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ATR-78(7642)-2

Final Report
Reduction and Analysis of ATS-6 Data
(1 November 1976—31 October 1977)

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Space Sciences Laboratory

10 November 1977

Prepared for

NASA GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

Contract No. NAS5-23788

The Ivan A. Getting Laboratories
THE AEROSPACE CORPORATION

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THE AEROSPACE CORPORATION
El Segundo, California

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ACKNOWLEDGMENTS

We thank Henry Hilton for the invaluable contributions he has made in perfecting and maintaining the ATS-6 reduction and analysis software. Production of ATS-6 was handled by Doretha (Ross) Mayfield and Vera Bledsoe.

ABSTRACT

Results obtained from the analysis of data returned by the Aerospace Corporation energetic particle spectrometer on ATS-6 are presented. The work reported here emphasizes study of the energetic electron environment and the effects of the solar wind parameters on the energetic electrons trapped at the synchronous altitude.

CONTENTS

FIGURES

I. Introduction

This report summarizes the work performed under NASA Contract NAS5-23788 at The Aerospace Corporation. The tasks performed under this contract consisted of the reduction of data obtained by The Aerospace Corporation experiment on ATS-6 and of scientific analysis of the data.

During the period covered by this contract we have reduced virtually all ($\geq$95%) of the data obtained by our experiment during 1974, 1975 and 1976. Data covering the first half of 1977 have also been reduced. These data have been used to develop a description of the energetic electron environment at the synchronous altitude in the 1974-1977 interval. We have also used ATS-5 data (obtained from Dr. C. E. McIlwain of UCSD) to extend our overview of the energetic electron population of the synchronous orbit back to 1969.

We have also continued our analysis of the effects of variations of of the solar wind parameters on the energetic electron population. In this connection we have acquired the data sets required for correlative studies from various sources, including NSSDC.

A plan for transfer of ATS-6 data has been developed, coordinated with NSSDC and is being implemented.

Each of these efforts is described below.

II. Progress in Data Reduction

A. ATS-6 Data Reduction

Data reduction activities proceeded smoothly during FY 77, interrupted occasionally by the inevitable machine hardware and systems software problems. First pass reduction of data between Day 165, 1974 and Day 120, 1977 was completed by July 1977. We then returned to attempt to process the days of data (in 1974 and 1975) which had resisted reduction on the first try. This sub-project was completed by early September 1977, with the result that we believe we have reached the point of diminishing returns with all but 6 and 4 days of data processed for 1974 and 1975, respectively. In September 1977 we resumed mass processing of data obtained during 1977 with the result that at the time of writing, we have processed most of the 1977 data through Day 180.

Appendix A contains a listing of the days of data processed.

B. ATS-1 Data Reduction

The ATS-1 spacecraft, stationed at 150^{o}W contains an experiment (developed by Aerospace) which measures the fluxes of energetic electrons above energy thresholds similar to those of our ATS-6 experiment. The Aerospace ATS-1 experiment continues to be operational and data have been acquired from this experiment during several time intervals: mid-1974 - during the initial operations of ATS-6, early-to-middle 1975, during the move of ATS-6 from 94^{o}W to 35^{o}E longitude and in late 1976, during the return of ATS-6 from 35^{o}E to 140^{o}W.

Although preliminary reduction of all ATS-1 data obtained in 1974 and 1975 has been completed, we find that the data presentation formats are inconvenient for easy comparison of ATS-1 data with ATS-6 data. Accordingly we are modifying the ATS-1 data reduction program to be compatible in output with the ATS-6 software. With this modification, we expect to be able to normalize the ATS-1 data to the ATS-6 results and then be able to perform an unambiguous determination of the variation of energetic electron fluxes with spacecraft longitude (really magnetic latitude). In addition, with the retrieval of our 1966-1968 ATS-1 data deposited with NSSDC the combined ATS-1, ATS-5 and ATS-6 data sets will give us coverage of the energetic electron environment from 1966 through 1977.

C. Utilization of ATS-5 Data

The ATS-5 spacecraft, launched in 1969 and stationed at 105^{o}W contains an experiment (developed by UCSD) which measures energetic electrons above several energy thresholds. The measurements made by ATS-5 are in many respects similar to the ATS-6 data. We have obtained a copy of a tape from Dr. C. E. McIlwain which contains the daily average fluxes of electrons (and solar protons) above several thresholds observed by ATS-5 from mid-1969 to early 1972. In addition, ATS-5 was turned on in mid-1974 during the early operation of ATS-6. It is thus possible to normalize these data sets and thus obtain an overview of the behavior of the energetic electrons at synchronous during a major fraction of the solar cycle. We have developed a program to present the UCSD ATS-5 data in a format compatible with the ATS-6 presentation. Figure 1 shows a sample of the ATS-5 results.

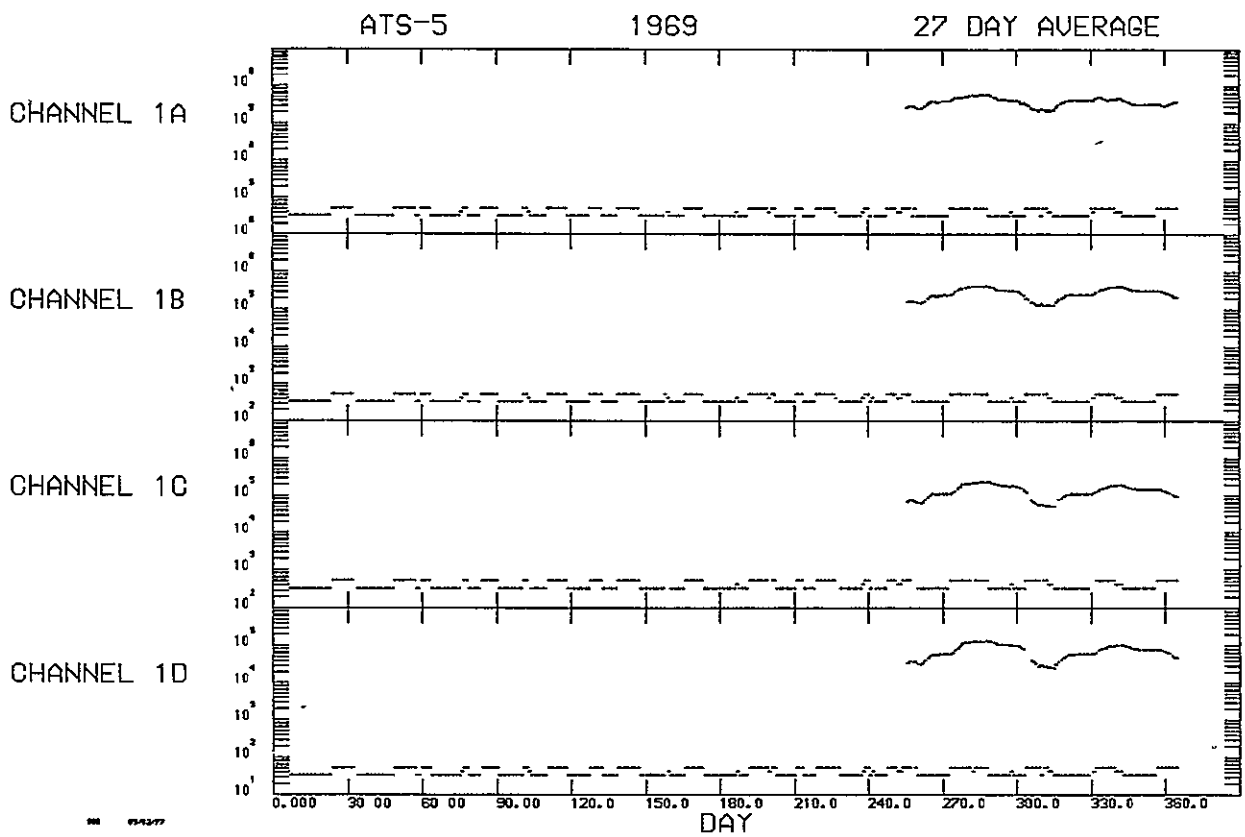

Figure 1. Running 27-day averages of four channels of ATS-5 data for 1969 presented in a format identical to ATS-6 data presenttion. Trace at bottom of each panel indicates polarity of interplanetary magnetic field. Similar data plots have been prepared for 1970, 1971 and portions of 1972 and 1974.

III. Scientific Analysis

A. Energetic Electrons at the Synchronous Altitude 1969-1977

1. Analysis of ATS-6 Data

Appendix B contains a report which describes the analysis we have carried out to date on the ATS-6 data in order to develop a picture of the behavior of the energetic electrons during the period of near solar minimum - the years 1974-1977.

2. Merging of ATS-5 and ATS-6 Data

The ATS-5 data, briefly mentioned earlier, has been combined with the ATS-6 data to give an overview of the properties of the energetic electron population at the synchronous orbit since 1969. Recall that the last maximum of solar activity, as measured by the Zurich sunspot number, occurred in 1969, with the subsequent miminum in the solar cycle estimated to have occurred in mid-1976. Thus the combination of ATS-5 and ATS-6 data, shown in Figure 2 cover more than half of a solar cycle, with only a two year data gap between mid-1972 and mid-1974. Several qualitative conclusions can be drawn from an examination of Figure 2.

a. There does not appear to be any major variations of the energetic electron radiation correlated with the solar cycle, although small, (less than a factor of two) effects may well be present.

b. The range of the variability of the electron fluxes is more or less constant as a function of solar activity. For example, a factor of 50 peak-to-peak excursions in the running 27-day average E4 ($\geq$ 3.9 Mev) flux are evident in the ATS-6 data as well as in the comparable ATS-5 channel.

B. Effects of Solar Wind Parameters on the Energetic Electron Population

Last year we reported finding a substantial variability of the energetic electron fluxes which was correlated with the passage of the sectors of the interplanetary

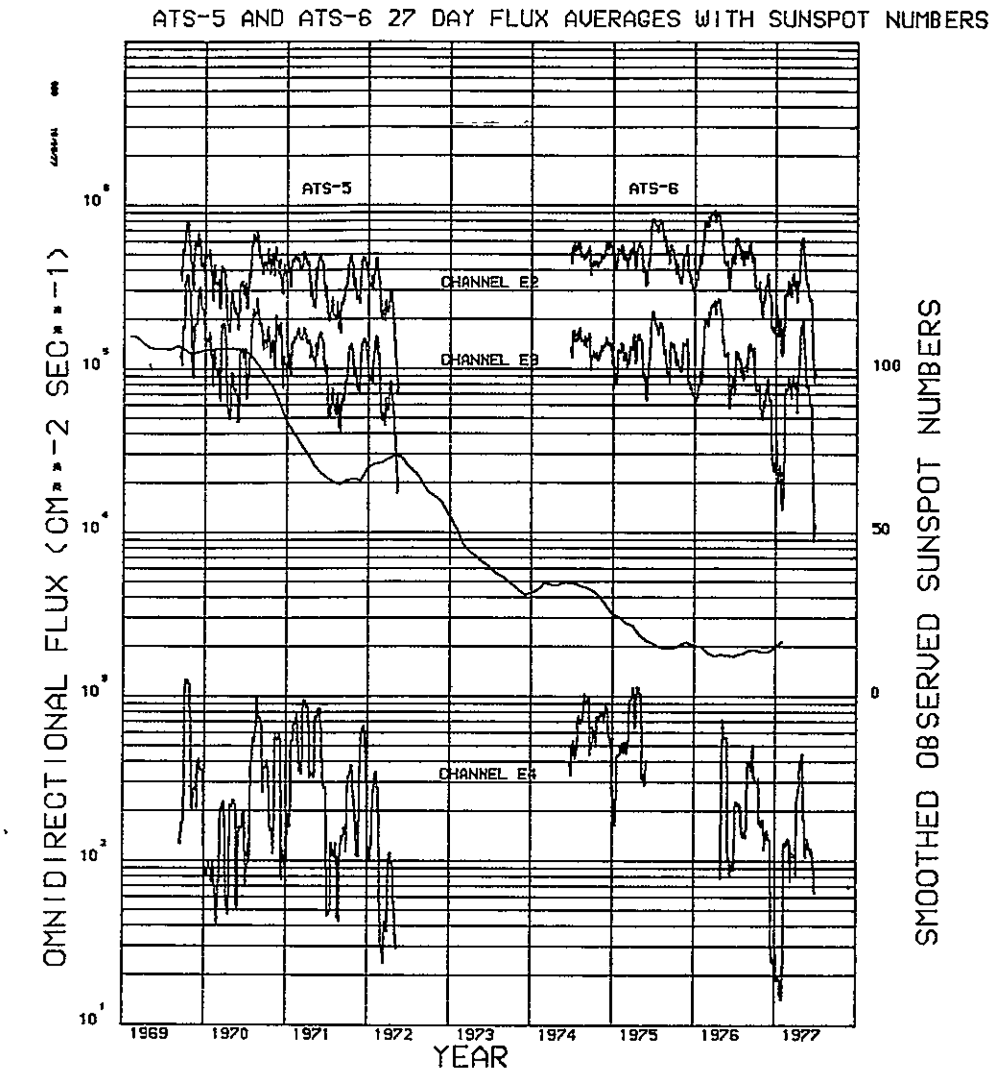

Figure 2. ATS-6 data and ATS-5 data (normalized to ATS-6 using the data overlap in 1974) on omnidirectional electron fluxes are plotted versus time. The data are running 27-day averages of fluxes E2 $\geq$ 0.7 MeV, E3 $\geq$ 1.55 Mev and E4 $\geq$ 3.9 MeV. Also shown are the smoothed monthly sunspot numbers.

magnetic field past the earth. In FY 77 we have continued studying this phenomenon using the now much larger data base available to us and have expanded the study to include correlation of the energetic electron fluxes with other parameters of the solar wind, for example the solar wind velocity. In order to perform such correlations we have acquired from NSSDC, LASL and MIT data on the solar wind plasma covering the periods of interest. We are now proceeding with such correlation analysis.

A preliminary result is illustrated in Figure 3 where we have superimposed a plot of the solar wind velocity (delayed by $1\frac{1}{2}$ days) on a plot of the energetic electron fluxes. This plot clearly illustrates the very close correlation between solar wind velocity and energetic electron fluxes, if a "generation time" of $1\frac{1}{2}$ days is postulated.

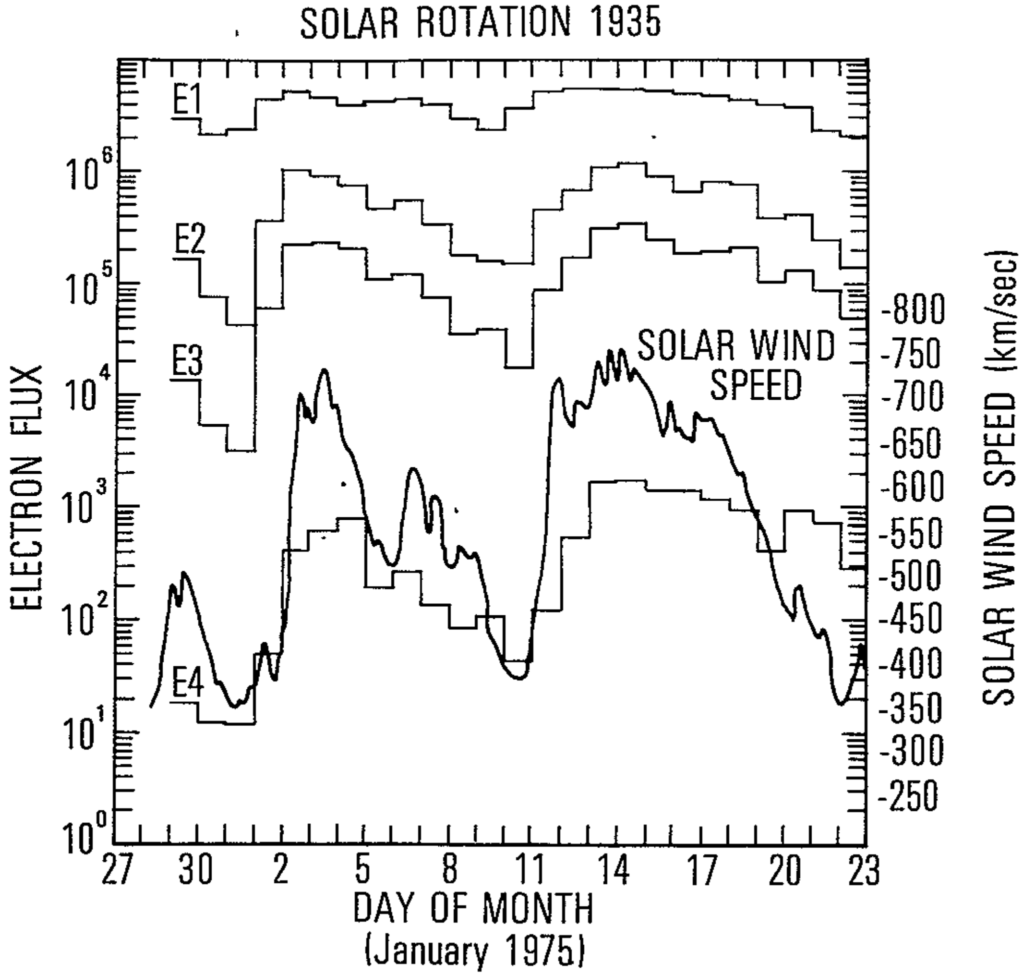

Figure 3. Energetic electra fluxes (150 Kev $\leq$ E1 $\leq$ 600 Kev, E2 $\geq$ 0.7 Mev, E3 $\geq$ 1.55 MeV and E4 $\geq$ 3.9 MeV) and solar wind speed (delayed by 1.5 days) plotted as a function of time for solar rotation 1935. Trace at bottom of page indicates polarity of interplanetary magnetic field.

IV. Transfer of Data to NSSDC

We have prepared a plan for submission of our data to NSSDC. Briefly, we plan to transfer hourly averages of our data in blocks ordered by calendar year. In preparation for this transfer we have already completed processing all data for 1974 that can be processed with reasonable effort. All 1974 hourly average data has been inspected and bad data points, mis-identified days and other anomalies have been edited out or corrected. We expect that the 1974 data can be transferred to NSSDC by November, 1977 with the 1975 and 1976 data following at approximately monthly intervals.

In addition to transferring the hourly averaged data, we also plan to transfer approximately one hundred days of typical ATS-6 data in a format which contains the highest time resolution ($\Delta t = 1$ sec) contained in our measurements. The data tape format for these data tapes has been coordinated with NSSDC.

We are preparing a "Users Guide to Aerospace Corp. ATS-6 Data." This document, to be included in the transfer to NSSDC, contains description of the experiment, the data reduction and analysis procedures we use, descriptions of the several formats of data tapes, listing of experiment and data anomalies as well as a compilation of papers and reports resulting from the ATS-6 data.

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APPENDIX A

Summary of ATS-6 Data Processed

FORMAT OF PRESENTATION

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Sequence Number	NASA Tape Number	Date Data Processed	Day Number	Month	Day	Year

1	044545	HD	07/23/77		165	6	14	1974
2	044462	HD	06/28/76		166	6	15	1974
3	044496	HD	06/28/76		167	6	16	1974
4	044511	HD	06/28/76		168	6	17	1974
5	045679	HD	07/15/77		169	6	18	1974
6	045688	HD	07/23/77		170	6	19	1974
7	044547	HD	07/16/77		171	6	20	1974
8	044485	HD	06/30/76		172	6	21	1974
9	044499	HD	06/30/76		173	6	22	1974
10	044498	HD	06/30/76		174	6	23	1974
11	044507	HD	06/30/76		175	6	24	1974
12	044494	HD	06/30/76		176	6	25	1974
13	044495	HD	06/30/76		177	6	26	1974
14	044546	HD	07/18/77		178	6	27	1974
15	044513	HD	07/30/76		179	6	28	1974
16	044516	HD	06/30/76		180	6	29	1974
17	044517	HD	07/01/76		181	6	30	1974
18	044500	HD	07/01/76		182	7	1	1974
19	044505	HD	07/09/76		183	7	2	1974
20	044515	HD	07/02/76		184	7	3	1974
21	044544	HD	07/18/77		185	7	4	1974
22	044501	HD	07/08/76		186	7	5	1974
23	045687	HD	07/23/77		187	7	6	1974
24	044492	HD	07/02/76		188	7	7	1974
25	044493	HD	07/02/76		189	7	8	1974
26	045686	HD	07/22/77		190	7	9	1974
27	045681	HD	07/15/77		191	7	10	1974
28	044484	HD	07/02/76		192	7	11	1974
29	044518	HD	07/08/76		193	7	12	1974
30	044512	HD	07/08/76		194	7	13	1974
31	044490	HD	07/08/76		195	7	14	1974
32	045682	HD	07/15/77		196	7	15	1974
33	044113	HD	07/08/76		197	7	16	1974
34	044079	HD	07/16/77		198	7	17	1974
35	044077	HD	07/08/76		199	7	18	1974
36	072290	HD	07/08/76		200	7	19	1974
37	044487	HD	07/08/76		201	7	20	1974
38	044488	HD	07/08/76		202	7	21	1974
39	044486	HD	07/08/76		203	7	22	1974
40	079007	HD	07/08/76		204	7	23	1974
41	044780	HD	10/15/76		205	7	24	1974
42	79002		01/15/76		206	7	25	1974
43	79018		01/15/76		207	7	26	1974
44	79001		10/15/75		208	7	27	1974
45	044497	HD	07/08/76		209	7	28	1974
46	044489	HD	07/08/76		210	7	29	1974
47	79028		08/14/75		211	7	30	1974
48	79005		01/20/76		212	7	31	1974
49	079070	HD	07/22/77		213	8	1	1974
50	079036	HD	07/22/77		214	8	2	1974
51	044476	HD	07/08/76		215	8	3	1974
52	045680	HD	07/15/77		216	8	4	1974
53	79104		08/22/75		217	8	5	1974
54	79111		08/22/75		218	8	6	1974
55	79051		01/05/76		219	7	8	1974
56	79071		01/16/76		220	8	8	1974

57	79061		01/06/76	221	8	9	1974
58	79072		01/07/76	222	7	11	1974
59	079021	HD	07/09/76	223	8	11	1974
60	044508	HD	07/09/76	224	8	12	1974
61	044506	HD	07/13/76	225	8	13	1974
62	044514	HD	07/13/76	226	8	14	1974
63	79013		08/27/75	227	8	15	1974
64	79016		08/28/75	228	8	16	1974
65	79010		08/28/75	229	8	17	1974
66	79015		08/28/75	230	8	18	1974
67	79006		08/29/75	231	8	19	1974
68	044112	HD	07/13/76	232	8	20	1974
69	79034		01/16/76	233	8	21	1974
70	79000		09/02/75	234	8	22	1974
71	79029		01/16/76	235	8	23	1974
72	044468	HD	07/13/76	237	8	25	1974
73	79105		09/03/75	238	8	26	1974
74	79033		09/03/75	239	8	27	1974
75	79073		09/05/75	241	8	29	1974
76	79031		01/06/76	242	8	30	1974
77	79079		09/05/75	243	8	31	1974
78	044114	HD	07/13/76	244	9	1	1974
79	044502	HD	07/13/76	245	9	2	1974
80	079035	HD	07/23/77	246	9	3	1974
81	079054	HD	07/23/77	247	9	4	1974
82	079053	HD	07/13/76	248	9	5	1974
83	079182	HD	07/13/76	249	9	6	1974
84	44013		11/06/75	250	9	7	1974
85	044503	HD	07/14/76	251	9	8	1974
86	079026	HD	07/14/76	252	9	9	1974
87	044510	HD	07/16/77	253	9	10	1974
88	079024	HD	07/14/76	254	9	11	1974
89	079032	HD	07/22/77	255	9	12	1974
90	079274	HD	08/11/77	256	9	13	1974
91	079118	HD	07/22/77	258	9	15	1974
92	079078	HD	09/16/77	259	9	16	1974
93	44015		11/05/75	260	9	17	1974
94	079076	HD	09/16/77	261	9	18	1974
95	079275	HD	08/12/77	262	9	19	1974
96	079058	HD	07/30/77	263	9	21	1974
97	079057	HD	09/16/77	264	9	21	1974
98	079276	HD	07/30/77	266	9	23	1974
99	079065	HD	08/11/77	267	9	24	1974
100	79080		09/24/75	268	9	25	1974
101	79063		09/24/75	269	9	26	1974
102	79103		09/25/75	270	9	27	1974
103	79059		09/26/75	271	9	28	1974
104	79064		09/26/75	272	9	29	1974
105	044018	HD	09/13/77	273	9	30	1974
106	79066		09/29/75	274	10	1	1974
107	44019		10/10/75	275	10	2	1974
108	79102		10/01/75	276	10	3	1974
109	79068		10/01/75	277	10	4	1974
110	79074		10/02/75	278	10	5	1974
111	44020		10/10/75	279	10	6	1974
112	79056		10/06/75	280	10	7	1974
113	044021	HD	08/26/76	281	10	8	1974

114	79060		10/20/75	282	10	9	1974
115	79565		01/23/76	283	10	10	1974
116	79115		10/23/75	284	10	11	1974
117	044022	HD	09/16/77	285	10	12	1974
118	79062		10/23/75	286	10	13	1974
119	79069		10/24/75	287	10	14	1974
120	79055		10/27/75	288	10	15	1974
121	79077		01/23/76	289	10	16	1974
122	79106		01/27/76	290	10	17	1974
123	44023		10/14/75	291	10	18	1974
124	79154		10/29/75	292	10	19	1974
125	044024	HD	09/16/77	293	10	20	1974
126	44025		10/17/75	294	10	21	1974
127	079169	HD	08/04/76	295	10	22	1974
128	79075		10/30/75	296	10	23	1974
129	79084		11/03/75	297	10	24	1974
130	079110	HD	07/16/77	298	10	25	1974
131	079012	HD	08/04/76	299	10	26	1974
132	44026		01/27/76	300	10	27	1974
133	044466	HD	08/04/76	301	10	28	1974
134	044483	HD	08/16/76	302	10	29	1974
135	079167	HD	08/16/76	303	10	30	1974
136	079081	HD	08/06/76	304	10	31	1974
137	044474	HD	08/16/76	305	11	1	1974
138	044475	HD	08/16/76	306	11	2	1974
139	044560	HD	08/16/76	307	11	3	1974
140	044481	HD	08/16/76	308	11	4	1974
141	044472	HD	08/16/76	309	11	5	1974
142	079181	HD	08/16/76	310	11	6	1974
143	044591	HD	08/16/76	311	11	7	1974
144	044467	HD	08/16/76	312	11	8	1974
145	044482	HD	08/26/76	313	11	9	1974
146	044478	HD	08/16/76	314	11	10	1974
147	044559	HD	08/27/76	315	11	11	1974
148	044471	HD	08/17/76	316	11	12	1974
149	044479	HD	08/17/76	318	11	14	1974
150	044464	HD	08/17/76	319	11	15	1974
151	044465	HD	08/17/76	320	11	16	1974
152	044477	HD	08/17/76	321	11	17	1974
153	044480	HD	08/18/76	322	11	18	1974
154	044469	HD	08/19/76	324	11	20	1974
155	044473	HD	08/18/76	325	11	21	1974
156	044549	HD	08/13/76	326	11	22	1974
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158	044555	HD	08/13/76	328	11	24	1974
159	044590	HD	08/13/76	329	11	25	1974
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161	044570	HD	08/12/76	331	11	27	1974
162	044574	HD	08/12/76	332	11	28	1974
163	044550	HD	08/12/76	333	11	29	1974
164	044579	HD	08/12/76	334	11	30	1974
165	044556	HD	08/12/76	335	12	1	1974
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167	044586	HD	09/16/77	337	12	2	1974
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169	044588	HD	08/12/76	339	12	5	1974
170	044561	HD	09/16/77	340	12	6	1974

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173	044578	HD	08/09/76	343	12	9	1974
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175	044576	HD	08/10/76	345	12	11	1974
176	044580	HD	08/10/76	346	12	12	1974
177	044582	HD	08/10/76	347	12	13	1974
178	044566	HD	08/10/76	348	12	14	1974
179	044567	HD	08/10/76	349	12	15	1974
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181	044584	HD	08/10/76	351	12	17	1974
182	044564	HD	08/10/76	352	12	18	1974
183	044583	HD	08/10/76	353	12	19	1974
184	044568	HD	08/18/76	354	12	20	1974
185	044581	HD	08/11/76	355	12	21	1974
186	044573	HD	08/11/76	356	12	22	1974
187	044569	HD	08/11/76	357	12	23	1974
188	044563	HD	08/18/76	358	12	24	1974
189	044585	HD	08/11/76	359	12	25	1974
190	044577	HD	08/11/76	360	12	26	1974
191	044572	HD	08/11/76	361	12	27	1974
192	044587	HD	08/11/76	362	12	28	1974
193	044575	HD	08/11/76	363	12	29	1974
194	044554	HD	08/11/76	364	12	30	1974
195	044589	HD	08/13/76	365	12	31	1974
196	044599	HD	08/27/76	1	1	1	1975
197	045741	HD	08/12/77	2	1	2	1975
198	044602	HD	10/15/76	3	1	3	1975
199	044604	HD	10/15/76	4	1	4	1975
200	044607	HD	10/15/76	5	1	4	1975
201	044600	HD	10/15/76	6	1	6	1975
202	044601	HD	08/26/76	7	1	7	1975
203	079907	HD	08/26/76	8	1	8	1975
204	079906	HD	08/30/76	9	1	9	1975
205	044608	HD	08/26/76	10	1	10	1975
206	045753	HD	08/12/77	11	1	11	1975
207	079912	HD	08/12/77	12	1	12	1975
208	044611	HD	08/27/76	13	1	13	1975
209	044610	HD	08/27/76	14	1	14	1975
210	044603	HD	08/27/76	15	1	15	1975
211	044606	HD	08/27/76	16	1	16	1975
212	044605	HD	08/27/76	17	1	17	1975
213	044609	HD	08/27/76	18	1	18	1975
214	044596	HD	08/27/76	19	1	19	1975
215	044595	HD	08/26/76	20	1	20	1975
216	044597	HD	08/26/76	21	1	21	1975
217	044594	HD	08/26/76	22	1	22	1975
218	044598	HD	08/26/76	23	1	23	1975
219	079922	HD	08/26/76	24	1	24	1975
220	079914	HD	08/26/76	25	1	25	1975
221	079905	HD	12/22/76	26	1	26	1975
222	079903	HD	08/12/77	27	1	27	1975
223	079926	HD	08/15/77	28	1	28	1975
224	079925	HD	09/01/76	29	1	29	1975
225	079908	HD	08/30/76	30	1	29	1975
226	079924	HD	08/30/76	31	1	31	1975
227	079931	HD	10/17/76	32	2	1	1975

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228	079930	HD	12/01/76	33	2	2	1975
229	079911	HD	12/01/76	34	2	3	1975
230	079917	HD	12/01/76	35	2	4	1975
231	79902		11/25/75	36	2	5	1975
232	79913		11/26/75	37	2	6	1975
233	79910		11/26/75	38	2	7	1975
234	79921		12/12/75	39	2	8	1975
235	79923		12/01/75	40	2	9	1975
236	79918		12/02/75	41	2	10	1975
237	79915		12/03/75	42	2	11	1975
238	79920		12/03/75	43	2	12	1975
239	79919		12/09/75	44	2	13	1975
240	44086		12/12/75	45	2	14	1975
241	44089		01/15/76	46	2	15	1975
242	44087		12/15/75	47	2	16	1975
243	44098		12/16/75	48	2	17	1975
244	44092		12/16/75	49	2	18	1975
245	79932		12/16/75	50	2	19	1975
246	44100		12/17/75	51	2	20	1975
247	79933		12/17/75	52	2	21	1975
248	44088		12/19/75	53	2	22	1975
249	44085		12/29/75	54	2	23	1975
250	44093		12/29/75	55	2	24	1975
251	44091		12/29/75	56	2	25	1975
252	44084		12/31/75	57	2	26	1975
253	44094		12/31/75	58	2	27	1975
254	44099		01/02/76	59	2	28	1975
255	044090	HD	06/25/76	60	2	29	1975
256	44095		01/02/76	61	3	2	1975
257	44096		01/02/76	62	3	3	1975
258	44097		01/05/76	63	3	4	1975
259	-0		01/08/76	64	3	5	1975
260	44104		01/08/76	65	3	6	1975
261	44105		01/09/76	66	3	7	1975
262	44102		01/09/76	67	3	8	1975
263	44107		01/09/76	68	3	9	1975
264	44106		01/12/76	69	3	10	1975
265	44108		01/12/76	70	3	11	1975
266	44101		01/12/76	71	3	12	1975
267	44109		01/13/76	72	3	13	1975
268	44063		11/10/75	73	3	14	1975
269	44069		11/12/75	74	3	15	1975
270	44068		11/12/75	75	3	16	1975
271	44070		11/12/75	76	3	17	1975
272	44065		11/13/75	77	3	18	1975
273	44110		01/13/76	78	3	19	1975
274	44072		11/14/75	79	3	20	1975
275	44073		11/17/75	80	3	21	1975
276	44067		11/17/75	81	3	22	1975
277	44066		11/19/75	82	3	23	1975
278	44071		11/21/75	83	3	24	1975
279	44064		11/21/75	84	3	25	1975
280	044691	HD	08/30/76	85	3	26	1975
281	044620	HD	08/30/76	86	3	27	1975
282	044622	HD	08/30/76	87	3	28	1975
283	044614	HD	08/30/76	88	3	29	1975
284	044627	HD	08/30/76	89	3	30	1975

285	044612	HD	08/30/76	90	3	31	1975
286	044677	HD	08/30/76	91	4	1	1975
287	044637	HD	08/30/76	92	4	2	1975
288	044613	HD	08/30/76	93	4	3	1975
289	044692	HD	08/30/76	94	4	3	1975
290	044629	HD	08/30/76	95	4	5	1975
291	044628	HD	08/30/76	96	4	6	1975
292	044626	HD	08/31/76	97	4	7	1975
293	044660	HD	08/31/76	98	4	8	1975
294	044621	HD	08/31/76	99	4	9	1975
295	044618	HD	08/31/76	100	4	10	1975
296	044633	HD	09/01/76	101	4	11	1975
297	044624	HD	09/01/76	102	4	12	1975
298	044632	HD	09/01/76	103	4	13	1975
299	044619	HD	09/01/76	104	4	14	1975
300	044631	HD	09/01/76	105	4	15	1975
301	044693	HD	09/01/76	106	4	16	1975
302	044625	HD	09/01/76	107	4	17	1975
303	044634	HD	09/01/76	108	4	18	1975
304	044630	HD	09/01/76	109	4	19	1975
305	044617	HD	09/01/76	110	4	20	1975
306	044615	HD	09/01/76	111	4	21	1975
307	044616	HD	09/01/76	112	4	21	1975
308	044642	HD	10/12/76	113	4	23	1975
309	044643	HD	10/12/76	114	4	24	1975
310	044635	HD	10/12/76	115	4	25	1975
311	044653	HD	10/12/76	116	4	26	1975
312	044641	HD	10/12/76	117	4	27	1975
313	044665	HD	10/12/76	118	4	28	1975
314	044645	HD	09/01/76	119	4	29	1975
315	044644	HD	09/01/76	120	4	30	1975
316	044646	HD	09/01/76	121	5	1	1975
317	044669	HD	09/01/76	122	5	2	1975
318	044638	HD	09/01/76	123	5	3	1975
319	044664	HD	09/01/76	124	5	4	1975
320	044647	HD	10/01/76	125	5	5	1975
321	044666	HD	10/01/76	126	5	6	1975
322	044659	HD	10/01/76	127	5	7	1975
323	044690	HD	10/01/76	128	5	8	1975
324	044673	HD	10/01/76	129	5	9	1975
325	044648	HD	10/01/76	130	5	10	1975
326	044694	HD	09/27/76	131	5	11	1975
327	044636	HD	09/27/76	132	5	12	1975
328	044639	HD	09/27/76	133	5	13	1975
329	044675	HD	09/27/76	134	5	14	1975
330	044654	HD	09/27/76	135	5	15	1975
331	044697	HD	10/12/76	136	5	16	1975
332	044640	HD	10/02/76	137	5	17	1975
333	044667	HD	10/02/76	138	5	18	1975
334	044695	HD	10/02/76	139	5	19	1975
335	044655	HD	10/02/76	141	5	21	1975
336	044656	HD	10/28/76	142	5	22	1975
337	044649	HD	12/22/76	143	5	23	1975
338	044663	HD	10/11/76	144	5	24	1975
339	044687	HD	10/11/76	145	5	25	1975
340	044668	HD	10/11/76	146	5	26	1975
341	044679	HD	10/11/76	147	5	27	1975

342	044662	HD	10/11/76	148	5	28	1975
343	044680	HD	10/11/76	149	5	29	1975
344	044688	HD	10/02/76	150	5	29	1975
345	044682	HD	10/02/76	151	5	31	1975
346	044651	HD	10/02/76	152	6	1	1975
347	044684	HD	10/02/76	153	6	2	1975
348	044652	HD	10/02/76	154	6	3	1975
349	044658	HD	10/02/76	155	6	4	1975
350	044685	HD	10/11/76	156	6	5	1975
351	044657	HD	10/11/76	157	6	6	1975
352	044659	HD	10/11/76	158	6	7	1975
353	044623	HD	10/11/76	159	6	8	1975
354	044689	HD	10/11/76	160	6	9	1975
355	044676	HD	10/11/76	161	6	10	1975
356	044674	HD	10/11/76	162	6	11	1975
357	044683	HD	10/11/76	163	6	12	1975
358	044681	HD	10/11/76	164	6	13	1975
359	044686	HD	10/11/76	165	6	13	1975
360	044678	HD	10/11/76	166	6	15	1975
361	044661	HD	10/11/76	167	6	16	1975
362	044679	HD	10/12/76	168	6	17	1975
363	044671	HD	10/12/76	169	6	18	1975
364	044737	HD	10/15/76	170	6	19	1975
365	044772	HD	10/15/76	171	6	20	1975
366	044748	HD	10/15/76	172	6	21	1975
367	045742	HD	08/11/77	173	6	22	1975
368	044771	HD	12/04/76	174	6	23	1975
369	044756	HD	12/04/76	175	6	24	1975
370	045745	HD	08/11/77	176	6	25	1975
371	044767	HD	10/17/76	177	6	26	1975
372	044781	HD	10/17/76	178	6	27	1975
373	044766	HD	10/17/76	179	6	28	1975
374	044742	HD	10/17/76	180	6	29	1975
375	044735	HD	10/17/76	181	6	30	1975
376	044736	HD	10/17/76	182	7	1	1975
377	044723	HD	12/04/76	183	7	2	1975
378	044776	HD	12/04/76	184	7	3	1975
379	044750	HD	12/04/76	185	7	4	1975
380	044754	HD	11/08/76	186	7	5	1975
381	044746	HD	11/24/76	187	7	6	1975
382	044773	HD	12/04/76	188	7	7	1975
383	044758	HD	10/15/76	189	7	8	1975
384	044770	HD	10/15/76	190	7	9	1975
385	044753	HD	10/15/76	191	7	10	1975
386	044760	HD	10/15/76	192	7	11	1975
387	044725	HD	10/15/76	193	7	12	1975
388	044762	HD	10/15/76	194	7	13	1975
389	044755	HD	10/17/76	195	7	14	1975
390	044726	HD	10/17/76	196	7	15	1975
391	044765	HD	10/17/76	197	7	16	1975
392	044739	HD	10/17/76	198	7	17	1975
393	044751	HD	10/17/76	199	7	18	1975
394	044782	HD	10/17/76	200	7	19	1975
395	044749	HD	10/15/76	201	7	20	1975
396	044672	HD	10/15/76	202	7	21	1975
397	044729	HD	10/15/76	203	7	22	1975
398	044738	HD	10/15/76	204	7	23	1975

399	045743	HD	08/12/77	205	7	24	1975
400	044733	HD	10/15/76	206	7	25	1975
401	044728	HD	10/25/76	207	7	26	1975
402	044783	HD	10/25/76	208	7	27	1975
403	044764	HD	10/26/76	209	7	28	1975
404	044752	HD	12/17/76	210	7	29	1975
405	044730	HD	12/17/76	211	7	30	1975
406	044775	HD	12/17/76	212	7	31	1975
407	044759	HD	10/22/76	213	8	1	1975
408	044731	HD	10/22/76	214	8	2	1975
409	044769	HD	10/22/76	215	8	3	1975
410	045767	HD	08/15/77	216	8	4	1975
411	044724	HD	08/15/77	217	8	5	1975
412	044747	HD	08/15/77	218	8	6	1975
413	044777	HD	11/30/76	219	8	7	1975
414	044745	HD	12/04/76	220	8	8	1975
415	044774	HD	10/15/76	221	8	9	1975
416	044732	HD	11/30/76	222	8	10	1975
417	044757	HD	10/22/76	223	8	11	1975
418	044740	HD	10/22/76	224	8	12	1975
419	044744	HD	10/22/76	225	8	13	1975
420	044778	HD	10/22/76	226	8	14	1975
421	044779	HD	10/22/76	227	8	15	1975
422	044761	HD	10/22/76	228	8	16	1975
423	044763	HD	12/04/76	229	8	17	1975
424	044768	HD	11/04/76	230	8	18	1975
425	044837	HD	11/23/76	231	8	19	1975
426	044868	HD	11/23/76	232	8	20	1975
427	044858	HD	11/23/76	234	8	22	1975
428	044851	HD	12/04/76	235	8	23	1975
429	044849	HD	11/22/76	236	8	24	1975
430	044839	HD	08/11/77	237	8	25	1975
431	044836	HD	11/19/76	238	8	26	1975
432	044867	HD	12/04/76	239	8	27	1975
433	044865	HD	12/04/76	240	8	28	1975
434	044844	HD	11/19/76	241	8	29	1975
435	044861	HD	08/12/77	242	8	30	1975
436	044845	HD	11/23/76	243	8	31	1975
437	044838	HD	11/23/76	244	9	1	1975
438	044846	HD	12/03/76	245	9	2	1975
439	045744	HD	08/12/77	246	9	3	1975
440	044872	HD	11/23/76	247	9	4	1975
441	044848	HD	08/12/77	248	9	5	1975
442	044853	HD	11/23/76	249	9	6	1975
443	044841	HD	11/23/76	250	9	7	1975
444	044842	HD	12/04/76	251	9	8	1975
445	044847	HD	12/04/76	252	9	9	1975
446	044843	HD	11/22/76	253	9	10	1975
447	044840	HD	12/04/76	254	9	11	1975
448	044873	HD	08/12/77	255	9	12	1975
449	044871	HD	08/12/77	256	9	13	1975
450	044864	HD	12/04/76	257	9	14	1975
451	044859	HD	12/04/76	258	9	15	1975
452	044863	HD	12/04/76	259	9	16	1975
453	044860	HD	11/19/76	260	9	17	1975
454	044856	HD	11/19/76	261	9	18	1975
455	044866	HD	12/04/76	262	9	19	1975

456	044855	HD	12/10/76	263	9	20	1975
457	044857	HD	12/10/76	264	9	21	1975
458	044854	HD	12/10/76	265	9	22	1975
459	044862	HD	12/10/76	266	9	23	1975
460	044870	HD	12/10/76	267	9	24	1975
461	044874	HD	12/10/76	268	9	25	1975
462	045746	HD	08/12/77	269	9	26	1975
463	044530	HD	07/01/76	270	9	27	1975
464	044527	HD	07/01/76	271	9	27	1975
465	044531	HD	07/01/76	272	9	29	1975
466	044526	HD	07/01/76	273	9	30	1975
467	044534	HD	06/30/76	274	10	1	1975
468	044535	HD	06/30/76	275	10	2	1975
469	044533	HD	06/30/76	276	10	3	1975
470	044519	HD	06/30/76	277	10	4	1975
471	044525	HD	07/01/76	278	10	5	1975
472	044463	HD	07/01/76	279	10	6	1975
473	044532	HD	07/01/76	280	10	7	1975
474	044529	HD	07/01/76	281	10	8	1975
475	044902	HD	12/22/76	282	10	9	1975
476	044912	HD	12/22/76	283	10	10	1975
477	044916	HD	12/22/76	284	10	11	1975
478	044914	HD	12/22/76	286	10	13	1975
479	045766	HD	08/15/77	287	10	14	1975
480	044869	HD	12/21/76	288	10	15	1975
481	044911	HD	12/21/76	289	10	16	1975
482	044528	HD	12/21/76	290	10	17	1975
483	044913	HD	12/22/76	291	10	18	1975
484	044917	HD	12/22/76	292	10	19	1975
485	044915	HD	12/22/76	293	10	20	1975
486	044893	HD	12/22/76	294	10	21	1975
487	044891	HD	12/22/76	295	10	22	1975
488	044918	HD	12/22/76	296	10	23	1975
489	044905	HD	12/22/76	297	10	24	1975
490	044897	HD	12/22/76	298	10	25	1975
491	044910	HD	12/22/76	299	10	26	1975
492	044895	HD	01/10/77	300	10	27	1975
493	044899	HD	12/27/76	301	10	28	1975
494	044909	HD	01/26/77	302	10	29	1975
495	045750	HD	08/11/77	303	10	30	1975
496	044898	HD	12/27/76	304	10	31	1975
497	045747	HD	08/11/77	305	11	1	1975
498	044906	HD	12/21/76	306	11	2	1975
499	044896	HD	12/21/76	307	11	3	1975
500	044892	HD	08/11/77	308	11	4	1975
501	044894	HD	01/07/77	309	11	5	1975
502	044907	HD	01/07/77	310	11	6	1975
503	044903	HD	01/07/77	311	11	7	1975
504	045749	HD	08/12/77	312	11	8	1975
505	044901	HD	12/22/76	313	11	9	1975
506	044904	HD	12/22/76	314	11	10	1975
507	044929	HD	01/15/77	315	11	11	1975
508	044926	HD	01/26/77	316	11	12	1975
509	044925	HD	01/15/77	317	11	13	1975
510	044927	HD	01/15/77	318	11	14	1975
511	044900	HD	01/17/77	319	11	14	1975
512	044924	HD	01/17/77	320	11	16	1975

513	044934	HD	01/17/77	321	11	17	1975
514	045748	HD	08/15/77	322	11	18	1975
515	044928	HD	01/17/77	323	11	19	1975
516	044922	HD	01/15/77	324	11	20	1975
517	044948	HD	01/15/77	325	11	21	1975
518	044935	HD	01/15/77	326	11	22	1975
519	044920	HD	01/15/77	327	11	23	1975
520	044921	HD	01/24/77	328	11	24	1975
521	044937	HD	01/24/77	329	11	25	1975
522	044923	HD	01/24/77	330	11	26	1975
523	044933	HD	01/24/77	331	11	27	1975
524	044931	HD	01/14/77	332	11	28	1975
525	044942	HD	01/14/77	333	11	29	1975
526	044947	HD	01/14/77	334	11	30	1975
527	044932	HD	01/14/77	335	12	1	1975
528	044938	HD	01/14/77	336	12	2	1975
529	044940	HD	01/14/77	337	12	3	1975
530	044939	HD	01/14/77	338	12	4	1975
531	044945	HD	01/14/77	339	12	5	1975
532	044936	HD	01/14/77	340	12	6	1975
533	044943	HD	01/14/77	341	12	7	1975
534	044944	HD	01/14/77	342	12	8	1975
535	044941	HD	01/15/77	343	12	9	1975
536	044930	HD	01/15/77	344	12	10	1975
537	044946	HD	01/15/77	345	12	11	1975
538	045030	HD	02/03/77	346	12	12	1975
539	045039	HD	02/03/77	347	12	13	1975
540	045028	HD	02/03/77	348	12	14	1975
541	045033	HD	02/03/77	349	12	15	1975
542	045001	HD	02/03/77	350	12	16	1975
543	045031	HD	02/03/77	351	12	17	1975
544	045021	HD	02/08/77	352	12	18	1975
545	045005	HD	02/08/77	353	12	19	1975
546	045003	HD	02/03/77	354	12	20	1975
547	045002	HD	02/03/77	355	12	21	1975
548	045007	HD	02/03/77	356	12	22	1975
549	045022	HD	02/03/77	357	12	23	1975
550	045018	HD	02/04/77	358	12	24	1975
551	045017	HD	02/04/77	359	12	25	1975
552	045016	HD	02/04/77	360	12	26	1975
553	045011	HD	02/04/77	361	12	27	1975
554	045009	HD	02/03/77	362	12	28	1975
555	045008	HD	02/03/77	363	12	29	1975
556	045034	HD	02/03/77	364	12	30	1975
557	045036	HD	02/03/77	365	12	31	1975
558	045024	HD	02/03/77	1	1	1	1976
559	045025	HD	02/03/77	2	1	2	1976
560	045010	HD	02/03/77	3	1	3	1976
561	045038	HD	02/03/77	5	1	5	1976
562	045006	HD	02/03/77	6	1	6	1976
563	045026	HD	02/03/77	7	1	7	1976
564	045032	HD	02/03/77	8	1	8	1976
565	045020	HD	02/04/77	9	1	9	1976
566	045029	HD	02/04/77	10	1	10	1976
567	045012	HD	02/04/77	11	1	11	1976
568	045023	HD	02/04/77	12	1	12	1976
569	045004	HD	02/03/77	13	1	13	1976

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570	044908	HD	02/03/77	14	1	14	1976
571	045589	HD	06/15/77	15	1	15	1976
572	045027	HD	02/03/77	16	1	16	1976
573	045013	HD	02/04/77	18	1	18	1976
574	045014	HD	02/04/77	19	1	19	1976
575	045015	HD	02/04/77	20	1	20	1976
576	045037	HD	02/04/77	21	1	21	1976
577	045071	HD	02/12/77	22	1	22	1976
578	045051	HD	02/12/77	23	1	23	1976
579	045059	HD	02/12/77	24	1	24	1976
580	045063	HD	02/12/77	25	1	25	1976
581	045060	HD	02/18/77	26	1	26	1976
582	045086	HD	02/18/77	27	1	27	1976
583	045052	HD	02/18/77	28	1	28	1976
584	045085	HD	02/18/77	29	1	29	1976
585	045053	HD	02/11/77	30	1	30	1976
586	045076	HD	02/11/77	31	1	31	1976
587	045065	HD	02/11/77	32	2	1	1976
588	045064	HD	02/11/77	33	2	2	1976
589	045055	HD	02/11/77	34	2	3	1976
590	045089	HD	02/11/77	35	2	4	1976
591	045066	HD	02/11/77	36	2	5	1976
592	045087	HD	02/18/77	37	2	6	1976
593	045067	HD	02/12/77	38	2	7	1976
594	045054	HD	02/12/77	39	2	8	1976
595	045126	HD	02/25/77	40	2	9	1976
596	045093	HD	02/12/77	41	2	10	1976
597	045075	HD	02/12/77	42	2	11	1976
598	045050	HD	02/11/77	43	2	12	1976
599	045073	HD	02/11/77	44	2	13	1976
600	045081	HD	02/11/77	45	2	14	1976
601	045083	HD	02/11/77	46	2	15	1976
602	045058	HD	02/11/77	47	2	16	1976
603	045091	HD	02/11/77	48	2	17	1976
604	045062	HD	02/11/77	49	2	18	1976
605	045092	HD	02/11/77	50	2	19	1976
606	045068	HD	02/11/77	51	2	20	1976
607	045056	HD	02/11/77	53	2	22	1976
608	045061	HD	02/11/77	54	2	23	1976
609	045057	HD	02/12/77	55	2	24	1976
610	045090	HD	02/12/77	56	2	25	1976
611	045088	HD	02/12/77	57	2	26	1976
612	045084	HD	02/12/77	58	2	27	1976
613	045069	HD	02/12/77	59	2	28	1976
614	045078	HD	02/12/77	60	2	29	1976
615	045074	HD	02/12/77	61	3	1	1976
616	045077	HD	02/12/77	62	3	2	1976
617	045082	HD	02/11/77	63	3	3	1976
618	045072	HD	02/11/77	64	3	4	1976
619	045079	HD	02/11/77	65	3	5	1976
620	045125	HD	02/26/77	66	3	6	1976
621	045134	HD	02/26/77	67	3	7	1976
622	045128	HD	02/26/77	68	3	8	1976
623	045133	HD	03/01/77	69	3	9	1976
624	045135	HD	02/26/77	70	3	10	1976
625	045151	HD	02/26/77	71	3	11	1976
626	045136	HD	02/25/77	72	3	12	1976

627	045157	HD	02/25/77	73	3	13	1976
628	045131	HD	02/25/77	74	3	14	1976
629	045132	HD	02/25/77	75	3	15	1976
630	045143	HD	02/26/77	76	3	16	1976
631	045146	HD	02/26/77	77	3	17	1976
632	045141	HD	02/26/77	78	3	18	1976
633	045145	HD	03/18/77	79	3	19	1976
634	045144	HD	02/25/77	81	3	21	1976
635	045140	HD	02/25/77	82	3	22	1976
636	045137	HD	02/25/77	83	3	23	1976
637	045139	HD	02/26/77	84	3	24	1976
638	045155	HD	02/26/77	85	3	25	1976
639	045174	HD	02/26/77	86	3	26	1976
640	045129	HD	05/06/77	87	3	27	1976
641	045138	HD	02/25/77	88	3	28	1976
642	045166	HD	02/25/77	89	3	29	1976
643	045130	HD	02/25/77	90	3	30	1976
644	045152	HD	02/25/77	91	3	31	1976
645	045147	HD	02/25/77	92	4	1	1976
646	045158	HD	02/25/77	93	4	2	1976
647	045171	HD	02/25/77	94	4	3	1976
648	045142	HD	02/25/77	95	4	4	1976
649	045149	HD	02/26/77	96	4	5	1976
650	045156	HD	02/26/77	97	4	6	1976
651	045172	HD	02/26/77	98	4	7	1976
652	045150	HD	02/26/77	99	4	8	1976
653	045159	HD	02/26/77	100	4	9	1976
654	045161	HD	02/26/77	101	4	10	1976
655	045148	HD	02/26/77	102	4	11	1976
656	045170	HD	02/26/77	103	4	12	1976
657	045160	HD	02/26/77	104	4	13	1976
658	045169	HD	02/26/77	105	4	14	1976
659	045177	HD	02/26/77	106	4	15	1976
660	045154	HD	02/26/77	107	4	16	1976
661	045175	HD	02/28/77	108	4	17	1976
662	045153	HD	02/26/77	110	4	19	1976
663	045173	HD	02/28/77	111	4	20	1976
664	045167	HD	02/28/77	112	4	21	1976
665	045164	HD	02/28/77	113	4	22	1976
666	045168	HD	02/28/77	114	4	23	1976
667	045165	HD	02/28/77	115	4	24	1976
668	045176	HD	02/28/77	116	4	25	1976
669	045162	HD	03/18/77	117	4	26	1976
670	045163	HD	02/28/77	118	4	27	1976
671	045178	HD	02/28/77	119	4	28	1976
672	045191	HD	03/09/77	120	4	29	1976
673	044786	HD	03/09/77	121	4	30	1976
674	044793	HD	10/15/76	122	5	1	1976
675	044792	HD	10/18/76	123	5	2	1976
676	044459	HD	10/18/76	124	5	3	1976
677	044788	HD	10/15/76	125	5	3	1976
678	044791	HD	10/18/76	126	5	5	1976
679	044790	HD	10/18/76	127	5	6	1976
680	045208	HD	03/09/77	128	5	7	1976
681	045194	HD	04/07/77	129	5	8	1976
682	045190	HD	03/09/77	130	5	9	1976
683	045193	HD	03/09/77	131	5	10	1976

684	045189	HD	03/09/77	132	5	11	1976
685	045236	HD	03/09/77	133	5	12	1976
686	045207	HD	03/09/77	134	5	13	1976
687	045198	HD	03/09/77	135	5	14	1976
688	045231	HD	03/09/77	136	5	15	1976
689	045192	HD	03/09/77	137	5	16	1976
690	045195	HD	03/09/77	138	5	17	1976
691	045199	HD	03/09/77	139	5	18	1976
692	045200	HD	03/09/77	140	5	19	1975
693	045217	HD	03/09/77	141	5	20	1976
694	045197	HD	03/11/77	142	5	21	1976
695	045230	HD	03/10/77	143	5	22	1976
696	045216	HD	03/11/77	144	5	23	1976
697	045196	HD	03/10/77	145	5	24	1976
698	045205	HD	04/07/77	146	5	25	1976
699	045206	HD	03/10/77	147	5	26	1976
700	045220	HD	03/10/77	149	5	28	1976
701	045204	HD	03/10/77	150	5	29	1976
702	045209	HD	03/10/77	151	5	30	1976
703	045237	HD	03/10/77	152	5	31	1976
704	045202	HD	03/10/77	153	6	1	1976
705	045218	HD	03/09/77	154	6	2	1976
706	045201	HD	03/09/77	155	6	3	1976
707	045214	HD	03/09/77	156	6	4	1976
708	045289	HD	03/18/77	157	6	5	1976
709	045203	HD	03/10/77	159	6	7	1976
710	045212	HD	03/10/77	160	6	8	1976
711	045238	HD	03/10/77	161	6	9	1976
712	045221	HD	03/10/77	162	6	10	1976
713	045219	HD	03/19/77	163	6	11	1976
714	045215	HD	03/19/77	164	6	12	1976
715	045241	HD	03/19/77	165	6	13	1976
716	045210	HD	03/19/77	166	6	14	1976
717	045188	HD	03/18/77	167	6	15	1976
718	045227	HD	03/18/77	168	6	16	1976
719	045240	HD	03/18/77	169	6	17	1976
720	045222	HD	03/18/77	170	6	18	1976
721	045223	HD	03/19/77	171	6	19	1976
722	045211	HD	03/19/77	172	6	20	1976
723	045243	HD	03/19/77	173	6	21	1976
724	045228	HD	03/19/77	174	6	22	1976
725	045233	HD	03/19/77	175	6	23	1976
726	045224	HD	03/19/77	176	6	24	1976
727	045225	HD	03/19/77	177	6	25	1976
728	045234	HD	03/19/77	178	6	26	1976
729	045229	HD	03/19/77	179	6	27	1976
730	045232	HD	03/19/77	180	6	28	1976
731	045239	HD	03/19/77	181	6	29	1976
732	045226	HD	03/19/77	182	6	30	1976
733	045327	HD	03/26/77	184	7	2	1976
734	045295	HD	04/07/77	185	7	3	1976
735	045297	HD	03/26/77	186	7	4	1976
736	045309	HD	03/26/77	188	7	6	1976
737	045319	HD	03/26/77	189	7	7	1976
738	045298	HD	03/26/77	190	7	8	1976
739	045308	HD	03/26/77	191	7	9	1976
740	045290	HD	03/26/77	192	7	10	1976

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741	045296	HD	03/26/77	193	7	11	1976
742	044704	HD	03/26/77	195	7	13	1976
743	045300	HD	03/25/77	196	7	14	1976
744	045320	HD	04/08/77	197	7	15	1976
745	045323	HD	04/08/77	198	7	16	1976
746	045293	HD	04/08/77	199	7	17	1976
747	045303	HD	04/07/77	200	7	18	1976
748	045299	HD	03/26/77	201	7	19	1976
749	045301	HD	04/07/77	202	7	20	1976
750	045342	HD	04/08/77	203	7	21	1976
751	045341	HD	03/26/77	204	7	22	1976
752	045302	HD	03/26/77	205	7	23	1976
753	045306	HD	03/26/77	207	7	25	1976
754	044705	HD	04/08/77	209	7	27	1976
755	045322	HD	04/15/77	210	7	28	1976
756	045333	HD	04/15/77	211	7	29	1976
757	045328	HD	03/26/77	212	7	30	1976
758	045316	HD	03/26/77	213	7	31	1976
759	045349	HD	04/15/77	214	8	1	1976
760	045326	HD	04/15/77	215	8	2	1976
761	045350	HD	03/26/77	216	8	3	1976
762	045313	HD	04/08/77	217	8	4	1976
763	045330	HD	03/26/77	218	8	5	1976
764	045339	HD	03/26/77	220	8	7	1976
765	045352	HD	04/08/77	221	8	8	1976
766	045351	HD	03/26/77	222	8	9	1976
767	045340	HD	04/08/77	223	8	10	1976
768	045332	HD	04/06/77	224	8	11	1976
769	045331	HD	04/06/77	225	8	12	1976
770	045324	HD	04/06/77	227	8	14	1976
771	045343	HD	04/06/77	228	8	15	1976
772	045347	HD	04/06/77	229	8	16	1976
773	045345	HD	04/07/77	231	8	18	1976
774	045317	HD	04/06/77	233	8	20	1976
775	045312	HD	04/06/77	234	8	21	1976
776	045344	HD	04/06/77	235	8	22	1976
777	045334	HD	04/07/77	236	8	23	1976
778	045335	HD	04/07/77	237	8	24	1976
779	045336	HD	04/07/77	238	8	26	1976
780	045346	HD	04/07/77	239	8	26	1976
781	045348	HD	04/07/77	241	8	28	1976
782	044884	HD	04/07/77	242	8	29	1976
783	044886	HD	04/07/77	243	8	30	1976
784	044885	HD	04/07/77	244	8	31	1976
785	045310	HD	04/07/77	245	9	1	1976
786	045377	HD	04/30/77	246	9	2	1976
787	045378	HD	04/30/77	247	9	3	1976
788	045318	HD	04/07/77	248	9	4	1976
789	045392	HD	05/04/77	249	9	5	1976
790	045379	HD	05/04/77	250	9	6	1976
791	045380	HD	04/05/77	251	9	7	1976
792	045382	HD	04/05/77	252	9	8	1976
793	045432	HD	04/05/77	253	9	9	1976
794	045389	HD	04/05/77	254	9	10	1976
795	045381	HD	04/29/77	255	9	11	1976
796	045390	HD	04/29/77	256	9	12	1976
797	045398	HD	04/29/77	257	9	13	1976

798	045434	HD	04/29/77	258	9	14	1976
799	045411	HD	05/04/77	259	9	15	1976
800	045412	HD	05/04/77	260	9	16	1976
801	045391	HD	05/04/77	261	9	17	1976
802	045384	HD	05/04/77	262	9	18	1976
803	045388	HD	05/04/77	263	9	19	1976
804	045385	HD	05/04/77	264	9	20	1976
805	045383	HD	05/04/77	265	9	21	1976
806	045386	HD	05/04/77	266	9	22	1976
807	045425	HD	04/05/77	267	9	23	1976
808	045414	HD	04/05/77	268	9	24	1976
809	045410	HD	04/05/77	269	9	25	1976
810	045387	HD	04/30/77	270	9	26	1976
811	045315	HD	04/06/77	272	9	28	1976
812	045394	HD	04/30/77	273	9	29	1976
813	045413	HD	04/30/77	274	9	30	1976
814	045397	HD	04/05/77	275	10	1	1976
815	045395	HD	04/05/77	276	10	2	1976
816	045393	HD	04/05/77	277	10	3	1976
817	045406	HD	04/05/77	278	10	5	1976
818	045129	HD	04/05/77	279	10	5	1976
819	045396	HD	05/04/77	280	10	6	1976
820	045399	HD	05/04/77	281	10	7	1976
821	045401	HD	05/04/77	282	10	8	1976
822	045407	HD	04/30/77	283	10	9	1976
823	045402	HD	04/30/77	284	10	10	1976
824	045403	HD	04/30/77	285	10	11	1976
825	045404	HD	04/30/77	286	10	12	1976
826	045405	HD	04/05/77	287	10	13	1976
827	045530	HD	05/18/77	288	10	14	1976
828	045438	HD	04/05/77	289	10	15	1976
829	045408	HD	04/05/77	290	10	16	1976
830	045427	HD	04/05/77	291	10	17	1976
831	045416	HD	05/18/77	292	10	18	1976
832	045420	HD	05/18/77	293	10	19	1976
833	045431	HD	04/05/77	294	10	20	1976
834	045426	HD	05/18/77	295	10	21	1976
835	045421	HD	05/05/77	296	10	22	1976
836	045415	HD	05/05/77	297	10	23	1976
837	045433	HD	05/05/77	298	10	23	1976
838	045435	HD	05/05/77	299	10	25	1976
839	045430	HD	05/05/77	300	10	25	1976
840	045422	HD	05/05/77	301	10	27	1976
841	045436	HD	05/05/77	302	10	28	1976
842	045424	HD	05/05/77	303	10	29	1976
843	045428	HD	05/05/77	304	10	30	1976
844	045423	HD	05/05/77	305	10	31	1976
845	045417	HD	05/05/77	306	11	1	1976
846	045439	HD	05/24/77	308	11	3	1976
847	045437	HD	05/05/77	309	11	4	1976
848	045466	HD	05/18/77	310	11	5	1976
849	045507	HD	05/18/77	311	11	6	1976
850	045533	HD	05/18/77	312	11	7	1976
851	045474	HD	05/18/77	313	11	8	1976
852	045467	HD	05/18/77	314	11	9	1976
853	045499	HD	05/18/77	315	11	10	1976
854	045472	HD	05/18/77	316	11	11	1976

855	045487	HD	05/18/77	317	11	12	1976
856	045568	HD	06/14/77	318	11	13	1976
857	045583	HD	06/14/77	320	11	15	1976
858	045469	HD	05/18/77	321	11	16	1976
859	044919	HD	05/18/77	322	11	17	1976
860	045475	HD	05/18/77	323	11	18	1976
861	045476	HD	05/18/77	324	11	19	1976
862	045477	HD	05/18/77	325	11	20	1976
863	045473	HD	05/18/77	326	11	21	1976
864	045468	HD	05/18/77	327	11	22	1976
865	045485	HD	05/18/77	329	11	24	1976
866	045498	HD	05/17/77	332	11	27	1976
867	045471	HD	05/17/77	333	11	28	1976
868	045480	HD	05/18/77	334	11	29	1976
869	045489	HD	05/18/77	335	11	30	1976
870	045482	HD	05/18/77	336	12	1	1976
871	045585	HD	06/14/77	337	12	2	1976
872	045490	HD	05/18/77	338	12	3	1976
873	045478	HD	05/17/77	339	12	4	1976
874	045497	HD	05/17/77	340	12	5	1976
875	045484	HD	05/17/77	341	12	6	1976
876	045486	HD	05/17/77	342	12	7	1976
877	045481	HD	05/17/77	343	12	8	1976
878	045503	HD	05/17/77	344	12	9	1976
879	045483	HD	05/17/77	345	12	10	1976
880	045496	HD	05/17/77	346	12	11	1976
881	045488	HD	05/18/77	347	12	12	1976
882	045581	HD	06/15/77	348	12	13	1976
883	045513	HD	05/18/77	349	12	14	1976
884	045575	HD	06/15/77	350	12	15	1976
885	045576	HD	06/15/77	351	12	16	1976
886	045493	HD	05/19/77	352	12	17	1976
887	045518	HD	05/19/77	353	12	18	1976
888	045525	HD	05/19/77	354	12	19	1976
889	045596	HD	06/15/77	355	12	20	1976
890	045553	HD	06/03/77	356	12	21	1976
891	045567	HD	06/14/77	357	12	22	1976
892	045569	HD	06/14/77	358	12	23	1976
893	045582	HD	06/14/77	359	12	24	1976
894	045495	HD	05/18/77	360	12	25	1976
895	045573	HD	06/14/77	361	12	26	1976
896	045570	HD	06/15/77	362	12	27	1976
897	045521	HD	05/18/77	363	12	28	1976
898	045580	HD	06/15/77	364	12	29	1976
899	045577	HD	06/15/77	365	12	30	1976
900	045517	HD	05/18/77	366	12	31	1976
901	045572	HD	06/15/77	1	1	1	1977
902	045512	HD	05/19/77	2	1	2	1977
903	045571	HD	06/15/77	3	1	3	1977
904	045501	HD	05/19/77	4	1	4	1977
905	045510	HD	05/19/77	5	1	5	1977
906	045494	HD	05/19/77	6	1	6	1977
907	045566	HD	06/15/77	7	1	7	1977
908	045574	HD	06/15/77	8	1	8	1977
909	045578	HD	06/15/77	9	1	9	1977
910	045579	HD	06/15/77	10	1	10	1977
911	045504	HD	05/19/77	11	1	11	1977

912	045502	HD	05/26/77	12	1	12	1977
913	045509	HD	05/19/77	13	1	13	1977
914	045506	HD	05/19/77	14	1	14	1977
915	045505	HD	05/19/77	16	1	16	1977
916	045598	HD	06/15/77	17	1	17	1977
917	045511	HD	05/19/77	18	1	18	1977
918	045590	HD	06/15/77	19	1	19	1977
919	045503	HD	05/19/77	20	1	20	1977
920	045532	HD	05/19/77	21	1	21	1977
921	045554	HD	06/02/77	23	1	23	1977
922	045595	HD	06/15/77	24	1	24	1977
923	045592	HD	06/15/77	25	1	25	1977
924	045599	HD	06/15/77	26	1	26	1977
925	045520	HD	05/19/77	27	1	27	1977
926	045593	HD	06/15/77	28	1	28	1977
927	045607	HD	06/15/77	29	1	29	1977
928	045605	HD	06/15/77	30	1	30	1977
929	045597	HD	06/15/77	31	1	31	1977
930	045586	HD	06/15/77	32	2	1	1977
931	045515	HD	05/19/77	33	2	2	1977
932	045526	HD	05/19/77	34	2	3	1977
933	045600	HD	06/15/77	35	2	4	1977
934	045601	HD	06/15/77	36	2	5	1977
935	045514	HD	05/19/77	37	2	6	1977
936	045522	HD	05/19/77	38	2	7	1977
937	045519	HD	05/19/77	39	2	8	1977
938	045636	HD	06/15/77	40	2	9	1977
939	045516	HD	05/19/77	42	2	11	1977
940	045633	HD	06/30/77	43	2	12	1977
941	045603	HD	06/16/77	44	2	13	1977
942	045531	HD	05/19/77	45	2	14	1977
943	045587	HD	06/16/77	46	2	15	1977
944	045602	HD	06/15/77	47	2	16	1977
945	045527	HD	05/19/77	48	2	17	1977
946	045508	HD	05/19/77	49	2	18	1977
947	045523	HD	05/19/77	50	2	19	1977
948	045604	HD	06/15/77	51	2	20	1977
949	045528	HD	05/19/77	52	2	21	1977
950	045524	HD	05/19/77	53	2	22	1977
951	045555	HD	06/02/77	54	2	23	1977
952	045610	HD	06/15/77	56	2	25	1977
953	045529	HD	05/19/77	57	2	26	1977
954	045611	HD	06/15/77	58	2	27	1977
955	045608	HD	06/15/77	59	2	28	1977
956	045370	HD	04/22/77	60	3	1	1977
957	045371	HD	04/22/77	61	3	2	1977
958	045372	HD	04/22/77	62	3	3	1977
959	045461	HD	05/16/77	63	3	4	1977
960	045374	HD	04/22/77	64	3	5	1977
961	045373	HD	04/22/77	65	3	6	1977
962	045363	HD	04/22/77	67	3	8	1977
963	045365	HD	04/22/77	68	3	9	1977
964	045376	HD	05/16/77	69	3	10	1977
965	045364	HD	04/22/77	70	3	11	1977
966	045464	HD	05/16/77	71	3	11	1977
967	045609	HD	06/15/77	72	3	13	1977
968	045465	HD	05/16/77	73	3	14	1977

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969	045375	HD	05/16/77	74	3	15	1977
970	045550	HD	05/25/77	77	3	18	1977
971	045451	HD	05/06/77	78	3	19	1977
972	045446	HD	05/06/77	80	3	21	1977
973	045449	HD	05/06/77	81	3	22	1977
974	045444	HD	05/06/77	82	3	23	1977
975	045462	HD	05/13/77	83	3	24	1977
976	045445	HD	05/06/77	85	3	26	1977
977	045448	HD	05/06/77	86	3	27	1977
978	045559	HD	06/02/77	87	3	28	1977
979	045463	HD	05/13/77	88	3	29	1977
980	045545	HD	05/25/77	89	3	30	1977
981	045561	HD	06/02/77	90	3	31	1977
982	045551	HD	05/25/77	91	4	1	1977
983	045546	HD	05/26/77	92	4	2	1977
984	045547	HD	05/26/77	94	4	4	1977
985	045814	HD	09/16/77	95	4	5	1977
986	045548	HD	05/26/77	96	4	6	1977
987	045805	HD	09/16/77	97	4	7	1977
988	045549	HD	05/26/77	98	4	8	1977
989	045776	HD	09/16/77	99	4	9	1977
990	045615	HD	06/15/77	100	4	10	1977
991	045635	HD	06/30/77	102	4	12	1977
992	045634	HD	06/30/77	103	4	13	1977
993	045616	HD	06/15/77	104	4	14	1977
994	045637	HD	06/30/77	106	4	16	1977
995	045811	HD	09/14/77	107	4	17	1977
996	045557	HD	06/02/77	108	4	18	1977
997	045556	HD	06/02/77	109	4	19	1977
998	045560	HD	06/02/77	110	4	20	1977
999	045786	HD	09/14/77	111	4	21	1977
1000	045558	HD	06/02/77	112	4	22	1977
1001	045791	HD	09/13/77	113	4	23	1977
1002	045613	HD	06/17/77	115	4	25	1977
1003	045612	HD	06/15/77	116	4	26	1977
1004	045636	HD	06/30/77	119	4	29	1977
1005	045614	HD	06/15/77	121	5	1	1977
1006	045794	HD	09/13/77	123	5	3	1977
1007	045777	HD	09/13/77	127	5	7	1977
1008	045772	HD	09/13/77	128	5	8	1977
1009	045771	HD	09/13/77	129	5	9	1977
1010	045797	HD	09/14/77	130	5	10	1977
1011	045782	HD	09/15/77	131	5	11	1977
1012	045795	HD	09/14/77	132	5	12	1977
1013	045774	HD	09/14/77	134	5	14	1977
1014	045773	HD	09/20/77	135	5	15	1977
1015	045781	HD	09/20/77	136	5	16	1977
1016	045796	HD	09/20/77	137	5	17	1977
1017	045779	HD	09/20/77	138	5	18	1977
1018	045775	HD	09/15/77	141	5	21	1977
1019	045778	HD	09/15/77	142	5	22	1977
1020	045785	HD	09/15/77	143	5	23	1977
1021	045788	HD	09/13/77	144	5	24	1977
1022	045787	HD	09/13/77	145	5	25	1977
1023	045783	HD	09/13/77	146	5	26	1977
1024	045793	HD	09/13/77	147	5	27	1977
1025	045789	HD	09/19/77	148	5	28	1977

1026	045790	HD	09/15/77	149	5	29	1977
1027	045792	HD	09/15/77	150	5	30	1977
1028	045804	HD	09/15/77	155	6	4	1977
1029	045808	HD	09/14/77	156	6	5	1977
1030	045812	HD	09/14/77	157	6	6	1977
1031	045800	HD	09/14/77	158	6	7	1977
1032	045799	HD	09/14/77	159	6	8	1977
1033	045798	HD	09/14/77	160	6	8	1977
1034	045801	HD	09/14/77	161	6	10	1977
1035	045803	HD	09/14/77	162	6	11	1977
1036	045802	HD	09/14/77	163	6	12	1977
1037	045816	HD	09/14/77	165	6	14	1977
1038	045807	HD	09/14/77	167	6	16	1977
1039	045806	HD	09/14/77	171	6	20	1977
1040	045809	HD	09/14/77	176	6	25	1977
1041	045815	HD	09/14/77	177	6	26	1977
1042	045813	HD	09/21/77	178	6	27	1977
1043	045810	HD	09/21/77	179	6	28	1977
1044	045817	HD	09/21/77	180	6	29	1977

APPENDIX B

Energetic Electrons at the Synchronous Altitude 1974-1977

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CONTENTS

Abstract

A description of the energetic (140 kev to > 3.9 Mev) electron environment observed at the synchronous altitude during the 1974-1977 time interval is presented. These results were obtained by an experiment carried on the geostationary ATS-6 spacecraft. Observations were made at several longitudes. Electron fluxes exhibit a complex temporal behavior ranging in time scale from a diurnal variation to a semi-annual variation. Average fluxes are computed and compared with earlier studies and models.

Energetic Electrons at the Synchronous Altitude 1974-1977

I. Introduction

The synchronous orbit, because of its obvious utility for terrestrial applications, is undoubtedly the single most heavily populated orbit in space. Many spacecraft, spread over longitude, are in this orbit today, and the plans of various nations (Ref. 1, Ref. 2) emphasize an even heavier utilization of it for future communications, earth observations, meteorology, and data relay spacecraft. It is clear that the investment in such space systems is likely to run into the billions of dollars.

The premium on a precise, quantitative understanding of the space environment and the impact of the environment on space systems is enormous. Even savings of fractions of a percent, derived as a result of better information regarding the energetic radiation (for example, extending the life of a spacecraft and thus decreasing the replenishment rate) translate directly into savings which run into the tens of millions of dollars.

The purpose of this report is to summarize, in a format useful to the designers and operators of synchronous orbiting of space systems, the observations of energetic electrons at the synchronous altitude made by The Aerospace Corporation particle spectrometer flown on the ATS-6 spacecraft. Preliminary results have been reported in a series of internal reports (Refs. 3-8). In this report we shall concentrate on defining the average properties of the electron population as it existed in the 1974-1977 time interval at the synchronous orbit. Thus this report can be viewed as a sequel to earlier work (Refs. 9-12) which treated the properties of the particle population at the synchronous orbit during earlier epochs. It seems useful to begin by describing some of the salient features of the ATS-6 observing program which we conducted and to point out how the present data and results may be similar to, or differ from, earlier work because of differences in epoch, instrumentation, spacecraft orientation and the location of the spacecraft in longitude.

The observations described here were made between mid-1974 and early 1977. This time interval straddled to solar minimum (as defined by sunspot number) (Fig. 1). In contrast, earlier observation of energetic radiation at the synchronous orbit made by instruments aboard ATS-1 and ATS-5 were made during times near the peak of solar activity: late 1966 to early 1968 in the case of ATS-1 and mid 1969 to early 1972 in the case of ATS-5. As is well known, the magnetosphere is relatively more quiescent during periods of low solar activity as contrasted to the time period near solar maximum. As we shall see below, periodic manifestations of solar-wind magnetosphere interactions emerge prominently in the ATS-6 data; in contrast, impulsive solar events which occur at frequent intervals during solar maximum and tend to mask the more regular features of magnetospheric dynamics are infrequently observed in the present data set. The ATS-6 data is thus unique because it represents the first observations of the particle populations of the synchronous orbit made during the interval near solar minimum.

The instrumentation used to obtain our data has been described elsewhere (Ref. 13); a brief summary of the relevant features is given in Appendix A. Briefly, we measured the directional fluxes of electrons in the 140-600 kev interval and the omnidirectional fluxes above thresholds of 700 kev, 1.55 Mev and 3.9 Mev. Energetic proton data were also obtained (during solar proton events; these data are not discussed here).

The ATS-6 was earth oriented so that the axes of the detectors were pointed radially outward along the earth-satellite line. Thus the (directional) 140-600 kev channel (E1) measured only one segment of the angular distribution, the precise segment depending on the (rather variable) orientation of the local magnetic field with respect to the detector axis. The omnidirectional fluxes (E2, E3, E4) obtained from the ATS-6 data were obtained from countrates registered by particles which could reach the detectors through a 2π steradian acceptance angle looking out along the earth-satellite line. In contrast, on ATS-1, for example, the rapid spin of the spacecraft coupled with a relatively slow count accumulation time served to form a true average of the in situ radiation.

During the period covered by our data, the ATS-6 spacecraft was moved several times to different longitudes. Because the geographic equator does not coincide everywhere with the geomagnetic equator, a spacecraft at the synchronous orbit may be at significantly different magnetic latitudes, depending on the longitude at which the spacecraft is stationed. ATS-6 observations began while the spacecraft was on the equator at 94°W, where the magnetic latitude is about 11°. Subsequently the spacecraft was moved to 35°E and finally to 140°W. At both of these locations the magnetic equator is nearly coincident with the geographic equator.

The displacment of the spacecraft as little as 11° off the magnetic equator has a significant effect on the observations. We find that the geomagnetic field may quite often, particularly near local midnight, assume a configuration with a strong radial component, i.e. the magnetic field at 6.6 R_e appears, at these times, to assume a configuration expected to be found near the magnetotail. Such tail-like configurations are characterized by the absence of very energetic electrons. The fluxes observed at 94°W, i.e. somewhat off the magnetic equator, exhibit a significantly more dynamic behavior on the timescale of a day than seen at the magnetic equator where the geomagnetic field exhibits a more regular behavior, however, the long-term average fluxes do not reflect a very significant longitudinal difference. Spacecraft longitude is taken as a parameter in the data analysis, although, as we shall see below, temporal variations in the average particle fluxes are considerably larger than effects due to change in longitude.

For the purposes of this report, we have formed hourly averages, centered on the half hour, of all the electron data presently available to us. These hourly averages are the basic material from which further analysis proceeds. Daily averages, running 27 day averages, probability distributions are all formed from hourly averages.

II. Overview of the Observations

Figures 2 through 5 give an overview of the observations of energetic electrons from mid 1974 through early 1977. Plotted here are daily averages of the electron fluxes, together with data on the sector structure of the interplanetary magnetic field as a function of time. The location in longitude of ATS-6 and the periods of spacecraft movement are indicated on the figures and separately summarized in Table I.

The dynamic nature of the energetic electron fluxes, particularly at the higher energies, is immediately apparent. The dominant periodicity (in addition to the diurnal variations (see Refs. 11 and 15) which is not visible on a plot of daily averages) is the

TABLE I

ATS-6 Geographic and Geomagnetic Locations

Time Interval	Geographic Longitude	Magnetic Latitude*
Day 165, 1974-140, 1975	94°W	11°
Day 140, 1975-180, 1975	In transit	——
Day 180, 1975-214, 1976	35°E	5°
Day 214, 1976-330, 1976	In transit	——
Day 330, 1976-present	140°W	0°

*Derived from UCLA ATS-6 Magnetometer Data (Courtesy R. L. McPherron) strong modulation of the energetic electron fluxes on a timescale corresponding to the solar rotation period as well on a timescale consistent with either a two- or four-sector structure of the interplanetary field. (The effects of the interplanetary sector structure on the energetic particle population has been discussed previously in Ret. 11.).

It will be immediately appreciated by the reader that long term averages of these data, used for the purposes of accurate estimates of the radiation environment, must be approached with caution becasue of the large variation in the fluxes occurring on several timescales.

If we now form 27-day running averages of the data presented above, we obtain Figure 6 through 9. In these figures we again see the strong effects of solar rotation-to-rotation variability of the electron fluxes. This effect is particularly noticeable in the data for the more energetic electrons and stands out particularly well in late 1976 - early 1977. Also visible is a semi-annual variation in the energetic electron fluxes, with a maxima found near the equinoxes and minima near the solstices. To be sure, the moves of the spacecraft complicate the determination of the amplitude of this variation but it appears that the semi-annual variation is comparable to, if not greater than, the longitudinal effect. The semi-annual variation in the electron flux is presumably but a reflection of the well known semi-annual variation in geomagnetic activity (Ref. 17).

III. Average Fluxes and $P(F > F_x)$ Distributions

Using the data base discussed above, we have computed the probability distributions $P(F)$ and $P(F > F_x)$ in a manner analogous to that first described by in Ref. 18. $P(F > F_x)$ is the probability of observing a flux greater than F_x for some particular energy threshold, while $P(F)$ is the differential probability distribution. These curves have been computed for the several time intervals of interest and are presented as Figs. 10 through 15. Also computed, and indicated on the figures are u, the mean of $\log_{10}F$, J, the $\log_{10}$ of the mean flux and s, the standard deviation about u. Note, from the P(F) curves that the distribution is not necessarily gaussian in $\log_{10}F$, in contrast to assumptions made in analyses of earlier data sets.

Table II summarizes the data presented in Figs. 10-15, while Fig. 16 presents spectra of the average flux for the various longitudes and time intervals covered by our data, together with the spectrum predicted by the AE-4 model (Ref. 9, 10). The points noted below can serve as a summary of our findings.

1. At energies greater than about 1.5 Mev, the ATS-6 data indicate the presence of a somewhat harder electron spectrum than the AE-4 model would predict. At energies below $\lessapprox$ 1.5 Mev, our data indicate, in general, fewer electrons than AE-4. These conclusions are, however, tempered by the fact that the electron fluxes are highly variable and one can find significant time intervals (for example the late 1966 - early 1967 interval illustrated in Figs. 14 and 15) where the spectral shape at the higher energies approached that which one might expect from AE-4.

2. Longitudinal effects (caused by differences in magnetic latitude) in the mean flux are relatively minor. This conclusion must be tempered by the fact that no systematic analysis of simultaneous observations made at several longitudes has yet been carried out. There is some limited evidence (based on ATS-1/ATS-6 comparisons, Refs. 3, 12) that longitudinal flux differences (150°W/94°W) may be as large as a factor of two.

3. Although the mean fluxes observed may not be similar, the probability distributions $P(F > F_x)$ differ show systematic differences because there are far more flux dropouts off the equator. The differences are significant only near the $P(F > F_x) \approx 1$ axis.

IV. Diurnal Variations

It is of interest to compare the diurnal variations observed at the several longitudes and at the several particle energies. The mean flux for the three available longitudes is presented in Fig. 17, 18, 19 as a function of local time. As had been found previously (Ref. 11), the diurnal variation is larger at the higher electron energies. There does not seem to be any significant systematic change of the diurnal variation with longitude.

TABLE II

COMPARISON OF ATS-6 DATA AND AE-4 MODEL

MEAN FLUX ($cm^{-2}sec^{-1}$)

	ATS-6				AE-4
	$94^oW, \lambda_M \approx 11^o$	$35^oE, \lambda_M = 0^o$		$140^oW, \lambda_M \approx 0^o$	
Energy	Day 166, 74-Day 140, 75	Day 180, 75-Day 214, 76	Day 137, 76-Day 210, 76	Day 330, 76-Day 120, 77	
> 140 keV	5.35×10^6	5.29×10^6	4.84×10^6	4.16×10^6	1.66×10^7 (> 150 kev)
> 700 keV	5.01×10^5	5.50×10^5	4.17×10^5	2.45×10^5	1.76×10^6
> 1.55 Mev	1.32×10^2	1.35×10^5	7.76×10^4	5.37×10^4	1.75×10^5
> 3.9 Mev	6.46×10^2	$6.8 \times 10^{2*}$	1.25×10^2	77.6	1.7×10^2 (> 3.6 Mev)

*Day 90, 76 - 214, 76 only

V. Effects of the Interplanetary Medium on Energetic Electrons

We had earlier discovered (Ref. 14) that the flux level of the energetic electrons at the synchronous orbit - and therefore presumably the flux of energetic electrons in the entire outer magnetosphere - was modulated by the passage of the sector boundaries of the interplanetary magnetic field (IMF) past the earth. Briefly, we found that the flux levels were higher during northern hemisphere fall when the earth was immersed in a positive sector than during the passage of a negative sector of the interplanetary magnetic field. Conversely, in the spring, negative sectors served to generate higher energetic electron fluxes. This finding was found to be in agreement with the picture of solar wind-magnetosphere interaction proposed by Russell and McPherron (Ref. 17).

The findings described above were based on a very limited set of data. In the past year we have attempted to confirm and extend our conclusions using the more than 2½ years of data presently available. The relevant points can be seen by examining Figures 2-5, where we have plotted the daily averages of the energetic electron fluxes, together with the sector structure of the interplanetary field (see the caption of Figure 2 for explanation of IMF data presentation). It can be seen from these figures that the sector structure of the interplanetary field provides the dominant modulation of electron fluxes. Our conclusion that higher fluxes result in the fall from + sectors than from - sectors (and that the converse holds true in the spring) can be verified by inspection of these figures. We are now in the process of trying to assess more quantitatively the relationship between the vector of the interplanetary field and the velocity of the solar wind and the generation of energetic particles in the magnetosphere.

This study, if successful, may lead to techniques for the quantitative prediction of the energetic electron fluxes at the synchronous altitude, using as input solar wind and IMF data. It appears that using data on the local (i.e. near earth) solar wind, radiation fluxes could be predicted several days in advance because of an apparent time lag between changes in interplanetary conditions and the generation by magnetospheric processes of energetic electron fluxes. Should our knowledge of solar physics, i.e. our understanding of the structure and properties of coronal holes and the solar wind advance sufficiently, then solar data, coupled with an appropriate understanding of interplanetary transport processes, might enable radiation predictions to be made of the order of a week ahead of time.

We mention this potential benefit, because it is clear that in the future, applications spacecraft of many varieties are likely to proliferate in the synchronous orbit (see Refs. 1 and 2, for example), and modest advances in radiation prediction - particularly for manned spaceflight applications, may yield extremely beneficial results.

VI. Future Work

We plan to update and revise this report as additional ATS-6 data are reduced and analyzed. At the time of writing (August 1977) the experiment continues to function well. With luck (and NASA's continued interest) ATS-6 will cover the rising portion of the solar activity cycle and provide unique data in this respect.

In addition, we plan to analyze ATS-1 data, which were acquired simultaneously with ATS-6 during portions of 1974, 1975 and 1976. The comparison between data from spacecraft fixed in longitude (ATS-1) and the ATS-6 which sampled a range of longitude-should provide definitive information of the variation of the properties of the electron radiation with longitude at the synchronous orbit.

VII. Acknowledgments

The ATS-6 experiment which yielded the results described in this report was developed with the able assistance of Sam Imamoto and Gloria Roberts. The data reduction efforts were handled by Doretha (Ross) Mayfield. This work was carried out as part of the program of Mission Oriented Investigations and Experimentation supported at The Aerospace Corporation by the USAF Space and Missile System Organization under Contract No. F04701-76-C-0077. Portions of the data reduction efforts were supported by NASA under Contracts NASW-2762, NASW-2879 and NAS5-23788.

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Figure Captions

Figure 1. Relationship between the intervals of data acquisition on energetic electrons at synchronous altitudes by experiments on board ATS spacecraft and the 11-year solar activity cycle as defined by the Zurich sunspot number

Figure 2. Daily average fluxes for 1974 for the four channels of ATS-6 electron data. The trace at the bottom of each panel gives the sector structure of the interplanetary magnetic field as determined by Svalgaard (Ref. 16). Positive sector days are indicated by the upper line, negative sector days by the lower line. Days when polarity is mixed are indicated by a point falling between the two lines.

Figure 3. Same as Figure 1, except for 1975. The data for the > 3.9 Mev channel are suspect after Day 140, 1975 and have been deleted.

Figure 4. Same as Figure 1, except for 1976. The data for the > 3.9 Mev channel are suspect between Day 1 and Day 90 and have been deleted.

Figure 5. Same as Figure 1, except for 1977. Isolated days of data are indicated by unconnected points.

Figure 6. Running 27 day average electron fluxes for the four channels of ATS-6 energetic electron data obtained in 1974. Interplanetary magnetic field sector structure is indicated on each panel of data (see Fig. 2 caption for explanation).

Figure 7. Same as Figure 7, for 1975. E > 3.9 Mev data after Day 140 is suspect and have been deleted.

Figure 8. Same as Figure 7, for 1976. E > 3.9 Mev data between Day 1 and Day 90 are suspect and have been deleted.

Figure 9. Same as Figure 7, for 1977.

Figure 10. Normalized differential probability P(F) of observing a flux F_x for the four ATS-6 electron channels during the interval Day 165, 1974 to Day 140, 1975 when ATS-6 was located at 94°W. This figure was constructed by sorting the observations into bins 0.1 wide in $\log_{10} F_x$. Data for all local times are included. The electron energies are E1: 140-600 kev, E2 > 700 kev, E3 > 1.55 Mev and E4 > 3.9 Mev. The units of F_x are $cm^{-2}sec^{-1}$ for all channels except E1 where the units are $cm^{-2}sec^{-1}\ sr^{-1}$ instead. The notation "ALL" on the figure indicates that all polarities of the interplanetary magnetic field are included in this analysis. The column U gives the mean of the logarithms of the (hourly average) fluxes during this interval, the column J gives the logarithm of the mean flux and S is the logarithm of the standard deviation from U.

Figure 11. The data of Figure 10 are presented as integral probabilities $P(F > F_x)$ of observing a flux greater than F_x during the Day 165, 1974 to Day 140, 1975 time interval. All other comments apply.

Figure 12. Same as Figure 10, except the time interval is Day 180, 1975 to Day 214, 1976 where ATS-6 was located at 35°E. The E4 curve contains data from the interval 90, 76 to 214, 76.

Figure 13. The data of Figure 12 are presented as integral probabilities of observing a flux greater than F_x during the Day 180, 1975 to Day 214, 1976 time interval. All other comments apply.

Figure 14. Same as Figure 10, except the time interval is Day 330, 1976 to Day 120, 1977 where ATS-6 was located at 140°W. The prominent peak in E4 near an apparent flux of $\gtrsim 10\ cm^{-2}sec^{-1}$ is due to the galactic cosmic ray background (see Appendix A) because the energetic electron flux was very low during this time period -see Figures 4, 5, and 8, 9.

Figure 15. The data of Figure 14 are presented as integral probabilities of observing a flux greater than F_x during the Day 330, 1976 to Day 120, 1977 time interval. All other comments apply. Note that for a flux of $\lesssim 15\ cm^{-2}\ sec^{-1}$ in the E4 channel all "electrons" are really galactic cosmic rays or their products.

Figure 16. Electron energy spectra constructed using the average fluxes for each time interval indicated. The fluxes measured in the 140-600 keV directional channel have been multiplied by 4π to obtain a measure of the omnidirectional flux in this energy interval. The $E_e >$ 3.9 Mev point associated with the Day 180, 1975 to Day 214, 1976 curve was obtained using data from the Day 92, 1976 to Day 210, 1976 interval.

Figure 17. Diurnal variation of the average electron flux observed during the time interval Day 165, 1974 - Day 140, 1975 when ATS-6 was located at 94°W.

Figure 18. Same as Figure 17, except that the time interval is Day 180, 1975 to Day 214, 1976 when ATS-6 was located at 35°E. The E4 channel is not shown.

Figure 19. Same as Figure 17, except that the time interval is Day 330, 1976 to Day 120, 1977. ATS-6 was at 140°W at this time.

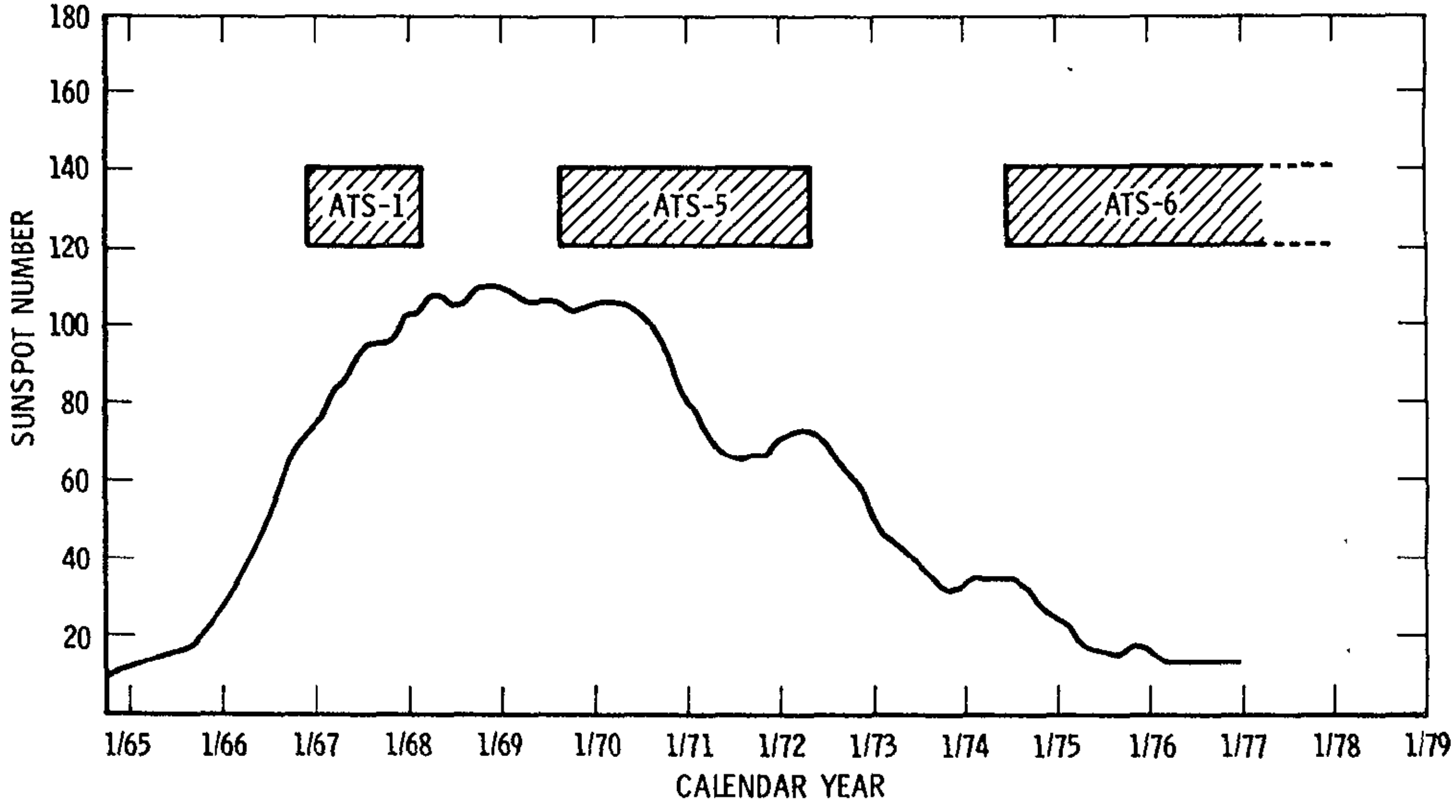
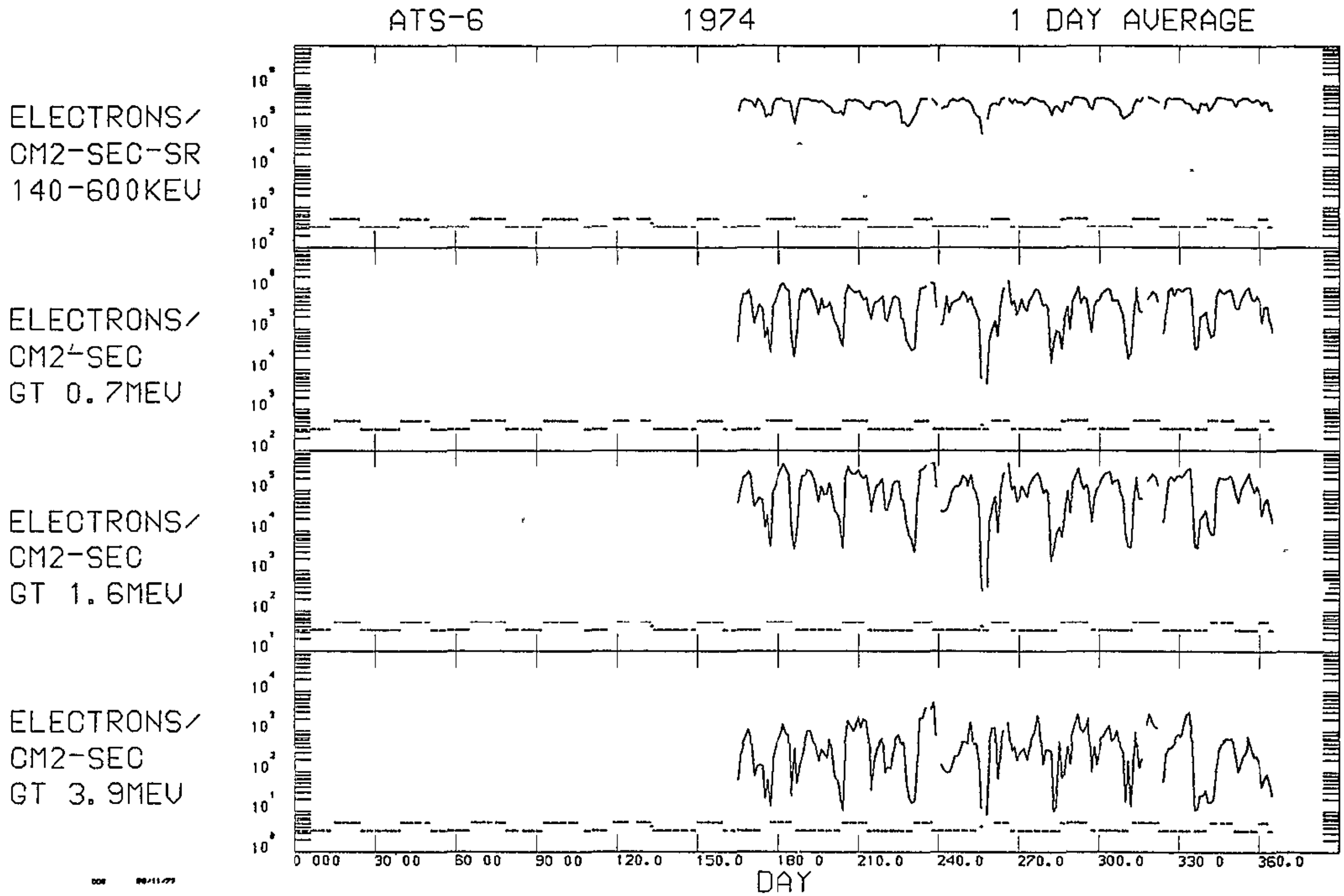

180
160
140
120
100
80
60
40
20
SUNSPOT NUMBER
ATS-1
ATS-5
ATS-6
1/65
1/66
1/67
1/68
1/69
1/70
1/71
1/72
1/73
1/74
1/75
1/76
1/77
1/78
1/79
CALENDAR YEAR

Fig.
1



ATS-6
1974
1 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
0 000
30 00
60 00
90 00
120.0
150.0
180 0
210.0
240.0
270.0
300.0
330 0
360.0
DAY

Fig. 2

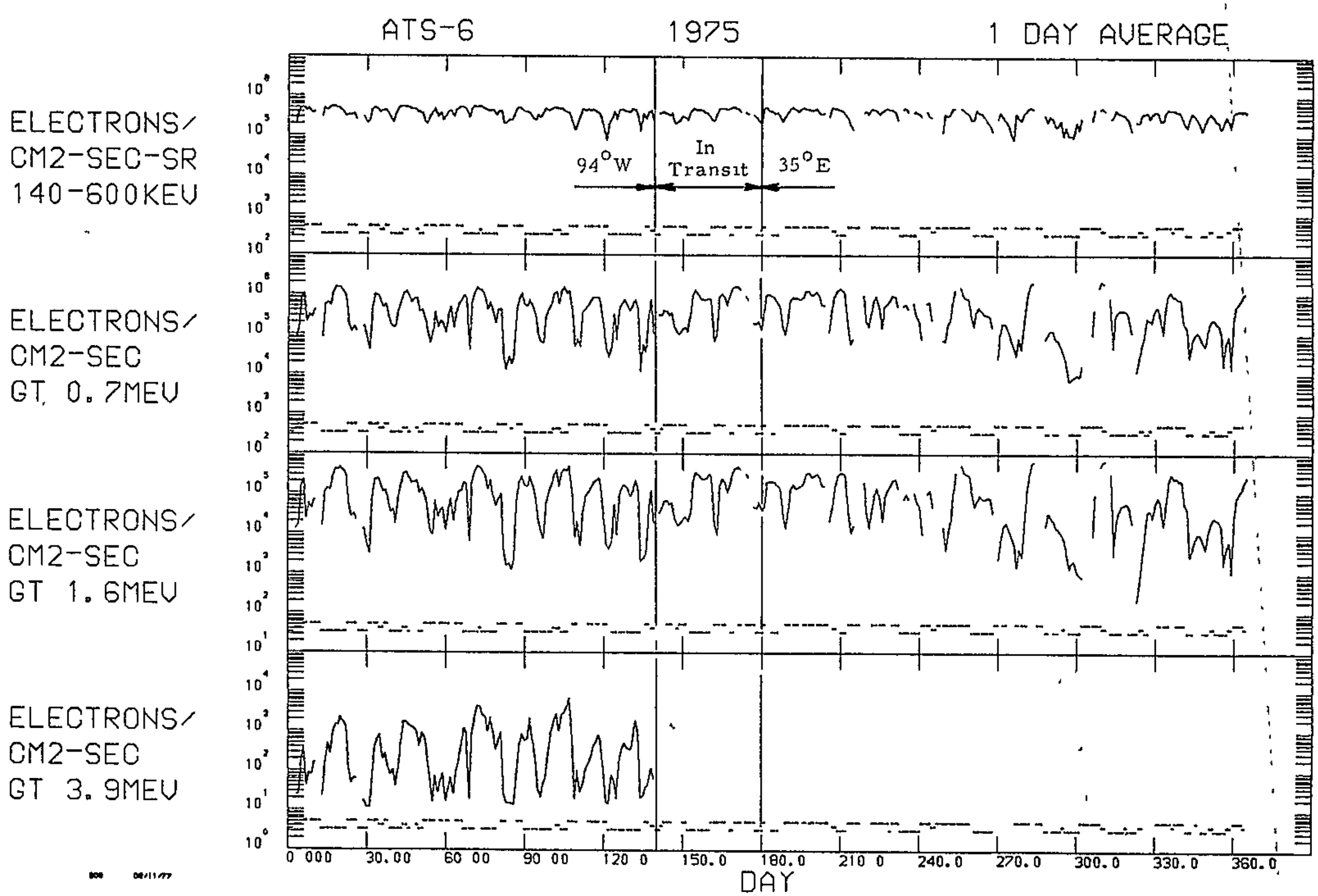

ATS-6
1975
1 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
94°W
In
Transit
35°E
0 000
30.00
60 00
90 00
120 0
150.0
180.0
210 0
240.0
270.0
300.0
330.0
360.0
DAY

Fig.
3

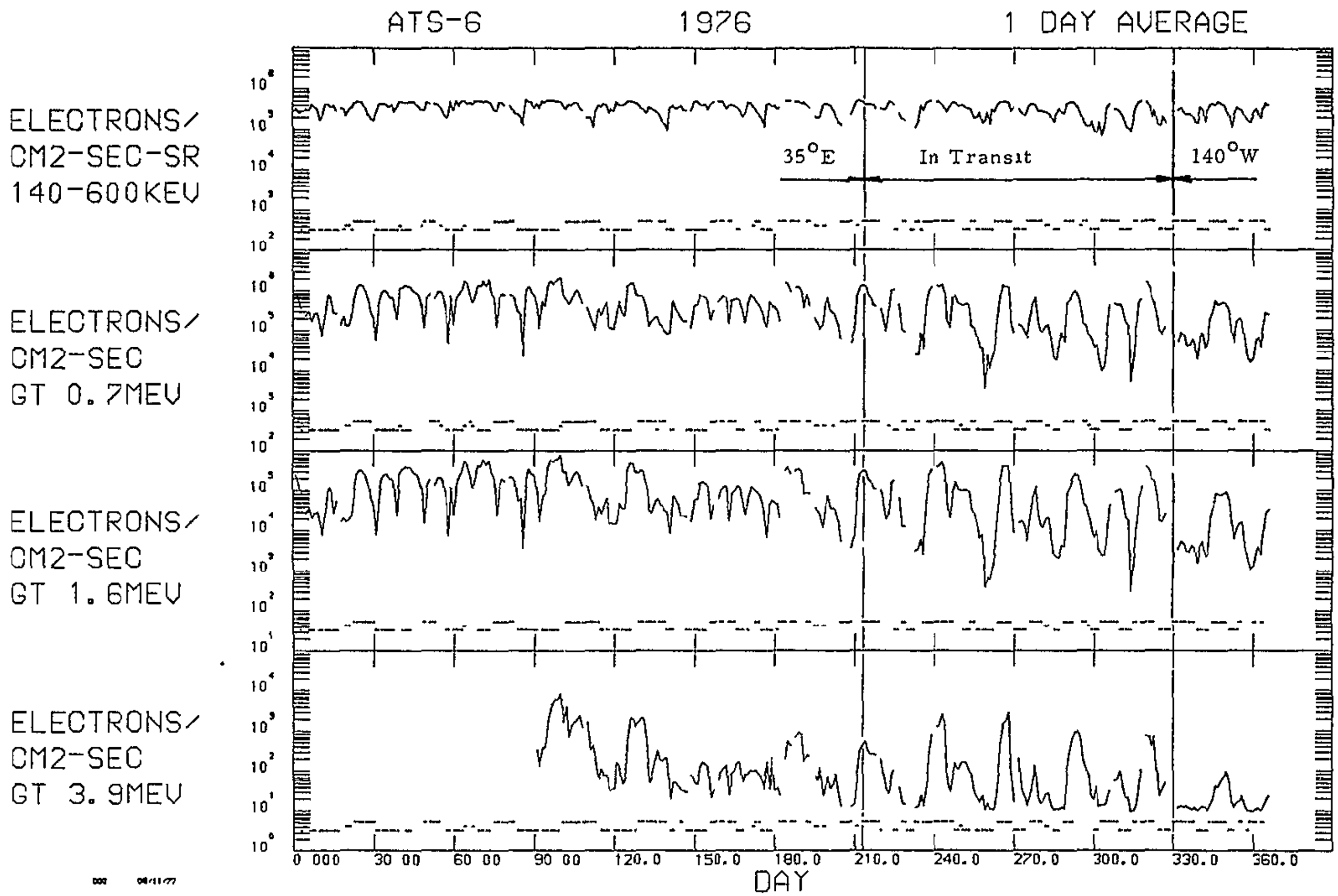

ATS-6
1976
1 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
35°E
In Transit
140°W
0 000
30 00
60 00
90 00
120.0
150.0
180.0
210.0
240.0
270.0
300.0
330.0
360.0
DAY

Fig.
4

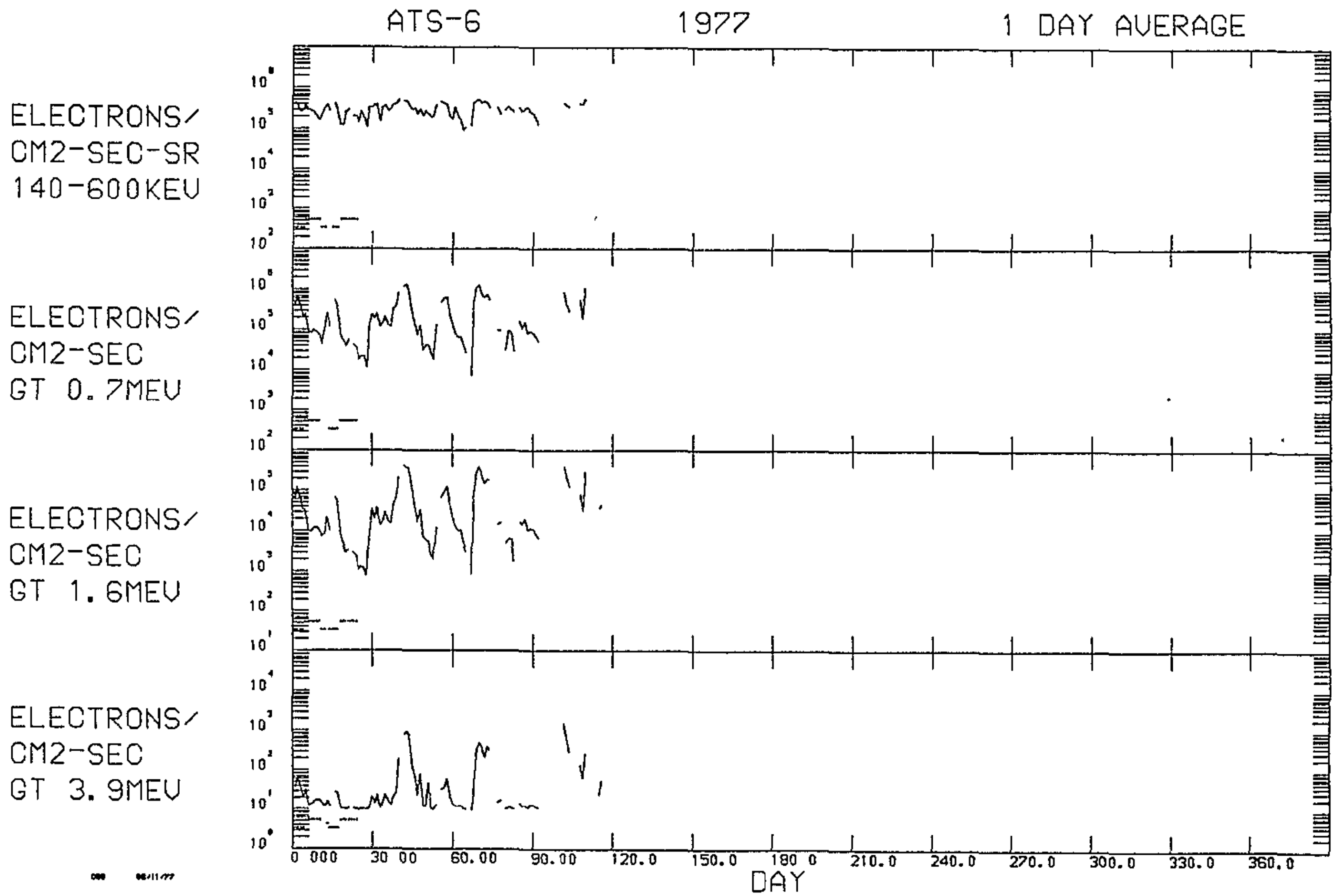

ATS-6
1977
1 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
0.000
30.00
60.00
90.00
120.0
150.0
180.0
210.0
240.0
270.0
300.0
330.0
360.0
DAY

Fig. 5

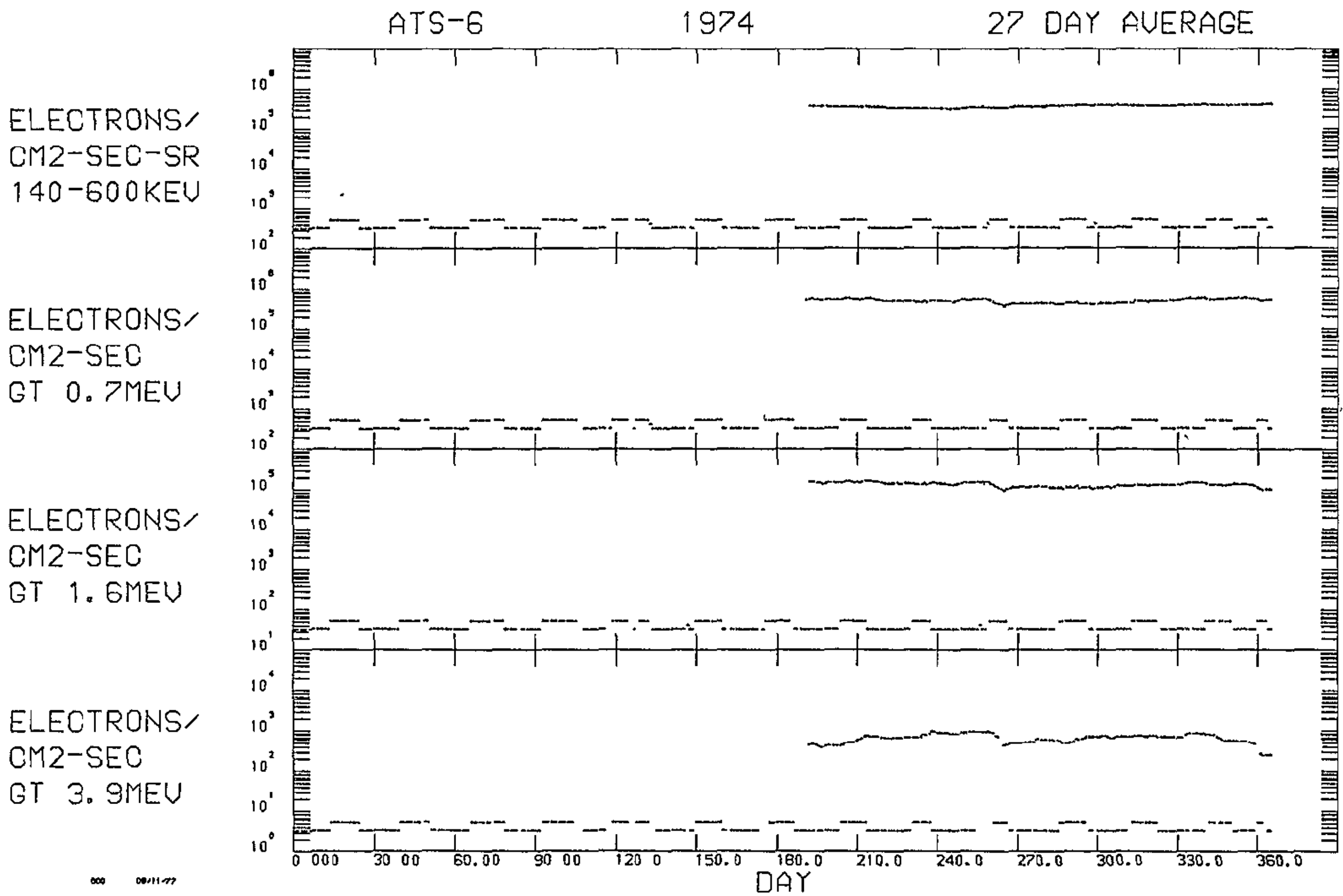

ATS-6
1974
27 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
0.000
30.00
60.00
90.00
120.0
150.0
180.0
210.0
240.0
270.0
300.0
330.0
360.0
DAY

Fig. 6

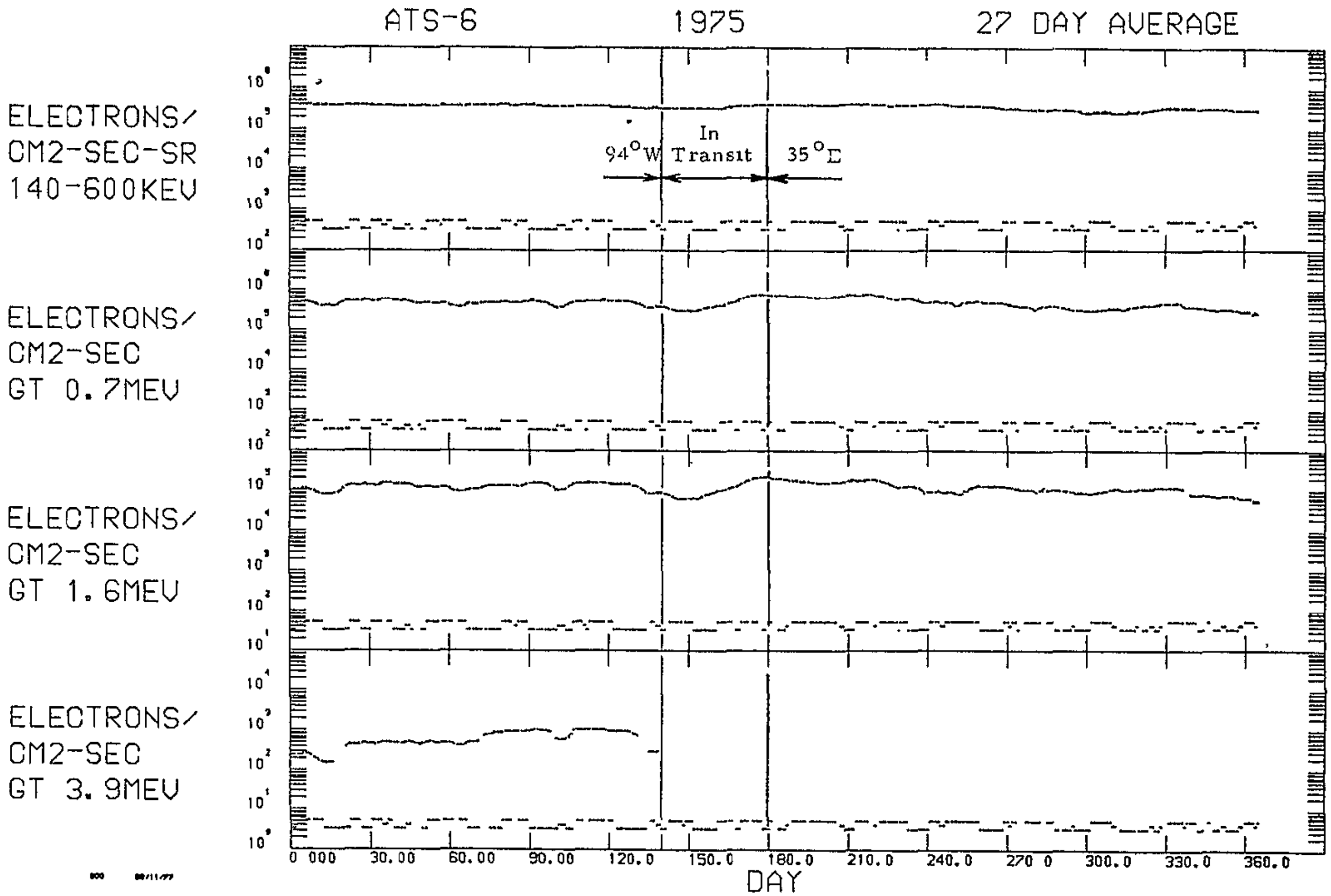

ATS-6
1975
27 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
In
Transit
94°W
35°E
0.000
30.00
60.00
90.00
120.0
150.0
180.0
210.0
240.0
270.0
300.0
330.0
360.0
DAY

Fig. 7

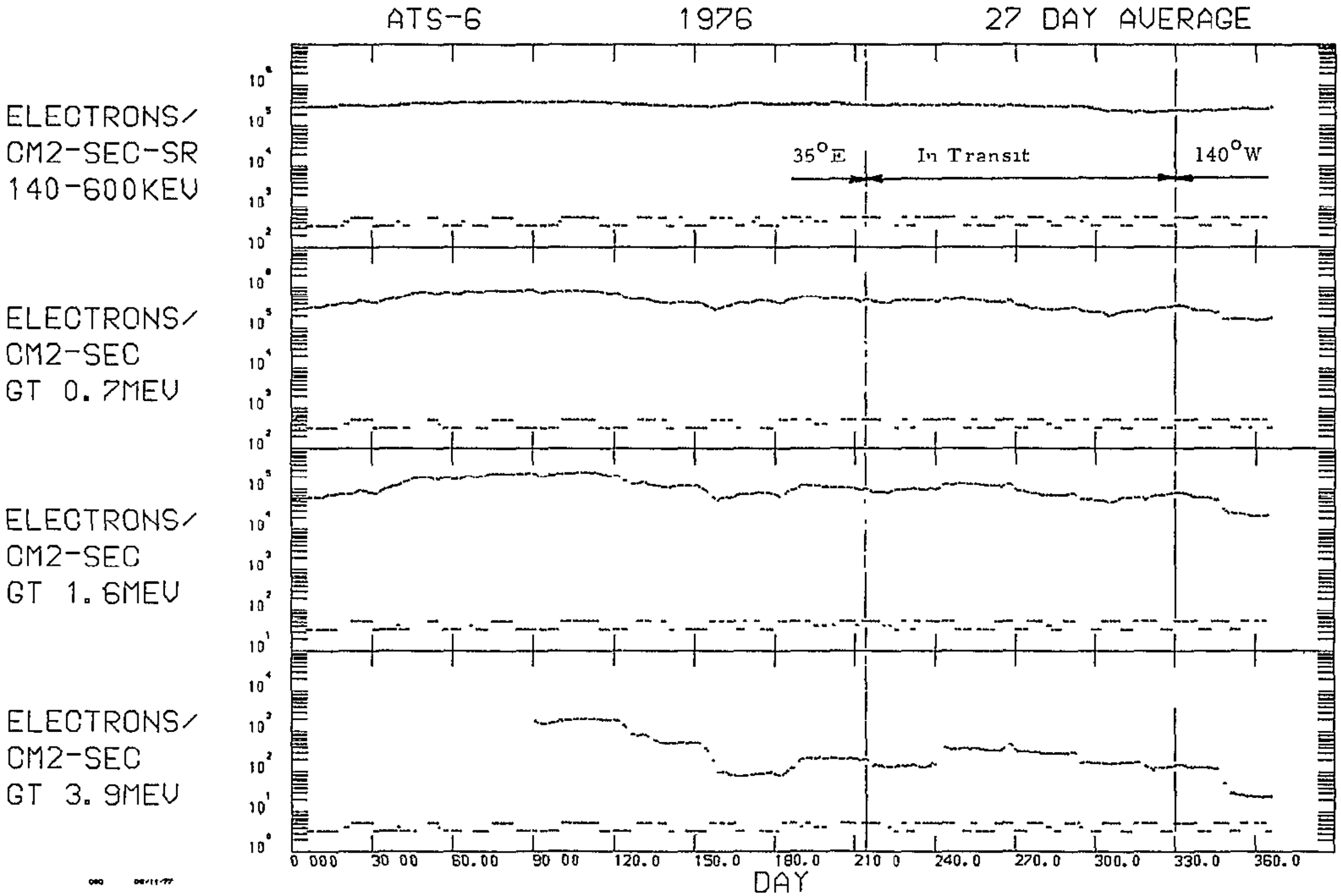

ATS-6
1976
27 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
35°E
In Transit
140°W
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
0 000
30 00
60.00
90 00
120.0
150.0
180.0
210 0
240.0
270.0
300.0
330.0
360.0
DAY

Fig.
8

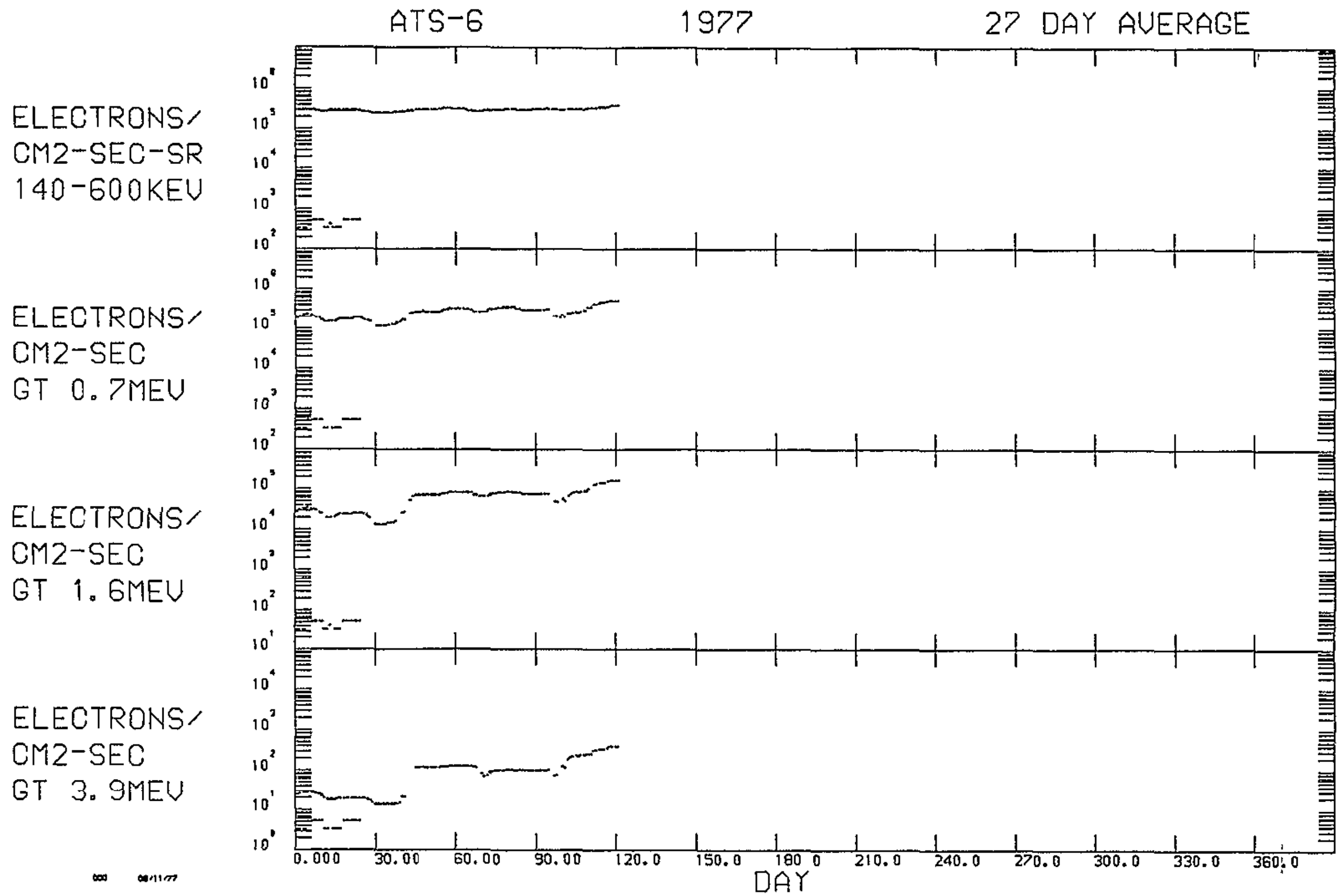

ATS-6
1977
27 DAY AVERAGE
ELECTRONS/
CM2-SEC-SR
140-600KEV
ELECTRONS/
CM2-SEC
GT 0.7MEV
ELECTRONS/
CM2-SEC
GT 1.6MEV
ELECTRONS/
CM2-SEC
GT 3.9MEV
0.000
30.00
60.00
90.00
120.0
150.0
180.0
210.0
240.0
270.0
300.0
330.0
360.0
DAY

Fig. 9

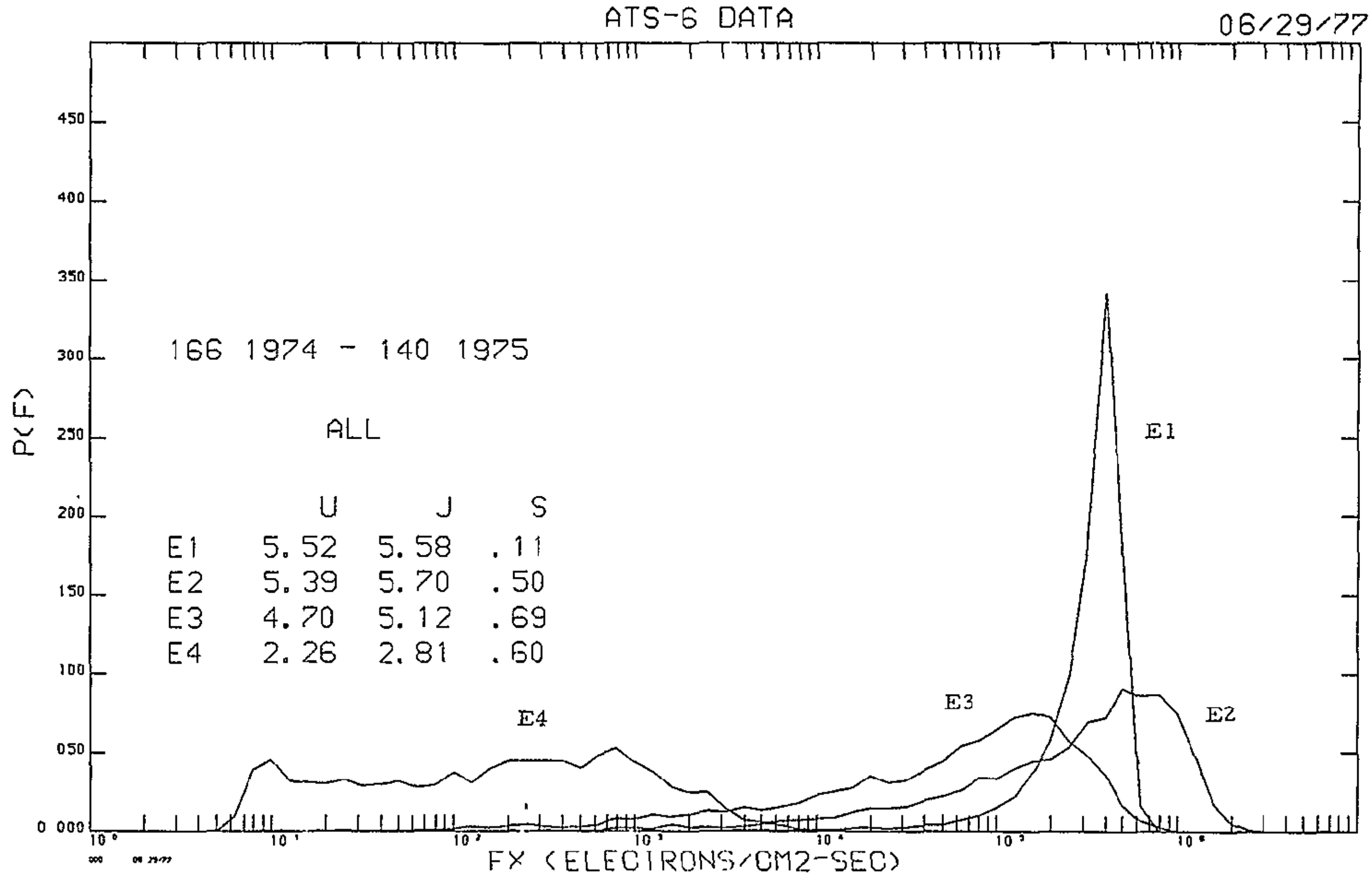

ATS-6 DATA
06/29/77
166 1974 - 140 1975
ALL
U J S
E1 5.52 5.58 .11
E2 5.39 5.70 .50
E3 4.70 5.12 .69
E4 2.26 2.81 .60
E1
E2
E3
E4
P(F)
FX (ELECTRONS/CM2-SEC)
450
400
350
300
250
200
150
100
050
0 000

Fig.
10

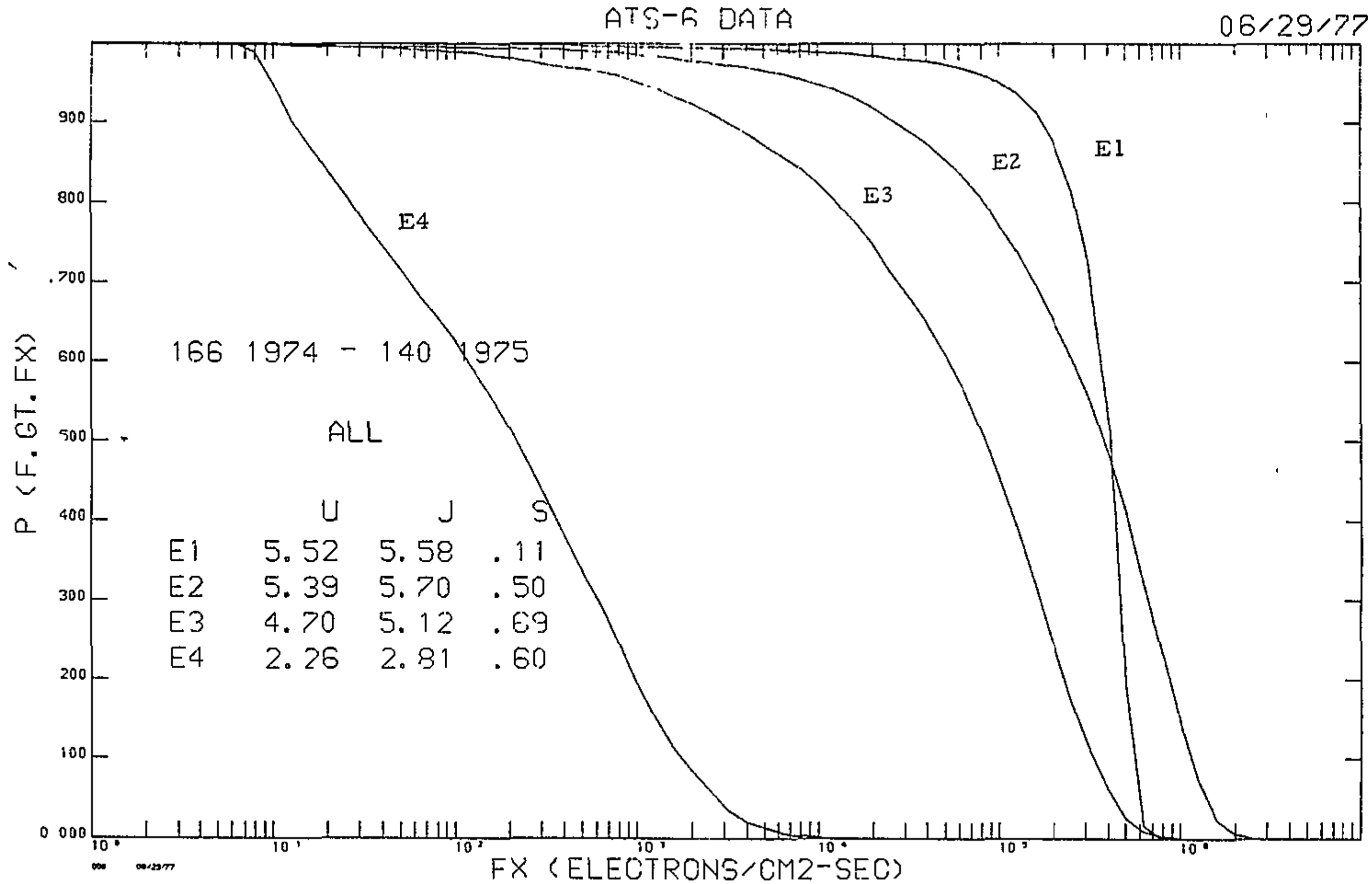

ATS-6 DATA
06/29/77
P (F.GT.FX)
900
800
700
600
500
400
300
200
100
0 000
FX (ELECTRONS/CM2-SEC)
E1
E2
E3
E4
166 1974 - 140 1975
ALL
U J S
E1 5.52 5.58 .11
E2 5.39 5.70 .50
E3 4.70 5.12 .69
E4 2.26 2.81 .60

Fig. 11

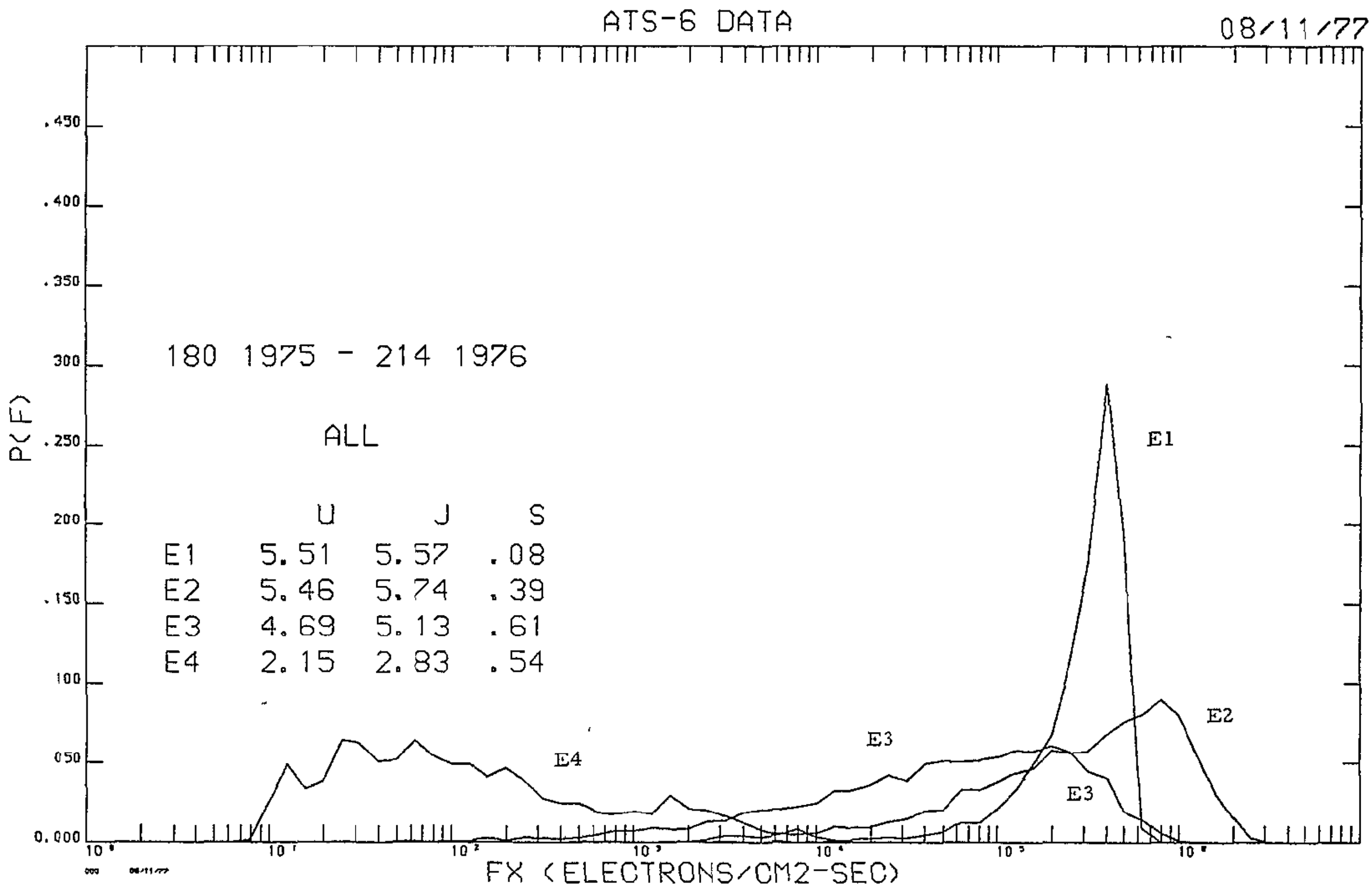

ATS-6 DATA
08/11/77
P(F)
FX (ELECTRONS/CM2-SEC)
180 1975 - 214 1976
ALL
U J S
E1 5.51 5.57 .08
E2 5.46 5.74 .39
E3 4.69 5.13 .61
E4 2.15 2.83 .54
E1
E2
E3
E3
E4
.450
.400
.350
300
.250
200
.150
100
050
0.000

Fig.
12

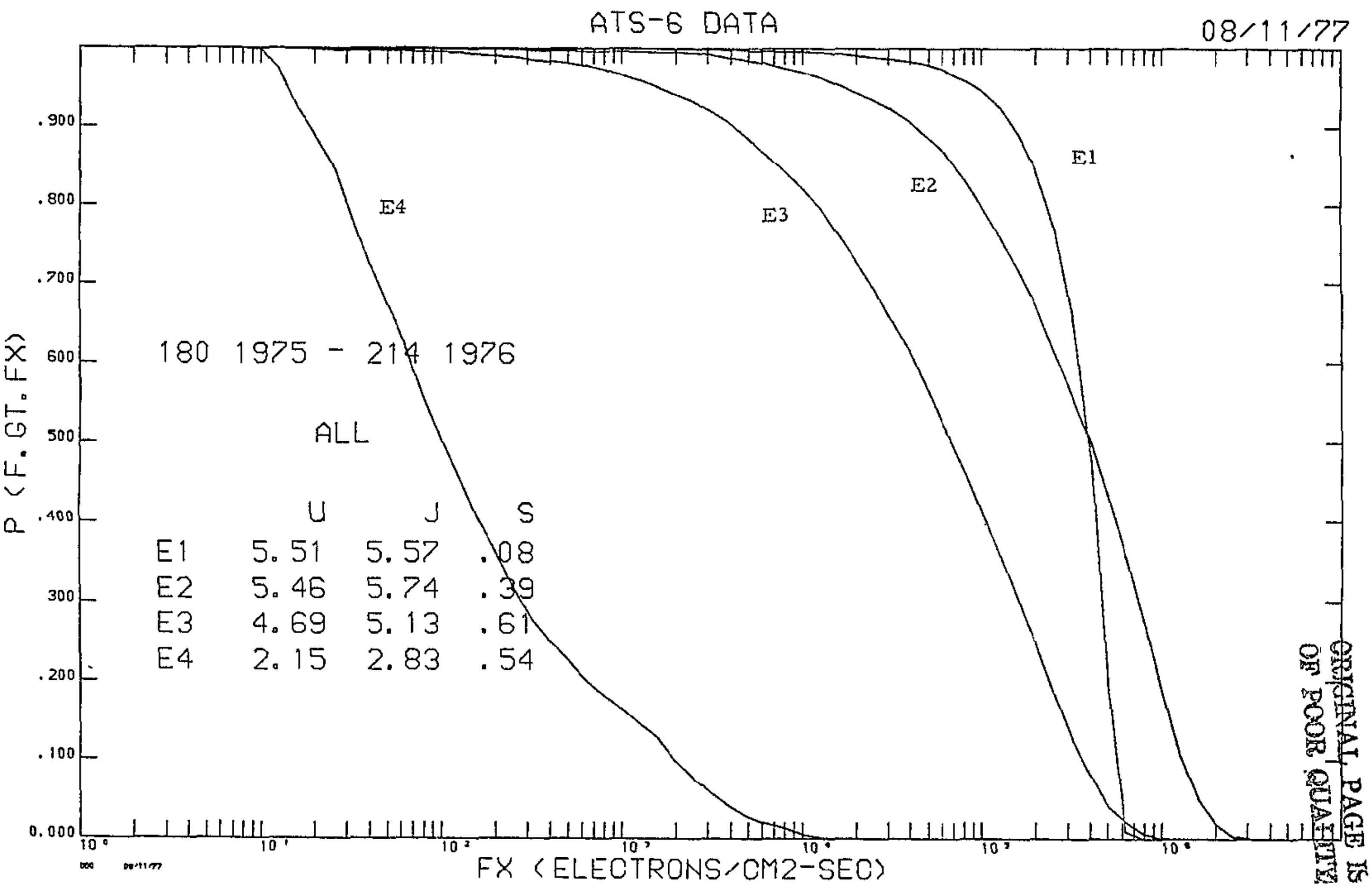

ATS-6 DATA
08/11/77
P (F.GT.FX)
.900
.800
.700
600
500
.400
300
.200
.100
0.000
180 1975 - 214 1976
ALL
U J S
E1 5.51 5.57 .08
E2 5.46 5.74 .39
E3 4.69 5.13 .61
E4 2.15 2.83 .54
E1
E2
E3
E4
FX (ELECTRONS/CM2-SEC)

Fig.
13

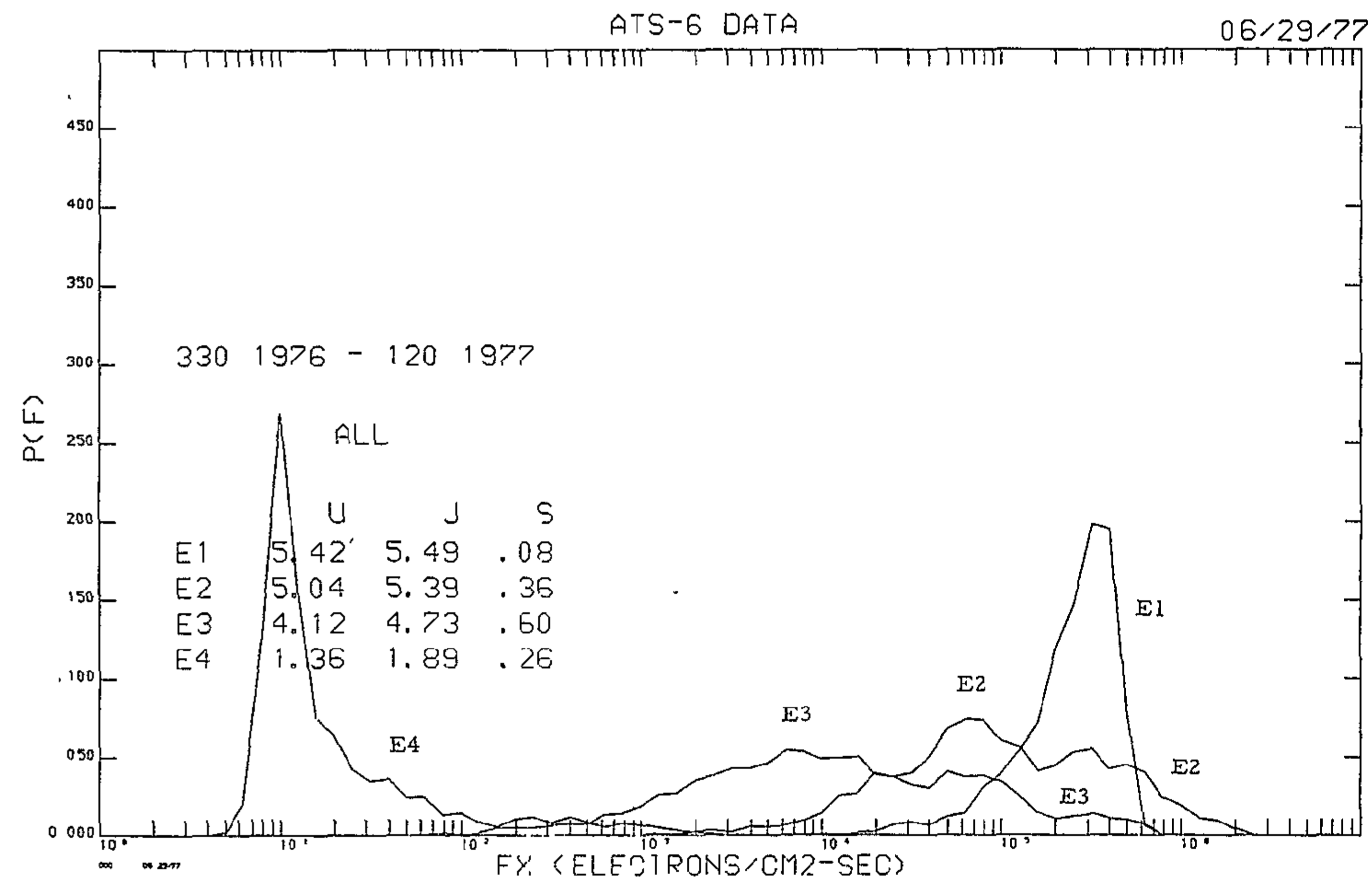

ATS-6 DATA
06/29/77
P(F)
450
400
350
300
250
200
150
100
050
0 000
330 1976 - 120 1977
ALL
U J S
E1 5.42 5.49 .08
E2 5.04 5.39 .36
E3 4.12 4.73 .60
E4 1.36 1.89 .26
E1
E2
E3
E4
FX (ELECTRONS/CM2-SEC)

Fig.
14

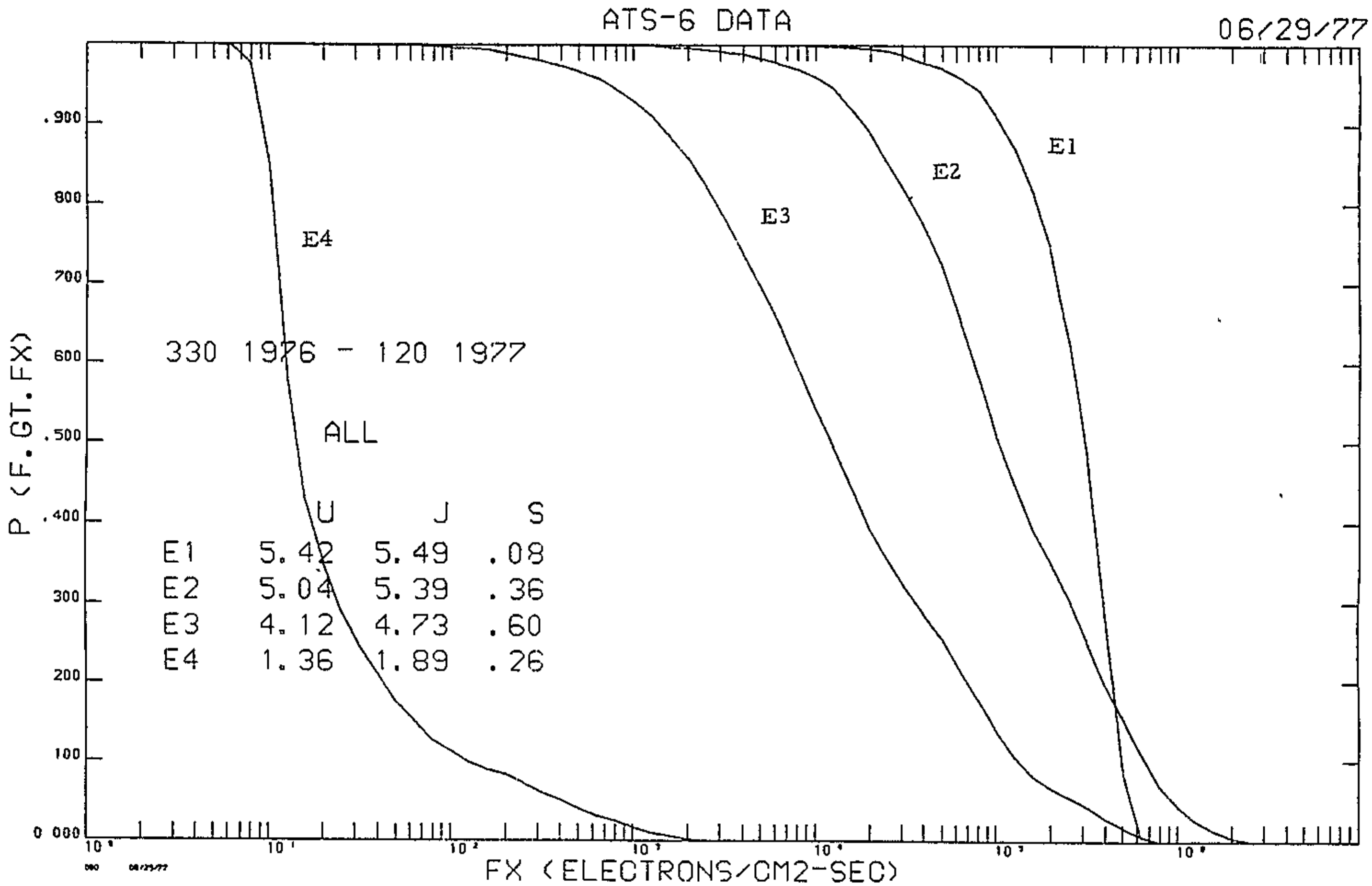

ATS-6 DATA
06/29/77
330 1976 - 120 1977
ALL
U J S
E1 5.42 5.49 .08
E2 5.04 5.39 .36
E3 4.12 4.73 .60
E4 1.36 1.89 .26
E1
E2
E3
E4
P (F.GT.FX)
FX (ELECTRONS/CM2-SEC)

Fig. 15

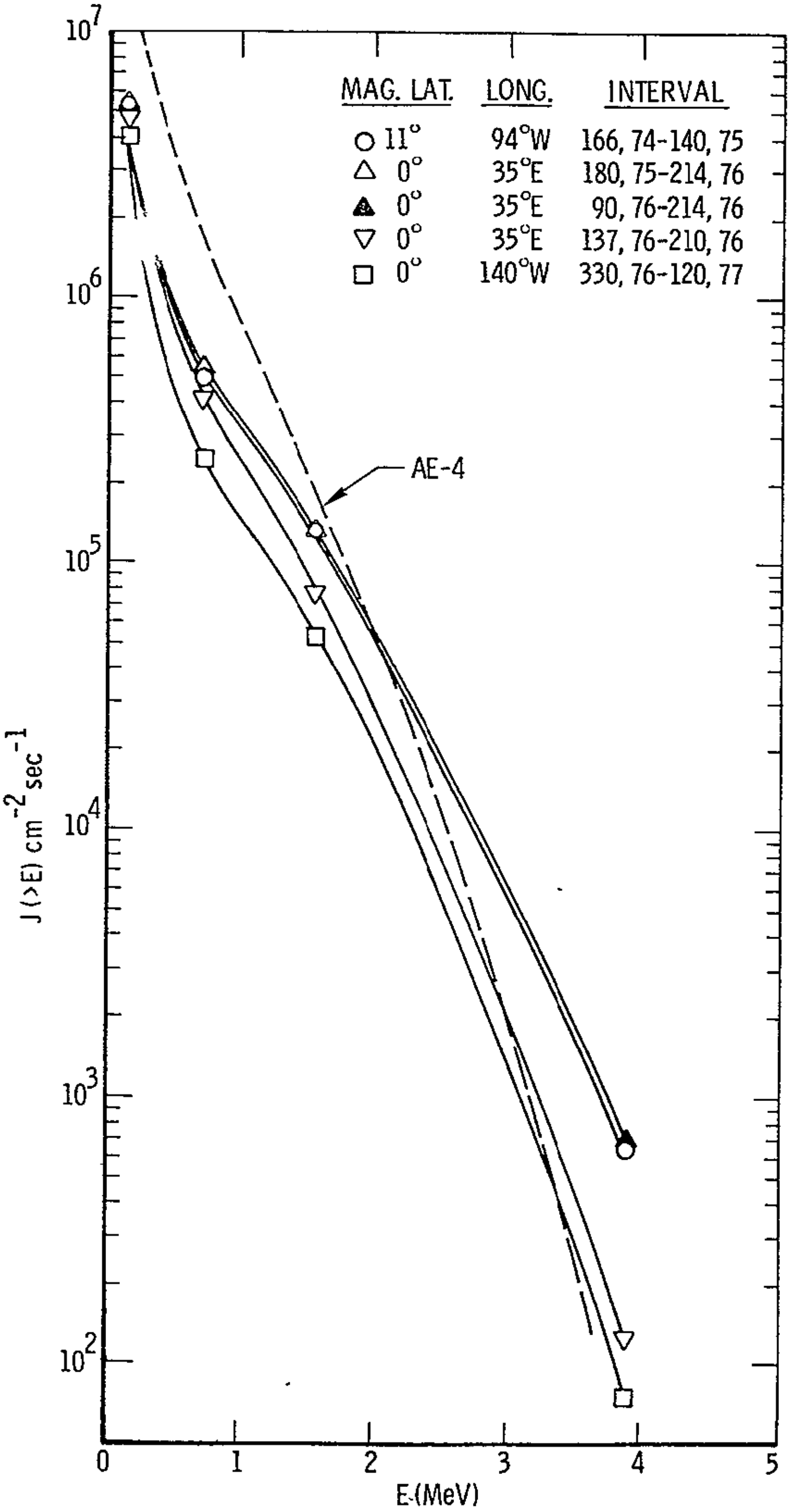
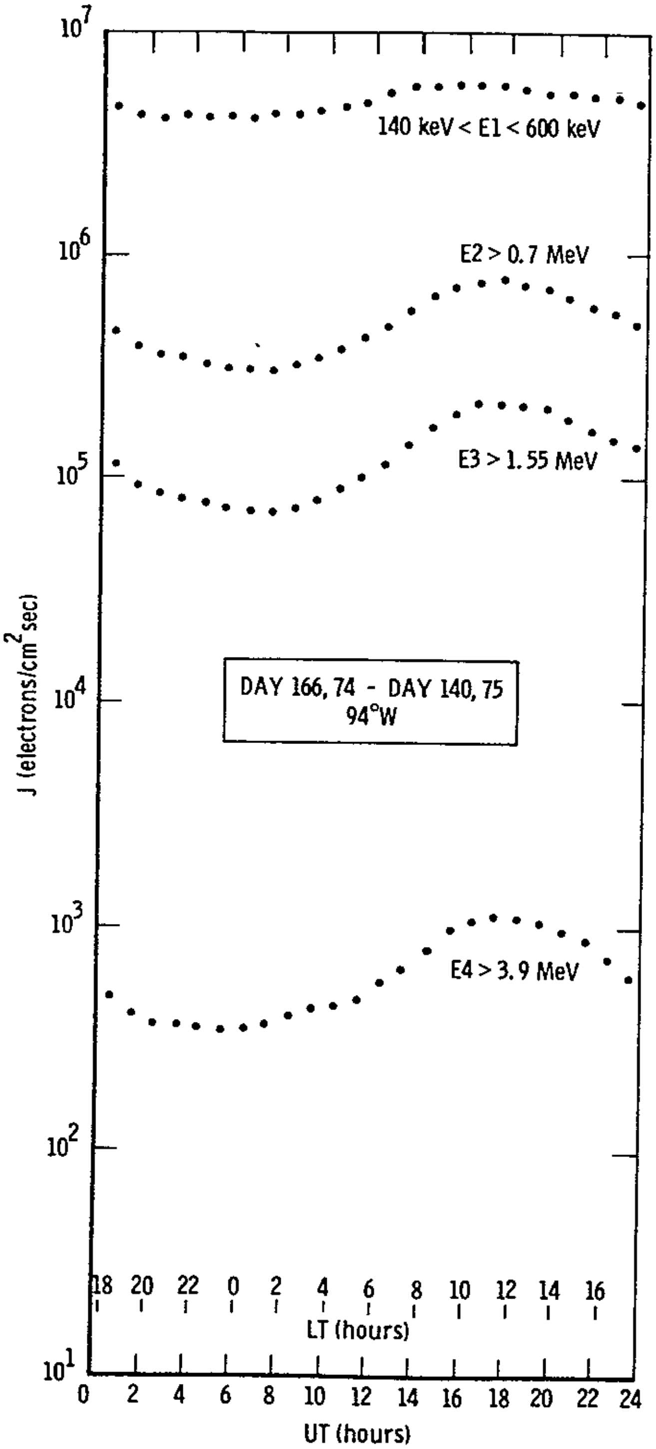
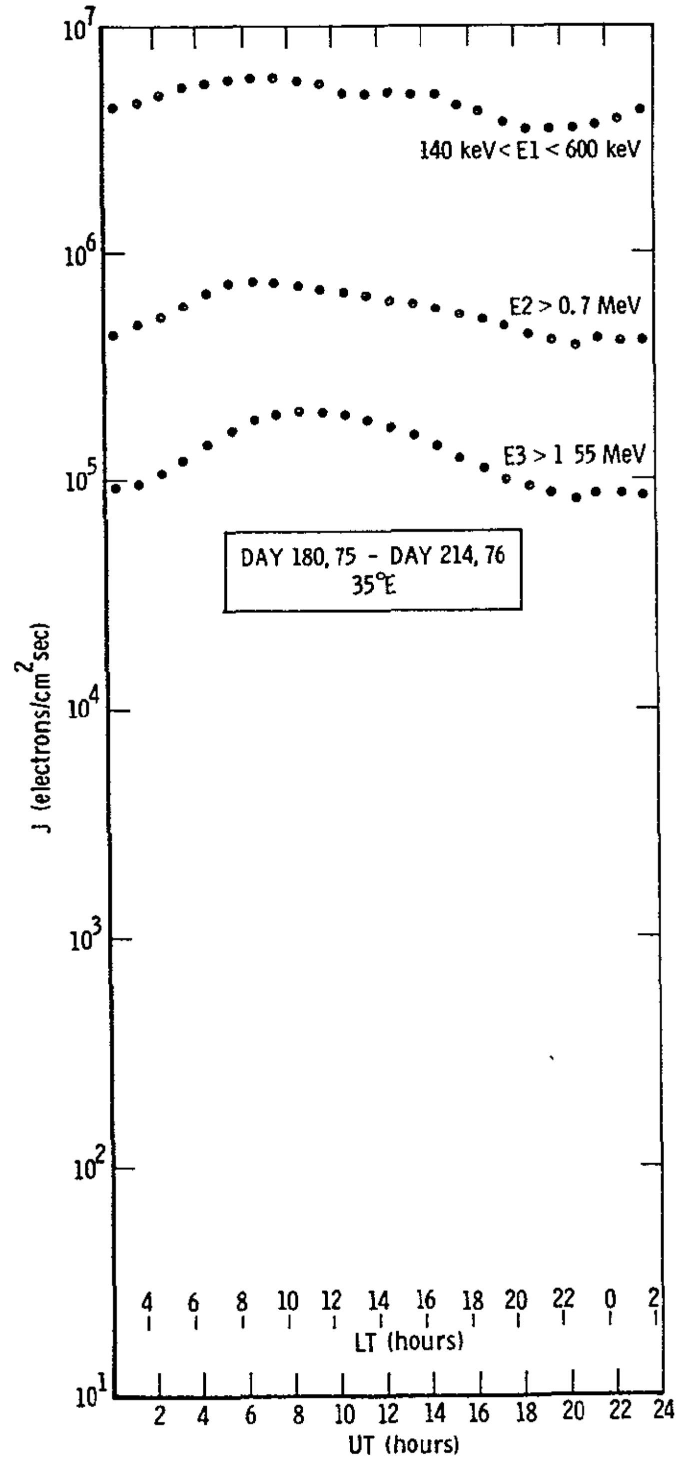

MAG. LAT.
LONG.
INTERVAL
11°
94°W
166, 74-140, 75
0°
35°E
180, 75-214, 76
0°
35°E
90, 76-214, 76
0°
35°E
137, 76-210, 76
0°
140°W
330, 76-120, 77
AE-4
J (>E) cm^{-2} sec^{-1}
10^7
10^6
10^5
10^4
10^3
10^2
0
1
2
3
4
5
E (MeV)

Fig. 16



10^7
10^6
10^5
10^4
10^3
10^2
10^1
140 keV < E1 < 600 keV
E2 > 0.7 MeV
E3 > 1.55 MeV
E4 > 3.9 MeV
DAY 166, 74 - DAY 140, 75
94°W
J (electrons/cm^2 sec)
18 20 22 0 2 4 6 8 10 12 14 16
LT (hours)
0 2 4 6 8 10 12 14 16 18 20 22 24
UT (hours)

Fig. 17



140 keV < E1 < 600 keV
E2 > 0.7 MeV
E3 > 1 55 MeV
DAY 180, 75 - DAY 214, 76
35°E
J (electrons/cm2sec)
LT (hours)
UT (hours)

Fig. 18

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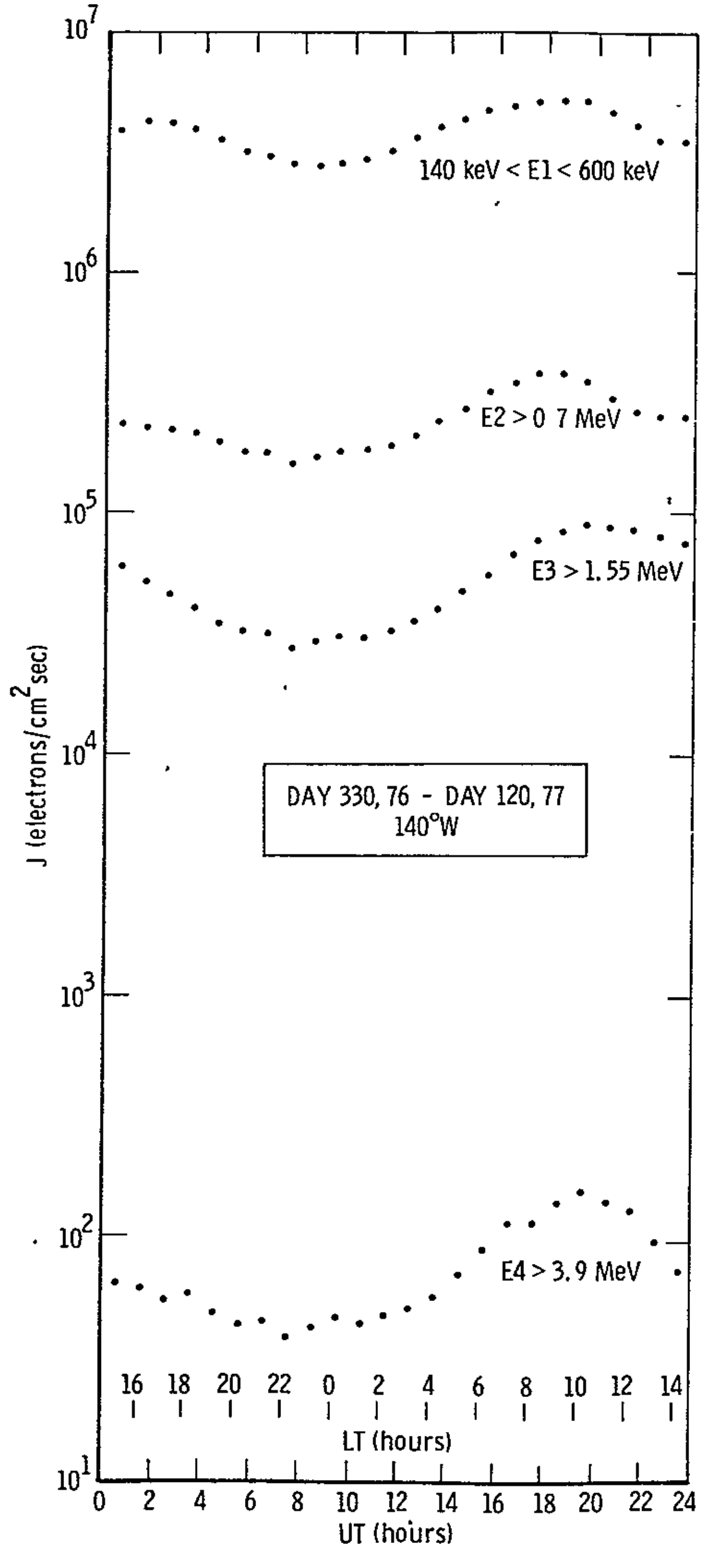

Fig.
19

Appendix A: A Description of Instrument Response

A full description of the ATS-6 Aerospace Corporation experiment has been presented in Ref. 13. Here we summarize, for ready reference, those salient features of the instrument response which may be of interest or assistance in interpretation of the results presented in earlier portions of this report.

Instrument Description

Figure A-1 shows a schematic block diagram of the detector/electronic system. The electron channels, E1, E2, E3, E4 are derived from Sensors 1-4 respectively. Figure A-2 shows the experiment.

Electron Detection

The responses of the electron channels are illustrated in Figures A-3 and A-4 respectively. These data, integrated over the angular acceptance angles of each detector give the average detector geometric factor as a function of energy. It has proven convenient to integrate these energy dependent geometric factors over various (assumed) shapes of the incident electron spectrum and finding a threshold (or set of thresholds for the E1 channel) which minimizes the variation of the geometric factor with spectral shape. The results are presented in Table A-1. The ϵG factors given in this table were used to convert from counts to flux above the indicated thresholds (or, for E1, in the indicated energy interval).

Proton Contamination

Proton channels which measure trapped and solar proton fluxes are also associated with each detector. In principle, the proton data can be used to correct for any proton contamination of the electron data. In practice, we found that during the 1974-1977 interval, solar proton activity was very low and no systematic correction was required; instead, days of data where some solar proton contamination (primarily of the E3, E4 channels) was suspected were rejected from the analysis. The sporadic fluxes of low energy (several Mev) trapped protons which we occasionally observed did not have any effect on the electron channels. Galactic cosmic rays and the products generated by their interaction with the spacecraft gave rise to a significant background in the E4 channel. This background has a diurnal signature characteristic of cosmic rays (i.e. a maximum near local midnight and a minimum near local noon). During time periods when the trapped electron flux was low, for example the late 1976 - early 1977 time period, this background can be clearly visible in the E4 data (see Fig. 5) as an apparent flux of $\approx 10\ cm^{-2}sec^{-1}$. The true flux is more likely $\approx 5\ cm^{-2}sec^{-1}$ because the geometric factor of the E4 channel for these very energetic, minimum ionizing particles is a factor of two larger than quoted in Table A-1. This background has not been subtracted from our results; although of galactic origin, the radiation masquerading as "energetic electrons" is always present at the synchronous orbit, is practically indistinguishable from energetic electrons, and may be of some practical consequence as an ever-present background.

Bremsstrahlung Effects

During our calibrations, the bremsstrahlung efficiencies of the E2, E3, E4 channels were measured. Upper limits for the efficiencies were determined; those upper limits fall well below 10^{-4} relative to the direct detection of electrons. In all cases, we find that the galactic cosmic ray background exceeds that which might be generated by bremsstrahlung.

Accuracy of Results

The dominant source of error in this experiment arises because of the uncertainty, estimated to be $\approx 20\%$, in the geometric factors. All other experimental sources of error are minimal. While, under some circumstances, counting statistics may contribute additional uncertainty, in this paper we are dealing with long term flux averages which effectively eliminate counting statistics on an error source. It is important to reiterate that our measurements deal with a high variable phenomenon characterized by significant deviations from the mean. Comparisons of our results with those of others need to take this into account and also recognize that imporant long term effects (related to the 11 year solar cycle) in the structure of the radiation belts exist.

TABLE A-1

Omnidirectional Geometric Factors

Channel	Passband or Threshold (Mev)	ϵG
E1	0.140-0.600	0.115 $cm^2 sr$
E2	0.700	0.00349 cm^2
E3	1.55	0.0176 cm^2
E4	3.90	0.0688 cm^2

Appendix Figure Captions

Figure A-1 Schematic block diagram of detector/electronic system.

Figure A-2. Overall view of the energetic particle spectrometer on ATS-6. Directional detectors (E1 channel) are housed inside the cylindrical collimator structure in the foreground.

Figure A-3. Efficiency of detection of electrons in the E1 channel. This channel has a nominal energy sensitivity of 140-600 keV. Sensitivity of this channel below the nominal electronic threshold is associated with the finite noise of the detector.

Figure A-4. Effective area of the E2, E3 and E4 electron channels as a function of electron energy. This effective area, when integrated over the angular response of the detector, yields the omnidirectional geometric factor. Bremsstrahlung efficiencies fall well below lower limits of this figure.

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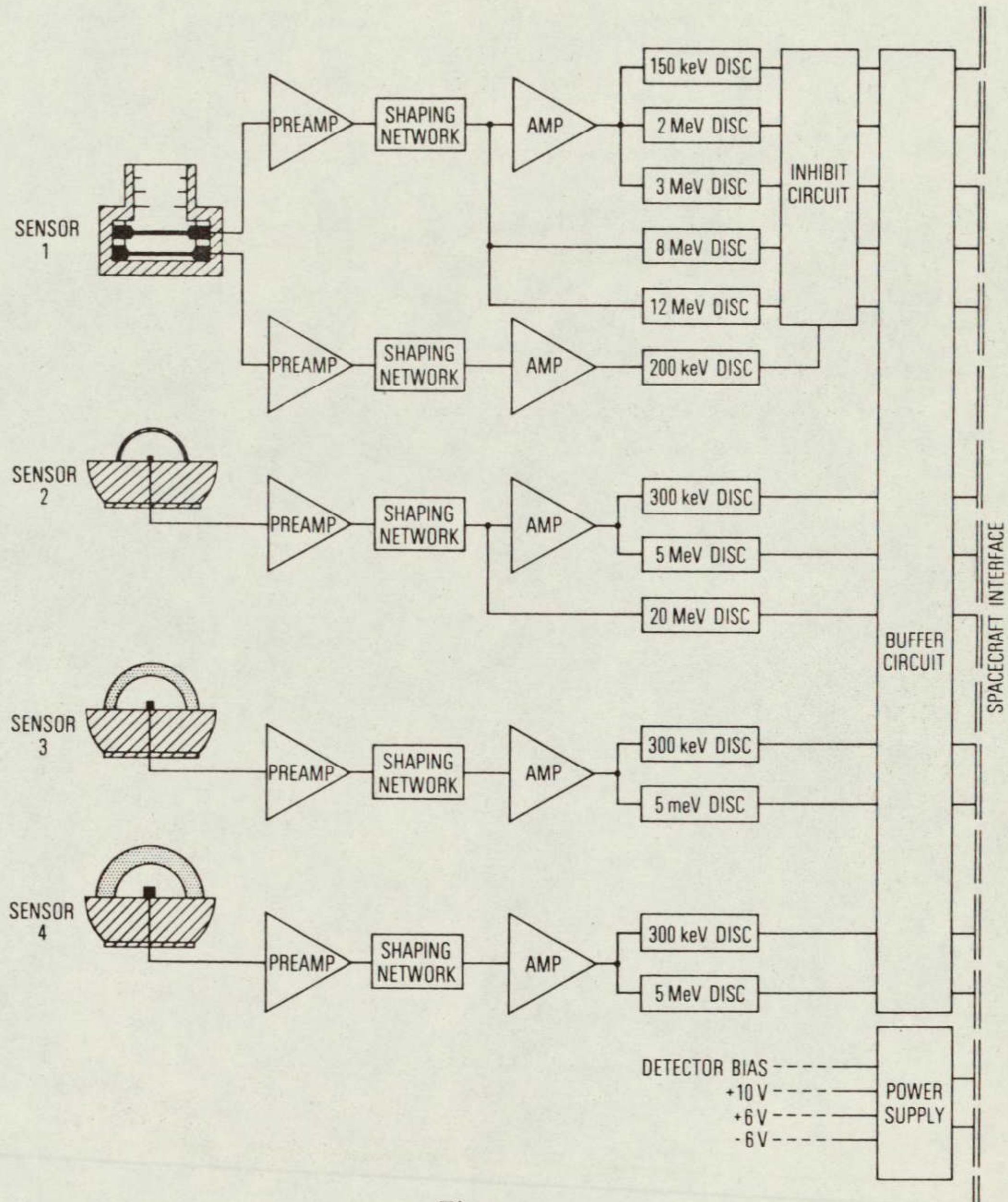

Fig.
A-1

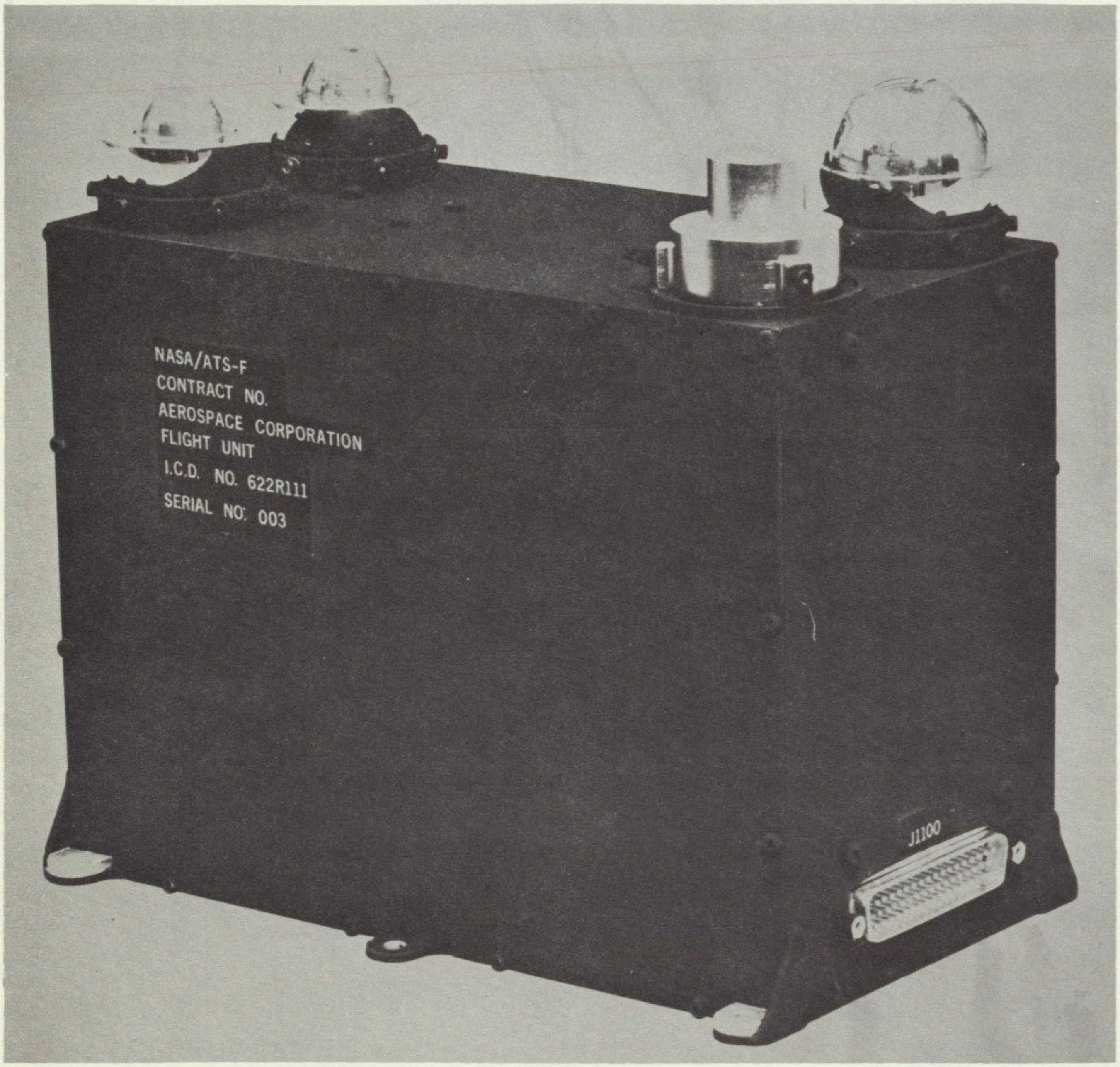
NASA/ATS-F
CONTRACT NO.
AEROSPACE CORPORATION
FLIGHT UNIT
I.C.D. NO. 622R111
SERIAL NO. 003
J1100

Fig.
A-2

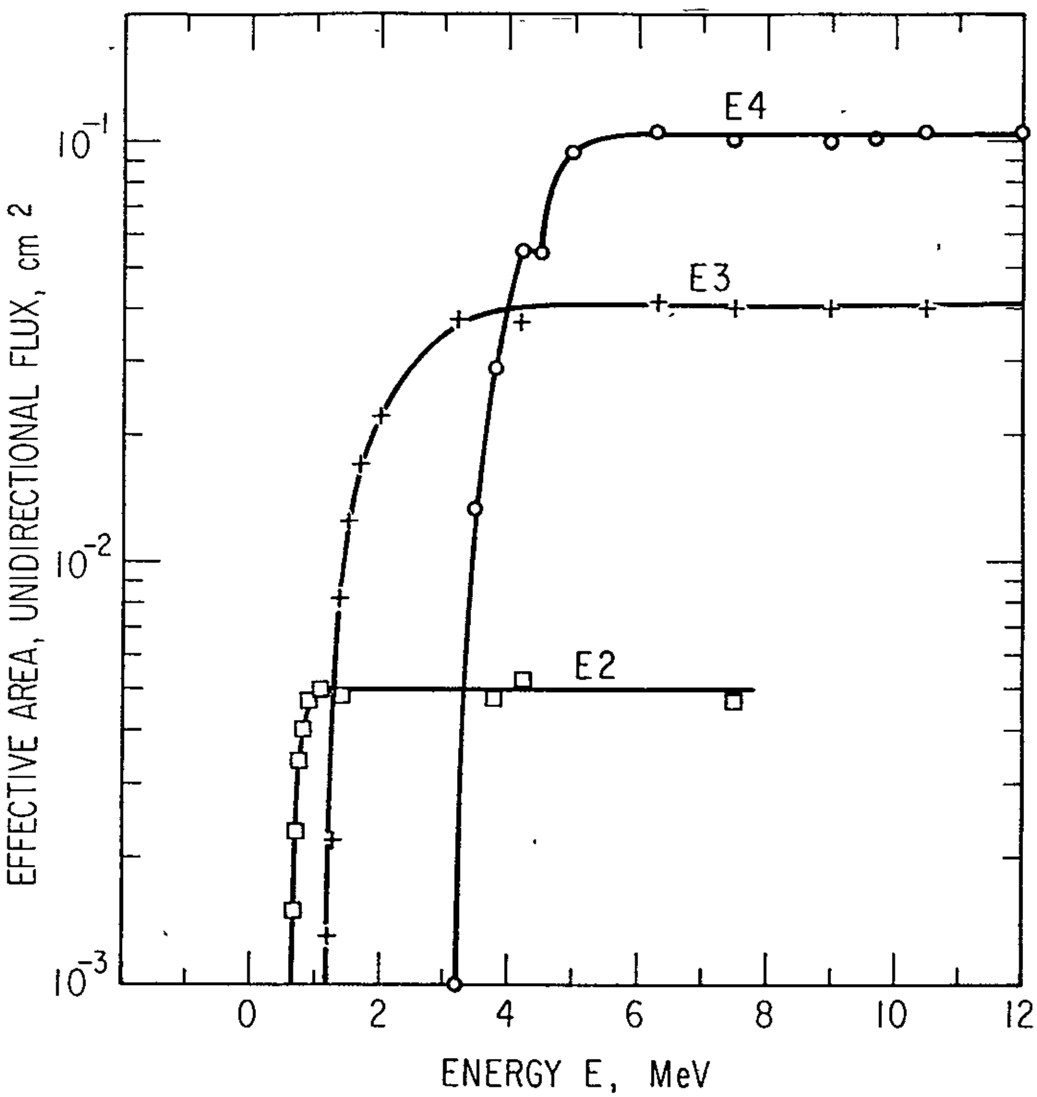
E4
E3
E2
10^{-1}
10^{-2}
10^{-3}
EFFECTIVE AREA, UNIDIRECTIONAL FLUX, cm 2
0
2
4
6
8
10
12
ENERGY E, MeV

Fig.
A-4