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Methods for Measuring Water Levels Using the Dodge Logging Van (I-127410)

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Technical Detailed Procedure HP-25
NNWSI Project Quality Assurance Program

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1.0 Purpose

1.1 The procedure is intended to assure the continuing applicability, validity, and acceptable standard for measurements performed for NNWSI by the U. S. Geological Survey (USGS).

1.2 To establish a method capable of consistent and accurate duplication of water-level measurements in wells, and to provide for the modification of this method when necessary.

1.3 Provide a field guide for all USGS personnel, and others supporting the USGS work, performing water-level measurements involving operation of this equipment.

2.0 Scope

2.1 This procedure applies to those water-level measurements carried out by a USGS Project Chief, or a designated representative, assigned to NNWSI by the USGS.

2.2 The procedure shall be followed by all USGS and supporting personnel assigned to NNWSI who make such measurements.

2.3 The procedure shall also be followed by any contractor performing such tests for the USGS if the contractor does not have a quality-assurance program that is acceptable.

2.4 Frequency of calibration is described in procedure HP-26, the calibration procedure for this equipment.

3.0 Modifications

If during the course of measuring, it is necessary to deviate from this approved procedure, the USGS Project Chief shall be informed and the procedure modification shall be documented. The documentation shall describe the modification, the affected section or sections of the procedure, and shall be dated and signed in ink by a hydrologist or a USGS

designated responsible person. If it is necessary to rewrite a number written incorrectly, the number shall be crossed out with one line, and dated and signed as above.

4.0 Principle

Precision and accuracy are required in measuring water levels at the Nevada Test Site (NTS). Water levels range in depth from a few hundred feet to over 2,000 feet, but most are deeper than 1,000 feet. Therefore the methods of measuring these water levels must be accurate, and the equipment, precise.

4.1 The water-level measuring "system" used at NTS and described in this procedure consists of several components. These components include:

1) Dodge Logging Van (I-127410), equipped with a cable-reel hoist and a mechanical footage-counter meter.
2) Electrical never supplier:
   a) 120-volt AC (± 10%), 60 H--supplies power to the hoist and control panel. (The Dodge Van is equipped with an AC generator, but a commerical-power source is recommended when available.
   b) Adjustable, 4 to 15-volt DC--needed to convert 120-volt AC power to that which is usable by a transducer.
3) Multi-conductor, armored cable attached to and supplies power to the probe; transmits signals from the probe to the electronic readout or recording equipment.
4) Data readout/recording equipment:
   a) Multimeter--measures volts, ohms, and amps on a readout display.
   b) Data logger records voltage and temperature digitally and/or on cassette tape (the digital recording unit is also equipped with readout display).
   c) Ship-chart recorder

5) Digital barometer--indicates atmospheric pressure in inches of mercury.
6) Water-level, or water-pressure sensing probe containing either a transducer or a float-actuated switch.

Use of the transducer or the float-actuated switch, chosen for their accuracy, are the primary methods for measuring deep, water-levels and require a brief discussion. The pressure transducer is an extremely sensitive device which converts pressure to electrical voltage in uniform proportion. The transducing element is a strain gauge bonded to a pressure sensing diaphram. As the diaphram is strained, gradual changes occur in its electrical resistance. It is capable of responding to pressure pulses 1 millisecond or less in duration, as well as having the advantage of measuring static or varying pressures with time. Data output may be recorded manually, or in analog form.

The float actuated switch utilizes a dipolar-magnetic equipped float acting as the singular moving part. The float slides vertically on a guide tube in response to liquid level. As the float falls on the guide tube, the magnetic field causes the switch located on the inside of the guide tube to open. Switch opening or closing is read as a large resistance change (in ohms), on the multimeter. The depth to water is measured from the footage-counter meter. Degree of accuracy is dependent on the dexterity and readiness of the operator to stop the cable reel, the moment with switch is actuated.

4.2 Along with the physical components of the water-level measuring system at NTS, several factors are involved in the "method" of water-level measurement. These factors become the responsibility of the operator and include technical skills, as well as the ability for sound decision making.

In making a water-level measurement, the operator's responsibilities are to:

1) Determine the operating mode--is a single water-level measurement desired, or a continuous series of measurements with time?
2) Select the water-level measuring system:
   a) The type of probe used (transducer for float-switch).
   b) The type of output signal, or recording (manual, data logger, or strip-chart recorder). If the output recording is in a continual-operation mode, such as the data logger or strip-chart recorder, the operator must estimate the expected pressure range for water level changes and select the appropriate transducer.
3) Assemble the system correctly, calibrate equipment when necessary, and test for any equipment malfunction.
   a) For a single water-level measurement, transducer calibration is not necessary. (Float switch does not need calibration.)
   b) In the continuous-operation mode, calibration of the transducer is required.
4) Conduct single, or continuous-operation water-level measurements.
5) Achieve an accuracy level as defined for this quality assurance procedure within a maximum deviation of 1:1000, or 0.1%.
6) Record data, general information, and any modifications on appropriate forms.

5.0 Methods

It has been discussed that a water-level measurement involves a system of components, a technique, and a background for making appropriate selections of sensing elements and recording equipment.

The basis for these selections are dependant upon particular data requirements, including single measurement, or continuous operation for trends in water-levels, characteristics of the well, etc.

The following table lists the equipment to be used for the two operational modes. Simply stated, the float-switch, or the transducer, can be used for the single water-level measurement mode and recorded manually by the operator. The transducer however, is the only sensing element capable of continuous operation for recording purposes. It should also be noted, that the only recording device capable of continuous data output is the strip-chart recorder, since it produces a graphic record with time. The data logger operates continually, but with time intervals between recorded measurements. A multimeter may be used independantly, in conjunction with, or as a verifier for the data logger or strip-chart recorder.

Further considerations involve particular characteristics of the sensing elements, and how they respond to well conditions (including hole diameter) and available power source. For example, the transducer can be mounted in a 1 1/8-inch diameter probe. The only probe available for the float-switch in 1-1/2 inches in diameter. The operator should measure the access to the water-level prior to selection of a probe. If it is less than 1-1/2 inches, the transducer with the 1-1/8 inch probes must be used.

5.1 Equipment needed:

5.1.1 Using transducer:

5.1.1.1 Dodge Van (I-127410)

5.1.1.2 Power supplier:

(1) 120 volts AC (± 10%), 60 cycle

(2) 10-volt DC module (assembly)

5.1.1.3 Copy of procedure HP-25

5.1.1.4 Forms for recording well information and data (see Appendix D)

5.1.1.5 Calibrated multimeter with meter leads

5.1.1.6 Transducer and probe

5.1.1.7 O-rings and grease

5.1.1.8 Cable and cable head on hoist reel

5.1.1.9 Data logger and/or calibrated strip-chart recorder (may be optional; see text).

5.1.1.10 Tripod and casing-top sheave

5.1.1.11 Watch and pen

5.1.2 Using float-actuated switch:

5.1.2.1 Dodge Van (I-127410)

5.1.2.2 Power supply - 120 volts AC (± 10%), 60 cycle

5.1.2.3 Copy of procedure HP-25

5.1.2.4 Forms for recording well information and data (Appendix D)

5.1.2.5 Calibrated multimeter with meter leads

5.1.2.6 Float-switch and probe

5.1.2.7 O-rings and grease

5.1.2.8 Cable and cable head on hoist reel

5.1.2.9 Tripod or casing-top sheave

5.1.2.10 Watch and pen

6.0 Operational procedure for the transducer system

6.1 Determine whether the tripod, or the casing-top sheave is to be used to guide the cable (both cable guides may be used simultaneously if necessary).

6.2 If the tripod is to be used, park the van to the left of the well with the casing opposite the hoist, at a distance from the well to the side of the van of from 5 to 7 feet. If the casing-top sheave is to be used, the distance from the side of the van to the well should be about 8 feet. At some wells, other unspecified arrangements may be necessary, especially at drill-rig sites.

6.3 Assembly of tripod or casing-top sheave:

a) Assemble and position the tripod between the van and well casing. If the casing-top sheave

is used, attach it to the side of the casing toward the van.

b) Check the position of the tripod sheave; it should be approximately centered above the well casing or access tube. If the position is incorrect, move the van or adjust the tripod legs to obtain the proper positioning.

c) Inside the van, shift the hoist gearbox to the neutral position by moving the shift lever (with 1" ball handle). Release the hoist brake by depressing the button atop the brown handle, and move the handle fully toward the hoist (toward rear to the van).

d) Remove the cable head from the PVC (storage) pipe on the side of the hoist frame (side toward the front of the van), and thread upward through the 2-inch hole in the van roof (directly above hoist). Lay the cable head on the roof.

e) Remove the 5-inch diameter roof-top sheave from the storage box, and screw it into the smaller pipe fitting on the roof top (hand tighten). Hand tighten the other roof-top sheave to the pipe fitting of the tripod with the sheave groove centered laterally above the well.

f) Thread the cable through the wire guide of the roof-top sheave, and slowly pull the cable heat out to the tripod (or casing-top) sheave. Thread the cable through the wire guide of the second sheave, positioning the cable into the groove. The cable head should extend to 2-3 feet below the sheave.

CAUTION: If the cable is pulled out to fast, the hoist will continue to rotate causing the cable to tangle.

g) Reset the hoist brake.

6.4 Connect AC-power source

To operate hoist, transducer, and possibly the multimeter, electric AC power is required. Four general sources of power may be available for use: 1) commerical power, 2) rig power, 3) portable general, and 4) van-mounted generated. An ivory-colored electrical outlet is mounted on the rear side of the control panel housing (the side toward the rear of the van). The cord running from this outlet should be plugged into any power source other than the van-mounted generator using whatever extension cords are required. The van-mounted generated is wired to the hoist via a switch on the upper panel extention.

If the van-mounted generator is used, check generator oil level and start the generator by depressing the start rocker switch of Onan electric power subpanel of the upper panel extension until generator is operating. The toggle switch just above the subpanel is switched to the down position. [This is a selector swtich for the type of power source.] If a power source other than the van-mounted generator is used, the above described switch is moved to the up position. [Note: This is a three-position switch, the center position is OFF.] Irrespective of the power source, the upper most toggle switch of the upper level extension needs to be in up position. The multimeter power cord then should be plugged into the ivory-colored mounted outlet. Power to the panel is indicated by a voltage reading on the AC voltmeter mounted on the panel, left

of the panel center. The voltmeter reading needs to be 115v ± 5%. If out of this range, adjust the 2-inch diameter black knob of the variac subpanel of the upper panel extension so that the voltmeter reads 115 volts. To supply 10-volt DC power to the transducer, locate toggle switch near top of the main panel marked xducer power and switch to (left) on position. A light indicates power is on.

6.5 Remove the transducer probe (length 20 inches by 1-1/8-inch diameter) from the storage box. Remove thread protectors from the cable head and from the transducer probe. Align key of cable head with keyway of probe, slowly inserting key into keyway. Hand tighten knurled nut of cable head into probe.

6.6 Check multimeter function

A digital multimeter will be used to sense voltage change as the transducer reaches water level. To check function, turn on the multimeter power switch. Depress the white DC button and the dark colored, 20V button. Do not depress the white volt button. Insert the banana plug of the black lead into "common" receptacle on the meter; insert the banana plug of the red lead into the volt-ohm receptacle. The multimeter is functioning when the digital display illuminates.

6.7 Check DC-power supply

Plug the red lead from the multimeter into #1 lower-module receptacle (upper right corner of main panel). Plug the black lead from the multimeter into #4 lower-module receptacle. Multimeter should read 10 volts ±2 volts in order to make transducer pressure measurements.

6.8 Connect multimeter to signal leads of the transducer

a) Move the alligator clip of the black lead from #4 lower-module receptacle on the panel to the #3 lower-module receptacle.

b) Move the alligator clip of the red lead from #1 lower-module receptacle on panel to the #2 lower-module receptacle.

c) Depress the dark-colored 200-mv button.

6.9 Test operation of the system

Block three of the four holes on the bullnose at the bottom end of the transducer probe, by pressing three fingers over the holes. Blow into the fourth hole and observe the increase in multimeter readout. If the reading decreases while blowing into the probe, reverse leads at the panel. Retest system and verify increase in multimeter readout (increase in millivolts corresponds to increase in pressure).

NOTE: At this point, data-recording equipment may be added to the system, if the continuous-operation mode for long-term measurements is desired. The operator is referred to:

Appendix A: Assembly and Operation of Data-Recording Equipment

Appendix B: Operation of a Digital Barometer.

6.10 Zero the transducer

a) If using the tripod, align the mating surface (or seam) of the bullnose and transducer housing (located about 1 inch from the bottom of probe), with the measuring point. (The measuring point is usually the top of casing, or top of tubing.) If using the casing-top sheave, inset the cable into the sheave groove and install probe in the casing. Align the top of the cable-head spring with the measuring point. The top of the spring is 2.45 feet above the sensing point of probe. (Computational adjustment will be made on the appropriate form for this interval.)

b) To move the probe during zero operation, set motor speed to STOP, release the brake on the hoist, set the direction lever as needed (up or down), and shift the gearbox lever to any numbered position, perferably numbers 1 or 2. Adjust the probe to the zeroing point by slowly rotating the speed-control knob. Set the hoist brake.

6.11 Zero the footage-counter meter

Locate the footage-counter adjustment knob. The knob is on the right side (away from hoist), of the recorder housing on the front panel. Of the three knobs in this area, use the lower, rear knob. Pull out and rotate, the small offset knurled knob to zero the footage-counter meter which is located on the lower, right section of the panel just below the line speed meter. Set the counter to 0000.0 feet.

6.12 Lower the probe into the well:

a) Set the speed-control knob to STOP; shift the gearbox level to gear number #5; set the direction-control switch to DOWN; release the brake and slowly rotate the speed-control knob clockwise to start the hoist reel turning. For the first 100 feet, lower the probe <u>slowly</u> (maximum control-knob rotation of 1/3 turn). At 100 feet, speed may be gradually increased to maximum (but never exceed a speed of 150 feet per minute). <u>(USE CAUTION)</u> During probe lowering, monitor sheaves for proper operation and monitor cable for proper tension. If difficulty develops, immediately rotate the speed-control knob counterclockwise to STOP, and gently apply brake to stop rotation of the hoist. Correct problem and continue to lower probe.

b) As probe is lowered down the hole, monitor and record the multimeter readout to define the range in pressure from land surface to water level (for example .046 mV at LSD to 1.00 mV at WL).

6.13 Lower the probe to a depth of no more than 1,000 feet and stop the hoist by rotating the speed-control knob to STOP, and slowly apply brake. Shift the gearbox lever from 5th to 4th gear, release brake and continue to lower at maximum speed (150 feet per minute) to 1,500 feet if the water level has not been reached.

CAUTION: Always release brake slowly, making certain that gears are engaged (if not, hoist will freewheel). At this depth, and at all subsequent 500-foot intervals, use the above procedure to shift the gearbox lever to the next lower gear to avoid a runaway cable.

6.14 Stop lowering of the probe at first indication of water; this is indicated when the millivolt reading increases rapidly. Record the last air reading. Continue down the hole with the probe to approximately 5 feet below water-level and stop rotation of the reel using procedures described above.

6.15 Change the direction-control switch to UP, release brake slowly and slowly rotate the speed-control knob to raise the probe while monitoring the multimeter readout. With one hand on the motor speed-control knob and the other on the brake, quickly and simultaneously rotate the control knob to STOP and apply the brake when the millivolt values reaches the last air reading. Record the millivolt readout and the footage-counter meter reading to the nearest 0.05 feet. NOTE: In the continuous-operation mode, calibration of the transducer is necessary after the static water level has been established. The operator should refer to Appendix C: Calibration of the Transducer.

6.16 Operate the hoist to remove the transducer from the well using the same sequence of gears and depth intervals as used in lowering the probe. At a depth of 200 feet, reduce the speed to half; at 50 feet reduce speed to 1/4; and at 10 feet reduce the speed to minimum to avoid damaging equipment. Raise probe slowly to zeroing point and stop rotation of reel. Read and record footage-counter meter to nearest 0.05 feet.

6.17 Repeat steps 6.9 to 6.16 to obtain a second water-level measurement for quality assurance. When determining a non-static water level, three measurements are required to establish a trend line. Note: Additional submersions of the probe without withdrawing it completely from the well may produce incorrect results.

6.18 Using the appropriate form, make calculations of water level below land surface. Provide all necessary information on form before leaving well site. (See Appendix D). Note any modifications of equipment or procedure and notify Project Chief of problems or procedure changes.

6.19 Disassemble equipment by unscrewing the probe from the cable head; replace thread protectors. Clean and stow probe. Feed cable head back into the hole in the van roof. Clean and stow head in PVC pipe mounted on hoist frame. Detach tripod pulley by unscrewing and stow it in the wooden tray. All electrical equipment must be shut off. Secure all equipment for travel.

7.0 Operation procedure for the float-actuated switch system

7.1 Determine whether the tripod, or casing-top sheave is to be used for cable guide (both cable guides may be used simultaneously if necessary).

7.2 If the tripod is to be used, park the van to the left of the well with casing opposite hoist and at distance from the well measured from the right side of the van, of from 5 to 7 feet. If the casing-top sheave is to be used, the distance from site of van

should be about 8 feet. At some wells, other unspecified arrangements may be necessary, especially at drill-rig sites.

7.3 Assembly of tripod or casing-top sheave

a) Assemble and position the tripod between the van and well casing. If the casing-top sheave is used, simply attach it to the side of the casing toward the van.

b) Check the position of the tripod sheave; it should be centered above the well casing or access tube. If the position is incorrect, move the van or adjust tripod legs to obtain the proper positioning.

c) Inside the van, shift the hoist gearbox to the neutral position by moving the shift lever (with the 1" ball handle). Release the hoist brake by depressing the button atop the brown handle and moving the handle fully toward the hoist (toward rear of the van).

d) Remove the cable head from the PVC (storage) pipe on the side of the hoist frame (side toward the front of van) and thread upward through the 2-inch hole in the van roof (directly above hoist). Lay the cable head, on the roof.

e) Remove the 5-inch diameter roof-top sheave from the wooden storage box, and screw it into the smaller pipe fitting on the roof top (hand tight). Hand tighten the other roof-top sheave to the pipe fitting of the tripod with the sheave groove centered laterally above the well.

f) Thread the cable through the wire guide of the roof-top sheave, and slowly pull the cable head out to the tripod (or a casing-top sheave). Thread the cable through wire

guide of the sheave, positioning the cable into the groove. The cable head should extend to 2-3 feet below the sheave. CAUTION: If the cable is pulled out to fast, the hoist will continue to rotate causing the cable to tangle.

g) Reset the hoist brake.

7.4 Connect AC power source

To operate the hoist, float-switch, and possibly the multimeter, electric power is required. Four general sources of power may be available for use: 1) commerical power, 2) rig power, 3) portable generator, and 4) van-mounted generator. An ivory colored electrical outlet is mounted on the rear side of the control panel housing (the side toward the rear of the van). An extension cord running from this outlet should be plugged into any power source other than the van-mounted generator using whatever extension cords are required. The van-mounted generator is wired to the hoist via a switch on the upper panel extension. If the van-mounted generator is used check generator oil level and start the generator by depressing the start rocker switch of Onan electric power subpanel of the upper panel extension until generator is operating. The toggle switch just above the subpanel is switched to the down position. [This is a selector switch for the type of power source.] If a power source other than the van-mounted generator is used the above described switch is moved to the up position. [NOTE: This is a three-position switch, the center position of OFF.] Irrespective of the power source, the upper most toggle switch of the upper panel extension needs to be in the up position. The multimeter power cord then should be plugged into the ivory-colored mounted outlet. Power to the panel is indicated by a voltage reading on the AC volt meter mounted on the panel, left of the panel center.

The voltmeter reading needs to be 115V ±5%. If out of this range, adjust the 2-inch diameter black knob of the variac subpanel of the upper panel extention so that the voltmeter reads 115 volts.

7.5 Remove the brass, float-switch probe (length about 16 inches by 1.5 inches diameter) from storage. Remove thread protectors from cable head and the float-switch probe. Align key of cable head with keyway of probe, slowly inserting key into keyway. Hand tighten knurled nut of cable head into probe.

7.6 Check multimeter function

A digital multimeter will be used to sense the closing or opening of the float switch contacts at water level. To check operation, turn on the multimeter-power switch; depress white ohm button (k-ohm button), and depress dark colored 200-ohm button. Select two meter leads of different colors each having a banana plug on one end and an alligator clip on the other. Insert one banana plug lead into the common receptacle of the meter; insert the other banana plug into the voltohm receptacle of the meter. Short together the two alligator clips. The meter model 8050A should change from a flashing readings of 188.88 units to a steady reading of about 00.10 units, or for meter model 8050A from one unit (steady reading) to about 0.10 units.

7.7 Connect the multimeter to the control panel of hoist unit:

a) With meter adjusted as in step 6 and
b) Leads attached to meter as in step 6,
c) Fasten either alligator clip into #2 lower-module receptacle (upper right on panel). Fasten the other alligator clip to the screw head (ground) directly below the previously described module receptacle.

7.8 Test function of float-actuated switch prob.

Invert float-actuated switch probe and observe multimeter reading, which should become nonflashing, non-varying number. Repeat inversion of probe several times to varify correct function.

7.9 Zero the float-actuated switch

a) If using the tripod, position the probe in the well with the "mid-level" hole of the probe centered with the measuring point (i.e., top of casing, etc.). If using the casing-top sheave, align the top of the cable-head spring with the measuring point. The top of the spring is 1.65 feet above the sensing point of the probe. (Computational adjustment will be made on the appropriate form for this interval.)

b) To move probe during zero operation, set motor speed to STOP, release the brake on the hoist, set the direction level as needed (up or down), and shift the gearbox lever to any numbered position, perferable numbers 1 or 2. Adjust the probe to the zeroing point by slowly rotating the speed-control knob. Set the hoist brake.

7.10 Zero the footage-counter meter

Locate the footage-counter adjustment knob. The knob is on the right side (away from hoist), of the recorder housing on the front panel. Of the three knobs in this area use the lower, rear knob. Pull out and rotate the small offset knurled knob to zero the footage-counter meter which is located on the lower, right section of the panel just below the line speed meter. Set the counter to 0000.0 feet.

7.11 To lower the probe into the well:

a) Set the speed-control knob to STOP; shift the gearbox lever to gear number 5; set direction-control switch to DOWN; release the brake and slowly rotate the speed-control knob clockwise to start the hoist reel turning. For the first 100 feet, lower the probe slowly (maximum control-knob rotation of 1/3 turn). At 100 feet, speed may be gradually increased to maximum (never exceed a speed of 150 feet per minute). (USE CAUTION) During probe lowering, monitor sheaves for proper operation and monitor cable for proper tension. If difficulty develops, immediately rotate the motor speed-control knob counterclockwise to STOP and gently apply brake to stop rotation of the hoist. Correct problem and continue to lower probe.

b) Lower the probe to a depth of no more than 1,000 feet and stop hoist by rotating the speed-control knob to STOP and slowly apply brake. Shift gearbox lever from 5th to 4th gear, release brake and continue to lower at maximum speed (150 feet per minute) to 1,500 feet if the water level has not been reached.

CAUTION: Always release brake slowly making certain that gears are engaged (if not, hoist will freewheel). At this depth, and at all subsequent 500-foot intervals, use the above procedure to shift the gearbox lever to the next lower gear to avoid a runaway cable.

7.12 Stop lowering the probe at first indication of water as indicated by a change in multimeter reading (the reading change will be the same

as observed during the float-switch inversion test). Continue down the hole with the probe to approximately 5 feet below water level and stop rotation of the reel using procedure described above.

7.13 Change direction-control switch to UP, release brake slowly, and slowly rotate the speed-control knob to raise the probe while monitoring the multimeter readout. With one hand on the motor speed-control knob and the other on the brake, quickly and simultaneously rotate the control knob to STOP and apply the brake when the multimeter indicates an open circuit (a sudden drop in meter reading). Record footage-counter reading to nearest 0.05 feet.

7.14 Operate hoist to remove the probe from the well using the same sequence of gears and depth intervals as used in lowering probe. At a depth of 200 feet, reduce speed to half; at 50 feet reduce speed to 1/4; at 10 feet reduce speed to minimum to avoid damaging equipment. Raise probe slowly to zeroing point, and stop rotation of reel. Read and record footage-counter meter to nearest 0.05 feet.

7.15 Repeat steps 7.9 through 7.14 to obtain a second water-level measurement for quality assurance. When determining a non-static water level, three measurements are required to establish a trend line.

NOTE: Additional submersions of the probe without withdrawing it completely from the well may produce incorrect results.

7.16 Using the appropriate form, make calculations of water level below land surface. Provide all necessary information on form before leaving well site. (See Appendix D) Note any modifications

of equipment or procedure and notify Project Chief of problems or procedure changes.

7.17 Disassemble equipment by unscrewing the probe from the cable head; replace thread protectors. Clean and stow probe. Feed cable head back into the hole in the van roof. Clean and stow head in PVC pipe mounted on hoist frame. Detach tripod pulley by unscrewing and stow it in the wooden tray. All electrical equipment must be shut off. Secure all equipment for travel.

Assembly and Operation of Data-Recording Equipment

Three types of data recording equipment are available for use with this water-level measuring system: (1) strip-chart recorder, (2) data logger with digital printout, and (3) magnetic-tape recorder. The latter two are output of the 2240A Data Logger. In addition, the data logger has an illuminated digital display for monitoring. The strip-chart recorder produces a graphic line on 6 inch strip charts. The strip-chart recorder is capable of recording a single channel, whereas the data logger can record 60 channels or more.

1.0 Data Logger (Fluke 2240A):

1.1 Digital Print out

1.1.1 Plug the cord of the data logger into the ivory colored, electrical outlet mounted on the right side of the control panel housing. (Figure 1)

1.1.2 On the lower, right side of the data logger lanel, locate the key that controls power to the unit. Turn power ON by turning the key to the vertical position. Notice that the red light in the lower left corner of the panel starts flashing.

1.1.3 Set time:

1) Determine the Julian day from the chart taped to the inside of the van. (Days of the year numbered from 1 to 365.)

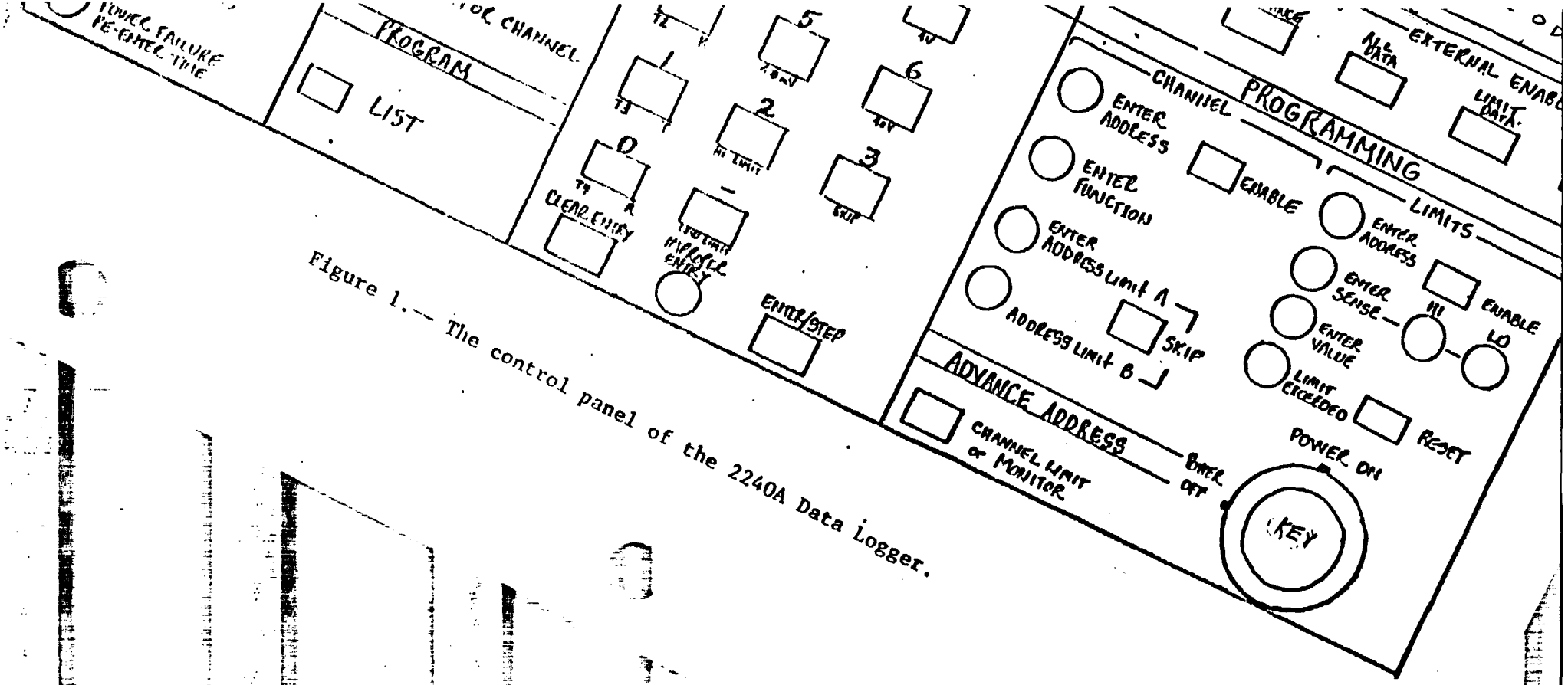


Figure 1.-- The control panel of the 2240A Data Logger.

Locate the TIME ENTRY section on the lower left part of the panel; and depress the DAYS button (Three zeros should appear above the day section on the digital display. In the DATA ENTRY section, enter the Julian date. Depress the nearby RED button labeled ENTER/ STEP (herein, referred to as the RED button). The flashing red light in the TIME ENTRY section will stop flashing.

2) Set hours, minutes, and seconds. In the TIME ENTRY section, depress the HR/MIN/SEC button. (This will cause the advancing-time display above the hr/min/sec section of the digital display to stop.) In the DATA ENTRY section, depress the appropriate white, numbered buttons to the military time, plus 30 seconds (this allows the operator sufficient time for the following step.) The precise moment the operators' calibration "watch time" reaches the readout "display time", depress the RED button. The time displayed, should correspond with the operators watch time.

1.1.4 Program the SCAN FORMAT:

1) Depress the FIXED DATA button in the SCAN FORMAT section of the panel. In the DATA ENTRY section depress six numbered buttons corresponding to month, day, and year (i.e. 06-01-83 corresponds to June 1, 1983). Depress RED button; and the entry should appear in the data section on the digital display.

2) Determine the number of channels of information to be recorded. (The first channel will always be numbered the zero channel; therefore, if a total of

10 channels of information are desired, the last channel will be number 9.) Depress the FIRST CHANNEL button of the SCAN FORMAT section, and in the DATA ENTRY section depress the zero button designating the first channel. Depress RED button. Display should now read 000.

Depress LAST CHANNEL button. As above, enter the number of the last channel to be used; then depress RED button. (Note: If air pressure is to be monitored as one of the information channels, see Appendix B: Operation of the Digital Barometer).

3) Determine the time interval between measurements. Depress the INTERVAL-HR/MIN/SEC button. In the DATA ENTRY section, depress 6 buttons corresponding to the selected interval in hr/min/sec (i.e., 1 hour = 01-00-00; 10 sec = 00-00-10. Depressing the RED button. The entry should appear above the hr/min/sec section on the display.

4) If desired, you may select one channel to be monitored. Depress MONITOR CHANNEL button. In the DATA ENTRY section, enter the channel number to be monitored by depressing the correct numbered key RED button. The digital readout will display the number of the channel.

1.1.5 Program the input of each channel:

Locate the PROGRAMMING section of the panel. Under the bracket labeled CHANNEL, depress the ENABLE button. This will cause

the adjacent red light (ENTER ADDRESS) to illuminate. In the DATA ENTRY section, depress the number of the channel to be programmed, then depress the RED button. (When the RED button is depressed the ENTER ADDRESS light goes out, and the ENTER FUNCTION light illuminates.) Select functions in the DATA ENTRY section designated on yellow tape below each button. These functions assign a measurement range to each channel.

There are 11 functions available, but only 6 are commonly used. The options are:

1. Temperature (Cooperconstantan thermo couple)--labeled T3 #1 button.
2. Millivolts -- labeled 40mV #8 button.
3. Millivolts -- labeled 400 mV #5 button.
4. Volts--labeled 4V, #9 button.
5. Volts--labeled 40V, #6 button.
6. Skip (this allows programmer to selectively omit any channel), labeled skip, #3 button.

Select the desired function by depressing the appropriate function button; then, depress the RED button. When the RED button is depressed the ENTER FUNCTION light goes out, and the ENTER ADDRESS light reilluminates.

For each channel to be programmed, Step 1.1.5 should be repeated.

1.1.6 After all channels have been programmed, depress DATA AND TIME button in the DISPLAY CONTROL section. The digital display should read and Julian date and time.

One isothermal input connector is required for every ten channels. The connector cover must be opened (use screw driver) for access to terminals. Positive and negative signal leads from all sensing equipment must be fastened under the appropriate terminal screws, as shown above. Reinstall cover on connector after leads are fastened.

1.1.9 Install the isothermal input connector in the rear of the data logger.

Looking at the rear of the data logger, there are six similiar boards. Each board accepts one, isothermal input connector. The board on the far left begins the use sequence, and records information for channels 0-9 in the first isothermal input connector. Each succeeding board to the right adds ten more channels. (Thus, the second board records channels 10-19 from the second input connector, the third board 20-29, etc.) The data logger has capacity for 60 channels.

1.1.10 Check the operation of the system.

In the SCAN CONTROL section on the panel, locate and depress the button labeled SINGLE. Each input channel will be scanned and measured once in accordance with all program data entered. One digital printout will be produced from the data logger.

1.1.11 Start the interval timer by using one of the methods below.

a) At the selected start time (on the hour, or quarter-hr, etc.), depress the INTERVAL button in the SCAN CONTROL section. (If, for example, the INTERVAL button is pressed at 10-30-00 and the measurement interval is one hour, using this method, subsequent records will be printed at 1030 hours, 1130 hours, etc.).

b) If the operator wants data recording to start at a preselected later time, and this time is many minutes away, he may use the method in the example given below:

EXAMPLE:

Given that,
- display time - 09-35-00 (hrs/min/secs)
- selected interval time - 1 hour
- the operator wishes to program the system to commence recording on the hour 10-00-00.

In the SCAN CONTROL section, depress the RESET button. In the SCAN FORMAT section depress the INTERVAL HR/MIN/SEC button. In the DATA ENTRY section, depress 24-00 (24 min); then depress RED button. (This allows one minute to complete the following steps). In the DISPLAY CONTROL section, depress the DATA AND TIME button. Observe the digital display. At exacting 24 minutes before the hour (or, 09-36-00-in this example, depress the INTERVAL button in the SCAN CONTROL section.

1.2 Magnetic-Tape Recorder (Techtran 8410 Cassette)

1.2.1 Position cassette recorder switches as follows:

1.2.1.1 Rear of recorder:

1. DUP switch OFF
2. Band-rates switch set to 2400

1.2.1.2 Front of recorder:

1. Duplex set to HALF
2. ON LINE switch OFF
3. POWER switch OFF.

1.2.2 Operation of the cassette recorder:

1. Plug the cassette recorder in the ivory-colored electrical outlet mounted on the right side of the control panel housing.
2. Connect the cassette recorder to the data logger with the interface cable: The interface cable connection on the recorder is located at the rear of the unit in the lower, left corner labeled TERMINAL. The cable connection on the data logger is also on rear of the unit. Locate the three small slots to the right of the isothermal-input connection(s). Plug the interface cable into the slot marked "T", for Techtran. Make sure the connection is secure.
3. Open cassette door (lift top latch to open).
4. Place cassette in door guide, with exposed portion of cassette facing down.
5. Close cassette door.
6. Turn POWER switch to ON.
   NOTE: The switch will illuminate if the unit is functioning properly.
7. Let the cassette recorder warm up for approximately 1 min.
8. Depress REWIND switch
   NOTE: The REWIND switch will remain illuminated until tape has completely rewound.
9. On 2240A Data Logger, locate the OUPUT CONTROL section, EXTERNAL ENABLE subsection and depress the ALL DATA button.
10. On the front panel of the cassette recorder, depress the switch labeled WRITE. The cassette tape will advance and then stop. The WRITE switch will continue to

illuminate to indicate the cassette recorder is in the recording mode. (NOTE: The light from the switch will flash in the event of a power failure or if the tape has ended.)

The recorder is not ready to accept data from the data logger.

1.2.3 To replace cassette tape after use:

NOTE: Change tape only when the data logger is not sending data (such as a power failure or if the tape has ended), or, when ample time exists before the data logger sends the next piece of data.

1.2.3.1 To change cassette if the WRITE switch is not flashing:

1. Depress WRITE switch; the tape advances and the light indicator on the switch flashes. NOTE: Never take tape out without first depressing the WRITE switch.
2. Open the door and remove the cassette; turn the cassette over or replace, and close the door.
3. Depress REWIND switch.
4. Depress WRITE swtich.

1.2.3.2 To change cassette if the WRITE light is flashing:

1. Open door and remove the cassette; turn the cassette over or replace, and close the door.
2. Depress the REWIND switch.
3. Depress the WRITE swtich.

2.0 Esterline Angus, Miniservo, Single-Channel Strip-Chart Recorder

2.1 At the rear of the recorder:

1. Use the adapter supplied with the recorder and insert one end into the receptacle labeled CHARGE CONNECTION/ EXTERNAL BATTERY. Insert the other end into the ivory-colored, electrical outlet mounted on the right side of the control panel housing.
2. On the recorder adjust the three-position slide switch to the center position (AC EXTERNAL BATTERY).

2.2 On the front of the recorder:

2.2.1 Speed selection

1. Locate the speed-control knob in the upper, right corner (marked 2,5,10,15 30,60).
2. Below the speed-control knob is a slide switch. The position of the switch determines cm/hr, or cm/min relative to the speed selection. Select chart speed by adjusting the knob and the slide switch.

2.2.2 Span control

1. Locate the span-control knob at the upper, left corner (marked 1, 5, 10, 20, 50, 100).
2. Below the span-control knob is a 3-position, toggle switch. Adjust the toggle switch to the MILLIVOLT position and the knob to the maximum expected transducer output, usually 50 millivolts or less.

2.2.3 Power switches

1. Turn on the recorder power switch, located in the lower right hand corner.

2.2.4 Front panel signal-input jacks

1. Both red (HI+), and black (LO-) signal-input jacks are located in the lower, left corner on the front panel.
2. Connect a lead between both signal input jacks causing a short. (Disregard the brown jack.)

3. With the signal shorted adjust the zero-control knob to position the pen on the right edge of chart.
4. Remove the shorting lead.

2.3 Connect a single input signal to the recorder:

1. To record transducer output signal, on the control panel of the hoist in the van, locate the #3 lower-module receptacle. Connect a lead from this receptacle to the red(+) jack on the front panel of the recorder. On the control panel of the hoist, locate the #2, module receptacle. Connect a lead from this receptacle to the black(-) jack on the panel of the recorder.
2. To record barometric-pressure output, connect the red(+) lead of barometer to the red(+) jack on the front panel of the recorder. Connect the green(-) lead of the barometer to the black(-) jack on the panel of the recorder.

   Note: Only one channel of data can be recorded. Select only one of the above.

2.4 The operator is required to record certain information: 1) on the chart, 2) in the log book, and 3) on the appropriate form.

1. Chart and log-book information
   - well number
   - date and time
   - chart speed
   - span (millivolts full scale)
   - task identification
   - operator identification
   - serial number of recorder
   - model number of recorder

- transducer serial number, PSI range, type, and manufacturer
- calibration information

2. Refer to the appropriate form for necessary information. (See Appendix D).

Digital Barometer

The digital barometer measures atmospheric pressure, with a display in inches of mercury. Barometric readings may be recorded along with other signals in the continuous mode when used in conjunction with the data logger or a magnetic-type recorder. If a single-channel strip-chart recorder is used, the user must select the one channel to be recorded.

1.0 Plug the digital barometer into the ivory-colored electrical outlet that is mounted on the rear side of the control panel housing.

2.0 Turn power switch of barometer ON. The display will readout the pressure in inches of mercury.

3.0 If the barometer is to be added as an additional channel after the data logger has been programmed, follow step 2 of 1.1.4 and all of 1.1.5 in Appendix A and then proceed with step 4.0, following.

NOTE: Volts are related to barometric pressure (i.e. barometric pressure may be 26.73 but is printed on data logger as 2.67v. Therefore entry would be 267v = 26.73 inches of Mercury.

For digital printouts every hour, on the hour, leave the INTERVAL button in the in position. Depress the INTERVAL HR/MIN/SEC button in the SCAN FORMAT section. In the DATA ENTRY section, enter 01-00-00 (1 hour); depress RED button to enter step. In the DISPLAY CONTROL section, depress DATE AND TIME button. By the use of one of these two methods the data logger will record measurements for example, at one hour intervals, on the hour.

3.1 After the system has been programmed for interval time, the operator should continue to step 1.2, for assembly of the magnetic-tape (Techtran 8410 Cassette) recorder, if used. This provides computer access for all data entered into the system.

3.2 The operator may be assured of proper functioning of the system by checking to see that the data are displayed and that the data are printed.

3.3 The operator is required to record certain information: 1) on the digital tape, 2) in the log book, and 3) on the appropriate form.

1) digital tape and log-book information:

- well number
- date and time
- task identification
- serial number(s) of recording equipment
- model number(s) of recording equipment
- transducer serial number, PSI range, type, and manufacturer.
- calibration information
- operator identification

4.0 For recording on the data logger, the data logger and magnetic tape, and/or the strip-chart recorder, use one of the three following procedures:

4.1 For recording barometric pressure on the data logger:

4.1.1 Locate an isothermal-input connector, at the rear of the data logger, with an unused channel.

4.1.2 Remove and open the cover of the connector housing so that the signal leads from the digital barometer may be fastened to the unused channel.

4.1.3 Fasten the red(+) lead of the barometer to the positive terminal in the isothermal connector. Fasten the green(-) lead of the barometer to the negative terminal in the connector.

4.1.4 Close the housing and reinstall the connector into the same board at the rear of the data logger.

4.2 For recording on the data logger and magnetic tape.

4.2.1 Perform all steps in 4.1, Appendix B.

4.2.2 Perform all steps in 1.2 of Appendix A.

4.3 For recording on the data logger, magnetic tape and strip-chart:

4.3.1 Perform all steps 4.2 of Appendix B.

4.3.2 Perform all steps from 2.0 thru 2.2.4 of Appendix A.

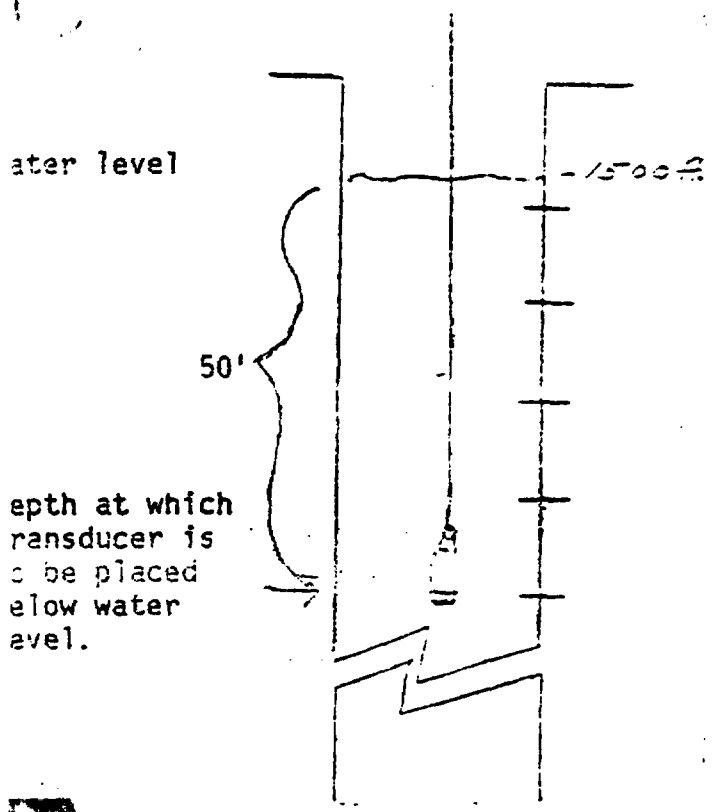
4.3.3 Perform #2 of step 2.3 of Appendix A.

NOTE: The digital barometer output leads are also connected into the data logger as in 4.1 of Appendix B. By performing this step the signal is connected in parallel with the data logger and the strip-chart recorder.

Calibration of the Transducer

If a transducer is to remain in the well for monitoring water-level fluctuations and trends, it must be calibrated before and after the measuring period. However, before the transducer can be calibrated, the operator must establish several parameters such as: a) The static water level of the well, b) anticipated water-level fluctuations, c) the depth at which the transducer will be placed below water level, and the appropriate transducer pressure (PSI) range (about 2.3 feet of water per PSI). Once these parameters have been established and the measuring system assembled and tested, the transducer is ready for calibration. The operator should keep in mind that calibration is always done as the probe is coming up the hole. This insures that the cable will be fully extended with maximum, consistent tension. Using the Dodge logging van procedure, measure the water level then:

1. Lower the transducer approximately five feet below the depth at which the transducer will be placed for the duration of the measuring period.
2. Raise the probe to the predetermined depth the transducer will be placed for the duration of use. This will also be the first calibration station. Allow transducer to stabilize to a constant millivolt readings (perhaps as long as 15 minutes); then record the depth and millivolt reading.
3. Select a minimum of four additional, equally spaced calibration stations between the first station (as in step #2), and just below the water level. At each station the depth and the millivolt readings must be recorded on the attached form after the transducer has been allowed to stabilize. (Refer to example given below.)
   The last calibration station should be approximately 2 to 5 feet below water level. In addition obtain on air reading 1 to 2 feet above water level.



Calibration Station #	Feet below GL	Feet below water level	mV reading
Air reading	1498	0	5.37
#5	1505	5	7.20
#4	1520	20	12.39
#3	1530	30	15.87
#2	1540	40	19.30
#1	1550	50	22.70

4. After the use period, recalibrate at the same depths as were used during the original (before) calibration.
5. After millivolt readings from the calibration stations have been determined, record results on the monitoring-equipment form. (See enclosure)
6. Reposition probe to desired depth (station #1) for the duration of measuring period. Set the hoist brake <u>securely</u>.
7. At the completion of measuring period recalibrate the transducer at the same calibration stations. Millivolt values obtained from the calibrations determine the ratio of millivolts to feet of water.

TRANSDUCER CALIBRATION

Well _____ ID of system _____

Date _____ Transducer ID _____

Time _____ Transducer range _____ - _____ psi

Operator _____ Voltage to transfer (measured at power-supply output

Depth of water: with transducer attached _____

Date _____ ID of system components: _____

Time _____ _____

DTW _____ below _____ _____

Datum info _____ _____

CALIBRATION DATA

Station number	Depth below G.L. (feet)	Depth below water level (feet)	Transducer reading (mV)	Station number	Depth below G.L. (feet)	Depth below water level (feet)	Transducer reading (mV)
	BEFORE USE (date_____)				AFTER USE (date _____)		
Air	_____	_____	_____	Air	_____	_____	_____
5	_____	_____	_____	5	_____	_____	_____
4	_____	_____	_____	4	_____	_____	_____
3	_____	_____	_____	3	_____	_____	_____
2	_____	_____	_____	2	_____	_____	_____
1	_____	_____	_____	1	_____	_____	_____

Calculation for DTW - psi - mV relations:

Remarks: Calibration results:

Depth-to-Water Data Form

Well	_____	ID of system	_____
Date	_____	Transducer ID	_____
Time	_____	Transducer range	_____ - _____ psi
Operator	_____	ID of system components:	_____
Last Calibration	_____	Altitude of GL _____	_____
Next Calibration	_____		_____
Measuring point	_____	Measurements	_____

	#1	#2	#3	#4	#5
In (feet)					
Out (feet					
Out correction (feet)					
Top-of-spring correction (feet)					
DTW below MP (feet)					
MP above GL (feet)					
DTW below GL (feet					

Difference-to-DTW ratio:

___	1:_____	#___#___	
___	1:_____	#___#___	
___	1:_____	#___#___	
___	1:_____	#___#___	
___	1:_____	#___#___	

Note: Differences between values used to calculate should be less than DTW X 0.001.

Procedure for selecting DTW values
(1)
(2)
(3)

Remarks:

Calculation of selected DTW value:

Selected DTW value:

K+E 1 YEAR BY DAYS X 250 DIVISIONS
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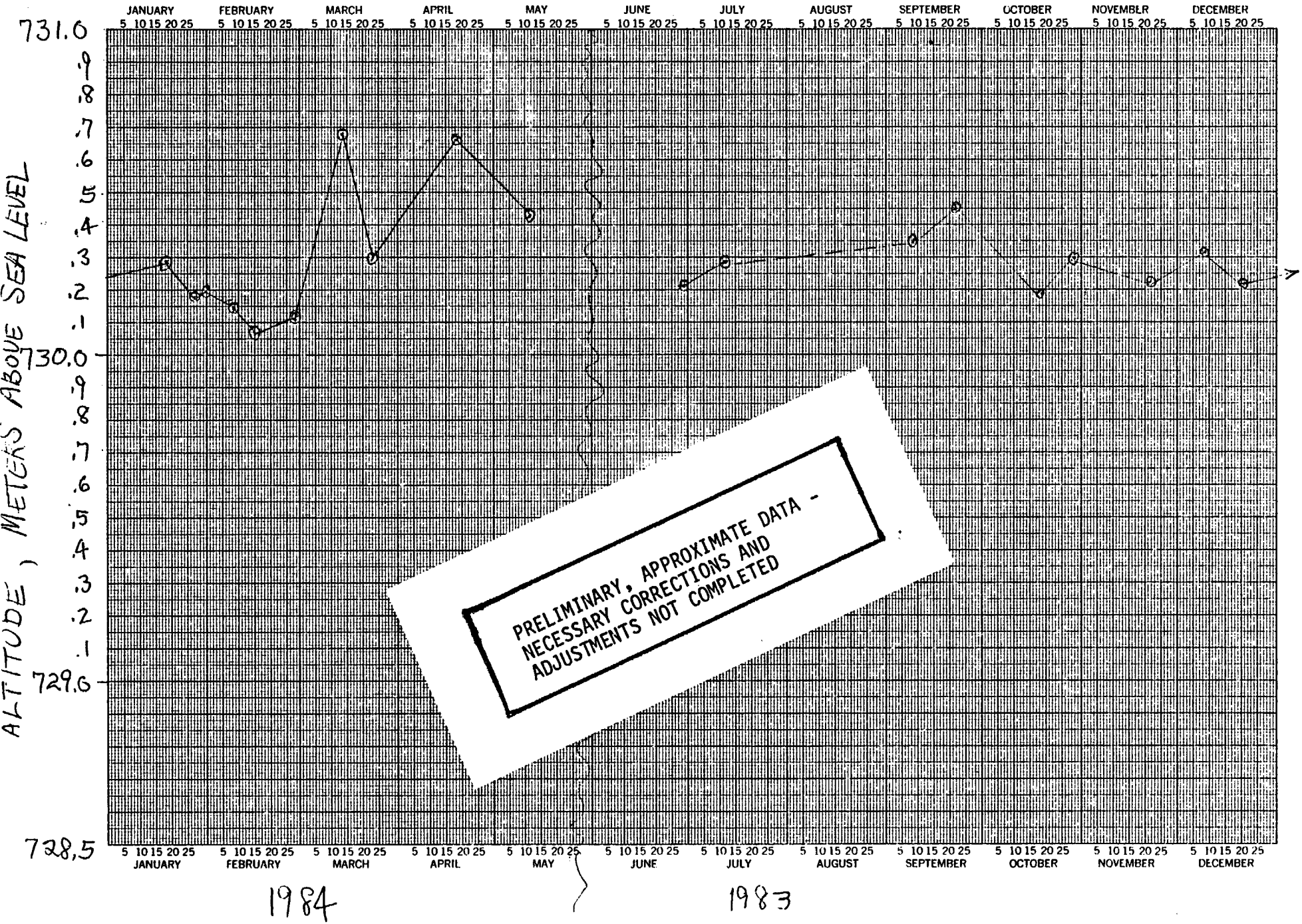
46 2890

USW WT-1



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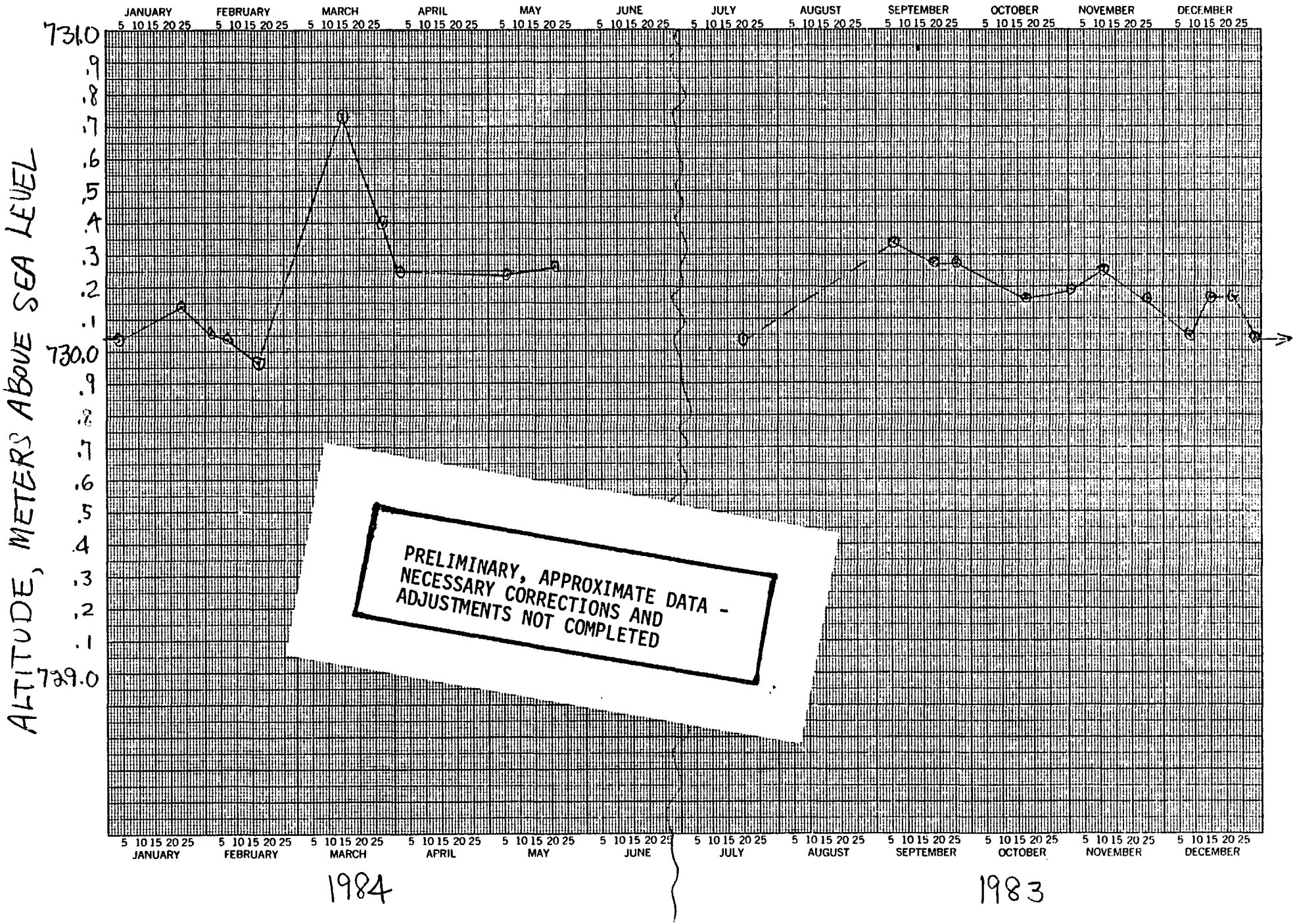
USW WT-2



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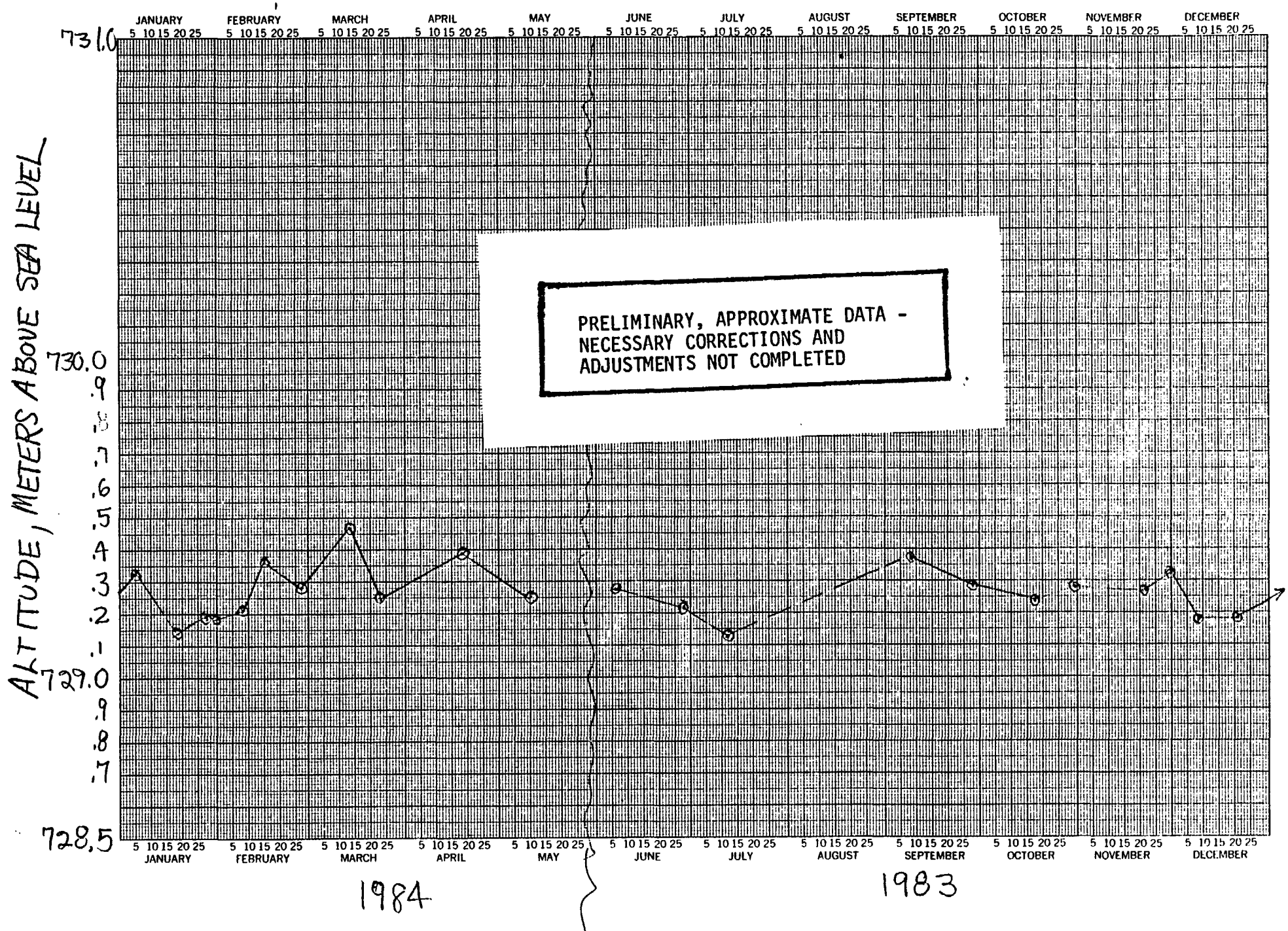
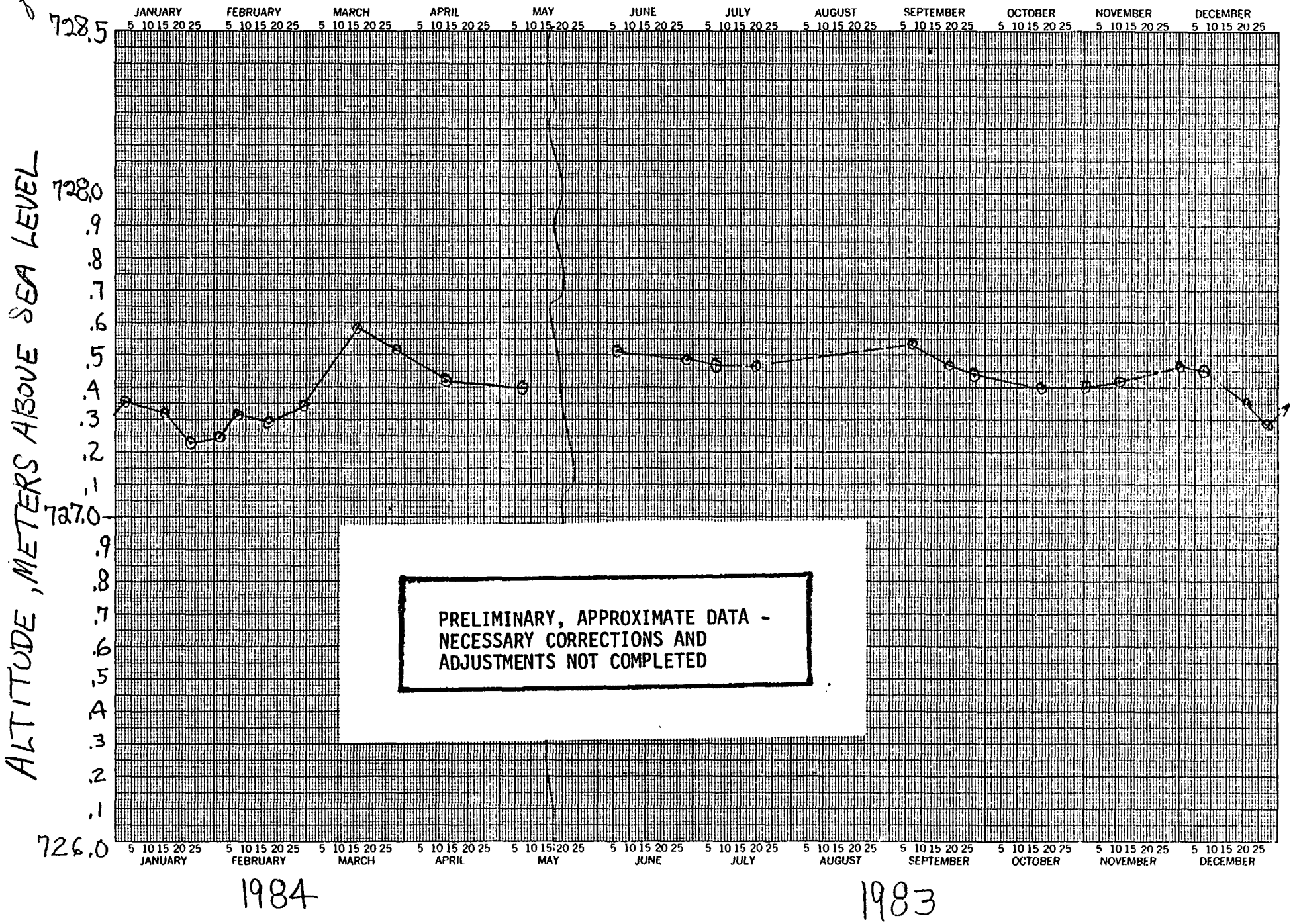
UE-25WT#3



K+E 1 YEAR BY DAYS X 250 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A. 46 2890

not adjusted for new LSD 6/11/84

UE-25 WT#4



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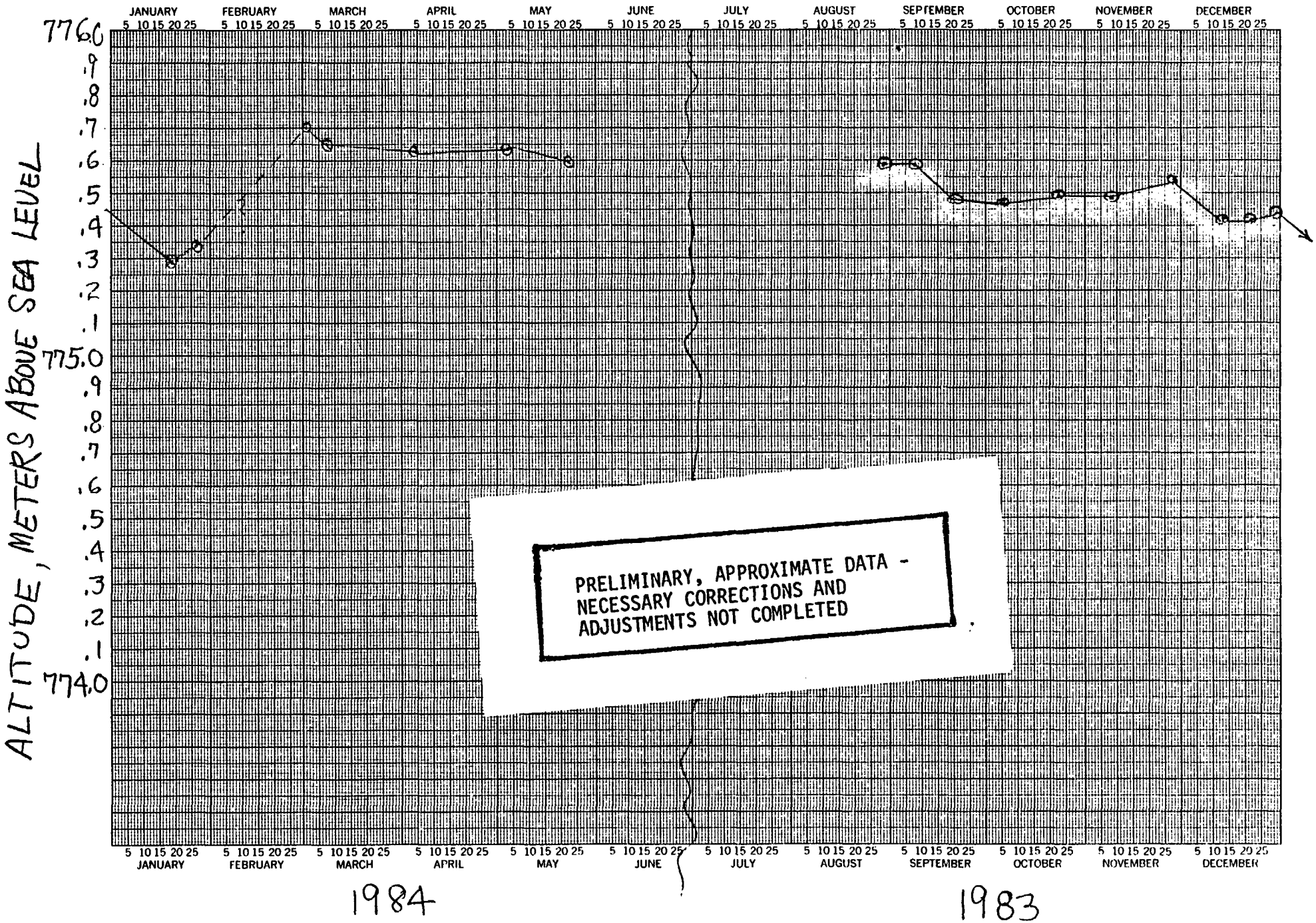
USW WT-7



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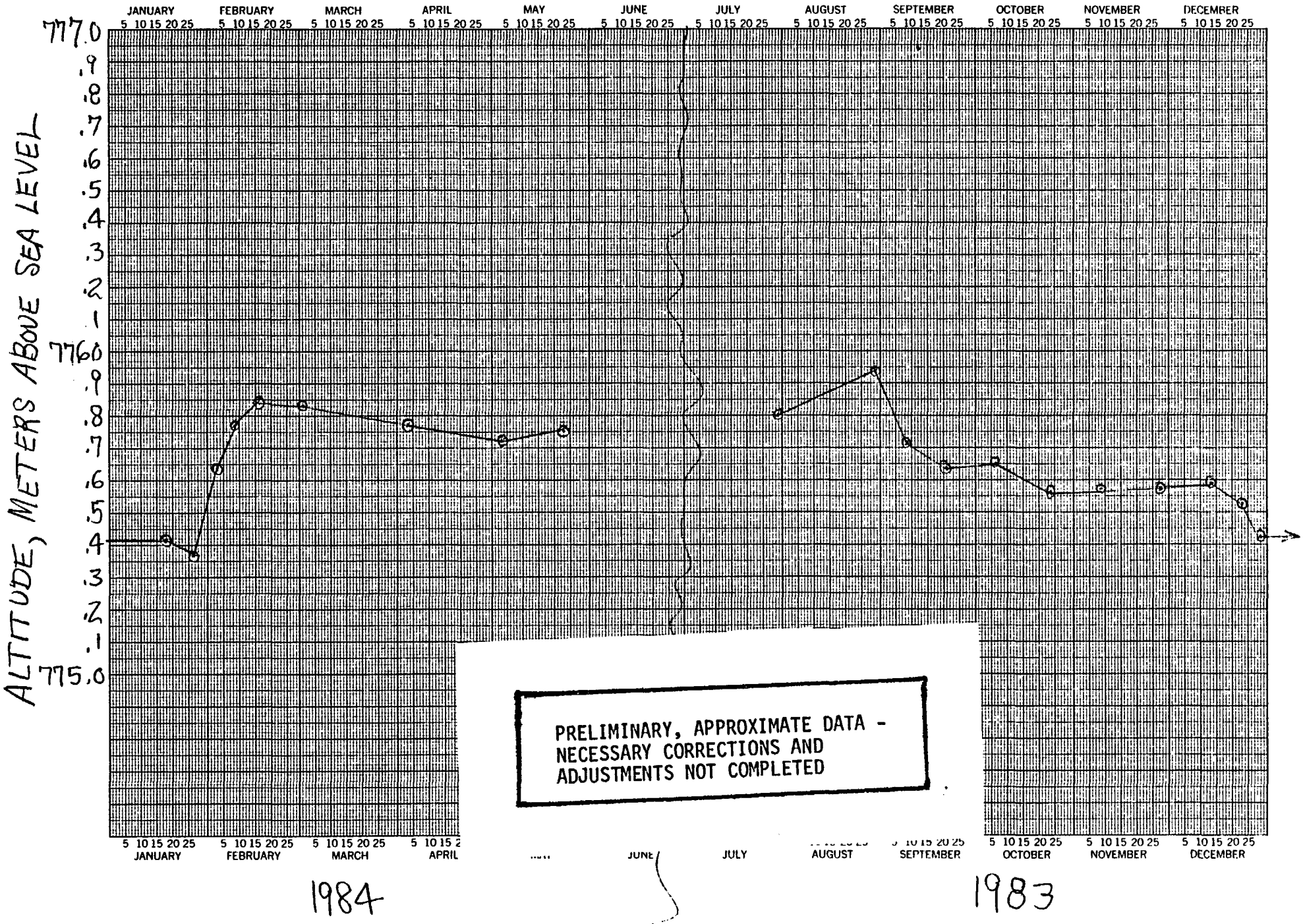
USW WT-10



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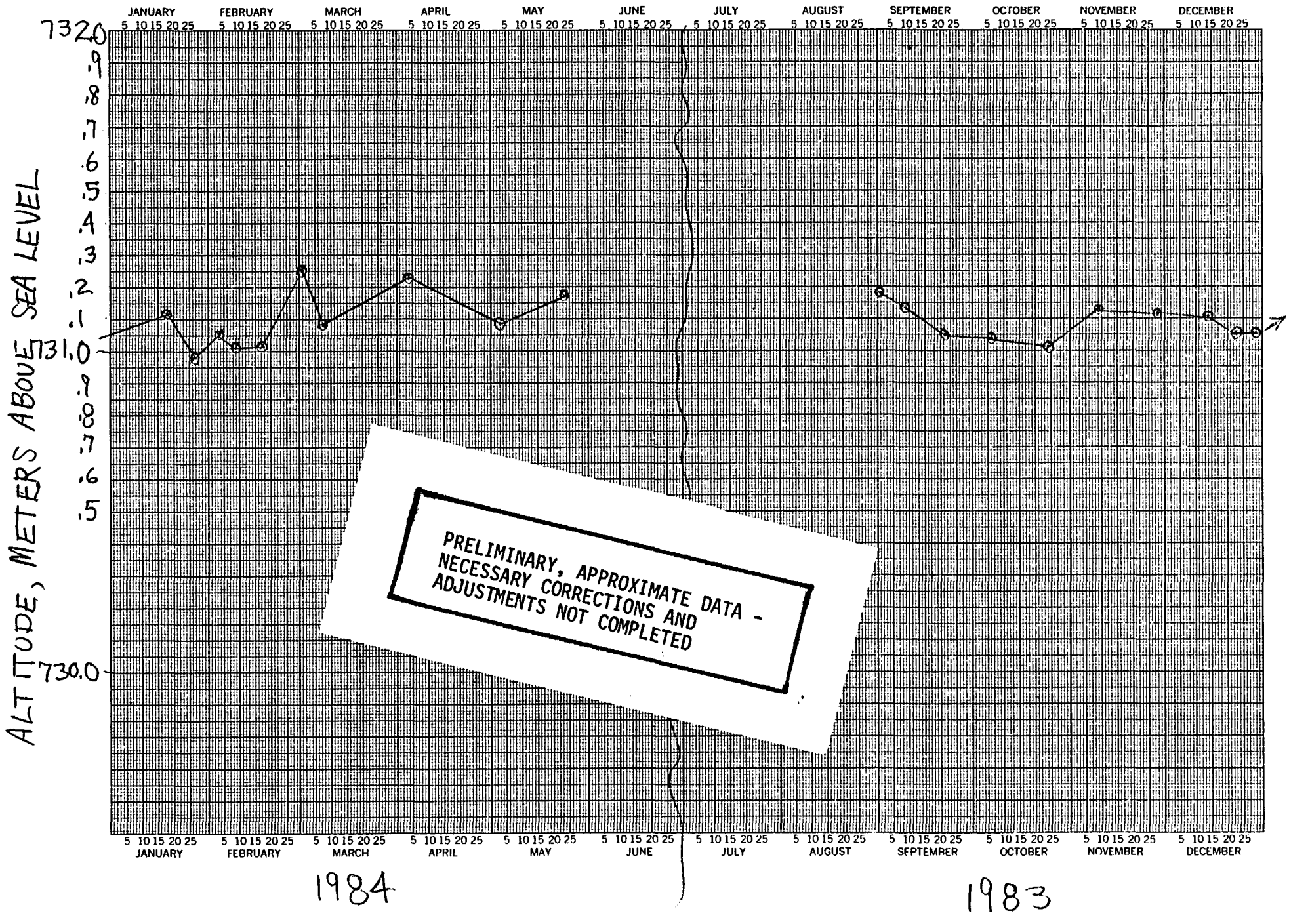
USW WT-11



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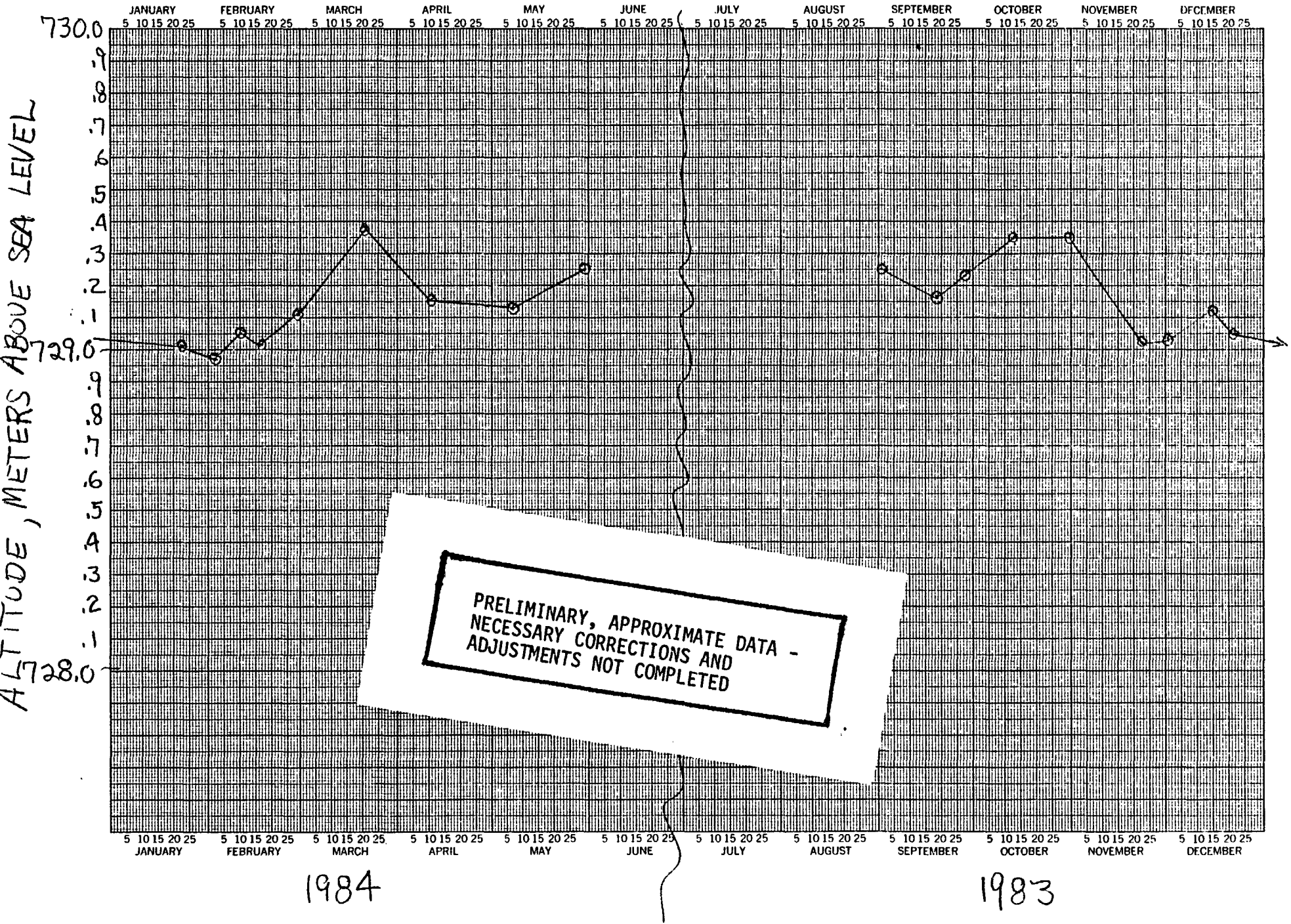
UE-25 WT#12



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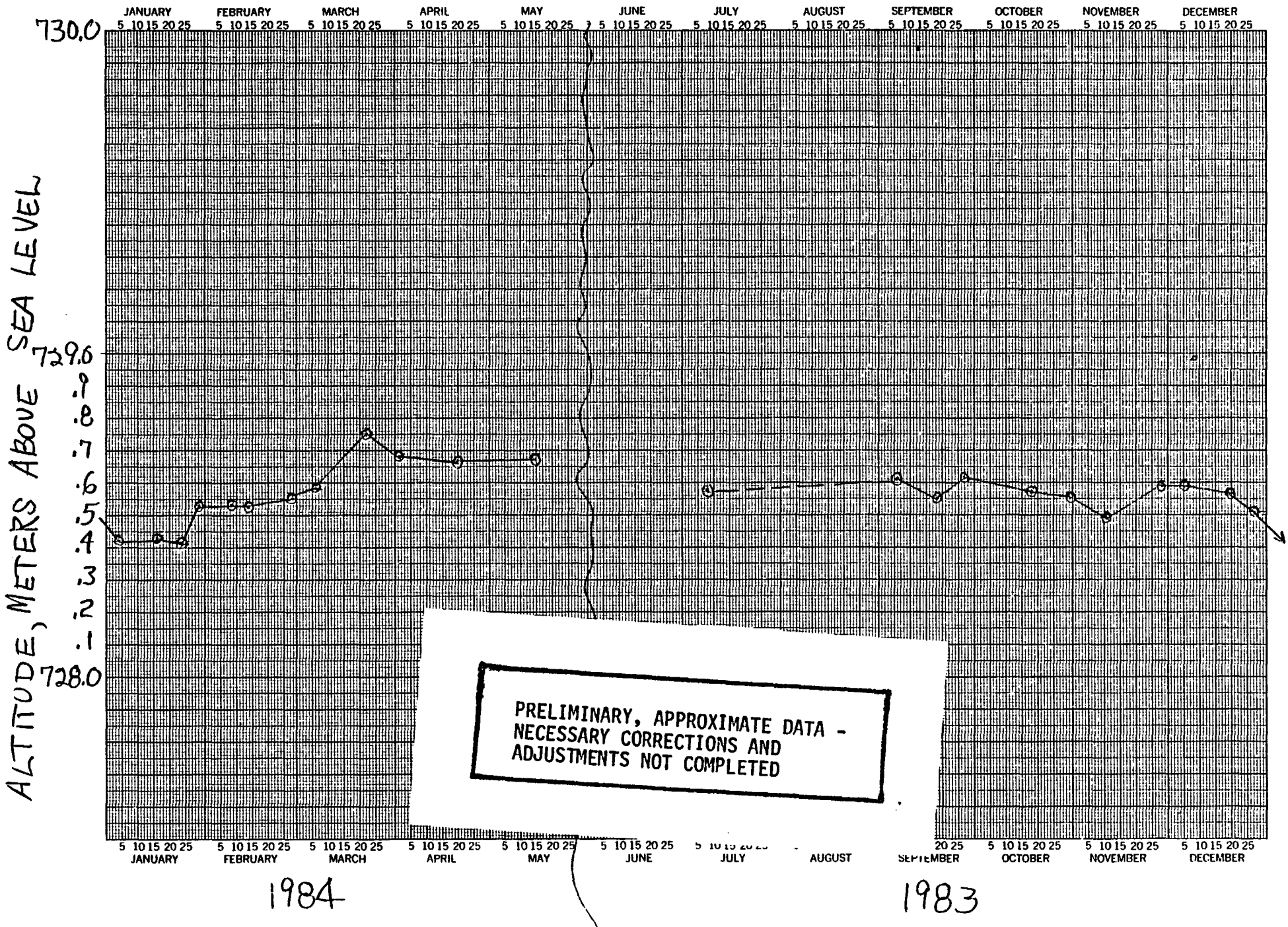
UE-25 WT#13



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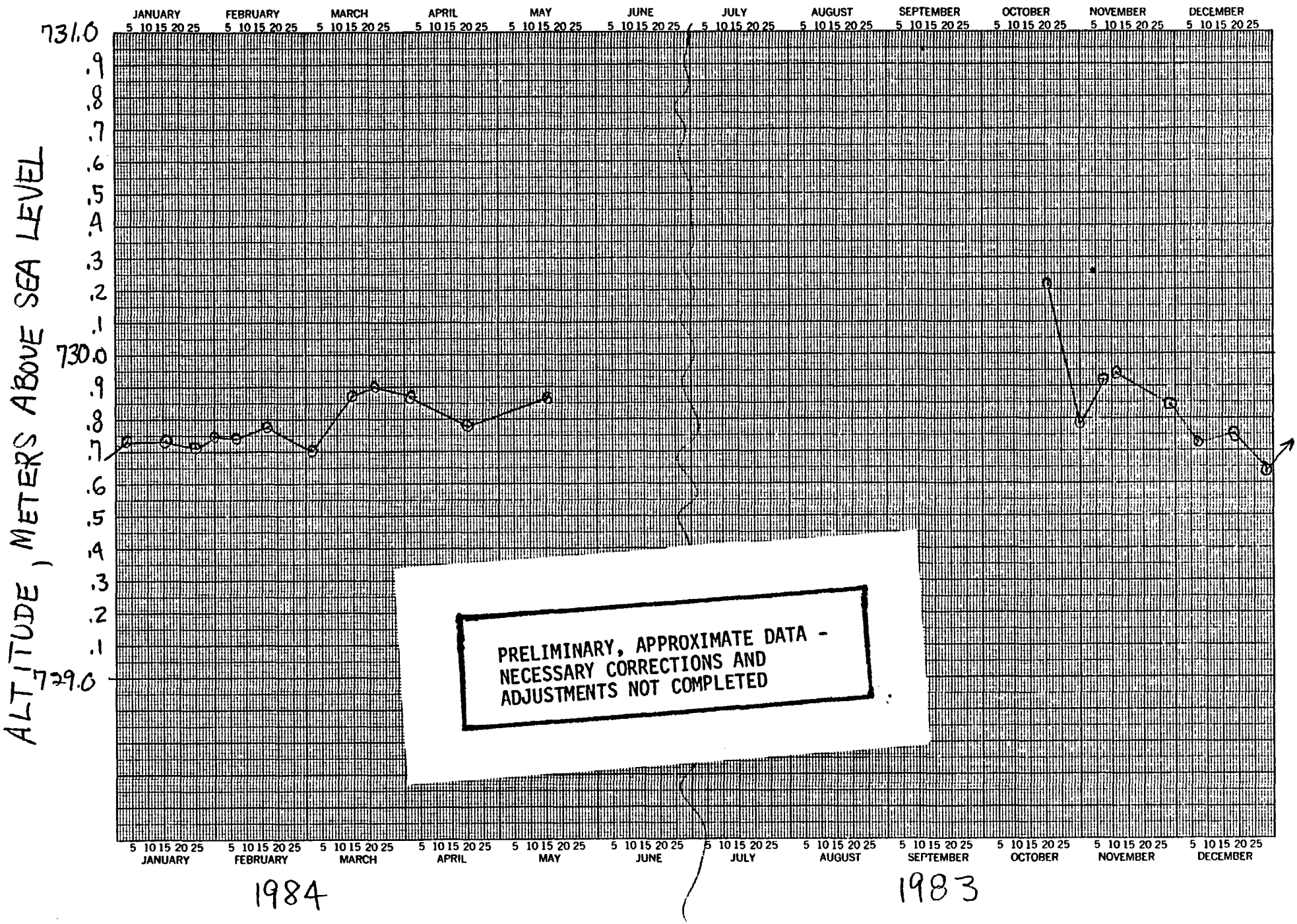
UE-25 WT#14



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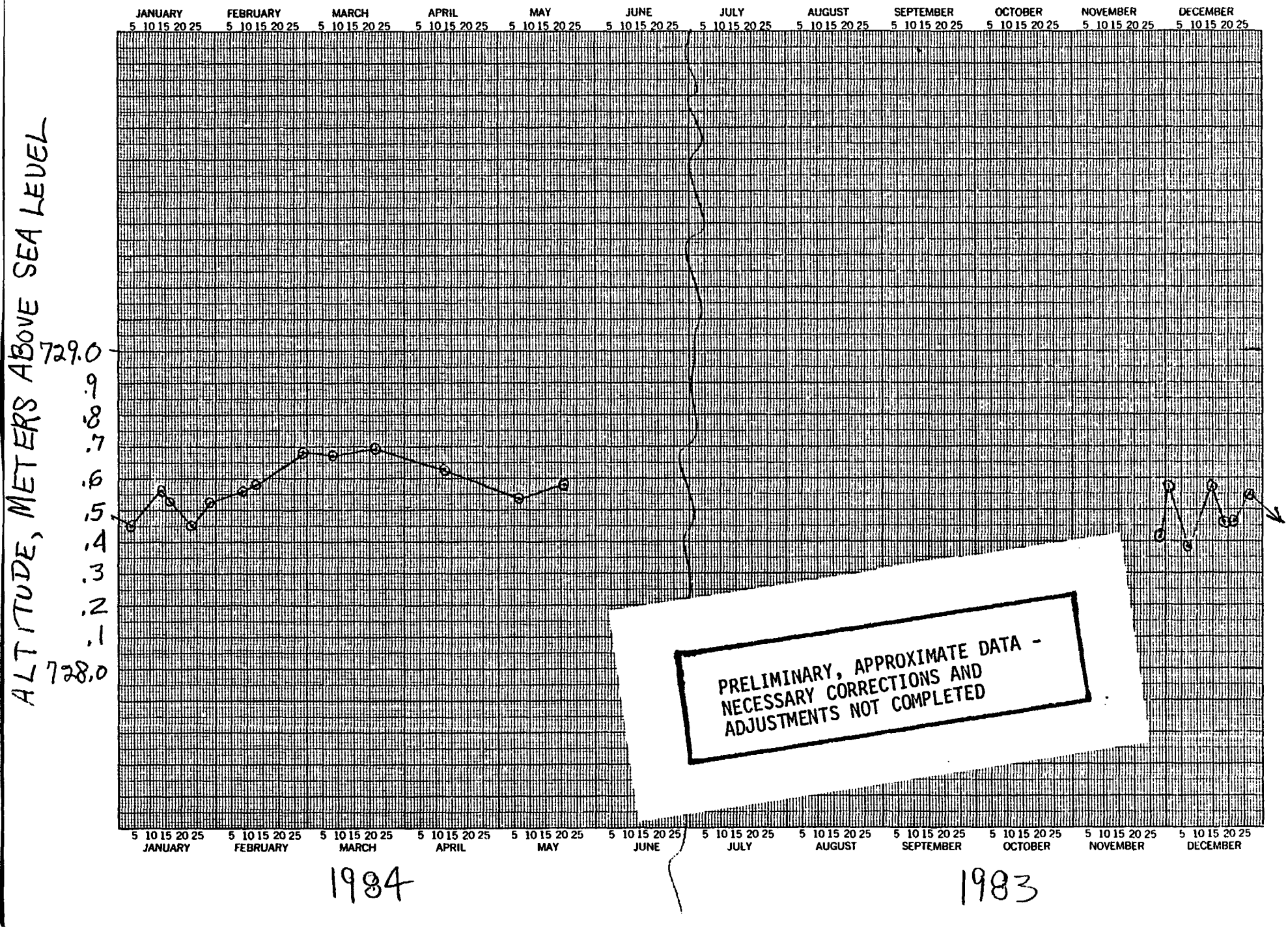
UE-25 WT#15



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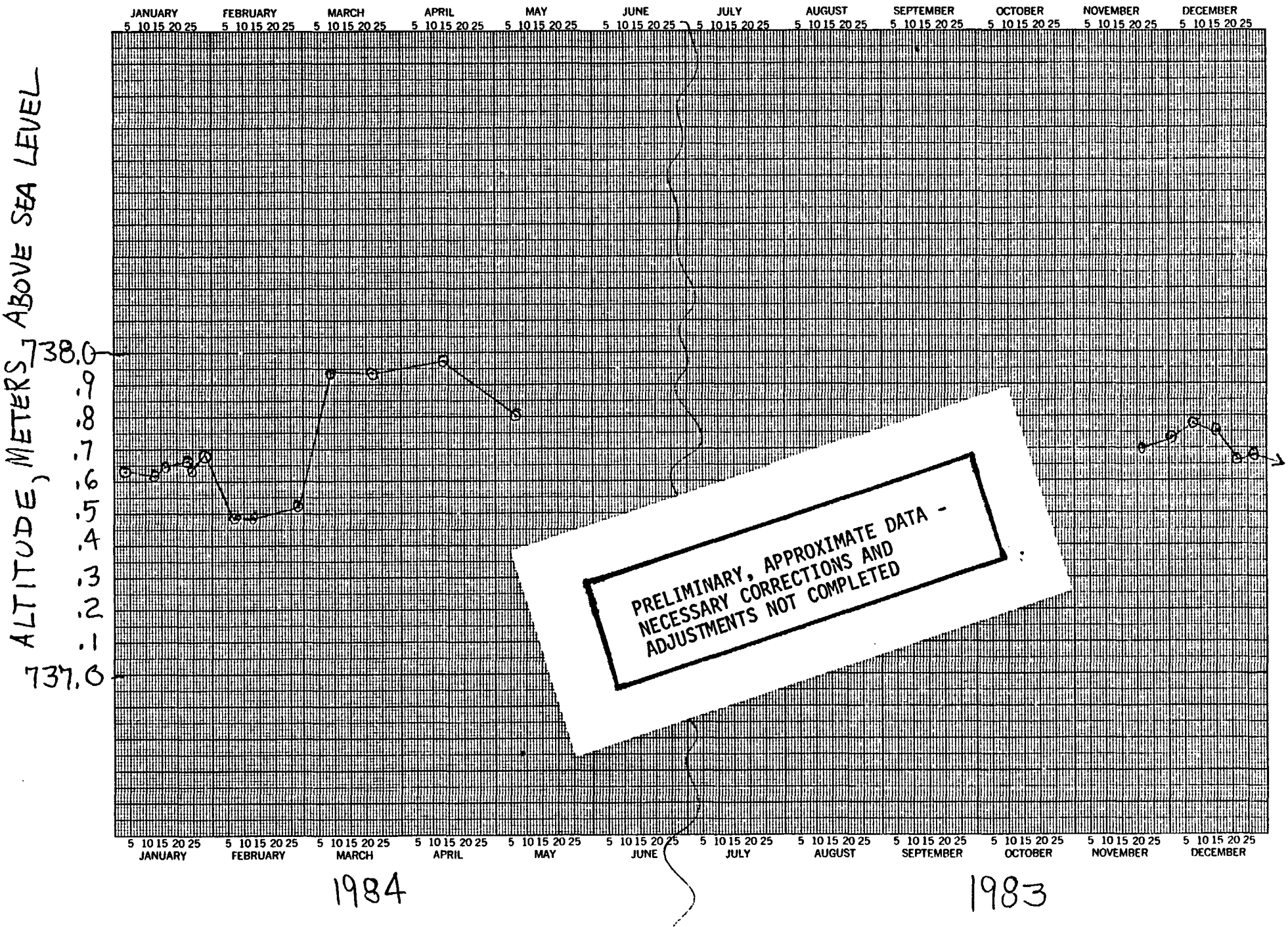
UE-25 WT#16



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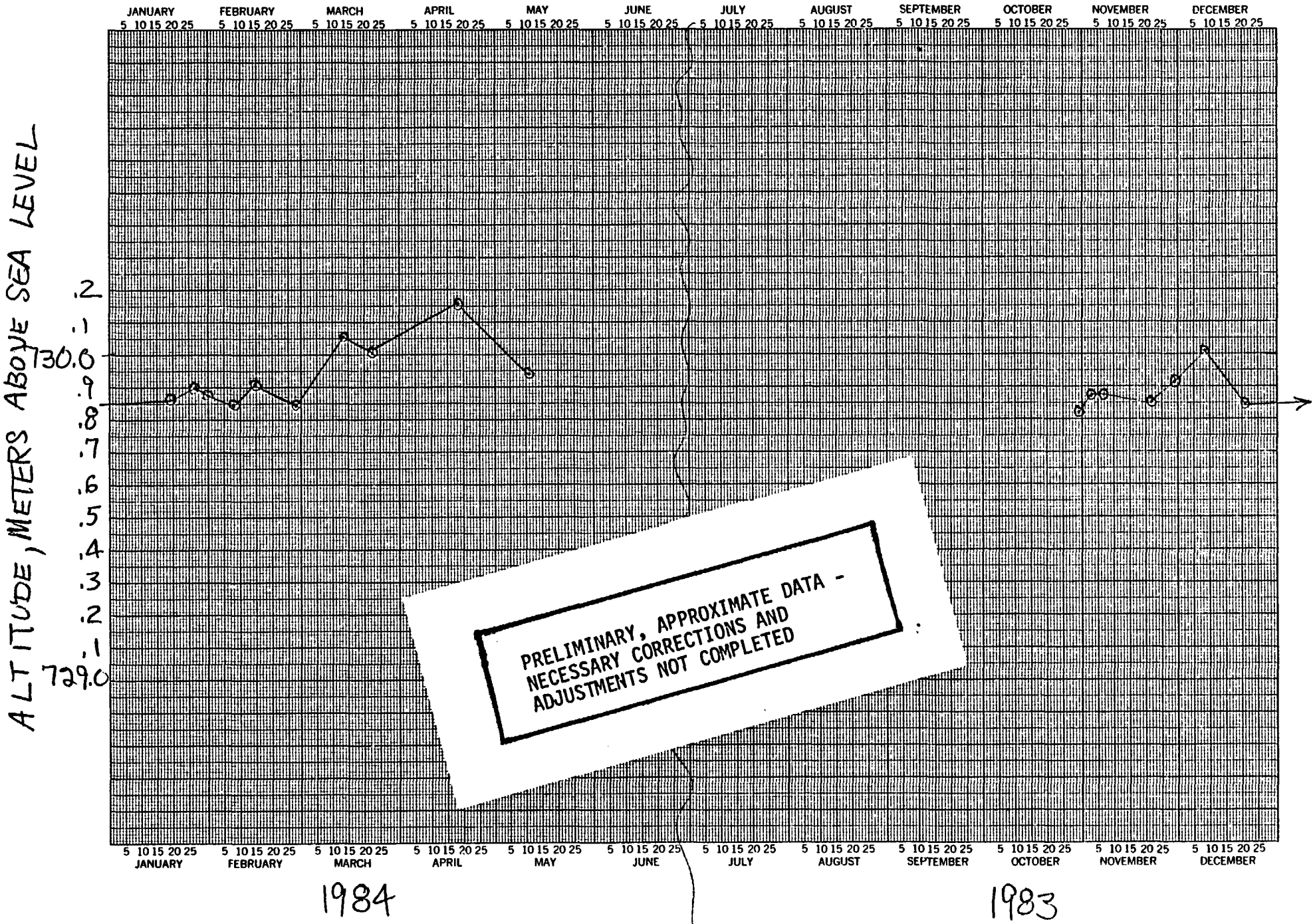
UE-25 WT#17



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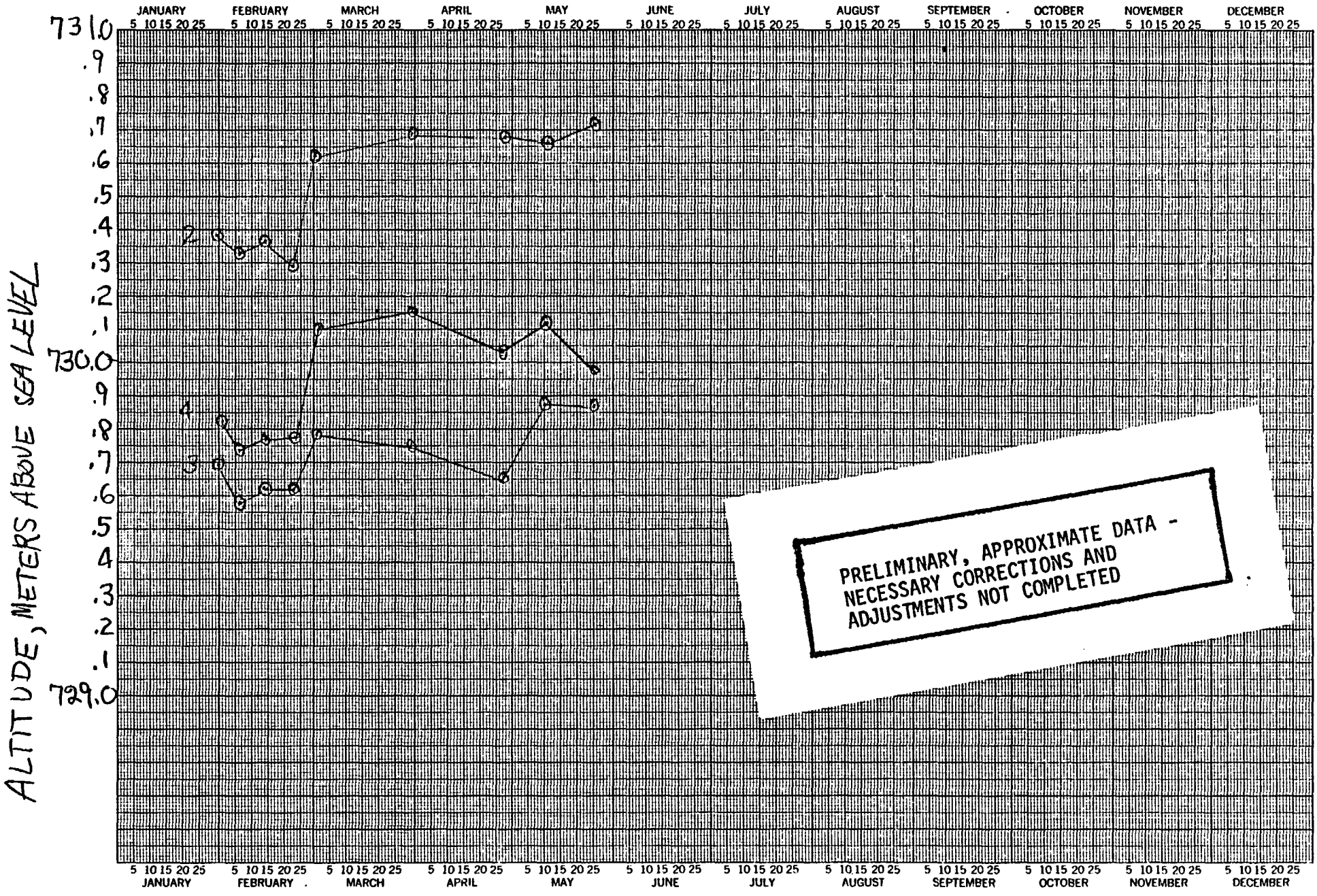
46 2890

USW H-1 Tobes 2,3,&4 (4 is shallowest)

jhr 6/13/84



1984

K+E 1 YEAR BY DAYS X 250 DIVISIONS
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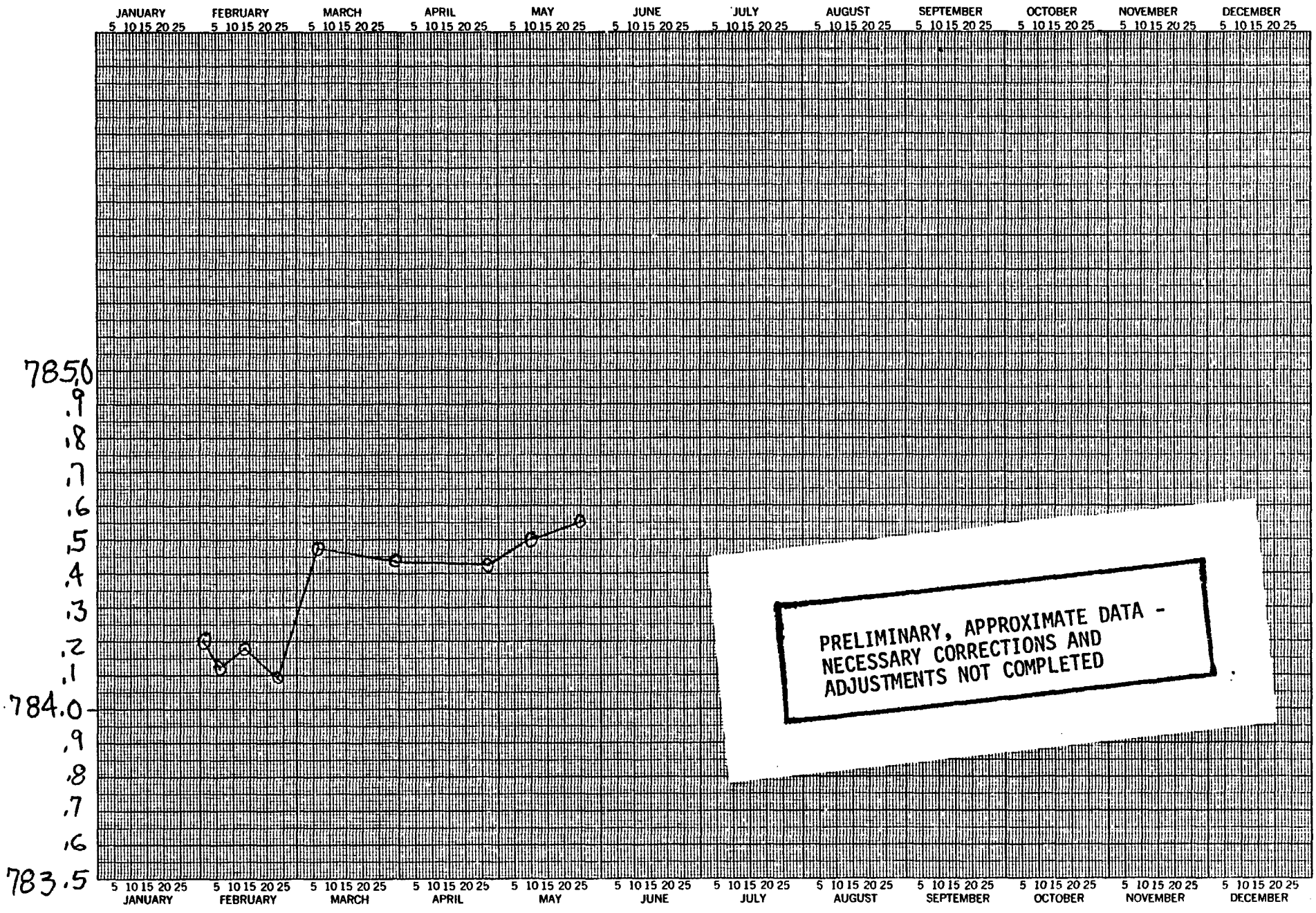
46 2890

USW H-1 Tube 1 (deepest

jhr
6/13/84



1984

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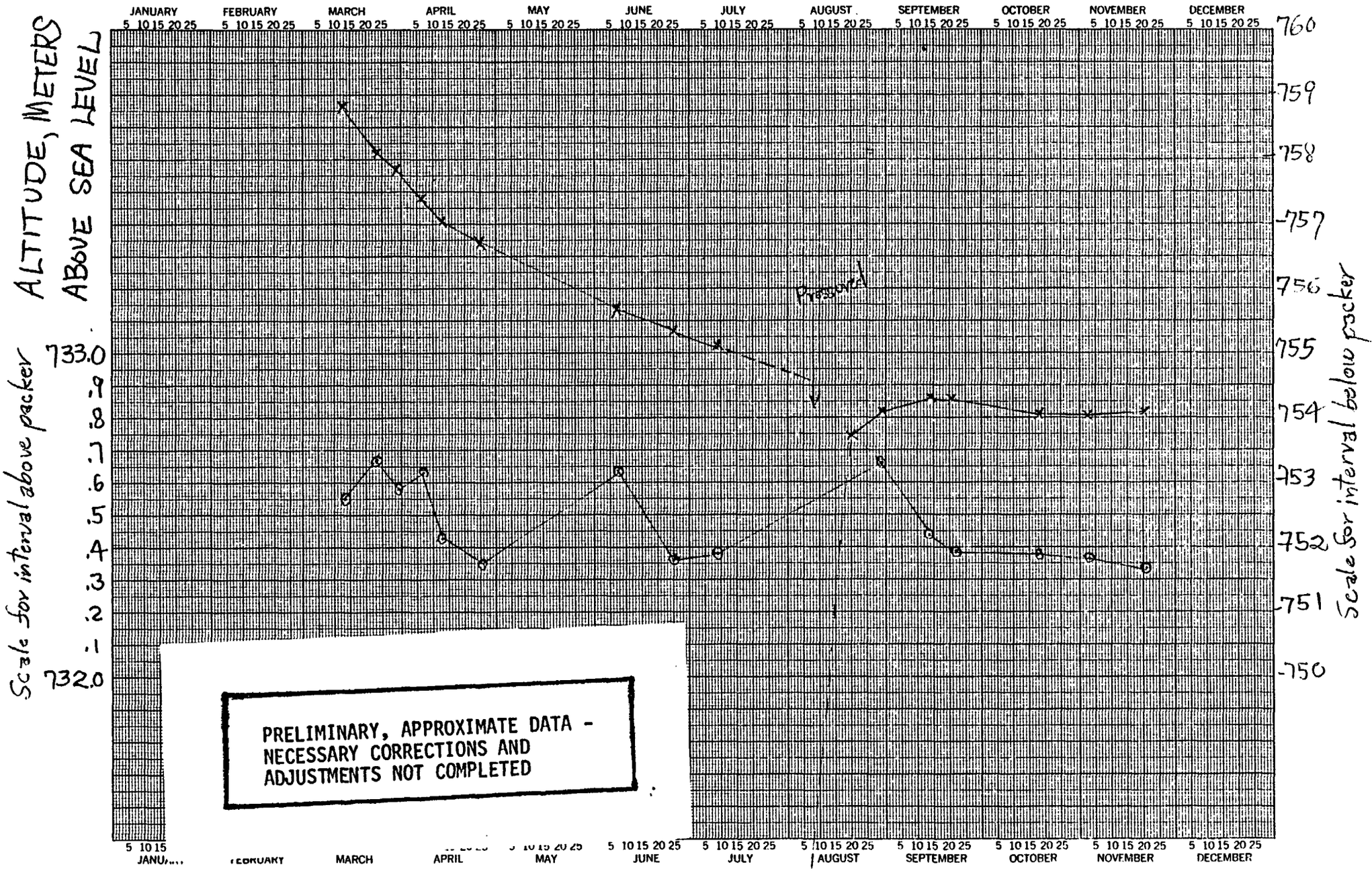
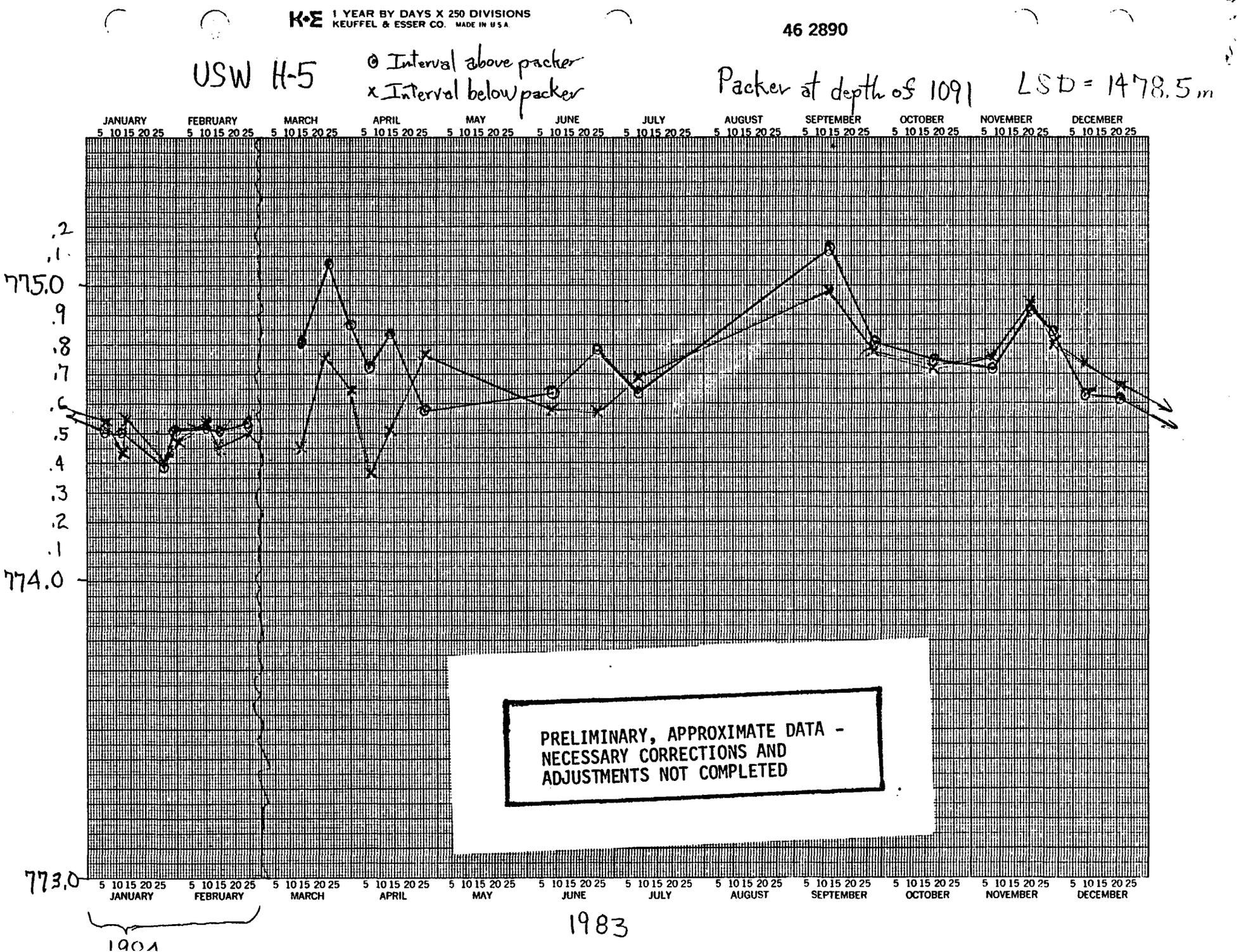
USW H-3

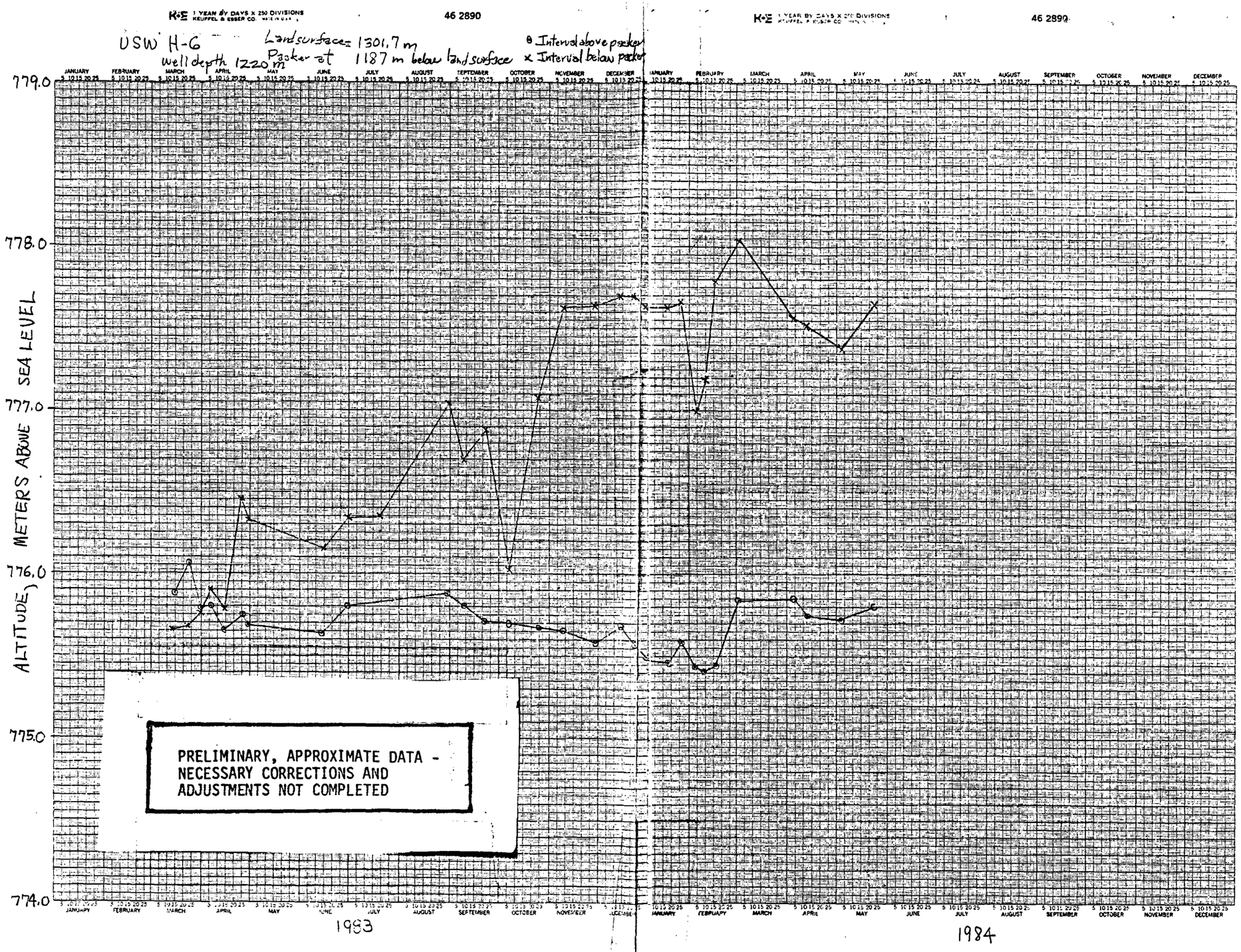
⊙ Interval above packer
× Interval below packer

Packer at depth of 1190 m



1983


K+E 1 YEAR BY DAYS X 250 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 2890
USW H-5
⊙ Interval above packer
x Interval below packer
Packer at depth of 1091
LSD = 1478.5 m
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
.2
.1
775.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
774.0
773.0
PRELIMINARY, APPROXIMATE DATA - NECESSARY CORRECTIONS AND ADJUSTMENTS NOT COMPLETED
1984
1983


USW H-6
Land surface = 1301.7 m
well depth 1220 m
Packer at 1187 m below land surface
⊖ Interval above packer
x Interval below packer
ALTITUDE, METERS ABOVE SEA LEVEL
779.0
778.0
777.0
776.0
775.0
774.0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1983
1984
PRELIMINARY, APPROXIMATE DATA - NECESSARY CORRECTIONS AND ADJUSTMENTS NOT COMPLETED