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ANALYSIS OF POLAR CAP ABSORPTION EVENTS V. RF PROFILES, ACTIVE SOLAR REGIONS AND ASSOCIATED PHENOMENA, REQUIREMENTS FOR A PROTON WARNING SYSTEM

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TABLE OF CONTENTS

		Page
1.0	SUMMARY	1
1.1	Use Flare Patrol Flares to Compare Multi-Peak RF Emissions with Possible Multi-Maxima Flares	1
1.2	Evaluation of RF Time Histories	2
1.3	Correlation of H α Flares and RF Time Histories	2
1.4	Analysis of Current RF and Hα Flare Data	3
1.5	Evaluation of Flare Position with Respect to Sunspot Umbra and Flares From Sunspots with a "δ" Configuration	3
2.0	RF PROFILES AND TIME HISTORIES	4
2.1	Peak Flux Classification of RF Emissions	4
2.2	RF Profile Classification	5
2.2.1	RF Class 1 Profiles	6
2.2.2	RF Class 2 Profiles	6
2.2.3	RF Class 3 Profiles	7
2.2.4	RF Class 4 Profiles	7
2.3	Profile Characteristics of RF Emissions Associated with Small or Doubtful PCA Events	8
2.3.1	Small Polar Cap Absorption Events Based on f_{min} Observations	8
2.3.2	Very Small Polar Cap Absorptions Based on High Sensitivity Vertical - Incidence Back Scatter	9
3.0	GREAT EVENTS AT 2800 Mc/s or 3750 Mc/s DURING THE 19TH SOLAR CYCLE	11
3.1	Great RF Bursts Not Followed by a PCA	11
3.2	Great Bursts Followed by a PCA	12

TABLE OF CONTENTS (cont'd)

		Page
3.2.1	The Sequence of Events During November 1960	12
3.2.2	RF Profiles for the Great Bursts during July 1959	15
3.2.3	Profiles for the Two Great RF Emissions From Solar Region 5615	16
4.0	MULTI-EVENT REGIONS DURING THE 19th SOLAR CYCLE	17
4.1	The Solar Region 3400 that Crossed the Solar Disk Between February 10 and 24, 1956	19
4.2	The Solar Region 3941 that Crossed the Solar Disk Between 16 and 28 April 1957	20
4.3	The Solar Region 470 that Crossed the Solar Disk between August 15 and 28, 1958	21
4.3.1	The RF Emission, Hα Flare, and PCA Event on 20, 21 August 1958	23
4.3.2	The RF Emission, Hα Flare and PCA Event on August 22, 1958	24
4.3.3	The RF Emission, Hα Flare and PCA Event on August 26, 1958	25
4.4	The Solar Region that Crossed the Solar Disk Between May 8 and 22, 1959	25
4.4.1	The RF Emission, Hα Flare, the PCA, and Ground Level Effect on 10 May 1959	26
4.4.2	The Major Flare and RF Emission on May 11, 1959	27
4.4.3	The Major RF Bursts at 3750 Mc/s on May 13, 1959	27
4.4.4	Other Major Bursts	27
4.5	The Recurrent Active Region that Crossed the Solar Disk Between May 17 and August 14, 1959	28
4.5.1	The Recurrent Regions 5070, 5105, and 5157	29
4.5.2	The Solar Region 5204 that Crossed the Solar Disk Between June 11 and 23, 1959	30

TABLE OF CONTENTS (cont'd)

			Page
	4.5.3	The McMath Plage 5265 and Great Events During July 1959	33
	4.5.4	The Final Passage of the Recurrent Sunspot Series	36
	4.6	The Solar Region 6964 that Crossed the Solar Disk Between September 13 and 26, 1963	36
	4.6.1	The Small RF Burst on September 14, 1963	37
	4.6.2	The Very Great Burst on September 16, 1963	37
	4.6.3	The Major RF Burst at 1436 on September 16, 1963	38
	4.6.4	The Great Burst at 3750 Mc/s Starting at 0100 on 21 September 1963	38
	4.6.5	The Major RF Burst and PCA on September 26, 1963	39
5.0	SPECTRA OF ACTIVE REGIONS, AND PROTON WARNING CRITERIA		40
	5.1	Time Relation of Flare Maximum and RF Peak Flux	40
	5.2	Spectral Characteristics of RF Emissions	41
	5.3	Spectra of Active Regions	42
	5.3.1	Spectral Characteristics of the Region 4708, August 1958	43
	5.3.2	Spectral Characteristics of the Region 5148 that Crossed the Solar Disk Between May 8 and 22, 1959	44
	5.3.3	Spectral Characteristics of the Region 5265. The Source of Three of the Largest PCA Events of the 19th Solar Cycle	44
	5.3.4	Spectral Characteristics of the June 1959 Active Region 5204	45
	5.3.5	Spectral Characteristics of RF Emissions Associated with White Light Flares	46

TABLE OF CONTENTS (cont'd)

		Page
5.3.6	Spectral Characteristics of the Active Region During the Increasing Branch of 20th Solar Cycle	47
6.0	SOLAR ACTIVITY SINCE 1963	48
6.1	The Small PCA Event on 16 March 1964	49
6.2	The Small PCA Event on 5 February 1965	49
6.3	The Small PCA Event on 24 March 1966	50
6.4	The PCA Event on 7 July 1966	50
6.5	The Active Region 8461	51
6.5.1	The RF Burst and Small PCA on 28 August 1966	51
6.5.2	The RF Burst, and PCA on 2 September 1966	51
6.6	The Active Region 8818 that Crossed the Solar Disk Between May 18 and June 1, 1967	52
REFERENCES		53
BIBLIOGRAPHY		54

TABLES

Number	Title	Page
1	CHARACTERISTICS OF CLASS 1 RF PROFILES AND ASSOCIATED PHENOMENA. EVENTS FOLLOWED BY A PCA	60
2	CHARACTERISTICS OF CLASS 2 RF PROFILES AND ASSOCIATED PHENOMENA. EVENTS FOLLOWED BY A PCA	60
3	CHARACTERISTICS OF CLASS 3 RF PROFILES AND ASSOCIATED PHENOMENA. EVENTS FOLLOWED BY A PCA	60
4	CHARACTERISTICS OF CLASS 4 RF PROFILES AND ASSOCIATED PHENOMENA. EVENTS FOLLOWED BY A PCA	60
4a	RF BURSTS AT 2800 ON 3750 Mc/s FOLLOWED BY A VERY SMALL OR DOUBTFUL PCA EVENT, PROFILE CHARACTERISTICS	8
5	ALL MAJOR RF BURSTS AT 2800 OR 3750 Mc/s NOT FOLLOWING A KNOWN PCA EVENT	61
6	MAJOR BURSTS AT 2800 OR 3750 Mc/s NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION, CLASS 1 PROFILE	63
7	MAJOR RF BURSTS AT 2800 OR 3750 Mc/s, NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION. CLASS 2 PROFILE	64
8	MAJOR RF BURSTS AT 2800 OR 3750 Mc/s NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION. CLASS 4 PROFILE	64
9	OUTSTANDING RF EVENTS (FLUX > 1000 UNITS) AT CENTIMETER WAVE LENGTH WITH SMALL (< 500 FLUX UNITS) OR NO EMISSION REPORTED AT 2800 OR 3750 Mc/s	64
10	GREAT RF EVENTS (PEAK > 5000 FLUX UNITS) AT 2800 OR 3750 Mc/s DURING THE 19TH SOLAR CYCLE	65

TABLES (cont'd)

Number	Title	Page
11	THE SOLAR REGION 3400 THAT CROSSED THE SOLAR DISK BETWEEN FEBRUARY 10 AND 24, 1956	65
12	THE SOLAR REGION 3941 THAT CROSSED THE SOLAR DISK BETWEEN APRIL 16 AND 28, 1957	65
13	THE SOLAR REGION 4708 THAT CROSSED THE SOLAR DISK BETWEEN AUGUST 15 AND 28, 1958, AND REGION 4686 THAT CROSSED THE DISK BETWEEN AUGUST 6 AND 18, 1958	65
14	THE SOLAR REGION 5148 THAT CROSSED THE SOLAR DISK BETWEEN MAY 8 AND 21, 1959	66
15	BASIC CHARACTERISTICS OF REGIONS THAT PRECEDED AND FOLLOWED THE JULY 1959 REGION 5265	66
16	THE SOLAR REGION 5265 THAT CROSSED THE SOLAR DISK BETWEEN JULY 8 AND 21, 1959	66
17	POLAR CAP ABSORPTION EVENTS SINCE 1963	48

FIGURES

Number	Title	Page
1	RF CLASS 1 PROFILES, EVENTS FOLLOWED BY A POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	67
2	RF CLASS 2 PROFILES, EVENTS FOLLOWED BY A POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	69
3	RF CLASS 3 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	71
4	RF CLASS 4 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	63
5	RF PROFILES, EVENTS FOLLOWED BY VERY SMALL OR DOUBTFUL POLAR CAP ABSORPTIONS, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	75
6	RF CLASS 1 PROFILES, EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA AND ALL REPORTED FLARE MAXIMA	76
7	RF CLASS 2 PROFILES, EVENTS THAT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	81
8	RF CLASS 3 PROFILES, EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA AND ALL REPORTED FLARE MAXIMA	82
9	RF CLASS 4 PROFILES EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA	83
10	SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUN SPOT GROUP 13464 (GREENWICH 18857) THAT CROSSED THE SOLAR DISK BETWEEN 15 AND 28 AUGUST 1958	84

FIGURES (cont'd)

Number	Title	Page
10a	SPECTRUM OF OUTSTANDING SOLAR RADIO BURSTS ASSOCIATED WITH THE ACTIVE REGION 4708 THAT CROSSED THE DISK BETWEEN 15 AND 28 AUGUST 1958, AND THE EVENT ON AUGUST 16 ASSOCIATED WITH REGION 4686	43
11	SOLAR AND TERRESTRAIL PHENOMENA ASSOCIATED WITH THE ACTIVE REGION 5148 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 22 MAY 1959	85
11a	SPECTRUM OF OUTSTANDING SOLAR RADIO BURSTS ASSOCIATED WITH THE ACTIVE REGION 5148 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 22 MAY 1959	44
12	DAILY AREA OF THE RECURRENT SUNSPOTS THAT PRECEDED AND FOLLOWED THE JULY 1959 GROUP 19448 (MW 14284)	29
13	SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP 14211 THAT CORSSED THE DISK BETWEEN 9 AND 23 JUNE 1959	86
13a	SPECTRUM OF THE OUTSTANDING SOLAR RADIO BURSTS ASSOCIATED WITH THE ACTIVE REGION 5204 THAT CROSSED THE SOLAR DISK BETWEEN 11 AND 23 JUNE 1959	31 45
14	SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP 14284 THAT CROSSED THE DISK BETWEEN 8 AND 21 JULY 1959	87
14a	SPECTRUM OF OUTSTANDING SOLAR RADIO BURSTS ASSOCIATED WITH THE ACTIVE REGION 5265 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 21 JULY 1959	44
15	SUNSPOT BROUP IN PLAGE REGION 2565 ON 13 JULY 1959	33
16	SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP 15353 THAT CROSSED THE DISK BETWEEN 8 AND 21 JULY 1961	88

FIGURES (cont'd)

Number	Title	Page
6-1	THE RF PROFILE, FOR 2800 Mc/s ON 16 MARCH 1964 SHOWING REPORTED FLARE MAXIMUM AND RELATED PHENOMENA	49
6-2	THE RF PROFILE, FOR 2700 Mc/s ON 7 JULY 1966 SHOWING REPORTED FLARE MAXIMA, AND RELATED PHENOMENA	50
6-2a	COMPARISON OF RF PROFILES FOR 2400, 2700, AND 3750 Mc/s FOR THE EVENT ON 7 JULY 1966	50
6-3	THE RF PROFILE FOR 2695 Mc/s ON 28 AUGUST 1966 SHOWING REPORTED FLARE MAXIMUM, AND RELATED PHENOMENA	51
6-3a	SPECTRUM OF THE GREAT SOLAR RADIO BURST ASSOCIATED WITH THE IMPORTANCE 3B FLARE ON 28 AUGUST 1966	47
6-4	THE RF PROFILE, FOR 2700 Mc/s ON 2 SEPTEMBER 1966 SHOWING REPORTED FLARE MAXIMUM AND RELATED PHENOMENA	51
6-5	THE GREAT RF BURST ON 2695, AND 2800 Mc/s ON 23 MAY 1967 SHOWING X-RAY EMISSION FLARES WITH REPORTED TIMES OF MAXIMUM AND RELATED PHENOMENA	52
6-5a	THE IMPORTANCE 2N FLARE, RF BURST AT 2695 Mc/s AND X-RAY 2-12A ON 21 MAY 1967	52

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1.0 SUMMARY

This report summaries the various tasks and the results of the analyses carried out under the subject contract (Ref. 2). The tasks set forth in the contract proposal (Ref. 1) are given below with a brief summary of accomplishments, problems conclusions, and recommendations.

The data, detailed analysis, and interpertations are presented in the subsequent sections. Many of the data used during this study were given in references 3, 4, 5, and 6, as well as sources listed in those reports.

1.1 USE FLARE PATROL FILM TO COMPARE MULTI-PEAK RF EMISSIONS WITH POSSIBLE MULTI-MAXIMA FLARES.

Flares patrol films at the McMath-Hulbert and the Sacramento Peak Solar Observatories were examined visually in a frame to frame search for brightness fluctuations and other indications of flare intensity changes. Most of the time were devoted to an analysis of those flares that are associated with RF emissions at centimeter wavelength with multi-peak or complex emission. We also examined flares that were observed by at least one observatory in addition to the McMath-Hulbert or Sacramento Peak observatories with different times of maximum. The reported time of flare maximum varied from one to forty minutes. The flares ranged in importance from 1 to 3+. We also looked for flares that were observed during a period that included the time when the Mt. Wilson polarity drawing were made. An attempt was made to detect:

(a) Fluctuations of flare brightness.

(b) Flare flash or explosive phase in its development.

(c) Flares from " δ " type spots.

(d) Flares that covered part of a sunspot umbra.

The visual analysis of the patrol films was extremely time consuming and detection of changes in a flare was very difficult, and probably quite unreliable, i.e., the time of a brightness change and/or a maximum phase could not be determined with sufficient accuracy to justify a continuation of the investigation. The results of the visual analysis of flare patrol films using a variable speed film reader was very disappointing although not completely unexpected. However, the theory that flares associated with multi-peak or complex RF emissions at centimeter wavelengths have periods of fluctuating brightness closely associated with the peaks of the RF emissions was strengthened.

It was decided that until the solar flare videometer becomes available for the analysis of flare patrol films the comparison and correlation of flare maxima and RF peaks would be limited to the times reported by the observatories as shown on the RF time histories, (Figures 1 through 9).

It was not possible to accurately identify flares with an initial flash phase or very rapid Hα emissions increase, except in a very few cases, although considerably more than the anticipated amount of time was spent on this phase of the work.

1.2 EVALUATION OF RF TIME HISTORIES

RF time histories at 2800 or 3750 Mc/s were reconstructed for 40 of the 59 basic PCA events as shown on Figures 1, 2, 3, and 4.

The nineteen missing events were distributed among the basic frequencies as shown below.

F	2800	2980	3000	3750	Other
No.	4	5	2	6	2

All of the missing events at 3750 had reported Peak flux less than 500 units, while the missing events at 2800 occurred during the sunrise or sunset period.

In addition to the RF emissions associated with basic PCA events, time histories were reconstructed for four events associated with small or doubtful PCA events and 61 events with RF peak flux greater than 500 flux units with no known PCA association.

1.3 CORRELATION OF Hα FLARES AND RF TIME HISTORIES

Because of the problems encountered in the analysis of flare patrol films it was decided to proceed with the correlation using all reported times for flare maximum. While this did not achieve the degree of reliability that had been anticipated, it did show that in general, if RF emissions at centimeter wave lengths with total integrated energy greater than 10^{-17} Joules $(m^2\ c/s)^{-1}$ as calculated by Lopez, et.al, were not followed by a known PCA event,the associated flare had a slow and gradual rise to maximum intensity. This is clearly shown in figures 6.44, 6.45, 7.6, 9.6, and others.

Due to the number of cases where the integrated energy and other criteria show strong indications that the events "should" have been followed by a PCA, it was decided to reexamine the problem with a more detailed analysis of active solar regions that produced one or more PCA events, and one or more major RF events that were not followed by a known polar cap absorption. The analysis of these "multi-event" is presented in Section 4 of this report.

1.4 ANALYSIS OF CURRENT RF AND Hα FLARE DATA

Sufficient data has been obtained to carry out a preliminary analysis of 10 possible polar cap absorption events (Table 18) reported during the first three years of the present (20th) solar cycle. The Preliminary analysis of these events is given in Section 6 of this report. Based on present criteria at least four and possibly five of these events would be classified as major.

1.5. EVALUATION OF FLARE POSITION WITH RESPECT TO SUN SPOT UMBRA AND FLARES FROM SUNSPOTS WITH A "δ" CONFIGURATION

Investigations under these two tasks has failed to contribute any new statistical evidence with respect to their importance as a necessary or sufficient condition for a flare to be followed by a PCA event, or that the region will produce a PCA flare sometime during disk passage. Both of these tasks will require a large amount of additional time before reliable conclusion can be made. It is felt at this time that the "δ" configuration is quite significant when combined with other criteria. However during our analysis of multiple event regions Mt. Wilson sun spot polarity drawings were not made in a number of critical cases and time did not permit a search for other sources.

2.0 RF PROFILES AND TIME HISTORIES

As stated above, RF time histories at 2800 Mc/s or 3750 Mc/s have been reconstructed for 40 of the 59 basic PCA events, and for 62 of the 95 events reported at 2800 or 3750 Mc/s with a peak ≥ 500 flux units* and were not followed by a known polar cap absorption. The missing events reported by Ottawa at 2800 Mc/s occurred during sunrise and sunset or the records were incomplete. In the case of the missing 3750 Mc/s events, the necessary original data have not been received.

2.1 PEAK FLUX CLASSIFICATION OF RF EMISSIONS

In order to simplify the classification of the RF Bursts, we have arbitrarily established seven importance classification as shown in Table 2.1.1 below:

Peak Flux Range	Imp. Class	Basic PCA Events: 2800 & 3750 Mc/s No. Events	Basic PCA Events: 2800 & 3750 Mc/s No. Analyzed	Basic PCA Events: f Other	No Known PCA: 2800 & 3750 Mc/s No. Events	No Known PCA: 2800 & 3750 Mc/s No. Analyzed	No Known PCA: Other
RF ≥ 10000	3+	3	3	0	0	-	0
10000 > RF > 5000	3	8	8	0	2	2	1
5000 ≥ RF > 2000	2+	4	4	3	8	5	2
2000 ≥ RF ≥ 1000	2	12	12	2	35	26	4
1000 > RF ≥ 500	1+	7	6	2	50	29	74
500 > RF ≥ 250	1	8	4	1	**		
250 > RF	1-	7	3	2	**		
TOTAL		49	40	10	95	62	81

** Not considered in this study

Table 2.1.1

Peak Flux Classification of RF emissions

It is clearly seen from this table that while 69% of the PCA events have been associated with RF bursts with a peak greater than 500 flux units, there is no correlation between Rf emission magnitude and PCA events. In fact, there is only a 58% probability that a peak emission greater than 2000 flux units will be followed by a PCA event.

* One flux unit equals 10^{-22} $W(M^2 c/s)^{-1}$

All RF bursts at 2800 or 3750 Mc/s that were not followed by a known PCA event are listed in Table 5 chronologically in each peak flux importance class. We have included the associated flares, short wave radio fade, spectral emissions Type II and Type IV.

2.2 RF PROFILE CLASSIFICATION

RF bursts at centimeter wave length have generally been grouped in several rather broad classifications. However, in order to compare the RF profiles for PCA and non-PCA events we established four profile classes that will, unambiguously, include all but two or three of the RF time histories.

Class 1. Impulsive burst with Narrow Profile

Class 2. Impulsive Burst with Two or More Major Peaks and A Broad Profile

Class 3. Bursts with Two or More Distinct Phases Separated by a Period of Low Flux

Class 4. Bursts with a Complex Slow Rate of Increase to the Peak Flux

The number of PCA and non-PCA events in each profile class and RF importance is shown in Table 2.2.0 Below.

Profile	Class 1		Class 2		Class 3		Class 4	
RF Imp.	PCA	No PCA	PCA	No PCA	PCA	No PCA	PCA	No PCA
3+	2	0	1	0	0	0	0	0
3	1	0	3	1	0	0	4	1
2+	1	5	2	0	0	0	2	0
2	4	22	1	3	6	1**	1	1
1+	2	19	1	3	1	0	0	6
1	1	*	2	*	0	*	2	*
1-	0	*	0	*	0	*	3	*
TOTAL	11	46	10	7	7	1	12	8

* Only events with peak flux ≥ 500 RF (importance ≥ 1+) are included.
**There is another event long delay time between Phases (Fig. 9.2)

Table 2.2.0 Peak Flux Distribution By Profile Class

Approximately 75% of the non-PCA events have an impulsive narrow profile.

2.2.1 RF Class 1 Profiles

The reconstructed Class 1 profiles are shown on Figure 1 for the PCA events and Figure 6 for the non-PCA events.

In order to compare the PCA and non-PCA events, three basic characteristics were chosen: (1) Rise Time in Minutes, (2) The Half Width, i.e., the time in minutes that the flux is greater than half (or 50%) the peak intensity, and (3) the time that the burst remained greater than 10% of the peak intensity.

The basic characteristics of the 11 PCA events and the 46 non-PCA events are given in Tables 1 and 6 respectively, where the events are listed in the sequence of increasing half width.

It is clearly seen from an examination of Figures 1 and 6 and Tables 1 and 6 that the half width and duration greater than 10% of the peak, tend to differentiate PCA from non-PCA events. This is shown in Table 2.2.1.

	50%		10%	
	PCA	No PCA	PCA	No PCA
Average Time	3	24	18	8

Table 2.2.1
Characteristics of Class 1 Profiles

If we use these characteristics the PCA event on 28 August 1957 (FIG. 1.1) would have been a failure, while 7 of the 46 non-PCA events would be classified as false alarms. In fact, all seven (Figures 6.40 through 6.46) have other PCA characteristics and their inclusion as Class 1 profiles is questionable.

2.2.2 RF Class 2 Profile

The reconstructed RF class 2 profiles are shown on Figure 2 for the PCA events and Figure 7 for non-PCA events. The basic characteristics of the Class 2 profiles are shown in Tables 2 and 7 for the PCA and non-PCA events respectively.

There does not appear to be any outstanding characteristic that will differentiate the PCA from non-PCA events. However, the time of RF peak follows the time of flare maximum ($\Delta t > 0$) for 8 of the 10 PCA events while the RF peak precedes the time of flare maximum for 6 of the 7 non-PCA events. We also find a relatively good correlation between the reported time of flare maximum and the multi-peaks of the RF emission in those cases where more than one time of flare maximum was reported.

In the case of the PCA events there is a relatively rapid increase in flare brightness, based on the cases where more than one flare maximum is reported, it is quite probable that the PCA flares have an initial flash phase or very rapid initial increase in brightness while the non-PCA increase slowly.

2.2.3 RF class 3 Profile

This profile class has been defined as a burst with two or more distinct phases separated by a period of low flux. The reconstructed RF time histories for the 7 PCA events and one non-PCA event are shown on Figures 3 and 8 respectively and the basic characteristics for the PCA events are given in Table 3. The time separation of the distinct phases varies from 17 minutes for the event of 6 May 1960, to 44 minutes on 7 July 1958.

Only one non-PCA event belongs in the class (Figure 8.1). The two narrow band impulsive events on June 9, 1958 (Fig. 6.10 and 6.46) were separated by a period of 35 minutes with a flux less than 10% peak and 50 minutes between peaks.

Their classification as a class 3 profile (Fig. 8.2) would be justified if they could be associated with a single flare with two distinct phases. In this case there was no flare reported at the time of the first burst (probably no flare patrol). However, the great short wave fade starting simultaneously with the start of the RF and continuing for three hours would indicate a flare starting sometime before 1635 UT.

2.2.4 RF Class 4 Profiles

This profile group includes events with a smooth gradual increase to peak flux and those with a complex slow rate of increase. The reconstructed time histories are shownon Figure 4 for the PCA events and Figure 9 for the non-PCA events.

It is quite significant to note that type IV emissions were reported at meter wavelength for the eight PCA flares and five of the non-PCA flares that occurred during the normal observing time at Fort Davis or Culgoora and at centimeter wavelength for all 12 of the PCA events, and seven of the non-PCA flares (derived by Svestka and Olmr, 1966).

Three of the Class 4 PCA-RF Bursts were very small and would not have been considered as possible PCA events. (Figure 4.2, 4.11, and 4.12, and Table 4). The flare PCA association may be questionable in these cases, however, a careful search of the records fail to reveal any other possible source either on the visible disk or behind the East or West limbs of the sun. The non-PCA event on 17 April 1967 (Figure 9.6) was one of the very great bursts observed during the 19th solar cycle (Table 10). It has all of the characteristics of a PCA event except an apparent very slow rate of increase in flare brightness. (Almost 80 minutes from the reported start to maximum.) This is also a case where the flare with reported importance 3+ occurred near the east limb. (See section 4.2 for an analysis of the region responsible for this great RF event.)

2.3 PROFILE CHARACTERISTICS OF RF EMISSIONS ASSOCIATED WITH SMALL OR DOUBTFUL PCA EVENTS.

2.3.1 Small Polar Cap Absorption Events Based on f_{min} Observations

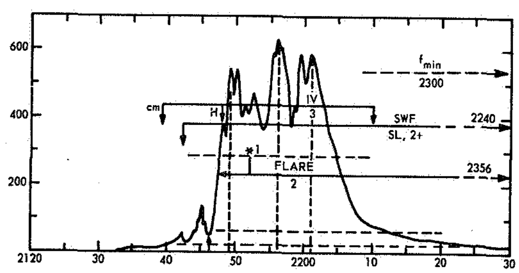
A list of small or doubtful Polar Cap absorptions events reported in the literature was given in Table 7 of Reference 3. Most of these events were based on f_{min} data. Only one of 23 events was associated with a major flare (importance 3+). The RF emission exceeded 500 flux units at centimeter wavelength in only three of the events, and two events at decimeter wavelength (1420 Mc/s), small bursts at 2800 or 3750 Mc/s were reported in a number of cases.

TABLE 4a RF BURSTS AT 2800 OR 3750 Mc/s FOLLOWED BY A VERY SMALL OR DOUBTFUL PCA EVENT, PROFILE CHARACTERISTICS

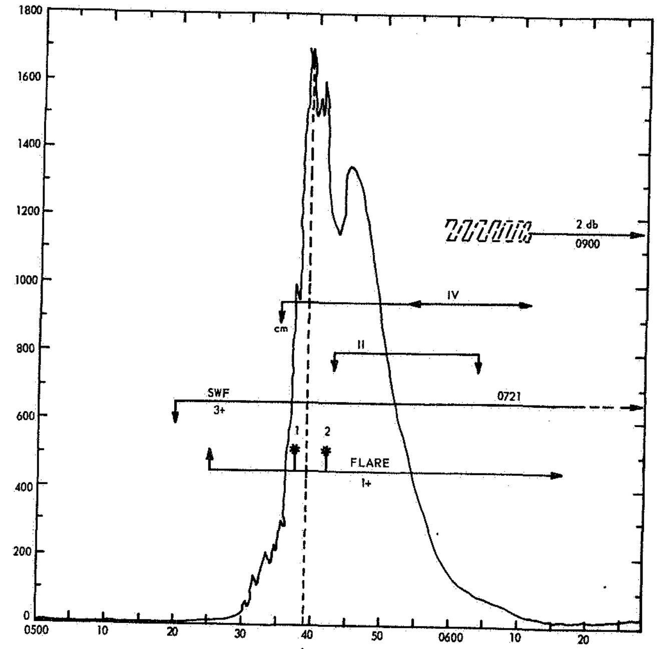
IMPORTANCE				DURATION					SPECTRAL							INTEGRATED Int. P/cm²		RF ENERGY
DATE	RF	FLARE	db	RISE TIME	≥ 50%	≥ 10%	PROFILE CLASS	RATE RISE	II	IVm	IVcm	Δt	ΔT	CMD	FIG. NO.	> 10 MeV	> 100 MeV	>10%
9/26/60	2	1 +	2	9	13	27	2	190	S/2	S/1	5g	0	$3^h\ 35^m$	W64	5.1	2.0×10^6	1.2×10^5	108
11/14/60	2+	2 +	VS	20	25	100	3	2150	-	S/3	10G	+ 50	19^h XX^m	W20	5.2			663
11/11/60	2+	2	VS	30	24	110	4	1130	S/2	S/3	10G	+ 5	1^h XX^m	E12	5.3			237
6/04/58	1+	2	fmin	3	17	26	2	147	-	H/3	6g	+ 3	$1^h\ 13^m$	W58	5.4			

A reliable flare association was not possible in six cases.

RF profiles were reconstructed for two of the events (4 June 1958, and 26 September 1960) associated with small PCA's (Table 4a) both were class 2 profiles, (Figures 5.1 and 5.4).



5.4 4 June, 1958; 2800 Mc's., R.F. Class 2 Profile, 1 – Sec. P.; N14W58 f_{min} Reported 2300



5.1 26 Sept., 1960., 3750 Mc's., R. F. Class I Profile, 1 – Tachk., Mitaka, 2 – Crime., S22W64

Data were not available for the RF burst on 3750 Mc/s with a peak of 530 flux units at 0357 on 13 June 1959. The flare occurred in the Region 5204 which will be analized in section 4.5.2, during our discussion of multi-event regions.

2.3.2 Very Small Polar Cap Absorptions Based in High Sensitivity-Vertical Incidence Back Scatter

A list of 24 very small PCA events not reported by other observers, were found by Gregory (Table 8, Ref. 3) during analysis of high sensitivity vertical incidence back scatter sounding of the lower Ionosphere at a frequency of 2.3 Mc/s at south 79° geomagnetic latitude. Gregories list is limited to events during 1960. Five of these events were associated with major flares (importance ≥ 3). Four of the very small PCA events were associated with the multiple event region 5925 that crossed the solar disk between November 8 and 18, 1960. The four small PCA's were reported by Gregory on November 10, 11, 14, and 19, 1960, while great PCA events occurred on Nov. 12 and 15, and a smaller event on the 21st when the region was at least 20 degrees behind the west limb. The PCA on the 19th started approximately eight hours after an importance 3 flare at E28 which was accompanied by small bursts at centimeter, decimeter and meter wavelengths as shown in table 2.3.1.

Date	Start	Max	Imp	f	Onset	Max	Peak Flux
11-10-60	1009	1023	3	9100	1012	1019	600
				2980	1015	1021.7	360
				1500	1016	1120.6	600
				800	1018	1224	> 320
				545	1020	-	100
				200	1020	-	480

Table 2.3.1

RF Emissions Associated with a Very Small PCA

This was followed by the second small event which started approximately **one hour** after an importance 2 flare and great RF burst at 3750 Mc/s (Fig. 5.3) and approximately 34 hours before the very great PCA on the 12th, with an absorption of 21.2 db, that PCA was still in progress when an importance 2+ flare and another very great burst was reported at 3750 Mc/s on the 14th (Figure 5.2) followed in less than an hour by another very small PCA (reported by Gregory).

Again this small event was followed within six hours by another great PCA. The fourth in this group of very small events reported by Gregory occurred about an hour after an importance 1 flare at the west limb. No RF emissions were reported at any wavelength at the time of the flare.

3.0 GREAT EVENTS AT 2800 Mc/s or 3750 Mc/s DURING THE 19TH SOLAR CYCLE

During our analysis of the flare - RF emission - PCA association we find 13 RF events reported in the literature with a peak greater that 5000 flux units at 2800 or 3750 Mc/s. There were no events of this magnitude reported at either 2980 Mc/s or 3000 Mc/s (Either Tokyo or HH1).

TABLE 10 GREAT RF EVENTS AT 2800 OR 3750 Mc/s DURING THE 19TH SOLAR CYCLE

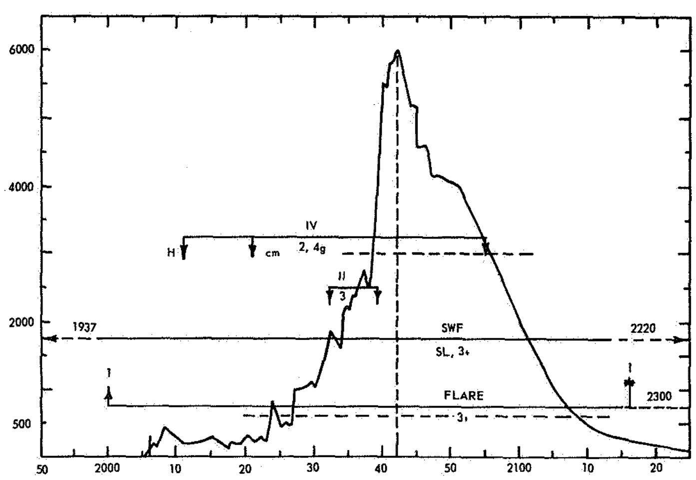
FIG.	DATE	CMD	FLARE IMP.	f	PEAK	PCA db	Δ T	PROFILE CLASS	FLARE ONSET	Δ t	OTHER f	PEAK
1.8*	2/23/56	W80	3 +	3750	18000 7400	13.0	$0^h\ 23^m$	1	0334	-6.5 +1.5	3000 200	> 4410 >20000
1.4*	9/03/60	E88	2 +	3750	12000	2.7	$4^h\ 23^m$	1	0037	-3, -6	9400 2000	14700 7100
2.1*	11/15/60	W35	3	3750	11600 7400	20.0	$2^h\ 23^m$	2	0207	+1. +17.5	9400 2000 1000	24000 4950 8100
4.5	3/29/60	E30	2 +	3750	8250	2.6	$1^h\ 20^m$	4	0640	+30, +23, +22, +20.5	2000 200	49000 38000
7.5	9/15/63	E75	2	3750	4500 8080	NONE	REPORTED	2	0015	+10, -1, -3, -5 +22, +11, +9, +7	9400 2000	17000 2500
2.9*	7/16/59	W30	3 +	2800	4000 6500	21.2	$1^h\ 36^m$	2	2114	-3.5, -7.5, -9.5 +29.5, +25.5, +23.5	200	1100
4.8	7/10/59	E63	3 +	3750	6300 4500	20.0	$1^h\ 54^m$	4	0206	+1.5, -12 +14.5, +0.5	9400 1000	26500 6000
4.7	7/14/59	E04	3 +	3750	6000	23.7	$1^h\ 20^m$	4	0325	+7	9400 200	6300 10000
4.4	4/05/60	W62	2	3750	6000	3.1	$1^h\ 45^m$	4	<0215	FLARE ONSET NOT SEEN	9400 2000 1000	14200 1230 18000
9.6	4/17/57	E69	1	2800	6000	NONE	REPORTED	4	2000	?		
1.10	8/16/58	W50	3 +	3750	5800	>15	$1^h\ 28^m$	1	0433	0, -1	9500 3000 200	7340 5030 18000
2.7*	11/12/60	W40	3 +	2800	4900 4800 5500	21.2	$0^h\ 45^m$	2	1315	+1.5 +6.5 +16	9100 1500 200	>7500 770 2000
1.7a	9/20/63	W09	2	3750	5350	PCA IN PROGRESS FOR ~50 MINUTES			2314	+ 51	9400 2000	3500 2100

* GROUND LEVEL EVENT

Ten of these great bursts were followed by Polar Caps absorption including seven with an absorption greater than 10 db. However, there is no good correlation between the PCA intensity and the RF magnitude or flare importance as shown in Table 10.

3.1 GREAT RF BURSTS NOT FOLLOWED BY A PCA

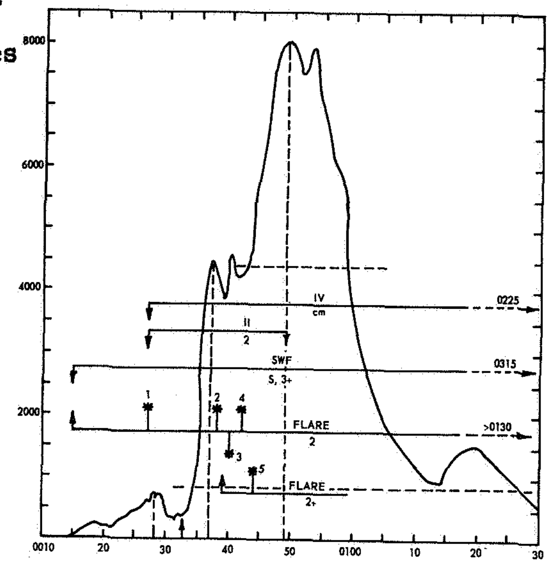
Only two of the great bursts were not followed by a Polar Cap absorption (Table 10). Both of the non-PCA events are associated with flares in solar regions that had been on the visible disk less than two days. The importance 3+ flare on April 17, 1957, was the third major flare from plage 3941. The sunspot group had an area of 1000 millionths on the 17th at E66. The group decreased to an area of



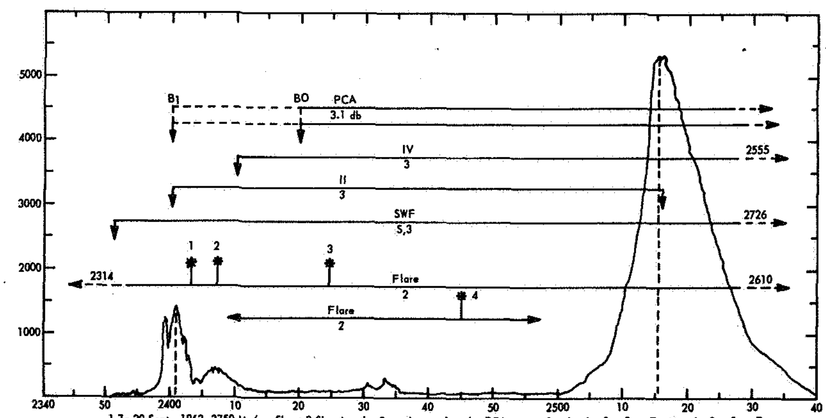
9.6 17 April, 1957; 2800 Mc/s.; 1 – Honol., N12 E70

329 millionths when it crossed the Central Meridian. While the region was the source of 36 flares during disk passage, the three major flares on the 16th and 17th were the only ones reported. (See section 4.2, and Table 12).

The other great burst not followed by a PCA was also associated with a flare near the east limb on September 15, 1963, in a region that produced 87 flares during disk passage and two PCA events one near the central meridian, the other near the west limb. The PCA event near the central meridian, was followed within approximately 50 minutes by the great burst on the 20th which reached a peak of 5350 flux units; the flare associated with the PCA was probably responsible for the great burst that started at 2314 UT and continued for approximately three hours.



7.5 15 Sept., 1963; 3750 Mc/s.; 1 – Ikom; 2 – Mani., 3 – Lock., 4 – Honol., N15E75; 5 – Erkut., S31E65



1.7a;20 Sept., 1963, 3750 Mc/s., Sheet 2 Showing the Great burst after the PCA onset, 1 – Lock., 2 – Sac. P., Honol., 3 – Sac. P., N10 W10;4 – Irkut. N18W04.

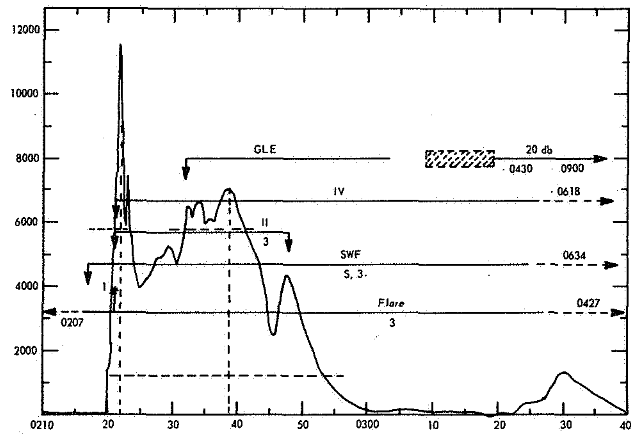
3.2 GREAT BURSTS FOLLOWED BY A PCA

Five of the great PCA bursts occurred in two very active regions. One group occurred on the 10th, 14th, and 16th, of July 1959, the other on November 12 and 15, 1960.

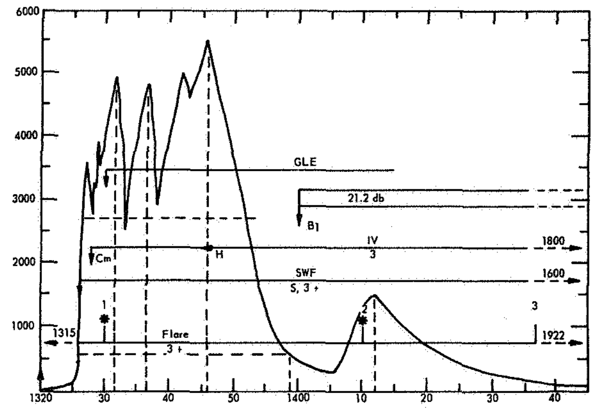
3.2.1 The Sequence of Events During November 1960

The two events during November 1960 have been classified as class

2-profiles as shown on figure 2.1 and 2.7.

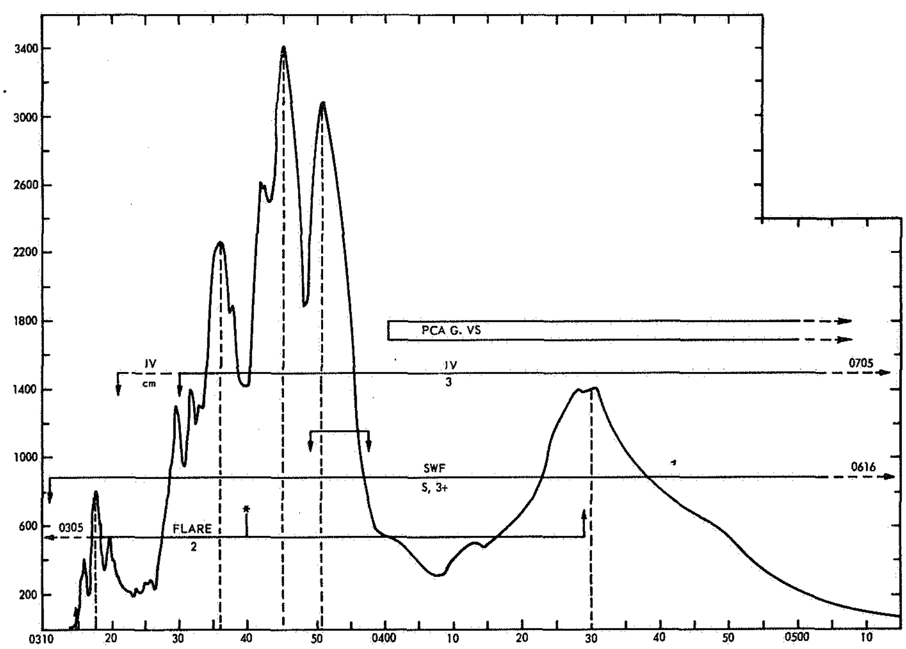


2.1; 15 Nov. 1960; 3750 Mc s., 1 – Mitaka N26W33



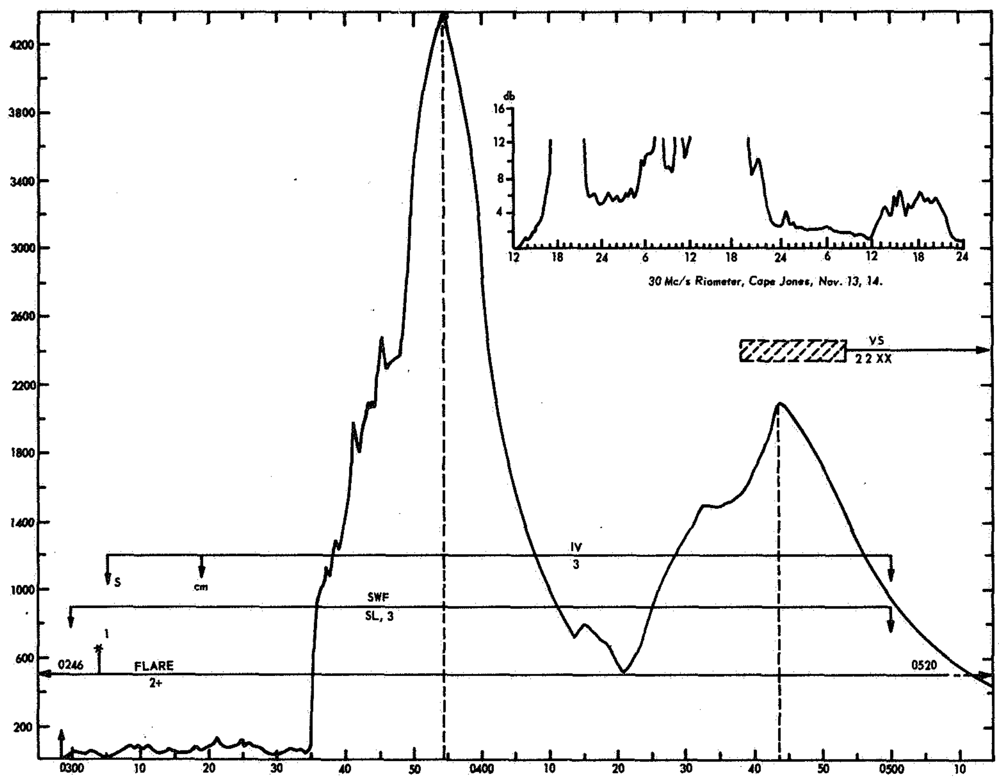
2.7; 12 Nov., 1960, 2800 Mc s., 1 – Cape T., 2 – Huan, 3 – Sac. P., N27W04

For the purpose of comparison we show the profile (Fig. 5.3) of the burst on 11 November. Gregory has reported a PCA based on analysis of high sensitivity vertical incidence back scatter soundings of the lower ionosphere at a frequency of 2.3 Mc/s at South 79° geomagnetic latitude. The shape of the profile and the associated pheomena, indicate that a PCA probably occurred.



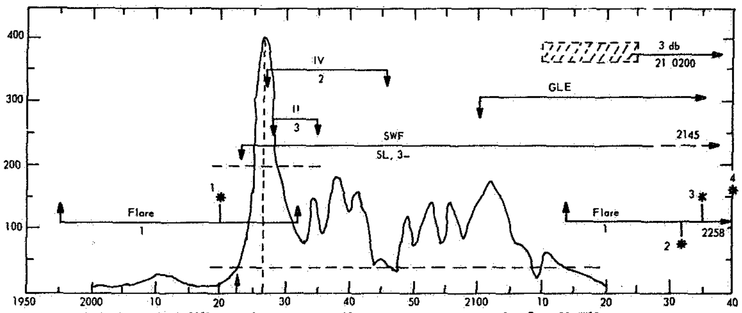
5.3 11 Nov., 1960, 3750 Mc s., R.F. Class 4 Profile, 1–Verosh. N29E12; Very Small PCA, Reported by Gregory

The RF burst starting at 0335 on the 14th also shows all of the characteristics for a PCA event, the 30 Mc/s Riometer at Capt Jones indicates an increase in absorption at about 1200 UT on the 14th approximately 9 hours after the start of the 2+ flare or $8^h\ 25^m$ after the RF onset. Gregory reports a small PCA with onset at approximately 2200 UT. The situation is confused since the great PCA which started at 1400 on the 12th is still in progress. The reconstructed time history is shown on figure 5.2 with the associated phenomena.



5.2 14 Nov., 1960; 3750 Mc/s., R.F. Class 3 Profile, 1– Mitaka, N27W20, Very Small PCA, Reported by Gregory.

The final event of the November 1960 sequence is a somewhat subdued impulsive burst with a peak of only 400 flux units followed by a prolonged complex post burst increase. This event is unique since the active region was approximately 20 degrees behind the West limb. The flare has been classified with importance 1.

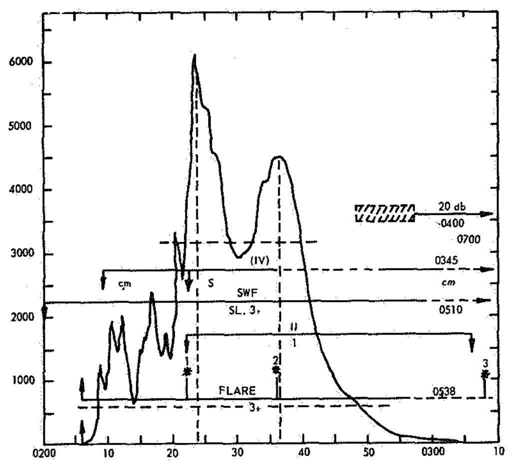


1.11; 20 Nov., 1960, 2800 Mc s., 1 – Lock., N25W120, 2 – Honol., 3 – Lock., 4 – Sac. P., N 28 W90.

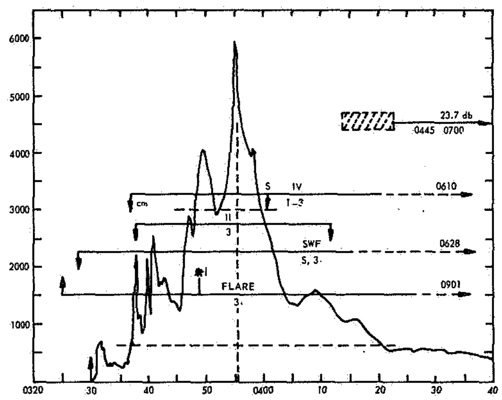
If the flare is associated with the active region 5925 it must have been of major importance.

3.2.2 RF Profiles for the Great Bursts During July 1959.

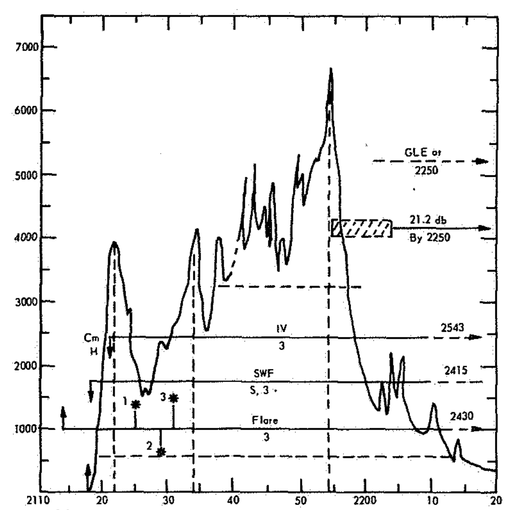
The active region responsible for the great series of events during July 1959 will be analized in detail in section 4.5. We have included the RF Profiles here for comparison.



4.8 10 July, 1959, 1 – Tachk., 2 – Syd., 3 – Alma A., N20E63



4.7 14 July, 1959, 3750 Mc 's., 1 – Tachk., N17E07

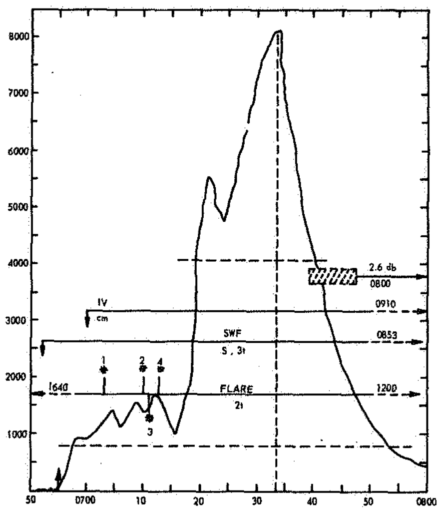


2.9; 16 July, 1959., 2800 Mc s., 1 – McM, 2 – Lock., 3 – Clim. N16 W30

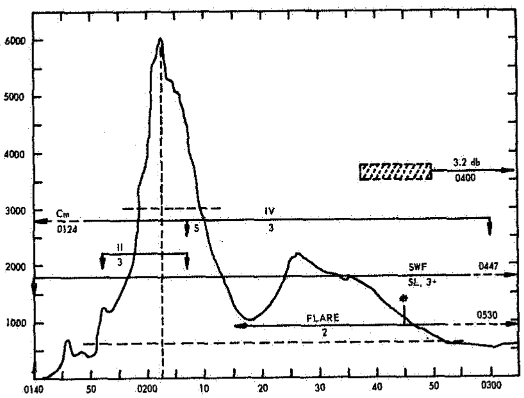
3.2.3 Profiles for the Two RF Emissions From Solar Region 5615.

This active region was the source of only one major flare, but has been associated with two of the very great bursts at centimeters wavelength and four PCA events.

The reconstructed time histories of the two great bursts are shown on figures 4.4 and 4.5.



4.5 29 March, 1960., 3750 Mc's., 1 – Alma A., 2 – Ondr., 3 – Abast., 4 – Bakov., N13E30



4.4 5 April, 1960., 3750 Mc s., 1 – Kodk., N 12 W61.

4.0 MULTI-EVENT REGIONS DURING THE 19TH SOLAR CYCLE

We have shown in a previous study (Ref. 4, Jonah 00.802, 1966) that 38 of the 59 basic PCA events were associated with flares with corrected importance ≥ 3. Twenty of the PCA events were associated with regions that produced two or more flares with importance ≥ 3 while there were only 13 regions with two or more importance > 3 flares that at least one was not followed by a PCA event. Four of the regions produced 2 PCA events each and one produced 3 PCA events.

In this section we have extended our analysis to all regions that produced at least three outstanding events, ie. An RF burst at centimeter wavelength with a peak greater than 1000 flux units, and/or a flare with importance ≥3 and/or a PCA event. We find eleven regions that meet this requirement. They produced 26 of the 59 basic PCA events, 34 of the 142 flares with importance≥3, and 31 of the 79 RF events with a peak ≥ 1000 flux units.

Region	CMP	Long	Lat	PCA	Flares ≥3	RF cm >1000	Total Flares	Small or Questionable PCA
*3400	2/17.29/56	183	N22	1	4	2	32	
3941	4/22.87/57	259	N28	0	3	2	36	
4125	8/31.33/57	353	S27	4	1	1	61	
4151	9/19.30/57	85	N23	1	3	1	83	1
4708	8/21.89/58	322	N18	3	4	4	60	
5148	5/14.52/59	60	N15	1	4	5	97	
*5262	7/14.66/59	330	N16	3	6	3	96	1
5615	3/31.50/60	30	N12	4	1	3	70	
*5925	11/12.20/60	28	N27	3	3	4	98	3
*6171	7/14.20/61	48	506	4	2	4	79	0
6964	9/20.63/63	309	N13	2	2	2	87	0
Total				26	33	31		5

* Source of Ground Level Effect. (GLE)

Table 4.0.1.

Solar Regions During the 19th Solar Cycle That Produced Three or More Major Events

26 of the large RF emissions were associated with flares with importance ≥ 3, while 53 were associated with minor flares. The distribution with frequency is shown in Table 4.0.2.

f	2800	2980	3000	3750
Flare Imp ≥ 3	10	4	1	11
Minor Flares	18	3	3	29

Table 4.0.2

Large RF events, Distribution With Frequency

The distribution of the minor flares with respect to flare importance is shown in Table 4.0.3. We have one case (NFR) with no flare reported, although records indicate that at least one flare patrol was operating and six cases (NEP) when there was no flare patrol.

Flare Imp.	NFR	NFP	1,1+	2	2+
Number	1	6	11	17	18

Table 4.0.3

Large RF Events (Peak > 1000 Flux Units)
With Minor Flare Importance

Only one of these multiple event Regions (3941) crossed the disk without producing at least one polar cap absorption. Three other regions were the source of one PCA each. Each of these four regions produced at least a major flares.

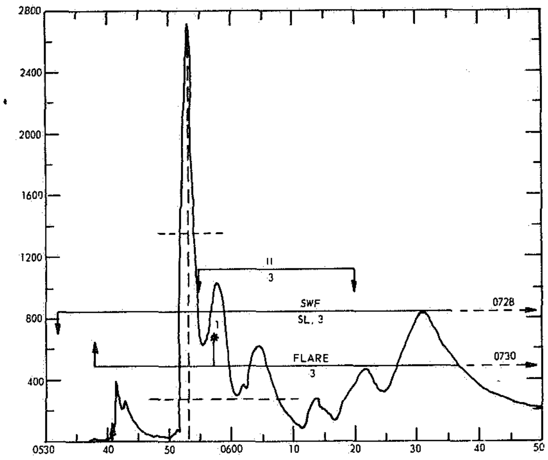
Four of the regions, as indicated on Table 4.0.1 were the source of high energy proton streams that were detected at the earth's surface.(GLE)

These regions were also the source of 13 of the 15 great RF Bursts (Peak > 5000 Flux Units) reported at centimeter wavelengths (2800, or 3750 Mc/s) during the 19th Solar Cycle (Table 10).

Because of the great productivity of these 11 multiple event region five were chosen for detailed study.

4.1 THE SOLAR REGION 3400 THAT CROSSED THE SOLAR DISK BETWEEN FEBRUARY 10 AND 24, 1956

The solar region that was the source of the fifth and largest of the solar high energy particle increase at ground level on 23 February 1956 crossed the east limb of the sun on 10 February 1956. This region was the source of a major east limb flare at 2110 UT on the 10th. The McMath Hulbert observatory reported the flare with, importance 3 because of its explosive nature and the bright loops. The RF burst at 2800 Mc/s had reached an intense of 346 flux units when Ottawa entered the sunset oscillation.



6.30 14 Feb., 1956; 3750 Mc s; 1 – Kodk., N23E26.

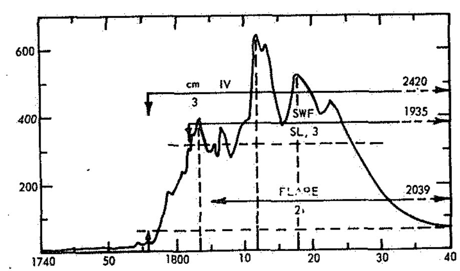
The very large, bright and active plage contained three large sunspot groups. Two of these spots were returns from the previous rotation. The spot 11463 that reached an area of 1734 millionths on the 17th was the source of five major flare, (Table 11) and four large RF burst at centimeter wavelength. The great burst at 3750 Mc/s on the 23rd is the largest recorded burst at centimeters wavelength (see Table 10). The RF profiles for four of the bursts are shown. The three

TABLE 11 THE SOLAR REGION 3400 THAT CROSSED THE SOLAR DISK BETWEEN FEBRUARY 10 AND 24, 1956

FLARE					SWF				SPECTRAL			R F EMISSION						PCA		
DATE	START	MAX.	IMP.	POSITION	START	DUR.	TYPE	IMP.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δt	db	ΔT	FIG. NO.
2/10/56	2110	2138	3	N23E90	2110	55	S	3+				2800	2112		28.5	346*				
2/14/56	0538	0557	3	N21E33	0532	116	SL	3	0554 26/3			3750	0541	0553	75.0	2720				6.30
2/16/56	1805	1837	2+	N20E08	1802	93	SL	3			1756 384/3	2800	1756	1813	51.0	623				9.5
2/17/56	1100	1120	3	N20W04	1102	44	S	3				NONE REPORTED AT CM WAVELENGTH								
2/19/56	1430	1445	1+	N23W27	1429	151	S	3			1428 57/6g	2800	1425	1485	29.0	643				9.2
2/23/56	0334	0342	3	N23W80	0330	160		3+			0335 50/2g	3750	0334	0336	15.5	18000	-6.5	13	$0^h\ 23^m$	1.8

*IN SUNSET OSCILLATION

(6.30; 9.5; and 9.2) that were not followed by known PCA events show the profile characteristic of PCA events. However, in two cases (6.30 and 9.2) the time of flare maximum definitely follows the time of the RF peak intensity. No time of flare maximum was reported for the third case (9.5).

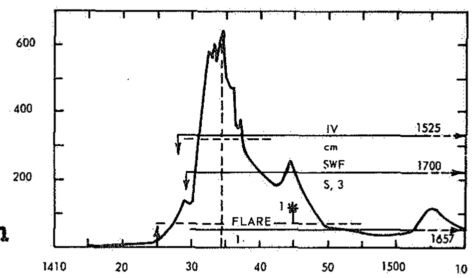


9.5 16 Feb., 1956; 2800 Mc s., No Flare Max. Rep.
Flare Reports; – McM., Sac. P., MtW., N20E08

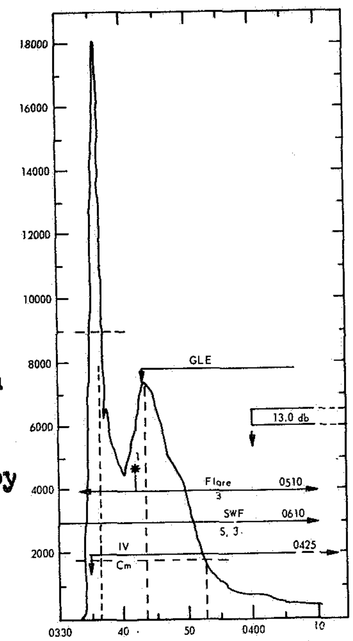
In the case of the great event on 23 February, the start of the flare was not observed, consequently, it is quite probable that the indicated time of flare maximum was a flare intensity increase assoċiated with and preceeding the post burst increast at 0343.5 UT.

An examination of the Mt. Wilson sunspot polarity drawings indicates a " δ " type spot group on the 15th, 17th and 20th of February.

4.2 THE SOLAR REGION 3941 THAT CROSSED THE SOLAR DISK BETWEEN APRIL 16 AND 28, 1957



9.2 19 Feb., 1956; 2800 Mc 's; 1 – Sac. P., N23W27



1.8; 23 Feb. 1956, 3750 Mc s., 1-Tokyo, N23W80.

The second of our multi-major event region is unique since it is the only multiple event region that did not produce at least one polar cap absorption during disk passage. The region was the source of three major flares and at least two were accompanied by great radio emissions at centimeter wavelength.

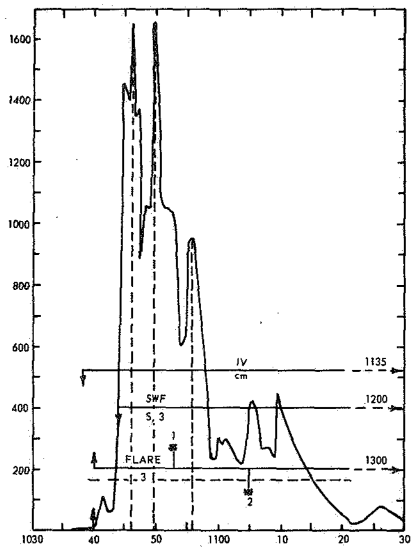
The three flares occurred near the east limb (Table 12) in the large, bright and active plage region 3941 and the magnetically complex sunspot group (Mt Wilson 12285, Greenwich 17976), which crossed the visible disk between April 17 and 28. There were strong indications during the first two days, that the region would produce a polar cap absorption.

TABLE 12 THE SOLAR REGION 3941 THAT CROSSED THE SOLAR DISK BETWEEN APRIL 16 AND 28, 1957

	FLARE				SWF				SPECTRAL				R F EMISSION					
DATE	START	MAX.	IMP.	POSITION	ONSET	DUR.	TYPE	IMP.	II	IVm	IVcm	f	ONSET	MAX.	DURATION	PEAK FLUX	Δt	Fig. No.
4/16/57	1044	1053 1105	3	N20E85	1044	76	S	3			1038 57/3 200-9400	2800	1040	1046	54	1650	- 19	7.1
4/17/57	1006	1022	3	N29E76								2980	1006		4			
4/17/57	2000	2116	3+	N20E69	1937	163	SL	3+	2032 7/3	2011 44/2	2021 34/4g 200-2800	2800	2006	2042	79.0	6000	- 34	9.6

The spot was the return of Mt. Wilson sunspot 12225 (Greenwich 17934) which started as a few tiny spots and developed into a stream of regular spots as it apporached the West limb. The group returned at the east limb as a large composit spot (area 1000 millionths) on the 17th, slowly breaking up. The area had decreased to 329 millionths at CMP and disappeared at approximately W55 on the 27th. Although the plage was the source of 36 flares during disk passage, no major flare or major centimeter RF bursts occurred after the region had been on the disk approximately two days.

The very great burst at 2000 UT on the 17th has already been discussed in Section 3.1 (figure 9.6, Page 11). This burst and the one on September 15, 1963, are the only known cases of very great bursts that were not followed by PCA. In both cases, the flare occurred near the east limb. However, the September region remained very active as it crossed the disk and produced two PCA events, while the April region decreased rapidly in importance.



7.1 16 April, 1957; 2800 Mc 's; 1 – Wend., 2 Meud., N20E85

The flares and RF bursts on the 16th and 17th showed nearly all of the characteristics for a PCA event, except that the flare development was slow and the time of flare maximum, followed the time of RF peak by 13 or 25 minutes on the 16th, and by 76 minutes on the 17th.

The third major flare, from this region, at 1006 on the 16 occurred during the normal observing time at HHl and Nederhurst, but no flux was reported at centimeter wavelength.

4.3 THE SOLAR REGION 4708 THAT CROSSED THE SOLAR DISK BETWEEN AUGUST 15 and 28, 1958

The large magnetically complex sunspot group that crossed the solar disk between August 15 and 28, 1958 at N18 and heliographic longitude 322 was the source of 60 flares. Three of the flares were followed by PCA events. The sunspot group was contained in the bright plage 4708, the third rotation of the solar region which first appeared on the visible disk on 23 June.

	CMP.	Latitude	Area	Brightness	Number Flares
4708	8/22	N18	8000	4/2.5/3.5	60
4657	7/26.5	N17	9000	2.5/3.5/2.5	7
4623	6/29.5	N12	12000	3/3/2	16

During the two earlier rotations, the region was relatively quiet, producing only 16 and 7 flares respectively. Plage 4623 produced only one flare with importance 2+ on June 26 at E49 which was associated with a minor RF emission at centimeter wavelengths and a type IV emission. The other 15 flares were of importance 2 or less with no RF activity. The region contained a normal type stream of bi-polar spots with a maximum area of 561 millionths on June 24, and a mean area of 327 millionths during disk passage.

The activity was about the same during the second rotation with only two importance 2+ flares on July 23rd between E34 and E41 accompanied by minor RF bursts at meter wavelength and a probable type IV emission. The plage 4657 contained a pair of very small spots that disappeared by July 22, at W23.

The first activity of any importance occurred in region 4708 on August 19, at E26 when an importance 2 flare was followed by a type IV emission, followed on the 21st, 22nd, and 26th by polar cap absorptions with intensities of 3.0, 10.6, and 16.6, db respectively. These PCA events have been associated with major flares and great RF bursts at centimeters wavelenghts. (Figures 1.2 4.9 and 2.5).

The first flare reported from Region 4708 occurred at 1316 on August 15, at N14E89 with importance 1 (reported with importance 2 by Wendelstein, and 1 by Capri F). This flare was associated with small bursts at centimeter wavelengths as shown on figure 10.

Five small flares were reported during the next 48 hours with very minor radio activity. An importance 2 flare at 0740 on the 18th at N18E49 was associated with small bursts at centimeter wavelength (Figure 10). This was followed by a period of relative quiet with five small flares, and no RF activity at centimeter wavelength, but considerable activity at meter wavelength. Another importance 2 flare at 2118 on the 19th was accompanied by a type IV emission at meter wavelength and small bursts at all frequencies between

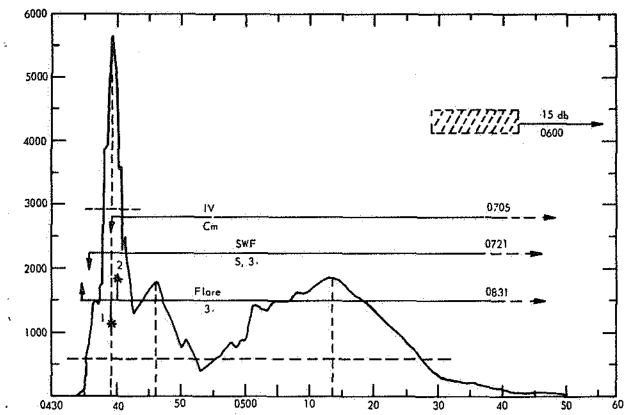
TABLE 13 THE SOLAR REGION 4708 THAT CROSSED THE SOLAR DISK BETWEEN AUGUST 15 AND 28, 1958 AND; REGION 4686 THAT CROSSED THE DISK BETWEEN AUGUST 6 AND 18, 1958

FLARE					SWF				SPECTRAL			RF EMISSIONS						POLAR CAP. ABS.			
DATE	START	MAX.	IMP.	POSITION	ONSET	DUR.	TYPE	IMP.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δ t	ONSET	Int. db.	Δ T	FIG. NO.
*8/07	1457	1505 1508 1509 1510 1511	3	S16E71	1500	105	S	3+				2800	1458 1500 1516	1503 1522	220 15.5 12.5	25 95 180	-17 to -11				
*8/13	1205	1220	2	S14W18	None Reported							2800	1207	1210	11.5	115	-10				
*8/16	0432	0439 0440	3+	S14W50	0432	168	S	3+		0438 57/3+	0439 146/5G 169-9500	3750	0434	0439	60.0	5800	0 -1	0600	15	1^h28^m	1.10
8/19	2118	2254 2258 2320 2331	2	N18E26	2200	65	S	2		2207 114/3	2150 140/6G 169-9500	2800 3750	2204 2206	2210 2210	17.0 10.0	335 315	-44 -48				
8/20	0042	0043 0046	2+	N16E17	0042	33	S	2+	0046 19/3			3750	0041.5	0042.5	5.0	1450	-0.5 -3.5	21/1400	3.0	37^h18^m	1.2
8/22	1417	1448 1506	3	N18W10	1435	170	S	3+		1500 617/2	1438 92/20G 167-9400	2800	1430	1506	120	1500	+18 0	1530	10.6	1^h23^m	4.9
8/25	0949	1000 1003 1005 1015	2+	N16W46								3000	0952	1005	74.0	334	+5 +2 0 -10				
8/26	0005	0027	3	N20W54	0010	240	SL	3+	0021 24/3	0030 240/3	0017 113/20G 167-9400	3750	0005	0041	50.0	5050	+14	0100	16.6	0^h55^m	2.5

* THESE SOLAR EVENTS OCCURRED IN SOLAR REGION 4686 WHICH CROSSED THE SOLAR DISK BETWEEN AUGUST 6 AND 18.

1000 and 9500 Mc/s (Table 13 and figure 10). Three hours later at 0042 UT on the 20th, an importance 2+ flare was reported, with a type II emission between 0045.9 and 0105, a probable type IV emission, and a major burst at 3750 Mc/s (Figure 1.2). The region produced 9 minor flares during the next 48 hours with no activity at centimeters wavelengths and only minor RF emissions at meter wavelengths. A small PCA (absorption 3db) started at about 1400 UT on the 21st.

It should be mentioned that the large polar cap absorption (>15 db) reported at 0600 UT on August 16, has been generally associated with an importance 3+ flare at 0433 in a large, (area 935millionths) and magnetically complex (on flare day) spot group in the southern hemisphere at W50. The RF burst from the flare in region 4686 is shown in figure 1.10 together with related phenomena.



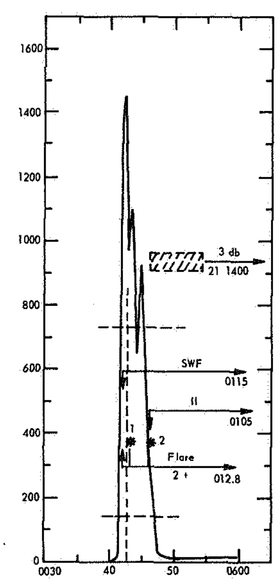
1.10; 16 August, 1958, 3750 Mc s., 1 – Mitaka, 2 – Tachk., S 13 W 50

4.3.1 The RF Emission, H α Flare, and PCA Event on 20, 21 August 1958

The major RF burst at centimeter wavelength and the importance 2+ flare that occurred near the central meridian starting at 0042 UT on August 20, has generally been considered the source of the PCA event on the 21st with an absorption of 3.0 db. The PCA started sometime between 1400 and 1730 UT, and if this association is correct, we have a time delay of more than 37 hours which makes this event almost unique.The only other PCA with a possible long delay was a very small event with an absorption of only 0.5 db, on 12 September 1957, starting more than 23 hours after an importance 3 flare at 0236 UT on the 11th at the central meridian.

The sunspot group in this solar region had an area of 1381 millionths, a Zurich classification E, and a γ magnetic classification on the 20th.

The flare occurred during a magnetically quiet period with no three hour K_p greater than 3+ the day



1.2; 20 Aug, 1958, 3750 Mc/s, 1 – Mitaka, 2 – Honol., N 16 E 17.

before the flare, or greater than 2 on flare day, and the day following. A sudden commencement magnetic storm started at 0227 on August 22, when the K_p index reached 6^- with the absorption still increasing.

The RF time history at 3750 Mc/s (Figure 1.2) shows a very rapid rise to a peak of 1450 flux units in less than a minute, then decreasing to nearly background flux within five minutes. The time of the RF peak intensity at 0042.2 0043.3, and 0044 at 3750, 3000, and 2000 Mc/s (Figure 10a) preceded the reported times of flare maximum by 3.6, 0.6, and 0.0 minutes respectively, or 1.6 minutes, if we use a mean value. Lopez, et.al., calculated an integrated energy of 15 x 10^{-18} $J(M^2c/s)^{-1}$ which according to interpretation, would predict a particle flux $> 10^5$ with energies greater than 30 MeV.

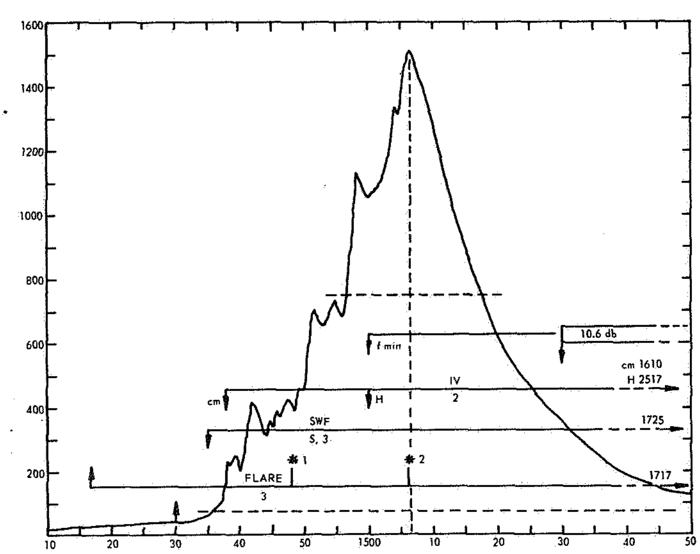
It is possible that one of the nine minor flares that occurred in this region between 0042 and 1617 on the 29th, may have influenced the PCA on the 21st; however, none of these minor flares were associated with other phenomena that might indicate that protons were ejected from the sun. As stated earlier, there was no activity at centimeters wavelenghts and very moderate bursts at meter wavelenghts.

Again the region was very quiet between 1617 on the 20th and 2350 UT on the 21st. Between 2350 UT on the 21st and 1417 UT on the 22nd, a series of six small flares were reported with very minor RF bursts on both meter and centimeter wavelengths, when an importance 3 flare occurred at N18W10.

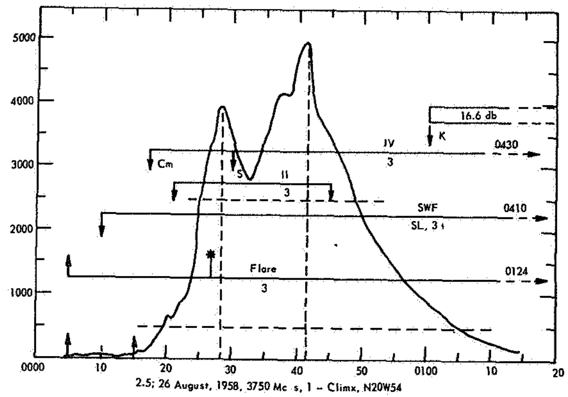
4.3.2 The RF Emission, H α, Flare, and PCA event on August 22, 1958

The PCA that started sometime between 1500 and 1745 on August 22 can be unambigously associated with the importance 3 flare at 1417 UT with major bursts at both meter and centimeter wavelengths. The reconstructed RF time history at 2800 Mc/s is shown on Figure 4.9

Leinbach reports that the Riometer onset of the PCA was obscured by a solar noise storm. Anderson (1958) observed solar protons starting at about 1530 with energies >100 MeV during a balloon flight above Fort Churchill, with maximum



4.9 22 August, 1958, 2800 Mc , 1 –McM., 2 – Otto., N18W10 flux between 1600 and 2000 UT. This event was also observed by Explorer IV at 50° north geographic latitude at 0925 and 1115 UT on the 23rd, and at 1100 UT on the 24th (Rothwell & McIlwain 1959). The satellite data shows that by the 23rd, the particles > 100 MeV had begun to decay while the counting rate of the low energy particles (< 40 MeV) remained high with particles still arriving early on the 26th.



2.5; 26 August, 1958, 3750 Mc s, 1 – Climx, N20W54

4.3.3. The RF Emission, Hα Flare, and PCA Event on August 26, 1958

The region produced a few small flares but was relatively radio quiet on the 23rd and 24th. Flare activity increased during the 25th. An importance 3 Flare started at 0005 on the 26th accompanied by a great burst at 3750 Mc/s (Figure 2.5) with spectral type II at meter wave length and type IV at meter and centimeter wavelengths. Solar protons with energy > 40MeV were detected by Explorer IV with the number of high energy particles decreasing as the event progressed.

Both flare and RF activity decreased as the region approached the West limb. The last flare was reported at 1607 on the 26th at N17 W65.

4.4 THE SOLAR REGION 5148 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 22 MAY, 1959

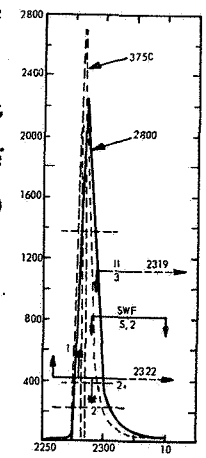
The very large, bright and flare productive plage crossed the East limb of the sun on May 7. This plage containted three large sunspot groups that lasted limb to limb, one spot that was seen in the 13th only, and two others that lasted approximately five days. The Greenwich spot 19335 is the leading part of Mt. Wilson 14121(βγ SPOT) and 19336 is the following part, while 19337 corresponds to Mt. Wilson 14122 (γ spot), Figure 11. This region produced four flares with importance ≥ 3 and six RF bursts at 2800 or 3750 Mc/s with peak intensity > 500 Flux units (Table 14).

TABLE 14 THE SOLAR REGION 5148 THAT CROSSED THE DISK BETWEEN MAY 8 AND 21, 1959

FLARE						SPECTRAL			PCA		RF EMISSION						
	START	MAX.	Imp	POSITION	SWF	II	IVm	IVcm	Δ T	IMP db	f	ONSET	MAX.	DUR.	PEAK	Δ t	FIG.
08	2252	2256 2258	2+	N23E86	S/2/22	2259 20/3					2800 3750	2254 2254	2257 2256.5	48 10	2200 2750	+1, -1	6.22
09*	0123	0150	3	N20E78	NR												
10	2055	2140 2148	3+	N19E47	SL/3+/560	2123 8/3+	2116 164/3	2108 157/8G	$2^h\ 05^m$	22	2800	2100	2149	>160	2500	+9, +1	4.10
	2315	NR	3	N19E51													
11	2006	2022 2034	3	N10E41	S/3-/67	2020 19/3+	2028 18/3	2023 22/4	absorption still increasing		2800	2010	2022 2033	200	900 750	0, -13	7.4
13	0457	0513 0514 0515	2+	N22E26	S/2/36	0516 9/3	0525 65/1	0512 18/3			3750	0510	0513.1	5.0	570	+0.1 -0.9 -1.9	
	1554	1610 1613	2	N14E18	G/1+/30						2800	1552	1553.4	5.0	100	-16.6 -19.6	
17	0523	0527	2+	N21W30	S/2+/35						3750	0523	0525	13.0	3300	-2	6.20
	0700	0707 0708	1	N20W30	S/2+/23						3750	0705	0706.7	3.0	1280	-0.3, +1.3	6.8
18	NFP				S/2/50	0407 5/-					3750	0403	0404.2	3.0	1750		6.6

* This major flare reported by Sydney only. No RF reported at any frequency, and no SWF.

Several importance 2+ flares were reported while the plage and sunspots were crossing the east limb. The first major event was a limb flare at 2250 UT on the 8th with a great burst of RF flux reported at both 2800 and 3750 Mc/s with large bursts (> 1000 flux units) at all frequencies from 200 to 9400 Mc/s. We have here a case of large bursts with a possible "U" type spectrum (Figure 11a Page 44). A strong type II emission was reported by Fort Davis but no Type IV appeared to be present.



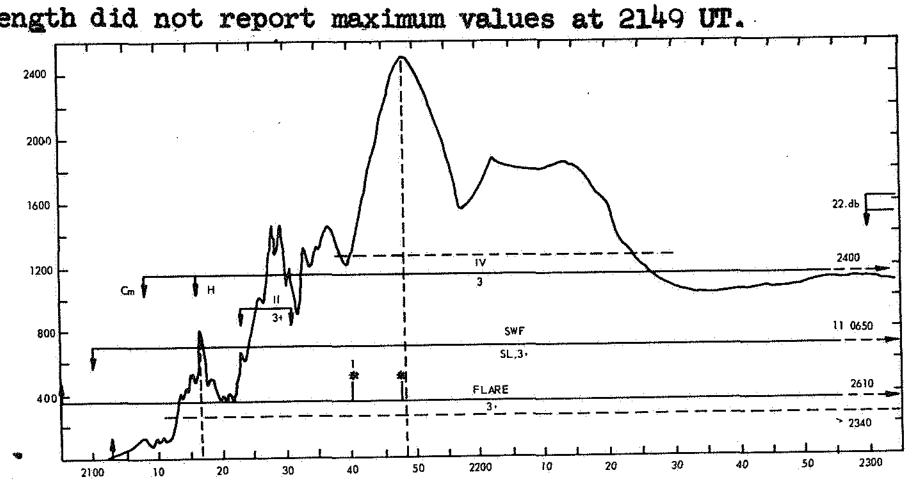
6.22 8 May, 1959; 2800 & 3750 Mc/s; 1–Voros., 2–Sac. P.; N22E86

This event was followed within about two and a half hours by a flare with importance 3,(reported by Sydney only) with no reports of short wave fade. The only RF emissions reported was a strong burst of very short duration at 200 Mc/s. It has been suggested that this major flare and several small flares at the limb were actually a part of the flare that started at 2252 UT on the 8th.

4.4.1 <u>The RF Emission, Hα Flare, The PCA, and a Ground Level Effect on 10 May 1959</u>.

A number of minor flares with only slight RF activity were reported between 0123 UT on the 19th and 2055 UT on the 19th when a great importance 3+ flare started. Within a very few minutes a very great RF Burst started at 2800 Mc/s which lasted for at least three hours. This burst had a complex rise to peak intensity, decreased very slowly and was still well above background at sunset.

The event was accompanied by both type II and type IV emissions with strong indications that the type IV extended to centimeter wavelength. It has not been possible to construct the spectrum for this event since the start was not observed at 3750, 2000 or 1000 Mc/s, while the observations at meter wavelength did not report maximum values at 2149 UT.



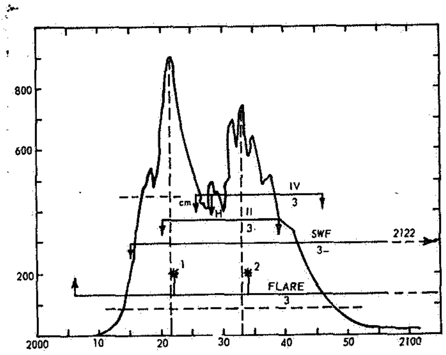
4.10 10 May, 1959., 2800 Mc/s., 1 – Lock., Soc. P., 2 – Honol., N19E47

Solar protons started to arrive at the surface of the earth at about 0030 UT on the 11th, about one hour after the start of the PCA. This PCA was one of the largest on record and lasted for at least 6 days.

4.4.2 The Major Flare and RF Emission on May 11, 1959

The RF burst at 2800 Mc/s that started four minutes after the start of an importance 3 flare at 2006 show all of the characterisitcs of a PCA event, except that the two reported times of flares maximum at 2022 (By Lockheed) and 2034 (by Sac. Peak) followed the times of the principal RF peaks (Figure 7.4) by less than one minute. The events also included a major type II emission at meter wavelength and type IV of relatively short duration at both meter and centimeter wavelengths.

It is quite probable that this event contributed to both the intensity and duration of the PCA which was still increasing when this new event started.



7.4 11 May, 1959; 2800 Mc/s.; 1 – Lock., 2 – Sac. P., N10E41

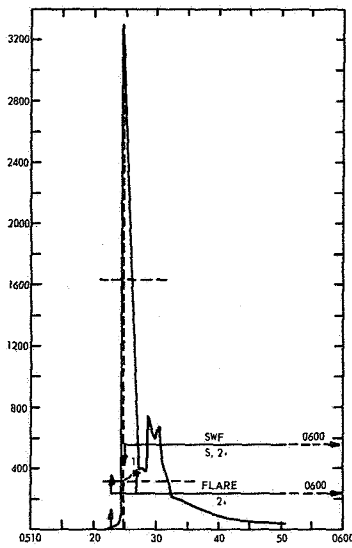
4.4.3 The Major RF Burst at 3750 Mc/s on May 13, 1959

Data necessary to reconstuct the RF Profile for this event was not available, however, it is probably of the narrow profile type - class I.

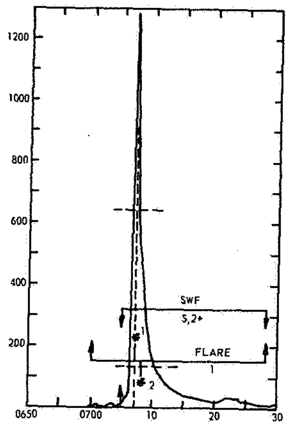
This event may have contributed to the PCA on the 10th that was still at a large absorption value.

4.4.4 Other Major Bursts

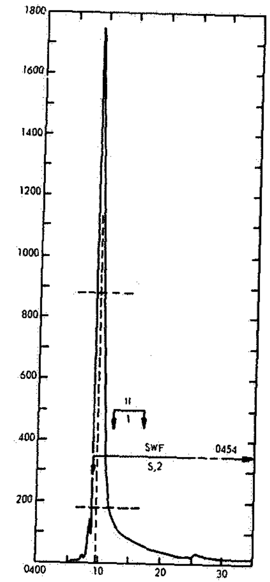
The region continuted to be both flare productive and radio noisy as it crossed into the western quadrant. The RF activity at centimeter wavelength consisted of impulsive major bursts with class 1 profiles as shown in Figure 6.20, 6.8, and 6.6.



6.20 17 May, 1959; 3750 Mc s; 1 ~ Tachk., N20W31



6.8 17 May, 1959 ; 3750 Mc s: 1-Abast., 2-Ondr N21W30



6.6 18 May, 1959, 3750 Mc s. No Flare Patrol

4.5 THE RECURRENT ACTIVE REGIONS THAT CROSSED THE SOLAR DISK BETWEEN MAY 17 AND AUGUST 14, 1959

The Plage region 5265, that was the source of three great PCA events on July 10, 14, and 16, 1959, and the ground level effect on the 16th was in

TABLE 15 BASIC CHARACTERISTICS OF REGIONS THAT PRECEDED AND FOLLOWED THE JULY 1959 REGION 5265

PLAGE				SUN SPOT										FIRST FLARE	
PLAGE NO.	CMP	CM AREA	MEAN POSITION	GREEN. NO.	CMP LONG. LAT.	DAYS SEEN CMD	MAX. AREA DATE	MEAN AREA	M.W NUMBER	CMP	DATES SEEN	MEAN MAG. CL.	NO. FLARES	DATE	CMD
5070	3/28.2	800	N 18	19253	3/28.51 320.5 N19.2	24-3 E53- W 78	365 4/2	127	14018	3/28.5 N 20	26-2	d β 1	2	3/31	W 36
5105	4/24.6	7500	N 18	19301	4/24.70 321.5 N21.1	19-29 E70- W 62	329 4/23	166	14074	4/24.8 N 21	19-28	d β pd	5	4/18	E 86
5157	5/21.4	4500	N 20 327	19352	5/20.96 334.5 N16.9	17-27 E45- W 81	872 5/24	508	14139	5/21.0 N 16	15-26	d β_p1	30	5/17	E 45
5204	6/17.5	9000	N 19 330	19396	6/17.46 330.4 N17.1	11-23 E80- W 79	1111 6/11	856	14211	6/17.5 N 17	11-23	1 γ 1	70	6/11	E 90
5265	7/13.7	12000	N 16 339	19448	7/14.66 330.4 N16	8-21 E84- W 85	1981 7/17	14/2	14284	7/14.7 N 17	8-20	1 γ 1	82	7/[illegible]7	E 90
5315	8/10.1	11000	N 17 342	19492	8/11.03 328.3 N14.9	5-14 E76- W 47	504 8/05	193	14348	8/11.3 N 14	4-15	1xd	None		

its fifth transit of the visible solar disk. After one more rotation with central meridian passage on August 10, the plage broke up and returned as four small regions with areas of 800, 1000, 3000, and 3200 millionths of the solar hemisphere, with central meridian passage on Septmeber 4.6, 5.5, 6.7, and 8.3, respectively.

The sequence of the plages with pertinent sun spot data and flare activity is given in Table 15.

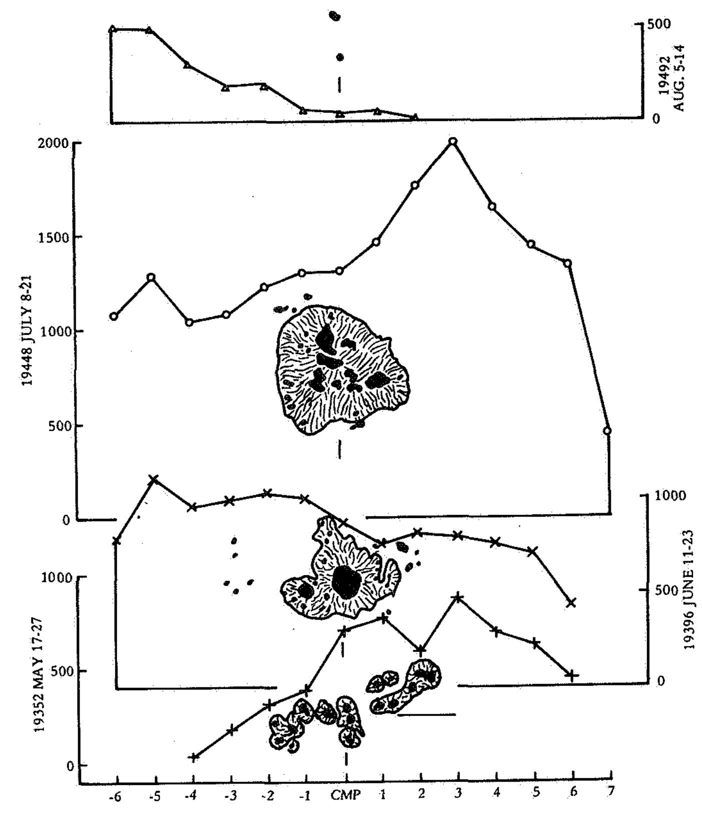


FIGURE 12 DAILY AREA OF THE RECURRENT SUNSPOTS THAT PRECEDED AND FOLLOWED THE JULY 1959 GROUP 19448 (MT. WILSON 14284)

The sunspot group 19448 (Greenwich) (Mt Wilson 14284) that crossed the Solar disk between July 8 and 21 was in its third rotation. The spot group returned on August 5, but decreased rapidly and disappeared two days after it crossed the central meridian. The daily areas and the sunspot drawings at CMP are shown on Figure 12.

4.5.1 <u>The Recurrent Regions 5070, 5105, and 5157</u>

The first plage in the sequence formed on the visible disk (McMath 5070) as a small and moderatley bright region. A tiny sunspot was seen on 24 March; several spots appeared by the 26th and the group reached maximum area of 365 millionths on April 2. Two small flares were reported on the 31st at 0758 UT and 0853 UT at W36 and W35 reapectively.

The region returned, at N18 (McMath 5105) with an area of 7500 millionths. A small sunspot group appeared at E65 on April 19th as a stream of spots lead by a diminishing regular spot. The group disappeared at W62 on the 29th. Five small flares were reported during disk passage, with no activity during the last five days on the visible disk.

The third return of the region (McMath 5157) occurred on May 14 at N20, and heliographic longitude 327. Two or three tiny spots were first seen on the 17th. The spot group grew into a moderate sized stream which developed rapidly into a large complex group reaching a maximum area of 872 millionths on the 24th. Greenwich reports rapid changes in the rear part of the group during disk passage. The region was flare productive after it passed the central meridian, infact, 20 of the 30 flares were observed after the region was 40 degrees west of the central meridian. None of the flares was classified with importance greater than 1+, and no radio bursts were reported at centimeter wavelength. Small coronal looped prominences and very bright yellow line emissions were reported at west limb passage.

4.5.2 The Solar Region 5204 That Crossed the Solar Disk Between June 11 and 23, 1959

It is evident that the sunspot 19352 (Mt. Wilson 14211) continued to increase in area during its passage of the farside of the sun since it returned to the east limb on June 11 as a complex group with a large composite spot as the principle component (Figure 13) in McMath plage 5204.

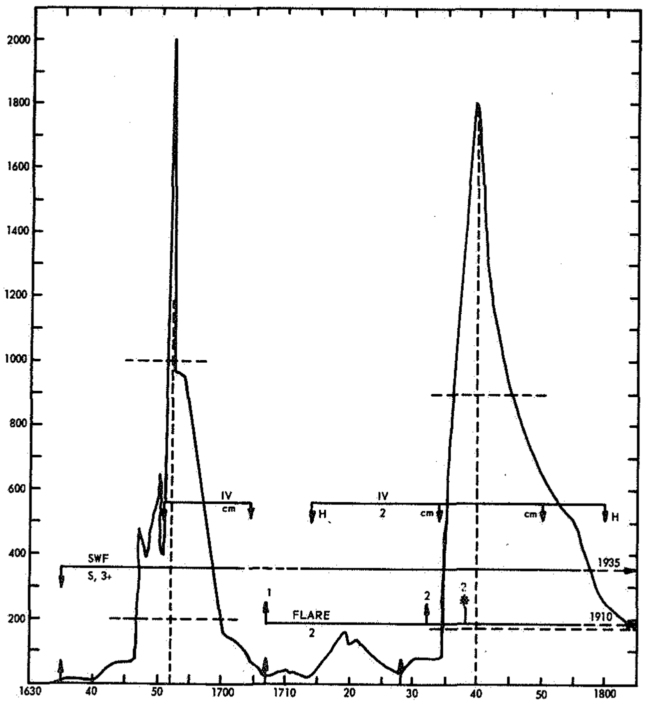
The region was extremely flare productive and radio noisy during disk passage. Seventy (70) flares were reported with importance as shown in Table 4.5.1. Where we have shown the number of flares in the eastern and western quadrants.

Flores Imp.	1	1+	2	2+	3	3+	Total
E	28	5	4	2	1	0	40
W	24	3	2	0	0	1	30
	52	8	6	2	1	1	70

Table 4.5.1
Importance and East-West
Distribution of Flare From Sunspot Group 14211

Twenty of these flares were accompanied by small burst at meter and/or centimeter wave lengths.

Trotter and Roberts report that moderate yellow line emissions, large complex coronal looped prominences, and moderate surges were observed at the east limb on 9 June with the loop prominences continuing through the 11th and the surges through the 12th. Because of these phenomena and the fact that none of the other spot groups on the visible disk at the time, (including several with areas greater than 500 millionths) produced a single important flare during the time spot group 14211 was on the visible disk, the major RF bursts at 2800 Mc/s at 1635 UT and 1738 UT on June 9 (Figure 6.10, and 6.46) can be associated with the region with a reasonably degree of confidence. No flare was reported at the time of the first RF burst, while a limb flare of importance 2 starting at 1707 is definitely associated with the second burst. Major bursts were also reported at decimeter and other centimeter wavelengths during the period from 1626 through 1735 UT.



9 June 1959; 2800 Mc/s RF Burst at 1640 Class I Impulsive Fig. 6.10; Burst at 1730 Class I Impulsive, Fig. 6.46.

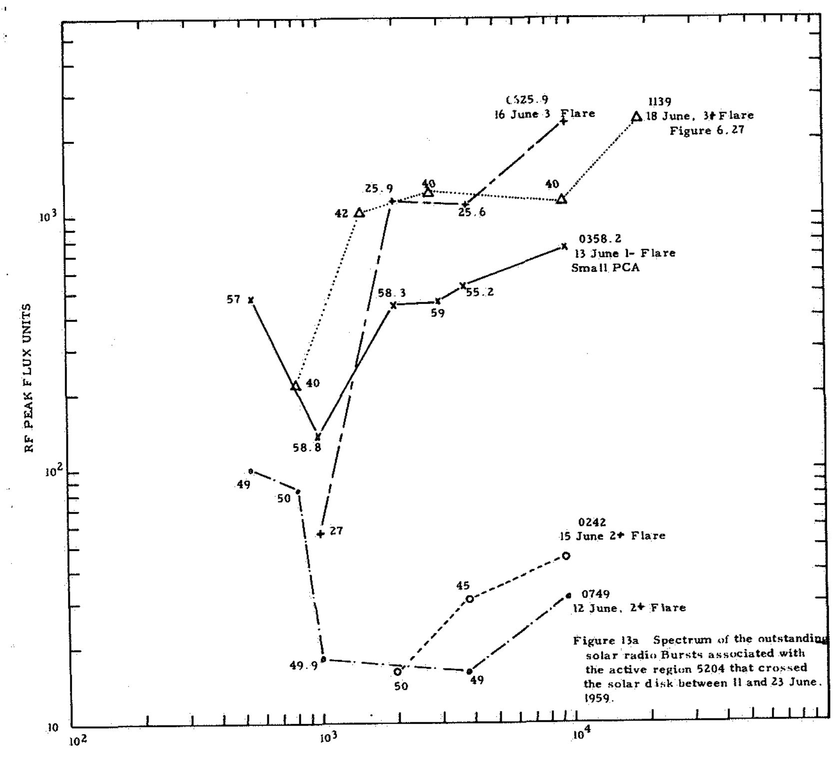


Figure 13a Spectrum of the outstanding solar radio Bursts associated with the active region 5204 that crossed the solar disk between 11 and 23 June, 1959.

Svestka and Olmr reported an emission of type IV on June 9 at centimeter, decimeter, and meter wavelengths starting at 1651, 1646, and 1635 UT respectively, ending at 1750 UT. A type IV emission over the frequency range 50 to 25 Mc/s starting at 1714 is included in the Maxwell, et.al., catalog of type II and IV radio bursts.

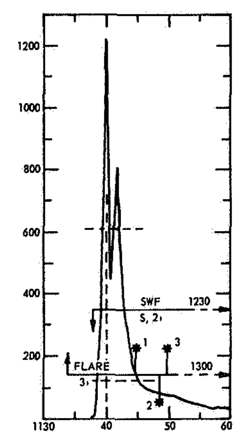
Jelly and Collins, report a polar cap event starting sometime on the 9th lasting for three days. Another small PCA was reported by Kahle, Besprovannaya and Jelly and Collins on the 13th with start times ranging from 0800 to 1330. This small PCA has been associated with an importance 1 flare starting at 0357 at N17 E58. Major bursts were reported all centimeter wavelenghts.

The spectral characteristic is shown on Figure 13a Page 45 . We have also shown the Spectral characteristics of the RF bursts associated with the importance 3 flare on the 16th, the 3+ flare on the 18th, and the two importance 2+ flares on the 12th and 15th.

Spot area, flare activity, and RF bursts at 2800 or 3750 Mc/s, associated with the sunspot group 14211 are shown on Figure 13. We have included the 3-hour-planetary index and the Deep River Neutron monitor data for the period of disk passage.

The Mt. Wilson sunspot drawings are also included for the 11th, 13th, 18th, and 23rd. These drawings have been oriented with east to the left.

The RF burst associated with the importance 3+ flare on the 18th is shown on Figure 6.27.



6.27 18 June, 1959; 2800 Mc 's; 1 – Wend., 2 – Meud., 3 – Loca.; N16W13

A moderately severe sudden commencement geomagnetic storm of short duration on June 11 was followed at 0909 by a small Forbush decrease of 4.4%. Neither the importance 3 flare on the 16th nor the importance 3+ flare on the 18th caused geomagnetic distrubances even though both flares occurred when the region was near the central meridian.

While this region was well above average RF activity during the first eight days on the visible hemisphere, it was relatively quiet during the last four days. The spot group decreased in area and complexity and the west limb passage occurred with minor coronal activity and only moderate surges.

There were strong indications that the region was dying out, however, when it returned to the east limb it had increased in area during its transit of the far side of the sun.

4.5.3. McMath Plage 5265 and Great Events During July, 1959

The most important return of this long lived solar region approched the east limb from the far side of the sun with coronal looped prominences and moderate sized surges on 7 July. The sunspot group was first seen by Mt. Wilson (14284) at 1843 UT and by Greenwich (19448) at 1550 UT on 8 July. The group crossed the east limb as a large complex spot (Figure 14) with occassional small companions that grew as it crossed the visible disk, reaching a maximum area of 1981 millionths on July 17. The group began to spread out On July 16 and break up into several diminishing components. The daily sunspot maps of spot group 14284 based on Mt. Wilson drawings are shown on Figure 14.

The McMath plage covers five additional spots as shown on Figure 15 for July 13, with the days the five spots were seen, (the position of spot 14296 is indicated on the figure, however, this spot was seen on June 14 and 15 only.)

Eighty-two flares of importance 1 or greater were reported in the neighborhood of spot 14284 during disk passage. The number of flares of each importance for the eastern and western quadrants are shown in Table 4.5.2.

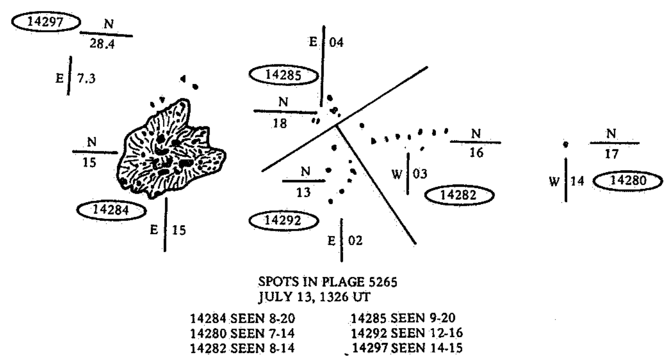


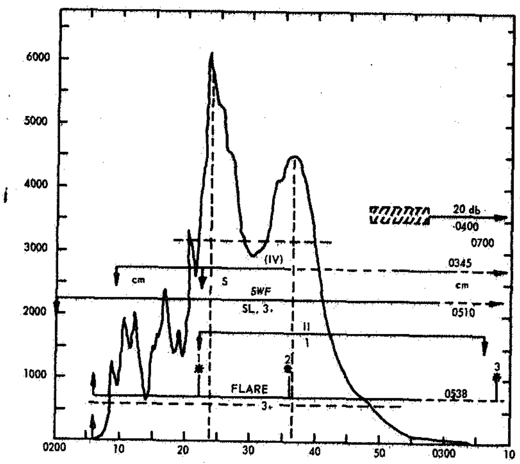
FIGURE 15 SUNSPOT GROUPS IN PLAGE REGION 5265 ON JULY 13, 1959

	1	1+	2	2+	3	3+	Total
E	33	6	2	1	2	3	47
W	27	3	3	0	1	1	35
	60	9	5	1	3	4	82

Table 4.5.2

Flares Associated with Sunspot Group 14284

Nine small flares were reported during the first two days on the visible disk with no RF emissions until a few hours before the very great event at 0206 UT on the 10th when three major flares were reported at 0206, 0514, and 0539 UT. (It is probable that these are one long duration flare starting at 0206 and ending at 1000 UT.) Great RF burst started at centimeter , decimeter , and meter wavelenghts almost simultaneously with the start of the flare with a peak of 26,500 flux units at 9400 Mc/s. The RF time history at 3750 Mc/s is shown on Figure 4.8. Spectral emissions of type II and type IV were reported by Sydney, starting at 0222 and 0223 respectively. Svestka and Olmr report a probable type IV emissions at centimeter, decimeter and meter wavelengths starting at 0209, 0208, and 0207 respectively. This great event was preceded by an importance 2 flare at 1930 on the 9th accompanied by a type IV emission at 2044 UT, reported by Fort Davis over the frequency range 580-25 Mc/s with importance 3, lasting for more than 3 hours. Svestka and Olmr report a type IV and type II emission over the centimeter, decimeter, and meter wavelengths starting at 2020, 2023, and 2042 UT respectively followed by another burst at 2110, 2103 and 2112 UT reapectively, ending at 2240, although the emissions at single frequencies in the centimeter and decimeter wavelengths were small. The major events associated with sunspot group 14284 are shown in Table 16.



4.8 10 July, 1959, 1 – Tachk., 2 – Syd., 3 – Alma A., N20E63

TABLE 16 THE SOLAR REGION 5265 THAT CROSSED THE SOLAR DISK BETWEEN JULY 8 AND 21, 1959

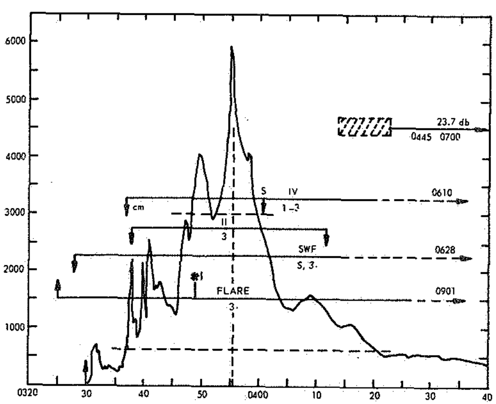
	FLARE				SWF				SPECTRAL			RF EMISSIONS						POLAR CAP. ABS.			Fig. NO.
DATE	START	MAX.	Imp.	POSITION	ONSET	DUR.	TYPE	Imp.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δ t	ONSET	Int. db	Δ T	
7/8	0703	0741	1+	N16E88	First flare in region 5265. No associated phenomena reported																
7/09	1930	1956 1959 2001 2046	2	N19E67	1943	29	S	1+		2044/H 196/3	2020 140/6g 167-9400	2800	2042	2046	20.0	475	+46 +43 +41 0	2000	∫min	$0^h 30^m$	
7/10	0206	0222 0236 0308	3+	N20E63	0200	190	SL	3+	0222/S 44/1		0209 97/3g 167-9400	3750	<0209	0224 0236.5 }	54	6300 5000	+2 +0.5	0400 9/2000 -	20.0 10/1000	$1^h 54^m$	4.8
	0514		3+	N16E59								3750	0514	0516	20.3	26					
	0539	0908	3	N20E58	0605	155	G	3+				None reported.									
7/12	2134	2230 2231 2240 2250	2+	N19E24	2220	100	G	2-				2800 3750	2224 2225	2228 2228	16.0 15.0	80 105	-2 -3 -13 -23				
7/13	0255	0410	3	N15E18	0405	77	G	2-				3750 3000	0248.8 0249	0249.5 0250	3.0 3.0	38 346					
7/14	0325 0520	0349 0527	3+	N17E04	0328	180	S	3+	0338/S 34/3	0401/S 129/3	0337 198/30G	3750	0330	0356	100.	6000	+7.0	0445 14/0445 -	23.7 14/0800	$1^h 20^m$	4.7
7/16	1525	1556 1615 1616 1618	3	N14W27	1610	28	S	2-	1616/H 7/3			2800	1613	1615	9.0	350	+19 0 -1 -3				
	2114	2125 2129 2131	3+	N16W30	2118	177	S	3+	2121	2121/H 262/3	2121 159/10G 167-7400	2800	2118	2122 2134 2154	>180	4000 4200 6500	-2, -7, -9 +9, +5, +3 +29, +25, +23	<2250 16/2200 -	21.2* 17/0600	$1^h 36^m$	2.9

* Ground level effect at 2250.

The great flare and RF bursts on the 10th was followed by one of the greatest PCA events reported during the 19th solar cycle. This was the first of a sequence of three great events from the region. The PCA was observed by riometers, ionosonde, and forward scatter techniques. Besprozvannaya gives the onset time at 2000 UT on the 9th, indicating that the flare at 1930 on the 9th may have caused minor polar black outs. There was also some indications of absorption on the College and Barrow riometers at about that time. However, the main event starts at about 0400 UT on both the College and Barrow riometers (Figure 14) with maximum absorption greater than 18db at 1630 UT on 11 July. A sudden commencement magnetic storm with a maximum K_p of 7- started at about the time of maximum absorption. This was followed in about one hour by a Forbush decrease of about 9.9%. The Deep River neutron monitor count remained at the depressed level until about 0830 on the 15th when a second decrease started.

The region remained flare productive during the next four days with 23 minor flares and one major flare, however, seven of the flares were accompanied by relatively weak RF emissions at centimeter wavelength.

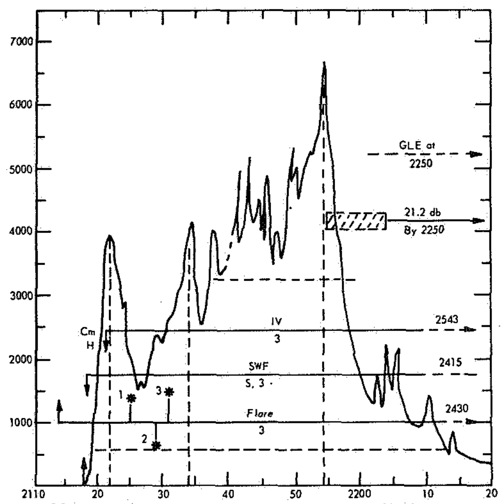
The absorption at College and Barrow was still high when another importance 3+ flare and great RF bursts at centimeter and decimeter wavelengths were reported at 0325 UT on the 14th, (Figure 4.7). Type II and type IV spectral emissions were observed at Sydney, and type IV was reported by Svestka and Olmr at centimeter, decimeter, and meter wavelengths preceded by a type II emission.



4.7 14 July, 1959, 3750 Mc 's., 1 - Tochk., N17E07

The second of the very large polar cap absorption events started in less than two hours after the flare, with an absorption of 23.7 db. The College and Barrow riometers (Figures 14) indicate onset time at about 0500 UT on the 14th while ionosonde data indicates onset sometime before 0700 UT reaching maximum absorption at about 0800 UT on the 15th. A severe sudden commencement magnetic storm with a maximum Kp of 9 started at 0803 UT followed in about 30 minutes by a Forbush decrease that reached approximately 15% by 2400 UT. In this case, the counting rate increased rapidly reaching nearly the pre-decrease rate by 1200 UT on the 17th about two hours before the third great PCA.

The third great PCA's associated with the major flare at 2114 UT on the



2.9; 16 July, 1959., 2800 Mc s., 1 – McM, 2 – Lock., 3 – Clim. N16 W30

16th and great RF burst at centimeter wave length , (Figure 2.9). The PCA started sometime before 2250 on the 16th, while the absorption was still high from the event on the 14th. High energy particles started arriving at the earth by 2250 and protons with energy greater than 90 MeV were arriving more than 9 days later.

Only six polar cap absorption events nave been observed with an absorption of 20 db or greater. Three of these followed major flares from sunspot 14284 on 10, 14, and 16 July 1959, with absorptions of 20, 23.7 and 21.2 db respectively.

Only 13 RF emissions at centimeter wavelength reached a peak greater than 5000 flux units, and three were associated with this group of events.

The sunspot group began to spread out on July 16 reached it maximum area on the 17th and began to break up into several decreasing components.

4.5.4. <u>The Final Passage of the Recurrent Sunspot Series</u>

The long lived active reginn returned to the visible disk on 2 August and was cataloged as McMath plage 5315 at mean latitude N18. Heliographic longitude 342. The plage contained three sunspot groups that lasted for ten days and two one day spots.

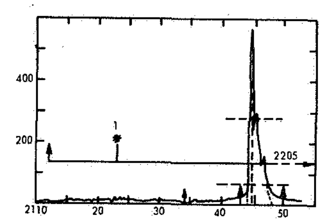
Sunspot 14348 was the fourth return of the spot that formed on the solar disk on May 15, and the return of the group 14284 which had started to break up as it approached the west limb of the sun. It is evident that the break up continued as the group crossed the far side of the sun, since it returned as a small complex group with several companions that gradually died out, at central meridian passage two tiny spots remained with an area of only 51 millionths (Figure 12) the spot group was last seen on August 14 at West 47. No flares were reported in the vicinity of this group.

4.6 THE SOLAR REGION 6964 THAT CROSSED THE SOLAR DISK BETWEEN SEPTEMBER 13 AND 26, 1963

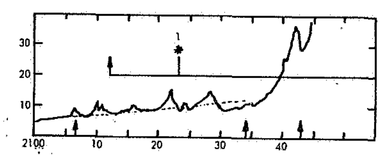
This bright and moderatley large plage was first seen on September 13, at N12, it contained a large (maximum area 1770 (USN Obs.) on the 20th) magnetically complex sunspot group (Mt. Wilson 15768). During disk passage, the region was the source of two importance 3 flares, 6 major RF burst at 2800 or 3750 Mc/s, and two polar cap absorption events, one near the central meridian, the other near the west limb. The reconstructed RF time histories are shown on Figures 6.7, 7.5, 9.3, 1.7a, and 2.6 respectively.

4.6.1 Small RF Burst on September 14

This RF Event does not quite meet our requirement of 500 flux units or greater for non-PCA events. This is a narrow impulsive profile superposed on a long duration gradual rise and fall in flux (Figure 6.7). However, because this event occurs near the east limb in the region that porduced 87 flares during disk passage, the event might be considered as an indication of events to come.



6.7 14 Sept., 1963; 2800 Mc s, 1 – McM., N12E72

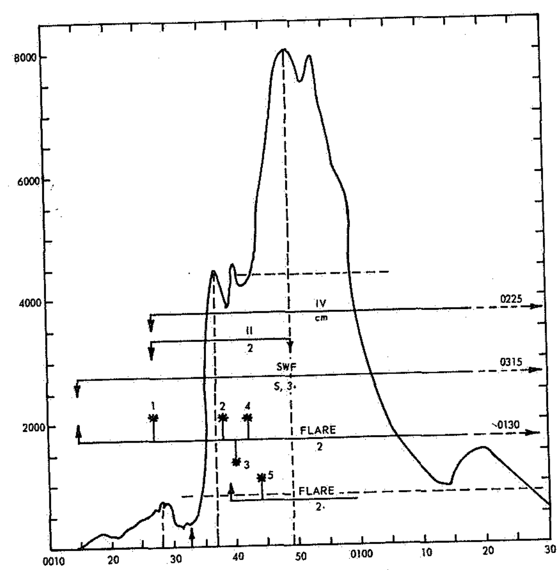


6.7a Expanded Flux Scale

4.6.2 The Very Great Burst On September 15

This was one of the very great RF events during the 19th solar cycle, the flare with importance 2 started at 0015, with reported maximum at 0027, 0038, 0040, and 0042. This event stisfied all of the conditions for a PCA including a type II emission at meter wavelength, a type IV (Svestka and Olmr) at centimeter wavelengths, and a great short **wave radio fade. The reported times of flare maximum can be reasonable associated with RF peaks as shown on Figure 7.5.**

Flare Max	RF Peak	RF Peak Int.
0027	0028	565
0038	0037	4500
0040	0040	4600
0042	0049	8080

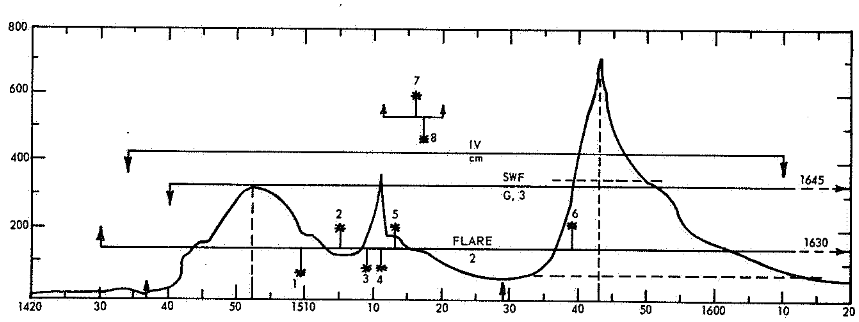


7.5 15 Sept., 1963; 3750 Mc 's.; 1 – Ikom; 2 – Mani., 3 – Lock., 4 – Honol., N15E75; 5 – Erkut., S31E65

All of the conditions for a PCA seem to have been met except that the flare and region are still near the east limb. An apparent unfavorable condition. However, Hakura reports a small PCA starting at 1030 UT, based on f_{min}, minimum observable frequencies on vertical sounding ionograms.

4.6.3 The Major RF Burst at 1436 on September 16

A flare starting at 0300 was reported by Tachkent and Kadaikanal with importance 3, and a very small burst at 3750 Mc/s, followed by an importance 2 flare at E48, starting at 1430 UT and an RF burst with a peak of 710 flux units. This was a long duration event and a flare with six different times reported for flare maximum as shown on Figure 9.3 Hakura reported a very small PCA starting at 1600 based on f_{min} ionosond data. Again, we have an event satisfying most of the conditions for a polar cap absorption. Masley et al, reported a period of enhanced cosmic noise absorption during the period of September 15 through September 29.

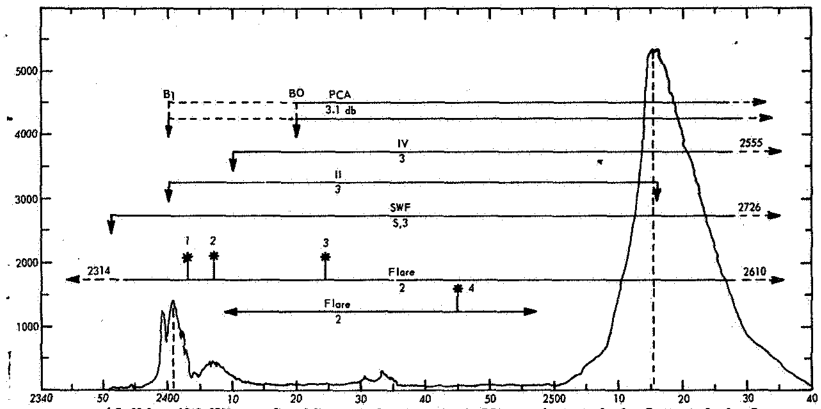


9.3 16 Sept., 1963; 2800 Mc 's., 1, 5, 6, – Otta.; 2 – Loca.; 3 – Sac. P., 4 – Herst., N13E49; 7 – Sac. P., 8 – McM, S09W08

4.6.4 The Great Burst at 3750 Mc/s Starting at 0100 on 21 September

This was the 13th (in order of magnitude) great burst during the solar cycle. The PCA starting sometime between 0000 UT (Bailey) and 0020 (Basler and Owren) has been associated with an importance 2 flare starting at 2314 on the 20th and the major burst with a peak of 1400 units at 0001. A period of relatively low emissions existed from about 0010 until 0100 when the great burst started, with a peak of 5050 units, at 0115 UT lasting for about 40 minutes.

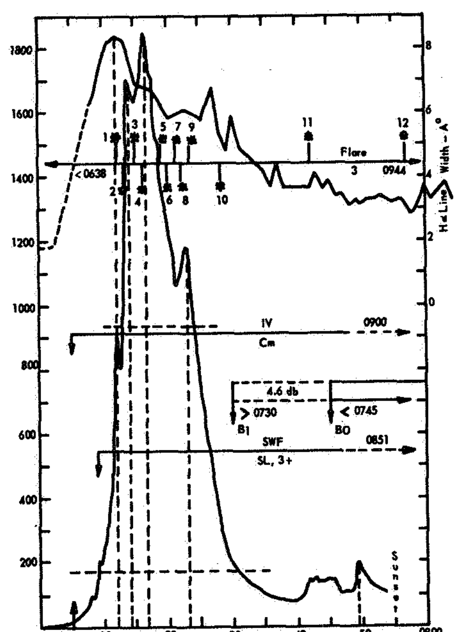
The flare associated with this event has been studied by the Lockheed group. They report bright spray like ejections and a giant dark surge preceding the flare, with high speed disturbances during the flare.



1.7a; 20 Sept., 1963, 3750 Mc s., Sheet 2 Showing the Great burst after the PCA onset, 1 – Lock., 2 – Sac. P., Honol., 3 – Sac. P., N10 W10, 4 – Irkut. N18W04.

4.6.4 The Major RF Burst and PCA on September 26

The last of the great sequence of events that occurred during the passage of Region 6964 across the solar disk, is associated with an importance 3 flare as the region approached the west limb. The flare is outstanding in many respects, having been observed by 16 observatories, with twelve times of flares maximum reported, maxima ranging from 0712 to 0757 as shown on Figure 2.6.



2.6; 26 Sept., 1963; 3750 Mc/s.; Ondrejov Hα Line-Width; 1 – Ondr, 2 – Athn, 3 – Tachk., 4 – Cape-T, 5 – Abast., 6 – Bakou, 7 – Crim, 8 – Buch., 9 – Haute-P., 10 – Kievko, 11 – Capri-F, 12 – Nizm., N13W78

5.0 SPECTRA OF ACTIVE REGIONS, AND PROTON-WARNING CRITERIA

5.1 TIME RELATION OF FLARE MAXIMUM AND RF PEAK FLUX

It was shown in Reference 4 that in the case of major flares (importance ≥ 3) that if the time of flare maximum, and RF peak intensity at centimeter wavelengths (1420 Mc/s to 3750) satisfied the conditions:

1. The time of RF peak followed the time of flare maximum ($\Delta t \geq 0$) there was a 79% probability that the flare would be followed by a polar cap absorption event.
2. The time of RF peak preceded the time of flare maximum ($\Delta t < 0$) there was a 90% probability that the flare would not be followed by a PCA event.

It was also shown that 87% of the major flares that were followed by a PCA event, the RF peak exceeded 500 flux units, while 75% of the non-PCA flares with importance ≥ 3 the RF peak was less than 500 flux units.

The study was extended in Reference 5 to include all events at cm wavelength with RF peak ≥ 500 units, and all PCA events associated with minor flares (importance < 3). It was found that the time of RF peak preceded the time of flare maximum for 78% of the events that were not followed by a PCA. While $\Delta t > 0$ for only 44% of the minor flares that were followed by a polar cap absorption.

It is recognized that the statistical analysis left several important questions unanswered. In a large percentage of the cases the numerical value of Δt is two minutes or less. It is well known that the reported time of flare maximum may be in error by several minutes. While our statistical sample is large enough for the number of errors to balance out, a more reliable determination is necessary to give a high confidence level to the study. As stated before, efforts to obtain more reliable values for the time of flare maximum through a visual analysis of flare patrol flares proved to be very time consuming and unreliable.

Reconstructed RF time histories with all reported times of flare maximum and other related prompt phenomena showed that the class of the RF profile is an important parameter.

The correlation of multi-peak RF emissions with different time of flare maximum reported by different observers, (multi-maxima flares) showed considerable promise, however, improved observations of the flare morphology must be developed before a reliable algebraic value for Δ t can be obtained.

5.2 SPECTRAL CHARACTERISTICS OF RF EMISSIONS.

The correlation of proton events and type IV radio emissions in the dynamic spectrum has been the subject of many investigations, although they have been severly handicapped by the limitations (until very recently) of spectral observations to meter wavelength 10-210 Mc/s at the CSIRO Solar Observatory at Culgoora, Australia, and 100-580 Mc/s at the Harvard Radio Astronomy Observatory at Fort Davis, Texas. With Spectral data limited to these two observatories there is a period of approximately 6 hours (0700 to 1300 UT) without spectral (sweep frequency) observations.

Several investigators have, derived type IV data from single frequency observations at meter ($<$ 300 Mc/s), decimeter (300 to 2000 Mc/s), and centimeter wavelengths ($>$ 2000 Mc/s). The most recent catalog of type IV emissions published by Svestka and Olmr has been used in this study to complement the type IV data from the sweep frequency data and the list of large centimeter type IV bursts observed at the Heinrich-Hertz Institute, (Krivsky and Kruger). Based on these data we have associated a type IV radio burst with 36 of the 40 PCA events that we have been able to reconstruct the RF profile at 2800 or 3750 Mc/s.

The distribution of events with type IV emissions is shown in Table 5.2.1. below.

	Number Events		IV m HARV or CULG		IV cm Svestka		IV cm and/or m	
	PCA	No PCA	PCA	NO PCA	PCA	No PCA	PCA	NO PCA
Class 1	11	46	6	10	8	15	8	15
Class 2	10	7	8	1	9	4	10	4
Class 3	7	1	6	1	6	1	6	1
Class 4	12	8	8	5	12	7	12	8
	40	62	28	17	35	27	36	28

Table 5.2.1

Emissions at centimeter and/or meter wavelength
for each RF profile class

In the case of the 62 non-PCA events with reconstructed profiles at 2800 or 3750 Mc/s we find type IV emissions for only 28 events.

Based on these data we find that 90% of the PCA events have a type IV emission at centimeter or meter wavelengths or both wavelengths, while only 45% of the non-PCA events show a type IV association. If the correlation is extended to include the 33 events that we have not been able to reconstruct the RF profile at 2800 or 3750 Mc/s the percentage with a type IV association is reduced to 35% for non-PCA events.

It must be recognized that type IV emissions may have existed for one or more of the PCA events and some of the 62 non-PCA events.

The type IV associations are shown in Table 1 through 4 for the PCA events and Tables 5, 6, and 8, for the non-PCA events.

Table 9 lists outstanding RF Events not followed by a known PCA with RF flux > 1000 units at one or more of the frequencies 2000, 2980, and 3000 Mc/s with small (< 500 units) or no reported emissions at 2800 or 3750 Mc/s. Four of the 12 events or only 33% have a probable type IV emission at centimeter wavelength. Six of the events occurred during the normal sweep frequency observing time at FT. Davis or Culgoora with no type IV emissions reported.

5.3 SPECTRA OF ACTIVE REGIONS

Recently Castelli et.al., (1967) and Castelli, (1968) have investigated the RF bursts associated with a number of active regions for which consistent observation at both meter and centimeter wavelengths were available from the Sagamore Hill Solar Radio Observatory. The spectral plots show the burst maximum flux reported at frequencies from the meter through the centimeter wavelengths. Six frequencies from 606 Mc/s to 15400 Mc/s were used. He found that at least for the regions studied, certain active regions consistenly have the same type of spectrum for many days. To present a valid spectrum the reported times of peak flux for each of the frequencies must not differ by more than a few minutes. Cases for which a time of peak flux is not given or where the actual peak is not recorded should not be used.

During the course of our study we have examined the RF spectral characteristics of a number of regions with sufficient RF data for several events during disk passage. We have included the spectral characteristics for the four outstanding regions listed in Table 5.2.2.

Figure	Active	Date of Disk Passage
10a	4708	Aug. 14 to 28, 1958
11a	5148	May 8 to 22, 1959
13a	5204	June 11 to 23, 1959
14a	5265	July 8 to 21, 1959

Table 2.2

Regions Analized for Spectral Characteristics

We have given the time of Peak flux for each of the frequencies and have indicated a PCA if one is associated with the event; the associated flare importance is also shown in some cases.

5.3.1 Spectral Characteristics of the Region 4708 August, 1958

The region that crossed the Solar disk between August 15 and 28, 1958 is an outstanding example showing the persistence of spectral characteristics for several days. Seven bursts with good data were recorded, ranging from small to major bursts at centimeter wavelength.

Figure 10a shows definite "U" shaped spectrum with a miminum between 1000 and 2000 Mc/s for the three PCA related RF Bursts with a peak flux: On August 16 between 0439 and 0040; August 20 between 0042 and 0046; and August 22 between 1503 and 1509; there were no valid observations at meter wavelengths for the related burst on August 26 with RF peaks at 0041 or 0042, however, the intensity decreases as we go from centimeter to decimeter wavelengths. The spectrum for the burst on August 19th is relatively flat. Finally we find fluctuating peaks

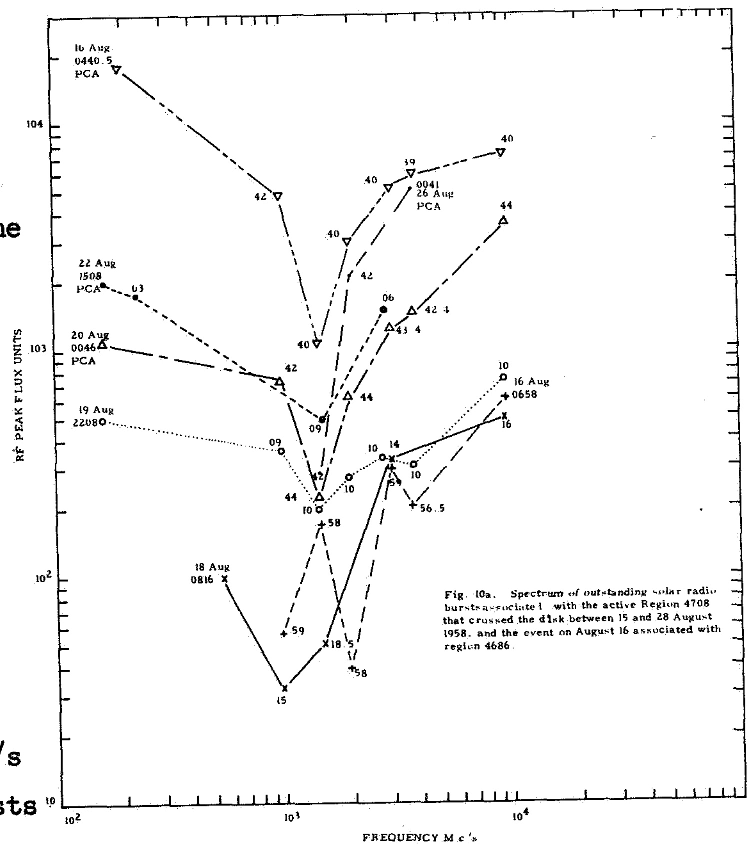


Fig. 10a. Spectrum of outstanding solar radio bursts associated with the active Region 4708 that crossed the disk between 15 and 28 August 1958. and the event on August 16 associated with region 4686.

in both the centimeter and decimeter wavelenghts, for the August 16 event at 0658.

5.3.2 Spectral Characteristics of the Region 5148 that Crossed the Disk Between May 8 22, 1959

We have sufficient reliable data to analize the region that was the source of the great PCA on May 10. Unfortunately we have only two points for the PCA related RF burst. The data for the large burst on May 17 with RF peaks 0525 and 0529 UT and the small burst on the 13th with peaks between 0512.5 and 0513.1 both show the "U" shape while we have a relatively flat spectrum for the event on May 8 with RF peaks, between 2256.5 and 2257 with decreasing flux from the centimeter to the decimeter wavelengths.

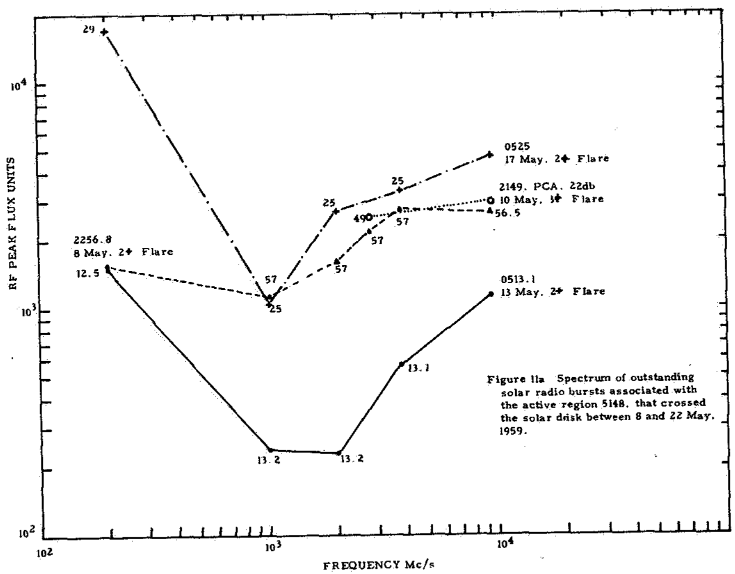


Figure 11a Spectrum of outstanding solar radio bursts associated with the active region 5148, that crossed the solar disk between 8 and 22 May. 1959.

5.3.3 Spectral Characteristics of the Region 5265, the Source of Three of the Largest PCA event of the 19th Solar Cycle

Large polar cap absorptions have been associated with major flares on July 10, 14, and 16, 1959 at 0206 UT, 0325 UT, and 2114 UT respectively. A small PCA event with onset at 2000 UT on July 9 based on f_{min} data has been associated with an importance 2 flare at 1930 UT on the 9th. The RF emission at 3750 Mc/s on the 10th and 14th, and the emission at 2800 Mc/s on the 16th were among the greatest bursts of the

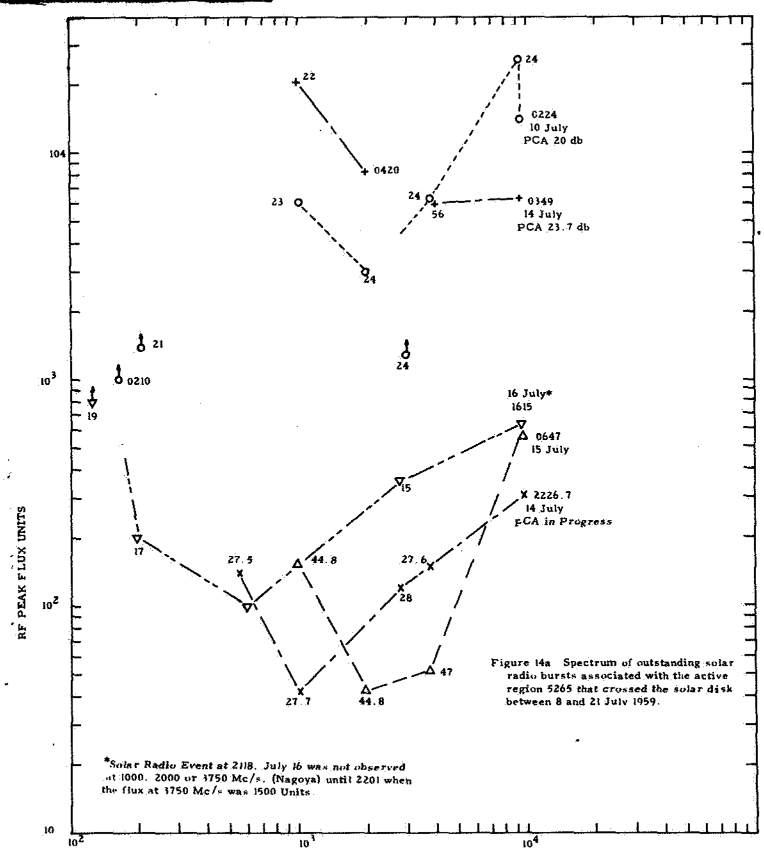


Figure 14a Spectrum of outstanding solar radio bursts associated with the active region 5265 that crossed the solar disk between 8 and 21 July 1959.

solar cycle. Unfortunately the RF data are too incomplete for the bursts that started at 0209 UT on the 10th and at 0330 UT on the 14th, to show a reliable spectral plot. The event on the 10th does show (Figure 14a) strong indications of a "U" shaped spectra. The data for the event on the 14th are quite unsatisfactory because of the unacceptable differences in the reported times of burst peaks i.e. The reported peaks at 3750 and 9400 Mc/s are 0356 UT and 0349 UT respectively while the peaks at 1000 and 2000 Mc/s are 0423 and 0420 UT respectively. A "U" shaped spectra is indicated but not without question.

In the case of the great RF and PCA events on the 16th we have the peak flux and time at 2800 Mc/s but the RF onset and peak occurred before sun rise at Nagoya (1000, 2000, 3750 and 9400 Mc/s) and Tokyo (200, 3000, and 9500 Mc/s). Data for the three small bursts with peaks at 2227.6 UT, July 14; 0647 UT July 15; and 1615 UT on the 16th are complete and show a strong "U" shape.

If this criteria is a real property of PCA or "Proton Regions" the necessity for a full 24 hour patrol of the sun with adequate overlap is clearly demonstrated.

5.3.4 Spectral Characteristics of the June 1959 Active Region 5204

The June 1959 active Region 5204 which crossed the East limb on June 11 was chosed because approximately 14 days after it crossed the West limb of the sun on June 23, it returned on July 8, to almost establish a proton productivity record as it crossed the disk as region 5265.

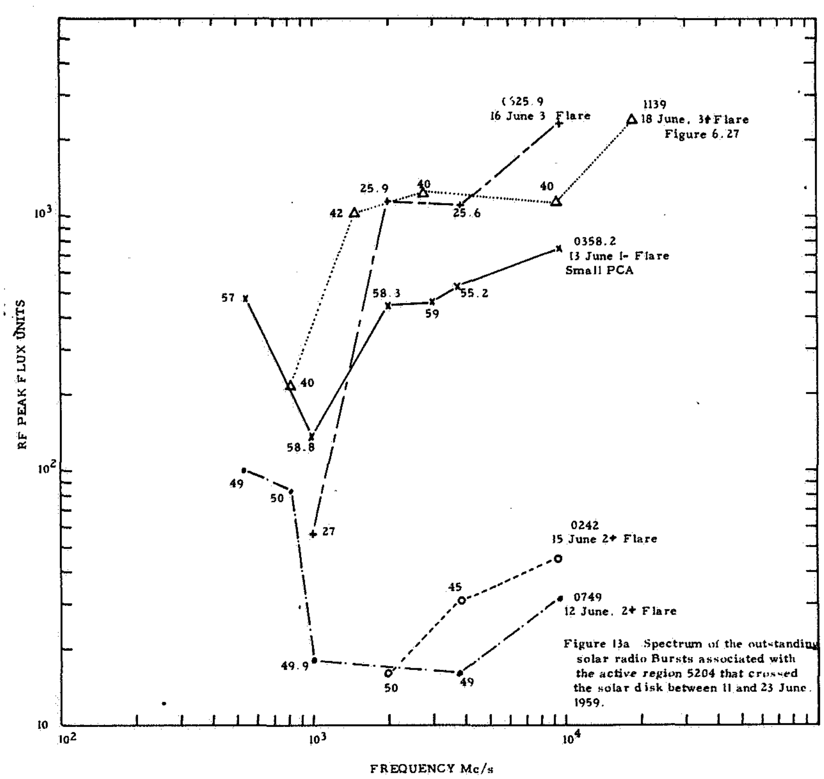


Figure 13a Spectrum of the outstanding solar radio Bursts associated with the active region 5204 that crossed the solar disk between 11 and 23 June. 1959.

The region 5204 was very active with 70 flares including two with importance 2+, one importance 3, and one importance 3+. There was also a probable small PCA event on June 13 associated with a small flare near the East limb. RF bursts were reported at centimeter wavelengths at the time of all five flares. These RF bursts show (Fig. 13a) the decreasing flux with decreasing frequency at the centimeter wavelengths. Peak flux data is reported at meter wavelengths for only two events, the very small RF burst on 12 June and the small PCA event on 13 June. Both of these events have the "U" shaped spectral characteristic.

5.3.5 Spectral Characteristics of RF emissions Associated with White Light Flares

Castelli et.al, examined the spectra of the RF bursts associated with nine white light flares that were reported between 1956 and 1960 listed by Svestka (1966) and included here for convenience. We have added the peak absorption for the PCA events and the RF profile number for the events with reconstructed RF time histories.

NO	FLARE				Related Phenomena			RF Fig. No. This Report
	Date	CMD	IMP	Durat. White Light	IV	PCA db	GLE	
1	2/23/56	+79	3+	5^m	Yes	13.0	Yes	1.8
2	8/31/56	-15	3+	1^m	Yes	4.9	?	4.1
3	8/30/57	-20	?	20^m	Yes	-	-	-
4	9/03/57	+30	3	6^m	?	?	-	7.2
5	3/23/58	-74	3+	8^m	Yes	3.2		-
6	3/30/58	-63	2	2^m	-	-	-	-
7	4/08/59	-85	2+	7	Yes	-	-	-
8	9/03/60	-88	2+	15^m	Yes	3.7	Yes	1.4
9	11/15/60	+33	3	3^m	Yes	20.0	Yes	2.1

Table 5.3.1
White Light Flares, 1956 Through
1960 with Related Phenomena

Five of these flares were followed by PCA events and three, (possibly four) were followed by a ground level events (GLE). Castelli et.al., show a definite "U" shape spectra for three of the events (1, 7, and 9). Possible "U" shape in two additional cases (2, and 5). The flux is decreasing with increasing wavelength in three cases (4, 6, and 8) while only one frequency (1000 Mc/s) with a very small flux is available for (3) the August 30, 1957, event. Only two of the definite "U" shape spectra were followed by PCA events (1, and 9) while both of the possible "U" shaped were followed by small PCA's (2, 5). The spectral shape of the remaining PCA (September 3, 1960) is incomplete with no emission reported at meter wavelengths. The RF emission at 3750 Mc/s on September 2, 1960 was the second greatest ever reported at centimeter wavelength.

5.3.6 Spectral Characteristics of the Active Regions During the Increasing Branch of the 20th Solar Cycle.

Castelli (1968) has shown the RF spectra for 15 RF bursts recorded at the Sagamore Hill Radio Astronomy observatory during 1966 and 1967. These include:

(1) Four large events during July and September 1966 without a type IV or PCA association. These spectra show decreasing flux with increasing frequency.

(2) Four large events with a type IV association. Two of these events have the "U" shape spectra. One is followed by a small PCA (August 28, 1966, see Table 18). The other on August 26 with low flux at centimeter wavelength. Both of these events together with the large "U" shaped event on September 2, occur in the same active region 8461. Castelli finds that all of the PCA associated events show the "U" type spectra or decreasing flux with increasing wavelength. This is also true for other large events not followed by a PCA but associated with a PCA region. We have included (Fig. 6-3a) the spectral plot for the PCA associated event August 28, 1966. Based on the events that we have analized from the 19th Solar Cycle and the events analized by Castelli from the present (20th) cycle there is strong evidence that a potential proton producing region may be identified during the first two or three days after it crosses the East limb. This may lead to two or three days of advanced warning of a proton event.

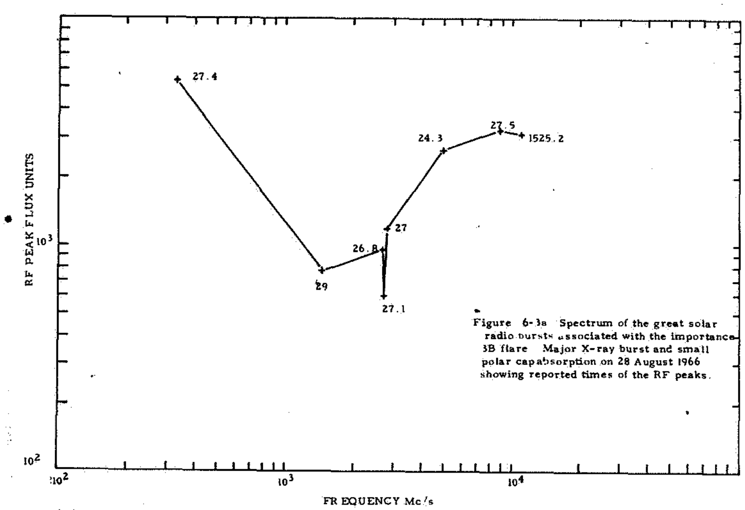


Figure 6-3a Spectrum of the great solar radio bursts associated with the importance 3B flare Major X-ray burst and small polar capabsorption on 28 August 1966 showing reported times of the RF peaks.

6.0 SOLAR ACTIVITY SINCE 1963

The minimum for the 19th solar cycle based on the smooth observed sun spot members occurred during October 1964. The time and magnitude of the maximum for the 20th solar cycle has been predicted by several investigators .* The predicated magnitudes range from a low of 55 to a high of 189 and the time of the maximum ranges from 1967.0 to 1968.1. Based on data published in Solar Geophysical data, it appears at this time that the maximum may occur during the latter part of 1968, with a smoothed maximum not greater than 100.

This sectinn will be limited to a very preliminary presentation of data for ten events that occurred between March 16, 1964, and May 28, 1967. (Table 17)

TABLE 17 POLAR CAP ABSORPTION EVENTS SINCE 1963

FLARE						SAF	SPECTRAL		PCA		RF EMISSION						X-RAY****	
DATE	START	MAX.	DUR.	IMP.	POSITION	START/MAX. TYPE/IMP./DUR.	II	IV	Δ T	IMP. db	f	START	MAX.	DUR.	PEAK FLUX	Δ t	ONSET/PEAK/ΔS/MILLI. ERG.	FIG
1964 3/16	1553	1600 1606 1611 1645	102	2	N05W74	1556/1625 SL/3/104	1557/C 30/1 21-41 1558/H 10/3 220-<50	1604/C 78/1+ 20-41 1605/H 3/1 320-180	$2^h\ 07^m$	0.3	2800	1553	1614	59	680	+14 +6 +3 NA		5-1
1965 2/05	1750	1808 1810	136	2+	N06W24	NR	1800/C 17/2 14-41 1800/H 11 Characteristics	1810/C 55/1 22-41 1800/H 100/3 >320-100		1.7	2700 2800	1753	1826	97	43			
1966 3/24	0223	0236 0239 0242	111	23	N20W42	0225/0235 S/2+/30	NO OBS			1.6								
7/07	0020	0030 0036 0038 0041 0043 0047 0052	139	23	N34W47	0025/0026 S/3/184		< 0053/C 70/3 20-41		2.5	2700 3750 2400	0025.9 0059.5 0112 0026 0059 0113 0025.5 0059	0038 0103 0120 0037.5 0102.4 0119.3 0037.5 0102	33.5 13 37 33 14 36 33.5 SUNSET	2650 680 770 4730 770 815 3420 1200		0025/0042/28/42 *	6-2
8/28	1523	1527 1529 1530 1537 1538	179	2B	N22E04	1524/1530 S/3+/96	1530/C 14/3 11-41 1531/H 17/3+ > 150-<25	1547/C 47/2+ 11-41 1527/H 73/3 >320-<50		1.0	2695 2700 2800	1521.8 1521.4 1522	1526.8 1527.1 1527	95.2 108.7 53.0	965 608 1200		1523/1531/70/- *	
9/02	0538	0551 0557 0558 0602 0603 0611	229	3B	N22W58	0535/0543 SL/3/135	0554.5/S 19.5/-		$1^{hr}\ 00^m$	30	2700 CARN	0546	0550.5 0554 0559.5 0602 0605	85	2400 2400 2200 2325 2250	-0.5		6-3
1967 1/28**	No flares reported on 26, 27 or 28 January with importance greater than IN.					None reported	0754.5/S 10.5/2-3			*** 3CA 4BIA 4 BA 13BSA	No major bursts reported 1000 - 2600 UT						0457/0552/2.5/- * 0737/0807/2.7/- *	
5/21	1919	1926	65	2B	N24E39	1924/1932 S/2/46	1923/H 22/3	1923/H 97/2			2695 2700 2800	1922.5 1920.3 1922	1923.7 1923.3 1924.2	25.5 13.5 26	1048 746 830		1921/1927/45/180 *	6-4
5/23	1804	1810 1812 1814 1817	129	2B	N30E25	1809/1815 SL/3/160			$7^h\ 26^m$	20	2695 2800	1800 1808	1809.7 1809.5	35.5 16.0	33.4 27.0	-.3 -.5	1759/1817/4/34 *	6-5
	1835	1843 1844	60	2B	N28E24	1834/- S/3+/236	1838/H 27/-	1839/H 261/3			2695 2800	1835.5 1835.5	1839.1 1839	35 34	2500 2300		1834/1846/27/650 *	
	1935	1944 1947 1951	141	2B	N27E28						2695 2800	1930 1930	1951.8 1952	62 62	5400 8000		1936/1953/4/280 *	
5/28	0525	0539 0543 0545 0552 0558 0559 0602	107	3B	N23W34	0530/0533 S/3/70	0539/S 17/2 0545/S 7/1		$1^{hr}\ 13^m$	5.5	3000		0542		1370		0528/0551/94/320 *	

* Based on Explorer 33, 2-12A°, Univ. Iowa data
** Ground level effect Deep River start 0330, max. 16% at 1115. Recovery 0700,1/29
*** Riometer data CA-College, Alaska onset 1800 max. at 2200; BIA-Barter Island, Alaska onset 1800, max. at 2200; BA-Barrow, Alaska onset 1800, max. at 2200: BSA - Byrd Station Antarctica, onset at 0000.
**** Milli-Er[illegible] (cm[illegible] sec.)$^{-1}$

* Scissum, J. A., Survey of Solar Cycles Prediction Modles, NASA Tmx-53593, dated 30 March, 1967.

RF time histories have been reconstructed for five of the events shown in Table 17.

In addition to showing the time relation of the short wave Radio Fade, spectral emissions type II and type IV, we have included in three cases the reconstructed time history of X-ray events reported by Van Allen et.al., from the Explorer 33 or 34 satellites.

Four of the PCA events are very small, and many more data are necessary before a realistic analysis can be carried out.

6.1 THE SMALL PCA EVENT ON 16 MARCH 1964

A very small PCA (absorption 0.2db) with onset at approximately 1500 UT has been associated with an importance 2+ flare that started before 1553 UT at N05 W75 in plage region 7102 with type IV emission from 1604 through 1722 UT. This event was observed by Explorer 18.

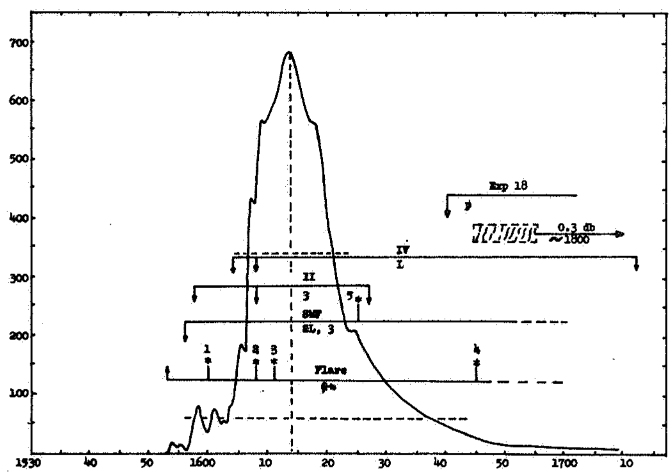


FIG. 6—1 16 March, 1964. 2800 Mc/s, 1-OTTA, 2-HUAN, CLMK, 3, 4-MCMA, NO5W74, 5-SWF Max.

6.2 THE SMALL PCA EVENT ON 5 FEBRUARY 1965

This PCA event with an absorption of 1.8 db was observed by Satellites 1964-45A and 1963-38C and Mariner IV. Observations were made with 30 and 50 Mc/s Riometers in both the Arctic and Antarctic polar caps. Onset in the Arctic polar cap was approximately one hour after the start of an importance 2 flare at N08 W24. A type IV burst was observed between 1810 and 1905. A very small burst at 2700 and 2800 Mc/s was reported at the time of the flare with the time of peak flux following the reported times of flare maximum by 18 and 16 minutes. Goedeke et. al., (1966) reported the start of absorption at 1906 UT on the 30 Mc/s Riometer and at 1930 on the 50 Mc/s Riometer. Mariner IV at 1.1 AU observed the first increase in proton intensity at 1840 UT ± 10 minutes. Data from Satellite 1963 38C integral intensities above 1.2, 10, 20, 40, and 80 MeV of 380, 350, 250, 100, and 5 protons/cm^2 respectively by 2150 UT. The peak integral intensity with energies $>$1.2 MeV was about 840 protons/cm^2 sec. at 0400 UT on February 6.

6.3 THE SMALL PCA EVENT ON 24 MARCH 1966

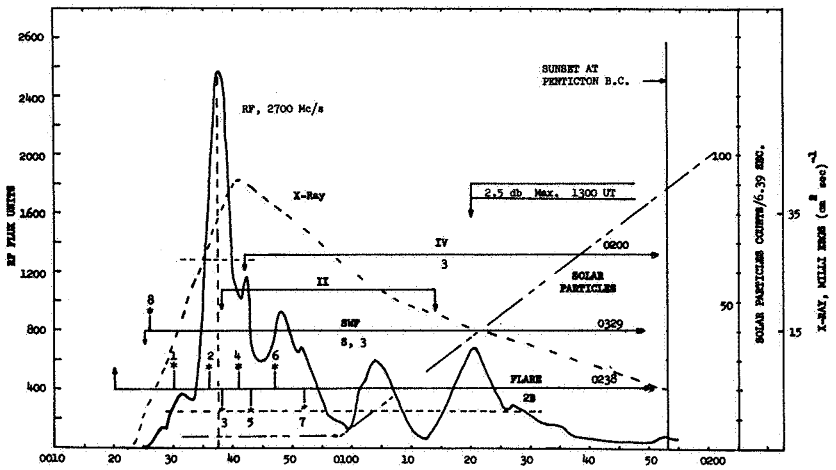


FIG. 6.2 7 JULY 1966, 2700 Mc/s (PENTICTON): X-RAY, 2-12 A° EXPLORER 33; SOLAR PARTICLES, EXPLORER 33; FLARE MAX: 1-HALE, 2-LOCK, 3-HALE, 4-MANI, 5-SACP, 6-IKOM, 7-CULG, N34W47, 8-SWF MAX. SATELLITE AT 68 EARTH RADII

This event has been associated with a large active region that crossed the east limb on March 15. The region was flare productive with at least 17 flares of importance 2 or greater during disk passage.

Several periods of small (< 1db) absorption were recorded between March 20 and 28. Sufficient data are not available to evaluate this event on the 24th

6.4 THE PCA EVENT IN JULY 7, 1966

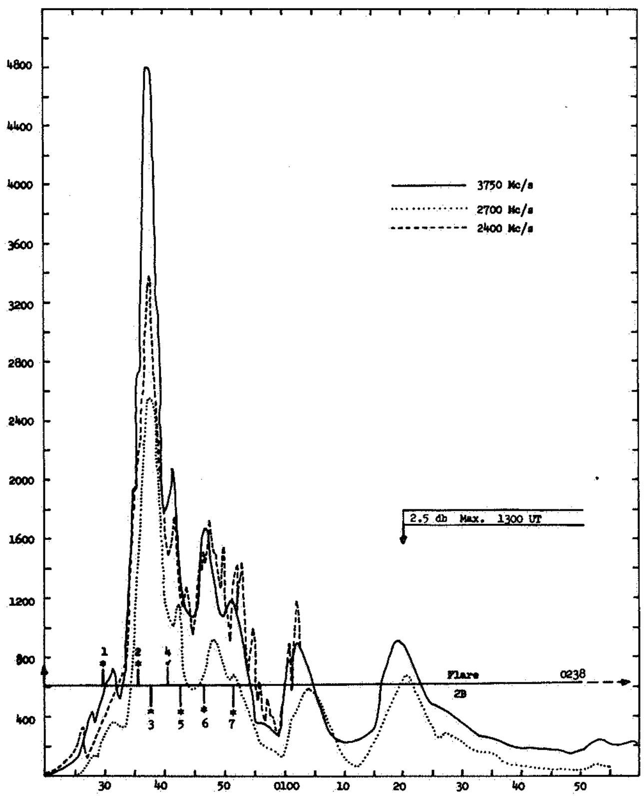


FIG. 6-2a 7 JULY 1966, COMPARISON OF RF EMISSIONS AT 2400 Mc/s, 2700 Mc/s PENTICTON, B.C.; AND 3750 Mc/s NAGOYA. SHOWING ASSOCIATED FLARE AND REPORTED FLARE MAXIMA. 1,3-HALE, 2-LOCK, 4-MANI, 5-SACP, 6-IKOM, 7-CULG, N34W47

The flare associated with this event started at 0020 with maximum sometime between 0030 and 0052 (Table 18) maximum was reported by 7 observatories. The RF burst started at 0025.9 at centimeter wavelenght with major peak of 2650, 4730, and 3420 flux units at 2700, 3750, and 2400 Mc/s respectively. The reconstructed curve at 2700 Mc/s with time of flare maximum, SWF, type II and type IV emissions are shown on Figures 6-2. We have also shown the smooth X-ray flux, (Van Allen) and proton count from Explorer 33. We have an interesting example of a probable multi-maximum flare and multi-peak RF emissions. Figure 6-2a shown the superposted time histories of the RF emission at 2400, 2700, and 3750 Mc/s. Castelli (1968) shown the "U" shape spectral characteristic for this event.

6.5 THE ACTIVE REGION 8461

The active region 8461 that crossed the solar disk between August 22 and September 4, 1966, was the source of two polar caps absorption events a small event (1 db) on August 28, and a great event (30 db) on September 2. The region was flare productive. Although all but five were classified with importance 1, or sub-flares. Three importance 2 flares were reported on August 26, 30, and 31.

6.5.1 The RF Burst and Small PCA on 28 August 1966

This appears to be an excellent example of multi-maximum flare and RF correlation. The flare, RF emission, and X-ray flux (2 to 12A°) start simultaneously. Five reported times for flare maximum are in reasonable correlation with the times of RF peak during the first 20 minutes of activity (Figure 6-3).

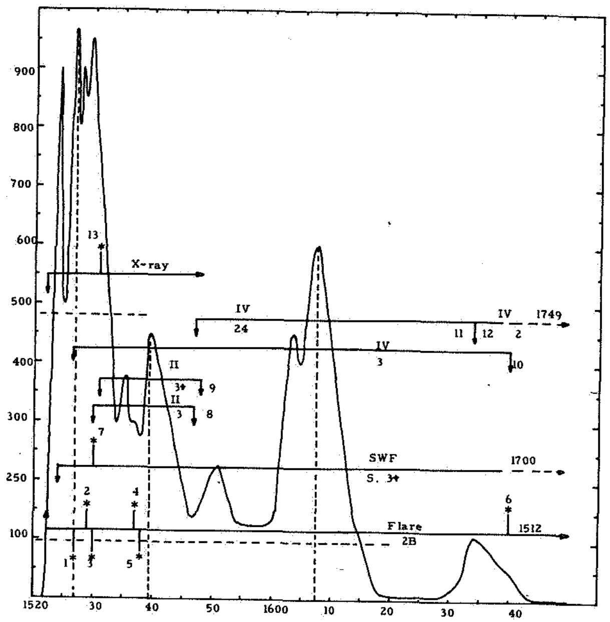


Figure 6.3 28 August, 1966. 2695 Mc/s. (SGMR) Reconstructed RF Time history. showing related phenomena. reported Flare Maxima 1-ATHN, 2-MCMA, HUAN; 3-LOCK, LOCA 4-SACP; 5-WEND; 6-HALE; N 22 EO4. 7-SWF max., Type II: 8, 11-41 Mc/s; 9, >150- <25 Mc/s. Type IV 10, >320- <50 Mc/s; 11-41 Mc/s. 12, 21-41 Mc/s 13, X-ray 70 x QS, 2-12A°

This event and the event on September 2, from the same active region will be studied in detail as soon as the necessary additional data are recorded.

6.5.2 The RF Burst, and PCA ON 2 September 1966

This is another excellent example of a flare with several (6) different times reported for flare maximum and a great RF Burst with a complex structure at peak flux. The reported value of 30db absorption is one of the greatest yet recorded.

X-ray and other data will be available in the near future, consequently, a detailed analysis will be carried out as soon as the necessary data are obtained.

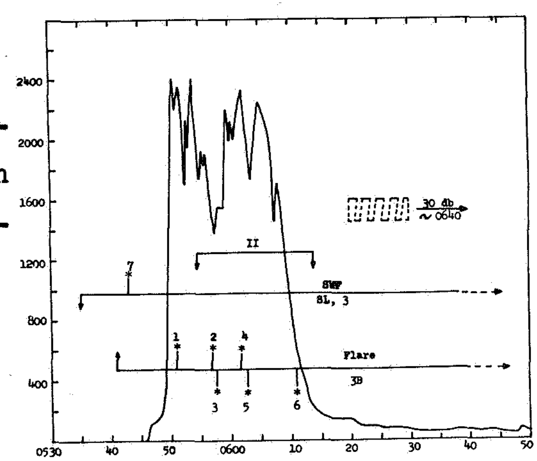


FIG. 6.4 2 Sept., 1966, 2700 Mc/s, CRON
1-TACH, 2-MANI, 3-ABST, 4-CAPS, 5-CATA, 6-CULG, N23W57, 7-SWF Max.

6.6 THE ACTIVE REGION 8818 THAT CROSSED THE SOLAR DISK BETWEEN MAY 18 AND JUNE 1, 1967

This appears to be the most active and productive region since the events during September 1963. The region will be analized in detail as soon as the necessary data is obtained. For the present we show the reconstructed time histories of the RF bursts on May 21 and 23 with the smooth plot of the X-ray data from explorer 33 kindly supplied by Dr. Van Allen.

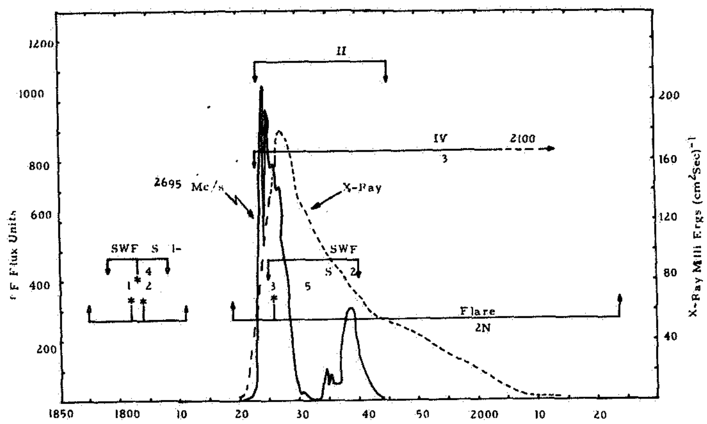


Figure 6.- 5a 21 May 1967 2695 Mc/s (SGMP) X-Ray 2-12A°. (Exp 33. IOWA) Flare Max 1-HALE 2-LOCK N26 E53 3-LOCK. SACP HALE N24E39 4. 5-SWF Max.

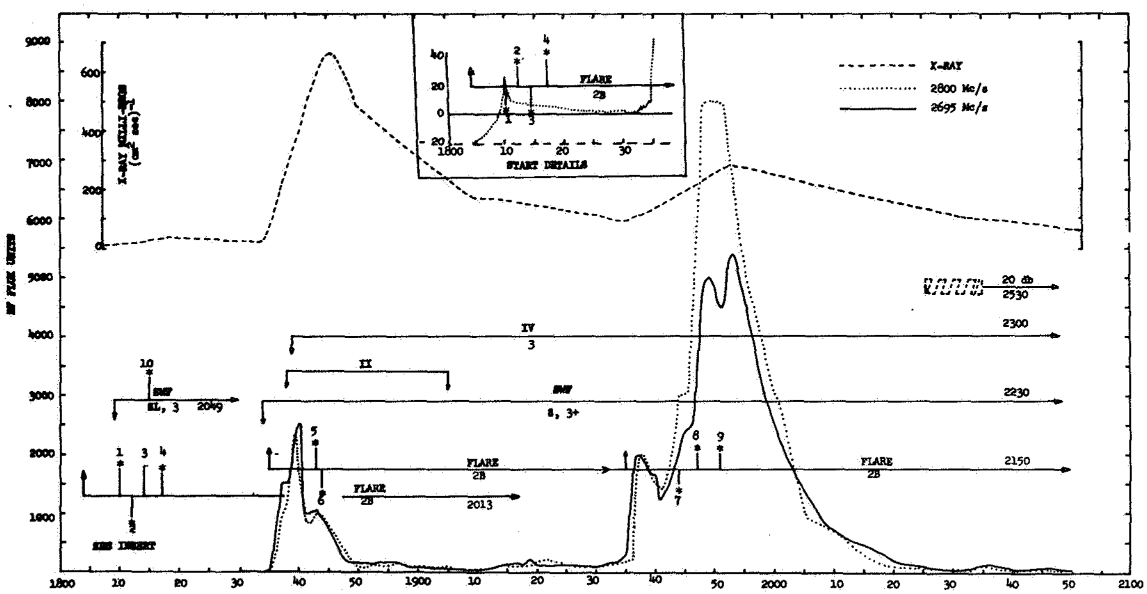


FIG. 6.5 23 MAY 1967. 2800 Mc/s (OTTA), AND 2695 Mc/s (SGMR), X-RAY, EXP. 33 (IOWA), 1-HOUS, 2-HALE, 3-LOCK, 4-SACP, N30E25; 5-HALE, 6-SACP, N26E24; 7-HOUS, 8-SACP, 9-HOUS, N27E28; 10-SWF MAX.

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TABLE 1 CHARACTERISTICS OF CLASS 1 RF PROFILES AND ASSOCIATED PHENOMENA, EVENTS FOLLOWED BY A POLAR CAP ABSORPTION

	Importance			Duration			Rate Rise	Spectral						Integrated Intensity		RF Burst	
														Proton /cm^2			
Date	RF	Flare	PCA db	Rise Time	≥ 50%	≥ 10%	Units/Min	II	IVm	IVcm	t	T	CMD	>30 mev	>100 mev	Energy >10% Peek	Fig. No.
2/23/56	3+	3	13.0	2	2	18.0	9000	-	-	2g	-6	$0^h 23^m$	W80	1.0x10^9	3.5x10^8	448	1.8
8/28/57	1+	2+	3.2	2	2.5	4.5	380	H/3			-4.5	$3^h 50^m$	E30			10	1.1
8/20/58*	2	2+	3.0	1	3	6.0	1450	S/3			-1.6	$37^h 18^m$*	E17			15	1.2
6/19/57	2+	2	f_{min}	1	3	6.5	2325	H/3			-3.0	$6^h 06^m$	E45			34	1.3
9/21/57	1+	3	5.1	7	3	10.0	112		H/3	5	+2.0	$3^h 30^m$	W06	1.5x10^6		19	1.6
9/20/63	2	2	3.1	3.5 5.5	3	14.0	351 254	H/2	H/3	8G	-2.7	$0^h 46^m$	W09				1.7
7/29/58	2	3	1.5	6	3	19.0	333	S/3	S/3	8G	+1.0	$1^h 01^m$	W44			15	1.9
8/16/58	3	3+	15.0	5	3	44.0	1160			5G	-1.0	$1^h 28^m$	W50	4.0x10^7		300	1.10
9/03/60	3+	2+	2.7	5	3.5	8.0	2500	S/1	S/2	6G	-3.4	$4^h 23^m$	W34	3.5x10^7	7.0x10^6	160	1.4
9/28/61	2	3	3.3	5.3	4	20.0	302	H/3+	H/3	12G	-5.7	$0^h 43^m$	E29	6.0x10^6	1.1x10^6	36	1.5
11/20/60	1	1	3.0	3.5	4	45.0	114	H/3	H/2	6g	+6.5	$6^h 05^m$	W90	4.5x10^7	8.0x10^6	25	1.11

*A very questionable association.

TABLE 2 CHARACTERISTICS OF CLASS 2 RF PROFILES AND ASSOCIATED PHENOMENA, EVENTS FOLLOWED BY A POLAR CAP ABSORPTION

	Importance			Duration			Rate Rise		Spectral						Integrated Intensity			
															Proton /cm^2			
Date	RF	Flare	PCA db	Rise Time	≥50%	≥10%	Units/Min a	b	II	IVm	IVcm*	Δ t	Δ T	CMD	>30 mev	>100 mev	Energy >10% Peek	Fig. No.
7/03/57	1	3+	9.2	11.1	7.5	27.5	60	38	No Obs.		10G	+3.1	$0^h 30^m$	W40	2.0x10^7		32	2.8
11/15/60	3+	3	20.0	2.0	11.5	33.5	3870	3870	S/3	S/3	10G	+1.0	$2^h 23^m$	W33	7.2x10^8	1.2x10^8	780	2.1
9/26/63	2	3	4.6	11.2	12.0	22	161	161	No Obs.		15G	-0.8	$1^h 07^m$	W78				2.6
10/20/57	2+	3	7.8	7.0	12.0	28	511	511	H/3	H/3	6g	+9.0	$4^h 23^m$	W45	5.0x10^7	1.0x10^7	209	2.2
4/29/60	1	2+	14.0	3.7	12.5	52	104	104	S/2	S/1		+0.7	~3^h	W02	7.0x10^6		51	2.10
5/13/60	2+	3	4.5	15.0	20.0	50	353	220	S/3	S/1	20G	0	$1^h 01^m$	W67	4.0x10^6	4.5x10^5	500	2.4
8/26/58	3	3	16.6	36.0	22.0	46	296	185	S/3	S/3	20G	+14.0	$0^h 55^m$	W54	1.1x10^8	2.0x10^6	550	2.5
7/16/59	3	3+	21.2	36.0	24.0	54	1143	176		H/3	10G	+26.0	$1^h 36^m$	W30	9.1x10^8	1.3x10^8	732	2.9
11/12/60	3	3+	21.2	26.5	25.0	33	435	210		H/3	20G	+16.0	$0^h 45^m$	W04	1.3x10^9	2.5x10^8	606	2.7
9/10/61	1+	1	2.9	31.0	25.0	42	140	49	H/3	H/3	10G	-9.0	>10^m	W90	3.7x10^7		95	2.3

*Svestka and J.Olmr Type IV Burst, I List of Bursts, BAC 17(1)(1966)4-16

TABLE 3 CHARACTERISTICS OF CLASS 3 RF PROFILES AND ASSOCIATED PHENOMENA EVENTS FOLLOWED BY A POLAR CAP ABSORPTION

	Importance			First Phase				Main Phase				Spectral						Integ. Intensity			
									Duration Min.												
Date	RF	Flare	PCA db	Rise Time	Peak % Max	Dur.	Peak Separation	Rise Time	50%	10%	Rate Rise	II	IVm	IVcm	Δ t	Δ T	CMD	>30 Mev	>100 Mev	Energy >10% Peak	Fig. No.
7/11/61	2	3	1.3	17.0	58	45	38.0	10.0	8	37	150	H/3	H/3	16G	+46	$5^h 45^m$	E31	3.0x10^6	2.4x10^5	138	3.3
7/20/61	2	3	w	1.5	67	14	28.0	15.5	11	19	116	H/3	H/3	12G	+20	$6^h 36^m$	W90	5.0x10^6	9.0x10^5	94	3.1
7/07/58	2	3+	23.7	3.0	58	15	44.0	11.5	15	>48	148	S/3	S/2	20G	+8	$0^h 20^m$	W08	2.5x10^8	9.0x10^6	156	3.2
5/06/60	1+	3+	16.0	10.5	37	16.5	17.0	11.5	15	>75	60	H/3	H/3	15G	-6	$1^h 56^m$	E07	4.0x10^6		69	3.6
3/30/60	2	2	5.0	6.5	36	20	29.5	8.0	16	29	219	H/3	H/3	8g	+16	$5^h 05^m$	E13			160	3.4
7/24/57	2	3	2.0	13.0 3.5	56 58	36	35.5 28.0	12.5	18	67	86		H/3	6g	+12	$3^h 03^m$	W26			94	3.5
3/10/56	2	2	3.5	4.8	53	10	31.0	15.0	20	53	68	No Obs.				$3^h 45^m$	E88	1.1x10^8		118	3.7
Average				7.5	7.5			12.0	15	47	121					$3^h 47^m$					

TABLE 4 CHARACTERISTICS OF CLASS 4 RF PROFILES AND ASSOCIATED PHENOMENA, EVENTS FOLLOWED BY A POLAR CAP ABSORPTION

	Importance			Duration			Rate Rise	Spectral						Integrated Intensity			
														Proton /cm^2			
Date	RF	Flare	PCA db	Rise Time	≥ 50%	≥ 10%	Units/Min	II	IVm	IV cm	Δt	Δ T	CMD	>30 mev	>100 mev	Energy 10% Peek	Fig. No.
9/18/57	1	3+	f_{min}	20.0	7.5	>50	18		H/3	6G	-22.5	$1^h 42^m$	E08			47	4.3
11/13/56	1-	2	5.4	9.0	8.0	35	19.4			4	-21.0	$5^h 30^m$	W10	1.2x10^8		13	4.2
7/14/59	3	3+	23.7	26.0	10.0	44	231	S/3	S/3	30G	+7.0	$1^h 20^m$	E07	1.3x10^9	1.0x10^8	400	4.7
9/11/57	1	3	0.5	29.0	10.0	>45	13		S/3	24G	+4.0	$23^h 24^m$	W02			27	4.6
4/05/60	3	2	3.1	22.5	10.0	60	267	S/3	S/3	8G		>$1^h 45^m$	W61	1.1x10^6		510	4.4
7/10/59	3	3+	20.0	18.0	14.0	40	350	S/1		3g	+1.0	$1^h 18^m$	E63	1.0x10^9	1.4x10^8	515	4.8
8/31/57	2+	3	4.9	14.5	21.0	35	269		H/3	20G	+3.5	$1^h 18^m$	W02	5.3x10^7		350	4.1
3/29/60	3	2+	2.6	38.0	21.0	56	217	No Obs.		5g	+24.0	$1^h 20^m$	E30	2.7x10^7		915	4.5
8/22/58	2	3	10.6	36.5	21.0	>70	41		H/2	20G	+16.0	$1^h 23^m$	W10	7.0x10^7	1.8x10^6	192	4.9
9/02/57	1-	2 1+	7.2	37.0	28.0	>70	4			6g	+18.0	$2^h 32^m$	W44 W26	1.4x10^7		30	4.11
9/26/57	1-	3	2.0	28.0	50.0	Indet.	4		H/3	6G	+12.0	$1^h 53^m$	E16			25	4.12
5/10/59	2+	3+	22.0	46.0	52.0	137	54	H/3	H/3	8G	+9.0	$2^h 05^m$	E47	9.6x10^8	8.5x10^7	811	4.10

TABLE 5 ALL MAJOR RF BURSTS AT 2800 IN 3750 Mc/s NOT FOLLOWED BY A KNOWN PCA EVENT

		Flare				Short Wave Fade				Spectral			RF Emission						
Date	Profile Class	Start	Max	Imp	Position	Start	Dur.	Type	Imp	II	IVm	IVcm	f	Start	Max	Dur.	Peak Flux	Δ t	Fig. No.
	10000 > RF > 5000																		
4/17/57	4	2000	2116	3+	N20E69	1937	163	SL	3+	2032 7/3	2011 44/2	2021 34/4g 200-2800	2800	2006	2042	79.0	6000	-34	9.6
9/15/63	2	0015	0042	2	N15E75	0015	180	S	3+	0027 22/2		0027 118/4g -9500	3750	0015	0028 0036.5 0044.4	90	650 4400 5000	 -5.5 -7.4	7.5
	5000 ≥ RF ≥ 2000																		
2/14/56	1	0538	0557	3	N21E33	0532	116	SL	3	0554 26/3			3750	0541	0553	75	2720	-4	6.30
9/07/57	*	0810	0823	1+	N15W88	0806	36	S	3				3750	0811	0812.8	3.0	2015	-10.2	*
12/26/57	*	NFP				0245	40	S	2+				3750	0245.8	0246.3	5.0	2650		*
8/02/58	1	1840	1841	1-	S14W90	1840	153	S	3+	1843 8/3			2800	1640	 1642.1	300 25	30 2050	-1.1	6.29
4/95/59	1	2316	2327	3	N16W67	2317	93	S	3+				3750	2318	2323	50	2300	-4	6.41
5/08/59	1	2252	2257	2+	N23E86	2258	22	S	2	2259 20/3			2800 3750	2254 2254	2257 2256.5	48 10	2200 2750	-0.5	6.22
5/17/59	1	0523	0527	2+	N21W30	0525	35	S	2+				3750	0523	0525	13	3300	-2.0	6.20
6/10/59	*	NFR				NR				0247 21-			3750	0245	0247		2250		*
	2000 ≥ RF ≥ 1000																		
2/24/55	*	NFP				NR				0104 20/-			3750	0101.5	0102.5	2.5	1470		*
6/18/55	1	1904	1910	2+	S22W21	1903	47	S	2+				2800	1906.5	1907.5	30.5	1500	-2.2	6.23
3/15/55	1	1625	1635	2+	N22E21	1623	120	S	3			1623 92/3g 167-2800	2800	1621 1644	1627 1652	23.5 33	1320 195	-2	6.42
11/22/56	1	1312	1341	2	S15W63	1330	65	S	3				2800	1333 1336	1334.7 1339	3.0 20.3	17 1000	-2.0	6.5
1/24/57	1	1638		2	S28W80	1638	27	S	2+				2800	1637	1638.8	10	1000		6.15
4/16/57	2	1040	1105	3	N20E65	1044	76	S	3			1038 57/3 200-9400	2800	1040	1046	54	1650	-19	7.1
8/10/57	*	0125	0129	1	N26W71	0100	60	SL	3	0129.4 44/3			3750	0126	0127.4	4	1700	-3.0	*
9/03/57	2	1412	1429	3	N23W30	1420	103	S	3				2800	1417	1424	25	1350	-5	7.2
9/19/57	*	0350	0410	3	N23E02	0359	54	SL	3		0427 183/3		3750	0359	0406	11.0	1000	-4	*
10/15/57	1	NFP				2150	12	S	1+				2800	2150	2152.7	10.0	1000		6.4
10/23/57	*	0621		1-	S27W76	0620	32	S	2				3750	0622.4	0623.4	5.5	1640		*
10/26/57	*	NFP				0135	20	S	2				3750	0138	0135.2	1.0	1440		*
1/15/58	1	1640	1642	2+	S13W58	1640	120	S	3				2800	1640 1640	1720 1642.7	240 28	40 1350	+0.7	6.35
3/29/58	1	1819	1823	2	S24E08	1821	59	S	3				2800	1820.5	1821.0	12.5	1400	-1.2	6.18
10/21/58	1	2318	2330	2+	S04W22	2328	72	S	3+	2328 13/3+ 2328 32/-	2327 23/3 2344 16/3	2328 67/160 67-9500	3750	2333	2327	55	1150	-3.0	6.43
12/11/58	1	1802	1812	2	S02W06	1808	32	S	2+		1803 45/3	1804 21/2 167-2800	2800	1805	1810	20.0	1225	-2.0	6.33
12/12/58	1	1215	1304	2+	S03W08	1257	38	S	2	1259 13/3	1301 234/2	1251 239/250 81-9401	2800	1252 1257	1252.8 1300.5	1.0 18.0	35 1500	-3.5	6.20
12/23/58	1	0543	0624	2+	S15E66	0540	73	G	3-			0553 82/40 169-9400	3750	0534	0605	50.0	1020	-19	6.45
1/14/59	*	2140	2142	1-	N21E11	NR							2800	2130		15.0	2000		*
3/29/59	*	0746	0754	2	N17E36	0750	40	S	3				3750	0746	0750	10.0	1050	-4	*
5/13/59	1	2339	2342	1+	S09E88	2340	10	S	1+				3750	2340	2340.6	1.5	1000	-1.4	6.3
5/17/59	1	0700	0707	1	N21W30	0705	23	S	2+				3750	0705	0706.7	3.0	1280	-0.3	6.8
5/18/59	1	NFP				0404	50	S	2	0407 5/-			3750	0403	0404.2	3.0	1750		6.6
6/09/59	1	NFR				1635	180	S	3+		1714 46/2	1651 14/4g 167-9400	2800	1635	1652	41.2	2000		6.10
6/09/59	1	1707		2	N17E90	NR					1714 46/2	1734 16/4g 167-9400	2800	1707.5 1716 1726	1709.5 1719 1740	5.0 12.0 70.0	15 135 1800		6.46
6/16/59	*	0618	0628	3	N15E15	0623	34	S	2				3750	0623	0625.6	6.0	1100	-2.4	*
6/18/59	1	1134	1148	3	N16W12	1138	52	S	2+				2800	1139	1140	18.0	1225	-8.0	6.27
7/27/59	1	1222	1230	2	N14E50	1228	26	S	2+				2800	1225	1229	76.0	1025	-1.0	6.21
11/30/59	*	0247	0250	2+	N08E16	0249	31	S	3-	0251 67/-	0312 38/-	0247 133/2 200-9400	3750	0247	0252.3	12.0	1750	+2.3	*
4/03/60	1	0317	0317	2	N12W33	0305	25	S	2+				2750	0306	0310.6	5.0	1300	-6.4	6.9
8/11/60	1	1916	1929	2+	N22E26	1925	65	S	2	1929 9/3+	1926 53/2	1925 18/4g 18-2800	2800	1916 1923.5	 1928	144.0 37.0	9 1100	-1.0	6.40
8/14/60	1	0511	0525	2+	N22W06	1515	45	S	3				3750	0514	0518.4	19.0	1410	-6.6	6.36
9/16/60	4	1710	1724	1	S22E68	1709	101	S	3	1714 14/3	1717 114/3	1718 67/80 18-9100	2800	1702 1725	1712 1756	23.0 74.0	550 2000	+12.0 +32.0	9.7
10/11/60	1	0517	0535 0600	2	S17W36	0525	63	S	3	0530 17/3	0532 >40/2	0527 33/4 200-9400	3750	0520	0532.8	40.0	1580	-2.2	6.44
5/01/63	2	0525	0608	2	N15E46	0530	39	SL	2+	0536 22/1			3750	0526	0544	34.0	1500	-24.0	7.3

TABLE 5 (CONTINUED)

	Profile Class	Flare				Short Wave				Spectral			RF Emission						
Date		Start	Max	Imp	Position	Start	Fade Dur.	Type	Imp	II	IVm	IVcm	f	Start	Max	Dur.	Peak Flux	Δt	Fig. No.
	1000 > RF ≥ 500																		
11/15/55	*	NFP				NR							2800	1734	1737	5.0	565		*
2/16/56	4	1805		2-	N22E06	1802	93	SL	3			1756 384/3 167-2800	2800	1756	1811.3	51.0	623		9.5
2/19/56	4	1430	1445	1+	N25W23	1429	151	S	3			1428 57/6g 81-2800	2800	1425	1435	29.0	643	-10.0	9.2
2/29/56	*	2220		3	S30W21	2228	72	S	3-				2800	2217		23.0	525		*
3/01/56	1	1730		2	N20W55	1726	22	S	2				2800	1721	1724	5.0	614		6.1
3/13/56	1	1453		2	N21E50	1452	118	S	3-				2800	1451	1454	14.5	860		6.38
5/18/56	*	1600		1-	S26E45	1605	15	S	1				2800	1604.3	1604.4	15.7	515		*
7/22/56	1	1624	1641	2	N29W54	1635	110	S	2+				2800	1638 1646.5	1641.8 1648	8.5 11.5	660 389	+0.8	6.31
12/26/56	4	1401	1412	2	S17W11	1403	97	SL	3-		1423/H 45/2		2800	1403	1454	165.0	915	+42.0	9.8
1/06/57	1	1822	NFR		N16	1702	53	S	2+	1703 9/3+	1711 169/3	1706 (114)/4g 167-2800	2800	1701.5 1719	1703.5 1722.5	10.0 13.0	700 70		6.39
1/06/57	4	1822		1-	N16W53	1802	63	G	1				2800	1758	1827	92.0	585		9.4
2/08/57	1	1550	1555	2	S28E38	1552	10	S	2	1551 4/3+			2800	1550	1551	6.0	865	-4.0	6.12
4/02/57	*	0255	0339	2	S14W44	0250	120	G	3				3000	0301	0336	60.0	800	-3.0	*
4/12/57	*	1850	1908	2	S25W73	1856	89	S	3+	1904.7 11.3/3			2800	1855.5	1900.5	23.0	525	-7.5	*
6/05/57	1	1326	1330	2	S17W43	1328	26	S	3-	1329 4/3+			2800	1327	1328.2	8.0	725	-1.8	6.25
6/06/57	*	1130	1133	1	S14W27	NR							2800	1129	1129.8	1.5	525	-3.2	*
7/21/57	1	1320	1337	2	N29E12	1335	45	S	2+			1329 121/6G 169-2800	2800	1321.5 1334.5	1322.5 1335.9	6.5 8.0	23 850	-1.1	6.13
8/30/57	1	NFP				2215	25	SL	2	2213.7 33/2	2212 31/3	2214 26/4g 167-9400	3750 2800	2209 2210	2213.1 2213.7	8.0 10.3	538 480		6.11
9/12/57	1	1510	1516	2	N11W18	1513	39	S	2+	1516 12/3+	1515 310/3	1515 165/15G 81-9400	2800	1514	1515	18.0	850	-1.0	6.17
11/05/57	1	1205	1207	2	S24W54	1207	14	S	2+				2800	1205	1207.3	8.0	550	0	6.26
12/13/57	*	<0227	0234	1	N15E90	0156	49	SL	3				3750	0155	0232	46.0	650	-2.0	*
2/26/58	*	0527	0550	2	S18W61	0540	56	SL	2+	0602 9.5/2			3750	0543	0551.7	14.0	500	+1.7	*
3/28/58	1	1703	1714	2+	S15E09	1708	70	S	3				2800	1708.5	1711.5	14.0	575	-2.5	6.19
3/28/58	2	2042	2047	2	S24E21	2042	26	S	2+				2800	2043	2045.1	33.0	520	-1.9	7.7
4/02/58	*	<0502		2	S23W34	0459	74	S	2+				3750	0458	0500.3	3.5	840		*
5/05/58	*	0356	0415	3	S18W29	0407	53	S	3				3750	0412	0414.1 0414.8 0419.6	9.0	900	-0.9	*
5/05/58	1	2025 2032	2035 2037	1+ 1+	N24W50 S15W39	2032	38	S	2+				2800	2034.7	2036.5	7.0	580	-0.5	6.2
7/04/58	*	0513	0517	1+	N29E26	0517	11	S	1				3750	0515	0517.1	2.5	800	+0.1	*
7/24/58	*	2327	2443	2+	N10E85	2444	56	G	2				3750	2441	2443.1	4.0	535	+0.1	*
10/19/58	*	0634	0725	2+	S17W35	0720	30	S	2				3750	0723	0723.9	2.0	585	-1.1	*
1/21/59	1	1700	1709	3	N10E48	1702	41	S	2+	1718 25/3			2800	1701.5	1707.5	26.5	600	-1.5	6.37
2/01/59	*	0352	0423	3	N12E83	0422	25	S	3-				3750	0408	0422	17.0	550	-1.0	*
3/02/59	*	2317	2320	1+	N25W26	2320	39	S	2				3750	2317.5	2319.4	4.0	640	-0.6	*
5/11/59	2	2006	2028	3	N10E41	2015	67	S	3-	2020 19/3+	2028 18/3	2023 22/4 167-2800	2800	2010	2022 2033	200.0	900 760	-6.0	7.4
5/13/59	*	0457	0514	2+	N22E26	0511	36	S	2	0516 9/3	0525 65/1	0512 18/3 127-9500	3750	0510	0513.1	5.0	570	-0.9	*
7/29/59	1	2117	2120	2+	N15E22	2120	45	S	2				2800	2118	2119	65.0	790	-1.0	6.14
8/28/59	*	0027	0039	1	N11E71	0028	140	SL	2+	0038 10/2	0053 155/	0031 19/2 200-9400	3750	0024	0041	30.0	540	+2.0	*
8/28/59	*	0111	0113	1	N13E69	NR						0115 15/- ?	3750		0118		890		*
12/02/59	1	1219	1249	2+	N07W16	1246	76	S	2+			1250 45/5g 167-2980	2800	1245	1247.5	12.0	375	-1.5	6.34
1/15/60	2	1336	1411	2	S20W68	1340	45	SL	1+			1347 18/10G 200-9400	2800 Interference	1340	1357	>100.0	700	-14.0	7.6
3/28/60	3	2042	2056	2	N15E37	2050	50	S	2+	2057 15/3	2050 >240/3	2100 290/7G 18-2800	2800	2047.7 2102.5	2055 >2115	14.8 55.2	750 >885	+19.0	8.1
6/25/60	*	<1026	1029	1+	N19E03	1027	33	S	2				2800	1026	1026.9	5.0	650	-2.1	*
6/25/60	1	2039	2046	2+	N19W04	2040	30	S	2-	2048 17/3	2045 68/3	2056 29/2 167-2800	2800	2037	2046	40.0	700	0	6.24
6/29/60	4	0125	0148	1	N21W50	0138	128	S	2	0149 8/2	0140 50/3	0138 17/4g 200-9400	3750	0135	0147.9	21.0	840	-0.1	9.1
8/07/60	1	0724	0737	1	N18E84	0730	55	S	2+				3750	0725	0729.3	20.0	610	-7.7	6.32
8/11/60	*	0223	0257	2	N21E15	0225	90	SL	2				3750	0222	0252.9	35.0	610	-4.1	*
8/14/60	1	1242	1310	2	N20E36	1307	53	S	3-				2800	1307	1310.7	16.0	680	+0.7	6.16
10/10/60	*	0710	0722	1+	S17W23	NR						0704 31/3 231-9400	3750	0708	0719.2	20.0	510	-2.8	*
9/14/63	1	2112	2123	1	N12E72	NR							2800	2134 2143	2144.5	9.0 7.0	24 550	+21.5	6.7
9/16/63 **	4	1430	1505	2	N12E48	1440	125	G	3			1434 -/15G 108-9400	2800	1436.5	1452 1543	133.5	318.0 710	+38.0	9.3

** Krivsky lists a PCA (reported by Pfotzer, et al) starting at 1920 based on balloon observations.
* Original RF data not obtained

TABLE 6 MAJOR RF BURSTS AT 2800 OR 3750 Mc/s
NOT FOLLOWED BY A KNOWN PCA EVENT;
CLASS 1 PROFILE (IMPULSIVE NARROW PROFILE)

		Importance			RF Duration				Spectral Data				
Date	f	RF	Flare	CMD	Rise Time	≥ 50%	≥ 10%	Rate Rise	II	IVm	IVcm	Δ t	Fig. No.
3/01/56	2800	1+	2	W55	4.0	0.2	2.4	152					6.1
5/05/58	2800	1+	1+	W39/W50	2.0	0.4	4.0	290				+1.5 to -0.5	6.2
5/13/59	3750	2	1+	E90	1.5	0.5	1.0	666				-1.5 to -3.5	6.3
10/15/57	2800	2	NFP		3.0	0.5	2.5	333					6.4
11/22/56	2800	2	2	W83	3.0	0.5	6.0	333				-1.0	6.5
5/18/59	3750	2	NFP		3.0	1.0	2.5	583	S/1				6.6
9/14/63	2800	1+	1	E72	2.0	1.0	3.0	550				+21.5	6.7
5/17/59	3750	2	1	W30	2.0	1.0	4.0	640				-0.3 to -1.3	6.8
4/03/60	3750	2	2+	W33	6.0	1.0	6.0	216				-6.4	6.9
8/30/57	2800 3750	1 1+	NFP		3.7	1.0	9.0	130	H/2	H/3	4g		6.11
6/09/59(1)	2800	2	NFP		6.0	1.0	13.0	333			4g		6.10
2/08/57	2800	1+	2	E38	1.0	1.5	3.0	865	H/3			-4.0	6.12
7/21/57	2800	1+	2	E12	1.4	1.5	4.0	607			6g	+4.9 to -11.1	6.13
7/29/59	2800	1+	2+	E22	1.8	1.5	5.0	439				-0.7	6.14
1/24/57	2800	2	2	W85	2.0	1.5	5.0	500					6.15
8/14/60	2800	1+	2	E36	4.0	1.5	5.0	170				+0.5	6.16
9/12/57	2800	1+	2	W18	1.0	1.5	6.0	850	H/3+	H/3	15G	+0.3 to -4.0	6.17
3/29/58	2800	2	2	E08	1.3	1.5	7.0	180				-0.2 to -2.2	6.18
3/28/58	2800	1+	2+	E09	3.0	1.5	7.0	192				-2.5 to -3.5	6.19
5/17/59	3750	2+	2+	W31	2.0	1.5	10.3	1650				-2.0	6.20
7/27/59	2800	2	2	E50	2.5	2.0	3.0	410				0 to -5.0	6.21
5/08/59	3750 2800	2+	2+	E86	3.0 3.5	2.0 3.0	4.0 6.0	917 629	H/2			-0.5	6.22
6/18/55	2800	2	2+	W21	2.0	2.0	4.0	790				-2.2	6.23
6/25/60	2800	1+	2+	W04	4.5	2.0	4.5	155	H/3	H/3	2	0 to -1.0	6.24
6/05/57	2800	1+	2	W43	1.7	2.0	5.0	43	S/3+			+0.2 to -2.8	6.25
11/05/57	2800	1+	2	W54	2.3	2.0	5.5	240				+0.3	6.26
6/18/59	2800	2	3+	W13	2.0	2.0	6.0	612				-5.0 to -10.0	6.27
12/12/58	2800	2	2+	W09	3.5	2.0	8.0	430	H/3	H/2	25G	-1.5+ to -4.5	6.28
8/02/58	2800	2+	1-	W90	3.0	2.0	9.0	683	H/3			+1.1	6.29
2/14/56	3750	2+	3	E26	3.0	2.0	16.0	907	S/3			-4.0	6.30
7/22/56	2800	1+	2	W55	3.8	2.5	5.5	180				+0.8	6.31
8/07/60	3750	1+	1	E84	4.5	2.5	6.5	130				+0.5 to +1.6	6.32
12/11/58	2800	2	2	W06	5.0	2.5	7.0	245		H/3	2	-2.0	6.33
12/02/59	2800	1+	2+	W16	2.5	2.5	8.0	350			5g	-1.5	6.34
1/15/58	2800	2	2+	W58	2.5	2.5	10.5	540				+0.7 to -3.0	6.35
8/14/60	3750	2	2+ 1	W06 E39	5.0	2.5	11.0	282				-4.6 to -8.6 -5.6 to -9.6	6.36
1/21/59	2800	1+	3	E48	6.0	5.0	9.0	100	H/3			-1.5	6.37
3/13/56	2800	1+	2	E50	4.0	3.0	8.0	215					6.38
1/06/57	2800	1+	NFP		2.0	3.5	7.0	350	H/3	H/3	4g		6.39
8/11/60	2800	2	2+	E26	5.0	4.0	14.0	220	H/3+	H/2	4g	0 to -1.0	6.40
4/05/59(2)	3750	2+	3	E68	8.0	4.5	11.0	290				-3.0	6.41
3/15/56	2800	2	2+	E21	5.5	5.5	12.5	220			3g	-8.0	6.42
10/21/58(3)	3750	2	2+	W22	7.0	2.5	51.0	164	H/3+	H/3	16G	0 to -6.0	6.43
10/11/60	3750	2	2	W37	9.0	6.5	11.0	172	S/3	S/3	4	-6.0 to -32.0	6.44
12/23/58	3750	2	2+	E66	7.5	9.5	27.5	128			4G	-19.0	6.45
6/09/59(4)	2000	2	2	E90	5.5	9.5	31.0	327		H/2	4g	+1.5	6.46
	Average				2.7	2.4	7.7						

(1), (4) These two events numbers 10 and 46 meet the group classification of Covington. The two events are separated by 21 minutes when the flux was less than 10% of the peaks.

(2) Burst in progress at 3750 sunrise, consequently Rise Time and Duration are questionable, probably less than the values that are based in extrapalation and reports at other frequencies.

(3) Profile classification of this event questionable. The major impulsive narrow profile burst is followed by a long duration burst with three major peaks not included in the 10% average.

TABLE 7 MAJOR RF BURSTS AT 2800 OR 3750 Mc/S,
NOT FOLLOWED BY A KNOWN PCA EVENT;
CLASS 2 PROFILE (IMPULSIVE BROAD PROFILE)

Date	f	Importance		CMD	RF Duration						Spectral Data			Δ t	Fig. No.
		RF	Flare		Rise Time a	Rise Time b	≥ 50%	≥10%	Rate Rise a	Rate Rise b	II	IVm	IVcm		
3/28/58	2800	1+	2	E31	5*	9.5	4	14	104*					-1.9	7.7
9/03/57	2800	2	3	W30	7*		7.5	14.5	193*					-1.0 to -8.0	7.2
4/16/57	2800	2	3	E85	6.5*	9.5*	9.0	31.5	254*	174*			3	-7 to -12	7.1
5/01/63	3750	2	2	E46	5.5	11.5*	12.0	22	202	130*	S/1			-2 to -4	7.3
9/15/63	3750	3	2	E65/E75	4.5	19*	16.5	52	980	490*	S/2		4g	+22.4 to +7.4	7.5
5/11/59	2800	1+	3	E41	11.5*		21.5	33	783*		H/3+	H3	4	-0.5 to -12	7.4
1/15/60	2800	1+	2	W69	4.5	14.5*	21.5	>77	110	49*			10G	-14.0	7.6
Average					10.6*	13.6	33.6								

*Maximum peak flux
a First peak
b Second peak

TABLE 8 MAJOR RF BURSTS AT 2800 OR 3750 Mc/s
NOT FOLLOWED BY A KNOWN PCA EVENT;
CLASS 4 PROFILE (SLOW COMPLEX RISE)

Date	f	Importance		CMD	RF Duration			Rate Rise	Spectral Data			Δt	Fig. No.
		RF	Flare		Rise Time	≥ 50%	≥10%		II	IVm	IVcm		
6/29/60	3750	1+	1	W44/W56	13	4	17	65	S/2	S/3	4g	-0.1	9.1
2/19/56	2800	1+	1+	W27	9.5	6	22	68			6g	-10.5	9.2
9/16/63(2)	2800	1+	2	E49	66.5	10	88	11			15G	+38(1)	9.3
1/06/57	2800	1+	1-	W53	29	13	>40	20		H/3*	4g	?	9.4
2/16/56	2800	1+	2+	E08	15.5	17	40	39			3	?	9.5
4/17/57	2800	3	3+	E70	36	17	41	167	H/3	H/3	4g	-34	9.6
9/16/60(1)	2800	2	1	E68	51	20	35	40	H/3	H/3	8G	+32	9.7
12/26/56	2800	1+	2	W10	19	22	56	48		H/2		+42	9.8

*Type IV in progress, started at 1706 cm, 1711 m.

(1) This event has all of the characteristics of a PCA event.

(2) Krivsky reports a PCA starting at 1920 based on balloon observations.

TABLE 9 OUTSTANDING RF EVENTS (FLUX > 1000 UNITS) AT CENTIMETER WAVE-LENGTHS WITH SMALL OR NO REPORTED EMISSION AT 2800 OR 3750 Mc/s

FLARE					SWF				SPECTRAL			RF EMISSION							
DATE	START	MAX.	IMP.	POSITION	START	DUR.	TYPE	IMP.	II	IVm	IVcm	f	MIS	START	MAX.	DUR.	PEAK FLUX	Δ t	PCA
12/29/56	0040	0045	1+	N16E59	0044	106	S	3+				3000	TOK	0043	0056	90	1150	+ 11	NO
6/06/57	1130	1132 1134	1	S14W27	NR							2980 2800	NED OTT	1129 1129	- 1129.8	1.0 1.5	1700 525	-2.2 -4.2	NO
10/20/57	NFP	0000-0310		UT	0242	38	S	2+				3000 3750	TOK NAG	0239 0238	0254 0254.4	40.0 18.0	1100 478		NO
12/13/57	<0227	0234	1	N15E90	0156	49	SL	3				3000 3750	TOK NAG	0153 0155	0232 0232	70.0 46.0	1130 650	- 2	NO
2/26/58	0527	0548 0552	2	S18W61	0540	56	SL	2	0602 4.5/2			3000 3750	TOK NAG	0543 0550 0543	0545.8 0550 0551.7	5.0 8.0 14.0	343 1048 500	+2, -2 +3.7, -0.3	NO
3/23/58	0947	1003 1005 1010 1018 1025 1033	3+	S14E78	0953	196		3			1003 132/10G 80-3000	2980 3000	NED HHI	0953 0958	- 1002	110.0 10	>1340 >1190	- 1 - 3 - 7 - 16 - 23 - 30	3.2 db 5h 13m TO 8h 42m
9/14/58	0822	0835 0836 0900	2+	S10W80	0851	58	S	3			0906 27/8g 81-9400	2980 3000	NED HHI	0833.5 0847.5 0830	- 0904	5.0 43.0 69.0	371 870 1259	+29, +28, +4,	NO
8/28/59	0111	0113	1	N13E69	NR						0115 15/-	2000 3000	NAG TAK	0111 0115	0123 0120	30.0 20.0	2250 1520	+ 10 + 7	NO
9/03/59	0421	0422 0423 0425	2+	N25E86	0422	20	S	3	0424 13.5/			3000	TAK	1420.5	1420.5	2.0	6850	- 1.5 - 2.5 - 4.5	NO
5/26/60	0850	0922 0928 0930 0934	2+	N14W15	0914	46	S	2			0902 48/6g 200/9100	2980	NED	0909	-	27.0	>1350	-	NO
*9/14/63	2202	2206	1	N12E73	NR							2000 2800	NAG OTT	2230 2229.5	2235.5 2235	12.0 10.5	1880 180	+ 29.5	NO
*9/18/63	2236	-	1	N12E20	NR							2000 3750	NAG NAG	2231 2234	2327.0 2330.5	130.0 120.0	1100 57		NO

* Sec. Table 17 for other events during September 1963.

TABLE 1[illegible] [illegible] RF EVENTS [illegible] 3750 Mc/s DURING
THE 19TH SOLAR CYCLE

FIG.	DATE	CMD	FLARE IMP.	f	PEAK	PCA db	Δ T	PROFILE CLASS	FLARE ONSET	Δ t	OTHER f	PEAK
1.8*	2/23/56	W80	3 +	3750	18000 7400	13.0	$0^h\ 23^m$	1	0334	-6.5 +1.5	3000 200	> 4410 > 20000
1.4*	11/03/60	E88	2 +	3750	12000	2.7	$4^h\ 23^m$	1	0037	-3, -6	9400 2000	14700 7100
2.1*	11/15/60	W35	3	3750	11600 7400	20.0	$2^h\ 23^m$	2	0207	+1. +17.5	9400 2000 1000	24000 4950 8100
4.5	3/29/60	E30	2 +	3750	8250	2.6	$1^h\ 20^m$	4	0640	+30, +23, +22, +20.5	2000 200	49000 38000
7.5	9/15/63	E75	2	3750	4500 8080	NONE	REPORTED	2	0015	+10, -1, -3, -5 +22, +11, +9, +7	9400 2000	17000 2500
2.9*	7/16/59	W30	3 +	2800	4000 6500	21.2	$1^h\ 36^m$	2	2114	-3.5, -7.5, -9.5 +29.5, +25.5, +23.5	200	1100
4.6	7/10/59	E63	3 +	3750	6300 4500	20.0	$1^h\ 54^m$	4	0206	+1.5, -12 +14.5, +0.5	9400 1000	26500 6000
4.7	7/14/59	E04	3 +	3750	6000	23.7	$1^h\ 20^m$	4	0325	+7	9400 200	6300 10000
4.4	4/05/60	W62	2	3750	6000	3.1	$1^h\ 45^m$	4	<0215	FLARE ONSET NOT SEEN	9400 2000 1000	14200 1230 18000
9.6	4/17/57	E69	1	2800	6000	NONE	REPORTED	4	2000	?		
1.10	8/16/58	W50	3 +	3750	5800	>15	$1^h\ 28^m$	1	0433	0, -1	9500 3000 200	7340 5030 18000
2.7*	11/12/60	W40	3 +	2800	4900 4800 5500	21.2	$0^h\ 45^m$	2	1315	+1.5 +6.5 +16	9100 1500 200	>7500 770 2000
1.7a	9/20/63	W09	2	3750	5350	PCA IN PROGRESS FOR ~50 MINUTES			2314	+ 51	9400 2000	3500 2100

* GROUND LEVEL EVENT

TABLE 11 THE SOLAR REGION 3400 THAT
CROSSED THE SOLAR DISK BETWEEN FEBRUARY 10 AND 24, 1956

FLARE					SWF				SPECTRAL			R F EMISSION						PCA		
DATE	START	MAX.	IMP.	POSITION	START	DUR.	TYPE	IMP.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δ t	db	Δ T	FIG. NO.
2/10/56	2110	2138	3	N23E90	2110	55	S	3+				2800	2112		28.5	346*				
2/14/56	0538	0557	3	N21E33	0532	116	SL	3	0554 26/3			3750	0541	0553	75.0	2720				6.30
2/16/56	1805	1837	2+	N20E08	1802	93	SL	3			1756 384/3	2800	1756	1813	51.0	623				9.5
2/17/56	1100	1120	3	N20W04	1102	44	S	3				NONE REPORTED AT CM WAVELENGTH								
2/19/56	1430	1445	1+	N23W27	1429	151	S	3			1428 57/6g	2800	1425	1485	29.0	643				9.2
2/23/56	0334	0342	3	N23W80	0330	160		3+			0335 50/2g	3750	0334	0336	15.5	18000	-6.5	13	$0^h\ 23^m$	1.8

*IN SUNSET OSCILLATION

TABLE 12 THE SOLAR REGION 3941 THAT CROSSED THE
SOLAR DISK BETWEEN APRIL 16 AND 28, 1957

	FLARE				SWF				SPECTRAL				R F EMISSION					
DATE	START	MAX.	IMP.	POSITION	ONSET	DUR.	TYPE	IMP.	II	IVm	IV cm	f	ONSET	MAX.	DURATION	PEAK FLUX	Δt	Fig. No.
4/16/57	1044	1053 1105	3	N20E85	1044	76	S	3			1038 57/3 200-9400	2800	1040	1046	54	1650	- 19	7.1
4/17/57	1006	1022	3	N29E76								2980	1006		4			
4/17/57	2000	2116	3+	N20E69	1937	163	SL	3+	2032 7/3	2011 44/2	2021 34/45 200-2800	2800	2006	2042	79.0	6000	- 34	9.6

TABLE 13 THE SOLAR REGION 4708 THAT
CROSSED THE SOLAR DISK BETWEEN AUGUST 15 AND 28, 1958
AND; REGION 4686 THAT CROSSED THE DISK BETWEEN AUGUST 6 AND 18, 1958

FLARE					SWF				SPECTRAL			RF EMISSIONS						POLAR CAP. ABS.			
DATE	START	MAX.	IMP.	POSITION	ONSET	DUR.	TYPE	IMP.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δ t	ONSET	Int. db.	Δ T	FIG. NO.
*8/07	1457	1505 1508 1509 1510 1511	3	S16E71	1500	105	S	3+				2800	1458 1500 1516	 1503 1522	220 15.5 12.5	25 95 150	-17 to -11				
*8/13	1205	1220	2	S14W18	None Reported							2800	1207	1210	11.5	115	-10				
*8/16	0432	0439 0440	3+	S14W50	0432	166	S	3+		0438 57/3+	0439 146/5G 169-9500	3750	0434	0439	60.0	5600	0 -1	0600	15	$1^h 23^m$	1.10
8/19	2118	2254 2258 2320 2331	2	N18E26	2200	65	S	2		2207 114/3	2150 140/6G 169-9500	2800 3750	2204 2206	2210 2210	17.0 10.0	335 315	-44 -46				
8/20	0042	0043 0046	2+	N16E17	0042	33	S	2+	0046 19/3			3750	0041.5	0042.5	5.0	1450	-0.5 -3.5	21/1400	3.0	$37^h 15^m$	1.2
8/22	1417	1448 1506	3	N18W10	1435	170	S	3+		1500 617/2	1438 92/20G 167-9400	2800	1430	1506	120	1500	+18 0	1530	10.6	$1^h 23^m$	4.9
8/25	0949	1000 1003 1005 1015	2+	N16W46								3000	0952	1005	74.0	334	+5 +2 0 -10				
8/26	0005	0027	3	N20W54	0010	240	SL	3+	0021 24/3	0030 240/3	0017 113/20G 167-9400	3750	0005	0041	50.0	5050	+14	0100	16.6	$0^h 55^m$	2.5

* THESE SOLAR EVENTS OCCURRED IN SOLAR REGION 4686 WHICH CROSSED THE SOLAR DISK BETWEEN AUGUST 6 AND 18.

TABLE 14 THE SOLAR REGION 5148 THAT CROSSED THE DISK BETWEEN MAY 8 AND 21, 1959

FLARE						SPECTRAL			PCA		RF EMISSION						
	START	MAX.	Imp	POSITION	SWF	II	IVm	IVcm	Δ T	IMP db	f	ONSET	MAX.	DUR.	PEAK	Δ [illegible]	FIG.
08	2252	2256 2258	2+	N23E86	S/2/22	2259 20/3					2800 3750	2254 2254	2257 2256.5	[illegible] [illegible]	[illegible] 2750	+1, -1	[illegible].22
09*	0123	0150	3	N20E78	NR												
10	2055	2140 2148	3+	N19E47	SL/3+/560	2123 8/3+	2116 164/3	2108 157/8G	$2^h\ 05^m$	22	2800	2100	2149	>160	2500	+[illegible], +1	4.10
	2315	NR	3	N19E51													
11	2006	2022 2034	3	N10E41	S/3-/67	2020 19/3+	2028 18/3	2023 22/4	absorption still increasing		2800	2010	2022 2033	200	900 750	0, -13	7.4
13	0457	0513 0514 0515	2+	N22E26	S/2/36	0516 9/3	0525 65/1	0512 18/3			3750	0510	0513.1	5.0	570	+0.1 -0.[illegible] -1.9	
	1554	1610 1613	2	N14E18	G/1+/30						2800	1552	1553.4	5.0	100	-16.6 -19.6	
17	0523	0527	2+	N21W30	S/2+/35						3750	0523	0525	13.0	3300	-2	6.20
	0700	0707 0708	1	N20W30	S/2+/23						3750	0705	0706.7	3.0	1280	-0.3, +1.3	6.8
18	NFP				S/2/50	0407 5/-					3750	0403	0404.2	3.0	1750		6.6

* This major flare reported by Sydney only. No RF reported at any frequency, and no SWF.

TABLE 15 BASIC CHARACTERISTICS OF REGIONS THAT PRECEDED AND FOLLOWED THE JULY 1959 REGION 5265

PLAGE				SUN SPOT										FIRST FLARE	
PLAGE NO.	CMP	CM AREA	MEAN POSITION	GREEN. NO.	CMP LONG. LAT.	DAYS SEEN CMD	MAX. AREA DATE	MEAN AREA	MtW NUMBER	CMP	DATES SEEN	MEAN MAG. CL.	NO. FLARES	DATE	CMD
5070	3/28.2	800	N 18	19253	3/28.51 320.5 N19.2	24-3 E53- W 78	365 4/2	127	14018	3/28.5 N 20	26-2	d β 1	2	3/31	W 36
5105	4/24.6	7500	N 18	19301	4/24.70 321.5 N21.1	19-29 E70- W 62	329 4/23	166	14074	4/24.8 N 21	19-28	d β pd	5	4/18	E 86
5157	5/21.4	4500	N 20 327	19352	5/20.96 334.5 N16.9	17-27 E45- W 81	872 5/24	508	14139	5/21.0 N 16	15-26	d β_p 1	30	5/17	E 45
5204	6/17.5	9000	N 19 330	19396	6/17.46 330.4 N17.1	11-23 E80- W 79	1111 6/11	856	14211	6/17.5 N 17	11-23	1 γ 1	70	6/11	E 90
5265	7/13.7	12000	N 16 339	19448	7/14.66 330.4 N16	8-21 E84- W 85	1981 7/17	14/2	14284	7/14.7 N 17	8-20	1 γ 1	82	7/07	E 90
5315	8/10.1	11000	N 17 342	19492	8/11.03 328.3 N14.9	5-14 E76- W 47	504 8/05	193	14348	8/11.3 N 14	4-15	1xd	None		

TABLE 16 THE SOLAR REGION 5265 THAT CROSSED THE SOLAR DISK BETWEEN JULY 8 AND 21, 1959

	FLARE				SWF				SPECTRAL			RF EMISSION						POLAR CAP. ABS.			FIG. NO.
DATE	START	MAX.	Imp.	POSITION	ONSET	DUR.	TYPE	Imp.	II	IVm	IVcm	f	ONSET	MAX.	DUR.	PEAK FLUX	Δ t	ONSET	Int. db	Δ T	
7/8	0703	0741	1+	N16E88	First flare in region 5265. No associated phenomena reported																
7/09	1930	1956 1959 2001 2046	2	N19E67	1943	29	S	1+		2044/H 196/3	2020 140/6g 167-9400	2800	2042	2046	20.0	475	+46 +43 +41 0	2000	ƒmin	$0^h\ 30^m$	
7/10	0206	0222 0236 0308	3+	N20E63	0200	190	SL	3+	0222/S 44/1		0209 97/3g 167-9400	3750	<0209	0224 0236.5	54	6300 5000	+2 +0.5	0400 9/2000 -	20.0 10/1000	$1^h\ 54^m$	4.8
	0514		3+	N16E59								3750	0514	0516	20.3	26					
	0539	0908	3	N20E58	0605	155	G	3+				None reported.									
7/12	2134	2230 2231 2240 2250	2+	N19E24	2220	100	G	2-				2800 3750	2224 2225	2228 2228	16.0 15.0	80 105	-2 -3 -13 -23				
7/13	0255	0410	3	N15E18	0405	77	G	2-				3750 3000	0248.8 0249	0249.5 0250	3.0 3.0	38 346					
7/14	0325 0520	0349 0527	3+	N17E04	0328	180	S	3+	0338/S 34/3	0401/S 129/3	0337 198/30G	3750	0330	0356	100.	6000	+7.0	0445 14/0445 -	23.7 14/0800	$1^h\ 20^m$	4.7
7/16	1525	1556 1615 1616 1618	3	N14W27	1610	28	S	2-	1616/H 7/3			2800	1613	1615	9.0	350	+19 0 -1 -3				
	2114	2125 2129 2131	3+	N16W30	2118	177	S	3+	2121	2121/H 262/3	2121 159/10G 167-7400	2800	2118	2122 2134 2154	>180	4000 4200 6500	-2, -7, -9 +9, +5, +3 +29, +25, +23	<2250 16/2200 -	21.2* 17/0600	$1^h\ 36^m$	2.[illegible]

* Ground level effect at 2250.

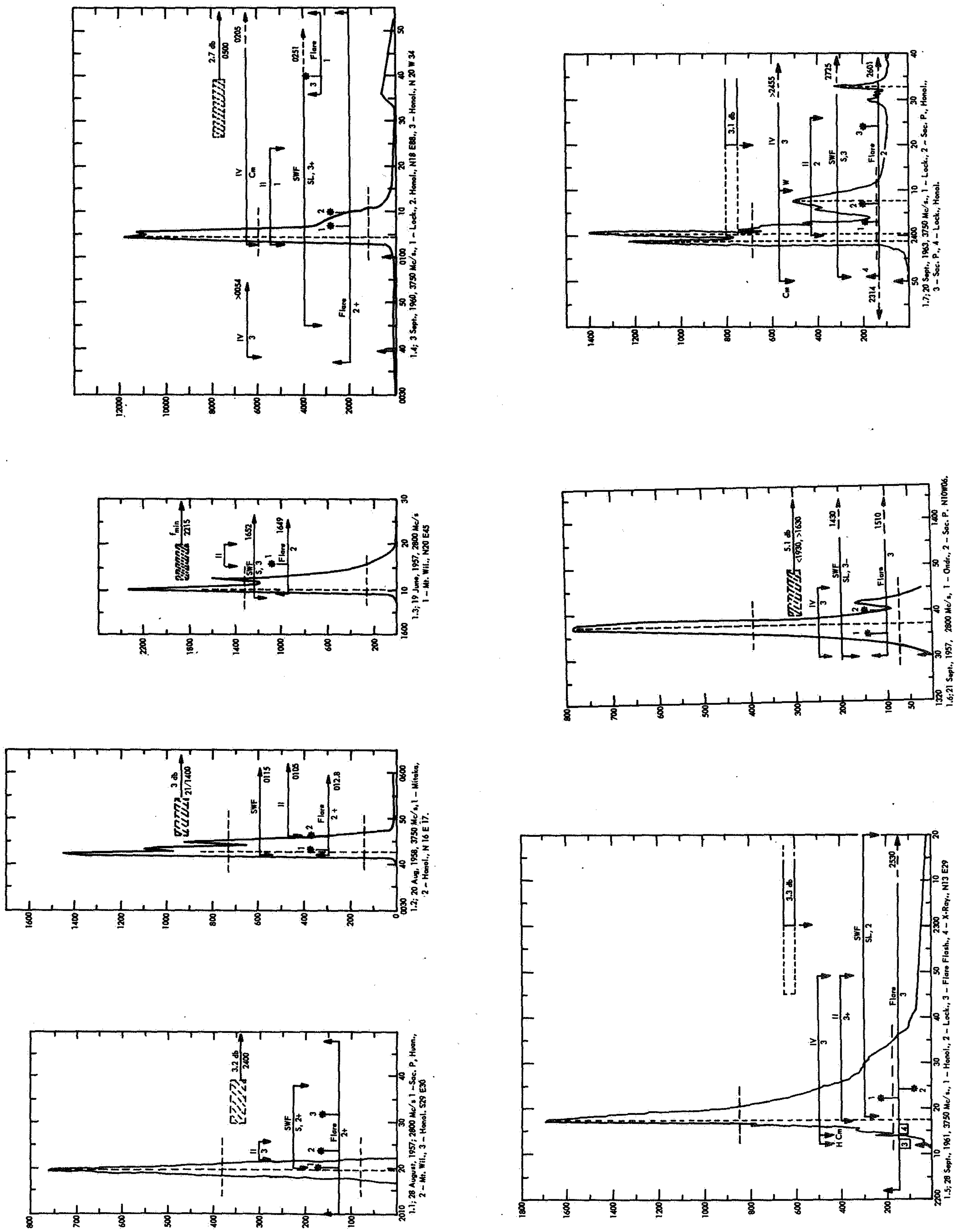


FIG.1 RF CLASS 1 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.

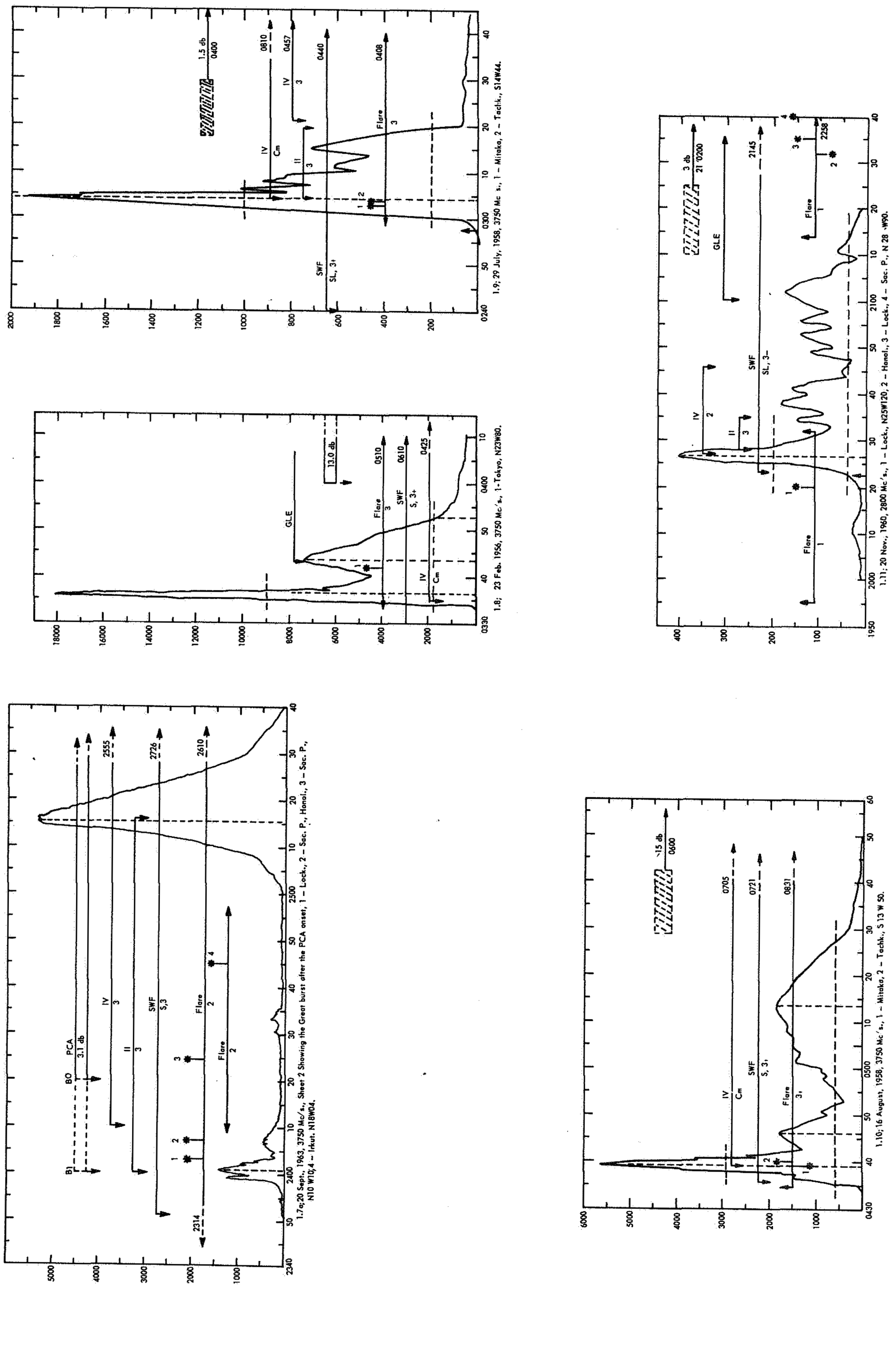
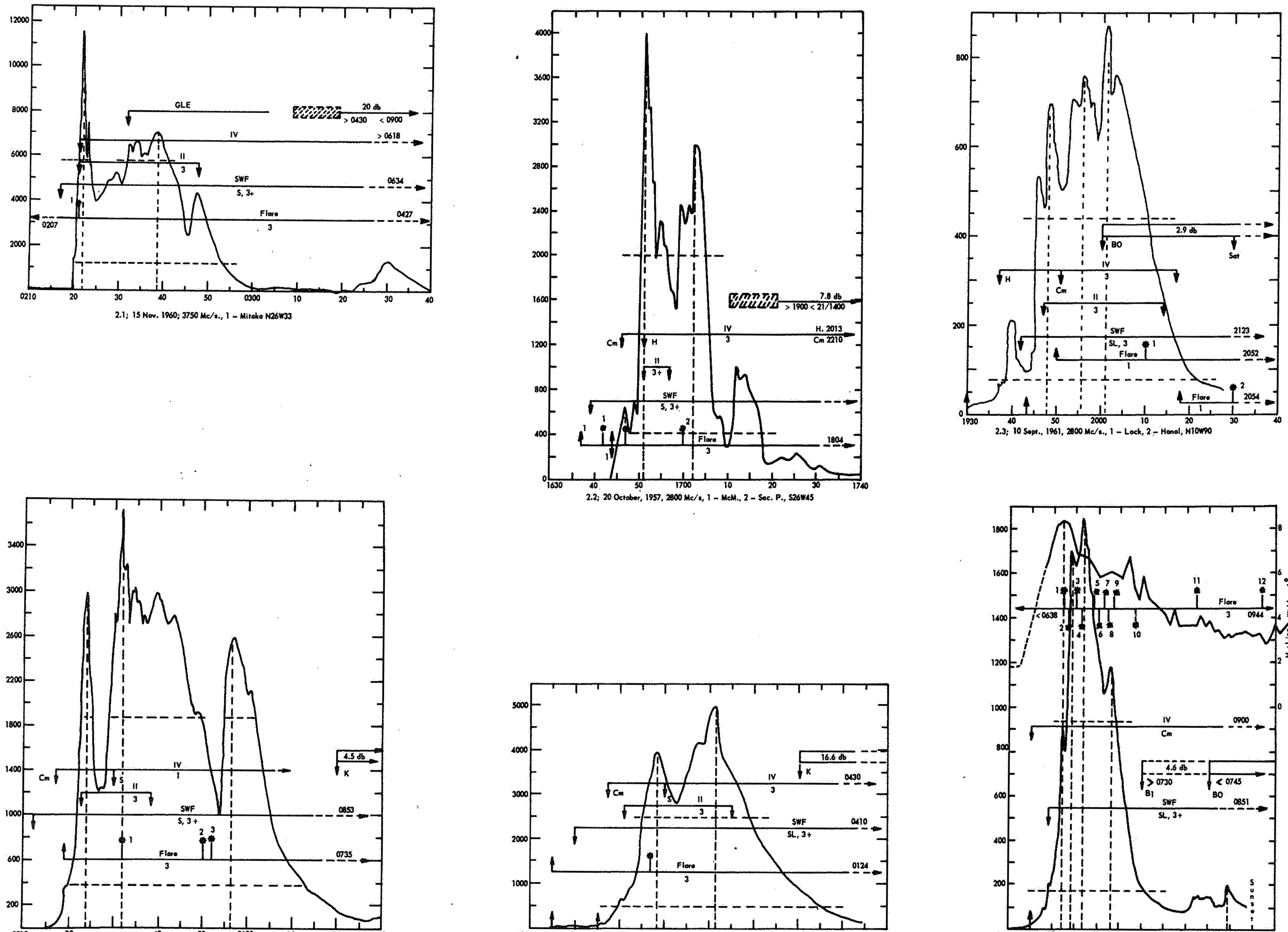


FIG. 1. RF CLASS I PROFILES CONTINUED.



2.1; 15 Nov. 1960; 3750 Mc/s., 1 – Mitaka N26W33

2.2; 20 October, 1957, 2800 Mc/s, 1 – McM., 2 – Sac. P., S26W45

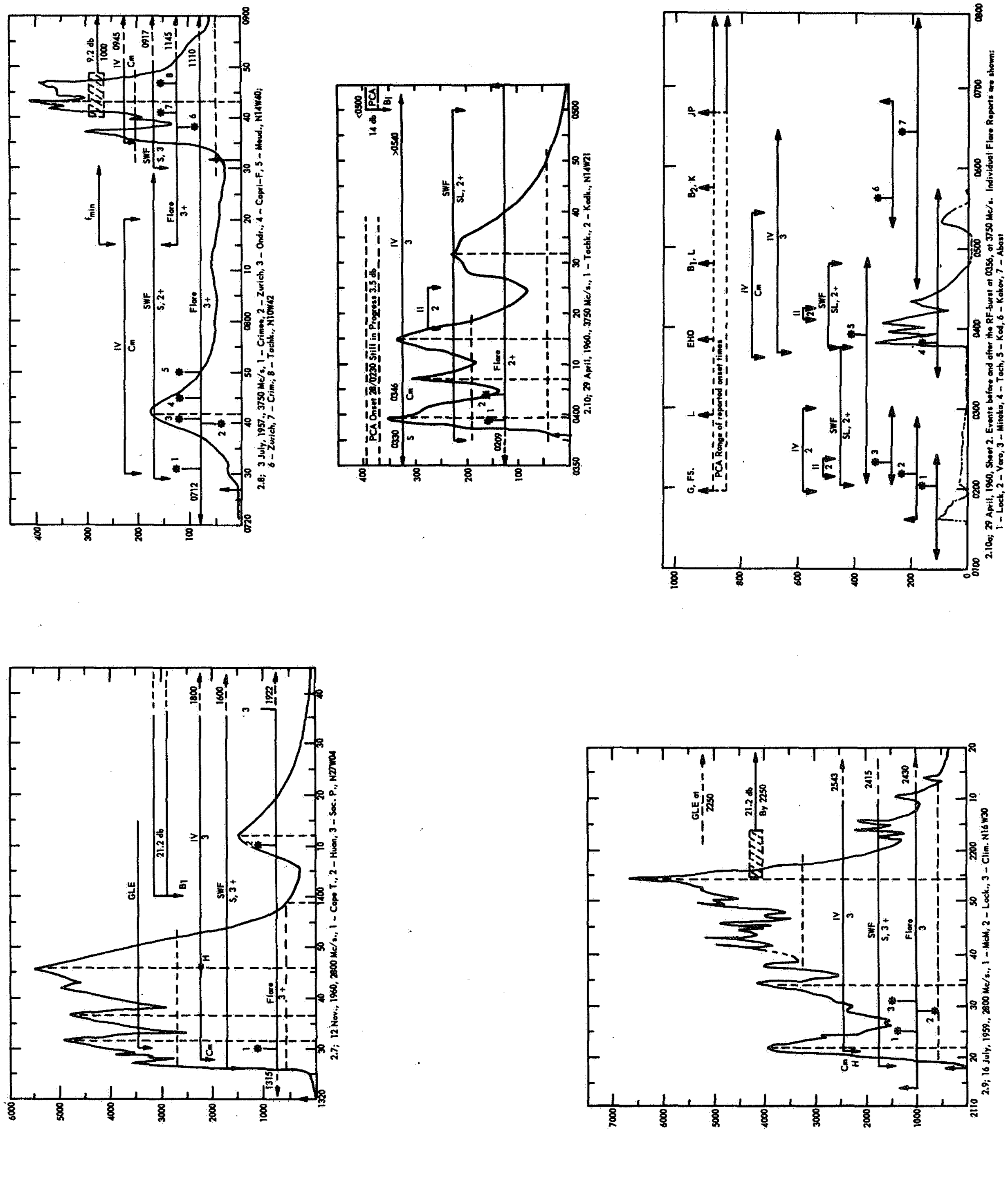
2.3; 10 Sept., 1961, 2800 Mc/s., 1 – Lock, 2 – Honol, N10W90

2.4; 13 May, 1960., 3750 Mc/s., 1 – Mitaka, Tachk., 2 – Wend., 3 – Abast., N29W67

2.5; 26 August, 1958, 3750 Mc/s, 1 – Climx, N20W54

2.6; 26 Sept., 1963; 3750 Mc/s.; Ondrejov Hα Line-Width; 1 – Ondr, 2 – Athn, 3 – Tachk., 4 – Cape-T, 5 – Abast., 6 – Bakou, 7 – Crim, 8 – Buch., 9 – Haute-P., 10 – Kievko, 11 – Capri-F, 12 – Nizm., N13W78

FIG.2 RF CLASS 2 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.



2.8; 3 July, 1957, 3750 Mc/s, 1 – Crimea, 2 – Zurich, 3 – Ondr., 4 – Capri-F, 5 – Meud., N14W40; 6 – Zurich, 7 – Crim., 8 – Tachk., N10W42

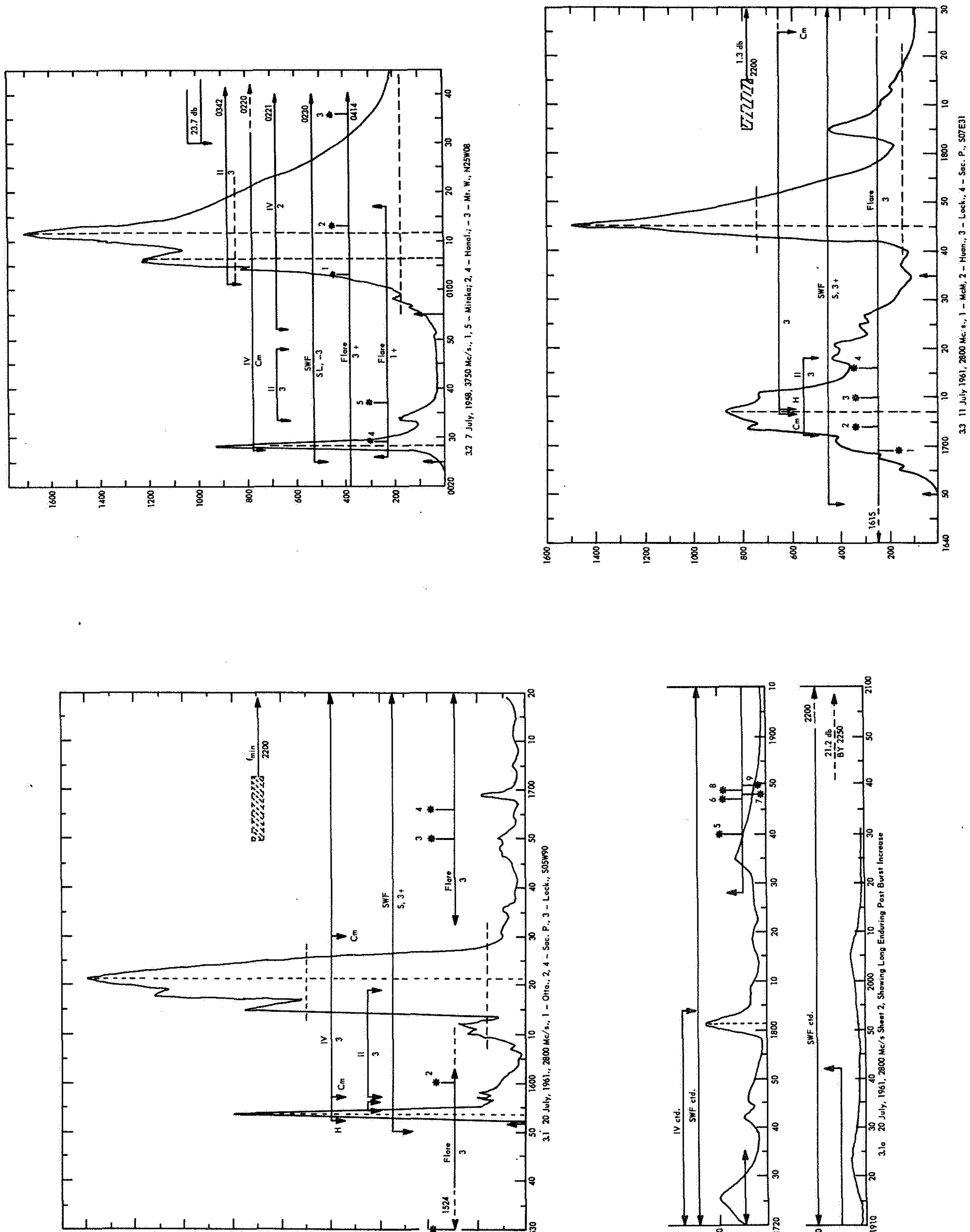
2.10; 29 April, 1960, 3750 Mc/s., 1 – Tachk., 2 – Kodk., N14W21

2.10a; 29 April, 1960, Sheet 2. Events before and after the RF-burst at 0356, at 3750 Mc/s. Individual Flare Reports are shown: 1 – Lock, 2 – Varo, 3 – Mitaka, 4 – Tach, 5 – Kod, 6 – Kakov, 7 – Abast

2.7; 12 Nov., 1960, 2800 Mc/s., 1 – Cape T., 2 – Huan, 3 – Sac. P., N27W04

2.9; 16 July, 1959, 2800 Mc/s., 1 – McM, 2 – Lock., 3 – Clim. N16W30

FIG.2 . CLASS 2 PROFILES CONTINUED.



3.1 20 July, 1961., 2800 Mc/s., 1 – Otta., 2, 4 – Sac. P., 3 – Lock., S05W90

3.1a 20 July, 1961, 2800 Mc/s Sheet 2, Showing Long Enduring Post Burst Increase

3.2 7 July, 1958, 3750 Mc/s., 1, 5 – Mitaka; 2, 4 – Honol.; 3 – Mt. W., N25W08

3.3 11 July 1961, 2800 Mc/s., 1 – McM, 2 – Huan., 3 – Lock., 4 – Sac. P., S07E31

FIG.3. R.F. CLASS 3 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTION SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.

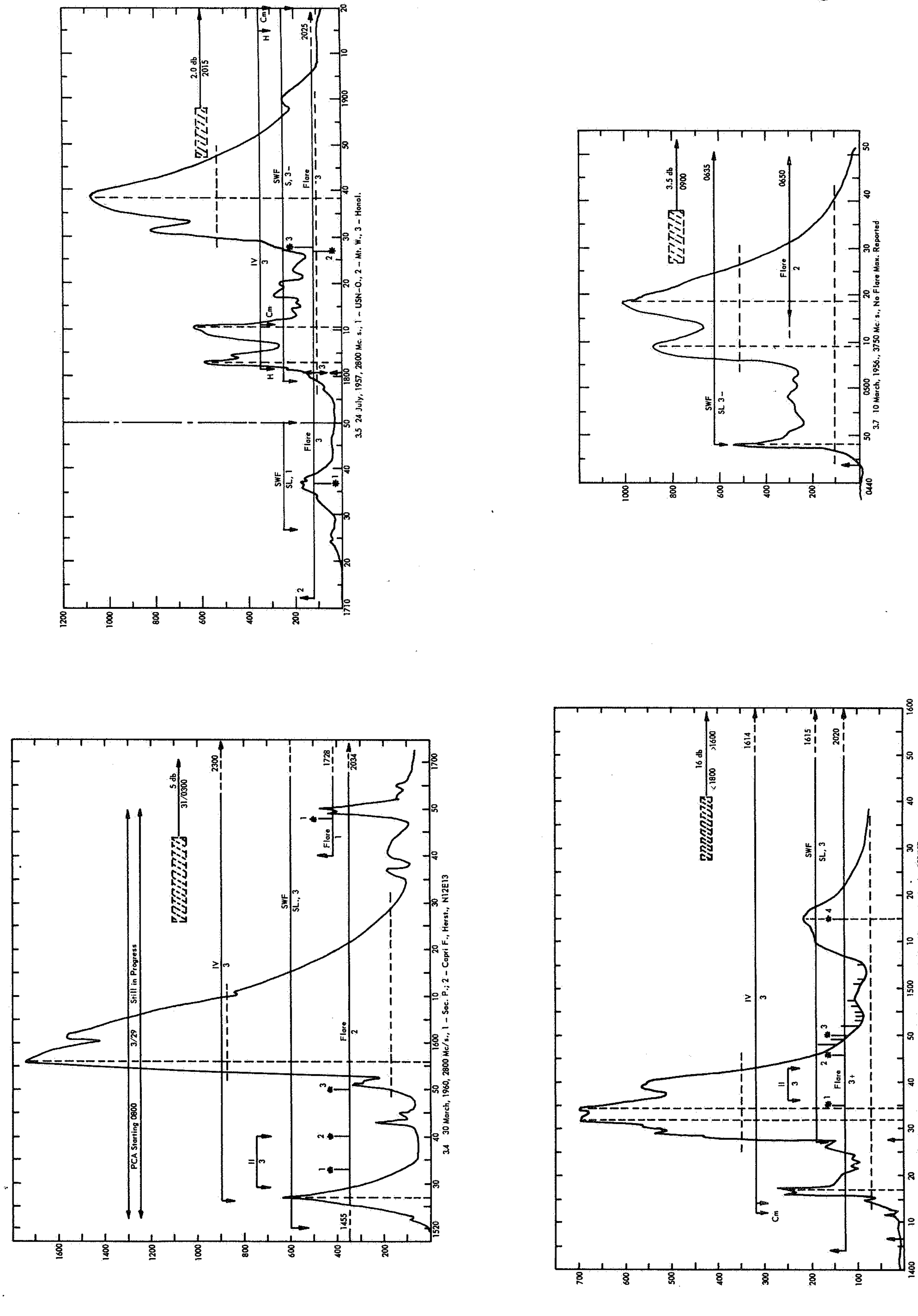


FIG. 3. R.F. CLASS 3 PROFILES, CONTINUED.

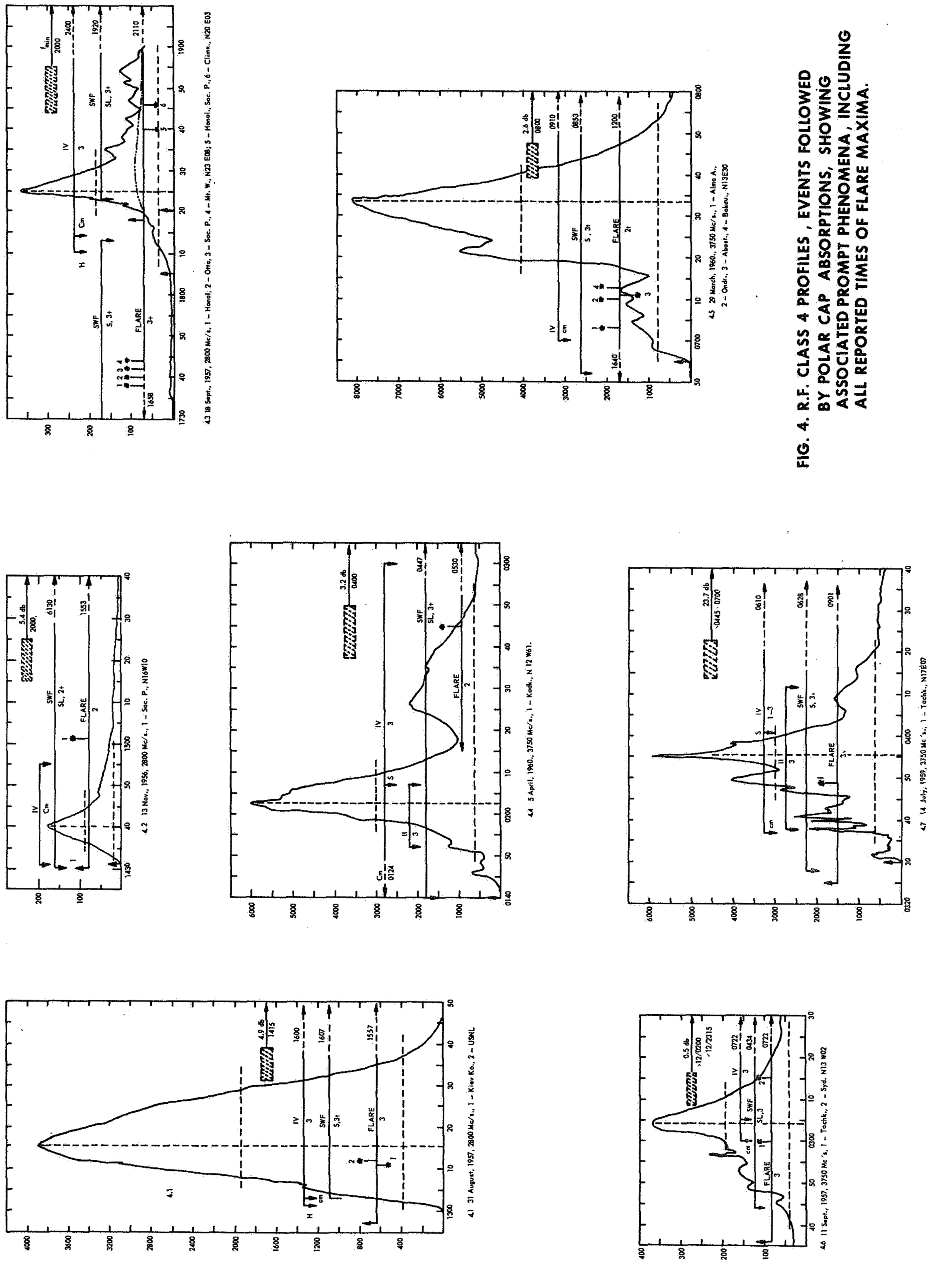
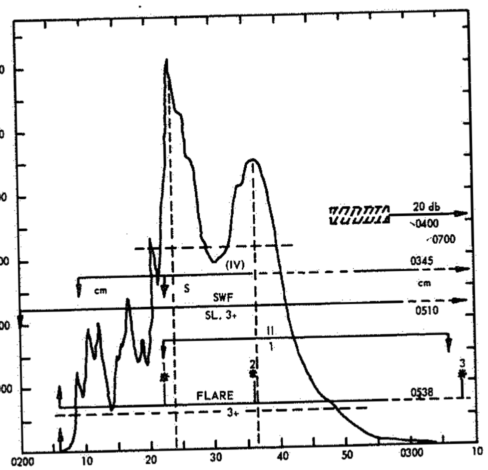
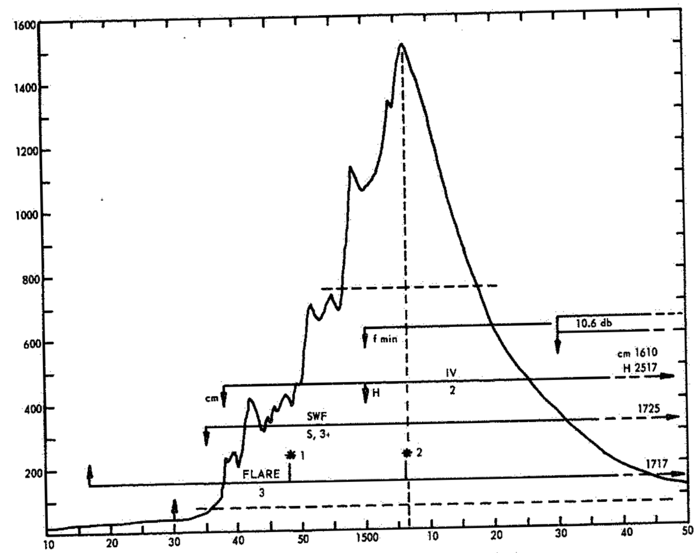


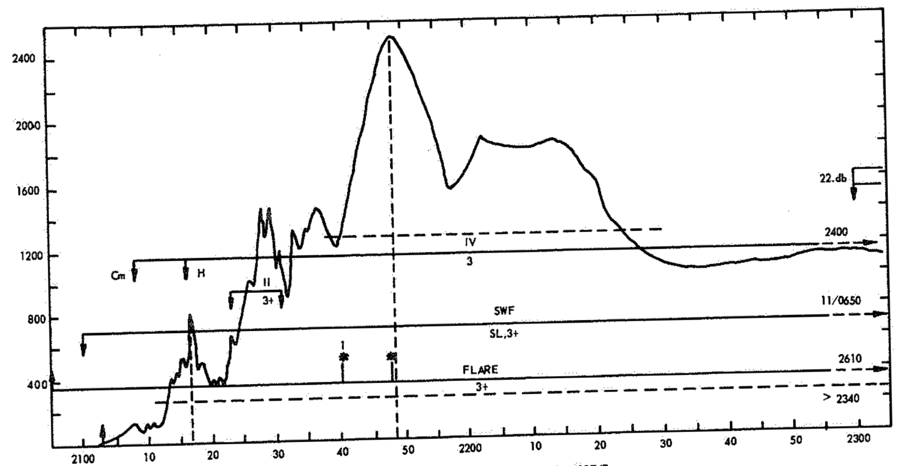
FIG. 4. R.F. CLASS 4 PROFILES, EVENTS FOLLOWED BY POLAR CAP ABSORPTIONS, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.



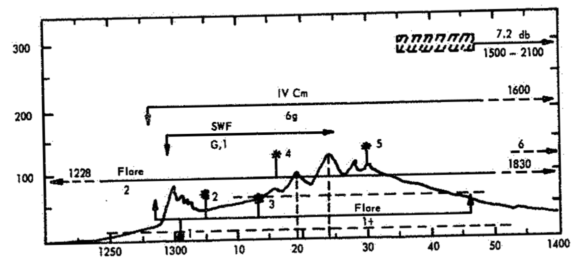
4.8 10 July, 1959, 3750 Mc/s., 1 – Tachk., 2 – Syd., 3 – Alma A., N20E63



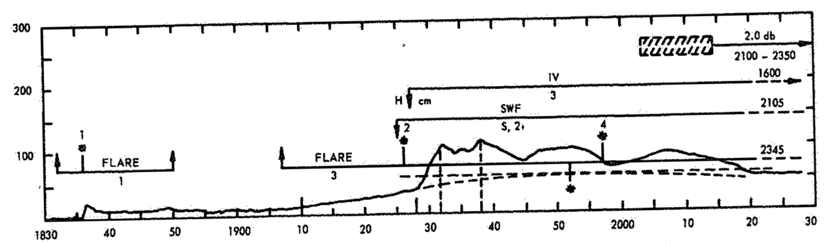
4.9 22 August, 1958, 2800 Mc/s 1 – McM., 2 – Otta., N18W10



4.10 10 May, 1959., 2800 Mc/s., 1 – Lock., Sac. P., 2 – Honol., N19E47.

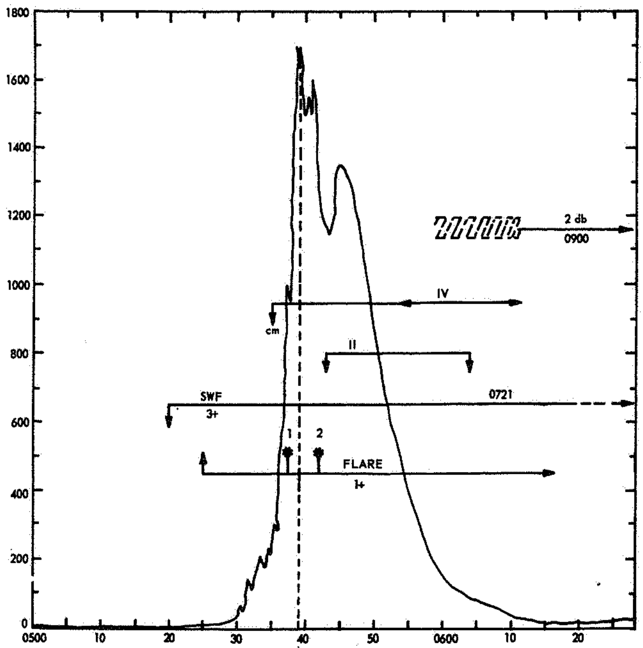


4.11 2 Sept., 1957., 2800 Mc/s., 1 – Herst., 2 – Kiev Ko., 3 – USNL.
N10W26; 4 – USNL., 5 – Uccle, 6 – Sac. P., at 1425; S34 W44

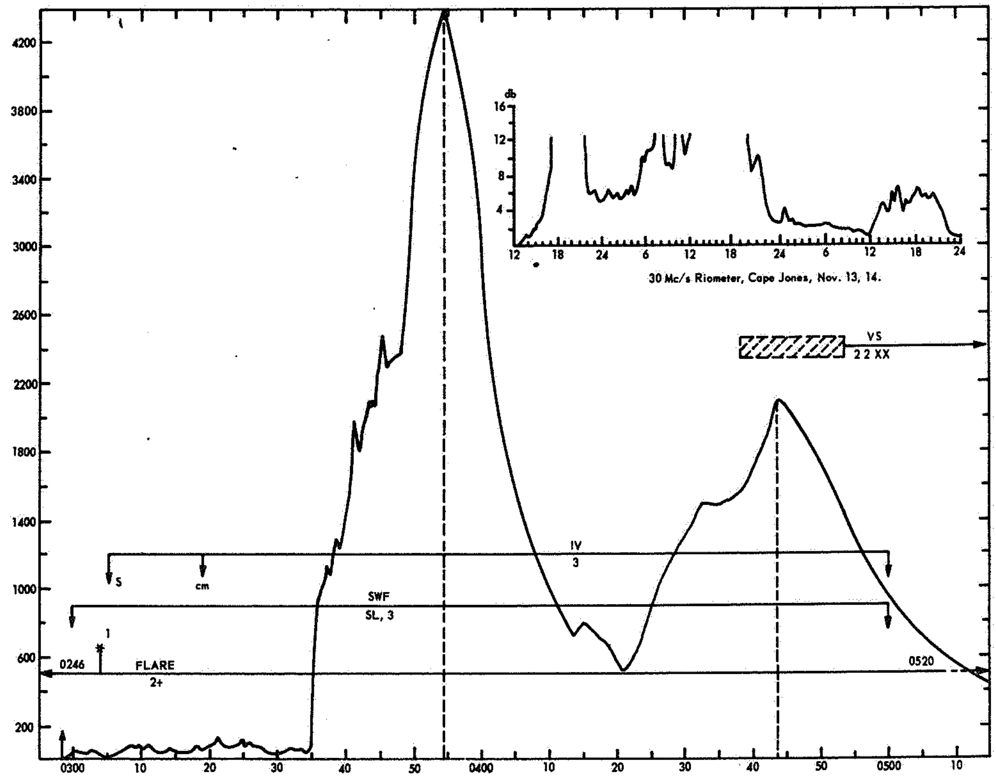


4.12 26 Sept., 1957, 2800 Mc/s., 1 – Sac. P., S26 E 29; 2 – Huan., 3 – Sac. P., 4 – Mt. W., N22E16

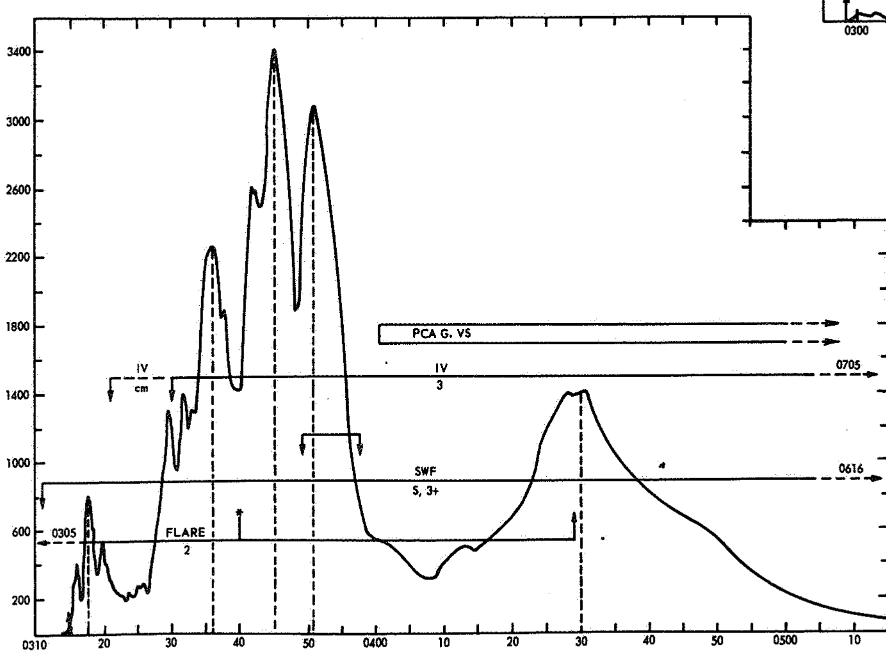
FIG. 4. R.F. CLASS 4 PROFILES, CONTINUED.



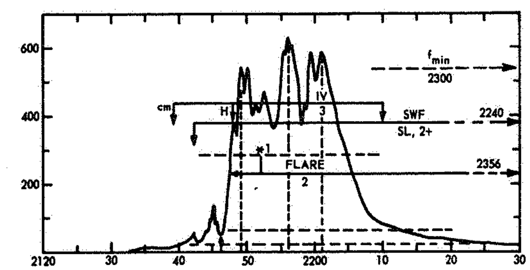
5.1 26 Sept., 1960., 3750 Mc/s., R.F. Class 2 Profile, 1 – Tachk., Mitaka, 2 – Crime., S22W64



5.2 14 Nov., 1960; 3750 Mc/s., R.F. Class 3 Profile, 1– Mitaka, N27W20, Very Small PCA, Reported by Gregory.



5.3 11 Nov., 1960, 3750 Mc/s., R.F. Class 4 Profile, 1–Vorosh. N29E12; Very Small PCA, Reported by Gregory



5.4 4 June, 1958; 2800 Mc/s., R.F. Class 2 Profile, 1 – Sec. P.; N14W58 f_{min} Reported 2300

FIG. 5 R.F. PROFILES, EVENTS FOLLOWED BY VERY SMALL OR DOUBTFUL POLAR CAP ABSORPTIONS SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.

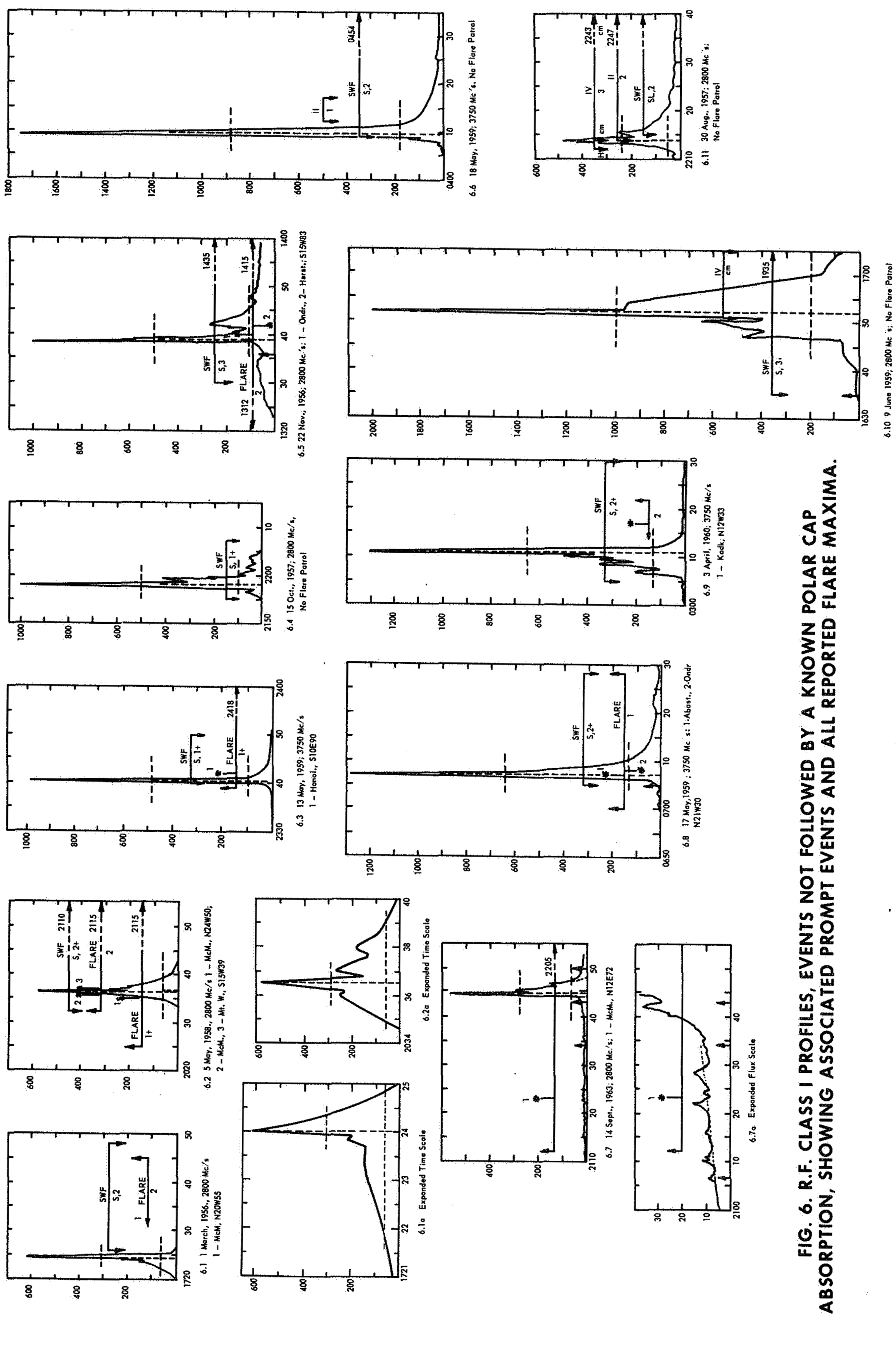


FIG. 6. R.F. CLASS I PROFILES, EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT EVENTS AND ALL REPORTED FLARE MAXIMA.

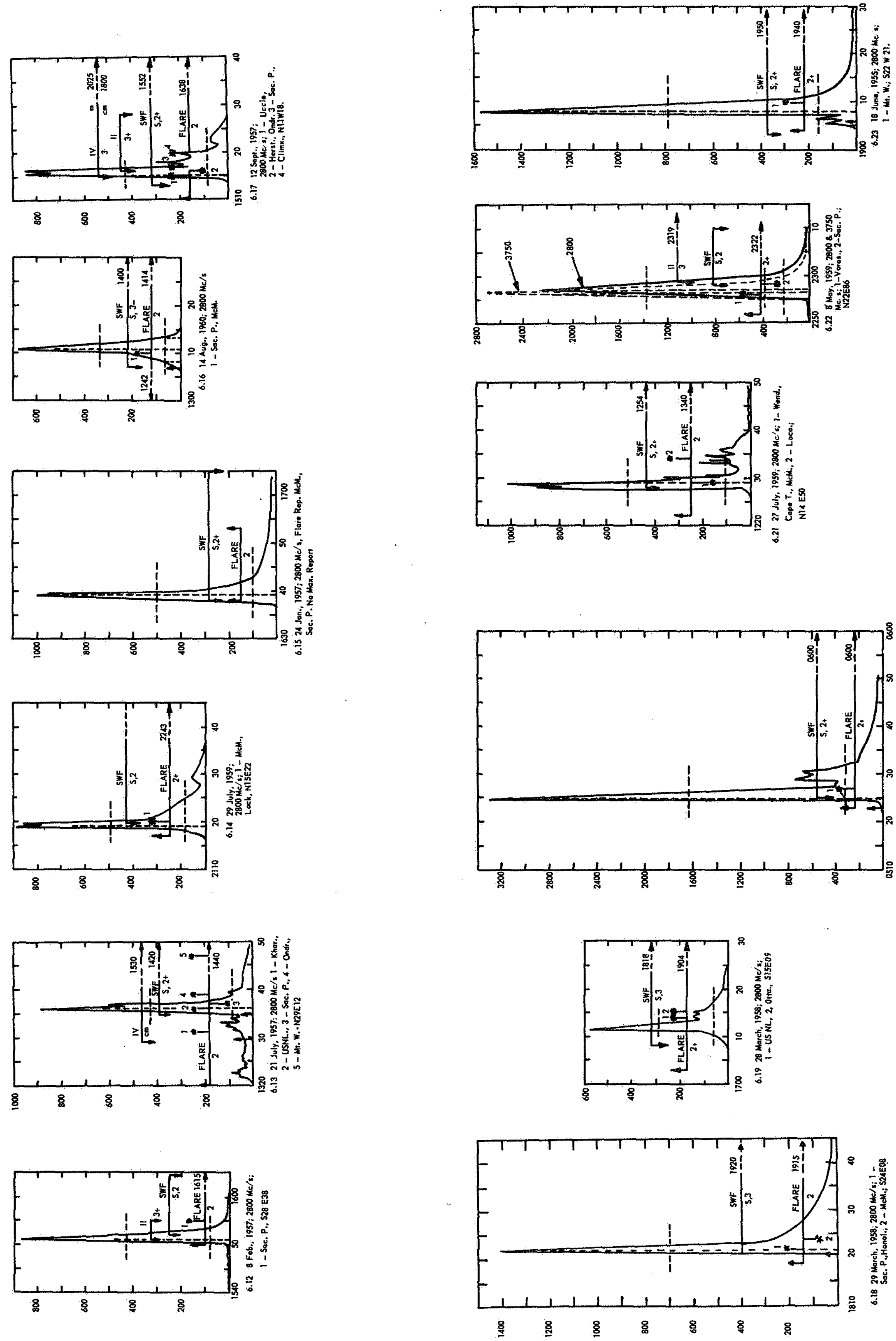


FIG. 6. R.F. CLASS 1 PROFILES, CONTINUED. (NO PCA)

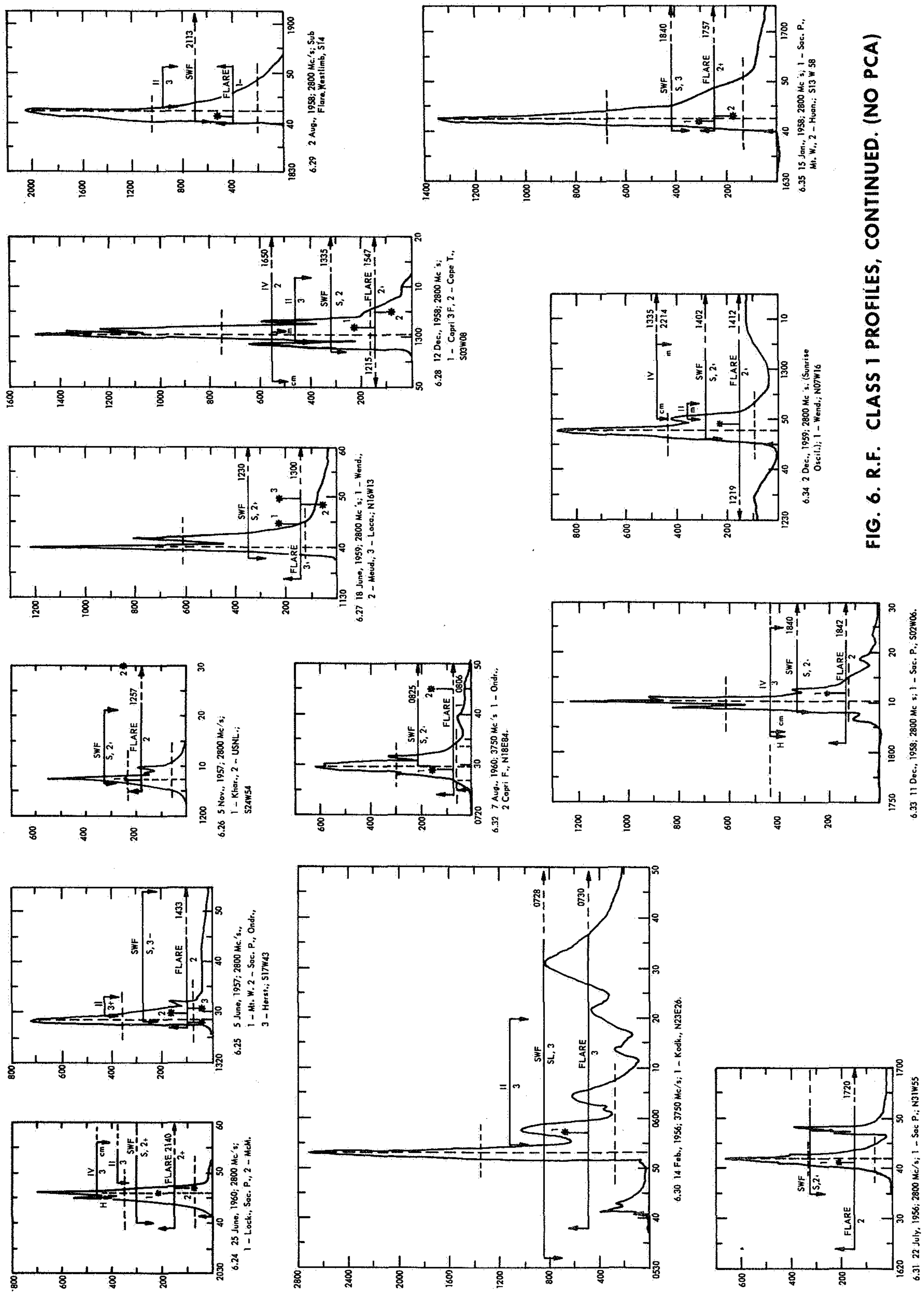


FIG. 6. R.F. CLASS 1 PROFILES, CONTINUED. (NO PCA)

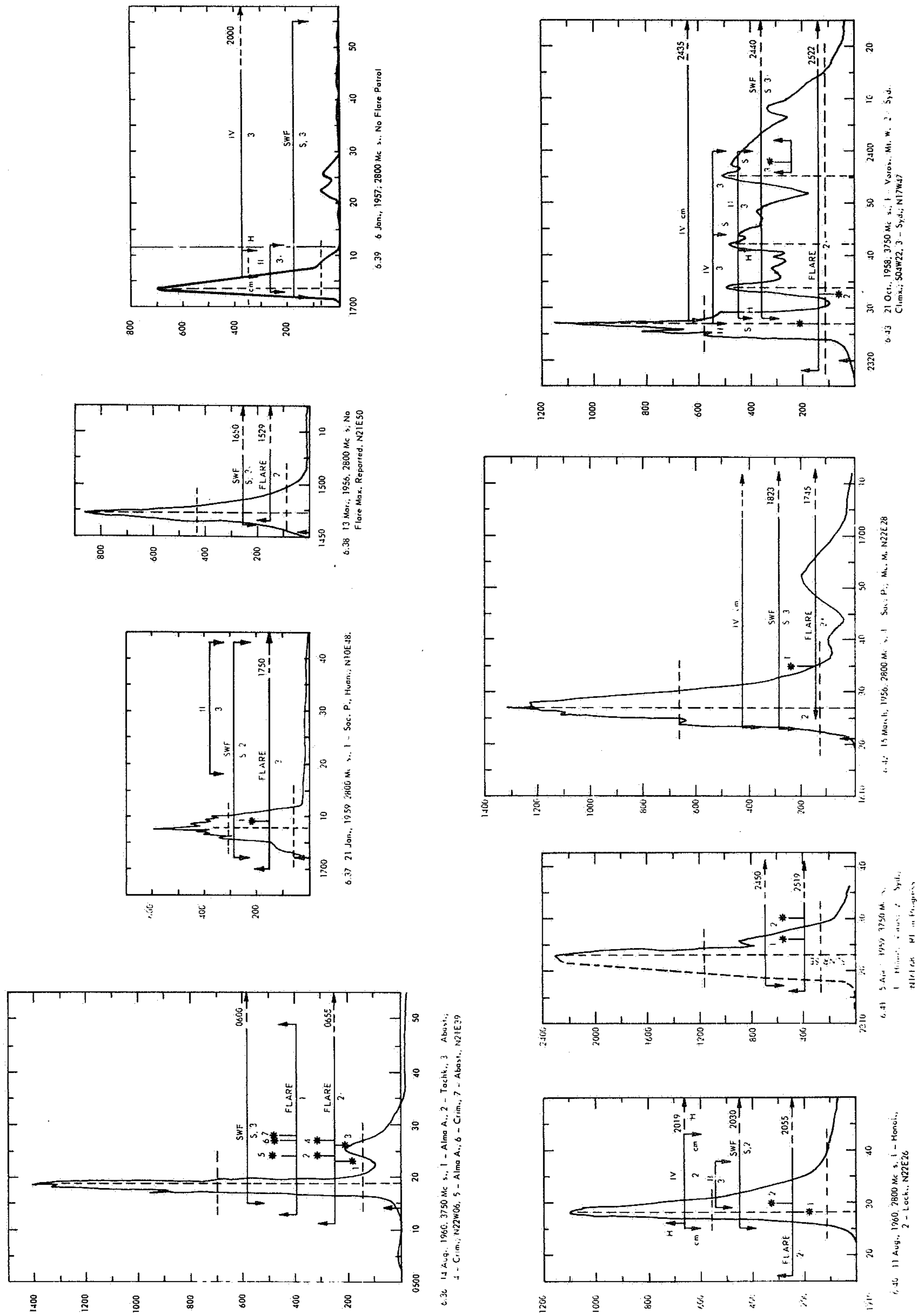
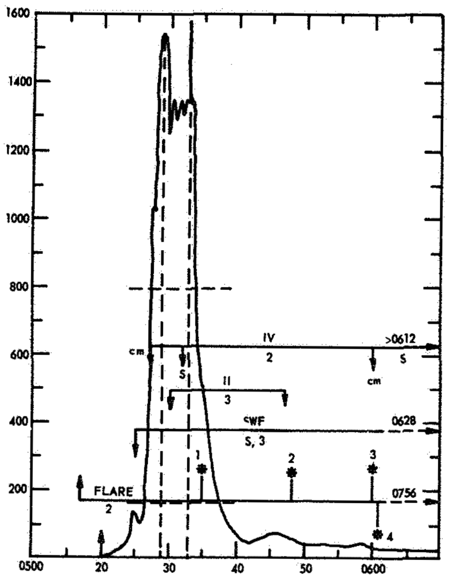
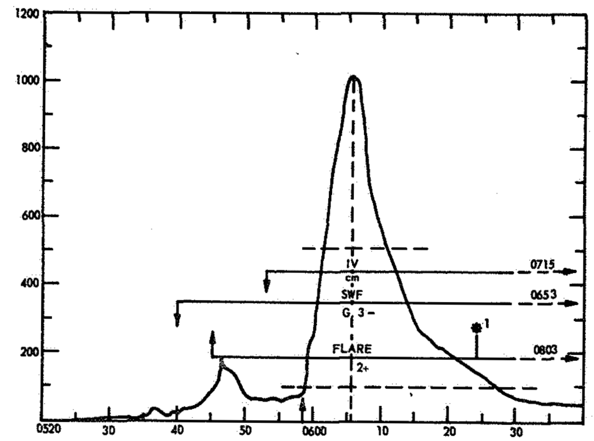


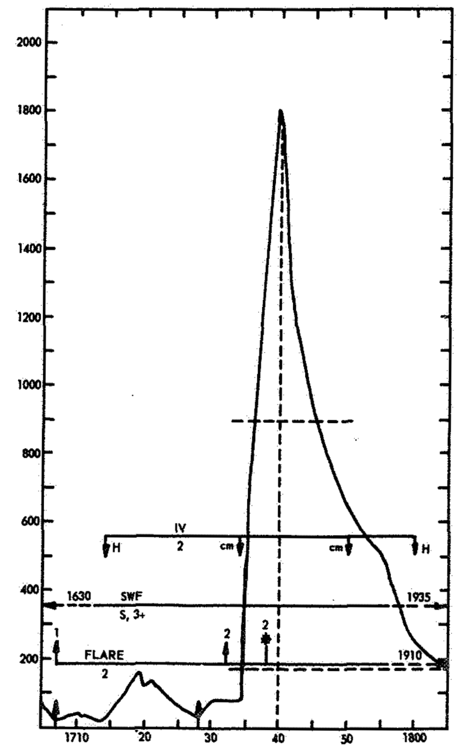
FIG. 6. R.F. CLASS 1 PROFILES, CONTINUED. (NO PCA)



6.44 11 Oct., 1960; 3750 Mc/s; 1 – Tachk., 2 – Abast., 3 – Alma A., 4 – Bakou; S17W36

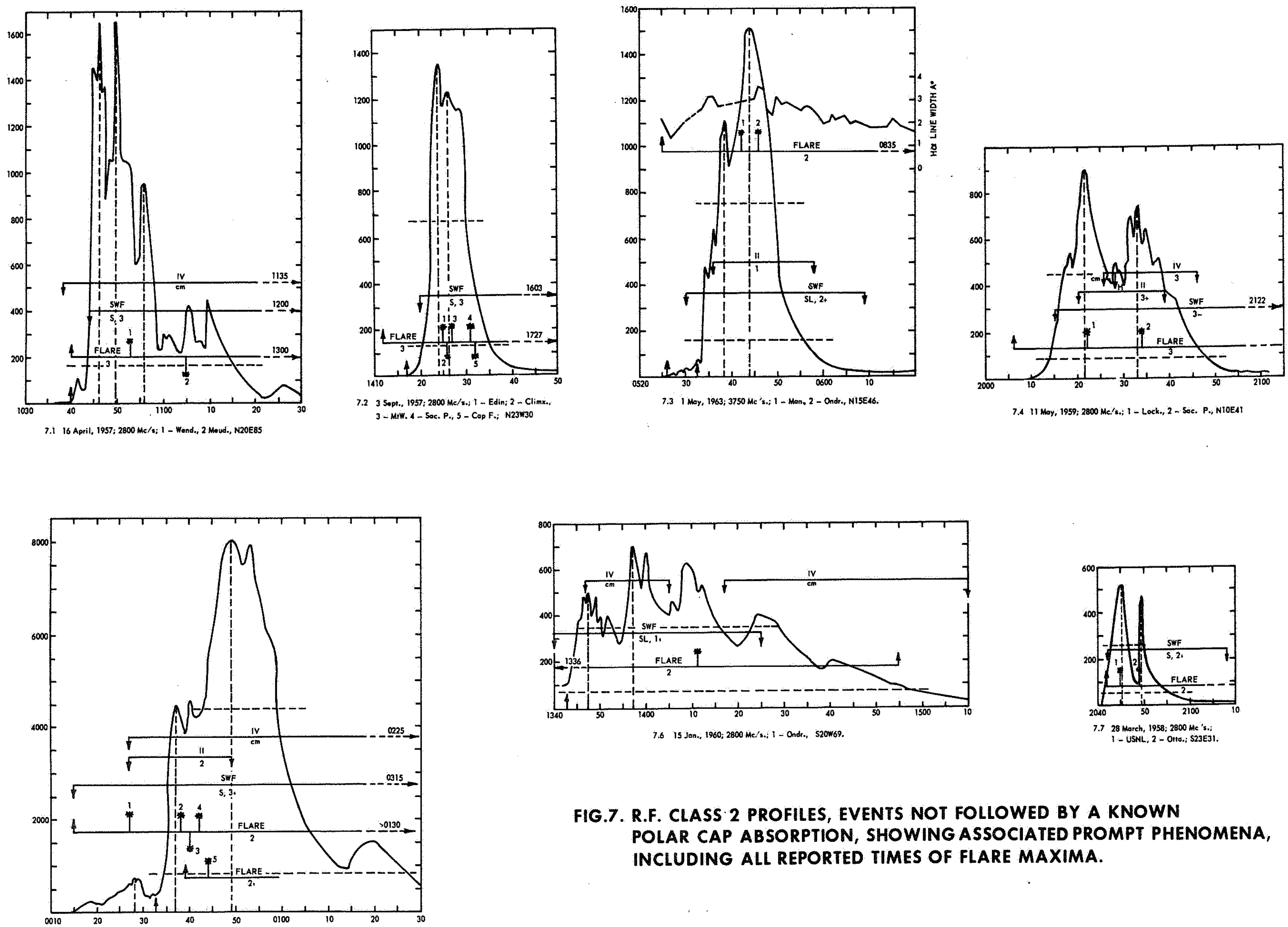


6.45 23, Dec., 1958; 3750 Mc/s; 1 – Abast.; S15E66



6.46 9 June, 1959; 2800 Mc/s

FIG. 6. R.F. CLASS 1 PROFILES, CONTINUED. (NO PCA)



7.1 16 April, 1957; 2800 Mc/s; 1 – Wend., 2 Meud., N20E85

7.2 3 Sept., 1957; 2800 Mc/s.; 1 – Edin; 2 – Climx., 3 – MtW. 4 – Sac. P., 5 – Cap F.; N23W30

7.3 1 May, 1963; 3750 Mc's.; 1 – Man., 2 – Ondr., N15E46.

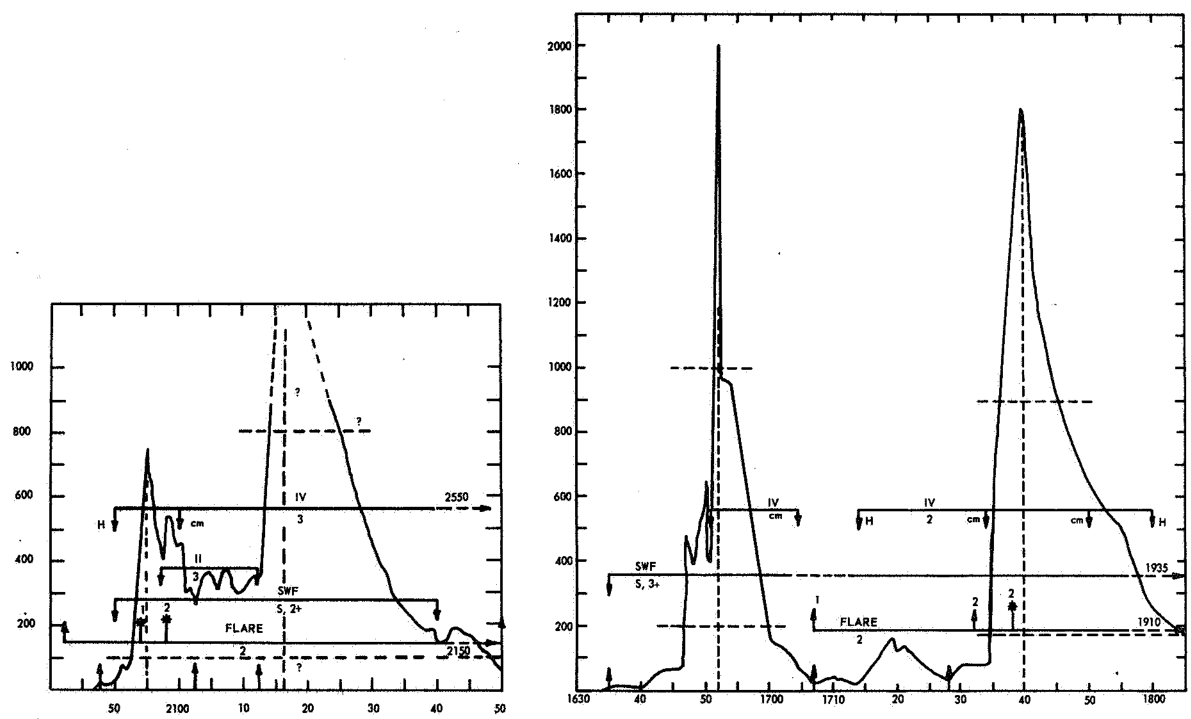
7.4 11 May, 1959; 2800 Mc/s.; 1 – Lock., 2 – Sac. P., N10E41

7.5 15 Sept., 1963; 3750 Mc/s.; 1 – Ikom; 2 – Mani., 3 – Lock., 4 – Honol., N15E75; 5 – Erkut., S31E65

7.6 15 Jan., 1960; 2800 Mc/s.; 1 – Ondr., S20W69.

7.7 28 March, 1958; 2800 Mc's.; 1 – USNL, 2 – Otta.; S23E31.

FIG.7. R.F. CLASS 2 PROFILES, EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.



8.1 28 March, 1960; 2800 Mc/s. (Off Scale 2114 – 2124. Peak Unknown)
1 – Sac P., N11E39; 2 – Honol., N18E34

8.2 9 June 1959; 2800 Mc/s RF Burst at 1640 Class I Impulsive Fig. 6.10;
Burst at 1730 Class I Impulsive, Fig. 6.46.

FIG. 8. R.F. CLASS 3 PROFILES, EVENTS NOT FOLLOWED BY A KNOWN POLAR CAP ABSORPTION EVENT, SHOWING ASSOCIATED PROMPT EVENTS, AND ALL REPORTED FLARE MAXIMA.

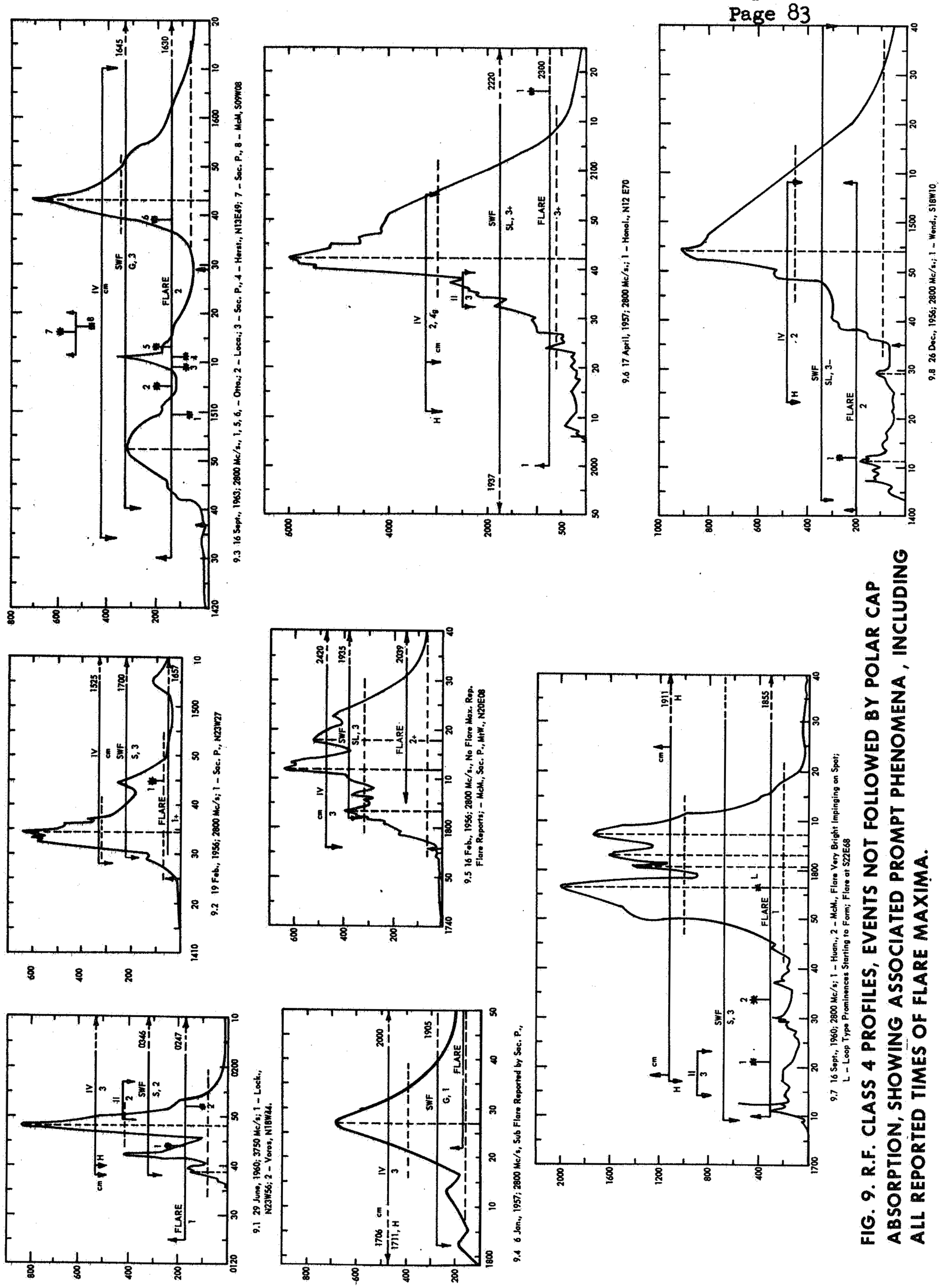


FIG. 9. R.F. CLASS 4 PROFILES, EVENTS NOT FOLLOWED BY POLAR CAP ABSORPTION, SHOWING ASSOCIATED PROMPT PHENOMENA, INCLUDING ALL REPORTED TIMES OF FLARE MAXIMA.

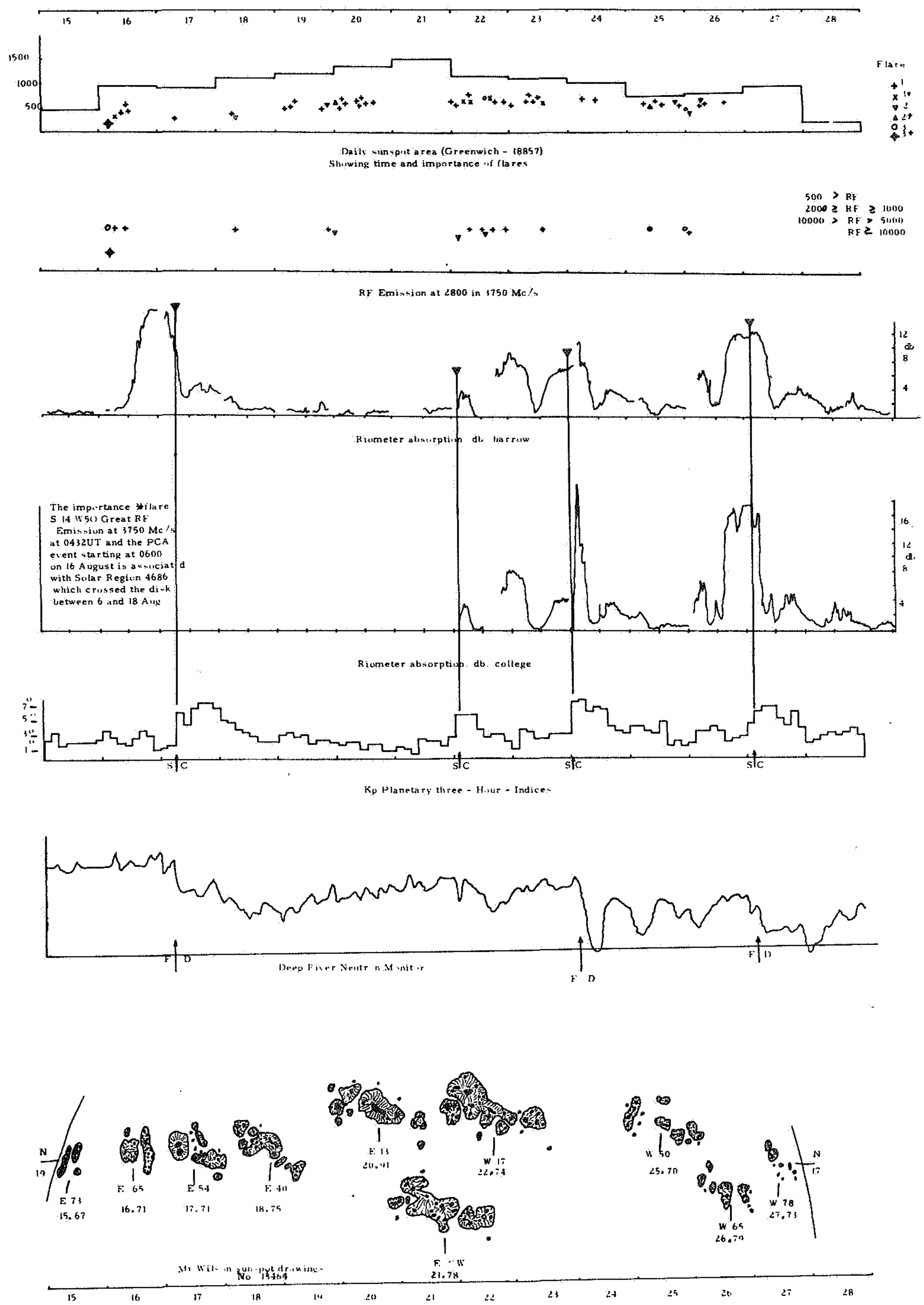


Figure 10 Solar and terrestrial phenomena associated with the active region 4708 and sunspot group 13464 that crossed the solar disk between 15 and 28 August 1958

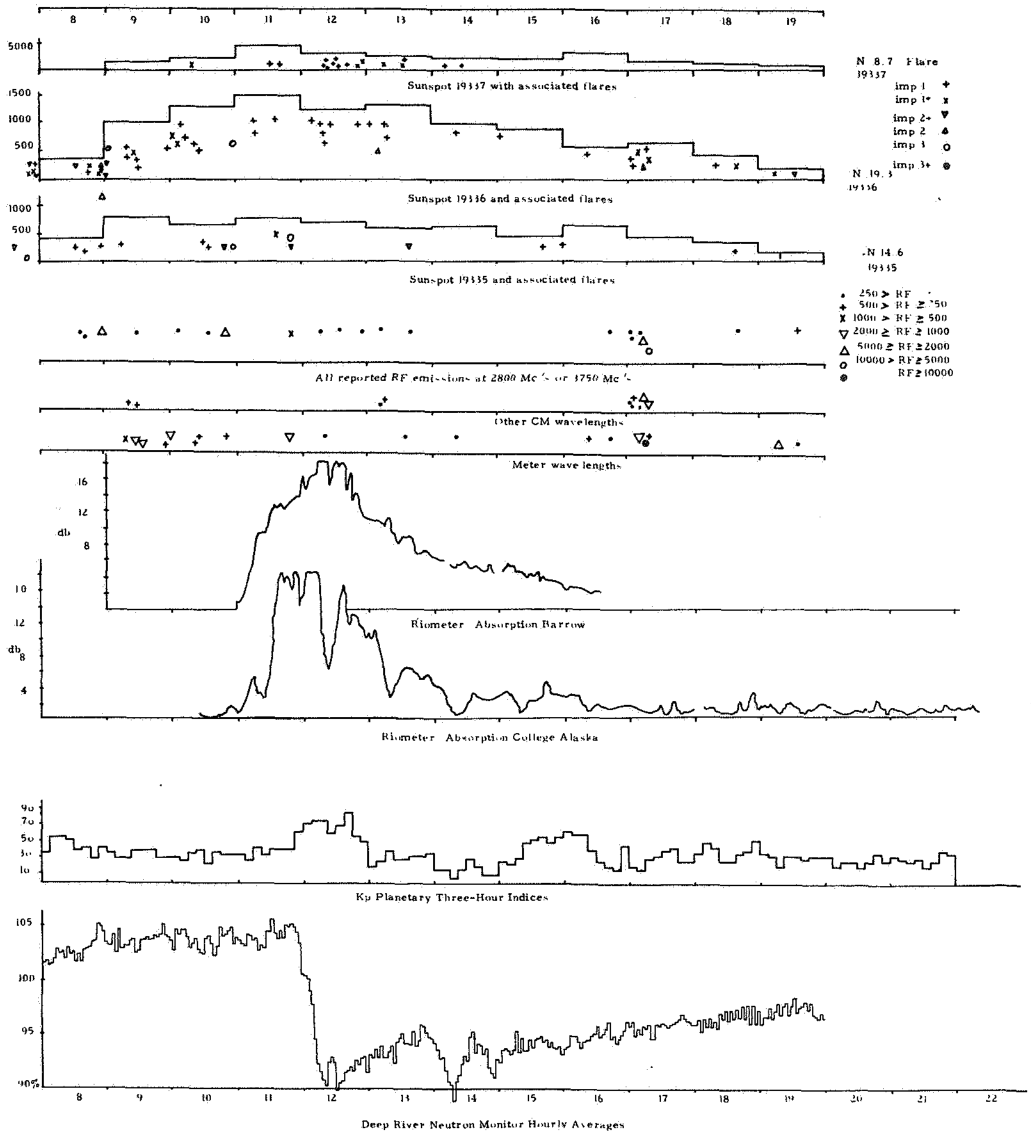
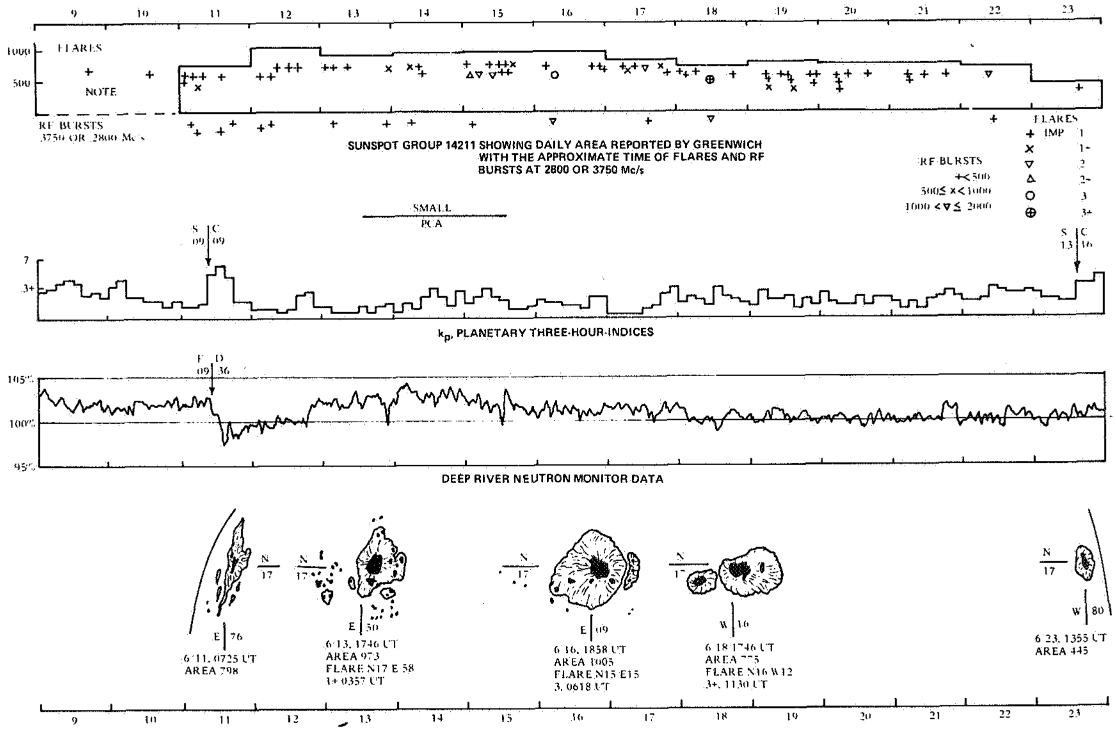


Figure 11 Solar and terrestrial phenomena associated with the active region 5148 that crossed the solar desk between 8 and 22 May 1959



NOTE: SUNSPOT 14211 FIRST SEEN BY MT. WILSON AT 1300 UT, JUNE 10

FIGURE 13 SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP THAT CROSSED THE SOLAR DISK BETWEEN 9 AND 23 JUNE 1959

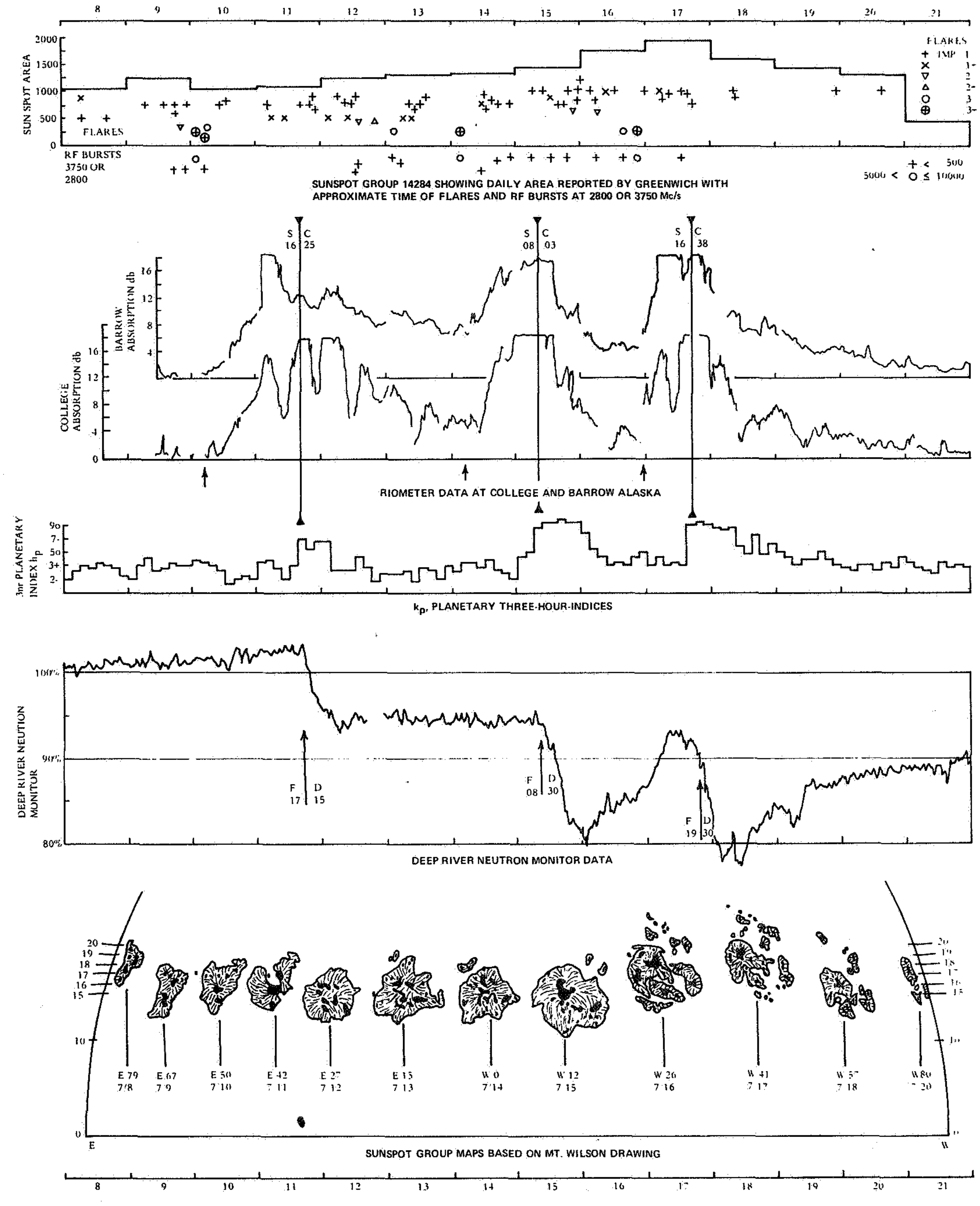


FIGURE 14 SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP 14284 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 21 JULY 1959

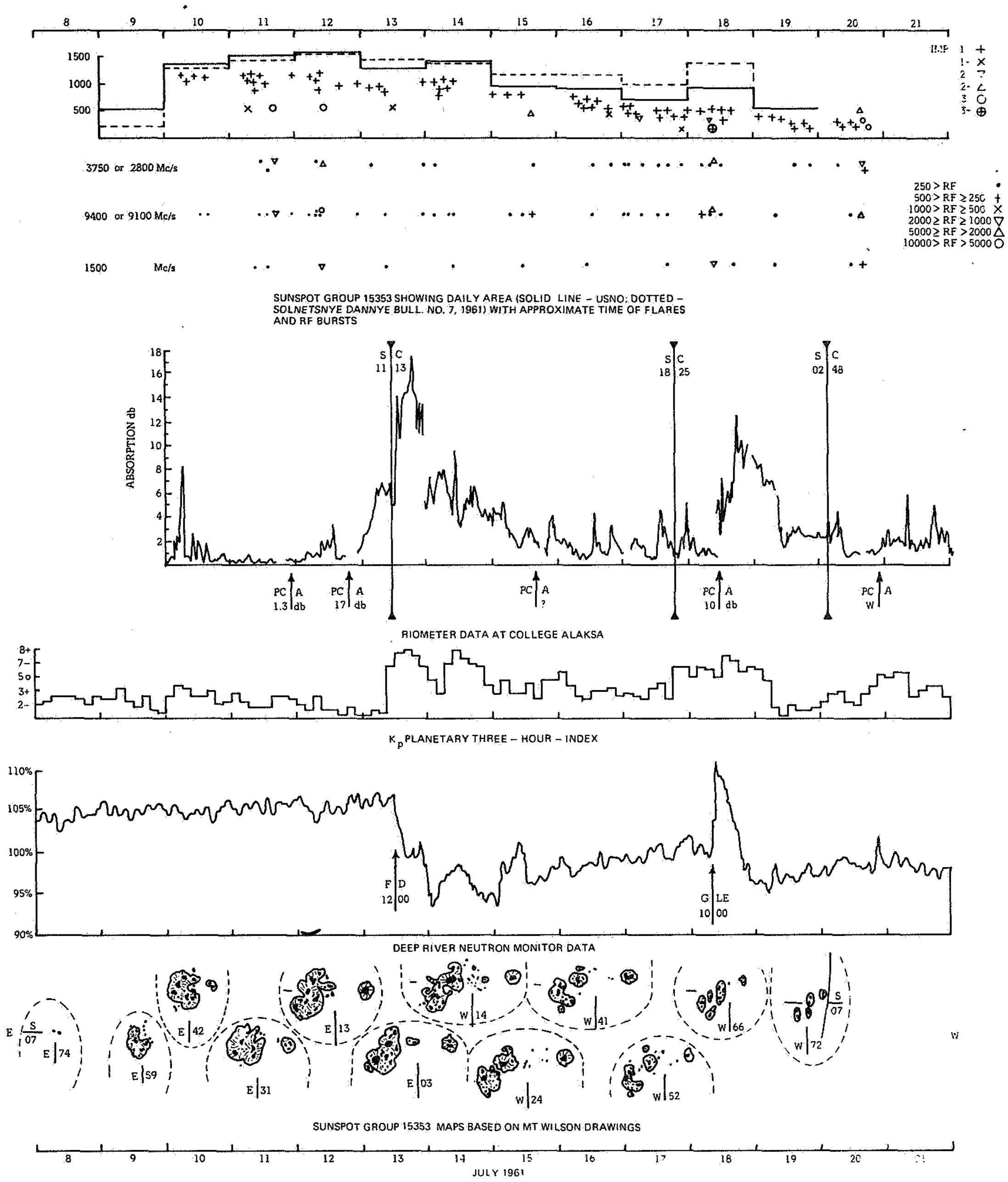


FIGURE 16 SOLAR AND TERRESTRIAL PHENOMENA ASSOCIATED WITH THE SUNSPOT GROUP 15353 THAT CROSSED THE SOLAR DISK BETWEEN 8 AND 21 JULY 1961