A Technical Memorandum ERL RFC-4

RESEARCH AIRCRAFT MEASUREMENT SYSTEM (RAMS) GRAPHIC SYSTEM USER GUIDE

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Research Facilities Center
Miami, Florida
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RESEARCH AIRCRAFT MEASUREMENT SYSTEM (RAMS)
GRAPHIC SYSTEM USER GUIDE

W. J. Brown

The Research Facilities Center WP3-D aircraft data system has been equipped with a graphic system. This system is used to analyze and display atmospheric and oceanic data collected by the aircraft. This report explains its operation and examines its uses.

I. INTRODUCTION

This manual is intended to give the reader a working knowledge of the Research Aircraft Measurement System (RAMS) Graphic System (RAGS). Through RAGS, the user can acquire the capability to display, and thus analyze, atmospheric and oceanic data that are collected by the RAMS (WP3-D aircraft) data system and the radar subsystem. Any parameter recorded by the RAMS system can be displayed in a variety of formats on any of the CRT's throughout the aircraft. These formats can be created, modified, and displayed in real time, giving the user real-time analysis of selected data. Such data can be in digital form from the RAMS and radar systems, or in video form from television cameras.

The sections of this manual are: Hardware, Software, Examples, and Errors. Because working knowledge of RAGS does not require a great deal of insight into the hardware, the first section contains only a brief description of the hardware. Human interaction with RAGS is mainly through the software, which is thoroughly described in the second section. The third section contains typical examples

in the usage of the software. The fourth section is a summary of program detectable errors and a troubleshooting guide.

It is suggested that the user read through the hardware and software sections, and concentrate on the examples. If unfamiliar usage is encountered, refer to the software section for an explanation. The examples are designed to give the user typical requests that are made of the RAMS Graphic System.

2. HARDWARE

The hardware consists of a RAMTEK GX-100B display system, a video distribution system, interactive terminals, and appropriate CRT's. The RAMTEK uses a raster scan technique that produces eight low-resolution channels (320 X 240 elements) and two high-resolution channels (640 X 480 elements). The video distribution system routes video information from the RAMTEK, radar, and television camera to the CRT's for the user. It also sends information back to the RAMS system through event switches. Figure 1 is a drawing of a video distribution control box with monitor. The four push-type buttons across the front are the event switches. The thumbwheel switches determine the video information to be displayed on the monitors, much like those of a regular television set. Channels 0 through 9 are the RAMTEK channels, which contain graphics from the RAMS system. Channels 10 through 13 contain diagnostic information from the CPU for system troubleshooting. Channels 14 and 15 are the radar video information from the radar system. Channels 16 through 19 are unused for the present. The push-type switch,

labeled "fix format," controls digital information that is displayed on monitor #2 from the RAMS system CPU 1 and CPU 2.

Information and data from CPU 1 (data acquisition computer) is transferred to CPU 2 once per second. CPU 2 controls the graphics through the RAMTEK GX-100B. CPU 2 also stores the data on the disk and lists it on the line printer. CPU 2 then performs data analysis tasks as requested by the user. The user communicates to the computer through interactive terminals and has at his command all the graphics software.

3. SOFTWARE

The graphics software runs under a real-time executive (RTE) system in the RAMS CPU 2 and is composed of a series of programs. These programs develop plots of parameter versus time (graphs), parameter versus parameter (flight tracks) and listings. Any plot can be created or modified in real time through interactive terminals that are in the aircraft. These terminals schedule the graphic programs to be executed and communicate through the programs to the computer to control the graphics. The six programs that control the graphics are:

1) CMND - creates or modifies graphs
2) PAST - plots past history of data
3) STAT - lists status of each graph
4) DISK - controls data recording and printing
5) FTRK - controls flight track parameters
6) FILTR - computes filter coefficient

In the hardware, there are eight low-resolution channels (0-7) and two high-resolution channels (8, 9). However, in the software there are 20 graphs that can be plotting at the same time. Graphs 0-7 and 10-17 plot on channels 0-7, respectively. Graphs 8 or 18 plot on channels 8, and 9 or 19 plots on channel 9. Thus, one channel can consist of two graphs for comparison purposes.

Figure 2 is an example of two graphs plotting on the same channel. The time appears in the upper left-hand corner. The graph name and the graph number appear on each side of the channel. The right- and left-hand carats show the plot that refers to the right- and left-side names, labels, and numbers, respectively. The graphic programs that control the function of these graphs are described next. At the end of the descriptions, there are examples in the use of these programs. To execute these programs, the user hits any key on the terminal, and the terminal will respond with XX> where XX is a number. The user then types in RUN, and the program name (as listed in 1 through 6 above). The program is then scheduled for execution.

3.1. CMND Program

The CMND program runs under RTE in background core. It is swapped into core only when scheduled, and modifies the graphic parameters that control graphs 0-8, and 10-18. There are 26 plot commands that modify the graphic parameters. The CMND program can be executed from any terminal in the aircraft. To execute the CMND program, depress any key. The CPU will respond with the terminal number followed by a prompt character; for example, 12>. Type on the keyboard RUN, CMND and the CMND program is executed. The program will respond with

GRAPH NUM?>. Answer 0-8 or 10-18 according to the graph you wish to modify. The next response is PLOT CMNDS?>. You may answer by typing any of the following commands. The commands modify the graph selected and do not affect the parameters for any other graph unless specifically mentioned. All numbers entered must include the decimal point and only the first two letters of the command are necessary.

1) PLOT - Starts plotting data on the graph selected at the current location. Does not reset current plotting position (CPP) to the beginning of the graph (extreme left). When the CPP reaches the end of the time scale an INITIALIZE or SAVE command is automatically executed and plotting resumes.

2) INITIALIZE - Draws grid upon the graph and the CPP is set to the beginning of the graph. A PLOT command must follow an INITIALIZE command before executing further commands. This command will erase the channel before it draws the grid, unless a previous SAVE command was given.

3) FREEZE - Freezes graph at CPP; plotting is discontinued. The PLOT command resumes the plotting.

4) ERASE - Erases the channel, unless a previous SAVE command was given, and draws grid. The CPP is unchanged. This command can be given again and does not need a PLOT command to execute again.

5) SAVE - Saves the old data on the channel. During plotting, when the CPP reaches the end of the time scale, the CPP is set to the beginning of the graph. Unlike the INITIALIZE command, no erase is executed.

6) ANNIHILATE - Undoes a previous SAVE command. When the CPP reaches the end of the time scale, the CPP is set to the beginning and the graph is erased.

7) MAXIMUM - Requests the maximum value of the vertical scale (Y-axis). This command displays the current value as XX.XX?>. If a change is desired, type in the new maximum value. If no change is desired, type (NO); thus the old value will remain.

8) MINIMUM - Acts exactly the same as the MAXIMUM command. However, the minimum value of the vertical scale (Y-axis) is affected.

9) TIC - Refers to the intervals (ΔY) on the vertical scale. If, for example, the maximum value of Y = 50.0 and the minimum = 0.0, a tic (ΔY) = 10.0 will produce five horizontal lines labeled 10, 20, 30, 40, 50, respectively, on the graph. The input, again, is similar to the maximum and minimum entries.

10) NAME - Refers to the two alphanumeric characters displayed on the graph. Typing NO causes no change.

11) LOCK - Locks the graph to your terminal. Thus, the graph parameters can only be changed from the locking terminal.

12) UNLOCK - Unlocks a graph that a terminal has previously locked. The UNLOCK command will not unlock a graph that was locked by a different terminal.

13) GAIN - Causes the vertical scale Y to be multiplied by the value entered. Thus our new Y equals our old Y multiplied by the entry; i.e., Y = GAIN *Y. Normally GAIN = 1.0.

14) OFFSET - Adds the constant entered here to the vertical scale Y; i.e., Y = Y + OFFSET. For normal use, OFFSET = 0.

15) SYNCHRONIZE - Causes the selected graphs to be synchronized. Each graph selected will thus be plotting at the same point on the X, or time axis. The command, when issued, will respond with SYNC GRAPH NUM?>. Enter a graph number. The command responds again with the same message. Enter the next number to synchronize. Upon termination of the graph list, enter STOP and the graphs will be synchronized. The CPP is set to the beginning of each graph synchronized.

16) SELECT - Allows the user to select another graph to modify, either 0-8 or 10-18. Selecting a graph locked by another terminal results in the program asking for another graph (see error section).

17) DUPLICATE - Causes the graph selected to be duplicated on another graph. The command responds with DUP GRAPH NUM?>. Enter the graph number where the duplication is desired. The CPP for both graphs is unaffected by this command.

18) FILTER - Calls for the filter constant ($0 \leq \alpha \leq 1$) to be entered. (See filter program). This affects only the selected graph. The filter equation is $Y_K = (1 - \alpha)\, Y_K + \alpha Y_{(K-1)}$. The default value for α is zero; i.e., no filtering.

19) RATE - Shows the plotting rate. The plotting rate is the time the CPU updates a graph. The default value is 5 sec plotting rate for each graph.

20) DELTA - Increments the horizontal (time) axis ($X_K = X_{(K-1)} + \Delta t$), where Δt = delta) after each plot. The default value Δt is 1 sec.

21) TOTAL TIME - Shows the plotting time required for the CPP to move from the beginning of the graph to the end. The total time

TO = 480 X RATE/DELTA in seconds. In the default mode TO = 480 X 5/1 = 2400 sec = 40 min. The horizontal (time) axis is partitioned equally by four lines. In the default mode, the first line corresponds to 40 min./4 = 10 min., the second line is 20 min., the third is 30 min., and the fourth equals 40 min.

22) LABEL - Labels the Y-axis. Up to 20 alphanumeric characters can be entered.

23) SUPPRESS - Suppresses plotting. Unlike the FREEZE command, the CPP is updated. Issuance of a PLOT command resumes plotting.

24) NO - Indicates that there should be no change in the present value given. This command works for any response from the program.

25) EXIT - Exits and ends program at any time. Can be used as a response for any command.

26) KCON - Controls the parameter that is plotted on the graph selected. The user can also enter the symbolic name for the plotting parameter. This automatically updates the name on the graph.

KCON	Plotting Parameter
1 or LA	Latitude (degrees)
2 or LO	Longtitude (degrees)
3 or NV	North velocity GS ($m\ s^{-1}$)
4 or EV	East velocity GS ($m\ s^{-1}$)
5 or HD	Heading (degrees)
6 or PI	Pitch (degrees)
7 or RO	Roll (degrees)

8 or GS	Ground speed (m s^{-1})
9 or DR	Drift (degrees)
10 or TK	Track (degrees)
11 or TS	True air speed (m s^{-1})
12 or VS	Vertical speed (m s^{-1})
13 or WD	Wind direction (degrees)
14 or WS	Wind speed (m s^{-1})
15 or GA	Geopotential altitude (m)
16 or PA	Pressure Altitude (m)
17 or RA	Radar Altitude (m)
18 or RS	Radiation sideward (C)
19 or SP	Surface pressure (mb)
20 or SA	Sideslip angle (degrees)
21 or RD	Radiation downward (C)
22 or TD	Dew point (C)
23 or AA	Attack angle (degrees)
24 or PS	Static pressure (mb)
25 or PQ	Diff pressure (mb)
26 or PH	Pressure height (m)
27 or TA	Free-air temperature (C)
28 or WY	East-west wind speed (m s^{-1})
29 or WY	North-south wind speed (m s^{-1})
30 or LW	JW liquiid water (g cm^{-1})
31 or WZ	Vertical winds (m s^{-1})

3.2. FTRK Program

The FTRK program modifies the parameters that control the flight track on channel 9. This is the only program in the graphic system allowed to access channel 9.

XX > RUN, FTRK

LONG CENTER? > Respond with center screen longitude or with CM. CM causes the program to skip to the plot command below.

LAT CENTER? > Respond with center screen latitude.

LONG MAX? > Enter maximum longitude for the screen.

LONG MIN? > Type in minimum longitude.

LAT MAX? > Type in maximum latitude.

LAT MIN? > Type in minimum latitude.

STORM LONG? > Respond with the longitude coordinates for the storm.

STORM LAT? > Respond with the latitude coordinates for the storm.

The last two commands draw a hurricane symbol at the coordinates given. If none is desired enter -1.0 for both.

LONG TIC? > Delta longitude for grid.

LAT TIC? > Delta latitude for grid.

PLOT CMNDS? > Respond with:

1) PLOT - Plots flight track.
2) INITIALIZE - Draws latitude and longitude grid.
3) WINDS - Plots wind vectors on flight track.
4) TIME - Shows Δt time in minutes to plot wind vectors.
5) TERMINATE - Terminates wind vector plotting on flight track.
6) AUTO - Automatically initializes screen when aircraft reaches edge of screen. It moves latitude and longitude grid to correspond with the aircraft position.

7) FIX - Terminates AUTO. When the aircraft gets to the end of the grid, no initialize occurs.

8) RATE - Plots flight track at desired rate (enter seconds).

9) NO - Indicates that value should remain unchanged. Works for all responses.

10) EXIT - Exit program.

3.3. DISK Program

This program controls the rate at which the data is written on the disk and printed on the line printer. It also controls data written to fix format 2, data written on the CRT from CPU 2.

XX> RUN, DISK

DISK CMND? > Respond with:

1) TRACK - Prints out current track disk is writing on.

2) SECTOR - Prints out current sector disk is writing on.

3) START - Starts writing data on disk.

4) TERMINATE - Terminates writing data on disk.

5) RATE - Respond with Δt in seconds to write on disk.
Example: Δt = 1.0 implies write on disk every second.

6) PRINT - Respond with Δt in seconds to write on line printer. This command, however, can be superseded by event switches.

7) DISPLAY - Turns display for fix format 2 on or off.

3.4. PAST Program

The PAST program runs under RTE in background core. It is swapped into core when executed and plots the past history of data.

The past data plotted are the data that have been previously stored on the disk. Therefore data must be present on the disk before executing this program. The past program uses the same graphic parameters that the CMND program modifies and uses. Thus past data can be plotted simultaneously with real time data, by selecting the graph number with the PAST program. The only requirements for this program then are the graph number and the time.

XX> RUN, PAST

GRAPH NUM? > Respond with graph number (0-8 or 10-18) that you wish to plot past history.

ENTER HHMMSS? > Enter starting time you want to see plotted.

Note: NO and EXIT work as in CMND program for responses.

3.5. FILTR Program

This program computes the filter coefficient α used to filter the plotted data. The filter equation is $Y = (1 - \alpha) Y_K + \alpha Y_{(K - 1)}$, $(0 \leq \alpha \leq 1)$. This equation is the formula for a recursive low-pass digital filter. By changing α, the user changes the amount of filtering done. For $\alpha = 0$, there is no filtering, for $\alpha = 1$, Y_K is constant. The input is T, the period for filtering.

XX> RUN, FILTR

ENTER PERIOD IN SECONDS? > Respond with filter time period.

FILTER COEFFICIENT = ANSWER

3.6. STAT Program

This program prints out on the user terminal all the parameters that effect the graph selected.

XX> RUN, STAT

GRAPH NUM?> Respond with desired graph number.

GRAPH NUM = XX NAME = XX KCON = XX

MAX = XXXX.X MIN = XXXX.X. TIC = XXXX.X

FILTER = X.XXX RATE = XX.X DELTA = XX.X

GAIN = XX.XX OFFSET = XX.XX DUP = XX

LOCK = XX STATE = ?????

LABEL = ?????

PRGM STATE COMPLETED

4. EXAMPLES

These examples, which are typical of the requests made on the aircraft, use the graphic programs as described before. The underlined text is the response from the computer.

Example 1. Plot the wind speed once per second in knots on graph 2. Maximum value is 100 kt and the minimum value is 0 kt. The results should appear as in Figure 3.

XX> RUN, CMND

GRAPH NUM?> 2

2 SELECTED: PLOT CMND?> MAXIMUM

    0.00?> 100.0

2 SELECTED: PLOT CMND?> MINIMUM

    0.00?> 0.00

2 SELECTED: PLOT CMND?> KCON

    $$$$?> WS

2 SELECTED: PLOT CMND?> TIC

$$$$?> 10.0

2 SELECTED: PLOT CMND?> GAIN

1.0?> 1.9438 Note: This is conversion from meters per second to knots.

2 SELECTED: PLOT CMND?> LABEL

ENTER LABEL?> WS (KNOTS)

2 SELECTED: PLOT CMND?> RATE

5.0?> 1.0

2 SELECTED: PLOT CMND?> INITIALIZE

2 SELECTED: PLOT CMND?> PLOT

Example 2. Assume the CMND program is still executing from Example 1. Change the maximum and minimum value in Example 1 to 150 kt and 50 kt respectively. Refer to Figure 2.

2 SELECTED: PLOT CMND?> MAXIMUM

100.00?> 150.00

2 SELECTED: PLOT CMND?> MINIMUM

0.00?> 50.0

Keep the plotting at the current position, but erase the previous data.

2 SELECTED: PLOT CMND?> ERASE

Save the data from the current CPP on.

2 SELECTED: PLOT CMND?> SAVE

Then duplicate the wind speed on graph 3 and change the label of graph 3 to reflect the duplication.

2 SELECTED: PLOT CMND?> DUPLICATE

DUP GRAPH NUM?> 3

2 SELECTED: PLOT CMND?> SELECT

GRAPH NUM?> 3

3 SELECTED: PLOT CMND?> LABEL

ENTER LABEL?> DUP OF GRAPH 2

3 SELECTED: PLOT CMND?> SELECT

GRAPH NUM?> 2

2 SELECTED: PLOT CMND?>

Example 3. Plot the surface pressure in millibars synchronized with the wind speed on the same channel. Maximum value of 1000 mb and a minimum value of 900 mb with a Δy of 10 mb. Assume Example 2 was just done. Refer to Figure 2.

2 SELECTED: PLOT CMND?> ANNIHILATE

Note: When graph 2 reaches the end, this command will erase the channel, since graph 2 plots before graph 12.

2 SELECTED PLOT CMND?> SELECT

GRAPH NUM?> 12

Note: Graph 2 and 12 plot on same channel.

12 SELECTED: PLOT CMND?> MAXIMUM

$$$$?> 1000.0

12 SELECTED: PLOT CMND?> MINIMUM

0.00?> 900.0

12 SELECTED: PLOT CMND?> TIC

100.0?> 10.0

12 SELECTED: PLOT CMND?> KCON

14?> SP

12 SELECTED: PLOT CMND?> LABEL

ENTER LABEL?> MILLIBARS

12 SELECTED: PLOT CMND?> SAVE

Note: Since graph 2 erases channel, graph 12 must not erase channel or the grid from graph 2 will be erased.

12 SELECTED: PLOT CMND?> PLOT

12 SELECTED: PLOT CMND?> SYNCHRONIZE

SYNC GRAPH NUM?> 2

SYNC GRAPH NUM?> 12

SYNC GRAPH NUM?> STOP

Lock graph 12 to your terminal.

12 SELECTED: PLOT CMND?> LOCK

12 SELECTED: PLOT CMND?> EXIT

PRGM CMND COMPLETE

Example 4. Set up the flight track with a grid of latitude 27°N to 23°N and a longitude of 88°W to 84°W; also draw in every degree. Position a storm center at 26.35°N, 86.23°W.

XX> RUN, FTRK

LONG CENTER 40.00?> 86.00

LAT CENTER 50.00?> 25.00

LONG MAX 44.00?> 88.00

LONG MIN 36.00?> 84.00

LAT MAX 54.00?> 27.00

LAT MIN 46.00?> 23.00

STORM LONG 41.00?> 86.23

STORM LAT 46.80?> 26.35

LONG TIC 2.0?> 1.0

LAT TIC 1.0?> 1.0

PLOT CMNDS?> INITIALIZE

PLOT CMNDS?> PLOT

PLOT CMNDS?> EXIT

Example 5. On the previous flight track, draw wind vectors every 5 min and automatically follow the aircraft position.

XX> RUN, FTRK

LONG CENTER 86.00?> CM

PLOT CMNDS?> TIME

10.00?> 5.0 Note: Enter minutes.

PLOT CMNDS?> WINDS

PLOT CMNDS?> AUTOMATIC

PLOT CMNDS?> EXIT

Example 6. Make the line printer list every 15 sec.

XX> RUN, DISK

DISK COMMANDS?> PRINT

0.00?> 15.00

DISK COMMANDS?>

Example 7. Assuming Example 6 just executed, make the disk record at a rate of 5 sec.

DISK COMMANDS?> RATE

0.00?> 5.0

DISK COMMANDS?> START

DISK COMMANDS?> EXIT

PRGM DISK COMPLETED

Example 8. Compute a filter coefficient α for a period T of 30 sec and filter the wind speed of graph 2.

XX> RUN, FILTR

ENTER PERIOD IN SECONDS? > 30.0

FILTER COEFFICIENT = 0.9672

PRGM FILTR COMPLETED

XX > RUN, CMND

GRAPH NUM? > 2

2 SELECTED: PLOT CMND? > FILTER

0.00? > 0.9672

2 SELECTED: PLOT CMND? > EXIT

Example 9. Determine the status of graph 12.

XX > RUN, STAT

GRAPH NUM? > 12

GRAPH NUM = 12 NAME = WS KCON = 14

MAX = 150.0 MIN = 50.0 TIC = 10.0

FILTER = 0.9672 RATE = 1.0 DELTA = 1.0

GAIN = 1.9438 OFFSET = 0.0 DUP = NO

LOCK = 14 STATE = PLOT

LABEL = WS (KNOTS)

PRGM STAT COMPLETED

Example 10. Turn FIX FORMAT 2 OFF. Assume it is on.

XX> RUN, DISK

DISK COMMANDS?> DI

DISK COMMANDS?> EX

PRGM DISK COMPLETED

Example 11. Assume that graph 1 is set up as example 1. Plot the past history of the wind speed starting at time 10:00:00. Refer to Figure 5.

XX> RUN, PAST

GRAPH NUM?> 1.0

ENTER HHMMSS?> 100000

The past history of the wind speed will plot on graph 1.

4. ERRORS

The software has been written to check for numerous input errors. All programs check for appropiate graph numbers. An entry outside the range will result in the CPU asking again for a correct graph number. If a graph number is selected that has been locked by another terminal, the CPU responds with the locking terminal number and asks again for an appropiate graph number. All programs will also terminate automatically if no entry is made within five minutes. Each time an entry is made the user is again given five minutes for the next entry. For all programs, an incorrect alpha entry is ignored. The EX and NO alpha entries apply to all alpha and numeric entries.

The KCON command in the CMND program checks for a legal numeric input. A numeric input outside the range results in the CPU asking for a correct KCON. The RATE command, for all programs that use a RATE command, checks for an entry between 1 and 60. Entries outside this range are ignored. A decimal point must be used for all numeric entries, failure to do so will produce an erroneous result. Many problems users have encountered have been traced to the lack of a decimal point for numeric entries.

Another common problem in the CMND program is that no plotting occurs. The user should check that he has indeed done a PLOT command,

especially after an INTIALIZE command. The data maybe out of range of the max and min values. Also, if the data is constant it may be plotting over a horizontal line and thus it will appear not to be plotting. This often occurs when data is constanly equal to zero and the data is plotted on the bottom axis. A solution is to offset the data slightly using the OFFSET command.

The best advice to be given is to execute a command, note the change, wait for a response, and then enter another command. These programs have logged well over 1000 hours of usage in actual aircraft operations. The programs have been well debugged and if properly used will give very good results.

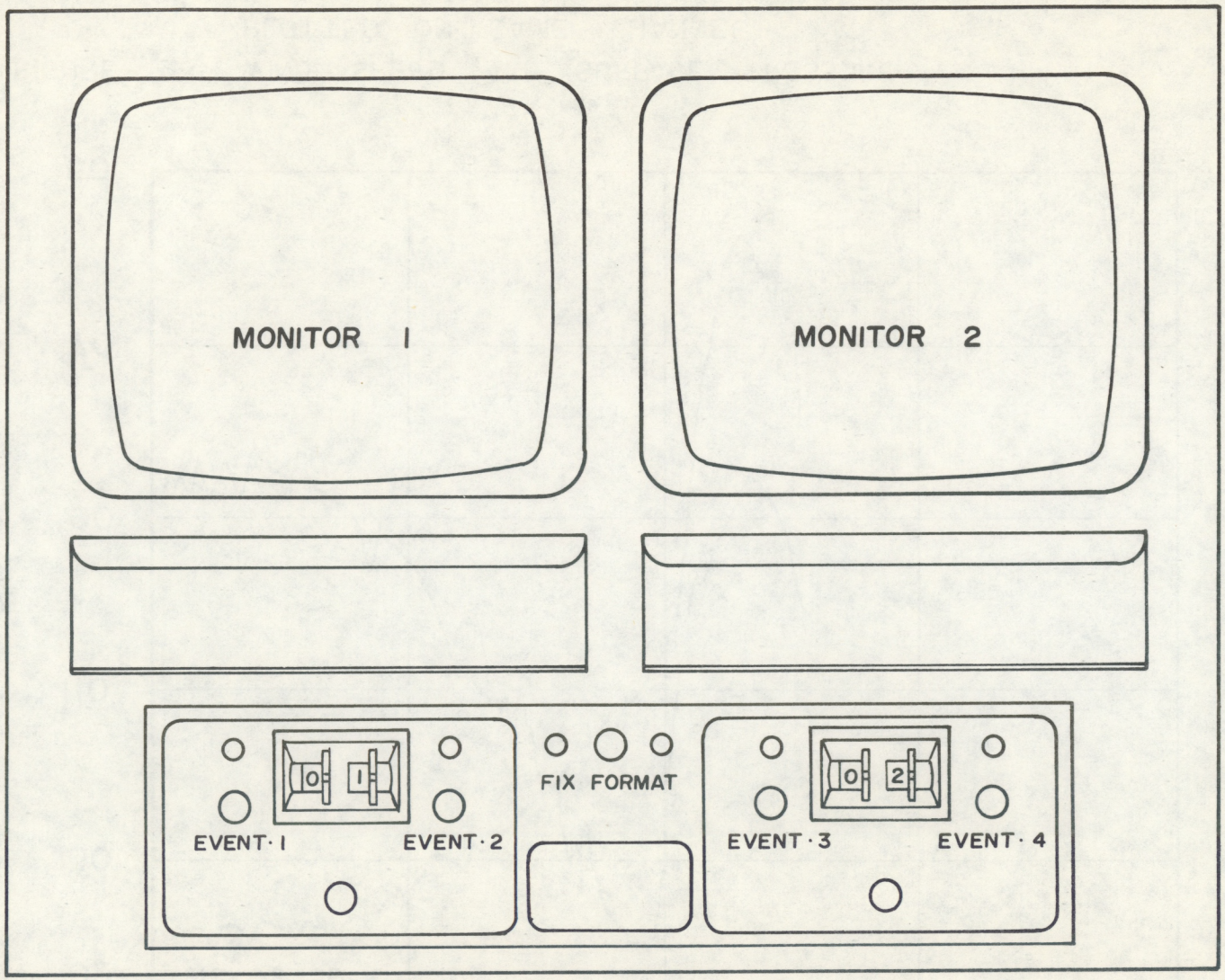

FIGURE 1. VIDEO DISTRIBUTION BOX.

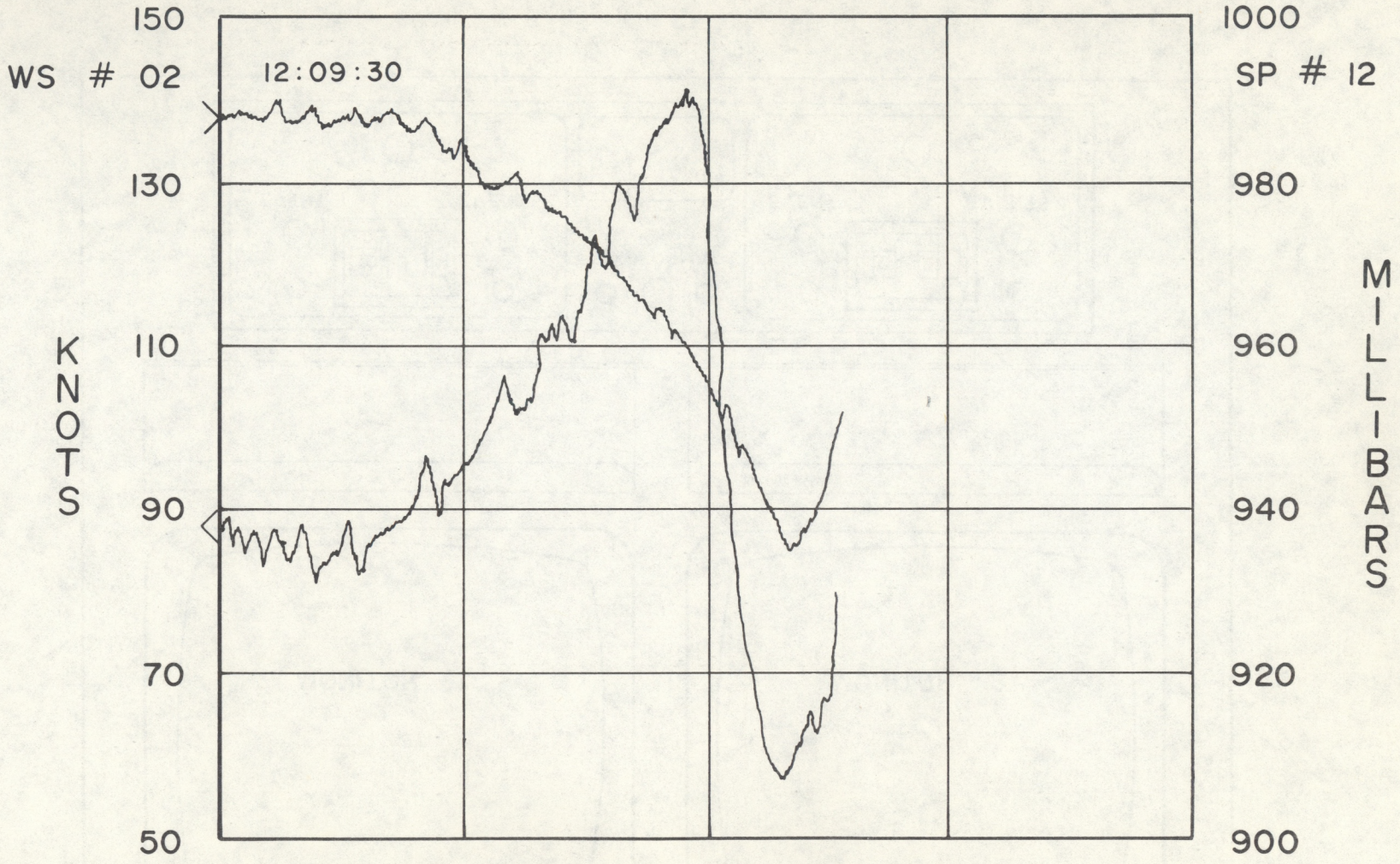

FIGURE 2 WIND SPEED AND SURFACE PRESSURE PLOTTED ON SAME CHANNEL.

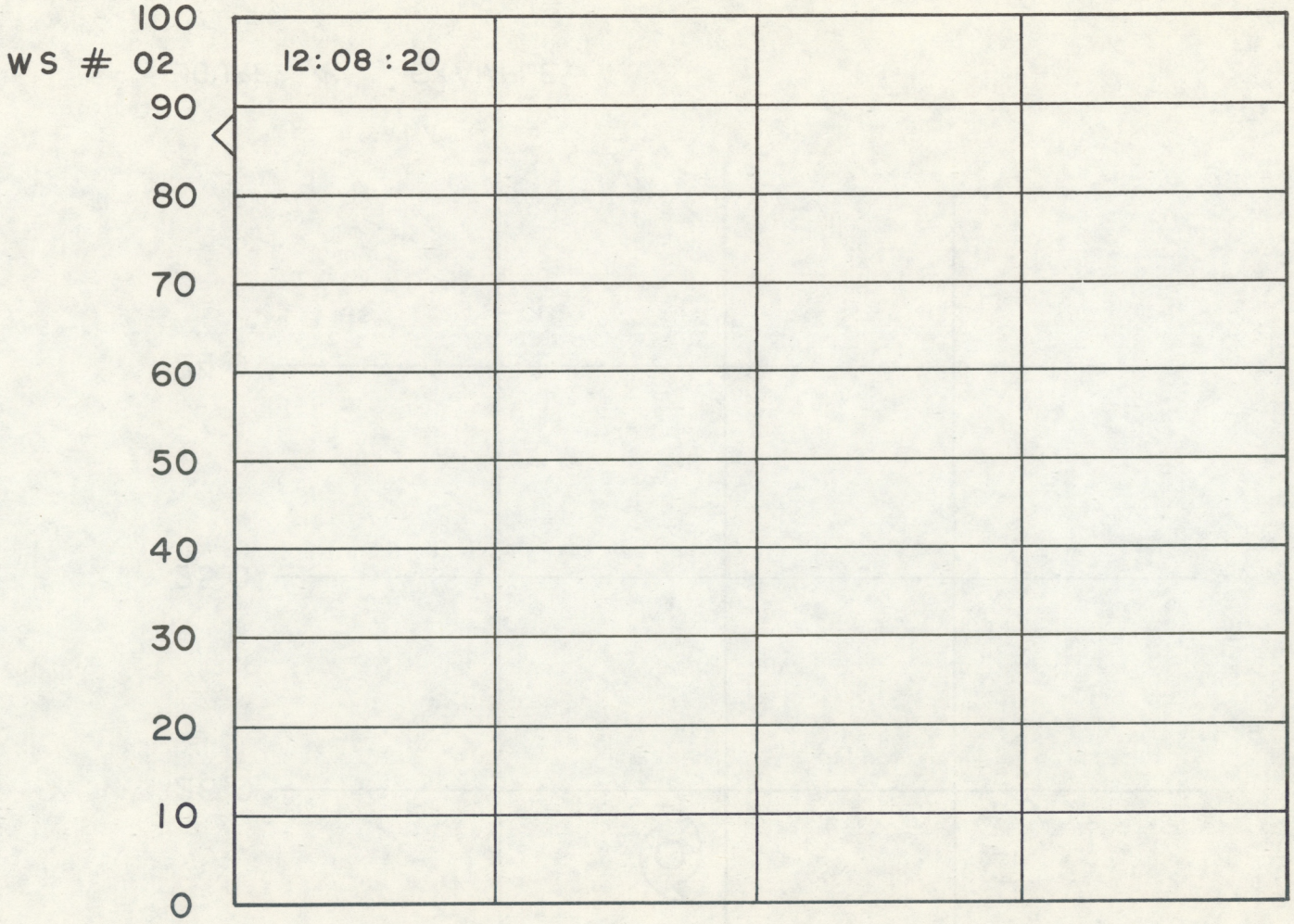

FIGURE 3. EXAMPLE 1.

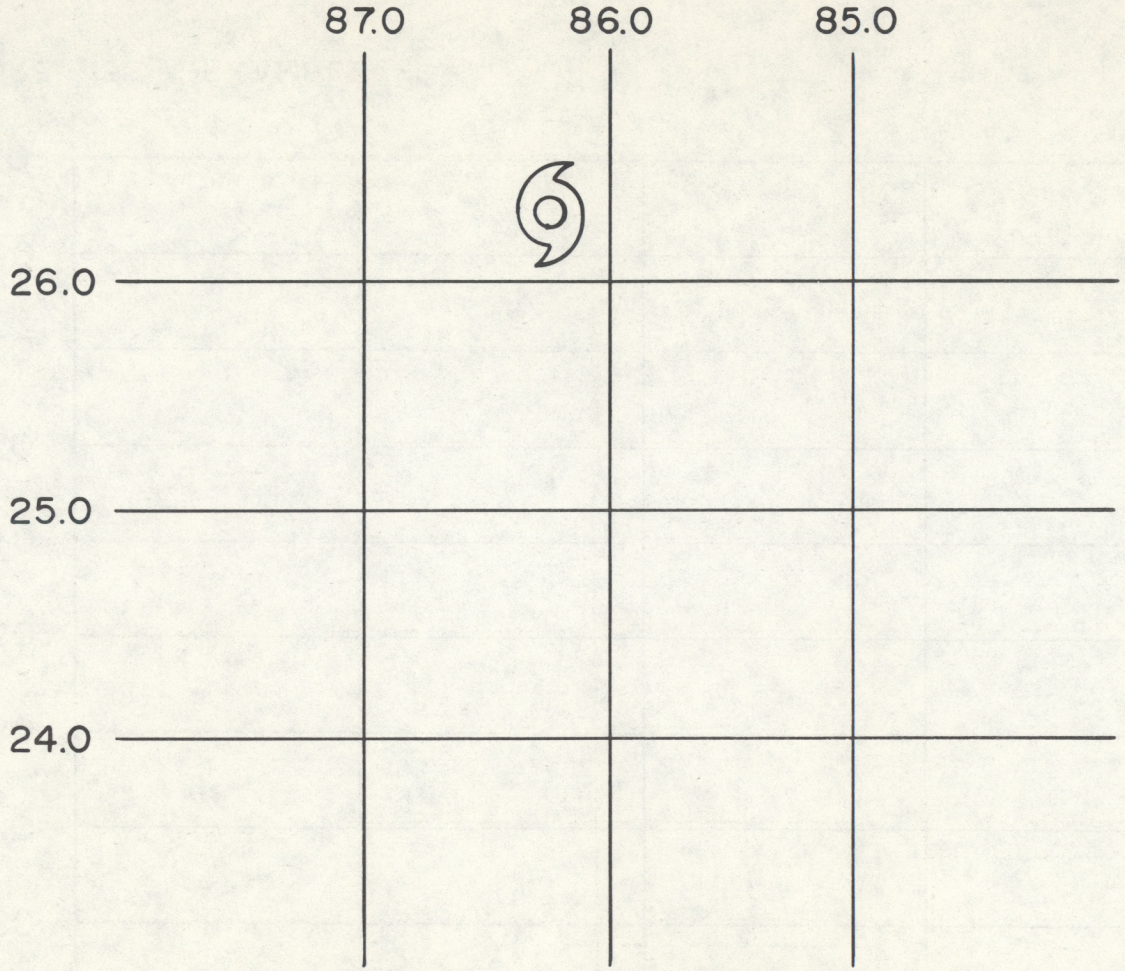

FIGURE 4. EXAMPLE 4.

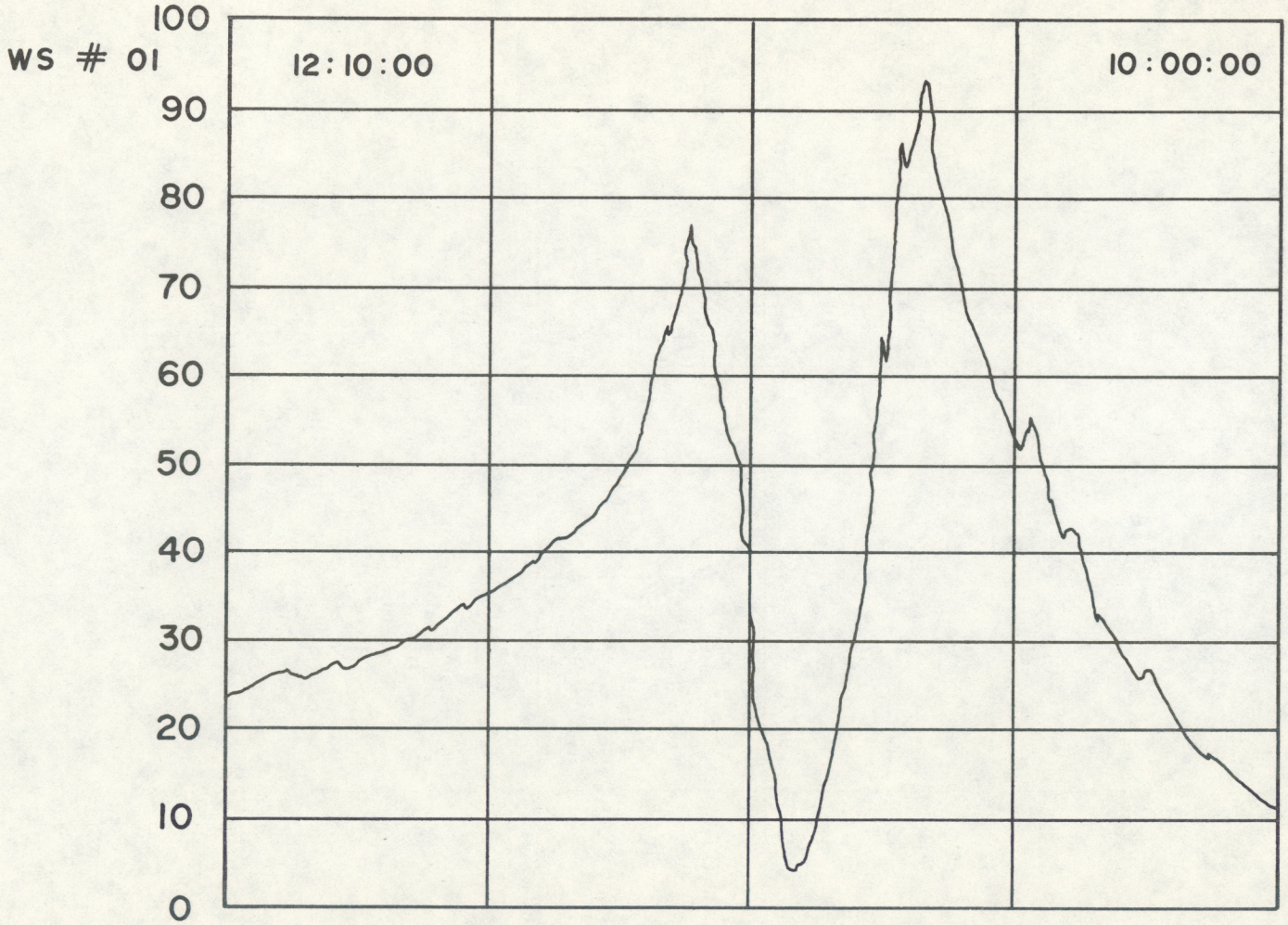

FIGURE 5. PAST EXAMPLE.