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**Volume II**  
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**Jupiter Through 1990**

**Andrey B. Sergeevsky**

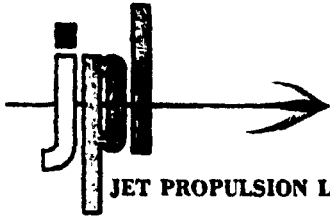
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## PREFACE

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.

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# MISSION DESIGN DATA FOR VENUS, MARS AND JUPITER THROUGH 1990

Andrey B. Sergeevsky

## 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 ( $\text{km}^2/\text{sec}^2$ ); same as the square of departure hyperbolic excess velocity  $V_\infty^2 = C_3 = V_1^2 - 2GM/R_1$ , where

$V_1$  = conic injection velocity (km/sec)

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

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

$GM_{\text{EARTH}} = 0.39860115E6$

$GM_{\text{MARS}} = 0.42828444E5$

$GM_{\text{JUPITER}} = 0.12670772E9$

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

$$R_{S\text{VENUS}} = 6052 \text{ (km)}$$

$$R_{S\text{EARTH}} = 6378.16$$

$$R_{S\text{MARS}} = 3393.4$$

$$R_{S\text{JUPITER}} = 71372$$

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  $\Delta V$ , at periapse, may be computed from  $V_\infty$ :

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

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:

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

B-PLANE A plane normal to the incoming  $V_\infty$  - 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  $V_\infty$  - vector. May impose launch constraints. (deg)

ZAL Angle between departure  $V_\infty$  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  $V_\infty$  vector and the arrival planet-to-Sun vector. Equivalent to planet-probe-Sun angle at far encounter; for subsolar impact would be equal to  $180^\circ$  (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  $V_\infty$  vector) in planetary equator system.

ZAE Angle between arrival  $V_\infty$  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  $V_\infty$  velocity vector error of 0.1 m/sec on departure asymptote (km).

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



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

YR/M/D Year, Month, Date.

### C. DESCRIPTION OF PLANETARY POSITIONAL DATA

#### 1. General

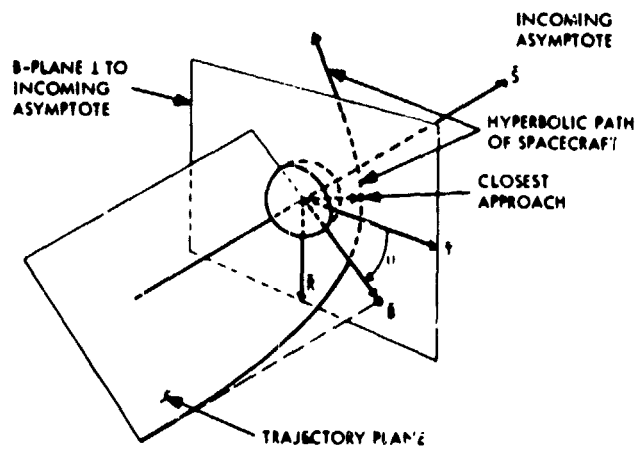
The data represent planetary geometry-related information plotted versus calendar arrival date at the target planet. Each set of seven plots represents the annual time history of 19 parameters, and may be used for flyby and orbiter missions.

#### 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.

#### 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 ≈ 0) and inferior (SEP ≈ 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.



- $b$  = TARGET PARAMETER
- $u$  = ORIENTATION OF  $b$
- $s$  = INCOMING ASYMPTOTE
- $y$  = PARALLEL TO ECLIPTIC PLANE AND  $\perp$  TO  $s$
- $r = s \times y$

Figure 1. Definition of B-Plane

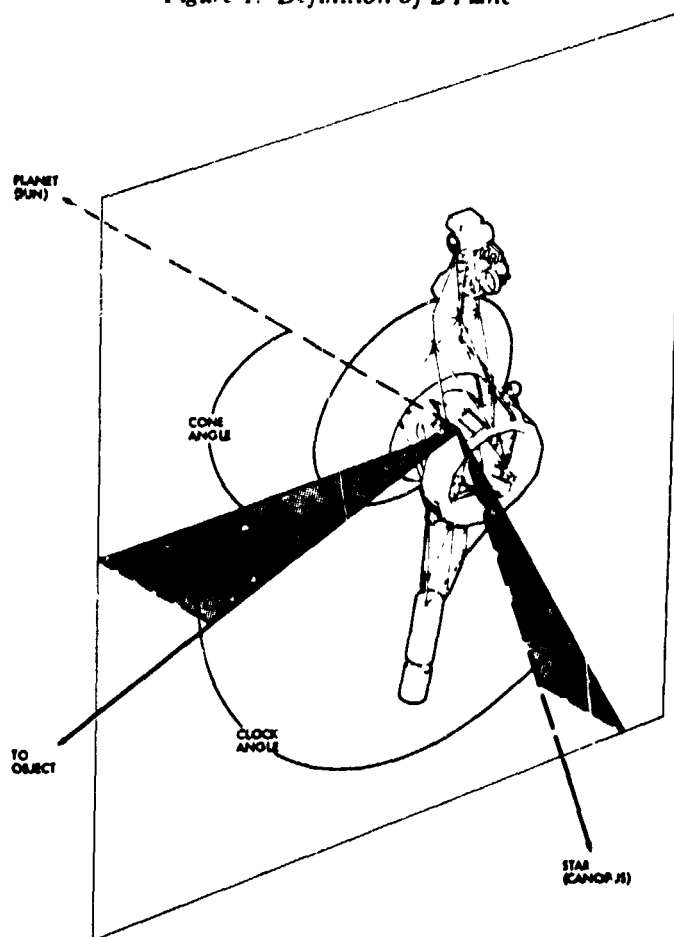


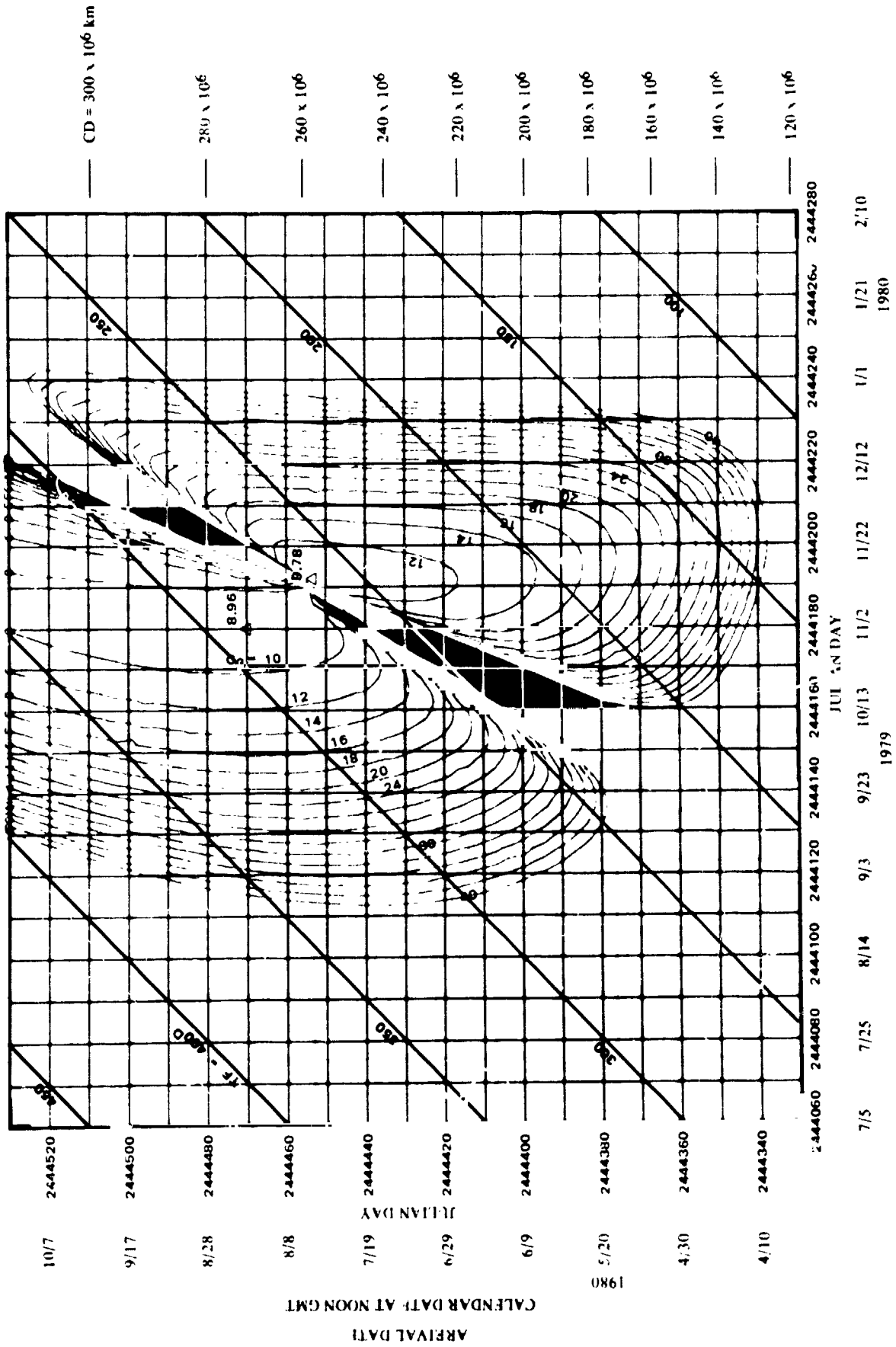
Figure 2. Definition of Cone and Clock Angle

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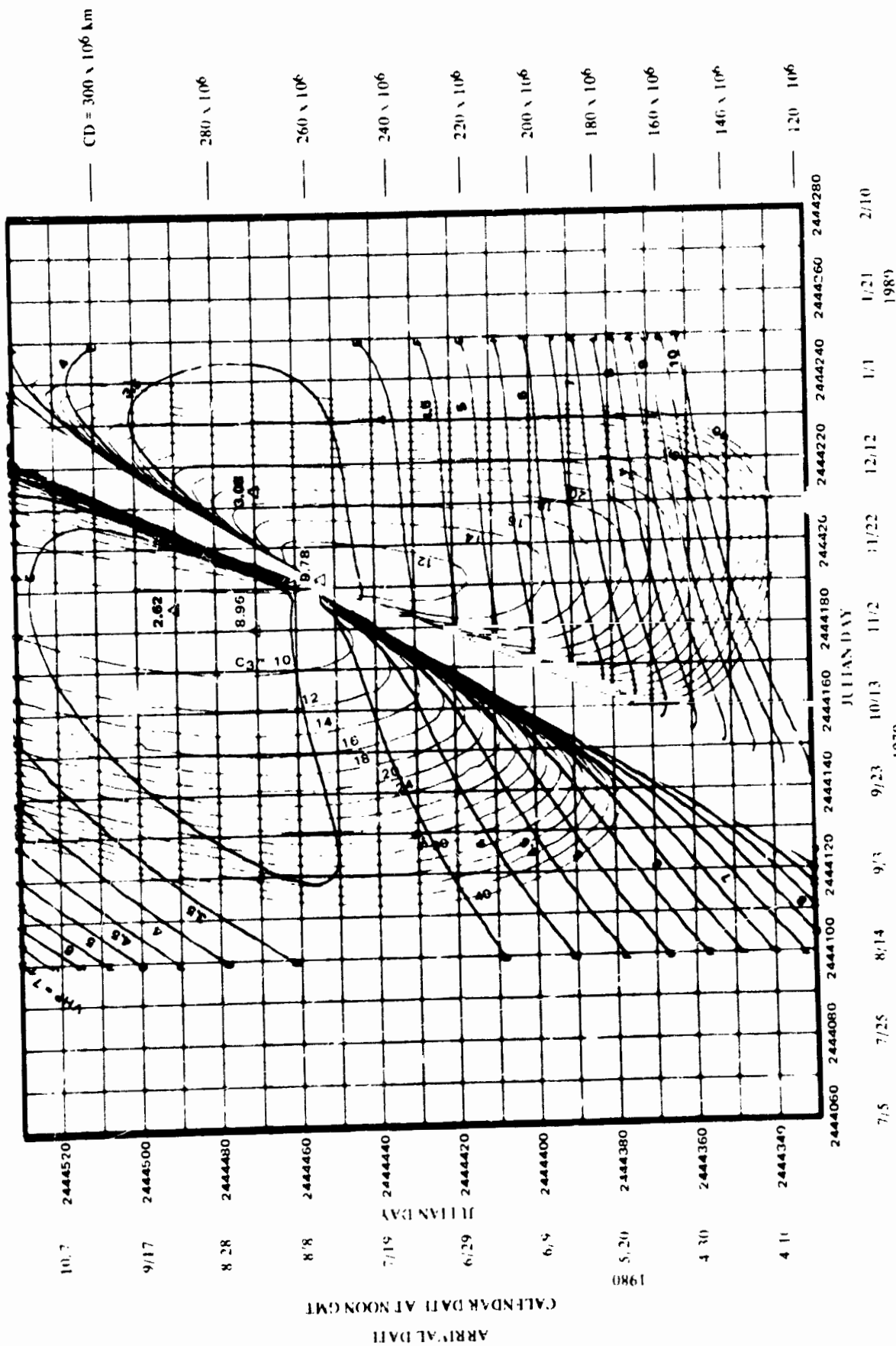
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\*JPL Internal Document

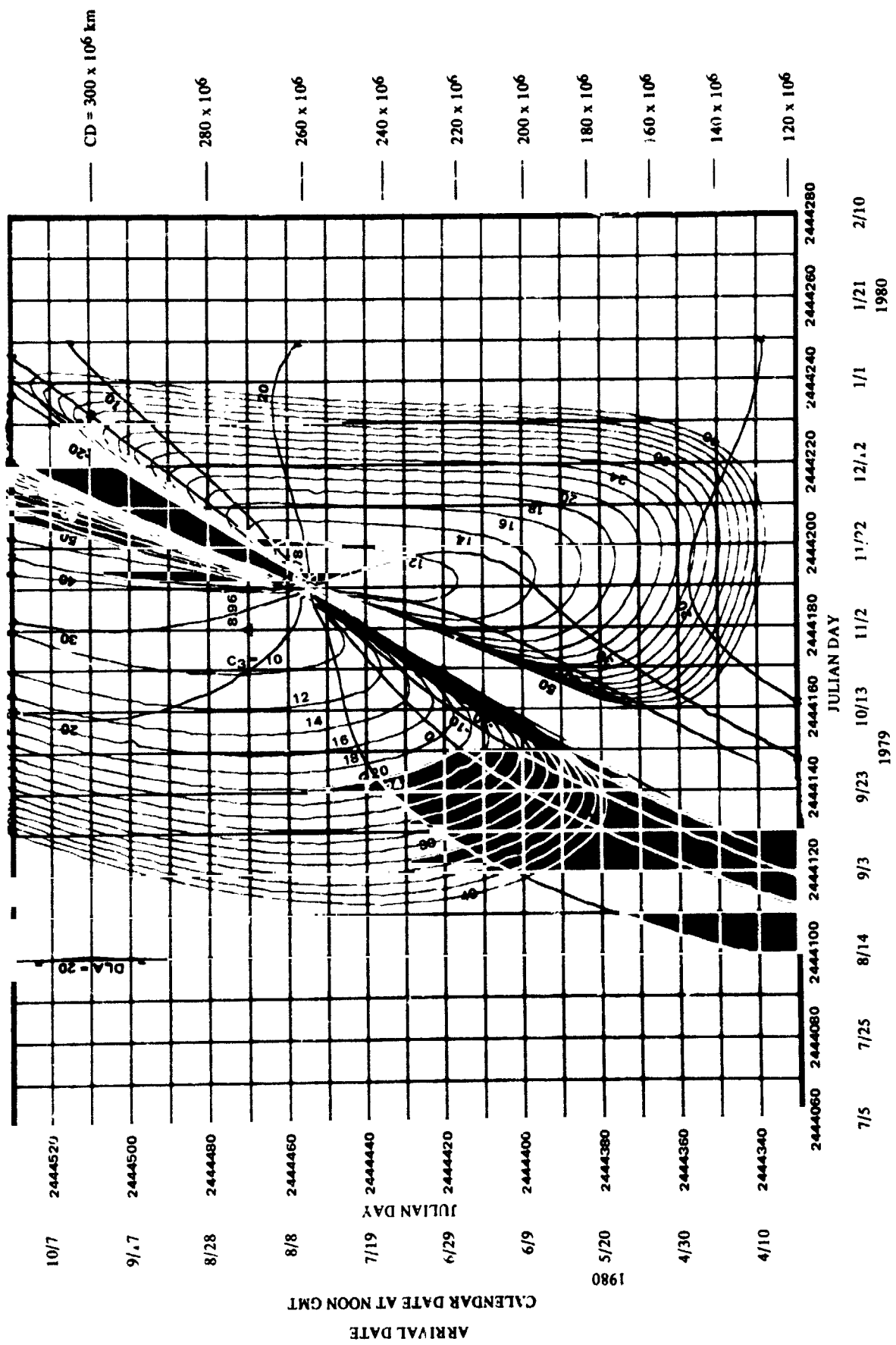


CONTOURS OF C<sub>3</sub> AND LIGHT TIMES EARTH TO MARS 1979-80  
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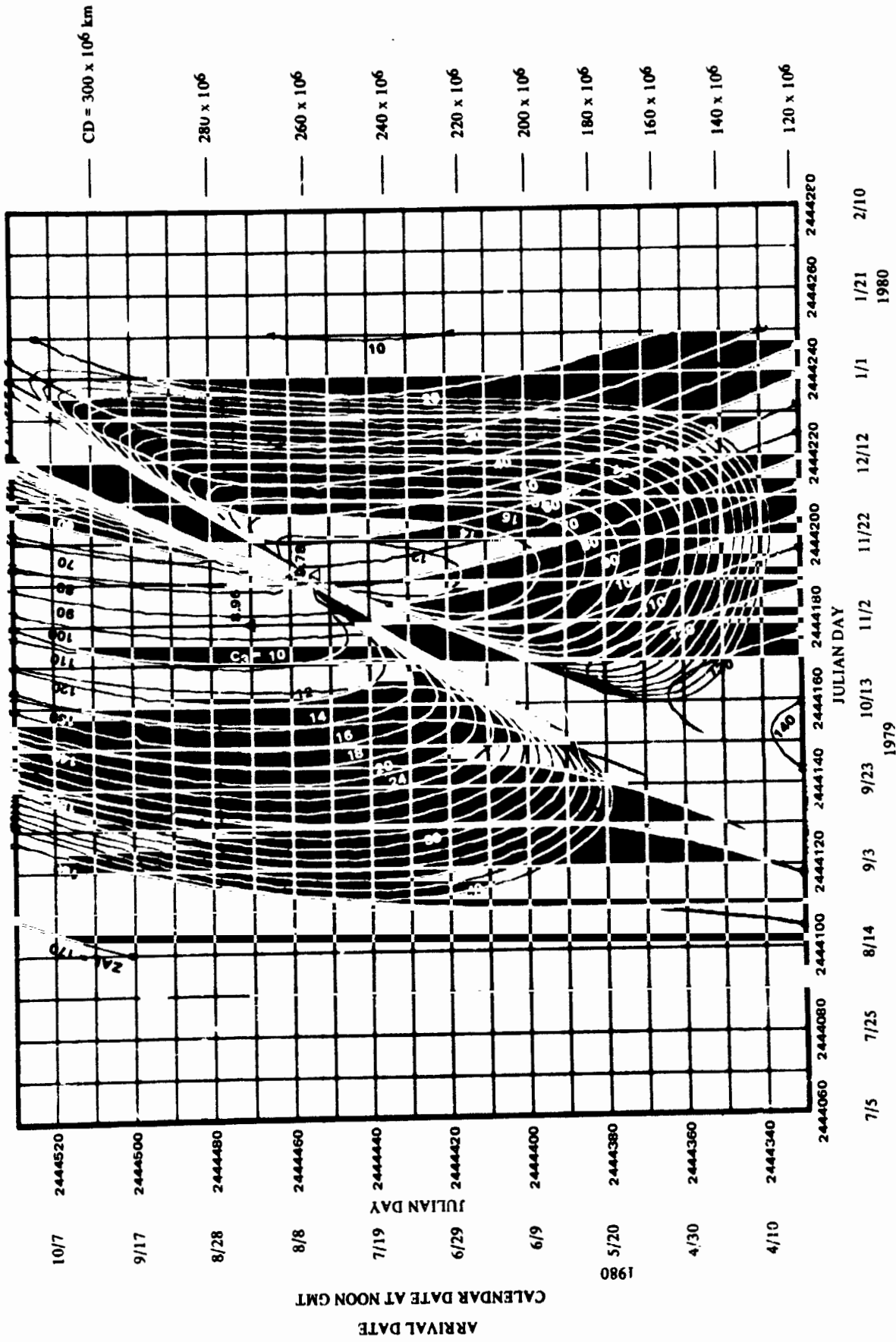
CONTOURS OF C<sub>3</sub> AND VHP EARTH TO MARS 1979-80

VHP  
♂  
1979



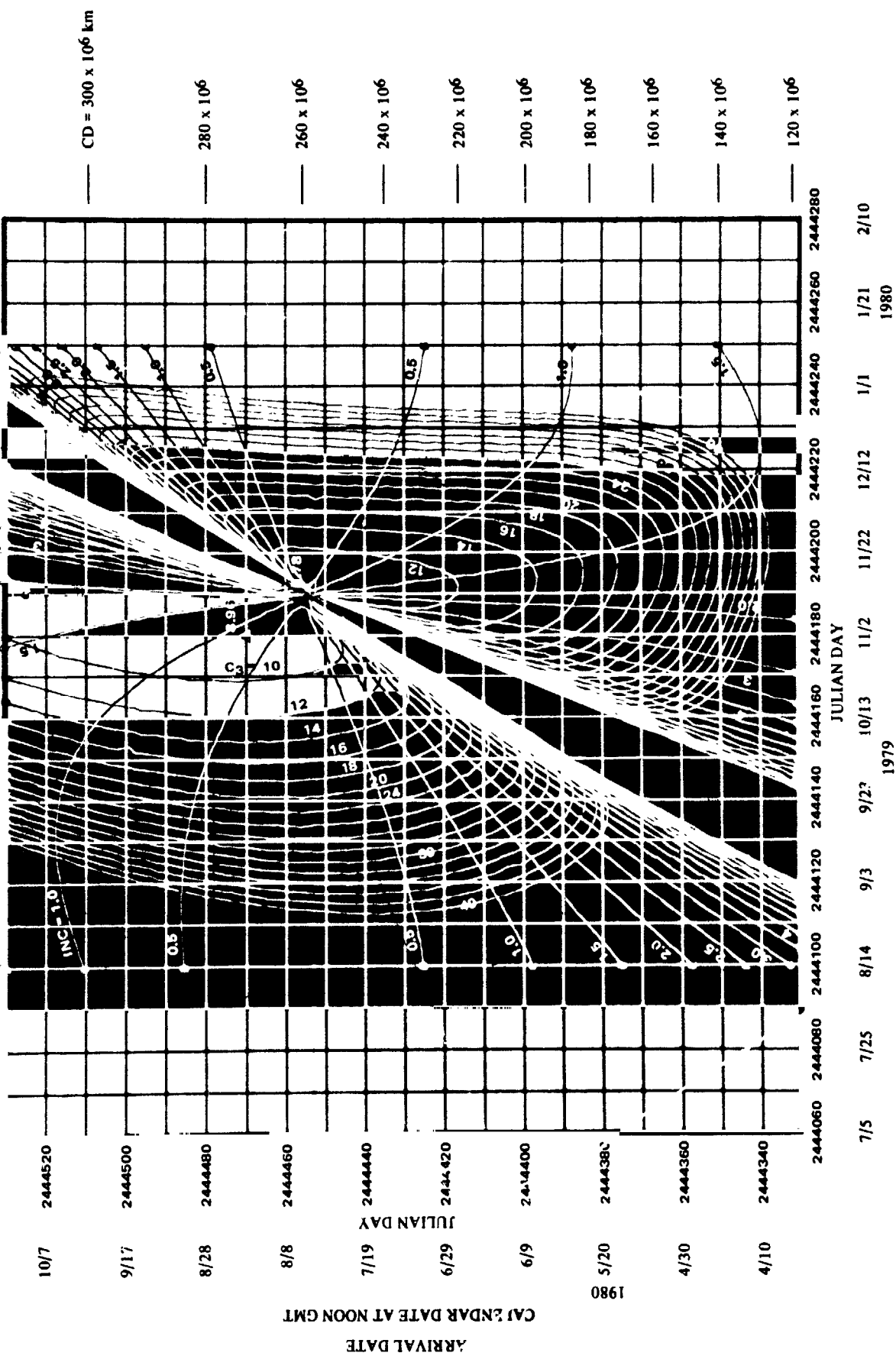
CONTOURS OF C<sub>3</sub> AND DLA EARTH TO MARS 1979-80

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CONTOURS OF C<sub>3</sub> AND ZAL EARTH TO MARS 1979-80

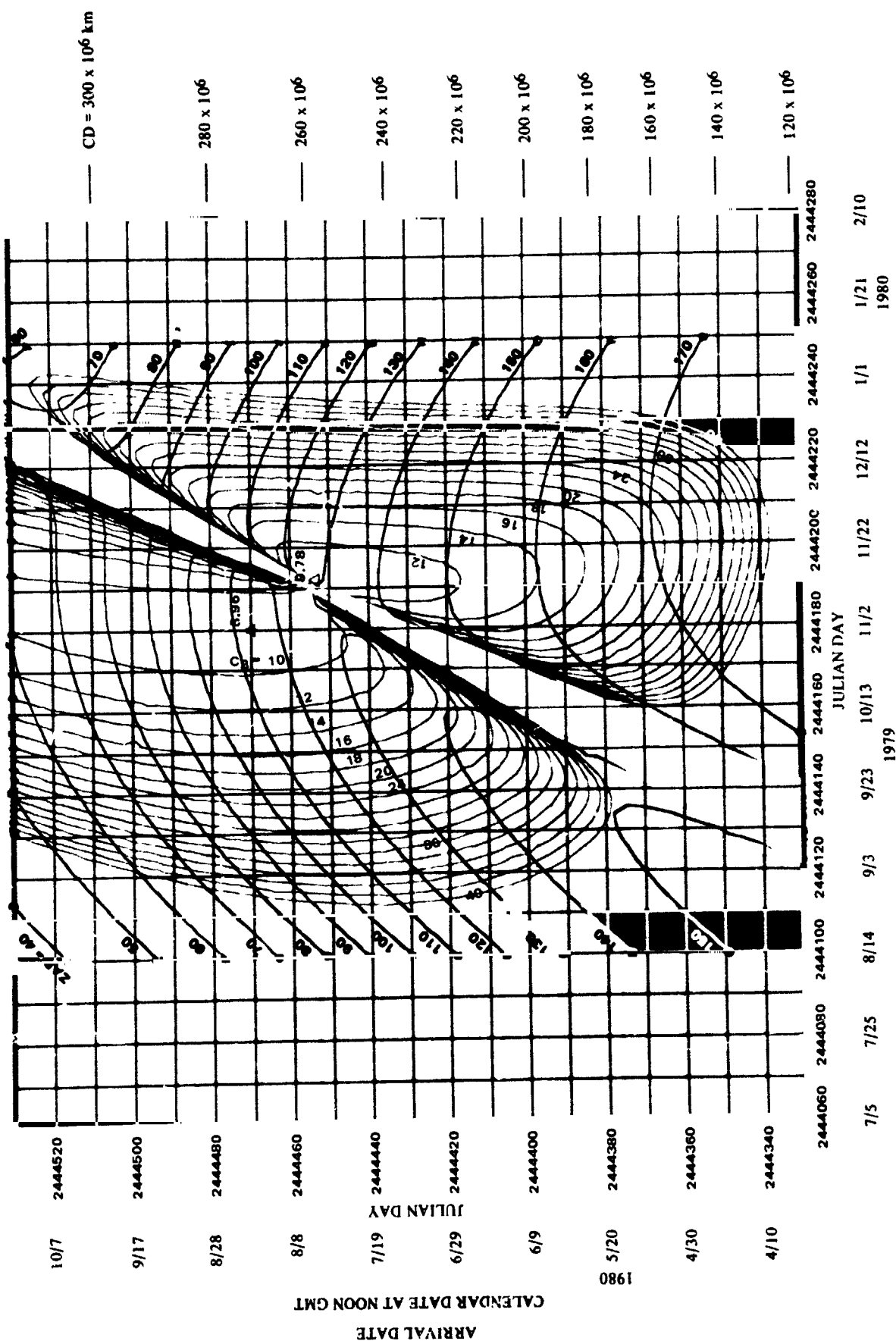
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CONTOURS OF C3 AND INC EARTH TO MARS 1979-80



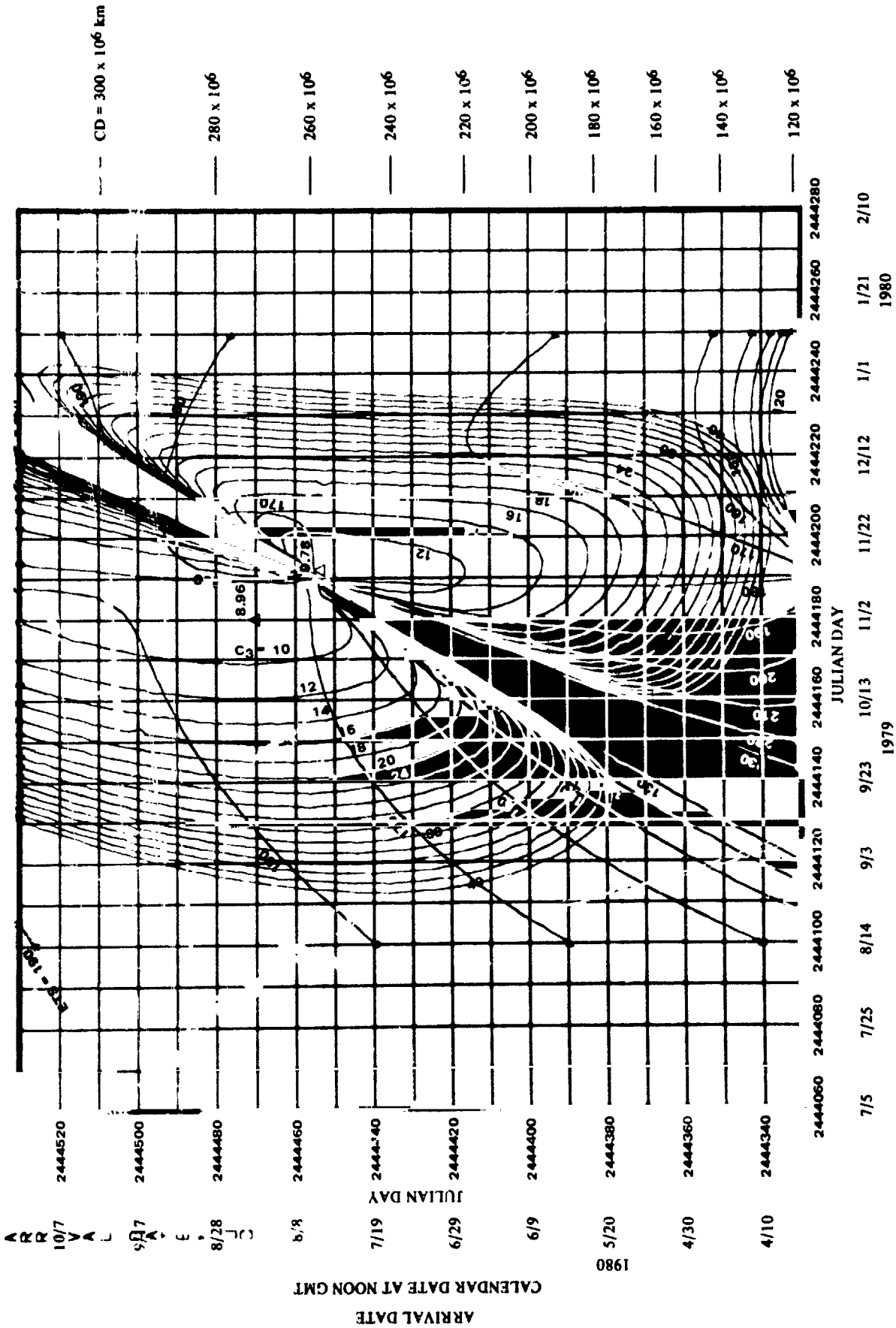


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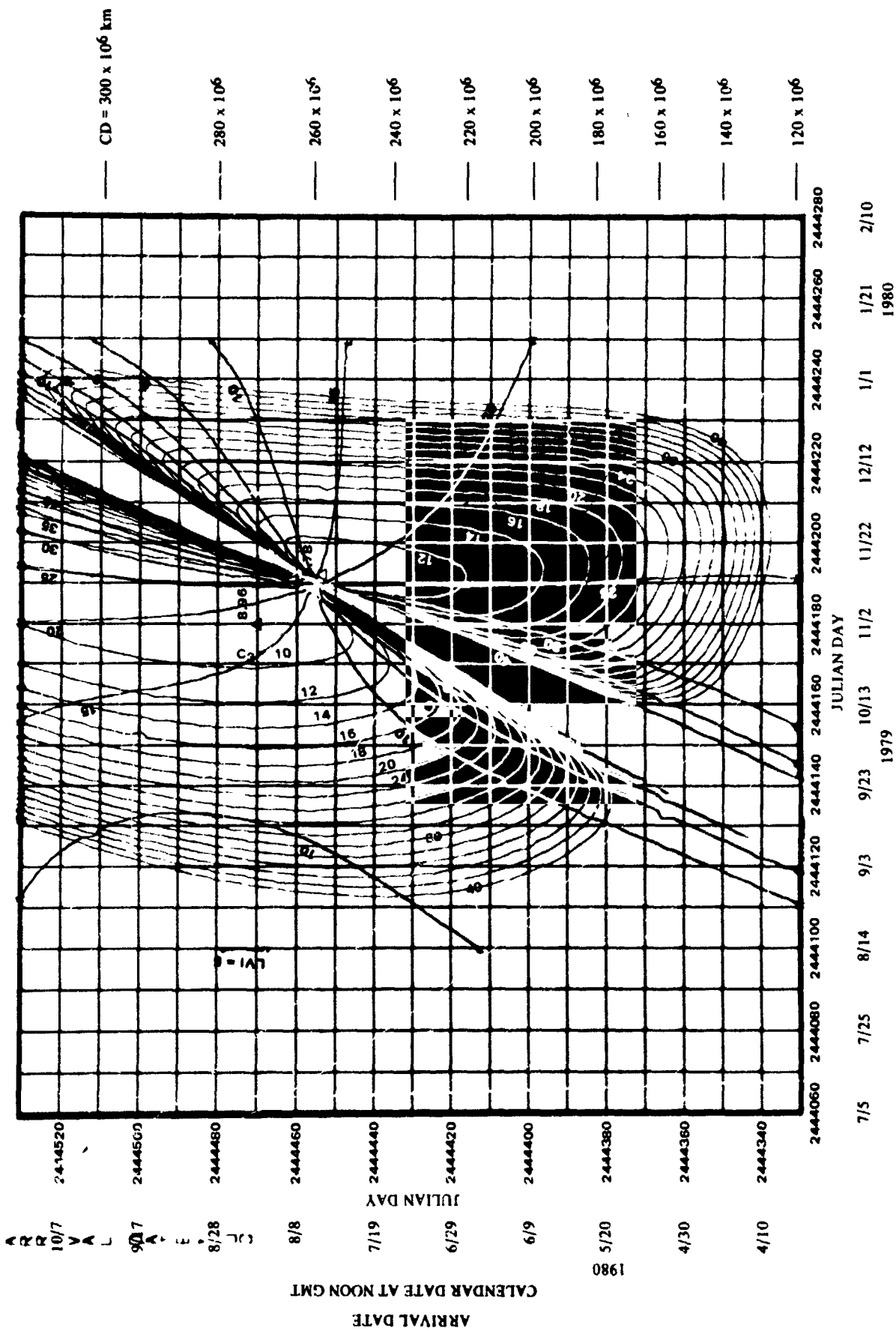
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CONTOURS OF C<sub>3</sub> AND ZAP EARTH TO MARS 1979-80

ZAP  
1979

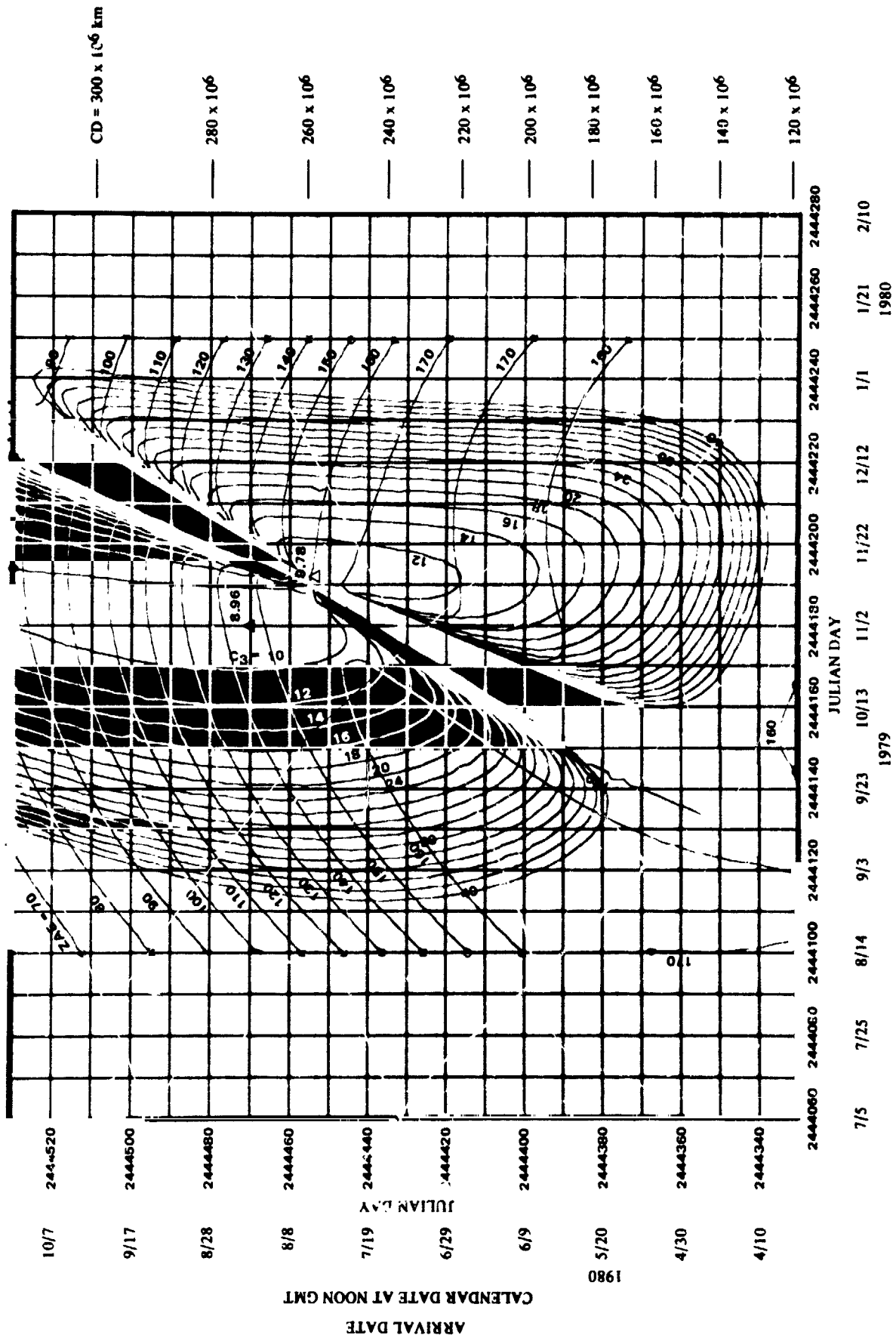


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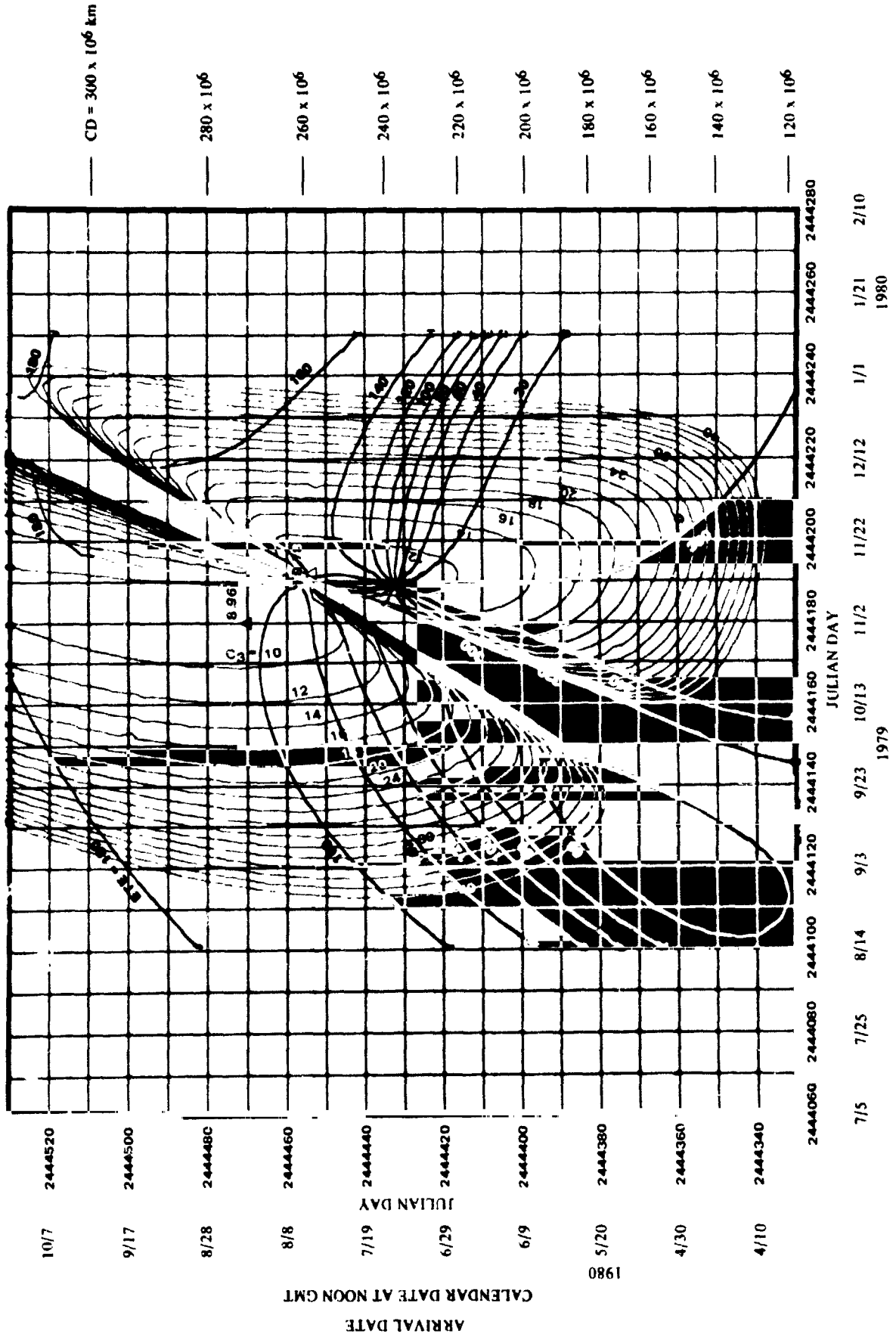
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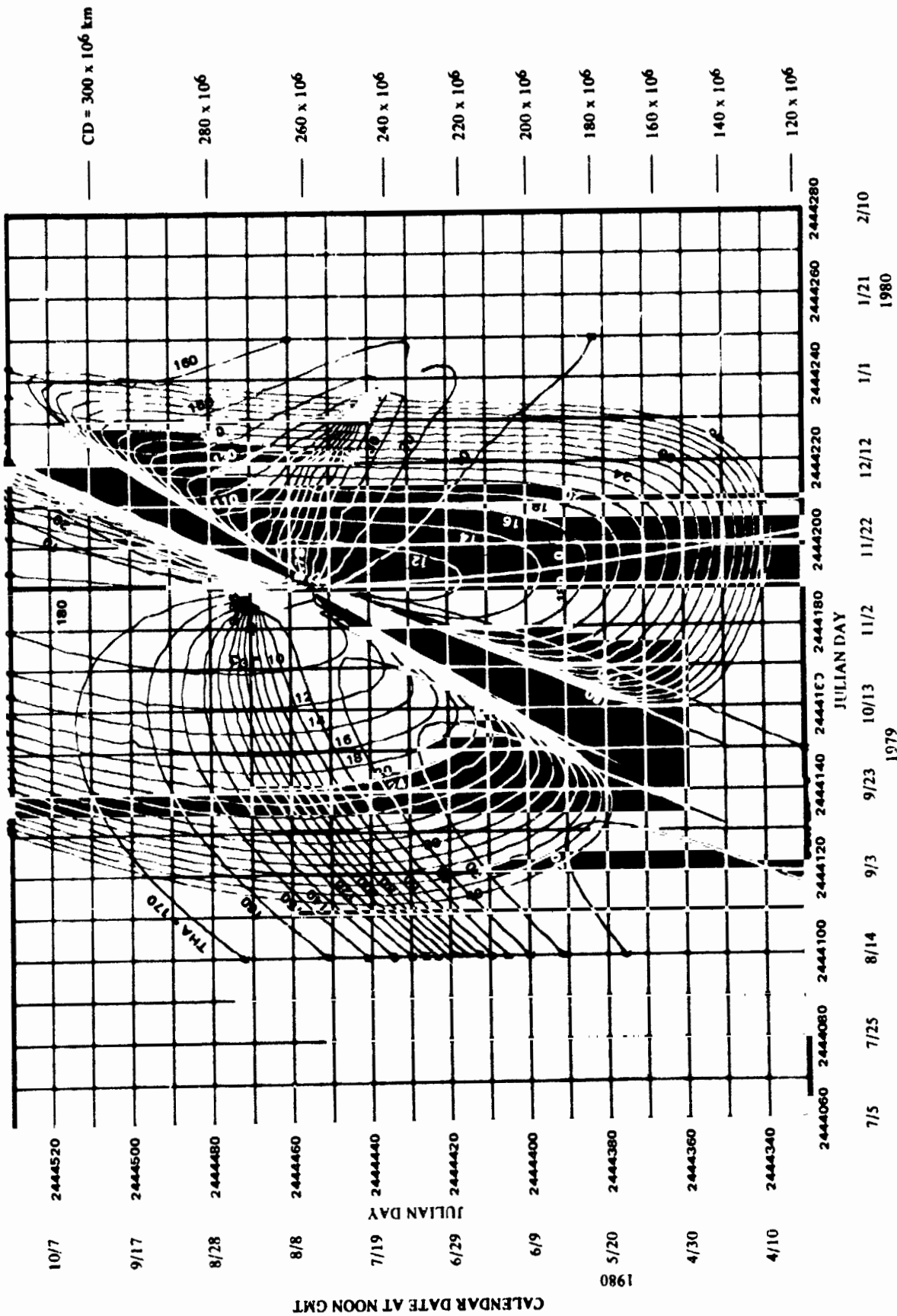
ZAE  
1979



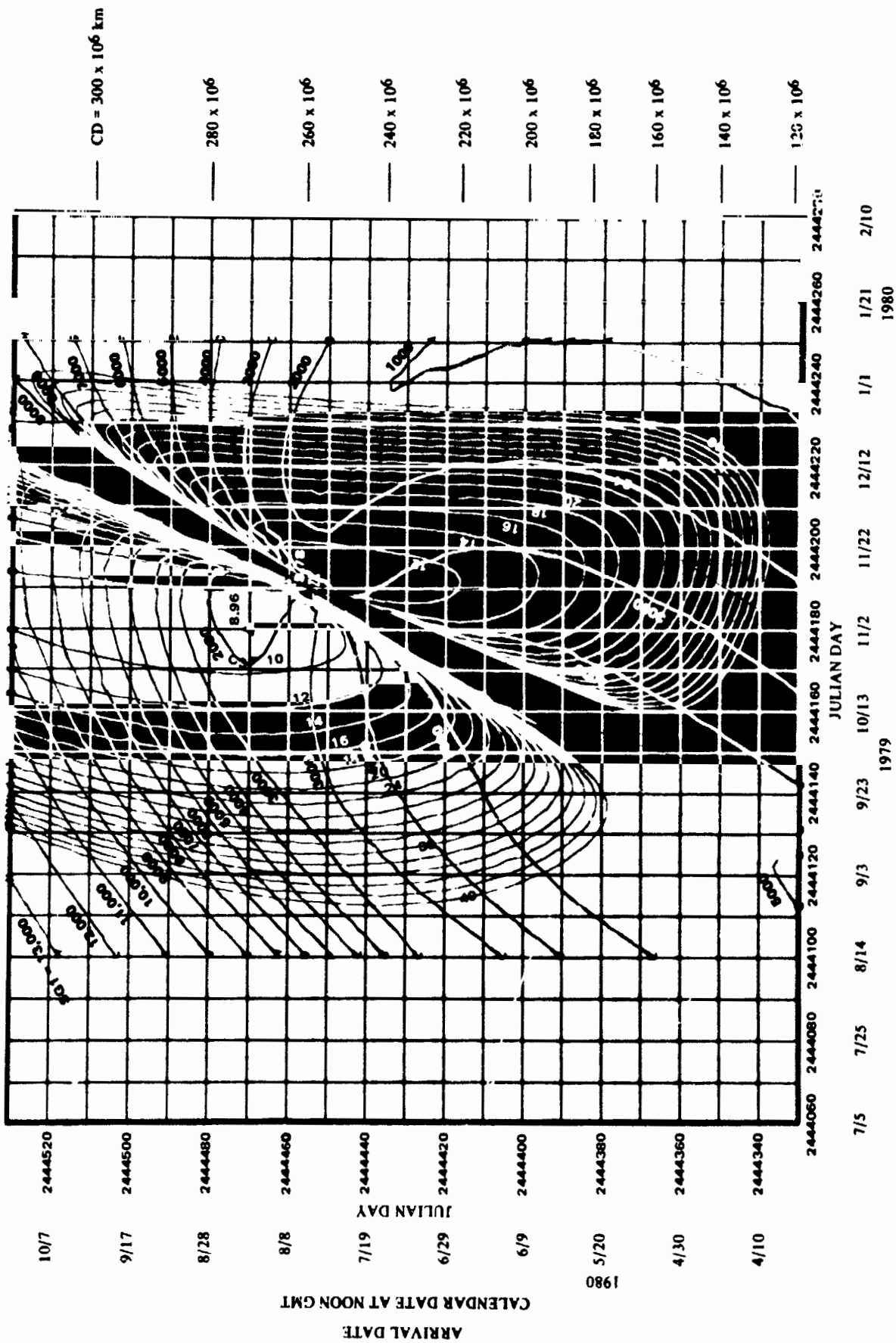
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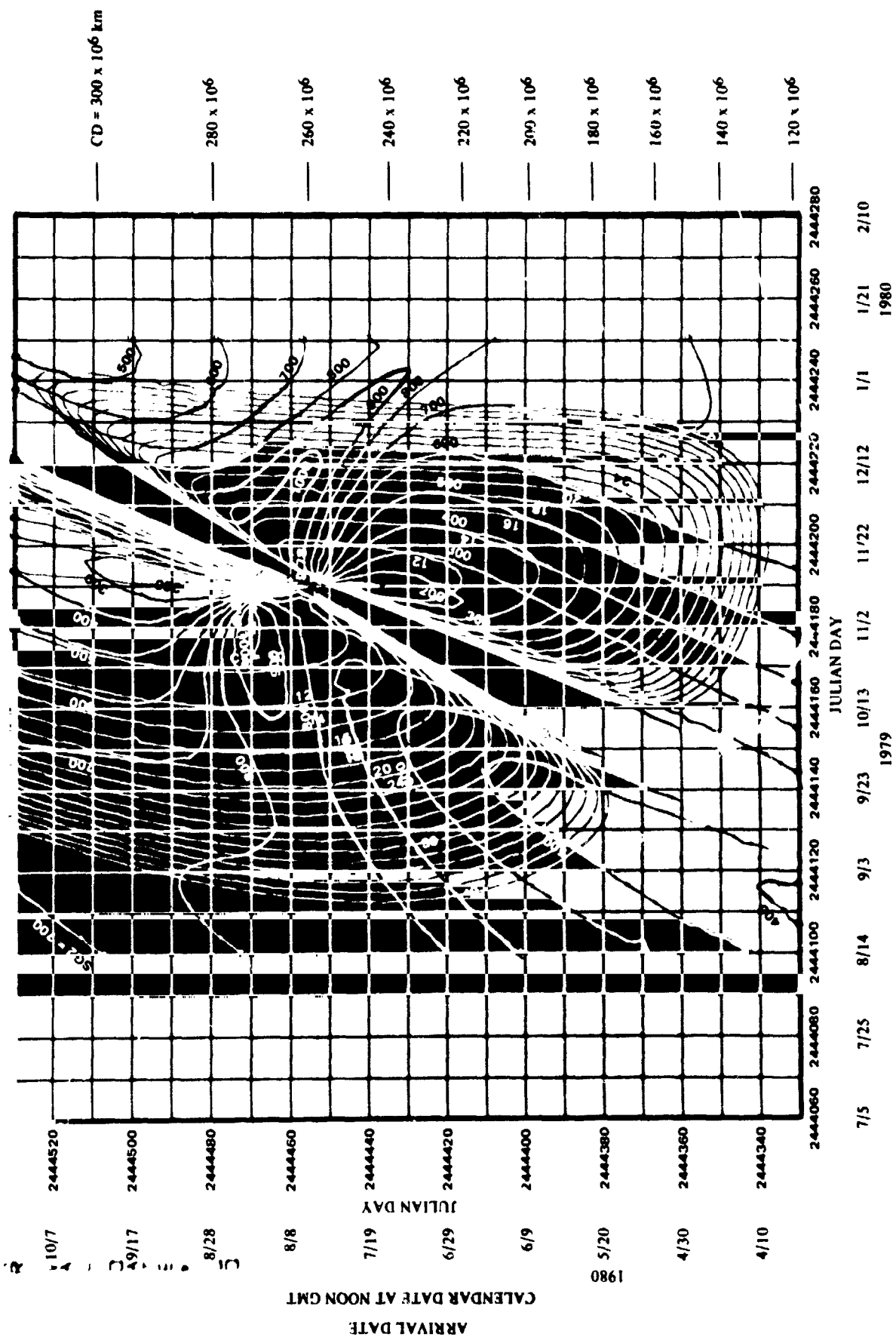
CONTOURS OF C<sub>3</sub> AND THA EARTH TO MARS 1979-80



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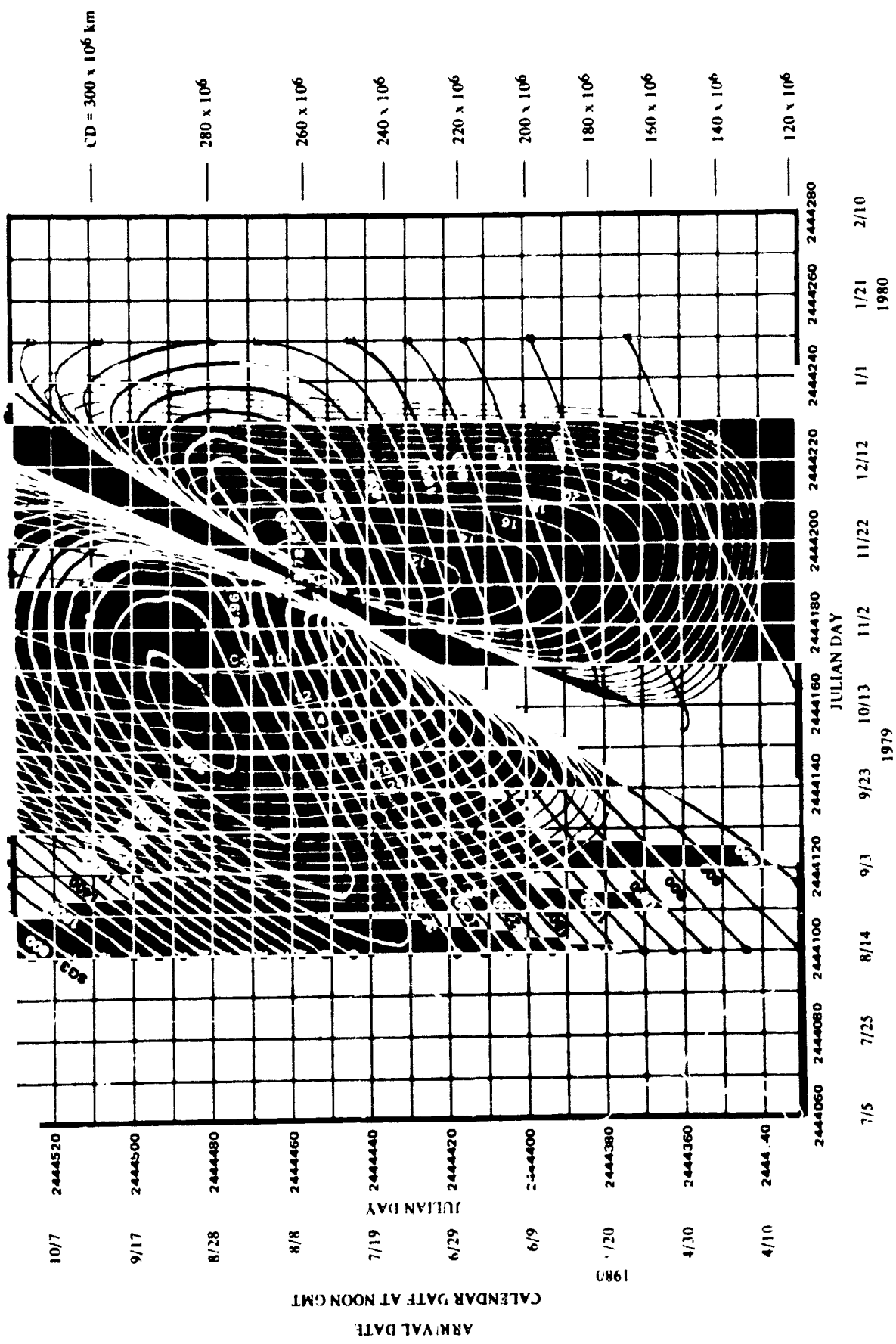


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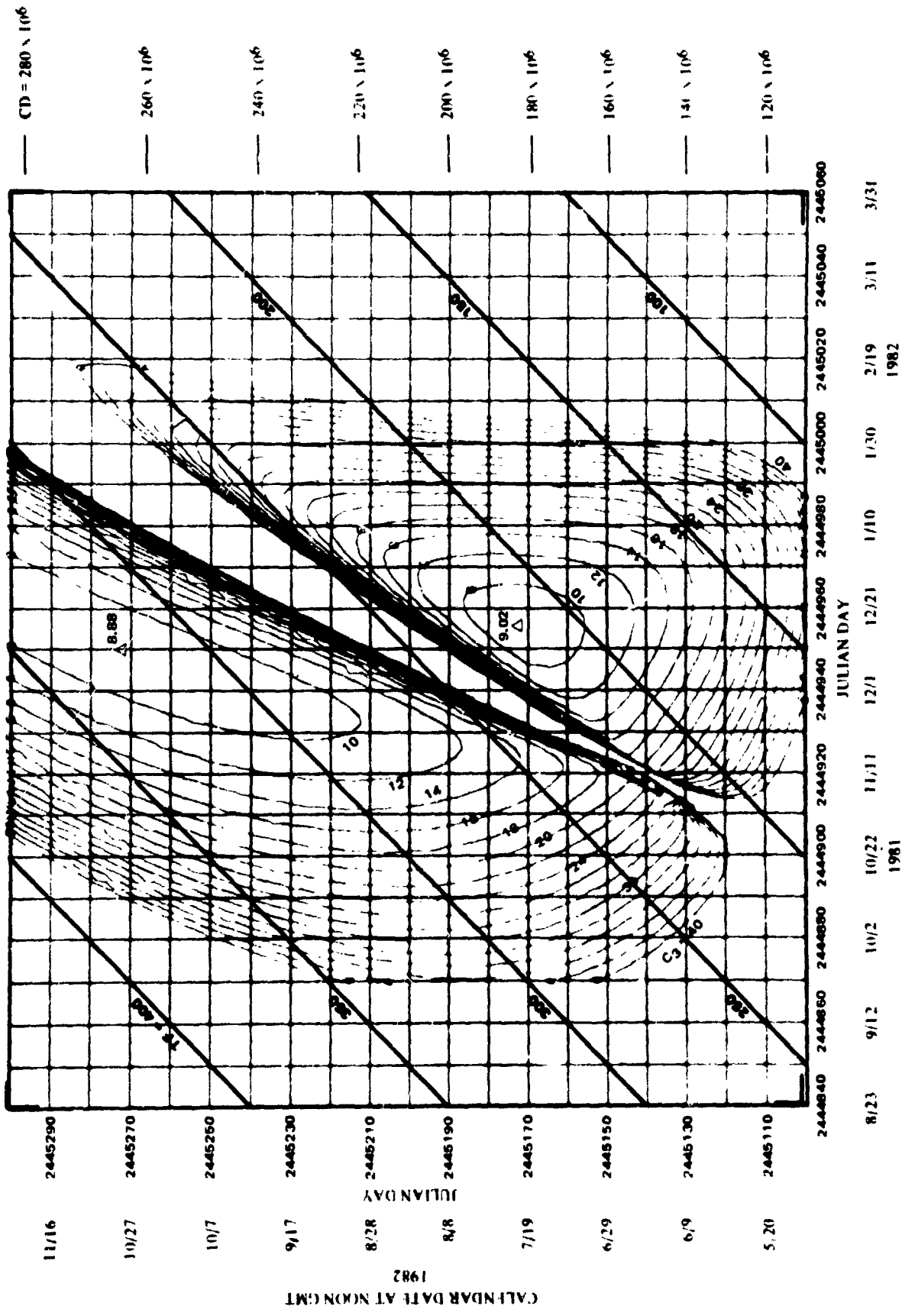
1979 ♀ SG2

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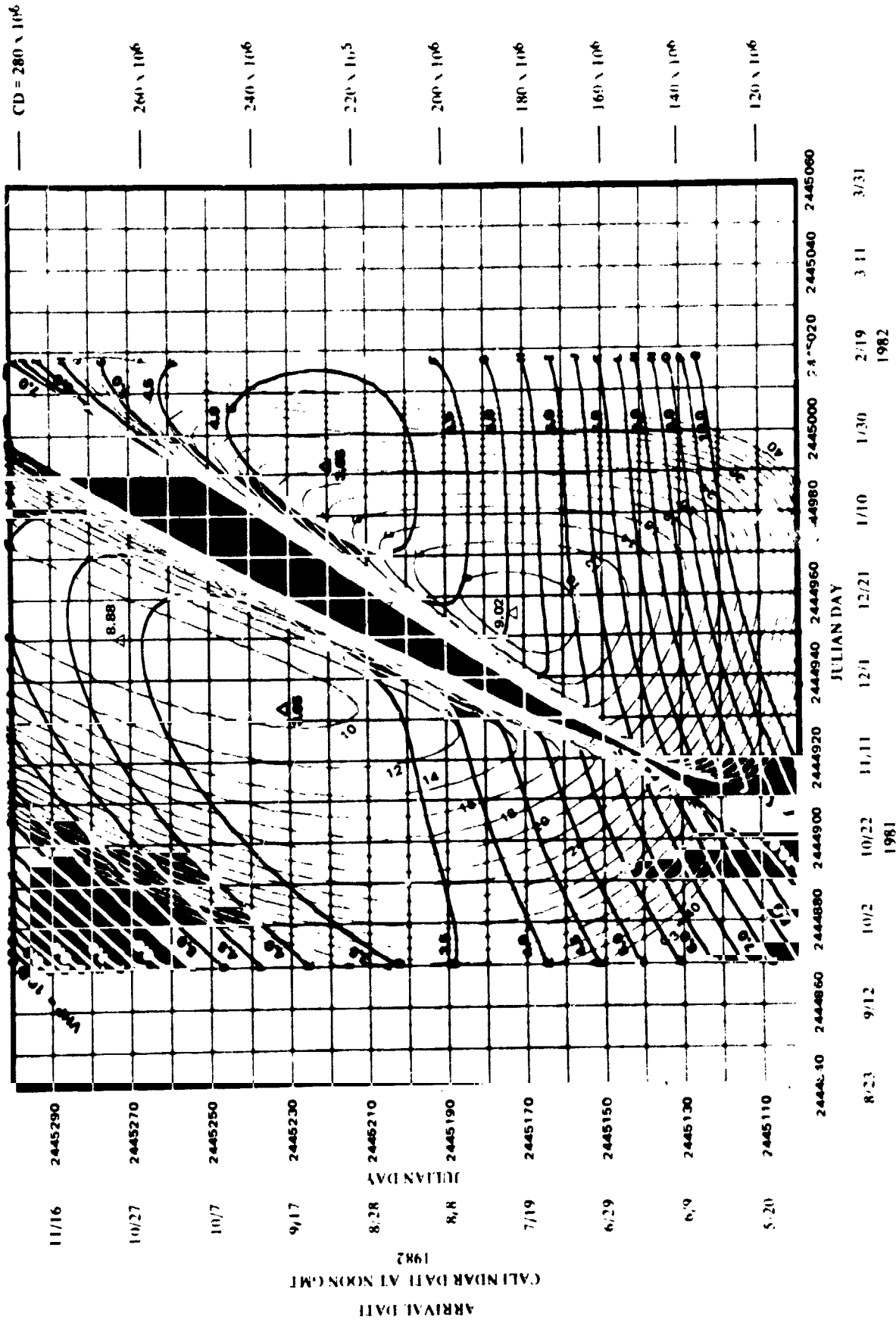


CONTOURS OF C<sub>3</sub> AND SG3 EARTH TO MARS 1979-80



CONTOURS OF C<sub>3</sub> AND FLIGHT TIMES EARTH TO MARS 1981-82

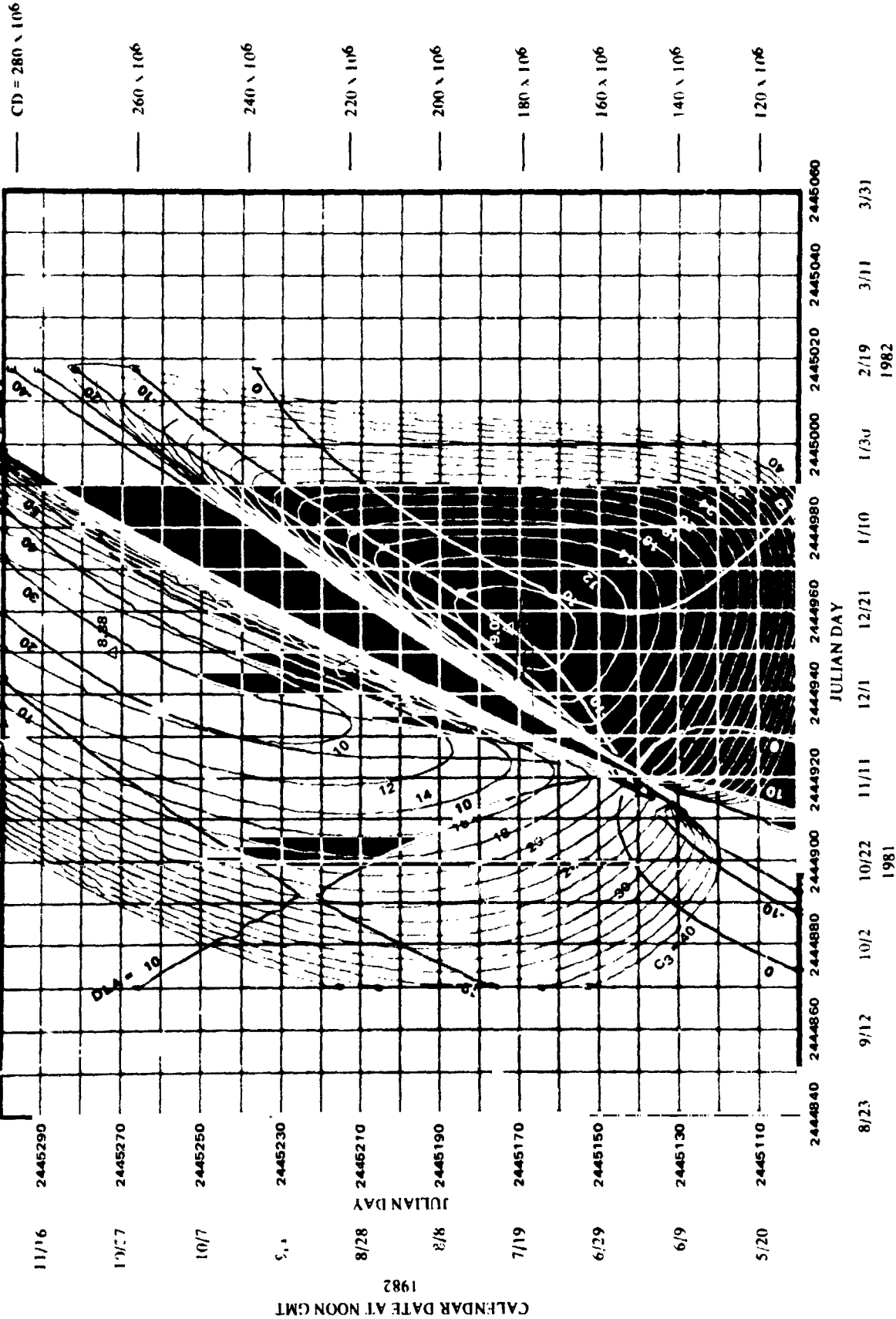
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CONTOURS OF C<sub>3</sub> AND V<sub>1P</sub> EARTH TO MARS 1981-82

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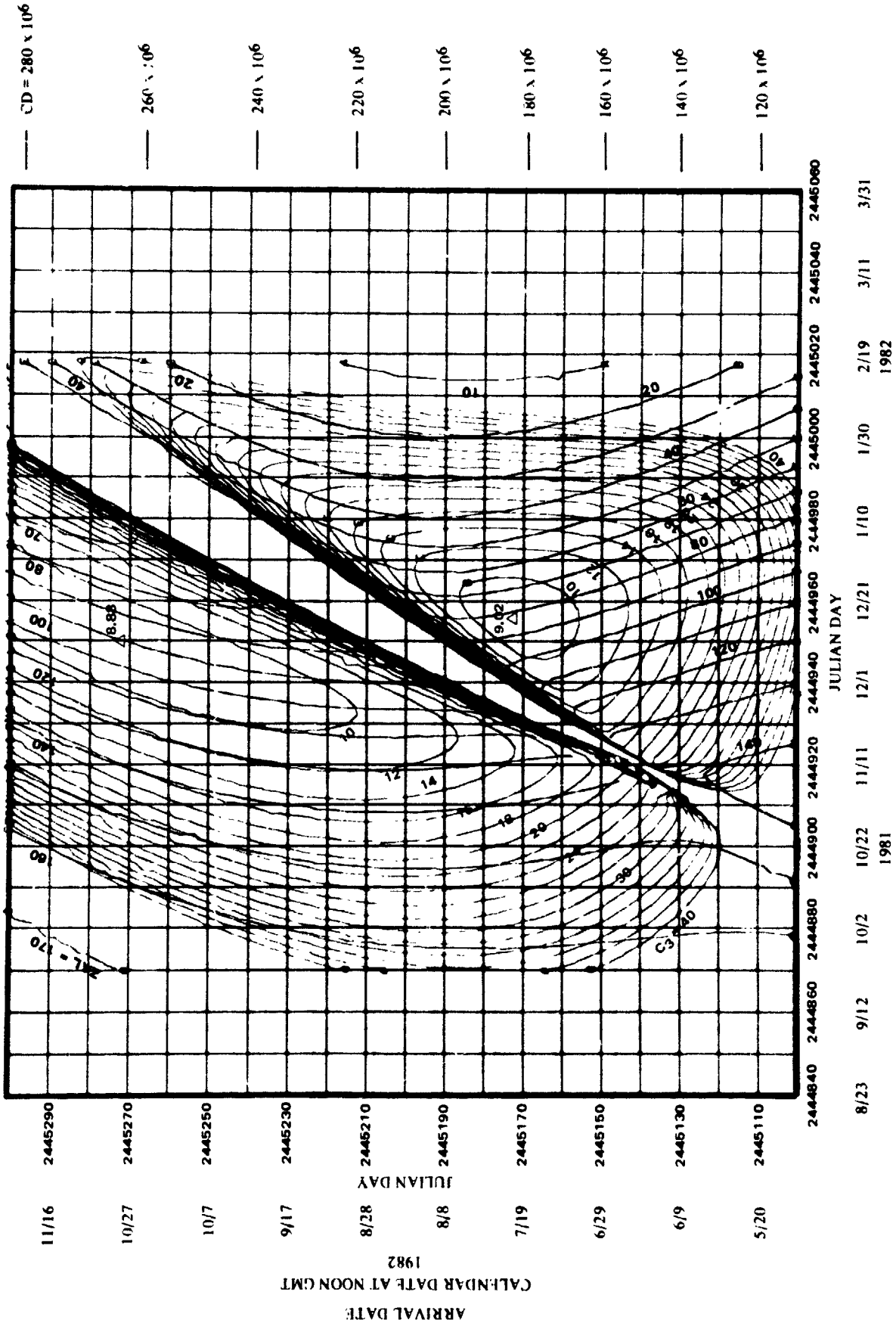
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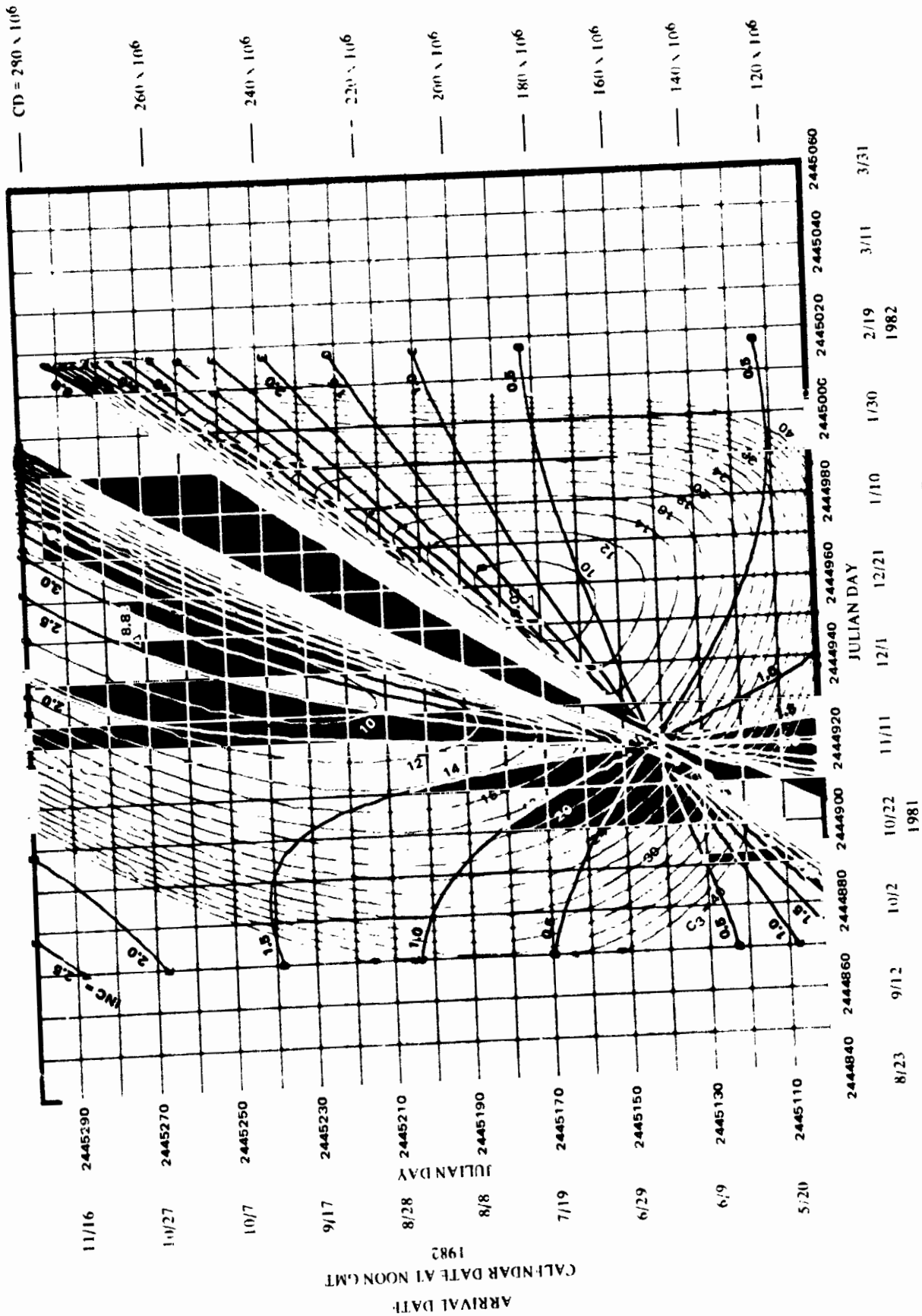
CONTOURS OF C<sub>3</sub> AND DLA EARTH TO MARS 1981-82

DLA  
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CONTOURS OF C<sub>3</sub> AND ZAL EARTH TO MARS 1981-82



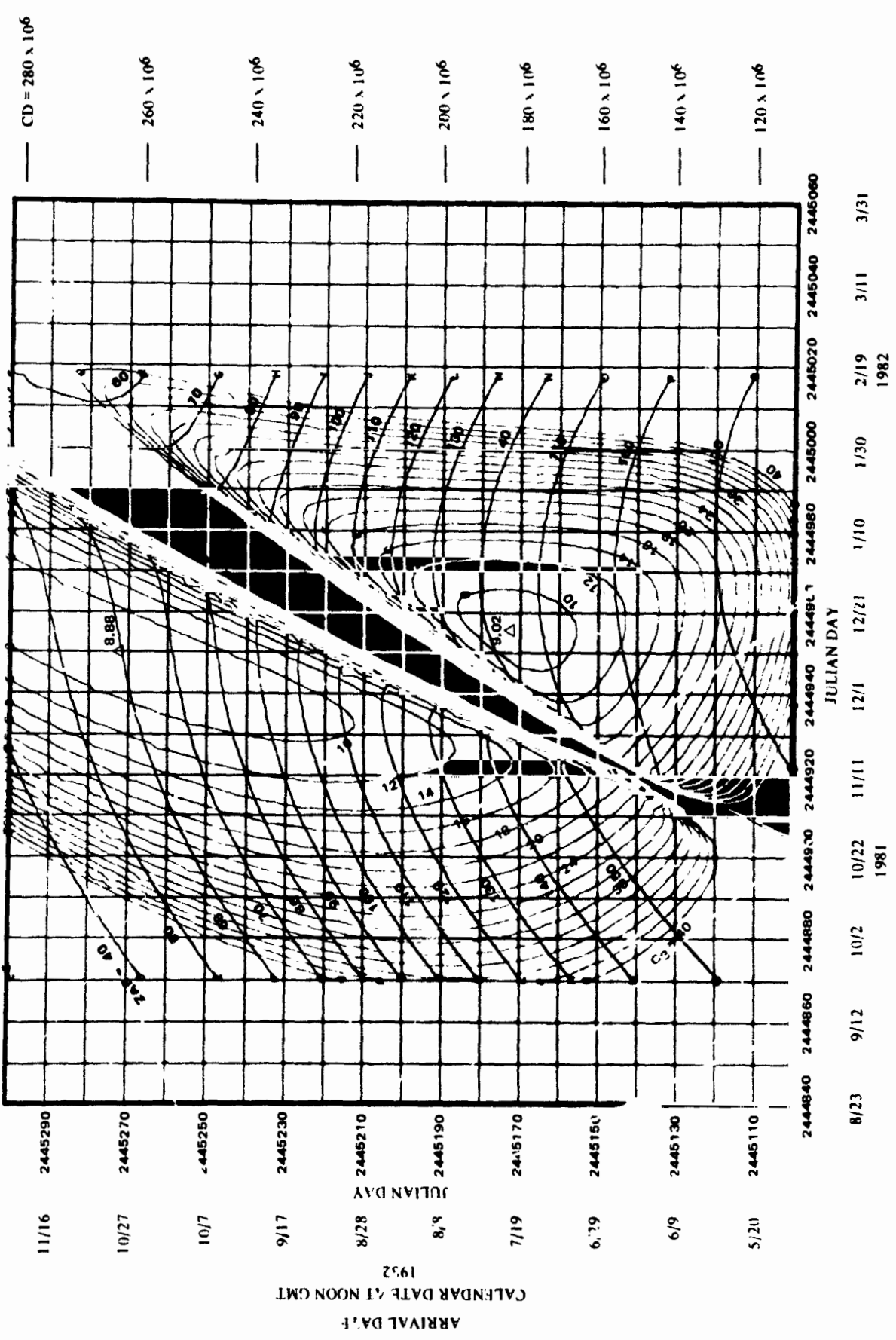


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CONTOURS OF C<sub>3</sub> AND INC EARTH TO MARS 1981-82

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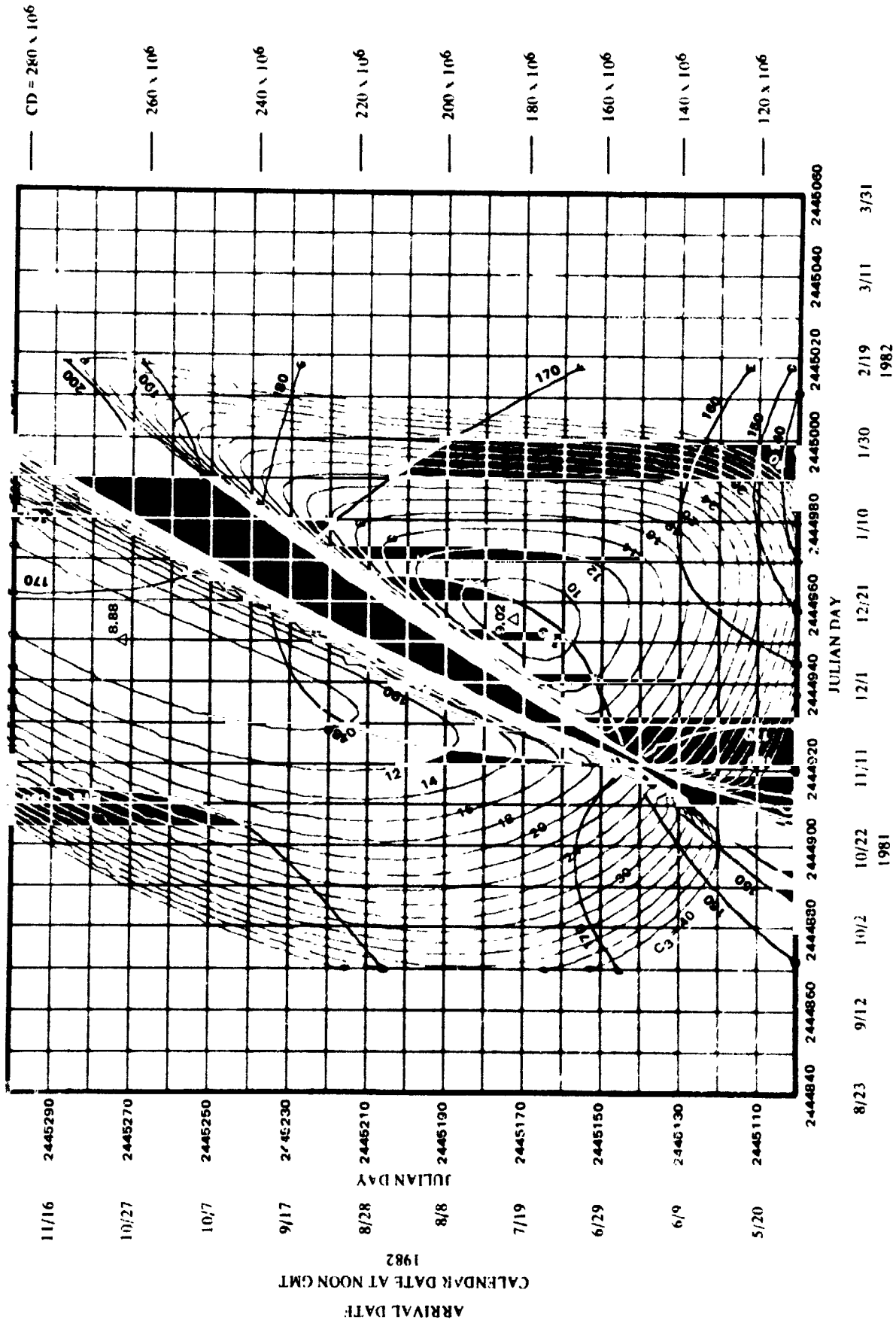
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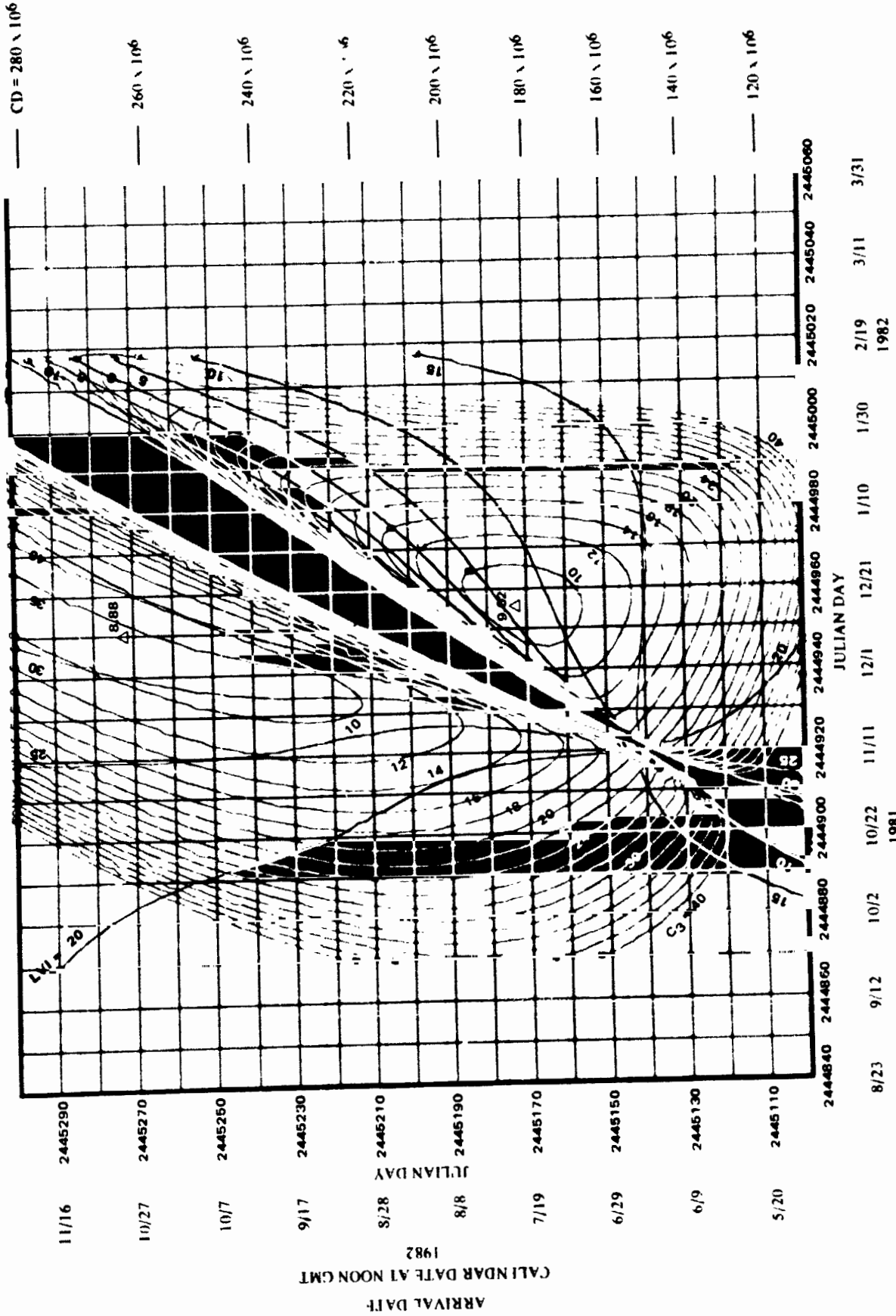
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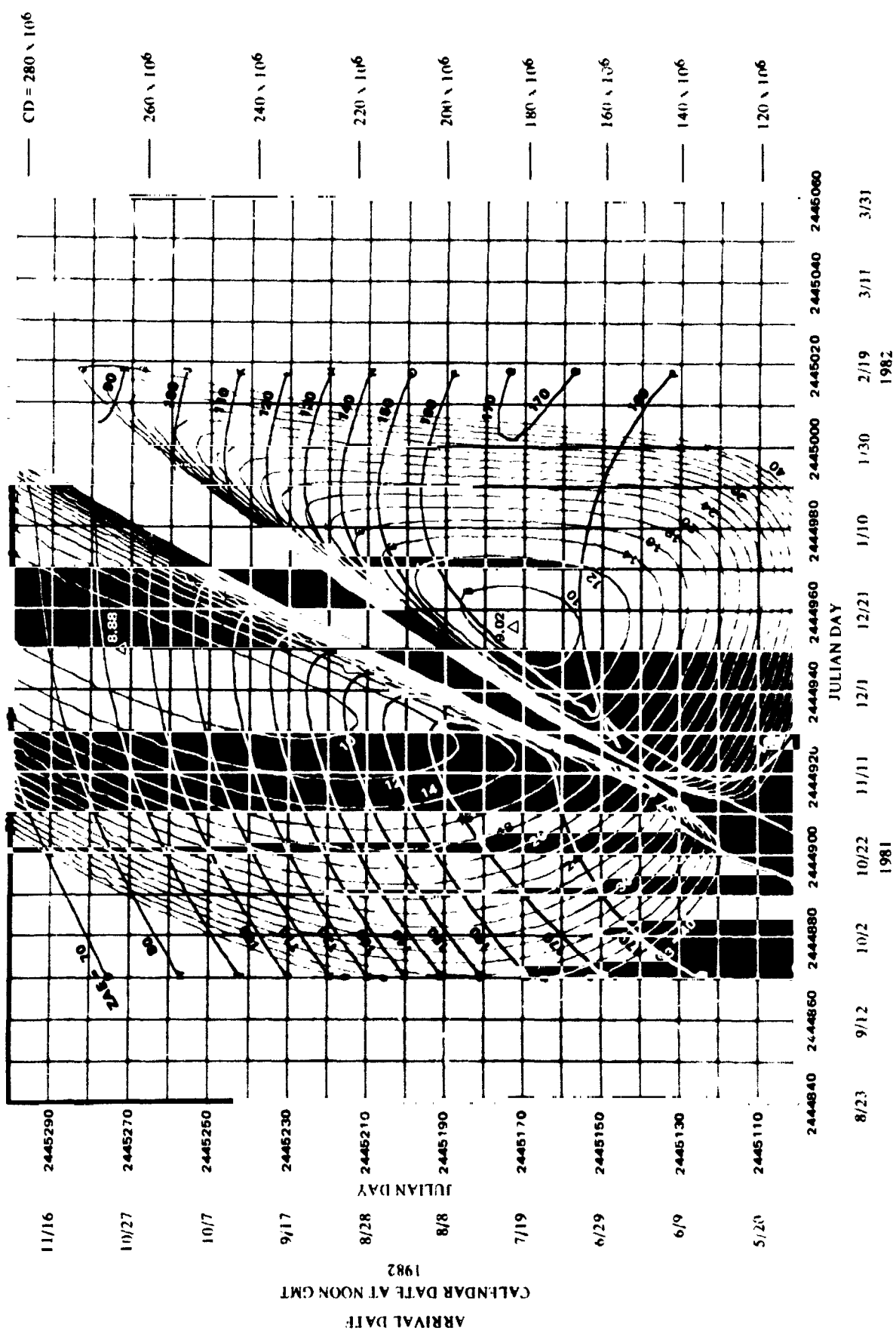


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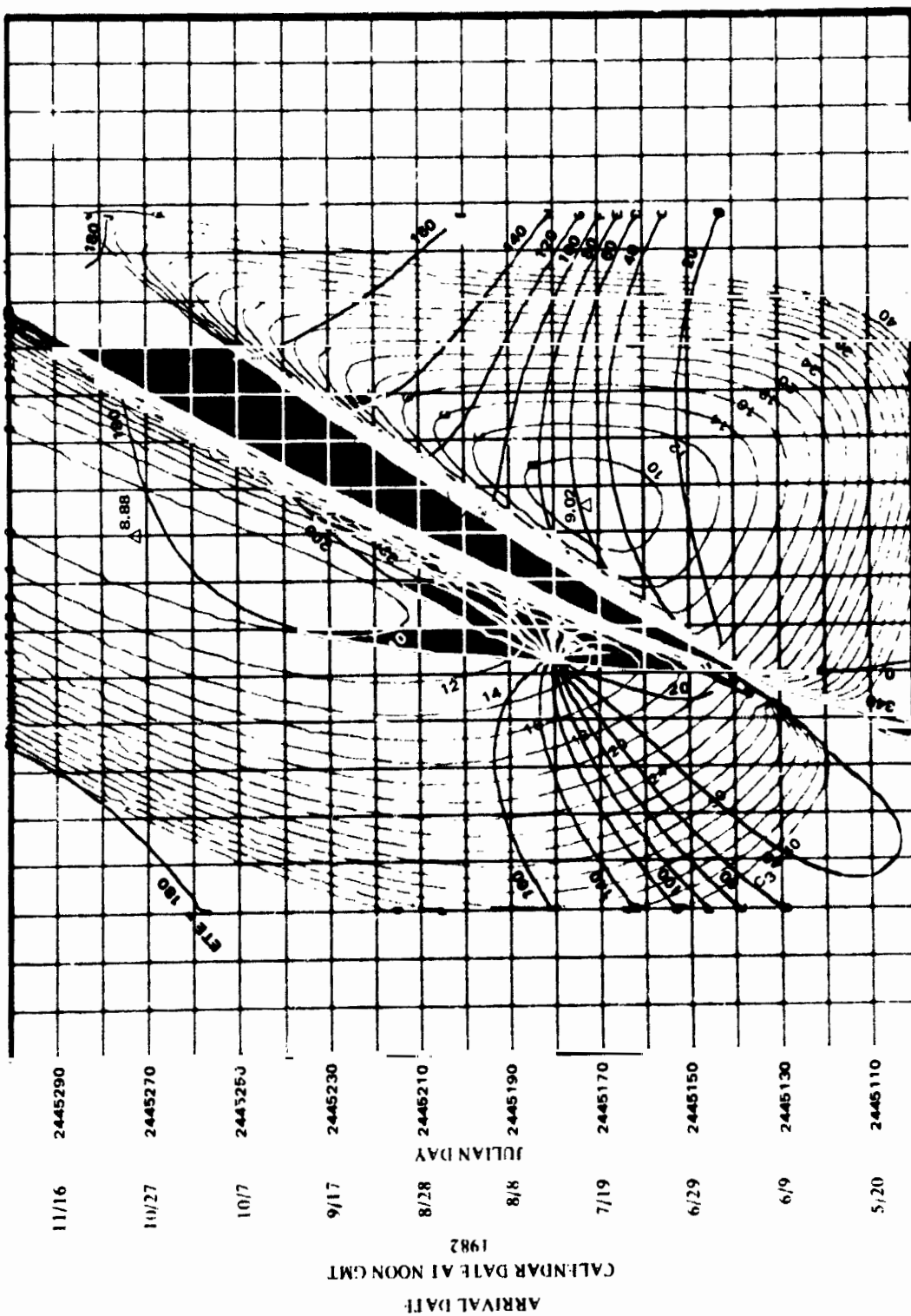
DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND LVI EARTH TO MARS 1981-82





— CD =  $280 \times 10^6$   
 —  $260 \times 10^6$   
 —  $240 \times 10^6$   
 —  $220 \times 10^6$   
 —  $200 \times 10^6$   
 —  $180 \times 10^6$   
 —  $160 \times 10^6$   
 —  $140 \times 10^6$   
 —  $120 \times 10^6$



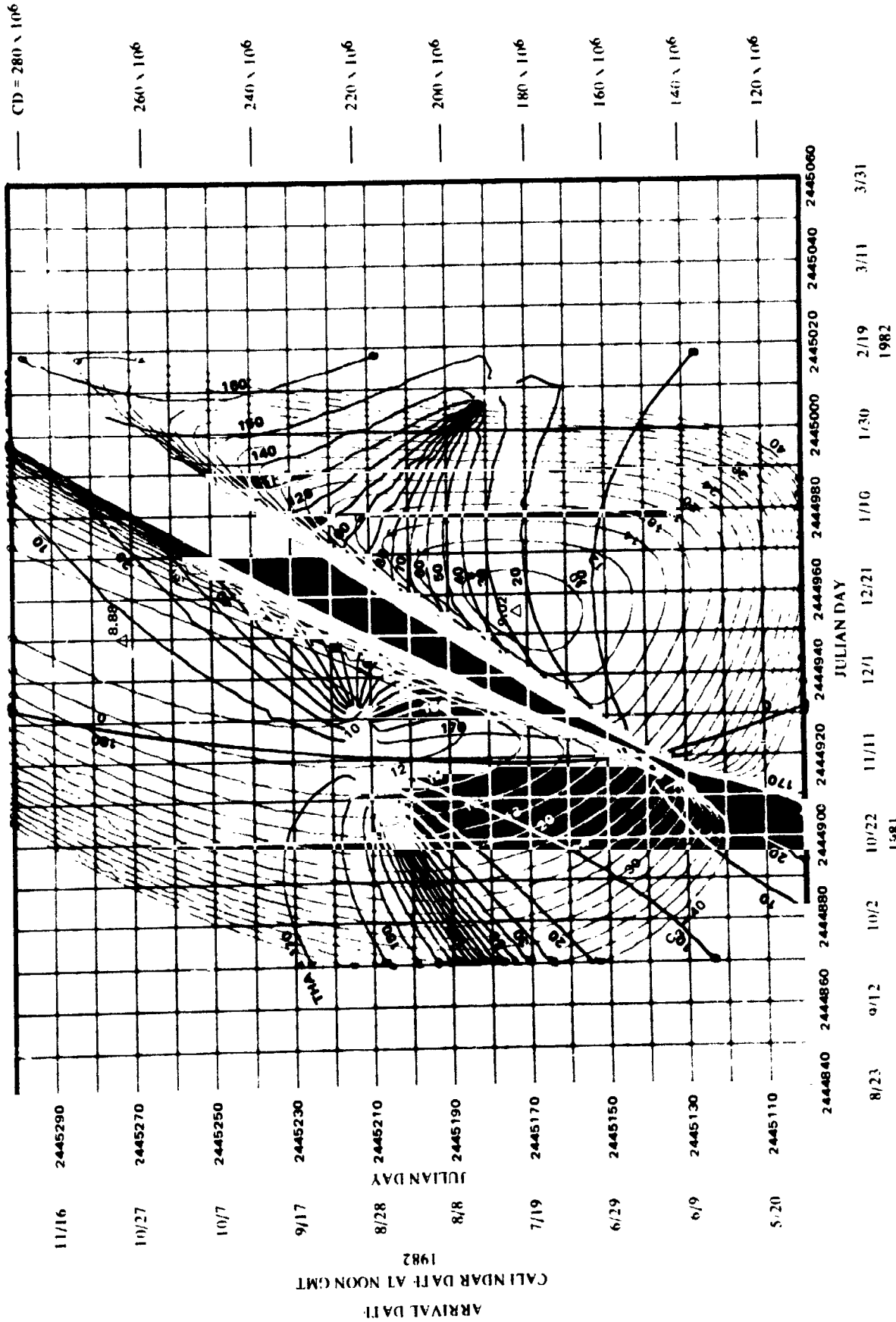
2444840 2444860 2444880 2444900 2444920 2444940 2444960 2444980 2445000 2445020 2445040 2445060  
 JULIAN DAY  
 8/23 9/12 10/2 10/22 11/11 12/1 12/21 1/10 1/30 2/19 3/11 3/31  
 1981 1982

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ETE EARTH TO MARS 1981-82



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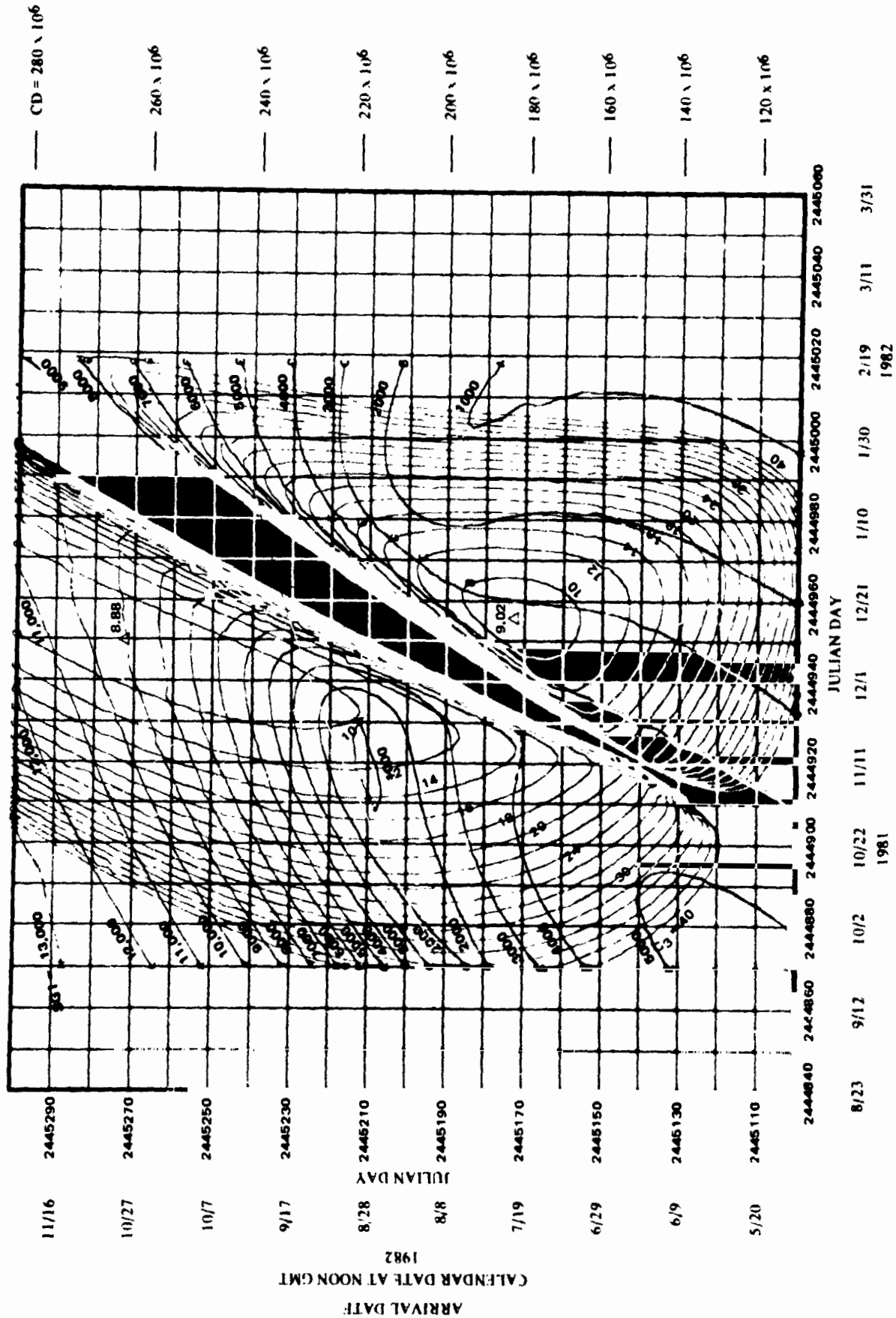


CONTOURS OF C<sub>3</sub> AND THE EARTH TO MARS 1981-82

CALENDAR DATE AT NOON GMT

DEPARTURE DATE

81 80 79



CD = 280 x 10<sup>6</sup>

260 x 10<sup>6</sup>

240 x 10<sup>6</sup>

220 x 10<sup>6</sup>

200 x 10<sup>6</sup>

180 x 10<sup>6</sup>

160 x 10<sup>6</sup>

140 x 10<sup>6</sup>

120 x 10<sup>6</sup>

11/16 2445290

10/27 2445270

10/7 2445250

9/17 2445230

8/28 2445210

8/8 2445190

7/19 2445170

6/29 2445150

6/9 2445130

5/20 2445110

ARRIVAL DATE  
CALENDAR DATE AT NOON GMT  
1982

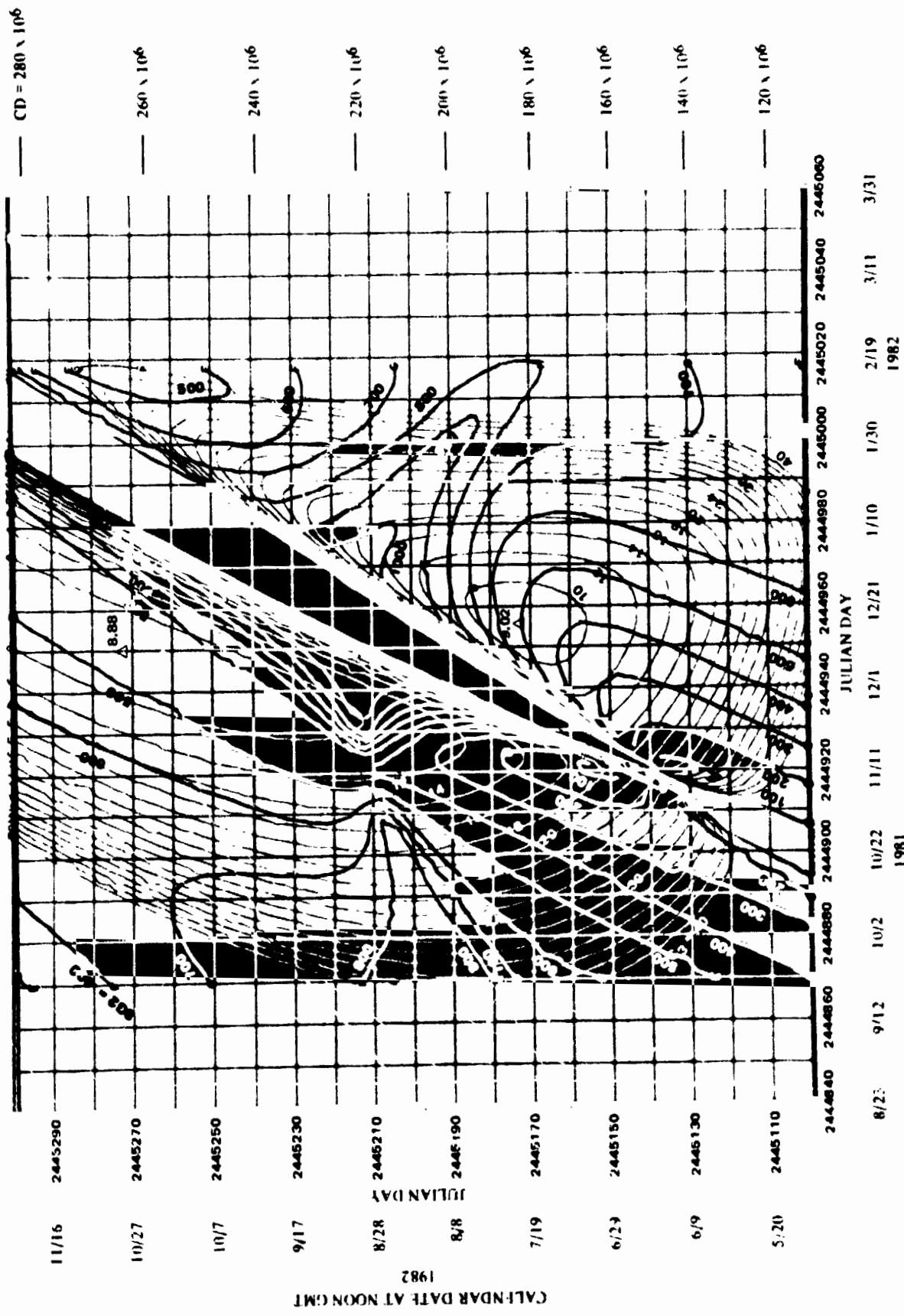
JULIAN DAY

2444840 2444860 2444880 2444900 2444920 2444940 2444960 2444980 2445000 2445020 2445040 2445060  
JULIAN DAY  
8/23 9/12 10/2 10/22 11/11 12/1 12/21 1/10 1/30 2/19 3/11 3/31  
1981 1982

CALENDAR DATE AT NOON GMT  
DEPARTURE DATE

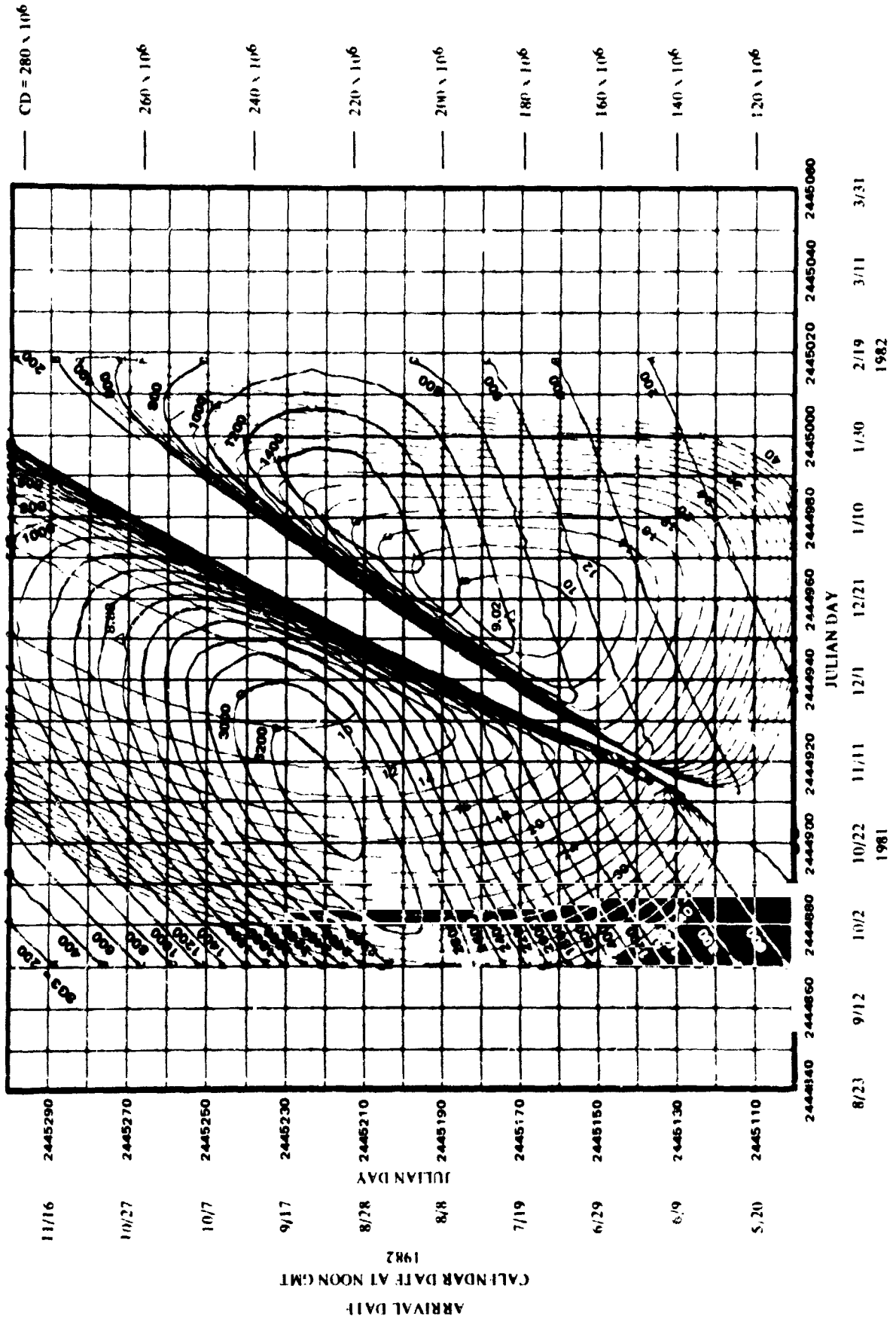
CONTOURS OF C<sub>3</sub> AND SGI EARTH TO MARS 1981-82

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CONTOURS OF C<sub>3</sub> AND SG2 EARTH TO MARS 1981-82

1981 **SG2**



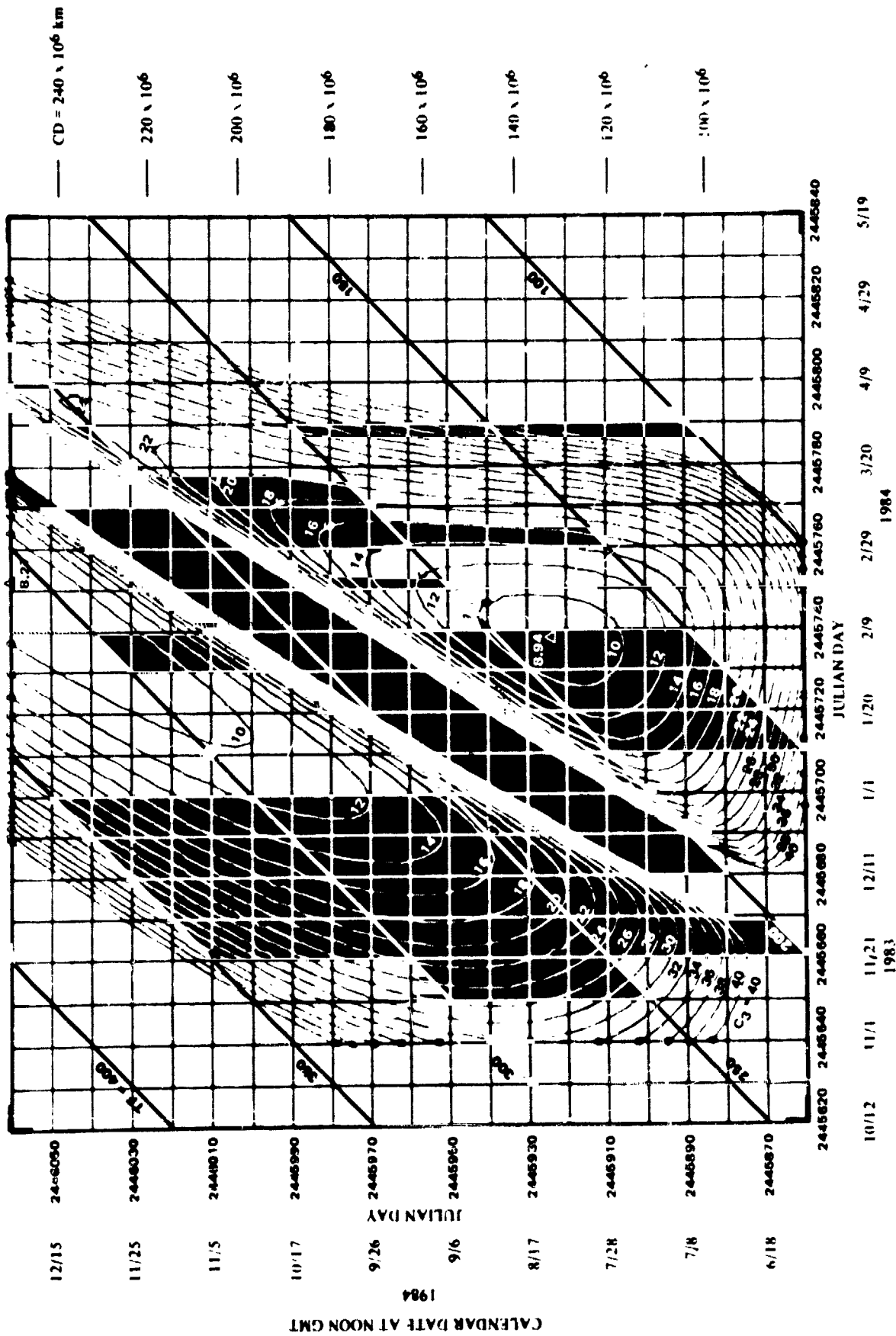
CONTOURS OF C<sub>3</sub> AND SG3 EARTH TO MARS 1981-82

CALENDAR DATE AT NOON GMT

DEPARTURE DATE

JULIAN DAY

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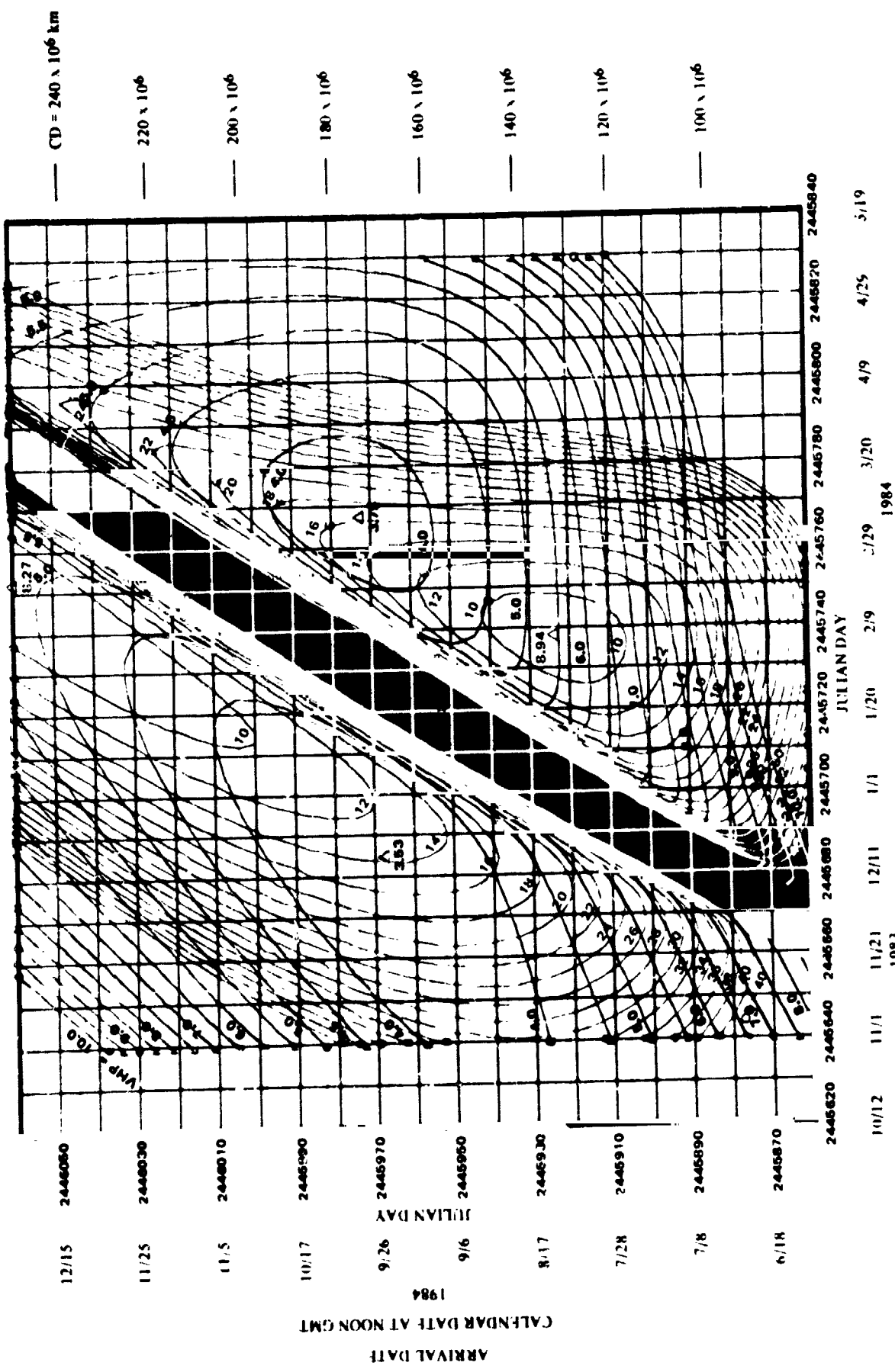
CALENDAR DATE AT NOON GMT

DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND FLIGHT TIMES EARTH TO MARS 1984

EQS





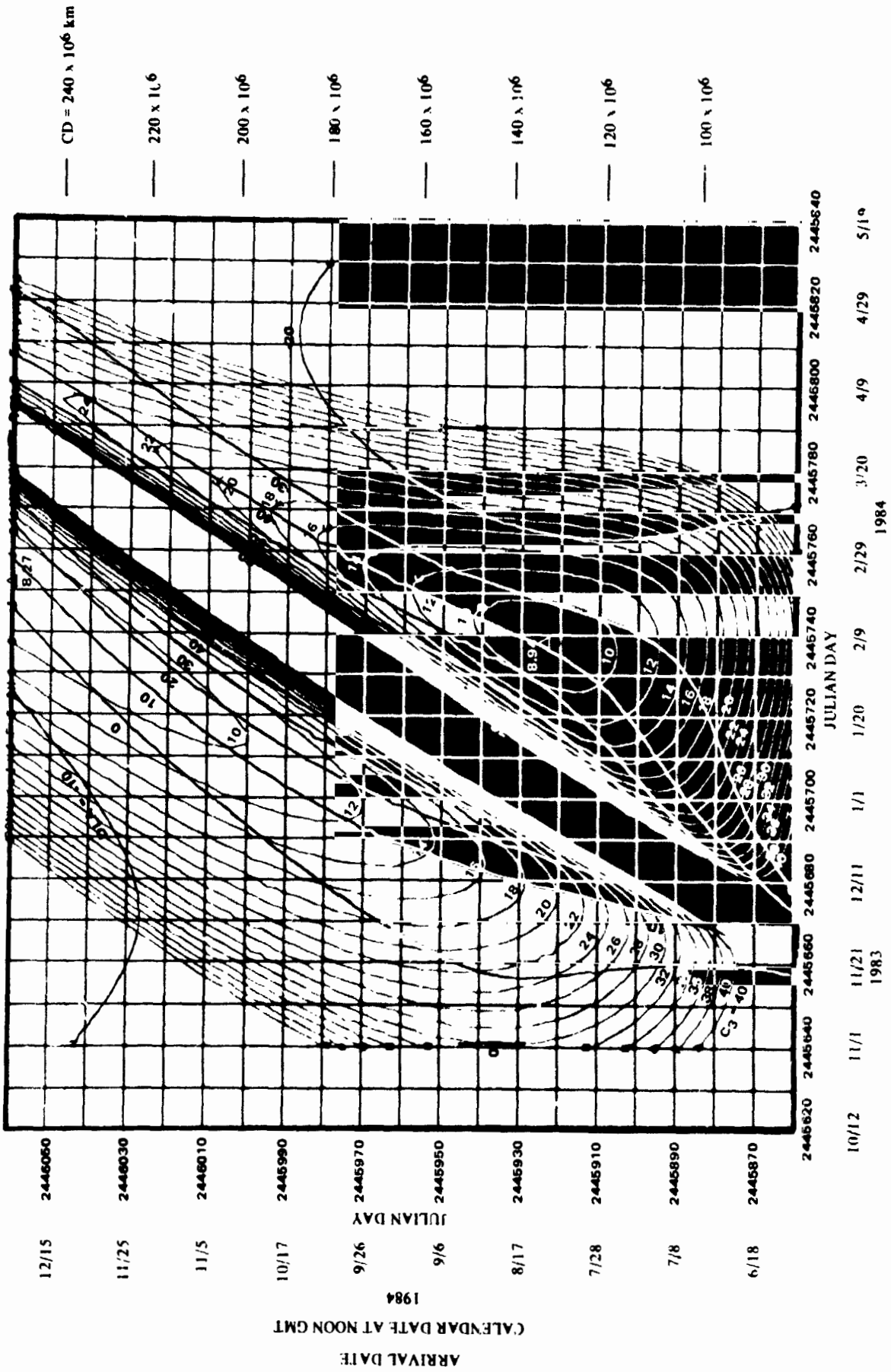
— CD =  $240 \times 10^6$  km  
 —  $220 \times 10^6$   
 —  $200 \times 10^6$   
 —  $180 \times 10^6$   
 —  $160 \times 10^6$   
 —  $140 \times 10^6$   
 —  $120 \times 10^6$   
 —  $100 \times 10^6$

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1984  
 JULIAN DAY  
 12/15 2445650  
 11/25 2445630  
 11/5 2445610  
 10/17 2445590  
 9/26 2445970  
 9/6 2445950  
 8/17 2445930  
 7/28 2445910  
 7/8 2445890  
 6/18 2445870

2445620 2445640 2445660 2445680 2445700 2445720 2445740 2445760 2445780 2445800 2445820 2445840  
 JULIAN DAY  
 10/12 11/1 11/21 12/11 1/1 1/20 2/9 2/29 3/20 4/9 4/25 5/19  
 1983 1984  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF  $C_3$  AND VHP EARTH TO MARS 1984





— CD =  $240 \times 10^6$  km  
 —  $220 \times 10^6$   
 —  $200 \times 10^6$   
 —  $180 \times 10^6$   
 —  $160 \times 10^6$   
 —  $140 \times 10^6$   
 —  $120 \times 10^6$   
 —  $100 \times 10^6$

12/15 2446050  
 11/25 2446030  
 11/5 2446010  
 10/17 2445990  
 9/26 2445970  
 9/6 2445950  
 8/17 2445930  
 7/28 2445910  
 7/8 2445890  
 6/18 2445870

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1984  
 JULIAN DAY

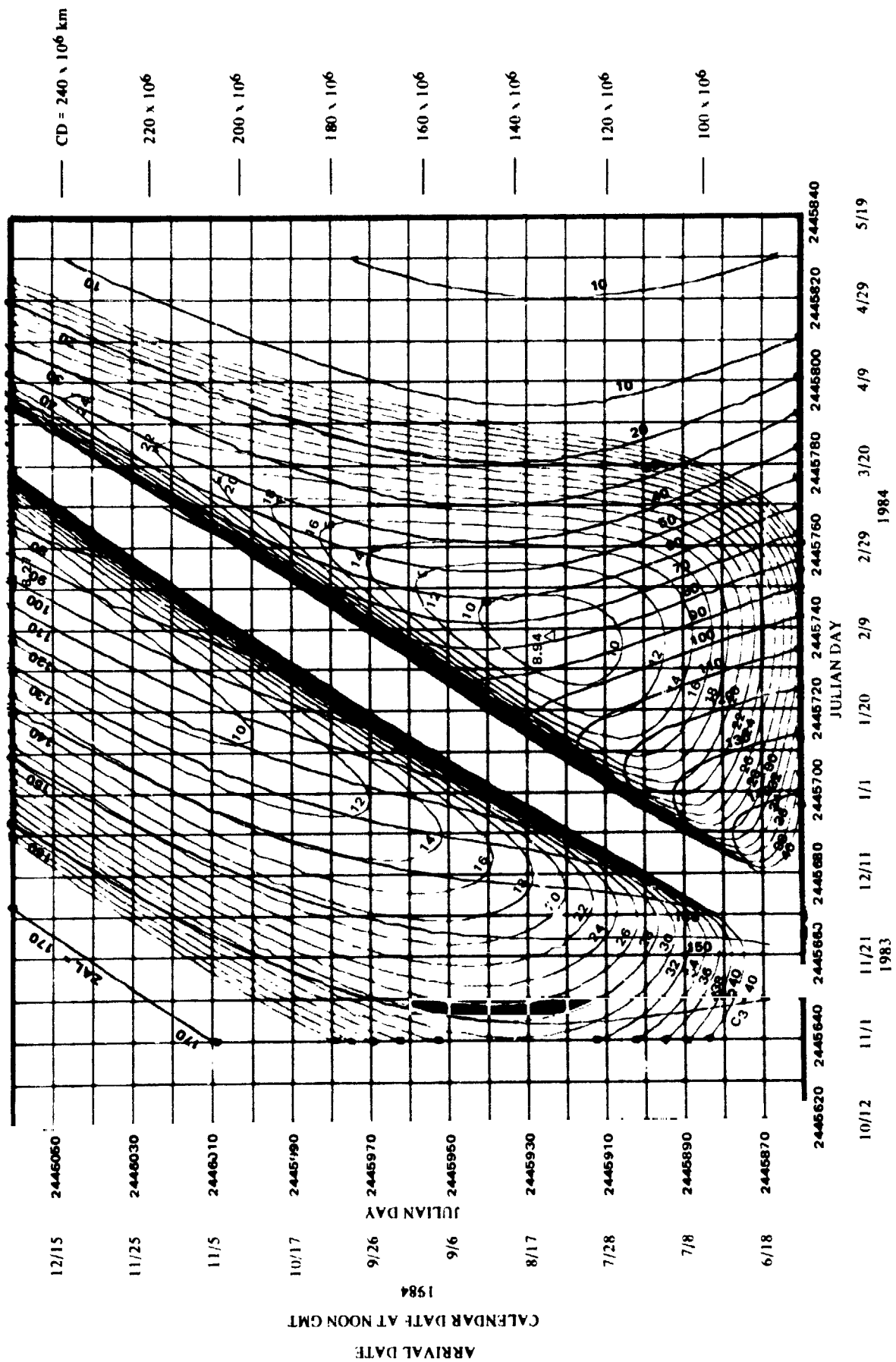
2445820 2445840 2445860 2445880 2445900 2445920 2445940 2445960 2445980 2446000 2446020 2446040 2446060

10/12 11/1 11/21 12/11 1/1 1/20 2/9 2/29 3/20 4/9 4/29 5/19

1983 1984

JULIAN DAY  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>j</sub> AND DLA EARTH TO MARS 1984



CONTOURS OF C<sub>3</sub> AND ZAL EARTH TO MARS 1984

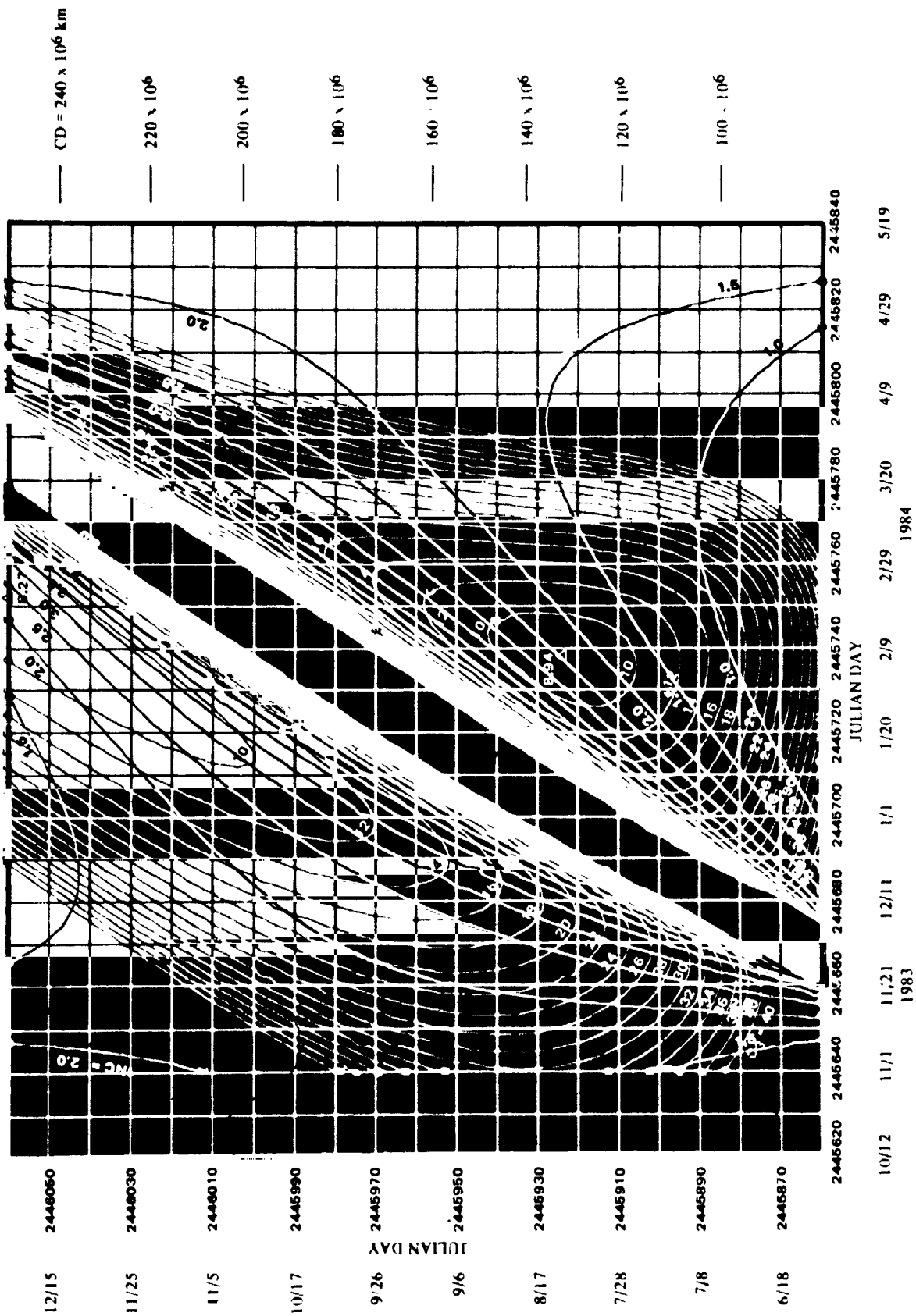
ARRIVAL DATE

CALENDAR DATE AT NOON GMT

DEPARTURE DATE



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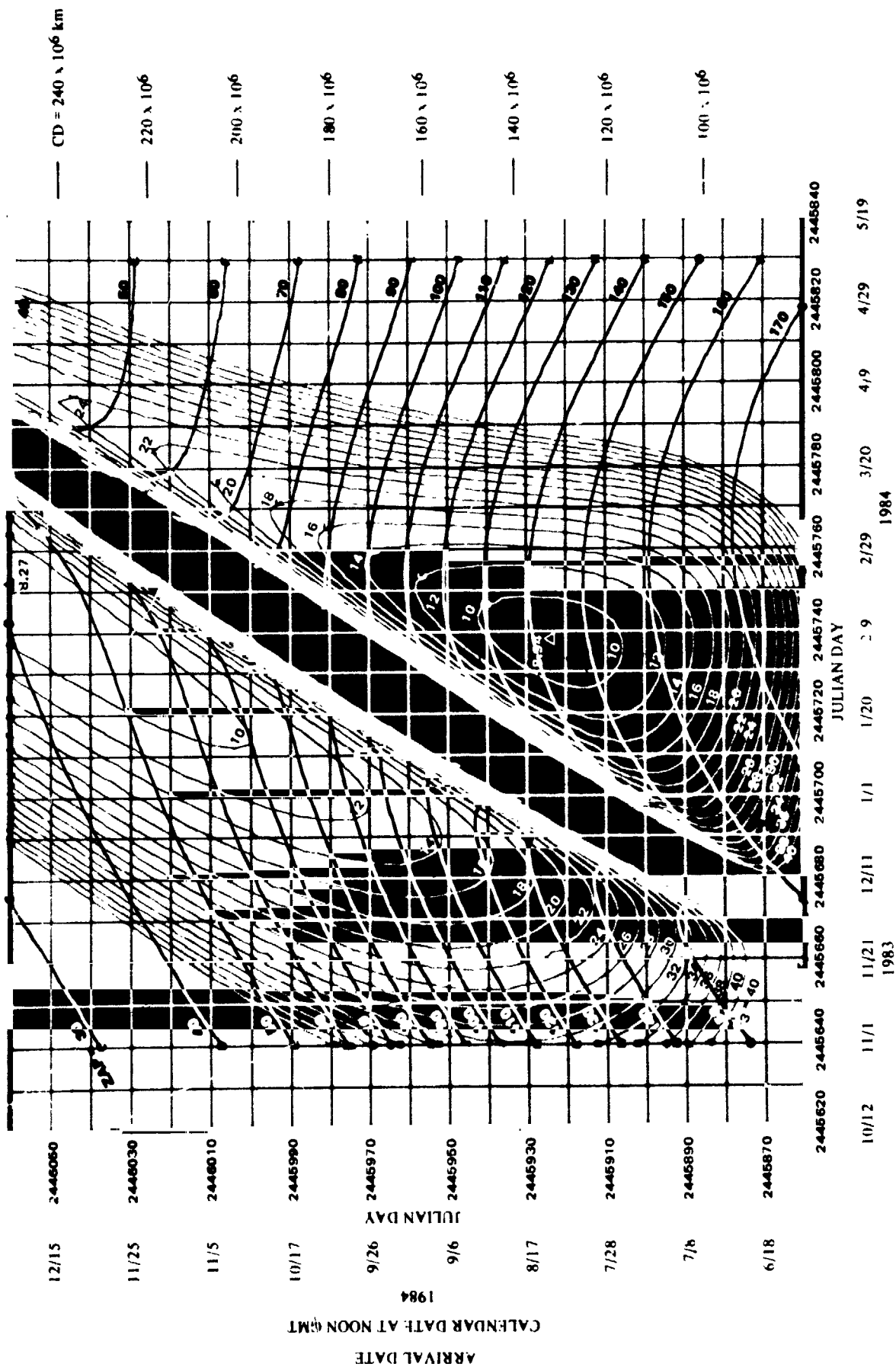


ARRIVAL DATE

DEPARTURE DATE

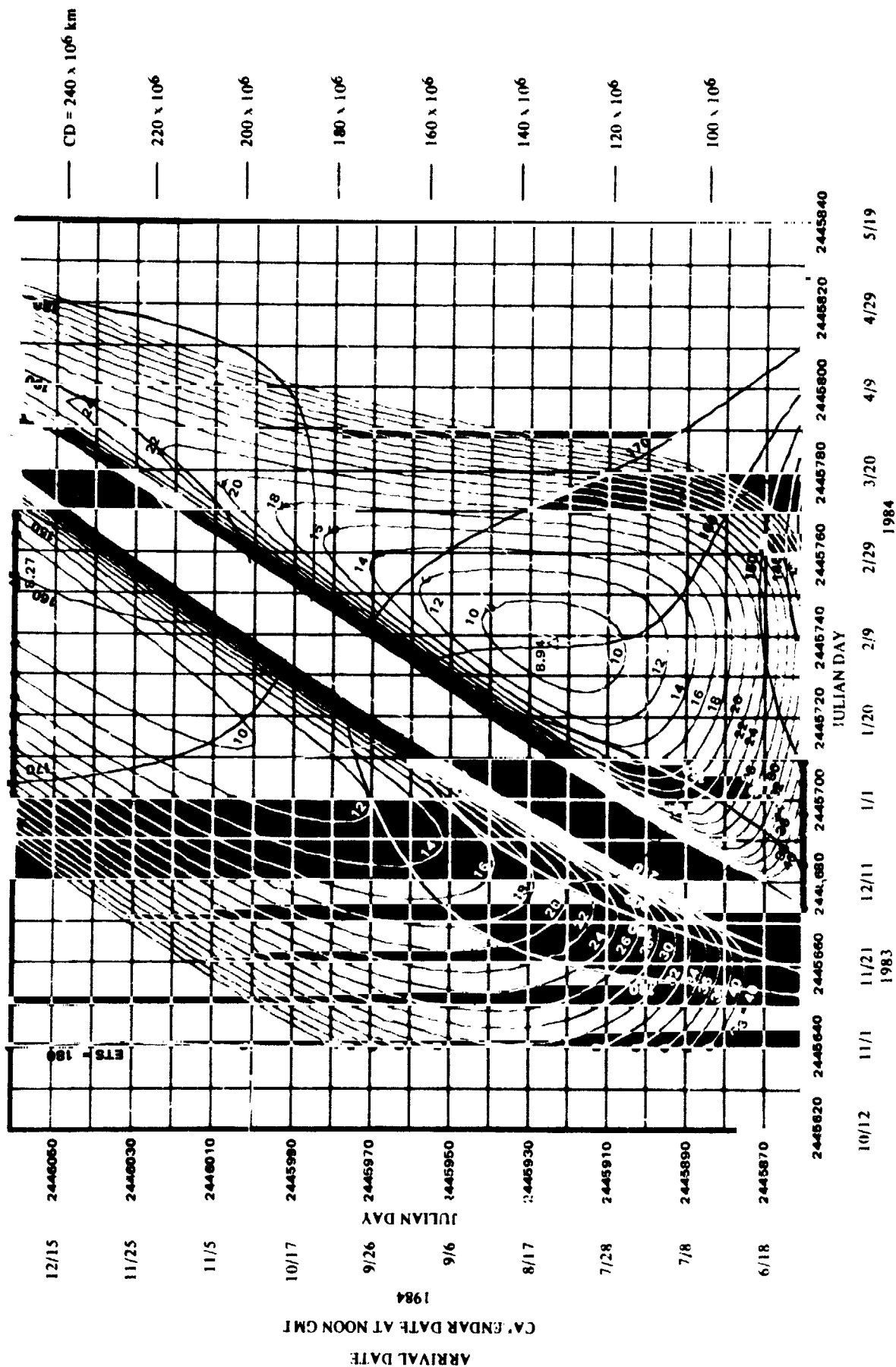
CONTOURS OF C<sub>3</sub> AND INC EARTH TO MARS 1984

180 181 182



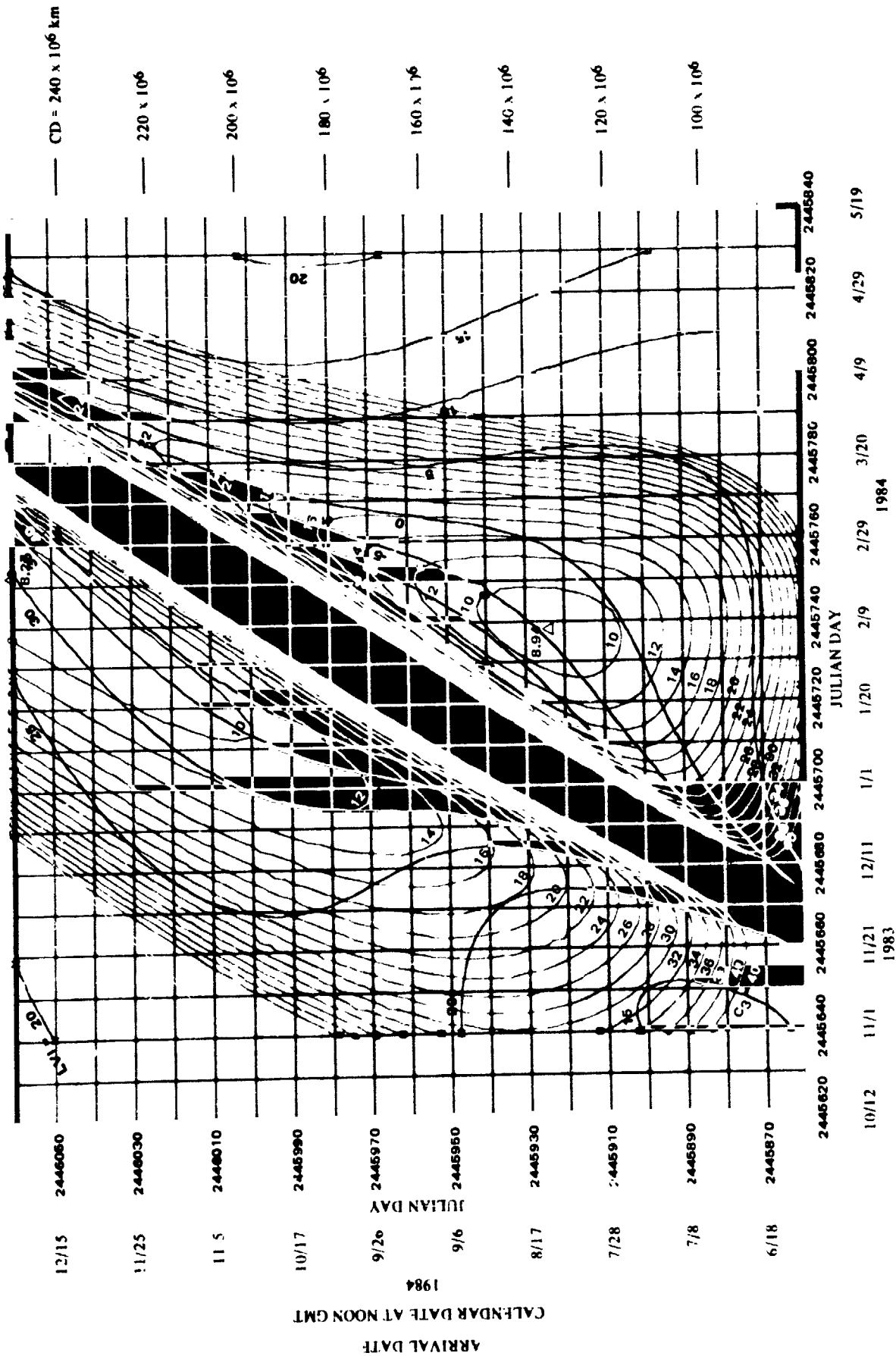
CONTOURS OF C<sub>3</sub> AND ZAP EARTH TO MARS 1984

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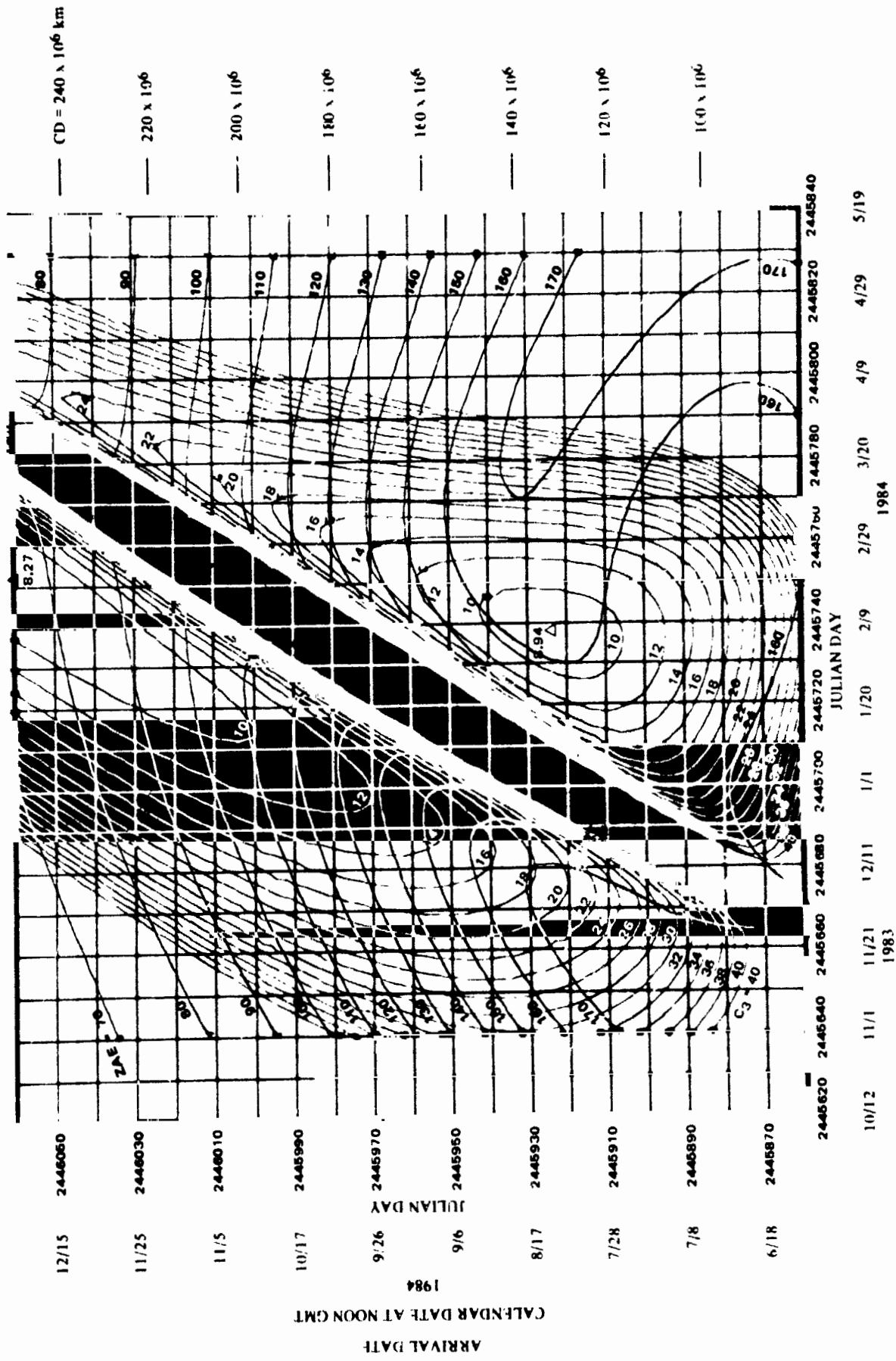
CONTOURS OF C<sub>3</sub> AND ETS EARTH TO MARS 1984

ETS - 189



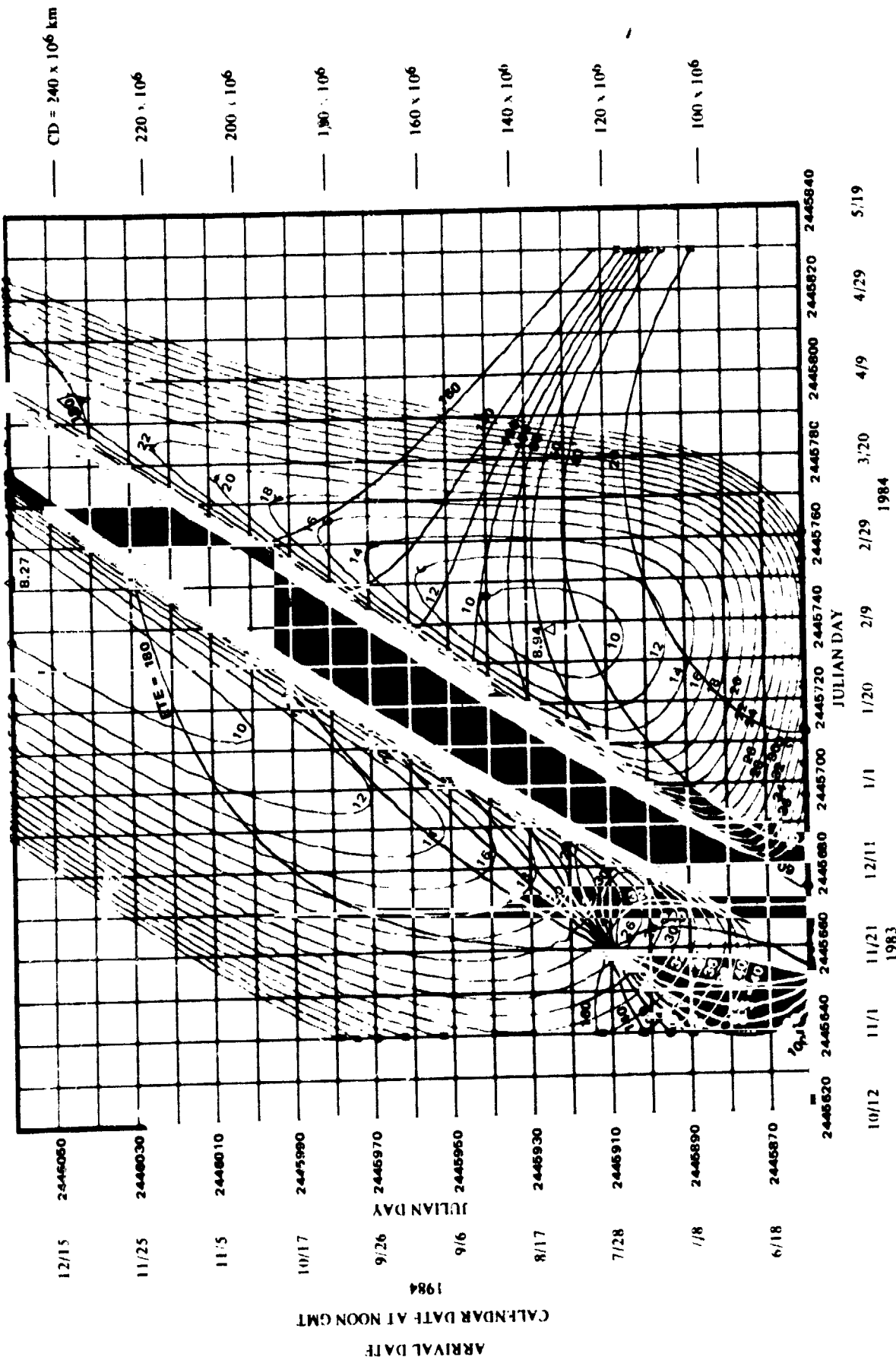
CONTOURS OF C<sub>3</sub> AND LVI EARTH TO MARS 1984

184 LVI



ZAE  
1984





— CD =  $240 \times 10^6$  km  
 —  $220 \times 10^6$   
 —  $200 \times 10^6$   
 —  $180 \times 10^6$   
 —  $160 \times 10^6$   
 —  $140 \times 10^6$   
 —  $120 \times 10^6$   
 —  $100 \times 10^6$

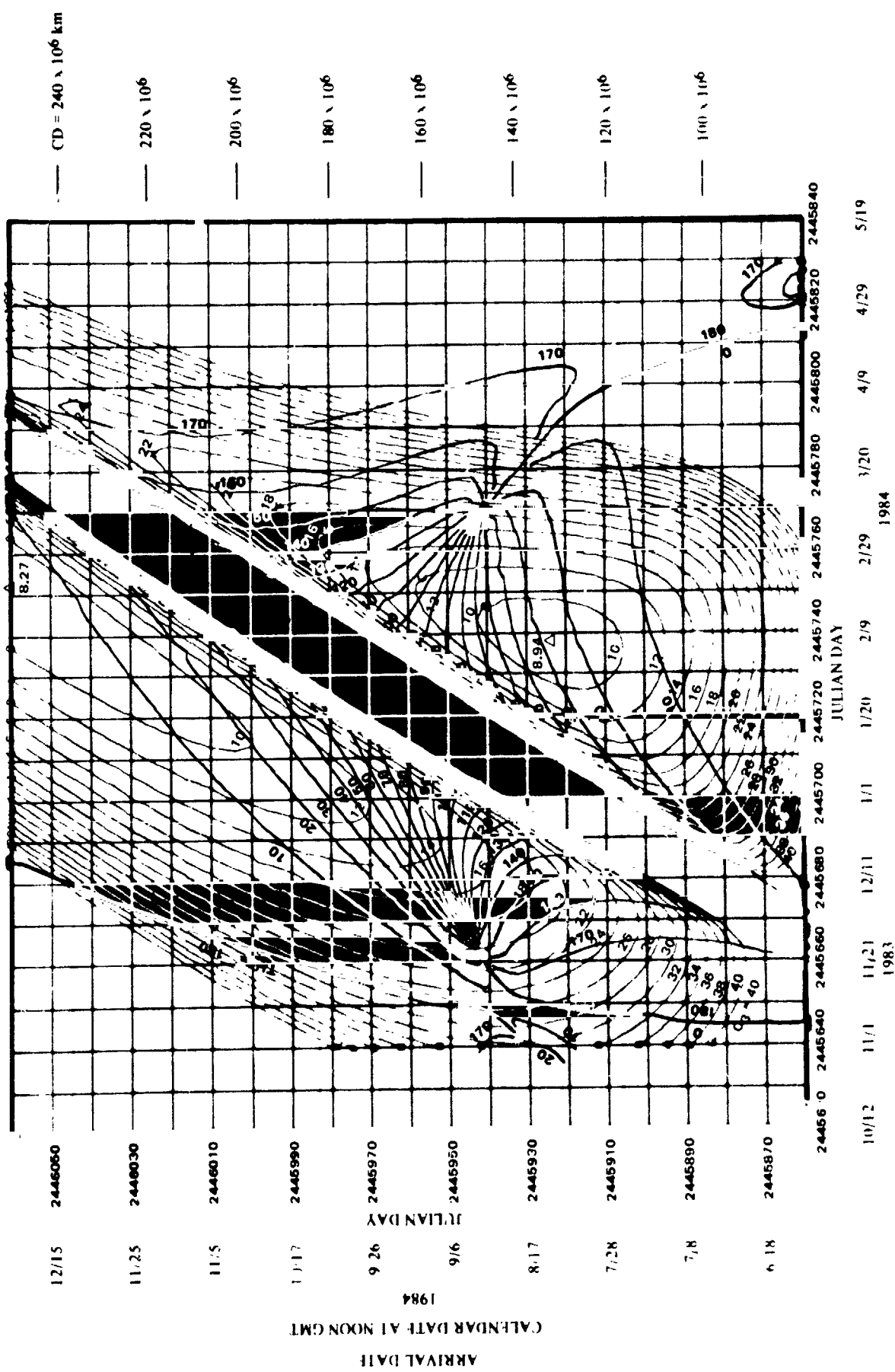
12/15 2445680  
 11/25 2446030  
 11/5 2448010  
 10/17 2445990  
 9/26 2445970  
 9/6 2445950  
 8/17 2445930  
 7/28 2445910  
 //8 2445890  
 6/18 2445870

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1984

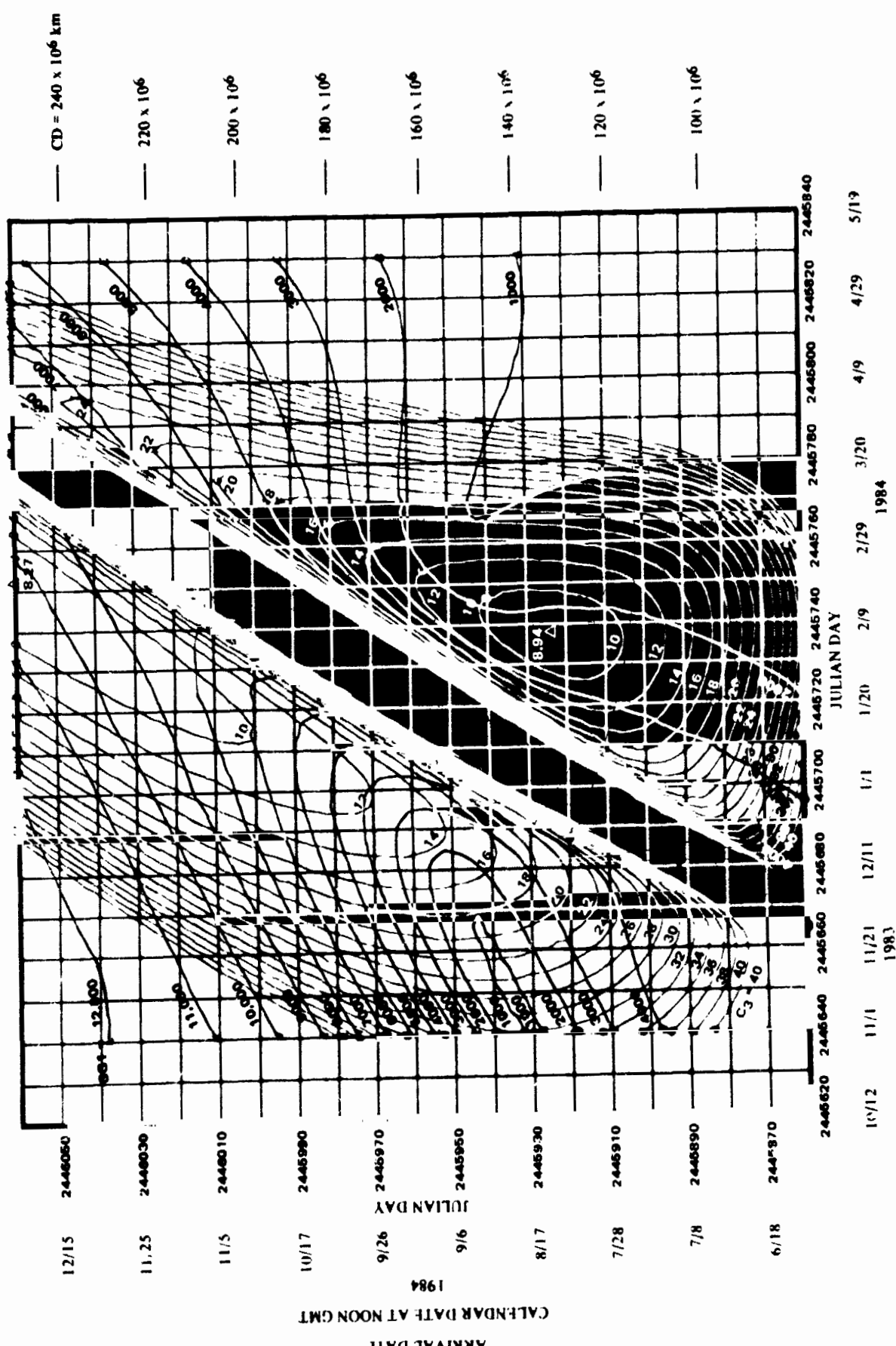
2445620 2445640 2445660 2445680 2445700 2445720 2445740 2445760 2445780 2445800 2445820 2445840  
 JULIAN DAY  
 10/12 11/1 11/21 12/11 1/1 1/20 2/9 2/29 3/20 4/9 4/29 5/19  
 1983 1984

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF  $C_1$  AND ETE EARTH TO MARS 1984



CONTOURS OF C<sub>3</sub> AND THA EARTH TO MARS 1984



— CD = 240 x 10<sup>6</sup> km

— 220 x 10<sup>6</sup>

— 200 x 10<sup>6</sup>

— 180 x 10<sup>6</sup>

— 160 x 10<sup>6</sup>

— 140 x 10<sup>6</sup>

— 120 x 10<sup>6</sup>

— 100 x 10<sup>6</sup>

ARRIVAL DATE  
CALENDAR DATE AT NOON GMT

JULIAN DAY

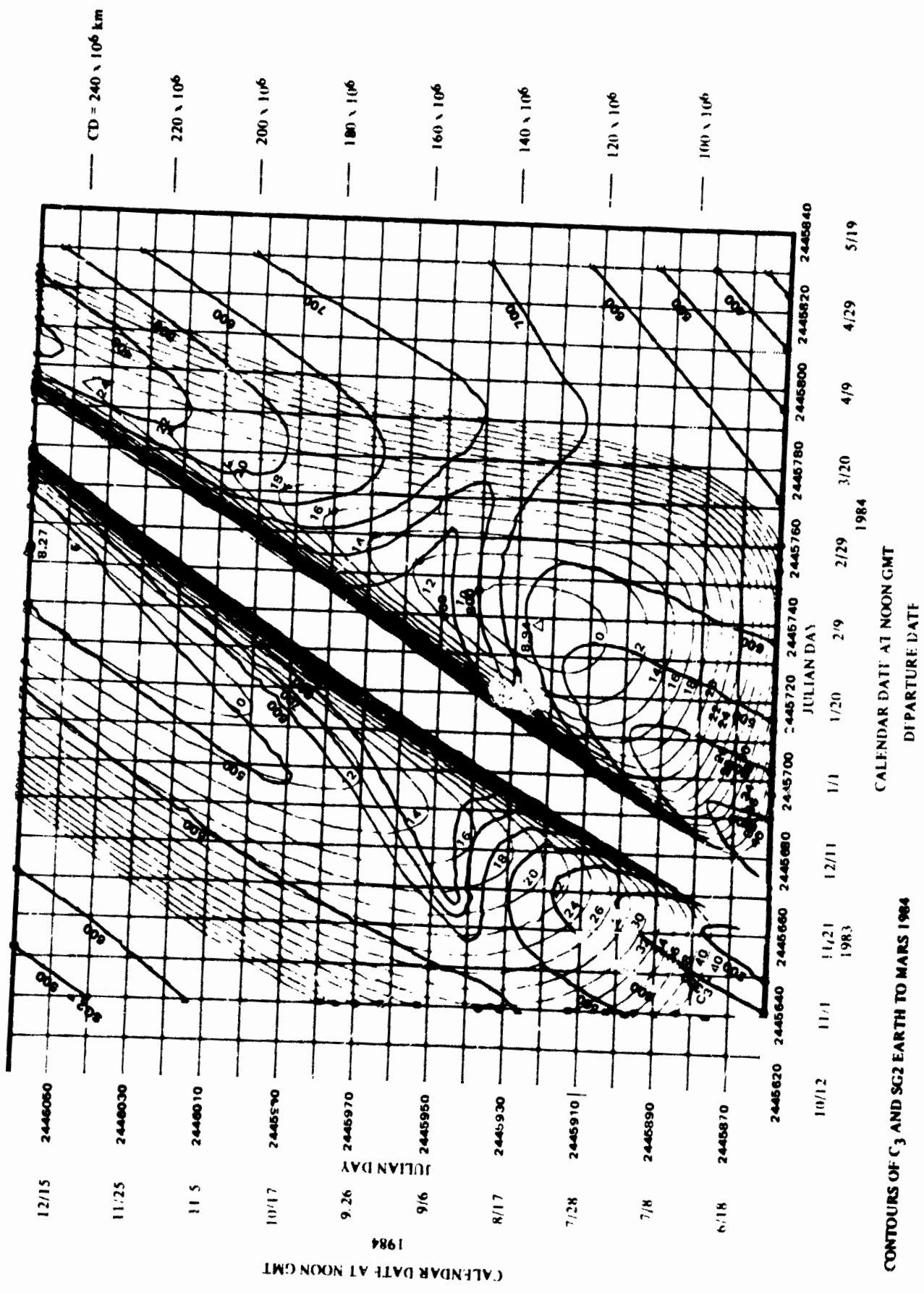
CALENDAR DATE AT NOON GMT

DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND SGI EARTH TO MARS 1984

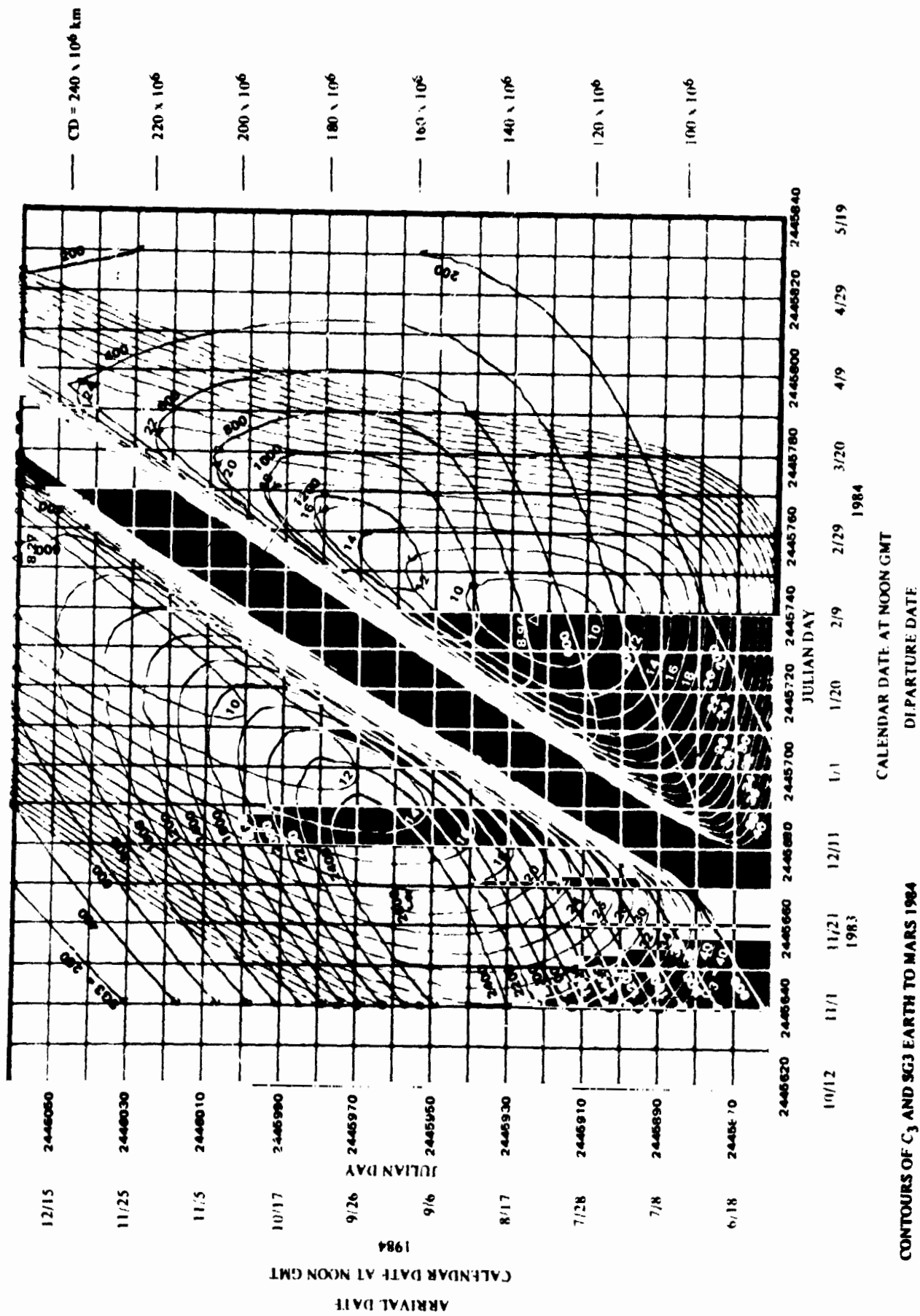


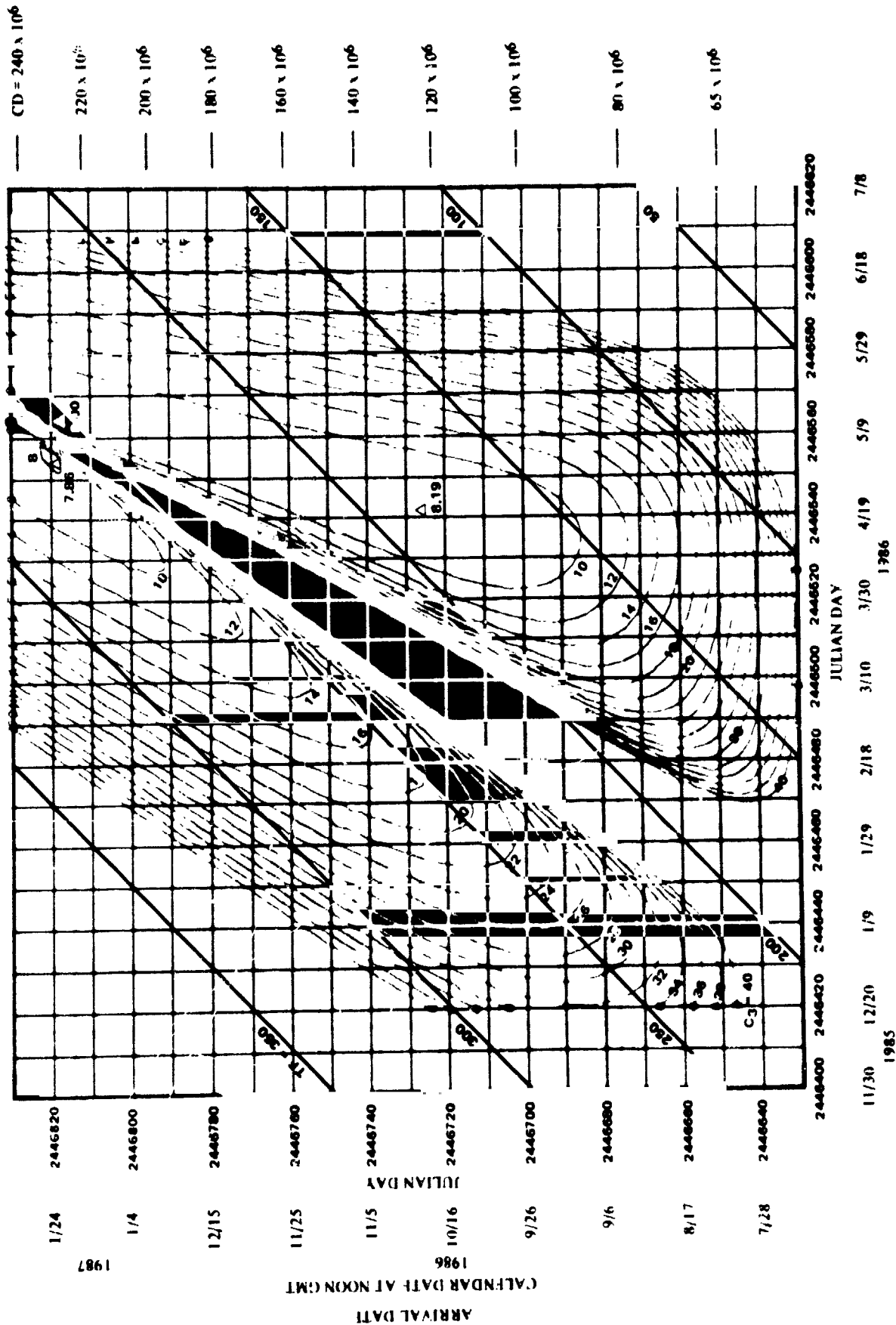
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CONTOURS OF C<sub>3</sub> AND SG2 EARTH TO MARS 1984

1984 SG2



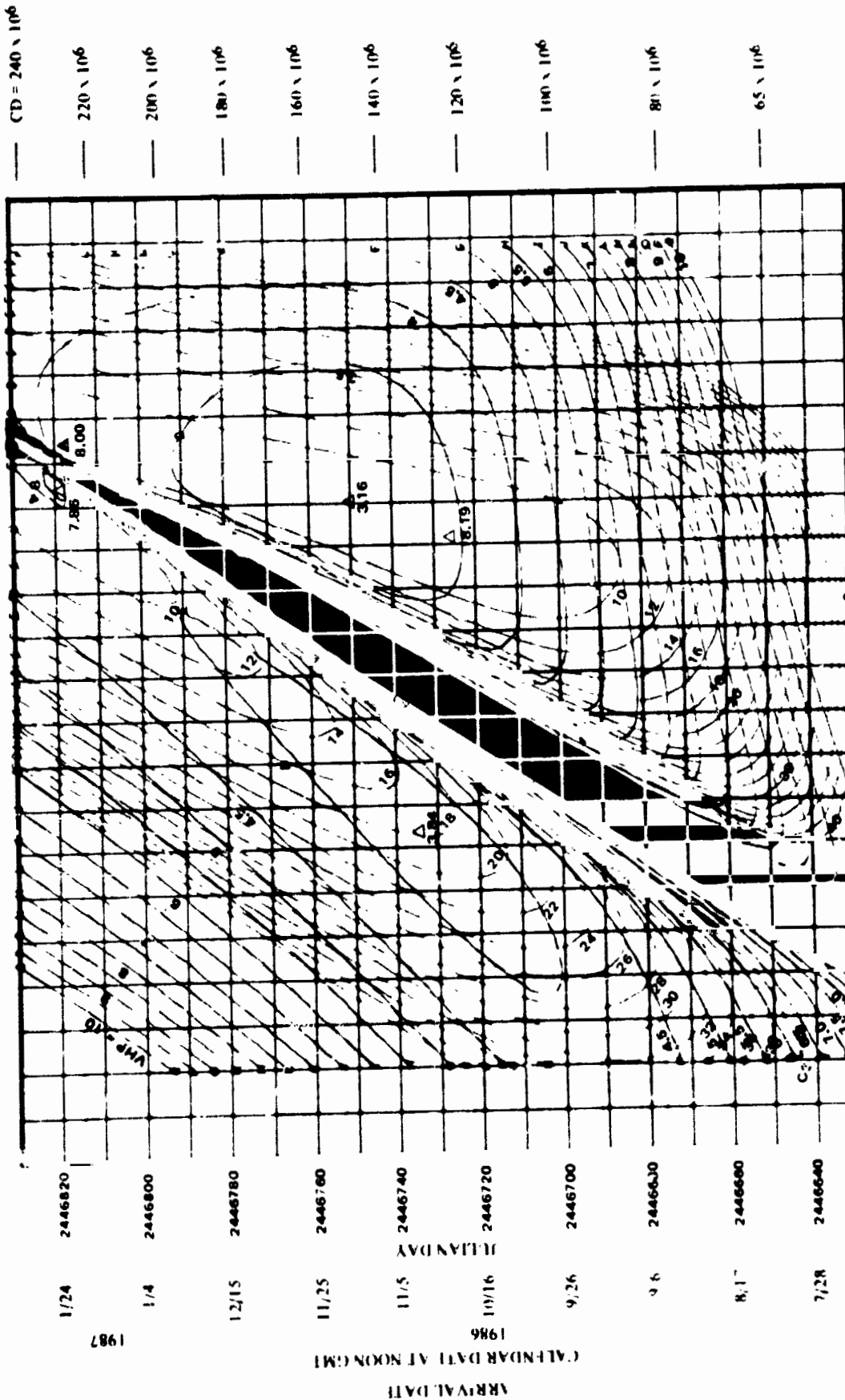


CALENDAR DATE AT NOON GMT

CONTOURS OF C<sub>3</sub> AND FLIGHT TIMES EARTH TO MARS 1985-86

DEPARTURE DATE

1988



- CD = 240 x 10<sup>6</sup>
- 220 x 10<sup>6</sup>
- 200 x 10<sup>6</sup>
- 180 x 10<sup>6</sup>
- 160 x 10<sup>6</sup>
- 140 x 10<sup>6</sup>
- 120 x 10<sup>6</sup>
- 100 x 10<sup>6</sup>
- 80 x 10<sup>6</sup>
- 65 x 10<sup>6</sup>

ARRIVAL DATE  
 1986  
 1/24 2446820  
 1/4 2446800  
 12/15 2446780  
 11/25 2446760  
 11/5 2446740  
 10/16 2446720  
 9/26 2446700  
 9 6 2446680  
 8,17 2446660  
 7/28 2446640

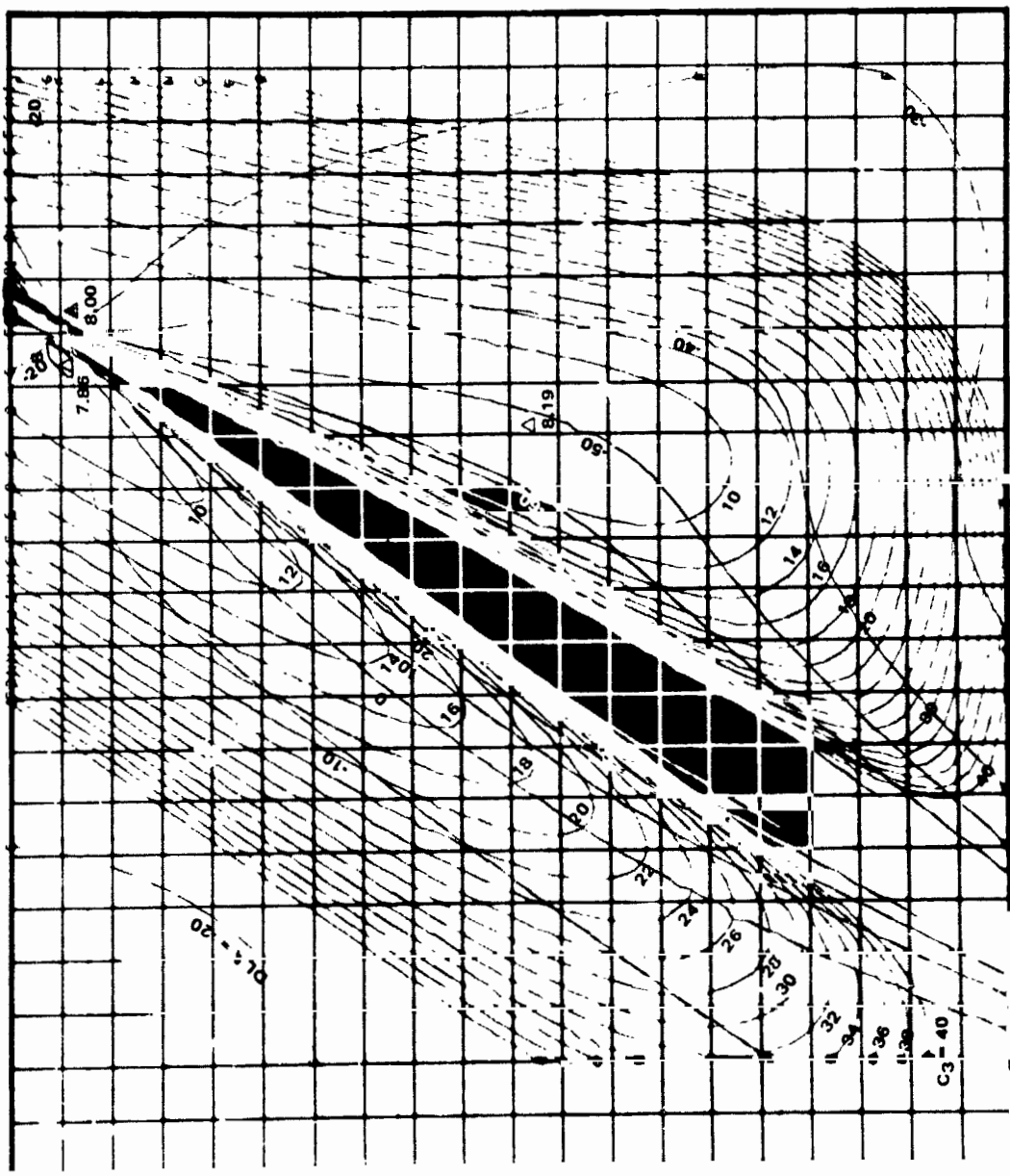
DEPARTURE DATE  
 1985  
 11/30 12/20 1/9 1/29 2/18 3/10 3/30 4/19 5/9 5/29 6/18 7/8

JULIAN DAY  
 2446400 2446420 2446440 2446460 2446480 2446500 2446520 2446540 2446560 2446580 2446600 2446620

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND VHP EARTH TO MARS 1985-86

— CD = 240 x 10<sup>6</sup>  
 — 220 x 10<sup>6</sup>  
 — 200 x 10<sup>6</sup>  
 — 180 x 10<sup>6</sup>  
 — 160 x 10<sup>6</sup>  
 — 140 x 10<sup>6</sup>  
 — 120 x 10<sup>6</sup>  
 — 100 x 10<sup>6</sup>  
 — 80 x 10<sup>6</sup>  
 — 65 x 10<sup>6</sup>



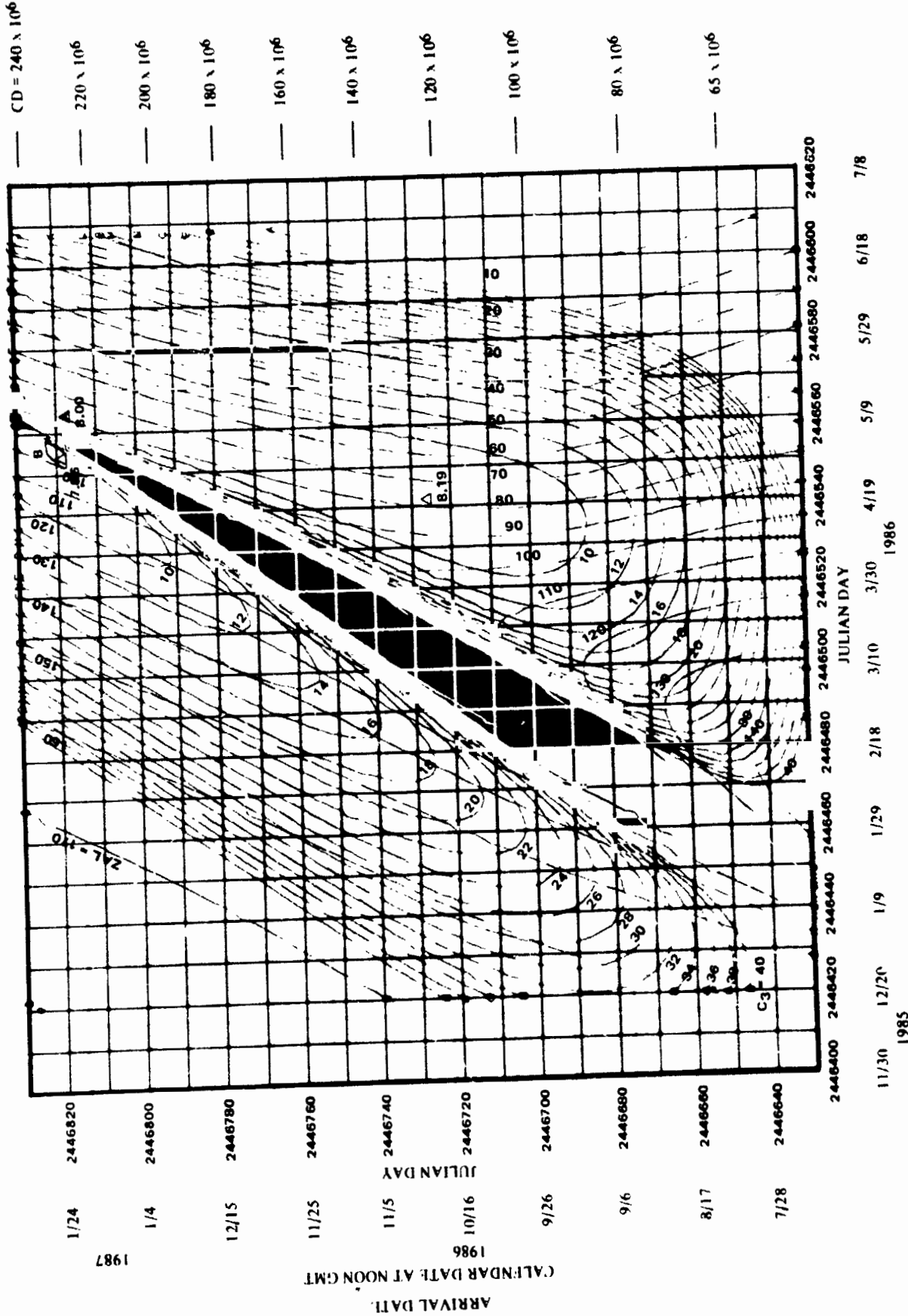
2446400 2446420 2446440 2446460 2446480 2446500 2446520 2446540 2446560 2446580 2446600 2446620  
 JULIAN DAY  
 11/30 12/20 1/9 1/29 2/18 3/10 3/30 4/19 5/9 5/29 6/18 7/8  
 1985

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND DLA EARTH TO MARS 1985-86

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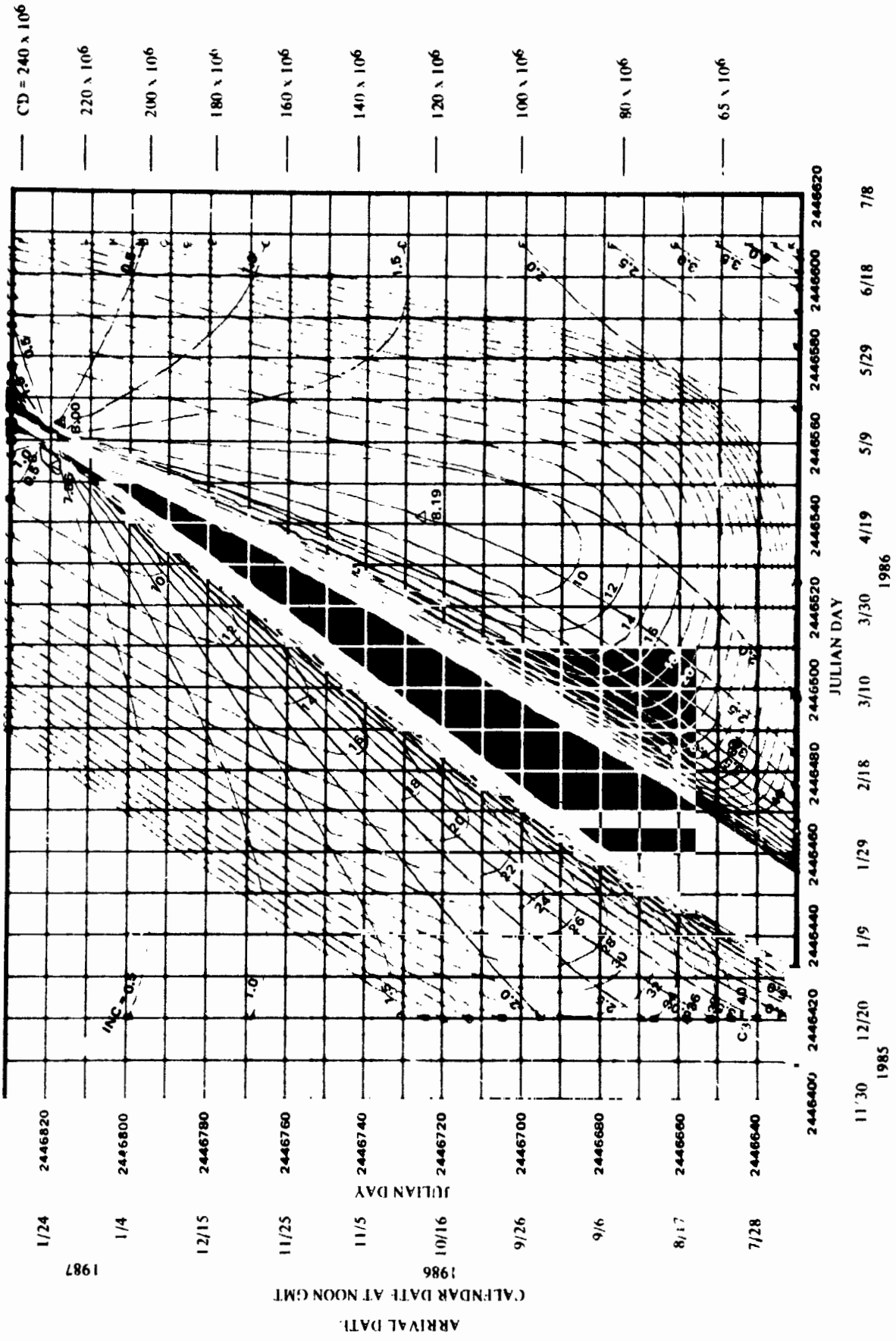




CALENDAR DATE AT NOON GMT

DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ZAL EARTH TO MARS 1985-86



ARRIVAL DATE  
(CALENDAR DATE AT NOON GMT)  
1986

DEPARTURE DATE  
(CALENDAR DATE AT NOON GMT)  
1985 1986

CONTOURS OF C<sub>3</sub> AND INC EARTH TO MARS 1985-86

CD = 240 x 10<sup>6</sup>

220 x 10<sup>6</sup>

200 x 10<sup>6</sup>

180 x 10<sup>6</sup>

160 x 10<sup>6</sup>

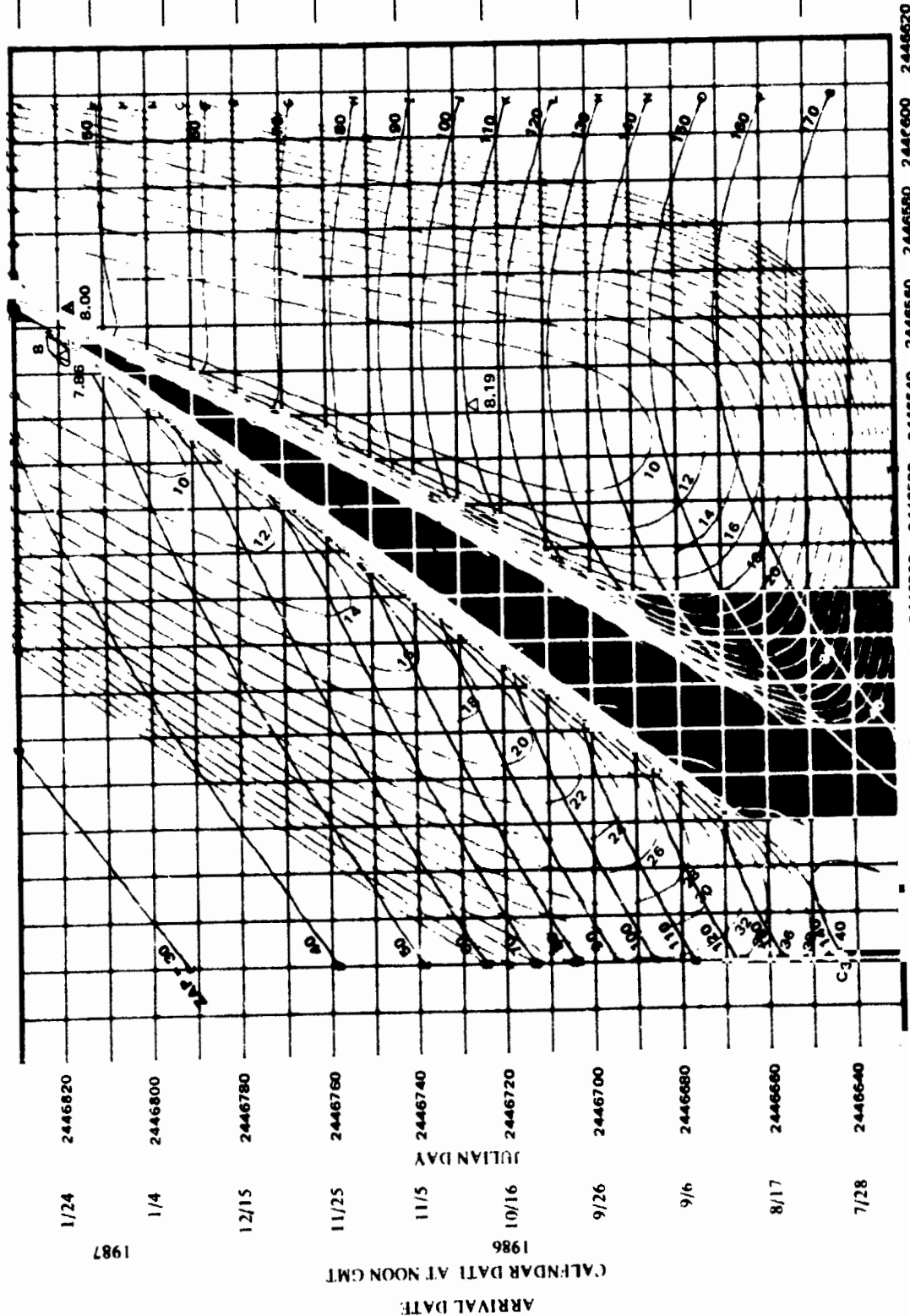
140 x 10<sup>6</sup>

120 x 10<sup>6</sup>

100 x 10<sup>6</sup>

80 x 10<sup>6</sup>

65 x 10<sup>6</sup>



2446400 2446420 2446440 2446460 2446480 2446500 2446520 2446540 2446560 2446580 2446600 2446620

JULIAN DAY

11/30 12/20 1/9 1/29 2/18 3/10 3/30 4/19 5/9 5/29 6/18 7/8

1985 1986

CALENDAR DATE AT NOON GMT

DEPARTURE DATE

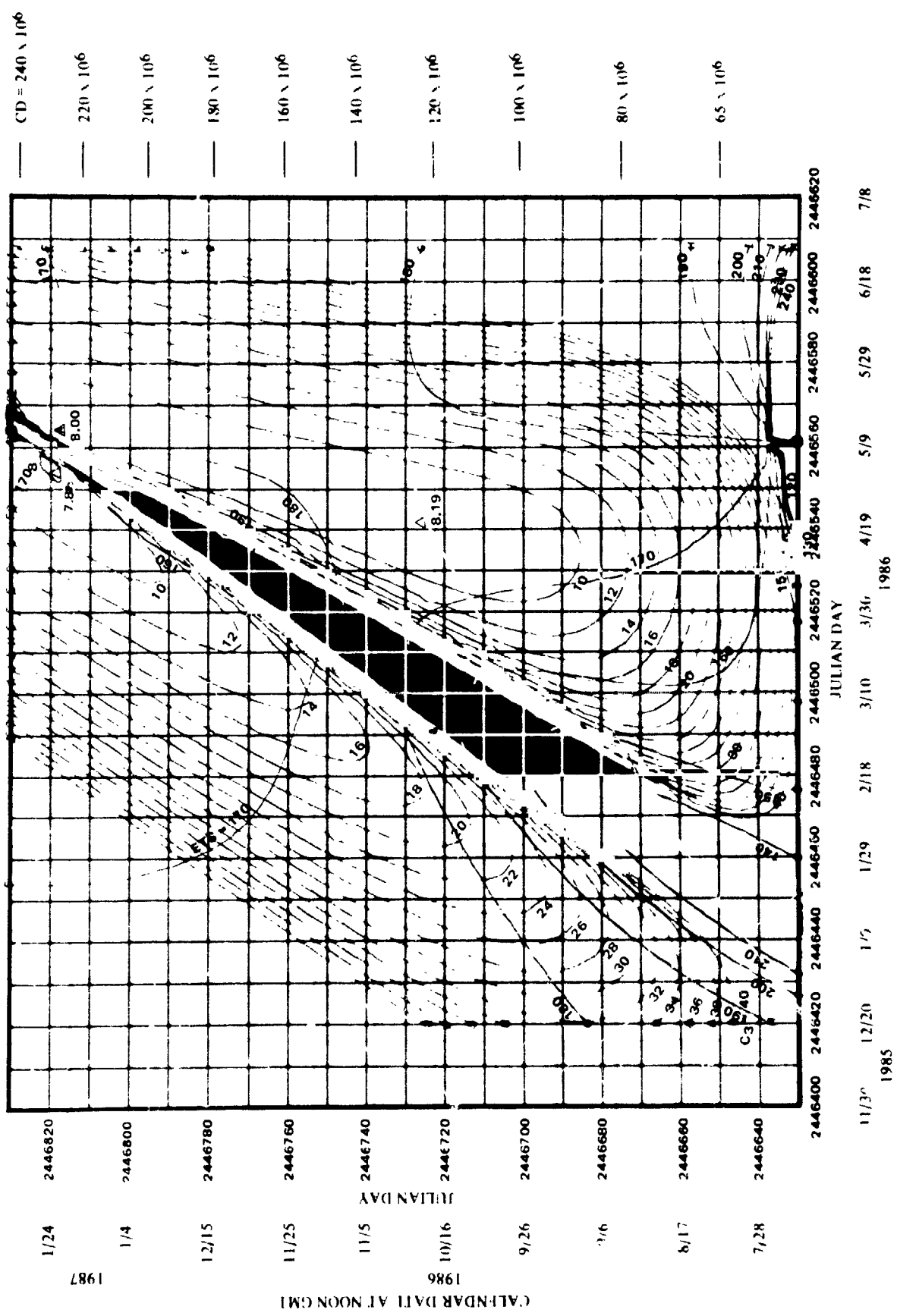
ARRIVAL DATE

CALENDAR DATE AT NOON GMT

DEPARTURE DATE

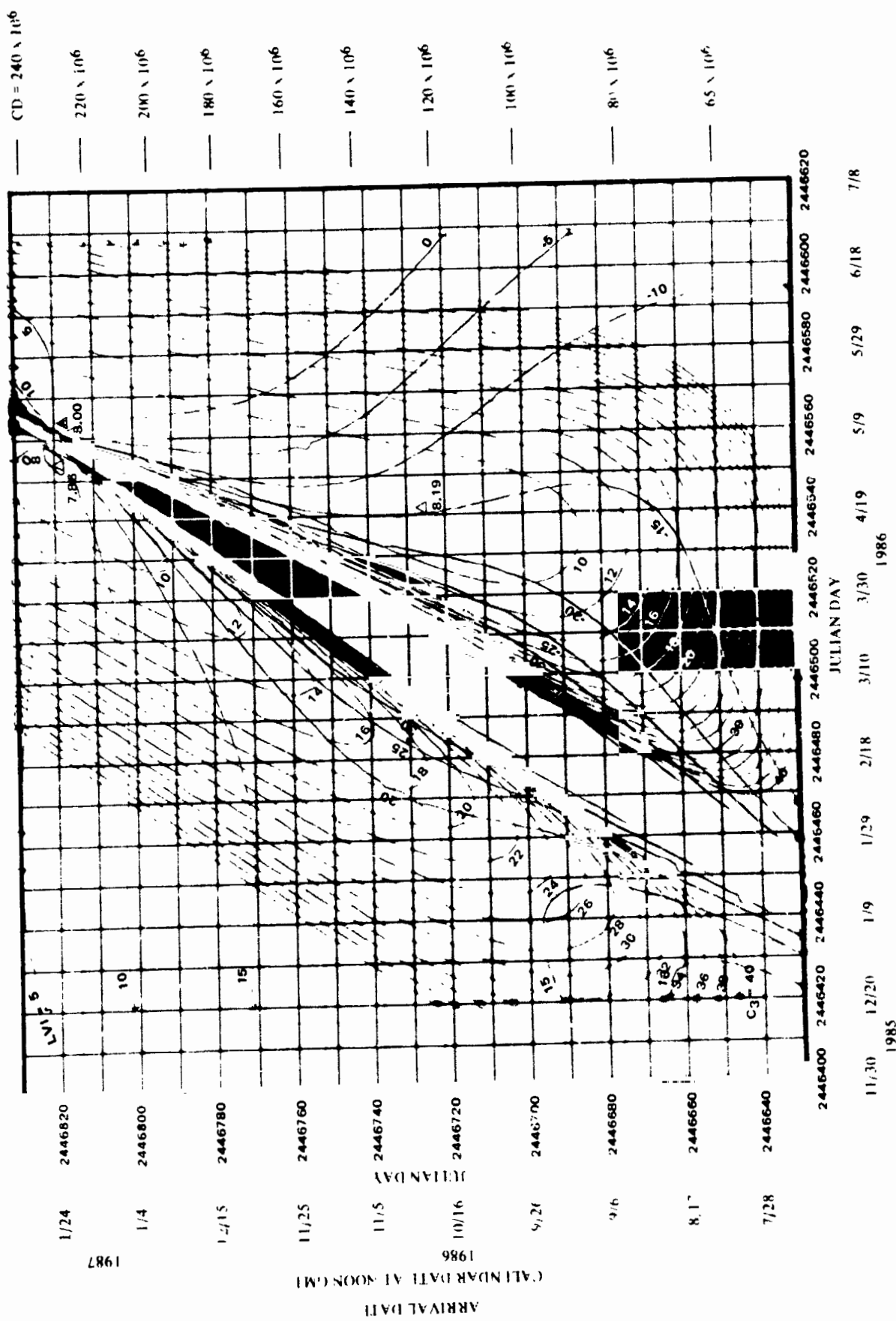
CONTOURS OF C<sub>3</sub> AND ZAP EARTH TO MARS 1985-86





CONTOURS OF J<sub>3</sub> AND ETS EARTH TO MARS 1985-86  
 ARRIVAL DATE AT NOON GMT  
 DEPARTURE DATE  
 1985  
 1986

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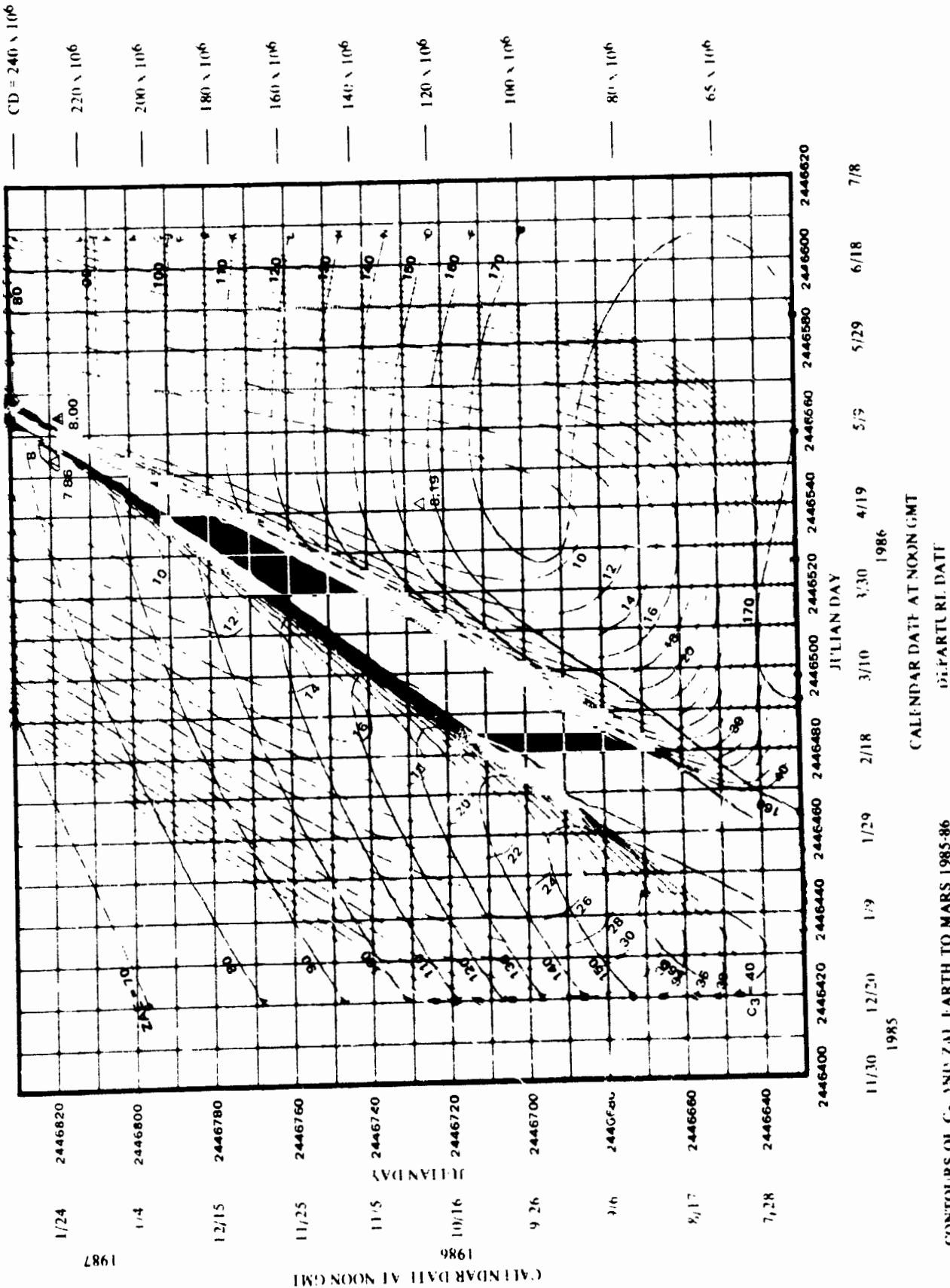


- CD =  $240 \times 10^6$
- $220 \times 10^6$
- $200 \times 10^6$
- $180 \times 10^6$
- $160 \times 10^6$
- $140 \times 10^6$
- $120 \times 10^6$
- $100 \times 10^6$
- $80 \times 10^6$
- $65 \times 10^6$

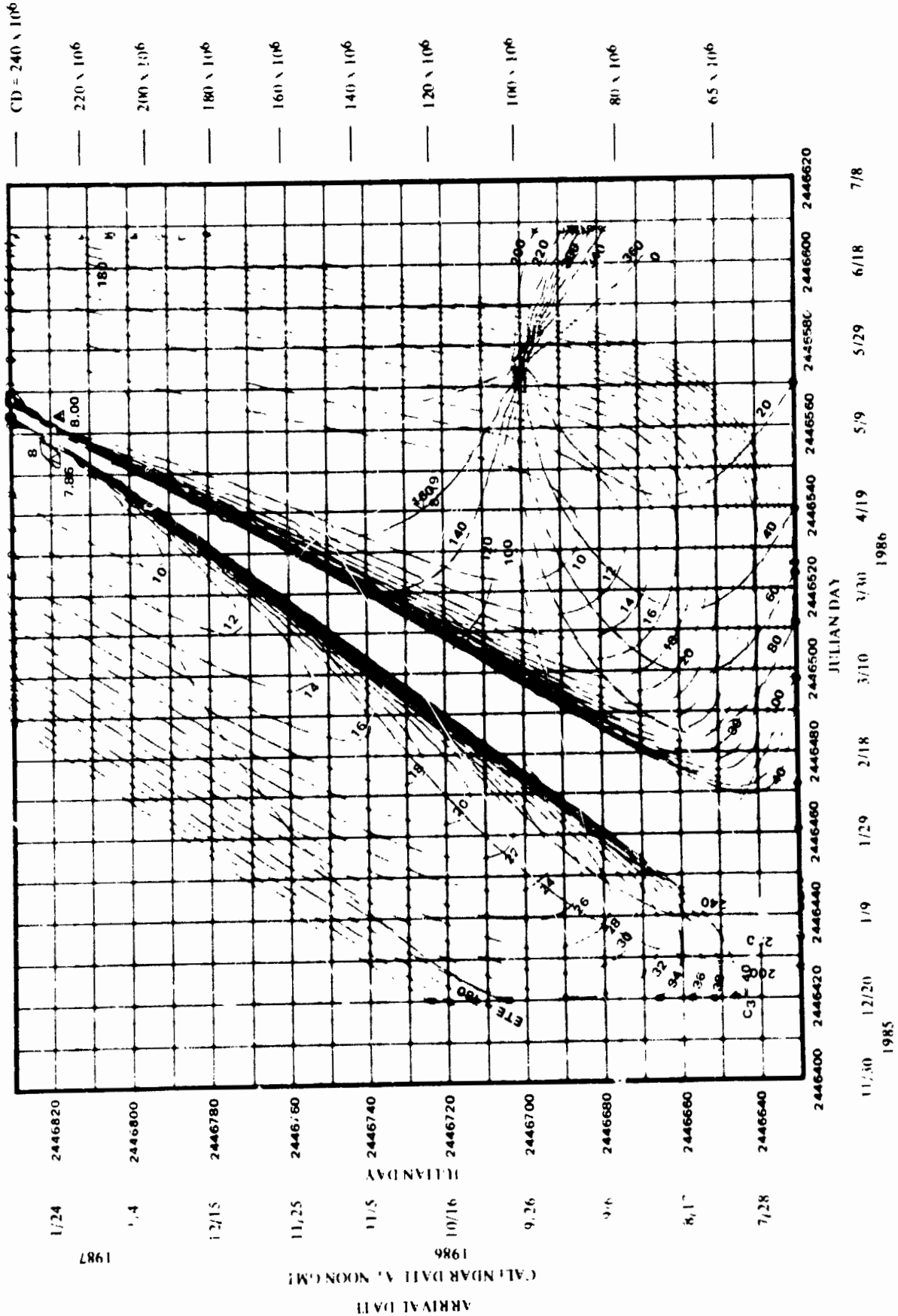
CALENDAR DATE AT NOON GMT  
DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND LVI EARTH TO MARS 1985-86

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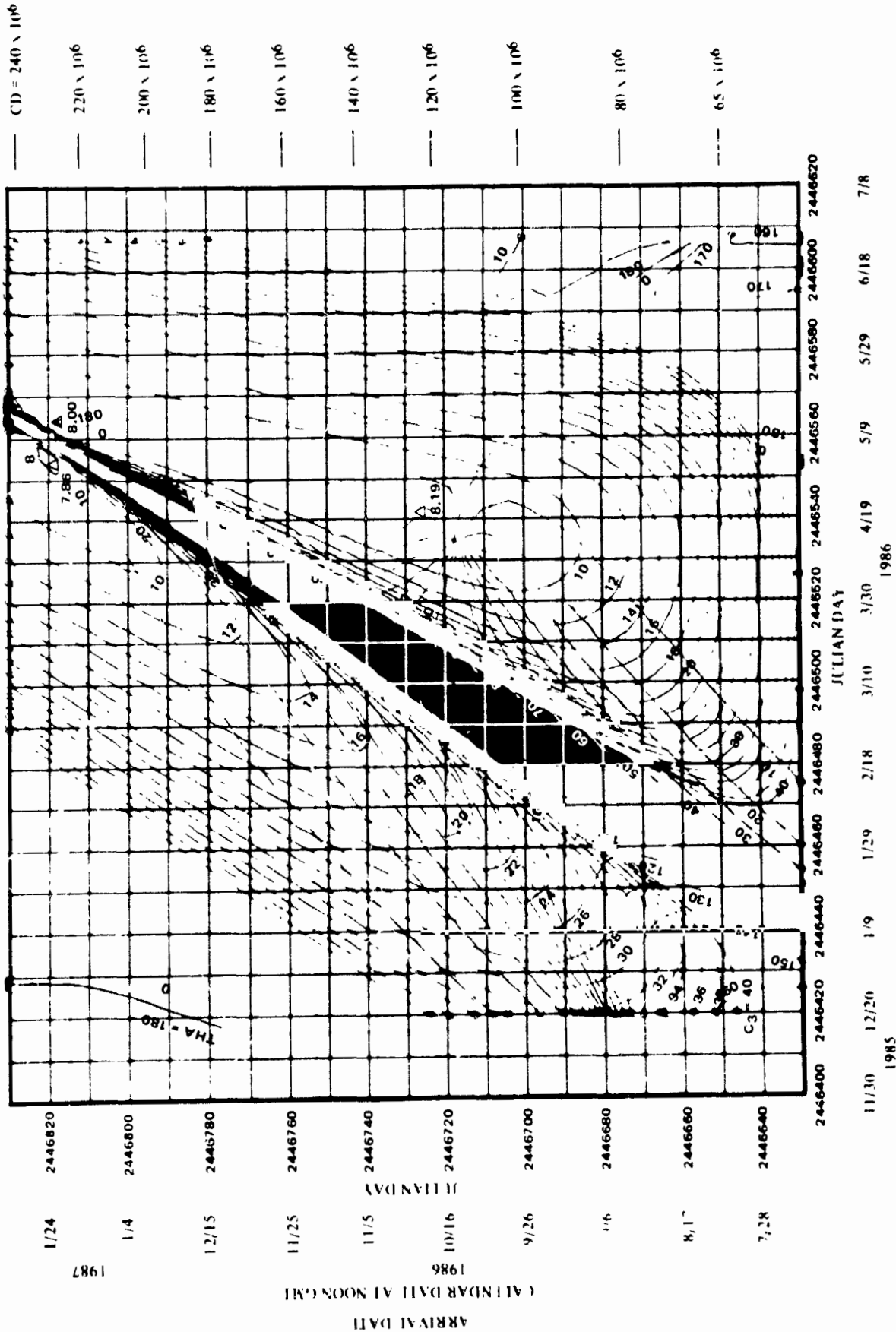
ZAE  
♂  
1986



ARRIVAL DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ETE FROM EARTH TO MARS 1985.86

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CONTOURS OF C<sub>3</sub> AND THA EARTH TO MARS 1985-86

THA  
 1986



— CD = 240 x 10<sup>6</sup>

— 220 x 10<sup>6</sup>

— 200 x 10<sup>6</sup>

— 180 x 10<sup>6</sup>

— 160 x 10<sup>6</sup>

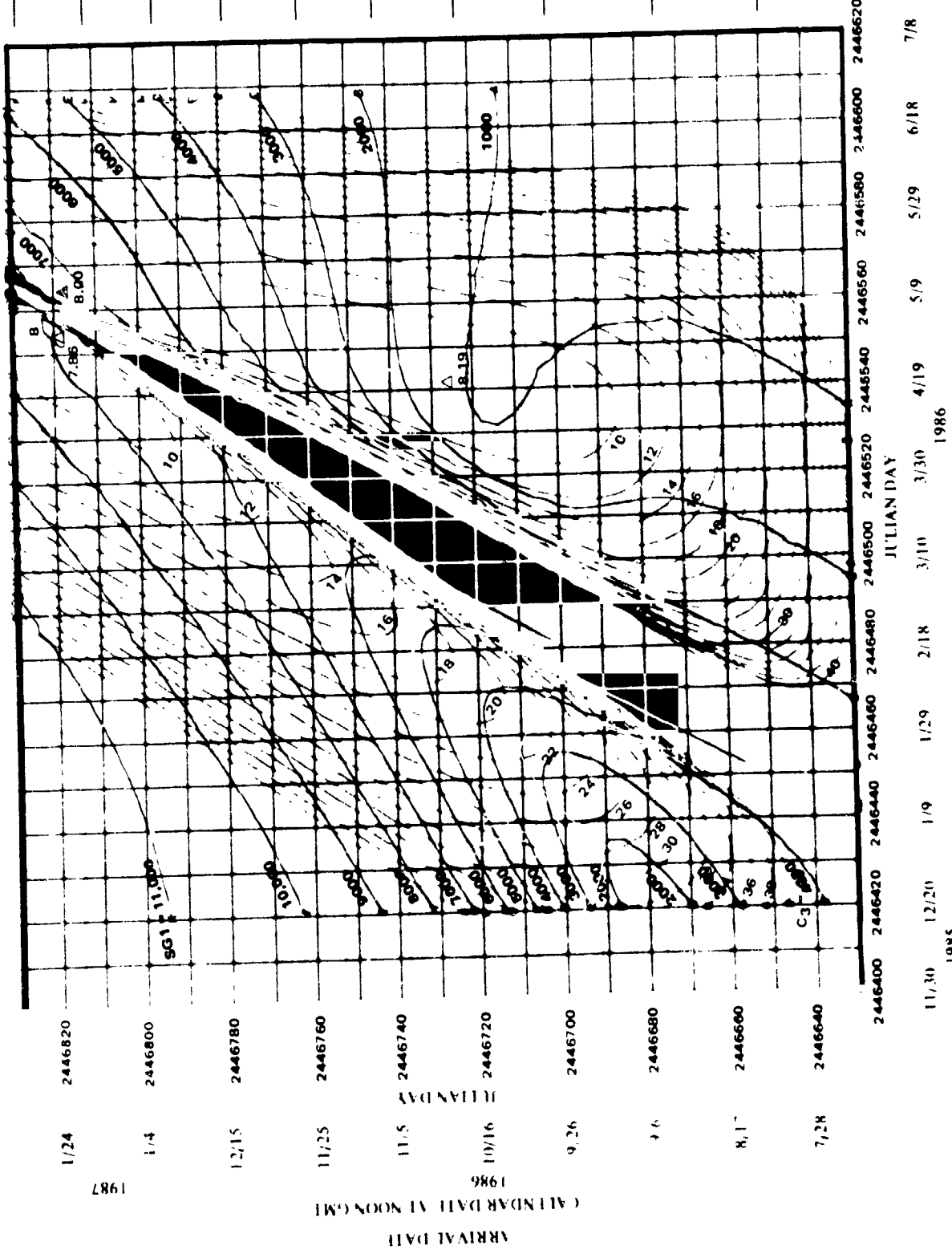
— 140 x 10<sup>6</sup>

— 120 x 10<sup>6</sup>

— 100 x 10<sup>6</sup>

— 80 x 10<sup>6</sup>

— 60 x 10<sup>6</sup>

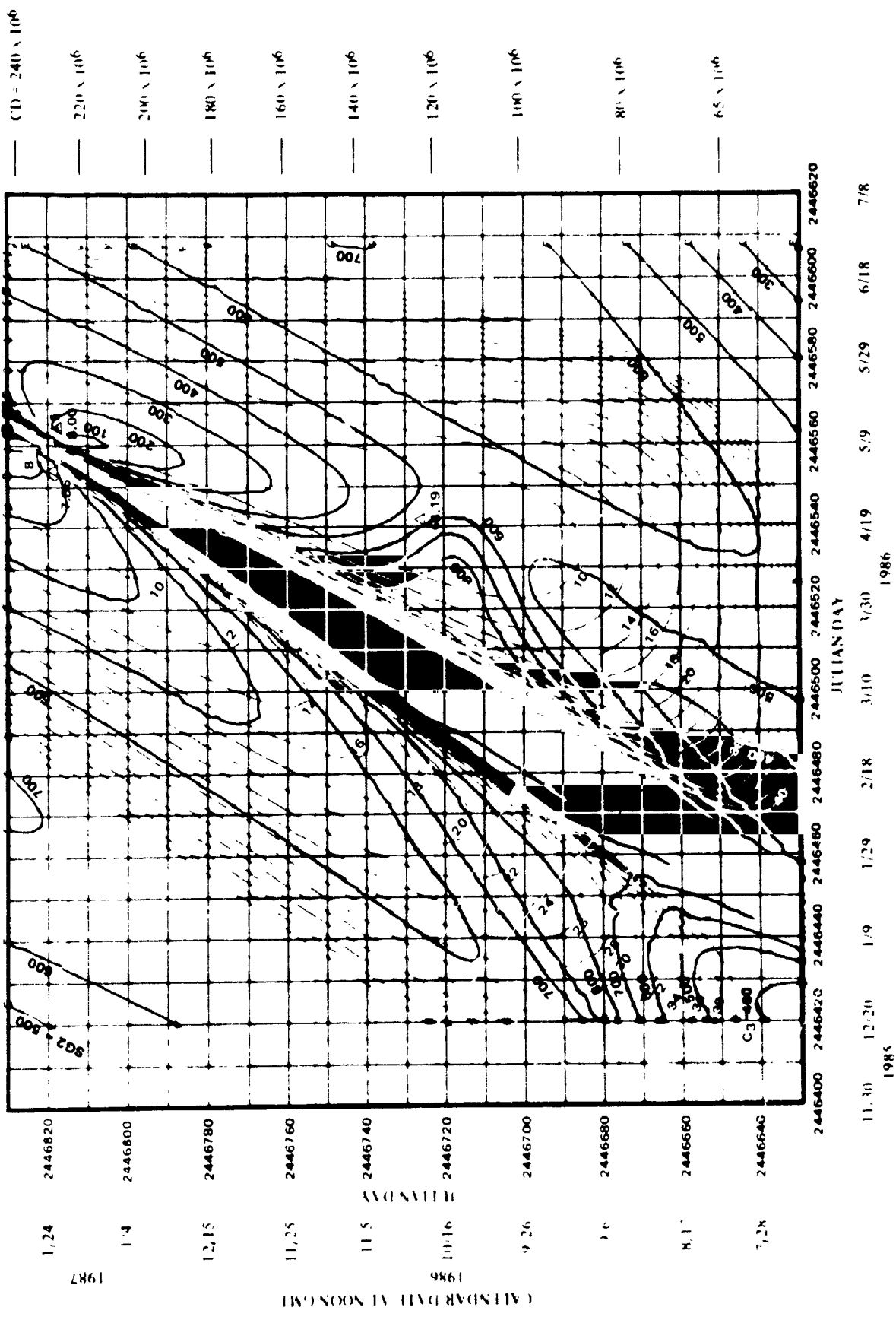


ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND SG1 EARTH TO MARS 1985-86

188  
 81

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CONTOURS OF C<sub>3</sub> AND SG2 EARTH TO MARS 1985-86  
 ARRIVAL DATE AT NOON GMT DEPARTURE DATE  
 JULIAN DAY

188 SG2

CD = 240 x 10<sup>6</sup>

220 x 10<sup>6</sup>

200 x 10<sup>6</sup>

180 x 10<sup>6</sup>

160 x 10<sup>6</sup>

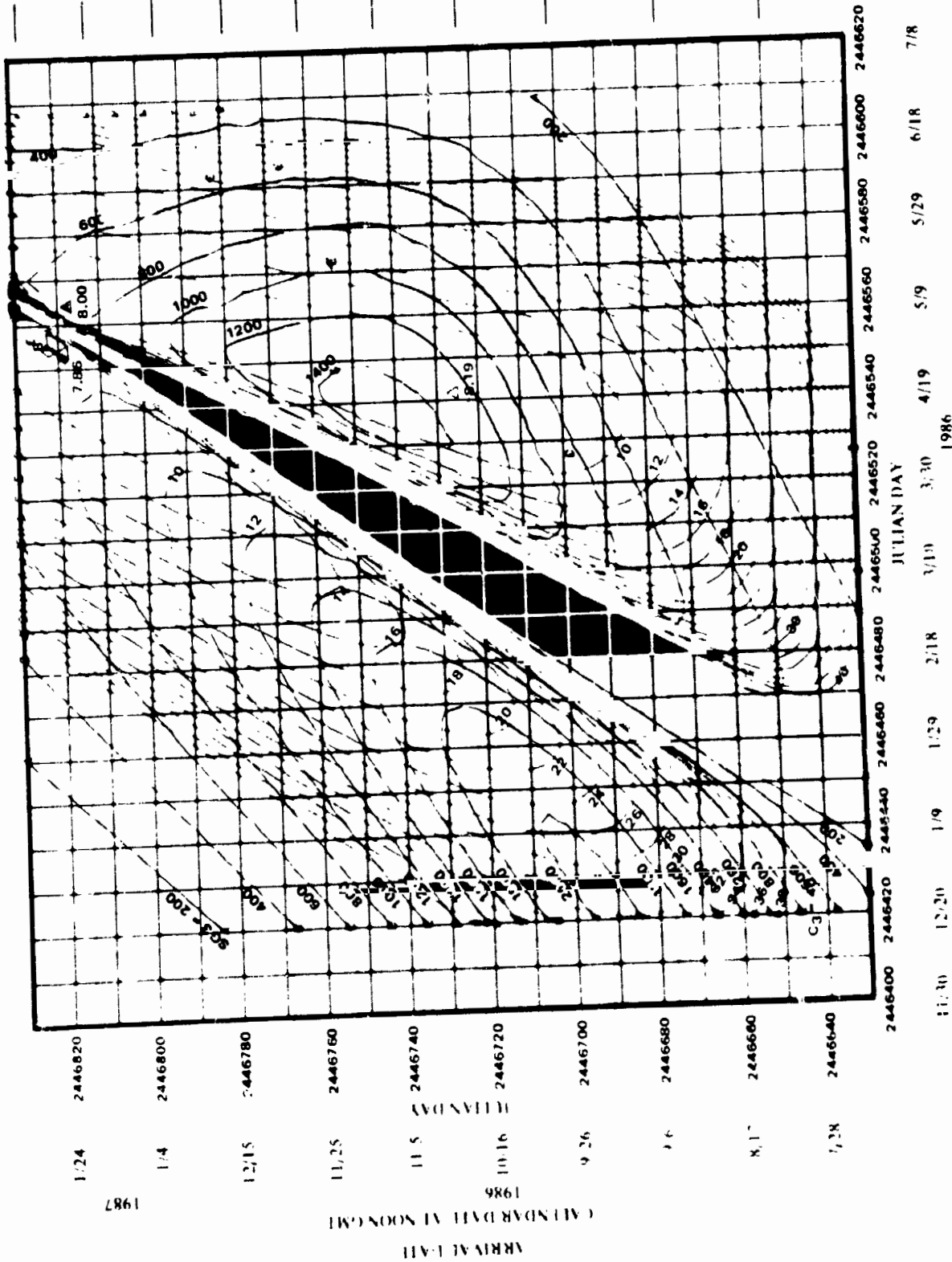
140 x 10<sup>6</sup>

120 x 10<sup>6</sup>

100 x 10<sup>6</sup>

80 x 10<sup>6</sup>

65 x 10<sup>6</sup>



1:24 2446820

1:4 2446800

12:15 2446780

11:25 2446760

11:5 2446740

10:16 2446720

9:26 2446700

8:6 2446680

8:17 2446660

7:28 2446640

2446400 2446420 2446440 2446460 2446480 2446500 2446520 2446540 2446560 2446580 2446600 2446620

11:30 12:20 1/9 1:29 2/18 3/10 3/30 4/19 5/9 5/29 6/18 7/8

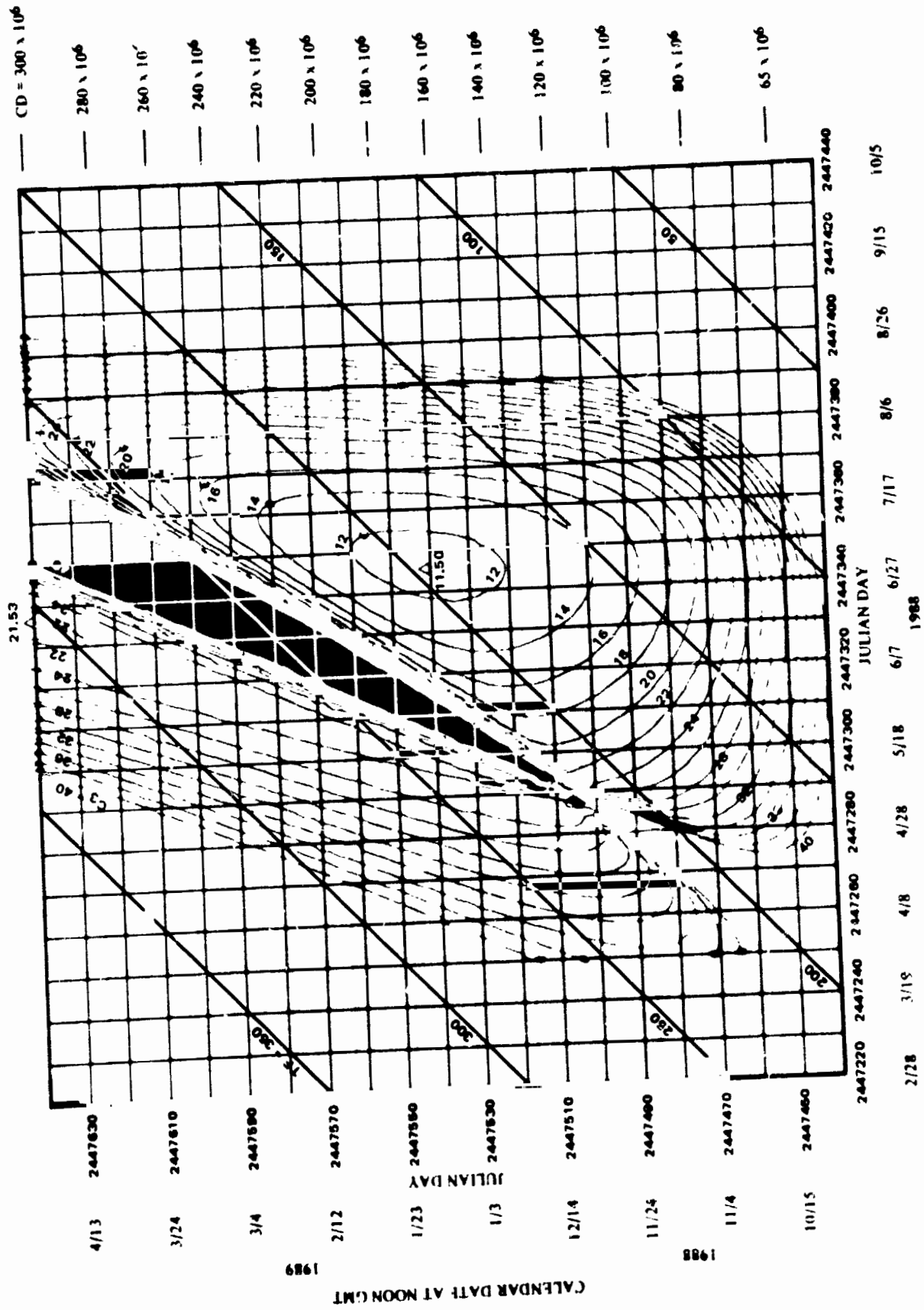
1985 1986 1987

CALENDAR DATE AT NOON GMT  
DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND S<sub>33</sub> EARTH TO MARS 1985-86

1986  
S<sub>33</sub>

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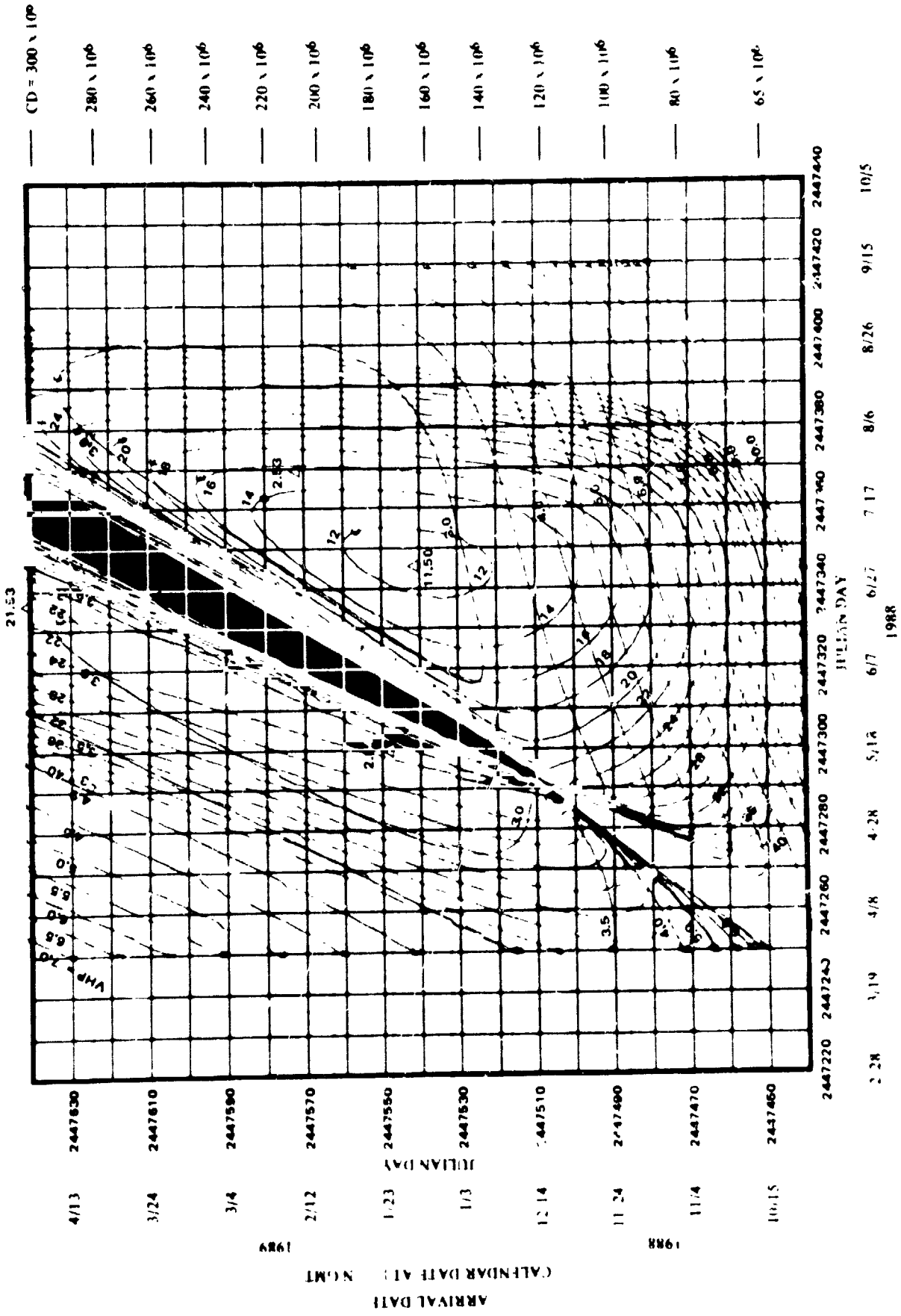


ARRIVAL DATE  
CALENDAR DATE AT NOON GMT  
1988

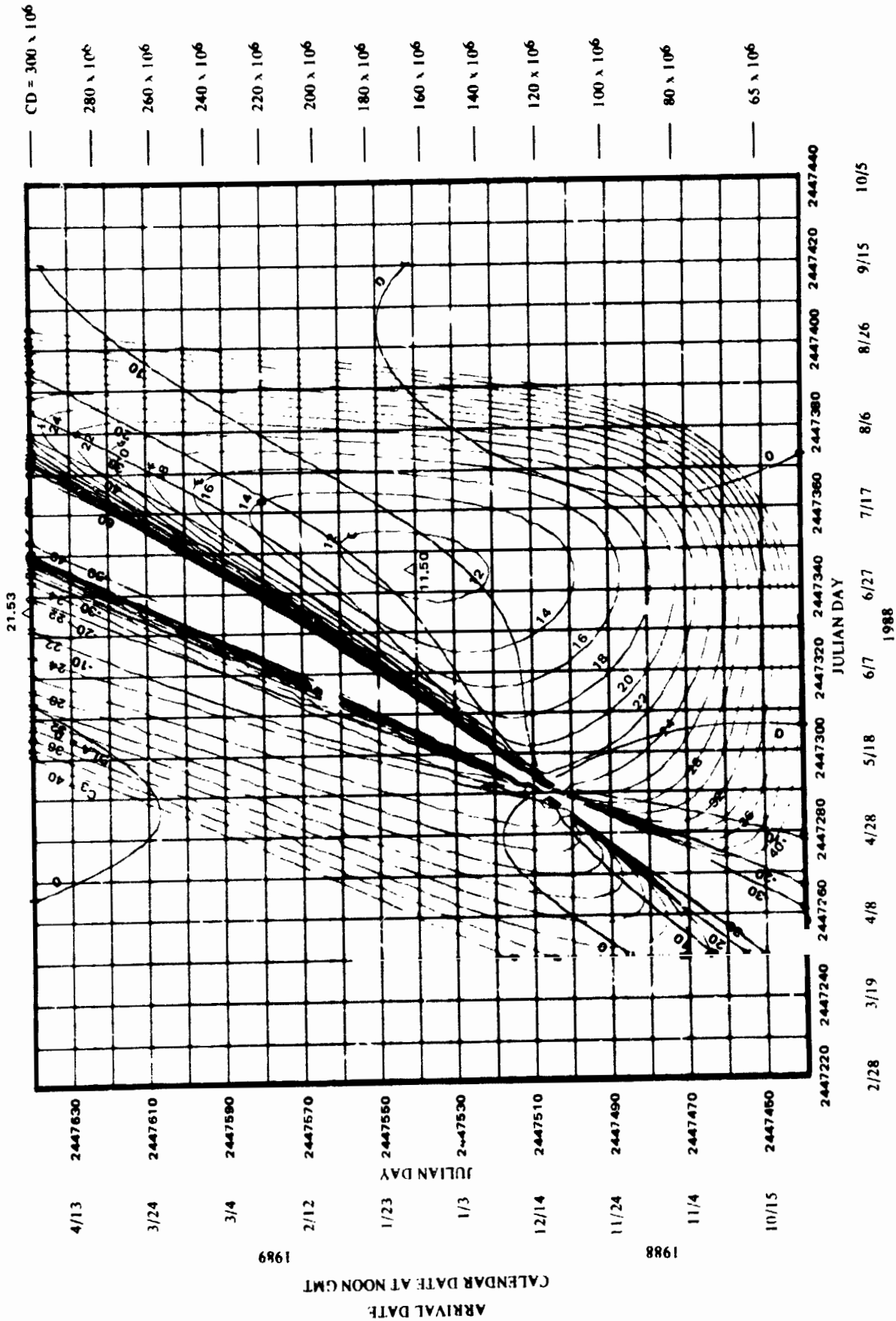
DEPARTURE DATE  
CALENDAR DATE AT NOON GMT  
1988

CONTOURS OF  $C_3$  AND FLIGHT TIMES EARTH TO MARS 1988

18043

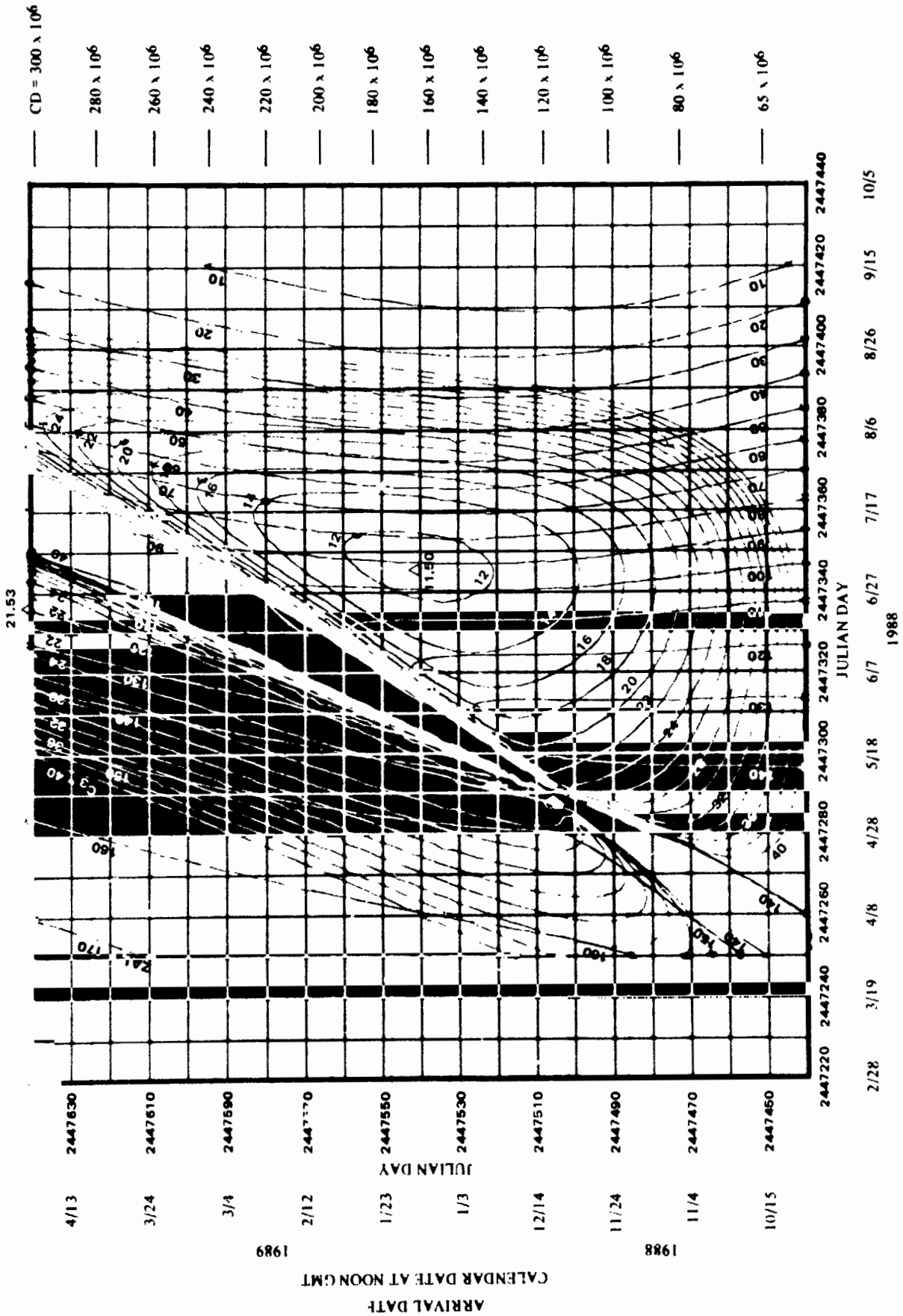


CONTOURS OF C<sub>3</sub> AND VHP EARTH TO MARS 1988



CONTOURS OF C<sub>3</sub> AND DLA EARTH TO MARS 1988

CALENDAR DATE AT NOON GMT  
DEPARTURE DATE

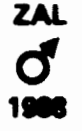


ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1988  
 1989

CONTOURS OF C<sub>3</sub> AND ZAL EARTH TO MARS 1988

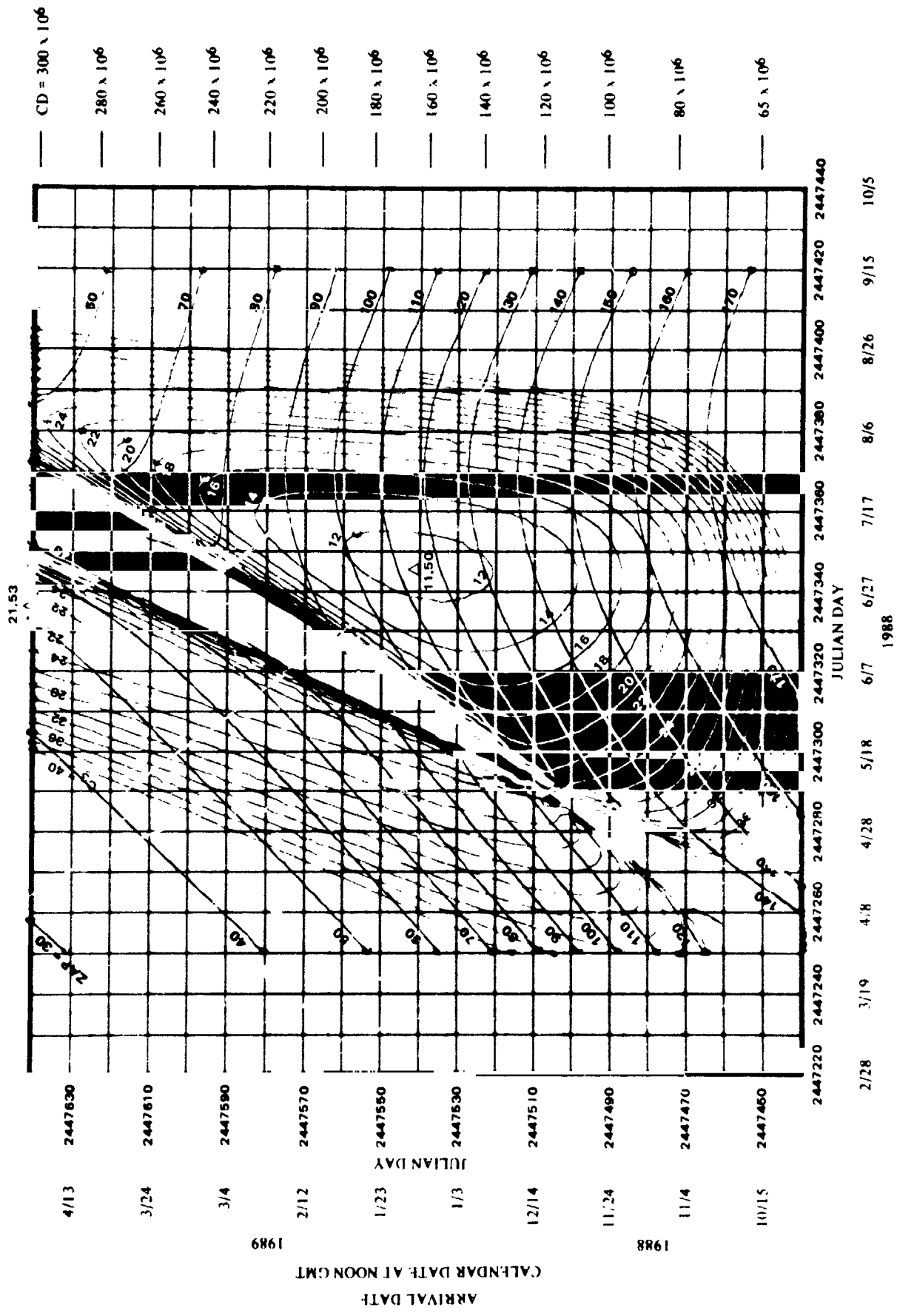
CALENDAR DATE AT NOON GMT

DEPARTURE DATE



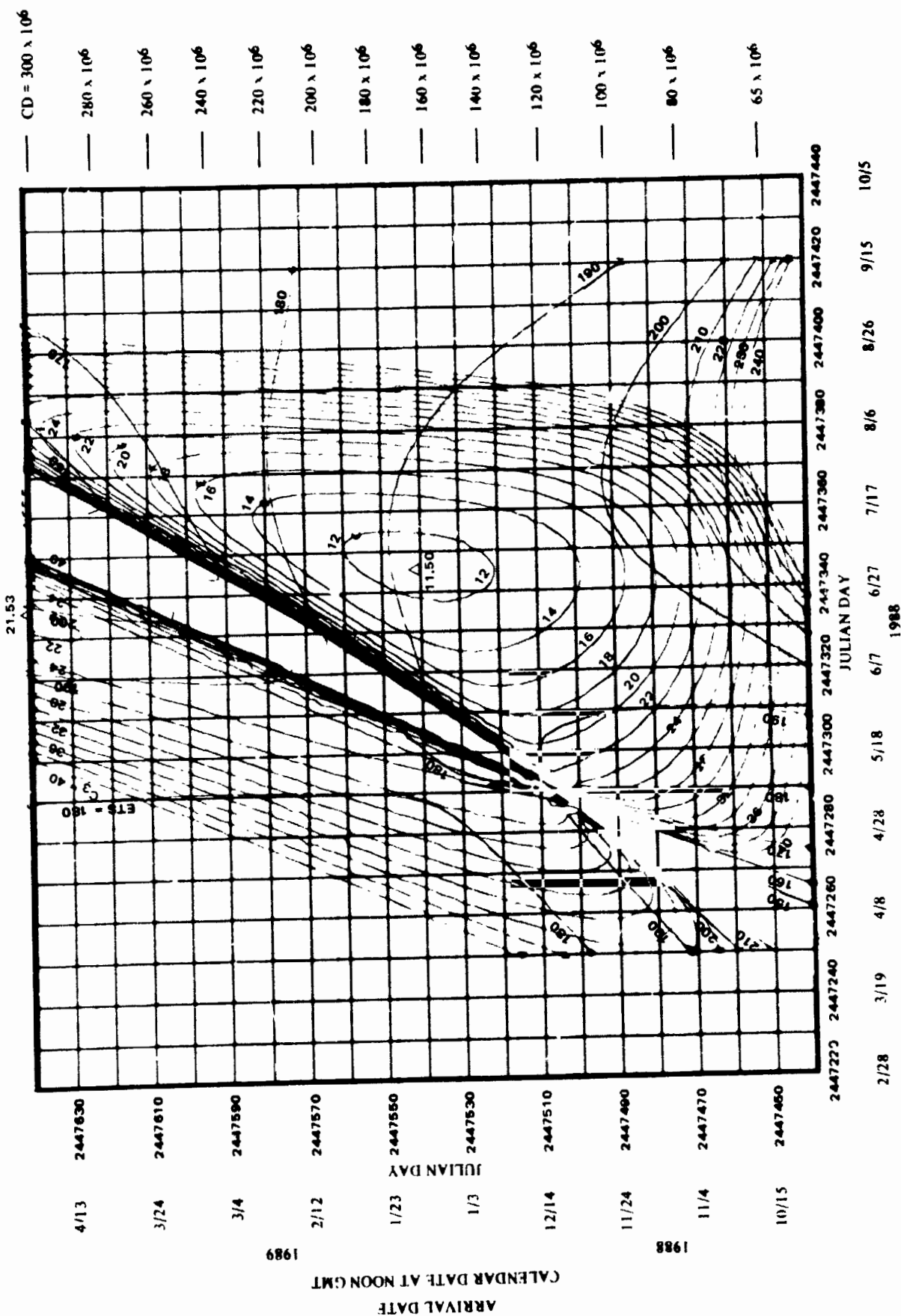






ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

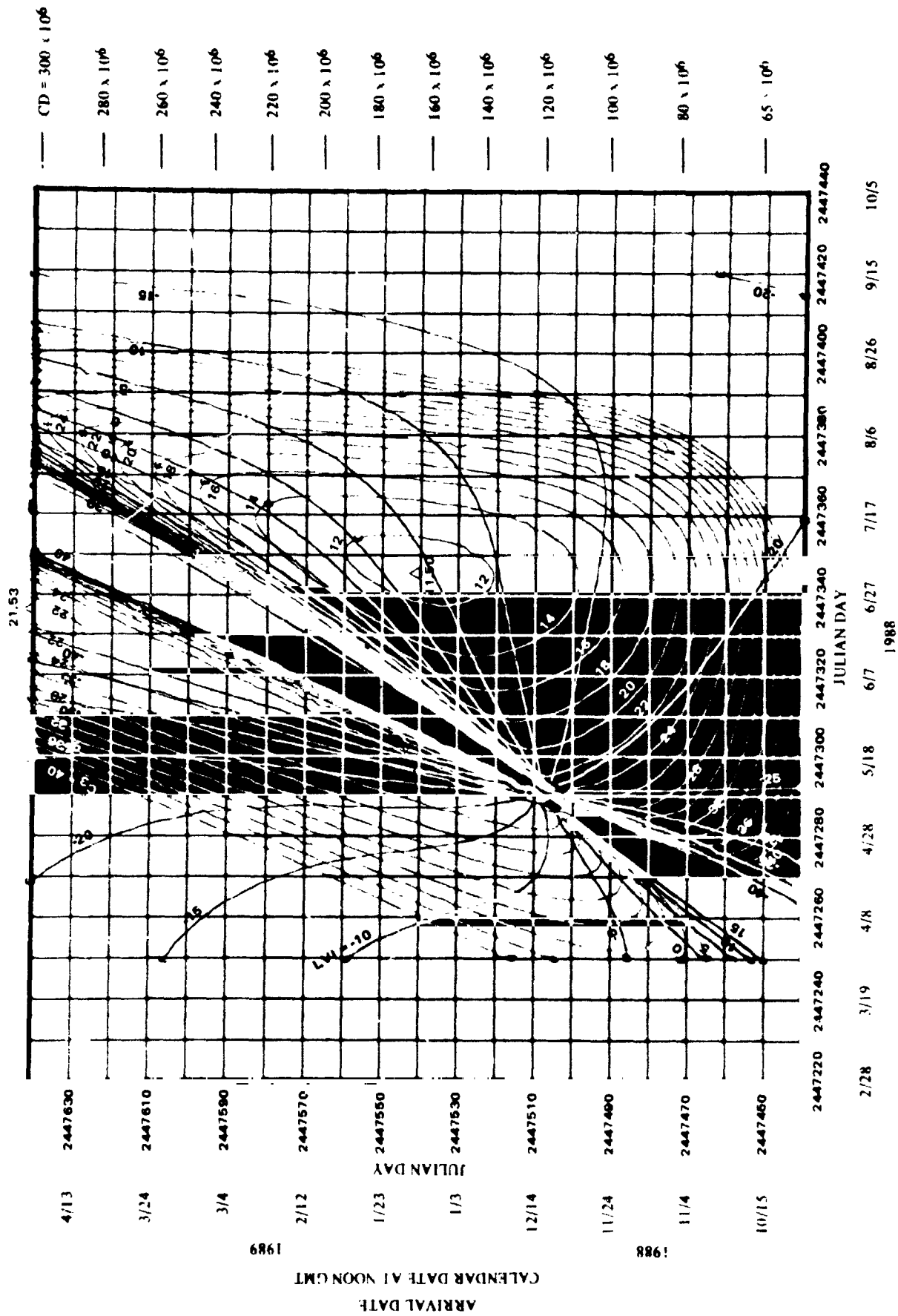
CONTOURS OF C<sub>3</sub> AND ZAP EARTH TO MARS 1988



CALENDAR DATE AT NOON GMT

DEPARTURE DATE

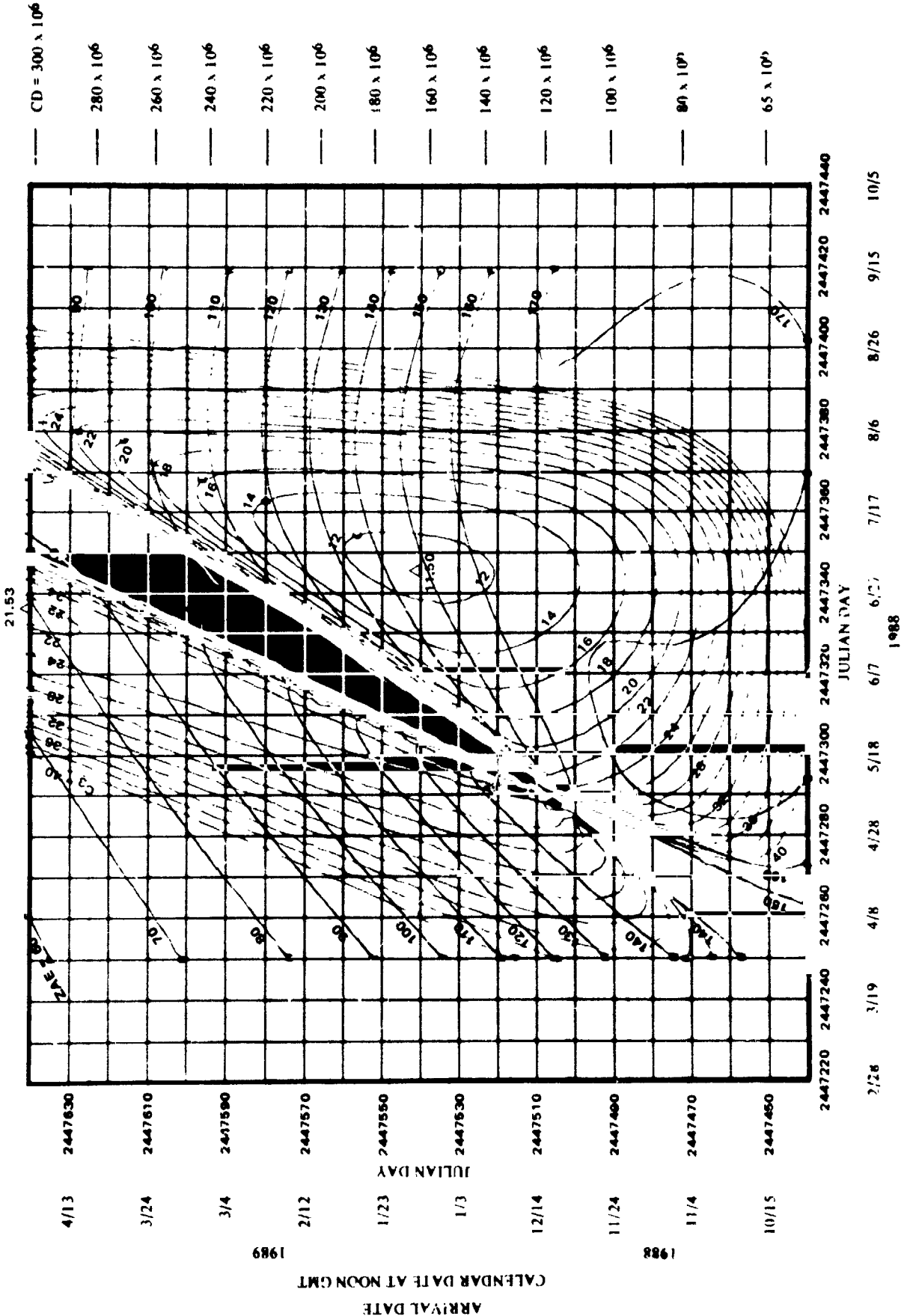
CONTOURS OF C<sub>3</sub> AND ETS EARTH TO MARS 1988



ARRIVAL DATE AT NOON GMT  
 DEPARTURE DATE

1988  
 1988  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

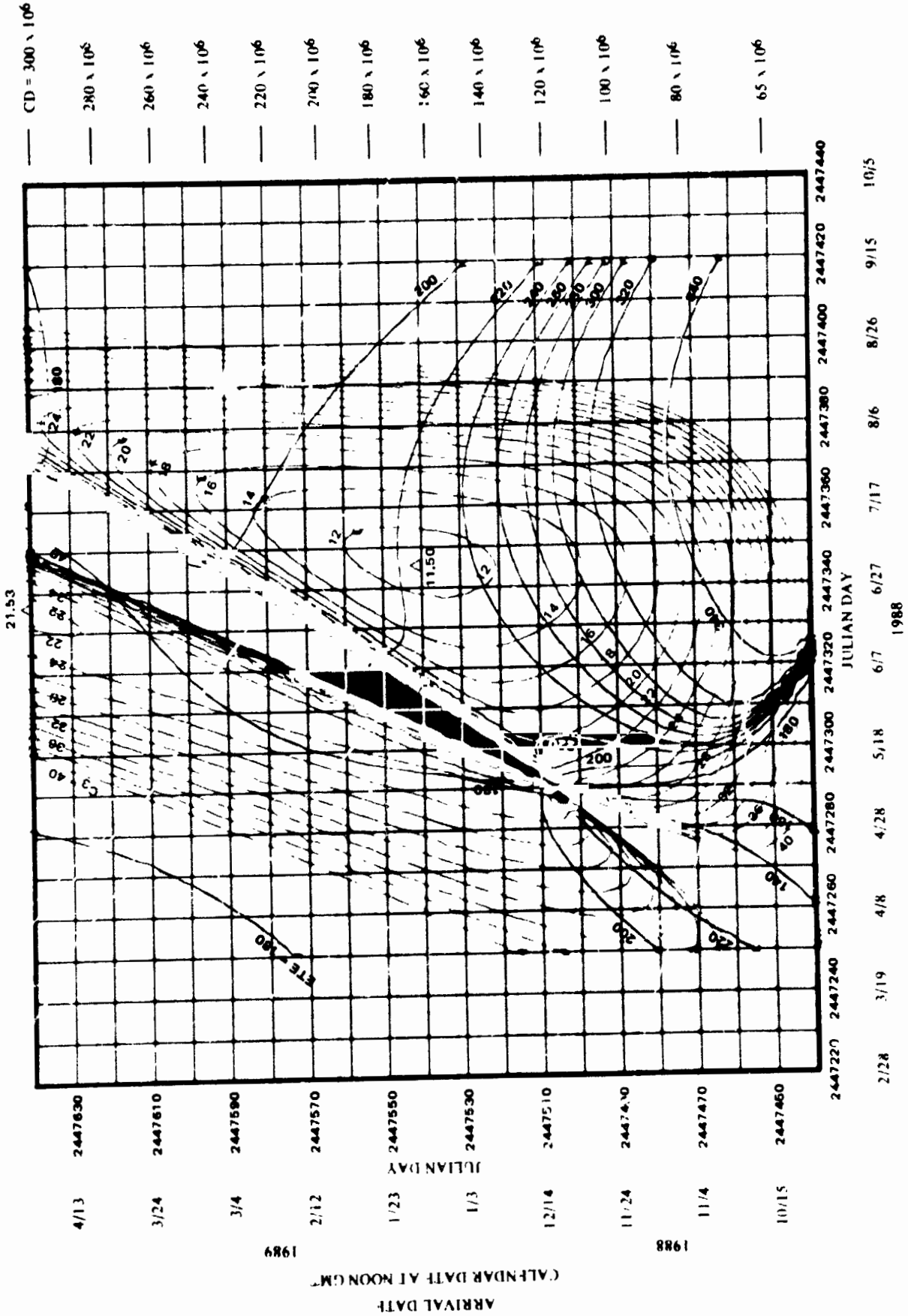
CONTOURS OF C<sub>3</sub> AND LVI EARTH TO MARS 1988



CALENDAR DATE AT NOON GMT

DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ZAE EARTH TO MARS 1988

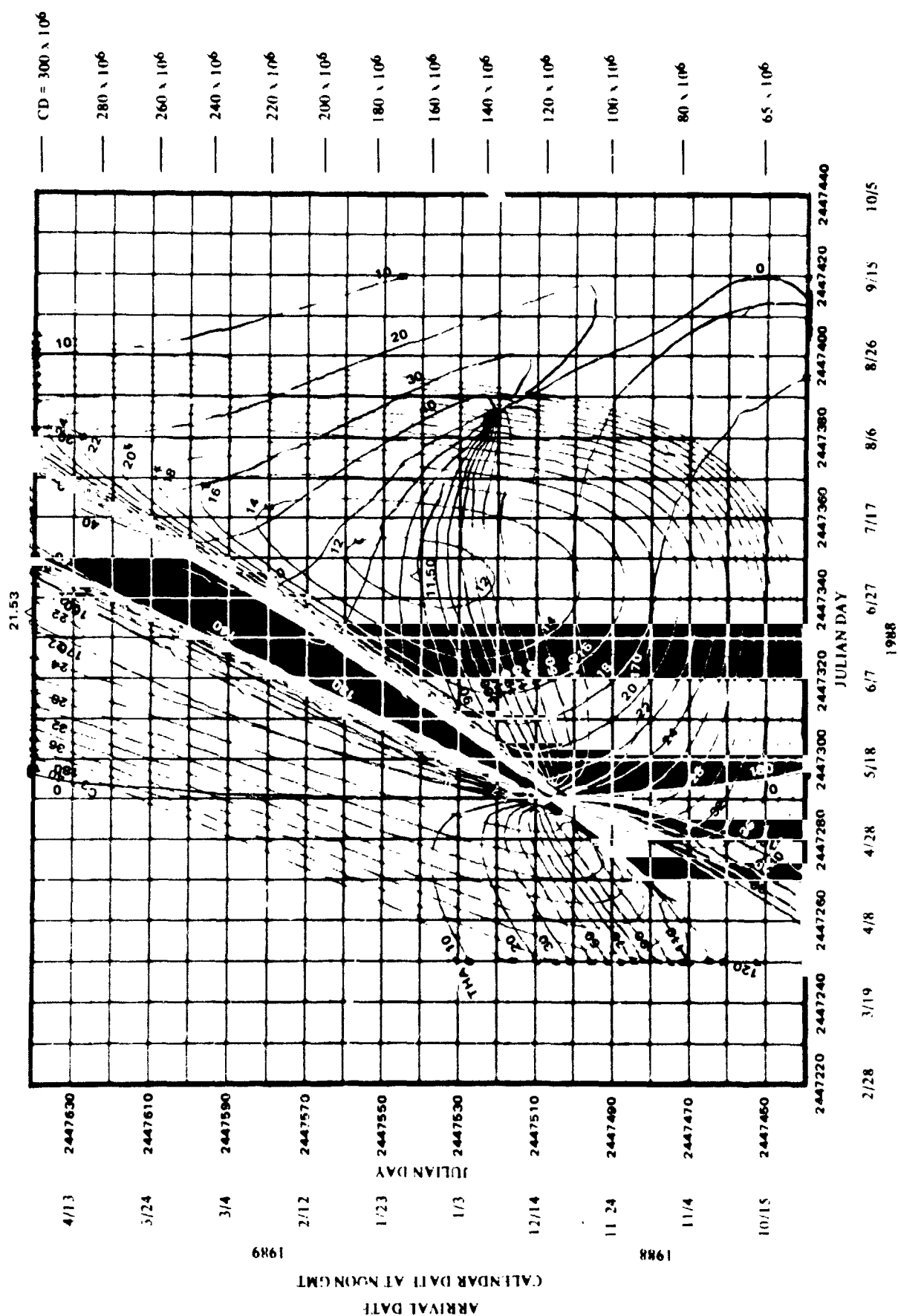


- CD = 300 x 10<sup>6</sup>
- 280 x 10<sup>6</sup>
- 260 x 10<sup>6</sup>
- 240 x 10<sup>6</sup>
- 220 x 10<sup>6</sup>
- 200 x 10<sup>6</sup>
- 180 x 10<sup>6</sup>
- 160 x 10<sup>6</sup>
- 140 x 10<sup>6</sup>
- 120 x 10<sup>6</sup>
- 100 x 10<sup>6</sup>
- 80 x 10<sup>6</sup>
- 65 x 10<sup>6</sup>

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND E1E EARTH TO MARS 1988

ETE  
 1988



- CD = 300 x 10<sup>6</sup>
- 280 x 10<sup>6</sup>
- 260 x 10<sup>6</sup>
- 240 x 10<sup>6</sup>
- 220 x 10<sup>6</sup>
- 200 x 10<sup>6</sup>
- 180 x 10<sup>6</sup>
- 160 x 10<sup>6</sup>
- 140 x 10<sup>6</sup>
- 120 x 10<sup>6</sup>
- 100 x 10<sup>6</sup>
- 80 x 10<sup>6</sup>
- 65 x 10<sup>6</sup>

21.53

ARRIVAL DATE  
 (CALENDAR DATE AT NOON GMT)  
 1988

4/13 2447630  
 3/24 2447610  
 3/4 2447590  
 2/12 2447570  
 1/23 2447550  
 1/3 2447530  
 12/14 2447510  
 11 24 2447490  
 11/4 2447470  
 10/15 2447450

2447220 2447240 2447260 2447280 2447300 2447320 2447340 2447360 2447380 2447400 2447420 2447440

JULIAN DAY

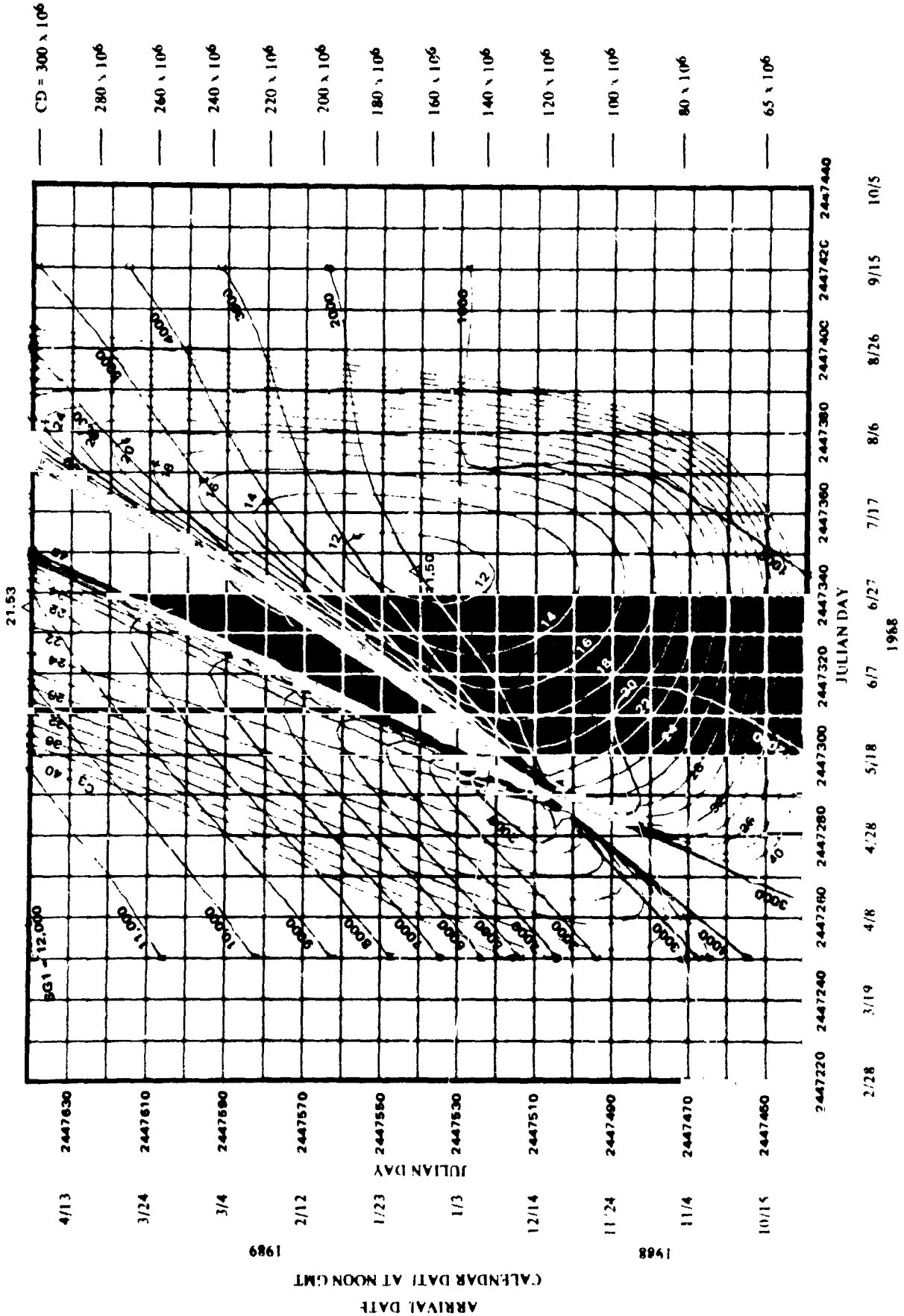
1988

2/28 3/19 4/8 4/28 5/18 6/7 6/27 7/17 8/6 8/26 9/15 10/5

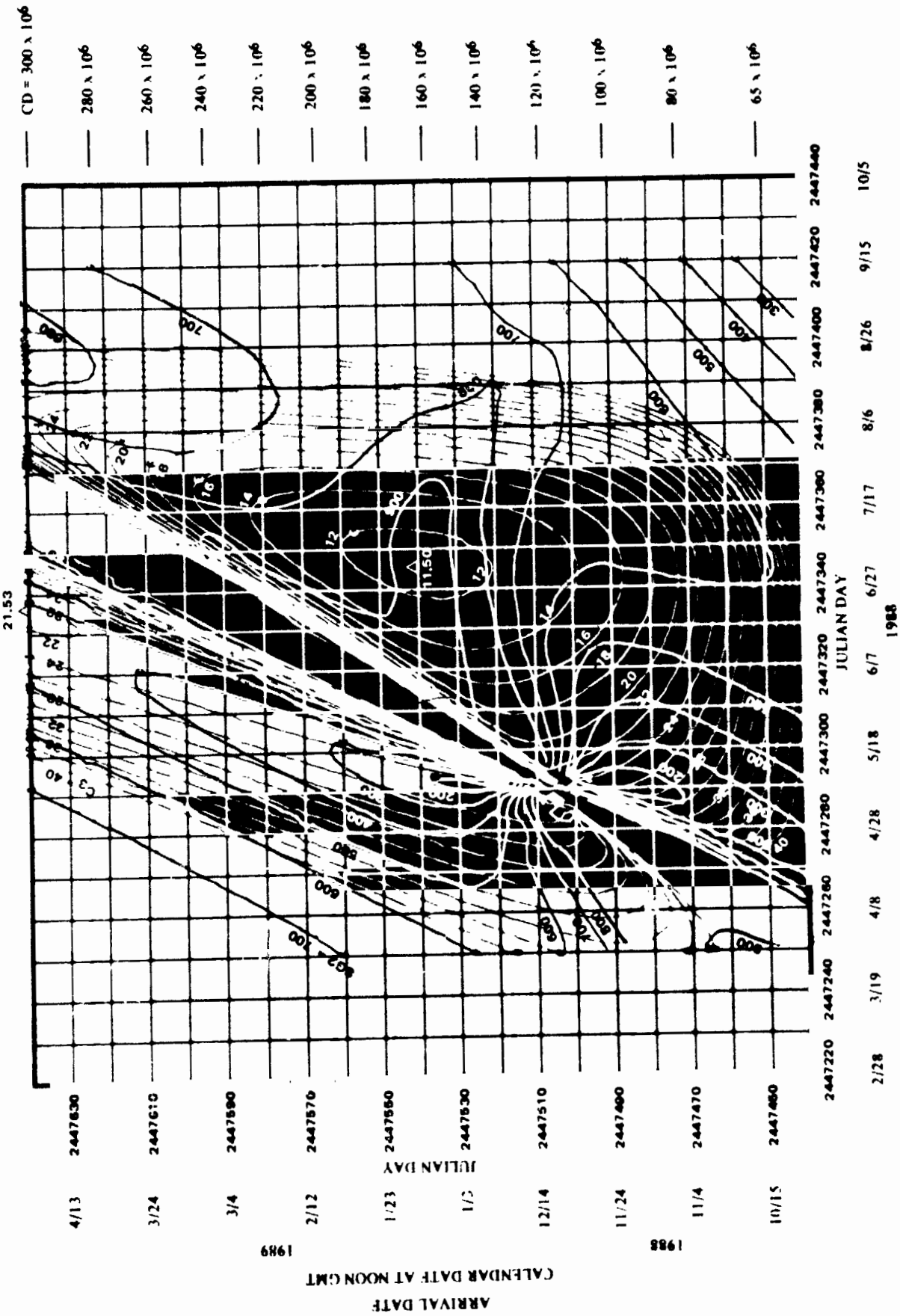
CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND THA EARTH TO MARS 1988





CONTOURS OF C<sub>3</sub> AND SGI EARTH TO MARS 1988



CD = 300 x 10<sup>6</sup>

280 x 10<sup>6</sup>

260 x 10<sup>6</sup>

240 x 10<sup>6</sup>

220 x 10<sup>6</sup>

200 x 10<sup>6</sup>

180 x 10<sup>6</sup>

160 x 10<sup>6</sup>

140 x 10<sup>6</sup>

120 x 10<sup>6</sup>

100 x 10<sup>6</sup>

80 x 10<sup>6</sup>

65 x 10<sup>6</sup>

ARRIVAL DATE AT NOON GMT

DEPARTURE DATE

1988

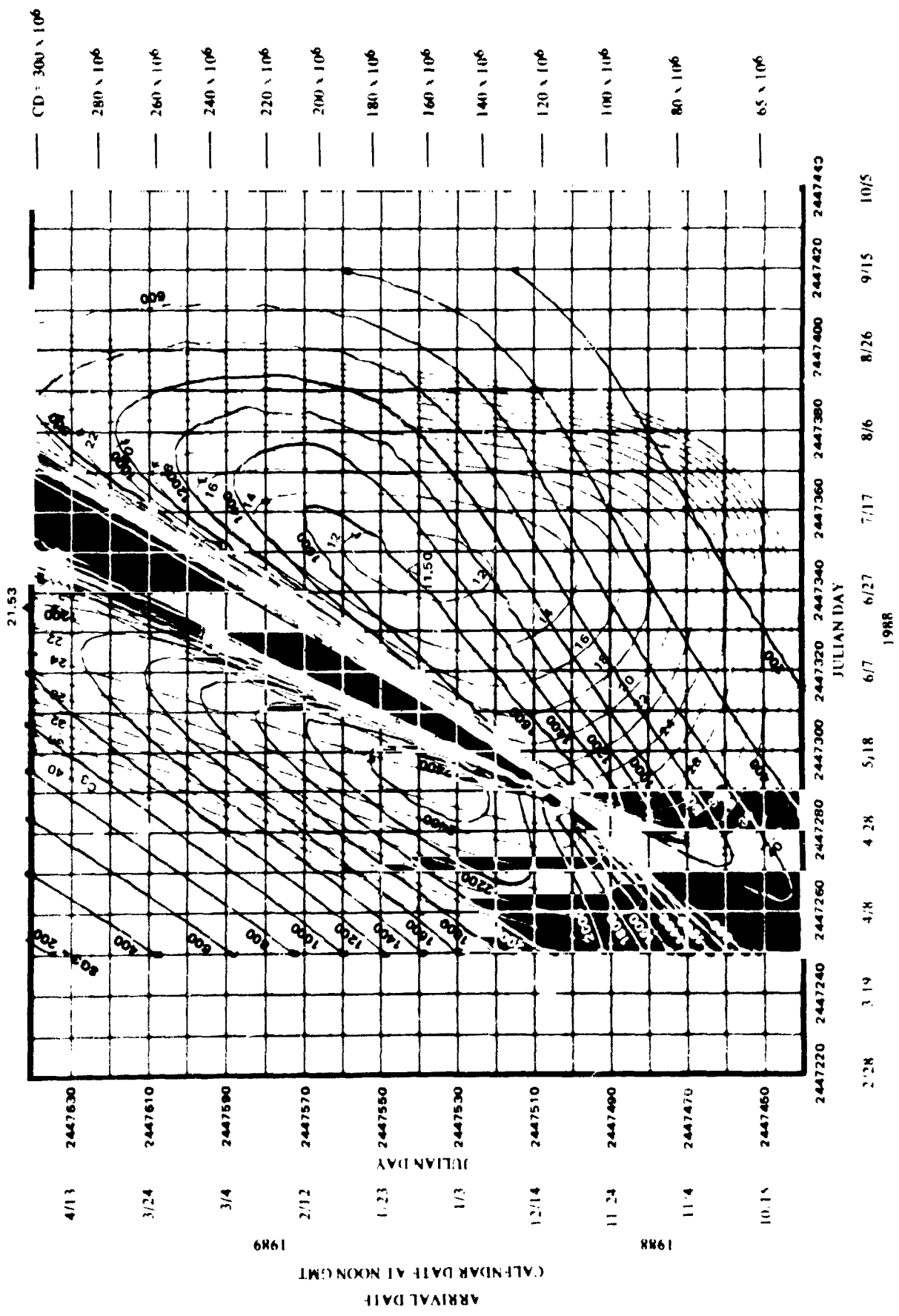
1989

21.53

69-3

1888 SG2

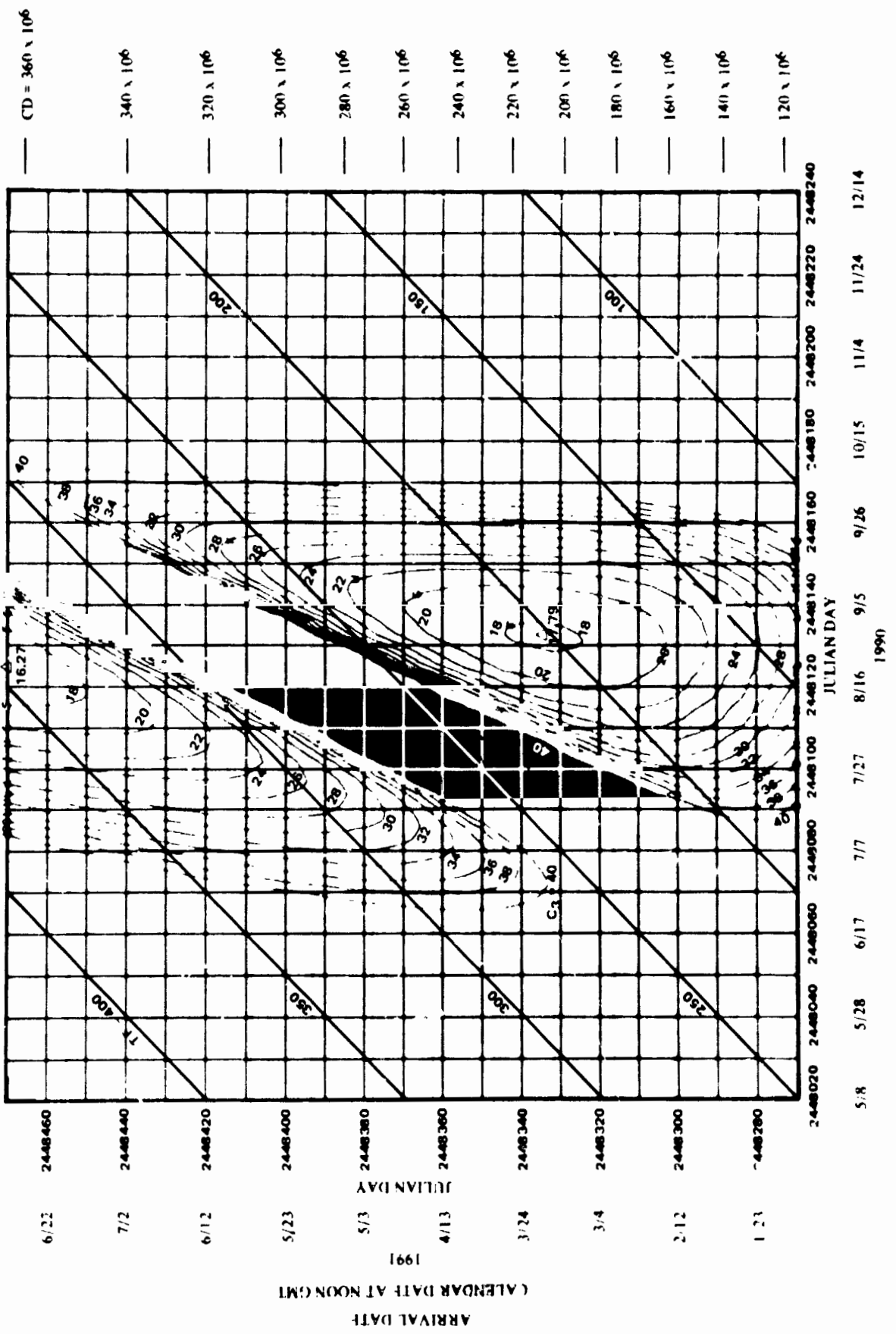




CALENDAR DATE AT NOON GMT  
DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND SG<sub>3</sub> EARTH TO MARS 1988



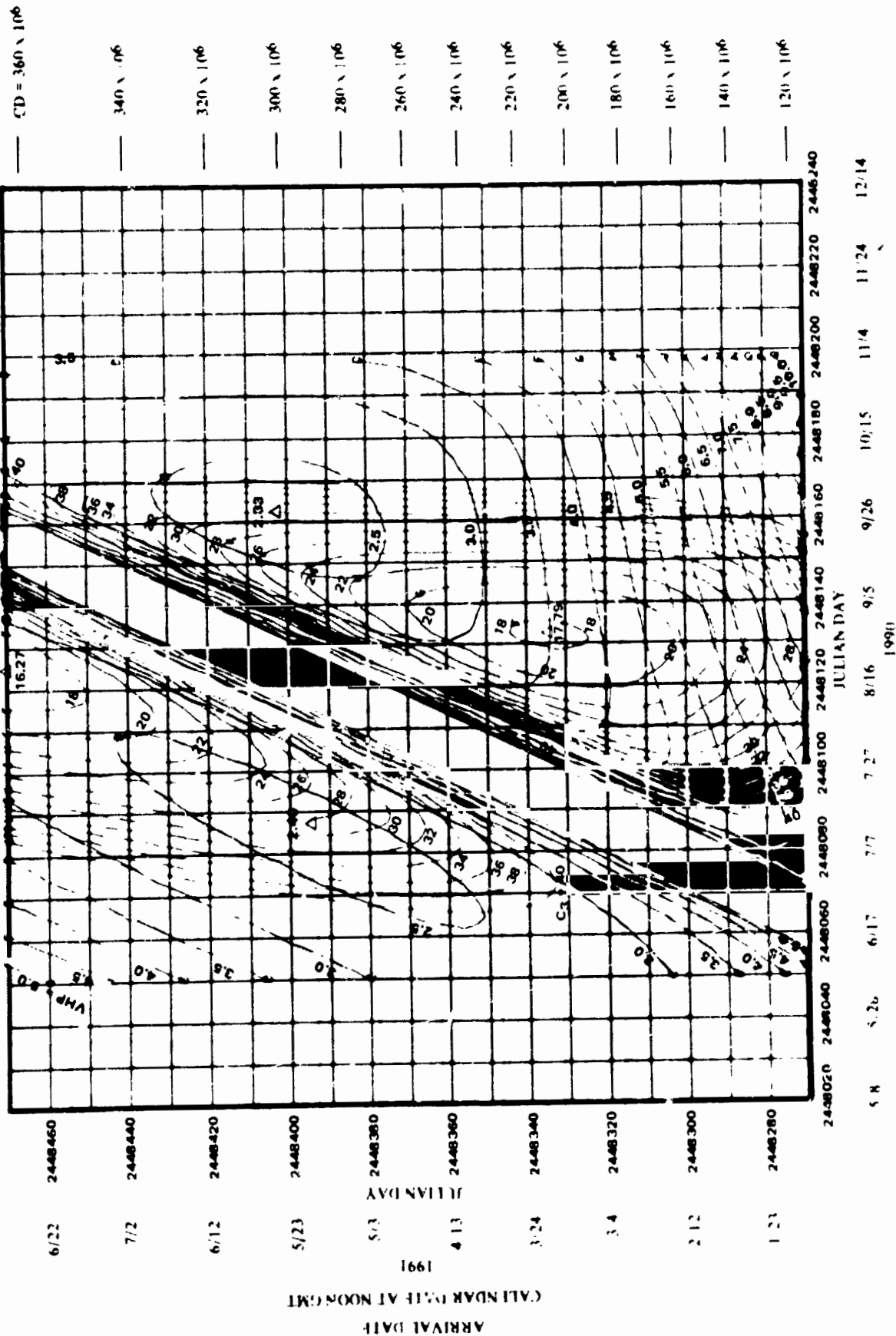


CALENDAR DATE AT NOON GMT

DEPARTURE DATE

CONTOURS OF  $C_3$  AND FLIGHT TIMES EARTH TO MARS 1990

ARRIVAL DATE  
CALENDAR DATE AT NOON GMT

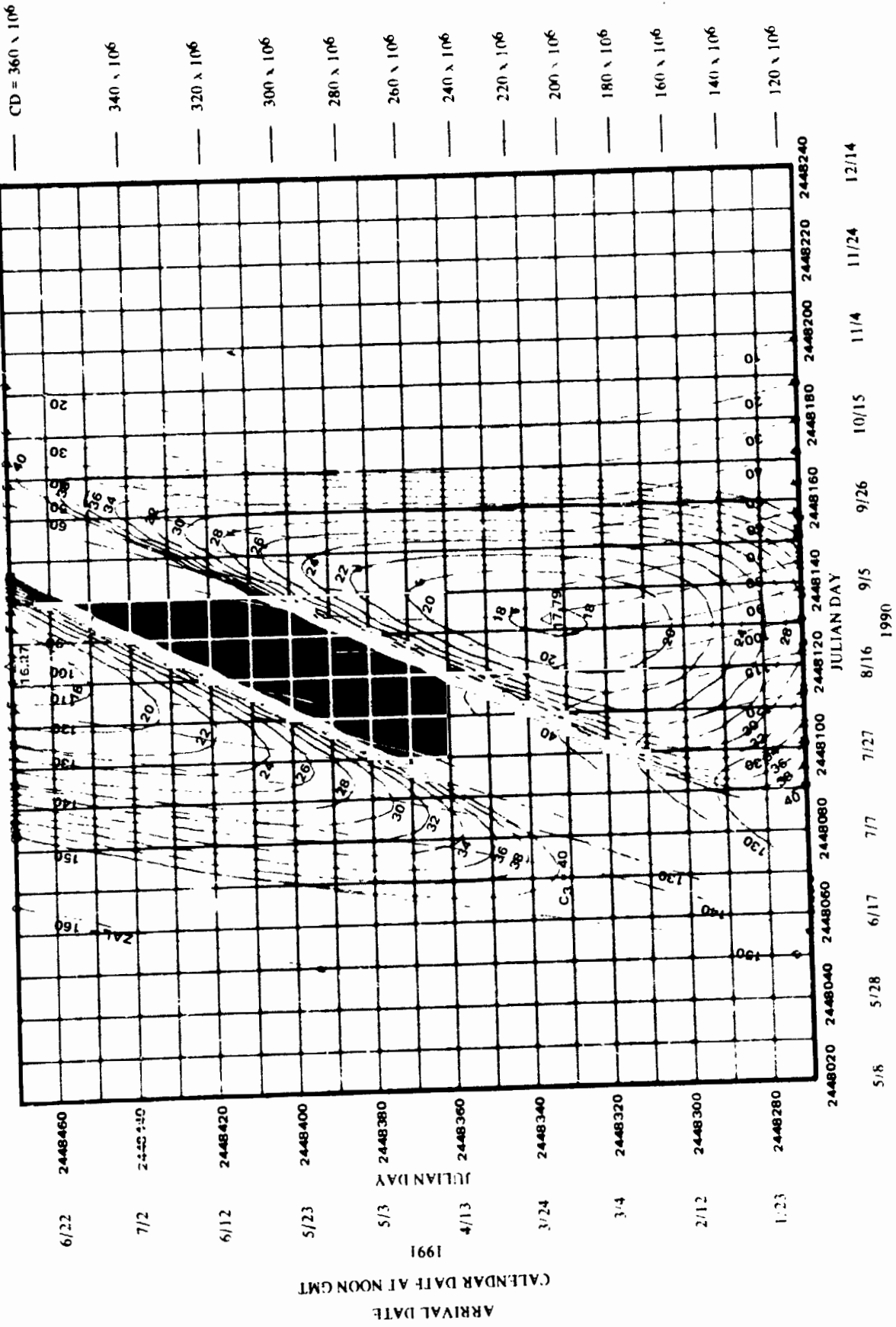


ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE  
 1990  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND VHP EARTH TO MARS 1990

VHP  
 1990





— CD = 360 × 10<sup>6</sup>

— 340 × 10<sup>6</sup>

— 320 × 10<sup>6</sup>

— 300 × 10<sup>6</sup>

— 280 × 10<sup>6</sup>

— 260 × 10<sup>6</sup>

— 240 × 10<sup>6</sup>

— 220 × 10<sup>6</sup>

— 200 × 10<sup>6</sup>

— 180 × 10<sup>6</sup>

— 160 × 10<sup>6</sup>

— 140 × 10<sup>6</sup>

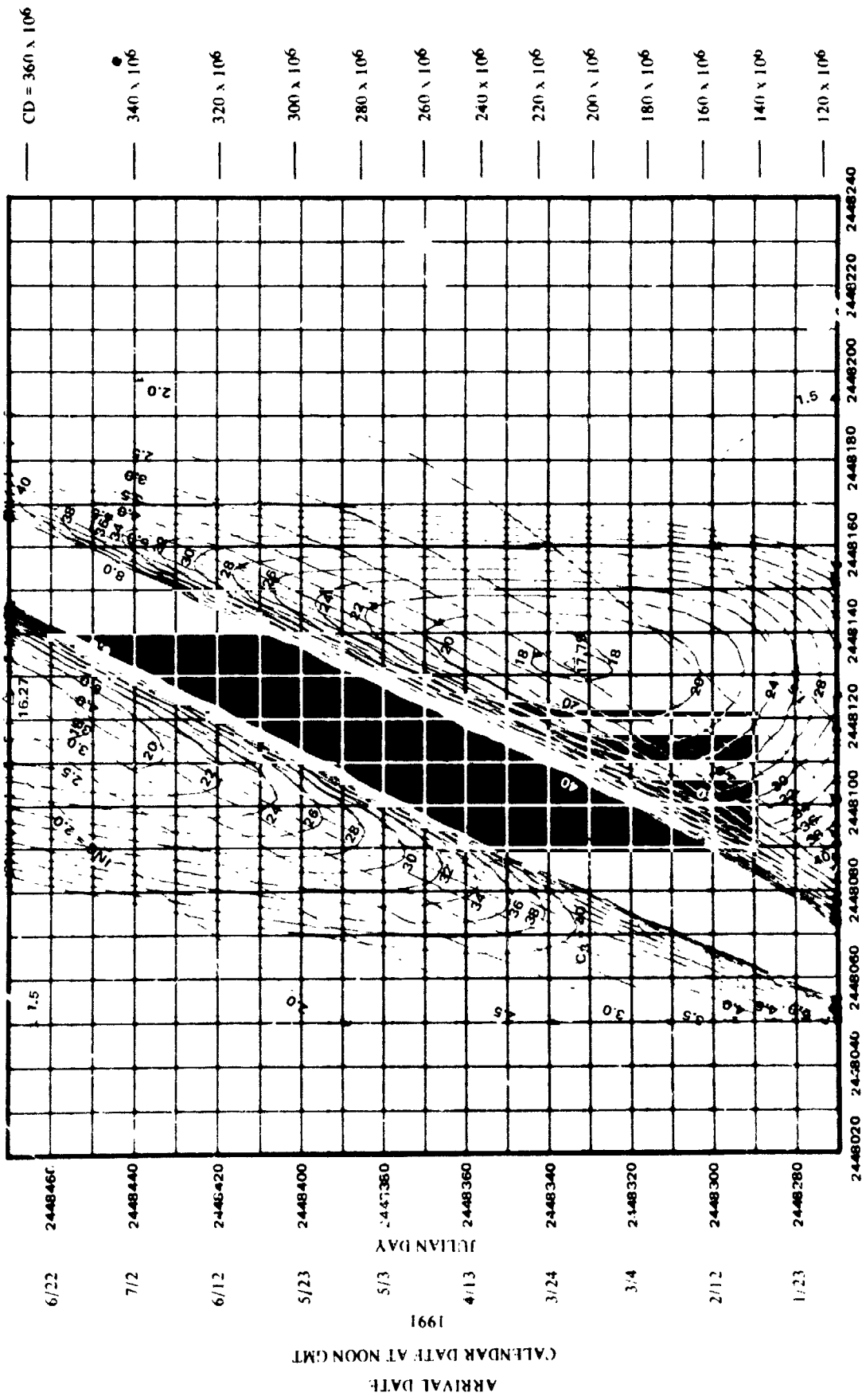
— 120 × 10<sup>6</sup>

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1991

6/22 2448460  
 7/2 2448440  
 6/12 2448420  
 5/23 2448400  
 5/3 2448380  
 4/13 2448360  
 3/24 2448340  
 3/4 2448320  
 2/12 2448300  
 1/23 2448280

2448020 2448040 2448060 2448080 2448100 2448120 2448140 2448160 2448180 2448200 2448220 2448240  
 JULIAN DAY  
 5/8 5/28 6/17 7/7 7/27 8/16 9/5 9/26 10/15 11/4 11/24 12/14  
 1990  
 CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ZAL FROM EARTH TO MARS 1990



ARRIVAL DATE

DEPARTURE DATE

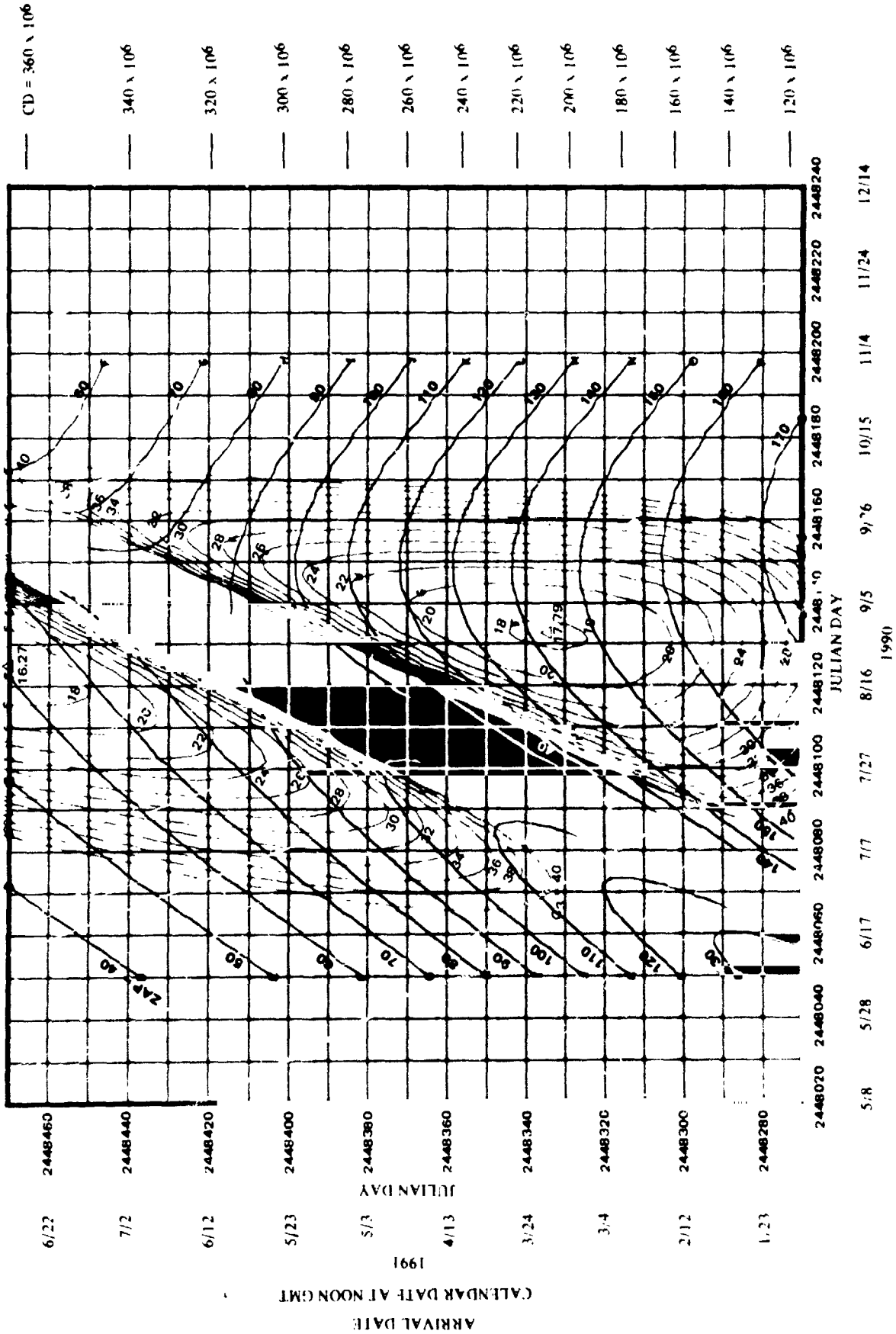
CONTOURS OF C<sub>1</sub> AND INC' EARTH TO MARS (1991)

CALENDAR DATE AT NOON GMT

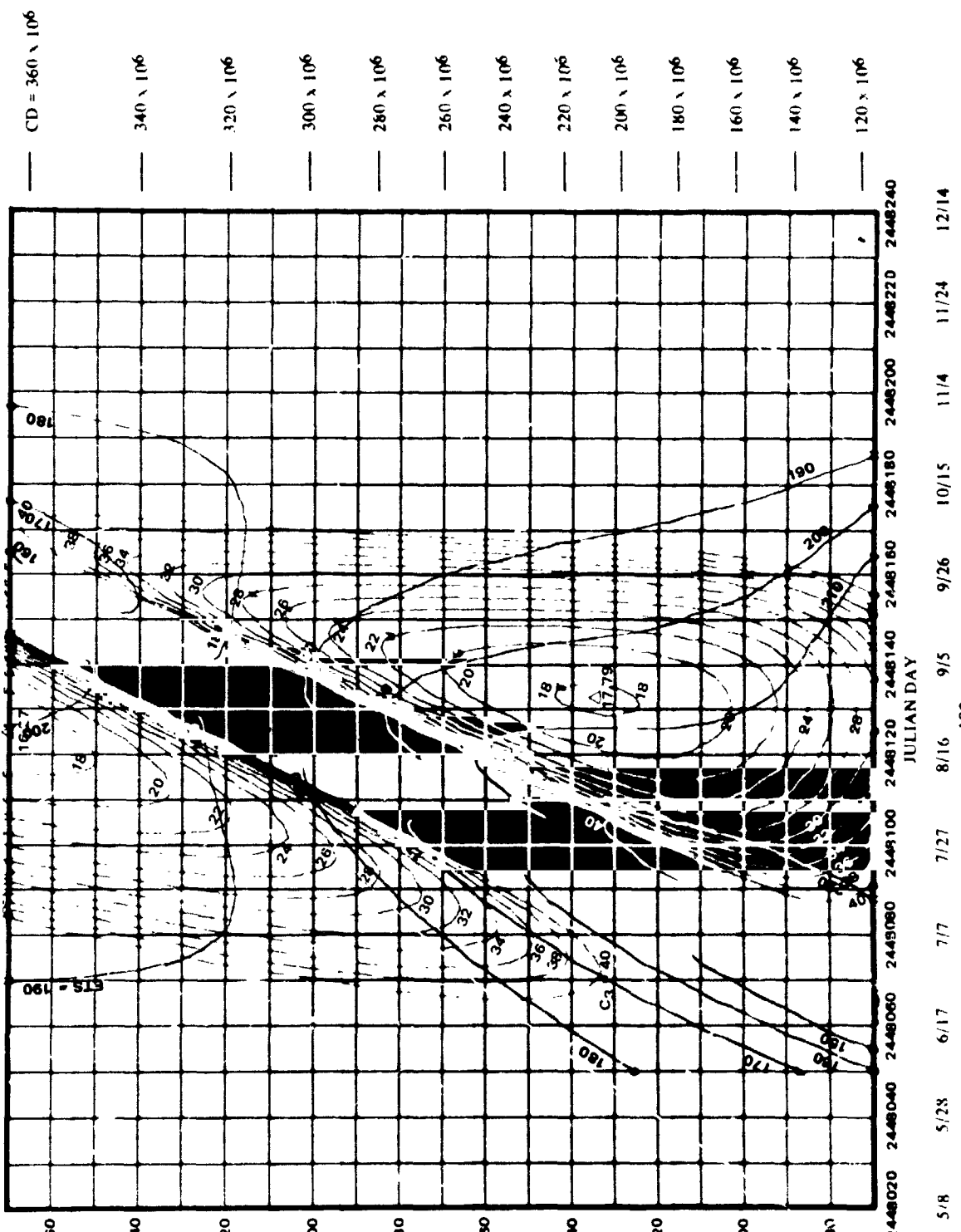
DEPARTURE DATE

1990

JULIAN DAY



CONTOURS OF C<sub>3</sub> AND ZAP EARTH TO MARS 1990



— CD = 360 x 10<sup>6</sup>

— 340 x 10<sup>6</sup>

— 320 x 10<sup>6</sup>

— 300 x 10<sup>6</sup>

— 280 x 10<sup>6</sup>

— 260 x 10<sup>6</sup>

— 240 x 10<sup>6</sup>

— 220 x 10<sup>6</sup>

— 200 x 10<sup>6</sup>

— 180 x 10<sup>6</sup>

— 160 x 10<sup>6</sup>

— 140 x 10<sup>6</sup>

— 120 x 10<sup>6</sup>

6/22 2448460  
 7/2 2448440  
 6/12 2448420  
 5/23 2448400  
 5/3 2448380  
 4/13 2448360  
 3/24 2448340  
 3/4 2448320  
 2/12 2448300  
 1/23 2448280

ARRIVAL DATE  
 CALENDAR DATE AT NOON GMT  
 1991

JULIAN DAY

2448020 2448040 2448060 2448080 2448100 2448120 2448140 2448160 2448180 2448200 2448220 2448240

JULIAN DAY  
 1990

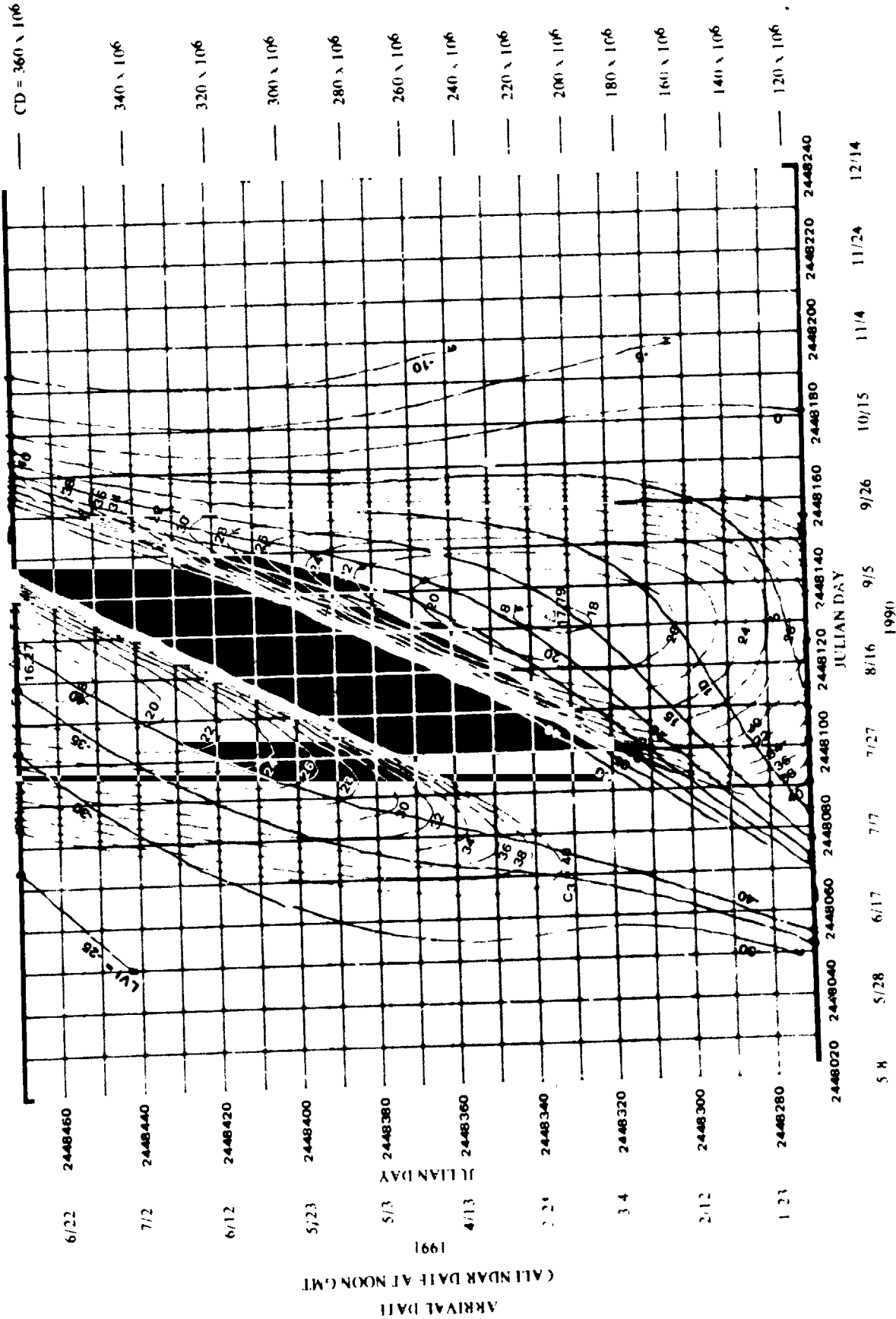
5/8 5/28 6/17 7/7 7/27 8/16 9/5 9/26 10/15 11/4 11/24 12/14

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

CONTOURS OF C<sub>3</sub> AND ETS EARTH TO MARS 1990

1880 ETS



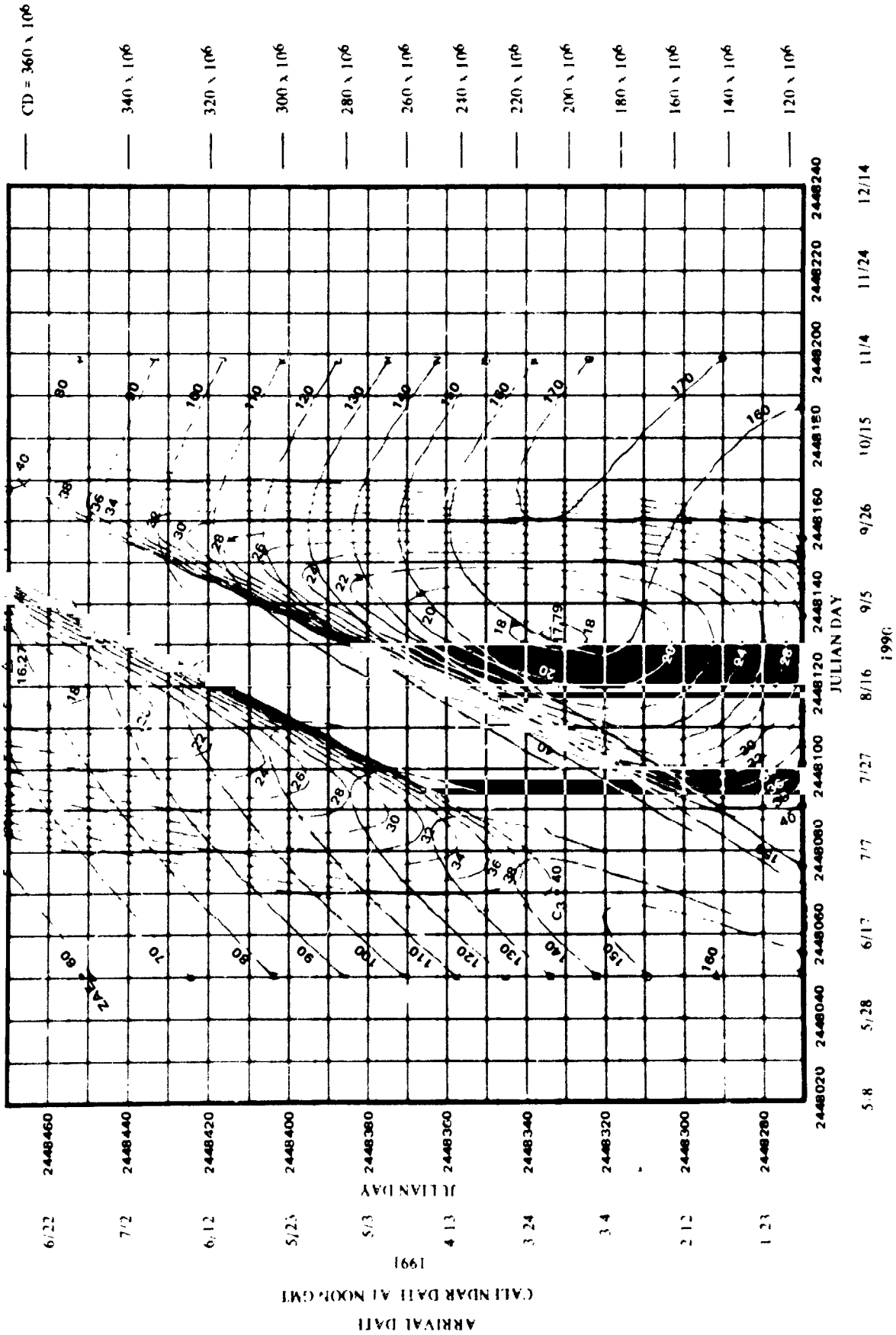


ARRIVAL DATE  
 (CALENDAR DATE AT NOON GMT)  
 1990

DEPARTURE DATE  
 (CALENDAR DATE AT NOON GMT)  
 1990

CONTOURS OF C<sub>3</sub> AND LVI EARTH TO MARS 1990

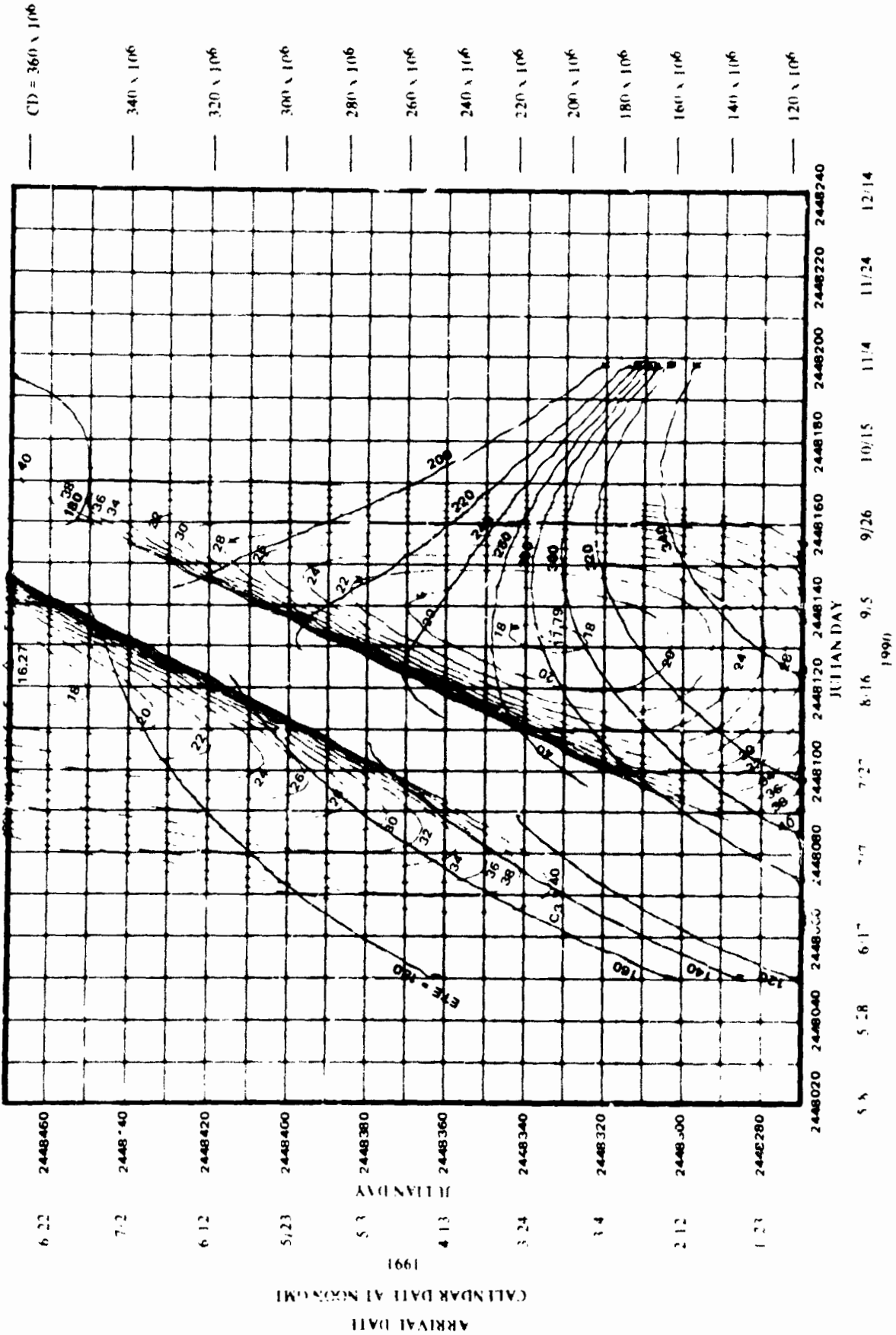
8045



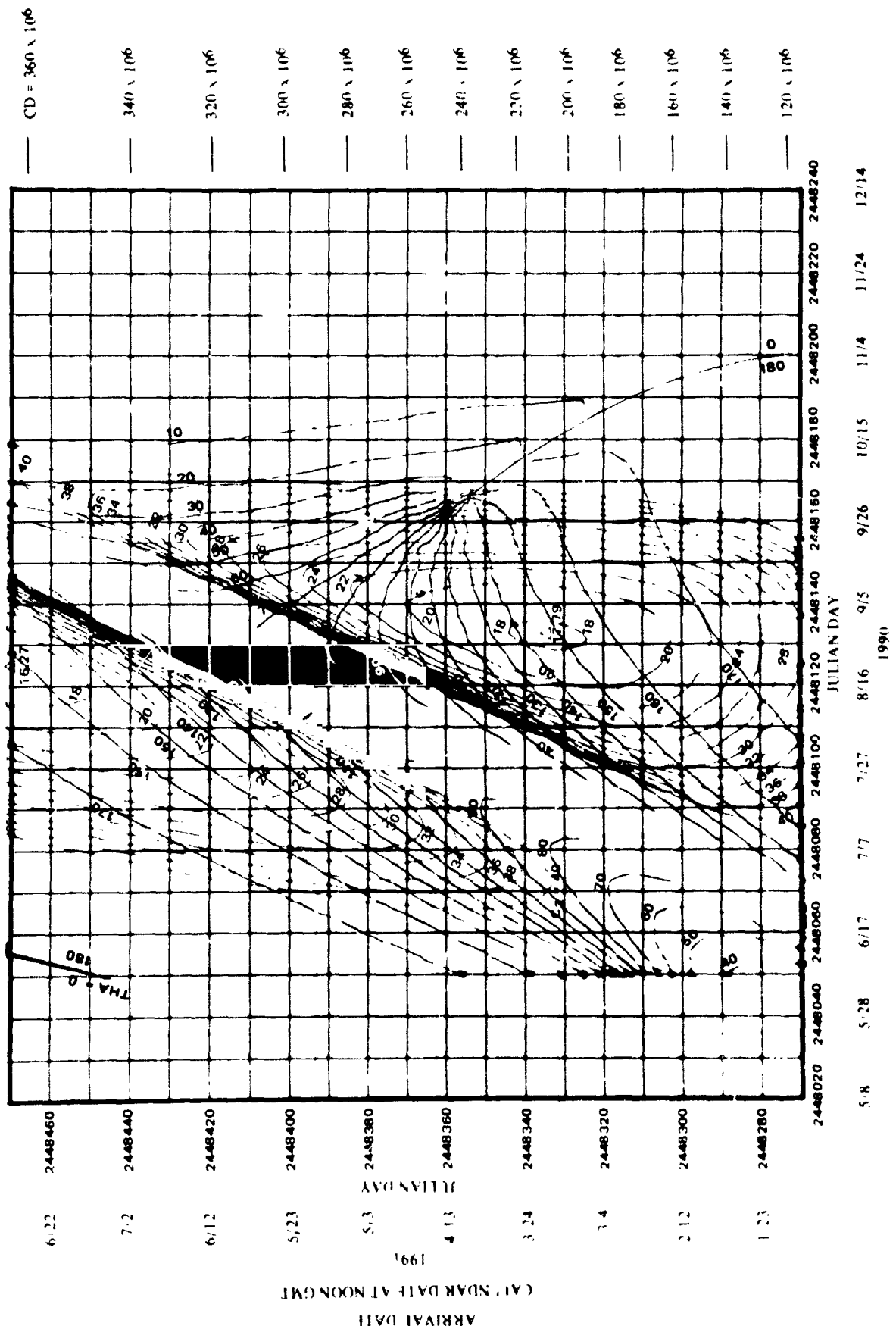
CONTOURS OF C<sub>3</sub> AND ZAI. EARTH TO MARS 1990

CALENDAR DATE AT NOON GMT

DEPARTURE DATE



CONTOURS OF C<sub>3</sub> AND ETE EARTH TO MARS 1990  
CALENDAR DATE AT NOON GMT  
DEPARTURE DATE



ARRIVAL DATE AT NOON GMT  
 1991  
 6/22 2448460  
 7/2 2448440  
 6/12 2448420  
 5/23 2448400  
 5/3 2448380  
 4/13 2448360  
 3/24 2448340  
 3/4 2448320  
 2/12 2448300  
 1/23 2448280

CD = 360 x 10<sup>6</sup>  
 — 340 x 10<sup>6</sup>  
 — 320 x 10<sup>6</sup>  
 — 300 x 10<sup>6</sup>  
 — 280 x 10<sup>6</sup>  
 — 260 x 10<sup>6</sup>  
 — 240 x 10<sup>6</sup>  
 — 220 x 10<sup>6</sup>  
 — 200 x 10<sup>6</sup>  
 — 180 x 10<sup>6</sup>  
 — 160 x 10<sup>6</sup>  
 — 140 x 10<sup>6</sup>  
 — 120 x 10<sup>6</sup>

2448020 2448040 2448060 2448080 2448100 2448120 2448140 2448160 2448180 2448200 2448220 2448240  
 JULIAN DAY

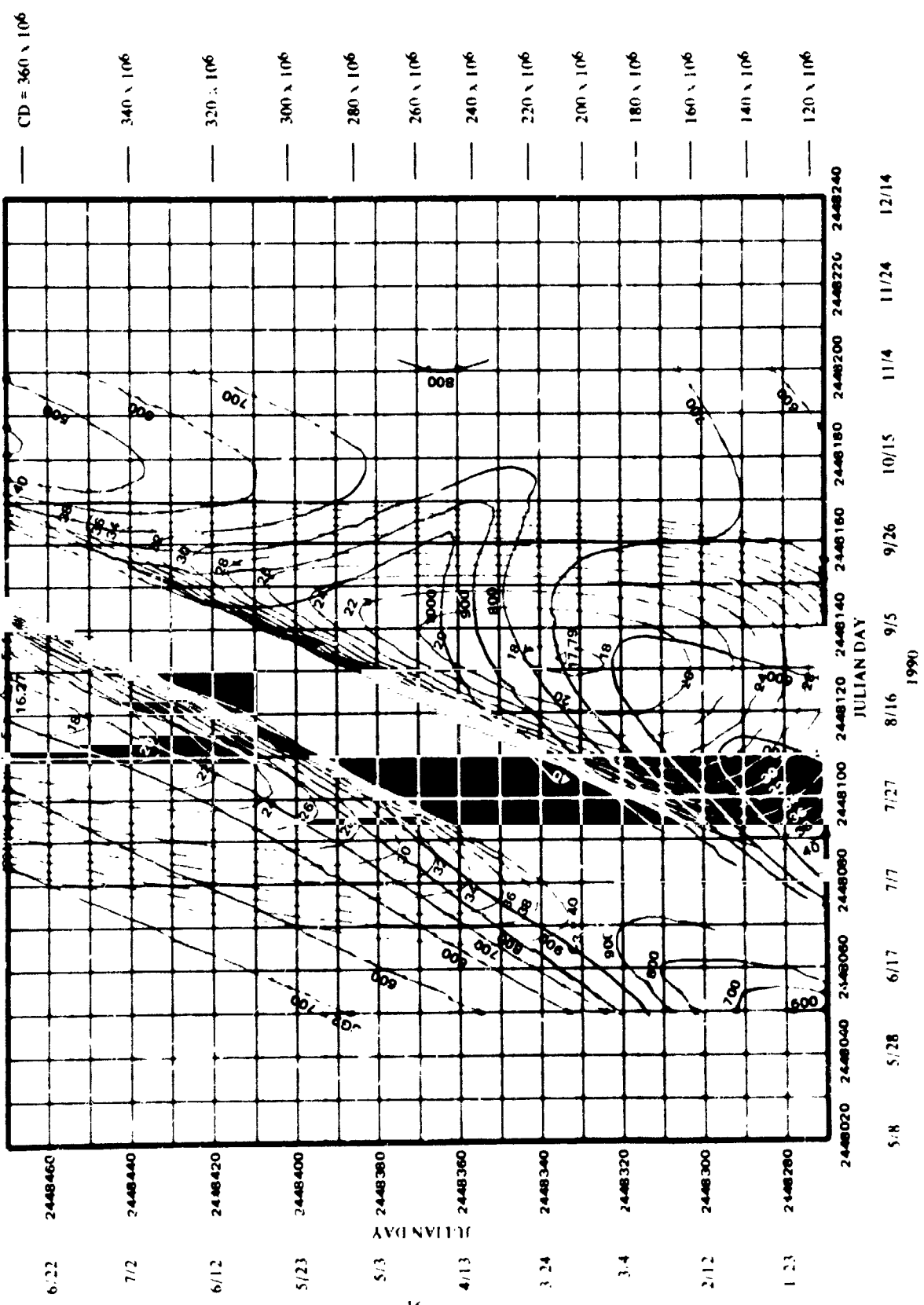
5/8 5/28 6/17 7/7 7/27 8/16 9/5 9/26 10/15 11/4 11/24 12/14  
 1990

CALENDAR DATE AT NOON GMT  
 DEPARTURE DATE

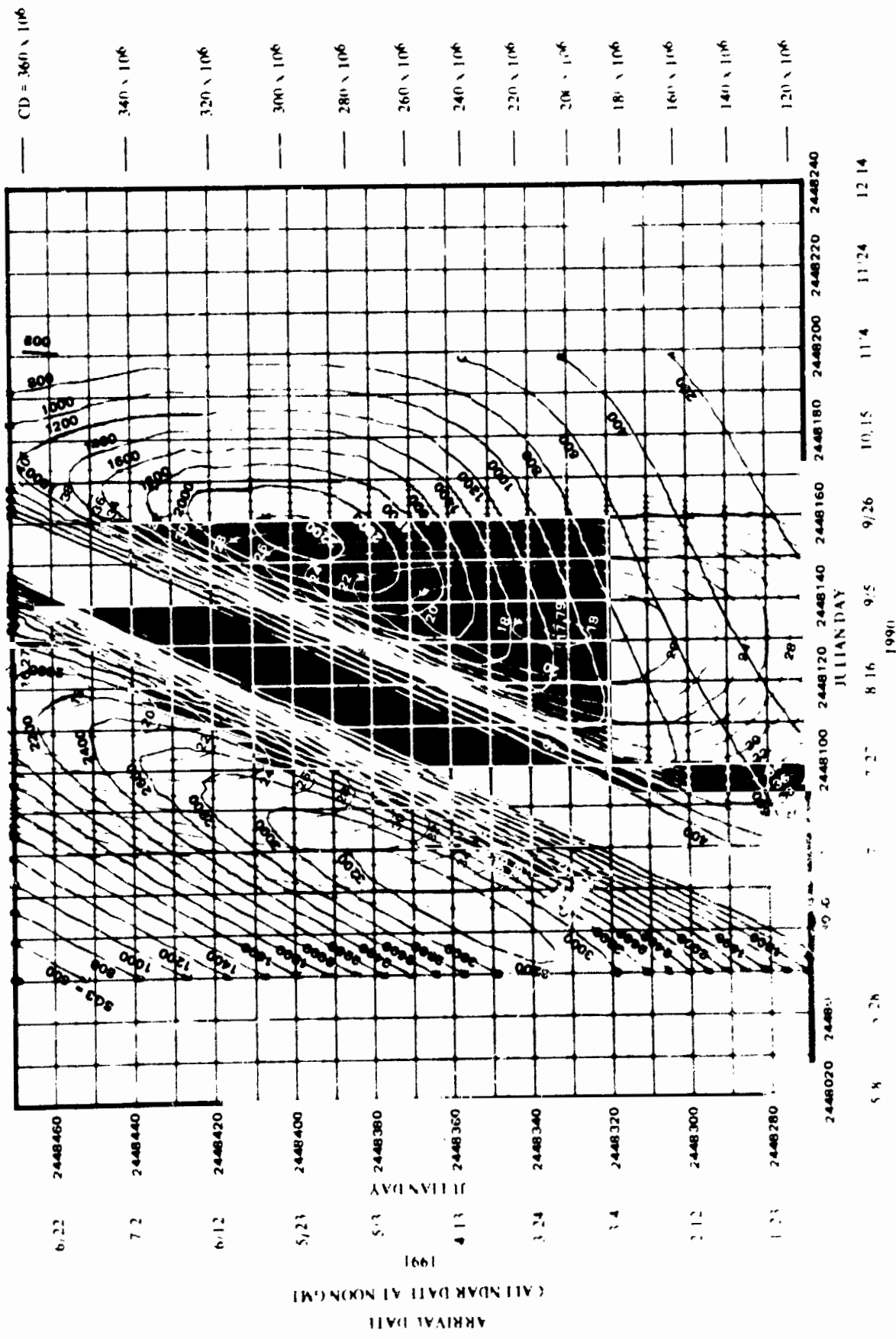
CONTOURS OF C<sub>3</sub> AND THA TO MARS 1990



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1990  
SG2

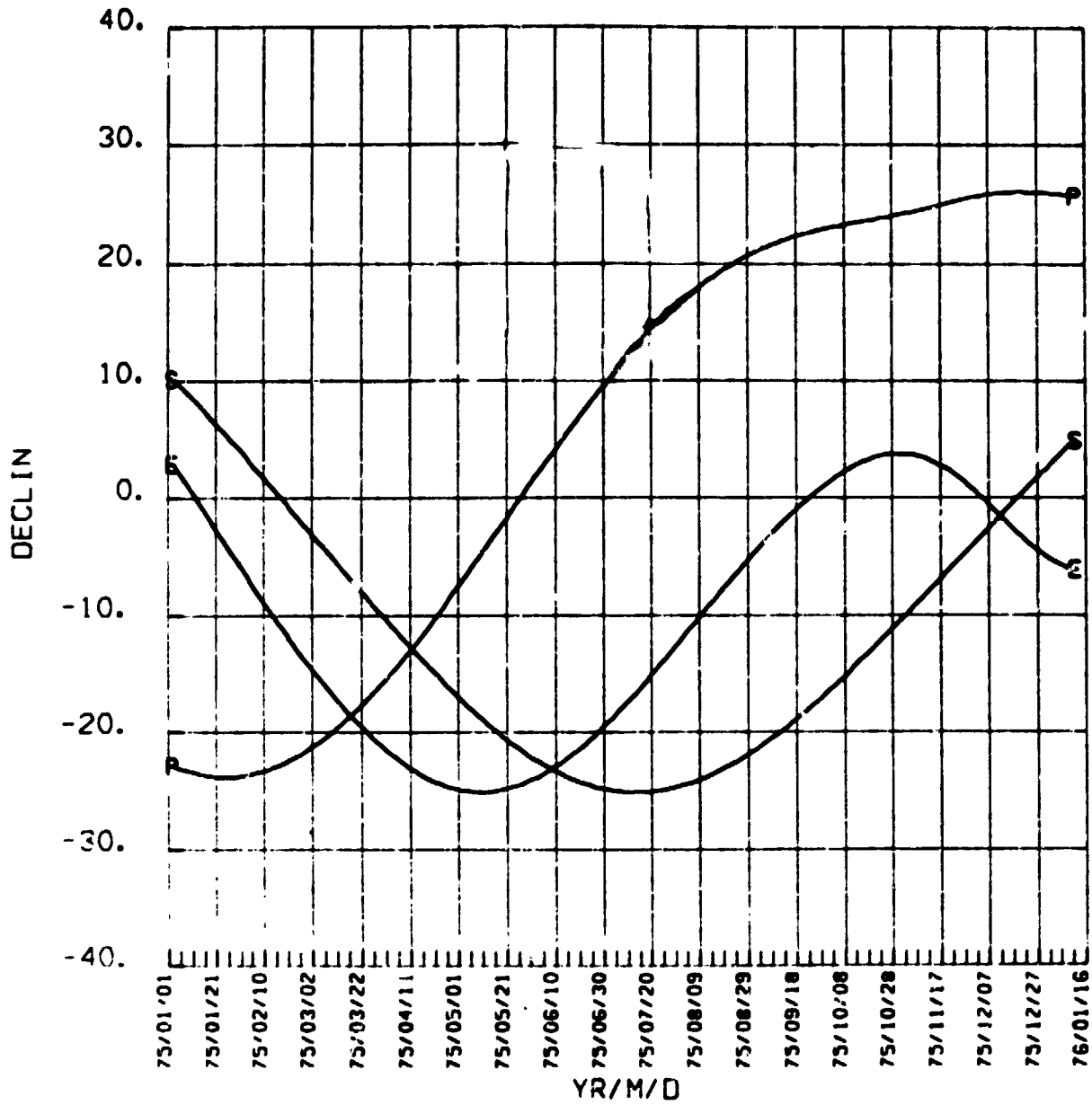


CONTOURS OF C<sub>3</sub> AND SG3 EARTH TO MARS 1990

CALENDAR DATE AT NOON GMT

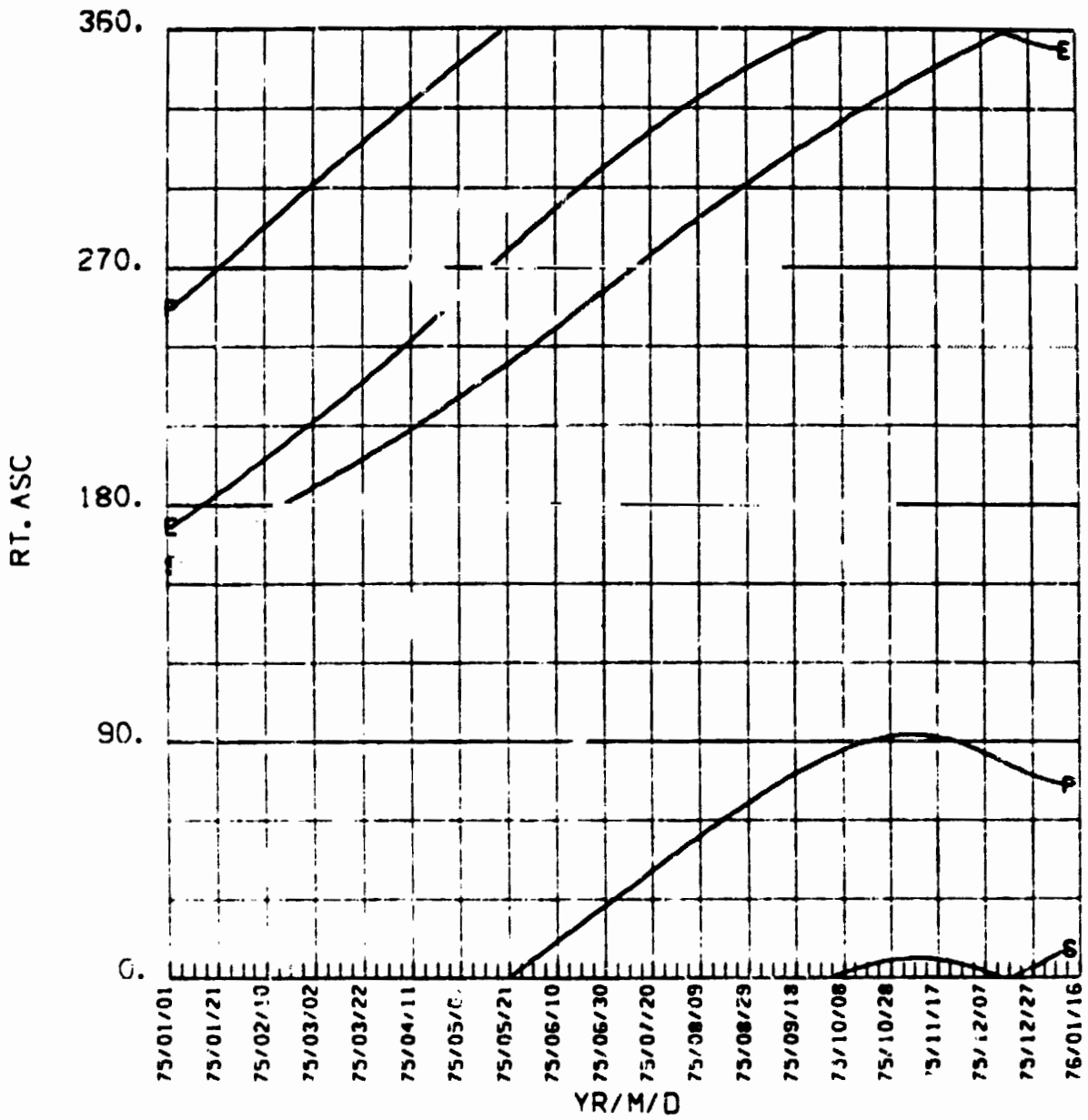
DEPARTURE DATE

MARS 1975

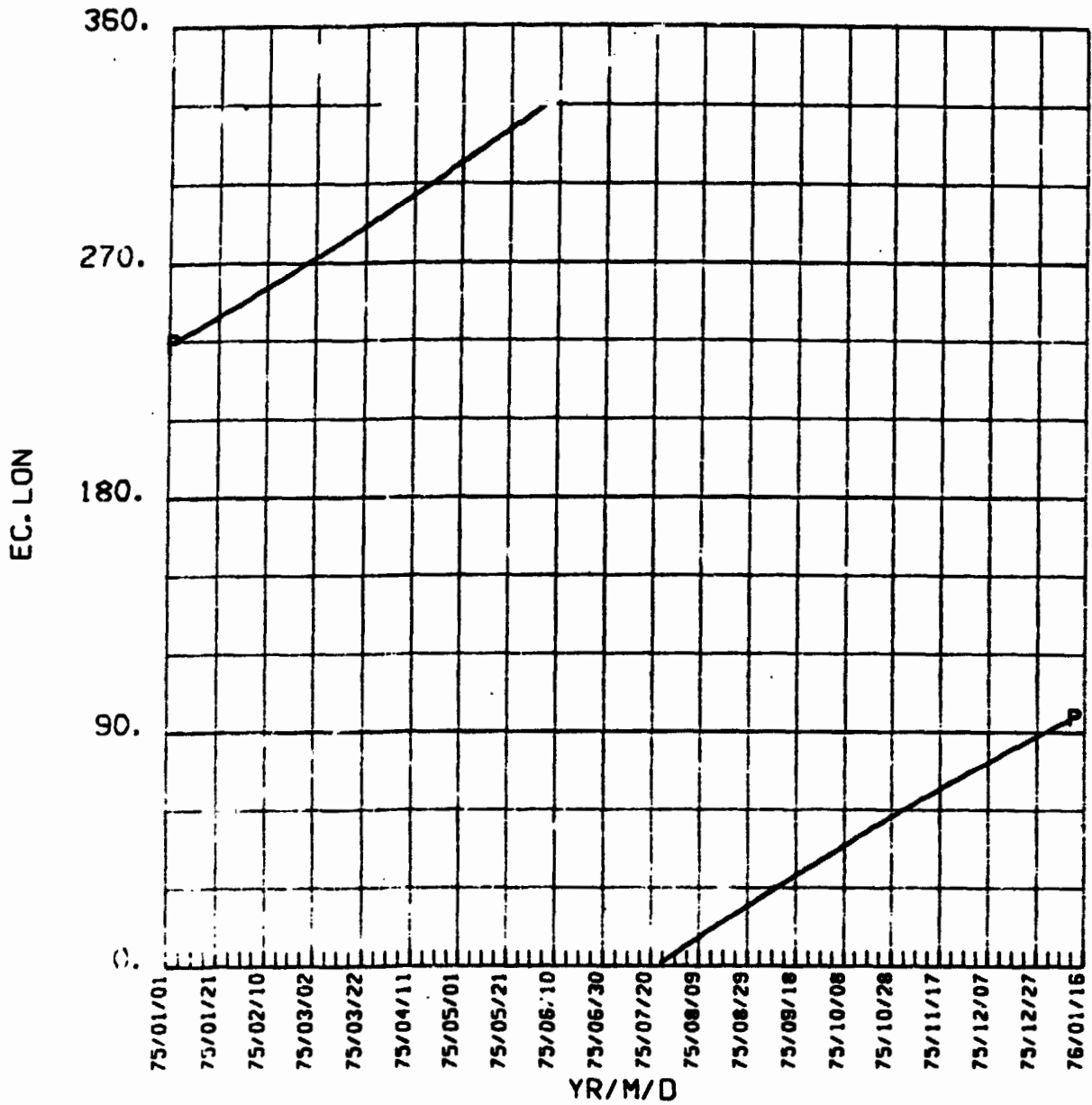




MARS 1975



MARS 1975

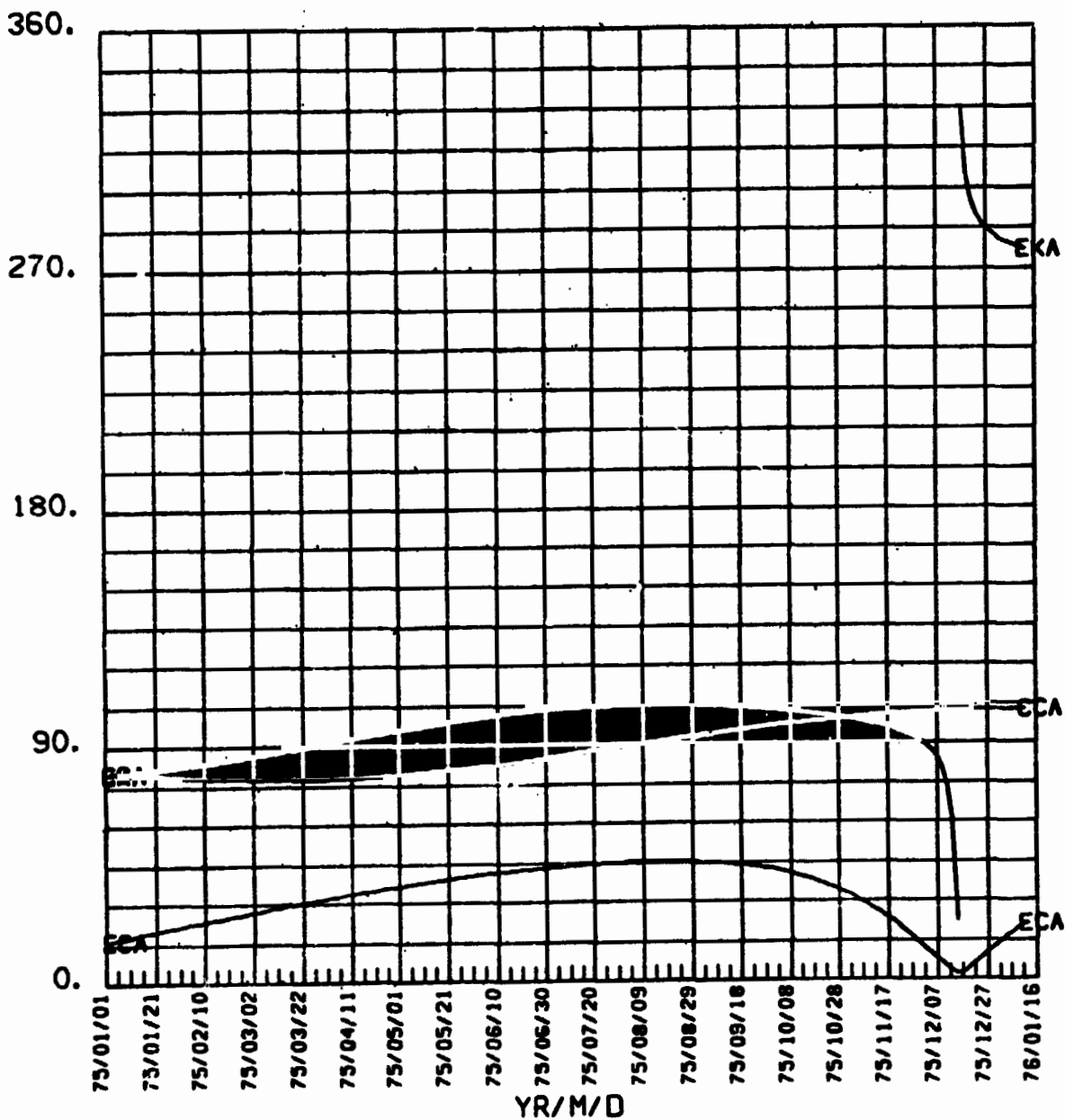


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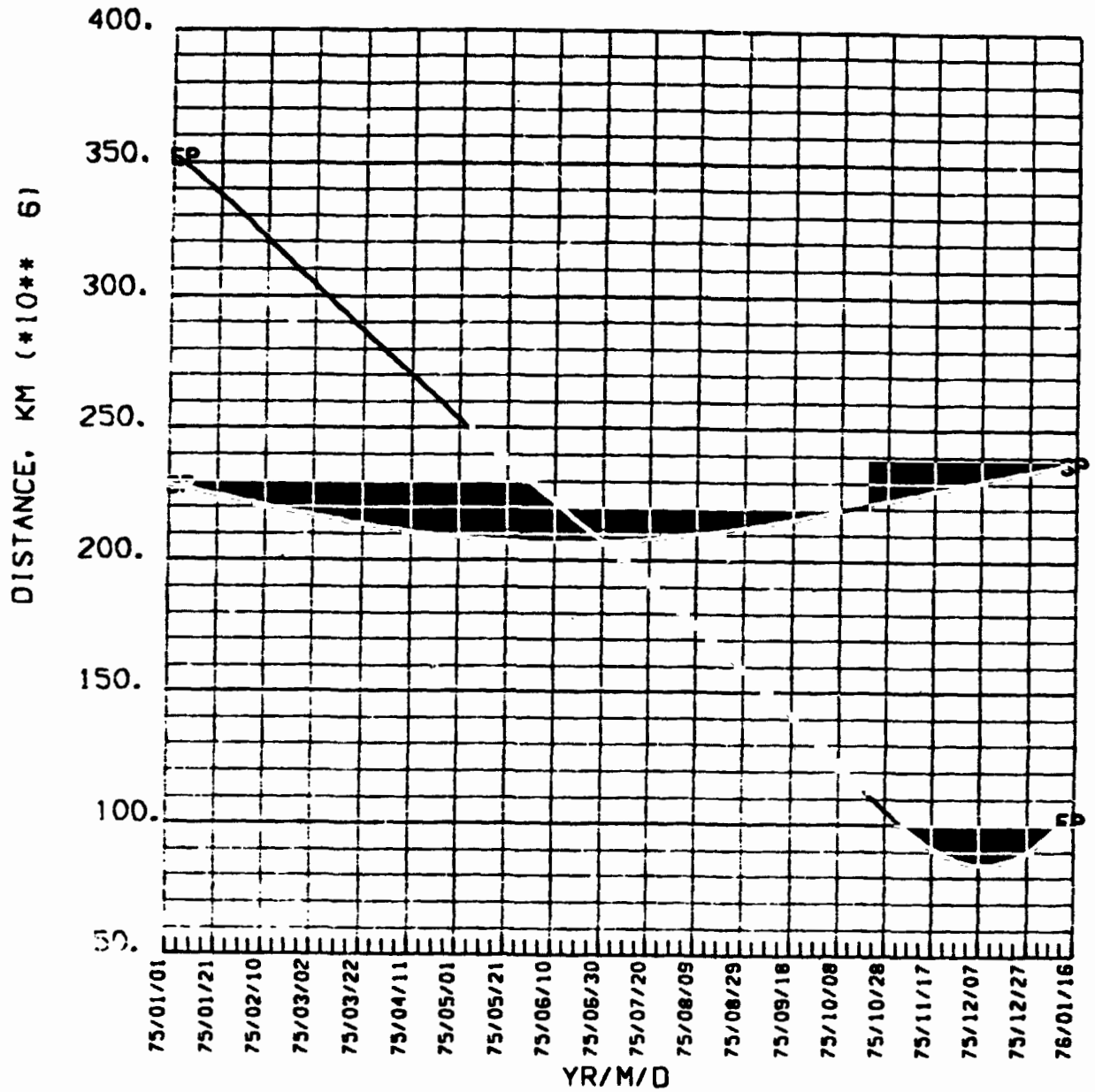
C-2

MARS 1975

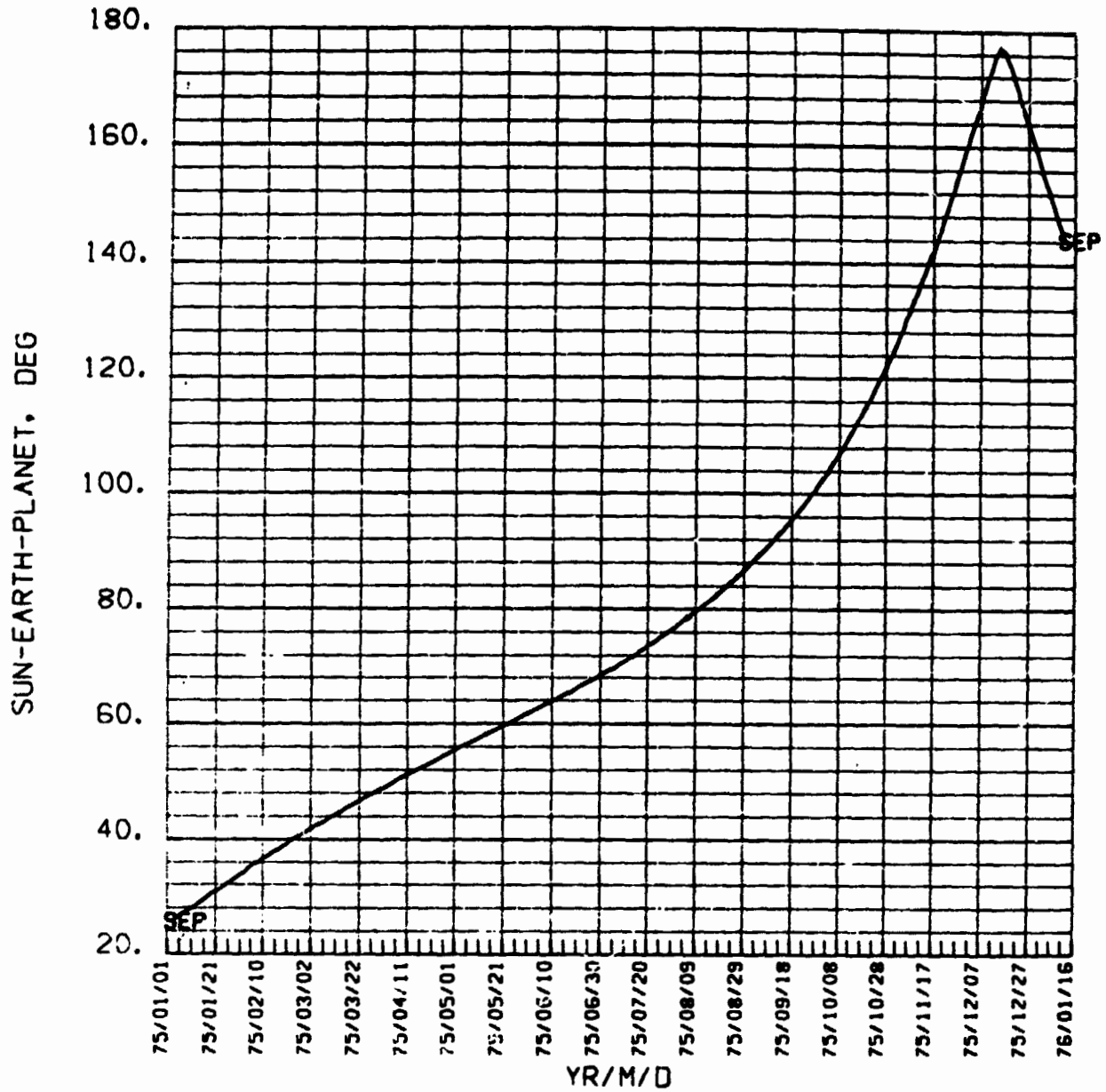
CA, KA OF EARTH, CA CANOP



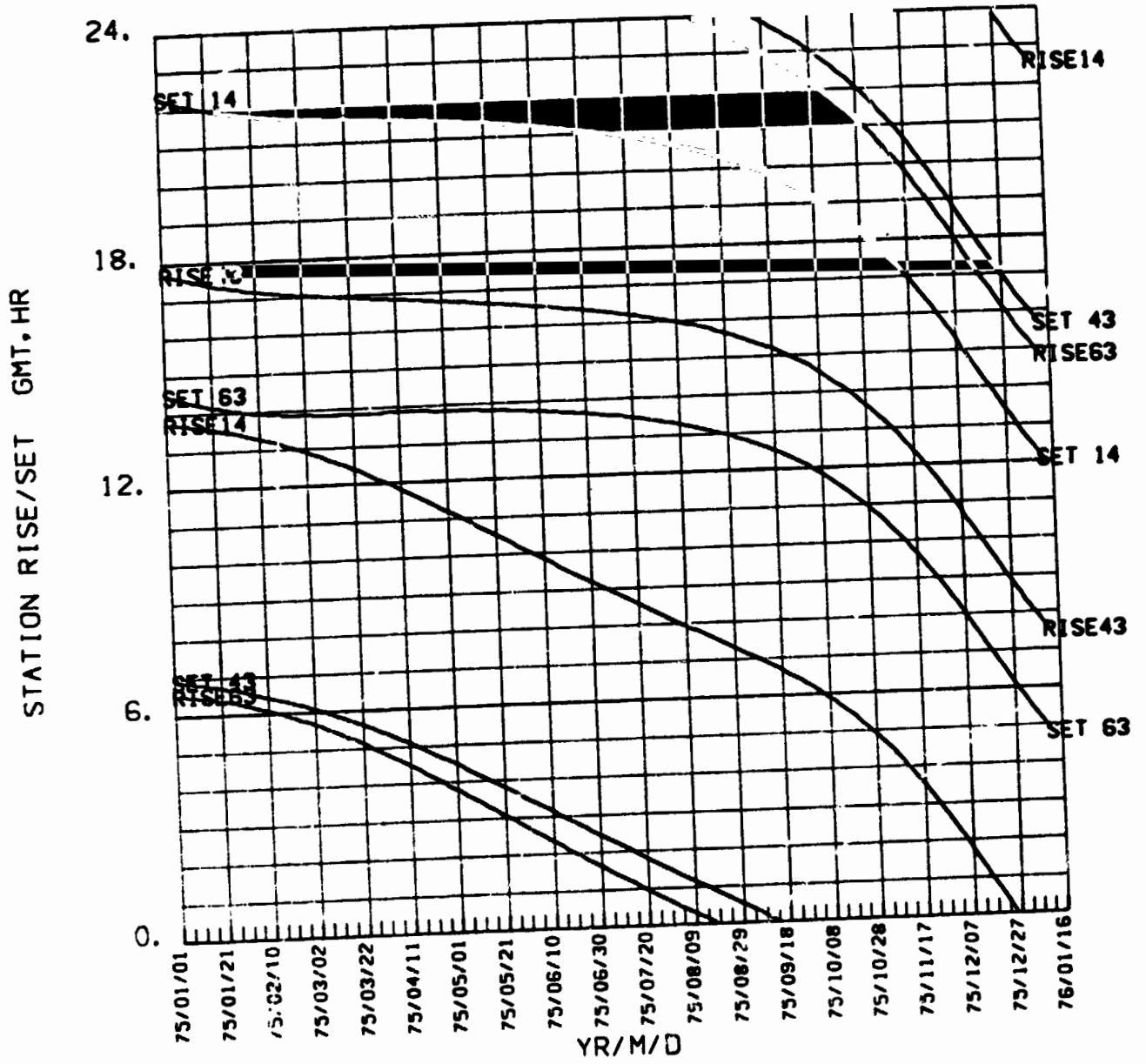
MARS 1975



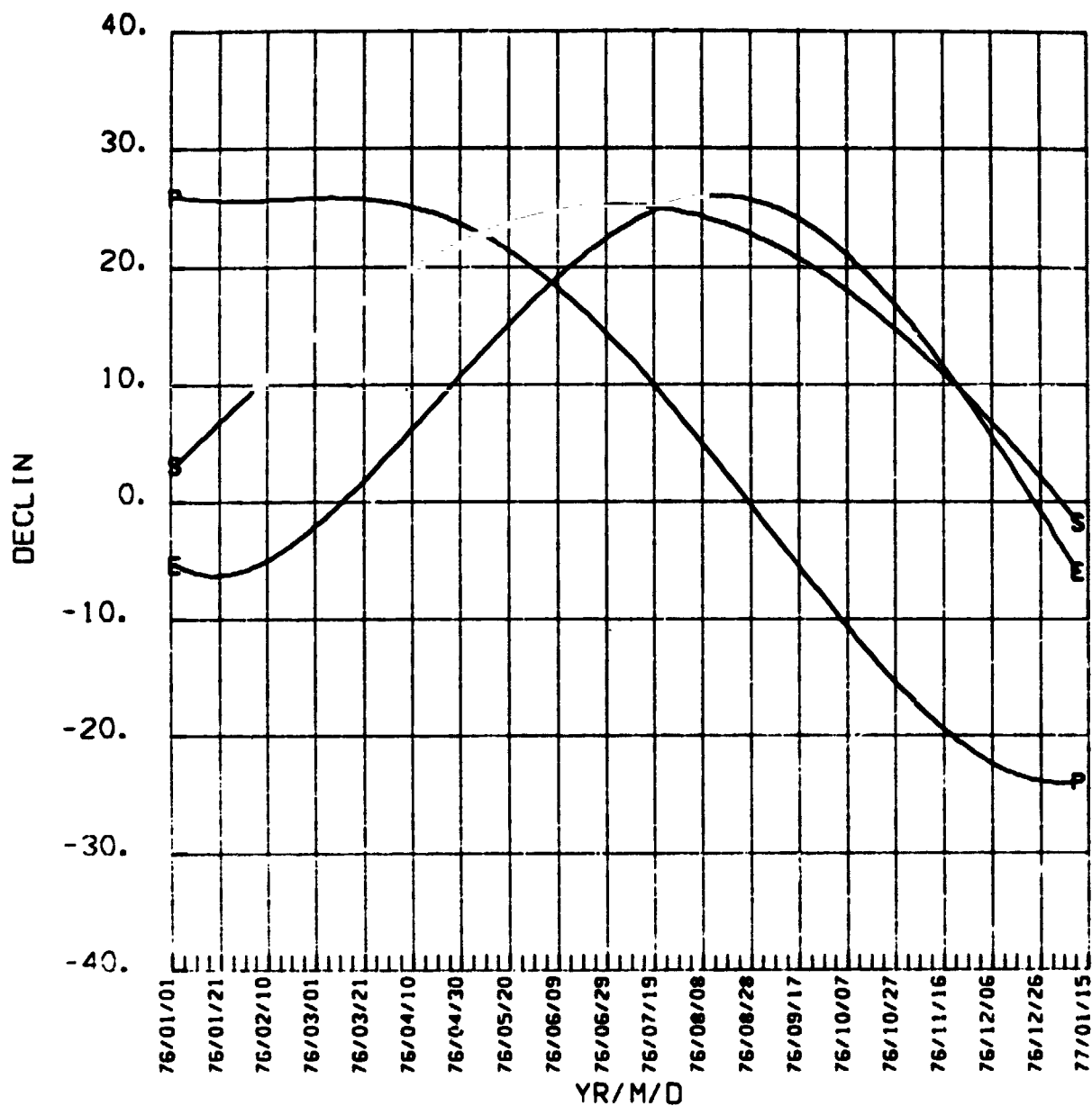
MARS 1975



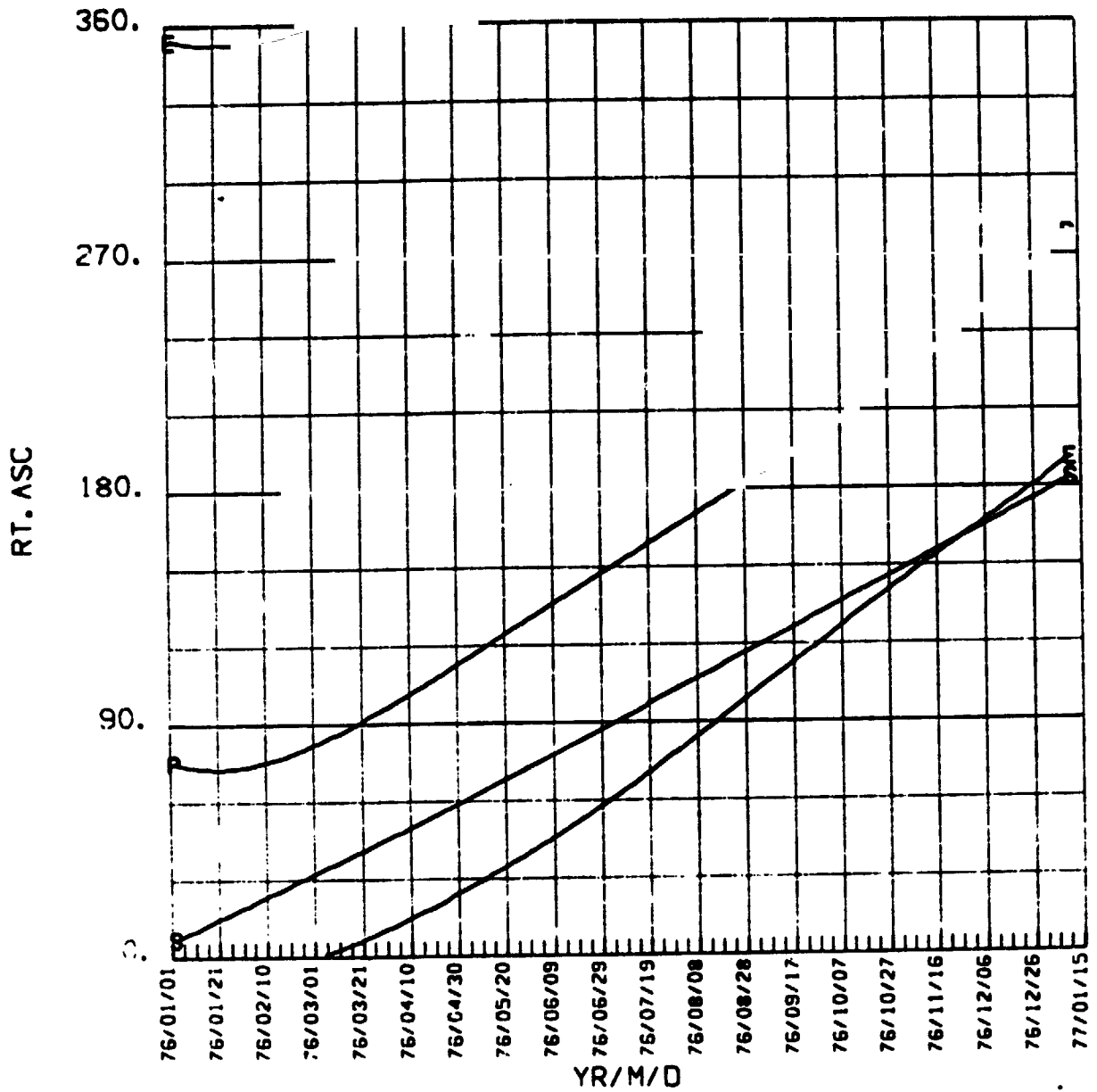
MARS 1975



MARS 1976

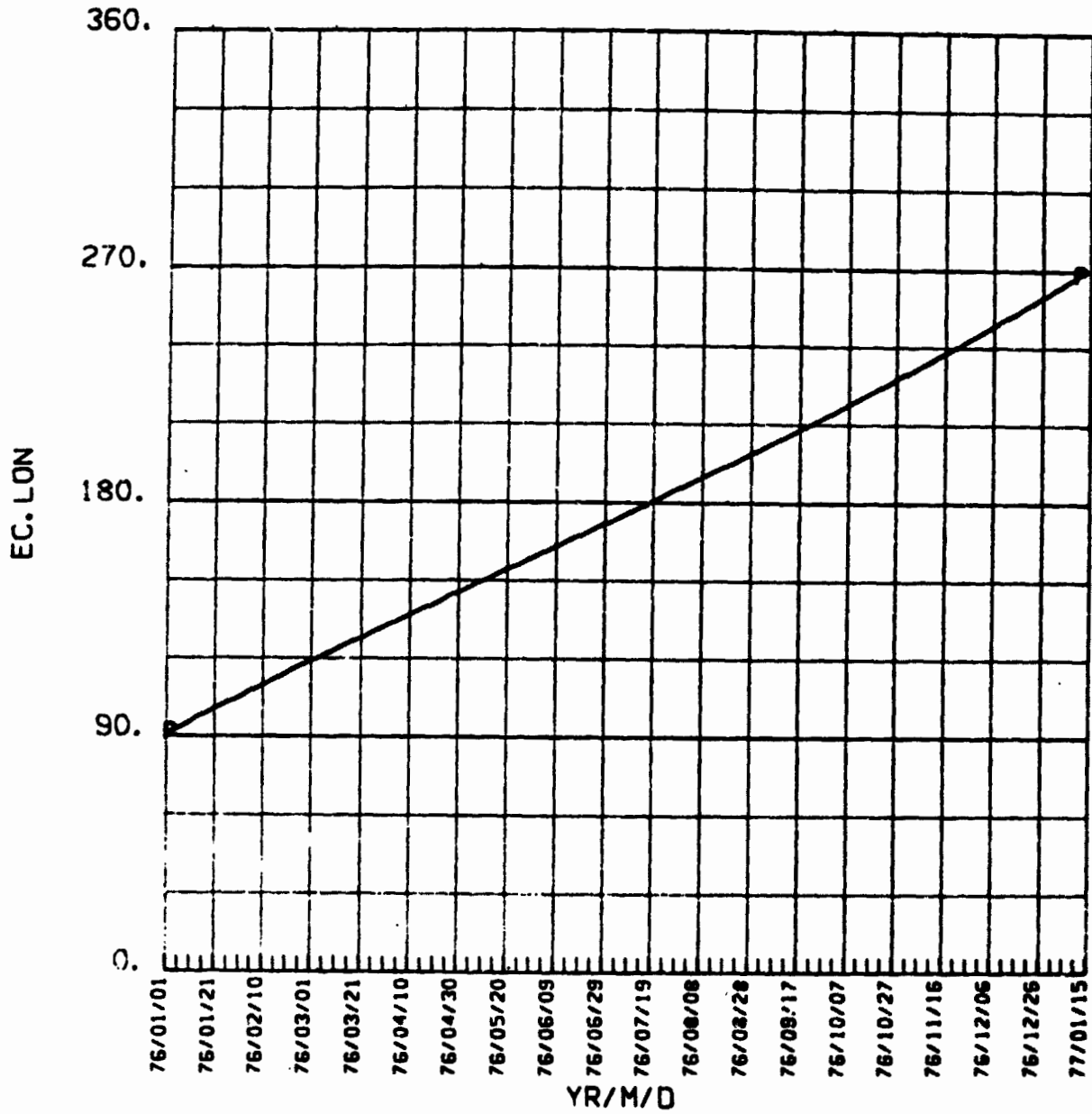


MARS 1976

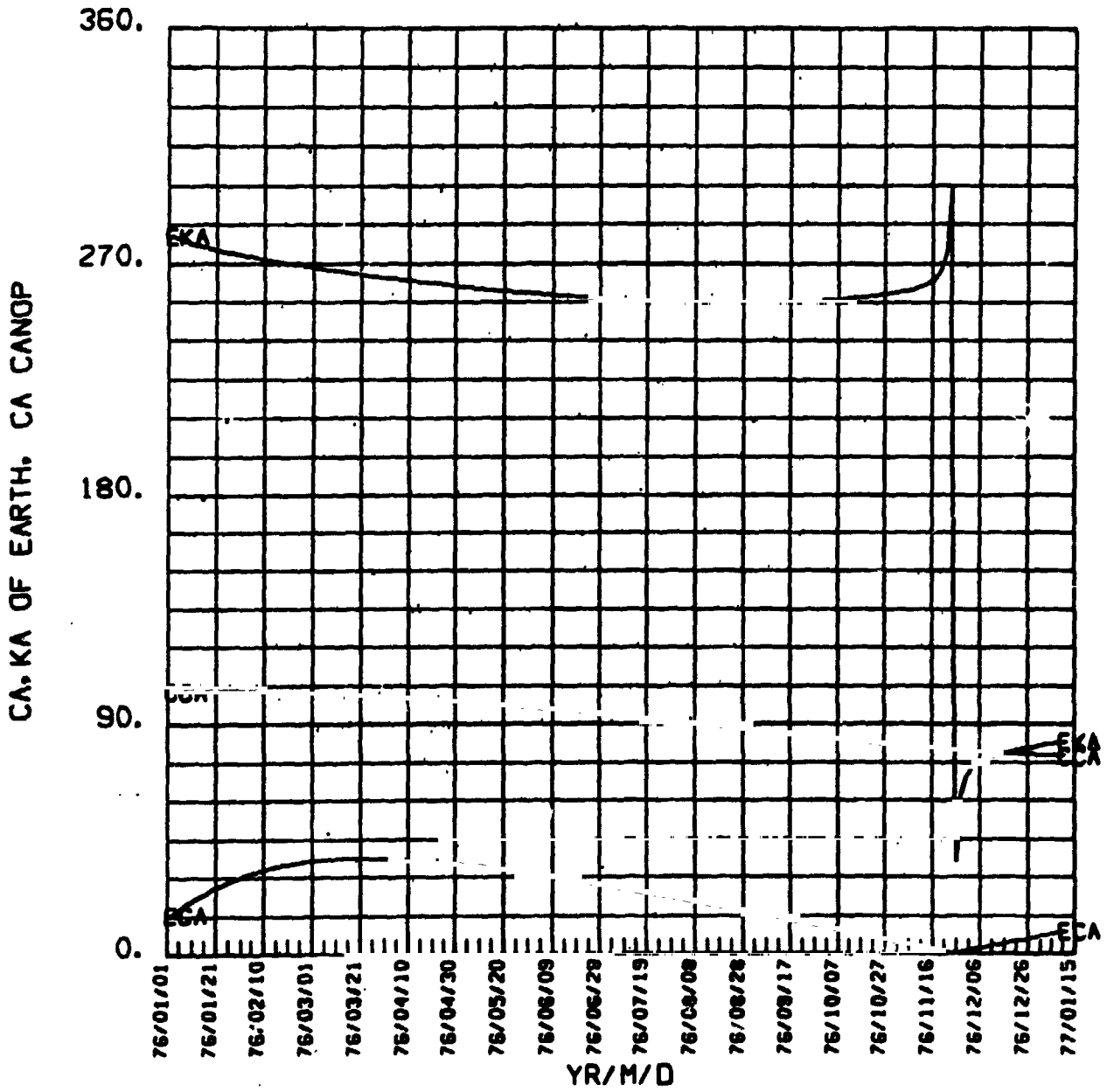




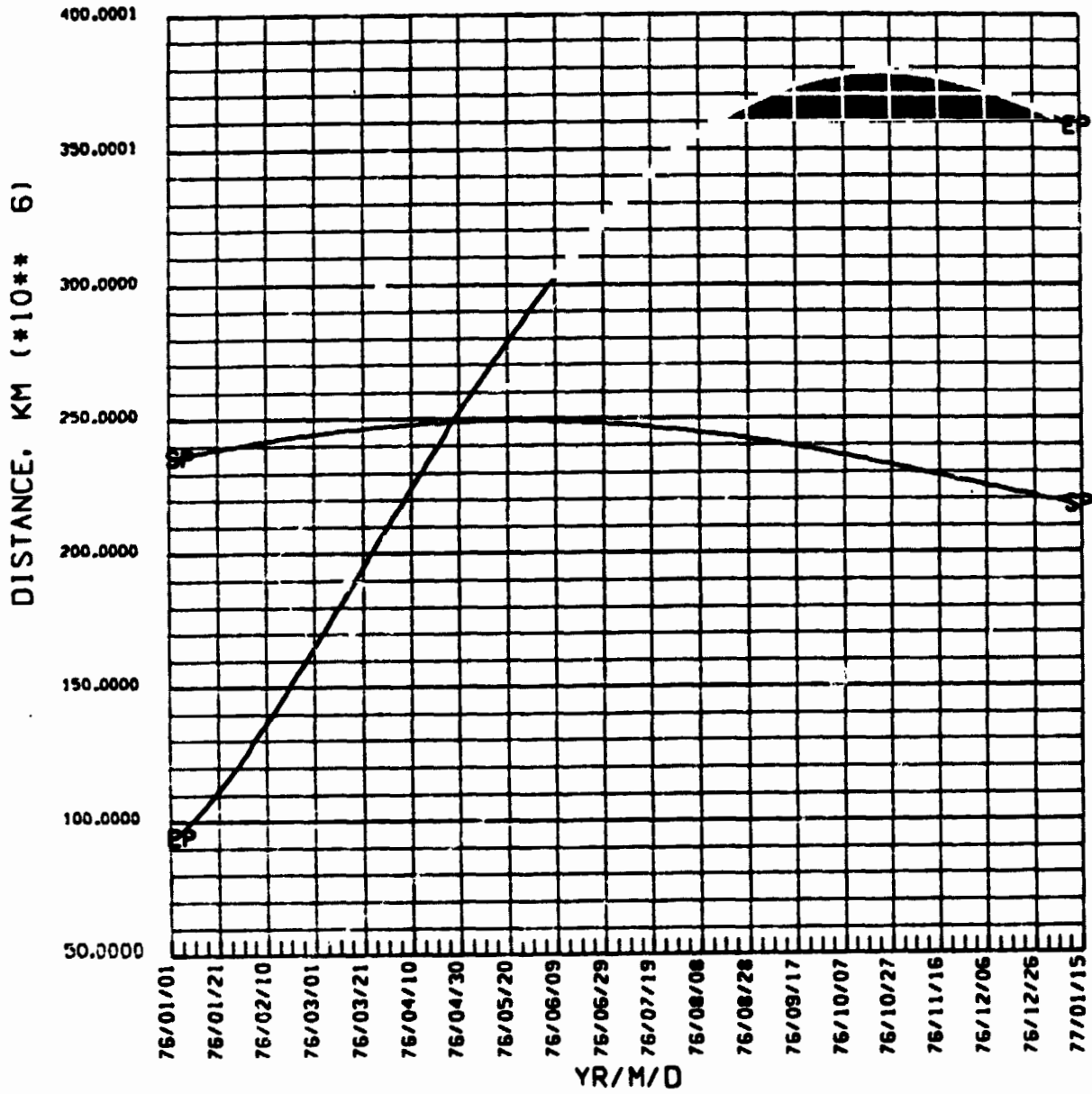
MARS 1976



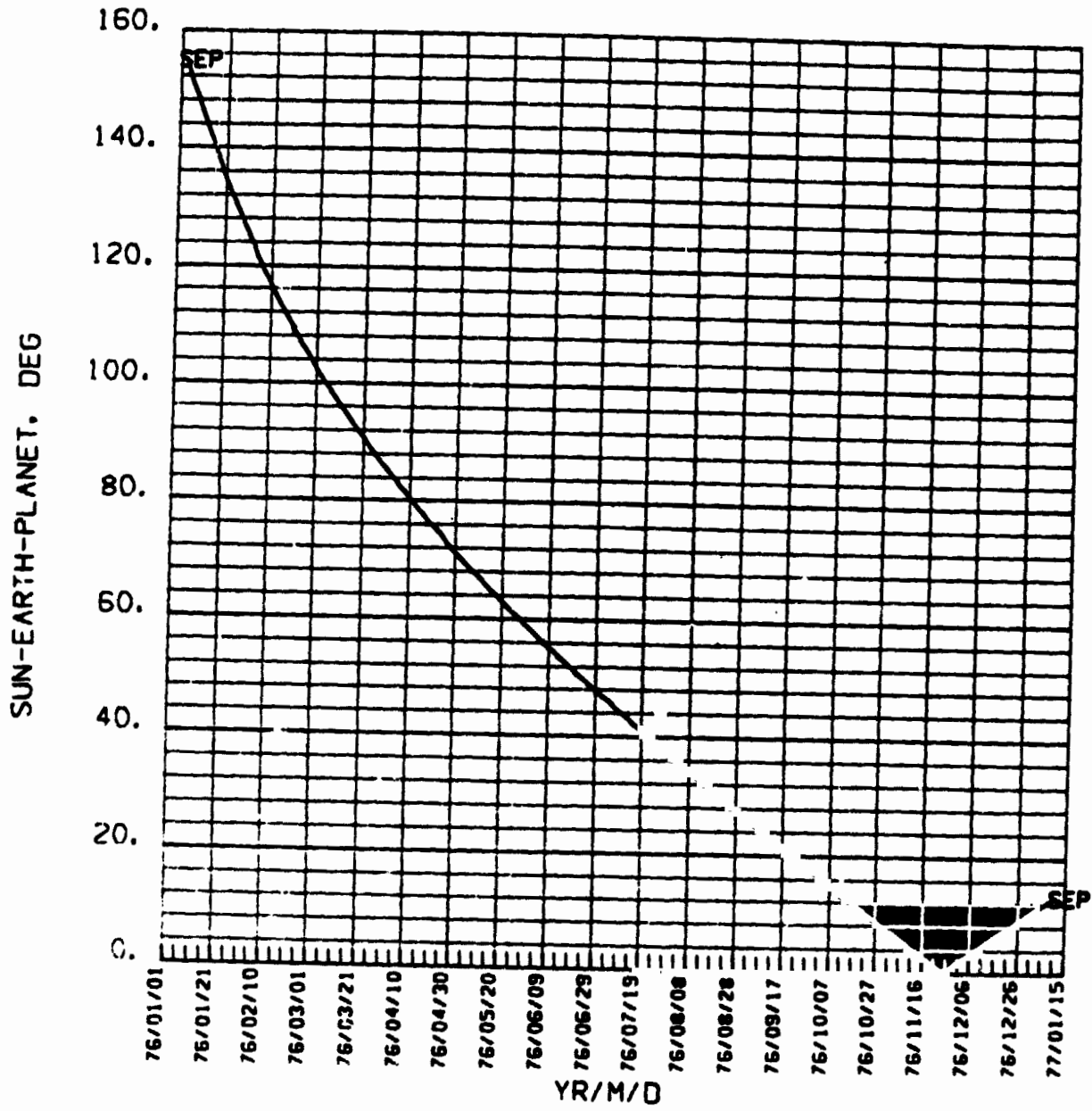
MARS 1976



MARS 1976

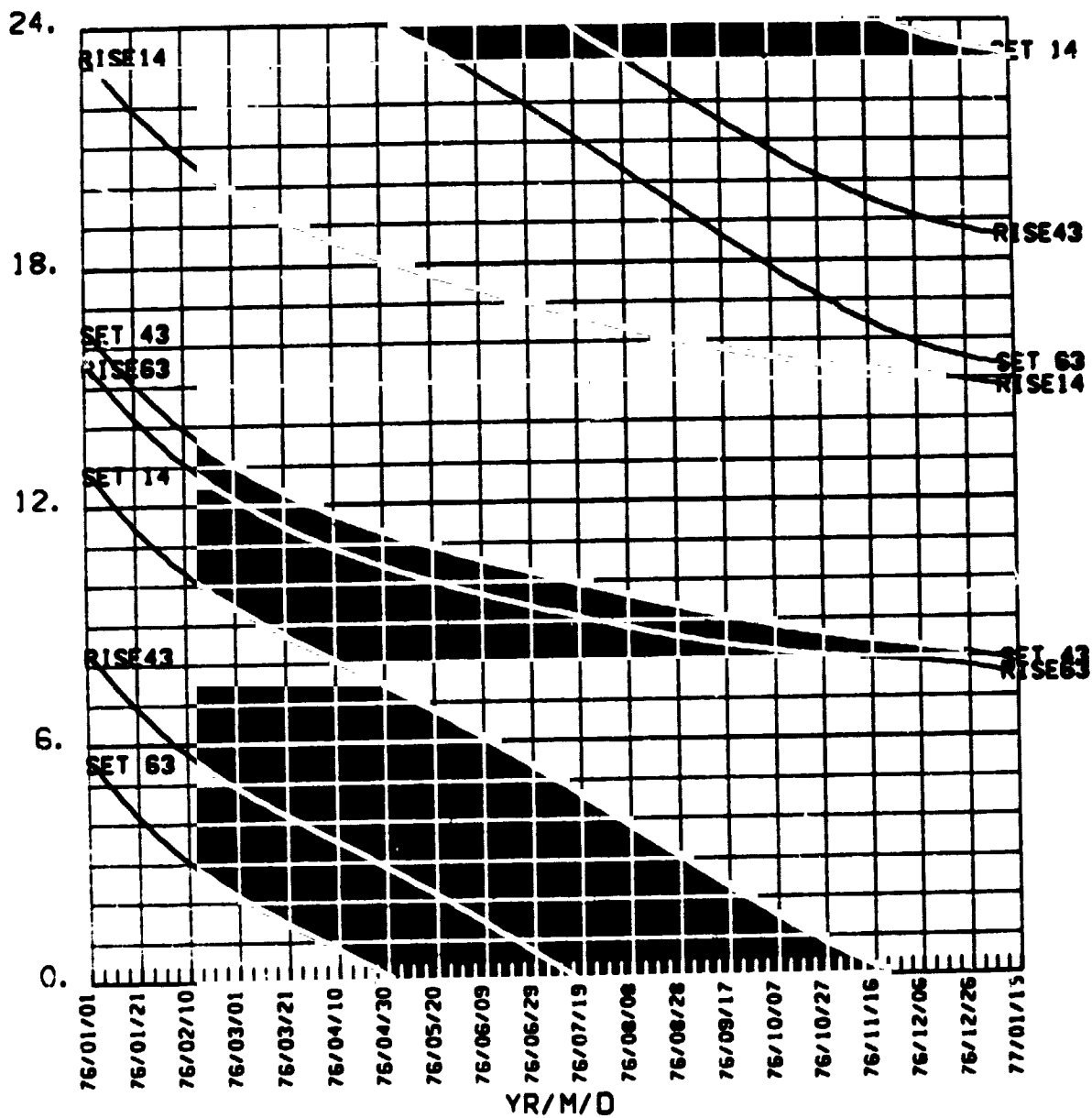


MARS 1976

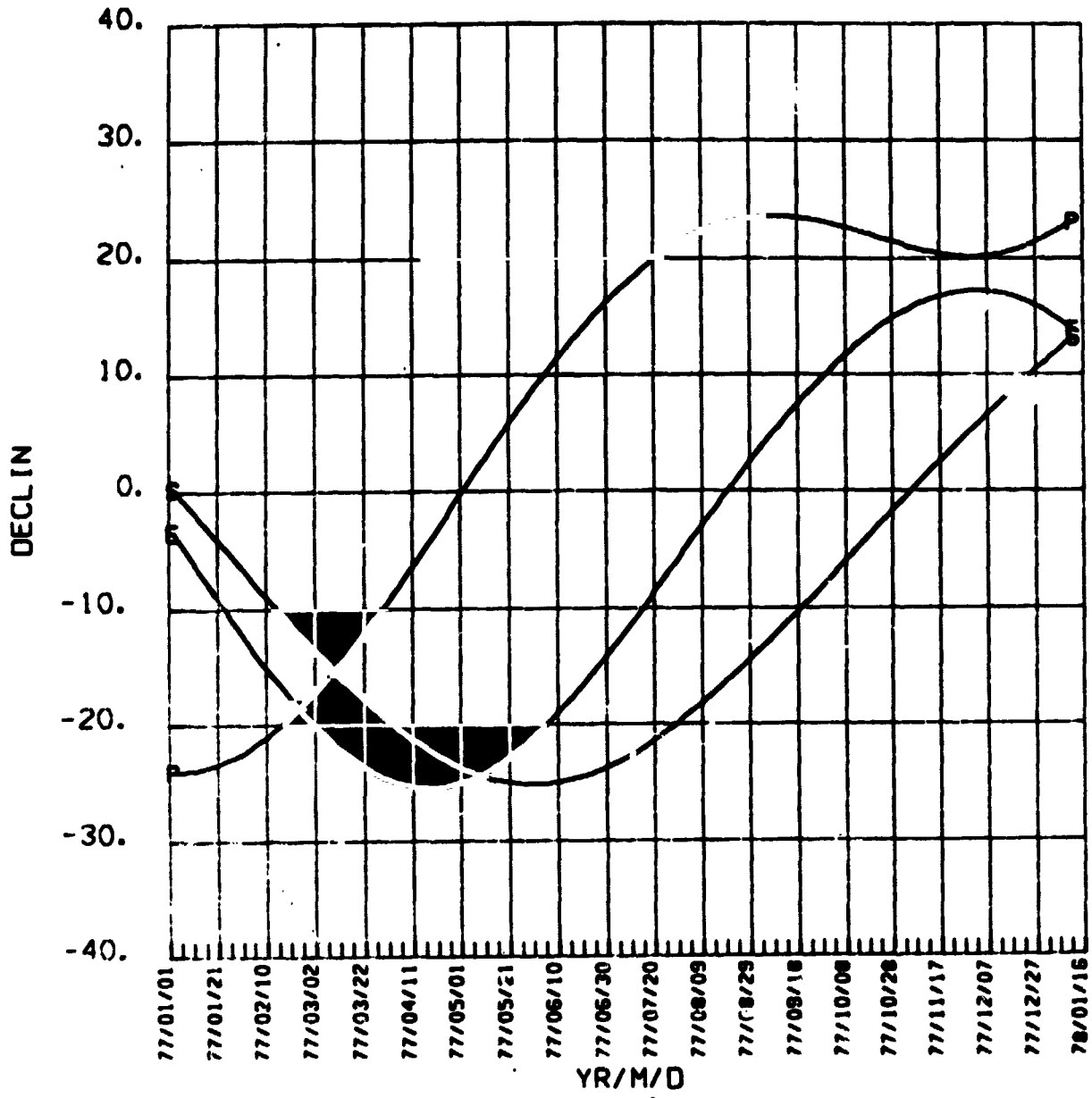


MARS 1976

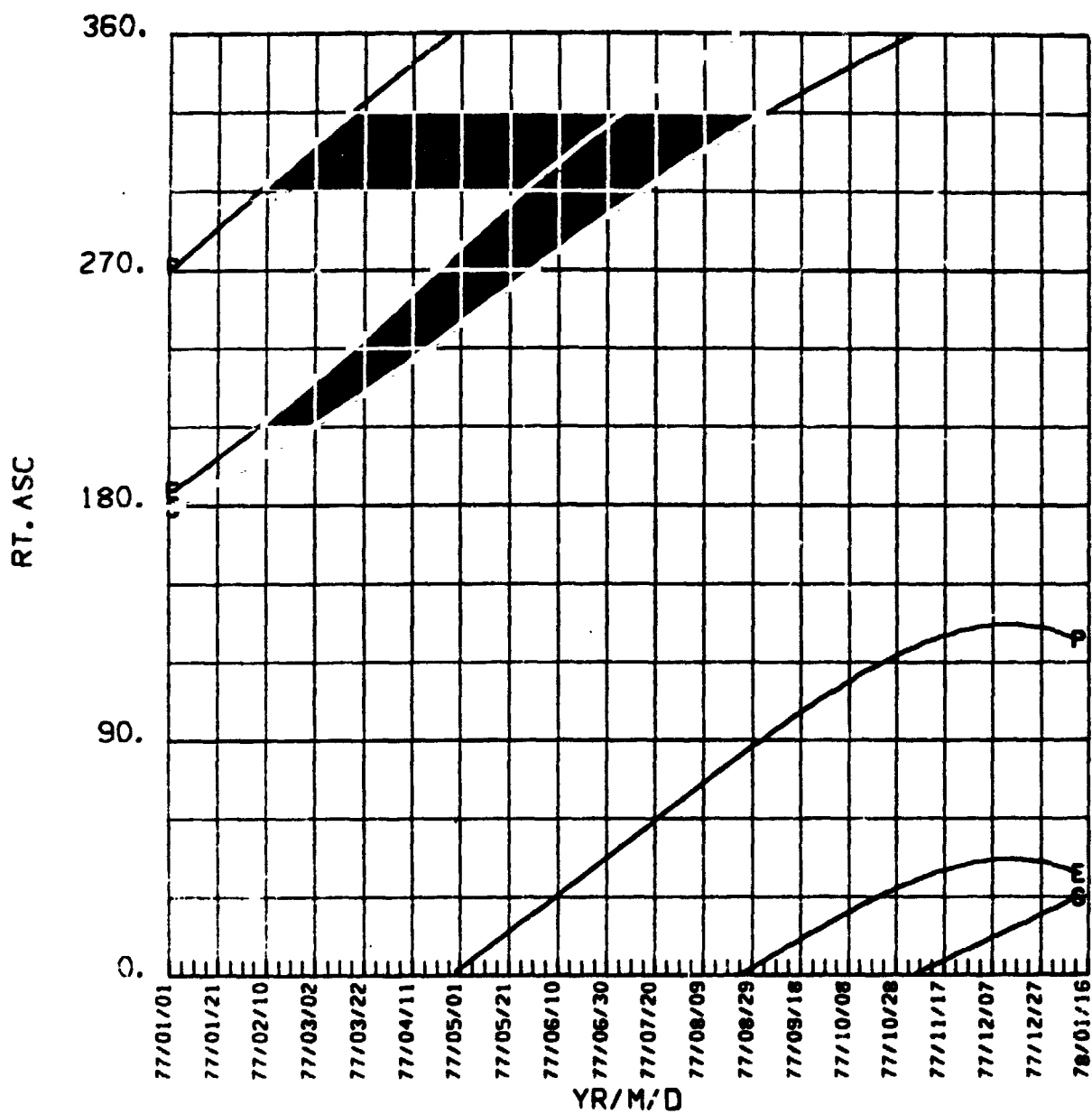
STATION RISE/SET GMT. HR



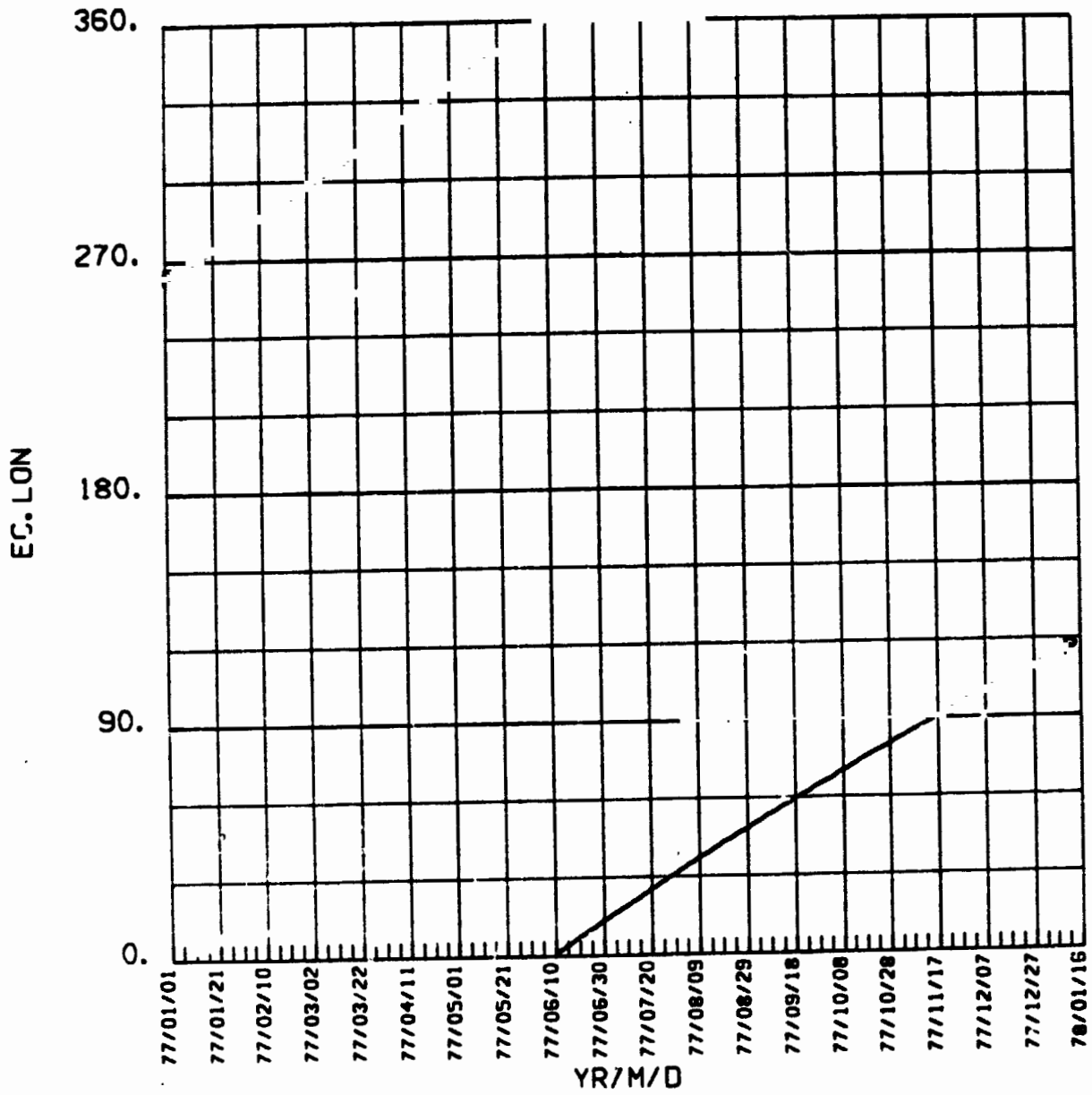
MARS 1977



MARS 1977



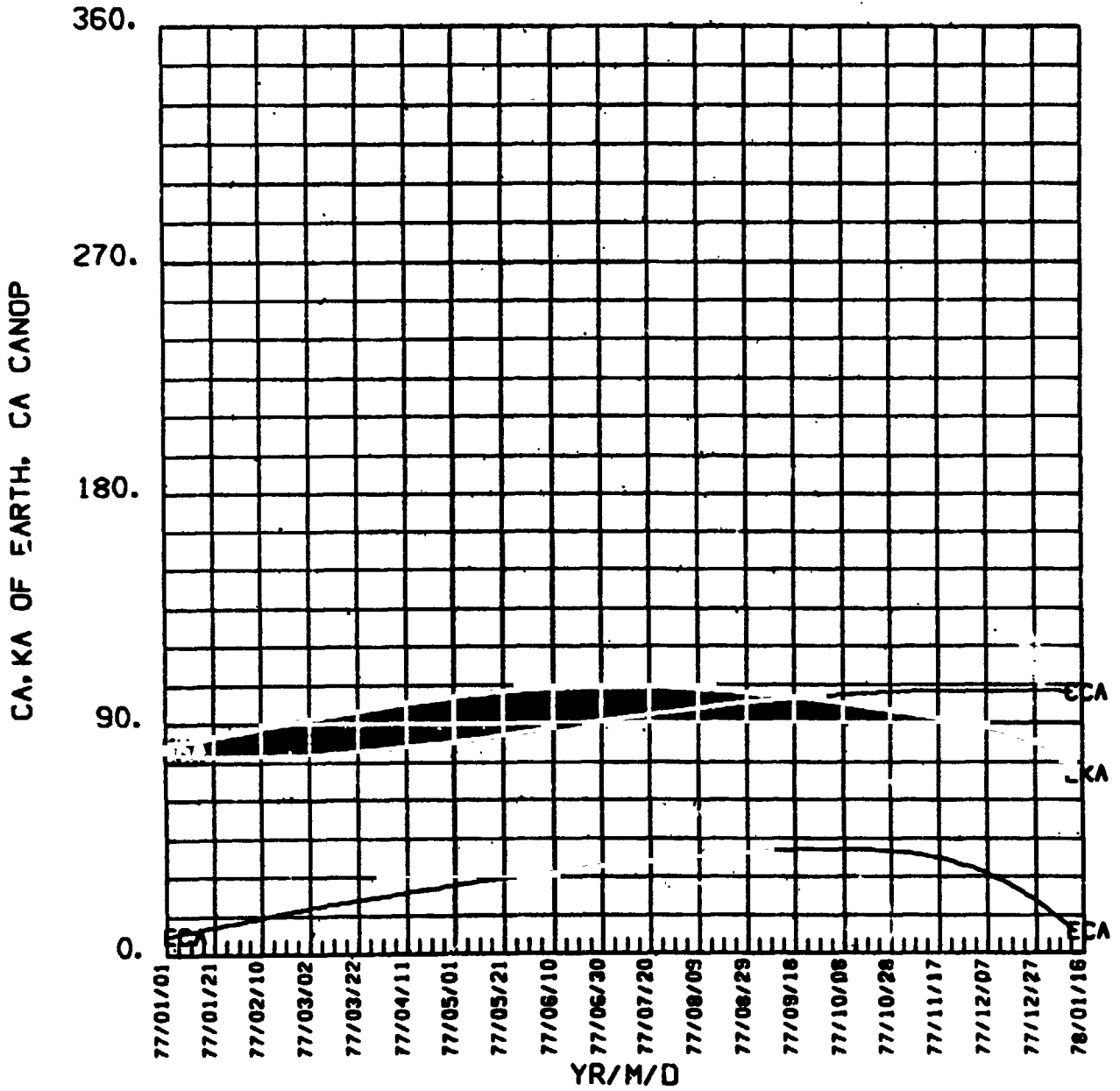
MARS 1977



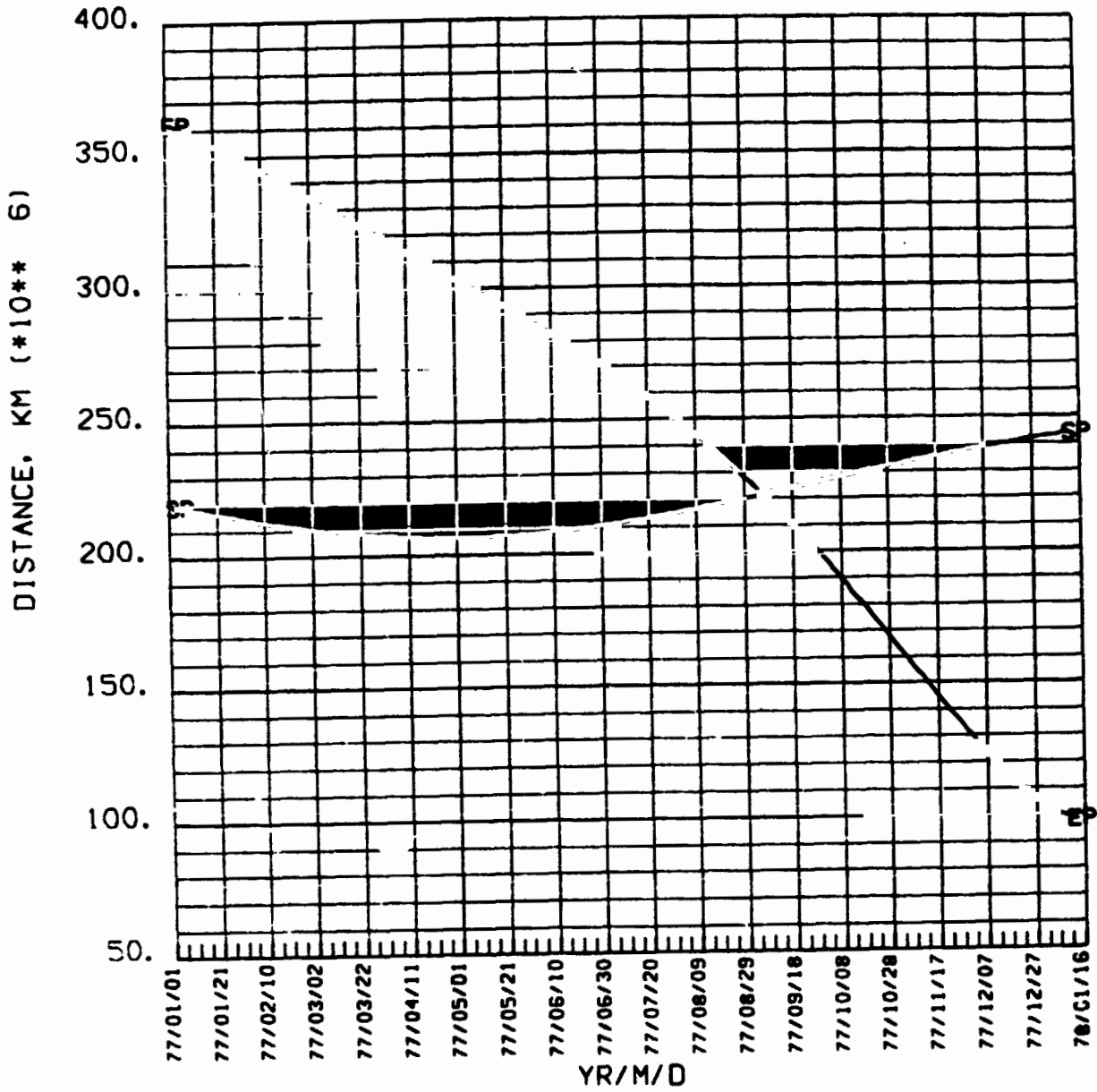


MARS

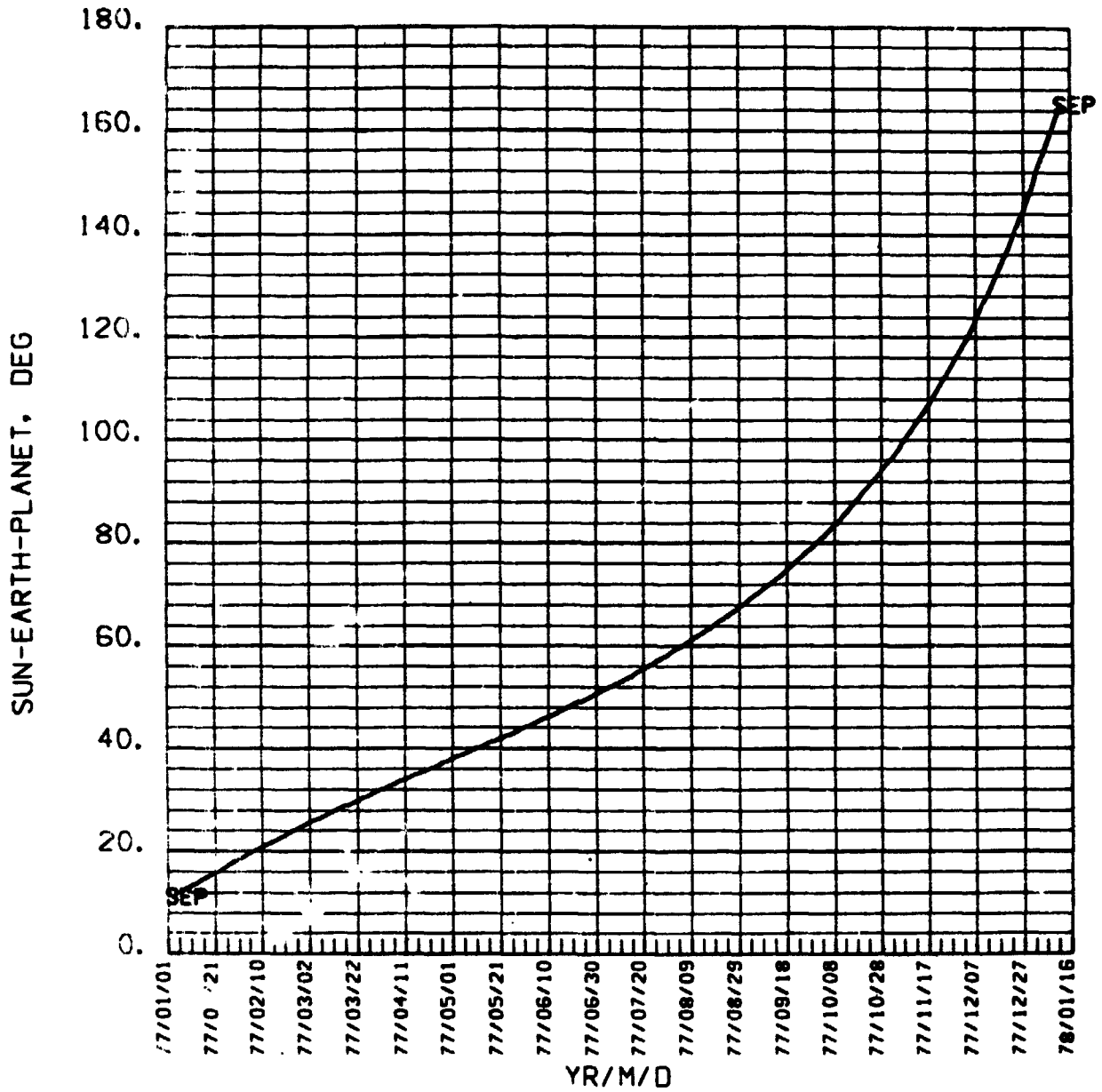
1977



MARS 1977

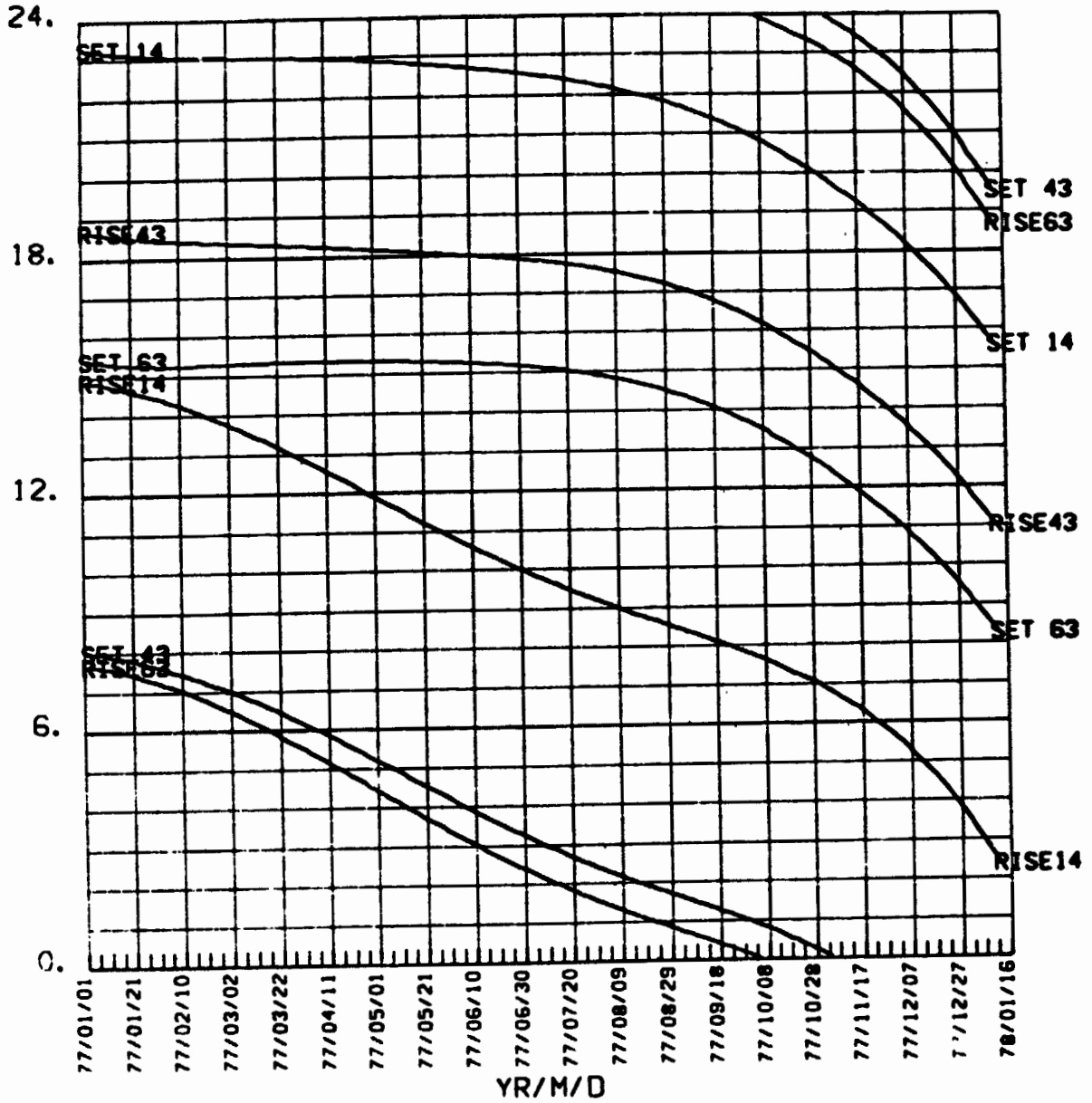


MARS 1977

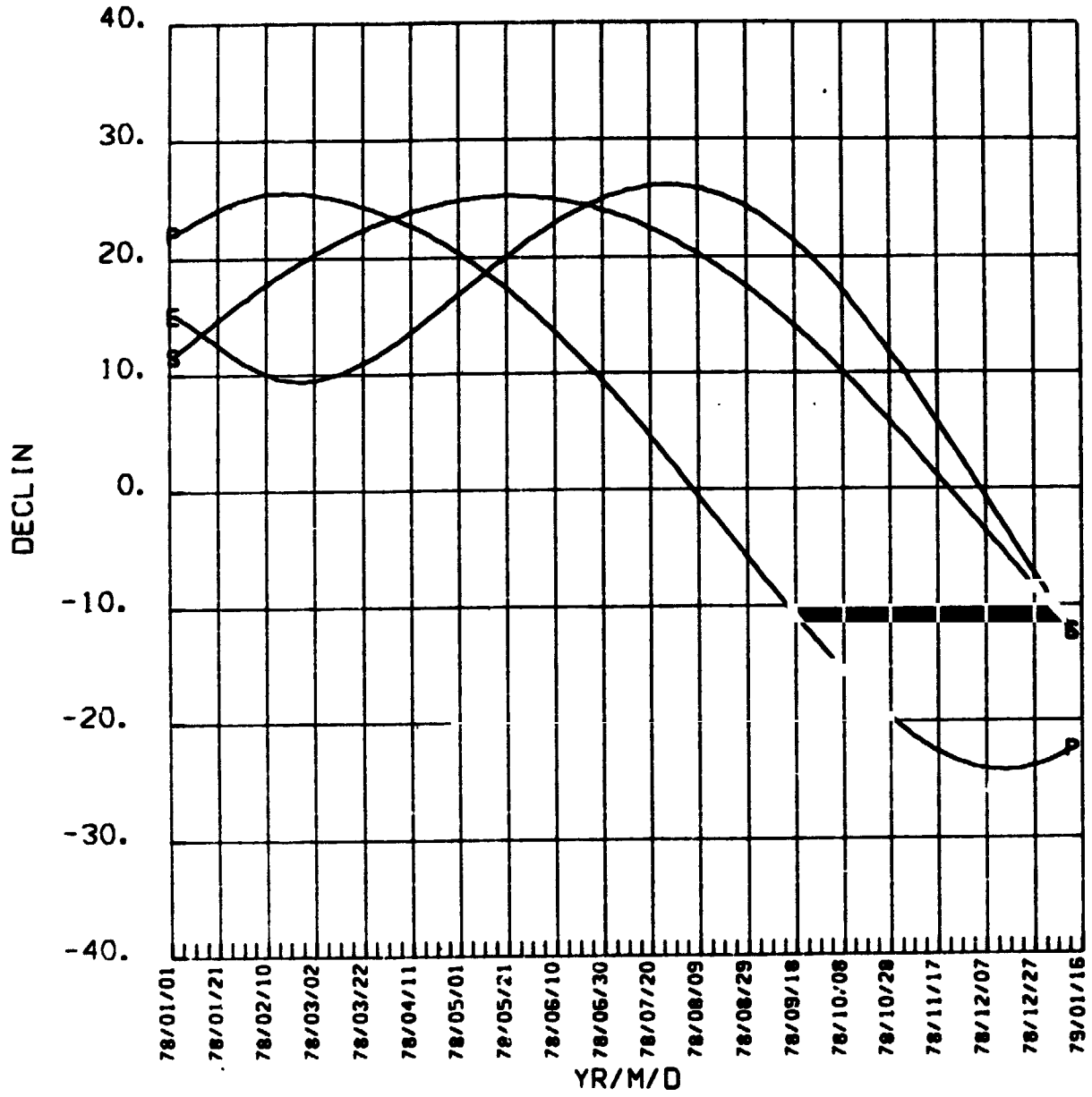


MARS 1977

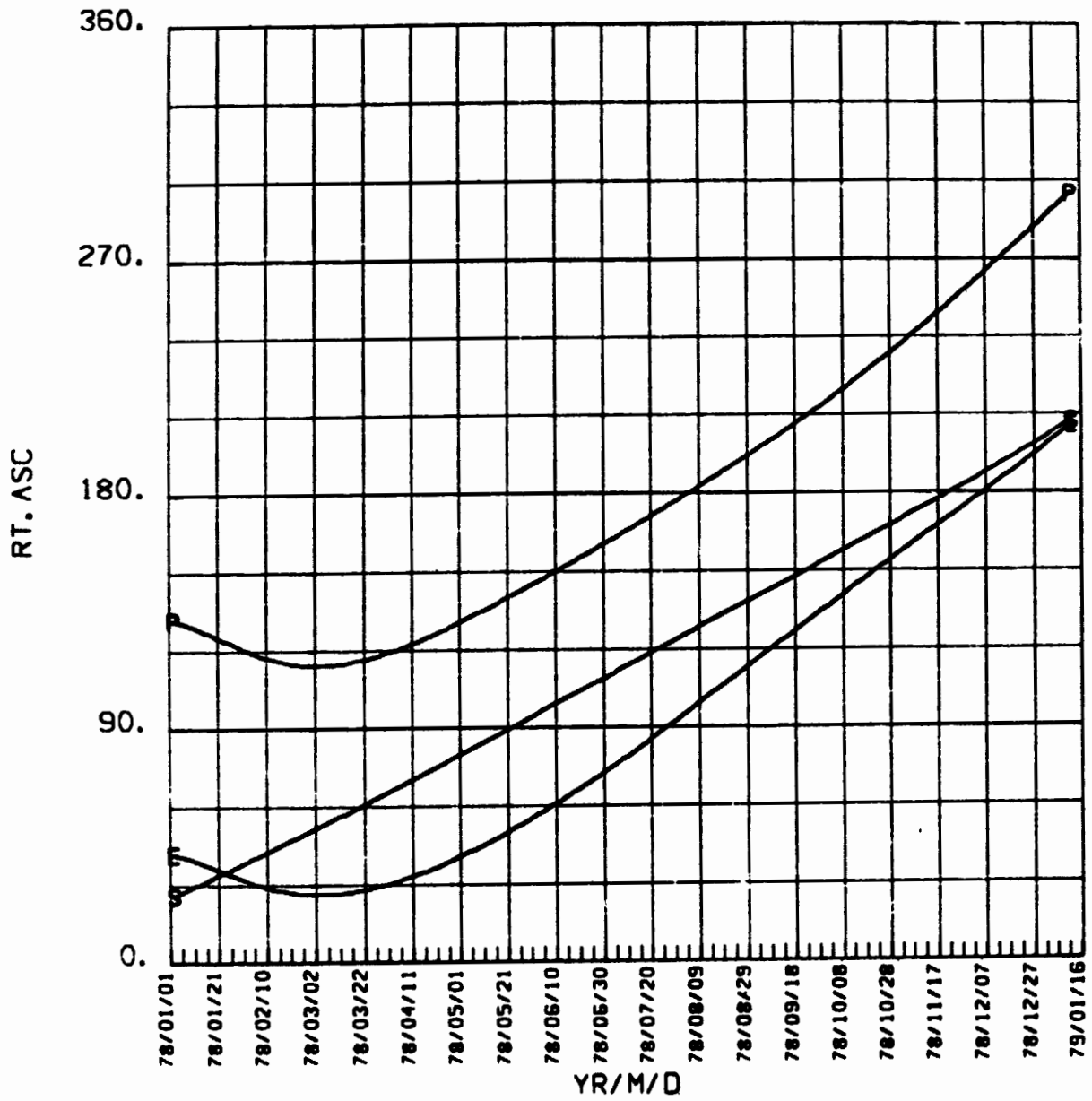
STATION RISE/SET GMT, HR



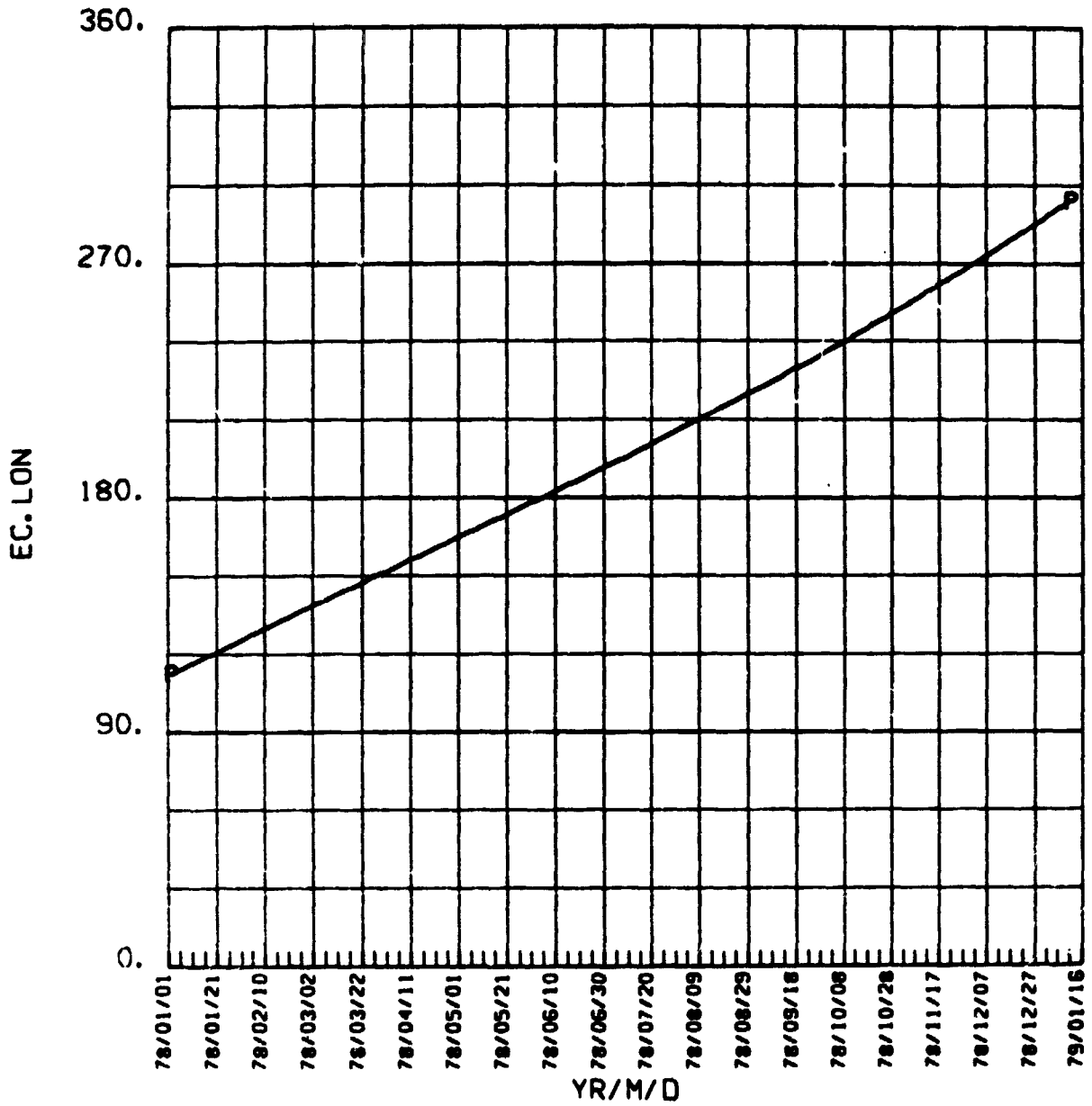
MARS 1978



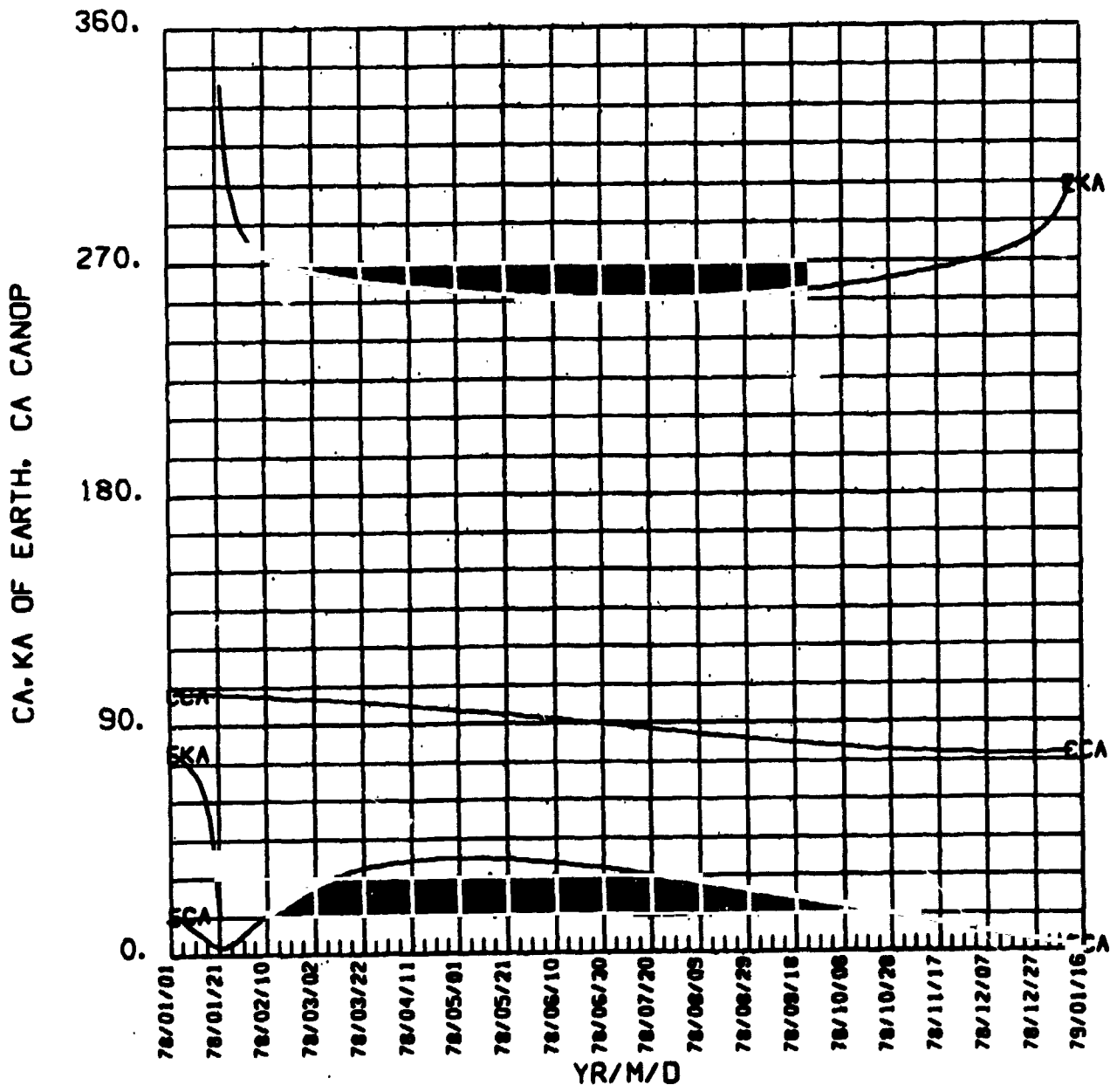
MARS 1978



MARS 1978

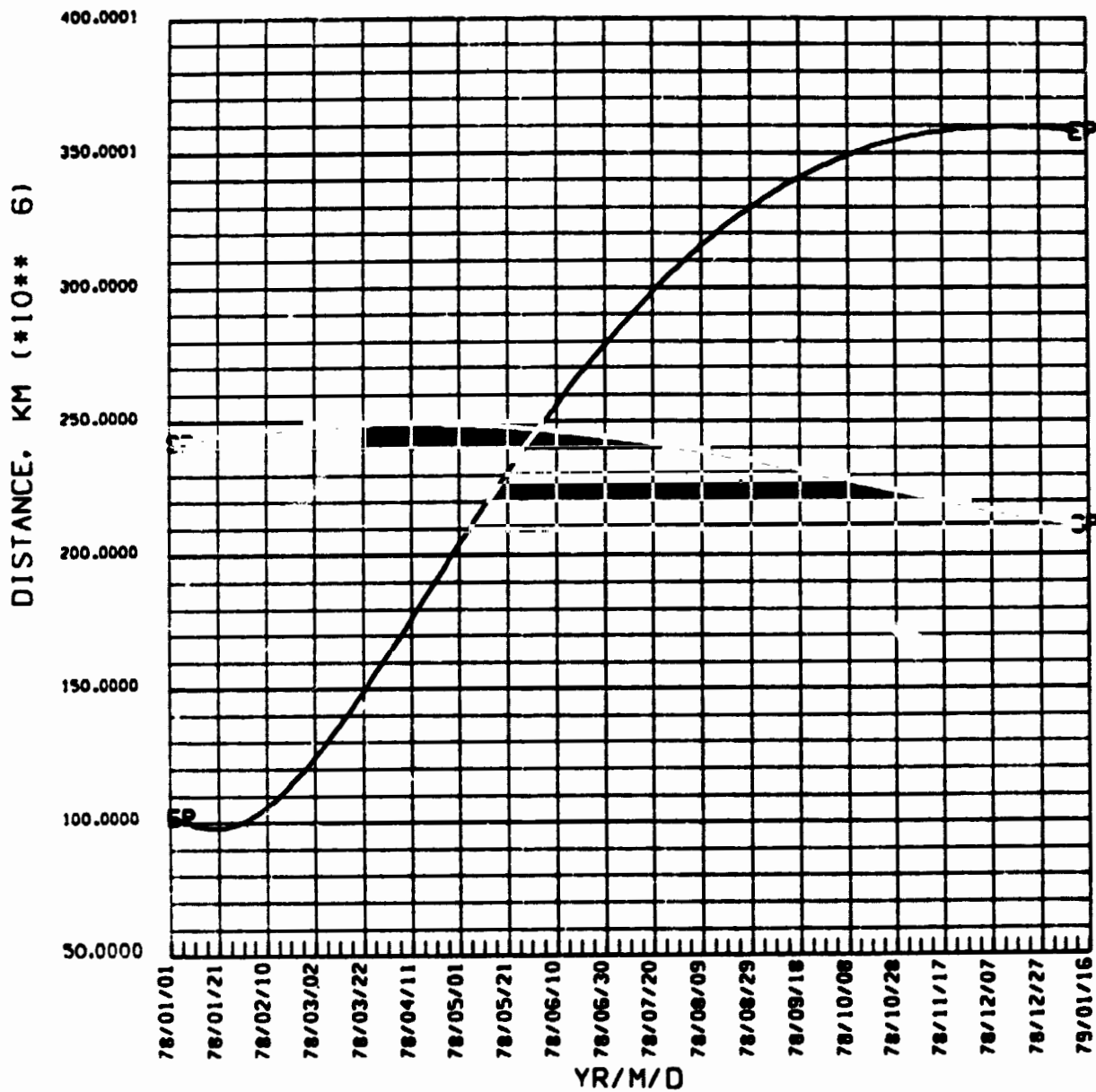


MARS 1978

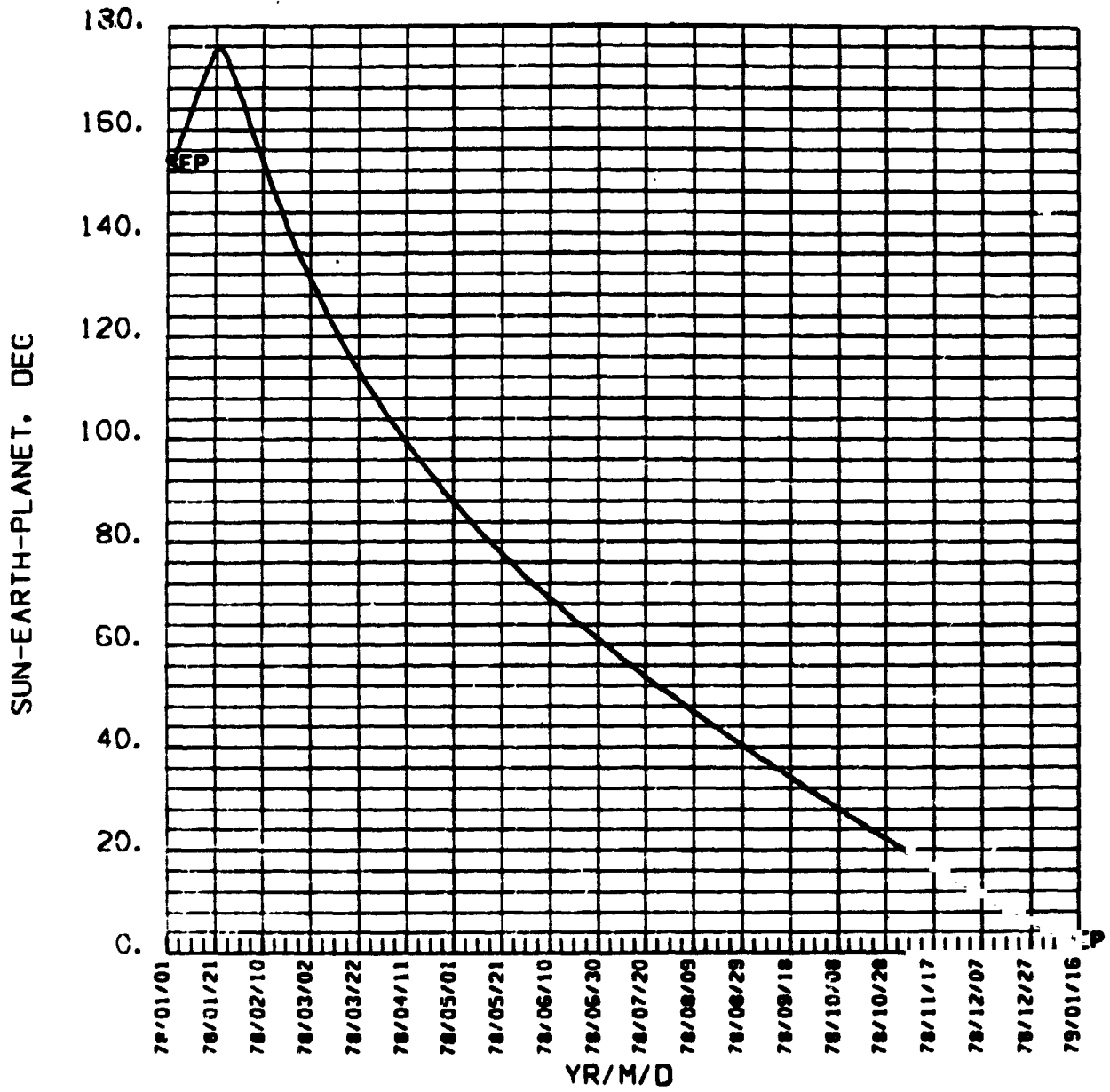




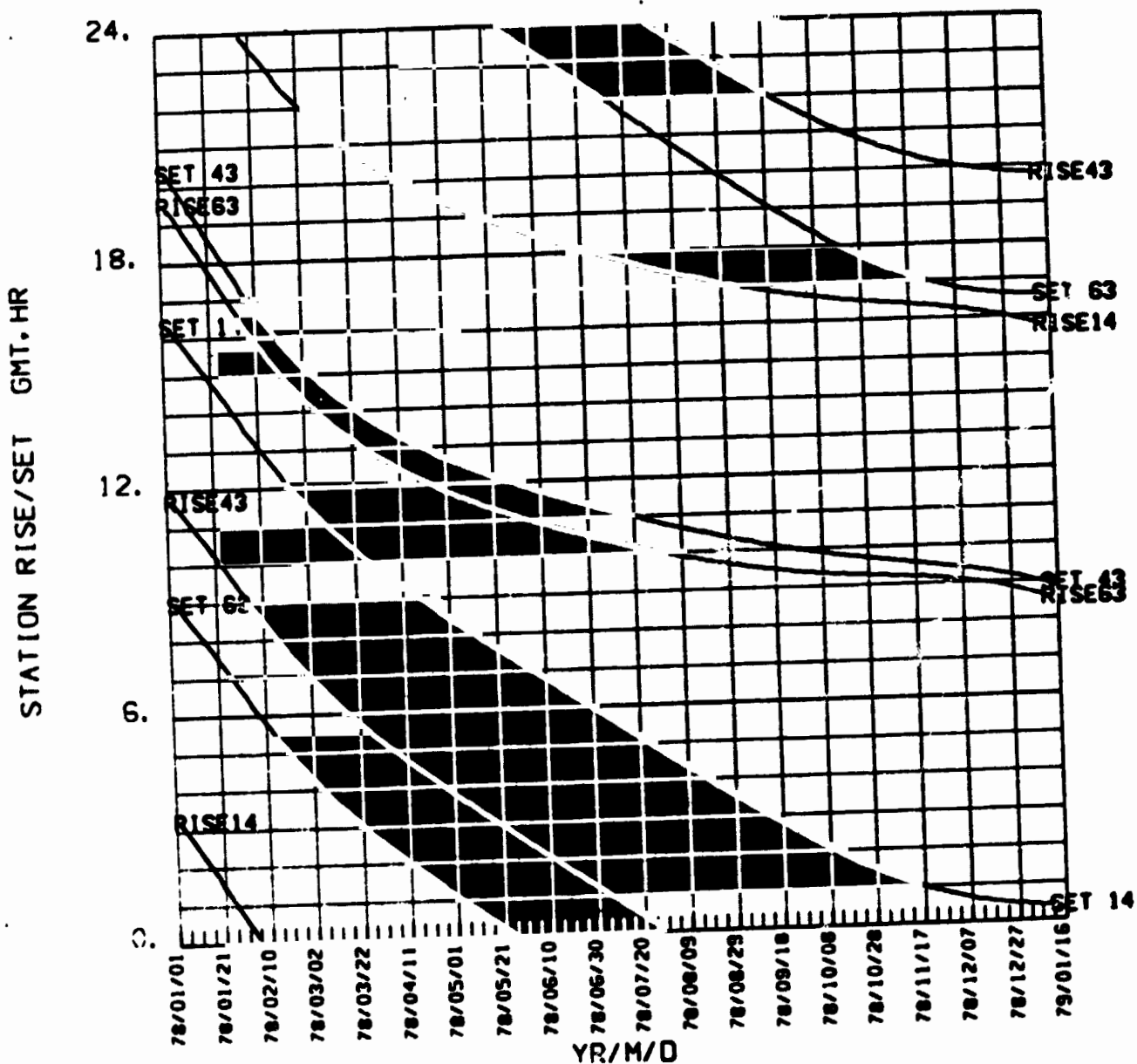
MARS 1978



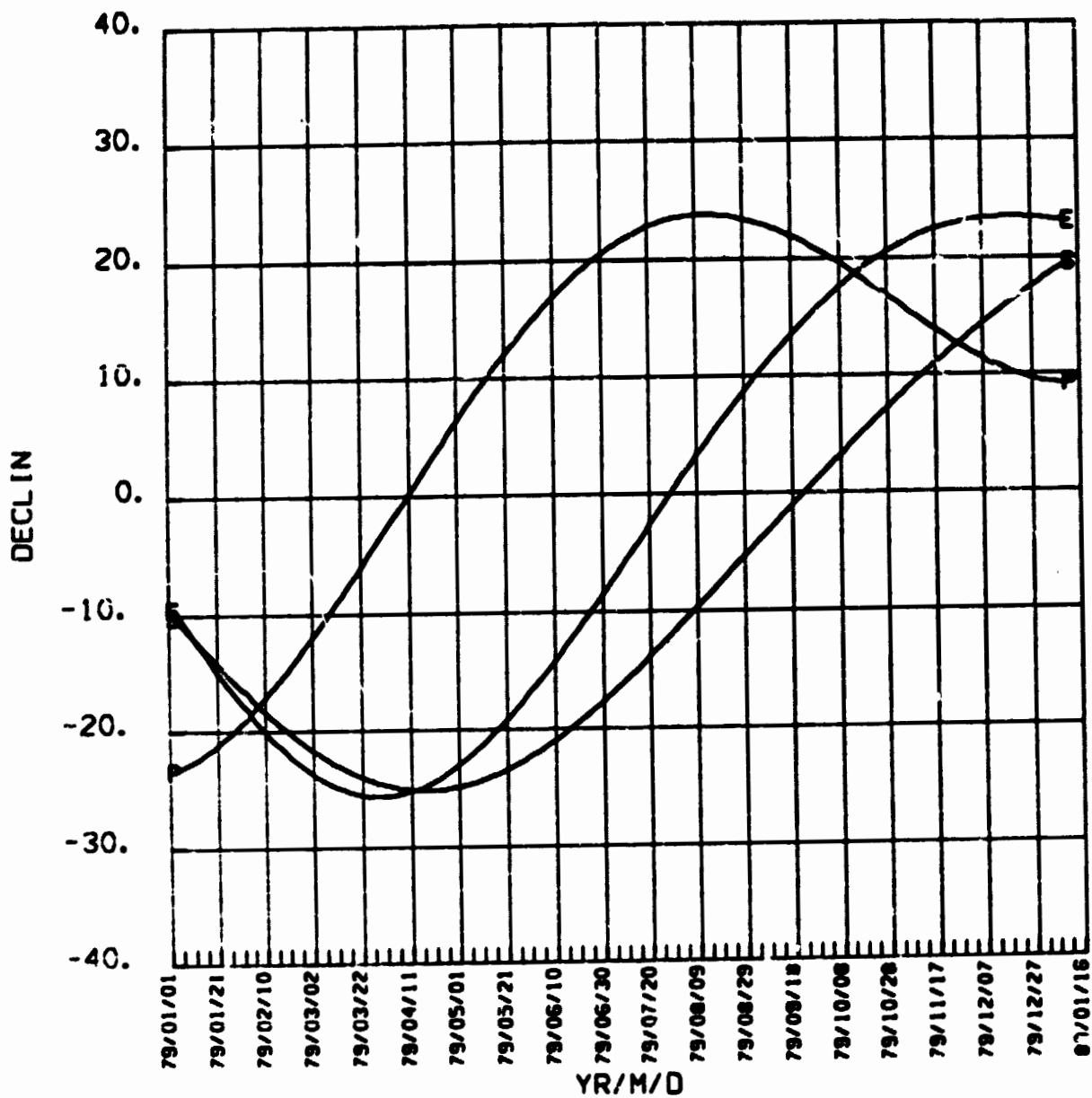
MARS 1978



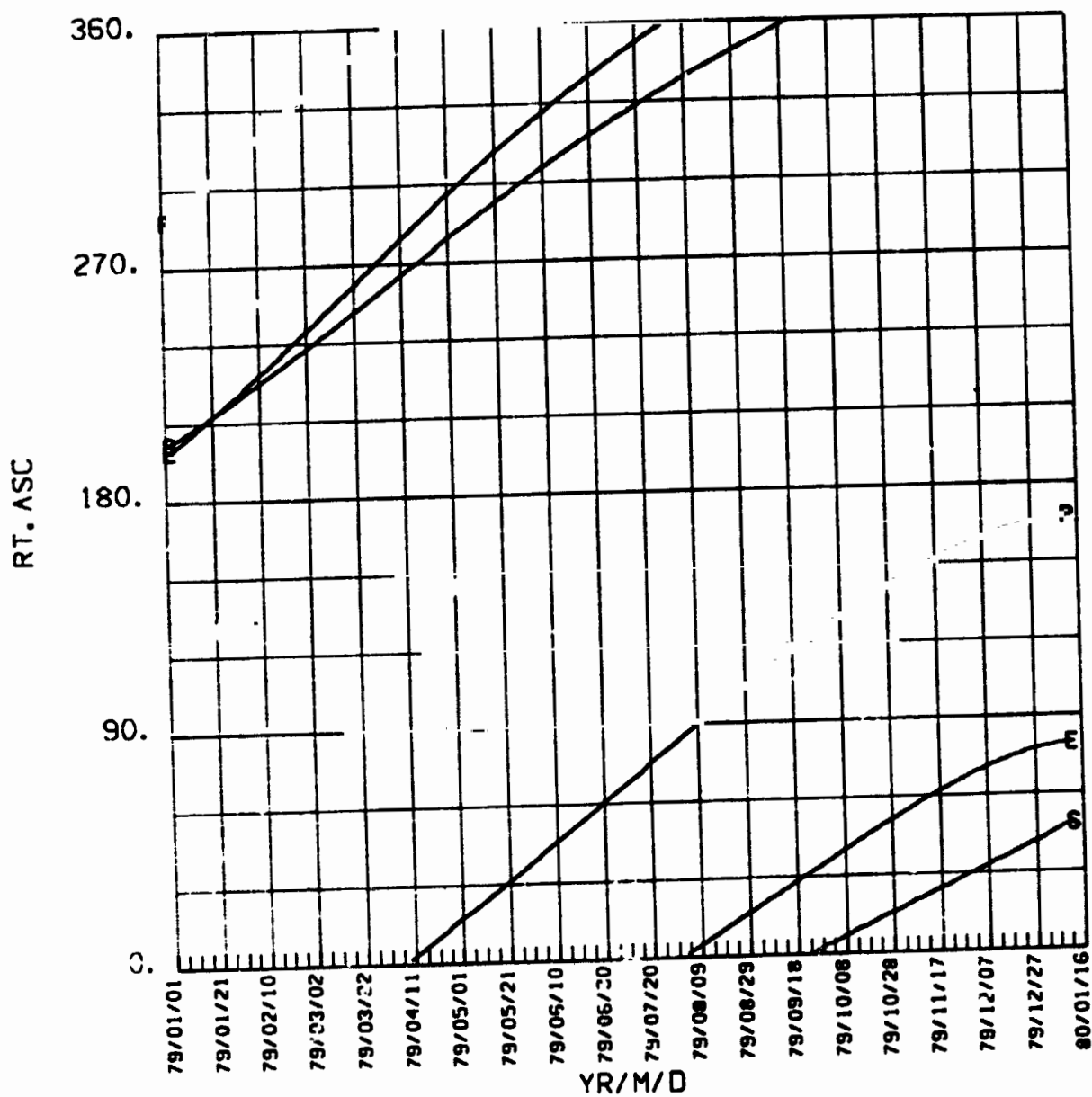
MARS 1978



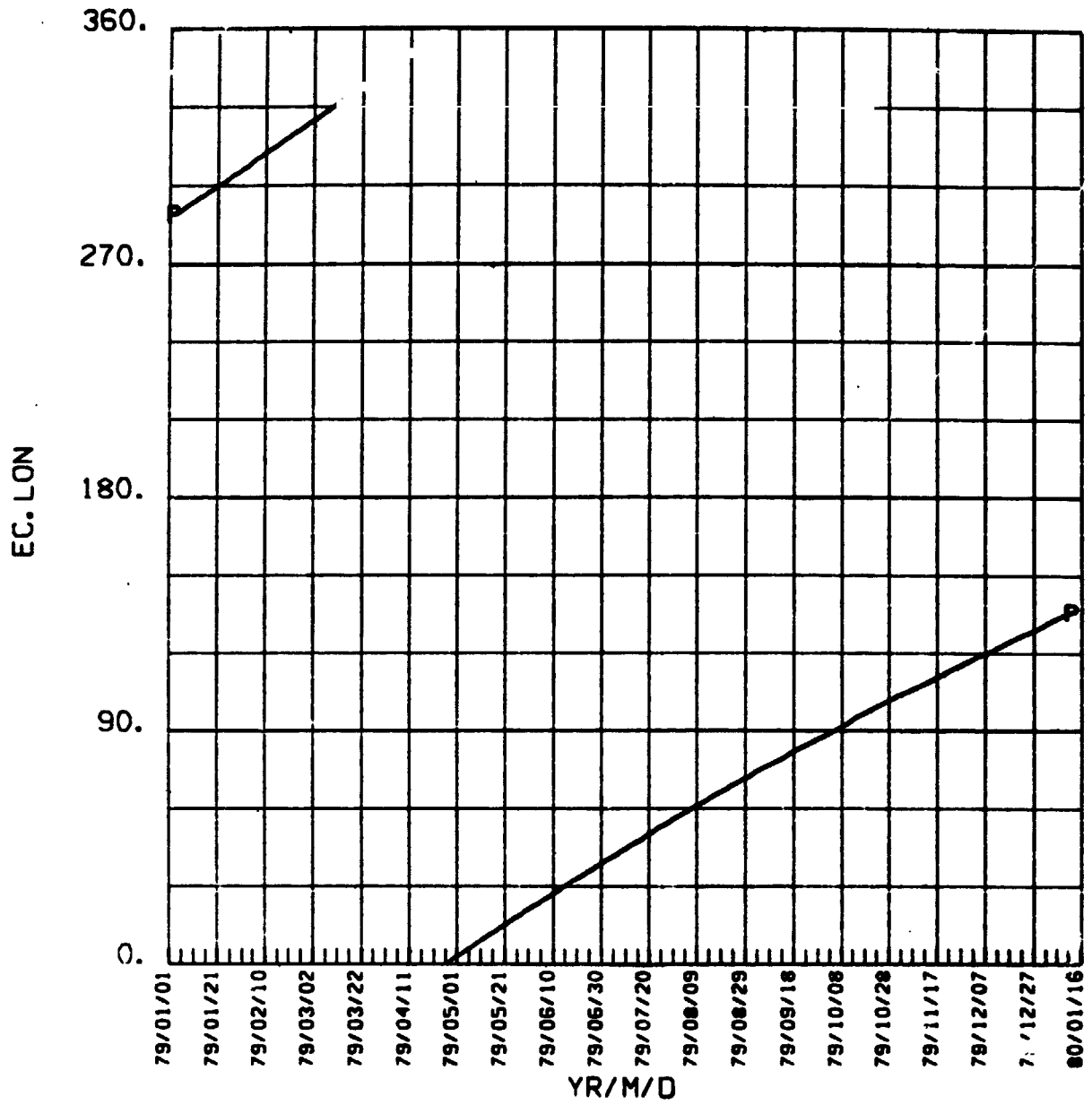
MARS 1979



MARS 1979

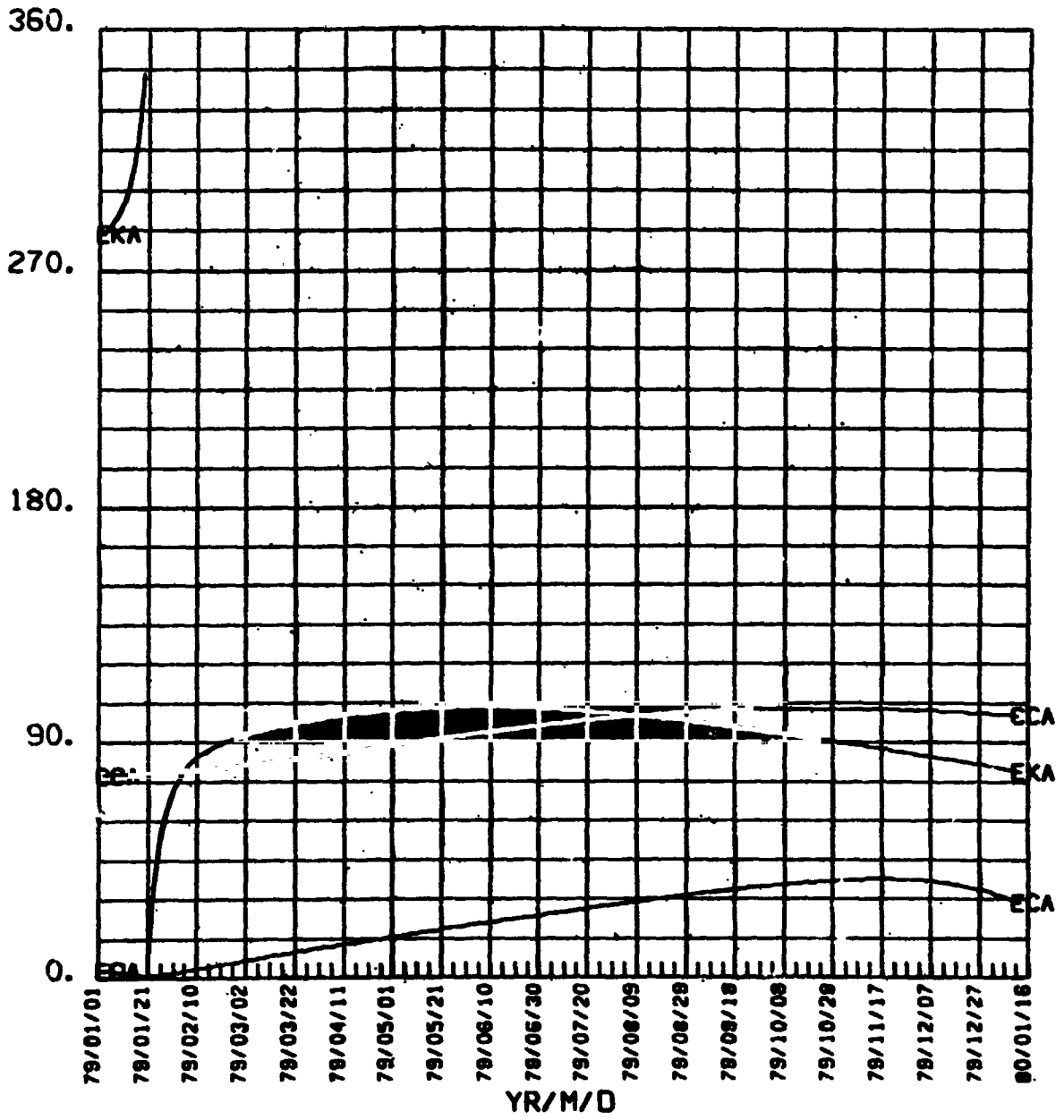


MARS 1979

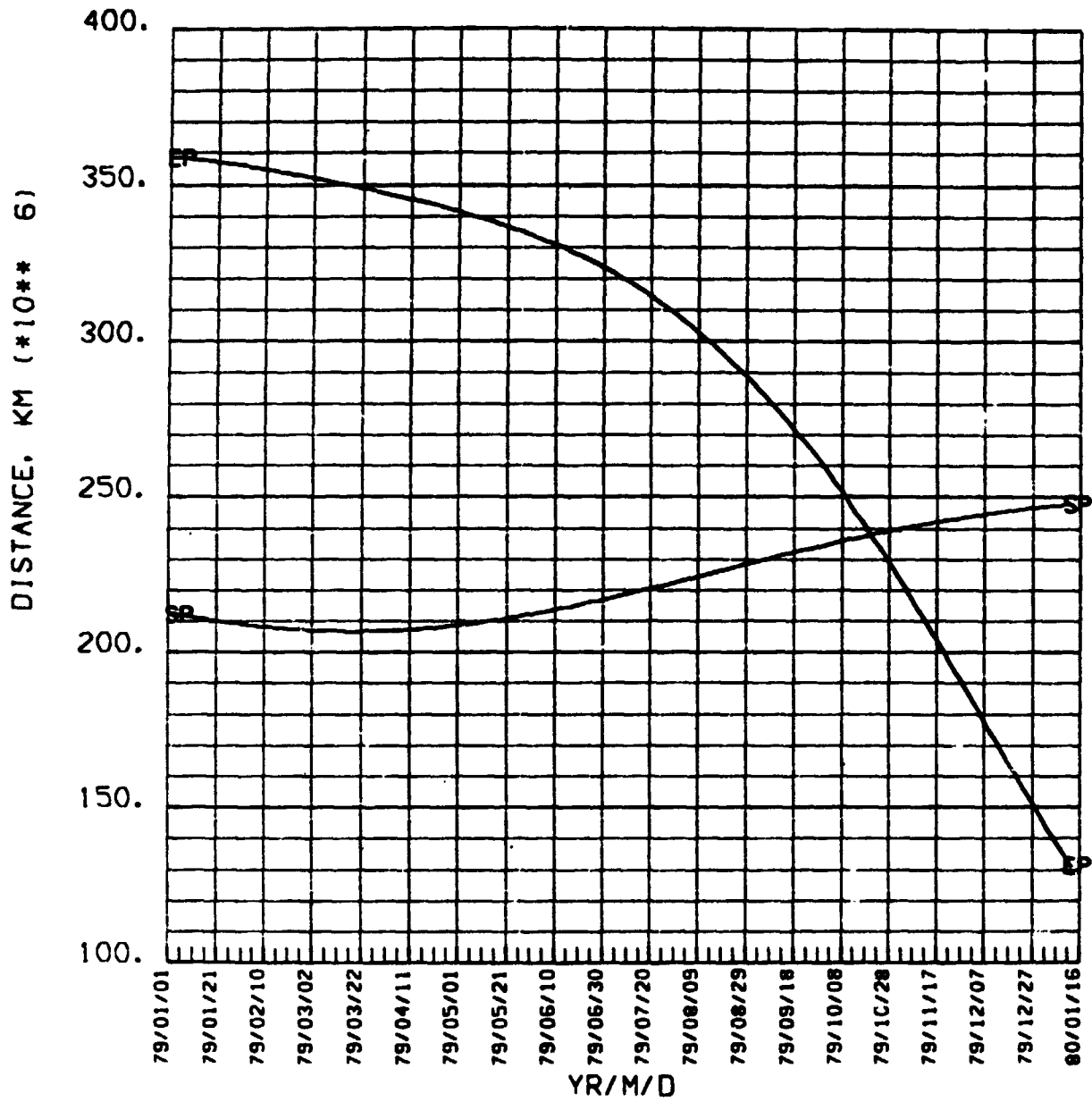


MARS 1979

CA. KA OF EARTH, CA CANOP

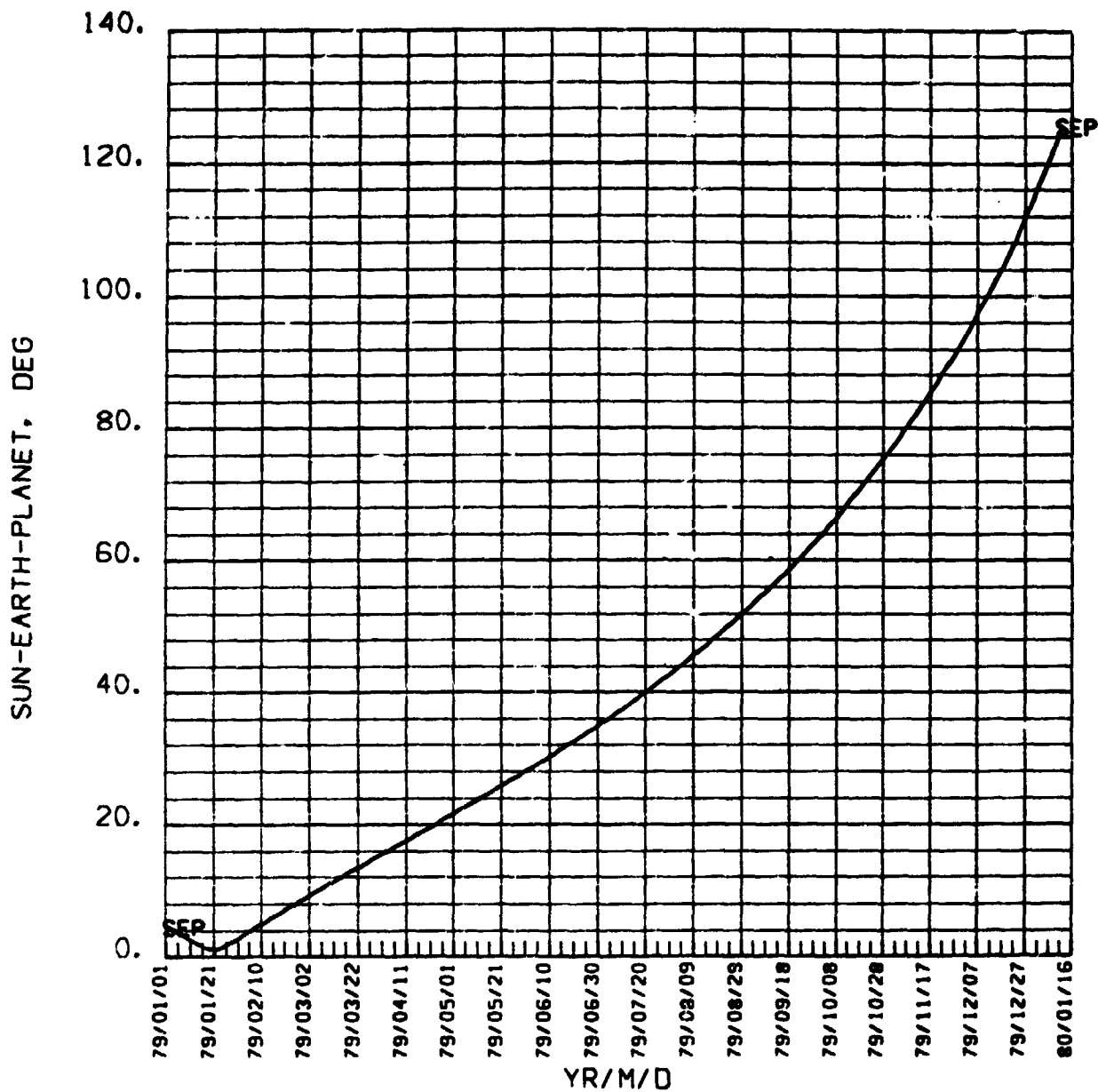


MARS 1979

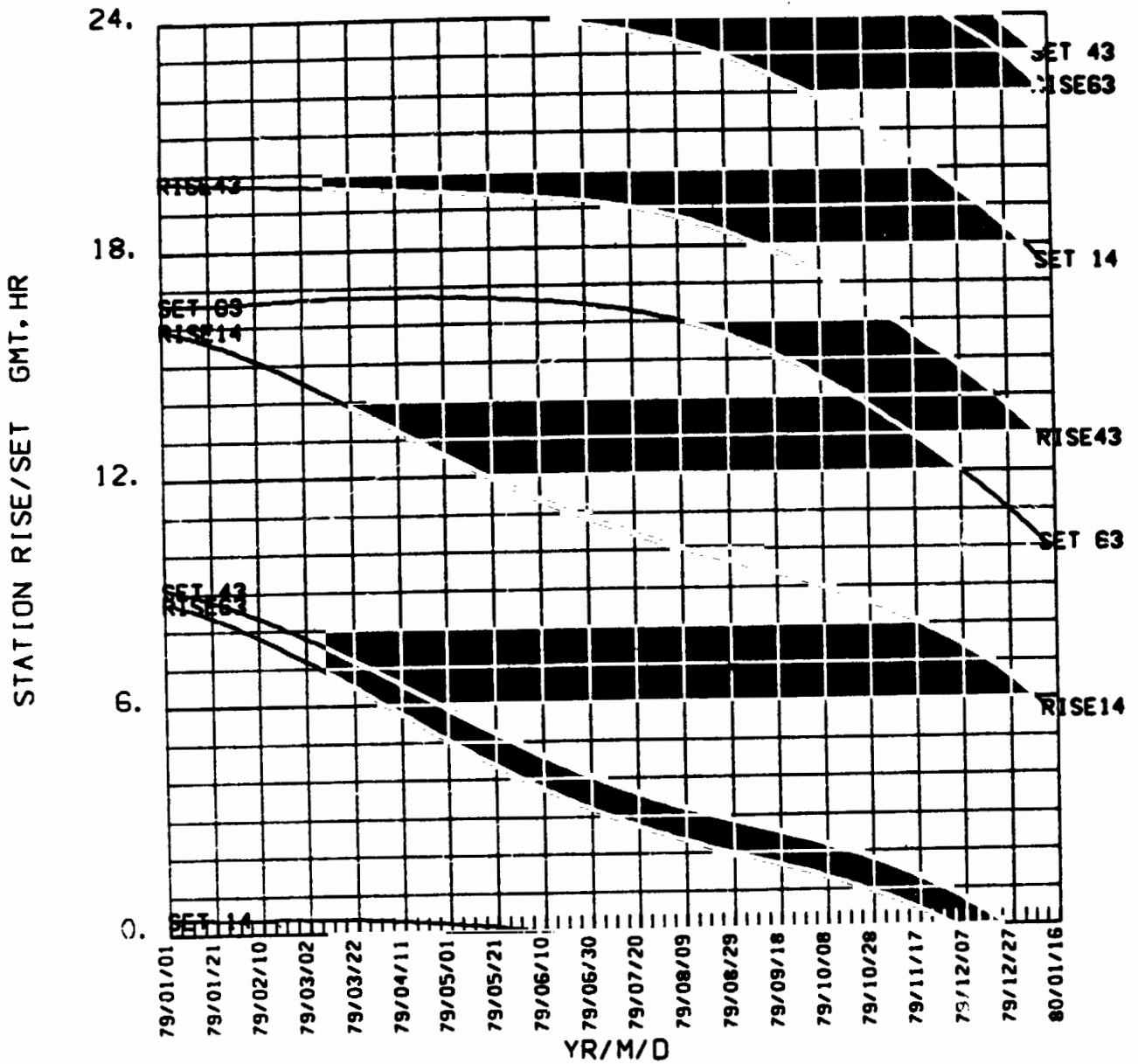




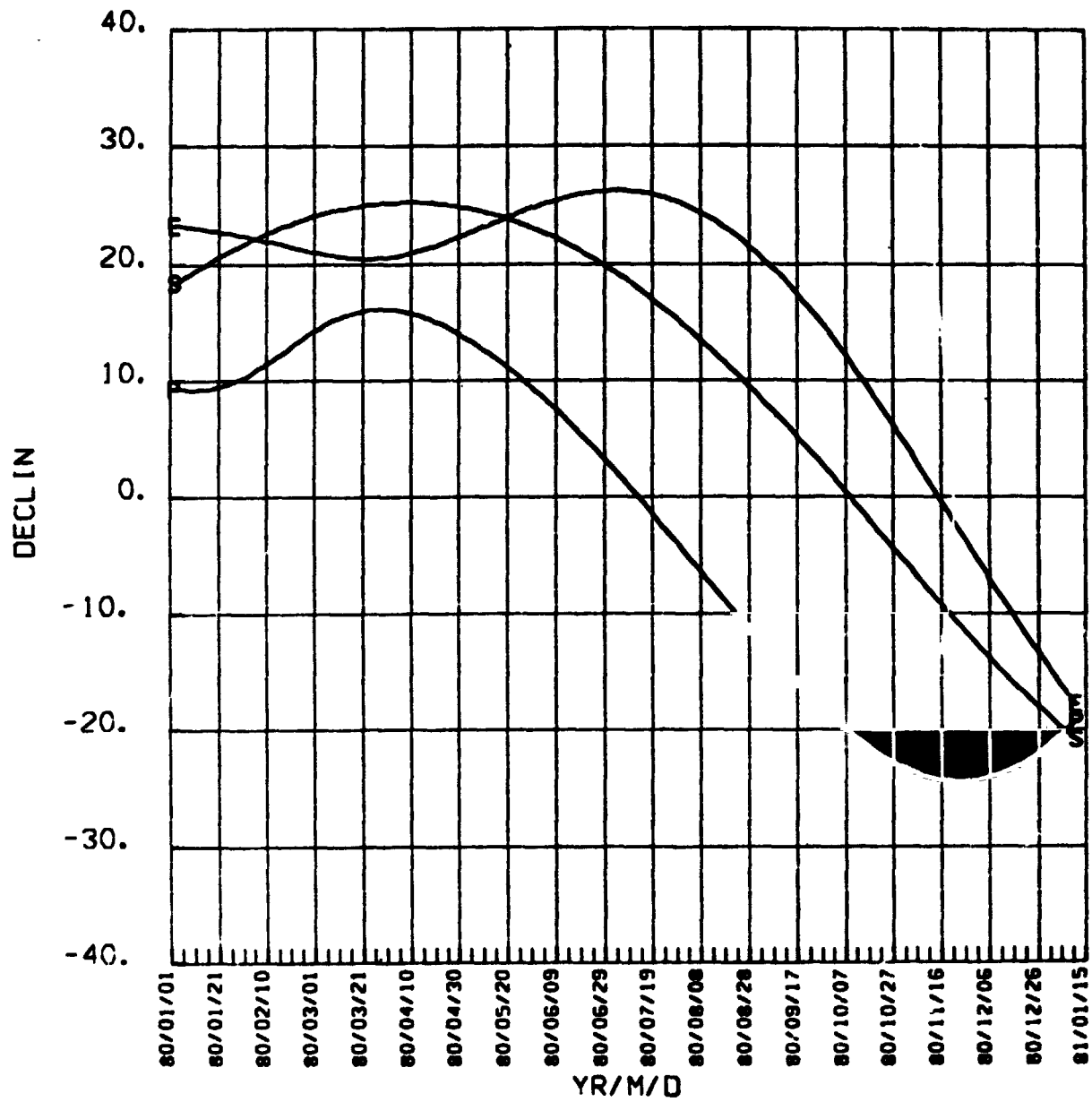
MARS 1979



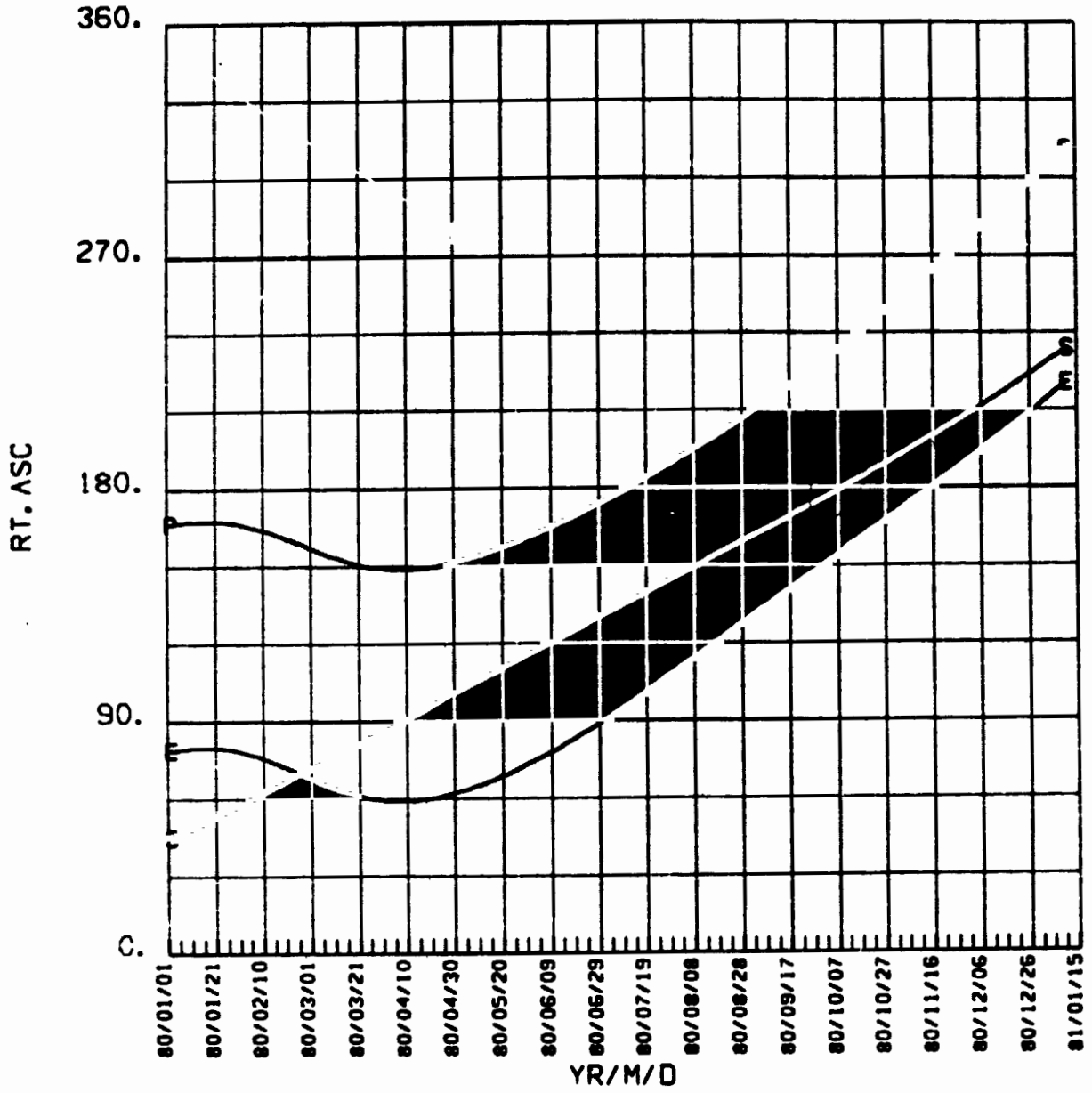
MARS 1979



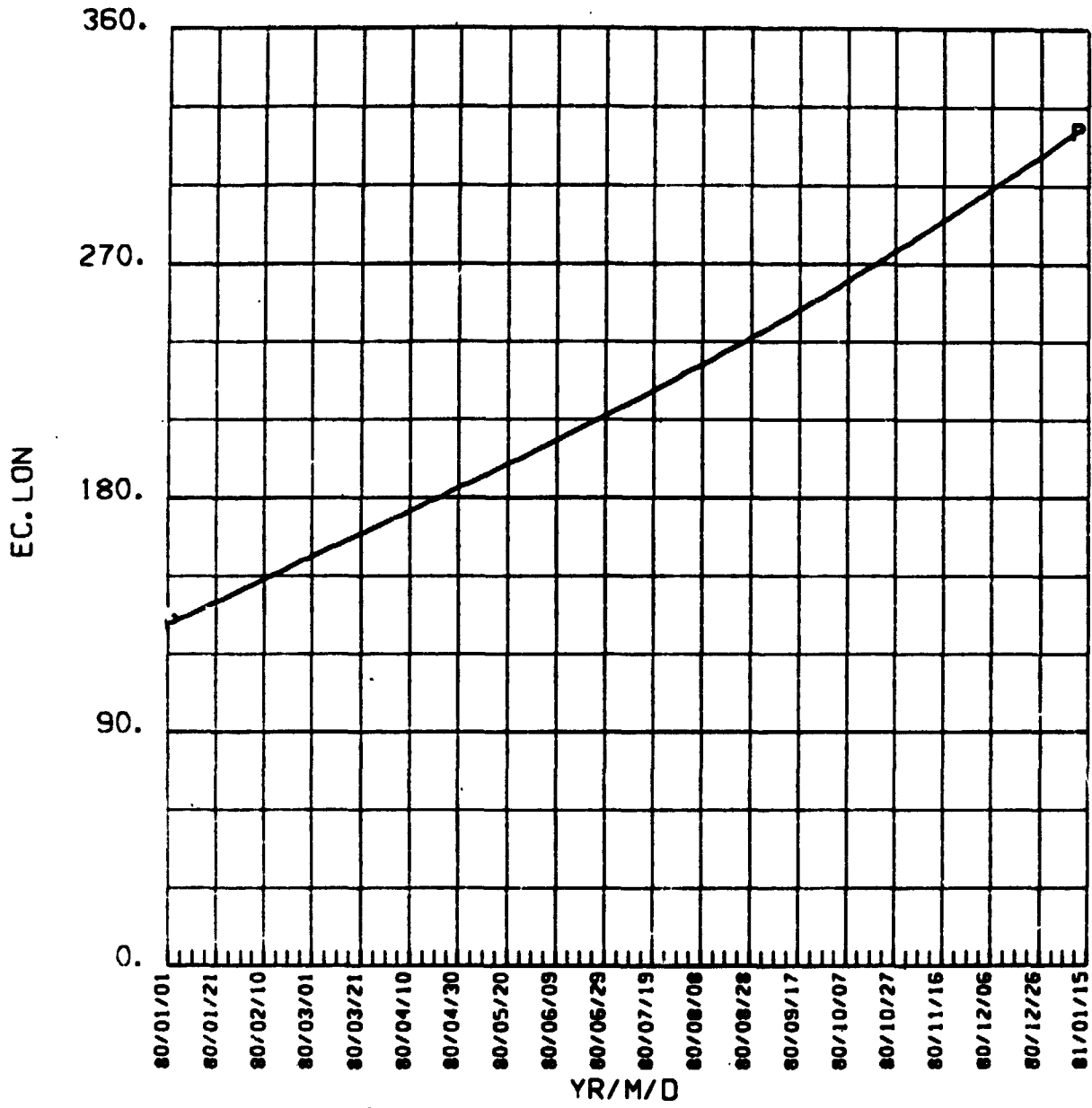
MARS 1980



MARS 1980



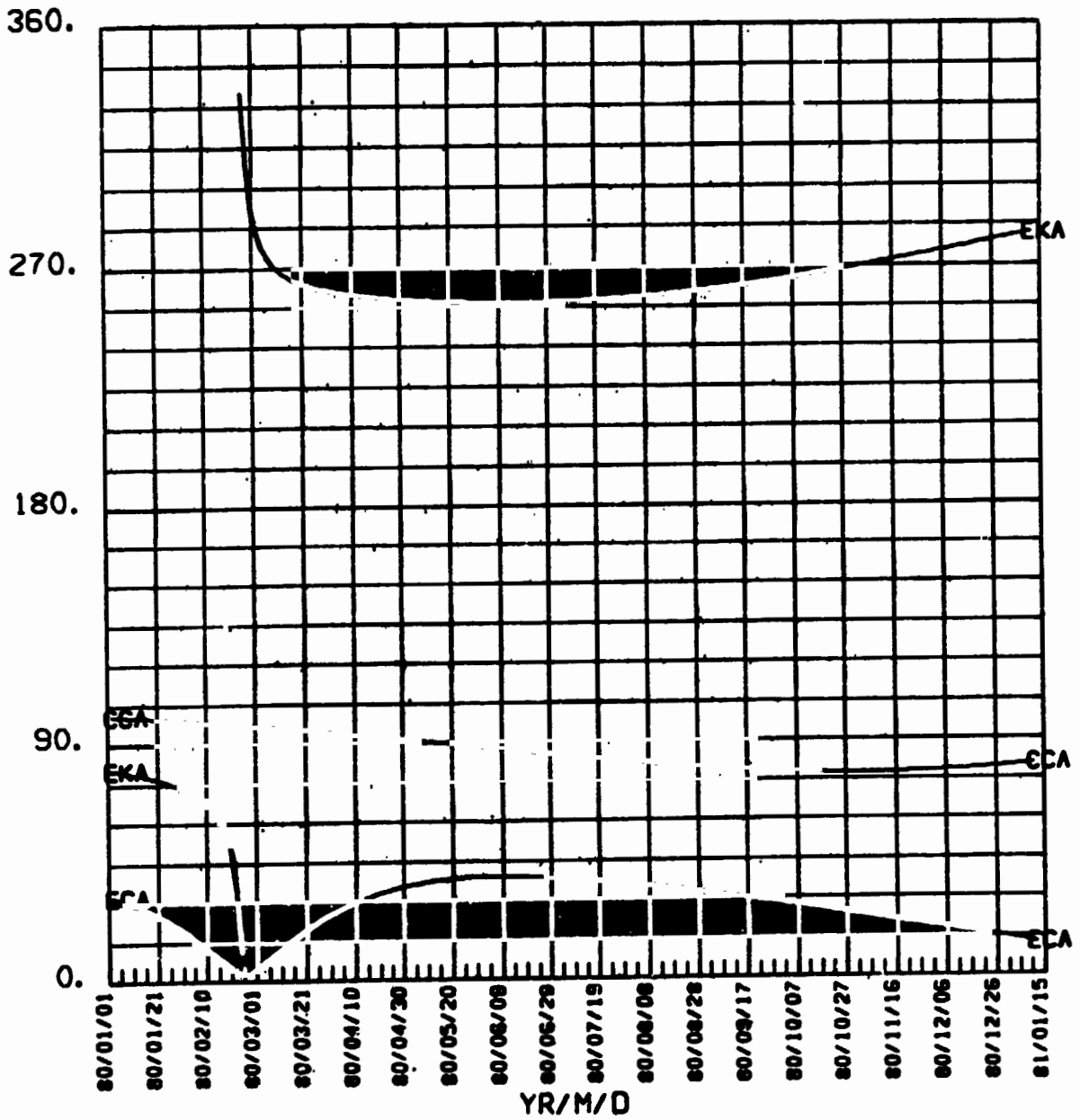
MARS 1980



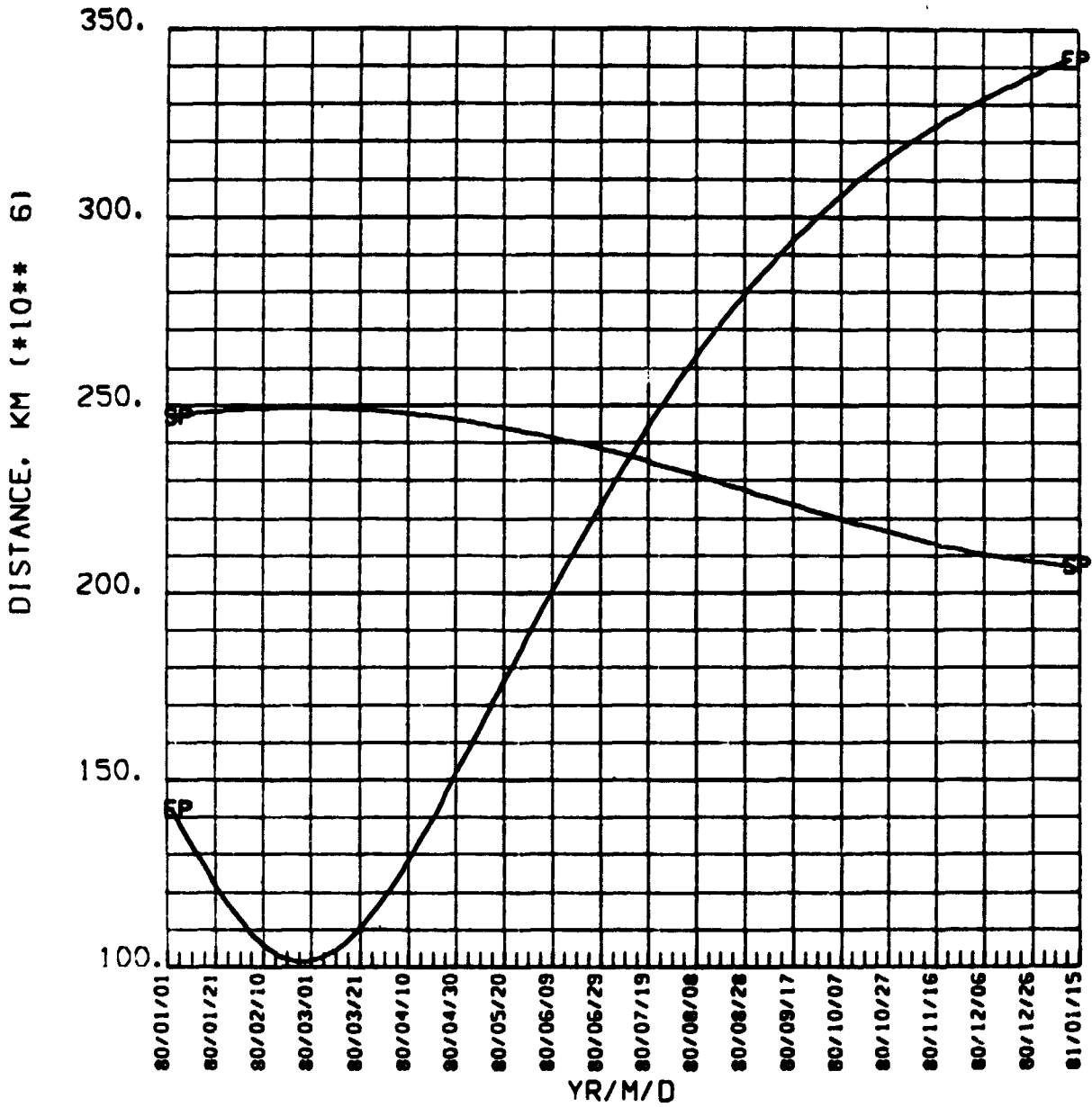
MARS

1980

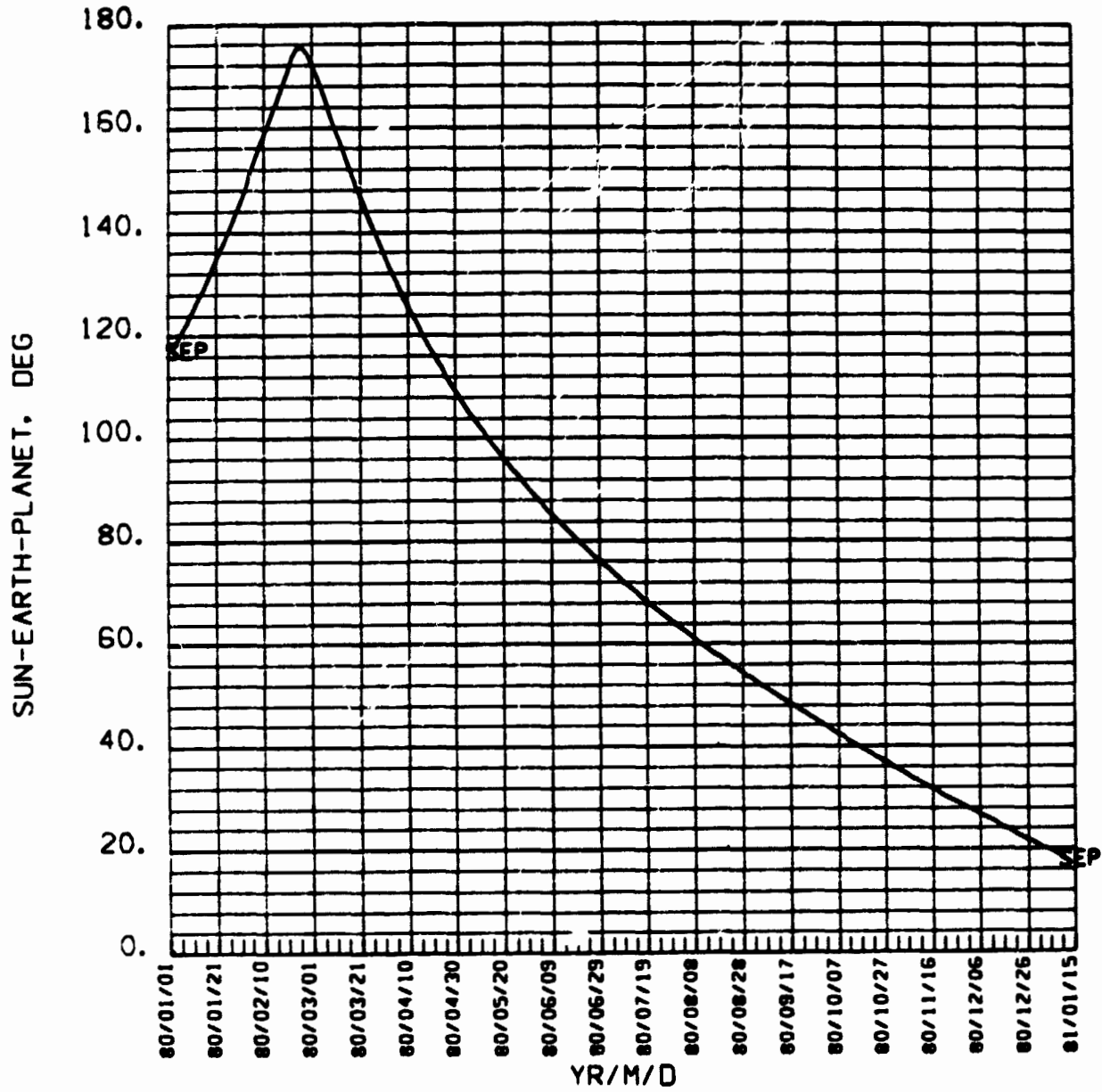
CA, KA OF EARTH, CA CANOP



MARS 1980

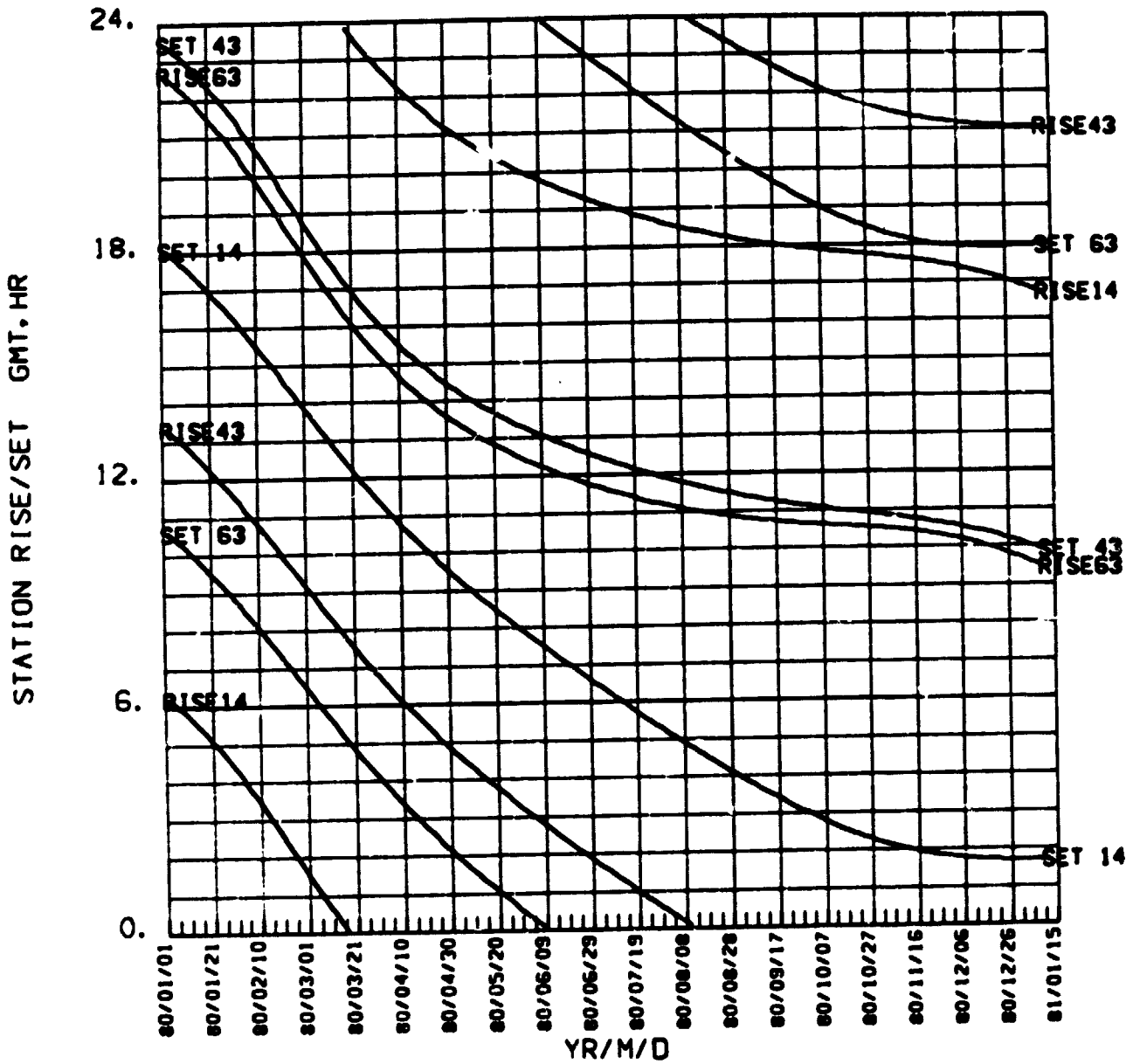


MARS 1980

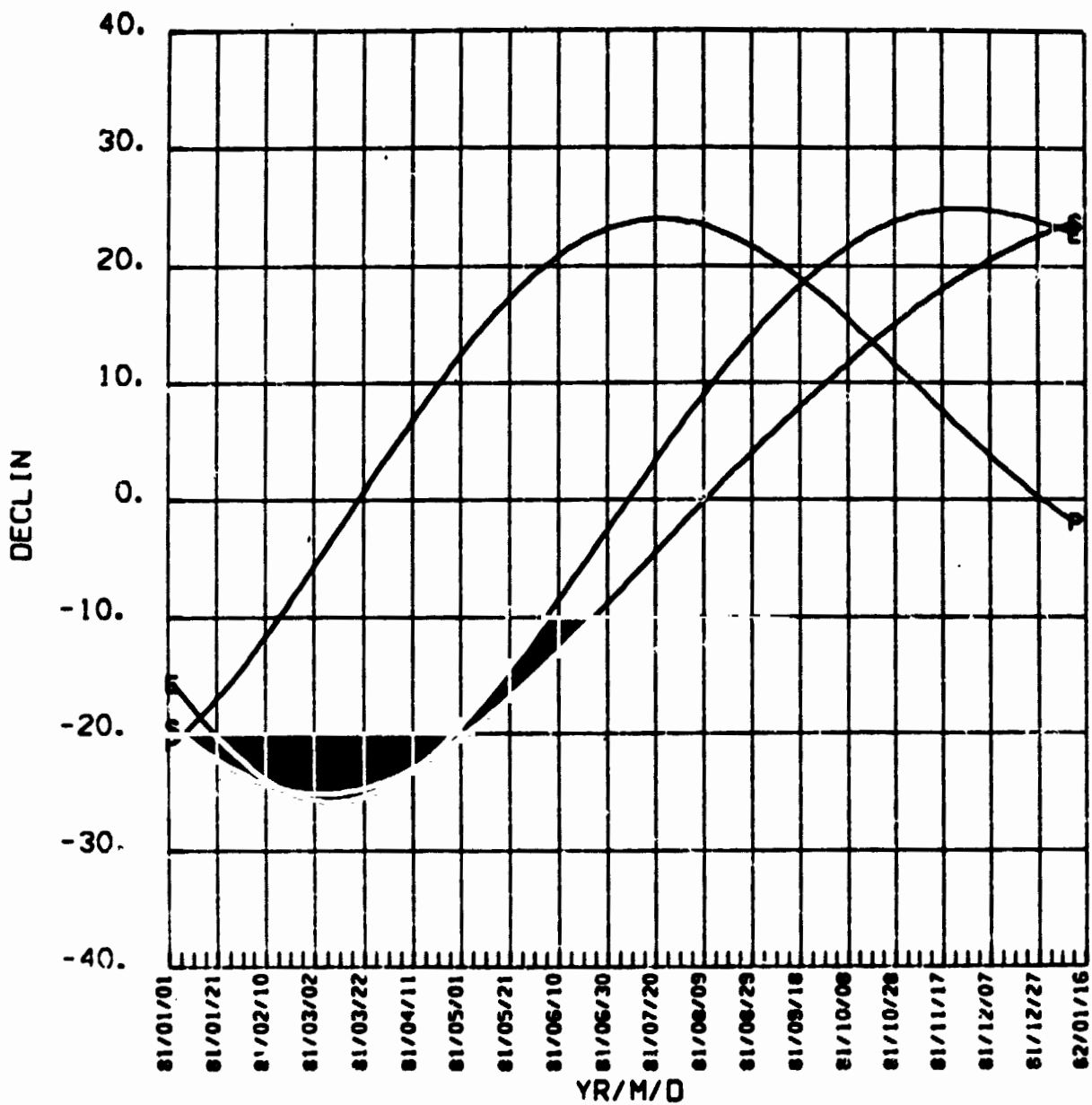




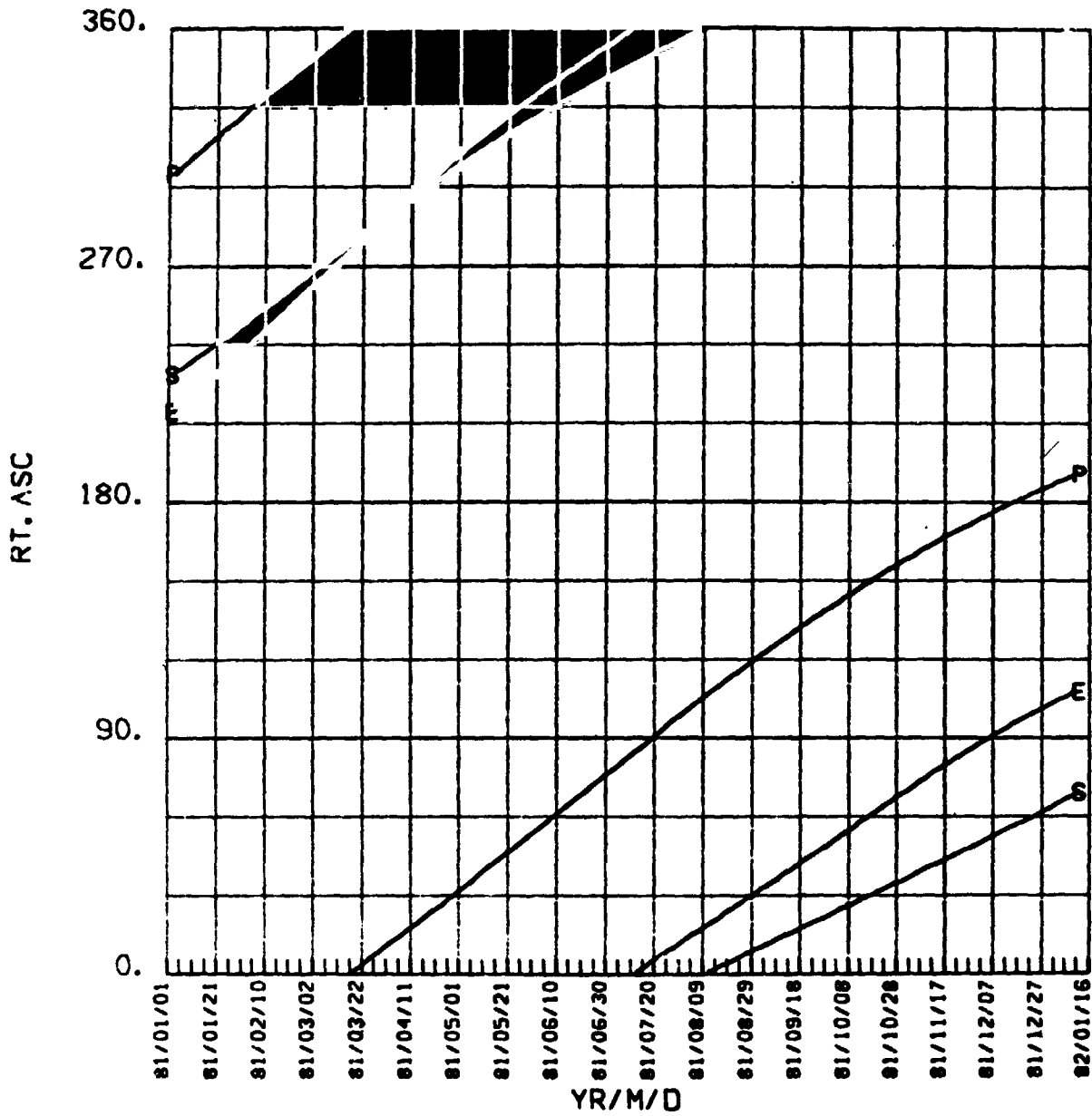
MARS 1980



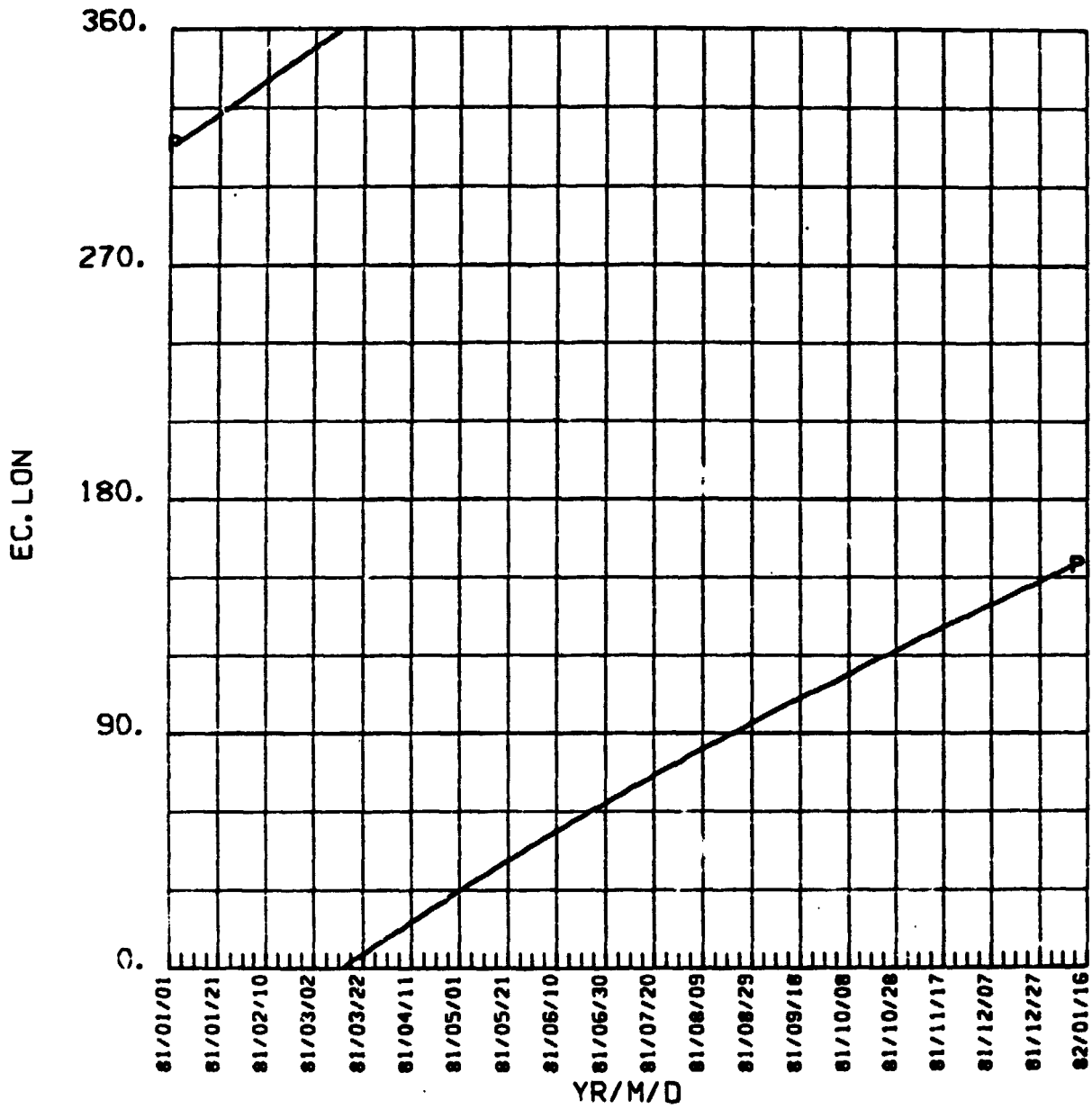
MARS 1981



MARS 1981



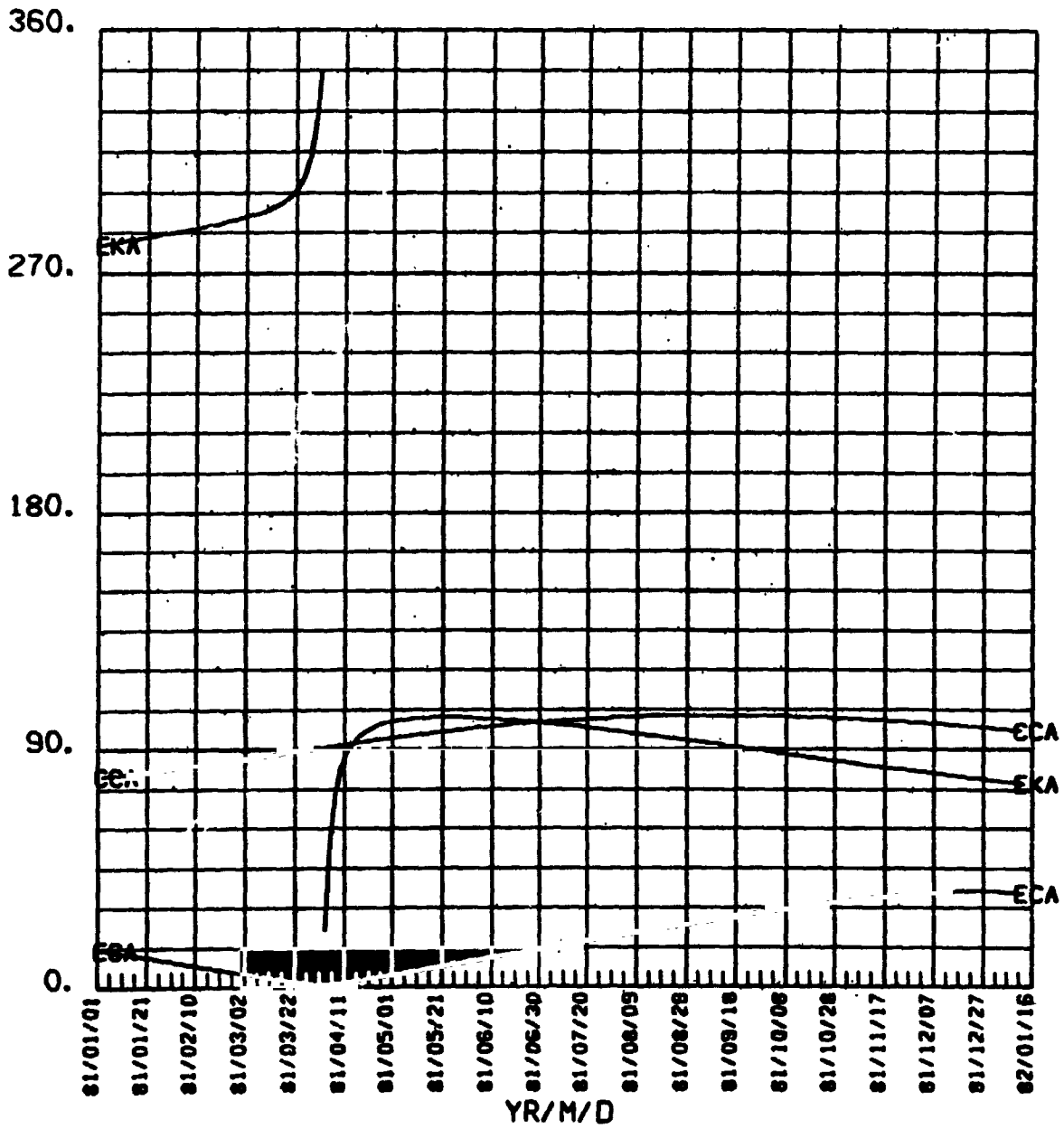
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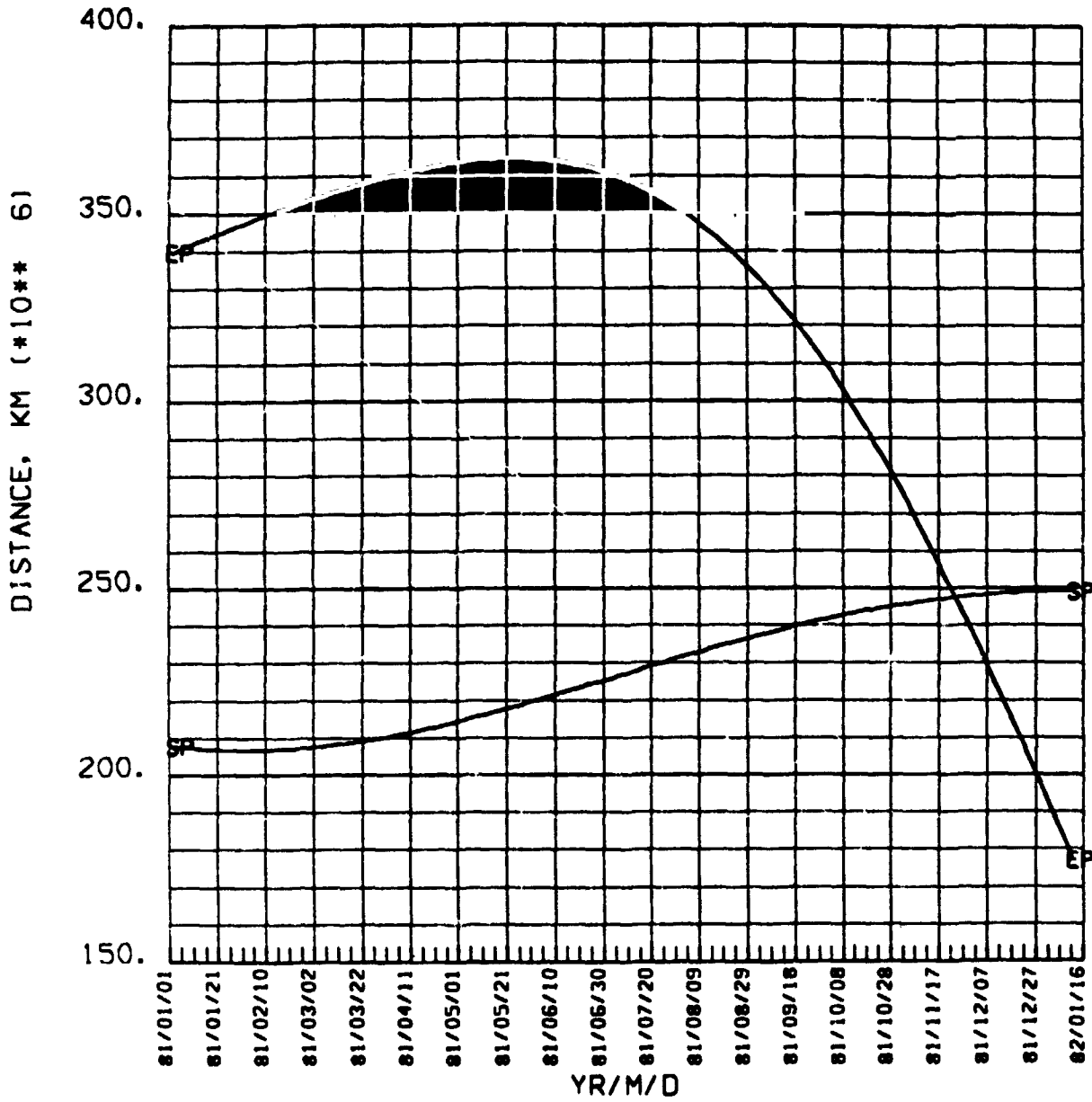
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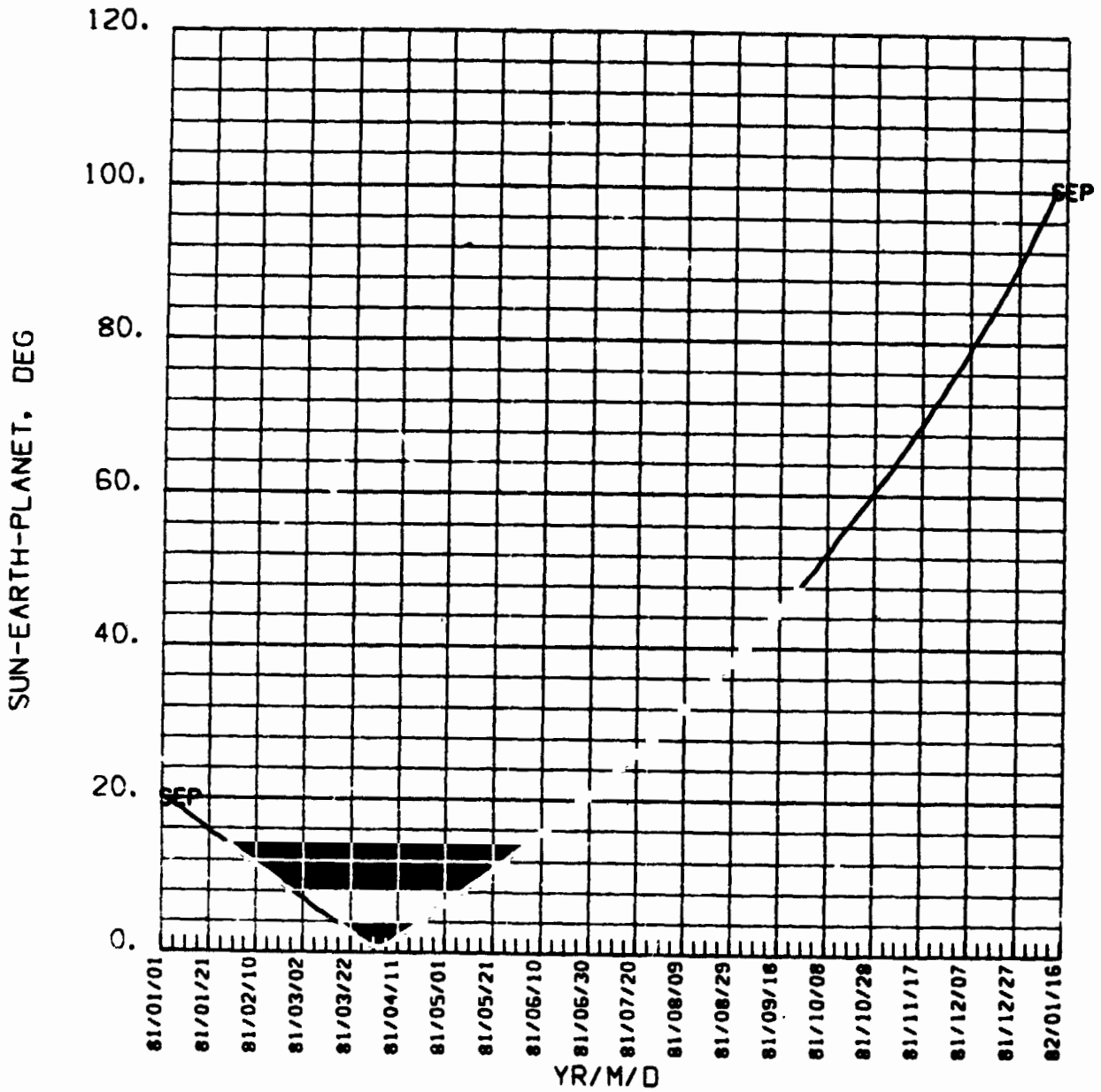
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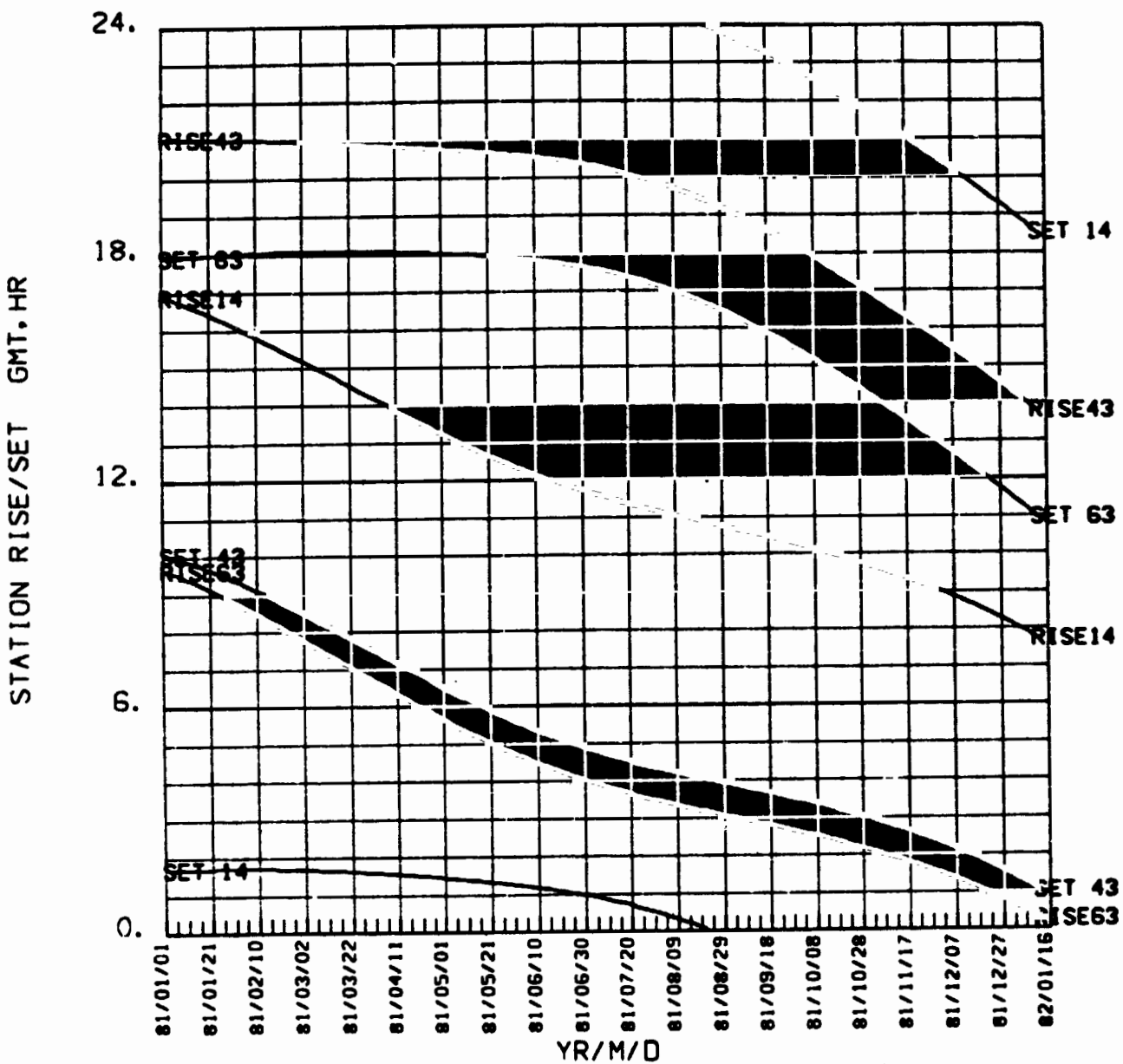
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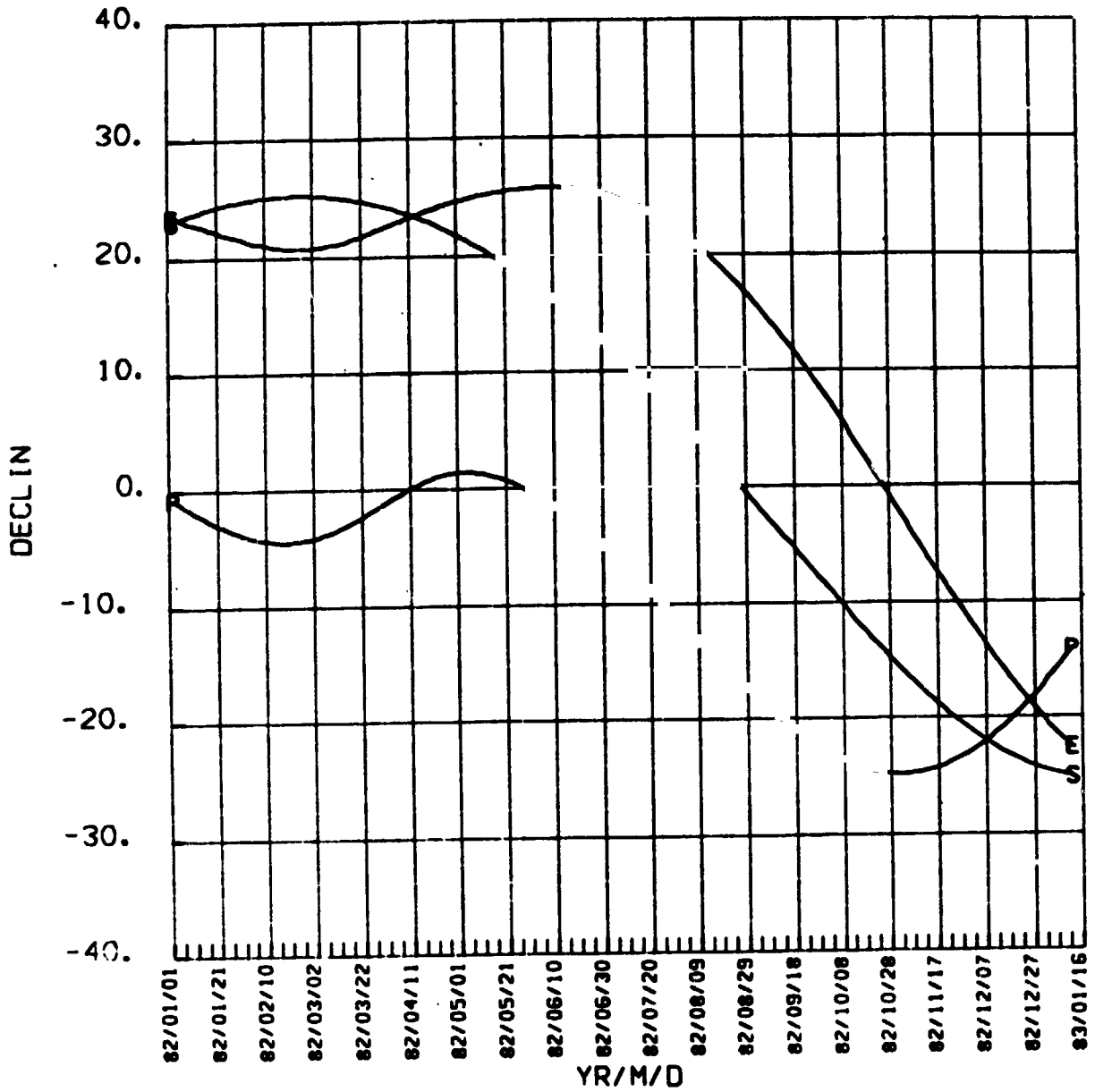


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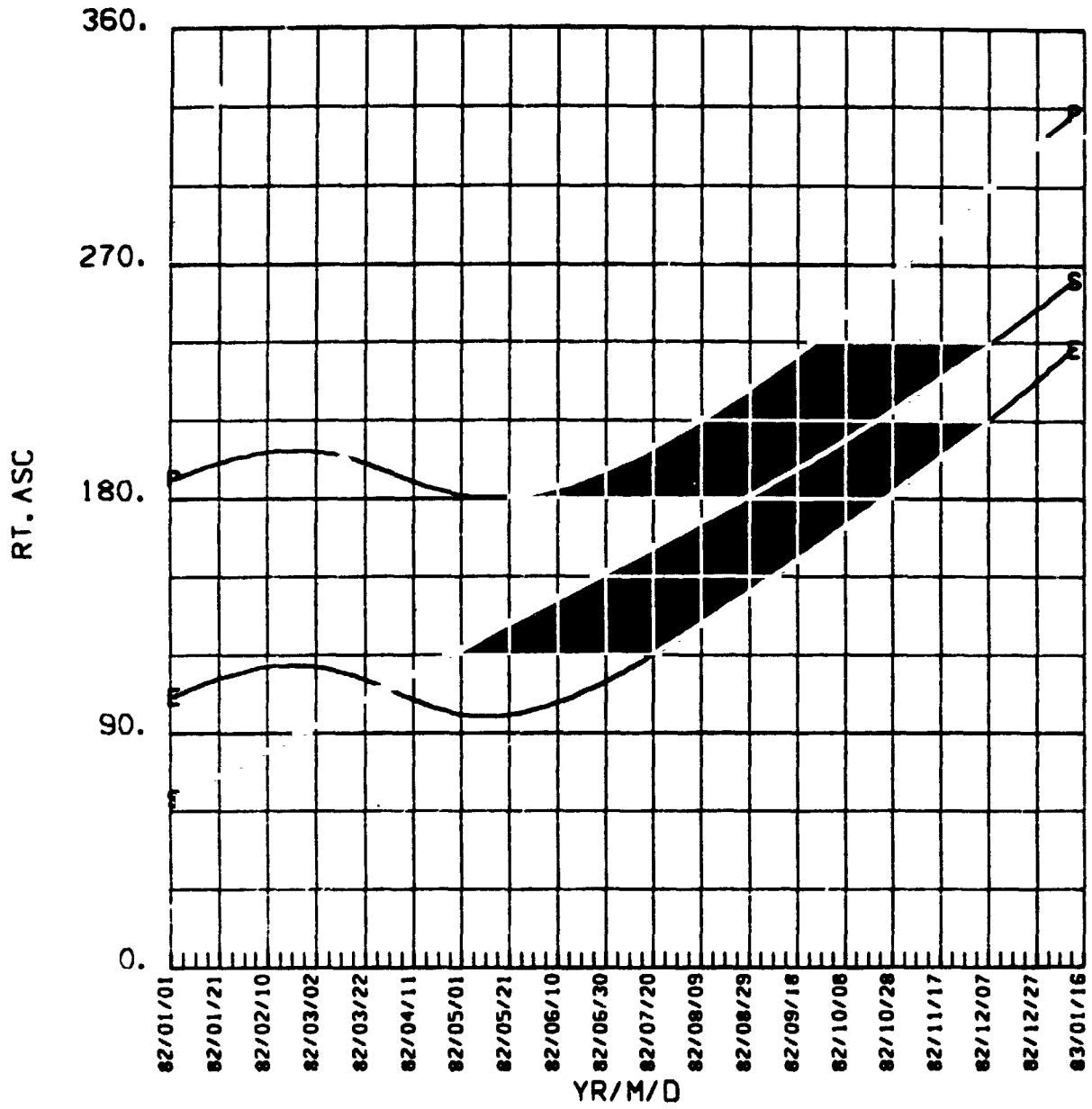


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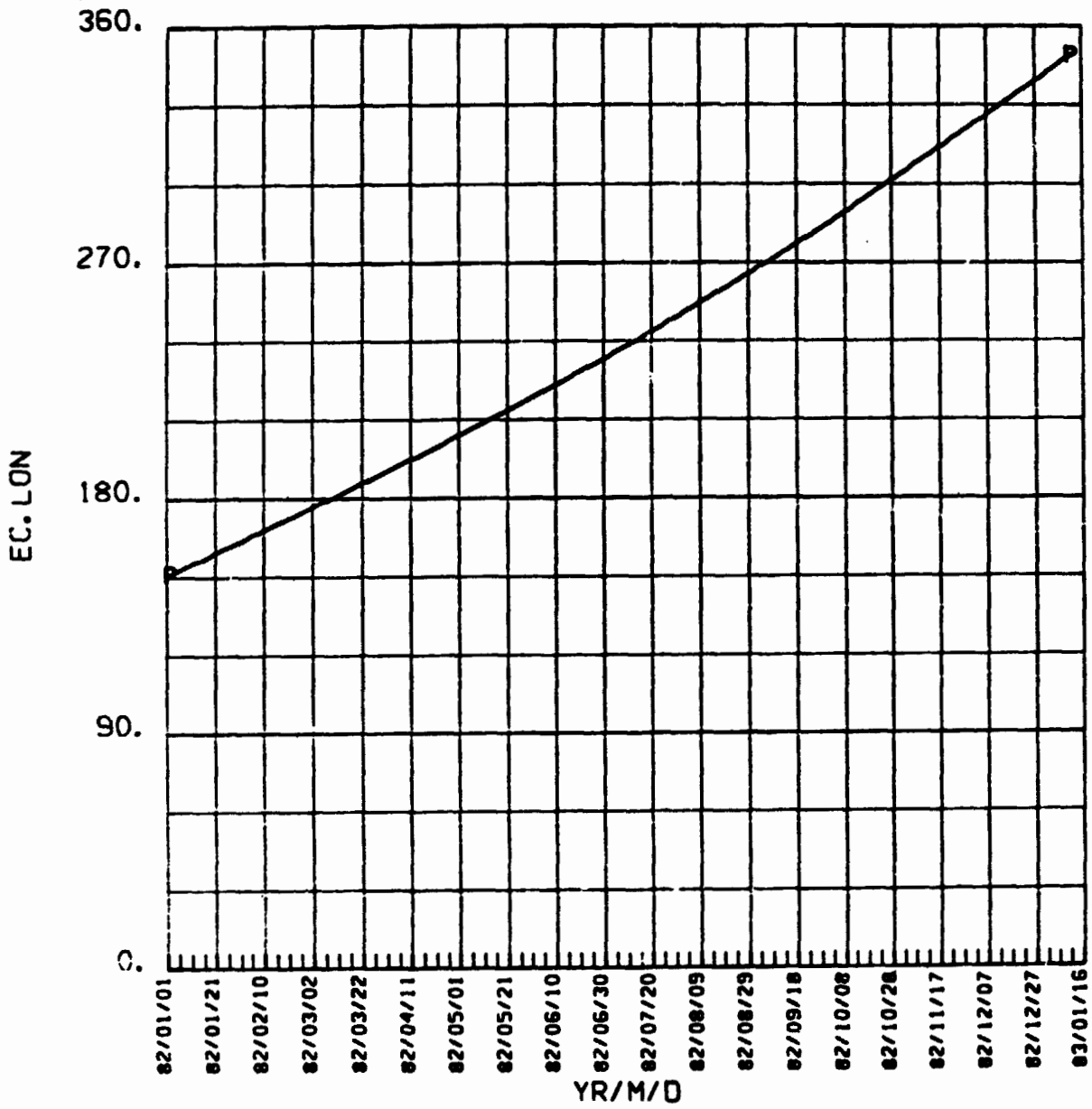


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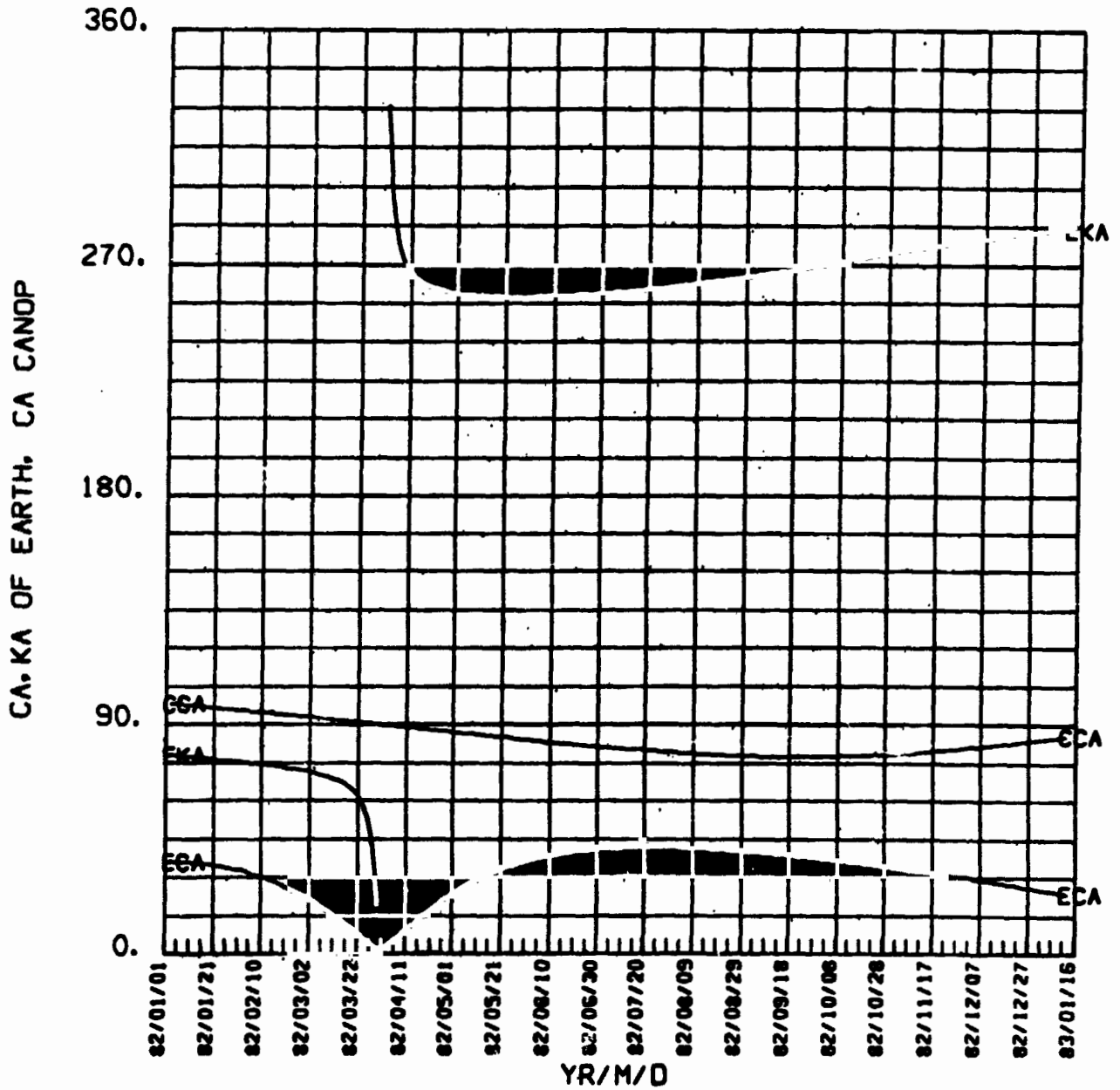
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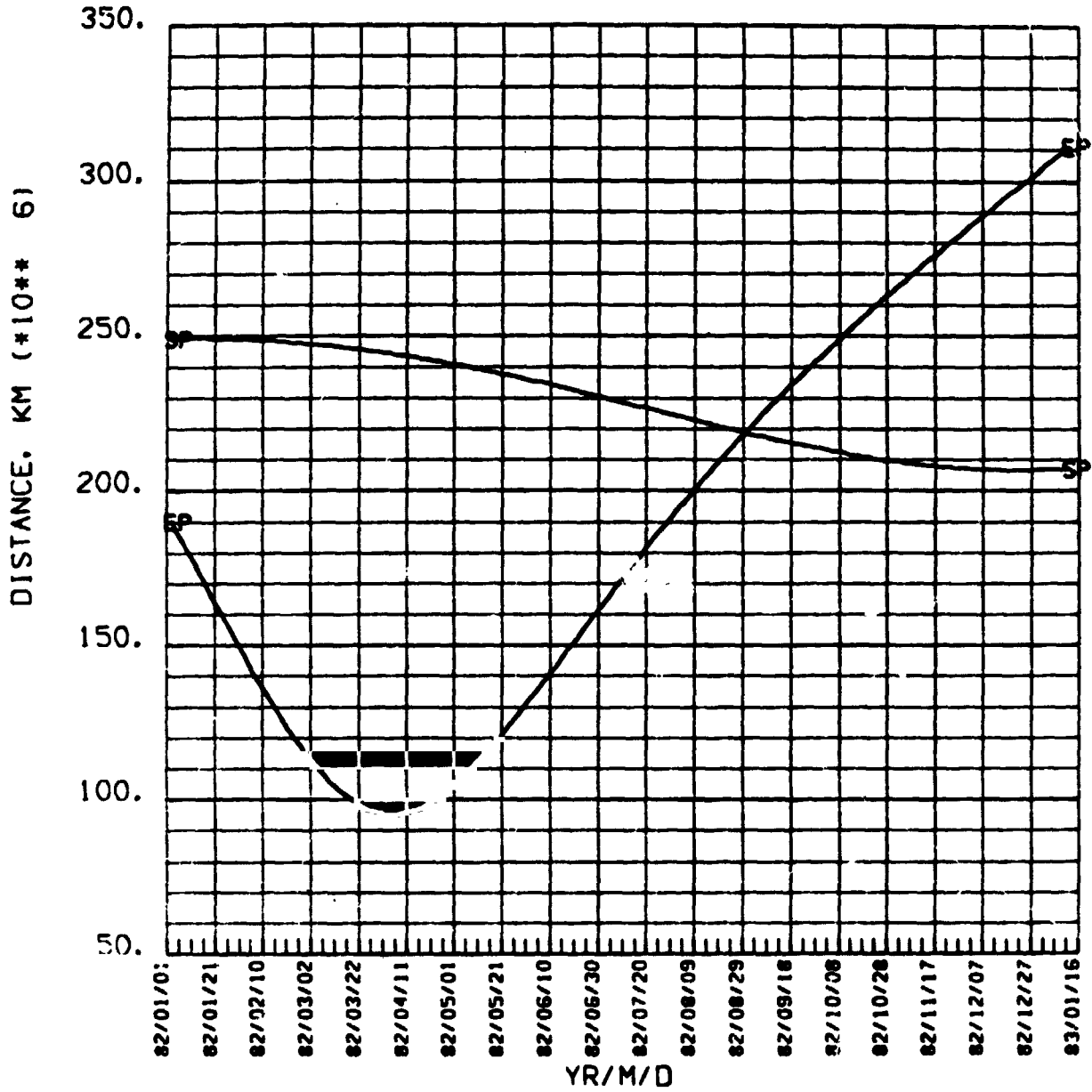
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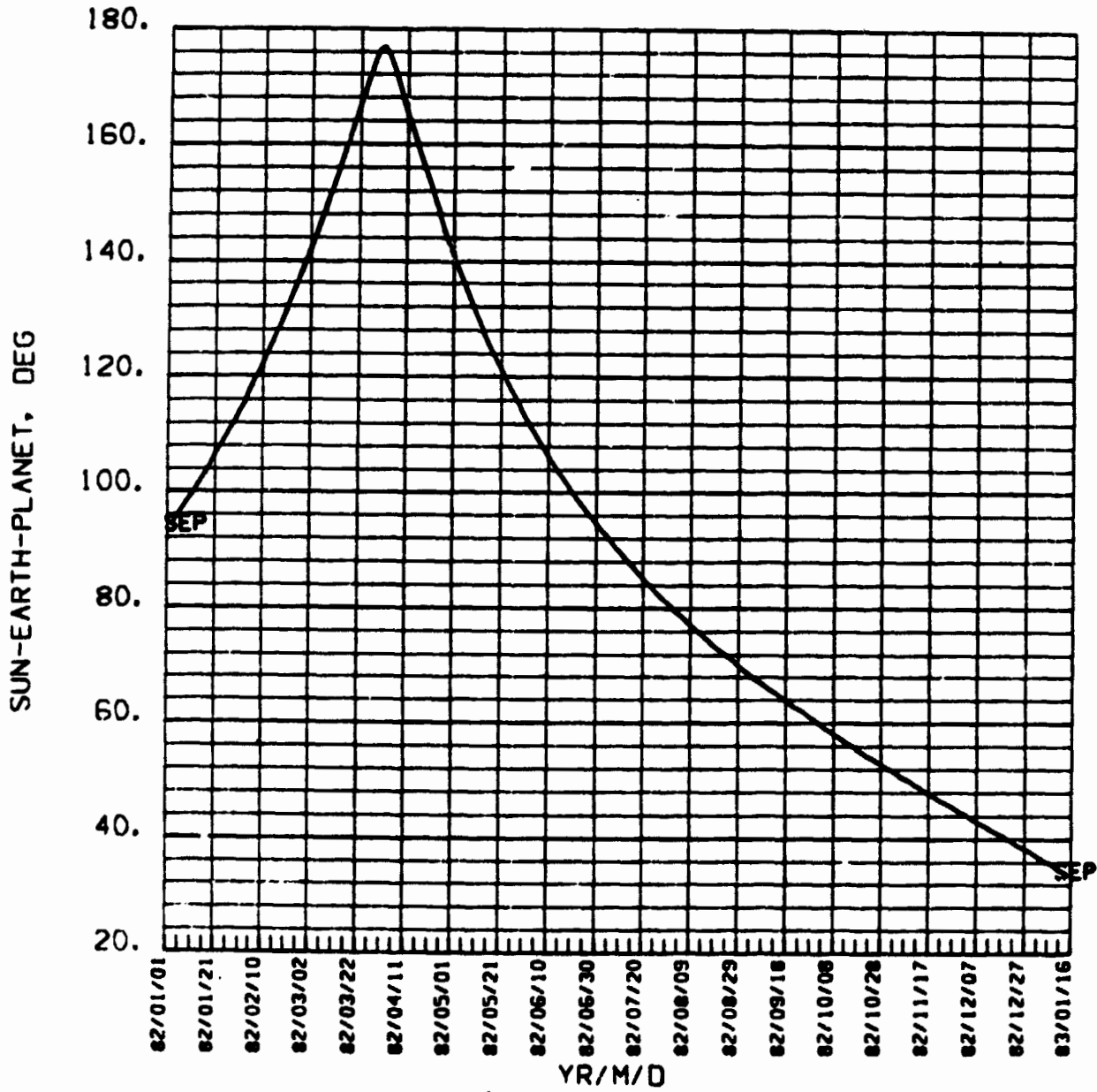
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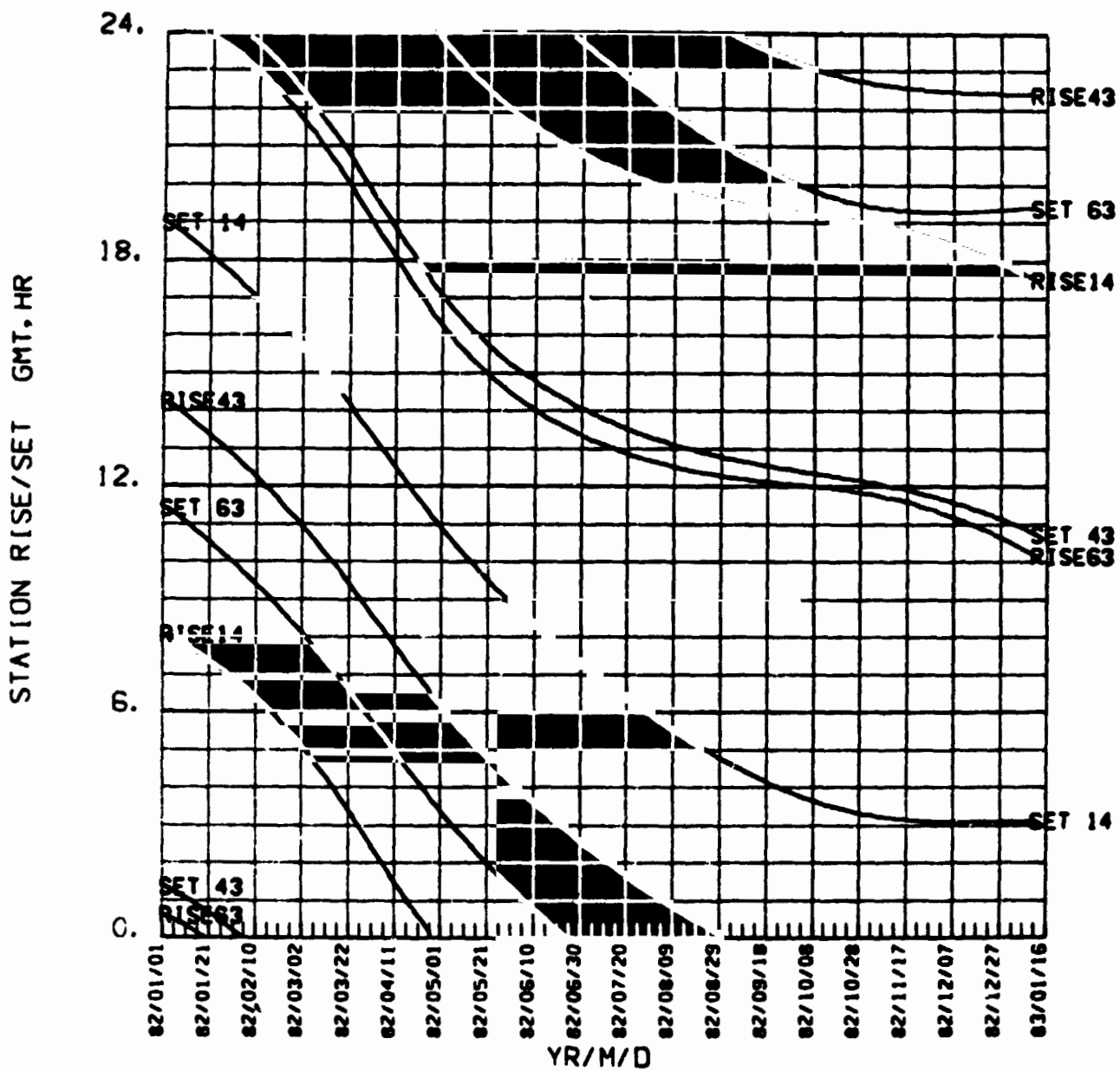
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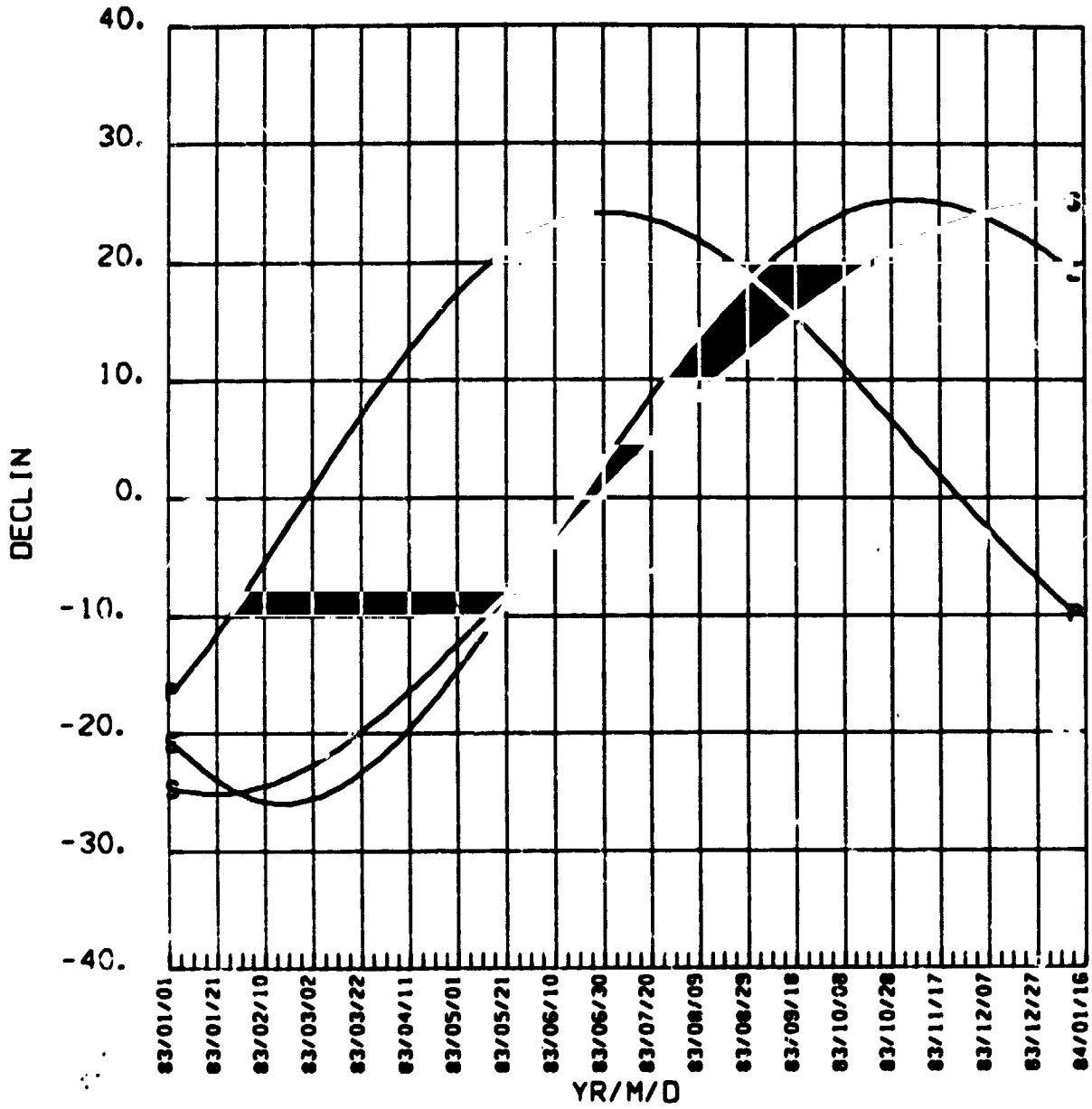
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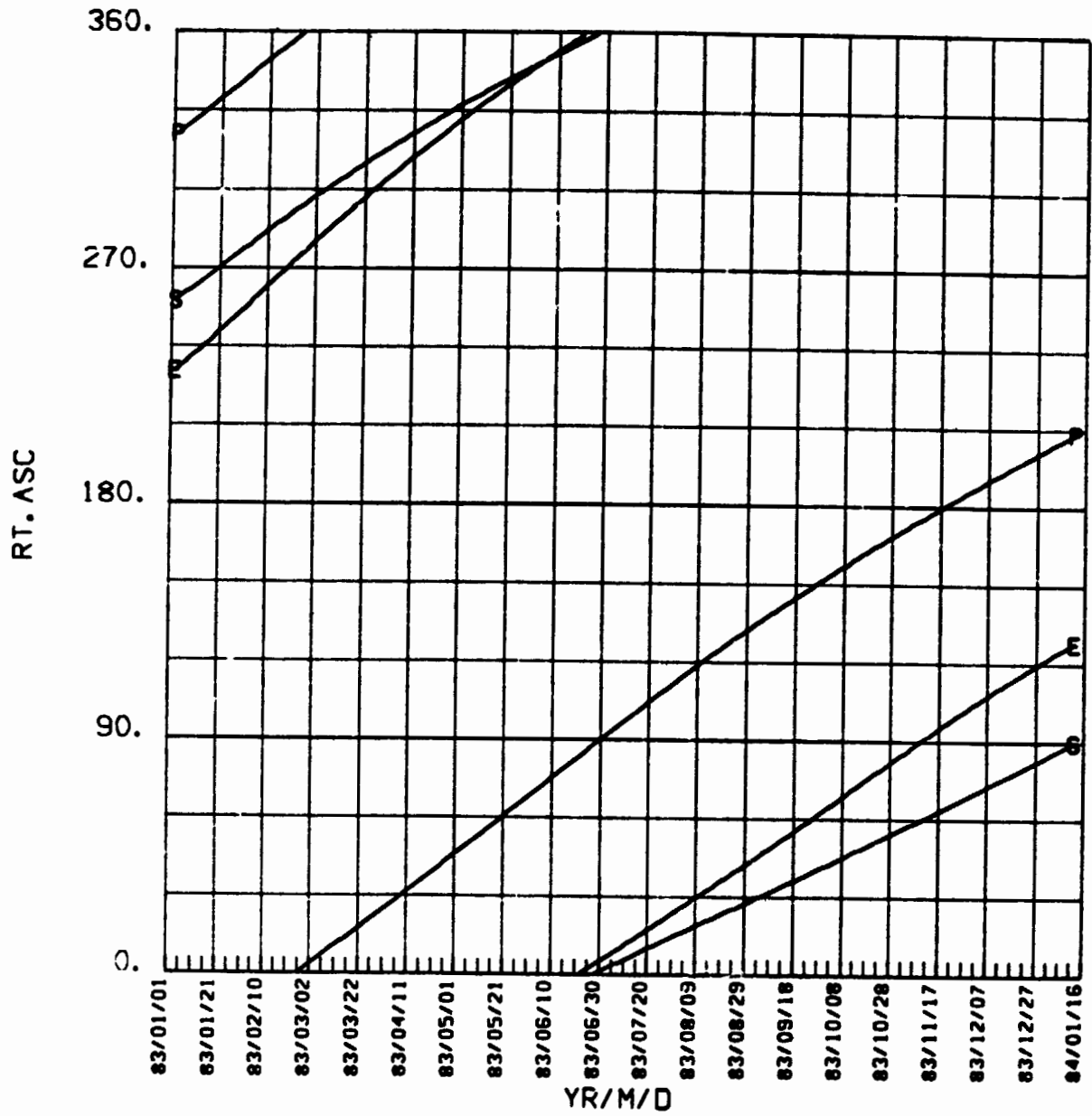


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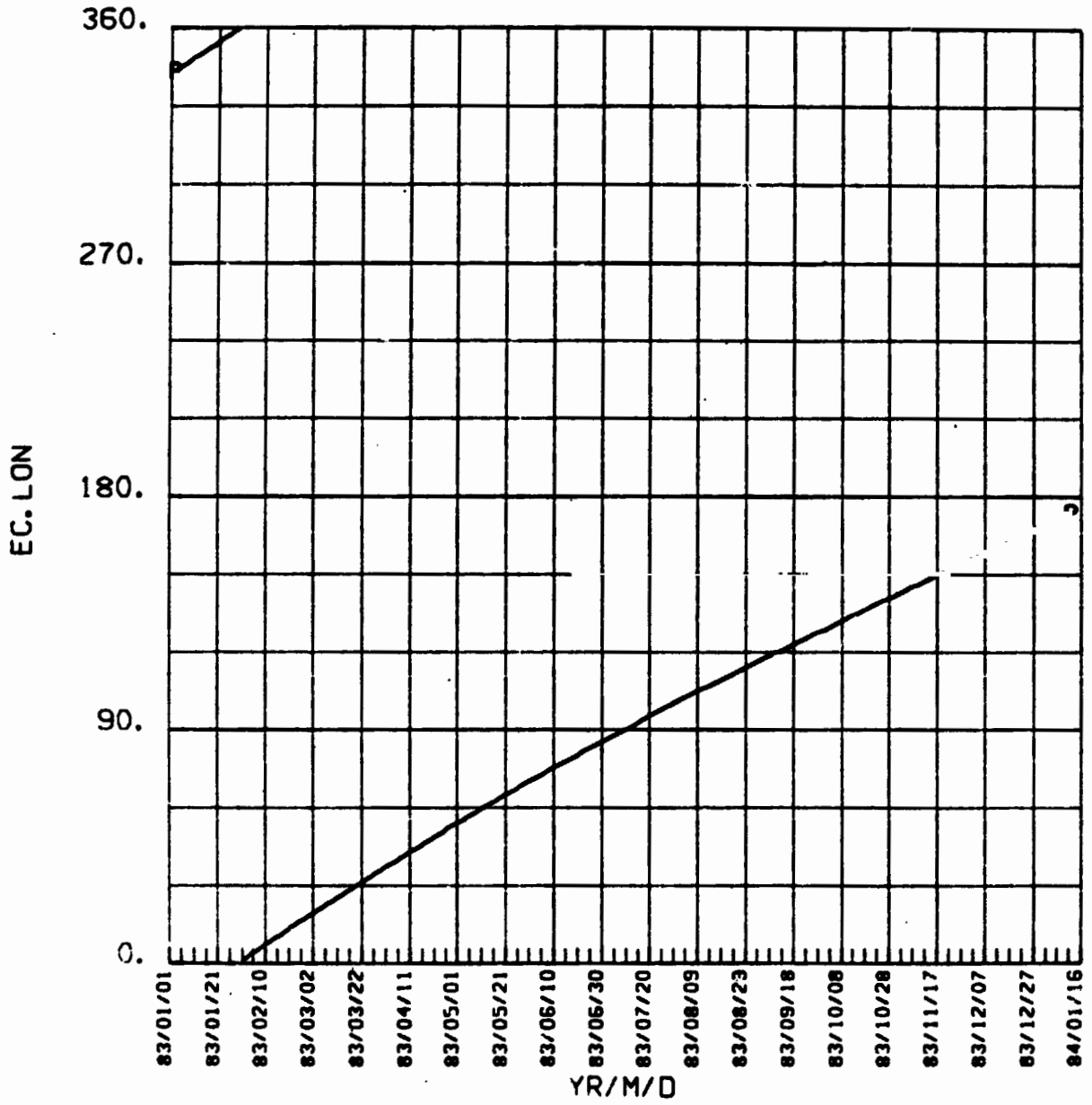




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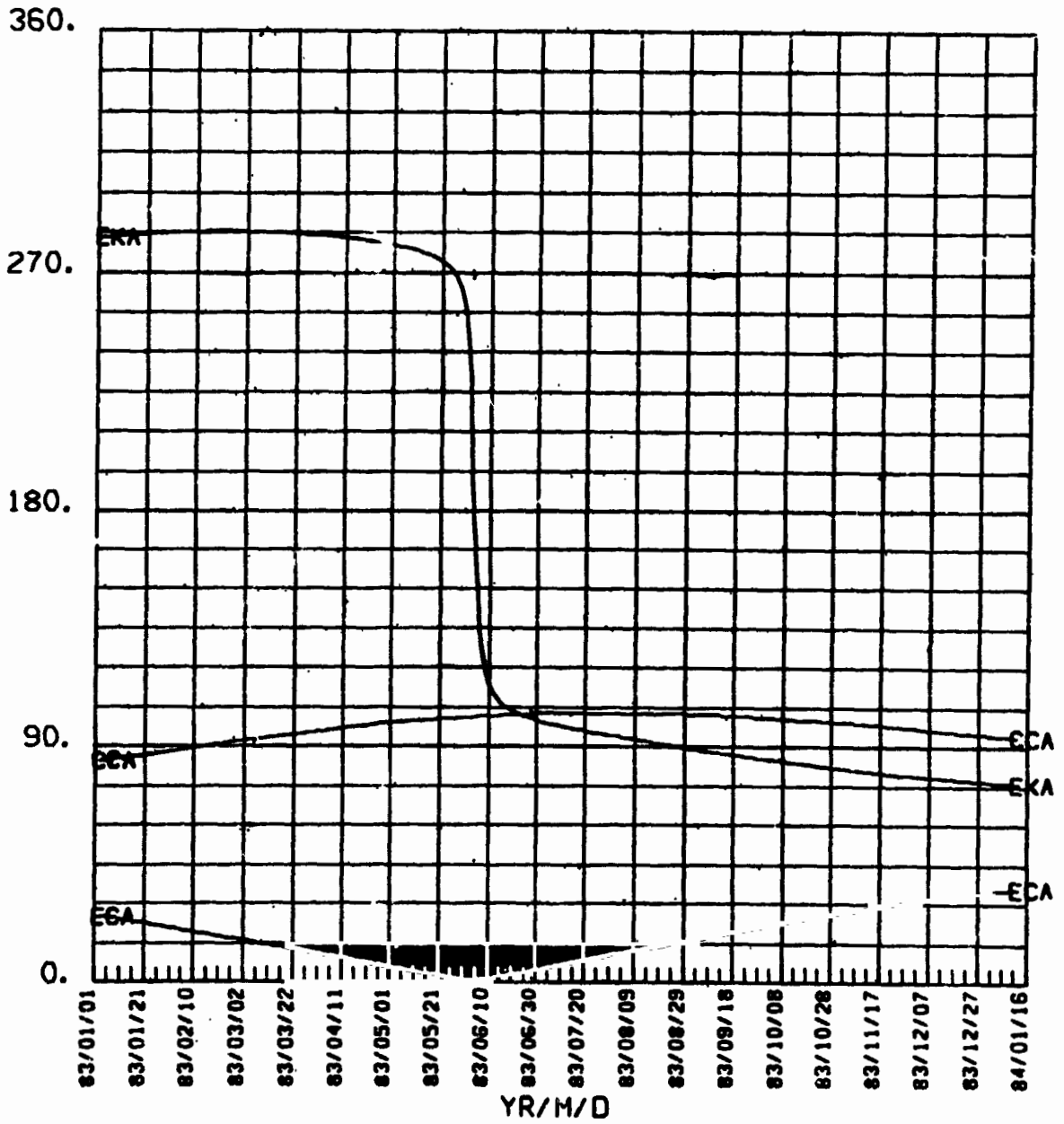


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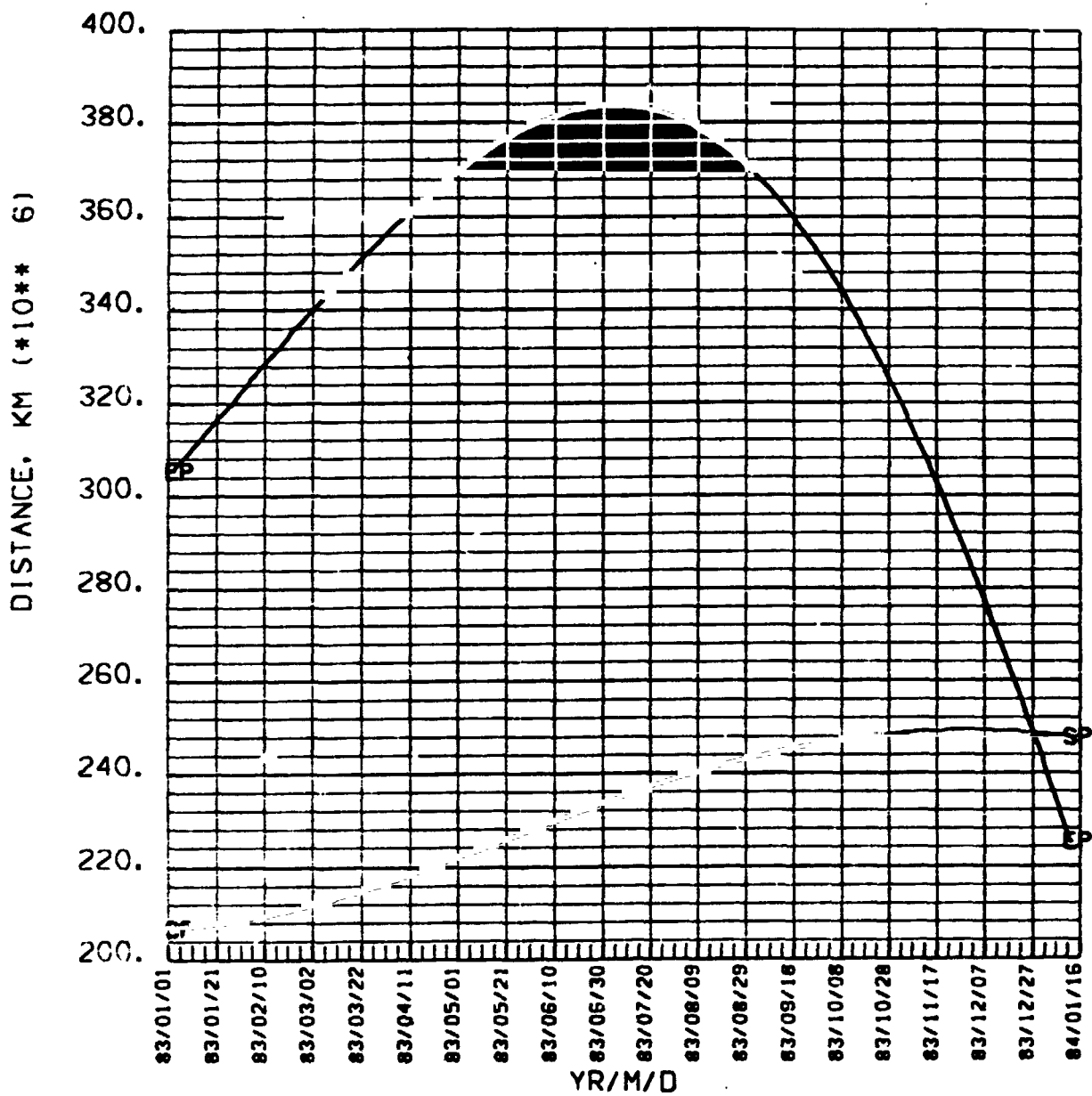


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CA, KA OF EARTH, CA CANOP

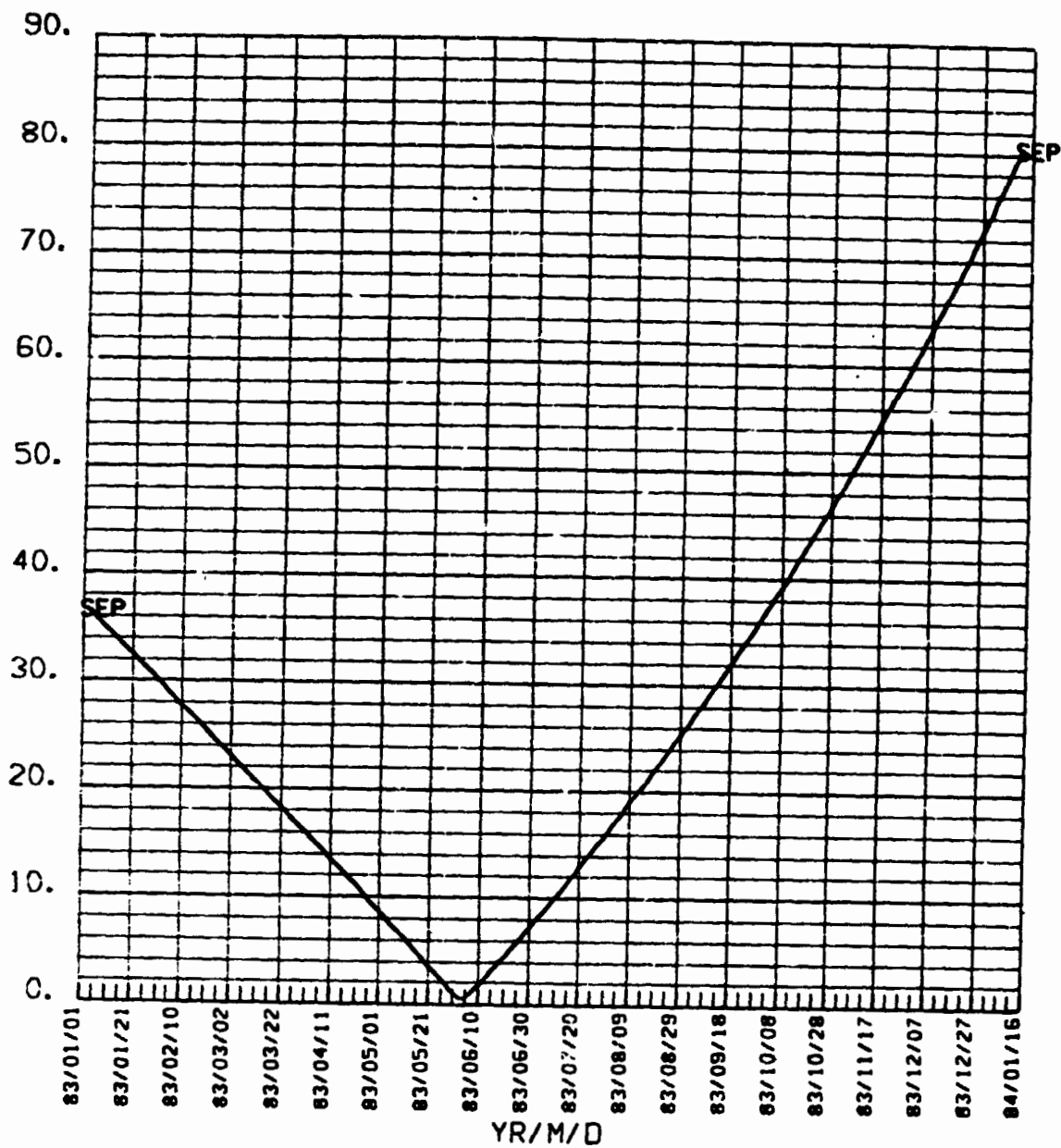


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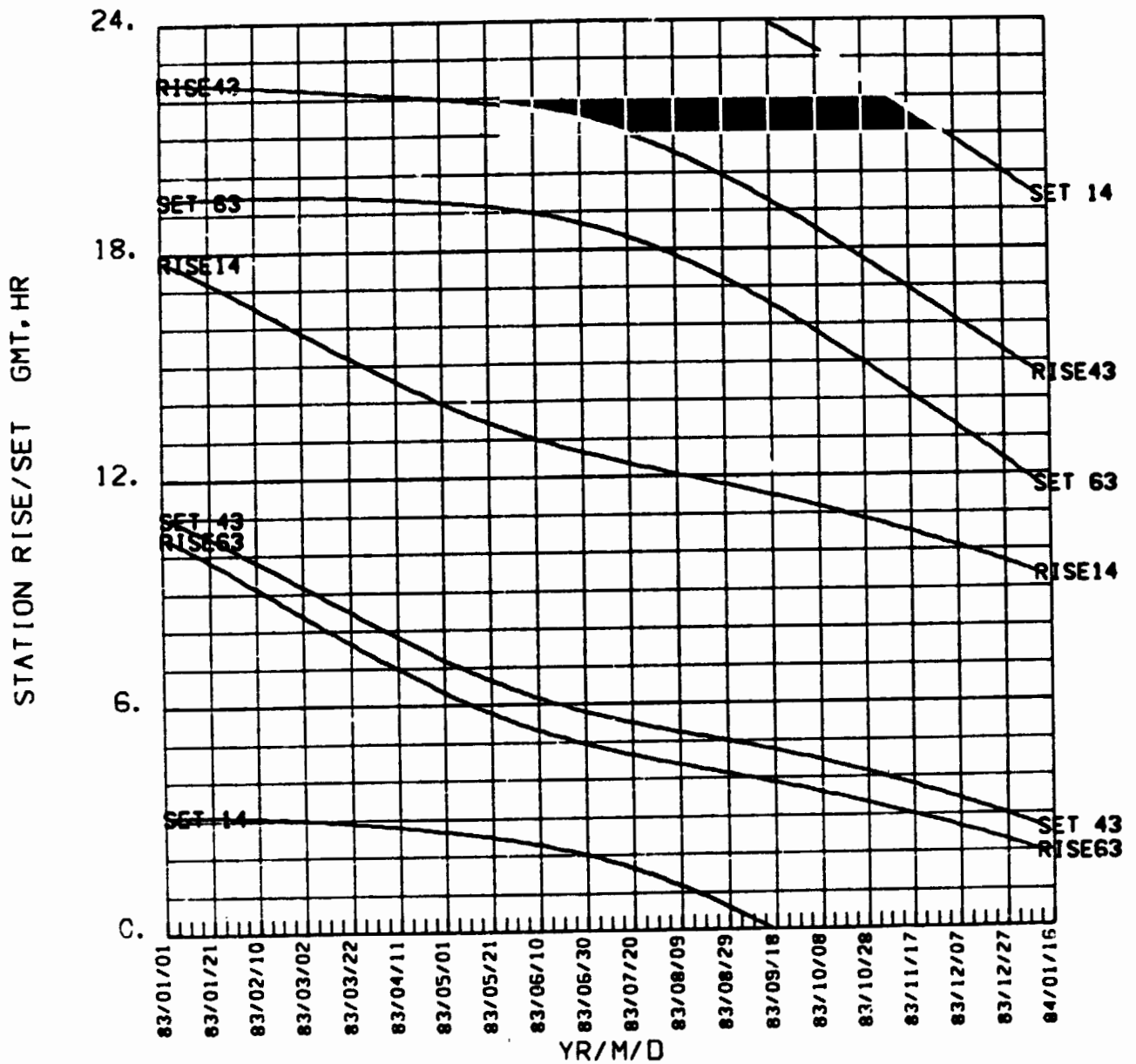


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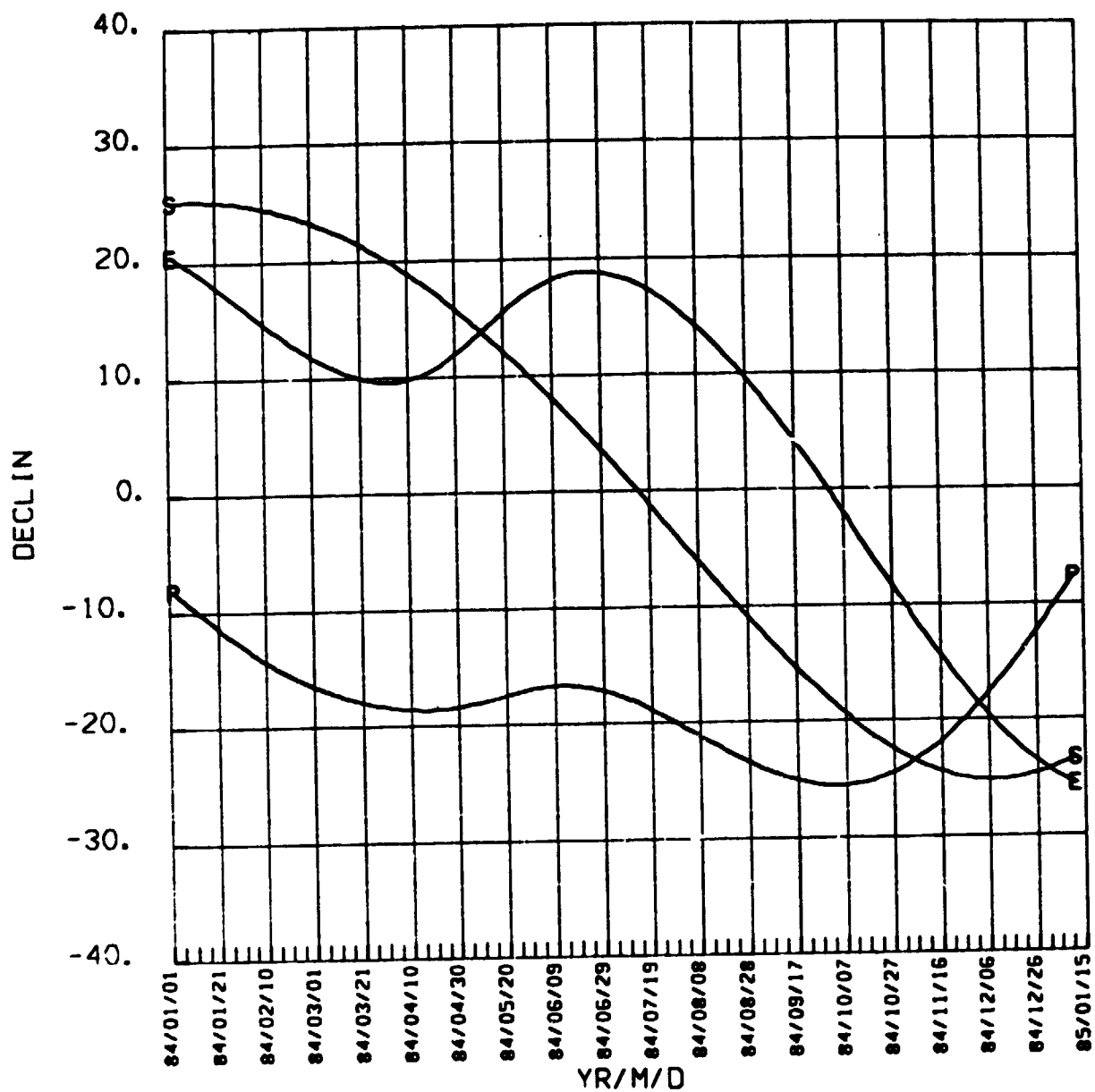
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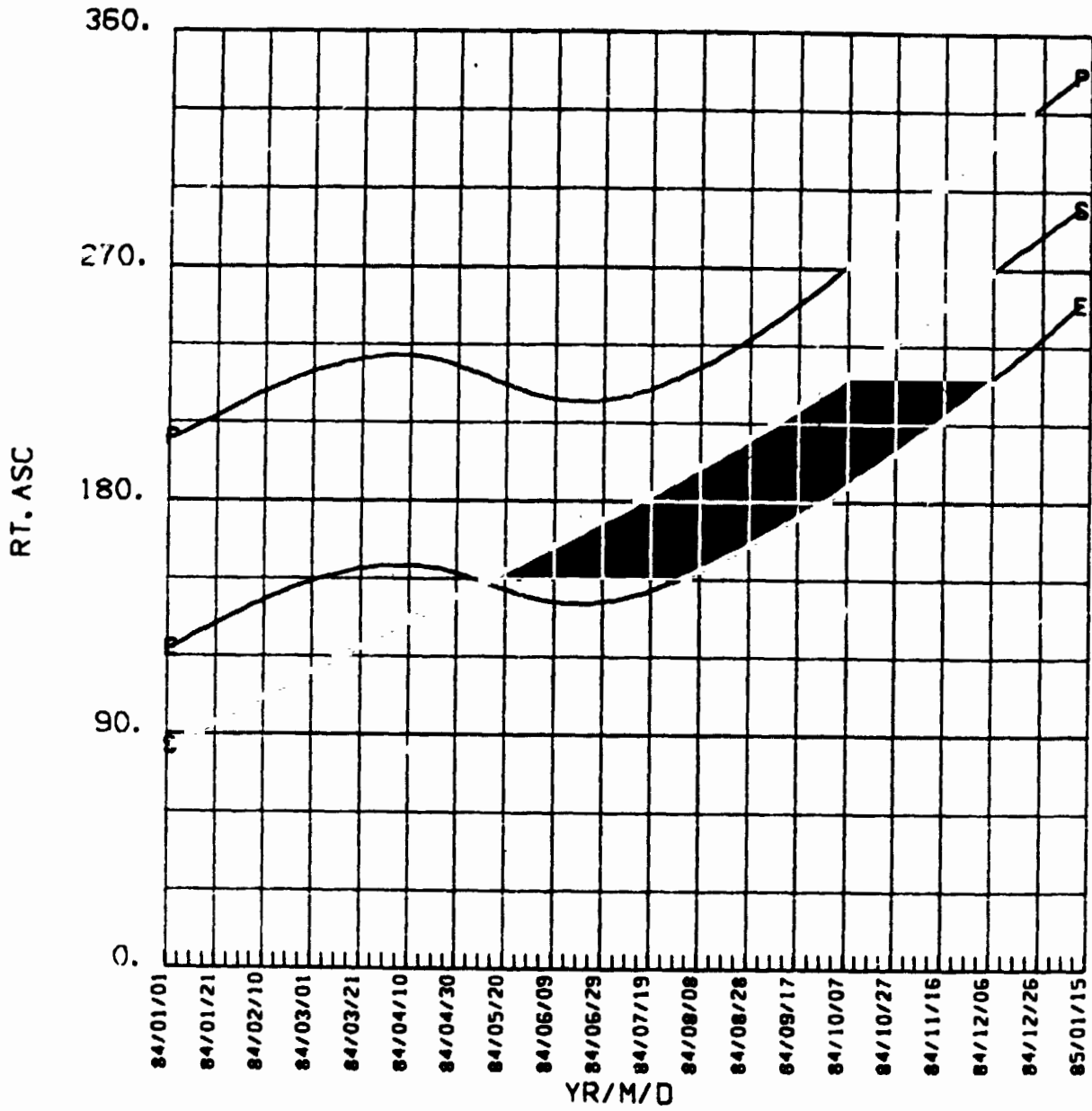
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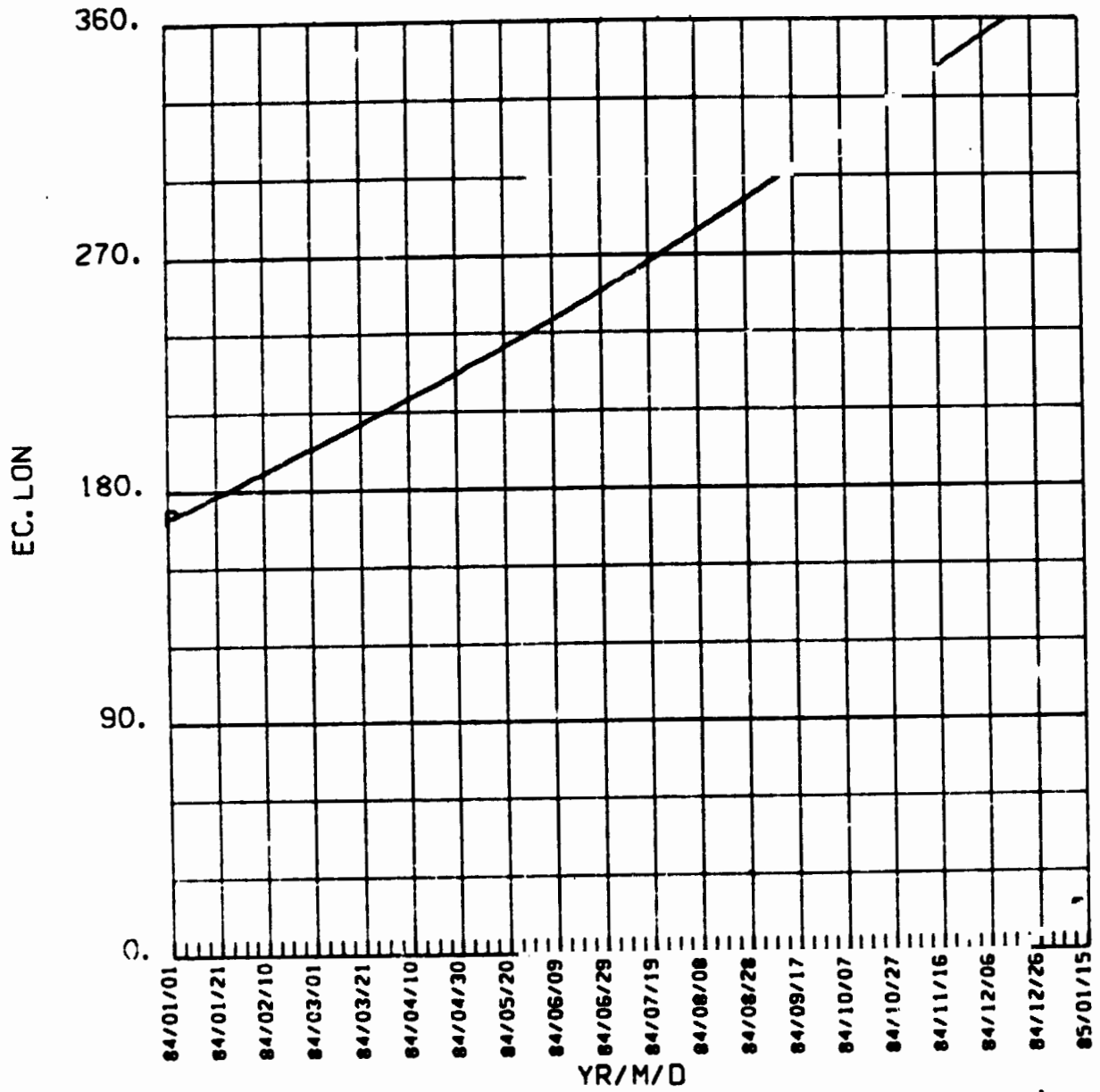
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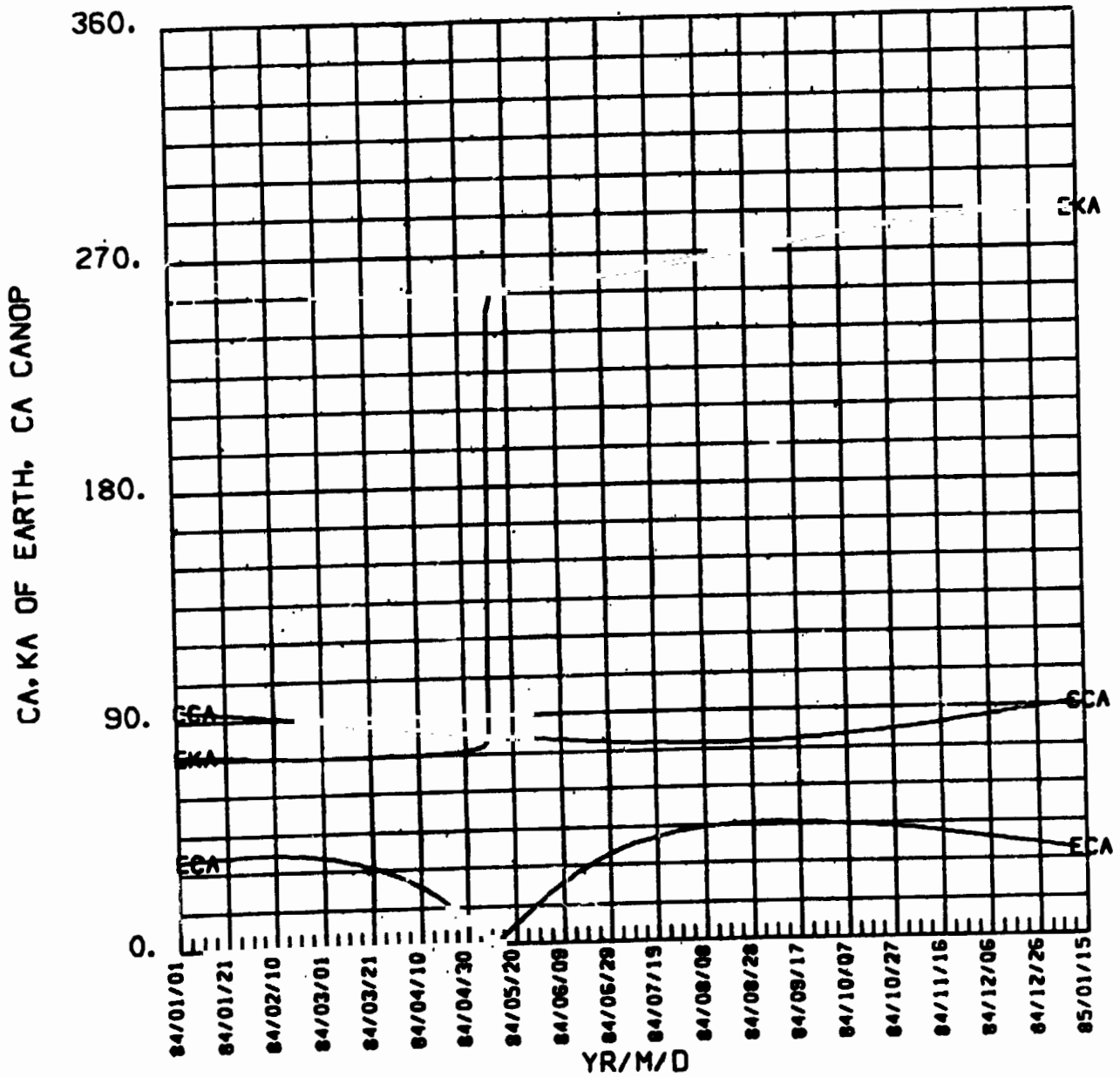


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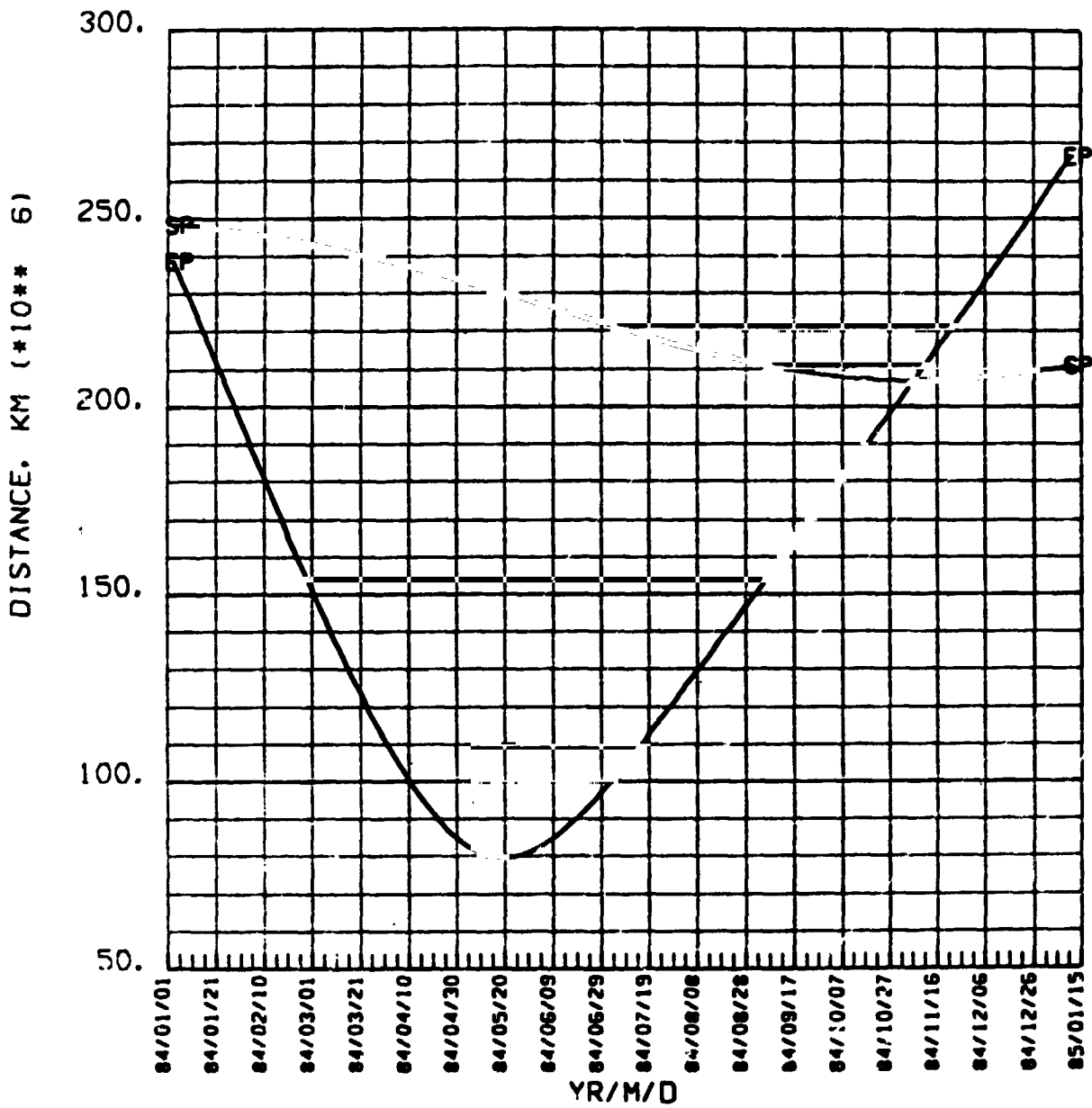
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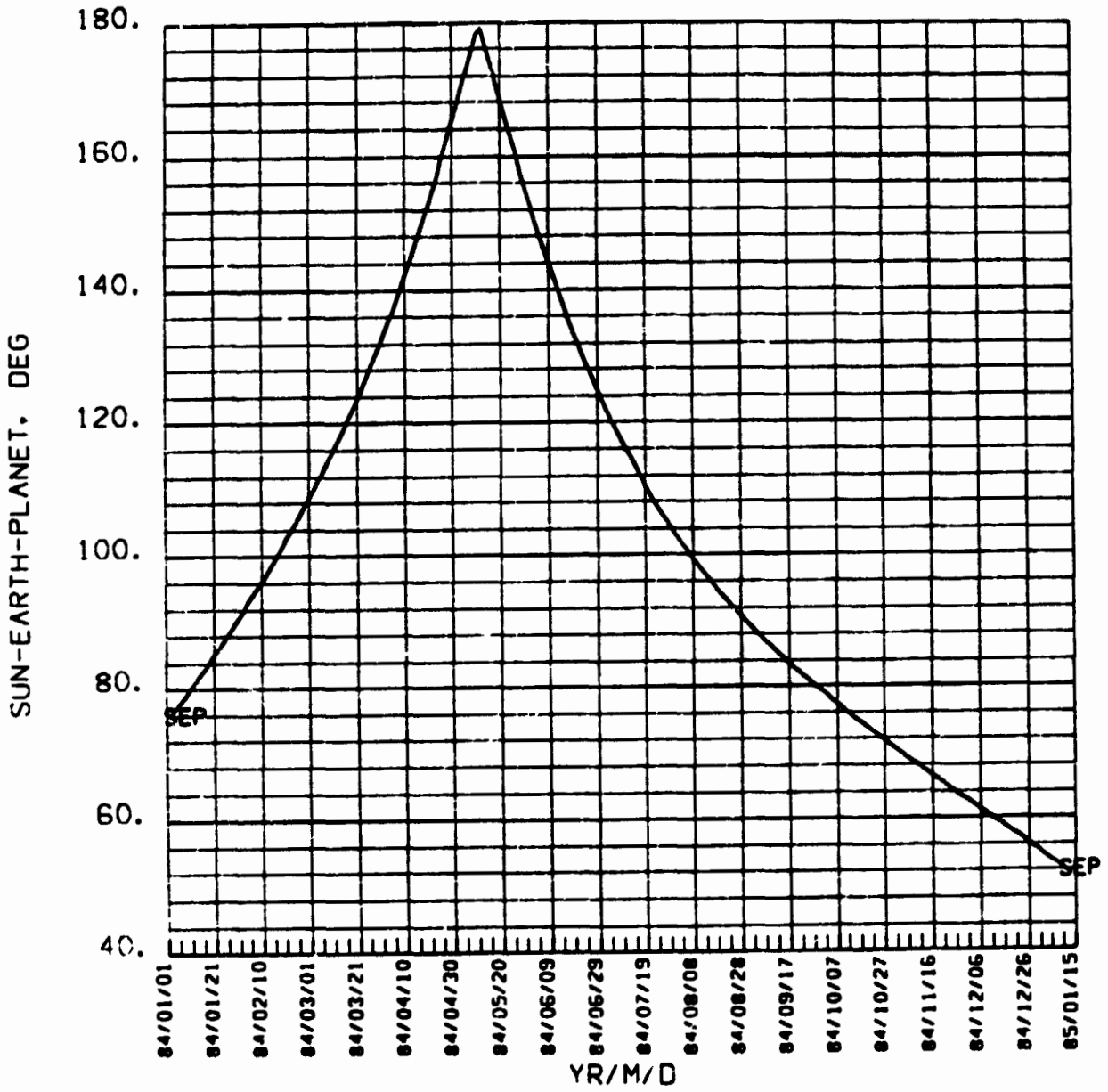
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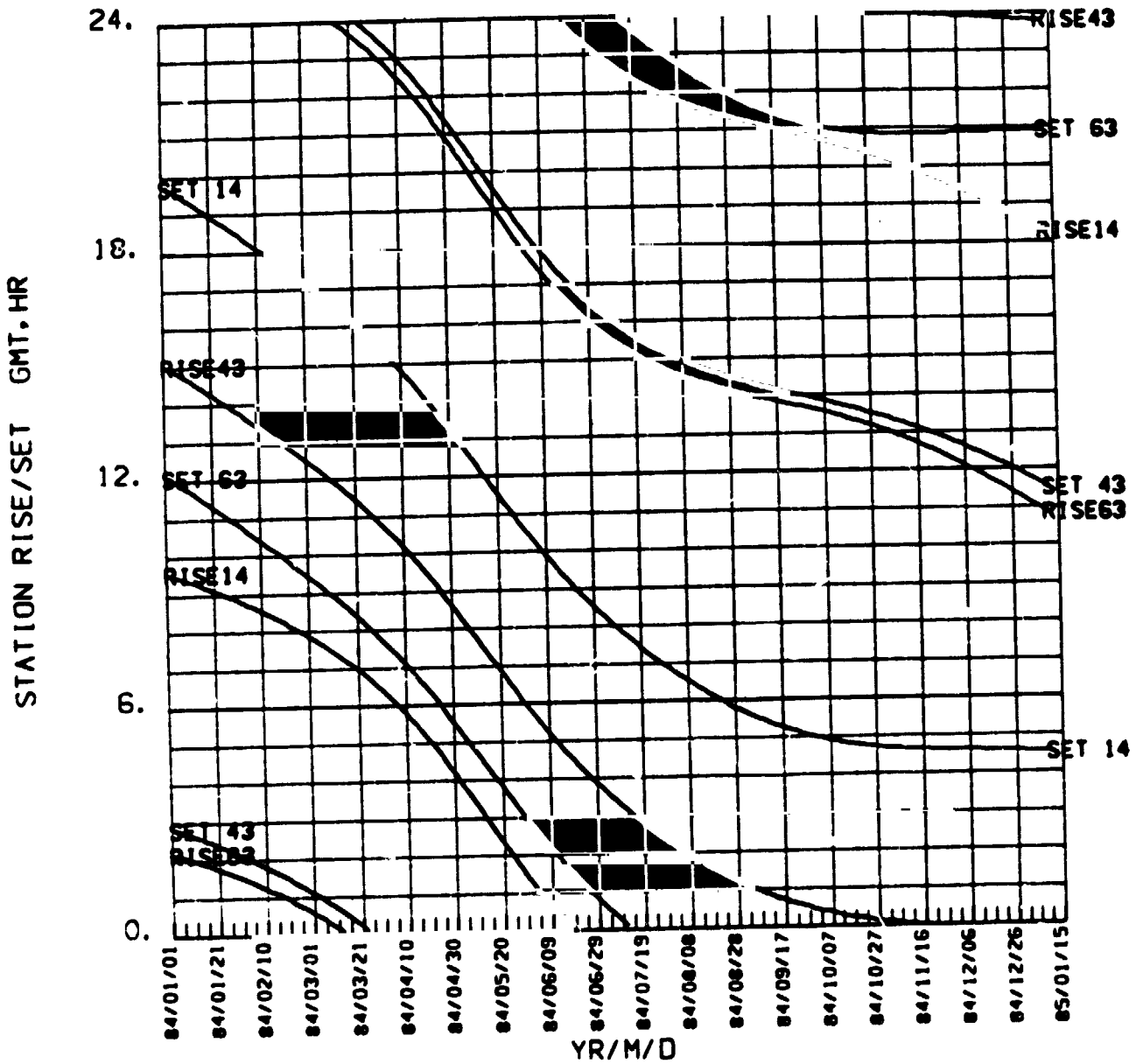
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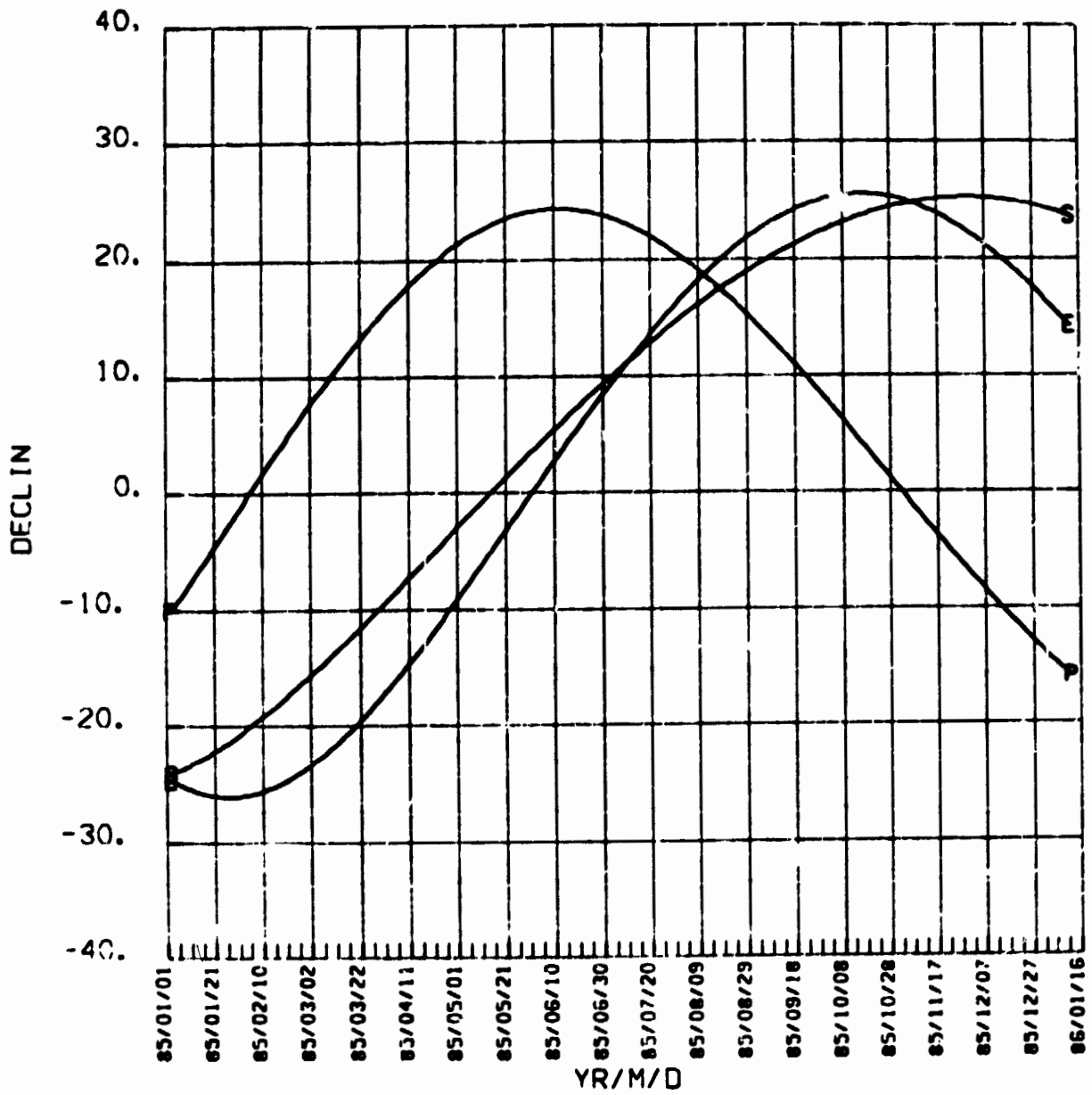
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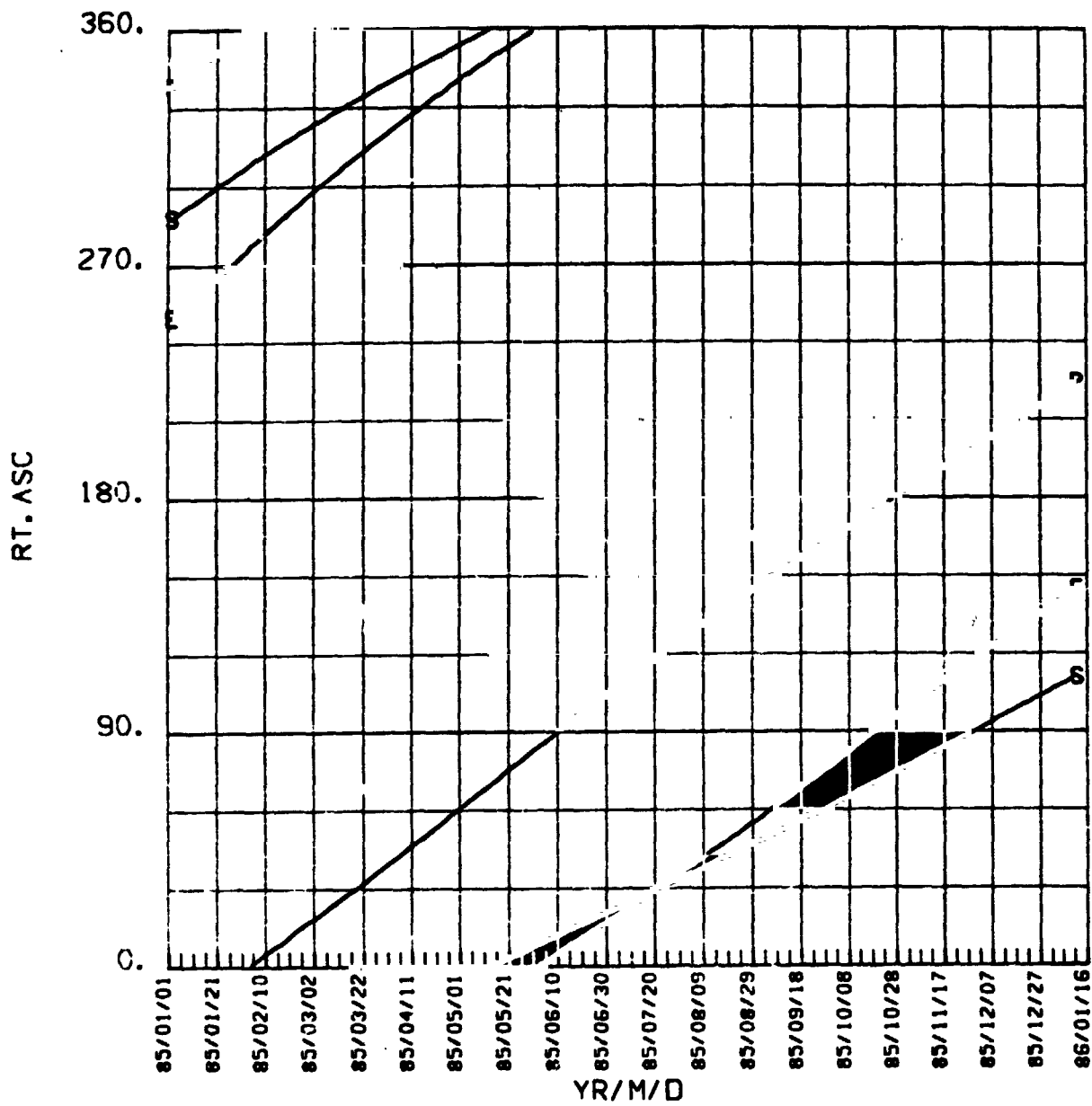
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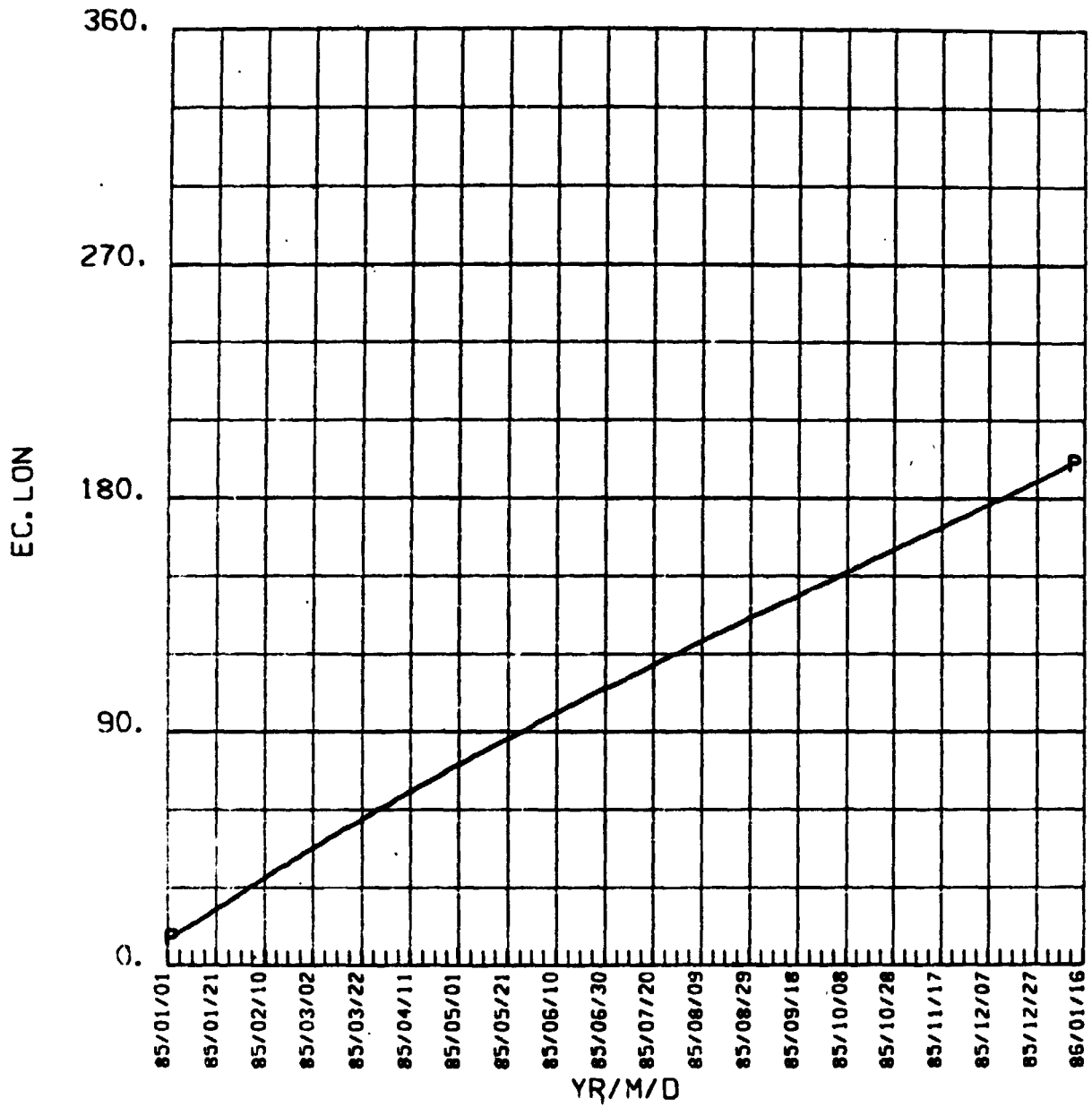
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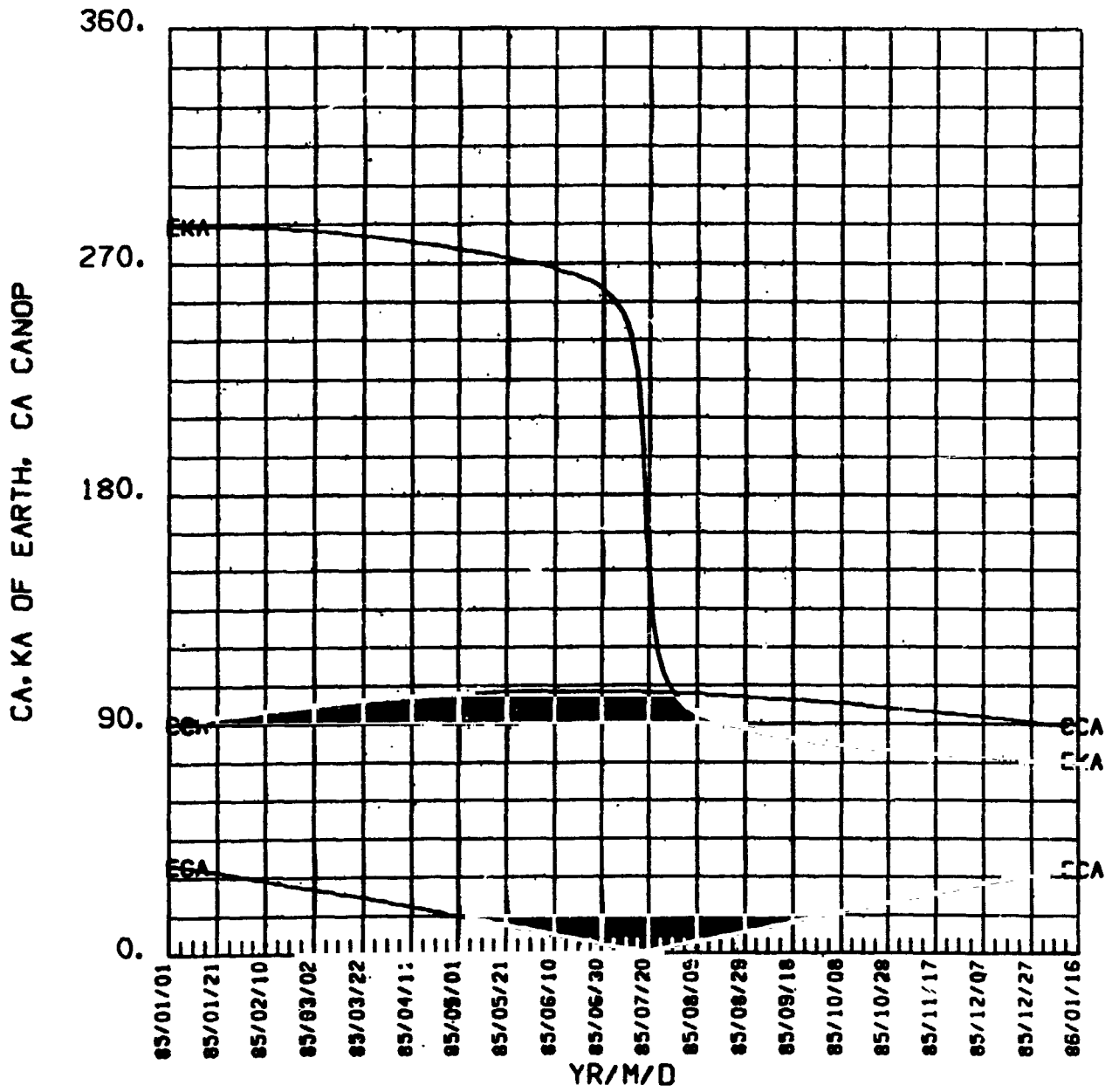


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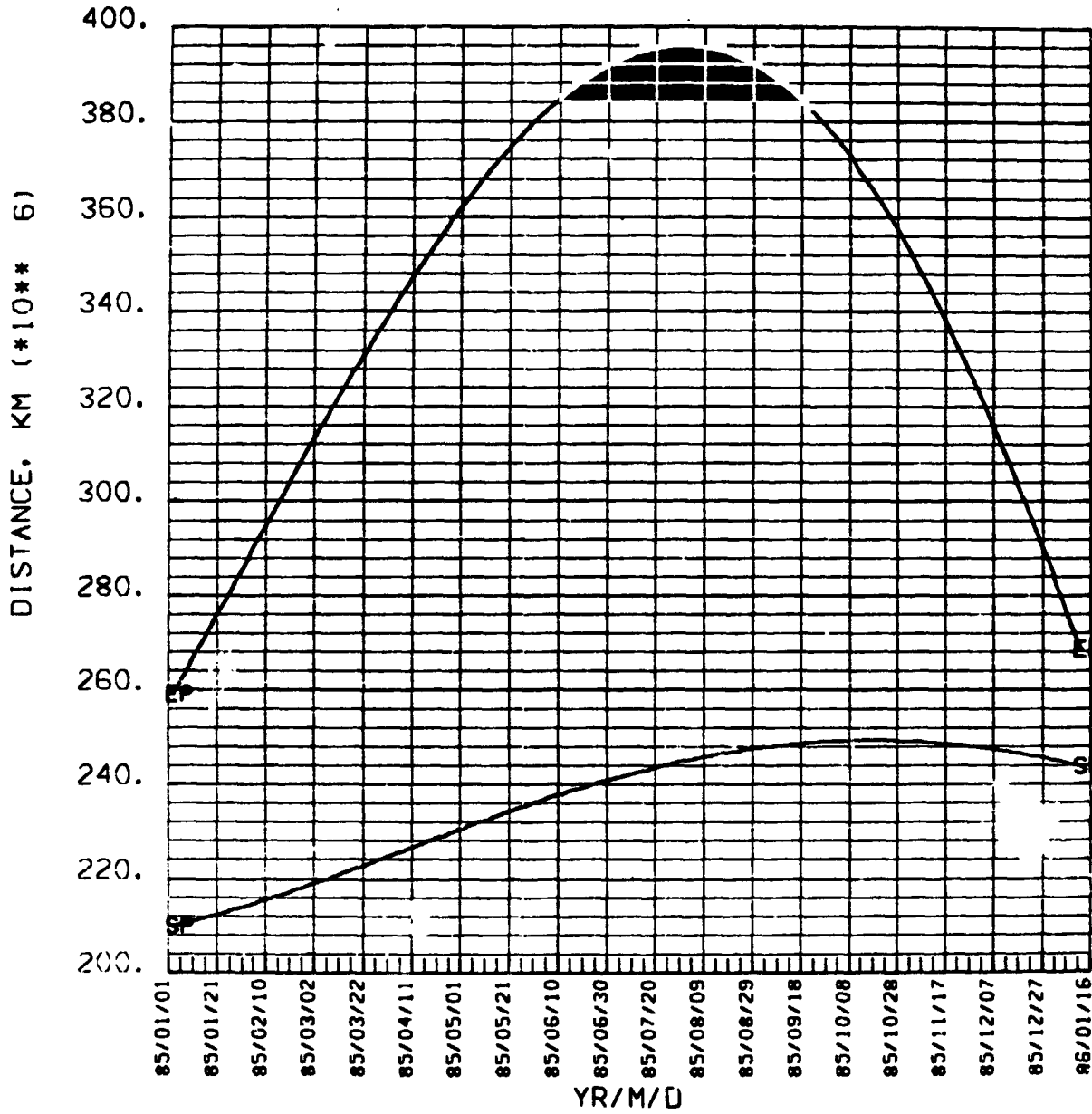




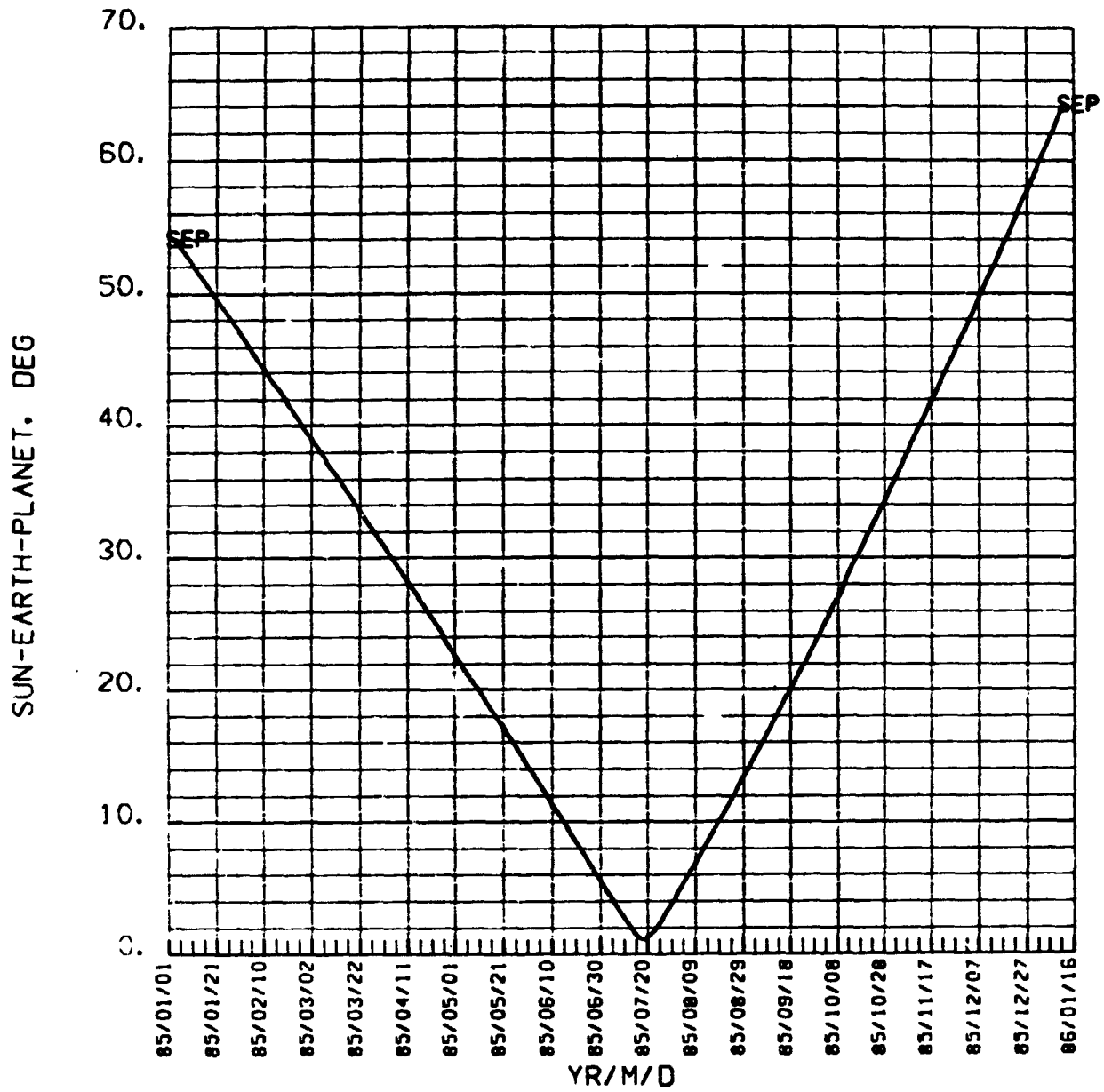
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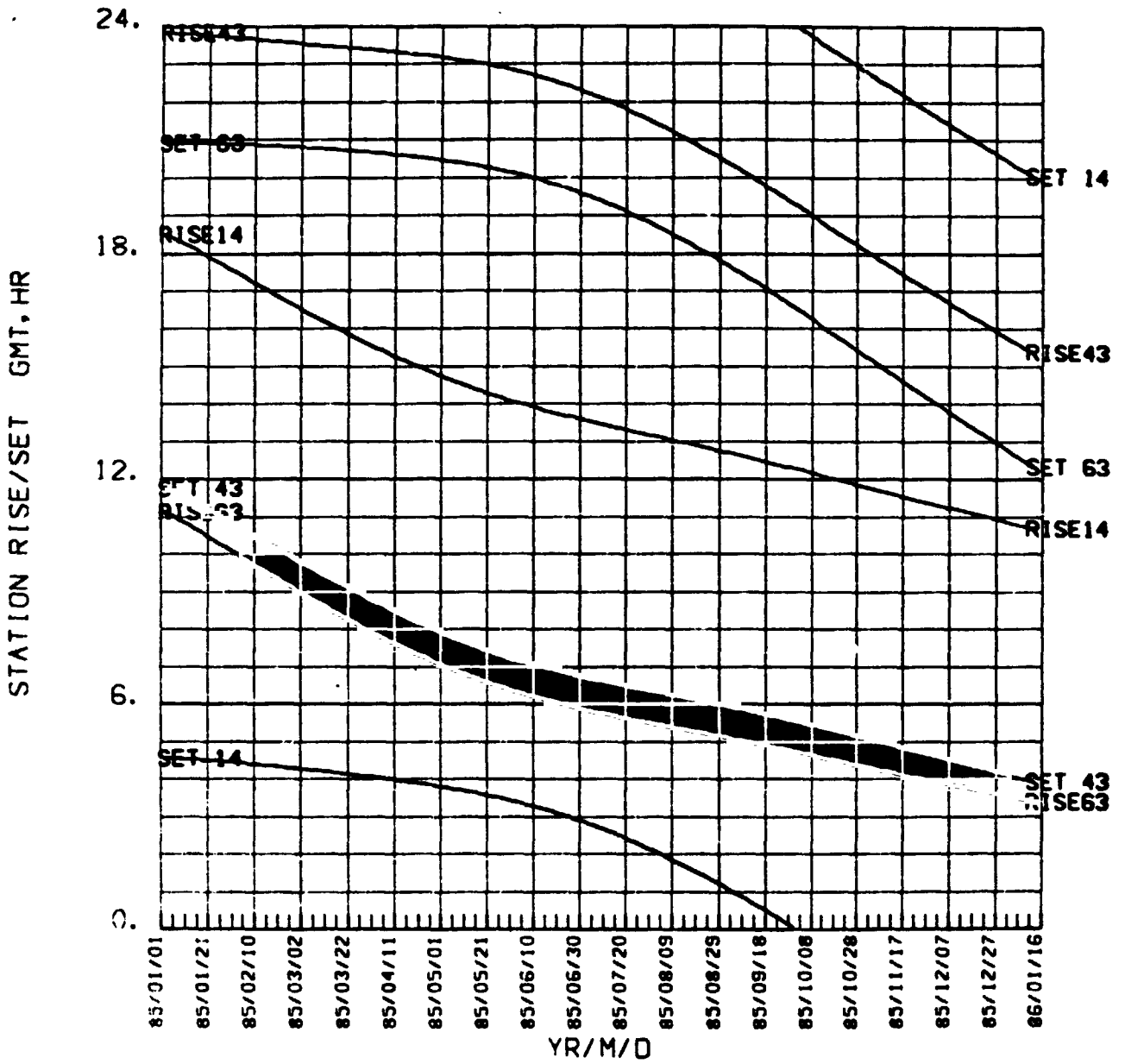
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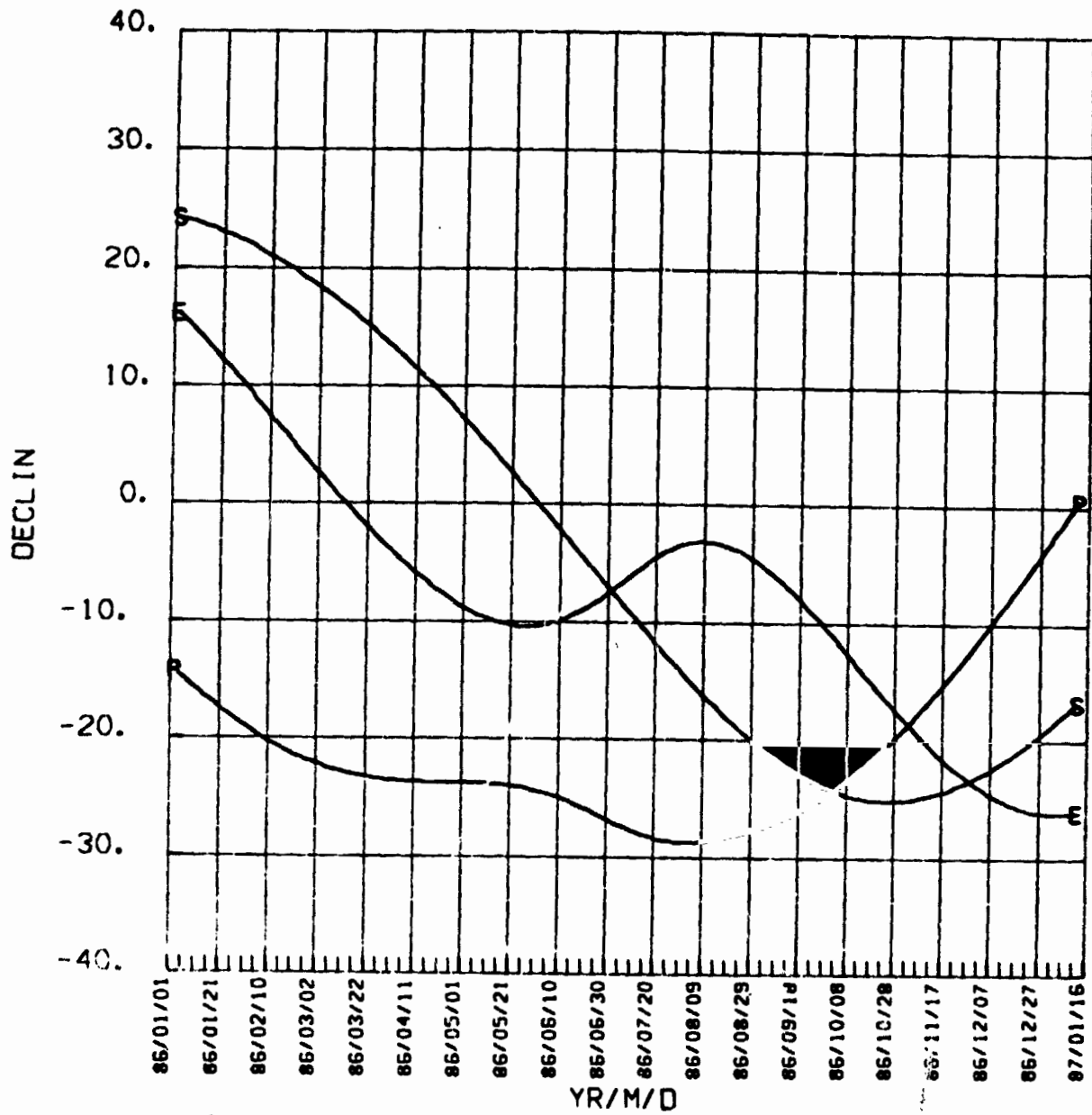
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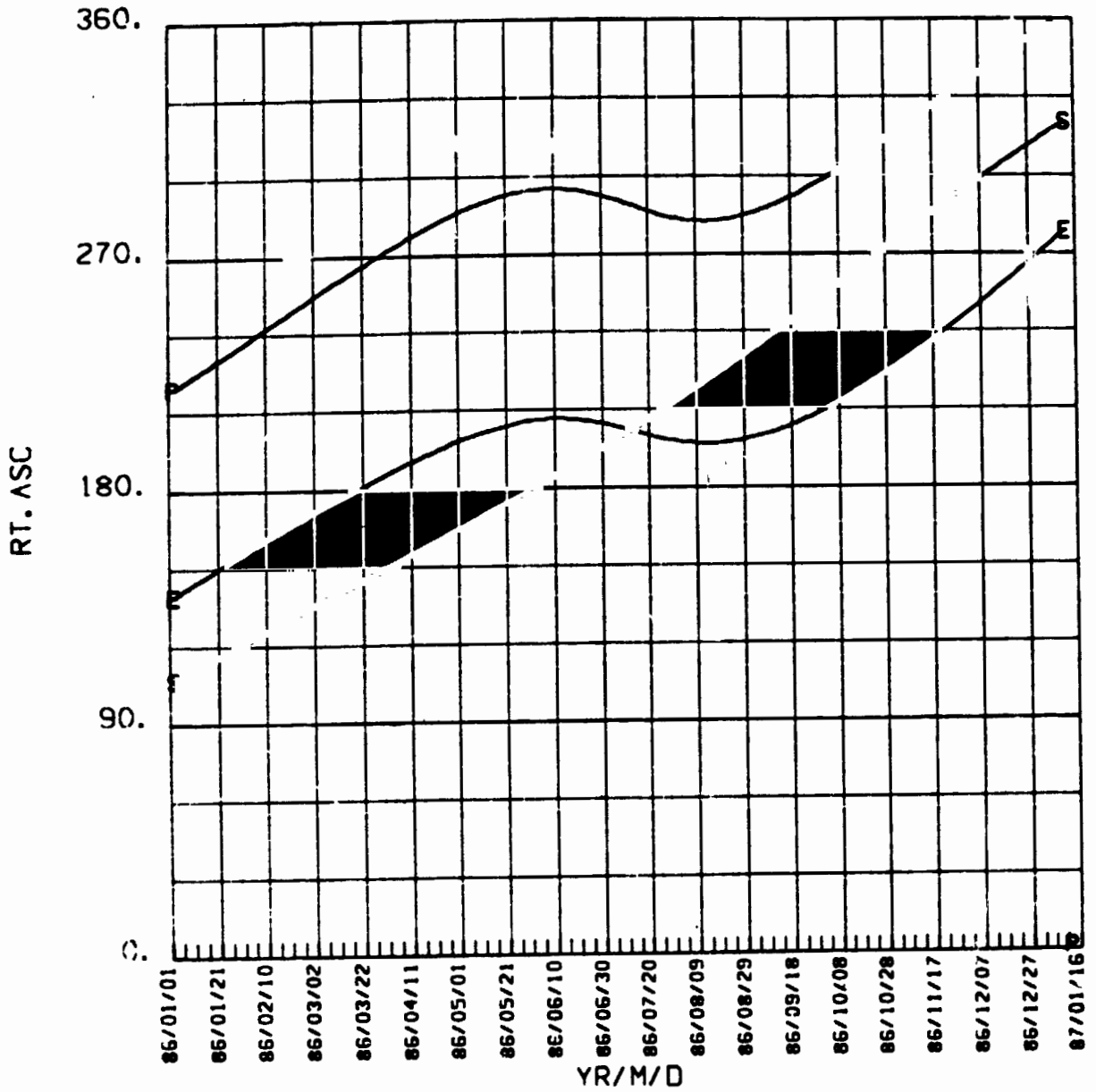
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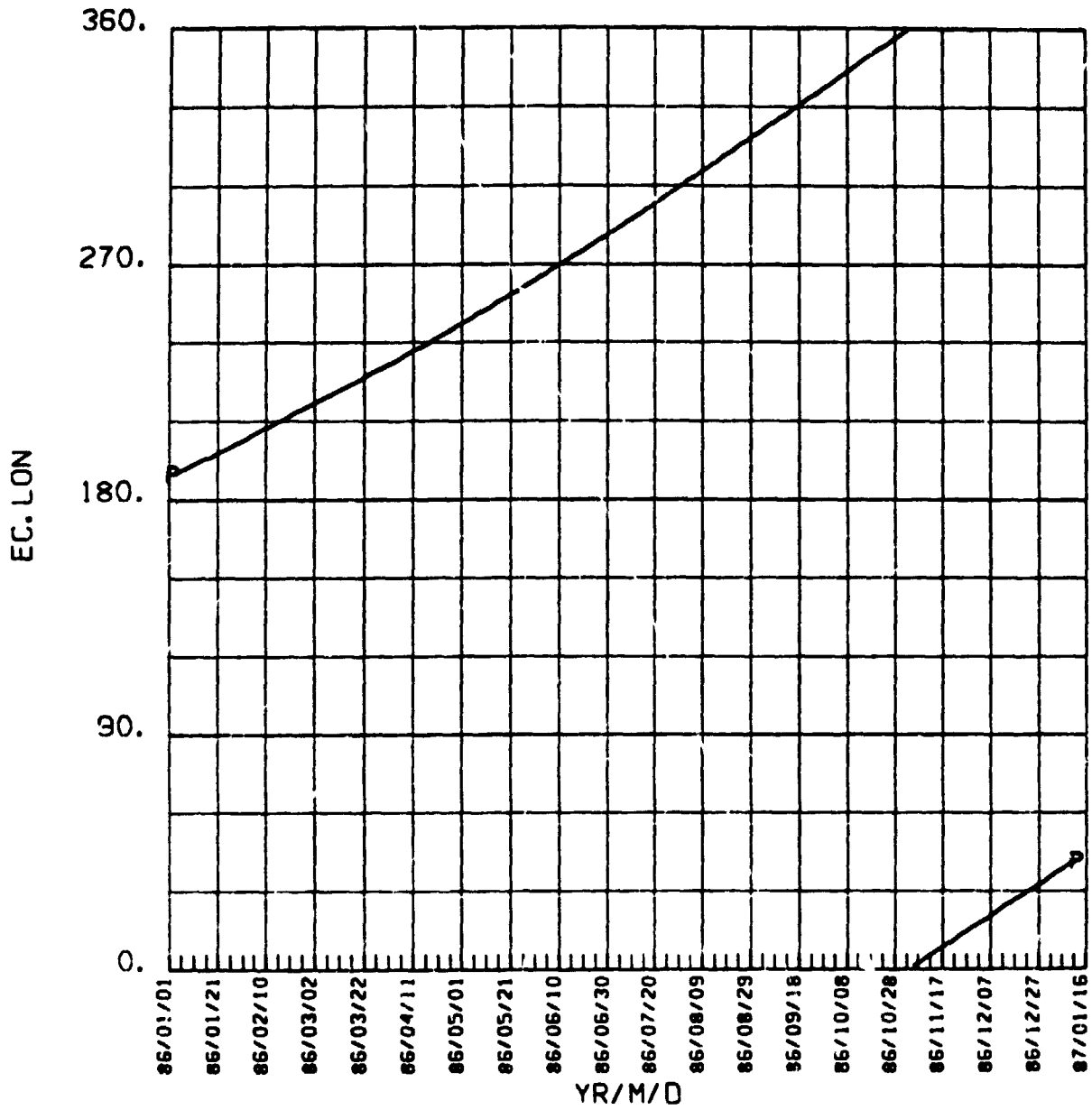
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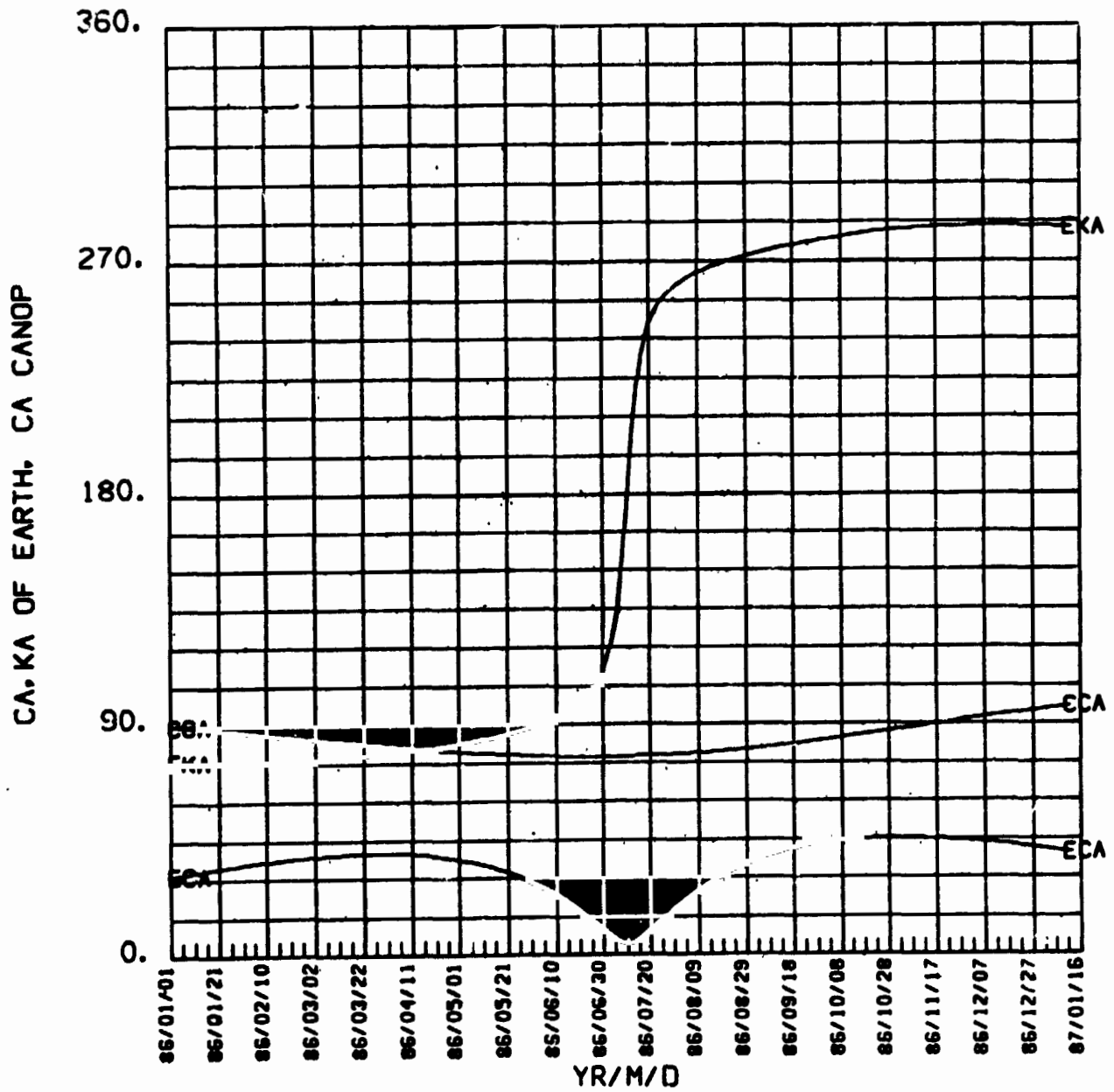
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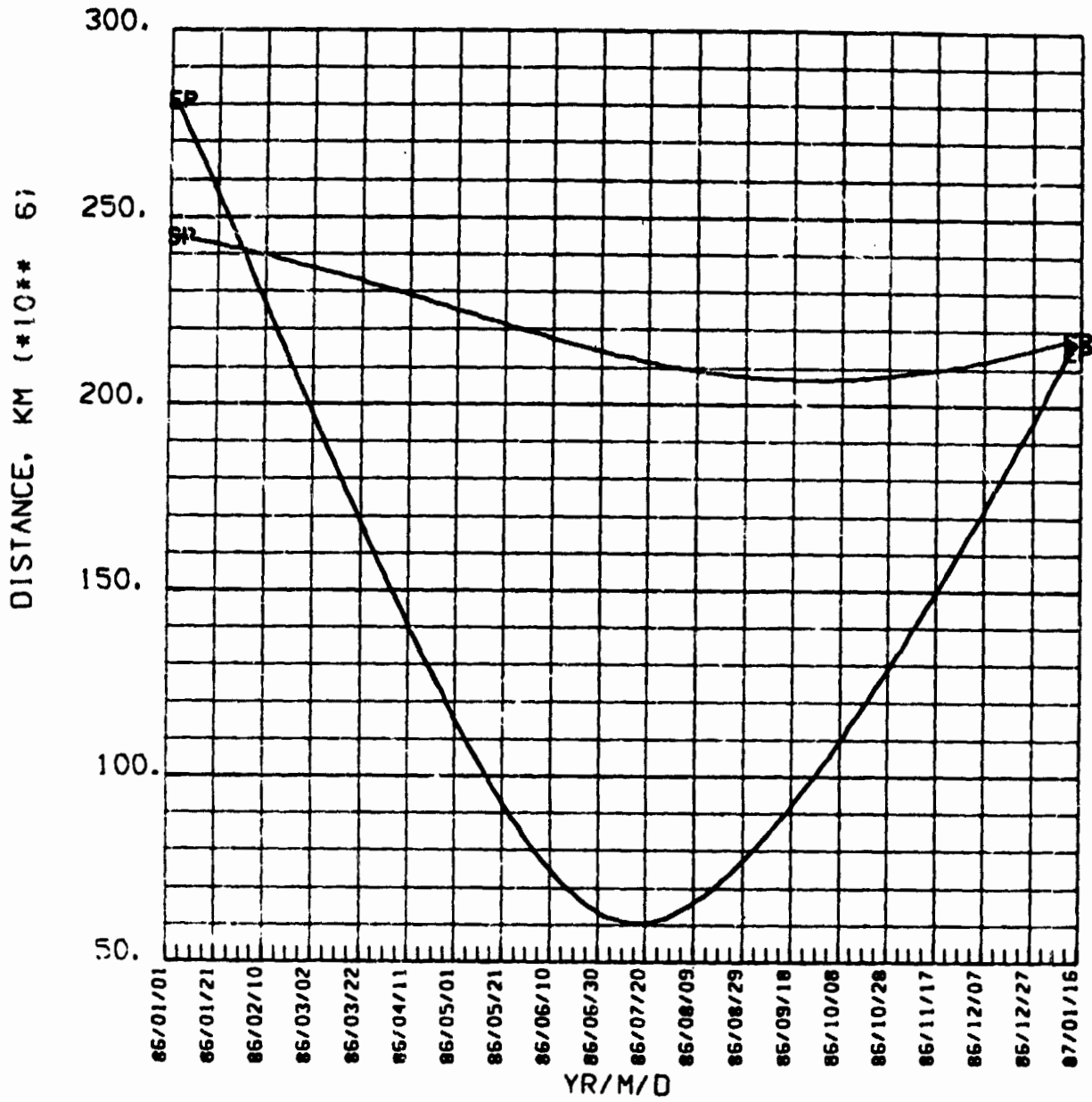


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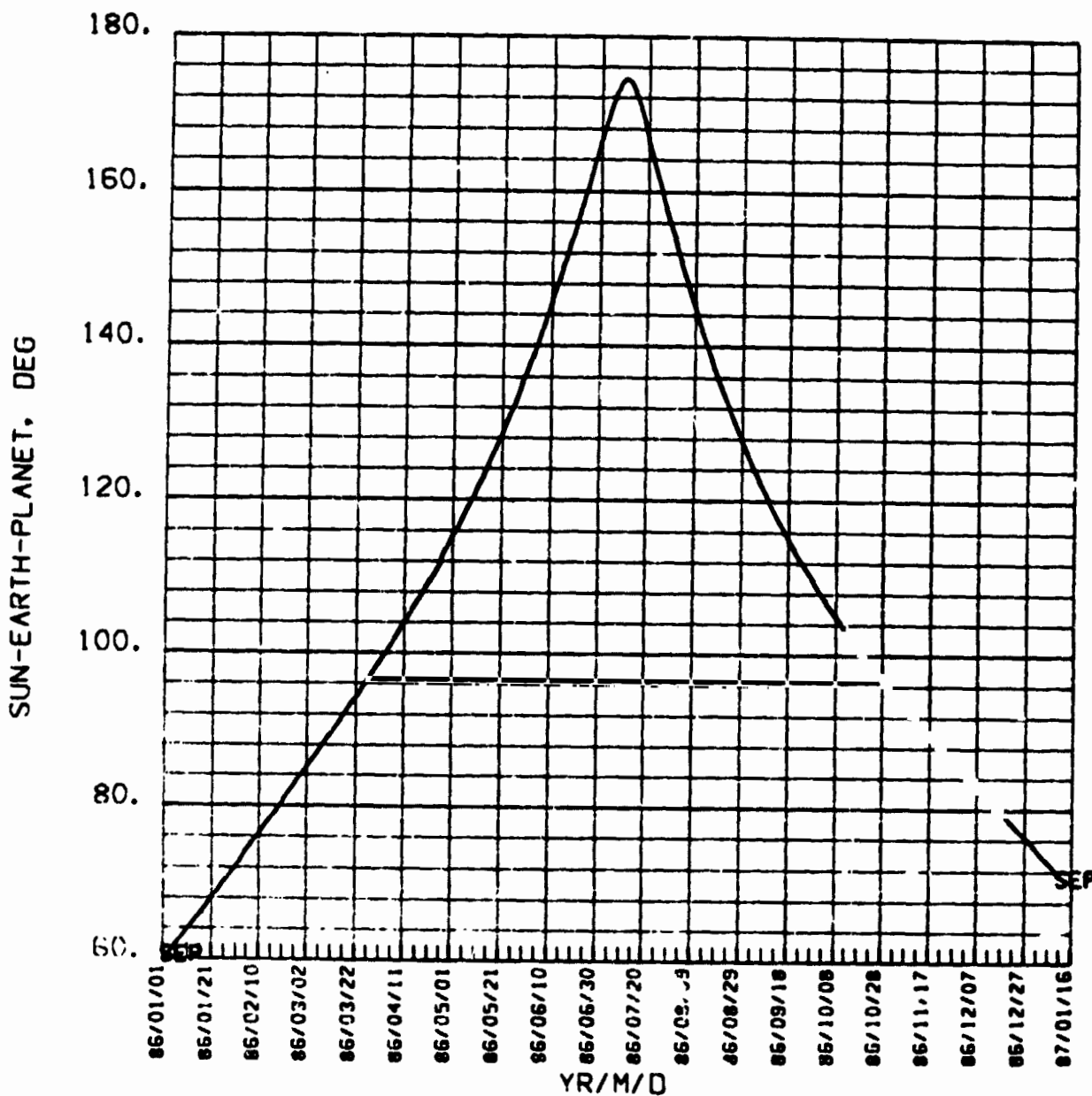




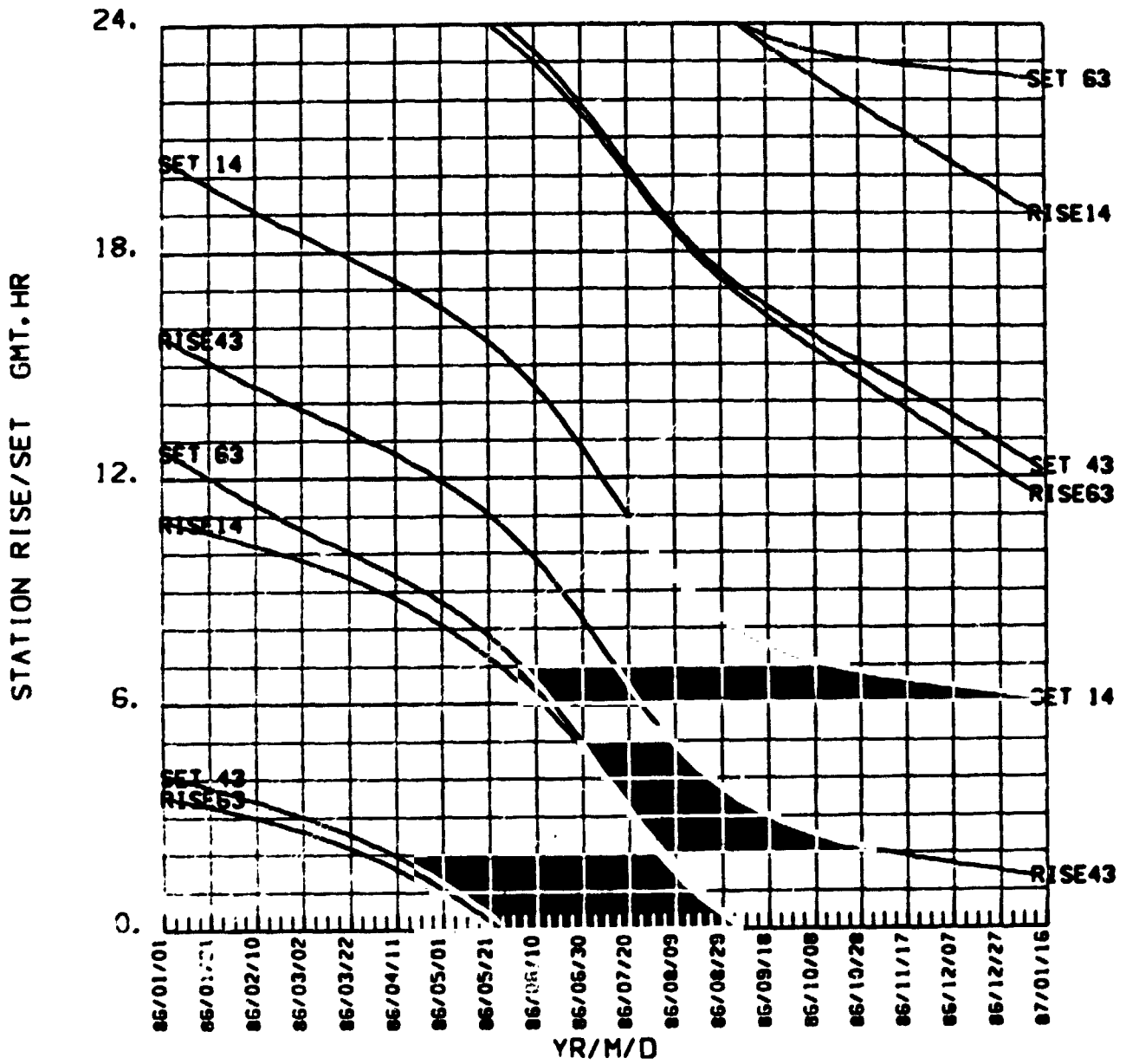
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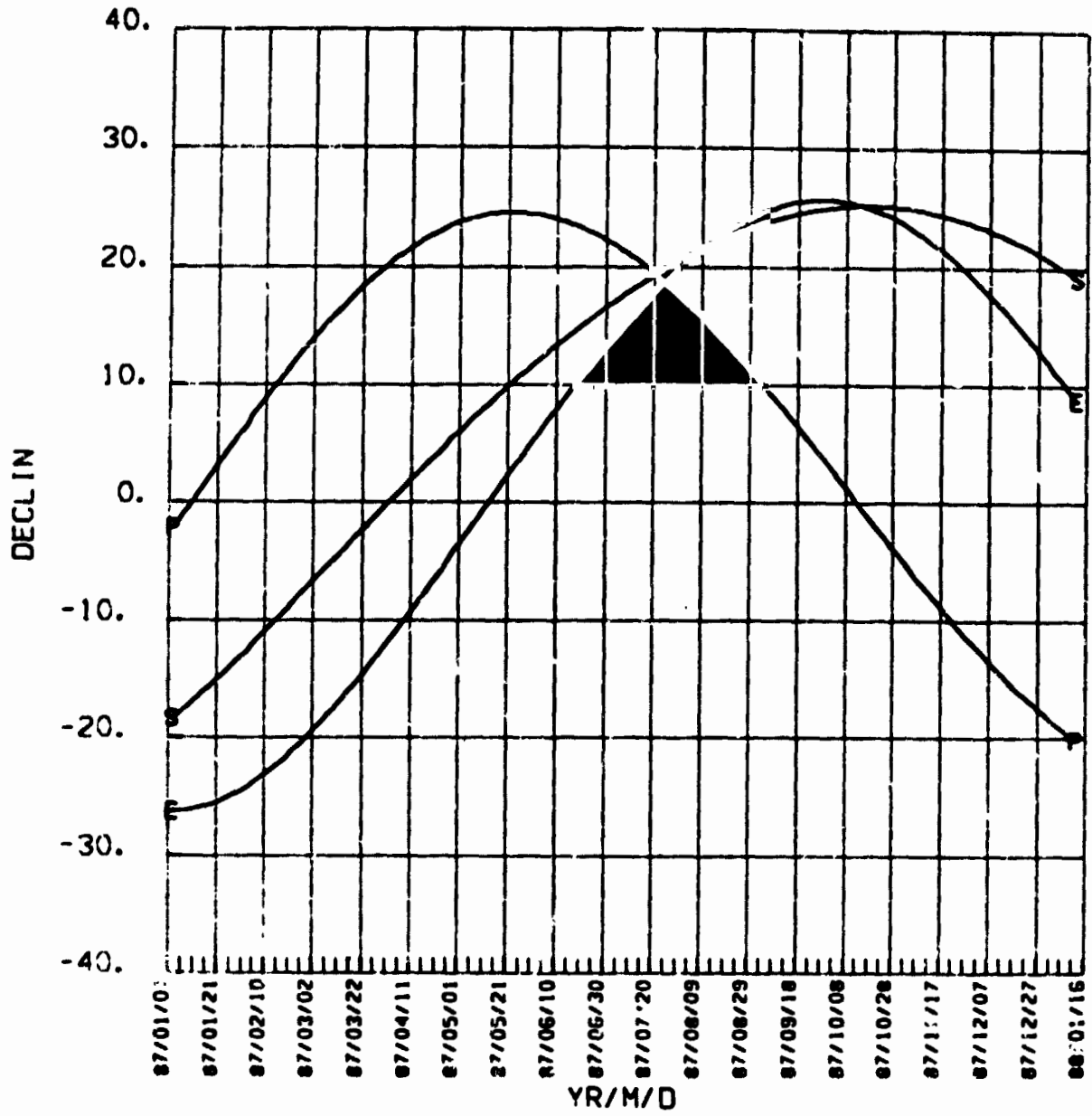
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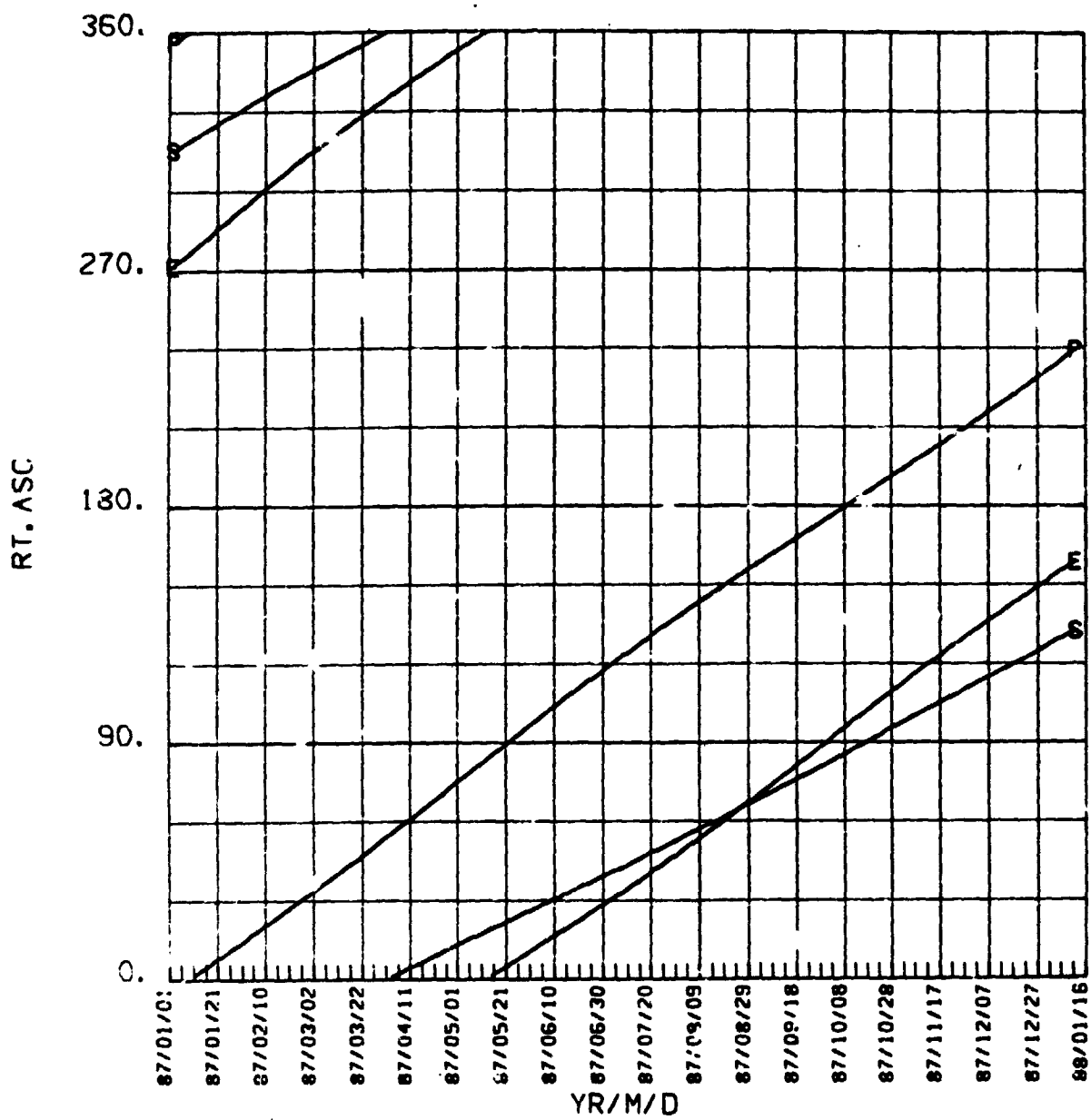
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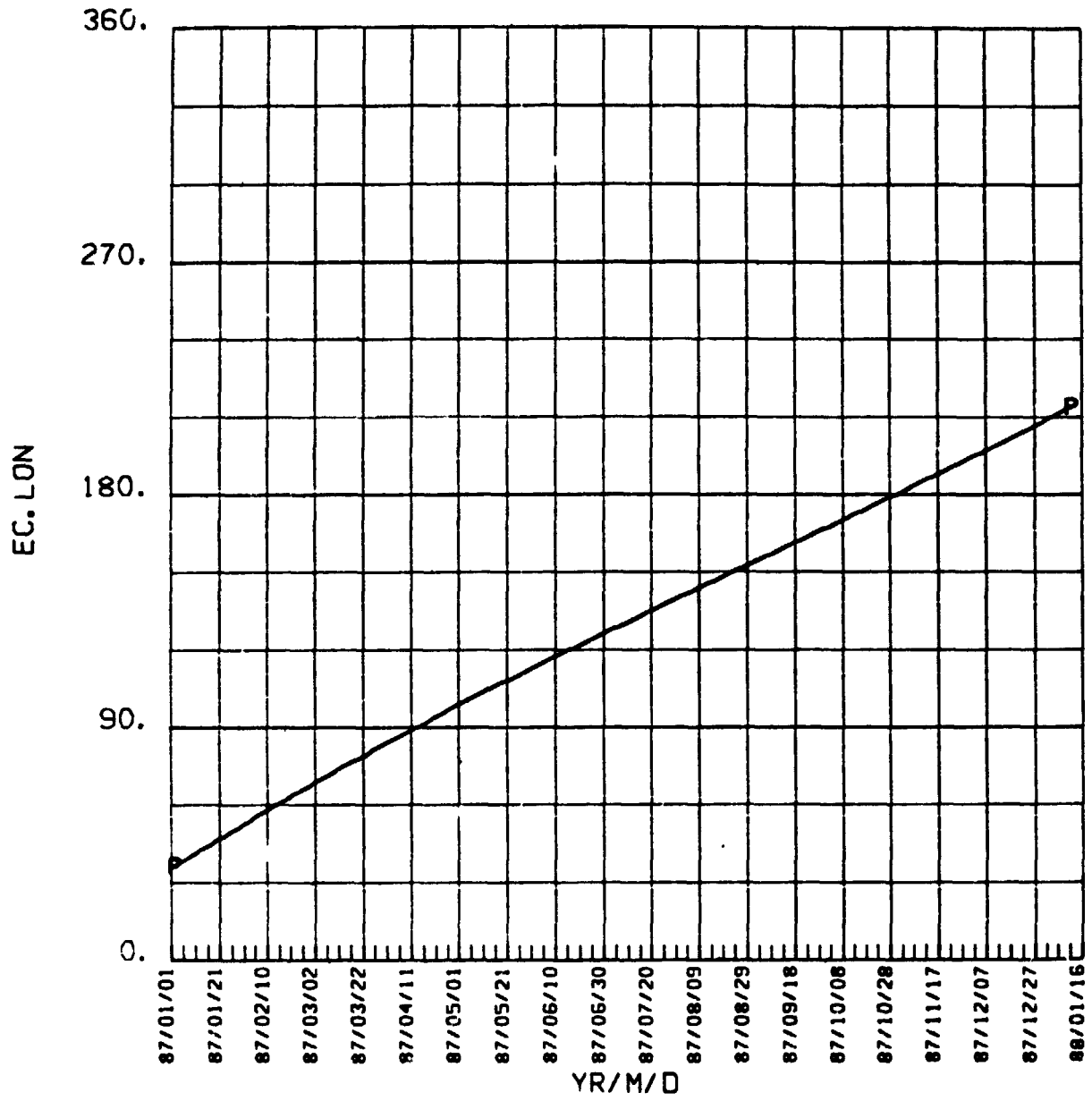
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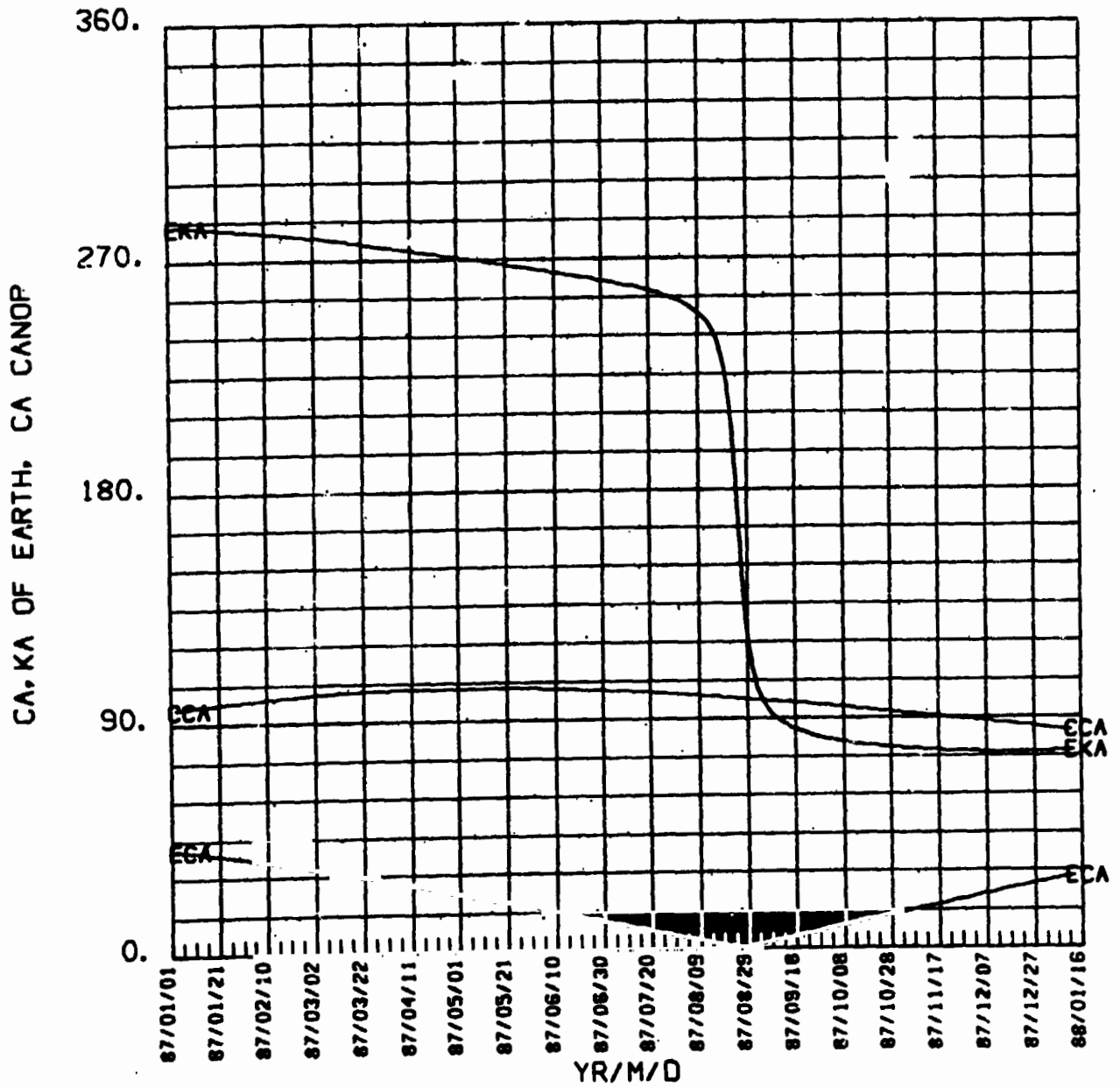
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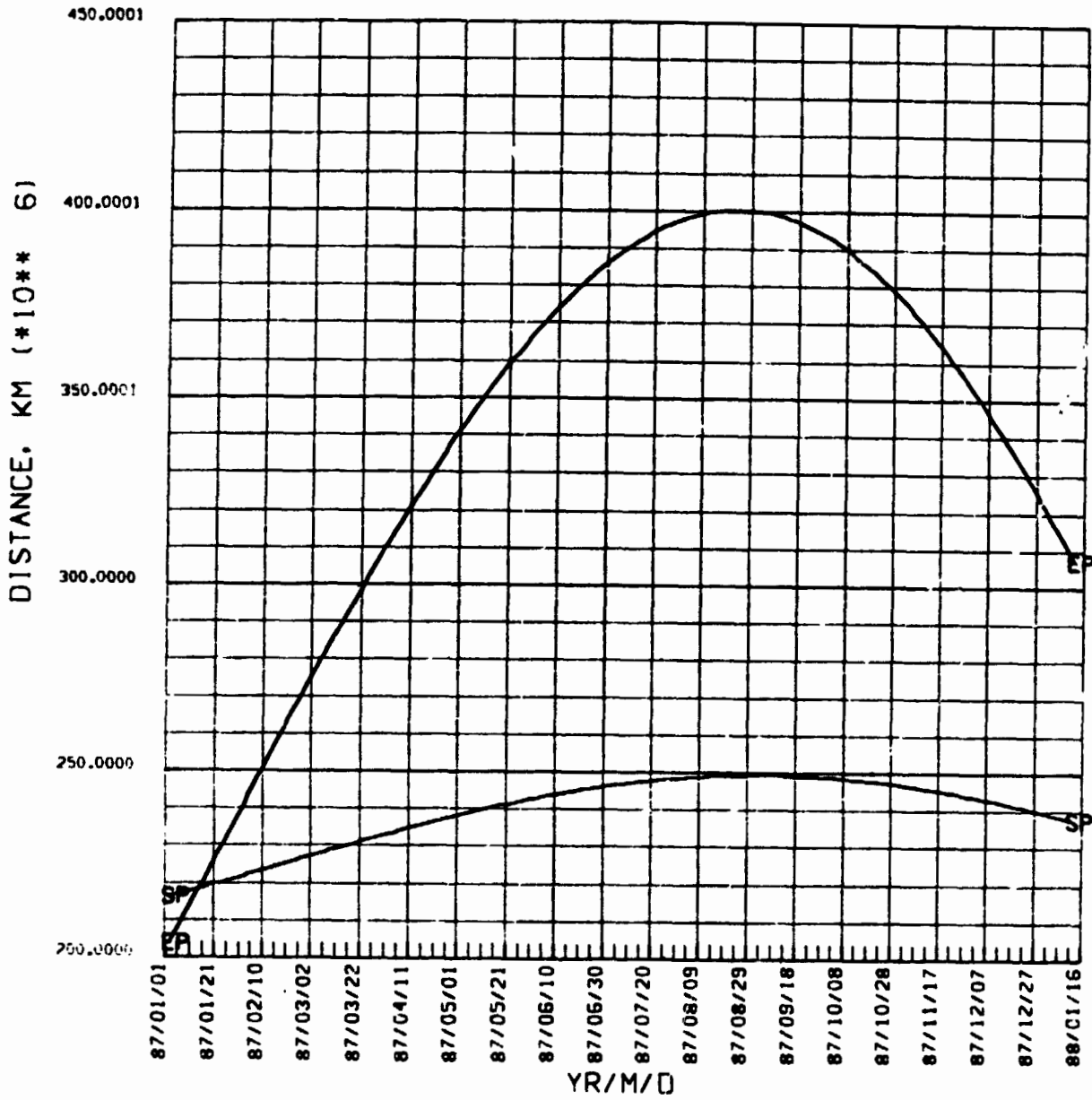
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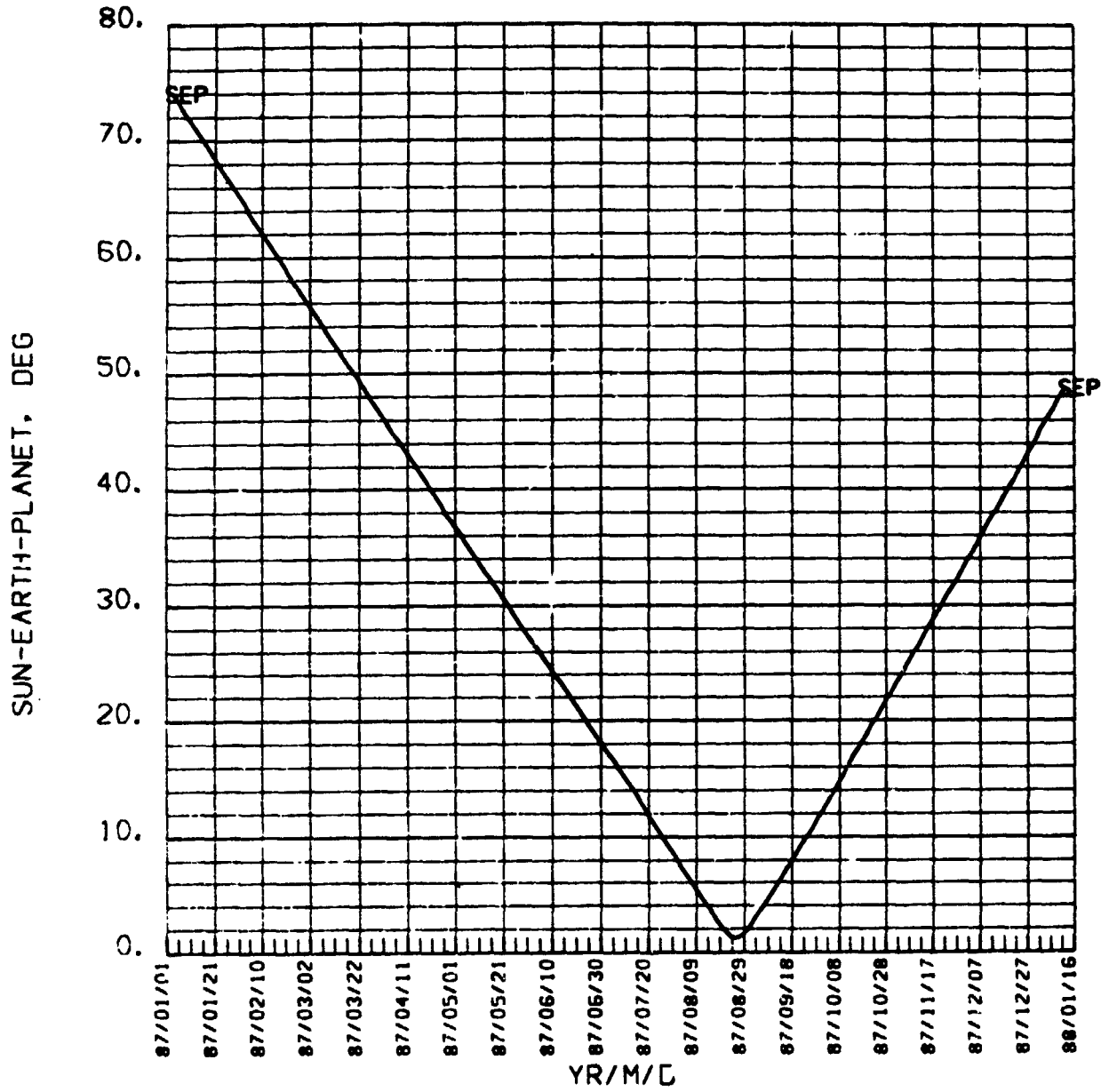


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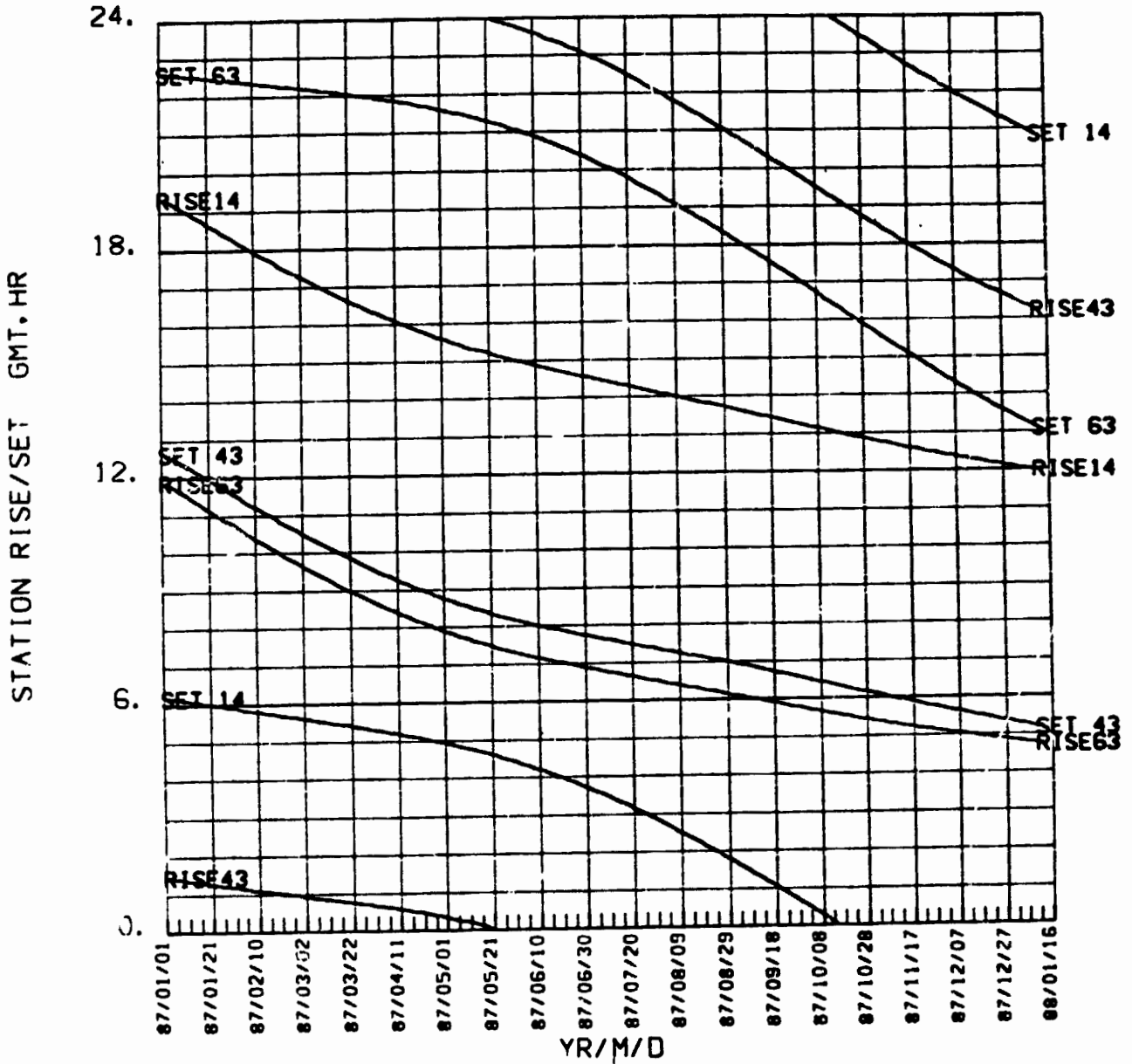




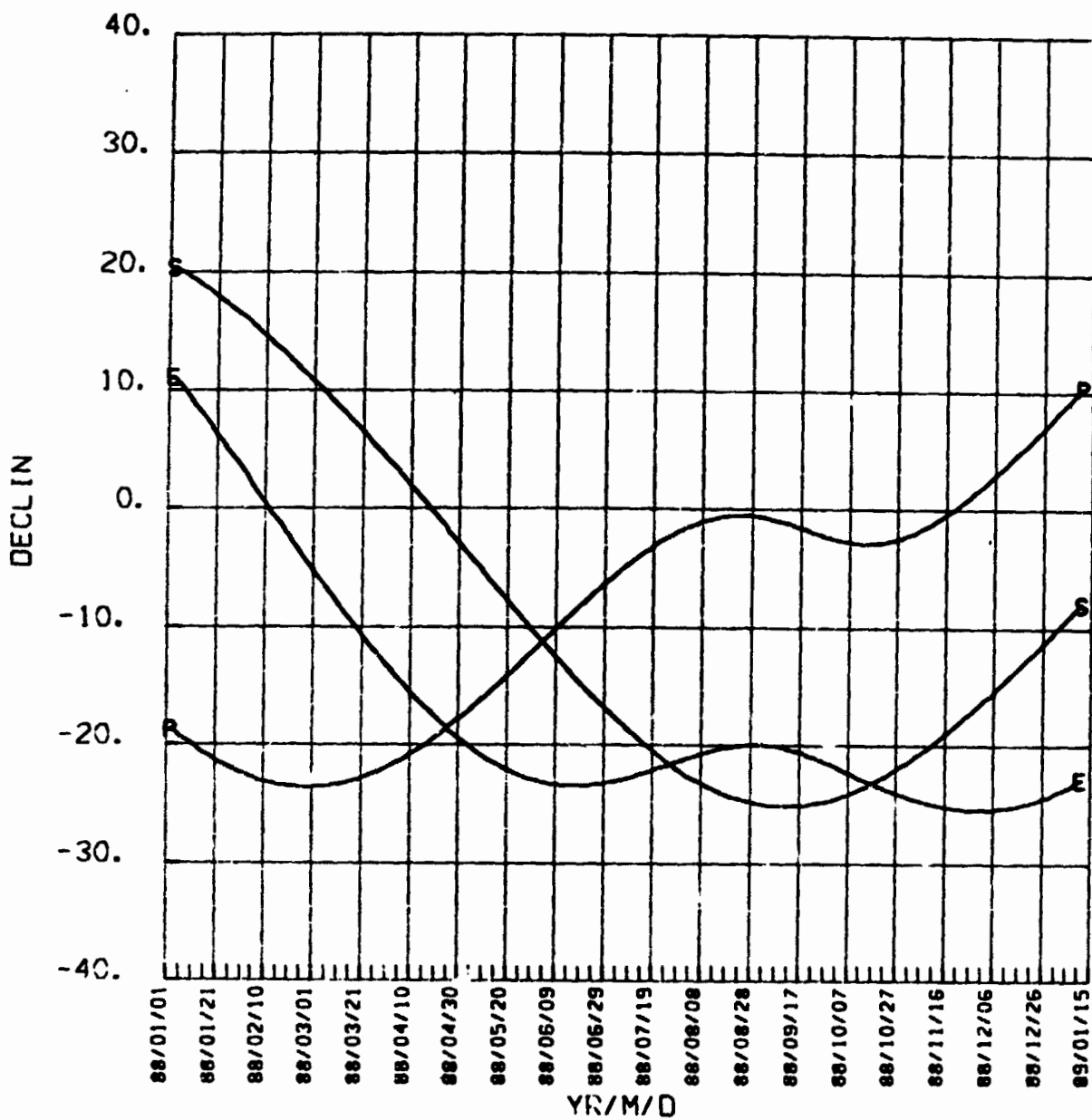
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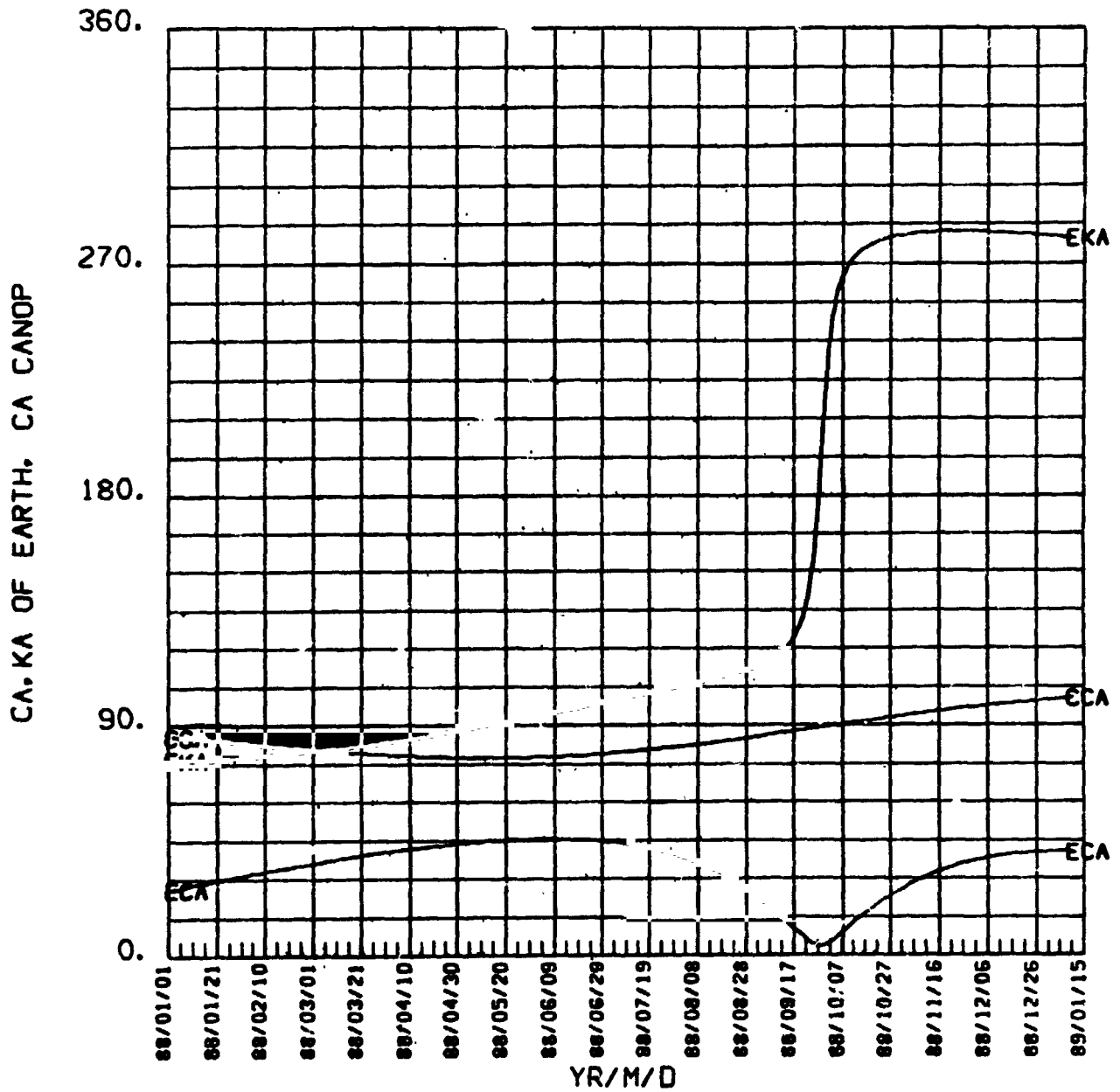


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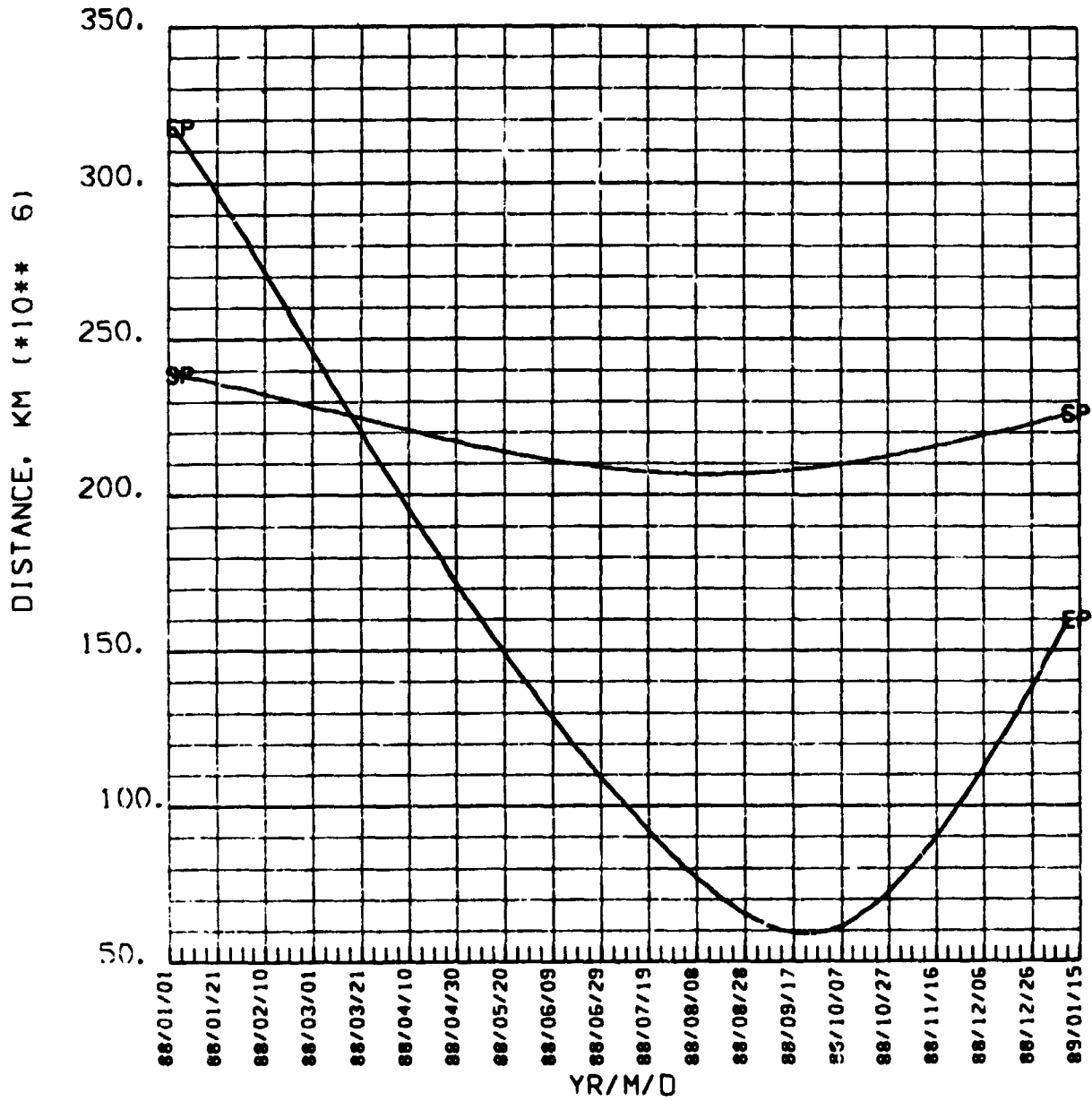
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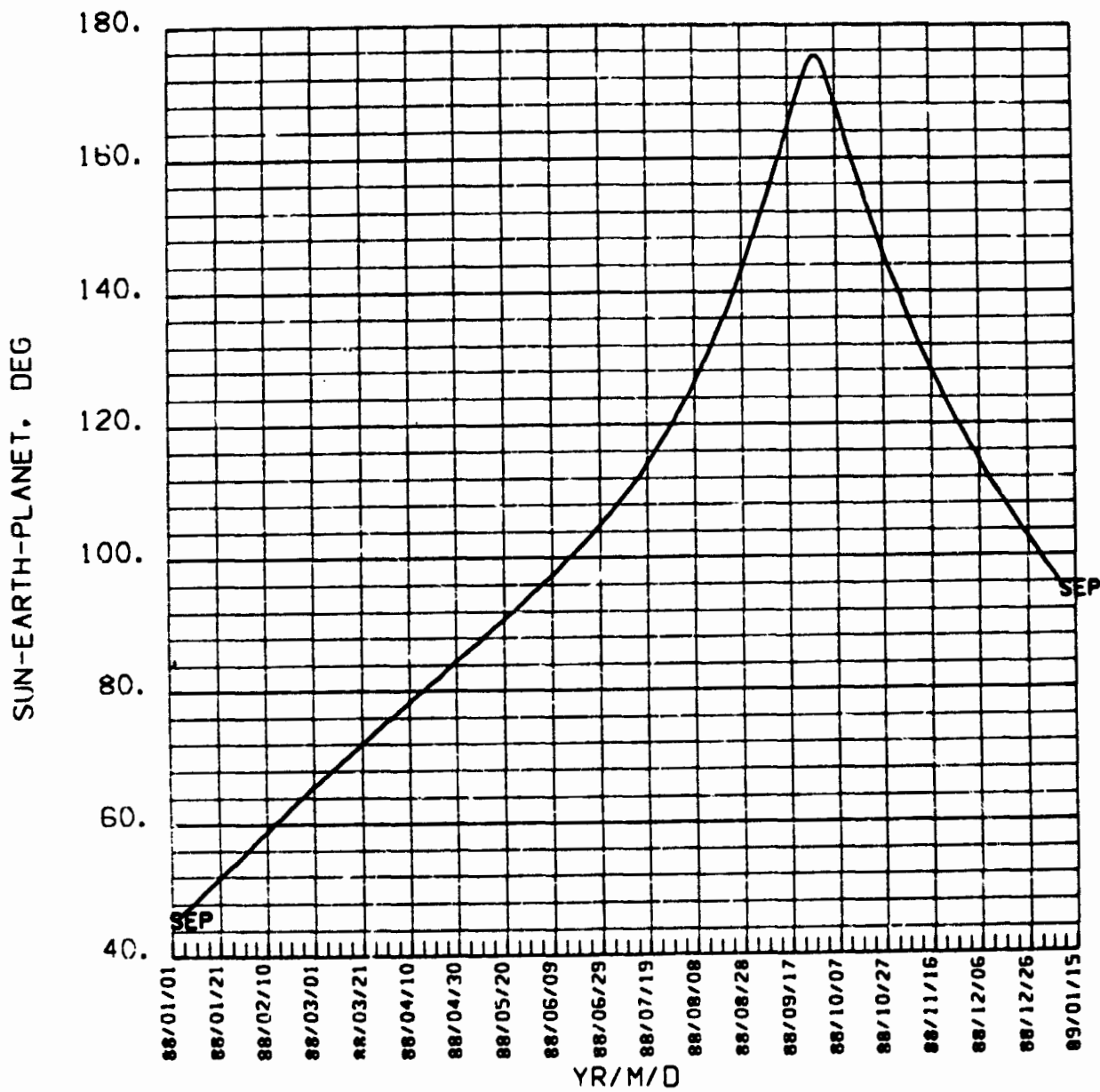


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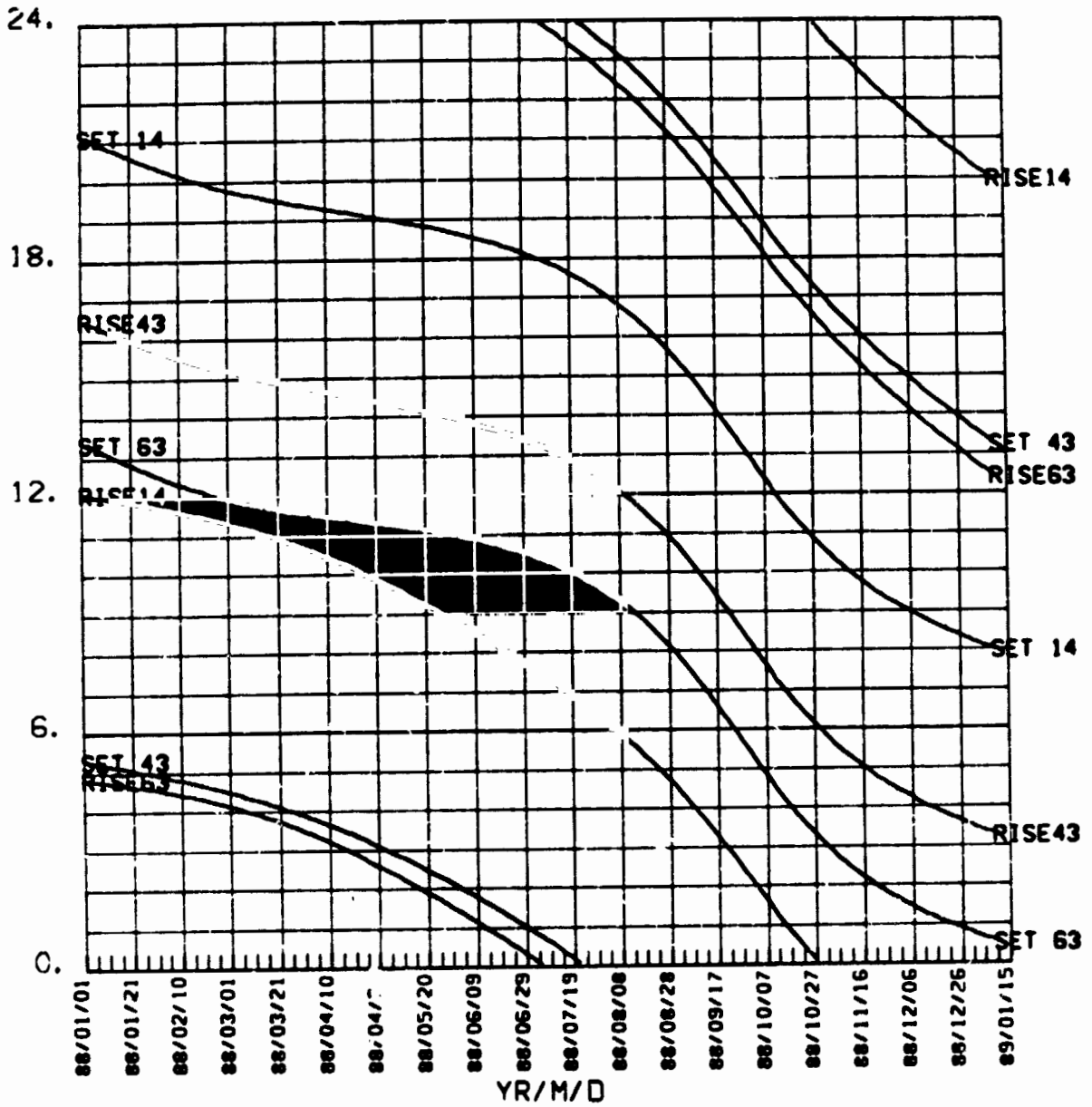


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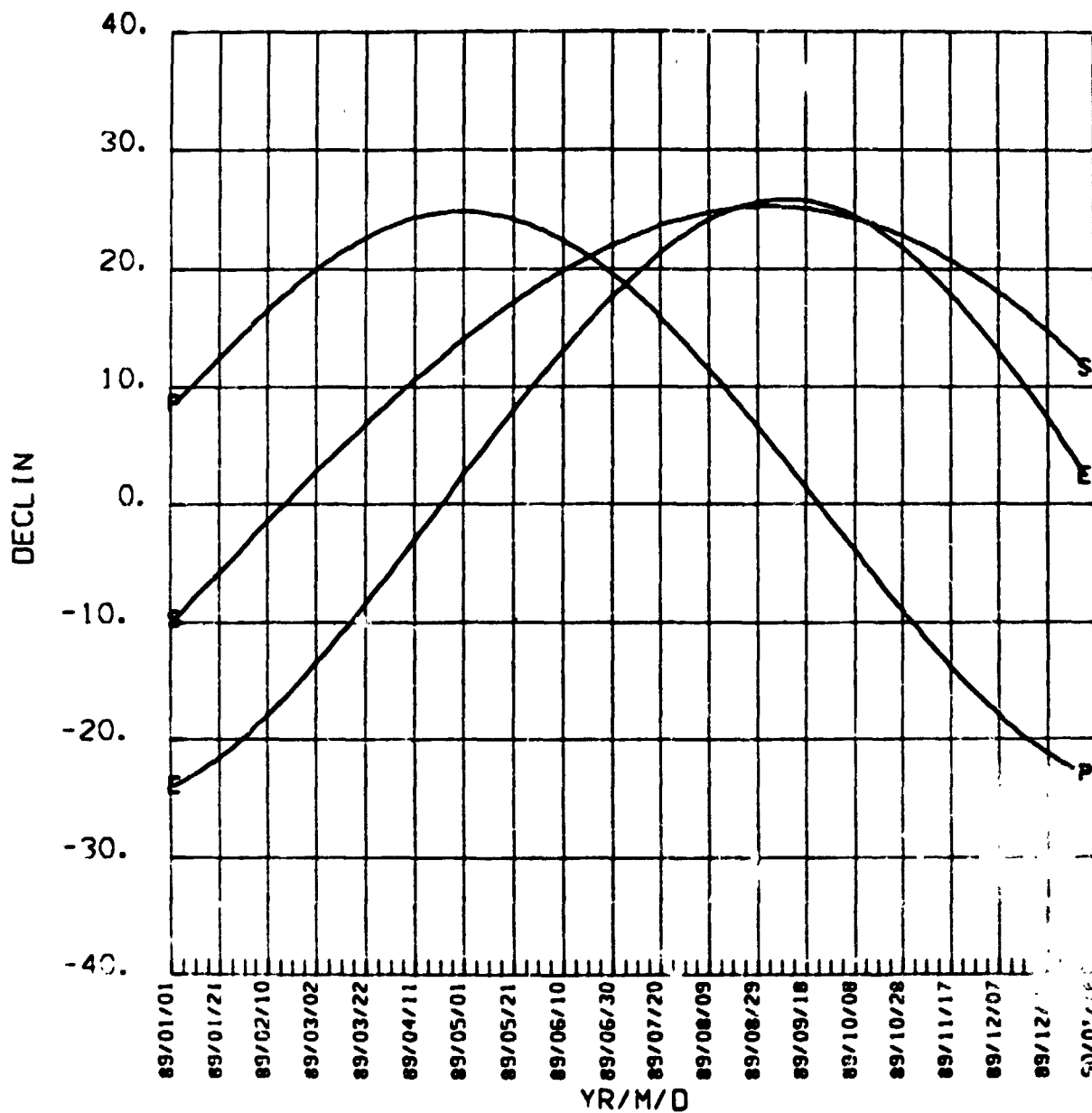


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STATION RISE/SET GMT, HR

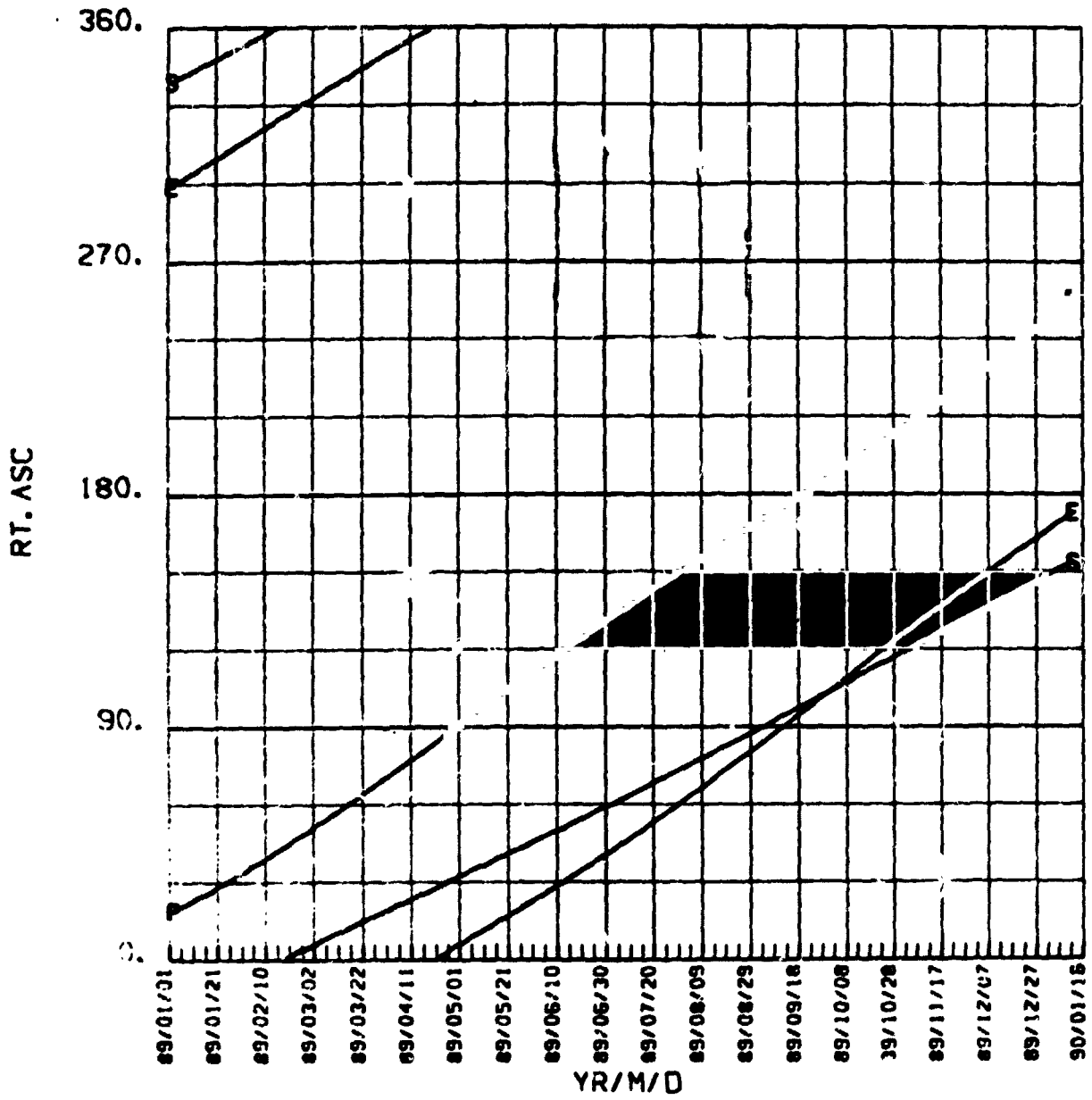


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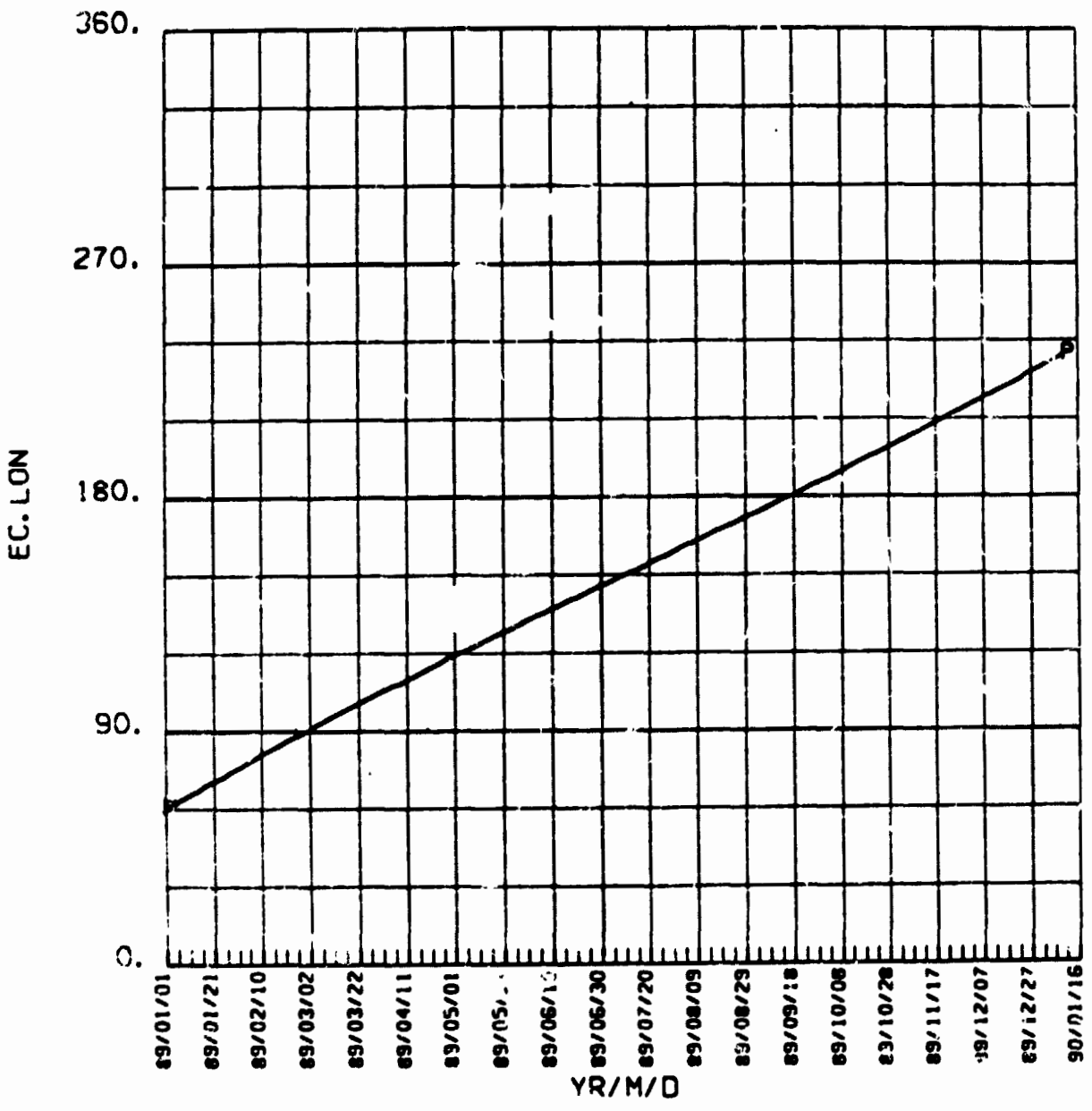




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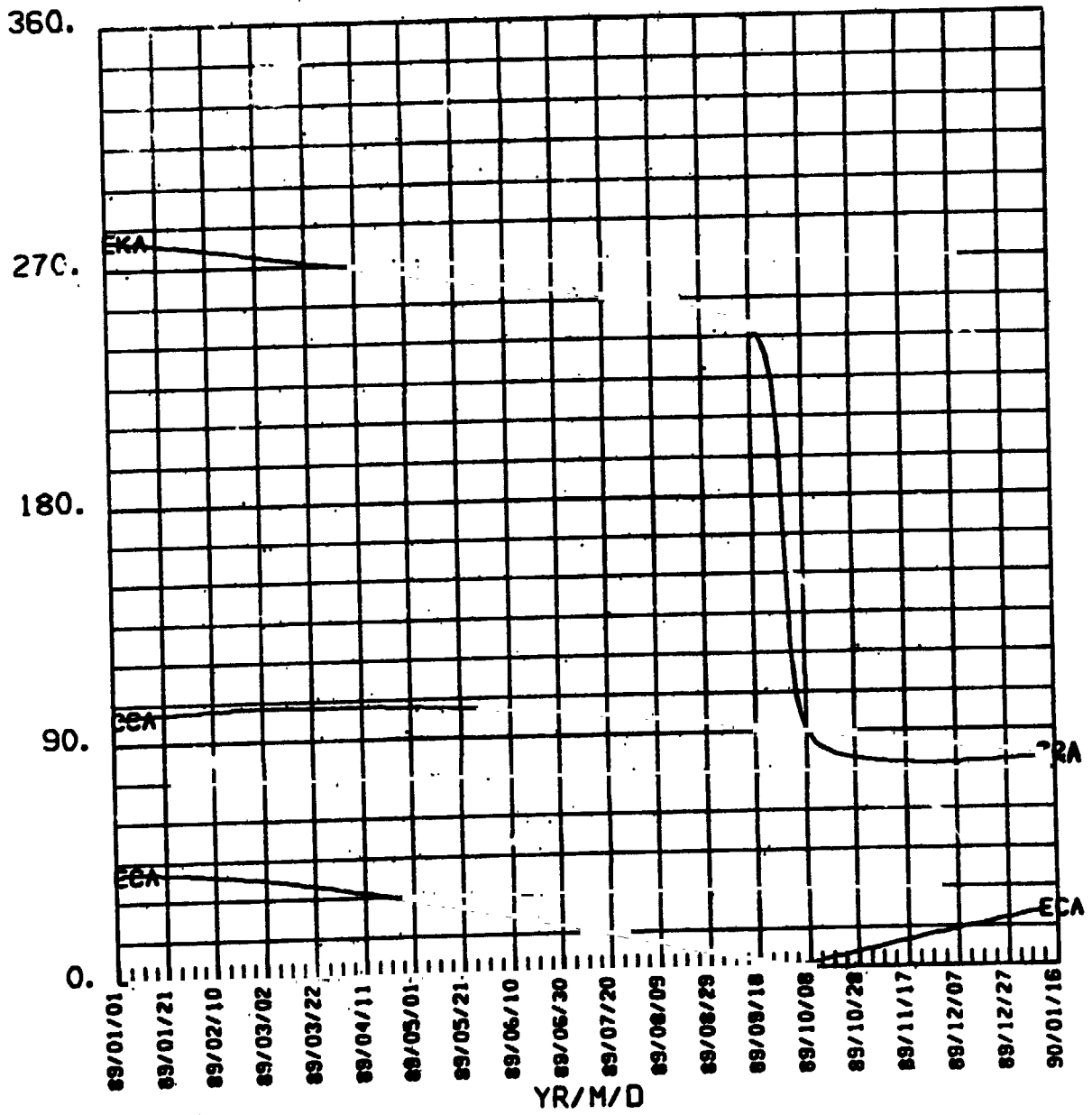
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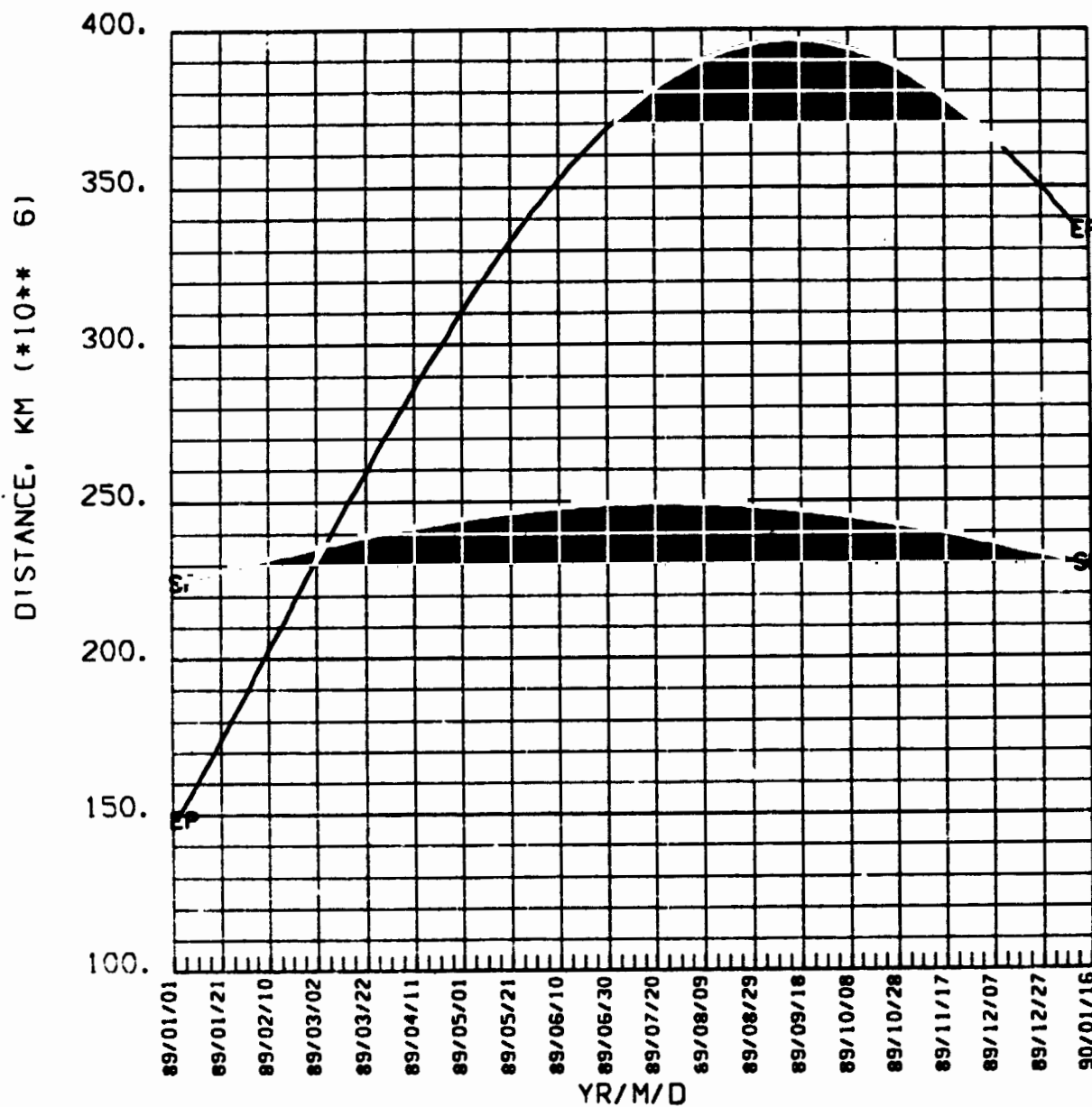
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CA, KA OF EARTH, CA CANOP



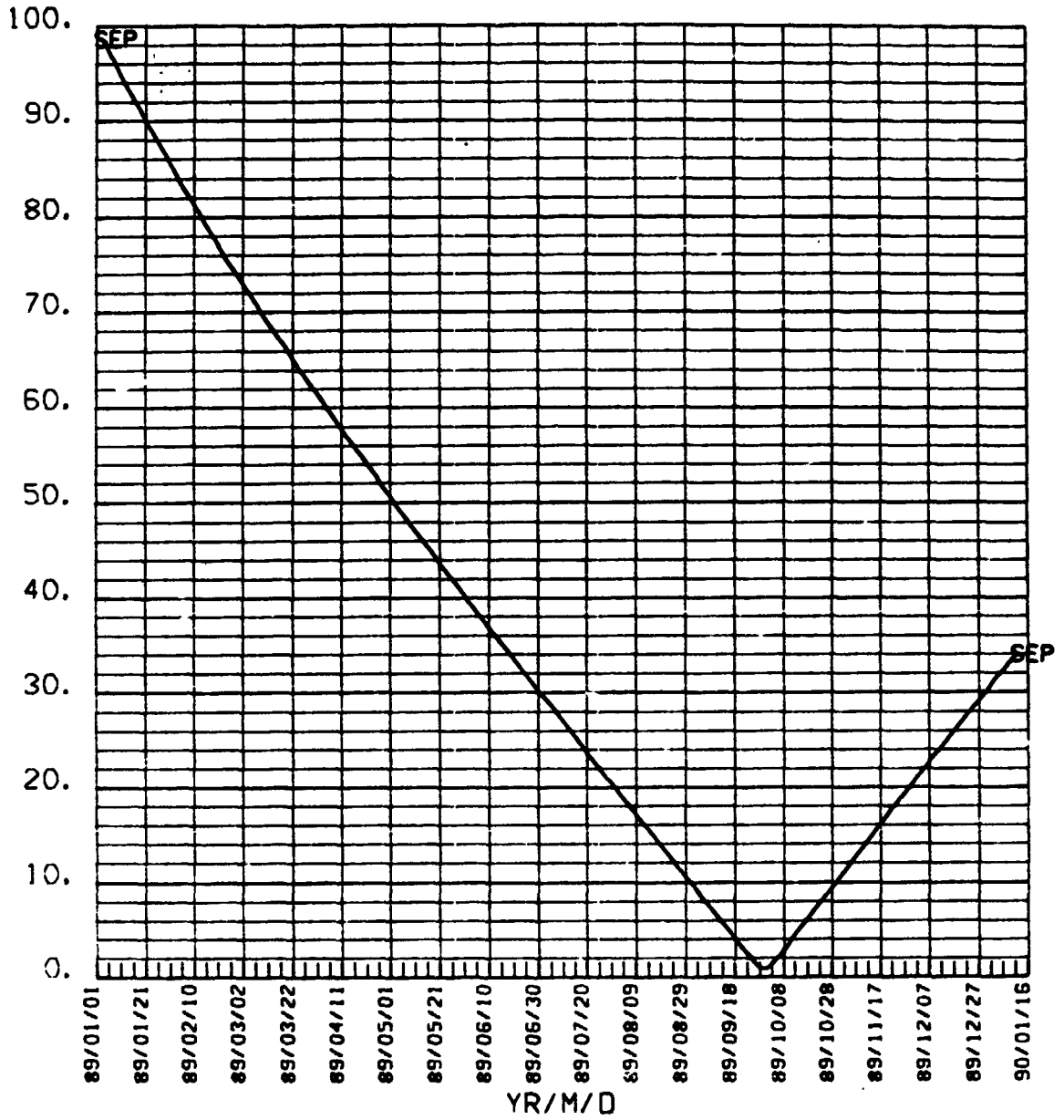
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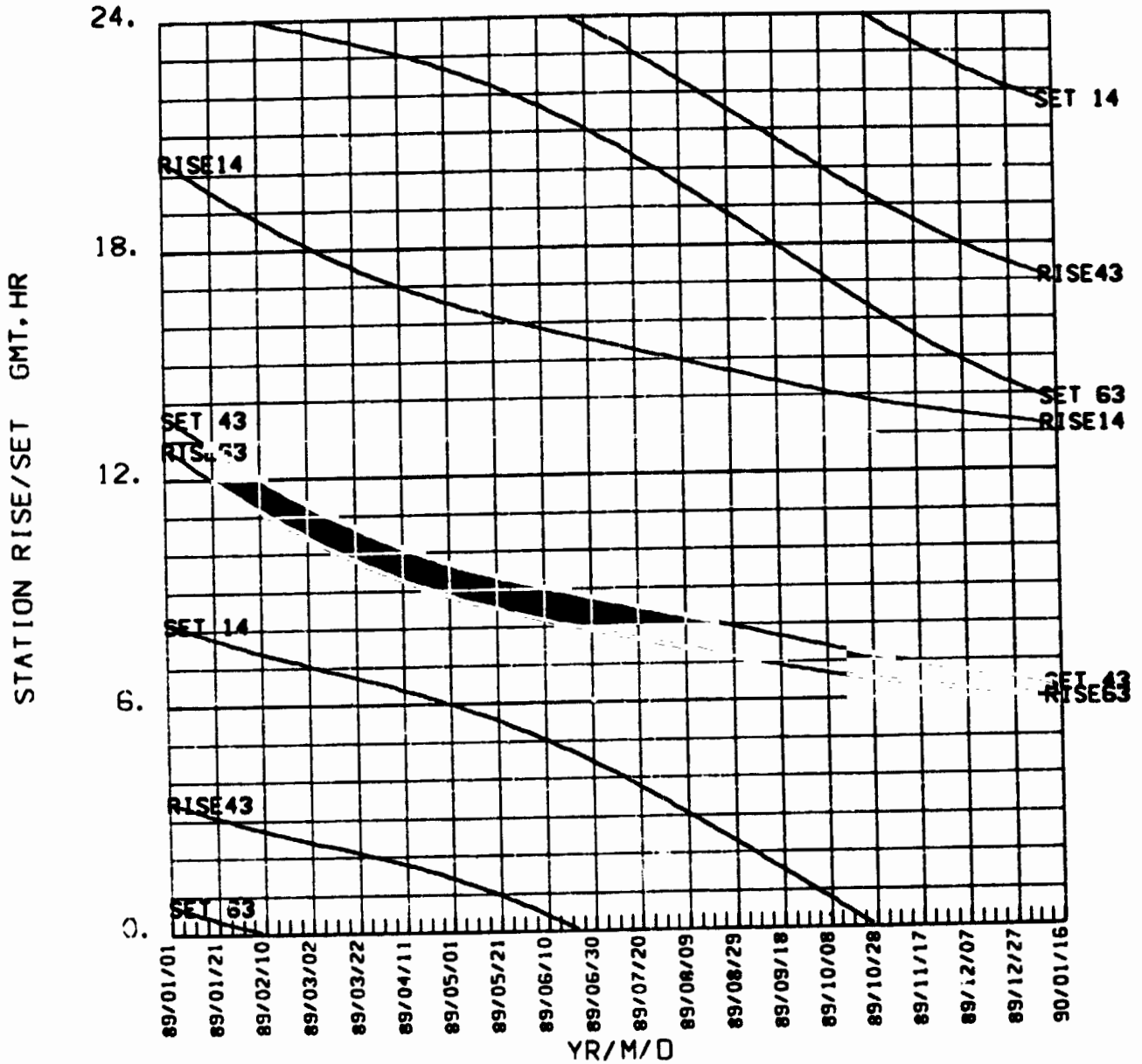


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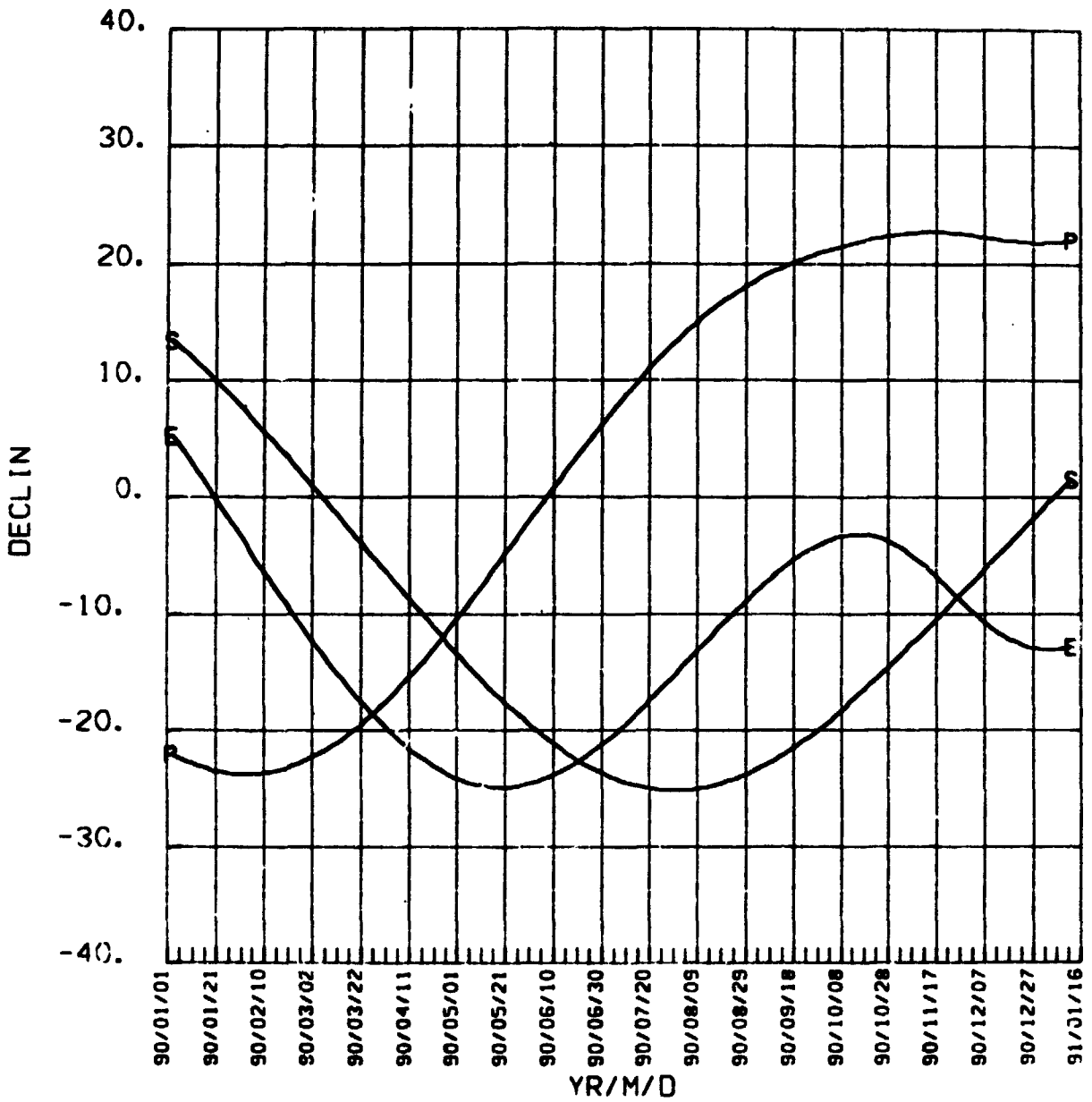
SUN-EARTH-PLANET. DEG



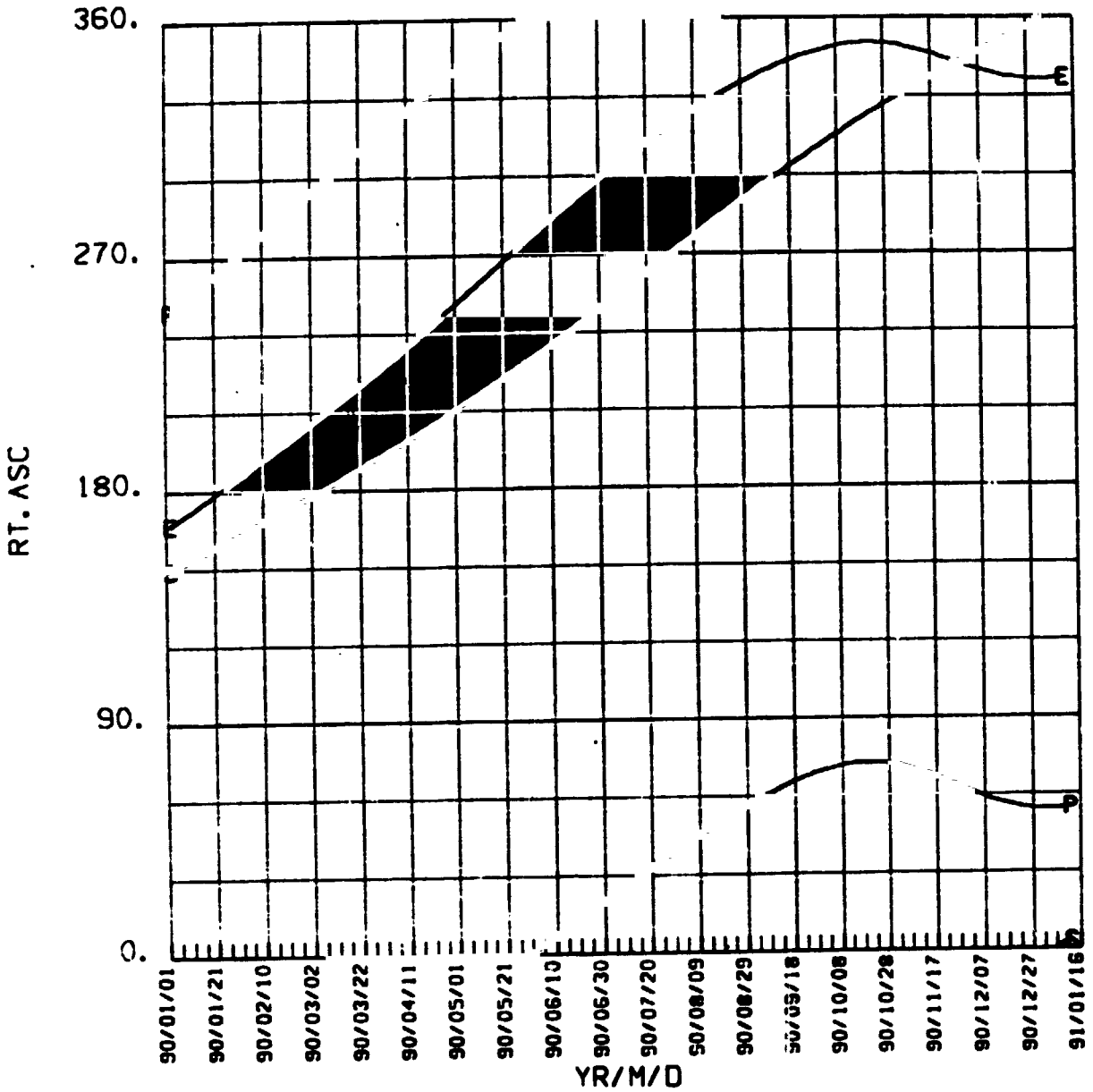
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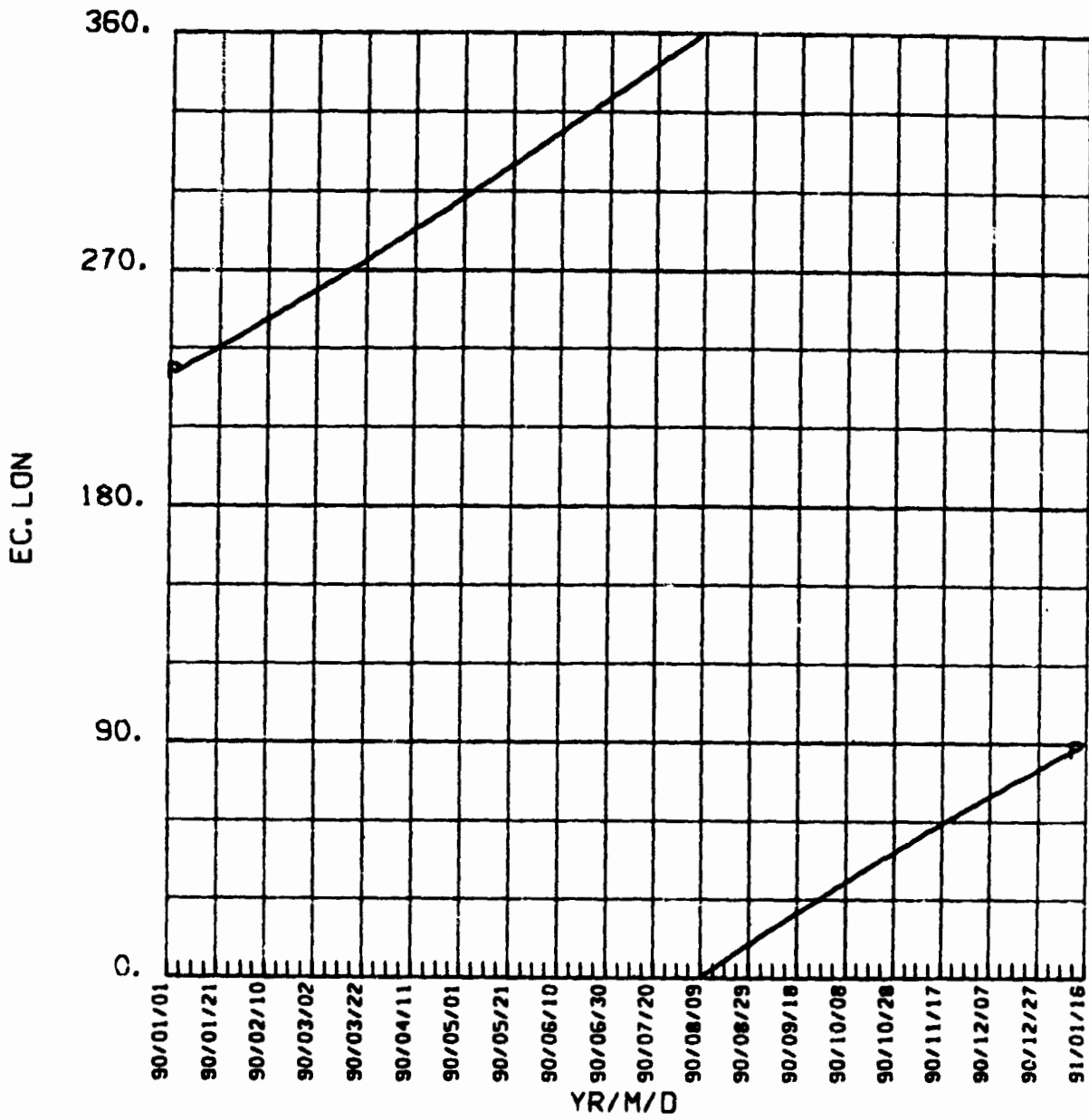


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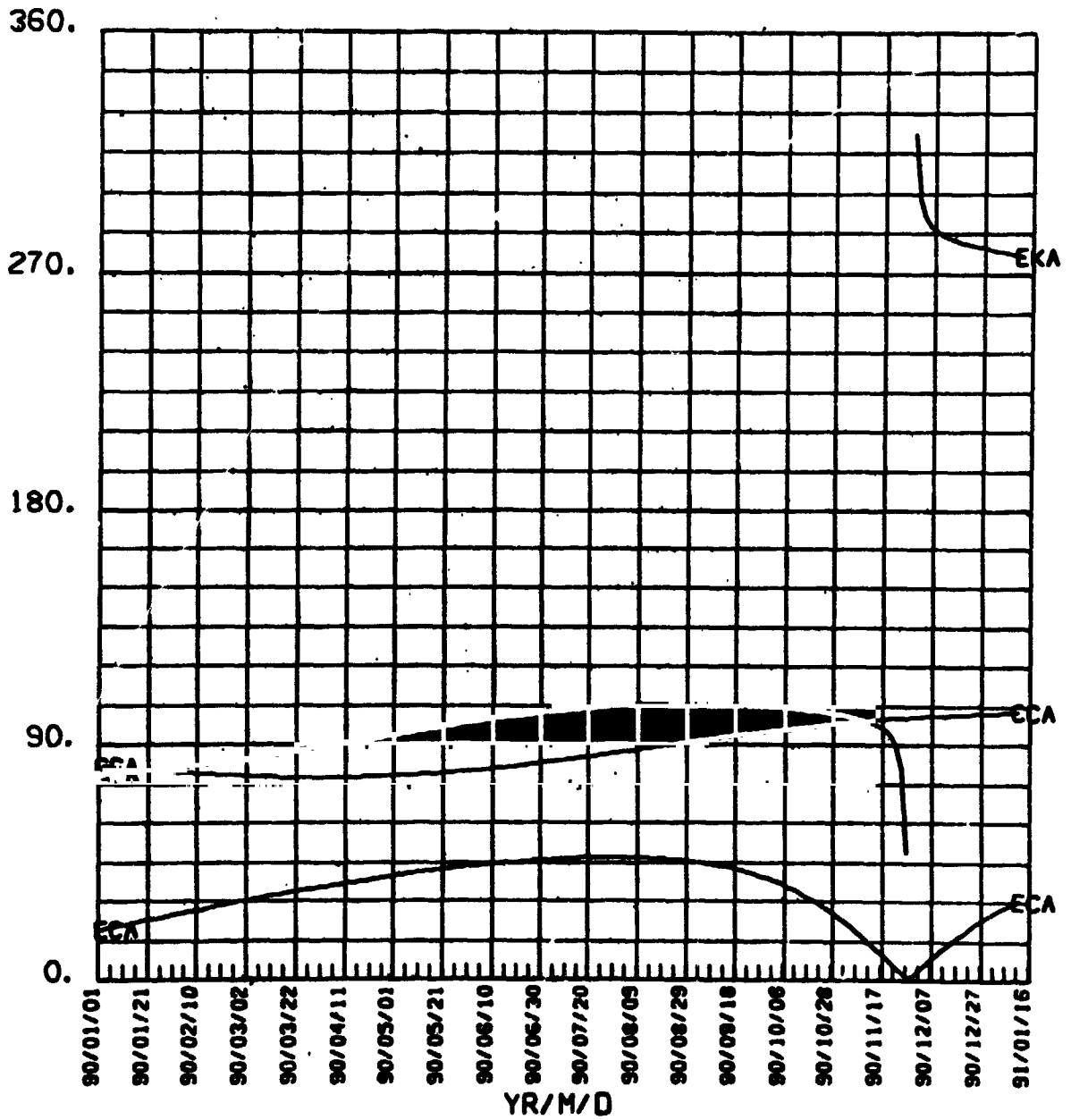


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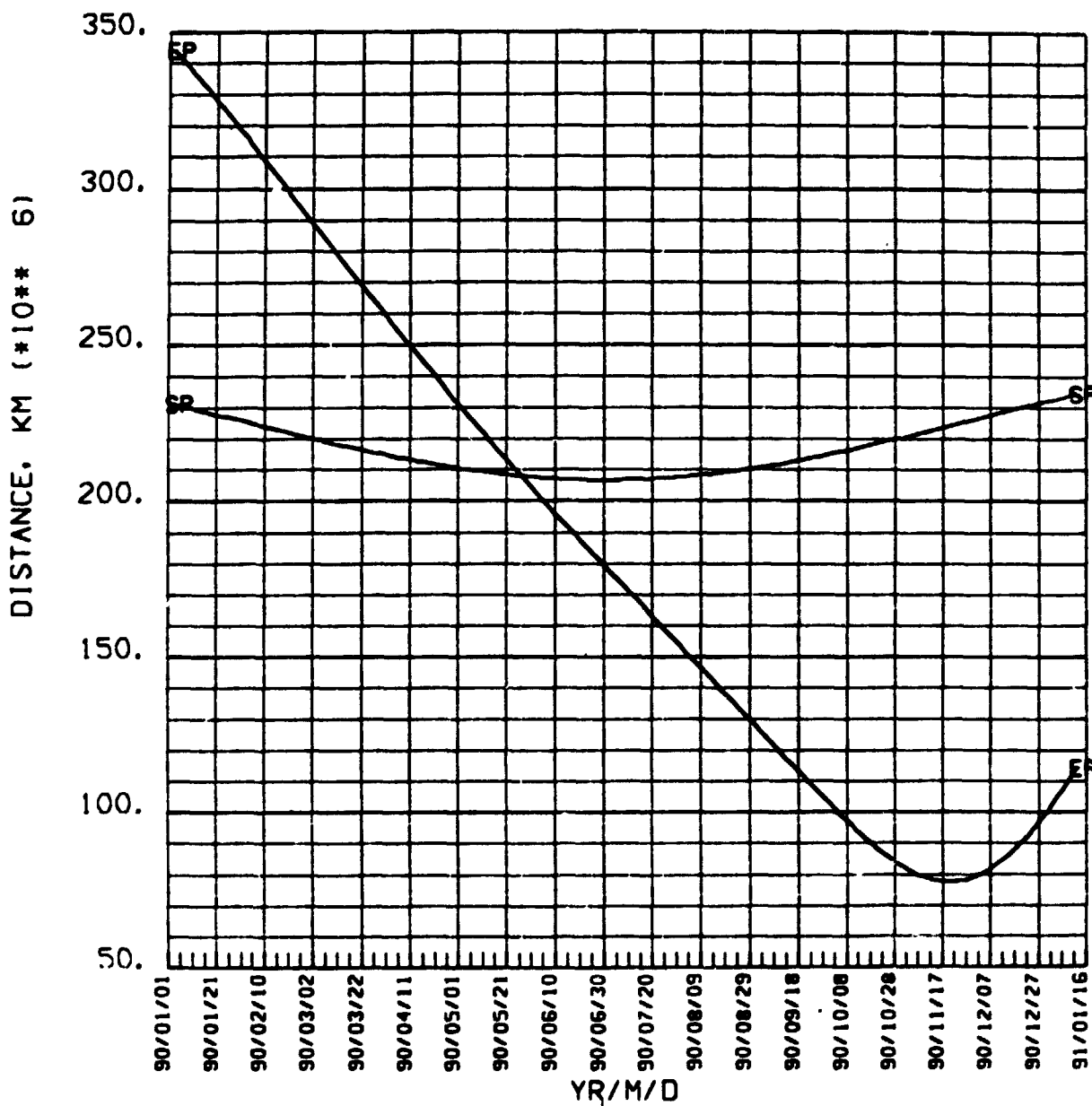


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CA, KA OF EARTH, CA CANOP

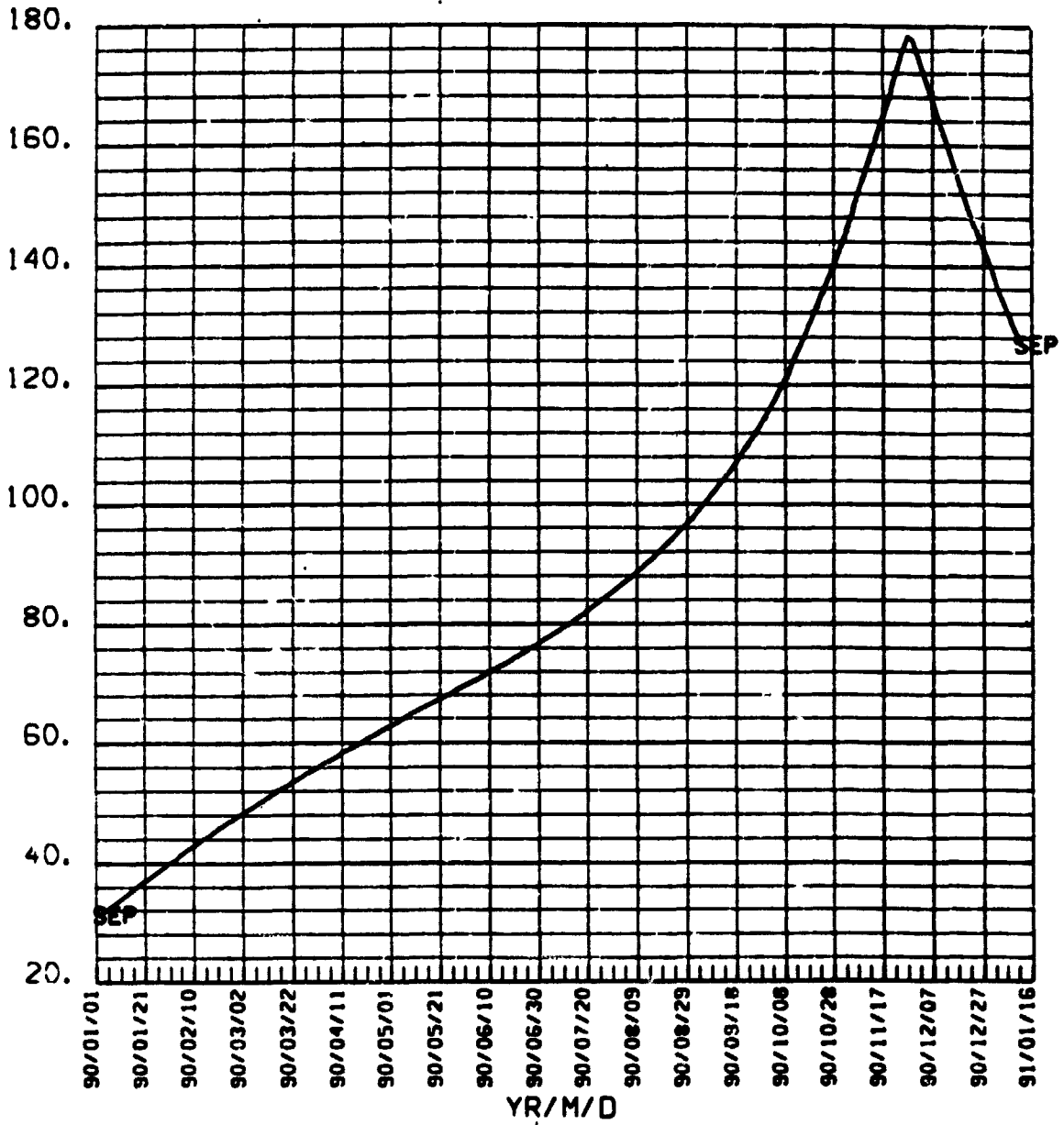


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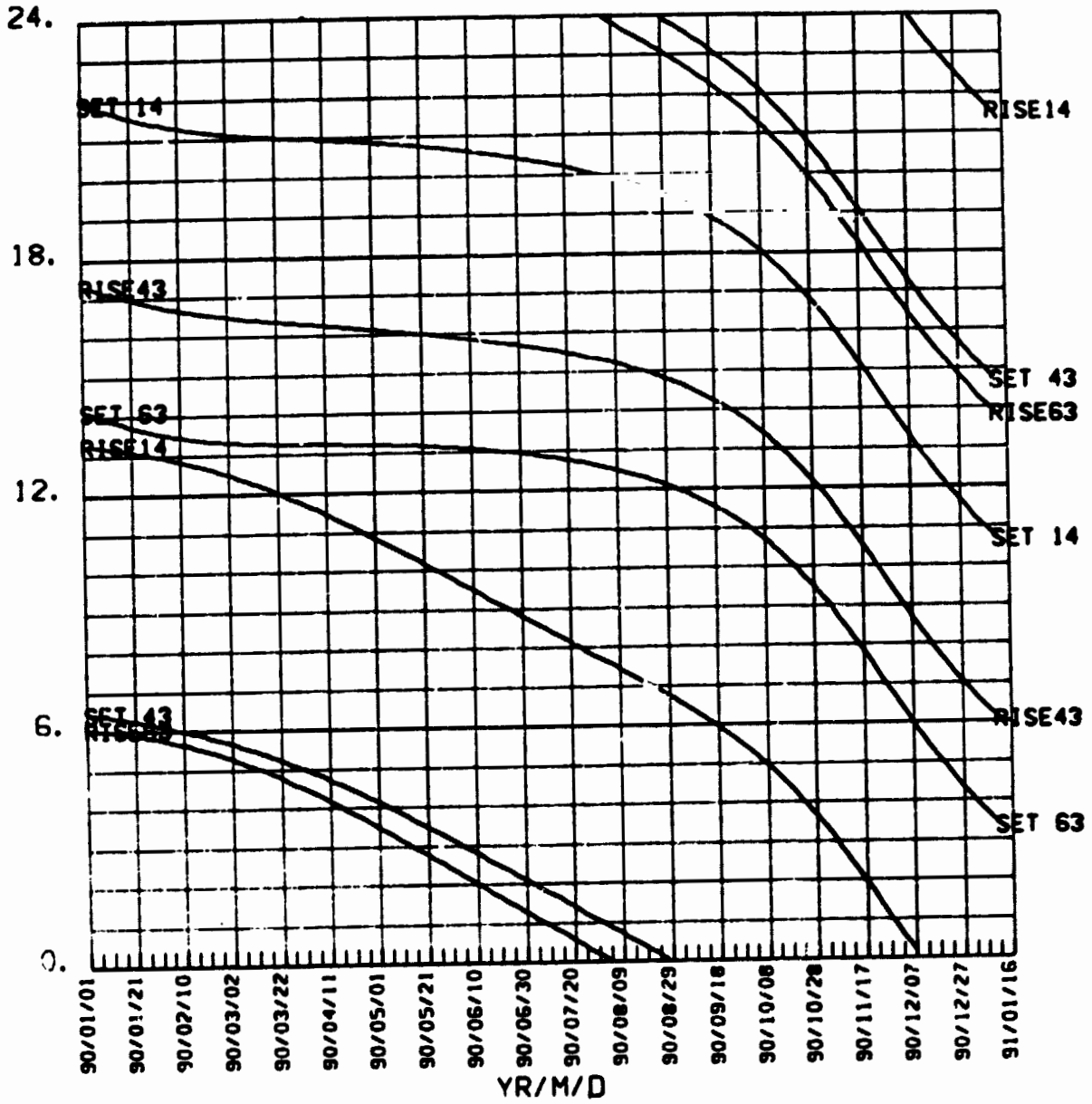
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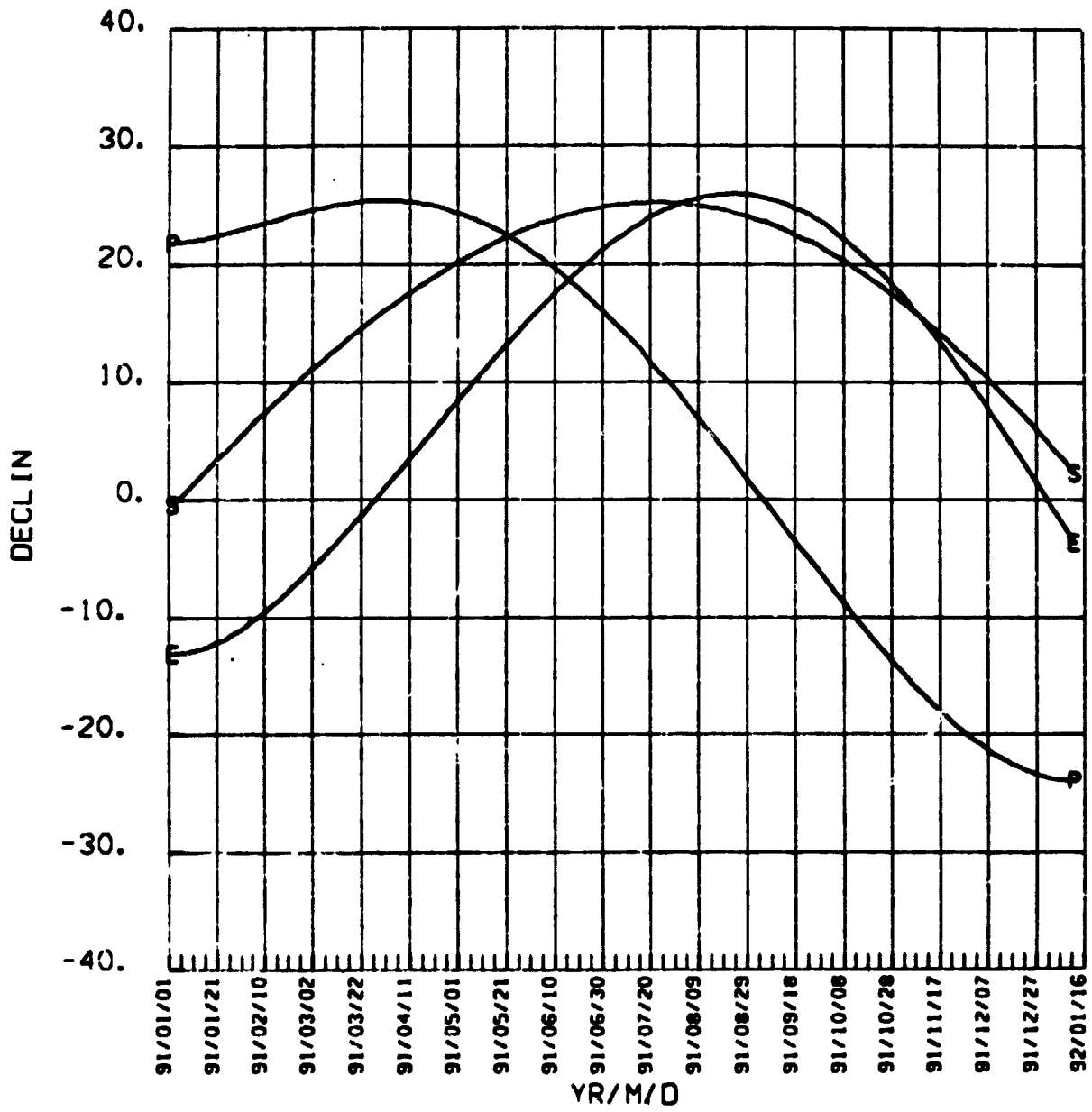
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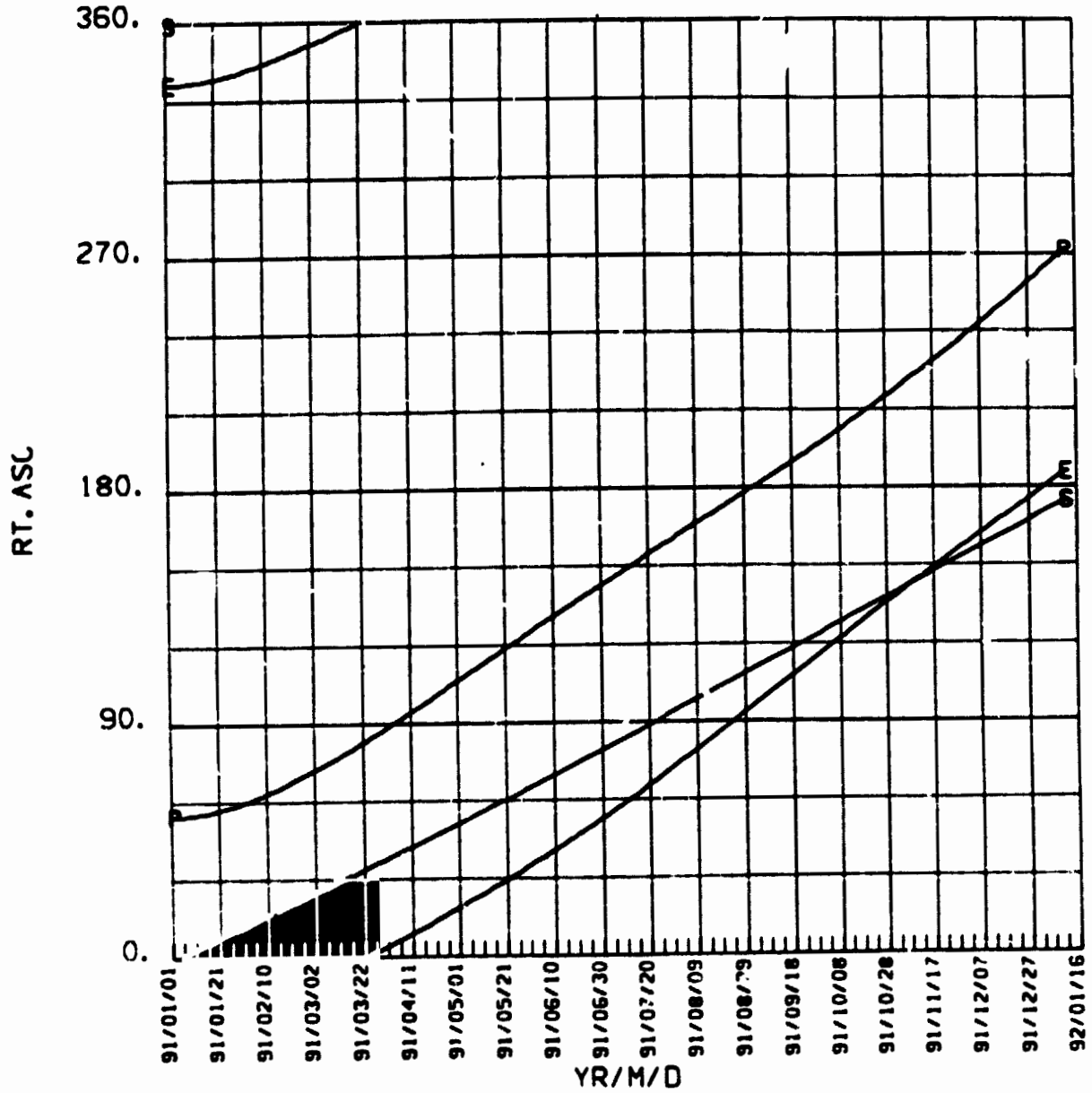
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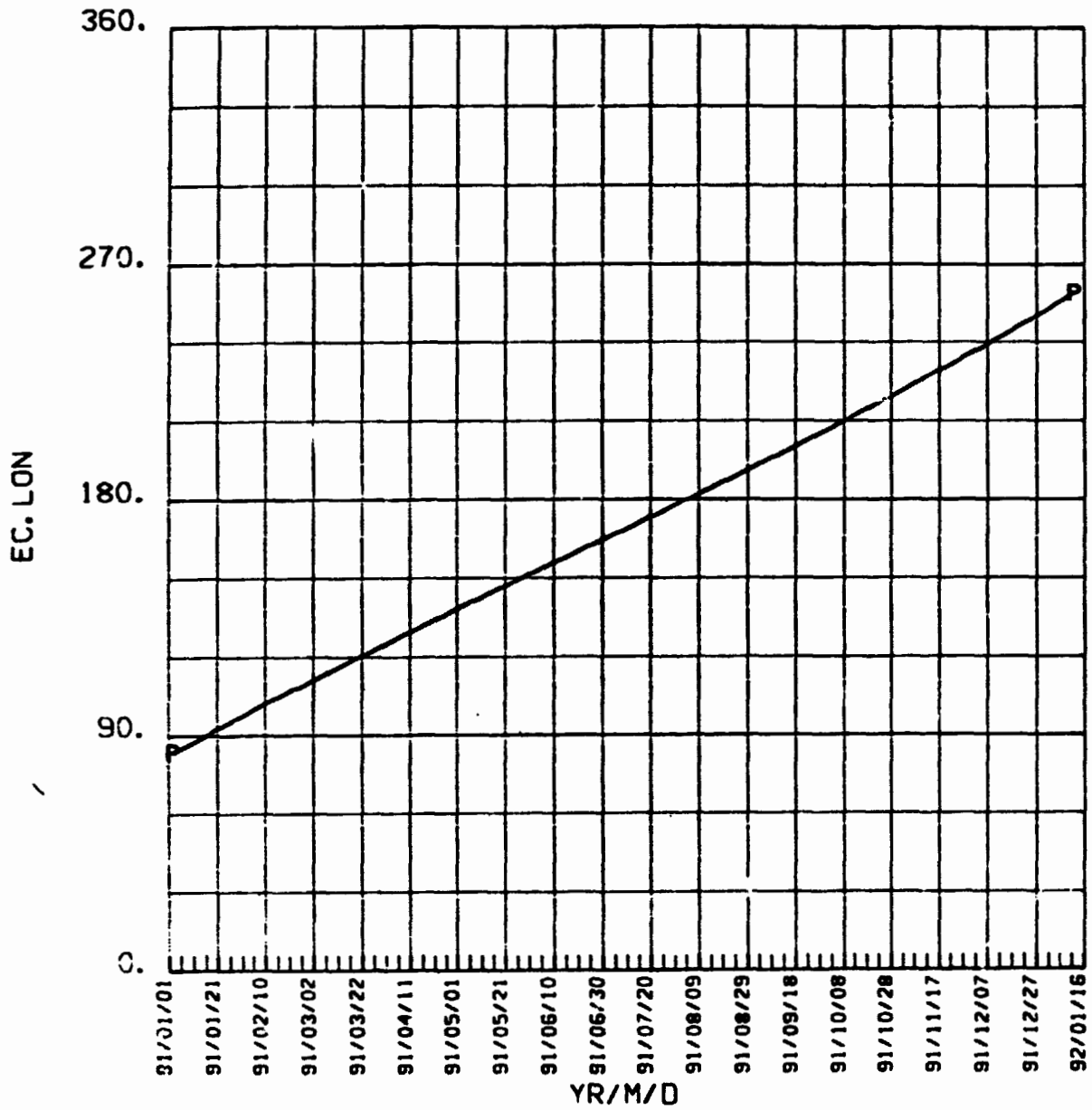
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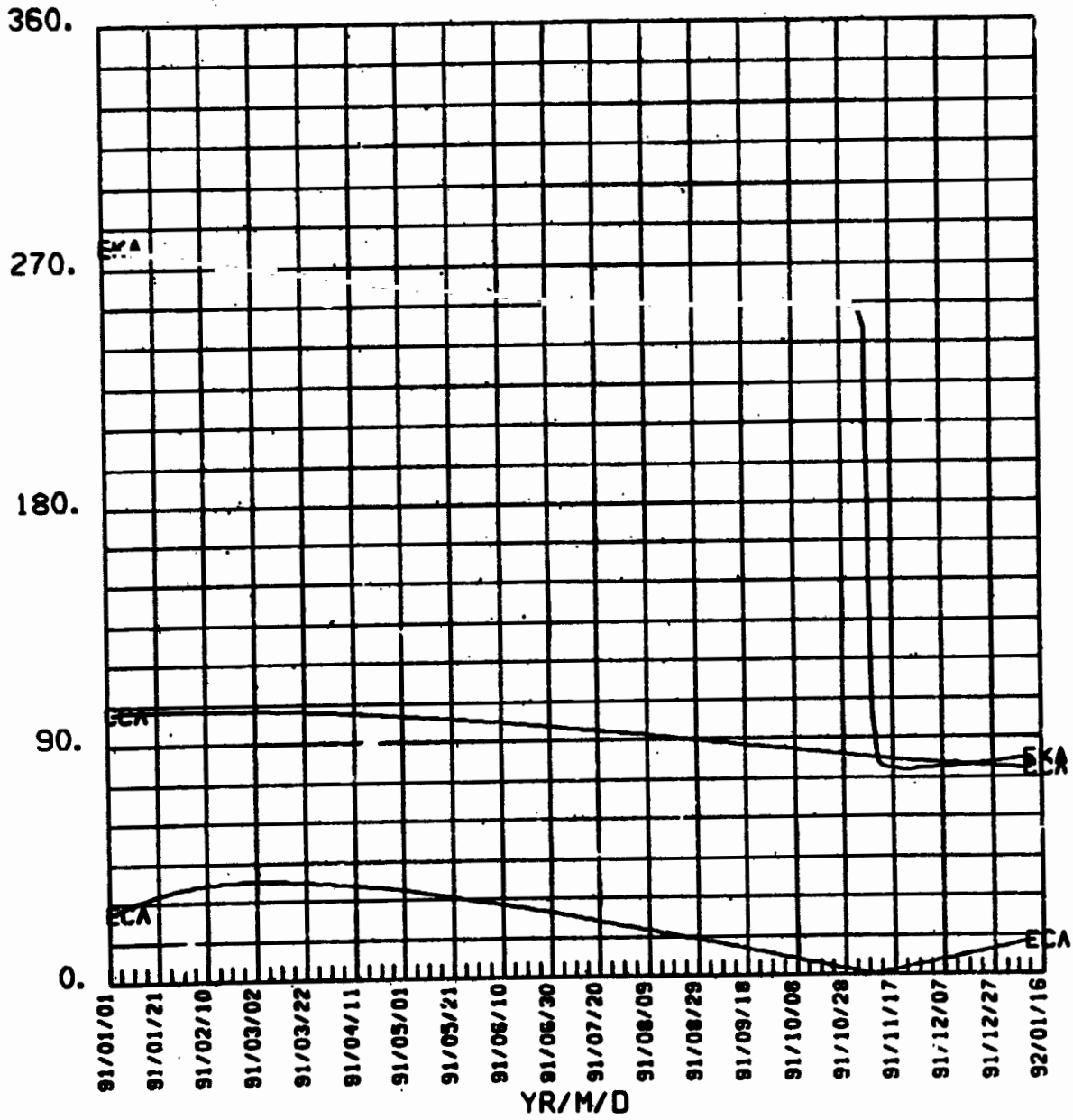
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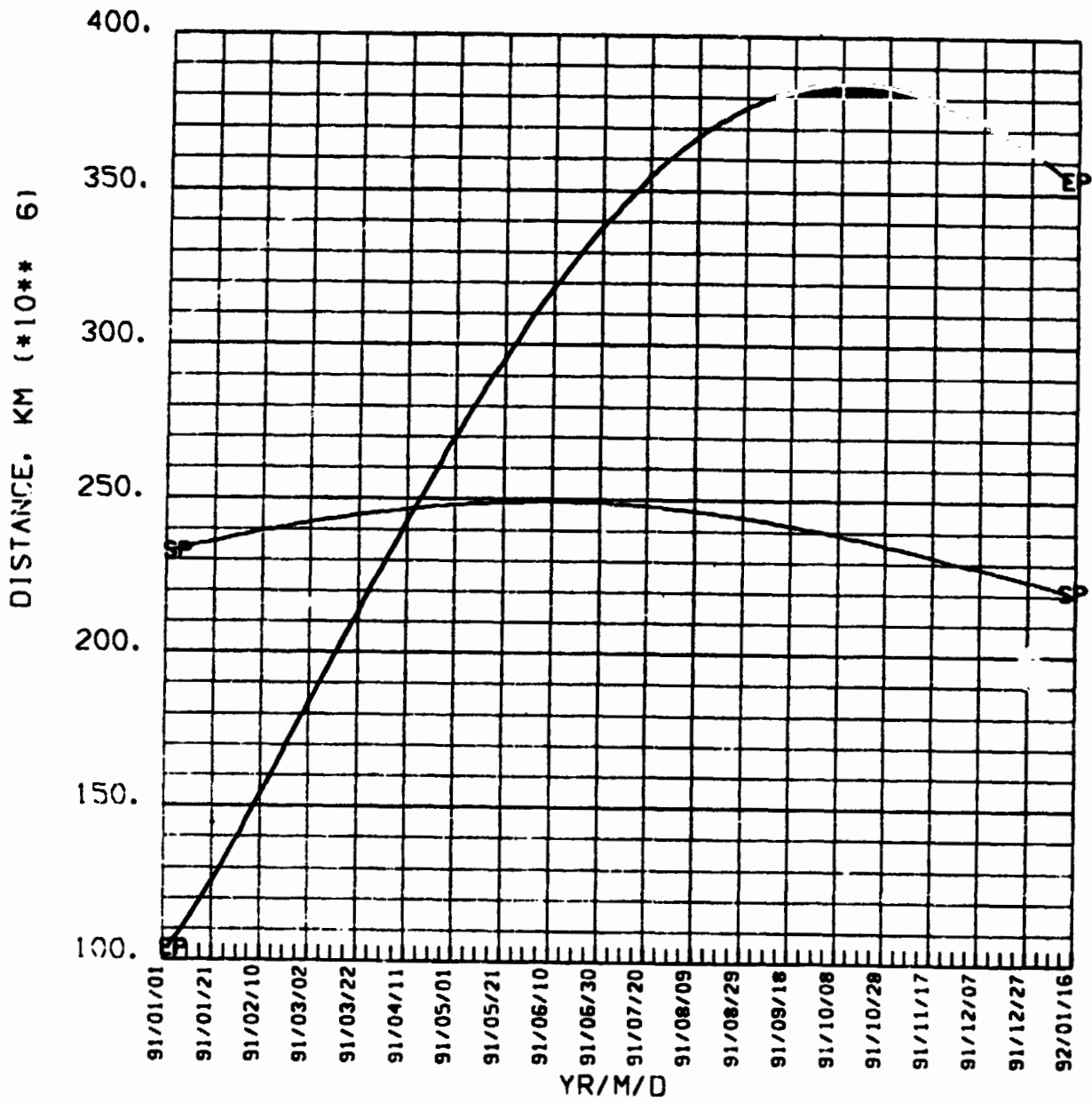


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CA. KA OF EARTH. CA CANOP

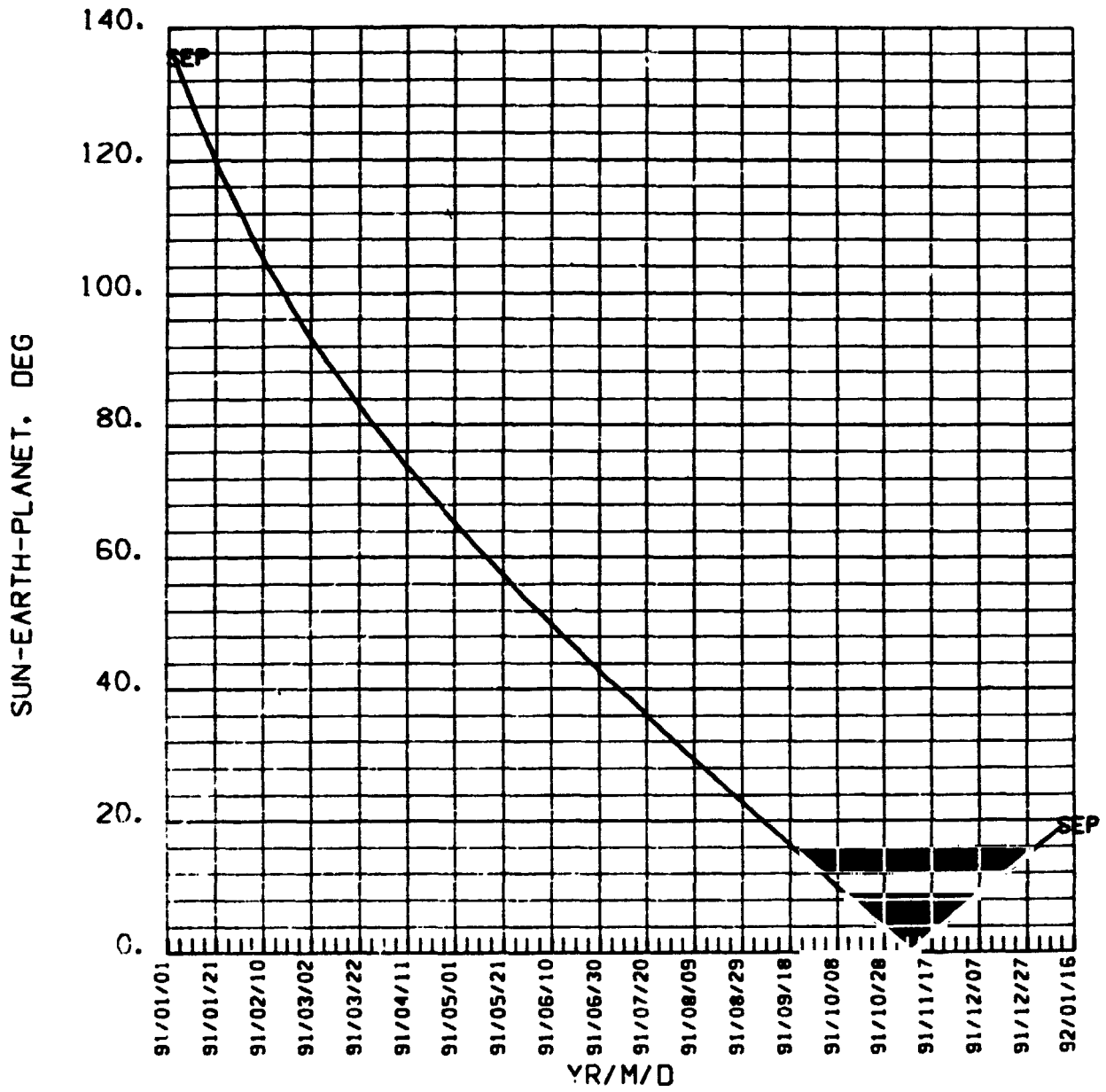


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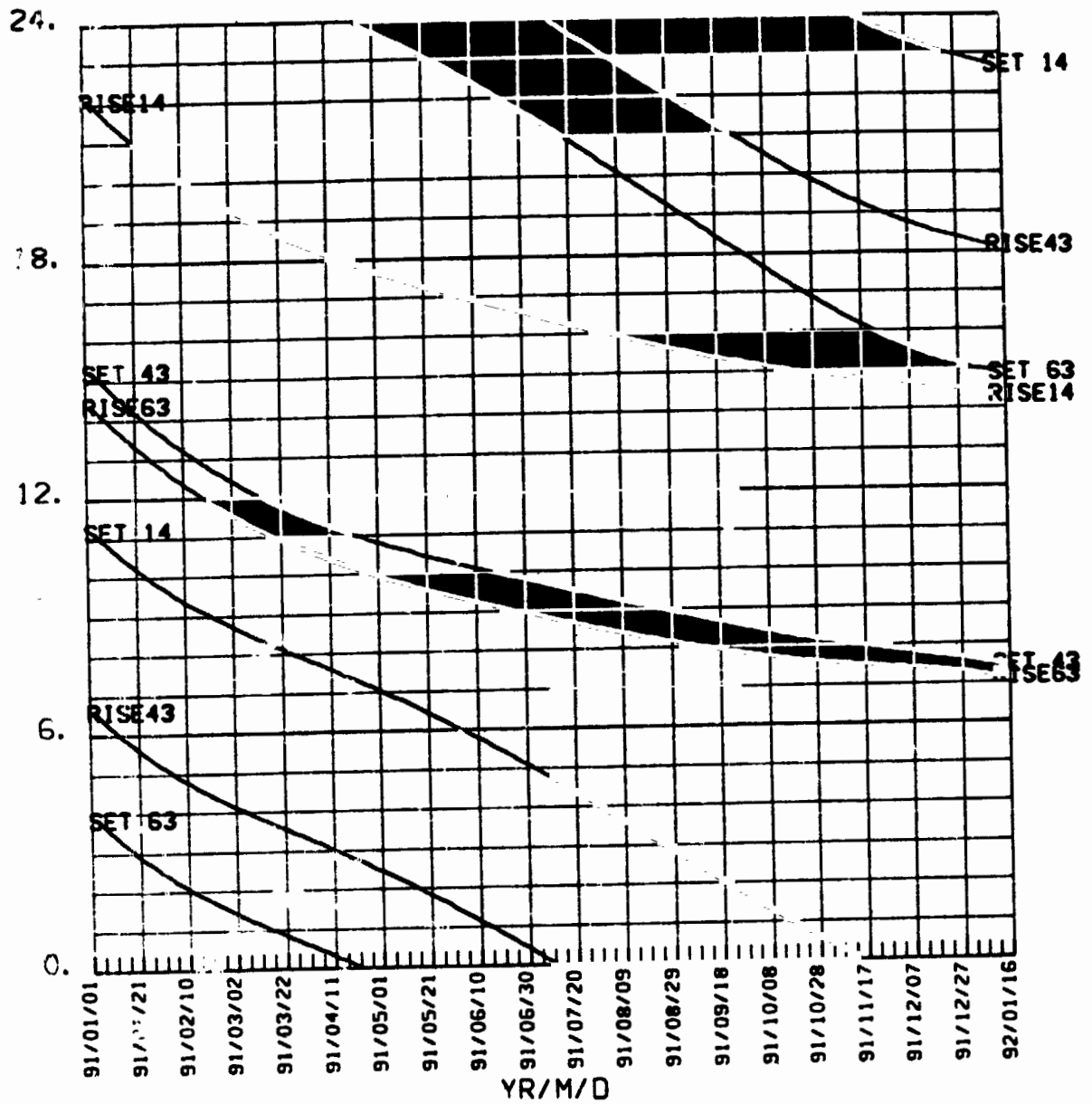
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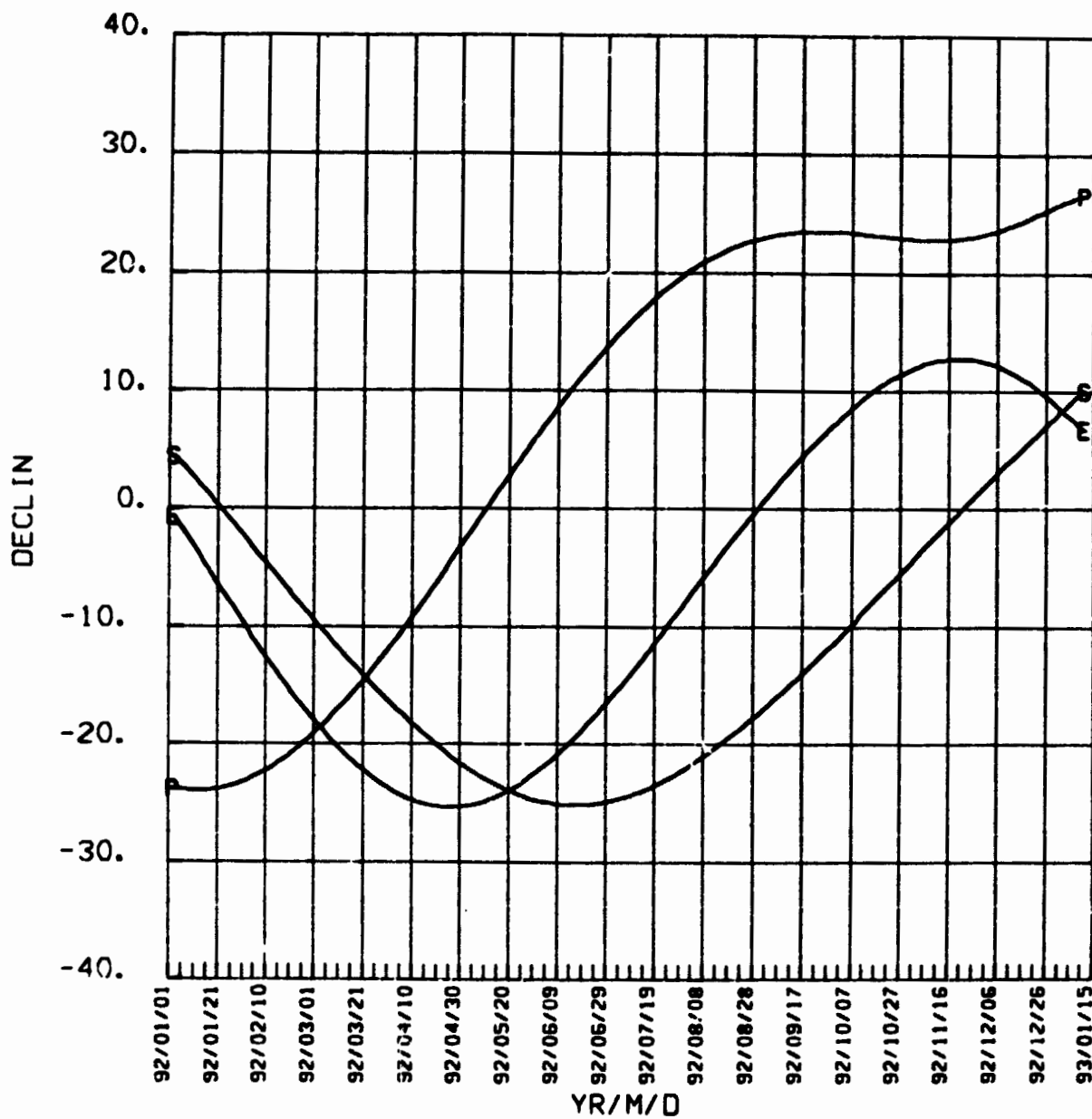


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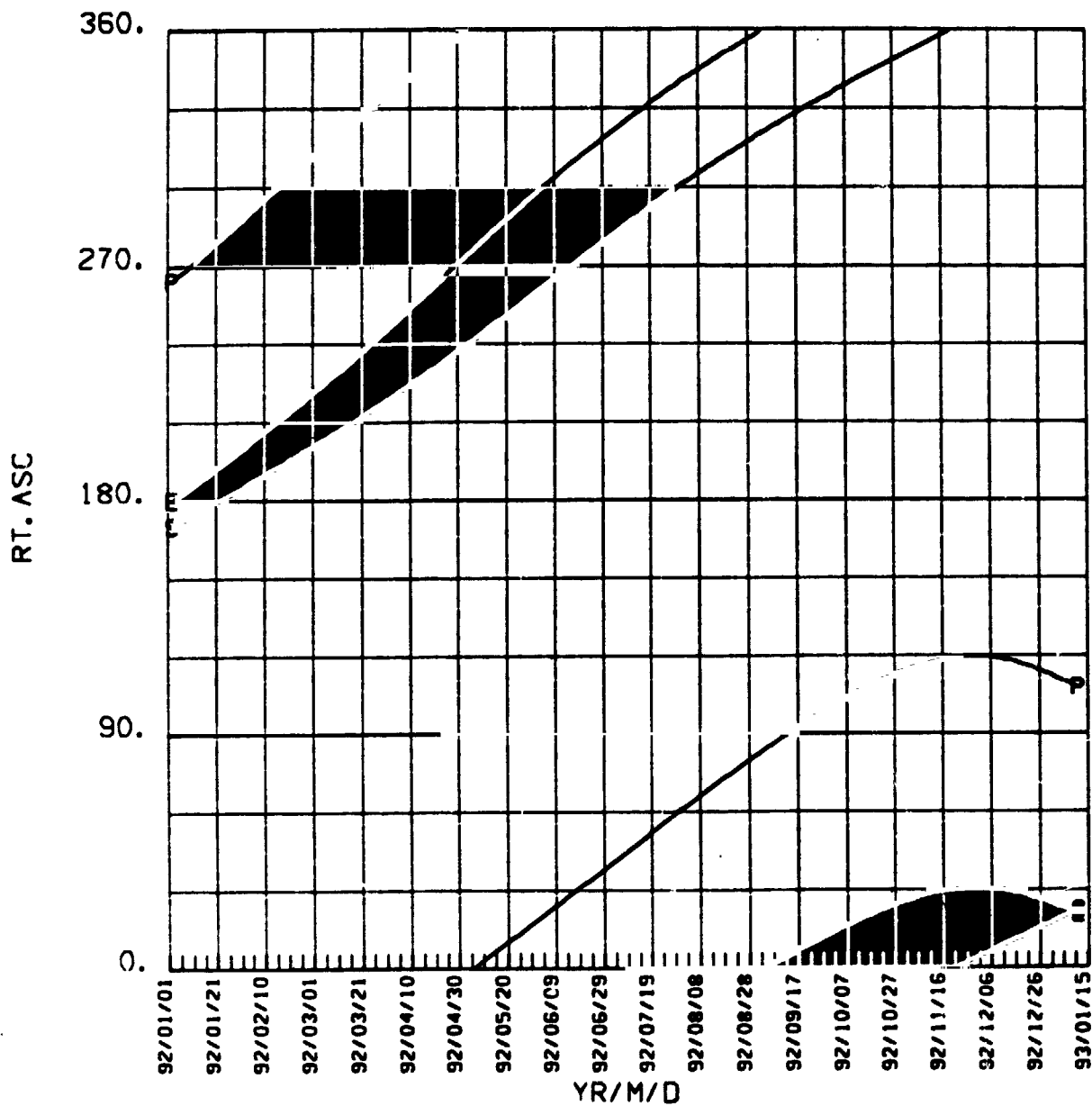
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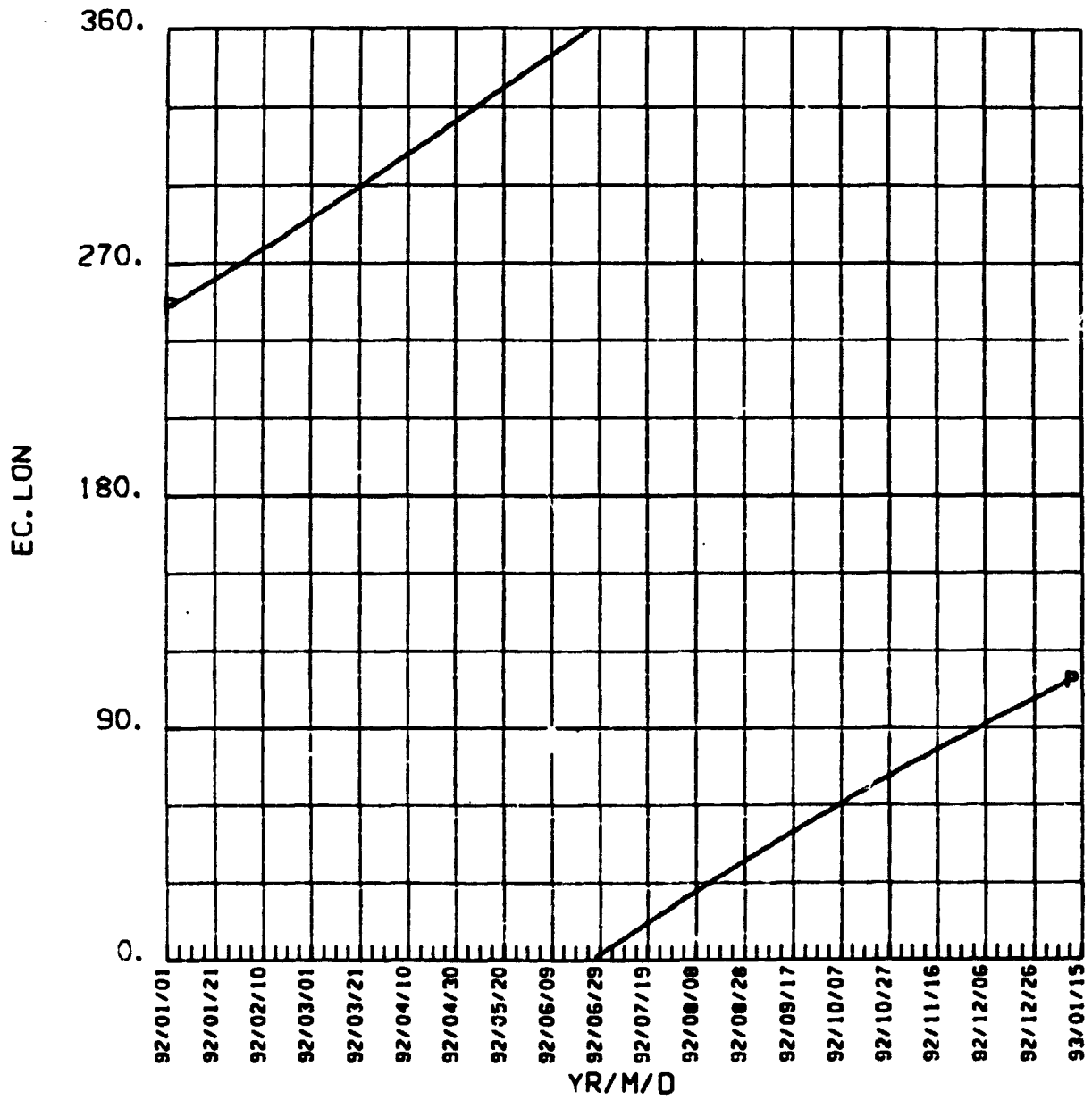
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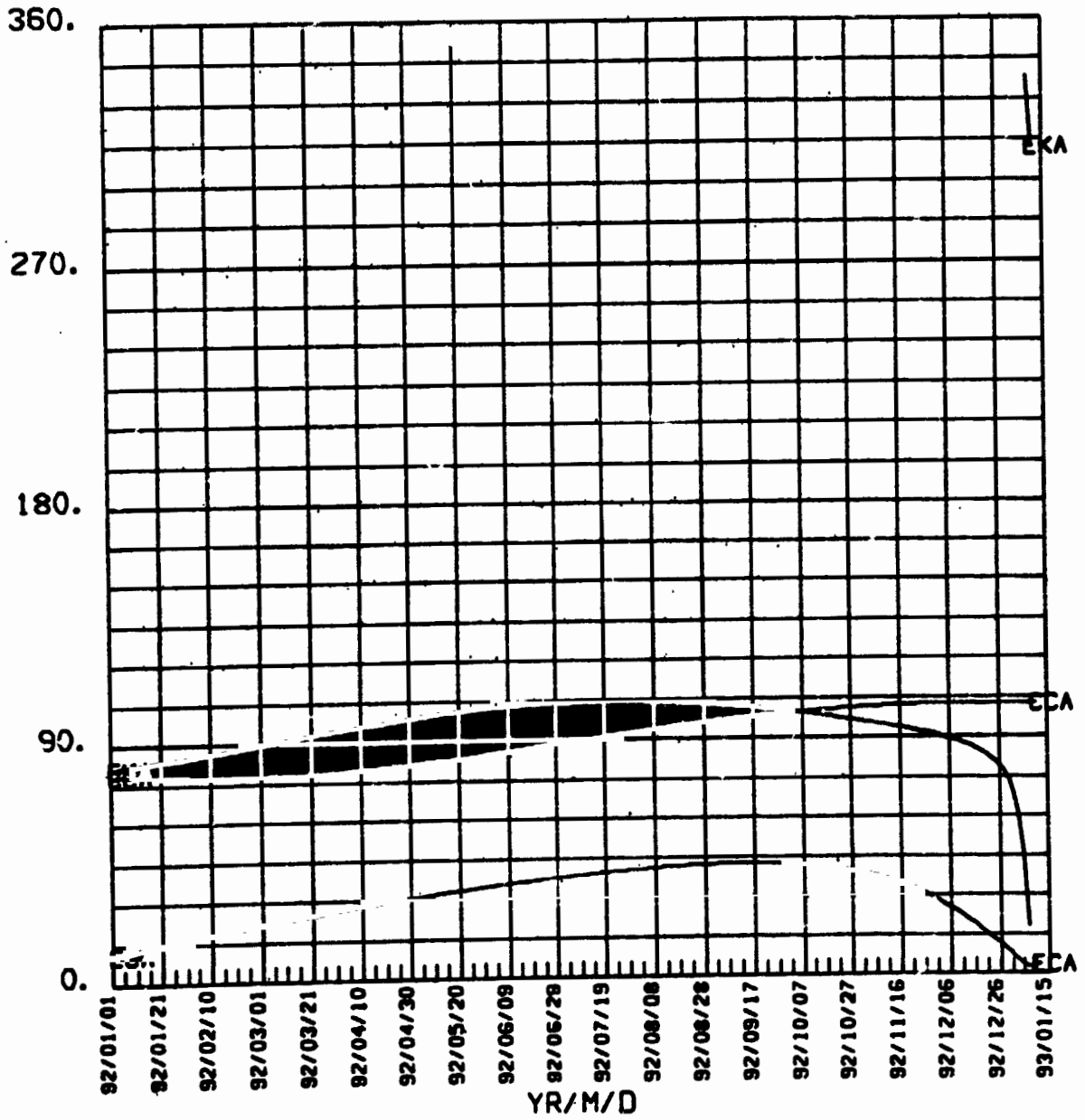


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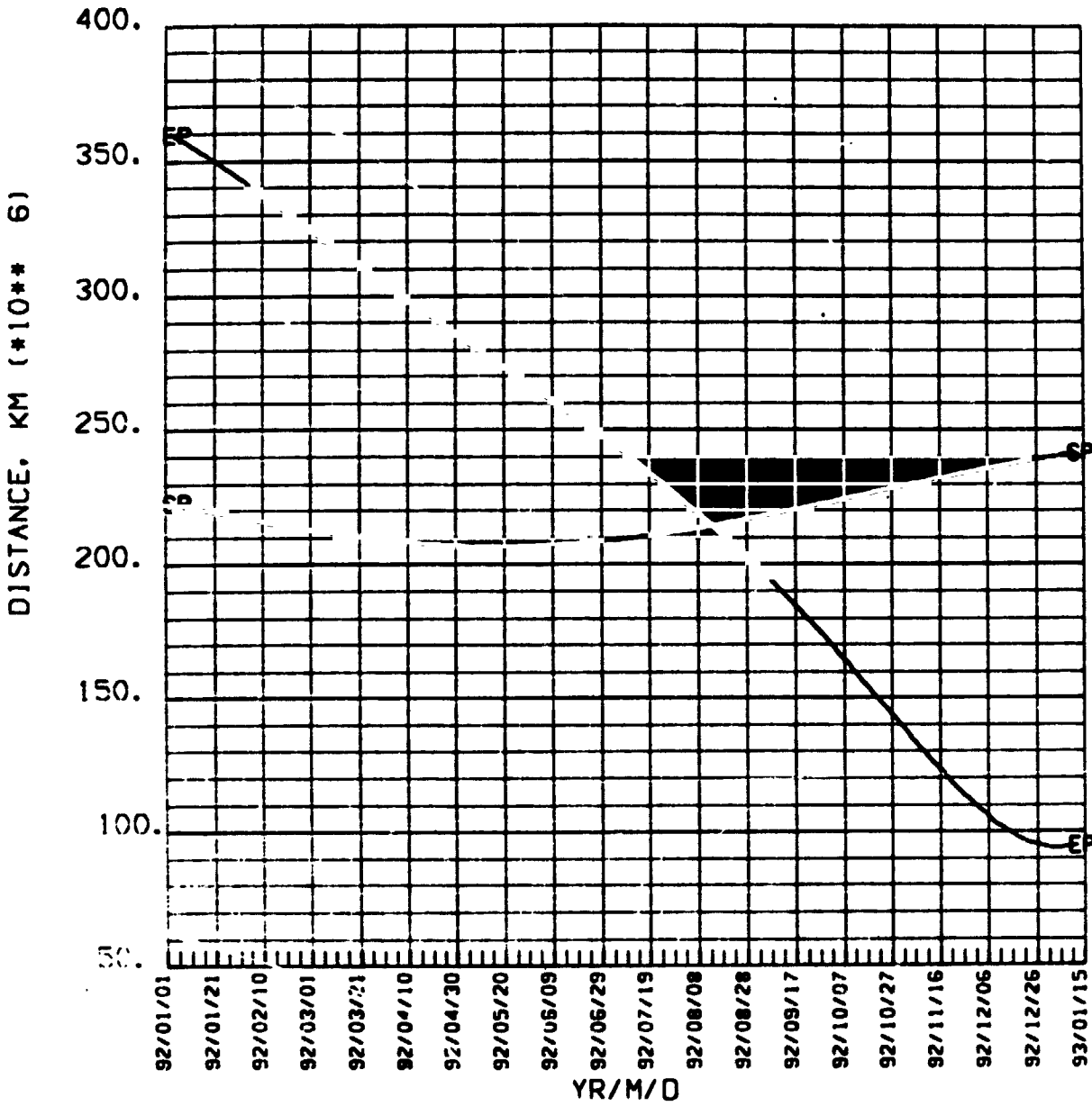
CA, KA OF EARTH, CA CANOP



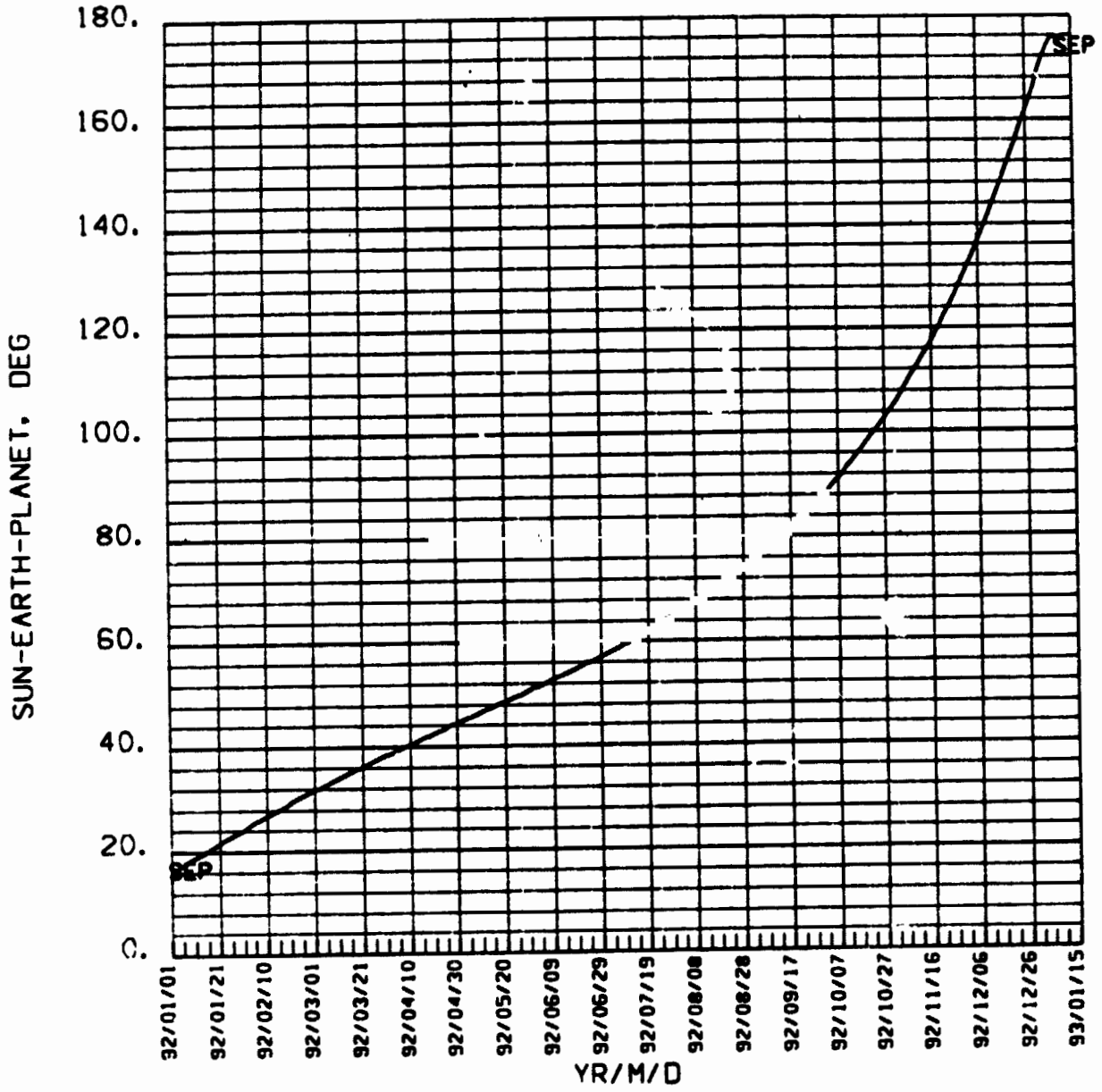


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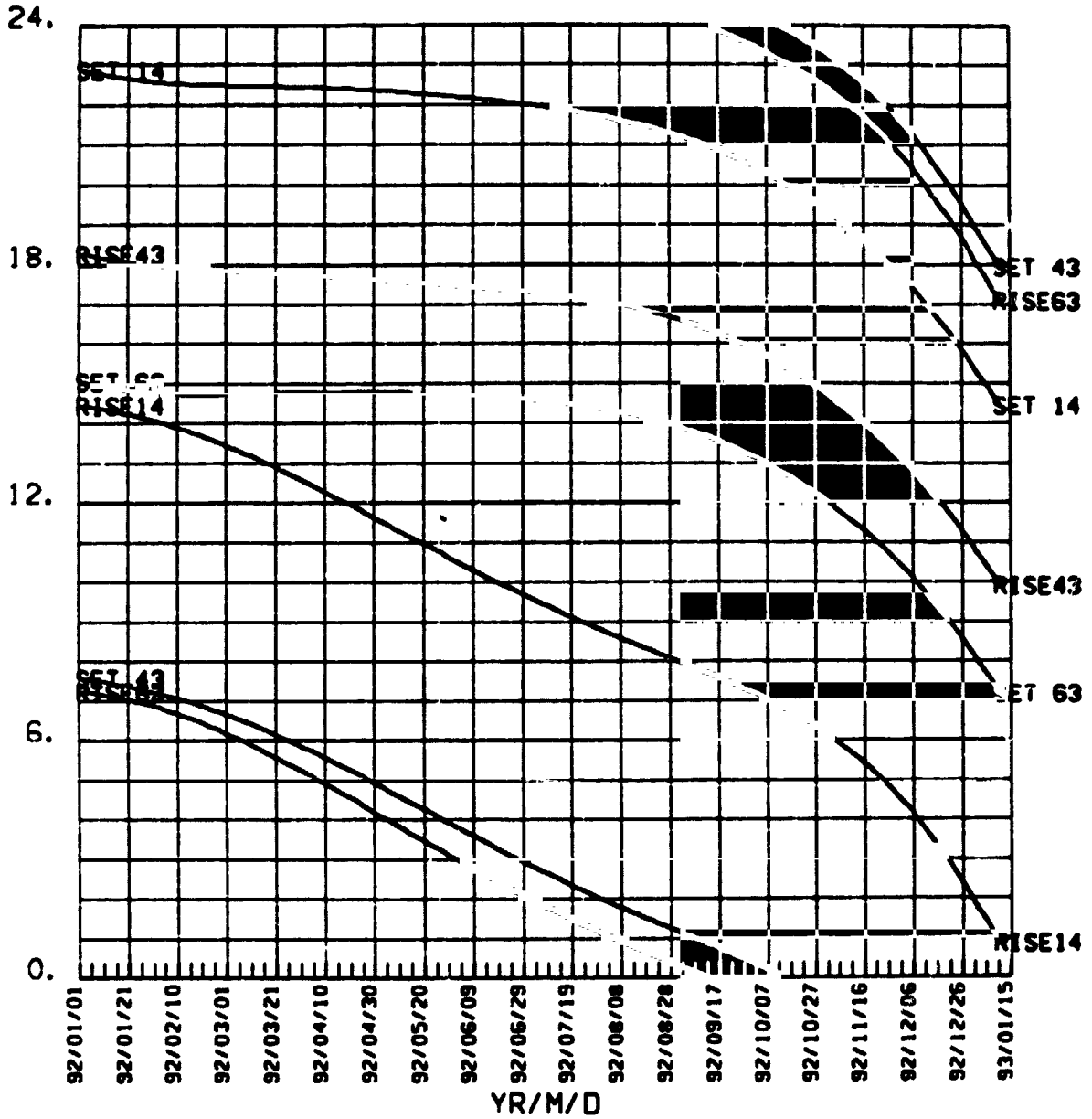


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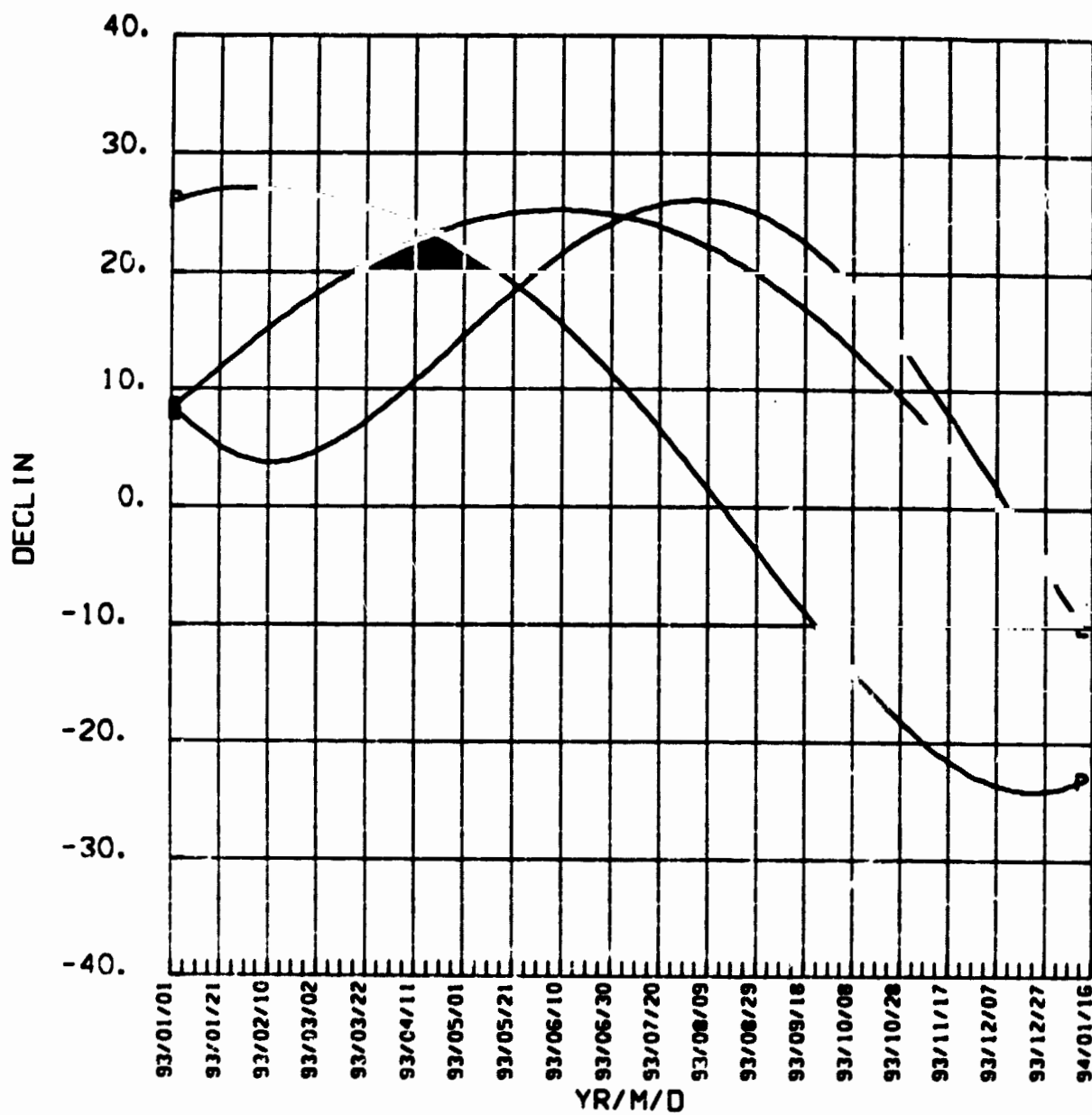


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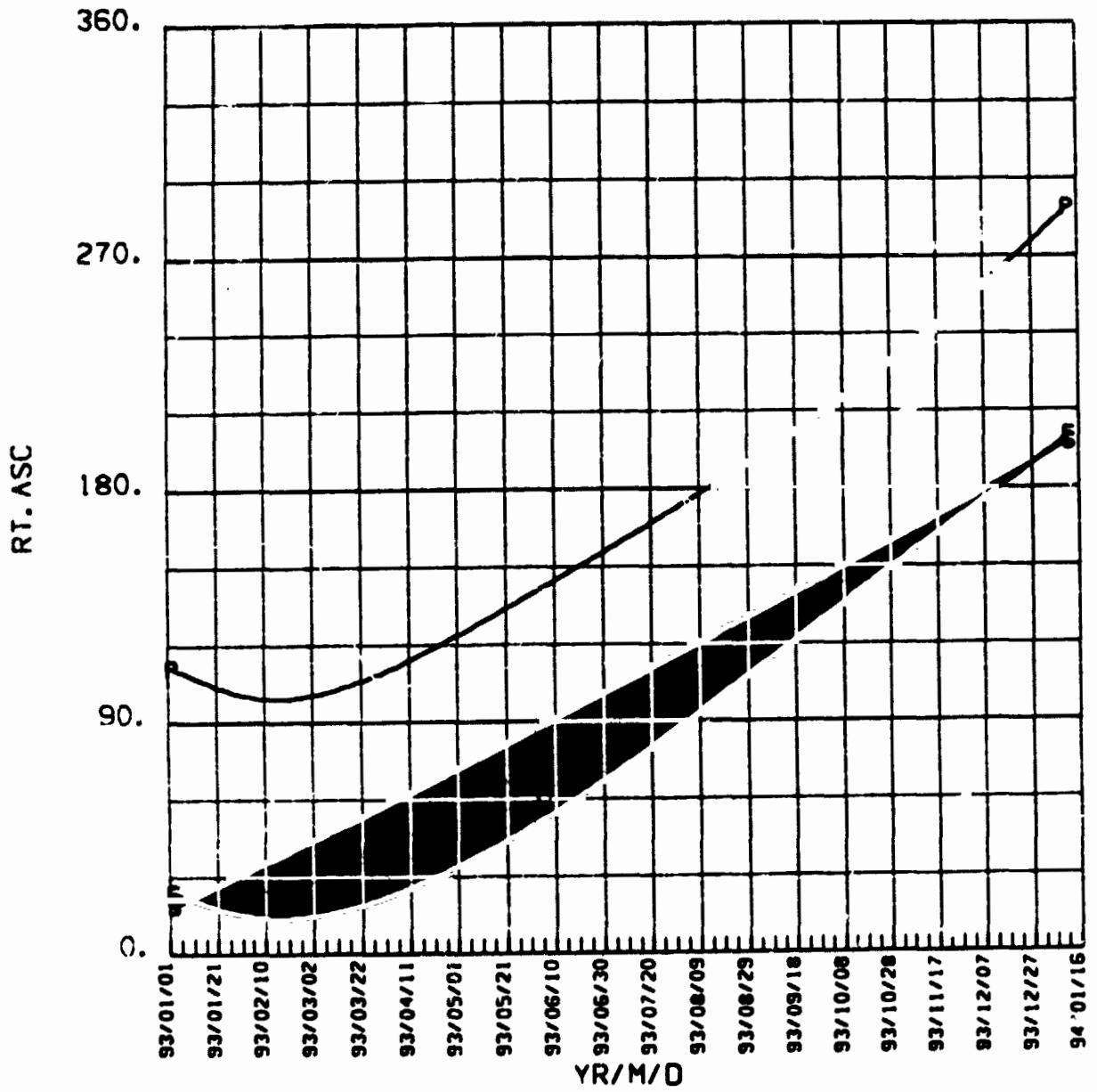
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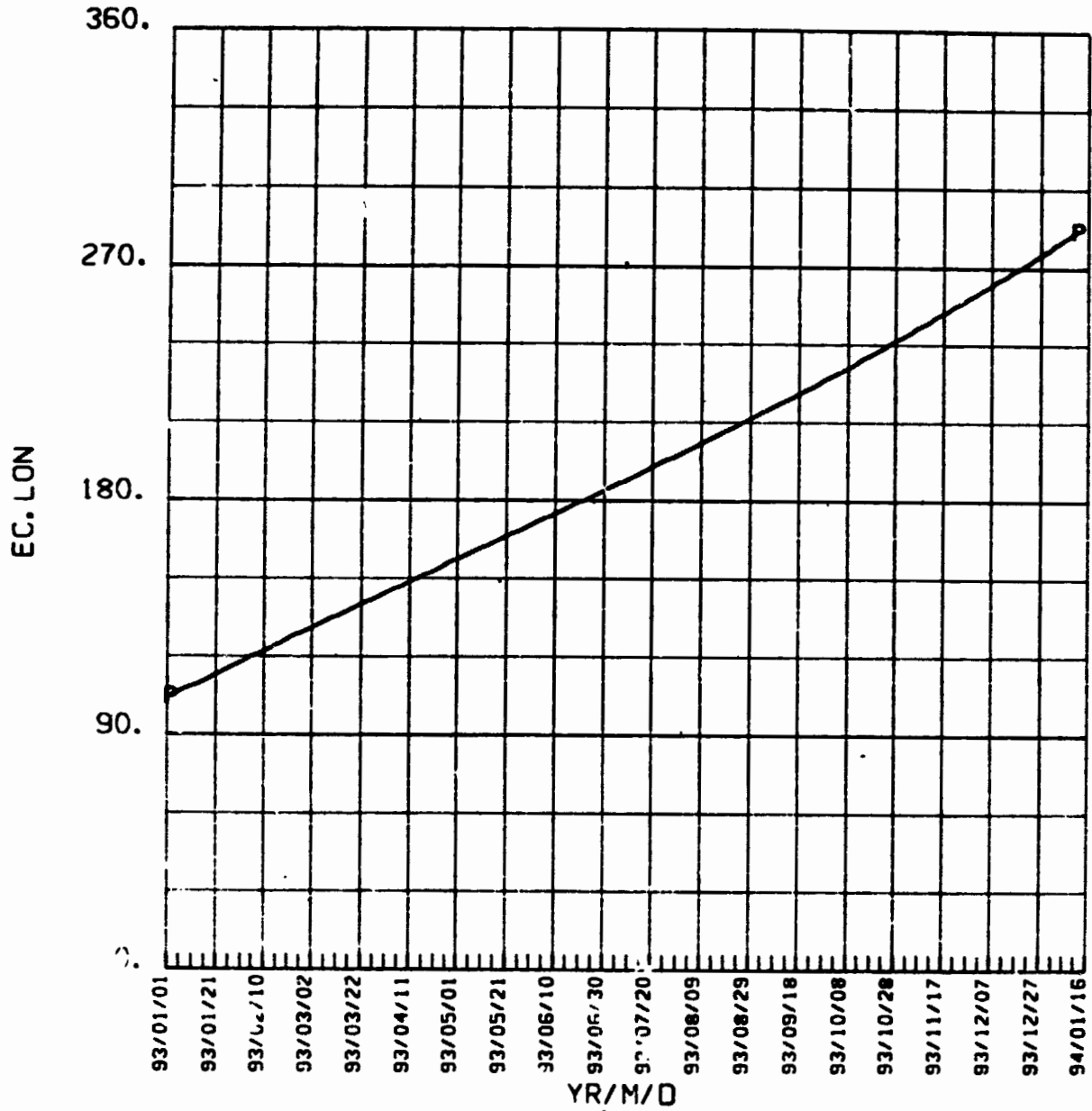
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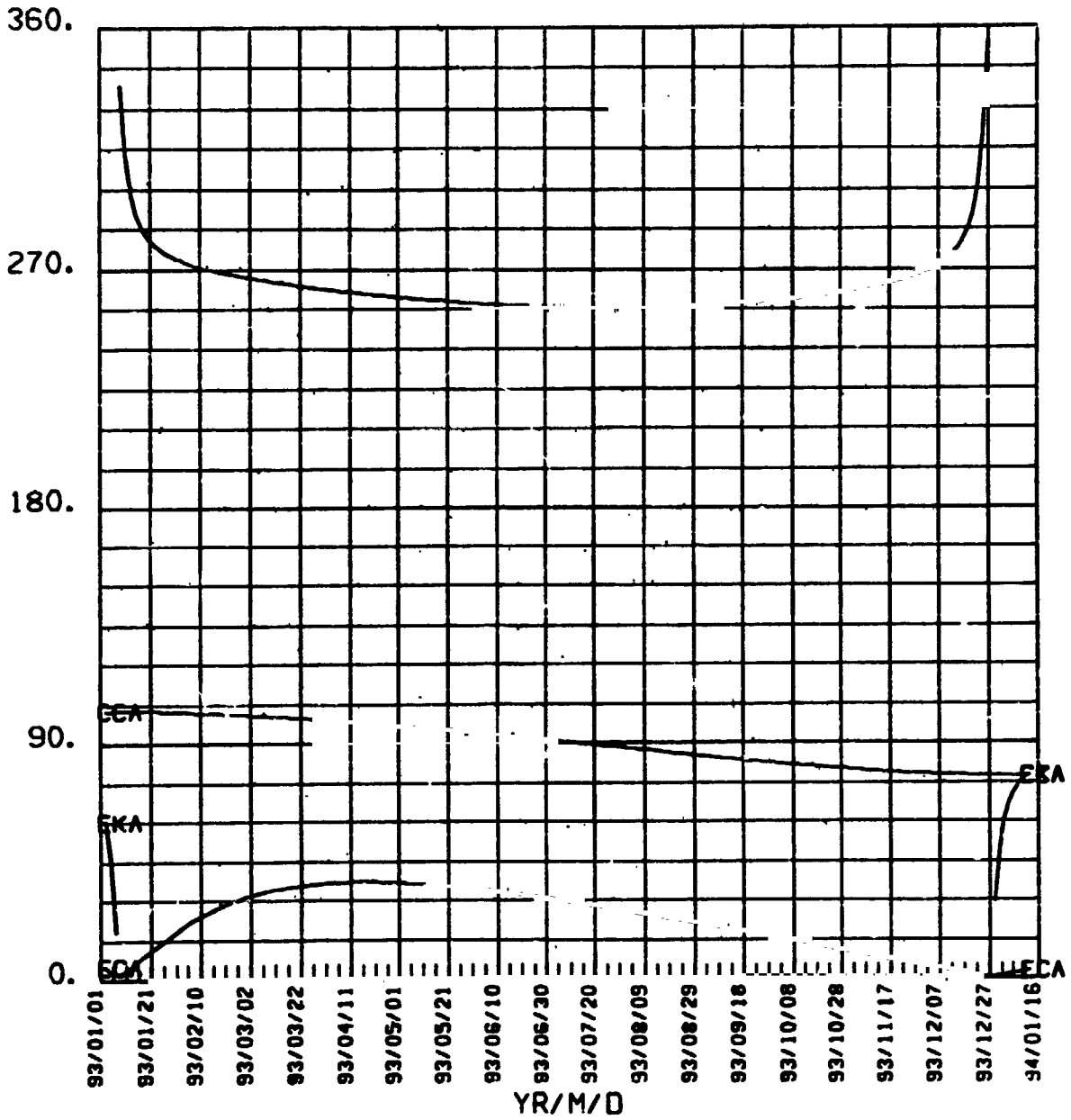


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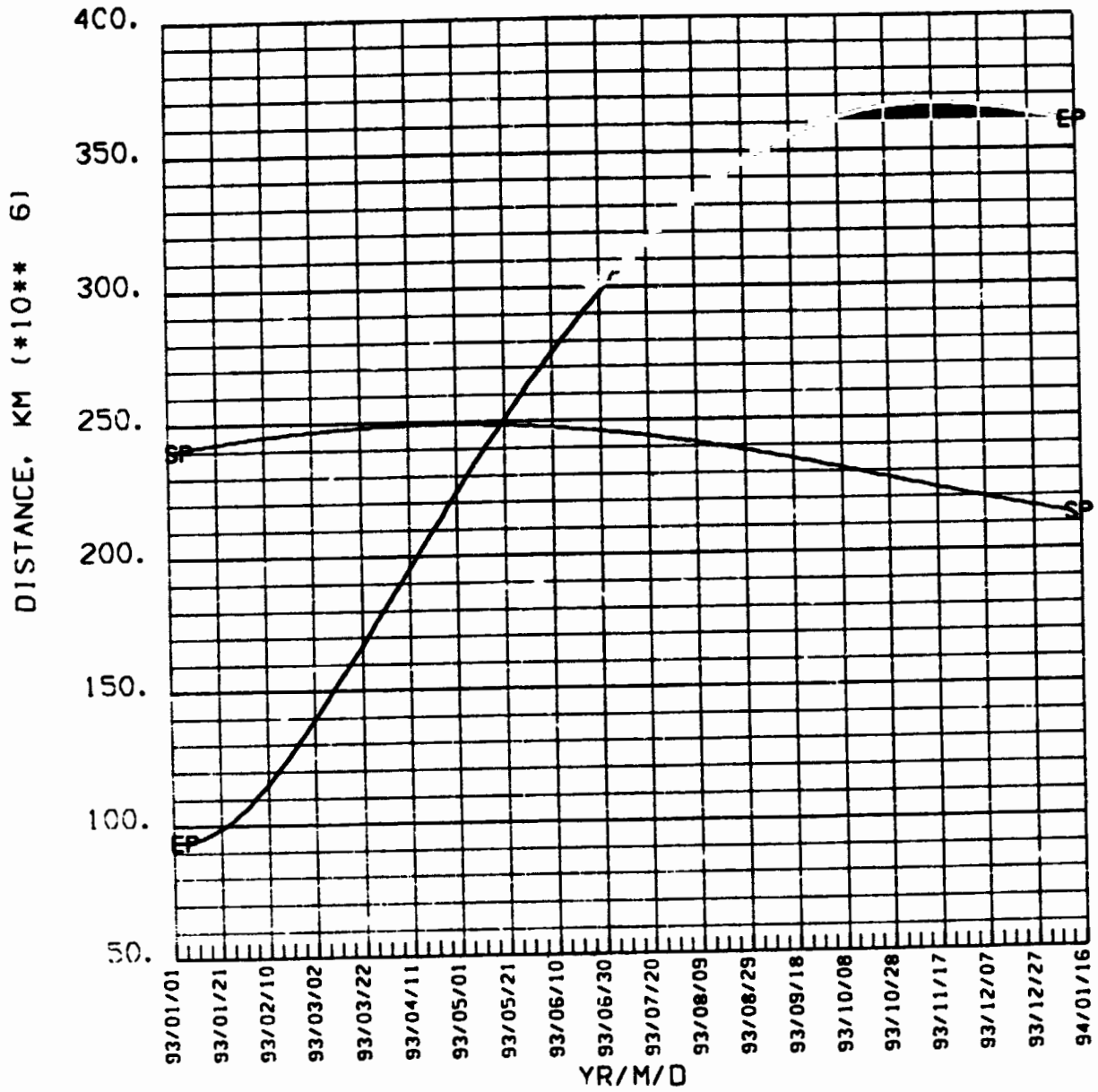


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CA, KA OF EARTH, CA CANOP

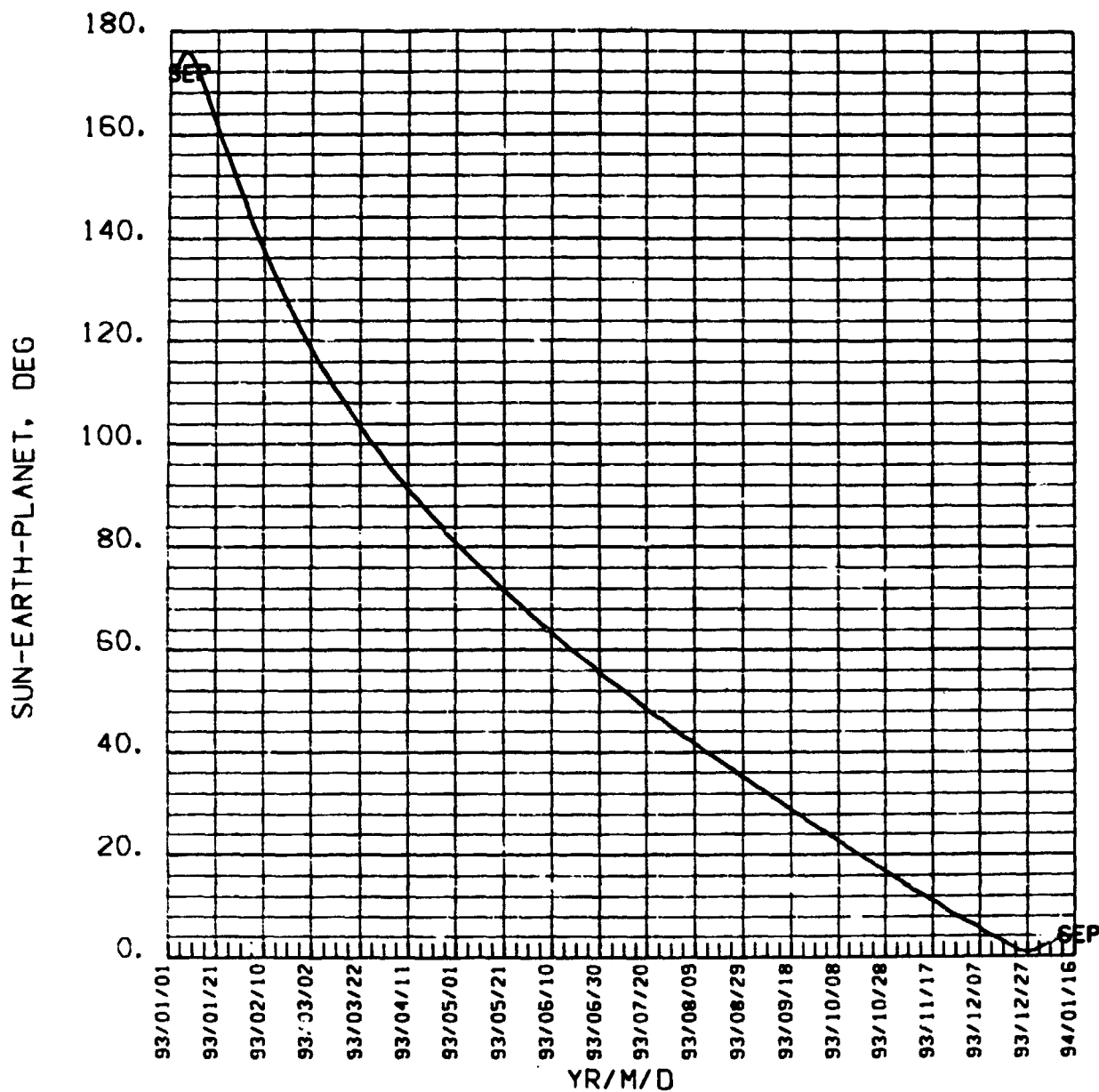


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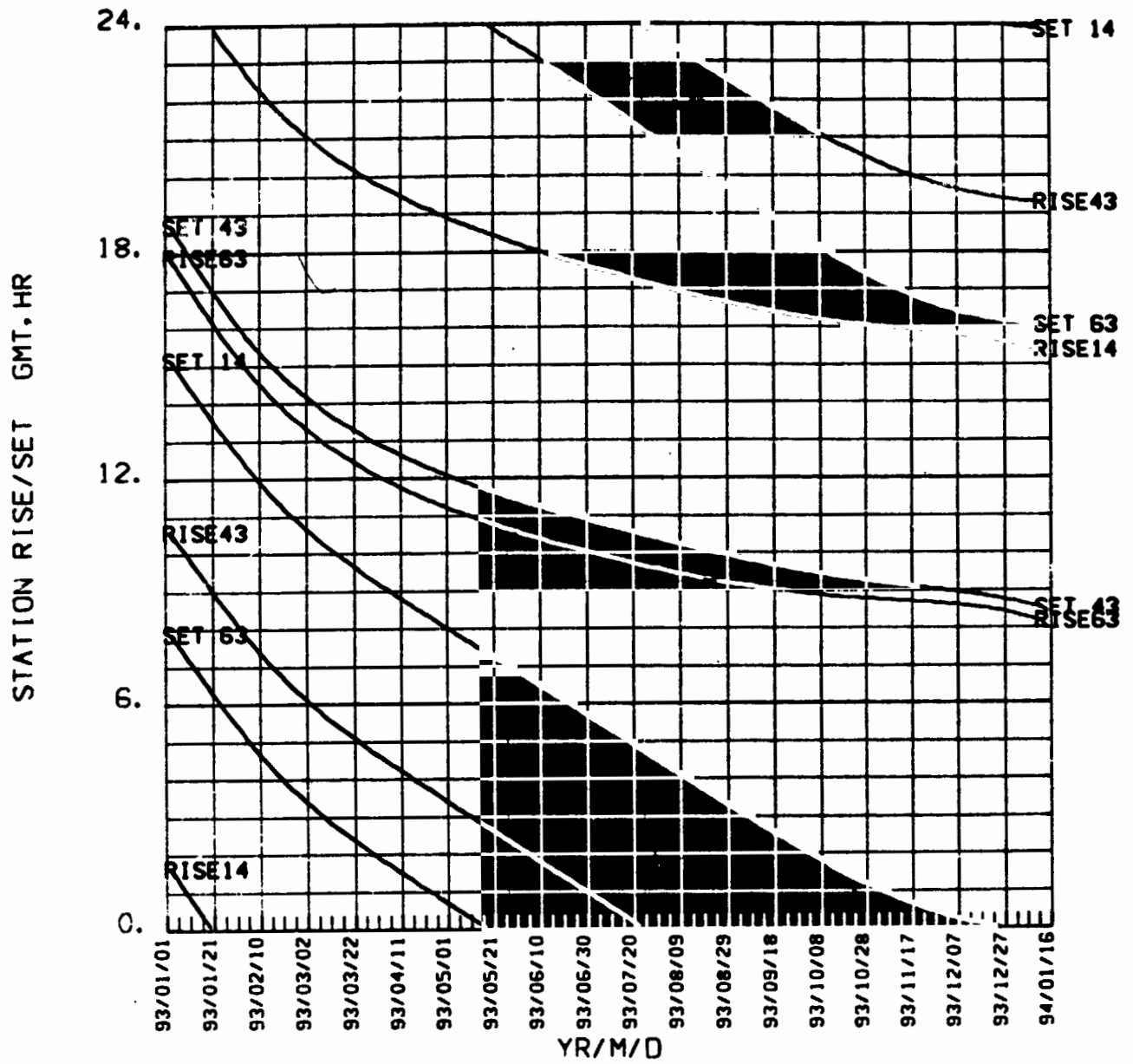




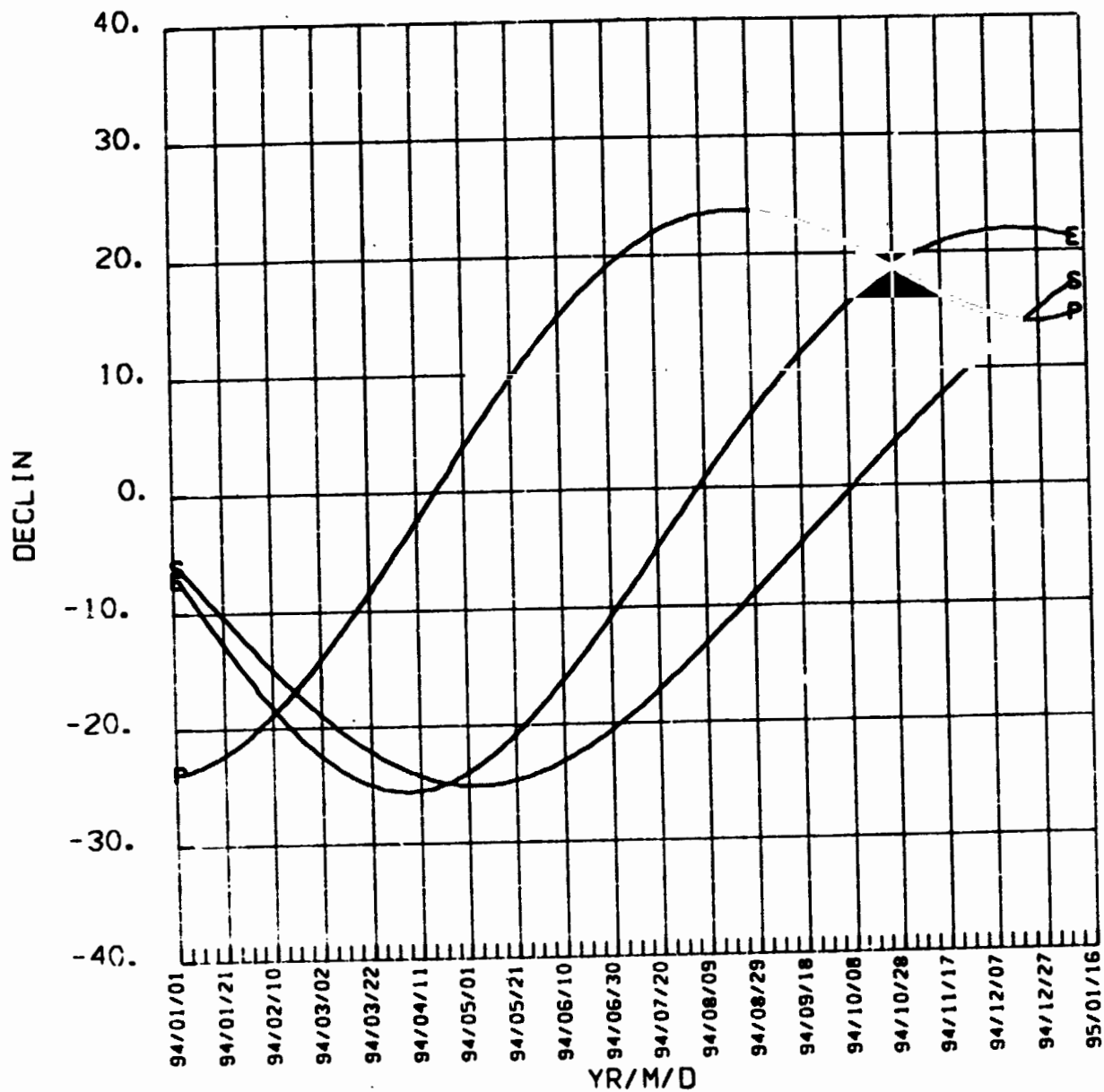
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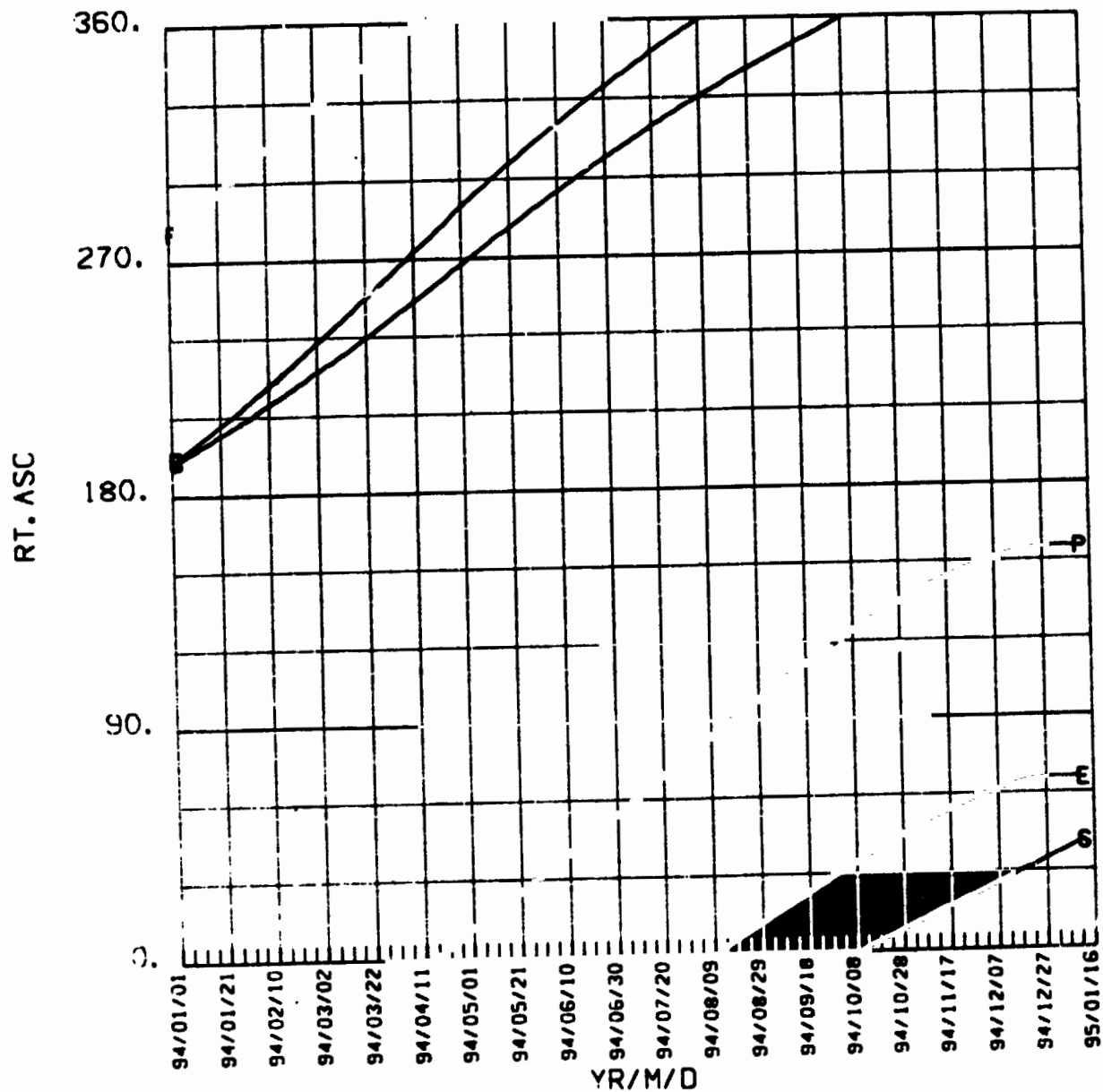
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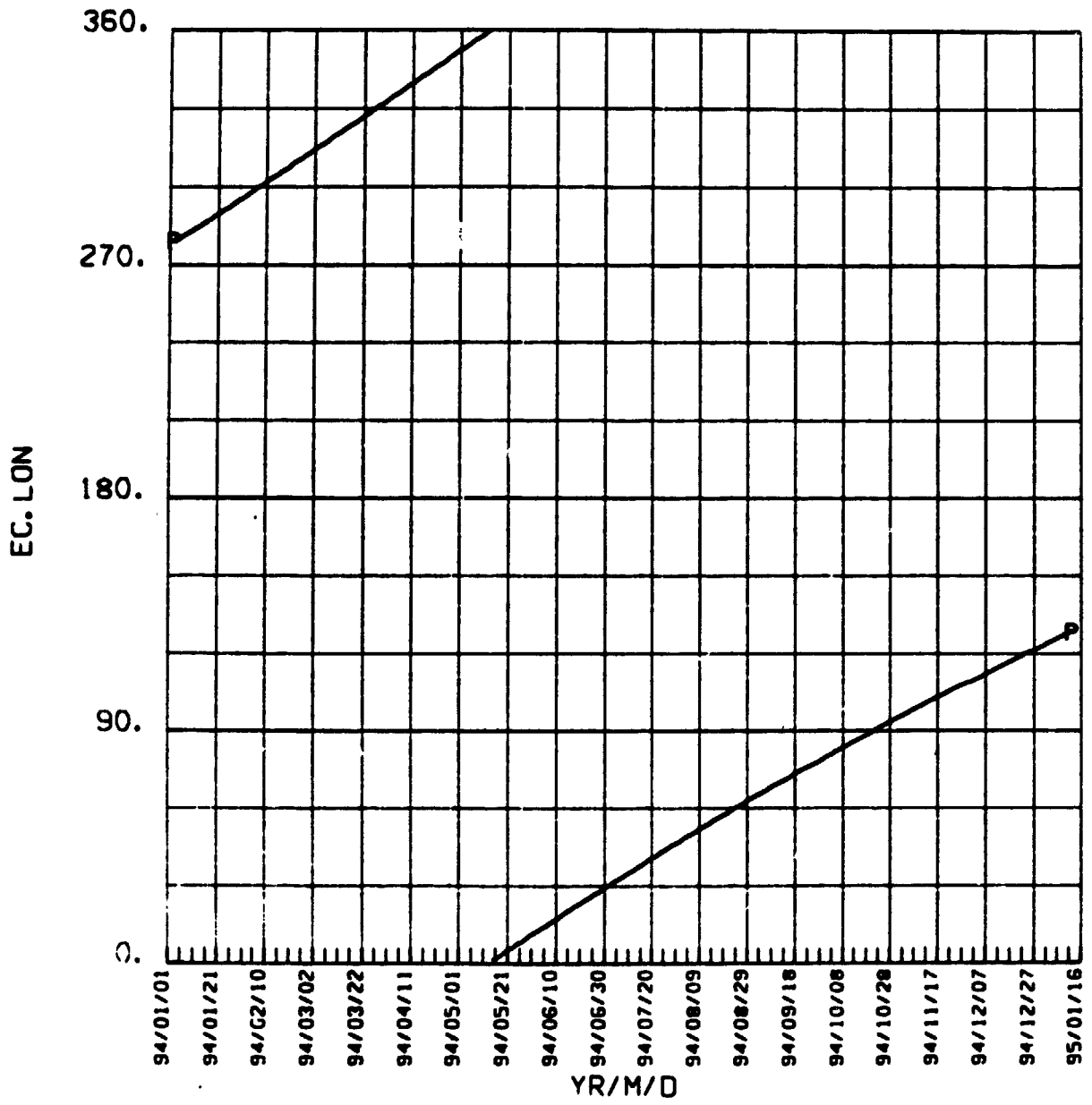
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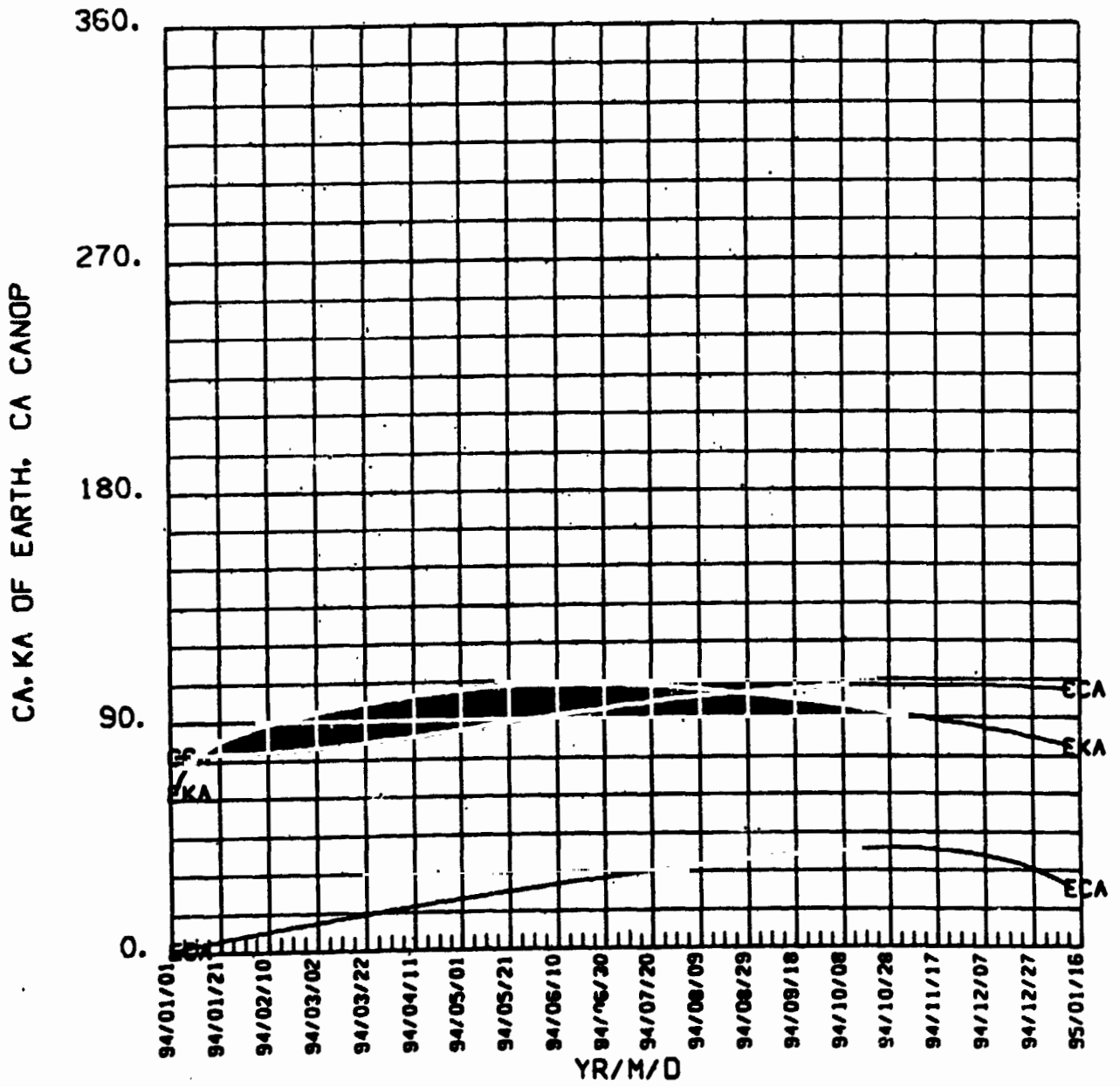


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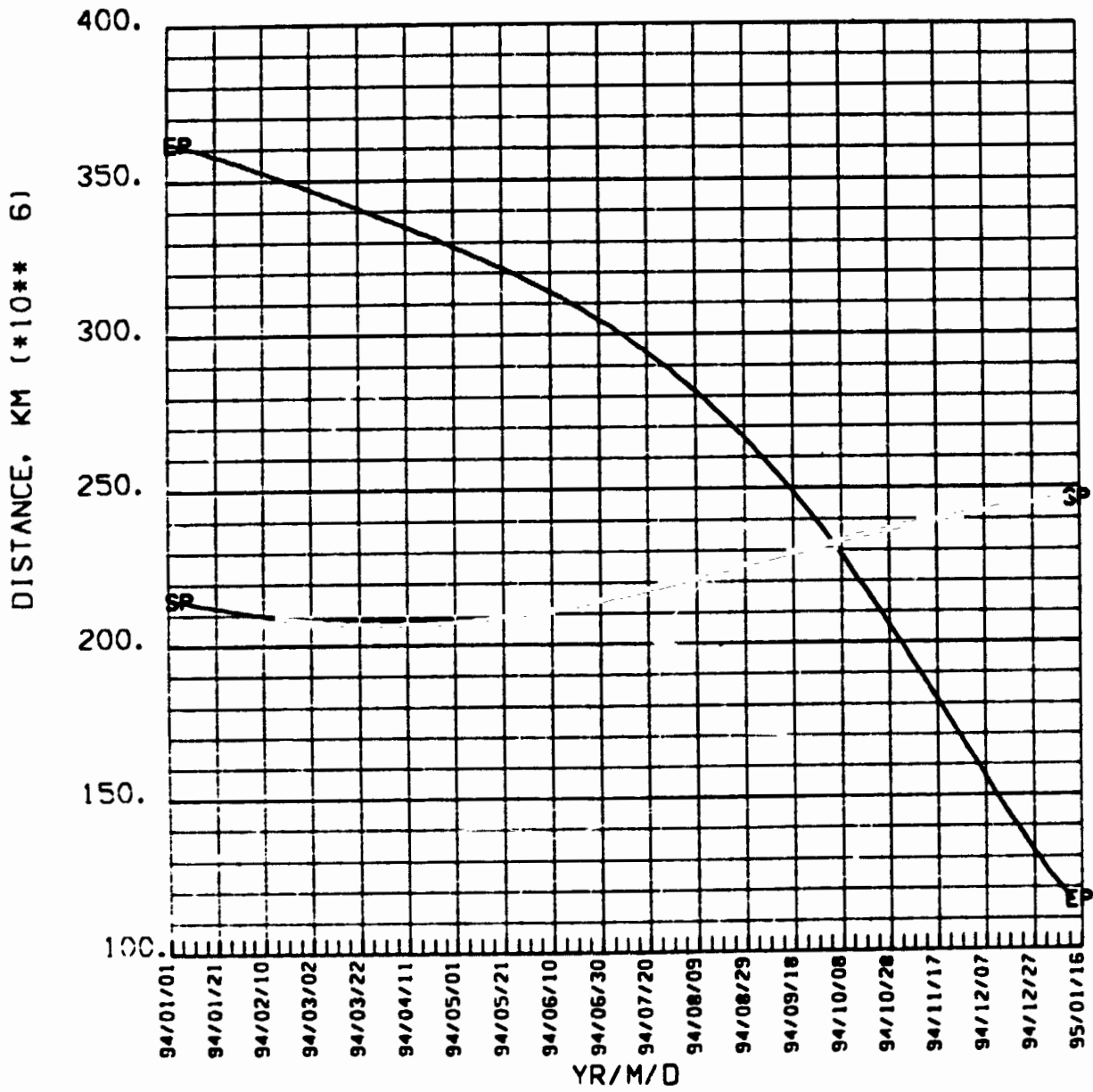


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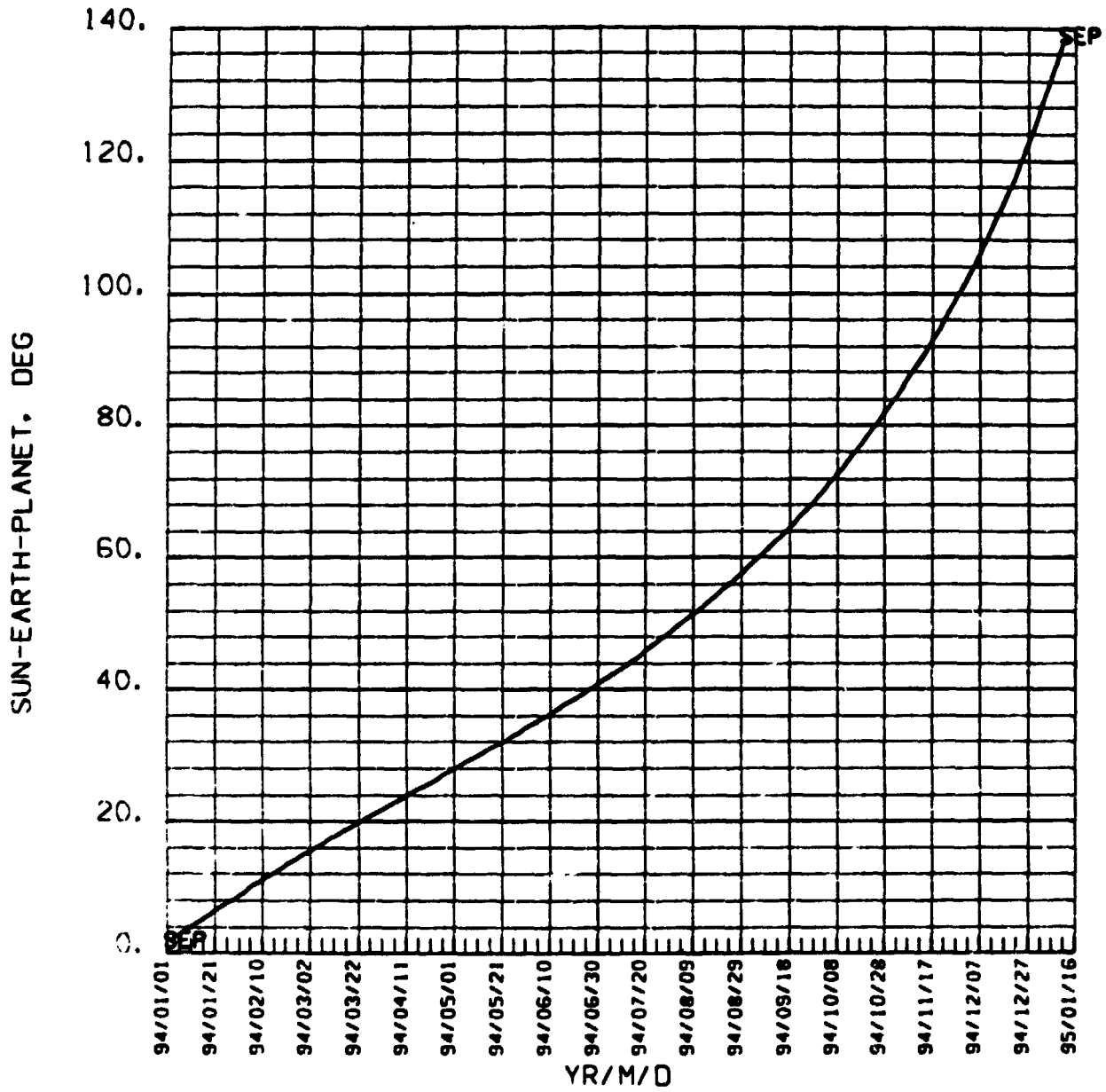
1994



MARS 1994



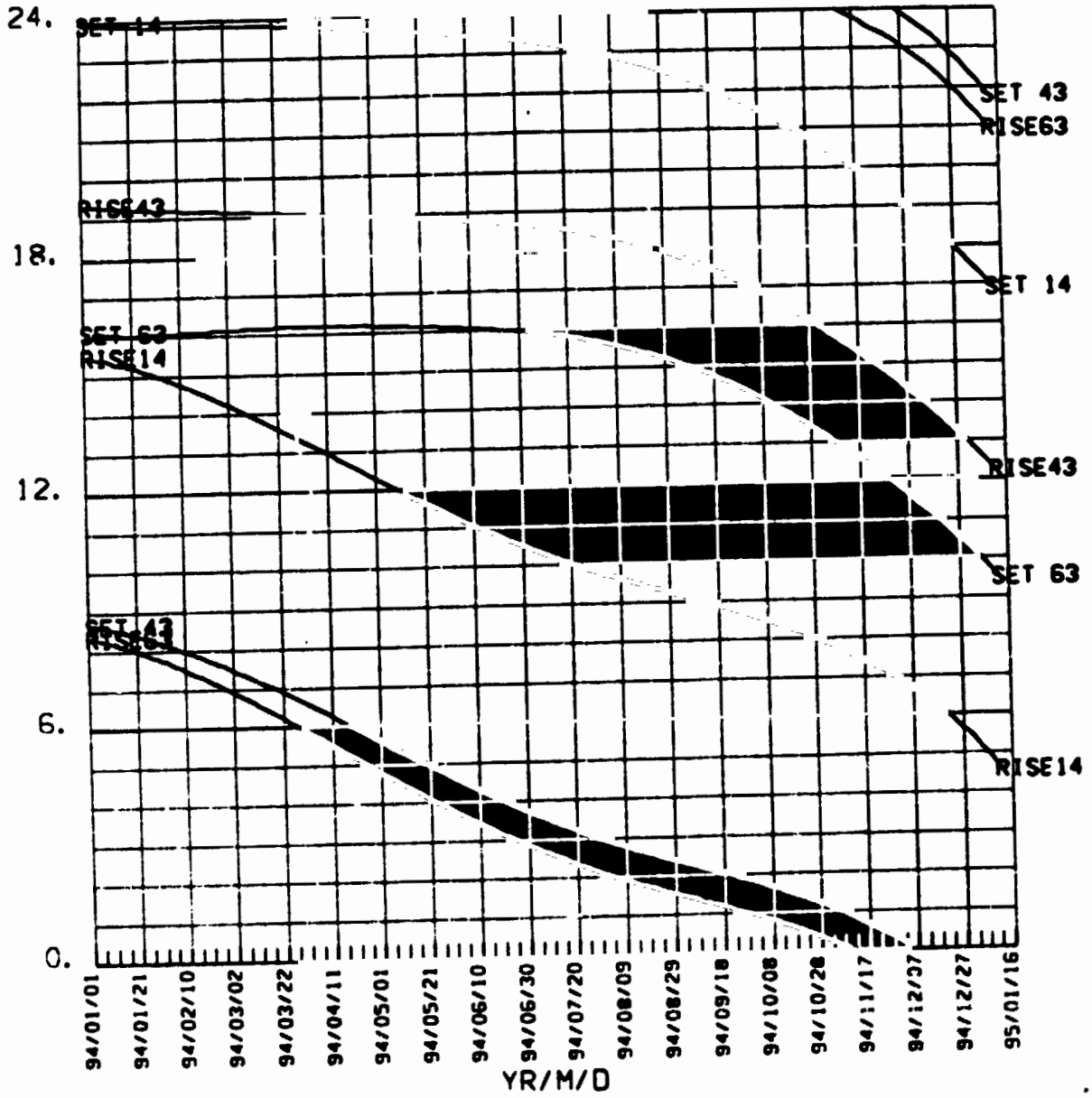
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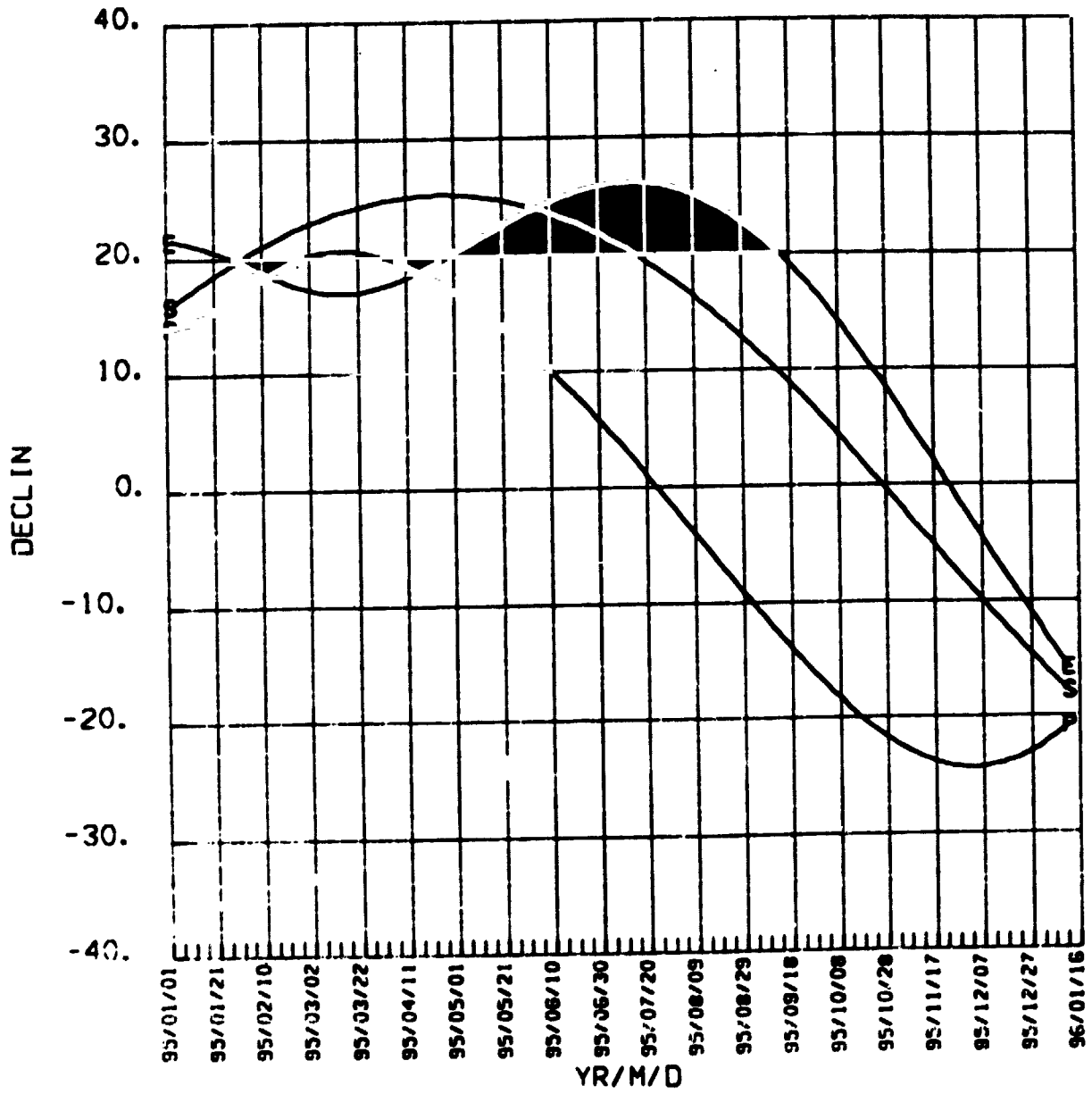


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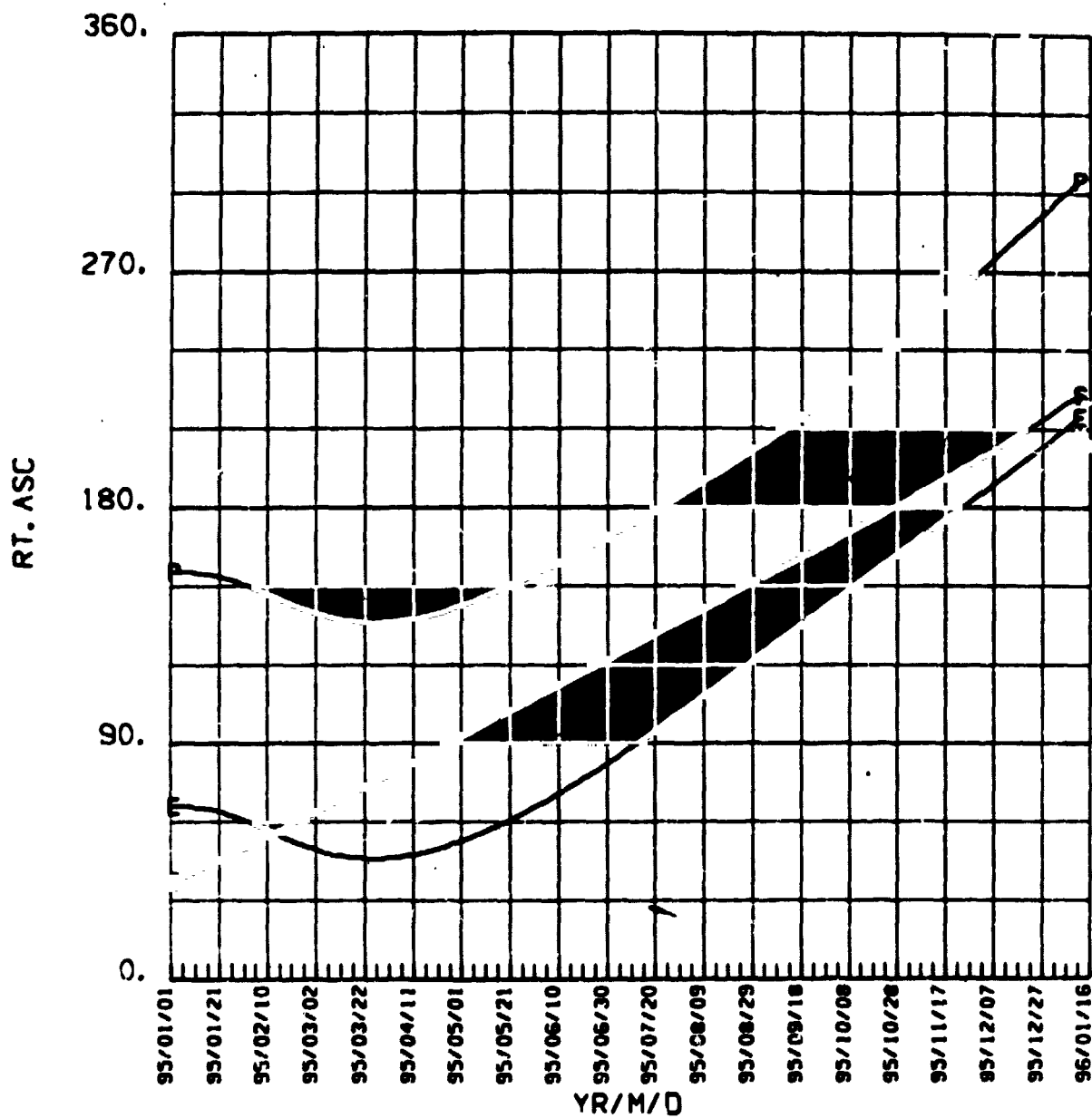
STATION RISE/SET GMT. HR



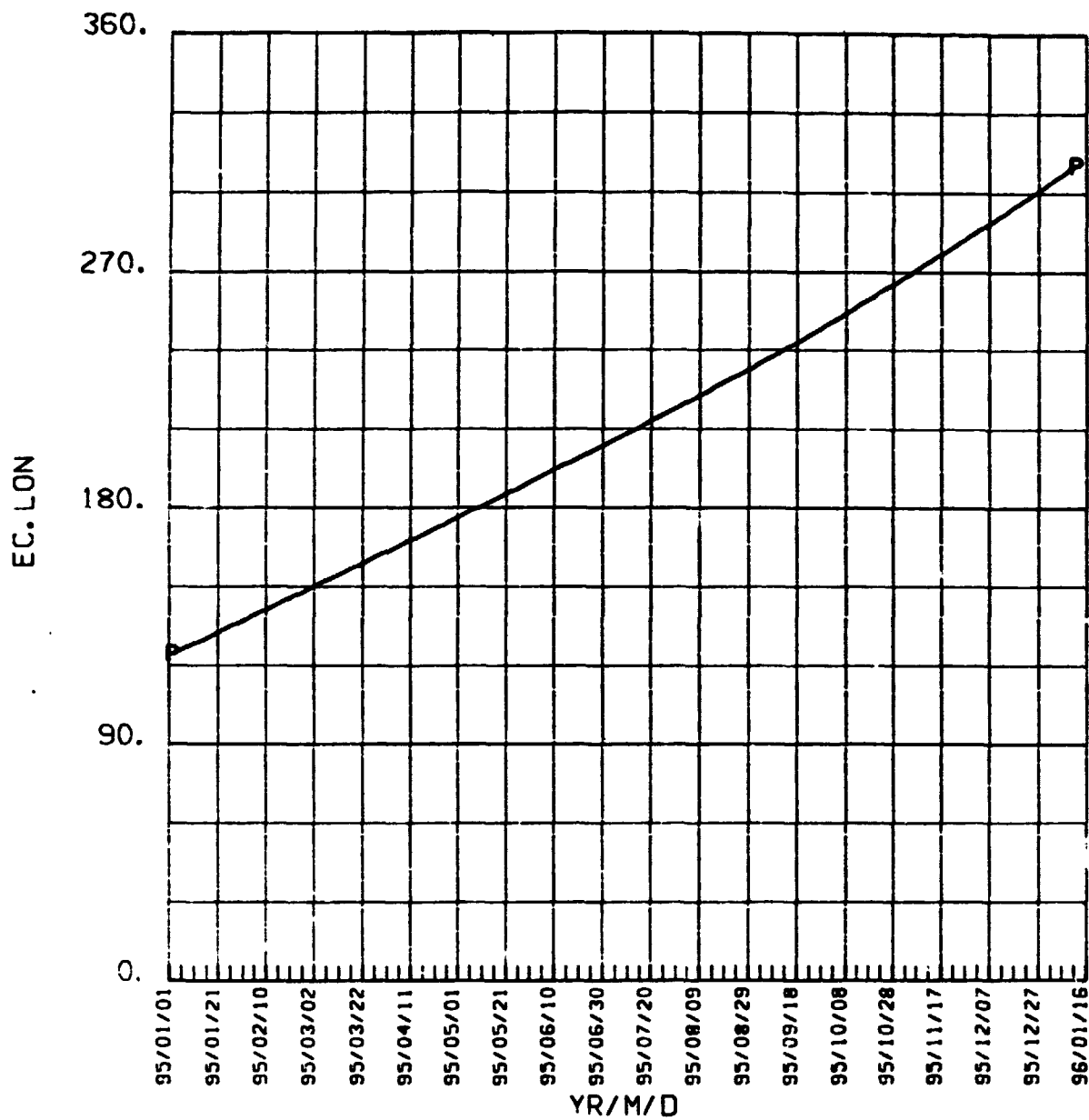
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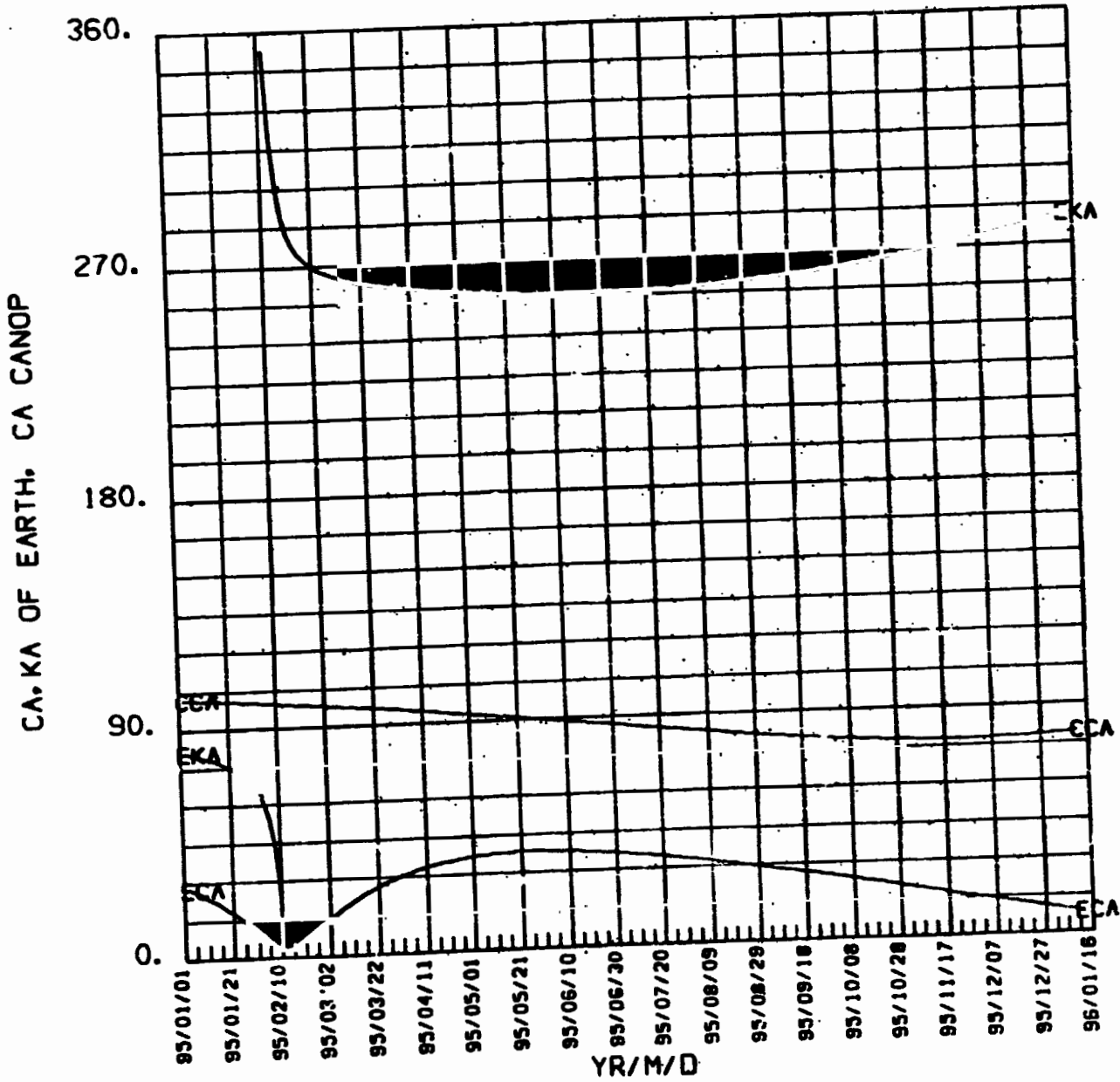
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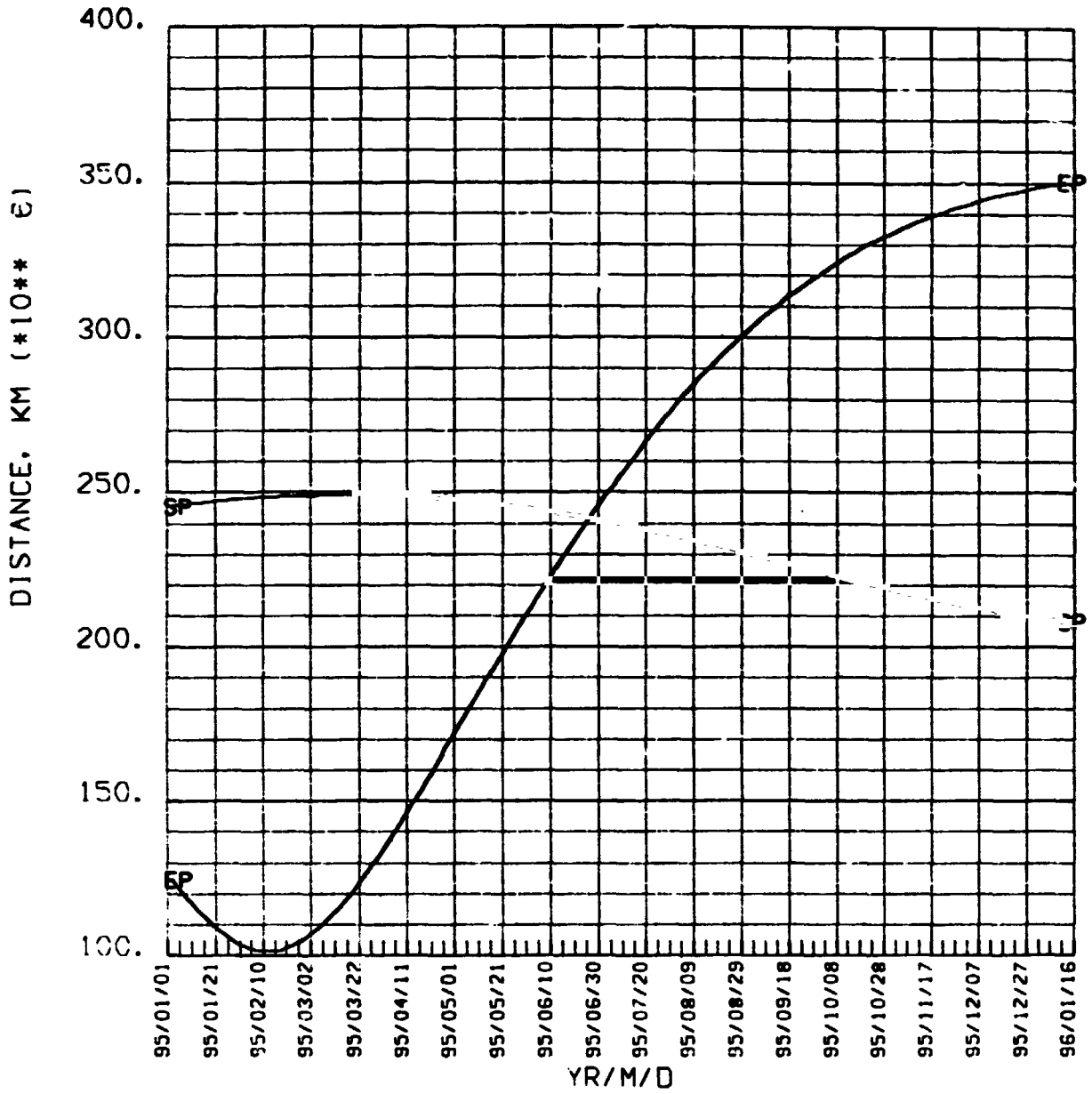
MARS 1995



MARS 1995



MARS 1995



MARS 1995

