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SOME GUIDELINES FOR THE SUBMARINE-LAUNCHED EXPENDABLE BATHYTHERMOGRAPH (SSXBT) SYSTEM

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FOREWORD

Antisubmarine warfare is similar to guerrilla warfare in that the tactician who has best knowledge of the surrounding environment has an advantage. Accurate sonar range prediction provides the submariner with information about this environment, but such predictions are only as good as the inputs used in their generation. Because the sound speed profile is one of the most sensitive inputs to sonar range prediction, submarine-launched expendable bathythermograph (SSXBT) data must be processed with care. This report provides sonar technicians with reference material to assist recognition of SSXBT system failure, trace interpretation and system utilization.

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Captain, USN
Commanding Officer

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The AN/BSQ-23 and AN/BQH-7 expendable bathythermograph (SSXBT) systems provide the means whereby a submariner can obtain information about the surrounding ocean. Because the systems are, of necessity, more complex than similar systems used aboard surface ships, the incidence of failure has been high. This report incorporates suggestions to improve system performance by providing insight into recognizing system failures and trace interpretation. Additional information is provided concerning frequency of observation, relationship to other onboard sensors, system calibration, use of the data with the Submarine

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Fleet Mission Program Library resident in the TEKTRONIX 4051 desktop calculator and trace disposition.

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INTRODUCTION

The submarine-launched expendable bathythermograph (SSXBT) system* provides information required for the tactical decision making process including propagation loss versus range curves (PROPLOSS), MK 48 torpedo settings and search plan selection. As with any data processing system, input of erroneous data can have considerable impact on the final product. Analysis of 118 SSXBT traces collected during recent submarine exercises shows that 37.3 percent experienced system malfunctions and should not have been used as input to the TEKTRONIX 4051/4052 desktop calculator (DTC). An additional 26.3 percent showed partial failure but still provided useful data to a depth of at least 1,000 feet. Unfortunately, many of the malfunctions were not recognized by the operator. When both SSXBT trace and DTC hard copy were available from the exercise data package, it was noted that a majority of the data had not been encoded properly as input to the SVP Entry and PROPLOSS routines of the Submarine Fleet Mission Program Library (reference 1). Review of available materal (references 1 through 3) shows that the operator is provided with limited guidance in the preparation and use of the data to generate tactical indices. Guidelines for the tactical use of the SSXBT system will be included in a forthcoming revision to reference 4.

The purpose of this report is to review operating guidelines, SSXBT system failure and procedures for using the data with the Submarine Fleet Mission Program Library (SFMPL). Examples are given based on actual observations. Where possible, suggestions are made to improve system performance. When data indicate that electomechanical problems exist or calibration is required, the user should refer to the appropriate technical material (references 2 and 3). It should be noted that the material provided in this report constitutes neither tactical doctrine nor maintenance/operating procedure. The reader is urged to consult the appropriate documentation (Naval Warfare Publication, tactical memo, NAVSEA technical manual) for this information.

TRACE EVALUATION

Examination of a newly acquired SSXBT trace will reveal considerable information about both the surrounding water and the SSXBT system itself. The trace should be compared with recent SSXBT and AN/BQH-1 data, sound speed profiles supplied from regional oceanography centers and historical values available from the SFMPL or microfiche produced by Fleet Numerical Oceanography Center, Monterey, CA. A trace is probably good if (a) the shape appears similar to data processed previously, (b) temperature values agree within a few degrees at the surface and $1^{o}F$ to $2^{o}F$ at 2,500 ft, and (c) if no system malfunctions are evident. If the trace appears reasonable to depths to 1,000 ft but indicates problems at deeper levels, then the valid portion of the trace should be used. It is recommended that deepwater traces providing good

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* Two systems are presently in use: the older AN/BSQ-23 and the newer AN/BQH-7. The former system is derived from units used aboard surface units whereas the latter is a miniaturized system designed for use aboard submarines.

data to depths less than 1,000 ft not be used because of problems which arise during the process of merging input SSXBT data with the historical data included in the SMFPL SVP Entry Routine.

When an observation differs considerably from previous data, either the ship has entered a new water mass or the SSXBT system malfunctions. The boundary separating water masses -- termed oceanic front -- is a region of variable temperature and sound speed, and is frequently accompanied by strong currents. Natural oceanic turbulence near fronts is greater than in other areas, thus SSXBT failure rate is likely to be above normal. Figure 1 shows the general location of recognized oceanic fronts. Transient fronts may occur elsewhere owing to natural environmental occurrences such as abnormally high winds and oceanic eddies. Several techniques using onboard sensors are useful in detecting fronts and eddies:

- Sound speed from the BQH-1, keel depth and submarine position can be logged hourly to provide a record of oceanic variability. Where a change in sound speed of 10 to 15 ft/sec or greater is noted without a change in depth, it is probable that an oceanic front was encountered. An example of BQH-1 sound speed and injection temperatures at constant depth and plotted at regular intervals during a transit of the Gulf Stream and adjacent waters is shown as figure 2. Although not as reliable an indicator, engine room injection temperature can be used if the BQH-1 is malfunctioning.

- Set and drift can be computed by comparison of SINS and EM log observations. Currents greater than normal and a shift in current direction in the open ocean are indicative of an oceanic front.

If observations indicate that a change has occurred, an SSXBT observation is desirable. However, the SSXBT should not be deployed until the front has been crossed and acoustic conditions have stabilized. It is recommended that an SSXBT observation be made daily even in the absence of information indicating change because of normal oceanic variability. Should the ensuing PROPLOSS curve show change, the sonar lineup must be adjusted accordingly. When an oceanic front is observed within an operating area, its position must be determined since different sonar lineups may be required on opposite sides of the feature.

CALIBRATION

The system should be calibrated regularly in accordance with the procedures given in references 2 and 3. During normal operation, calibration can be checked by observing the movement of the stylus during the CHECK/RUN and RUN modes of operation. If the stylus registers outside specified limits, the recorder requires calibration. Most frequent signs of recorder problems include:

- The stylus did not move to the calibration temperature of $62.0^{o}F \pm 0.2^{o}F$ during CHECK/RUN mode.

- At the start of the RUN mode, the stylus moves from the 62°F point on the SURFACE line to the ambient sea surface temperature. Adjustment to the gain control is required if the recorder chart moves more than 5 ft (one quarter of a depth division) for every 10°F of temperature change.

- As the stylus moves from the calibration point at the start of the RUN cycle, it should overshoot surface temperature. If the overshoot exceeds 1.5°F to 2.0°F or undershoots (forms a downward arc from the calibration point to the ambient temperature value), the servo amplified gain control requires adjustment.

- Depth is not measured by the SSXBT probe but is estimated from average probe sink rate. Recorder run time to depth of 2,500 ft should be 2 minutes and 58 seconds. Run time that differs by more than 4 seconds from this value indicates that calibration is required.

- If a probe shows consistent failure at launch as indicated by immediate movement of the stylus to the high temperature side of the scale and erratic movement thereafter, the problem is probably an electrical ground. It is recommended that the connector box and breech mechanism be inspected and thoroughly cleaned.

- Rapid vibration of the stylus (noise, chatter) can be caused by the recorder (groove on the potentiometer), mechanical noise (tether wire rubbing against the ship) or electrical interference (radar, radio transmission). Noise caused by the potentiometer generally occurs whenever the stylus crosses a particular temperature value (62°F). Mechanical noise is generally at irregular periods, while electrical interference occurs at regular periods (radar sweep, CW keying).

ERROR RECOGNITION

Having determined the nature of the surrounding ocean and whether the system is in calibration, it is necessary to determine if an individual probe operated as designed. Examples of both valid and problem traces are provided in the appendix. Error recognition and, where possible, adjustment of the data for use in the DTC require considerable judgment and experience on the part of an operator. There are times when even a highly experienced oceanographer cannot distinguish between good and bad data. The best recognition aids are knowledge of the thermal characteristics of the local operating area and the ability to recognize system failure. If recent data are not available, inspection of the microfiche sound speed profiles is recommended. The Naval Oceanographic Office is publishing a series of environmental guides (NAVOCEANO SP-3160 series) which provide an excellent overview of oceanic and acoustic conditions for specific ocean areas. The bottom loss values used in these guides may differ from those developed for RAYMODE and should not be used with the DTC.

The following review is recommended to determine if a specific trace is suitable for entry into the DTC:

- The recorder stylus should have made a calibration tick at 62°F ± 0.2°F. If the mark is outside these limits recorder calibration is required.

If no mark appeared or if the stylus did not proceed directly to ambient sea surface temperature upon launch, the data should be used with caution.

- Immediate movement of the stylus to the right or left margin of the trace upon launch suggests that an electrical problem existed. The difficulty of determining surface temperature and layer depth under such conditions makes traces useful only when the required information is available from other means. The operator cannot be sure that the trace recovered fully at depths below the off-scale portion.

- Presence of oceanic structure (sound channels, surface heating) not observed on earlier observations should be examined carefully. A second probe or a SVP sounding is recommended. Checking an independent source, such as microfiche is helpful. The operator should consider if the observed feature is known to exist under present environmental conditions or, in fact, if such a feature is physically possible.

- In the absence of an oceanic front, the general shape of the trace should be similar to previous traces. It is, however, possible for a trace to be offset toward high or low temperatures. If surface temperature differs by more than $5^{\circ}F$ or temperature at 2500 ft differs by more than $2^{\circ}F$ from previous traces, the probe may have failed. Such data should be used with caution as it is difficult to tell at what depth such probes failed.

- In shallow water, the depth of the tick mark indicating bottom strike should be compared with those provided by the fathometer or appropriate nautical charts. If not, either ship's position or the chart may be in error. More oceanic variability should be expected in shallow water than in deep water.

- If erratic stylus movements occurred, it must be determined if they are the result of actual conditions or a system malfunction.

TRACE REDUCTION

An SSXBT trace must be reduced to 20 or less depth-temperature pairs* for entry into the DTC. Point selection is often a matter of individual interpretation with the only criterium being that a curve reconstructed from the selected pairs should closely resemble the original trace. The following features should be digitized:

- Sea surface temperature (or temperature at first valid point below the surface if the surface value is in question).

- Sonic layer depth -- approximated by the bottom of the surface mixed layer if present.

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* Although the BQH-7 recorder is designed to provide data in either temperature or sound speed units, use of temperature is preferrable because it is the parameter measured by the probe thermistor whereas sound speed is derived. Conversion will occur automatically upon input to the DTC.

- Inflection (flexure) points including bottom of the seasonal thermocline, sound channel axis(es) and boundaries, top and bottom of gradients, and suitable intermediate points between widely separated depth or temperature values.

- The deepest valid point on the trace but in no case deeper than 2,500 ft.

Figure 3 is a sketch of the ocean thermal structure giving the names of the various features in the upper layer of the ocean. Arrows indicate the points on the schematic that should be digitized on this trace. Minor deviations (0.5°F) from the trace -- either real or spurious -- should be ignored. A pencil or straightedge held along the trace can be useful as a guide in locating inflection points. Arrows or lines drawn on the record mark points for later encoding.

A common tendency is to encode values at depths that are multiples of 100 ft (example 200, 400, 500, ...) or whole degrees of temperature (52°, 60°). This procedure is not as effective as the method described above because important features may be missed. There is no need to manually convert metric units to English units as the DTC performs this function automatically.

The AN/BSQ-23 recorder stylus may not be centered on the SURFACE line of the recorder chart prior to launch. This problem -- called <u>depth offset</u> -- can be corrected after the fact by adding or subtracting the amount of offset from the depth values when encoding the trace. For example, if the recorder stylus started the trace 40 ft above (below) the surface line, a 40 ft correction must be added (subtracted) to the depth scale. The surface (0 ft) would be taken at the point where the stylus started its downward trace.

This problem appears to have been corrected in the AN/BQH-7 system by addition of an optical sensor which locates a hole in the recorder paper, thereby assuring that the stylus is on the SURFACE line at launch.

A typical problem trace is shown as figure 4. Two features are immediately evident: 1) the stylus was not on the SURFACE line when activated, and 2) a region exists between 30 ft and 140 ft where stylus vibration above a step-like discontinuity suggest that the probe encountered difficulty separating from the float. The first problem is corrected by considering the trace to start at the 30-ft mark and subtracting this value from all subsequent depths. The area of uncertainty (corrected depth: 0 to 110 ft) could have been treated by entering the first point at a depth of 110 ft and letting the DTC extrapolate upwards to the surface. Because the extrapolation is a linear extension of the first two points, the user must ensure that these points reflect the overlying gradient. The trace as actually input (without correction) to the DTC and the resulting PROPLOSS curve are shown in figure 5a. Neither of the recommended surface corrections were made. Furthermore, with the exception of points between the surface and SLD, temperature values were input at intervals in multiples of 100 ft (600, 700, 900, ... ft) rather than at inflection points.

Figures 5b. and 5c. show the same trace digitized as recommended. The two profiles differ only in uncertainty as to whether the temperature step in the mixed layer was real. The resulting PROPLOSS curves show little difference between them, but differ considerably from the incorrect curve in figure 5a.

Space does not permit description of the cause and effect of all SSXBT problems. However, it is important to realize that the purpose of good trace interpretation is to permit the range prediction module of the SFMPL to correctly determine how acoustic energy will be transmitted in the sea. Results will differ with respect to the relative geometric position of own ship and target to thermal structure features. Seemingly minor features may have considerable impact of a tactical nature. A submarine at periscope depth seeking a shallow target may not be affected by presence of a sound channel located at the bottom of the seasonal thermocline, whereas a submarine searching for a below-layer target would want to consider the dimensions of the channel when determining a search plan.

When computing the distribution of acoustic energy, the prediction model is influenced particularly by gradients and changes of gradients in the ocean thermal (sonic) structure. This is the rationale for the selection of the depth-temperature pairs used in figure 3. In direct path and cross-layer situations, point selection is critical for accurate determination of propagation loss versus range (PROPLOSS) information. Even in the convergence zone (CZ) mode of operation, where the SFMPL deep history controls the range and width of the CZ, the amount of available energy is determined by the near-surface structure.

PROPLOSS INPUT/OUTPUT

Once a trace has been examined for errors and digitized, it is necessary to generate appropriate tactical indices on the DTC. This section is not intended as a comprehensive review of SFMPL routine; however, a brief discussion of system input/output is in order. Owing to frequent misuse of RANGE INTERVAL, this input parameter is discussed in greater detail. The user must remember that good model results require careful selection of input parameters.

Input

a. Water Depth: Use fathometer or charted depth to ocean floor. Because the RAYMODE acoustic model considers a flat bottom only, charted depth midway to the CZ should be used if ranges beyond 50 KYD are required and the bottom is not flat.

b. Sea State/Wind Speed: Observed values should be used where possible. Table 1 is included to assist conversion from wave height to sea state. The use of wind speed should be avoided because the fetch and duration assumptions used in converting wind speed to sea state may not be fulfilled.

c. Bottom Province: Integer input (1 through 9) is required using the MGS values provided in Appendix D of reference 1. Neither the low frequency (<1.0 KHz) nor high frequency (≥1.0 KHz) bottom loss values promulgated by COMNAVOCEANCOM and used with PHITAR, microfiche and the ASW Prediction Area Charts (NWPBC 2401 Series) should be used with the SFMPL routines.

Table 1. Beaufort Scale with corresponding sea state codes

Wind	Estimating Wind Speed	State of the Sea		
Mean Velocity (knots)	Effects Observed at Sea	Sea State	Descriptive Term	Height of Waves (feet)
<1	Sea like a mirror.			
1 to 3	Ripples with the appearance of scales are formed, but without foam crests.	0	Calm (glassy)	0
4 to 6	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break.	1	Calm (rippled)	0 to 1/3
7 to 10	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses.	2	Smooth (wavelets)	1/3 to 1-2/3
11 to 16	Small waves, becoming longer; fairly frequent white horses.	3	Slight	1-2/3 to 4
17 to 21	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray).	4	Moderate	4 to 8
22 to 27	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray).	5	Rough	8 to 13
28 to 33	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.			
34 to 40	Moderately high waves of greater length; edges of crests begin to break into the spindrift; the foam is blown in well-marked streaks along the direction of the wind.	6	Very rough	13 to 20
41 to 47	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble and roll over; spray may affect visibility.			

Table 1. Con'd.

Estimating Wind Speed

Wind: Mean Velocity (knots)	Effects Observed at Sea	State of the Sea: Sea State	Descriptive Term	Height of Waves (feet)
48 to 55	Very high waves with long overhanging crests; the resulting foam, in great patches, is blown in dense white streaks along the direction of the wind; on the whole, the surface of the sea takes a white appearance; the tumbling of the sea becomes heavy and shock-like, visibility affected.	7	High	20 to 30
56 to 63	Exceptionally high waves (small and medium-sized ships might be for a time lost to view behind the waves); the sea is completely covered with long white patches of foam lying along the direction of the wind; everywhere the edges of the wave crests are blown into froth; visibility affected.	8	Very high	30 to 45
64 and over	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected.	9	Phenomenal	over 45

d. Range Limits: Range values should be selected to cover all ranges of interest. While plots including multiple convergence zones are helpful in determining maximum detection range, they may require multiple runs. If bottom depth or SVP changes over the range selected, the model assumptions are not met and PROPLOSS accuracy may suffer accordingly. Range increments are discussed later in more detail.

e. Target/Own Ship Depths: Keel depths are normally input for these parameters. In instances where own ship is near layer depth or a sound channel, the PROPLOSS routine may run faster and provide more accurate results if depth is adjusted to give sensor depth vice keel depth. In the case of a towed array, sensor depth must be determined as a function of ship's speed and wire scope.

Range Intervals

Range increments in the SFMPL PROPLOSS routine can be varied for any increment greater than 0.1 KYD. This option has the advantage of allowing either detailed PROPLOSS curves over short ranges or less detailed curves over greater distances (including multiple convergence zones) as long as the maximum number of computed points does not exceed 100. An unintended and undesirable side effect is the tendency of some operators to use excessively large increments in an attempt to decrease DTC run time. Increments of 10 to 20 KYD appear to be used routinely with increments of 40 KYD used on at least one occasion. Unfortunately, the loss of detail in the PROPLOSS curve more than negates the small savings in time realized.

The effect of large range increments is shown in figures 6 and 7. PROPLOSS curves are provided for: 1) a typical short range situation (1 to 20 KYD), and 2) a 20 KYD section covering the first convergence zone. All inputs were held constant with the exception of the range interval, which was varied selectively. The interval used in each run is shown in the lower left corner of each graphic. The gradual loss of detail as interval size increases is obvious. The effect is particularly undesirable when range to 50 percent probability of detection (R50) is determined using a typical figure of merit (for example, 85 dB). In the short range example, R50 changes from 4.5 KYD using a 1 KYD interval to 18 KYD using a 20 KYD interval. The effect in the convergence zone case is similar. In both cases the use of large range intervals could have contributed to the selection of overly optimistic sonar search plans.

For reasonable run times without undue loss of detail it is recommended that range interval should be approximately two percent of the total range covered. Thus, a two KYD range interval would be about right for a PROPLOSS curve covering from 1 to 80 KYD. The DTC has been modified to question users when intervals 5 KYD or greater are used.

Output

Abnormal output may be encountered occasionally owing to the difficulty of modelling the acoustic environment. The most obvious problem is a downward spike at ranges less than 10 KYD (figure 8). The spike occurs at lower frequencies (below 1.0 KHz) where searcher and target are near the surface with a shallow sonic layer. Although the spike can be reduced by adjusting search/target depths and range increments, it is easier to smooth the curve by drawing a line between the inner and outer limits of the spike.

The physics of the model are such that searcher and target depths are interchangeable. For example, a PROPLOSS curve generated with searcher at 300 ft and target at 60 ft would not differ from a curve with searcher at 60 ft and target at 300 ft. Thus, a single set of curves will cover two possible situations.

The relative position of own ship and target with respect to sonic layer depth (SLD) is of considerable importance when considering the refraction of acoustic energy. A search plan based on the incorrect premise that both searcher and target were on the same side of the layer would be overly optimistic in an actual cross-layer situation. Thus, when operating near SLD it may be best to develop search plans for above layer, cross-layer, and below-layer cases. An example of the effect of layer depth is shown in figure 9. In such cases it is important that SLD be monitored continually using the AN/BQH-1 with search plan adjusted accordingly.

TRACE DISPOSITION

Reference 5 states that, as consistent with mission and operations requirements, submarines shall make one or two observations each day when operating in areas where temperature versus depth data are likely to be sparse. Few observations are reported on a synoptic basis because submarine operations in these areas are normally classified. However, the data are of considerable value in preparing atlas-type presentations such as the NAVOCEANO Environmental Guide series and microfiche. Thus, the recorder trace, properly marked with position, date/time group (ZULU time) and proper security classification (confidential or unclassified only) should be either mailed directly or included in the patrol or exercise package for eventual transmittal to:

Commanding Officer
Fleet Numerical Oceanography Center
Monterey, CA 93940
ATTN: Code 41

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1. NAVTACSUPPACT Report FPL43-1, Fleet Mission Program Library, Effective Submarine Programs (U), CH 1-5, Feb 1978. CONF.

2. Sippican Corp., Report R-633B, Preliminary Technical Manual for Submarine Bathythermograph Set AN/BSQ-23, Sep 1977.

3. NAVSEASYSCOM, Publication SE 365-BO-MMA-010/BQH-7, Bathythermograph AN/BQH-7, Submarine Launched, Expendable (SSXBT), FOMM Support Volume, (Final Preliminary), Dec 1980.

4. CNO, Evasion, Pyrotechnic, and Signal Devices Reference Manual (U), Naval Warfare Publication 75-1A (under revision), CONF.

5. NAVOCEANCOMINST 3140.1 series, U. S. Navy Meteorological and Oceanographic Support Manual.

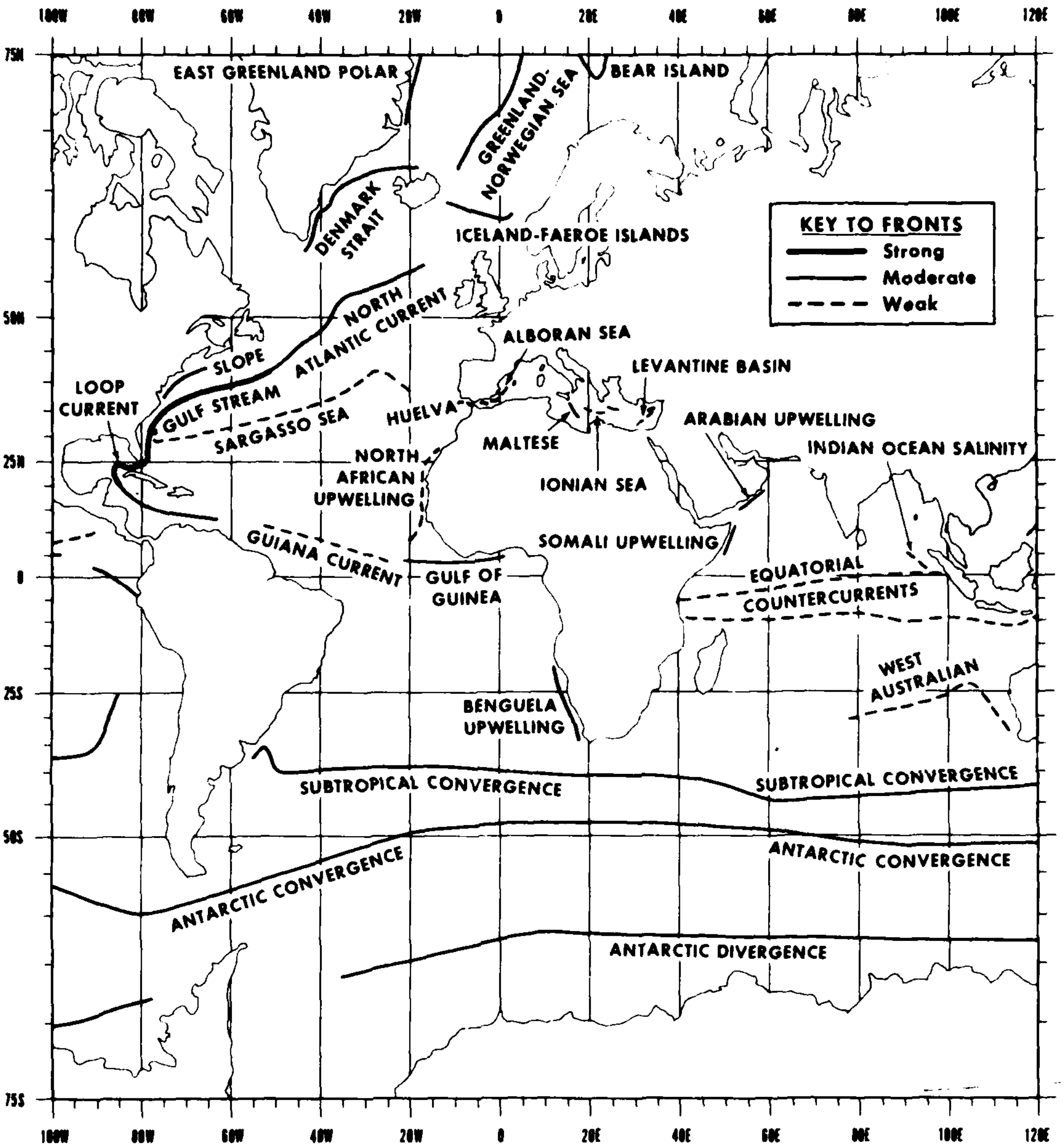

Figure 1a. Worldwide distribution of ocean fronts: Atlantic and Indian Oceans

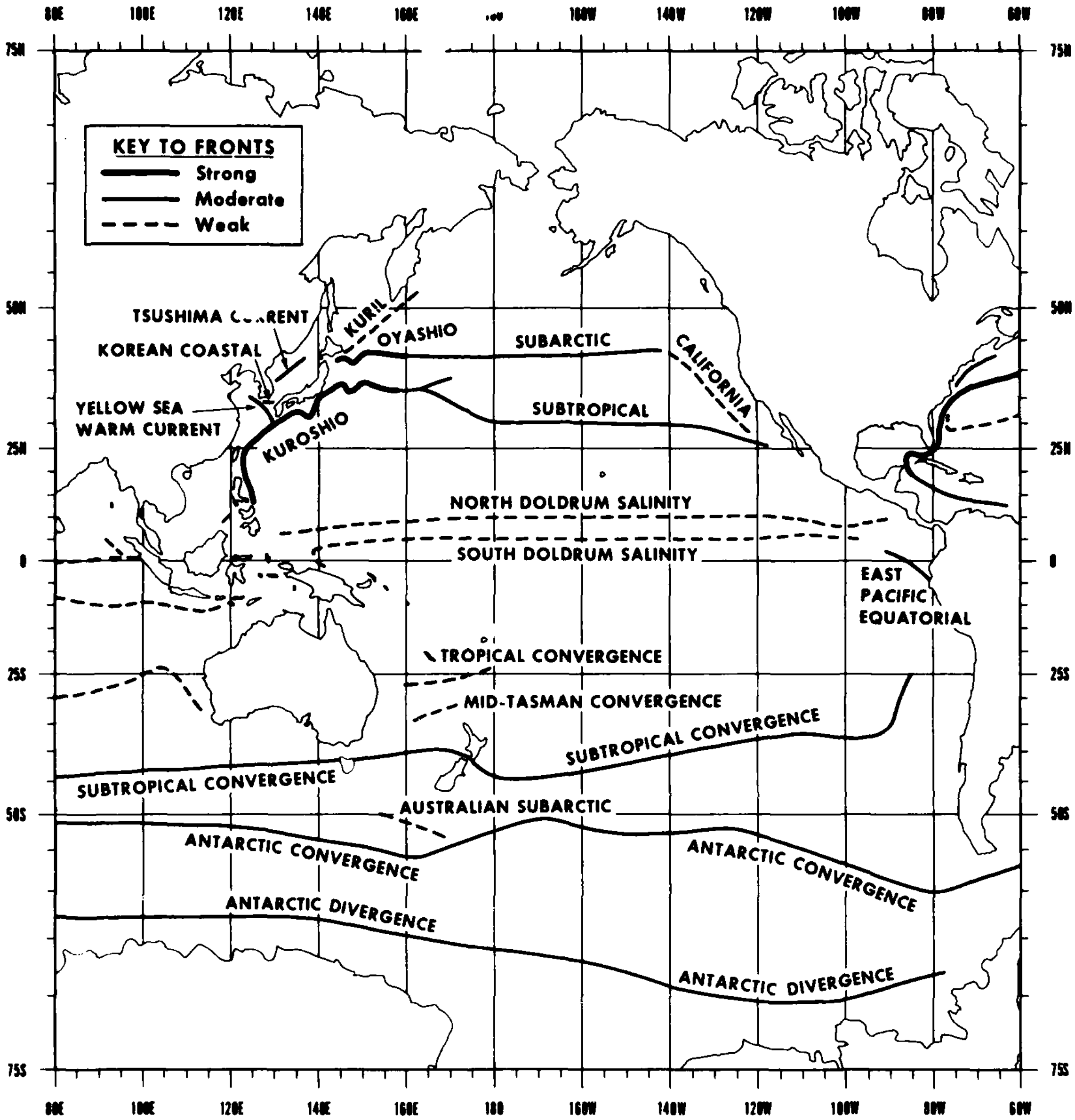

Figure 1b. Worldwide distribution of ocean fronts: Pacific Ocean

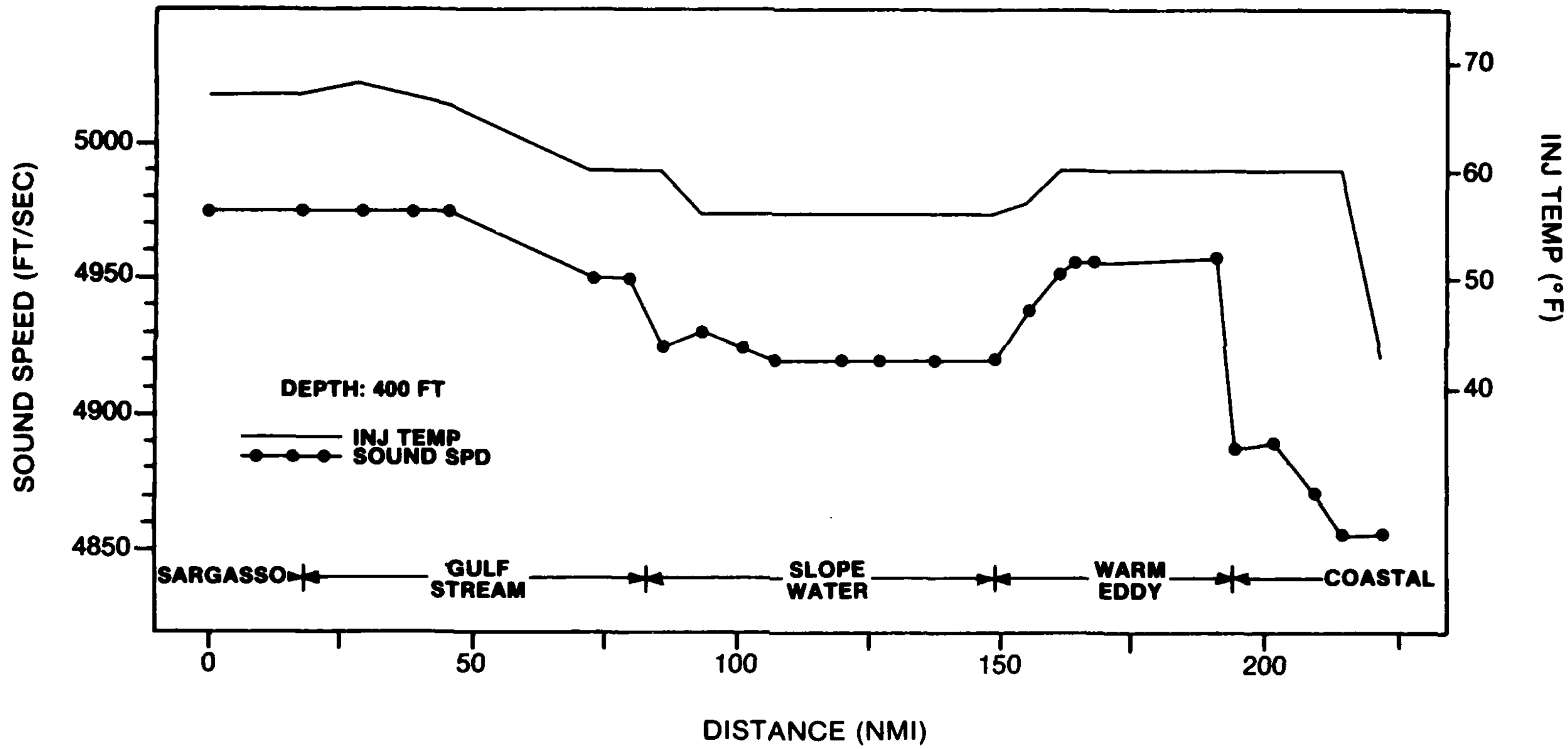

Figure 2. Sound speed at constant depth: Gulf Stream and adjacent waters.

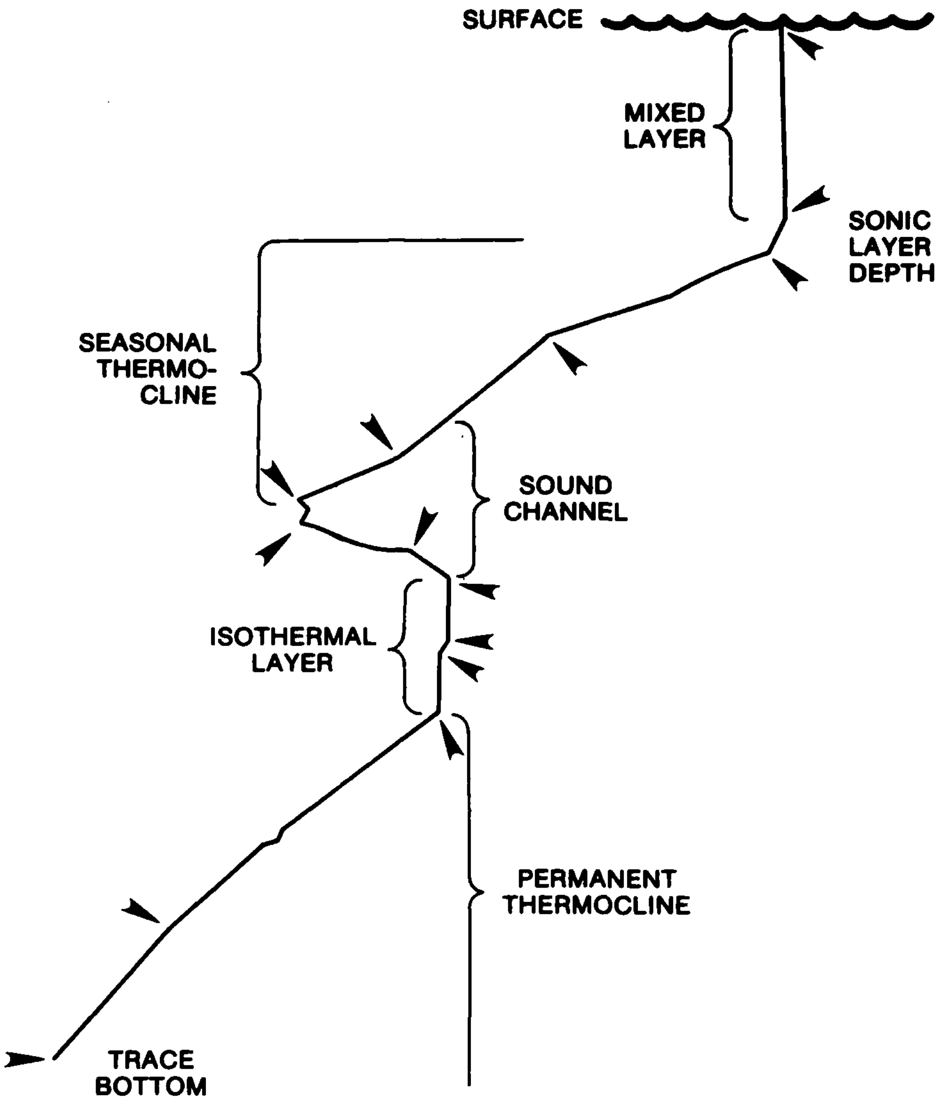

Figure 3. Schematic of oceanic features

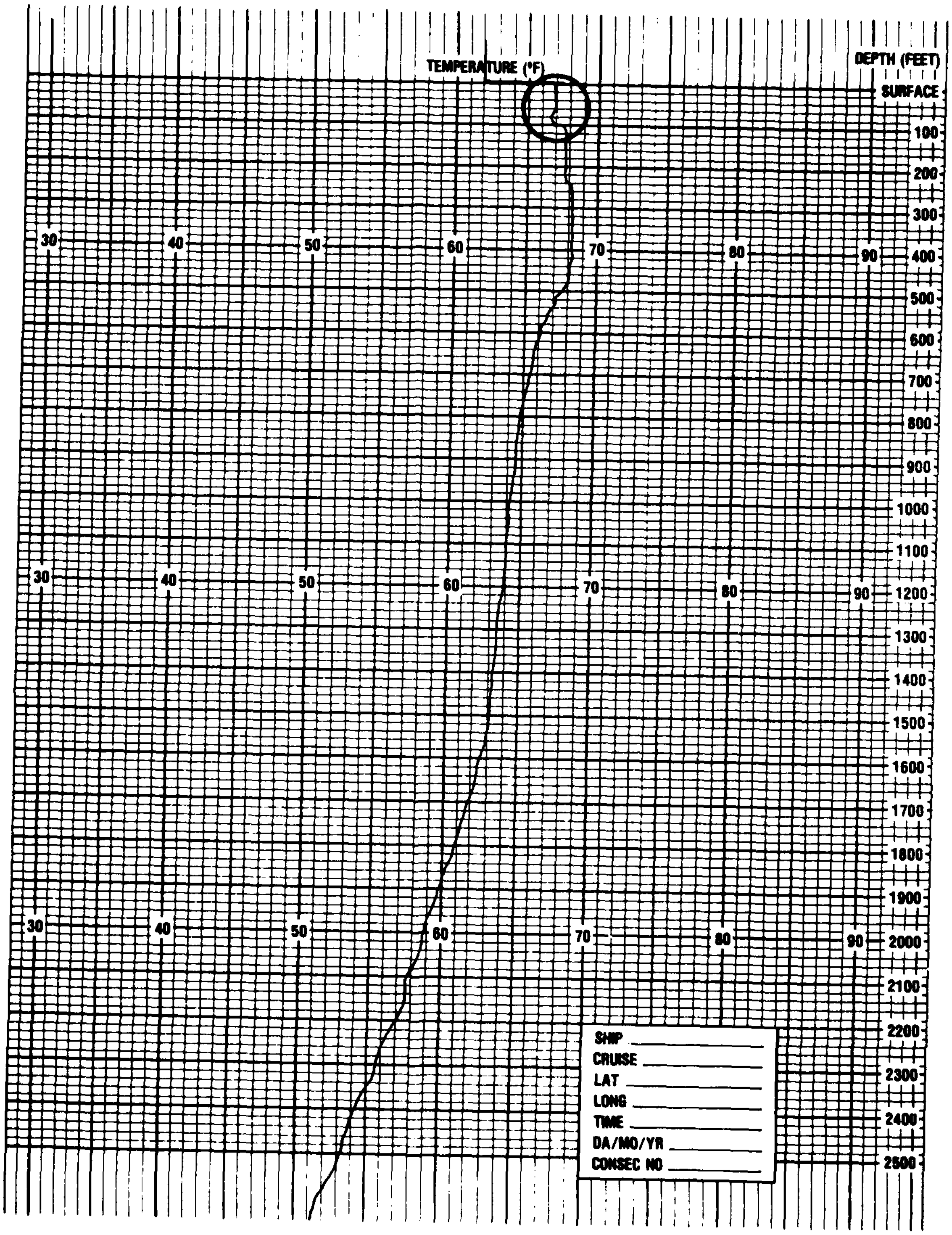

Figure 4. Example of XBT surface problem.

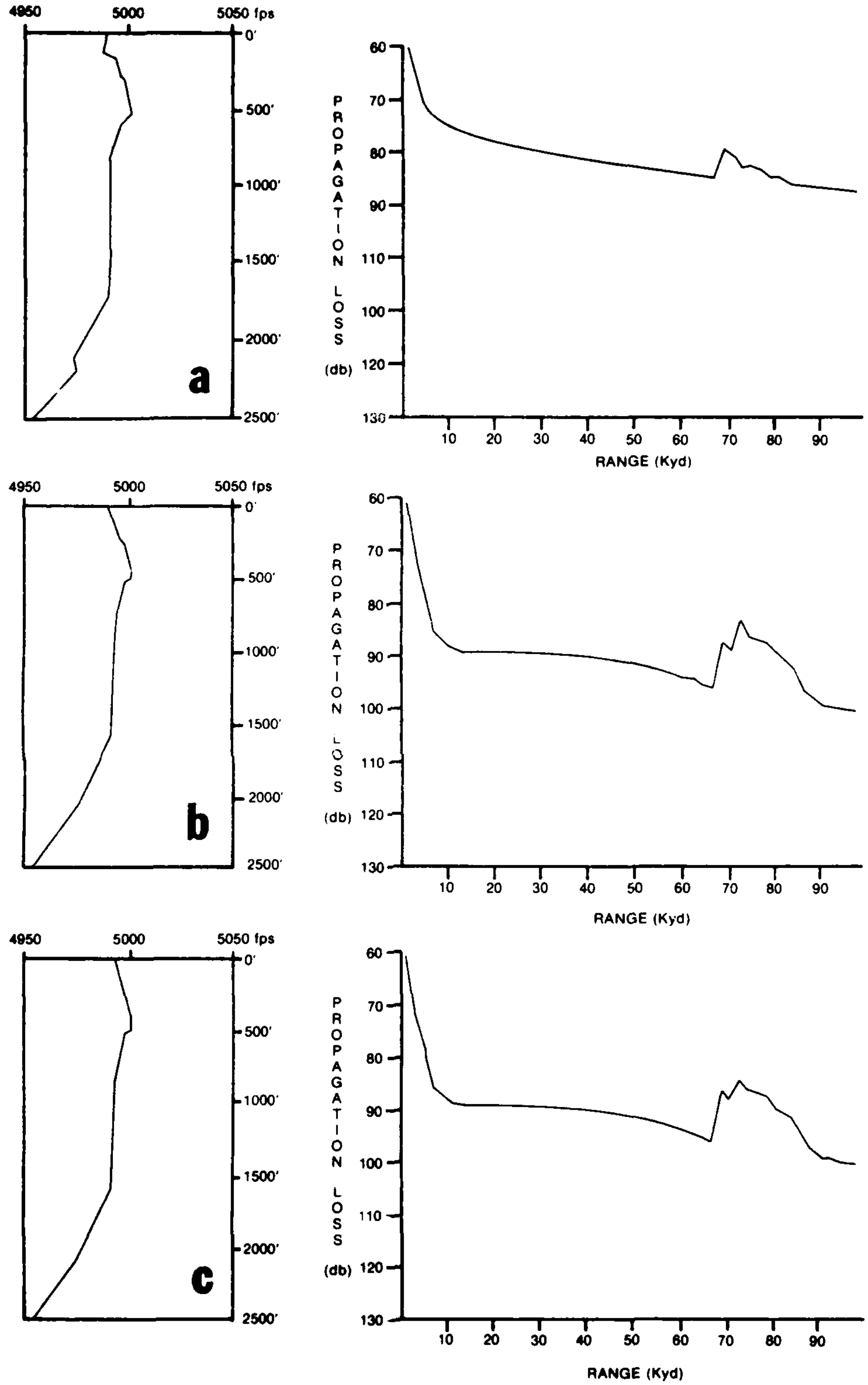

Figure 5. Effect of XBT digitization on proploss using (a) incorrectly digitized trace and correctly digitized with (b) and without (c) temperature step

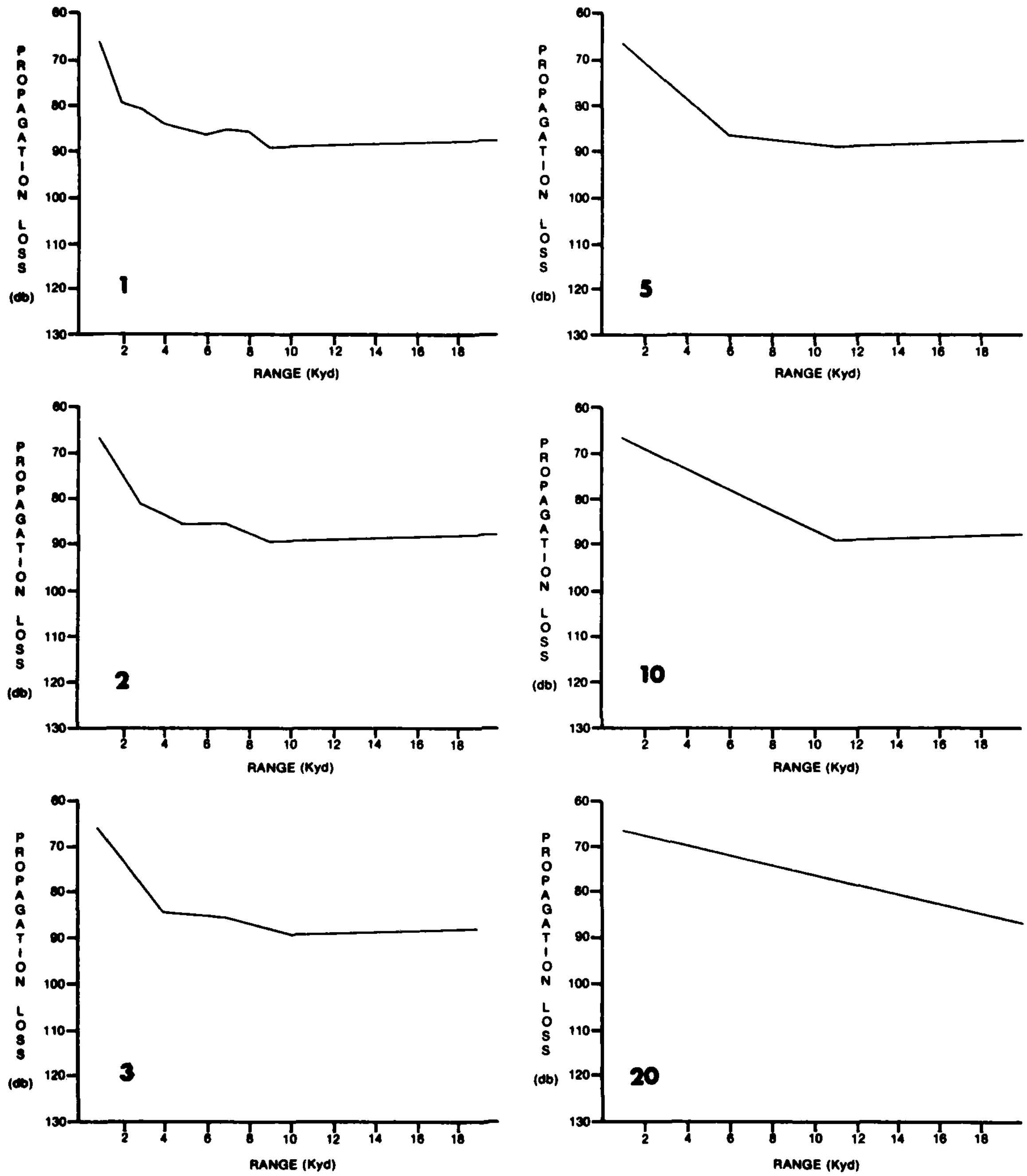

Figure 6. Effect of change in range interval on proploss: short range case

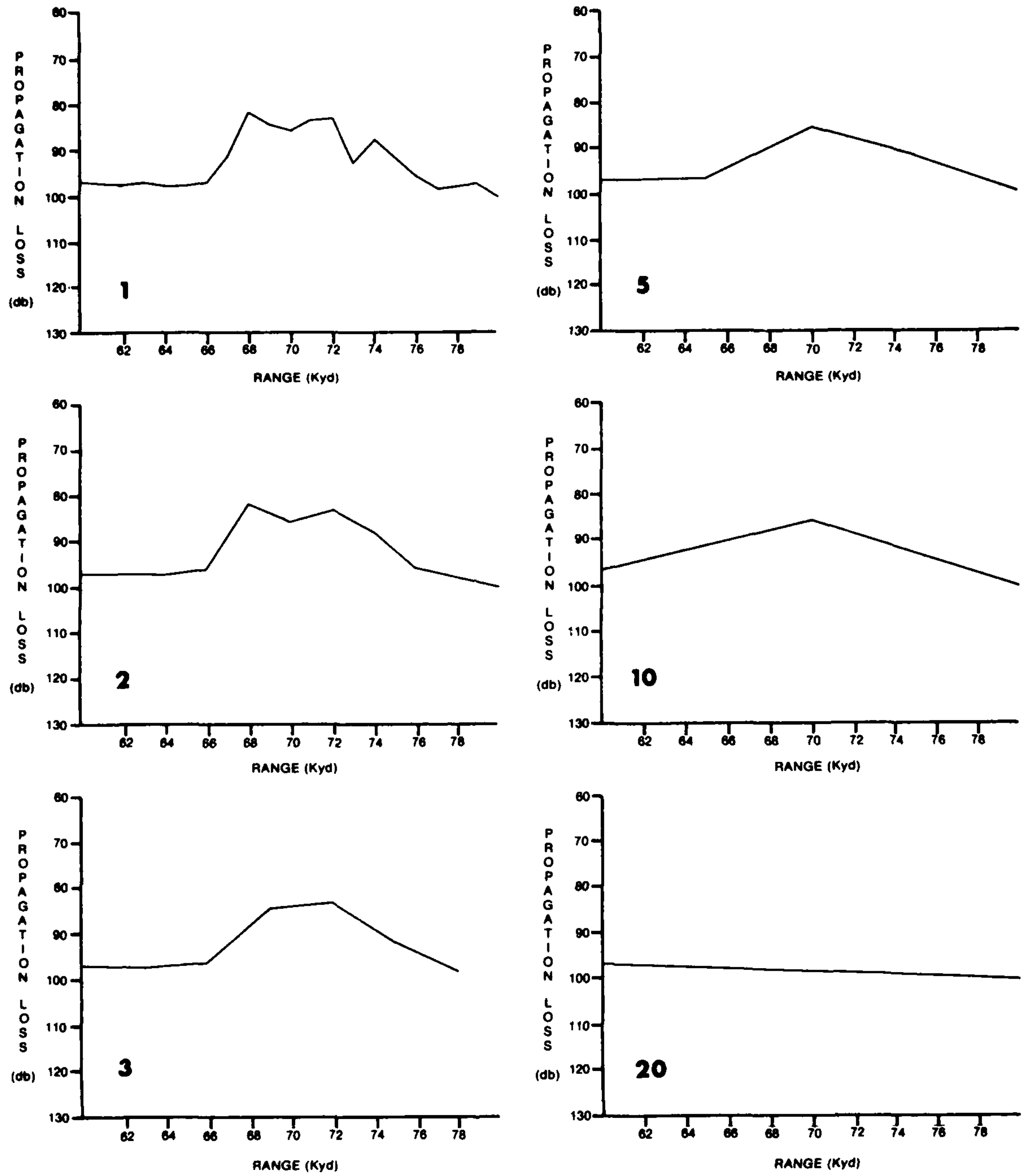

Figure 7. Effect of change in range interval on proploss: convergence zone case

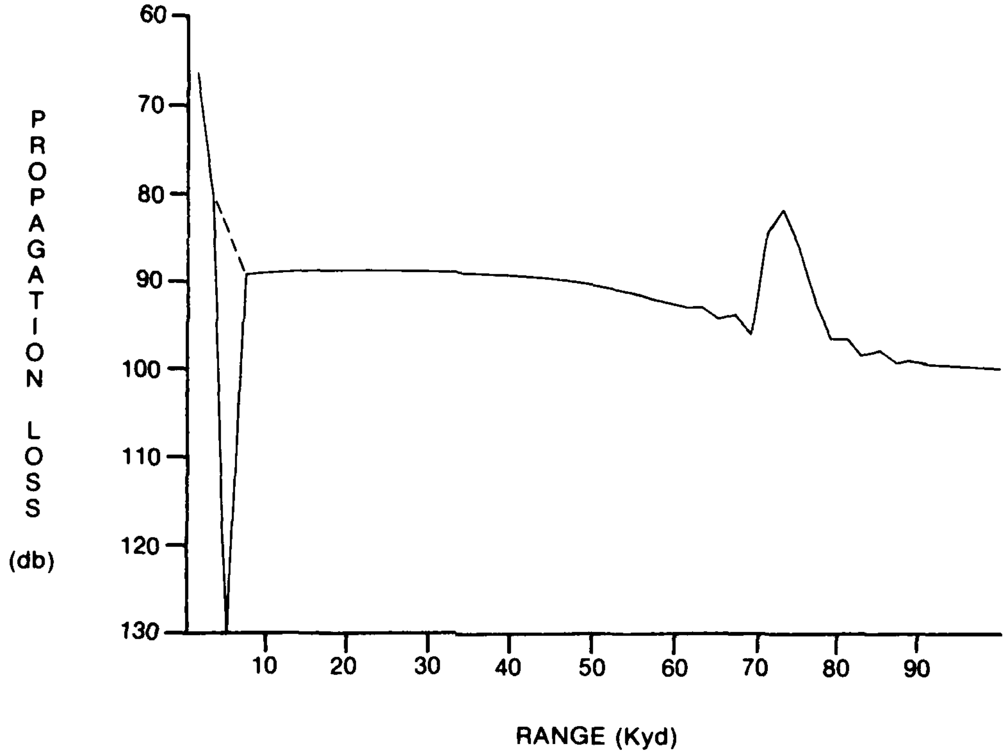

Figure 8. Example of false downward spike and recommended correction

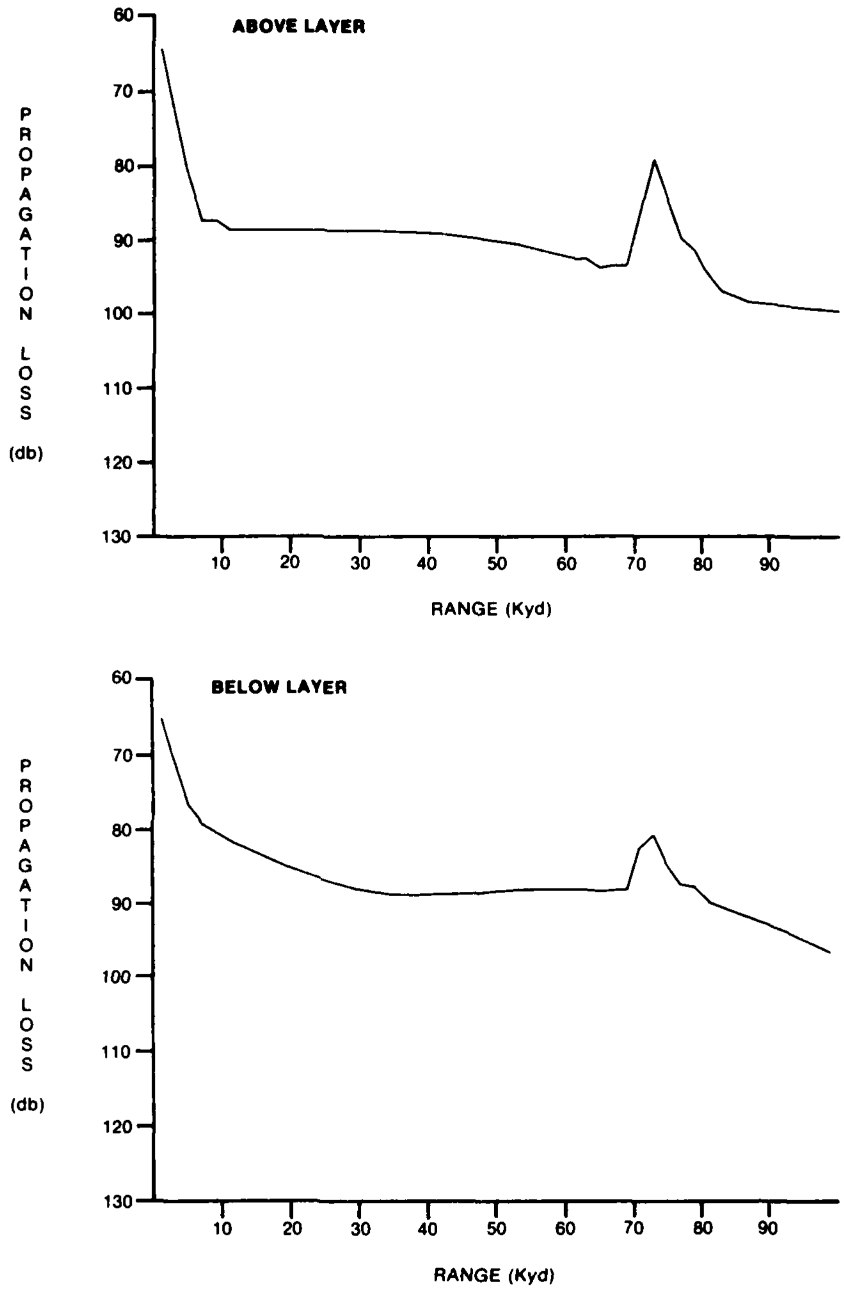

Figure 9. Proploss curve, above and below layer cases

APPENDIX A

SAMPLE SSXBT TRACES

This appendix provides samples of valid and problem SSXBT traces. The former are included to familiarize the operator with actual oceanic conditions whereas the latter are intended to provide guidance in recognizing probe and system malfunctions. Features of interest are circled for clarity.

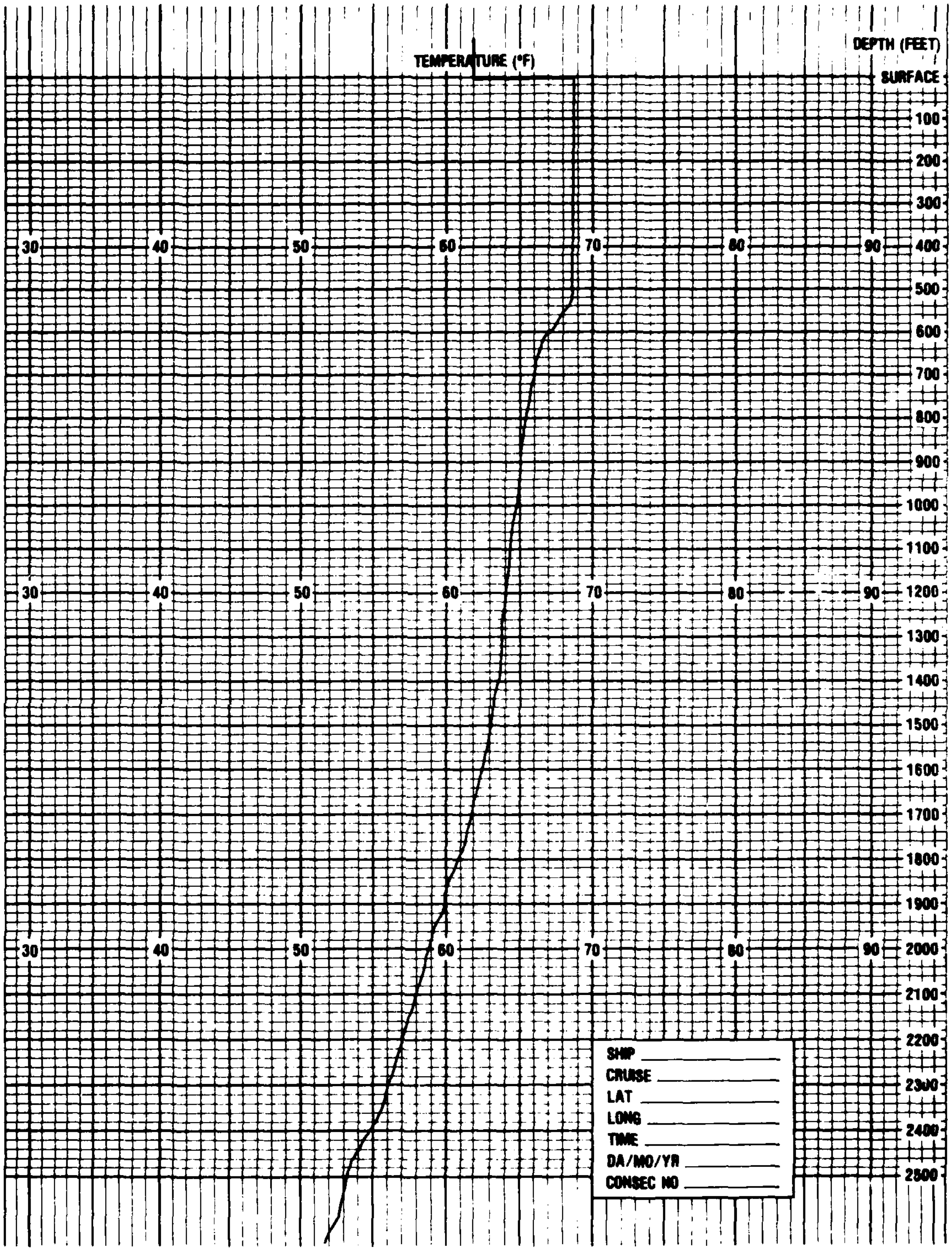

Figure A-1. Valid SSXBT trace. Note presence of calibration tick at 62^{O}F immediately above surface line.

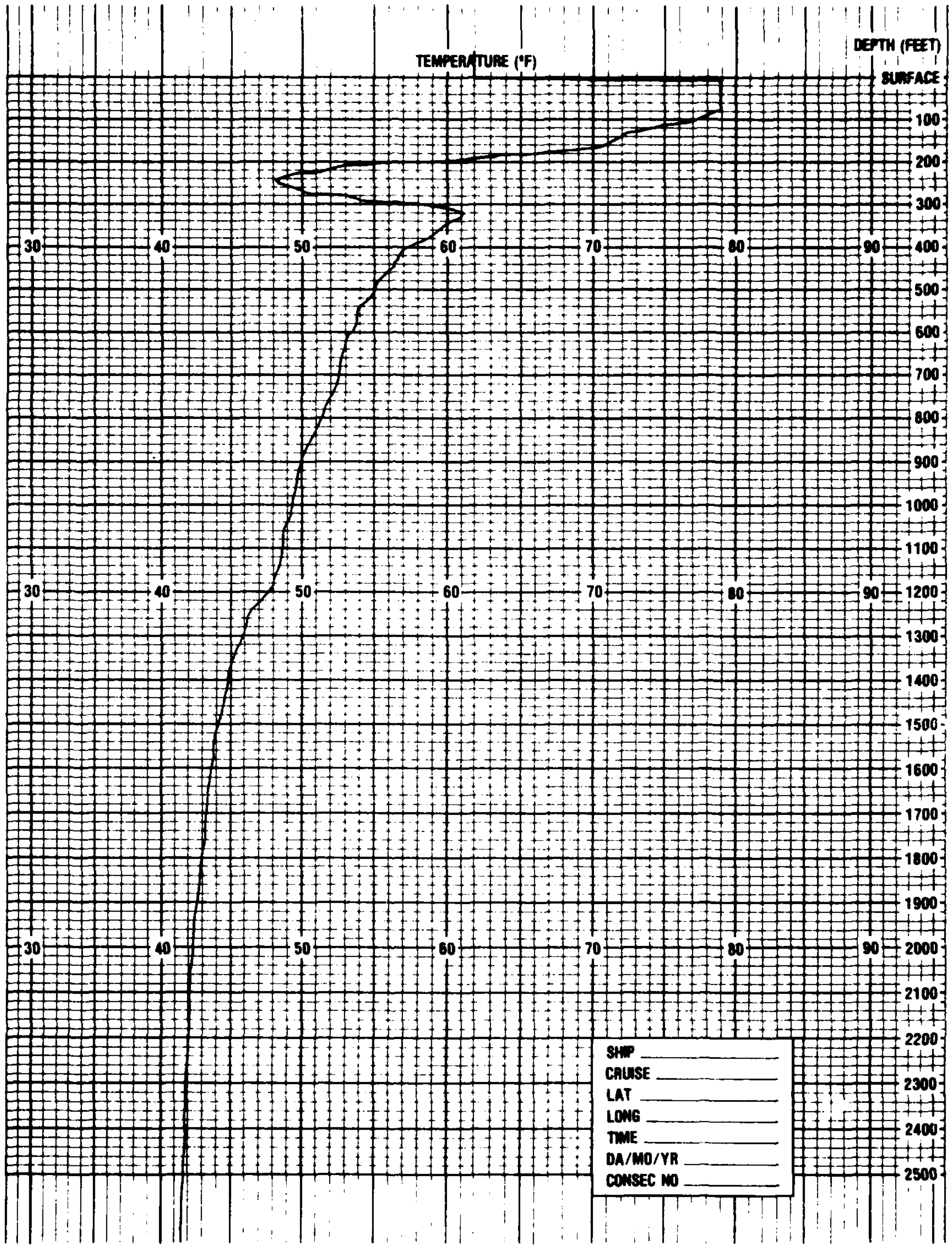

Figure A-2. Near-surface sound channel frequently observed near oceanic fronts

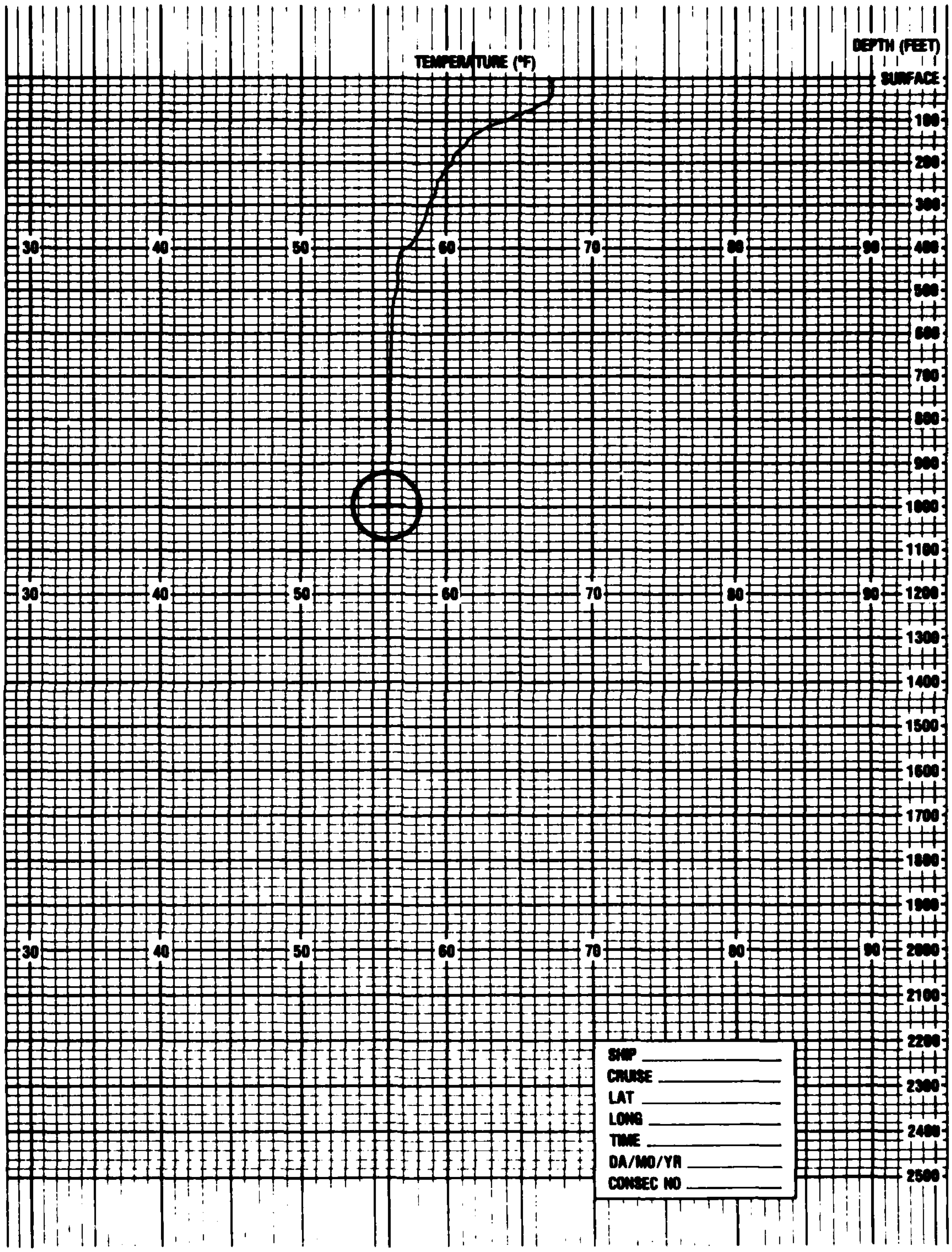

Figure A-3. Horizontal tick mark indicative of bottom strike. Disregard trace below this point.

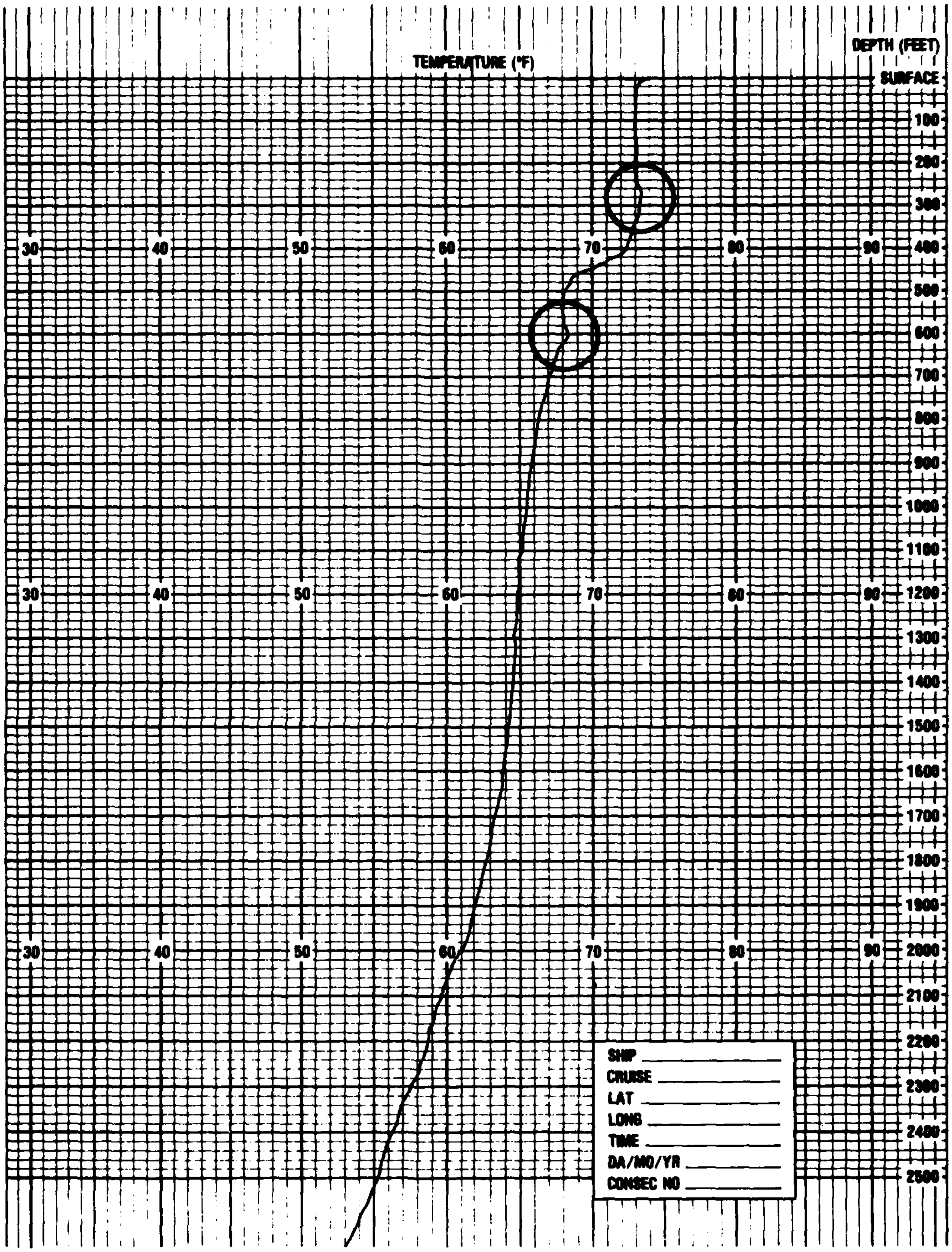

Figure A-4. Unusual thermal features must be verified from multiple observations before accepting.

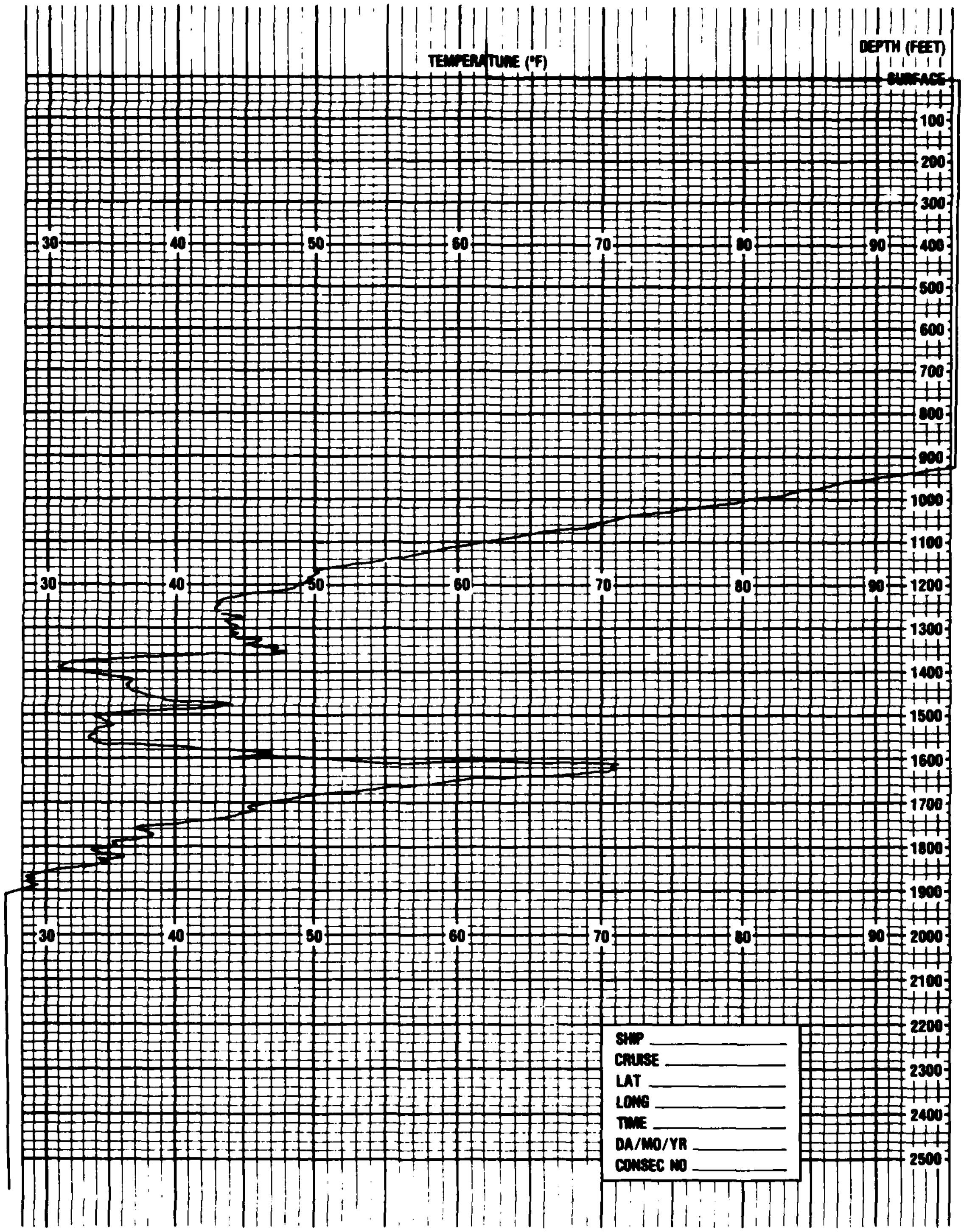

Figure A-5. Complete probe failure, probably from wire break

Figure A-6. Electrical failure near surface requiring rejection of entire trace

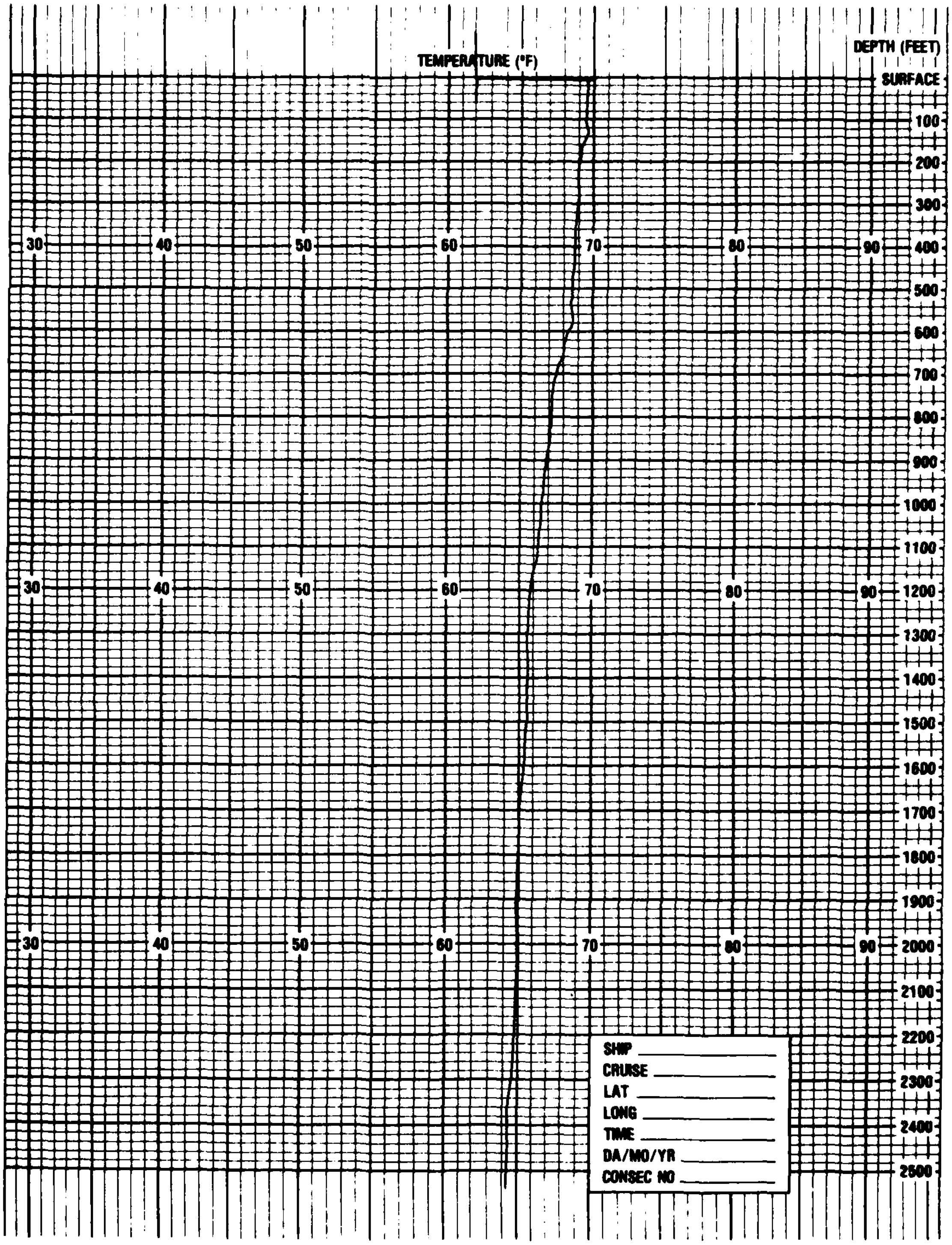

Figure A-7. Abnormally high temperatures recorded at depth. Adjacent observations indicate that temperature should be near 52°F at 2500 ft. Depth of malfunction cannot be determined.

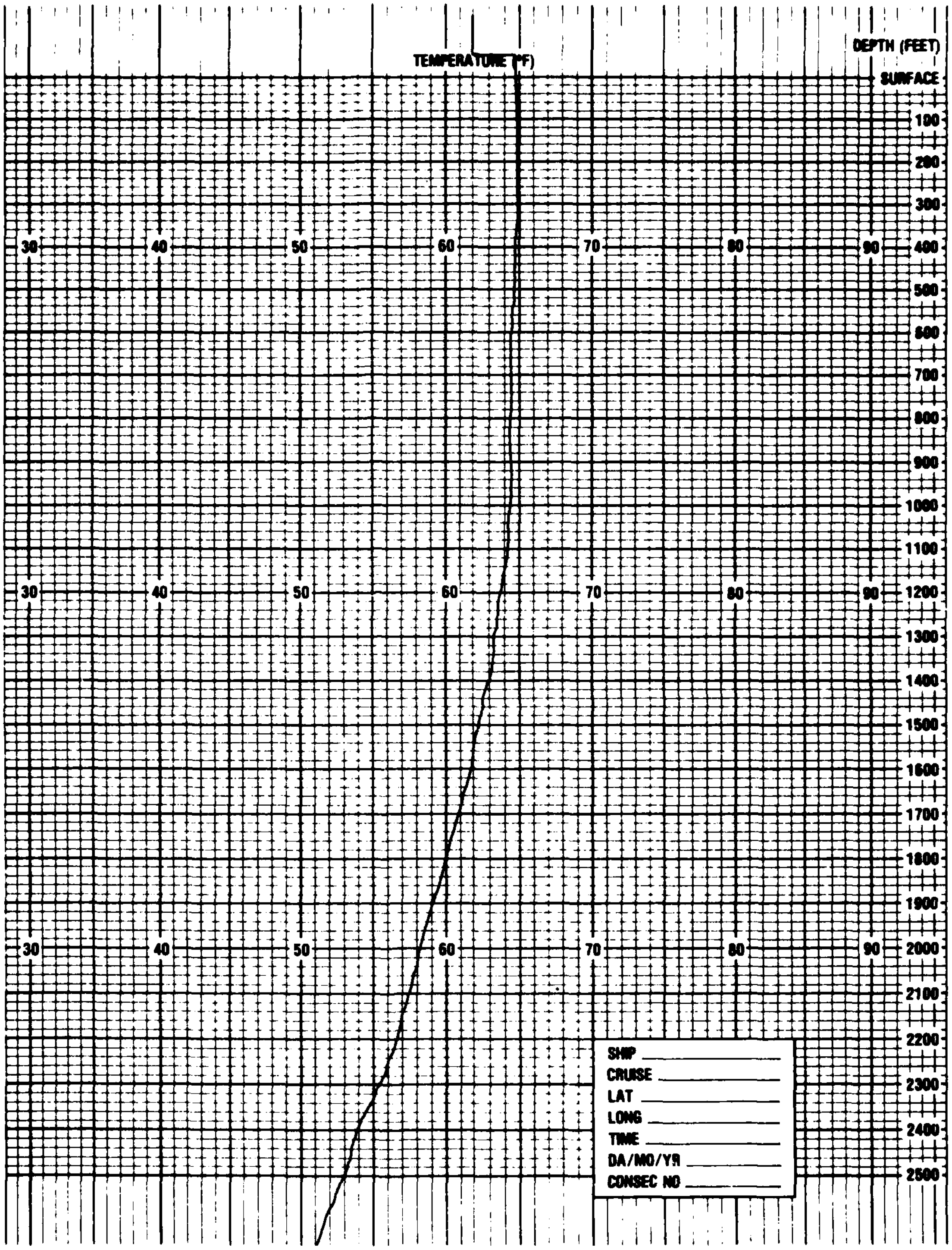

Figure A-8. Stylus not on surface at launch. Depth values must be adjusted for amount of offset from surface line (+50 ft).

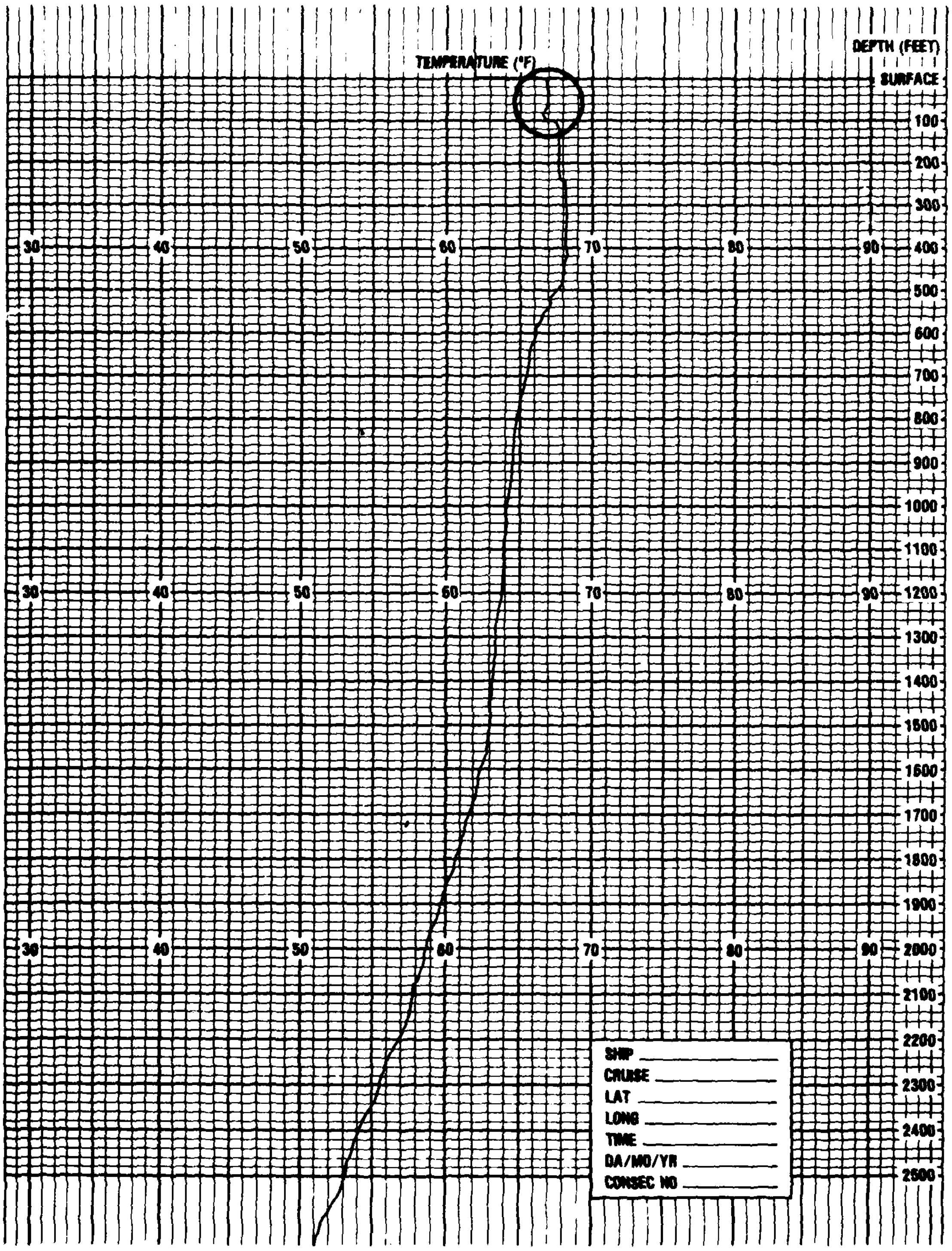

Figure A-9. Artifically low temperature at surface occurred during separation of probe from float. Disregard such values (low or high) by selecting first good point (67.5°F at 100 ft). Desktop calculator will extrapolate to surface.

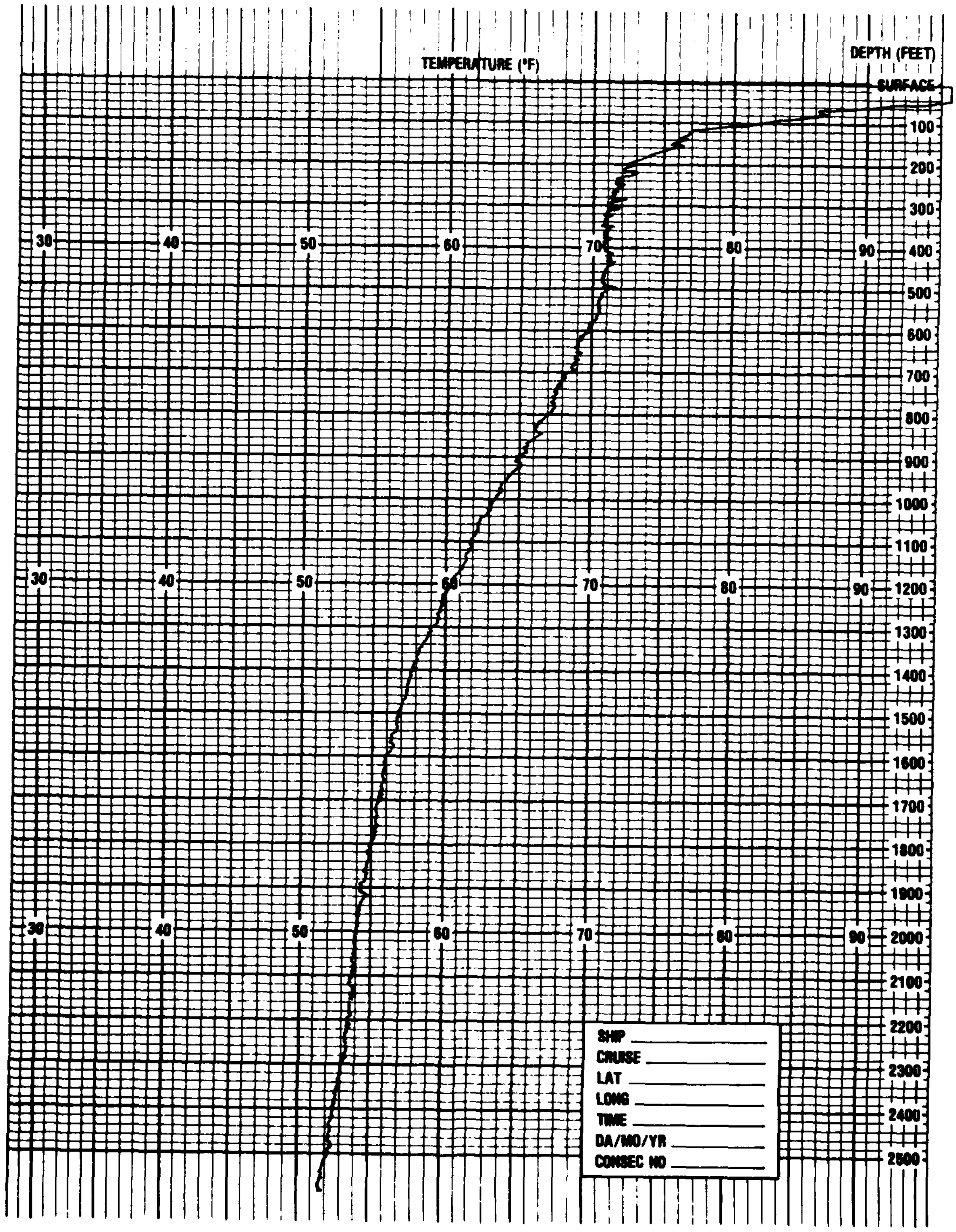

Figure A-10. Stylus off-scale at surface and electro-mechanical interference over entire trace causes rejection.

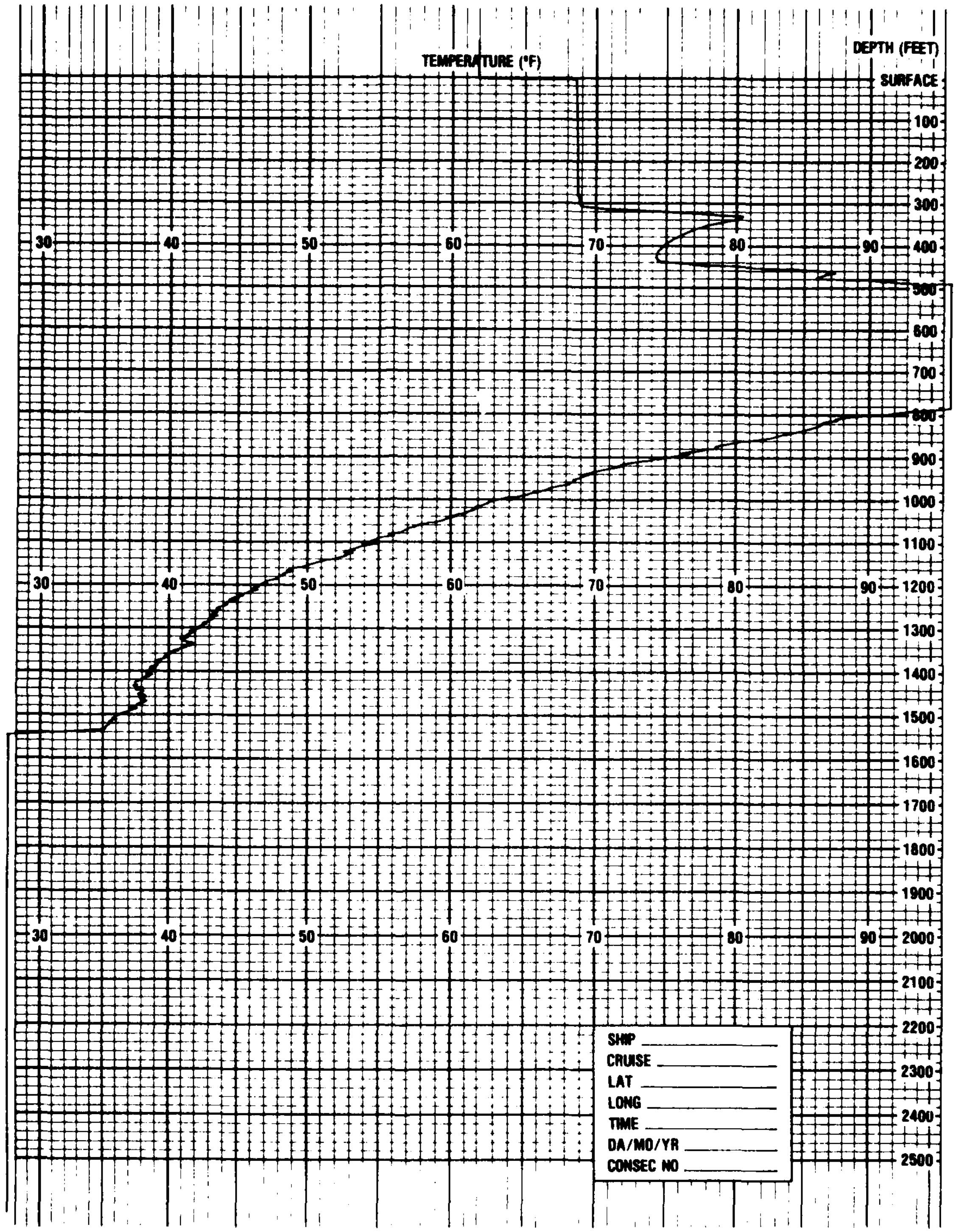

Figure A-11. Signal wire snagged stern plane due to low ship's speed at shallow depth

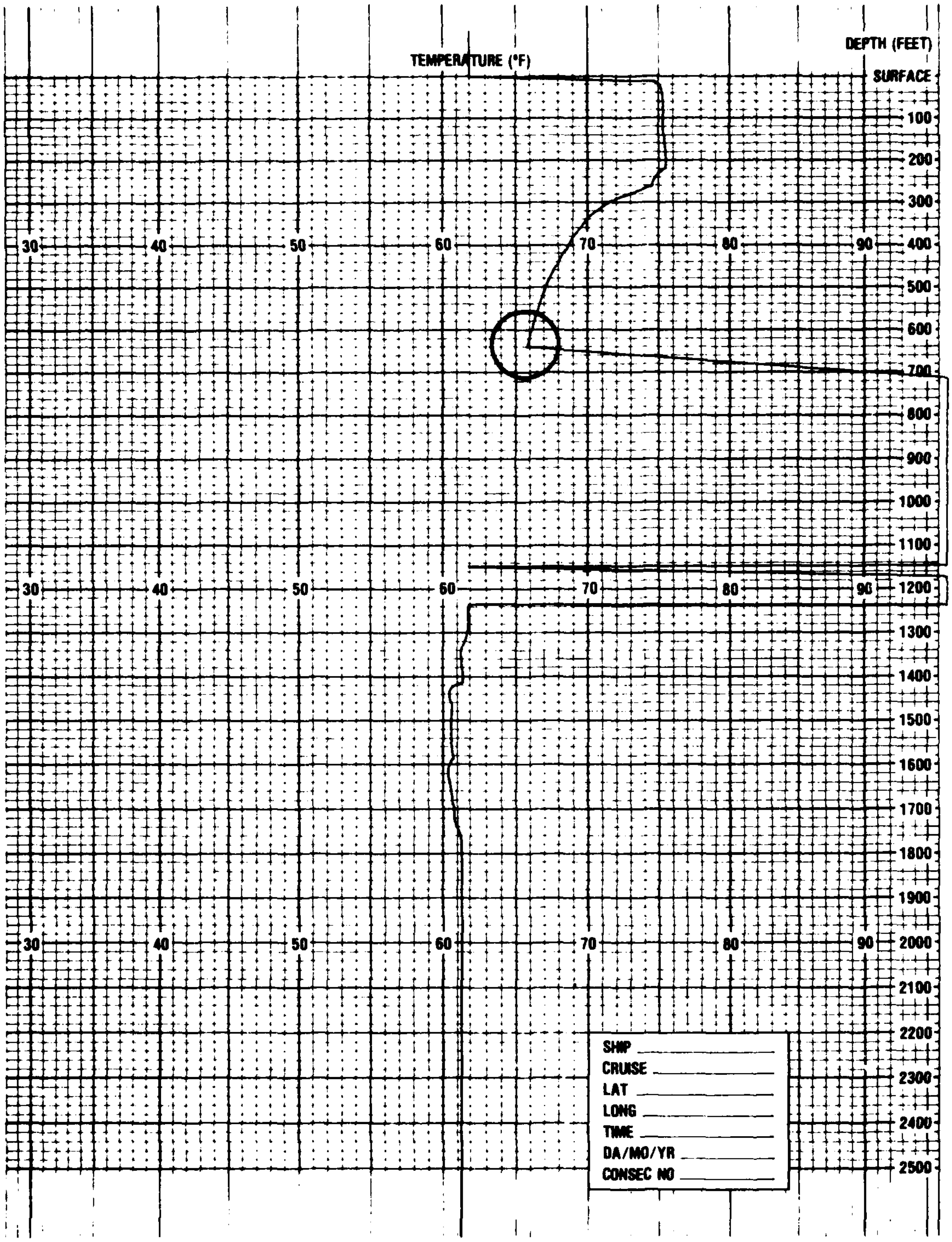

Figure A-12. Wire break at 640 ft. The possibility of important oceanic features below this depth makes another observation desirable.

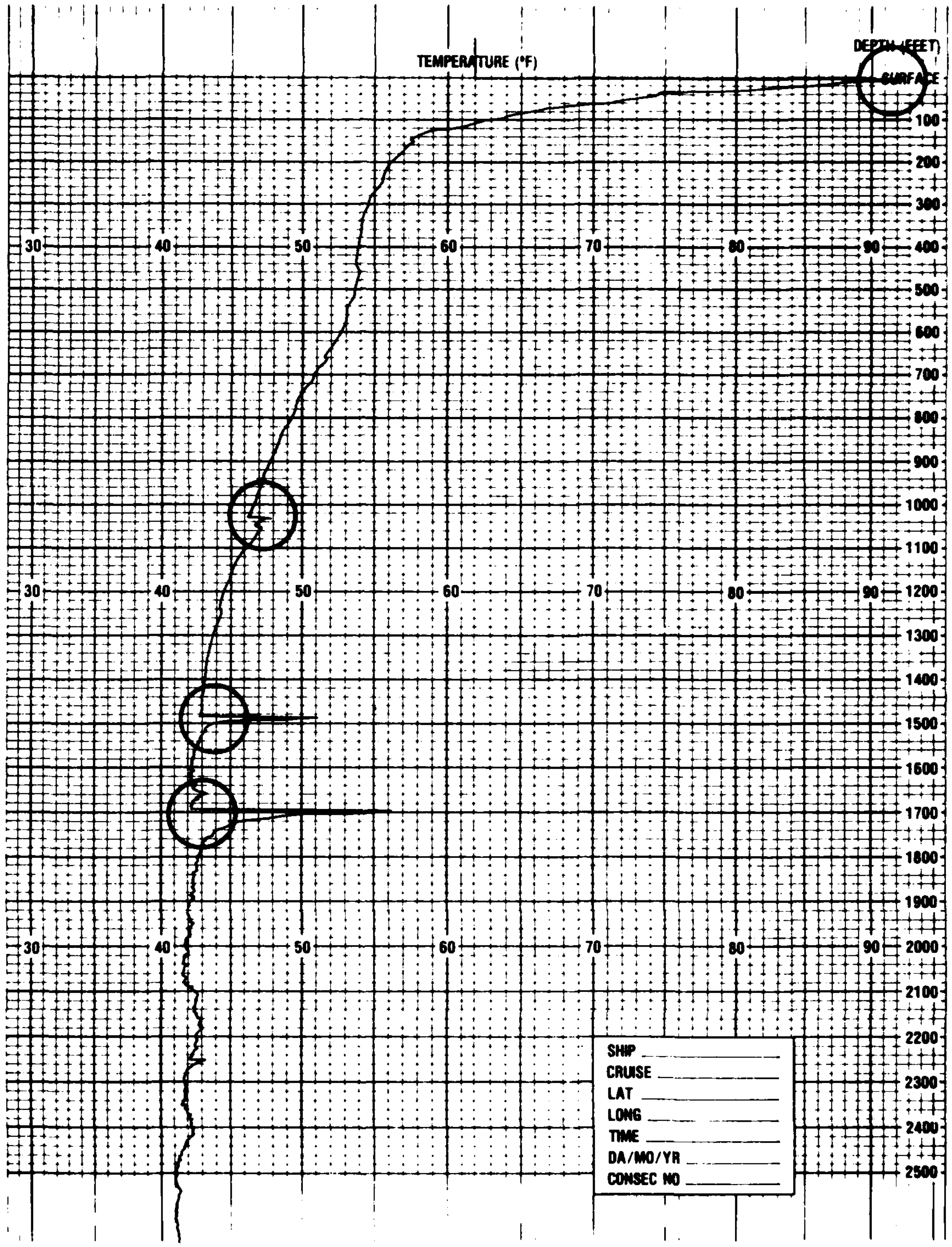

Figure A-13. Pinhole leak in signal wire caused high temperature spike. Small spikes that do not affect curve can be ignored but not these.

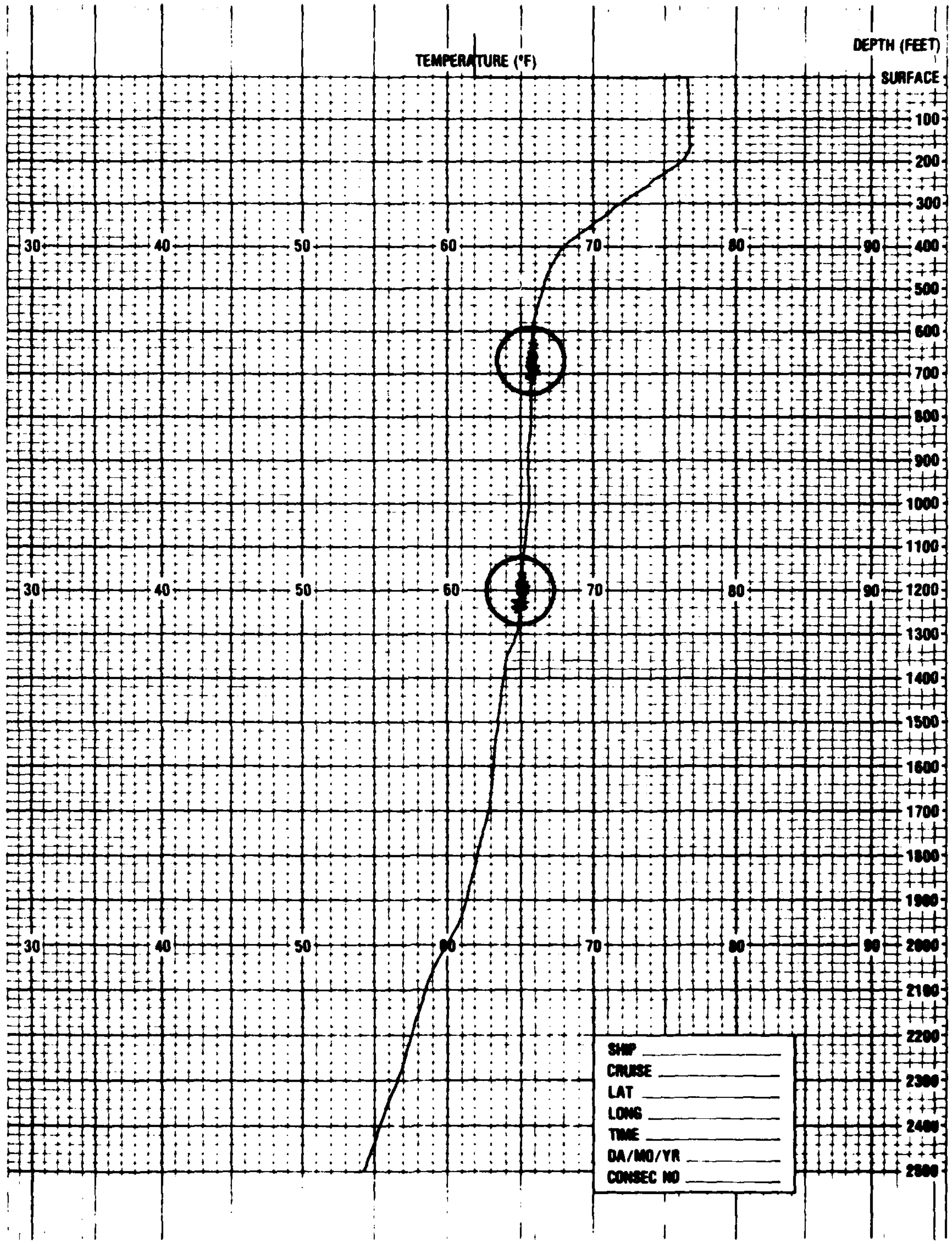

Figure A-14. Interference from electronic radiation. Trace still usable.

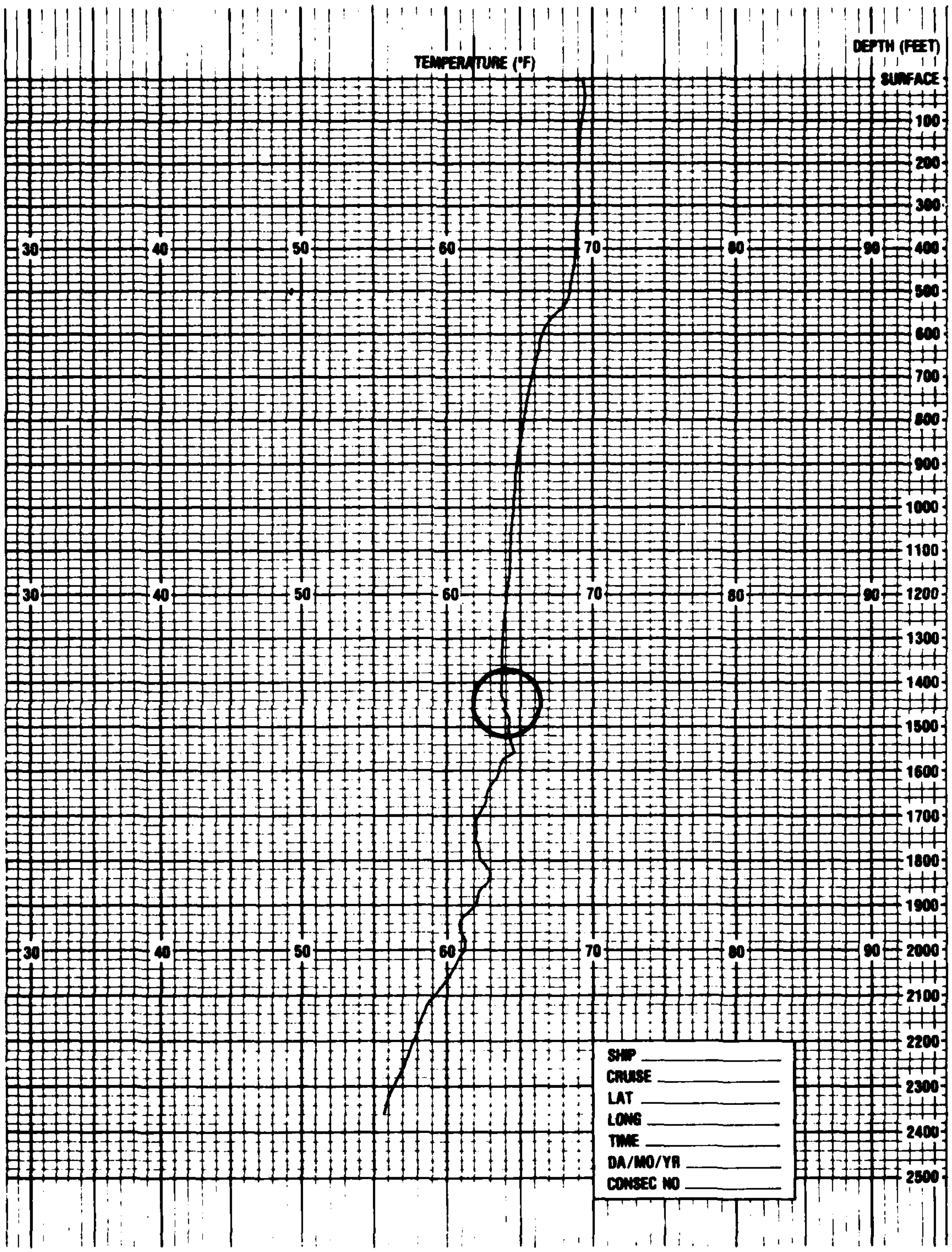

Figure A-15. Erratic temperature at depth caused by stretching of signal wire. Reject data below this point.

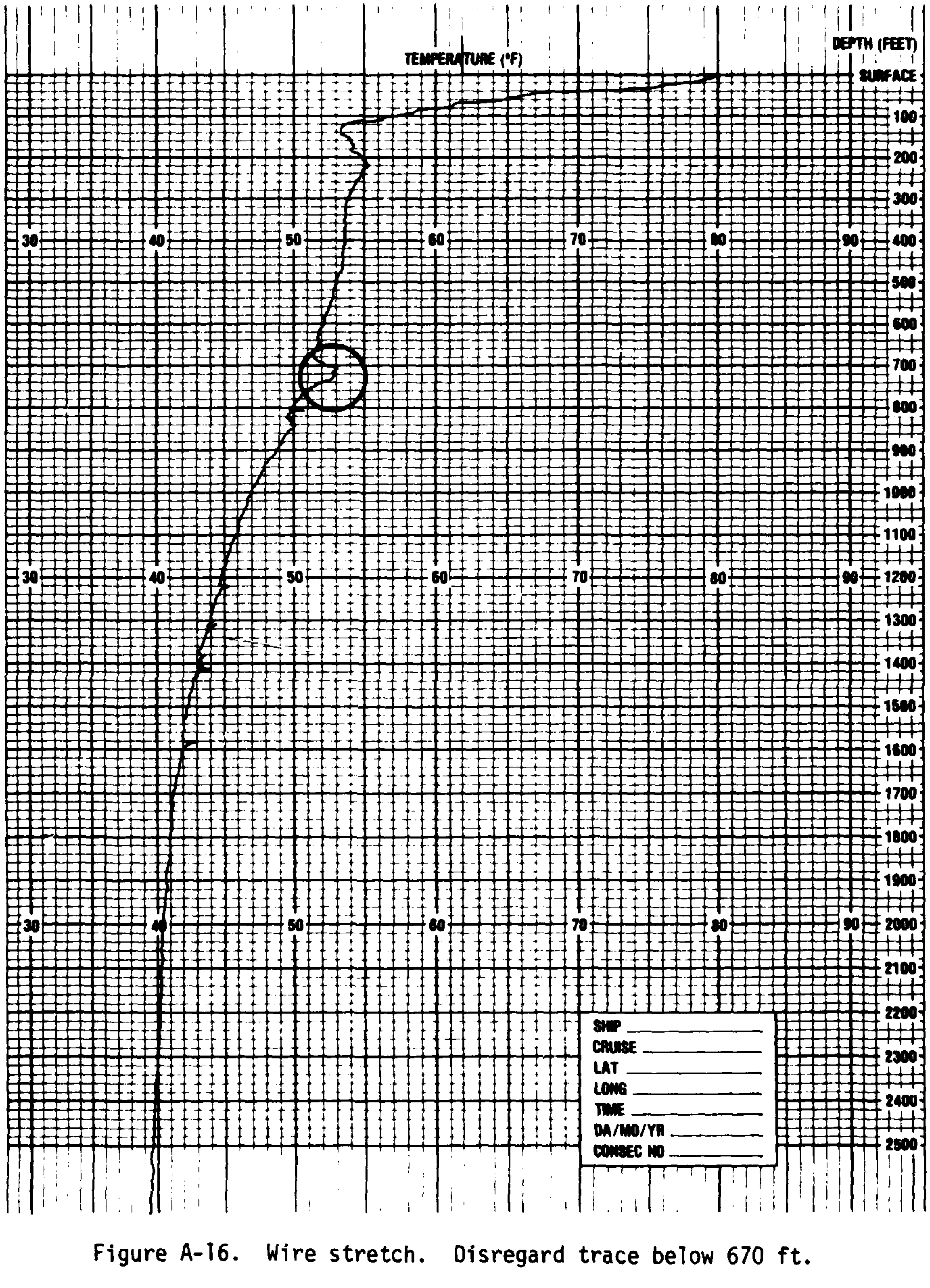

Figure A-16. Wire stretch. Disregard trace below 670 ft.

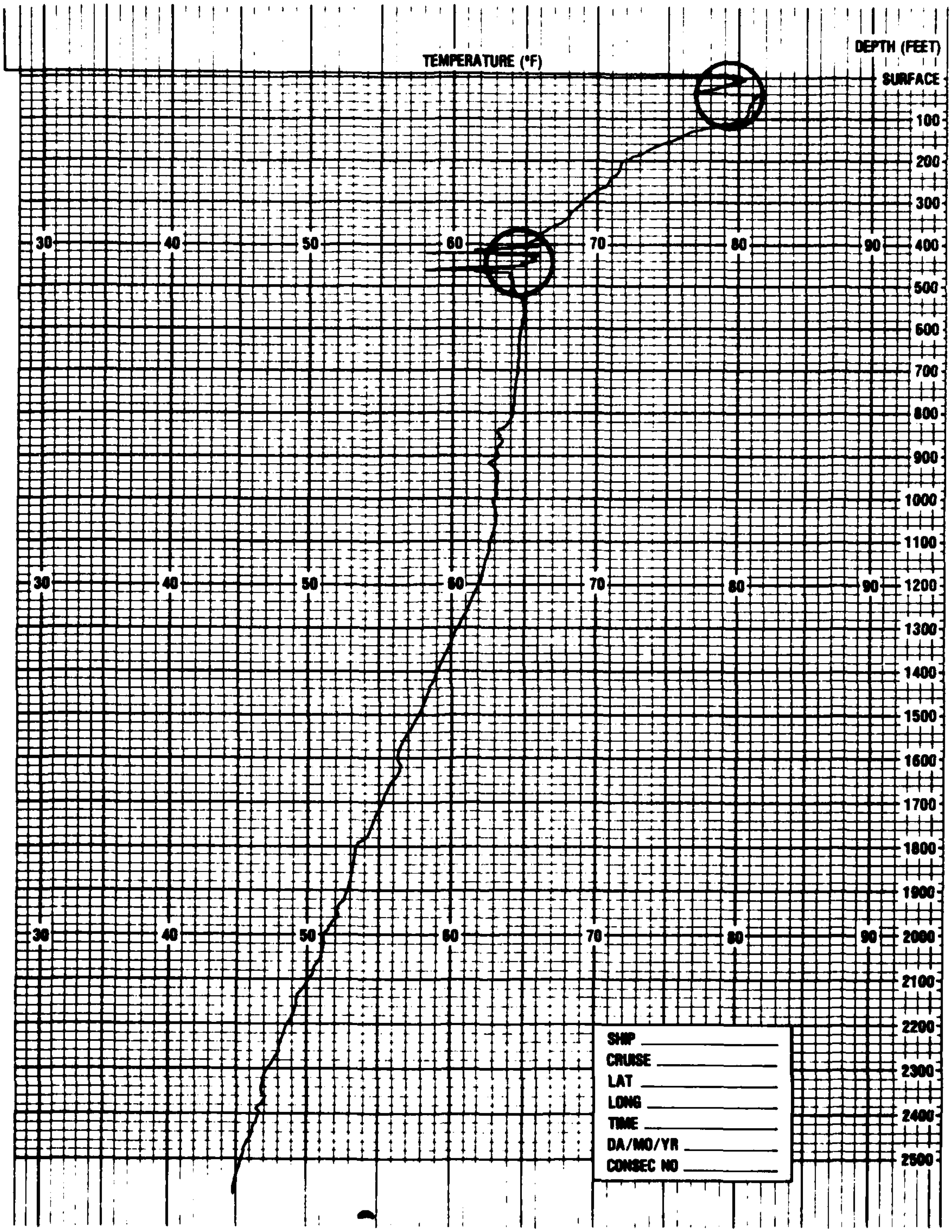

Figure A-17. Spikes to left of trace indicate electrical ground. Check launcher circuits. Trace unusable.

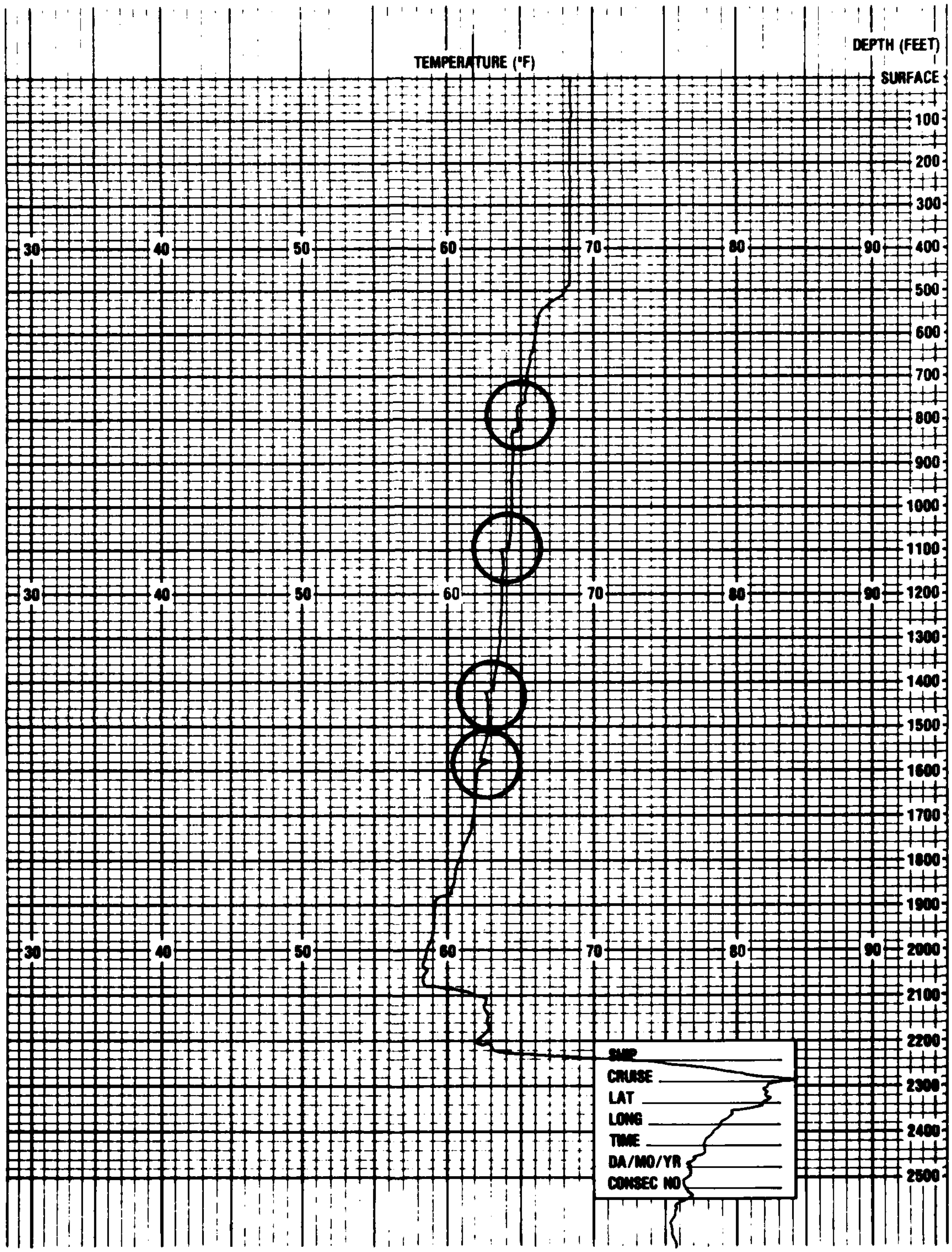

Figure A-18. Stepping between 670 and 1320 ft indicates that recorder is out of adjustment. Pinhole leak at 1470 ft and wire failure at 1760 ft. Data usable above break if smoothed.

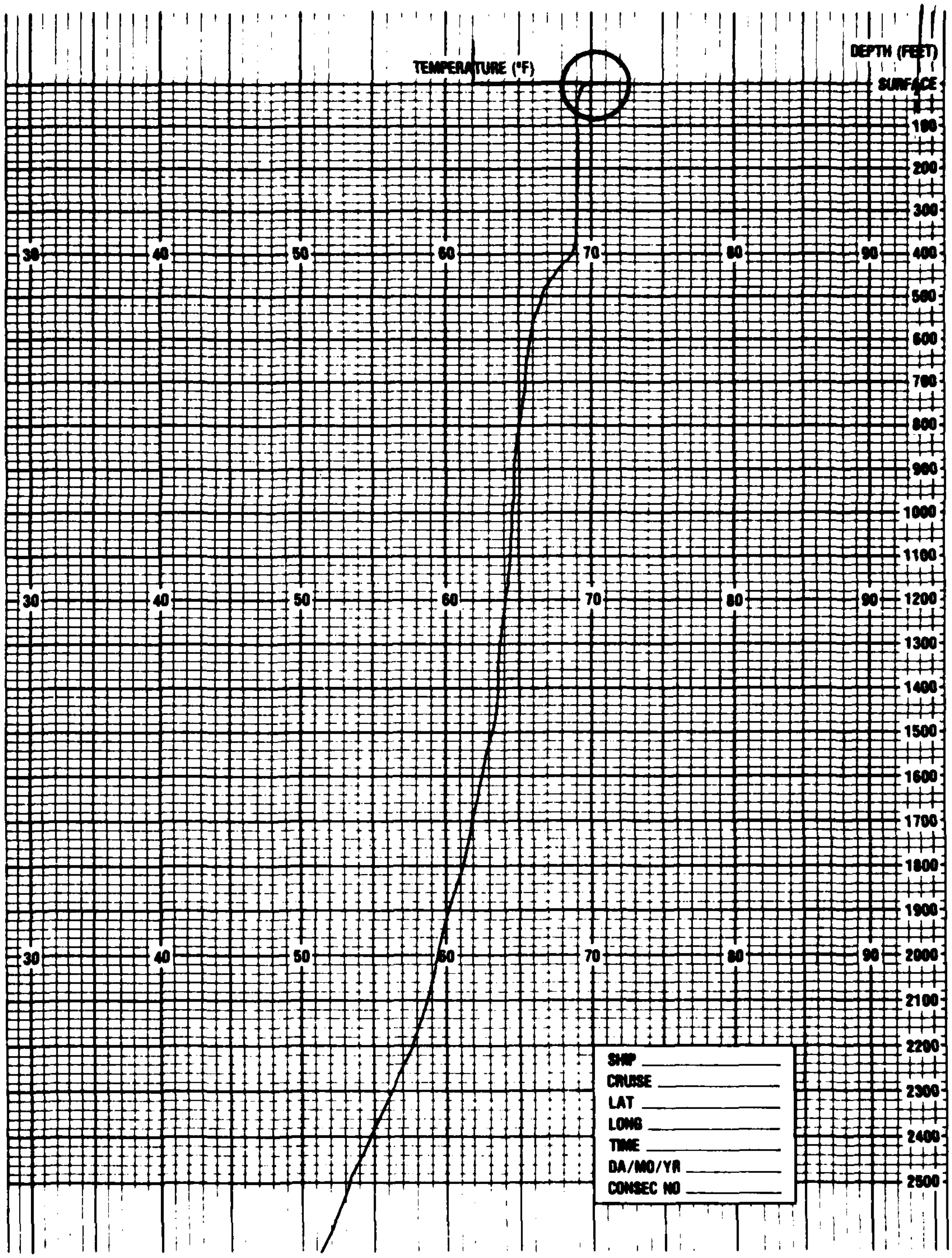

Figure A-19. Recorder stylus overshoot of surface temperature indicates that recorder gain is too high. Do not encode overshoot.

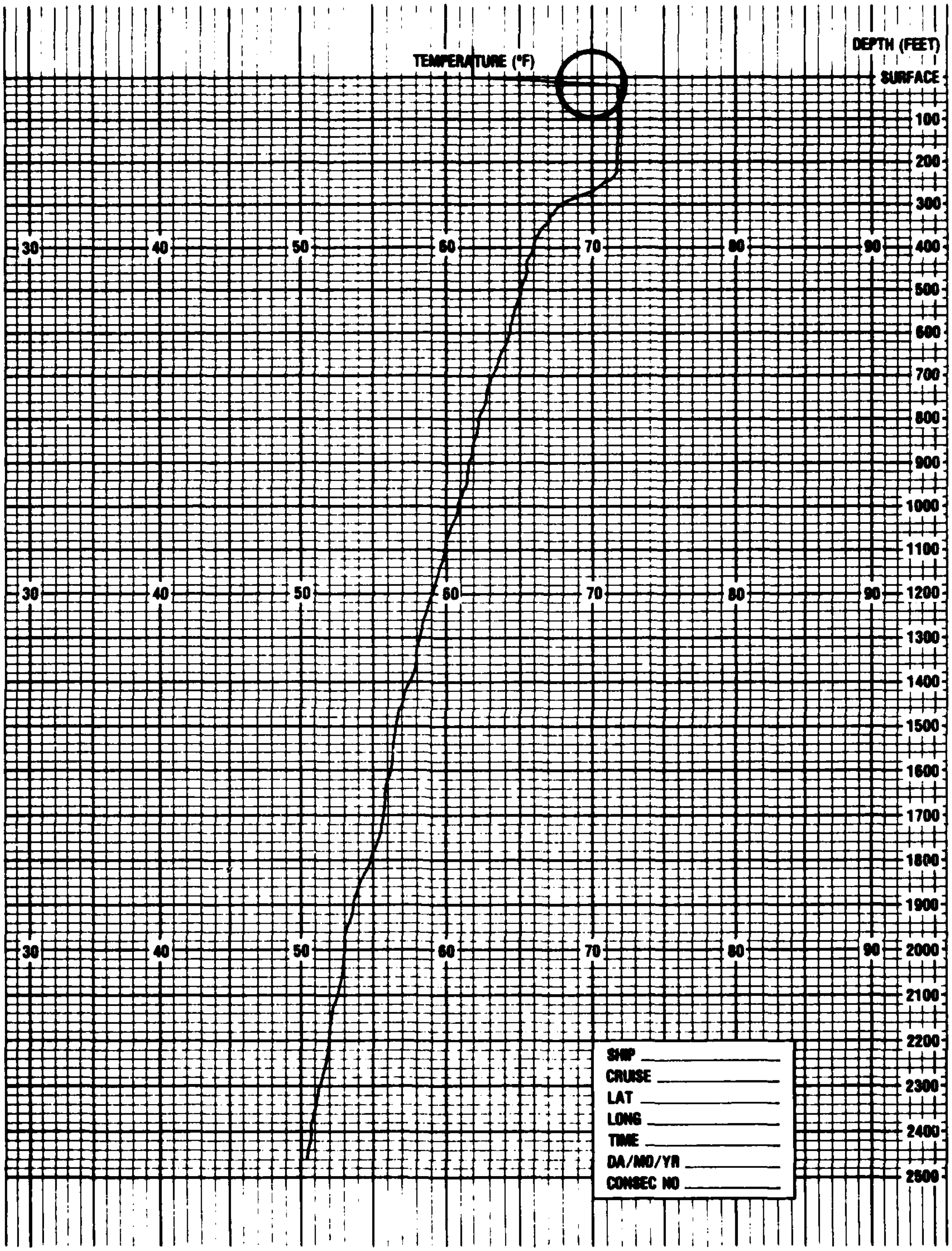

Figure A-20. Downward slope from tick mark to surface temperature indicates that recorder gain is too low. Surface temperature must be determined from upward extrapolation of underlying gradient by the DTC.

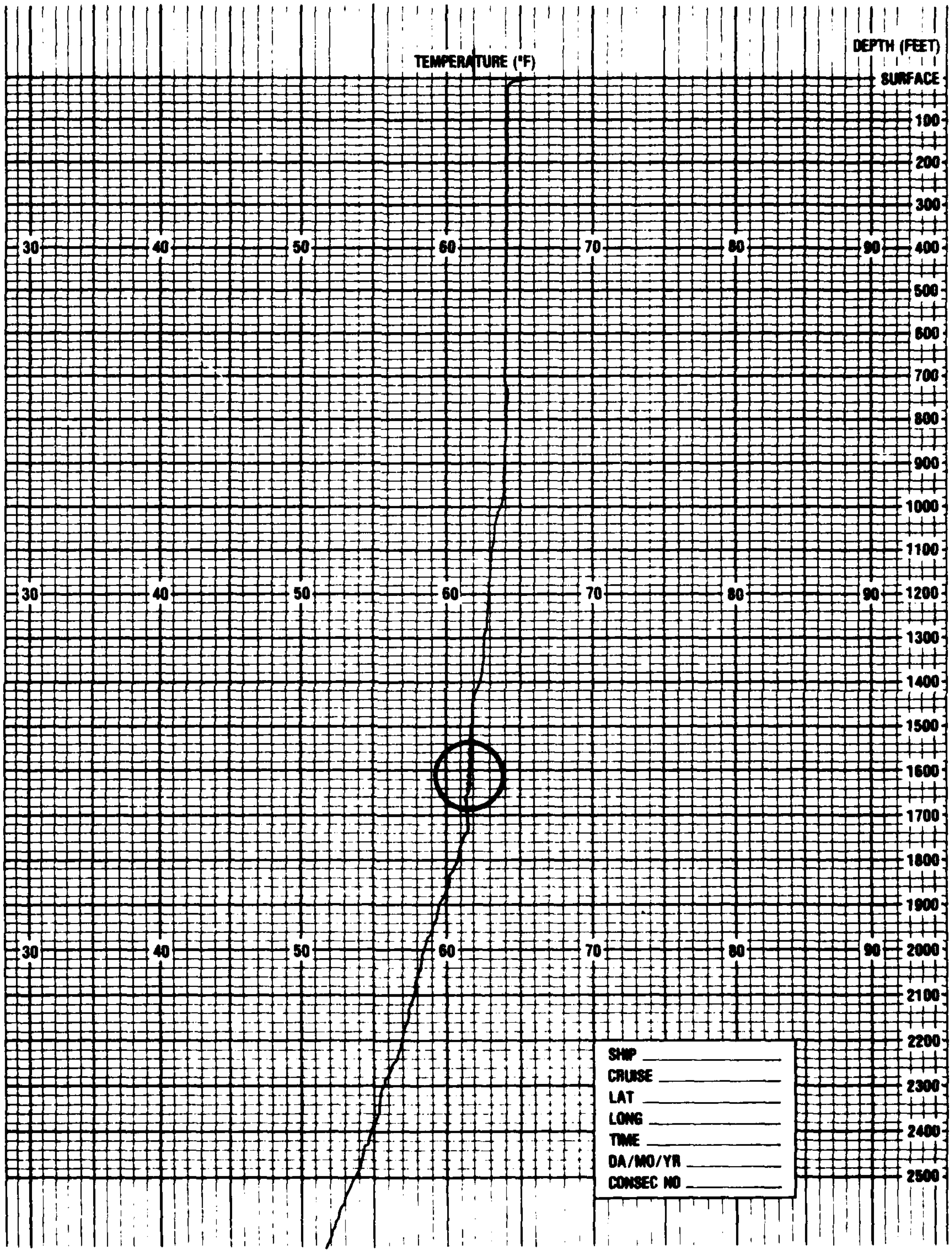

Figure A-21. Worn potentiometer captured stylus at 62°F. Disregard data below 1400 ft. Replace potentiometer.

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