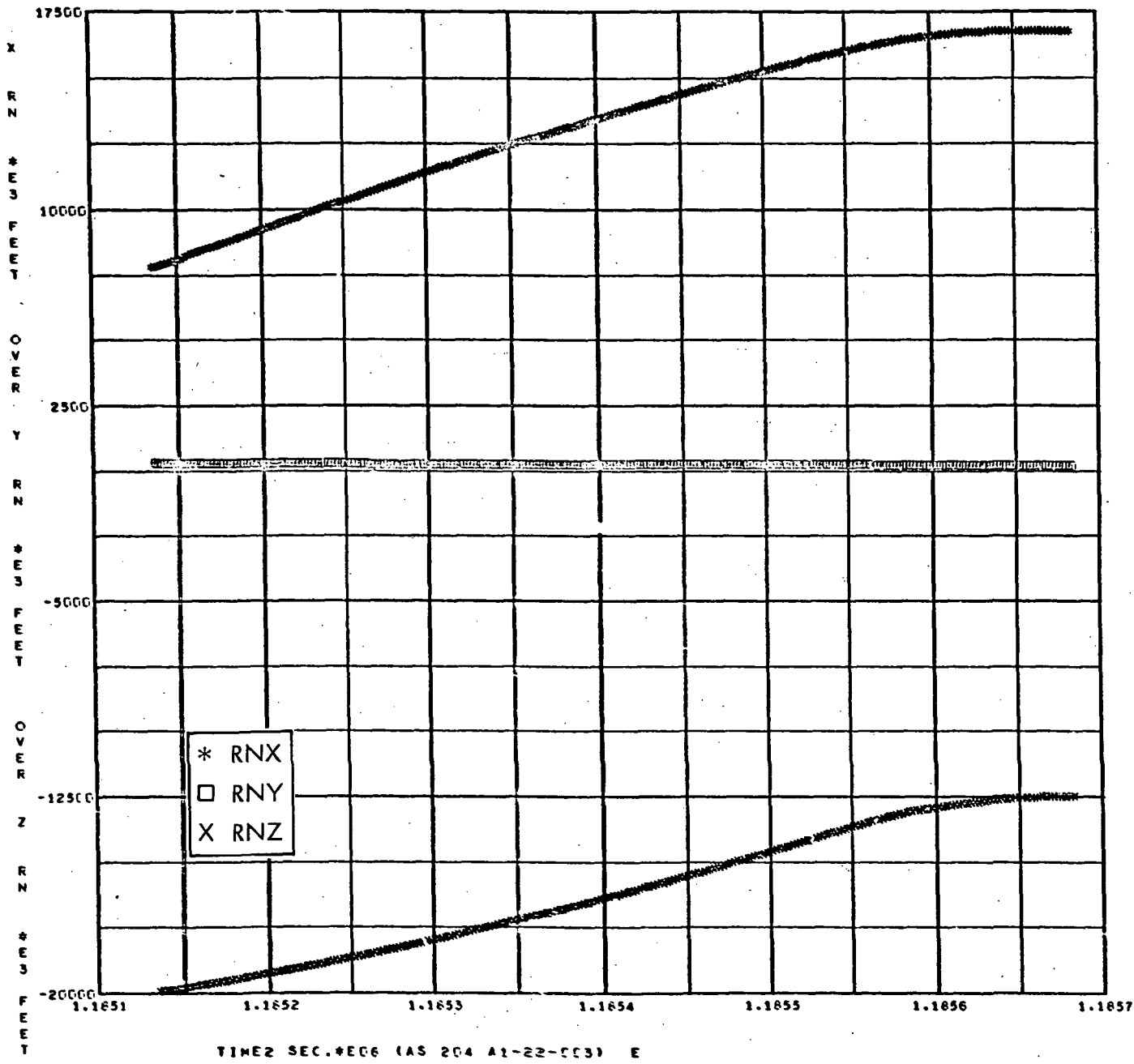


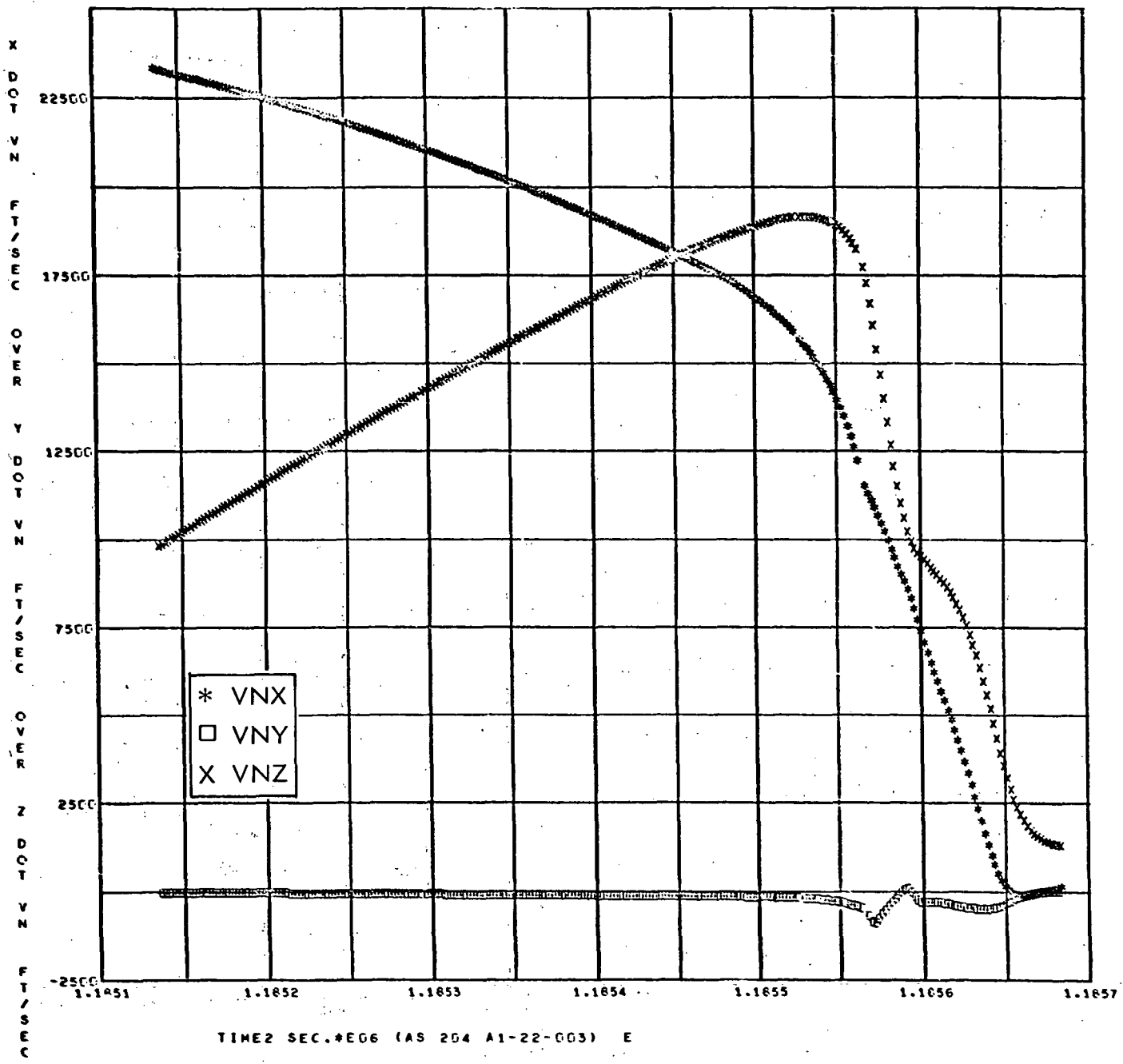
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ENVIRONMENT PLOTS

AS-204A1-22-003

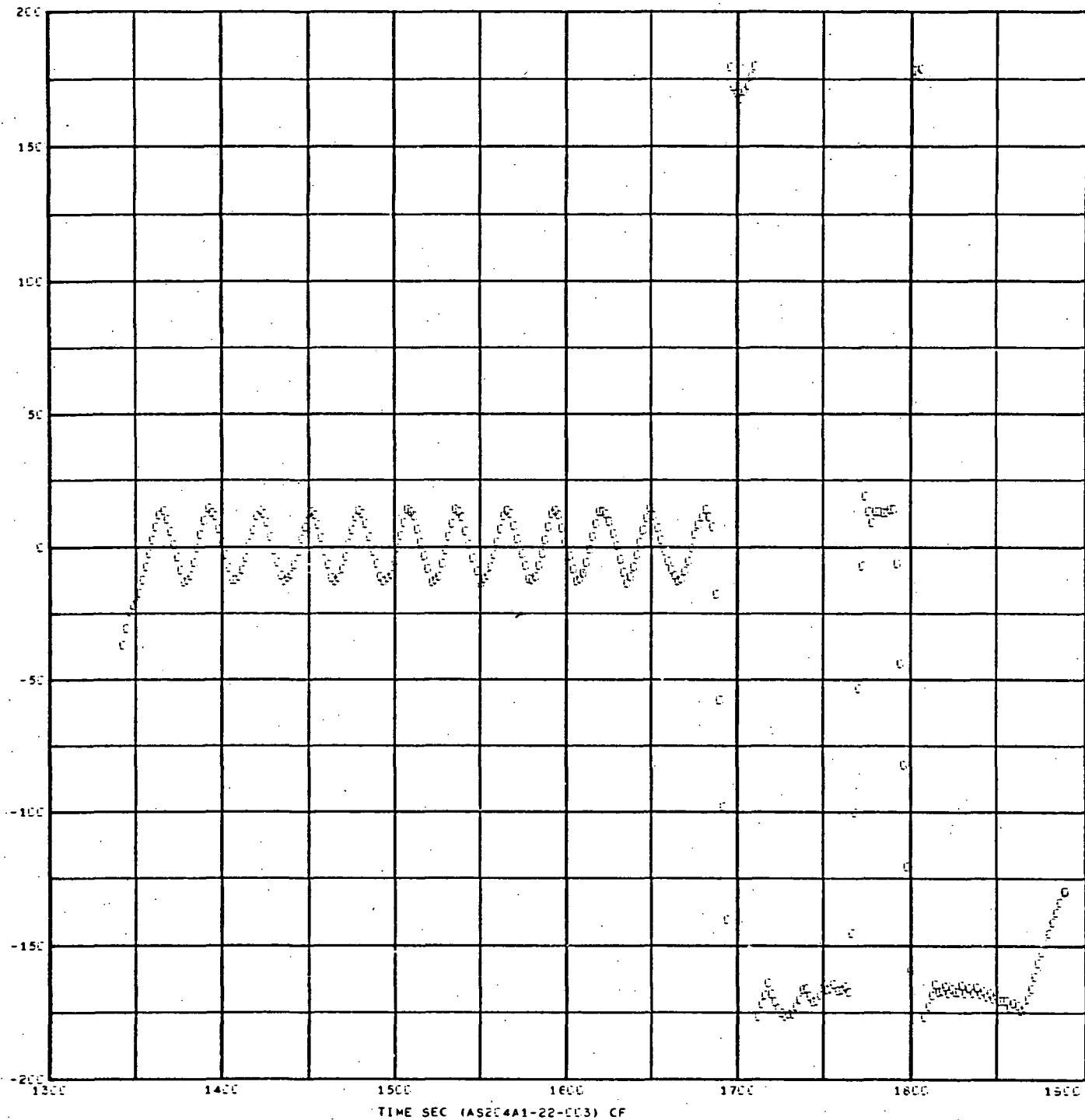
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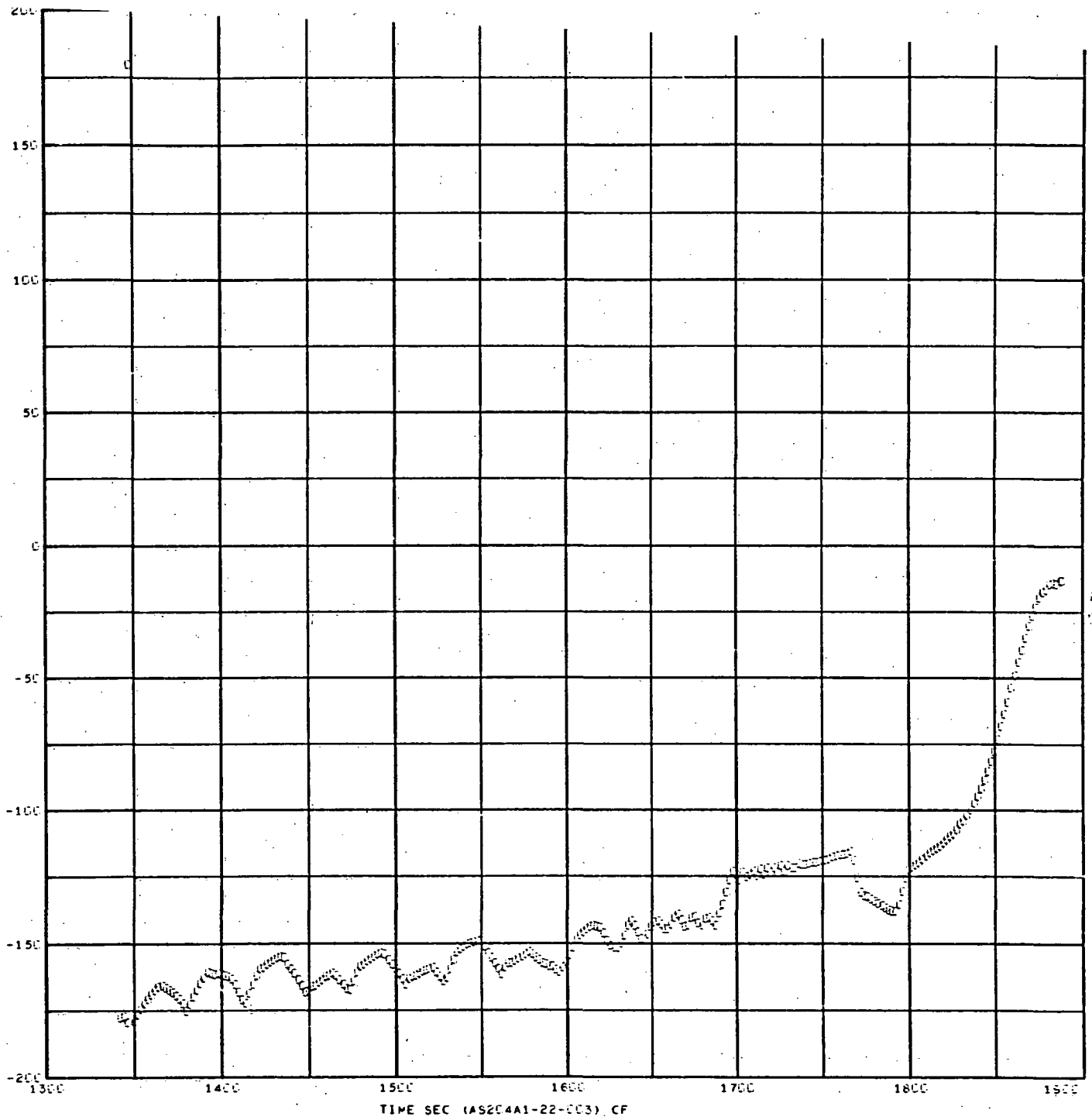
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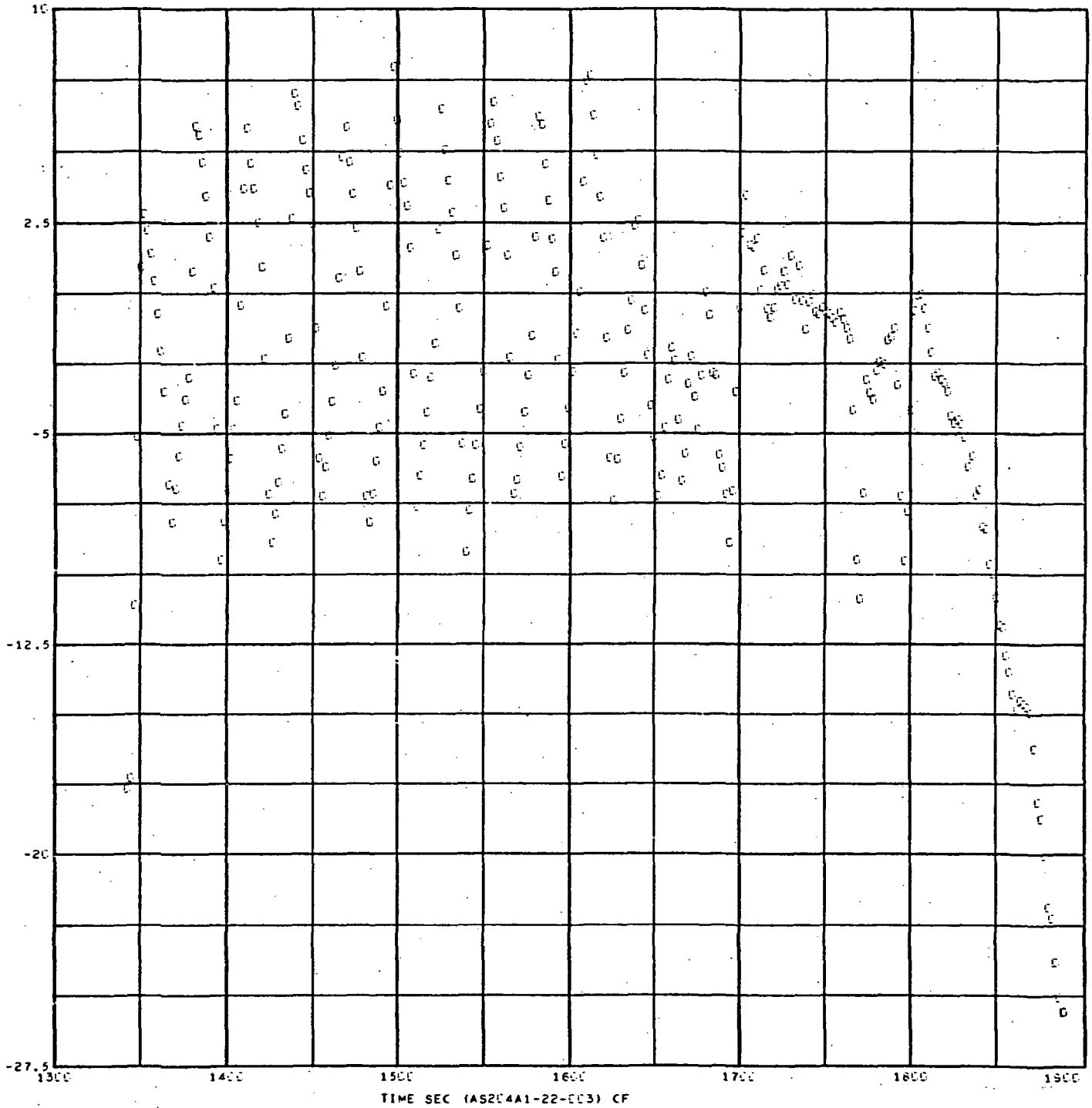
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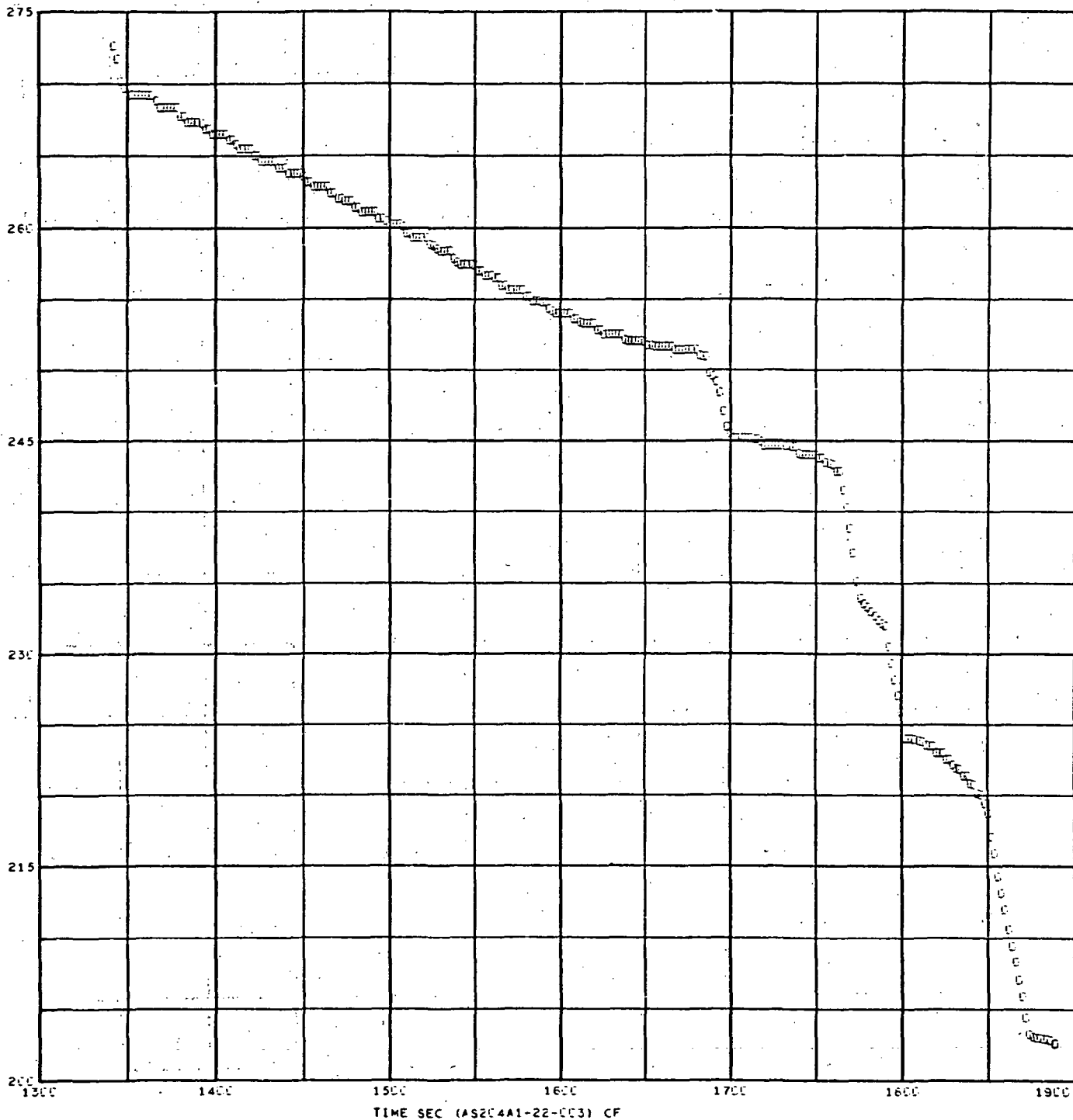
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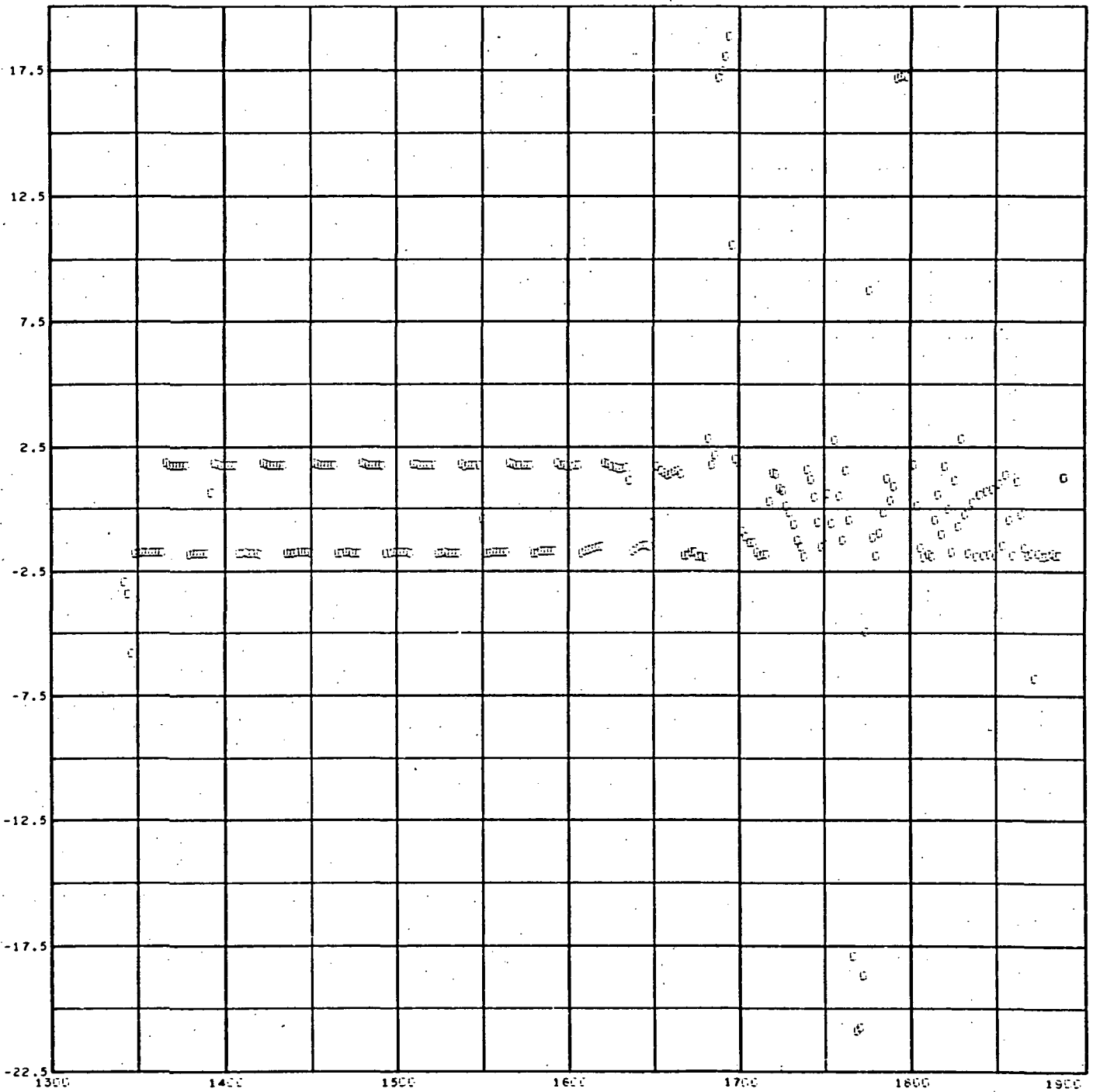
MIDDLE GIM ANGLE IN DEGREES



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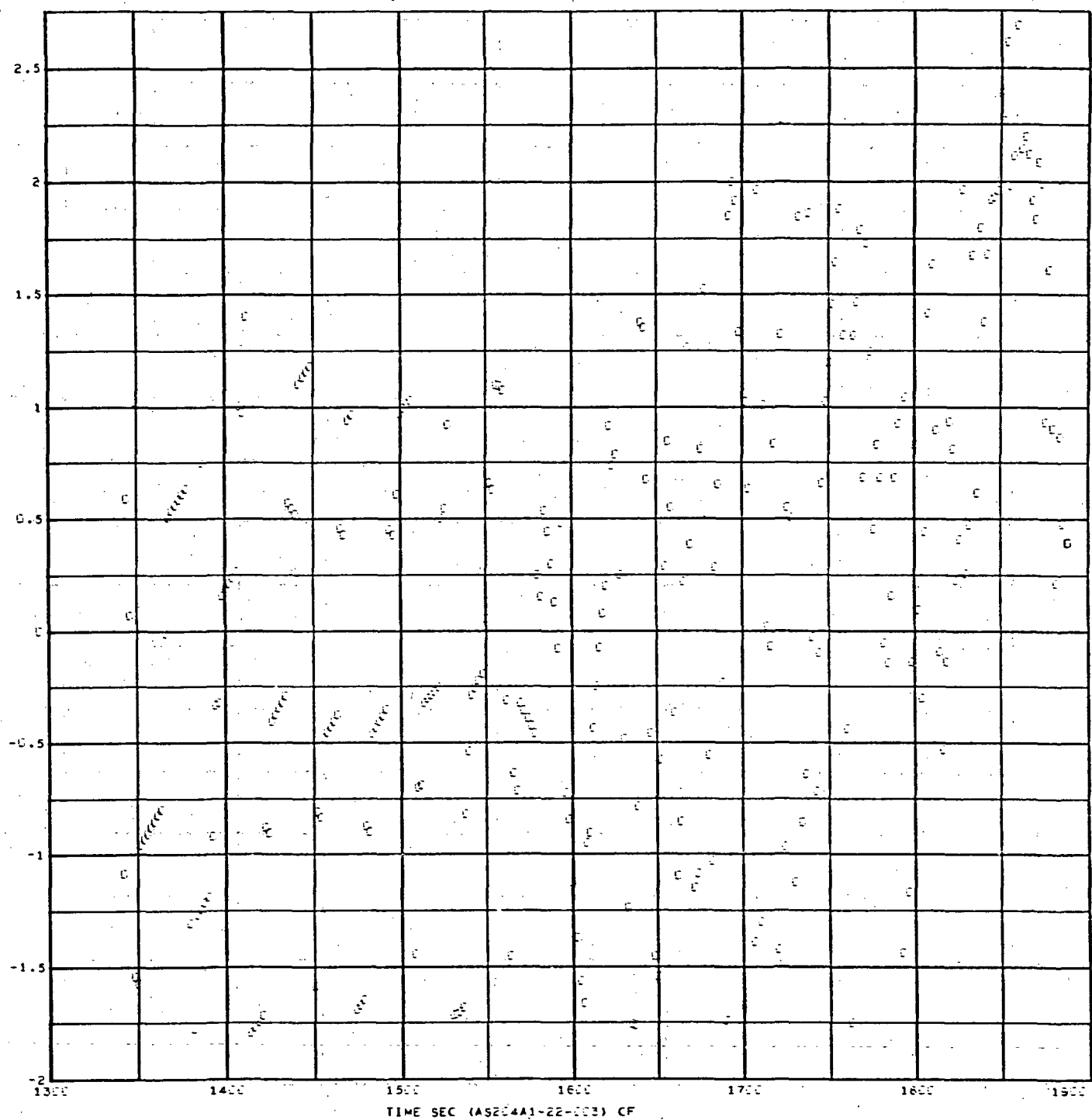


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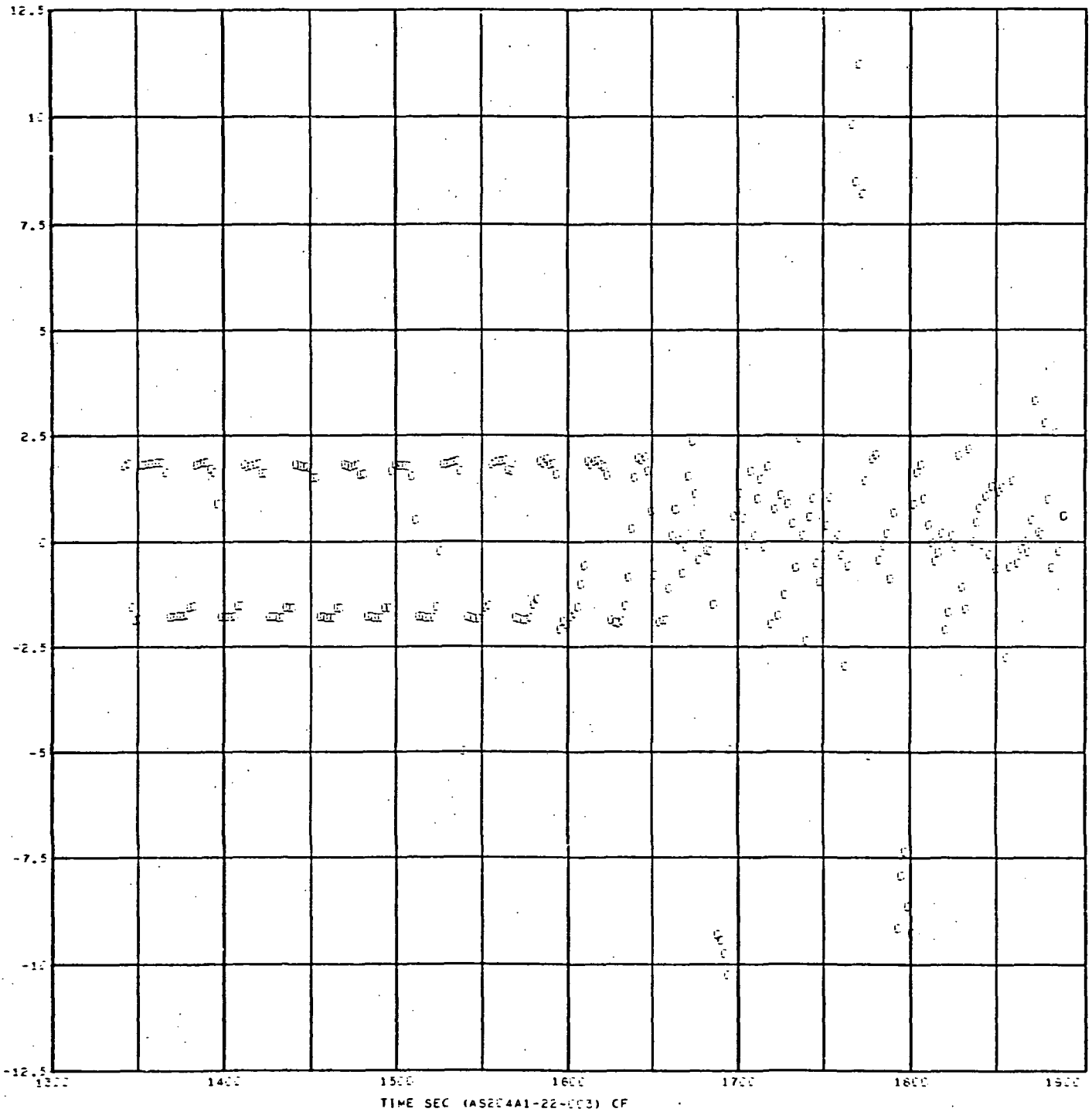


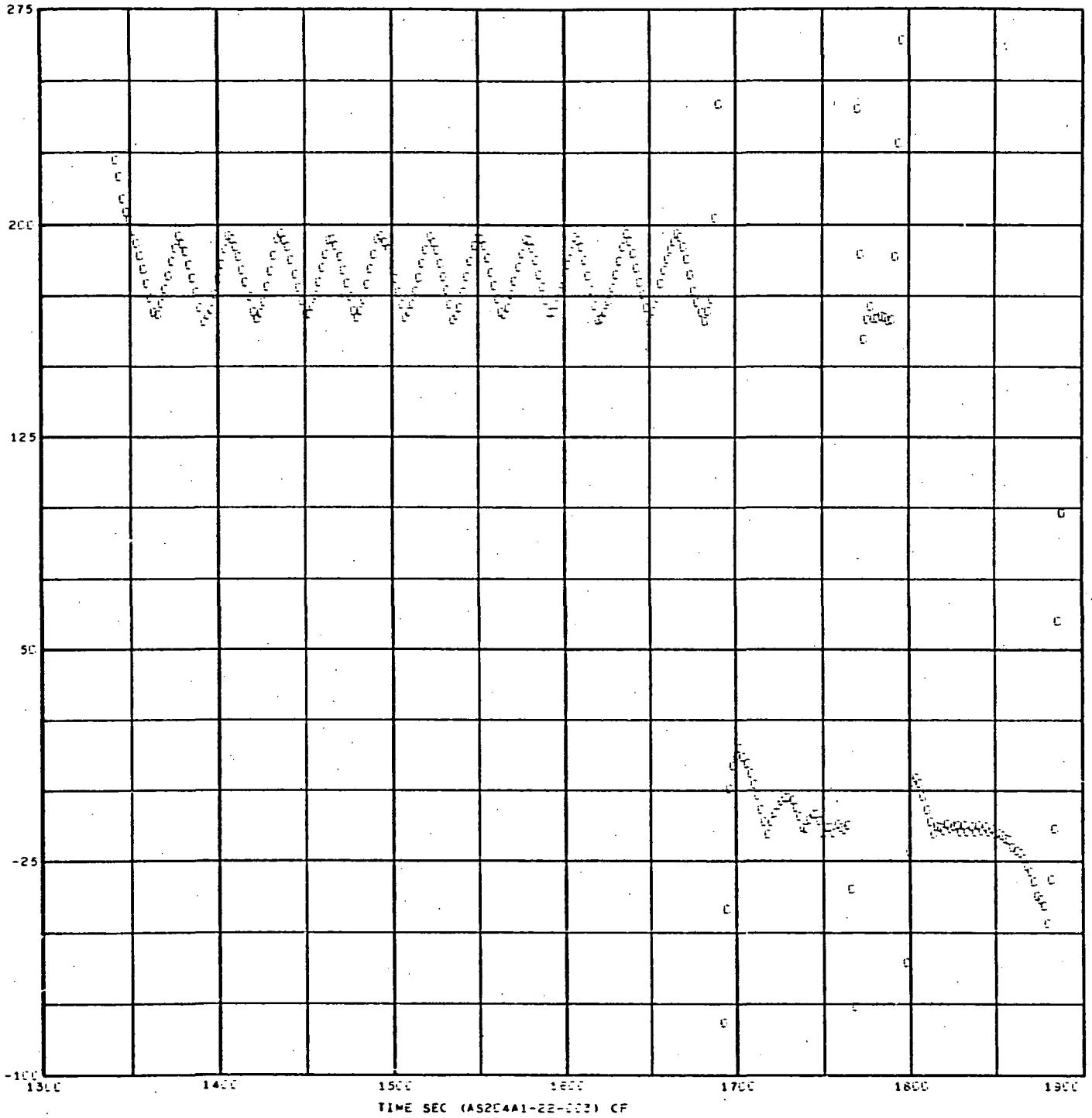
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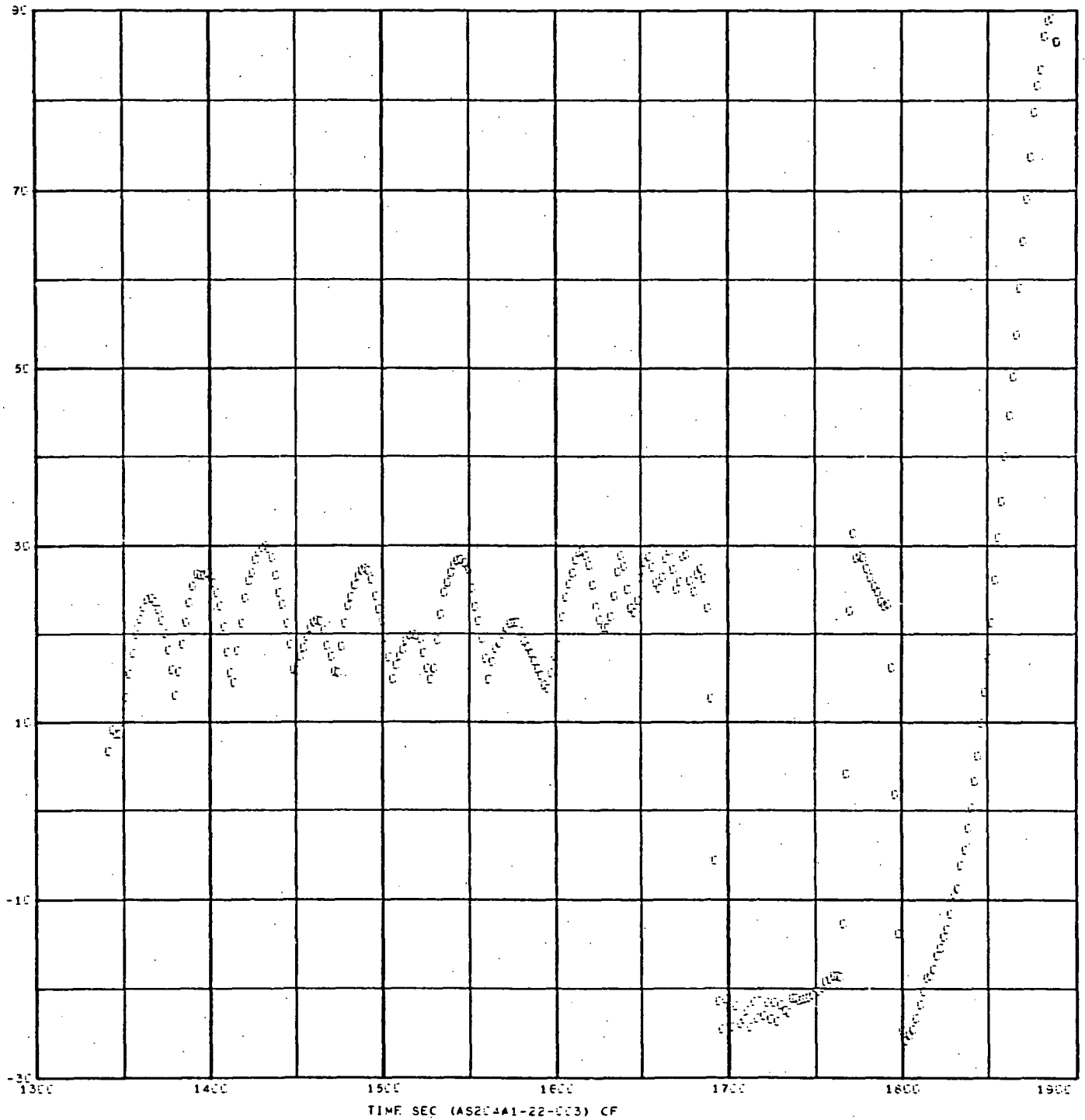


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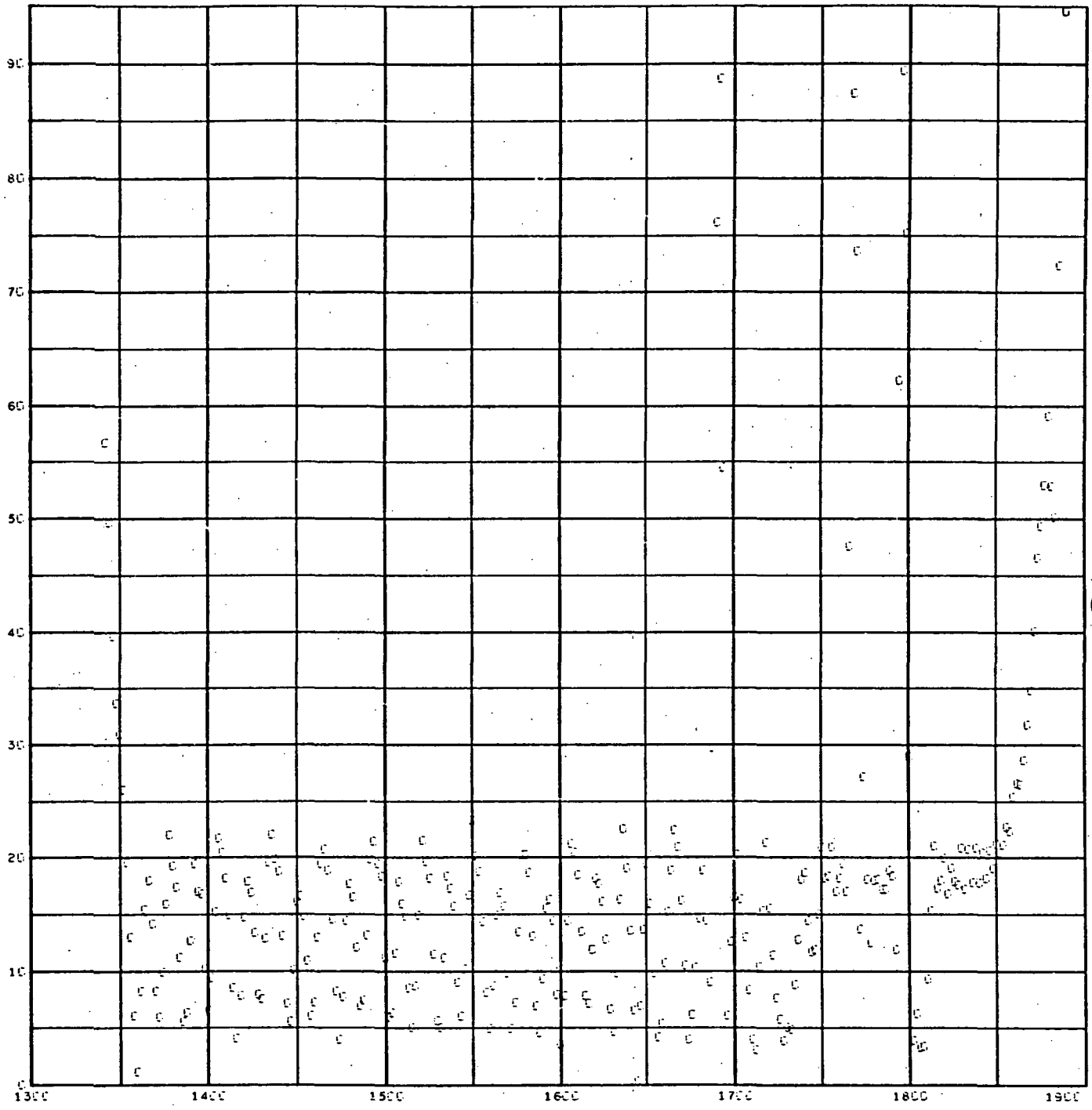




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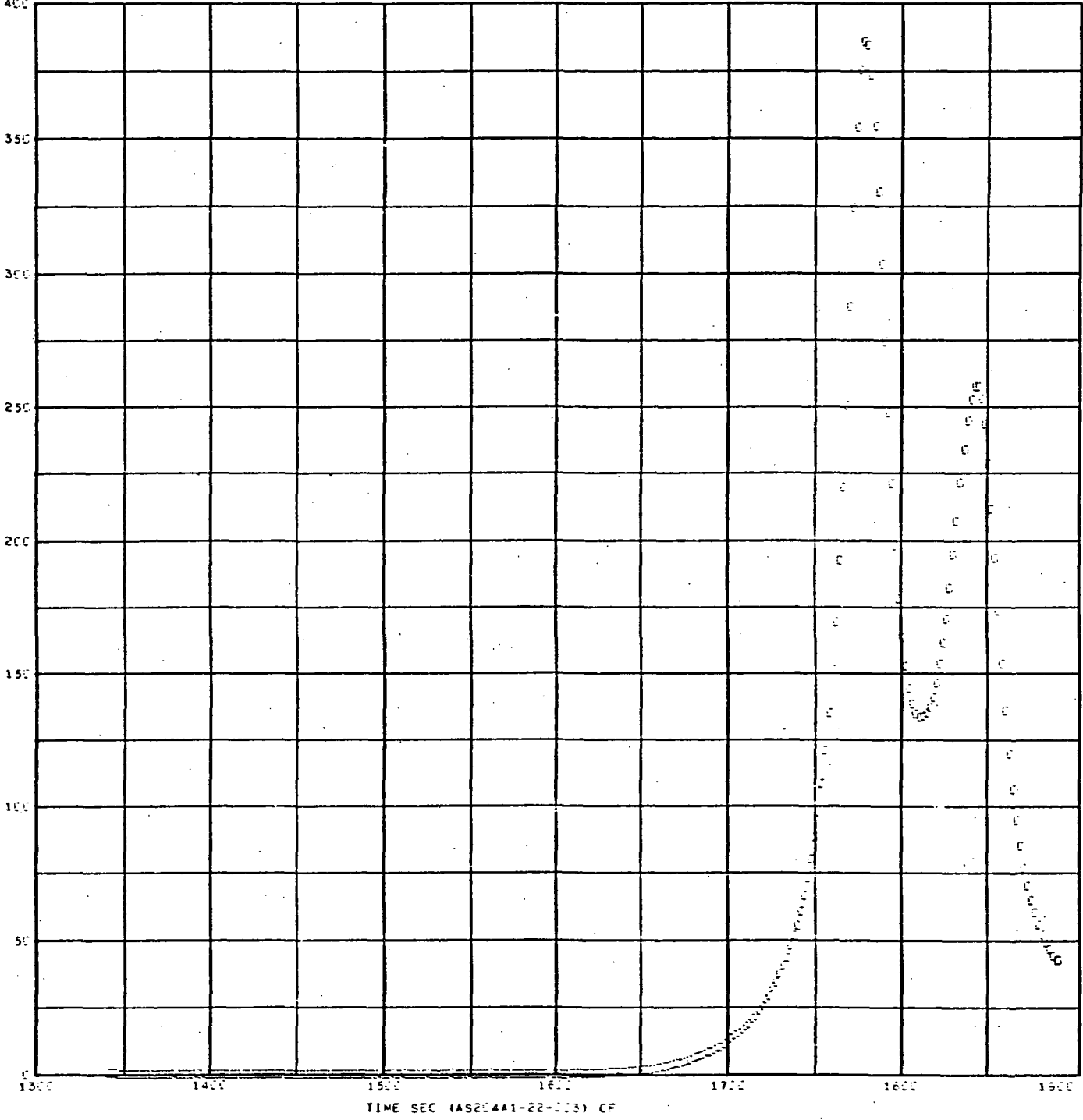
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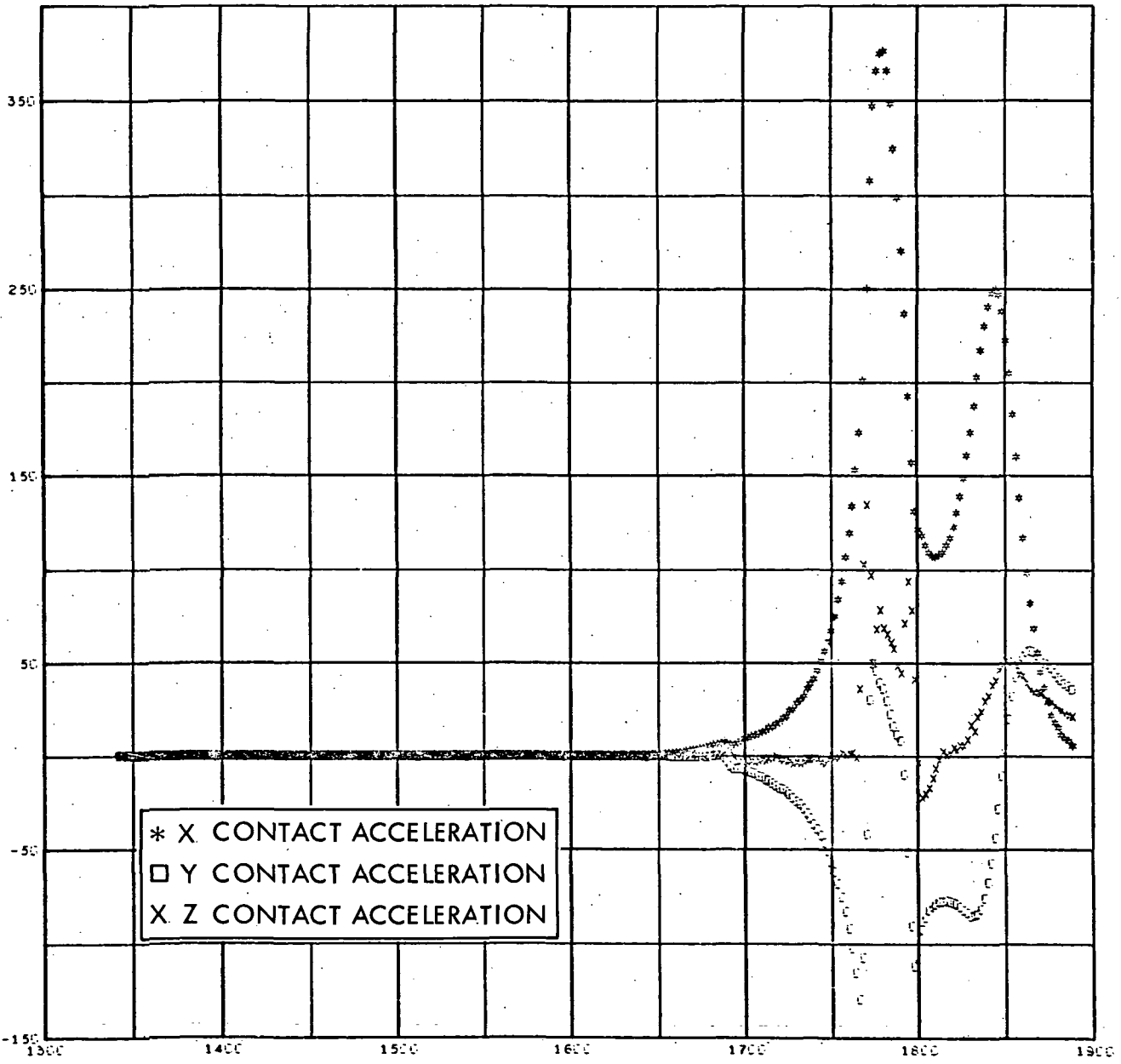
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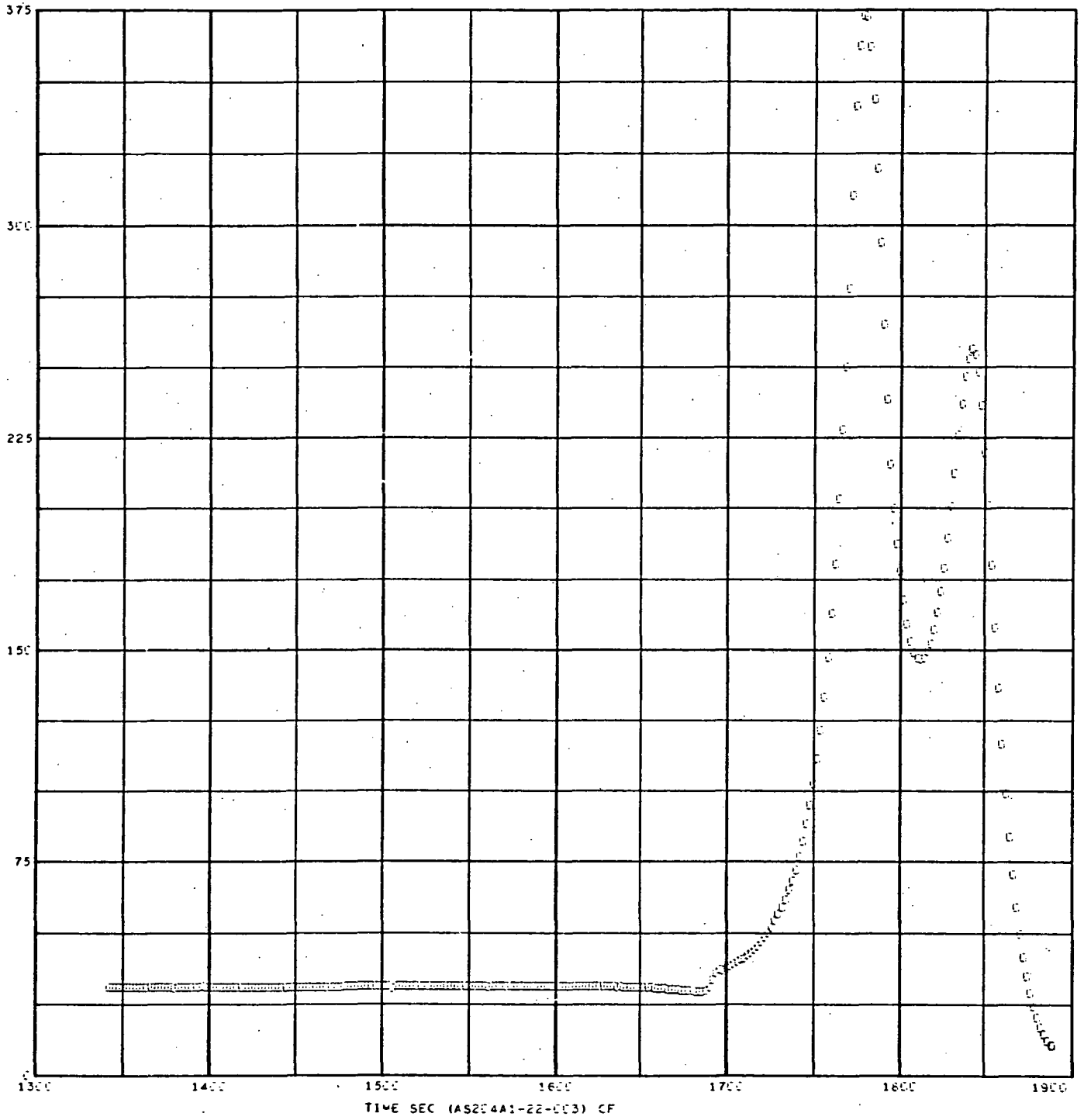


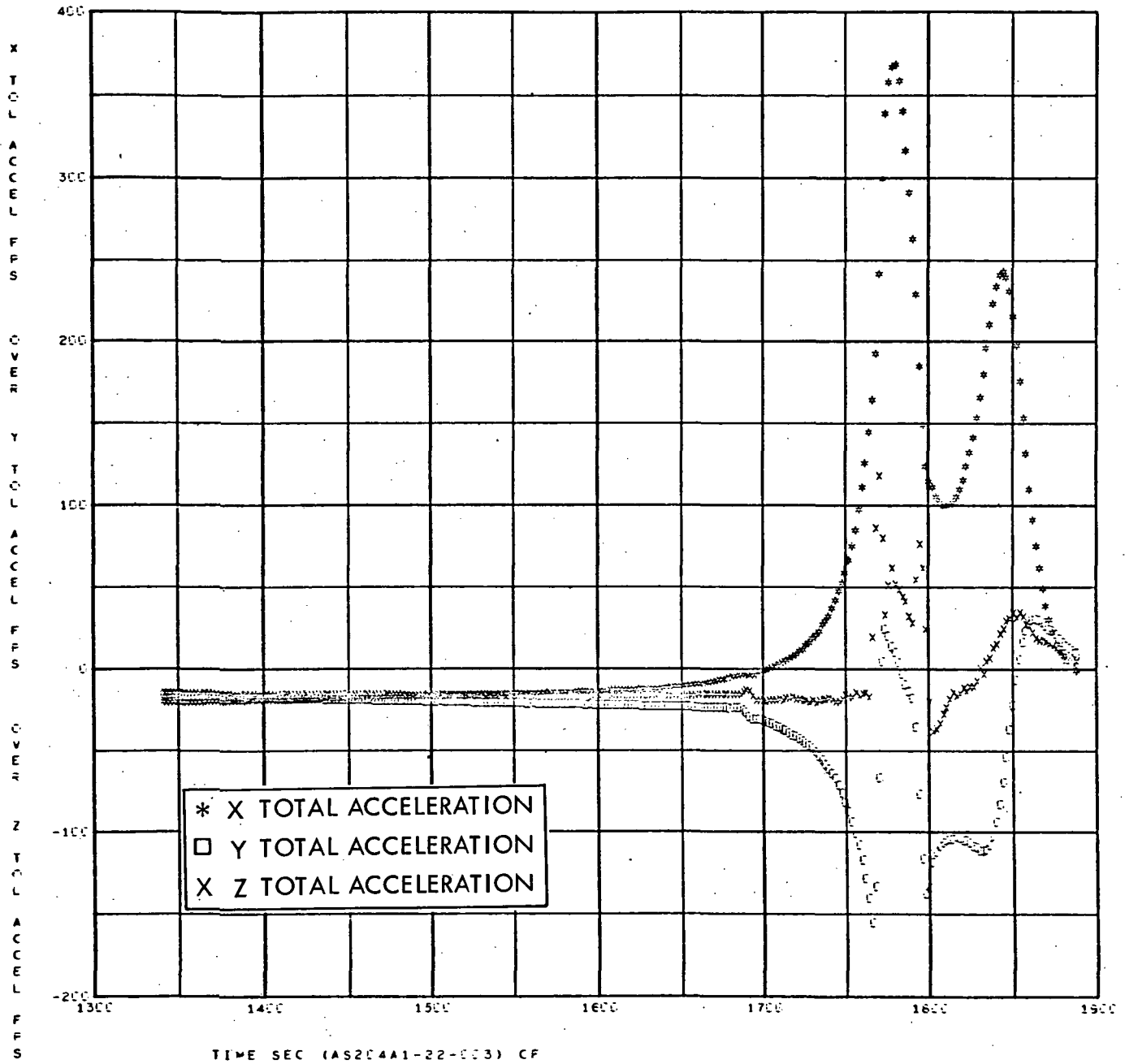
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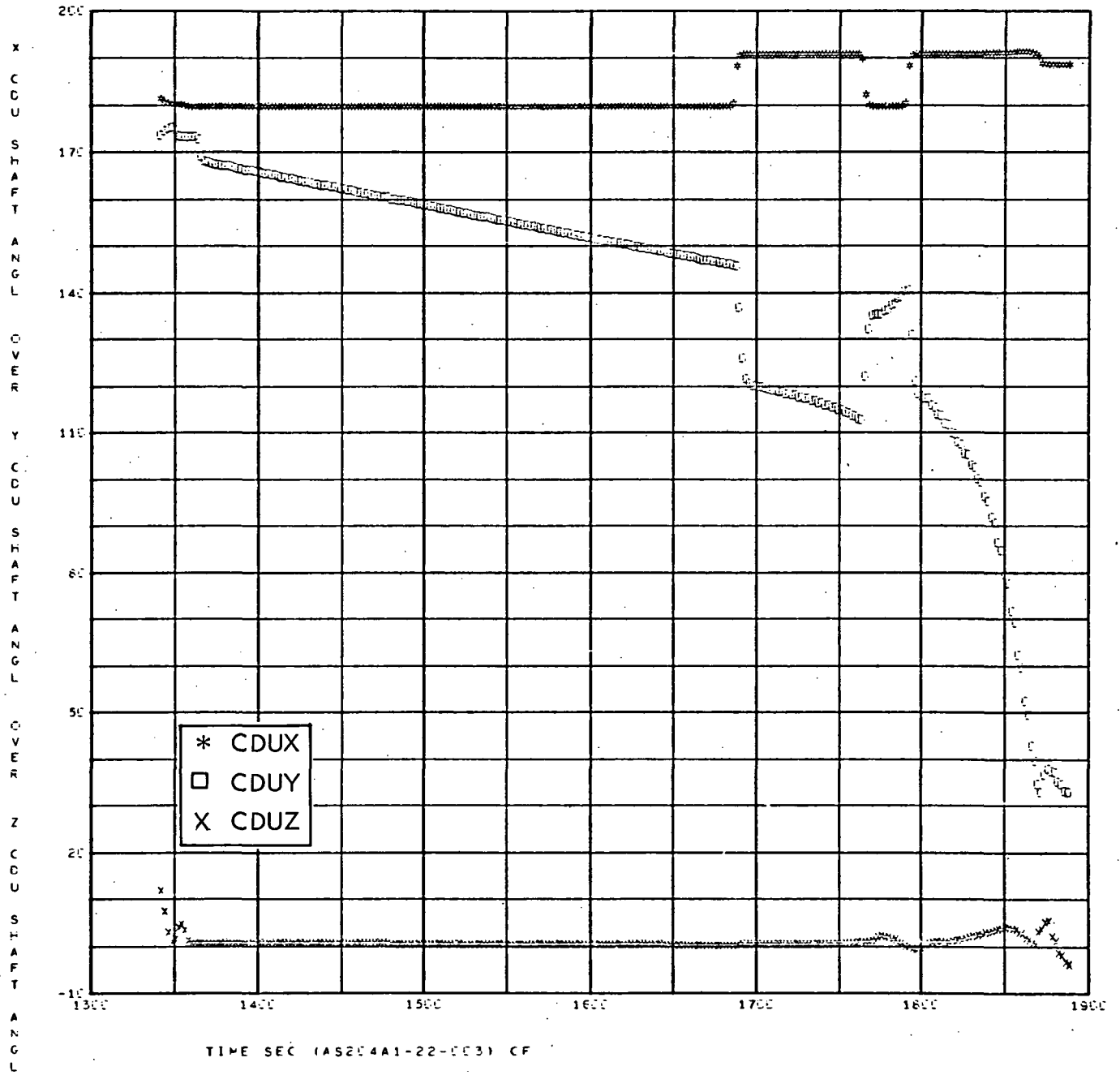


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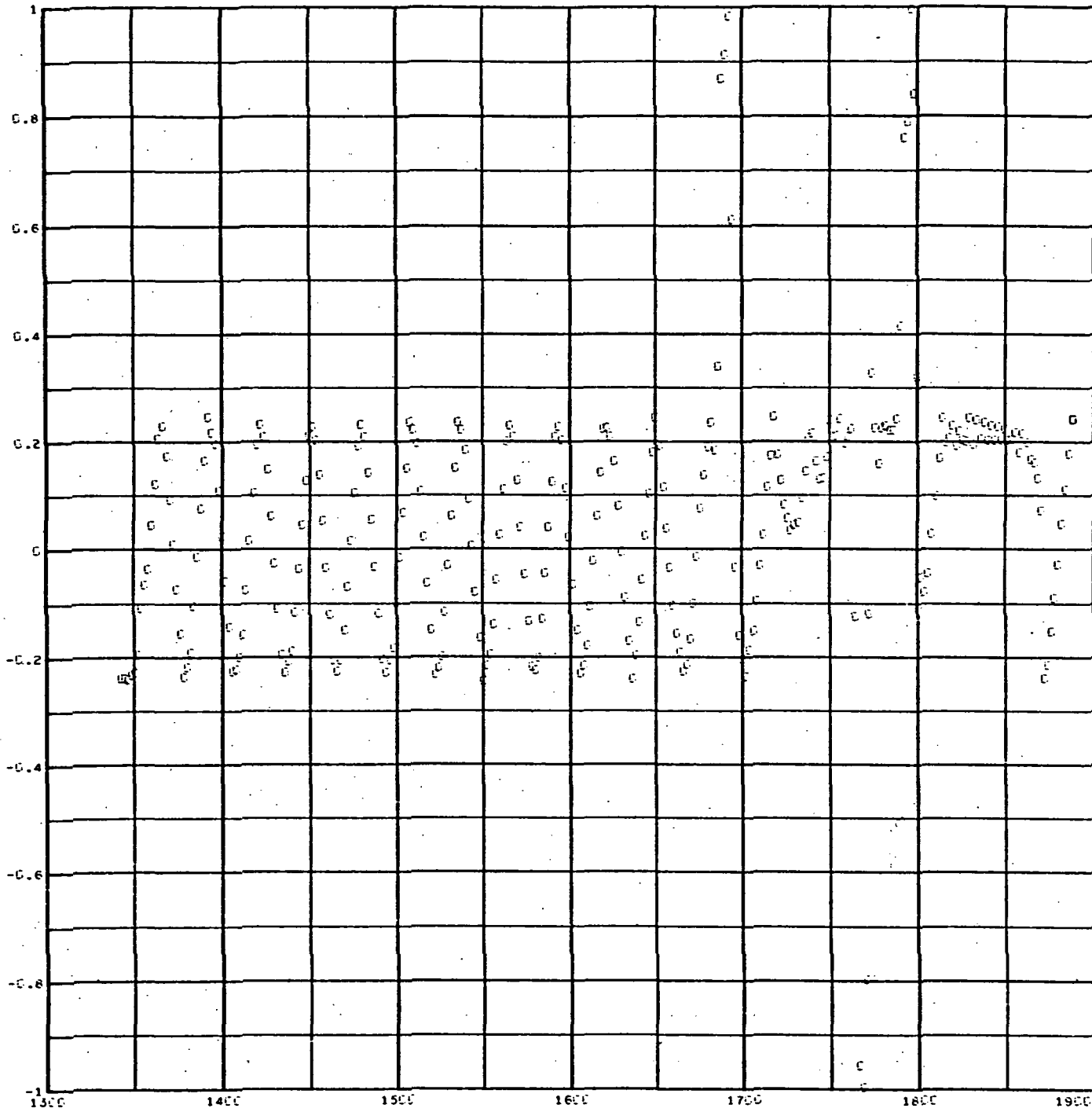
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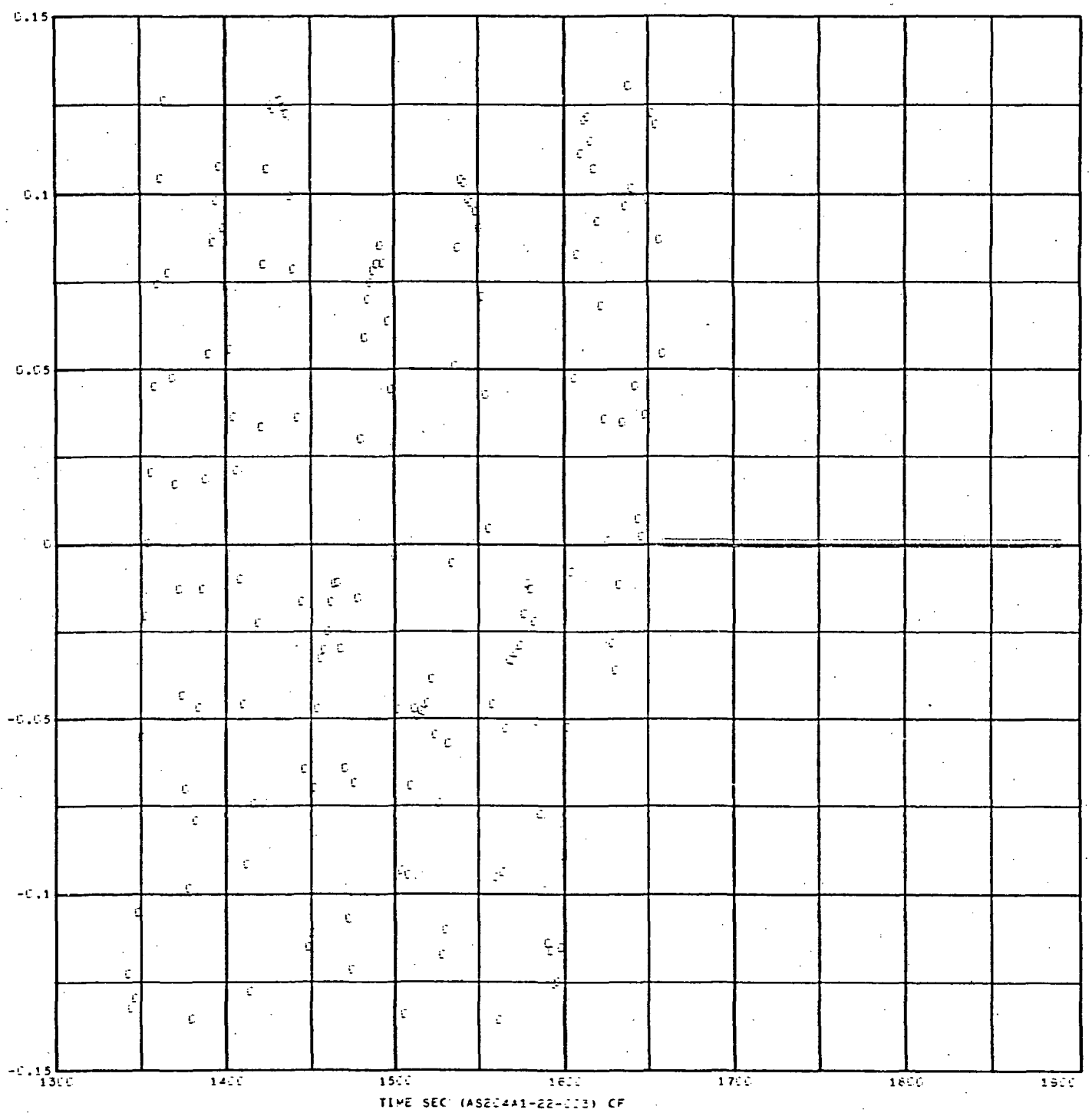




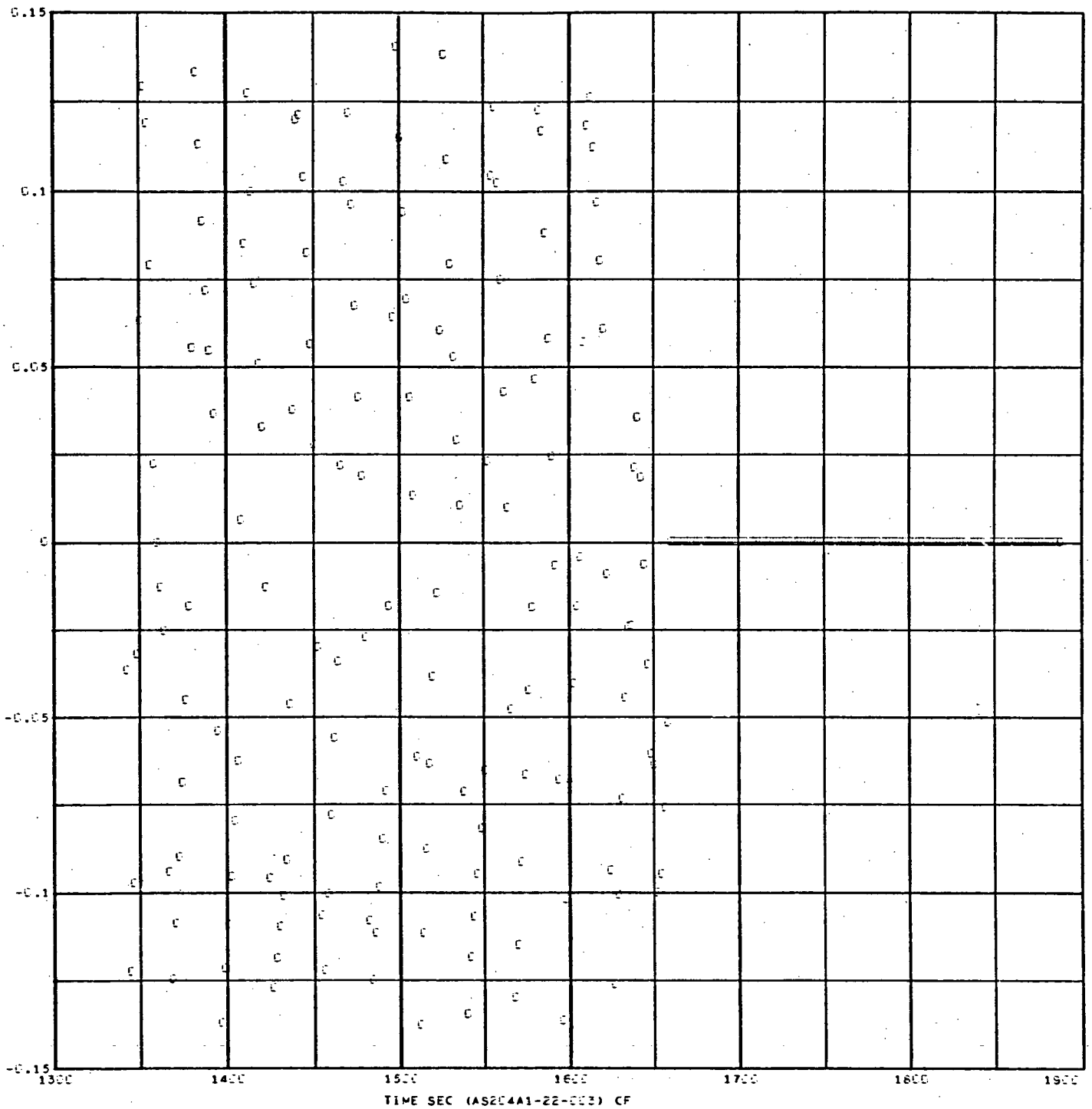
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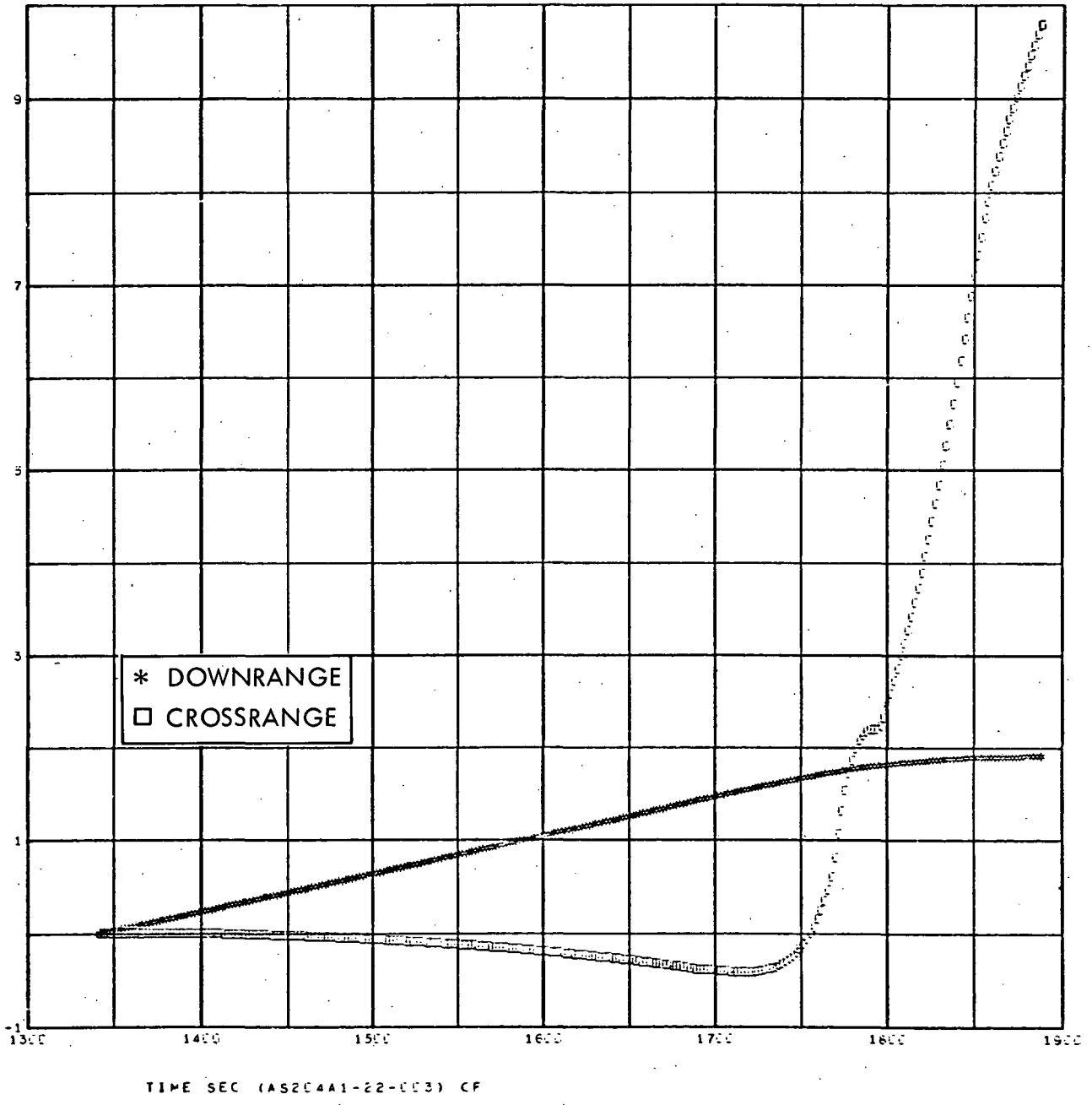
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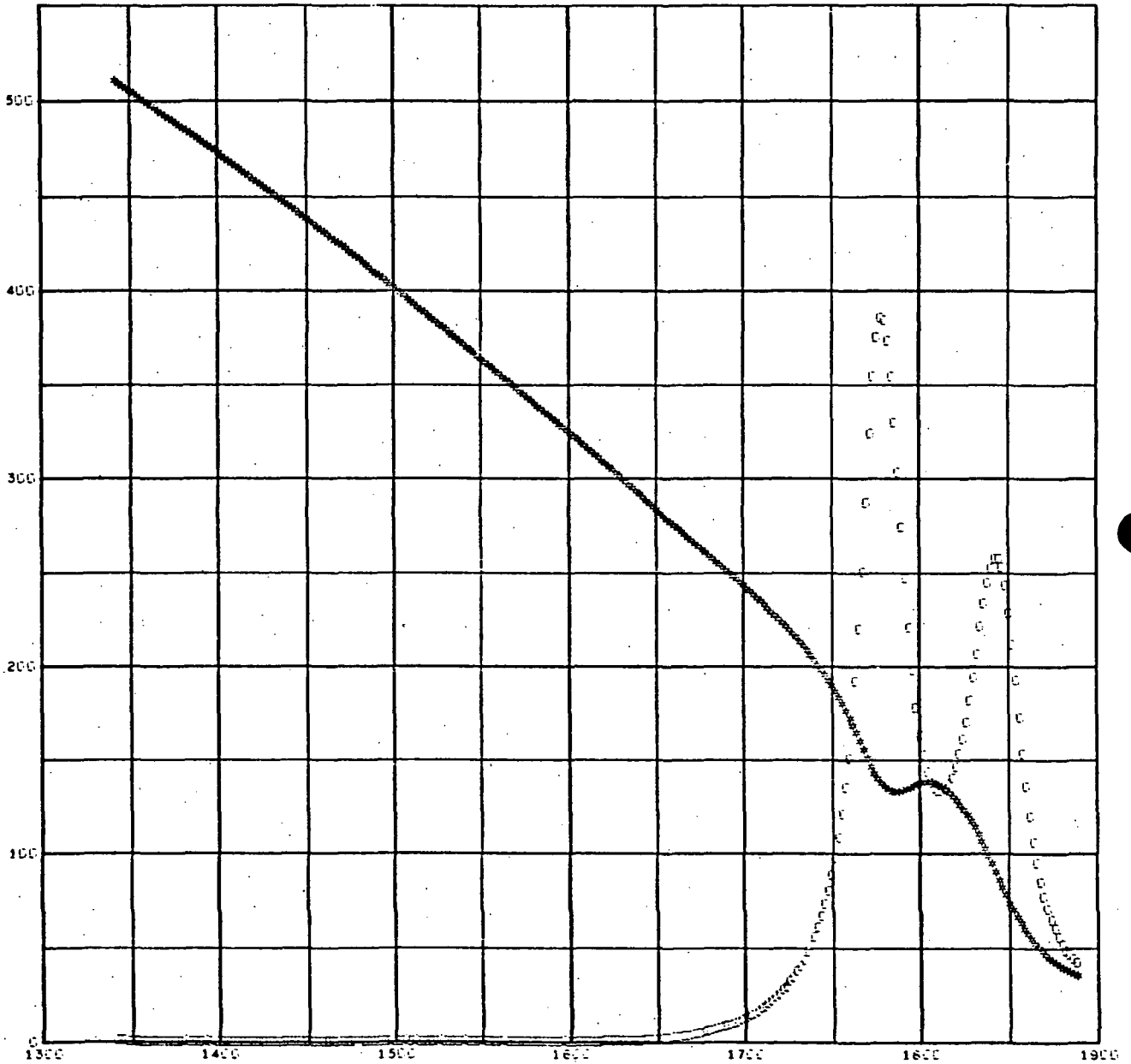
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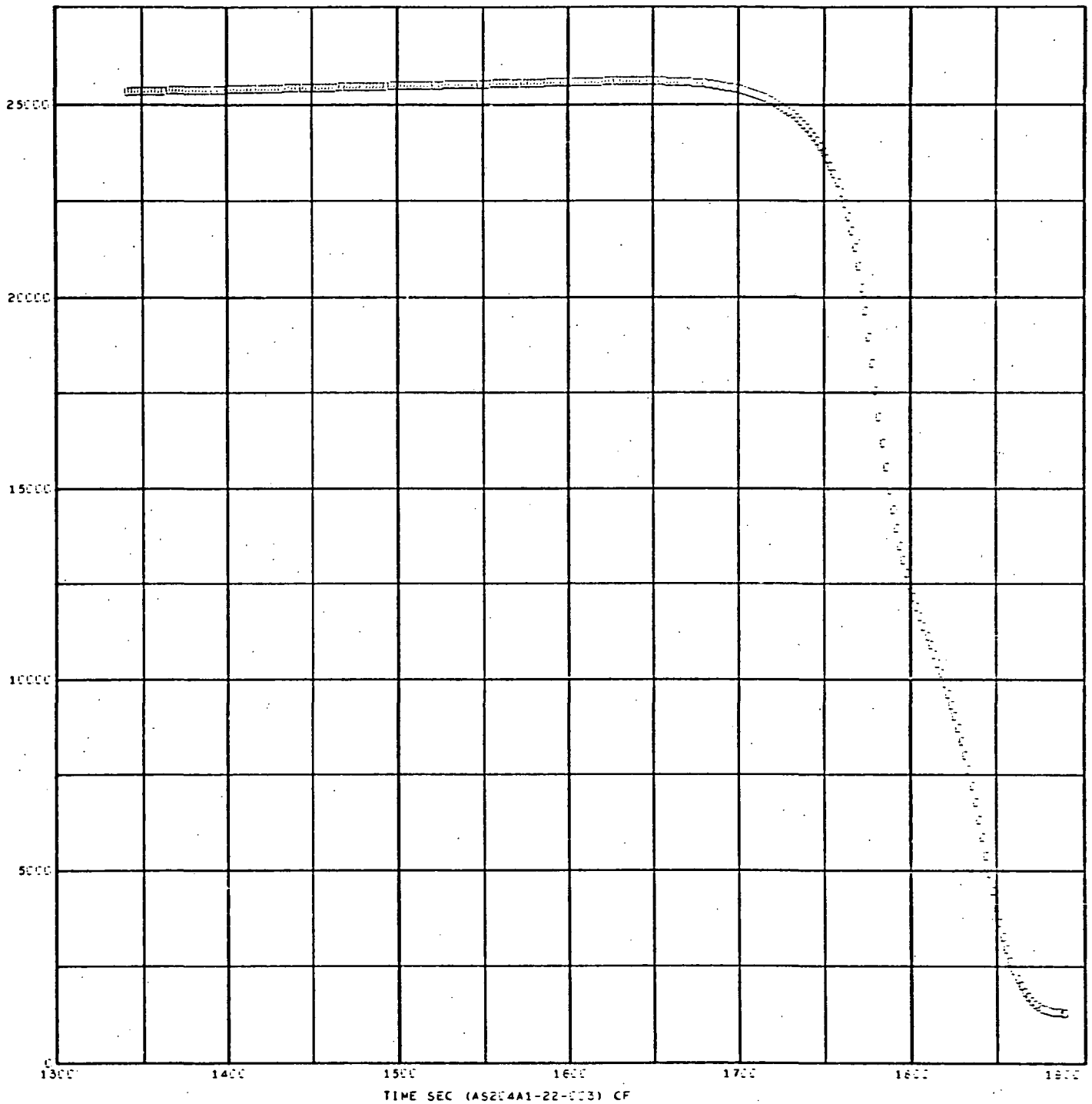


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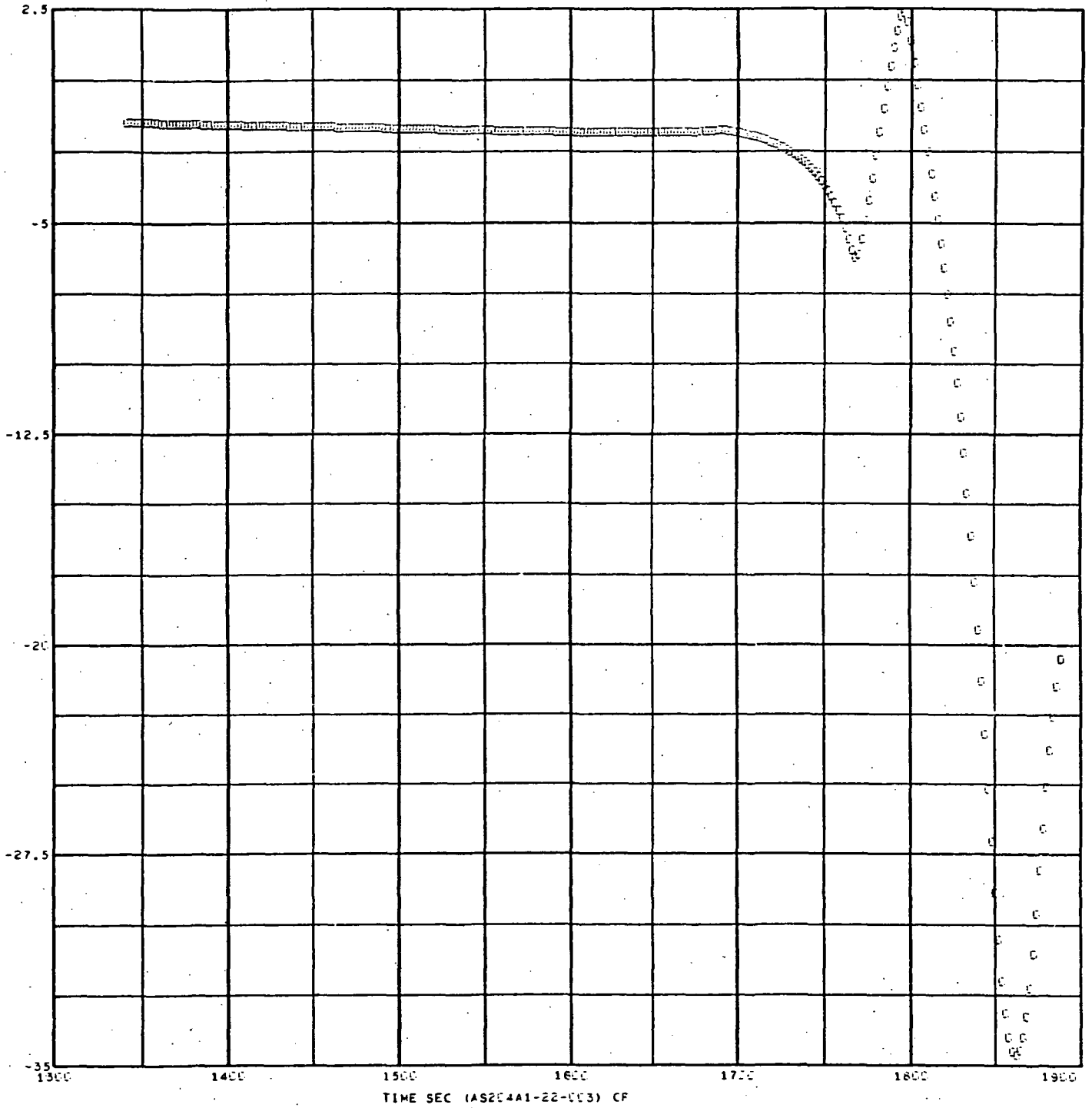
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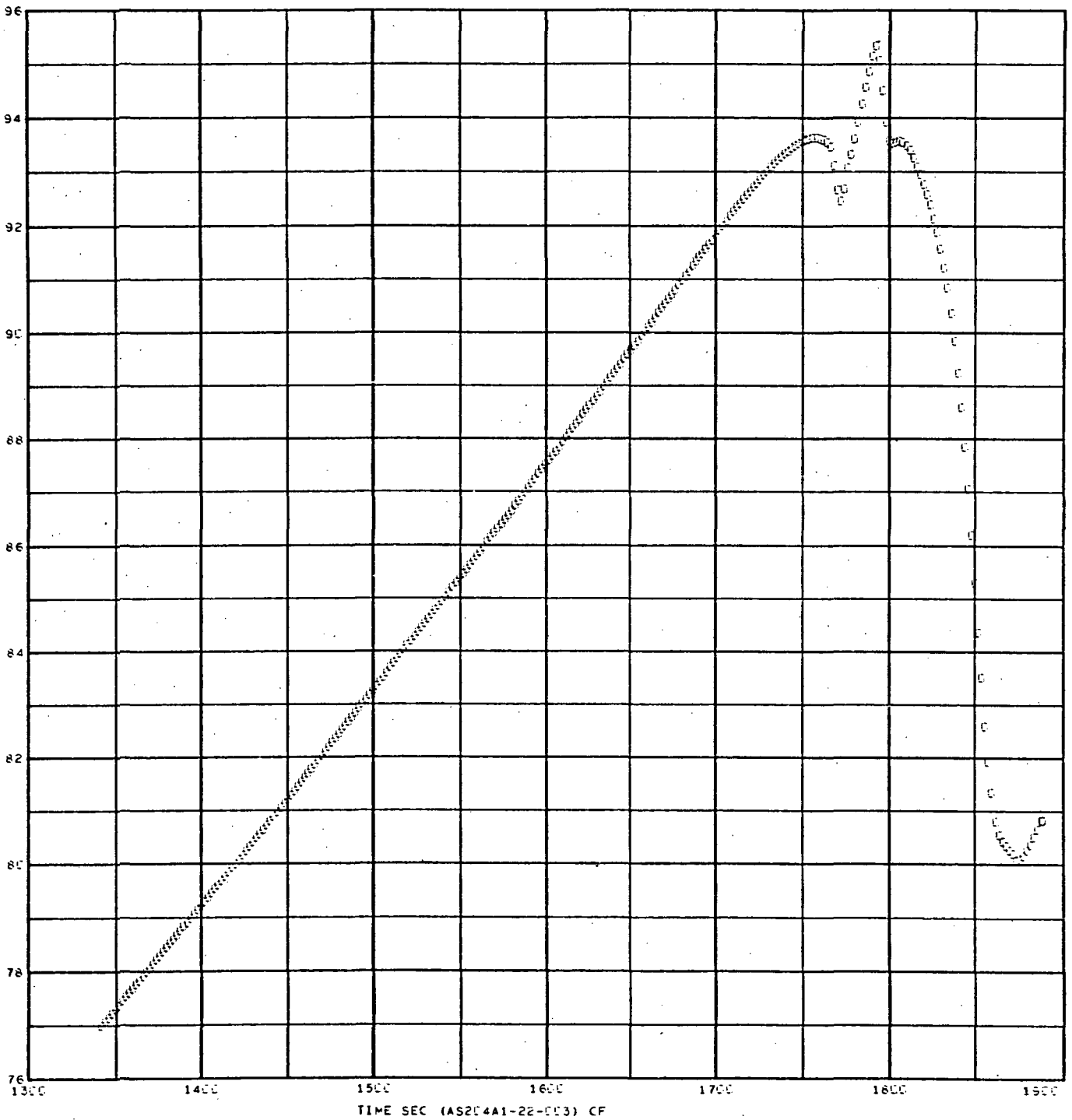
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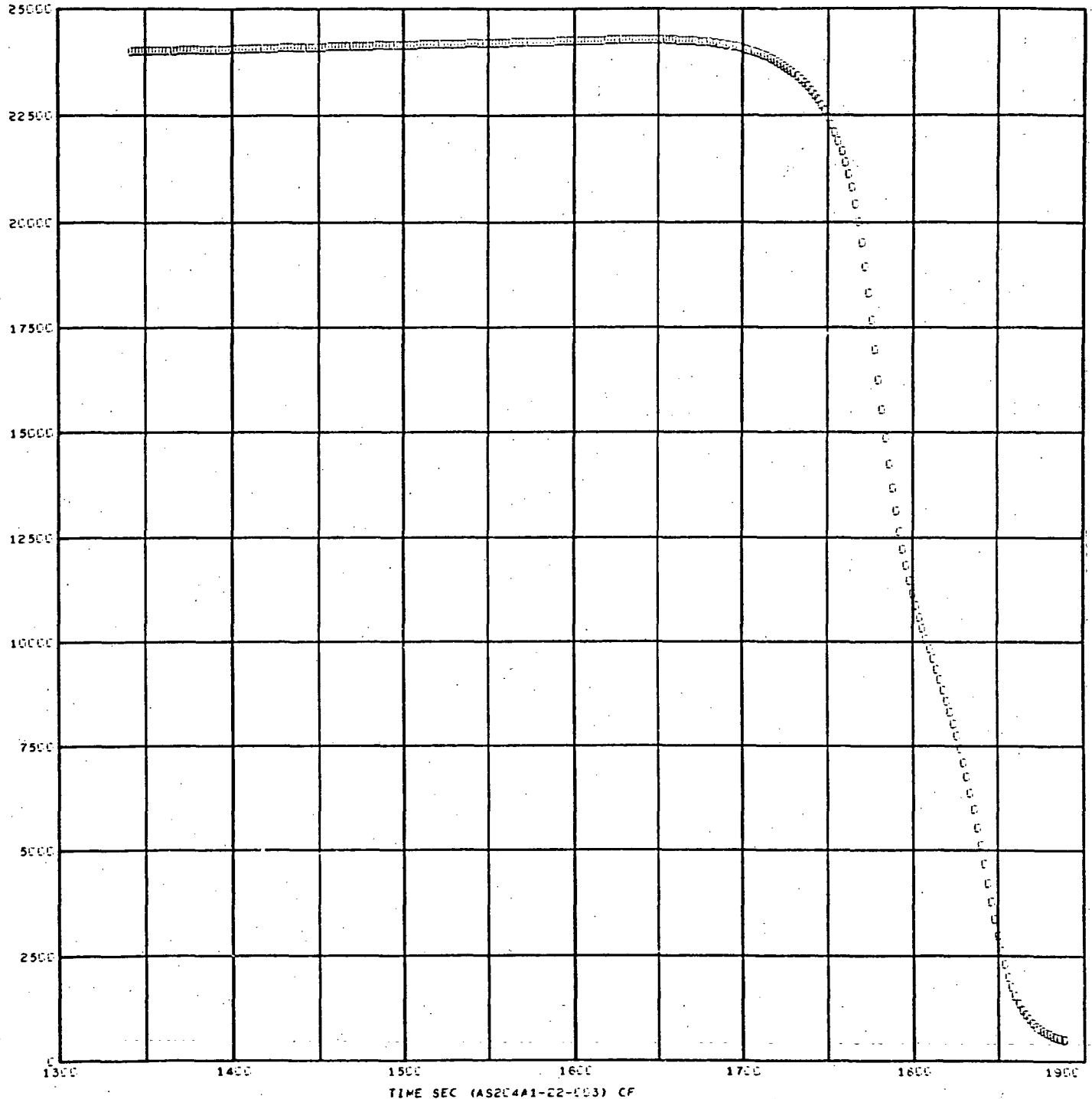
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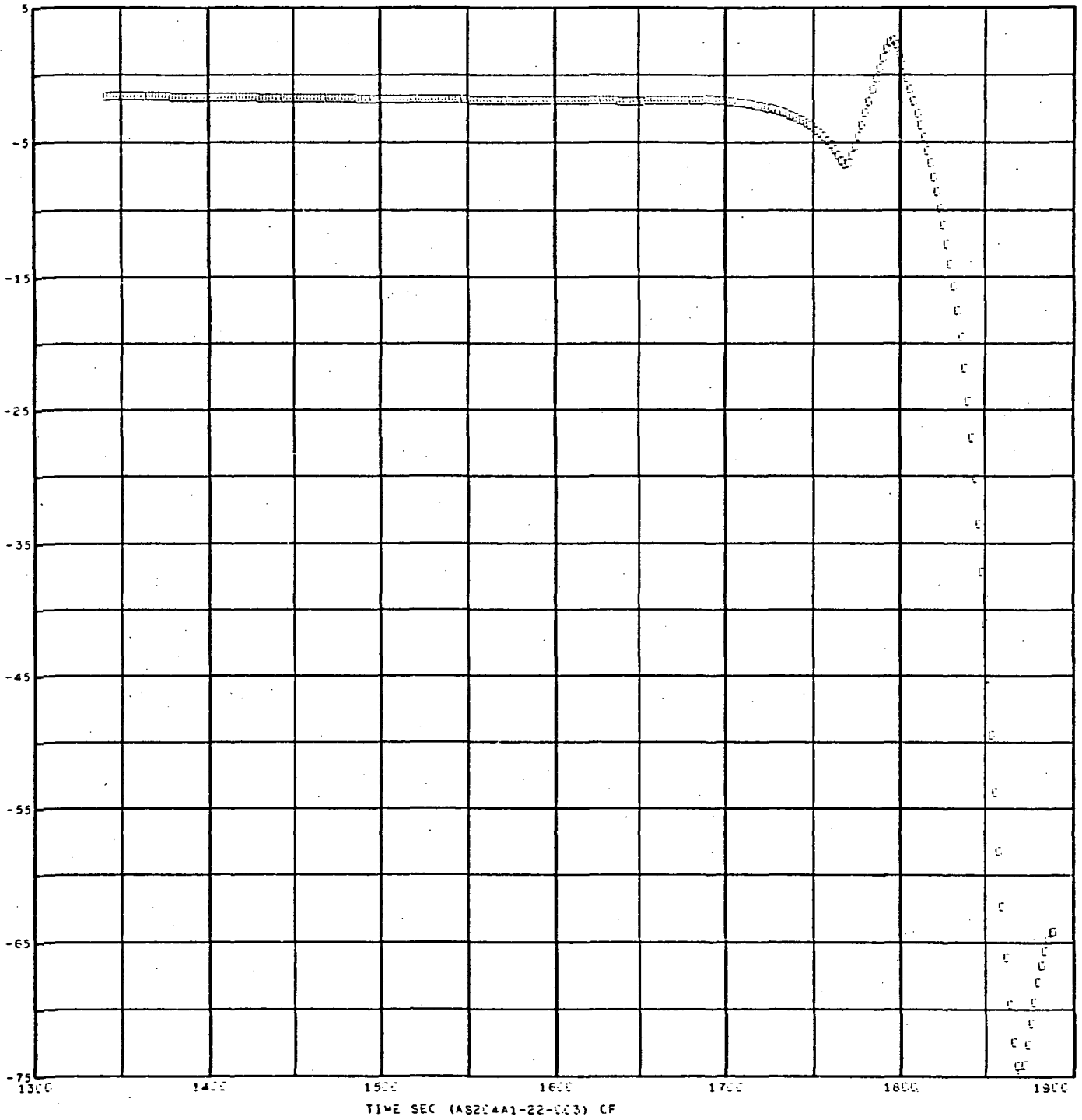
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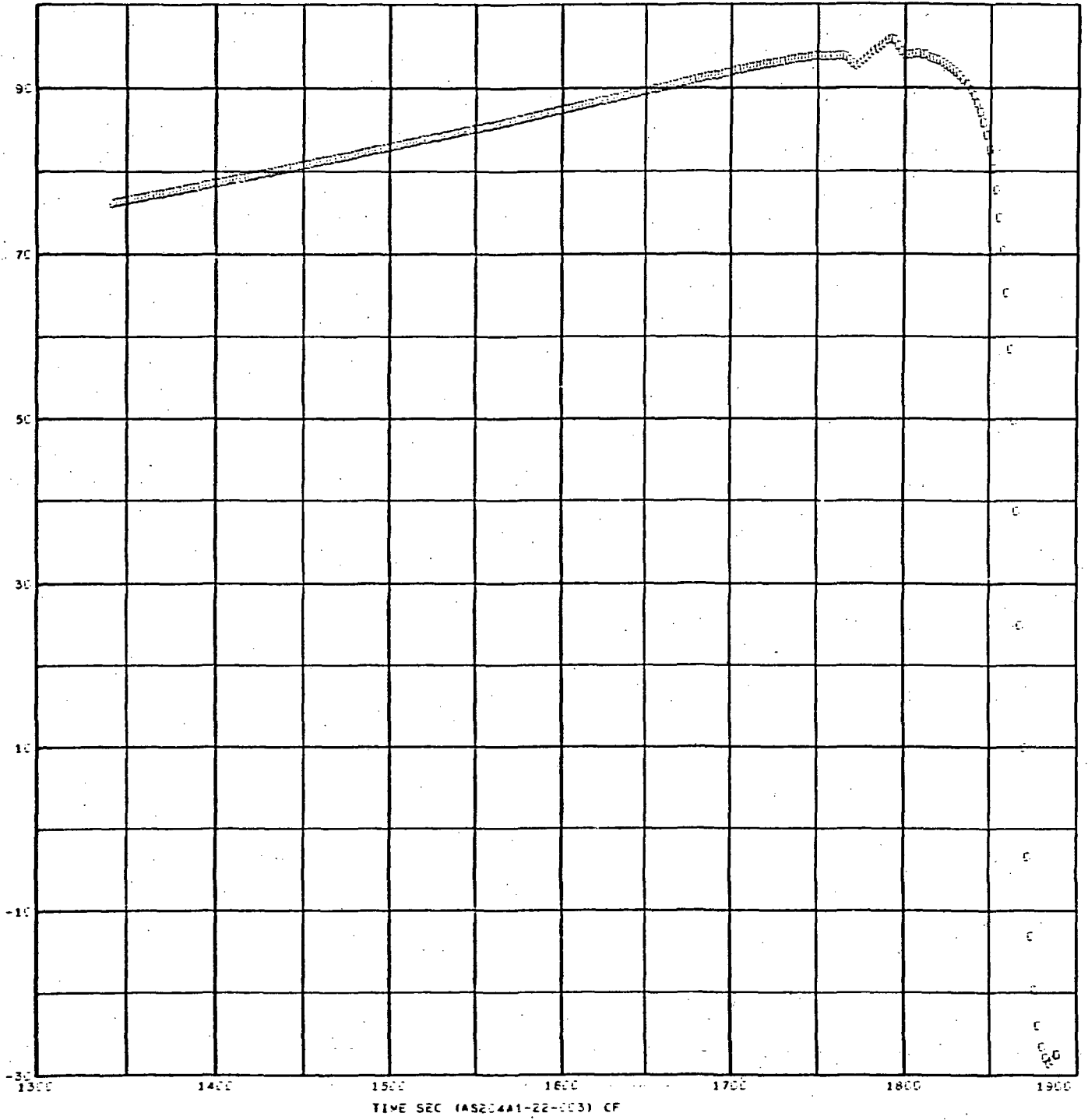


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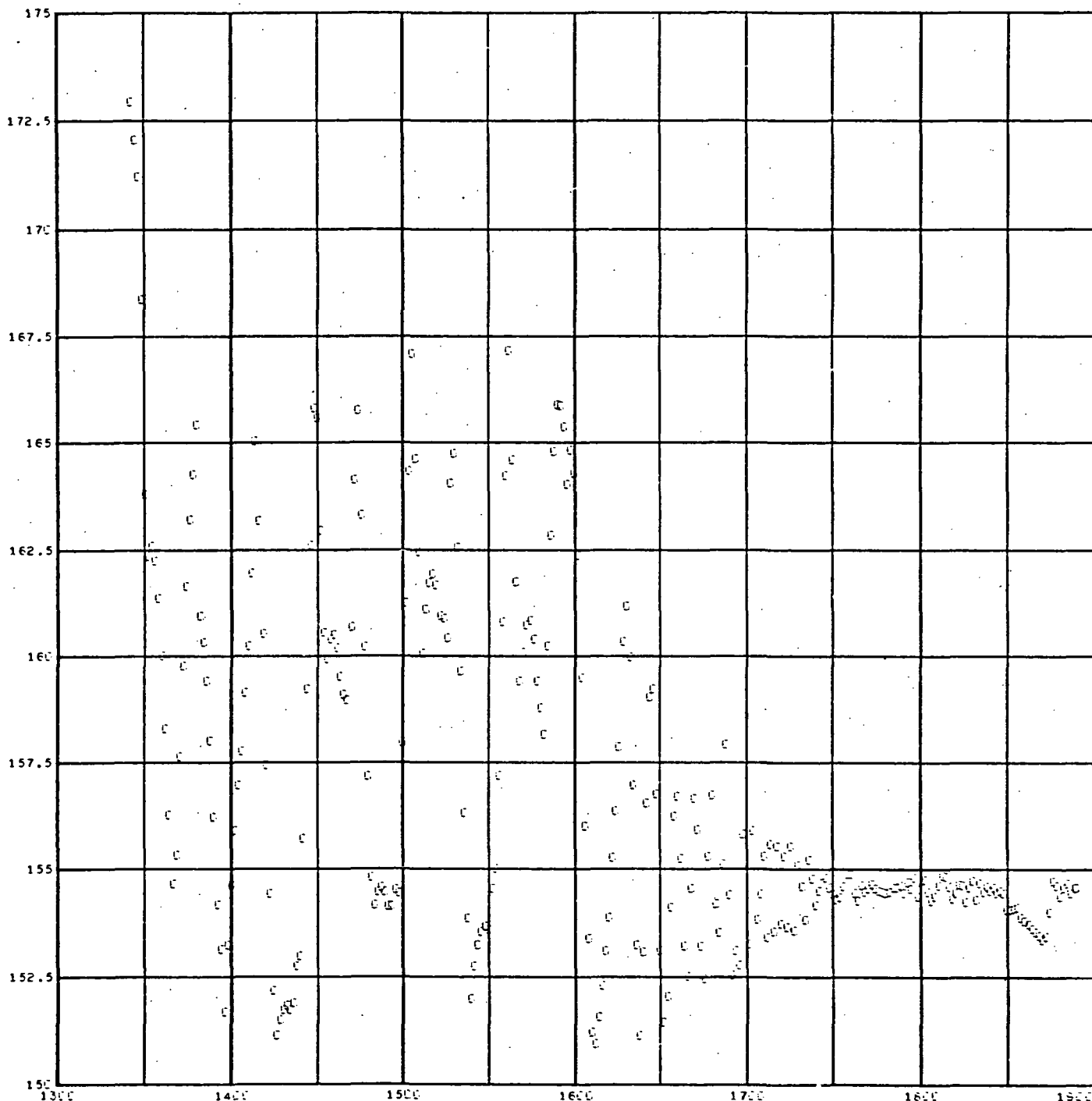
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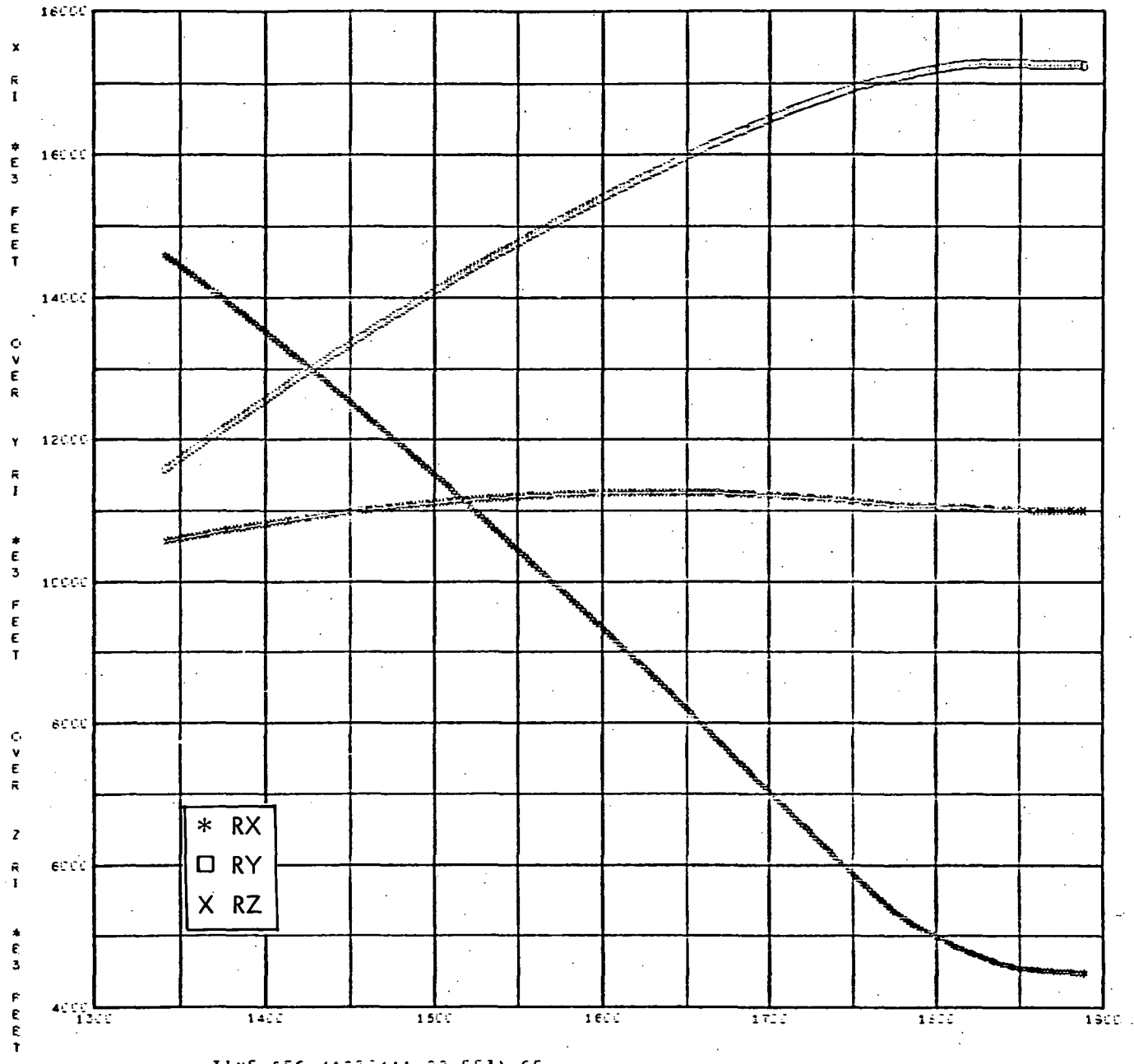
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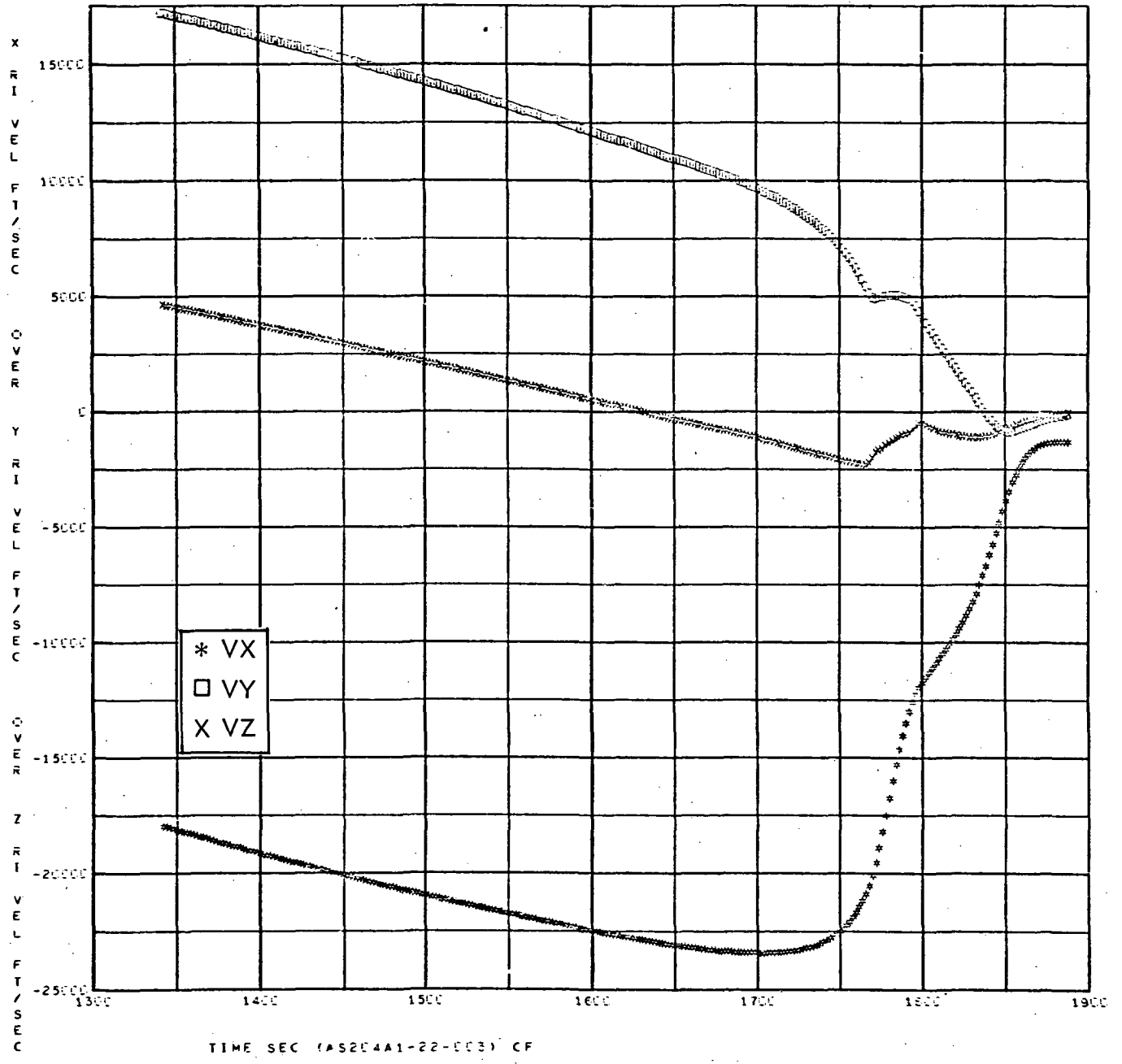
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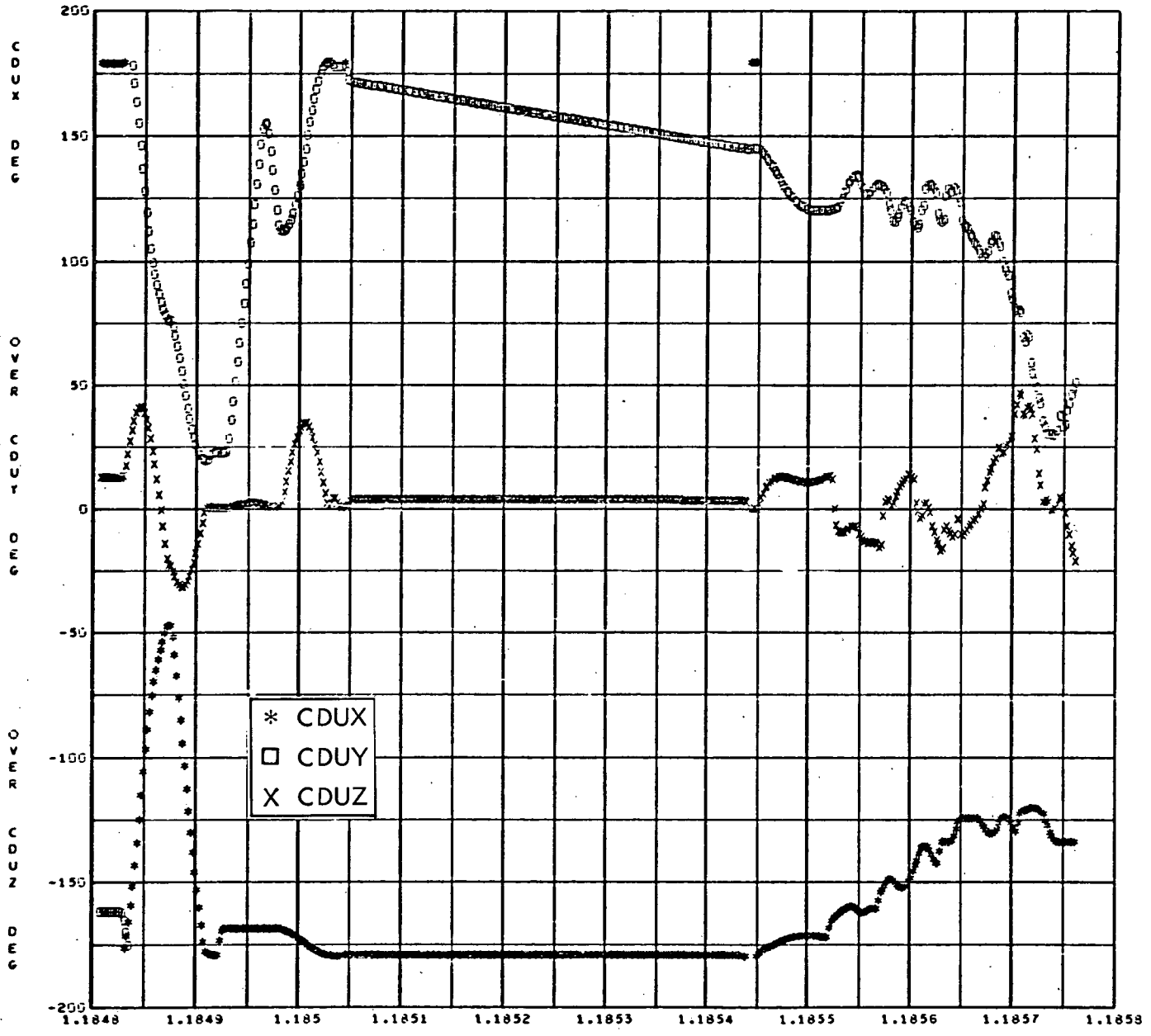
APPENDIX G

PLOTS OF OFF-NOMINAL TRAJECTORY FOR A
COMMAND MODULE CG OFFSET DURING ENTRY

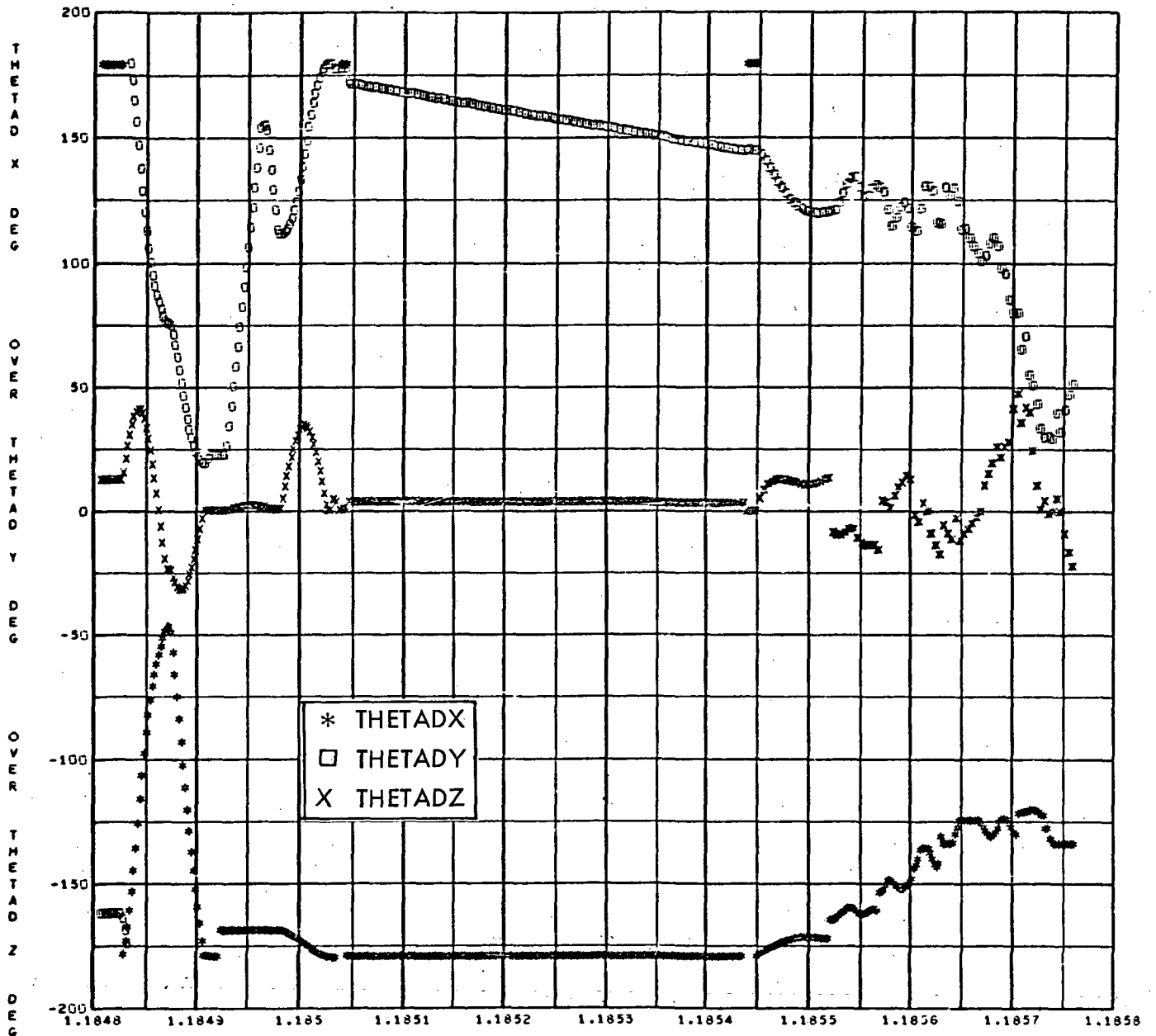
AS-204A1-01-019

AGC PLOTS

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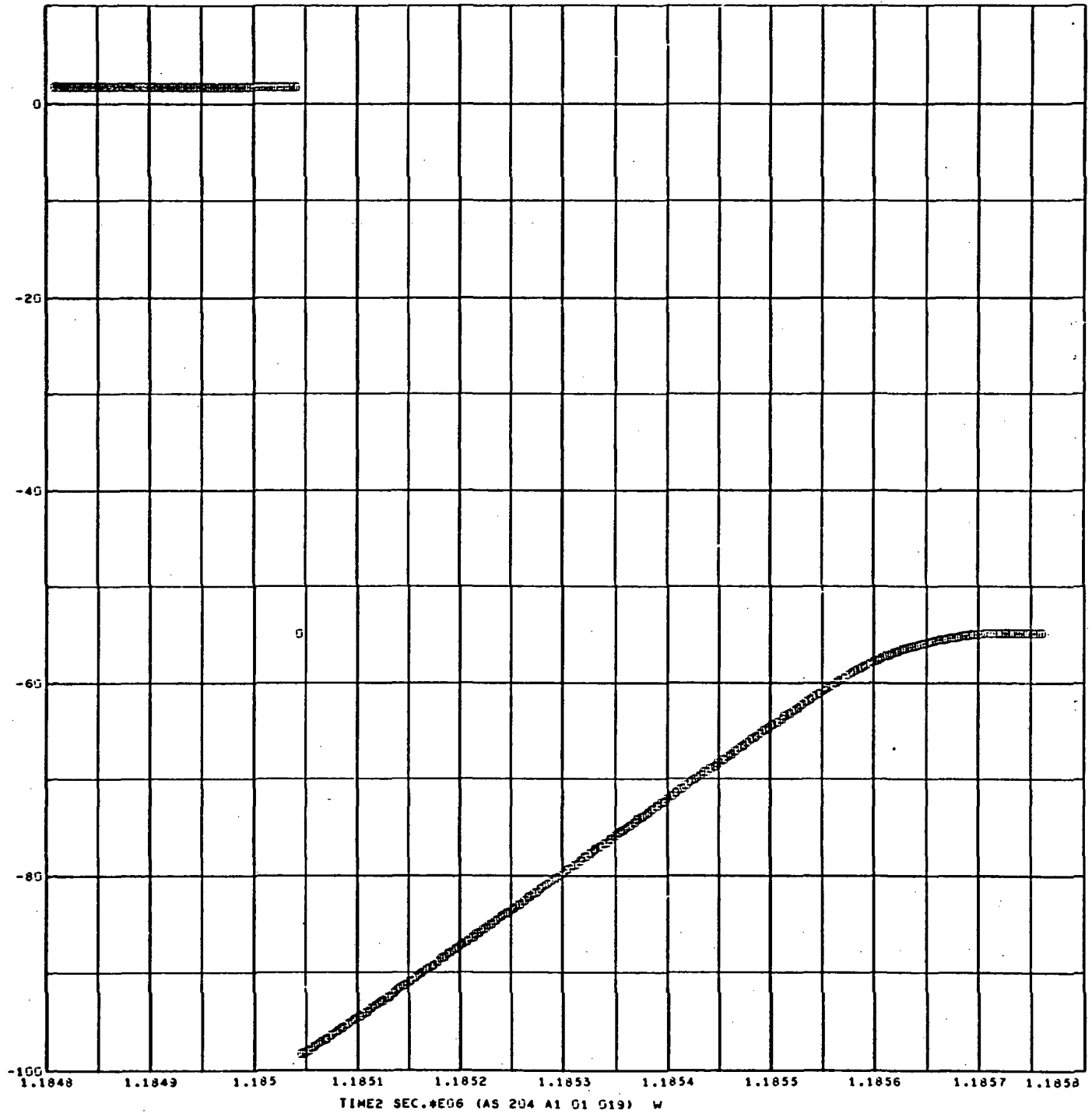


TIME2 SEC.+E06 (AS 204 A1 01 019) W



TIME2 SEC.*E06 (AS 204 A1 01 019) W

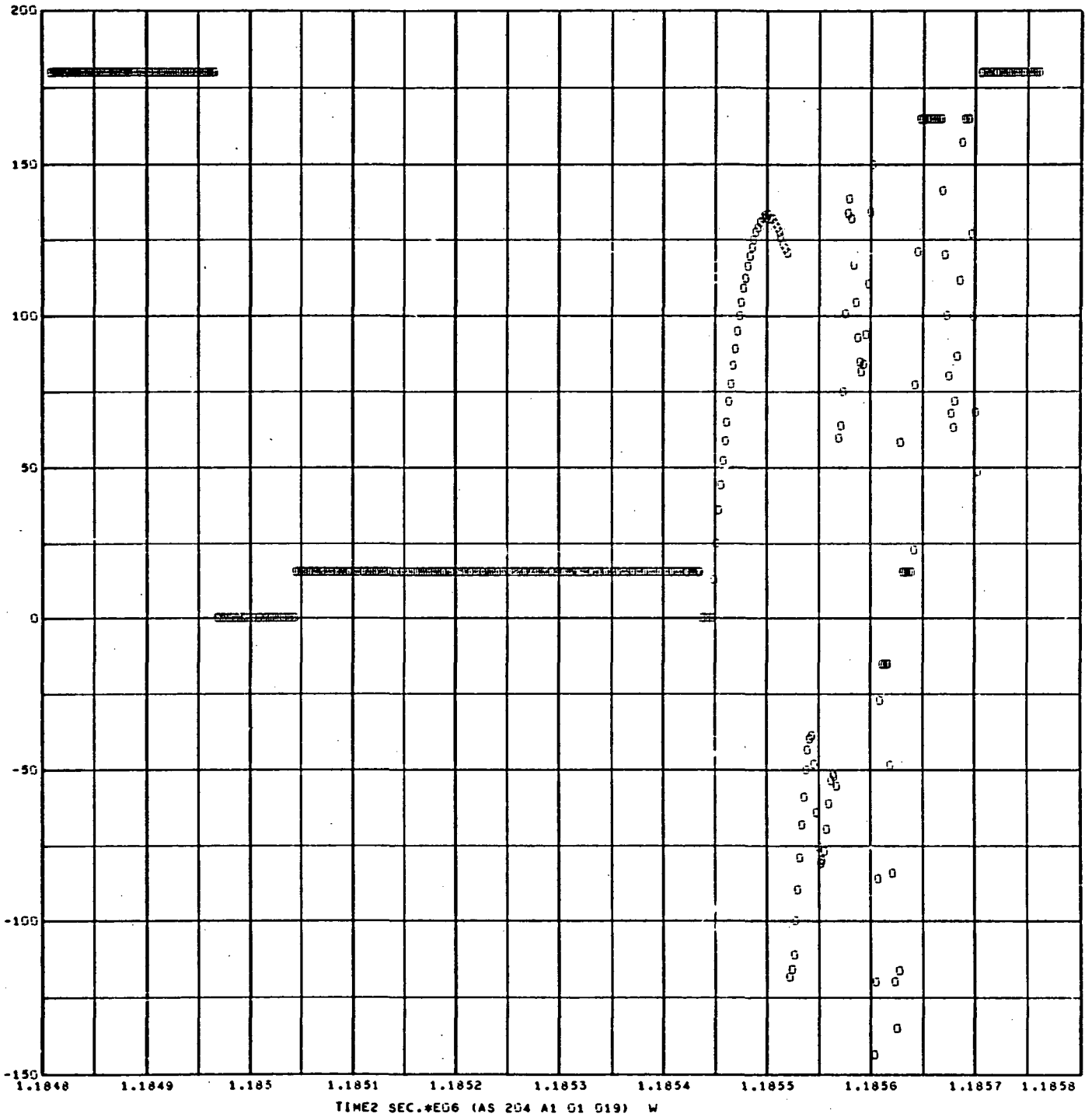
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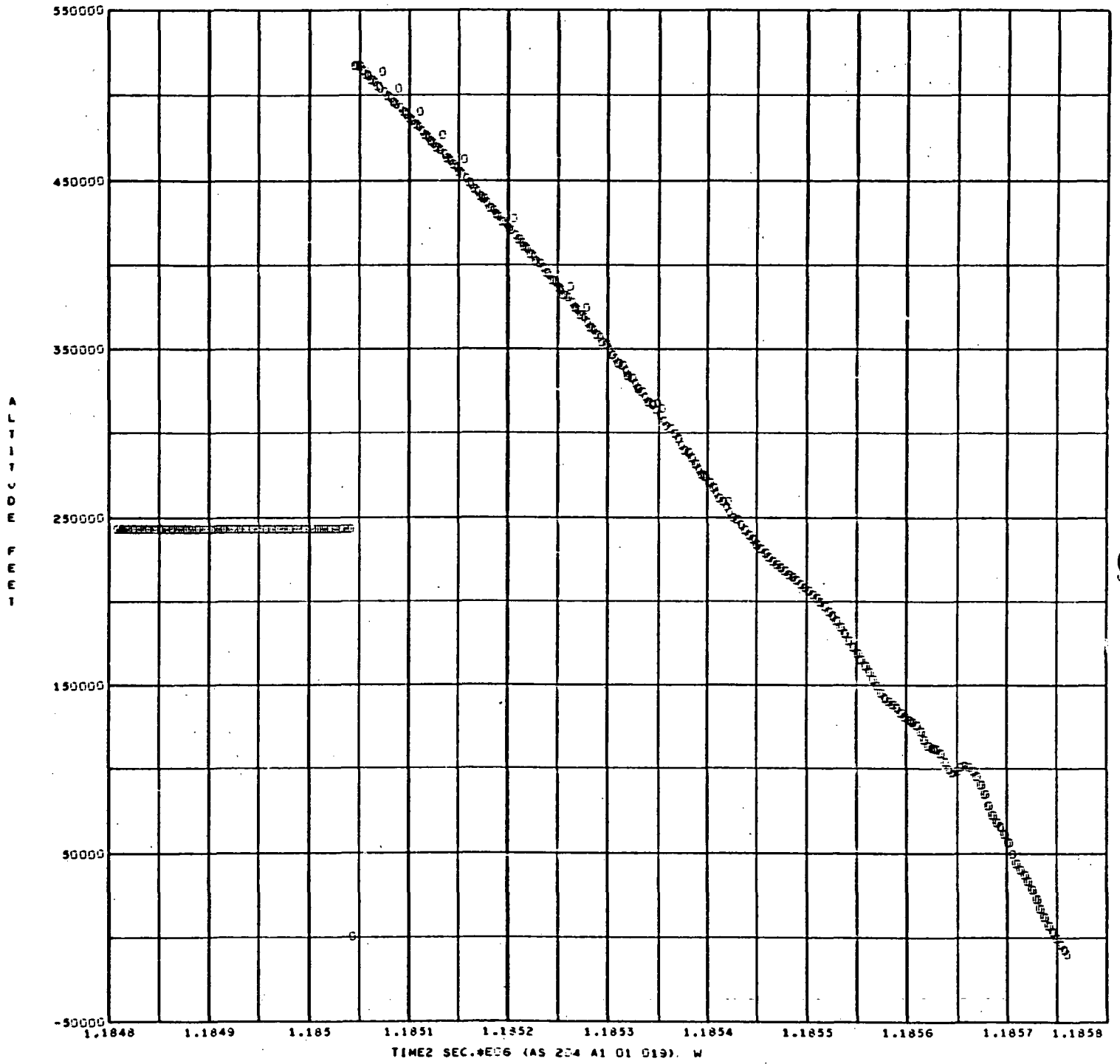


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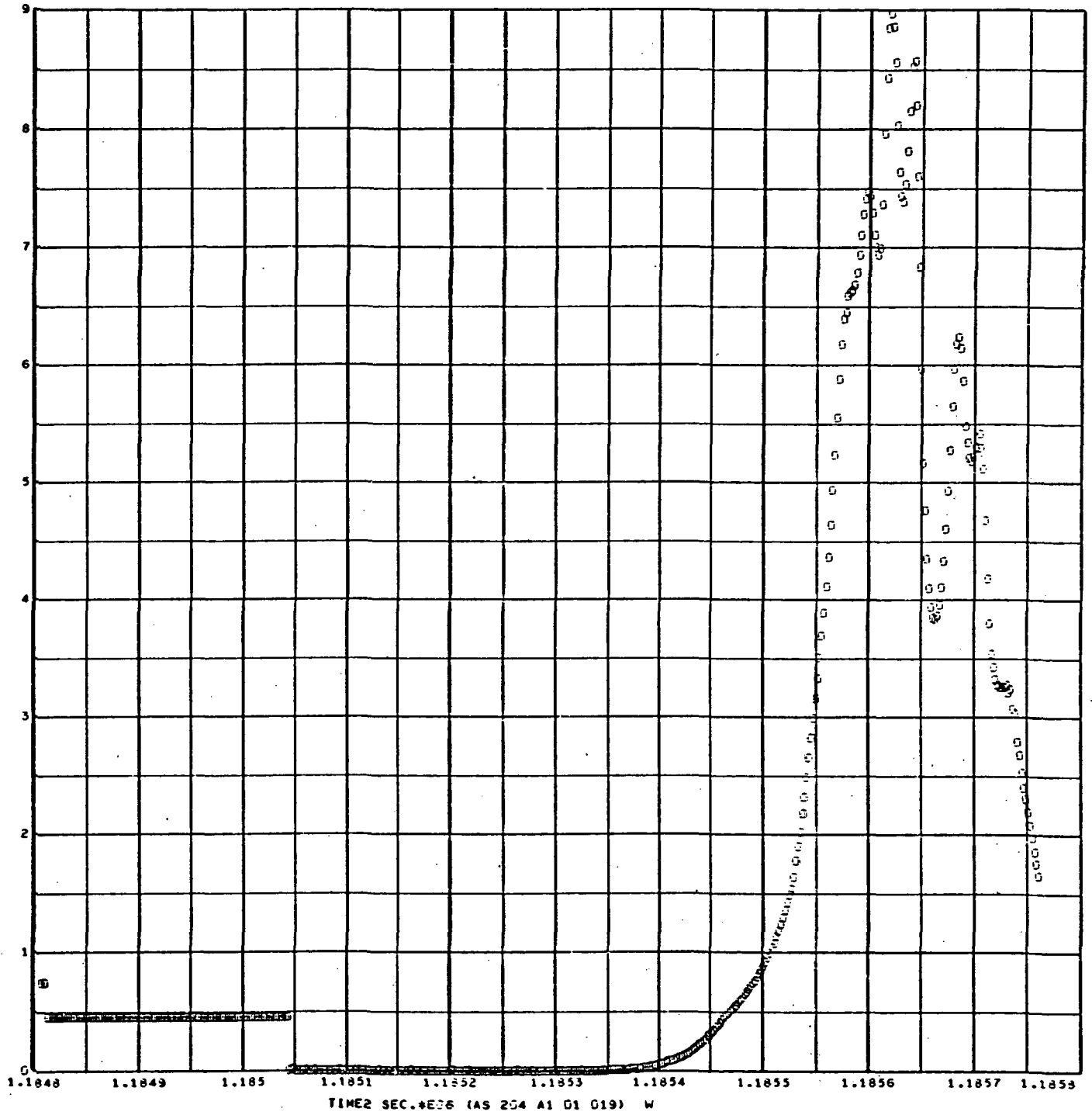


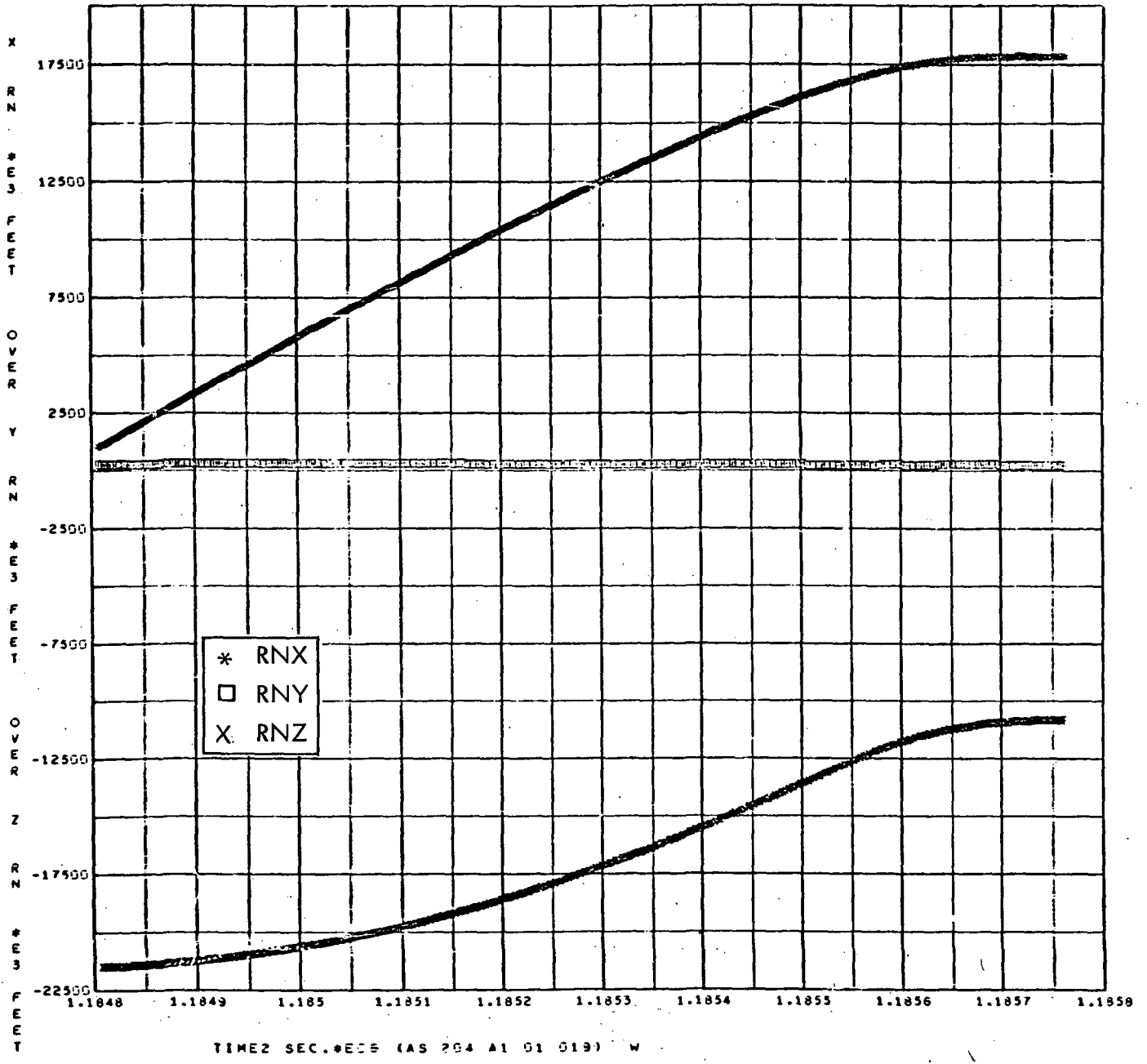
D I A G N O S T I C F L O O R

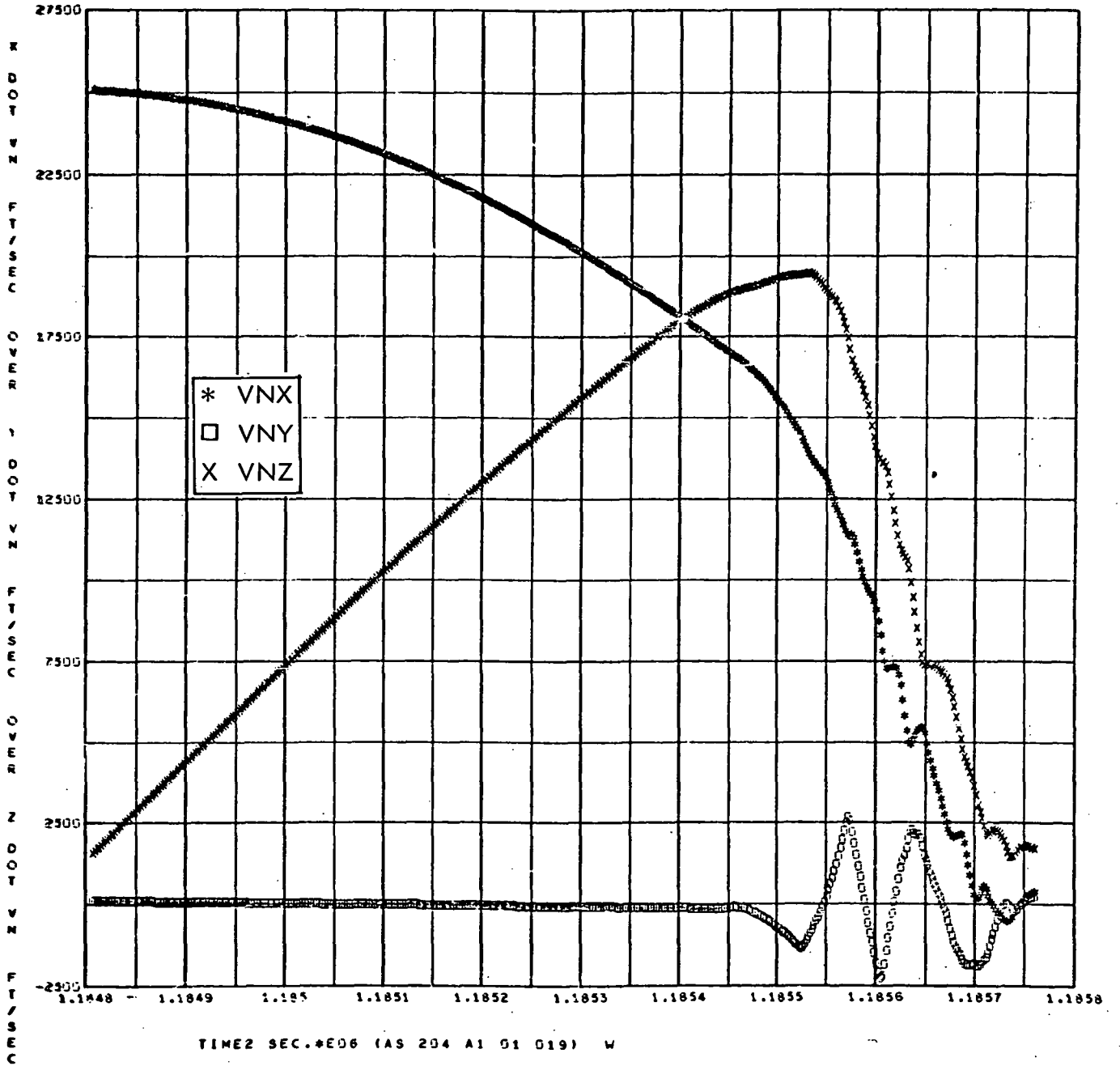




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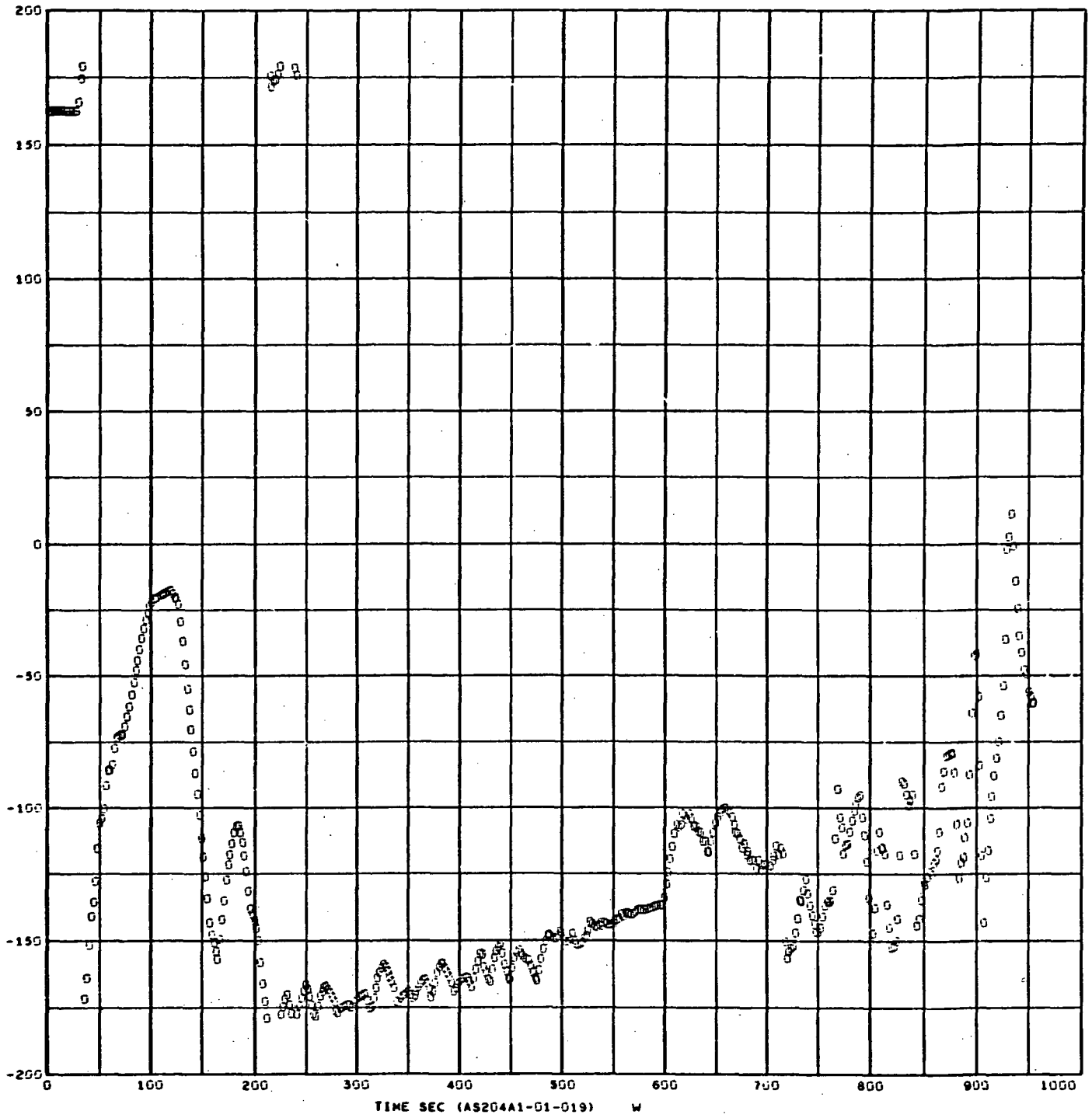




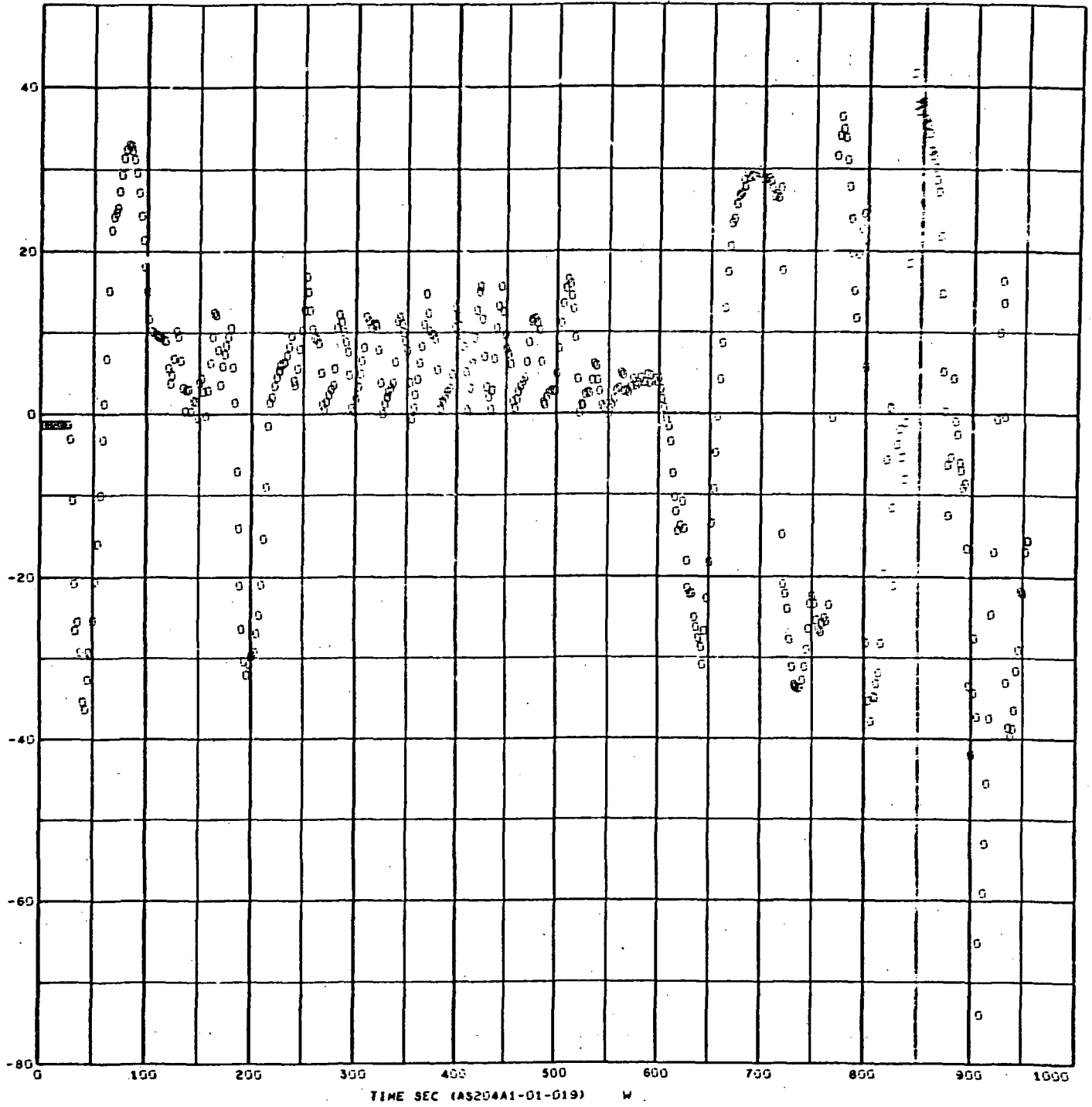
ENVIRONMENT PLOTS

AS-204A1-01-019

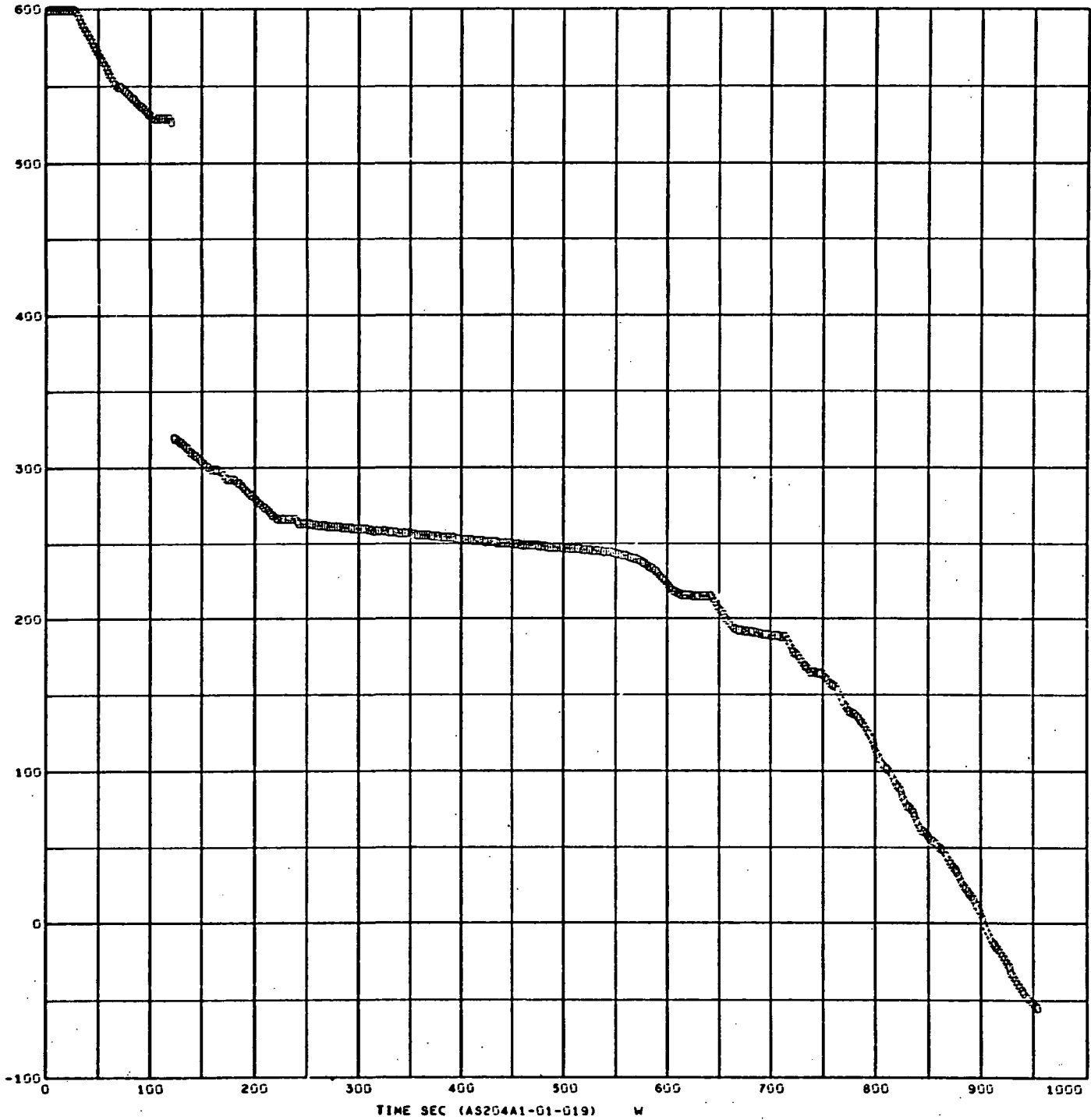
INNER GIMBAL ANGLE IN DEGREES



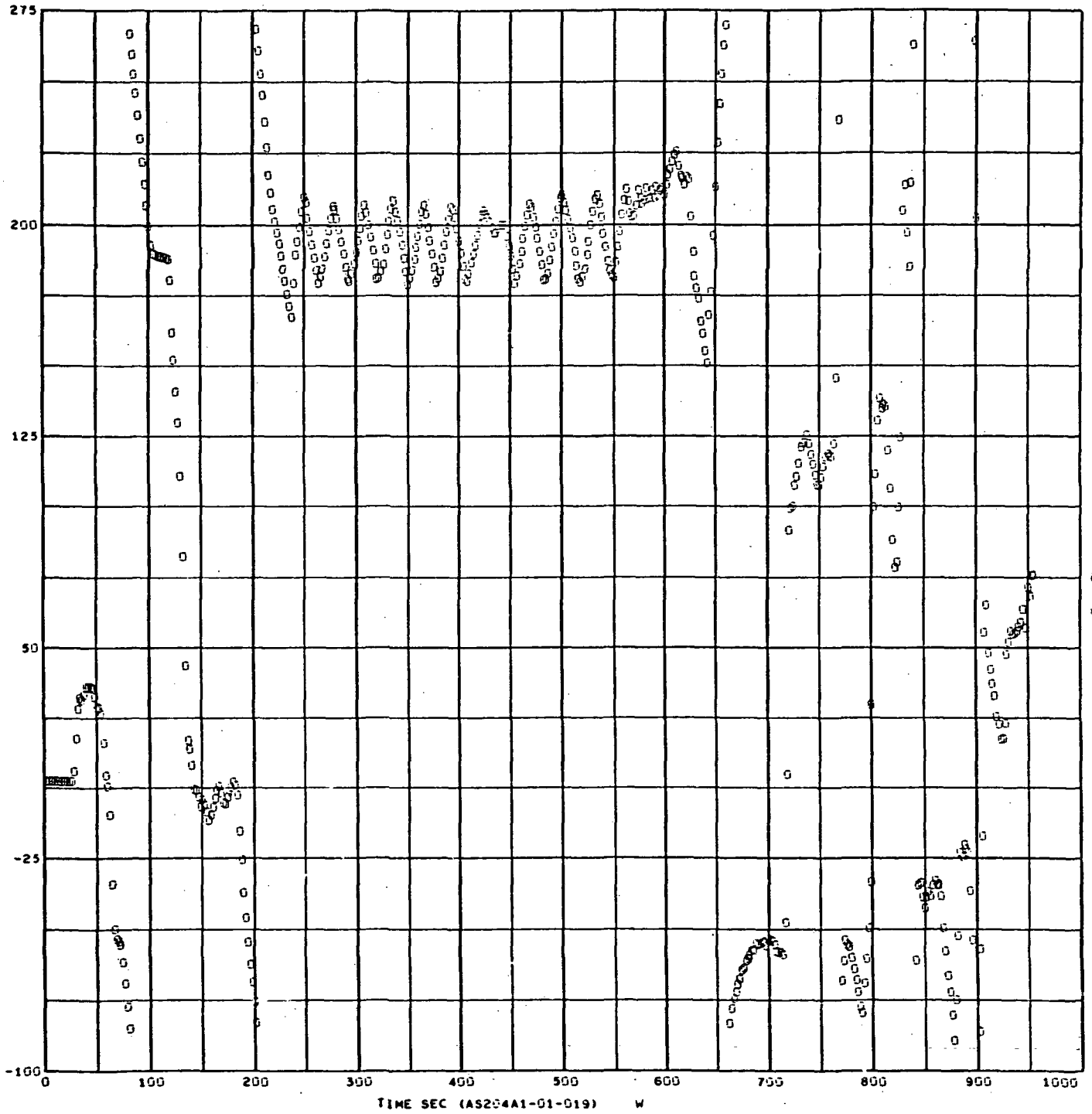
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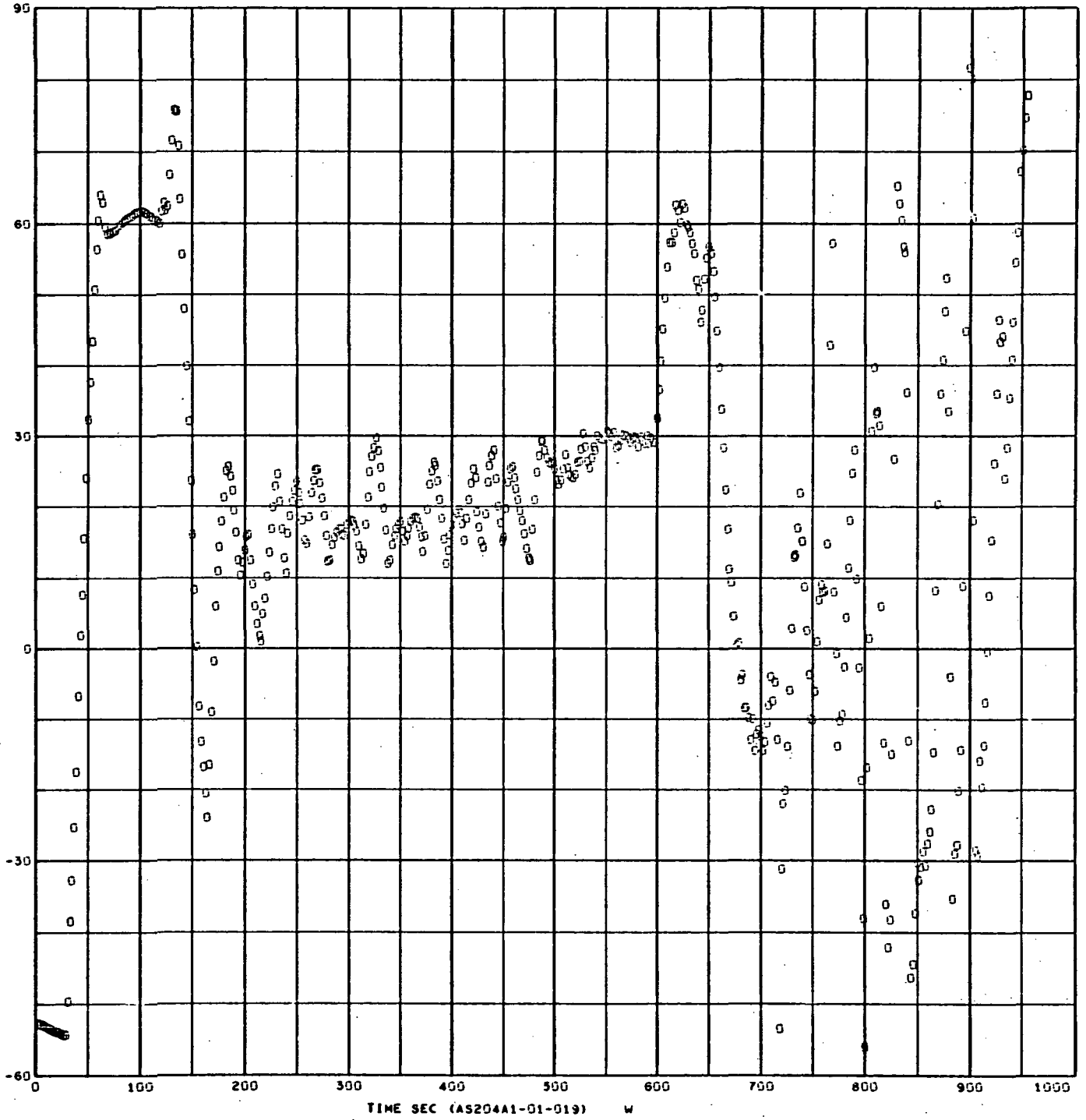
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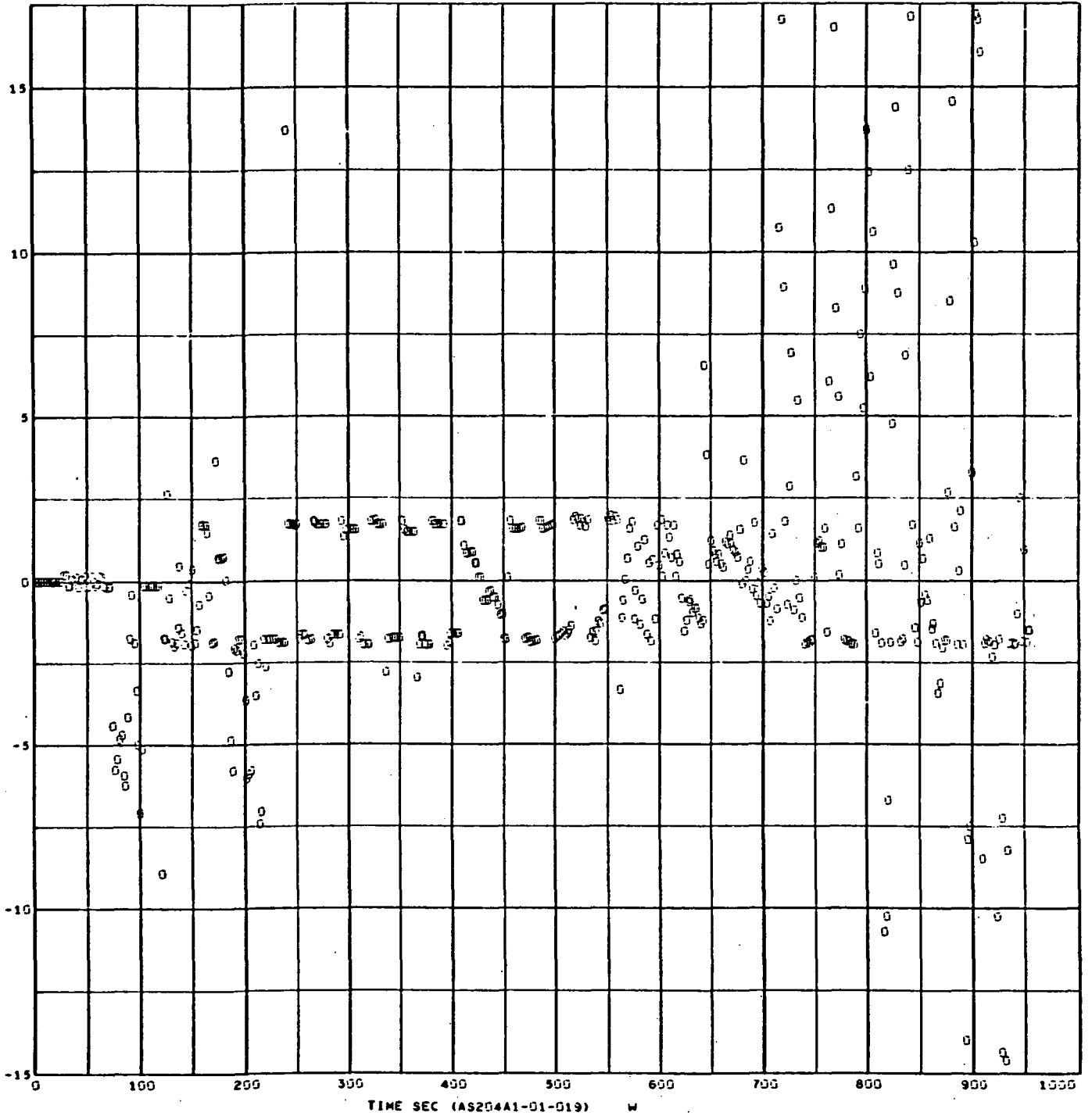
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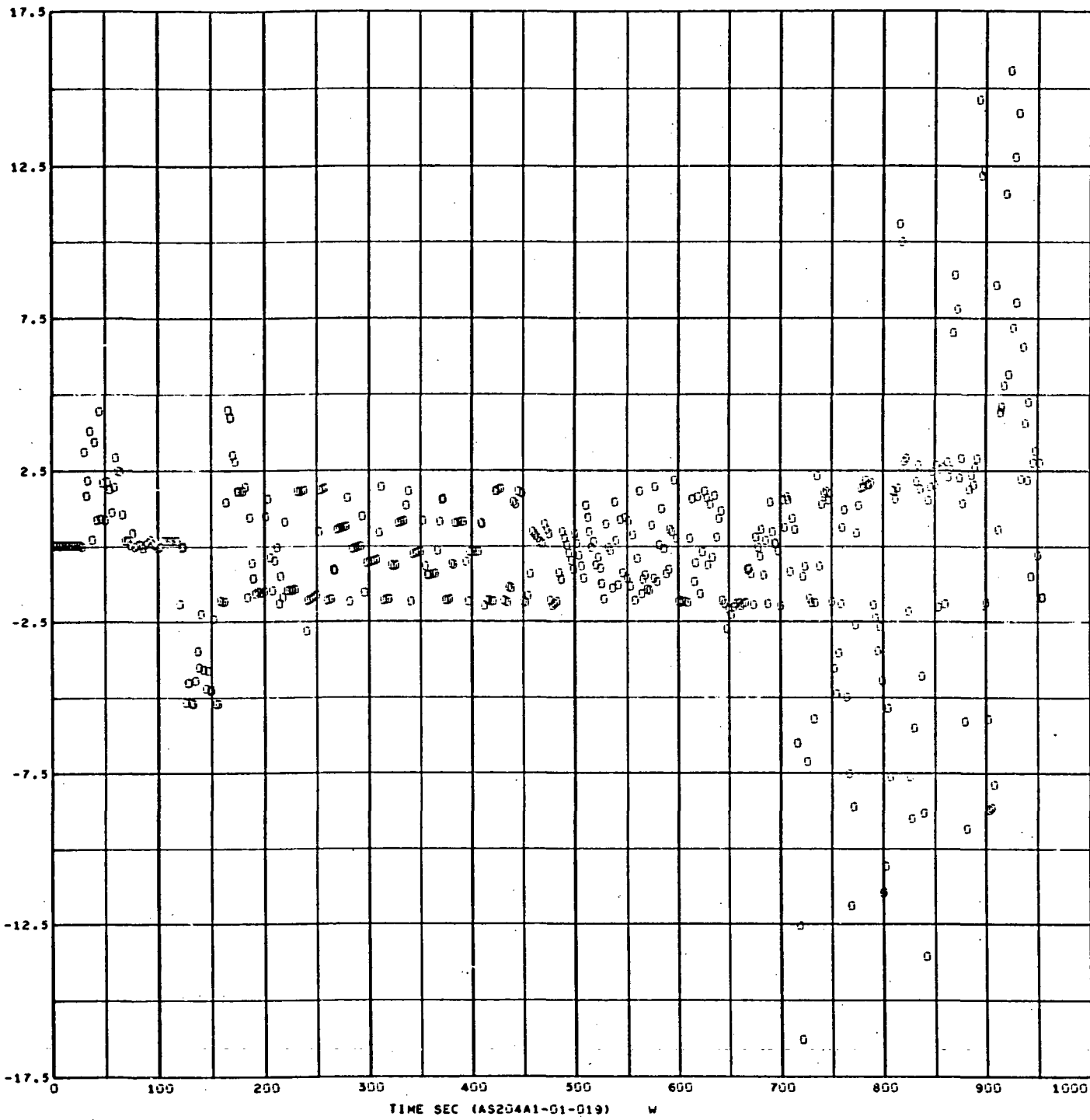
GEODETIC POSITION



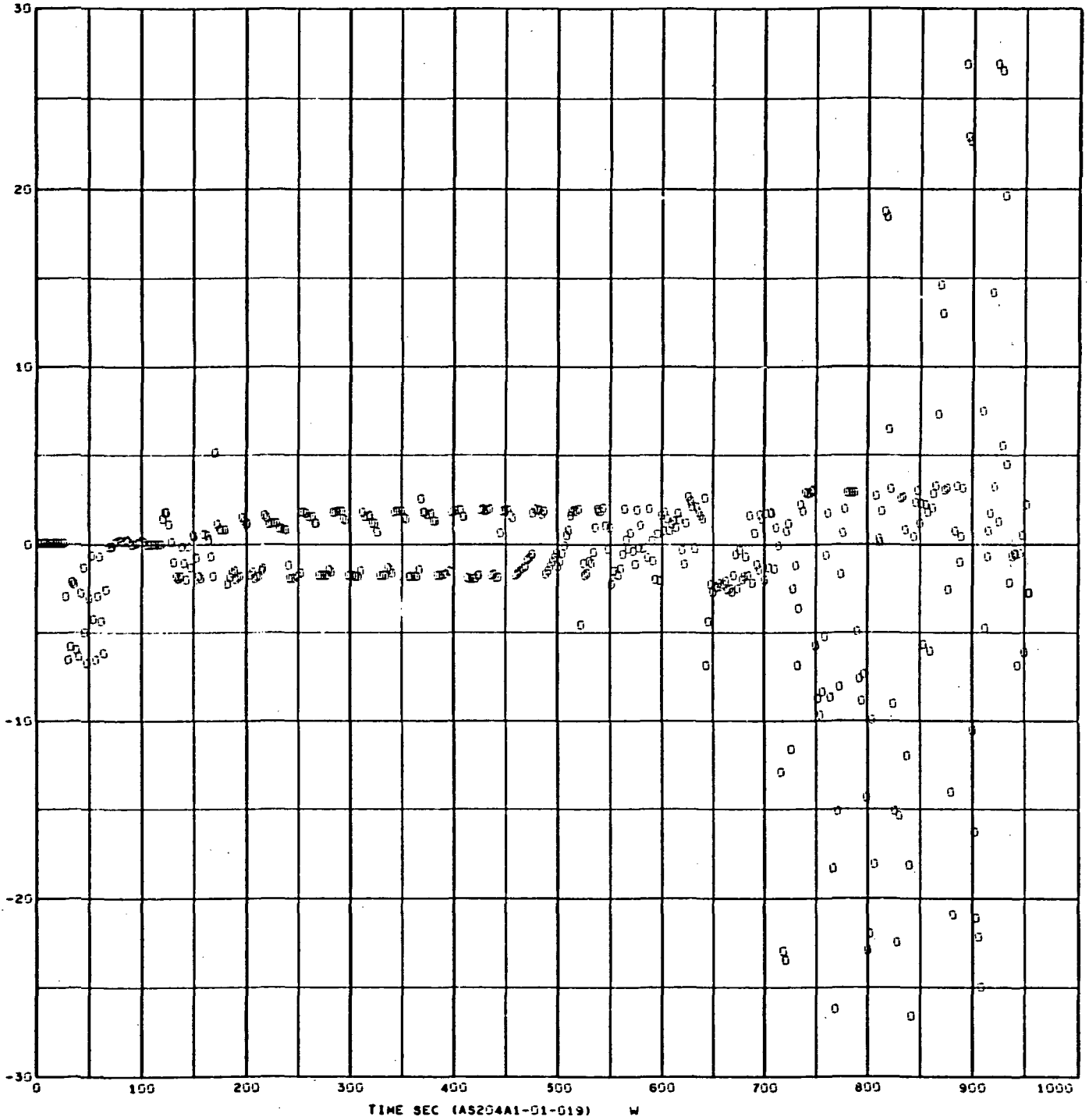
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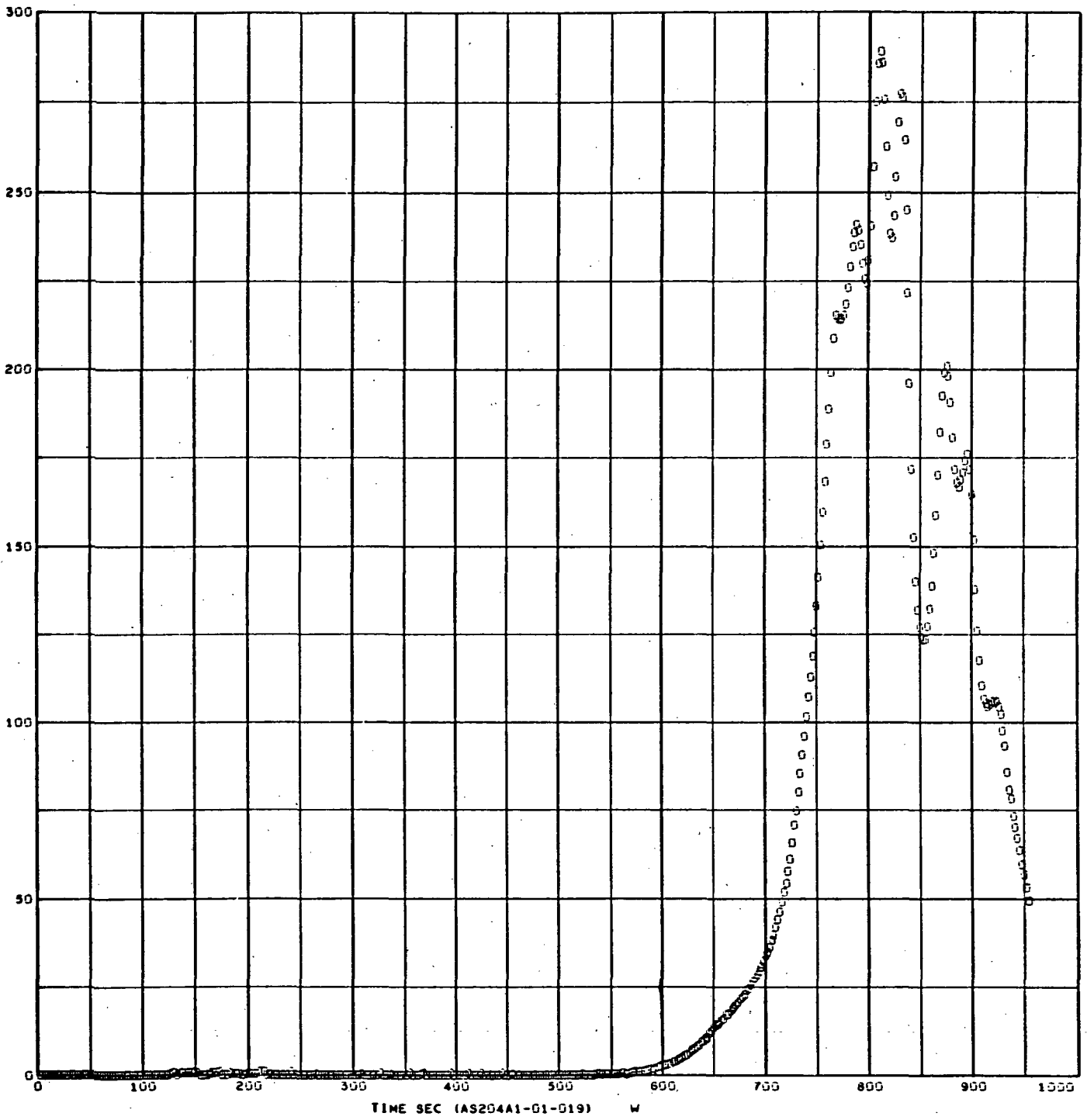
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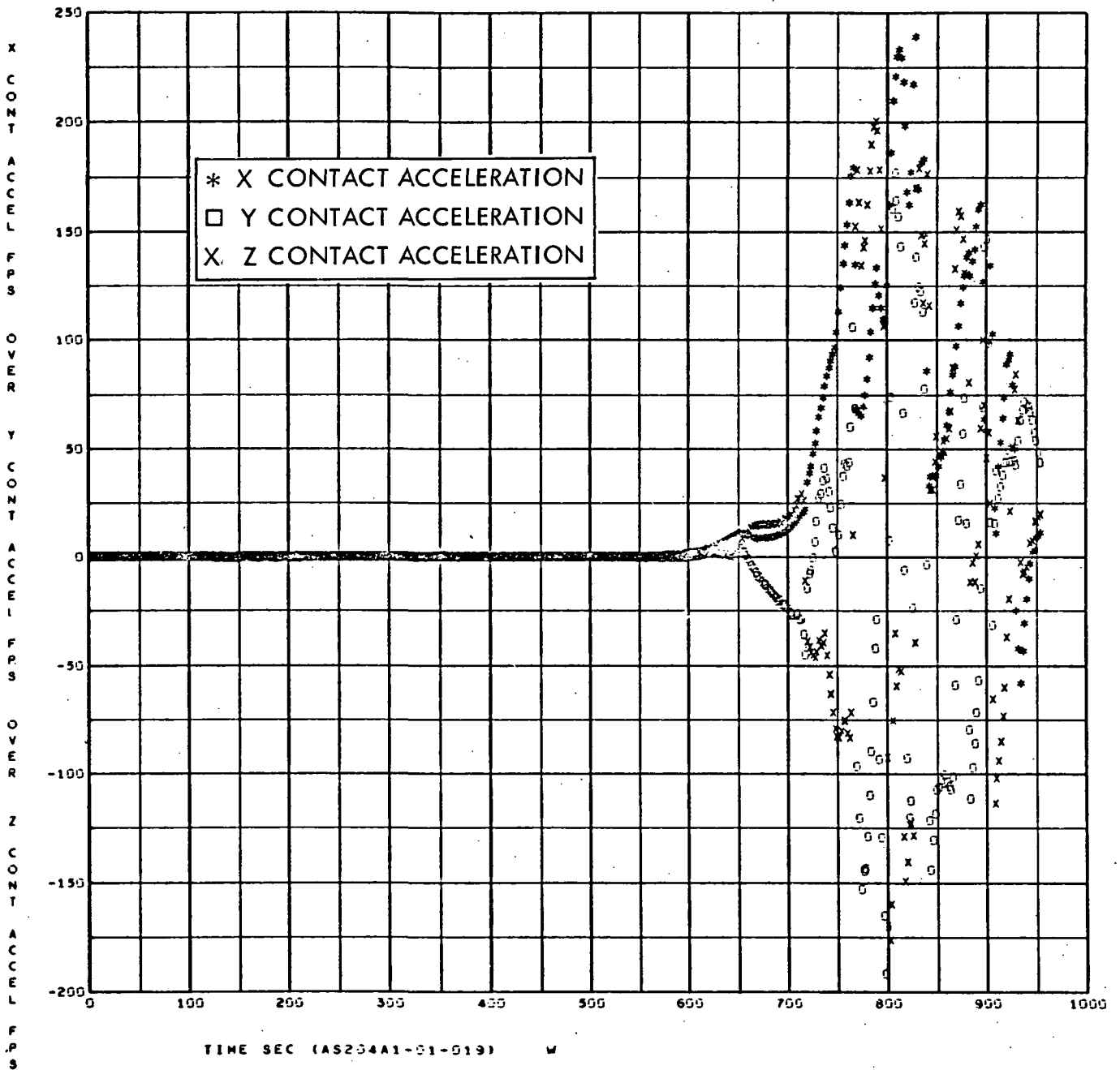


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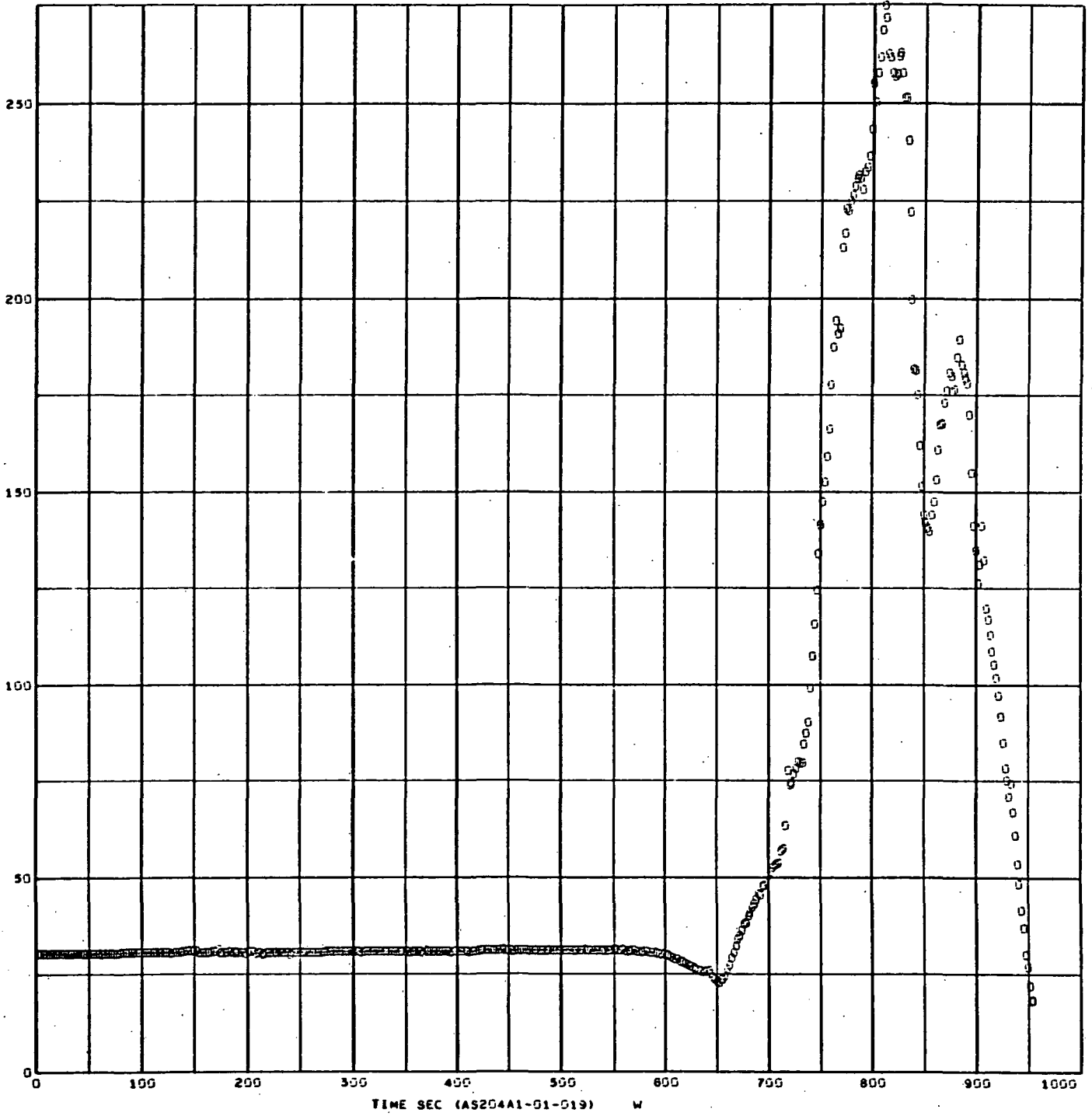
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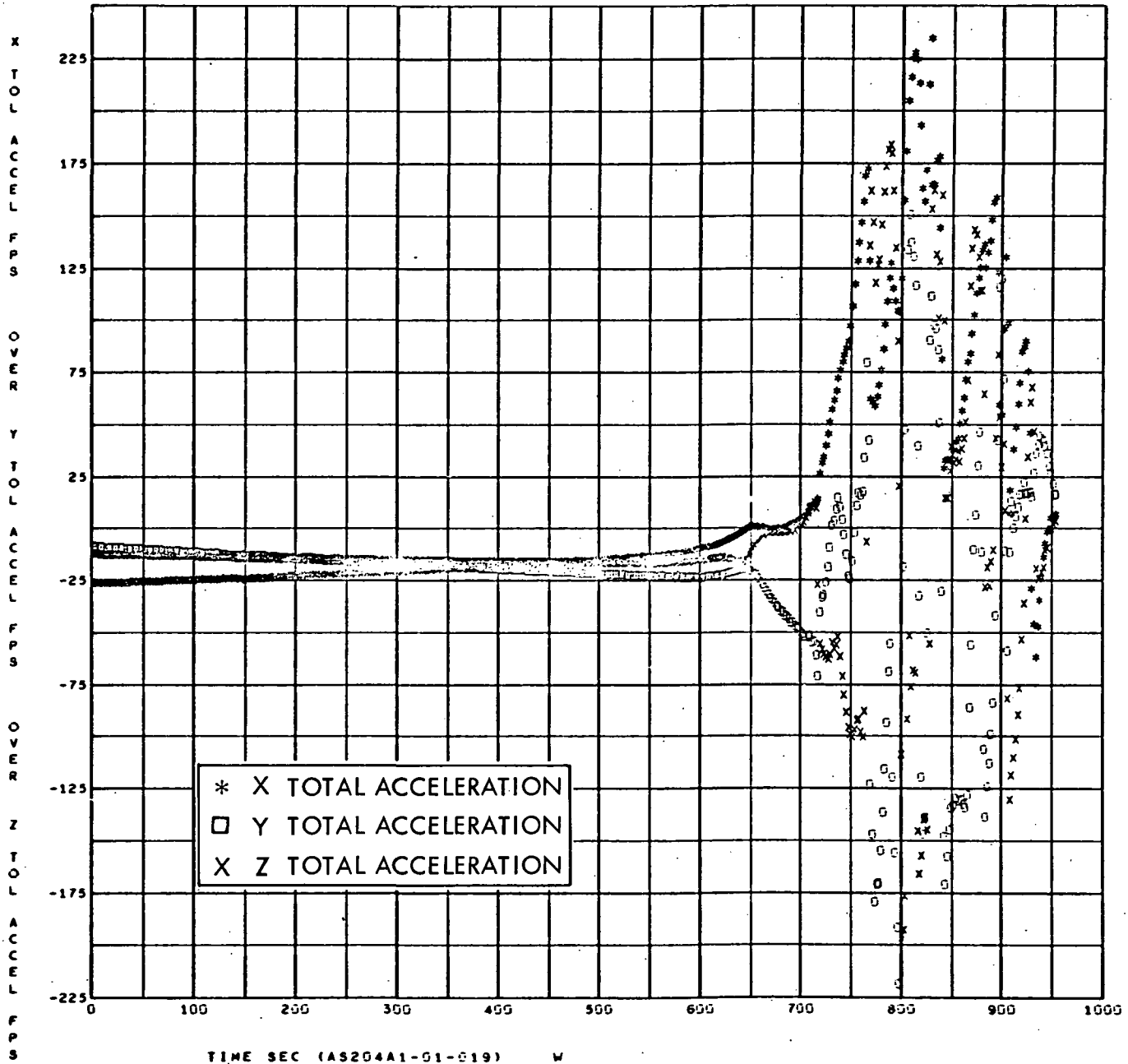
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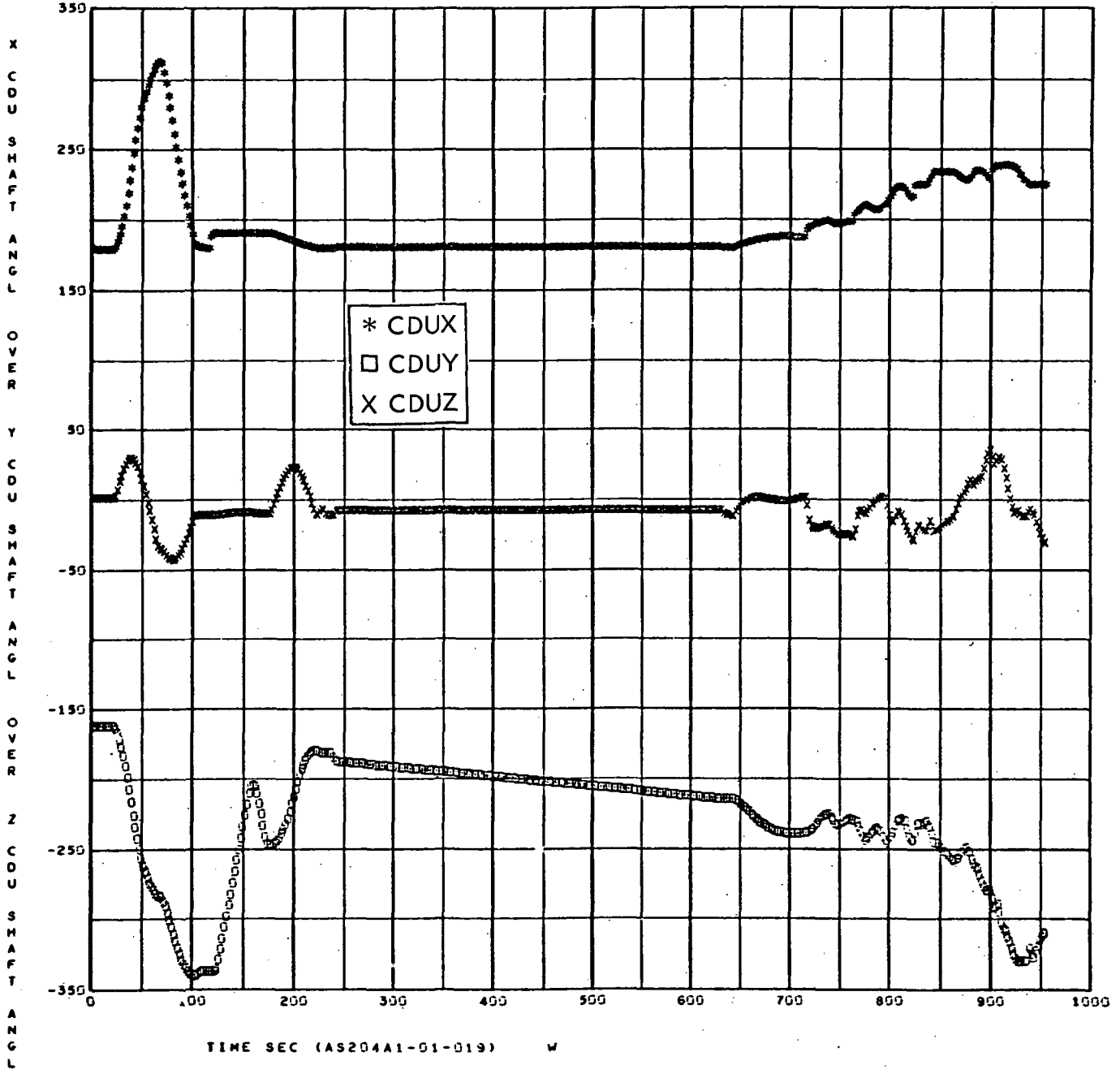




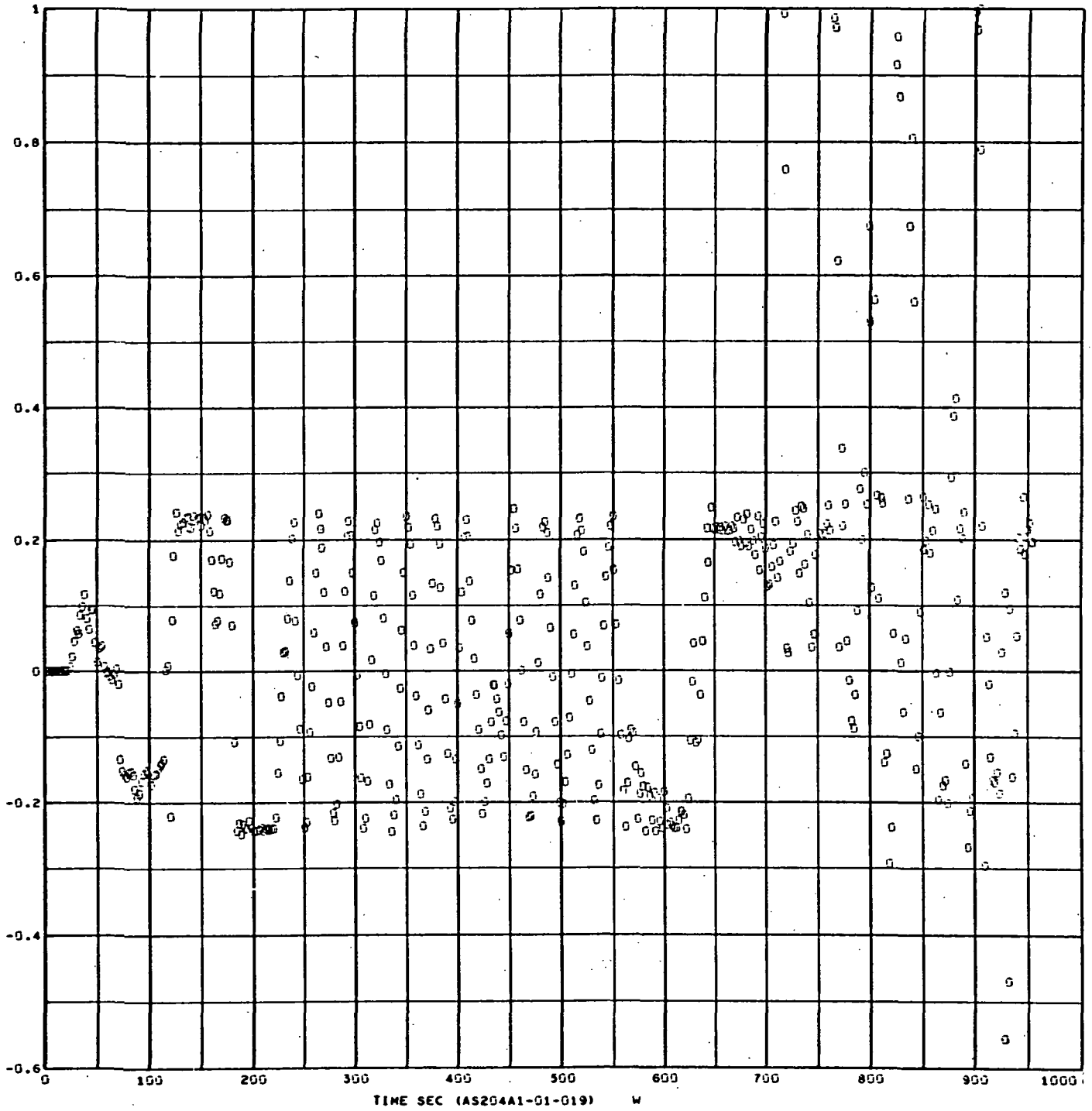
TOTAL ACCEL MAG FT/SEC**2

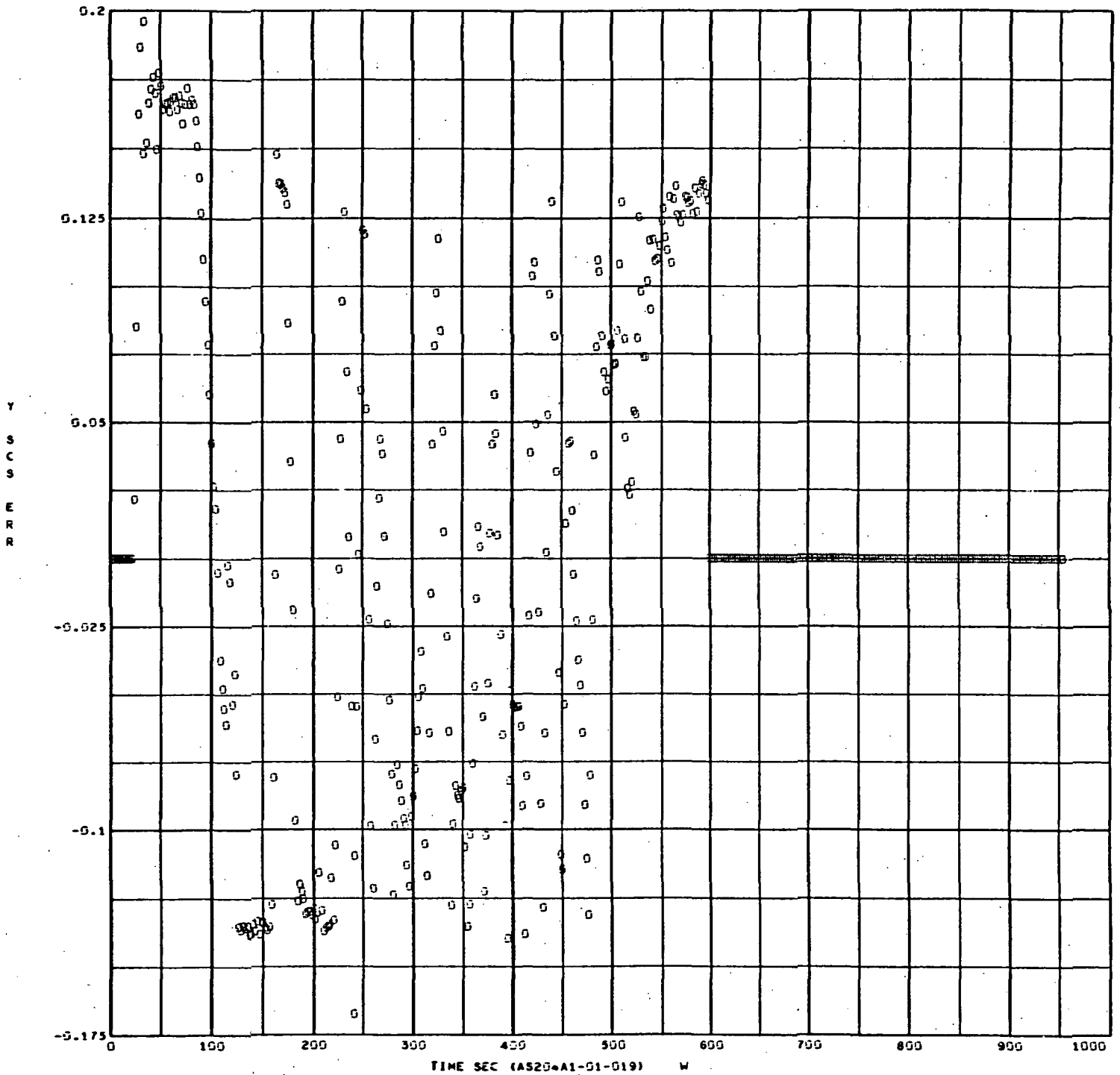




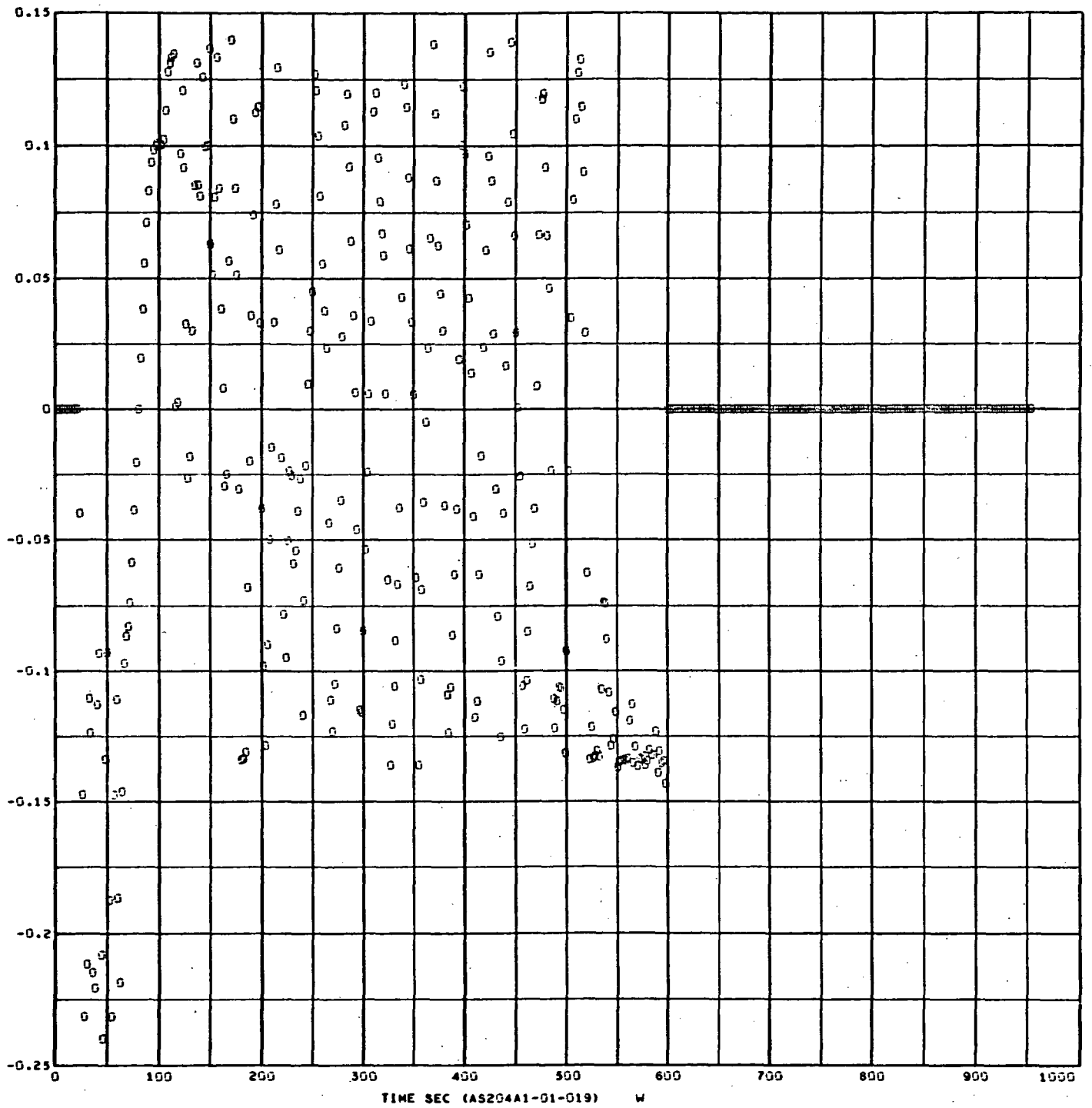


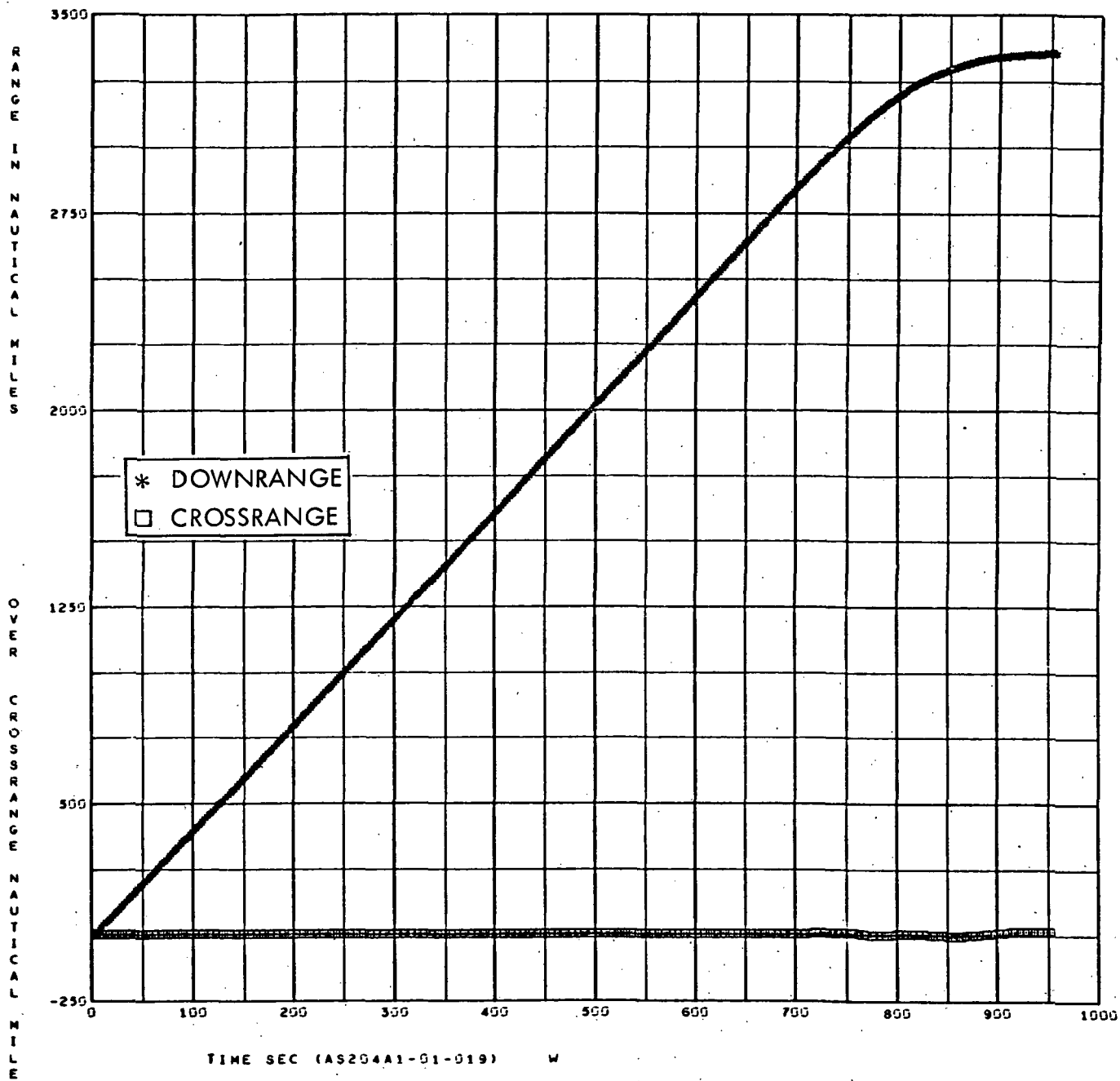
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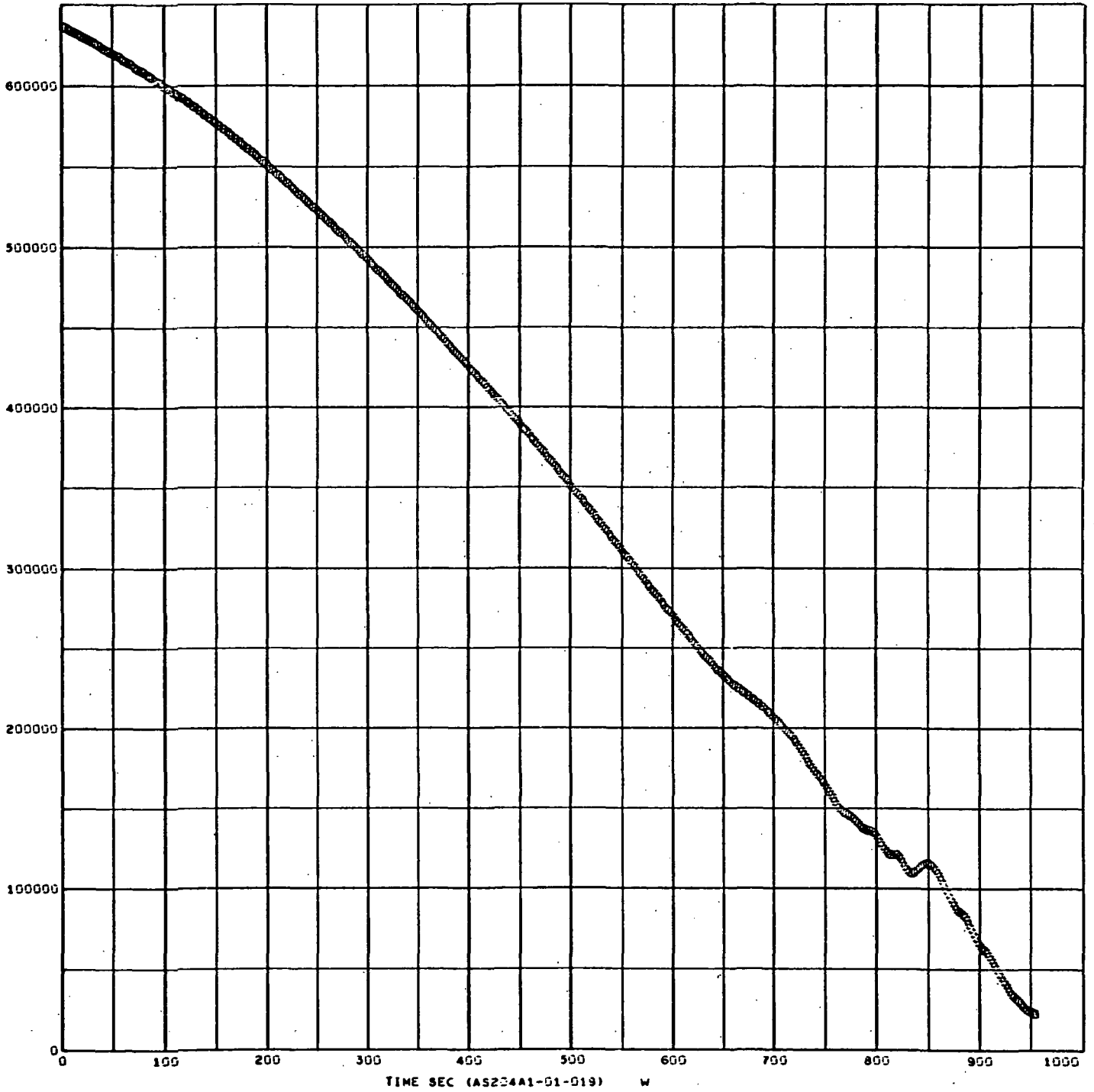


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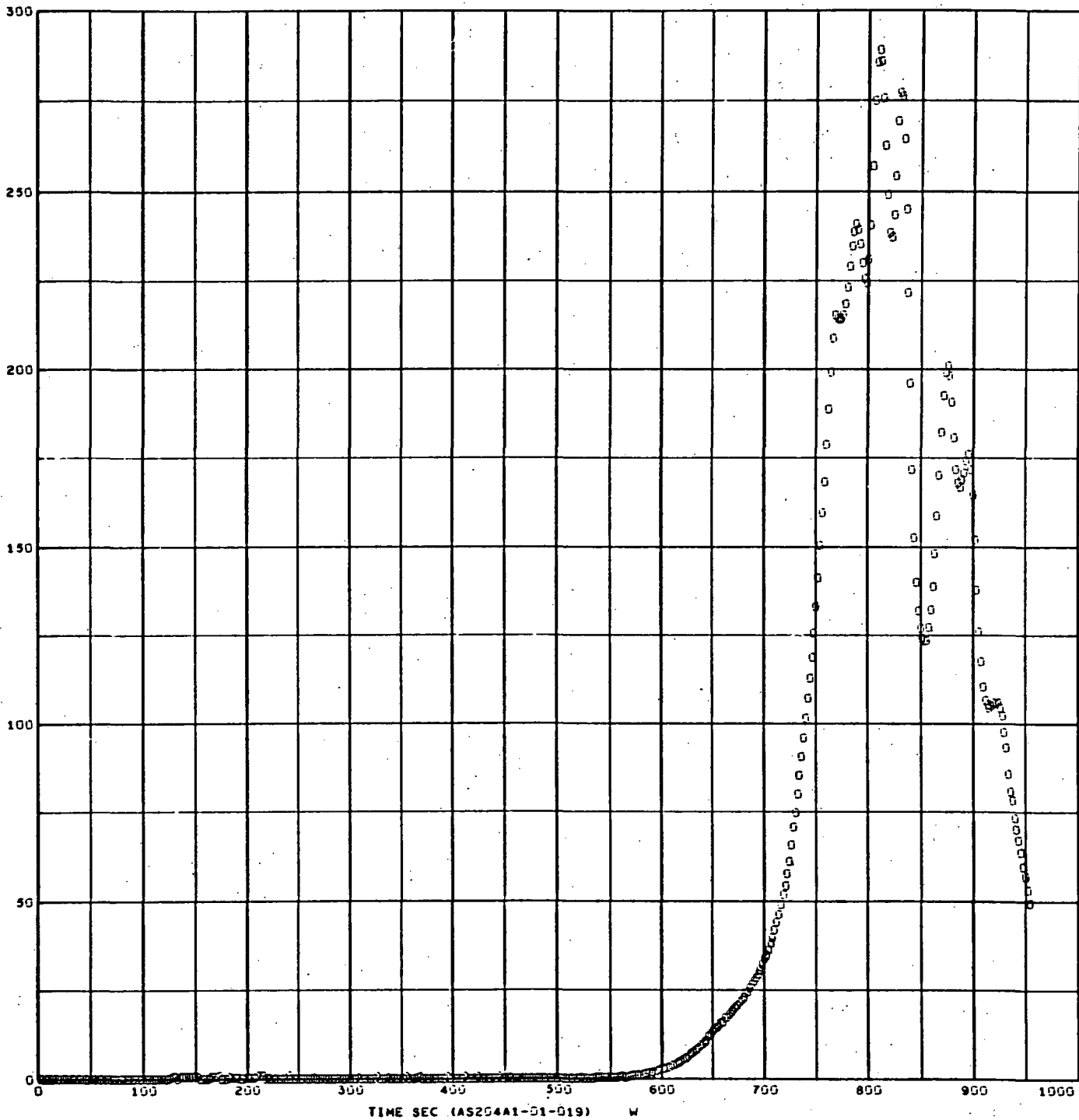
G E O D E T I C
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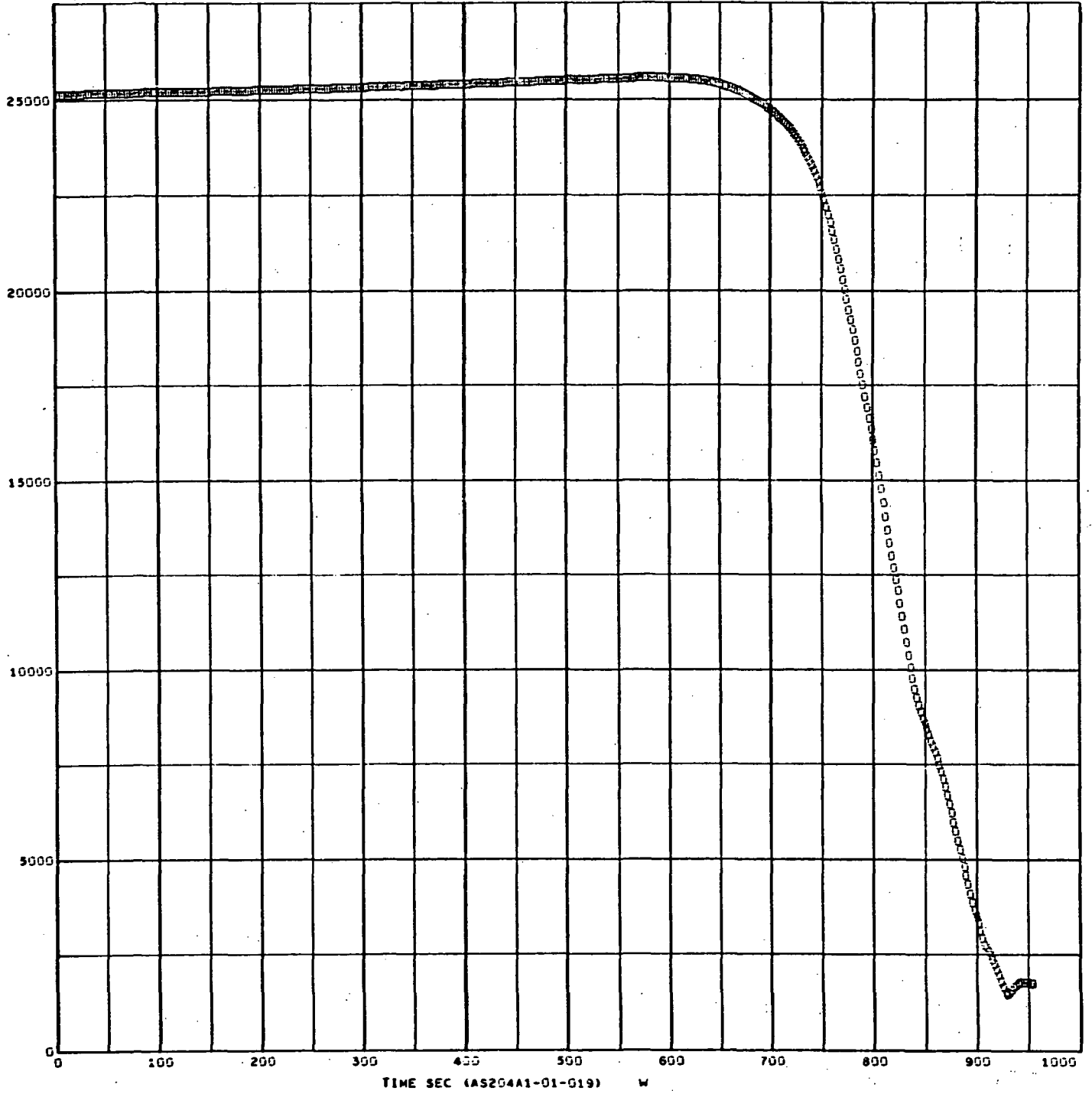
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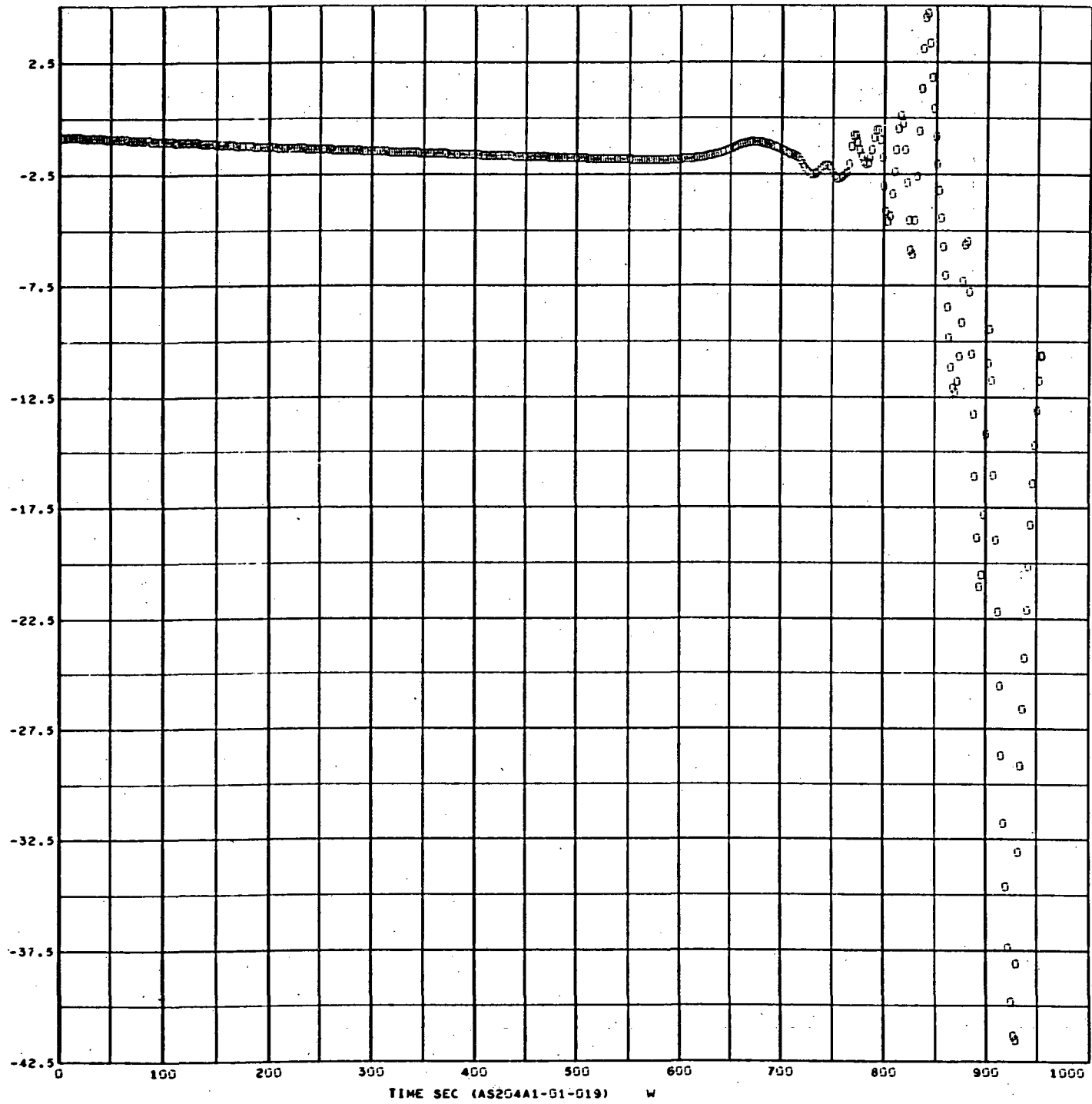
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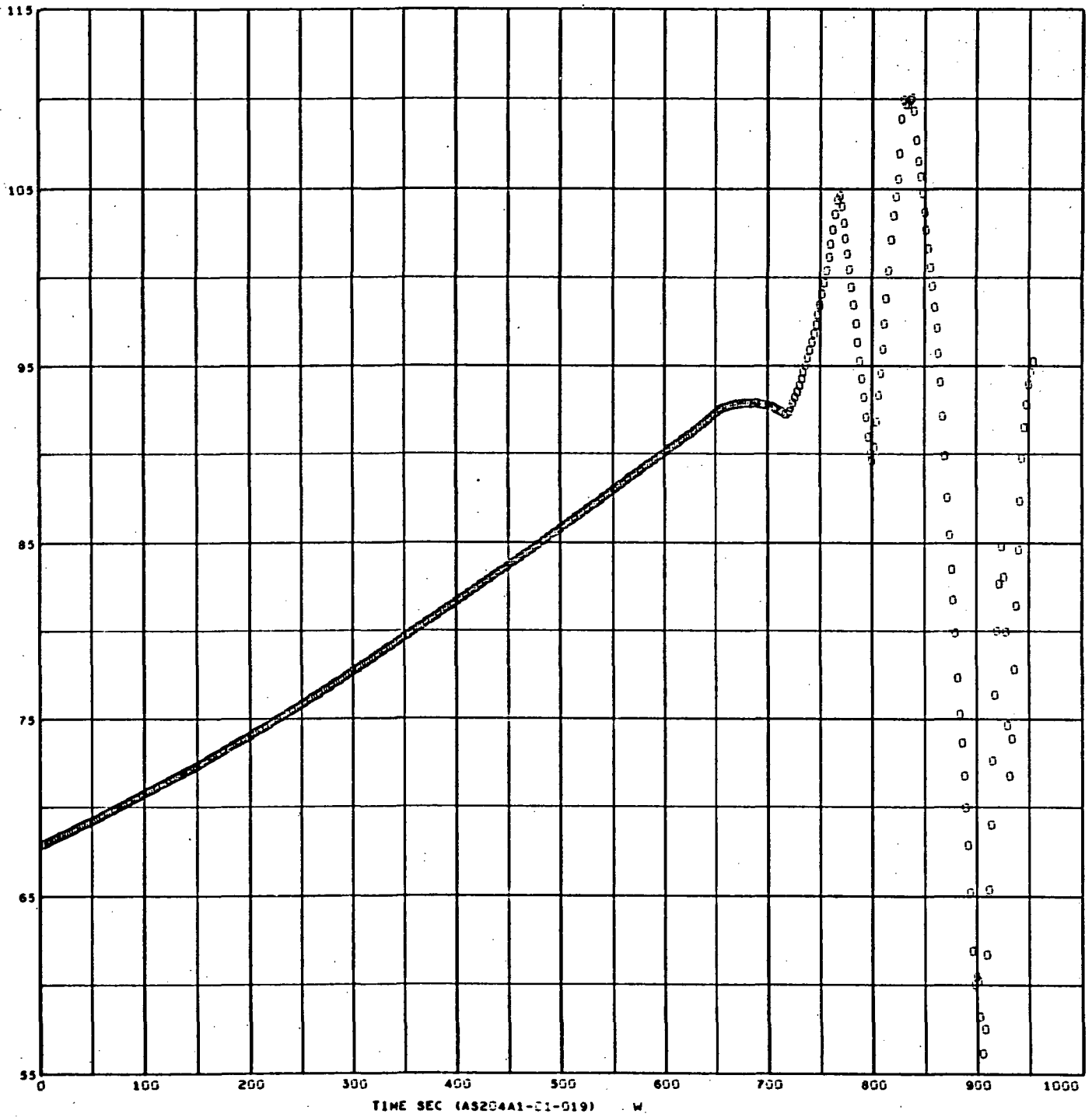


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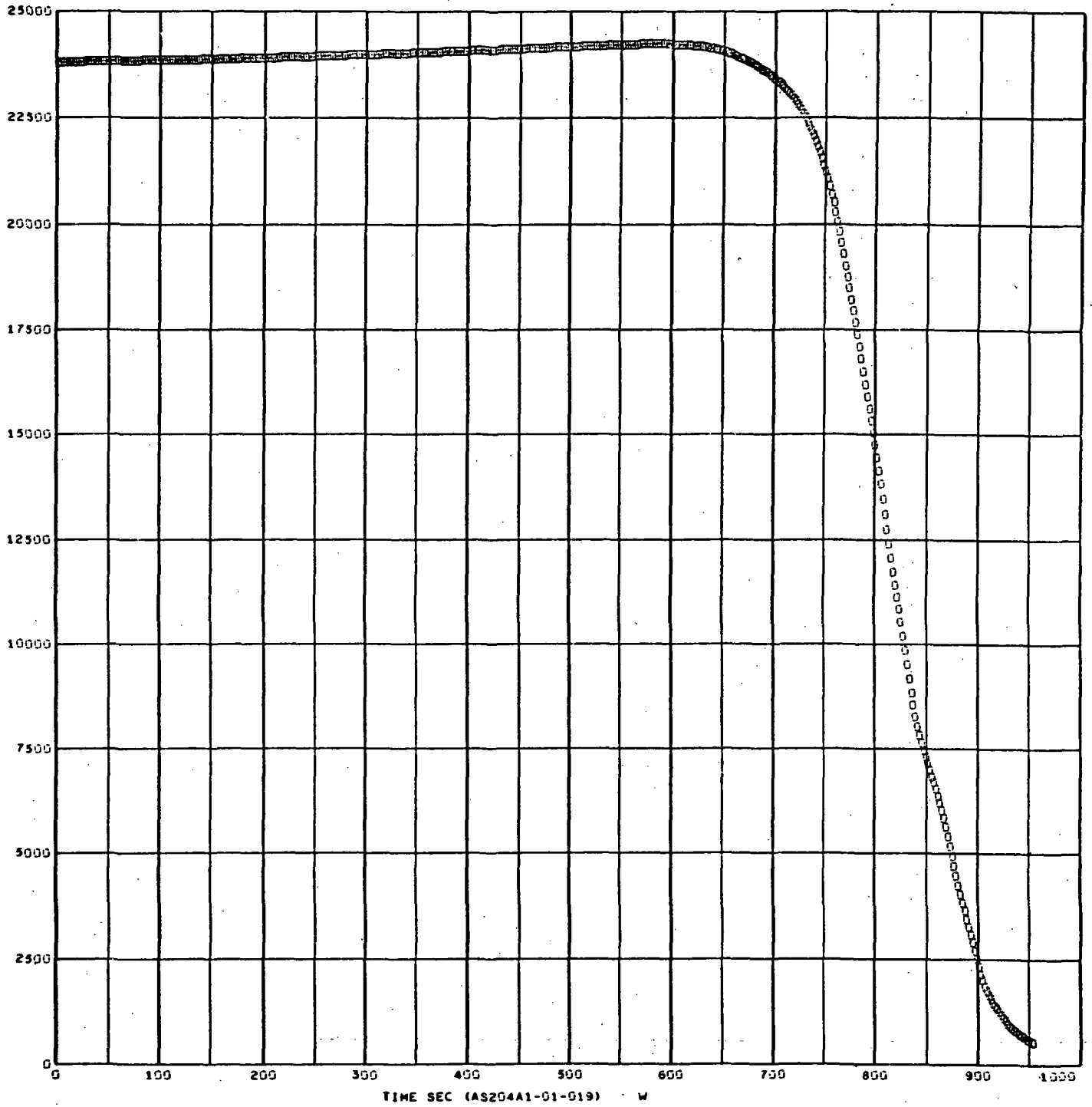
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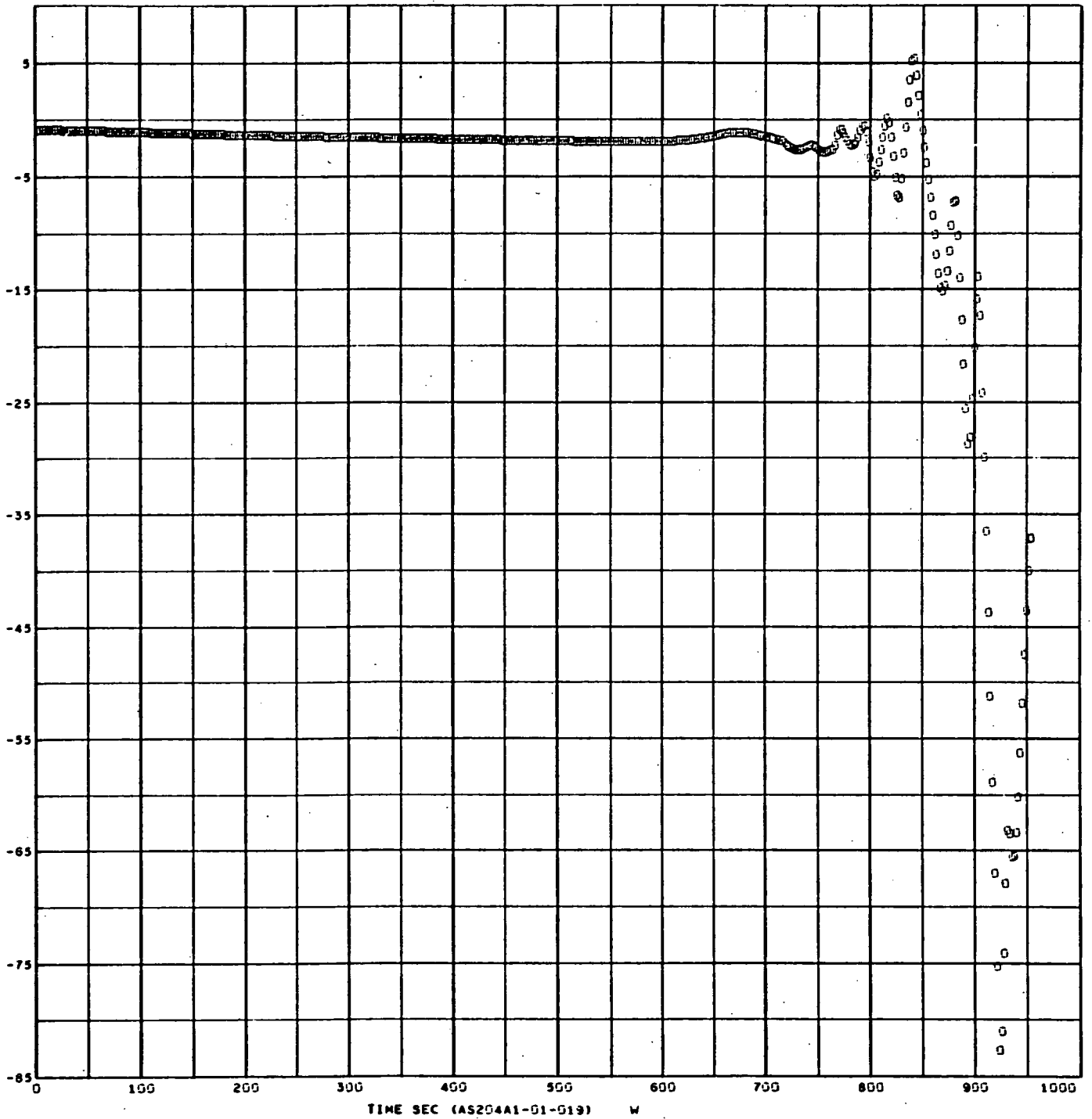
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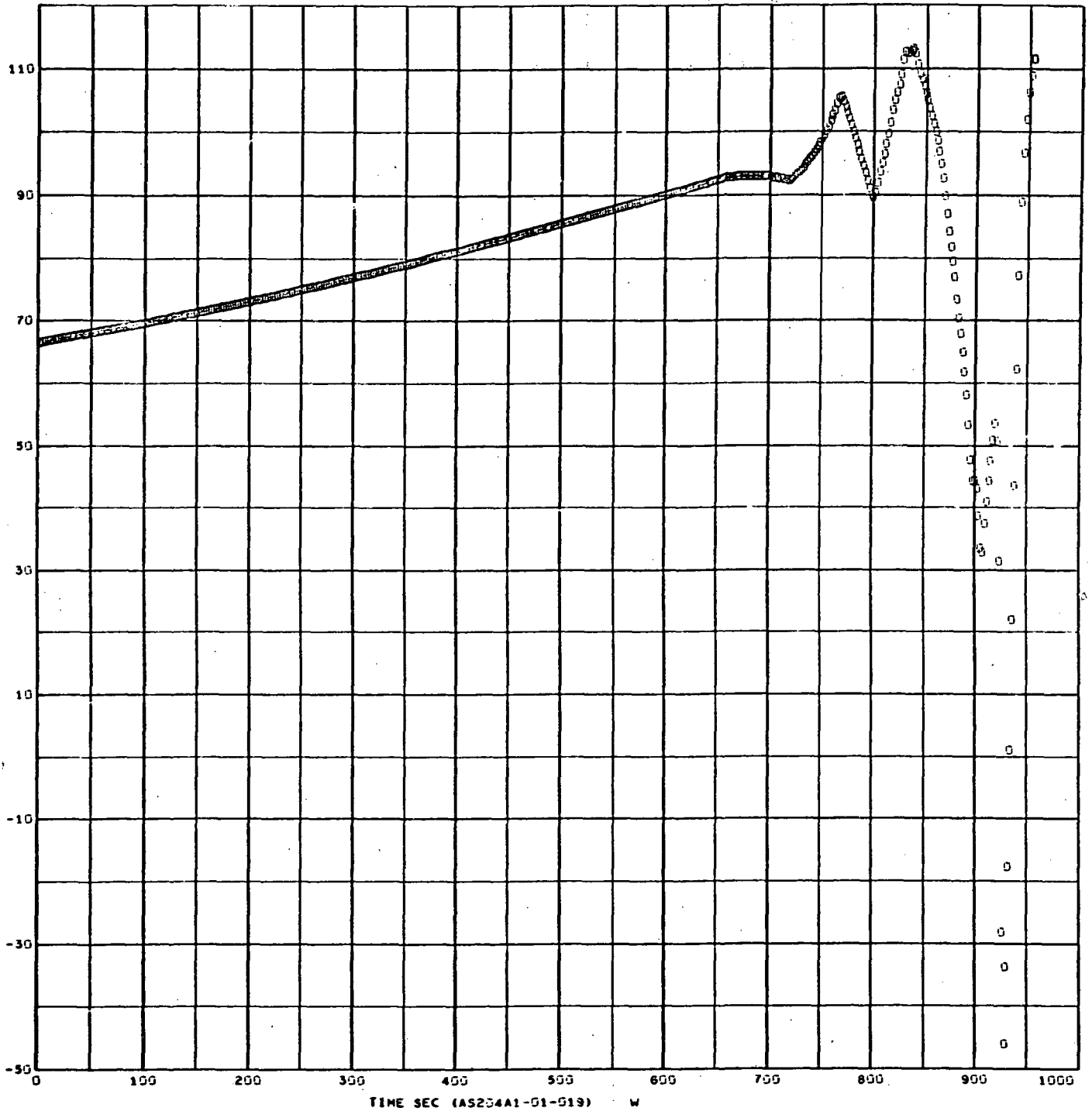
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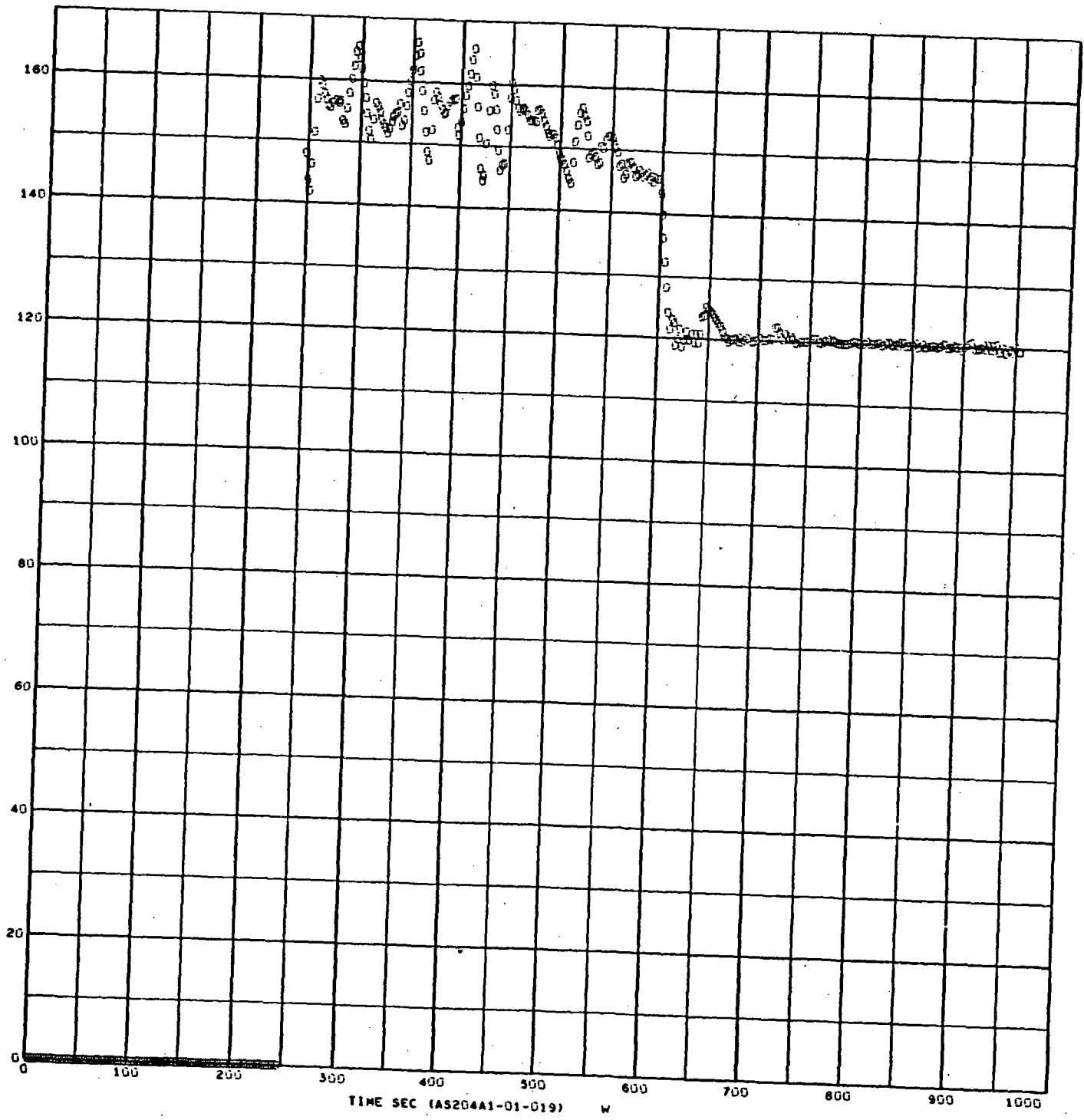
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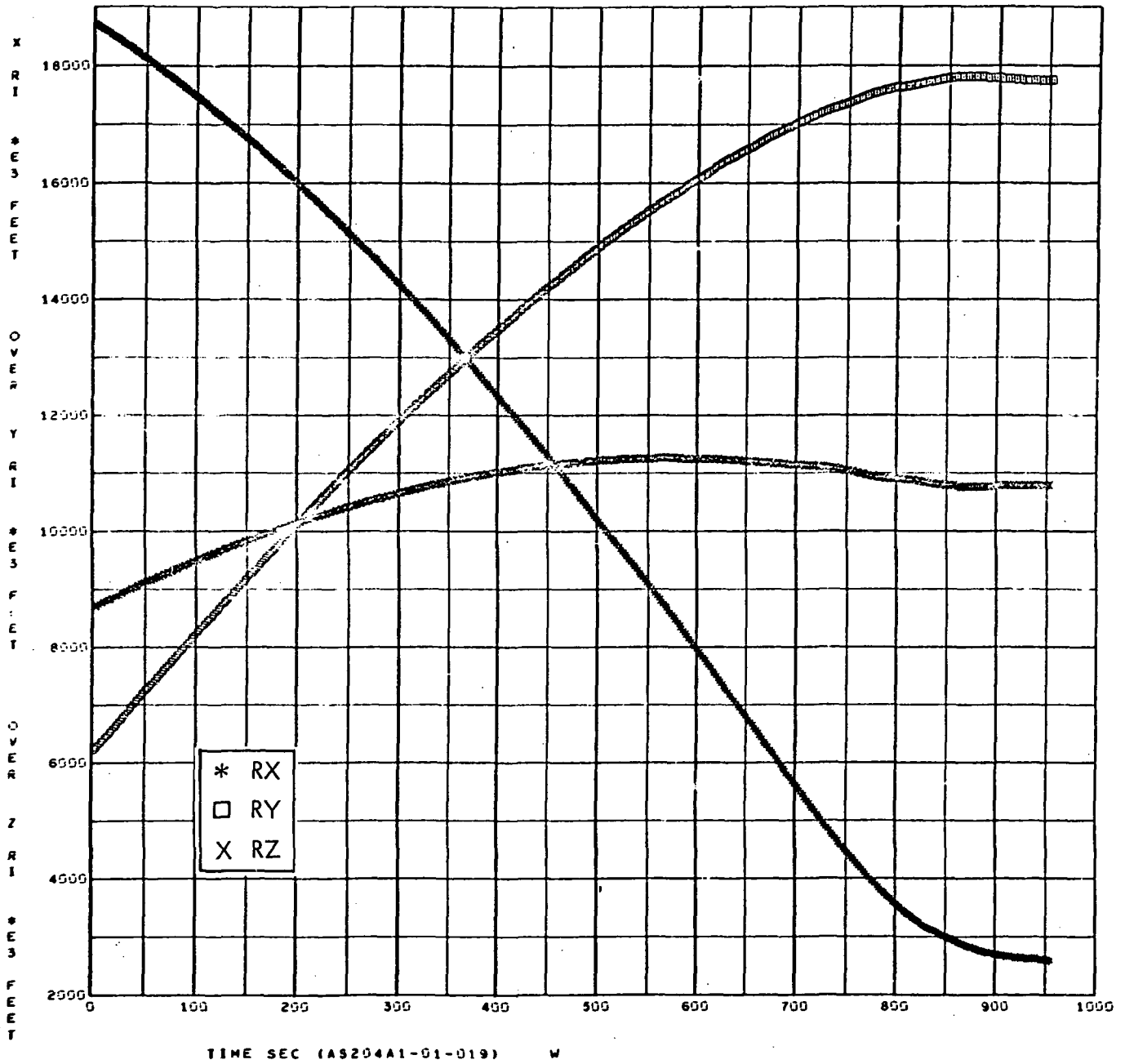
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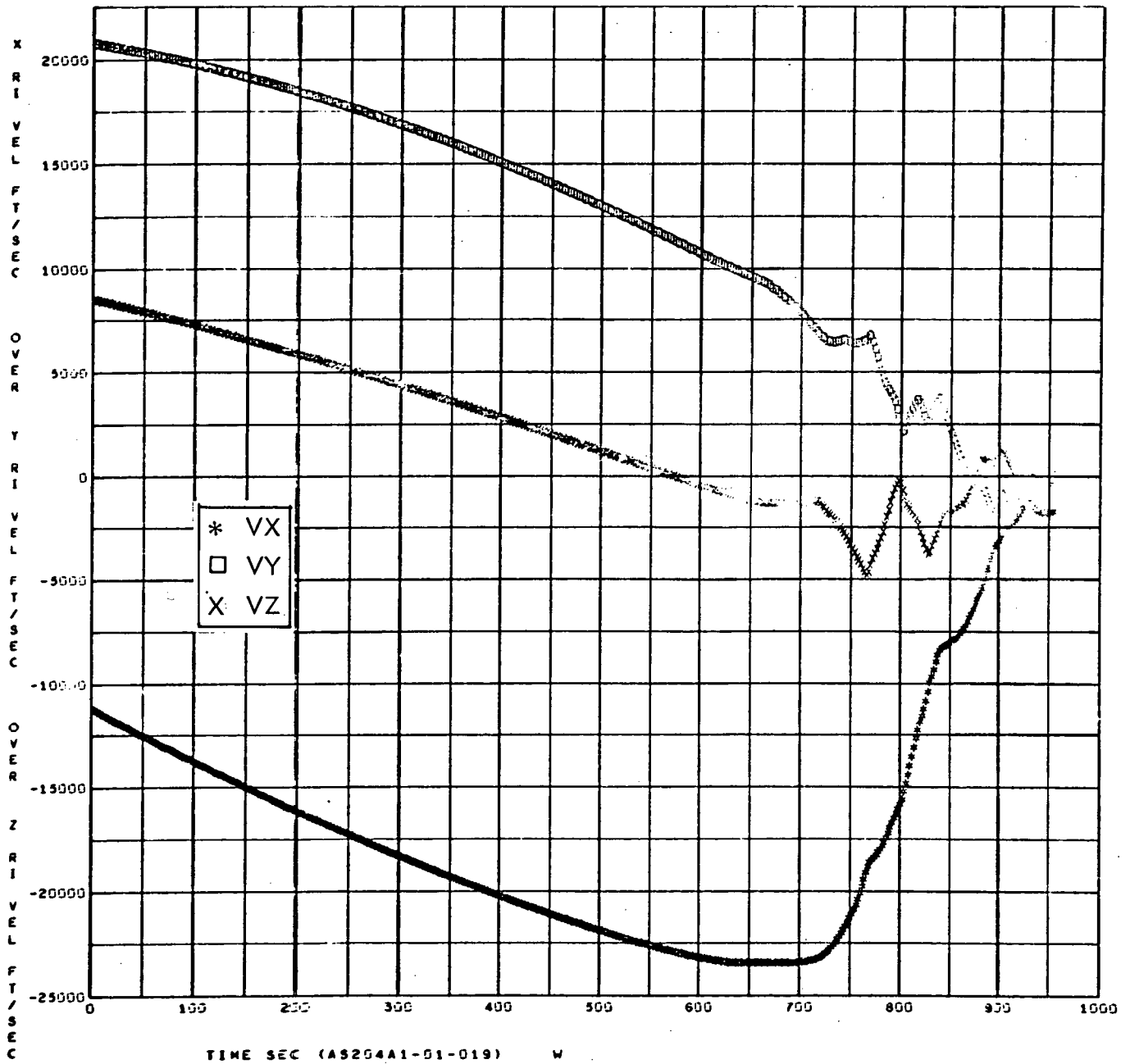
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APPENDIX H

TARGET LOCATIONS FOR OFF-NOMINAL TEST CASES

APPENDIX H

TARGET LOCATIONS FOR OFF-NOMINAL TEST CASES

State vector following an SPS deorbit maneuver:

Reentry longitude	83.607961°W
Reentry latitude	31.601836°N
Inertial velocity	25424.871 ft/sec
Inertial geocentric flight-path angle	-1.6657694 deg
Altitude	400000.24 ft
Inertial geocentric azimuth	83.324602 deg

Targets for test runs:

Test Run #1

Touchdown latitude	30.989°N
Touchdown longitude	54.9616°W

Test Run #20

Touchdown latitude	30.9°N
Touchdown longitude	59.5°W

Test Run #21

Touchdown latitude	30.5°N
Touchdown longitude	47.7°W

Test Run #22

Touchdown latitude	32.0°N
Touchdown longitude	65.0°W

Test Run #24

Touchdown latitude	30.989°N
Touchdown longitude	54.9616°W

TARGET LOCATIONS FOR OFF-NOMINAL TEST CASES (Continued)

Test Run #25

Touchdown latitude	30.989°N
Touchdown longitude	54.9616°W

Test Run #XX

Touchdown latitude	34.0°N
Touchdown longitude	53.0°W

State vector following a RCS deorbit maneuver:

Reentry longitude	114.58459°W
Reentry latitude	30.390893°N
Inertial velocity	25721.205 ft/sec
Inertial geocentric flight-path angle	-.63285354 deg
Inertial geocentric azimuth	78.745114 deg
Attitude	399999.50 ft

Targets for test runs:

Test Run #4

Touchdown latitude	25.266826°N
Touchdown longitude	54.957340°W

New state vector for overshoot test case of reentry guidance following RCS deorbit:

Reentry longitude	84.4°W
Reentry latitude	31.9°N
Inertial velocity	26000 ft/sec
Inertial geocentric flight-path angle	-.8853 deg
Inertial geocentric azimuth	82.9 deg
Altitude	400000 ft

TARGET LOCATIONS FOR OFF-NOMINAL TEST CASES (Continued)

Targets for test case:

Test Run #23

Touchdown latitude	17.5144°N
Touchdown longitude	14.7786°W

APPENDIX I

PLOTS FOR AS-204A NOMINAL
ENTRY ENGINEERING SIMULATION
DEVELOPED UNDER TASK A-9

(To be supplied later)

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