GOES DATA-COLLECTION SYSTEM INSTRUMENTATION, INSTALLATION, AND MAINTENANCE MANUAL

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ACRONYMS AND ABBREVIATIONS

A — Ampere
ac — Alternating current
A/D — Analog to digital
ADR — Analog to digital recorder
ADAPS —Automated DAta Processing System
Ah — Ampere-hour
AIMS—Automated Instrumentation Monitoring System
BCD — Binary coded decimal
dB — Decibels
dc — Direct current
DCP — Data-collection platform
DCS — Data-collection system
DIMS — Data Collection Platform Information Monitoring System
DIS — Distributed Information System
DRGS — Direct Readout Ground Stations
GND — Ground
GOES — Geostationary Operational Environmental Satellite
HIF — Hydrologic Instrumentation Facility
I/O — Input/output
IRAC — Interior Radio Advisory Committee
mA — Milliamperes
NESDIS — National Environmental Satellite Data and Information Service
PASS — Platform Assignment Scheduling Subsystem
RF — Radiofrequency
USGS — United States Geological Survey
V — Volt
VPC — Volts per cell
WATSTORE — WATer Data STOrage and REtrieval System
WRD — Water Resources Division

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1.0 INTRODUCTION

1.1 Purpose

This manual is designed to aid in the installation and maintenance of Geostationary Operational Environmental Satellite (GOES) data-collection platforms (DCP). The manual is not meant to be a substitute for DCP manufacturers' manuals but rather a source of information not generally included in manufacturers' manuals, which specifically addresses the application of data-collection platforms in the Water Resources Division (WRD).

The manual brings together the collective expertise of WRD personnel into a single DCP manual. The looseleaf format allows for information to be added as new equipment and techniques become available and for future contributions by other WRD personnel. We recommend you file all information regarding the GOES data-collection system including copies of pertinent WRD memoranda with this manual.

1.2 Overview of the GOES Data-Collection System

The GOES data-collection system allows data to be transmitted from locations on Earth to a geostationary satellite that retransmits the data to a ground-receive site. Two active satellites in the system are located over the equator at an altitude of approximately 23,500 miles—one at longitude 75°W (east satellite) and the other at longitude 135°W (west satellite). Each satellite has 266 channels (CH1 through CH266). The east satellite uses only the odd-numbered channels and the west satellite the even-numbered channels. The two general types of channels on each satellite are:

1. Self-timed channels, which require that data be collected and stored in the DCP and then transmitted at a specific assigned time. The interval between transmissions usually is 4 hours for WRD DCP's; however, 1-, 2-, 3-, and 6-hour intervals are used at some stations. The available time to make each transmission is 1 minute at a data-transmission rate of 100 bits per second.

2. Random channels, which allow transmissions to be made at some random interval after each data-acquisition cycle (data collected from the sensor). The time period in which the random transmission is made is usually the same length as the data-acquisition cycle.

All models of DCP's used by WRD except LaBarge CDCP[1] can use both types of channels. WRD normally uses self-timed channels to relay routine data and the random channels to relay alert data; however, the random channels also can be used to receive routine data. DCP's can be programmed to make the more frequent random transmissions when a preprogrammed parameter threshold or rate of change is detected by the DCP. This feature makes it possible to acquire data more frequently when streams are flooding. DCP's can also be programmed to extend messages to include data that previously were transmitted, thus preventing loss of data due to loss of a single transmission.

1.3 Data Retrieval

Each WRD District receives its GOES real-time data from one of seven Survey-operated Direct Readout Ground Stations (DRGS) located in Tacoma, WA; Denver, Co; Phoenix, AZ; Ft. Worth, TX; Harrisburg, PA; Anchorage, AK; and Columbia, SC. The Tacoma, Denver, Anchorage, and Phoenix DRGS receive data transmitted through the west satellite, and Harrisburg and Columbia recieve data transmitted through the east satellite. The Ft. Worth DRGS is operated for the Corps of Engineers by WRD and receives data transmitted through both the east and the west satellites. Each WRD District has been assigned a DRGS from which they may receive their data. The Districts responsible for each DRGS are shown in figure 1.0.

Before data can be received by the DRGS, certain information is needed by the DRGS operator. The information needed for each DCP is conveyed to the operator by submitting the DCP/DRGS Information Form. These forms may be obtained from the operator or by spooling the file "DCP.Form" from the directory WRDADR>SHRDOC. Data received by the DRGS is transferred to the host District's Prime using the Automated DAta Processing System (ADAPS) and is then transferred to the appropriate user District by the Distributed Information System (DIS). The user District must have the ADAPS software loaded on their Prime to receive and store GOES telemetry data. After data have been loaded to the user District's ADAPS unit-values data base, the data may be processed further into various tables and graphs. Users that want direct access to a DRGS for data verification and trouble shooting DCP messages prior to conversion are referred to Chapter 8. Instructions are provided that will permit the user to connect his/her terminal to the DRGS

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[1]Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

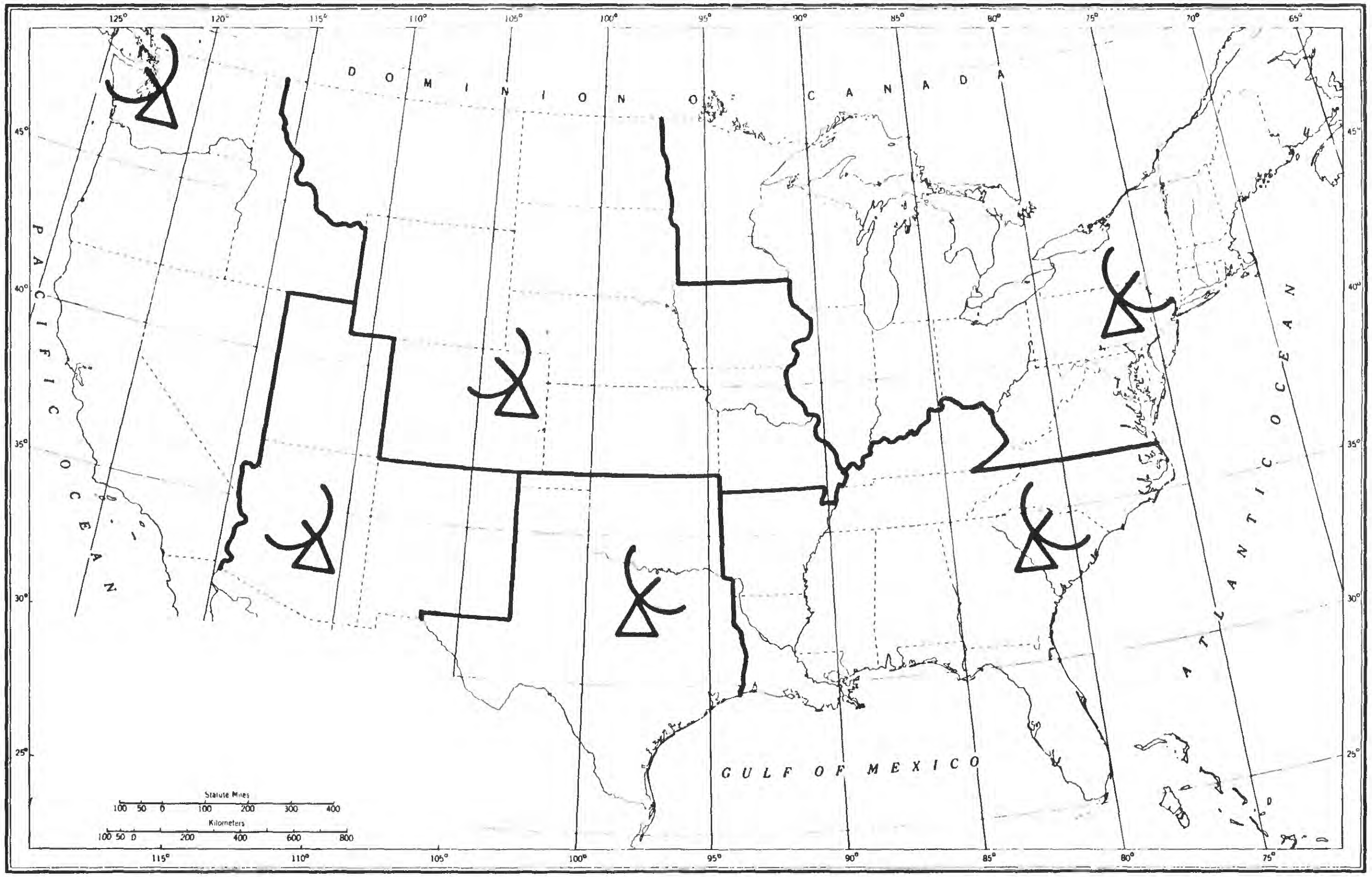

Figure 1.0.--Locations of Direct Readout Ground Stations
and areas the stations serve.

computer and to access DCP data in the transmission format. This will permit the user to inspect the data as received by the DRGS and to look at DCP performance information generated by the DRGS.

1.4 Getting Started with GOES Data-Collection System

The first thing to do once the decision is made to use the GOES data-collection system (DCS) is to make a request for channel and time-slot assignments. This is done by logging on QVARSB Prime and entering the Platform Assignment Scheduling Subsystem (PASS). A user identification and password can be obtained by contacting the Data-Relay Project Office at National Headquarters in Reston, Virginia, FTS 928-6014. Instructions for using PASS are contained in section 7.0; updates of the instructions will be placed in a file named "PASS.DOC" (QVARSB).

PASS permits registration of users of the GOES data-collection system in the office information file. The Data-Relay Project will use this information to communicate with you via Prime E-Mail or the Postal Service regarding changes in the data-collection system or updates to this manual. PASS is used to support the scheduling of DCP transmissions and allow users to request a new DCP assignment or modify existing assignments. This information is used by the Data-Relay Project to create forms requesting authorization from the Department of the Interior for licenses to generate radio transmissions and the Department of Commerce for GOES data-collection system assignments. The request should be made as soon as possible so the assigned stations can be processed by the Department of the Interior because the license must be obtained before the DCP is put on the air. The processing may take as long as 3-6 months. After the platform identifications, time slots, and channels are issued, the "DCP/DRGS Information Form" (see appendix F) should be completed and sent to the operator at the DRGS site assigned to receive your Districts' DCP transmissions.

After the requests are made for DCP assignments and transmission license, the next step is to acquire technical information and price lists from DCP, solar-panel, battery, and sensor manufacturers to obtain equipment specifications for designing the system. Appendix A contains a partial list of component manufacturers. The information in the following section will assist in the design.

A survey of the stations in which the equipment is to be installed is also useful for designing and installing the system. The survey would include dimensions of the shelter, material used in construction of the shelter, equipment presently installed at station, type of station (manometer or float), shading (if solar panels are used), vandalism potential, accessibility, and whether the station is in the line of sight of the satellite.

The equipment should be properly tested before it is placed in the field. All the equipment, including the DCP, sensor, input/output

(I/O) cable, and radiofrequency (RF) coaxial cables, should be tested together as a unit. After testing is completed, the equipment should be kept together as a unit and installed in the same manner.

2.0 DATA-COLLECTION PLATFORMS

The three basic functions of the data-collection platform (DCP) are (1) sensor interfacing, (2) controlling the frequencies of sensor sampling and transmissions, and (3) transmitting data to the satellite. At a minimum, all DCP's perform these functions; however, DCP's can perform additional functions depending on the model and make.

The first DCP's used by WRD were built by LaBarge Electronics in the mid-1970's and many are still in operation today. Since that time, three additional manufacturers have entered the DCP market. Over the years, new microprocessor advancements have made DCP's capable of many more complex functions. In addition to performing the basic functions, newer DCP's are capable of transmitting on two different channels, time tagging data, manipulating and converting data, self testing, executing multiple sample algorithms, and computer terminal communication through an RS-232 interface. The following section is an overview of DCP's presently used by WRD.

2.1 Handar 524

The Handar 524 is no longer being manufactured because it has been replaced by the Handar Model 560 (fig. 2.0). The 524 is widely used by WRD and many are presently in operation. The 524 performs only the basic DCP functions; however, it is capable of making alert random transmissions on a secondary channel and all 266 transmit channels are selectable. The Handar 524 does not convert data to engineering units or have different sampling intervals for different parameters. The only data manipulation that can be done is averaging an input parameter over the period of the transmission interval.

To use the 524 to its most advanced capabilities, it must contain the most recent version of firmware, which is an electronically programmable memory (EPROM) chip. From the time the 524 was first manufactured until it was discontinued, it has had several versions of firmware. Handar should be contacted to determine if the firmware in your platform is the most recent. A charge is made to exchange old firmware for the new version. The Handar 526 programming set is required to program the 524 (fig. 2.1). The 524 does not have RS-232 communication capabilities; therefore, no substitute programming unit can be used.

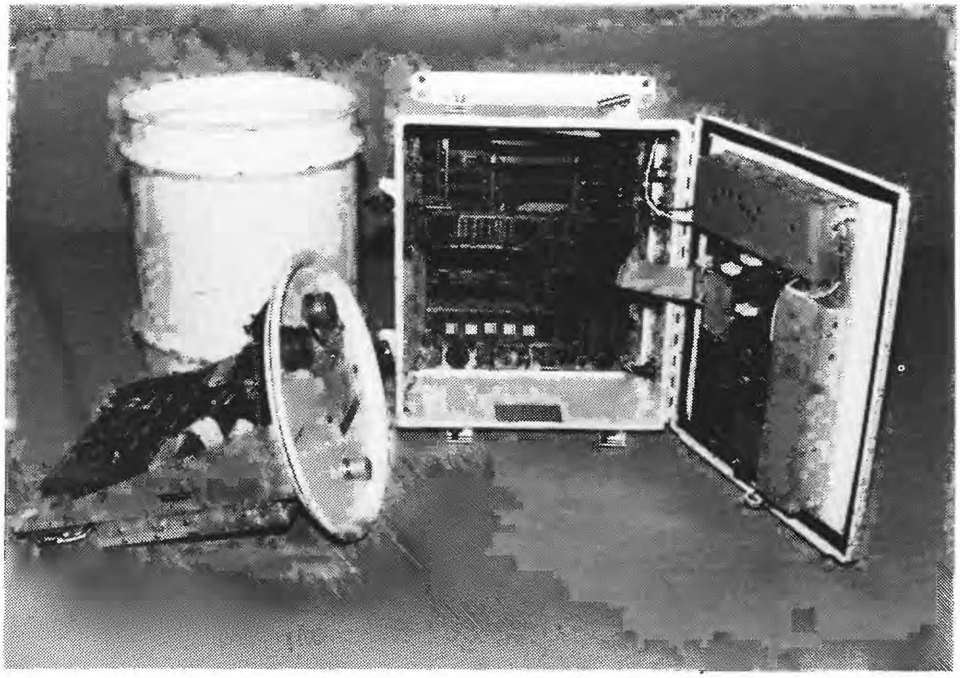

Figure 2.0.--Handar 524 (left) and 560 (right) data-collection platforms.

Figure 2.1.--Handar 526 programming set for 524 data-collection platform (left) and Handar 545A programming set for 540 and 560 data-collection platforms (right).

2.1.1 Handar 524 Specifications

FREQUENCY	
(Crystal controlled)	401.700996-401.847905 MHz (NESS CH 1 - 266)
FREQUENCY STABILITY	
Temperature	$\pm 5 \times 10^{-7}$ (-40 to +50°C)
Long Term	$< \pm 1 \times 10^{-6}$ /Year
Phase Noise	$< 3^{\circ}$ RMS (100 Hz BW)
Supply Sensitivity	$< 1 \times 10^{-8}$ (11-14V)
MODULATION	
Long Term	$< \pm 6^{\circ}$
Medium Term	3° RMS (100 Hz Bandwidth)
RF POWER OUTPUT	
524A	+40 dBm (10 Watts ±1 dB)
525A	+46 dBm (40 Watts ±1 dB)
SPURIOUS OUTPUT	-60 dBc
HARMONIC OUTPUT	-60 dBc
TIMING SEQUENCE	
Transmission Interval	5 min to 63 hours 59 minutes(1)
Synoptic Delay Interval	5 min to 63 hours 59 minutes(1)
TIMING ACCURACY	±30 Sec/Year
DATA STORAGE	1664 Bits
Scan readings	104
DATA FORMAT	
Unmodulated Carrier	5 sec
Bit Synch (101010...)	2.5 sec
MLS Code	15 Bits
BCH Code (User Programmable)	31 Bits
Data ASCII Character Set	8 Bits/Character Odd Parity
EOT	3 EOT (00100000)
DATA COLLECTION SCAN INTERVAL	5 mins to 63 hrs 59 mins(1)
DATA COLLECTION SCAN DELAY	5 mins to 63 hrs 59 mins(1)

(1) Programmable in 1 minute increments

2.1.1 Handar 524 Specifications—Continued

SENSOR INITIATE	
Scan Time	15 second/Digital Channel
Positive going line 1 minute before Sensor Data Scan	11-14V External Sensor Power 200 mA Max.
Optional user programming in one minute increments	1 min to 31 mins before scan
Channel Selection Strobes	1=7.5V 0=0V
Maximum Current (7.5V)	2A Surge 500 mA Continuous
ANALOG INPUT	8 Channels
Digitizing Time per Channel	0.1 second/Channel
ADC	Dual Slope (8 Bit)
Input Impedance	1 meg.
Input (Full Scale)	0-5V (Differential)
Maximum Input	-20 to +20 (Differential)
Common Mode (Max.) over full I/P range	-2V to +7V
DC Common Mode Rej.	±2 Bits
AC Common Mode Rej.	±2 Bits (0-10 kHz)
Non-Linearity	<1 Bit
Accuracy	.4%(±1 Bit)
Resolution	8 Bits (1/256)
Temperature Coefficient	.02%/°C
DIGITAL INPUT	4 Channels
Number of Bits	16 Bits Parallel Ent.
Logic Levels	Logic 0 = +5V Logic 1 = 0V
ADR Interface	Leupold Stevens or Fischer Porter
Input	524A/525A Inputs Internally Pulled High to +5V
Input Current	Hi (Logic 0) -100μA (Input 4.5V to 5.5V) Lo (Logic 1) -1mA (Input 0.5V to -0.5V)
DC POWER INPUT	
Voltage	12.5V ±1.5V
Current	
Quiescent	< 6 mA @ 12.5V
Peak 524A	< 3.5A @ 12.5V
525A	< 9.0A @ 12.5V

2.1.1 Handar 524 Specifications—Continued

ENVIRONMENTAL

Operating	$-40^{o}C$ to $+50^{o}C$
Storage	$-65^{o}C$ to $+70^{o}C$
Humidity	100%

MECHANICAL HOUSING

Enclosure	Airtight Canister 11" (28 cm) Dia. 13" (33 cm) length
Weight	15 lbs. (6.8 kg)
Data I/O, Power	55 Pin MS3126F-22-55S (Supplied)
Programming I/O	26 Pin MS3126F-16-26S (Supplied)
RF Output	Type N

OPTIONS

001 Guaranteed Cold Temperature Performance to $-55^{o}C$

002 High Gain Crossed Yagi Antenna

003 Omni Directional Antenna, Quad. Helix 1λ (525A only)

004 15' N/N Coax 142 B/U

005 Precipitation Card

ADR Cables are available in various configurations.
Consult factory for further details.

2.2 Handar 560

The Handar 560 is the hydrologic DCP that replaced the model 524. The 560 is a single unit housed in a NEMA environmental enclosure with airtight I/O connectors. The 560 is capable of scaling input data, converting raw data to engineering units, and executing several data-manipulation algorithms.

The basic unit has an up/down counter and an interface for an incremental encoder, an event counter for a tipping bucket rain gage, and a supply-battery voltage-monitoring system. If analog-to-digital recorders (ADR's) or analog inputs are to be used, an additional ADR/analog card must be purchased as an option. The ADR/analog card is capable of handling two ADR's and four analog inputs. If more input is needed, more cards can be added.

The programming of the 560 can be done with a Handar 545A programming set or with an ASCII terminal with RS-232 communication (fig. 2.1). An optional method of programming the 560 is with a TRS-80 model 100 portable computer. The TRS-80 model 100 can store 20 or more individual programs for loading to the 560 with only a few key strokes. The model 100 also can be used in the field as a terminal for checking DCP sites through the Prime or receive site.

2.2.1 Handar 560 Specifications

Standard Sensor Inputs	
Precipitation	Tipping Bucket Counter
Incremental Shaft Encoder	Handar 436A Shaft Encoder
Data Processing	
Data Log	Precision: 16-Bit Signed Binary
Mean (Average)	Sensor Difference
Standard Deviation	Measurement Difference
Minimum	Maximum
Analog Input	Type: 8-Bit Successive Approximation
Input	0-5 Volt Full Scale
Digitizing Time	1 msec
Resolution	8 Bits
Linearity and Accuracy	±0.4% of Full Scale @ 25°C
Ram Data Storage	Up to 650 Data Samples
System Clock	
Crystal Controlled	±30 sec/no (±30 sec/year with Option 101)
Data Measurement	
Sensor Sample	1 second to 18 hours
Battery Monitor	
Range	0-15 volts
Accuracy	±3%
Resolution	±0.1 volts
DC Power Input	11-14 volts
Environmental	
Operating	-20°C to +50°C (-40°C to +60°C Optional)
Storage	-65°C to +70°C
Humidity	100%
Mechanical	NEMA Type 4 Enclosure
Enclosure	12" x 14" x 6" (30.48 x 35.56 x 15.24 cm)
Weight	35 lbs (15.89 kg)
Option 560-7003	ADR Interface Assembly
ADR Inputs	4 Fischer Porter or Leuppold Stevens Recorders
Shaft Encoder	2 BCD or Gray Code Absolute Shaft Encoders
Precipitation	Weighing Guage (Potentiometer Type)
Temperature	
Sensor Type	2 YSI 44301 or 44006 Thermistors
Accuracy	±0.4°C (-40°C to +50°C)
Resolution	±0.4°C (-40°C to - 50°C)

2.2.1 Handar 560 Specifications—Continued

Analog Inputs	4 (0-5 volts) Uses Temp & Precip Inputs
Connector Type	55-Pin MS3126-F-22-55S (Supplied)
Maximum Sensor Input (4 Cards Installed) (16-Bit)	16 Analog Sensors, 8 Digital Sensors
Option 560-7005	Incremental Encoder Interface Assembly
Analog Inputs	8 Analog Inputs Including Weighing and Temperature Gauge
Digital Input	One 436A Shaft Encoder, One Tipping Bucket

Option 540-7002
Same as 540-7002

Option 560-7001
(Bell Type 103/113 Compatible)
Same as 540-7009

Option 560-7006
Same as 540-7006

1.8 560A Options List

The following Options are available for the 560A:

Part Number	Description
432A	Temperature Probe
436A	Incremental Shaft Encoder
540-7004	GOES Radio
545-3012	Data Terminal Programming Cable
560-7001	Modem Interface
560-7003	ADR Interface
560-7005	Incremental Encoder Interface
560-7006	Single Tape Drive
600-0700	10 dB Gain GOES Antenna
600-0753	Tipping Bucket Rain Guage
600-0774	Second Tape Drive

2.3 Sutron 8004C

The 8004C is packaged in an environmentally sealed aluminum casting (fig. 2.2). The DCP will accommodate 16 sensors plus two dedicated switch-closure (tipping-bucket) inputs; the sensors can be arranged in any mixture of analog and (or) digital inputs. The data acquisition is controlled by microprocessor firmware to operate sensors, collect data, and detect failure. The DCP can be programmed with any RS-232 ASCII terminal (fig. 2.2). An adapter assembly is used to connect the RS-232 connector to the DCP. Available options include (1) parallel/serial interface used with an LS-7000 digital recorder, (2) parallel/serial interface used with snow-measuring equipment, (3) ADR/BDI recorders, (4) modem interface, and (5) magnetic-tape storage.

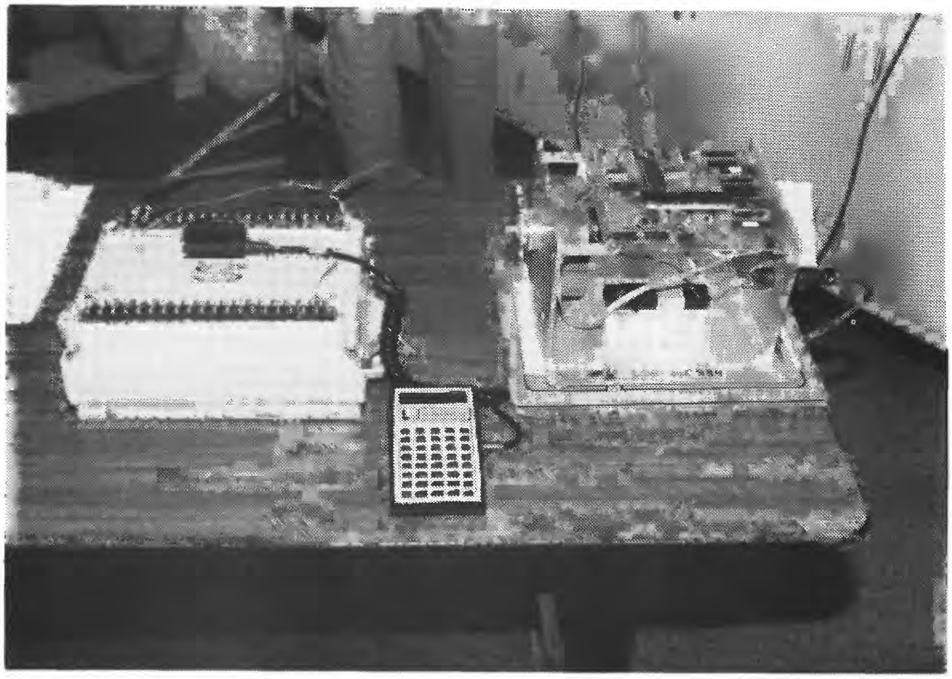

Figure 2.2.--Sutron 8004C data-collection platform (left), programming terminal (center), and Sutron incremental shaft encoder (right).

2.3.1. Sutron 8004C Specifications

SUTRON MODEL 8004A DCP SPECIFICATIONS

OUTPUT FREQUENCY	401.7010 — 402.0985 MHz Any two NESS channels from 1-266 Use of either channel is under program control
SPURIOUS OUTPUTS	-60 dBc
FREQUENCY STABILITY	± 1 ppm over 1 yr and -40° to +50° C temperature range
POWER OUTPUT	Variable with potentiometer setting from 3-15W Permits matching cable losses and antenna gain to achieve the maximum NESS-permissible radiated power under a wide variety of conditions and applications
REPORTING INTERVAL/ SELF-TIMED	Settable within 1-min increments in a range of 5 min to 1440 min (24 hr)
TIMING STABILITY	± 15 sec/6 months and -40° to +50° C
REPORTING AND DATA ACQUISITION TIMING	Initiate time to 1-sec increments using internal Julian clock
POWER INPUT	12 v ± 1.5 v
Quiescent	5 milliamps
Peak	1.5-3.0 amps (depending on power setting)
Average current input with 3-hr reporting, 15-sec message	9 milliamps
RANDOM-REPORTING FORMAT	0.5-sec carrier .48-sec clock pattern 15 bits MLS pattern 31 bits BCH ID code 2 to 48 data characters 8 bits EOT
SELF-TIMED FORMAT	*5-sec carrier 2.5-sec clock pattern 15 bits MLS pattern 31 bits BCH ID code 2 to 512 data characters 8 bits EOT
PACKAGING	Sealed aluminum casting (purgable); Volume, ¼ ft³ (4 x 11 x 8½ in.); Weight, 15 lb

* Optional short message self-timed format available.

2.3.1. Sutron 8004C Specifications—Continued

SUTRON MODEL 8004A DCP SPECIFICATIONS	
ENVIRONMENTAL	-40° to +50° C operating; -50° to +70° C storage; 100% humidity
DATA INPUT PARAMETERS	16 input parameters, any mixture of analog or digital
ANALOG INPUT	0 - 5.0 v 10-bit conversion accuracy
POTENTIOMETER INPUT	Using 5.0 v DCP reference voltage, ratio conversion is to 10 bit accuracy
DATA STORAGE AVAILABLE	384 bytes (expandable to 3k bytes)
DIGITAL INPUT	Serial input; interfaces to parallel output devices with parallel-serial interface unit
MICROPROCESSOR INTERFACE	Modified RS232C
SETUP PROGRAMS AVAILABLE	GMT set Transmission Control Sensor check and setup Forward and reverse RF power
AUXILIARY OUTPUTS	+5.00 v reference 10 milliamps output capability Switched 12 v, 2 amp capability Spare ground terminals
FAIL-SAFE	Permanent shut down of self-timed transmissions in event of • Input battery voltage of $\leq$10.5 v • Messages longer than 90 sec External manual reset Random transmissions limited to a maximum message length of 10 sec
AUXILIARY EQUIPMENT	• Variable gain antenna 9 dBi - 15 dBi • Hand-held ASCII terminal • P/S Interface for Stevens or F&P ADR interface or tipping bucket • Air/water temperature thermistor ± ½° C accuracy

2.4 Synergetics 3400 Series

The Synergetics 3400 series DCP is the only modularized DCP of those used by WRD (fig. 2.3). The basic 3400 is composed of three modules—the master control module, which supervises the collection processing and transmission of data; the hydrologic-sensor interface module, which interfaces sensors to the control module; and the communications module, which contains the GOES transmitter.

The basic 3400 is not in an environmental enclosure; therefore, cost of the environmental enclosure must be included in the total price of the unit. The 3400 is the second smallest DCP used by WRD; however, when placed in its environmental enclosure, it becomes by far the largest.

Programming of the 3400 is done with a handheld terminal or an Epson portable computer from Synergetics; however, any terminal with RS-232 output can be used. The Epson portable computer allows platform programs to be stored on magnetic tape in the computer and then loaded to the platform when it is put into operation. This process allows complex programs to be loaded faster with less chance of mistakes.

The 3400 does not contain firmware algorithms for data manipulation; the algorithms must be defined and entered by the user. This makes the 3400 more complicated to put into operation but gives greater versatility in data sampling and manipulation. The basic 3400 has one "up" counter, two "up/down" counters, four 16-bit digital inputs, and eight analog inputs.

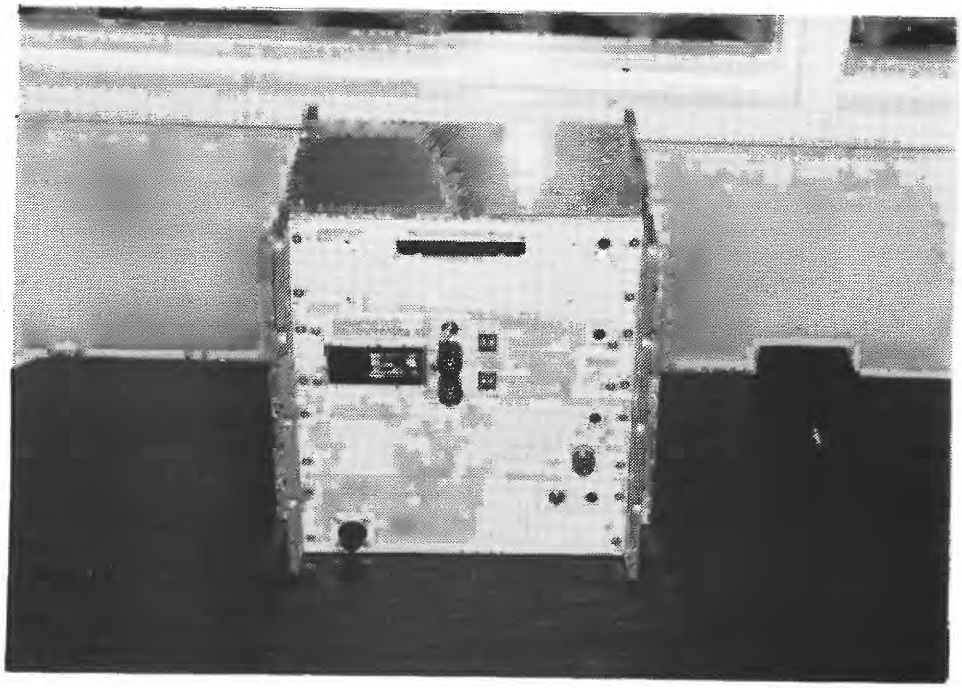

Figure 2.3.--Synergetics 3400 series data-collection platform (left) and incremental shaft encoder (right).

2.4.1 Synergetics 3400 Series Specifications

Electrical

* CPU	8-Bit 6802 with transparent, high-speed wake/sleep mode control	
* Memory (pluggable daughter board)	Up to 61,568 bytes RAM/PROM/ROM/EPROM/ EEPROM as required	
* External I/O	S-34 Bus® Control Port	
Power Available		
VBB	4 Amps	Maximum
+5 C	100 mA	Maximum
Analog Input Channel		
Input Voltage Range (AN+ and AN-)	-2.0 to +7.0 V DC	
Input Conversion Range (Differential)	0 to +5.0 V DC	
Resolution	8 bits	
Absolute Accuracy	±1 LSB	Typical
(Including offset, linearity, temperature)	±1½ LSB	Maximum
Input Impedence	10 MegΩ	Nominal
Digital I/O	Fully S-34-compatible	
Device Addressing	1-254	
Register Addressing (each device)	0-7 Read 0-7 Write	
* Programmer I/O		
Electrical Interface	RS-232C	
Handshake Support	DTR, CTS, RTS	
Wake Control	Positive Transition on DTR	
Baud Rate (Software-Selectable)	110-9600 Baud	Nominal
Mode	Full Duplex	
Terminal Power Available	+5.0 V DC @ 500 mA	Maximum
* Front Panel I/O		
Wake Control	Activate Button	
Display	Active LED	
* Calendar Clock	128 years with leap year settable and readable YR,MO, DAY, HR, MIN, SEC.	
* Alarm Clock	Automatically wakes MCM if in Sleep Mode and activates event(s) at preset YR, MO, DAY, HR, MIN, SEC.	
* Auxiliary Hardware Timer	Interrupts CPU at software-controlled frequency while in Wake Mode.	

2.4.1 Synergetics 3400 Series Specifications—Continued

* External Clock Reference Requirements†

Frequency	3.0 MHz	Nominal
Frequency Stability		
Temperature (-40° C to + 55° C)	$\pm 5 \times 10^{-7}$	Maximum
Long Term (1 year, including temperature)	$\pm 1 \times 10^{-6}$	Maximum
Input Level	0 - 5.0 V	Nominal
Duty Cycle (Square Wave)	50% ±10%	
Input Impedence	74C244 CMOS gate†	

Internal Diagnostic Channels

Channel #	Voltage Measured
0	+5 V_C (internal)
1	+5 C (to S-34 Bus®)
2	VBB
3	+5 V_S
4	+8 V_S
6	-8 V_S
7	Temperature

* Power Requirements

Input Voltage	+10.5 to +15.0 V DC	
Input Current (internal to MEM)		
Sleep Mode	+5.0 mA	Typical
Wake Mode (Memory Option Dependent)	200-300 mA	Typical

* Interface Connectors

Reference Input	con-hex Jack
Power In	Weidmuller SL-2
S-34 Bus®	3M-3494-1002
RS-232C Port	AMP 206486-1

S-FORTH® Operating System Version 1.0

* High-level language interface to hardware systems.
* S-FORTH® includes a stack-oriented, extensible, high-level language interpreter and compiler.
* S-FORTH® contains an extensive set of 16- and 32-bit integer arithmetic operators.
* S-FORTH® high-level interpreter facilitates interactive debugging of systems.
* Real-time Operating System with three levels of time-critical event timing
  1. 5 msec time-sliced event execution with highest level of priority.
  2. Pseudo-Interrupt-driven event execution with second-order priority.
  3. Chain events with variable priority, executing under the EXECUTIVE routine.
* Tasks can be enabled at each level and execute concurrently.

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† External Clock Reference required only for operation with GOES Data Collection Platorms or other high-stability timing applications; supplied by 3421A GOES Transmitter for GOES applications.

* Programmer Port (RS-232C) I/O executes concurrently with other tasks in the EXECUTIVE routine.

* Transparent software timers with 5 msec resolution; settable, resettable and readable.

* S-34 Bus® Commands

  1. CLEAR
  2. READ (Device Address, Register)
  3. WRITE (Device Address, Register, Data)

* S-34 Bus® Interrupts wake 3401A to initiate or execute an event

Environmental

* Operating Temperature	-40° C to +55° C
* Storage Temperature	-55° C to +85° C
* Relative Humidity	0-95% (non-condensing)
* Altitude	0-20,000 ft.

Mechanical

* Size (Standard 3400 Module)	2.62" H x 9.75" W x 9.50" D including all connectors
* Weight	3.75 lbs.
* Mounting	Case is stackable with all 3400 Series modules.

3.0 POWER SUPPLIES

A major element of any DCP installation is the electrical energy source necessary to power the platform and associated equipment. The power supply for a DCP installation should be designed carefully. A number of elements must be considered—amount of power used by the equipment, ambient temperatures, available sunlight (if solar panels are used), cost, vandalism potential, and time between routine visits to the site.

The answer obtained in any power-consumption calculation is the average current drawn by the system. For a power study, the power requirements must be expressed in ampere-hours (Ah). The average current, in amperes, is multiplied by the number of hours in the period—24 hours (day), 732 hours (30.5 day/month), 8,760 hours (year)—for which the power study is to be calculated. Most average power-consumption calculations are expressed in milliamperes (mA); therefore, the decimal place must be moved three places to the left to express the answer in amperes, such as 350 mA = 0.350 A.

The power supply for a DCP installation can be separated into two categories: (1) A system where the battery's state of charge is maintained at the site by a charging system such as a solar panel, AC power, or some other charging source and (2) a system where the battery must be changed periodically and charged at another location. On-site battery charging is the best type of system but is not always practical or possible; therefore, both approaches will be discussed. A power-supply system in which the battery charge is maintained on site can be divided into three elements: (1) battery, (2) regulator, and (3) charging-power source. These elements will be discussed in detail separately and how they relate to each other in a well-balanced power-supply system.

3.1 Batteries

Many different types of batteries are available; each type of battery has advantages and limitations. Batteries are generally classified into two types—primary and secondary. A primary battery cannot be recharged efficiently after it has been discharged; therefore, this type is not economically practical for a DCP power supply. A secondary battery is a storage battery that can be recharged many times after being discharged. The most common type of battery used in solar-panel charging and other float-charging systems is the lead-acid battery. The lead-acid battery is available in a number of sizes and types and is designed with different characteristics to satisfy different operational requirements. Not all lead-acid batteries are well suited to DCP application;. however, a sharp line of division does not exist between those types that are suitable to DCP application and those that are not. In general, an automotive battery is unacceptable, particularly where solar panels are used, because they typically exhibit self-discharge rates as high as 300 percent per year and can last as little as 2 years in float-charge service. Because solar panel sizes are typically 300 to 600 mA and batteries are generally 20 to 50 Ah in DCP installations, the self-discharge of an automotive-type battery could waste as much as 30 percent of the solar panel's output. The types of lead-acid batteries normally used for DCP installation are liquid electrolyte-calcium alloy grid and sealed-gelled electrolyte.

3.1.1 Liquid Electrolyte-Lead-Calcium Alloy Batteries

This type of lead-acid battery is made in sealed and unsealed versions and is the type most commonly used for solar-panel charging systems. The grids are made from lead-calcium alloy rather than the lead-antimony alloy used in conventional lead-acid batteries. The lead-calcium construction reduces self-discharge losses by almost an order of magnitude over the lead-antimony batteries. This is particularly true at high temperatures.

Most conventional lead-acid batteries are acid limited, which is particularly true of the gelled-electrolyte and starved-electrolyte batteries. Acid limited means that the ultimate capacity of the cell is limited by the amount and concentration of acid electrolyte present in the cell. The design of the cells specifically used for photovoltaic application have overcome this shortcoming by increasing both the volume of available electrolyte and its concentration. These two factors not only improve the capacity but also prevent freezing of the electrolyte when the cells are in a deep-discharge condition. Most batteries designed for photovoltaic application have a full-charge specific gravity of 1.300. A curve showing the relation between the electrolyte's (H_2SO_4) specific gravity and the freezing point is shown in figure 3.0. The relation between specific gravity and percent 500-hour capacity is shown in figure 3.1.

An advantage the liquid electrolyte battery has over the gelled- and starved-electrolyte battery is that the state of charge can be determined by measuring the specific gravity of the electrolyte. Most batteries of this type are supplied with a built-in hydrometer for determining state of charge, which can be of great help when partial shading at a site may cause solar panels to be marginally sized. The state of charge of the battery can be observed over several months and can be compared with the power-supply analysis. If a power deficit is going to occur, it can be predicted and the solar-panel array or battery capacity can be enlarged before any power failure takes place. Most liquid electrolyte-calcium-lead alloy batteries should last from 10 to 15 years if given proper care, and these batteries are recommended for cold climates where solar-panel charging is to be used.

3.1.2 Sealed Gelled-Electrolyte Batteries

The gelled-electrolyte batteries have the advantage of being spill proof which makes transportation easier. Sealed gelled-electrolyte

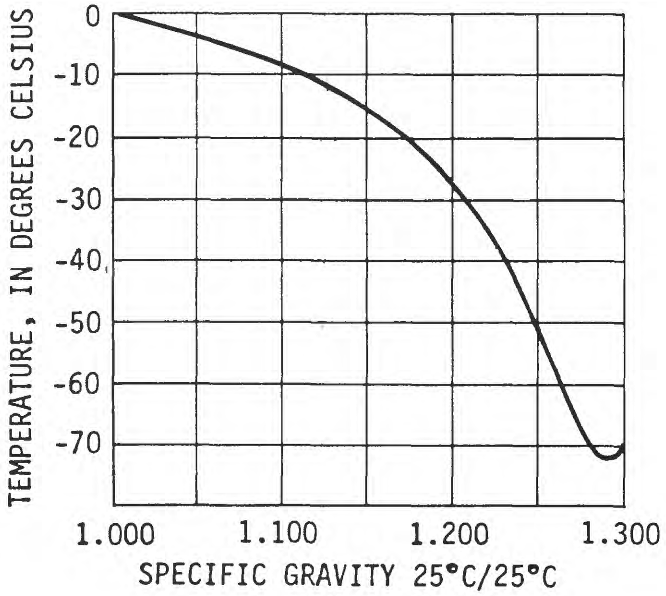


Figure 3.0--Freezing point of electrolyte H_2SO_4 versus specific gravity.

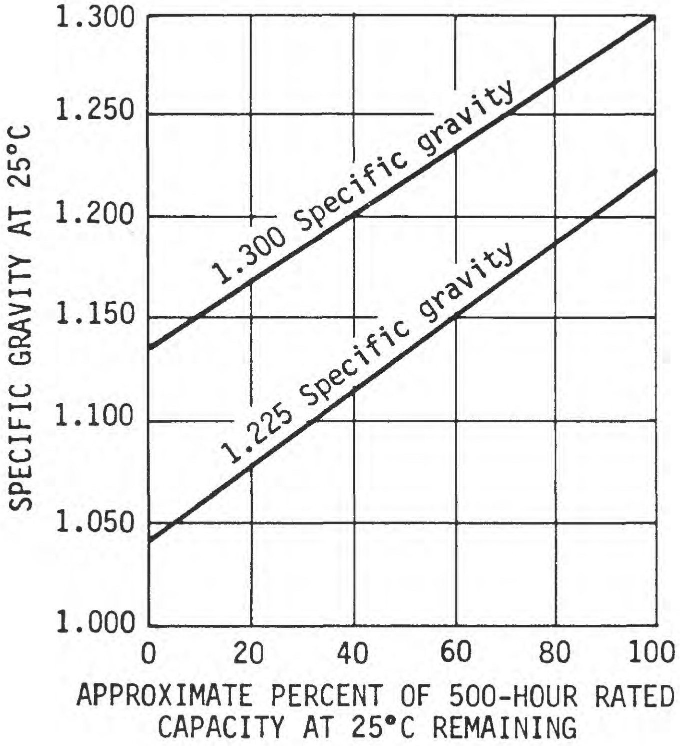


Figure 3.1.--Approximate 500-hour rated capacity remaining versus specific gravity for lead-calcium battery.

batteries also tend to be smaller in relation to their rated capacity than the liquid electrolyte photovoltaic batteries, because gelled batteries do not have as much active material and electrolyte. Some gelled-electrolyte batteries however have a tendency to fail suddenly or will not recover after being deep discharged. The gelled-electrolyte battery is widely used to power DCP installations and with proper sizing should last from 2 to 4 years if they do not go into deep discharge. If gelled or any other sealed batteries are used with a solar panel, a voltage regulator must be included for reliable charging operation and long battery life.

3.1.3 Lead-Acid Battery Specifications

Before batteries are purchased, the manufacturer's specifications should be consulted to determine if the batteries meet the requirements for the job they are to perform. The capacity, voltage, specific gravity of electrolyte, self-discharge rate, temperature characteristics, and battery construction can be determined from the specifications.

3.1.4 Battery Capacity

Secondary battery capacities are expressed in ampere hours—the product of the current being drawn from the battery in amperes times the number of hours taken to deplete the battery—for example, 2 amperes x 25 hours = 50 ampere-hour (Ah). A lead-acid battery however does not have a fixed capacity but is dependent on the rate at which it is being depleted, the temperature at which it is operated, and the final cell voltage at which the battery is considered depleted. The ampere-hour capacity of lead-acid batteries is usually specified together with some standard hour rate of discharge, such as 8 or 20 hours. The load is set so that the current drawn from the battery will completely discharge it in the specified period. This means that the battery has a certain ampere-hour capacity if it is discharged at the specified hour rate. If the battery is discharged for a longer period at a lower current drain, the capacity will be somewhat higher; therefore, the capacity of a battery can only be expressed in terms of the job it is to perform. The discharge rate for batteries over 20 Ah employed at DCP installations is in excess of 500 hours. Not all manufacturer's specifications give rates as high as 500 hours; therefore, capacity of the battery should be determined on the basis of the highest hour rating given.

Temperature also affects the capacity of a battery. If the temperature of a lead-acid battery is lowered, the capacity will be lower, which must be taken into consideration when sizing a battery for a DCP installation. Figure 3.2 shows the relation between cell temperature and capacity for a typical lead-calcium battery. The curve for the 500-hour discharge rate would be the expected performance for this type of battery at a DCP installation. A manufacturer's specifications will usually give battery capacities at several different temperatures.

Another critical element in determining the usable capacity of a battery is the final cell voltage the manufacturer uses in rating the battery. The final volts per cell (VPC) can range from 1.50 to 1.95 VPC. The final VPC is important because if a battery's rated capacity is 30 Ah per 500 hours per 1.75 final VPC, only part of the 30-Ah capacity is usable to operate a DCP. This is because 1.75 volts times six cells (12-volt battery) equals 10.5 volts, which is too low a voltage to operate most DCP's. A well-matched system should not allow the battery to drop below 50-percent capacity, and in extremely cold conditions it should be designed to drop less than that. The battery's reserve however may be called on to power the equipment if the charging system fails. This reserve capacity should be determined on the basis of no less than a final VPC of 1.90 volts (1.90 volts x 6 cells = 11.4 volts).

An example of typical battery specifications is shown in table 3.0. The example used is for a C & D 6-volt lead-calcium photo-voltaic battery. Two batteries in series would be needed for a complete battery pack. The specifications show that this particular battery can tolerate -70°C at full charge and -20°C at 100-percent discharge before freezing (table 3.0 and fig. 3.0). Many lead-acid batteries have full-charge specific gravities of 1.225 or less and would freeze at about -35°C in full charge and about -5°C at 100-percent discharge. Thus, with a final VPC of 1.95 volts, all the battery's rated capacity could be used without going below the operating voltage of the DCP. Figure 3.3 shows three typical lead-acid type batteries.

3.2 Charger-Regulators

A regulator is used between the solar panel and the battery to insure that the charging voltage does not become higher than the recommended float voltage. If a battery is charged at an excessively high voltage, the battery life can be substantially shortened. This is particularly true of gelled-electrolyte batteries that require float voltages of 13.5 to 13.8 volts for a 12-volt battery. Liquid electrolyte lead-acid batteries require float voltages of 14.1 to 14.5 volts.

3.2.1 USGS Hydrologic Instrumentation Facility Regulator

The Hydrologic Instrumentation Facility (HIF) of the U.S. Geological Survey has a good temperature-compensated regulator available through their catalog—Stock No. 5305007 (fig. 3.4). This regulator provides for convenient hookup of the solar panel or other direct-current (dc) input, with the battery and the 12-volt power supply for the DCP. In addition to the 12-volt power supply, the regulator also provides a 7½-volt output for a manometer or other equipment requiring the lower voltage. The USGS regulator is repairable whereas many of the regulators sold by the solar-panel companies are potted and are not repairable. Another advantage of the USGS regulator is that the float-charging voltage to the battery can be set by the user. The voltage is set by removing the cover and, while applying 16 to 18 volts to the dc

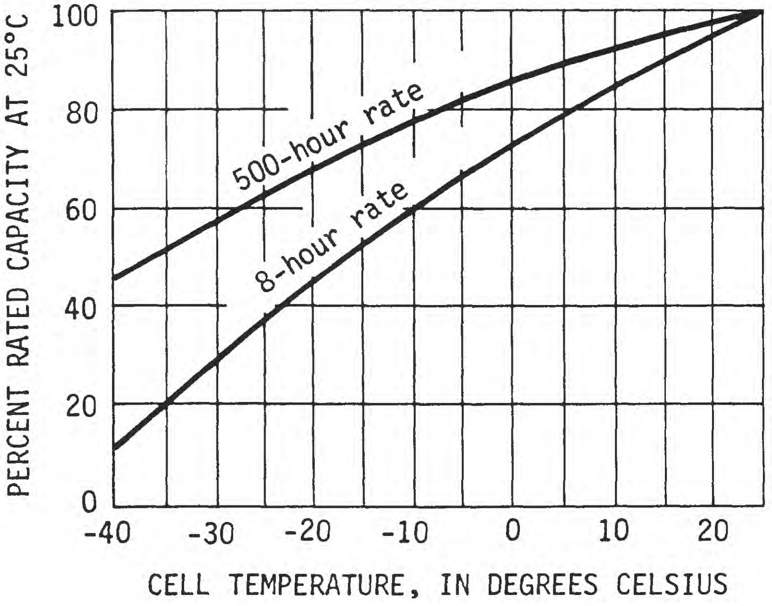


Figure 3.2.--Typical lead-calcium cell capacity versus cell temperature.

Table 3.0.--Example of manufacturer's battery specifications

Cell	Ampere-hour capacity				
	8 hour	100 hour	500 hour		
Type	25°C	25°C	25°C	0°C	18°C
3 DCPSA-3	31	42	50	45	36

Specific gravity at 25°C - full charge = 1.300

Specific gravity at 25°C - 100-percent discharge - 1.130 @ 500-hr rate

Specific gravity at 0°C - 100-percent discharge - 1.180 @ 500-hr rate

Final voltage @ 500-hr capacity - 1.95 volts per cell

Self-discharge rate - 1 percent per month @ 25°C, 6 percent at 40°C

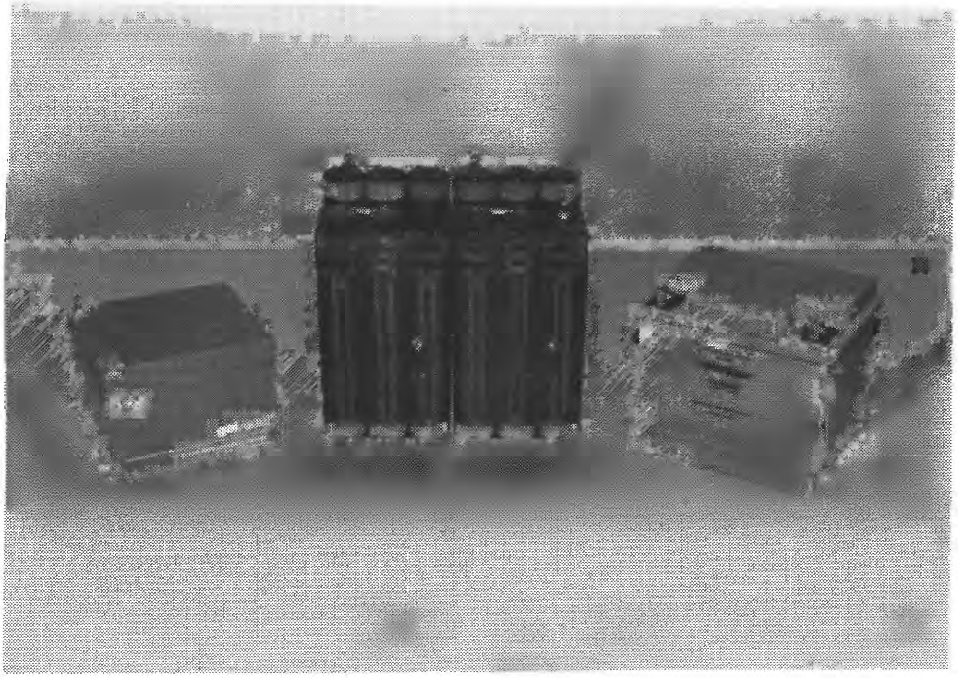


Figure 3.3.--Globe 20 ampere-hour gelled-electrolyte battery (left), C & D 50 ampere-hour lead-calcium battery (center), and Power Sonic 40 ampere-hour gelled-electrolyte battery (right).

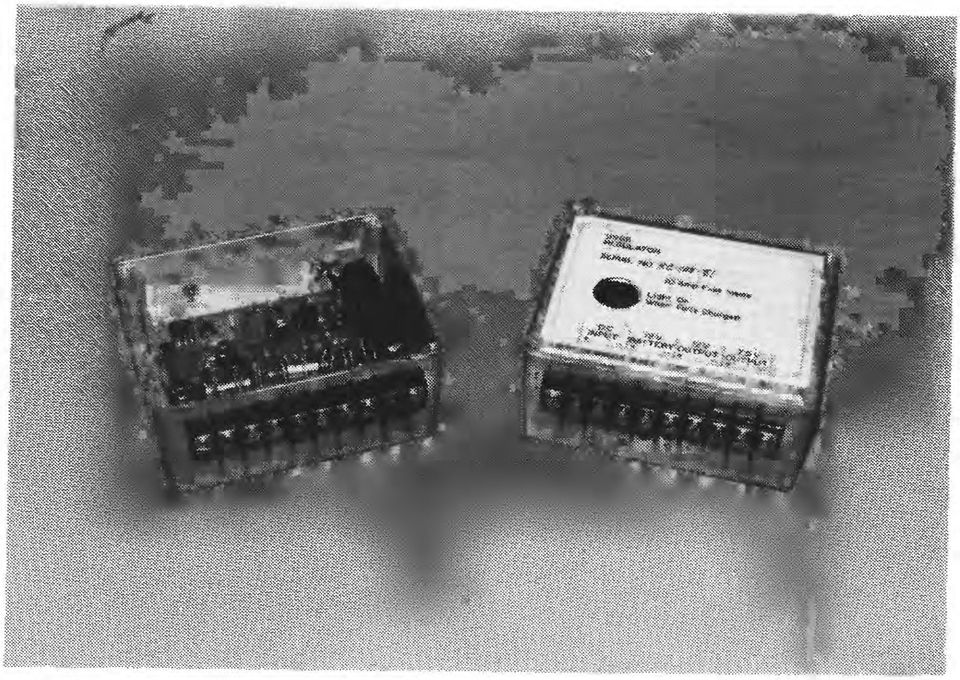


Figure 3.4.--USGS charger-regulator.

input, adjusting the trim pot on the printed-circuit board until voltage at the terminal marked "battery" is at the desired level. The battery should not be connected to the regulator while performing this adjustment. A solar panel or regulated dc power supply can be used for the input, and a digital voltmeter is used to measure the output. The output or float-charging voltage will depend on the kind of battery being used. This information is included on the battery manufacturer's specifications. Typically, the USGS regulators are already set at 13.7 volts, which is the value for gelled-electrolyte batteries, but the float voltage should still be checked before installing the regulator.

3.3 Power Supply Where Alternating Current is Available

If 110-volt alternating current (ac) is available at a station, it can be used as a charging source for the DCP battery. Because the ac power is supplied constantly (except during power failures), a much smaller battery is needed than is used in a solar-charging system. A 6 to 8 Ah gelled-electrolyte battery is an adequate size for this type of power system.

Data-collection platforms powered directly by an ac to dc power supply should never be put into service without a battery in the power circuit. With a battery in the power circuit, the DCP will not lose its program and timing and will continue to operate properly even if ac power is lost.

The proper type of charger must be used when batteries are being charged continuously from an ac source. A float charger for gelled electrolyte batteries delivers a constant voltage of 2.25 to 2.30 VPC (13.5 to 13.8 volts for a 12-volt battery), which allows the battery to seek its own current level and maintain itself in a fully charged condition. If a typical cycling charger is used under these conditions, full-charge voltages may reach as high as 2.45 VPC (14.7 volts for a 12-volt battery) and, after the battery reaches full charge, excessive current will flow and cause decomposition of water in the electrolyte, and hence a shorter battery life.

Battery manufacturers' specifications will give charging requirements for their batteries and the requirementts should be adhered to in order to obtain maximum service life. In many cases, the battery manufacturers sell chargers that are designed especially for their batteries.

3.4 Periodic Battery Exchange

If batteries are to be periodically exchanged and charged at some other location, the battery or batteries should be as large as is practical to handle and store at the site. The larger the battery the less often it will have to be exchanged.

When the size has been selected, a determination can be made of how often the batteries need to be changed. This is done by first determining how much of the battery's capacity may be reduced by temperature, self-discharging, and aging. The terminal voltage of a lead-acid battery will begin decreasing at a rapid rate when the battery has been discharged to about 60 percent of its capacity; therefore, the battery should not be discharged below what is considered the minimum operating voltage for the DCP. The minimum operating voltage for most DCP's is 10.7 volts; however, 11.5 volts would be better for computing battery life because supply voltages below that value may cause the DCP transmission-power output to be marginal. The 11.5 volts could be higher or lower depending on the DCP location, length of antenna coaxial cable, and other factors that govern RF output. When all the factors that affect the available capacity of a lead-acid battery are considered and some margin of safety is added, only about 60 to 75 percent of the battery's 20-hour rated capacity generally is available to power the DCP between charges.

3.5 Solar Panels

Solar panels may be called photovoltaic chargers, solar-cell arrays, solar-electric generators, or light-energy converters. All these terms mean essentially the same thing. Solar panels probably are the easiest and most cost-effective way to provide an uninteruptible power supply at a DCP installation where ac power is not available. Solar panels are relatively maintenance free, simple to install, highly reliable, and reasonably priced. Two major problems that can limit the use of solar panels are vandalism and excessive shading. Vandalism and theft are common problems at many gaging stations and cannot be totally eliminated; however, some steps can be taken to minimize them. The solar panel can be protected by cutting a hole slightly smaller than the solar panel in the top of the gage shelter, mounting a sheet of clear 3/8- to 1/2-inch high-impact polycarbon over the opening from the inside, and mounting the solar panel beneath the polycarbon sheet. This protective installation cannot be used in areas where snow might cover the panel; also, the solar panel may need to be 20 to 30 percent larger because of the poor solar angle. For a mast-mounted solar panel, a protective plate can be installed on the mast as described in figure 3.5. Covering a mast-mounted solar panel with a polycarbon sheet will also help to protect it from vandalism.

Problems of excessive shading of the solar panel are sometimes difficult if not impossible to overcome. The amount of shading would be considered excessive if the solar panel is in direct sunlight for less than 40 percent of the day. If the solar panel is partially shaded, the size of the solar panel or battery, or both, must be increased proportionately beyond the size recommended by the basic power analysis. Do not make the assumption that solar-panel charging is not a viable method even when partial shading occurs. Only from a power analysis can it be determined if solar panels are practical.

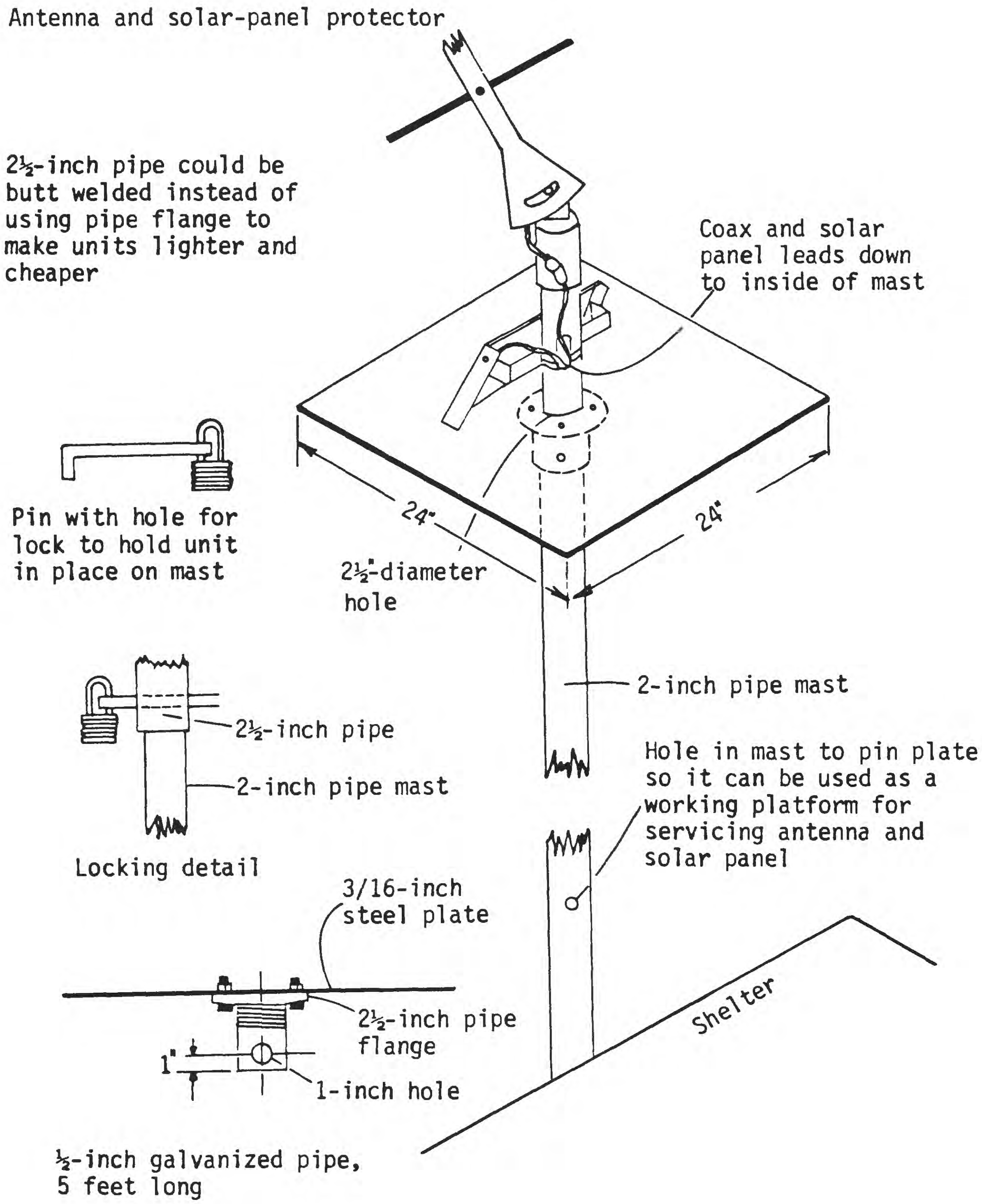


Figure 3.5.--Antenna and solar-panel antitheft device.

When estimating the effects of shading on power production, the time of day that shading occurs on the solar panel must be considered. Shading in the morning and late afternoon will cause far less power loss than shading during midday. The current output from a Solarex 435H solar panel facing south at a 45° angle on a cloudless day in September is shown in figure 3.6. The total Ah output for that particular day was 2.52 Ah, and 1.4 Ah or 56 percent of the total output was produced in the 4-hour period between 1000 and 1400 hours.

Where shading is caused by a fairly low canopy of vegetation, a higher antenna mast can be used to position the solar panel above the shade. Where shading is caused by some feature close to the gage, such as a bridge or cliff, the solar panel can be located at a point away from the gage. If the solar panel is located within 50 feet of the battery, 18-gage wire can be used to connect the panel to the voltage regulator. For distances of 100 feet or greater, 16- to 14-gage wire should be used to avoid excessive power loss.

3.5.1 Current Versus Voltage Curves

When a source of electrical energy is used, it is helpful to know how the terminal voltage and current will vary as the load is changed. One way to represent the relation between voltage and current of a solar cell under a load is by a curve that shows current and voltage output as load resistance is varied over a large range. If a load resistance applied to the cell is so high that for all practical purposes it could be considered an open circuit, the current would be zero because no current can flow into an open circuit. Under these conditions, the silicon solar cell would have a terminal voltage of about 0.56 volts. If the cell is subjected to 1 sun (1 kW/m^2) and the load resistance is decreased, the terminal voltage will drop very slowly but the current will increase rapidly. This rapid increase continues until the voltage has dropped to about 0.45 volts and the current has increased to about 100 percent of rated output (See point A on the curve in figure 3.7). The shape of the curve changes drastically at this point and is called the knee of the voltage-current curve. If the load resistance continues to decrease, the voltage will continue to drop, but the current will remain nearly constant. When the load resistance reaches zero, the voltage will be zero, because there cannot be a voltage across a short circuit. Point A in figure 3.7 represents the solar cell's optimum output in full sun. If the cell receives less sun, it will produce less current; however, the voltage produced by the cell will remain about the same. Solar cells are designed to operate at or above the knee of the voltage-current curve when battery load is applied. The cell operating at this point on the voltage-current curve will output its maximum power for any given light level.

To use solar cells as a charging device for a battery, enough cells must be connected in series to produce the necessary voltage. The array of solar cells constitute the solar panel. Solar panels used for

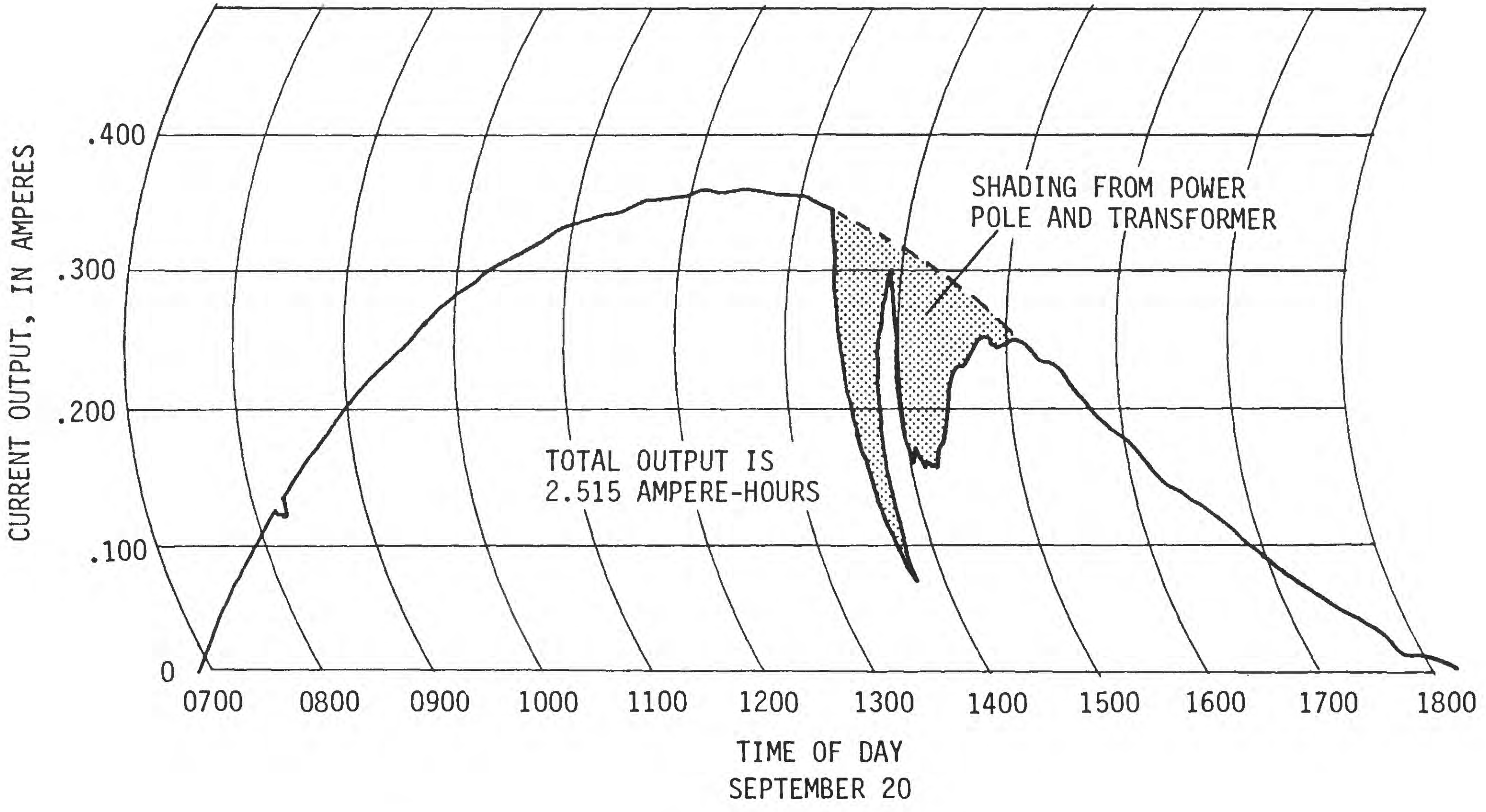


Figure 3.6.--Current output from Solarex 435H solar panel.

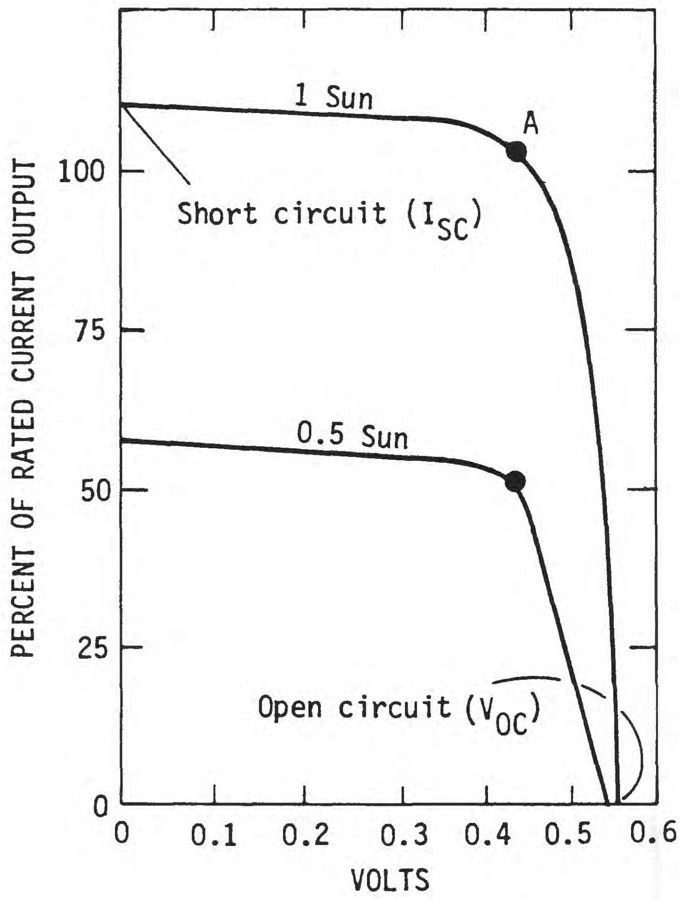


Figure 3.7.--Typical voltage-current relation under varying load of a silicon solar cell.

charging 12-volt batteries will contain from 32 to 36 cells, which gives them working voltages from about 14 volts (32 x 0.45 volts) to 16 volts (36 x 0.45 volts). The voltage needs to be higher than the nominal battery voltage because a 12-volt lead-acid battery requires a float-charge voltage of about 13.5 to 14.5 volts at 25°C, depending on the type of battery construction. Voltage losses also occur in the solar panel's blocking diode and in the wires from the panel to the regulator. High temperatures will also cause the solar panel to produce less than the rated voltage.

Owing to the voltage drop, the 16-volt (36 cells) panel is the best suited to deliver the necessary charging voltage under the worst condition, whereas the 14-volt (32 cells) panel may be marginal. When 16-volt solar panels are used for charging batteries, a voltage regulator should be employed, particularly for gelled-electrolyte batteries. If a voltage regulator is not used, the solar panel will deliver excessive voltage when operating under optimum conditions and substantially shorten the battery's life.

A blocking diode must always be used with a solar charger. Otherwise, the solar panel will discharge the battery at night and might damage the solar cells. Voltage regulators that are designed for photovoltaic charging generally include a blocking diode in their circuitry.

3.5.2 Manufacturers' Specifications

When selecting solar panels for a power system, it is advisable to gather information from a number of manufacturers so that a selection can be made from various sizes and prices. The manufacturer's specifications will contain information similar to that shown in table 3.1. The two most important items to consider are the voltage at peak power and the current at peak power, sometimes referred to as the current at nominal voltages. The panel should be capable of delivering the necessary voltage for your particular power system as described earlier. The current output should be high enough to keep the battery charged while supplying power for the DCP equipment. Solar panel current output is discussed in section 3.6, "Power-Supply Analysis."

3.6 Power-Supply Analysis

A power-supply analysis is used to determine the size of solar panels and batteries needed to power a DCP installation. The elements that must be considered in such an analysis are (1) the amount of power needed to operate the platform and associated equipment; (2) the amount of available solar insolation; (3) minimum air temperatures; and (4) operational considerations, such as remoteness of the site and time between scheduled visits.

Table 3.1.--Information typically supplied on solar panel manufacturers' specifications

[Panel characteristics at standard condition: 1 kW/m^2 illumination (1 sun) at 25°C. Individual panels may vary ±10 percent]

Type	X
Peak power (W)	6.5
Current (A) at peak power	0.4
Voltage (V) at peak power	16.0
Open-circuit voltage (V)	20.5
Watt-hour per week[1]	180
Ampere-hour per week[1]	12.0

[1]Output based on U.S. average insolation.

3.6.1 Operating Power

The first element to determine in a power analysis is the amount of power needed to operate the system, which includes the platform and all other equipment requiring electrical power. The platform manufacturers' manual should be consulted when computing power consumption for a particular platform. If the power-consumption calculation is complex owing to the number of sensors or some unusual situation, the platform manufacturer should be consulted for assistance. The result of this calculation will be the average current used by the system and is usually expressed in milliamperes (mA). For most DCP installations, the average current requirement will range from 15 to 35 mA.

3.6.2 Amount of Available Solar Insolation

The amount of solar insolation, as it relates to solar-panel power production, can be determined for any point in the continental United States using figures 3.9 through 3.20. The isolines on these maps represent the total monthly Ah output per A of rated solar-panel output. To find the Ah output of any given solar-panel size for a particular month, multiply the solar panel's maximum rated current by the value of the isoline. For example, 60 (Nov. in Central Ill.) times 0.4 Ah (400-mA panel) equals 24 Ah of output.

3.6.3 Minimum Air Temperature

If the power system is to be operated in a cold climate, the minimum average daily air temperature should be determined from weather records so that the final battery size can be adjusted upward to allow for derating due to low temperatures. The graph shown in figure 3.2 can be used to determine the capacity loss as a result of low temperatures.

3.6.4 Operational Considerations

To help eliminate unscheduled visits to a station because of a failure in the battery-charging system, the battery should be large enough to operate the system until a scheduled visit is made. Failures in the charging system can be caused by the vandalizing or theft of the solar panel or by failure of the regulator. The amount of additional battery capacity needed will depend on the frequency of scheduled visits and the average power consumption of the equipment. Sixty days of reserve power would be reasonable for most DCP installations.

An example of a power-supply analysis for Central Illinois is shown in table 3.2. The values in column 1 of table 3.2 are taken from figures 3.9 through 3.20, which show solar-panel output for each month of the year throughout the continental United States. Columns 2 and 3

Table 3.2.--Example of power-supply analysis for central Illinois

Month	(1) Ampere-hours per ampere	(2) Ampere-hours, 0.4-ampere panel	(3) Ampere-hours, 0.6-ampere panel	(4) Ampere-hours, 0.6-ampere panel, less 40 percent for shade	(5) Power used, ampere-hours (35 mA average)	(6) Surplus (+) or deficit (-), in ampere hours	(7)	(8)	(9) Accumulated deficit, in amperes	(10)	(11)
						A	B	C	A	B	C
June	150	60	90	54	26	+34	+64	+28	0	0	0
July	150	60	90	54	26	+34	+64	+28	0	0	0
August	130	52	78	46	26	+26	+52	+20	0	0	0
September	107	43	64	38	26	+17	+38	+12	0	0	0
October	80	32	48	29	26	+6	+22	+3	0	0	0
November	55	22	33	20	26	-4	+7	-6	-4	0	-6
December	40	16	24	14	26	-10	-2	-12	-14	-2	-18
January	50	20	30	18	26	-6	+4	-8	-20	0	-26
February	70	28	42	25	26	+2	+16	-1	-18	0	-27
March	85	34	51	31	26	+8	+25	+5	-10	0	-22
April	110	44	66	40	26	+18	+40	+14	0	0	-8
May	140	56	84	50	26	+30	+58	+24	0	0	0

show the monthly Ah output for 400 mA and 600 mA solar panels (column 1 multiplied by 0.4 and 0.6, respectively). Column 4 is the monthly Ah output from a 600 mA solar panel reduced 40 percent by shading. Column 5 is the power used by the equipment (0.035 A x 24 hours x 30.5 days). Columns 6, 7, and 8 are the surpluses or deficits of power production for each month for the 0.4-Ah, the 0.6-Ah, and the 0.6-Ah (less 40 percent) panels, respectively. The surpluses and deficits are determined by subtracting the power used from the power produced (value in column 2, 3, or 4 minus the value in column 5). Columns 9, 10, or 11 are the accumulative power deficits with time and are the values used to determine solar-panel and battery sizes needed. In column 9, which is the accumulative deficit for a 400 mA panel, the maximum deficit is 20 Ah. Therefore, the battery would have a capacity of at least 20 Ah. Because it is not good practice to allow the battery to be discharged below 50 percent of capacity, however, the minimum-size battery selected for the conditions of this example should be 40 Ah. If a larger solar panel is used, the required battery size would be smaller. If a power reserve is required, the capacity of the battery must be increased depending on the amount of reserve needed. As can be seen in table 3.2, both the solar-panel and battery sizes can vary for any given power requirement. The purpose of the power-supply analysis is to serve as a guide in the selection of a good balance between solar-panel size and battery size. A graphical representation of the accumulated deficit of the example of power-supply analysis is shown in figure 3.8.

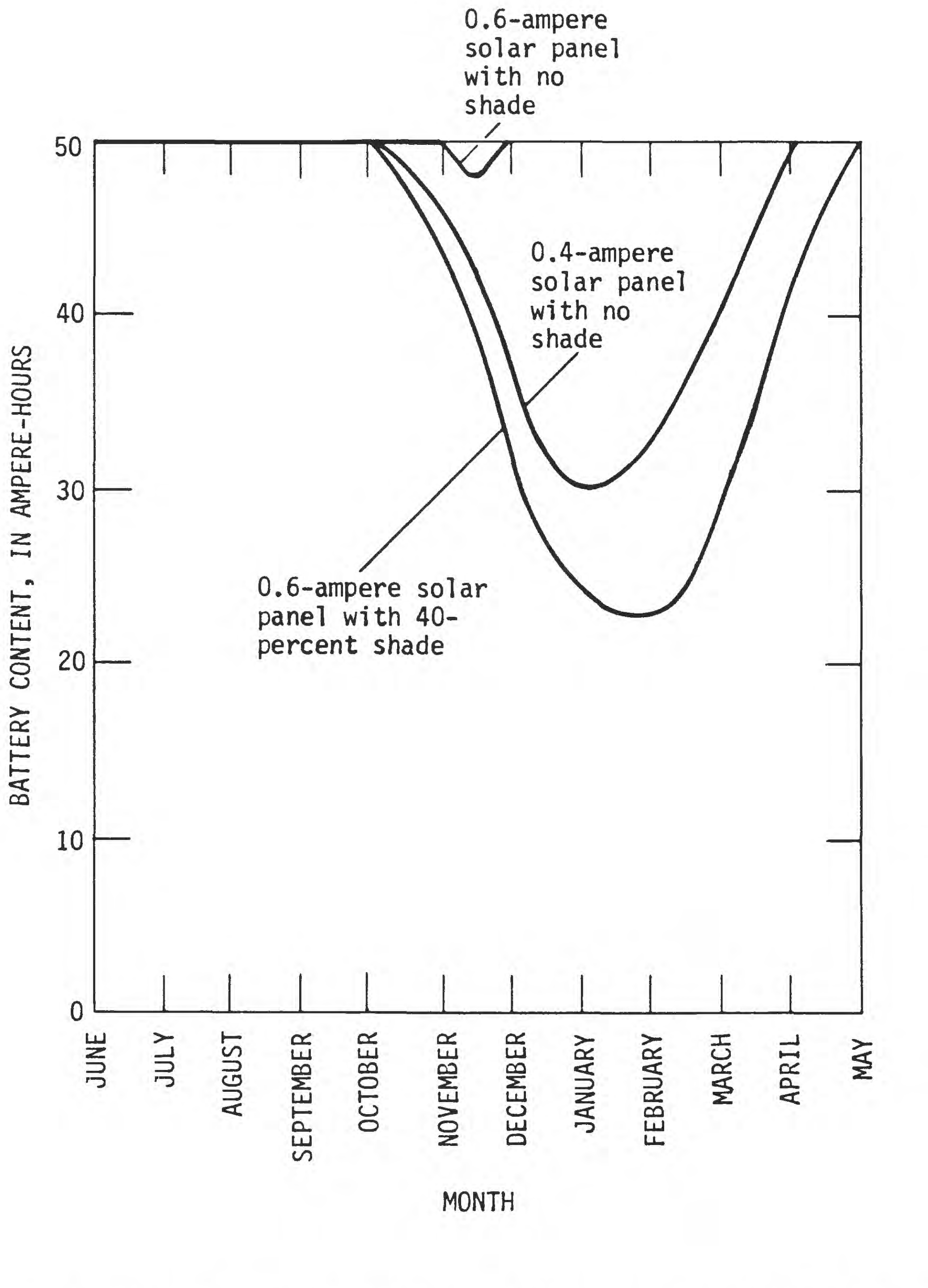


Figure 3.8.--Example of power-supply analysis for central Illinois.

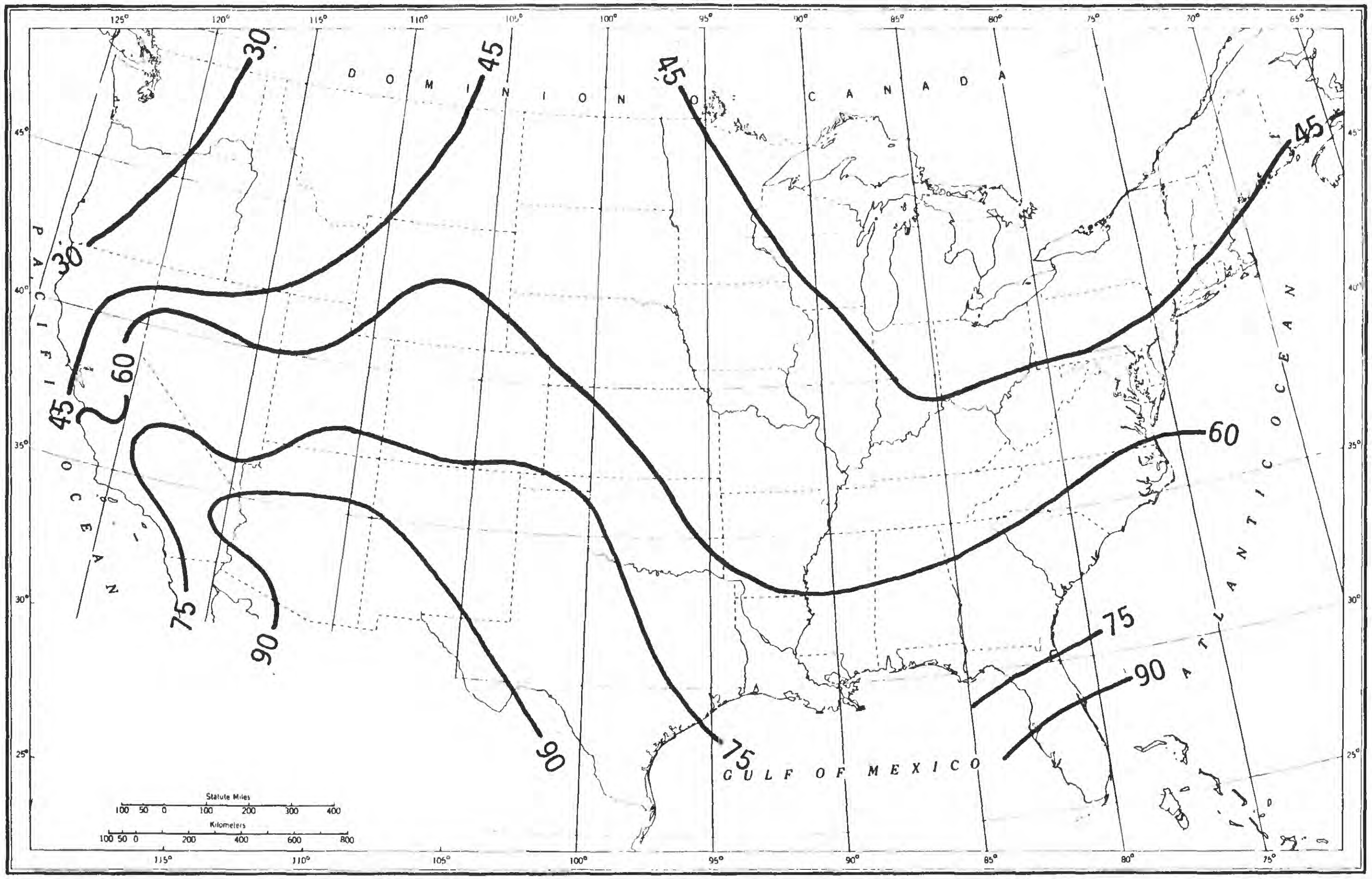


Figure 3.9.--Isoline of ampere-hour output from solar panels for January.

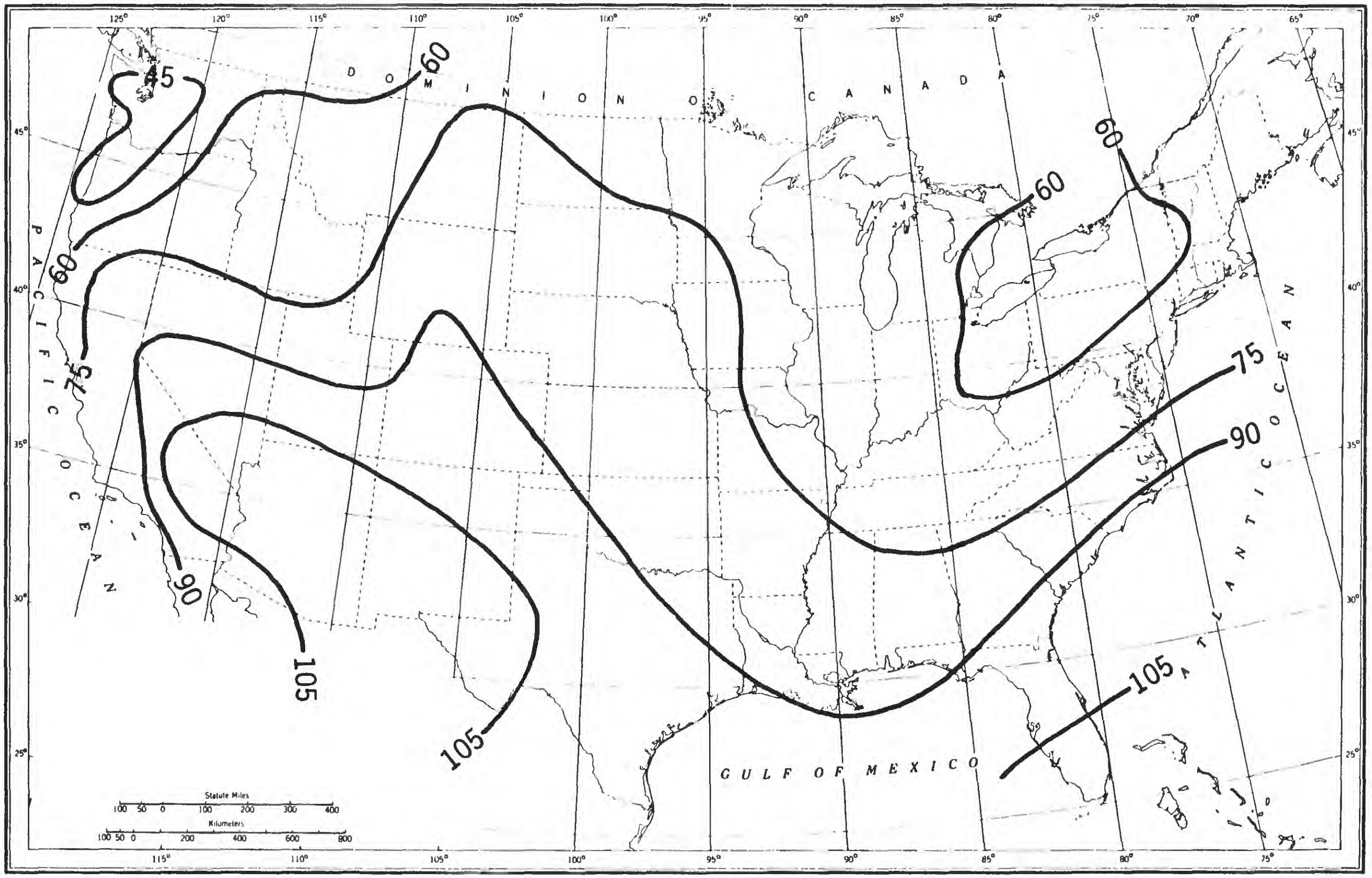


Figure 3.10.--Isoline of ampere-hour output from solar panels for February.

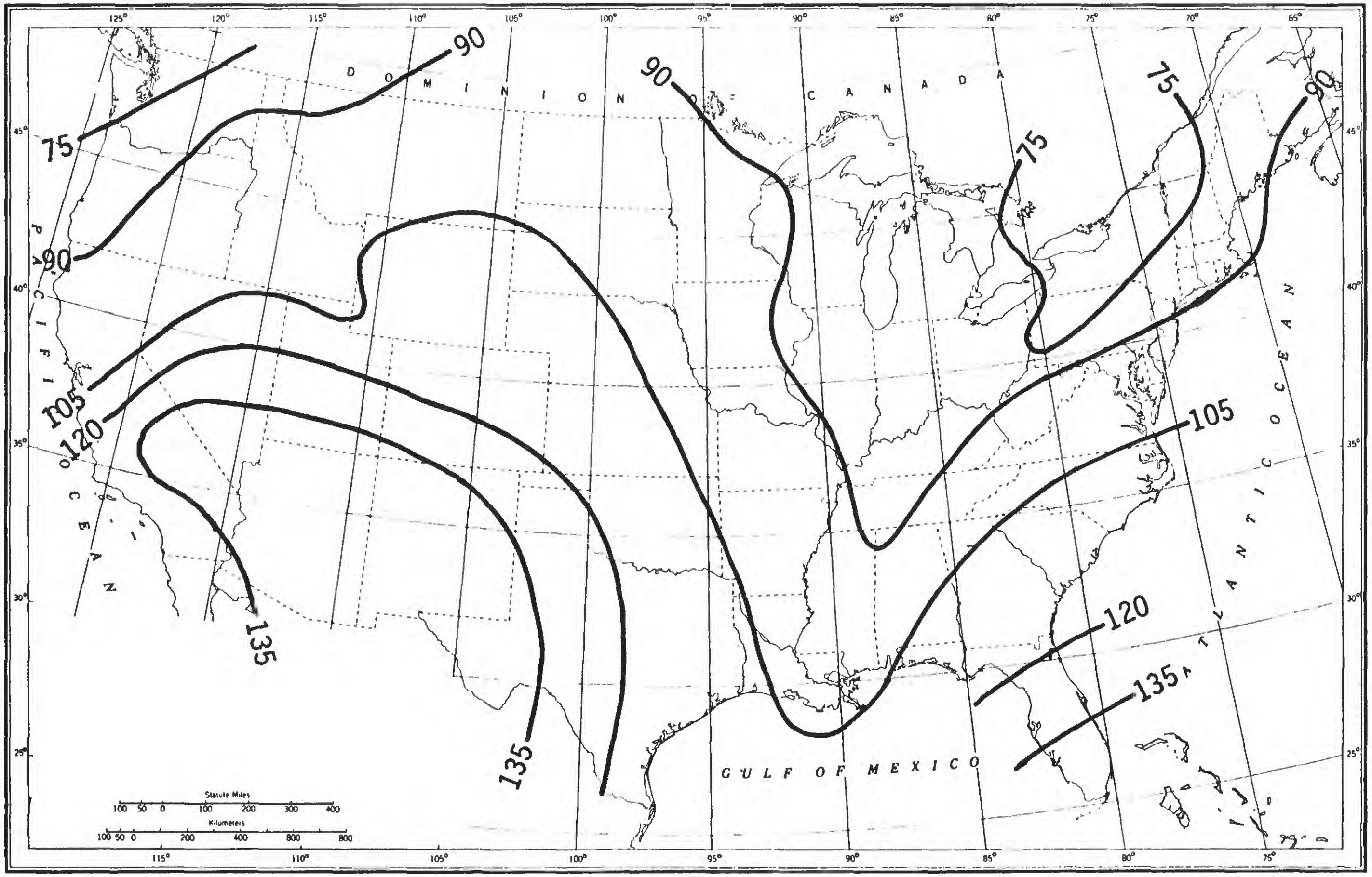


Figure 3.11.--Isoline of ampere-hour output from solar panels for March.

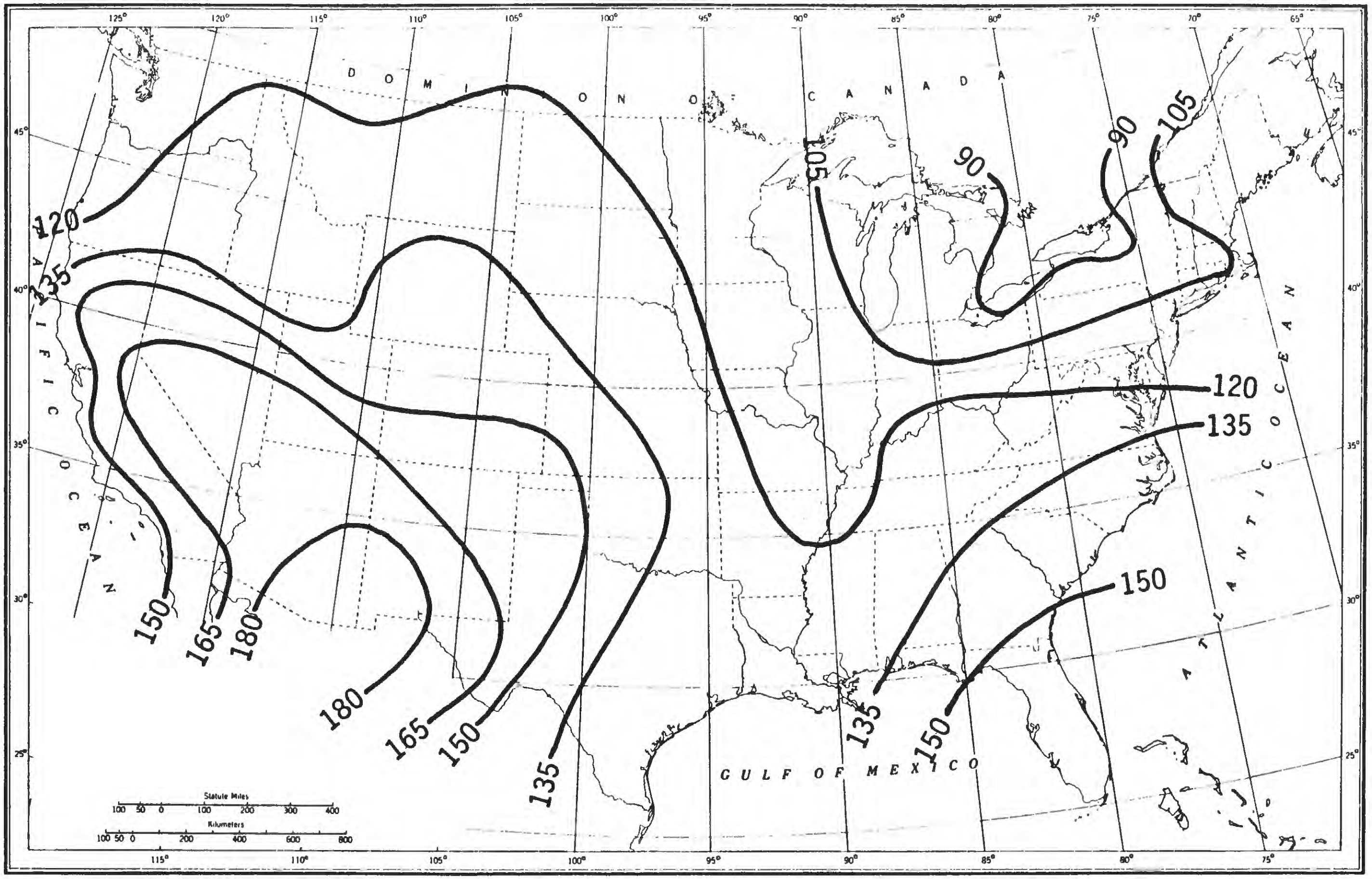


Figure 3.12.--Isoline of ampere-hour output from solar panels for April.

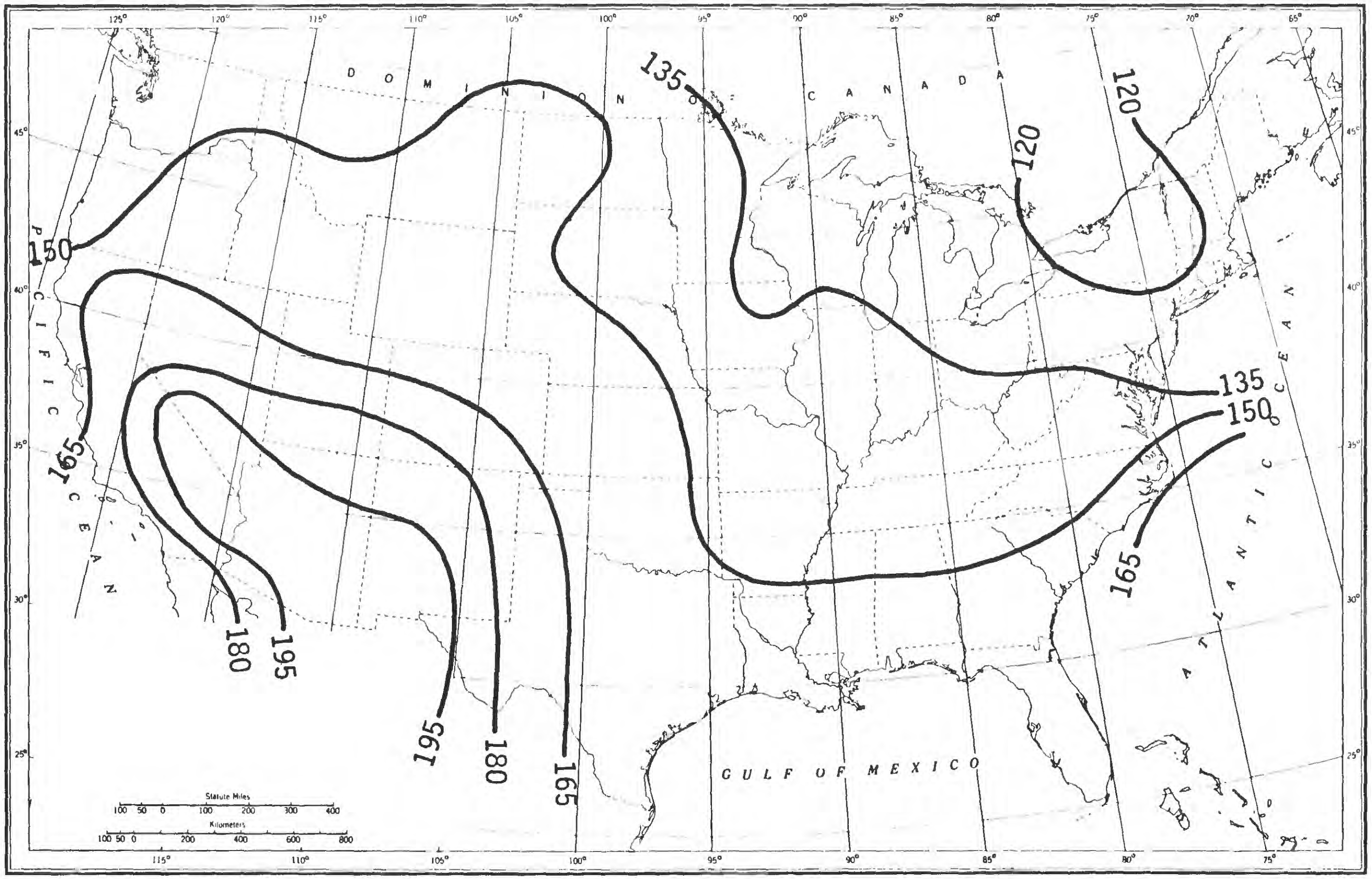


Figure 3.13.--Isoline of ampere-hour output from solar panels for May.

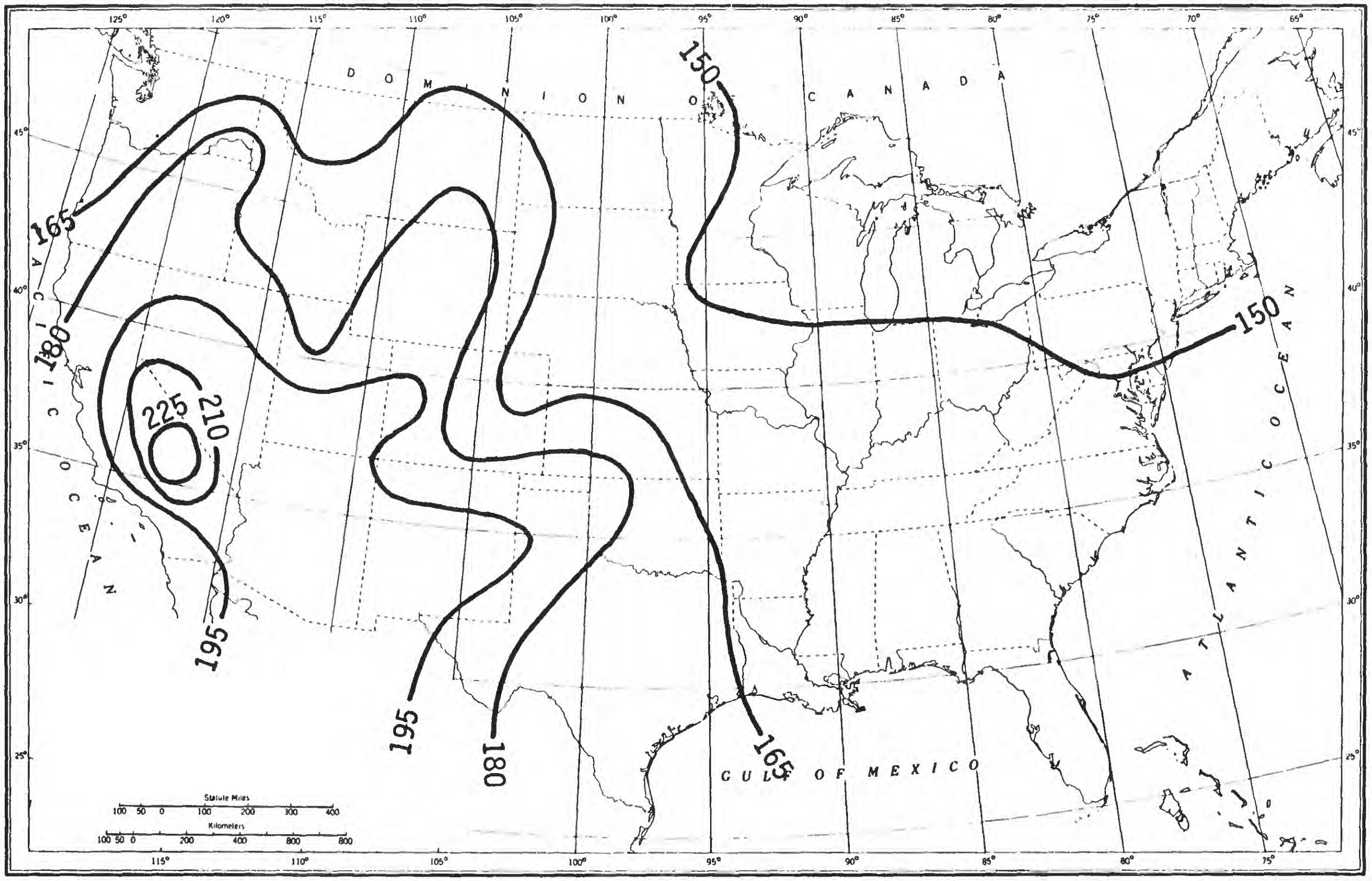


Figure 3.14.--Isoline of ampere-hour output from solar panels for June.

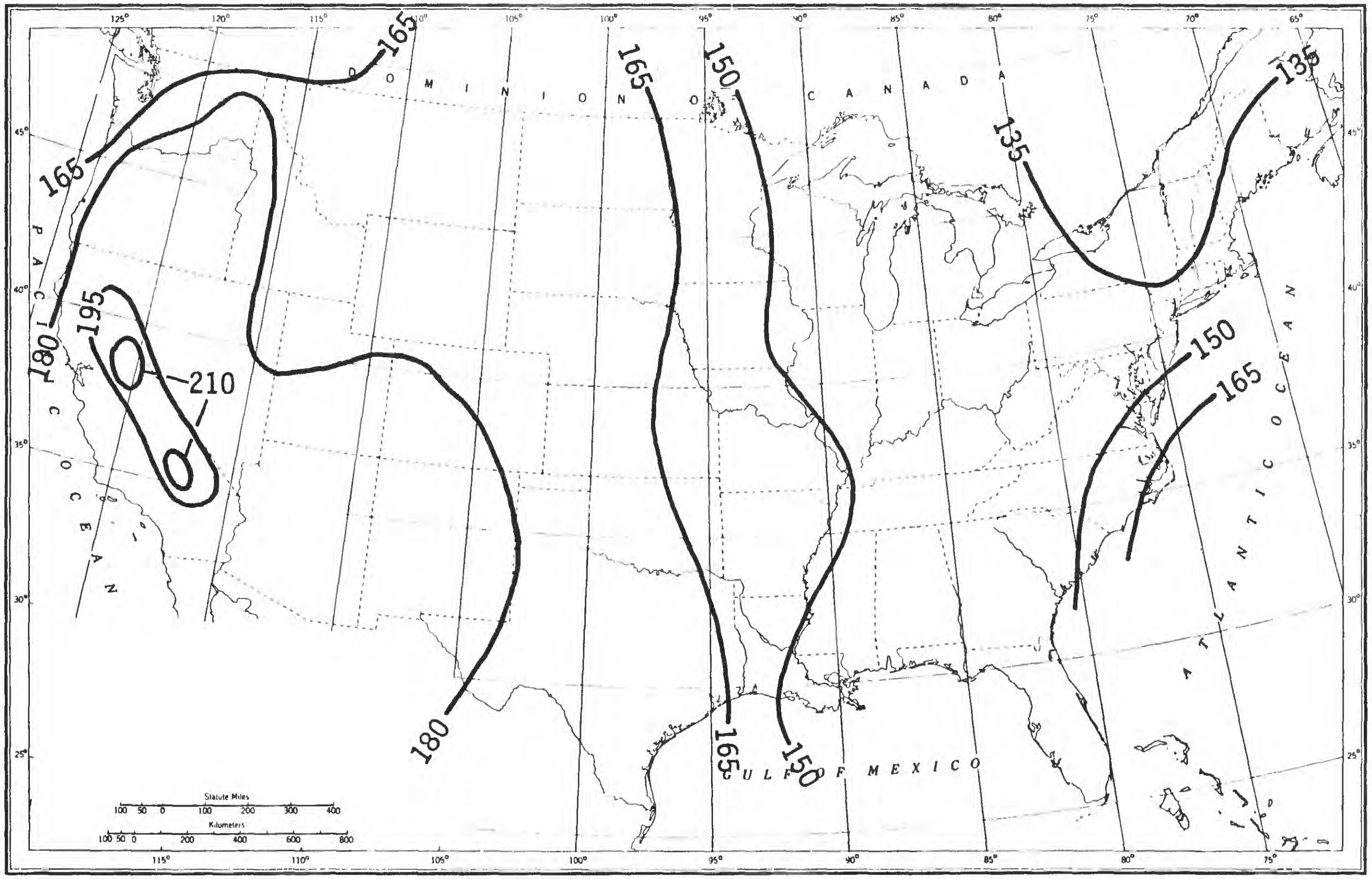


Figure 3.15.--Isoline of ampere-hour output from solar panels for July.

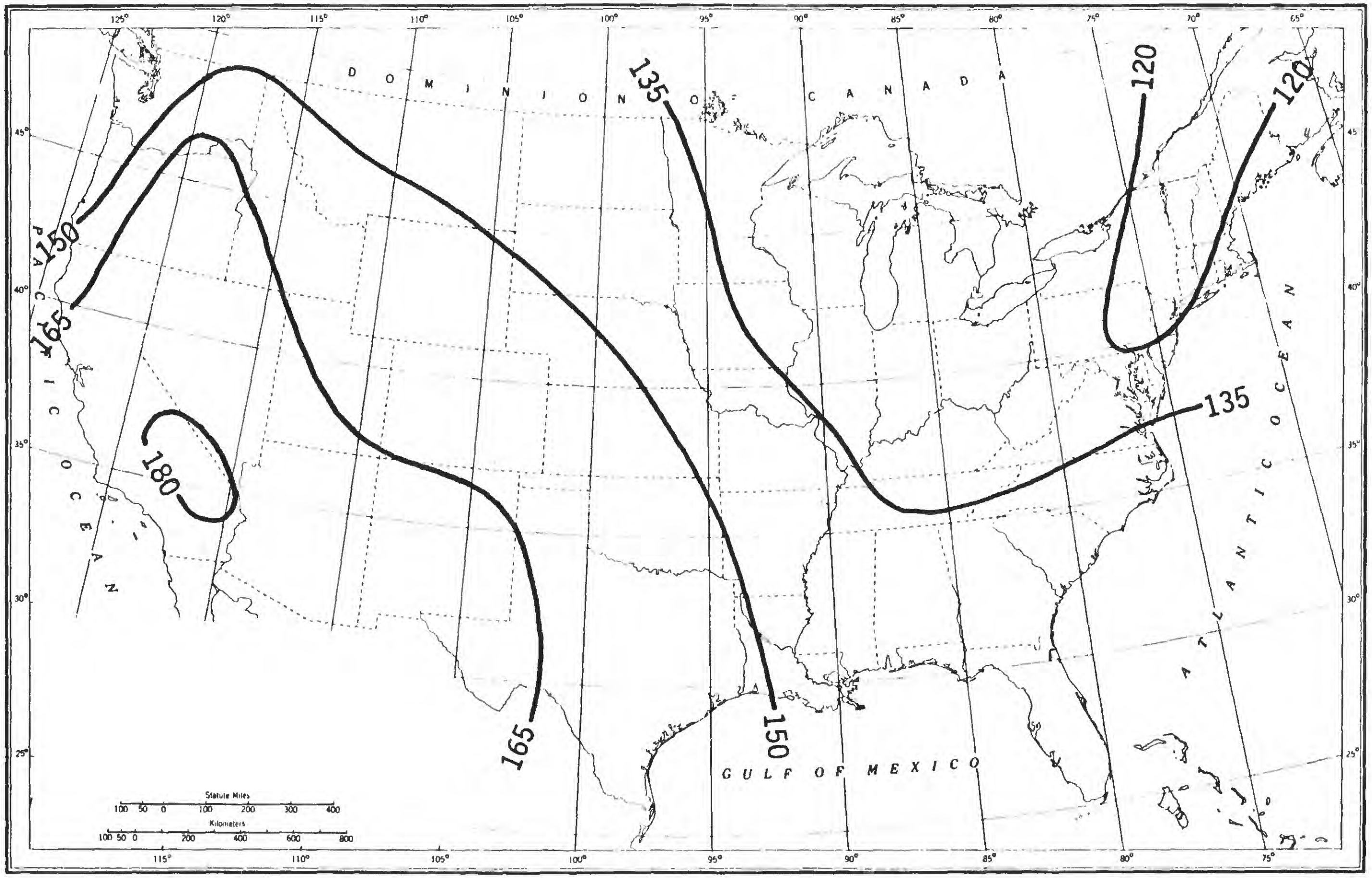


Figure 3.16.--Isoline of ampere-hour output from solar panels for August.

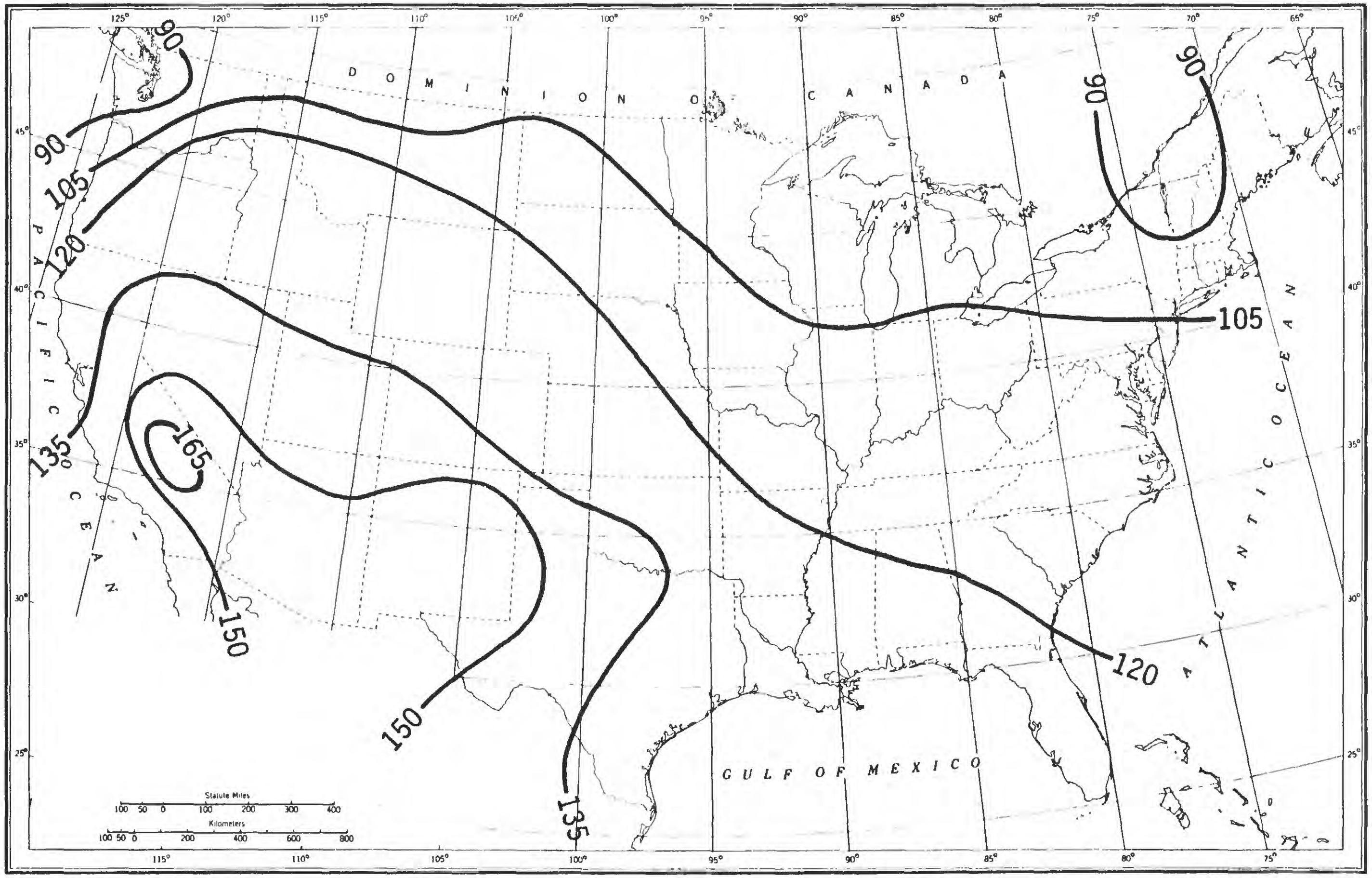


Figure 3.17.--Isoline of ampere-hour output from solar panels for September.

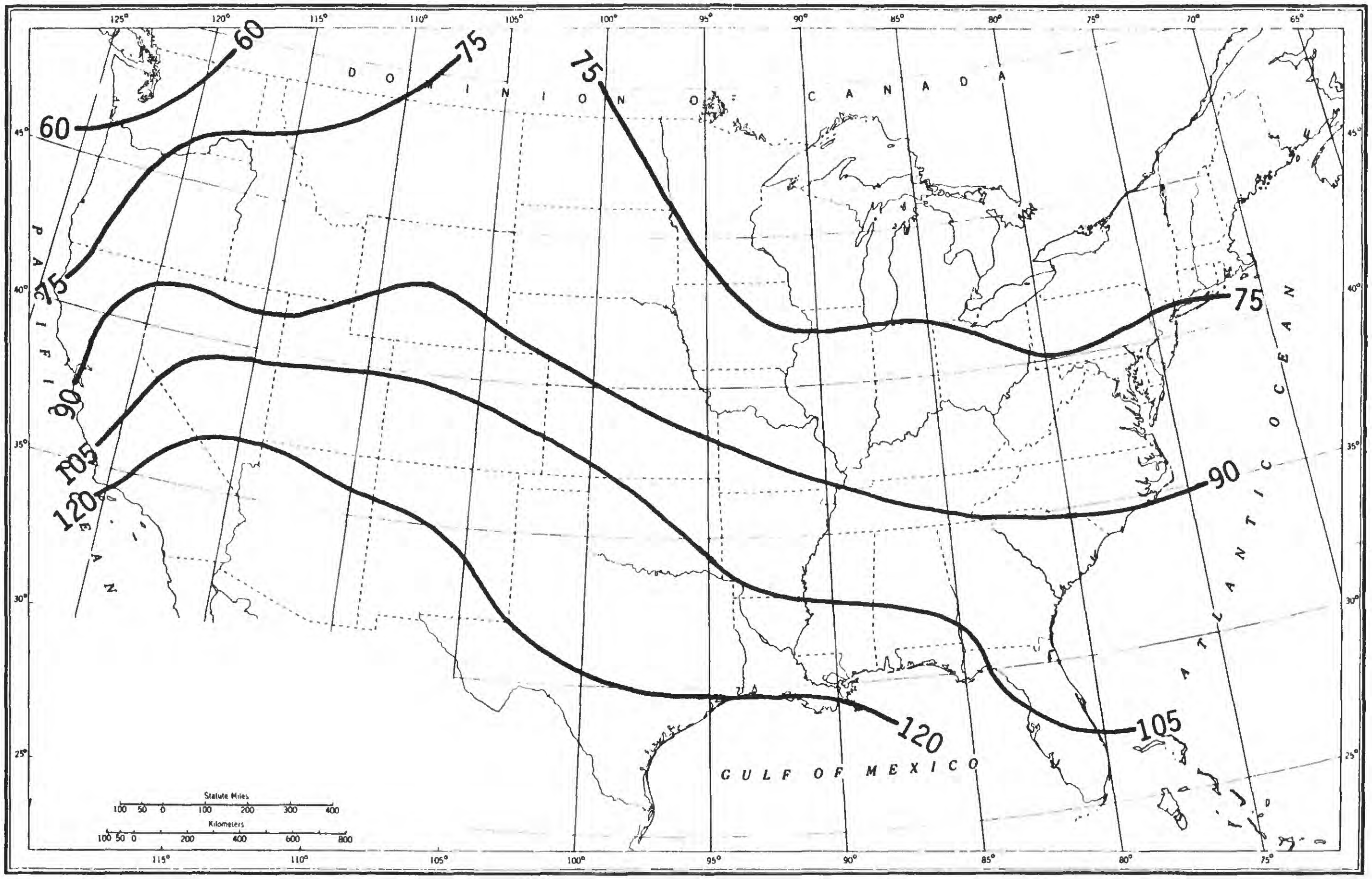


Figure 3.18.--Isoline of ampere-hour output from solar panels for October.

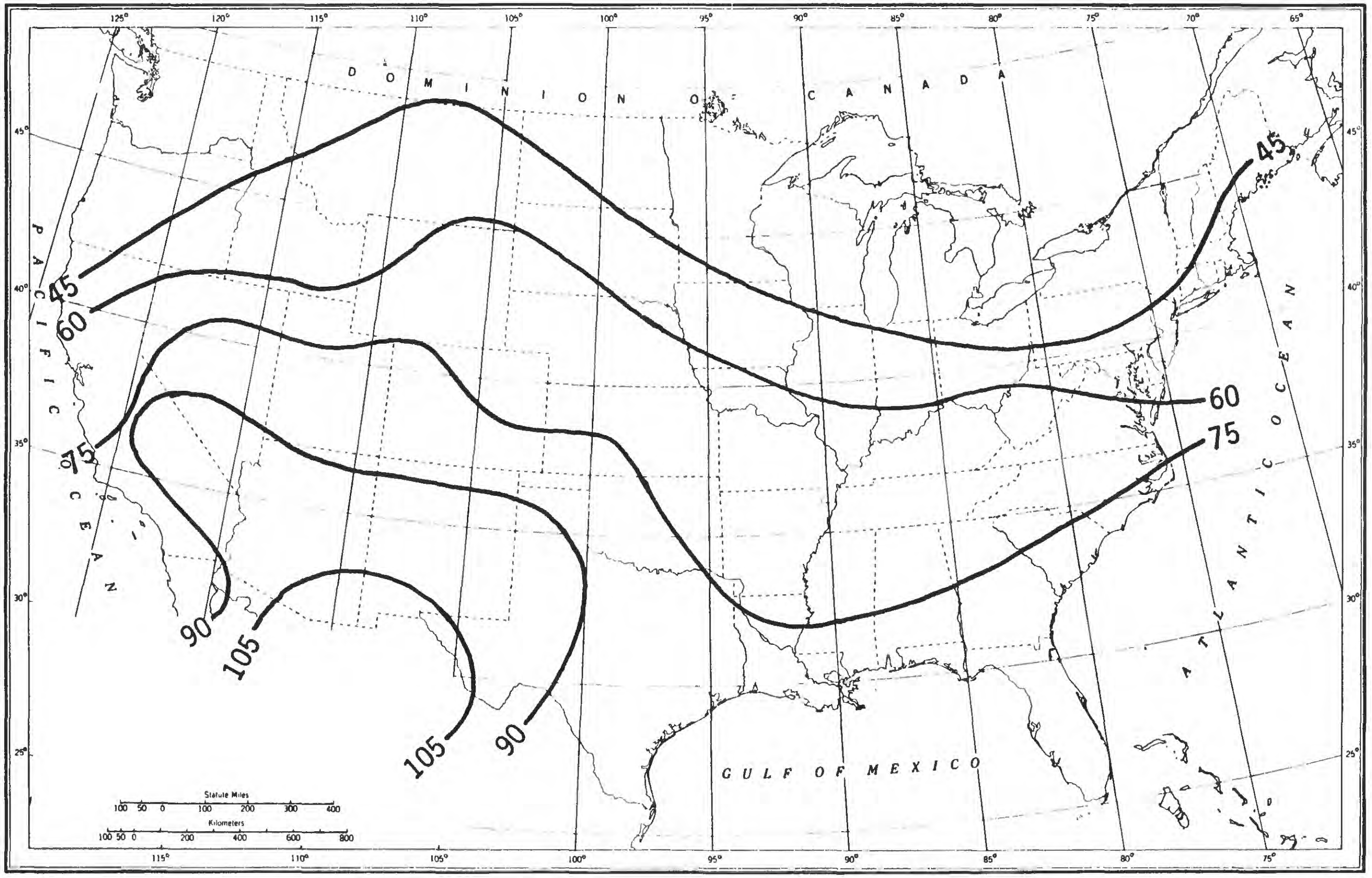


Figure 3.19.--Isoline of ampere-hour output from solar panels for November.

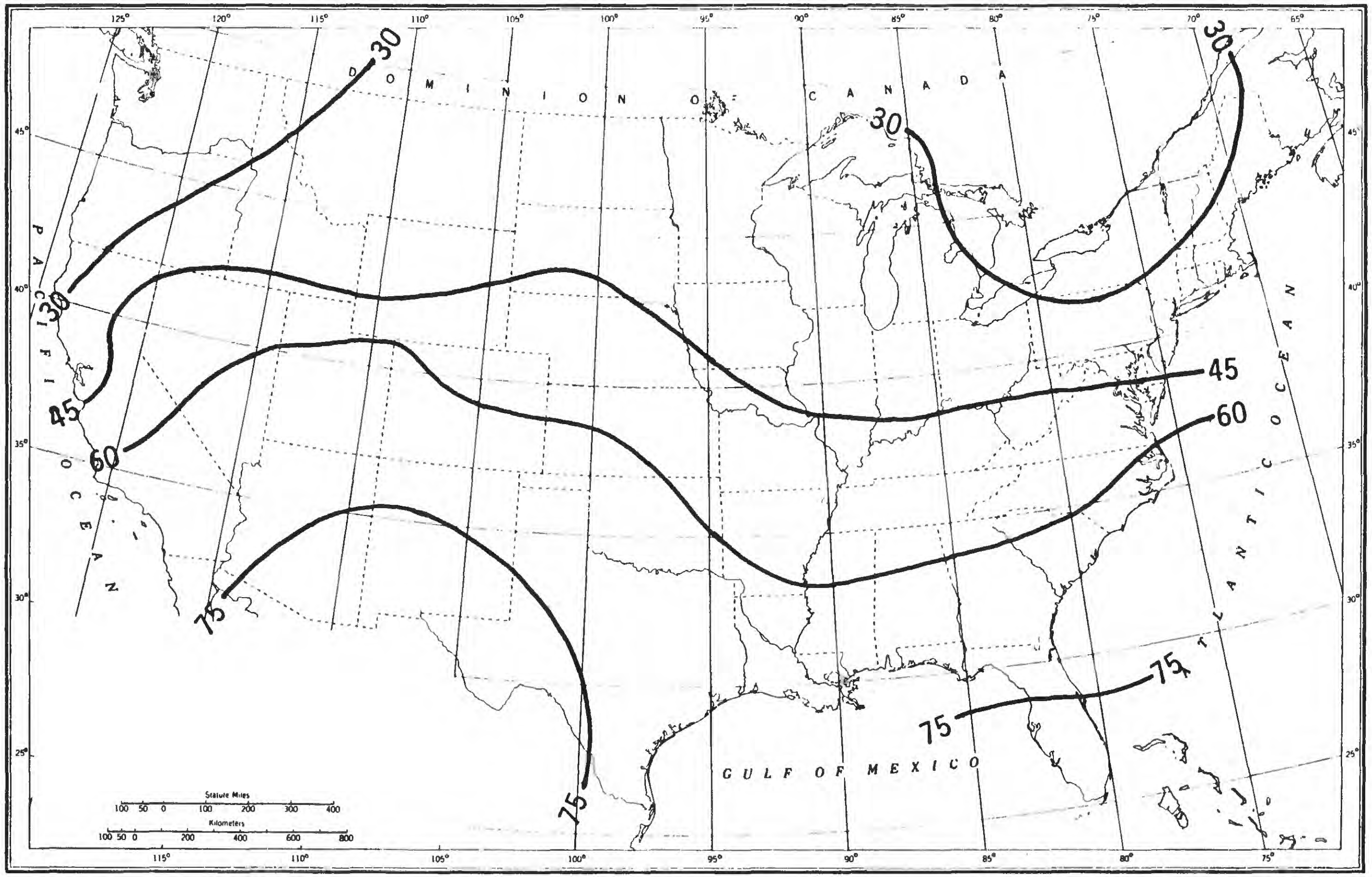


Figure 3.20.--Isoline of ampere-hour output from solar panels for December.

3.7 Lightning Protection for Data-Collection Systems

Before lightning can discharge within a cloud or from cloud to earth, opposite charges of electricity must build up. Generally, the top of the cloud is positively charged and the cloud base nearest the earth is negatively charged and has an excess of free electrons. This negative charge at the base of the cloud and the resultant strong electrostatic field forces a positive charge on the earth's surface beneath the cloud. When the electrostatic field becomes great enough to ionize the air between the charges, lightning results—either within the cloud or between cloud and earth.

An electrical discharge between cloud and earth, called a down strike, equalizes the charge allowing a tremendous current to flow through the plasma path created by the strong electrostatic field. During this current flow, and until the difference in electrical potential has equalized to the point that the electrostatic field is no longer strong enough to maintain the ionized conducting path, there is a voltage gradient along this path. Because of the very rapid rate at which this discharge occurs, inductance in the discharge path plays an important role in the distribution of the voltage drops in the lightning discharge path. As a general rule, the points in the discharge path will be increasingly negative as the distance from the earth along the lightning electrical circuit increases. ("Inductive kick" can however cause a positive after-pulse.) The total path of current flow from earth to cloud takes many paths (or parallel circuits) between earth and the final direct circuit through the ionized plasma path into the cloud. This final path of ionized air from earth to cloud, about 6 inches across, may reach a temperature of about 15,000°C. Hundreds of thousands of amperes of current may flow through this path for 20 to 500 microseconds—this pulse may be increased into milliseconds by the distributed inductance and capacitance along that part of the circuit involving electrical distribution lines.

Obviously, a direct hit on the power lines entering the gage house would result in catastrophic damage to the equipment. The odds against a direct hit on or very near the gage house are high. The likelihood is great however that earth current in a down strike within 10 or 20 miles of the gage house will result in significant current through the wiring. Fortunately, damage and disruption of service that might result from these electrical transients can be effectively guarded against by providing a more direct path for these currents to bypass the equipment wiring.

A number of commercial devices designed to protect delicate equipment from power-line surges are available. One device is made by TII Industries, Inc., 1375 Akron Street, Copiague, New York 11726. It is recommended that their "Zeus" lightning surge arrester be installed at the service entrance panel. Alternately, but slightly less effective, their TII-425 or TII-411 power-line surge protector may be installed between the power outlet connector and the battery charger. It is further recommended that all wiring that enters the gage house from the outside (including wiring from solar panels, rain gages, telephone lines, and other equipment) be protected by a model PB-5 or PB-8 surge protector board manufactured by Teledyne Geotech, 3401 Shile Road, Garland, Texas 75041.

All components of the system—the DCP, the ADR, the negative terminal of the battery, the ground terminals of the surge-protection devices, and the metal parts of the gage house—must be connected to a common point on a 1-inch-wide (minimum) copper strap (made from 0.050-inch or heavier copper sheet or copper braid) that runs directly from the DCP to the water-level recorder (fig. 3.21). In addition, a #12-AWG (minimum size) wire must run from this same common ground point to an earth ground that has less than 100 ohms of resistance to the ground side of the power line. Metal water pipe that runs from the gage house into the river generally will meet this requirement; otherwise, 6- to 8-foot copper-clad steel ground rods may be driven into the ground. It is important that the copper groundstrap that connects the DCP and the ADR units be as short as possible, and in any event, less than half the length of the interconnecting signal wiring between the DCP and ADR.

The purpose of these recommendations is to keep system components within the gage house at the same electrical potential relative to one another any time the data-collection system becomes part of a lightning discharge circuit. Clean, well-made connections at all points cannot be overemphasized. The recommended protection is thought to be the minimum required in installations that use commercial electrical power. If solar panels are used, the minimum requirement should be the earth grounding of all equipment including mast and negative terminal of the battery.

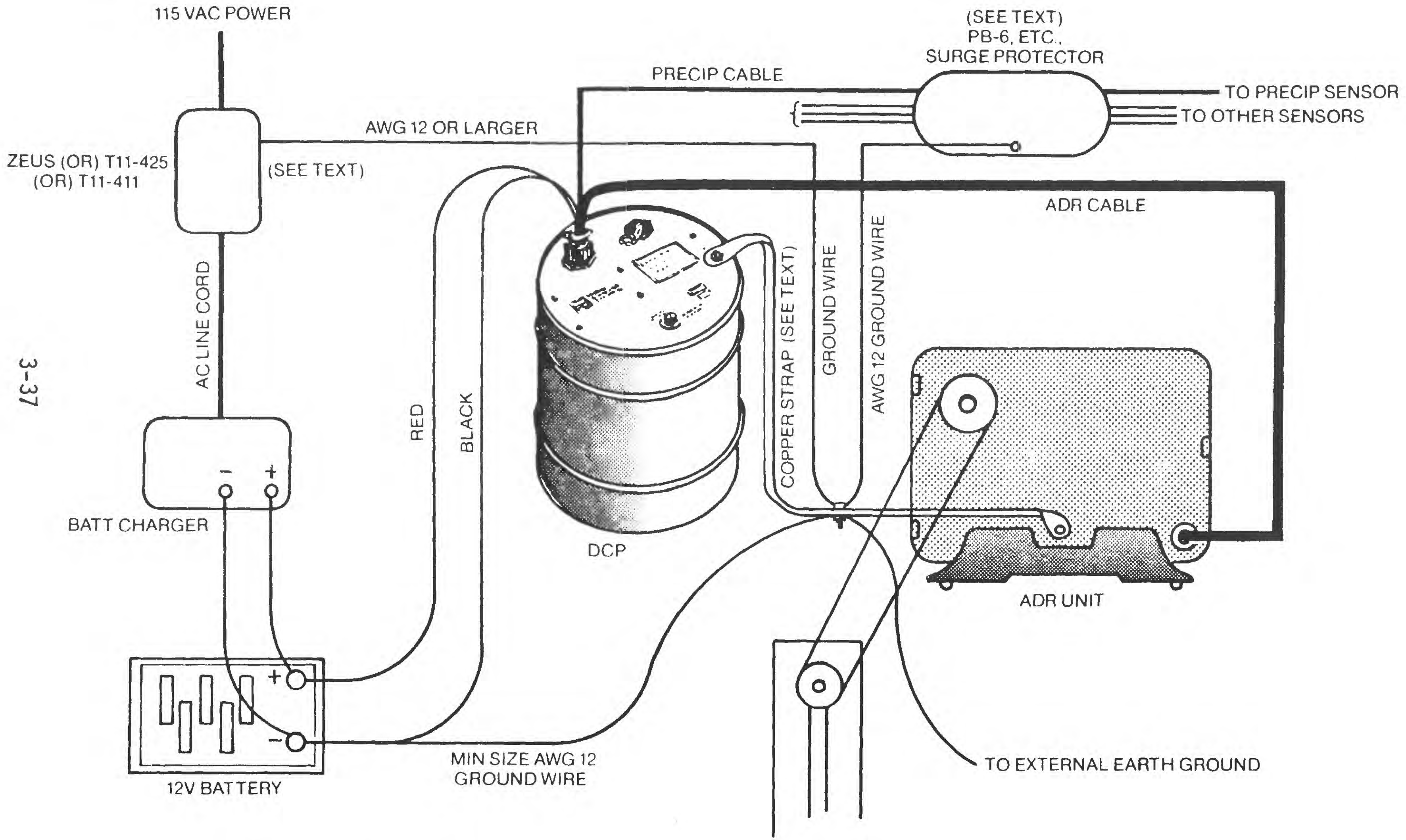


Figure 3.21.--DCP-ADR gage-house installation with lightning protection.

4.0 ANTENNAS

The most common GOES antenna in use is the crossed Yagi (fig. 4.1), although some older helix types are still in use. The crossed Yagi antenna is smaller and lighter than the old LaBarge and Magnavox helix but is more fragile and will not stand as much ice loading or vandalism.

The crossed Yagi antennas are shipped with the elements removed and must be assembled before use. The antenna should be assembled on site rather than transporting it already assembled, because the elements can easily be broken off. Care must be taken to assemble the elements in their proper order. Each set of four elements must be attached at points that are specified in the instructions that accompany each antenna. The crossed Yagi antenna with threaded elements comes with a small tube of wicking adhesive to prevent loosening of the elements. One drop of the adhesive should be placed on the element threads before the element is screwed into the main stem of the antenna. The element should be hand tightened; pliers or vise-grips should never be used to tighten the antenna elements.

In some crossed Yagi antenna, water may leak into the square tubular main stem and collect around the internal wiring. The collected water will cause shorting and impair the antenna's performance. Therefore, if a drain hole does not already exist, an 1/8-inch hole should be drilled near the lower end of the square tubular main stem to allow water to drain. When drilling the hole, care must be taken not to allow the drill bit to go too far into the antenna and sever any internal wires.

4.1 Antenna Masts

Most GOES antennas are designed to fit on 2½-inch-diameter masts. The most popular mast material is 2-inch water pipe or 2-inch thick-walled conduit (both 2.375 outside diameter). Both are widely available and are strong enough to stand 15 feet high or more without requiring guy-wire support. The mast should be high enough for the transmission pattern to clear surrounding objects and put the antenna out of easy reach of people. A mast length of 10 to 13 feet generally will satisfy both requirements.

4.2 Antenna Cable

The antenna should be installed with low-loss coaxial cable. A cable length of 15 feet is long enough for most installations; however, longer lengths can be used as long as cable losses are not more than about 4 decibels (dB). Typical losses for a variety of coaxial cable types are given in table 4.1.

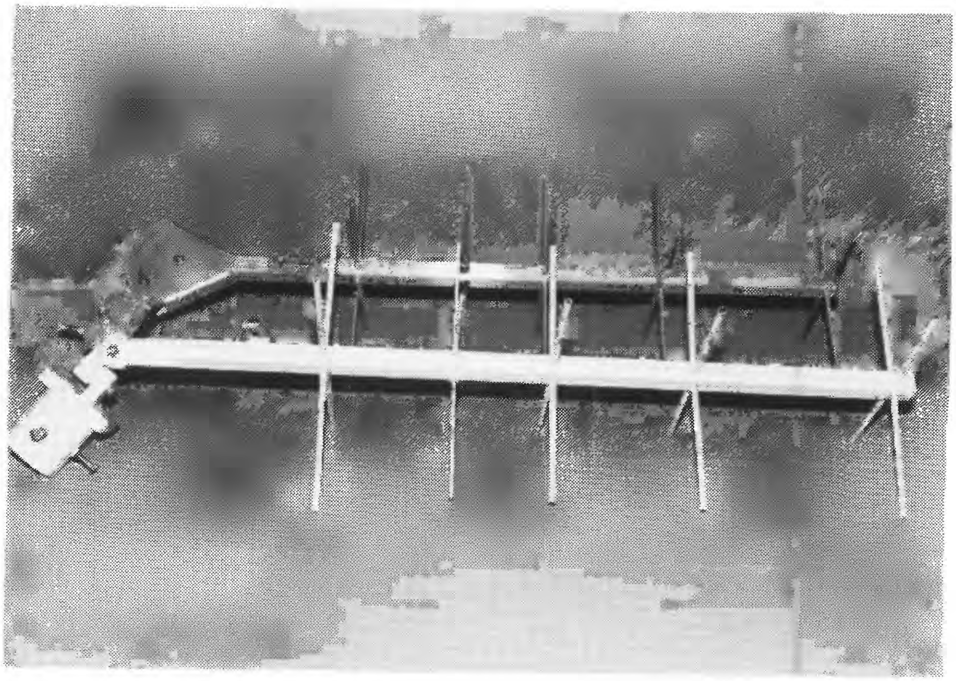


Figure 4.1.--Synergetics crossed Yagi antenna (top) and Handar crossed Yagi antenna (bottom).

Table 4.1.--Typical coaxial cable losses

Coaxial type	15 feet	100 feet	Type N coaxial connector
RG-142/U	1.28 dB	8.50 dB	UG-536 B/U
RG-9AB/U	.75 dB	5.00 dB	UG-21 B/U
RG-8B/U	.57 dB	3.8 dB	UG-21 B/U
RG-14A/U	.48 dB	3.12 dB	UG-32 B/U

If coaxial cables are purchased from the platform manufacturer, there is no control on what type coaxial cable is used; however, most manufacturers supply RG-8B/U coaxial cable in a variety of standard lengths. Even if coaxial cables are ordered from the manufacturer, 100 feet of low-loss coaxial cable and the appropriate connectors should be kept on hand for installation where longer lengths are needed and to replace damaged cables.

4.3 Antenna and Mast Installation

Because of the large variety of designs and construction materials used for gaging stations throughout the country, it is difficult to prescribe any specific way to install antenna masts. Some general methods however can be applied to most situations. One of the simplest and least expensive methods for attaching the mast to the gage shelter is by using "U" bolts as shown in figures 4.2 and 4.3. The elbow at the bottom of the mast is used to bring the coaxial and solar-panel cables down through the inside of the mast and into the gage shelter to prevent the cables from being vandalized. Because the elbow does not allow the mast to mount flush with the wall, the mast must be shimmed out 1 inch; any roof overhang must be cut back to within 1 inch of the shelter wall.

If the gage shelter is made of concrete or concrete block, crest-stage gage mounting brackets can be used to mount the mast. Whatever method is used to mount the mast must be strong enough to hold heavy 2-inch pipe. In cases where gage shelters are made out of wood, the mast may have to be brought to ground level or some other stabilizing point because of the leverage that can be applied from an unguyed 10- to 15-foot mast.

Placing the coaxial, solar-panel, and mast-mounted-sensor cables inside the mast will protect them from vandalism and excessive weathering and should be done at all DCP stations. Two methods of placing the cables into the mast are (1) by cutting a hole about 6 inches below the top of the mast with an acetylene torch and (2) by placing a 2-inch pipe tee on top of the mast, with a 4- to 6-inch-long pipe nipple extending upward for mounting the antenna. The cables can then be inserted in the remaining opening in the pipe tee and down through the inside of the mast.

The antenna and solar panel should be installed on the mast before the mast is raised to its full height. Installation is done by attaching the mast to its mounting bracket and temporarily securing it in a vertical position so that the top of the mast is at a safe working height. The solar panel and antenna are then attached to the mast and their respective elevations set. The angle between due south and satellite azimuth can be set between the solar panel (faces south) and the antenna. The cables can then be inserted down the center of the mast to rest temporarily at the pipe elbow at the bottom of the mast. The coaxial connector should be wrapped with rubber tape to help prevent water from leaking into the coaxial cable. Once the mast is raised, it can be rotated to point the solar panel south or the antenna to the satellite azimuth. In

Figure 4.2.--Close view of antenna mast installation with ground clamp.

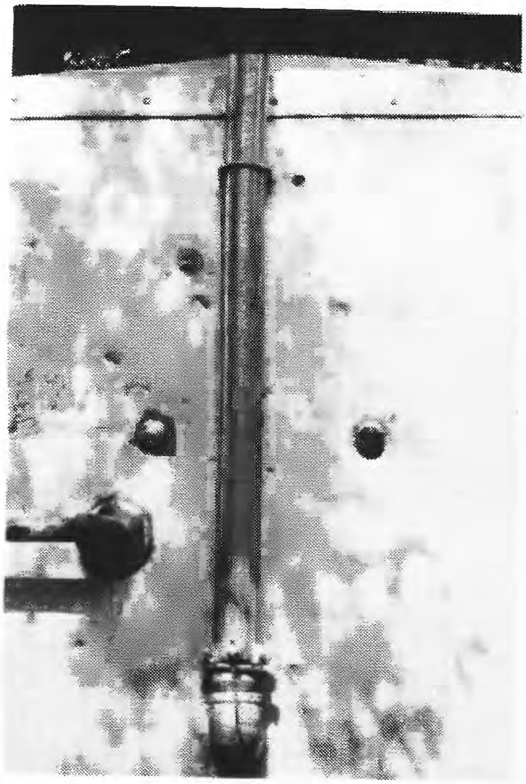


Figure 4.3.--View of antenna mast installation.

either case, each element on the mast will be pointing in its proper direction and no adjustment to the solar panel and antenna will be needed (fig. 4.4).

The azimuth and elevation of a DCP antenna can be determined by using the map and overlay in Appendix D or from WRD's platform assignment and scheduling subsystem. To find the azimuth and elevation from Appendix D, place the center of the overlay over the position of the satellite to be used. The normal position of the two operational satellites are on the equator at longitude 75°W for the east satellite and longitude 135°W for the west satellite. Read the azimuth and elevation from the overlay at the DCP's location. The azimuth on the overlay represents true north therefore be sure the proper magnetic declination is applied for your area.

4.4 Troubleshooting Radiofrequency Problems

A through-line wattmeter (Bird type) is used to check the radiofrequency (RF) power output from a DCP. The procedure for checking the RF output through the antenna system is:

1. Remove coaxial cable from the DCP and connect wattmeter to the RF output connector on DCP. A short length (6 inches) of coaxial cable with standard connectors or a UG-57 B/U adapter will be needed because the connector on the DCP and wattmeter are of the same sex. Connect the 50-Ohm, 10-watt attenuator (dummy load) to other connector on the wattmeter. Point the arrow on the wattmeter-sensing element toward the attenuator and make a forced or timed transmission. The wattmeter should read between 8 and 10 watts. If it does not, platform should be replaced.

2. Remove the wattmeter from the DCP and connect the coaxial cable. Disconnect the coaxial cable from the antenna and connect the wattmeter to the coaxial cable with attenuator attached. Make a timed transmission, allowing enough time to get from the DCP to the wattmeter. With 15 to 20 feet of coaxial cable, the wattmeter should read 1.5 to 2 watts lower than it did at the DCP. If the difference in wattmeter readings is substantially higher, the coaxial cable may be shorted due to moisture or may have a bad connector and should be replaced.

3. To check the antenna requires that a transmission be made through the antenna. Therefore, the check procedure must take place during an assigned transmit time. (WARNING: Do not make a forced transmission through antenna outside of assigned time slot.) To make check, connect wattmeter to DCP and the coaxial cable leading to the antenna so that the wattmeter is in series with the

Figure 4.4.--Antenna, solar panel, and theft-protection plate.

DCP and the antenna. Point the arrow on the wattmeter-sensing element toward the DCP and wait for the timed transmission. When the transmission occurs, read the wattmeter, then turn the sensing element 180° and read the wattmeter again before the transmission is completed. The first reading is the reflected power and should be less than 2 watts. The second reading is the forward power and should be between 8 and 10 watts. If the forward power is between 8 and 10 watts and the reflected power is higher than 2 watts, there is probably an antenna mismatch due to moisture in the antenna or some other damage. In any case, the antenna should be replaced and taken to the shop for closer inspection and repair.

By following the prescribed steps, each external RF component can be checked and most problems can be isolated and repairs made. If steps 1 and 2 do not indicate any problem with the RF output from the DCP or through the coaxial cable and it is inconvenient to wait for a scheduled transmission, the antenna can be replaced and taken to the shop for testing.

5.0 DIGITAL DEVICES

Data from mechanical analog sensors such as floats, manometers, and deflection vanes must be digitized before they can be input to a DCP. Some type of encoder must be used to code the data into a form that the DCP can understand. In the WRD, this code is typically binary coded decimal (BCD).

The two most commonly used devices for encoding mechanical analog data (such as stage) to the DCP are (1) a digital recorder with an encoding attachment such as the Module A encoder for the Stevens 7000 recorder or the Tel-Kit for the Fisher-Porter recorder and (2) incremental shaft encoders, which are made by most DCP manufacturers.

5.1 ADR's with Encoder Attachment

The only encoder attachment presently purchased and made available on the rental program by HIF is the Stevens Module A. The Fisher-Porter Tel-Kit is not in common use by WRD because it is not as dependable as the Stevens Module A.

The Stevens Module A encoder is an electrical/mechanical device (fig. 5.0) that, during an update, drives 18 latch bars to the recorder code drum. Each latch bar has a small reed switch attached to it. If a latch bar strikes a ridge on the code drum (1 logic), the bar is forced down and positions the reed switch near a magnet which closes the switch. If the latch bar is opposite a valley on the code drum (0 logic), the reed switch is left open. Upon scanning, the DCP reads—in parallel—the momentary closure of the reed switches. When the recorder is near the end of its cycle, all reed switches are set to an open position and remain that way until the next update.

5.1.1 Testing ADR's with Encoder Attachment

The ADR with Module A should be tested thoroughly before being placed in the field. The tests that should be performed as follows:

1. Check cycle time. The recorder should make a complete cycle in 8 to 15 seconds.

2. Check cycling current. The recorder should not draw more than 400 mA.

3. Check Module A. Connect recorder to a DCP, set recorder to all zero's, scan and then read encoded value from programming set connected to DCP. Repeat this process by setting recorder to all one's, all two's, through

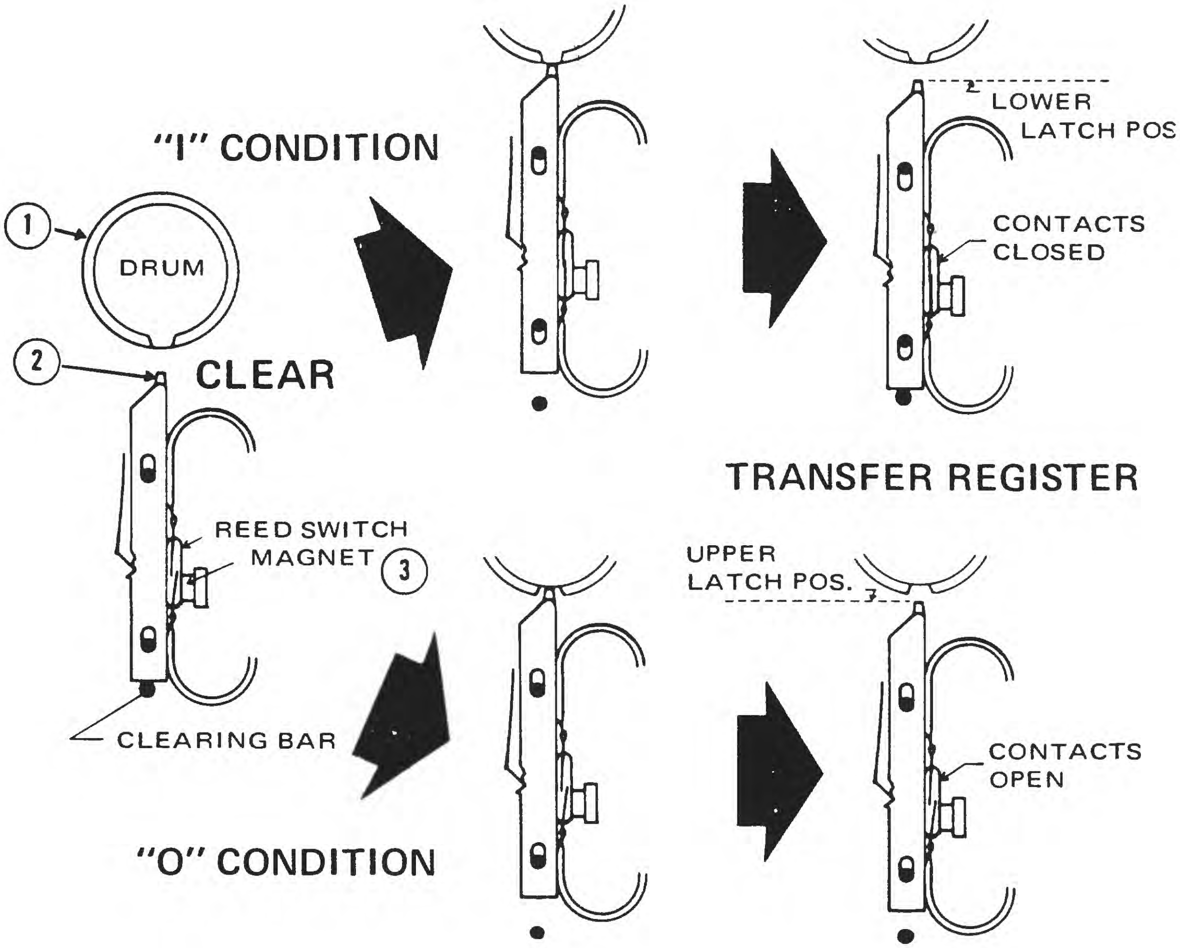


Figure 5.0.--Operation of Stevens Module A encoder.

all nine's or setting recorder to 1248, 2481, 4812, 7777, and 8124. If erroneous values appear through the programming set, scan recorder again and observe latch bars while recorder is cycling to see that only the appropriate latches necessary to encode the value are driven down.

If the ADR and Module A do not pass the tests, return the unit to HIF with a clear and detailed description of the problems that were encountered.

5.1.2 Troubleshooting the Module A

A number of different types of failures can occur to a Stevens ADR equipped with a Module A. Each type of failure can be identified by a particular symptom. Failure symptoms and the types of failures that associated with them are:

Symptom A: Encoded data contains intermittent gage-height values of 00.00. This type of encoding error generally is caused by one of the three following reasons:

(a) Platform is failing to strobe or deliver power to the ADR. The ADR 7½-volt power supply should be checked with a voltmeter during a scan to check the 7½-volt strobe (see manufacturer operations manual for pin location). If the platform does not deliver the 7½-volt strobed voltage, the platform is at fault.

(b) ADR is failing to cycle because ADR microswitch is faulty or out of adjustment. Microswitch being out of adjustment often causes alternating good data and all zeros to be encoded.

(c) ADR is cycling too slow or too fast. If the ADR cycles too slow or too fast, the momentary closures of the Module A reed switches will be outside of the specific time window that the DCP reads the encoder. By timing the ADR cycle, one can determine whether or not this type of malfunction is occurring. This type of failure is rare if the cycle time is checked before the ADR is placed in the field.

Failure types (a) and (b) both caused by the ADR failing to cycle; therefore, if the digital tape time is running slow, 00.00 will be encoded to the DCP for every missing tape punch.

Symptom B: Encoded gage-height values on the paper tape are valid BCD characters but values in the DCP are incorrect or gage-height values are invalid BCD characters (HEX A, B, C, D, E, F). Some examples of this type of encoder error are:

EXAMPLE 1

Erroneous value		Correct value	
Binary	Platform output	Binary	Platform output
0000 0110 1101 0111	06.D7	0000 0110 1001 0111	06.97
		or	
		0000 0110 0101 0111	06.57

In example 1, the 0.8-bit or the 0.4-bit reed switch has closed when it should have remained open. The bit that is in error can usually be determined by observing correctly encoded values adjacent to the erroneous ones. In any case, the 0.10's place has an invalid BCD character.

EXAMPLE 2

Erroneous value		Correct value	
Binary	Platform output	Binary	Platform output
0001 0101 0111 1000	15.78	0000 0101 0111 1000	05.78

In example 2, the erroneous value does not have any invalid BCD characters. The 10 bit is being encoded in error. If this type of error is large, such as in the example, they are fairly easy to detect. If the error occurs in the .10's or .01's place, however, they will be difficult to identify.

Several conditions will cause Module A to encode erroneous values. Some of those conditions are:

(a) Too much side play in latch bars. The latch bar must have a small amount of lateral movement. If they are too close together, the friction of one dragging against the other will cause adjacent bars to be drawn down when they should have remained up. However, if the lateral movement is too great, a bar can move under an adjacent code disk on the coding drum and be pushed down and deliver a one condition when a zero condition is called for. This can be tested by moving the latch bars through their full lateral movement while conducting the ADR bench test.

(b) Latch bars draw adjacent bars down because of foreign material between the bars. If dirt or fine sand becomes lodged between the latch bars, the friction can cause adjacent bars to be drawn down. Also, if too much moisture finds its way between latch bars and freezes, this will cause the same problem.

If erroneously encoded data are being received and Module A encoders are being used, nine times out of ten the fault will be with the Module A.

5.2 Incremental Shaft Encoders

The incremental shaft encoder is a device used to digitize the position of a rotating shaft by causing two switches to be closed and opened as the shaft rotates. The closing and opening of the switches are arranged so that each switch outputs a square wave form that is 90° out of phase with the other (fig. 5.1). Each side of the square wave form that is pulsed by the switches is read by an accumulating up/down counter. As long as the shaft is rotating in one direction, one count will be added to or subtracted from the counter (depending on the direction of rotation) for each pulse that is made by the switches. As the shaft is rotating in any given direction, the pulses will be alternating between switches. If the direction of rotation is changed, the same switch will output two consecutive pulses. When this occurs, the condition is detected by a logic circuit and the counter begins to accumulate counts in the opposite direction.

The switches may be mechanical or solid-state devices and usually output 100 pulses per revolution. Therefore, if the encoder shaft is rotated once per 1-foot change in stage, each pulse or count will equal 0.01 foot. This arrangement allows the use of float wheels and sprockets presently used to drive ADR's.

5.2.1 Installation of Incremental Shaft Encoder

Incremental shaft encoders manufactured by Handar, Sutron, and HIF have a 5/16-inch shaft with 24 threads per inch, which are the same as the float wheel shafts on Fisher-Porter and Stevens ADR's. The Synergetics shaft encoder has a 1/4-inch-nonthreaded shaft; therefore, other provisions must be made for driving the Synergetics encoder.

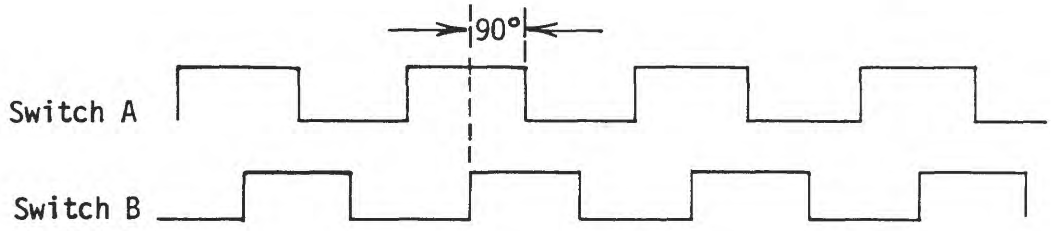


Figure 5.1.--Output from incremental shaft encoder.

A Handar 436A incremental shaft encoder installation is shown in figures 5.2 and 5.3. The Handar encoder is driven by a 1.5-foot-circumference (1:6) Stevens A-35 float wheel using PIC "No Slip" geared pulleys and drive belt (figs. 5.4 and 5.5). The PIC belts are made of molded polyurethane with multiple strands of dacron or stainless-steel core; allowable static pull strength is 20 pounds for the dacron core and 100 pounds for the steel core. The Winfred M. Berg Co. (Appendix A-2) manufactures a similar type of belt and geared pulley that is interchangeable with the PIC system. The geared pulleys are made of anodized aluminum and will need to be tapped to fit the recorder and encoder shaft threads and have a drive ratio of 1.5:1. The geared pulley on the recorder has 72 teeth and the encoder pulley has 48 teeth. If the encoder is driven by the float wheel of an ADR, the drive ratio should be 1:1.

Belt tension is set with the A-35 recorder's level adjustment on the legs. If an encoder is driven by an ADR, some other provision must be made for adjusting belt tension. This adjustment can be accomplished by either slotting the fastening holes on the encoder or providing a base with slotted fastening holes.

Standard copper ladder chain and sprockets can be used to drive an encoder from an ADR by using two 20-tooth or two 10-tooth sprockets (HIF Catalog No. 5305001 or No. 5305002). A standard sprocket combination is not available to drive an encoder from an A-35 recorder while utilizing the recorder's float wheel. If an incremental encoder is used with a manometer, any combination of recorder and encoder can be used. The various copper ladder chain sprocket sizes that can be used for different combinations of recorders and encoder are shown in figure 5.6.

In the interest of lower cost and of standardizing incremental encoder drive linkages for all types of installation, the PIC geared-belt system or a similar system is the best method to use. Only two geared-pulley sizes would be needed to drive the encoder regardless of station type (manometer or float) or recorder type. This system requires that the encoder always be driven by the recorder. The only exception is a 3.0-foot-circumference (1:12) Stevens A-35 or A-71 float wheel, which cannot be used because the float wheel protrudes into the plane of the drive belt. If a 1:12 gage-height scale is needed in a float-operated station, a scale-reducing attachment (Stevens gage-scale standard with clamp assembly for ratio 1:12, part No. 31140) can be added to the recorder. This attachment will produce a 1:12 chart scale using a 1.5-foot-circumference (1:6) float wheel. Various PIC geared-pulley sizes for different encoder-recorder combinations are shown on table 5.0.

5.2.2 Remote Location of Incremental Shaft Encoder

One advantage of an incremental shaft encoder is that it can be located some distance from the DCP. This is particularly useful if an auxiliary gage is needed or two gages are close enough so that one DCP

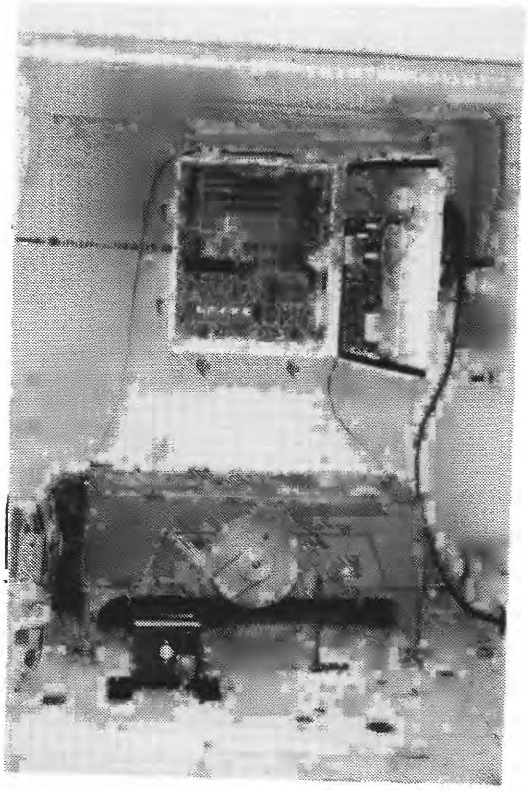


Figure 5.2.--Gaging station data-collection platform installation with Handar 560 platform and Handar 436A incremental shaft encoder.

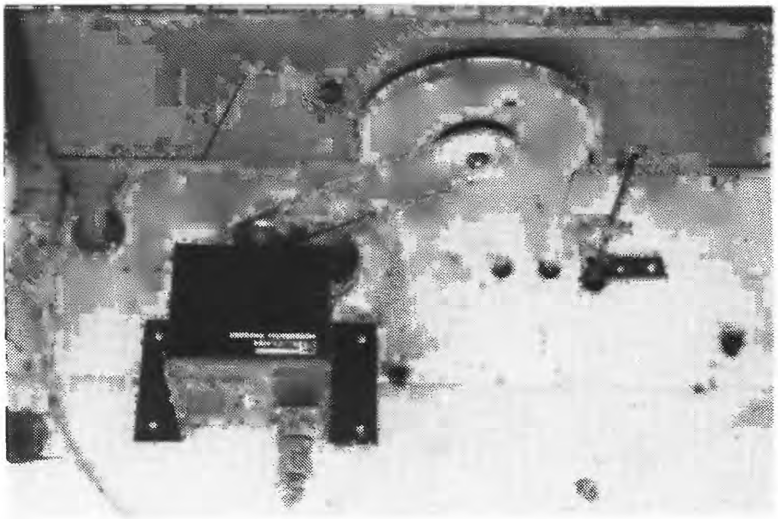


Figure 5.3.--Handar 436A incremental shaft encoder driven by a Stevens A-35 recorder using a PIC geared-belt system.

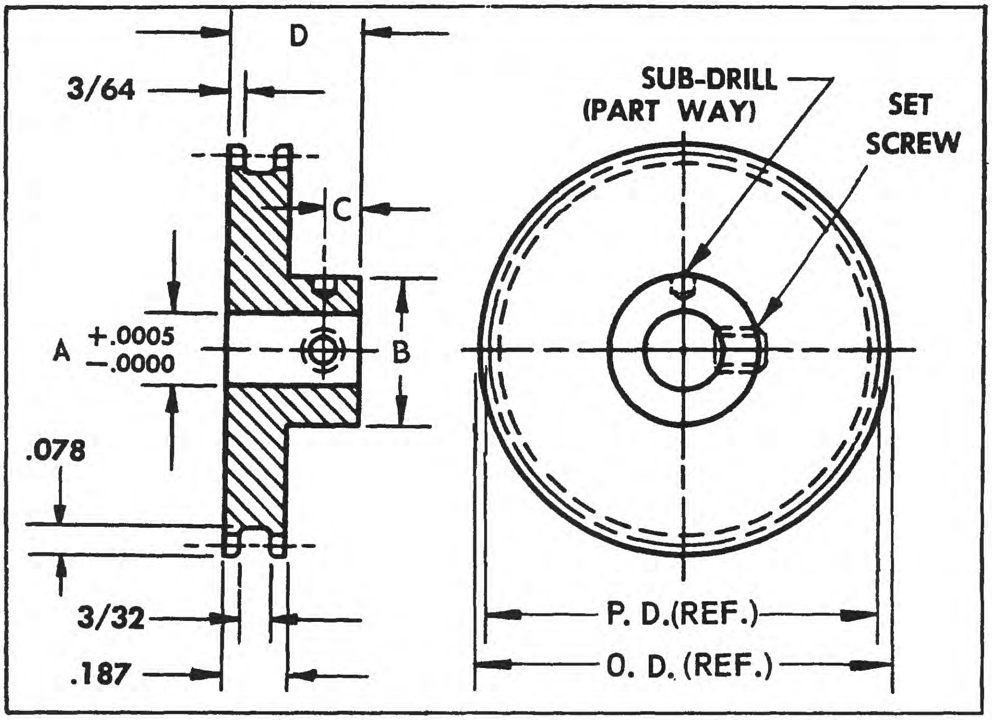


Figure 5.4.--PIC "No Slip" geared pulley.

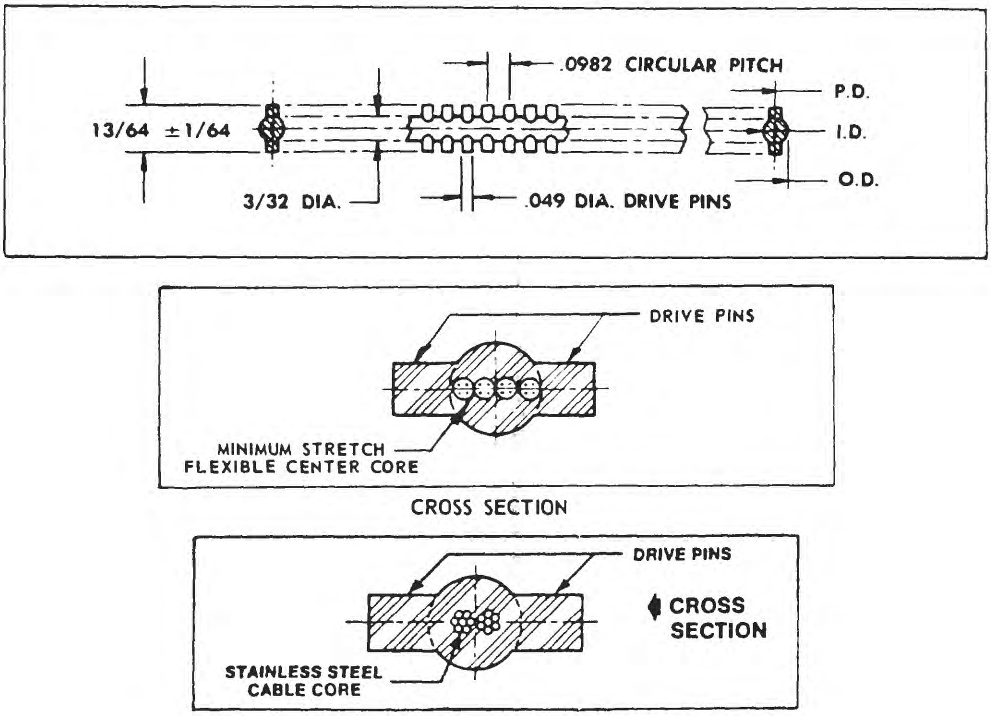


Figure 5.5.--PIC "No Slip" drive belt.

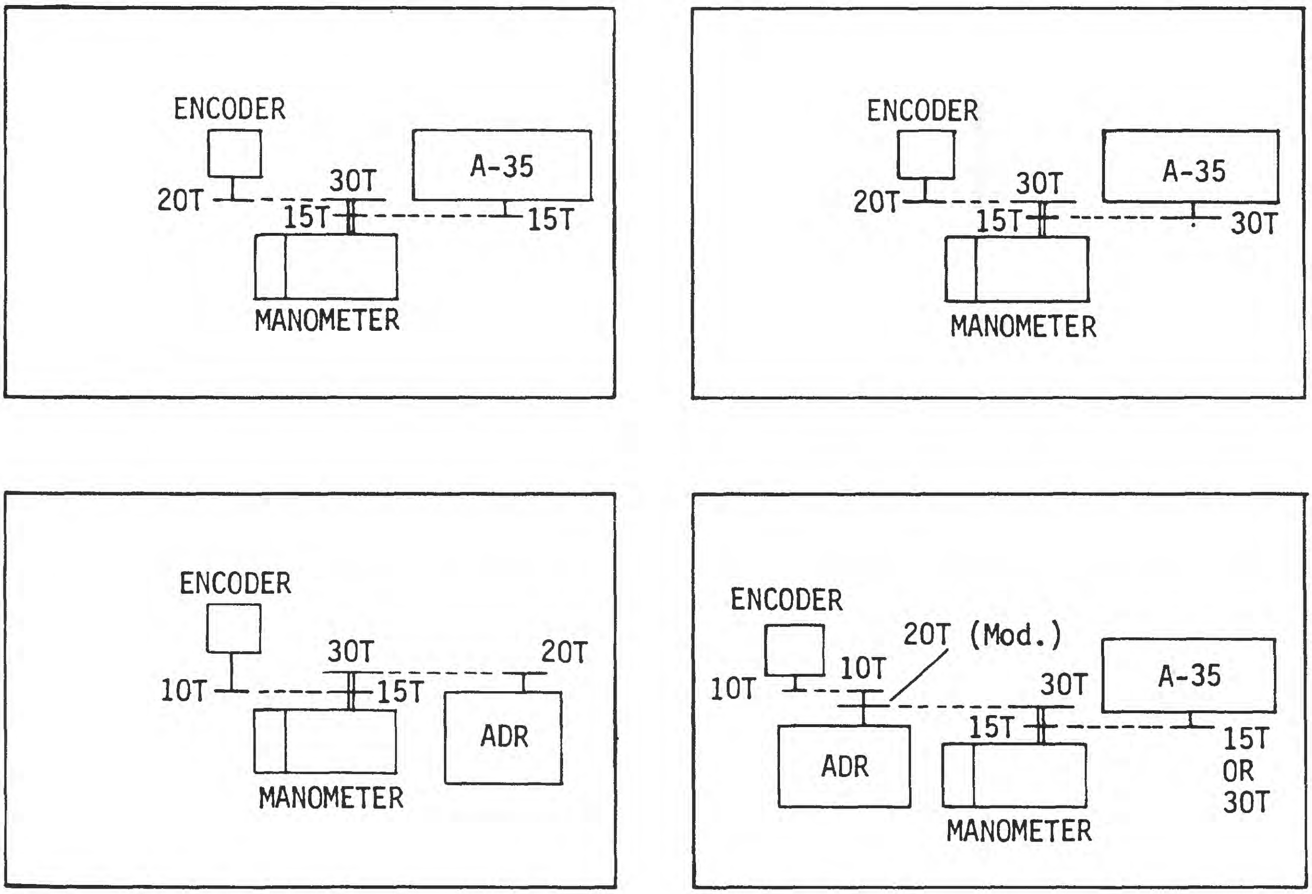


Figure 5.6.--Combinations of copper ladder chain hookups between manometer, recorders, and incremental shaft encoder.

Table 5.0.--PIC geared-belt system

Combination	Recorder geared pulley	Encoder geared pulley
ADR to encoder[1]	72 tooth, tapped for 5/16-inch - 24 threads per inch	72 tooth, tapped for 5/16-inch - 24 threads per inch
A-35 or A-71 with 1.5-foot float wheel (1:6) to encoder[2]	72 tooth, tapped for 1/4-inch - 32 threads per inch	48 tooth, tapped for 5/16-inch - 24 threads per inch

[1]If ADR is driven by manometer, a 20-tooth modified copper ladder chain sprocket (HIF No. 5305000) must be used for manometer linkage.

[2]If 1:12 chart scale is needed, use scale-reducing attachment.

could be used to transmit data from both gages. The maximum distance that the encoder can be located from the DCP depends on whether the data are transmitted as pulses from the encoder switches or from the up/down counter.

Sutron Model 8201 incremental shaft encoder is a stand-alone unit that contains both the pulsing switches and the up/down counter. The output data from the counter are transmitted serially to the DCP by a three-conductor cable. This arrangement allows the encoder to be located as much as 5,000 feet from the DCP.

Handar Model 436A, Synergetics, and HIF incremental shaft encoders contain only the pulsing mechanism, and therefore the distance between encoder and DCP is limited to about 400 feet. The counter portion is contained either in the DCP or in an interface unit, depending on the type and model of DCP. A four-conductor cable is required to connect the encoder to the DCP or interface unit. If the encoder is to be located more than 10 feet from the DCP, the connecting cable should be shielded and the shielding should be properly grounded. If the cable does not have grounded shielding, external interference can cause spurious counts, which would produce an accumulative error in gage height.

5.3 Handar 565A Incremental-Encoder System

The Handar 565A consists of a Handar data encoder and a Handar 436A incremental shaft encoder (fig. 5.7). The system emulates a Leupold-Stevens and Fisher-Porter ADR and provides an interface for most DCP's. The 436A senses the pulley-angle position and sends the information to the data encoder, which stores the data in low-power CMOS circuits. Upon command from the DCP, the 565A transfers the data to the DCP with the same timing as a slow-cycle ADR. A lithium battery is used as a backup power source to maintain the operation of the encoder system if the external power is interrupted. The data encoder contains four LED displays for observing the current gage height. The display is activated when the READ button is pressed. The data encoder can be calibrated with four switches which can be set to the current gage reading.

5.3.1 Installation of the 565A Incremental-Encoder System

The plastic insulators should be removed from the lithium-battery holder when the unit is placed into service. The lithium batteries are intended to provide power to the unit for only short intervals during servicing of the DCP system. When the 565A is taken out of service, the insulators should be replaced.

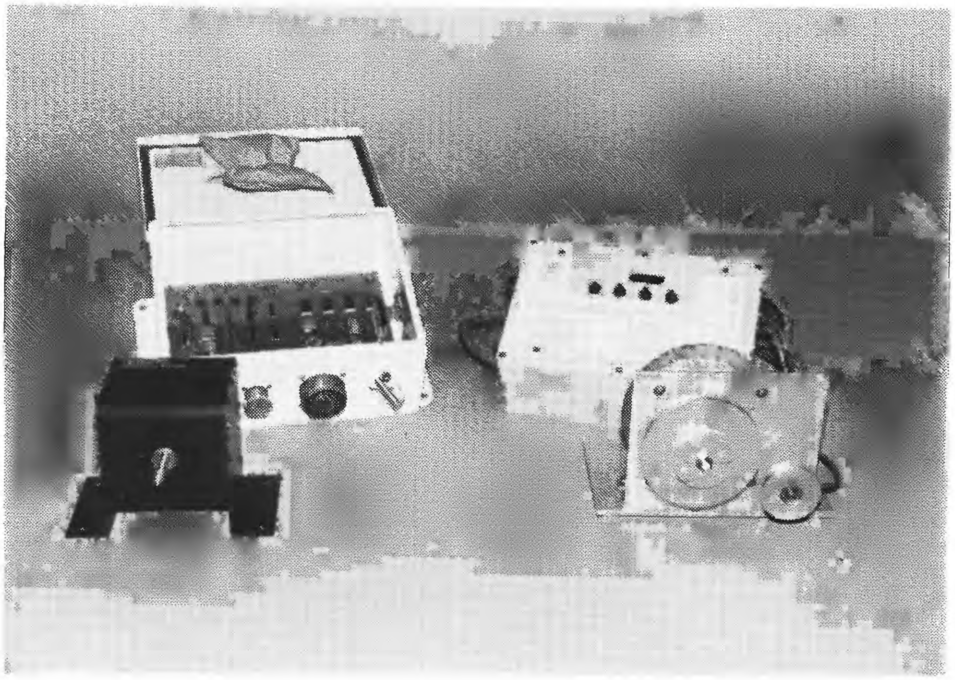


Figure 5.7.--Handar 436A incremental shaft encoder and 565A interface (left) and HIF incremental shaft encoder and interface (right).

The 436A should be installed in the same manner as a standard ADR recorder. The shaft on the 436A is compatible with a Leupold-Stevens Model 7000 float shaft so that most pulleys and clamps can be easily installed. The 6-pin cable supplied with the 436A should be connected to the data encoder. The output of the data encoder is connected to the DCP by the 26-pin connector with the same pin connections as the standard Leupold-Stevens or Fisher-Porter ADR installations. The system is normally operated with the 436A connected so that clockwise rotation of the pulley corresponds to increasing readings. The direction of the pulley rotation can be changed by reversing the connection of the red and yellow wires in the 565A.

5.3.2 Operation of the 565A Incremental-Encoder System

The data encoder can be calibrated by setting the internal switches to the measured gage reading and pressing the LOAD switch. The current reading of the encoder can be observed by pressing the READ switch.

The 524 reading of the encoder can be observed by placing the 524 programming unit in the program mode and by monitoring digital channel 01. The reading observed in the 524 should be the same as the reading observed on the internal LED display assuming that the ADR cable is wired to provide the strobe on channel 01.

The internal lithium batteries have an extremely long shelf life and should not require replacement for the life of the 565A under normal operation. The current drain on these batteries is about 0.7 mA anytime the 565A is not connected to an operating 524 or equivalent platform supplying 7.5 volts of continuous power to the 565A. The capacity of the lithium batteries is 160 mA hours, and the total service (not shelf) life of the battery is about 228 hours. It is extremely important that the insulating strip to be in place under the + terminals of one of the batteries (or both of the batteries removed) when the 565A is in storage or not being used.

5.4 HIF Incremental Encoder for Handar 524, LaBarge CDCP, and Sutron DCP's

This instrument consists of a shaft encoder unit and a microprocessor-controlled interface, which will also interface with a tipping-bucket rain gage and analog devices. The encoder has a shaft input identical to a Leupold-Stevens water-level recorder. Thus, any Stevens float wheel or sprocket-drive assembly can be used.

To install the encoder, anchor it using the mounting holes and level the encoder with the leveling adjuster. The encoder can be either chain or float driven. Connect the encoder to the interface with the four-pin connector. If the cable is not long enough, it can be cut and a section spliced in. The encoder is usable with up to 400 feet of cable. Connect the interface's large cable connector to the Handar, LaBarge, or Sutron DCP. The interface equipped for the Sutron platform has spade lugs on its output cable in place of the plug. Refer to the table in the Sutron manual (ADR connection) for their proper connection. Connect the battery cable from the back of the platform connector to a 12-volt power source. This power source will power both the platform and the encoder interface units.

Press the down button to observe the stage reading on the display. If the encoder shaft is turned, the reading should change. To display rainfall, press the up button and hold until the left-most digit indicates channel 1. Manually tip the bucket on the rain gage and the reading on the display will increase by 1. The rain-gage switch must be open for a second or two before a closure will be counted. Thus, operating the switch rapidly in succession will cause no counts. This design is to prevent switch bounces from being counted.

5.4.1 Setting Initial Values of Stage and Rainfall

Channels 2 through 7 are used in conjunction with switches A and B to set initial values. Channels 2, 3, and 4 set stage and channels 5, 6, and 7 set rainfall. An interlock is provided to prevent the readings from being accidentally changed. To advance past this interlock to the set channels, press both up and down buttons at the same time. Each channel is used in conjuction with buttons A and B to perform tasks as indicated on the cover. For example, going to channel 2 and then pressing A will cause the stage to be decremented by 0.01 feet. Thus, the user can use channel 2 to set the 0.01 digit. In a similar way, channel 3 is used to set the 0.1 and 1 digits and channel 4 to set the 10 digit. Rainfall is set in the same way as stage except channels 5, 6, and 7 are used.

After the values are set, the platform programming set can be used to read the data from the interface. Follow the instructions provided with the platform. The interface is read by the platform in the same way as is a stage recorder equipped with a Fisher-Porter Tel-kit or a Stevens Module A.

5.4.2 ADR Channel Selects

The interface is shipped with stage outputting to platform digital channel 1 (ADR 1) and rainfall outputting to digital channel 2 (ADR 2). These channel selections are determined by jumpers on the interface circuit card. Stage can be selected to output on channels 1, 2, 3, or 4. Rainfall can also be selected for channels 1, 2, 3, or 4. The same channel however should not be selected for both. The following chart shows the jumper's position for the various channels.

	COLUMN					COLUMN		
	E		F			J		A
Row 1	0	CH 1	0		Row 1	0	CH 1	0
Row 2	0	CH 2	0		Row 2	0	CH 2	0
Row 3	0	CH 3	0		Row 3	0	CH 3	0
Row 4	0	CH 4	0		Row 4	0	CH 4	0

To change channels remove the jumper and install in the proper row.

5.4.3 Standby Battery

When the power is disconnected, the interface will lose the stage and rainfall readings. If the display is off and the battery is changed within 10 seconds, the readings will not be lost. If the loss of data with power is a problem, the standby-battery lead can be connected to a 12-volt standby battery. The interface will draw its power from the higher-voltage battery. Thus, it will be necessary to replace or recharge the standby battery when the platform battery is serviced. An alternative is to use a General Electric or Gates rechargeable 8-volt lead acid battery. If this alternative is used, the interface will trickle charge the standby battery from the main battery eliminating standby-battery maintenance (fig 5.8). If the standby-battery leads are not used, they should be tied or taped back to prevent them from shorting to other power devices.

5.4.4 Analog Connections

For convenience, an analog plug has been provided for connection of analog signals to the DCP. The pins in this plug are connected directly to the pins in the DCP as indicated in table 5.1.

Because of wiring differences between the LaBarge and the Handar platforms, the analog grounds must be connected differently. Before using the analog on the interface, the user must check to see if these wires are connected properly for the platform being used. For the LaBarge DCP, the WHT-RED-BLK wire is connected to pin 1 of the analog jack, and the WHT-PUR is left open. The open wire should be insulated to prevent it from shorting to the circuit card. For the Handar 524 platforms, the WHT-RED-BLK and the WHT-PUR are both connected to pin 1 of the analog plug.

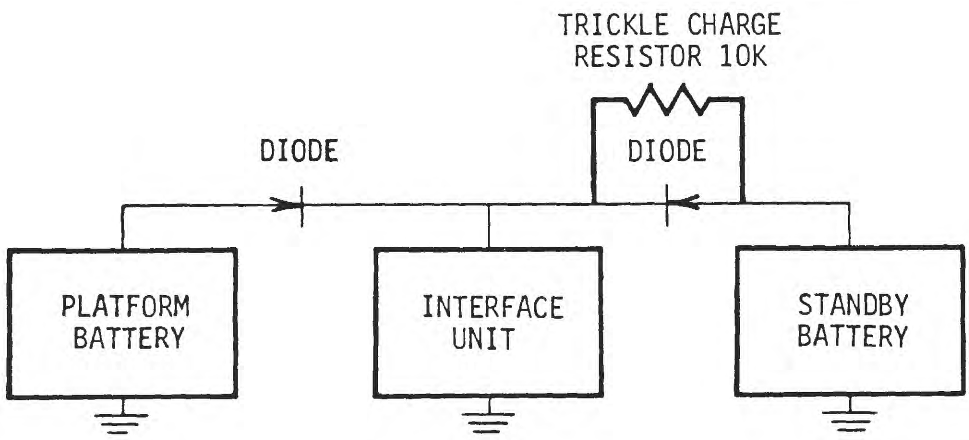


Figure 5.8.--Battery circuit for HIF shaft encoder interface.

Table 5.1.--Pin positions for analog connector

Interface pin	Interface color	Use	Platform pin
A	WHT-YEL	ANL1	(j)
B	WHT-BLU	ANL2	(z)
C	WHT-BLK-BRN	ANL3	(m)
D	RED-YEL	ANL4	N
E	WHT-BLK-BLK	ANL5	AA
F	WHT-BLK-GRN	ANL6	T
G	WHT-BLK-PUR	ANL7	U
H	WHT-BLK-RED	ANL8	(n)
I	WHT-RED-BLK	GRD	E,F,DD
I*	WHT-PUR	ANL GD	(r)
J	WHT-BLK-GRAY	12V SWITCHED	A

*Note: (r) must be left open for use on the LaBarge platform.

5.5 Sutron Incremental Shaft Encoder

The Sutron Model 8201 incremental shaft encoder (fig. 5.9) is a stand-alone instrument for measuring stage. The encoder includes a 1-foot-diameter float wheel, low-power optical sensor, LED display, and initializing buttons. The average power consumption is 1.5 mA from an external 12-volt supply; an internal rechargeable battery provides a week of standby power.

The shaft encoder interfaces to the Sutron DCP using a ±12-volt ground and a single parameter connection (B1-B16) for control and data. The encoder can be located more than 5,000 feet from the DCP and has a range of 0 to 655.25 feet.

The encoder can be read at any time by pressing the READ button. The other buttons UP and DOWN are used to preset or alter the current encoder value; however, the UP and DOWN button will operate only if the READ button is also pressed. The encoder has an internal switch to select whether the unit will operate clockwise or counterclockwise.

5.5.1 Internal Battery Connections

The internal battery is a rechargeable 6-volt gell-cell battery. When the battery is connected to the encoder circuitry, the circuitry will activate and draw 1.5 mA even if no other power is connected. Connect the battery only if the unit is to be tested or installed. To connect the battery, attach the black cable to the minus (-) terminal and the red cable to the plus (+) terminal. The circuitry is reverse voltage protected so the circuitry cannot be damaged by reverse hookups.

5.5.2 Clockwise/Counterclockwise Operation

The encoder reading can be set to increase with either clockwise or counterclockwise shaft rotation. The jumper pins on the solder side of the encoder circuitry allow the selection of clockwise or counterclockwise operation. With the pins shorted together (use the blue jumper provided), the unit is configured for counterclockwise operation; with the pins disconnected (no jumper installed), the encoder operates clockwise. The blue jumper is normally taped to the cover for future use when not installed.

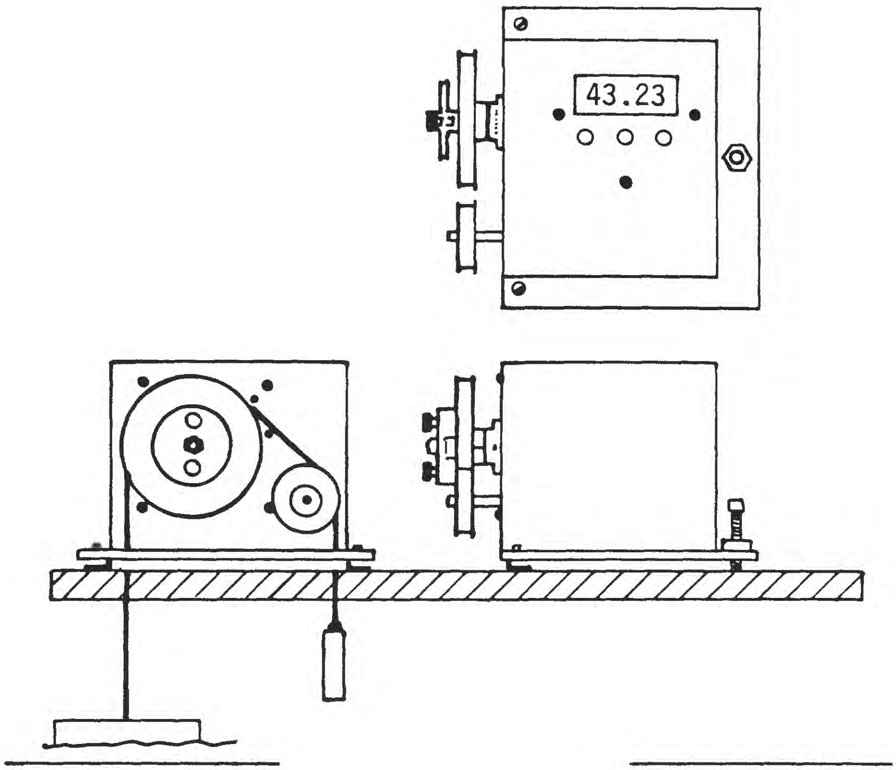


Figure 5.9.--Sutron Model 8201 incremental shaft encoder.

5.5.3 DCP Connections and Setup Consideration

The 8201 encoder interfaces directly to Sutron 8004B or the LaBarge CDCP. The 8201 encoder interface can be used with the Sutron 8004A DCP at an increased cost; however, the maximum value sent to the DCP is 9999.) The encoder comes equipped with 10 feet of 3-wire cable, which can be replaced if a longer cable is needed. The cable connects (fig. 5.10) to ground (GND), +12 volts, and any parameter (1-16 on the DCP). The encoder GND and +12-volt lines are protected so that reverse connection will not damage the encoder.

5.5.4 Activating the Display

Press READ to activate the display. The display will remain lighted for 30 seconds after READ is released. If the display shows an incorrect value or an E indicating an error condition, use the procedures in the following sections to set a proper value or clear the error indicator.

5.5.5 Increasing and Decreasing the Encoder Value

There are two ways to increase the encoder value. One is to rotate the shaft with the drive chain or float wheel. The other is to use the buttons marked READ and UP. With READ pressed, momentarily press UP—the value will increase by 1 (0.01 if decimal point included). If large increases are needed to arrive at the proper value, press UP and READ simultaneously. After 4 seconds, the value will change by 50 (0.50 if the decimal point is included) every quarter of a second. Release UP and READ to stop at a value and then use momentary pressure to go to the exact value. The encoder value will not go up indefinitely. The maximum value is 65525 after which the value will roll over to 0.

There are three ways to decrease the encoder value. One is to rotate the shaft with the drive chain or float wheel. Second is to reset the display as described in the next section. The third way is to use the buttons marked READ and DOWN. With READ pressed, momentarily press DOWN—the value will decrease by 1 (0.01 if a decimal is included). Unlike the UP button, holding DOWN will not cause a quick decrease in the value. Any decrease of the value below 0 rolls the number over to the maximum value—65525.

5.5.6 Clearing the Error Indicator/Resetting Encoder to Zero

Whenever the encoder is powered up, the encoder value is set to 0 and any error conditions are cleared. One way to reset the

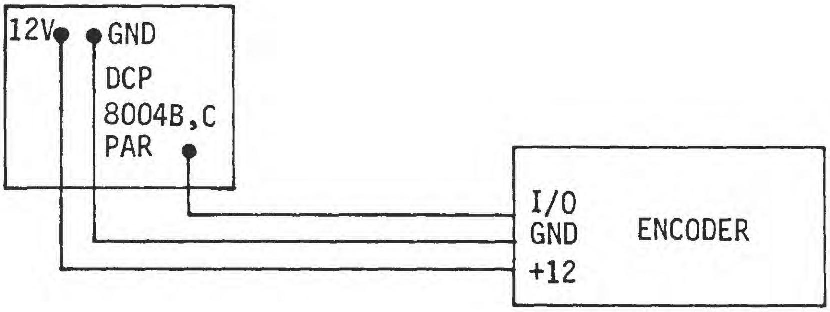


Figure 5.10.--Sutron DCP/encoder connections.

indicator and value is to remove all power to the encoder and then reapply it. The buttons, if pressed correctly, will also reset the encoder. The reset is requested by first holding down the UP and DOWN buttons and then momentarily pressing READ. If the error indicator E is on the display, the reset will clear the indicator but leave the value intact. The value is cleared by performing the same reset sequence (hold down UP/DOWN buttons, momentarily press READ) when no error conditions are indicated.

5.5.7 Error Indicator

Whenever READ is pressed, the current encoder value is displayed and, if an error is detected, an E is displayed to the left of the data. Whenever an E is present, the data displayed may be in error. Like many encoders, the 8201 samples the code wheel to detect changes in the wheel position. If the wheel rotates faster than half the sample rate (300 Hz), the changes cannot be detected reliably. The encoder can detect these conditions and set the error indicator. The current maximum rate sensed by the encoder is 1½ feet (1½ turns) per second. If the level sensed by the encoder changes faster than this, the dash-pot should be used to limit the rate of change.

5.6 Tipping-Bucket Rain Gages

The tipping-bucket rain gage is a true digital sensor and is one of the easiest to interface with a DCP. An electronic counter either within or external to the DCP accumulates the count of switch closures activated by each bucket tip—each tip being equivalent to some increment of precipitation. The earlier DCP's such as the LaBarge CDCP and Handar 524 required that tipping bucket counters be added as an optional item. All DCP's that are presently being manufactured however include tipping-bucket counters as a standard feature.

Three types of switches are used on tipping buckets—mercury switches, microswitches, and magnetically actuated proximity switches. The microswitch, which is found on some models of the USGS type 0.10-inch tipping-bucket rain gage (fig. 5.11), is of marginal reliability when used with electronic counters. Better results can be obtained if the microswitch is replaced with a proximity switch, such as the Hamlin proximity switch No. 5801 or mercury switch. To make the switch change, the microswitch actuator cam must be replaced with an actuator arm to which the magnet is attached. The magnet can be secured to the actuator arm with shrink tubing. The switch is mounted by drilling and tapping an additional mounting hole as shown in figure 5.11. The actuator arm should be made of sheet aluminum or brass, 1-3/8-inch L x 1/4-inch W x 1/16-inch T.

When tipping-bucket rain gages are installed, it is important that they be accurately leveled. If they are not, measurements can be highly inaccurate. After a tipping-bucket rain gage has been installed, it should be tested to see that it is functioning properly and is making accurate measurements. A test can be accomplished by slowly pouring a quantity of water the equivalent volume of one tip into the rain gage. This test should be done four or five times, observing the tip count each time to see that each tip is registering. If the bucket tips before all the water is poured in or does not tip, then the rain gage may be out of level or the bucket may be out of adjustment. The quantity of water for various types of rain gages is:

Type	Amount of water equivalent to one tip
8-inch ID orifice, 0.1-inch per tip	82.37 ml
8-inch ID orifice, 0.01-inch per tip	8.24 ml
12-inch ID orifice, 1 mm per tip	72.97 ml

This test should be made periodically to insure that the rain gage has maintained its calibration and that all elements are working properly.

5.7 Other Uses of Electronic Counter

The electronic counter can be put to uses other than for tipping-bucket rain gages. It can be used as an event counter. Some possible applications are:

1. Counting the number of samples taken by a QW or sediment sampler.
2. Totalizing anamometers.
3. Counting the cycles of an auxiliary ADR to monitor its operation.

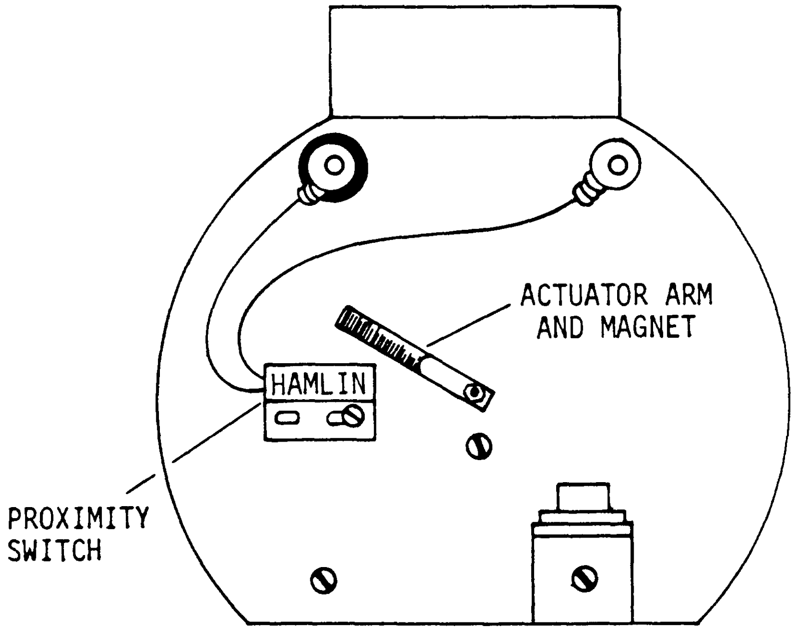


Figure 5.11.--USGS 0.1-inch tipping-bucket rain gage with switch modification.

6.0 ANALOG DEVICES

Analog sensors used with DCP's are voltage-analog devices. The voltage (0 to 5 volts) output to the platform is directly proportional to the parameter value. A generalized block diagram of a voltage-analog sensor is shown in figure 6.0. The sensor is a potentiometric device, which means that the electrical resistance of the sensor changes proportionally to the change of the parameter being measured. The sensors include thermistors, pressure transducers, and multiturn potentiometers.

Because the DCP requires a voltage representation of the parameter being measured by the sensor, change in the the electrical resistance of the sensor must be translated to a voltage that is proportionately scaled between 0 and 5 volts. This function is performed by the signal conditioner, which supplies a regulated voltage to the sensor and outputs the voltage change across the resistive element. Most signal conditioners also perform a ranging and scaling function. They have zero and span (gain) adjustments to adjust the zero and parameter range of the 0- to 5-volt output. First and second generation DCP's, such as the LaBarge CDCP and the Handar 524, did not have signal conditioners included within the platform. Signal conditioning was done outside the platform with the 0- to 5-volt analog signal being supplied to the appropriate analog channel at the DCP I/O. Many later DCP's included signal conditioner cards within the DCP so that the sensor may be connected directly. Most of these signal conditioners however are designed for sensors of a particular type and manufacture.

Because all data must be in a digital form for storage and transmission, the 0- to 5-volt analog input must be digitized. This is done by an analog to digital (A/D) converter. The A/D converter may be 8 bit to 12 bit. This means that the 0- to 5-volt analog voltage is converted to an 8-bit to 12-bit binary number, which, in base 10, would have a range from 0 to 255 or 0 to 4,095 counts, respectively. The LaBarge CDCP, Handar 524, and Handar 560 DCP's have 8-bit A/D's. The Handar 540 meteorological platform and Sutron 8004C have 12-bit A/D's. The Synergetics 3400 series DCP has a standard 8-bit A/D but offers a 12-bit A/D as an option.

6.1 Resolution

The resolution or accuracy of analog-sensor output from the DCP can be no greater than the element with the least amount of resolution. The elements are the sensor, signal conditioner, and the A/D converter. For example, if a DCP contains an 8-bit A/D converter, the best resolution that can be obtained is 1 part in 255 ± 1 bit no matter how good the sensor resolution.

If a temperature sensor with the 0- to 5-volt output representing 0° to 50°C were input to an 8-bit A/D, the best resolution

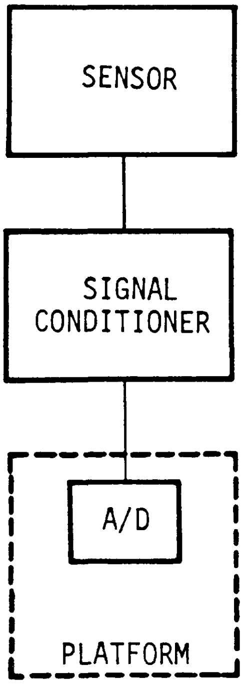


Figure 6.0.--Voltage-analog sensor.

that could be obtained would be 50°/255 or +0.20°C; if the temperature range was -50° to +50°C, the best resolution would be 100°/255 or ±0.39°C. Therefore, the limiting factors on resolution in this example would be the 8-bit A/D and the range of temperature covered by the sensor.

If a 12-bit A/D were used in the previous example, the A/D resolution would be 50°/4095 or ±0.012°C and 100°/4095 or ±0.024°C, respectively. The limiting factors on resolution in this case however probably would be the sensor or signal conditioner because most voltage analog sensors do not have resolution as high as 1 part in 4000.

As seen from the examples, all elements of an analog system must be considered before the system is purchased. The main point is that an expensive high-resolution analog sensor and signal conditioner should not be purchased if they are to be used with a DCP that contains an 8-bit A/D converter.

6.2 Calibration

If the signal conditioner has zeroing and spanning (gain) adjustments, it can be calibrated to cover whatever portion of the sensor range is needed. As pointed out in section 6.1, the smaller the range the better the absolute resolution.

Two methods can be used to calibrate a signal conditioner. The first method is to submit the sensors to known parameter values near each end of the range to be covered—such as submerge a thermistor in water. The second method is to substitute a precision resistor for the sensor, which is equivalent to sensor resistance at different parameter values.

The next steps to calibrate the signal conditioner and sensor are as follows:

1. Connect a good digital voltmeter (0.5 percent or less error accuracy) to the 0- to 5-volt output on the signal conditioner.

2. Apply a known parameter value to the sensor input that is near the low end of the output range (0 to 5 volts) and allow it to stabilize.

3. Turn zero adjustment so that the

$$\text{Output voltage} = \frac{5}{U-L} P$$

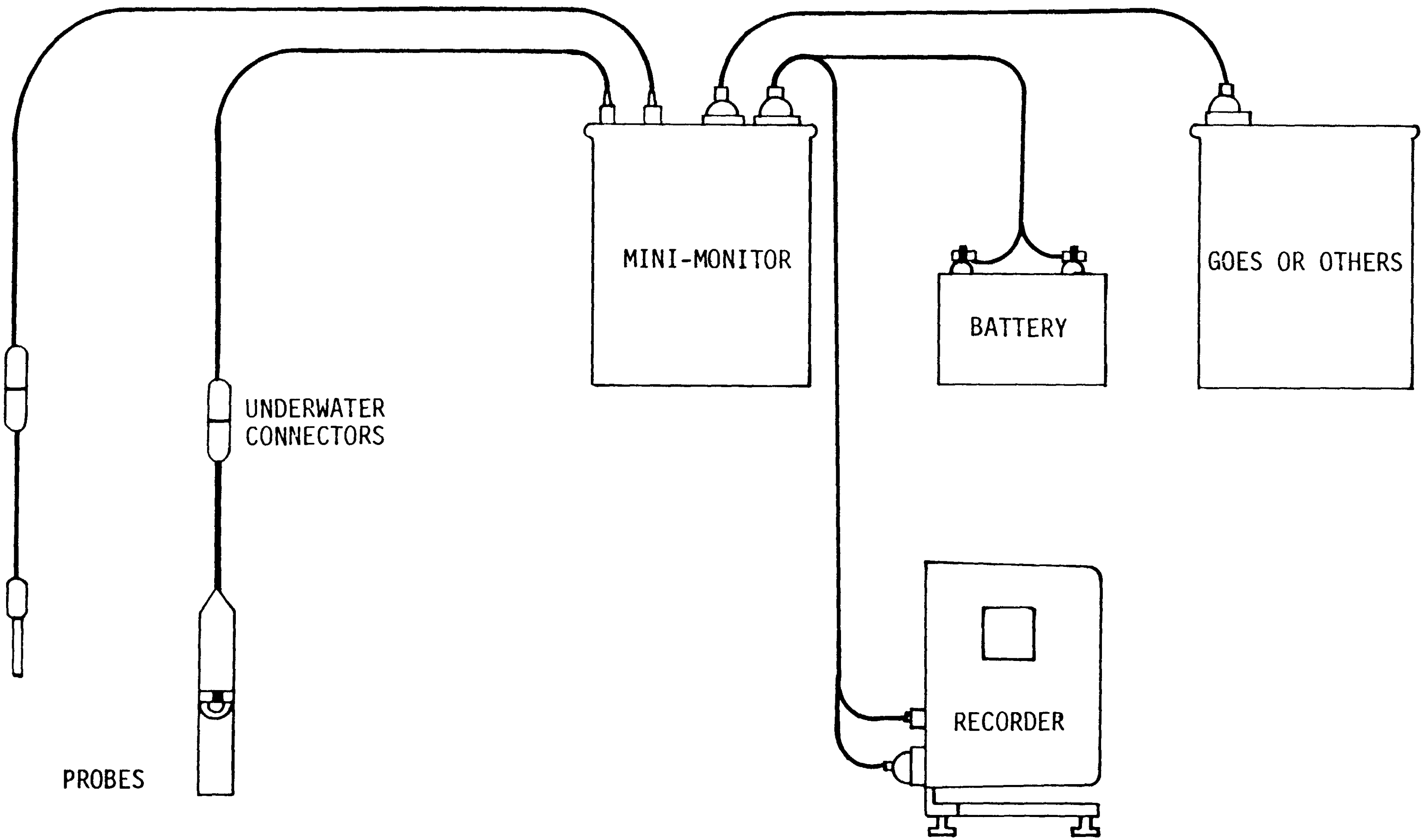


Figure 6.1.--Mini Monitor components.

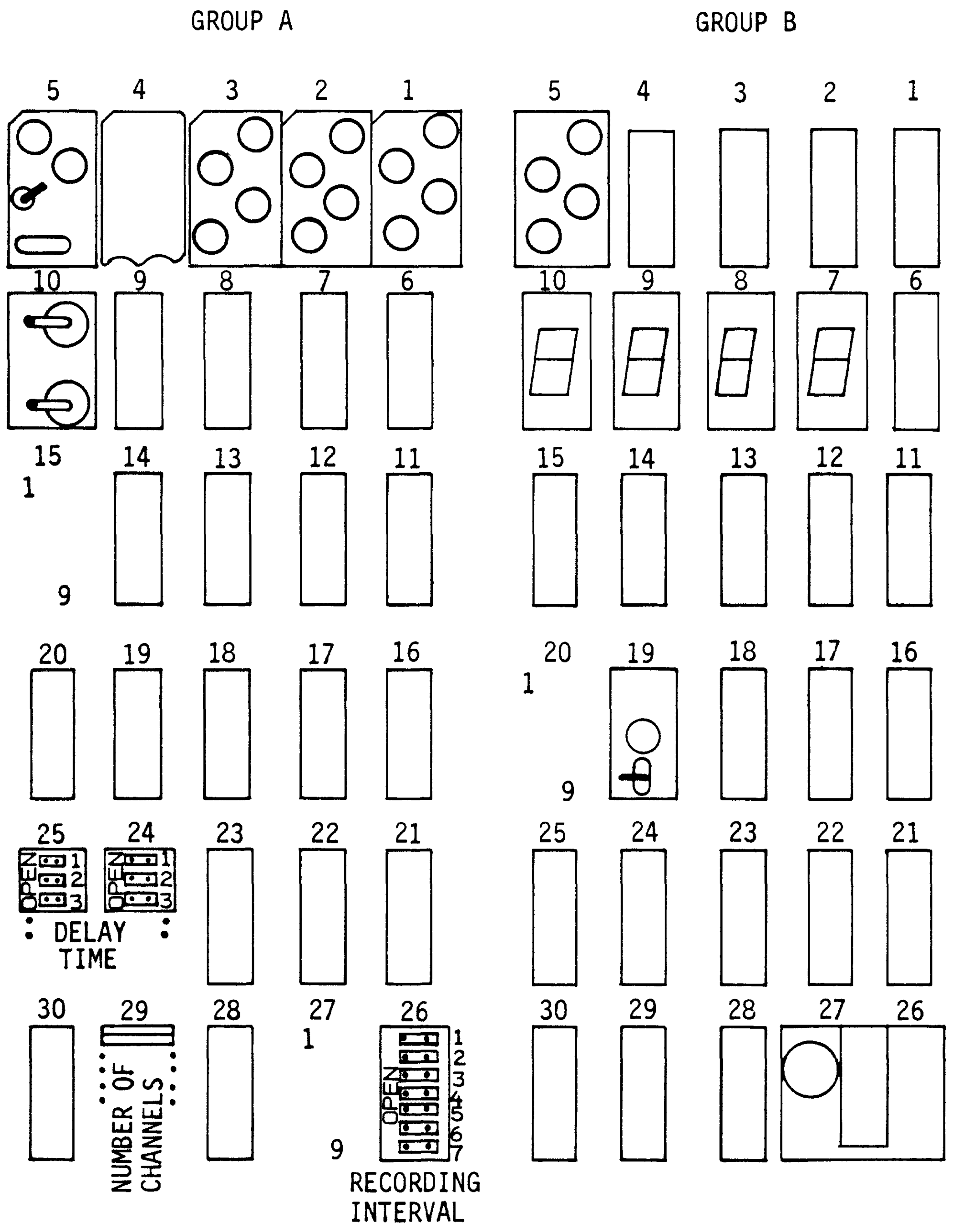


Figure 6.2.--Mini Monitor setup switch locations.

SOCKET 26A

Switch	SWITCH VALUES	5 MINUTES	15 MINUTES	30 MINUTES	60 MINUTES
1	1 min.	CLOSE	CLOSE	OPEN	OPEN
2	2 min.	OPEN	OPEN	OPEN	OPEN
3	4 min.	CLOSE	CLOSE	OPEN	OPEN
4	8 min.	OPEN	OPEN	OPEN	OPEN
5	10 min.	OPEN	CLOSE	CLOSE	OPEN
6	20 min.	OPEN	OPEN	CLOSE	CLOSE
7	40 min.	OPEN	OPEN	OPEN	CLOSE
	NONE	NONE	NONE	NONE	NONE

OPEN

Figure 6.3.--Switch settings for Mini Monitor timing.

6.3.4 Delay Times

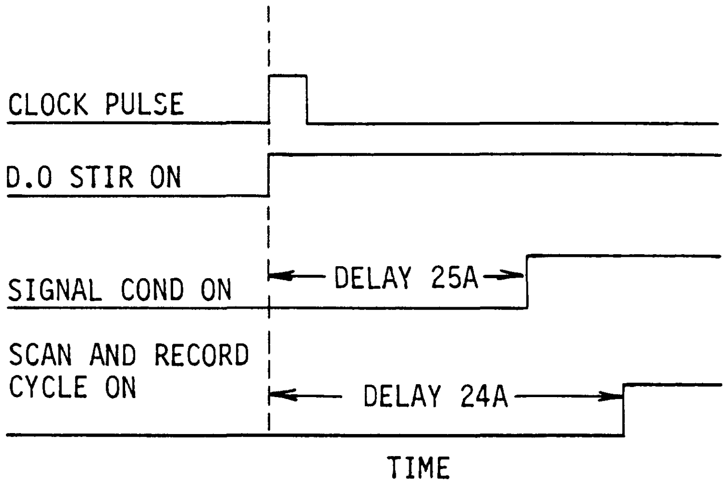
The Mini Monitor has two delay times that are can be set by the user. The monitor scan-and-record cycle is initiated by a clock pulse. The D.O. stir signal is first turned on. After a time delay set by the switches in 25A, the signal conditioner power is turned on. Next the scan and record cycle begins, its starting time being determined by the switch settings in 24A. (See timing diagram, fig. 6.4.) Note that the delay time of the scan-and-record cycle must always be longer than the delay of the signal conditioner power-on cycle. The delay time in either 24A or 25A equals the sum of the value of the closed switches. Note that only three switch closures are allowable in each socket and that these three switches can be installed only in adjacent rows. If the desired delay cannot be obtained where the three-switch assembly is located, move the assembly to a different row in the socket.

6.3.5 DCP Interfacing

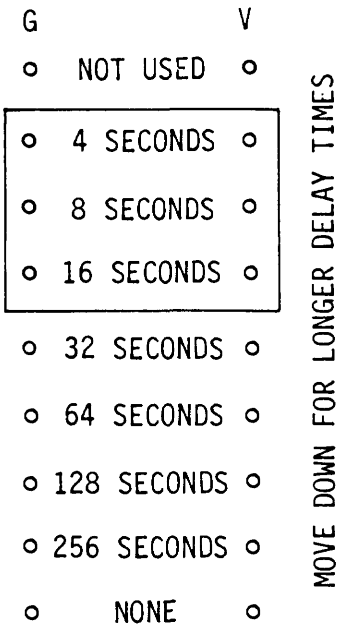
The Mini Monitor has been designed to interface to the LaBarge or Handar 524 DCP. For operation with the platform, the following switches must be set to the closed (ON) position on the programmer card: 26A6, 26A7, 25A3, 25A4, 24A5, and 24A4. All other switches on 24A, 25A, and 26A must be open. These switch settings will cause the Mini Monitor to come on once an hour, wait 48 seconds then turn on the signal conditioners, wait 48 seconds more and then record (fig. 6.5). The 10-pin analog telemetry jack connects to the platform as shown in table 6.0.

After setting the monitor for the proper delays and hooking up the telemetry, the following test can be performed to verify that the system is working properly.

1. Set the platform on a 5-minute data-acquisition cycle.
2. Advance the Mini Monitor through all the channels and back to 0 by using channel advance switch.
3. Set the Mini Monitor clock to 01.
4. When the 12-volt strobe from the platform turns on, the Mini Monitor's clock should reset to 00. About 80 seconds later the platform should record the analog data, and 96 seconds after the clock resets, the scan and record cycle of the Mini Monitor should start.
5. The sequence in 4 should repeat every 5 minutes. One can verify the analog data by reading the data stored in the platform through the platform programming set.



TIMING DIAGRAM



SWITCH VALUES FOR BOTH SOCKETS 24A AND 25A

Figure 6.4.--Mini Monitor timing.

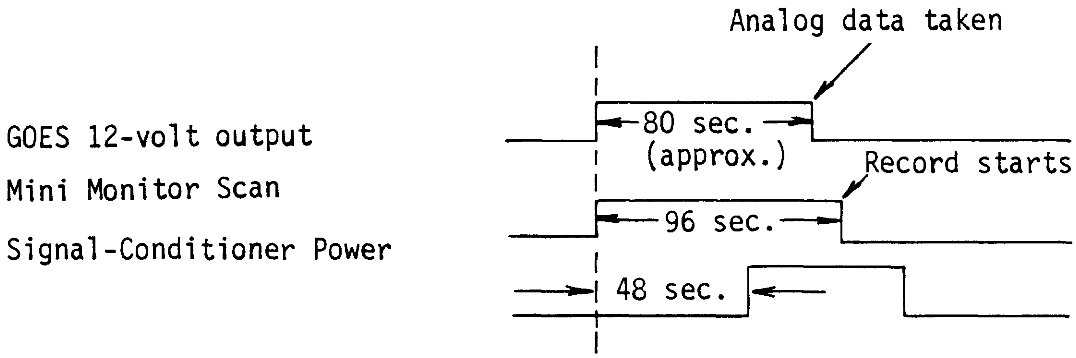


Figure 6.5.--Data-collection platform timing.

Table 6.0.--Mini Monitor pin connections for the LaBarge data-collection platform

Mini Monitor pin	Function	Platform pin
A	CH 1 out (0 to 5 volts)	j
B	CH 2 out (0 to 5 volts)	z
C	CH 3 out (0 to 5 volts)	m
D	CH 4 out (0 to 5 volts)	N
E	CH 5 out (0 to 5 volts)	AA
F	CH 6 out (0 to 5 volts)	T
G	CH 7 out (0 to 5 volts)	U
H	CH 8 out (0 to 5 volts)	n
I	Analog ground	P
J	12-volt switched from platform	A

6. When the test is complete, return the platform to its 1-hour data-acquisition time.

After the above-noted testing is completed, the system can be put in operation by proceeding as follows:

1. Set the platform to the correct time and set the platform data-acquisition time and Mini Monitor recording interval to the same desired length.

2. Advance the Mini Monitor through all the channels and back to zero using the channel advance switch.

3. Set the Mini Monitor clock to 00.

4. The Mini Monitor will be triggered by the next data-acquisition cycle of the platform. This will keep the Mini Monitor's clock synchronized with the platform's clock.

6.4 Setting Up Mini Monitor for Use With Handar 524 and 560 DCP's

6.4.1 Using the Mini Monitor With Handar 524

The Handar 524 uses the same I/O cable (55-pin connector to DCP) as the LaBarge CDCP except that the analog pin positions are slightly different. The 524 uses analog 1 (55-pin connection J) to monitor the power-supply voltage; therefore, the first parameter from the Mini Monitor must be connected to analog channel 2 (pin z) on the 55-pin platform connector. The 10-pin analog telemetry jack connects to the Handar 524 as shown in table 6.1. Be sure that the Mini Monitor telemetry connector is wired as shown in table. Set Mini Monitor switches as described in section 6.3.5. If three or four digital channels are used, set switch 25A to 64 seconds and 24A to 128 seconds. Connect Mini Monitor and 524 power cables to a single power supply or two separate power supplies—either arrangement will work. Program the platform as described in Handar 524/525A operating and service manual. Remember that A1 (Analog No. 1) is used by the platform to monitor battery voltage; therefore, program one more analog channel in addition to the number of analog parameters from the Mini Monitor. To read the Mini Monitor analog outputs using the monitor key on the 525A programming set, the Mini Monitor must be in manual mode. The analog reading from the platform will not be in engineering units but will be the decimal equivalent of the A/D 8-bit binary reading. This number will range between 0 and 255, where 0 = 0 volts and 255 = 5 volts. To convert the analog output to engineering units, use the equation:

$$\text{Parameter value} = \frac{U-L}{255} R,$$

Table 6.1.--Mini Monitor pin connections for the Handar 524 data-collection platform

Mini Monitor pin	Function	Platform pin
A	CH 2 input (0 to 5 volts)	z
B	CH 3 input (0 to 5 volts)	m
C	CH 4 input (0 to 5 volts)	N
D	CH 5 input (0 to 5 volts)	AA
E	CH 6 input (0 to 5 volts)	T
F	CH 7 input (0 to 5 volts)	U
G	CH 8 input (0 to 5 volts)	n
H	N/A	
I	Analog ground	
J	12-volt switched from platform	A

where

U = value for upper end of parameter range,
L = value for lower end of the parameter range, and
R = analog reading from the platform.

Although the Mini Monitor recording interval switches (26A) are set for a 1-hour sampling interval, the platform scan interval may be set to 1 hour or less. Because the platform is controlling the recording interval, the Mini Monitor's clock is set to zero each time the platform scans. After the platform has been programmed and is running, be sure the Mini Monitor is set to AUTO and clock is set to zero.

6.4.2 Using the Mini Monitor with Handar 560

To use a Mini Monitor with the Handar 560 DCP requires an additional card not supplied with the basic platform. The card needed is an 8-channel analog/incremental encoder interface assembly, Handar Part No. 560-7007. The 560-7007 card contains eight analog inputs, an additional incremental encoder input, and an additional tipping-bucket precipitation counter. The 26-pin Handar 560-7007 interface card input/output description is shown in table 6.2.

To put the Mini Monitor and Handar 560 into operation, set the Mini Monitor timing switches as described in section 6.3.5 and connect the 10-pin Mini Monitor cable to the 560 26-pin connector as described in table 6.2. Program the platform as described in Handar 560 operating and service manual using sensor type 10 for each Mini Monitor parameter. Program the input address and power address as shown in table 6.1. To make a fast scan (FSCAN), the Mini Monitor must be in manual mode.

6.5 Setting Up a Mini Monitor for Use with a Sutron 8004C DCP

The U.S. Geological Survey Mini Monitor, although designed to interface with the LaBarge DCP, will also interface with the Sutron DCP. For operation with the Sutron platform, the following switches must be set to the closed position on the programmer card: 26A6, 26A7, 25A3, 25A4, 24A5, 24A4. All other switches on 24A, 25A, and 26A must be open. These switch settings will cause the Mini Monitor to come on once an hour, wait 48 seconds then turn on the signal conditioners, wait 48 seconds more then record data.

The 10-pin analog telemetry jack connects to the Sutron DCP as shown in table 6.3. After setting the monitor for proper delays and hooking up the telemetry jack, program the Sutron DCP as follows:

Table 6.2.--Description of 26-pin connector with the Handar 560-7007 interface card

Mini Monitor 10-pin connector	Handar 560 26-pin connector	436A Incre-mental encoder	Function	Input address	Power address
A	T	-	Analog 1	2	0
B	R	-	Analog 2	7	0
C	S	-	Analog 3	5	0
D	M	-	Analog 4	4	0
E	B	-	Analog 5	0	0
F	W	-	Analog 6	1	0
G	U	-	Analog 7	3	0
H	K	-	Analog 8	6	0
I	N or L	-	Analog ground	-	-
J	c or b	-	12-volts switched	-	-
-	a	E	Encoder signal (01)	-	-
-	Z	D	Encoder signal (02)	-	-
-	Y	C	Encoder 5-volt switched	-	-
-	X	F	Encoder ground	-	-
-	F	-	Tipping-bucket input	-	-
-	E	-	Tipping-bucket input	-	-
-	J	-	5-volts switched	-	-
-	H	-	5-volts switched	-	-
-	D	-	5 volts	-	-
-	G	-	5 volts	-	-

Table 6.3.--Mini Monitor pin connections for the Sutron 8004C data-collection platform

Mini Monitor pin	Function	Platform
A	CH 1 out	Par 1
B	CH 2 out	Par 2
C	CH 3 out	Par 3
D	CH 4 out	Par 4
E	---------	-----
F	---------	-----
G	---------	-----
H	---------	-----
I	Analog ground	Ground
J	12-volt from platform	Switched 12 volts

Sutron DCP To Mini Monitor Interface Sample Program

OM - 1
ID1 - 12345678
ID2 - 12345678
TT - 000:00:00:00
TI - 180
GMT - 000:00:00:00
STD - 0
FMT - 1
NS - 24
TNC - 000:00:00:00
UI - 15
WT - 65
INC - 1
PAR 1 through 4
PT - 1
GA - 2
CO - 4
MV - 0

This program will collect data from all parameters on a 15-minute acquisition cycle, store 24 values for each parameter, and transmit on a 3-hour interval.

At the data-collection time, the Sutron DCP will turn on the switched 12-volt terminal and reset the Mini Monitor clock to 00. The switched 12-volt terminal turns off 65 seconds later and the DCP inputs the analog data from each sensor; 96 seconds after the clock resets, the scan-and-record cycle will begin. This sequence will repeat every 15 minutes. To put the system in operation proceed as follows:

1. Set the platform to the correct time and set the platform data-acquisition time and the Mini Monitor recording interval to the same desired length.

2. Advance the Mini Monitor through all the channels and back to zero.

3. Set Mini Monitor clock to 00.

The Mini Monitor will be triggered by the next data-collection cycle of the platform. This will keep the Mini Monitor clock synchronized with the platform's clock.

6.6 Setting Up a USGS Mini Monitor for Use with a Synergetics 3400 Series DCP

The U.S. Geological Survey Mini Monitor will also interface with the Synergetics DCP. It is recommended that the Synergetics DCP be equipped with the 12-bit A/D converter option (3451-001) for better resolution. Also, it should be noted that several software versions for the Synergetics DCP are available. The processing equations listed in this manual should work on all the Synergetics DCP's.

For operation with the Synergetics platform, the Mini Monitor programmer card switches must be reset for the type of data being collected. For the most part, this depends on whether or not dissolved oxygen (DO) is being monitored. If DO is monitored, the time delays set on 25A and 24A should be set with reference to the HIF OPERATING MANUAL for the USGS Mini Monitor (40 seconds on 25A and 48 seconds on 24A). If DO is not monitored, there should be NO DELAY set on 25A and not less than 4 seconds set on 24A.

The DCP is normally programmed to strobe the Mini Monitor and scan for data at each Mini Monitor recording interval. The same delay set in the Mini Monitor will have to be programmed into the DCP to insure that the DCP will scan for data while there is power to the SIGNAL CONDITIONER card. Each time the DCP strobes the Mini Monitor, the Mini Monitor clock will be reset and the two clocks sychronized.

The 10-pin analog telemetry jack, located on the Mini Monitor, connects to the Synergetics 3451A End Device Interface Module (EDIM) as shown in table 6.4. After setting the Mini Monitor for proper delays and hooking up the telemetry jack, the DCP must be programmed. Each change in the number of inputs or data acquisition frequency will require a change in the program.

The following program will collect data from four Mini Monitor channels (including DO) every 15 minutes. This program will store 32 values for each Mini Monitor parameter and give one full transmit cycle of back-up data for each Mini Monitor parameter when using a 4-hour transmit interval.

```
S(n) SCAN.INT = 0 0 15 0 S(n)
SCAN.TIM = 0 0 0

T(n) <- 64 ON 4 0 64 OUTPUT 10 DELAY 0 0 64 OUTPUT ;
T(n+1) <- 530 DELAY 1 64 INPUT 500 4096 */ 32 DIM ;  ---(50.0 DEGREES = 500)
T(n+2) <- 2 64 INPUT 1000 4096 */ 32 DIM ;     ---------(1000 micromhos = 1000)
T(n+3) <- 3 64 INPUT 1000 4096 */ 32 DIM ;     ----------(10.0 pH units = 1000)
T(n+4) <- 4 64 INPUT 1000 4096 */ 32 DIM 64 OFF ;  -------(0-10.0 mg/L = 1000)
```

T(n) equation does the following:

64 ON = turn the ED.IM address 64 on.
4 0 64 OUTPUT = sets the output strobe #3 "HI"
10 DELAY = one second delay
0 0 64 OUTPUT = sets the output strobe "LO"

Table 6.4.--Mini Monitor pin connections for the Synergetics 3400 Series data-collection platform

Mini Monitor pin	Function	Data-collection platforms TERMINAL STRIP	PIN
A	CH 1 out	1 ANALOG HI	49
B	CH 2 out	2 ANALOG HI	47
C	CH 3 out	3 ANALOG HI	45
D	CH 4 out	4 ANALOG HI	43
E	CH 5 out	5 ANALOG HI	41
F	CH 6 out	6 ANALOG HI	39
G	CH 7 out	7 ANALOG HI	37
H	CH 8 out	8 ANALOG HI	35
I	ANALOG GROUND	ANY ANALOG LO	50
J	7 1/2 VDC SWITCHED (strobe from DCP)	3 OUT	11

T(n+1) equation does the following:

480 DELAY = 48 seconds delay
1 64 INPUT = retrieves data from analog input #1
500 4096 */ = multiplies the input by 500 and divides by 4096
32 DIM = store 32 data updates

T(n+2-4) does the same as T(n+1) except they retrieve data from analog inputs 2-4 and multiply by 1000, and T(n+4) turns the EDIM off.

NOTE: The strobe outputs are controlled by channel 0 on address 64. There are 4 outputs labeled 1, 2, 3, & 4 which are set "HI" (on) or "LO" (off) as if represented by a 4-bit binary number. If you program (1 0 64 OUTPUT), the 1 is represented by the 4-bit binary number 0001; in this case, the number 1 output will be turned on. If you program (15 0 64 OUTPUT), the 15 is represented by the binary number 1111; in this case all four outputs will be turned on. Program a 4 (0100) and the number 3 output will be turned on. Program a 5 (0101) and the number 3 & 1 outputs will be turned on. In the above programs output 3 has been used because output 1 is used with an ADR and outputs 1 & 2 are used with a Series 500 Interface.

The following program will collect data from two Mini Monitor channels every hour and store 8 values for each parameter (for 4-hour transmit interval this will give one full transmit cycle of back-up data for each Mini Monitor parameter).

```
S(n) SCAN.INT = 0 1 0 0
S(n) SCAN.TIM = 0 0 0
```

```
T(n) <- 64 ON 4 0 64 OUTPUT 10 DELAY 0 0 64 OUTPUT ;
T(n+1) <- 90 DELAY 1 64 INPUT 500 4096 */ 8 DIM ; ----(50.0, DEGREES = 500)
T(n+2) <- 2 64 INPUT 10000 4096 */ 8 DIM 64 OFF ; --(10,000 micromhos = 1000)
```

T(n) is the same as the first program.
T(n+1) is the same as the first program except the delay is for 4 seconds and stores 8 updates.
T(n+2) is the same as the first program except it stores 8 updates and also monitors conductance values from 0 to 10,000 micromhos.

Using either of the above programs, it is possible to collect and store (DIM) time along with the Q.W. parameters. The time of data collection is helpful if there is room in the transmission time slot.

The following T Equations will collect and store time as a data parameter and may be used with either of the above programs.

```
T(n) <- 11 0 INPUT 60 / SAVE ;
T(n+1) <- 10 0 INPUT 100 * T(n) + SAVE ;
T(n+2) <- T(n+1) 32 DIM ;
```

T(n) equation does the following:

> 11 0 INPUT = senses the input from channel 11 address 0
> 60 / SAVE = divide the input by 60 and save the value

T(n+1) equation does the following:

> 10 0 INPUT = senses the input from channel 10 address 0
> 100 * T(n) + SAVE = multiply the input by 100, add the value of T(n), and save the answer

T(n+2) equation stores 32 values of the answer produced by T(n+1)

> NOTE: Address 0 is 3401A Master Control Module (MCM), channel 11 is current seconds into hour and channel 10 is current hour.

In the above program for 4 Mini Monitor inputs, plus stage and time, the length of transmission every 4 hours will be about 54.1 seconds (with binary format and long preamble). The transmission time can be shortened by reducing the DIM to 16 with no redundant data or by changing the data recording interval to a longer period.

7.0 DCP INFORMATION MANAGEMENT SYSTEM (DIMS)

7.1 Platform Assignment and Scheduling Subsystem General Information

7.1.1 Introduction

The Platform Assignment and Scheduling Subsystem (PASS) is designed to support scheduling of data-collection platform (DCP) reception and to allow users to request a new DCP assignment or to modify existing assignments. This information is used by the Data Relay Project to create forms for requesting authorizations from the Departments of Interior and Commerce for GOES Data Collection System (DCS) assignments and licenses to generate radio transmissions.

PASS uses the information to select a GOES DCP id on the proper channel for the site location, to assign the DCP to a Water Resources Division (WRD) direct readout ground station (DRGS), and to calculate antenna azimuth and elevation. PASS also allows for modification of most of the information and has features for listing and transferring the assignment records to another PRIME computer. PASS does extensive checking to prevent such things as duplicate station numbers and duplicate device numbers.

In addition to processing DCP assignments, PASS is used to optimize the scheduling of message reception by each DRGS. This scheduling will insure maximum use of each demodulator monitoring a GOES DCS channel. To insure that this scheduling can be supported on a nationwide basis for all DRGS, it is necessary that any DCP whose messages are scheduled for reception by any WRD-operated DRGS be entered into PASS. PASS will automatically create and transmit a preliminary DCP maintenance form to the appropriate DRGS operator.

The system uses Fortran 77 for the main menu and for information needed for calculations. The remaining screens and input use PRIME INFO.

7.1.1.1 Authorization Forms

Two authorizations are needed to use the GOES DCS—one for use of the GOES DCS and the other to emit radio transmissions of any type. When entering a new station or changing a primary operating parameter, PASS will automatically generate the proper form for the Data Relay Project to submit to the Department of Interior. The approval cycle for this authorization requires 3 to 4 months. The authorization for new DCP stations or stations that have been deactive for 30 days must be generated by the user using PASS (see section 1.4.7) no sooner than 30 days before the DCP is activated. PASS will print the authorization for the Data Relay Project, who will submit the forms to NESDIS 2 weeks prior to DCP activation. To meet this NESDIS imposed schedule, users must request PASS to print the authorization no sooner than 30 days and no later than 21 days before activation of the DCP. Users must contact the NESDIS DCS operator and the appropriate WRD DRGS operator 24 hours before actual activation.

7.1.2 INFO Conventions

The conventions presented below are to be followed during data entry or update using the PASS computer screen input forms. The following controls are used by INFO. Use only the keys contained in < >.

<space> <return>	This will leave a blank value for the input
<=> <return> or <tab> <return>	During update, this will retain the current value and the cursor will move to the next entry
<back-slash> <return>	This will return the cursor to the previous entry

For all other information, enter the value followed by <return>.

7.1.3 Getting Started

At the present time PASS is in the QVARSB PRIME and it is necessary to netlink to QVARSB to use it. To obtain the person id and password, please contact Mike Field at QVARSB or FTS 959-5362. Once logged on to QVARSB the following command is typed:

PASS

Because of the many different types of terminals being used on the PRIME's, it is necessary that INFO be set up so that the screen controls will work for the terminal being used. The following procedure does just that. If a TAB, GraphOn, or VT-100 type is being used, the screen should clear before the first question listed below in the example, answer with a Y and continue. If the screen does not clear, make a selection from the list printed by the computer. If the terminal type is not included in the list, try to find a selection that is compatible with the terminal being used. For example, the SuperBrain and Compustar use the AREG type and the VT-100 type uses the ANSI type. An example of the procedure for clearing the screen follows:

IF YOUR SCREEN DID NOT CLEAR BEFORE THIS MESSAGE, YOU WILL HAVE TO CHANGE YOUR TERMINAL TYPE. DID YOUR SCREEN CLEAR? (Y OR N)? N

ACT-I	VACT5A	ADDS	ADML1	ADM3	ANSI	ANSIW
AREG	BEEH	CONCEPT	CYBERNEX	DGRX	DMED	HARD
HONW	HP2621	I304	IBM1	LYNW	NEWB	NONE
OWL	PST100	SOROC	TVI924	VCRG	VT52	SEIKO

PLEASE TYPE IN THE TERMINAL TYPE SELECTED. ANSI

DID YOUR SCREEN CLEAR (Y OR N)? Y

The process is completed using menus. The options for the first menu (main menu) are presented in the section 1.4. Examples are given in section 1.6.

** NOTE: Please use all upper case. **

7.1.4 OPTIONS

7.1.4.1 Option 1 - ADD NEW STATION

This option selects a DCP id and the corresponding channel, assigns the proper supporting DRGS, and calculates the antenna azimuth and elevation. This calculation is absolute, using no magnetic variations. Some of the data displayed on the screen is either calculated (azimuth and elevation) or is assigned data (DCP id, channel, DRGS, and transmit times) and cannot be changed. The NESDIS PDF and and DRGS DCP maintenance forms are automatically generated by the Data Relay Project 30 days prior to the date input by the user for DCP deploy date. The user will be notified when the form is sent to NESDIS. If the deploy date changes, the Data Relay Project must be notified. This date is critical to receiving NESDIS permission to use GOES.

7.1.4.2 Option 2 - ADD NEW STATION FOR NON-USGS DCP

This option allows the entry of a DCP, whose assignments have not been coordinated .by the USGS, into the database. This procedure will require the user to enter the cooperator assigned DCP id, channel, and transmitting times. Once the DCP id is entered, the software follows the same procedures as option 1. Because all authorizations have been coordinated by another agency, this option does not create the authorization forms.

7.1.4.3 Option 3 - MODIFY EXISTING STATION INFORMATION

This option allows the station information, such as station number and the number of devices, to be modified. Any new authorization forms that may be necessary are automatically created. Neither this option nor any other will allow the change of DCP id. The station must be deleted (option 4) then input as a new station (option 1).

7.1.4.4 Option 4 - DELETE STATION

This option is used when DCP operations at a station are to be permanently discontinued. It deletes all the station information and unassigns the DCP id (the id is then available for reassignment). If the DCP id is a non-USGS id, the software will delete the id from the database.

7.1.4.5 Option 5 - MODIFY FIELD OFFICE INFORMATION

This option is used to change any field office information for an existing person id. New field office information is requested when a new person id is entered under options 1, 2, or 3. Person id's are added or changed using options 1, 2, or 3. Field office information is automatically deleted (options 3 and 4) for a person that no longer has any stations assigned to them.

7.1.4.6 Option 6 - MODIFY DEVICE INFORMATION

This option allows all of the device information for a station to be changed except the device number. Devices are identified and modified by device number. To add or delete devices use option 3.

7.1.4.7 Option 7 - SUBMIT NESDIS PLATFORM DATA FILE

This option will allow the user to reschedule the generation of the NESDIS PLATFORM DATA FILE. This file will be used by the Data Relay Project to request authorization to use the GOES DCP's for the assigned DCP id and channel. This option is used to update the DEPLOY DATE if necesary. This update must be made no later than 21 days before the DCP is activated.

7.1.4.8 Option 8 - LIST STATION INFORMATION

This option displays all the station information on the screen. Copies can be made from terminals with attached printers.

7.1.4.9 Option 9 - TRANSFER STATION INFORMATION

This option sends the station information report, via electronic mail, to the person and node specified.

7.1.4.10 Option 10 - LIST STATION SUMMARY BY STATE OR PERSON ID

This option provides the user with a short summary of the group of stations that are retrieved by the responsible person id (person responsible for all DCP's in the group) or by state code. The information listed on the terminal screen is station number, station name, DCP id, channel, and assigned time.

7.1.4.11 Option 11 - TRANSFER STATION INFO BY STATE OR PERSON ID

This option sends the user the short summary for a group of stations retrieved by person id or state code. The output is transferred to the mailbox for the person and node selected.

7.1.5 Item Descriptions

The following is a description of all the items needed for PASS.

NOTE (*) after the name means the information is MANDATORY.
(**) after the name means the information is supplied by PASS and cannot be directly updated by the user.

7.1.5.1 Office Information

PERSON ID* PRIME person id. (22 chars)

NODE* PRIME node in the PRIME DIS network. (6 chars) (for example, QVARSB or DAZTCN)

NAME*	Person responsible for the site who can be contacted in case of problems or desires to receive the transmitted data. (First name - 12 chars, init - 1 char, last name - 22 chars)
ADDRESS*	Mailing address of the NAME person. (22 chars)
AGENCY	NAWDEX agency code of the contact. (5 chars) (for example, USGS or USCOE)
PHONE*	FTS and (or) commercial number for contacting the NAME person. (xxx-xxx-xxxx)
PRIME DIRECTORY*	Full path-name to PRIME directory that data are to be transferred to via the PRIME DIS network. (30 chars)

7.1.5.2 Station Information

STATION NAME*	Standard USGS station name. (48 chars)
STATION NUMBER*	USGS downstream station number or latitude-longitude-sequence number. (15 chars) (for example, 01234567)
NEAREST CITY*	Name of nearest city to the station that is shown on a USGS topo map. (16 chars)
LATITUDE*	Latitude of station as DDMMSSD include (N)orth or (S)outh. (for example, 352515N)
LONGITUDE*	Longitude of station as DDDDMMSSD include (E)ast or (W)est. (for example, 0835343W or 1211917W)
STATE CODE*	FIPS numeric state code where the station is located. (2 char) (for example, 42)
OWNER AGENCY*	NAWDEX agency code of the agency that owns the DCP located at the station. (5 chars) (for example, USGS or USCOE)
SITE ELEVATION*	Elevation in feet above sea level for the station. (5 digits including sign and no decimal) (for example, 4244)

7.1.5.3 DCP Information

TRANSMIT INTERVAL**	For self-timed DCP's the time interval (hh) in hours between regularly scheduled transmissions. (for example, 04)
PLATFORM MANUF*	Name of the DCP manufacturer. (H)andar, (L)aBarge, (SU)tron, (SY)nergetics, (other). (2 chars)
MODEL*	Model number of the DCP. (6 chars) (for example, 3400)
TRANSMIT TYPE*	Type of transmission from DCP. (S)elf-timed, (R)andom, (A)lert, (I)nterrogated (1 or 2 chars). Can be 2 modes, such as (SA) self-timed with alerts.
NUMBER OF DEVICES*	The number of different devices to be transmitted from the DCP including any internal devices such as battery voltage or DCP status. Number must correspond to the number of DEVICES described in the next section of the form. (1 to 20)
ANTENNA HEIGHT*	The height in feet that the antenna is located above the land surface. (2 chars) (for example, 10)
DEPLOY DATE*	The approximate date of deployment to the field. This date is used to generate the NESDIS platform data file (PDF) at the proper time. (8 chars including /) (for example, 01/12/86). This does not relieve the user from the responsibility of contacting NESDIS 24 hours in advance of the DCP deployment. This data allows the Data Relay Project to send the DCP information to NESDIS at least 2 weeks in advance of the DCP deployment. The user call to NESDIS must confirm that this information has been entered into the NESDIS PDF and that the DCP will be operating within 24 hours. If the deployment date is delayed, please contact the Data Relay Project.
NESDIS NOTIFIED**	Date indicating when the NESDIS PDF was sent.

The office information screen shown below will only be displayed if the person id is new to the data base.

* Indicates a mandatory item (cursor will not move until an entry is made)

** Indicates entry will be made by PASS - PASS will complete the screen entry if: (1) Data has been previously supplied (for example, station number or person id), (2) an assignment is made (for example, DCP id or DRGS), or (3) a calculation is made (for example, antenna azimuth or antenna elevation).

```
*********************   OFFICE INFORMATION   *********************

PERSON ID:**________________________            NODE:*     _________

NAME:*______________ MID INIT.: _ LAST NAME:*____________________

ADDRESS:*_______________________
ADDRESS: _______________________

CITY:* _________________  STATE:** _________________  ZIP:*________

AGENCY:    ______________

FTS PHONE: __ __ ___   NON-FTS PHONE: __ __ ___

PRIME DIRECTORY:*_________________
```

This is the next screen that appears.

```
*********************   STATION INFORMATION   *********************

STATION NUMBER:**_______________   NEAREST CITY:**______________

STATION NAME:*____________________________________________________

LATITUDE:**                 __________  LONGITUDE:**      __________

STATE CODE:**                        _  OWNER AGENCY:         ______

SITE ELEVATION:*                 _____
```

This is the next screen.

```
*********************        DCP INFORMATION        *********************

DCP ID:**________                          DRGS:**______

ASSIGNED TIME:**          ___              TRANSMIT            INT:**
___

PRIMARY CHANNEL:**        ___              SECONDARY CHANNEL:**___

ANTENNA AZIMUTH:**        ____             ANTENNA  ELEVATION:**___

PLATFORM MANUF (L,H,SY,SU):*___            PLATFORM MODEL:*  _____

TRANSMIT TYPE (S,R,A,SA,RA,):*__           NUMBER OF DEVICES:* ___

ANTENNA HEIGHT ABOVE SITE:* __             INVENTORY CNTL NO.:_____

DEPLOY DATE (MM/DD/YY):*__/__/__           NESDIS NOTIFIED:**__/__/__

NESDIS QUEUE:**          ________          DEMOD SCHEDULE:**        _
```

The following screen will appear once for each device specified.

```
************ DEVICE INFORMATION ************
DEVICE
  NUMBER:**              __
PARAMETER
  CODE    :*          ______
  DESC    :          _______
  UNITS   :          _______
DEV UPD INT (HHMM):*_____
INVENTORY CNTL NO.:___________

 DONE WITH STATION INPUT.
 DOING FORMS.  PLEASE WAIT.
 IRAC FORM DONE.
 NESDIS PDF WILL BE SENT AT THE PROPER TIME.
   YOU WILL BE NOTIFIED OF THE TIME OF TRANSMITTAL.
```

The IRAC FORM is used by the Data Relay Project to request authorization to emit radio transmissions. The NESDIS GOES assignments and DRGS DCP maintenance forms are automatically printed.

7.1.6.3 Option 2 - ADD NEW STATION FOR NON-USGS DCP

This information is needed to install a new DCP whose authorizations have been coordinated by another agency. The DCP ID, CHANNEL, ASSIGNED TIME, and TRANSMIT INTERVAL are from those authorizations. Following the entries listed below, the same screens as option 1 are used.

```
INPUT OPTION NUMBER = 2
PERSON ID =
STATION NUMBER =
DCP ID (CCCCCCCC) =
CHANNEL (CCC) =
ASSIGNED TIME (HHMM) =
TRANSMIT INTERVAL (HH) =
2 DIGIT STATE CODE =
6 DIGIT LATITUDE + (N OR S) =
7 DIGIT LONGITUDE + (E OR W) =

IS THE ABOVE INFORMATION CORRECT (Y OR N)?
```

7.1.6.4 Option 3 - MODIFY EXISTING STATION INFORMATION

The following is requested for preliminary calculations.

```
INPUT OPTION NUMBER = 3
PERSON ID =
STATION NUMBER =
DO YOU WANT TO CHANGE LAT OR LONG (Y OR N)?
DO YOU WANT TO CHANGE THE NEAREST CITY (Y OR N)?

IS THE ABOVE INFORMATION CORRECT (Y OR N)?
```

The following is the first screen. PASS will fill screen entries from the data available in the computer files. All entries may be updated except those marked with a **. Entries marked with a * cannot be replaced with a null or blank entry.

```
*********************   STATION INFORMATION   *********************

STATION NUMBER:*_______________     NEAREST CITY:*_______________
STATION NAME:*_____________________________________________________
LATITUDE:*              _________   LONGITUDE:*           _________
STATE CODE:*                   __   OWNER AGENCEY:          _______
SITE ELEVATION:*          _______   PERSON ID:*____________________
```

DATAFILE NAME: PARMS
4 ITEMS: STARTING IN POSITION 1

COL	ITEM NAME	WDTH	TYP	KEY
1	PARM-CDE	5	I	ØB
6	NESS	2	C	-
8	DESC	55	C	-
63	S-DESC	6	C	D1B

```
**********************     DCP INFORMATION     **********************

DCP ID:**________                      DRGS:**________
ASSIGNED TIME:**              ___      TRANSMIT INT:**              ___
PRIMARY CHANNEL:**            ___      SECONDARY CHANNEL:**         ___
ANTENNA AZIMUTH:**            ___      ANTENNA ELEVATION:**         ___
PLATFORM MANUF (L,H,SY,SU):*___        PLATFORM MODEL:*         _______
TRANSMIT TYPE (S,R,A,SA,RA):*__        NUMBER OF DEVICES:*          ___
ANTENNA HEIGHT ABOVE SITE:*___         INVENTORY CNTL NO.:__________
DEPLOY DATE (MM/DD/YY):__/__/__        NESDIS NOTIFIED:**__/__/__
NESDIS QUEUE:**           ________     DEMOD SCHEDULE:**              _
```

If the NUMBER OF DEVICES is not changed, the following screen will appear.

```
LIST STATION DONE.
IRAC FORM DONE.
```

If the NUMBER OF DEVICES is increased (example NUMBER OF DEVICES changed from 2 to 4), the following screen will appear.

```
DEVICE = 1          PARM CODE =               PARM DESC =
DEVICE = 2          PARM CODE =               PARM DESC =

NEW DEVICE NUMBER =

**********   DEVICE INFORMATION   **********

DEVICE NUMBER:**       _
PARAMETER CODE:*   _____
PARAMETER DESC:    _____
PARAMETER UNITS:   _____
DEV UPD INT (HHMM):*_____
INVENTORY CNTL NO.:__________

LIST STATION DONE.
IRAC FORM DONE.
```

The DEVICE INFORMATION input fields would appear twice allowing the user to enter data for NEW DEVICE NUMBER = 3 and NEW DEVICE NUMBER = 4 (providing the user was adding to the end of the list). If the DCP reporting order required that a new device be placed at the front of the list (inserted), the user would specify NEW DEVICE NUMBER = 1 and PASS would increment by one the DEVICE NUMBERS for all other devices.

DCP INFORMATION FOR STATION 12040700

DCP ID:	1635D590	DRGS:	DWATCM
ASSIGNED TIME:	0048	TRANSMIT INTERVAL:	04
PRIMARY		SECONDARY	
CHANNEL:	34	CHANNEL	118
IRAC SERIAL NUMBER:		IRAC SERIAL NUMBER:	
IRAC DATE ASSIGNED:	/ /	IRAC DATE ASSIGNED:	/ /
ANTENNA AZIMUTH:	194	ANTENNA ELEVATION:	33
PLATFORM MANUF:	H	PLATFORM MODEL:	524
TRANSMIT TYPE:	SA	NUMBER OF DEVICES:	2
ANTENNA HEIGHT ABOVE SITE:	20	INVENTORY CNTL NO.:	______
DEPLOY DATE (MM/DD/YY):	__/__/__	NESDIS NOTIFIED:**	__/__/__
NESDIS QUEUE:**	USGS12	DEMOD SCHEDULE:**	__
DATE ASSIGNED:**	__/__/__		

ENTER Q TO QUIT
OR
KEY RETURN TO CONTINUE

DEVICE INFORMATION FOR STATION 12040700

DEVICE NUMBER:	1	2
PARAMETER		
CODE :	65	70969
DESC :	STAGE	BATVLT
UNITS :	FEET	VOLTS
DEV UPD INT (HHMM):	15	400
INVENTORY CNTL NO.:	________	________

KEY RETURN TO CONTINUE

7.1.6.10 Option 9 - TRANSFER STATION INFORMATION

```
INPUT OPTION NUMBER = 9

INPUT PERSON ID OF PERSON TO RECEIVE LIST
VIA E-MAIL                         PERSON   ID  = ______________
INPUT  PRIME  NODE  OF  ABOVE  PERSON.   NODE = ______________

INPUT STATION NUMBER                     = ______________

STATION 123456            PLACED IN MAILBOX FOR MLFIELD
```

7.1.6.11 Option 10 - LIST STATION SUMMARY BY STATE OR PERSON ID

One of the following two procedures are used to select the station group. The first example shows a selection by state code and the second demonstrates selection by person id. All output is to the user's terminal.

Procedure one:

```
INPUT P FOR SELECTION BY PERSON ID
            OR
INPUT 2 DIGIT STATE CODE
SELECTION = 01
```

STATION NUMBER	STATION NAME	DCP ID	CH	TIME
02371500	CONECUH RIVER AT BRANTLEY, ALA.	16CAE48C	3	0057
02423380	CAHABA RIVER NEAR MOUNTAIN BROOK, AL	16CC92D2	3	0151
02423390	CAHABA RIVER AT BWWB PUMP STATION NR B'HAM	16CC8F76	3	0150
02423410	L. CAHABA RIVER BL LK PURDY NR CAHABA HEIGH	16CC9C00	3	0152
02424000	CAHABA RIVER AT CENTREVILLE, ALA.	16CAD116	3	0055

PRESS RETURN TO CONTINUE

Procedure two:

```
INPUT P FOR SELECTION BY PERSON ID
          OR
INPUT 2 DIGIT STATE CODE
SELECTION = P
INPUT PERSON ID = CDFARRAR
```

STATION NUMBER	STATION NAME	DCP ID	CH	TIME
10265150	HOT CREEK FLUME	1634D9B8	6	0255
11242400	NF WILLOW CREEK NR. SUGAR PINE CALIF	16C1AAFC	77	0111
373745118554003	SHERWIN CREEK WELL, NR. MAMMOTH LAKES, CA.	1632CA00	6	0139
373759118474101	CORE HOLE 5, NR. MAMMOTH LAKES, CA.	1632BC90	6	0137
373930118491602	HOT CREEK DRILL HOLE NO. 2, NR. MAMMOTH LA	1632C4D2	6	0138
374045118491001	CORE HOLE 1 NR. MAMMOTH CA.	1632B242	6	0136

PRESS RETURN TO CONTINUE

7.1.6.12 Option 11 - TRANSFER STATION SUMMARY BY STATE OR PERSON ID

The first part of this option is the same for both retrieval options. All output is to the user's mailbox.

```
INPUT PERSON ID OF PERSON TO RECEIVE LIST
VIA E-MAIL.                          PERSON ID = MLFIELD
INPUT PRIME NODE OF ABOVE PERSON.        NODE = QVARSB
```

Procedure one:

```
INPUT P FOR SELECTION BY PERSON ID
          OR
    INPUT 2 DIGIT STATE CODE
SELECTION = P

INPUT PERSON ID = MLFIELD
LIST STATION DONE.
```

Procedure two:

```
INPUT P FOR SELECTION BY PERSON ID
              OR
     INPUT 2 DIGIT STATE CODE
SELECTION = 01
LIST STATION DONE.
```

An example of the station list that is transferred is found in Option 10.

8.1 Accessing the DRGS Computer

8.1.1 Access Using Host Prime Computer

For access via the DRGS host Prime Computer, login to the host Prime using the user ID and password supplied by the DRGS operator. To maintain security on the different Prime and DRGS computers, no access information will be published herein; therefore, the lines below are for entering the pertinent information supplied by the DRGS host operator.

USER ID:____________________ ON PRIME COMPUTER NODE:________

PRIME PASSWORD:_________________________

After introductory information, attach to the Ground Station Data General by issuing the proper command supplied by the host operator.

ACCESS COMMAND TO DRGS USING PRIME COMPUTER:__________

If the line is available, a message will be received that the linkage is established. Respond to the message with a carriage return (CR). When asked for the Data General computer password, enter the proper password. If the line is not available, follow the disconnect procedures supplied by the DRGS host operator.

LINE BUSY DISCONNECT PROCEDURES:_______________________________

When communicating with the Data General, all characters must be in upper case (CAPITALS). If a mistake is made, simply enter a CARRIAGE RETURN (CR) or backslash (\) and retype the command.

8.1.2 Access Using Telephone Modem

If access to the DRGS is by direct dial to the DRGS modem, then the following steps apply:

1. Set the dialout modem and terminal to the correct configuration. The Synergetics DRGS model 10C supports the following protocal:

   Data bits = 7
   Parity = EVEN
   Stop bits = 1
   Baud rate = 300 or 1200 (Others available upon special request. Consult the DRGS host operator.)

2. Dial the DRGS number supplied by the DRGS host operator.

3. When modem connect is established, enter a CARRIAGE RETURN (CR).

4. Enter the proper password. Only three attempts are allowed to enter the password. After the third unsuccessful attempt, the connection will be automatically dropped and the user must redial if further attempts are to be made.

   DRGS PASSWORD:_____________(Supplied by DRGS host operator)

8.2 Reading DCP Data

8.2.1 Accessing the Data Files

The user is now connected to the DRGS Data General computer ready to access data files. Two different files are available for reading the DCP data. The first is DISMSG, which contains the actual transmission as received by the DRGS. Normally, only a few days of data are stored in DISMSG. The second data file is EUMSG where DCP data are stored in engineering units with parameter names and time attached to the data. Data stored in EUMSG may cover several months in time. Data from newly installed DCP's will appear only in DISMSG file until the DRGS operator enters the proper DCP decode data necessary to convert the data to engineering units and store in EUMSG. Once this is complete, data will automatically be transferred to EUMSG following each DCP transmission. The following commands will allow the user to read the data.

PASSWORD?	Enter the proper password. Computer responds with RETRV:
CRT	Tells the Data General the user is operating from a CRT type terminal and sets the correction characters for CRT.
DISMSG	Attaches the user to the raw data file access program. The computer responds back with DISMSG:
EUMSG	Attaches the user to the engineering units data base. The computer responds with EUMSG:

EXIT	Used to exit the DISMSG or EUMSG retrieval program back to RETRV. EXIT must be used before moving from one data base to the other.
TIME	Displays Julian day and GMT time. TIME can only be used when in DISMSG or EUMSG.

8.2.2 Setting the Time Block

After selecting the desired file to check, DISMSG or EUMSG, the user sets the time block for the period to be read. The time block stays in effect until the user either redefines it or exits back to RETRV.

TIMBLK bbb hh:mm eee hh:mm

Where:
bbb= beginning Julian day
hh:mm= hour : minute
eee= ending Julian day
hh:mm= hour : minute

(Note: The use of spaces and colons.)

The time block can be automatically set by using one of the following commands in place of using TIMBLK.

THREEHOUR	Sets the time block for the last three hours from the current time.
FOURHOUR	Sets the time block for the last four hours.
ONEDAY	Sets the time block for the last 24 hours.
THREEDAY	Sets the time block for the last 72 hours or three days.

8.2.3 Listing the Data

To retrieve the desired DCP data, use the LIST command as shown below:

LIST (dcp id) (pp) — List either the NESDIS id number or the character name if known. If the id is not given, the retrieval will list data for all DCP's received during the time selected. After the id is listed, a print processor (pp) must be given. The four commonly used print processors are:

HD	Lists only the header information for the DCP retrieved. HD can be used in either DISMSG or EUMSG data files.
AL	Lists both the header information and the data. AL can only be used in the DISMSG data file.
DT	Lists the header information and data in engineering units. DT can only be used in the EUMSG data file.
MSMSG	Checks the DCP transmissions for the time period selected and summarizes the number of messages received and missing. MSMSG can only be used in the EUMSG data file and is best used with ONEDAY or THREEDAY time blocks.

8.3 Disconnecting From the DRGS

After retrieving all data desired, exit DISMSG or EUMSG by using the EXIT command. To log off the DRGS, issue the command BYE. When the password prompt appears, either hang up the telephone if the

DRGS was accessed via the modem or enter a BREAK if the DRGS was accessed via the prime (BREAK key in some terminals or CTRL P combination on other terminals).

EXIT	Exits from DISMSG or EUMSG back to RETRV.
BYE	Logs out the user from RETRV. After about four seconds, the password prompt appears. The DRGS is then ready for the next user. If entry to the DRGS was via the direct access modem, then hang up the phone at this time, otherwise:
<BREAK>	Press the BREAK key on the terminal. If the terminal does not have a BREAK key, press CRTL P. After the computer response, enter a Q.
Q	Linkage from the host Prime to the DRGS is disconnected and the user is returned to the host Prime. The user may then log off.

8.4 Help Command

There is a help command HELP that will list out the available commands and their functions. It can be issued from any of the programs in the Data General.

8.5 Sample DRGS Retrievals

PASSWORD?	(Enter proper password)
RETRV:	
<u>CRT</u>	(Selects CRT correction characters)
RETRV:	
<u>DISMSG</u>	(Access the raw DISMSG DCP data files)
DISMSG:	
<u>TIME</u>	(Show current Julian date and GMT time)

EUMSG:
THREEHOUR
EUMSG:
LIST ANRDC DT (List converted and reformatted data using DT print processor)

	STATION	JULIAN DAY	TIME GMT	DEMOD /CHAN	# CHAR	#-BAD CHAR	EIRP (DBM)	MOD (DB)	FREQ (HZ)	(S+N)/N (DB)	E #
ANRDC	16329A7C	85/298	16:33:23	2/006	171	0	+47.2	-06.2	+038	+10.2	0

DATA	START TIME	SAMPLE INTERVAL	DATA VALUES					
STAGE	16:30	0:15	2.74	2.74	2.74	2.74	2.74	2.74
			2.74	2.74	2.73	2.73	2.73	2.73
PREC	16:30	0:15	33.60	33.60	33.60	33.60	33.60	33.60
			33.60	33.60	33.60	33.60	33.60	33.60
BTVT	16:30	1:00	12.4	12.5	13.1			

EUMSG:
ONEDAY
EUMSG:
LIST LCCNDC MSMSG (Check for missing transmissions using MSMSG print processor)

MISSING MESSAGE REPORT FOR 51452762
OVER THE TIME BLOCK OF 297 18:28 298 18:28

51452762 297 21:19
51452762 298 5:19
51452762 298 9:19
51452762 298 17:19

#MSSGS FOUND= 2 #MSSGS MISSING= 4
****

(UNDERSCORE INDICATES USER INPUT)

EUMSG:
EXIT RETRV:
BYE (Stops the program)
PASSWORD? (Enter BREAK or CTRL P)
ENTER COMMAND CODE (Q,R,E,S,A) * Q
(Disconnects from the DRGS)

(UNDERSCORE INDICATES USER INPUT)

85 298 18:45:22 USING NBS TIME	(Year 1985, Julian day 298, 18:45:22 GMT) (or USING INTERNAL TIME with the colons in the time replaced with ?)
DISMSG:	
<u>ONEDAY</u>	(Set TIMBLK to previous 24 hours)
DISMSG:	
<u>LIST</u> 16329A7C HD	(List only header information for each DCP transmission transmission using HD print processor)

(UNDERSCORE INDICATES USER INPUT)

	STATION	JULIAN DAY	TIME GMT	DEMOD /CHAN	# CHAR	#-BAD CHAR	EIRP (DBM)	MOD (DB)	FREQ (HZ)	(S+N)/N (DB)
ANRDC	16329A7C	85/297	19:33:24	2/006	171	0	+46.6	-06.6	+134	+08.2
ANRDC	16329A7C	85/297	22?33?23	2/006	171	0	+46.6	-06.2	+106	+15.2
ANRDC	16329A7C	85/298	1:33:23	2/006	171	0	+45.6	-06.0	+050	+18.6
ANRDC	16329A7C	85/298	4:33:23	2/006	171	0	+46.4	-06.2	+030	+13.8
ANRDC	16329A7C	85/298	7:33:23	2/006	171	0	+46.2	-06.0	+028	+12.6
ANRDC	16329A7C	85/298	10:33:23	2/006	171	0	+47.8	-05.8	+034	+18.8
ANRDC	16329A7C	85/298	13:33:23	2/006	171	0	+46.4	-05.8	+034	+17.2
ANRDC	16329A7C	85/298	16:33:23	2/006	171	0	+47.2	-06.2	+038	+10.2

DISMSG:	
<u>THREEHOUR</u>	(Set TIMBLK for previous three hours)
DISMSG:	
<u>LIST ANRDC AL</u>	(List transmitted data using AL print processor ANRDC is an alternate abbreviated name for the station)

	STATION	JULIAN DAY	TIME GMT	DEMOD /CHAN	# CHAR	#-BAD CHAR	EIRP (DBM)	MOD (DB)	FREQ (HZ)	(S+N)/N (DB)	E #
ANRDC	16329A7C	85/298	16:33:23	2/006	171	0	+47.2	-06.2	+038	+10.2	0

02.74 02.74 02.74 02.74 02.74 02.74 02.74 02.74 02.73 02.73 02.73
02.73
33.60 33.60 33.60 33.60 33.60 33.60 33.60 33.60 33.60 33.60 33.60
33.60
12.4 12.5 13.1

DISMSG:	
<u>EXIT</u>	(Exit DISMSG back to RETRV)
RETRV:	
<u>EUMSG</u>	(Attach to EUMSG to read converted data)

8.6 Interpreting DCP Transmitted Information

The information displayed for a DCP contains much information that can tell the user how well the DCP is operating. An example of the DCP header information and the explanations about the various parameters are given below:

	STATION	JULIAN DAY	TIME GMT	DEMOD /CHAN	# CHAR	#-BAD CHAR	EIRP (DBM)	MOD (DB)	FREQ (HZ)	(S+N)/N (DB)
ANRDC	16329A7C	85/297	19:33:24	2/006	171	0	+46.6	-06.6	+134	+08.2
ANRDC	16329A7C	85/297	22?33?23	2/006	171	0	+46.6	-06.2	+106	+15.2
ANRDC	16329A7C	85/298	1:33:23	2/006	171	0	+45.6	-06.0	+050	+18.6
ANRDC	16329A7C	85/298	4:33:23	2/006	171	0	+46.4	-06.2	+030	+13.8
ANRDC	16329A7C	85/298	7:33:23	2/006	171	0	+46.2	-06.0	+028	+12.6
ANRDC	16329A7C	85/298	10:33:23	2/006	171	0	+47.8	-05.8	+034	+18.8
ANRDC	16329A7C	85/298	13:33:23	2/006	171	0	+46.4	-05.8	+034	+17.2
ANRDC	16329A7C	85/298	16:33:23	2/006	171	0	+47.2	-06.2	+038	+10.2

STATION	Eight-digit NESDIS identification number unique to the DCP. An abbreviation name may precede the number. Both are valid identifiers for retrieving information from the DCP. The abbreviation name is not transmitted by the DCP. It is assigned to the DCP by the DRGS operator and is used only in the DRGS.
JULIAN DAY	The last two digits of the year and the Julian Day of the transmission. Julian Day is the number of days from the beginning of the calendar year.
TIME GMT	The time of the transmission in GMT. The hour figure should change according to the frequency of transmission (for example, 3 hour or 4 hour). Minute readings should all be the same. The seconds readings should also be the same but may vary by 1 to 2 seconds. A continuous change, sometimes observed over days, indicates a possible drift in the DCP clock, which may require servicing by the manufacturer. If an alert transmission is received for the DCP, it would be listed along with the self-timed transmissions but the time values may not correspond.
DEMOD /CHAN	The DRGS demodulator unit and assigned channel number the DCP information was received on. Values should not change.
# CHAR	Number of data characters transmitted by the DCP. Values should not change unless the DCP has been reprogrammed. The DCP transmits approximately 12.5 characters per second. Alert transmissions will have a different number of characters but all alert transmissions should have the same number.

#-BAD CHAR	Number of bad characters received in the transmitted message. This may indicate a bad DCP transmitter, damaged antenna, or interference from another DCP transmitting at the same time.
EIRP (DBM)	Effective Isotropic Radiated Power. This is an estimation of the DCP transmitted power. Normal transmission levels are +43 to +50 dBm. Variations may be due in part to inherent system noise, satellite wobble in orbit, satellite load at time of transmission, DCP transmitter degradation, or DCP antenna alignment.
MOD (DB)	Modulation Index. This is the measurement of the carrier suppression during modulation. Standard value is -6dB but it may vary from -4 to -8dB. Preferred is from -5 to -7dB. Values outside this range indicate possible DCP transmitter problems.
FREQ (HZ)	DCP frequency offset. It should be within 400 Hz of channel center frequency. Transmitter drift outside this range may not be received by the DRGS. Frequency offset are generally within 200 Hz from message to message. DCP temperature changes can cause fluctuations.
(S+N)/N (DB)	Signal plus Noise over Noise ratio. This gives an estimate of DCP transmitted power (EIRP) relative to the Pilot signal transmitted power. Normal range is from 10 to 20dB but signals can be received as low as 4dB. Fluctuations are caused by movement of the satellite, changes in satellite loads, and weather. Consistent low values may be the result of a poor transmitter, bad antenna connections, or poorly aimed antenna.
ER #	Error number can be listed to indicate different types of errors encountered during the transmission. Value should be 0. If other values are listed, they may be deciphered by typing the command XMTERR n where n is the error number shown. The XMTERR command is used in either DISMSG or EUMSG. Messages indicating a loss of the end of message can indicate a DCP transmit time insufficient for the data being transmitted or weak batteries causing the DCP to stop transmitting part way through the transmission.

APPENDIXES A-F

APPENDIX A

Manufacturers List

MANUFACTURERS LIST

PLATFORM MANUFACTURERS

LaBarge, Inc.
Electronics Division
P.O. Box 926
Tulsa, OK 74101

Handar, Inc.
1380 Borregas Avenue
Sunnyvale, CA 94086
Phone: (408) 734-9640

Sutron Corp.
11150 Main Street
Fairfax, VA 22030
Phone: (202) 471-0810

Synergetics International, Inc.
P.O. Box E, 6565 Odell Place
Boulder, CO 80306
Phone: (303) 530-2020

BATTERY MANUFACTURERS

C & D Batteries
3043 Walton Road
Plymouth Meeting, PA 19462
Phone: (215) 828-9000

Delco Remy
2401 Columbus Avenue
Anderson, IN 46011
Phone: (317) 646-7406

Exide
Philadelphia, PA

Gates
1050 S. Broadway
P.O. Box 5887
Denver, CO 80217
Phone: (303) 744-4806

Power Sonic Corp.
P.O. Box 5242, 3106 Spring Street
Redwood City, CA 94063
Phone: (425) 364-5001

BATTERY MANUFACTURERS—Continued

Yuasa Battery (America), Inc.
8108 S. Freestone Avenue
Santa Fe Springs, CA 90670
Phone: (213) 698-2275

SOLAR PANEL MANUFACTURERS

Altantic Solar Power
6455 Washington Boulevard
Baltimore, MD 21227
Phone: (301) 796-3357

Photowatt International, Inc.
2414 W. 14th Street
Tempe, AZ 85281
Phone: (602) 894-9564

Solarex Corp.
1335 Piccard Drive
Rockville, MD 20850
Phone: (301) 948-0202

Spectrolabs
12484 Gladstone Avenue
Sylmar, CA 91342
Phone: (213) 365-4611

ACCESSORIES MANUFACTURERS

PIC
P.O. Box 335, Benrus Center
Ridgefield, CT 06877
Phone: (203) 431-1500

Bird Electronics
30303 Aurora Road
Cleveland, OH 44139

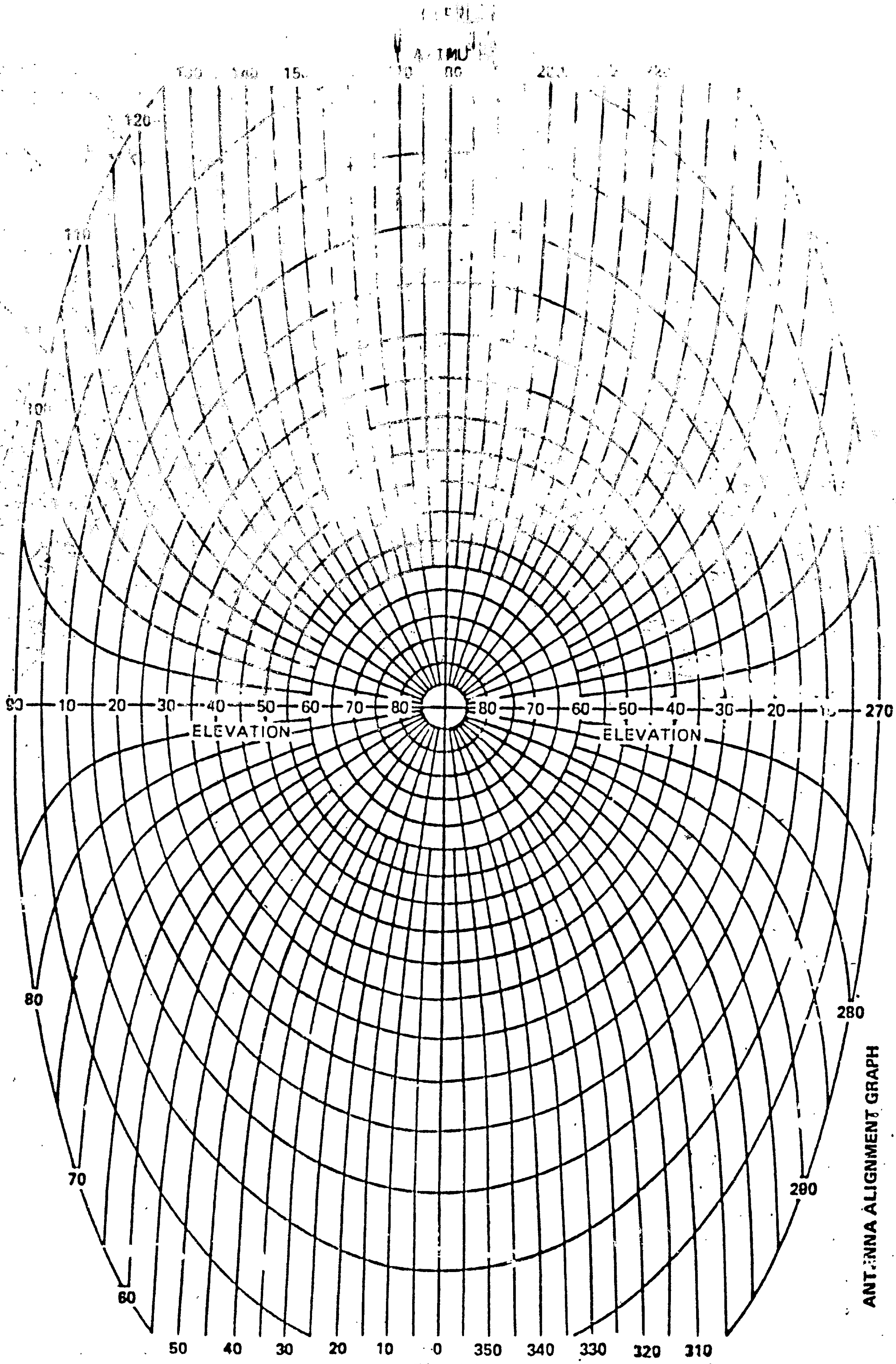
Winfred M. Berg, Inc.
499 Ocean Avenue
East Rockaway, L.I., NY 11518

APPENDIX B

Suggested Supplies and Equipment

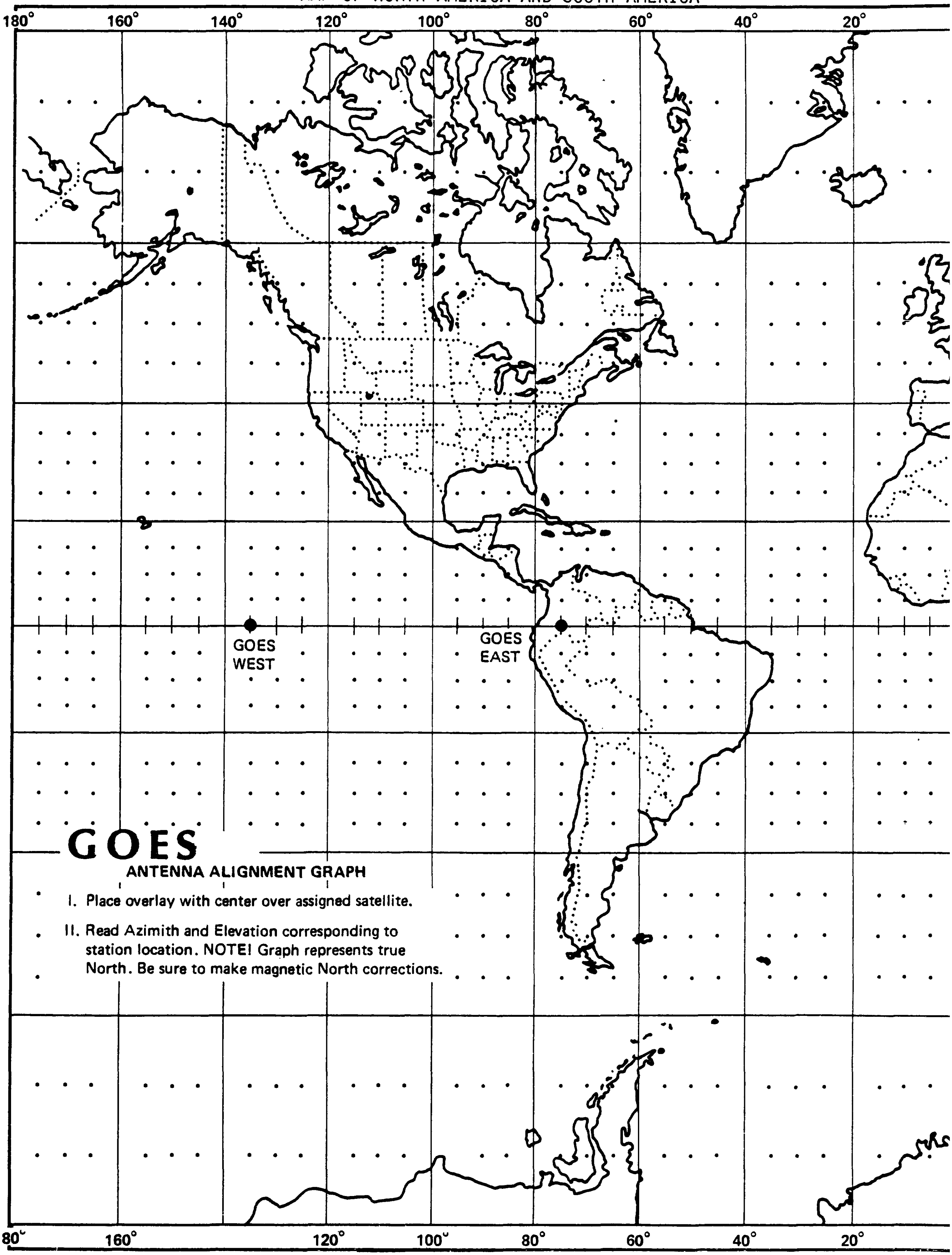
APPENDIX D

Overlay and Map of North America and South America



ANTENNA ALIGNMENT GRAPH

MAP OF NORTH AMERICA AND SOUTH AMERICA



DATAFILE NAME: CHAN-MASTER
14 ITEMS: STARTING IN POSITION 1

COL	ITEM NAME	WDTH	TYP	KEY
1	DCP-ID	8	C	1B
9	CHAN	3	C	ØB
12	ASSIGN-TIME	4	C	-
16	XMIT-INT	2	C	-
18	STA-NUM	15	C	D2B
33	NODE	6	C	-
39	PERS-ID	22	C	-
61	DTE-ASSIGN	8	D	-
69	IRAC-SNN1	6	C	-
75	IRAC-DTE1	8	D	-
83	SEC-CHAN	3	C	-
86	IRAC-SNN2	6	C	-
92	IRAC-DTE2	8	D	-
1ØØ	NESSQ	7	C	-
	** REDEFINED ITEMS **			
9	CH-TME	7	C	ØB

DATAFILE NAME: STATES
9 ITEMS: STARTING IN POSITION 1

COL	ITEM NAME	WDTH	TYP	KEY
1	STATE-CDE	2	C	ØB
3	S-ABB	2	C	-
5	IRAC-CDE	4	C	-
9	S-LONG	14	C	-
23	DRGS	6	C	-
29	CHAN3	9	C	-
38	CHAN4	9	C	-
47	SEC-CHAN	3	C	-
5Ø	NESSQ	7	C	-

APPENDIX F

DCP/DRGS Information Form

DCP/DRGS INFORMATION FORM

PERSON ID:* NODE:*
NAME:*
ADDRESS:*
ADDRESS:
CITY:* STATE:* ZIP:*
AGENCY:
FTS PHONE:* NON-FTS PHONE:*
PRIME DIRECTORY:*

*************************** STATION INFORMATION ***************************

STATION NAME:*
STATION NUMBER:* LL SEQUENCE NUMBER:
NEAREST CITY:*
LATITUDE:* LONGITUDE:*
COUNTY CODE: STATE CODE:* OWNER AGENCY:
DISTRICT ID: UTC TIME ZONE:* HYDRO UNIT CODE:
DRAIN AREA: SITE ELEVATION:* ACCOUNT NUM:*

*************************** DCP INFORMATION ***************************

DCP NAME:
TRANSMIT INT:**
ANTENNA AZIMUTH:* ANTENNA ELEVATION:*
PLATFORM MANUF:* PLATFORM MODEL:*
TRANSMIT TYPE:* NUMBER OF SENSORS:*
ANTENNA HEIGHT ABOVE SITE:*

*************************** SENSOR INFORMATION ***************************

SENSOR
NUMBER:*
TYPE :*
PARAMETER
CODE :*
DESC :
UNITS :
EQUATION
A*X**B+C
A =:*
B =:*
C =:*
VALUE TYPE:
DATA TYPE :*
NUMBER OF
CHARACTERS:*
NEW VALUES:*
OLD VALUES:*
DEV UPD INT(HHMM):*
XMT DLY INT(MMSS):*