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ABSTRACT

All Sky Cameras (ASCA) observations were made at the field line conjugate of the ATS-5 Satellite. The field of view of these cameras covered the region of the magnetosphere from L=5 to L=11 at the approximate longitude of the ATS field line conjugate. With this coverage, definite statements can be made concerning the correlation of the auroras observed by the ASCA's and the magnetospheric trapped fluxes. In general, auroral forms cannot be correlated with the synchronous altitude electron fluxes. The presence of hot plasma at the ATS-5 satellite is a necessary but not sufficient condition for the occurrence of local auroras. On quiet days the hot plasma does not penetrate into the magnetosphere far enough to reach the ATS-5 orbit. Under these conditions no auroras are observed at the field line conjugate, in spite of the fact that auroras are observed on higher latitude field lines. On more disturbed days, when the ATS-5 enters the plasma sheet containing plasma clouds, an equatorward motion of the lowest latitude auroral arc is observed. Significant qualitative correlation between the ASCA data and the trapped fluxes can be observed when a local plasma injection event occurs near ATS-5. The clearest signature of the injection event is magnetic and is most pronounced as a recovery of a negative bay at the ATS-5 magnetometer. The local injection generally produces a break-up event and sometimes a westward traveling surge. However, the most significant correlations are observed with the intensification of the diffuse uniform glow which intensifies during the injection event.

INTRODUCTION

Synchronous altitude satellites offer a unique opportunity to monitor continuously the energetic particles and compare the fluxes with the ground phenomena at the field line conjugate. There have been a number of studies using ground-based measurements and experiment on-board the ATS satellites to understand the phenomena occurring at the region near L= 6.6 of the magnetosphere (Freeman and Maguire, 1967; Lanzerotti et al., 1967; Pfitzer and Winkler, 1969; Lezniak and Winkler, 1970; Cummings et al., 1968; DeForest and McIlwain, 1971; McIlwain, 1972).

Individual auroral substorm events were studied by Mende et al. (1971) and Hones et al. (1971). These studies examined an individual substorm each involving more than just the ATS satellite using a broad data base in an attempt to understand the specific mechanisms which were responsible for the production of substorms.

Akasofu et al. (1974) addressed the specific question of the relationship of auroral displays near the foot of the field line of the ATS-5 satellite. This study was based on the ATS-5 plasma detector (UCSD) and the dominion observatory all sky cameras operated at Great Whales River. Since the field of view of the Great Whale River all sky cameras does not cover the ATS-5 field line conjugate, it was difficult to draw detailed conclusions whether or not specific local auroral events correlate with the observed synchronous altitude plasma.

In this present paper we are using all sky camera data taken at Thompson and Gillam, Manitoba, and the combined field of view covers the projected field line position of the ATS-5 (see Figure 1).

The concentric rings around the station represent the computer generated latitude, longitude position of the 110 km altitude point corresponding to zenith viewing angles of 15, 30, 45, 60 and 75°. The computed position of the ATS-5 field line (GSFC 12-66 field model) is also shown on this figure as an elongated rectangle allowing for the longitudinal drift through the period covered by this discussion.

Based on the same field model we have calculated the L value and lines of constant L have been superimposed. Thus, the all sky camera field of views at Thompson or Gillam or for Fort Churchill include the invariant geomagnetic latitude range from L value of 5 to L value of 11. The ATS-5 L value is 6.9 based on the same field model. All of these are of course subject to the field model. The diurnal motion of the field is not expected to be more than about 1° (Fairfield, 1968). According to Fairfield and Ness (1970), before the substorm onset the field is stretched out toward the tail on the nightside compared to the dipole-like configuration. The estimate for the equatorial movement of the ATS-5 conjugate point is about another 1° in latitude just before the substorm. The very essence of the present investigation of auroras at the conjugate point and at synchronous altitude can be regarded as a search for a method of field line tracing using the auroral particles as tracers and thus corroborate the models. Such field line tracing would enable us to derive the correct time dependent model during a substorm. This would permit the mapping of the configuration changes of the magnetosphere which are closely related to the magnetospheric magnetic energy processes. Unfortunately, as we shall see, the auroras observed by the all sky cameras do not show a unique relationship to the trapped synchronous fluxes. Nevertheless, there are some clues regarding to when the auroral processes at the field line conjugate represent well the trapped particle fluxes at synchronous altitudes.

Recently, Sharp et al. (1974) have shown that a quantitative relationship exists between the synchronous altitude particle fluxes and the auroral electrojet current at a near ground-based station. The explanation of Sharp et al. (1974) relates the electrojet to the trapped fluxes by means of the conductivity enhancement caused by the precipitating fluxes, thus presupposing that there is a definite relationship between precipitating and trapped fluxes. Since the auroras observed by the ASCA are a manifestation of the precipitation, one would expect close correlation between the trapped fluxes measured and ATS-5 and the auroras observed by the ASCA. In order to study the close correlation of the auroras at the field line conjugate, we have developed a technique for plotting the density of the all sky camera film as a function of time at selected points on the negative. The technique is explained in Appendix I.

As a starting point, we will examine the simultaneous coordinated data available for 2 very quiet days during which the ATS-5 does not encounter plasma clouds. Since during these days no auroras are observed at the conjugate point, we may conclude that the existence of energetic particle fluxes at ATS-5 is a pre-condition for auroras to occur at the field line conjugate.

Following that, we will examine two days in which the ATS-5 encounters the plasma as a result of a local injection event on the evening-side. It is possible to find correlation between the ASCA data and the freshly arrived plasma at the satellite.

After that, we will examine somewhat more disturbed days in which the plasma sheet envelopes the satellite fairly early and auroras occur and are generally uncorrelated to the drifting plasma clouds. However, fresh injections will be shown to precipitate and cause auroral emissions.

QUIET DAYS

Figures 2 and 3 represent spectrograms from the ATS-5 (DeForest and McIlwain, 1971) from days 38 and 43. During these days there are no significant strong plasma clouds at the region of ATS-5 and these were magnetically quiet days. The ASCA was operated at Thompson from about 0445 to 0845 UT. A careful study of the all sky camera records for both of these days show absolutely no auroral activity discernible during these days at Thompson. The clarity of the sky can be easily established from the all sky camera pictures by means of a star count.

It is interesting to investigate the extent of the quiet region in which there was no detection of auroras. Furthermore, it is interesting to study the simultaneous auroral activity at Ft. Churchill in the range of L=7 to L=12.

All sky camera coverage at Ft. Churchill on day 38 begins at around 0100 UT. Fairly bright arc appears around 0450 in a direction somewhat northwest to southeast located near the northern horizon. There is a discernible loop structure on the eastern side, it fades out as it moves southward and disappears around 0514. A single loop structure shows up on the western horizon at 0612 and an overhead zenith arc intensifies. A fairly bright loop-like structure persists on the western horizon around 0648 and brightens and intensifies and it finally shows up as an arc across the northern half of the sky. The arc breaks up at 0720 and only patchy structures are left. The sky clears up around 0830. No more auroral displays until 1220, which is twilight.

The all sky camera at Ft. Churchill was operated from 0049 UT to about 1130 UT on day 43. The first discernible auroral display appeared around 0500 UT. It consisted of a zenith arc, slowly intensifying around 052[illegible]. It disappeared by 0541 in order to reappear very much more intensely at around 0615. The arc broke up around 0629 forming a strange loop at around 0632. The aurora fades out and becomes very dim around 0650. An arc located somewhat south of the zenith turns up around 0736 showing multiple structure and intensification by 0804. It shifts towards the northern part of the sky and persists through 0822 as it forms a slight loop towards the eastern side of the sky at 0836. A poleward shift takes place slowly between 0836 and 0900. Small patchy structures show up around 0929 near the zenith. Very diffused morning-type aurora is observed around 1107. There is still aurora around 1201 at which point twilight is breaking.

In summary, both day 38 and 43, when viewed from Fort Churchill, looked like average days in terms of auroral presence in the all sky camera pictures. By comparison with more active days, one would expect that plasma clouds are present on the field line above Ft. Churchill and if a satellite similar to ATS-5 could be flown at the L value corresponding to Ft. Churchill, i.e. at a geocentric distance of 8 or 9 earth radius, then one would find plasma clouds at this location.

MODERATE ACTIVITY - SUDDEN PLASMA SHEET EXPANSION

In reviewing the all sky camera and simultaneous ATS-5 data on day 44, 1970 (Mende et al., 1971), we have found that the first large plasma injection was simultaneous with a substorm occurring around 0536 UT and was accompanied by corresponding auroral display.

In Figure 4 we are presenting the UCSD results in a spectrogram for day 44. There are two distinct arrivals of electron clouds at the satellite. The one already mentioned and another at around 0720 UT. In Figure 5 and 6 we are presenting a collage of the ASCA pictures from Thompson and Ft. Churchill respectively. In Figure 7, we are representing the all sky camera data from day 44 in a time history plot as per Appendix I. The first cloud suddenly enveloping the satellite at 0530 correlates very well with the auroral intensification as seen by the time history plots. This intensification is uniform extending all the way from the southern-most to the northern-most latitudes.

Besides this substorm, auroral activity is present periodically. For example, on the northern half of the sky down to the zenith there is clear activity between 0640 and 0710. However, there is nothing very exciting happening at 0720 and thereafter when a plasma cloud arrives to the satellite. The collage of all sky camera photographs is shown in Fig. 5. Examining the all sky camera pictures alone it would be rather difficult to derive any qualitative difference between the event occurring at 0530 or at 0630. Following the interpretation of DeForest and McIlwain (1971), 0530 event was a local injection since the high energy protons trace back to the injection point of 0530. The plasma cloud intensification at 0720 is due to some other injection event. Thus, the auroras generated simultaneously with the 0530 injection event are fresh particles which are being precipitated as soon as they enter the region containing the field lines associated with ATS-5. The 0720 plasma cloud is just a drifting cloud in the magnetosphere which had previously lost its particles whose pitch angles were in the loss cone. It appears that pitch angle diffusion alone is not able to maintain auroras which are visible to the all sky camera.

The day 44 data has been published and discussed extensively by Mende et al. (1971). Their discussion, however, was restricted to the first, the 0530 event, and the period prior to that.

The major difference between the 2 events is the behavior of the ATS magnetogram. The first event at 0530 is accompanied by the sudden recovery of the magnetic depression of the Bz northsouth component of the ATS magnetometer. This is a configuration change (Mende et al.,1971) since the plasma injection should not result in a field recovery; in fact, it should depress the field even further. There is no magnetic field signature associated with the plasma cloud appearing at 0720, thus, there is no sudden magnetospheric temporal change. Another thing of interest of the day 44, 1970 event, which needs to be pointed out in relation to our present discussion, is the fact that ATS-5 is not in a strong plasma cloud or it is not in the region of strong plasma clouds prior to the 0536 event. In fact, the 0536 injection event which seems to broaden the region of plasmas and thereby suddenly enveloping ATS-5.

In the following discussion we shall examine other cases in which there is correlation between the observed auroras and fluxes at ATS-5. This occurs always in the presence of local injection events. In Figure 8 we have presented day 44 Thompson magnetogram in an expanded time scale. It is rather noteworthy that the 0720 plasma event does indeed show up quite distinctly in this ground-based magnetogram and in fact is much clearer than in the aurora data. This would be in agreement with Sharp et al. (1974).

On February 5, 1970, a very clean and single event has occurred on this date in the all sky camera data (see Fig. 9). The all sky camera data has been replotted in the time plot (see Appendix I). The event is clearly indicated that the 0430 event (Fig. 10). These plots illustrate the presence of a southward movement arc starting around 0400 and the sudden appearance of the central arc at around 0432 and the breakup and onset immediately after that. This 0430 event is not too well represented in the H-component presented in Figure 11 (bottom). This event occurred in the early evening period and the direction of the local currents is eastward showing a positive D-component just after 0430; however, it shows the commencement of the local activity at 0430. The positive D-component represents upward moving current north of the station if a field aligned Birkeland current model is considered. The H-components from the selected polar stations show a maximum at Churchill at 0430, which is in agreement with the center of the event being poleward of ATS.

On Figure 12 we have shown the Lockheed ATS particle plasma data. (Data was obtained as per Appendix of Mende et al., 1971.) We can see that the ATS energy flux climbs very slowly reaching a maximum level at 0500 or later. Thus, the measured satellite data shows that this event was extremely soft at this locality and high fluxes of low energy particles were injected into the satellite location. The event was accompanied by a magnetic signature, both at ATS and on the ground as a moderate negative bay at Gt. Whale River east of the station, and a strong negative bay at Ft. Churchill north of the station.

The sudden positive excursion at the local station signifies that the satellite was a little too far on evening side from the center of the event. Nevertheless, there was a real event as shown by the magnetometers as it appears that a configuration change did indeed occur pushing the soft edge of the particle fluxes into the region of the satellite (Vasyliunas, 1968; Mauk and McIlwain, 1973). This was accompanied by a moderate breakup activity at the location of the field line as seen in the all sky camera.

INCREASED ACTIVITY - INJECTION EVENTS INSIDE THE PLASMA SHEET

As the activity increases plasma injection occurs with increasing frequency and the ATS-5 satellite is enveloped by the plasma earlier in the day. Since the all sky cameras were of the rapid run variety, film was conserved by photographing only the near midnight region.

All sky camera coverage from Thompson at the foot of the field line (see Fig. 1) was available starting from around 0451 UT on Day 326 (326, 1969) following a fairly quiet day. Note, a sudden commencement occurs at around 0250 (see Tucson and San Juan) and at ATS-5 (Fig. 13). Activity is following the sudden commencement as indicated at Ft. Churchill. The ATS omni-energy flux increases from 0400 and this signifies the arrival of plasma clouds at the position of ATS-5. Thus, ATS-5 enters the plasma sheet just after 0400.

All sky camera film starts at 0451 UT (Fig. 14). There is some faint aurora emissions evident even at this time. Strong moonlight inhibits very sensitive all sky camera observations. A northern arc is getting stronger at around 0506. It disappears around 0510. Some discernible activity takes place around 0520, showing multiple overhead arc structure. Fairly intense auroral arc appears near northern horizon at 0551. The arc is quite disturbed as its traveling south very fast. By the time 0555, it reaches the zenith. Another arc, strong southward of this arc, brightens up while the arc at the zenith fades out -- 0557. A surge-like loop development is formed by 0559 and its moving westward. This moves out of the field of view by 0601. Some more folds follow the westward motion, 0602-0605. Note that this is a very bright aurora since it is comparable to bright moon in the field of view. A bright arc in the southern half of the sky appears and northern of this the sky is filled with diffused patches of aurora. This arc travels slowly northward by 0612, it is around the zenith again. The display fades out around 0616. There is very little discernible aurora activity following this time because of the strong moonlight inhibiting the detection.

In the all sky camera, a clear event occurs around 0600 which overpowers all previous events. We have not generated the ASCA time plots from this day since the strong moonlight inhibited the generation of such data.

The bright event corresponds very nicely to the ATS sudden energetic particle injection as seen in the peak in the energy fluxes (Fig. 15). The particle injection was accompanied by a strong recovery of the ATS magnetogram just after 0600 showing that this event was a real configuration change of the magnetosphere and the magnetospheric current systems. This change was not a local increase in particle pressure because that would have produced an increase in the magnetic field.

In summary, from the day 326 data we can make the following deductions. The ATS has arrived to the region of energetic magnetospheric plasma around 0400-0430. Auroras are present in the sky in the following period, but these auroras are not related in any way to the ATS flux observations. As has been pointed out (e.g. Akasofu et al., 1974), the aurora is far more dynamic than the trapped particle fluxes observed at synchronous altitude. The only time when auroras correlated with the particle emissions is when we see the injection of fresh particles in the magnetosphere at the location of the satellite represented by a configuration change. Such an event was clearly observed approximately at 0600 in which auroras and the injection of the hot plasma was simultaneous and was accompanied by a configuration change, as observed by the recovery of the ATS-5 magnetic field H-component depression.

All sky camera data was available from the Nov. 9, 1969 (Day 313) night from Thompson. This night was discussed by Akasofu et al.(1974) based on the Gt. Whale ASCA camera data. This night is very disturbed with a huge local injection occurring at around 0630. In view of the correlation observed between electrojet currents and ATS-5 flux by Sharp et al.(1974) all through the substorm, it might be worth looking at the event of day 313. In spite of the fact that the all sky camera observations were initiated rather late in the day, at 0630 UT, and the huge substorm was already in progress. In Fig. 16 we have presented the ATS-5 omni-energy flux for day 313. There are several peaks in the plasma flux reaching a peak at around 0613 and later and the second peak occurs around 0730. The all sky camera data is not presented in the pictorial form. The all sky camera pictures turn almost completely black between 0630 and 0700. The event is very large and we indeed observe auroras with hundreds of ergs (see the omni-energy flux of the trapped particles, Fig. 16). From the all sky camera data (Fig. 17) there is clearly an event which is over by about 0715 UT and another event comes about which culminates around 0735-0740. Both of these events are actually recognizable from the magnetograms as well as in the ATS trapped fluxes. In particular, the ATS magnetogram (Fig. 19) shows a very sharp recovery between 0610-0635. A distant peak, however, is observed at 0730 with a small recovery. This actually is seen both on ATS-5 and at Lynn Lake. The Tucson magnetogram (Fig. 18) shows a positive H-component with field aligned currents similar to the model of Akasofu and Meng (1969) at the onset of the 0630 event. However, it shows a second rather smaller peak for the 0730 event.

In summary, therefore, one can see that the fluxes which are spatially distributed very broadly are precipitating and these are in good agreement with the particle fluxes as measured at ATS-5. This broad auroral precipitation is so strong in this event that this is blackening the entire frame of the ASCA and the auroral forms are not discernible in the all sky camera data even if they are present. For lower intensity substorms, this broad diffused auroral precipitation is generally near the all sky camera threshold, and had to be brought out by the time plot technique of Appendix I. This broad precipitation shows fairly good correspondence with the particle fluxes as observed by ATS-5. During this period, we have evidence from the ATS-5 magnetometer data that this is a local event and the ATS-5 is observing freshly arrived particles which were recently injected into the inner magnetosphere.

MAGNETIC ACTIVITY AND NO APPARENT CORRELATION

In summary, from the preceding discussions, we have seen that auroras generally do not correlate with plasmas as observed at ATS-5 on the field line containing the ATS-5. We have looked at cases which were exceptions and have found that at times auroras do reflect activity also observed at synchronous altitude.

In order to complete our study of events in which we could observe coordinated all sky camera ATS-5 particle data, we will review a typical day (045 1970) in which there are distinct auroral and plasma events at ATS-5 but only very little correlation can be found between the two sets of data. All sky camera observations began at Gillam at 0308 UT (Fig.19). An auroral arc is present in the field of view north of the station. This arc is steadily moving southward until 0350. At 0400, a confused multiple arc structure appears which develops into a looped configuration by 0413 and 0425. The most intense structures develop north of the station at 0437. The sky clears up by 0449 and remains so until 0513. An arc appears on the northern horizon at 0523 and begins to move southward. The corresponding ASCA time plot is presented in Figure 20. The ASCA coverage continued from Thompson is shown in Figure 21 and the corresponding time plot in Figure 22. For completeness, the Ft. Churchill data is presented in Figure 23. The ATS-5 spectrogram for day 45 is presented on Figure 24.

It is interesting to note that the auroras pass the foot of the field line around no later than 0400 at the ATS-5. However, looking at Fig. 24, ATS omni-energy flux for day 45 (Lockheed particle data), we find that energy flux intensifies only well after this. However, if we look at Fig. 23, the spectrogram, we can see that the low energy particles have indeed started exactly at 0400 to rise in counts. Thus, the ATS-5 goes into the plasma sheet(or the region of the plasma clouds)at around 0400. A quite spectacular event is observed between 0425 and 0437 in the all sky camera data. However, this does not show up very readily in the plasma data (Fig.25).

(Energy ranges and plasma parameters are discussed in Mende et al., 1971.) Indeed the electron energy shows a slight peak at 0430, but it is not a very spectacular increase in the fluxes and is somewhat masked by the general increase in fluxes as the ATS is moving into the center of the plasma sheet. The ATS - 5 conjugate is further south then is indicated on map 1 of Fig. 1 has been concluded by Akasofu et al. (1974). This can also be enhanced by the fact that ATS-5 magnetic field is somewhat depressed at this time, which means that we are in at lower magnetic field region at ATS-5 and therefore the more tail-like configuration of the field puts ATS to lower latitudes. The ASCA time plot was generated for this set of frames at Gillam and is shown on Fig. 19. The only general overall increase in brightness which can be observed occurs around 0420, and is representative of the very tiny event which we have seen in the ATS plasma data. None of the more intense auroral forms, however, correlated with any event observed in the satellite data.

The all sky camera coverage was continued with the Thompson all sky cameras which came on at 0452. A southern arc was observed at 0607 which broke up into a rayed north-south aligned formation at 0649. Another pair of arcs intensified at 0706. The northward arc moved equatorward and at around 0730 it became a rayed structure. An intense surge type formation presented itself at 0757 towards the east, but never actually moved westward (Akasofu, 1968). After that eventless diffuse morning, auroral arcs and patches continued.

In order to facilitate the complete coverage of the ATS plasma region, we have included day 45 Churchill all sky camera slides too (Fig. 26). These are unfortunately in the negative and much lower quality than the pictures taken at Thompson. To facilitate the observation of the correlation with fluxes, we have also included time plots for the Thompson all sky camera (Fig. 22). There are a large number of individual auroral forms which can be observed in the plots, but there isn't really very much correspondence. Several distinct plasma clouds can be observed appearing to ATS-5, but none of these are local injections as seen from the magnetogram (Fig. 27).

In summary, besides the slight correlation observed at the time when the satellite enters the plasma sheet, the following auroral events do not correspond to plasma injection at the satellite. Conversely, the plasma clouds which are observed at the satellite seem to cause no noticeable changes in the aurora.

CONCLUSIONS

Several days of varying degrees of disturbance were reviewed and it was found that correlations are only observed at the time of fresh plasma injection to the local field line as distinct from drifting plasma clouds. A case can be made that the equatorward motion of the plasma sheet in the Earth's frame of reference is always accompanied by precipitation at the foot of the ATS-5 field line. In a number of cases, we could identify a temporal event which was responsible for pushing the plasma sheet at such times. In one case, day 45, no clear temporal event could be found which was responsible for the plasma motions. Nevertheless, auroral activity was accompaning the equatorward motion of the plasma sheet. From the present body of data, it is yet unclear whether the satellite can travel into a quasi-stationary inertial space plasma sheet as part of its daily rotation or whether it is always necessary for some injection event to push the plasma inward. In all the cases discussed here and in Akasofu et al. (1974), some auroral activity was observed as the plasma sheet moved into the region of the ATS-5 satellite. If the satellite is within the plasma sheet, auroras can occur at the foot of the field line. These auroras generally are not the product of a plasma injection event and are not correlated with increases or decreases at the ATS-5 particle fluxes. The clearest signal for a local injection event was signaled by the sudden recovery of the negative bay in the ATS-5 magnetogram. At such times, the data invariably shows auroral precipitation.

However, clear correspondence is obtained more with the general diffused background of the all sky camera fields rather than with individual auroral forms. The individual auroral forms appear to be superimposed on this general diffused background. The failure to discover any correlated general auroral component in the ATS-5 trapped fluxes suggests that auroras are generated at low altitudes involving loss cone particles only. One might speculate that too much emphasis has been placed on the observation of these intense visible auroral displays as being important in magnetospheric substorm processes. Since they seem to be the product of low altitude phenomena involving only a fraction of the particles, they could only be regarded at most as trigger mechanisms for magnetospheric events (substorms).

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APPENDIX I

The Digitization of All Sky Camera Pictures

In order to facilitate the comparison of all sky camera pictures with other forms of time series data it was felt desirable to generate a time history plot. The advantages of this type of presentation to complement the conventional photographic presentation are self-evident.

In this technique the all sky camera frames were illuminated by a uniform light source. A TV camera using a silicon vidicon was used to view the frame under examination. The video signal generated by this camera was digitized on 10 selected TV lines per frame and was written in a digital form on an incremental tape recorder. Calibration frames were also recorded with zero transmission through the frame and with known transmission. These were used as reference frames for calculating the percentage transmission of the all sky camera picture at appropriate points. Ten lines were digitized by sampling them 256 times each with 64 level guntization. These lines were in the north-south direction.: Seven selected points on each line were chosen. A computed generated plot of an all sky camera frame is shown on Figure A1. The lines represent a 256 intensity point taken at each line which have been connected by the computer. The small circles represent the position of the point which is being plotted in a time history plot. Actually, four adjacent samples were averaged for each point. In the presentation of the time history plots, such as Figs. 7, 10, 17, 20 and 22, the seven averages on a line are plotted, one above the other. The time plot nearest to the bottom represents the most equatorward point on the frame and the time plot nearest to the top represents most poleward part. The generation of this time history plot has given us the opportunity to make definite statements about the correlation of particle fluxes and other time dependent functions with the time history of the all sky camera data.

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LIST OF FIGURES

Figure 1 Computer-generated map of all sky camera field of views at Ft. Churchill, Gillam, Thompson and Gt. Whale River. The curves surrounding the stations represent field of view angles from 15°, 30°, 45°, 60° and 75°. Using the GSFC 12-66 field model invariant L values were computed and superimposed.

Figure 2 UCSD spectrogram from ATS-5.

Figure 3 UCSD spectrogram for ATS-5.

Figure 4 UCSD spectrogram for ATS-5.

Figure 5 ASCA pictures, Thompson, Feb. 13, 1970.

Figure 6 ASCA pictures for Churchill, Feb. 13, 1970.

Figure 7 ASCA Time Plot, Thompson, Feb. 13, 1970.

Figure 8 Thompson magnetometer H-component, Feb. 13, 1970.

Figure 9 ASCA pictures, Gillam, Feb. 5, 1970.

Figure 10 ASCA time plot, Gillam, Feb. 5, 1970.

Figure 11 Magnetometer H-components, Feb. 5, 1970.

Figure 12 Lockheed ATS-5 particle data.

Figure 13 Magnetometer H-component data, Nov. 22, 1969.

Figure 14 ASCA pictures, Thompson, Nov. 22, 1969.

Figure 15 Lockheed ATS-5 particle data, Nov. 22, 1969.

Figure 16 Lockheed particle data, ATS-5, Nov. 9, 1969.

Figure 17 ASCA time plot, Thompson, Nov. 9, 1969.

Figure 18 Magnetometer H-components, Nov. 9, 1969.

Figure 19 ASCA pictures, Gillam, Feb. 14, 1970.

Figure 20 ASCA time plot, Gillam, Feb. 14, 1970.

Figure 21 ASCA pictures, Thompson, Feb. 14, 1970.

Figure 22 ASCA time plot, Thompson, Feb. 14, 1970.

Figure 23 ASCA pictures, Ft. Churchill, Feb. 14, 1970.

Figure 24 UCSD plasma experiment, ATS-5.

Figure 25 Lockheed particle data for Feb. 14, 1970.

Figure 26 Magnetogram H-components, Feb. 14, 1970.

Figure A1 Computer presentation of single frame as digitized with the system. 10 TV lines north-south aligned are digitized in 256 samples each. The circles represent positions from which time history plot curves are produced.

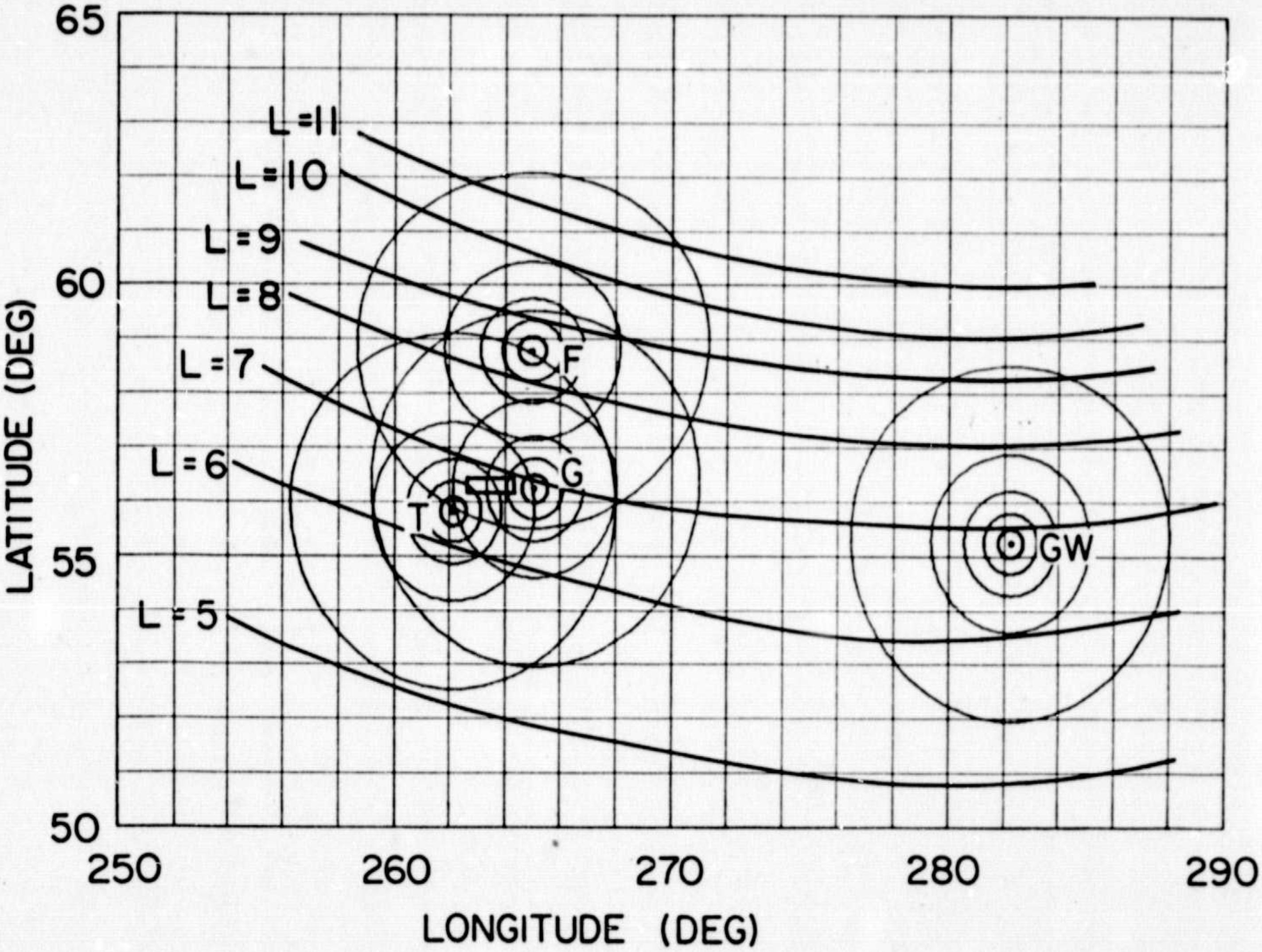

Figure 1

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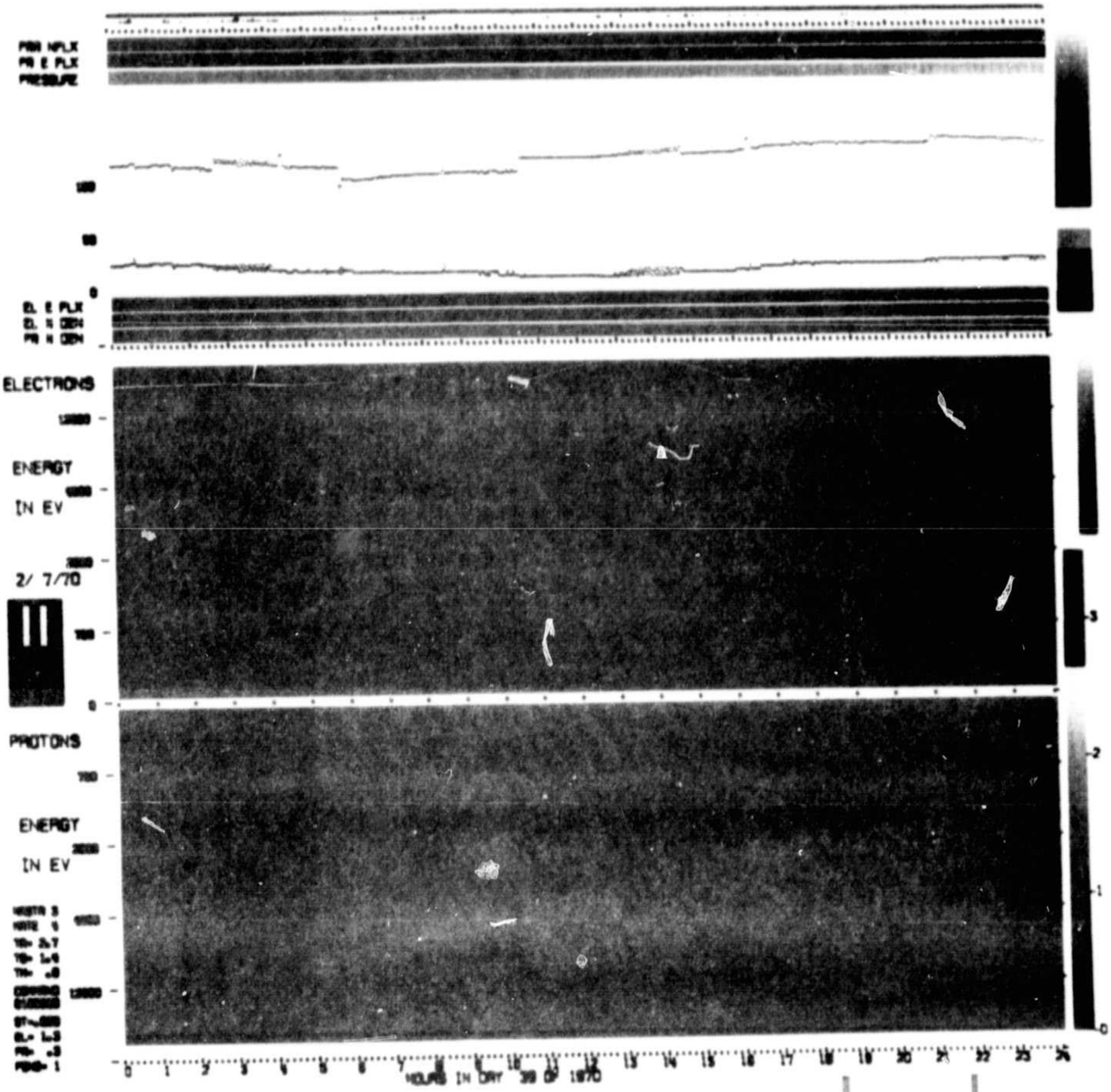
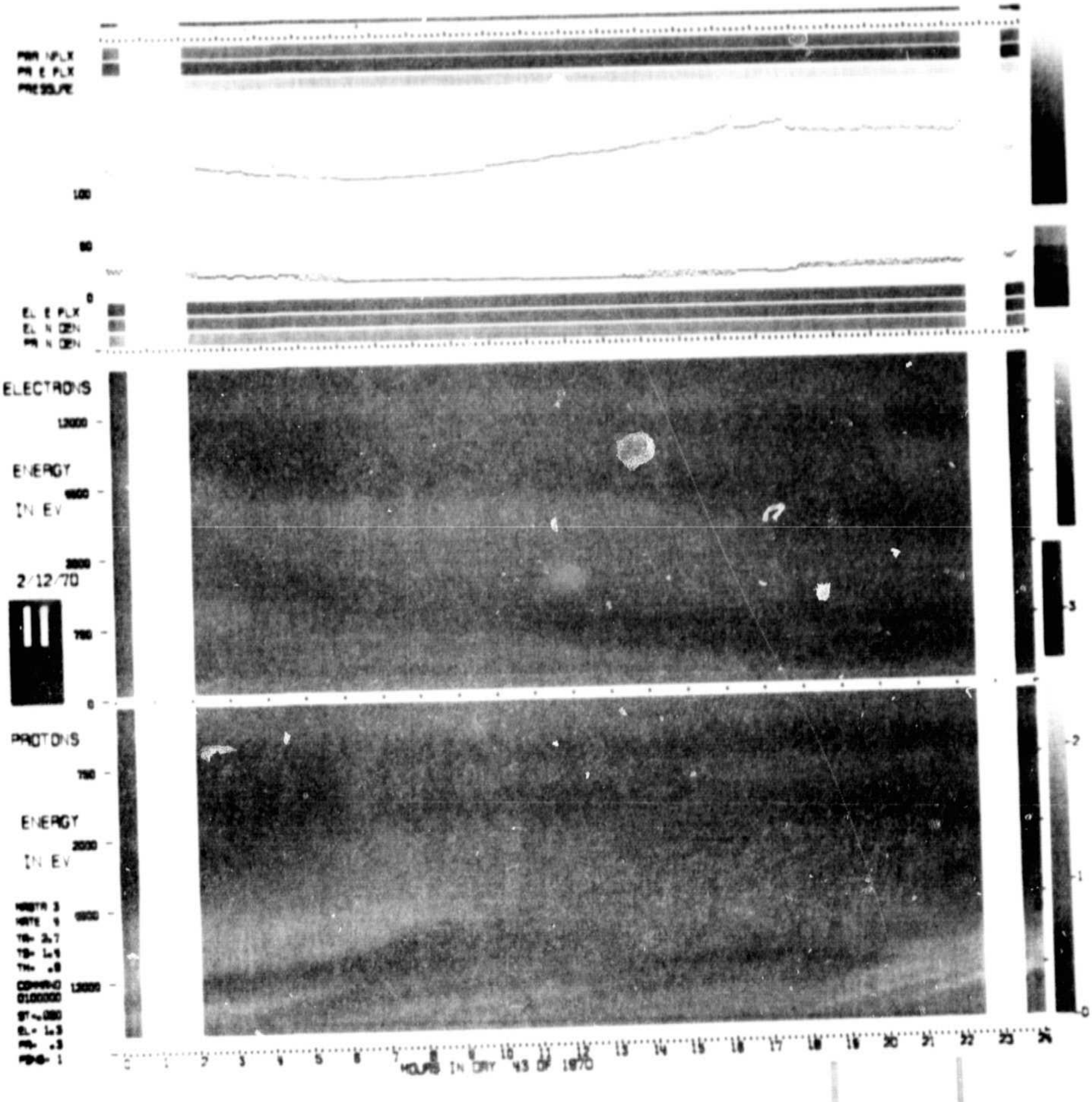
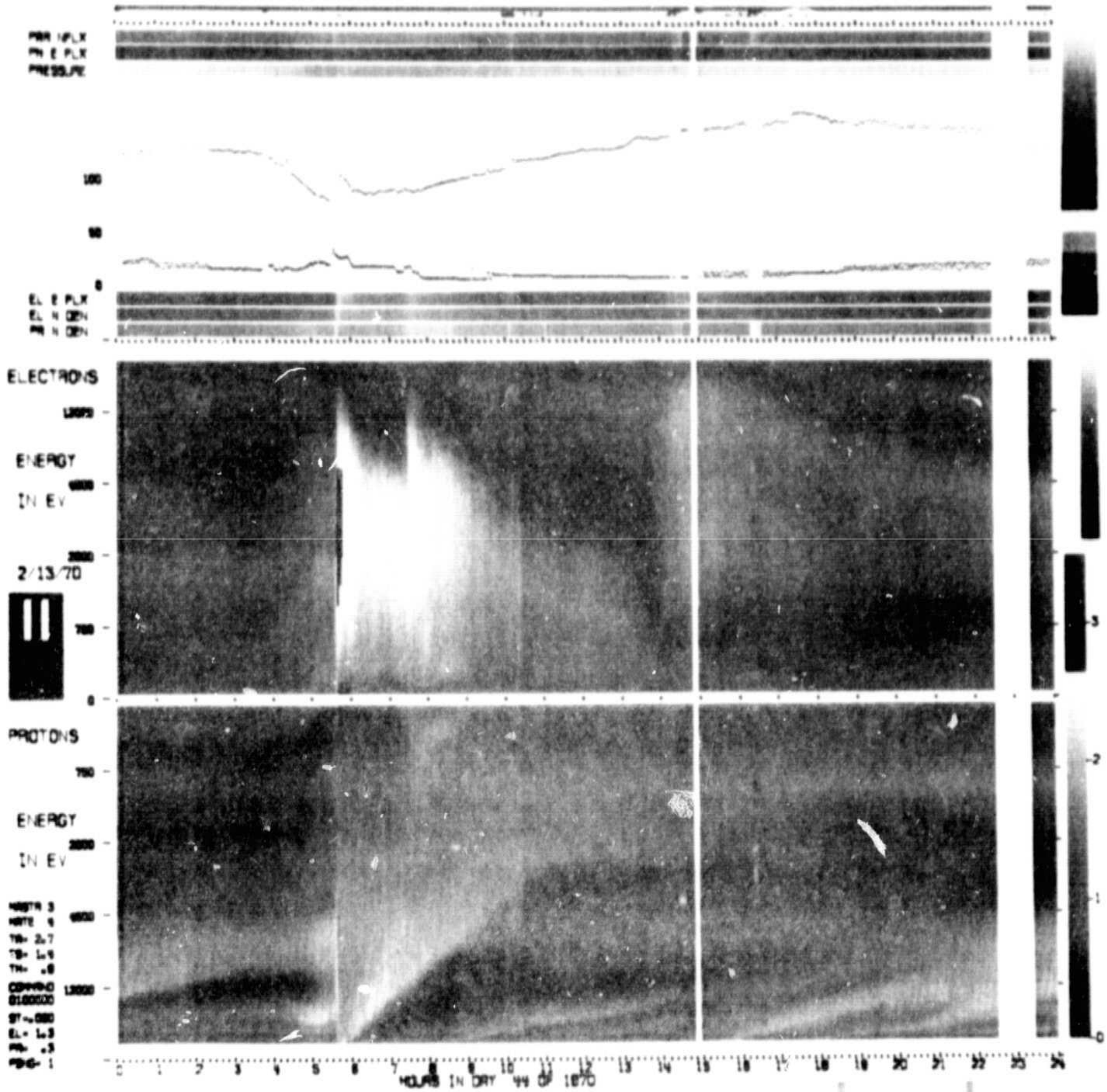


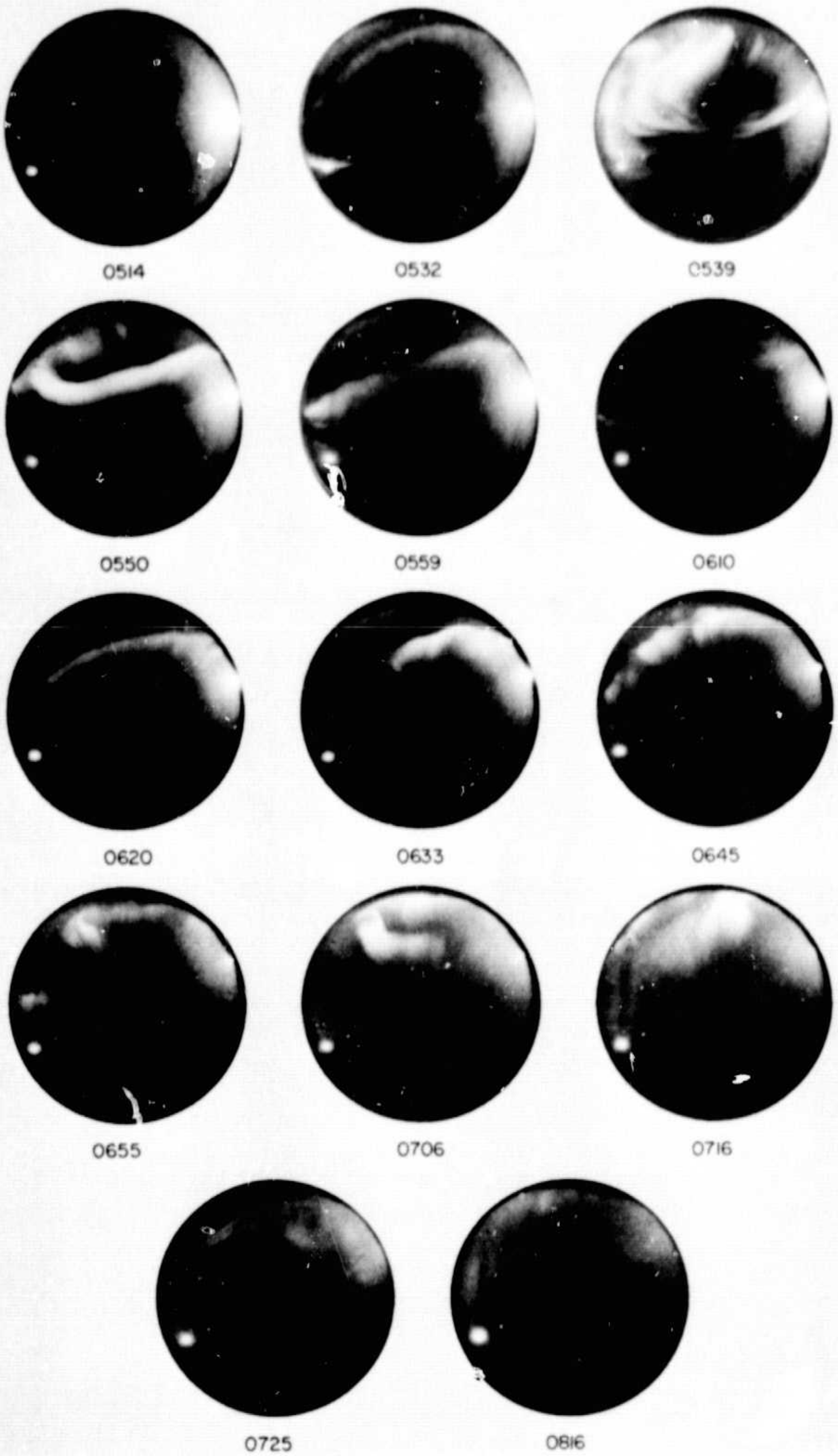
ELECTRONS
ENERGY
IN EV
2/ 7/70
PROTONS
ENERGY
IN EV
HOURS IN DAY 38 OF 1970



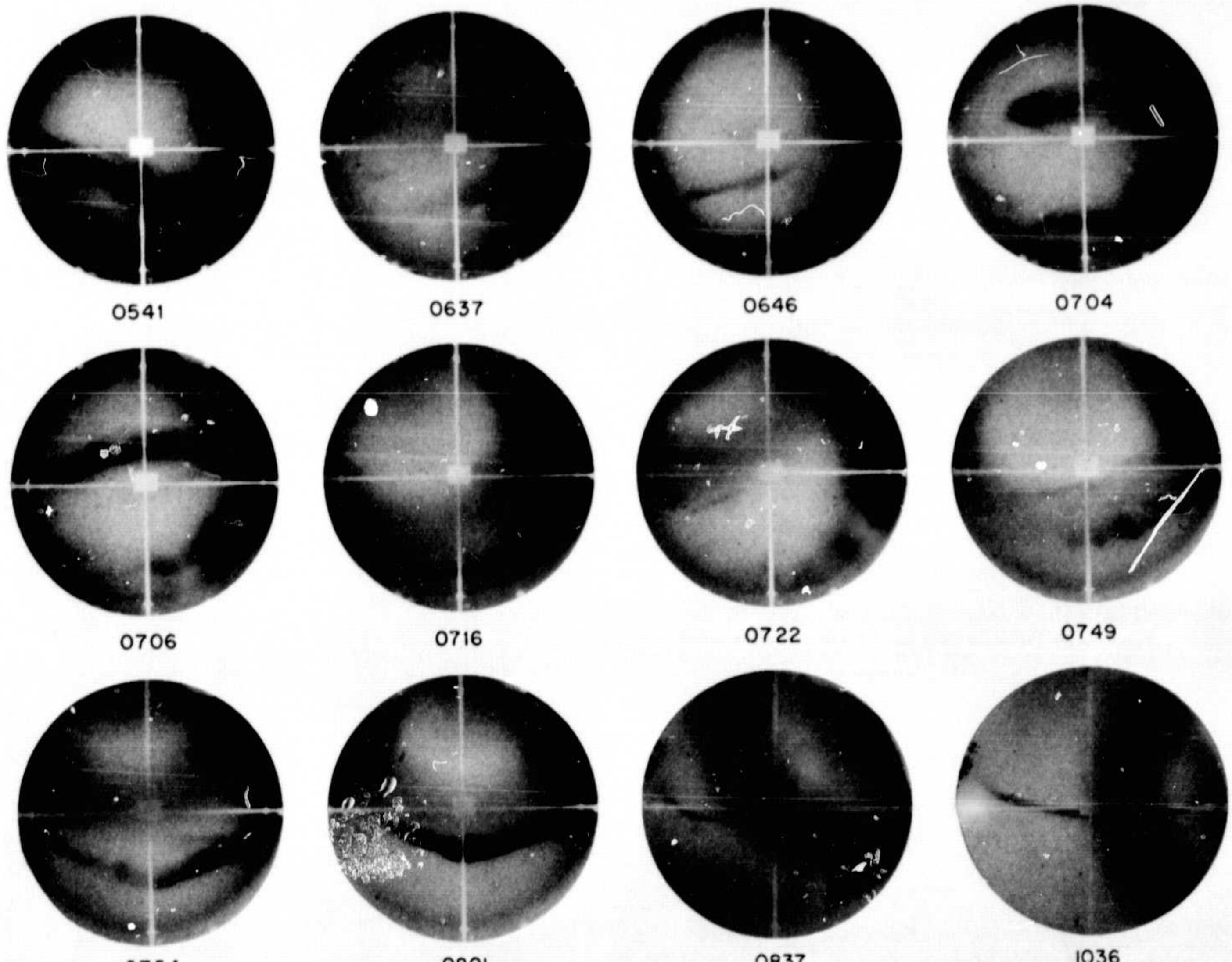
PRR N FLX
PR E FLX
PRESSURE
100
50
0
EL E FLX
EL N DEN
PR N DEN
ELECTRONS
ENERGY
IN EV
2/12/70
PROTONS
ENERGY
IN EV
HOURS IN DAY 43 OF 1970


ELECTRONS
ENERGY IN EV
2/13/70
PROTONS
ENERGY IN EV
HOURS IN DAY 44 OF 1970

DAY 44, 1970


0514
0532
0539
0550
0559
0610
0620
0633
0645
0655
0706
0716
0725
0816

DAY 44, 1970



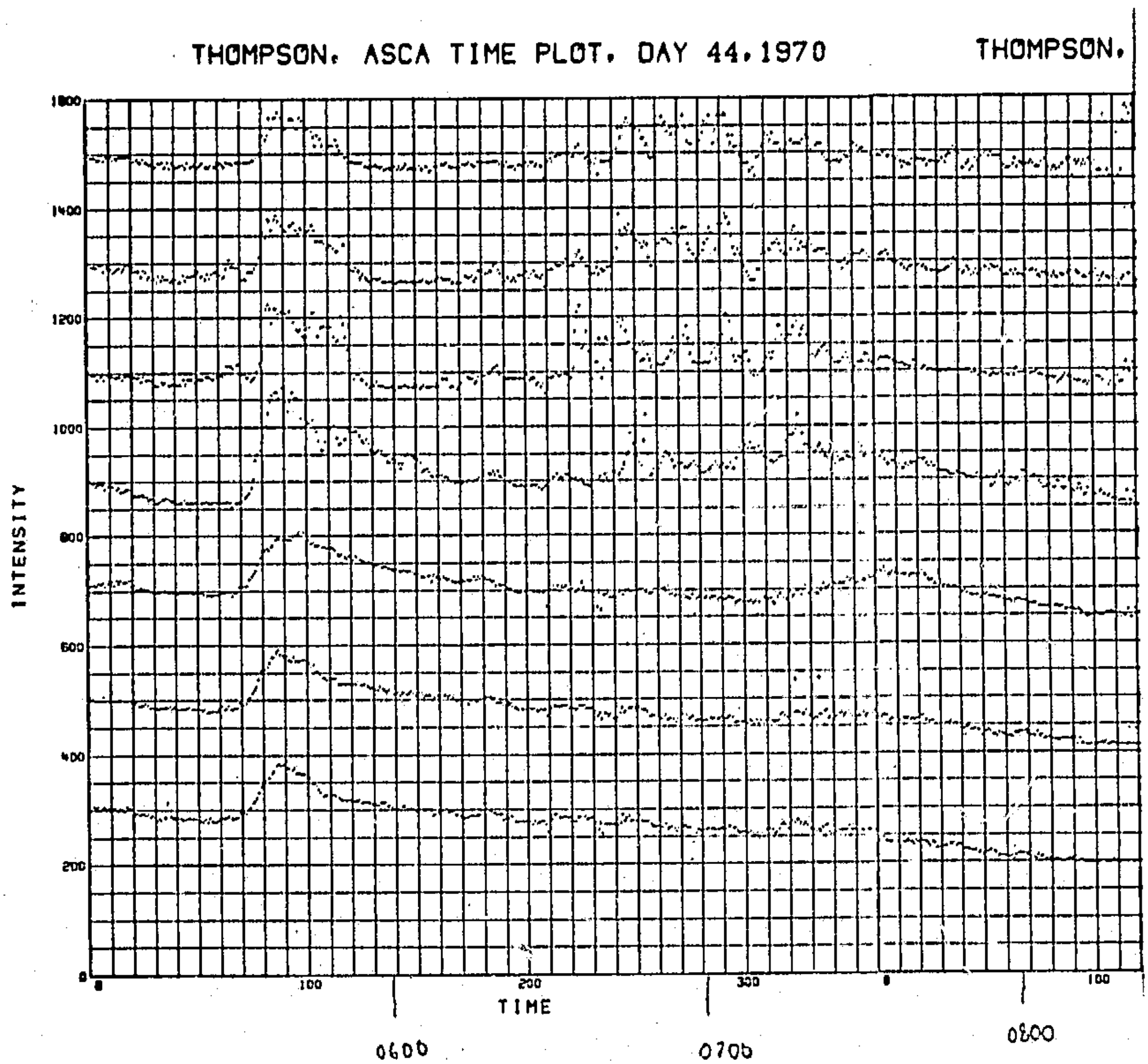

THOMPSON, ASCA TIME PLOT, DAY 44,1970
THOMPSON,
INTENSITY
1800
1400
1200
1000
800
600
400
200
0
0
100
200
300
0
100
TIME
0600
0700
0800

Figure 7

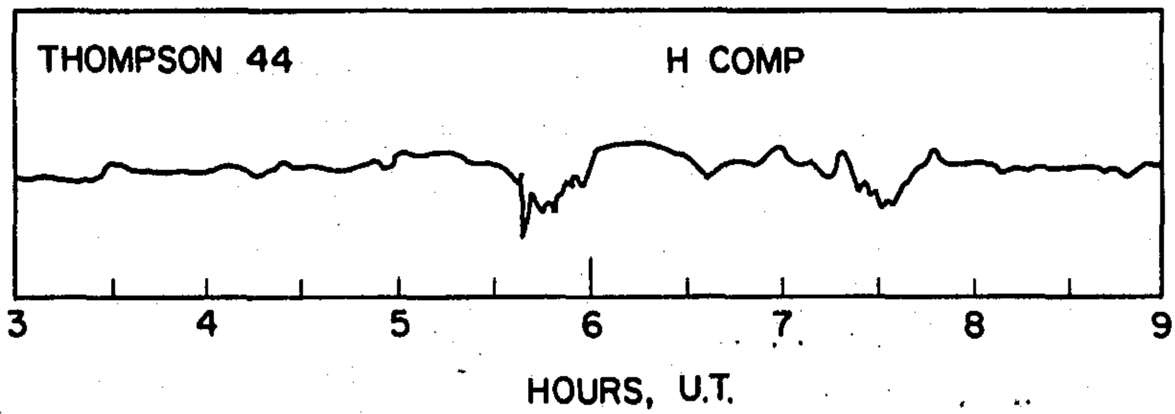
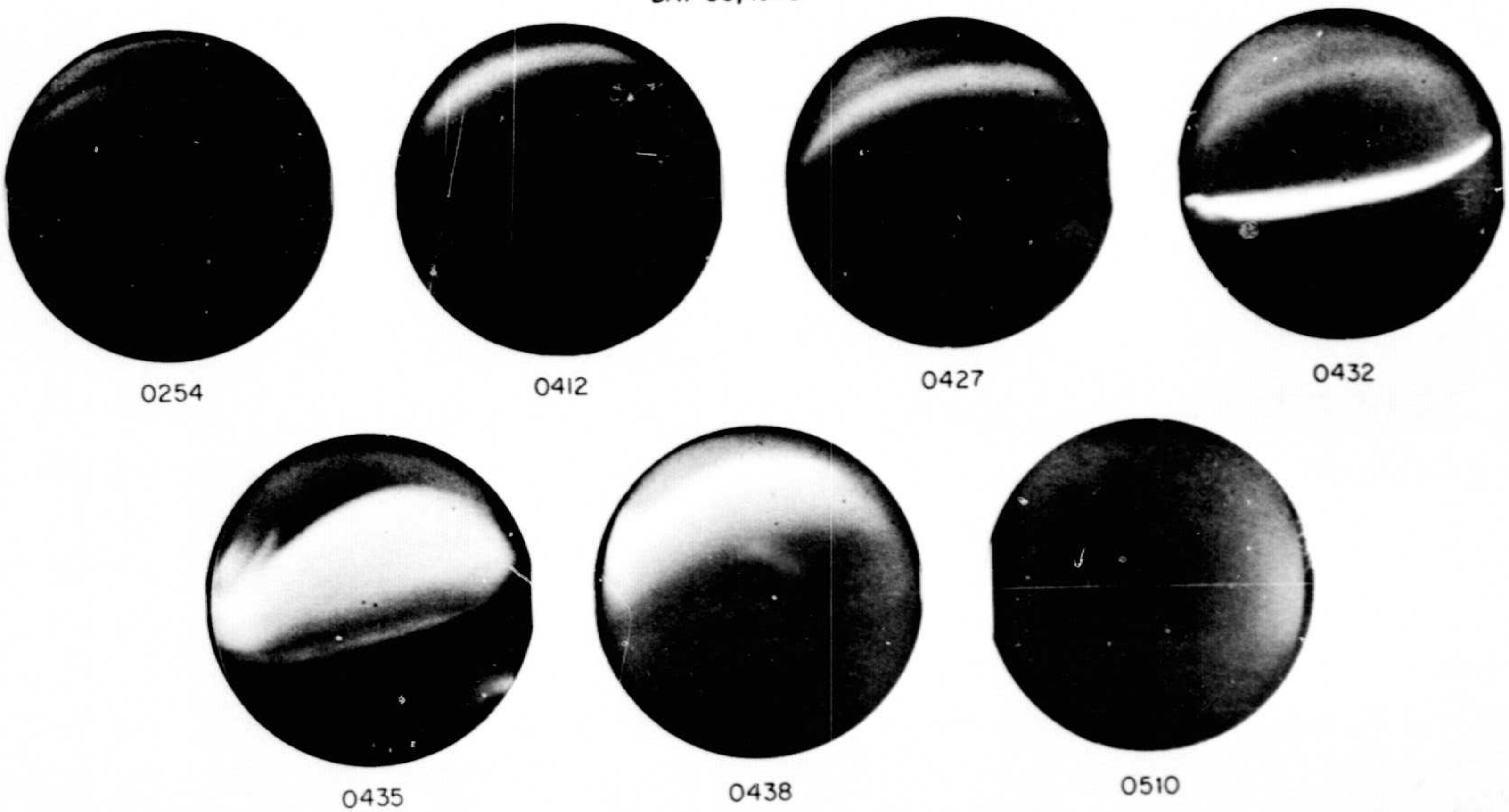


Figure 8

DAY 36, 1970



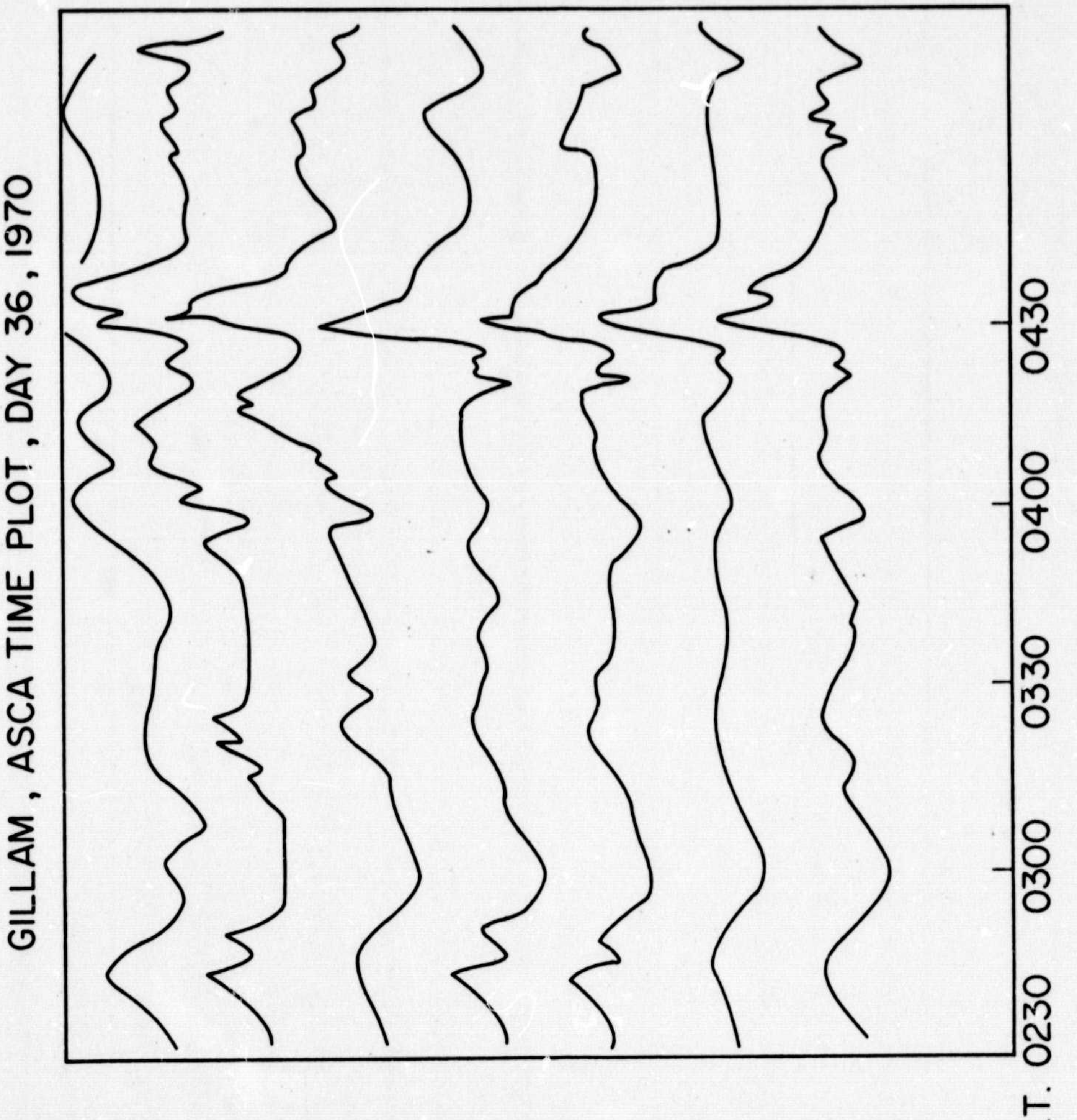


Fig. 10

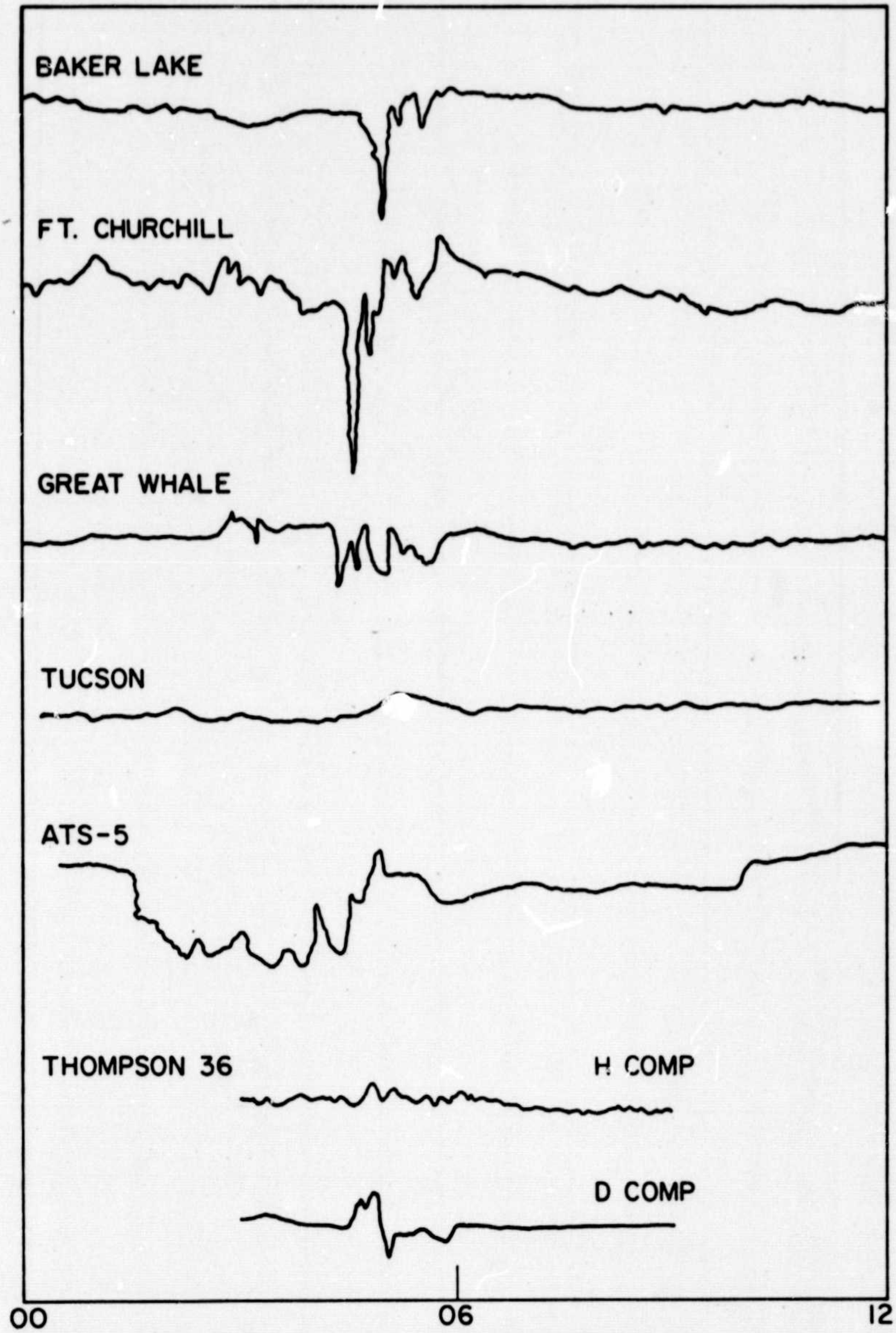

BAKER LAKE
FT. CHURCHILL
GREAT WHALE
TUCSON
ATS-5
THOMPSON 36
H COMP
D COMP
00
06
12

Figure 11

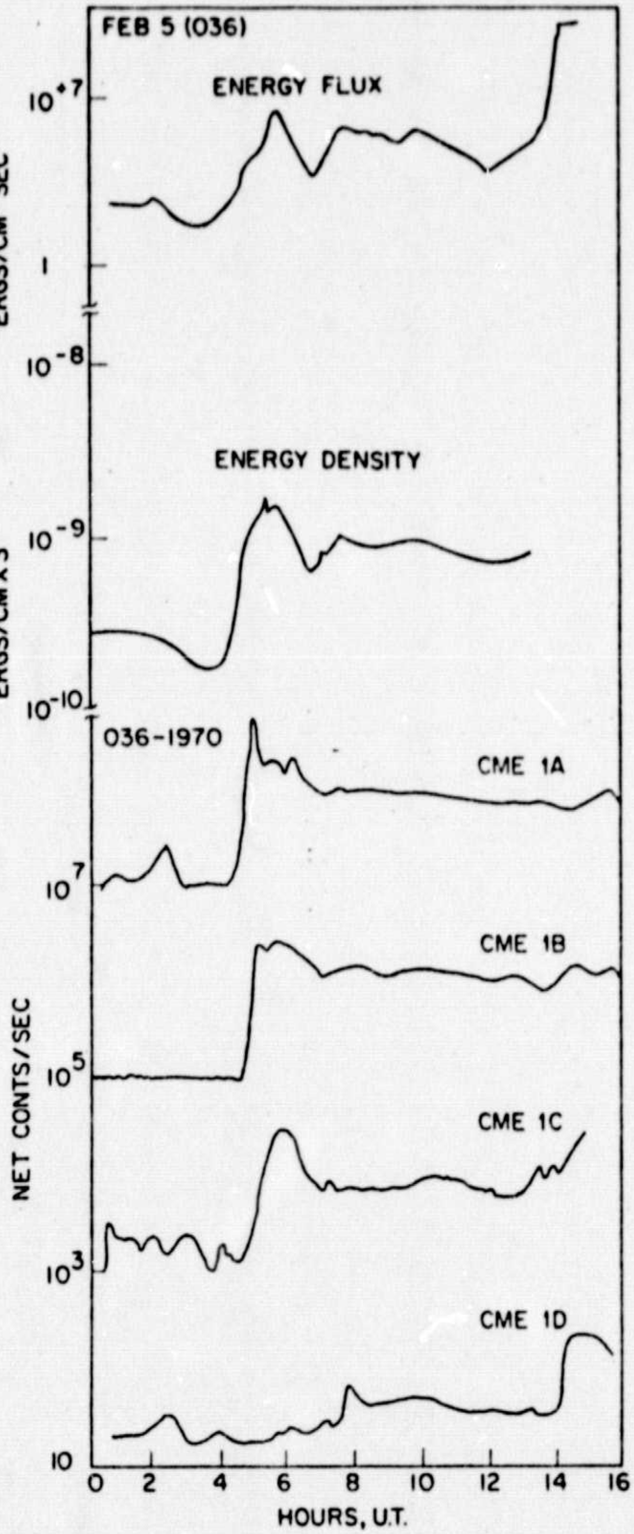

FEB 5 (036)
ENERGY FLUX
ERGS/CM^{-2}SEC^{-1}
10^{+7}
1
ENERGY DENSITY
ERGS/CM X 3
10^{-8}
10^{-9}
10^{-10}
036-1970
CME 1A
CME 1B
CME 1C
CME 1D
NET CONTS/SEC
10^{7}
10^{5}
10^{3}
10
0
2
4
6
8
10
12
14
16
HOURS, U.T.

Figure 12

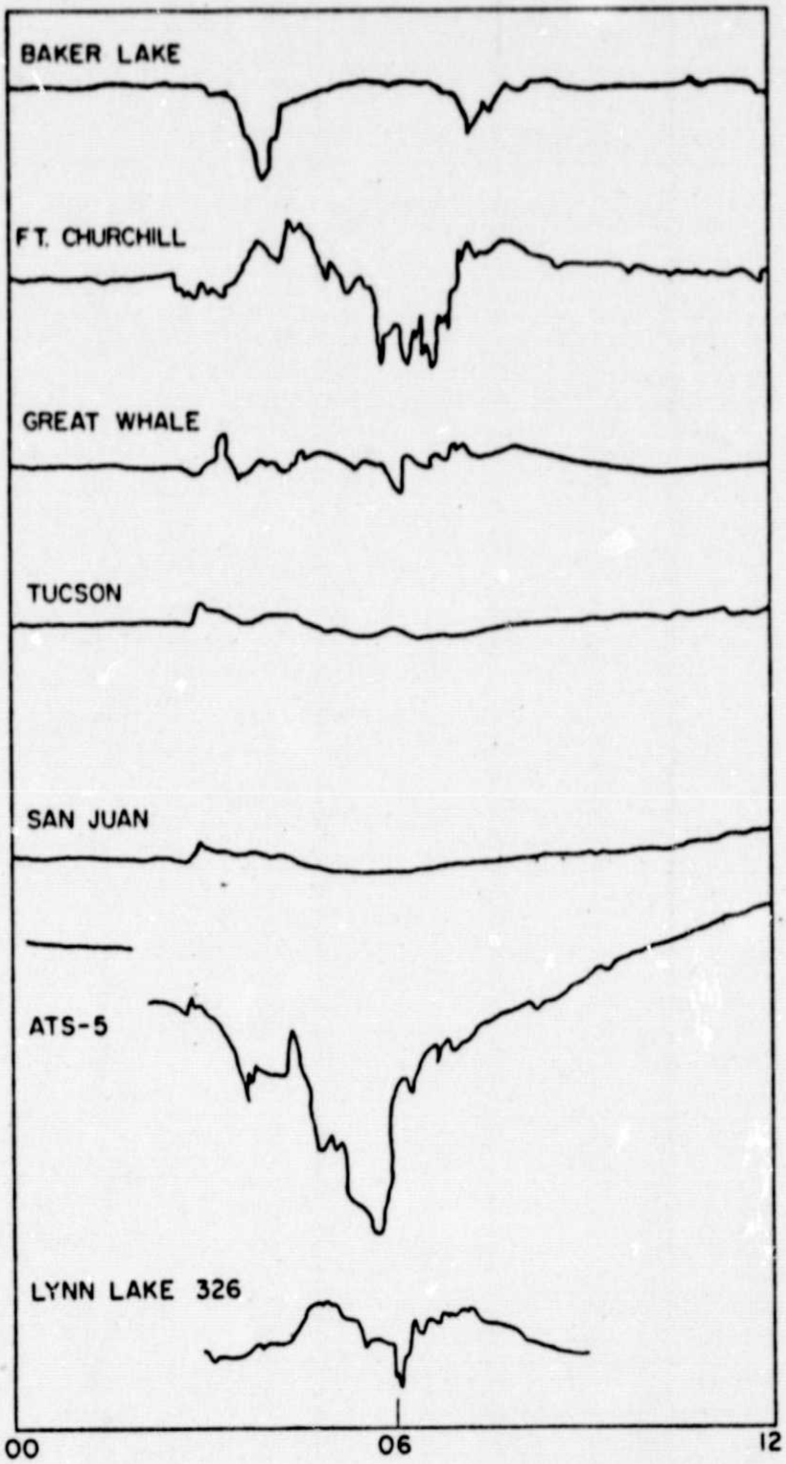
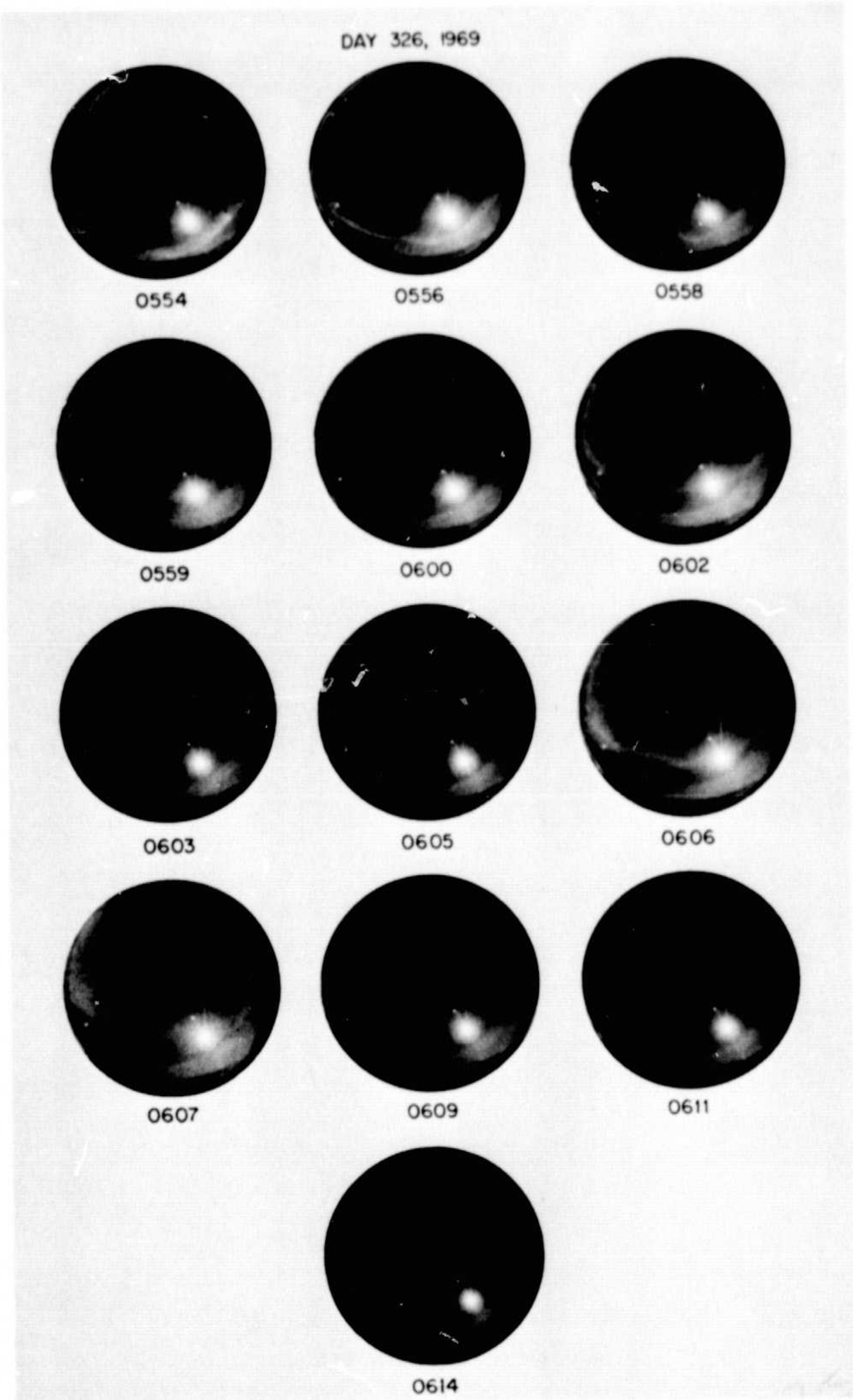

BAKER LAKE
FT. CHURCHILL
GREAT WHALE
TUCSON
SAN JUAN
ATS-5
LYNN LAKE 326
00
06
12

Figure 13


DAY 326, 1969
0554
0556
0558
0559
0600
0602
0603
0605
0606
0607
0609
0611
0614

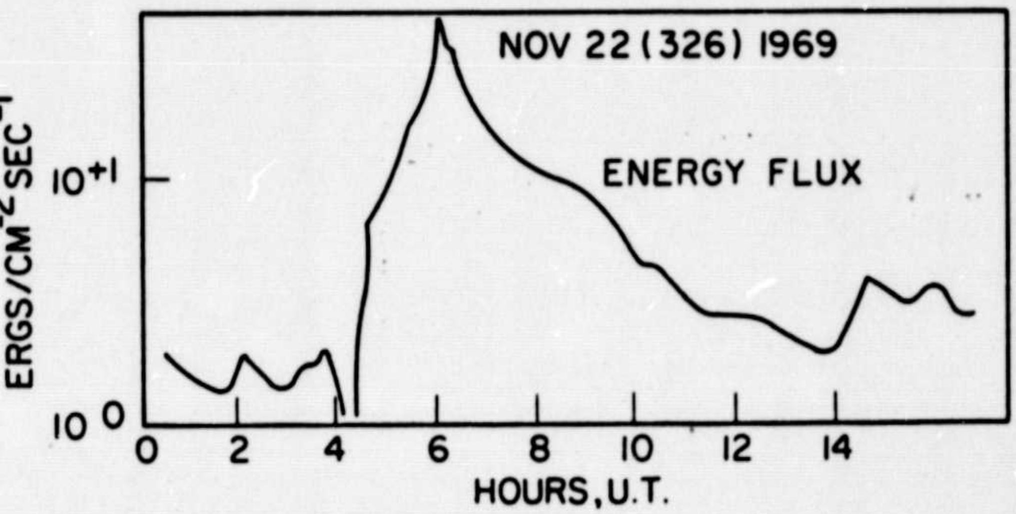

NOV 22 (326) 1969
ENERGY FLUX
ERGS/CM^{-2} SEC^{-1}
10^{+1}
10^{0}
0
2
4
6
8
10
12
14
HOURS, U.T.

Figure 15

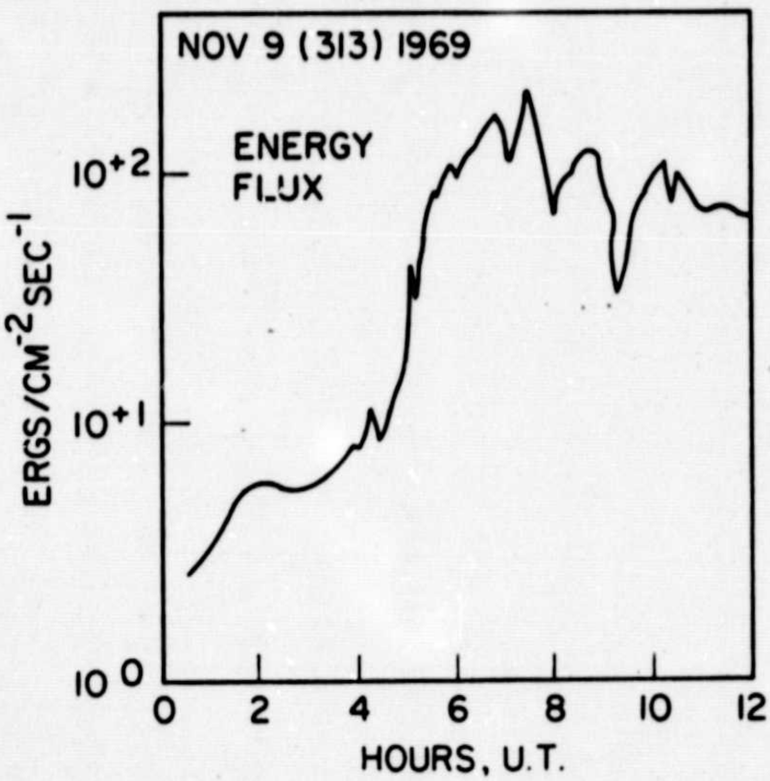

NOV 9 (313) 1969
ENERGY
FLUX
10+2
10+1
10 0
ERGS/CM-2 SEC-1
0
2
4
6
8
10
12
HOURS, U.T.

Figure 16

THOMPSON. ASCA TIME PLOT. DAY 313.1969

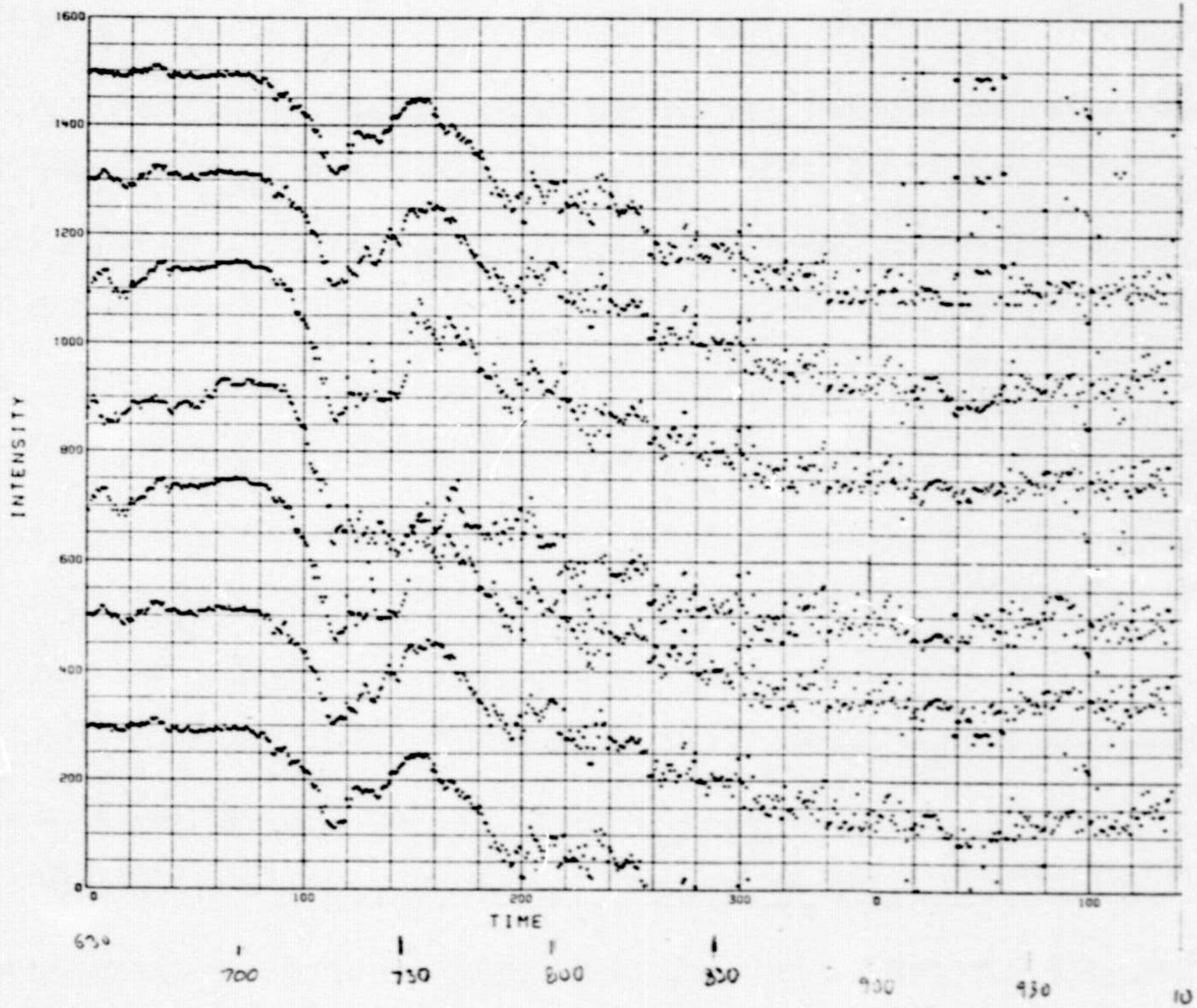


Figure 17

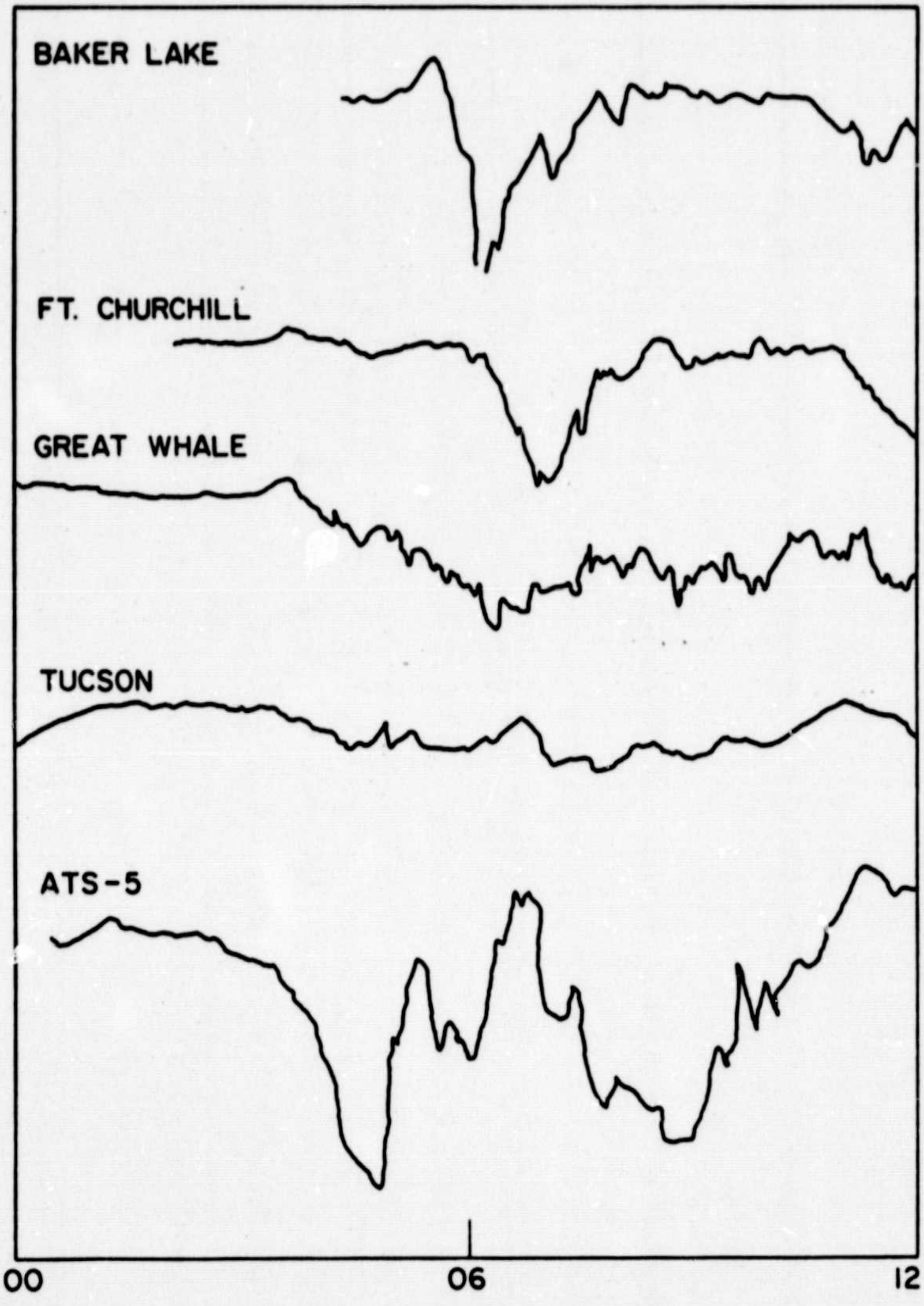
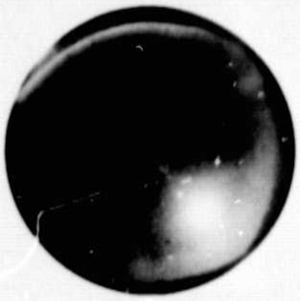
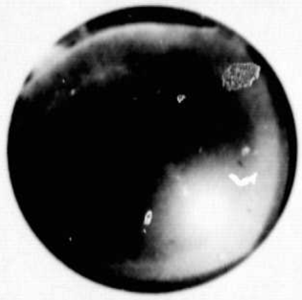


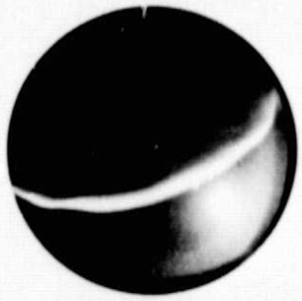
Figure 18


0305


0310

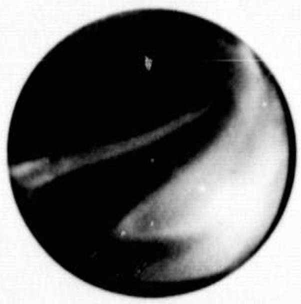

0320

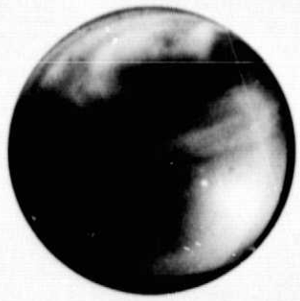

0330


0340


0350


0400


0410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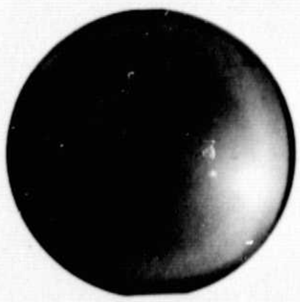
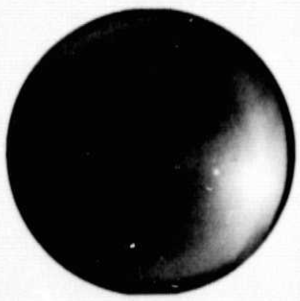

0430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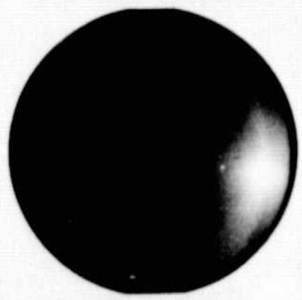
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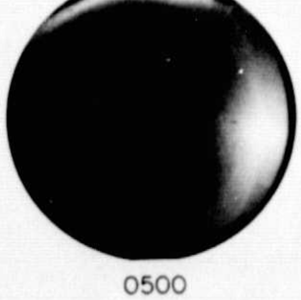
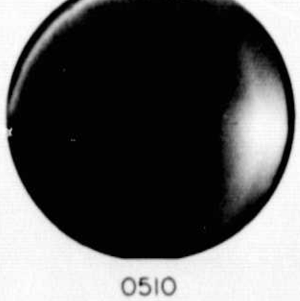

0500


0510

GILLAM, ASCA TIME PLOT, DAY 45, 1970

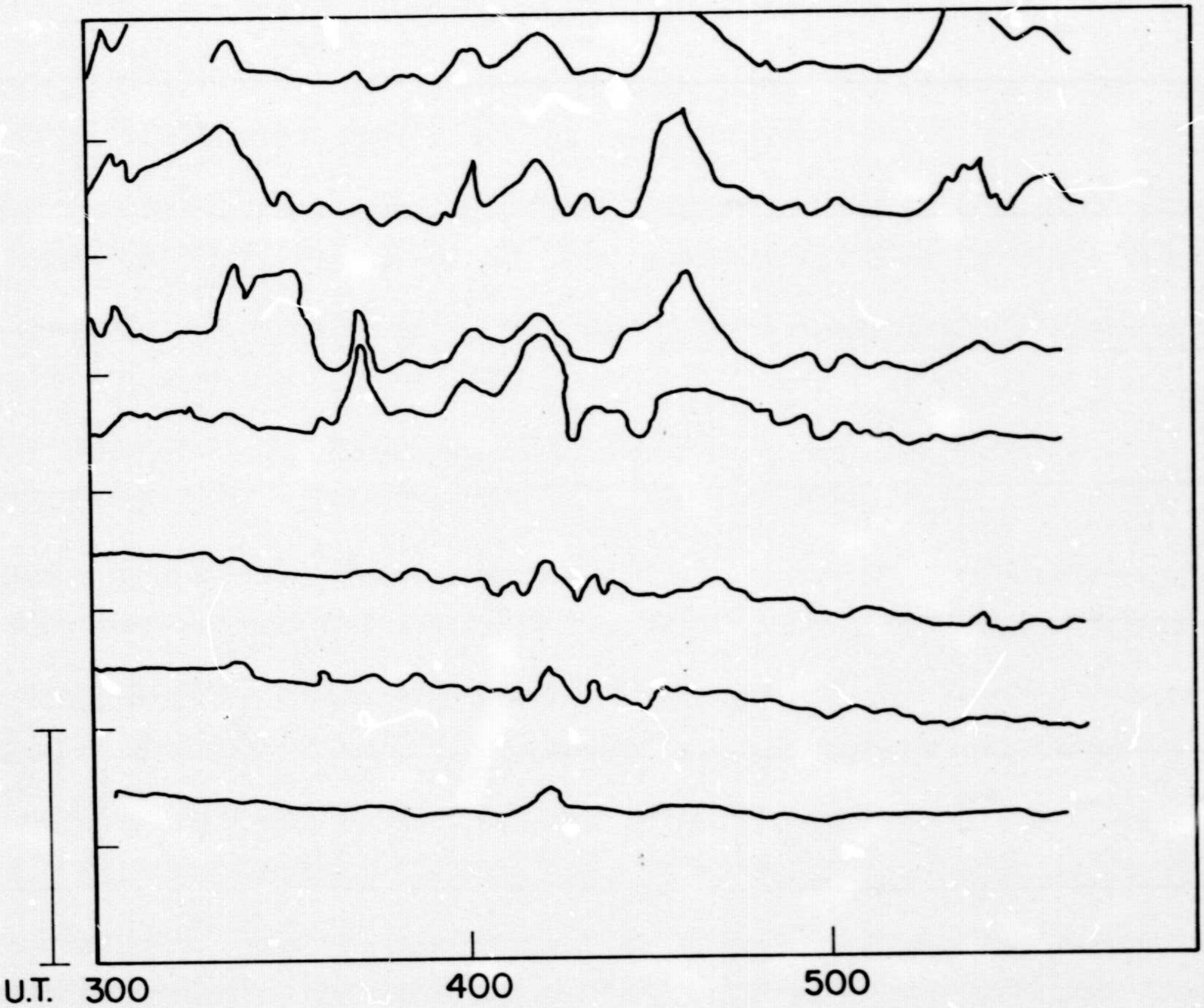
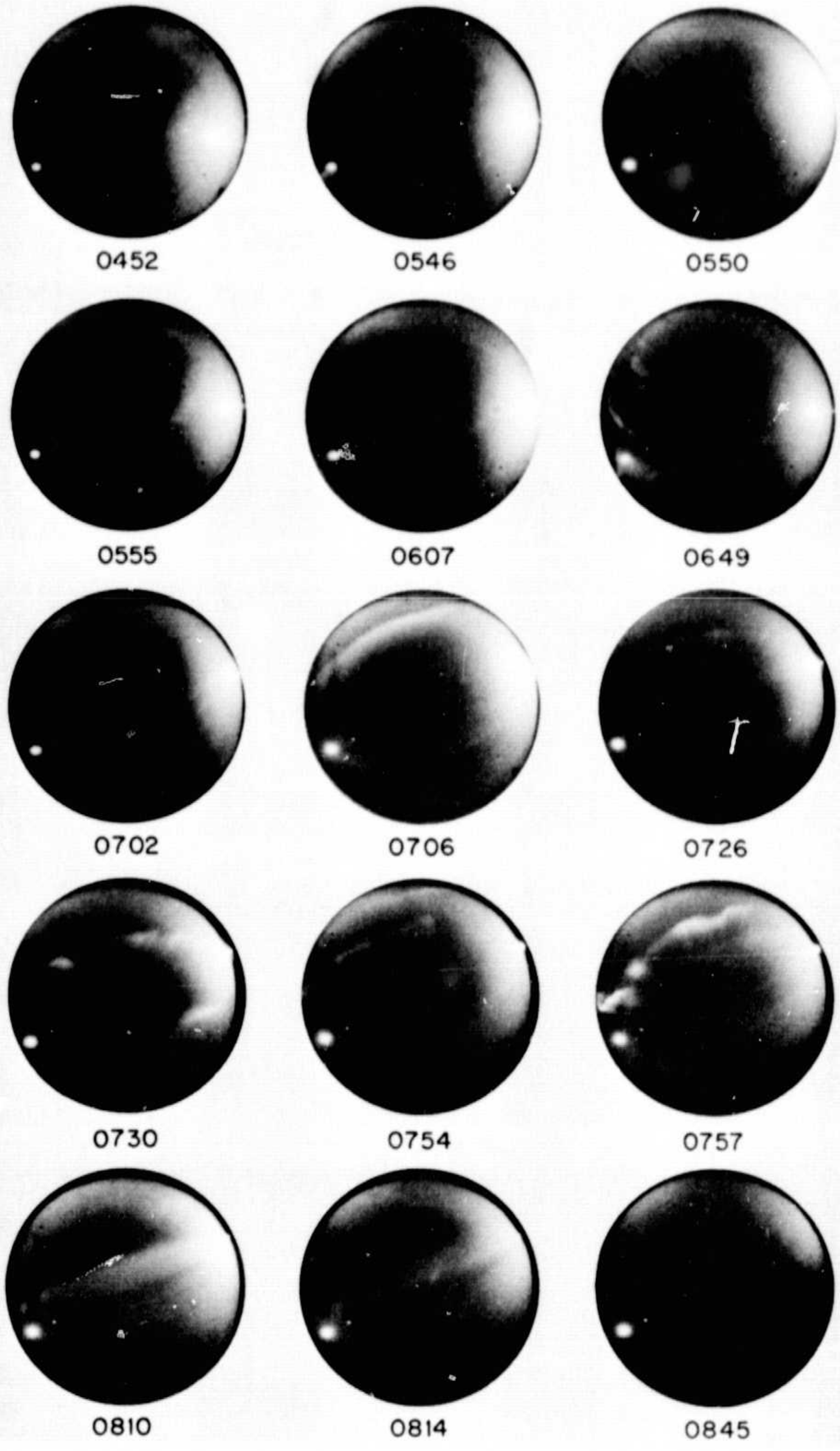


Figure 20

DAY 45, 1970


0452
0546
0550
0555
0607
0649
0702
0706
0726
0730
0754
0757
0810
0814
0845

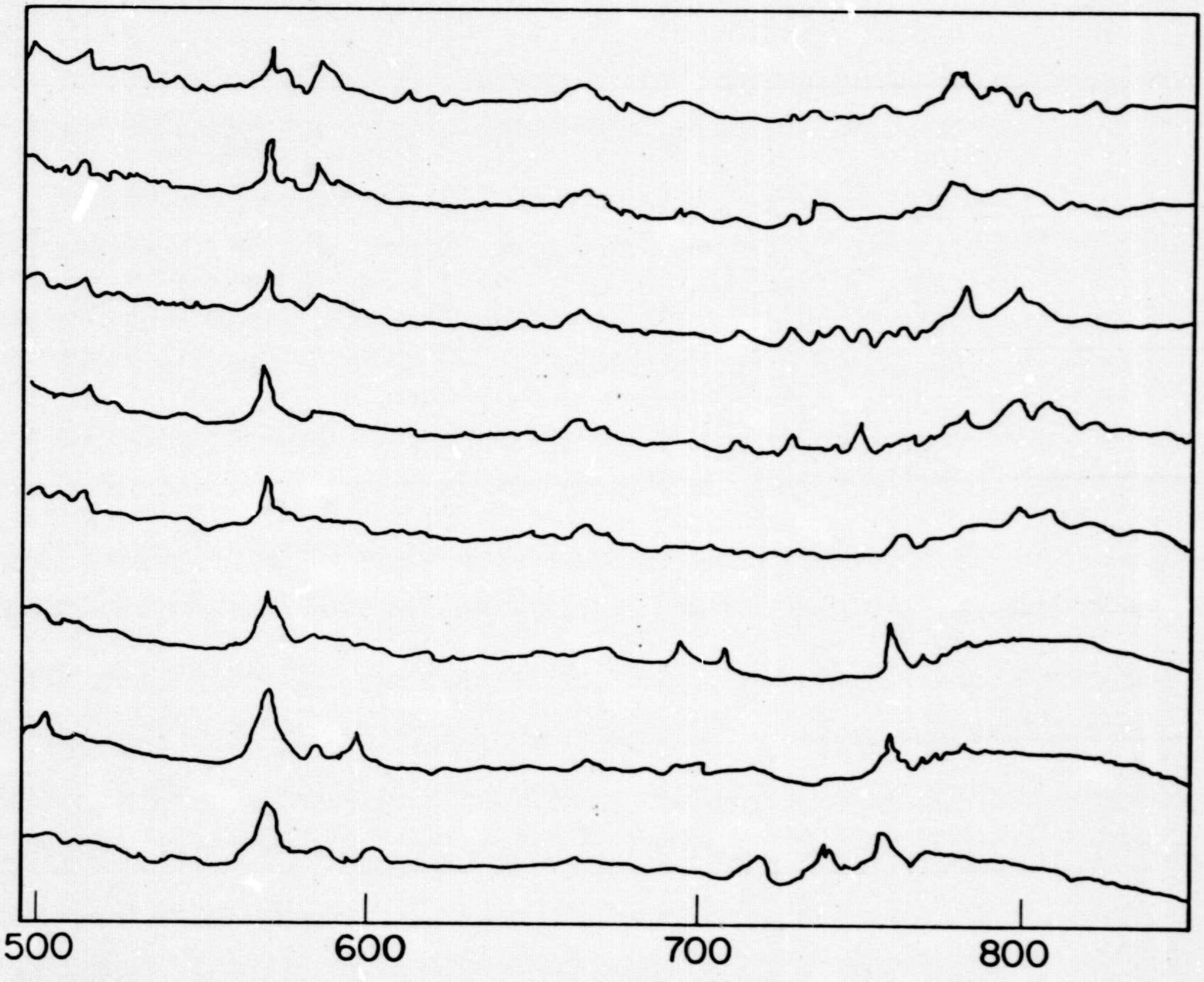
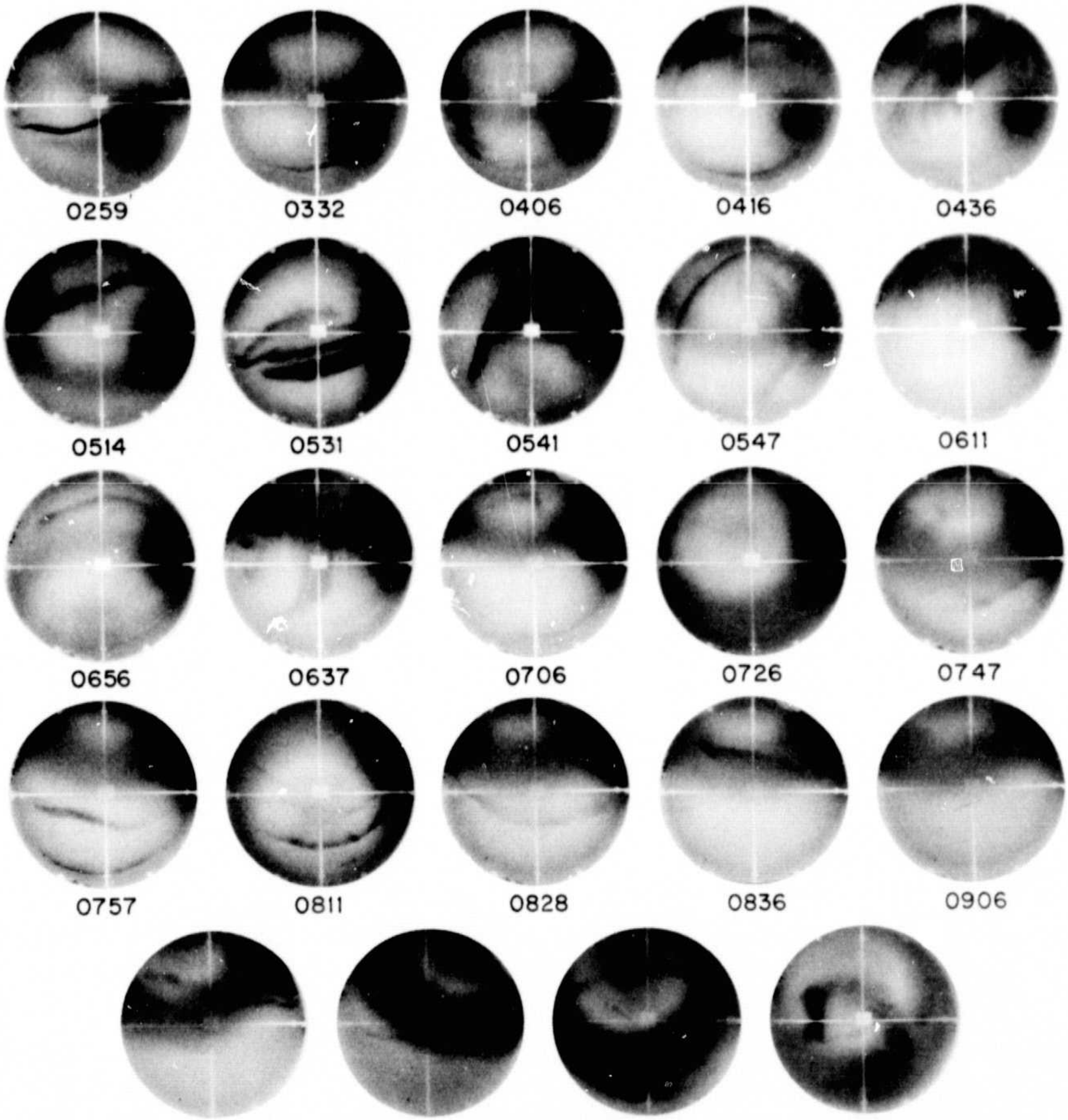
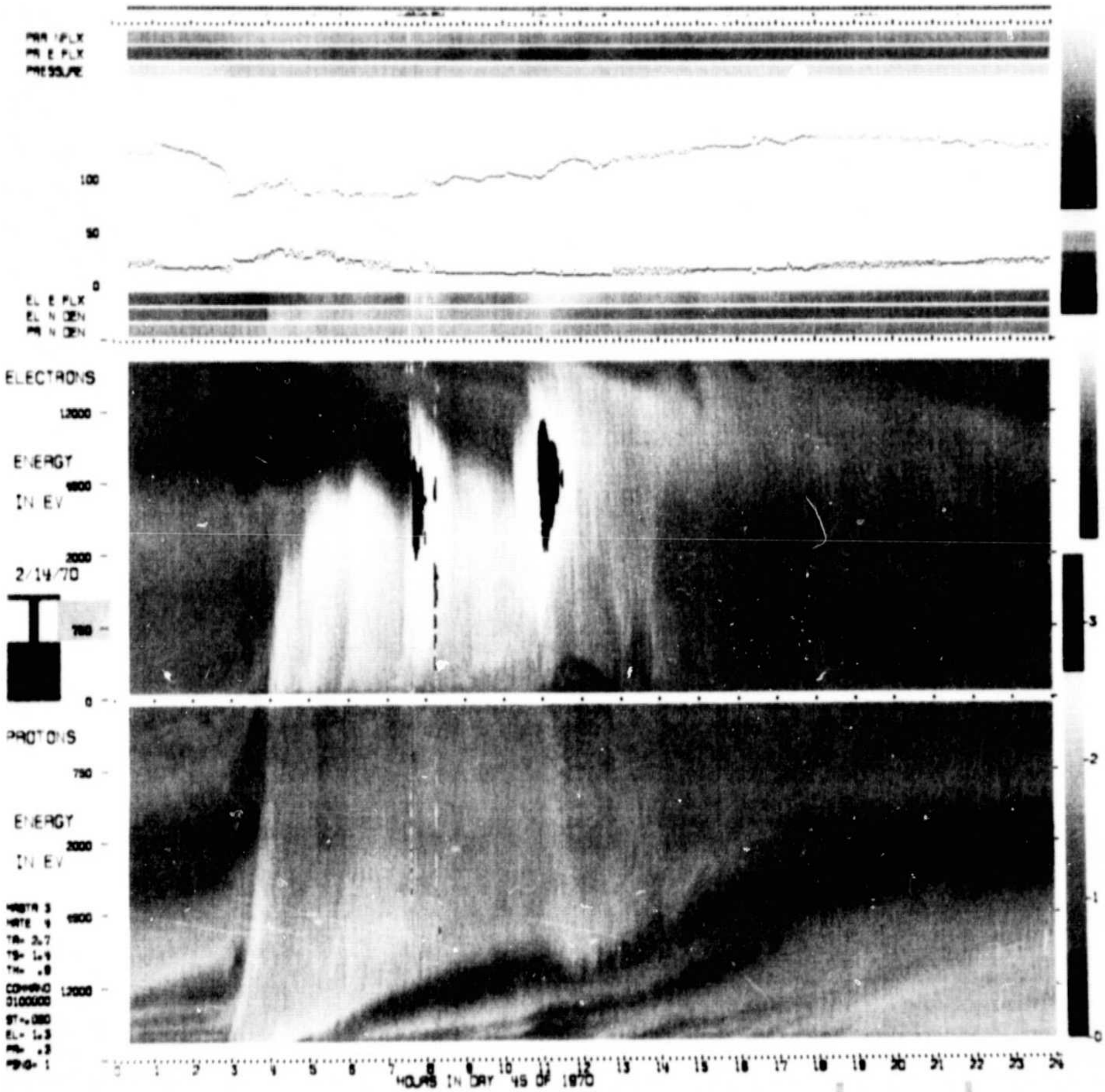
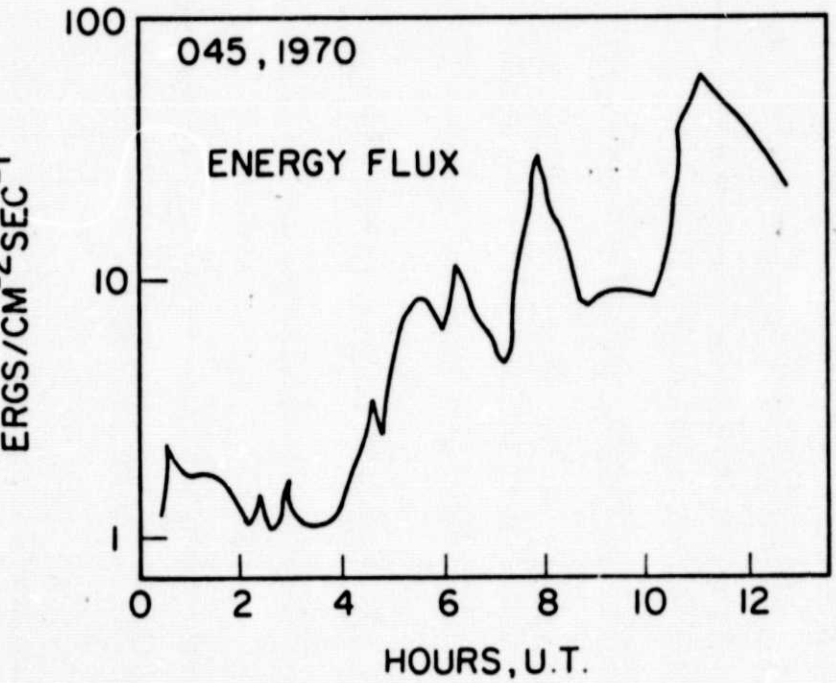


Figure 22

DAY 45, 1970


0259
0332
0406
0416
0436
0514
0531
0541
0547
0611
0656
0637
0706
0726
0747
0757
0811
0828
0836
0906
0924
1001
1026
1116


PRR N FLX
PR E FLX
PRESSURE
100
50
0
EL E FLX
EL N DEN
PR N DEN
ELECTRONS
12000
ENERGY
IN EV
2000
2/14/70
PROTONS
750
ENERGY
IN EV
2000
12000
HOURS IN DAY 45 OF 1970



100
045, 1970
ENERGY FLUX
ERGS/CM^{-2}SEC^{-1}
10
1
0
2
4
6
8
10
12
HOURS, U.T.

Figure 25

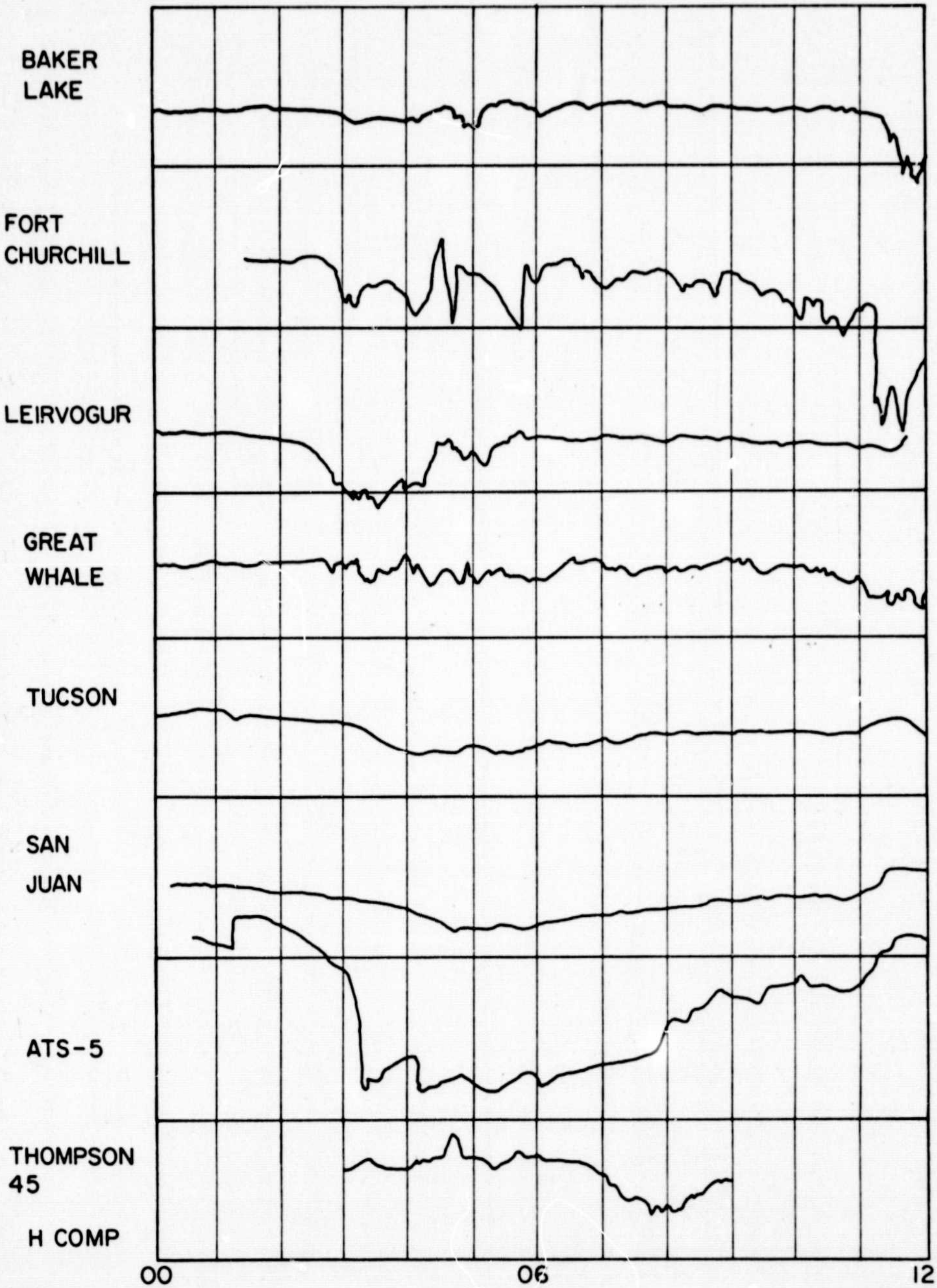
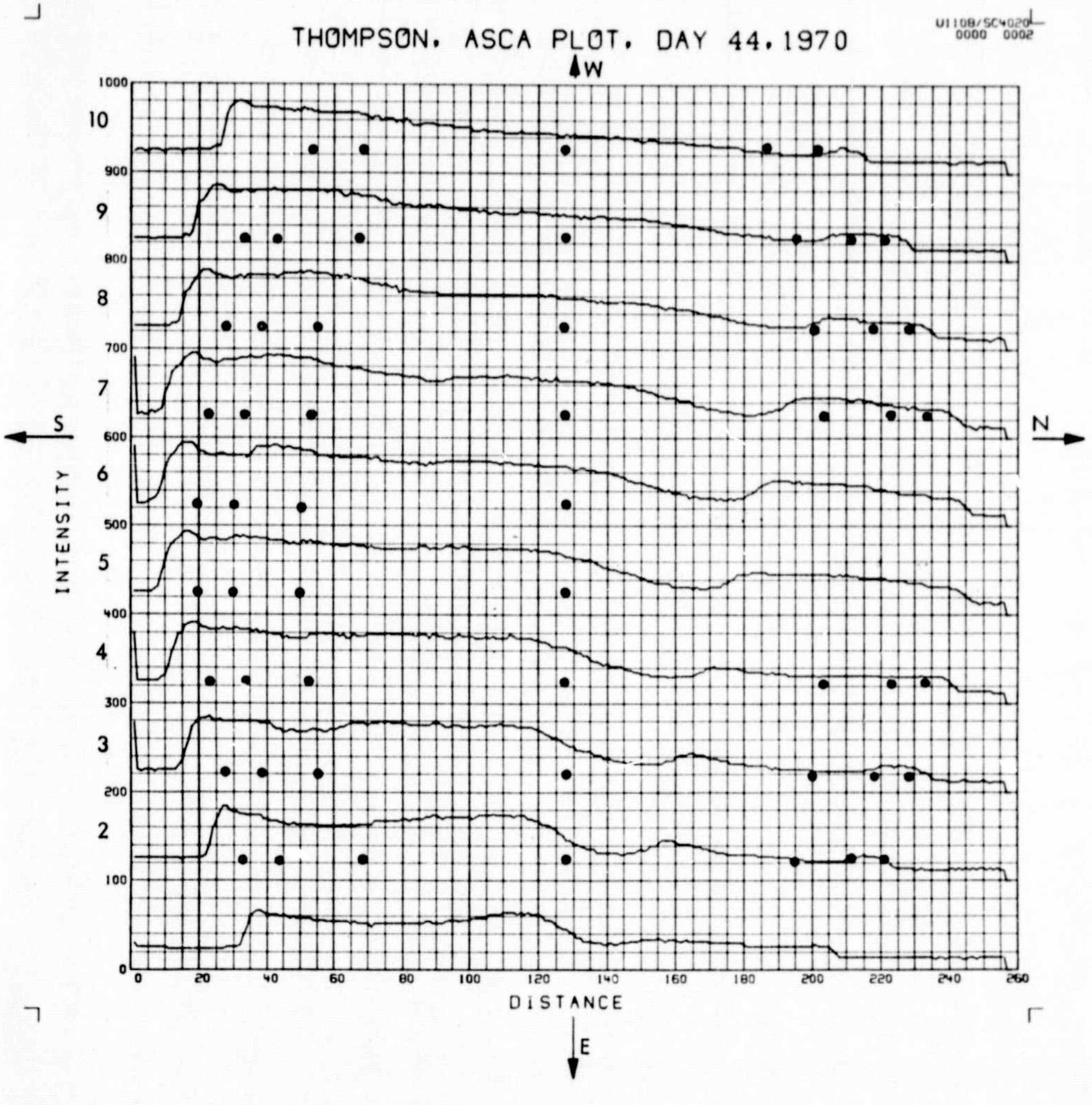

BAKER LAKE
FORT CHURCHILL
LEIRVOGUR
GREAT WHALE
TUCSON
SAN JUAN
ATS-5
THOMPSON 45
H COMP
00
06
12

Fig. 26



U1108/SC4020
0000 0002
THOMPSON, ASCA PLOT, DAY 44,1970
W
S
N
E
INTENSITY
DISTANCE
1000
900
800
700
600
500
400
300
200
100
0
10
9
8
7
6
5
4
3
2
0 20 40 60 80 100 120 140 160 180 200 220 240 260

Figure A1