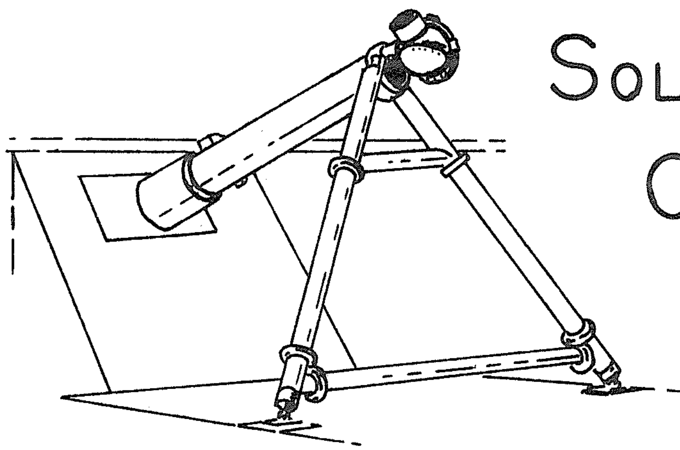

SOLAR OBSERVING OPTICAL NETWORK

DATA PRODUCTS

PREPARED BY:
DETACHMENT 4, 3D WEATHER WING
HOLLOMAN SOLAR OBSERVATORY
FEBRUARY 1982

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DET 9, 1WW	2
DET 3, 2WW	1
DET 2, 3WW	1
DET 3, 3WW	2
DET 4, 3WW	25
OL-B, AFGWC	5
AFGL/PHS	2
NOAA/SESC	5

PREFACE

The Solar Observing Optical Network (SOON) uses a new type, one-of-a-kind, solar telescope which was designed by Dr. Richard Dunn of the Sacramento Peak Solar Observatory. When the network is fully operational, it will have the capability of observing and reporting solar data continuously, synoptically, and automatically with the standardized AN/FMQ-7 solar telescope and uniform operating procedures. Since the first SOON telescope became operational in July 1975, numerous changes have occurred to the equipment, computer software, and operating procedures. This publication presents the data products available from the SOON at this time. It explains these products in general terms and provides examples, wherever possible. We've distributed it to the operators, users, and managers of the SOON. Additional copies will be provided upon request.

Captain Gerard D. Wittman
Detachment 4, 3d Weather Wing
Holloman Solar Observatory
February 1982

SOLAR OBSERVING OPTICAL NETWORK DATA PRODUCTS

FIGURES

Chapter 1
General Information

1-1. Background. The sun is constantly emitting various forms of radiation. Our environment is strongly dependent on the character of these radiation emissions. Significant solar events produce variations in the terrestrial and space environments which may seriously affect military operations. These variations in the ionosphere, atmospheric density, solar radiation, and geomagnetic field may disrupt surveillance and warning systems, radio communication systems, satellite tracking and orbital predictions, and may be hazardous to human life operating in the space environment. Solar events can be observed, analyzed, and forecast only through systematic synoptic observation. In the past, AWS has had only a limited solar observing (optical) capability. The Razdow optical telescopes were deficient because they were not real-time, employed non-standard equipment, did not provide adequate data in terms of content and accuracy, and couldn't be maintained by the standard USAF logistics system.

1-2. Mission of the Solar Observing Optical Network (SOON). The AN/FMQ-7, SOON telescope (Figures 1-1 and 1-2), was developed in response to an AWS requirement for an operational network of solar observatories. To meet customer support requirements, this network must have the capability of observing and reporting solar data continuously, synoptically, and automatically using standardized equipment and procedures. To accomplish this mission, AWS is establishing five fixed solar optical telescopes in a global network (Figure 1-3). Currently, the SOON consists of four observatories:

Det 3, 3WW - Ramey Solar Observatory - Ramey, Puerto Rico
Det 4, 3WW - Holloman Solar Observatory - Holloman AFB, New Mexico
Det 6, 4WW - Palehua Solar Observatory - Palehua, Hawaii
Det 9, 4WW - Learmonth Solar Observatory - Learmonth, Australia
Det 8, 4WW - San Vito Solar Observatory - San Vito, Italy

The exact location of the fifth site hasn't been determined, but will be located in the Mideast.

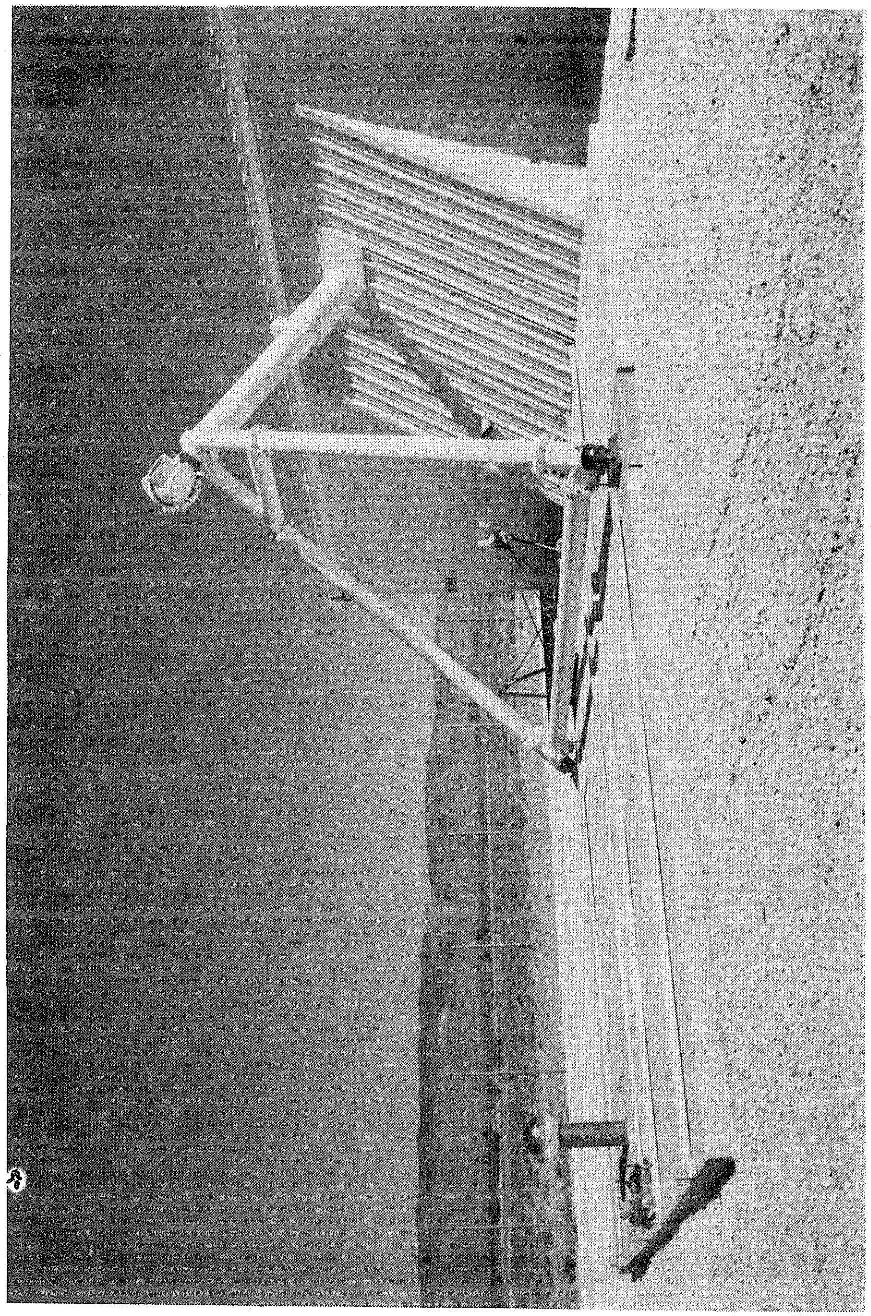


Figure 1-1. SOON Facility - Exterior

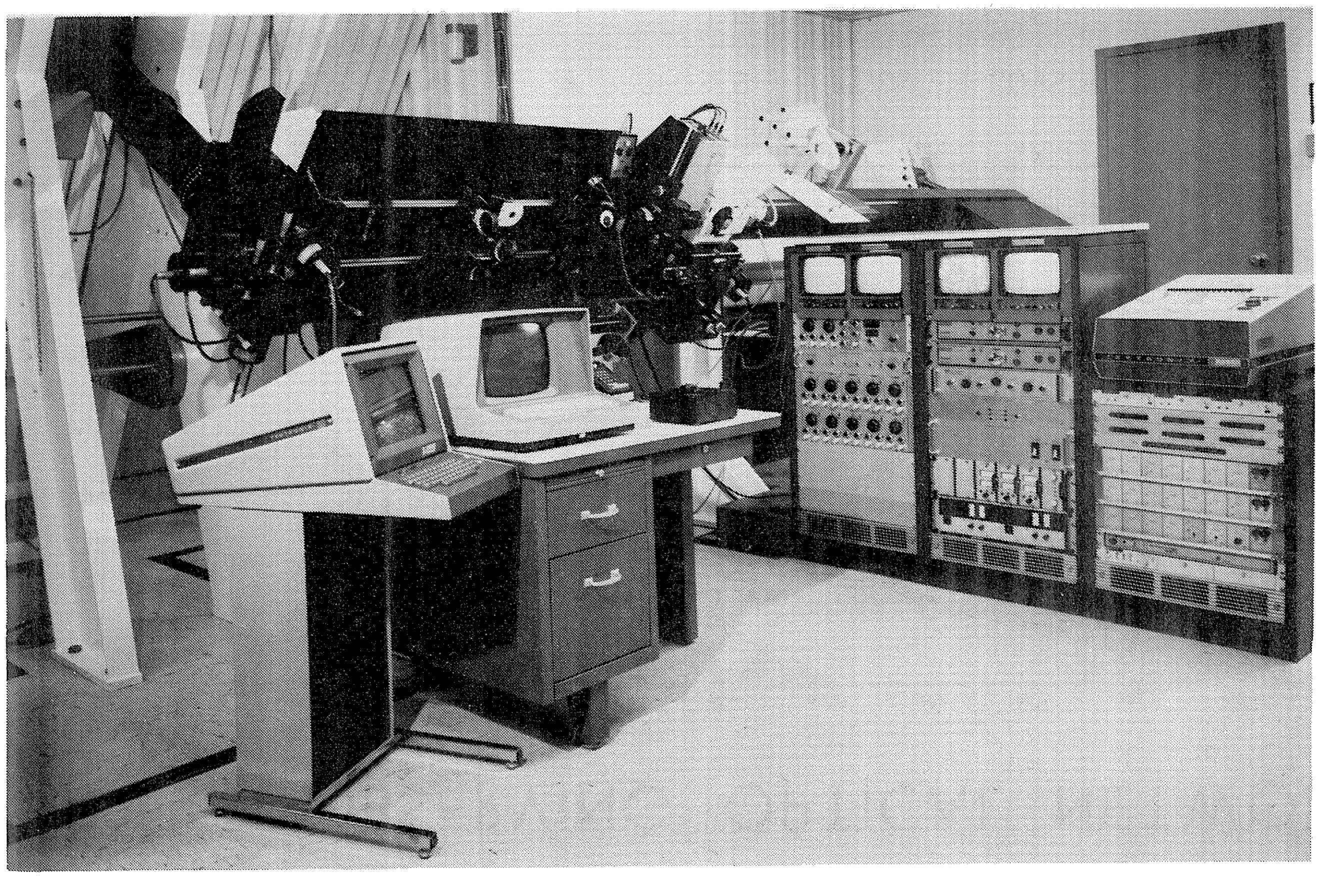
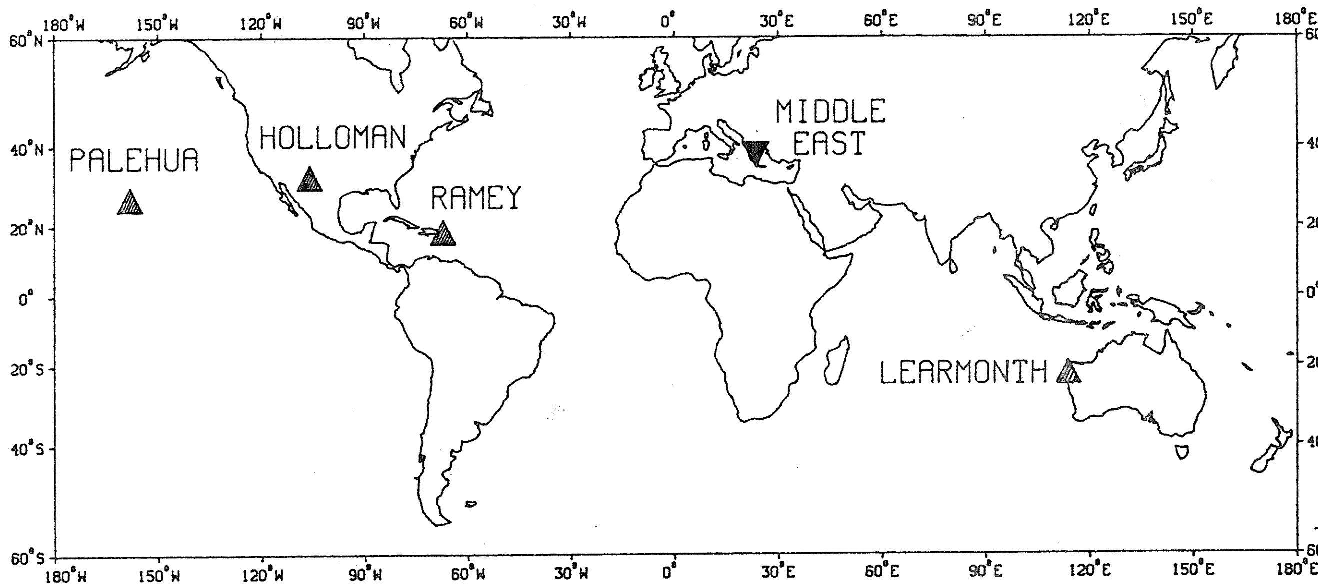


Figure 1-2. SOON Facility - Interior

SOLAR OBSERVING OPTICAL NETWORK*



▲ OPERATIONAL ▼ PROPOSED ◪ UNDER CONSTRUCTION

*operated by USAF Air Weather Service

Chapter 2
Videometer Data

2-1. The Videometer. The videometer is one of the most important components in the SOON system. It virtually removes the subjective guess work from solar flare reporting. The videometer detects and measures solar flares by determining their brightness and area.

Used in conjunction with the computer and TV subsystems, the videometer samples a specific area of the solar disk, computes brightness levels for that region, and determines the area of extent for each brightness level. It does this by electronically scanning a video image of the sun. This image is divided into a maximum of 525 elements horizontally and 256 vertically to yield 125,000 possible area elements or pixels. Each pixel is analyzed for brightness and put into one of 64 brightness categories. These digitized brightness levels are then stored on a magnetic disc and can be displayed on a graphics terminal. This graphical output of the videometer is called a "histogram" (Figure 2-1) which is plotted as brightness level horizontally and the total area at that brightness vertically. The entire area of the histogram (the area under the curve) corresponds to the total area of the solar region that the videometer sampled. This area is separated into several component areas: filament (S), quiet sun (Q), plage (P), faint (F), normal (N), and brilliant (B). The brightest areas are to the right of the graph. The numbers above the horizontal axis denote the actual brightness level and the numbers below represent percentage brightness above the quiet sun level (quiet sun=10=100%).

A time/history plot is also available in two different formats. The first (Figure 2-2) displays the peak brightness of each histogram for a particular region within the past 105 minutes. The second (Figure 2-3), displays the minimum and maximum brightness for a specified hour.

2-2. Coded Videometer Data Reports. Hourly reports of videometer data for selected solar regions of special interest are made using the HSTRY code (see para 7-8).

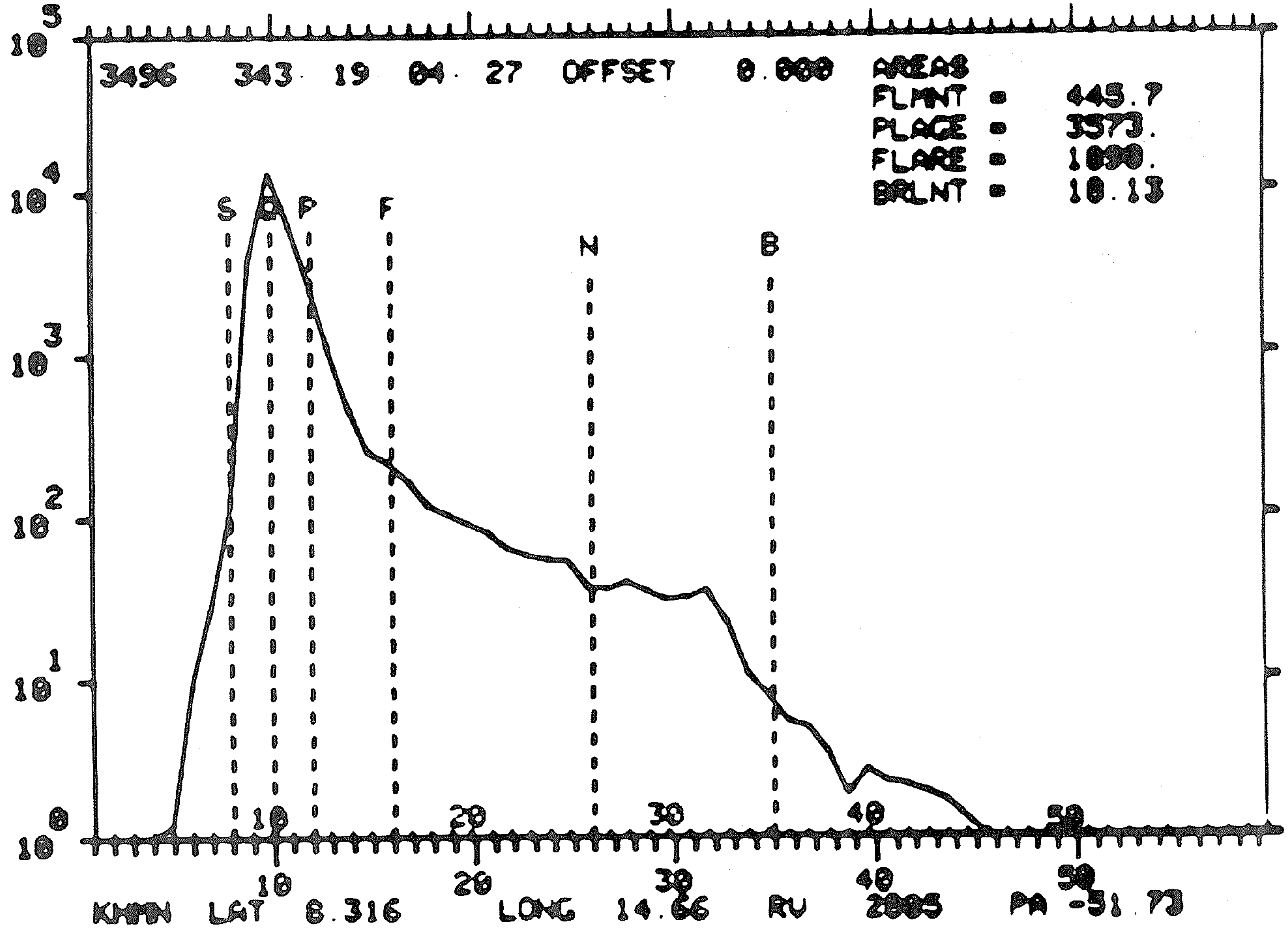


Figure 2-1. Plotted Histogram

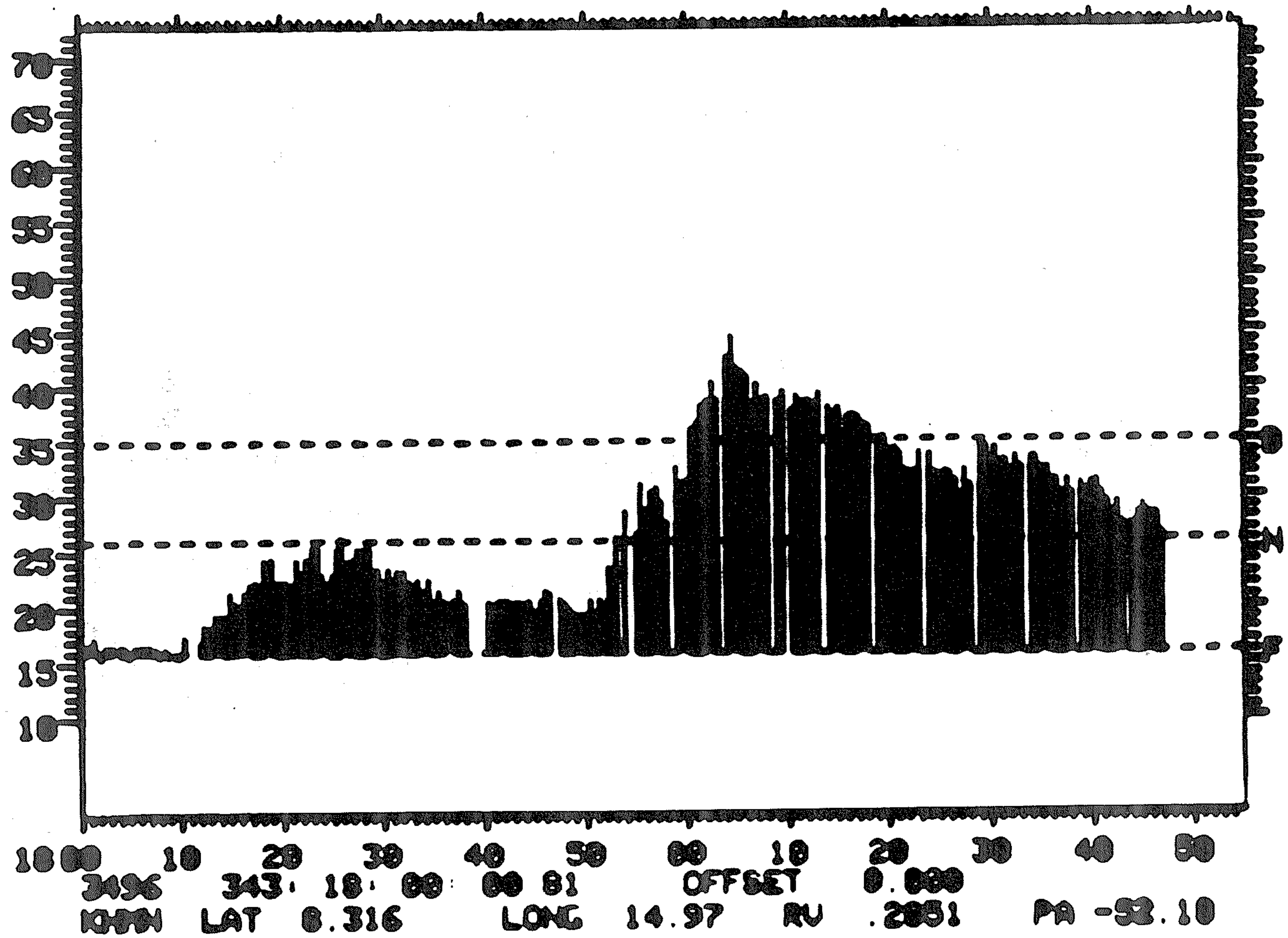


Figure 2-2. Peak Brightness History (PKHST) Plot

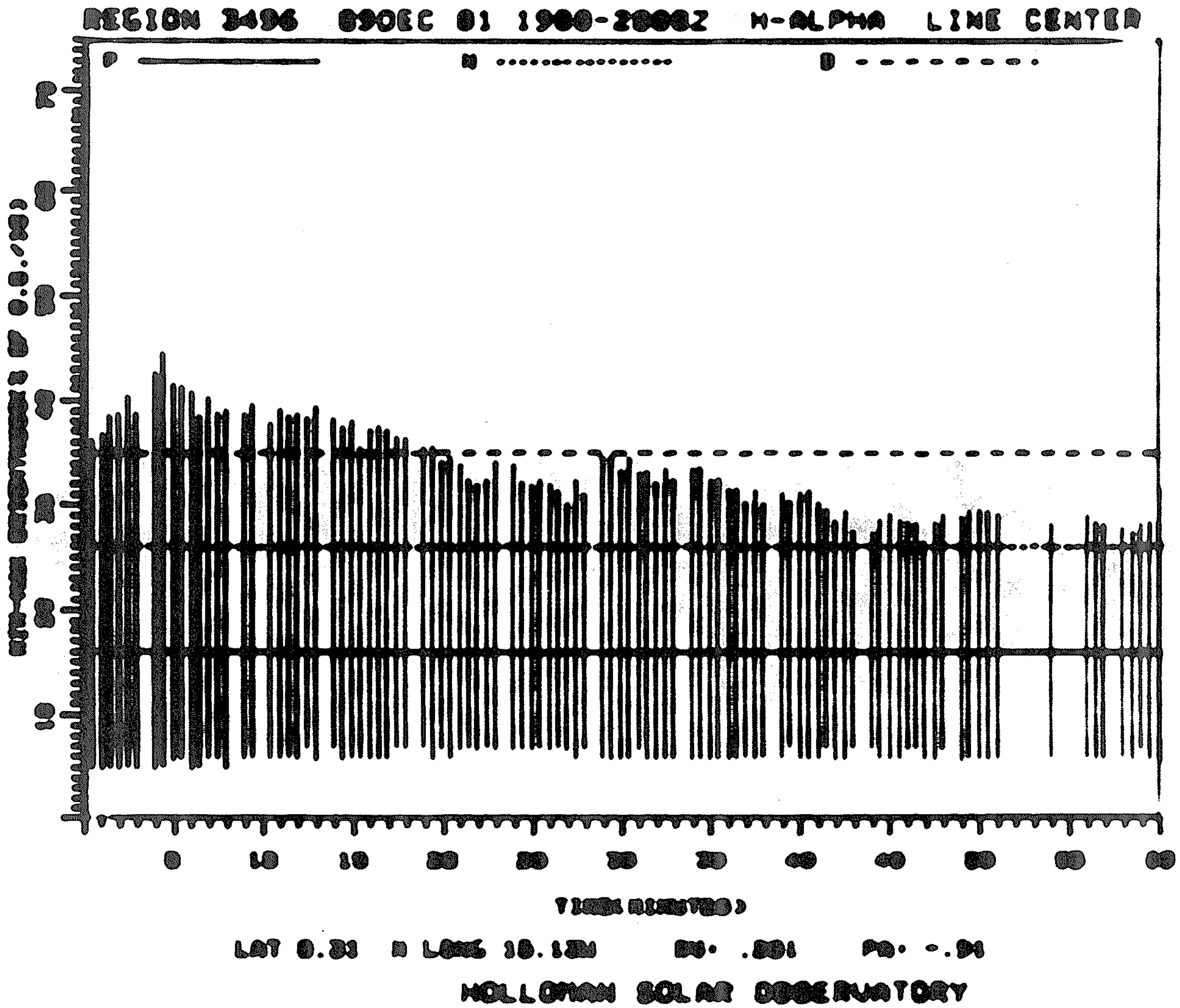


Figure 2-3. Time History (TMHST) Plot.

Chapter 3
Magnetograph Data

3-1. <u>The Magnetograph</u>. The SOON magnetograph is incorporated into the spectrograph subsystem of the SOON telescope. The magnetograph takes advantage of the fact that magnetic fields cause a broadening or splitting (the Zeeman effect) of certain spectral lines. Since the amount of splitting is proportional to the strength of the magnetic field, the strength can be determined by measuring the amount of splitting. These measurements are complicated by the circular polarizations of the spectral line components, either left or right hand depending on the sense of the magnetic field. The magnetograph's KD*P crystal, under the influence of a chopped high voltage current, adds and subtracts 1/4-wave for each spectral line component, changing the circular polarization to plane polarization which can be measured. Four measurements are required for each sampling point on the sun. Each measurement is then compared to a calibration, or "quiet sun", curve and the displacement is calculated in terms of either magnetic field strength, radial velocity, or intensity. The resolution is 2 arc seconds for large scale and 5 arc seconds for full disk.

3-2. <u>Magnetic Field Contour Plot</u>. This plot was the first magnetograph product and is still the primary output. The plot (Figure 3-1) is a map with isogauss lines or contours depicting the sun's magnetic field. The areas of positive polarity are indicated by the solid contours, while the dashed contours represent areas of negative polarity. The map includes a heliographic coordinate plot, location and value of the peak strength for each polarity, and the values of the contour levels. Date/time and region identification are also provided. The maps clearly indicate neutral line positions and areas of strong gradients (contour packing). Region sunspot magnetic classifications can be objectively assigned using the map. SOON magnetographs have also proven their worth by the early identification of delta configurations and reversed polarity regions.

3-3. <u>Magnetic Gradient Contour Plot</u>. This product was developed to meet the needs of the solar forecast centers for magnetic gradient data. Using the magnetic data collected to produce the magnetic field contour plot, the magnetic gradient is calculated and displayed (Figure 3-2) as a contour plot, or gradient map. The map includes a heliographic coordinate plot, value of the peak gradient (gauss/100km), and values of the contour levels. Date/time and region identification are also provided. The maps clearly indicate areas of strong magnetic gradients.

3-4. <u>Coded Magnetic Data Reports</u>. Magnetic field and gradient data are reported with the MGMSG code (see para 7-10).

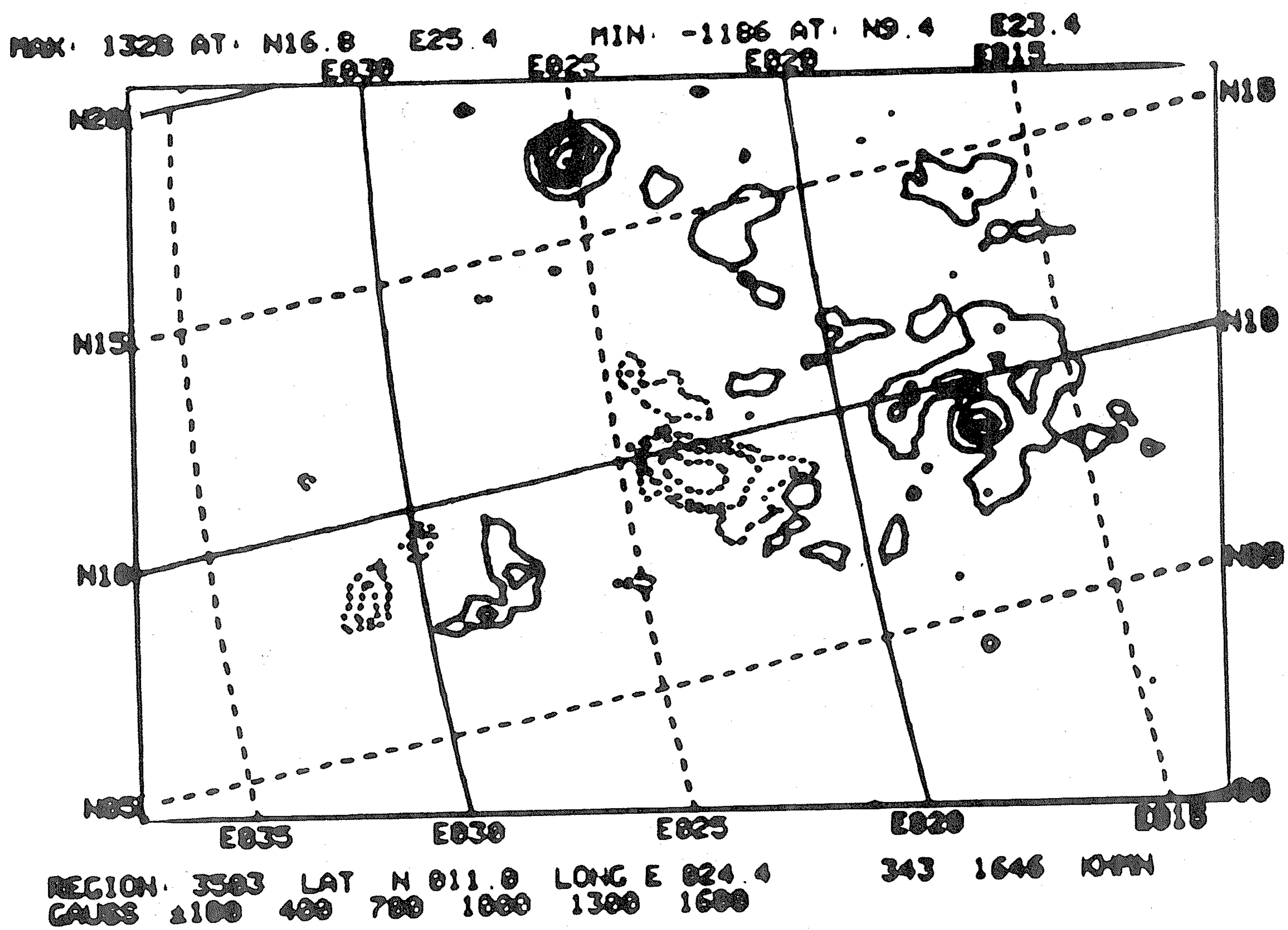


Figure 3-1 Magnetic Field Contour Plot

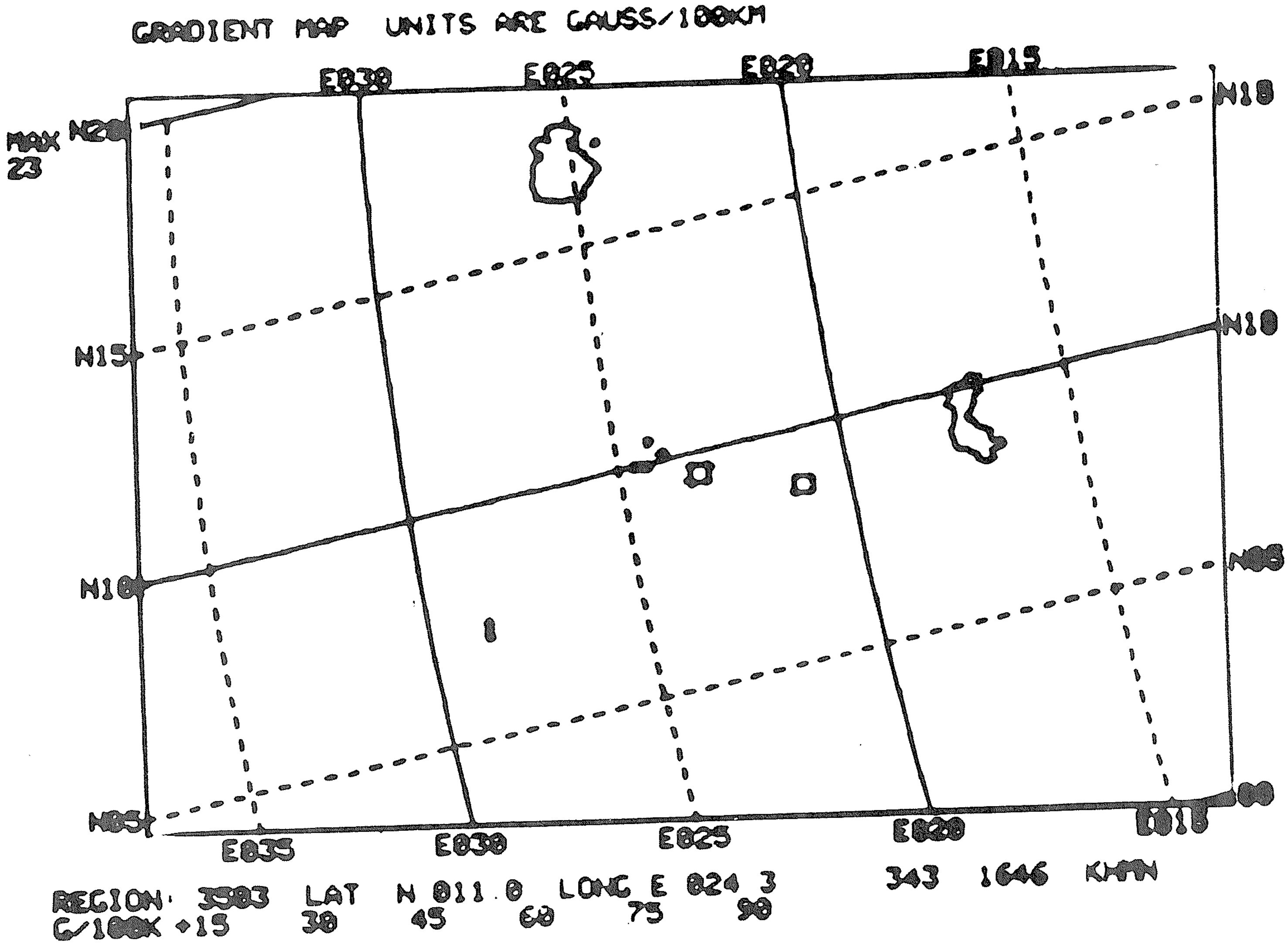


Figure 3-2 Magnetic Gradient Contour Plot

3-5. Other Magnetograph Products. Several other magnetograph products are or will be available:

a. Intensity contour plot - This product (Figure 3-3) plots brightness contours (isophotes) in a format similar to the magnetic contour plots. At this time, there is no operational requirement for this product.

b. Radial velocity contour plot (tachogram) - This product (Figure 3-4) plots velocity contours in a format similar to the magnetic contour plots. At this time, there is no operational requirement for this product.

c. Coronal hole data - Coronal hole data acquisition is under development. The infrared Helium (10,830Å) line will be used to obtain full disk maps.

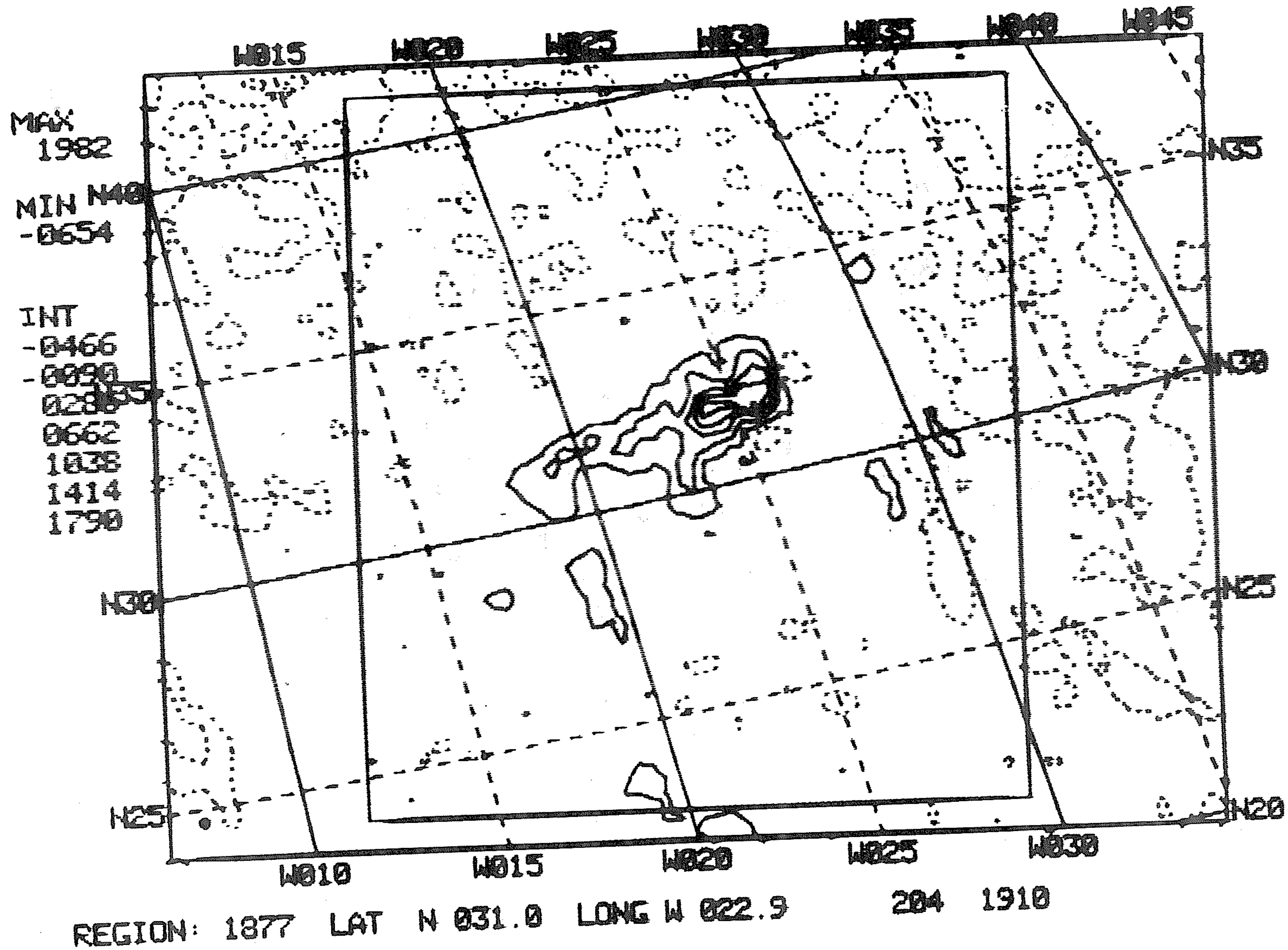


Figure 3-3 Intensity Contour Plot

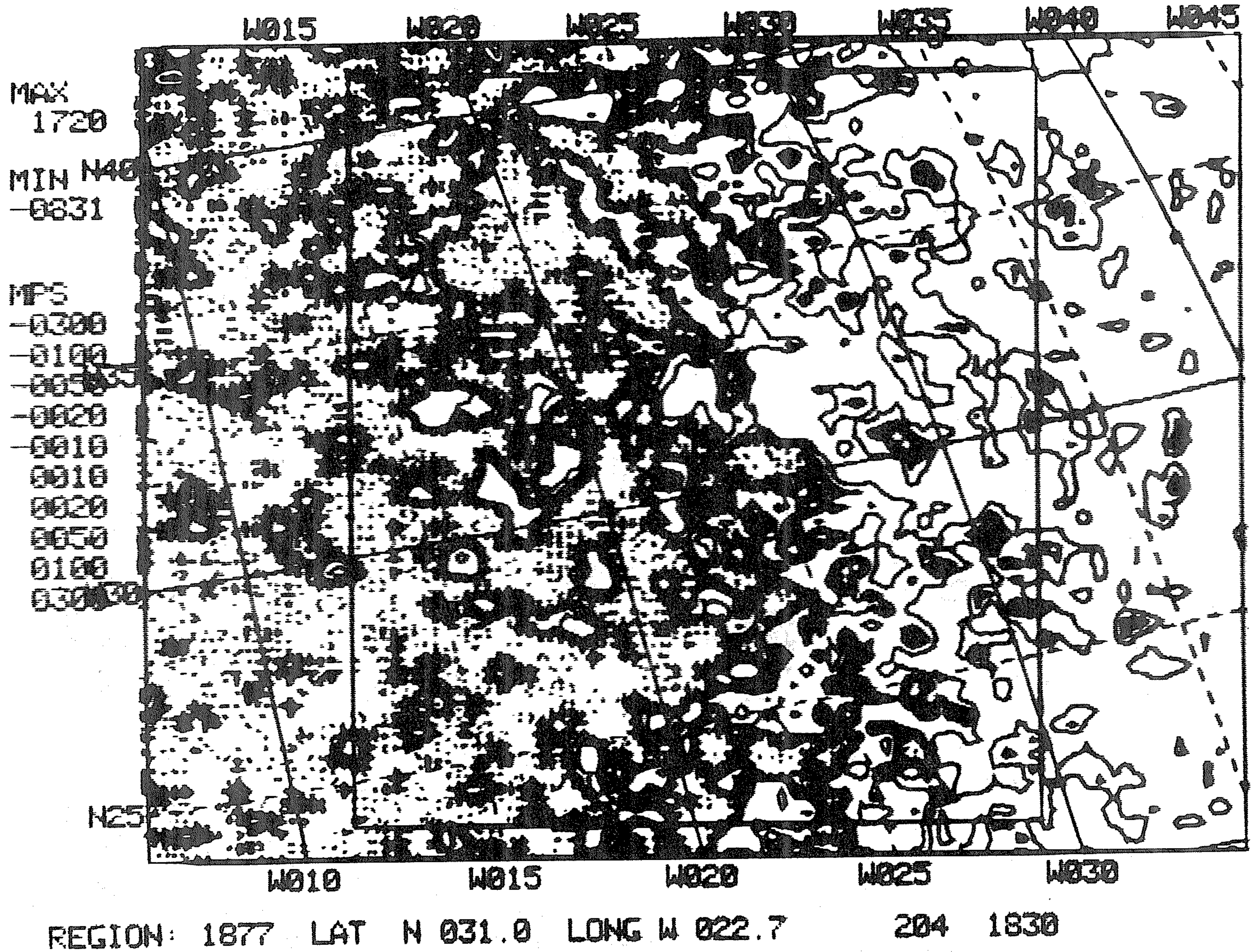


Figure 3-4 Radial Velocity Contour Plot

Chapter 4
Trackball Data

4-1. The Trackball. The trackball, in conjunction with the graphics terminal and two scan convertors, is an interactive graphics device which allows the analyst to trace solar features from a frozen video image (large scale or full disk). The features commonly traced are umbrae, penumbrae, plages, filaments, pores, and neutral lines. The tracings (Figure 4-1) drawn by the analyst are converted to vectors representing eight points of the compass and connecting grid points on a 1000 by 1000 grid enclosing the solar disk. Grid point (500, 1000) is the apparent north pole and (1000, 500) is the westernmost point on the sun. Since the diameter of the sun is approximately 2000 arc seconds, the grid resolution is about 2 arc seconds.

4-2. Coded Trackball Data Reports. Trackball tracings are reported with the TBMAP code (see para 7-9).

4-3. Trackball Data Displays. The SOON system can display the feature tracings in two different formats:

a. Full disk display - The trackball data stored on the SOON data cartridge is plotted (Figure 4-2) within a circle representing the full disk. The orientation is the same as the full disk image on the SOON TV monitors; South is at the top and East is to the right.

b. Mercator projection - The features encoded in a TBMAP message are plotted (Figure 4-3) on a mercator projection using Carrington longitude. Several messages may be decoded and plotted on the same display since the time of the data is read from the message and the appropriate Carrington longitude is computed. This display format easily depicts relative sunspot motion and neutral line changes when data from successive days are drawn on the same plot.

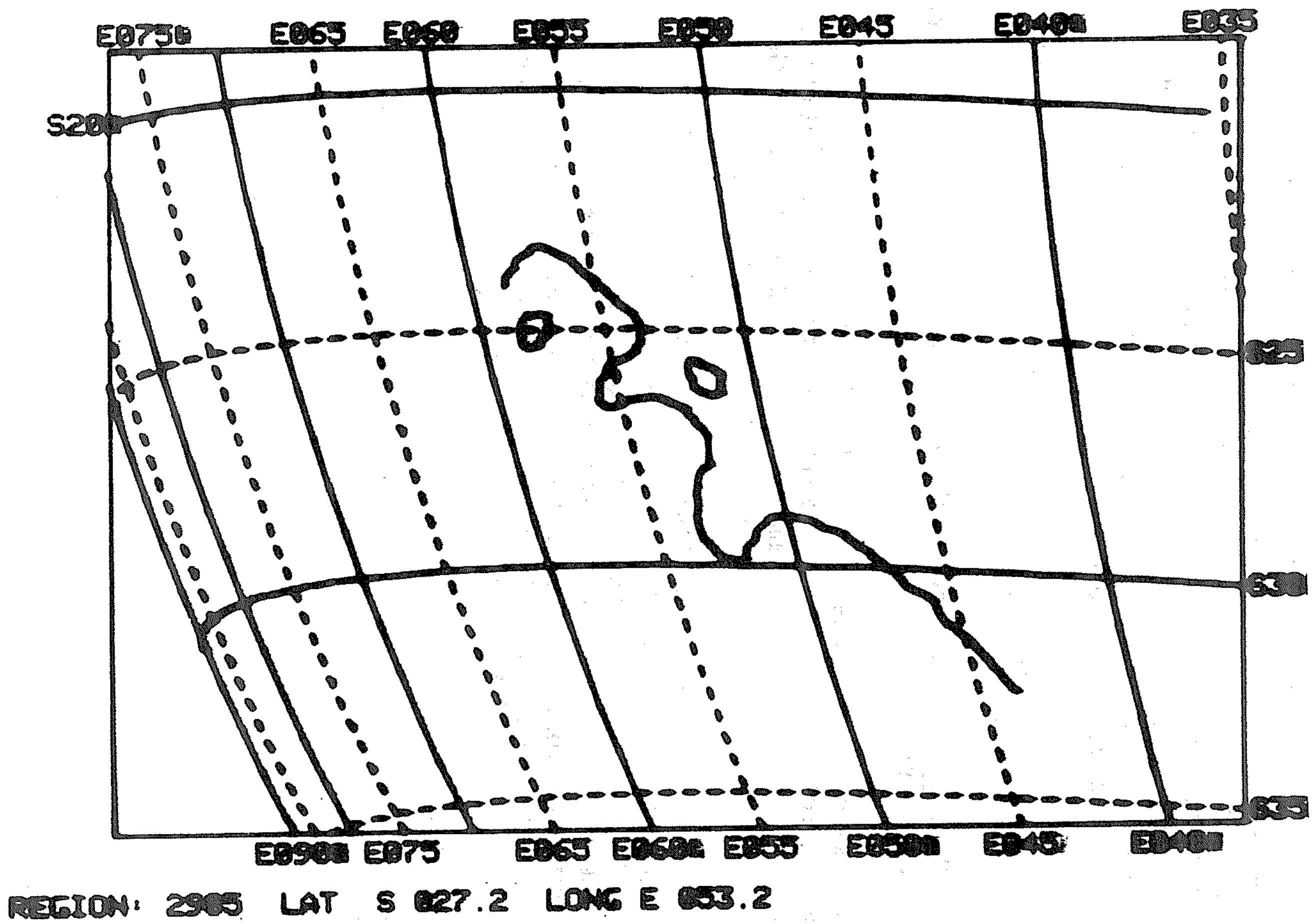


Figure 4-1 Trackball Tracing

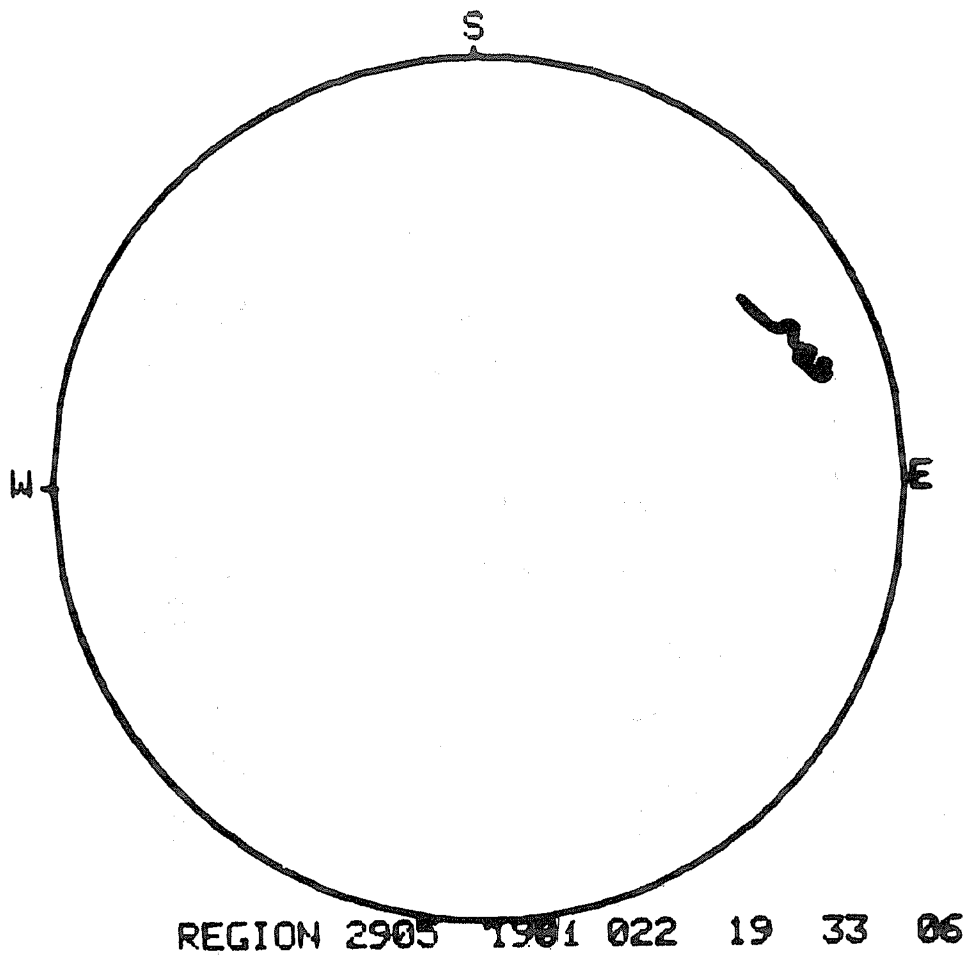


Figure 4-2 Full-Disk Plot of Trackball Data

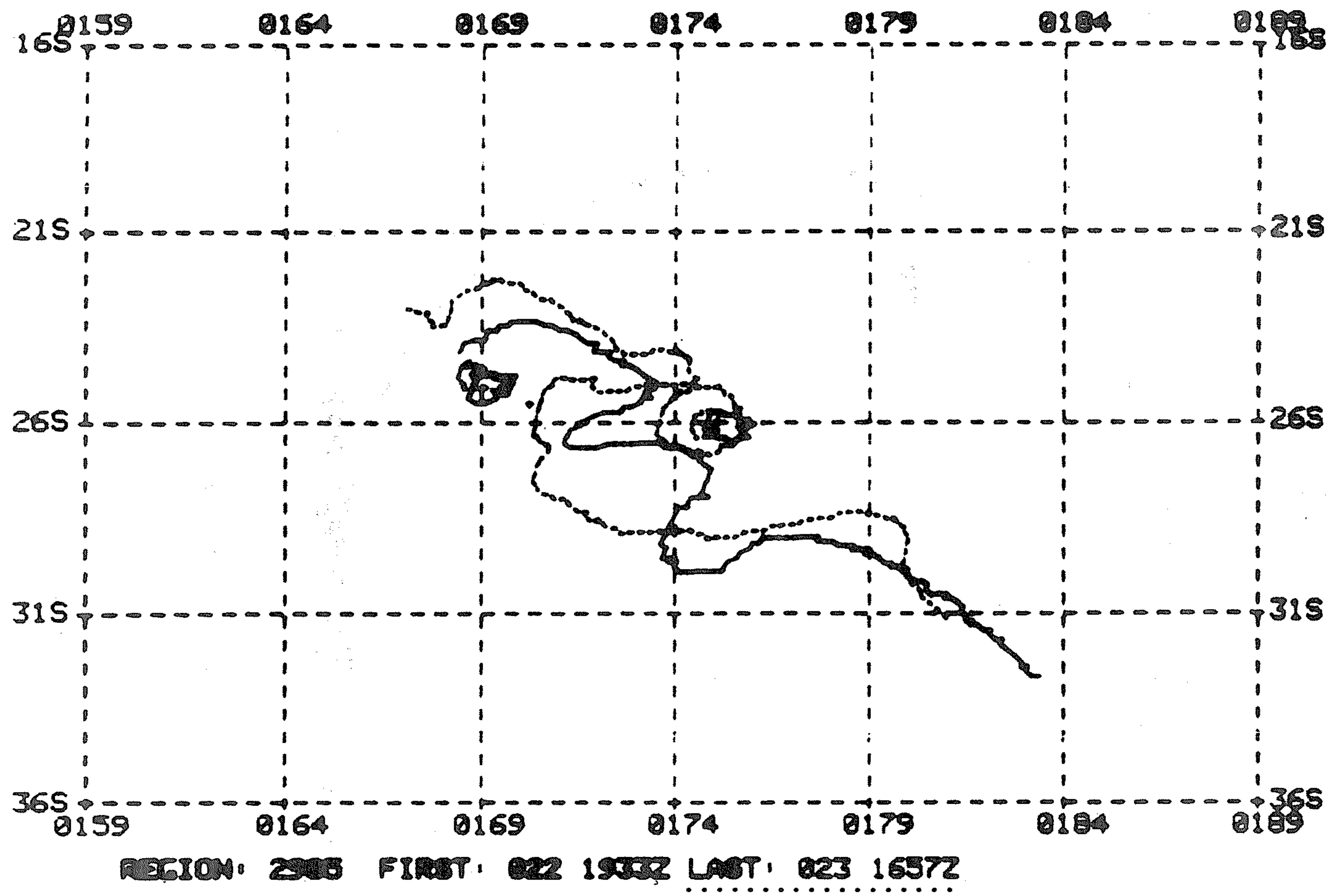


Figure 4-3 Mercator Plot of TBMAP Messages

Chapter 5
Region Analysis Data

5-1. The Region Analysis Program. In order to satisfy operational requirements, NOAA/SESC has developed a 24 hour flare prediction model--the Region Analysis Program. SOON analysts collect and code those parameters found through the logistic regression process to be favorable for flare predictions. The following parameters were isolated from the entire field after several years of data were analyzed:

a. Sunspot classification.
b. Magnetic classification.
c. Maximum magnetic field strength.
d. Maximum magnetic gradient.
e. Number of sunspots.
f. Plage area.
g. Plage area change.
h. Peak brightness.
i. Peak brightness change.
j. Magnetic inversion line complexity.
k. Magnetic inversion line orientation.
l. Filament activity.
m. Arch filament.

5-2. Coded Region Analysis Data Reports. Region analysis data are reported with the RGANL code (see para 7-12).

Chapter 6
Photographic Data

6-1. Wavelengths. The sun may be viewed with the AN/FMQ-7 telescope in the hydrogen-alpha wavelength, 6563Å, or the magnesium B_2 wavelength, 5172Å. In addition the telescope's birefringent filter is tunable to ±1.00Å of line center.

6-2. Image Scales. The AN/FMQ-7 is equipped with optics for two different viewing scales. The first is the traditional full-disk representation of the sun. The other, a large scale representation, provides the solar analyst with additional detail by "blowing-up" approximately one-sixth of the full-disk area.

6-3. Photographic Products. Figures 6-1 through 6-4 are examples of the various wavelength and scale capabilities of the AN/FMQ-7 telescope.

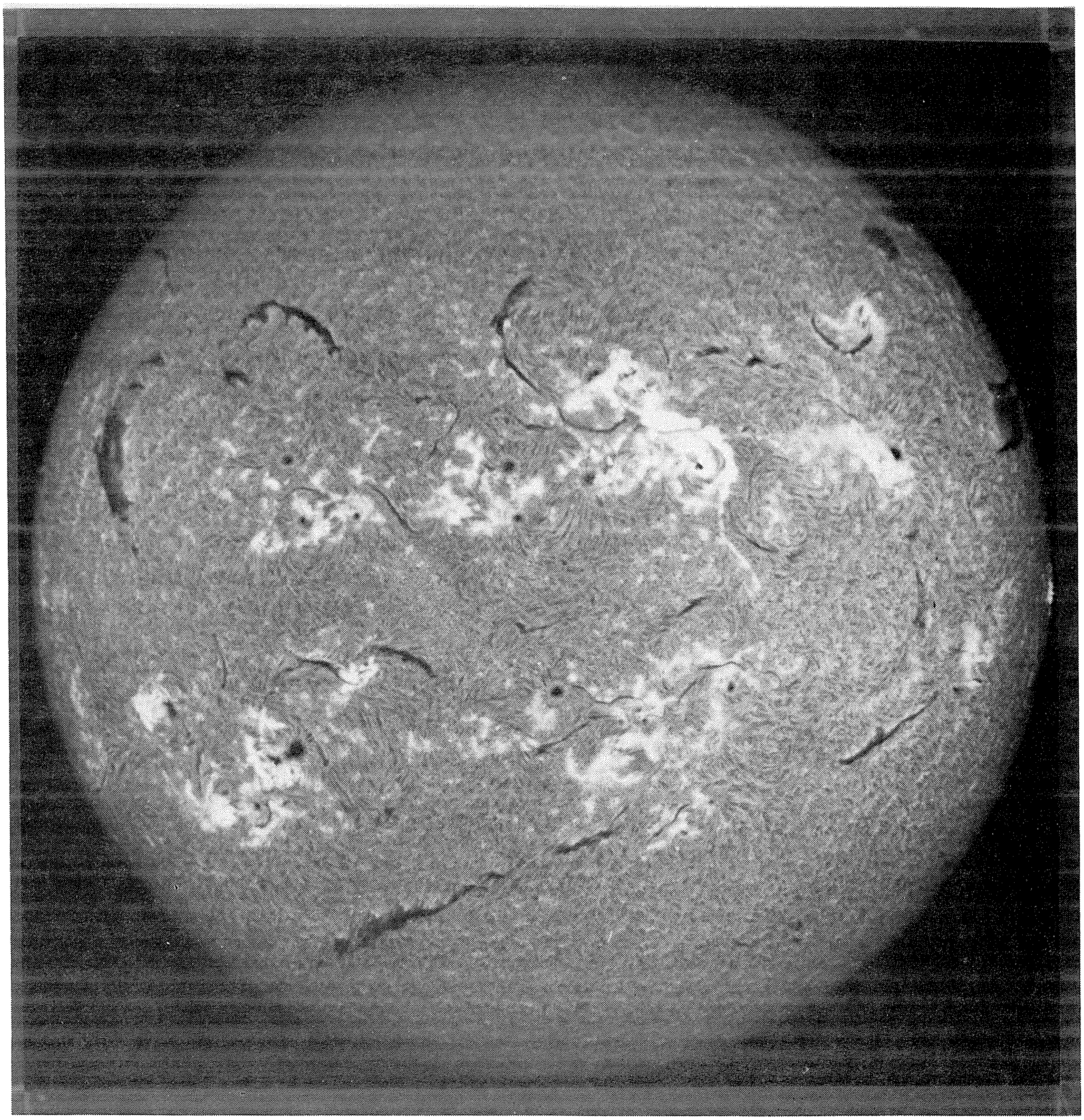


Figure 6-1 Full-Disk, Hydrogen-alpha Photograph
9 December 1981, 1912 UT

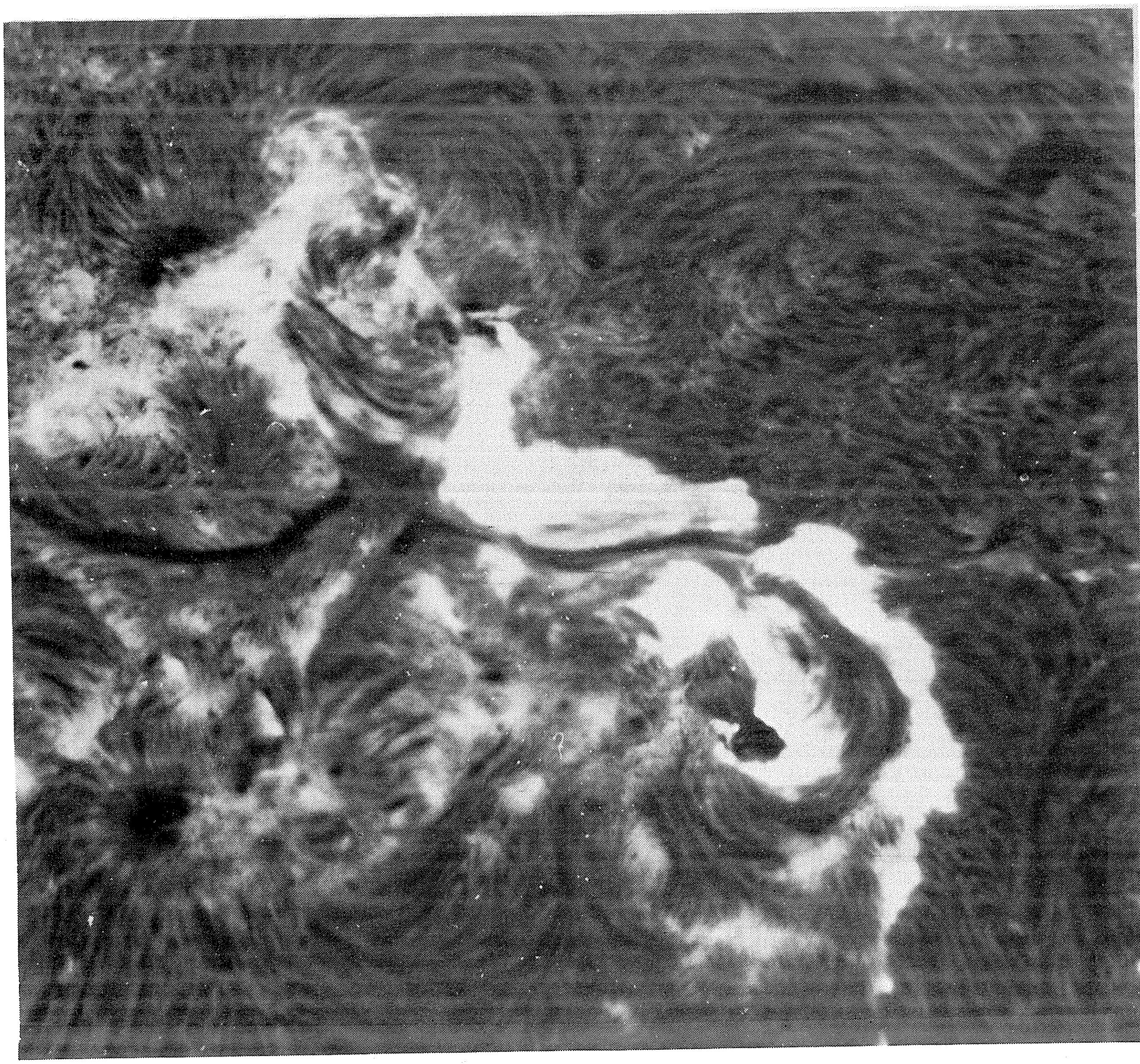


Figure 6-2 Large-Scale, Hydrogen-alpha Photograph
9 December 1981, 1912 UT
Regions 3492 and 3496

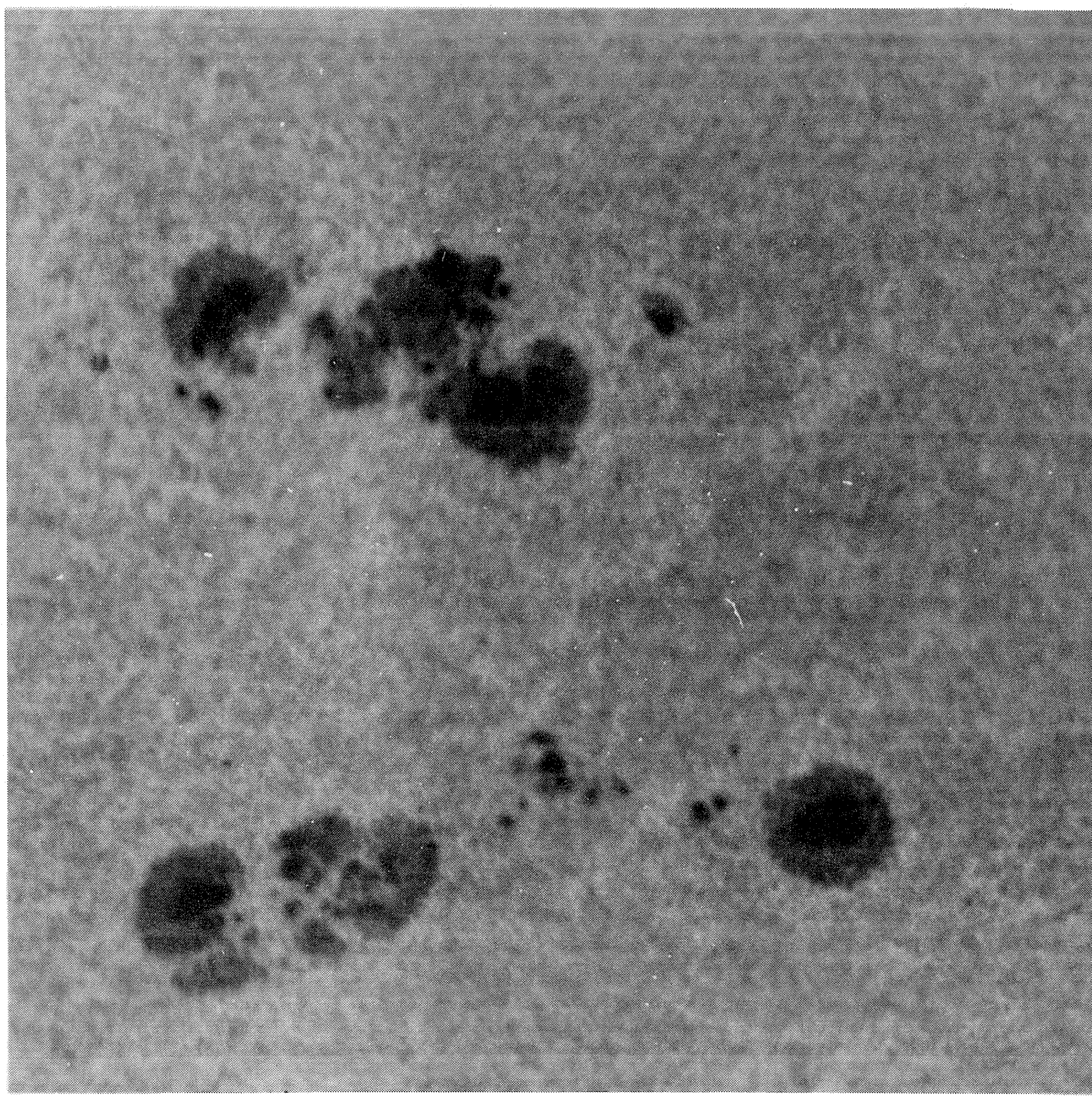
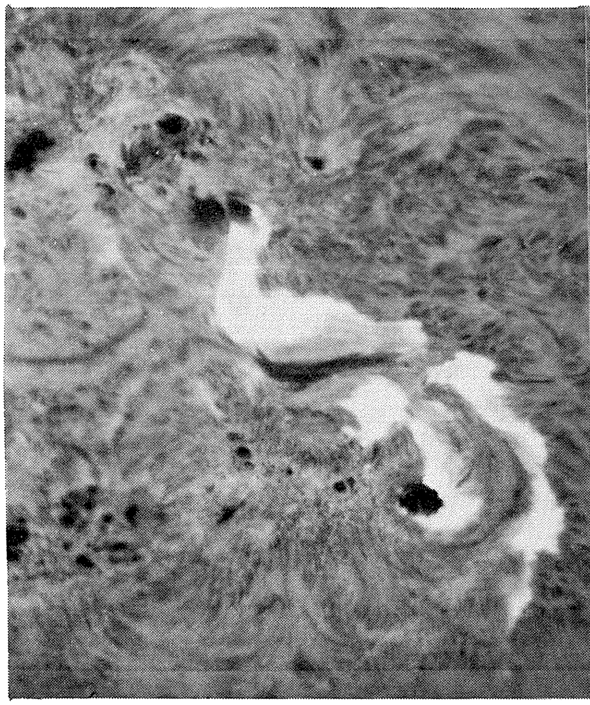
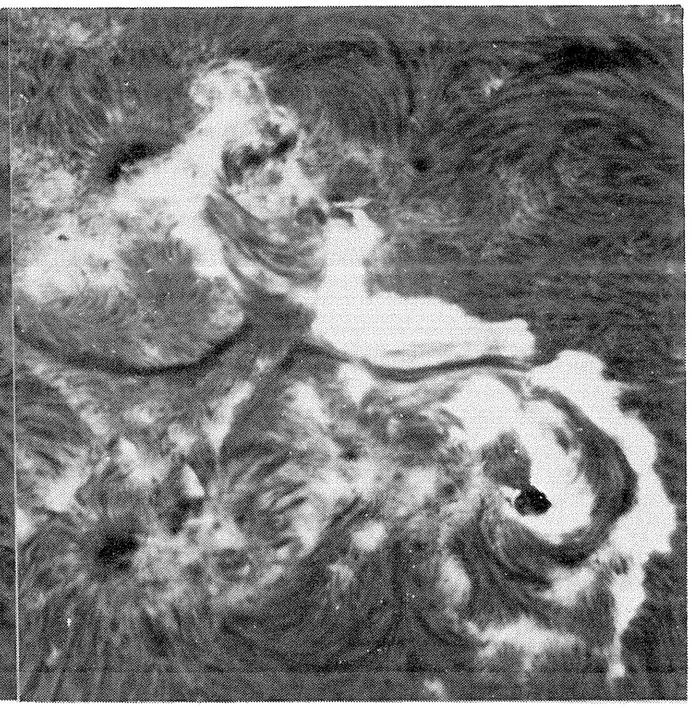


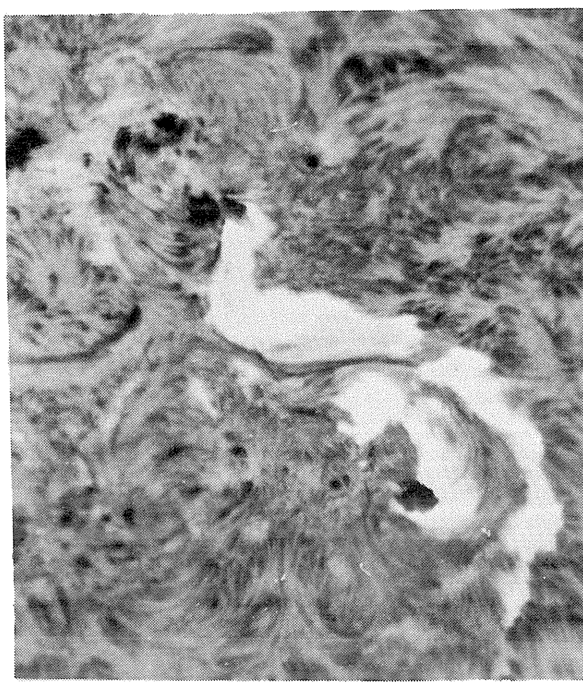
Figure 6-3 Large-Scale, Magnesium B_2 Photograph
9 December 1981, 1912 UT
Regions 3492 and 3496



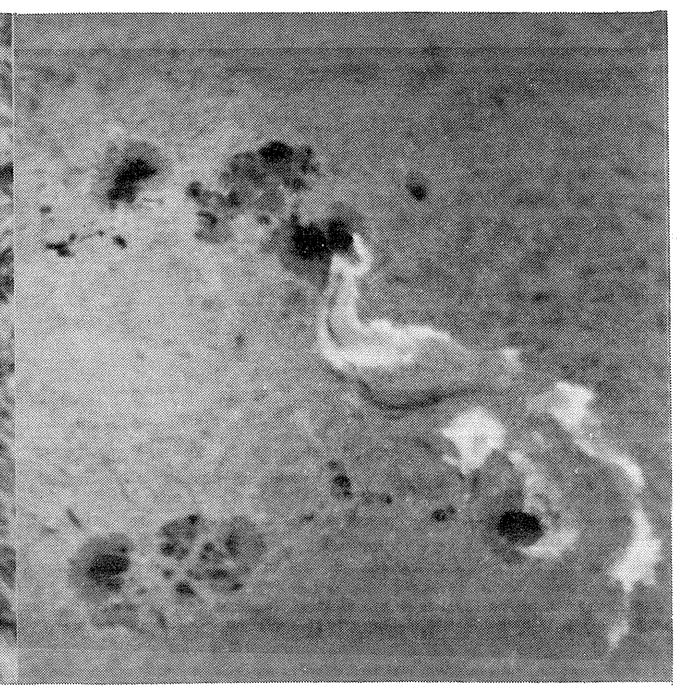
-0.5Å



Hα Line-Center



+0.5Å



+1.0Å

Figure 6-4 Off-band Hydrogen-alpha Photographs

Chapter 7
Coded Messages

7-1. Solar Flare Code - FLARE. This code is used to make special or routine reports of solar flares as observed in the Hydrogen-alpha (6563Å) wavelength. Data reported include:

a. Quality of the observation.
b. Start time of the flare.
c. Flare location.
d. Method of observation.
e. Flare Importance.
f. Flare brightness.
g. Flare characteristics.
h. Time of maximum brightness.
i. Apparent flare area.
j. End time of the flare.
k. Importance, brightness, area, and time of any secondary maxima.

Typical FLARE Message:

```
HEUS1 KHMN 555555
FLARE
72269 00204 3//01
11111 31008 17121 11217 419// 17131 70230 17162 92271 99999
```

(For additional information, see AWSR 105-11, para 1-1)

7-2. Solar Disk and Limb Activity Summary Code - DALAS. This code is used to make special or routine reports of activity on the disk and limb of the sun as observed in the Hydrogen-alpha wavelength. Data reported include:

a. Quality of the observation.
b. Type of activity.
c. Level of activity.
d. Radial/heliographic extent of the activity.
e. Start and end time of the activity.
f. Method of observation.
g. Observed amount of Doppler shift in the blue and red wings.
h. Location of the activity.

Typical DALAS Message:

```
HOUS1 KHMN 032307
DALAS
72269 00203 3//01
11111 32001 10/01 14453 22533 475// 9//// 29014 9999
```

(For additional information, see AWSR 105-11, para 1-2)

7-3. Sunspot Code - SPOTS. This code is used to make a daily report of sunspots as observed in total (white) light. Data reported include:

a. Time of the observation.
b. Method of observation.
c. Quality of the observation.
d. Location of the sunspot group(s).
e. Total area of the sunspot group(s).
f. Number of sunspots in each group.
g. Modified Zurich classification.
h. Compactness of the sunspot group(s).
i. Magnetic classification of the sunspot group(s).

Typical SPOTS Message:

```
HOUS3 KHMN 041615
SPOTS
72269 00204 31600 43311
11111 22044 44505 03001 01004 62072 92259
11111 22045 44615 02010 02001 672/1 92260
11111 22050 42414 13037 08014 65573 92262
11111 22052 10618 00000 00001 610/1 92265
11111 22053 20415 17110 17061 66585 92266
11111 22055 11418 06009 02008 64272 92271
11111 22056 40319 06004 02007 64272 92270
11111 22058 15726 08016 02009 64272 92273
11111 22059 11704 06002 01005 63272 92274
11111 22060 32826 03004 02007 63272 92275
11111 22061 28112 08013 02005 64272 92276 99999
```

(For additional information, see AWSR 105-11, para 1-3)

7-4. Optical Patrol Hours Code - PTROL. This code is used to report start and stop times of an observatory's Hydrogen-alpha solar patrol and a general summary/outlook of operating conditions. The message is transmitted as soon as feasible after both opening and closing the observatory and as needed to report operating conditions throughout the day. Data reported include:

a. Method of observation.
b. General summary of operating condition.
c. Expected operating condition for the remainder of the day.
d. Outlook for the next day's operating condition.
e. Reason for delay between local sunrise and start of observation.
f. Reason for ending the observing period or observing day.
g. Begin - End time(s) of observation.

Typical PTROL Message:

```
HOUS2 KHMN 040300
PTROL
72269 00203 24606
11111 11427 11512 /1541 11904 /2224 12253 99999
```

(For additional information, see AWSR 105-11, para 1-5)

7-5. Significant Event Code - EVENT. This code is used to report significant real-time (less than 5 minutes from event start time) solar events. The event being reported has a unique identifier depending on the type of data being reported, e.g., solar flare event, solar limb event, etc.

Typical EVENT Message:

HEUS KHMN 555555
EVENT
72269 21/01
11111 FLA// 99999

(For additional information, see AWSR 105-11, para 4-2)

7-6. Plain Language Message - PLAIN. This message is used to make routine (every three hours) reports of the following information:

a. Information requested by AFGWC.
b. A discussion of all active regions with a sunspot group having a magnetic class betagamma, gamma, or delta.
c. A discussion of system/subsystem outages.

Typical PLAIN Message:

HOUS KHMN 041700
PLAIN
PART 1. CONTUS OBS SINCE PTROL BGN, FAIR TO POOR SEEING IN TURBC,
SLT IMPRV NXT 3 HRS.
RGN 2262 NR N14W24 BRKN INT 3 PLAGE, SOME ENHANCEMENT RMNS IN
TRLR WHERE OF FLARE OCCURRED EARLIER. THE TRAILING RGN HAS
COMPLETELY DISAPPEARED. THAT BEING THE OLD RGN 2267.
RGN 2266 NR S15E04 RMNS ENHANCED AND INTERESTING, SHOWING LATERAL
GROWTH SINCE YESTERDAY WITH A MINOR FLARE EARLIER THIS PD.
RGN 2270 NR N19W03 SHOWS LITTLE ACTIVITY BUT HAD A SMALL FLARE
EARLY IN PD.
RGN 2271 NR N18E14 SCTD PLAGE, SLTLY ENHANCED IN AREA WHERE OF
FLARE ENDED AT 1622.
THE DISK APPRS ACTIVE, AND THE EMERGING RGN ON THE SE APPRS
CAPABLE OF SIG ACTIVITY, BUT EVIDENCES LITTLE AT THIS TIME.
RMDR OF DISK AND LIMBS SHOW LITTLE SIG CHANGE SINCE YSTDY.
PART II. N/A
99999

(For additional information, see AWSR 105-30, para 2-5a)

7-7. Videometer Box Definition Code - BXOUT. This code is used to make routine reports of videometer box definitions. Data reported include:

a. SESC region identification.
b. Location of videometer box center.
c. Dimensions of videometer box.
d. Time of the data.

Typical BXOUT Message:

```
HOHW6 PHFF 261825
BXOUT
91178 11226 3//13
RGN  HIGH WIDE  P-ANGL    RV   LAT LON
3516 0244 0193  M0.994 0.500 N12 W27
3522 0241 0197   0.223 0.397 N21 E03
3521 0233 0204  M2.428 0.480 S25 W18
3523 0187 0173   2.111 0.277 S09 E15
3517 0156 0174  M1.163 0.951 N17 W70
3512 0173 0177  M1.910 0.940 S24 W69
3524 0175 0136  M1.772 0.977 S16 W78
3519 0225 0186  M1.208 0.647 N08 W39
3520 0264 0201   2.936 0.398 S25 E07
3525 0142 0131   2.320 0.442 S18 E21
3526 0017 0023   1.839 0.610 S08 E37
TIME: 031170069.10 (360 1821:09) 99999
```

(For additional information, see AWSR 105-11, para 5-1)

7-8. Histogram History Code - HSTRY. This code is used to make routine reports of videometer data for selected solar regions of special interest. Data reported include:

a. SESC region number.
b. Peak brightness for each minute of the previous hour.
c. Plage area for each minute of the previous hour.

The code is also used to make special reports of data for the previous 9 minutes for all flare-producing regions.

Typical HSTRY Message:

```
HOUSI KHMN 142120
HSTRY
72269 10114 3//06
2882/ 2000/ 16962 16902 15882 16912 16922 16862 15862 16882 16942
16942 15902 17952 16982 16103 16962 16103 16972 16103 16882 17992
16892 16932 16952 17952 15892 17972 17952 17942 16922 17952 16922
16942 16952 16972 17992 17103 17972 16952 16962 16942 16952 16922
16922 16902 17992 16912 16942 16972 16902 16912 17103 16942 16922
17962 17962 17992 17103 16902 16932 16892 99999
```

(For additional information, see AWSR 105-11, para 5-2)

7-9. Trackball Data Code - TBMAP. This code is used to report the data collected with the trackball. This message is designed for computer decoding and plotting. Data reported include:

a. SESC region number.
b. Time of the data.
c. Feature identification and type.
d. Vectors and grid points which describe the feature.

Typical TBMAP Message:

```
HOUS4 KHMN 221940
TBMAP
72269 10122 3//07
2905 1933 0118 0349
NLIN2 0169 0088 0376 ///// 0177 0304 221022020200070707770660
067060777675746546445565666700010000000600770677666667446646666666
676606067000002212120200000006007006006077060777076700607767606070
6706777760670
SPTA1 0021 0125 0358 00031 0125 0358 2142434346666060707103
SPTB1 0018 0095 0367 00026 0095 0367 22224444666670120
99999
```

(For additional information, see AWSR 105-11, para 5-3)

7-10. Magnetic Data Code - MGMSG. This code is used to make routine reports of magnetic data. Data reported include:

a. SESC region number.
b. Time of the data.
c. Maximum magnetic gradient value and its location.
d. Total area within the region having a gradient value greater than or equal to 0.2, 0.5, and 0.8 gauss/km.
e. Maximum positive field value and its location.
f. Maximum negative field value and its location.

Typical MGMSG Message:

```
HOUS1 KHMN 081705
MGMSG
72269 01108 3//08
92779 1601/ 03190 01366 20081 02999 05050 08016
22222 04345 01067 21180 03158 01377 71277
92776 1605/ 02783 00906 40098 02999 05194 08033
22222 03061 00925 41183 02767 00879 91075
92777 1622/ 03017 01257 30041 02624 05000 08000
22222 03206 01773 30457 03081 01187 81097
92782 1645/ 00797 02105 20038 02999 05000 08000
22222 00769 02045 20824 00041 01799 71008 99999
```

(For additional information, see AWSR 105-11, para 5-4)

7-11. Limb Scan Data Code-LMBSC. This code is used to make routine reports of solar limb activity. Data reported include:

a. Time of the data.
b. Feature type.
c. Blue wing extent.
d. Red wing extent.
e. Position on the limb.

Typical LMBSC Message:

```
HOUS1 KHMN 132101
LMBSC
72269 20113 2101/ 3//02
11111 23655 23099 23001 23103 23003 22904 22906 23006 23106
22222 23206 23306 23406 23506 23606 23604 23503 23603 23699
99999
```

(For additional information, see AWSR 105-11, para 5-5).

7-12. Region Analysis Data Code-RGANL. This code is used to make a daily report of SOON inputs to the region analysis forecast model. Data reported include:

a. SESC region identification and location.
b. Time of data.
c. Sunspot classification.
d. Magnetic classification.
e. Maximum magnetic field strength.
f. Maximum magnetic gradient.
g. Number of sunspots.
h. Plage area.
i. Plage area change.
j. Peak brightness.
k. Peak brightness change.
l. Magnetic inversion line complexity.
m. Magnetic inversion line orientation.
n. Filament activity.
o. Arch filament.

Typical RGANL Message:

```
HOUS KHMN 132034
RGANL
72269 20113 32106
63549 24109 01999 02999 03385 04023 05999 06089 07619
55555 08166 09031 10999 11999 12999 13999 14999 15999
63540 36316 01310 02111 03385 04032 05011 06024 07120
55555 08144 09011 10111 11590 12000 13000 14999 15999
63543 35206 01000 02000 03999 04999 05000 06019 07126
55555 08136 09008 10111 11590 12000 13000 14999 15999 99999
```

(For additional information, see AWSR 105-11, para 5-6).