10 Liters 1.729 / 2.085 / 10 Liters 2.420 — 0.356 / 0.335

Field and Data Reduction Manual
Hydrogeological Monitoring Program
Southeast Landfill
Hillsborough County, Florida

Ardaman & Associates, Inc.

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Consulting Engineers in Soil Mechanics,
Foundations, and Materials Testing

March 10, 1983
File Number 81-159

County of Hillsborough
Department of Solid Waste
P.O. Box 1110
Tampa, Florida 33601

Attention: Mr. William Holsonback

Subject: Proposed Southeast Hillsborough County Sanitary Landfill - Miscellaneous Items.

Gentlemen:

As requested by Ms. Elaine Hayes we enclose the following items for your use and information as per the above mentioned project:

- Final Copy of Field and Data Reduction Manual for Water Resources Monitoring at Landfill Site.
- Copy of all groundwater analyses performed by Orlando Laboratories on project.
- Manufacturer's Manuals for all weather station instrumentations for project.
- Instrumentation records for January 1983 from site.

The field and data reduction manual discusses the following field efforts: (1) Rainfall station; (2) Evaporation Station; (3) Wind Station; (4) Water-level recorder; and (5) Observation Wells. The information on the water-level recorder and observation wells is provided for your future reference. It is our understanding that you are not servicing these equipment at this time.

The analyses from Orlando Laboratories included a December and January sampling. Five laboratory analysis sheets summarize these data.

The maufacturer's manuals are appendices in the field and data reduction manual. Our weather station equipment was purchased from Science Associates, Inc. under order no. 1157-82 through Mr. Daniel A. Mazzarella, Vice President. When you have questions or problems work through him at 609/924-4470. The wind station equipment was a subcontract to Climatronics Corporation in Bohemia, New York. Their phone number is 516/567-7300. Recorder charts can be ordered through Science Associates, Inc.

The rainfall charts for January 1983 are enclosed for your data reduction of January records. According to our files you have the evaporation station and wind station records for January.

Please do not hesitate to contact us if you have questions or we can be of further assistance. We appreciate the opportunity to serve you for this element on this project.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Herbert G. Stangland, Jr., P.E.
Senior Water Resources Engineer

HGS
John E. Garlanger, Ph.D., P.E.
Principal
Florida Registration No. 19782

HGS/ss
Enc.
cc: Mr. R. Hauser, CDM

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Chapter 1

INTRODUCTION

As part of the data collection program for the proposed sites of the Southeast Hillsborough County Landfill near Picnic, Florida, a weather station has been constructed on a site owned by Gardinier. The weather station is less than one mile from both Settling Area 1 and Settling Area 2, as shown on the Site Location Map in Figure 1.1. The weather station consists of the following individual data stations:

- Rainfall Station
- Evaporation Station
- Wind Station

The rainfall station consists of a Universal Recording Rain Gage (weighing-type).

The evaporation station includes the following devices:

- Class A Weather Bureau Evaporation Pan with a hook gage to measure the water level.

- Graduated reservoir to automatically replenish the evaporation pan when the level drops below 3 inches from the top of the pan.

- Overflow to remove and store excess rainfall from the pan (to prevent overtopping and maintain record of overflow volume).

- System to measure the amount of pan overflow.

- Maximum-minimum air and water thermometers.

- Totalizing, non-recording anemometer.

The wind station includes an anemometer and wind direction vane, both of which are connected to a recorder.

The layout of the equipment within the weather station is illustrated in Figure 1.2.

In addition to the weather station, field instrumentation proposed for the landfill includes groundwater observation wells. The locations of these groundwater monitoring sites are illustrated on the aerial photograph in Figure 1.3. The surficial aquifer well located at auger boring AB-21 near the southwest corner of Settling Area 1, had been installed with a water level recorder.

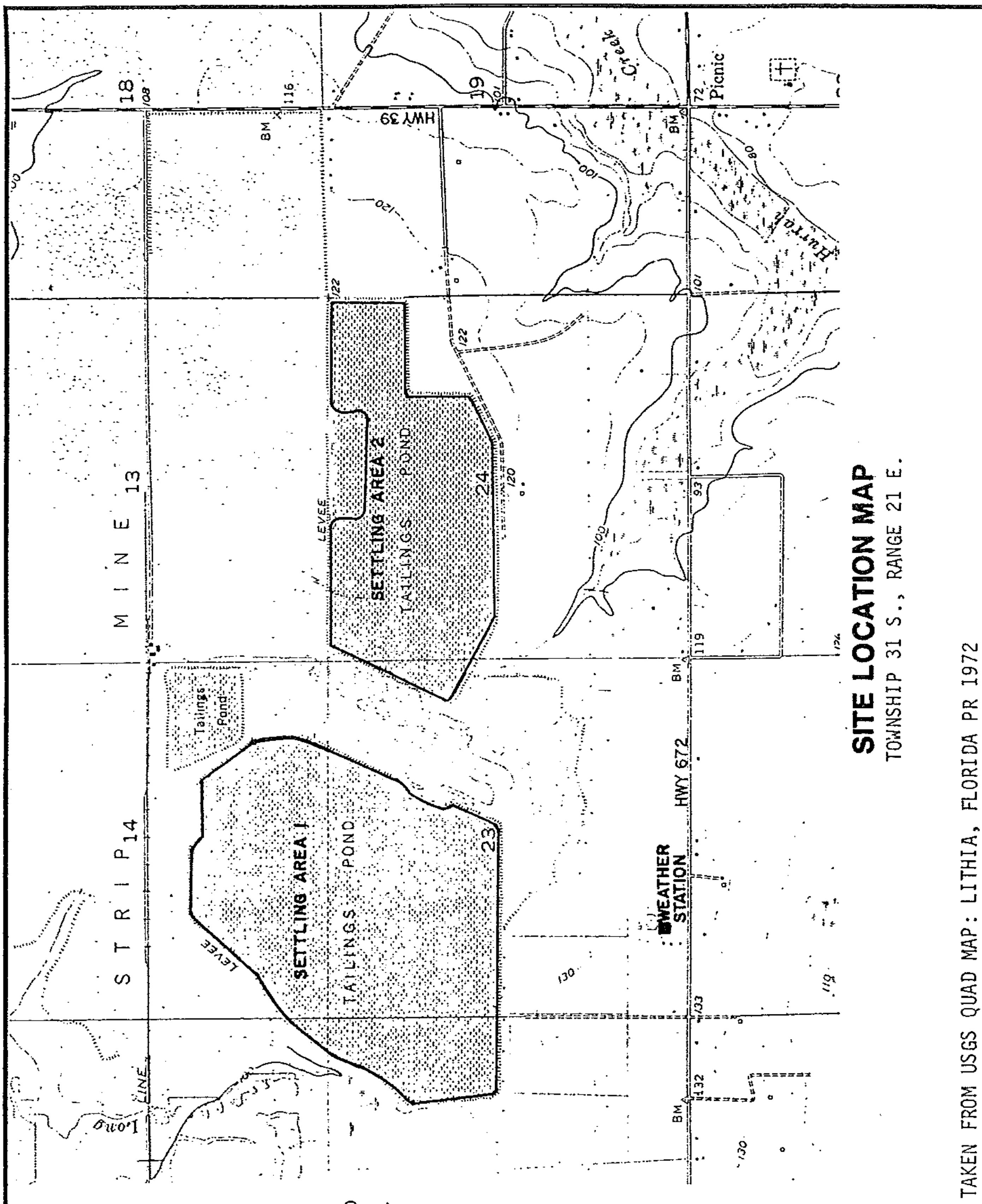
This manual is intended to familiarize Hillsborough County personnel with installation, operation, and data reduction procedures for the above mentioned field instrumentation. Table 1.1 presents the recommended monitoring frequencies for the instruments. Manufacturer's information concerning assembly, calibration, routine care, and maintenance are contained in the Appendices.

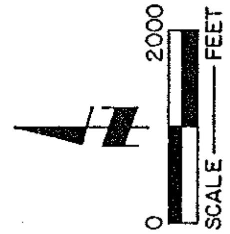
Table 1.1

RECOMMENDED INSTRUMENTATION MONITORING FREQUENCIES

Station Type	Recorder Type	Monitoring Frequency
Rainfall	8-Day	Weekly
Evaporation	None	Weekly
Wind	30-Day	Weekly*
Piezometers	None	Monthly**
Water Level Recorder	8-Day	Weekly

*The wind recorder has a battery life and chart length of thirty days, but weekly monitoring is recommended to ensure proper operation of clockworks and facilitate any time adjustments required during data reduction.
**Desired fequency but not required.





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HILLSBOROUGH COUNTY, FLORIDA

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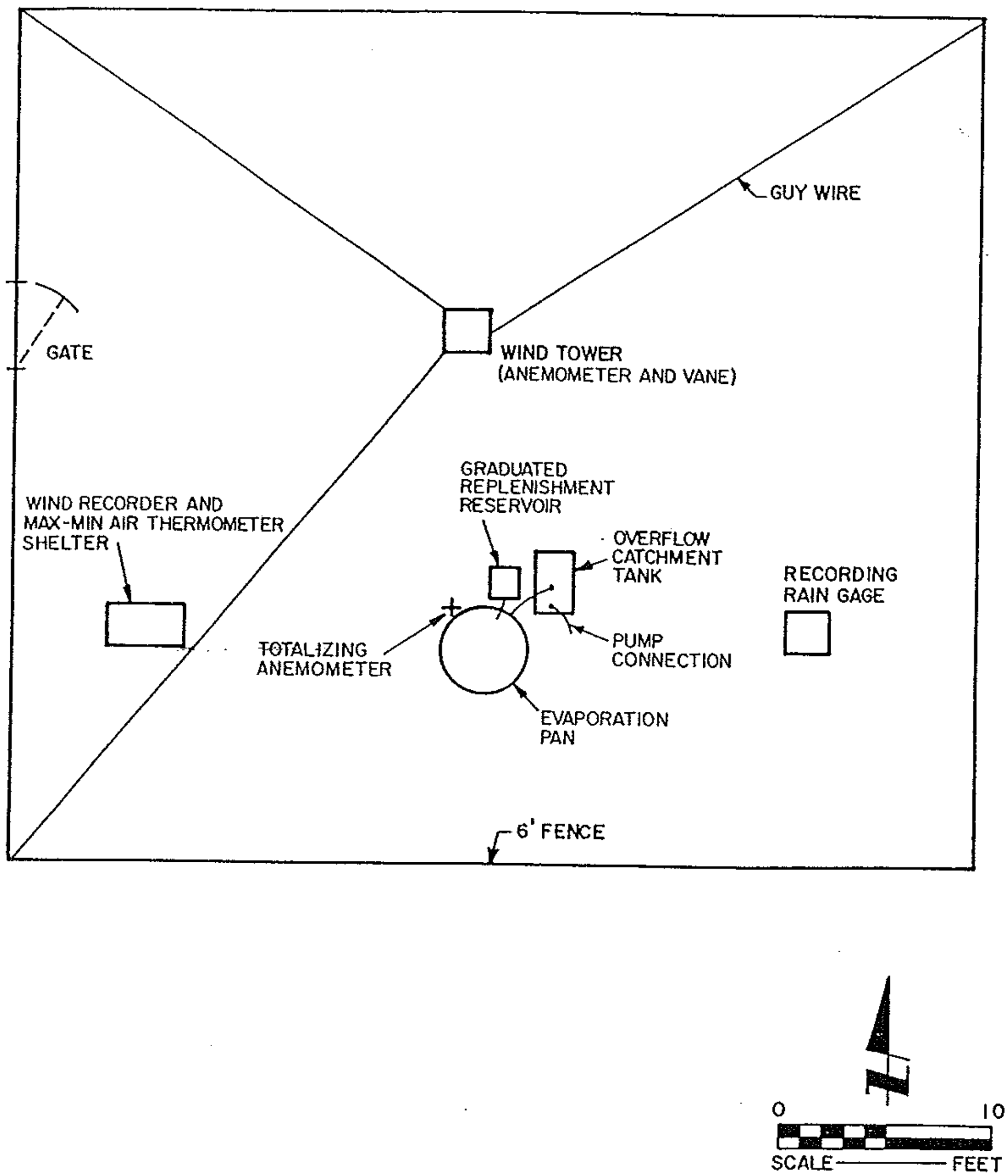
FIGURE 1.1



WEATHER STATION LAYOUT

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FIGURE 1.2

BORING LOCATION PLAN INCLUDING GROUNDWATER MONITORING SITES

PROJECT NO

SHEET NO

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FIGURE 2

Chapter 2

RAINFALL STATION

2.1 Installation

Figure 2.1 shows the typical rain gage installation, utilizing a Universal recording rain gage. Manufacturer's information on this instrument is contained in Appendices I, II, and III. The following important factors need careful attention:

- A 45 degree cone of open space must be maintained above the collection tube to ensure proper exposure. Trees and/or branches of trees may need to be trimmed during the study period to maintain this open area.
- The rainfall collection tube needs to be installed level through use of a carpenter's level.
- The rain gage should be fenced to protect it from animals and/or man.

2.2 Operation

The following routine steps need to be followed weekly to service the gage and to collect accurate, complete records.

- Unlock gate to fenced area and to recorder, if pertinent.
- Slide the recorder access door at the bottom of the housing up and read the pen or chart for rainfall amount and time.
- Lift the pen from the chart drum, remove the collection shroud from the top of the housing, and remove chart from drum by loosening and removing the knurled nut from the drum spindle and lifting the drum upward. Pull the clip from the slot (clip retains chart paper in place).
- Record the station name, date, time, initials of person servicing recorder, and pen reading on chart taken off. Note if clock is stopped on chart. Figure 2.2 shows a typical rain gage chart.
- Remove bucket from installation, empty water from bucket and replace bucket on platform. Once every 3 to 6 months, calibrate rain gage. Pour water into Standard Weather Bureau calibration tube. Measure water in inches in tube. Record on chart. Inches of water in tube and rainfall amount at pen reading should be equal. If two values are different by more than 0.10 inch, calibrate rain gage as per manufacturer's instructions. The calibration tube is 2.53 inches in diameter and 20 inches deep.
- Wind clock. If clock has stopped two times in a row or is more than four hours off correct time at end of chart three visits in row, replace clock. This criteria assumes that each time the speed of the clock was adjusted or a repair was attempted.

- Check ink supply and replenish when necessary. Be sure pen point is clean and working properly.

- Install new chart; record the station name, date, time and initials of person servicing recorder on new chart ; set pen on correct time and zero on chart; and secure recorder shelter. To set the pen at the proper time and day, the chart drum may be rotated to position the pen tip.

- Service recorder every 7 to 8 days.

2.3 **Office Calculations**

The output from the office calculations is daily, monthly, and annual rainfall amounts. The following steps are relevant to these office calculations:

- Check to be sure all notes from field visit are written on chart.

- Be sure all charts for a particular station are together and no charts are missing. If chart is missing, insert note in file explaining why.

- For each chart, do the following items:

  - Compare pen time and clock time at end of chart. Note time correction.

  - Compare pen time and clock time at beginning of chart to see that the pen was set properly.

  - Determine whether and note where clock stoppage occurred.

  - If no clock stoppage occured and time is more than two hours off per week, make no time adjustments.

  - Mark off midnight times for each day if different from chart times (e.g. if pen at beginning of chart is set improperly).

  - If clock did not stop and time is more than two hours off, make time adjustments for period of record in direct proportion to the number of days and total correction, e.g. the correction for the third day would be 3/7 times total weekly correction. Round daily correction to the nearest one hour.

  - If clock stopped at end of chart (i.e., most common), and pen was set at the beginning properly, make time adjustments at end of chart accordingly.

  - If clock stopped during middle of chart and clock started again for some reason, assume time at start and end is correct. Make time adjustments in middle where clock appeared to have stopped.

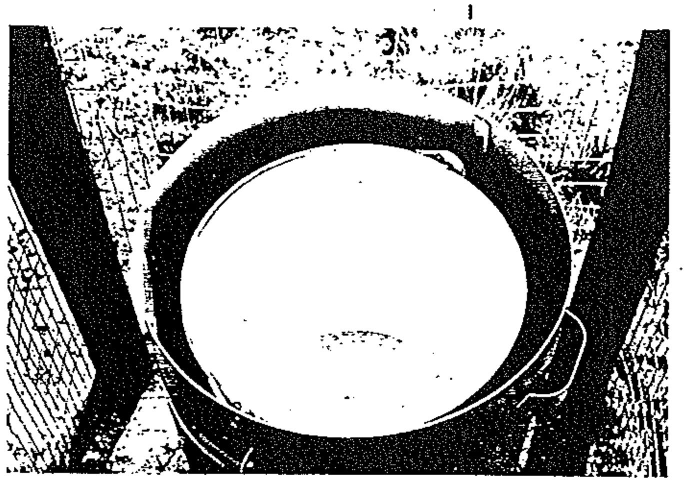
- If clock stopped at beginning of chart (e.g., clock running at end, time off more than two hours, and the pen trace appears to have stayed in one place for a long time), assume time of chart is correct at end. Make time adjustments accordingly.

- Rainfall for day is sum of rainfalls for each storm during the 24-hour period. Rainfall for each storm equals maximum pen reading minus minimum pen reading just before pen rise. Rainfall for day is not pen reading at end of day minus pen reading at beginning of day because evaporation loss in bucket would be ignored.

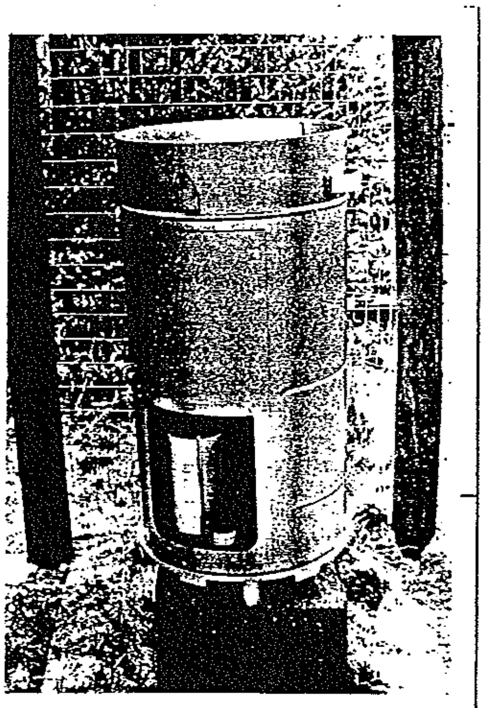
- Note amount of daily rainfall on recorder chart. Make calibration corrections if necessary. As a general rule, calibration corrections should be related to beginning pen readings on chart. If properly calibrated, the pen trace should begin at the same rainfall reading each week after bucket is emptied of water. If beginning pen rainfall readings change from week to week, these periods represent potential calibration correction periods. Calibration corrections should not be made if correction is less than 0.05 inch. As a general rule, calibration corrections with utilized equipment are not common.

- Periods of missing record can sometimes be estimated from pen trace. Precipitation amount at highest pen reading less amount just prior to the clock stoppage is the estimated rainfall for the storm(s). For multievent storms rainfall represents the amount for the period and not for each event. Record rainfall for period on chart and note with an "e" (estimated).

● Tabulate daily rainfalls in a table and plot daily rainfalls on K&E graph paper 1 year by days x 250 divisions (#472893). Summarize monthly and yearly totals in tables.



TOP OF RAINFALL GAGE WITH SHROUD REMOVED



RAIN GAGE WITH CHART VISIBLE

CLOSE-UP VIEW OF RAINFALL GAGE

TYPICAL RAIN GAGE INSTALLATION

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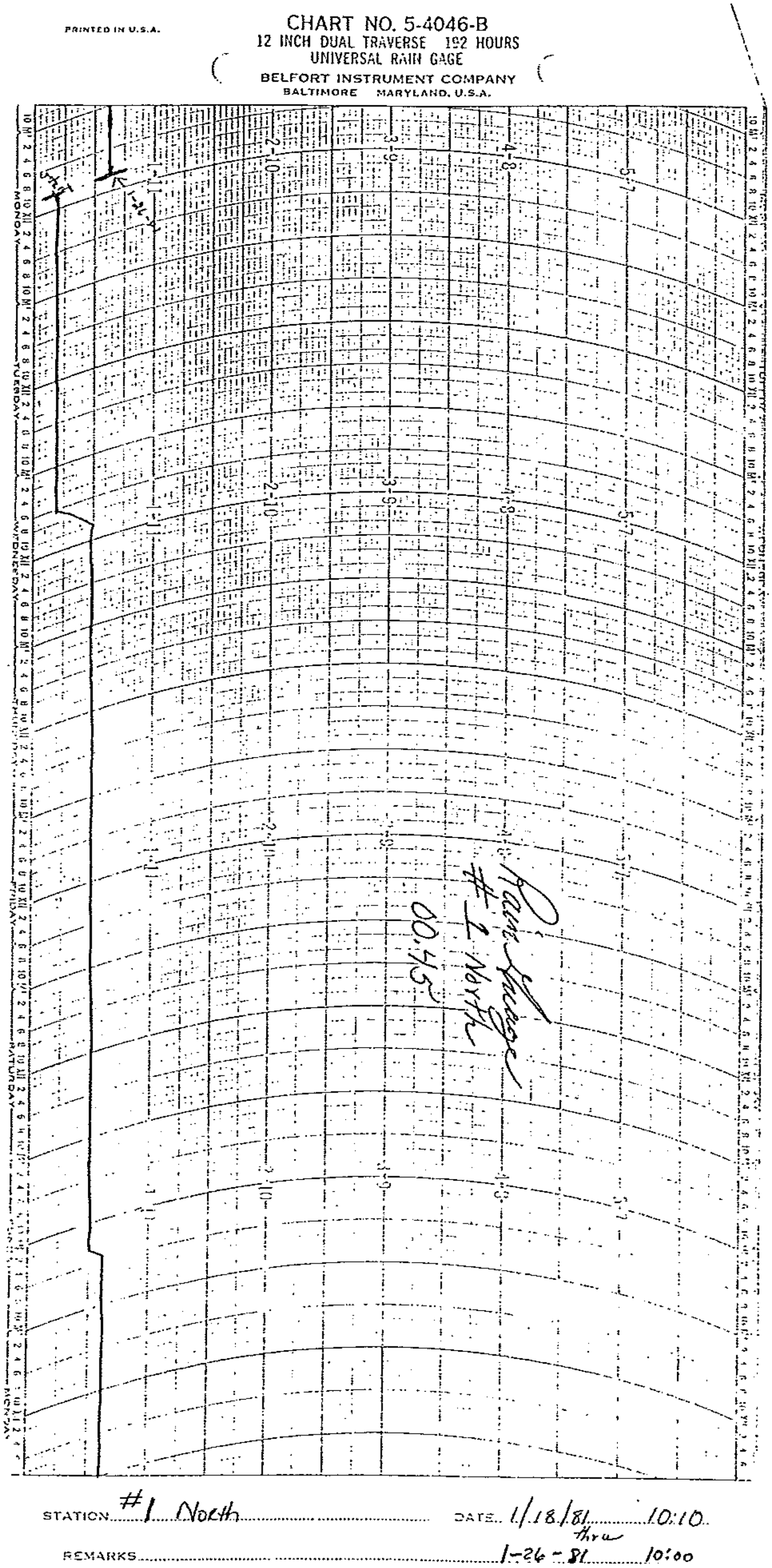
FIGURE 2.1



TYPICAL RAIN GAGE CHART

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FIGURE 2.2

Chapter 3

EVAPORATION STATION

3.1 Equipment Installation

A standard evaporation station consists of the following equipment:

- Evaporation pan
- Anemometer
- Micrometer hook gage and stilling well
- Weighing-type recording rain gage
- Maximum-minimum water temperature thermometer
- Maximum-minimum air temperature thermometer
- Standard weather bureau shelter for air thermometer
- Water-storage tank

Observations during each visit are made on the amount of evaporation from the open pan, anemometer reading, maximum and minimum temperatures of the water, maximum and minimum temperatures of the air, and precipitation. The installation and servicing of the precipitation equipment is discussed in another chapter of this manual.

If automatic replenishing and overflow of the evaporation pan is installed to keep the water level within specified limits during week-long periods of unattended service, the additional required equipment includes the following:

- Elevated, graduated reservoir
- Overflow catchment tank
- Pump for overflow tank

For automatic operation during periods of unattended service, additional weekly observations are made of the water level in the elevated reservior and the water volume in the overflow tank. The overflow volume is measured by pumping into a graduated container until the overflow tank level is down to a predetermined level.

3.1.1 Site Selection and Preparation

The site of the equipment should be fairly level, sodded, and free from obstructions. It should be representative of the principal natural soils and conditions of the area. Under no condition should the pan, or the instrument shelter, be placed on a concrete slab or pedestal, or over a layer of asphalt or crushed rock. Obstructions such as trees, buildings, and nearby shrubs should not be closer to the instruments than four times the height of the object above the pan. Weeds and grass in and around the enclosure should be mowed often enough to keep them below the level of the pan. The exposure should be free from obstructions that cast shadows over the pan during any part of the day other than brief periods during sunrise and sunset. Nearness to ponds, or swamps of not more than a few miles in diameter, particularly if they are temporary in character, and areas or locations on lawns with frequent sprinkling or flooding should be avoided. The instruments and equipment within the station should be positioned to conform with the obstruction conditions described above. A satisfactory station layout is illustrated in Figure 3.1.

The plot will be enclosed by a fence, adequate to protect the equipment, and to prevent animals from drinking the water. A steel link fence, 9 or 11 gauge, minimum of 4 feet high, with steel posts set in concrete is suggested. It may be necessary to bury some sort of barrier and add 18 to 24 inches of one inch chicken mesh (galvanized) along the bottom of the link fence to keep animals out of the area.

3.1.2 Evaporation Pan

The pan is of cylindrical design - 10 inches deep and 47½ inches in diameter (inside dimensions). This dimension will usually eliminate the need for seams across the bottom of the pan. The pan is constructed of monel metal.

The pan should be centered on a supporting platform. The support for the evaporation pan should be constructed of 2 by 4 lumber or heavier. Recommended dimensions are illustrated in Figure 3.2. The 2 by 6 shown in the platform design will permit complete support of anemometer pintle. Rot resistant lumber or lumber treated with cresote or other effective wood preservative should be used.

A micrometer hook gage is used for measuring water level. Two short lines are painted on the inside of the pan, 2 inches and 3 inches, below the rim, to assist in maintaining the desired water level.

The ground should be filled sufficiently to level the support and keep the bottom of the pan above the level of surface water in rainy weather. Earth fill should be used around the support to anchor it. It should be tamped firmly between the top members to within 1/2 inch of the top of the support, thus leaving an air space between the bottom of the pan and the fill to facilitate inspection of the pan for leaks while it is in use. During inspection, the level of the platform will be checked and corrected as needed.

3.1.3 Hook Gage and Stilling Well

The stilling well for the hook gage provides an undisturbed water surface around the hook gage and, in addition, provides support for the gage. The well consists of a cylinder or tube of unpainted brass, monel, or other non-corrosive metal. Less electrolytic action will occur if the metal is the same as that used in the pan or close to it in the electrolytic series. The cylinder is 8 inches high and 3 1/2 inches in outside diameter. It is mounted on a triangular base (the same as tube), 12 inches on each side and 1/4 to 1/2 inch thick. A brass (or monel) pipe, about .281 inch in inside diameter, is threaded into a hole in the center of the base plate, and extends up into the cylinder about 1 inch. The pipe damps oscillations in the well by retarding the flow of water to and from the well. The base is provided with leveling screws and lock nuts in each corner. The stilling well is illustrated in Figure 3.3.

The above described stilling well is placed in the pan about 1 foot from the north edge as shown in Figure 3.2. Level the top rim of well using the three leveling screws in its base using a spirit level. A small carpenter's hand level may be used for this purpose. The well should rest firmly on the bottom of the pan, which must be free from buckling in order to maintain a level adjustment of the well.

A micrometer hook-gage is used to indicate changes in the level of water in the evaporation pan. The gage consists of a hook in the end of a stem that is graduated in thousandths of an inch over a range of several inches. The stem is constructed with double threads throughout its range of adjustment.

A 3-leg spider and adjusting-nut assembly supports the hook and provides for adjustment of the height of the hook when the gage is installed on the stilling well. The adjusting nut is threaded to screw on the stem of the hook after assembly, the gage is placed on the stilling well with the three legs of the spider resting on the top rim of the well and the hook centered in the well. The stem should then be vertical. The adjusting nut is free to turn within the spider so that it may be used conveniently to adjust the height of the hook. The relative height of the hook in the well is indicated by the scales of the gage. The hook gage is illustrated in Figure 3.3.

3.1.4 Anemometer

An anemometer for measuring wind movement over the pan is mounted on the wooded pan support. The anemometer is provided with a counter on which the total movement can be read. The 5-digit, 3-cup anemometer is used. Manufacturer's information on the totalizing anemometer is contained in Appendix IV.

The anemometer is mounted on a specially designed display stand type pintel on the northwest projecting corner of the pan platform with the center of the cup about 6 to 8 inches above the rim of the pan, as shown in Figure 3.2. In this position the shadow of the cup falls on the pan only during late afternoon. The anemometer retaining screw is the knurled headset screw in the adapter at the bottom end of the anemometer housing. Be careful not to turn it any tighter than it can be turned by hand. The anemometer is illustrated in Figure 3.4.

3.1.5 Water Storage Recepticles

A 50 gallon covered recepticle should be located near the plot for storage of water for replenishment of water in the pan. A tank having a capacity of at least 30 gallons usually provides an adequate reserve of water. The storage tank should be thoroughly cleaned at the beginning of each year. The water placed in the tank should be completely free of oil.

For automatic replenishing of the evaporation pan during weekly periods, a 13-gallon, air-tight, rigid, graduated reservoir is provided north-northeast of the pan instead of the storage tank. This reservoir is connected to a clear plexiglass tube suspended vertically within the pan with its bottom edge at the desired minimum pan water level (e.g. 3 inches below top of pan). The tube is suspended by means of a laboratory burrette clamp and stand. The base of the reservoir is elevated a sufficient distance above the top edge of the pan to minimize sharp bends in the connecting flexible tubing which might impede the travel of air bubbles up into the reservoir. The reservoir is graduated in units of inches of evaporation in the pan. The rigid plexiglass tube is fitted with a rubber or cork stopper to be used when refilling the reservoir. The reservoir is shielded from direct sunlight by a reflective cover.

Near the desired maximum pan water level , a polyvinyl chloride (PVC) fitting has been installed in the side of the pan to provide an overflow orifice for use in times of heavy rain. The inside diameter of the fitting should be not less than 3/4 inch. The fitting is connected by means of flexible tubing to a 55 gallon tank buried next to the evaporation pan. The buried tank is fitted with a rigid tube extending down from the top to 1/2 inch above the deepest point in the tank. A small diameter flexible tube fits onto the rigid tube and extends above the earth backfill to allow weekly pumping of the tank down to the bottom of the rigid tube. The flexible tube also serves as a vent during periods of flow into the tank. The evaporation pan is elevated above the ground to facilitate drainage into the tank.

Both the above described automatic filling tube and overflow orifice are located within the clear plexiglass semicircular stilling well suspended on the side of the evaporation pan. The stilling well will minimize the effects of wind-induced surface waves on these water-level control devices.

3.1.6 Maximum-minimum Water Temperature Thermometer

The maximum and minimum temperatures of the water in the evaporation pan are determined from a Six's, floating, indicating thermometer. A submerged-type thermometer may also be used.

The floating thermometer is provided with a shield and mounted horizontally on a float-supported non-magnetic frame. The frame supports the thermometer, which can be set to ride about 1/4 inch below the water surface by adjusting the screws that hold the bulb end. The float is attached to an anchor using flexible lines which are at least 10 inches long, but short enough to keep the unit approximately one foot from the edge of the pan and the gage. Two lines, one attached to each end of the frame, should suffice. The floating type thermometer is shown in Figure 3.5.

3.1.7 Maximum-minimum Air Temperature Thermometer

The maximum and minimum ambient air temperatures are determined by a U-shaped, liquid-in-glass, Six's type thermometer. The thermometer has a minimum measurement range from - 40 to +120 degrees Fahrenheit, with painted scales marked in divisions of two degrees. A column of mercury contained in the U-shaped tube responds to the expansion and contraction of a volatile temperature-sensitive liquid in one end and pushes spring loaded iron indices to the levels of highest and lowest temperature. The indices are reset by depressing a button. A typical air thermometer is illustrated in Figure 3.5.

The thermometer is mounted in a wooden reflective shelter with double top and side louvers to allow free movement of air and still shield the instrument from precipitation, condensation , and radiation. The shelter is installed with the bottom about four feet above the ground and with the door facing north, so that the sun cannot shine directly on the instrument when the door is opened during the day. The shelter is mounted rigidly to minimize vibrations from strong winds. The inside of the shelter should be dusted occasionally with a dry cloth. The shelter supports should also be inspected to insure that the shelter is securely mounted. A typical shelter which is satisfactory for the air thermometer is shown in Figure 3.6. Manufacturer's assembly instructions for the instrument shelter are contained in Appendix V.

3.2 Field Measurements And Maintenance

3.2.1 Pan Water Level Reading

At the time of each hook gage observation, place the gage on the stilling well and adjust the hook in the well until the point is below the surface of the water. Slowly turn the adjusting nut clockwise until the point just pierces the water surface. Reflection of the sky in the water will assist in determining when the point first breaks through the surface. Remove the gage from the well and read the scales.

The figures on the stem represent whole inches, and the intermediate graduations represent tenths of an inch. The figures on the circular scale represent hundredths of an inch, and the intermediate graduations represent thousandths. Whenever an observation is taken, the scale on the stem is read to tenths of an inch, as indicated by the first graduation at or above the top of the knurled adjusting nut. The circular scale on the adjusting nut is read to the nearest thousandths of an inch at the index. Both scale readings are added, and the sum represents the gage reading. Enter the reading obtained as above in the appropriate spaces on the forms. Precipitation, small unavoidable inaccuracies in measurements, and condensation of water into the pan, may occasionally cause the water level to be higher than that of the previous observation.

When the gage is assembled after cleaning, determine that the threads of the stem and adjusting nut are properly matched, by turning the adjusting nut counter-clockwise (as viewed from the top) until the top of the nut coincides with one of the graduations of the stem. If the scale has been properly assembled, the index line on the ring of the spider will coincide with "0" on the circular scale. If it does not coincide, it will be necessary to unscrew the adjusting nut and reassemble the gage by matching the alternate combination of threads.

Experiments have shown that the height of the rim of the pan above the water surface affects the rate of evaporation. In order that the records from all stations using hook gages will be comparable, the pan should be filled to a level two inches below the rim, and refilled to this level at each regular observation. Cleaning the pan or adjusting the water level should be done immmediately following an observation. Read the gage immediately before and after making any change in the water level and enter the readings on the forms.

Clean the pan as frequently as necessary to keep it free from sediment, scum, and oil films. An oil film will materially reduce the rate of evaporation. The pan should be emptied by siphoning and/or by dipping the water out. Under no circumstance is the pan to be lifted and emptied with any signficant amount of liquid remaining in the pan.

Carefully inspect the pan for leaks at least once a month, since any leaks will render the measurements valueless. Report the finding of any leaks on the observation form for the month and report both the date the leak was discovered, and the date the pan was repaired or replaced.

3.2.2 Storage Recepticle Levels

For operation with automatic replenishing of the evaporation pan, the level in the reservoir must also be read at each pan level observation. The reservoir is graduated in divisions of 0.05 inches of pan evaporation. Readings should be estimated to the nearest 0.01 inch. After reading the reservoir level, the discharge tube must be plugged with the stopper, the reservoir cap removed, and the reservoir refilled with water to the top of the scale (0.00 inch). The cap is then replaced and tightened, the stopper removed from the tube, and the reservoir level allowed to reach equilibrium. A new reading must then be recorded for the reservoir. The reflecting cover on the reservoir should be tightly secured around the reservoir stand with duct tape to prevent ponding of water on top.

The volume of excess rain water which has overflowed from the evaporation pan into the catchment tank must also be determined on each weekly visit. The tank should be pumped "dry" and the pumped water retained in a bottle graduated in divisions of 0.05 inch of pan evaporation. The total volume pumped is recorded on the forms and is estimated to the nearest 0.01 inch of pan evaporation. The graduated bottle should be placed on a level surface when the water level is read.

3.2.3 Wind Movement

The anemometer counter is read at the time of the evaporation observation to the nearest whole mile. The five digits appearing in the window of the meter indicate the total wind movement to tenths of a mile. Ten thousand miles is indicated as five zeros (00000) on the meter and coincides with zero miles for the succeeding 10,000-mile cycle of operation.

3.2.4 Water Temperatures

The maximum and minimum water temperatures are read to the nearest whole degree, as indicated by the end of the metal index nearest the column of mercury in each tube. If possible, the thermometer should be read submerged, before removal from the pan for resetting the indices. Enter the highest and lowest readings in the proper water temperature columns of the record form. To reset the thermometer, place the horseshoe magnet, open end down and parallel to the thermometer tube, directly above one of the metal indices. Move the magnet slowly toward the mercury column until the index touches the mercury. Gently lift the magnet away from the tube to prevent the index from springing away from its contact with the mercury. Repeat this procedure with the other index. The magnet may be hung on the lower end of the metal handle using the small strip furnished for that purpose with the submerged-mount thermometer. If the metal strip is lost, a nail or other small metal piece may be substituted.

If the mercury column should become separated, the resulting temperature readings will be erroneously recorded. When this condition is noted, action should be taken immediately to rejoin the column. Remove the thermometer and holder or float frame. Hold the thermometer near its bulb end and swing it rapidly in an arc until the mercury column is rejoined, taking care not to strike any object. If the thermometer tube is removed, it will be difficult to perform this function with out breaking the thermometer at the sharp "U" bend.

3.2.5 Air Temperatures

The maximum and minimum air temperatures are read at each evaporation observation from the indices on the thermometer mounted in the instrument shelter. After recording the temperatures on the appropriate form, the indices are returned to current temperature by depressing the reset button.

3.3 Office Calculations

With the weekly measurements described in Section 3.2, values of average daily pan evaporation, average daily wind movement, intermediate water temperature, intermediate air temperature, and coefficient of net energy advection may be calculated. Using these values with a nomograph developed by the U.S. Weather Bureau, average daily lake evaporation at the station site may be computed. The office calculations required to obtain the above described values are described in the following sections, and a computation format which will facilitate the calculations is presented with example calculations in Table 3.1.

3.3.1 Average Daily Pan Evaporation

The average daily pan evaporation is computed as follows:

$$E_p = (SR_i - SR_{i-1}) - (HG_{i-1}) + R - CT/Time$$

Where:

- E_p = average daily pan evaporation (inches per day)
- SR_i = current storage reservoir reading (inches)
- SR_{i-1} = previous storage reservoir reading (inches)
- HG_i = current hook gage reading (inches)
- HG_{i-1} = last previous hook gage reading (inches)
- R = total rainfall since last hook gage reading (inches)
- CT = volume of water collected in catchment tank since last hook gage reading (inches)
- Time = time between current and last readings (days)

3.3.2 Average Daily Wind Movement

The average daily wind movement over the surface of the water in the evaporation pan is computed as follows:

$$W_{avg} = \frac{W_i - W_{i-1}}{Time}$$

Where:
W_{avg} = average daily wind movement (miles per day)
W_i = current anemometer reading (miles)
W_{i-1} = last previous anemometer reading (miles)
Time = time between current and previous readings (days)

3.3.3 Intermediate Water Temperature

The intermediate water temperature is computed as follows:

$$T_s = \frac{Temp_{w_{max}} + Temp_{w_{min}}}{2}$$

Where: T_s = intermediate water temperature (^oF)
$Temp_{w_{max}}$ = maximum water temperature since last reading (^oF)
$Temp_{w_{min}}$ = minimum water temperature since last reading (^oF)

3.3.4 Intermediate Air Temperature

The intermediate air temperature is computed as follows:

$$T_a = \frac{Temp_{a_{max}} + Temp_{a_{min}}}{2}$$

Where: T_a = intermediate air temperature (^oF)
$Temp_{a_{max}}$ = maximum air temperature since last reading (^oF)
$Temp_{a_{min}}$ = minimum air temperature since last reading (^oF)

3.3.5 Coefficient of Net Energy Advection

The coefficient of net energy advection of sensible heat through the walls of the evaporation pan (α_p) is obtained from the nomograph in Figure 3.7. The value will be approximate (since the nomograph corresponds to atmospheric pressures for an elevation of 1000 feet) but it will be sufficiently accurate for calculation purposes. The coefficient is obtained from the nomograph as follows:

1. Enter the horizontal axis of the nomograph with the intermediate water temperature (T_s) computed in Section 3.3.3.

2. Move vertically upward to intersect the curve corresponding to the average daily wind movement (W_{avg}) computed in Section 3.3.2

3. From the intersect point in Step 2, move horizontally to the left and read the coefficient ($_p$) from the vertical scale.

3.3.6 Average Daily Lake Evaporation

The average daily lake evaporation is obtained from the nomograph in Figure 3.8 using the values and coefficients described above as follows:

1. Enter the vertical scale of the nomograph with the average daily wind movement (W_{avg}).

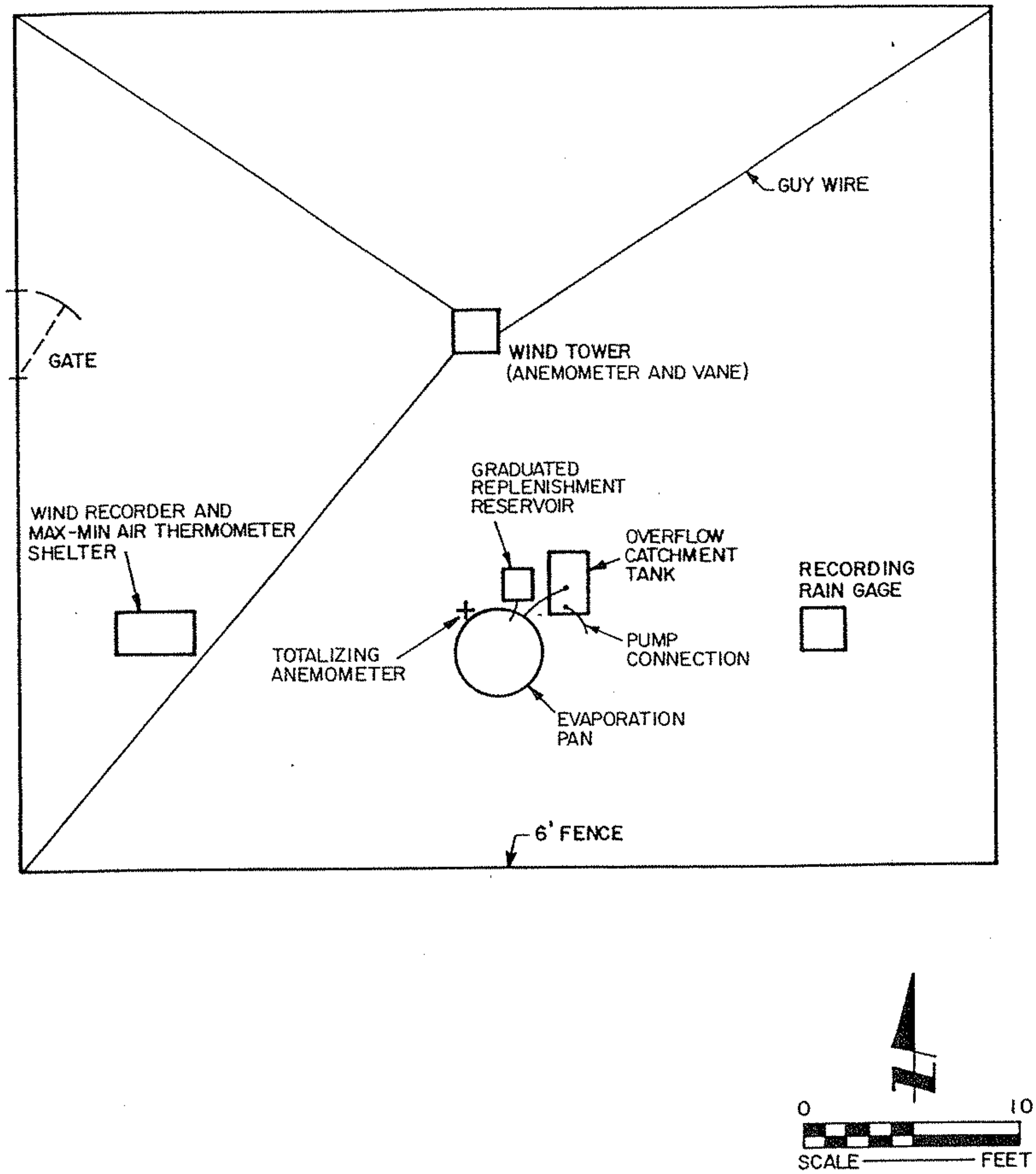
2. Move horizontally to the right to intersect the appropriate curve for the elevation (in feet above mean sea level) of the station site. (Use the zero elevation line on chart).

3. From the intersect point in Step 2, move vertically downward to intersect the appropriate curve for the coefficient of net energy advection obtained in Section 3.3.5.

4. From the intersect point in Step 3, move horizontally to the right to intersect the curve corresponding to $T_s - T_a$, i.e., the intermediate water temperature, T_s, (computed in Section 3.3.3) minus the intermediate air temperature, T_a, (computed in Section 3.3.4).

5. From the intersect point in Step 4, move vertically upward to intersect the curve corresponding to the average daily pan evaporation (E_p) computed in Section 3.3.1.

6. From the intersect point in Step 5, move horizontally to the right and read the daily lake evaporation in inches per day from the right-hand scale.



WEATHER STATION LAYOUT

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FIGURE 3.1

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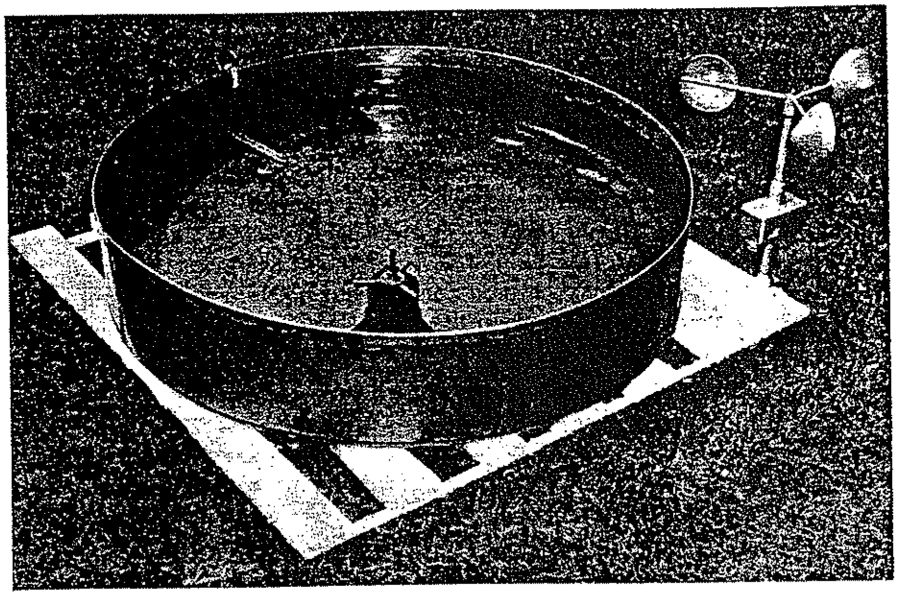

TYPICAL EVAPORATION PAN INSTALLATION

(SHOWING REQUIRED ORIENTATION OF STILLING WELL,
HOOK GAGE, AND TOTALIZING ANEMOMETER)

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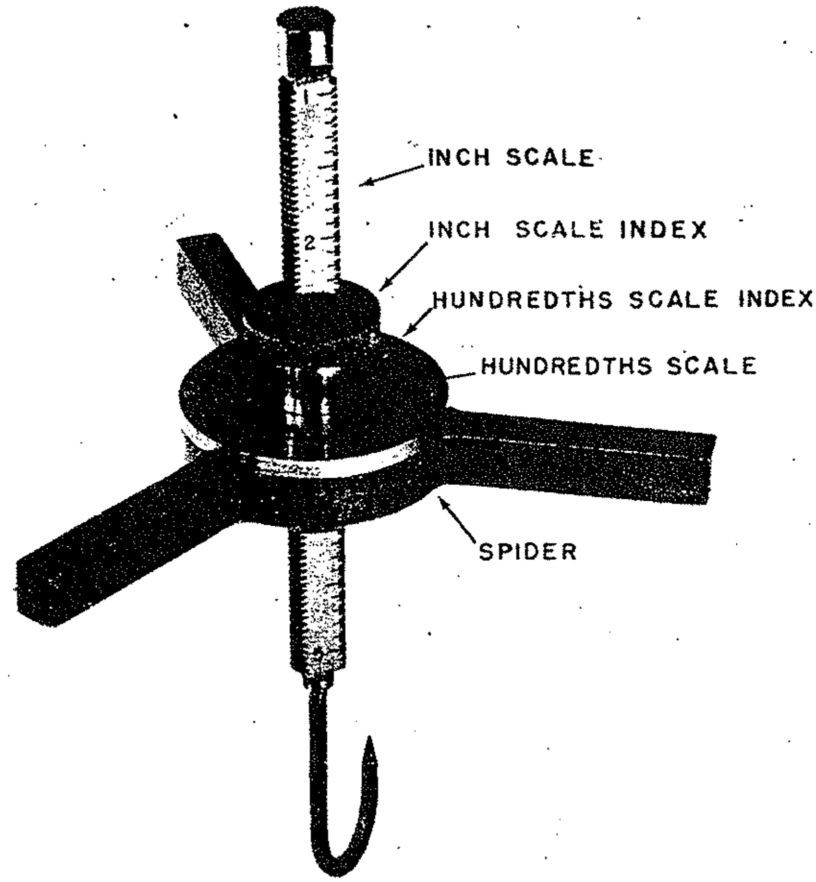
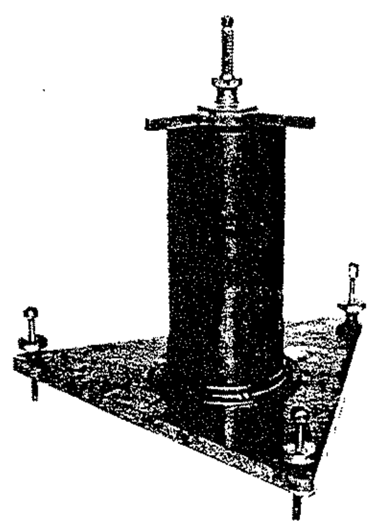
FIGURE 3.2



HOOK GAGE



STILLING WELL

(WITH PROPERLY INSTALLED HOOK GAGE)

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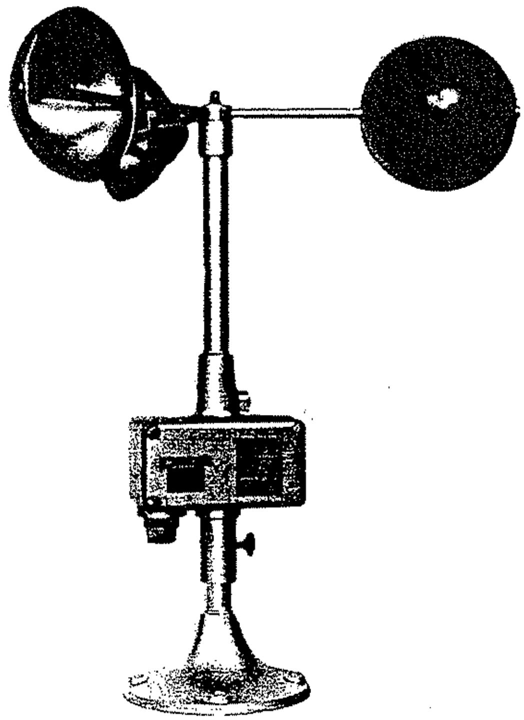
FIGURE 3.3



FIVE-DIGIT TOTALIZING 3-CUP ANEMOMETER

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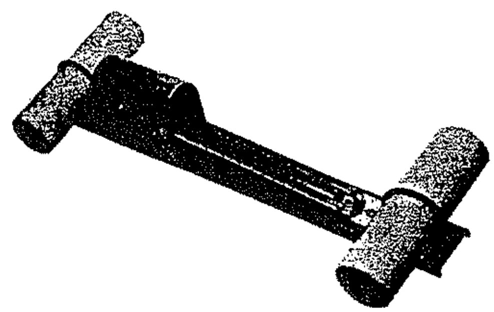
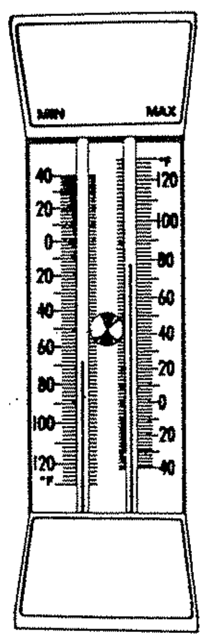
FIGURE 3.4



FLOATING MAXIMUM-MINIMUM WATER THERMOMETER



MAXIMUM-MINIMUM AIR THERMOMETER

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FIGURE 3.5

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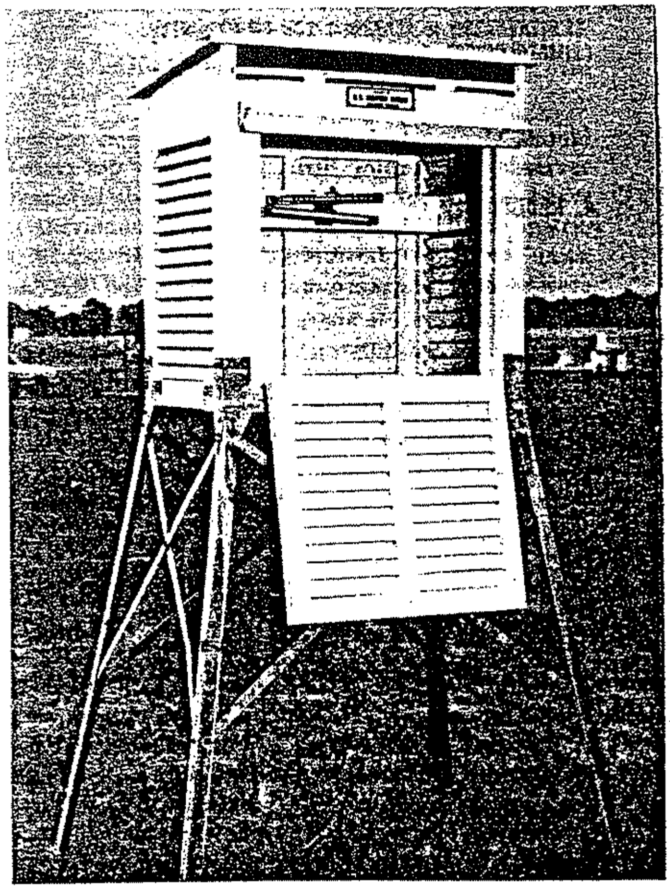

SHELTER FOR MAX-MIN AIR THERMOMETER AND WIND RECORDER

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FIGURE 3.6

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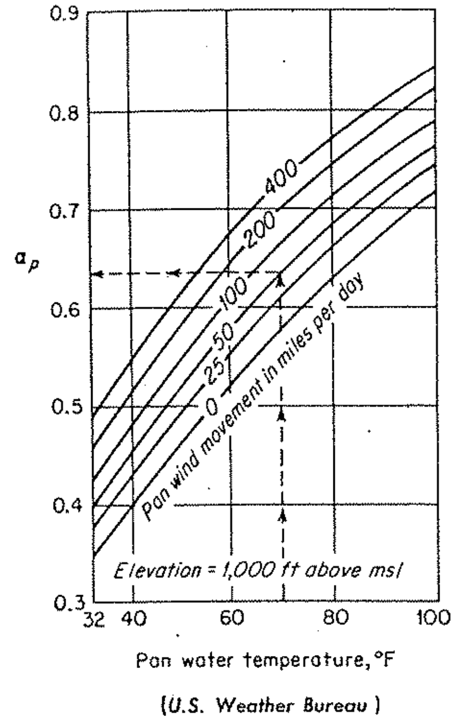

COEFFICIENT OF NET ENERGY ADVECTION AS A FUNCTION OF PAN WATER TEMPERATURE AND WIND MOVEMENT

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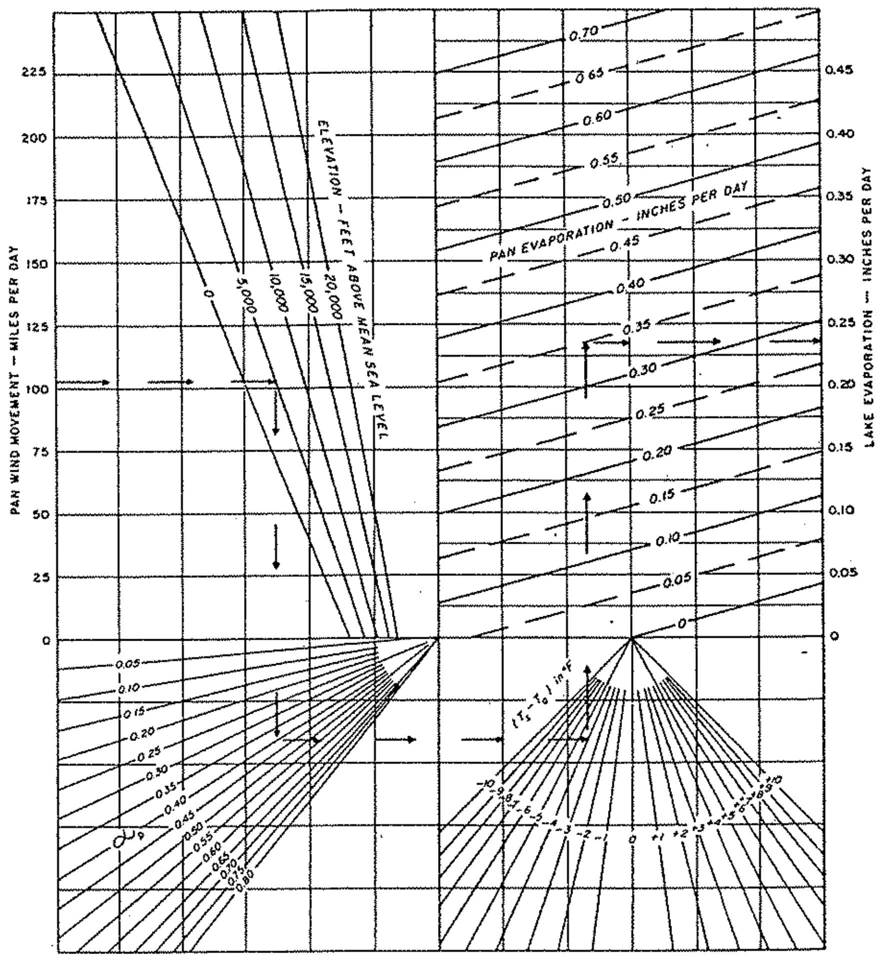
FIGURE 3.7



(U.S. Weather Bureau.)

LAKE EVAPORATION AS A FUNCTION OF PAN EVAPORATION AND HEAT TRANSFER THROUGH PAN

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FIGURE 3.8

TABLE 3.1

EXAMPLE LAKE EVAPORATION CALCULATION

Date (Month/Day)		Time of Day (Hrs/Min)		Change In Time (Days)	Hook Gage Reading (Inches)			Reservoir Reading (Inches)			Volume Pumped From Overflow Tank (In)	Rainfall From Rain Gage (In)	Net Daily Pan Evaporation (In/Day)	Anemometer Reading (Miles)			Average Daily Wind Movement (Miles/Day)	Water Temperature (°F)			Air Temperature (°F)			T_s-T_a (°F)	Coeff. of Net Energy Advection	Daily Lake Evaporation (In/Day)
Current	Previous	Current	Previous		Current	Previous	Change	Current	Previous	Change				Current	Previous	Change		Max	Min	T_s	Max	Min	T_a			
11-24	11-17	4:00	2:00	7.1	2.563	2.124	+0.439	0.31	0.01	0.30	0.65	1.00	0.03	1525.5	1500.5	25.0	3.5	85	75	80	75	65	70	10	0.63	.04

Chapter 4

WIND STATION

The equipment for the wind station includes the following:

- Wind speed sensor (anemometer) with voltage output
- Wind direction vane with voltage output (battery-powered)
- Two-channel chart recorder
- Recorder shelter
- Ten-meter high instrument mast with guy wires

The recorder integrates and plots readings from the instrument sensors for periods of up to one month. Thus, essentially continuous plots of wind speed and direction versus time are obtained. The installation and field monitoring of the equipment and the office analysis of the recorded data are described in the following sections.

4.1. Equipment Installation

4.1.1 Instrument Mast

The ten-meter high aluminum instrument mast should be installed in accordance with the manufacture's recommendations or with the installation recommendations contained in Appendix VI. The mast installation consists of the following basic steps:

- Pour concrete base pier for mast support and blocks for guy wire anchors
- Join and secure mast sections
- Attach hinged connector on mast base to footing base plate
- Mount instruments and attach guy wires
- Erect mast
- Secure guy wires and adjust tension
- Adjust instrument orientation

4.1.2 Recorder Shelter

The same shelter used to protect the maximum-minimum air temperature thermometer (see Section 3.1.7) is used to house the wind station recorder. This standard, "medium-sized" shelter is generally sold and shipped disassembled. It was assembled in the field using simple hand tools (see Appendix V). The metal legs were embedded in concrete for rigid support. A typical shelter is illustrated in Figure 4.1.

4.1.3 Anemometer, Vane and Recorder

The wind sensing instruments and recorder are generally sold together as a "system" and come complete with electronic cables and connectors, recorder roll charts, protective case, and instrument mounting crossarm.

The wind speed instrument is a stainless steel, three-cup anemometer with a photo chopper and solid state light source which produces a voltage output signal. Anemometer system accuracy is two percent over the selectable ranges of 0 to 50 or 0 to 100 miles per hour. The instrument has a threshold wind velocity of 0.75 mph and a distance constant of eight feet.

The wind direction vane is coupled to a potentiometer with a system accuracy of two percent. The direction range spans from 0 to 540 degrees. The vane also has a threshold of 0.75 mph and a distance constant of eight feet. Both instruments are illustrated in Figure 4.2. The manufacturer's specifications and instructions are contained in Appendix VII.

The chart recorder is a dual channel, inkless recorder with a chart width of 2 5/16 inch per channel. The recorder integrates over selectable time intervals of 30, 60 or 90 seconds. It can be operated in the tear-off or reroll mode at a speed of one inch per hour. It will operate under battery power for a period of one month at above freezing temperatures. The recorder is illustrated in Figure 4.2.

The initial steps in the installation of the instruments are as follows:

- Place the wind speed and direction transmitters on a flat surface.
- Connect the sensor mating connector end of the cable to the crossarm and the opposite end of the cable to the mainframe.
- After making and checking all the above described connections, turn the unit on.
- Rapidly spin the wind speed shaft, and note that the translator output voltage, measured by a volt meter connected to pin B of the output connector, increases. (If voltage does not increase, recheck cable connections.)
- Slowly rotate the wind direction shaft, and note that the wind direction output measured by a volt meter connected to Pin C of the output connector, changes. (If output does not change, recheck cable connections.)
- Turn unit off.

The instruments are calibrated at the factory and should not require additional calibration. If additional calibration does become necessary, however, it may be performed in the field using only a volt meter. This procedure is described in Appendix VII.

The final steps in installation of the instruments are as follows:

- Align the crossarm as shown in Figure 4.2. The flat on the wind direction cap should be as indicated.
- Place the vane on the shaft and align the flats so they are parallel. A small coin placed against the flats will insure proper orientation of the vane on the sensor (see Figure 4.2).
- Tighten the set screws in the van hub. With the vane as shown in Figure 4.2, the wind direction recorder will indicate 90°.
- Place the cup set on the wind speed transmitter and tighten the set screws.
- Mount the crossarm on a 3/4-inch pipe.
- Install cable in its final location, secure to mast and/or guy wire.
- Rotate the crossarm to an east-west orientation, tighten the set screws in the crossarm mount, and connect the cable to the crossarm.
- Place recorder in shelter, install batteries, and connect transmitter cables to outlets inside and outside of shelter.
- Turn unit on and observe pen trace for short period to confirm system activation.

4.2 Field Monitoring

Although the chart paper rolls and batteries last one month, the recorder should be monitored at each weekly rain gage and evaporation station readings. Proper pan and chart roll action should be confirmed and actual times noted on the chart to serve as references for future evaluation of chart speed accuracy. When performing a monthly chart change, observe the following:

- Turn the system power off, making sure that the recorder pens are not pressing against the chart paper.
- Always start with a fresh roll of chart paper.
- The cardboard sleeve on the take-up reel must remain on at all times. This, plus starting with a full roll, ensures that the proper chart speed will be maintained for the duration of the roll. Failure to start with a full roll, while using the take-up mode, will result in variable chart speeds and inaccurate time keeping of the recorder.

- Seat the supply roll so that the chart perforations mesh with the gear drive.
- After installing a fresh roll, advance the paper to the correct time using the circular thumb wheel switch on the left front panel of the recorder.
- When changing chart paper or making time marks on the recorder, be careful not to damage or bend the recorder pens.
- Always mark the correct time at the beginning and end of each roll of chart paper.

4.3 Office Analysis

From the chart records, values of maximum and minimum wind velocities and the corresponding wind directions are to be picked off for each day. However, prior to the search for maximum and minimum trace points, it is prudent to examine the chart and evalulate chart speed accuracy. This evaluation is done by completing the following:

- Compare pen time and clock time at end of chart. Note time correction.
- Compare pen and clock time at beginning of chart to see that the pen was set properly.
- Determine whether and where clock stopped.
- If clock did not stop and time is no more than two hours off, make no time adjustments.
- Mark off midnight times for each day if more than two hours different from chart times (e.g., if pen at beginning of chart was set improperly).
- If clock did not stop and time is more than two hours off, make time adjustments for the period in direct proportion to the number of the days and the total correction (e.g. the correction for the third day would be 3/7 times total correction). Round correction to the nearest hour.
- If clock stopped at end of chart (i.e., most common) and pen was set properly at start, make time adjustments at end accordingly.
- If clock stopped during middle of chart and clock started again for some reason, assume time at start and end is correct. Make time adjustments in middle where clock appeared to have stopped.
- If clock stopped at beginning of chart (e.g., clock running at end, time off more than two hours, and the pen trace appears to have stayed in one place for a long time), assume time at end is correct. Make time adjustments accordingly.

Once chart speed accuracy has been confirmed, or appropriate time adjustments have been made and beginning and ending points for each day have been marked on the chart, the assessment of daily maximums and minimums and corresponding wind directions can be performed. Remember that the anemometer scale is usually set at 0 to 50 mph, and that 0 degrees corresponds to a northerly wind direction.

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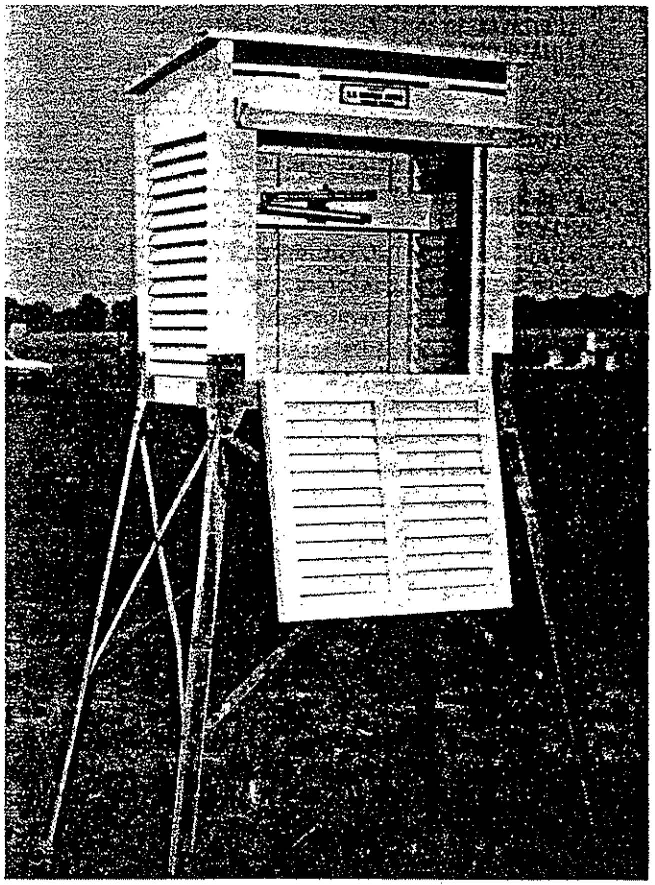

SHELTER FOR MAX-MIN AIR THERMOMETER AND WIND RECORDER

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FIGURE 4.1

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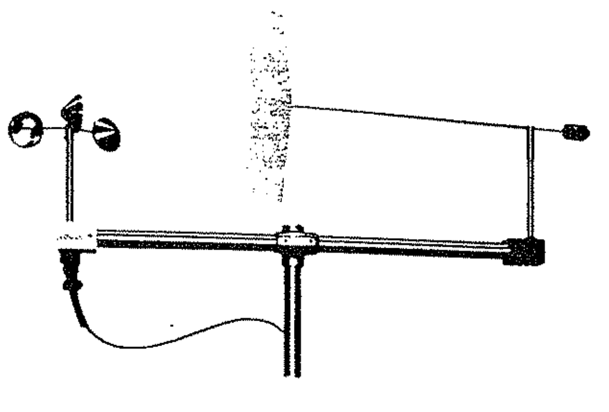
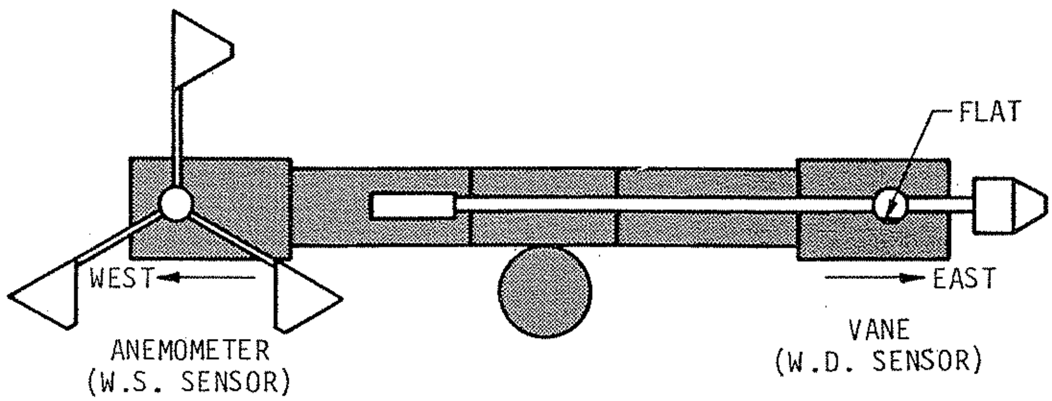
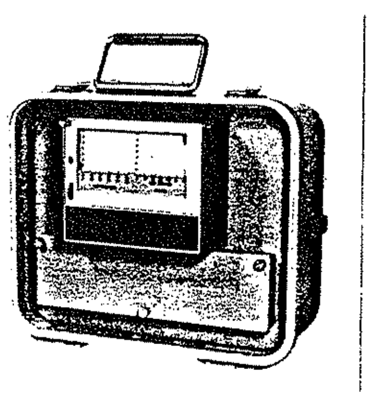


RECORDING ANEMOMETER AND VANE



PROPER CROSSARM AND SENSOR ALIGNMENTS



INKLESS WIND STATION RECORDER WITH CASE

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FIGURE 4.2

Chapter 5

WATER-LEVEL RECORDER

5.1 Installation

The water level within the water-table aquifer was continuously monitored from a well constructed of 6-inch diameter pipe which has a slotted collection zone. The float attached to the recorder followed the rise and fall of the water level in the well. The float, in turn, was connected to the chart drum of the recorder. A closed, 2-inch diameter PVC casing adjacent to the well housed the counterweight for the float. A clock-driven stylus moving across the chart at a constant speed documents a permanent graph of water level versus time on the chart. The well station installation is illustrated in Figure 5.1. The well recorder was located at AB-21 near the southwest corner of the landfill site as located on Figure 1.3. This equipment can be put back in operation should it be deemed prudent. The county owns the recorder. Therefore, this chapter is provided for future reference.

5.2 Field Monitoring and Maintenance

The charts on the Type F water-level recorders should be changed every 7 to 8 days. The following procedures should be followed:

- Unlock the plywood cover at the top of the structure, and slide to the side to gain access to the recorder.
- Unlock the protective cover, raise the pen from the chart drum and advance the carriage a short distance and remove chart (do not roll float before raising and advancing pen).
- Replace the cover for the recorder and lock.
- Lift the float line from the pulley and hang on the housing or stilling well wall.
- Remove the recorder and place on a suitable work area to change chart and service the recorder. (An alternate method would be to service the recorder inside the structure with the float line on the pulley.)
- Make sure the date and time are recorded on the chart. A properly marked chart showing typical data is presented in Figure 5.2.
- Roll the chart holder spring bands to the edge of the chart drum and remove the used chart.
- Wind the clock mechanism counterclockwise with the key provided inside the clock housing.
- Slip a new chart from the far side underneath the chart drum, pulling the edges together and lapping the trimmed edge over the margin. (See that the

hole on the left chart margin engages the pin and the chart drum.)

- Match the lines and push the chart against the left flange of the chart drum.

- Replace the spring chart bands at the left and right ends of the drum. (Place the spring bands within the chart margins and not on the graph portion of the drum.)

- Return the pen carriage to the starting position by pushing the carriage with a finger to the left side of the recorder. The left line on the chart is 12:00 midnight. The distance between each thin vertical line on the chart is equal to two hours. The distance between heavy vertical lines is equal to 24 hours.

- Check the ink reservoir to see if there is a sufficient supply for the pen. Directions for filling the ink reservoir are given in the Stevens Manual in Appendix VIII.

After chart replacement is complete, replace recorder on the table support in the well. Hang the float line on the left side of the pulley and loosen knurled nut on the pulley to allow adjustment and positioning of the chart pen at the proper location (time and water level) on the chart. The distance between thin horizontal lines on the chart is equal to .05 feet. The distance between heavy horizontal lines is equal to 0.5 feet. After resetting the pen at the proper location on the chart, retighten nut, being careful not to disturb the pulley position. (The pen location can only be checked with the pen touching the chart paper.) Reset the pen on the chart paper and write the correct date, time, and gage height (water level) on the chart. After determining the system is again operational, replace the metal recorder cover a final time, place the cover over the top of the stilling well, and lock. See the Stevens Instruction Manual in Appendix VIII for a discussion of recorder maintenance. Note that the recorders should be lightly oiled once each year.

Attention to the following items will increase the accuracy and continuity of the well record:

- The datum of the gage should be maintained to 0.01 foot by running levels to reference marks at least once every year. If conditions are known to be unstable, then levels should be run more often.

- The recorded gage height should be checked against the water level in the well during each visit to assure or that there is no malfunction. Water level in the well is determined by tape down to water level from top of casing inside the shelter.

- Malfunctions of the recorder can be reduced by the periodic cleaning and oiling of the recorder and the clock.

- Excessive humidity and temperatures in the gage house should be reduced to a minimum by proper ventilation.

5.3 **Office Calculations**

The objective of this effort is to generate a table of mean daily water-level elevations (NGVD) for the year. The 12-month period can start at any month; however, the water year (October 1 to September 30) or the calendar year are most common.

The steps required to generate the above mentioned table are: (1) pick off mean daily water levels from weekly charts, (2) determine elevation for zero of gage from datum analyses, and (3) generate table of water-level elevations. Water-level elevations are altitudes referenced to mean sea level or the national geodetic vertical datum (NGVD). The NGVD water-level value equals the zero of the gage (in feet NGVD) plus the gage height reading.

The procedure for developing the mean daily gage height is:

- Check to be sure all notes from field visit are written on chart.
- Be sure all charts for a particular station are together and no charts are missing. If chart is missing, insert note in file explaining why.
- For each chart, do the following items:
  - Compare pen time and clock time at end of chart. Note time correction.
  - Compare pen and clock time at beginning of chart to see that the pen was set properly.
  - Determine whether and note where clock stoppage occurred.
  - If no clock stoppage occurred and time is no more than two hours off per week, no time adustments.
  - Mark off midnight times for each day if more than two hours different from chart times (e.g., if pen at beginning of chart was set improperly).
  - If clock did not stop and time is more than two hours off, make time adjustments for the period of record in direct proportion to the number of the days and the total correction (e.g. the correction for the third day would be 3/7 times total correction). Round correction to the nearest hour.
  - If clock stopped at end of chart (i.e., most common) and pen set properly at start, make time adjustments at end accordingly.
  - If clock stopped during middle of chart and clock started again for some reason, assume time at start and end of chart is correct. Make time adjustments in middle where clock appeared to have stopped.

- If clock stoppage is at beginning of chart (e.g., clock running at end, time off more than two hours, and the pen trace appears to have stayed in one place for a long time), assume time at end is correct. Make time adjustments accordingly.

- Mean daily gage height for each day is the gage height at midday based on the average area concept illustrated in Figure 5.3. The concept means that the area bounded by the 0 hour vertical line, the pen trace, and the template line below the pen trace must equal the area bounded by the 24-hour vertical line, the pen trace, and the template line above the pen trace. The gage height where the vertical midday line and the template line intersect is the mean daily gage height. (For days when gage height changes more than 0.5 feet, the template method is done for small within day periods such as 4, 6 or 8 hour periods and then these averages averaged to obtain a mean daily value).

- Note mean daily gage height on recorder chart.

- Publish mean daily water-level elevations for the year as a graphic or table. The mean daily water-level elevations equal datum of the zero point on gage plus mean daily gage-height reading. Ardaman & Associates, Inc. can generate this output in a graphic form from our computer program set up for this purpose. The computer program inputs mean daily gage heights and datum elevation.

Chapter 6

OBSERVATION WELLS

6.1 Introduction

6.1.1 Observation Wells

The observation wells have been placed to predetermined depths to monitor the groundwater level. The wells consist of various diameter risers with variable length porous or open ends, the location of each well is shown in Figure 1.3 and data about each well is presented in Table 6.1. The shallow groundwater level should be measured in each well monthly.

6.1.2 Obtaining Readings

The water level in the riser can be obtained using 1/8-inch diameter polyethylene tubing. The tubing should be marked in one-foot intervals. As an alternate a tape graduated in feet and hundredths of a foot could be used to measure the water level. Other devices may also be acceptable.

To check the water level, remove the protector cap from the top of the well and insert the tube into the well to the estimated water level. Blow into the tube and move the tube up or down until you hear a bubbling sound. Adjust the tube up and down until you determine the top of the water. Hold or temporarily mark the tube, exactly, at the top of the observation well and measure with steel tape to the nearest 0.01-foot mark. Add or subtract measurement as necessary to determine the depth to the water level.

6.2 Field Work

- Water levels are measured during each visit. Preferably visit wells on same day each week and each day of month.
- Remove protective caps from wells.
- Measure the depth to water level from top most point of well to the nearest 0.01 foot. Also measure the distance to land surface from top most point of well to the nearest 0.1 foot.
- Record reading date, and time on log sheet as shown in Table 6.2. The distance from top of well to ground level should be entered on the log sheets.
- Replace protective caps on wells.

6.3 Office Work

- Compute the depth to water below or above land surface for each reading by the following equation:
  MHW-HTPL = DWL

where:	MHW	=	measured depth to water surface from top of pipe (feet)
	HTPL	=	height between top of pipe and land surface (feet)
	DWL	=	depth to water surface below land surface (feet)

If DWL is a positive value, then water level is below land surface.
If DWL is a negative value, then water level is above land surface.

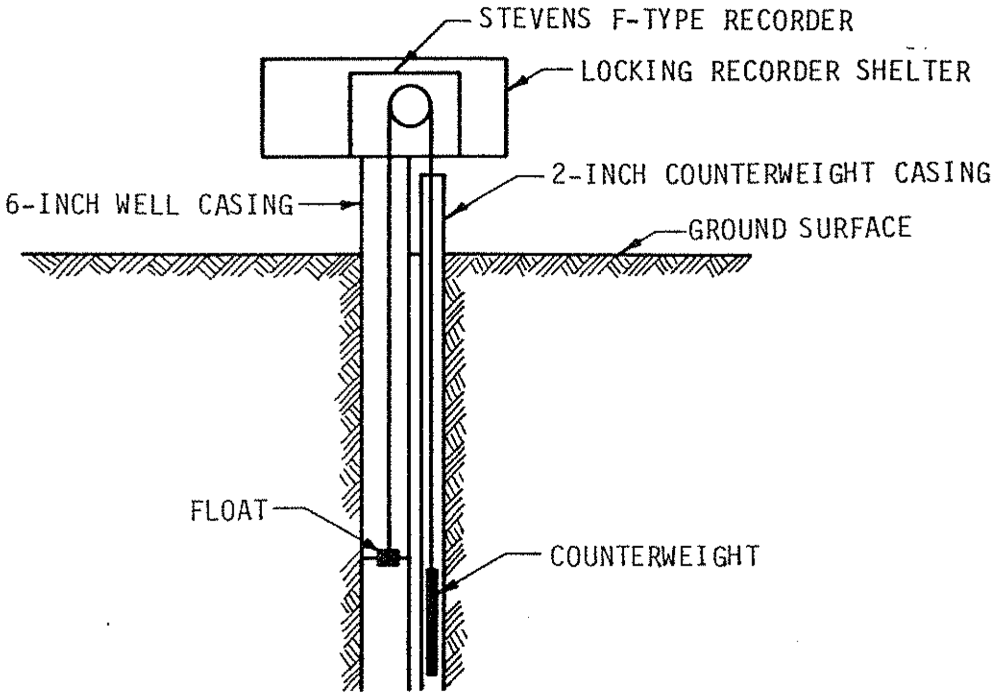
- Plot each DWL reading on arithmetic hydrograph paper (i.e. K&E graph paper #472893). Join DWL readings with straight lines on hydrograph form. Make sure low water-level readings (e.g. high positive DWL values) are shown as low values on the hydrograph form.

Table 6.1

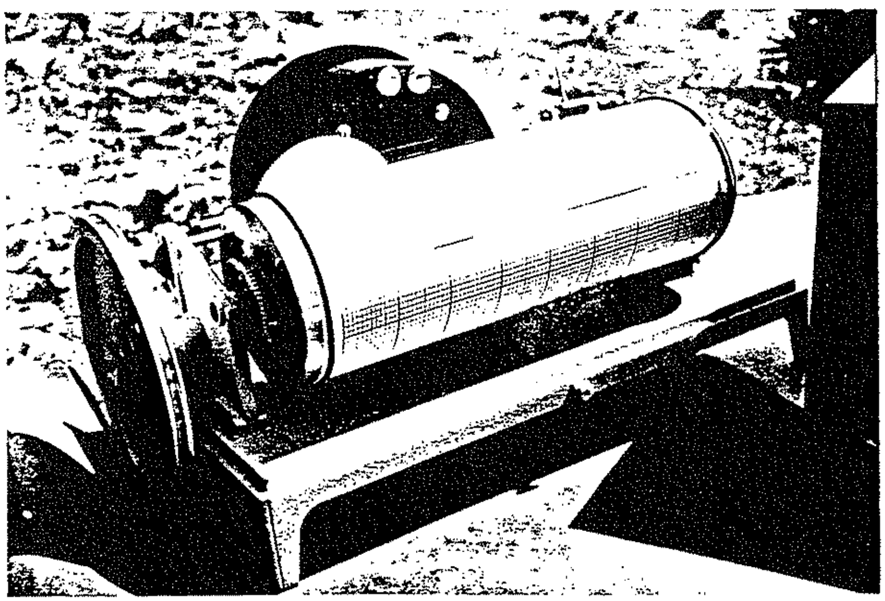
PIEZOMETERS/OBSERVATION WELLS

Hole	Diameter (inches)	Land Surface Elevation (feet, NGVD)	Riser Height (feet)	Collection Zone Elevation (feet, NGVD)	Aquifer	Remarks
TH-19	2	126.9	3.0	-13.0 to -23.0	Floridan	
TH-20	2	130.5	3.0	120.0 to 102.0	Surficial	
AB-21	6	122.1	3.5	122.1 to 110.0	Surficial	
TH-22	2	126.4	3.7	125.0 to 101.0	Surficial	
AB-22	2	113.0	2.7	109.0 to 97.0	Surficial	
TH-24	2	128.0	3.0	127.0 to 104.0	Surficial	
TH-26	2	125.1	3.0	121.0 to 107.0	Surficial	
TH-28	2	128.8	3.0	107.0 to 99.0	Surficial	
TH-30	2	125.9	3.0	106.0 to 83.0	Surficial	
TH-32	2	129.5	3.0	120.0 to 109.5	Surficial	
TH-33	2	142.3	3.0	117.0 to 94.0	Surficial	
TH-34A	2	150.0	3.0	112.5 to 89.0	Surficial	
TH-35	2	135.9	3.0	112.0 to 94.0	Surficial	
TH-36	2	145.6	2.25	116.5 to 98.0	Surficial	
AB-37	2	121.8	2.8	109.0 to 104.0	Surficial	Collection zone below clay
TH-37A	2	131.0	3.7	114.0 to 96.0	Surficial	
TI[illegible]	2	134.0	3.0	116.0 to 108.5	Surficial	
TH-40	2	122.1	3.1	-30.0 to -42.0	Floridan	
TH-41	2	122.1	3.0	-68.0 to -91.0	Floridan	
TH-42	2	112.7	3.0	-42.0 to -51.0	Floridan	
TH-48	2	123.0	2.7	111.0 to 106.0	Surficial	Collection zone below clay
TH-56	2	130.0	2.8	116.0 to 111.0	Surficial	Collection zone below clay
Prod. Well	24	116.4	1.4	-85.6 to -764.6	Floridan	Agrico Well No. 10 Driller's Log
Prod. Well	24	128.25	0.25	30.2 to -17.2	Floridan	

K&E 19 1153 12-80 MC1983e



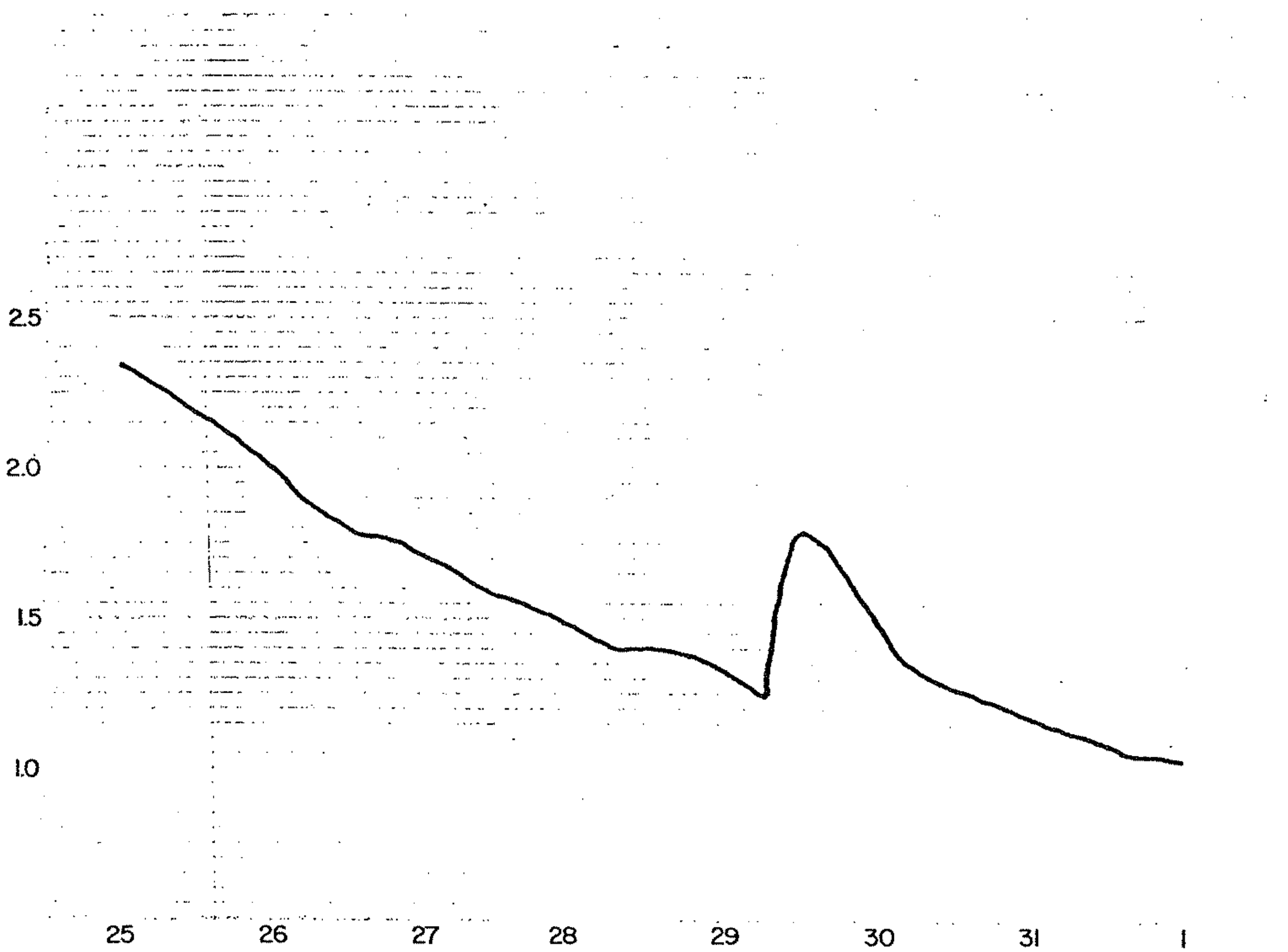
SHALLOW WELL STATION



WATER LEVEL RECORDER

Ardaman & Associates, Inc. Consulting Engineers in Soil Mechanics, Foundations, and Material Testing		
FIELD AND DATA REDUCTION MANUAL HYDROGEOLOGICAL MONITORING PROGRAM SOUTHEAST COUNTY LANDFILL HILLSBOROUGH COUNTY, FLORIDA		
DRAWN BY: R.J.F.	CHECKED BY: [illegible]	DATE: 11/15/82
FILE NO. 81-159	APPROVED BY:	

FIGURE 5.1



TYPICAL GAGING STATION CHART

STATION NO. I
DATE JULY 25, 1977 TIME 11:44
O.S. READING 2.34
PEN READING 2.34
CHART OPERATOR HGS

STATION NO. I
DATE AUGUST I, 1977 TIME 11:30
O.S. READING 1.15
PEN READING 1.04
CHART OPERATOR HGS

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FIELD AND DATA REDUCTION MANUAL
HYDROGEOLOGICAL MONITORING PROGRAM
SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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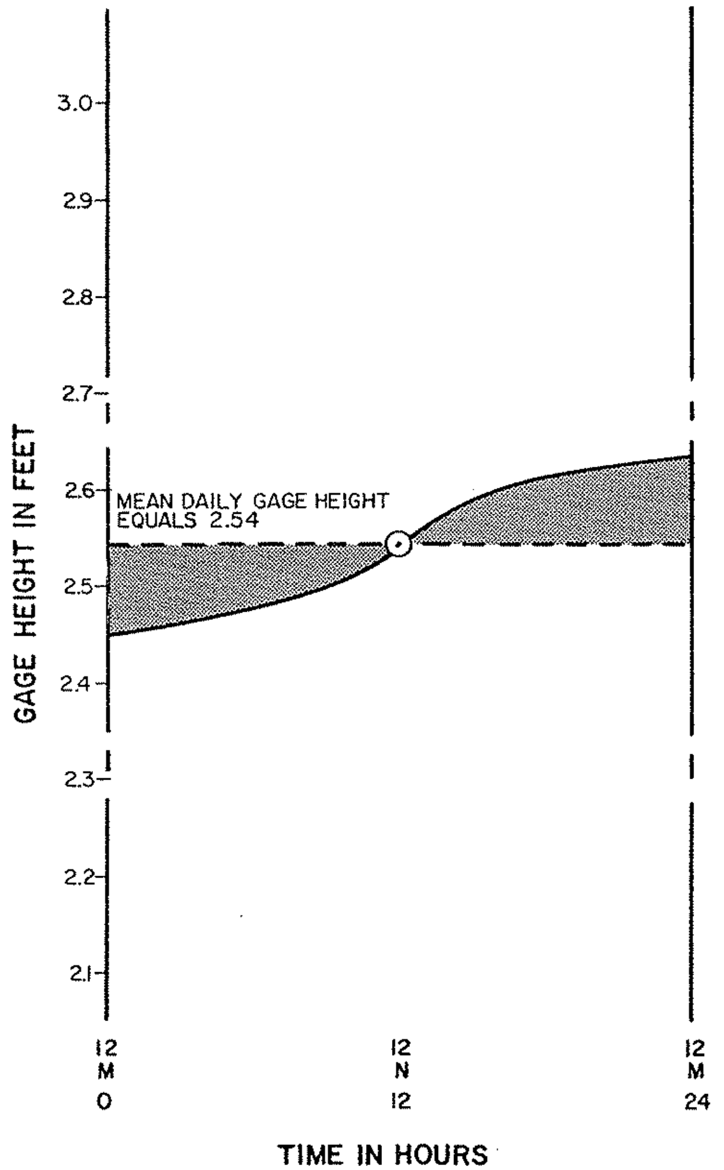
FILE NO. 81-159	APPROVED BY: HG Standland	

FIGURE 5.2



AVERAGE END AREA METHOD

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SOUTHEAST COUNTY LANDFILL
HILLSBOROUGH COUNTY, FLORIDA

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FILE NO. 81-159	APPROVED BY: H.G. Staneland	

FIGURE 5.3

APPENDIX I

UNIVERSAL RECORDING RAIN GAGE

(Belfort Instrument Company)

INSTRUCTION BOOK
FOR
UNIVERSAL RECORDING RAIN GAGE
CAT. NO. 5-780 SERIES

RELATED INSTRUCTION BOOKS

TITLE	BOOK NO.
CHART DRIVES (SPRING-POWERED), PENS, AND INK	12049
CHART DRIVES, BATTERY-POWERED	15783

SEPTEMBER 1979

BELFORT INSTRUMENT COMPANY
1600 SOUTH CLINTON STREET
BALTIMORE, MARYLAND 21224

BOOK NO. 8777

page	Sept1976	Oct1978	Sept1979					page	Sept1976						
cover	x		x					17	x						
i	x		x					18	x						
ii	x							19	x						
iii	x							20	x						
								21	x						
1	x							22	x						
2	x							23	x						
3	x							24	x						
4	x							25	x						
5	x							26	x						
6	x	x	x					27	x						
7	x							28	x						
8	x	x						29	x						
9	x							30	x						
10	x							31	x						
11	x														
12	x														
13	x														
14	x														
15	x														
16	x														

Page Revision Dates

LIST OF ILLUSTRATIONS

LIST OF TABLES

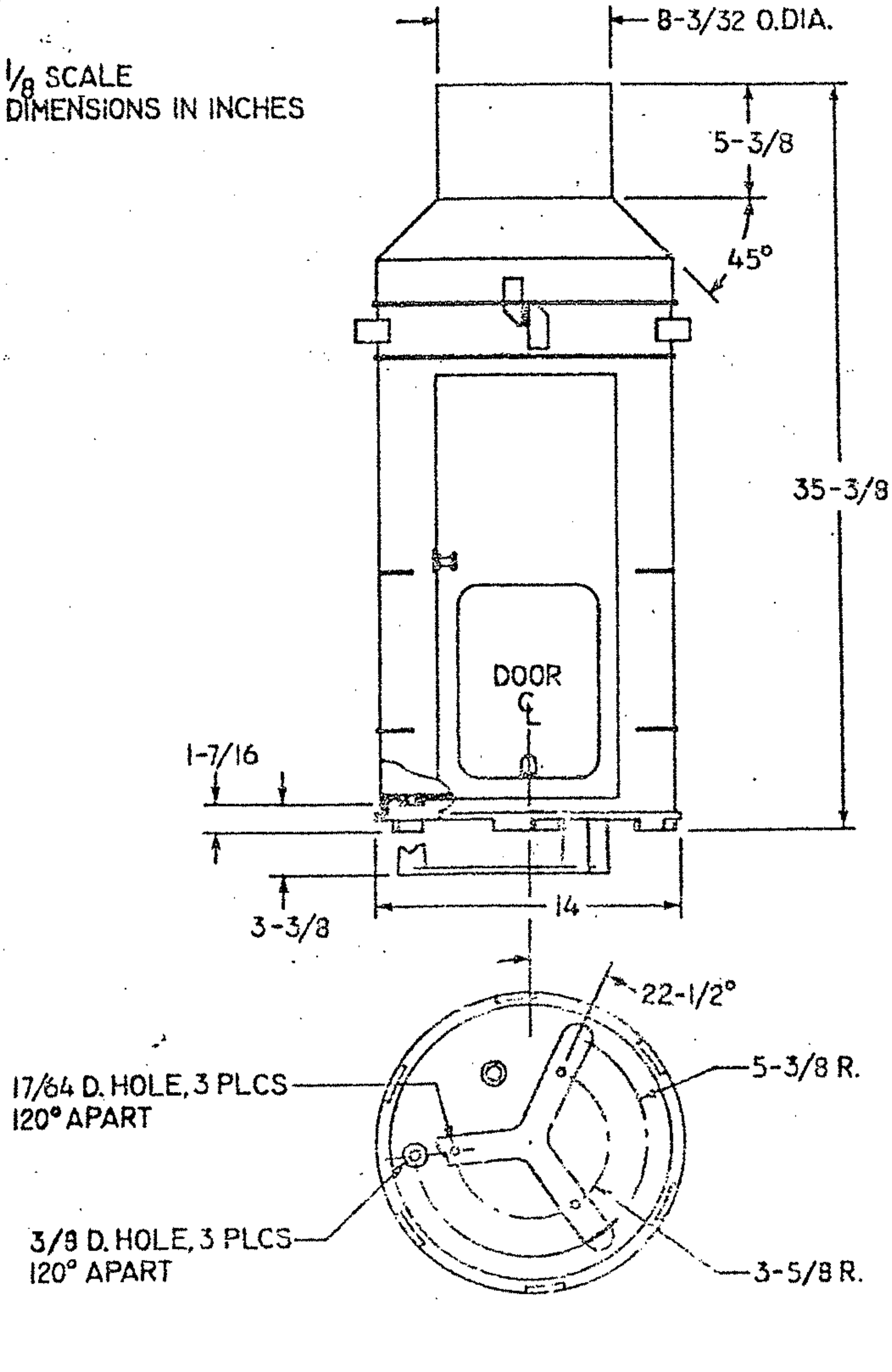


Fig.1-1 Outline - Universal Recording Rain Gage

Chart Timing Accuracy: within 14 minutes/week

Finish: aluminum lacquer

Gage Weight: 25 lbs.,empty

2-7. Government Specifications. The Cat. No. 5-780 Series Universal Recording Rain Gages are built to National Weather Service Specifications #450.2201 and 450.2203.

3-4. Installation. The rain gage is installed on its foundation as follows:

A. Remove the collector (Fig.7-1,12) by rotating it sufficiently clockwise to disengage the bayonet lock and pulling it up and off of the gage housing. Use extreme care not to distort the area of the collector opening.

B. Remove the catch bucket. The chart cylinder, recording ink, and damping fluid have been packed and shipped in the bucket.

C. Remove the screw (Fig.7-4,30), washer (29), and bucket platform (17).

D. Remove five screws and washers (Fig.7-1,14), and remove gage housing (13) from the base (23). Note the location of the sliding access door relative to the chart drive and pen arm.

E. Three 3/8"-diameter holes, 120° apart on a 10-3/4"-diameter circle, are provided in the mechanism base for mounting it to the support base or foundation. Exercise extreme care in mounting the mechanism base: the machined gage housing shoulder must be horizontal, and the bolting-up must not distort the base. Hardware for mounting the mechanism base is not supplied with the gage, however, hardware is supplied with the support base for mounting it to the mechanism base. Additionally, hardware is supplied with the support base for mounting it to the foundation, or to assist in imbedding it in the concrete foundation.

F. Remove the shipping tie holding the pen arm to the pen shifter (Fig.7-2,25).

G. Loosen the mechanism locking screw (Fig.7-4,46) and nut, and back out the screw until the top lever is stopped by limit screw (32). Retract the locking screw a turn or two farther; lock in position with its nut. Remove the stop sleeve (Fig. 7-1,45) from about the movement bracket limit screw (44). Do not discard the sleeve; it will be needed for reshipment of the gage. Do not disturb the setting of the limit screws (par.2-2): their positions are a part of the gage's calibration.

H. Remove the wrapping from the chart drive mechanism, and unscrew the mechanism from the base.

I. The dashpot (Fig.3-1,3) is mounted to the mechanism base with two identical thumbscrews (1,2). Remove thumbscrew (2), loosen thumbscrew (1), push up the dashpot cover (4), and pull dashpot out from between the mechanism frame as shown in Fig.3-1(a) and (b).

J. From the bottle of damping fluid shipped in the catch bucket, fill the dashpot cylinder to within an 1/8" of its rim, and replace the dashpot between the mechanism frame. Empty the catch bucket, setting aside the recording ink and discarding all packing materials, and set the bucket on its platform. If the gage is equipped with an overflow attachment, the overflow tube is placed in the round hole in the platform centering the tube over the overflow funnel mounted in the mechanism base.

K. Replace the chart drive mechanism. The mounting stud of the chart drive mechanism has been adjusted so that the winding key of the spring-powered chart drive and the movement viewing part of the battery-powered chart drive are accessible from the sliding access door of the gage housing. Make certain that the stud flange is firmly seated against its mounting surface, but do not overtighten the mechanism and disturb the stud setting.

L. Remove thumbnut from chart drive mechanism spindle. Mount chart cylinder (with chart clip), supplied in the catch bucket, on the spindle, making certain that the mechanism pinion and the cylinder gear are meshed, and replace the thumbnut.

M. Replace the gage housing, positioning it on the mechanism base so that the chart drive and pen arm are accessible from the sliding access door. If the gage is equipped with overflow protection, make certain that the overflow-clearance hole in the dust shield, which rests on a interior bead of the gage housing, is centered over the overflow funnel in the base. Fasten the housing in place with five screws and washers (Fig. 7-1,14).

N. Replace the bucket platform (Fig. 7-4,17) on the movement bracket (27) and fasten it in place with the washer (29) and screw (30). If the gage is equipped with an overflow attachment, make certain the round hole in the bucket platform is over the overflow funnel (Fig. 7-3,25) mounted in the mechanism base.

O. Replace the collector on the gage housing, reversing the procedure of par. A of this section. The collector can be padlocked to the gage housing through the staples provided on each.

P. The gage housing and its sliding access door are equipped with a sliding-bolt and staple so that the door can be padlocked shut.

Q. The gage is now ready to be put into operation.

2. Clamp the chart to the cylinder by placing the clip inside the fold at the overlapping end of the chart, placing the straight end of clip in the slot in the cylinder, and seating the formed end of the clip in the notch in the upper edge of the cylinder.
3. If the chart is the single-edge type, wrap it snugly around the cylinder so that a) time is read left to right, b) corresponding rainfall graduations meet, c) the bottom edge of the chart is against the cylinder flange, d) the untabbed end is at the right-hand edge of both the notch in the upper edge of the cylinder and the slot in the cylinder flange.
4. Clamp the chart to the cylinder by placing the clip over the untabbed end of the chart, inserting the straight end of the clip into the slot in the cylinder flange, and seating the formed end of the clip in the notch in the upper edge of the cylinder.

H. Replace the chart cylinder and thumbnut on the chart drive mechanism spindle making certain that the mechanism pinion and cylinder gear mesh.

I. Refill the pen, and push in pen shifter to return the pen almost to the chart surface. If the catch bucket is empty, and the pen does not indicate zero within the gage tolerance, set the pen to the zero-line with the coarse (Fig. 7-4,31) and fine (42) adjustment screws. Set chart to time by first turning the cylinder clockwise past the correct time and then returning it counterclockwise to the correct time. Be sure the time is correctly set with respect to a.m. or p.m.

J. Push the pen shifter all the way in to put the pen on the chart. Lightly touch the bucket platform to make a time check on the chart. The gage is now ready for a new recording period. Close and padlock the access door.

4-2. Chart Sets. Charts available for use with the 5-780 Series Rain Gages are listed in Table 4-2. Chart sets of the 6 through 192-hour period charts contain 100 charts; sets of the 861-hour charts contain 25 charts.

4-3. Gage Winterizing. During the winter months the gage should be protected against possible damage from snow, ice pellets, and freezing temperatures by taking the following steps:

TABLE 4-2

AVAILABLE RAIN GAGE CHARTS

CHART NUMBER	RANGE	CHART PERIOD HRS/REV	GRID SIZE		LEAST DIVISION	
			WIDTH	LENGTH	RANGE	TIME
5-4003-B	0 to 6",ST	24	6.00"	11.52"	.05"	20 min
5-4005-MM	0 to 150mm,ST	192		11.30"	1 mm	2 hrs
5-4041-B	0 to 12",DT	6		11.52"	.05"	5 min
5-4042-B		12				10 min
5-4044-B		48				15 min
5-4045-B		96				1 hr
5-4046-B		192				2 hrs
5-4046-MM	0 to 300mm,DT	192		11.30"	1 mm	2 hrs
5-4047-B	0 to 12",DT	24		11.52"	.05"	15 min
5-4047-MM	0 to 300mm,DT	24		11.30"	1 mm	15 min
5-4048-B	0 to 4.8",DT	6		11.52"	.02"	5 min
5-4049-B		24				15 min
5-4050-B		192				2 hrs
5-4068	0 to 20",DT	168			.1"	2 hrs
15620	0 to 300mm,DT	861(1)			1 mm	6 hrs
15668	0 to 12",DT				.05"	
15669	0 to 20",DT				.1"	

VI CALIBRATION

Not necessary w/ new unit, only if readings are suspect.

6-1. General. Calibration of the gages described herein is based on the assumption that 822.7 grams is the weight of a volume of water 1" high with an area equal to the area of the 8"-diameter collector opening of the gage. It also assumes that the weight of the bucket used in the gages of up to 12" (300mm)-capacity is 1 kilogram, 2.1 kg. for the 20"(500mm)-capacity gages, and that the gage zero-adjustment range is sufficient to accommodate normal variations in bucket weight.

6-2. Calibration Equipment. Calibration of the gages requires one of the calibration-weight sets listed in Section VII and a small machinist's level (approximately 2" long.) Each set consists of an equivalent-bucket weight, a number of calibration weights, and a linearity-setting tool (Fig.6-1, 43.) Inch-weights are finished in aluminum lacquer, mm-weights in gold.

6-3. Pre-calibration. Calibration of all gage mechanisms requires the mechanism base to be level and the following preliminary adjustments to be made:

A. Back out the limit screws (Fig.7-1,44;Fig.7-4,32,46) sufficiently so that they are not likely to restrict the movement of the top lever (19) and the movement bracket (27) within the range of the calibration.

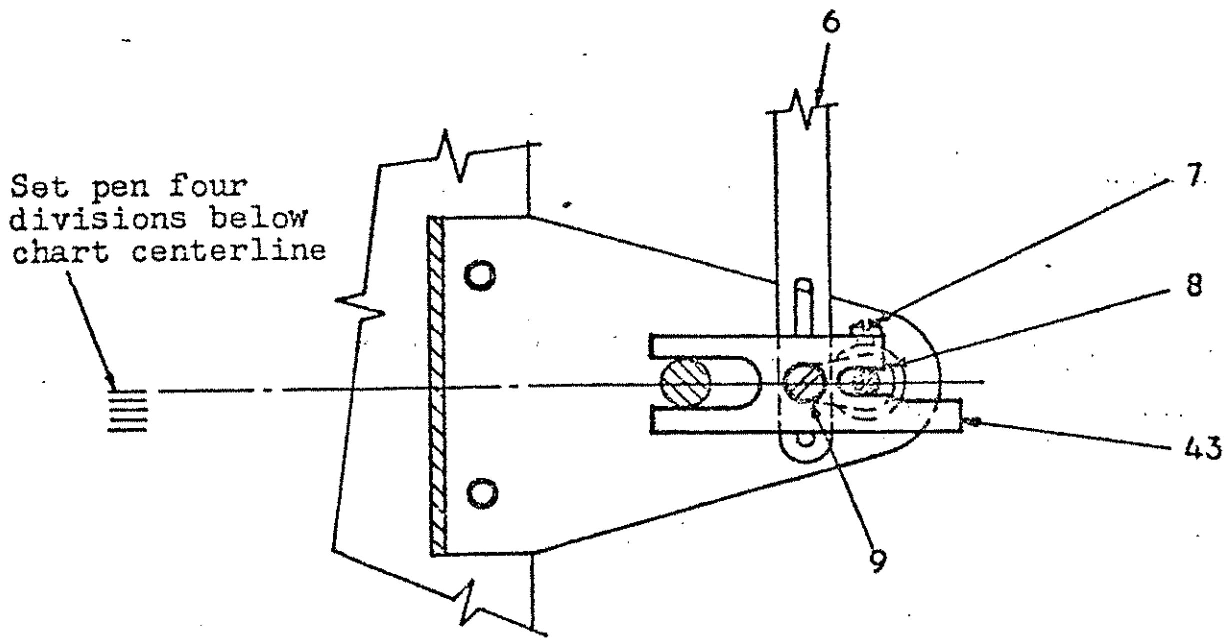
B. Center the screws and nuts (34) in the slot lengths of the lever extensions (18).

6-4. Single-Traverse Calibration. A single-traverse gage is calibrated with the following procedures:

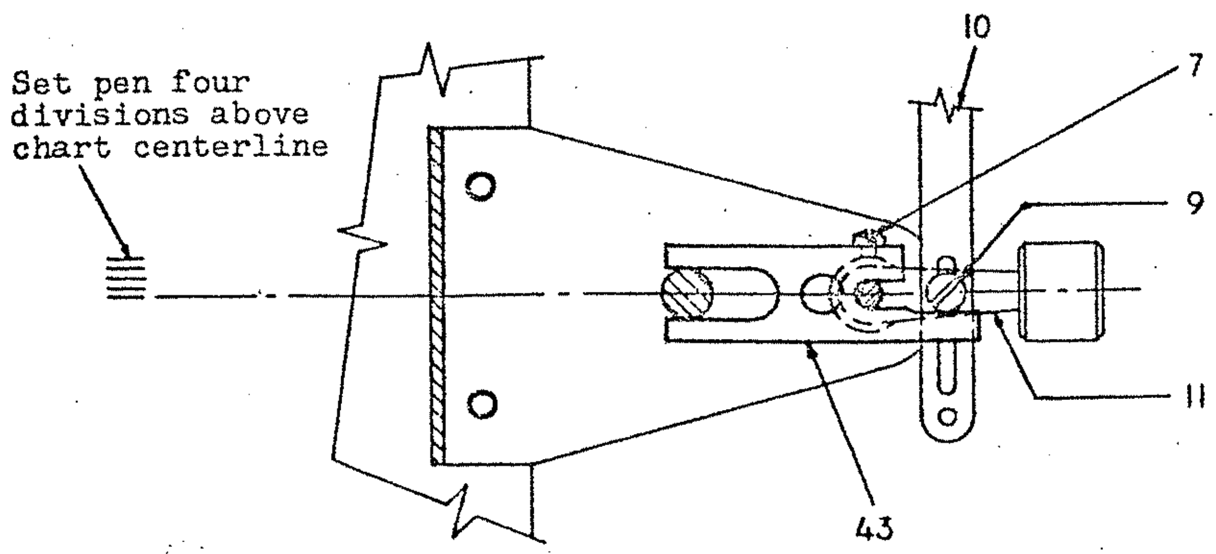
A. Center the equivalent-bucket weight in the bucket platform, and place a number of calibration weights equal to one-half of the gage capacity on the bucket weight.

B. Place the machinist's level across the two pads in front finger of the top lever (Fig.7-4,19), and rotate the linkage with the zero-adjustment thumb-screws (31,42) so as to make the pads level. In making continued zero-adjustments, care should be taken to make use of both the fine and coarse adjustments so as to keep the fine-adjustment setting bar reasonable parallel to the top of the mechanism frame.

C. Loosen the set screw (7) fastening the lever (8) to the pen arm shaft (38), and rotate the pen arm shaft to put the recording pen in the center of the chart; retighten the set screw.



(a)



(b)

Fig.6-1 Linearity Settings,Dual-Traverse Gages

Viewed from the pen arm side of the gage, rotation of the pen arm shaft in a counter-clockwise sense relative to the lever will increase the pen movement per calibration weight through the upper half of the first traverse; rotation in a clockwise sense will decrease it. The magnitude of the adjustment required will be about three chart divisions. Loosen the setscrew(7) fastening the lever to the pen arm shaft, rotate the shaft as required, and retighten the setscrew. Remove the calibration weights from gage, rezero the pen, and repeat the procedures of par.E and this paragraph until the requirements of par.E are met.

H. With the linearity and accuracy of the pen movement through the first traverse now as is required by par. E, reversal of the pen traverse exactly at the uppermost chart graduation can be effected by the turning of the screw in the adjustable link(10) to change the distance from the upper link pivot to the bottom of the slot in the link. With half of the calibration weights on the bucket weight, grip the platform(17) between the thumb and forefinger, and move the platform up and down. Observe the pen movement while moving the platform: adjust the link length, by turning the screw, so that any movement of the platform will result only in a downward movement of the pen away from the uppermost chart graduation.

I. Add the remaining calibration weights to the bucket weight one at a time. After the addition of each weight, tap the gage lightly, and determine if the pen position is within the accuracy tolerance of par.2-6.

J. If the pen movement is linear but the pen positions are not sufficiently accurate, it will be necessary to change the lever extension(18A) length. Moving the link pivot(35) away from the top lever will lower the pen position. Adjust the extension length in a fashion similar to that described in par.F, and repeat the procedure of par.I. Repeat the procedures of this paragraph and par.I until the pen positions are within tolerance.

K. If the pen movement is unlinear as well as inaccurate, it also will be necessary to rotate the pen arm shaft relative to the counterweighted lever(11). Viewed from the pen arm side of the gage, rotation of the pen arm shaft in a counter-clockwise sense will decrease the 'speed' of the pen through the lower half of the second traverse. The magnitude of the adjustment will be in the order of three chart divisions. Loosen the setscrew(7) fastening the lever to the pen arm shaft, rotate the shaft as required; retighten the setscrew. Repeat the calibration procedure, beginning with par.H, until the accuracy requirement of par.2-6 is satisfied.

VII REPLACEMENT PARTS LIST

7-1. General. The item number of a part or an assembly will be the same in all illustrations. Only the figure number of the first illustration in which a part or an assembly is called out will be shown in the list below.

Fig. No.	Item No.	Description	Part No.	Cat.No.5-780						Accessory
				-6	-4.8	(12"DT)	-300MM	-20	-500MM	
3-1	-1	Screw,Mtg - Dashpot.......	7207	x	x	x	x	x	x	
	-2	Ditto...........................		x	x	x	x	x	x	
	-3	Dashpot Cylinder Assy.....	8621	x	x	x	x	x	x	
	-4	Cap,Dashpot..............	928	x	x	x	x	x	x	
	-5	Piston,Dashpot............	8625	x	x	x	x	x	x	
6-1	-6	Link,Non-adjustable.......	16246-1		x	x	x	x	x	
	-6	Link......................	16246-4	x						
	-7	3-56x3/16" Fil Hd Screw, St St...........................		x	x	x	x	x	x	
	-8	Lever,Short..............	917	x	x	x	x			
	-8	Lever,Short..............	10503					x	x	
	-9	Screw,Shoulder...........	991	x	x	x	x	x	x	
	-10	Link,Adjustable...........	16246-2		x	x	x	x	x	
		2-64x5/8" Oval Hd Screw, St St...........................			x	x	x	x	x	
	-11	Lever,Long................	914		x	x	x			
	-11	Lever,Long................	10502					x	x	
		Counterweight............	909		x	x	x	x	x	

Fig. No.	Item No.	Description	Part No.	Cat.No.5-780						Accessory
				-6	-4.8	(12"DT)	-300MM	-20	-500MM	
7-2	-20	Bracket,Zero Adj..........	16252	x	x	x	x	x	x	
		Stud,Pen Arm.............	16250	x	x	x	x	x	x	
		3-56x5/8"Fil Hd Screw, St St....................	....	x	x	x	x	x	x	
		2-64x3/8" Oval Hd Screw, St St....................	....	x	x	x	x	x	x	
	-21	Retainer Clip,Shaft.......	3279	x	x	x	x	x	x	
	-22	Pen Arm Assy..............	992	x	x	x	x	x	x	
		Bearing(Screw),Pen Arm...	918	x	x	x	x	x	x	
	-23	Base,Mechanism............	8598	x	x	x	x	x	x	
	-23	Base(used w/overflow option)..................	16473					x	x	x
	-24	Pen,#3-LS.................	559	x	x	x	x	x	x	
	-25	Pen Shifter...............	933	x	x	x	x	x	x	
	-26	Chart Drive Assy, 8-day Spring-powered......	14253-4	x	x	x	x	x	x	
		Chart Drive Mechanism....	11460	x	x	x	x	x	x	
		Chart Cylinder...........	8572-4	x	x	x	x	x	x	
		Chart Clip...............	8570-4	x	x	x	x	x	x	
	-26	Chart Drive Assy, 3V Battery-powered........	16474-4	x	x	x	x	x	x	
		Chart Drive Mechanism....	15349	x	x	x	x	x	x	
		Chart Cylinder...........	8572-4	x	x	x	x	x	x	
		Chart Clip...............	8570-4	x	x	x	x	x	x	
	-27	Bracket,Movement..........	8713	x	x	x	x	x	x	
		Shaft,Plain...............	985	x	x	x	x	x	x	
		2-56x5/16" Fil Hd Screw, St St....................	....	x	x	x	x	x	x	
		Shaft(Connector), Dashpot Piston..........	8586	x	x	x	x	x	x	
		Retainer Clip,Shaft......	3279	x	x	x	x	x	x	

Fig. No.	Item No.	Description	Part No.	Cat.No.5-780						Accessory
				-6	-4.8	(12"DT)	-300MM	-20	-500MM	
7-4	-36	(continued)								
		Nut,Spring Mtg...........	5243					x	x	
		Bar(Lower),Spring Mtg....	5270					x	x	
		Pin,Coupling............	5246					x	x	
		Retainer Clip(Pin).......	3279					x	x	
		Coupling,Spring..........	5269					x	x	
	-37	Pivot,Pen Arm Shaft.......	906	x	x	x	x	x	x	
		3-56x3/16" Fil Hd Screw, St St..................	....	x	x	x	x	x	x	
	-38	Shaft,Pen Arm.............	905	x	x	x	x	x	x	
	-39	Bracket,Pen Arm(Stud).....	903	x	x	x	x	x	x	
		3-56x3/16" Fil Hd Screw, St St..................	....	x	x	x	x	x	x	
	-40	Shaft(Spring Link)........	8586	x	x	x	x	x	x	
		Retainer Clip,Shaft......	3279	x	x	x	x	x	x	
	-41	Mechanism Frame...........	ref							
		Front Sideplate Assy.....	8597	x	x	x	x	x	x	
		Plate,Top................	8292	x	x	x	x			
		Plate,Top................	10504					x	x	
		Pen Shaft Bracket Assy...	933	x	x	x	x	x	x	
		Plate,Base...............	8717	x	x	x	x	x	x	
		Sideplate,Rear...........	7204	x	x	x	x	x	x	
		Bracket,Stop(Limit)......	8741	x	x	x	x	x	x	
		6-32x3/16" Bd Hd Screw, St St..................	....	x	x	x	x	x	x	
		8-32x5/16" Bd Hd Screw, St St..................	....	x	x	x	x	x	x	
	-42	Zero Setting Assy.........	8319	x	x	x	x			
		Setting Bar Assy.........	8317-1	x	x	x	x			
		Screw,Setting............	8306	x	x	x	x			
	-42	Zero Setting Assy.........	16072					x	x	
		Setting Bar Assy.........	16072-1					x	x	
		Screw,Setting............	16472					x	x	

Fig. No.	Item No.	Description	Part No.	Cat.No.5-780 -6	-4.8	(12"DT)	-300MM	-20	-500MM	Accessory
ns		Calibration Weight Set, 2.4"/4.8"-capacity Gages, Specify Range............	16476-1							x
		Weight, .4-inch..........	10890							x
		Bucket-weight/Holder.....	16468-1							x
6-1	-43	Tool, Linearity-Setting, Dual-trav Gages Only.....	16453							x
ns		Calibration Weight Set, 60mm to 120mm-capacity Gages, Specify Range.......	16476-2							x
		Weight, 25-MM.............	10973							x
		Bucket-weight/Holder.....	16468-2							x
6-1	-43	Tool, Linearity-Setting, Dual-trav Gages Only.....	16453							x
7-1	-44	Screw(Stop)...............	8471	x	x	x	x	x	x	
		10-32 Hex Nut, St St............		x	x	x	x	x	x	
	-45	Stop, Shipping.............	8517		x	x	x	x	x	
	-45	Stop, Shipping.............	16461	x						
7-4	-46	Screw(Limit)...............	8471	x	x	x	x	x	x	
		10-32 Hex Nut, St St............		x	x	x	x	x	x	
ns		Silicone Fluid, 1000 cs, 3-1/2 oz.................	5601	x	x	x	x	x	x	
ns		Ink, #10, Purple, 1/2 oz.....	5592	x	x	x	x	x	x	