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Mission Design Data for Venus, Mars, and Jupiter Through 1990

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PASADENA, CALIFORNIA
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16. Abstract

The purpose of this document is to provide a handbook, containing working data to be used in the selection and trajectory design of missions to Venus, Mars and Jupiter during the 1975-1990 time period.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Astronautics (General) Astrodynamics Space Transportation Lunar and Planetary Exploration (Advanced)	Unclassified -- Unlimited

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Unclassified	Unclassified	3-231	

PREFACE

This document is divided into three volumes. Volume I comprises the mission design data for Venus, Volume II the data for Mars, and Volume III the data for Jupiter.

TABLE OF CONTENTS

LIST OF FIGURES

MISSION DESIGN DATA FOR VENUS, MARS AND JUPITER THROUGH 1990

Andrey B. Sergeyevsky

A. INTRODUCTION

This document presents mission design data for direct transfer trajectories from Earth to three planets – Venus, Mars and Jupiter, extending previously published information (see Refs. 1, 2, 3, 4 and 5) through the 1990 departure opportunity.

The primary purpose of this effort is to provide the mission analyst with graphical information, sufficient for preliminary mission design and evaluation. The data follows closely the format of Reference 4 and reflects methods of Reference 2. A specially modified version of the Space Research Conic Program (SPARC) (see Ref. 6) was used to generate the trajectory information presented. The data were automatically contour-plotted on the SC4020 plotter using the General Plot Program (GPP) (see Ref. 7), then hand retouched and labeled. A special program (VIEWPE) was constructed to provide planetary positional data in graphical form, plotted on the SC4020, and presented in original format.

The data are arranged in three sections by arrival planet, in natural sequence. Each section consists of two parts – the trajectory characteristics for all available opportunities to the particular planet, in chronological order, followed by that planet's positional data for every calendar year, from 1975 to 1995.

The persevering and encouraging insistence of management, especially that of Mr. Willard E. Bollman to carry this effort through to completion, as well as the graphic and editorial support of Mr. Richard W. Rackus are gratefully acknowledged.

B. DESCRIPTION OF TRAJECTORY CHARACTERISTICS DATA

1. General

The data represent trajectory performance information plotted in the departure date/arrival date space, thus defining all possible transfer trajectories between the two bodies, within the time-span considered. Fourteen individual parameters are contour-plotted on the departure energy (C_3) background contour chart, for each opportunity. The following opportunities are presented:

To Venus:	1975, 1976/7, 1978, 1980, 1981, 1983, 1984/5, 1986, 1988, 1989/90.
To Mars:	1979, 1981/2, 1983/4, 1985/6, 1988, 1990.
To Jupiter:	1977, 1978, 1979, 1980/81, 1981/82, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990.

2. Definition of Terms

The following parameters are displayed on the contour plots:

C_3 Earth departure energy (km^2/sec^2); same as the square of departure hyperbolic excess velocity $V_\infty^2 = C_3 = V_I^2 - 2GM/R_I$, where

V_I = conic injection velocity (km/sec)

GM = gravitational constant times mass of the attracting body, from Reference 8:

GM_{VENUS} = 0.32486010E6 (km^3/sec^2)

GM_{EARTH} = 0.39860115E6

GM_{MARS} = 0.42828444E5

$GM_{JUPITER}$ = 0.12670772E9

R_I = $R_S + h_I$, Injection radius (km), sum of surface radius $R_{S_{PLANET}}$ and injection altitude h_I, where (see Ref. 8):

$R_{S_{VENUS}}$ = 6052 (km)

$R_{S_{EARTH}}$ = 6378.16

$R_{S_{MARS}}$ = 3393.4

$R_{S_{JUPITER}}$ = 71372

TF — Time of flight (Days)

CD — Earth to planet communication distance at arrival (km)

VHP — Arrival hyperbolic excess velocity

$$V_\infty = \sqrt{V^2 - \frac{2GM}{R}}, \text{(km/sec)},$$

where

V = Heliocentric conic arrival velocity at heliocentric radius R (km).

Arrival Planet Orbit insertion velocity increment ΔV, at periapse, may be computed from V_∞:

$$\Delta V = \sqrt{V_\infty^2 + \frac{GM}{R_P}} - \sqrt{\frac{2GM\,R_A}{R_p(R_A + R_p)}}$$

where R_p and R_A are planetocentric periapse and apoapse radii (km), respectively. Similarly, if specific capture orbit period P(sec) and periapse radius R_p are desired:

$$\Delta V = \sqrt{V^2 + \frac{2GM}{R_p}} - \sqrt{\frac{2GM}{R_p} - \sqrt[3]{\left(\frac{2GM\pi}{P}\right)^2}}$$

B-PLANE — A plane normal to the incoming V_∞ - vector and passing through the center of planet.

T-AXIS — Axis in B-plane, parallel to ecliptic (Earth mean orbital) plane (see Figure 1).

DLA — Geocentric declination (vs. mean Earth equator of launch date) of the departure V_∞ - vector. May impose launch constraints. (deg)

ZAL — Angle between departure V_∞ vector and Sun-Earth vector. Equivalent to Earth-probe-Sun angle, several days out. (deg)

INC — Heliocentric inclination of transfer trajectory with mean ecliptic (Earth orbital) plane of launch date. (deg)

ZAP — Angle between arrival V_∞ vector and the arrival planet-to-Sun vector. Equivalent to planet-probe-Sun angle at far encounter; for subsolar impact would be equal to 180° (deg).

ETS — Angle in arrival B-plane, measured from T-axis, clockwise, to projection of Sun-to-planet vector. Equivalent to solar occultation region center-line. (deg)

LVI — Planetocentric latitude of vertical impact vs arrival planet equator. Note that Venusian north is below ecliptic, while Mars' and Jupiter's is above. Equivalent to declination of the incoming asymptote (i.e., the negative of incoming V_∞ vector) in planetary equator system.

ZAE — Angle between arrival V_∞ vector and the planet-to-Earth vector. Equivalent to planet-probe-Earth angle at far encounter. (Deg.)

ETE — Angle in arrival B-plane, measured from T-axis, clockwise, to projection of Earth-to-planet vector. Equivalent to Earth occultation region centerline. (deg)

THA — Angle in arrival B-plane, from T-axis, clockwise, to major axis of error dispersion ellipse (0 - 180 deg).

SG1 — Semi-major axis magnitude of B-plane dispersion ellipse, resulting from a spherically distributed V_∞ velocity vector error of 0.1 m/sec on departure asymptote (km).

SG2 — Semi-minor axis of above dispersion eclipse (km).

SG3 Arrival time dispersion, normal to B-plane, for above error model (sec).

C. DESCRIPTION OF PLANETARY POSITIONAL DATA

1. General

The data represent planetary geometry-related information plotted versus calendar arrival date at the target planet. Each set of seven plots represents the annual time history of 19 parameters, and may be used for flyby and orbiter missions.

2. Description of Curve Labels

P	Target planet, equivalent to probe approaching or in orbit about target planet.
E	Earth
S	Sun
CA	Cone Angle, i.e., Sun-probe-object (Earth or Canopus, etc.) angle. (See Figure 2.)
KA	Clock Angle, i.e., angle between projections of the Probe-Canopus and probe-object vectors into the plane normal to the sun-line (for which CA = 90°). (See Figure 2.)
RISEXX	Rise time (GMT) of planet through 6° horizon mask at DSN Station No. XX. (e.g., XX = 14 = GOLDSTONE, 43 = CANBERRA, 63 = MADRID.)
SETXX	Set time (GMT) of planet through 6° horizon mask at DSN Station No. XX.
YR/M/D	Year, Month, Date.

3. Description of Plots

Plot	Y-axis label	
a)	DECLIN	Geocentric Earth equatorial declination of planet (P), planetocentric planetary equatorial declination of Earth (E) and Sun (S). Note that Venusian north is below ecliptic.
b)	EC.LON	Heliocentric ecliptic longitude of planet.
c)	CA,KA	Cone (ECA) and Clock (EKA) angle of Earth and cone angle of Canopus (CCA) as seen from a Sun-Canopus oriented spacecraft near target planet, P (see Figure 2).
d)	DISTANCE	Sun-Planet distance (SP) and Earth-Planet communication distance (EP) in mill. km.
e)	SUN-EARTH-PLANET	Sun-Earth-Planet angle (SEP), indicating times of superior (SEP $\simeq$ 0) and inferior (SEP $\simeq$ 180°) conjunction; SEP > 5° is a communications constraint.
f)	STATION RISE/SET	Rise and Set times (GMT) of planet at 3 DSN Stations on Earth, 6° mask.

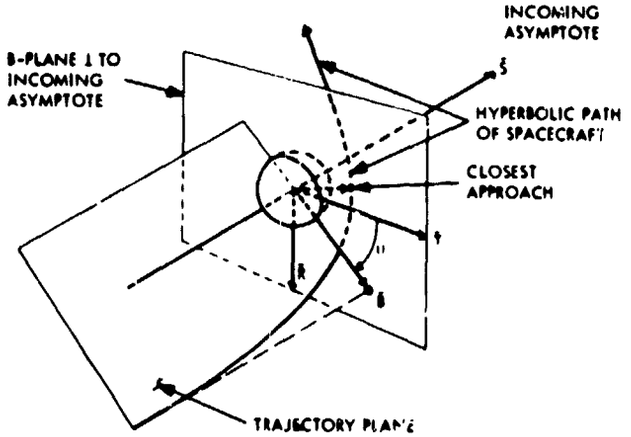

Figure 1. Definition of B-Plane

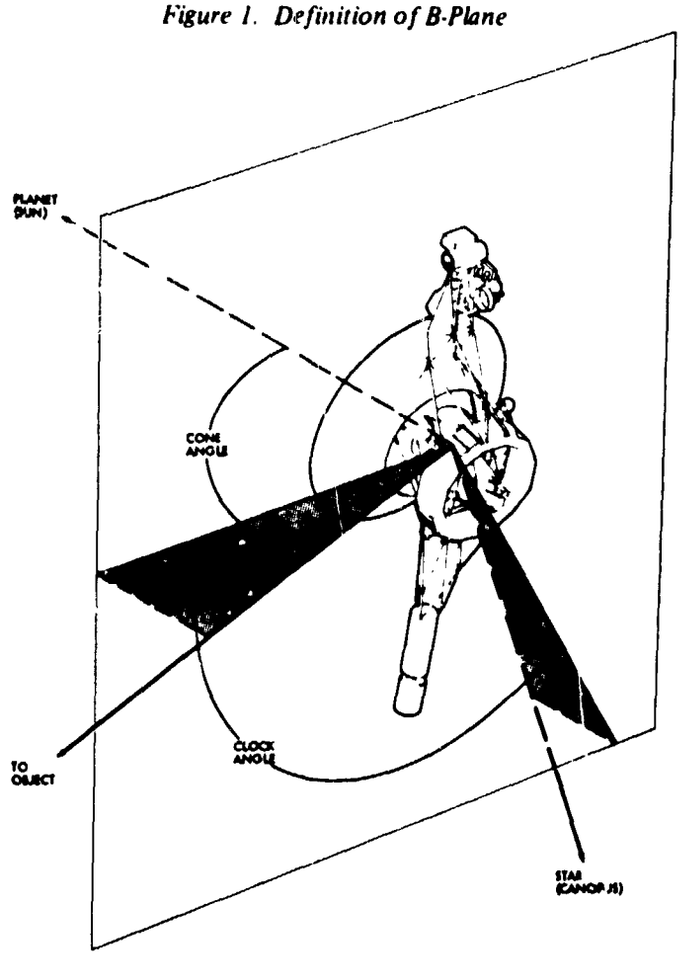

Figure 2. Definition of Cone and Clock Angle

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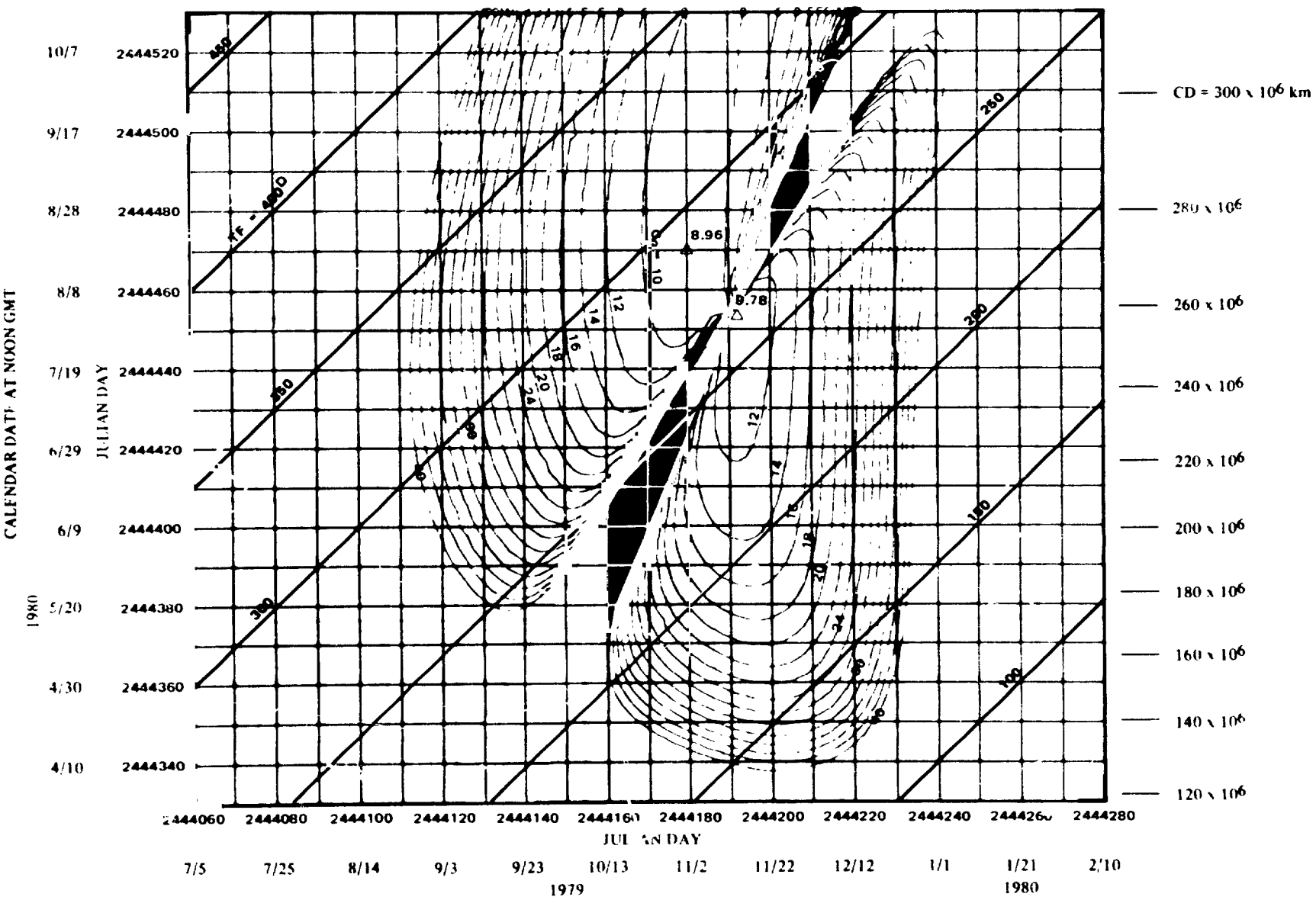
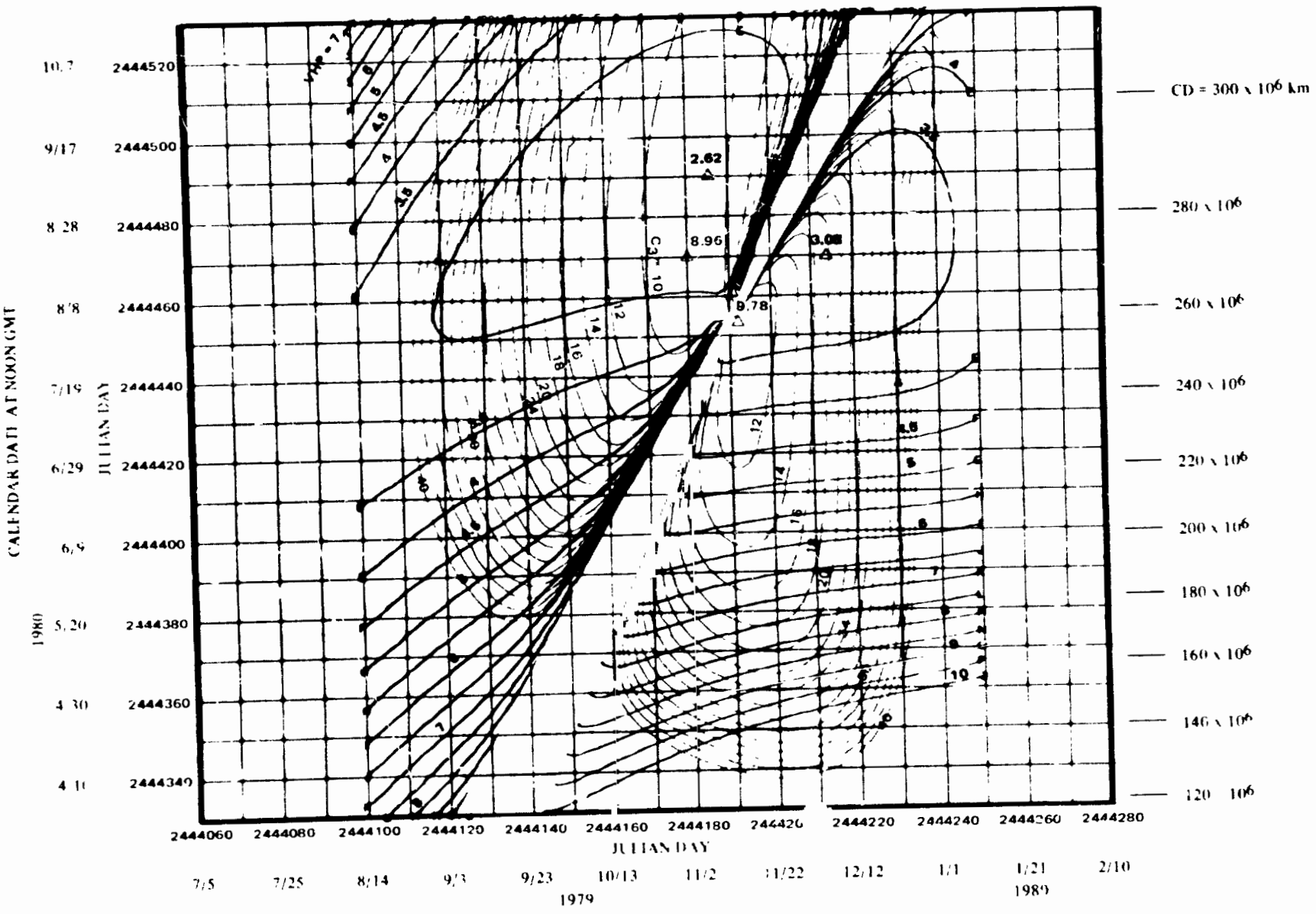


CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1979-80

1979 C_3



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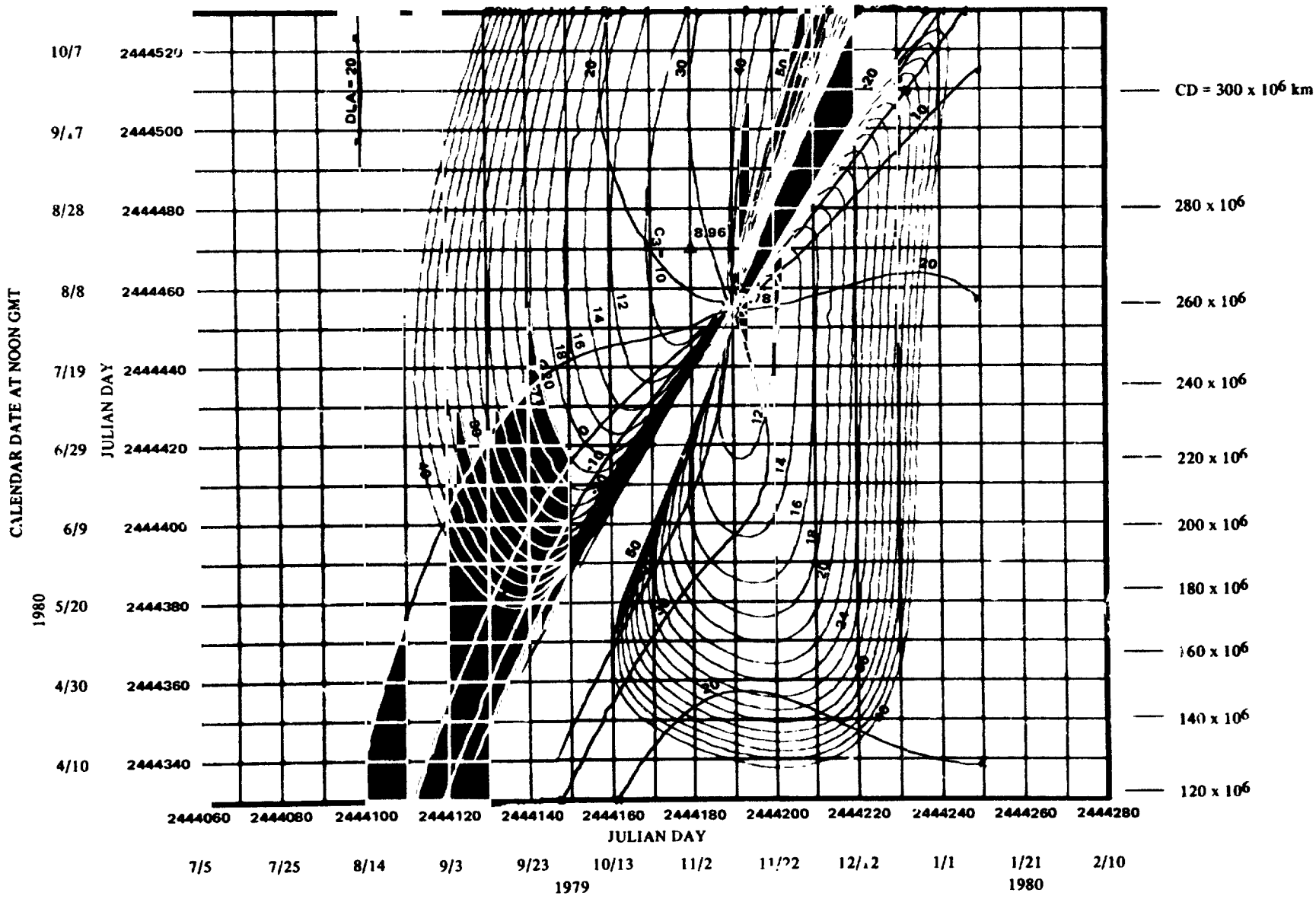
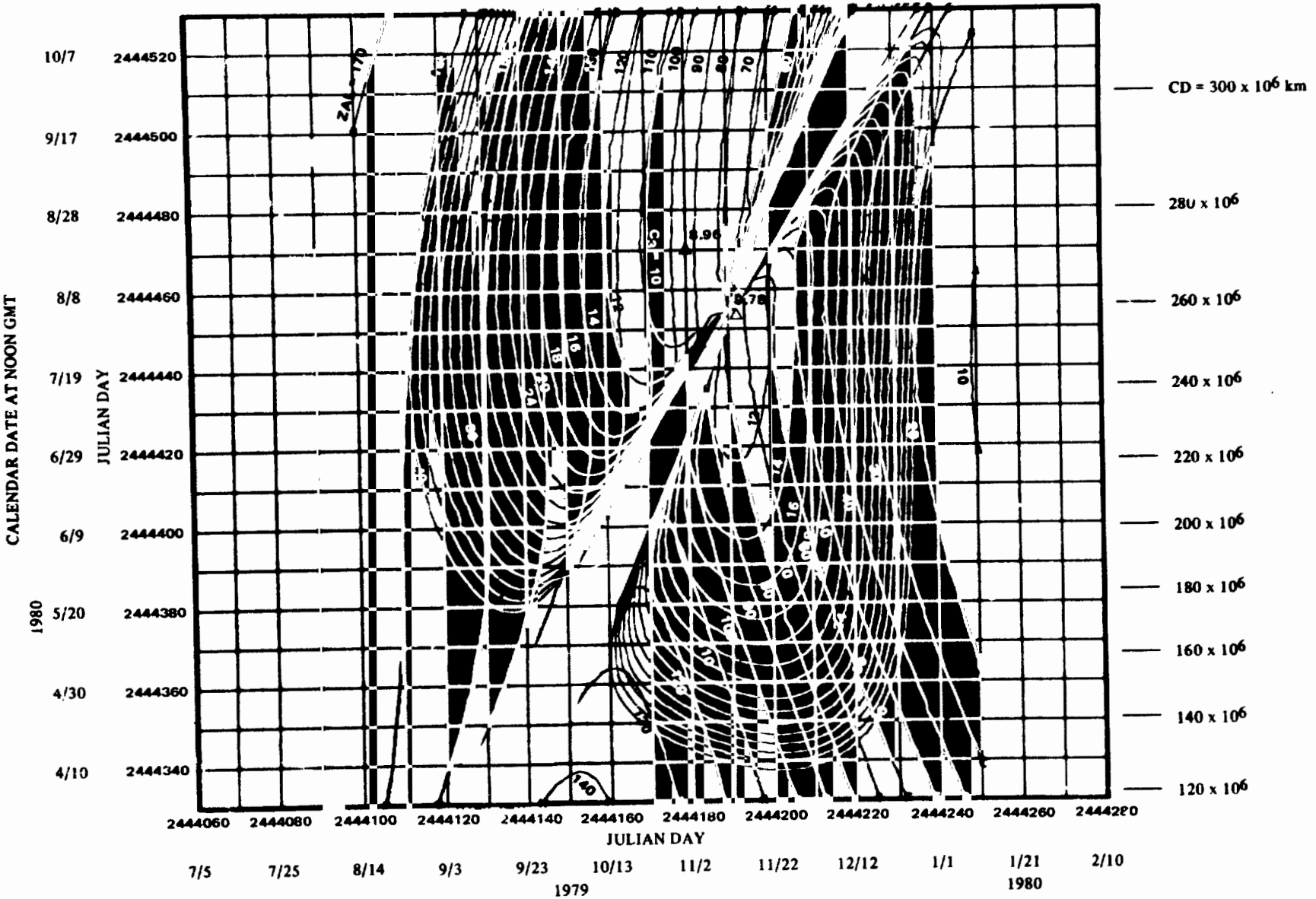


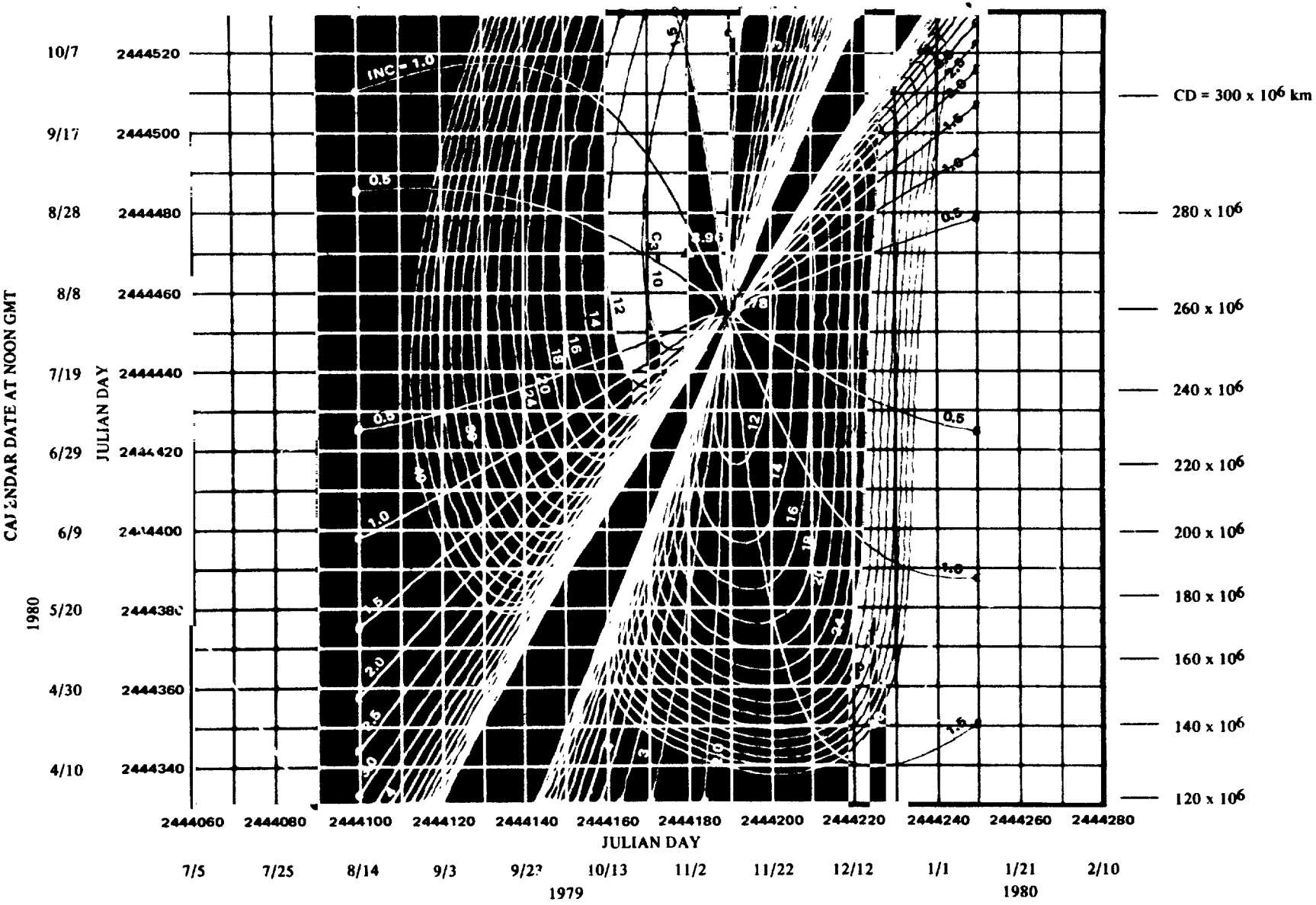
CONTOURS OF C_3 AND DLA EARTH TO MARS 1979-80

DLA 1979



CONTOURS OF C_3 AND ZAL EARTH TO MARS 1979-80

ZAL 1979



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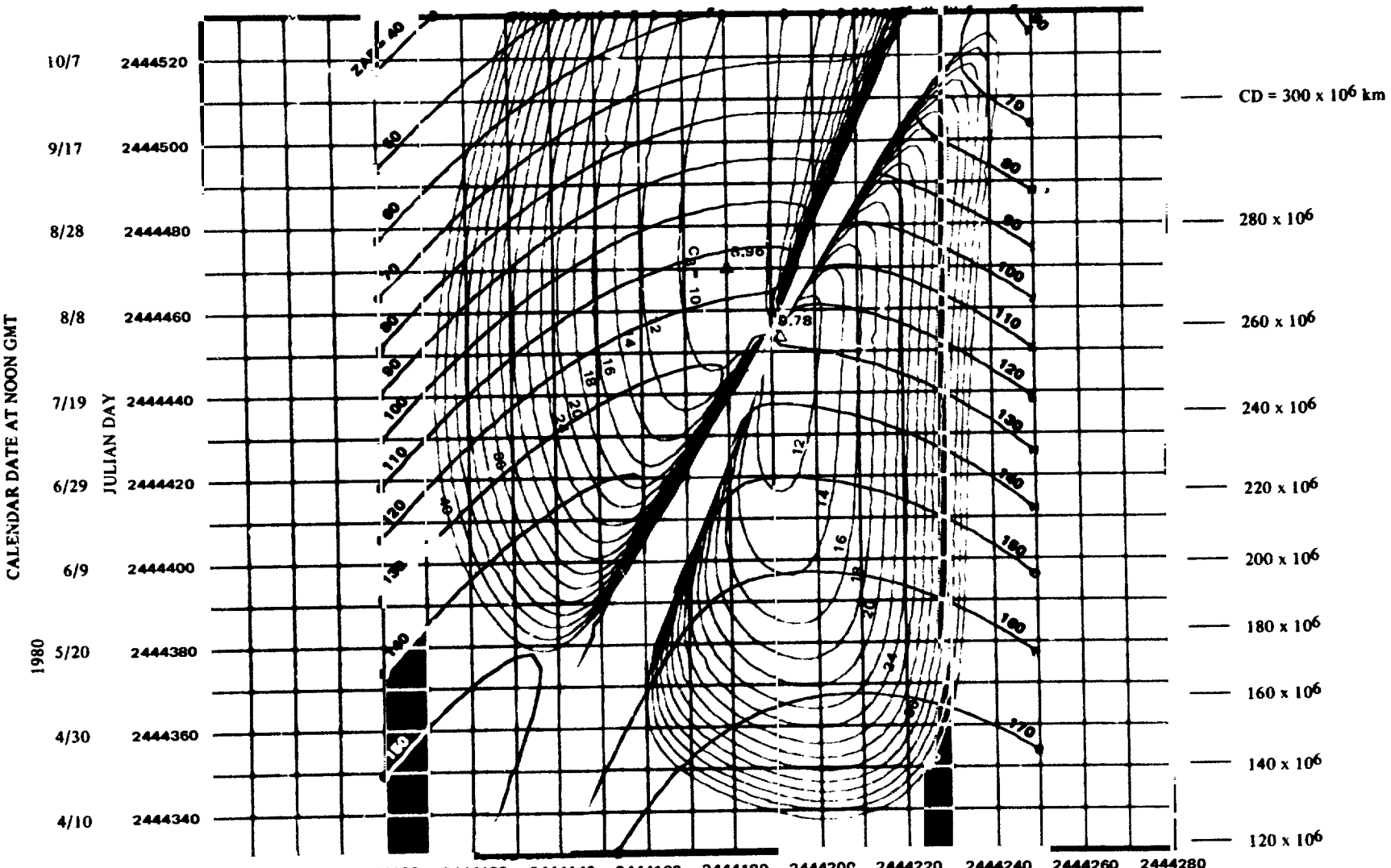
1979 INC



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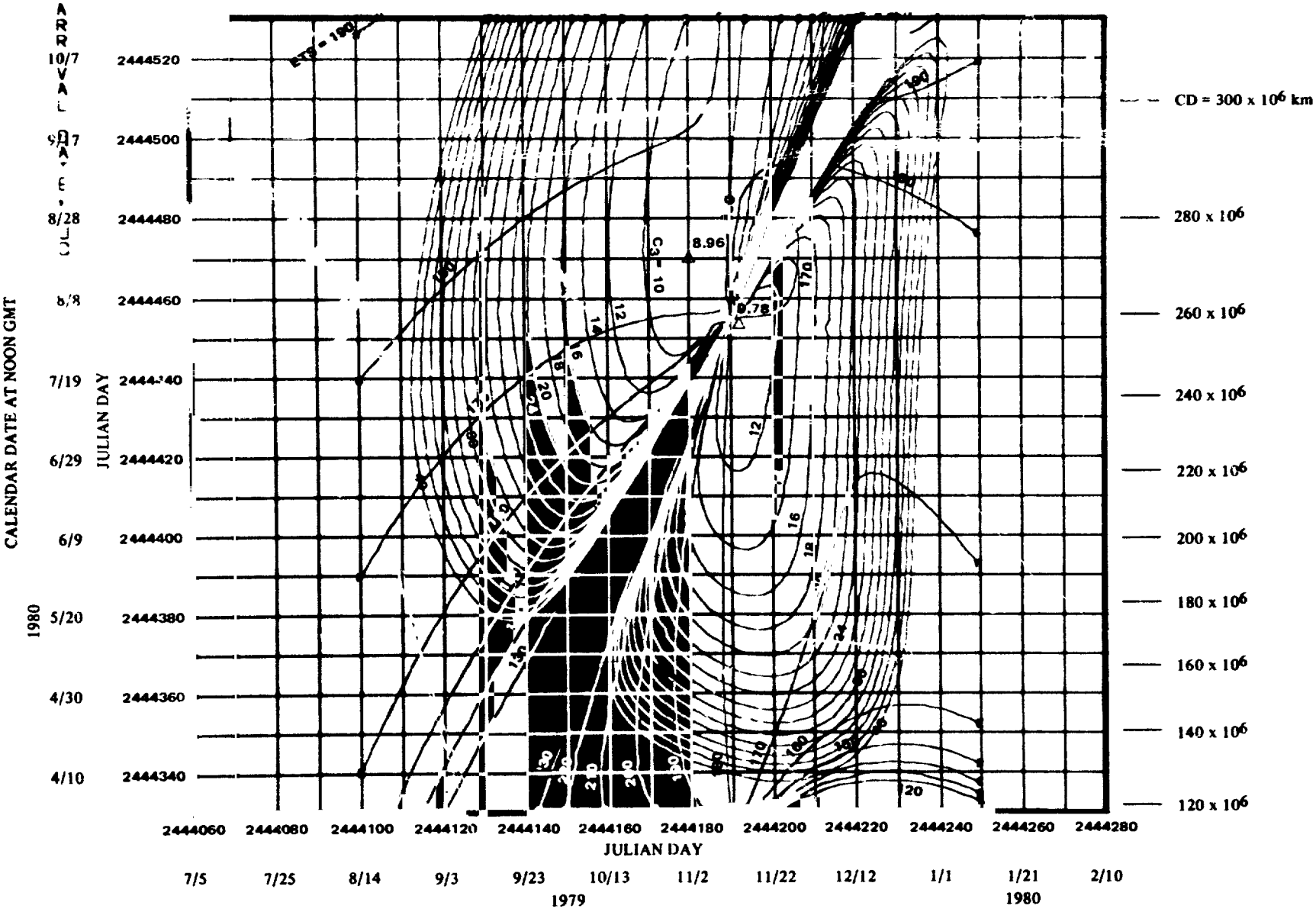
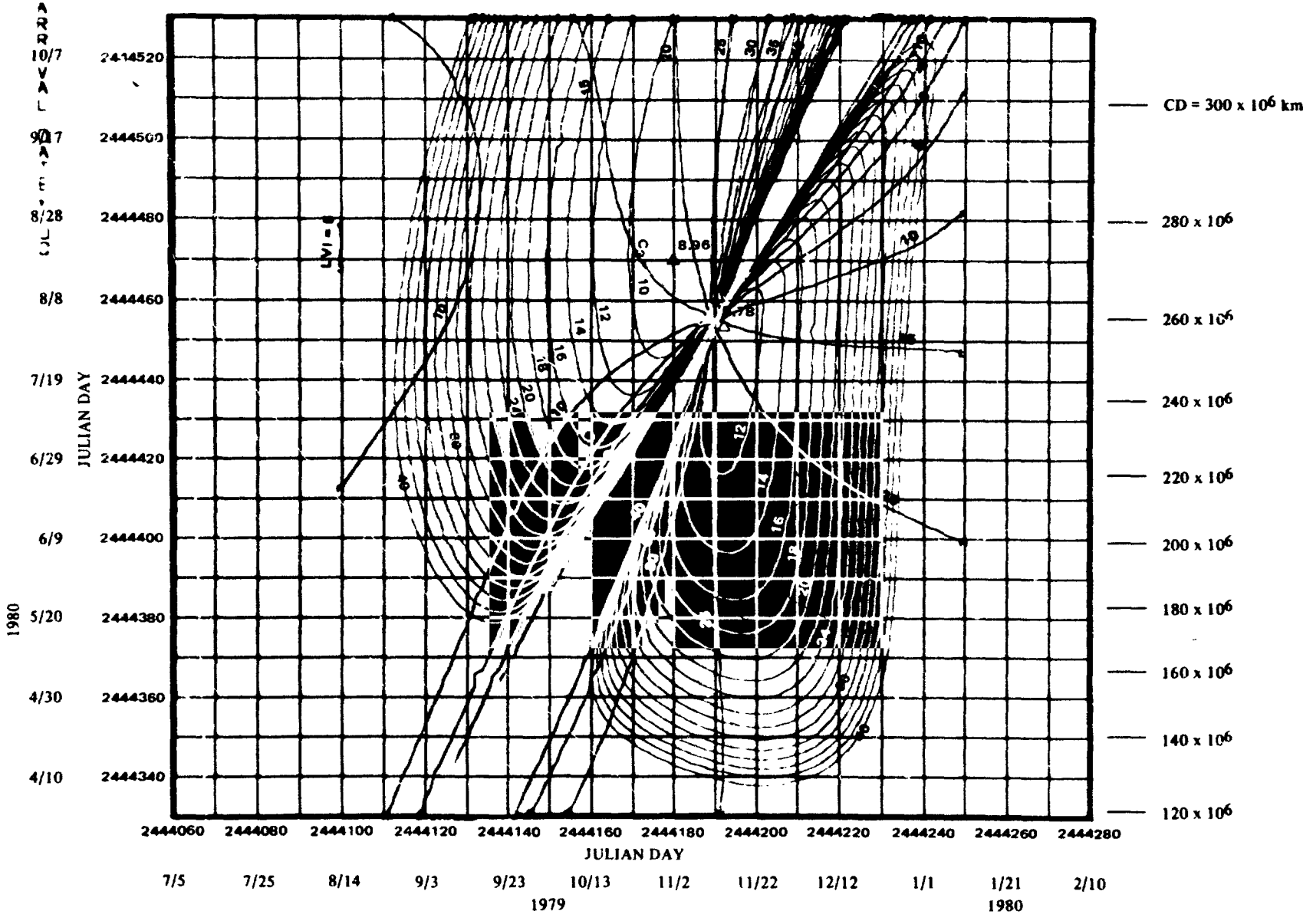


CONTOURS OF C_3 AND ETS EARTH TO MARS 1979-80

ETS 1979



CONTOURS OF C_3 AND LVI EARTH TO MARS 1979-80

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1979 LVI

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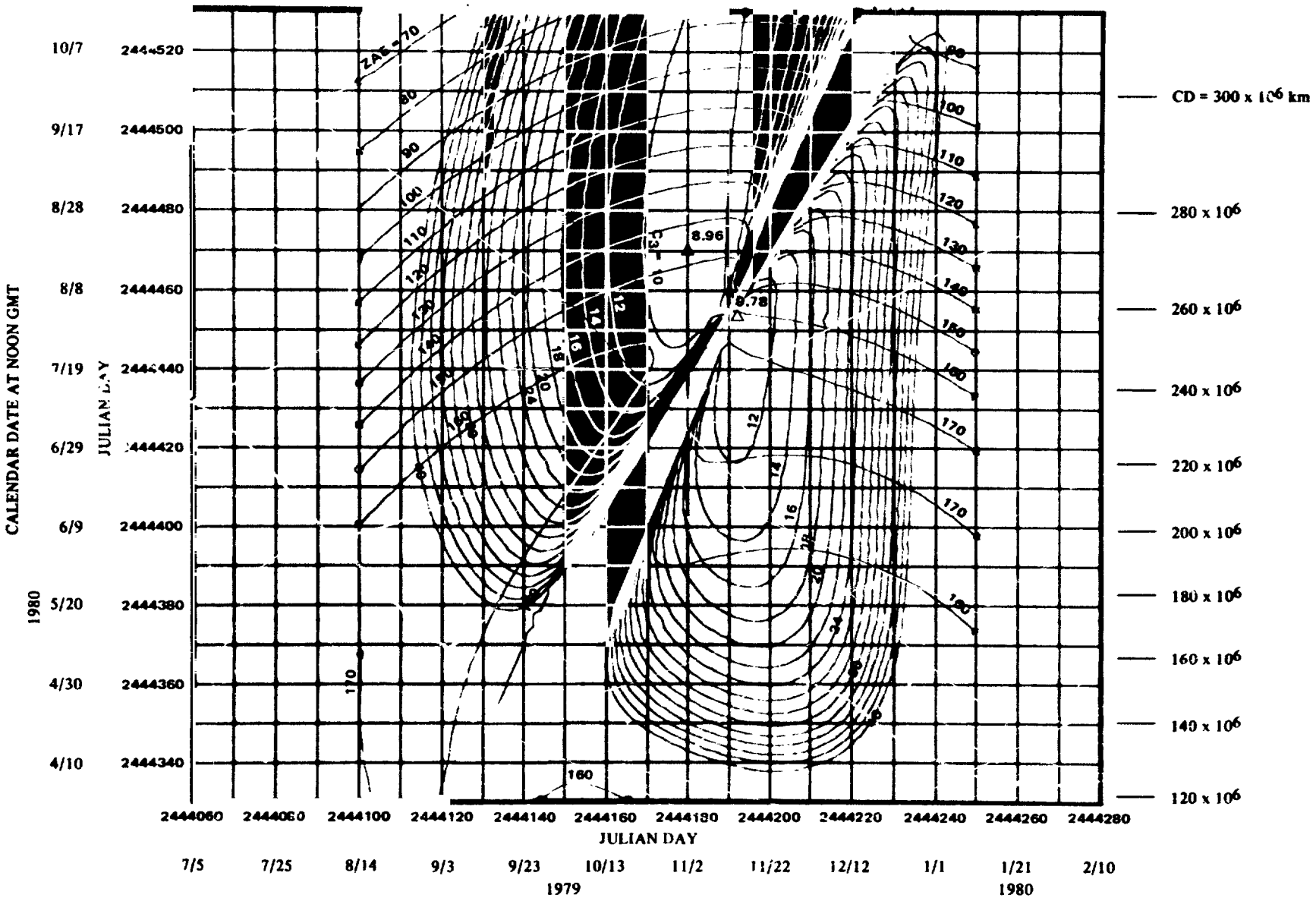
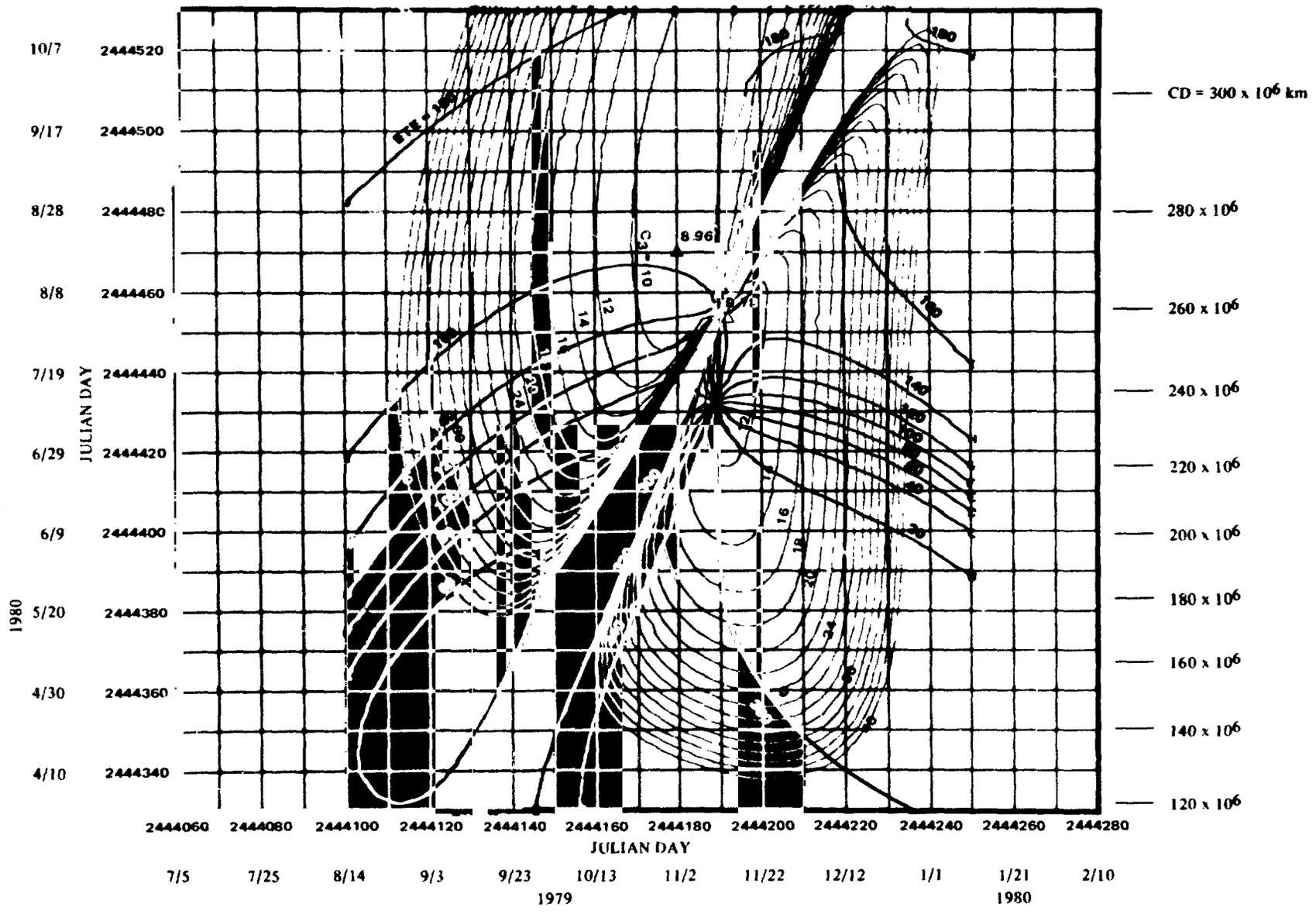


CONTOURS OF C_3 AND ZAE EARTH TO MARS 1979-80

ZAE
1979



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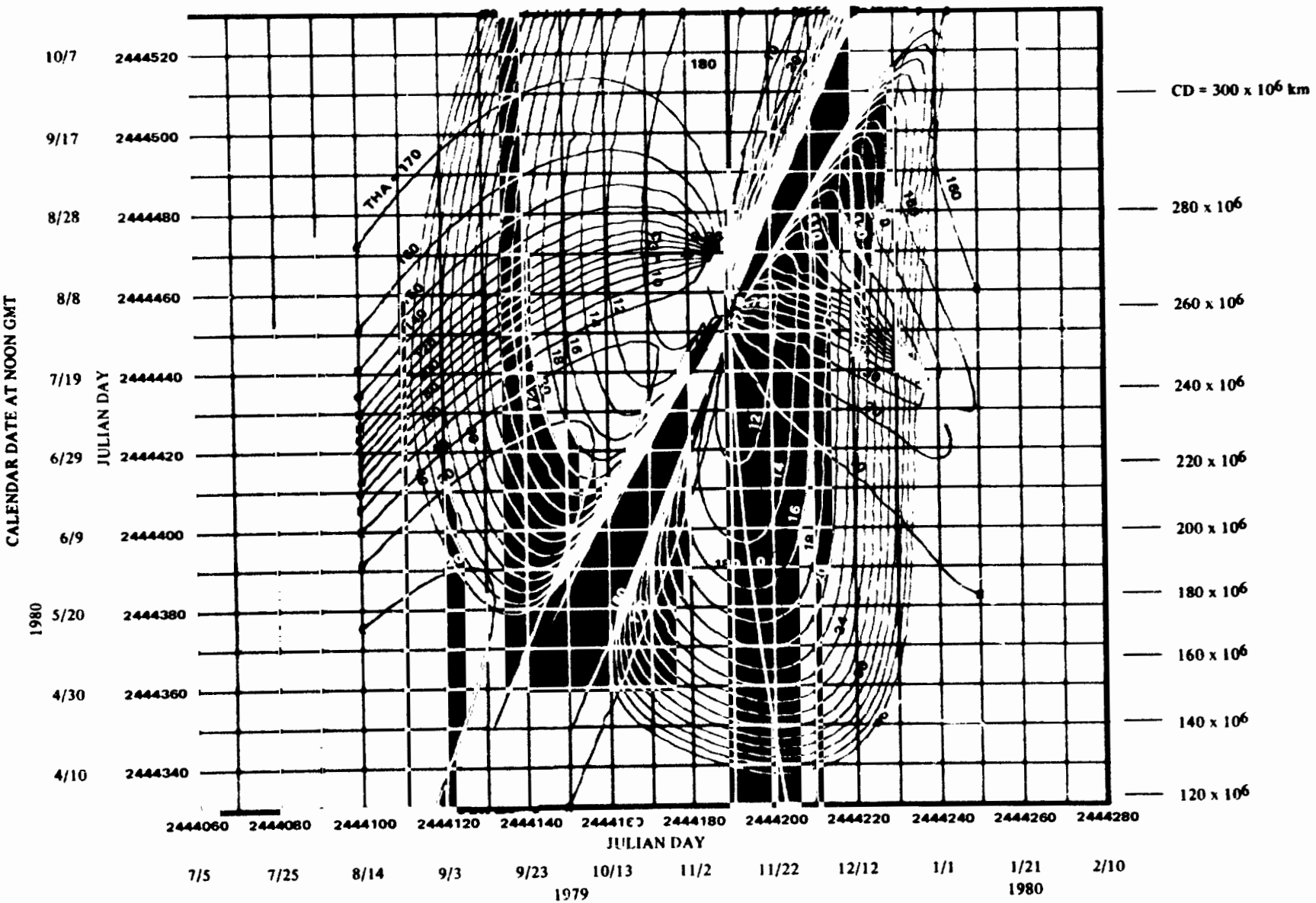
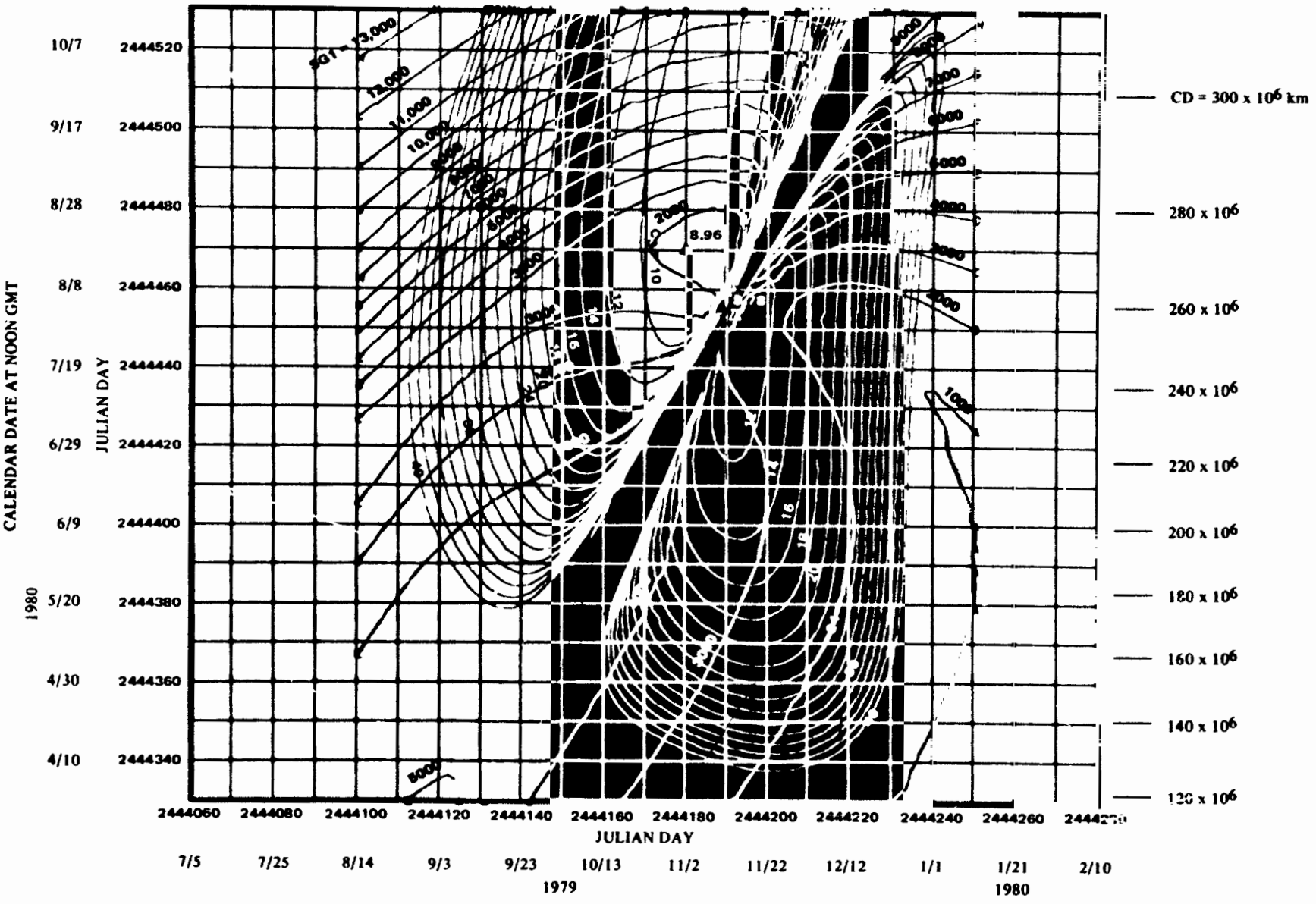


CONTOURS OF C_3 AND THA EARTH TO MARS 1979-80

THA ♂ 1979



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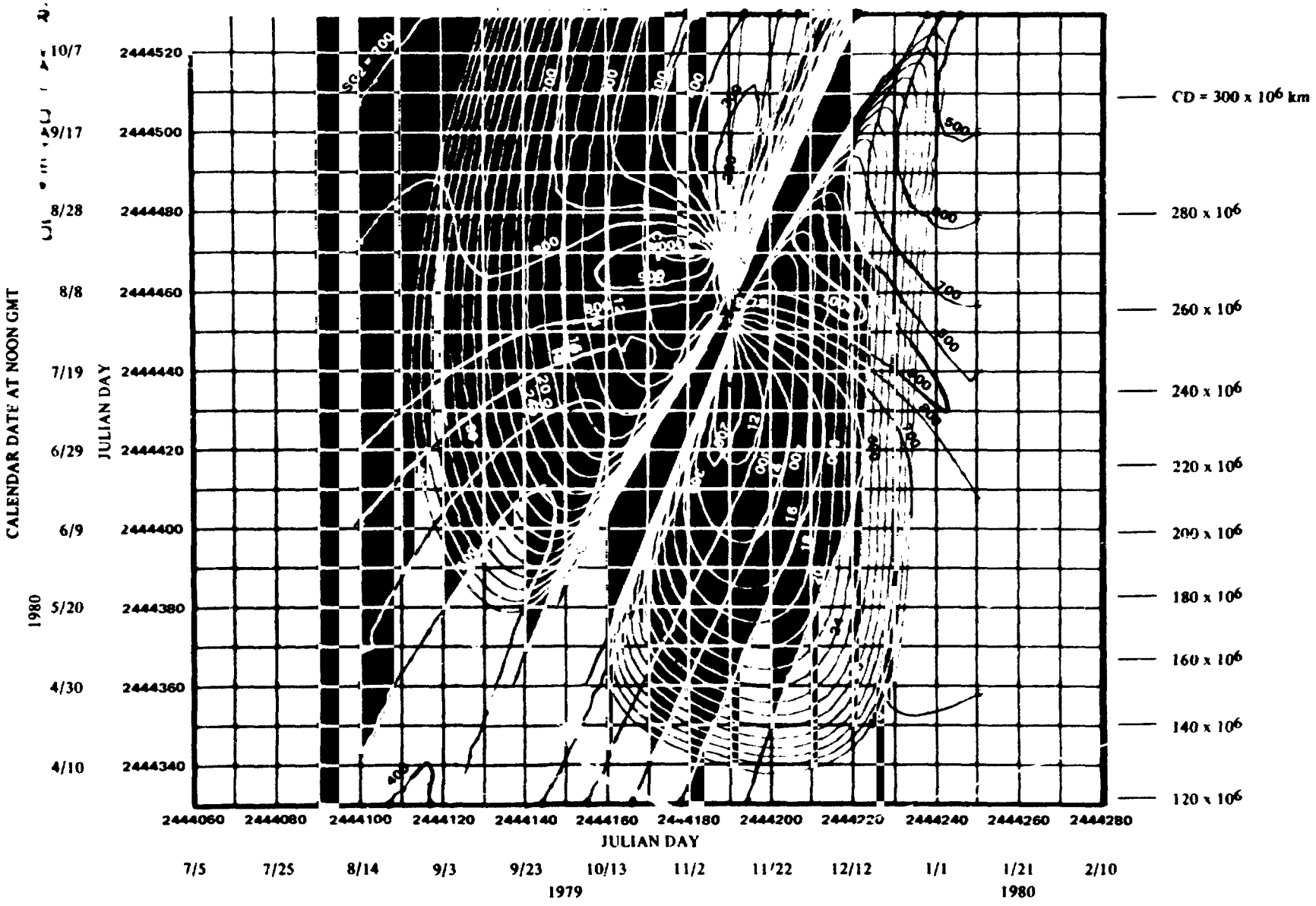
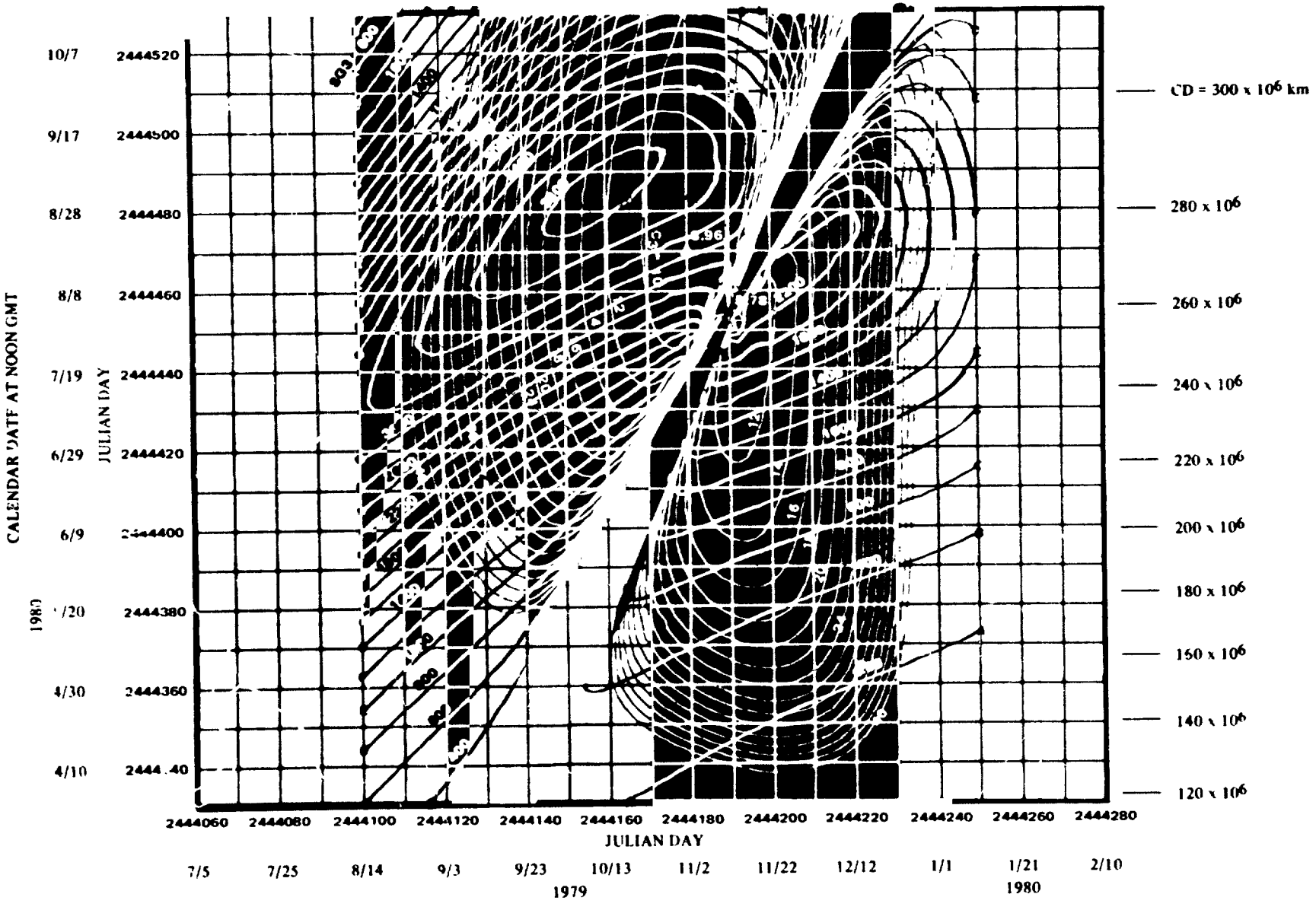


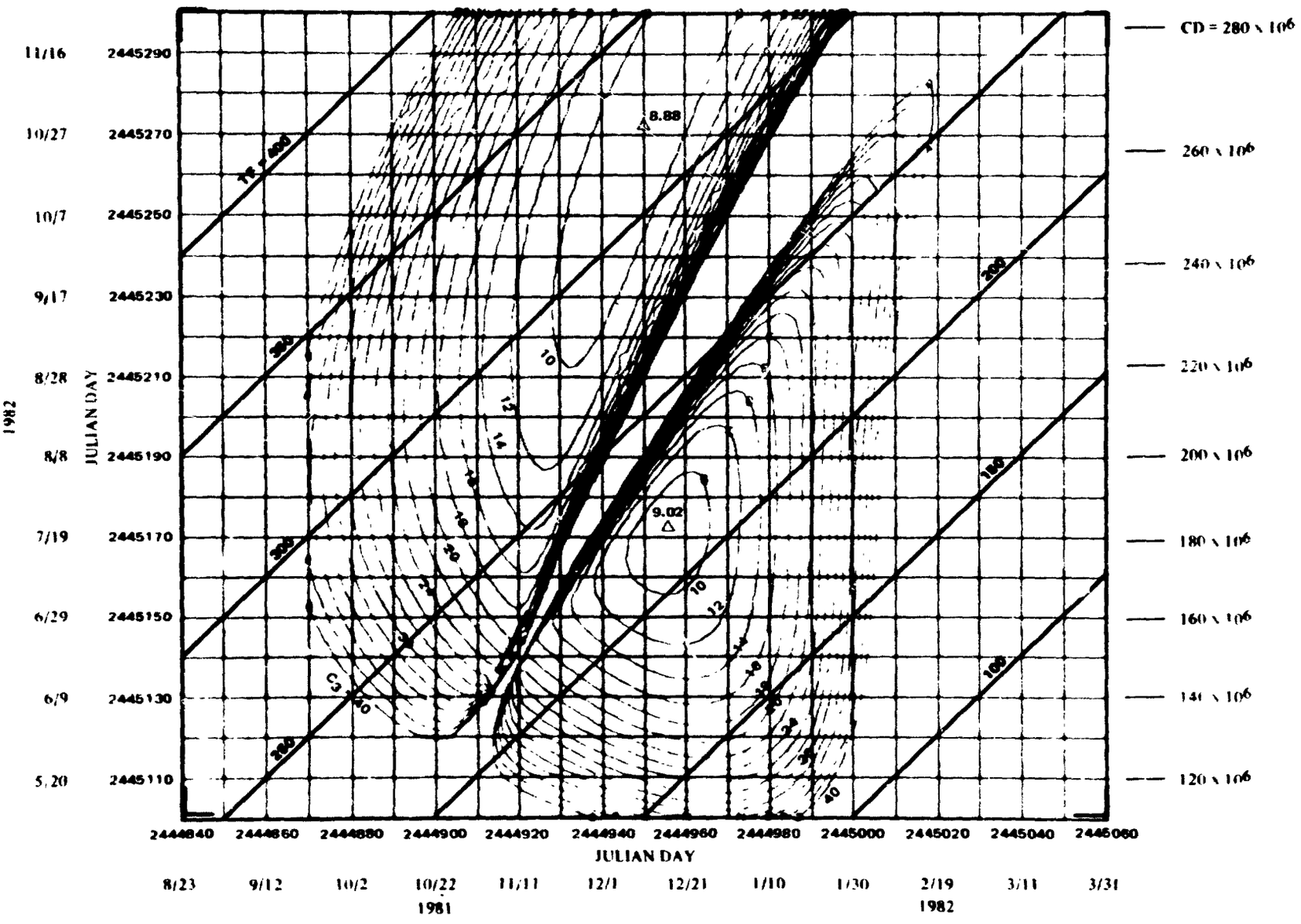
CONTOURS OF C_3 AND SG2 EARTH TO MARS 1979-80

SG2
1979



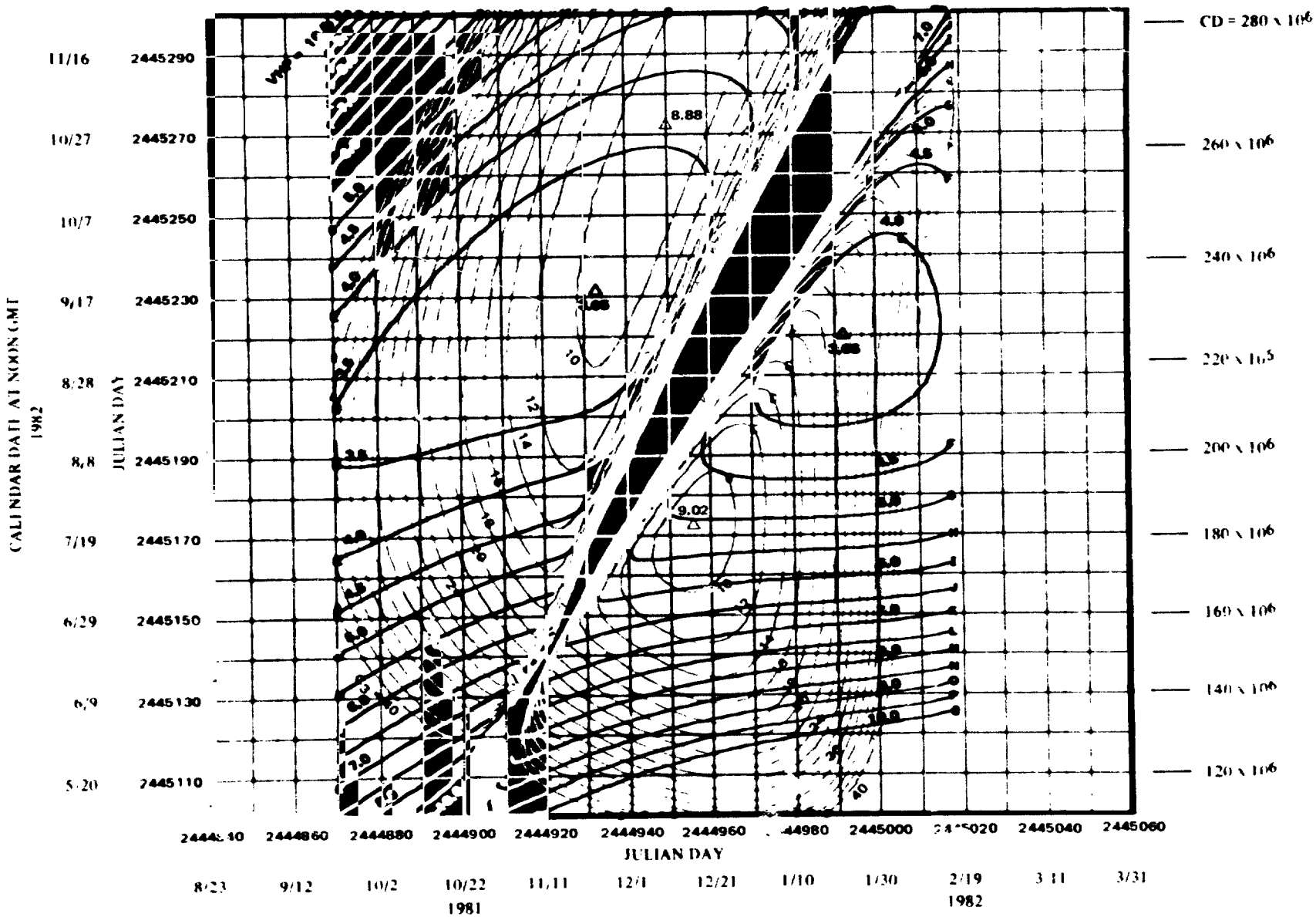
CONTOURS OF C_3 AND SG3 EARTH TO MARS 1979-80

1979 SG3



CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1981-82

1981 C_3



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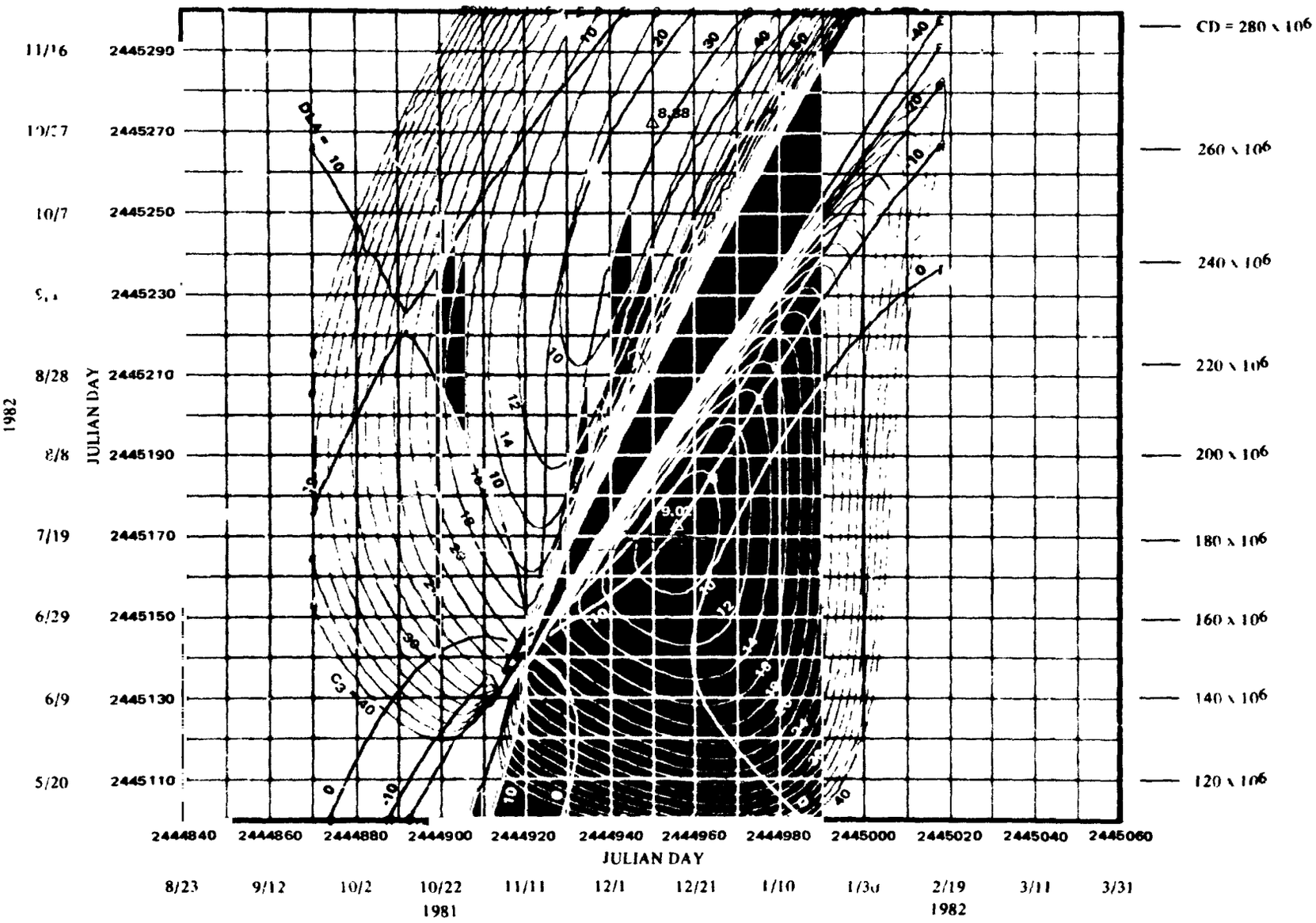

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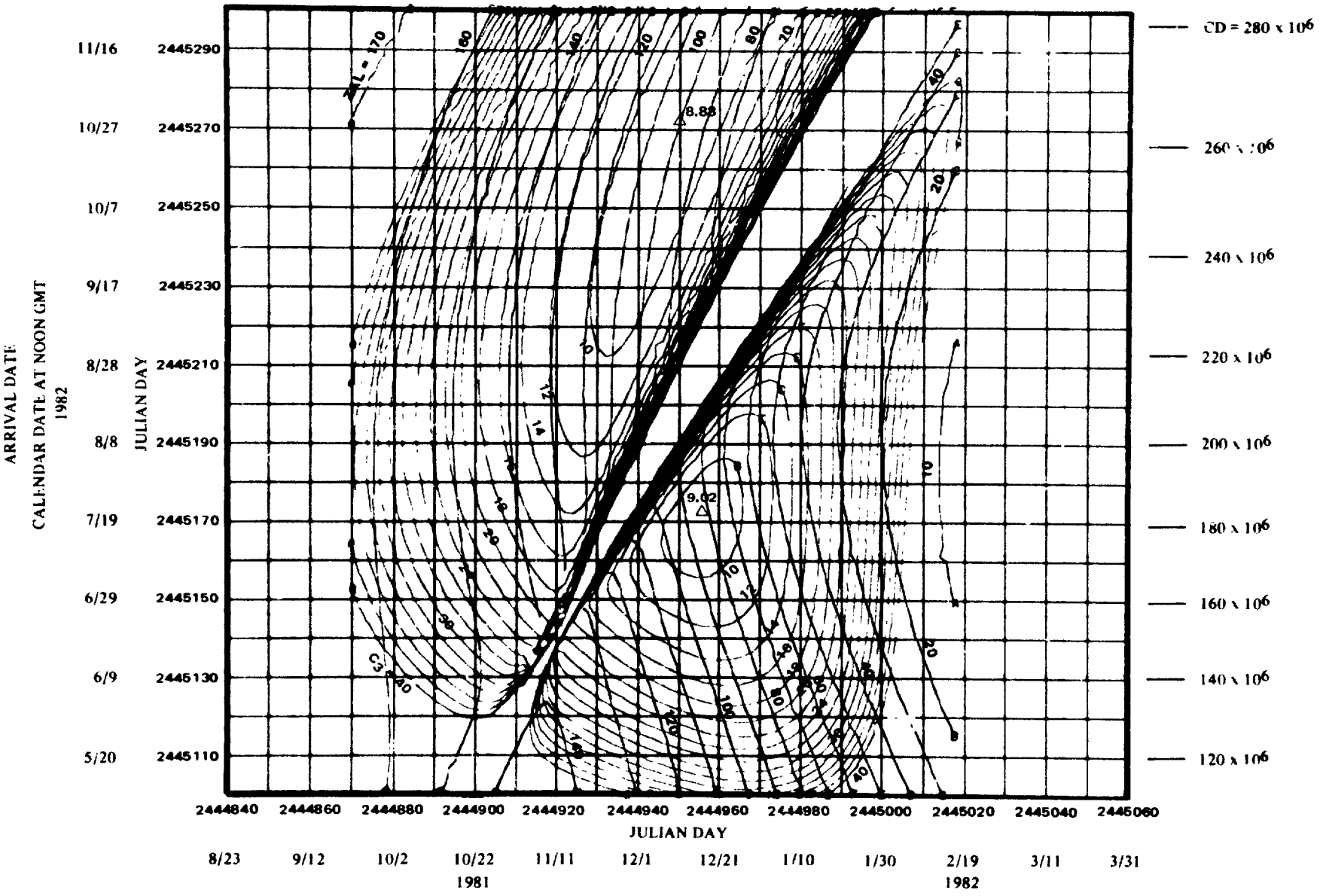
DLA 1981



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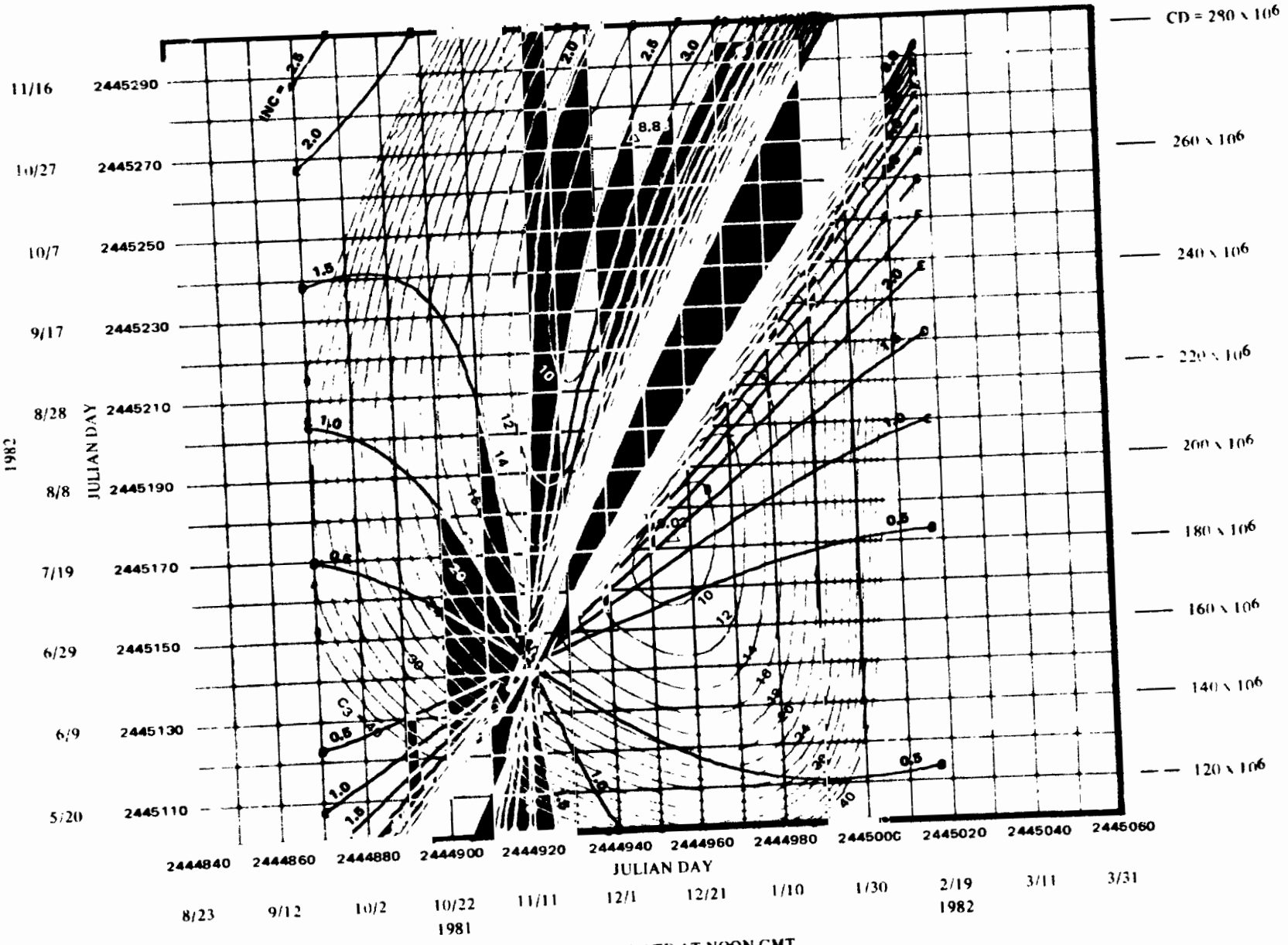
ZAL
1981



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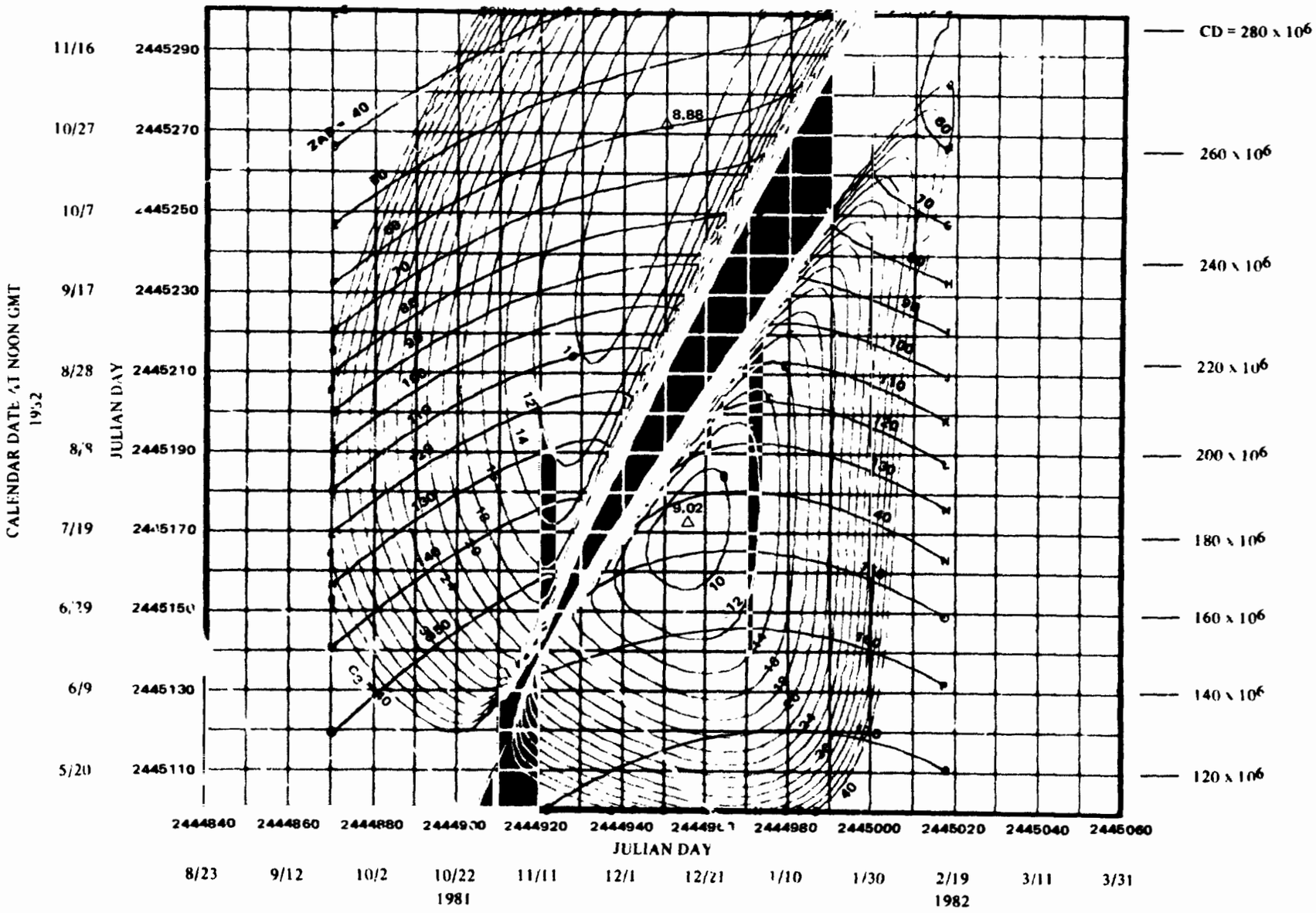

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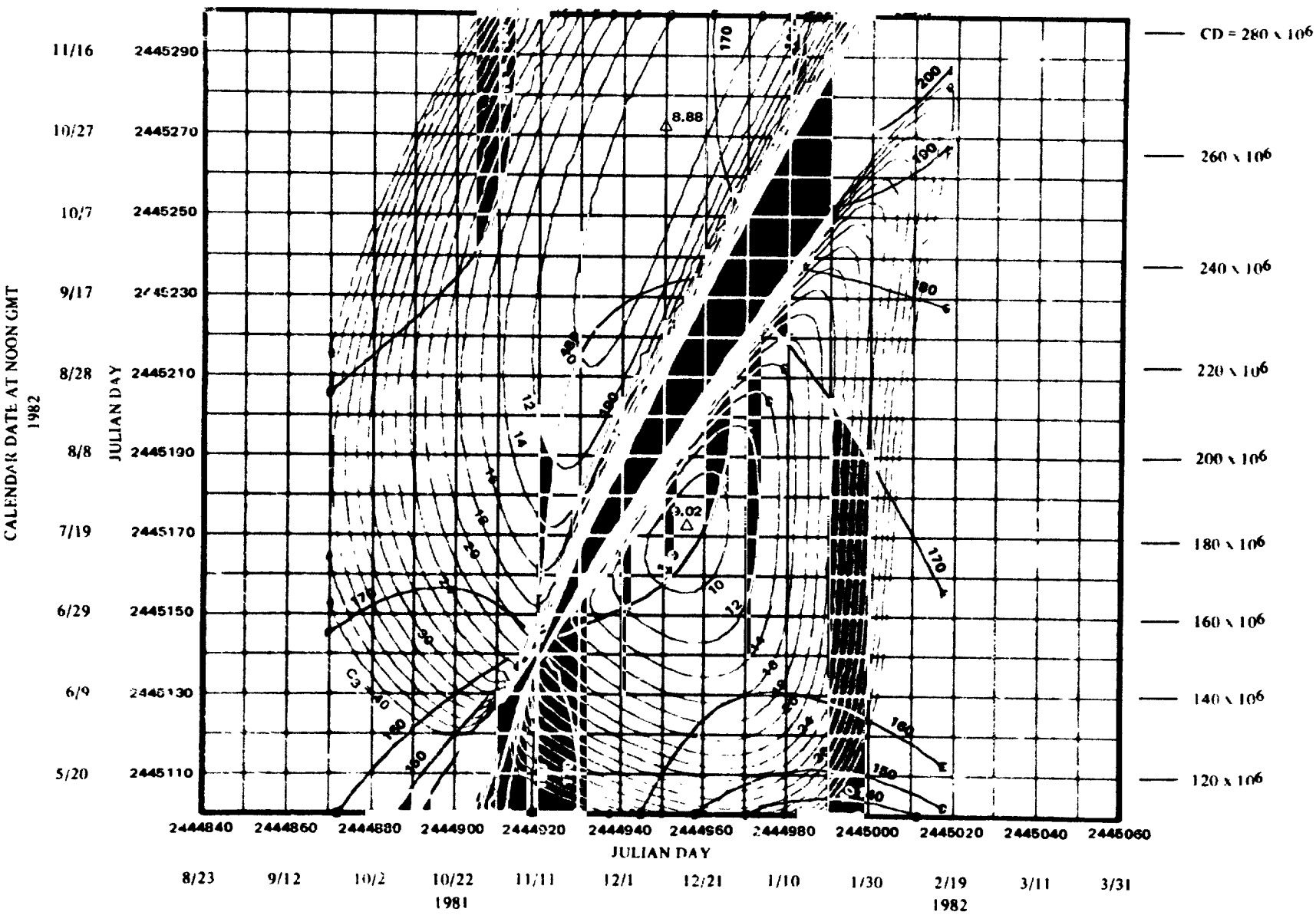

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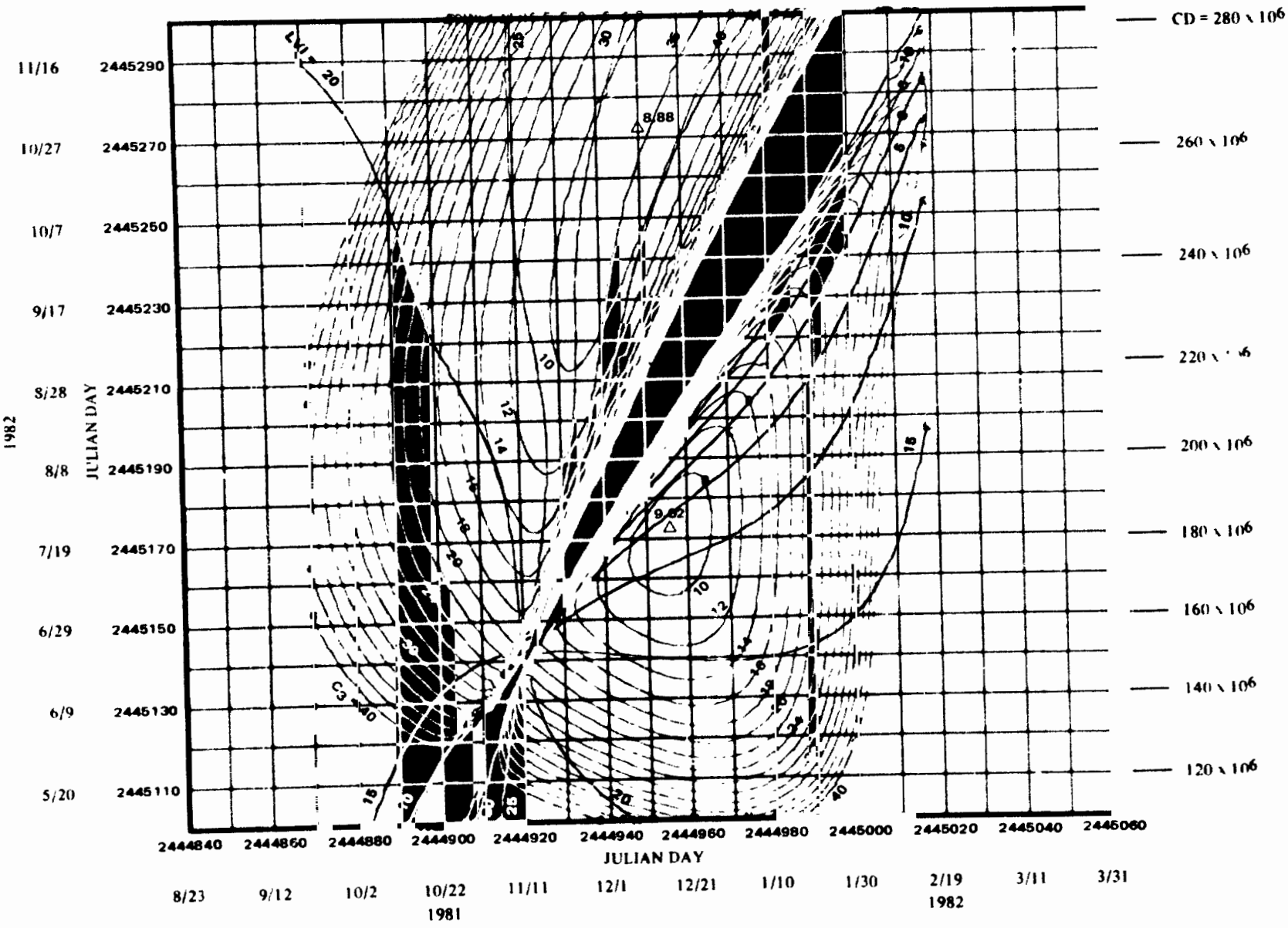

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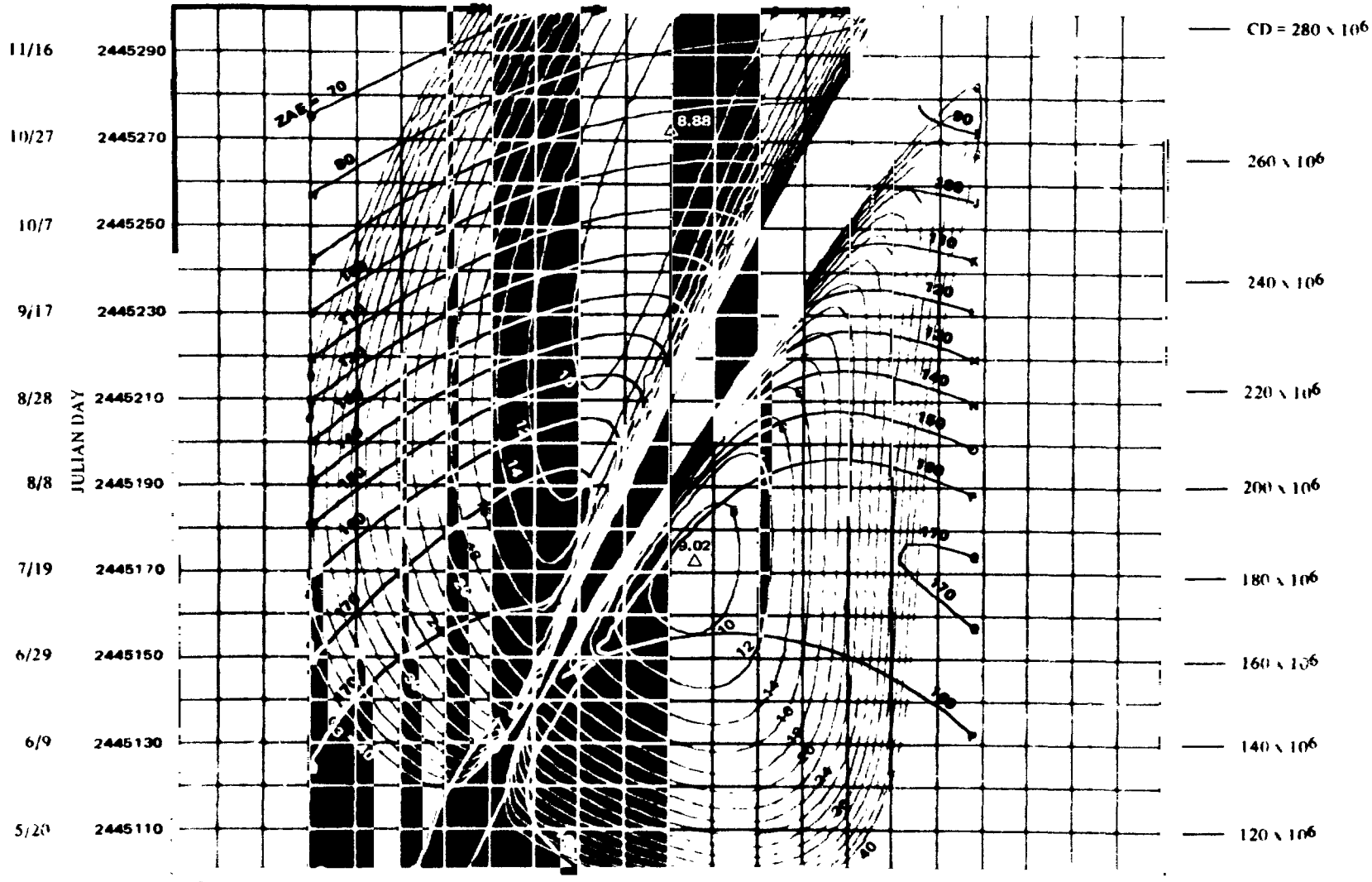

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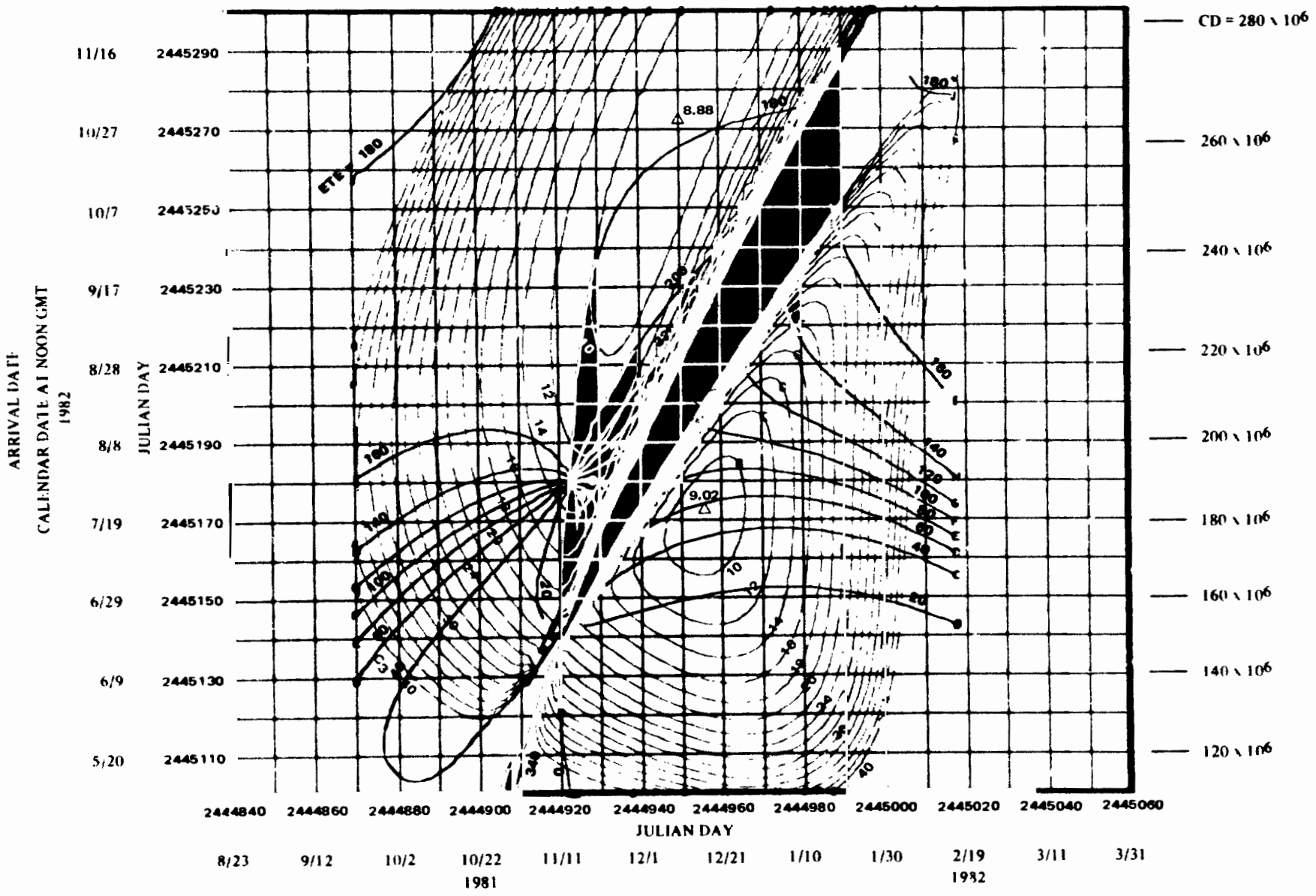
1981



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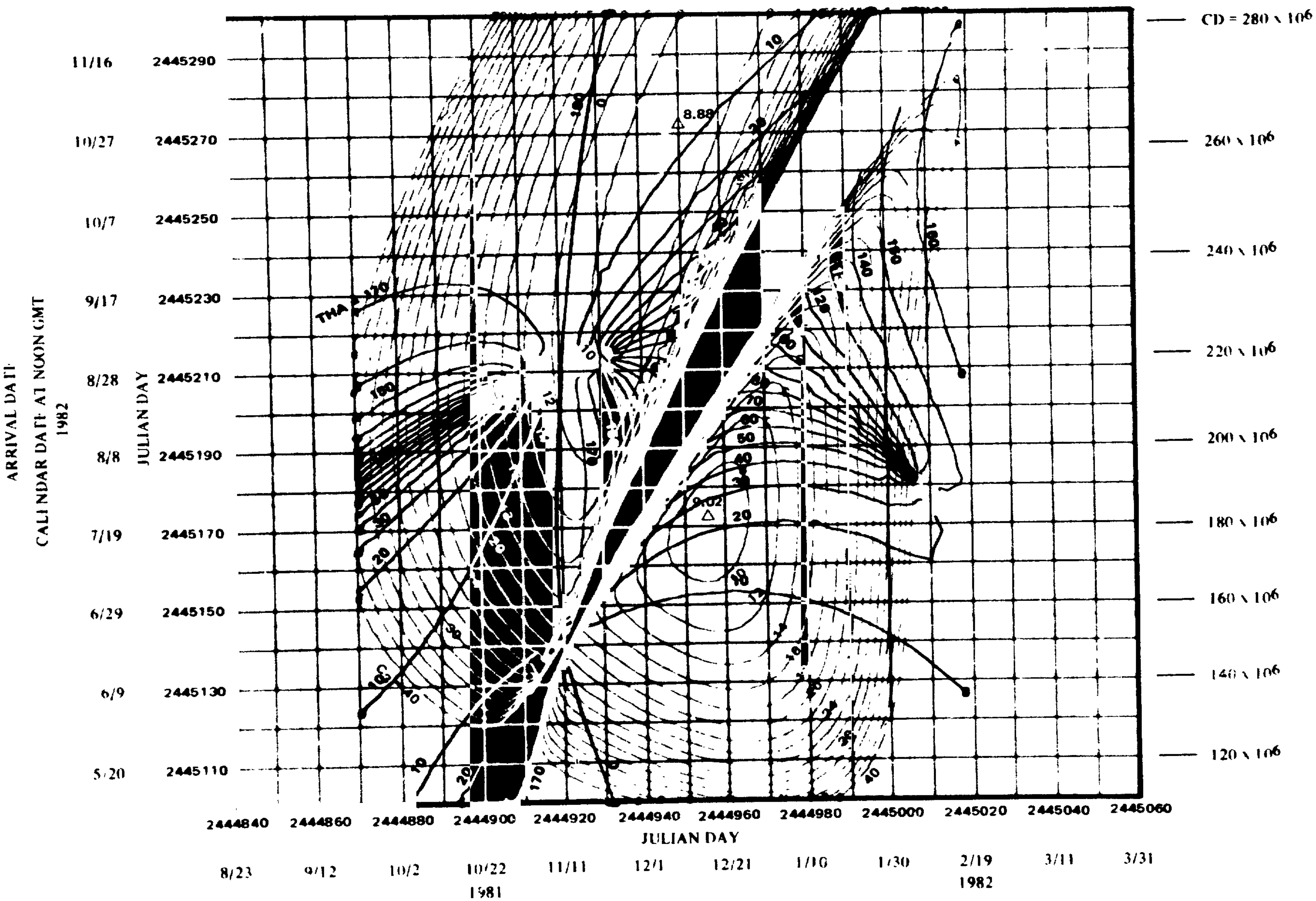

CONTOURS OF C_3 AND THA EARTH TO MARS 1981-82

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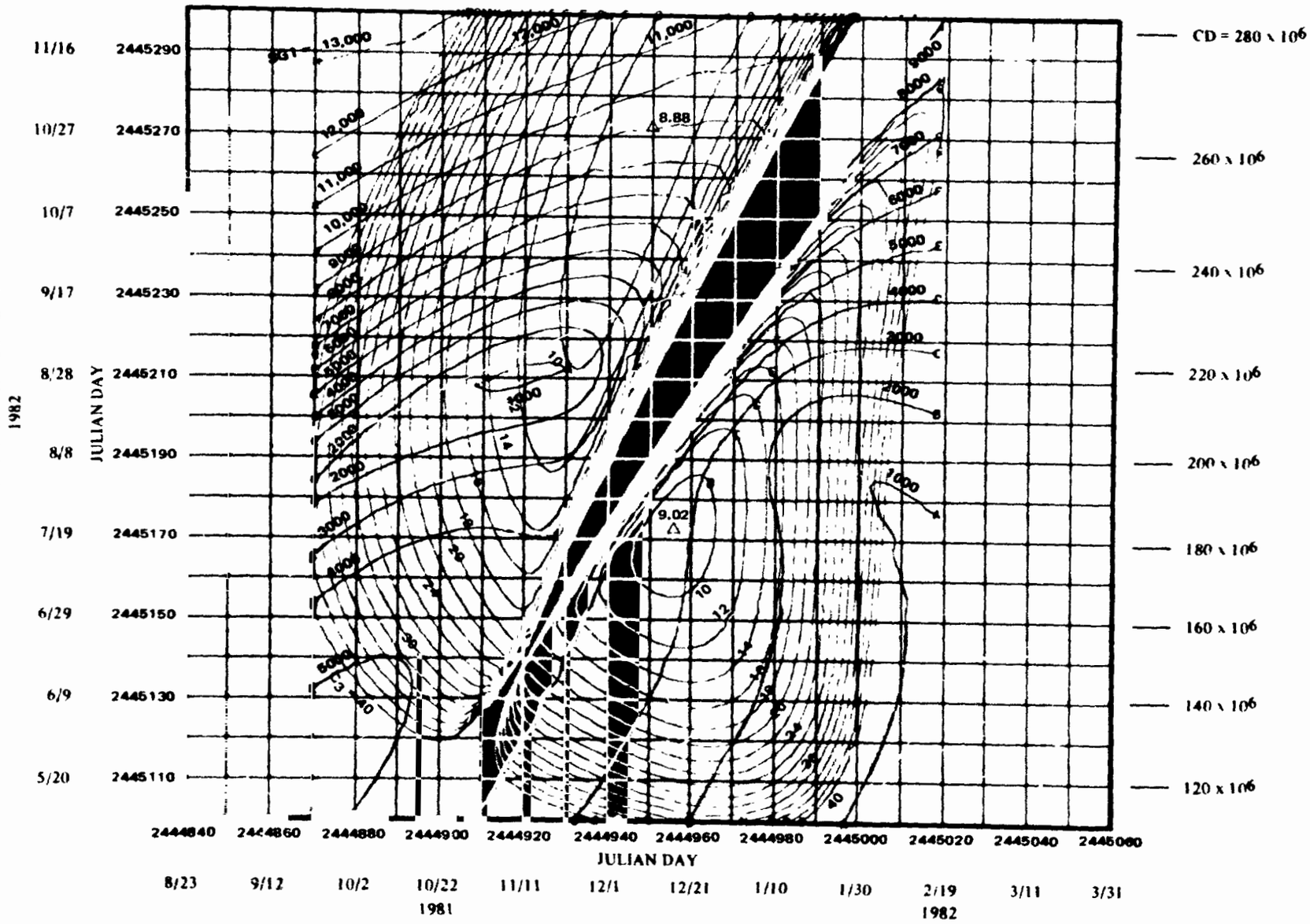
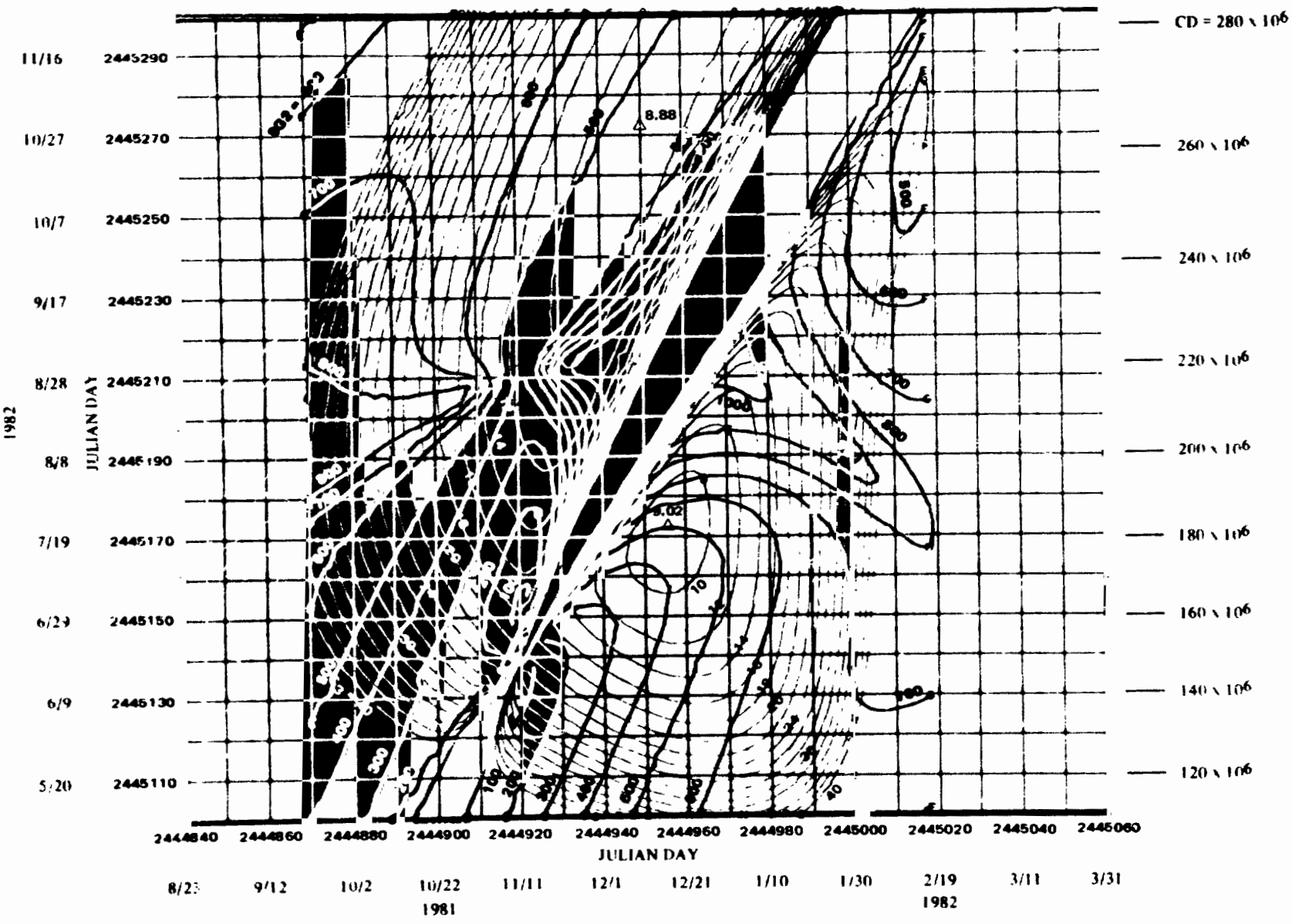
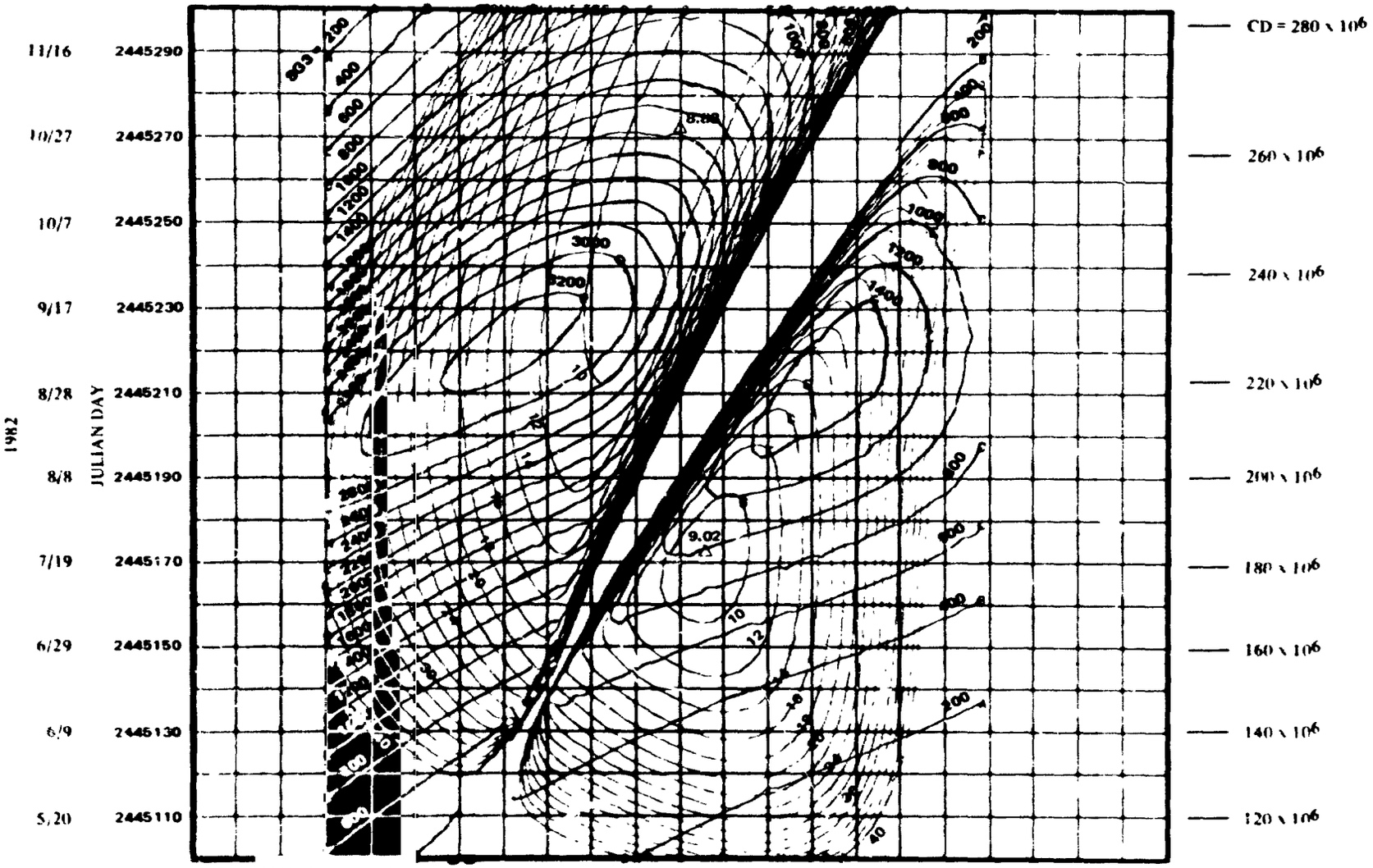


CONTOURS OF C_3 AND SGI EARTH TO MARS 1981-82

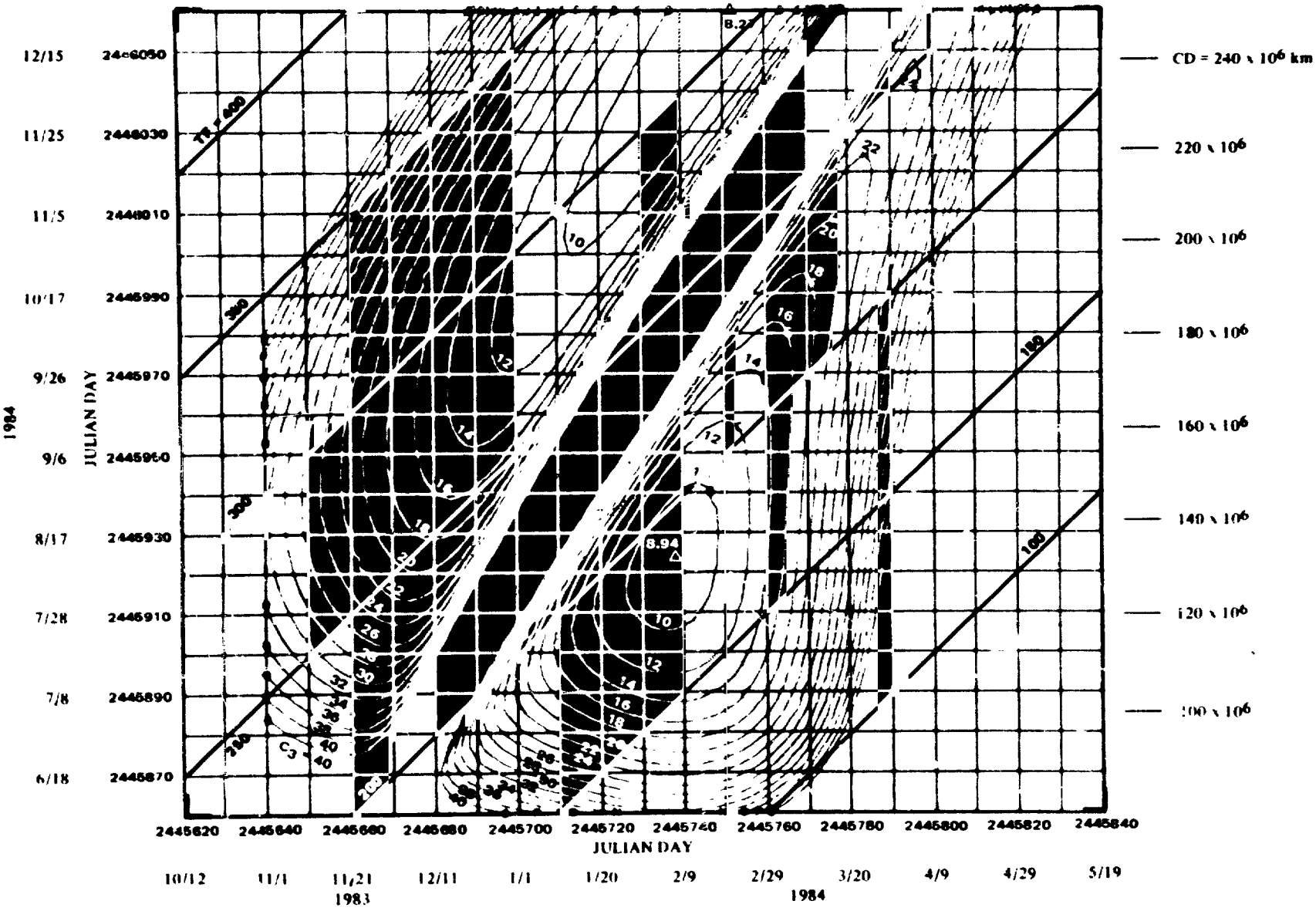


CONTOURS OF C_3 AND SG2 EARTH TO MARS 1981-82

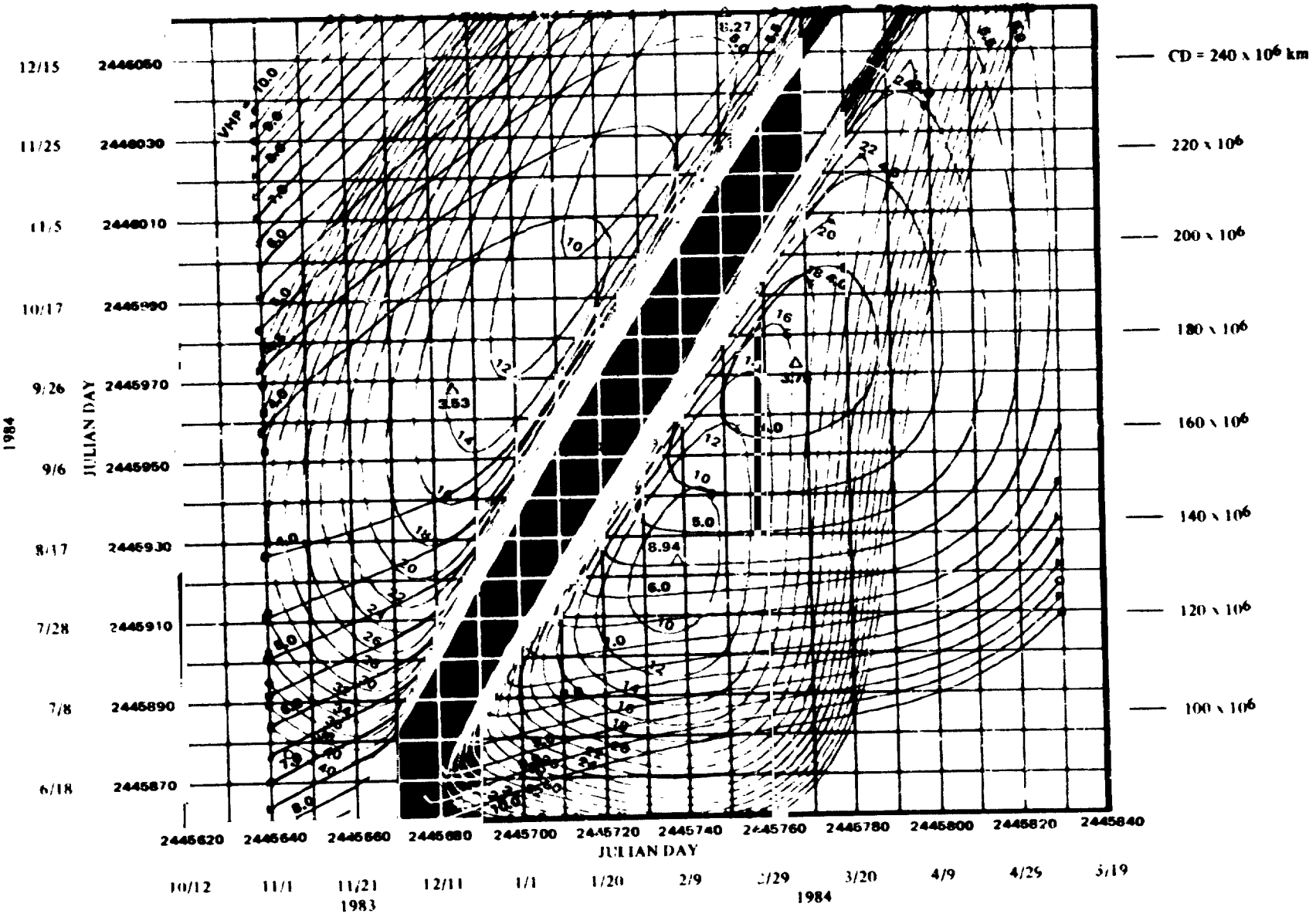


CONTOURS OF C_3 AND SG3 EARTH TO MARS 1981-82

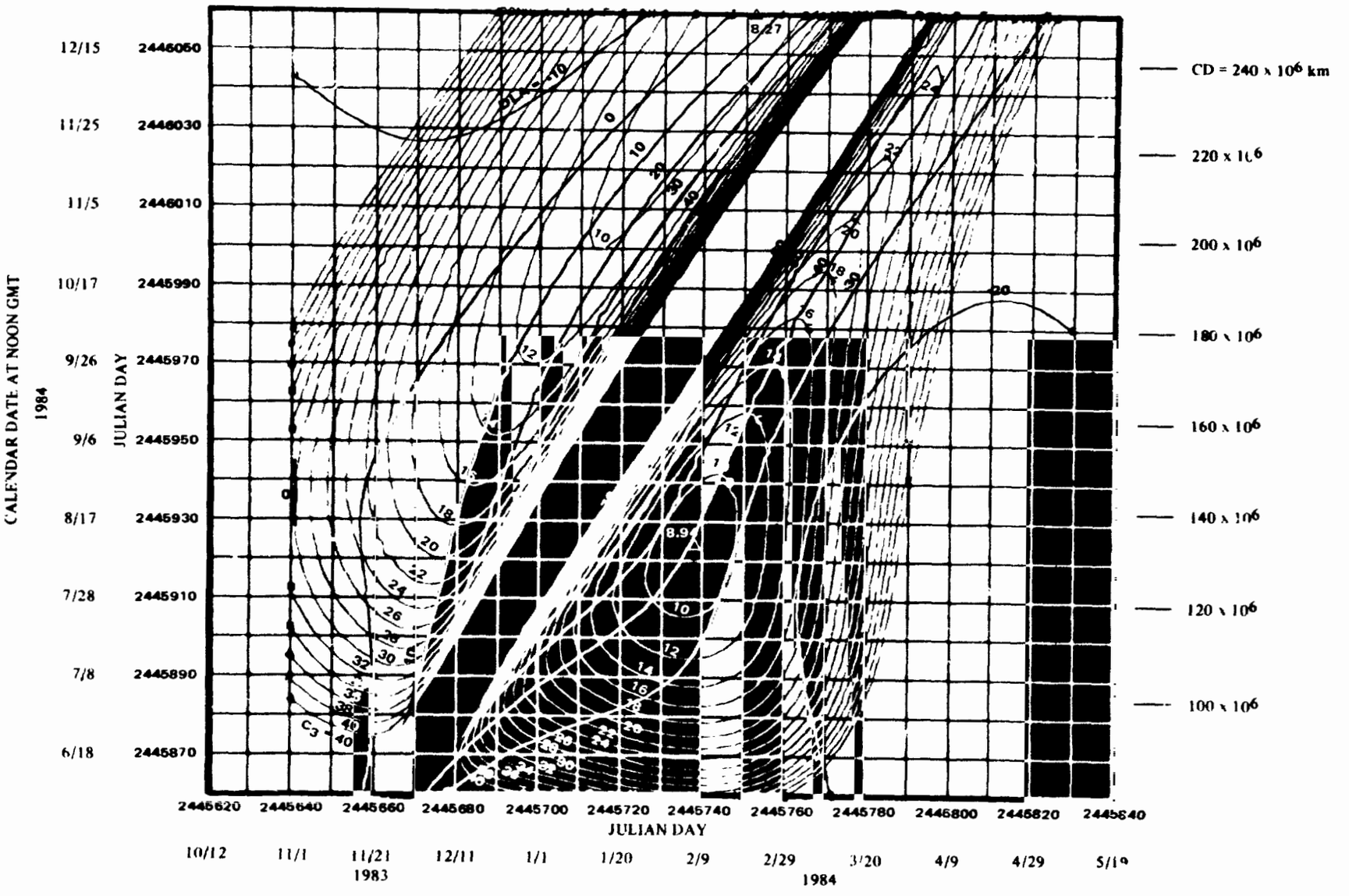
1981 SG3



CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1984

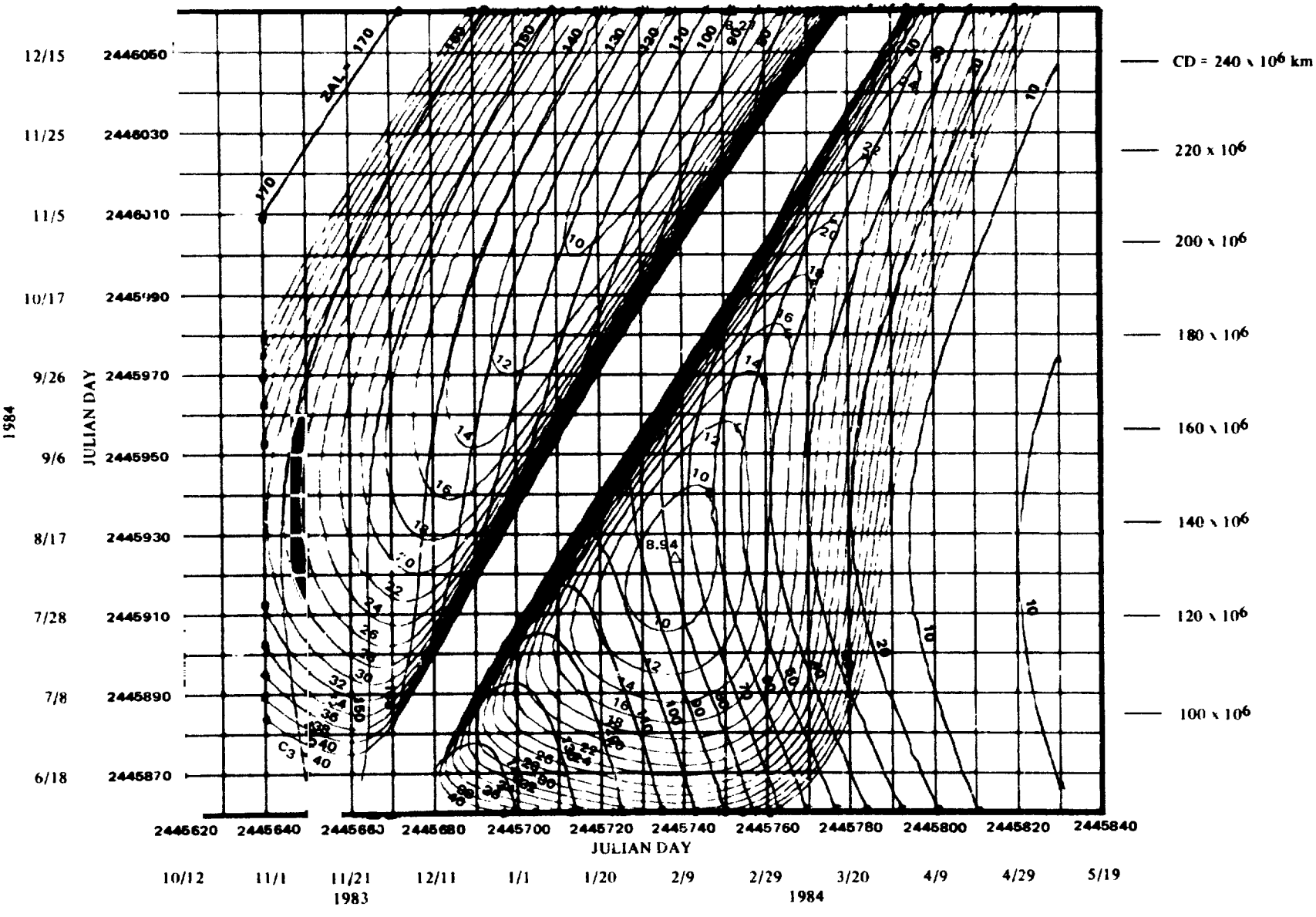


CONTOURS OF C_3 AND VHP EARTH TO MARS 1984



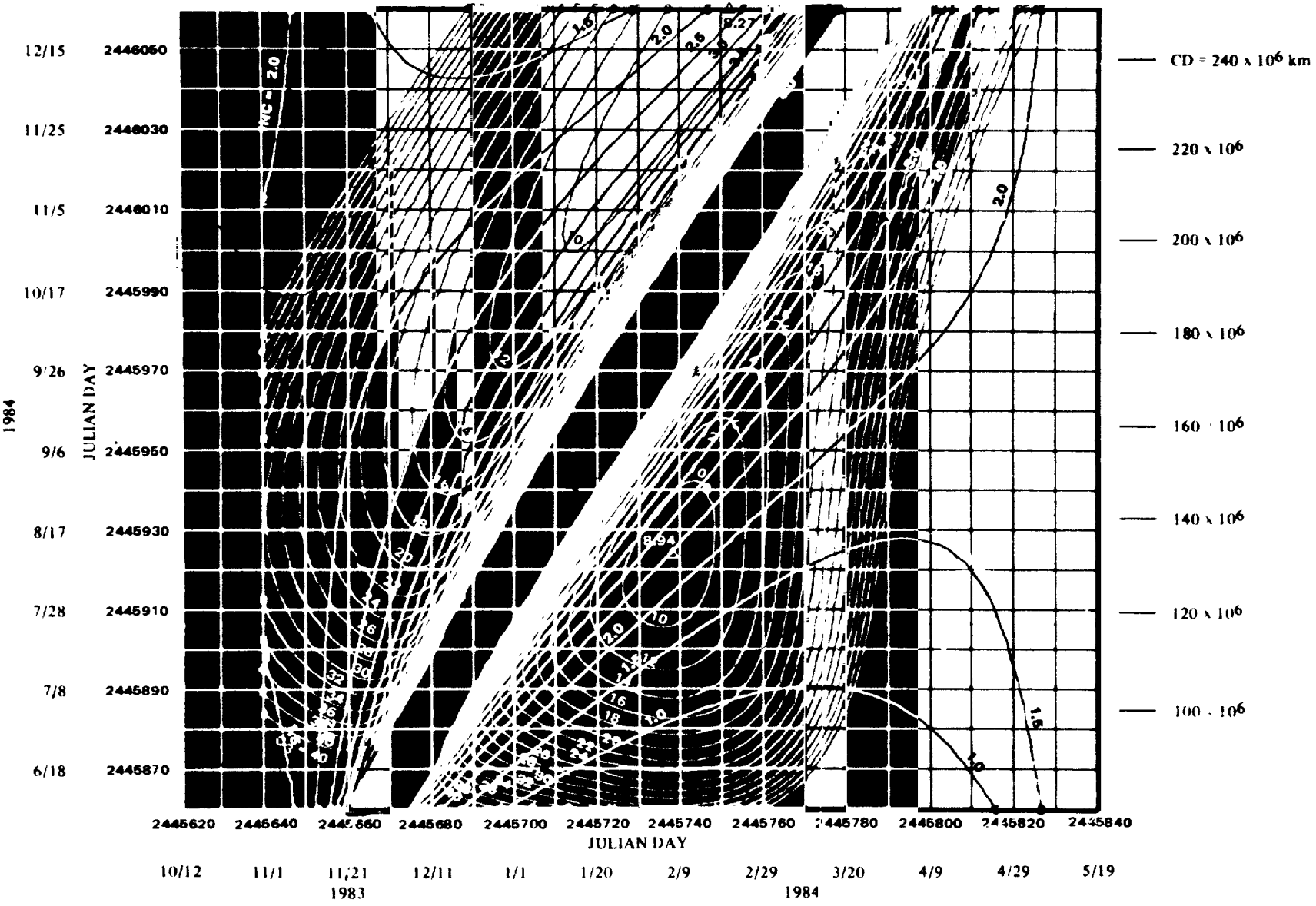
CONTOURS OF C_3 AND DLA EARTH TO MARS 1984

DLA 1984



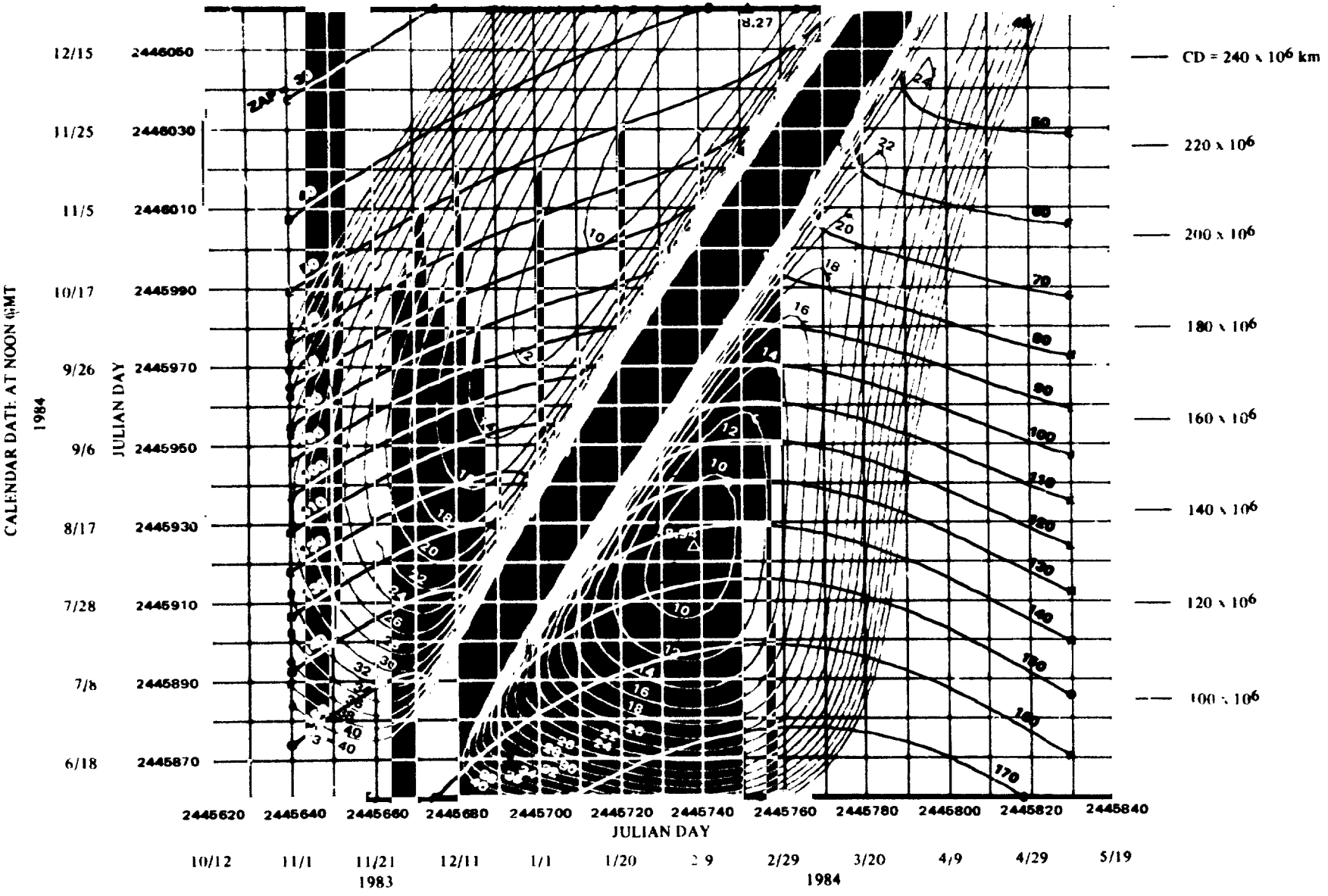
CONTOURS OF C_3 AND ZAL EARTH TO MARS 1984

ZAL
1984



CONTOURS OF C_3 AND INC EARTH TO MARS 1984

INC
1984



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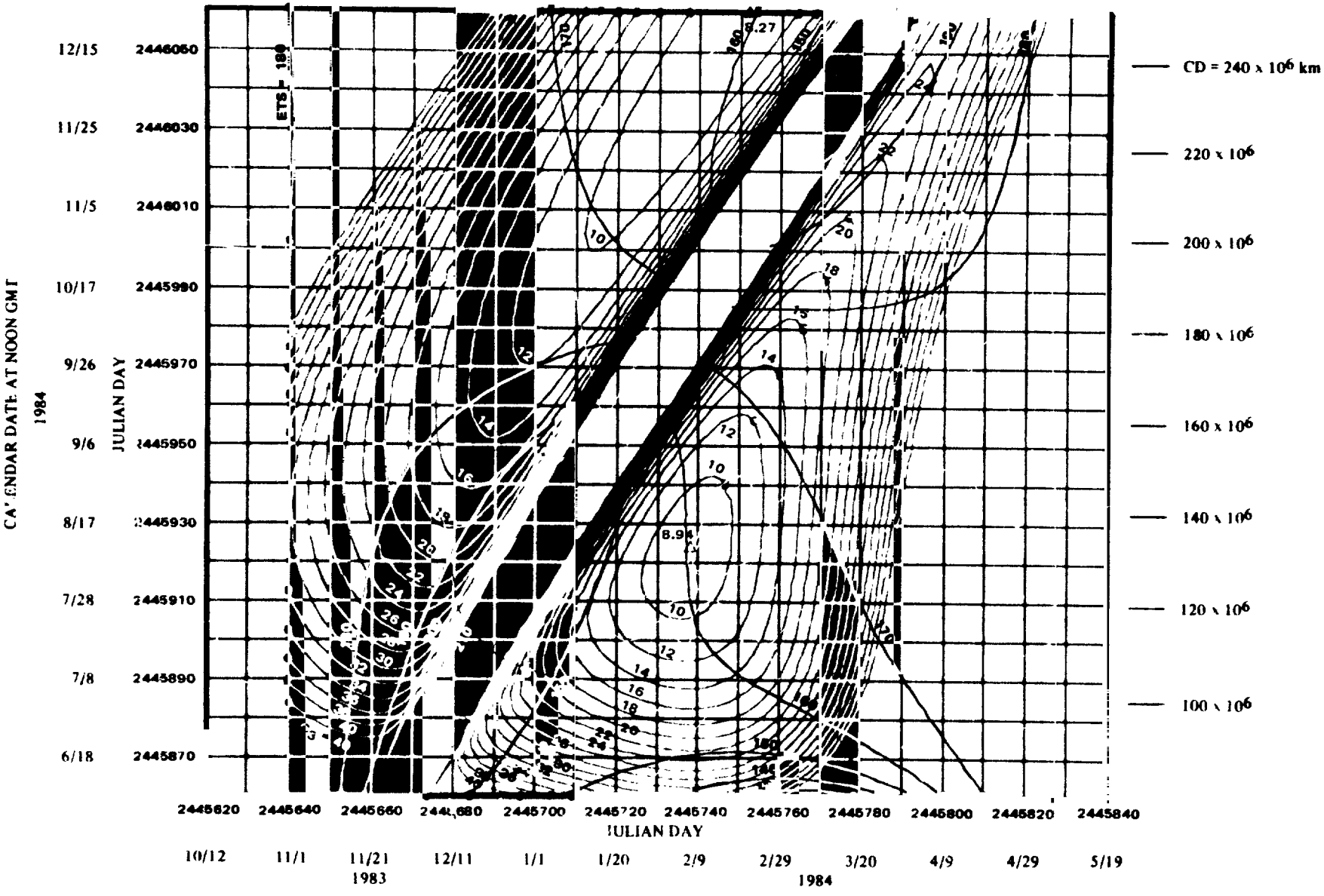
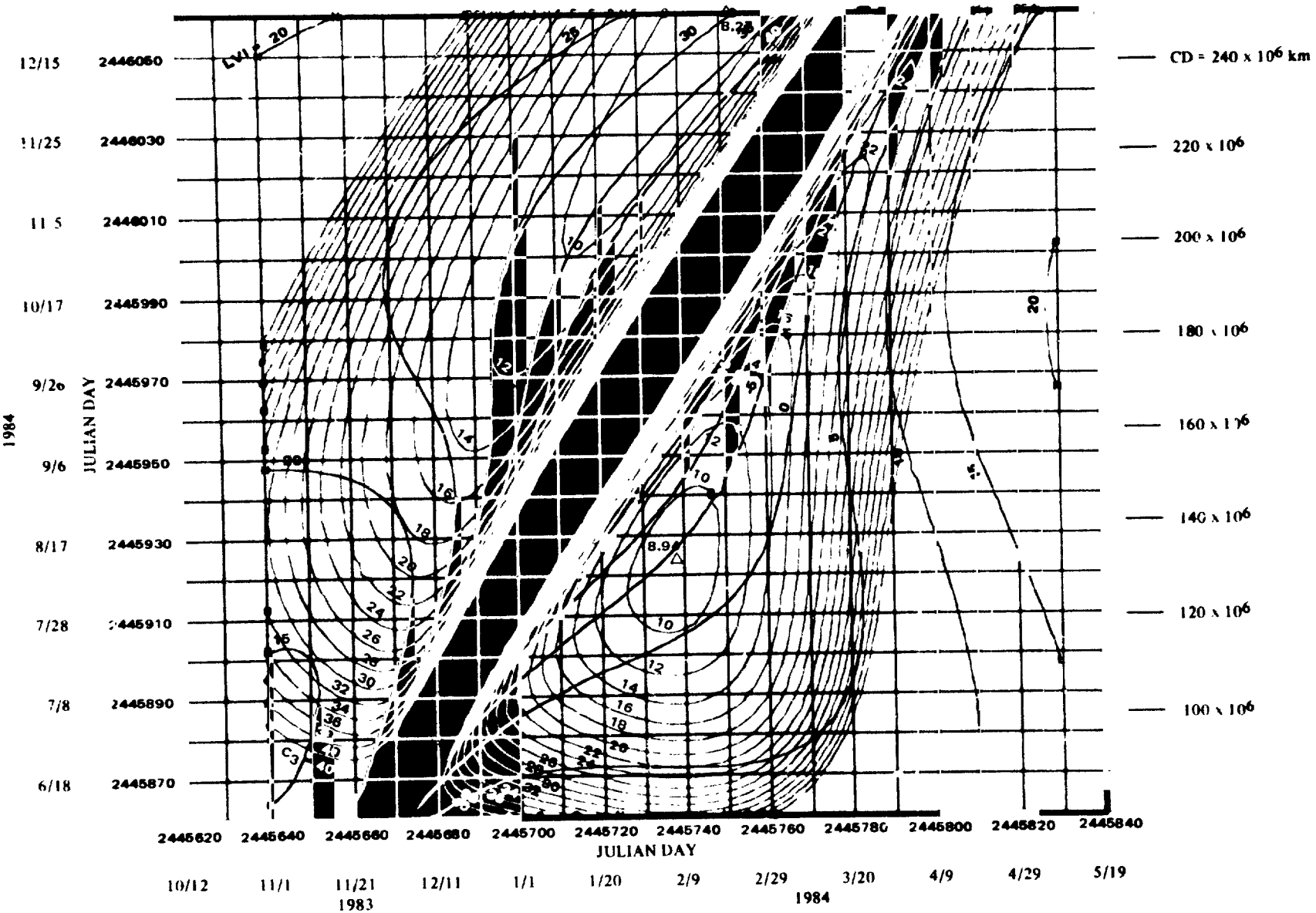
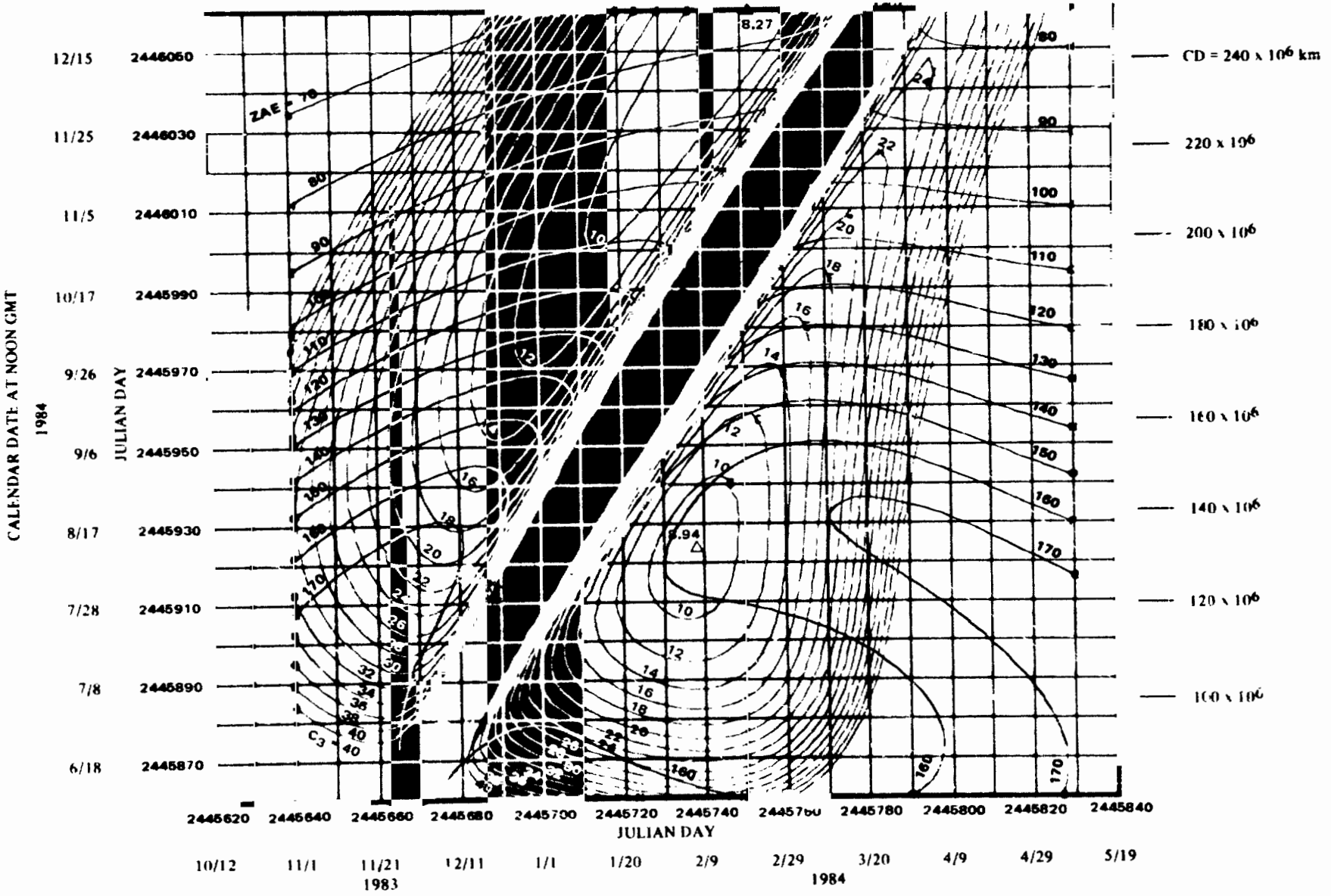


CONTOURS OF C_3 AND ETS EARTH TO MARS 1984

ETS 1984

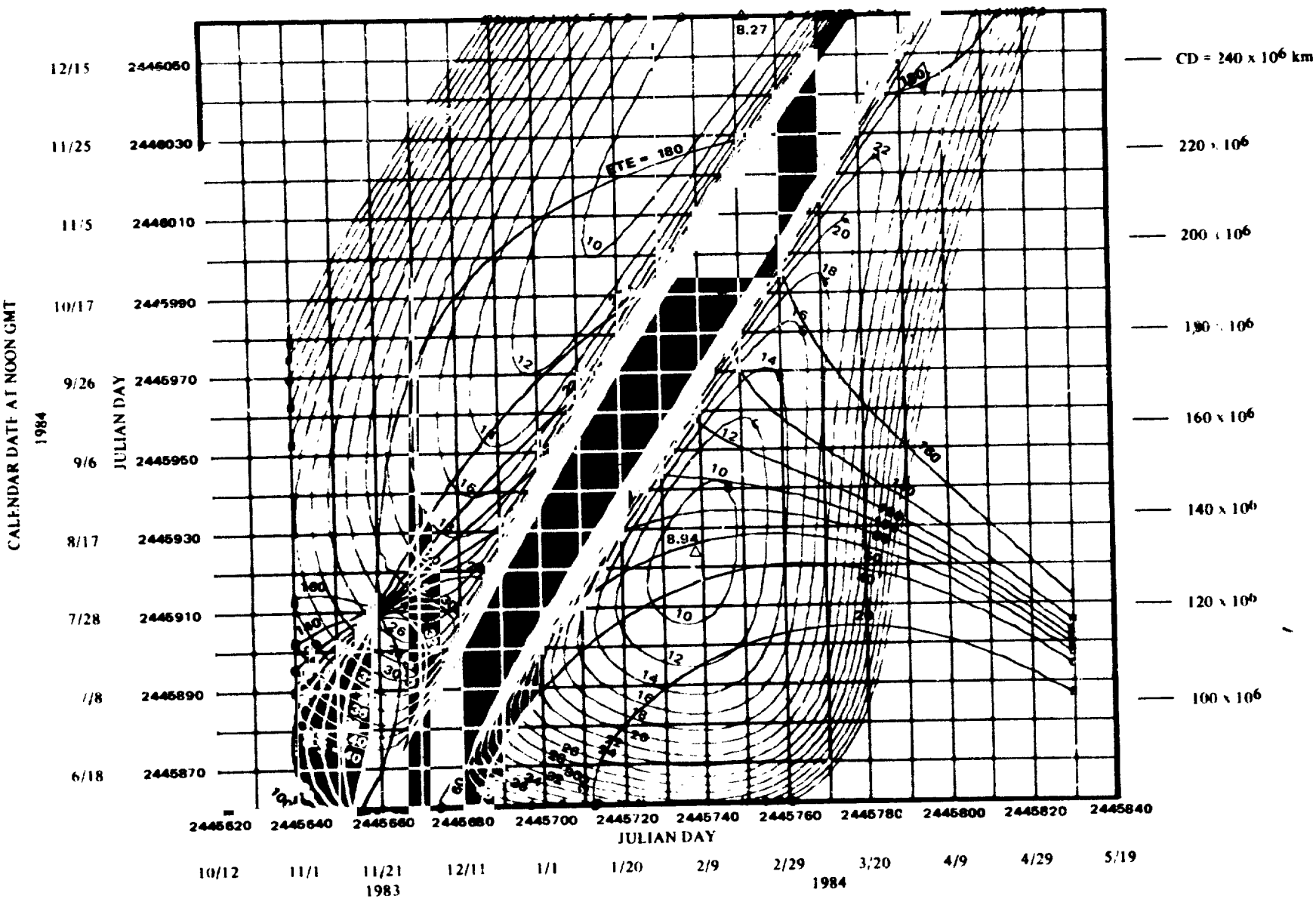


CONTOURS OF C_3 AND LVI EARTH TO MARS 1984



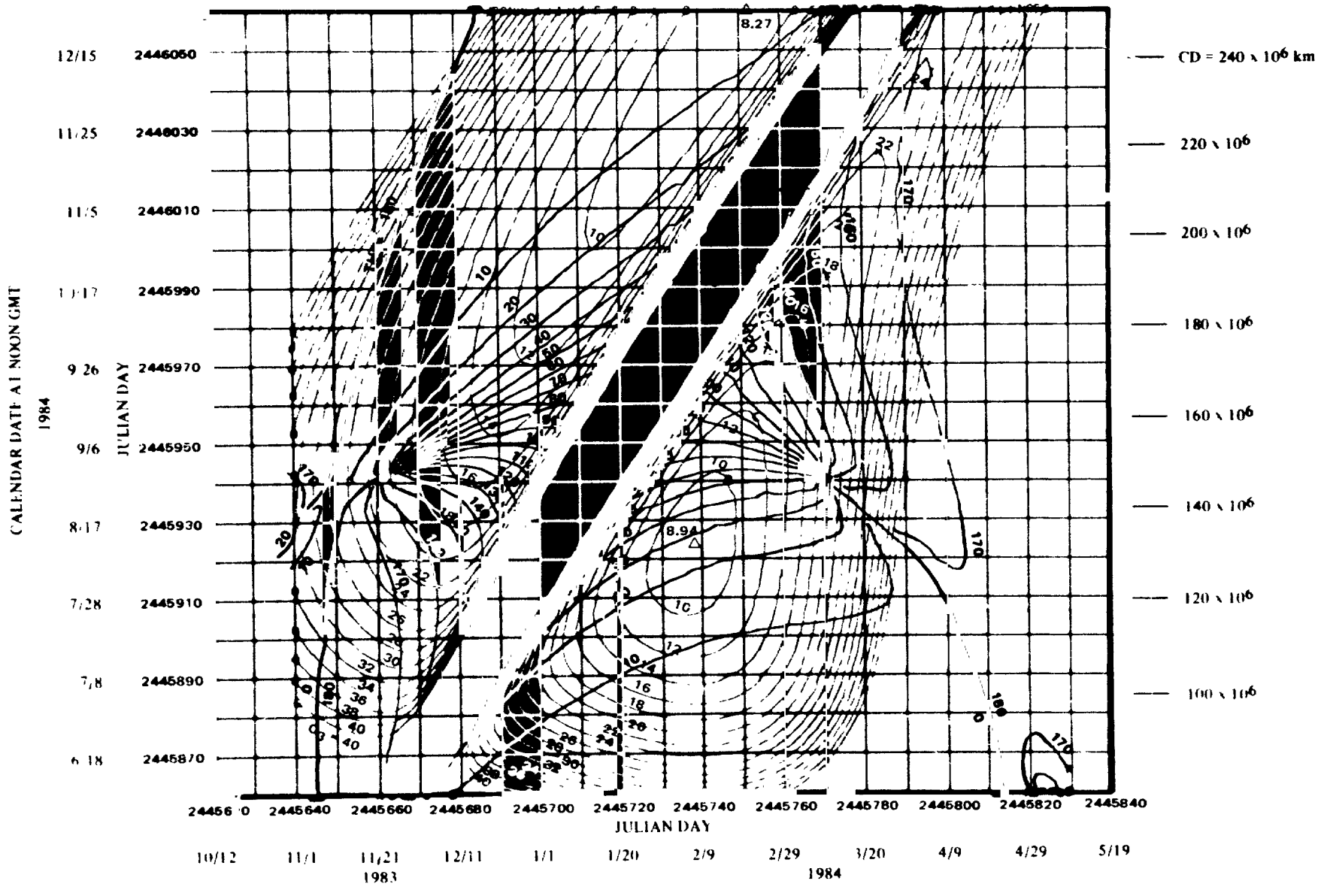
CONTOURS OF C_3 AND ZAE EARTH TO MARS 1984

ZAE 1984



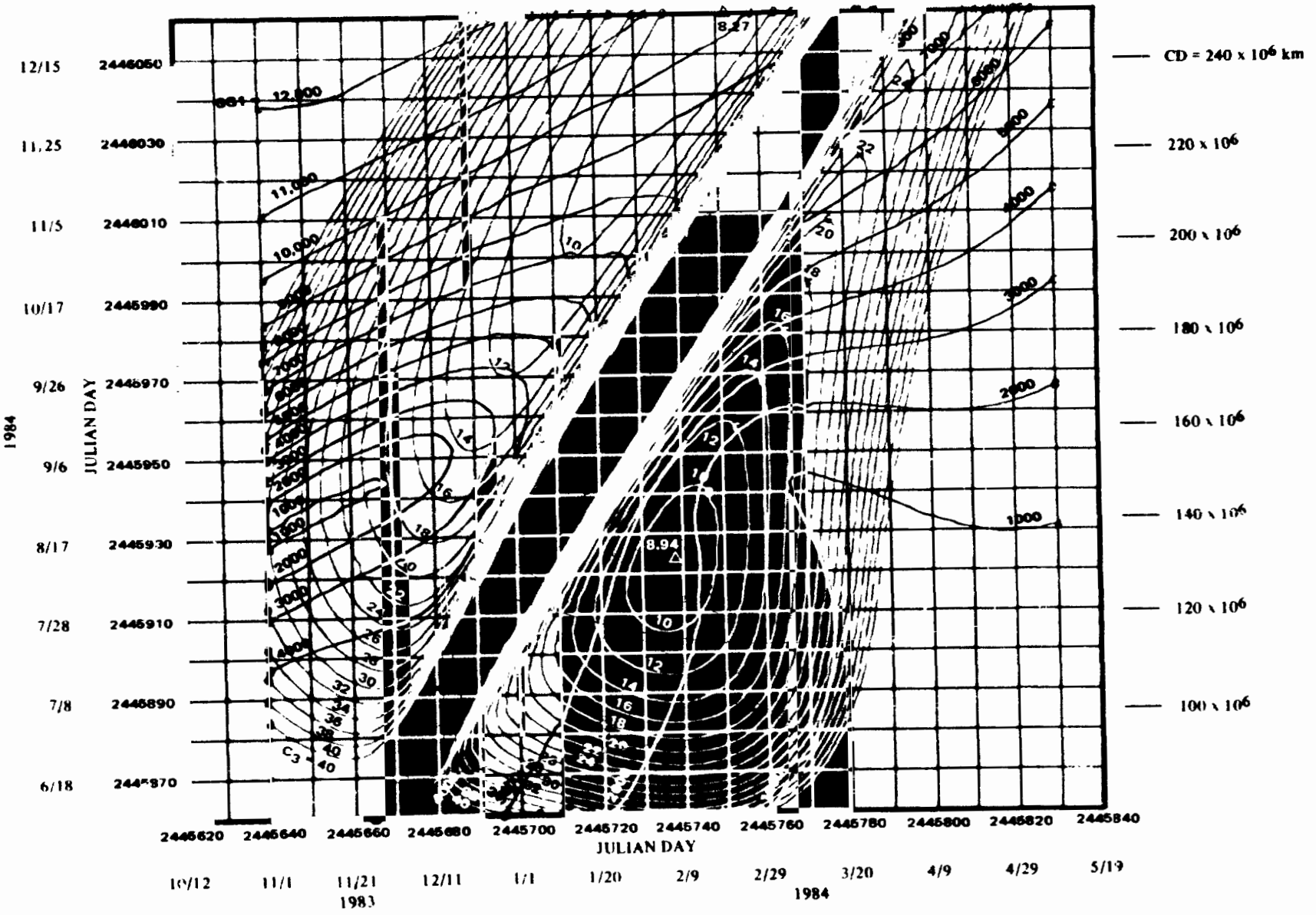
CONTOURS OF C_3 AND ETE EARTH TO MARS 1984

ETE
1984



CONTOURS OF C_3 AND THA EARTH TO MARS 1984

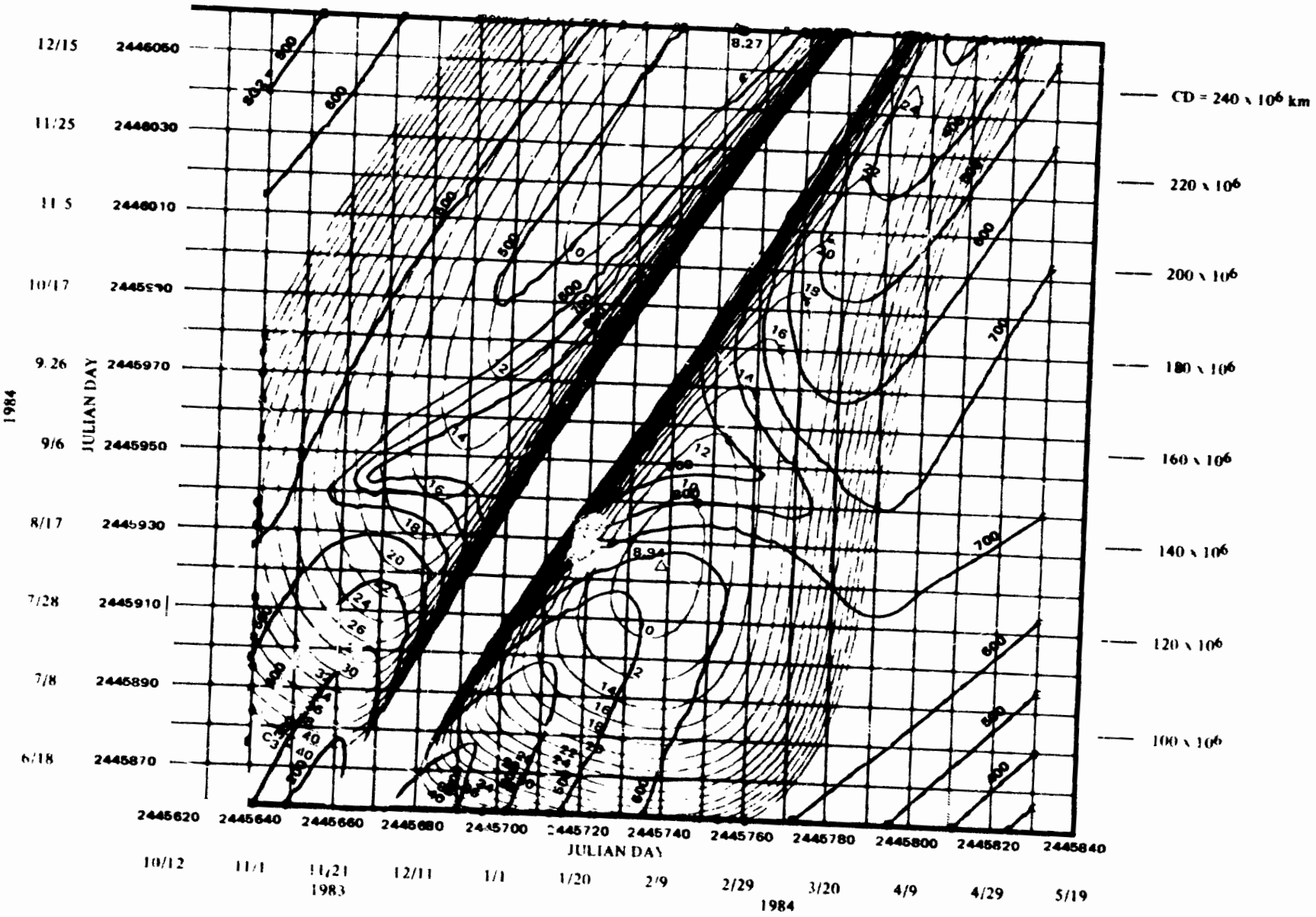
THA 1984



CONTOURS OF C_3 AND SGI EARTH TO MARS 1984

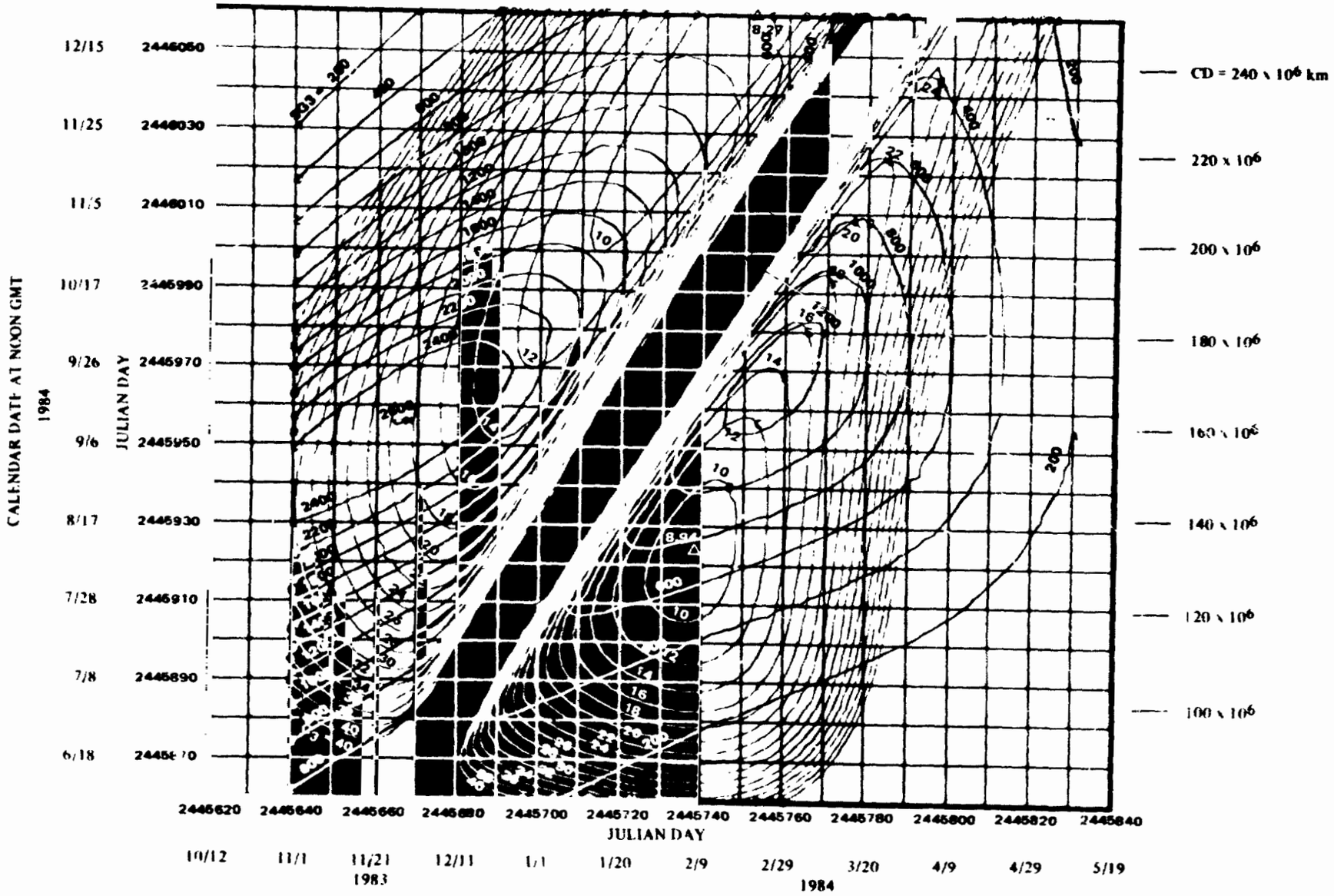
3-40

SGI 1984

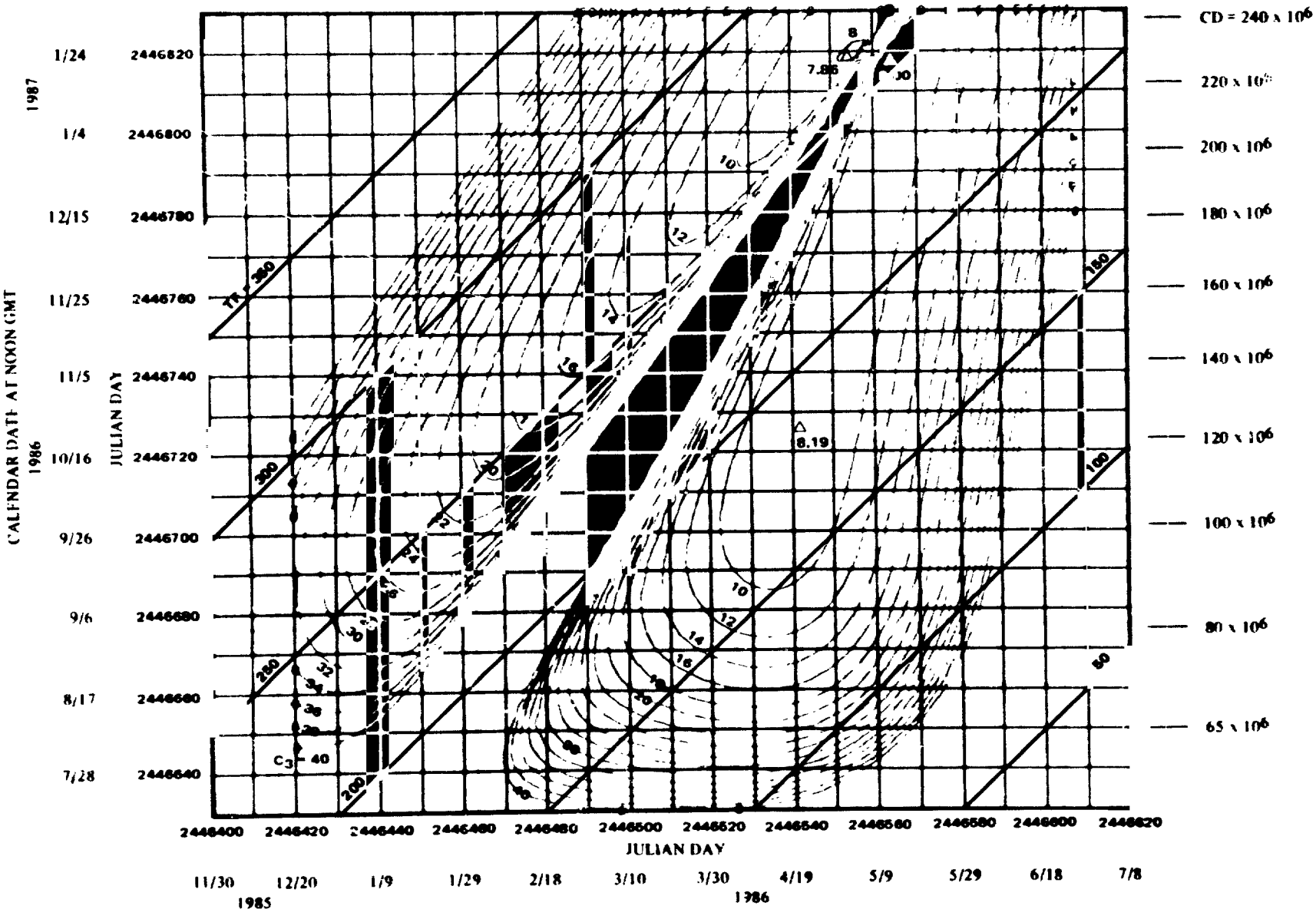


CONTOURS OF C_3 AND SG2 EARTH TO MARS 1984

SG2 1984

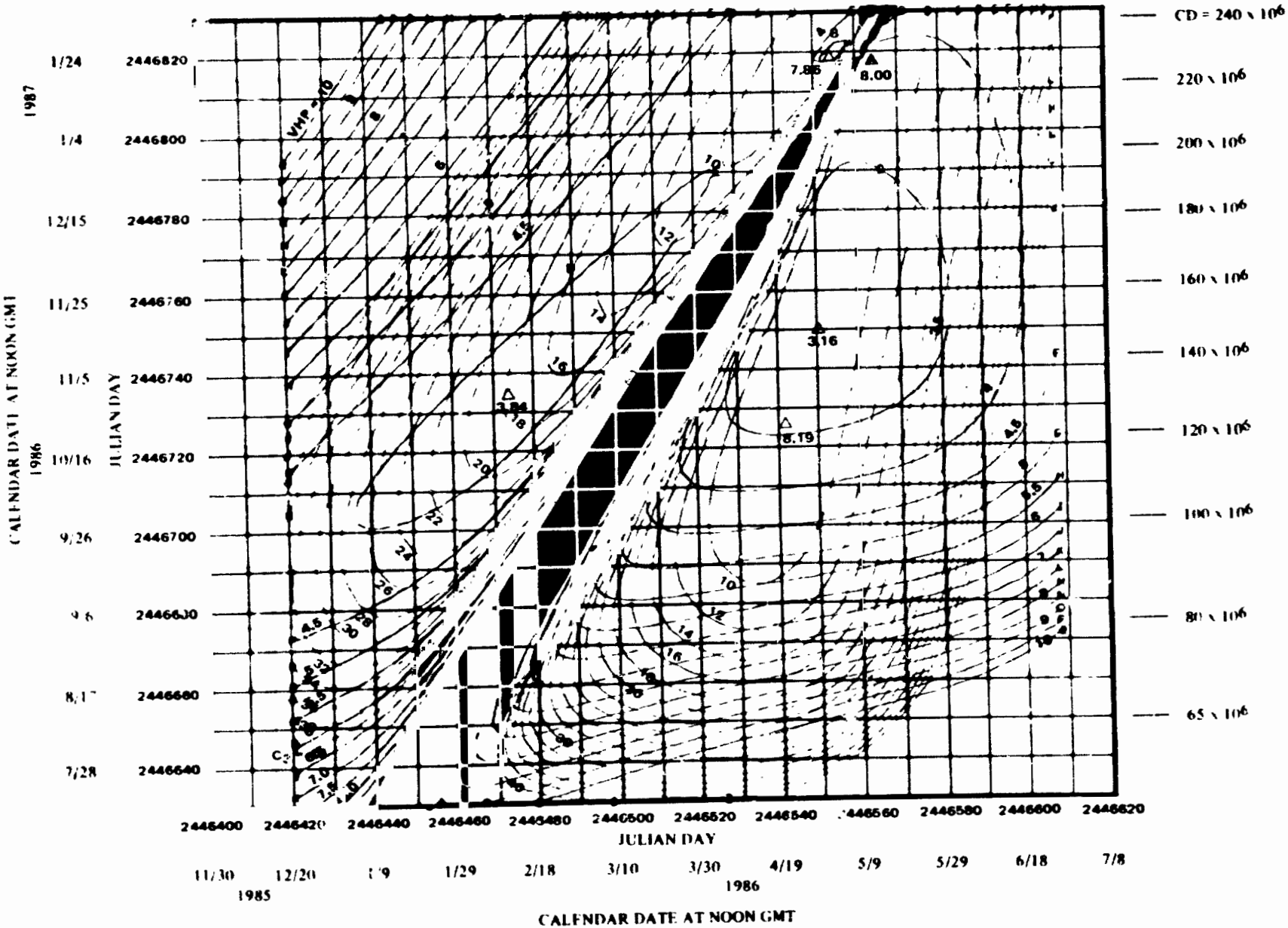


CONTOURS OF C_3 AND SG3 EARTH TO MARS 1984

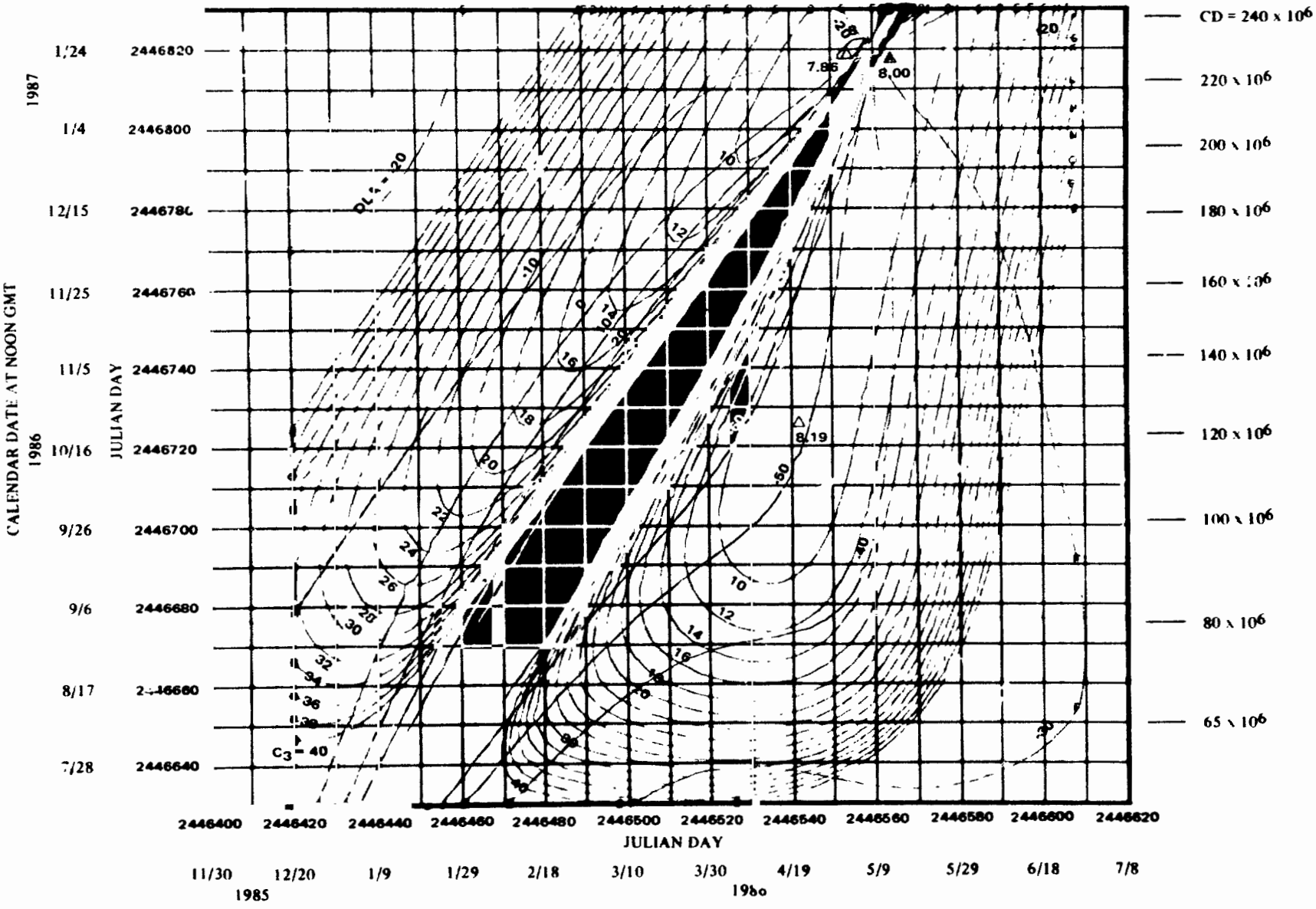


CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1985-86

1986 Q3

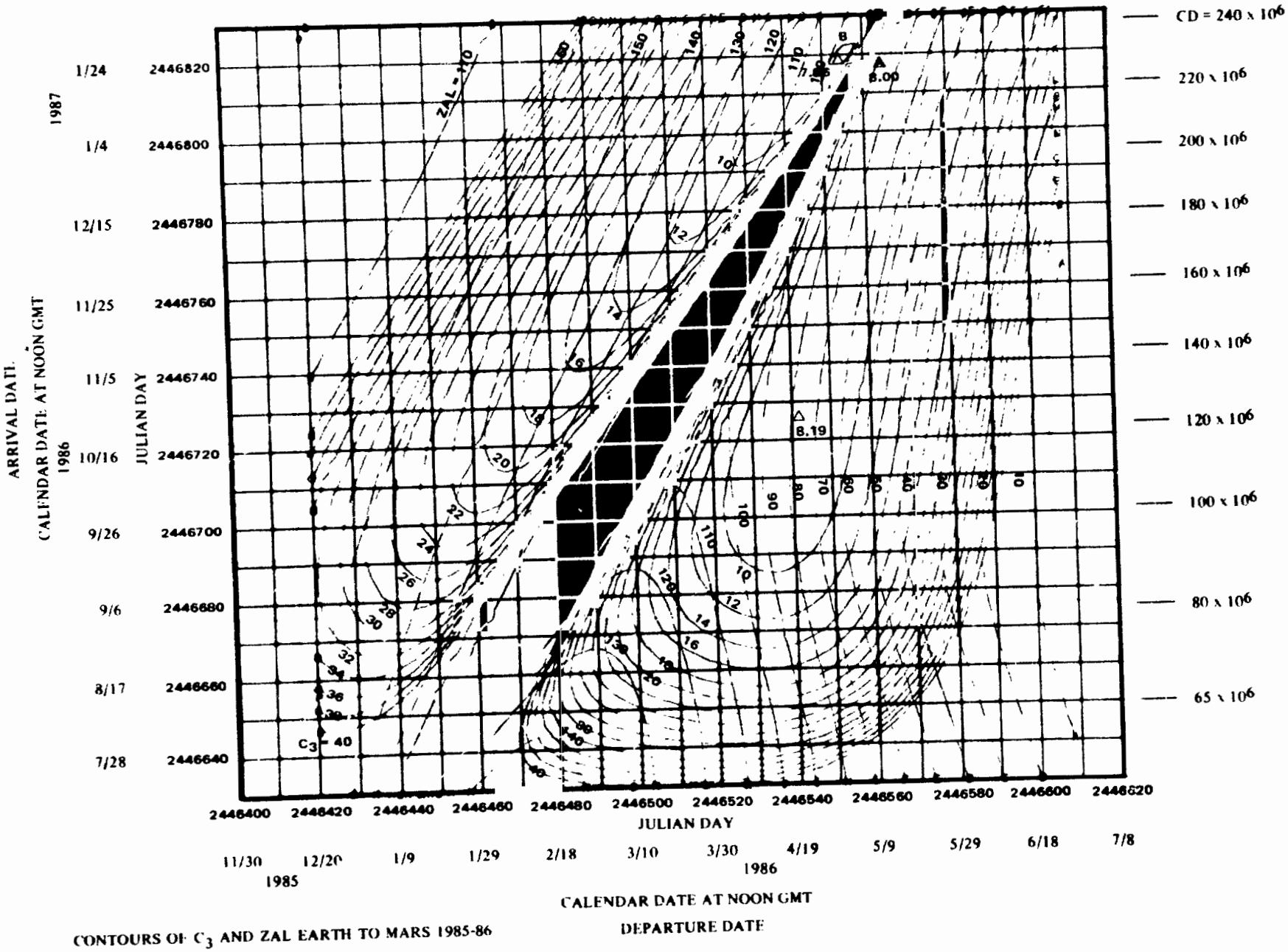


CONTOURS OF C_3 AND VHP EARTH TO MARS 1985-86



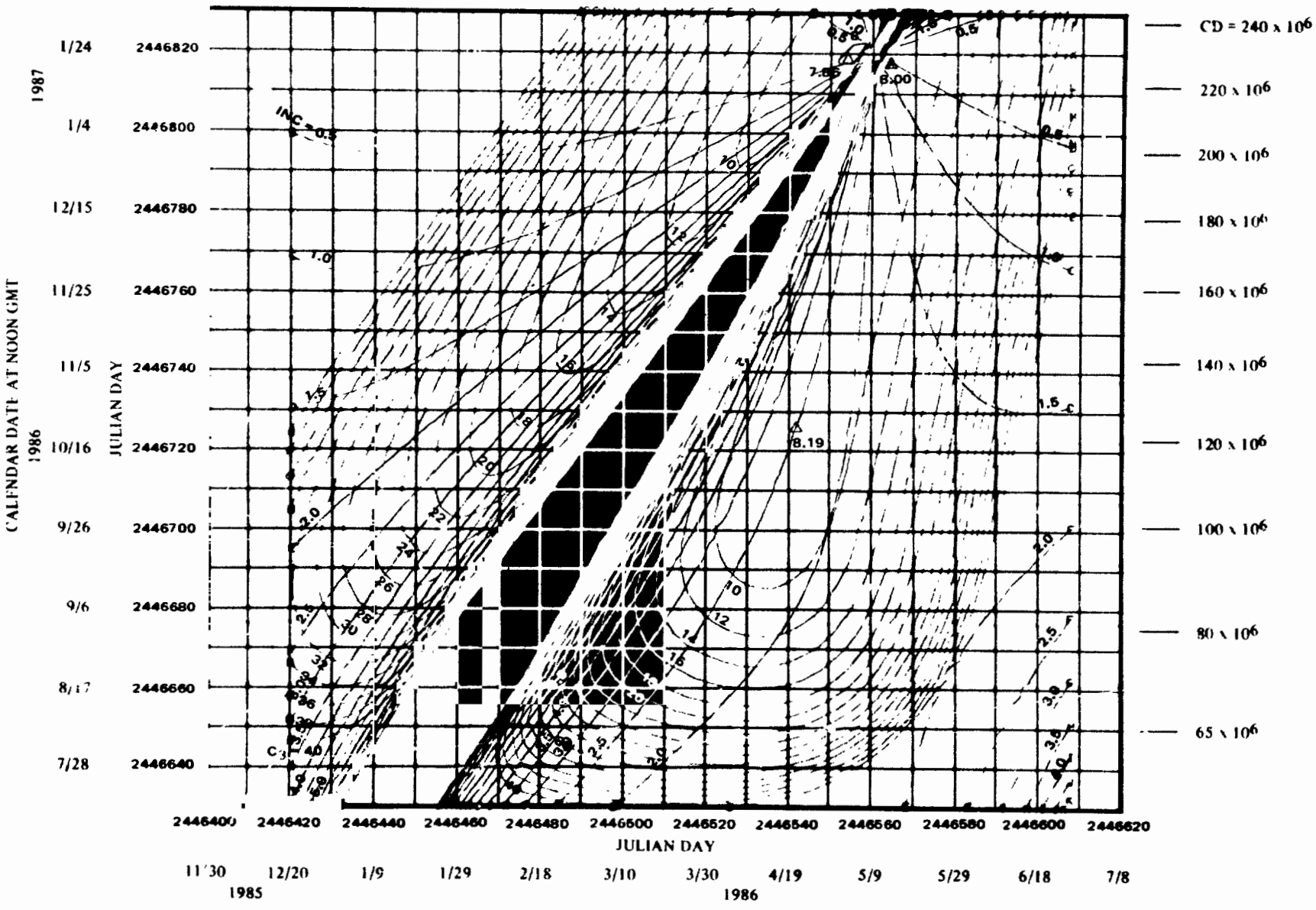
CONTOURS OF C_3 AND DLA EARTH TO MARS 1985-86

DLA
1986



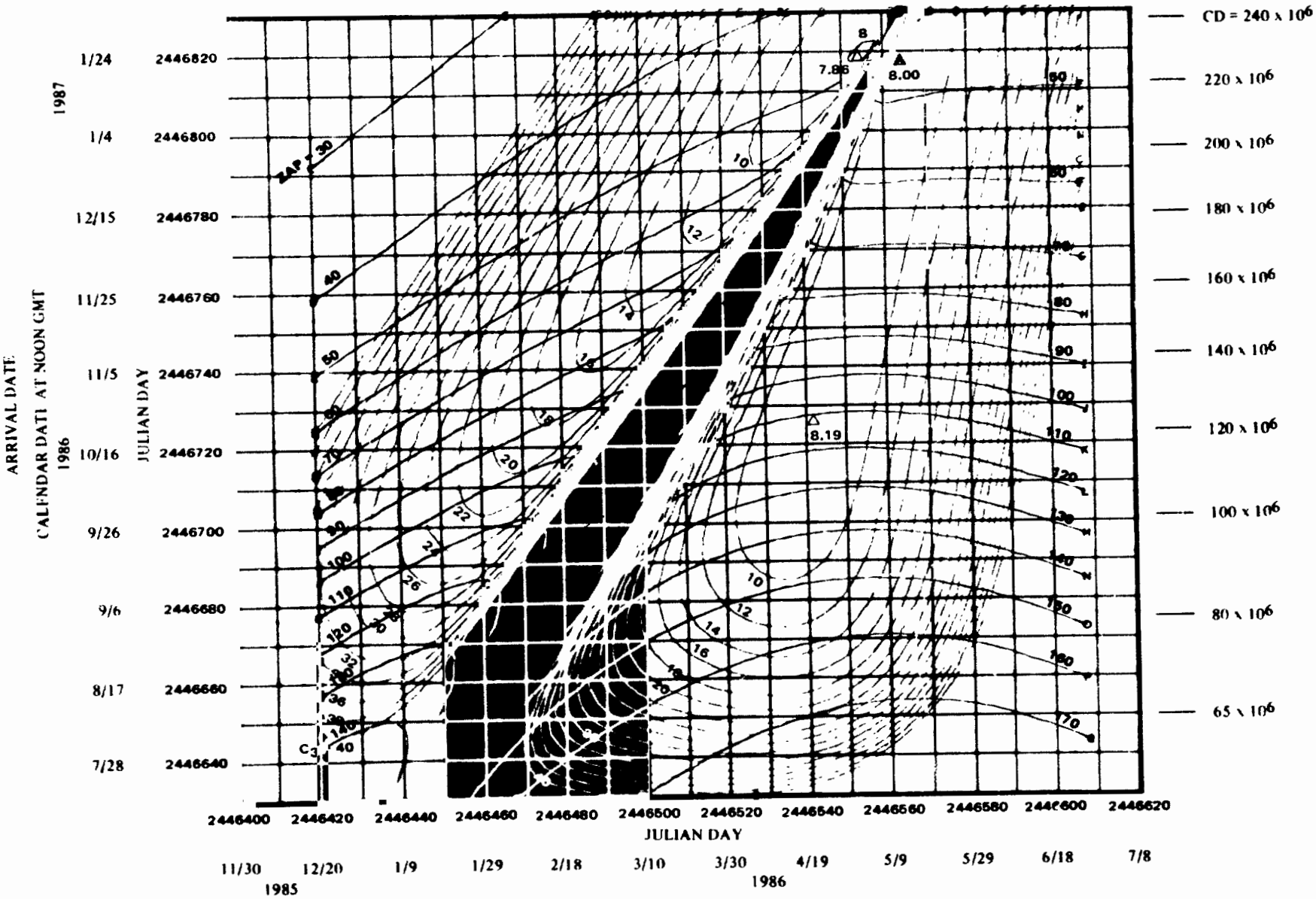
CONTOURS OF C_3 AND ZAL EARTH TO MARS 1985-86

ZAL ♂ 1986



CONTOURS OF C_3 AND INC EARTH TO MARS 1985-86

INC 1985



CONTOURS OF C_3 AND ZAP EARTH TO MARS 1985-86

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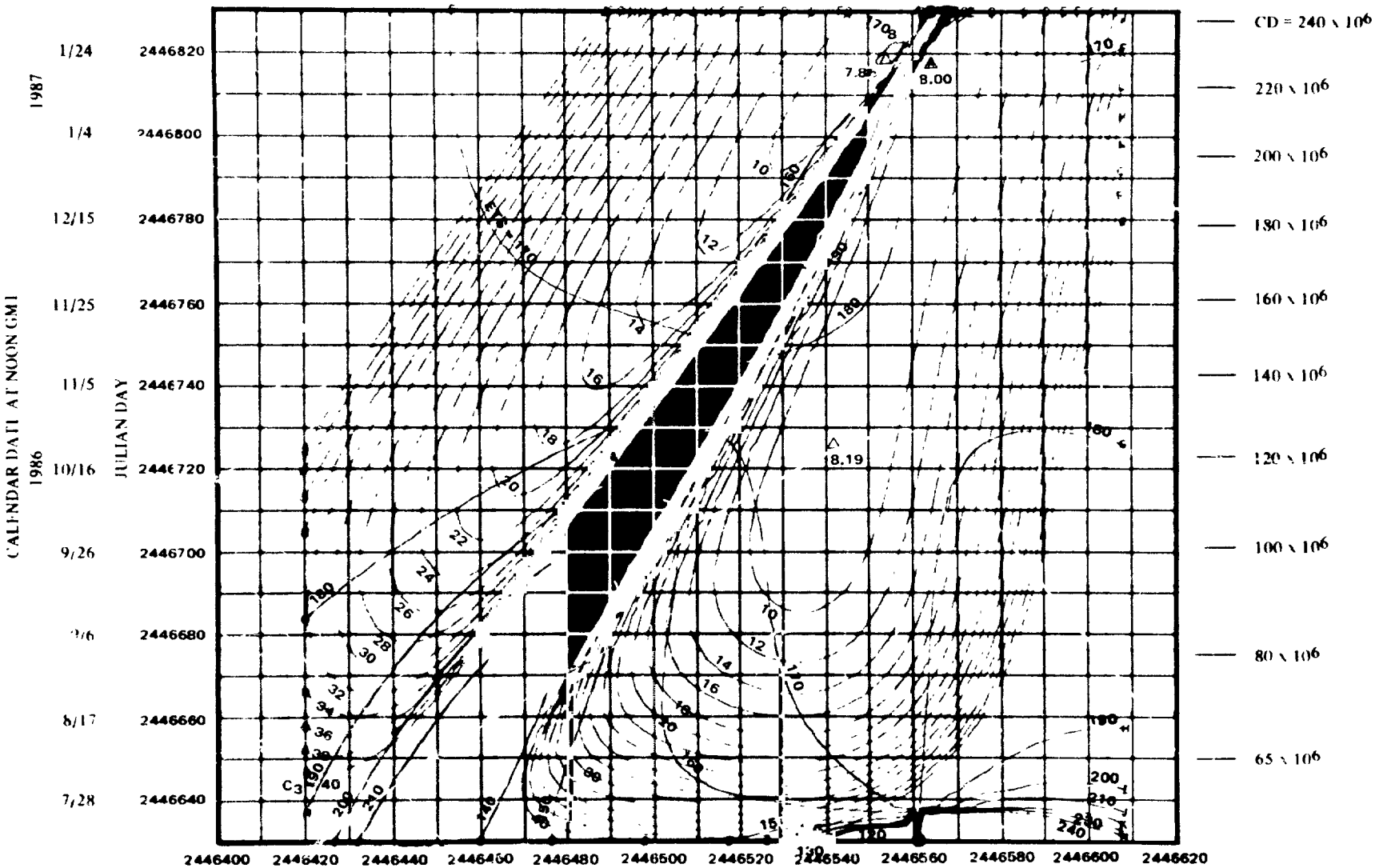
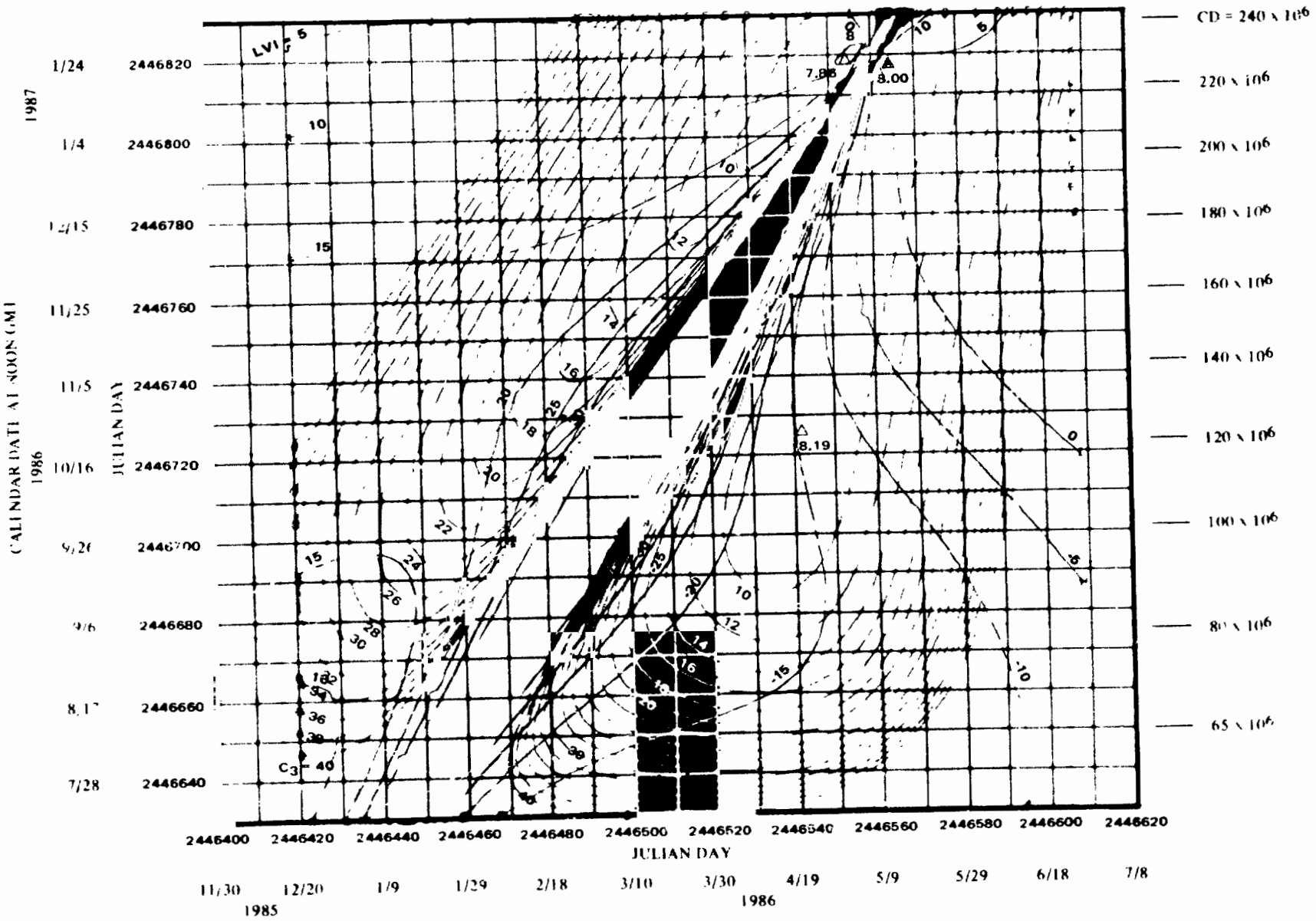


CONTOURS OF C_3 AND ETS EARTH TO MARS 1985-86



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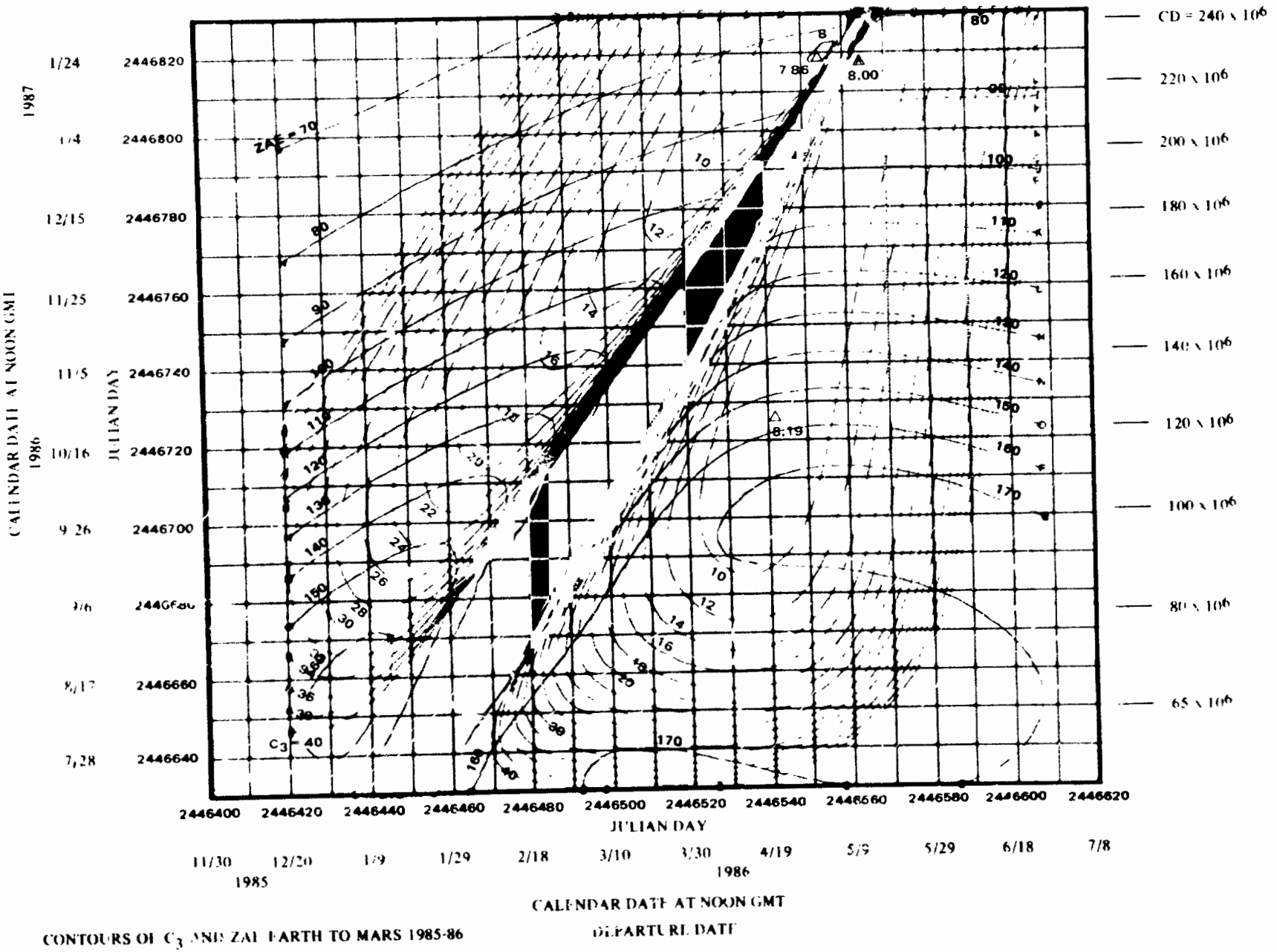
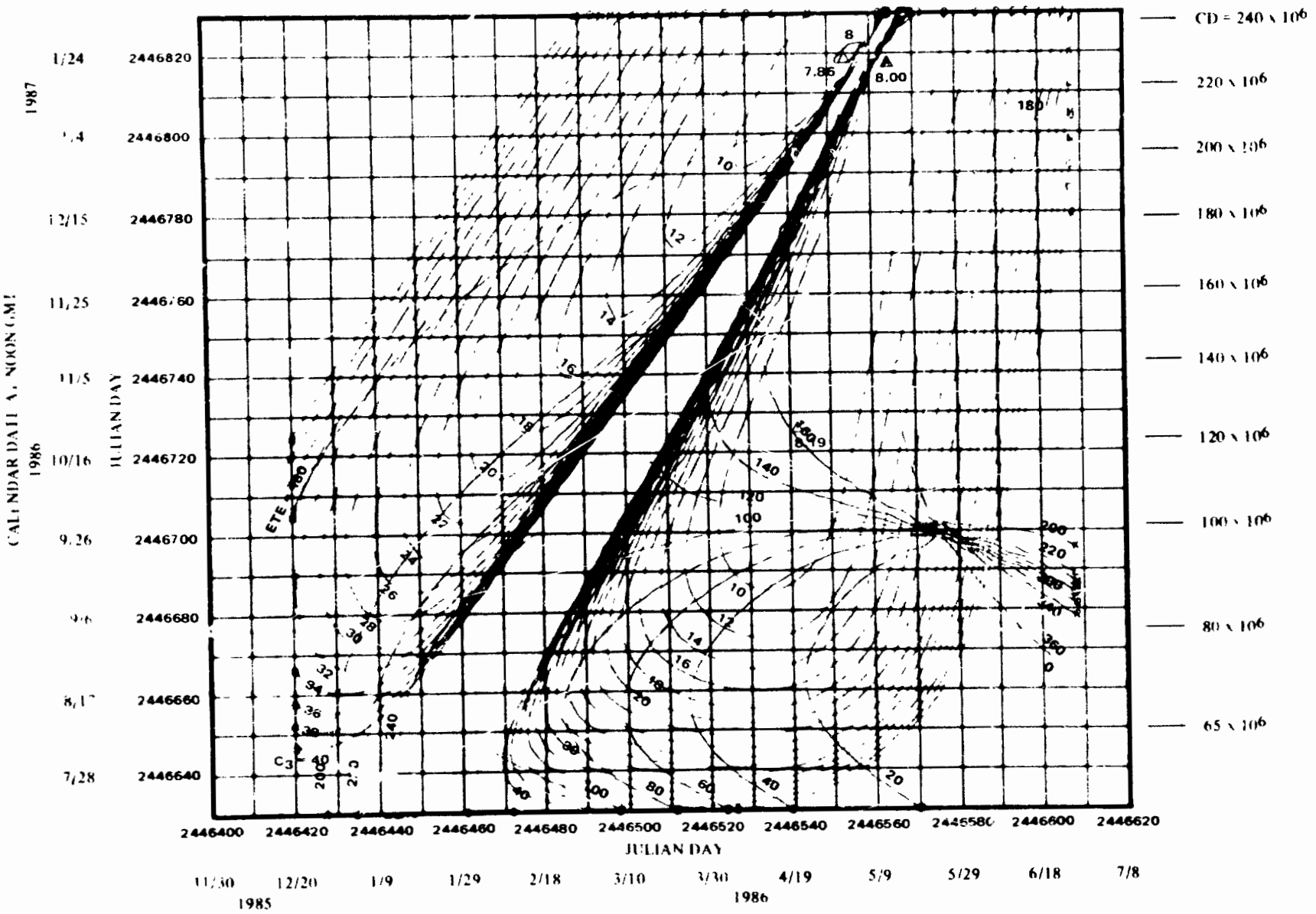


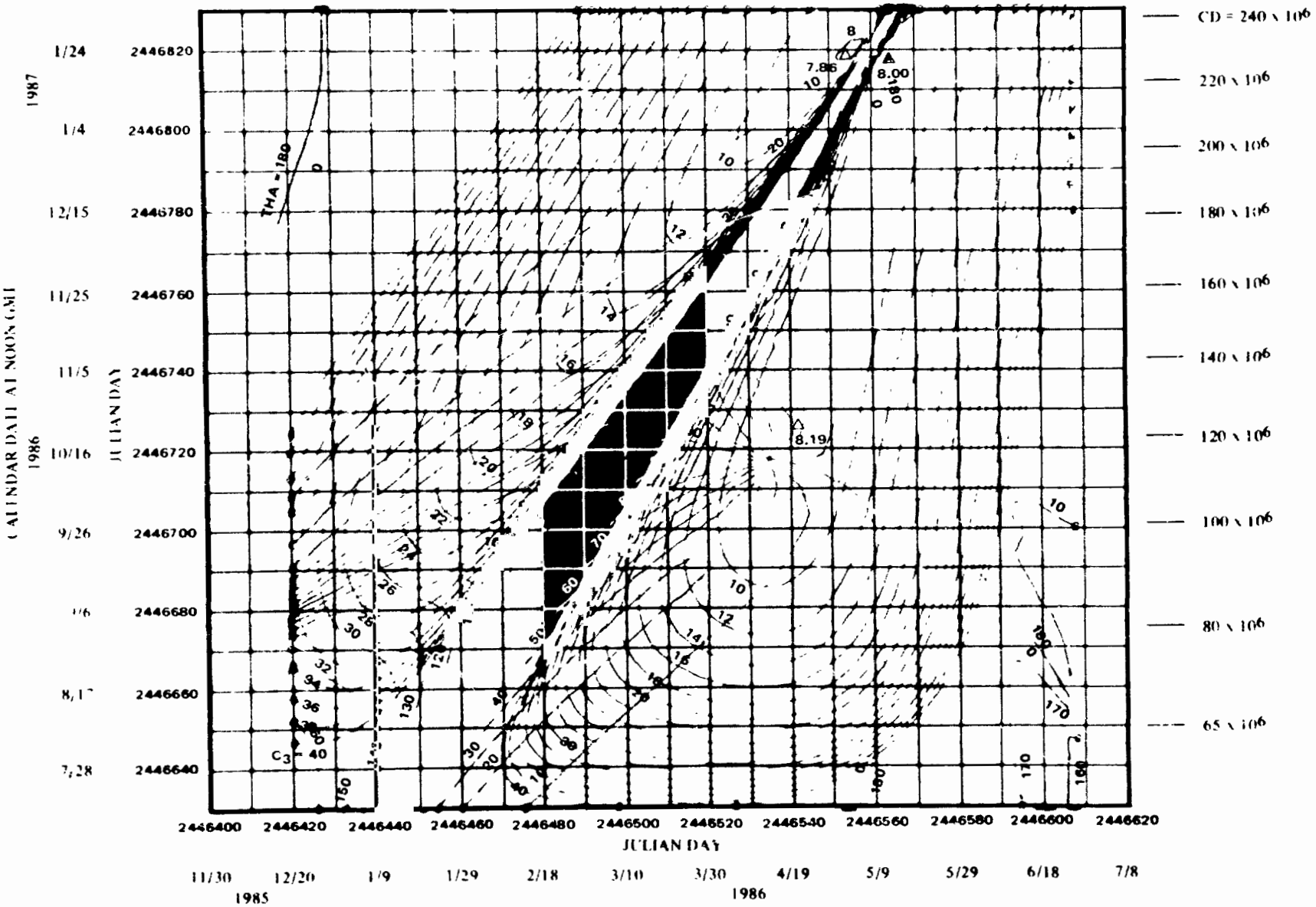
CONTOURS OF C_3 AND ZAE EARTH TO MARS 1985-86

ZAE
1985



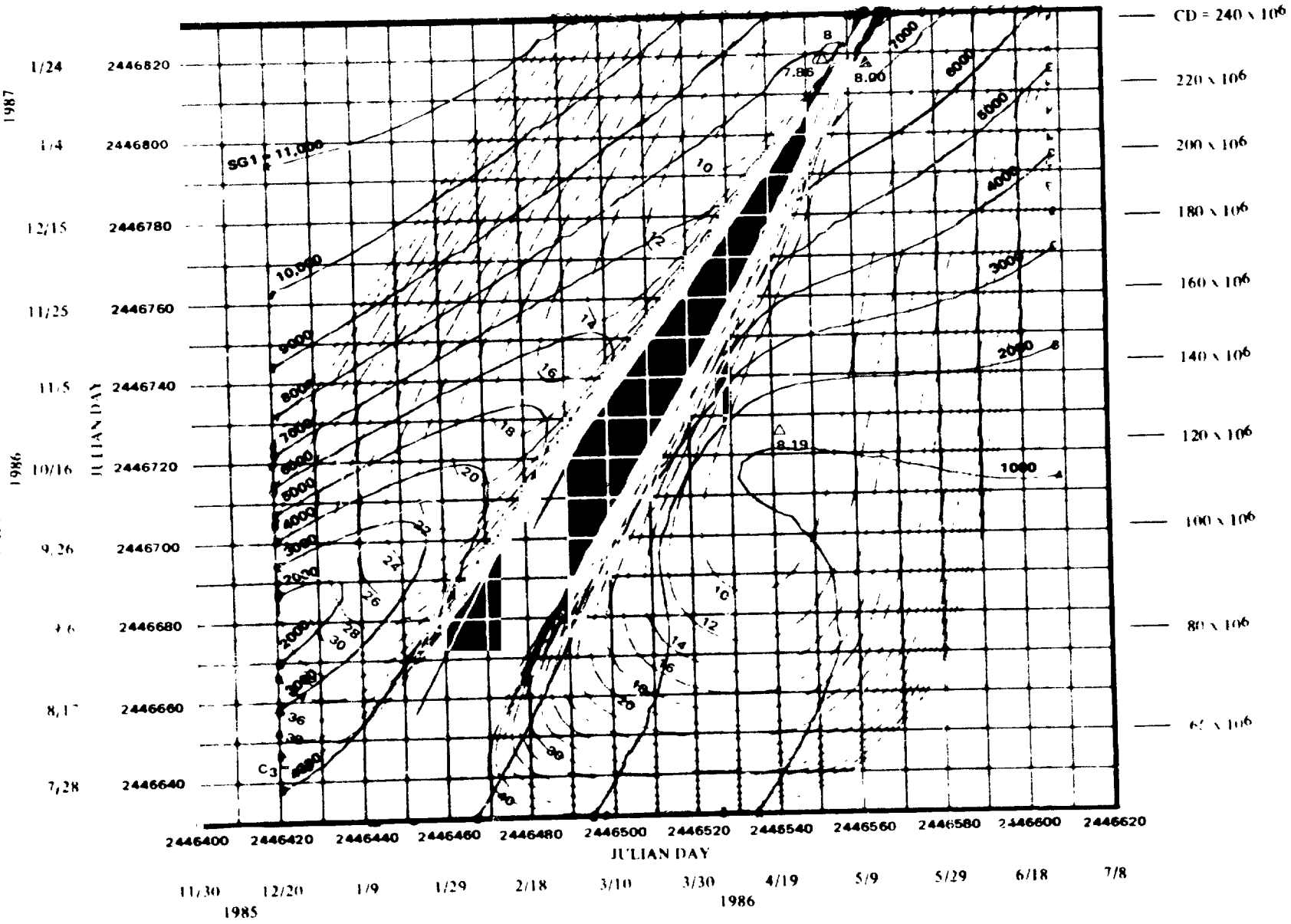
CONTOURS OF C_3 AND ETE EARTH TO MARS 1985 86

ETE ♂ 1986



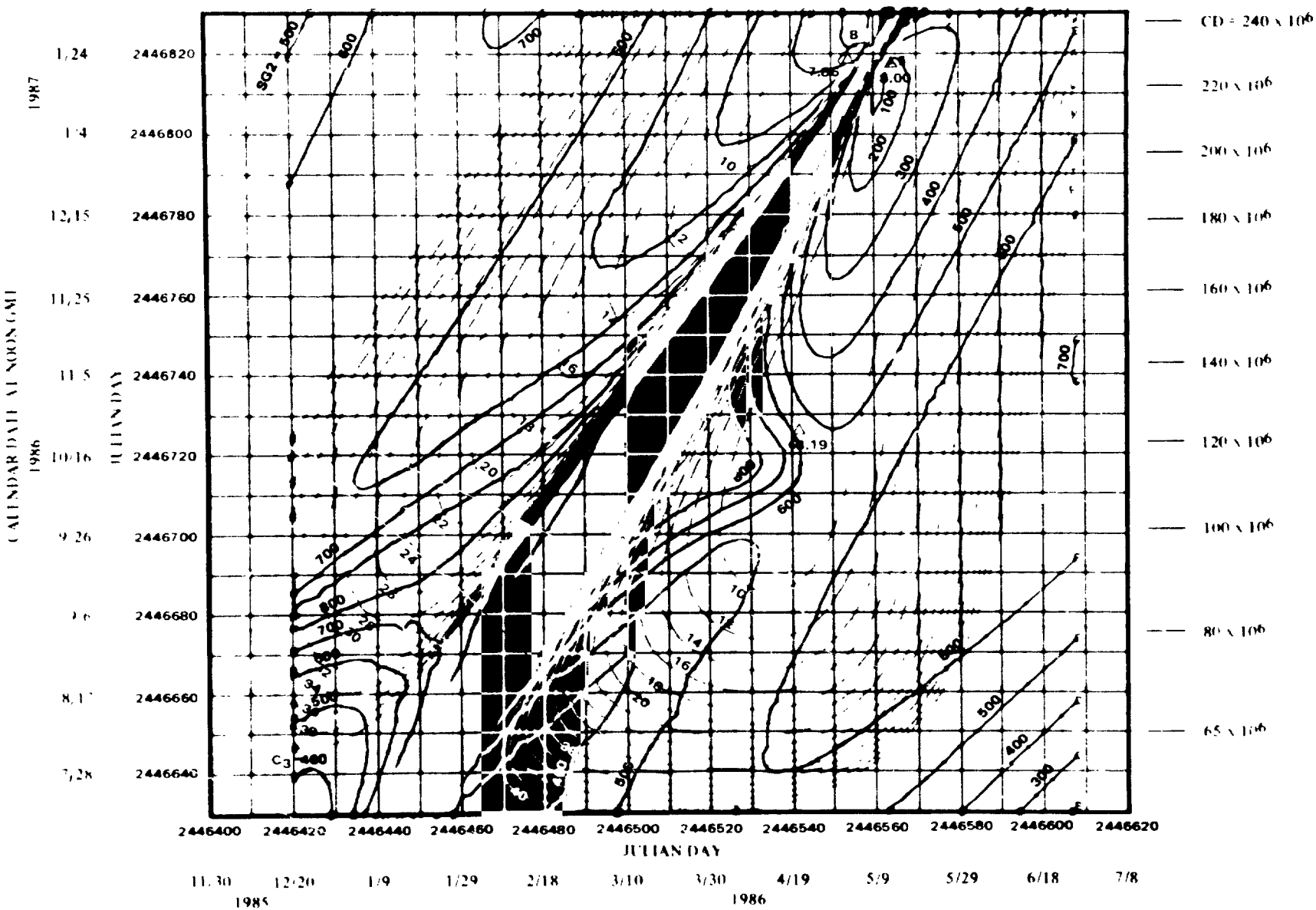
CONTOURS OF C_3 AND THA EARTH TO MARS 1985-86

THA
1986



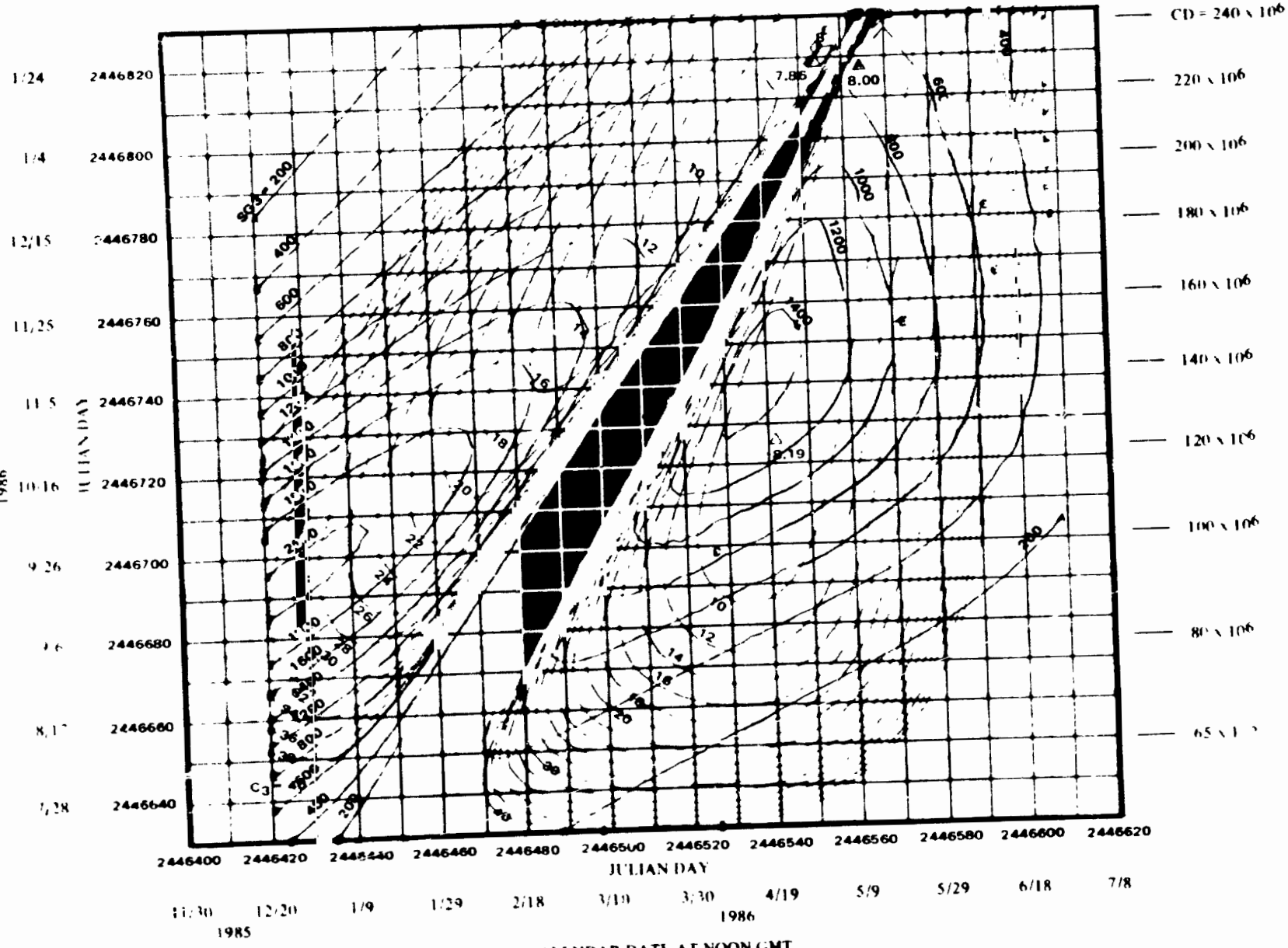
CONTOURS OF C_3 AND SG1 EARTH TO MARS 1985-86

SG1 1986



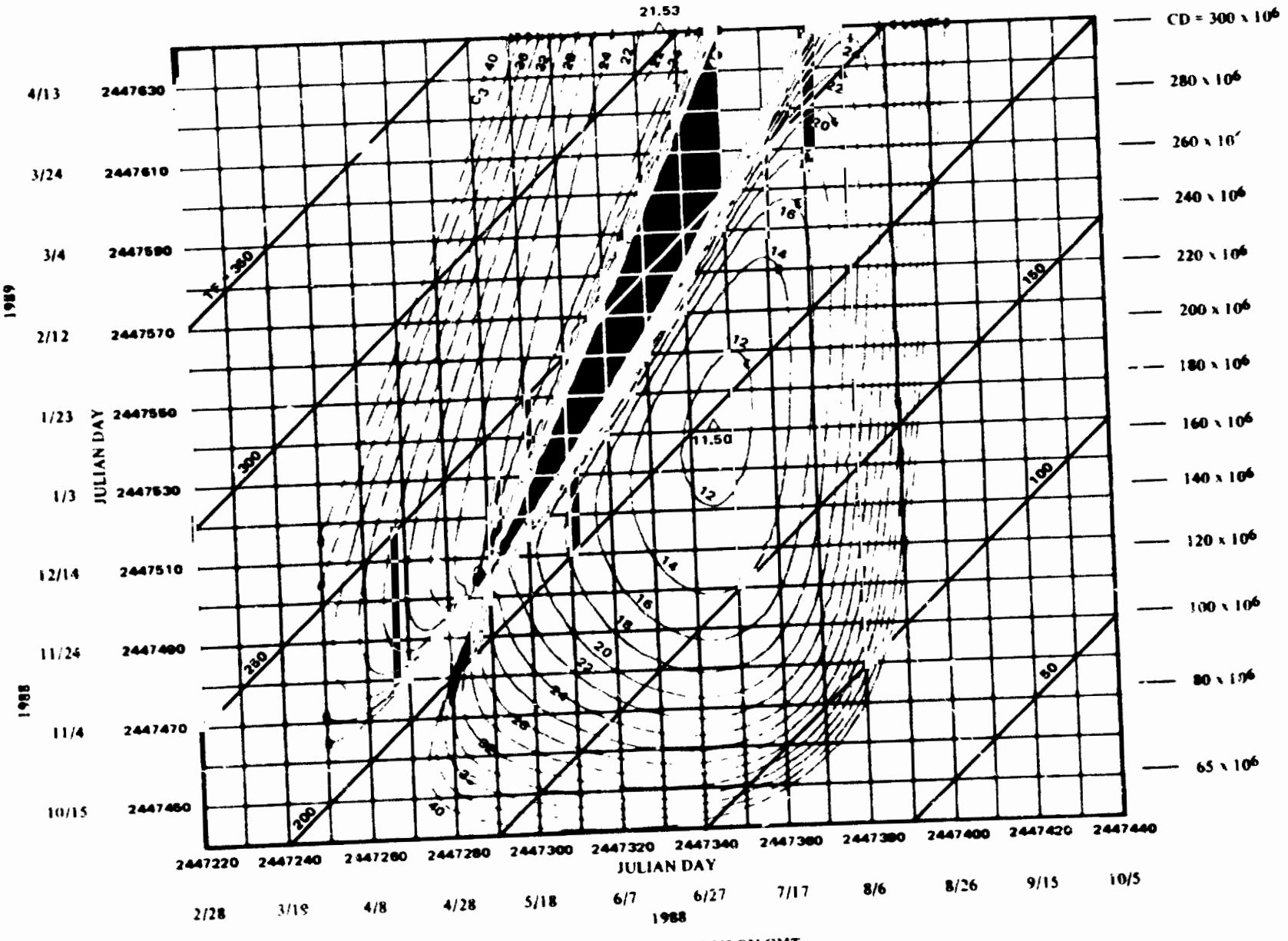
CONTOURS OF C_3 AND SG2 EARTH TO MARS 1985-86

SG2
1986

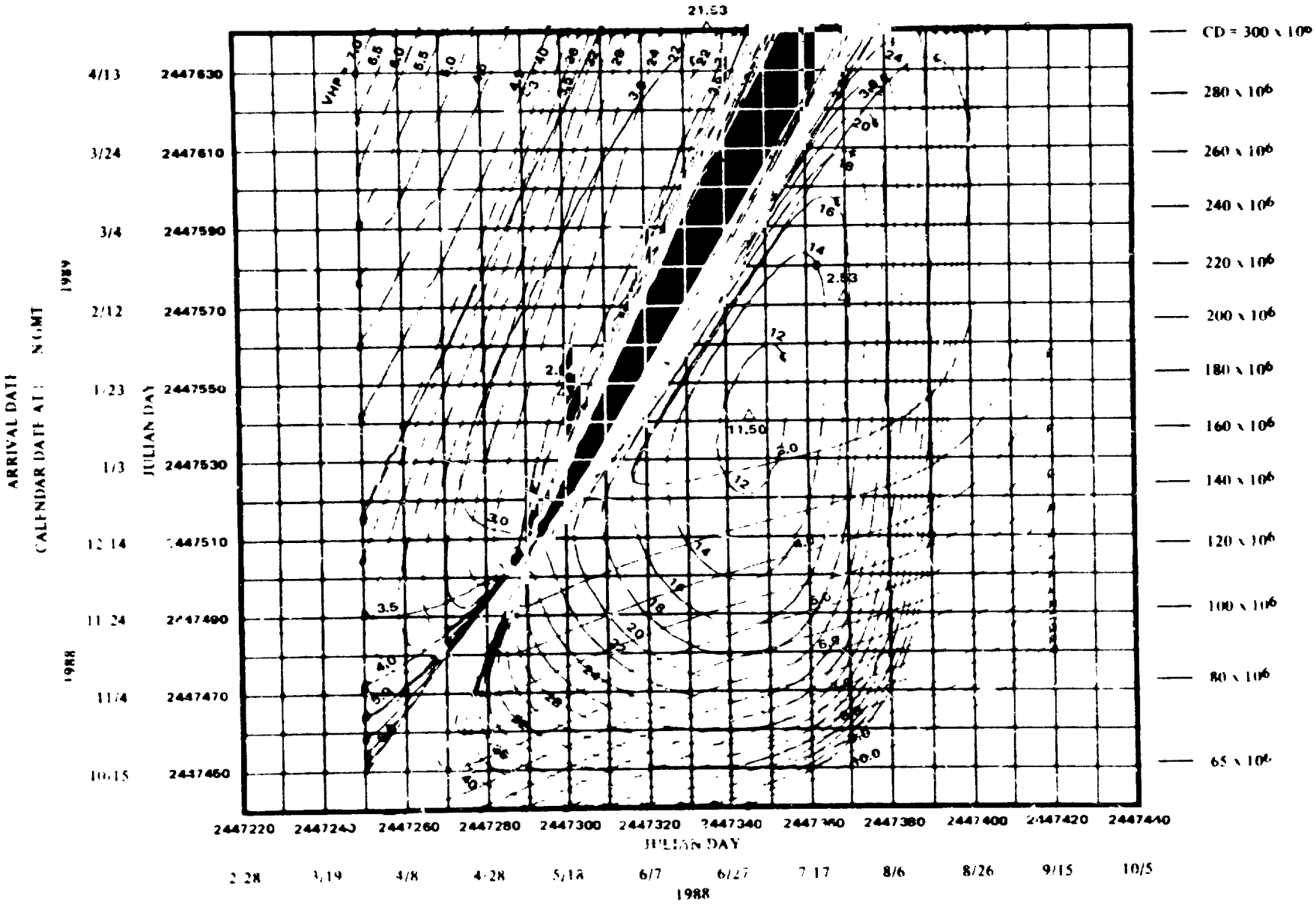


CONTOURS OF C_3 AND SG3 EARTH TO MARS 1985 86

SG3
1986

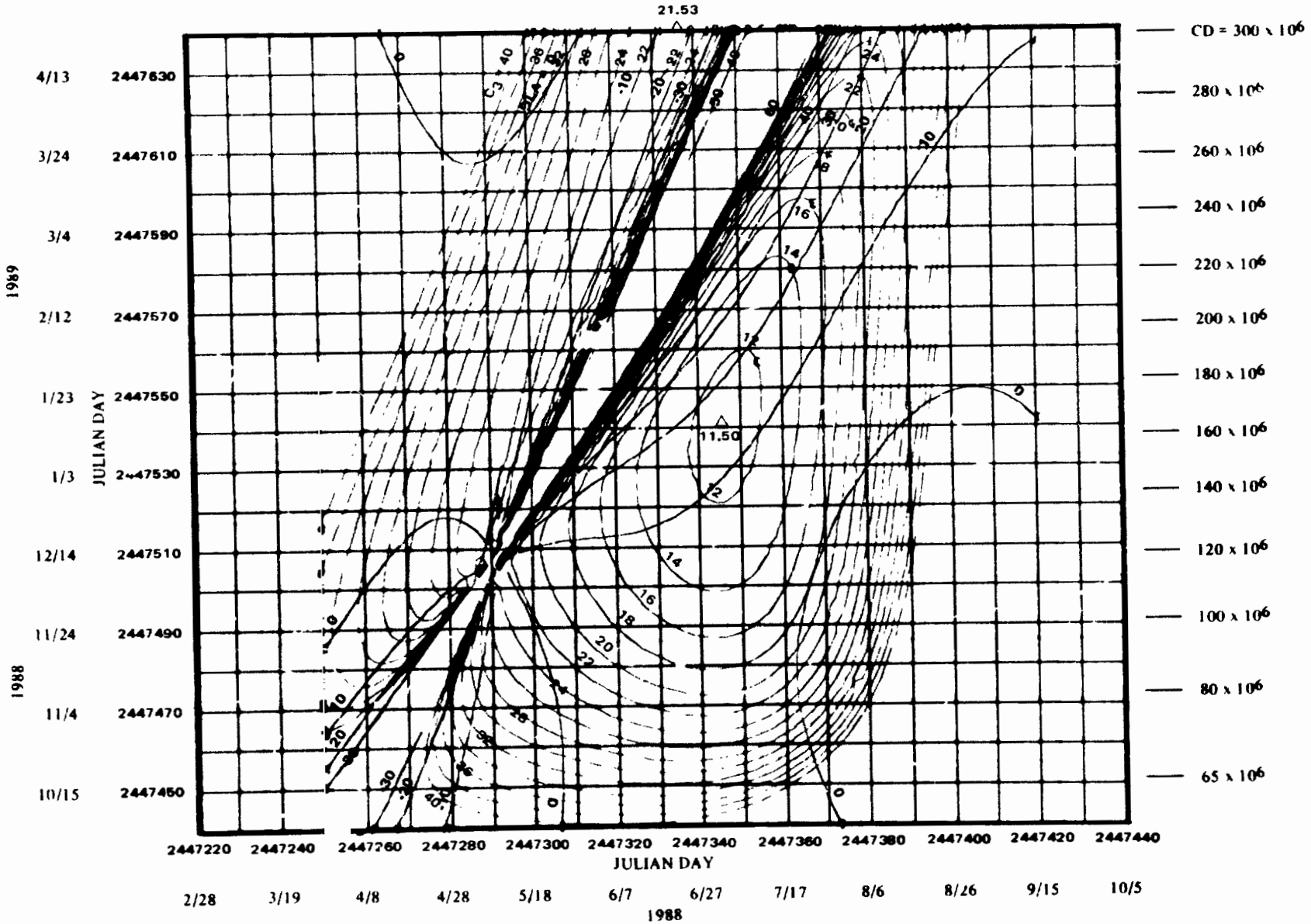


CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1988



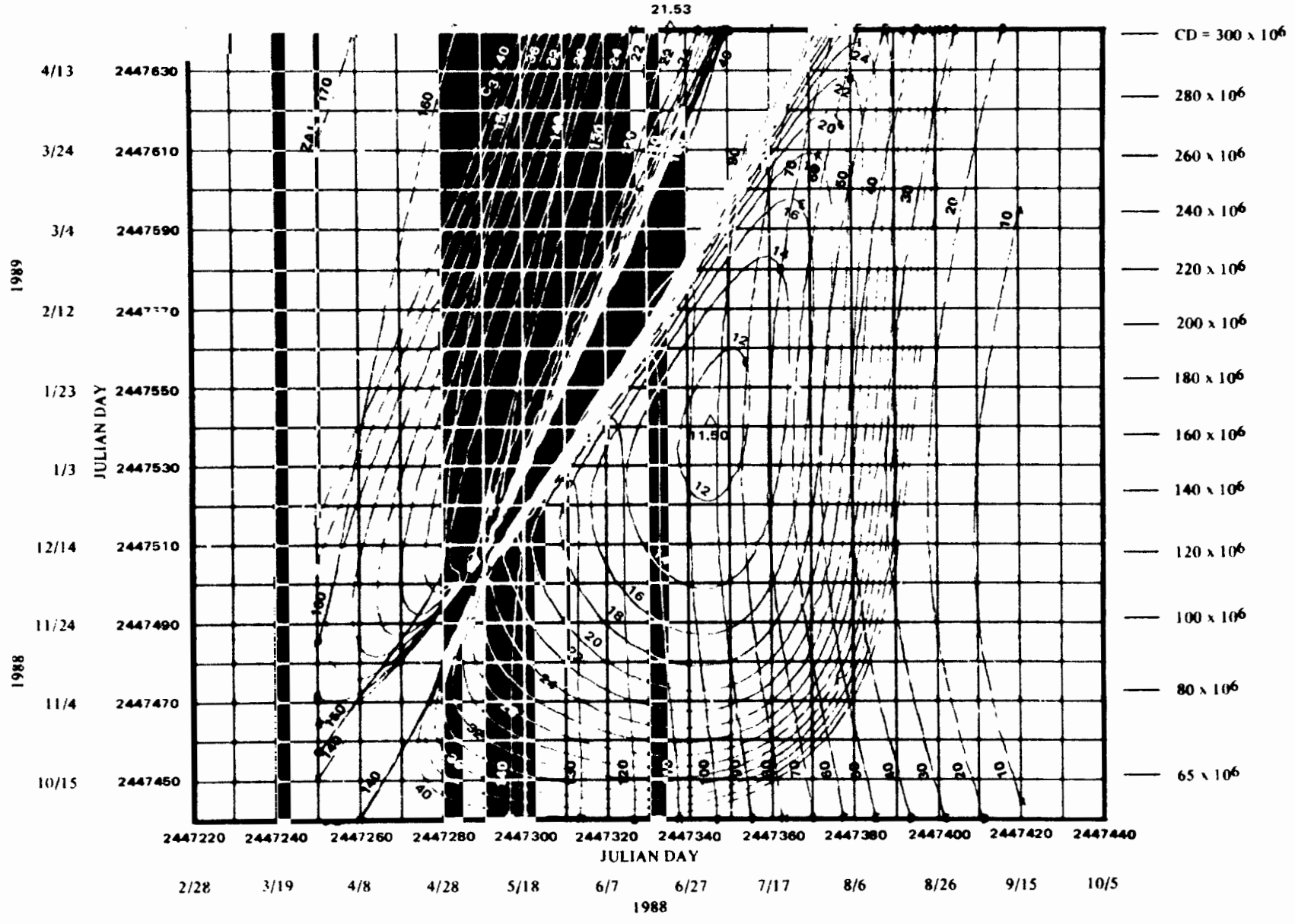
CONTOURS OF C_3 AND VHP EARTH TO MARS 1988

VHP 1988



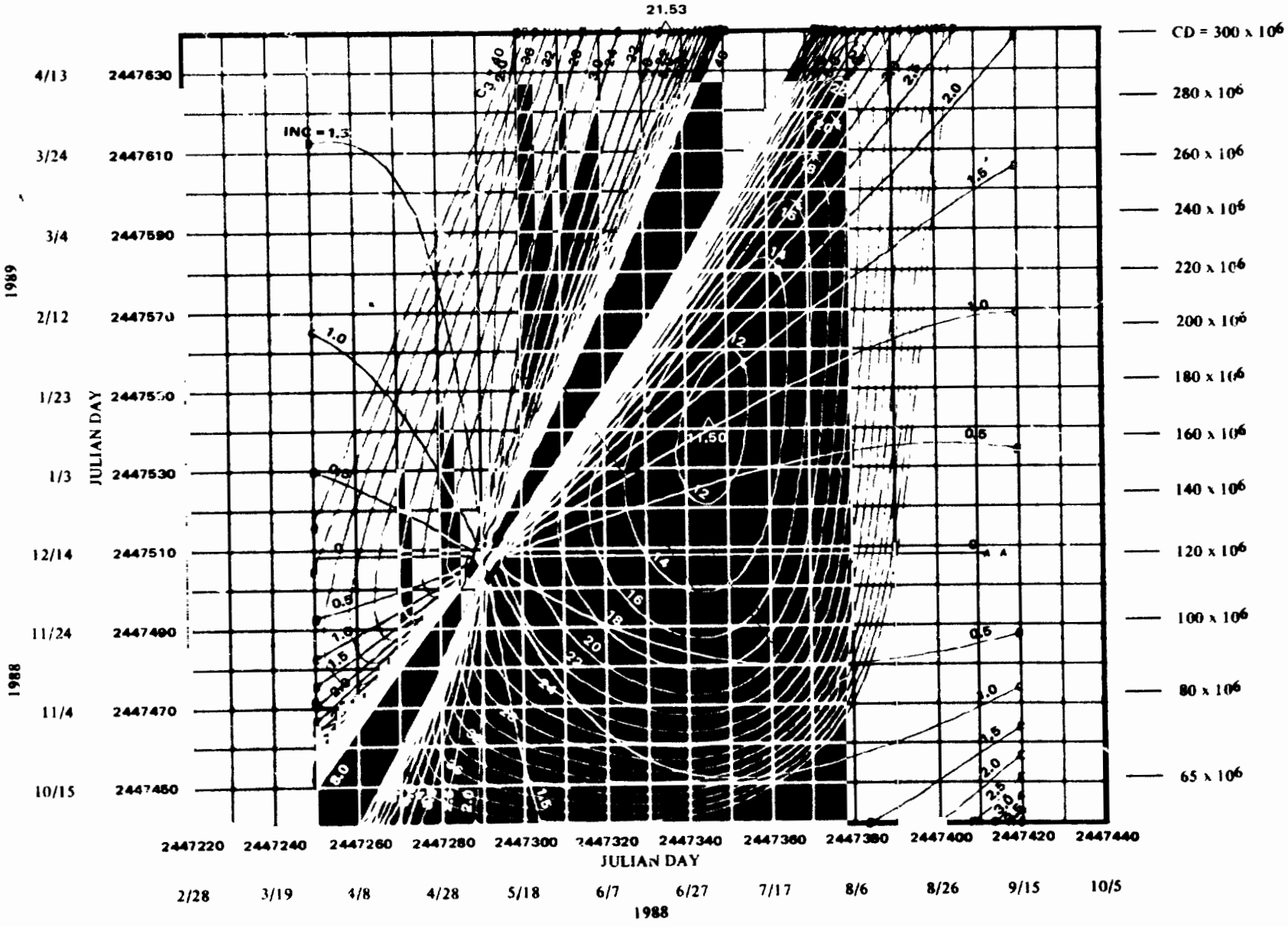
CONTOURS OF C_3 AND DLA EARTH TO MARS 1988

DLA 1988



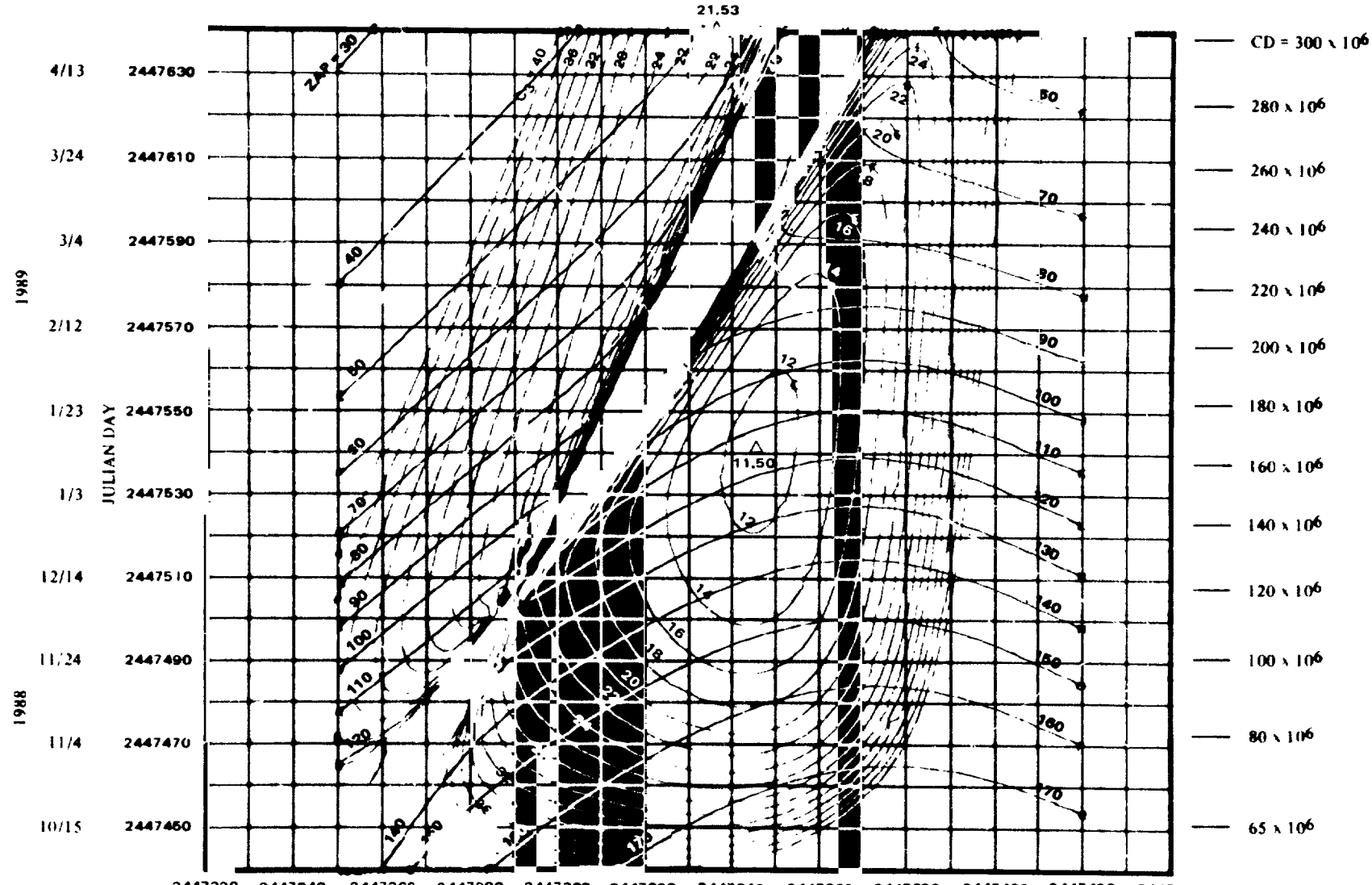
CONTOURS OF C_3 AND ZAL EARTH TO MARS 1988

ZAL 1988

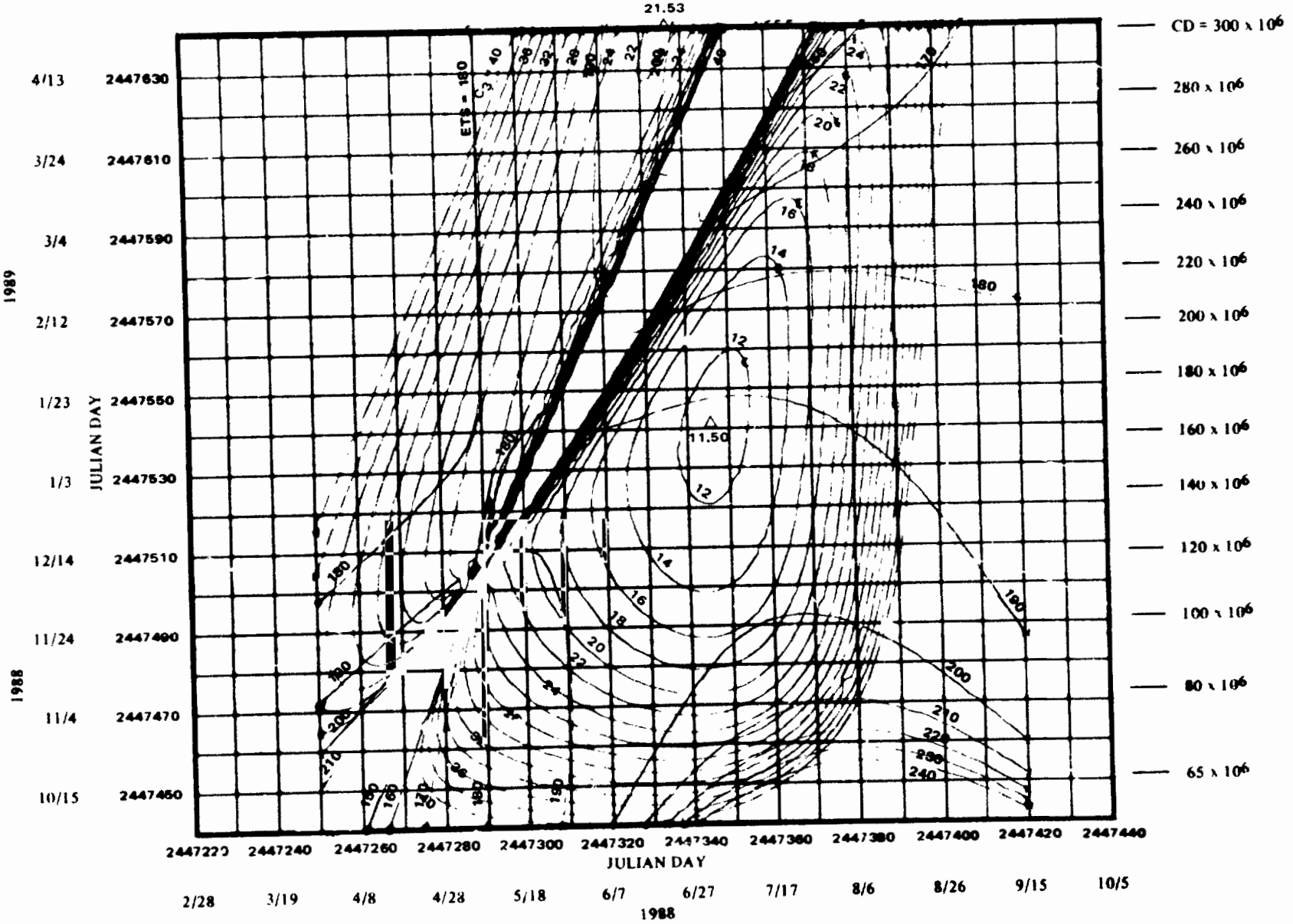


CONTOURS OF C_3 AND INC EARTH TO MARS 1988

1988 INC

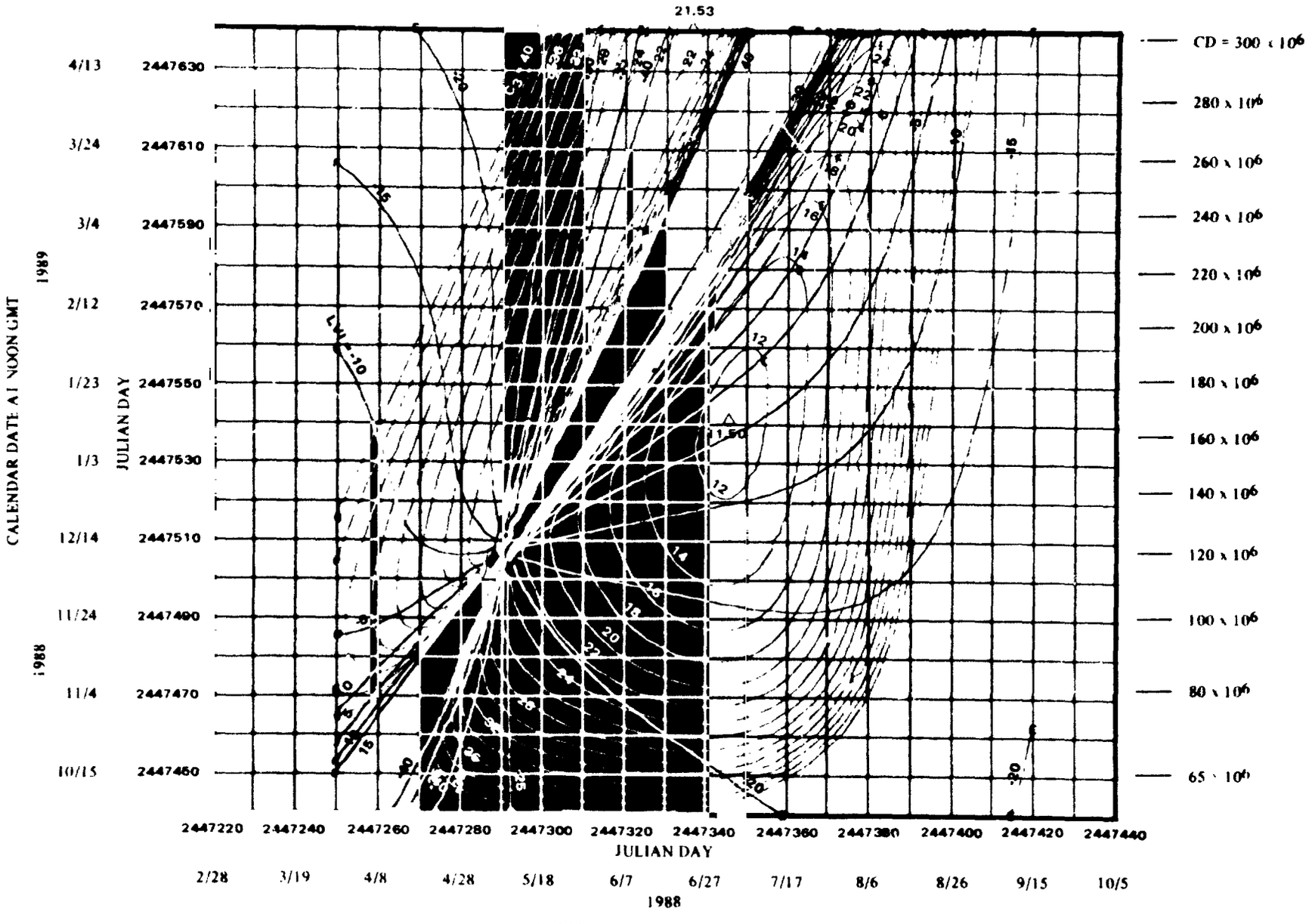


CONTOURS OF C_3 AND ZAP EARTH TO MARS 1988

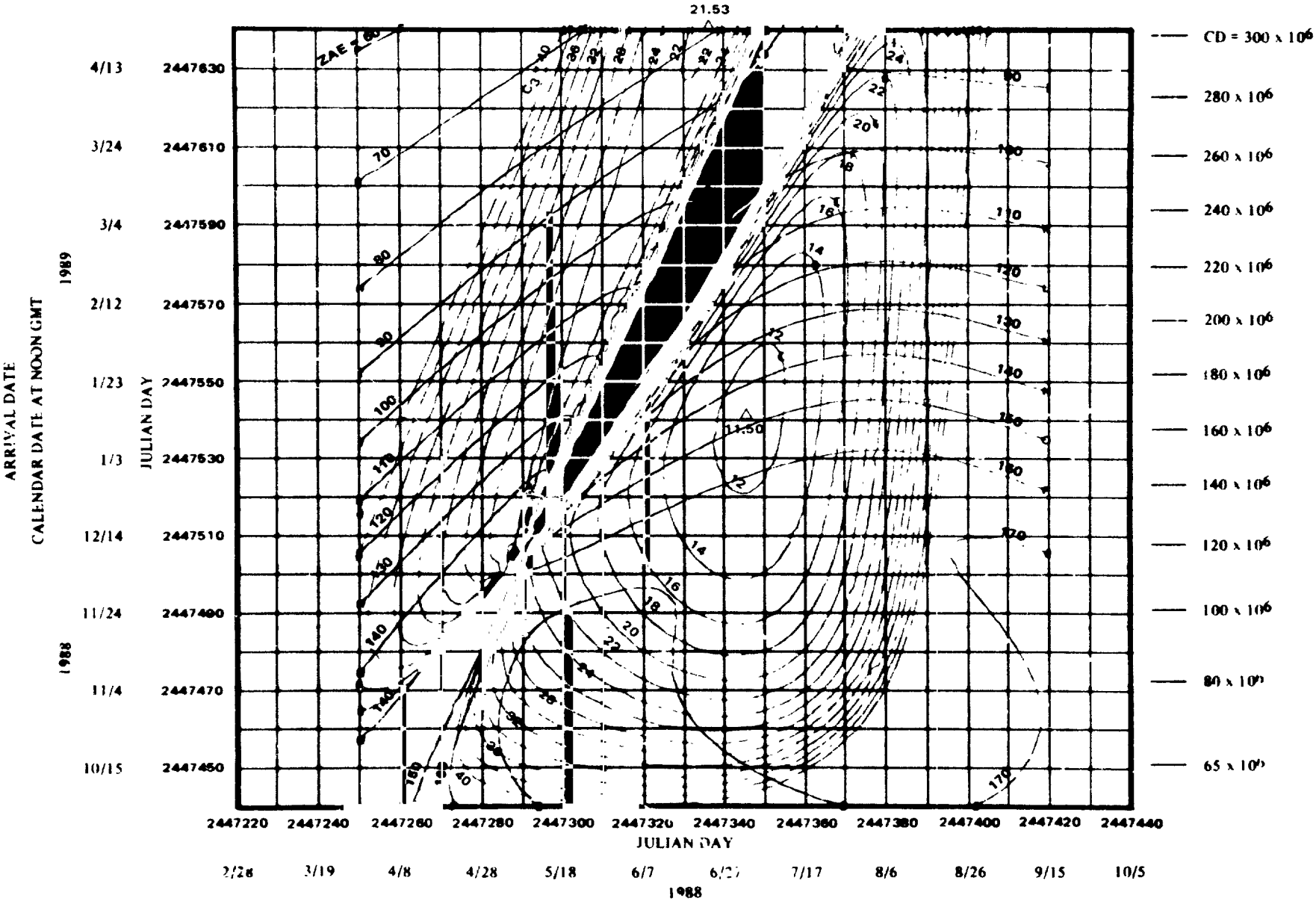


CONTOURS OF C_3 AND ETS EARTH TO MARS 1988

ETS
O
1988

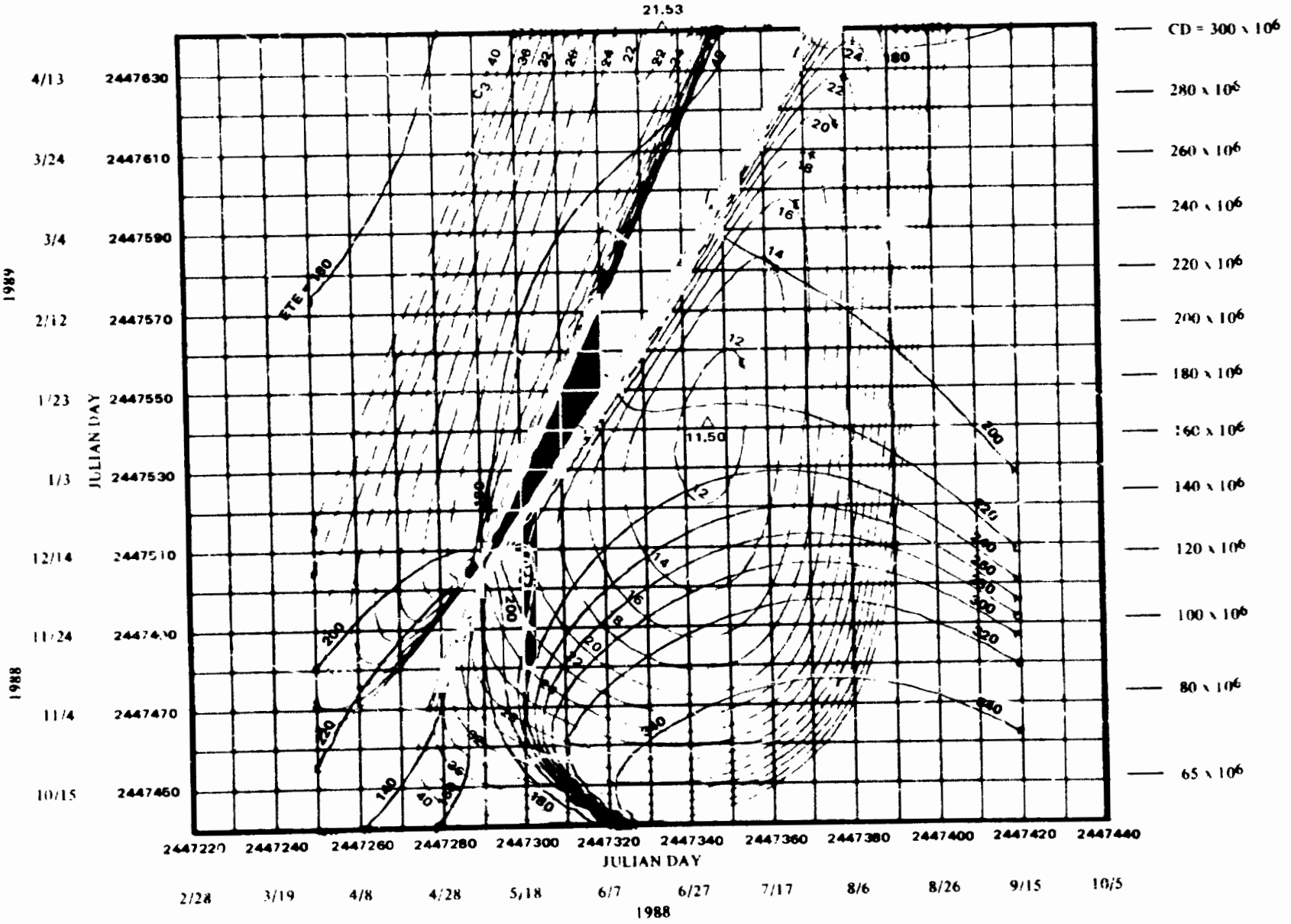


CONTOURS OF C_3 AND LVI EARTH TO MARS 1988



CONTOURS OF C_3 AND ZAE EARTH TO MARS 1988

ZAE ♂ 1988



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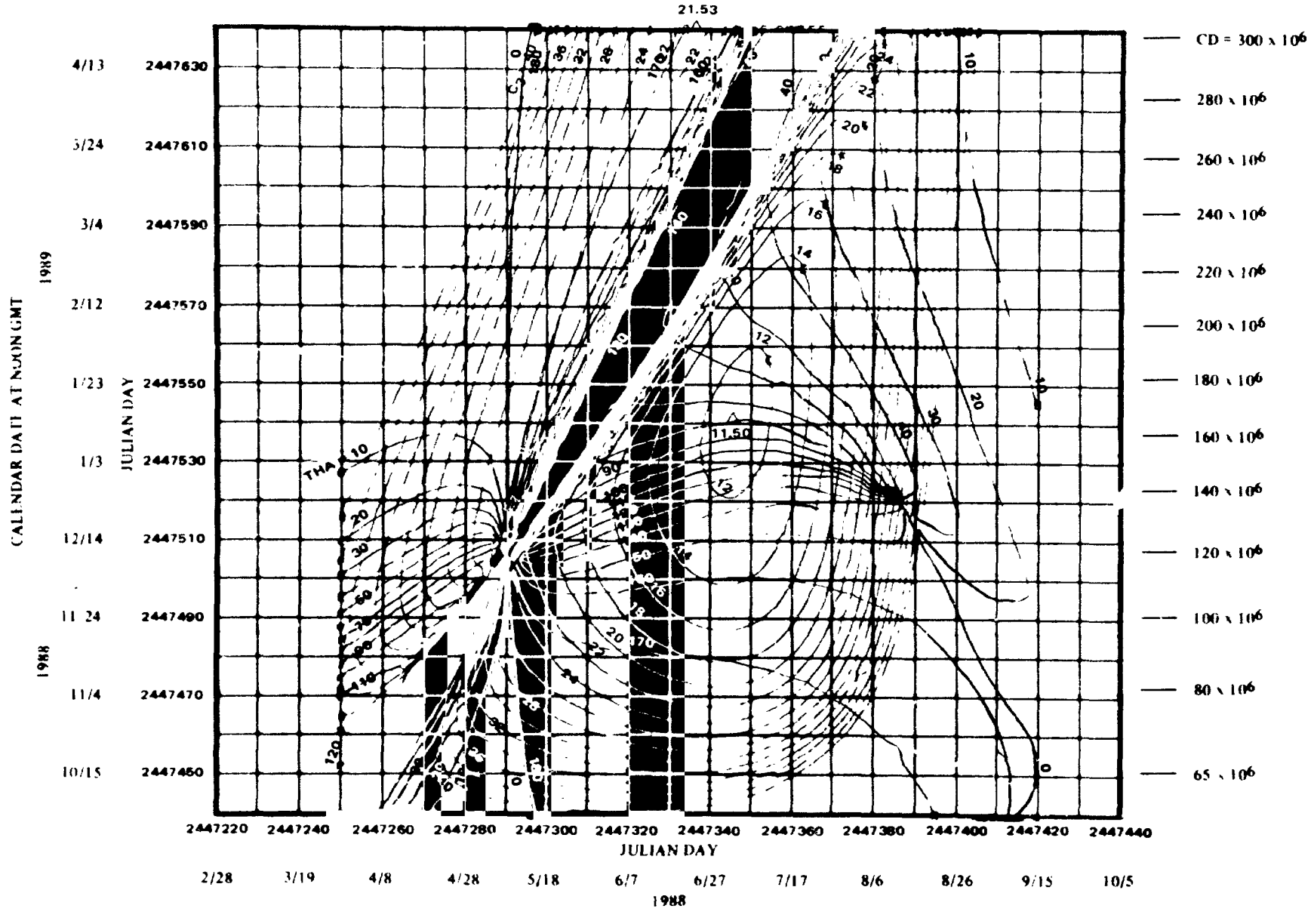
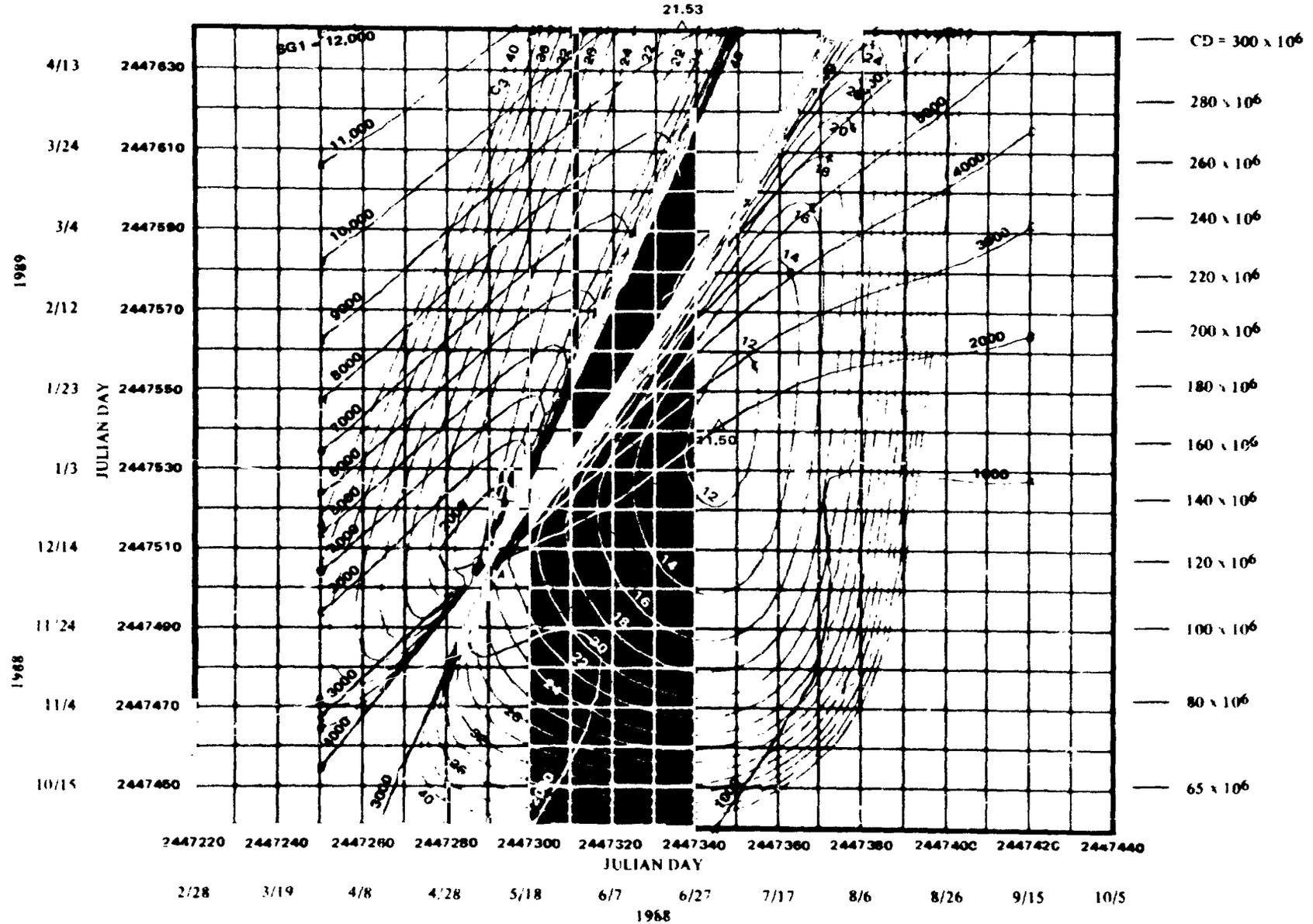


CONTOURS OF C_3 AND THA EARTH TO MARS 1988

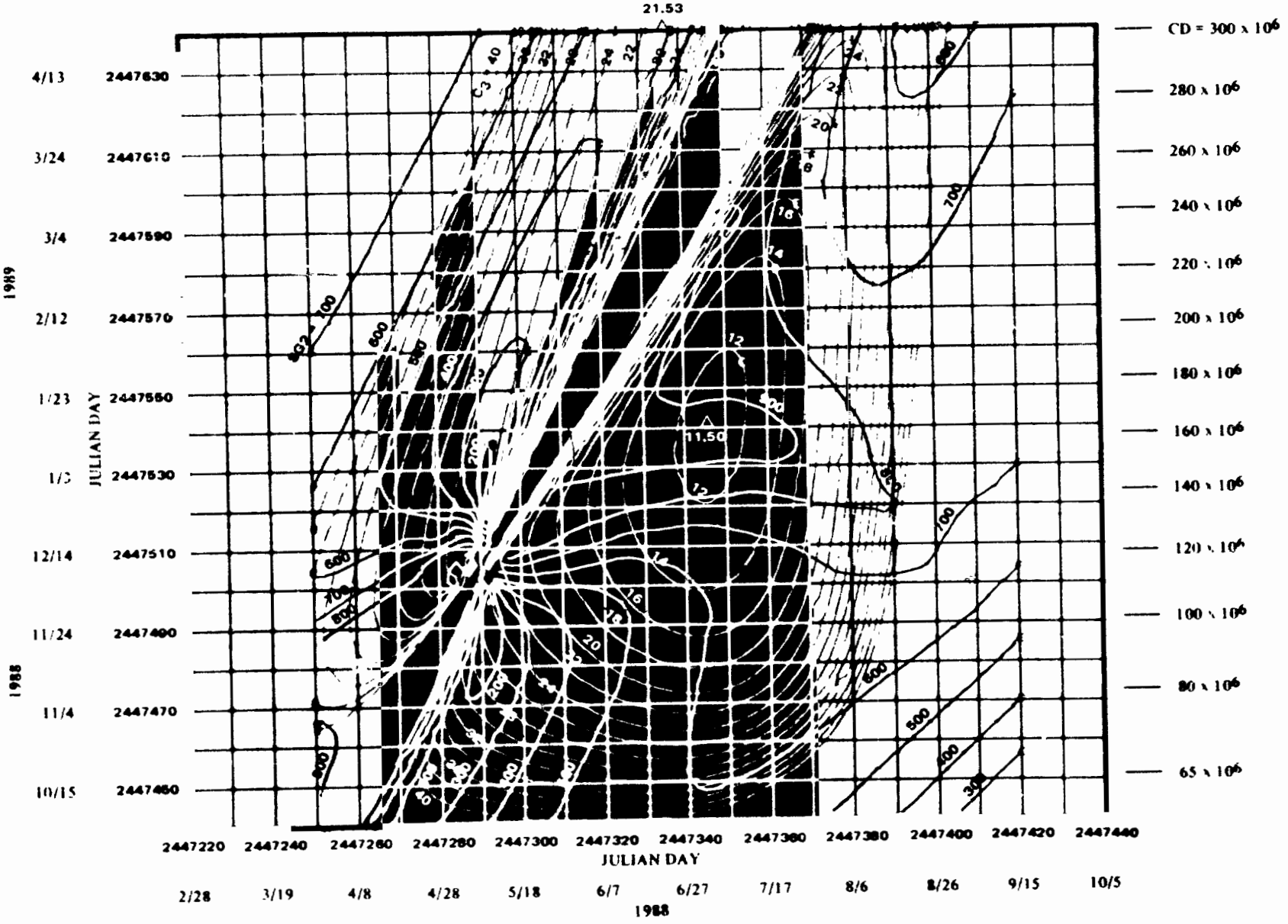
THA
1988



CONTOURS OF C_3 AND SG1 EARTH TO MARS 1988

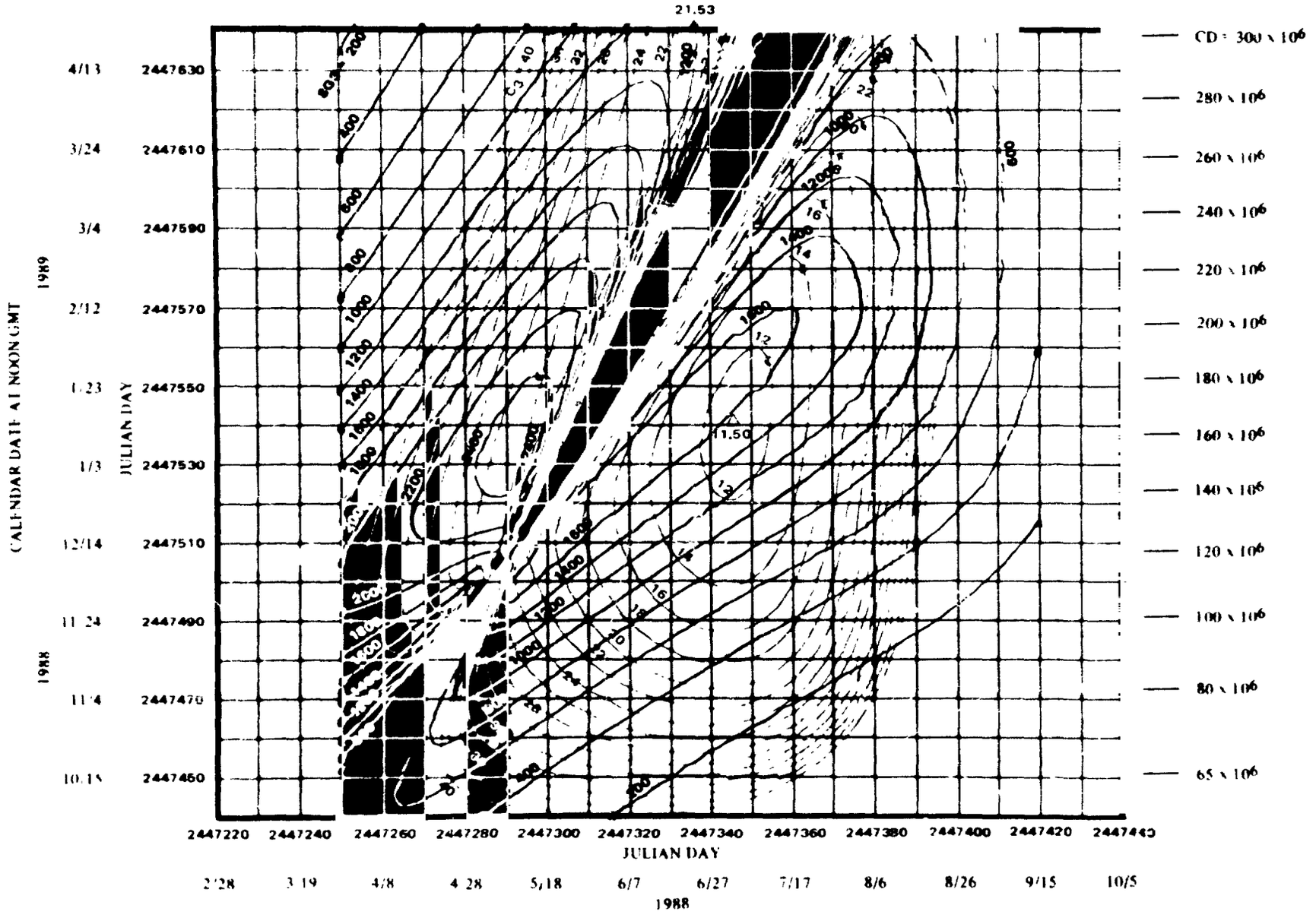
3-68

SG1

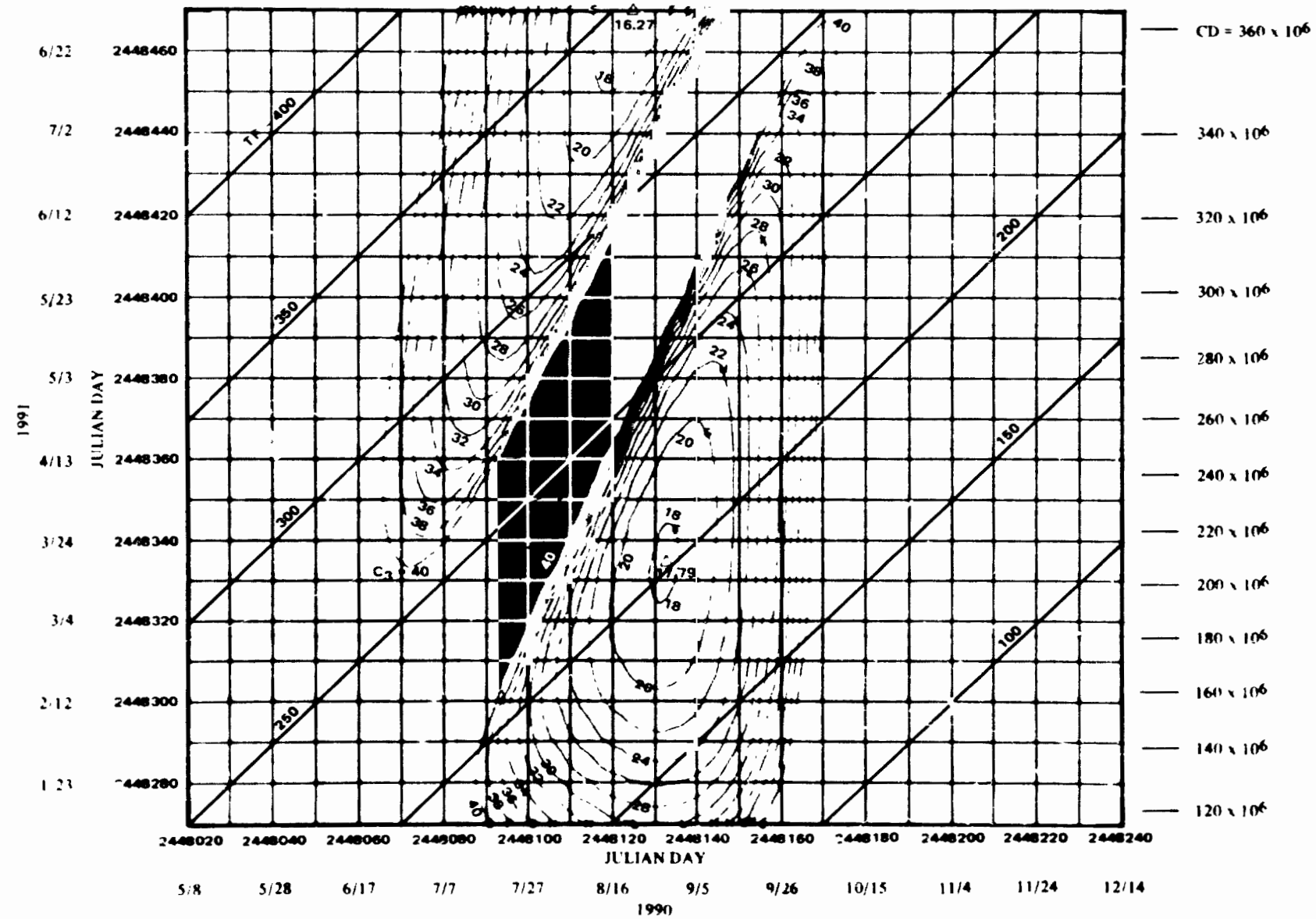


CONTOURS OF C_3 AND SG2 EARTH TO MARS 1988

SG2
1988

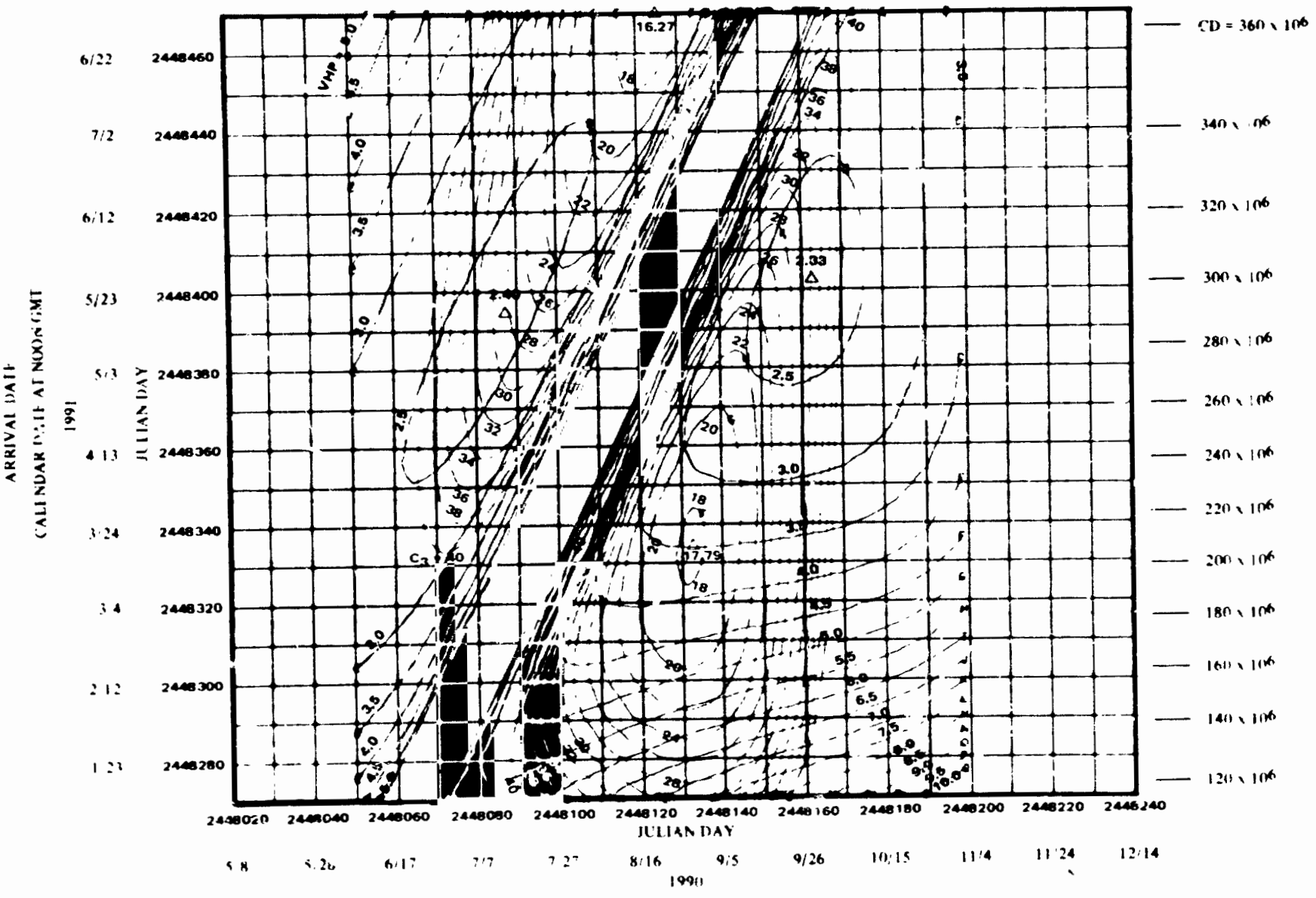


CONTOURS OF C_3 AND SG3 EARTH TO MARS 1988

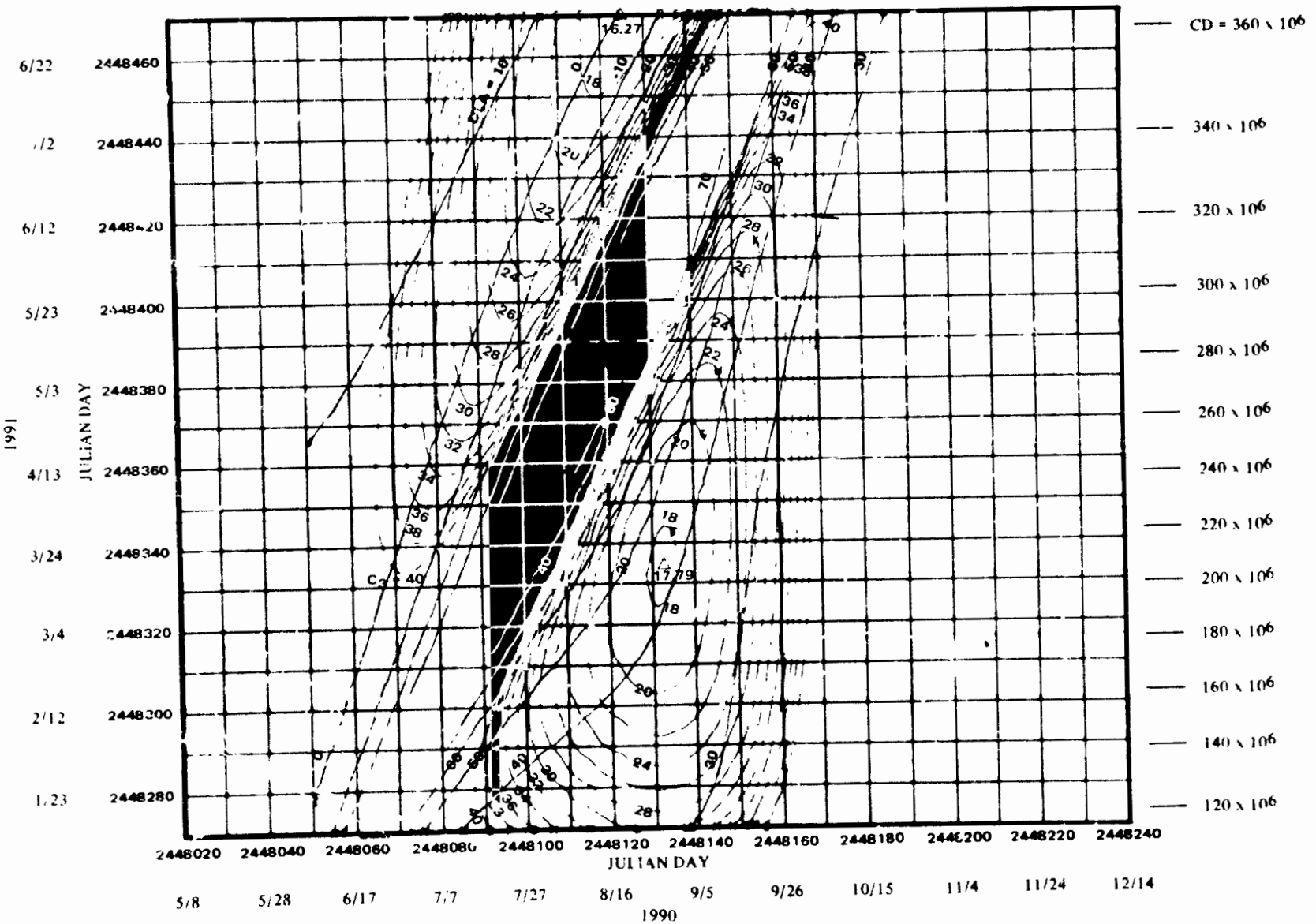


CONTOURS OF C_3 AND FLIGHT TIMES EARTH TO MARS 1990

C_3 1990

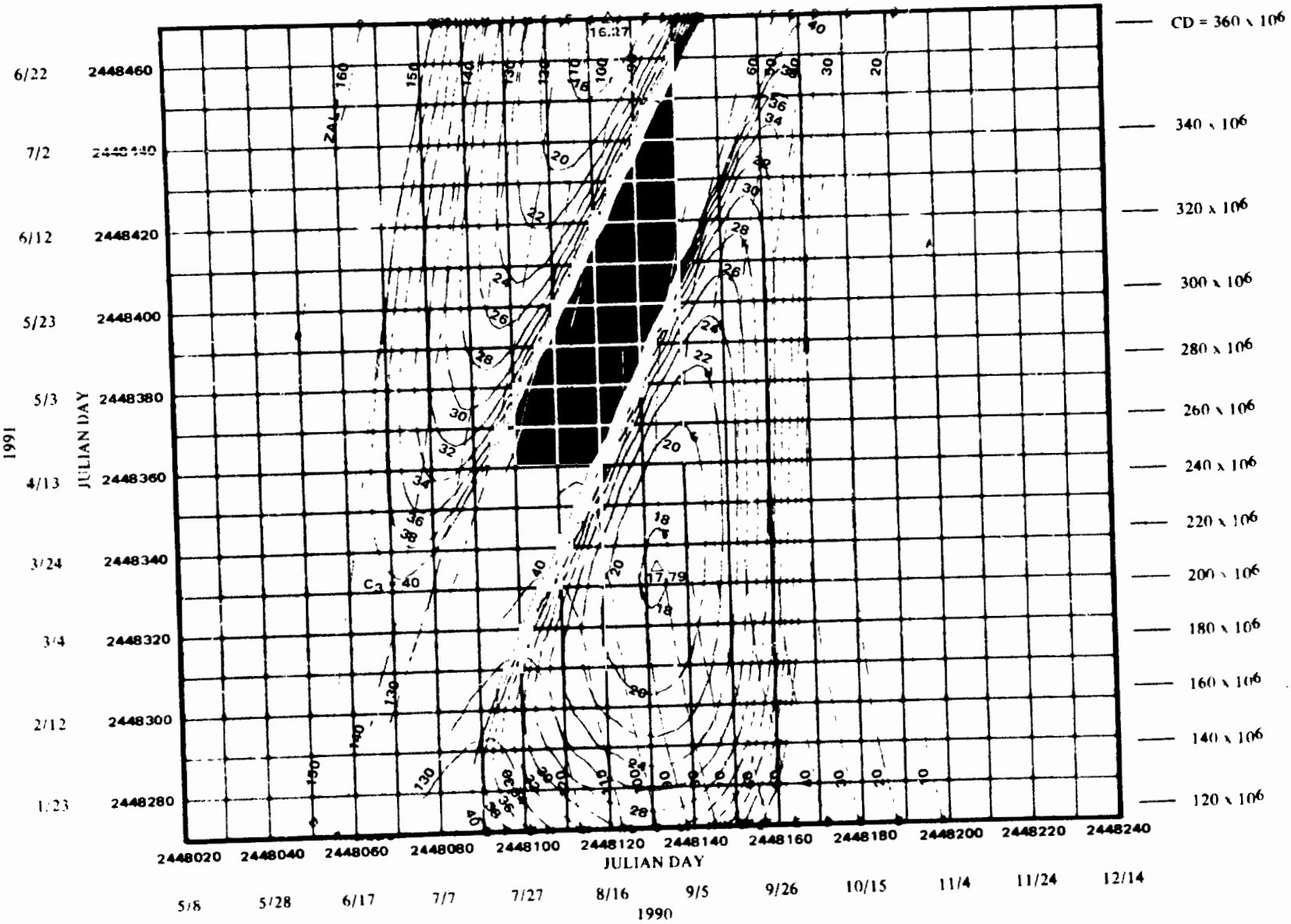


CONTOURS OF C_3 AND VHP EARTH TO MARS 1990



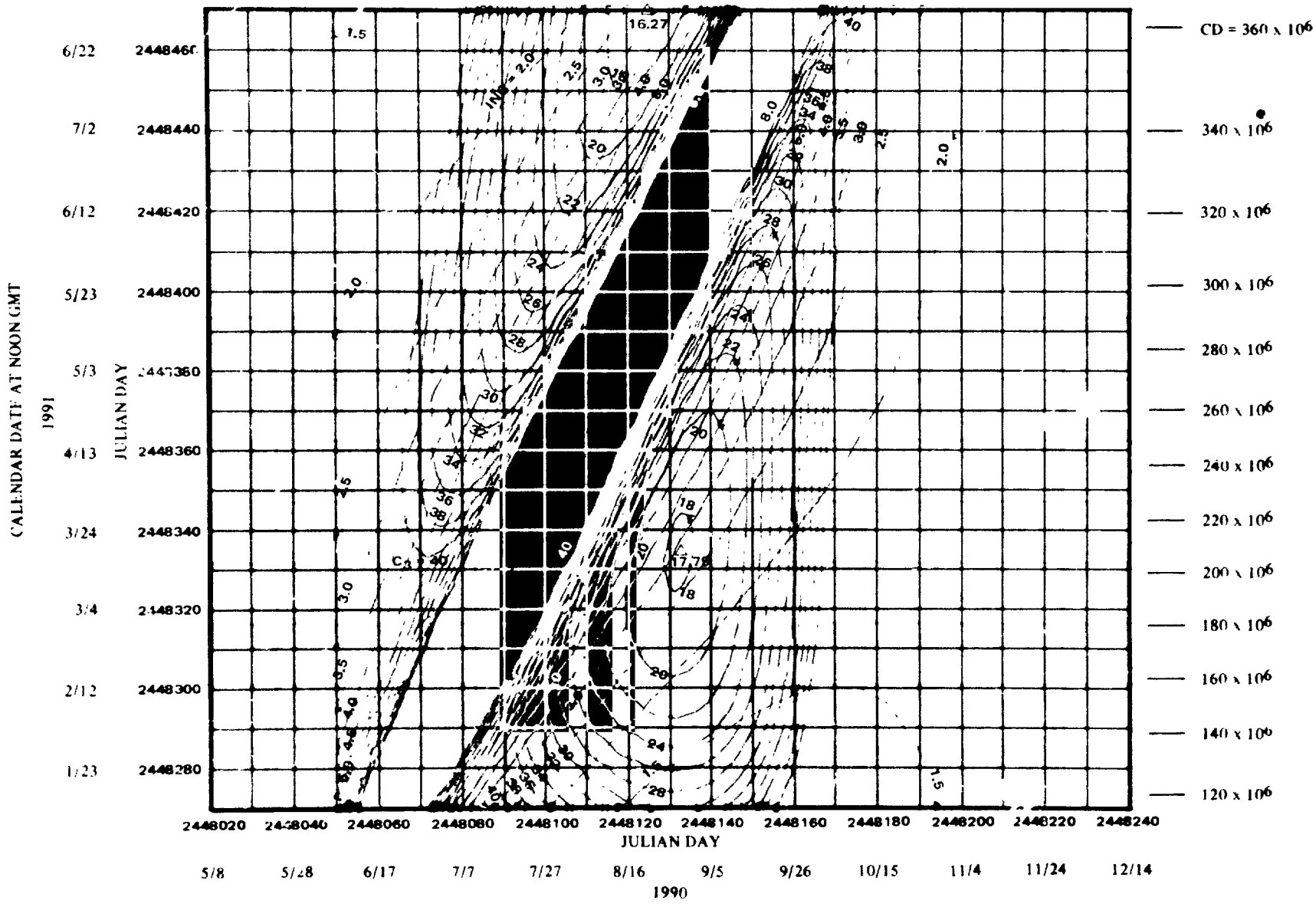
CONTOURS OF C_3 AND DLA EARTH TO MARS 1990

DLA
♂
1990

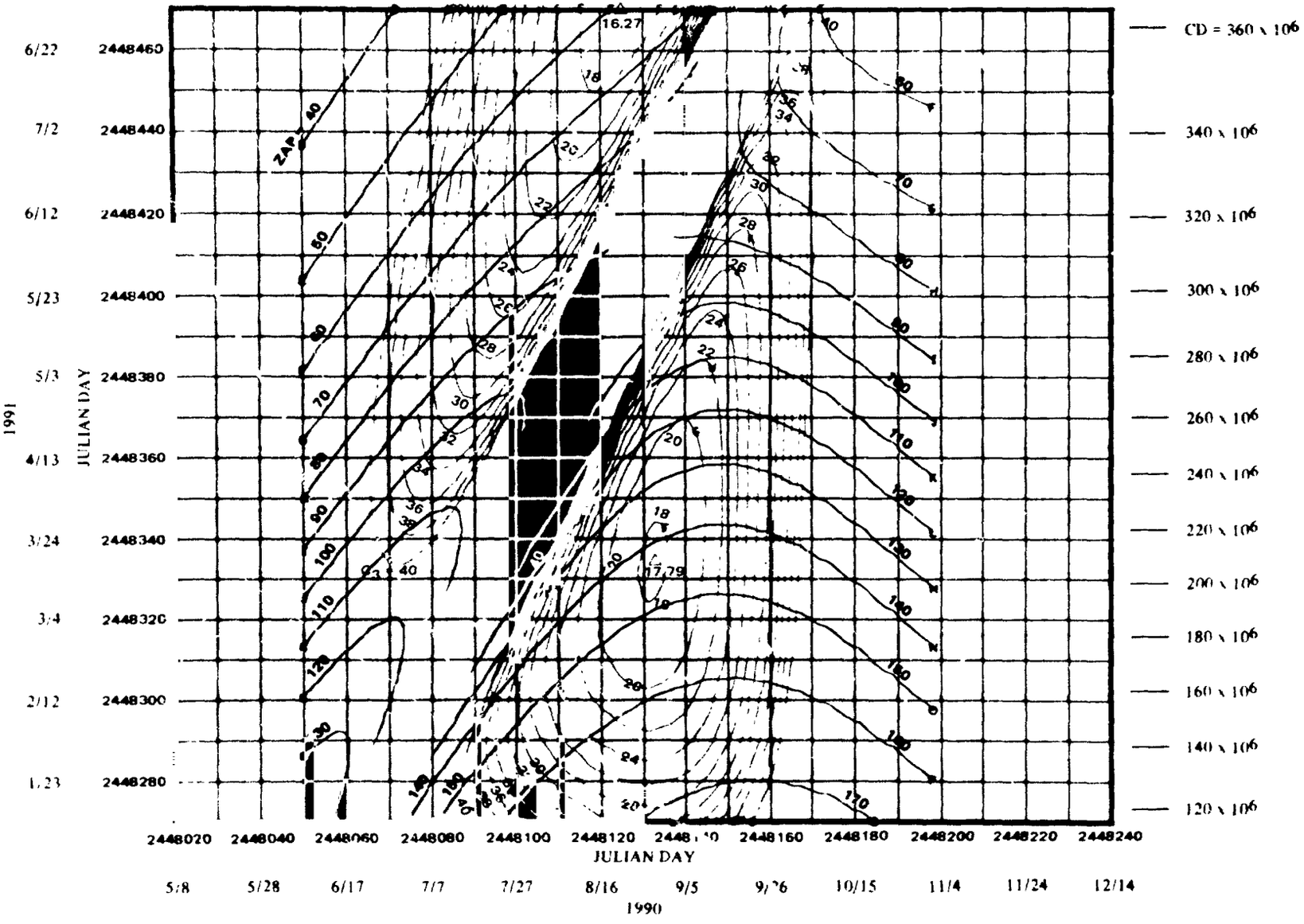


CONTOURS OF C_3 AND ZAL EARTH TO MARS 1990

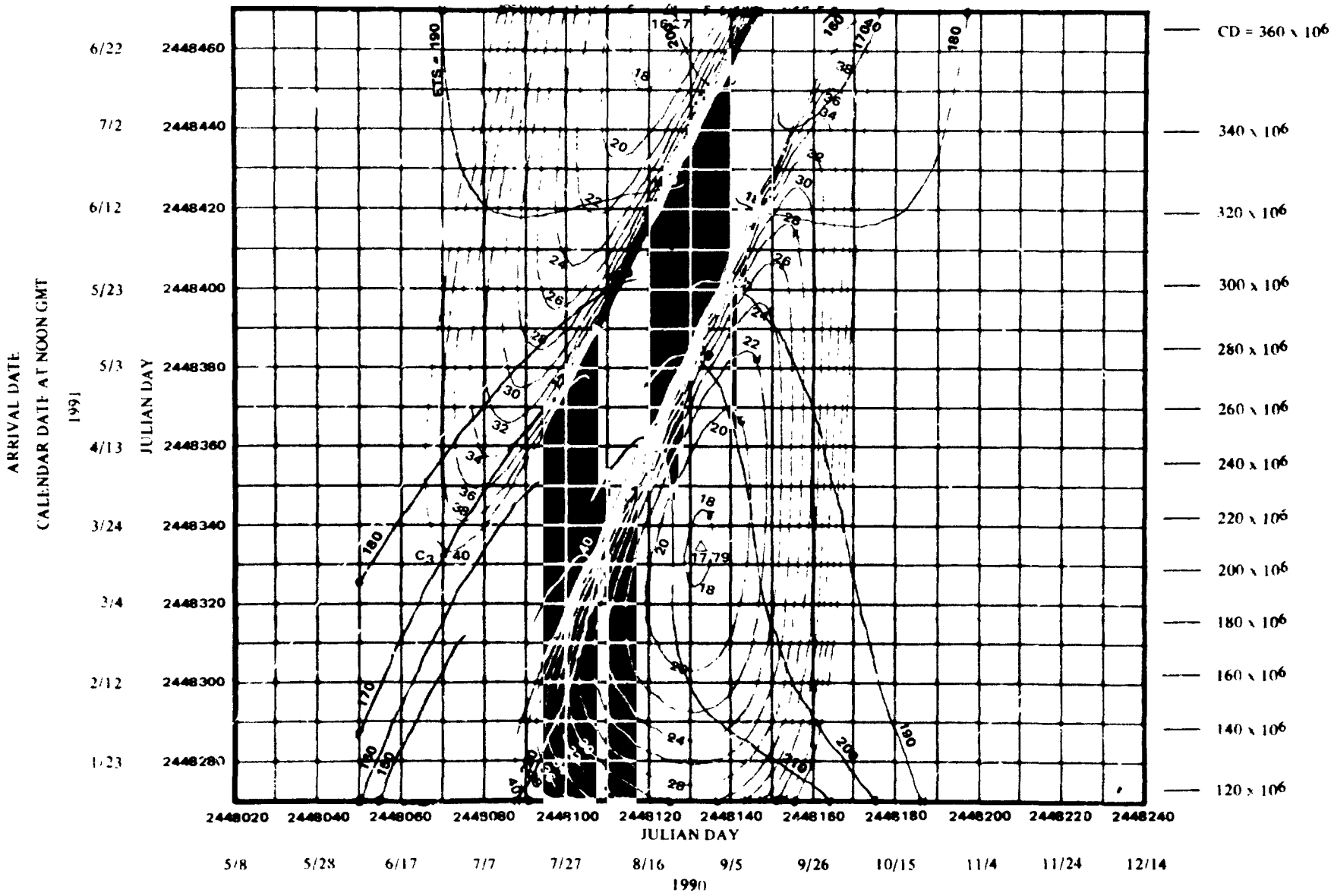
ZAL ♂ 1990



CONTOURS OF C_3 AND INC EARTH TO MARS 1990

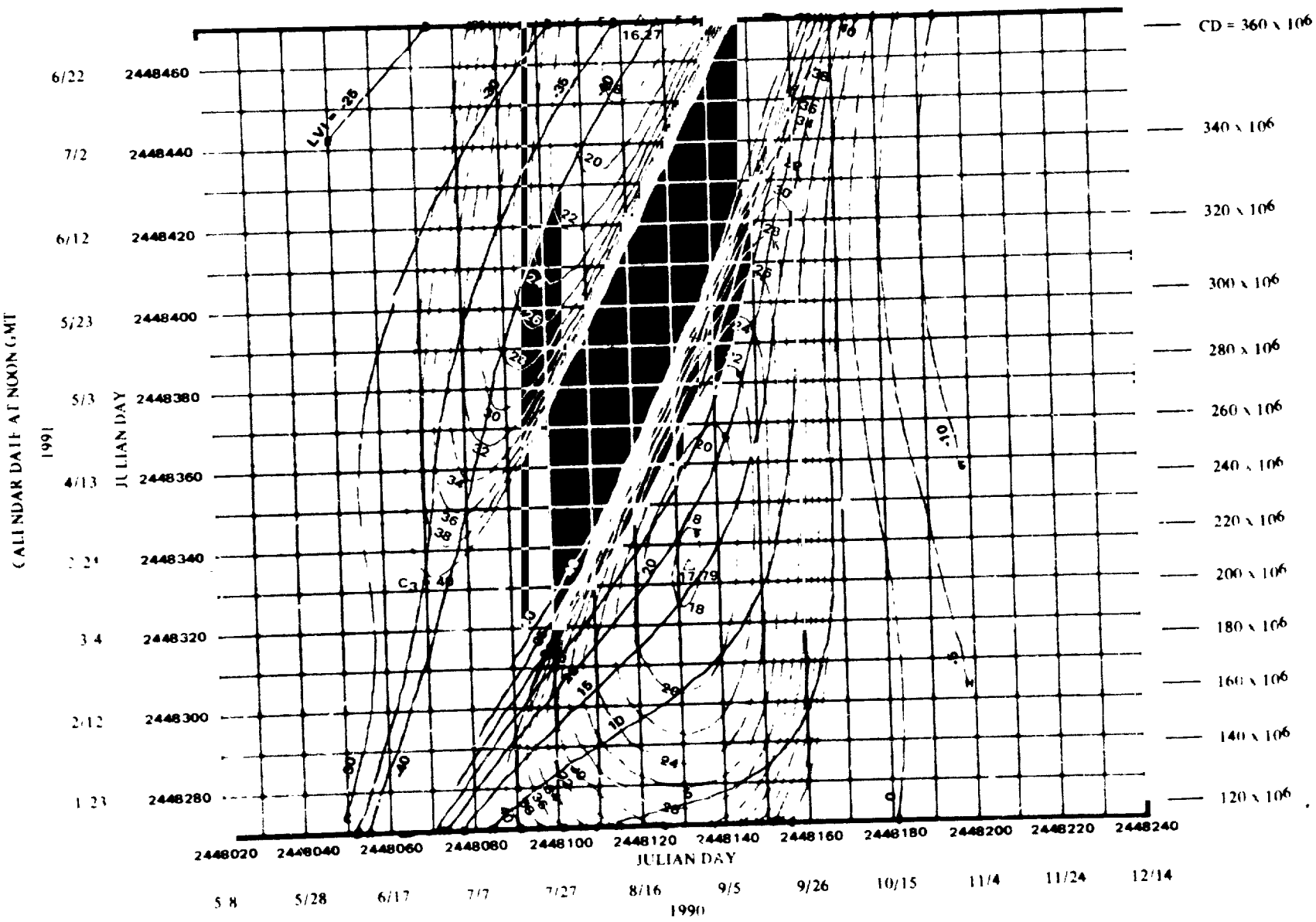


CONTOURS OF C_3 AND ZAP EARTH TO MARS 1990

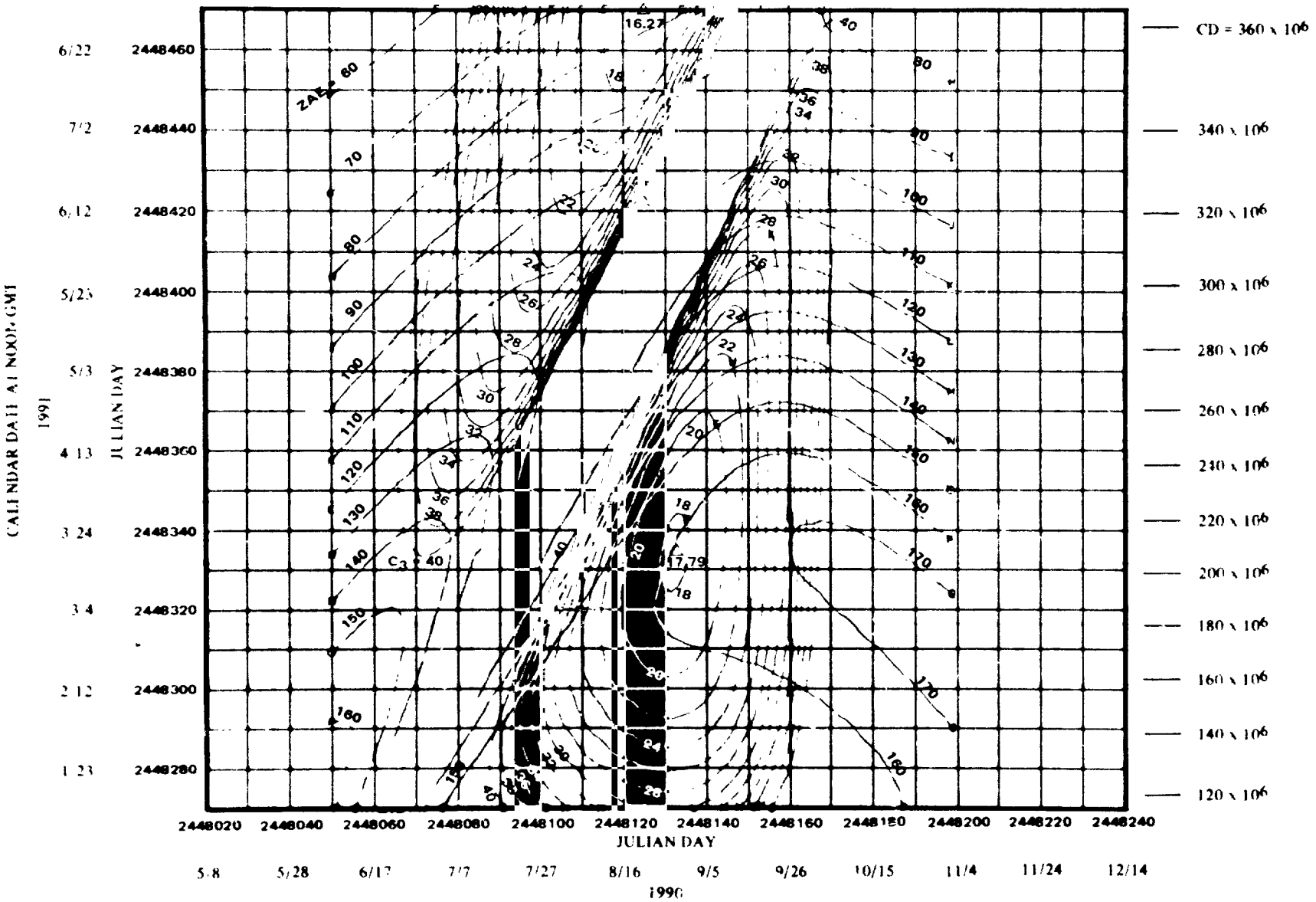


CONTOURS OF C_3 AND ETS EARTH TO MARS 1990

ETS 1990

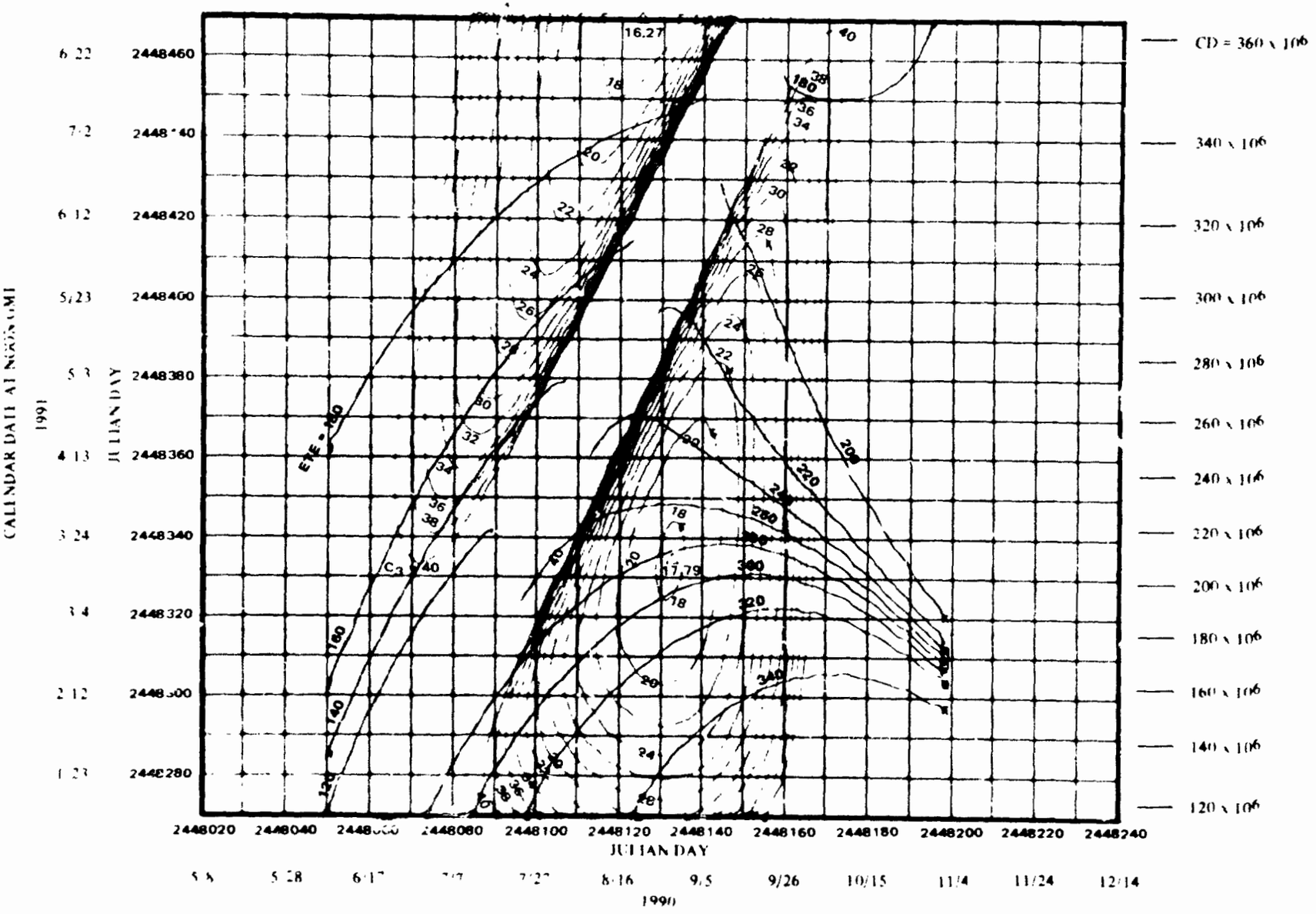


CONTOURS OF C_3 AND LVI EARTH TO MARS 1990



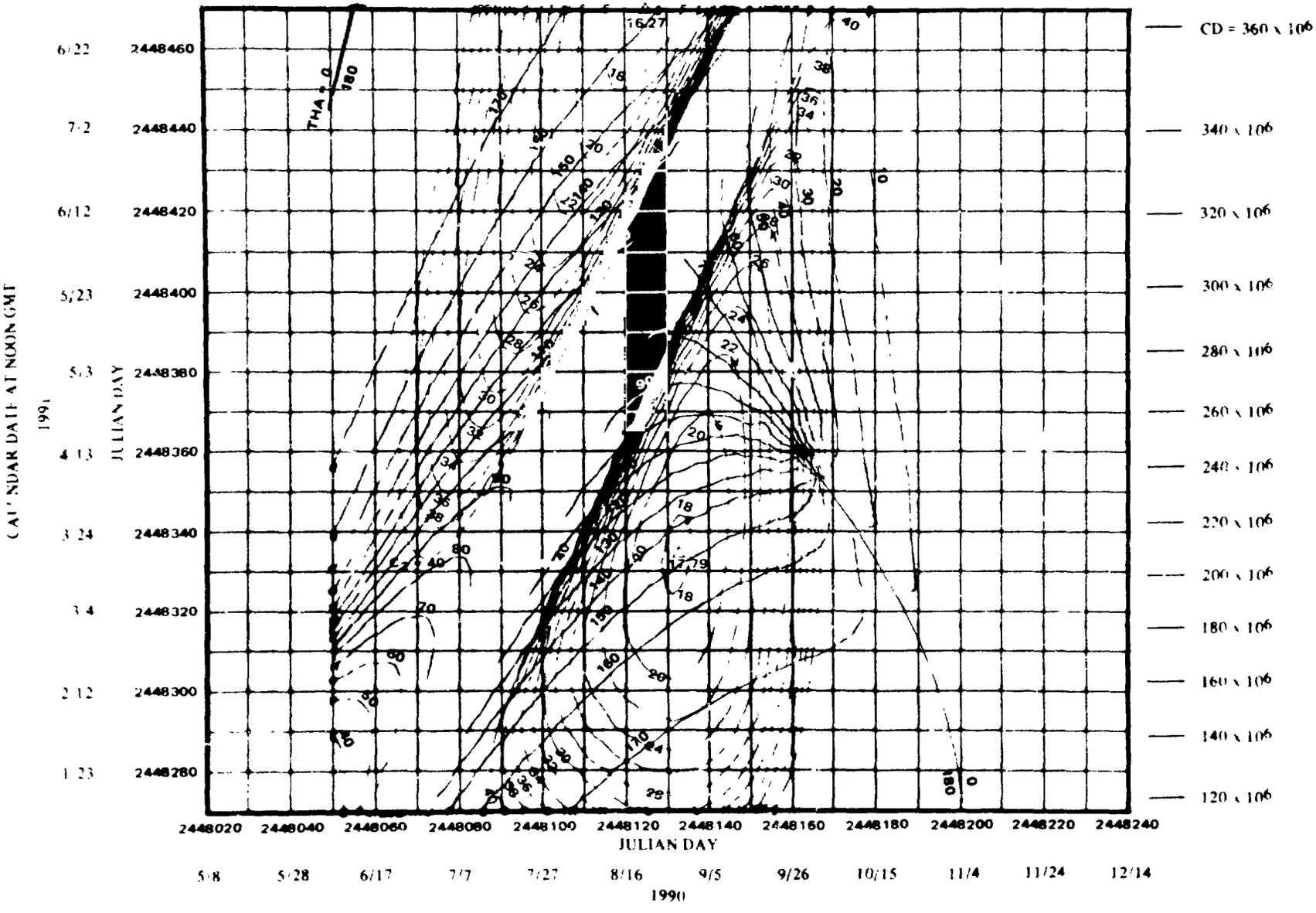
CONTOURS OF C_3 AND ZAE EARTH TO MARS 1990

ZAE 1990



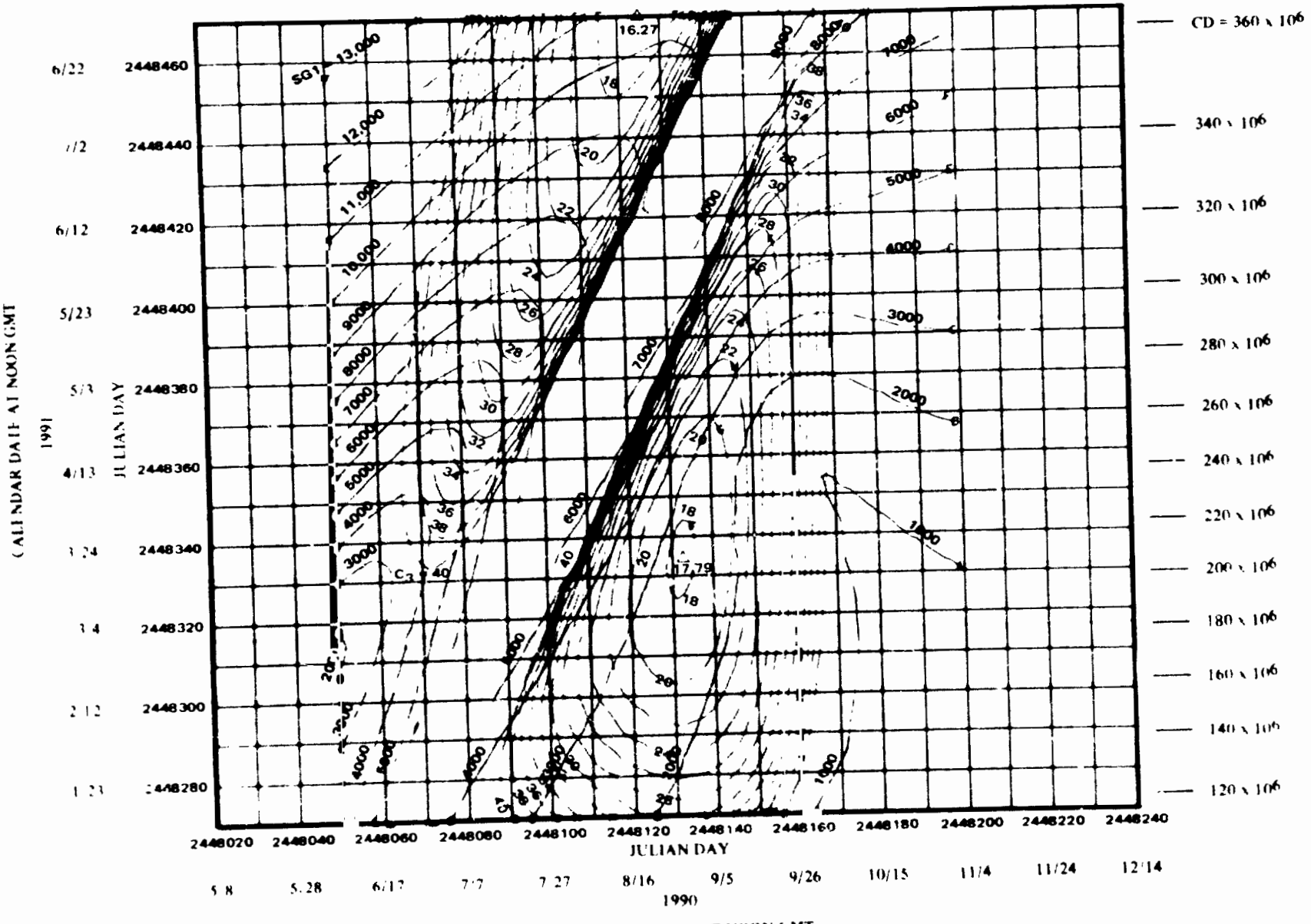
CONTOURS OF C_3 AND ETE EARTH TO MARS 1990

ETE 1990



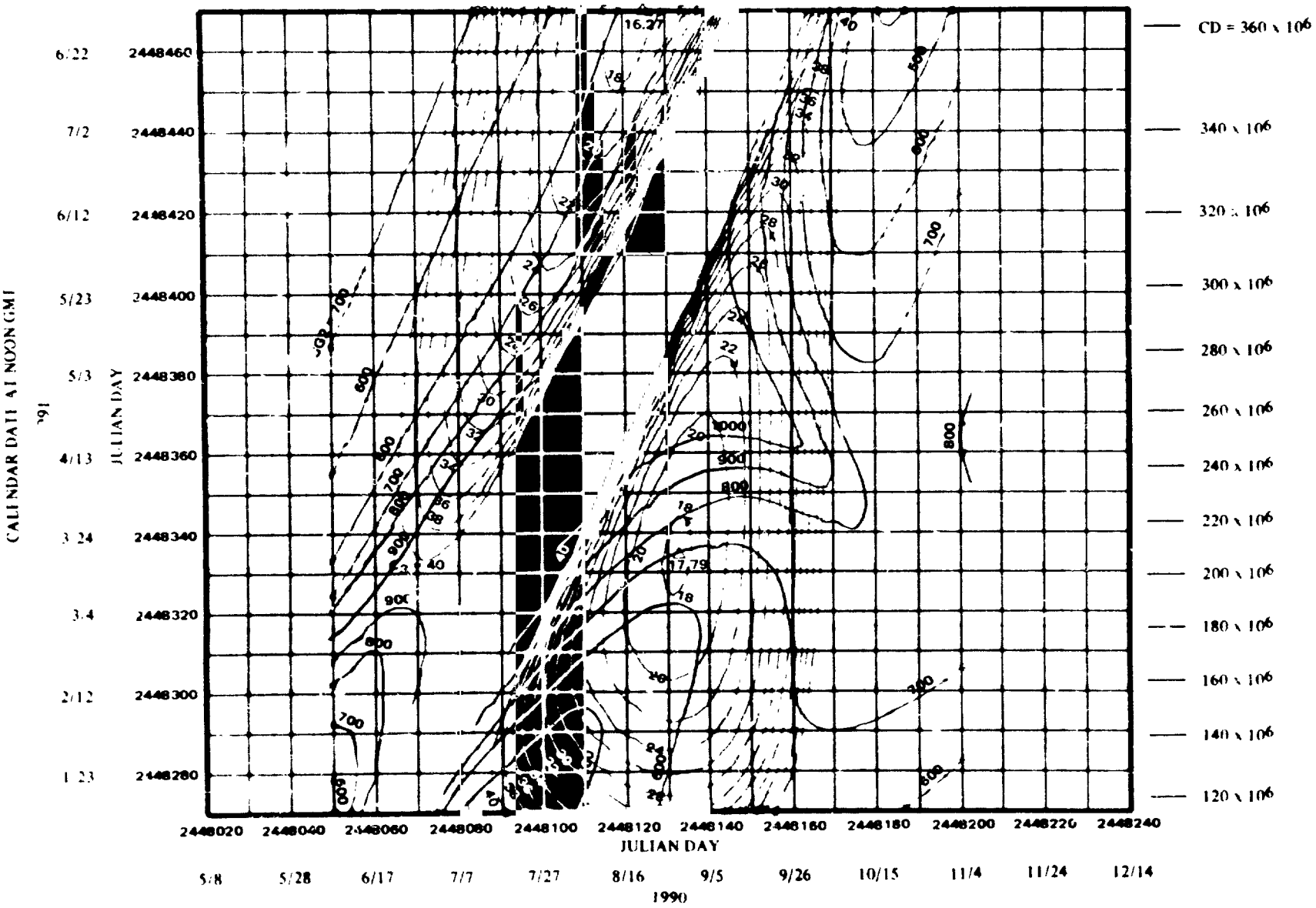
CONTOURS OF C_3 AND THA EARTH TO MARS 1990

THA 1990



CONTOURS OF C_3 AND SG1 EARTH TO MARS 1990

SG1 1990



CONTOURS OF C_3 AND SG2 EARTH TO MARS 1990

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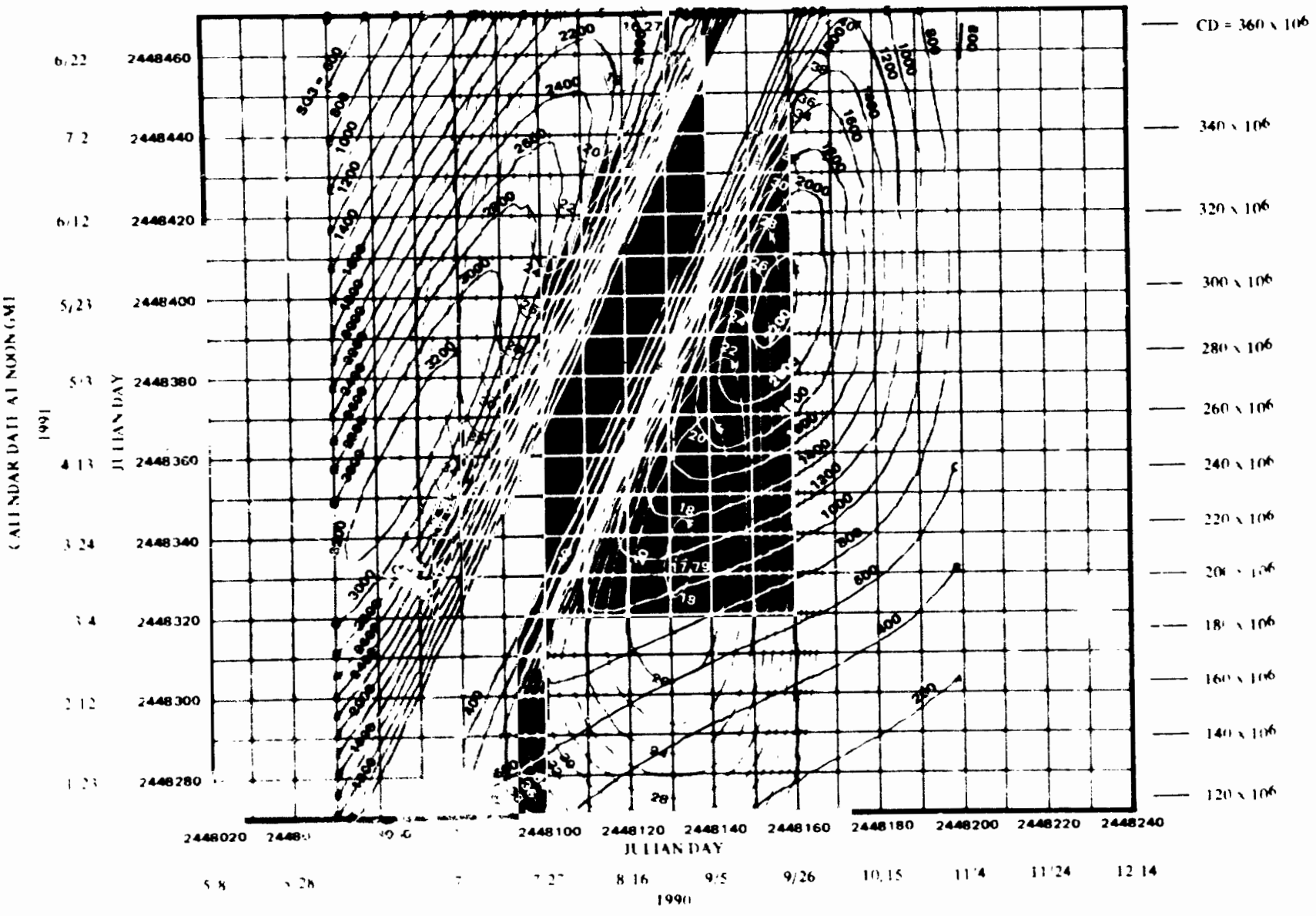
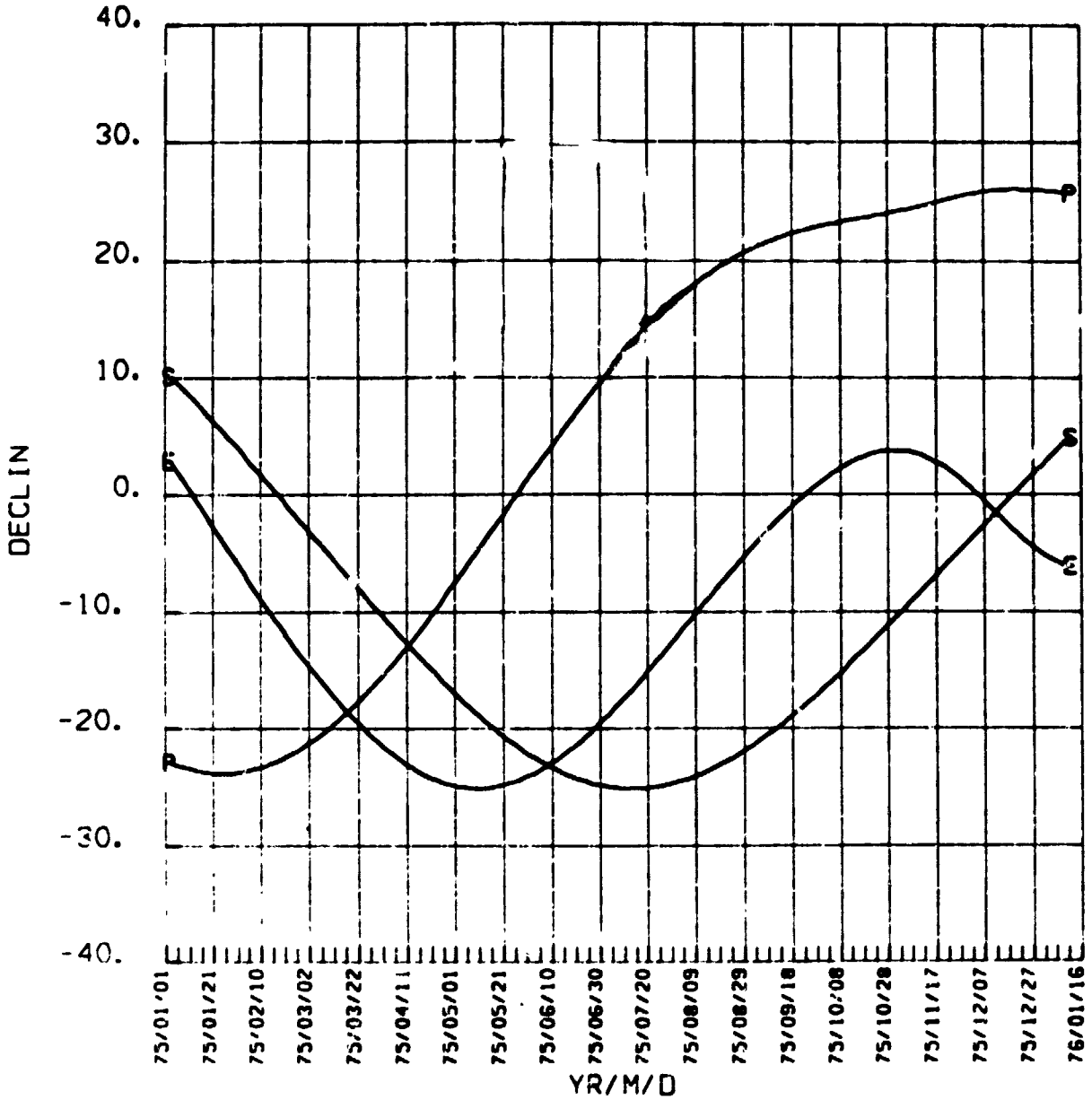


CONTOURS OF C_3 AND SG3 EARTH TO MARS 1990

3-84

1990 SG3

MARS 1975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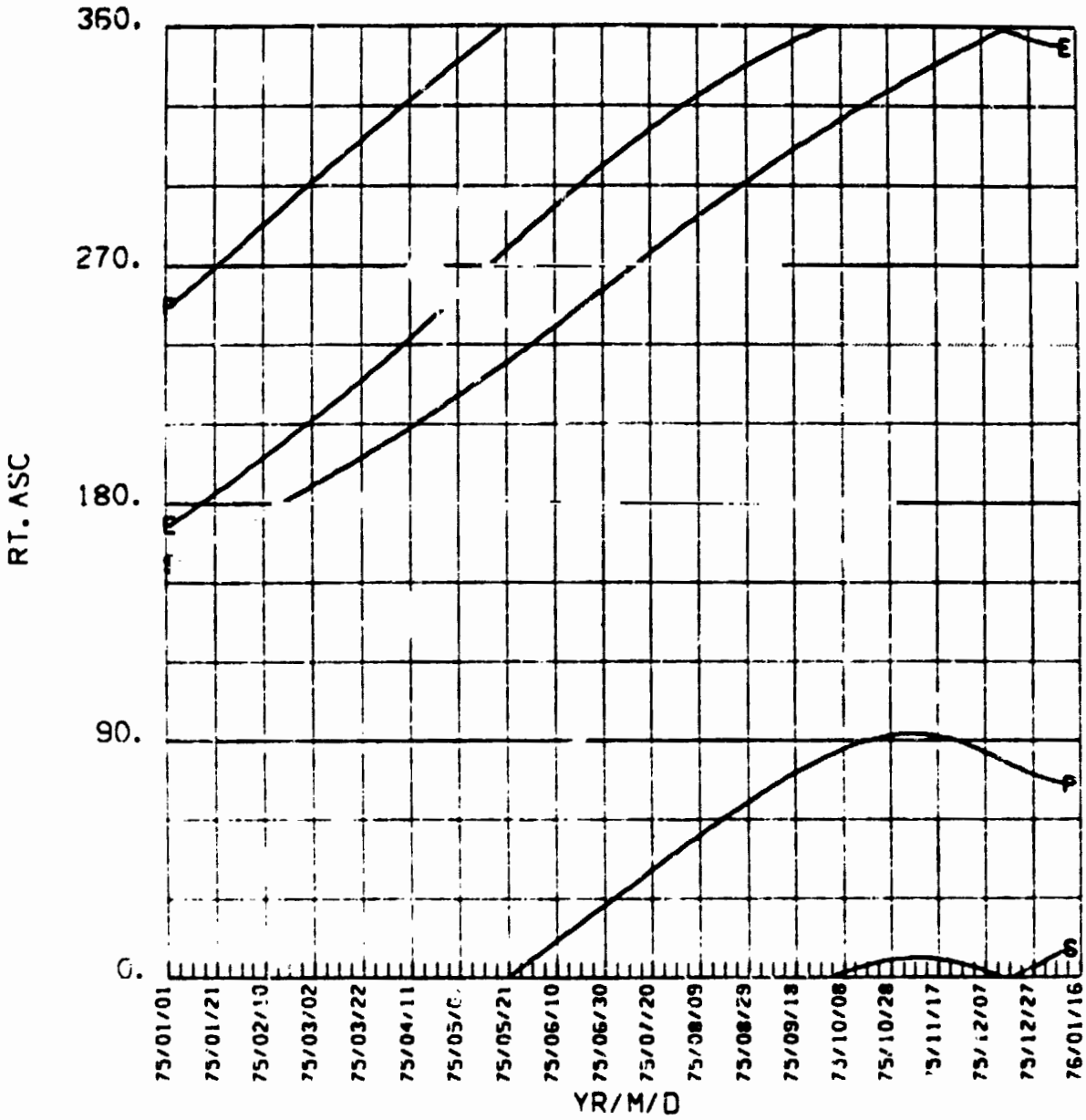
YR/M/D

MARS 1975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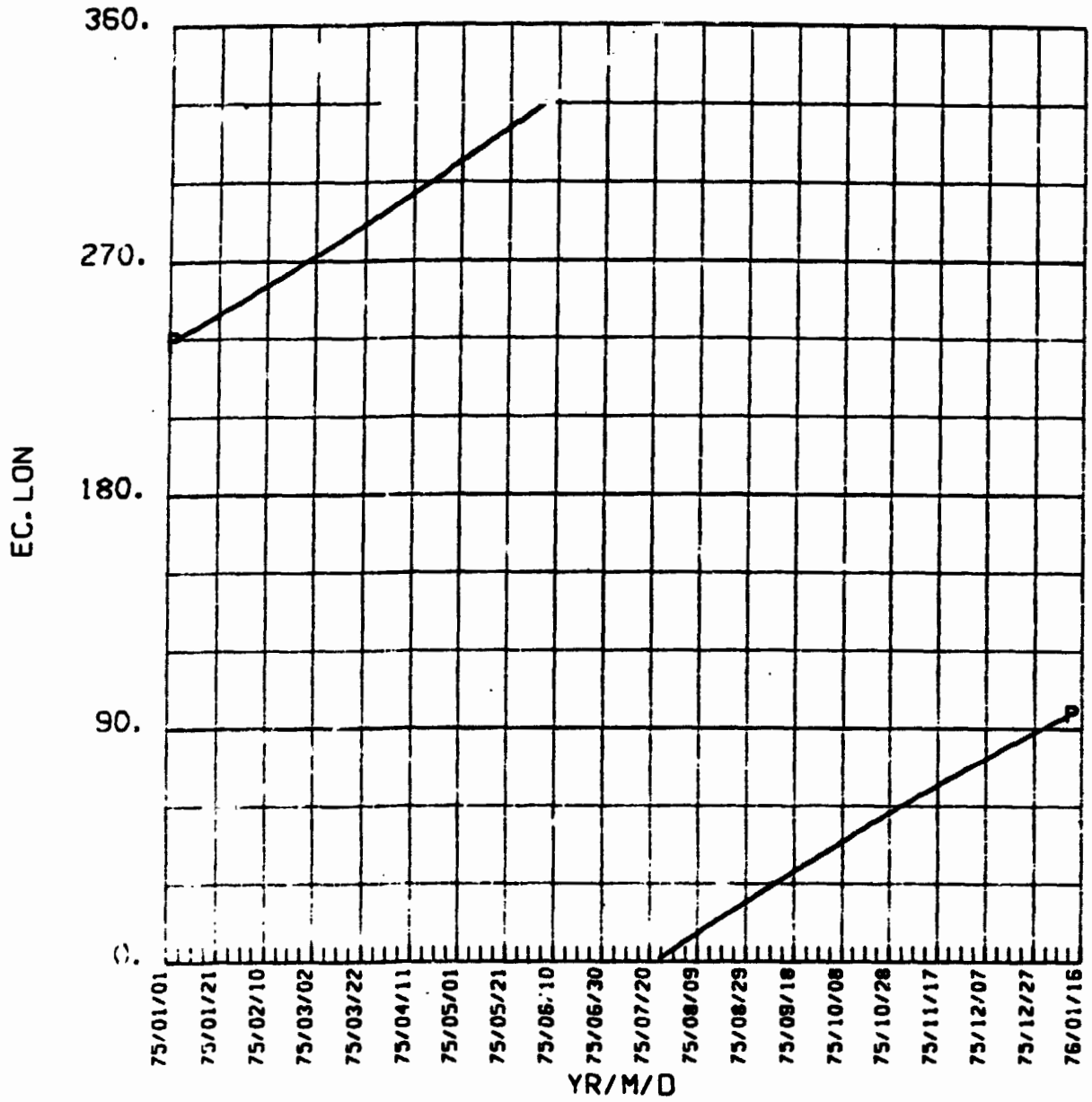
MARS 1975



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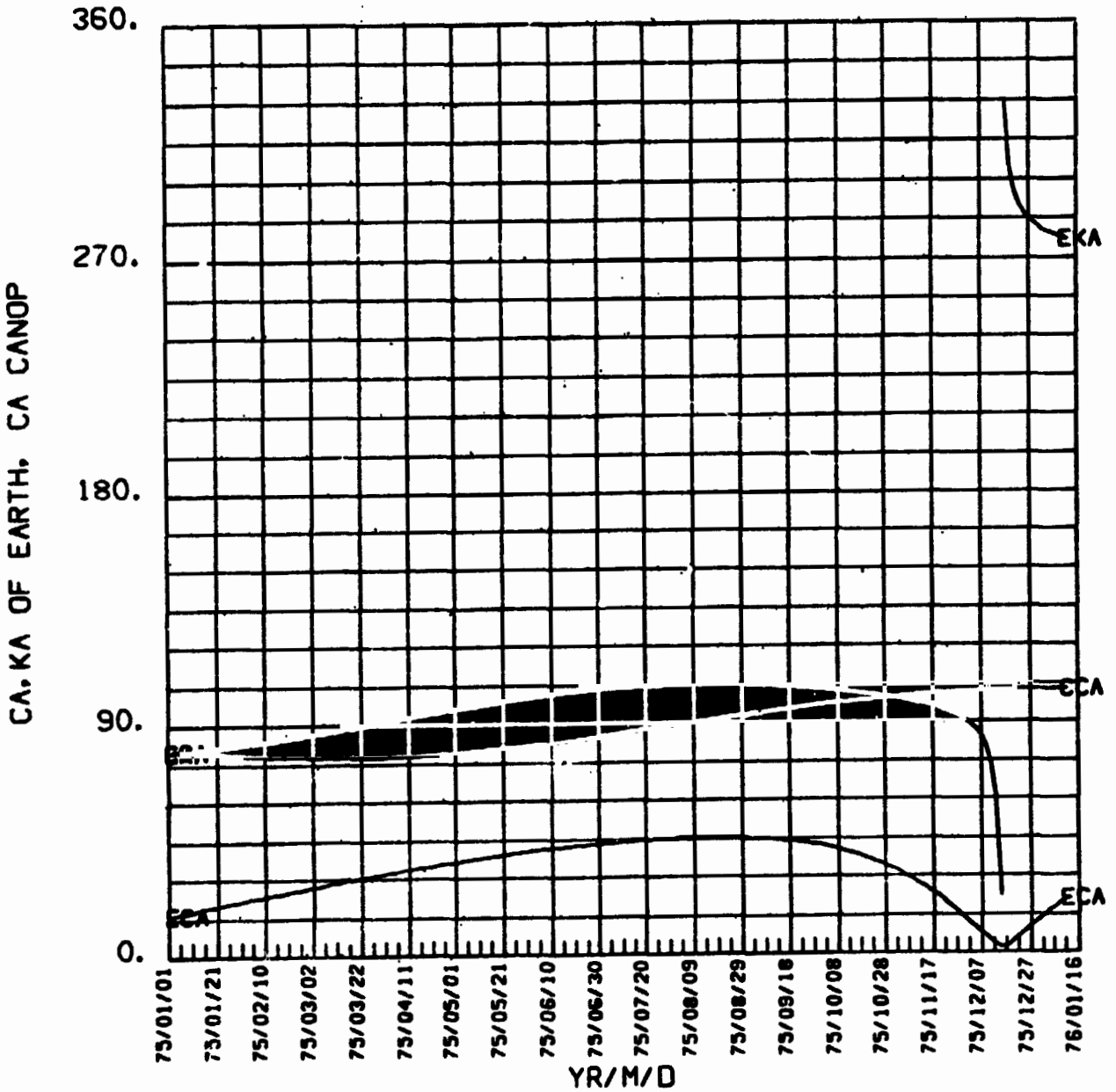
C-2

MARS 1975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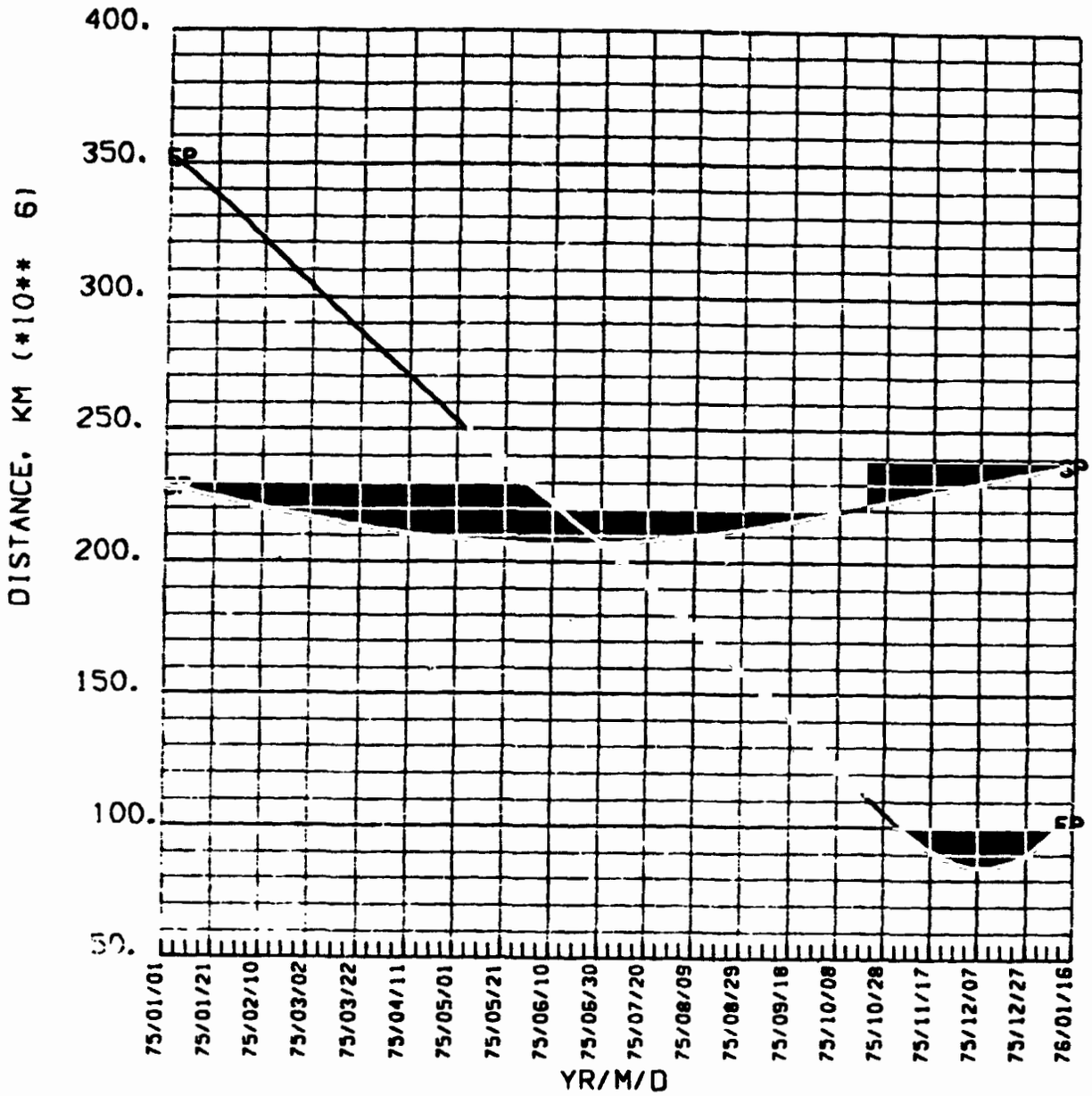
MARS 1975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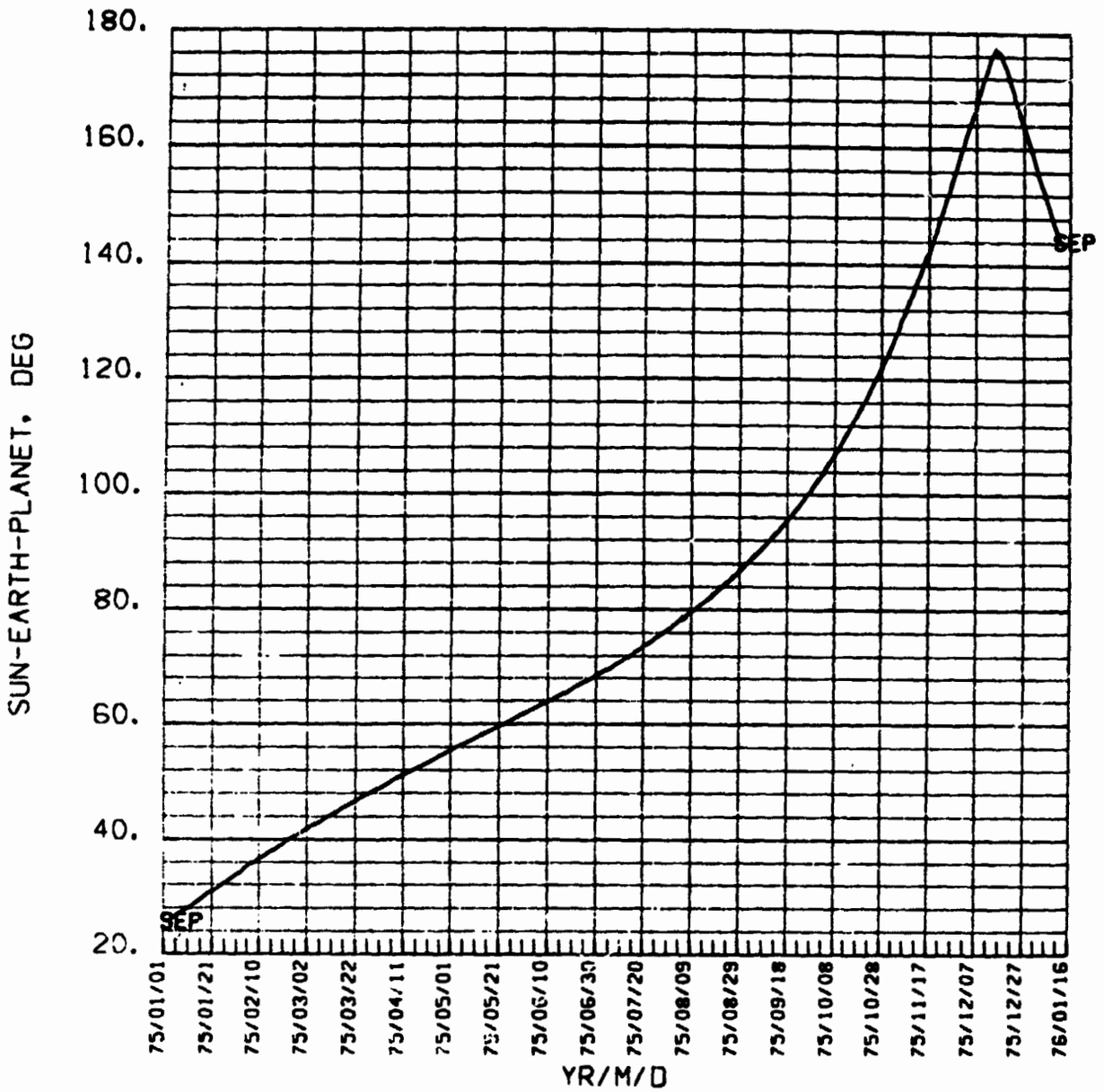
MARS 1975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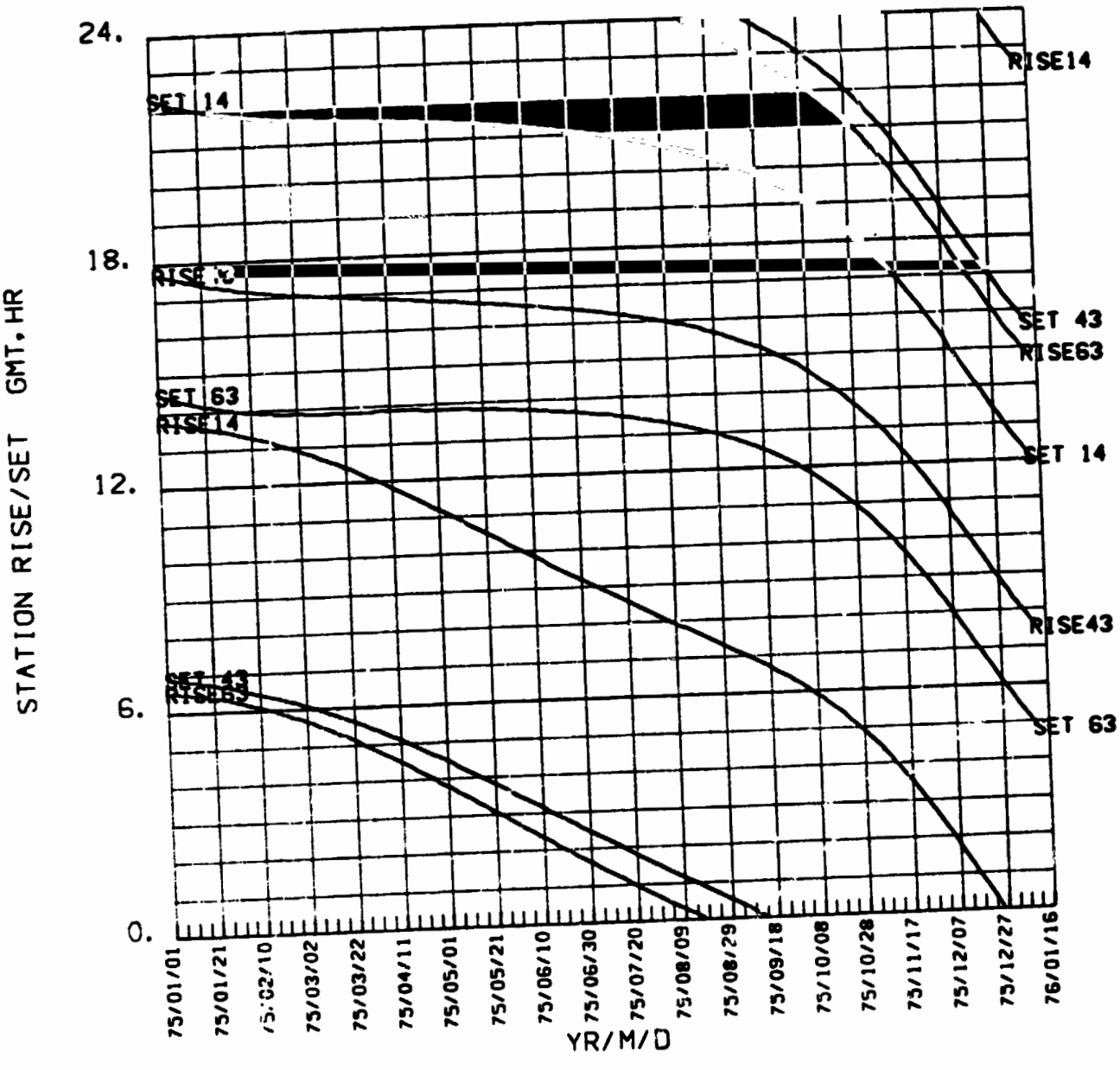
MARS 1975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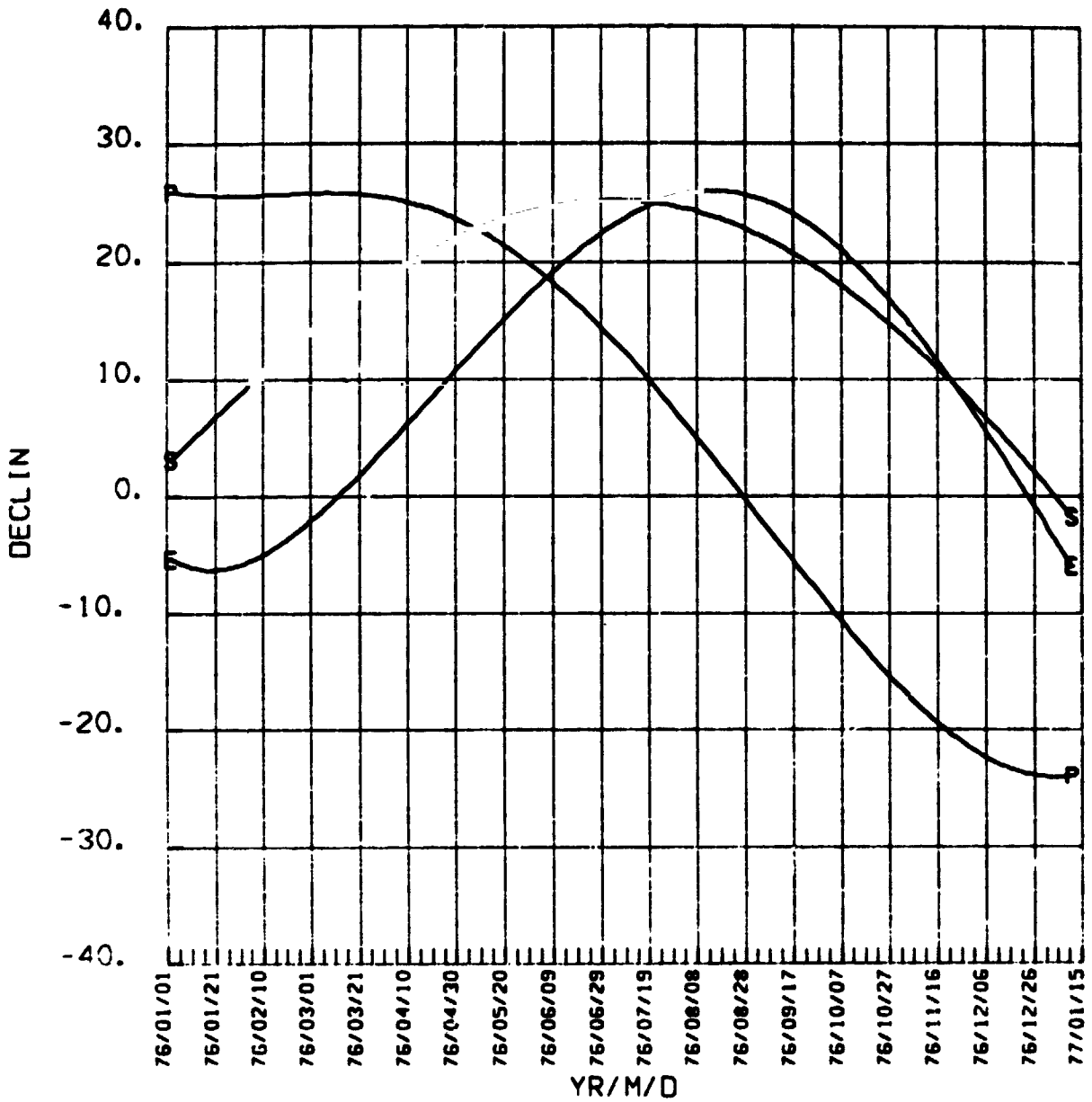
MARS 1976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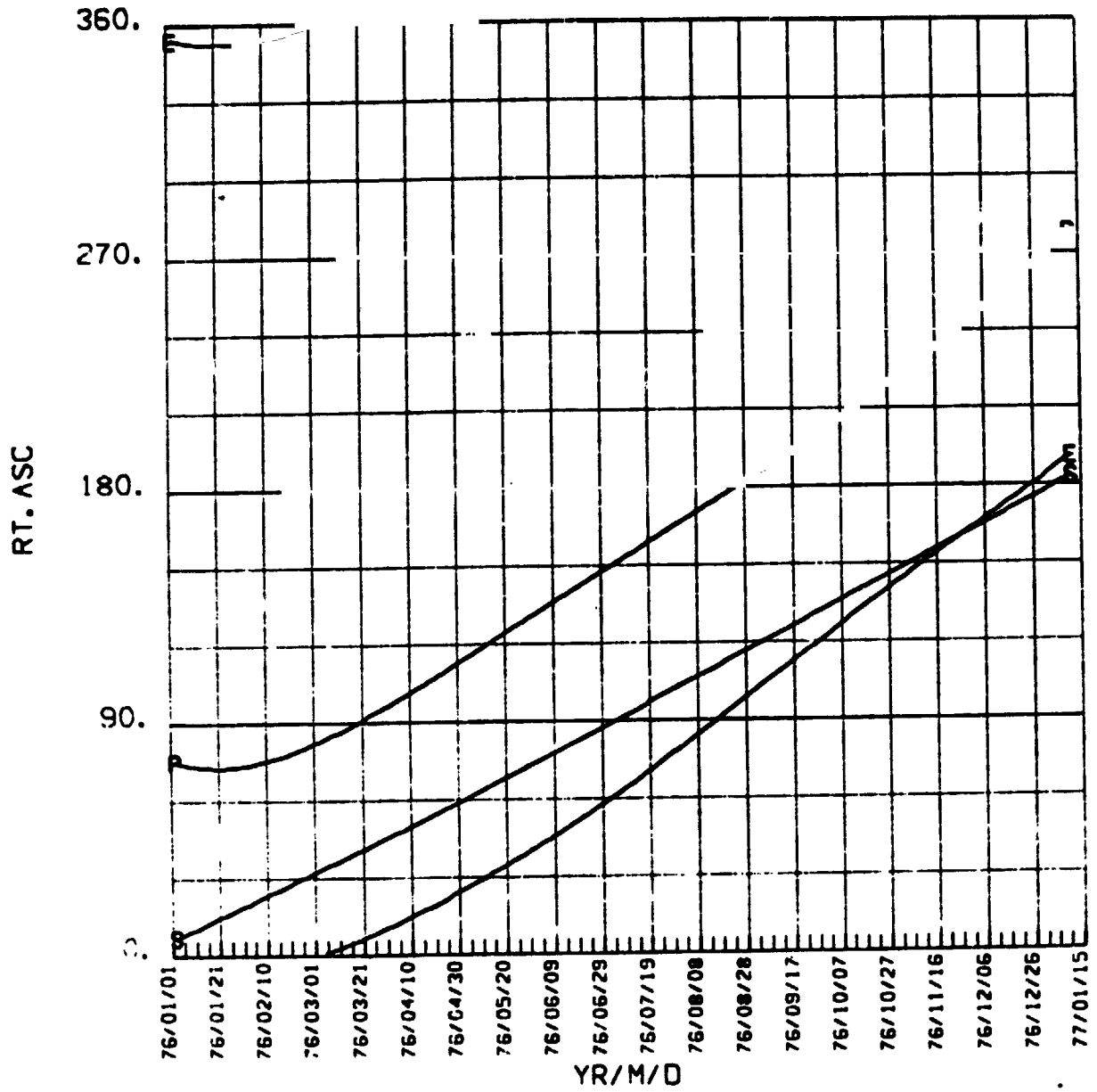
MARS 1976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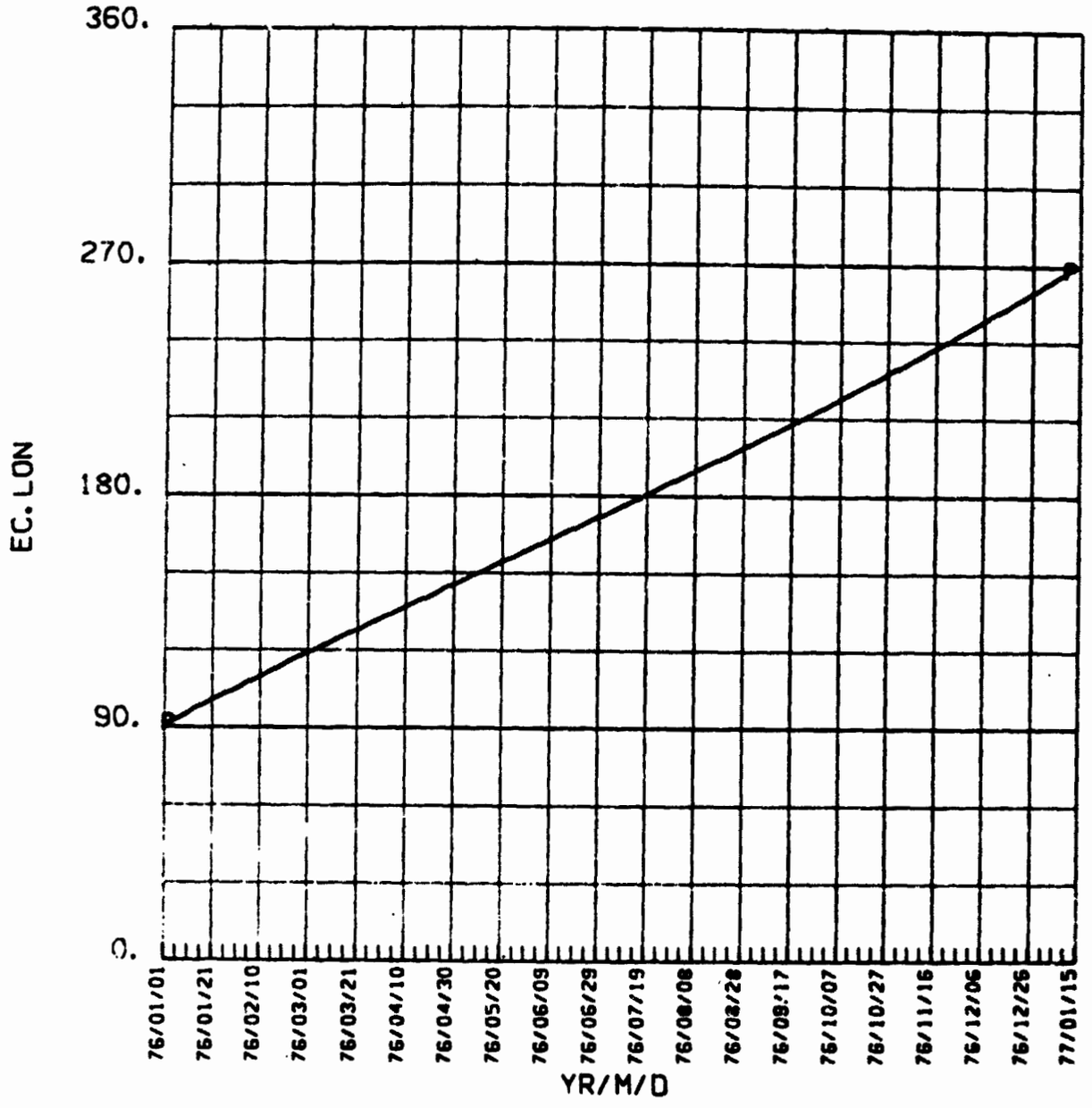
MARS 1976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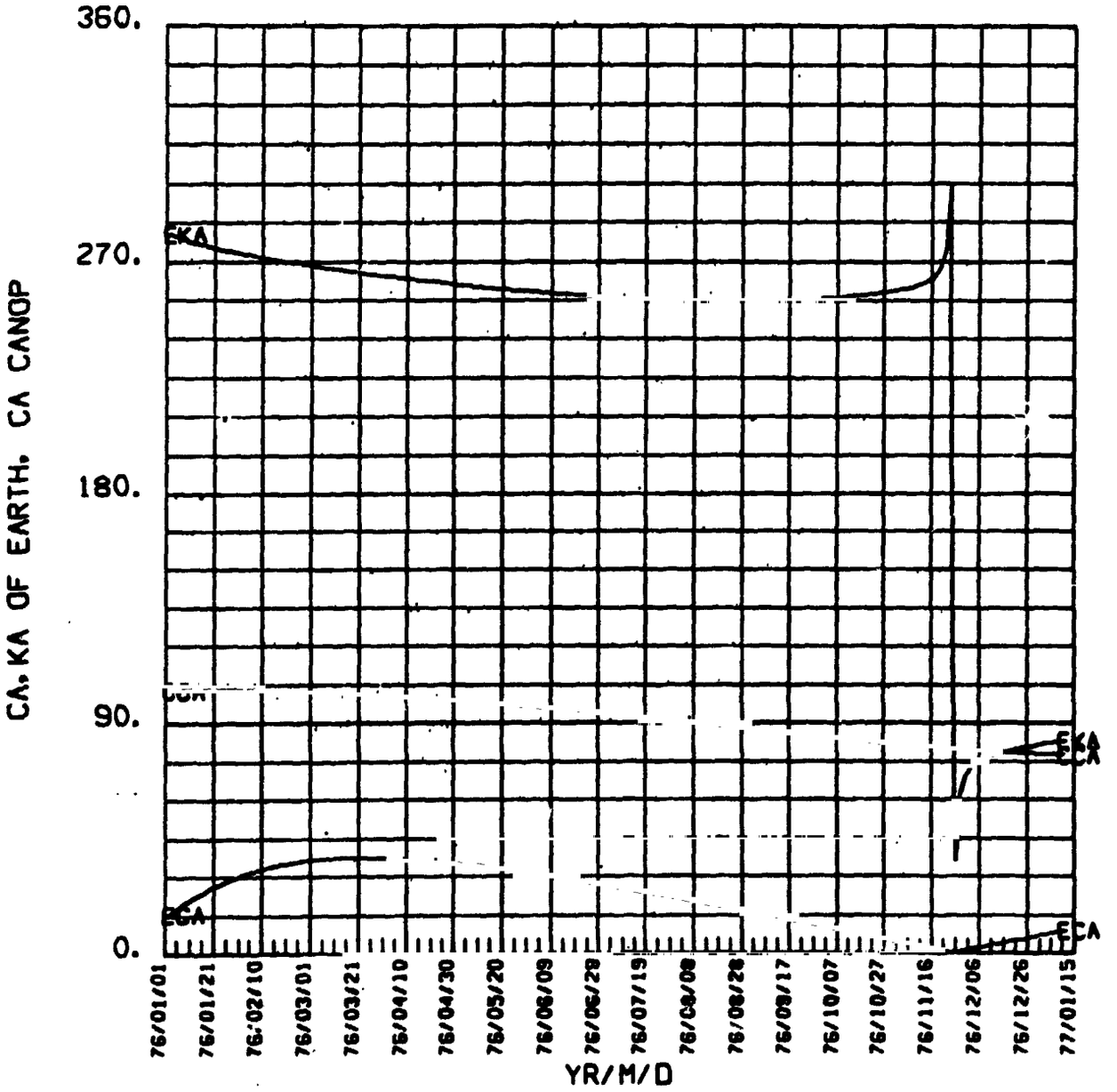
MARS 1976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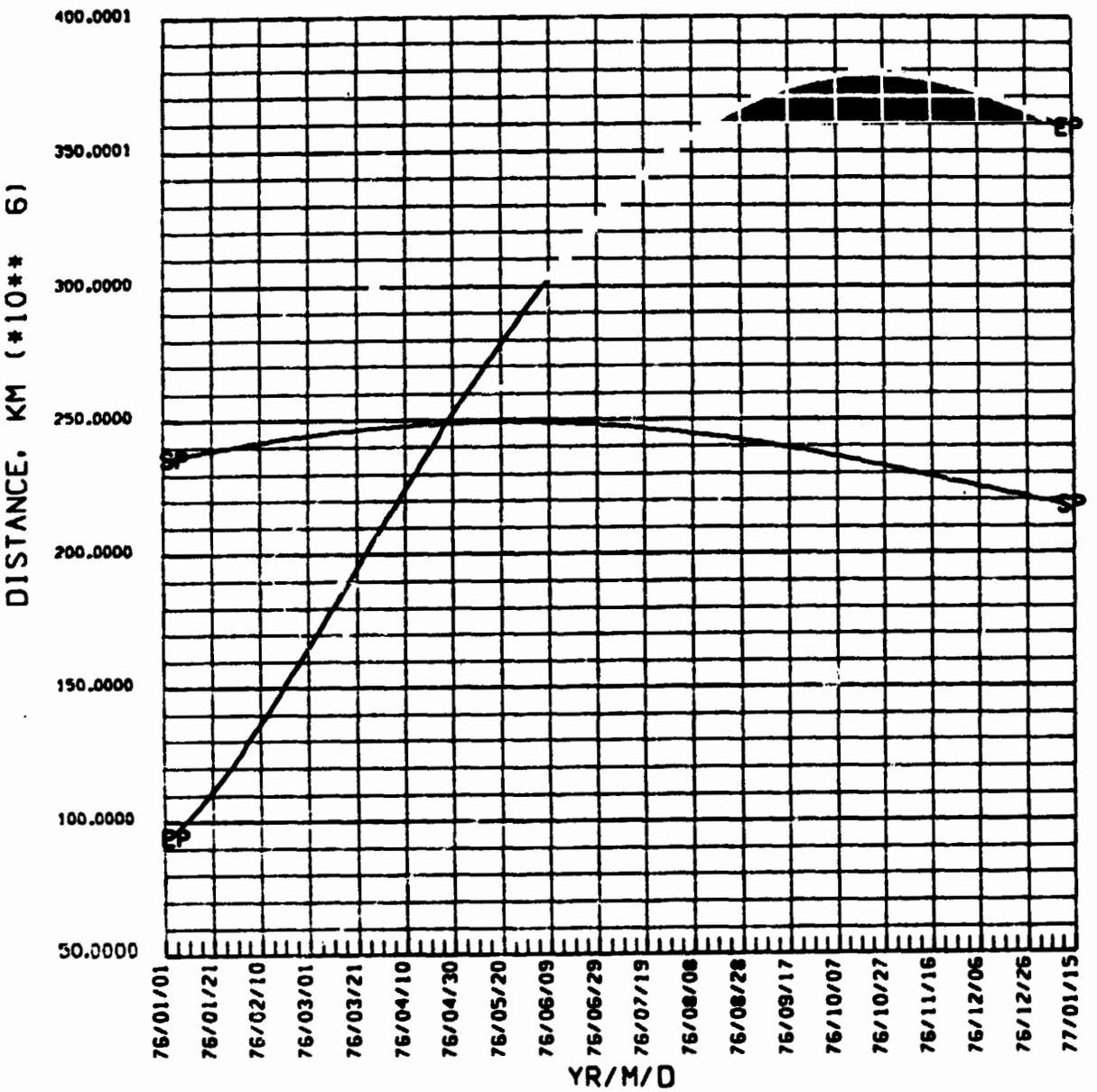
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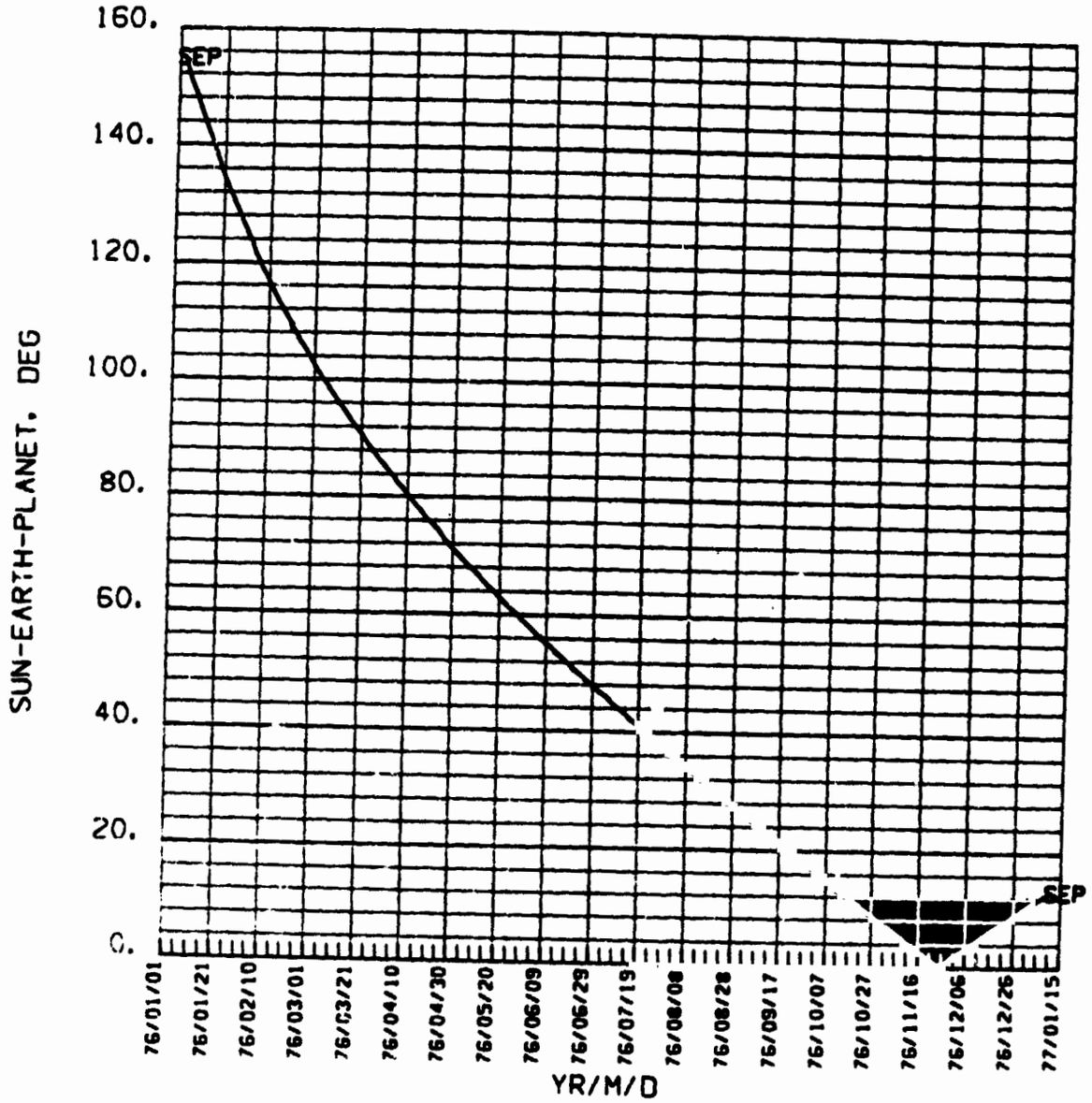
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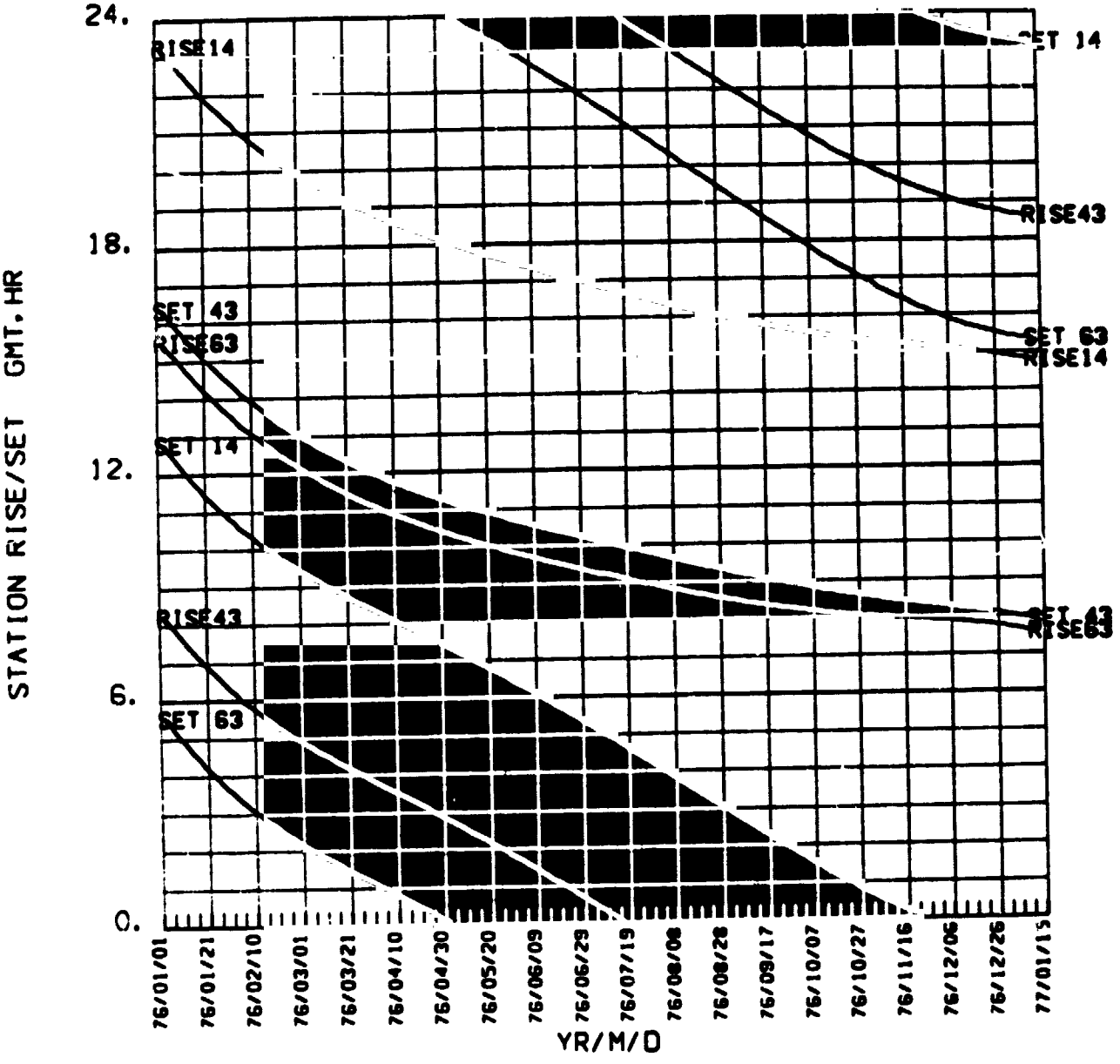
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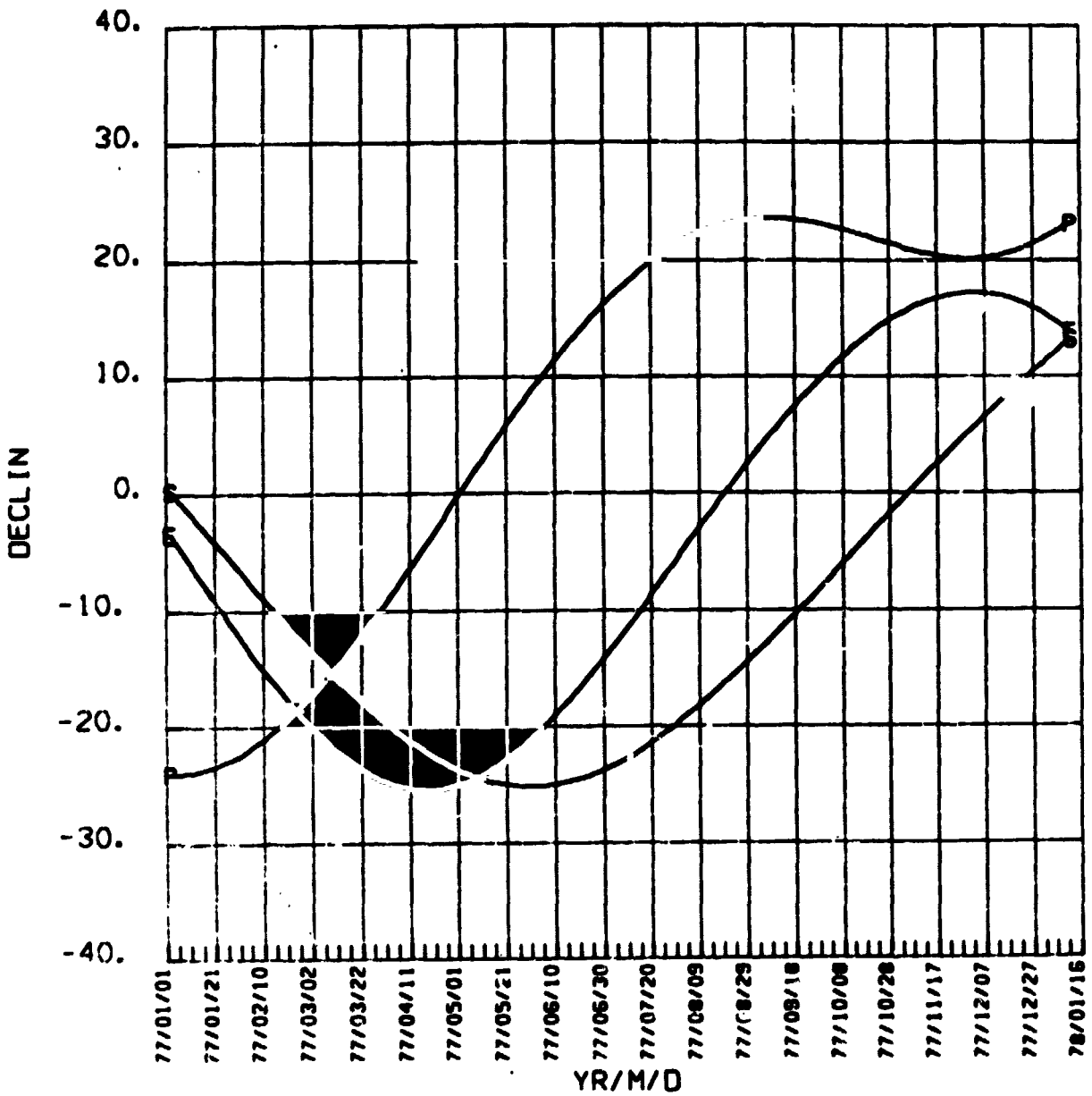
MARS 1977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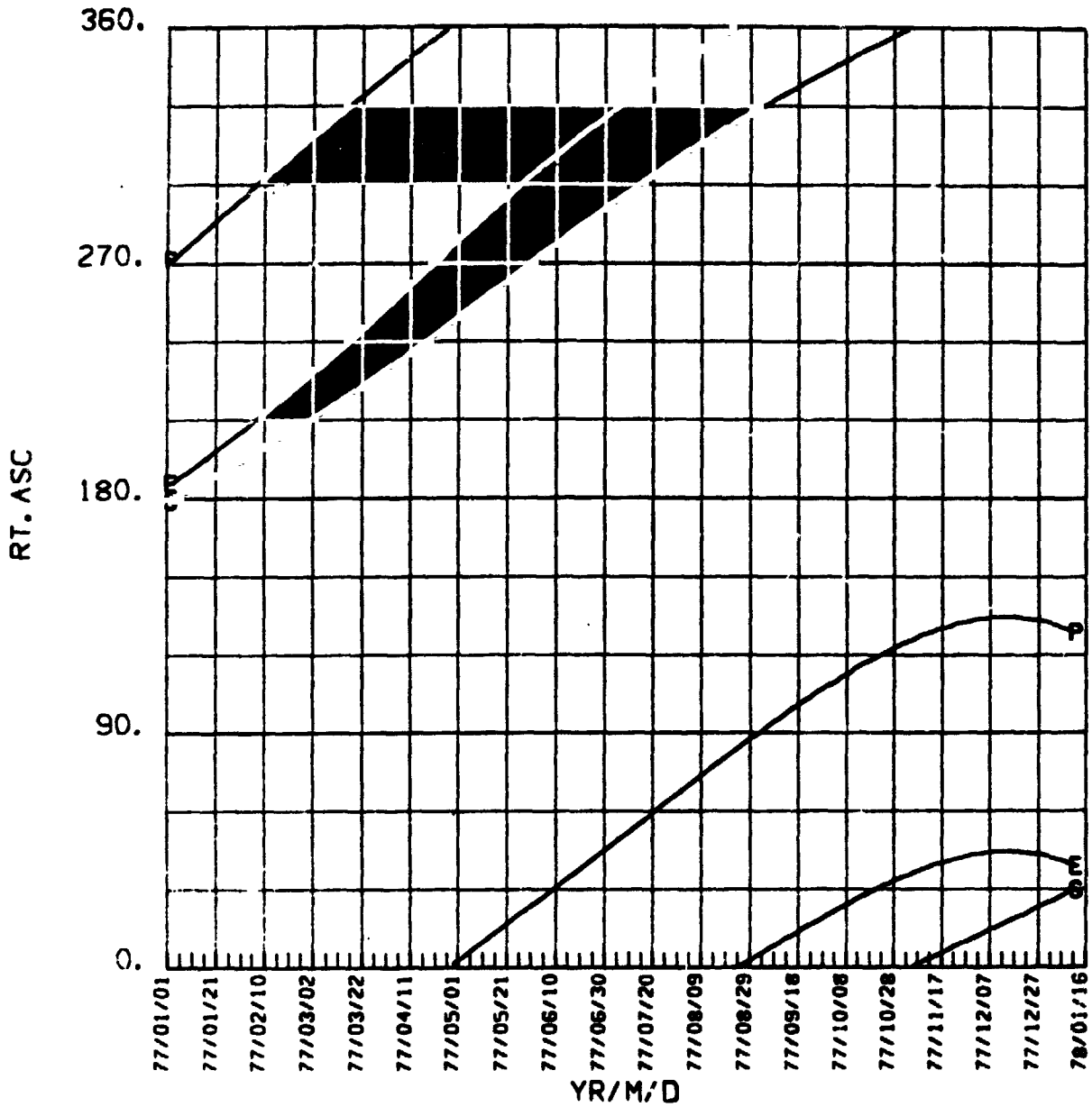
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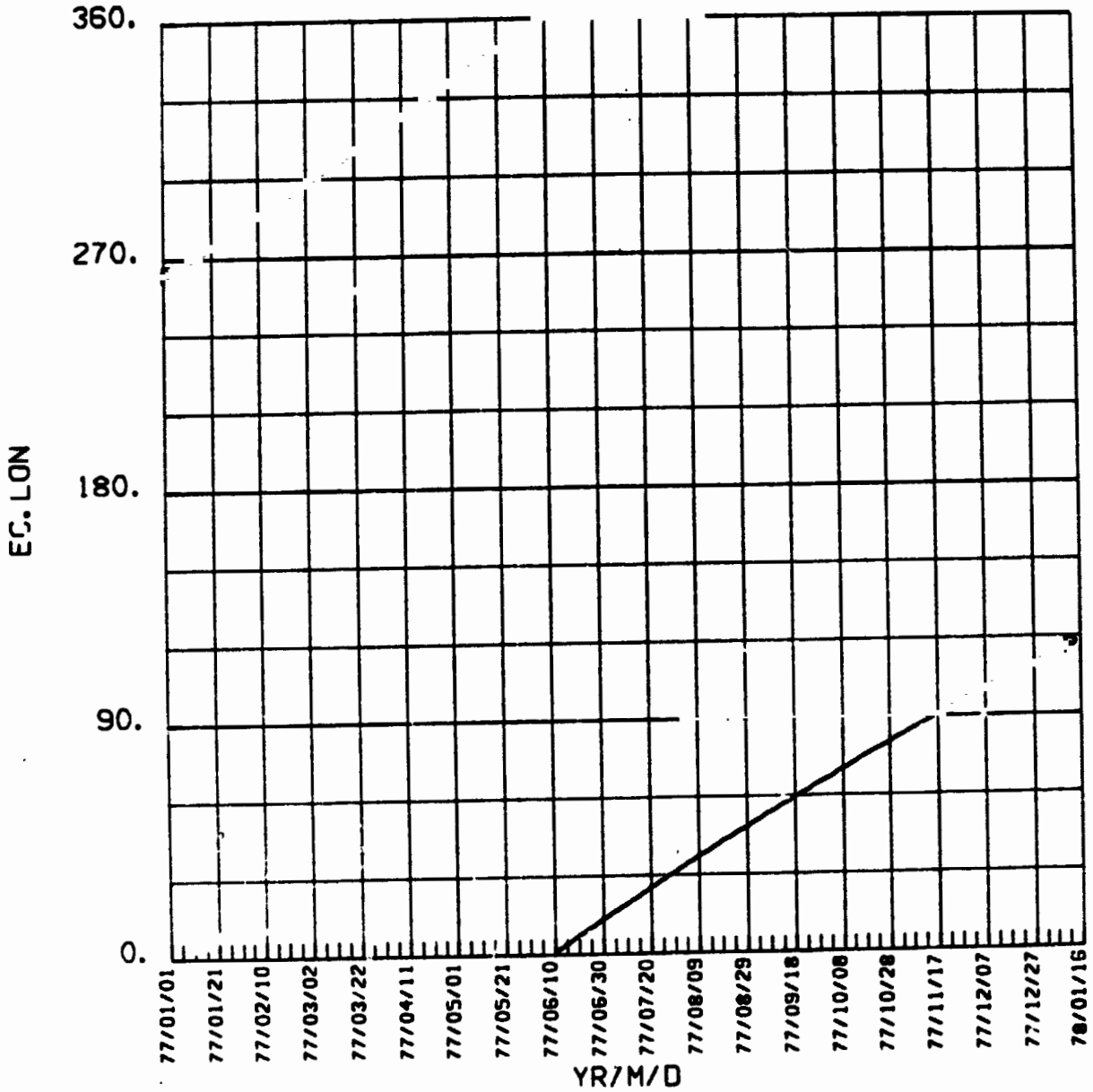
MARS 1977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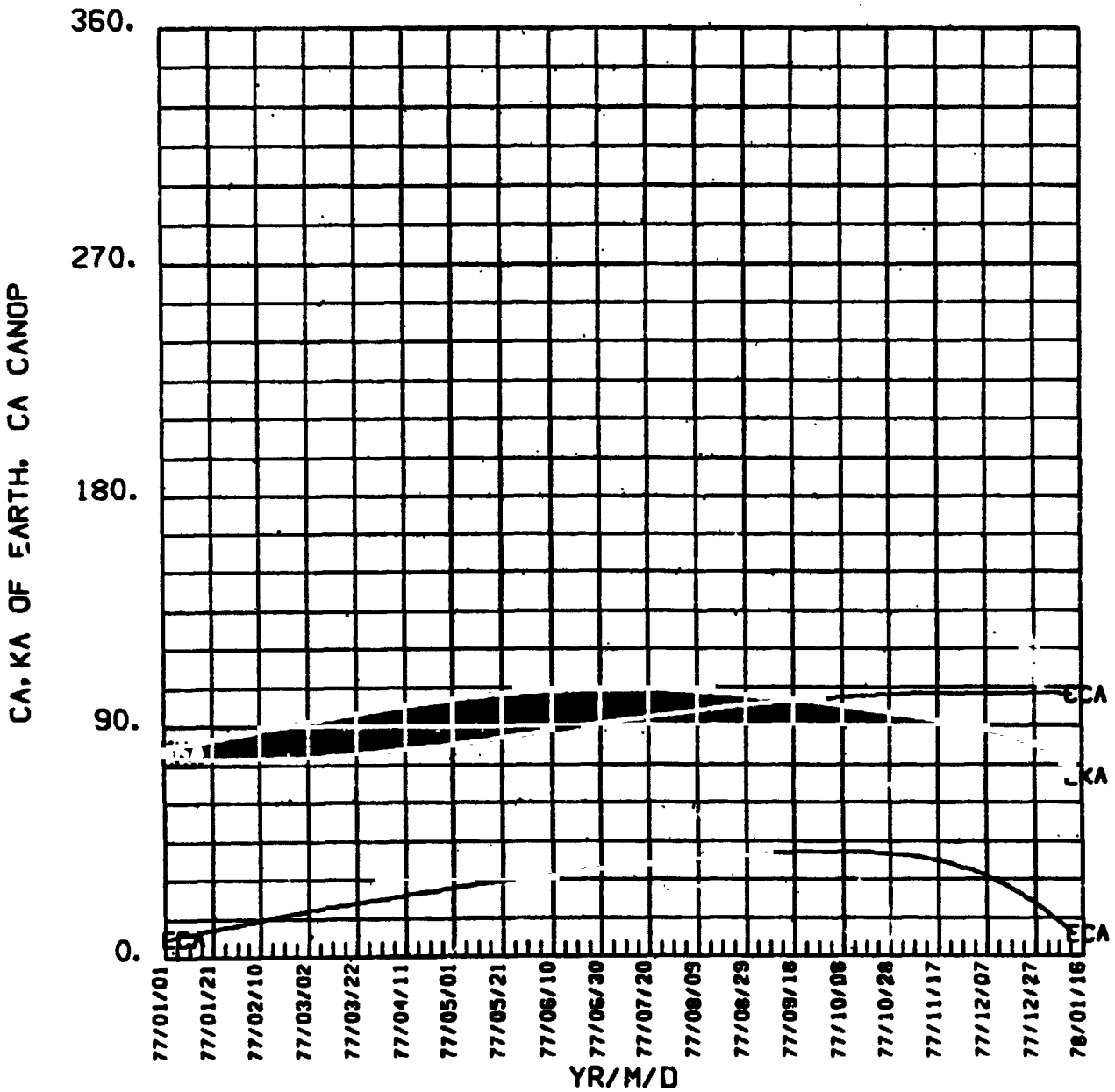
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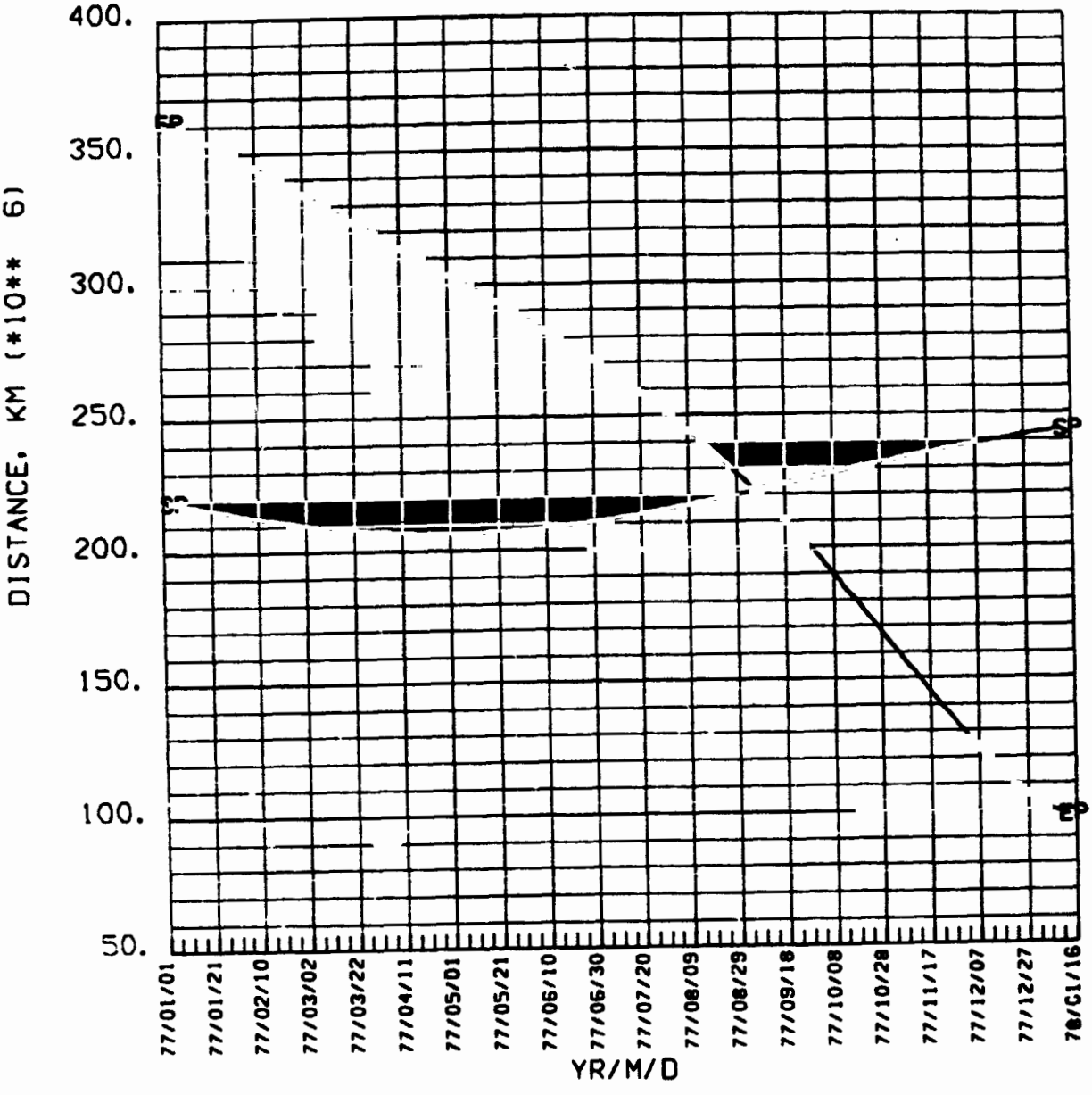
MARS 1977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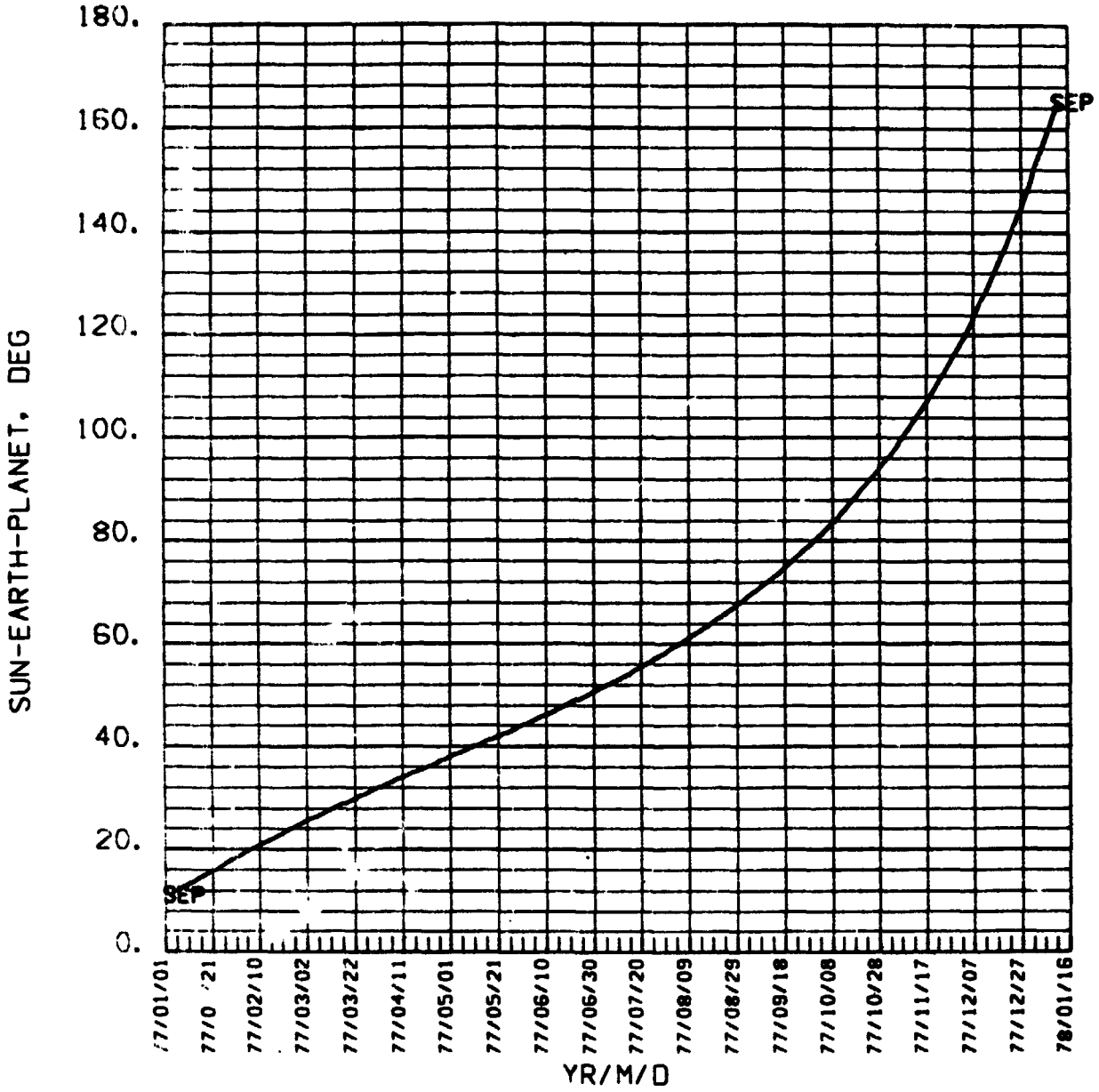
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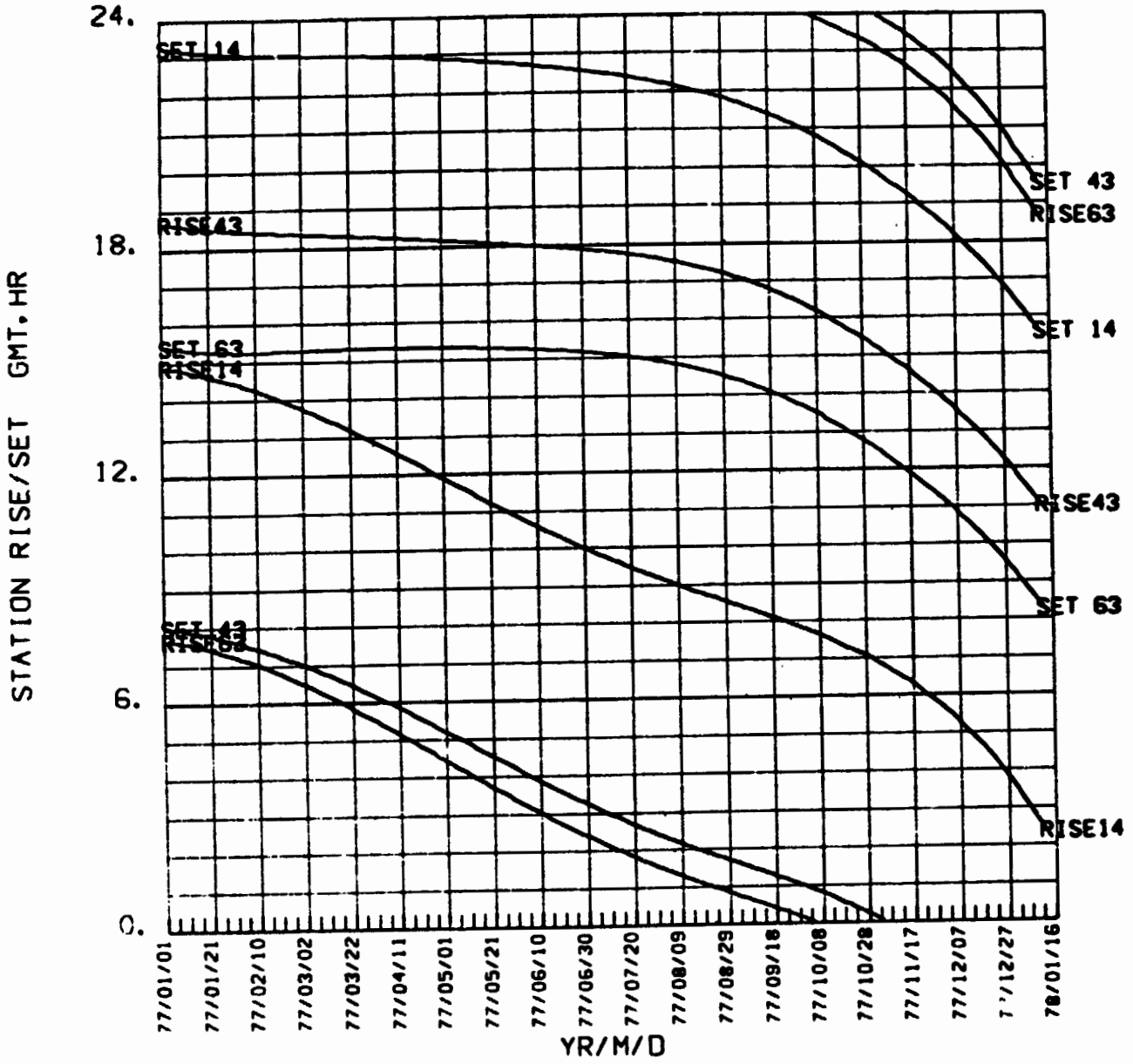
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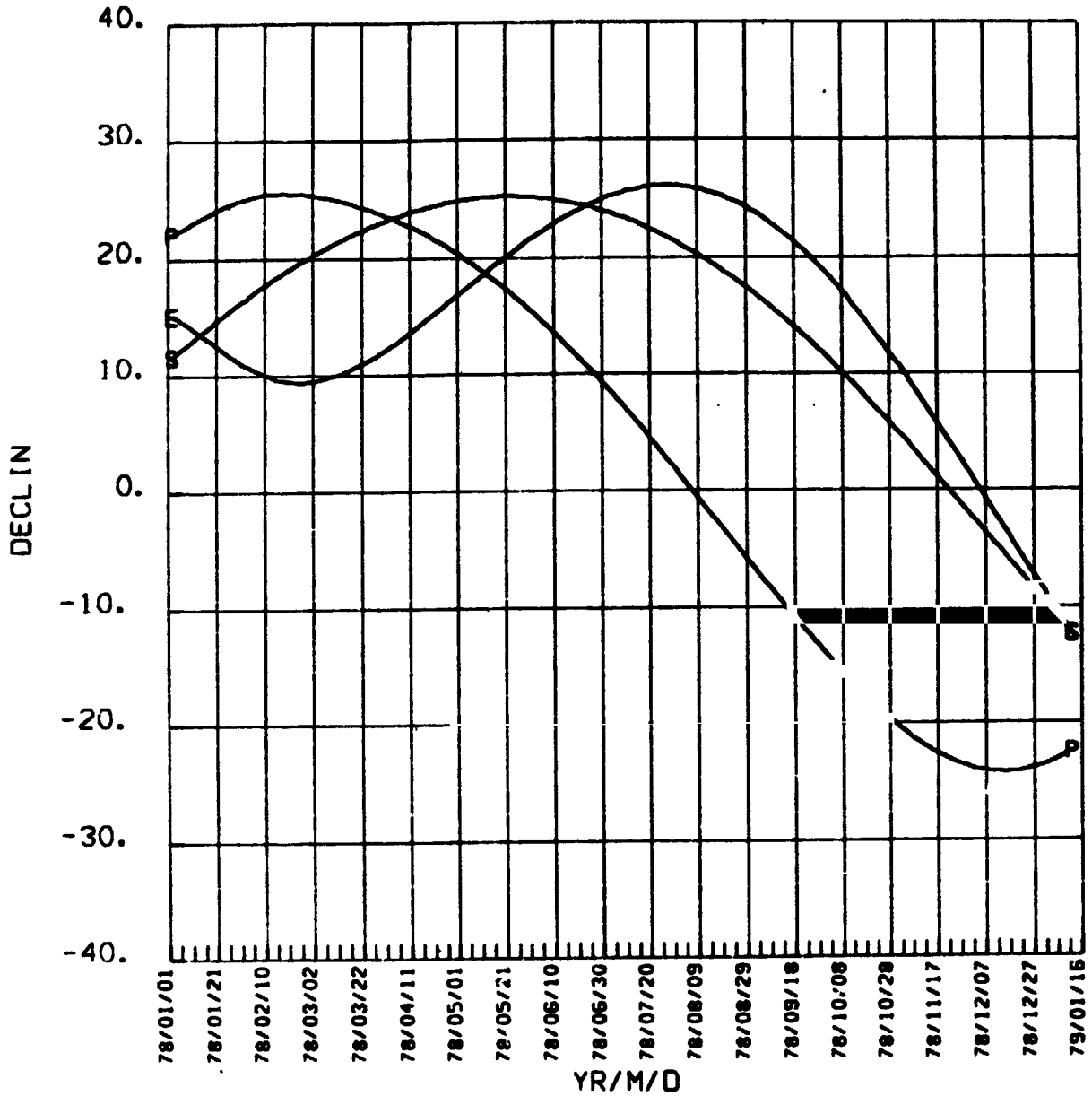
MARS 1978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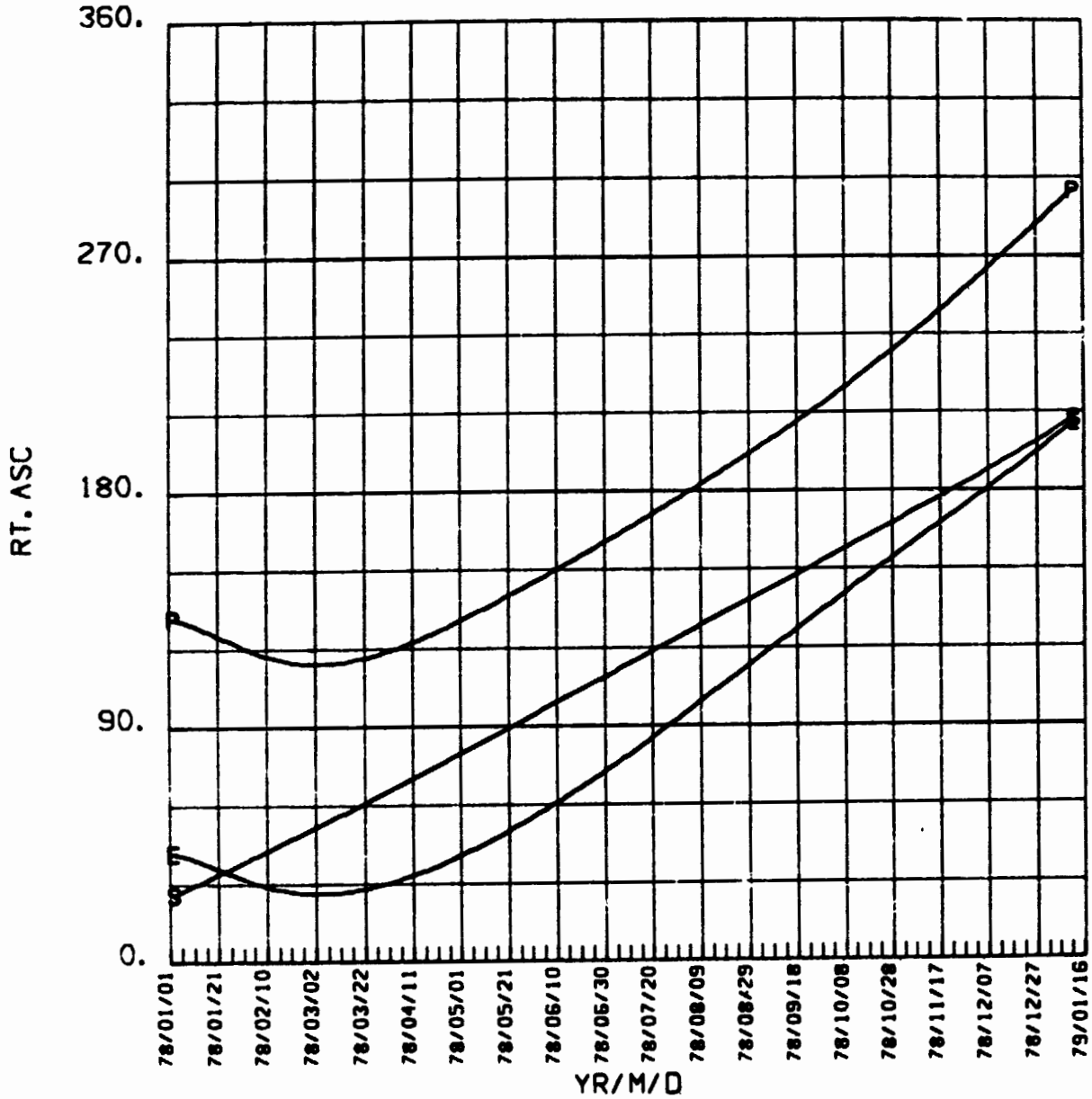
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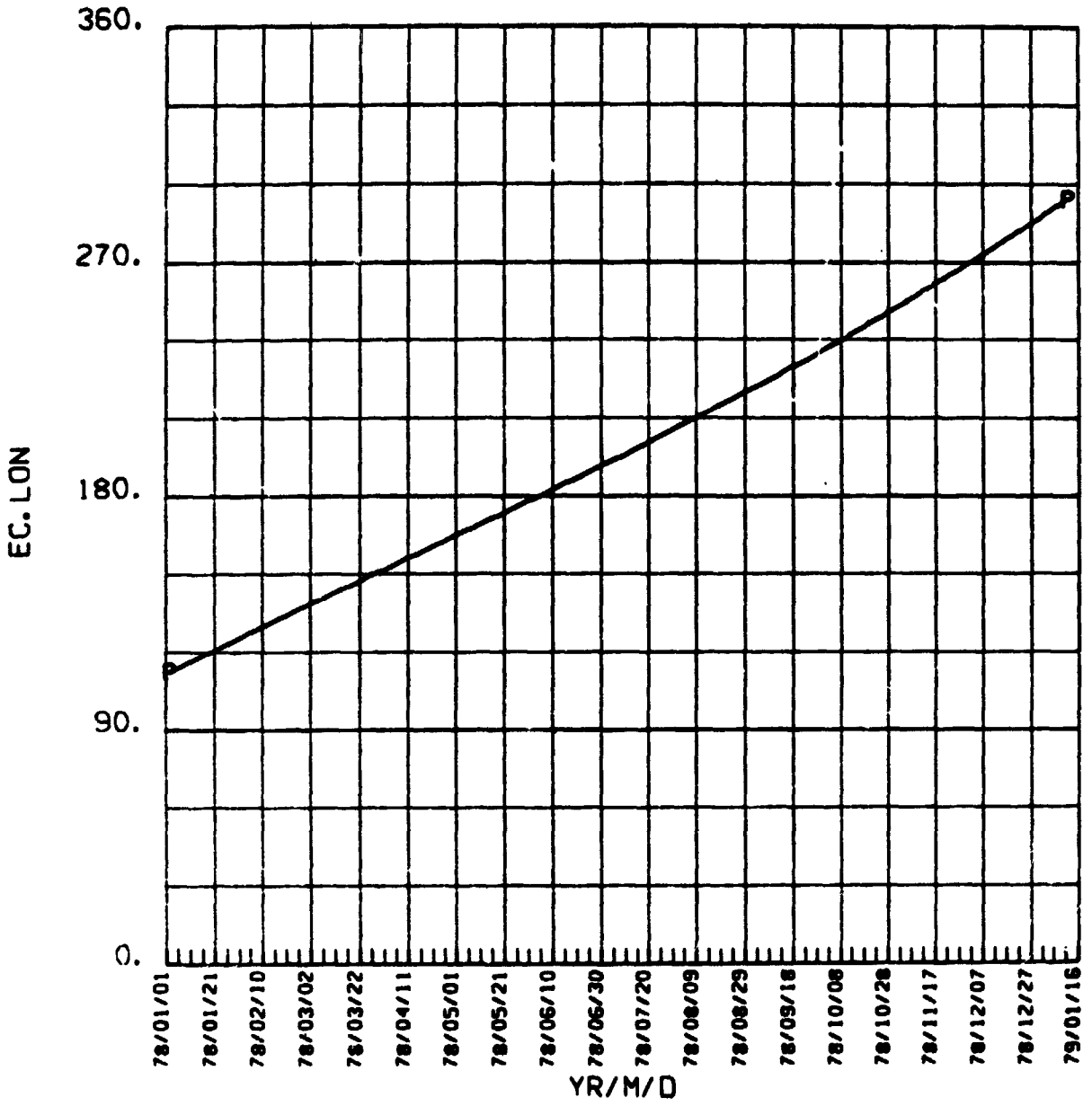
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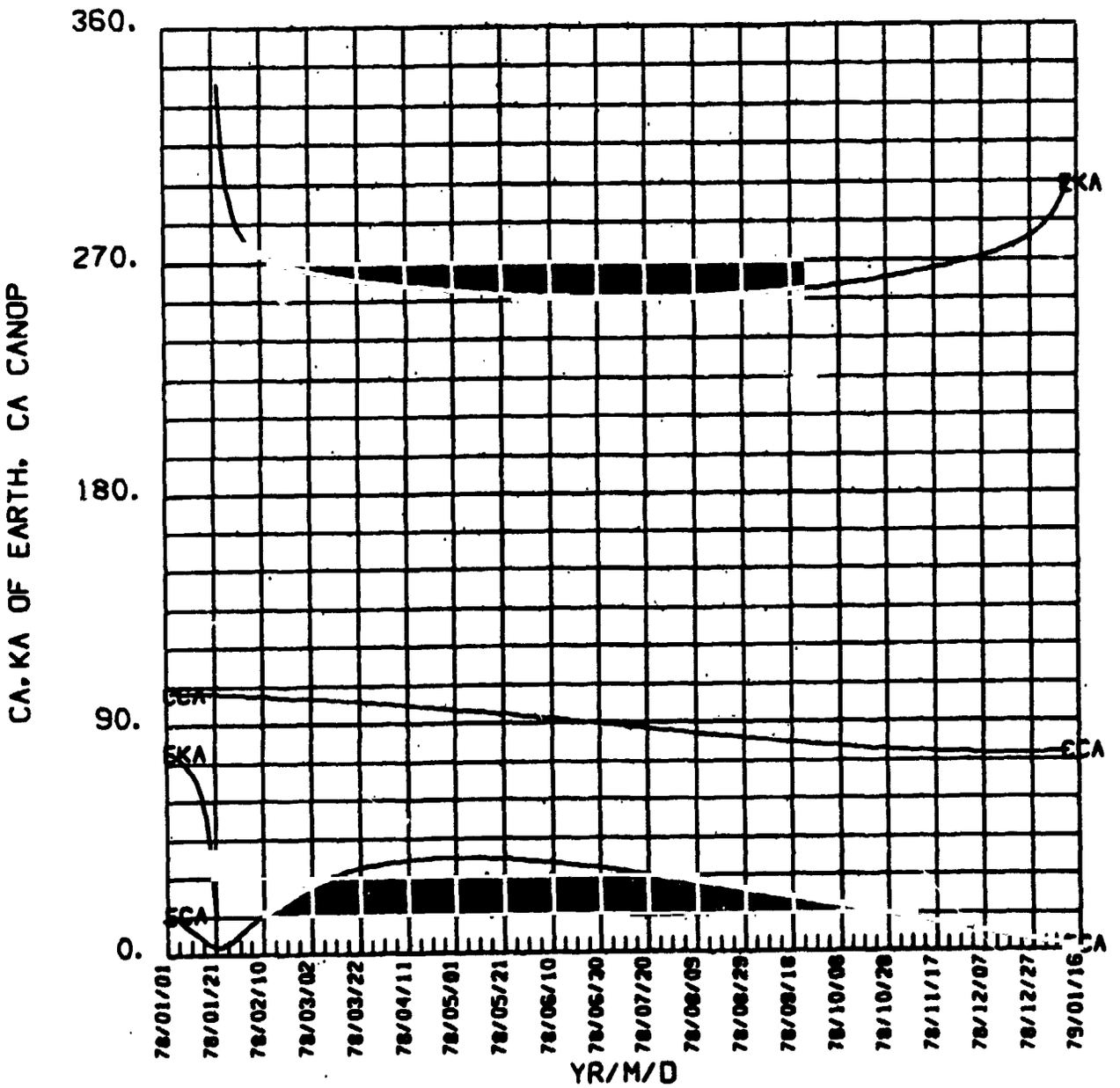
YR/M/D

MARS 1978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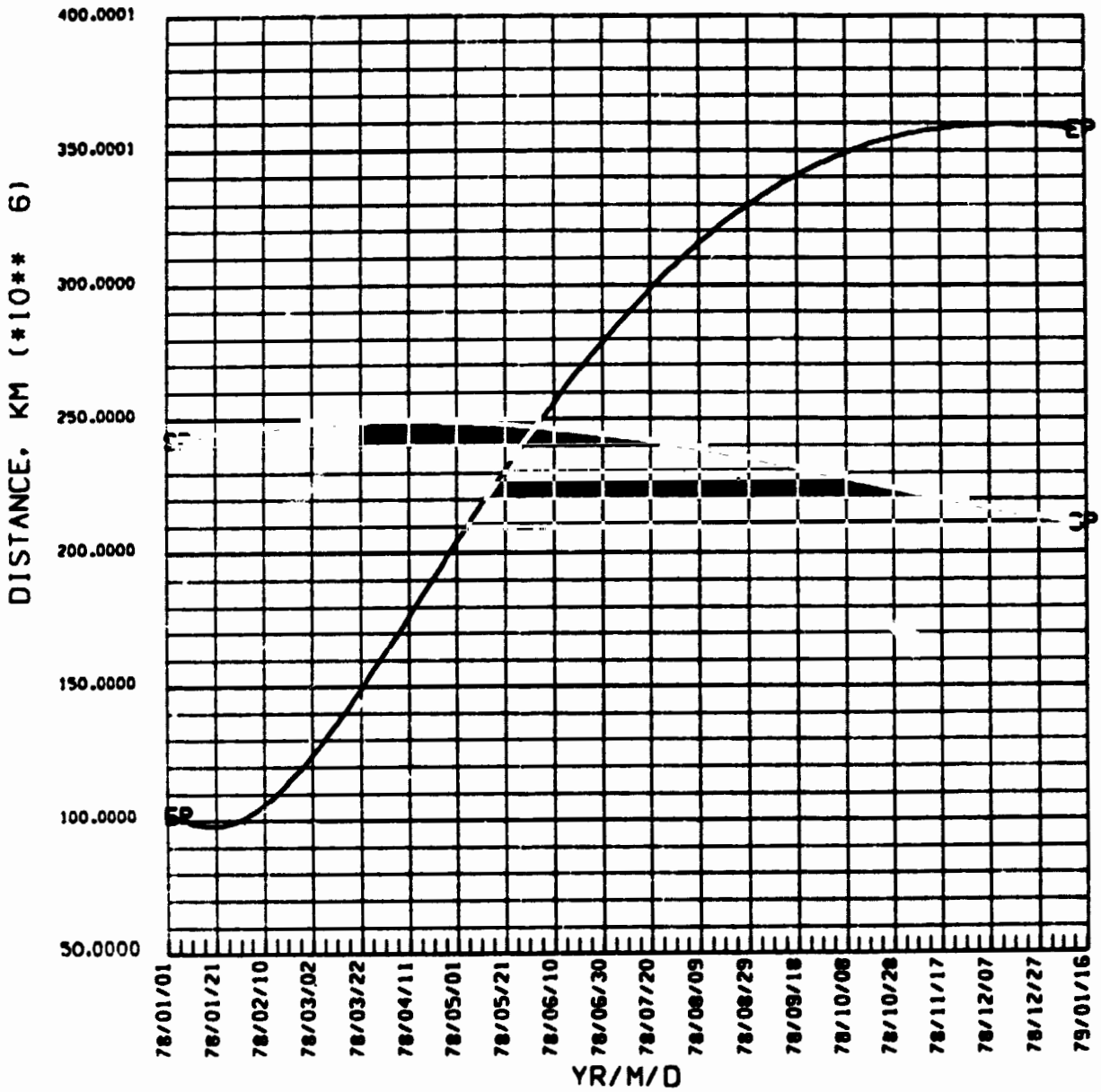
MARS 1978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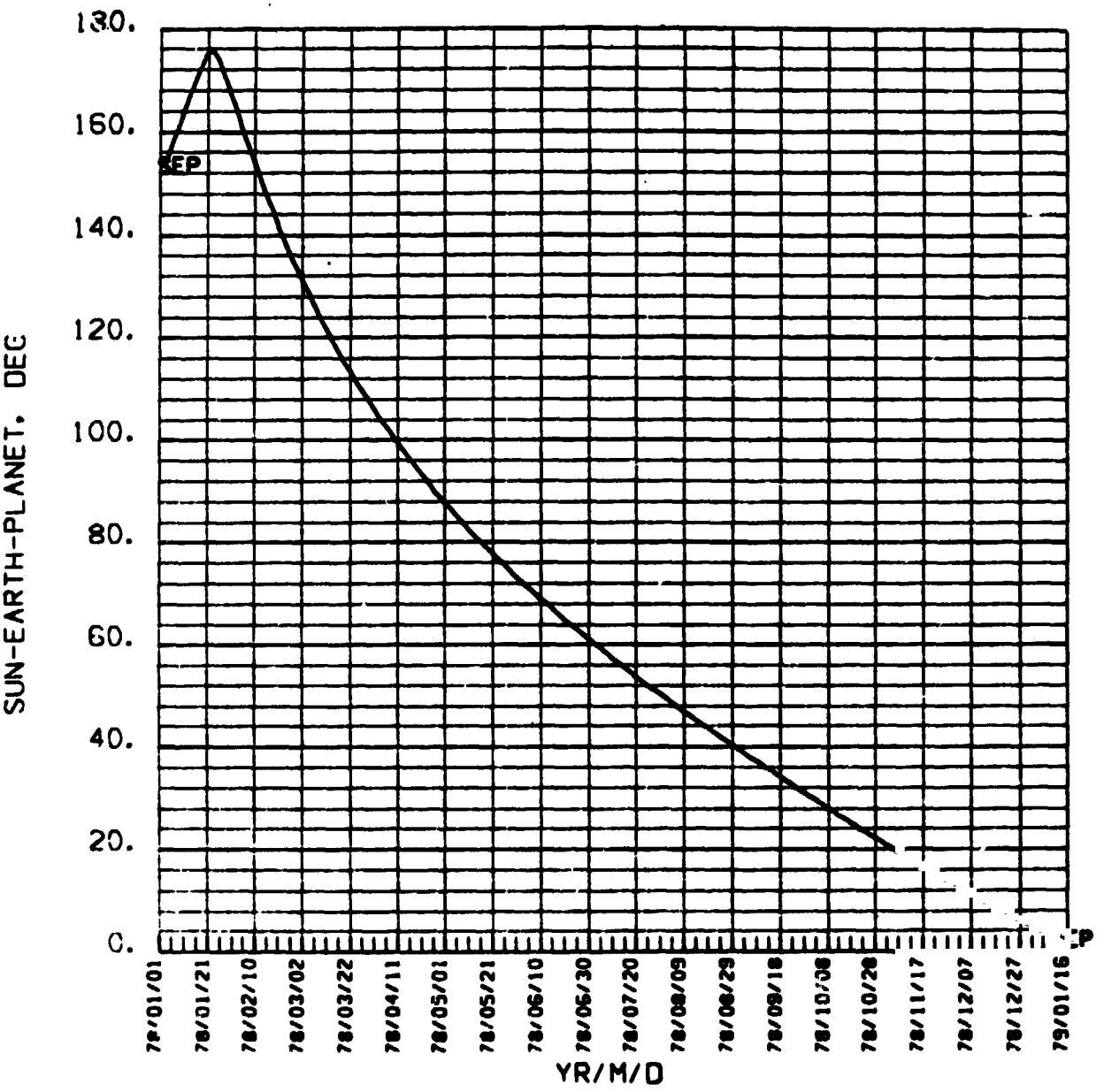
MARS 1978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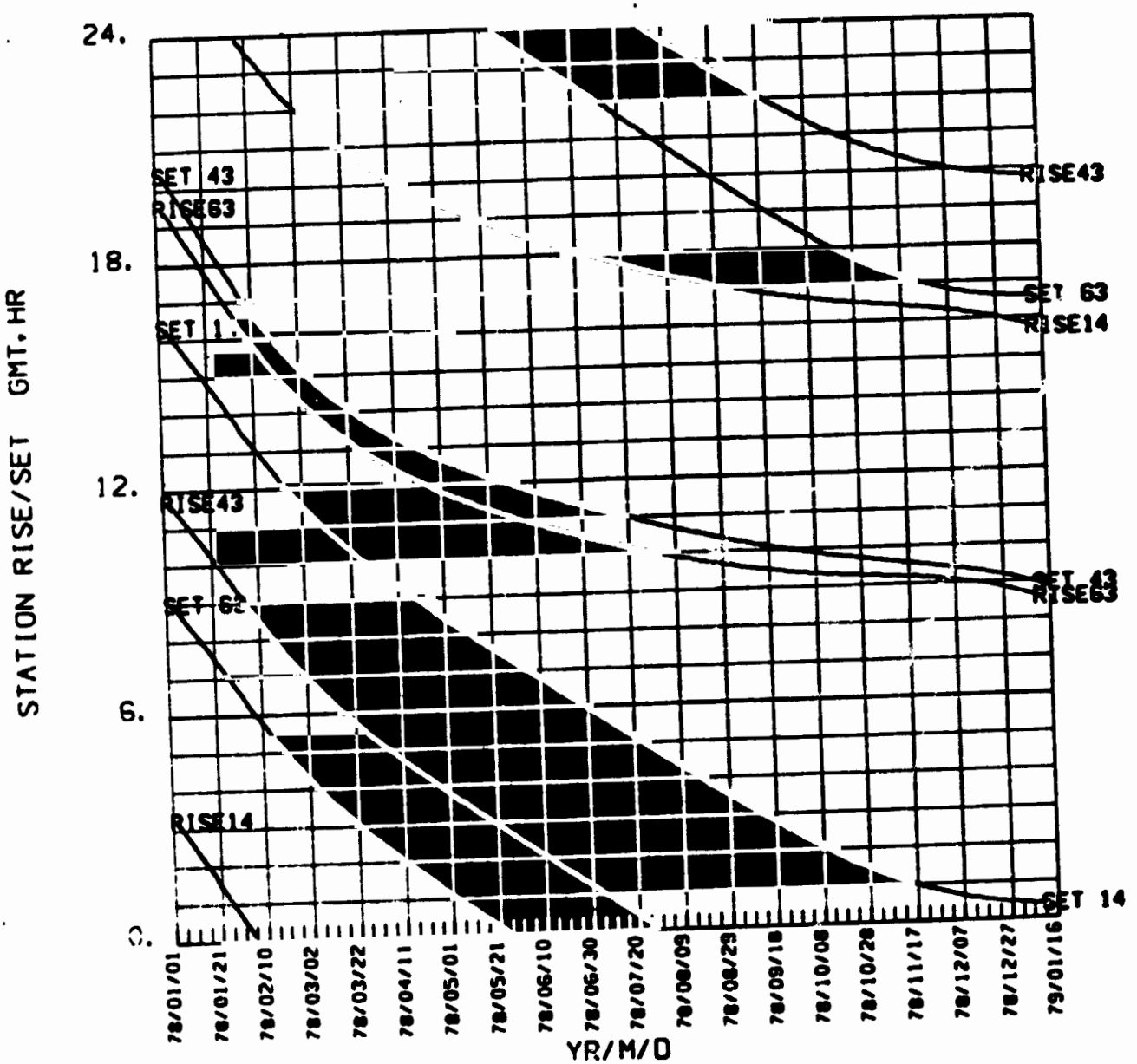
MARS 1978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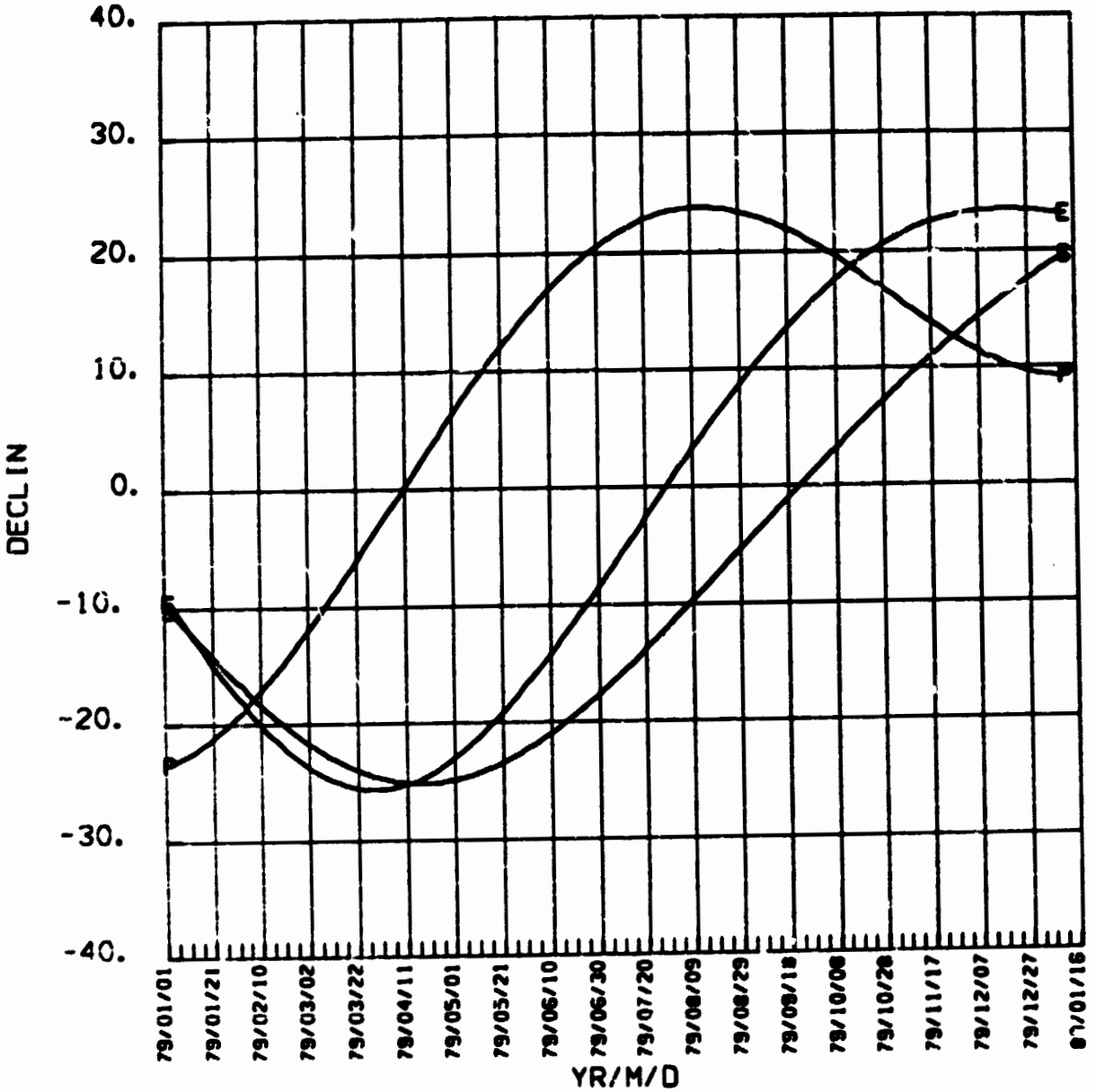
MARS 1979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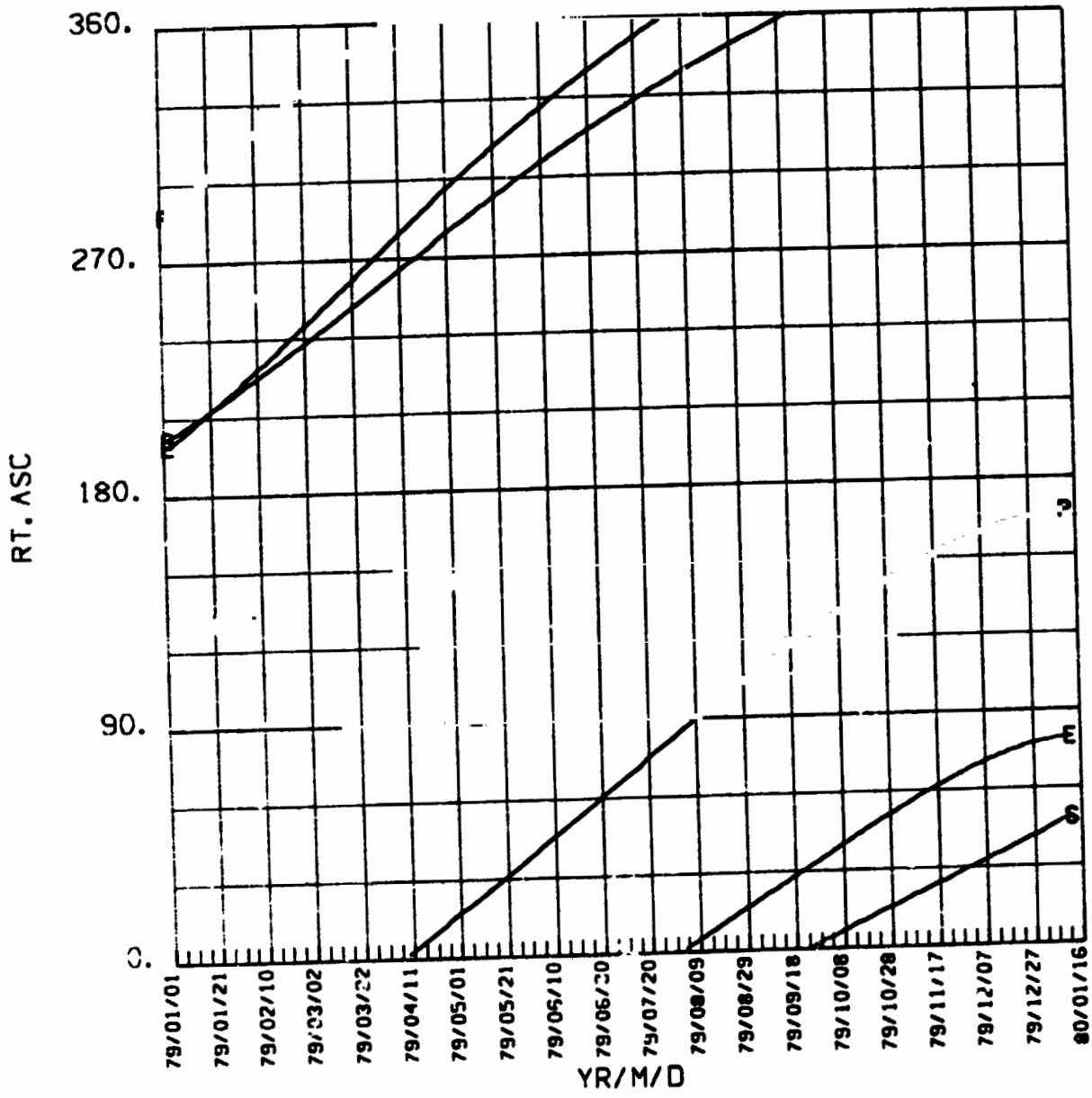
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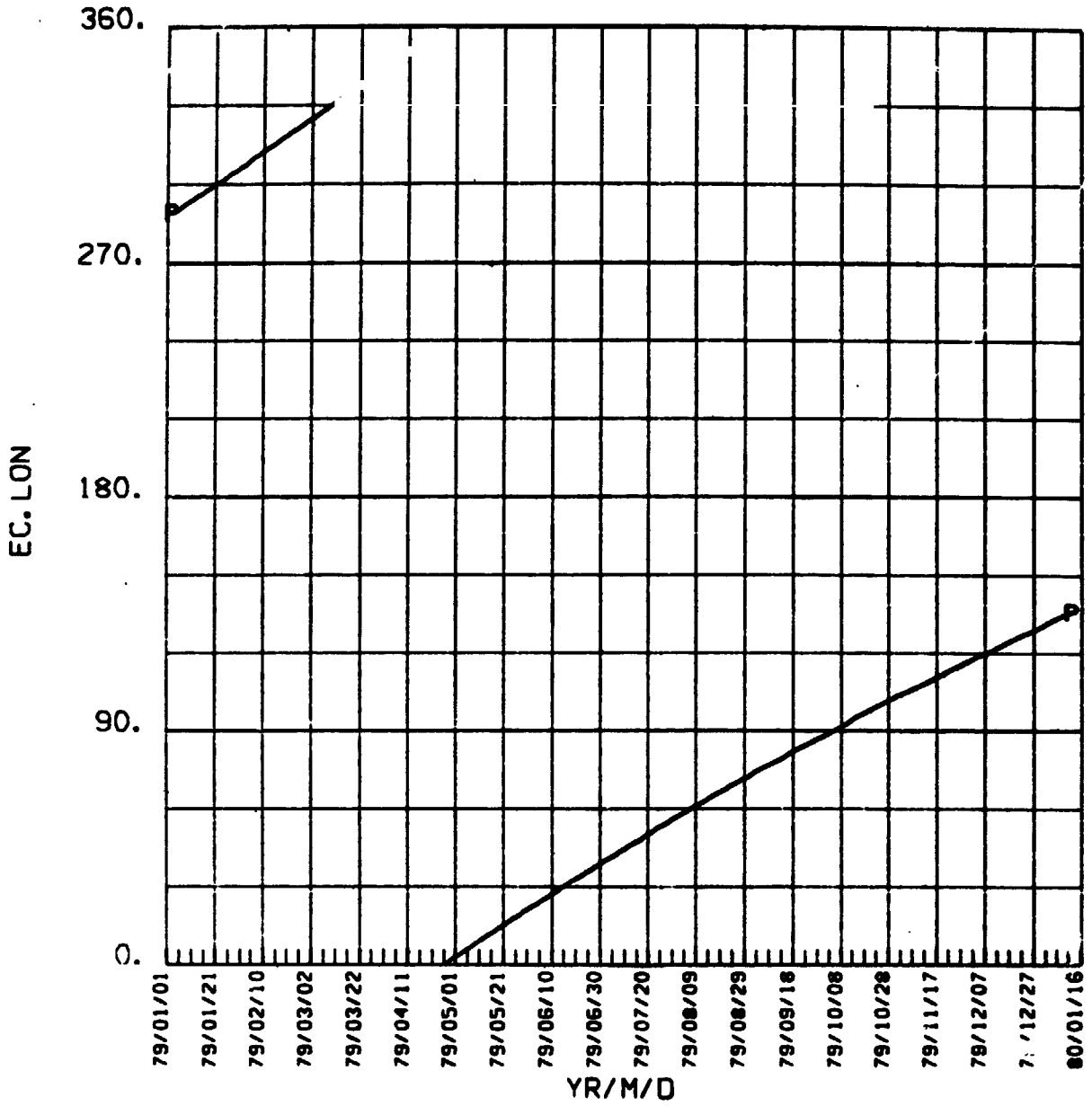
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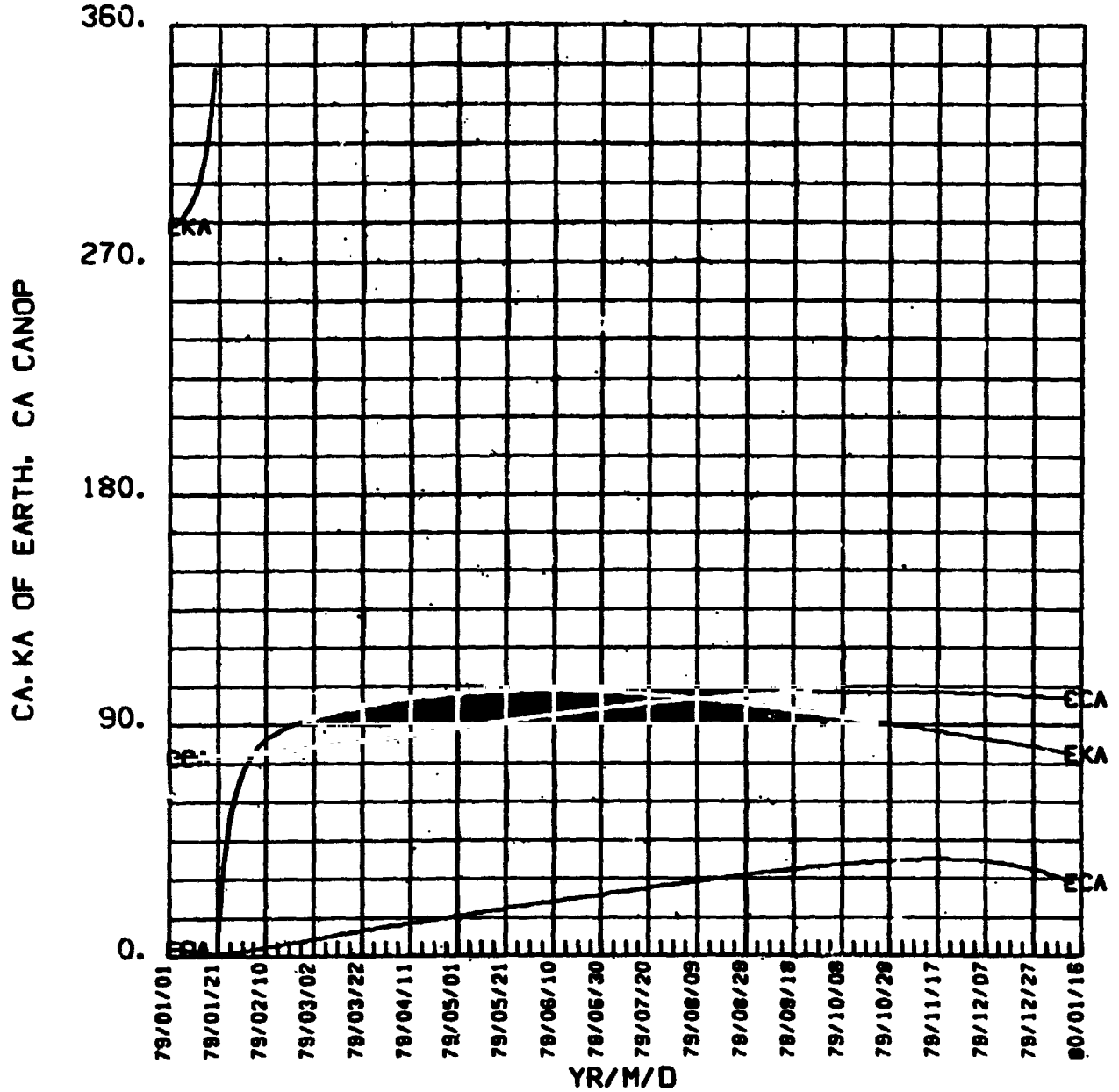
MARS 1979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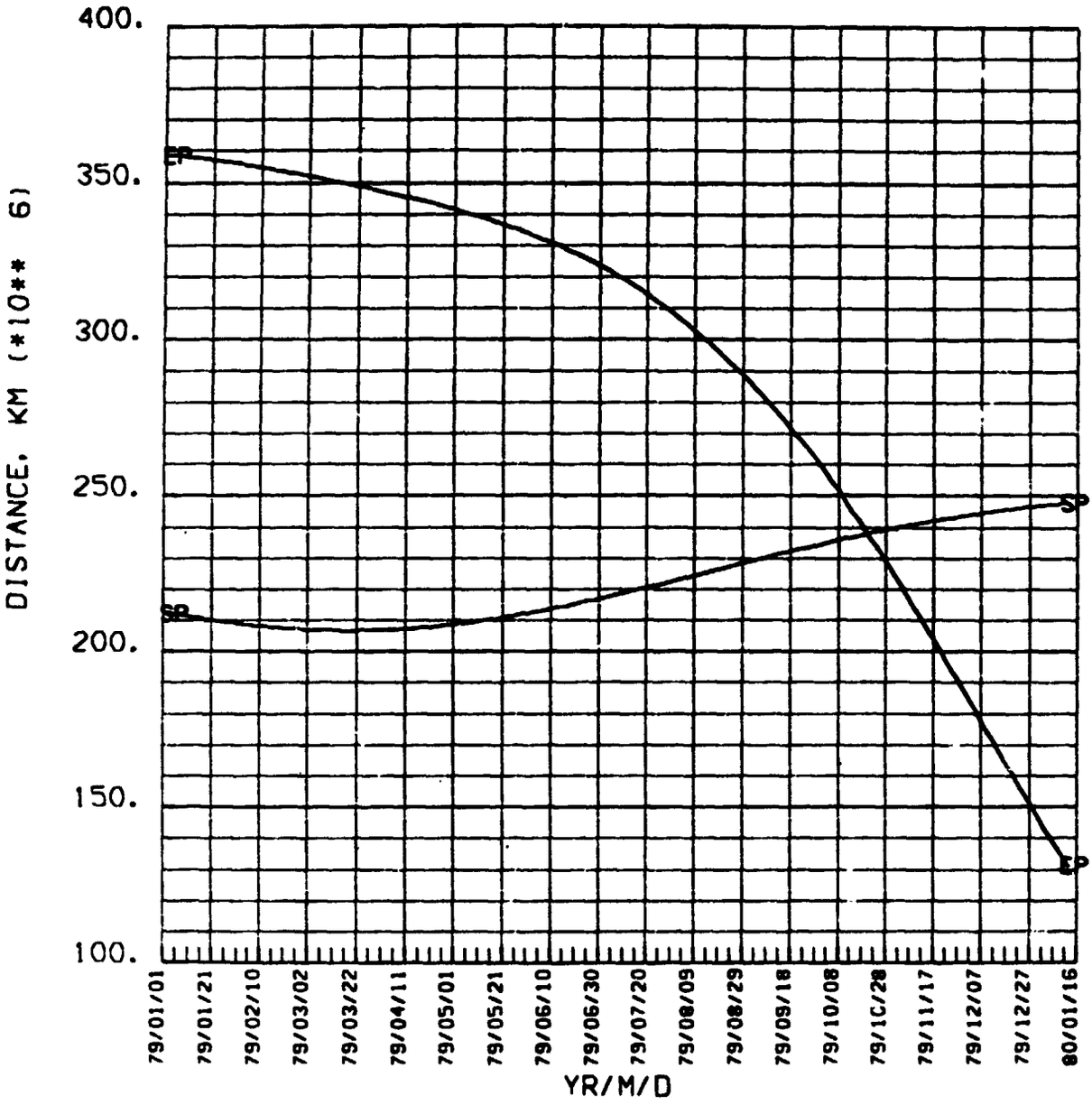
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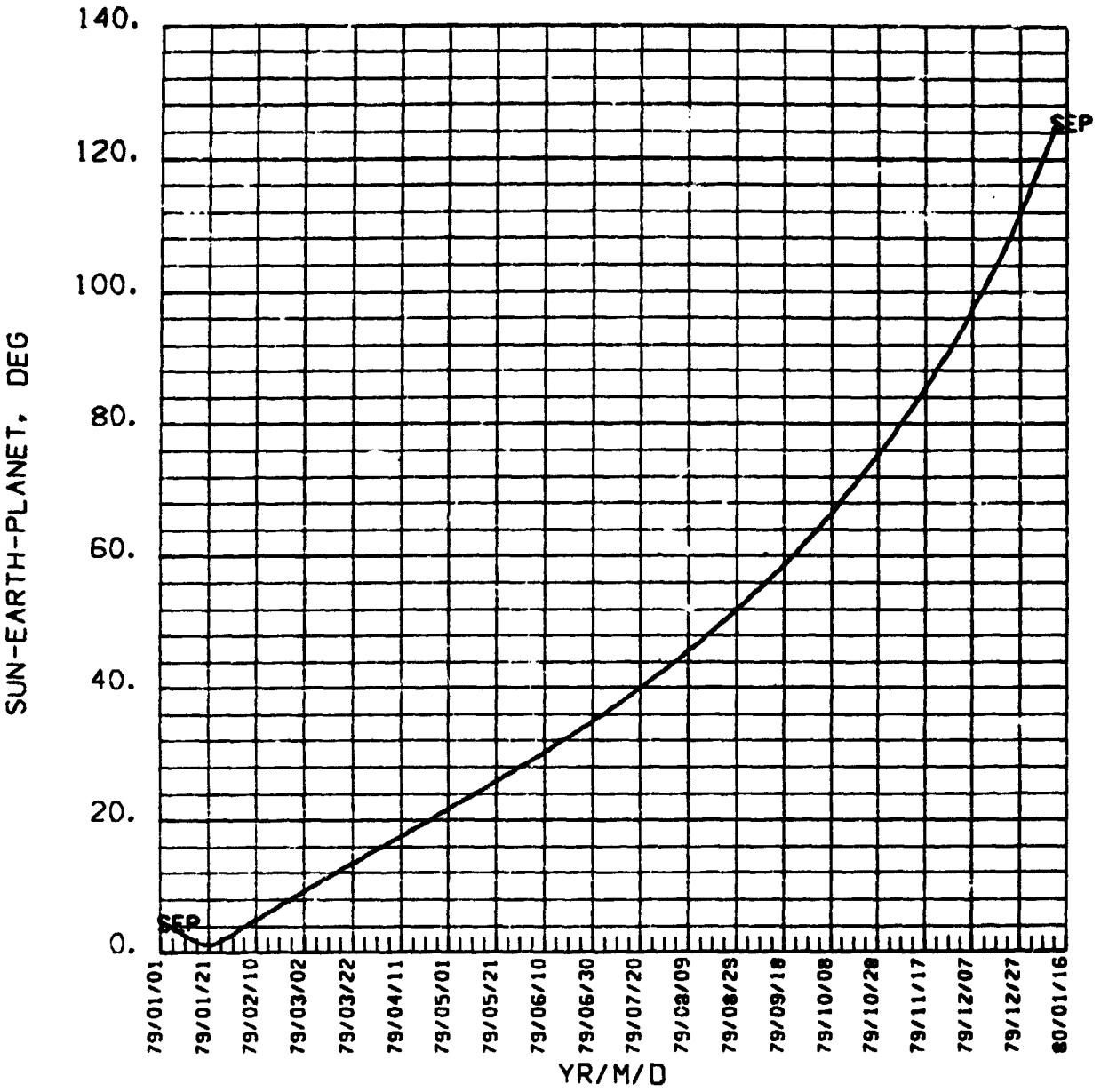
MARS 1979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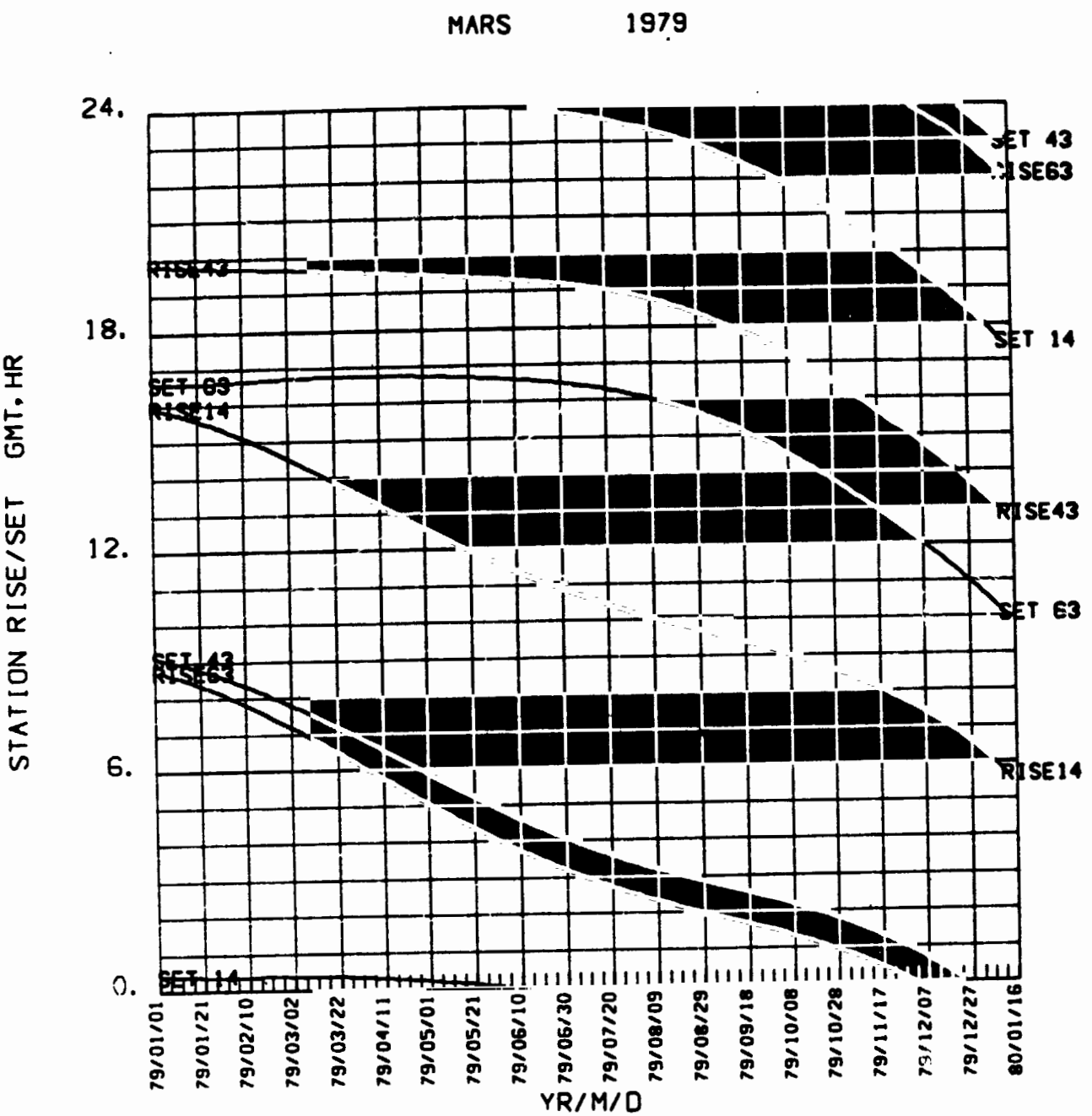
MARS 1979
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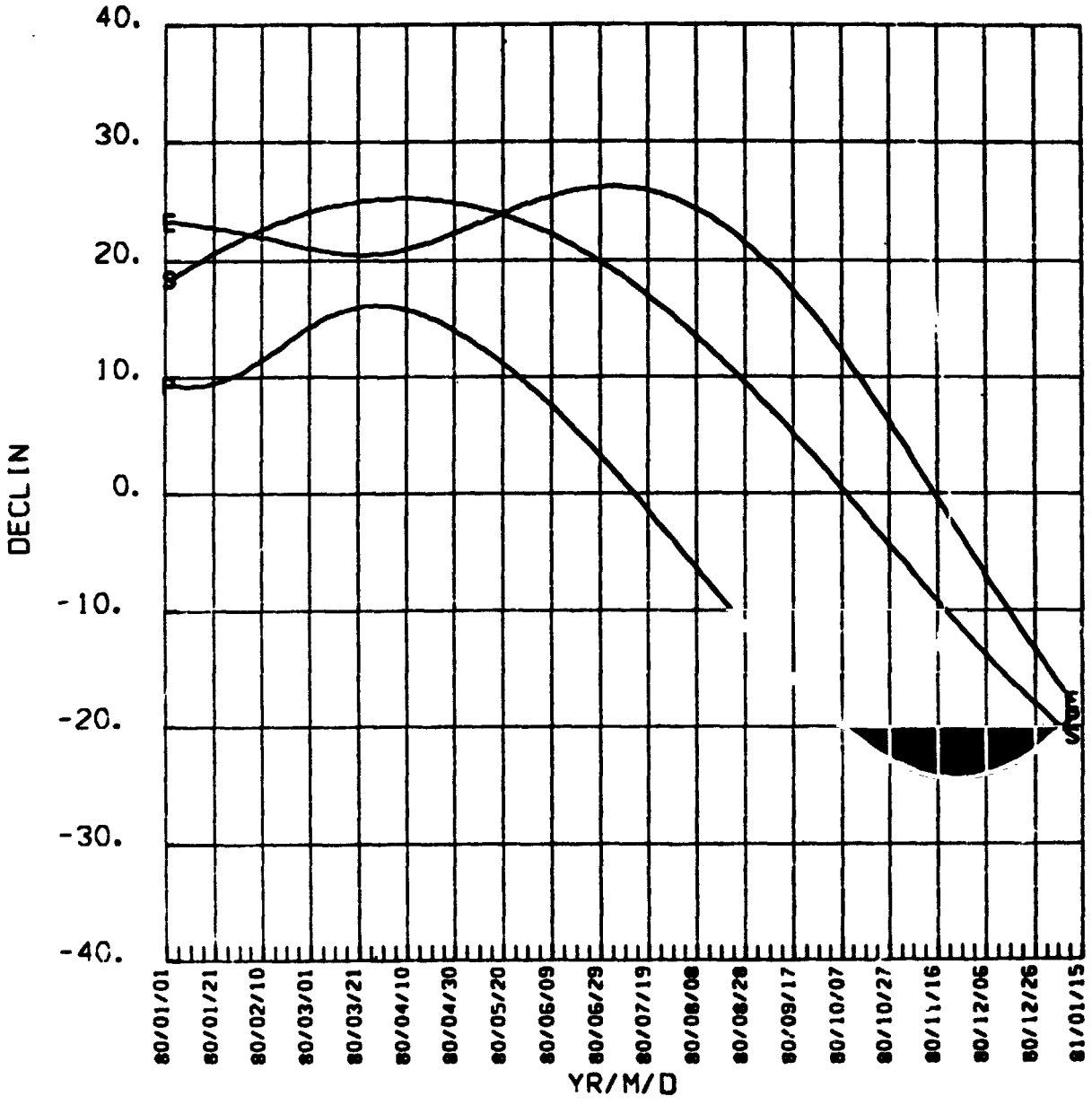
MARS 1980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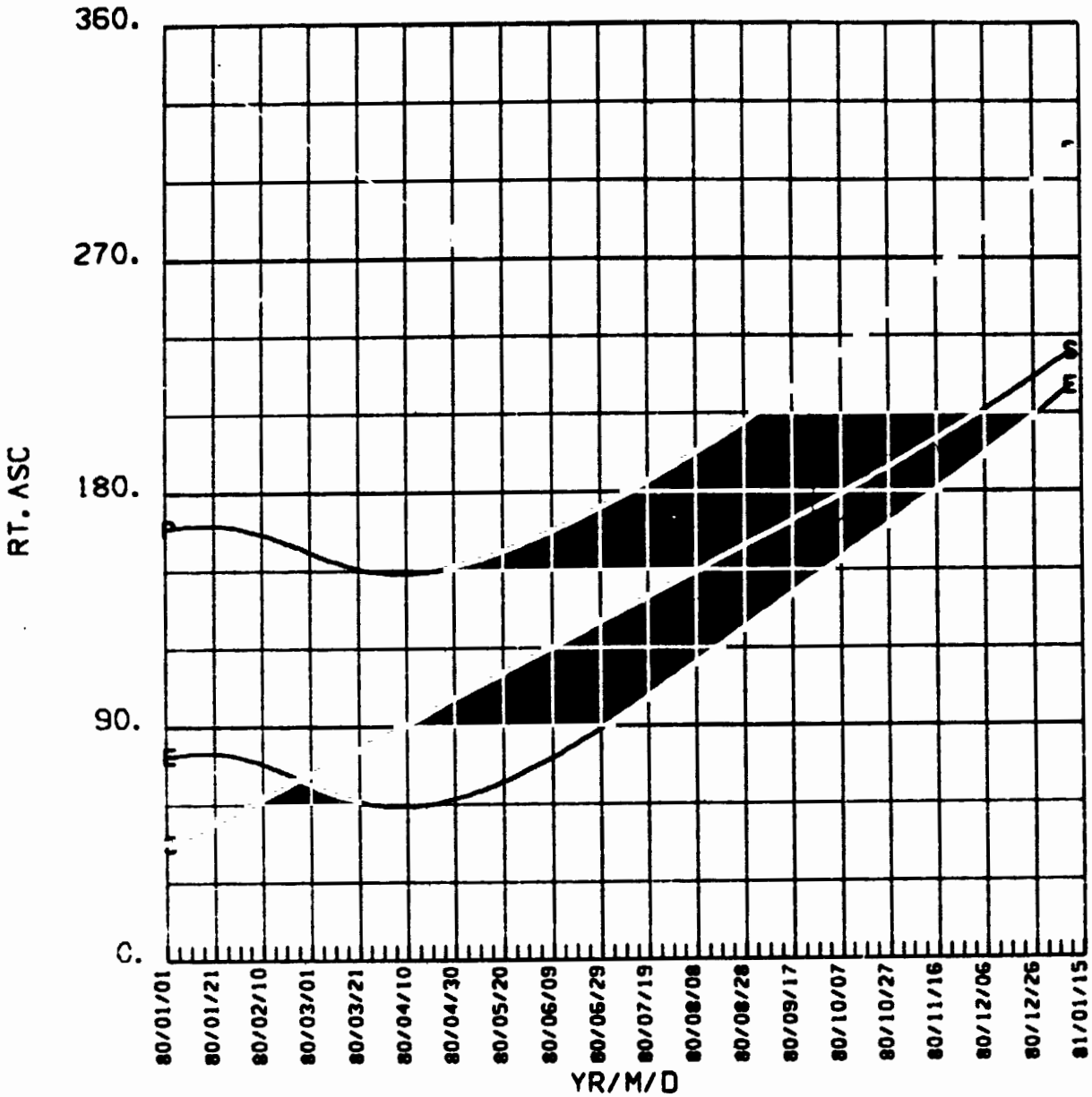
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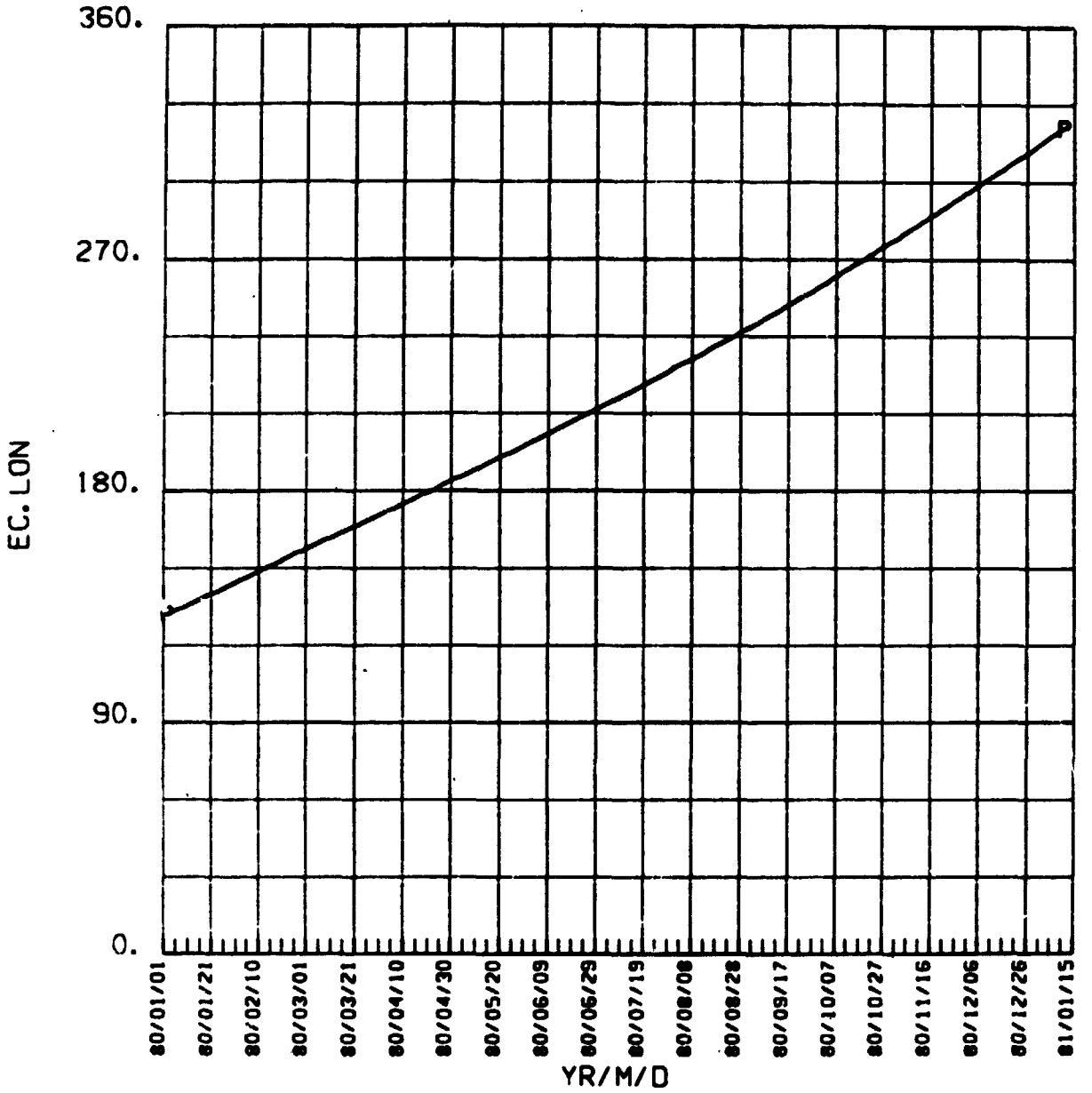
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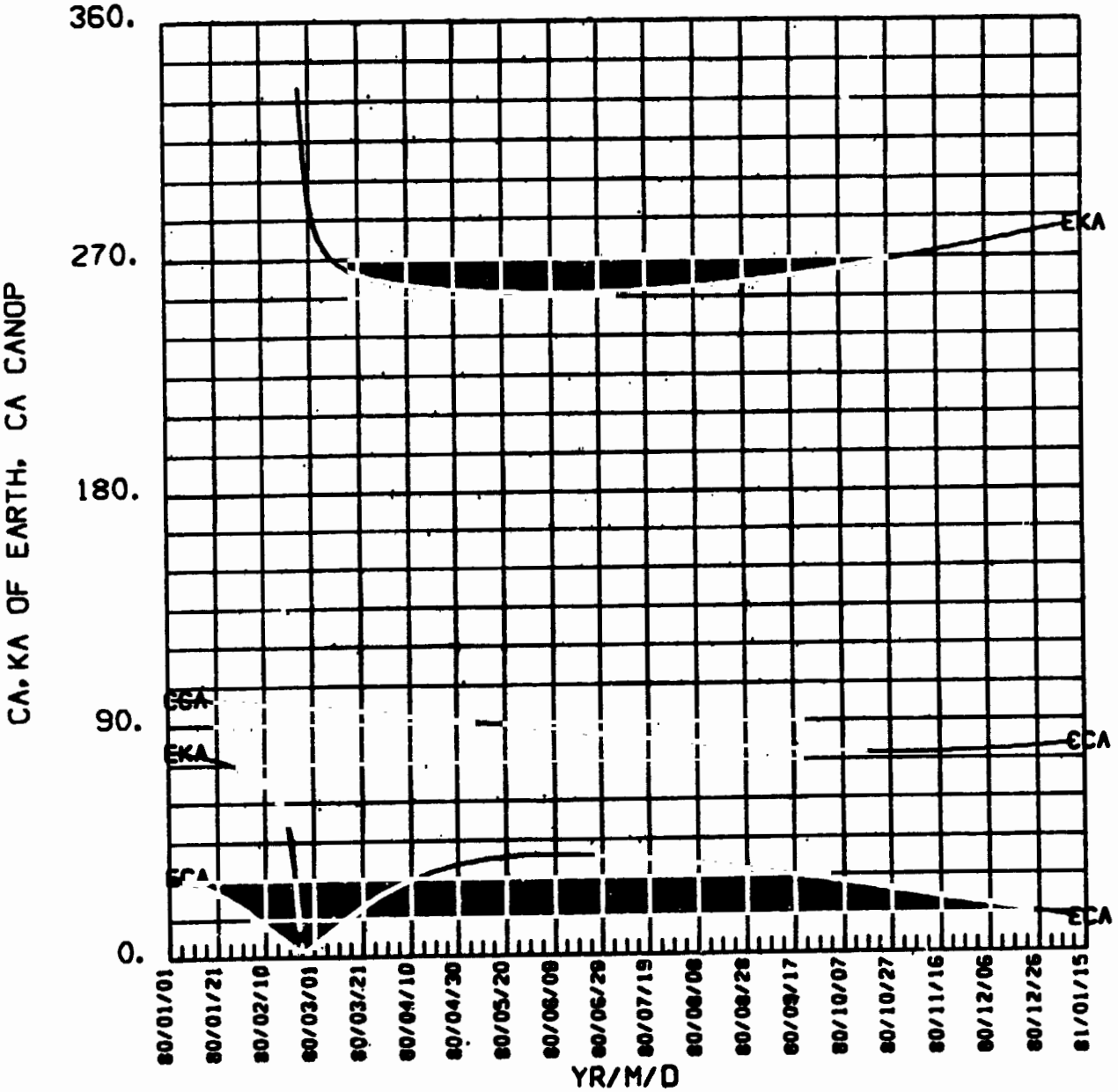
MARS 1980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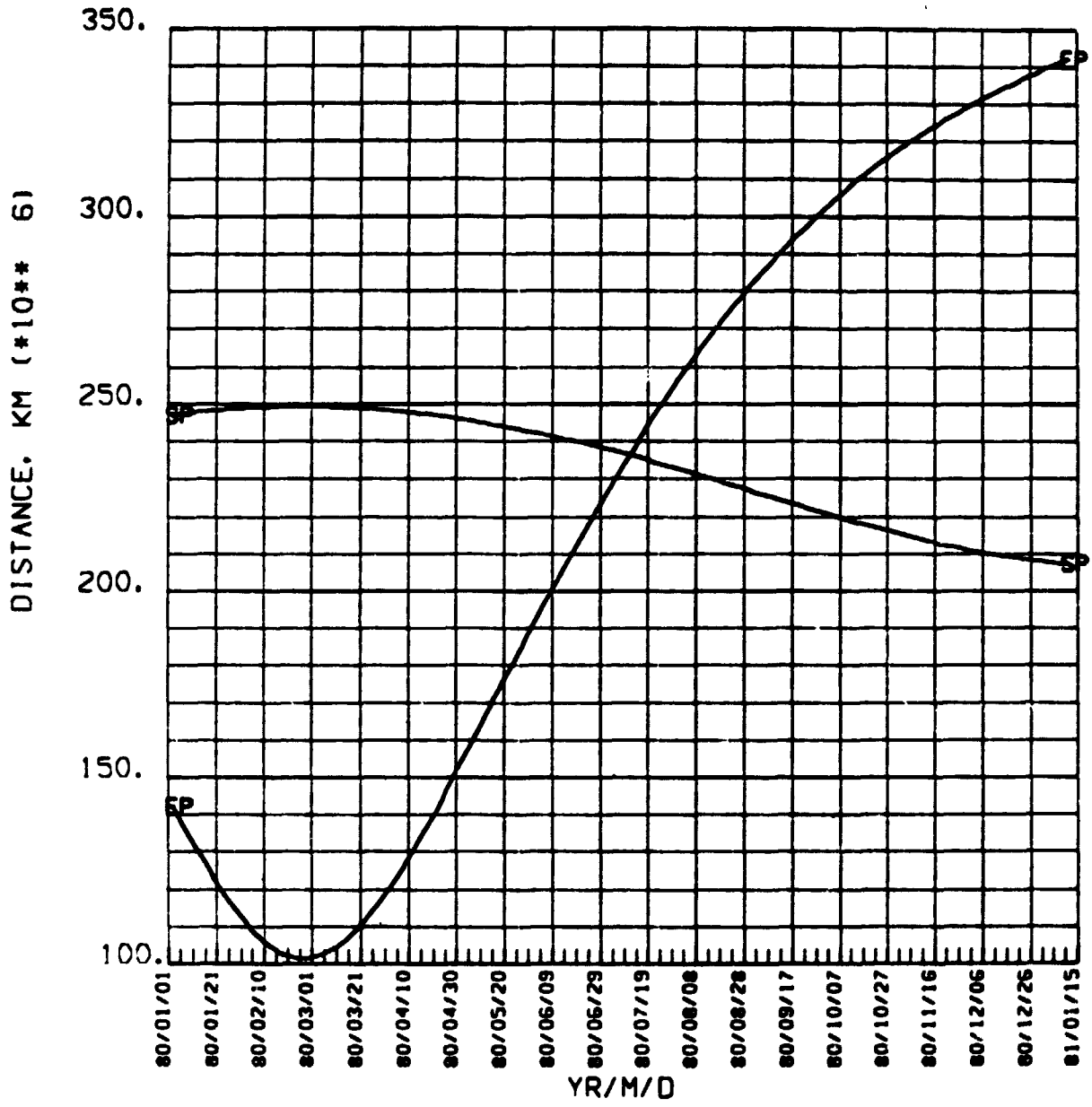
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DISTANCE, KM (*10** 6)
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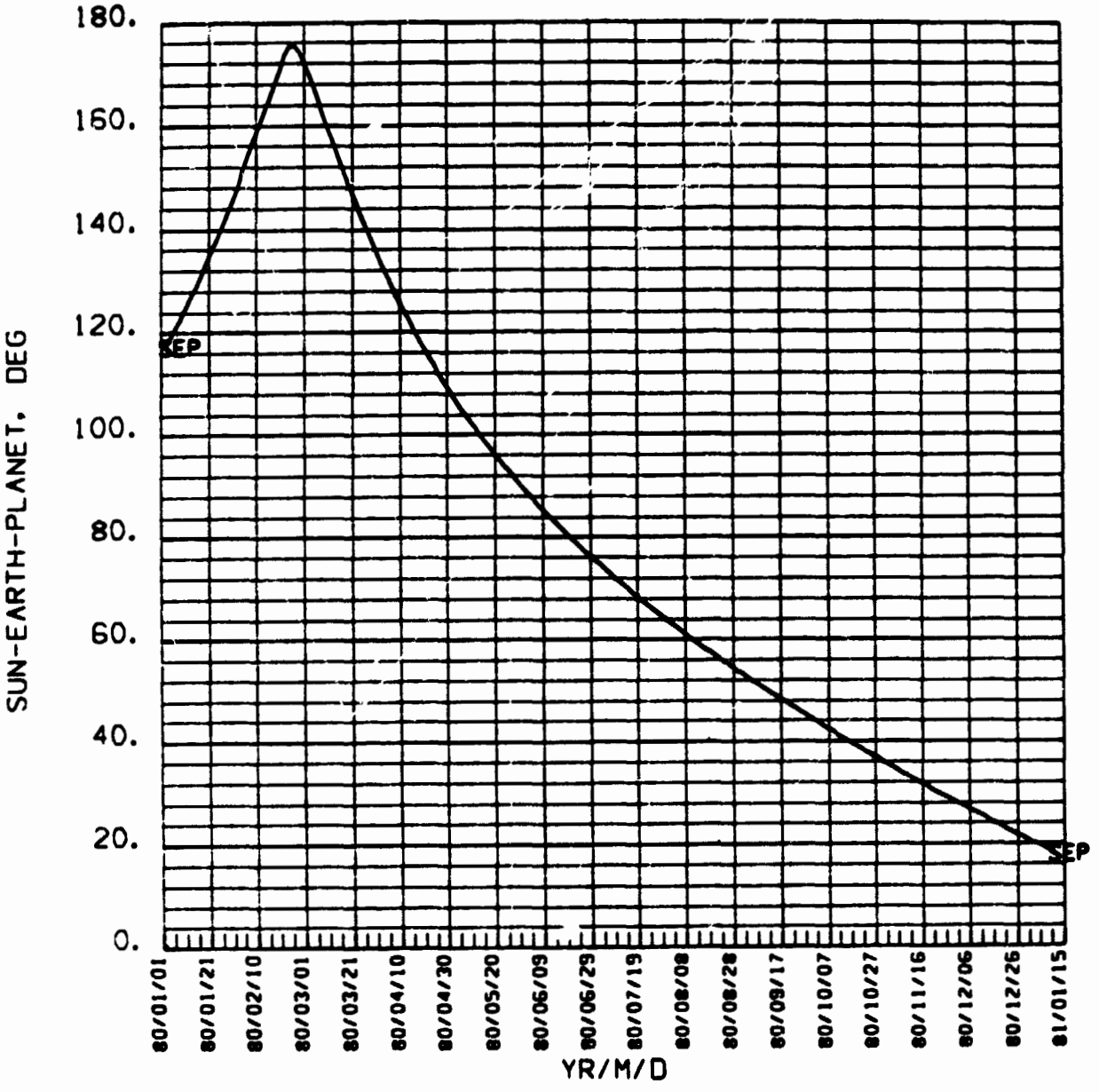
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SUN-EARTH-PLANET, DEG
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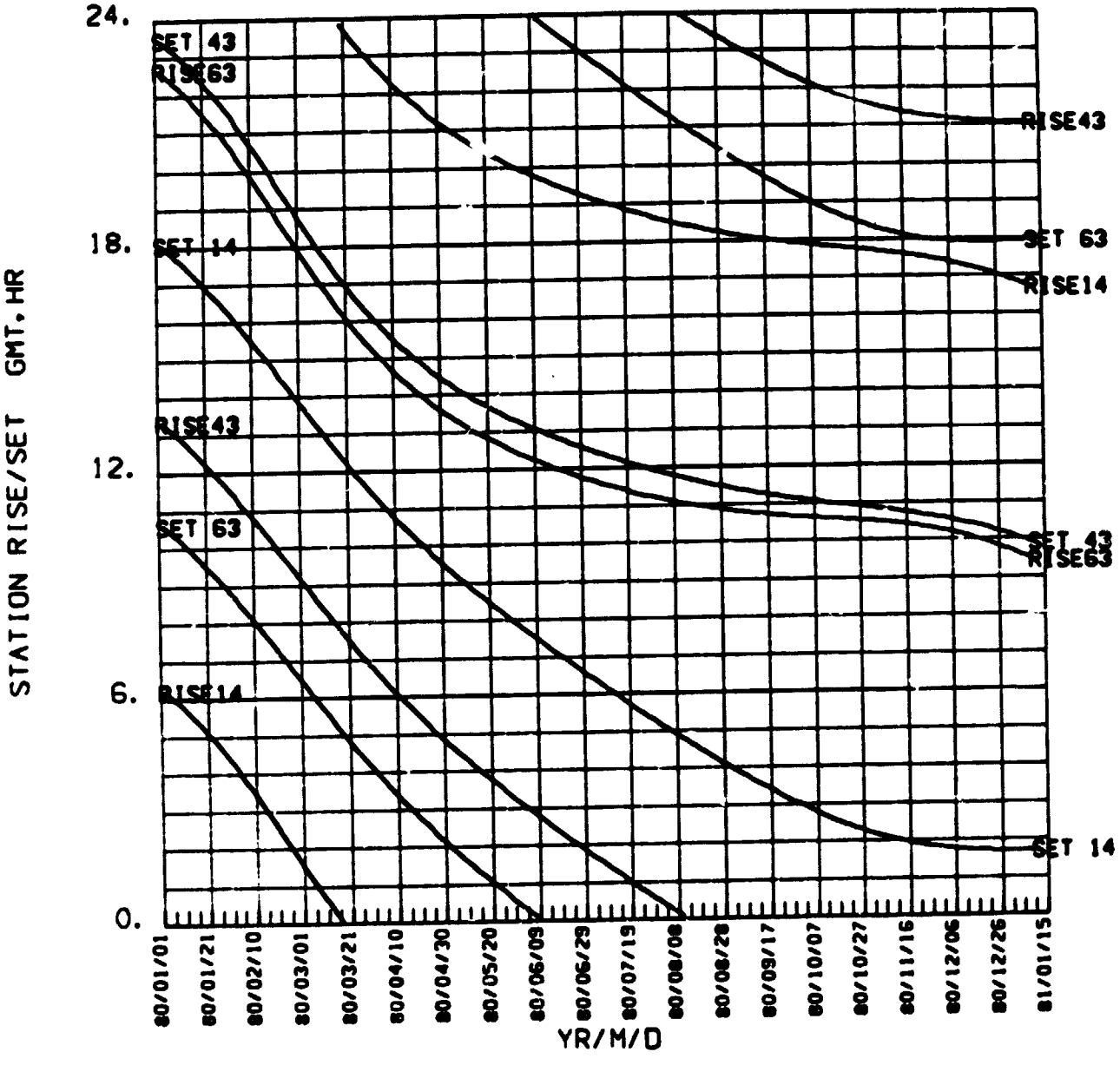
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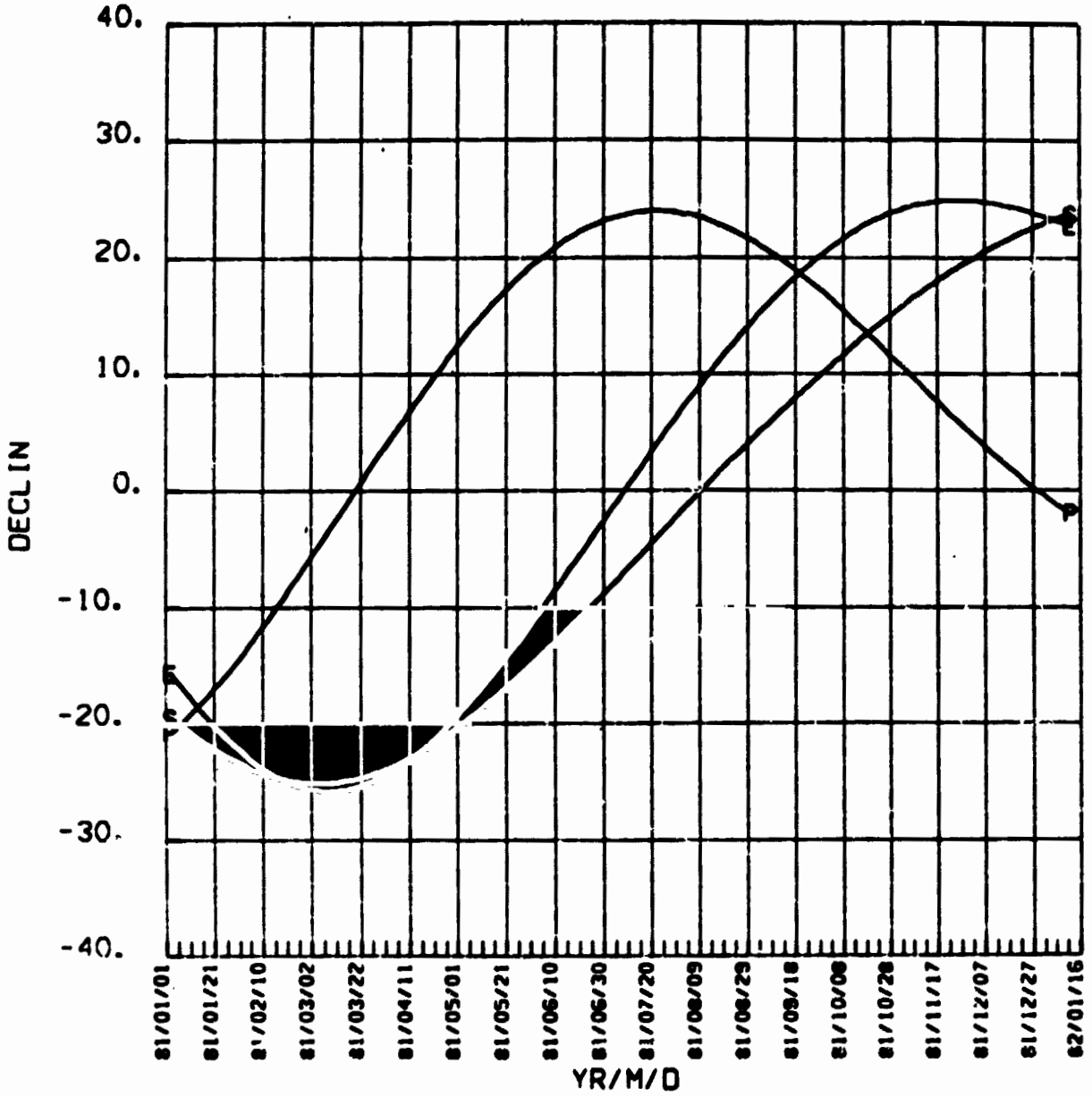
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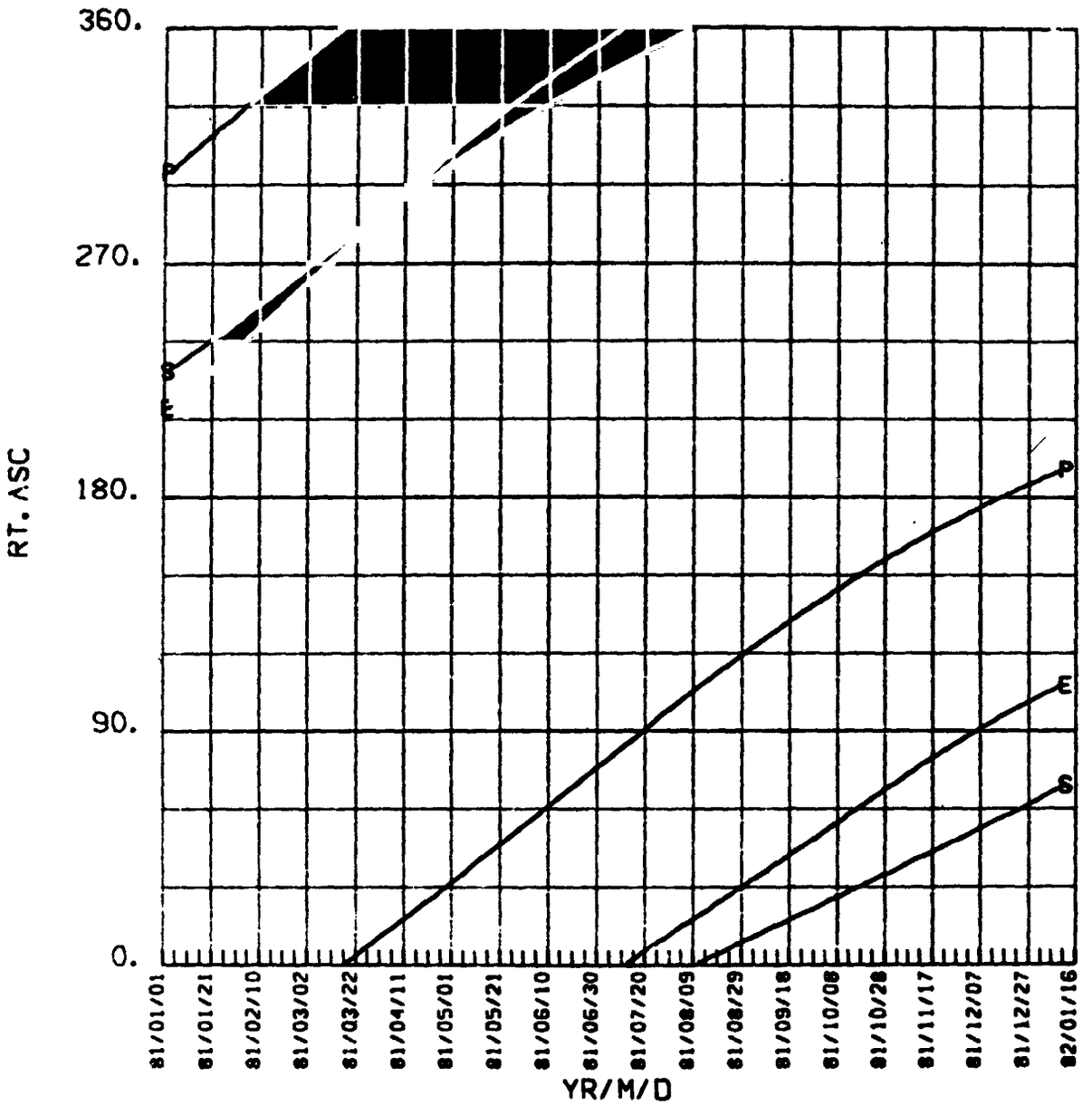
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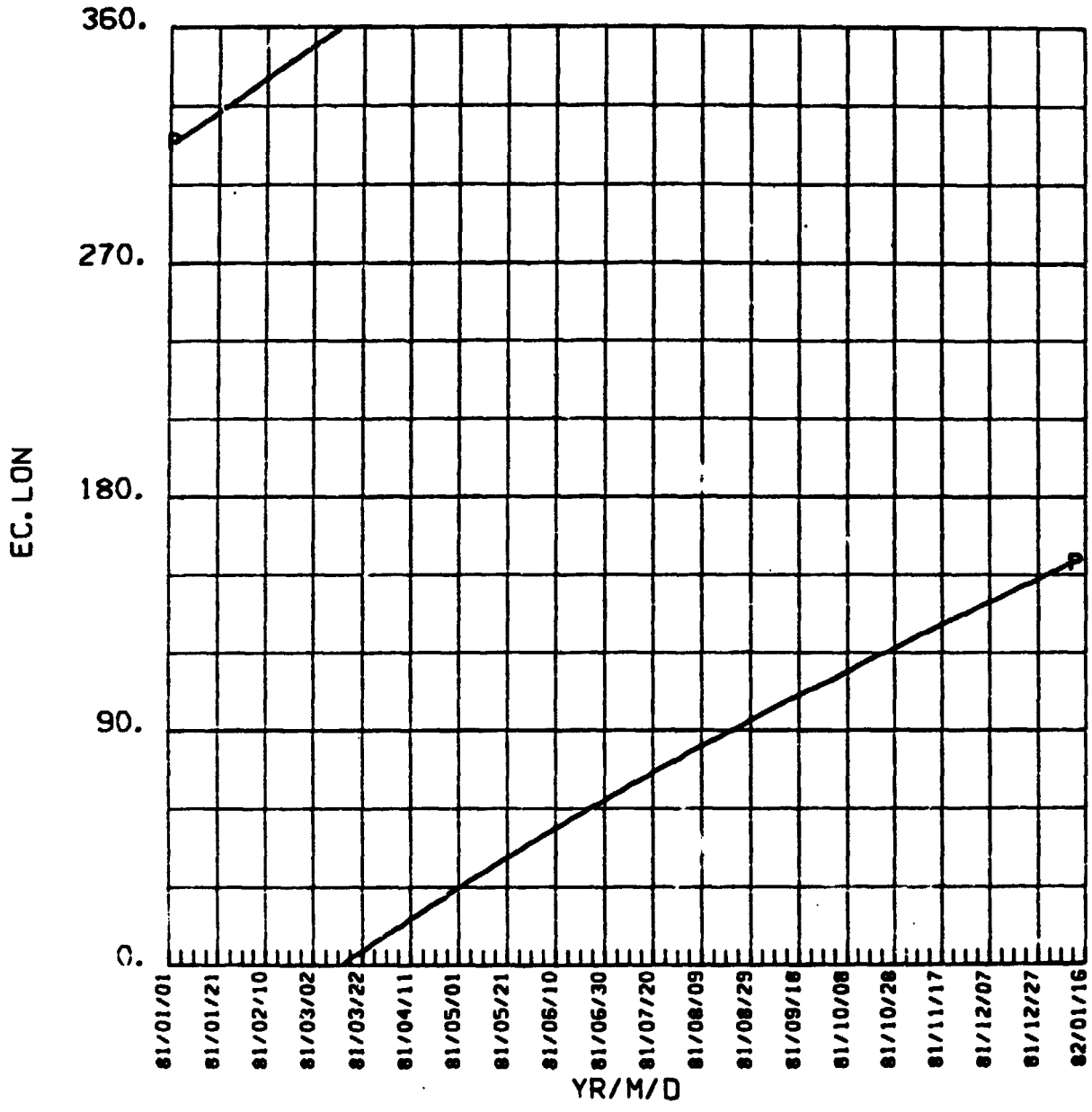
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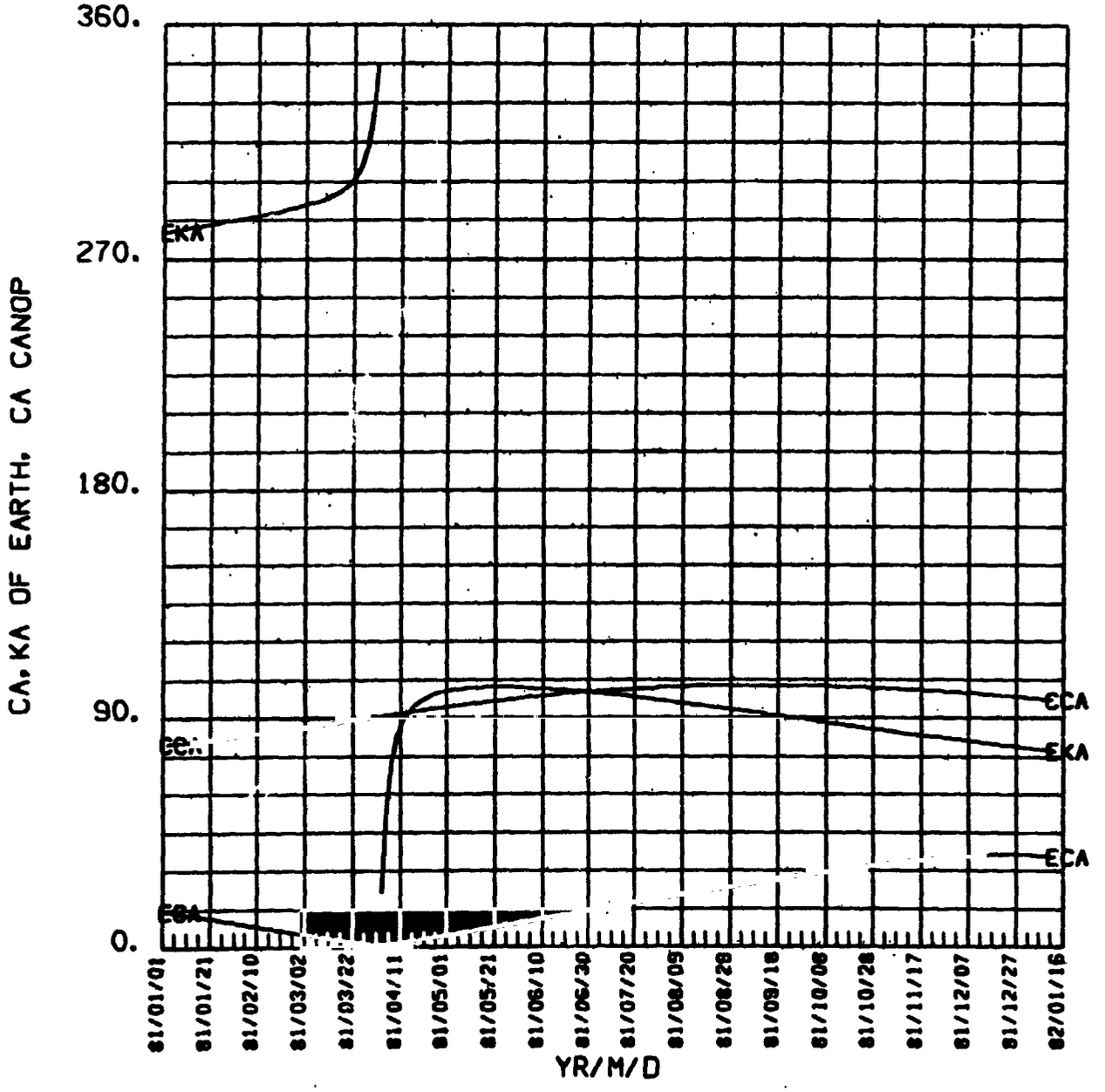
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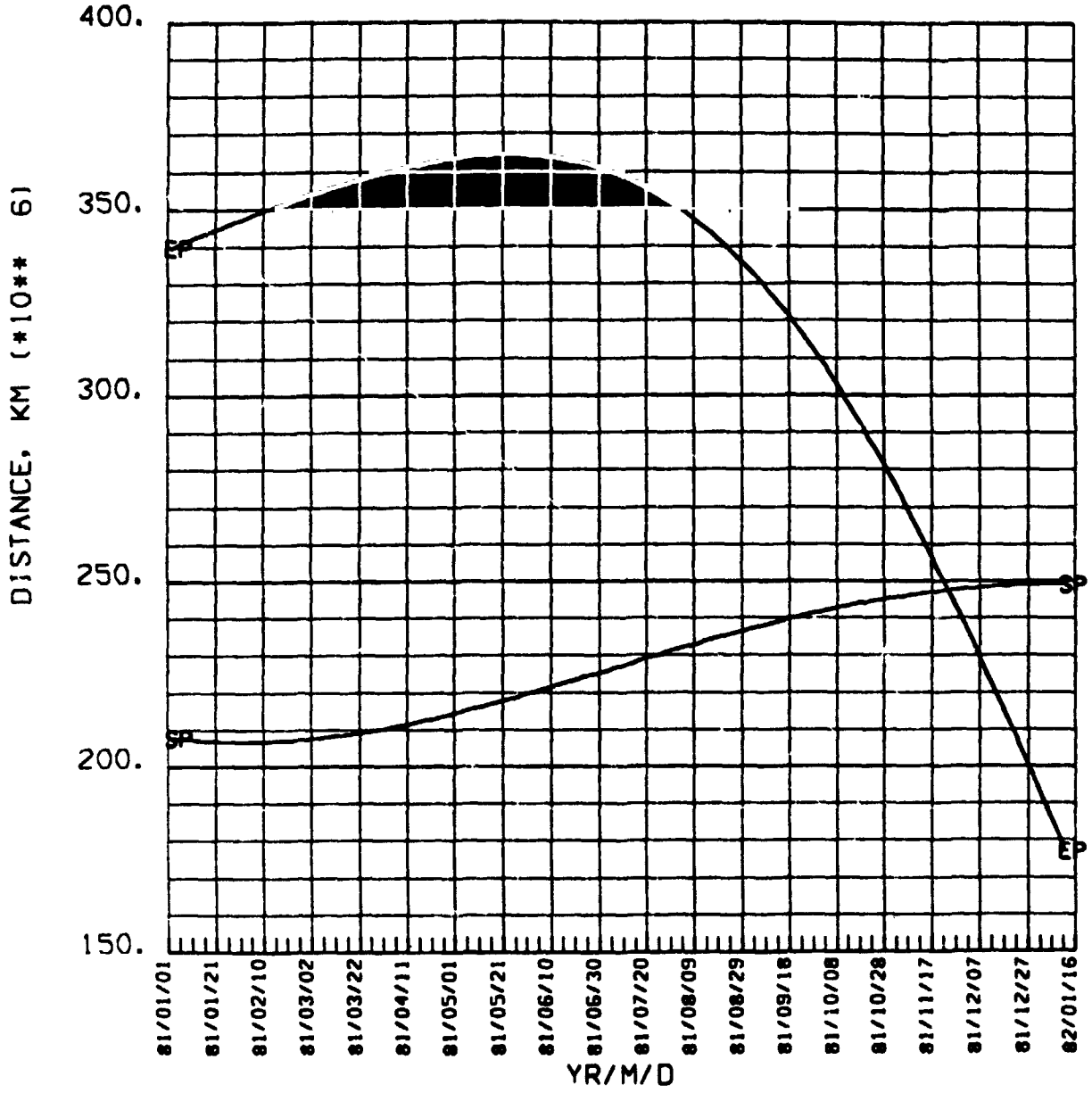
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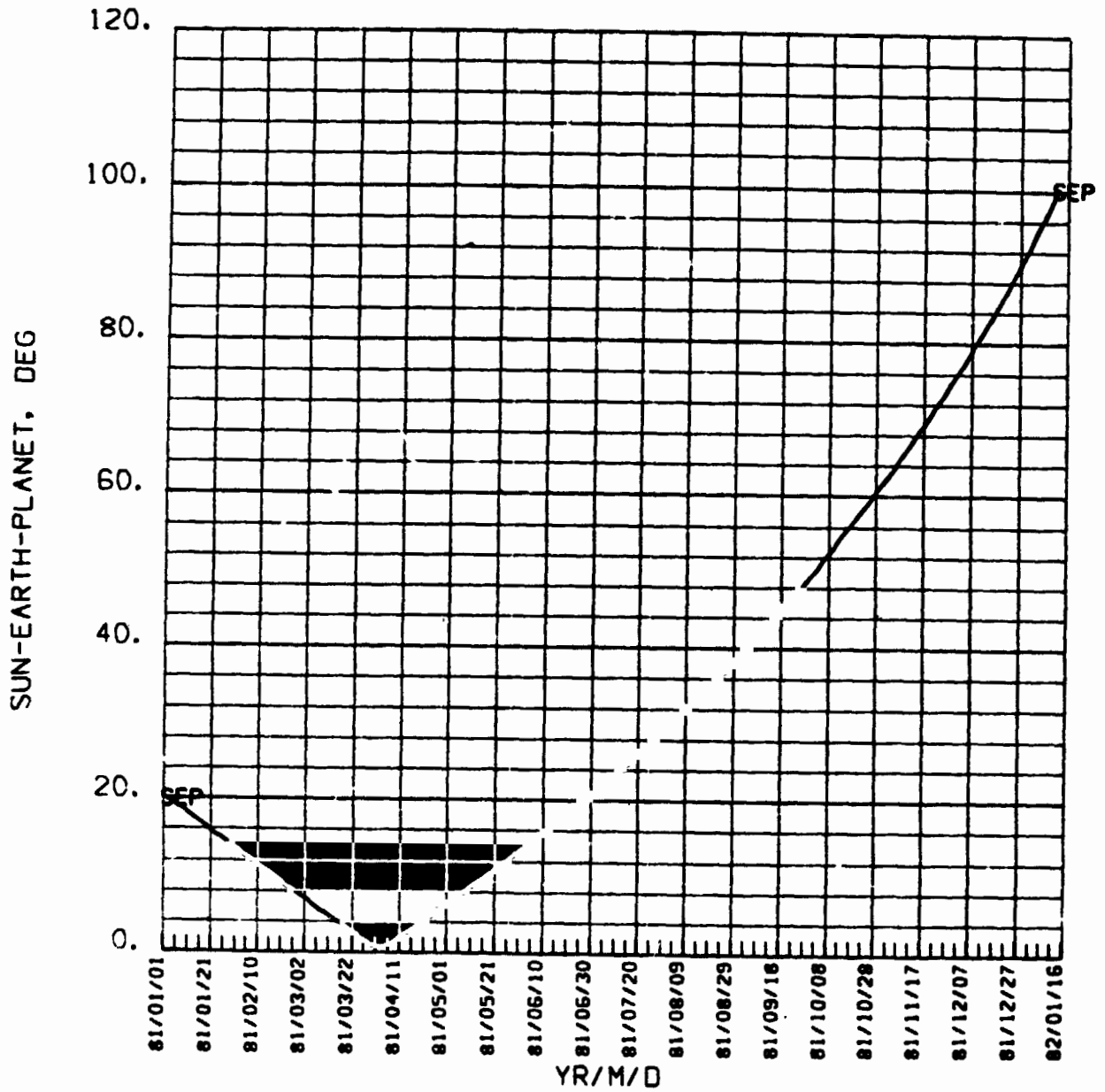
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SUN-EARTH-PLANET, DEG
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YR/M/D

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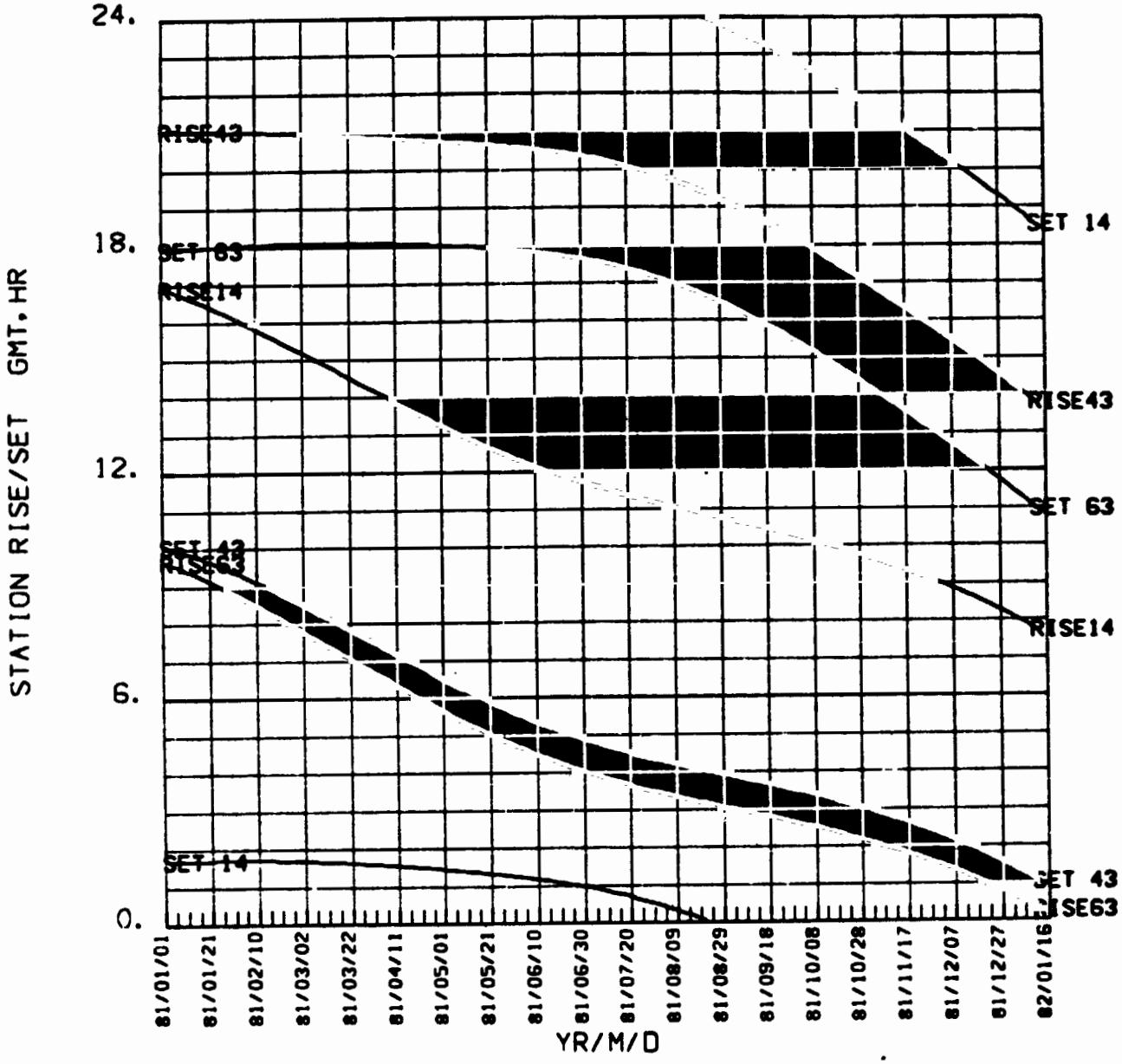
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SET 43
RISE63
81/01/01
81/01/21
81/02/10
81/03/02
81/03/22
81/04/11
81/05/01
81/05/21
81/06/10
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81/08/09
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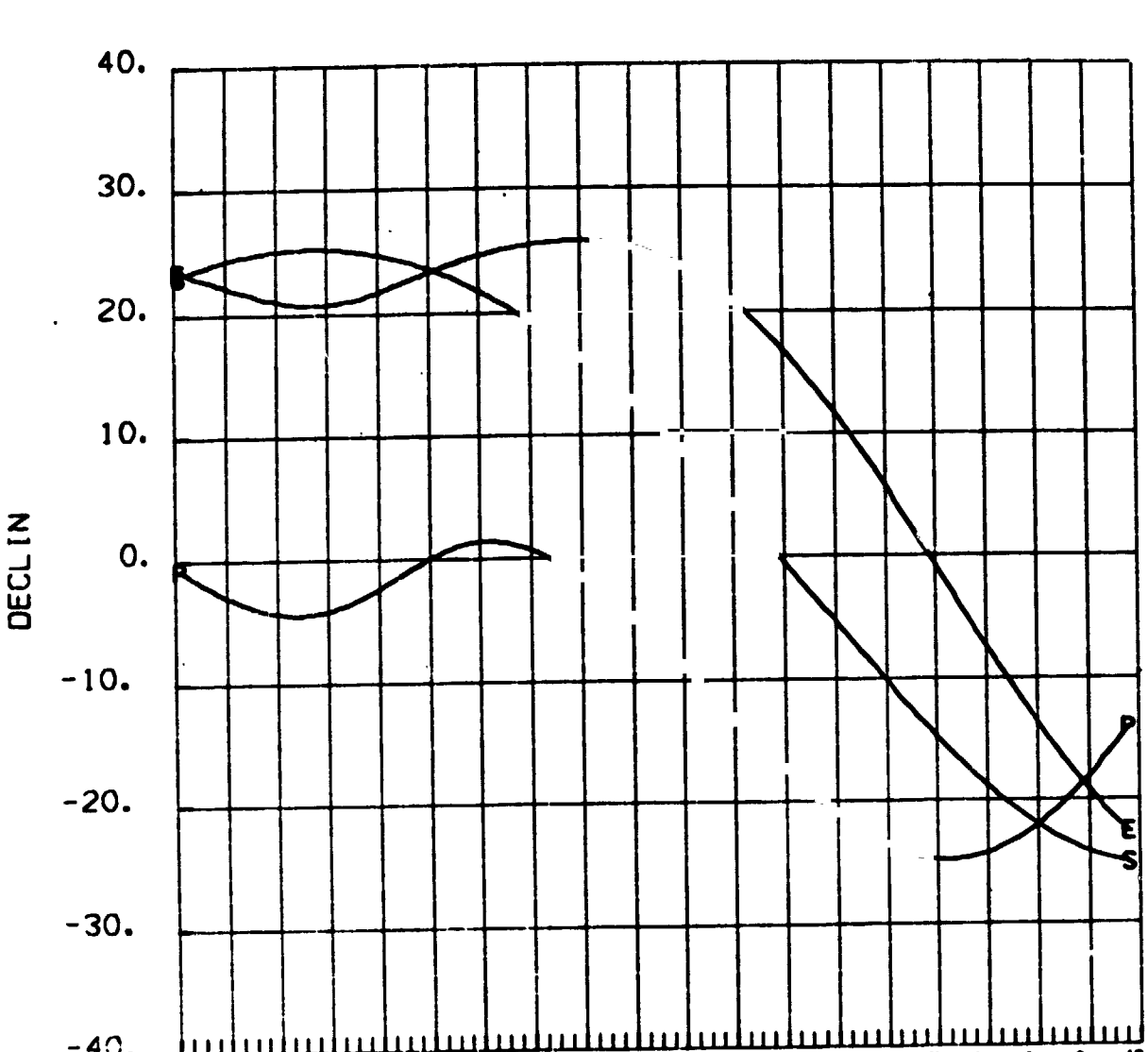
YR/M/D

MARS 1982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83/01/16
YR/M/D
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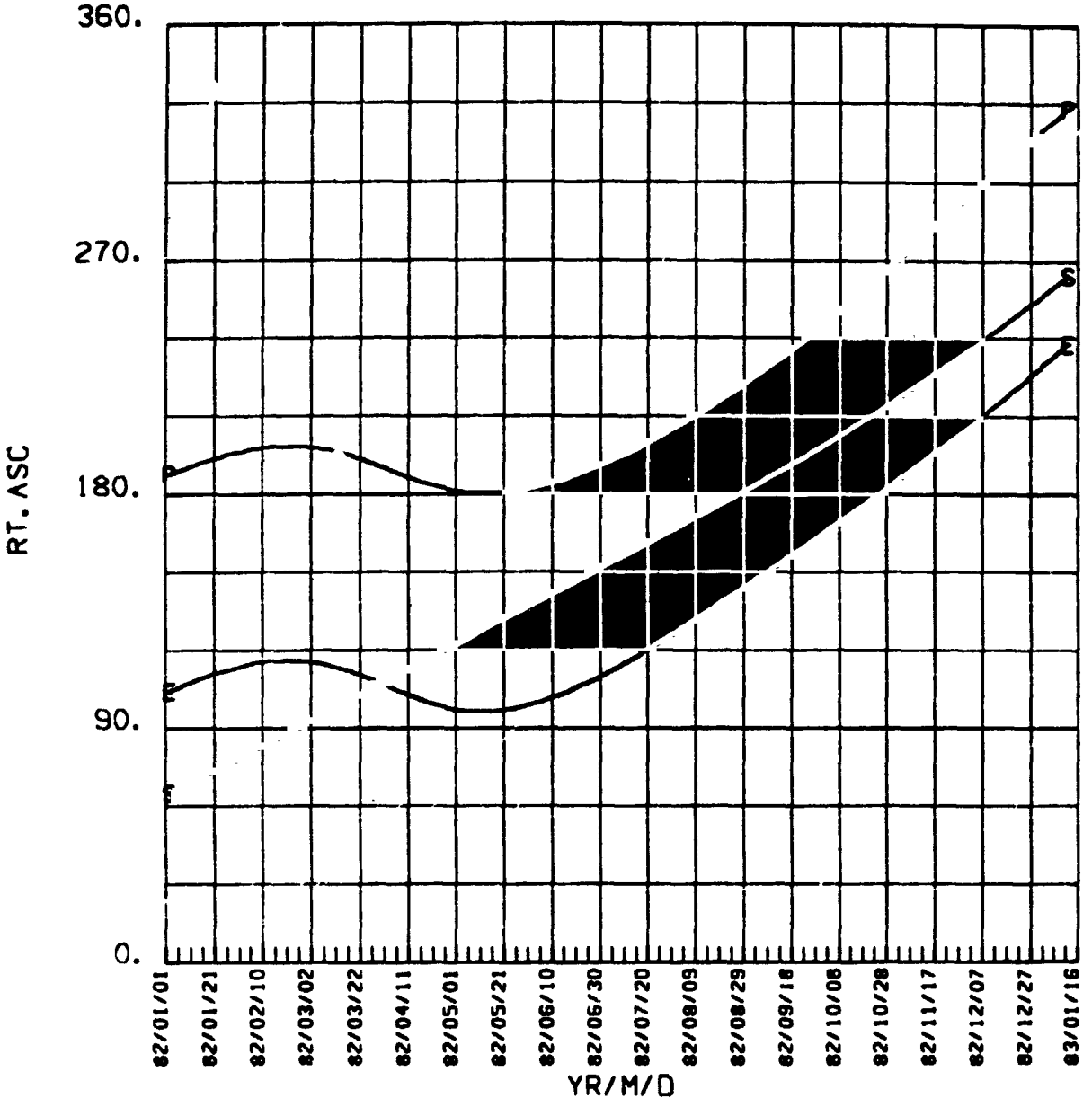
MARS 1982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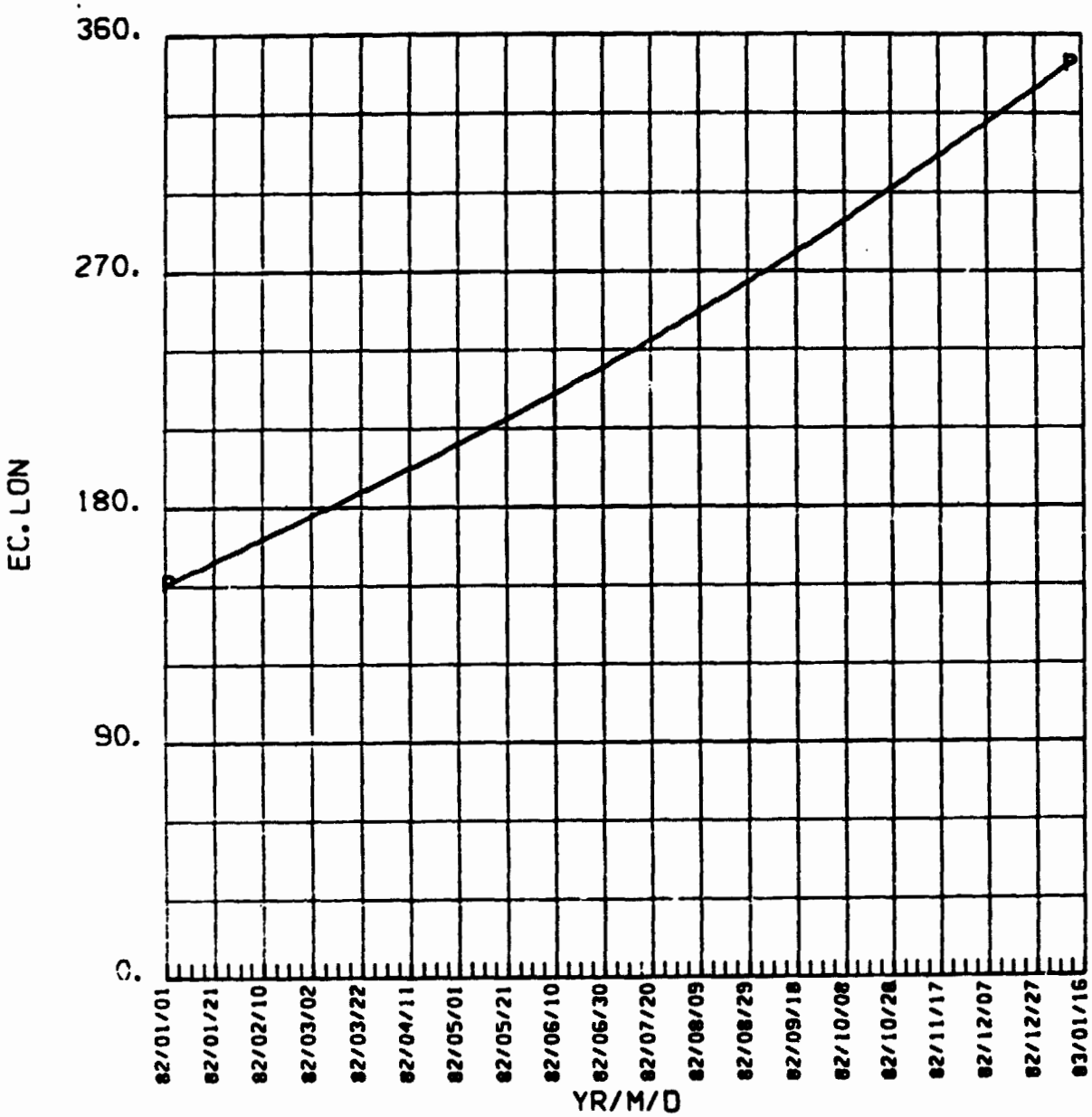
83/01/16
YR/M/D

MARS 1982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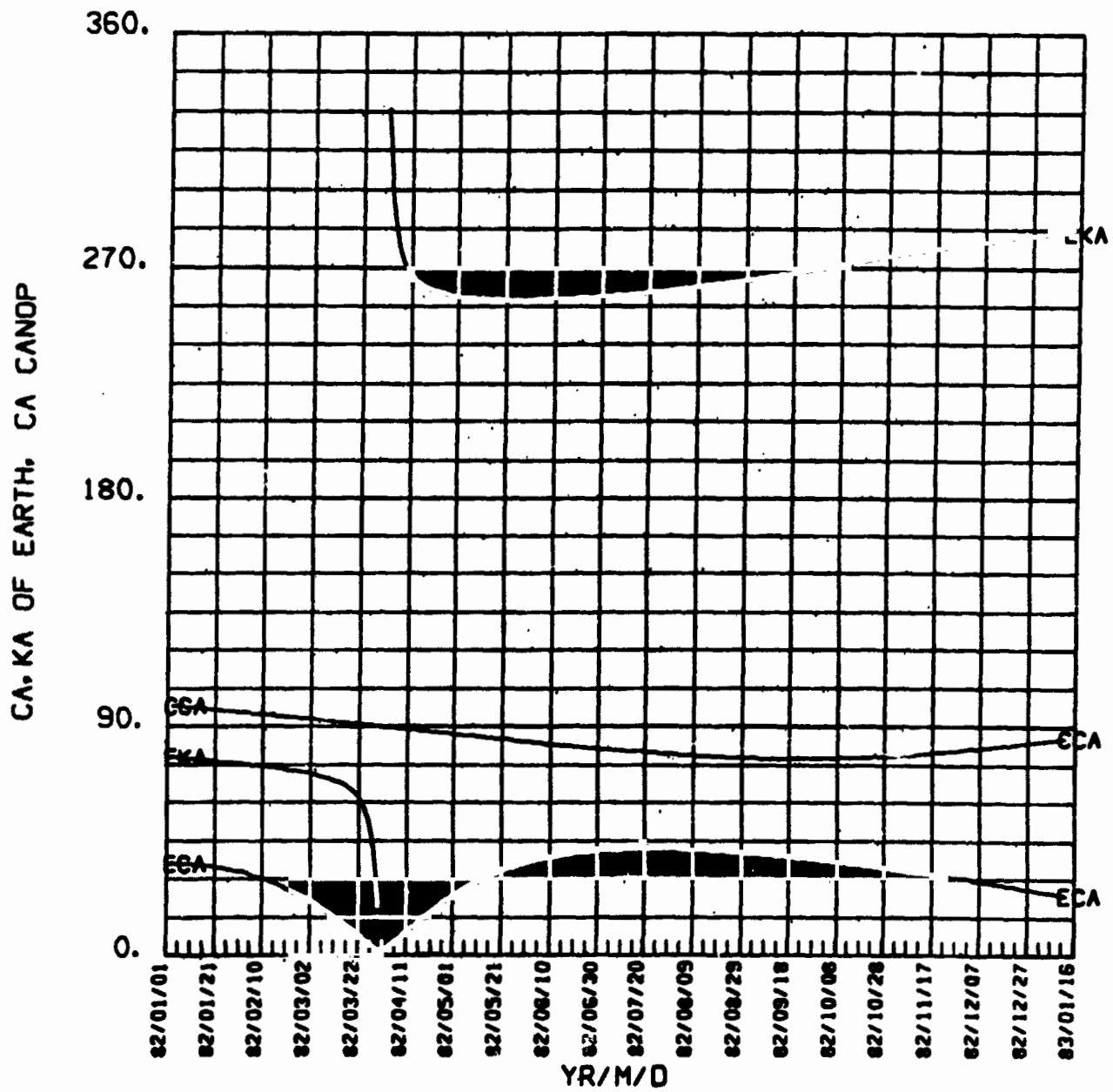
83/01/16
YR/M/D

MARS 1982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YR/M/D
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82/05/01
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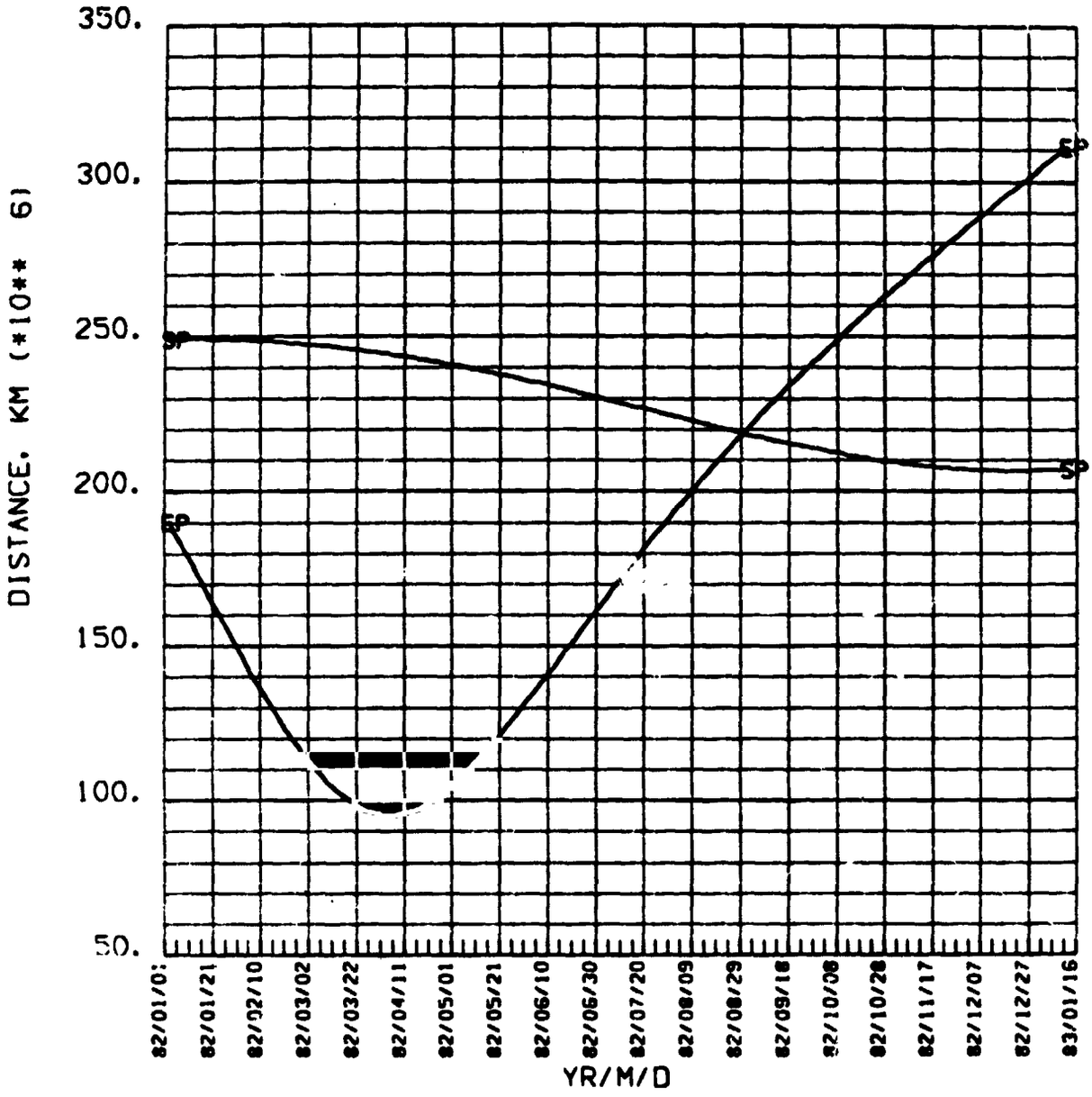
83/01/16

MARS 1982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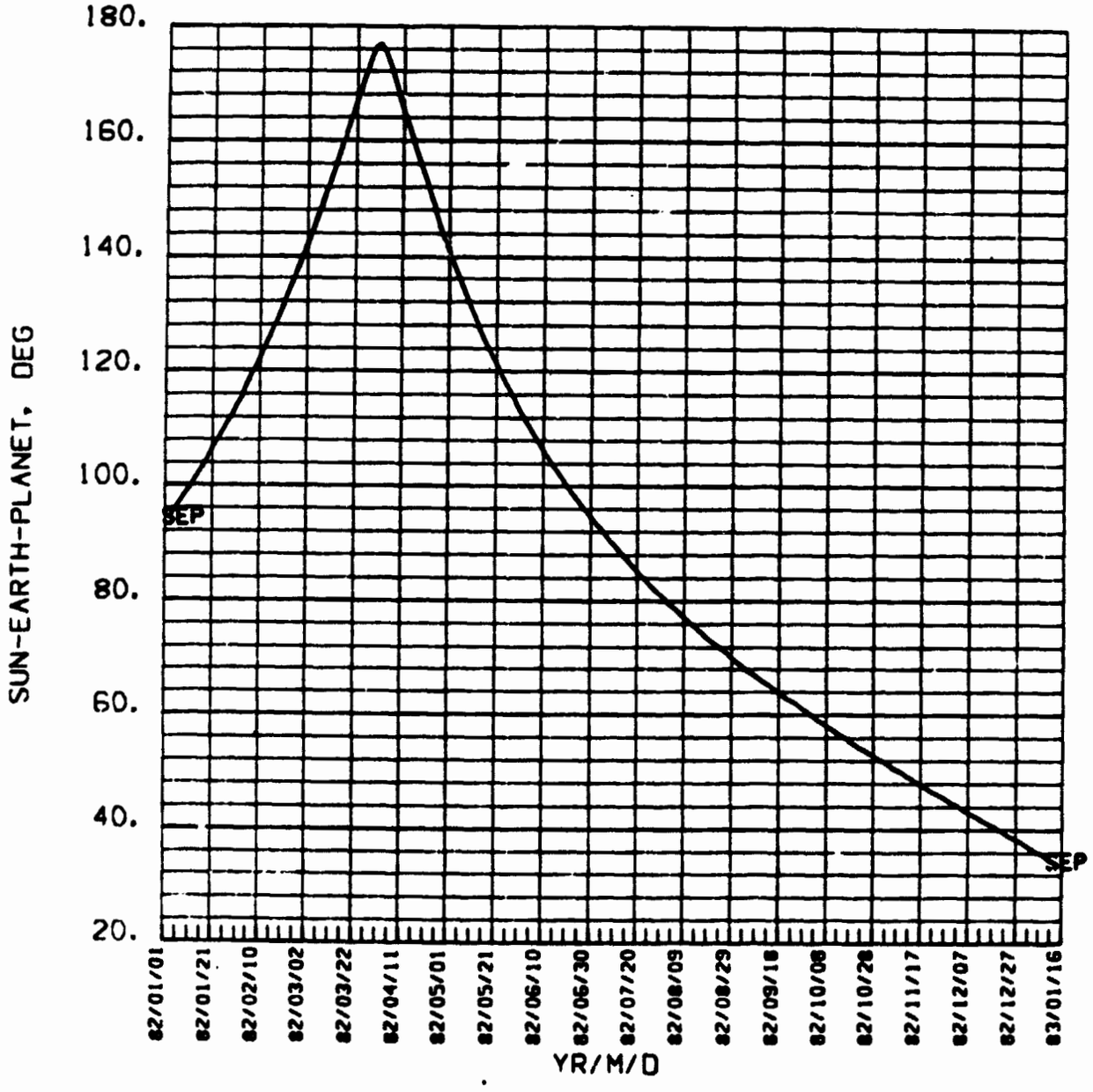
82/12/27
83/01/16
YR/M/D

MARS 1982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120.
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20.
SUN-EARTH-PLANET, DEG
SEP
SEP
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82/02/10
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82/05/01
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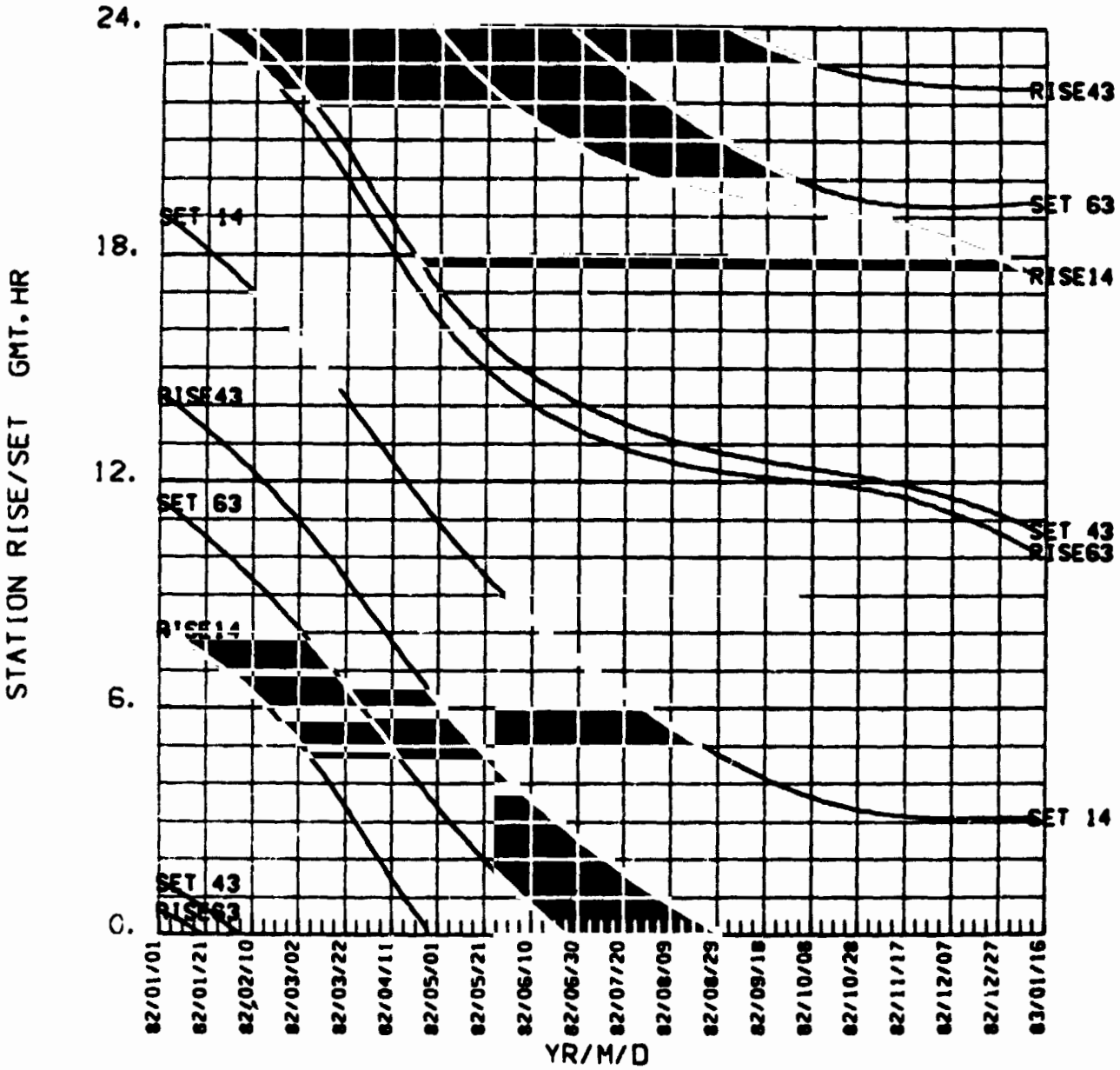
83/01/16
YR/M/D

MARS 1982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RISE43
SET 63
RISE14
SET 14
RISE43
SET 63
SET 43
RISE63
SET 14
SET 43
RISE63
82/01/01
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82/04/11
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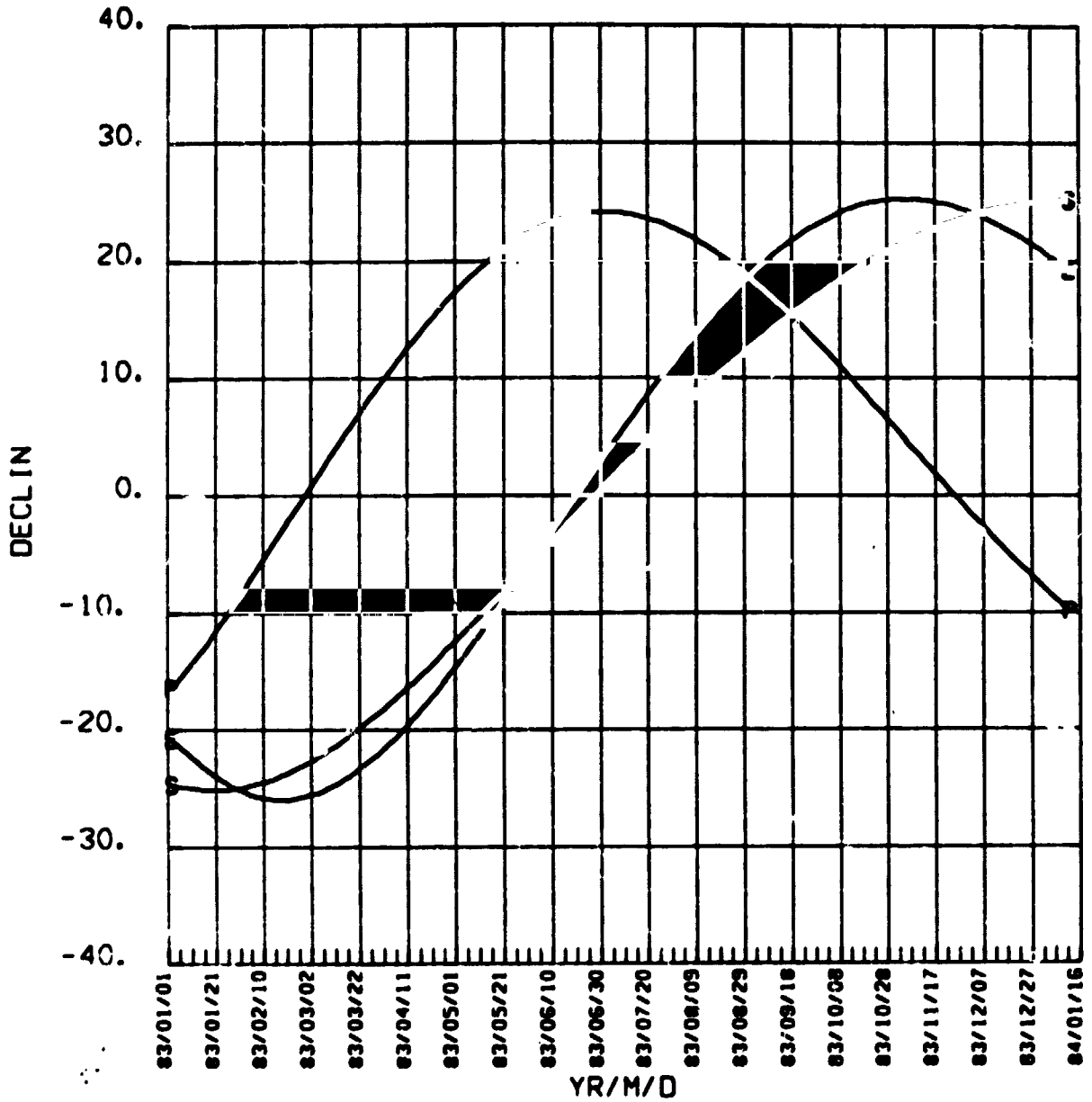
82/12/27
83/01/16
YR/M/D

MARS 1983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10.
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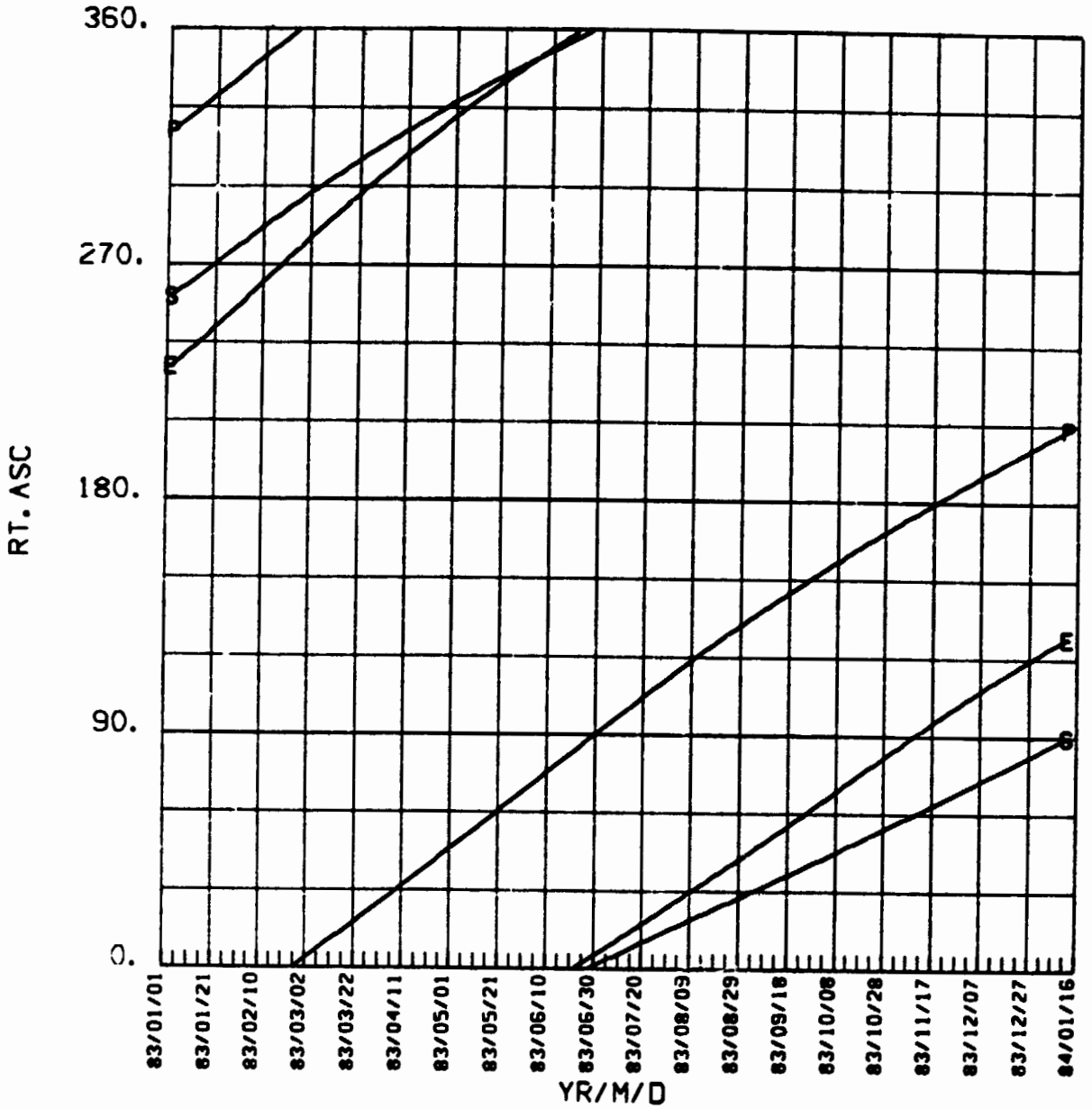
84/01/16
YR/M/D

MARS 1983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270.
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90.
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RT. ASC
83/01/01
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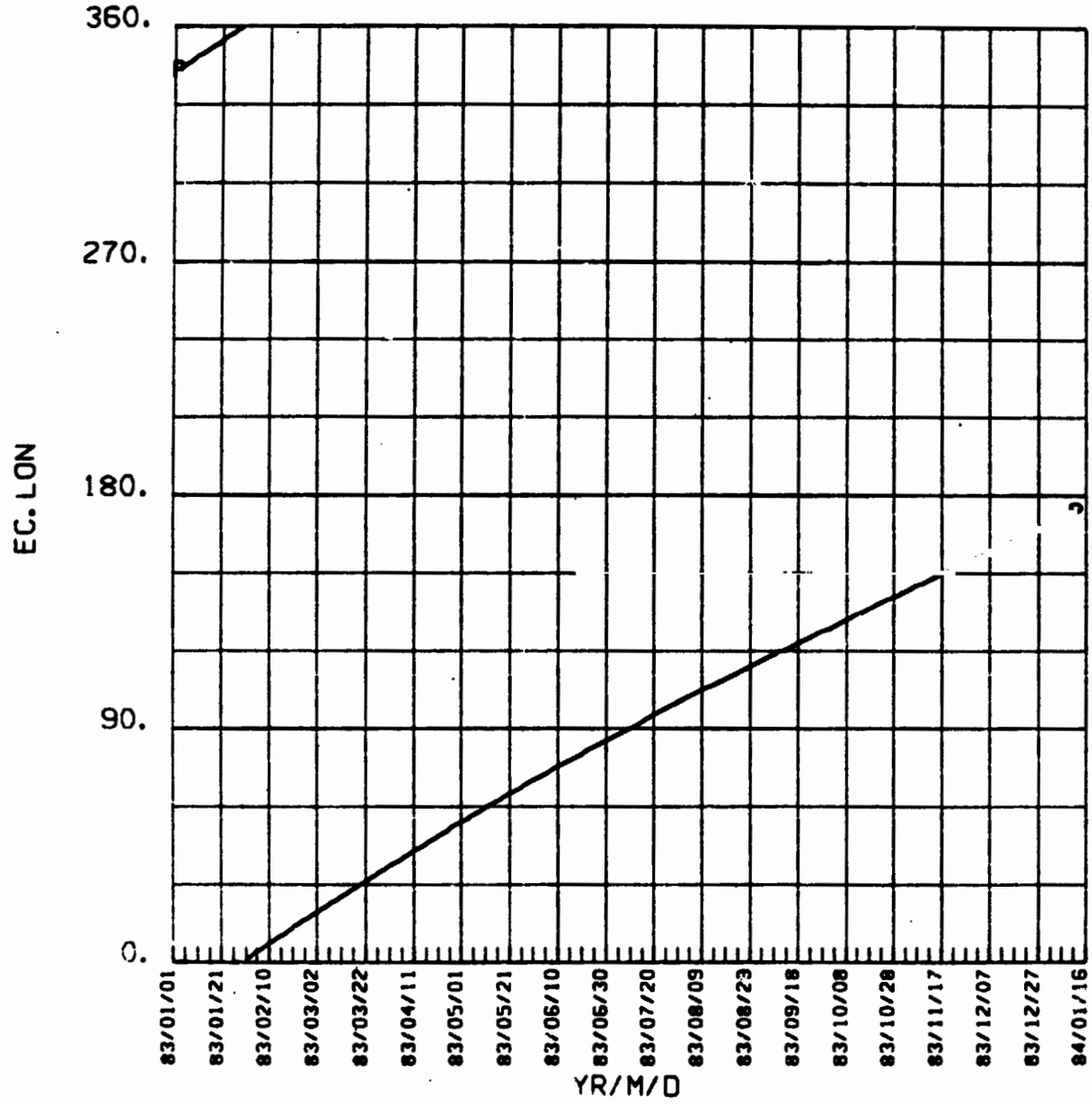
84/01/16
YR/M/D

MARS 1983


360.
270.
180.
90.
0.
EC. LON
83/01/01
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83/03/22
83/04/11
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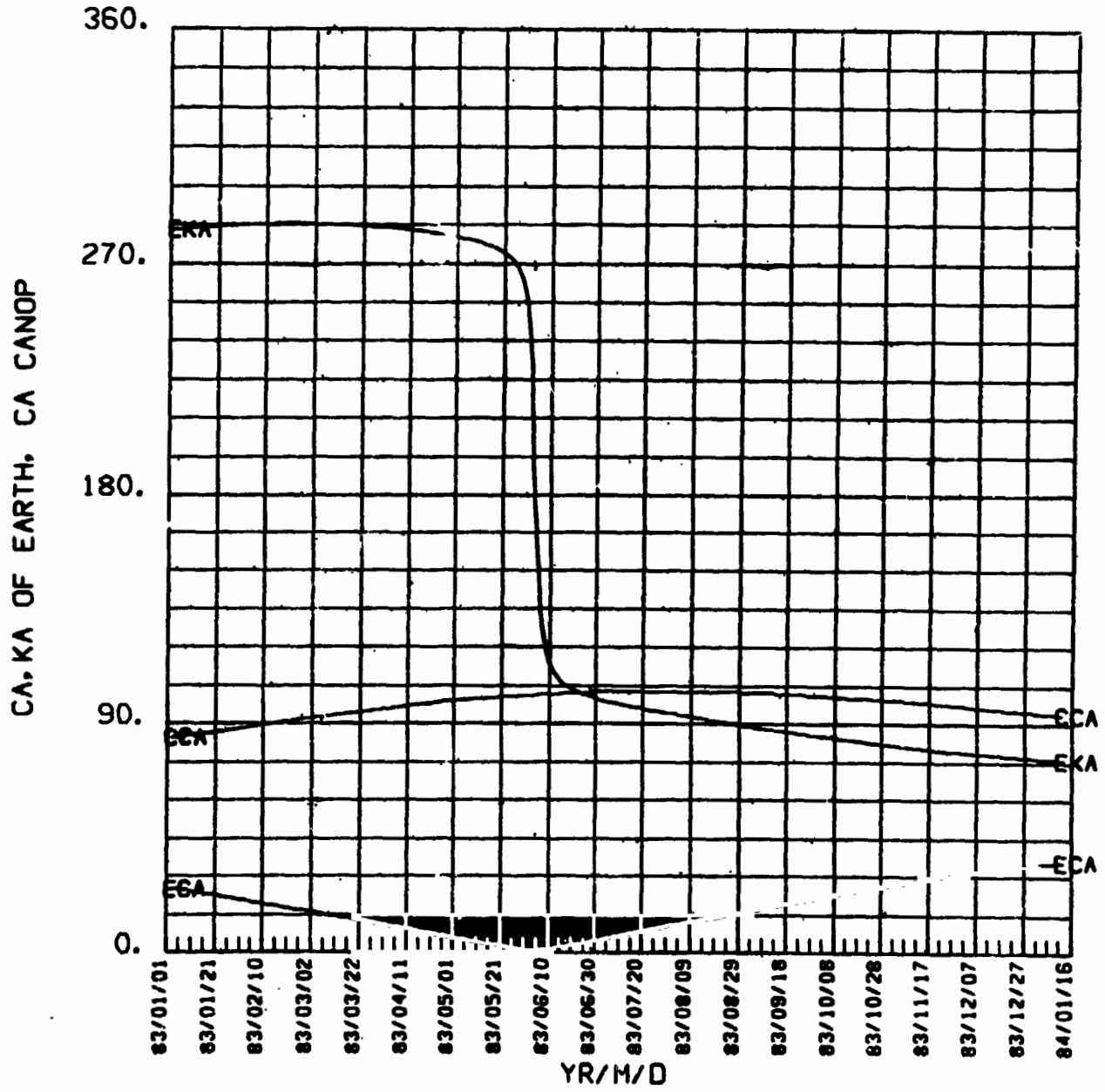
84/01/16
YR/M/D

MARS 1983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CA, KA OF EARTH, CA CANOP
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EKA
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83/01/01
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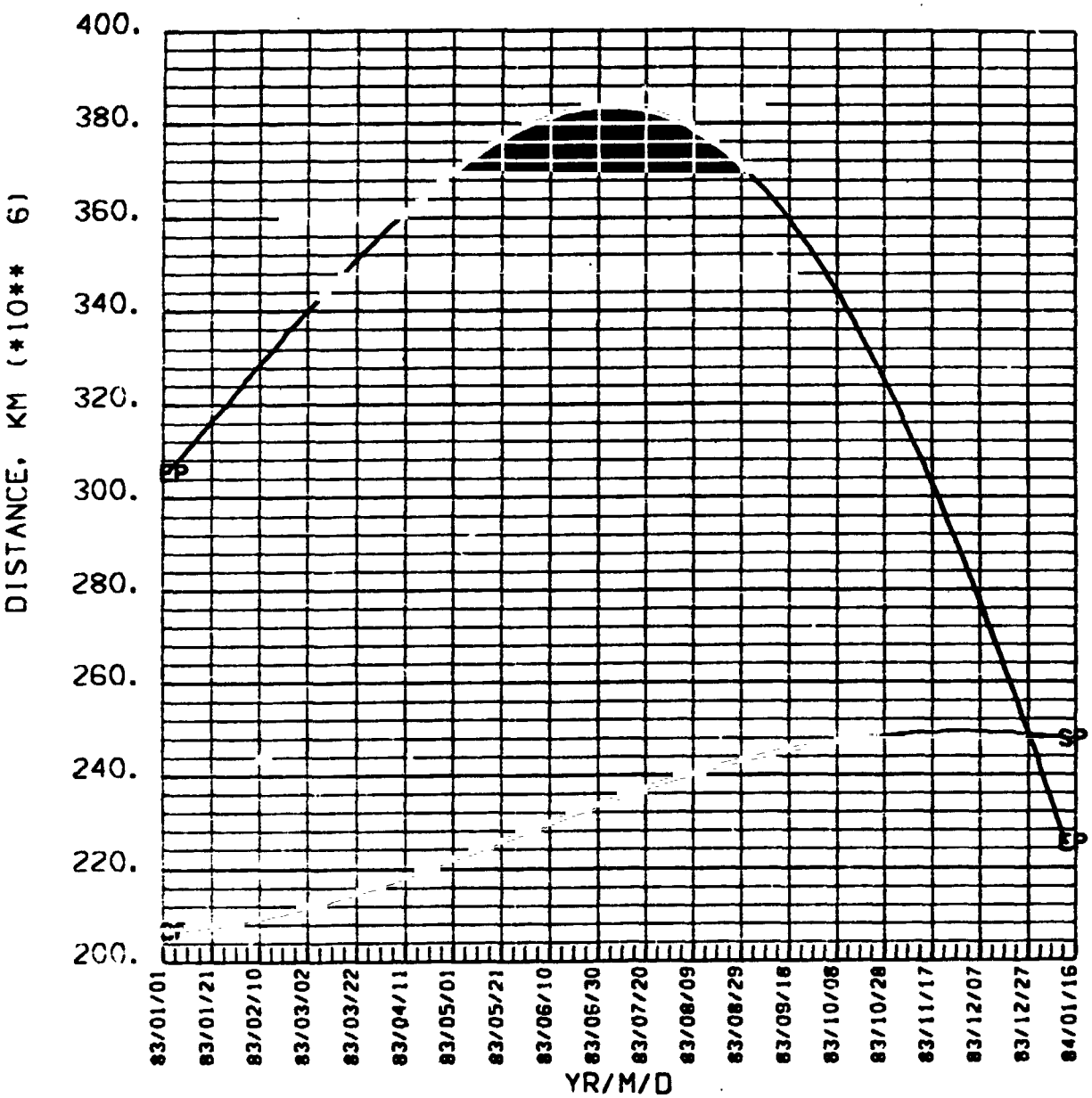
84/01/16
YR/M/D

MARS 1983


DISTANCE, KM (*10** 6)
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380.
360.
340.
320.
300.
280.
260.
240.
220.
200.
83/01/01
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83/04/11
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83/06/10
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83/07/20
83/08/09
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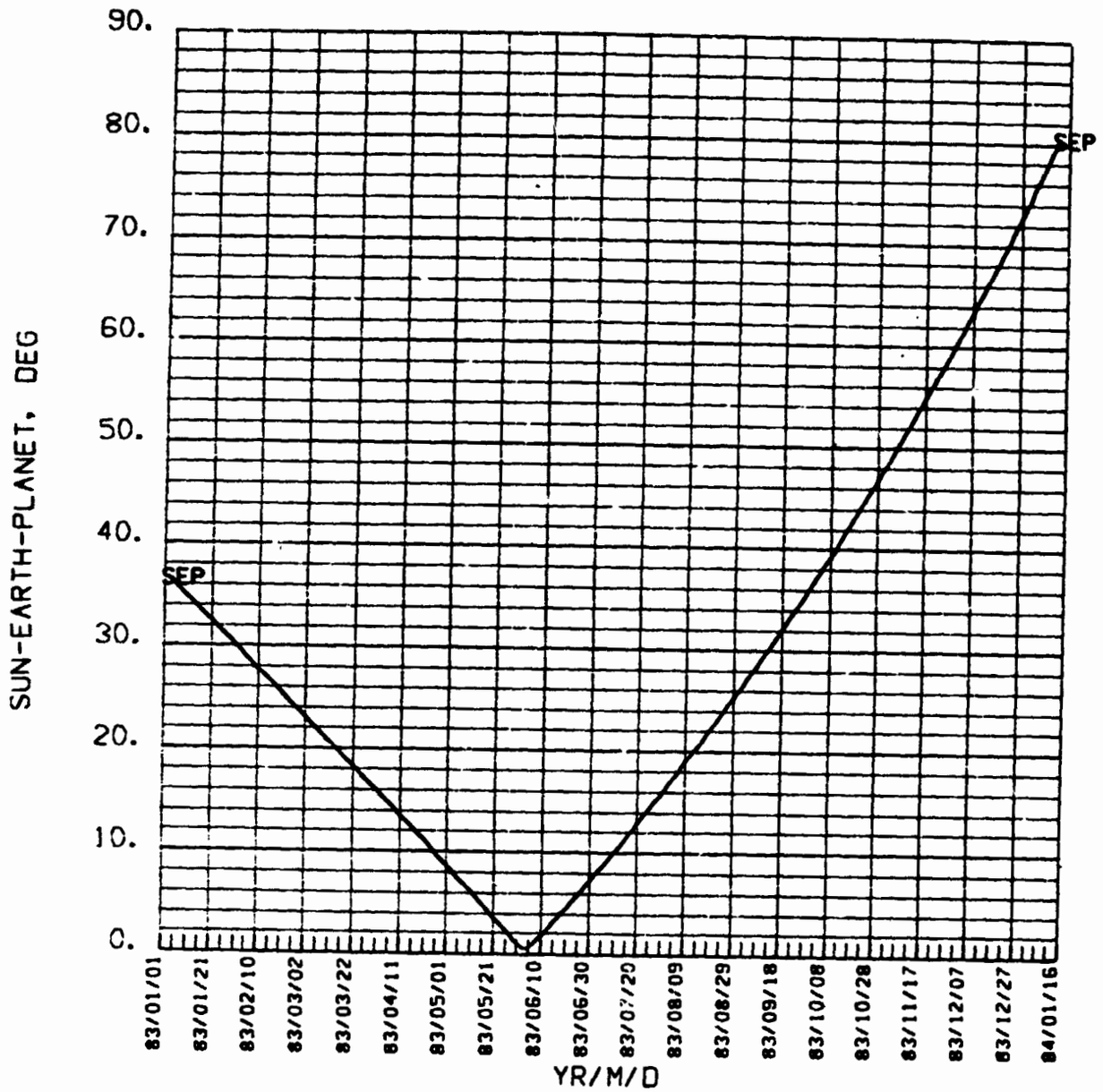
84/01/16
YR/M/D

MARS 1983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70.
60.
50.
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10.
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SUN-EARTH-PLANET, DEG
SEP
SEP
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83/05/01
83/05/21
83/06/10
83/06/30
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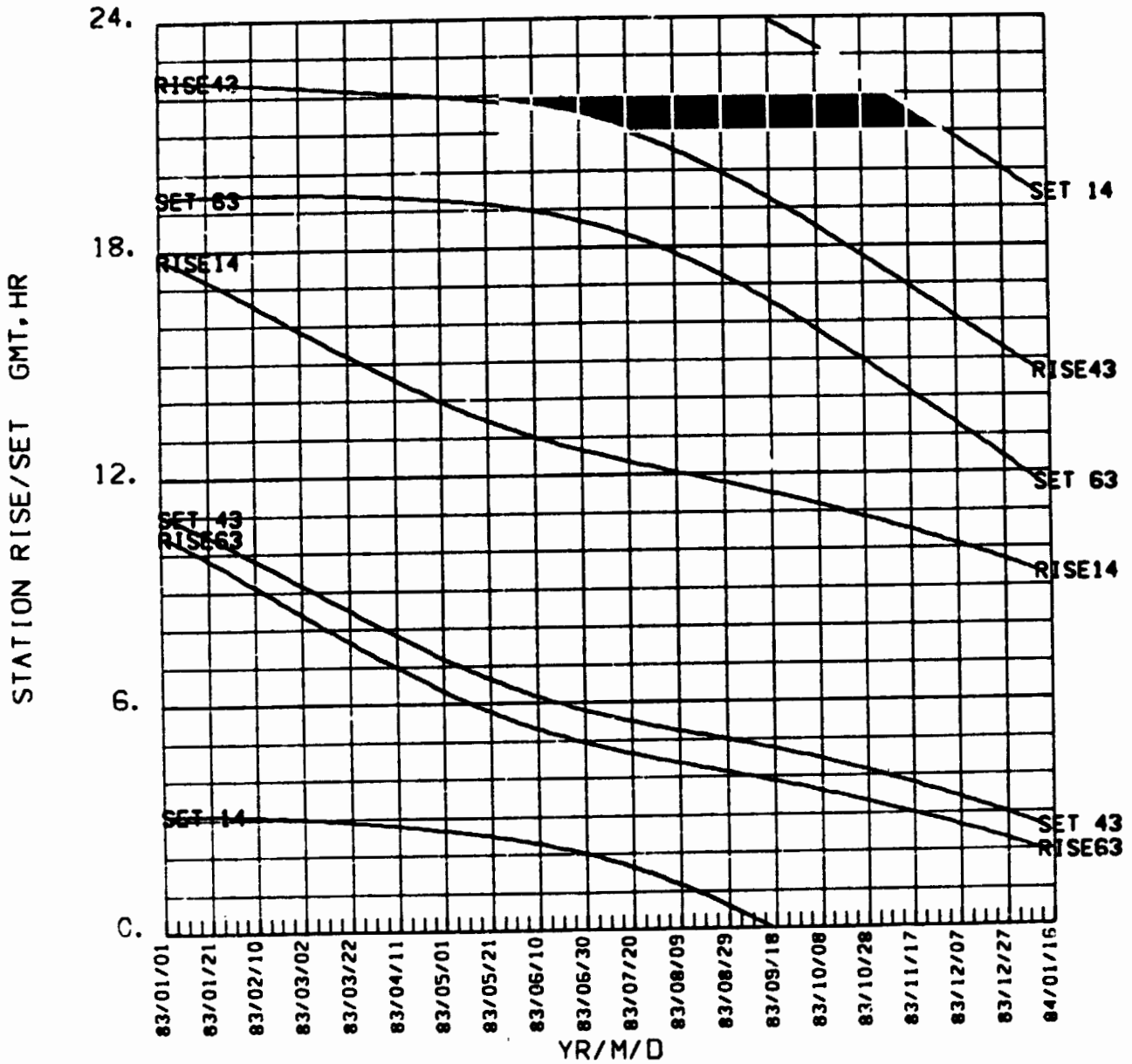
84/01/16
YR/M/D

MARS 1983


24.
18.
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6.
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STATION RISE/SET GMT.HR
RISE43
SET 63
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SET 43
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RISE63
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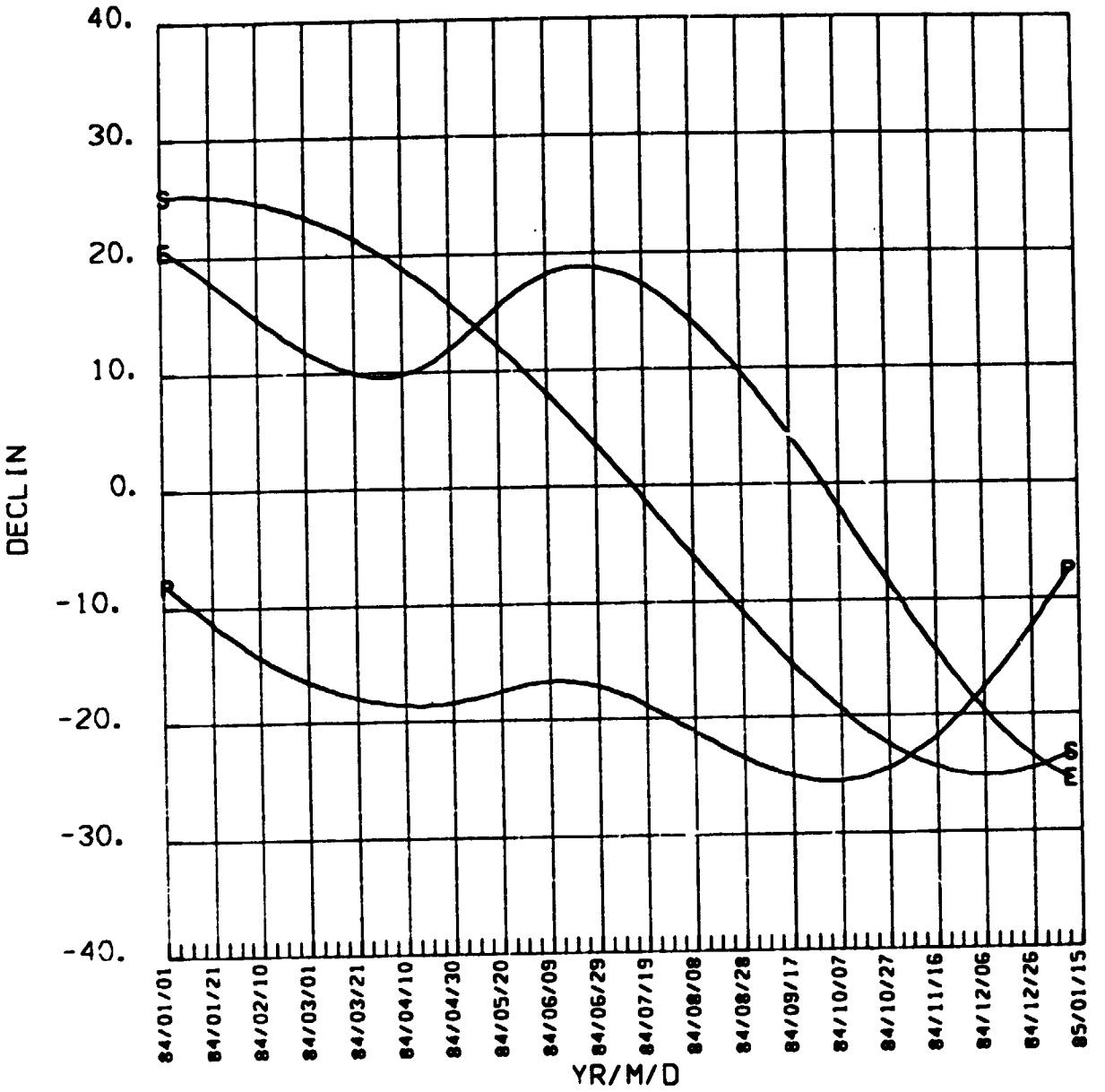
84/01/16
YR/M/D

MARS 1984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DECLIN
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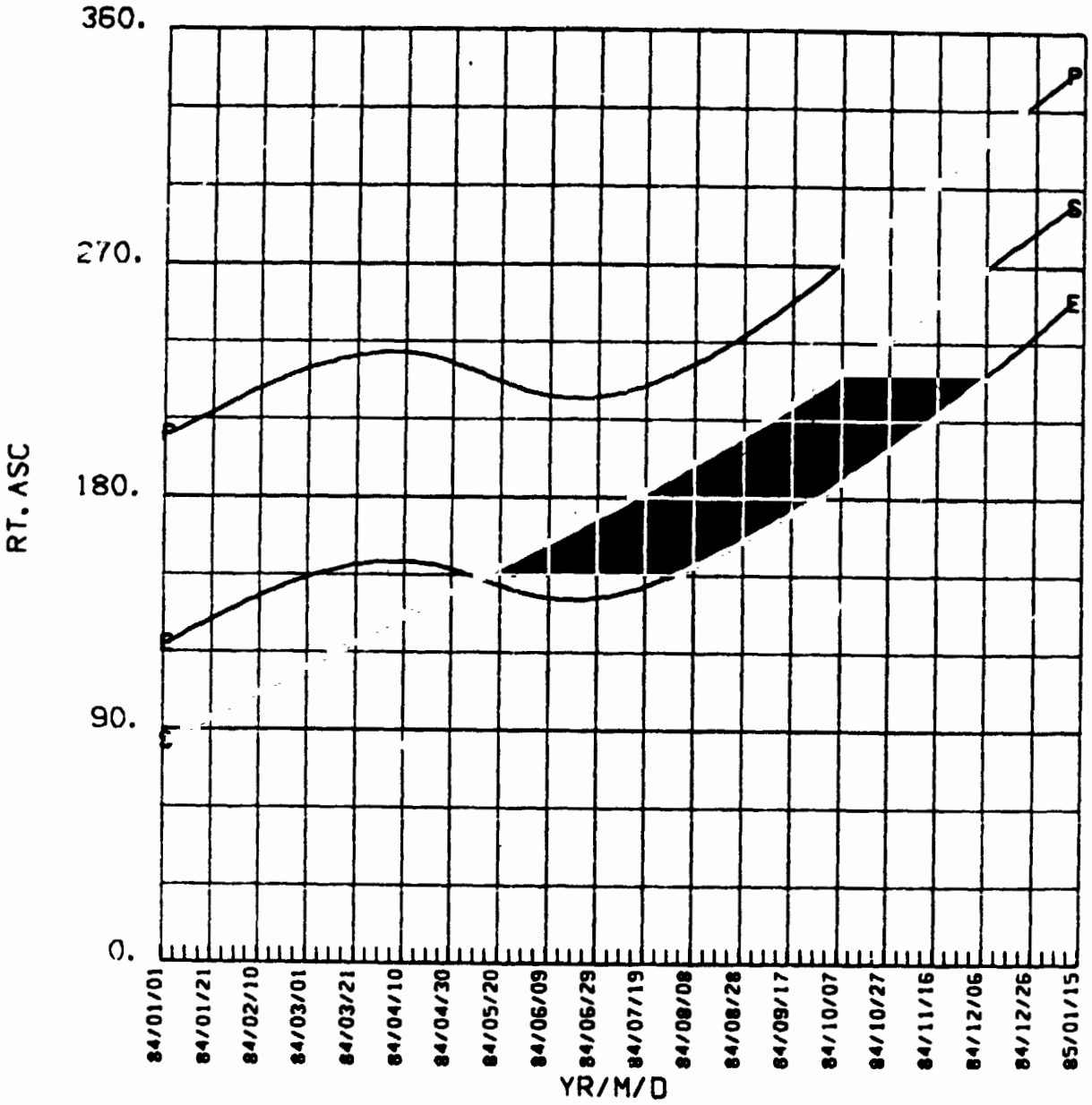
85/01/15
YR/M/D

MARS 1984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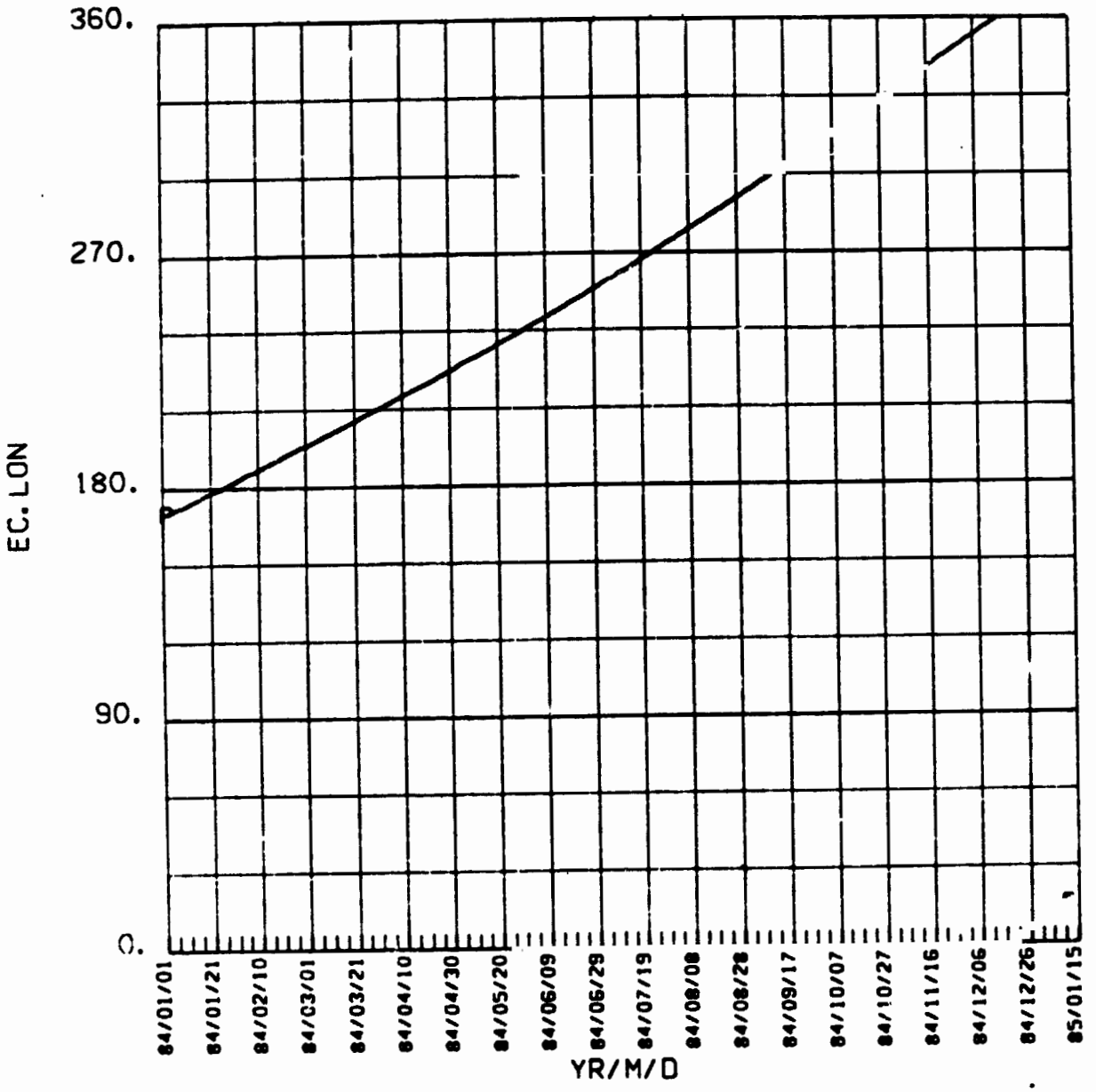
YR/M/D

MARS 1984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EC. LON
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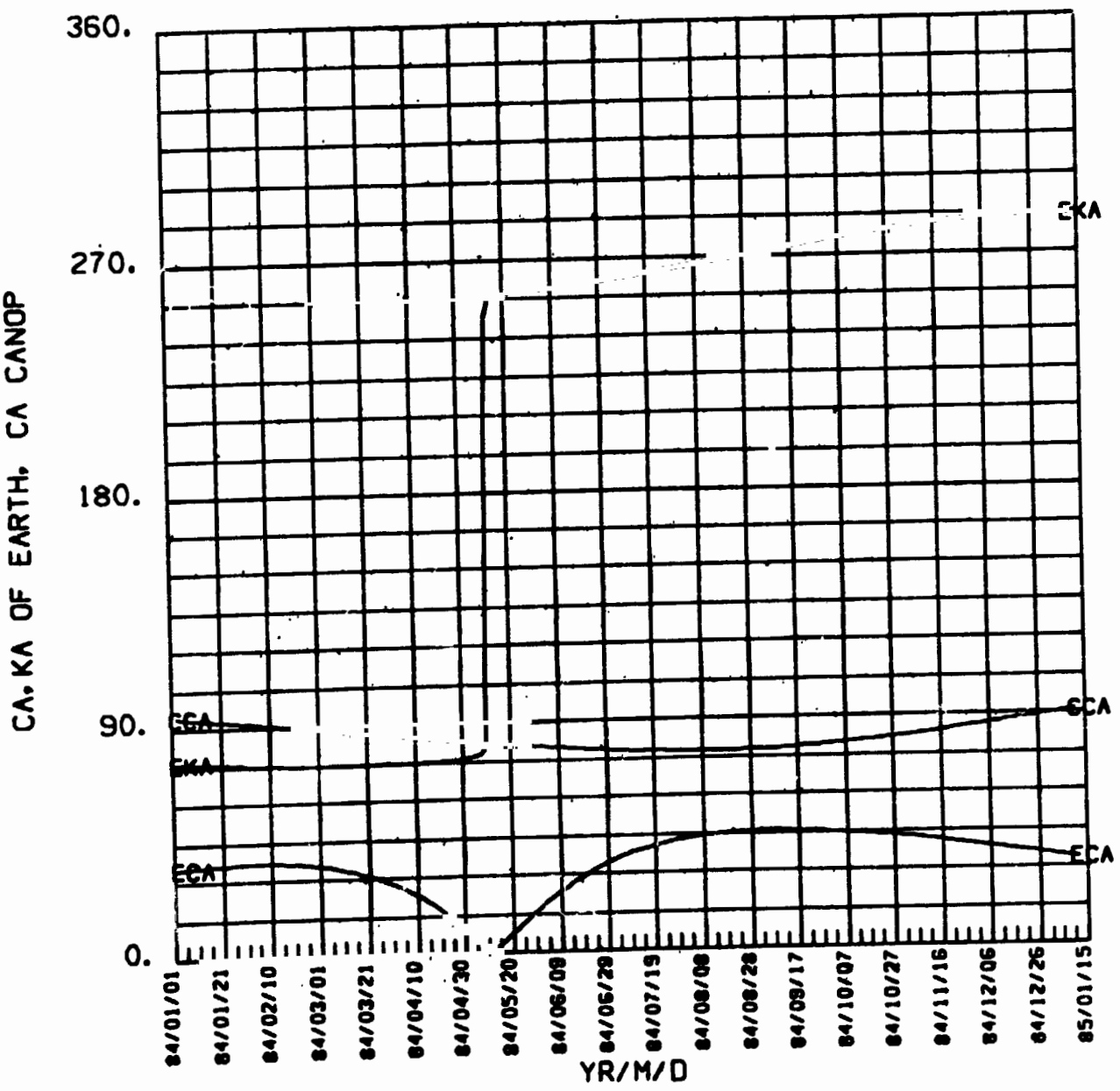
YR/M/D

MARS 1984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CA. KA OF EARTH. CA CANOP
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EGA
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ECA
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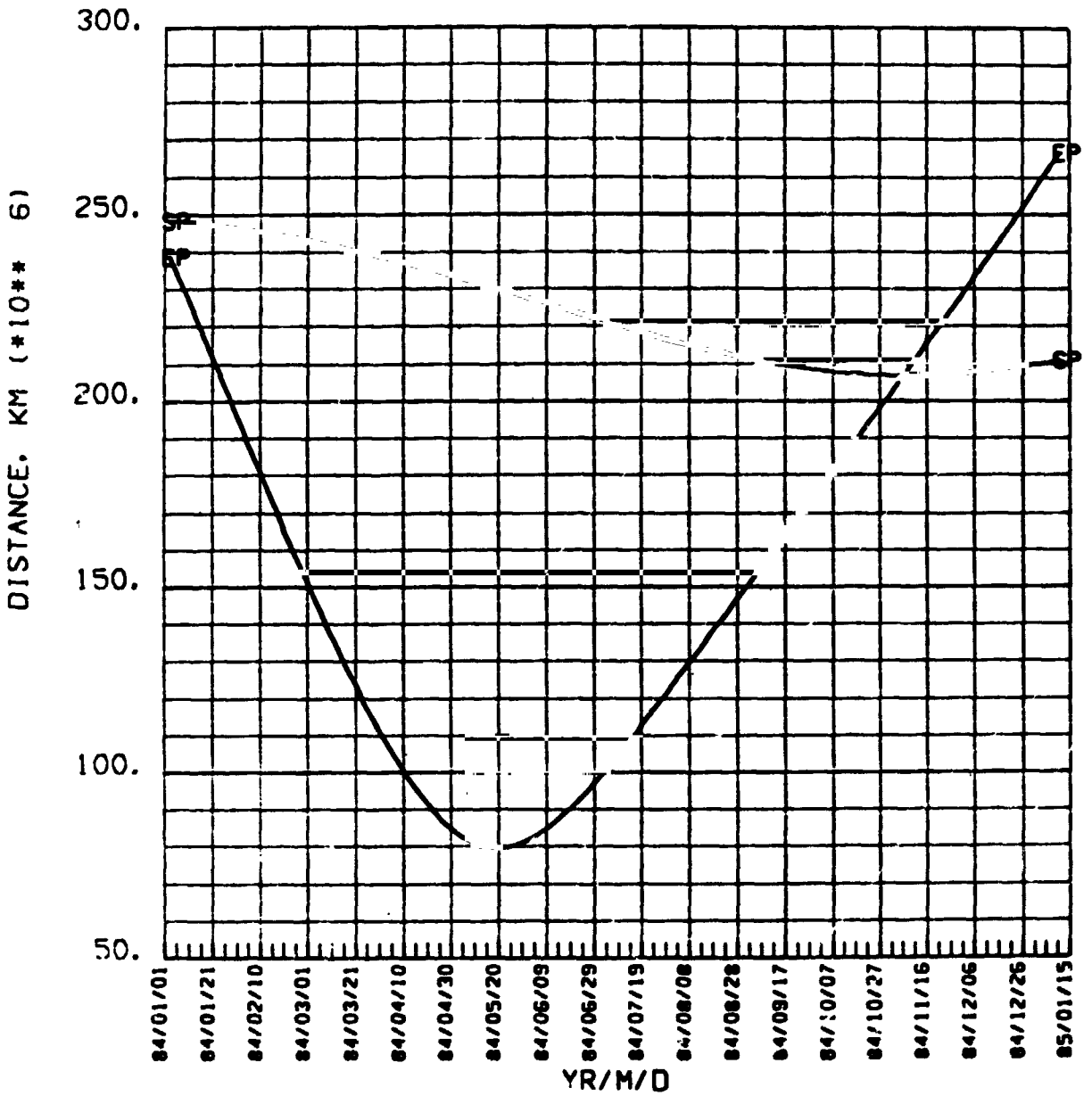
YR/M/D

MARS 1984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DISTANCE, KM (*10** 6)
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EP
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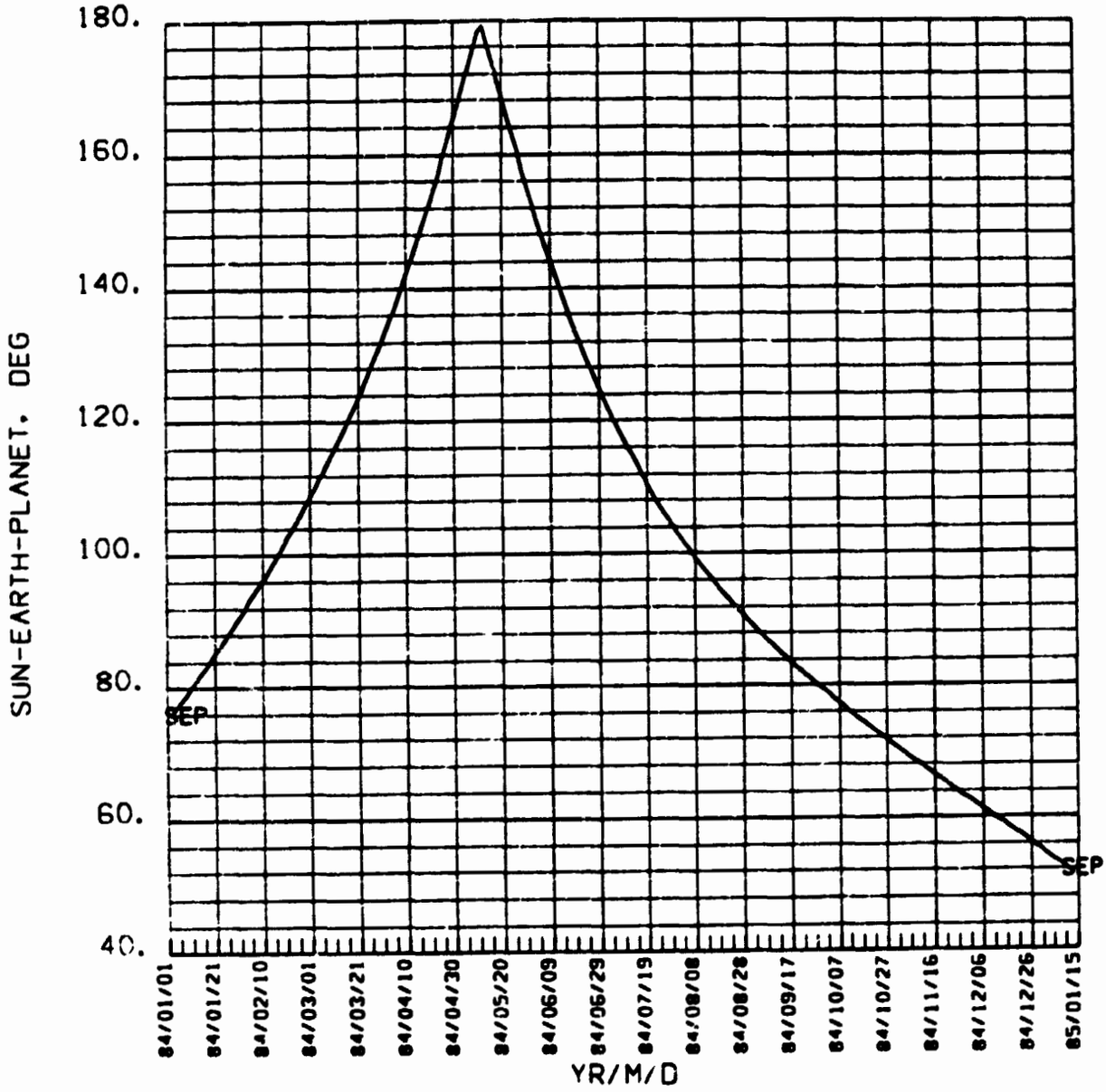
85/01/15
YR/M/D

MARS 1984


180.
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80.
60.
40.
SUN-EARTH-PLANET, DEG
SEP
SEP
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84/03/01
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84/04/30
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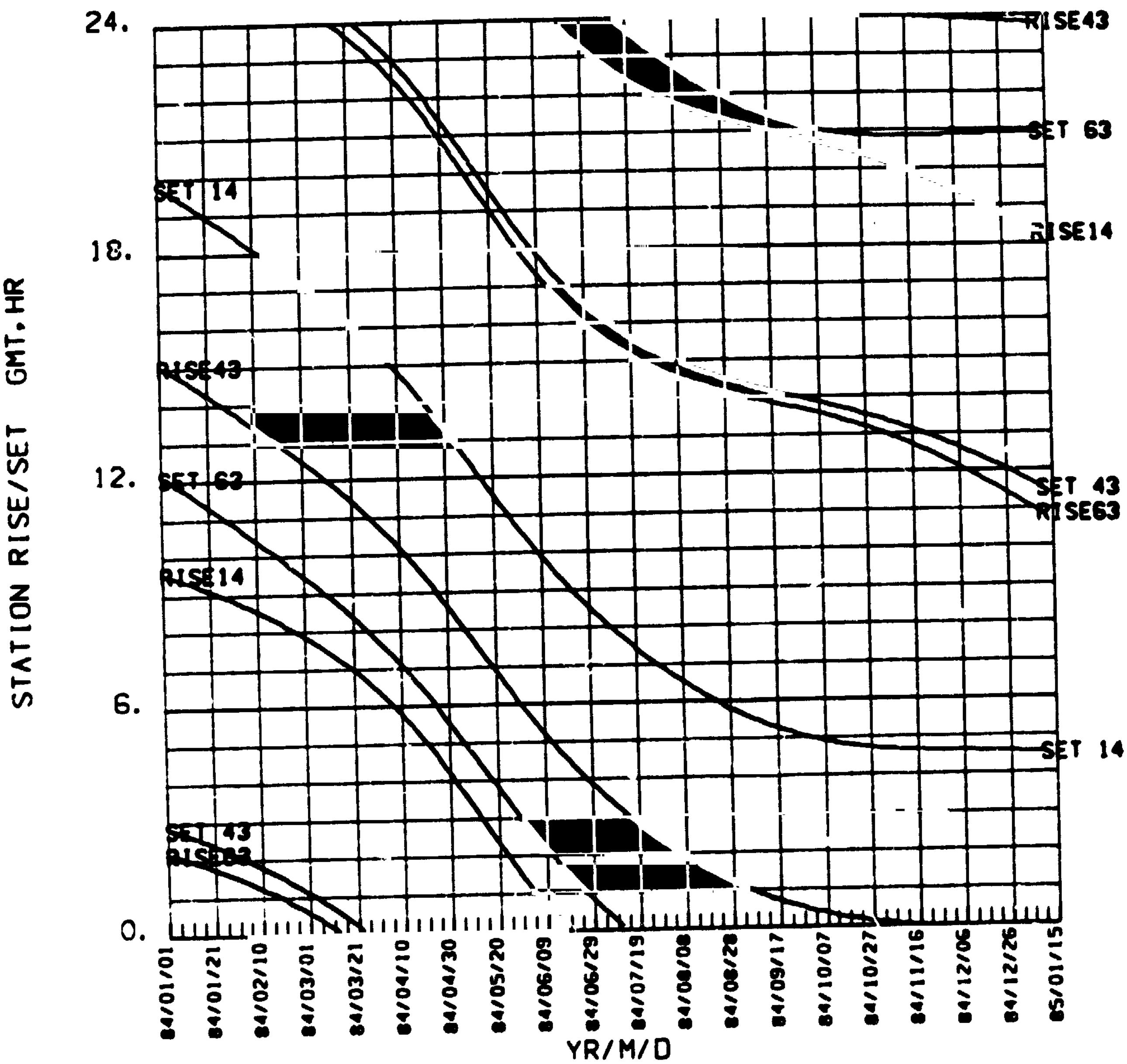
YR/M/D

MARS 1984


RISE43
SET 63
SET 14
RISE14
RISE43
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STATION RISE/SET GMT.HR
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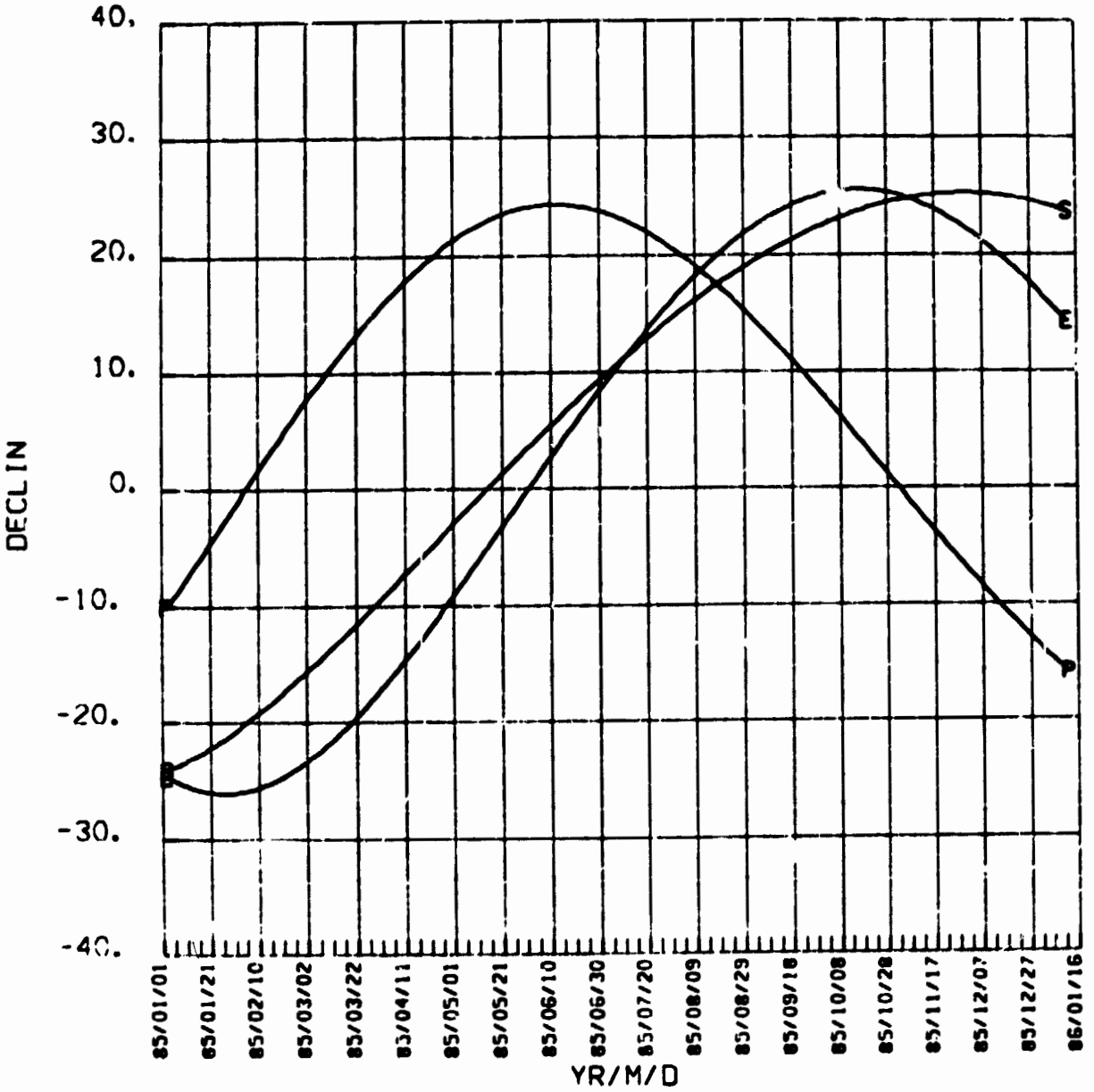
YR/M/D

MARS 1985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DECLIN
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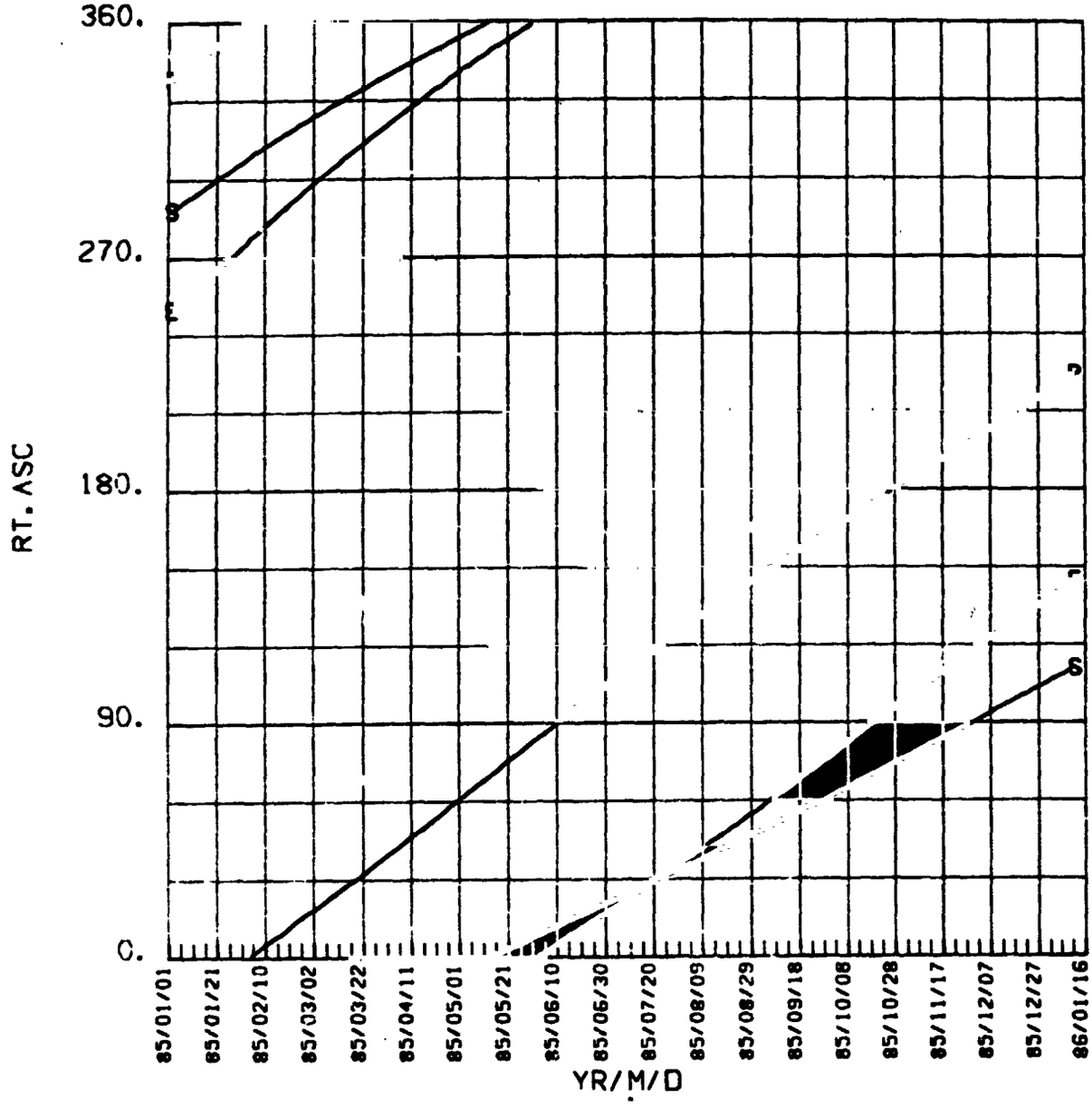
YR/M/D

MARS 1985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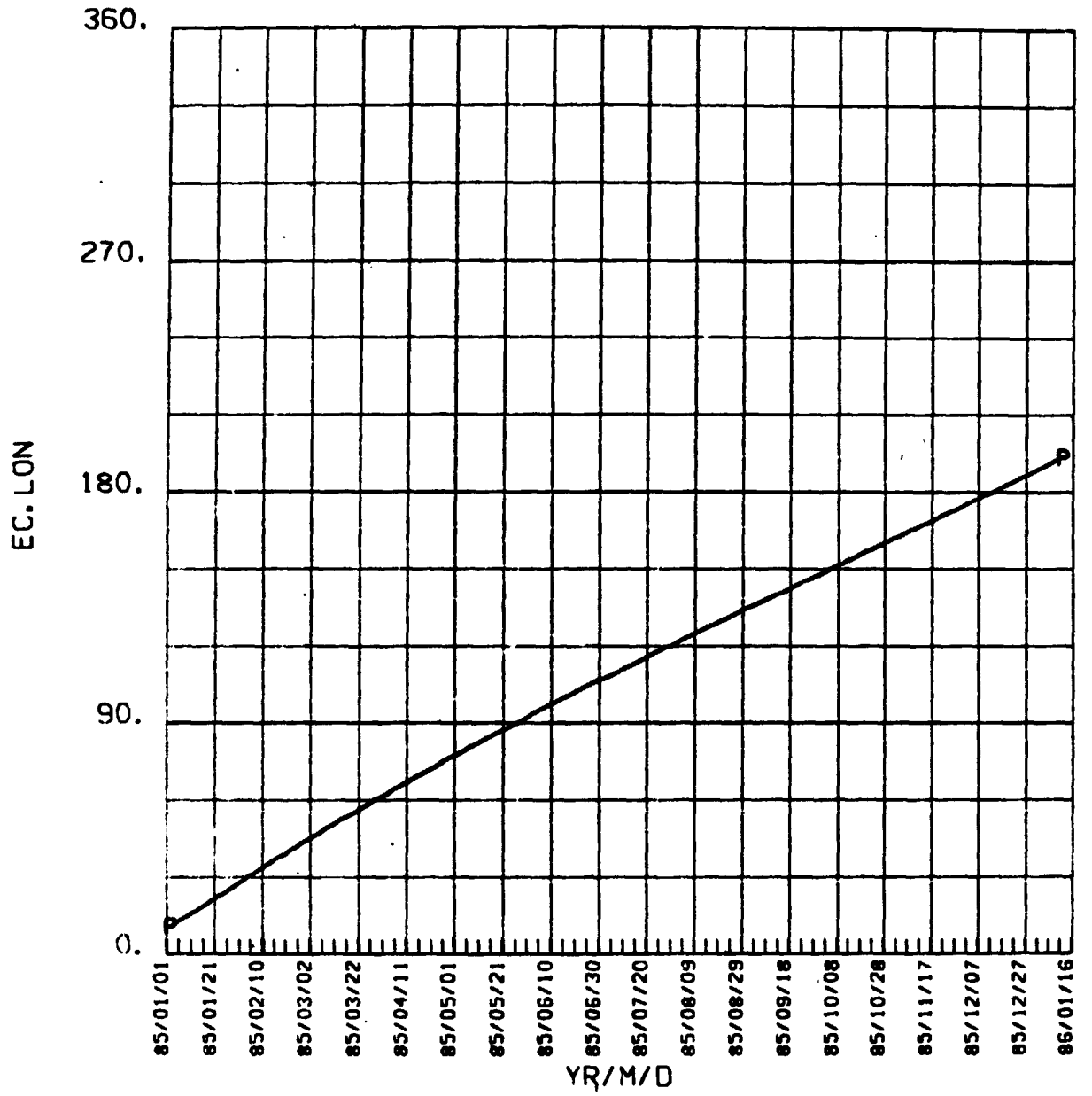
86/01/16
YR/M/D

MARS 1985


360.
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EC. LON
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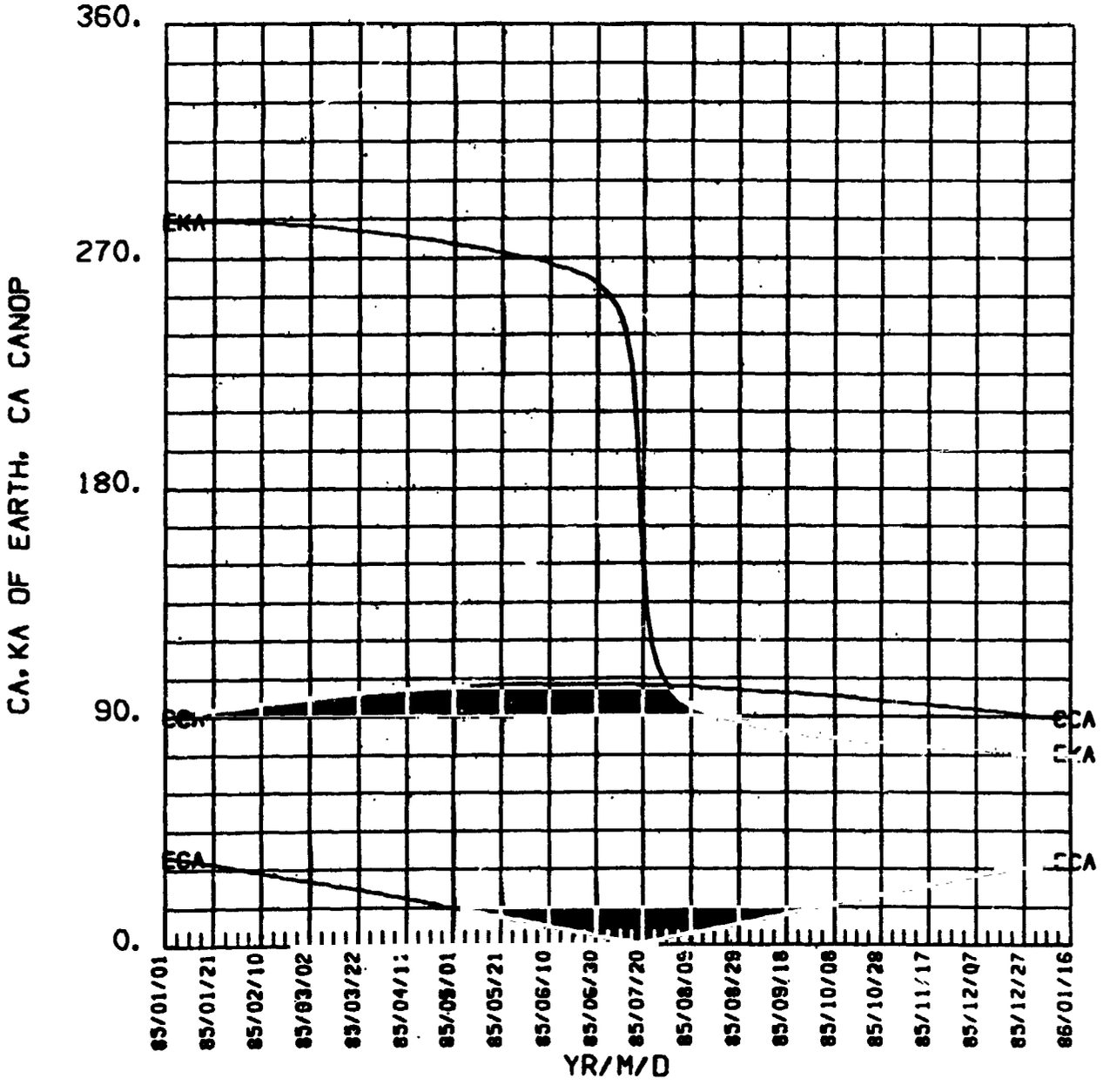
86/01/16
YR/M/D

MARS 1985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CA, KA OF EARTH, CA CANOP
EKA
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85/08/09
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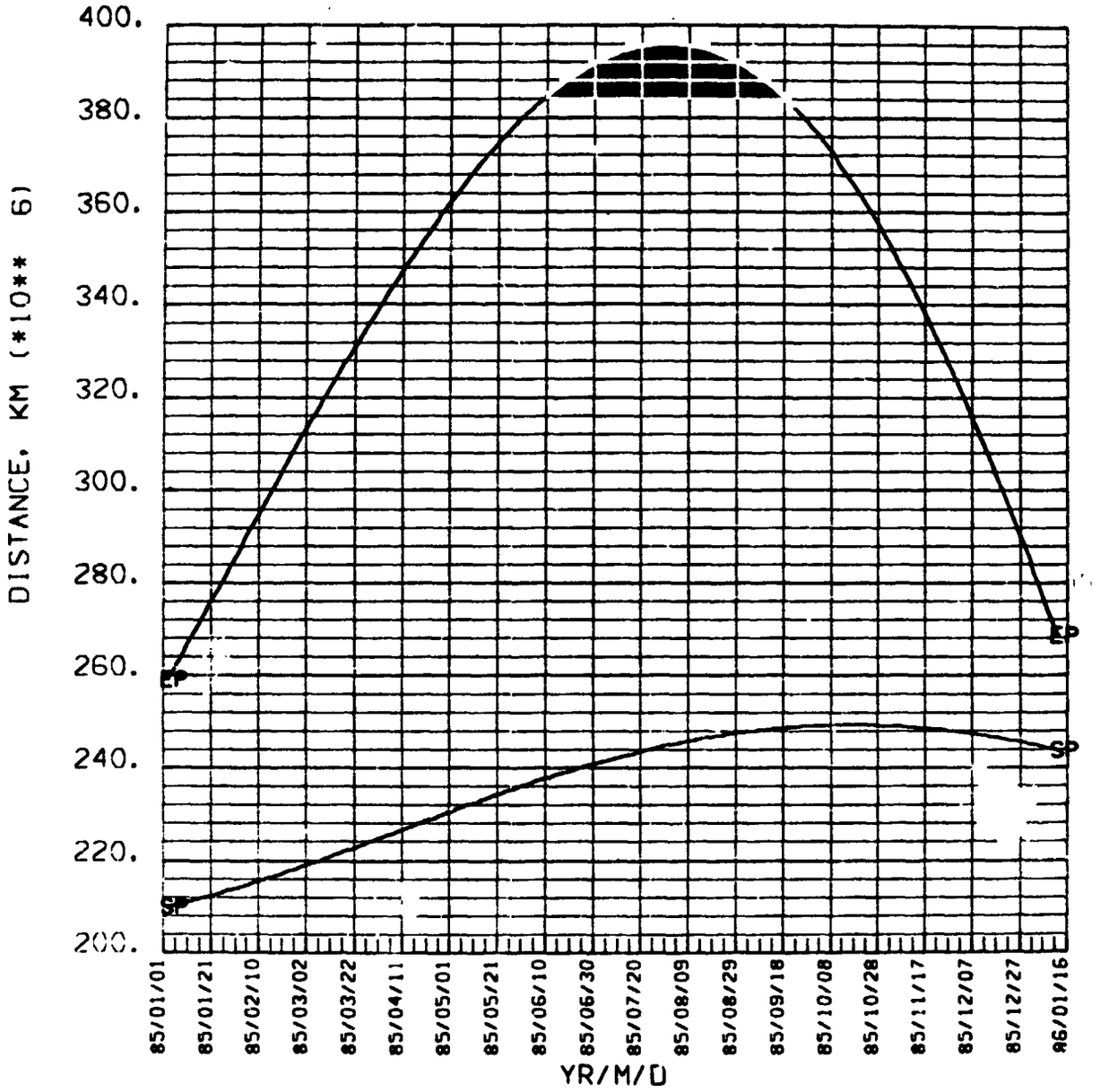
YR/M/D

MARS 1985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220.
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85/01/01
85/01/21
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85/03/02
85/03/22
85/04/11
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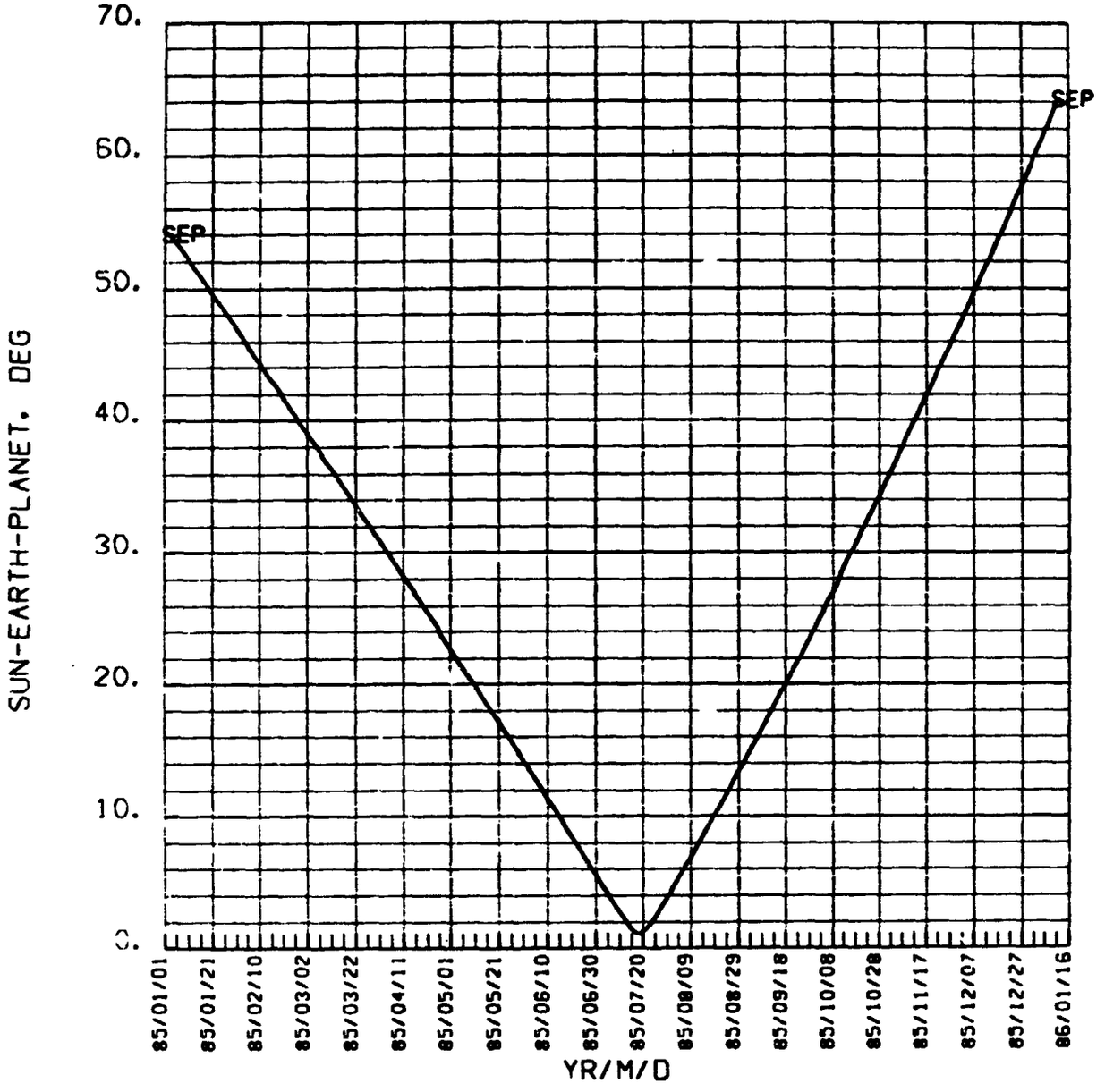
YR/M/D

MARS 1985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SUN-EARTH-PLANET. DEG
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SEP
85/01/01
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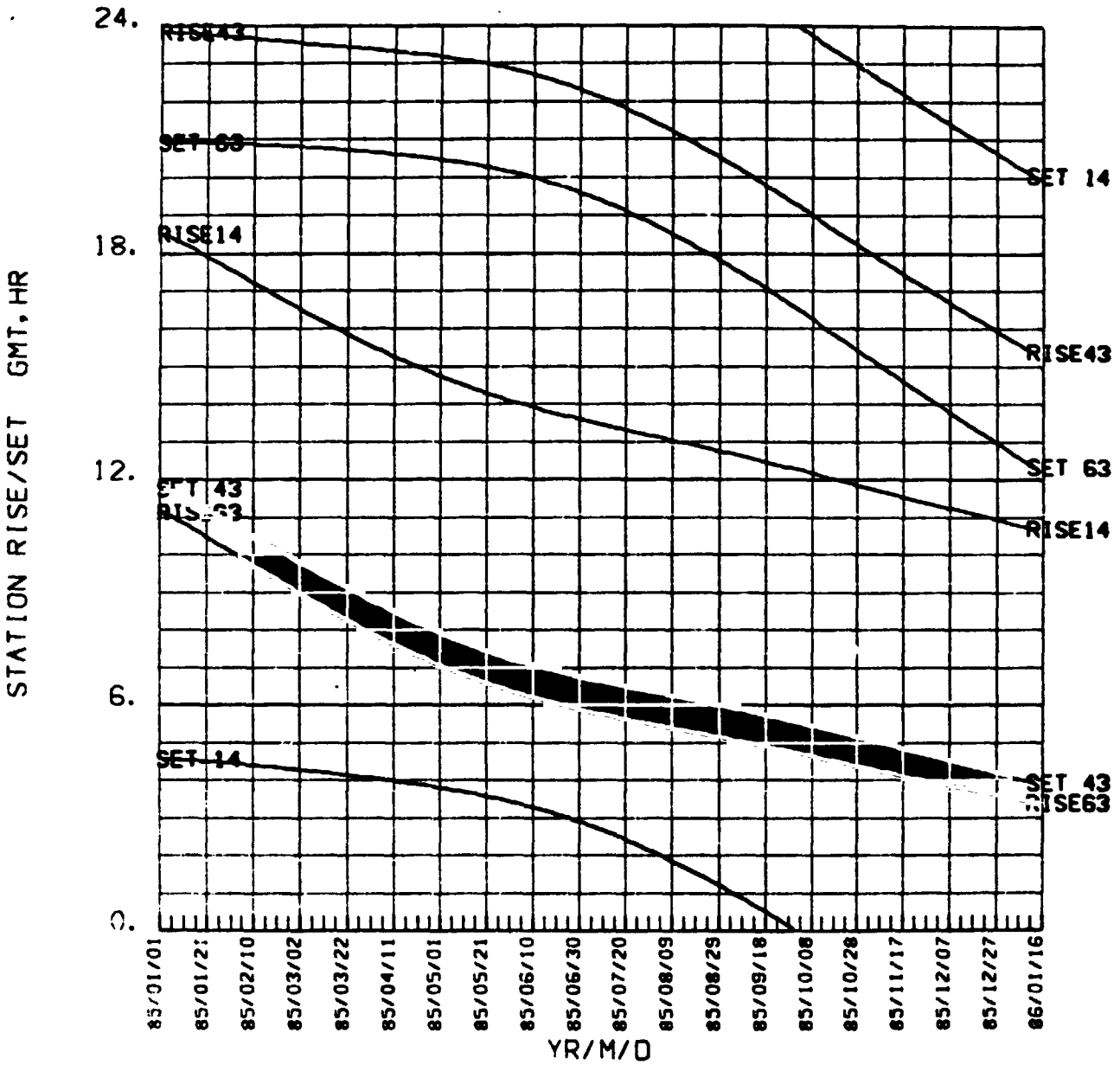
86/01/16
YR/M/D

MARS 1985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6.
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RISE43
SET 63
RISE14
SET 43
RISE63
SET 14
SET 14
RISE43
SET 63
RISE14
SET 43
RISE63
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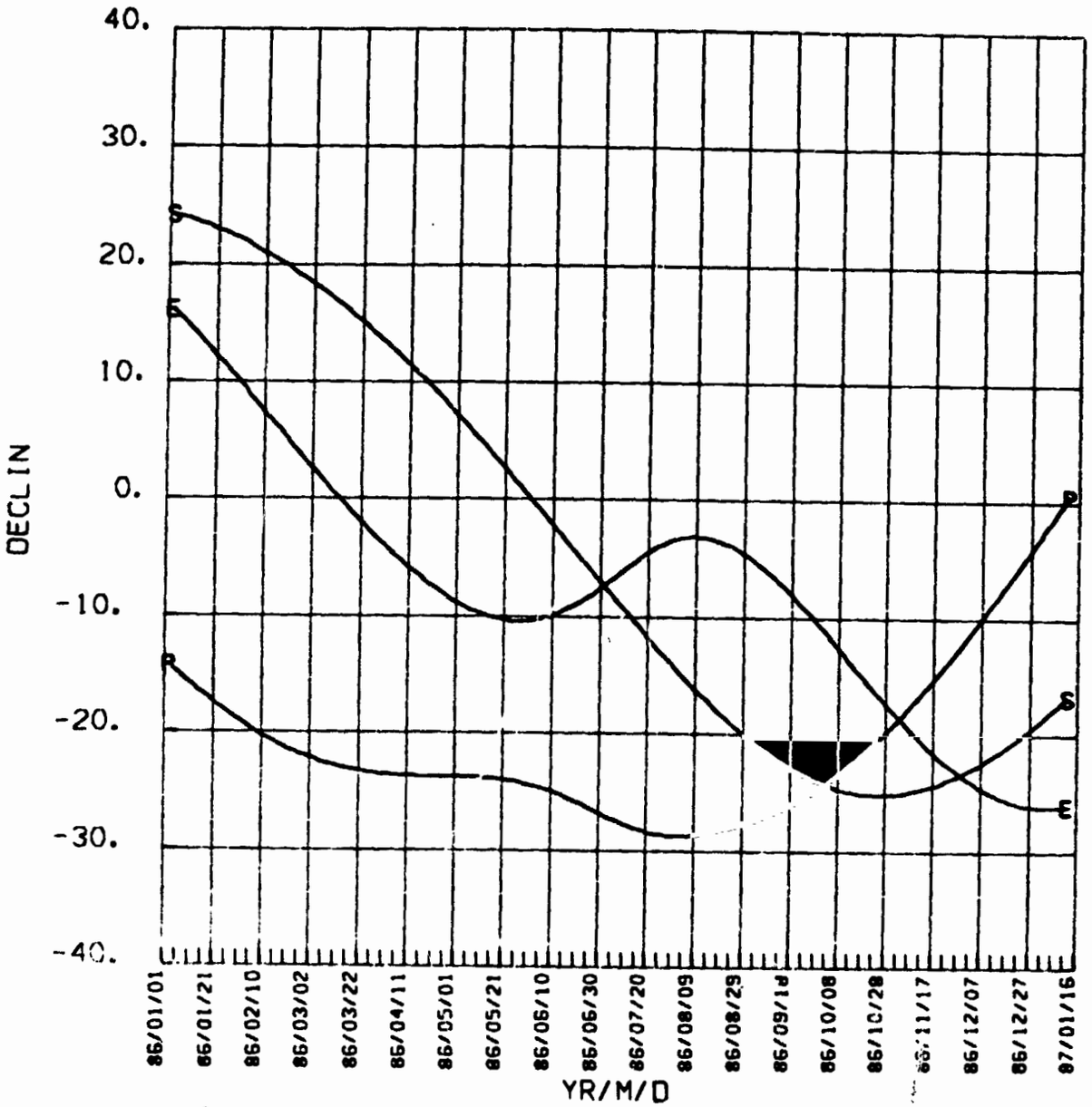
YR/M/D

MARS 1986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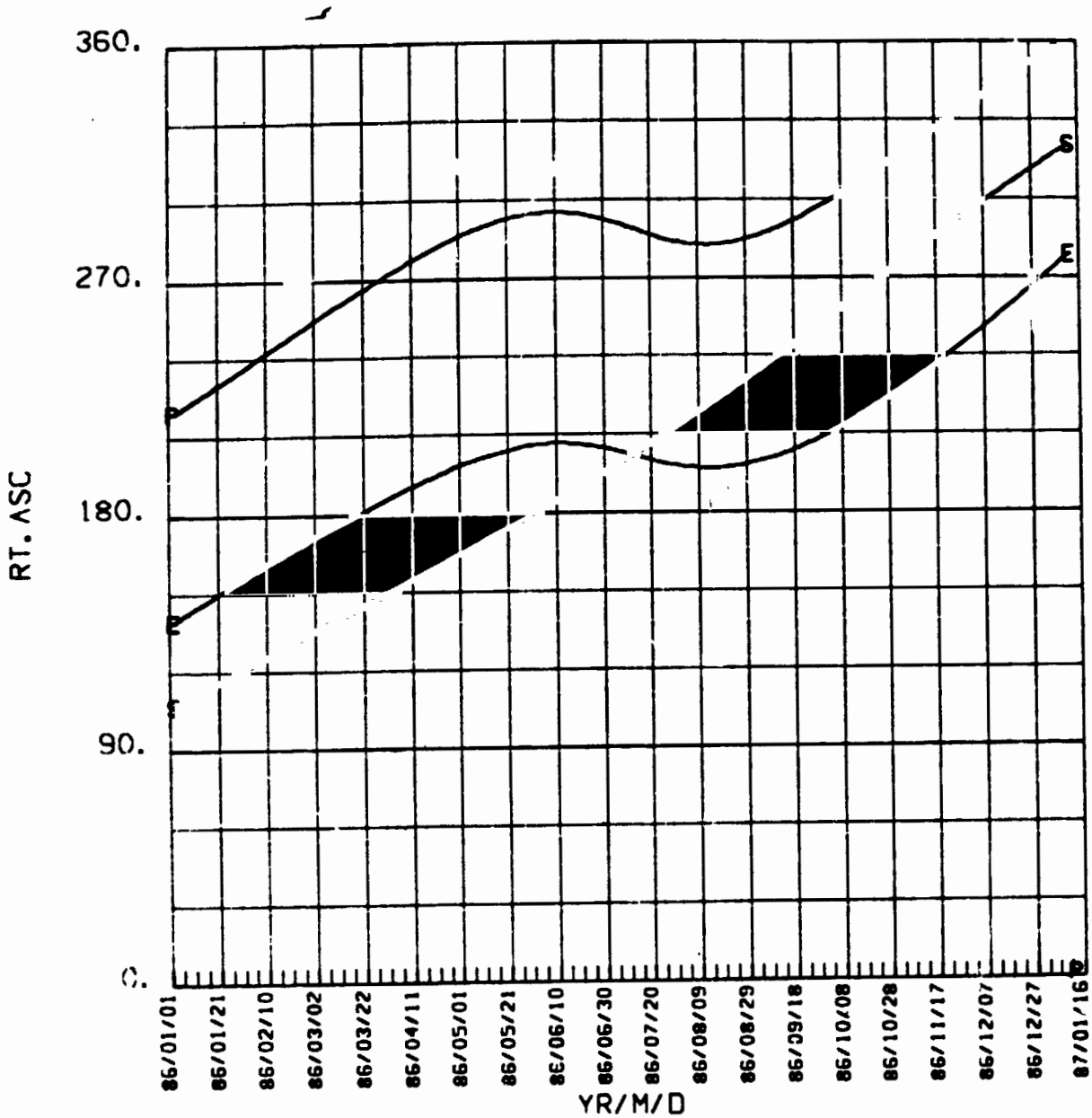
YR/M/D

MARS 1986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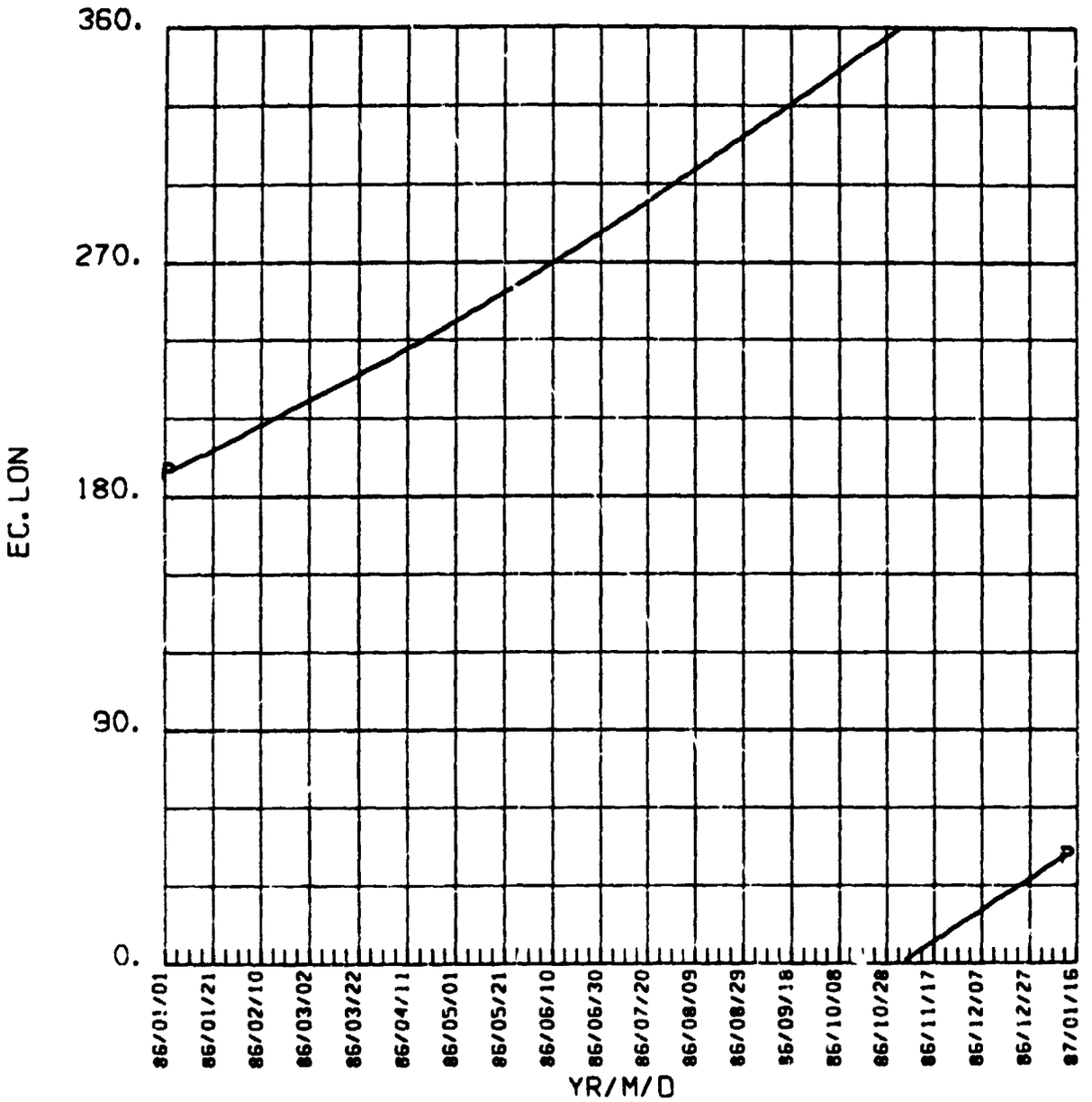
YR/M/D

MARS 1986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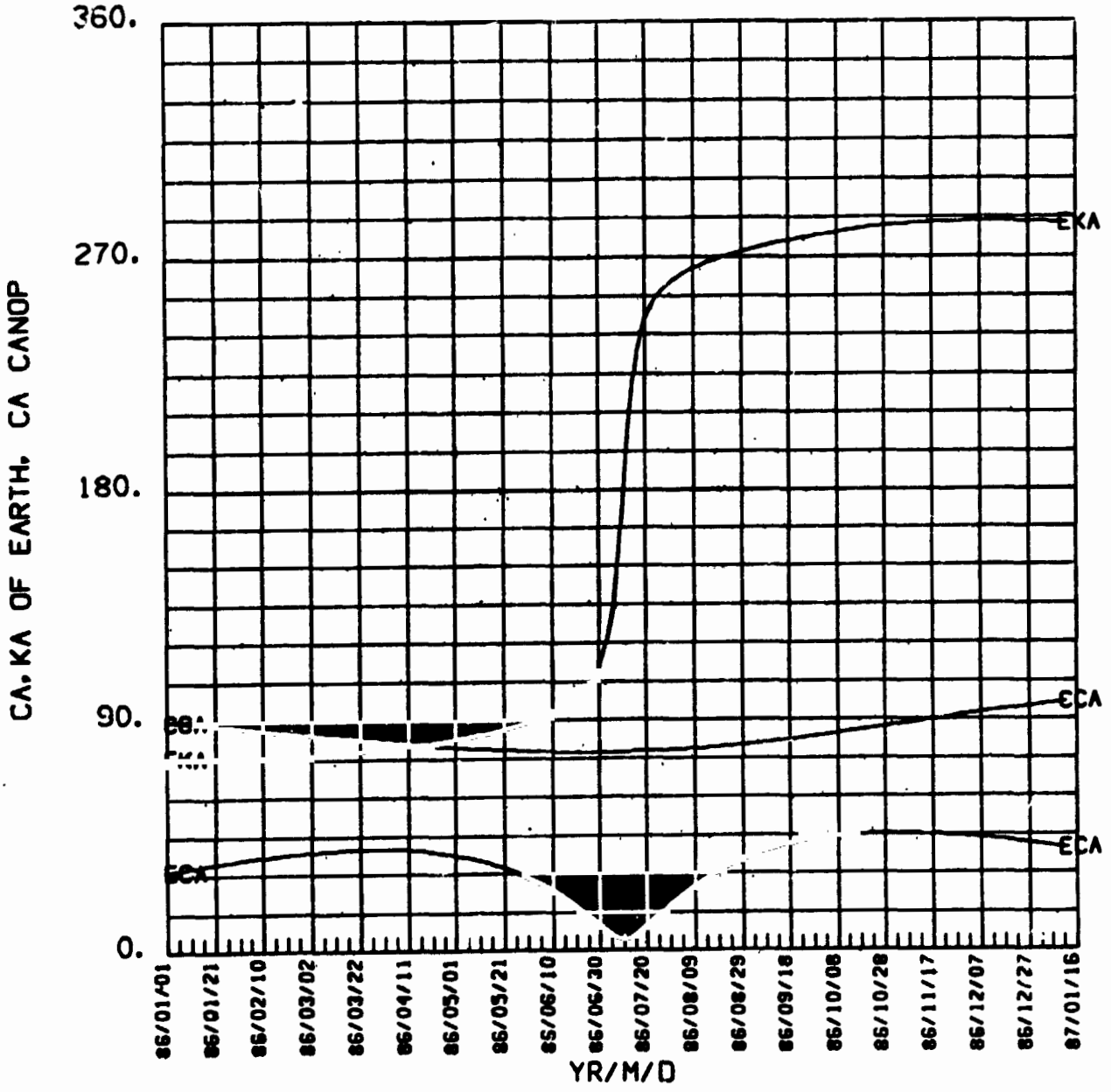
YR/M/D

MARS 1986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CA. KA OF EARTH. CA CANOP
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ECA
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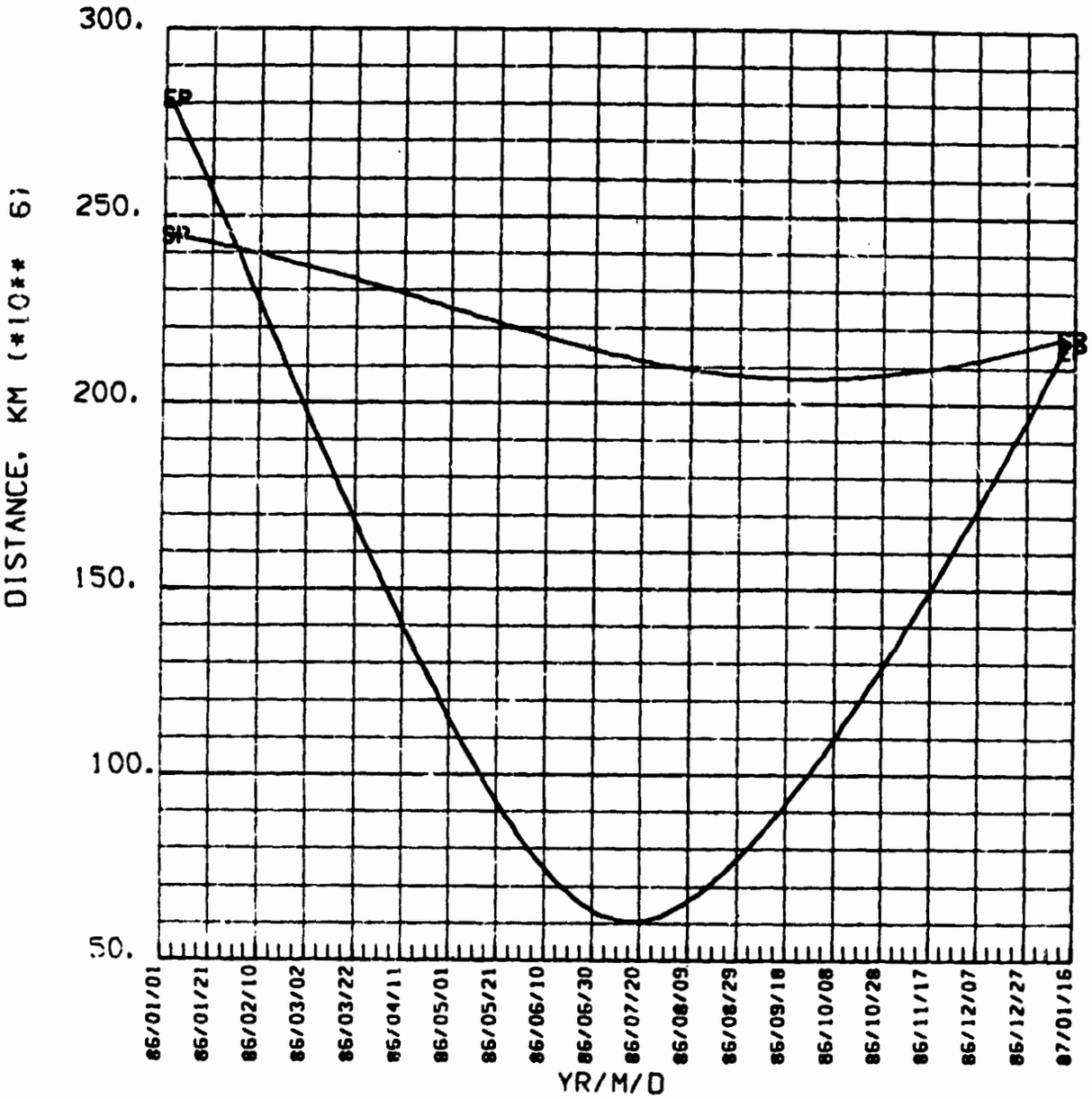
MARS 1986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DISTANCE, KM (*10** 6)
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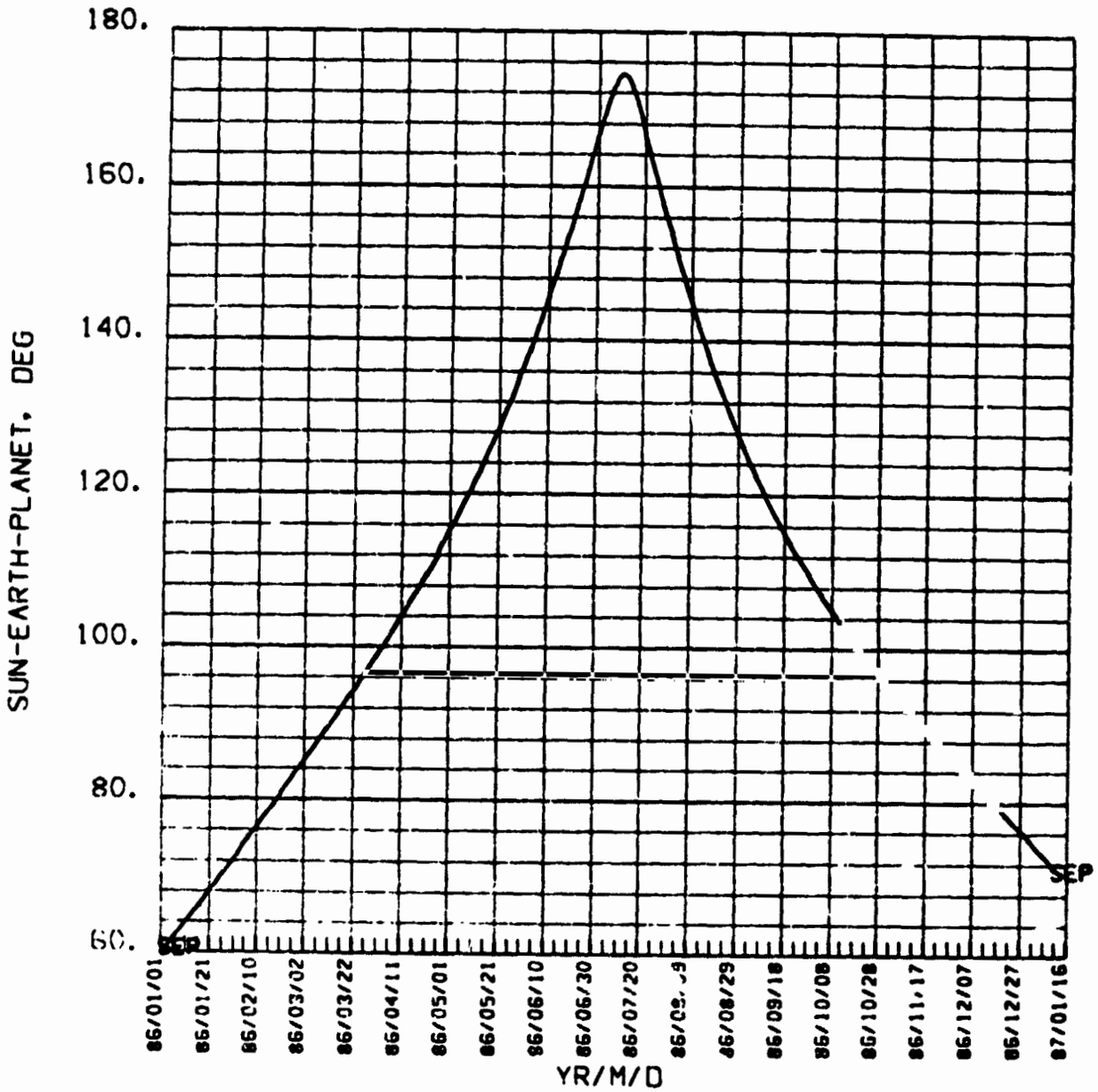
87/01/16
YR/M/D

MARS 1986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SUN-EARTH-PLANET, DEG
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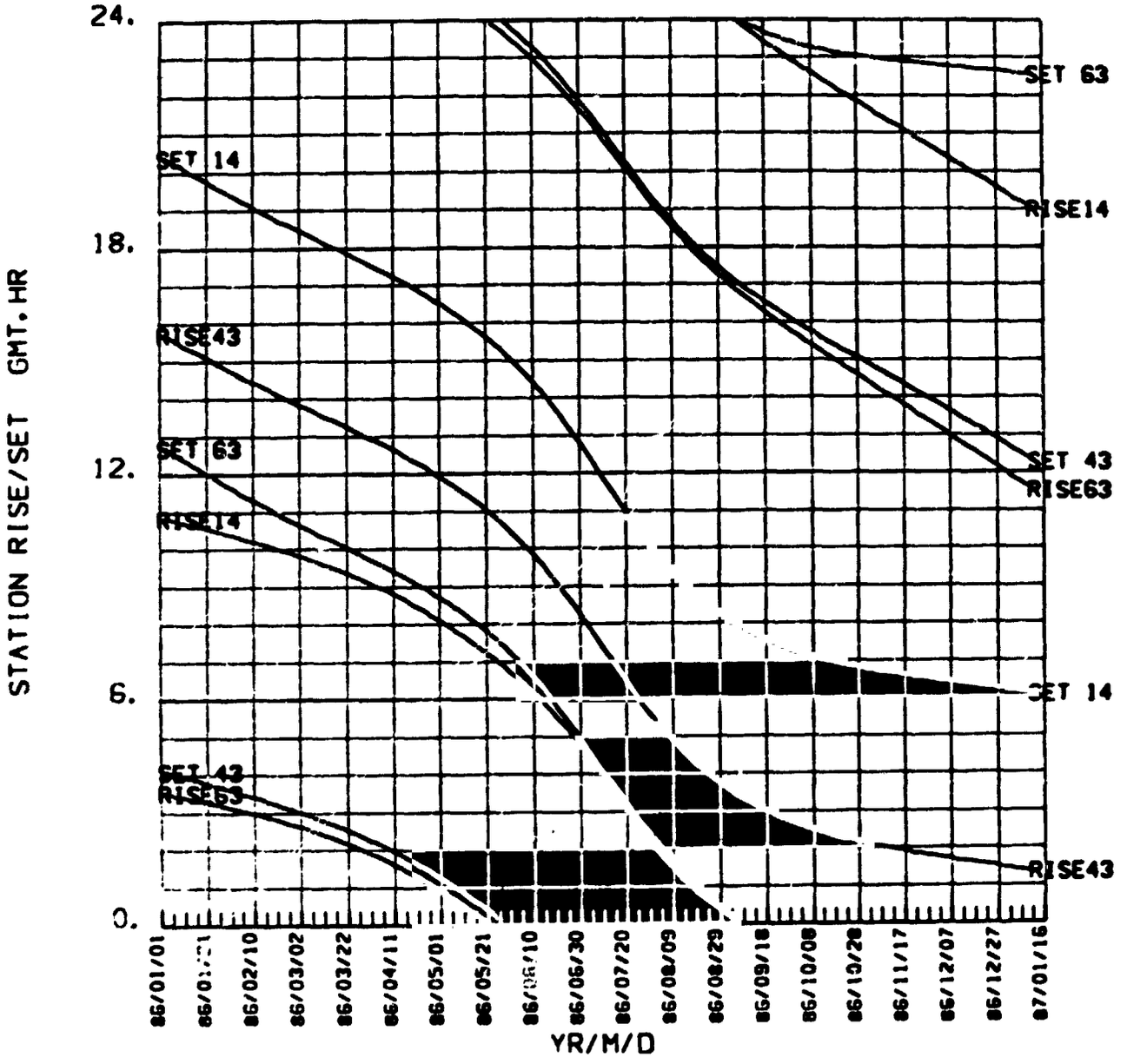
YR/M/D
SEP

MARS 1986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STATION RISE/SET GMT.HR
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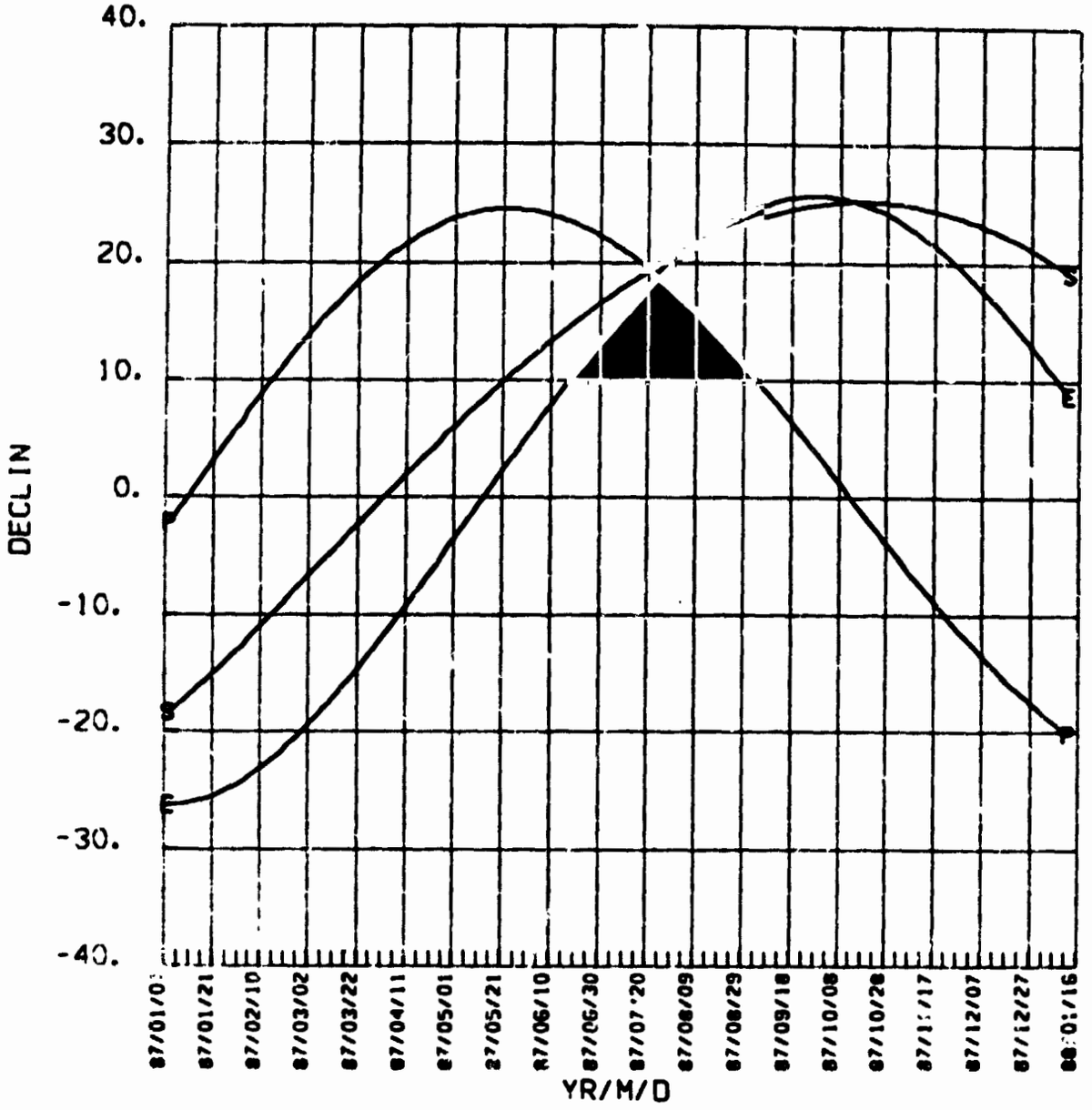
YR/M/D

MARS 1987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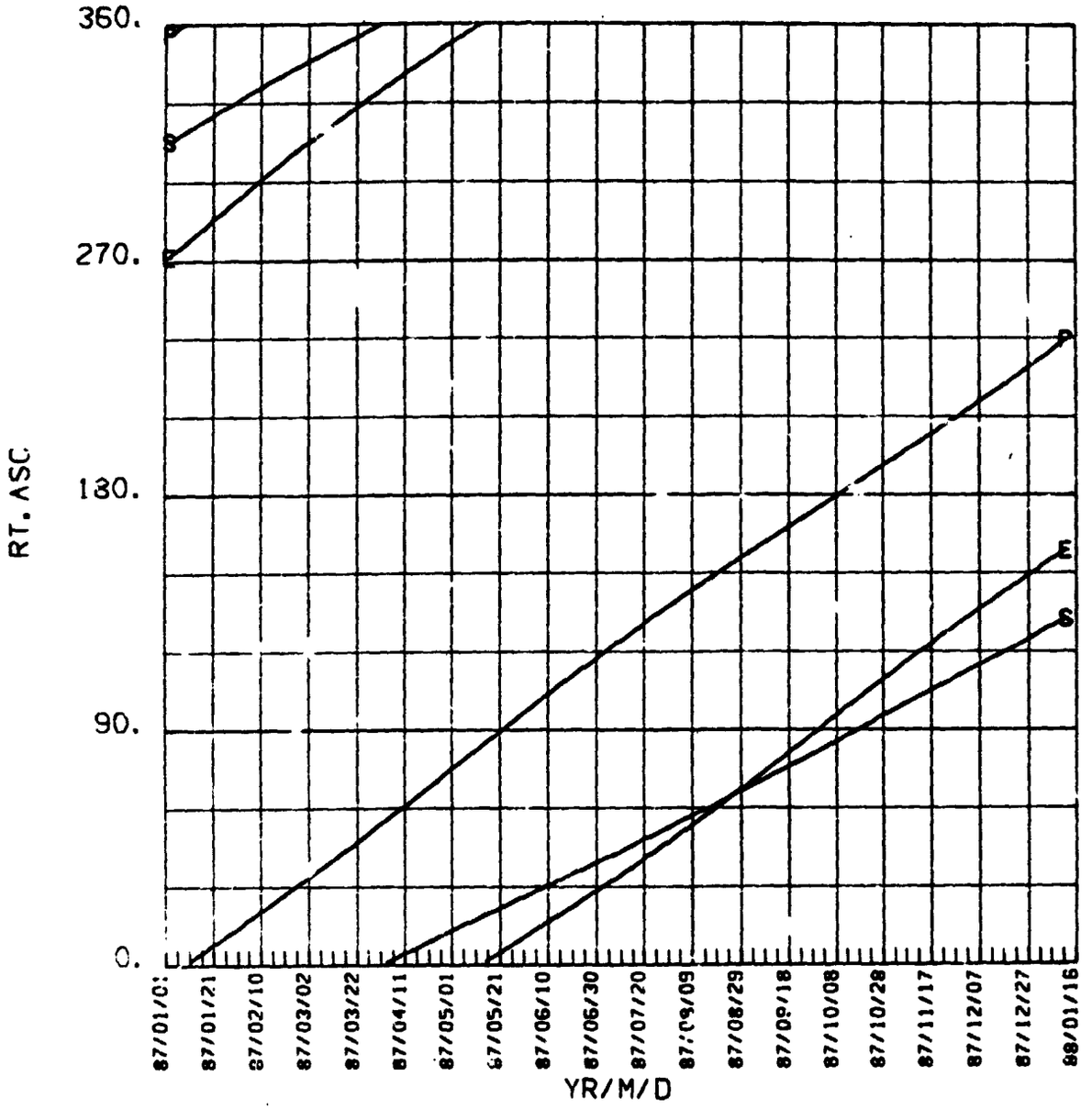
YR/M/D

MARS 1987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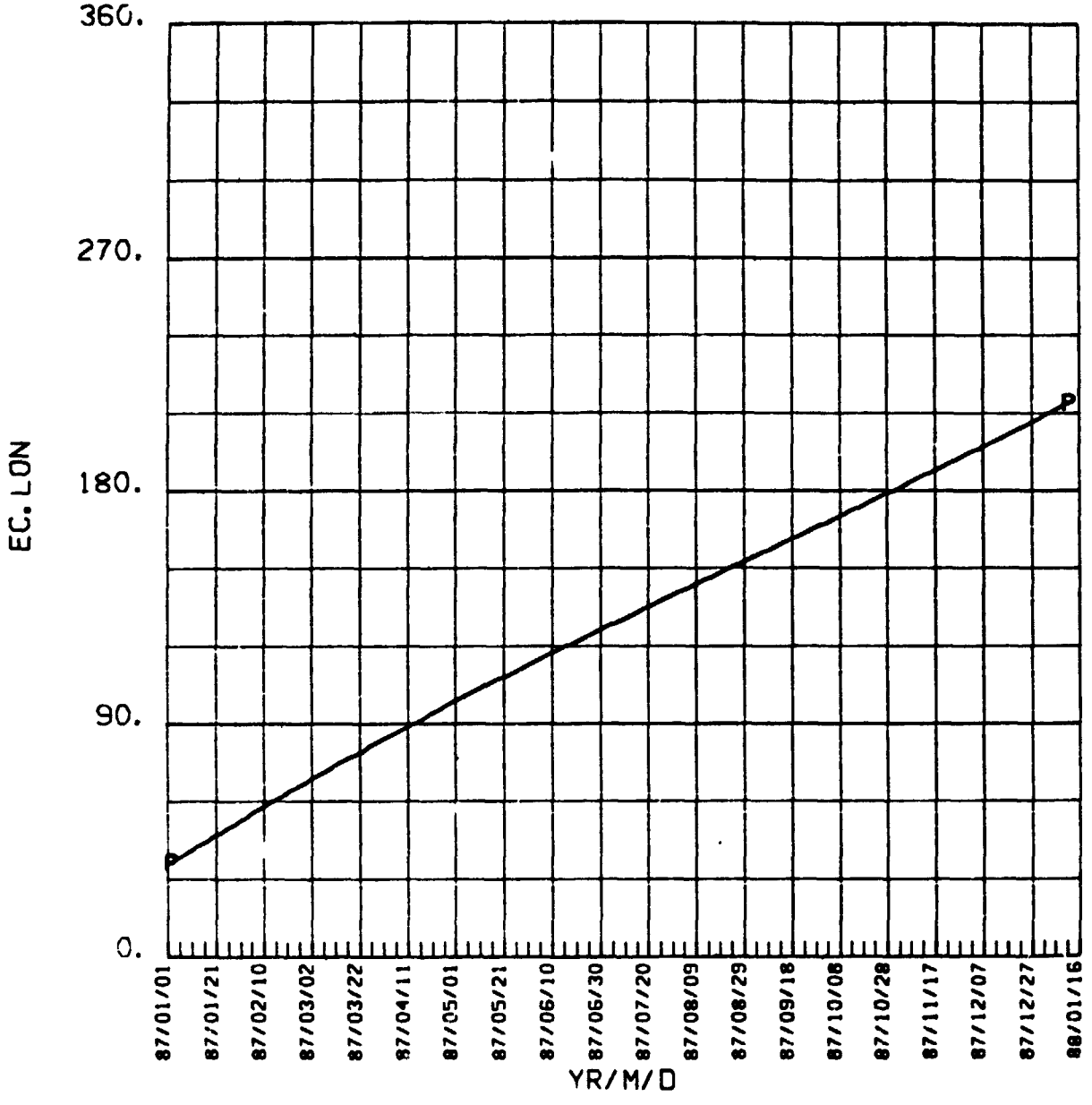
MARS 1987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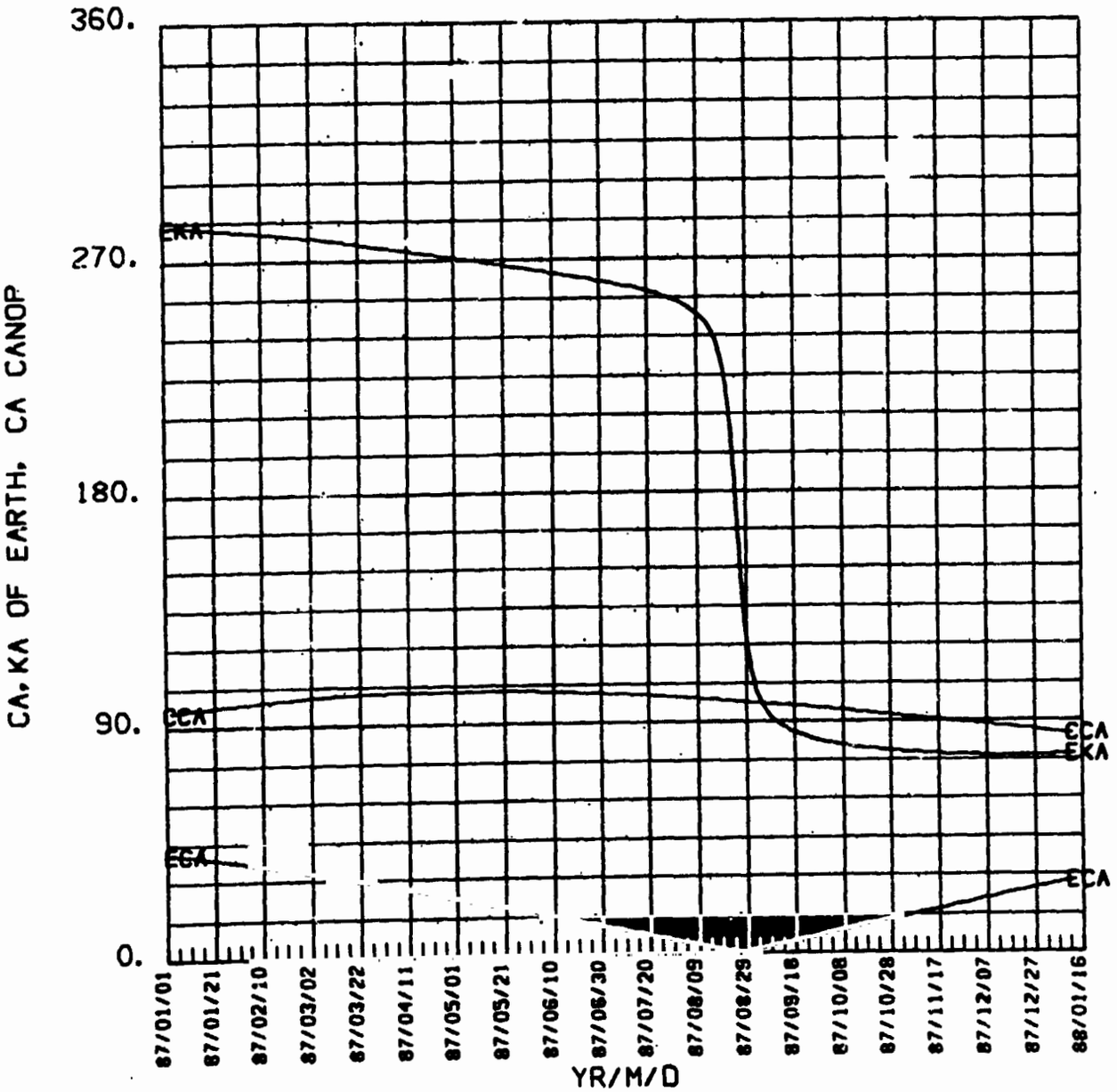
YR/M/D

MARS 1987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CA, KA OF EARTH, CA CANOP
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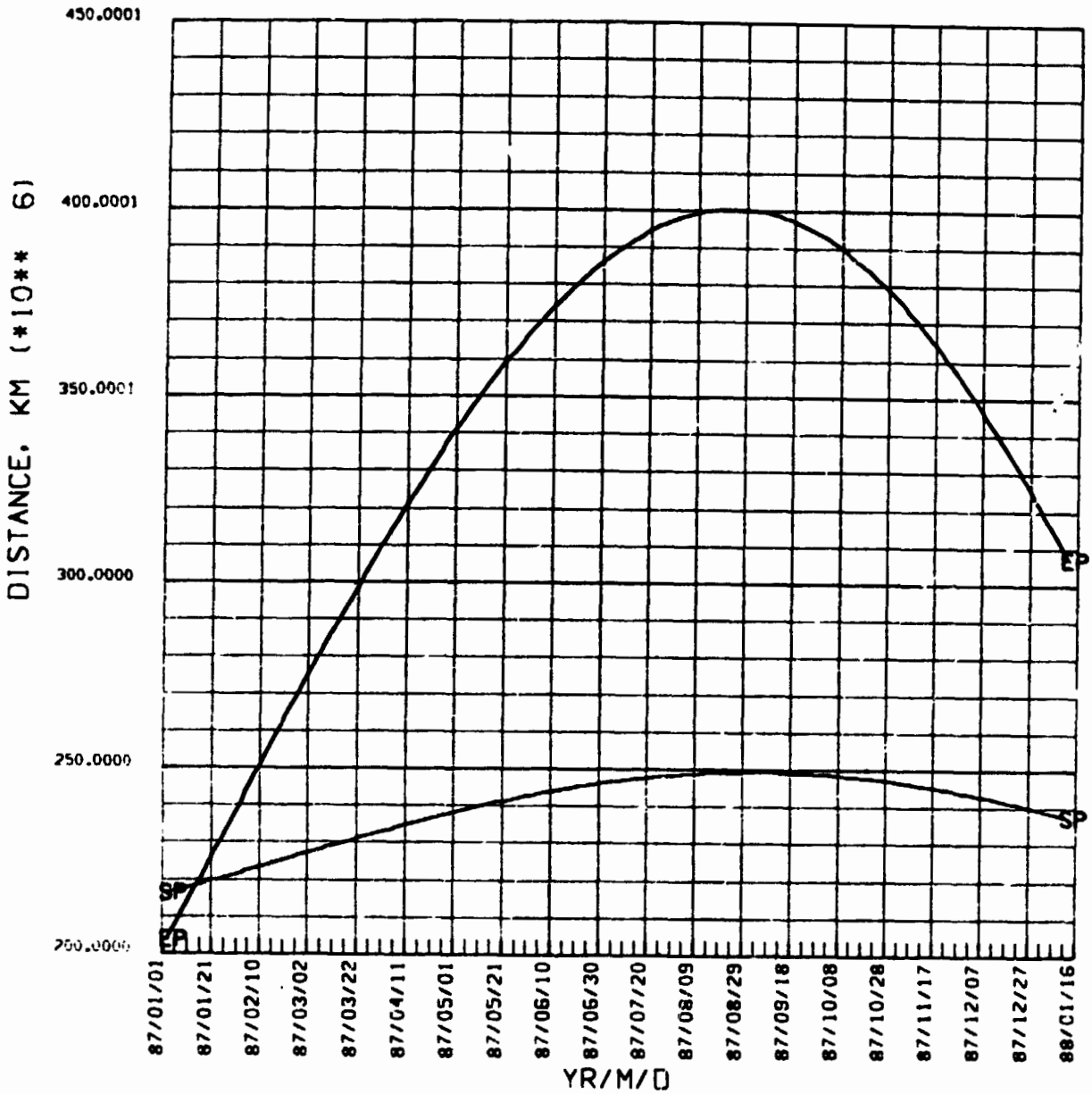
88/01/16
YR/M/D

MARS 1987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DISTANCE, KM (*10** 6)
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87/04/11
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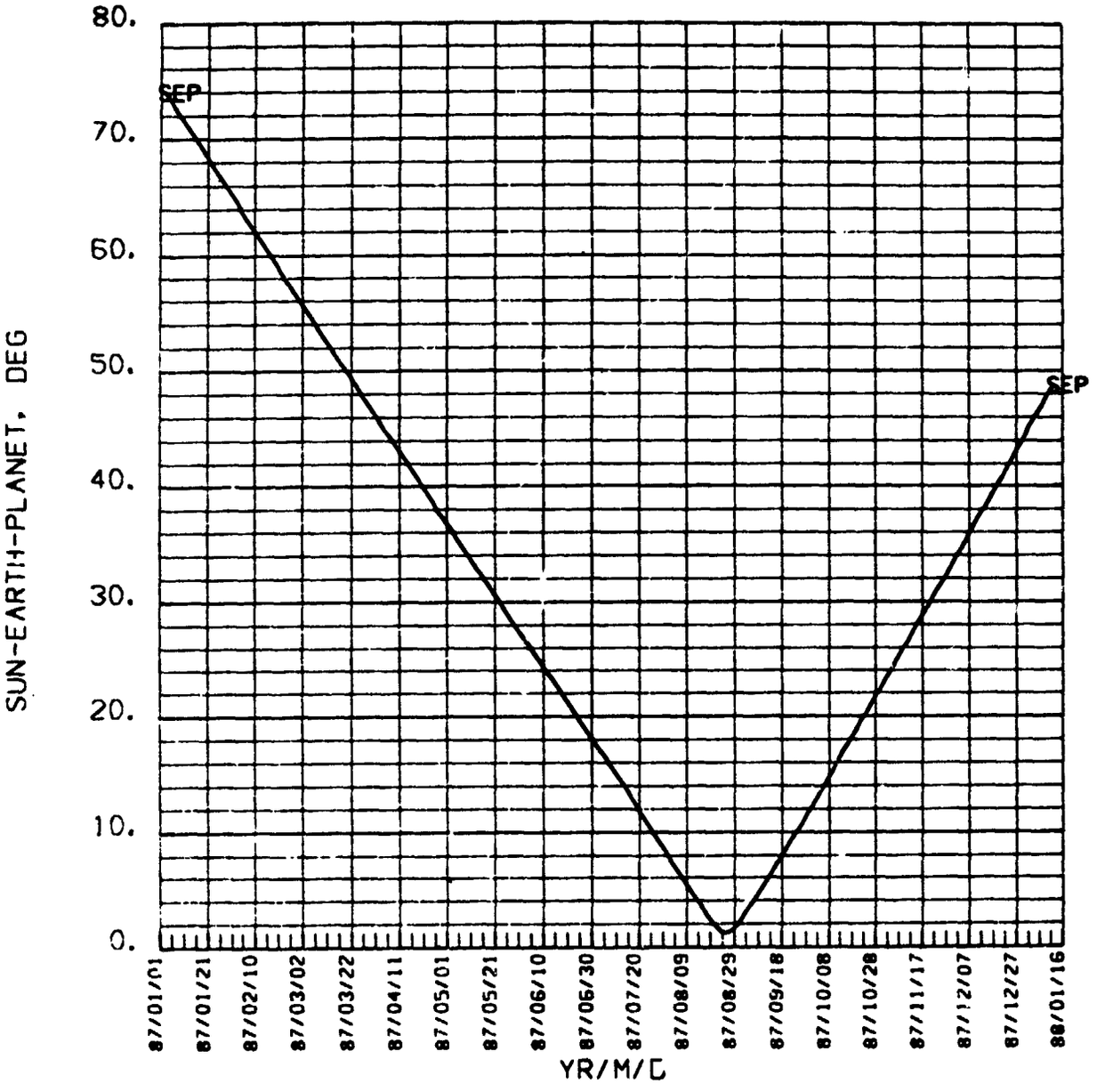
88/01/16
YR/M/D

MARS 1987


80.
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SUN-EARTH-PLANET, DEG
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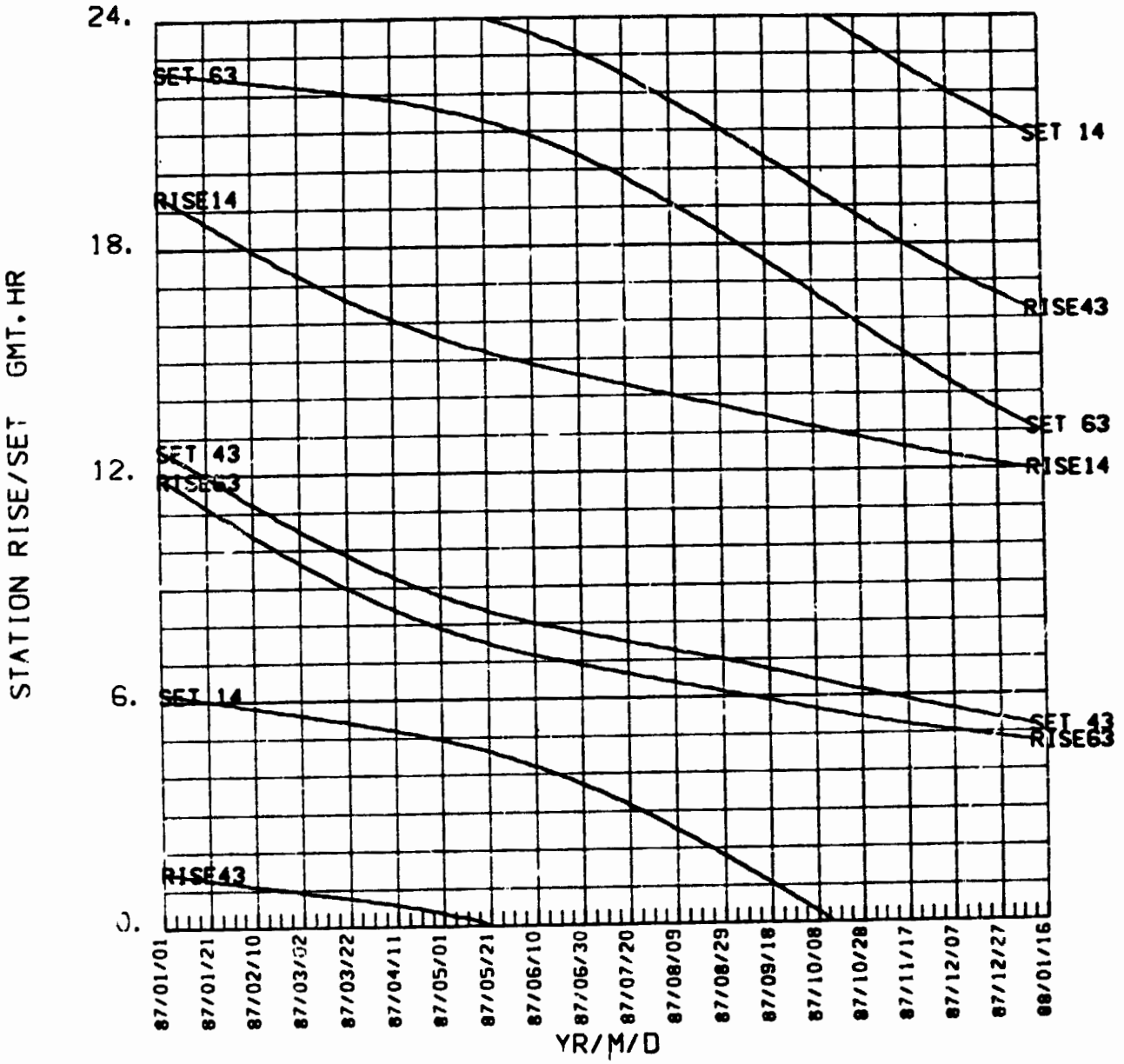
88/01/16
YR/M/D

MARS 1987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SET 63
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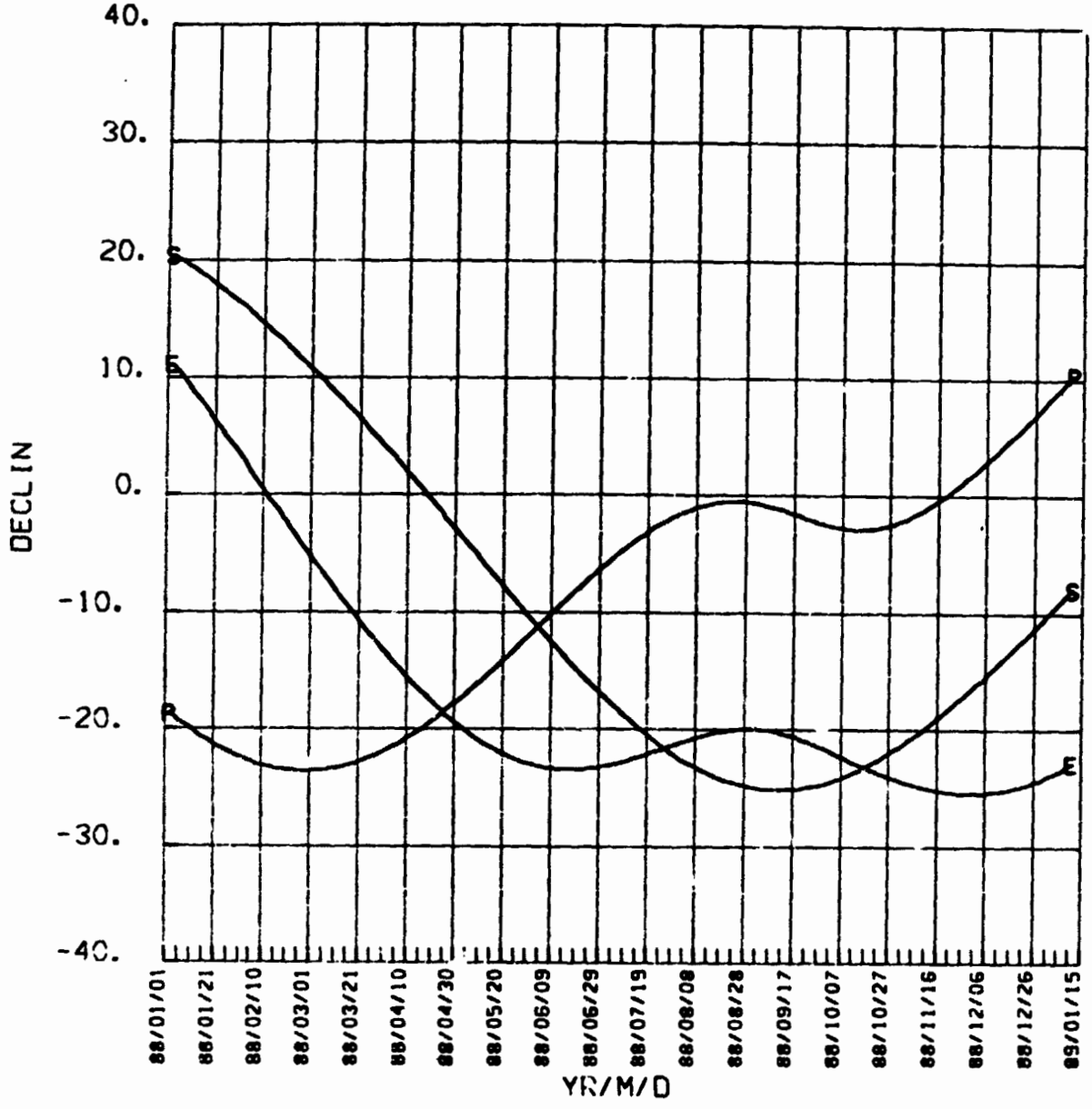
YR/M/D

MARS 1988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DECLIN
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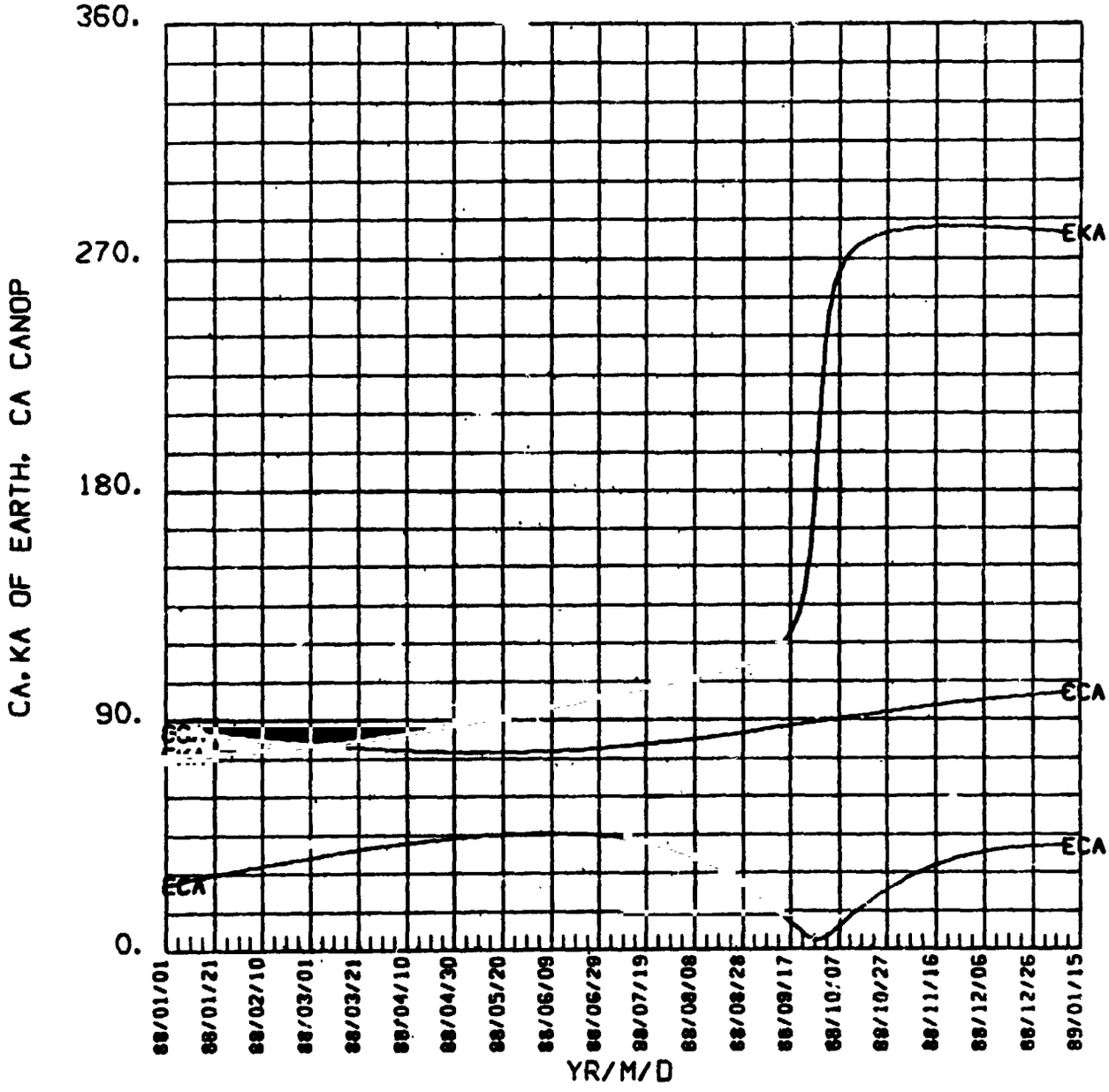
YR/M/D

MARS 1988



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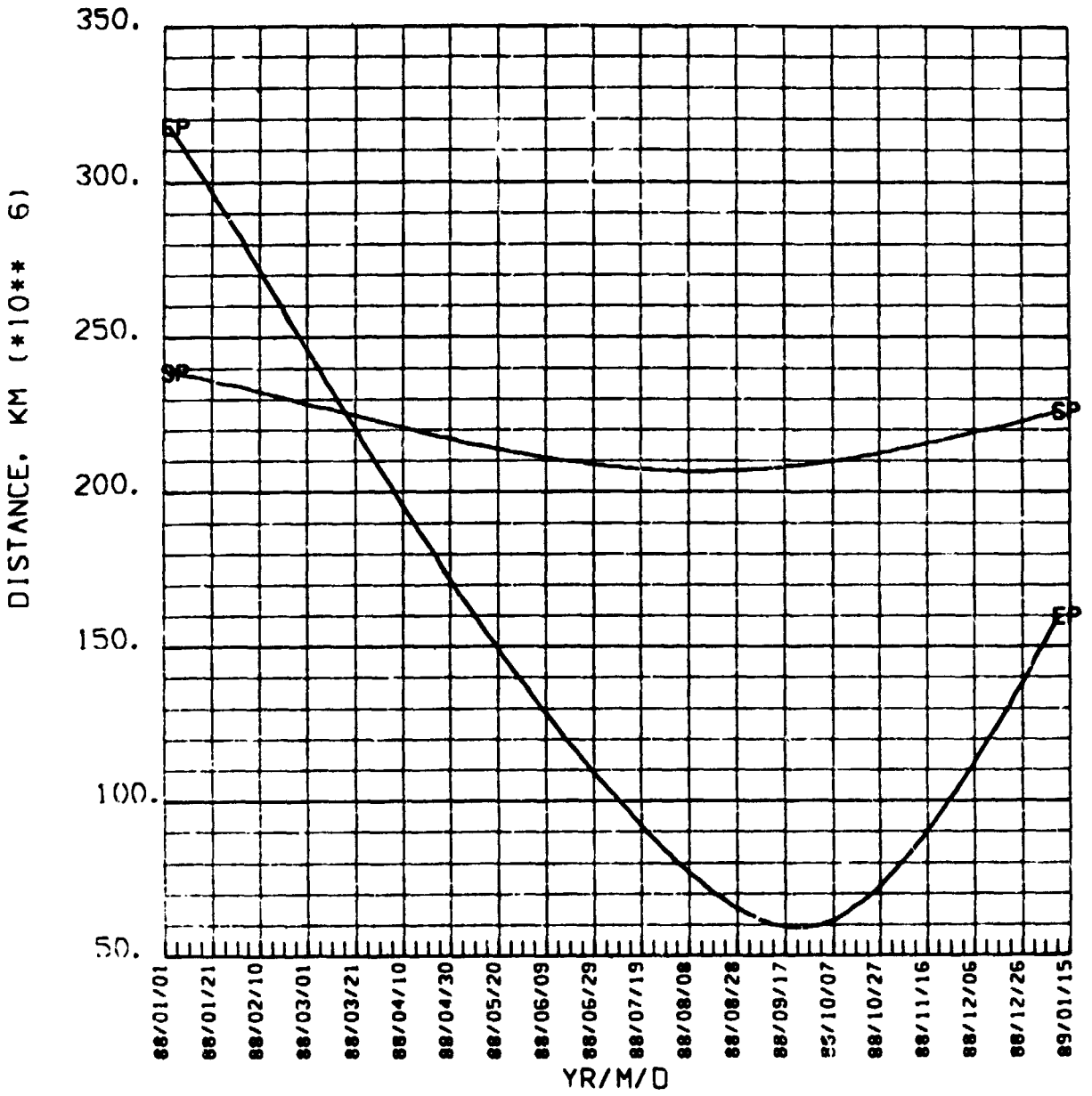
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200.
150.
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DISTANCE, KM (*10** 6)
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EP
88/01/01
88/01/21
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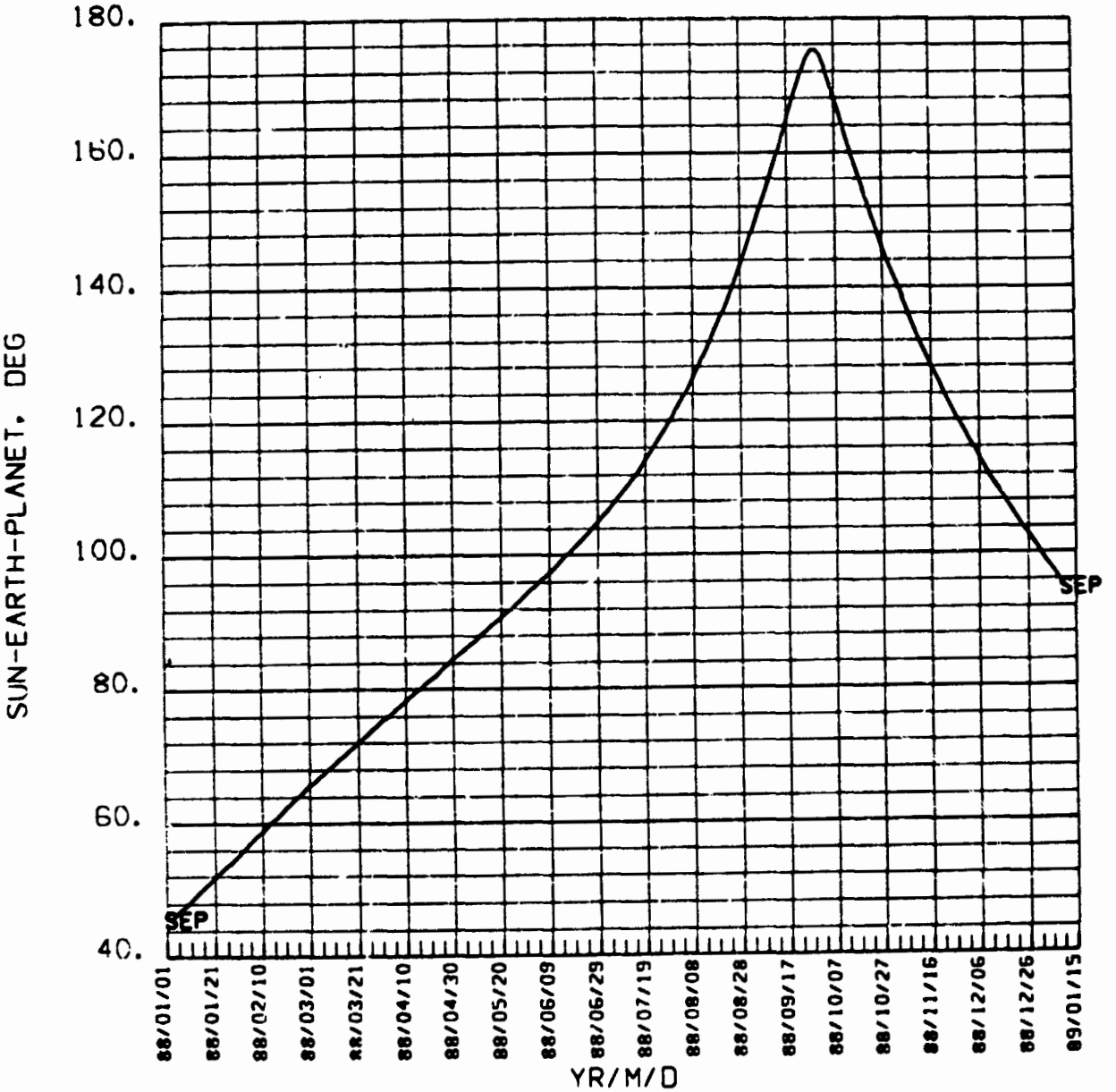
YR/M/D

MARS 1988


180.
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SUN-EARTH-PLANET, DEG
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SEP
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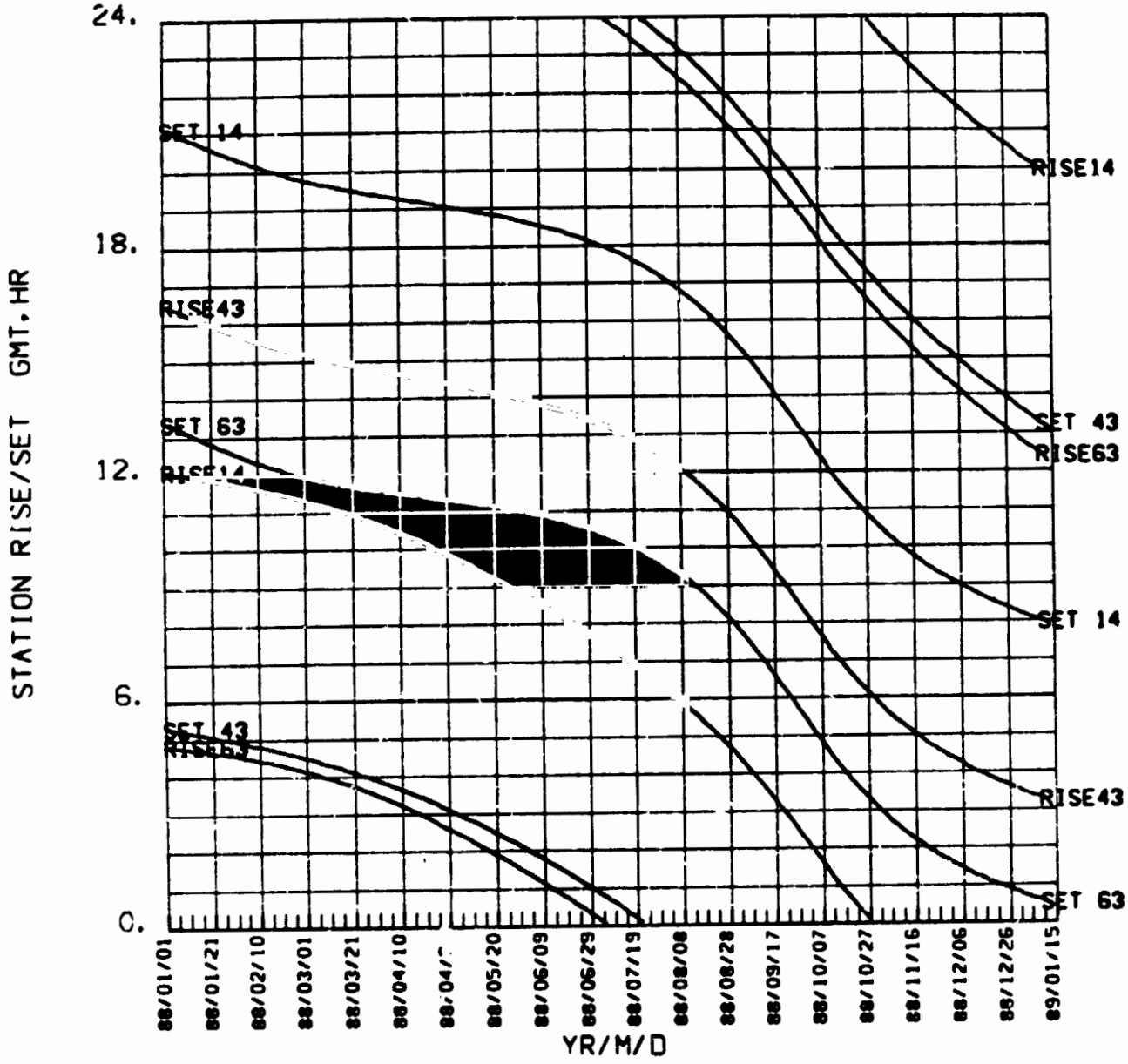
MARS 1988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STATION RISE/SET GMT. HR
SET 14
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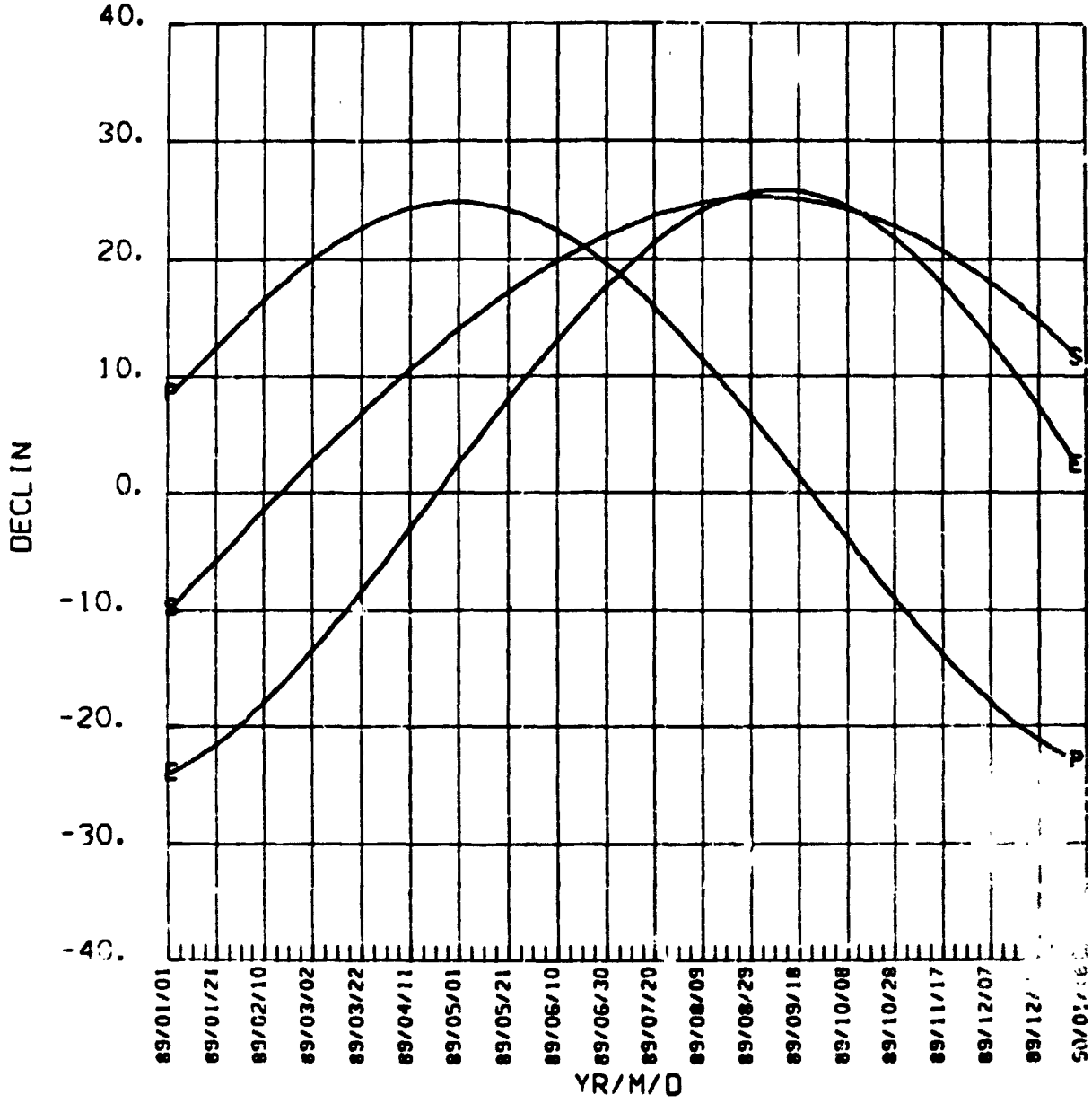
MARS 1989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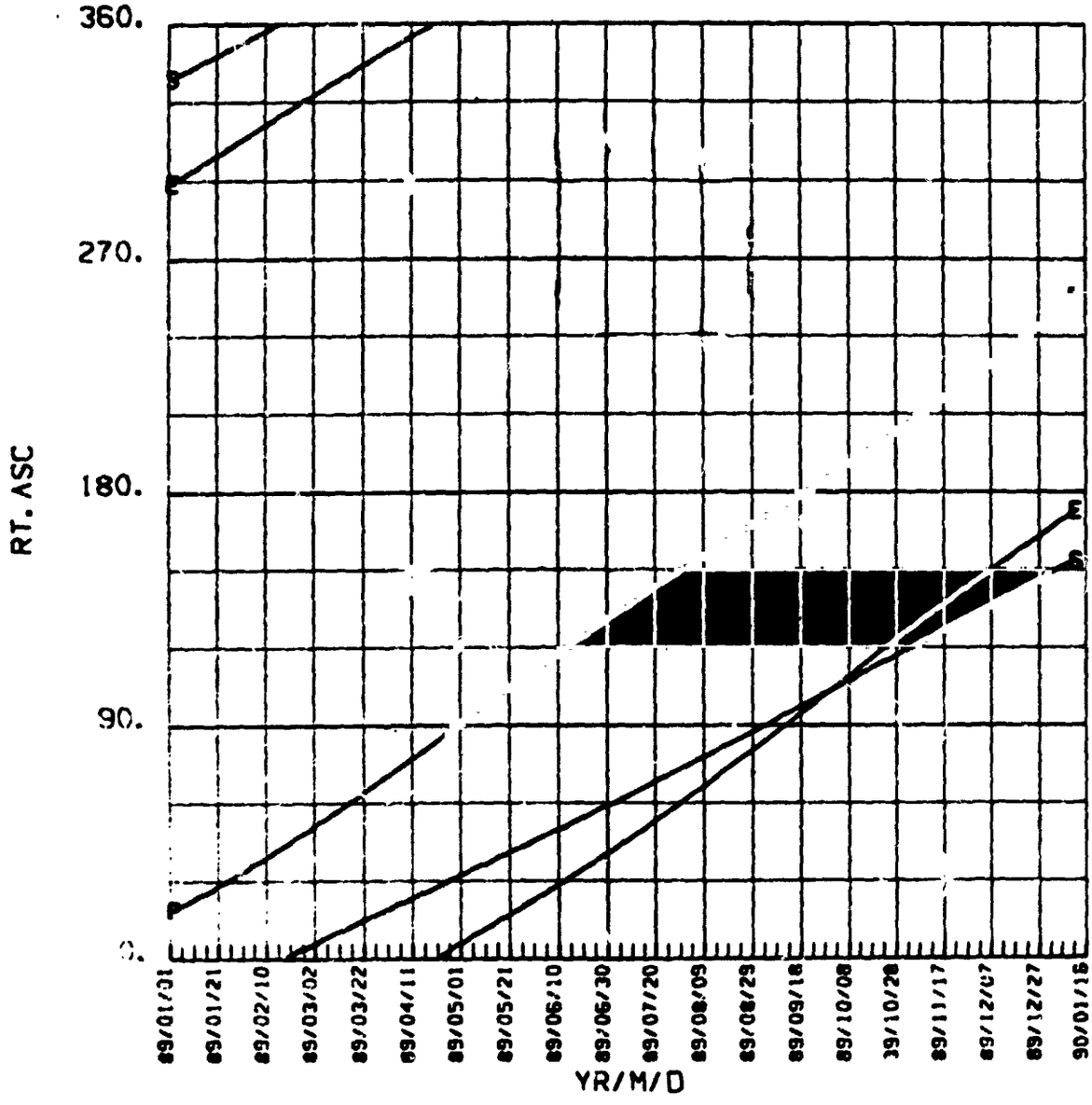
MARS 1989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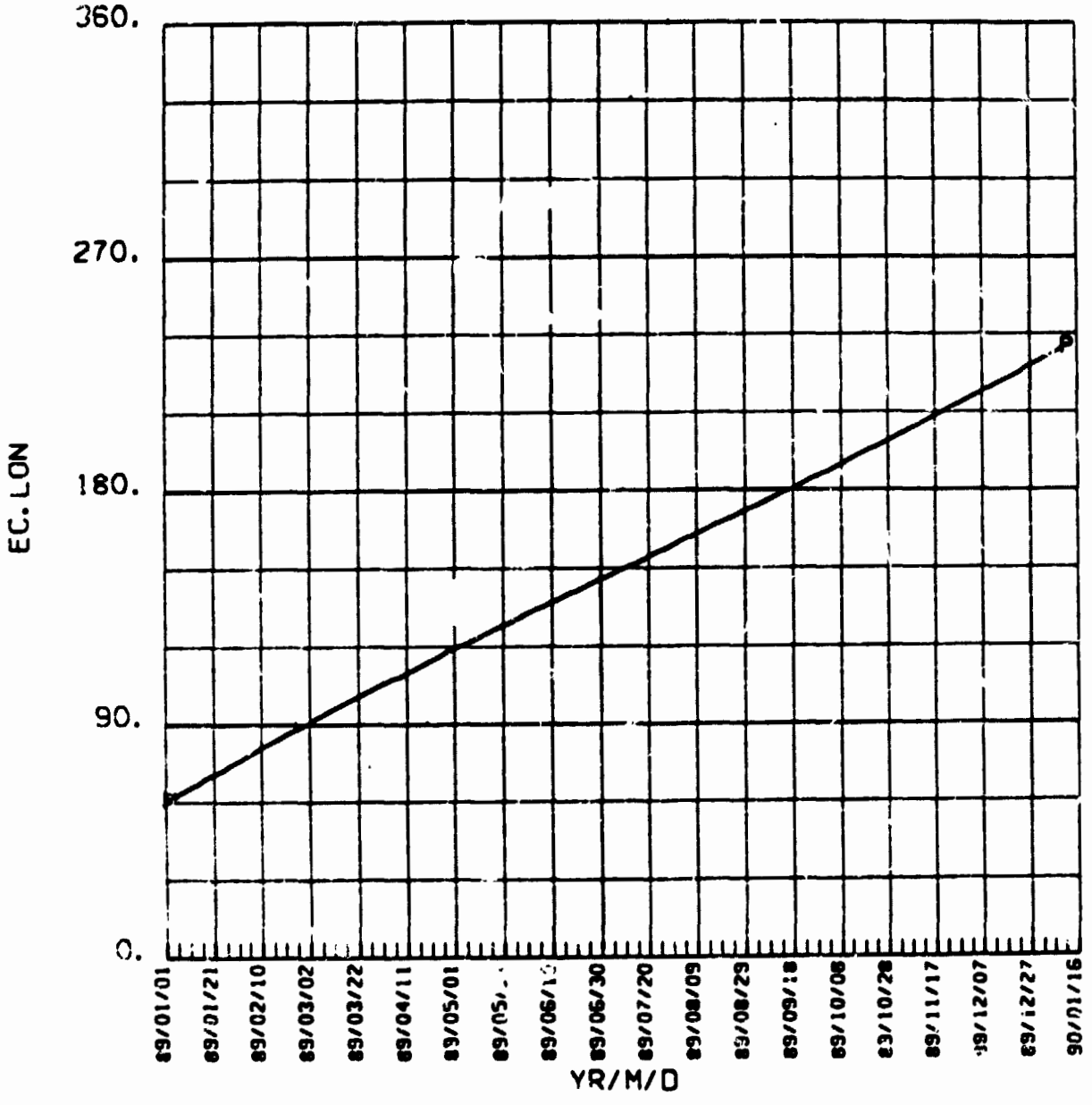
YR/M/D

MARS 1989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EC. LON
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YR/M/D

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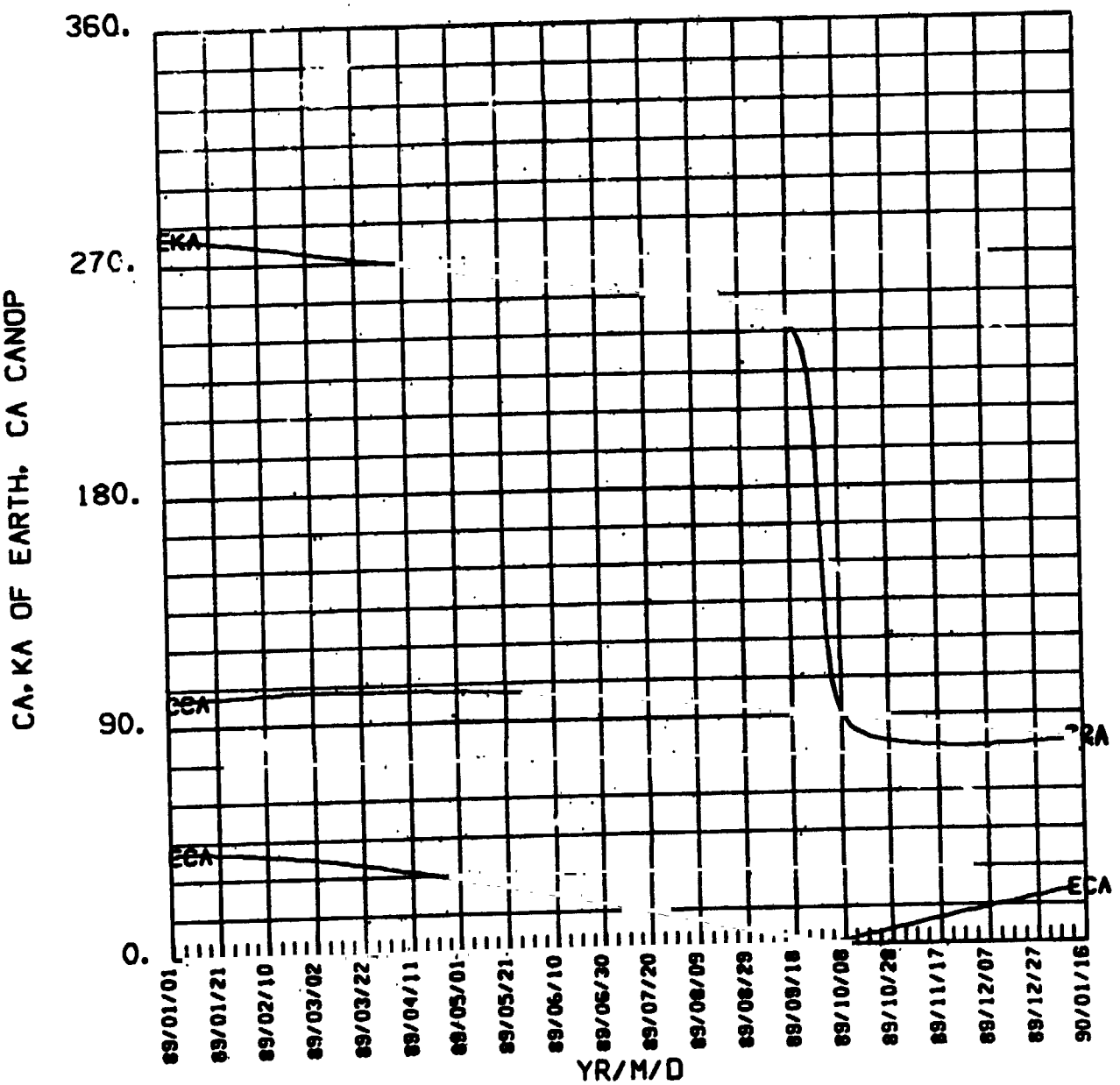
360.
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CA, KA OF EARTH, CA CANOP
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89/05/01
89/05/21
89/06/10
89/06/30
89/07/20
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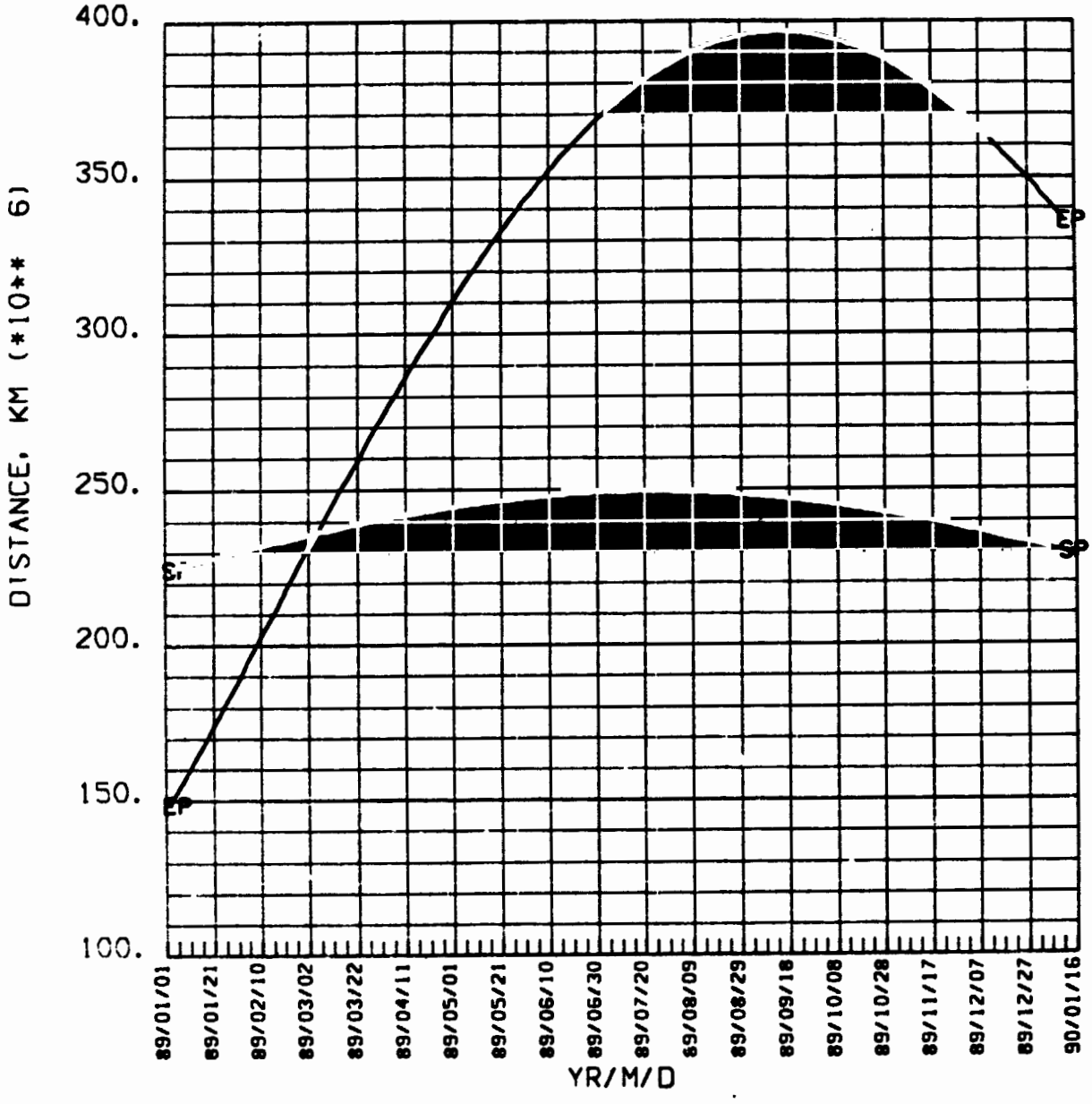
90/01/16
YR/M/D

MARS 1989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250.
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100.
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SP
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89/01/21
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89/03/22
89/04/11
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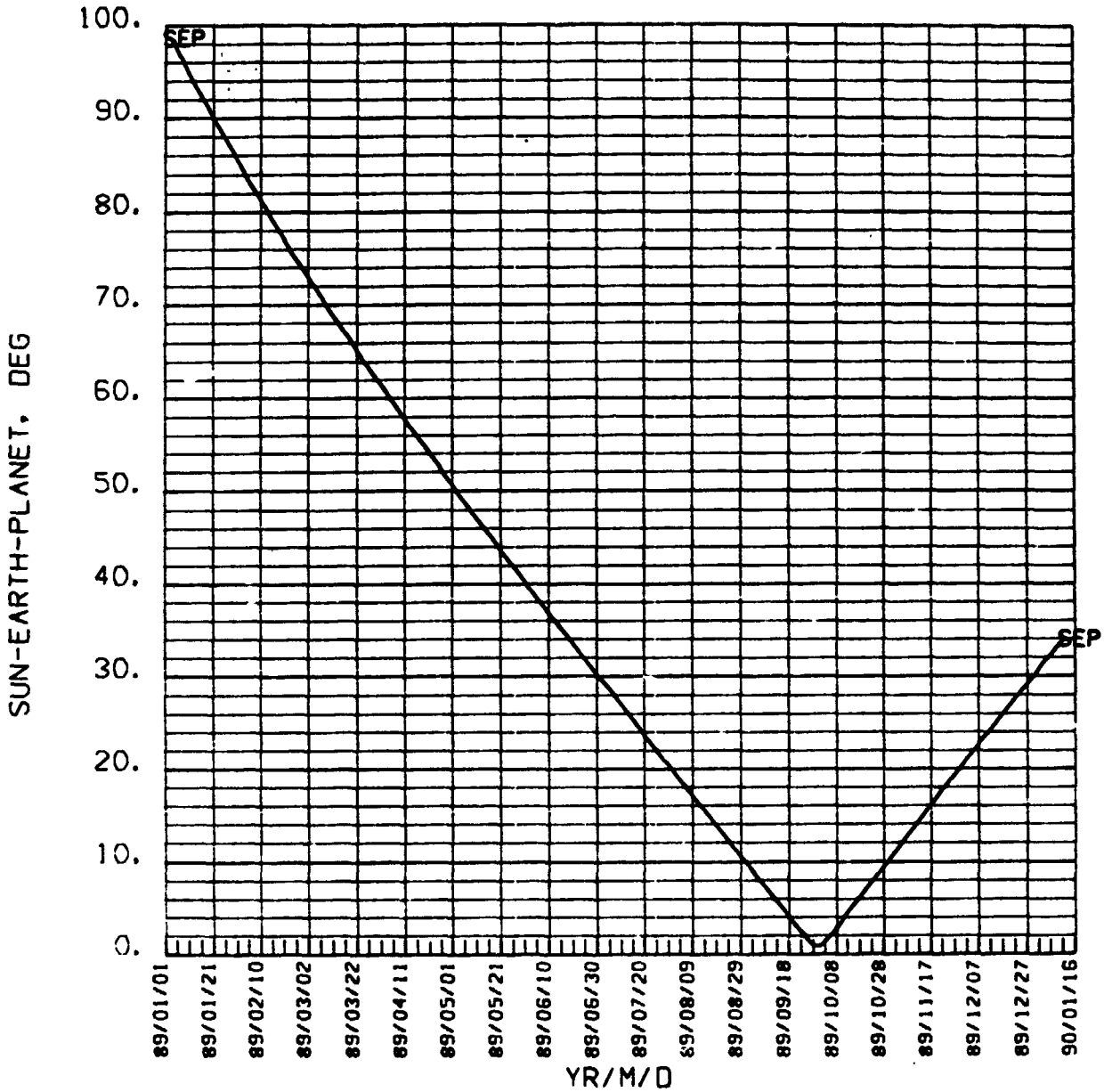
YR/M/D

MARS 1989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80.
70.
60.
50.
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10.
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SEP
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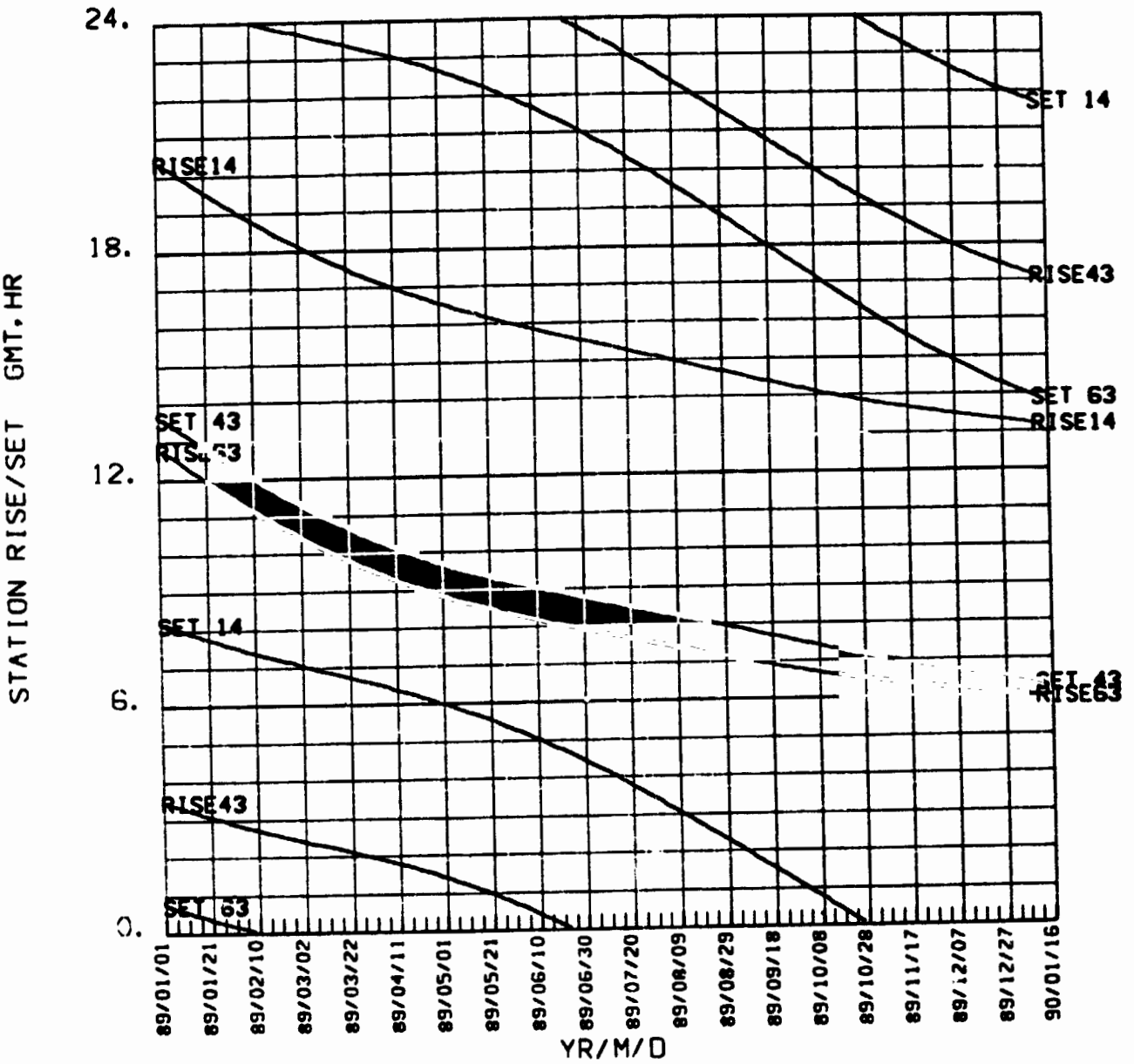
90/01/16
YR/M/D

MARS 1989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12.
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RISE14
SET 43
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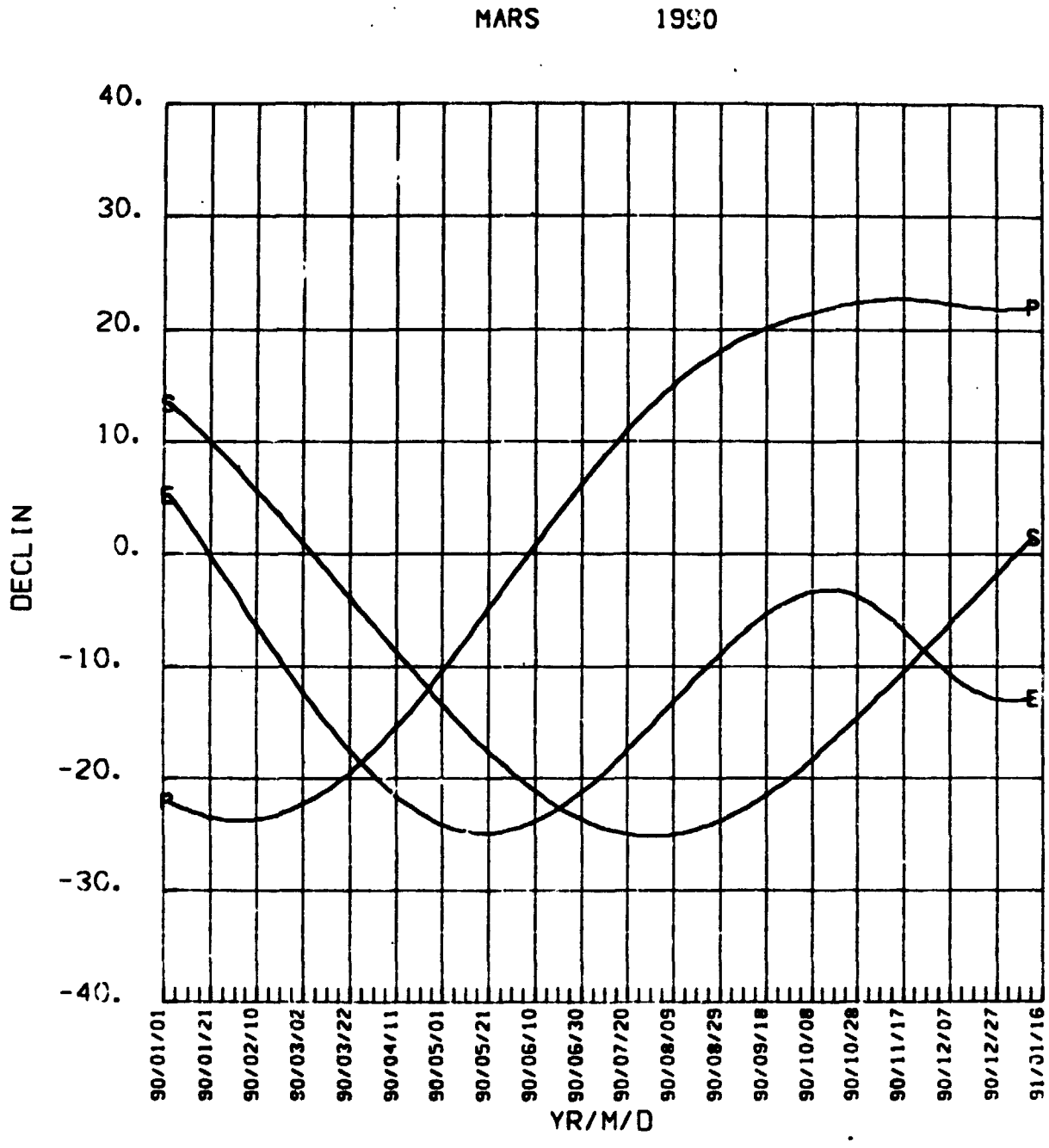
YR/M/D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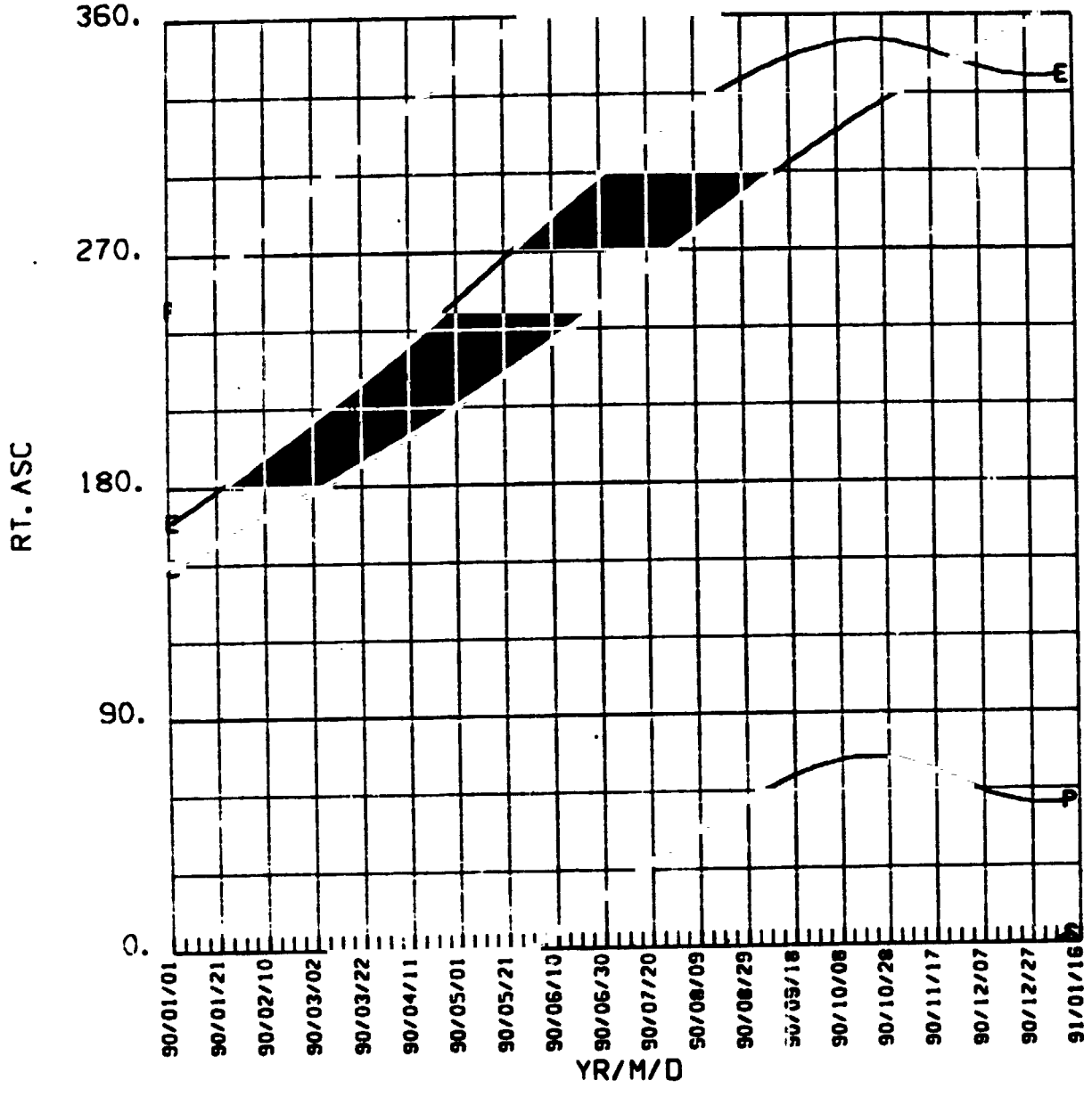
YR/M/D

MARS 1990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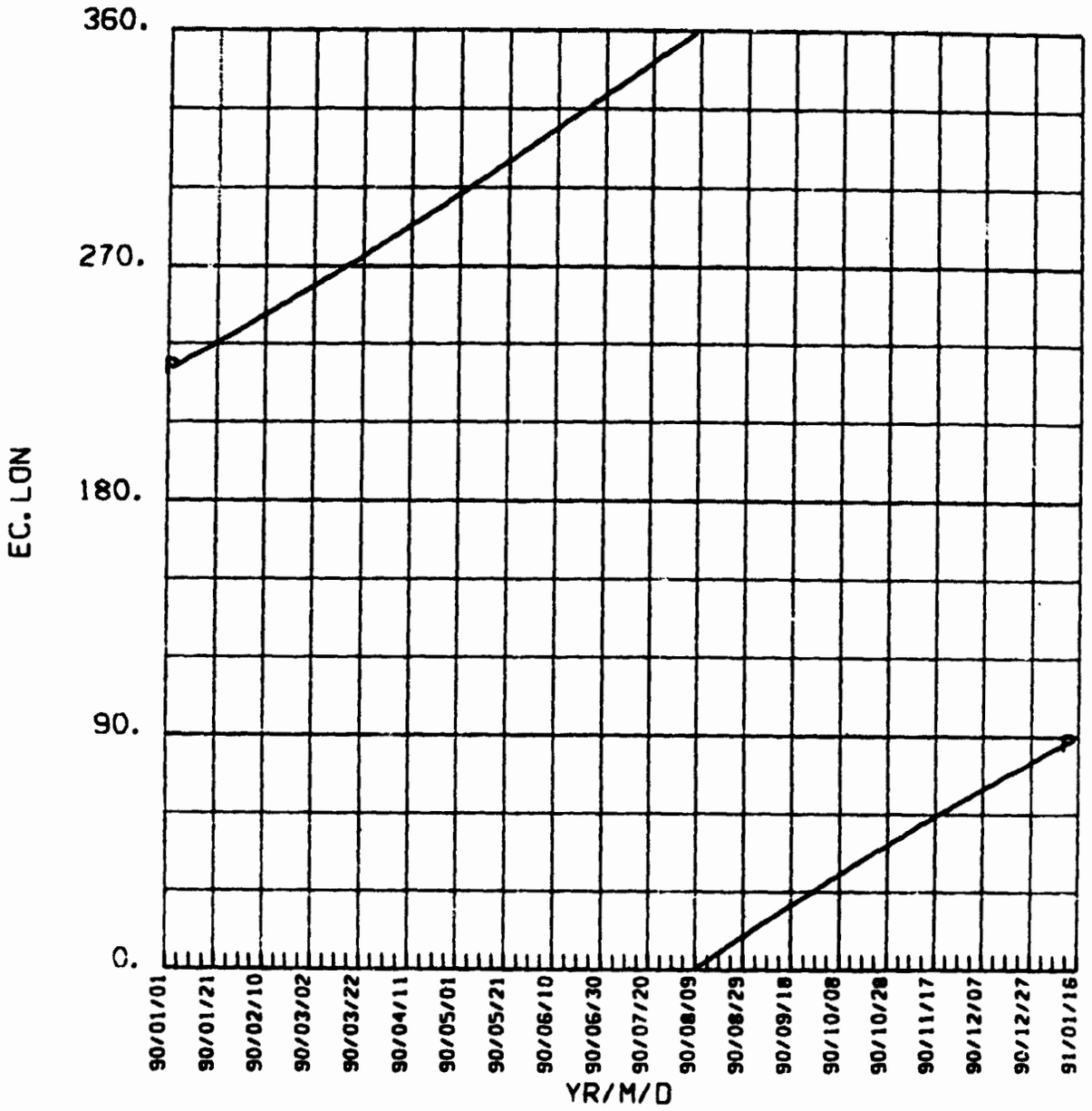
YR/M/D

MARS 1990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EC. LON
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YR/M/D

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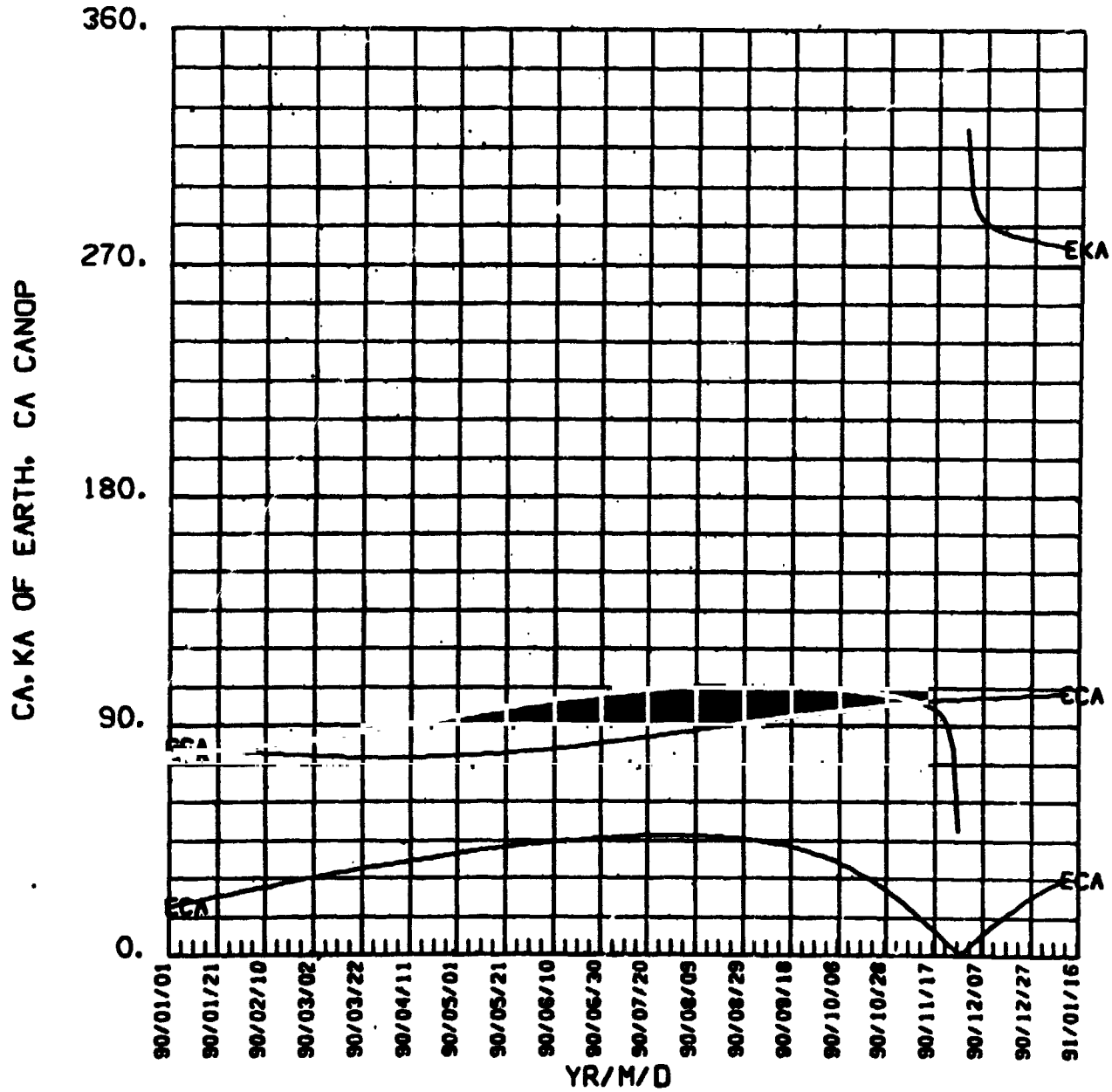
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CA, KA OF EARTH, CA CANOP
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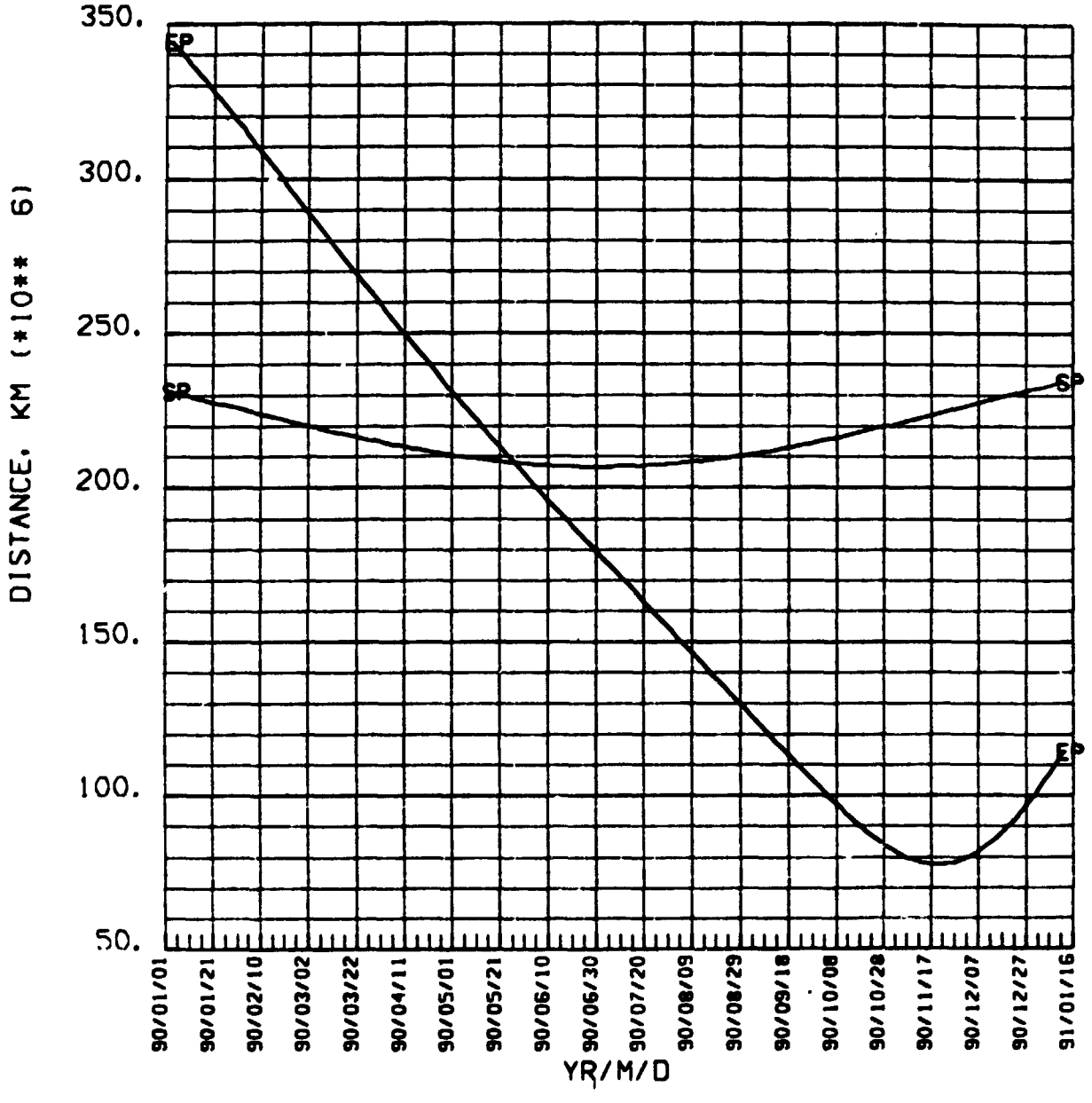
YR/M/D

MARS 1990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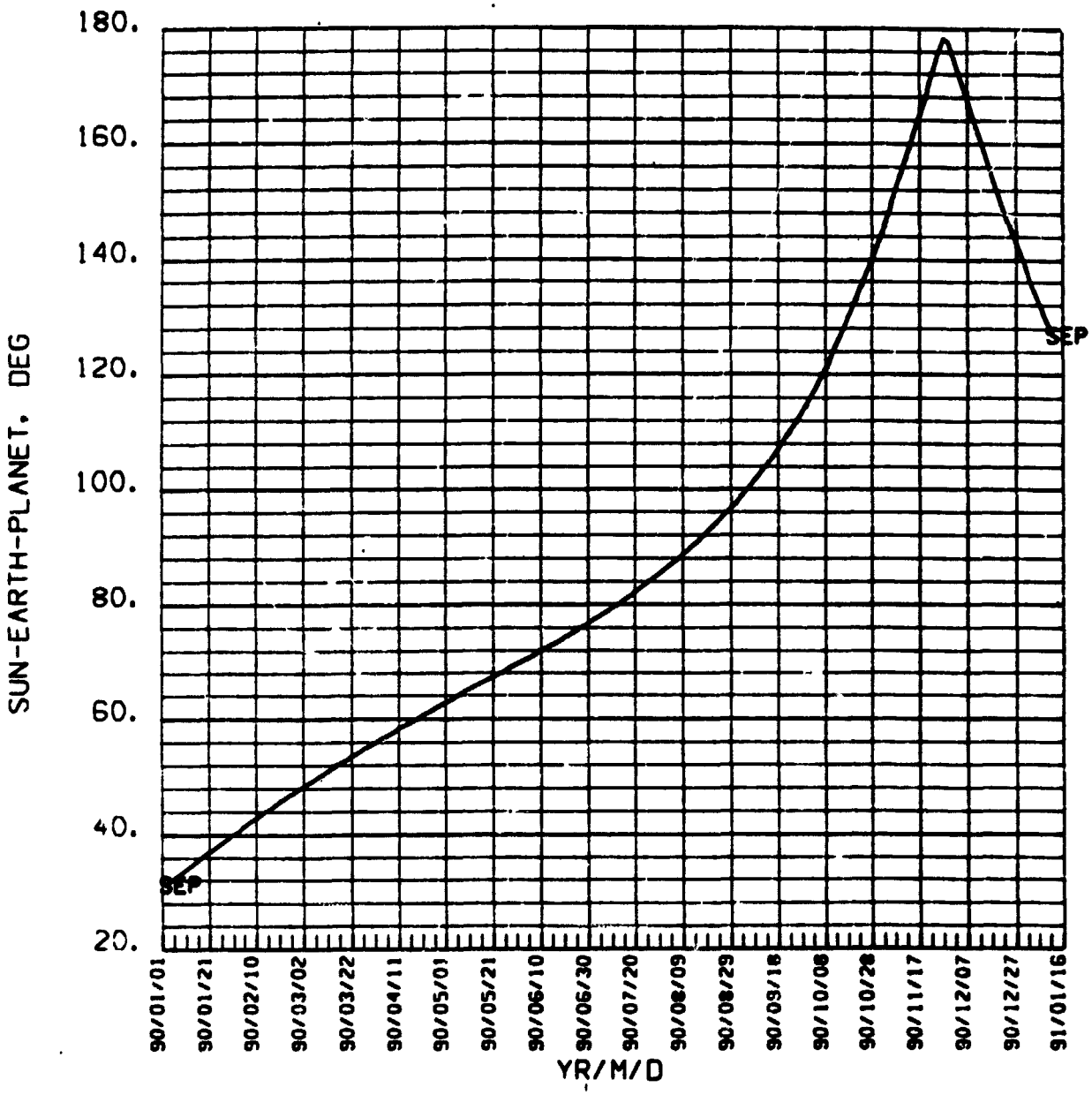
91/01/16
YR/M/D

MARS 1990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SUN-EARTH-PLANET. DEG
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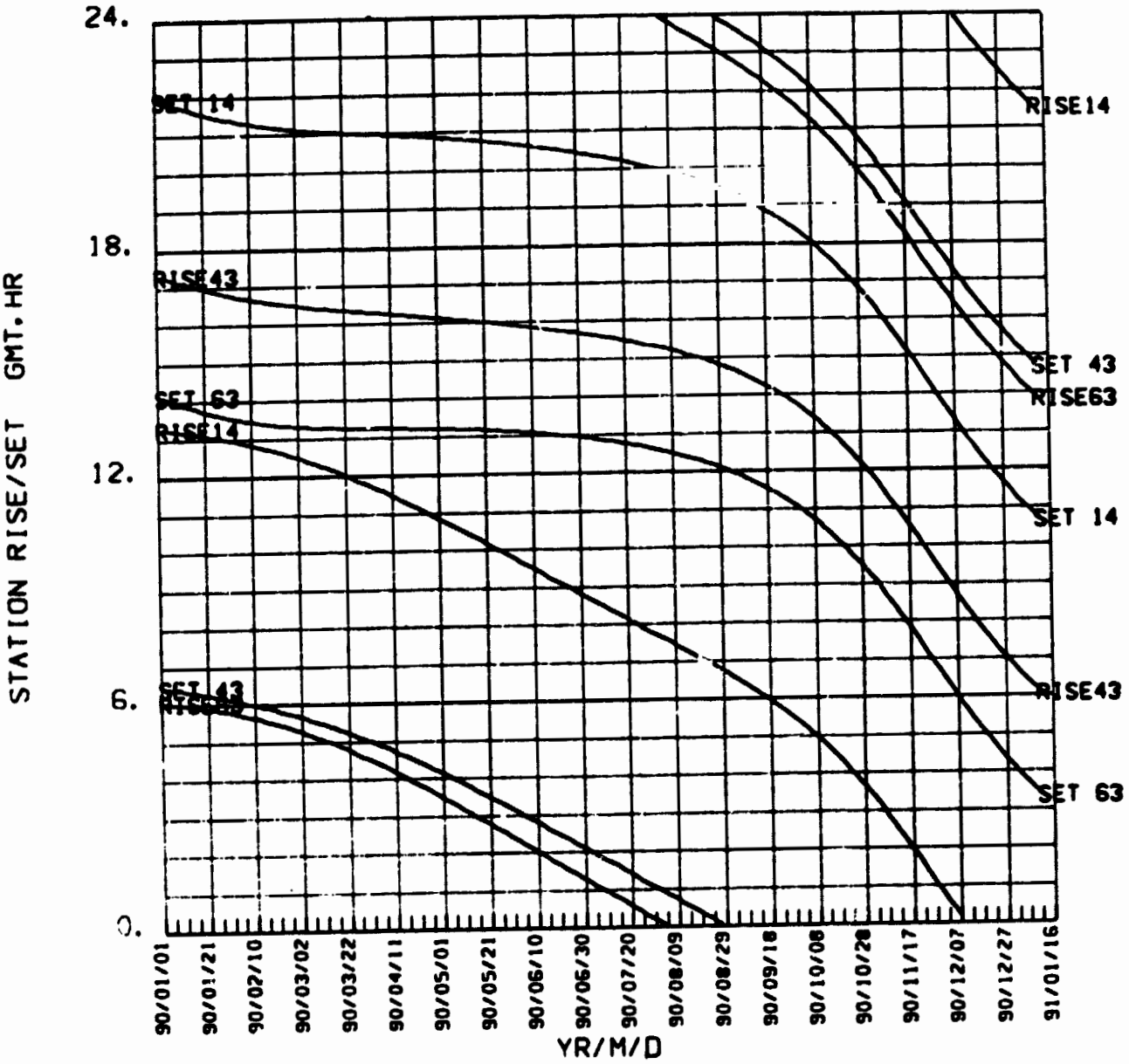
91/01/16
YR/M/D

MARS 1990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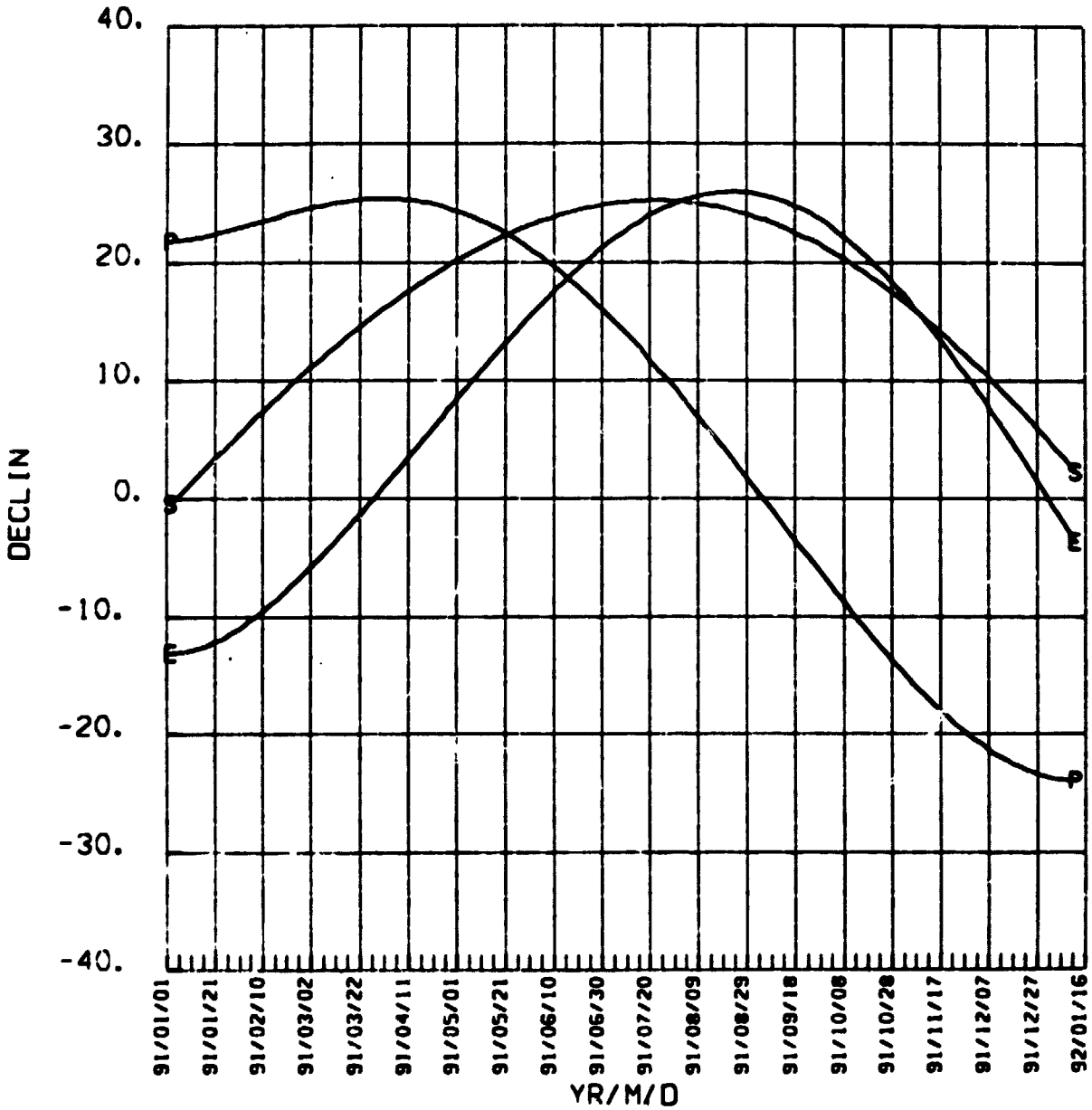
MARS 1991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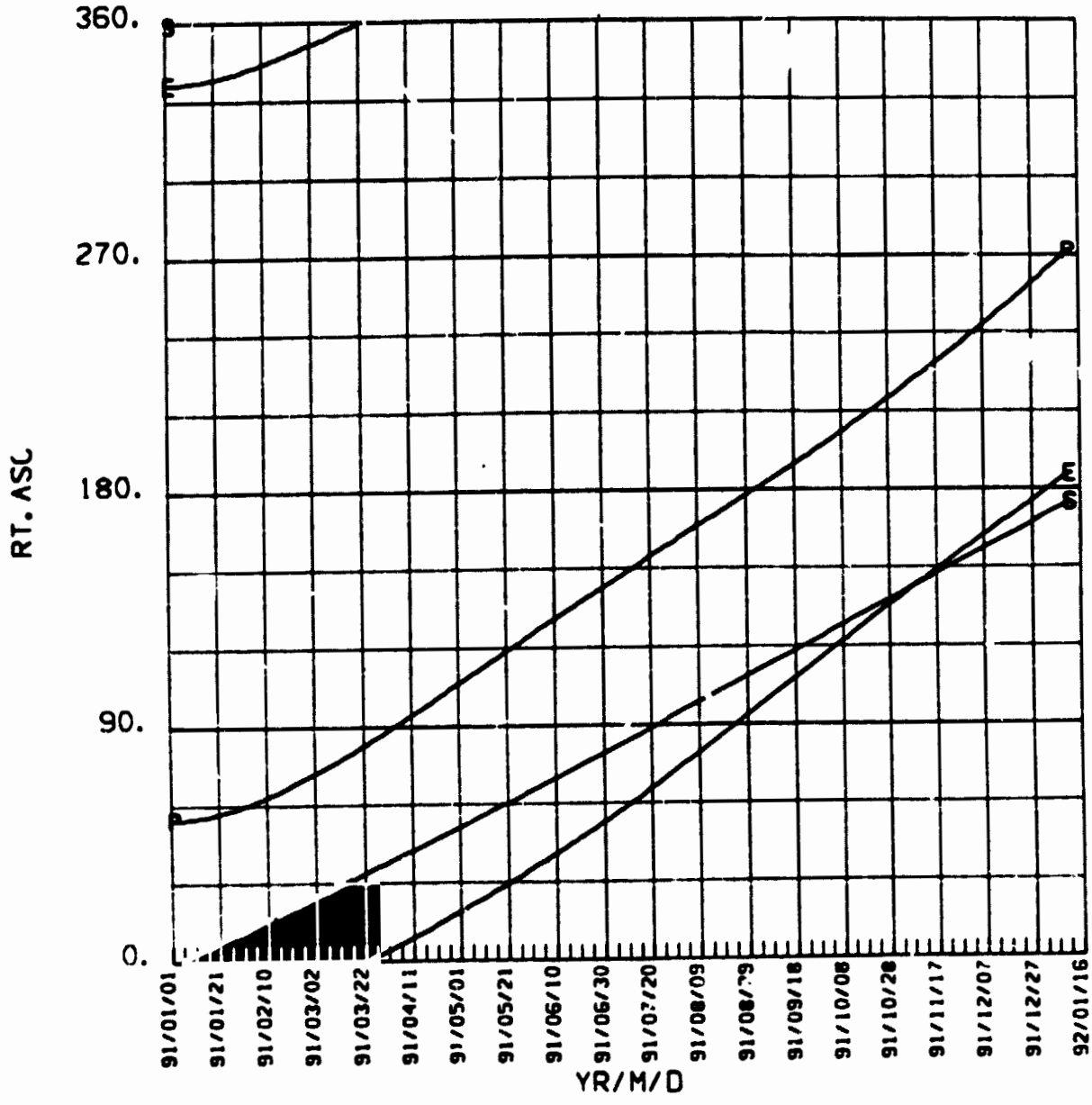
MARS 1991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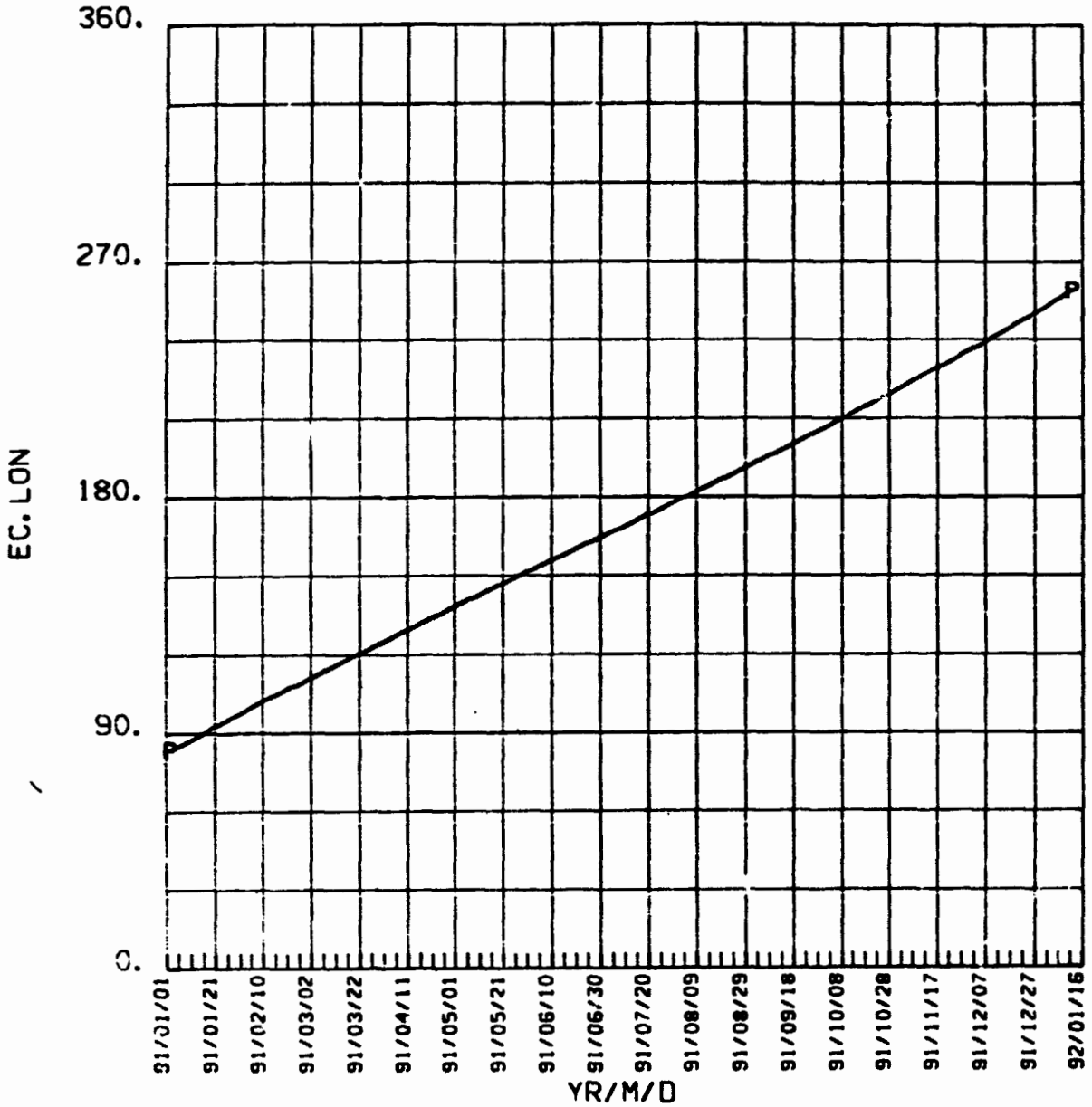
MARS 1991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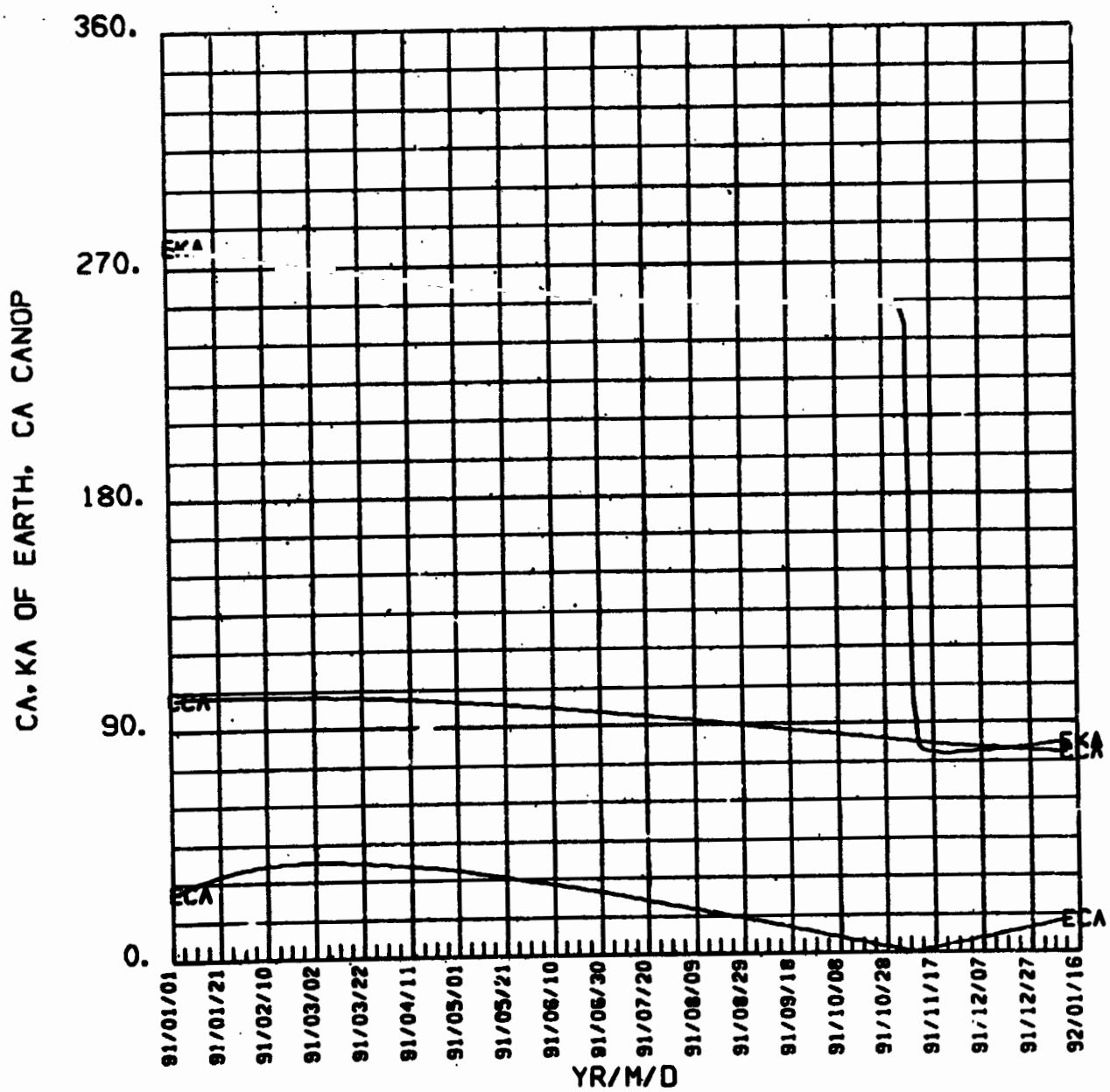
MARS 1991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CA, KA OF EARTH, CA CANOP
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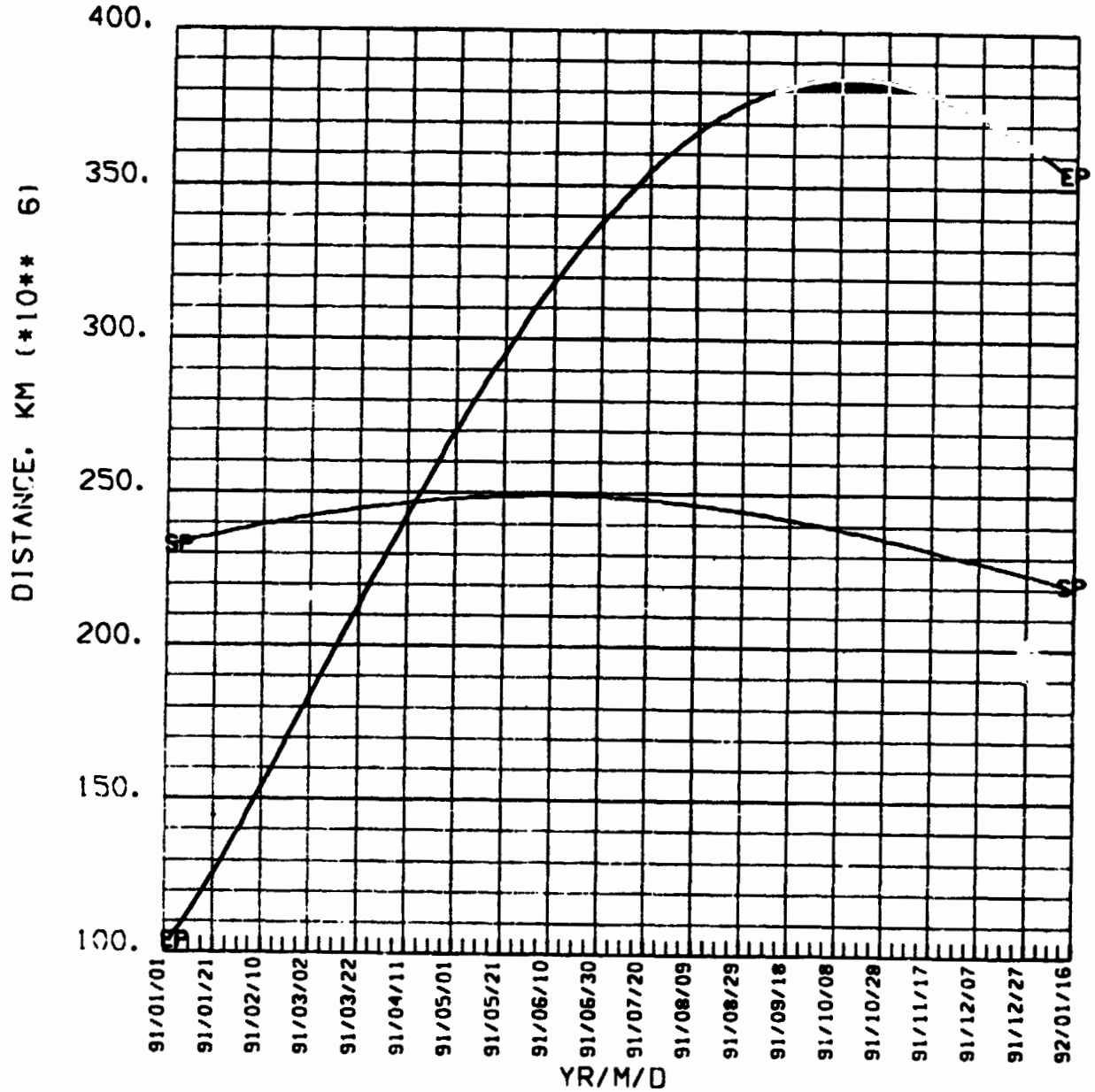
92/01/16
YR/M/D

MARS 1991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DISTANCE, KM (*10** 6)
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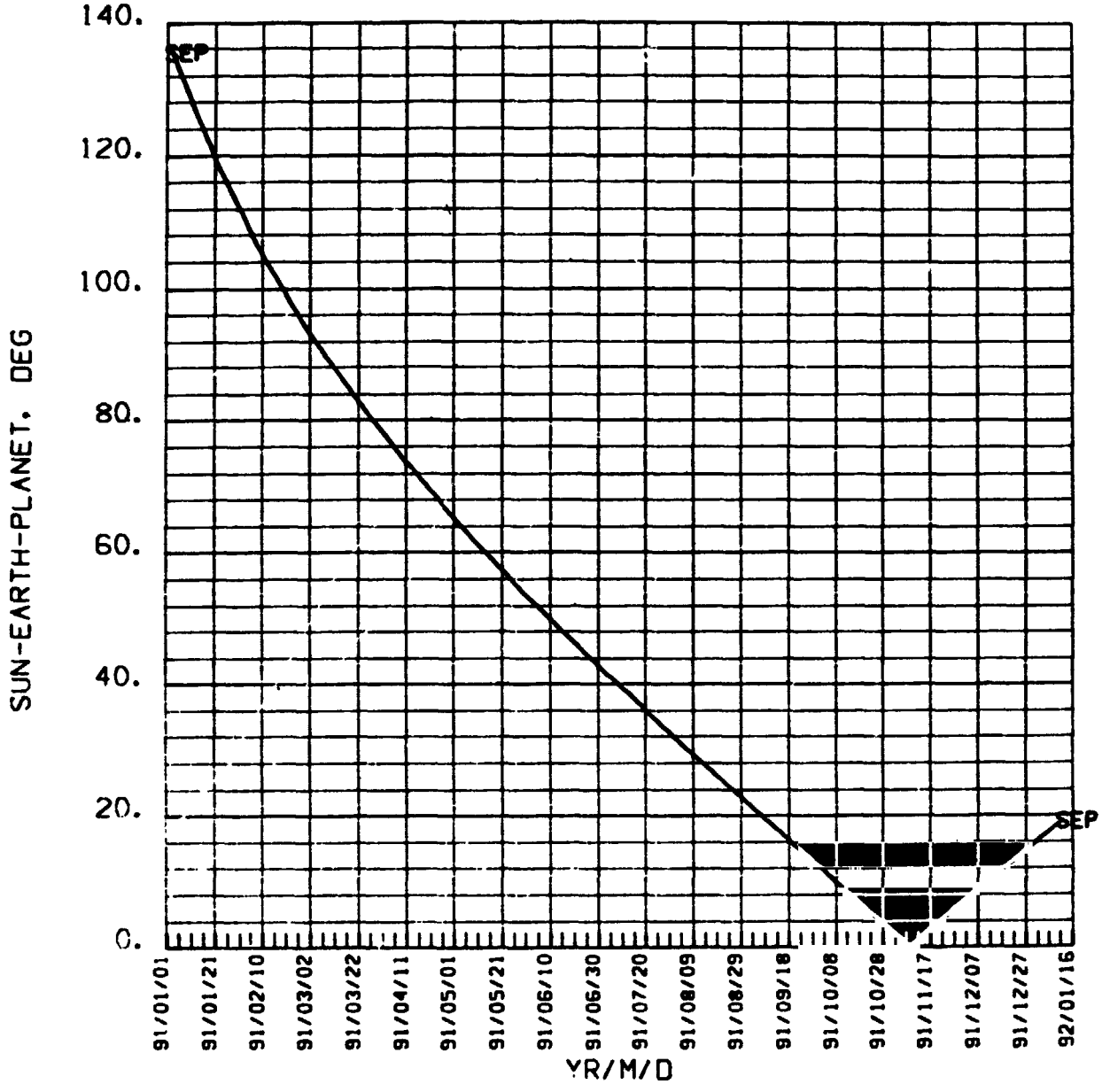
92/01/16
YR/M/D

MARS 1991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SUN-EARTH-PLANET, DEG
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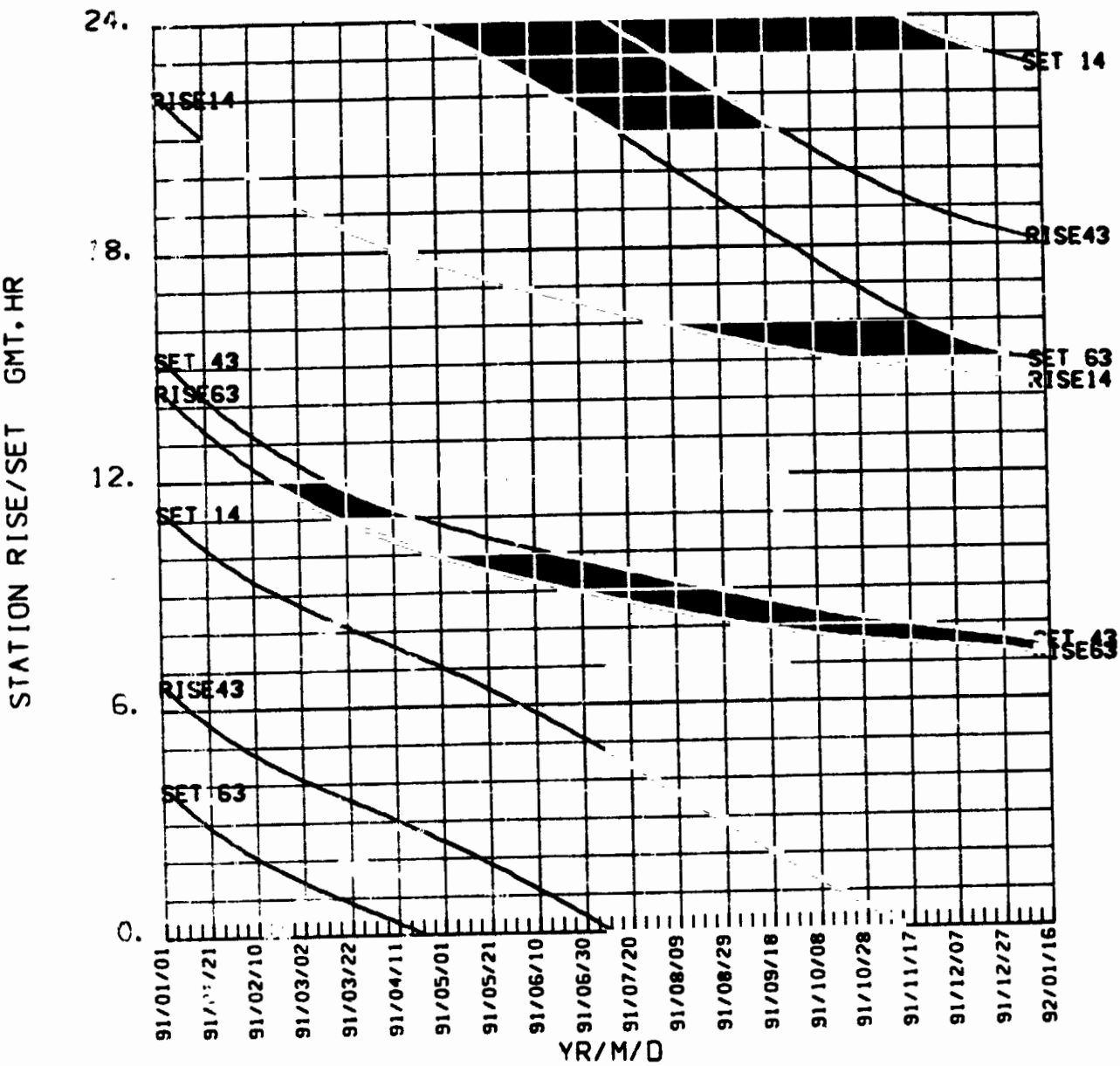
YR/M/D

MARS 1991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STATION RISE/SET GMT.HR
SET 14
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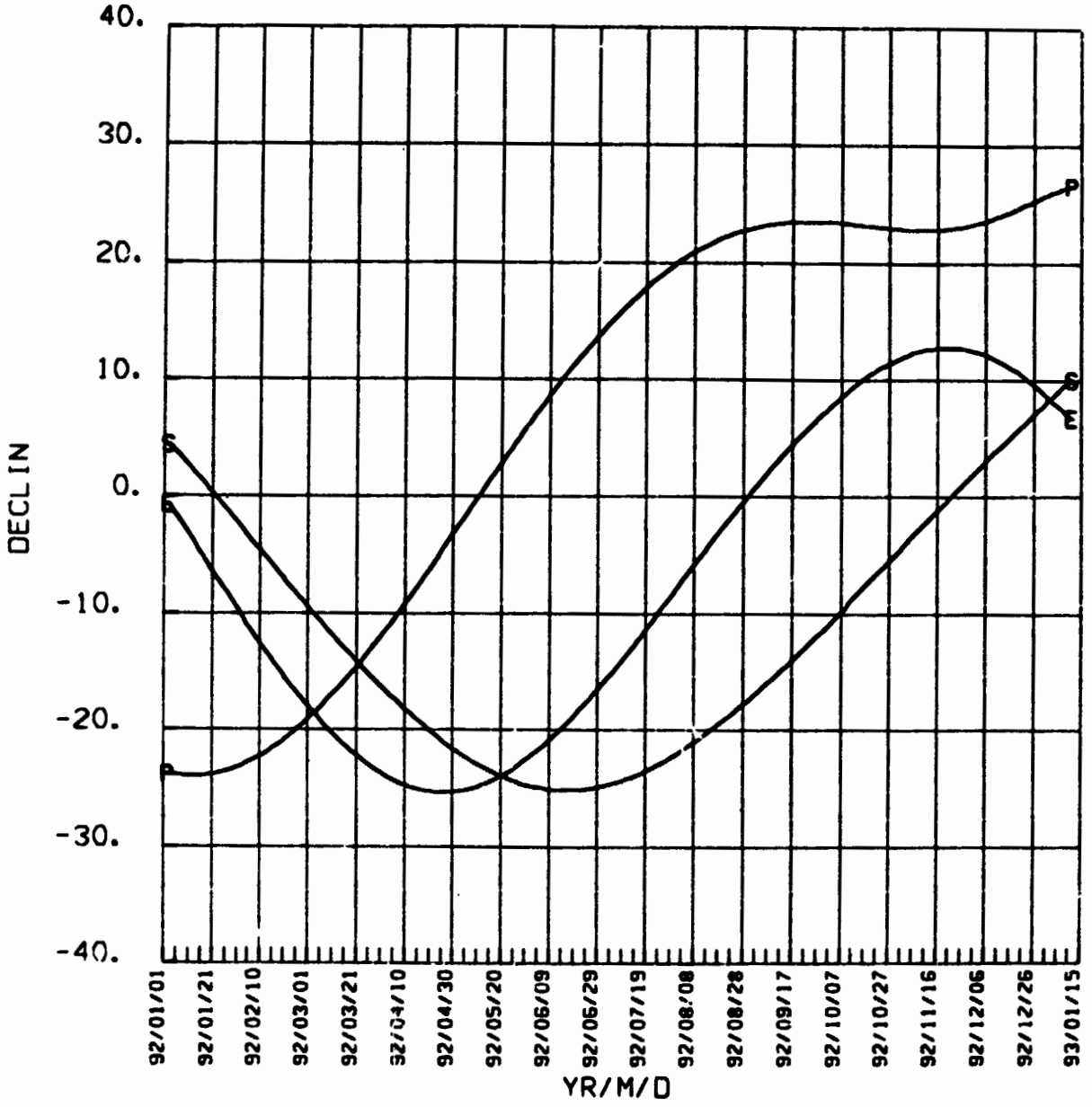
YR/M/D

MARS 1992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YR/M/D

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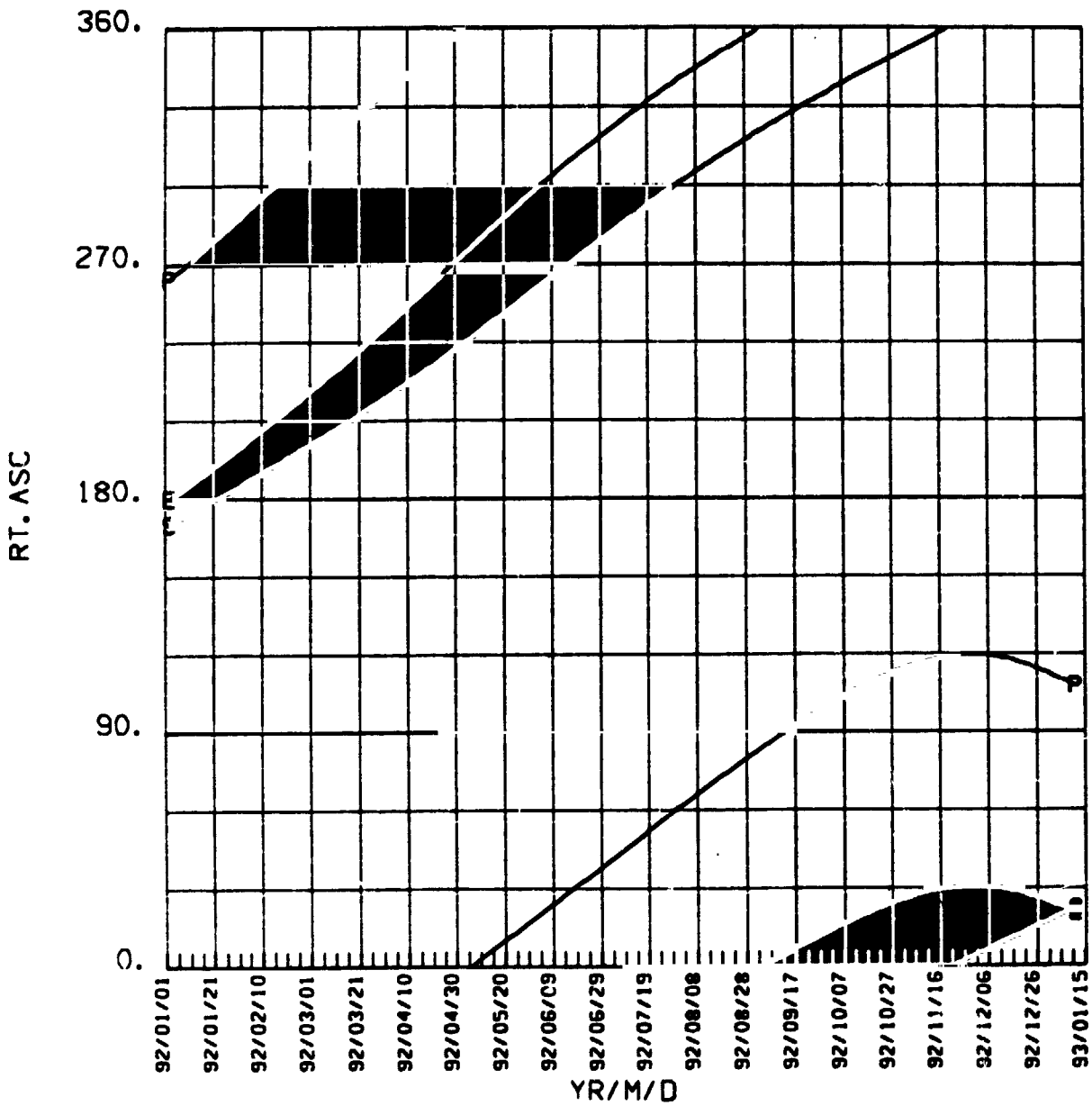
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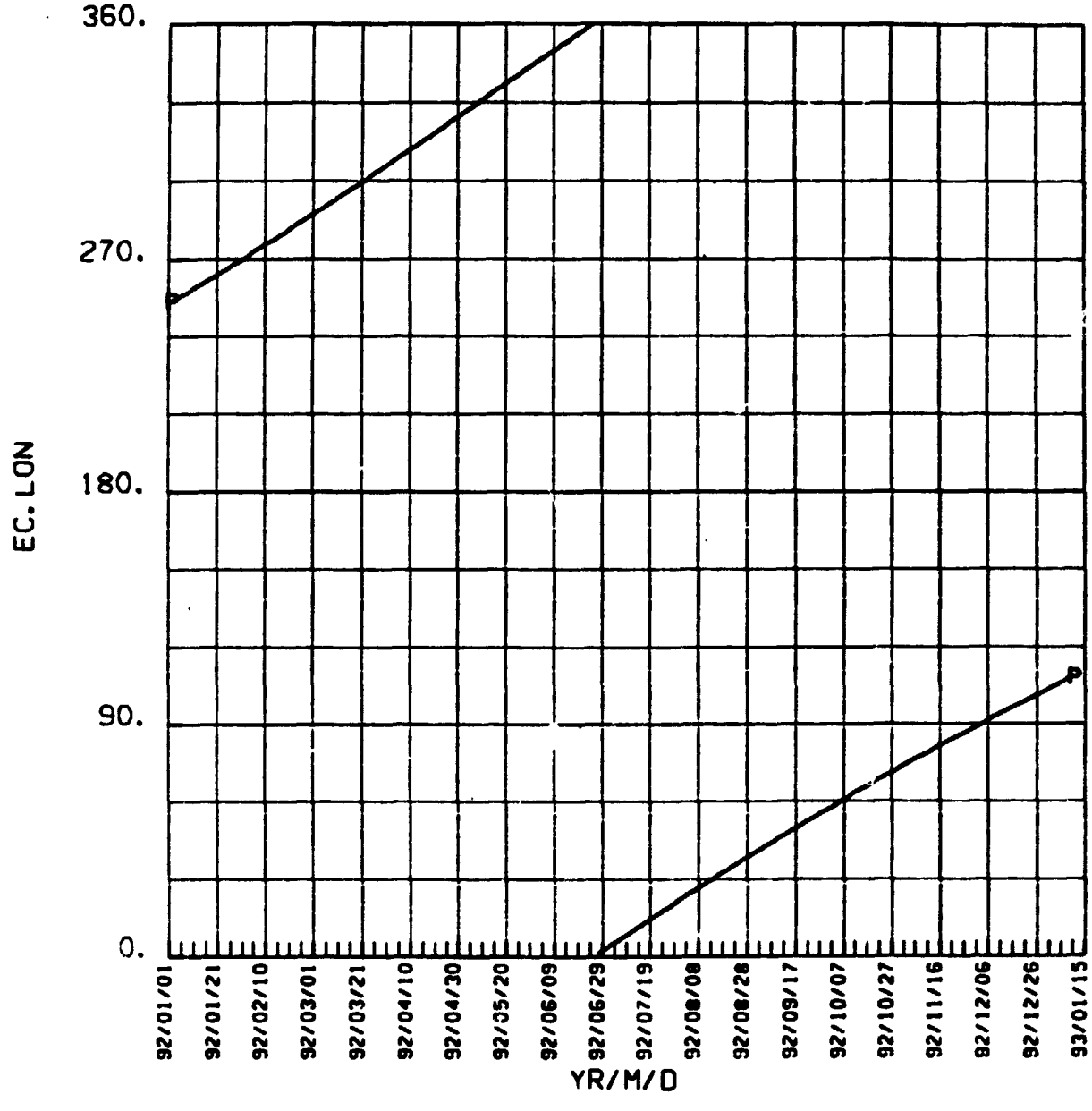
YR/M/D

MARS 1992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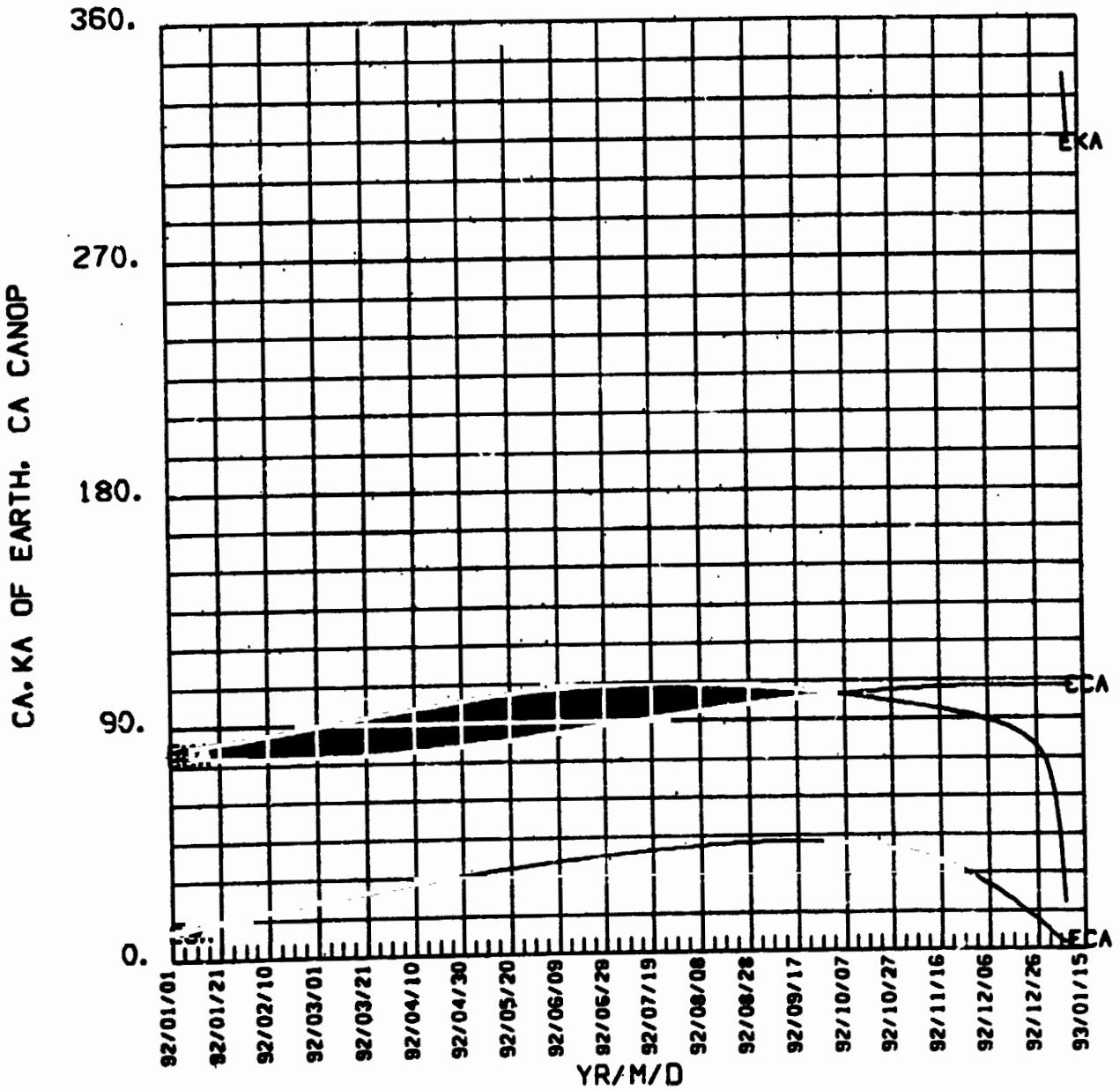
YR/M/D

MARS 1992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CA.KA OF EARTH. CA CANOP
EKA
ECA
ECA
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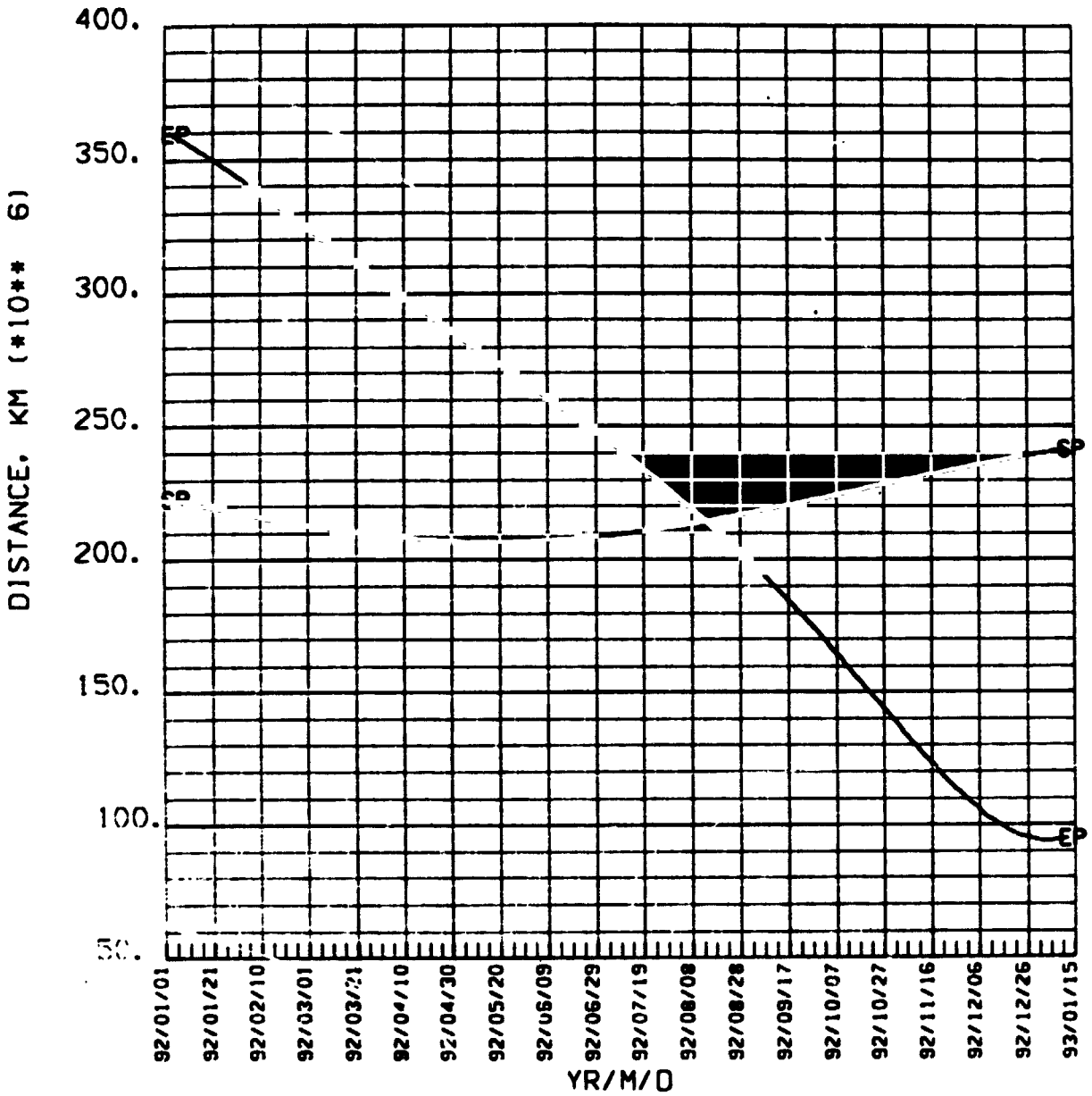
YR/M/D

MARS 1992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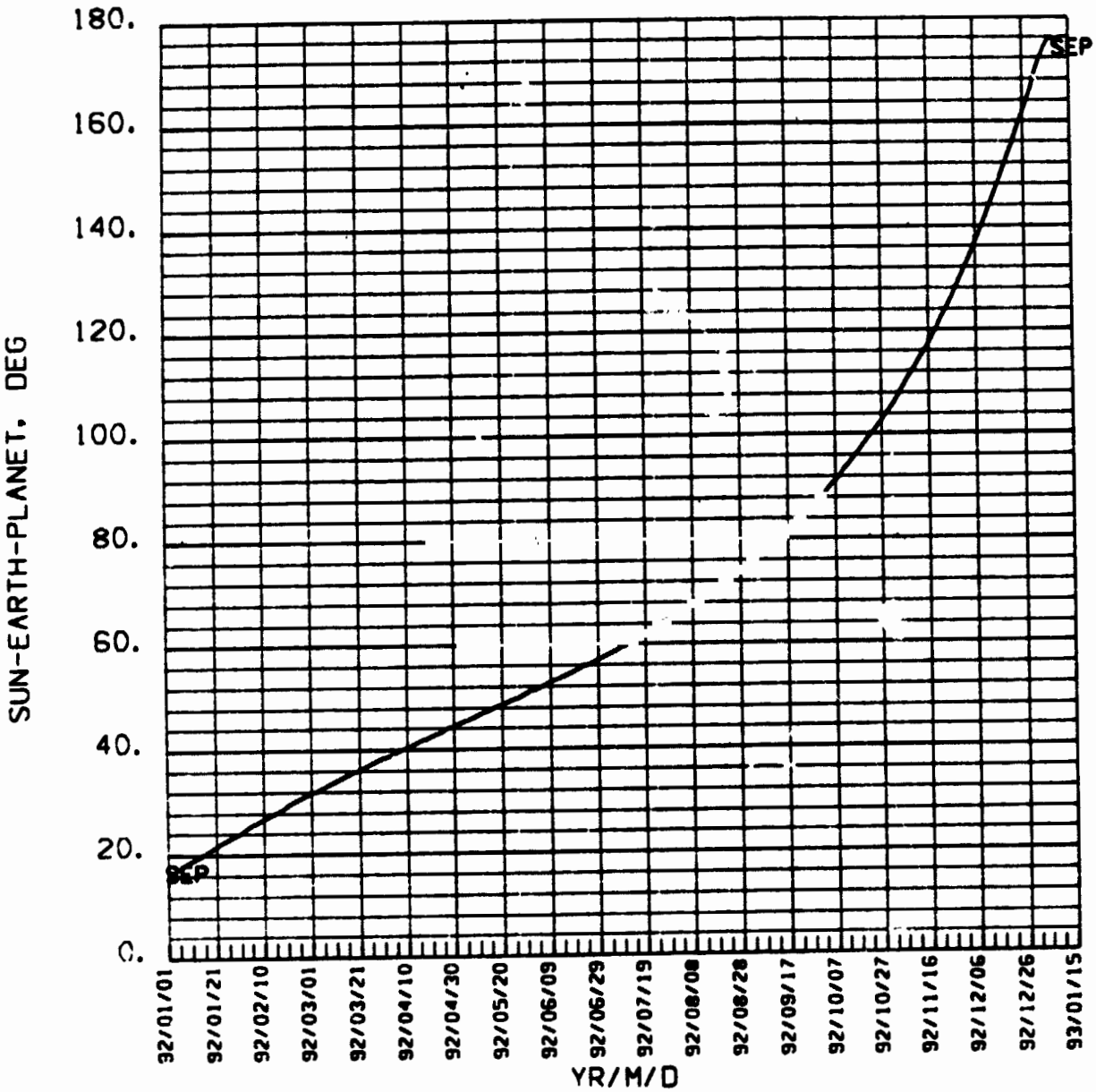
YR/M/D

MARS 1992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SUN-EARTH-PLANET, DEG
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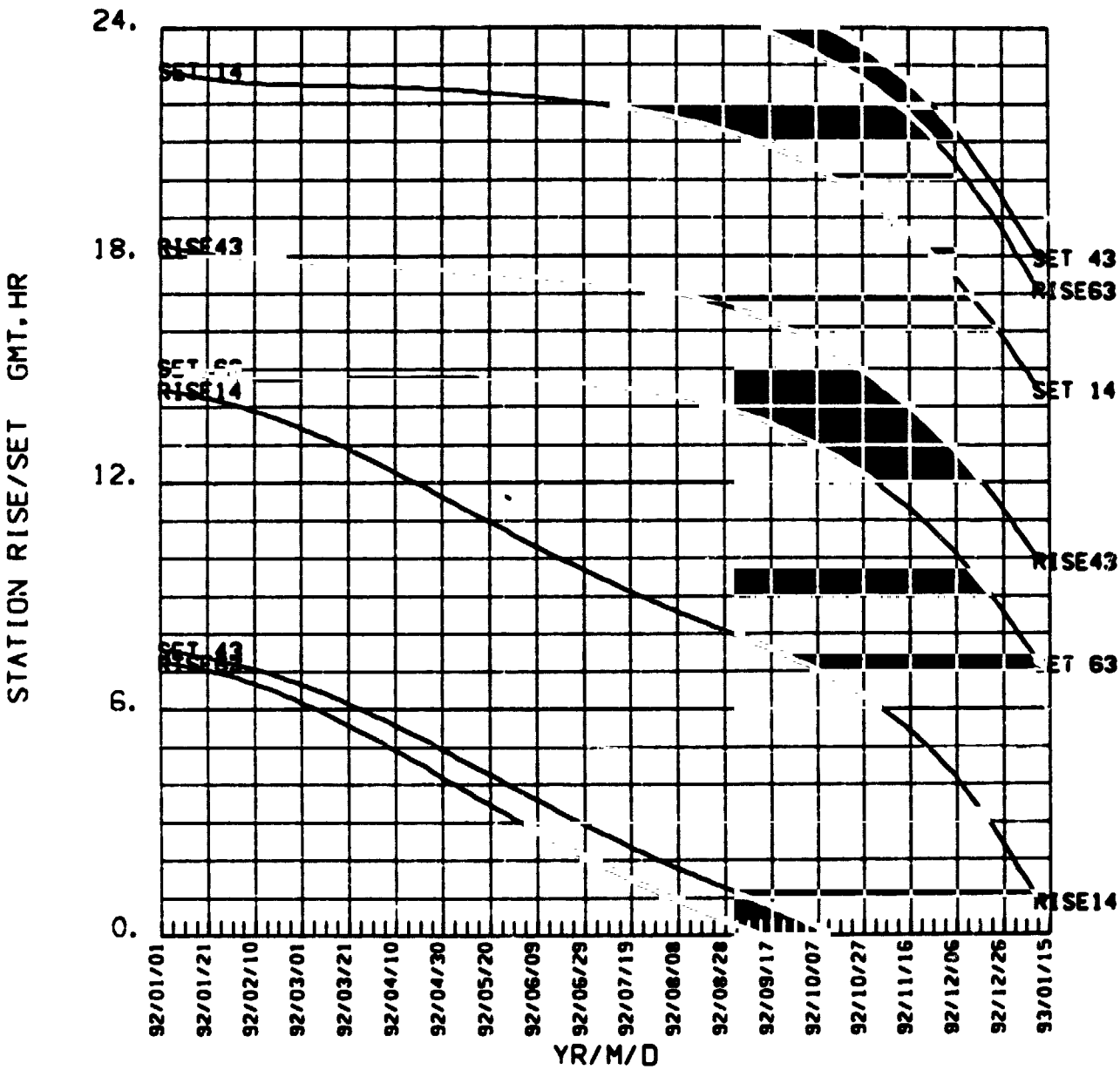
YR/M/D

MARS 1992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RISE63
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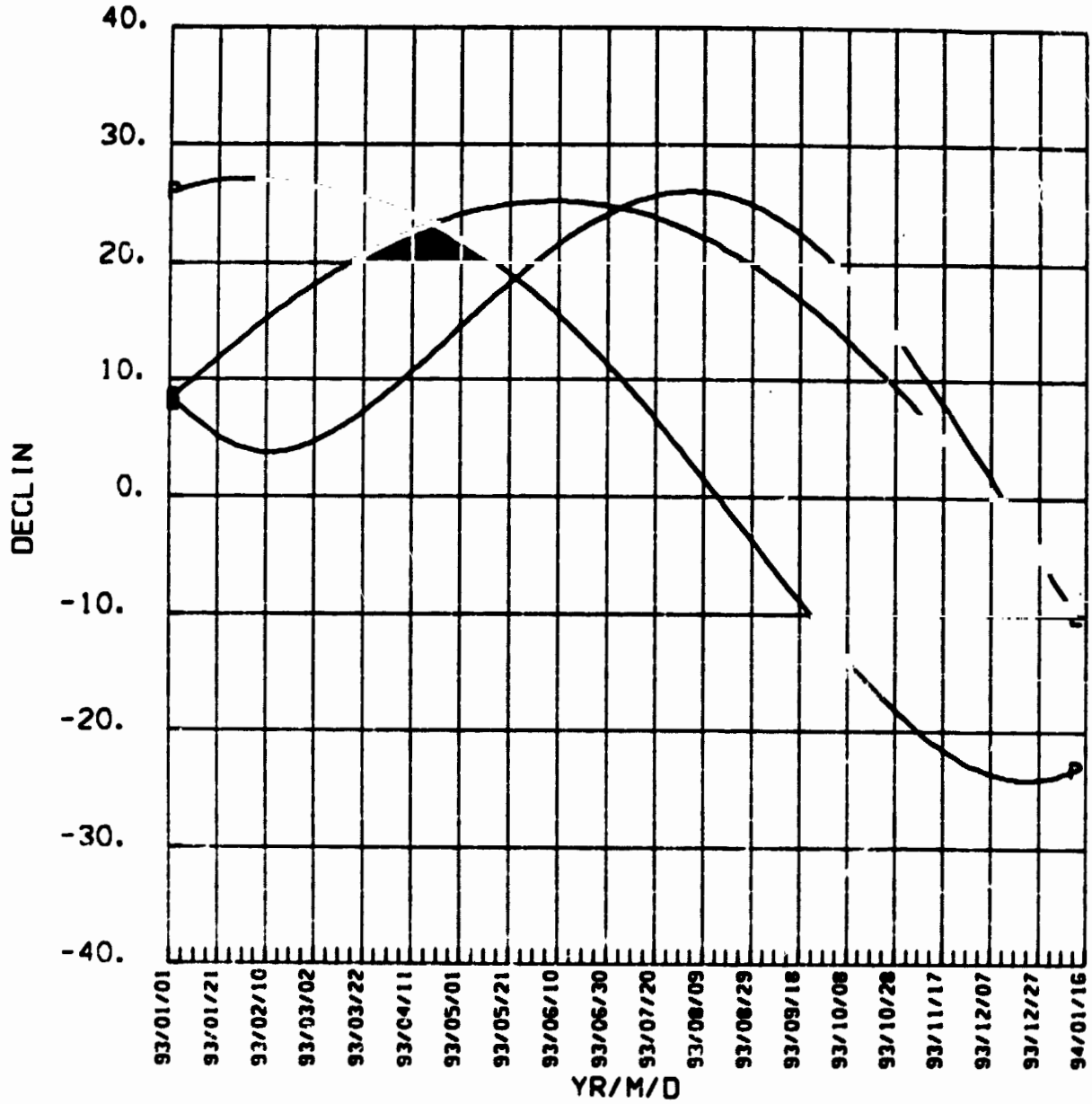
YR/M/D

MARS 1993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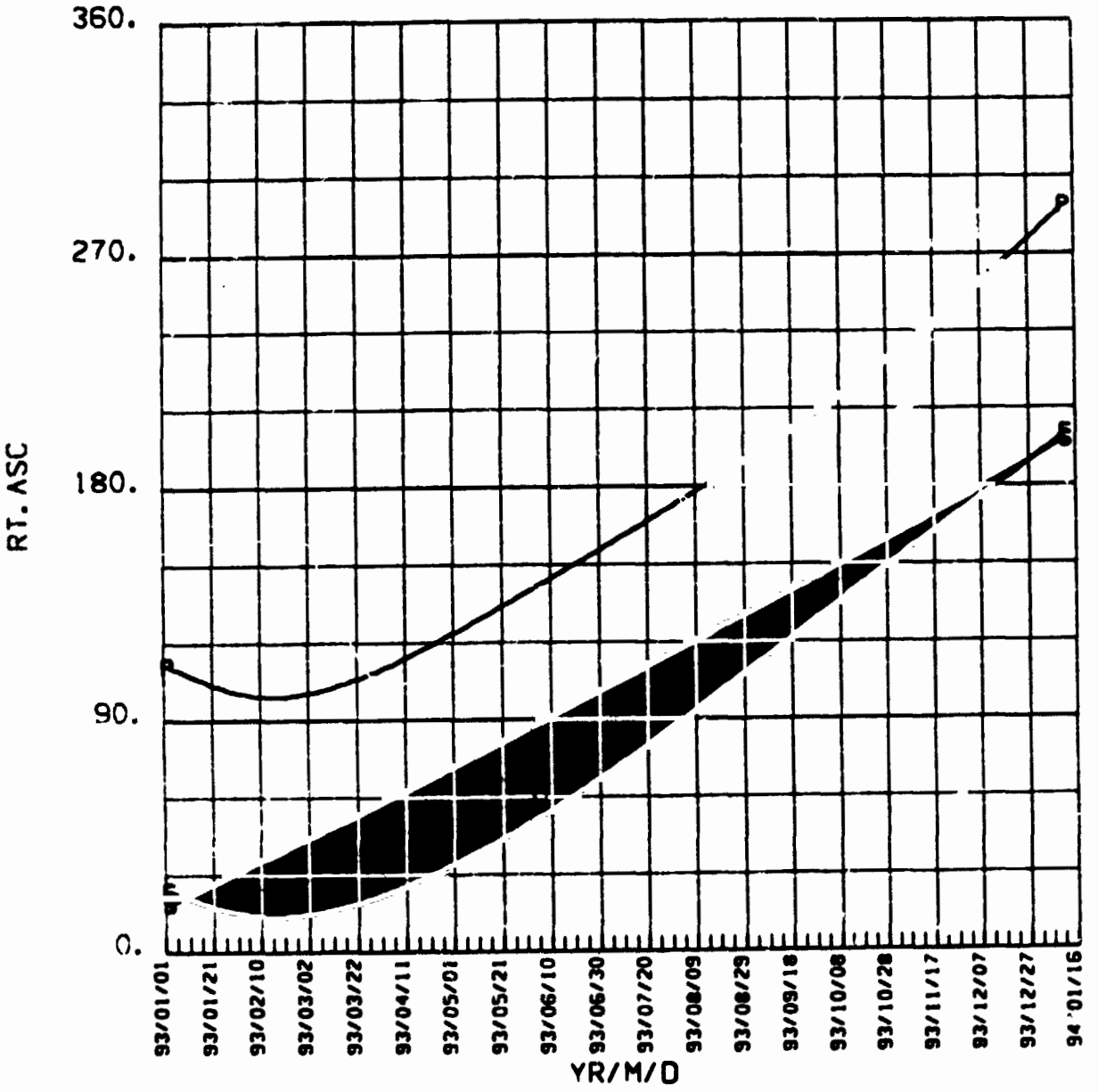
YR/M/D

MARS 1993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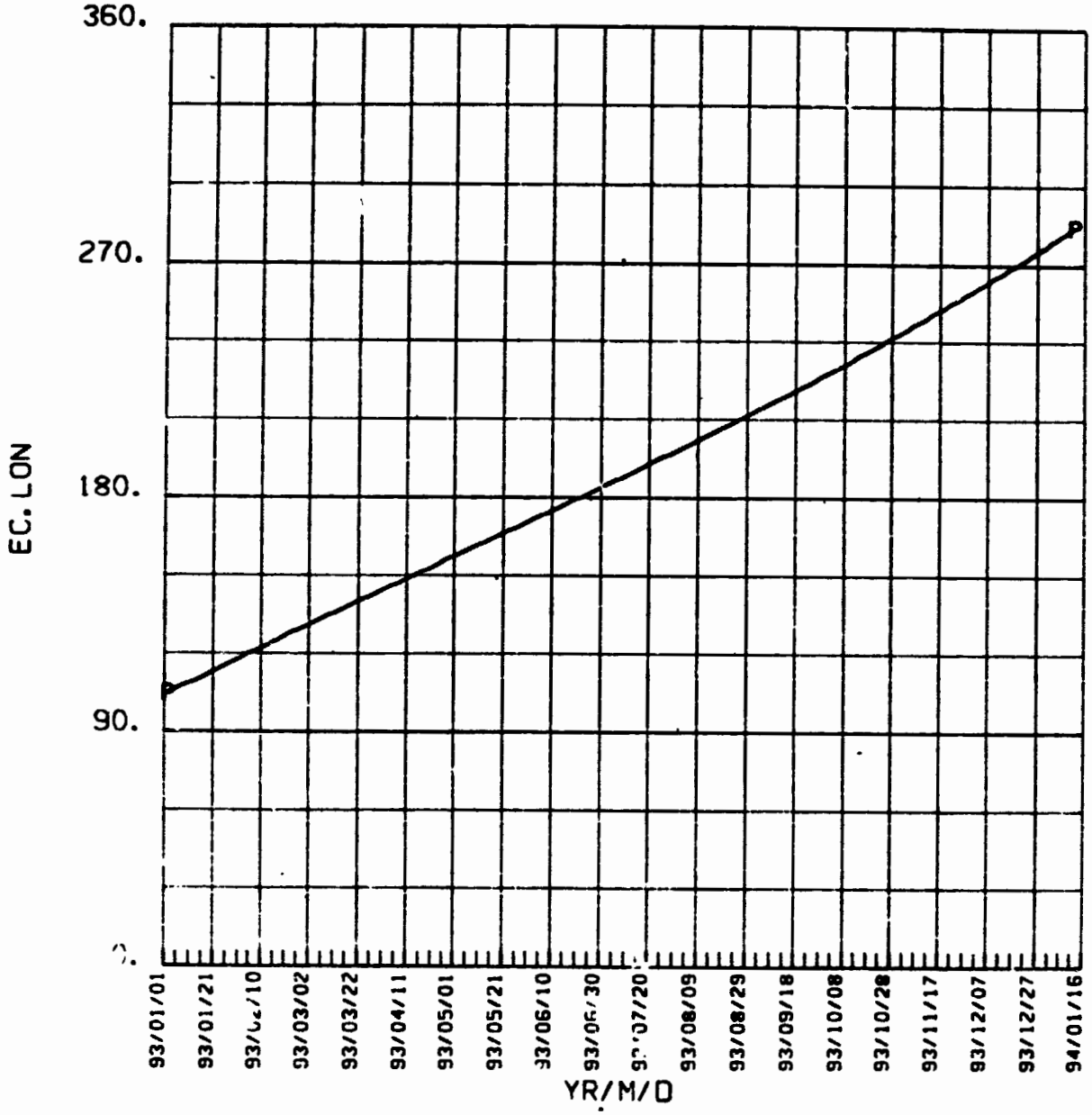
YR/M/D

MARS 1993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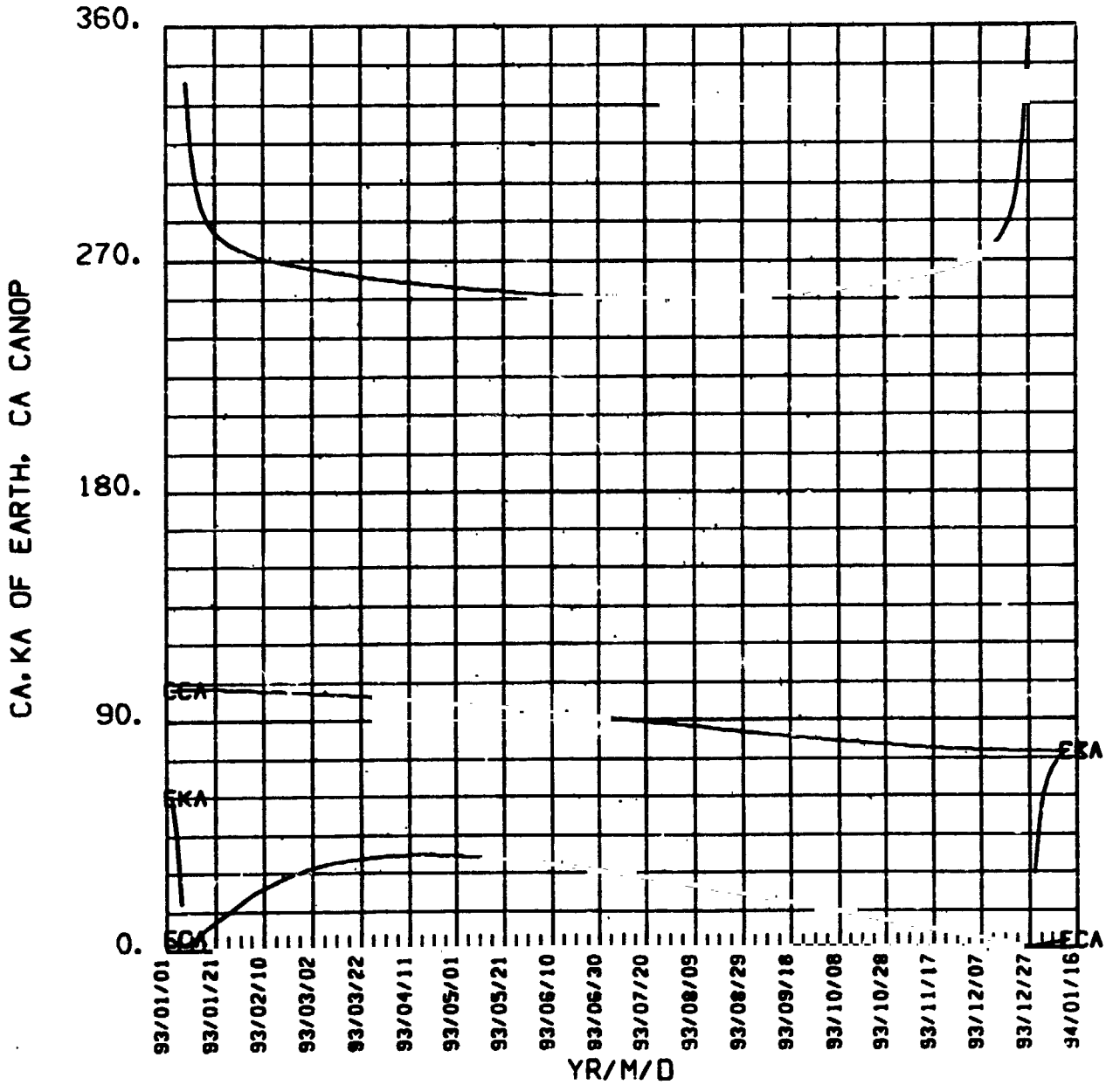
YR/M/D

MARS 1993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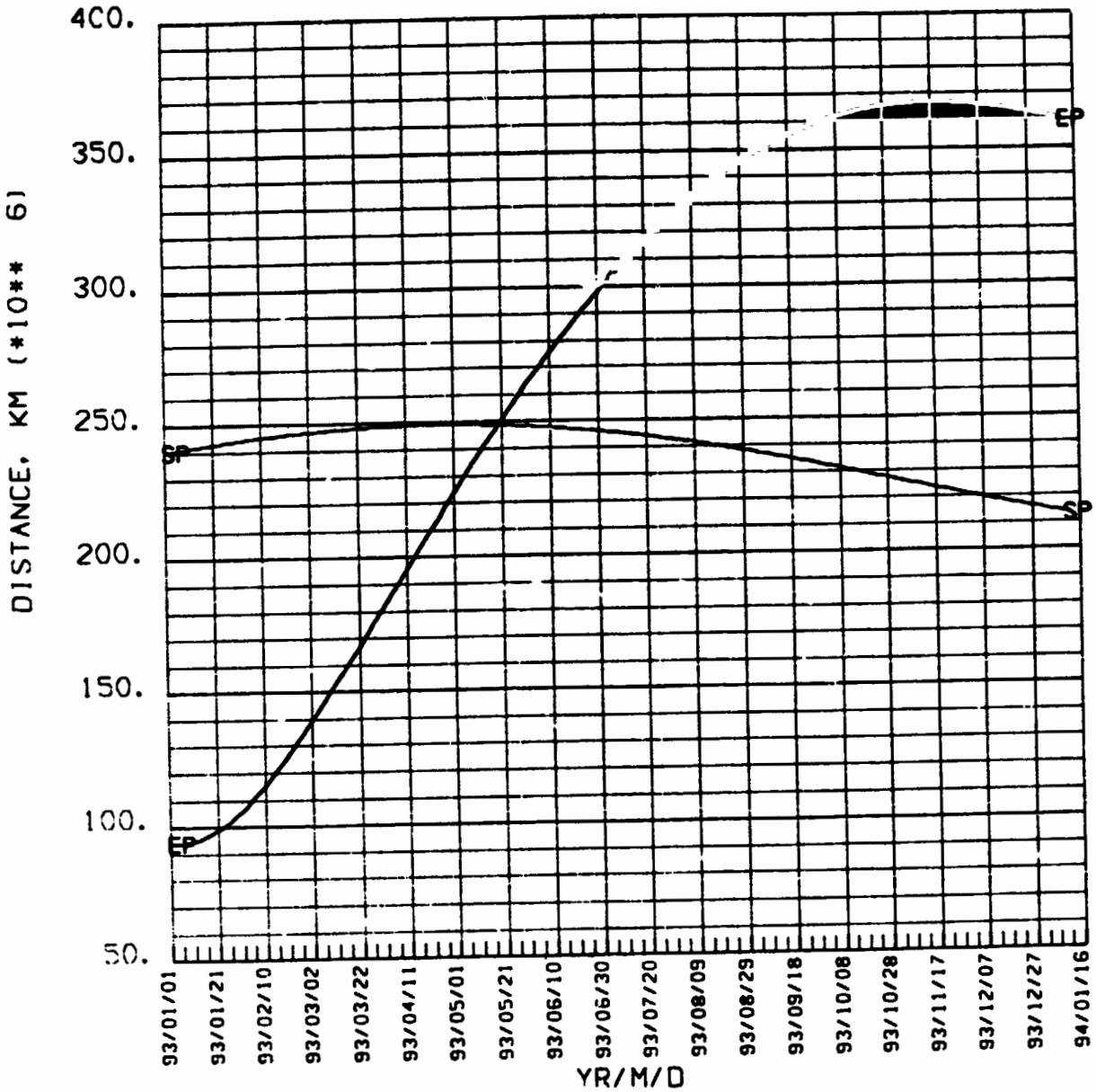
MARS 1993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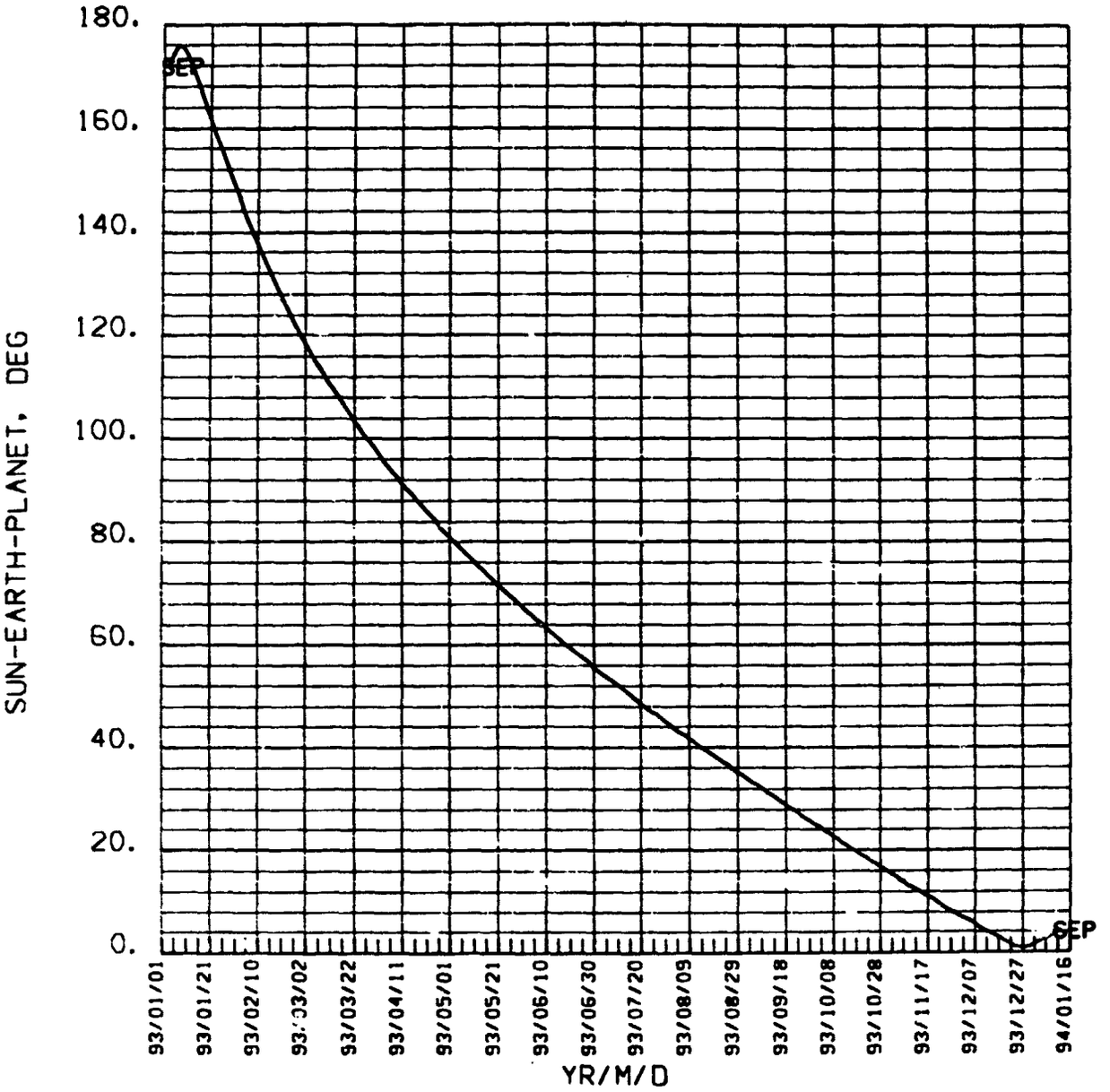
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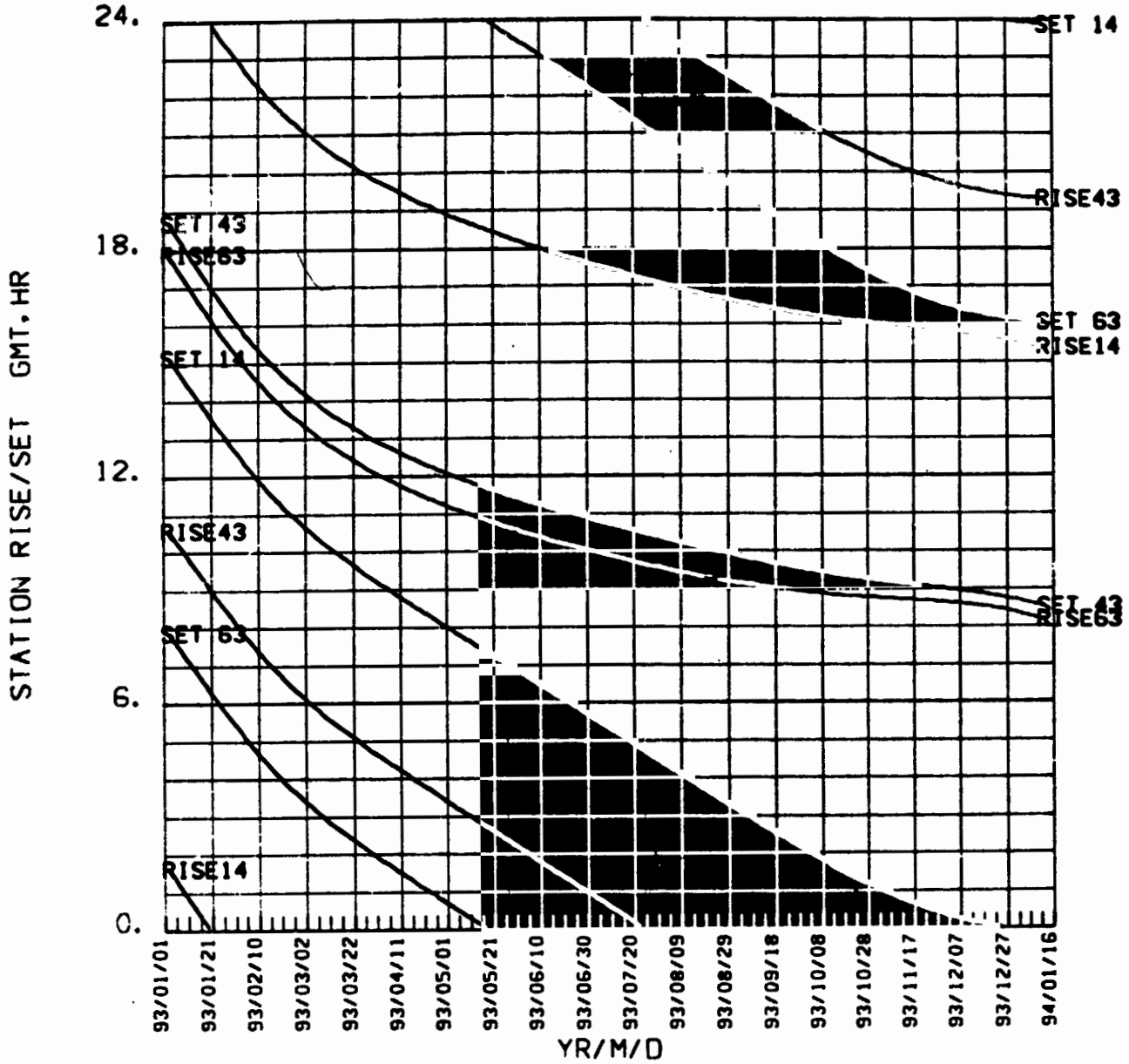
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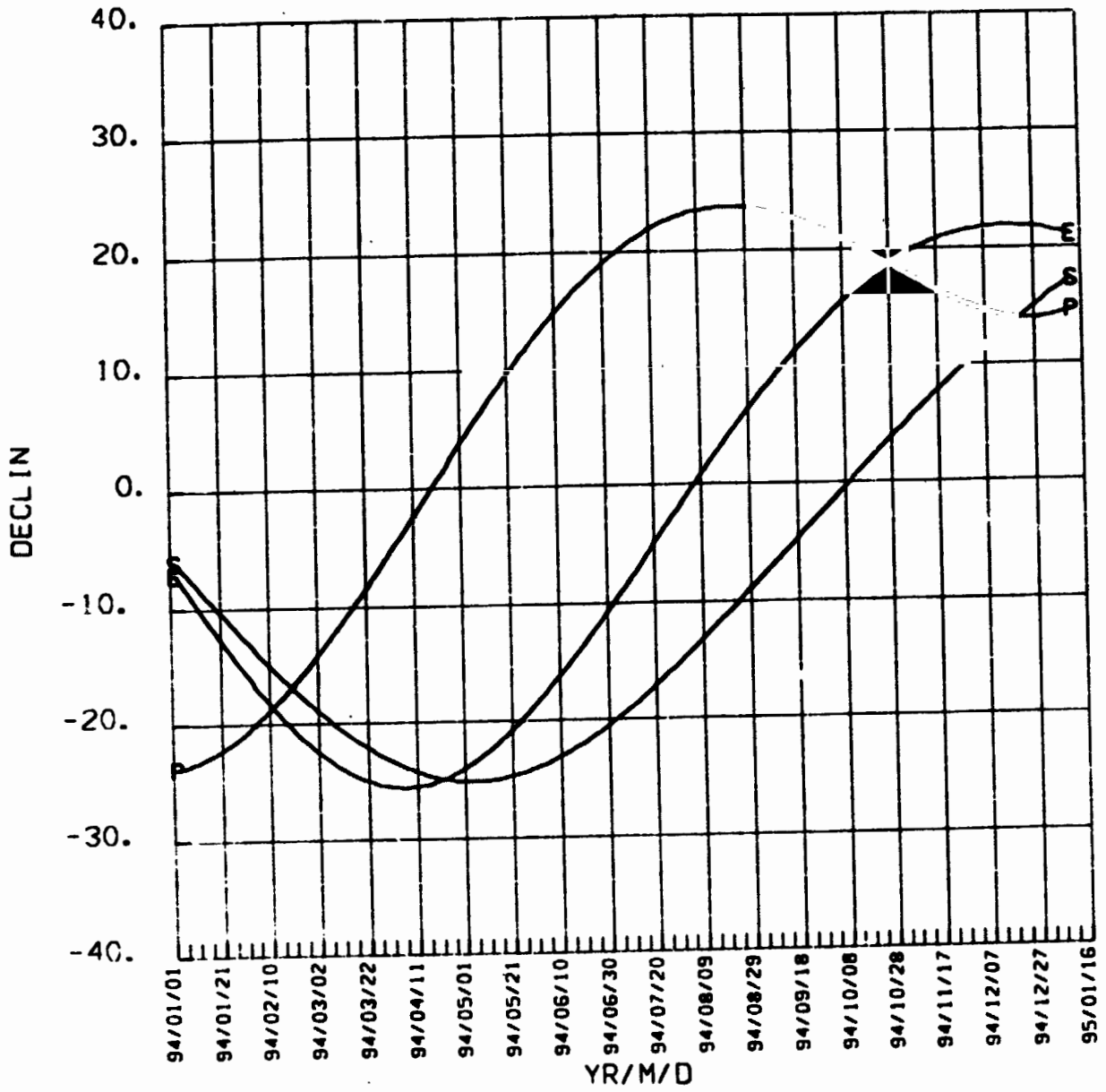
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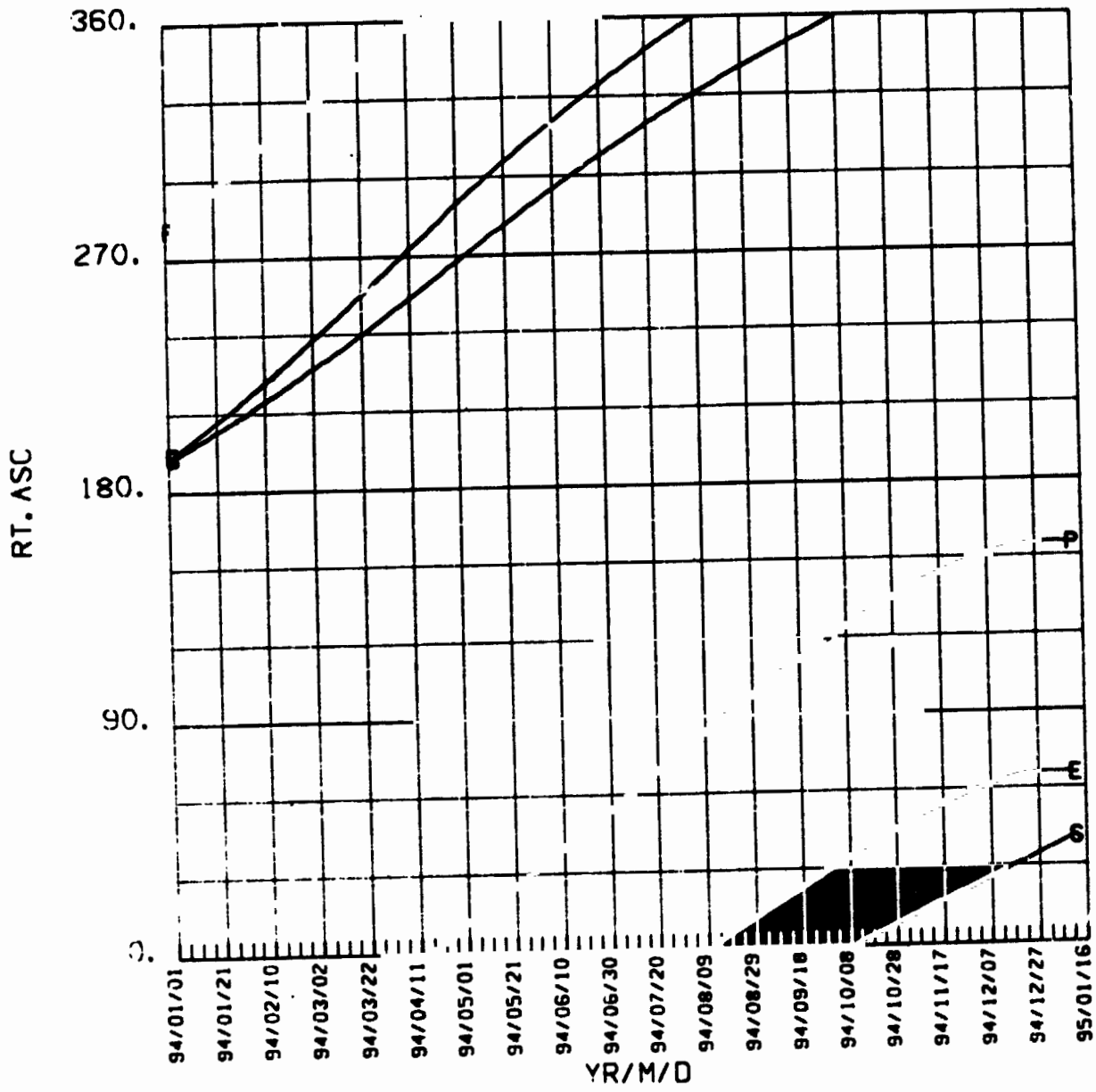
YR/M/D

MARS 1994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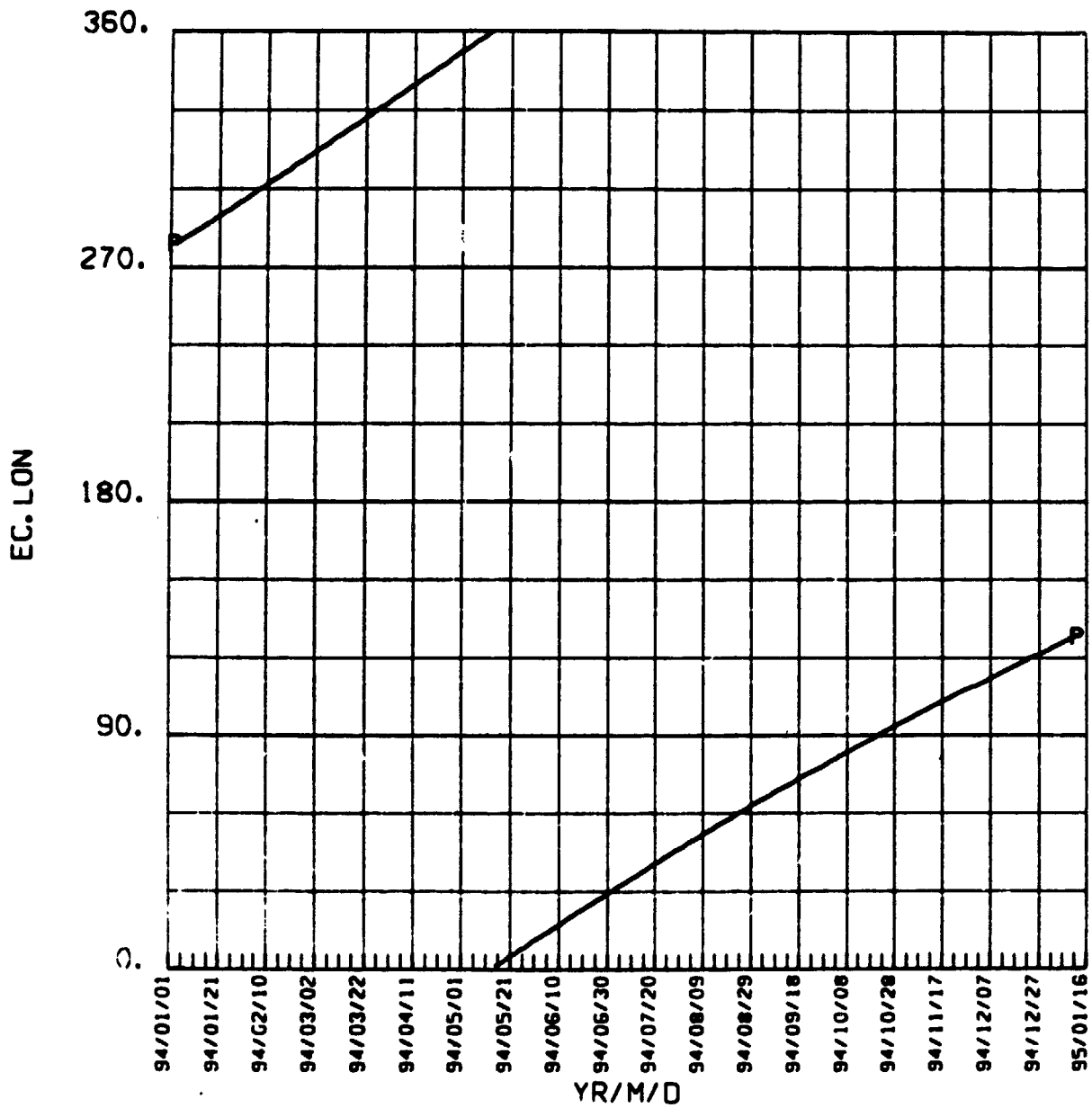
MARS 1994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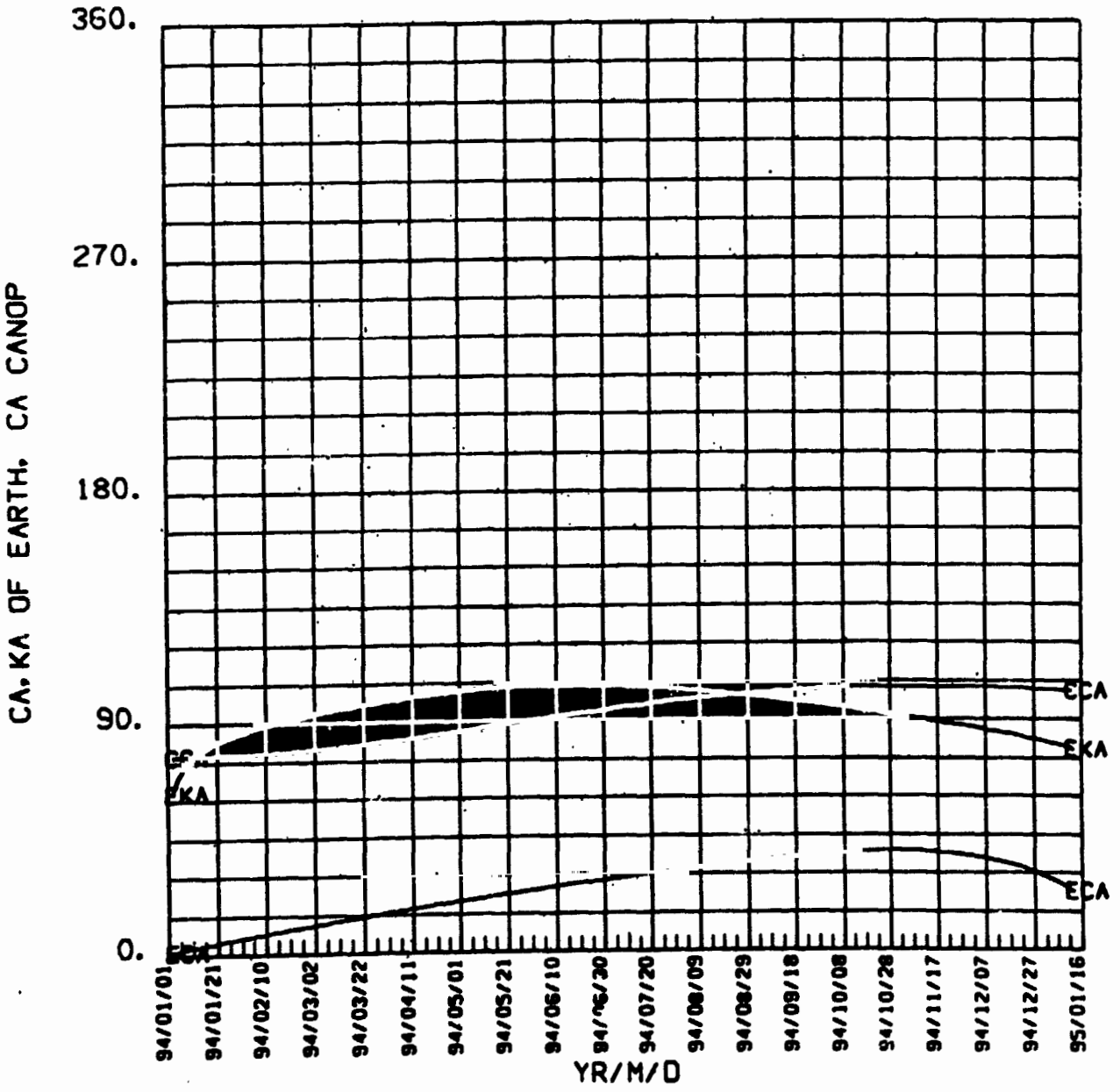
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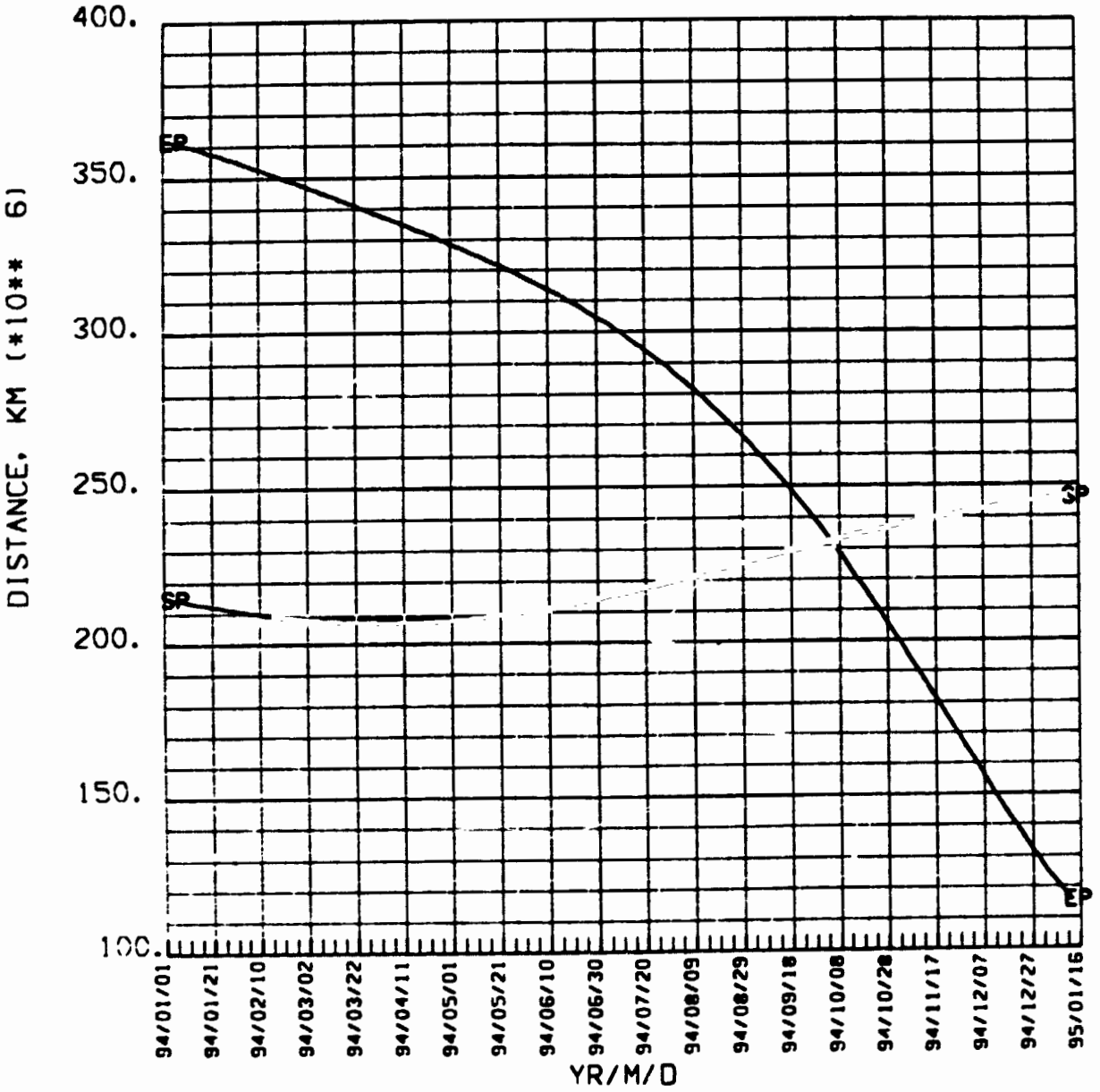
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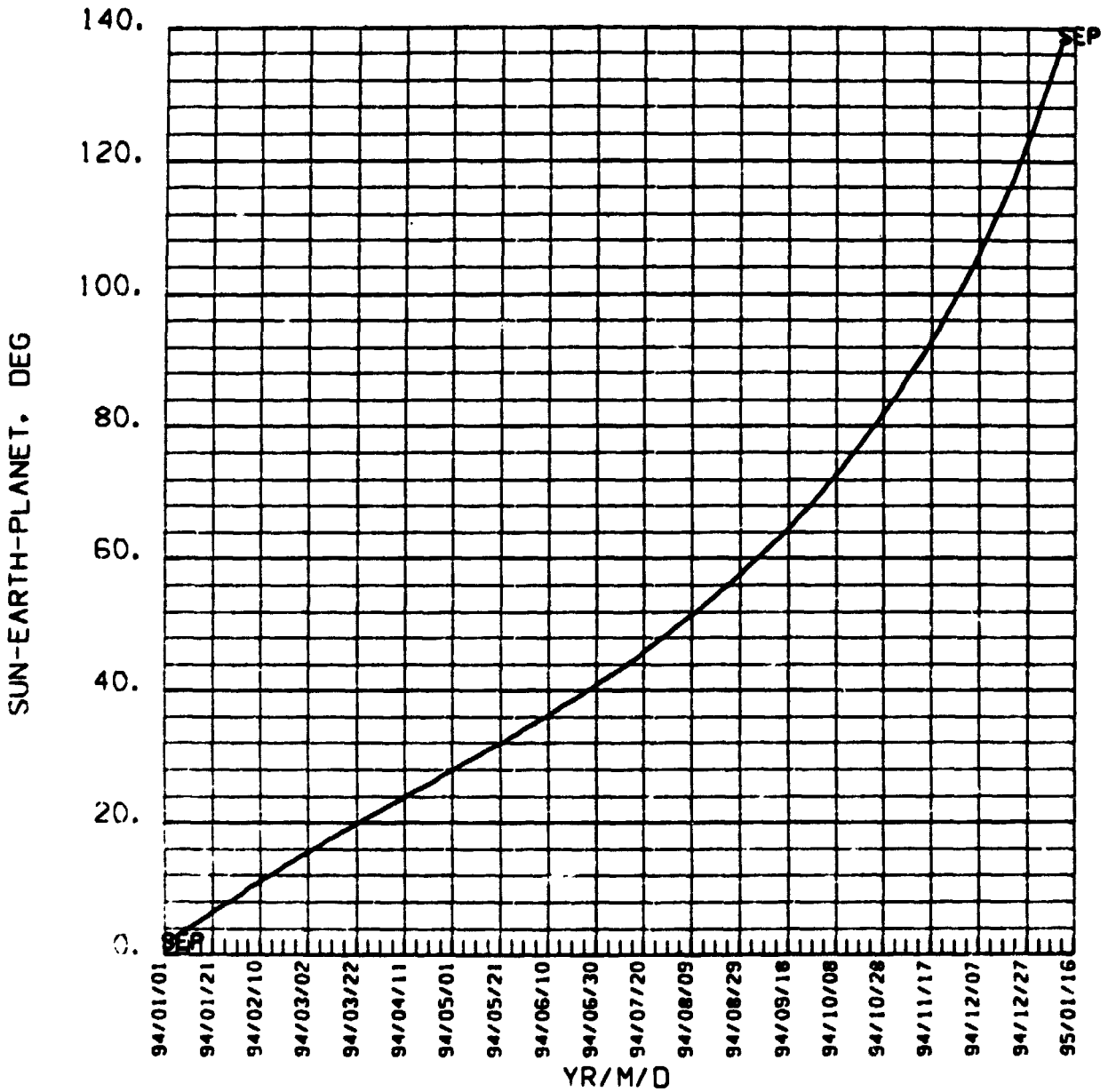
MARS 1994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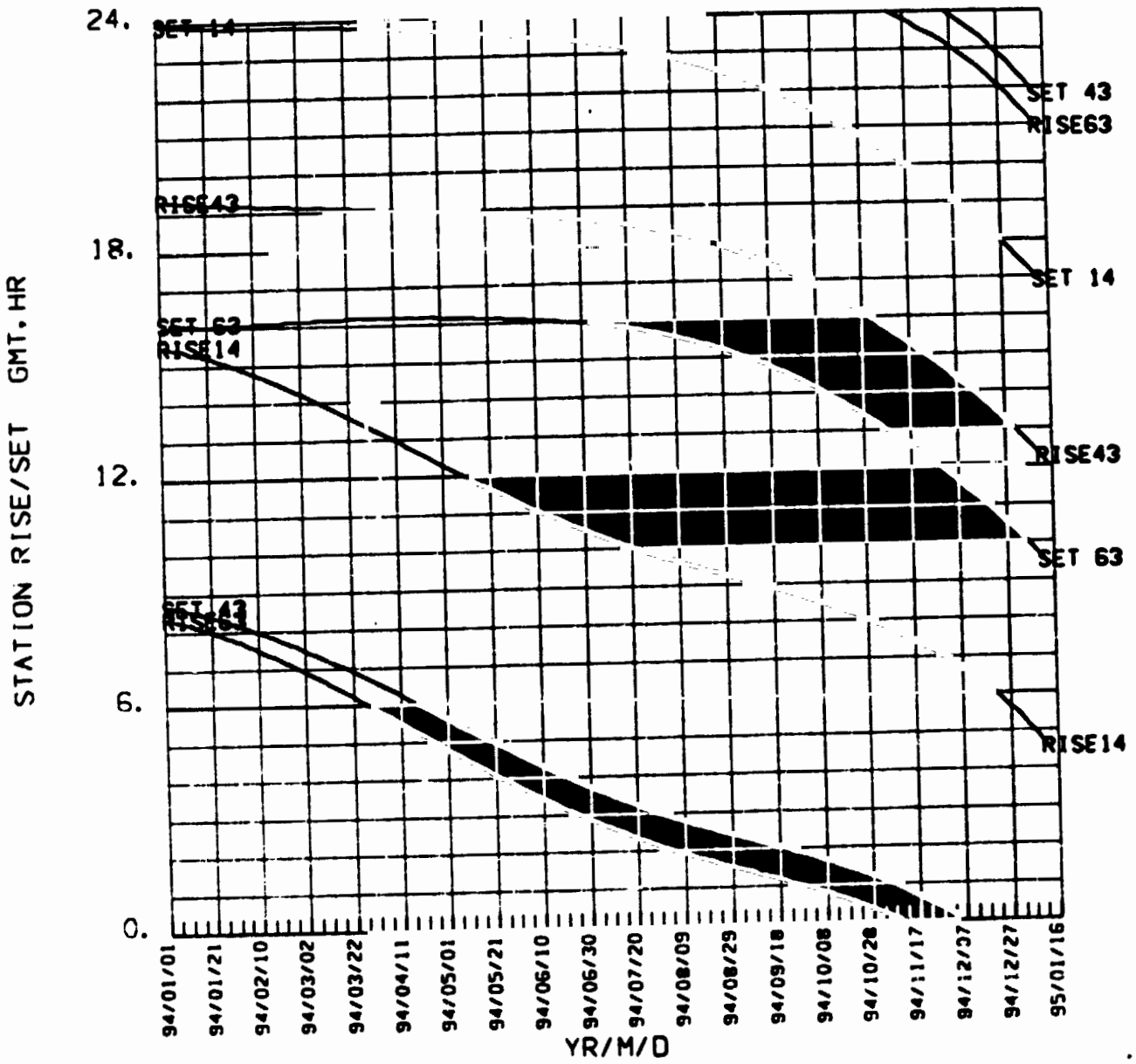
MARS 1994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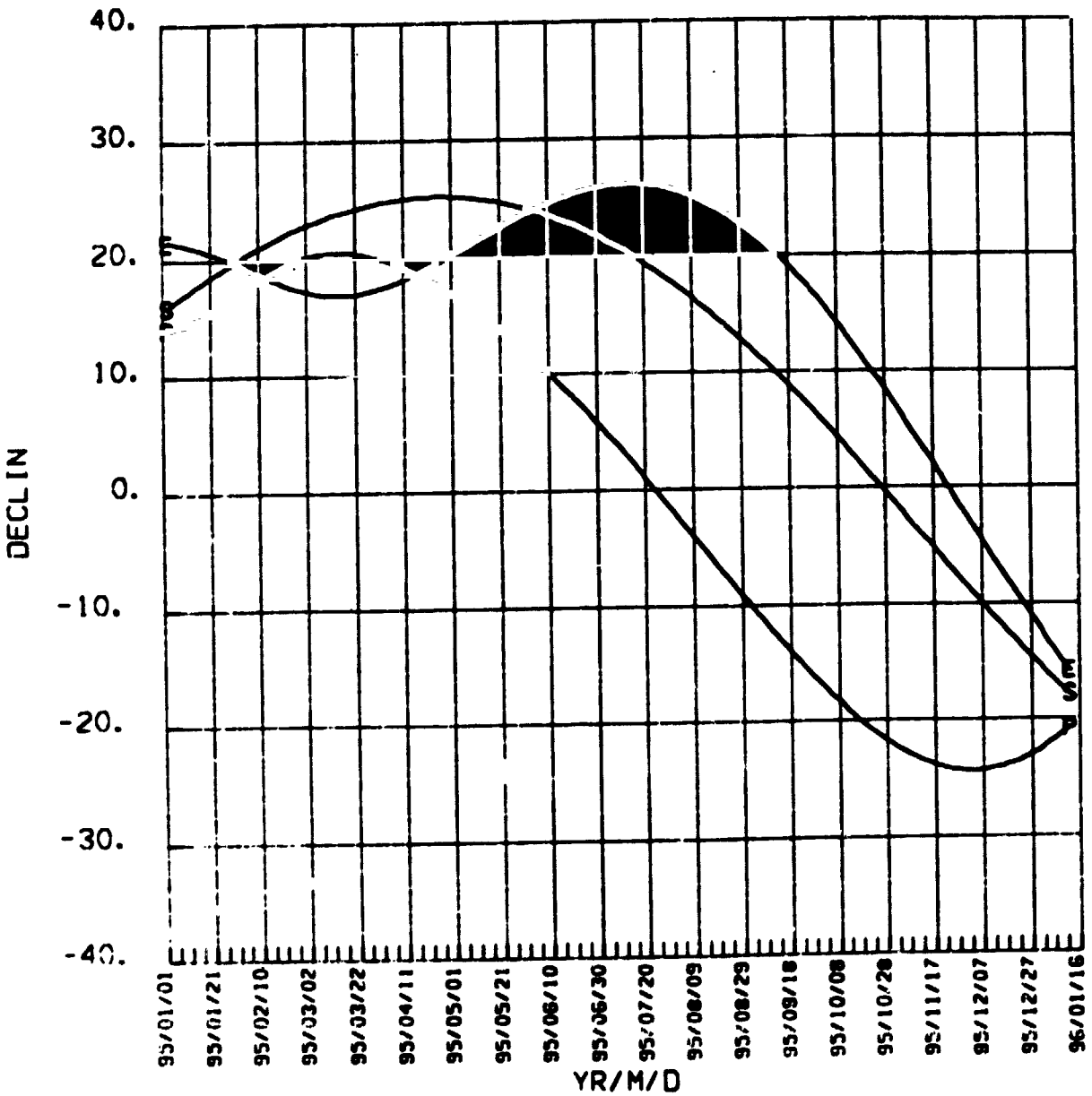
YR/M/D

MARS 1995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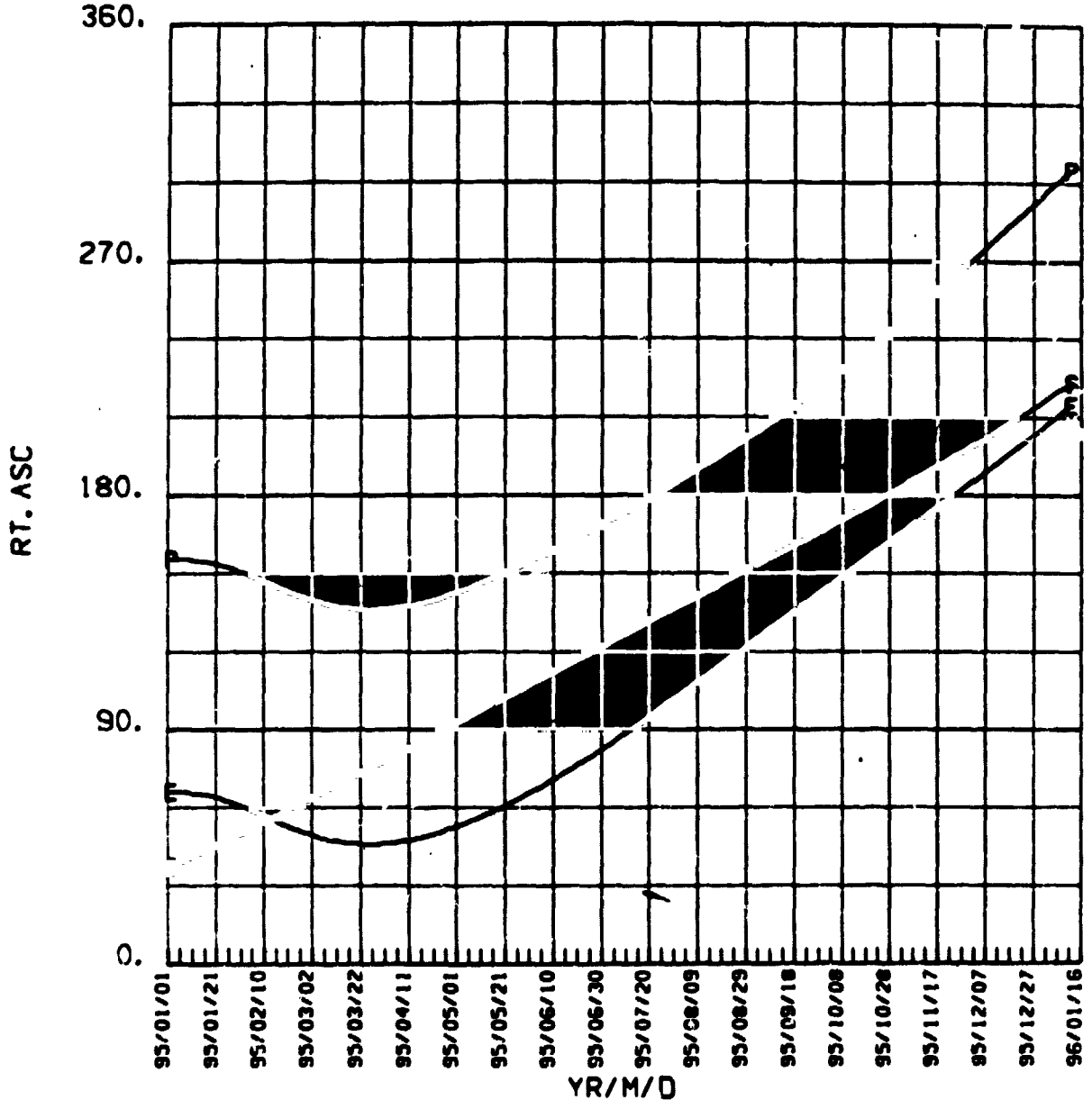
MARS 1995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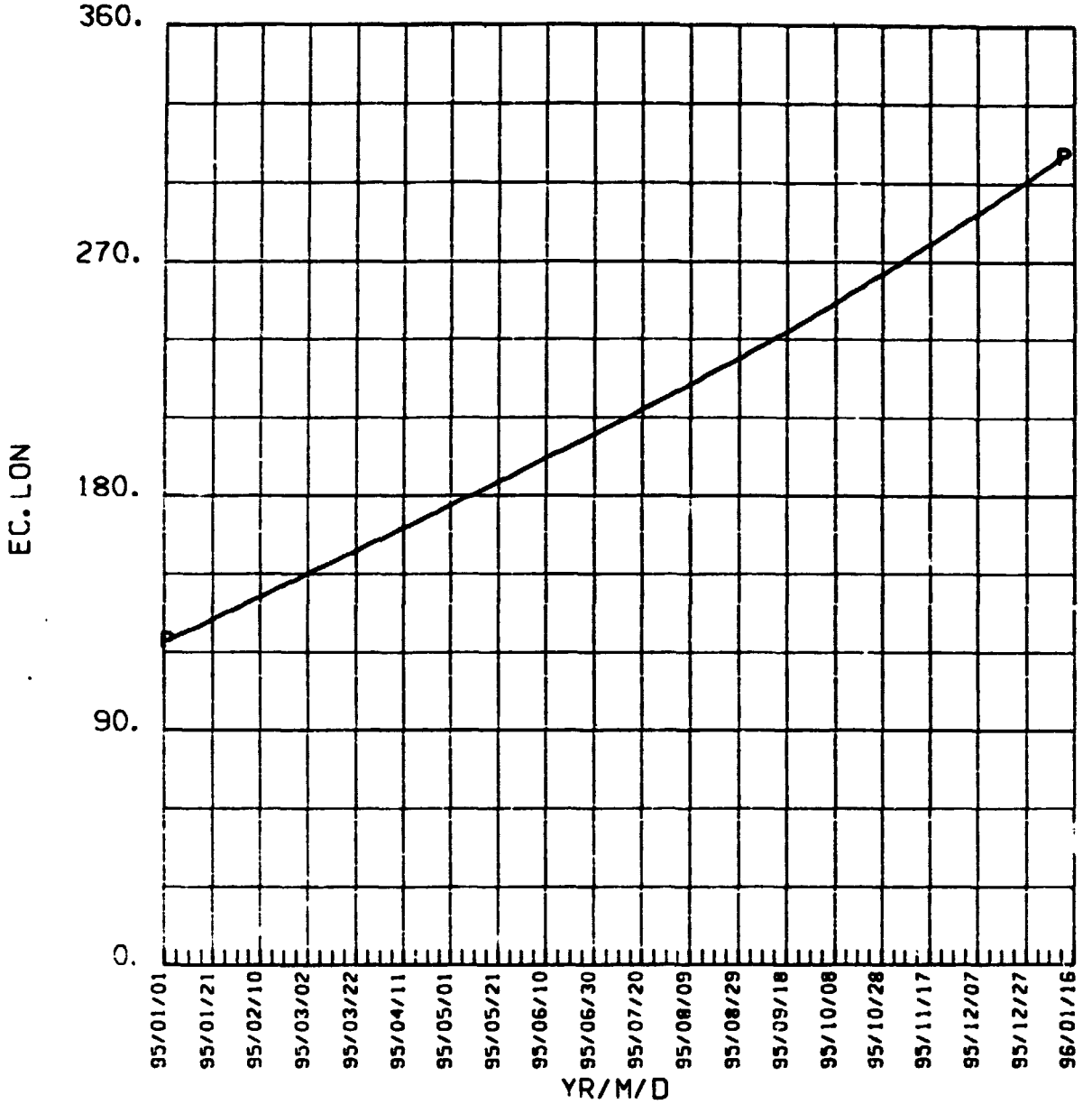
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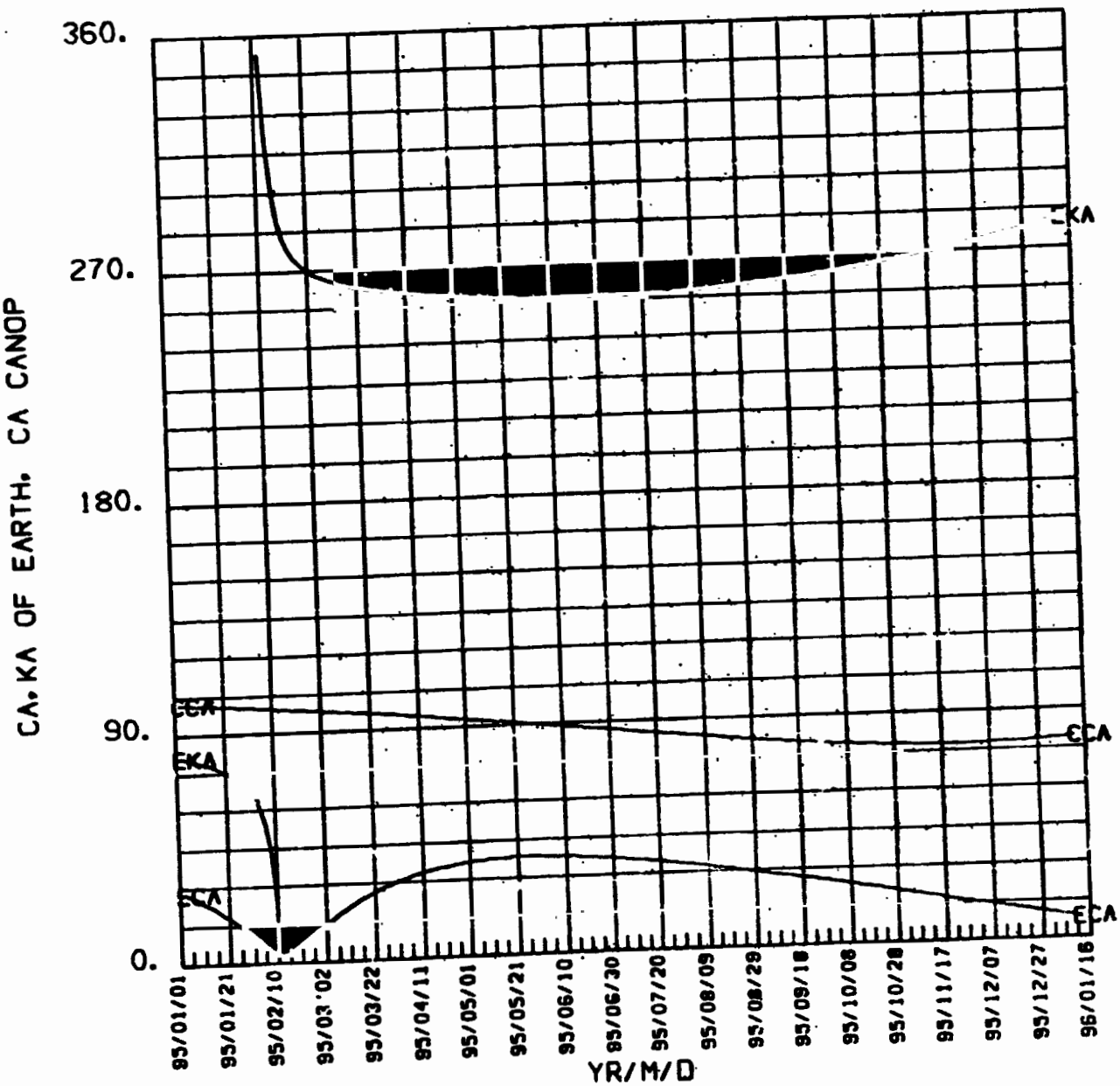
MARS 1995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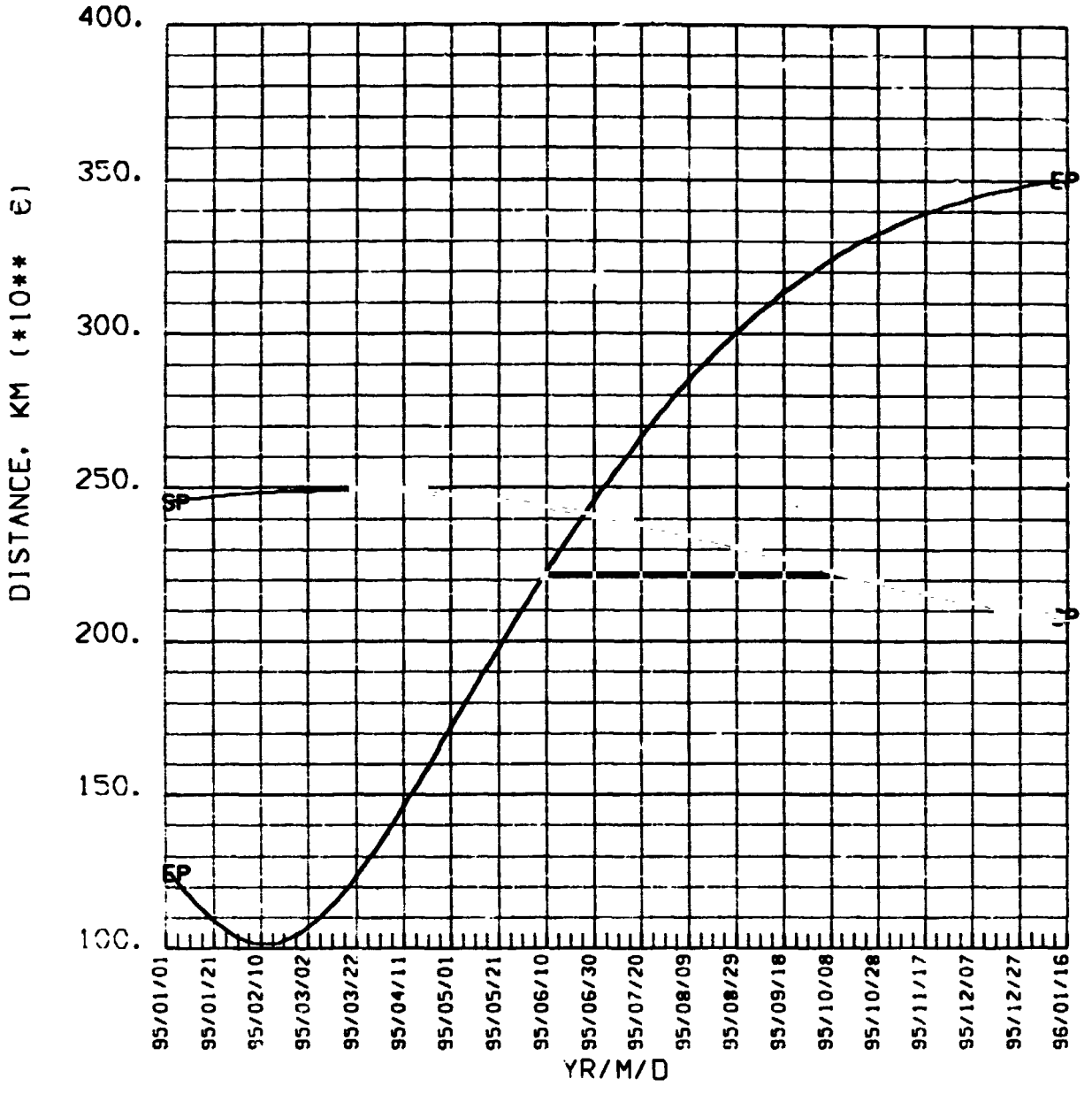
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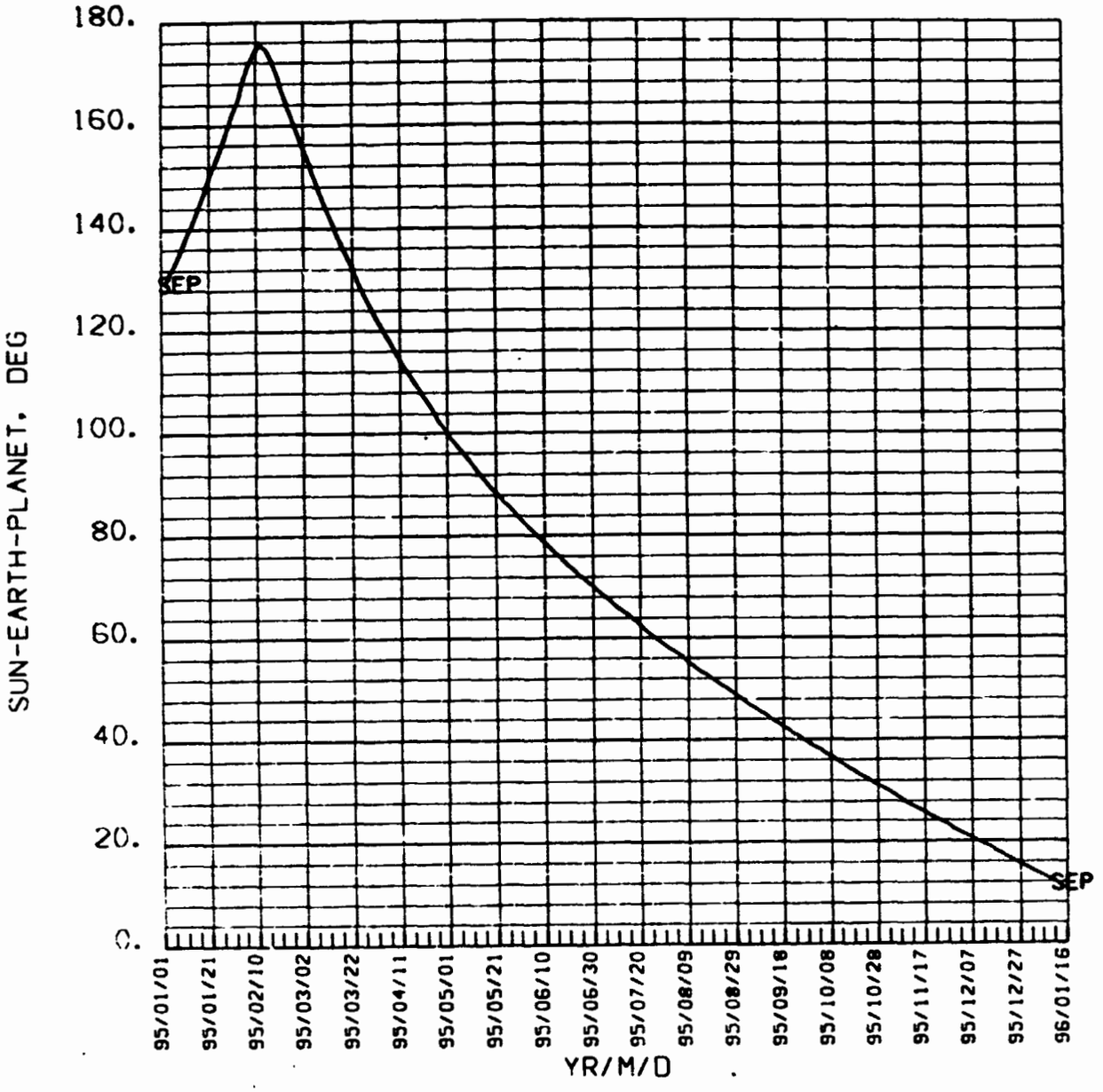
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SUN-EARTH-PLANET, DEG
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