Preliminary Results, PGC 77-6 Cruise,
VECTOR, 1977

by

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Geothermal Service of Canada

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Introduction

The purpose of this informal report is to make available to the people working on this data and planning the second cruise, an initial account of the results. These results are not interpreted and additional corrections will have to be made. Sounder profiles and core descriptions are not included here.

The main purpose of two cruises to the northern B.C. inlets is to measure heat flow along profiles crossing the Coast Plutonic Complex, employing an oceanic technique in the inlets. Large and complex corrections are necessary for bottom water temperature disturbances, sediment refraction and warm rim effects, sedimentation, glacial disturbances and uplift and erosion. Consequently data are needed on water temperature changes, sedimentation rates, shape and size of sediments prism in addition to common heat flow data. The data concerning the sediments are part of the geological studies of the environment of the inlets.

A return cruise is planned for late May or June, 1978, approximately 7 months after the first cruise and at a time of maximum run-off in many of the inlets.

Many of the stations will be re-occupied to see if there are changes in temperature or temperature gradient. More coring and conductivity measuring will be required. Deeper sounding is required and longer gradiometers are needed.

This report includes recommendations for the next cruise.

The scientific personnel for the PGC 77-6 cruise were:

Mr. Vic Allen Ms. M. Burgess. Mr. John Collyer Dr. Trevor Lewis, chief scientist	Seismology & Geothermal Studies, Earth Physics Branch, 3 Observatory Crescent, Ottawa, Ontario. K1A 0Y3
Dr. Brian Bornhold	Pacific Geoscience Centre Geological Survey of Canada Institute of Ocean Sciences, 9860 W. Saanich Rd., Box 6000 Sidney, B.C. V8L 4B2
Dr. Earl DAvis Dr. Roy Hyndman (until Oct. 7)	Pacific Geoscience Centre Earth Physics Branch Institute of Ocean Sciences, 9860 W. Saanich Rd., Box 6000, Sidney, B.C. V8L 4B2

The Vector's itinerary was: (see figure 1)

Oct. 3	Testing in Saanich Inlet Work and testing of Vector's propulsion main controls delayed our departure from Pat Bay until Tues. Oct. 4 at approx. 1400.
Oct. 5	Re-occupied a station in Desolation Sound for testing of equipment and stability
Oct. 6-9	Dean Inlet and Burke Channel. Stopped at Ocean Falls for fresh water.
Oct. 10-13	Douglas Channel and Whale and Squally Channels. Stopped in Prince Rupert for fresh water, supplies and straightening corer tube.
Oct. 14-16	Portland and Observatory Inlets, Alice and Hastings Arms.
Oct. 17	Squally Channel
Oct. 19	Arrived back in Pat Bay.

A complete list of the stations is given in Appendix C.

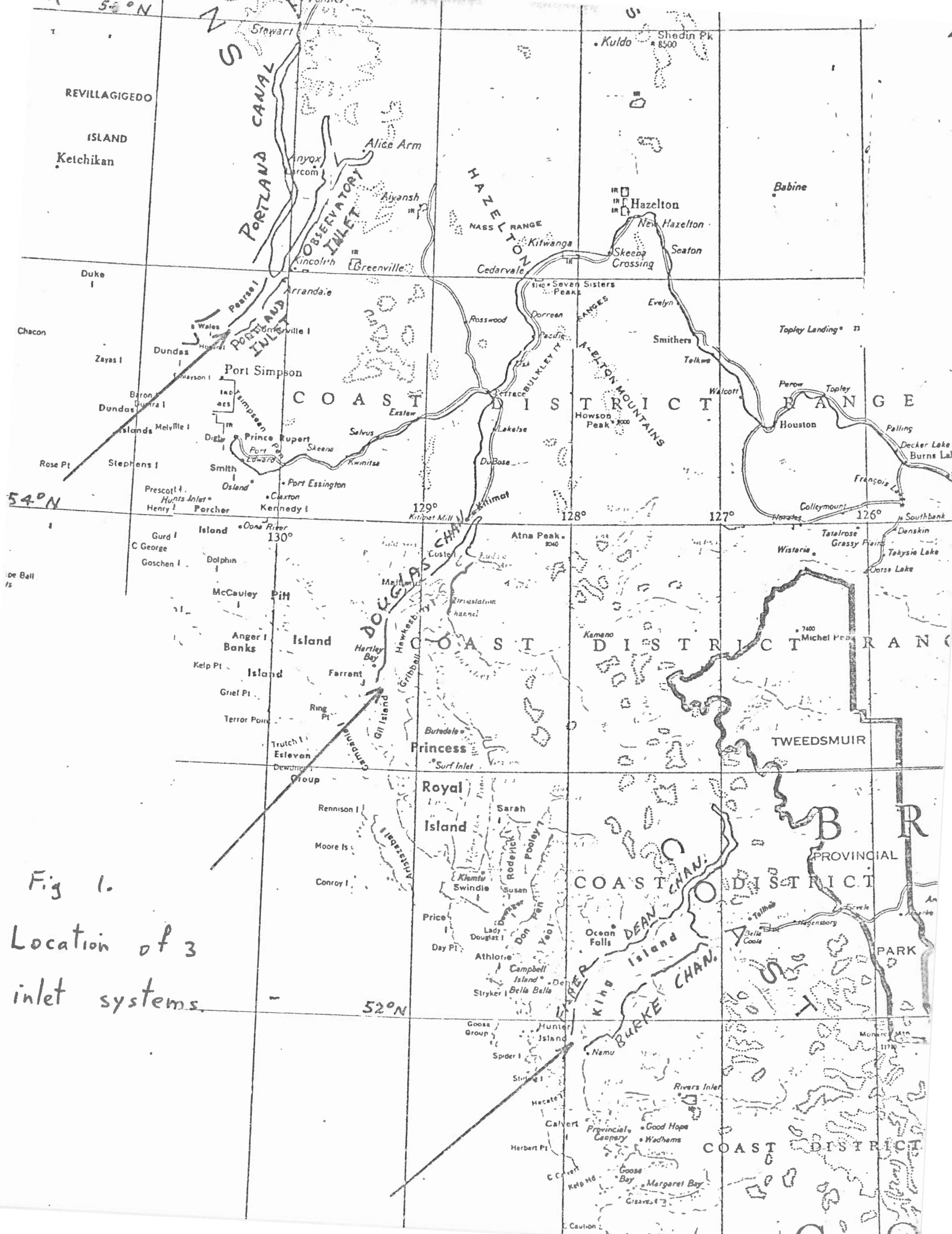


Fig 1.

Location of 3 inlet systems.

3.5 khz Sounder Profiles

Except in lower Dean Channel, the 3.5 khz sounder system worked well and gave us good records. Two copies of the complete records were made. The sounder did not penetrate to bedrock in the centre of the inlets. Usually we made a profile up the centre of each channel, a parallel one 660 m (3 cables) to one side when practical, and several cross-channel profiles. Table 1 is a listing of the profiles. The common depth scale was 40 fathoms per division.

The cross-channel profiles showed the steeply dipping bedrock on each side disappearing under the sediments, as in the typical profile at stations 54 to 59B (figure 2). But the inlets were not usually so simple. Sediments were deposited at an angle, as shown in figure 3 for stations 70 to 74, and in figure 4 for stations 76 to 80. Profiles along the centre of the channel can be quite misleading when such assymetry is present.

Table 1

PGC 77-6 Sounder Profiles, October 1977

3.5 kHz

No.	Start	Finish	Stations	Name
1				Saanich Inlet
2	0300 Oct. 5	0915 Oct. 5	7-11	Desolation Bay
3	0220 Oct. 6	0550 Oct. 6		Dean Channel
4	0920 Oct. 6	1830 Oct. 6	13-19	Dean Channel
5	1835 Oct. 6 2250 Oct. 6	1905 Oct. 6 1045 Oct. 7	20,23-30	King Island, W. side
6	1410 Oct. 7	0800 Oct. 8	34	Burke, Dean Chans to Kimsquit
7	0615 Oct. 8	1500 Oct. 8	35-40	Top of Dean Chan. S.
8	1717 Oct. 8	1130 Oct. 9	44-58	Dean Chan & Burke Chan
9	0250 Oct. 10	0700 Oct. 10		Douglas Chan to Coste Is.
10	0700 Oct. 10	1310 Oct. 10	60-62	Clio Pt. to Kitimat
11	1310 Oct. 10	0215 Oct. 11	63-74	Douglas Channel
12	0325 Oct. 11	1405 Oct. 11	76-83	Douglas Channel
13	1515 Oct. 11	0135 Oct. 12	84	Whale & Squally Chans.
14	0135 Oct. 12	0600 Oct. 12	85-86	Squally & Whale Chans.
15	0710 Oct. 12	1440 Oct. 12	87-93	Whale Channel
16	1600 Oct. 12	0420 Oct. 13	94-103	Whale & Squally Chans.
17	0440 Oct. 14	1600 Oct. 14	104-107	Portland & Observatory Inlets & Alice Arm
18	1740 Oct. 14	1840 Oct. 14	108	in Alice Arm
19	1900 Oct. 14	1130 Oct. 15	109-122	Alice & Hastings Arms, Portland Inlet
20	1245 Oct. 15	1125 Oct. 16	123-134	Observatory & Portland Inlets
21	1225 Oct. 16	1810 Oct. 16	137-140	Portland Inlet
22	0630 Oct. 17	1525 Oct. 17	141-144	Upper Squally Channel

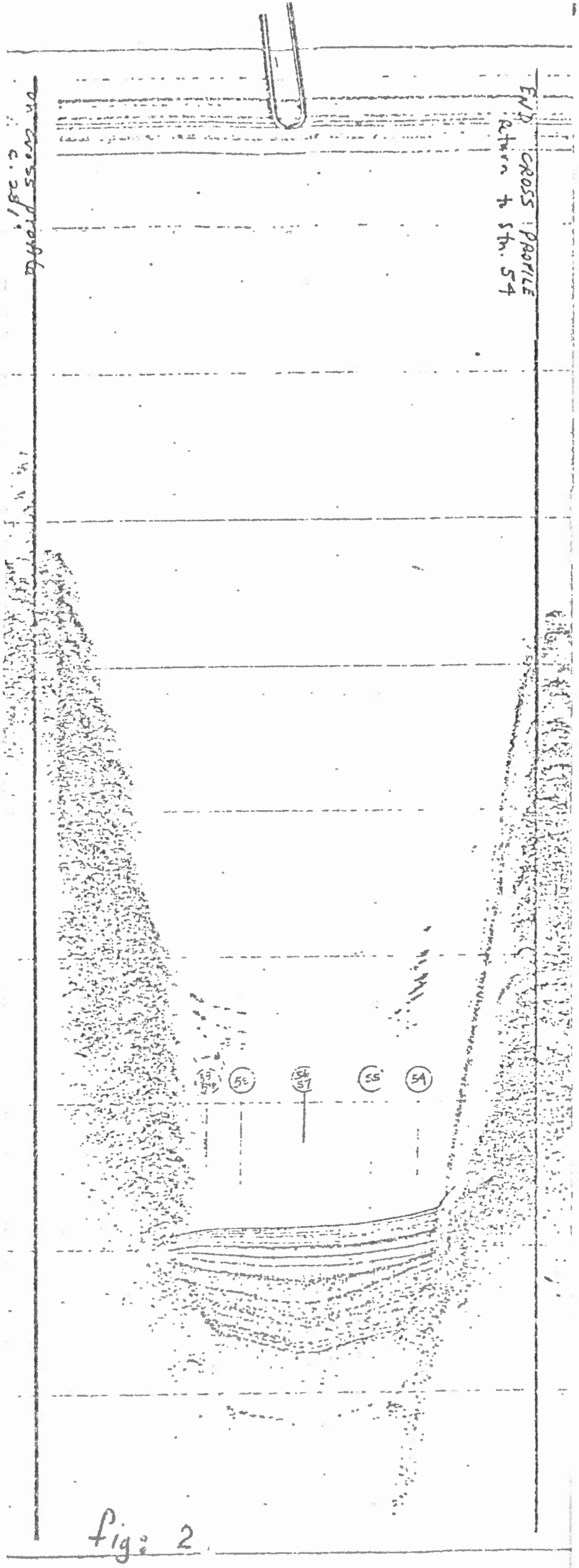

END CROSS PROFILE
Return to Stn. 54
on cross profile
c. 28/
59
58
56
57
55
54

fig: 2

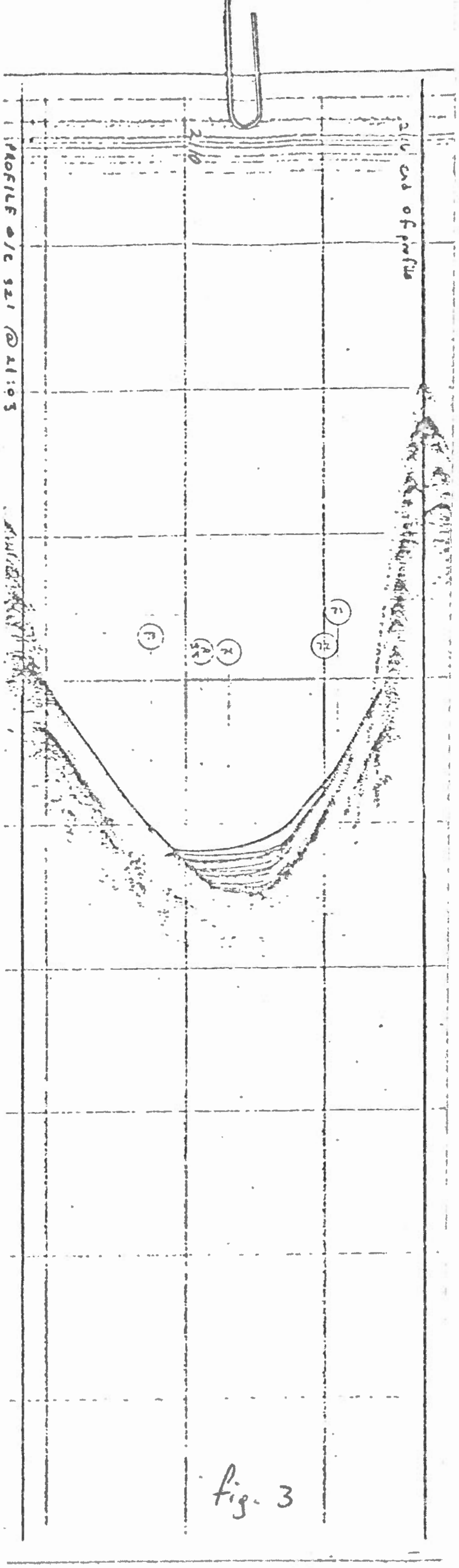


fig. 3

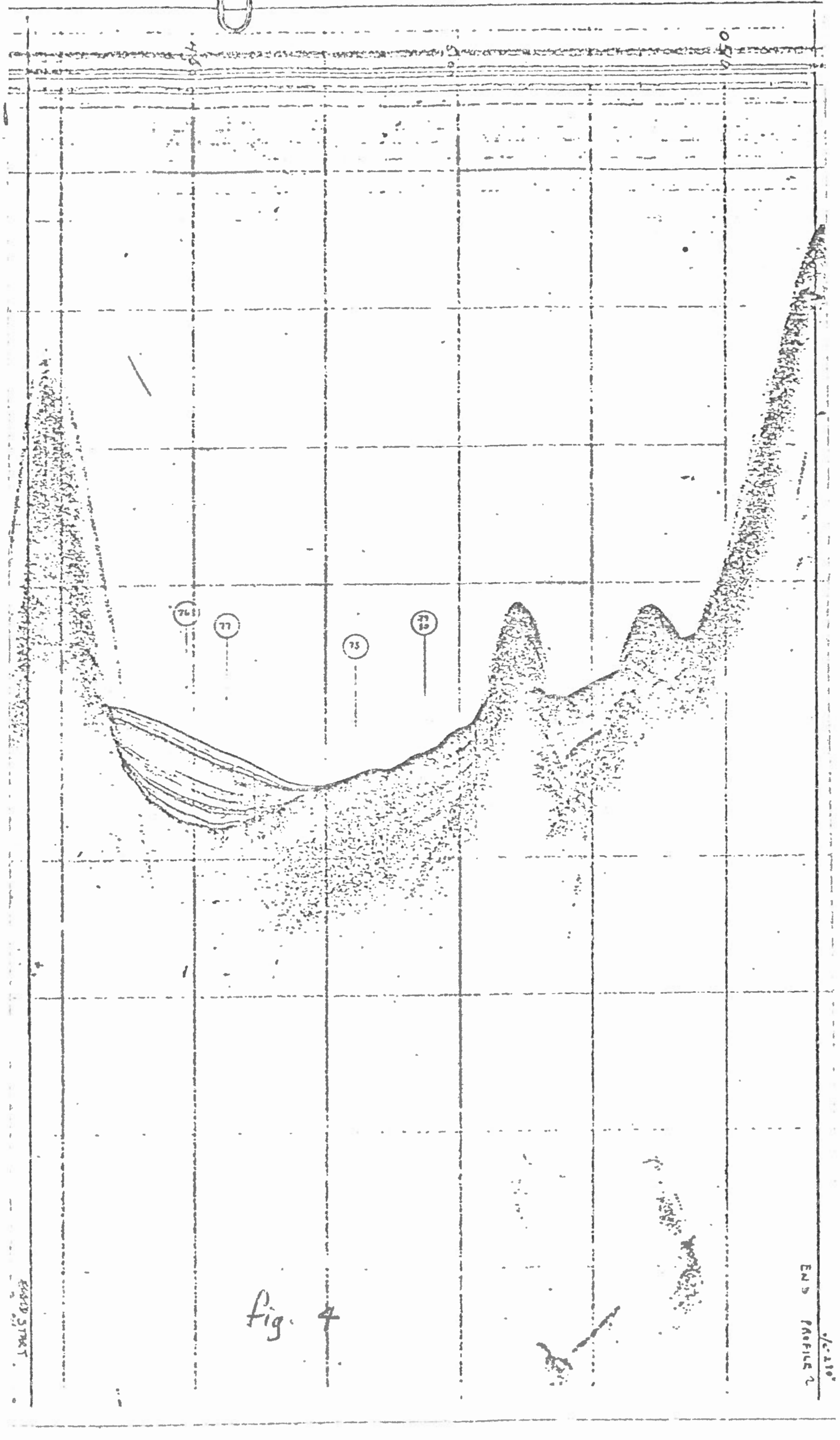


fig. 4

Coring

Two gravity corers were used: A Benthos corer and a 20-foot outrigger corer with a 1200-lb head. The maximum length cores obtained were 1.42 and 5.2 m respectively. To use the larger corer required extra crew, but the long cores were a real bonus.

B. Bornhold logged the cores. Some samples have been submitted for ^{14}C dating. The average water contents are given in Table 4. The core log is not included here.

Water Temperature Profiles

Water temperature profiles were measured, mostly using a light borehole logging system. The near-bottom temperatures are listed in Table 2 , and the profiles are figures 5 to 21 . It was very difficult to tell when the probe first penetrated these soft sediments. The two profiles run while the ship was drifting are useless (stations 129 and 142 in figs. 17 and 18).

In most inlets bottom temperatures from widely separated stations are quite uniform. The water immediately above the sediment interface is very nearly isothermal at most stations. In Desolation Sound a pronounced warming occurs in the bottom half of the water column. A very slight warming occurs at stations 70 and 115B. In Alice Arm and Hastings Arm temperature reversals occurred and the sediments were cooler than the bottom waters, indicating recent overturn.

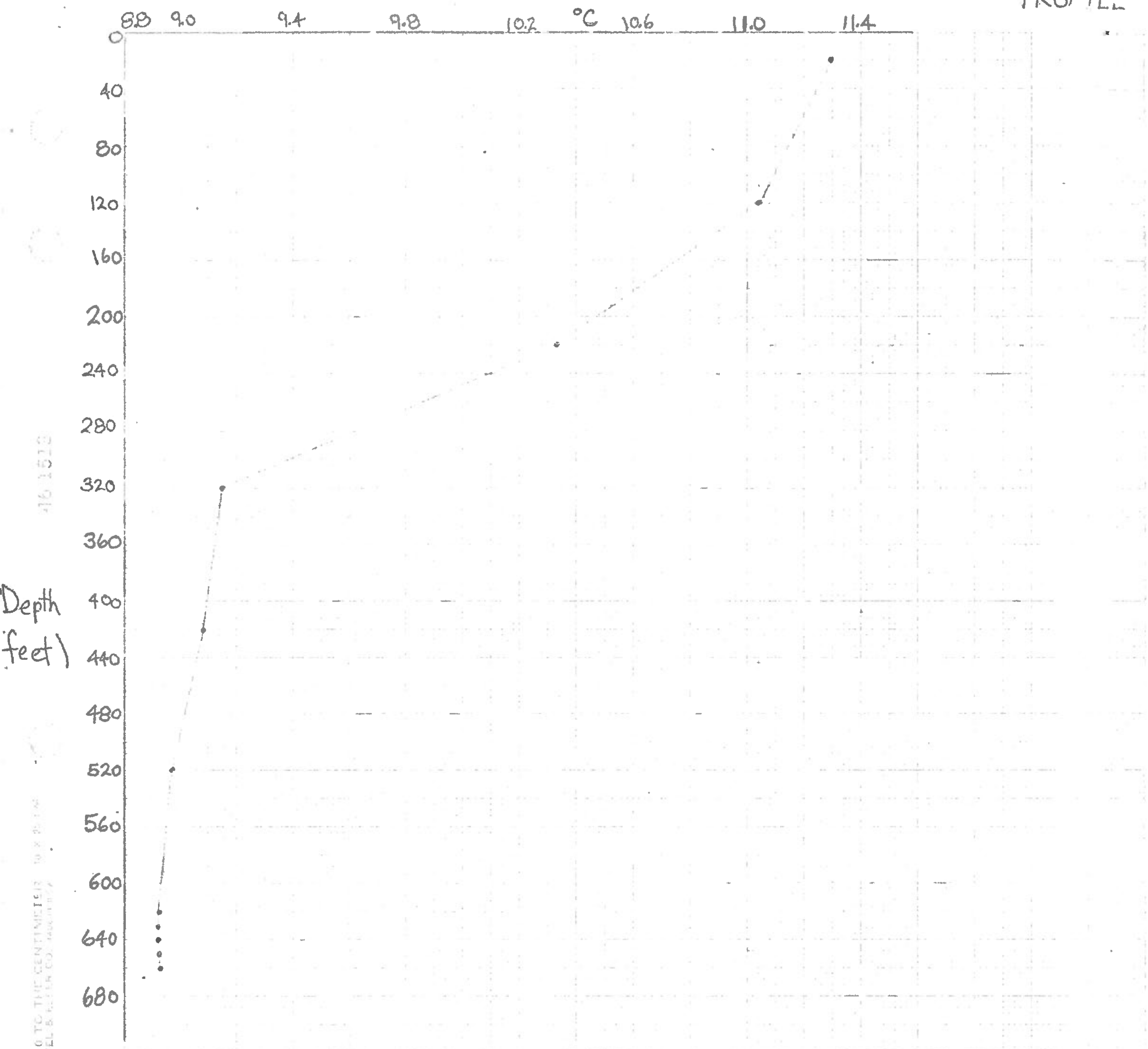
Two thermographs were left to record the bottom water temperatures near Cathedral Point in Burke Channel and in upper Dean Channel (See Table 3).

Table 2 : Bottom Water Temperatures

Region	Stn.	Equipment	Temperature °C	Depth m	Remarks
Saanich Inlet	1	Borehole probe	8.93	201	increasing with depth
Desolation Sound	7	"	8.43	503	instability
S. Dean Chan.	12	"	6.61	270	*
N. Dean Chan.	40	"	6.68	466	*
Burke Chan.	59	"	6.68	582	
Douglas Chan.	70	"	6.83	381	*
Douglas Chan.	80	"	6.84	383	2 pts increasing with depth
Whale Chan.	91	"	6.81	576	*
Squally Chan.	102	"	6.86	648	*
Alice Arm	107	"	5.37	381	Seds. colder
Hastings Arm	111	"	6.67	300	Seds. colder
Observatory Inl.	115B	"	6.43	582	*
Portland In.	129	"	6.02	approx. 505	large ship drift
Squally Chan.	142	"	6.87	approx. 521	large ship drift
Dean Chan.	116	SR3MO5S	6.64	407	
Portland In.	136	"	6.10	485	
Squally Chan.	145	"	7.00	523	

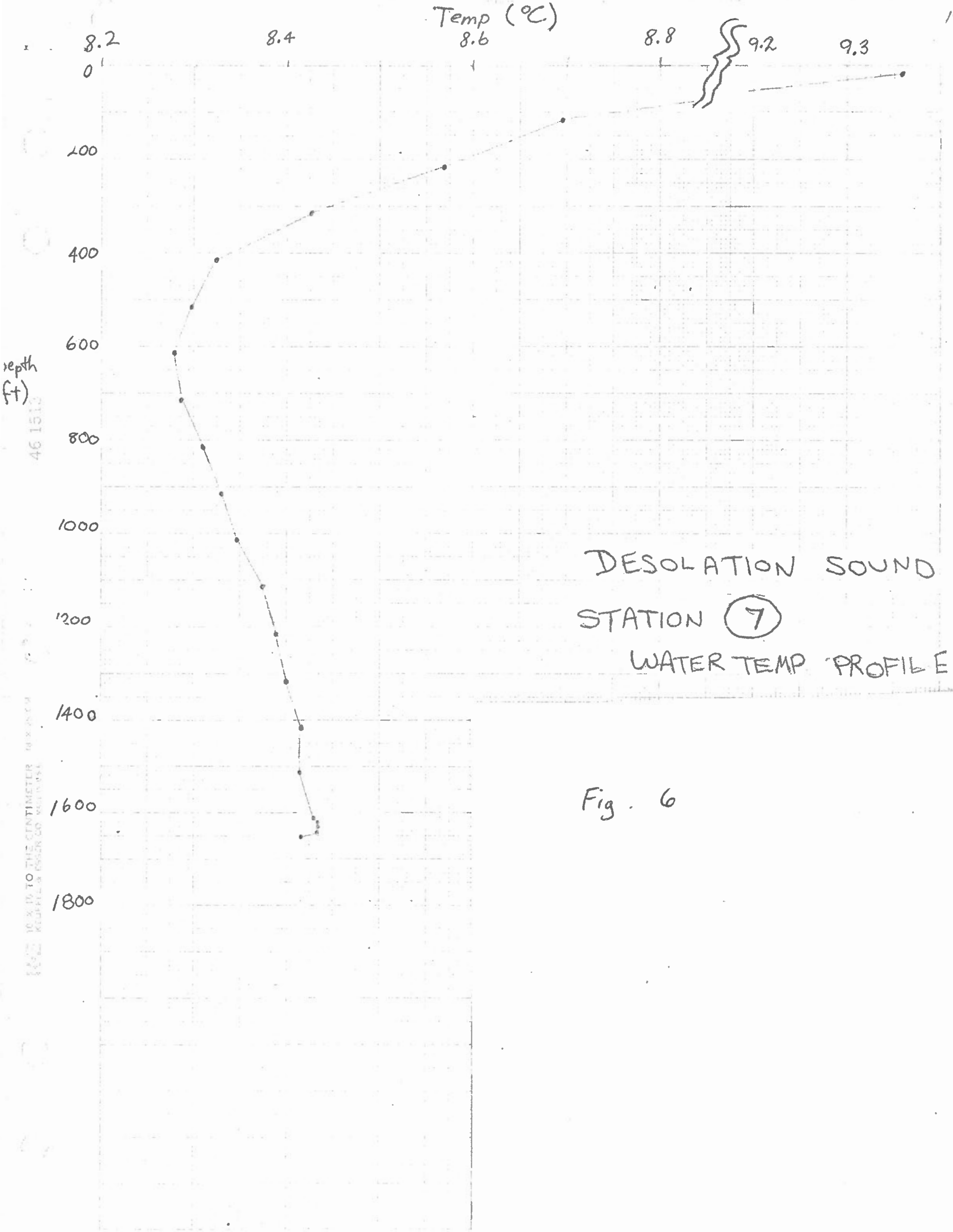
* the bottom value at higher temperature probably because the probe is into the soft sediments.

SAANICH INLET STATION ① WATER TEMPERATU
PROFIL



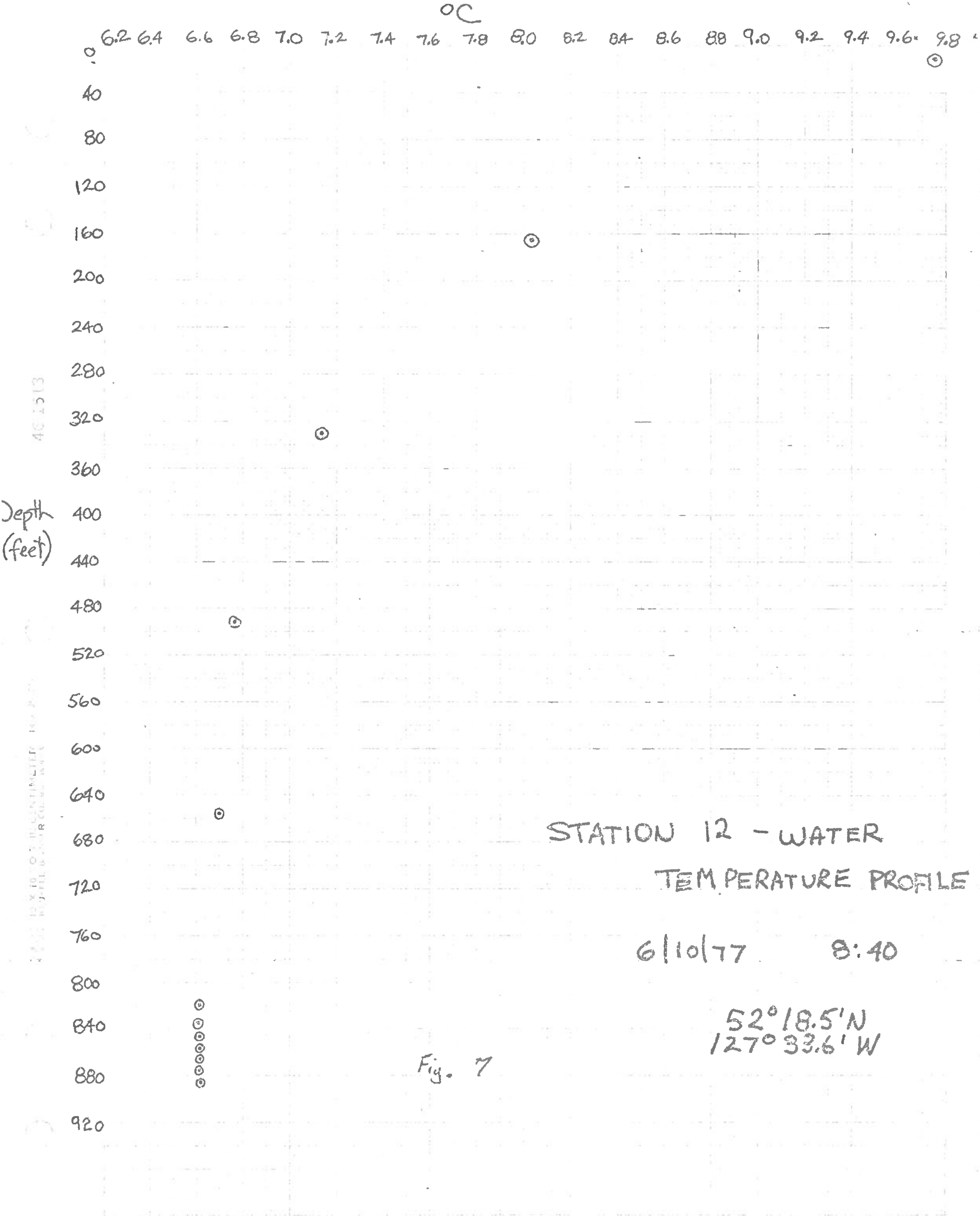
3/10/77

Fig. 5



DESOLATION SOUND
STATION ⑦
WATER TEMP PROFILE

Fig. 6

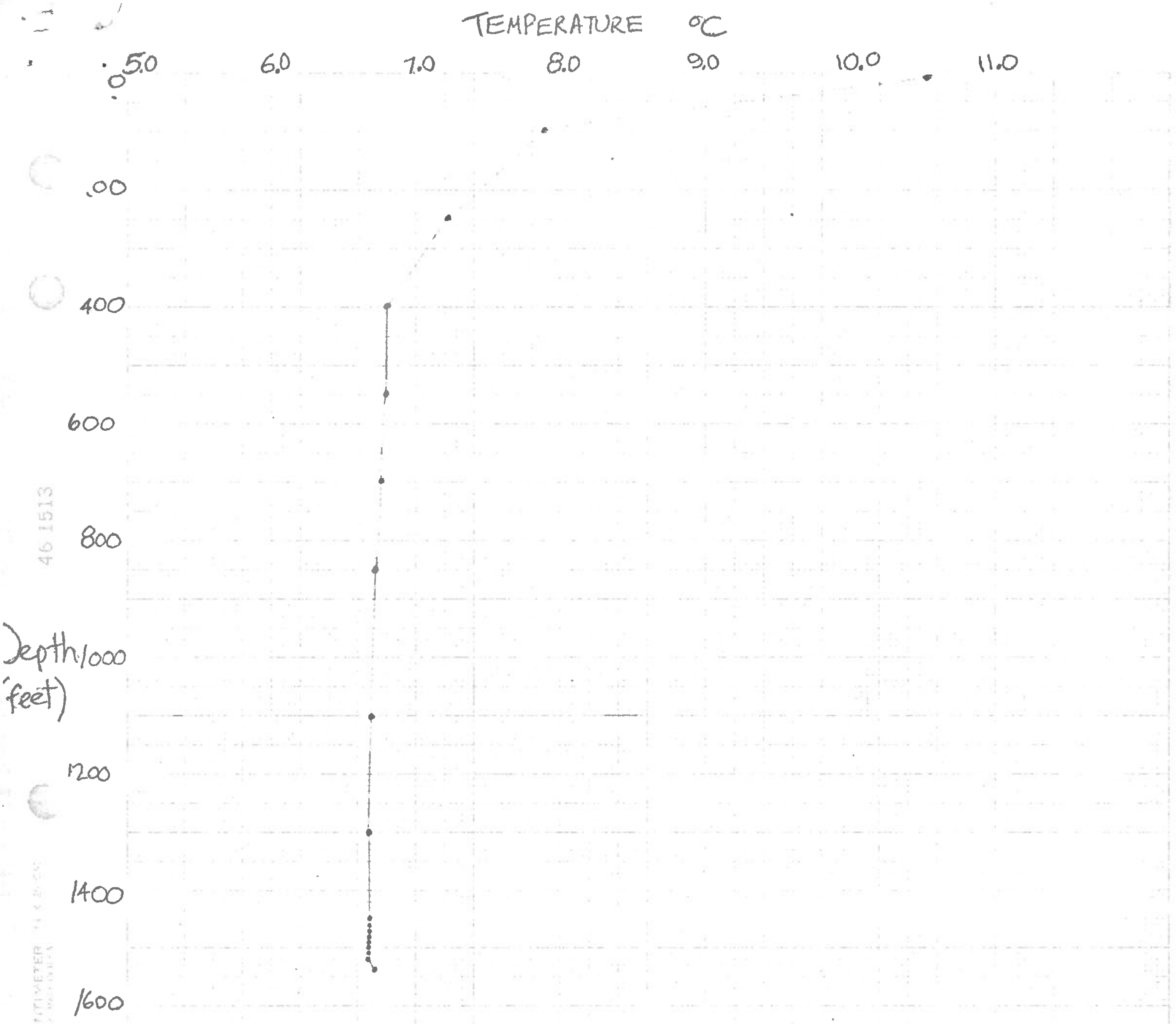


STATION 12 - WATER TEMPERATURE PROFILE

6/10/77 8:40

52°18.5'N
127°33.6'W

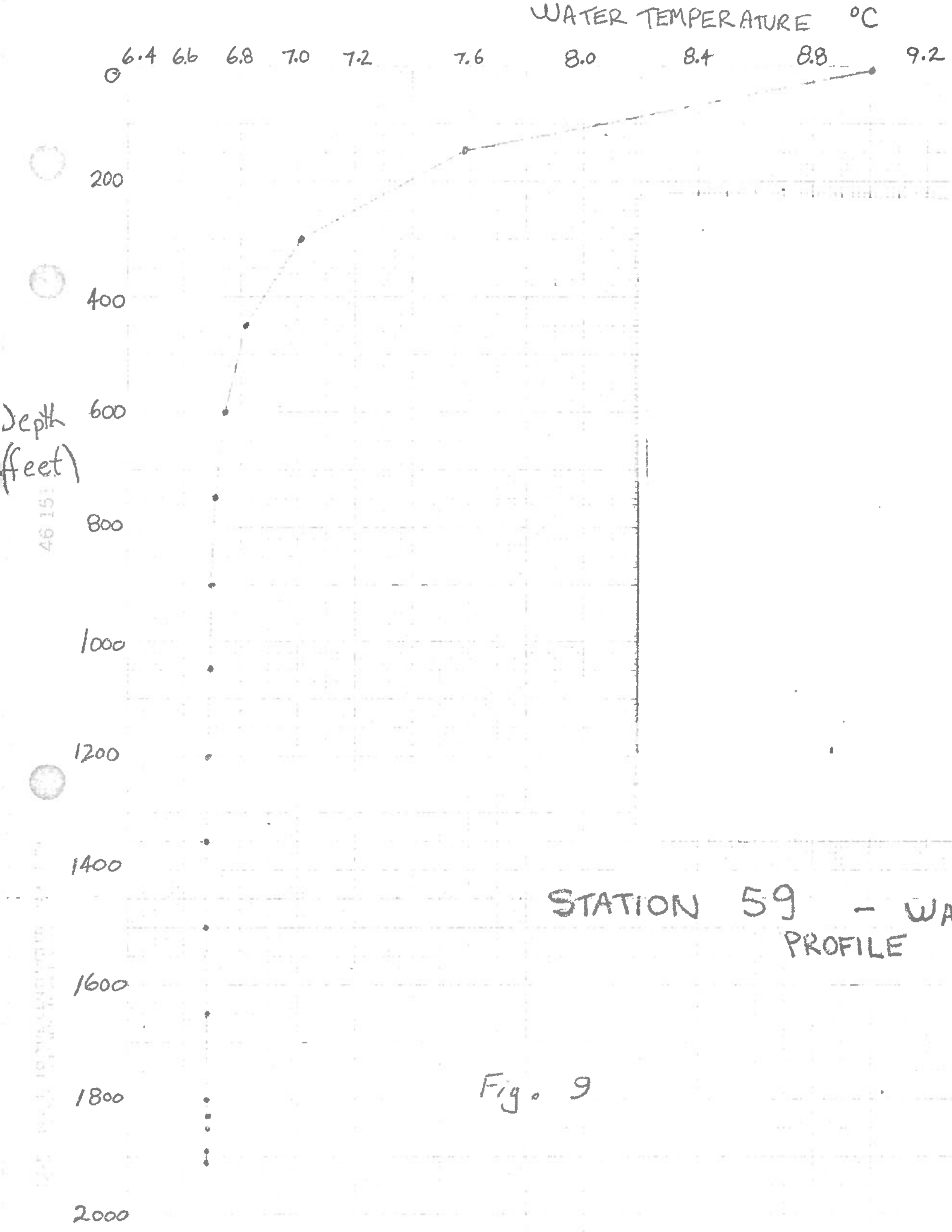
Fig. 7



STATION 40
8/10/77

WATER TEMP. PROFILE

Fig. 8



STATION 59 - WATER TEMP PROFILE 13:00hrs 9/10/77

Fig. 9

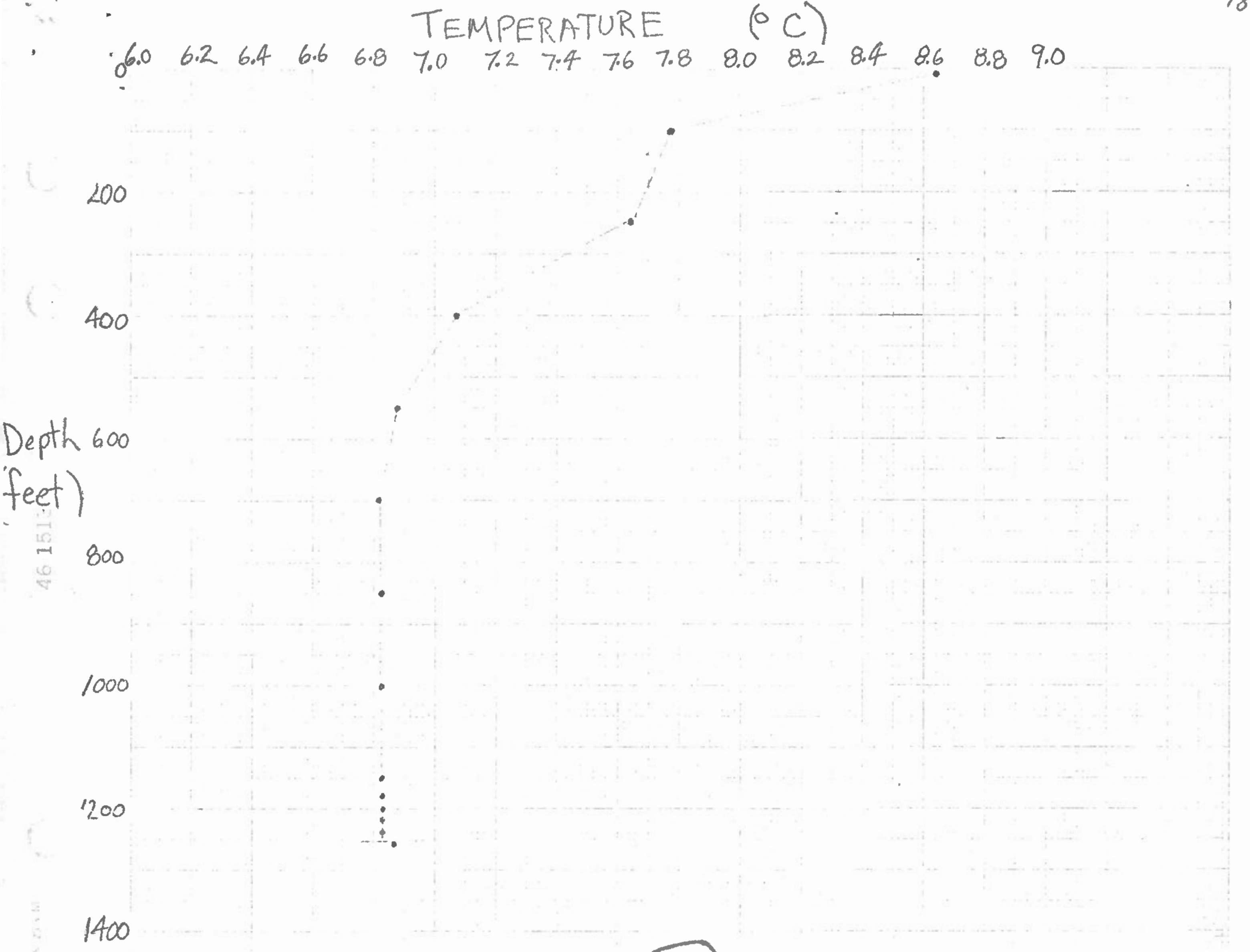
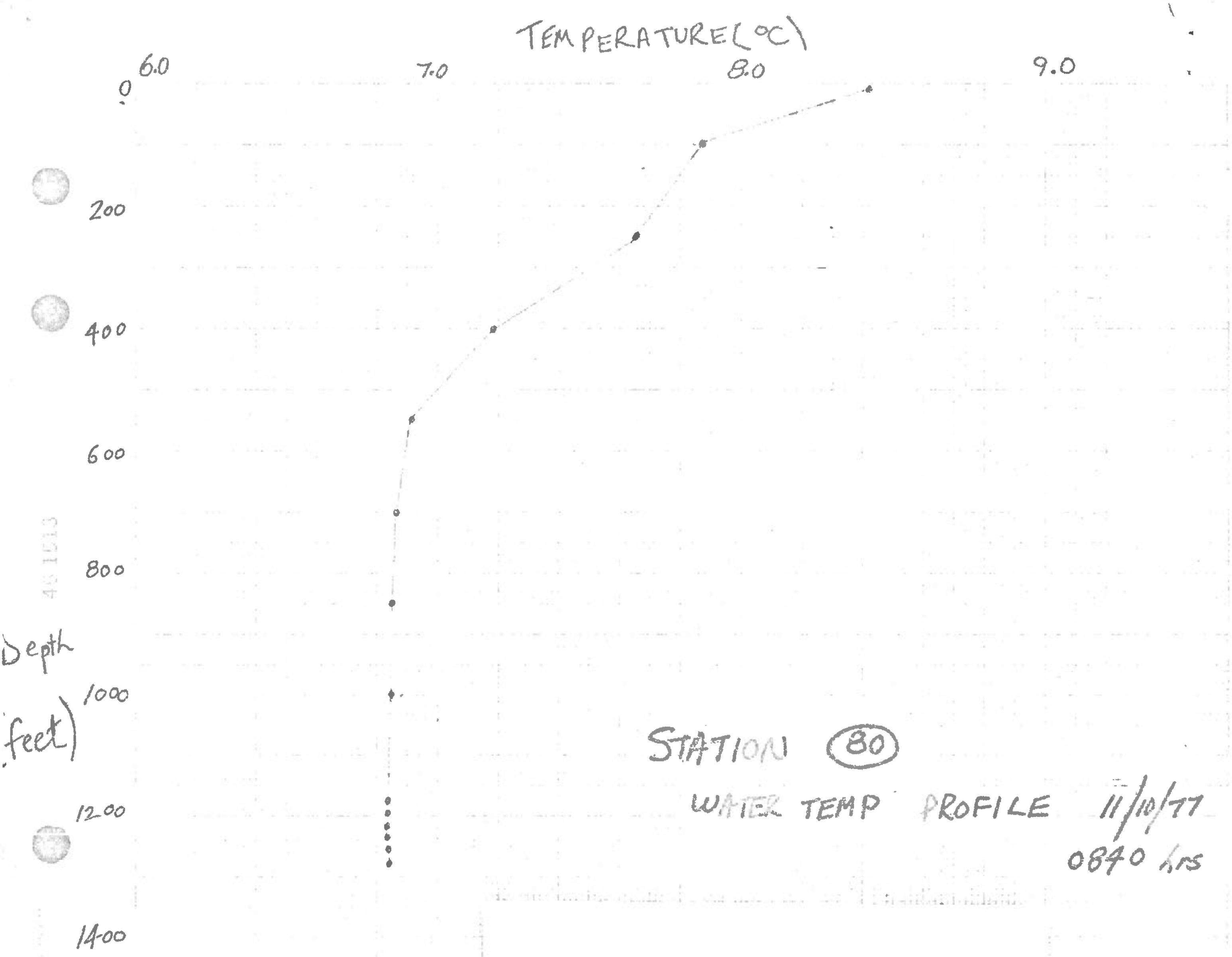
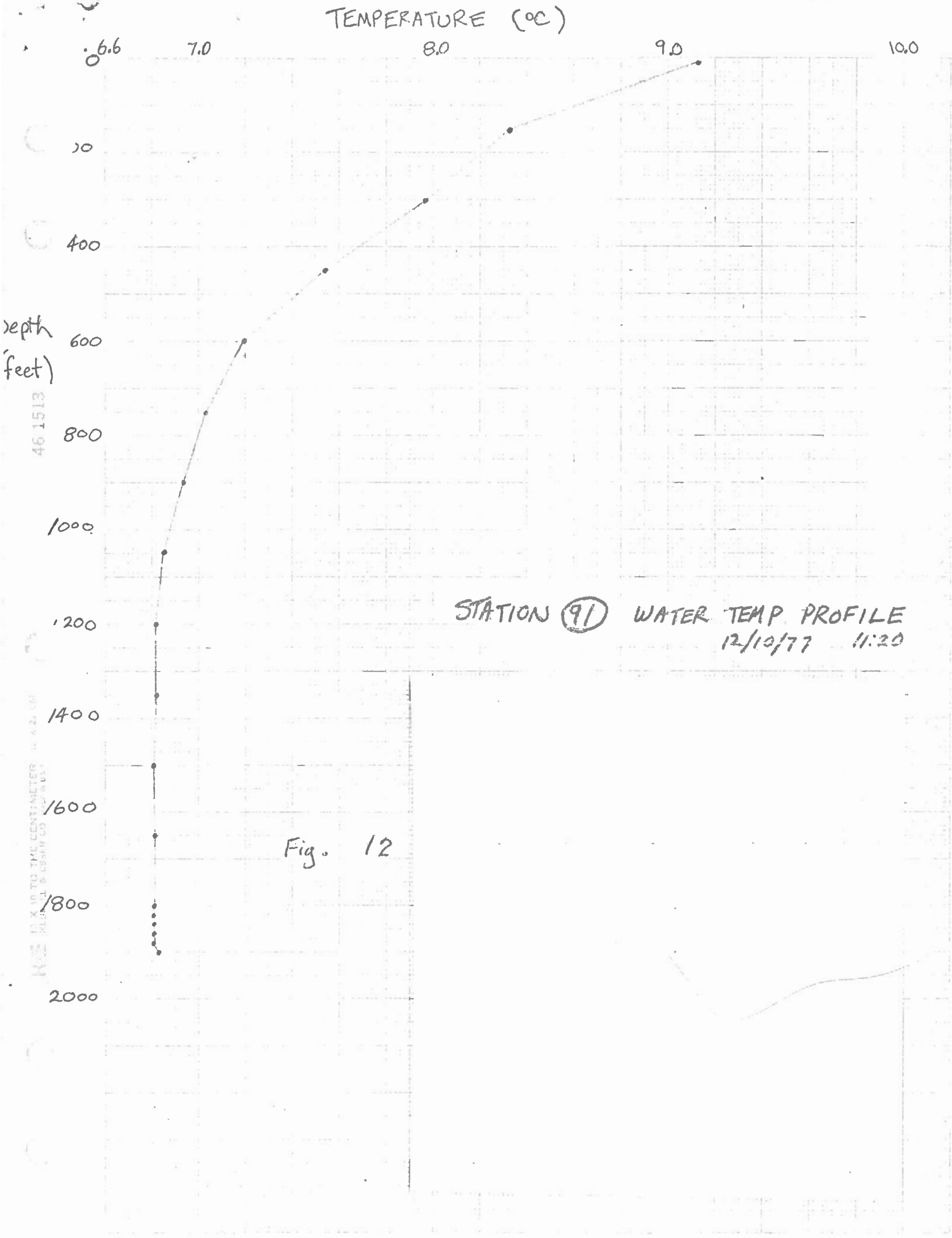


Fig. 10 STATION (70) WATER TEMP PROFILE
10/10/77 20:15 hrs



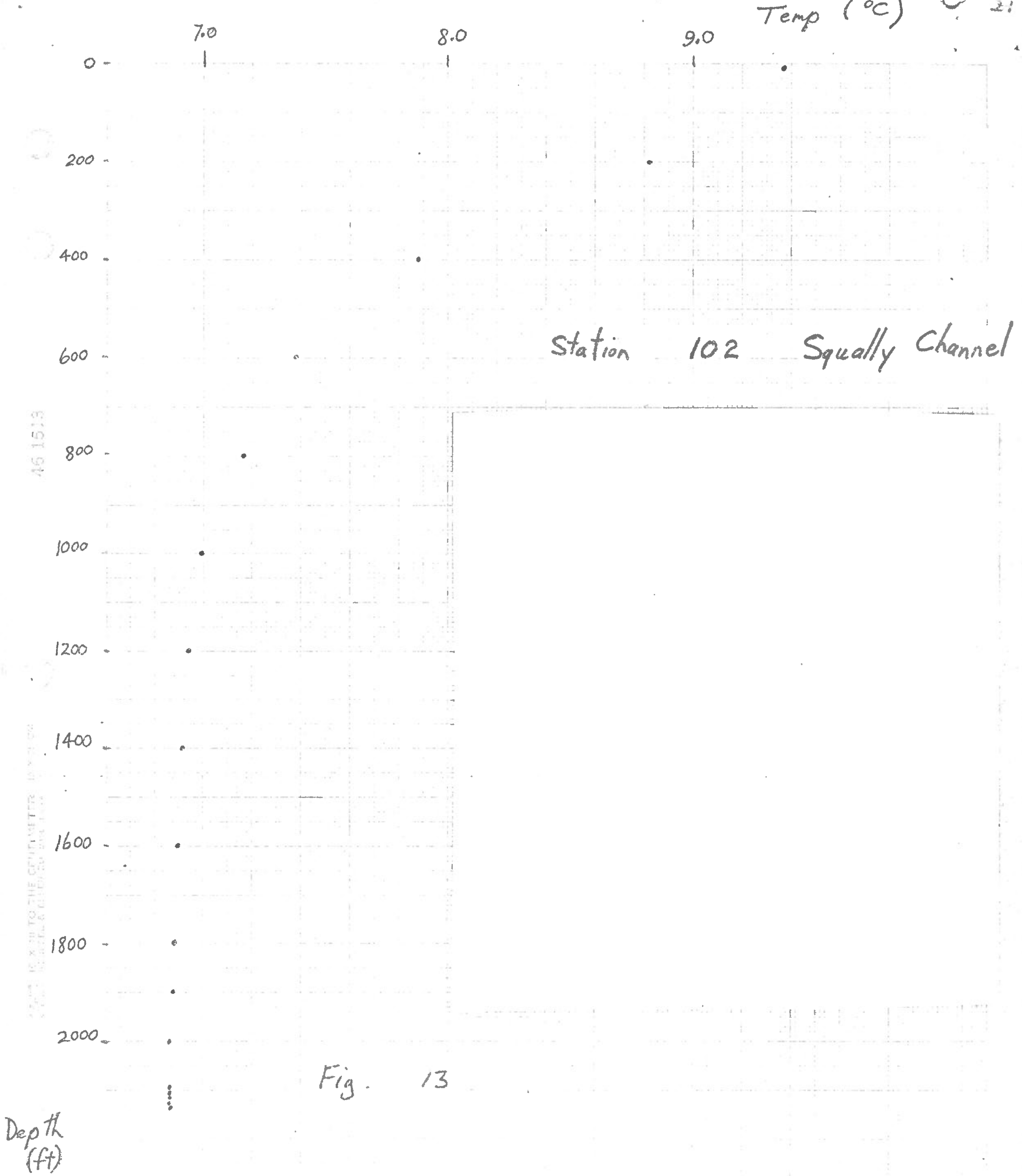
STATION 80
WATER TEMP PROFILE 11/10/77
0840 hrs

Fig. 11



STATION (91) WATER TEMP PROFILE
12/10/77 11:20

Fig. 12



Station 102 Squally Channel

Fig. 13

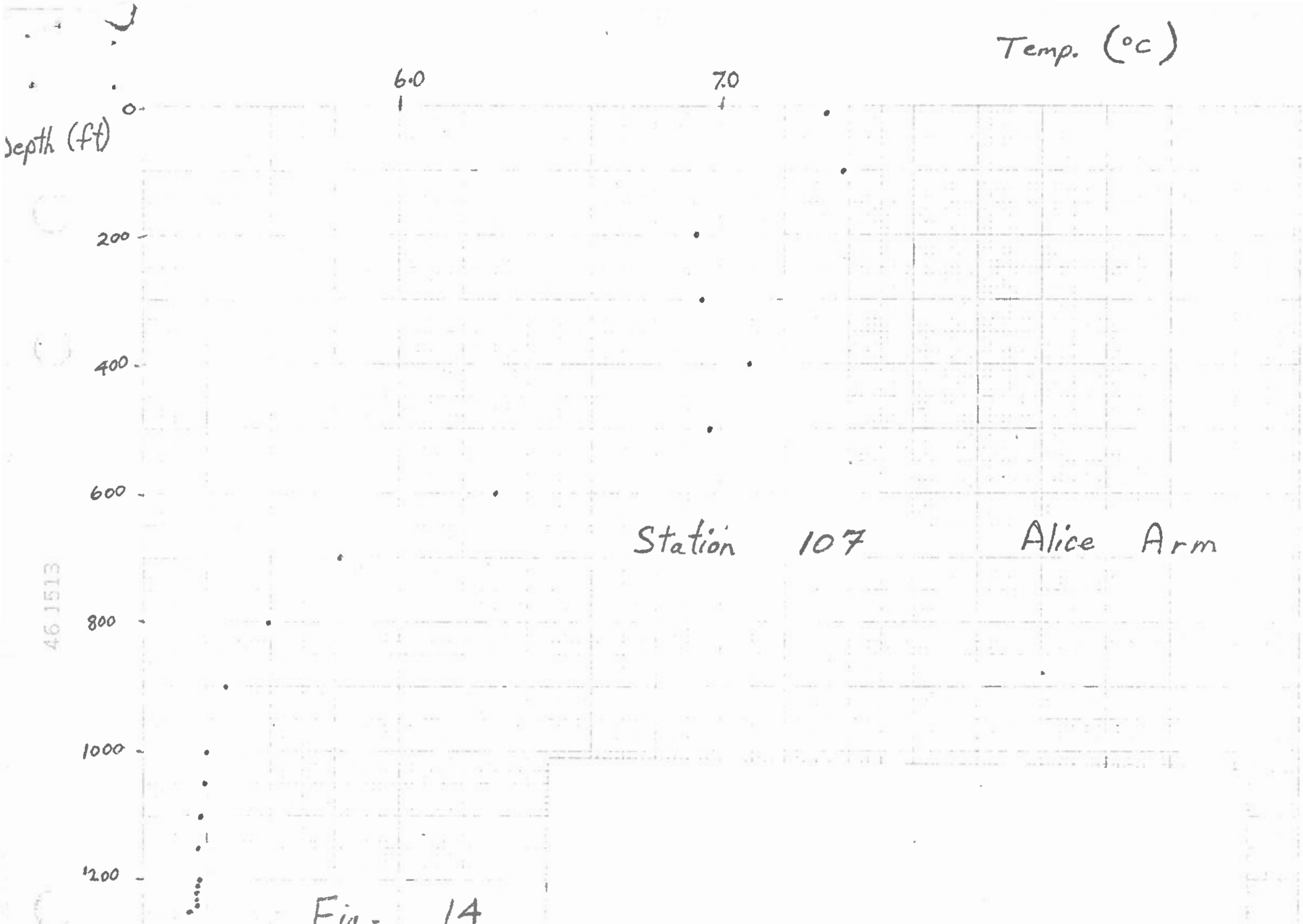

Temp. (°c)
6.0
7.0
Depth (ft)
0
200
400
600
800
1000
1200
Station 107 Alice Arm

Fig. 14

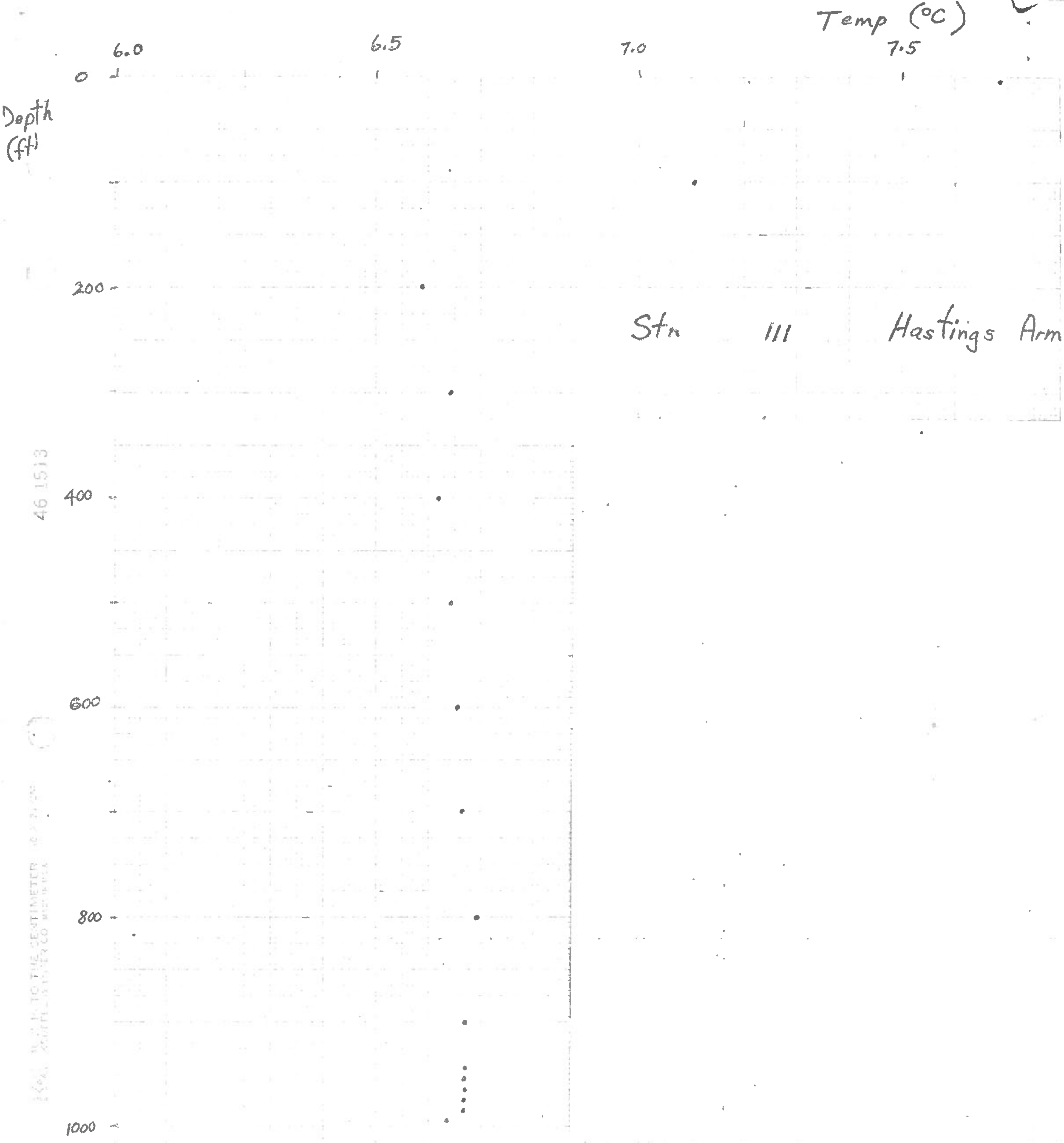
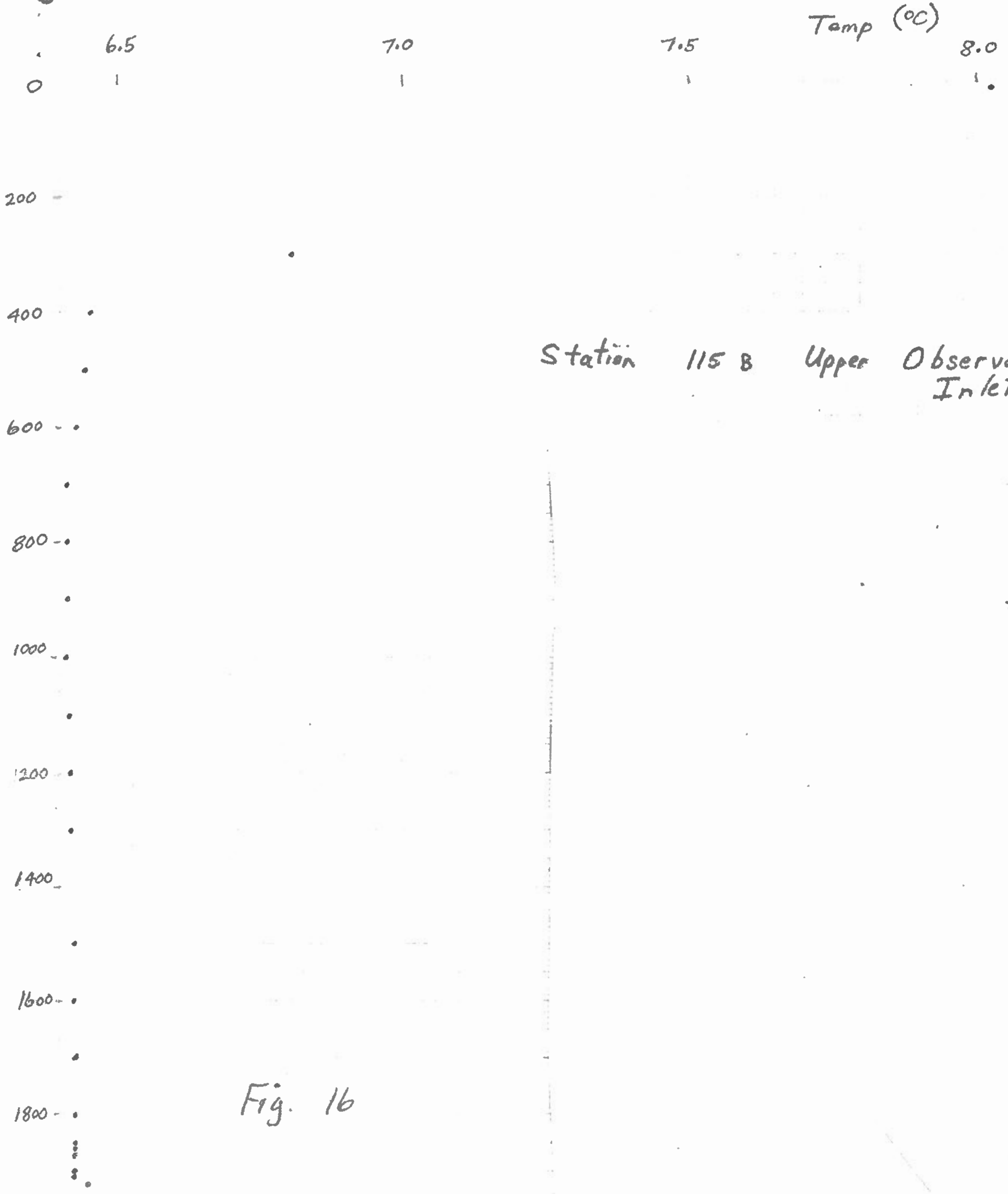

Temp (°C)
6.0
6.5
7.0
7.5
Depth (ft)
0
200
400
600
800
1000
Stn 111 Hastings Arm

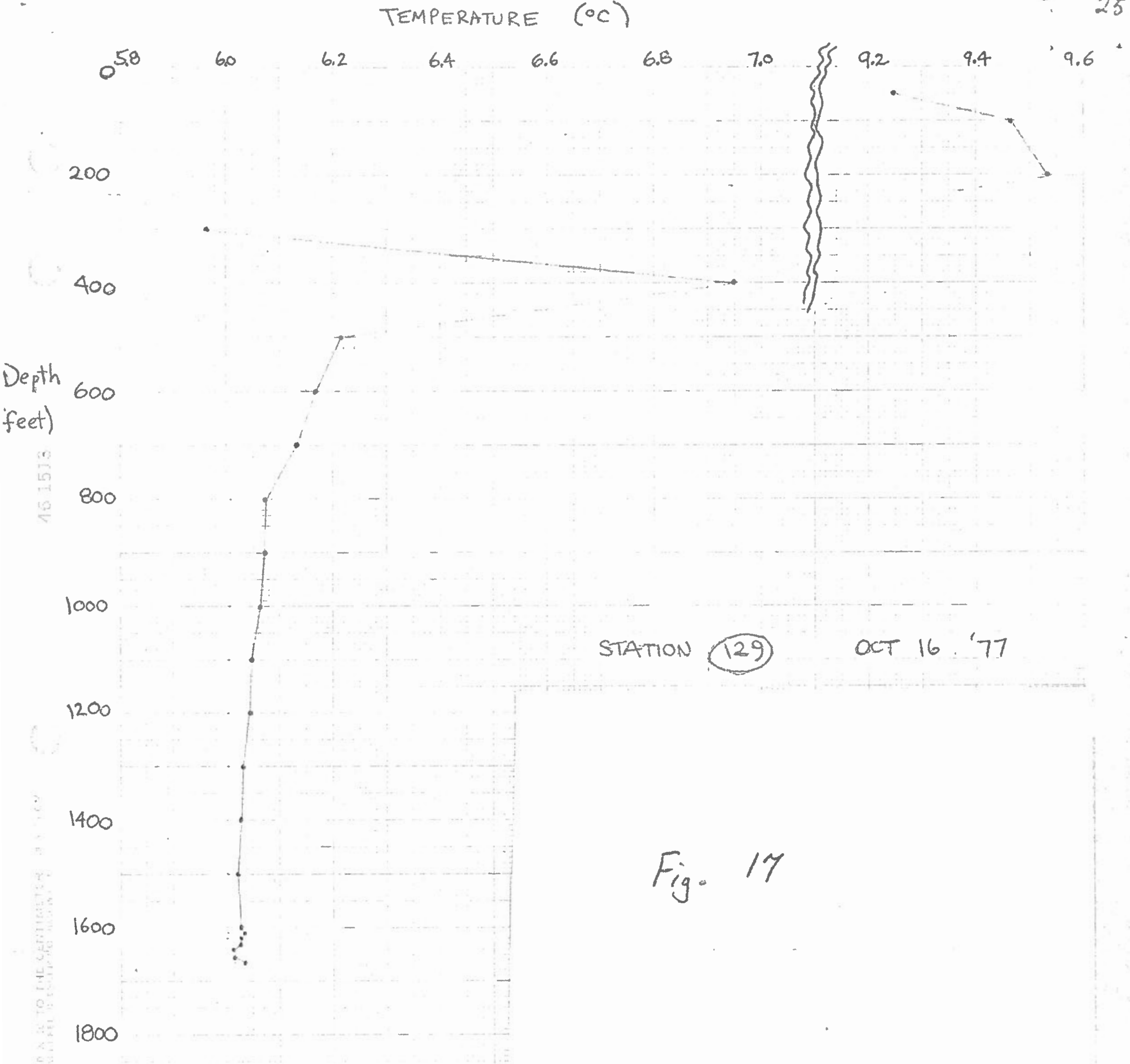
Fig. 15



Station 115 B Upper Observatory Inlet

Fig. 16

wire angle ≥ 60°



STATION (129) OCT 16. '77

Fig. 17

Large Ship drift
2 bottom measurements at
different "depths" — ie lengths
of cable out.

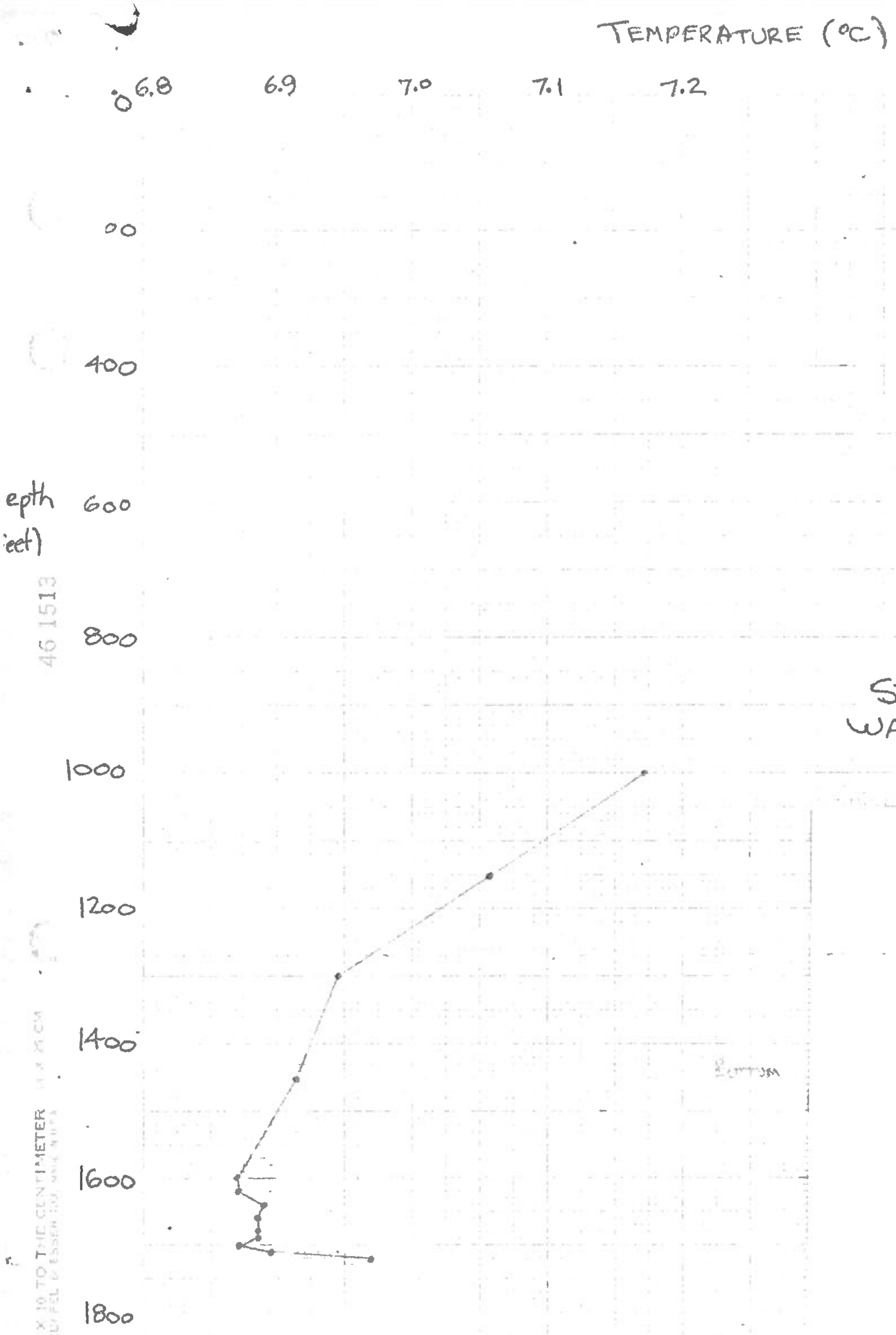
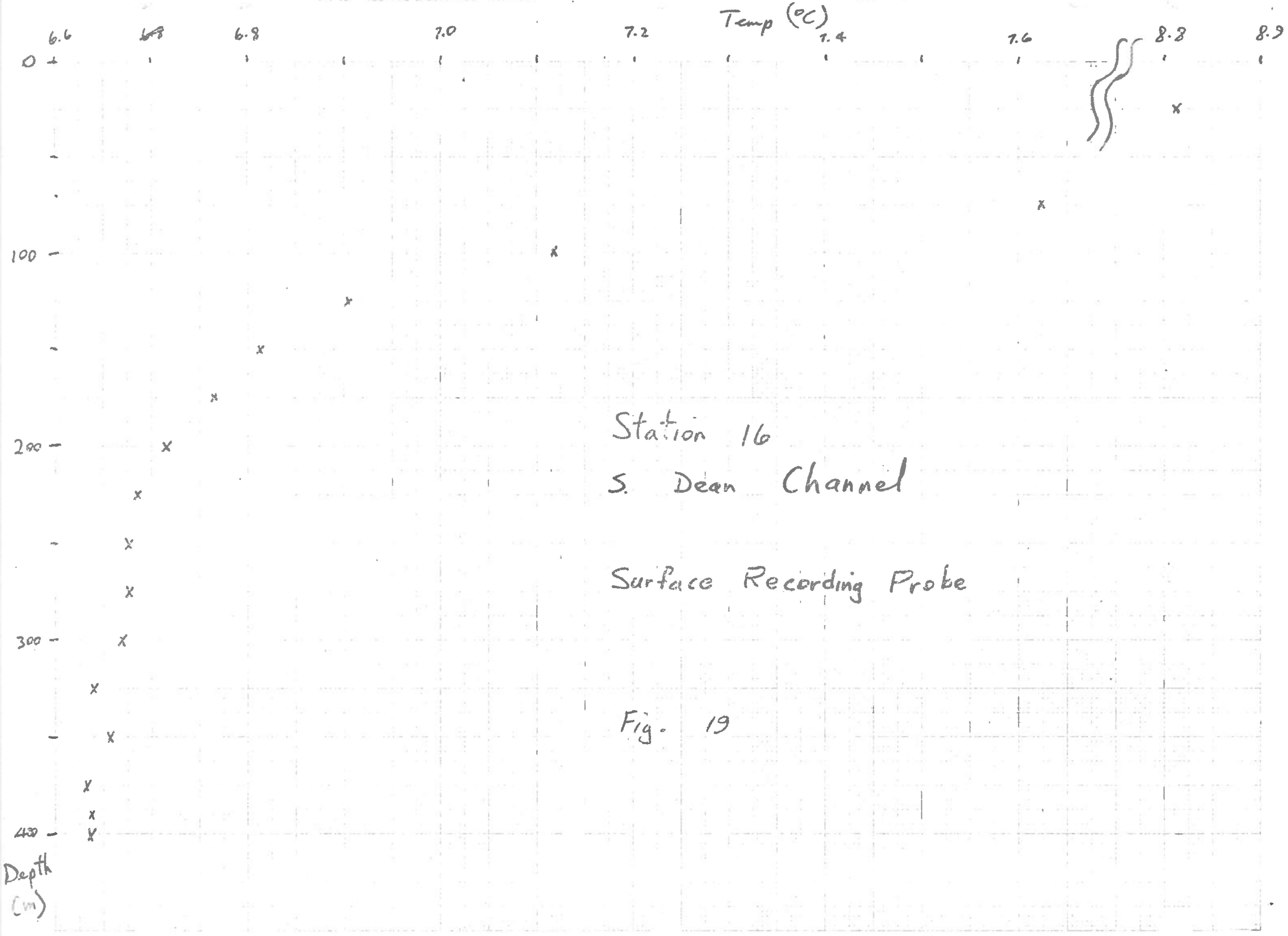


Fig. 18

STATION ⑭②
WATER TEMP PROFILE
17/10/77

note large differences in resistances for normal and reverse battery voltage applied.

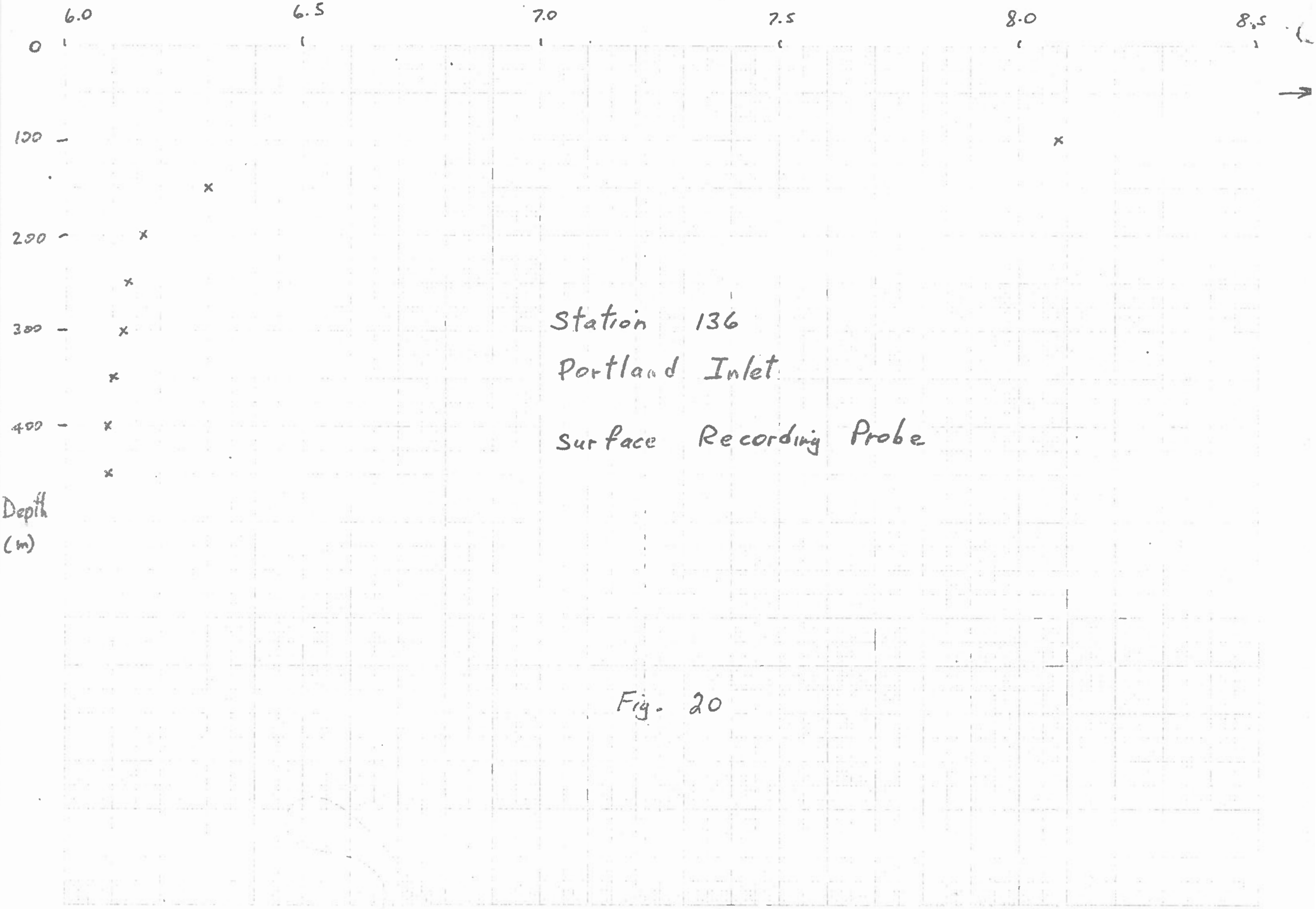


Station 16

S. Dean Channel

Surface Recording Probe

Fig. 19

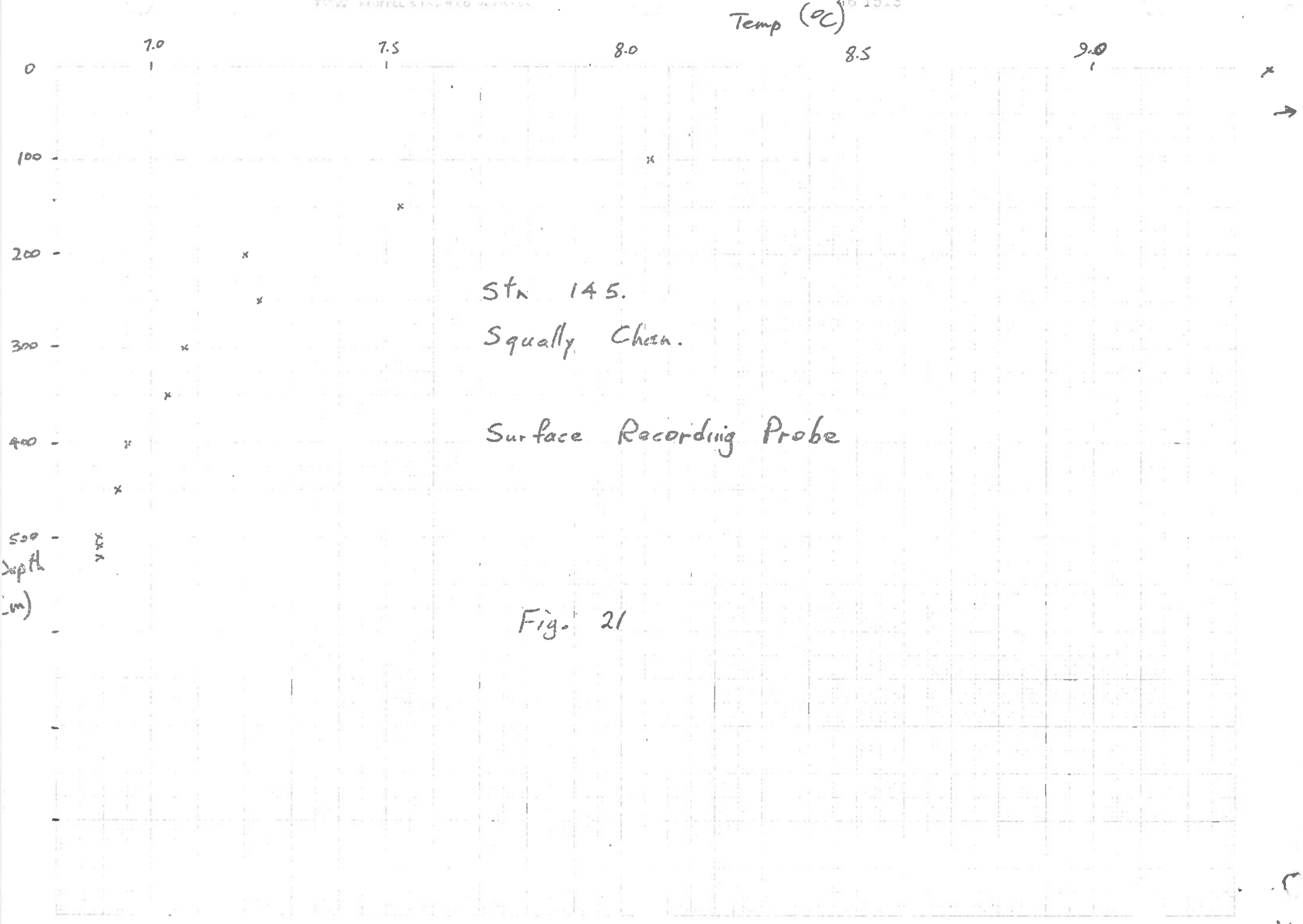


Station 136

Portland Inlet

Surface Recording Probe

Fig. 20



Stn 145.
Squally Chan.

Surface Recording Probe

Fig. 21

Table 3 : Thermograph Details

Serial No.	loaded	launched	N.	W.
006	0030 on 08.10.77	1100 on 08.10 77	52° 37 .65'	127° 03.7'
007	2330 on 07.10.77	0930 on 09.10.77	52° 11.3'	127° 29.7'

times P.D.T.

Thermal Conductivity (k)

The thermal conductivities of cores were measured using the needle probe technique aboard VECTOR, and the water contents of cores from which k can be determined were measured ashore later.

Using the transient needle probe technique (Von Herzen and Maxwell, 1959), the temperature, V, at a line source of constant heat increases with time, t, since the heater was turned on according to:

$$V = A + B \ln t \tag{1}$$

where

$$B = \frac{Q}{4 \pi k} \tag{2}$$

and Q is the amount of heat from the source per unit length per second, k, the thermal conductivity. This assumes that the core is homogeneous, is at constant ambient temperature before the measurement, and that the time is large enough for the presence of the needle probe to be of little effect and small enough for the reflected wave from the outside of the sample to be negligible. Since the lab could not be kept at constant temperature a term was added to (1) to allow for the linear drift of temperature with time:

$$V = A + B \ln t + Ct \tag{3}$$

Observations were taken at 15, 30, 60, 90, 120, 180, 300 and 420 s after the heater was turned on. The parameters A, B and C were obtained for (3) by minimizing the sum of the squares of the differences between the measured temperature and V.

The heat input, Q, was calculated using the constant voltage, 5.0 v, the heater's average resistance while heating, and the heater's length, defined by the resistance of the heating wire (52.10 ohms) and its resistivity (115.9 ohms/ft.), both at 20°C. Q was between 6.88 and 7.08 Wm^{-1} for 224 of 228 determinations on core samples. The average heater temperature during a set of measurements varied from 17 to 30°C, causing a 2% variation in Q.

Measurements with very little drift in temperature before the heater is turned on give a linear plot of V versus ln t for the sediments (See. fig 22.) Consequently the additional term in (3) corresponds to the long term temperature drift in the lab. The largest values of C from (3) are equivalent to temperature changes of +.47 and -.51 K during the seven minute measuring period. These occurred in the samples having the largest drifts in heater temperature before the heater was turned on; the magnitude of C was generally related to the drift measured before turning the heater on. The average drifts from C, .1 K during the seven minute period, and from before the heater is turned on, indicate that most cores were warming in the lab. Fig. 23 shows how the use of the extra term betters the fit of the calculated temperatures to the observed ones and demonstrates the resulting large change in slope.

The conductivity of a fused silica block was measured to check the calibration, mostly in water to improve the thermal contact between the walls of the hole and the probe. Using (1), the average of 19 measurements during the cruise is 1.37 W/mK (3.27 m cal/cm s °C), the expected value. However, all of the curves were concave downwards. Fitting (3) to all of the observations produces a much better fit (fig. 24), but k is 8.5% less. The measurements in the geometric middle of the time period give a slope very close to the expected one.

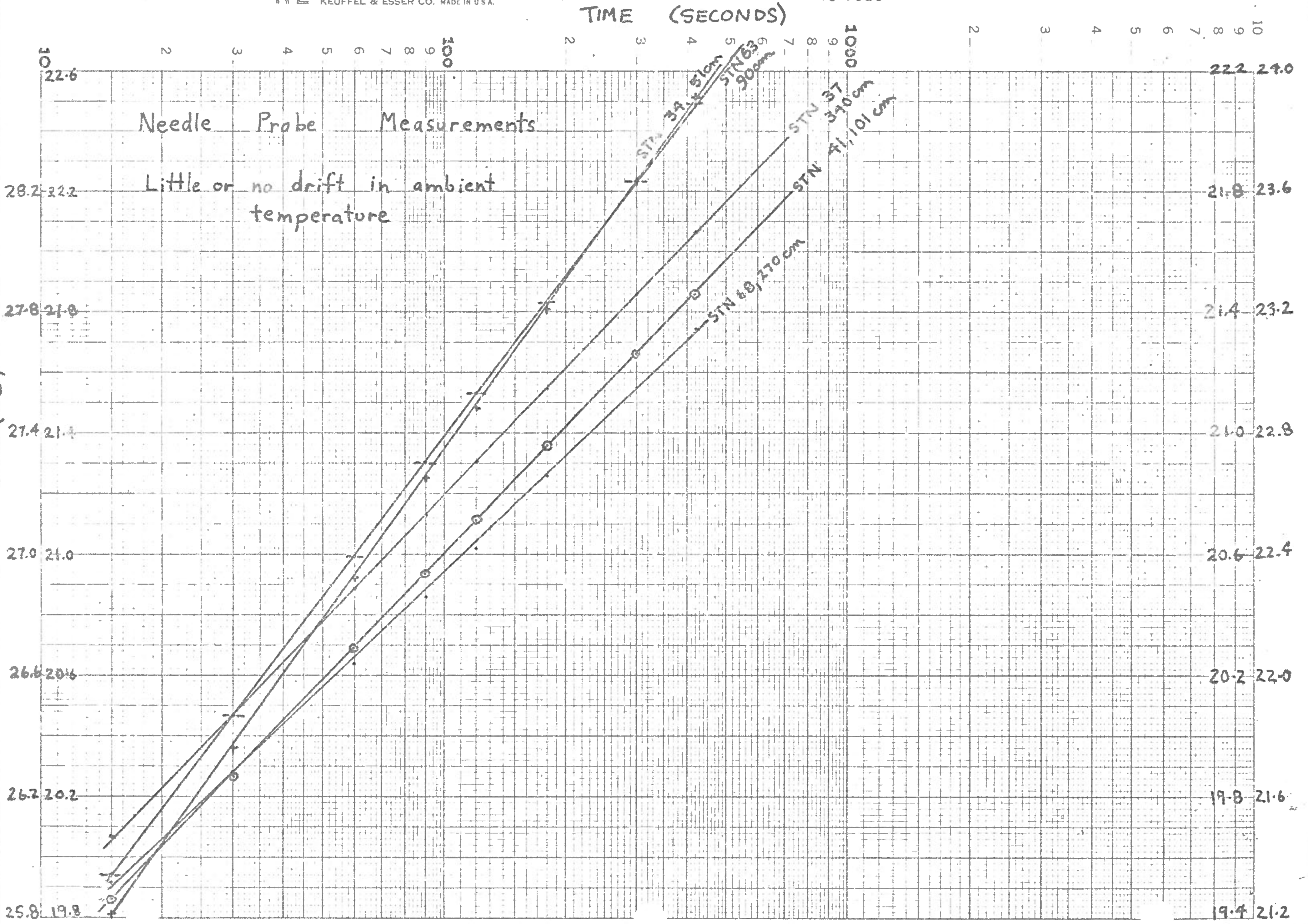

TIME (SECONDS)
10
2
3
4
5
6
7
8
9
100
2
3
4
5
6
7
8
9
1000
2
3
4
5
6
7
8
9
10
Needle Probe Measurements
Little or no drift in ambient temperature
STN 34, 51cm
STN 63 90cm
STN 37 340cm
STN 41, 101 cm
STN 68, 270 cm
22.6
28.2 22.2
27.8 21.8
27.4 21.4
27.0 21.0
26.6 20.6
26.2 20.2
25.8 19.8
22.2 24.0
21.8 23.6
21.4 23.2
21.0 22.8
20.6 22.4
20.2 22.0
19.8 21.6
19.4 21.2

Fig. 22

K+E SEMI-LOGARITHMIC 3 CYCLES x 140 DIVISIONS
KEUFFEL & ESSER CO MADE IN U.S.A.

46 5810

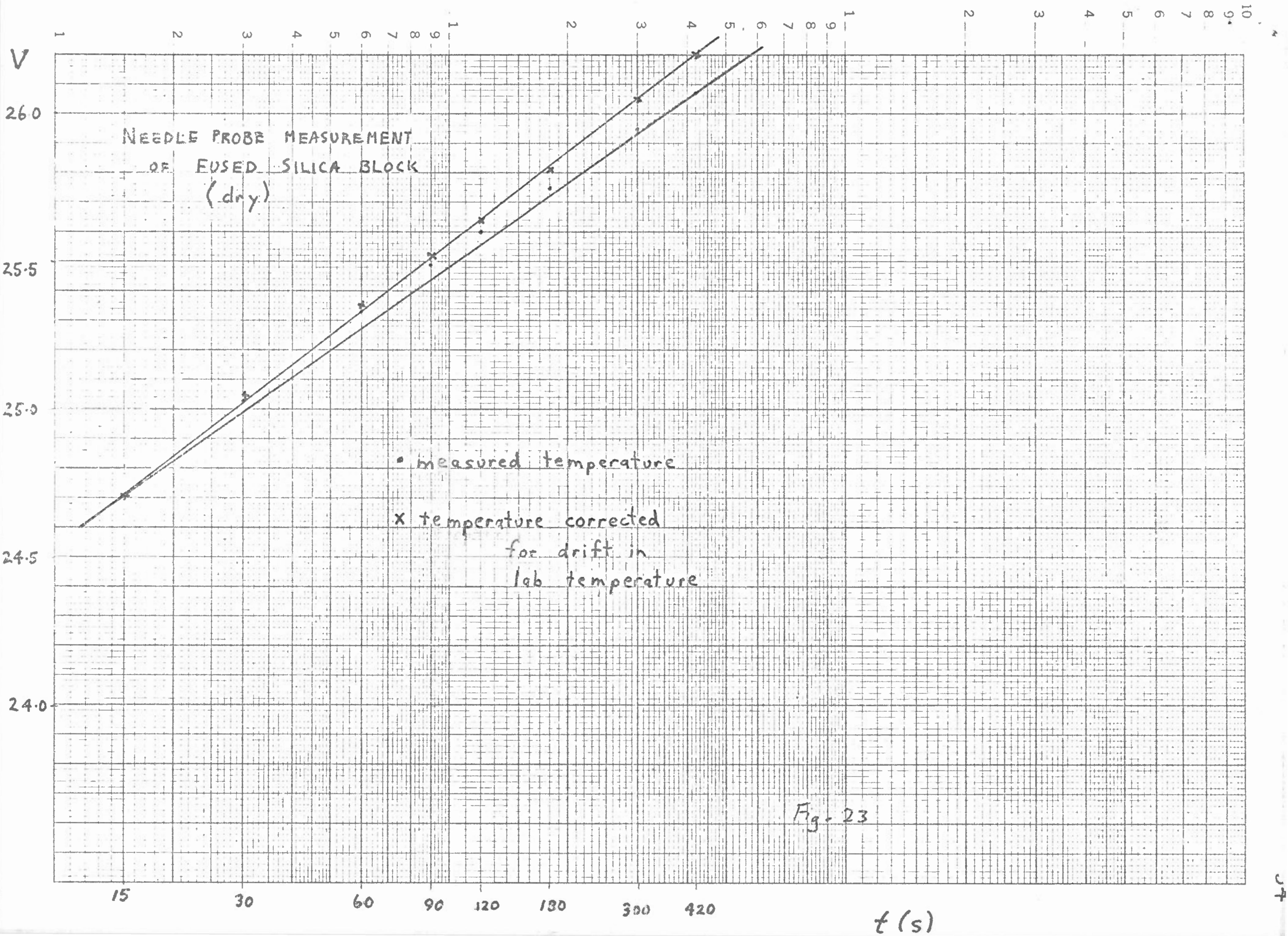


Fig. 23

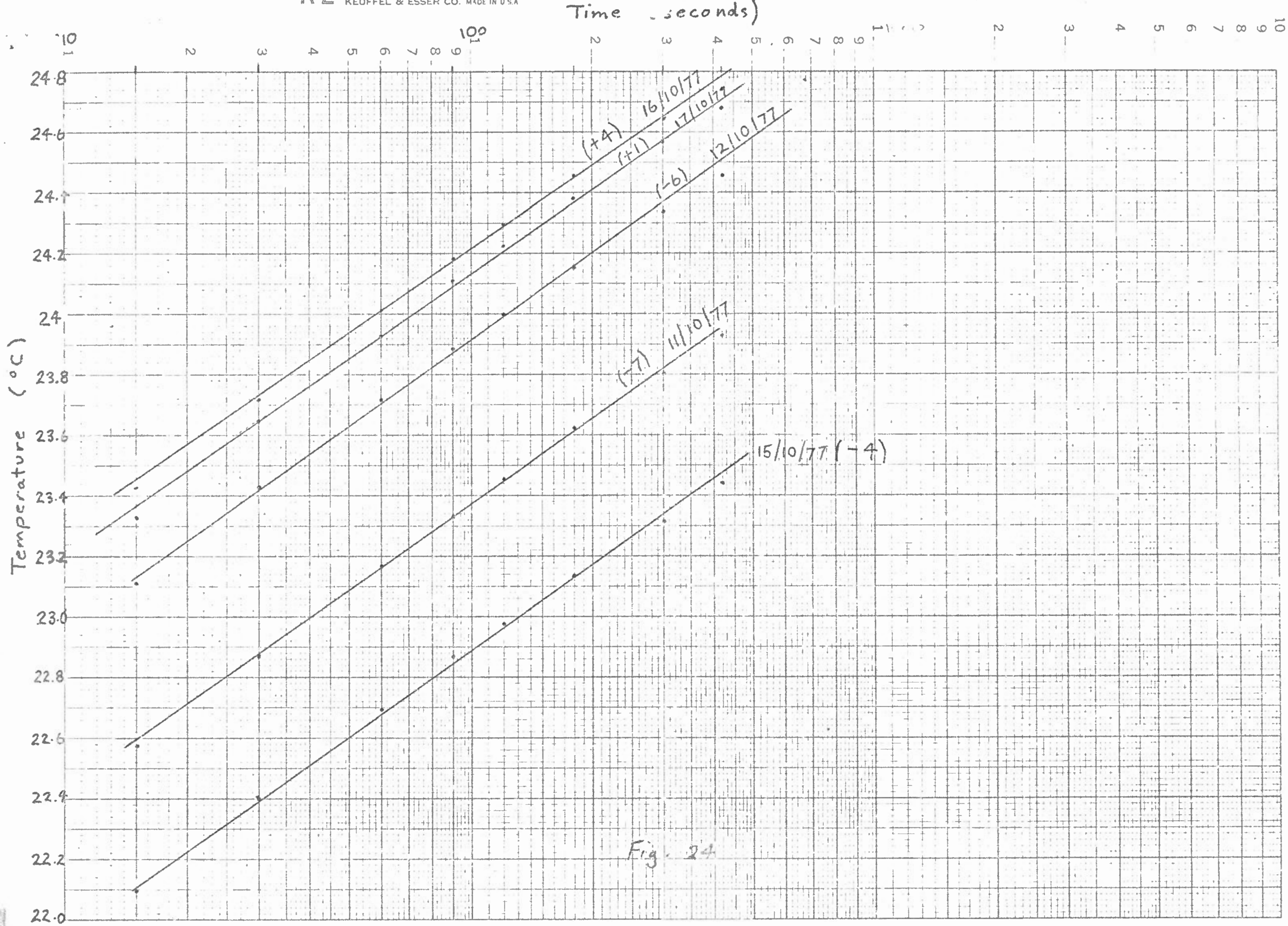


Fig. 24

Fused Silica Wet — Needle Probe Measurements

The concavity is not related to observed temperature drifts before the heater is turned on. The same fit was obtained in air on both this cruise and an earlier cruise aboard Endeavour.

The conductivities of the cores are listed in appendix A and plotted as a function of depth in figures 25 to 30, and Table 4 contains a summary of the average conductivity for each station. These conductivities are corrected to their values under in situ pressure and temperature using a correction of 1% per 1830 m of water depth (Ratcliffe, 1960) and 1% per 5.2 K temperature difference (MacDonald and Simmons, 1972). The values vary a lot: between .65 and 1.12 W/mK (1.55 to 2.67 m cal/cm s °C), the average value being .78 W/mK (1.86 m cal/cm s °C). The majority of the cores have a thermal conductivity which does not vary appreciably along their length, but a large number of cores do have large variations. Some stations, eg 67 and 68, have sampled two different layers. This is not surprising if one observes the large number of shallow reflectors on the 3.5 khz sounder profiles. An extensive examination revealed that in most cases large conductivity changes correlate with a reflector. However the correlation is uncertain in some cases, in two cases (stations 82 and 121) apparently no reflector correlates with an observed change, and in some cases (eg station 57) a reflector was present but no conductivity contrast was observed.

Even though k varies so much, for the upper section the average k is systematically higher than for the lower section of Dean and Burke Channels and for Observatory Inlet. (See Table 5).

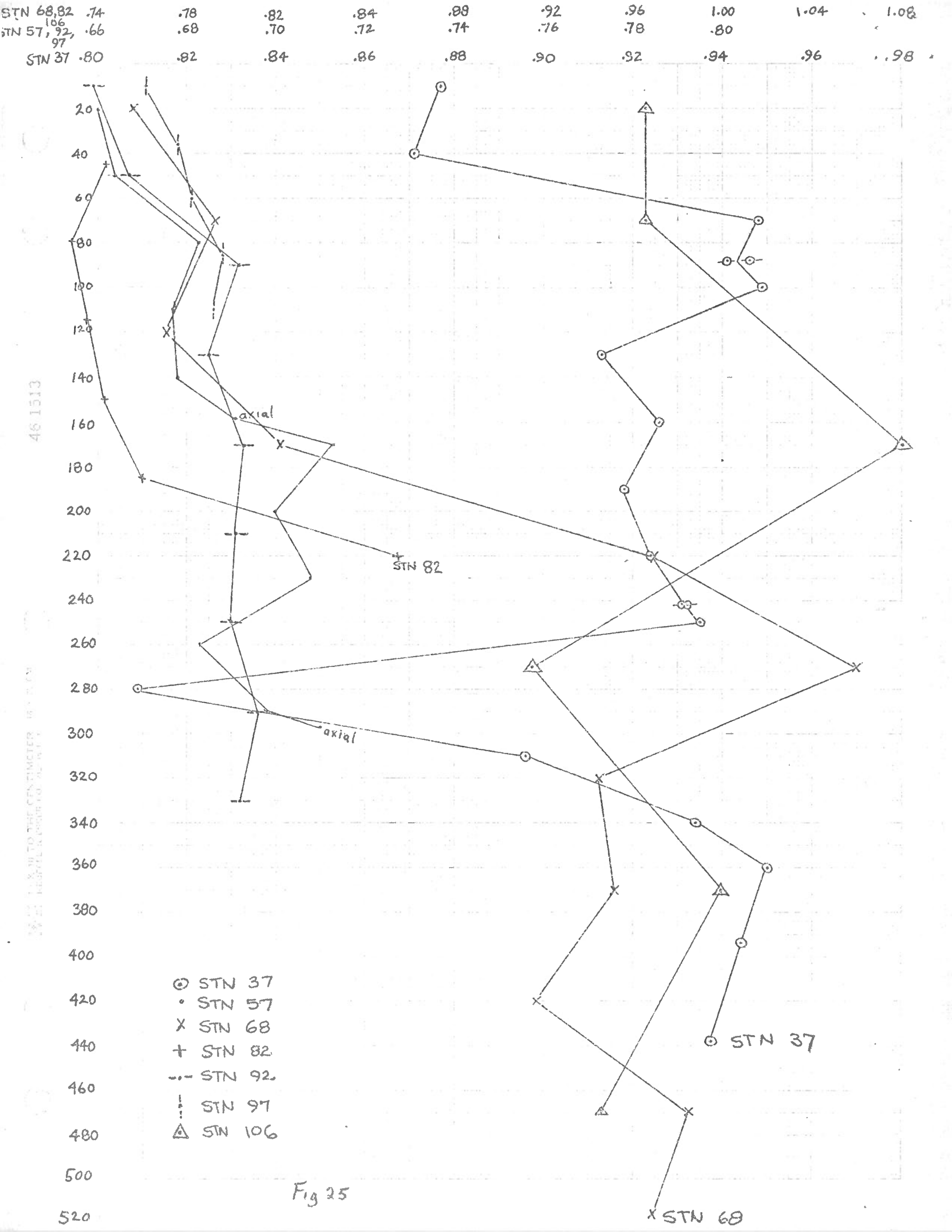

STN 68,82,106 .74 .78 .82 .84 .88 .92 .96 1.00 1.04 1.08
STN 57, 92, 97 .66 .68 .70 .72 .74 .76 .78 .80
STN 37 .80 .82 .84 .86 .88 .90 .92 .94 .96 .98
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
axial
axial
STN 82
STN 37
STN 68
⊙ STN 37
• STN 57
X STN 68
+ STN 82
-.- STN 92
¦ STN 97
△ STN 106

Fig 25

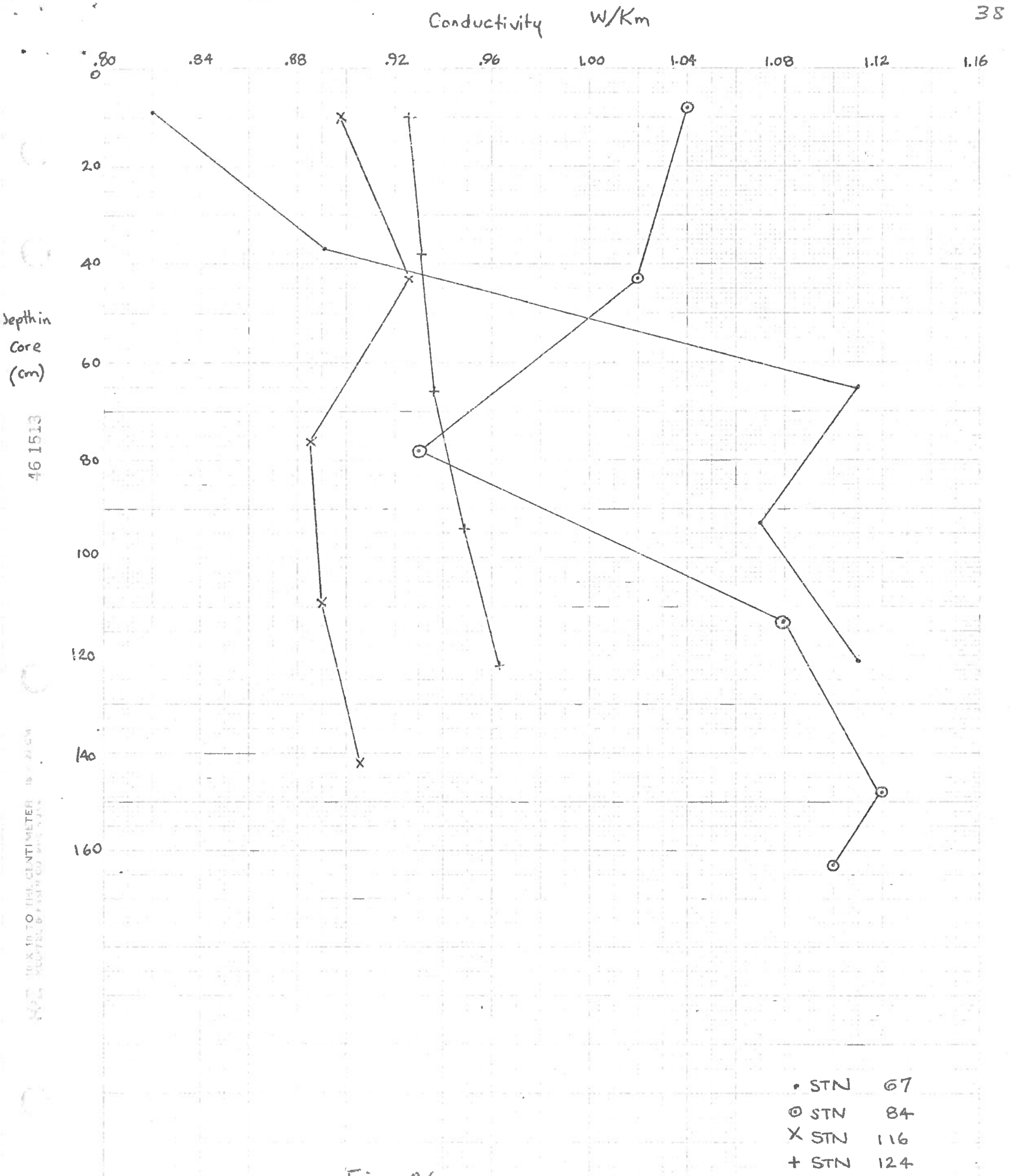

Conductivity W/Km
.80
.84
.88
.92
.96
1.00
1.04
1.08
1.12
1.16
0
20
40
60
80
100
120
140
160
Depth in Core (cm)
• STN 67
⊙ STN 84
X STN 116
+ STN 124

Fig. 26

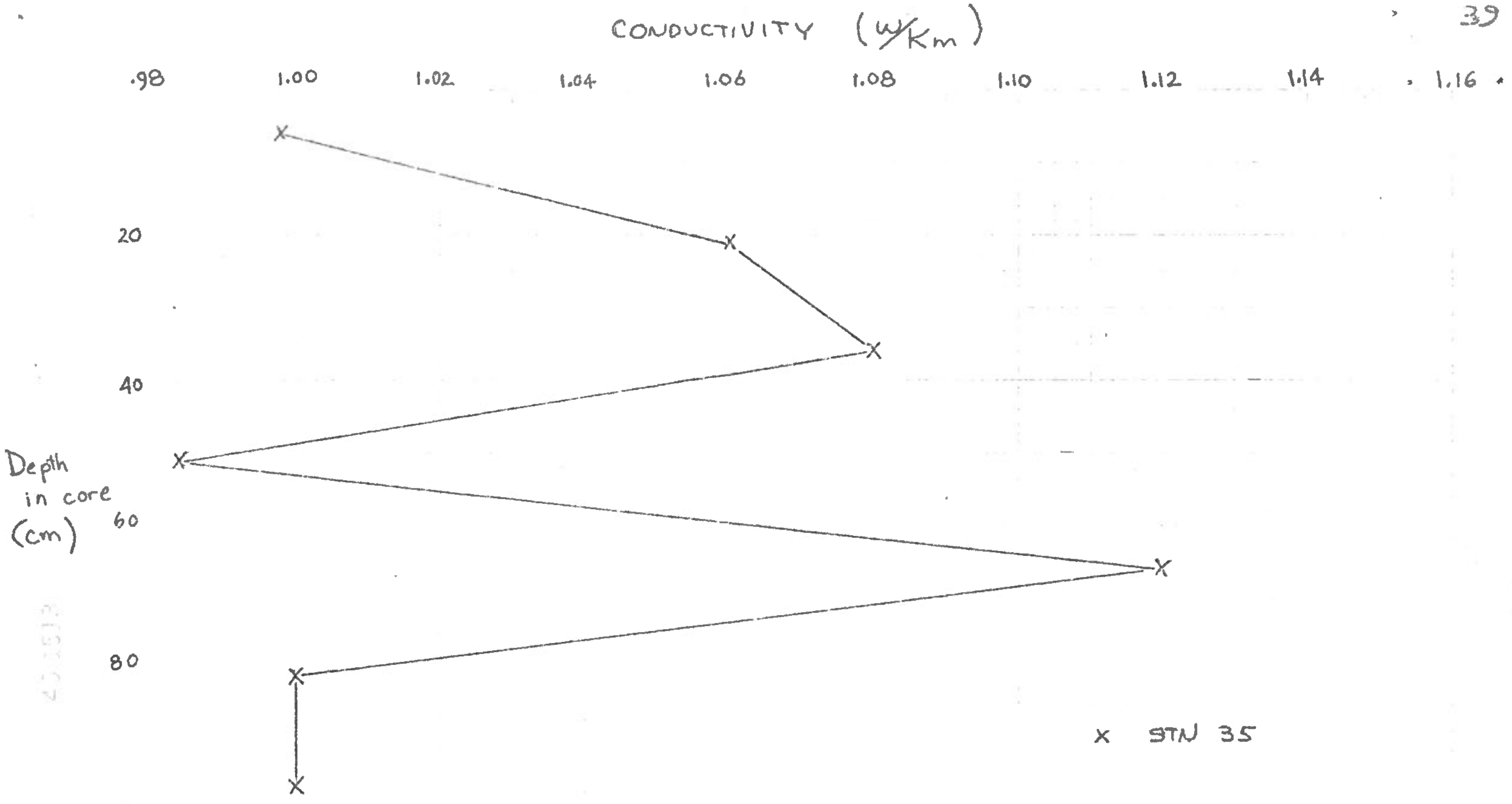

CONDUCTIVITY (W/Km)
.98
1.00
1.02
1.04
1.06
1.08
1.10
1.12
1.14
1.16
20
40
60
80
100
Depth in core (cm)
x STN 35

Fig. 27

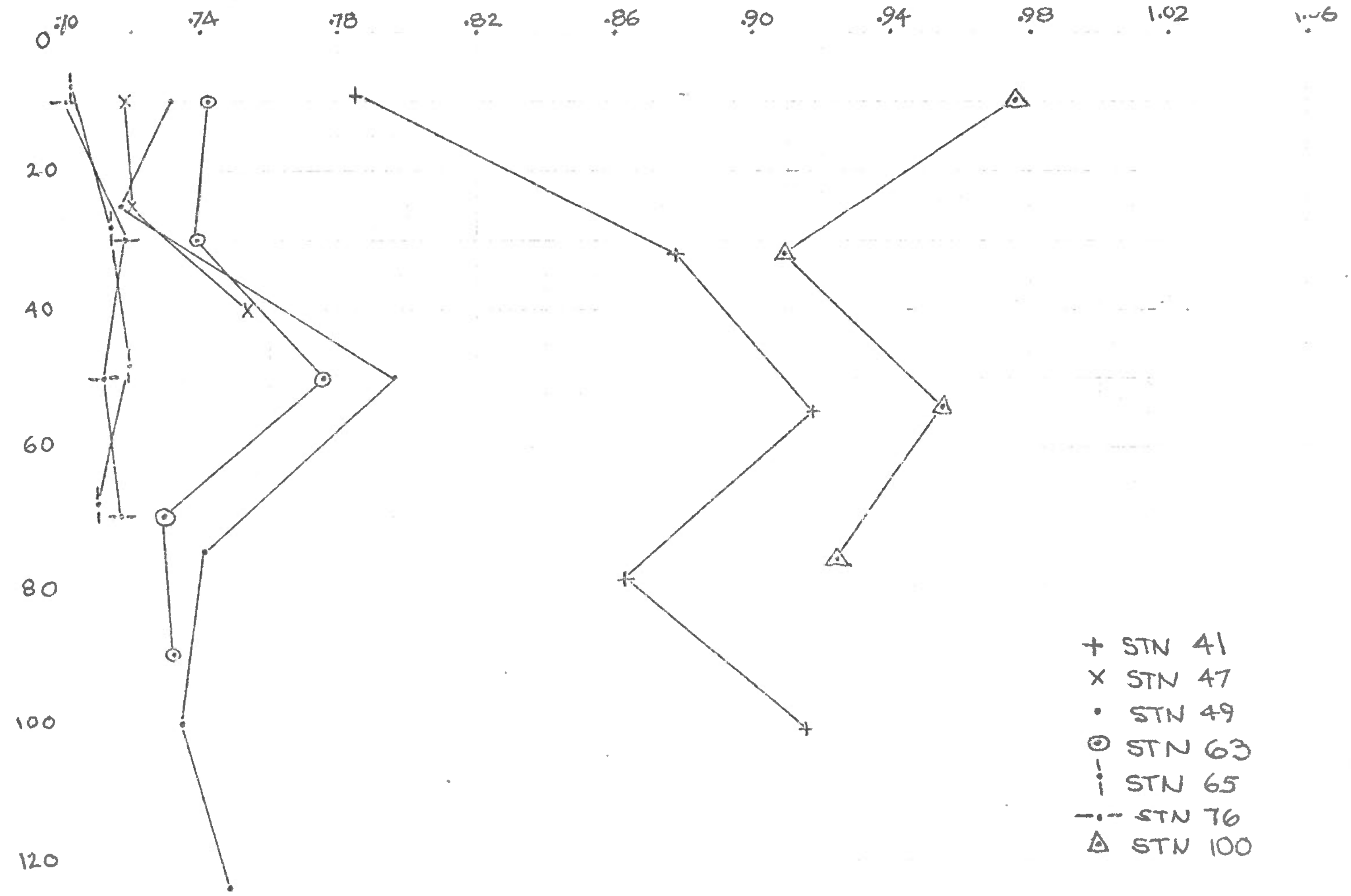

0
.70
.74
.78
.82
.86
.90
.94
.98
1.02
1.06
20
40
60
80
100
120
+ STN 41
x STN 47
• STN 49
⊙ STN 63
¦ STN 65
-•- STN 76
△ STN 100

Fig 28

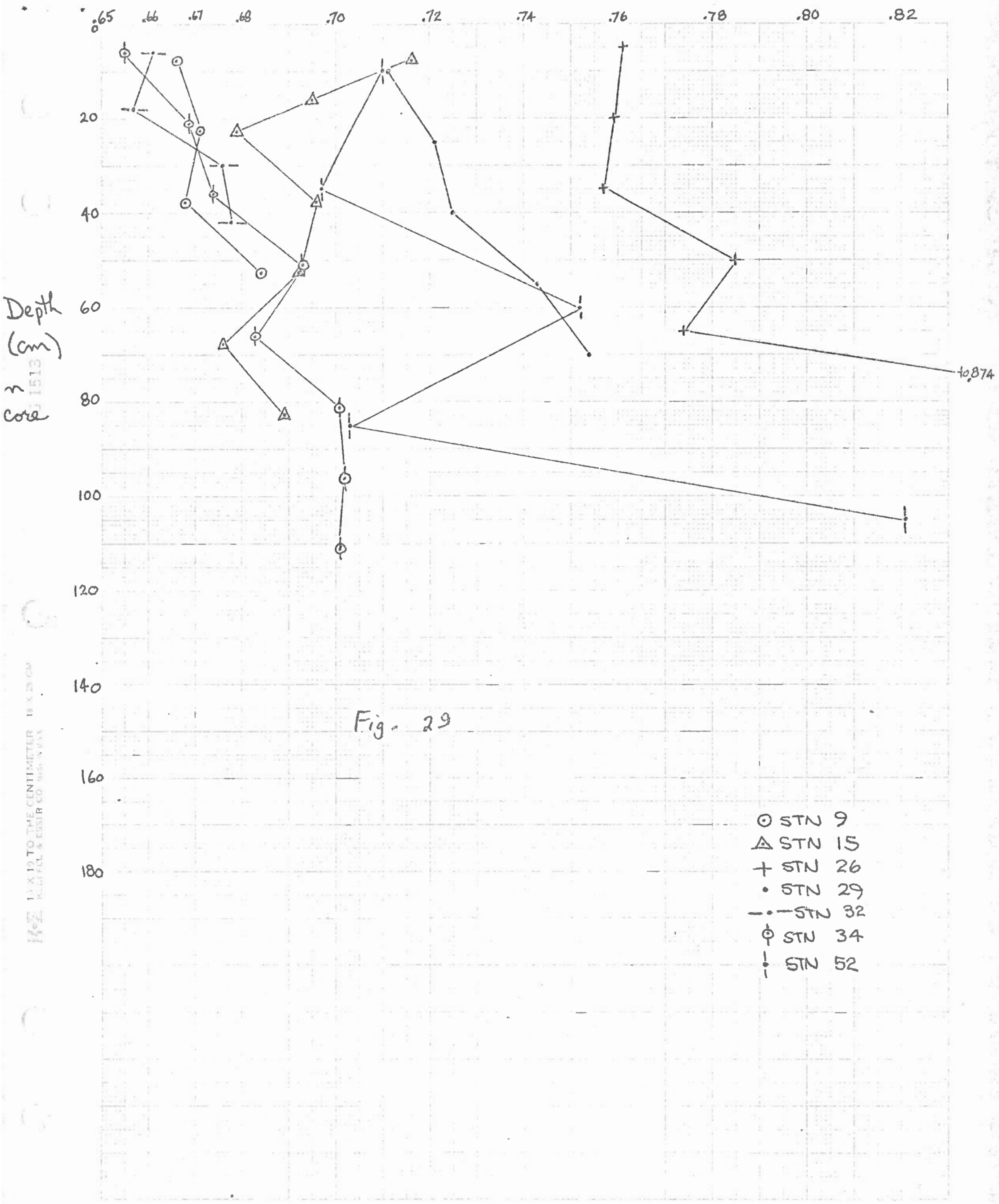

CONDUCTIVITY (SI - W/Km)
.65
.66
.67
.68
.70
.72
.74
.76
.78
.80
.82
0
20
40
60
80
100
120
140
160
180
Depth (cm) in core
0.874
⊙ STN 9
△ STN 15
+ STN 26
• STN 29
—•— STN 32
⊕ STN 34
¦ STN 52

Fig. 29

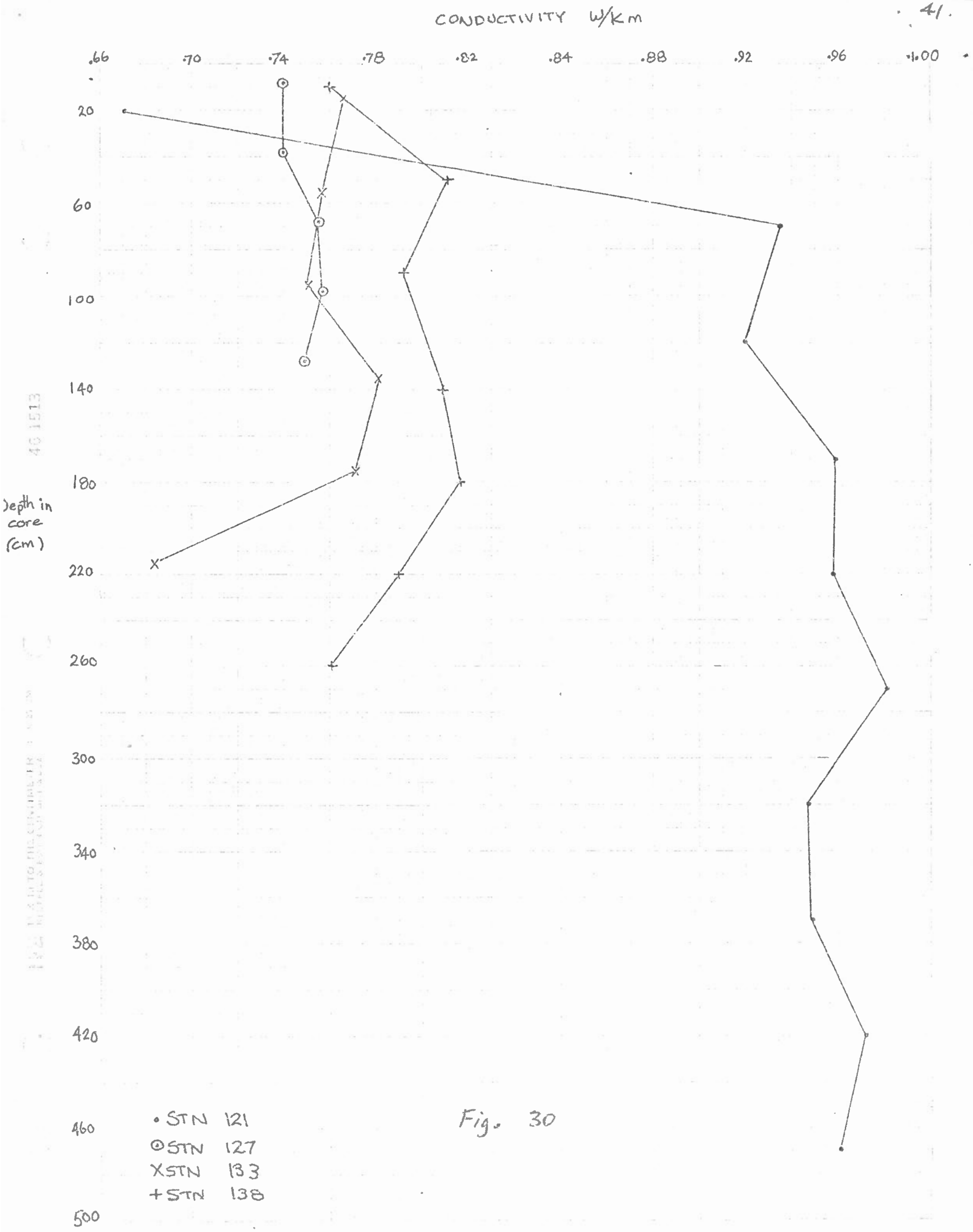

CONDUCTIVITY W/Km
.66
.70
.74
.78
.82
.84
.88
.92
.96
1.00
20
60
100
140
180
220
260
300
340
380
420
460
500
Depth in core (cm)
• STN 121
⊙ STN 127
X STN 133
+ STN 138

Fig. 30

Table 4 : A comparison of thermal conductivities derived from water contents and needle probe measurements.

Core	average k measured	derived from water	Δ (%)	average $ water content (%)
9	.65	.61	-6	78.6
15	.67	.64	-4	71.6
26	.77	.75	-3	57.5
29	.71	.67	-6	65.5
32	.65	.62	-5	77.0
34	.66	.65	-2	70.2
35	1.01	.98	-3	37.6
37^{t}	(12).90	.90	0	43.0
41	.86	.87	1	45.6
47	.73	.68	-7	66.2
49	.72	.71	-1	61.8
52^{t}	(4) .70	.67	-4	67.5
57	.67	.65	-3	71.5
63	.73	.69	-5	63.1
65	.70	.67	-4	67.7
67*	(2) .83	.84	1	54.7
	(3)1.07	.96	-10	30.4
68*	(6) increasing			
	(5) .93			
76	.69	.66	-4	69.0
82^{t}	(5) .72	.69	-4	63.1
84	1.02	.98	-4	37.3
88	.67	.64	-4	73.3
92	.67	.64	-4	70.8
97	.66	.63	-5	74.1
100	.92	.88	-4	44.5
106^{t}	.96	(6) .91	-5	43.2
116	.87	.83	-5	49.1
121^{t}	(9) .93	.87	-6	45.2
124	.92	.85	-8	48.1
127	.73	.68	-7	65.0
133	.75	.70	-7	62.6
138	.77	.74	-4	58.6
Average results:	.784		-4.3%	59.2 (31)

numbers in brackets indicate no. of results averaged if all were not used.

t odd result ommitted, * seemingly systematic variation with depth

$ average of water contents, ommitting ones that were obviously very different.

Table 5 : Variation of Thermal Conductivity within Inlet Systems

	W/Km Top	Middle	Bottom
Dean and Burke	.92 (35 - 41)	-	.68 (15, 52, 57)
Gardner	.77 (65 - 82)	.73 (26, 29, 47, 49)	.82 (84 - 100)
Observatory	.91 (116 - 124)	-	.75 (127 - 138)

station numbers in brackets

The thermal conductivity of the core was calculated from the water contents using the relation published by Ratcliffe (1960) for oceanic cores. These results, shown in appendix A and their average values, given in Table 4, generally agree with the values measured by the needle probe, but are approximately 4.% less. This calculated value of k is for 4°C and 1 atm pressure, which would be .4% less than a core at 7°C and 400 m depth. The 4% difference in conductivity may indicate that the conductivity of the rock grains is 11% higher in the inlet sediments than the rock in oceanic sediments. In Observatory Inlet the measured difference is 6%.

The cores were capped and sealed until the water content was determined ashore a few weeks later. If moisture escapes, the conductivity becomes higher, causing k to become closer to the measured k. The core from Squally Channel (station 143) was out-gassing, could not be sealed, and was not measured.

Thermal Gradients in the Sediments

Several different probes were aboard VECTOR to measure the thermal gradient in the sediments. We measured large variations in the thermal gradients over short, vertical distances. Good penetration was obtained in the soft sediments, and temperature changes in bottom waters are attenuated exponentially in the sediments. The large variations are probably caused by changes in the temperature of the bottom waters. Consequently most of the measurements were made with the two longest instruments: a 5-m Bullard probe and a 7-m outrigger probe. We had intended using mostly the shorter Micro-systems telemetry Probe and the surface recording outrigger probe which are easier to launch than the 7-m outrigger probe and have a much shorter time constant than the 5-m Bullard probe.

All of the probes were held above the bottom in the supposedly isothermal water, before they were quickly lowered into the sediments. The three sensors of the outrigger probe recorded the temperature above and in the sediments, and the relative temperature differences were determined accurately, assuming that the bottom water was isothermal. The differences in temperature between the water and the 4 sensors on the 5-m Bullard probe were recorded; the water temperature was not accurately determined, but the relative temperature differences were accurate, assuming again that the bottom water was isothermal.

The depth of penetration on the outrigger probe was determined by the mud mark. For the 5-m Bullard probe the uppermost measured gradient was extrapolated upwards to determine the position of the interface, as shown in figure31. Sometimes this gives an impossible value, as for station 86 in the figure (1.5m)

Rigging the large, heavy outrigger corer took considerable time, and extra crew were required to launch and recover it. Therefore, the much lighter 5-m Bullard probe was used for the majority of the measurements. At 10 sites both probes were used and the results are compared in figures 32to 35. Considering the fact that the water temperature was not measured accurately by the 5-m Bullard probe, the curves can be translated horizontally and vertically to obtain a match in 8 of 10 cases. Stations 68-69 and 138-139 seem quite different. At other stations the gradients may be different because they are determined over different intervals, but the temperatures appear quite reasonable.

Tables 6 and 7 give the gradients measured by the outrigger and 5-m Bullard probes. The large variability in gradients could be related to both bottom water

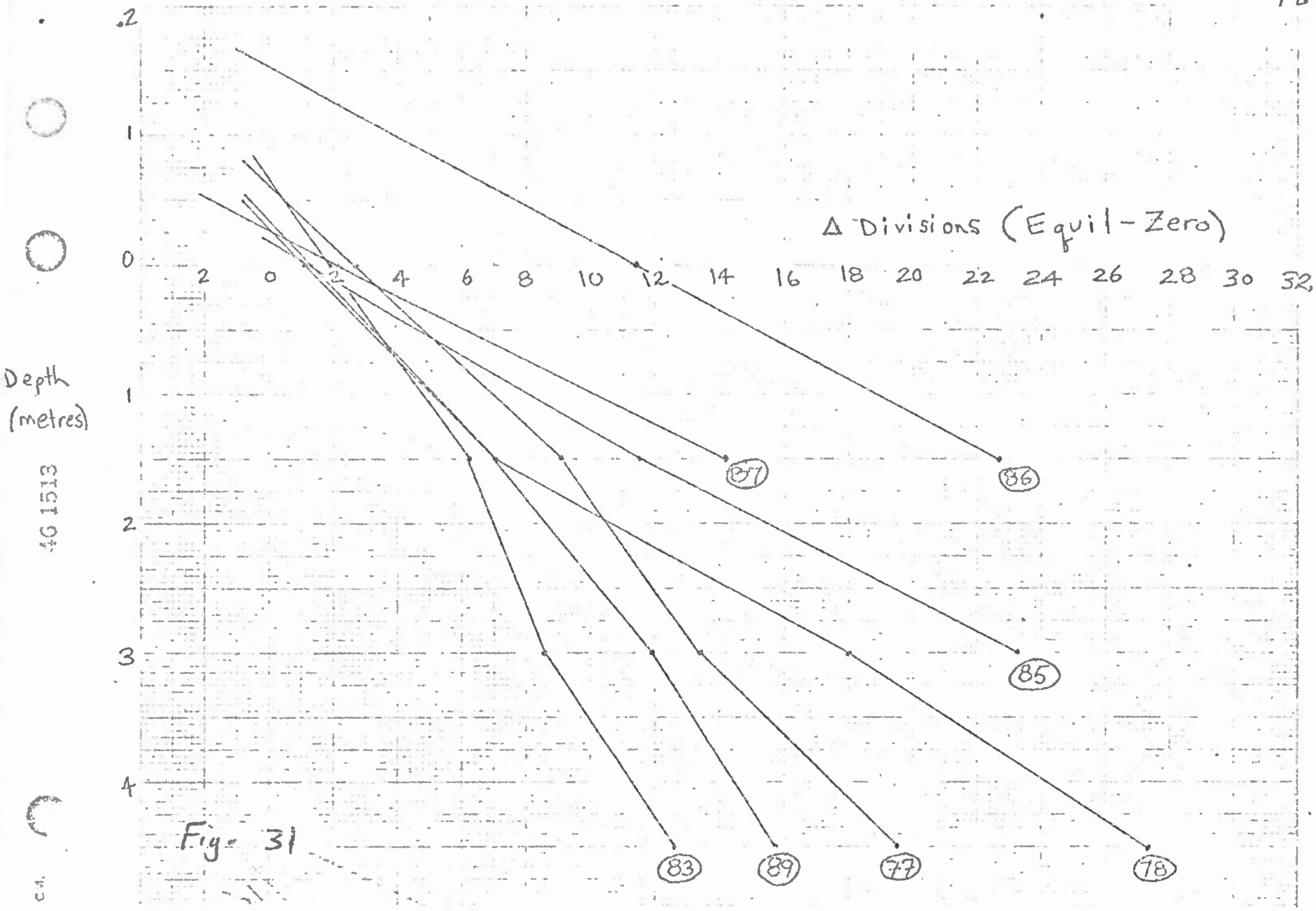

Δ Divisions (Equil-Zero)
2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Depth (metres)
2
1
0
1
2
3
4
87
86
85
83
89
77
78

Fig. 31

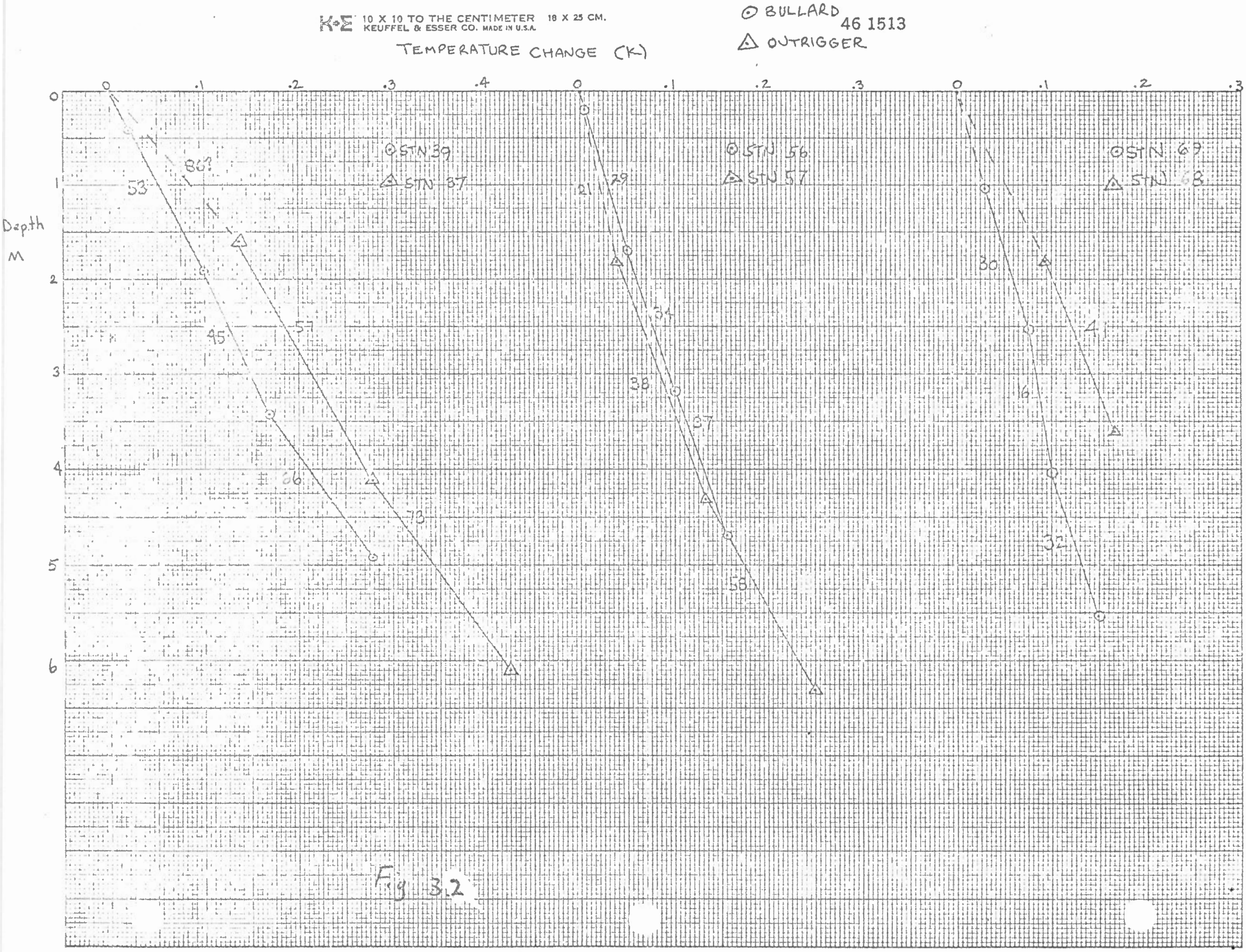

TEMPERATURE CHANGE (K)
⊙ BULLARD
△ OUTRIGGER
0
.1
.2
.3
.4
0
.1
.2
.3
0
.1
.2
.3
Depth
M
0
1
2
3
4
5
6
⊙ STN 39
△ STN 37
86?
53
45
57
66
73
⊙ STN 56
△ STN 57
21
29
34
38
37
58
⊙ STN 69
△ STN 68
30
41
16
32

Fig 3.2

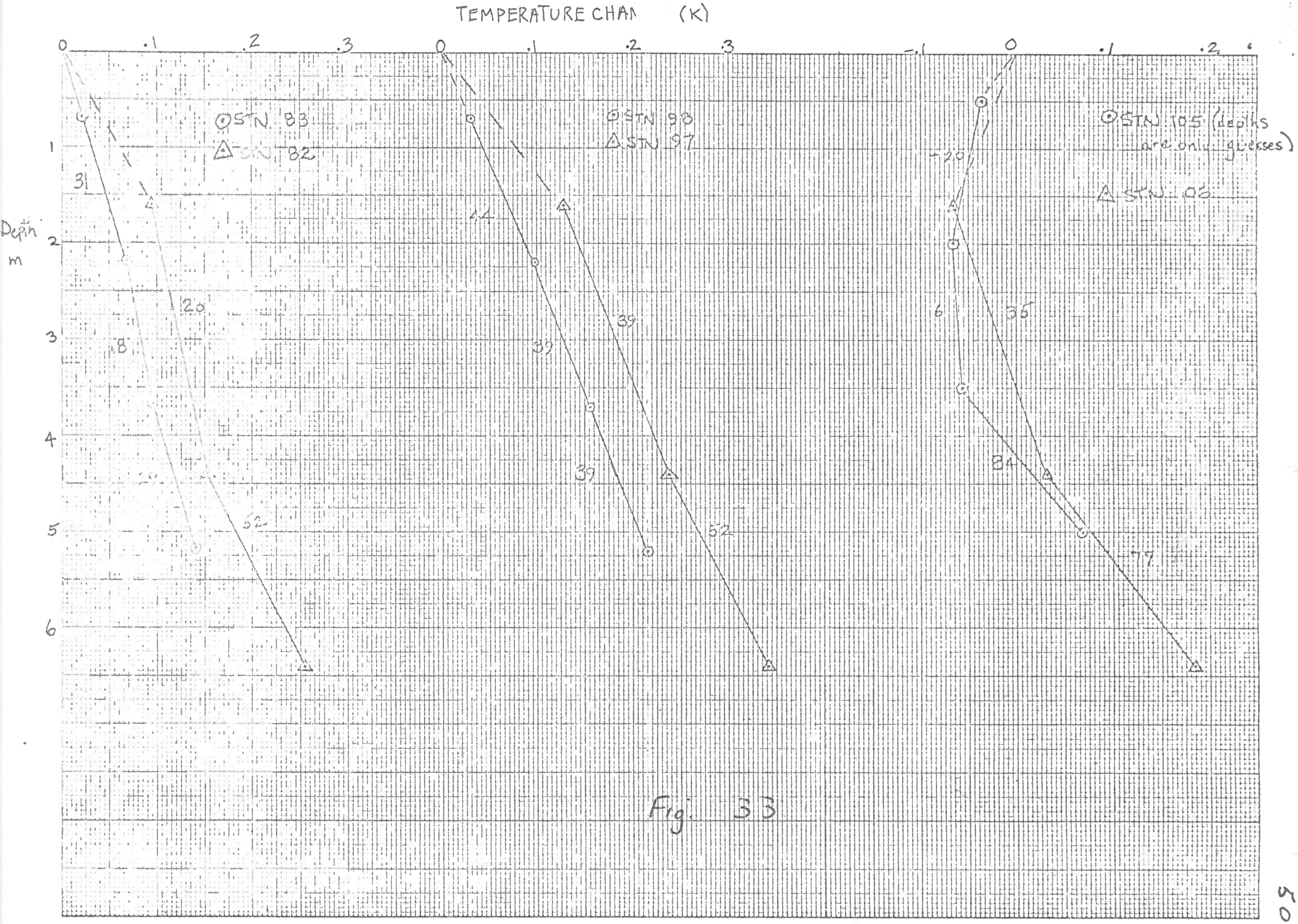

TEMPERATURE CHAN (K)
0
.1
.2
.3
0
.1
.2
.3
-.1
0
.1
.2
Depth m
1
2
3
4
5
6
⊙ STN 83
△ STN 82
⊙ STN 98
△ STN 97
⊙ STN 105 (depths are only guesses)
△ STN 06
31
8
20
20
52
44
39
39
39
52
20
6
35
84
77

Fig. 33

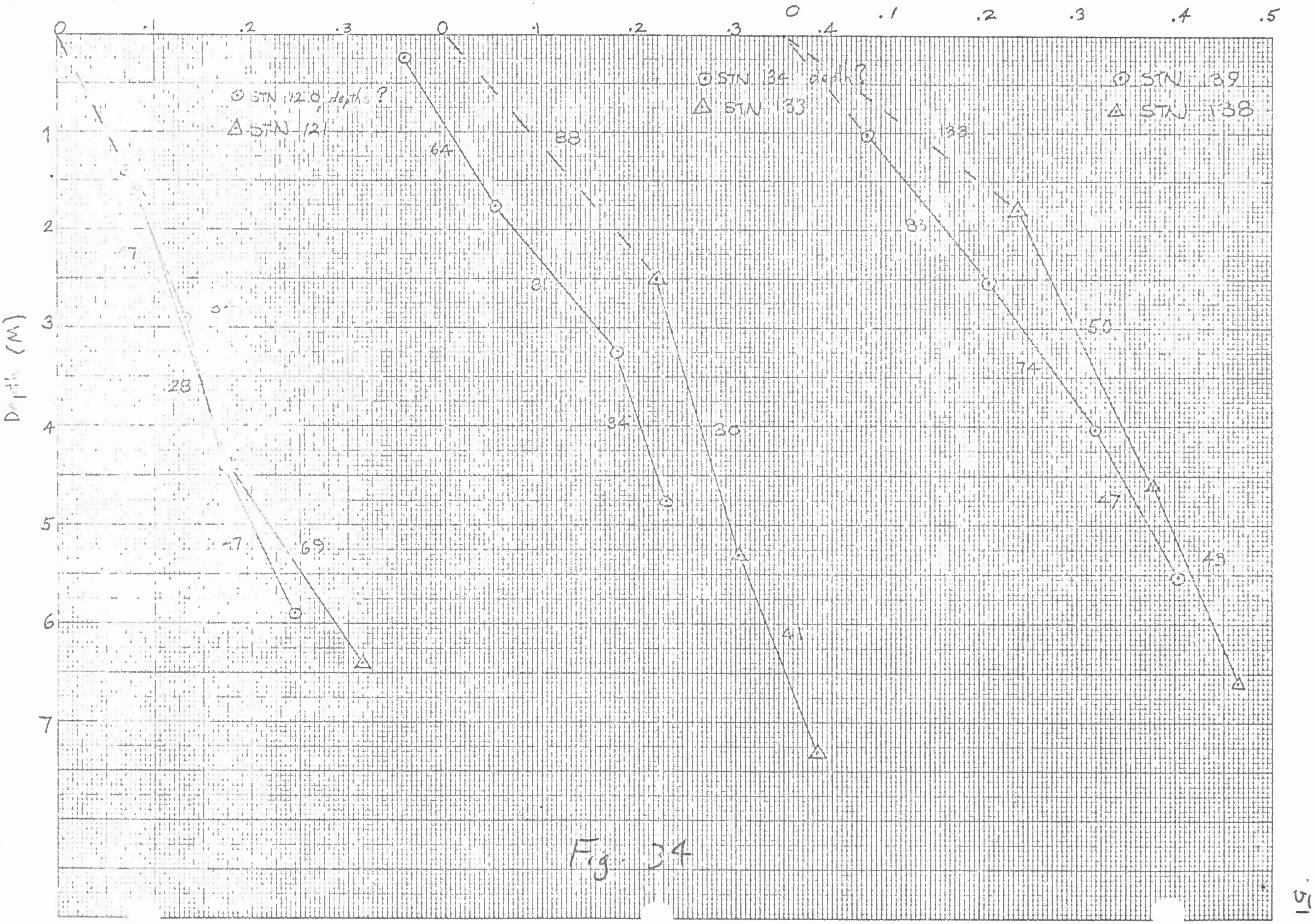

0
.1
.2
.3
0
.1
.2
.3
.4
0
.1
.2
.3
.4
.5
⊙ STN 120 depths ?
△ STN 121
⊙ STN 134 depth?
△ STN 133
⊙ STN 139
△ STN 138
Depth (M)
1
2
3
4
5
6
7
64
88
133
47
81
83
28
34
30
50
74
47
47
69
45
41
v₁

Fig. 34

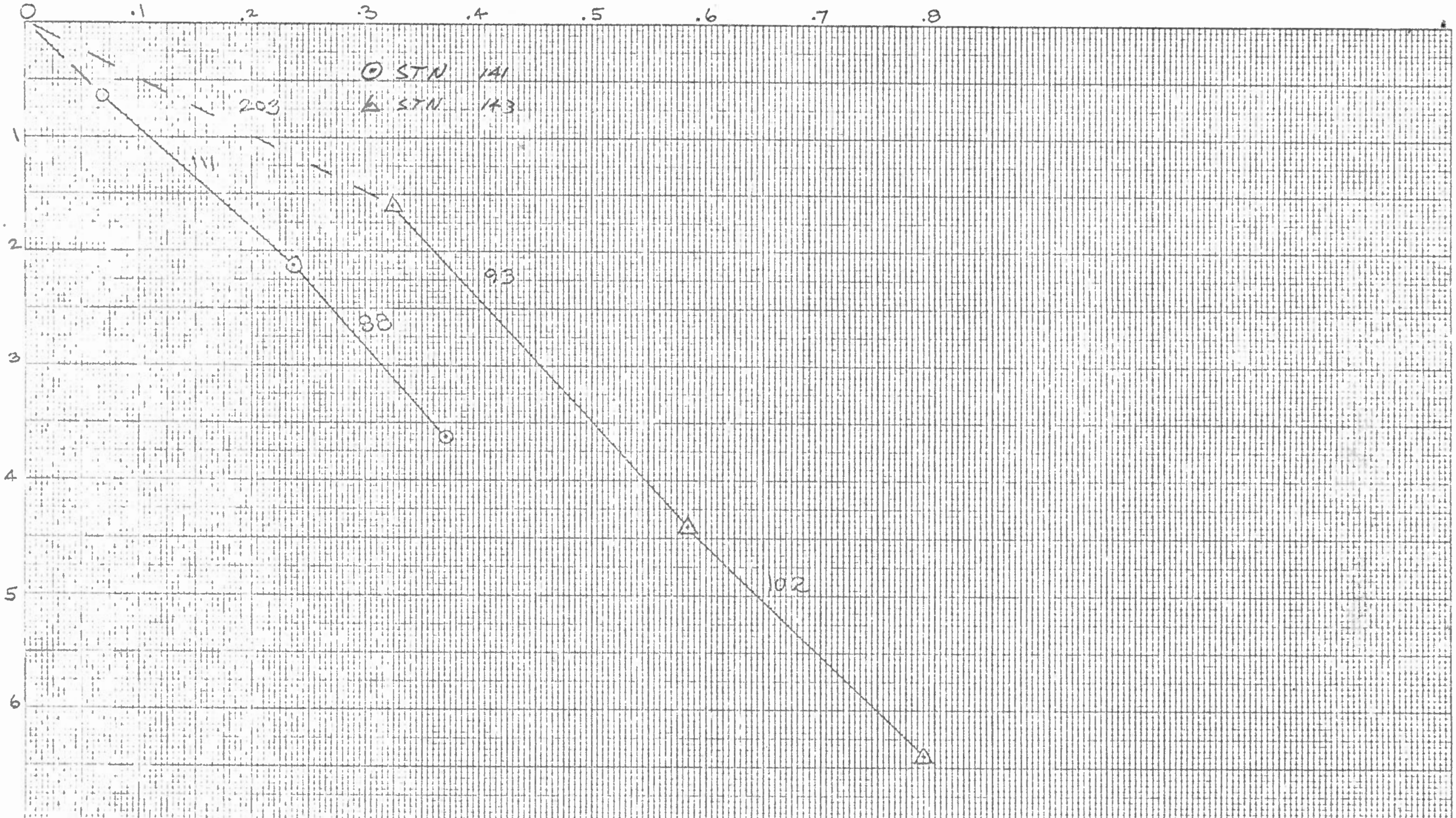


Fig. 35

Table 6 : Outrigger Gradients and Heat Flow

Station	Depth (m)	ΔT (K)	Gradient (mKm^{-1})	Cond. from station	H.F. (mWm^{-2})	Average (mWm^{-2})
17	0	0	(181)	15 x	121	82
	2.0	.361	112	x	75	
	4.25	.612	75	x	50	
	6.50	.780				
37	0	0	(86)	37 m	77	64
	1.6	.137	57	m	51	
	4.1	.279	73	x	65	
	6.1	.425				
57	0	0	(21)	57 m	14	26
	1.8	.038	38	m, x	25	
	4.3	.133	58	x	39	
	6.3	.249				
68	0	0	(52)	68 m	40	40
	1.8	.093	41	m	40	
	3.6	.167				
82	0	0	(59)	82 m	42	29
	1.6	.094	20	x	15	
	4.4	.151	52	x	38	
	6.4	.254				
84	0	0	(45)	84 m	45	52
	.2	.009	51	m	52	
	2.2	.111				
92	0	0	(86)	92 m	57	37
	1.6	.137	31	x, m	21	
	6.4	.352				

Table 6: Outrigger Gradients and Heat Flow

(continued)

Station	Depth (m)	ΔT (K)	Gradient (mKm^{-1})	Cond. from station	H.F. (mWm^{-2})	Average (mWm^{-2})
97	0	0	(80)	97 m, x	53	35
	1.6	.128	39	x	26	
	4.4	.238	52	x	34	
	6.4	.341				
106	0	0	(-41)	106 m	-40	-
	1.6	-.065	35	m	34	
	4.4	.032	77	x, m	73	
	6.4	.185				
121	0	0	(52)	121 m	43	44
	1.6	.083	34	m	32	
	4.4	.177	69	x, m	62	
	6.4	.315				
133	0	0	(88)	133 m	64	39
	2.5	.219	30	x	21	
	5.3	.303	41	x	30	
	7.3	.385				
138	0	0	(133)	138 m	103	55
	1.8	.240	50	x, m	38	
	4.6	.379	43	x	33	
	6.6	.465				
143	0	0	(203)			-
	1.6	.325	93			
	4.4	.585	102			
	6.4	.789				

m: measured conductivity; x: extrapolated cond. values to depth.

Table 7 : 5-m Bullard Probe gradients and heat flows

Station	Cond. from station	Gradients and Heat Flows (mKm^{-1}) (mWm^{-2}) U-UM	UM-LM	LM-L	Av. H.F. (mWm^{-2})
5	-	20 -	26 -	22 -	-
8	9	58 m,x 38	66 x 43	(-26)	40
33	34	-	-	110 m 73	73
39	37	53 x 47	45 x 40	66 x 59	49
42	41	(34) m	42 x 36	45 x 39	37
48	47	(3) m	36 x 26	42 x 31	29
51	49	- m	37 x 27	48 x 35	31
53	52	- m	23 m 16	28 x 20	18
54	57	- x	46 x 31	51 x 35	33
55	57	- x	39 x 26	47 x 32	29
56	57	29 x 19	34 x 23	37 x 25	22
58	57	(21) m	45 m 31	56 x 38	34
59	57	34 x 23	48 x 33	55 x 37	31
64	63	42 m 31	39 x 28	50 x 36	32
66	65	11 m	2 x	17 x	-
69	68	30 m 24	16 m 15	32 m 30	23
71	68	58 x 46	43 x 41	67 x 62	49
72	68	50 x 38	33 x 32	43 x 40	37
73	68	- x	40 x 34	26 x 24	25
74	68	28 x 24	20 x 18	37 x 34	25
75	67	- x	37 x 36	37 x 36	36
77	76	47 m, x 32	31 x 21	45 x 31	28
78	76	42 x 29	80 x 55	69 x 48	44
83	82	31 m 23	18 x 13	29 x 21	20
85	84	- m	75 m 77	86 x 88	83
86	84	- x	-	82 x 83	83
87	84	- x	-	88 x 90	90
89	88	43 m, x 29	36 x 24	28 x 19	24
90	92	68 m 45	63 m 43	56 x 38	42
93	97	- x	97 x 64	75 x 50	57
94	97	42 x 28	42 x 28	35 x 23	26
95	97	46 x 30	33 x 22	26 x 17	23

Table 7 : 5-m Bullard Probe gradients and heat flows

(continued)

Station	Cond. from	Gradients and Heat Flows (mKm^{-1}) (mWm^{-2})			Av. H.F. mWm^{-2}
		U-UM	UM-LM	LM-L	
96	97	131 x 86	99 x 65	(≥4) x	76
98	97	44 m, x 29	39 x 26	39 x 26	27
99	97	83 x 55	77 x 51	77 x 51	52
101	100		80 m, x 74	89 x 82	78
103	100		126 x 116	93 x 86	101
105		-20	6	86	-
108		(-4)	49	66	-
109		-30	50	56	-
113		-118	21	8	-
117	116	55 m 48	44 x 38	64 x 56	47
118	121	34 x 30	31 x 29	39 x 37	32
119	121	61 x 52	52 x 49	60 x 56	52
120	121	40 m 37	28 m 26	47 m 44	36
122	116	60 x 52	58 x 51	66 x 58	53
123	116	58 x 51	58 x 51	57 x 50	51
125	124	19 m 17	12 x 11	27 x 25	18
126	-	89	50	18	-
130	127	89 x 65	47 x 34	31 x 23	41
131	127	84 x	72	26	-
132	127	88 x 65	80 x 59	61 x 45	56
134	133	64 m 47	81 m, x 60	34 x 25	-
135	133	108 x 80	47 x 35	42 x 31	33
137	138	95 x 73	43 x 33	22 x 17	41
139	138	83 m 64	74 m, x 58	47 x 36	56
140	138	135 x 104	59 x 45	39 x 30	60
141	-	111	88	39	outgassing
144	-	108	76	57	outgassing

Sensors used: u-upper, um-upper middle, lm-lower middle, l-lower

m: conductivity measured; x: conductivity extrapolated either to depth or from a nearby station.

temperature changes and variations in the thermal conductivities which are evident in many of the long cores.

The extrapolation of the Bullard probe temperatures, an exceedingly lengthy process, must introduce some errors, even when the plotting is most carefully done.

Heat Flow

Heat flows calculated for the four types of probes are given in four Tables, 6 - 9 . Where possible, measured conductivities were used from the same depth interval as that over which the gradient was determined. In most cases this was not possible. Average values of conductivity from a shallow core were used at deeper depths, and were used for nearby stations as well.

The heat flow for different depth intervals varies a lot, often not in a systematic fashion. This could be caused by many reasons, but the three most likely ones are recent changes in bottom water temperatures, a varying sedimentation (erosion) rate, and the use of assumed conductivities in different sediment layers. Only seven stations (42, 54, 68, 75, 98, 99 and 123) have heat flows which appear to vary with depth by 10% or less. All of these values appear reasonable except for 27mWm^{-2} at station 98 very near to station 99 where the heat flow is 52 mWm^{-2}.

Table 8 : Telemetry Probe Gradients and Heat Flow

Station	Interval	Gradient (mKm^{-1})	Core from station	H.F. (mWm^{-2})
18	L-LM	111	15 x	74
	LM-M	131	x	88
	M-UM	175	x	117
	UM-U	171	x	115
	L-U	147	x	99
19	etc.	141	15 x	95
		134	x	90
		147	x	99
		175	x	118
		150	x	100
20		105	15 x	70
		148	x	99
		171	x	115
		165	x	111
		147	x	99
21		148	15 x	99
		161	x	108
		188	x	126
		192	x	129
		172	x	116
22		131	15 x	88
		155	x	104
		175	x	117
		188	x	126
		162	x	109
24		24		
		17		
		(17)		
		–		
		–		

Table 8 : Telemetry Probe Gradients and Heat Flow

continued

Station	Interval	Gradient (mKm^{-1})	Core from station	H.F. (mWm^{-2})
25		134	26 x	108
		148	x	119
		168	m, x	135
		175	m	131
		156	av.	120
28		24	29 x	17
		77	x	55
		111	x	79
		124	m	88
		84	av	60
30		100	29 x	71
		156	x	111
		174	x	124
		169	x	120
		150	x	107
31		105	32 x	68
		144	x	94
		175	x	114
		243	m	103
		167	av.	109
36		12	35 x	12
		36	x	36
		41	m, x	41
		54	m	54
		36	av.	36

Sensors used: L-lower, LM-lower middle, UM-upper middle, U-upper

Table 9: SR3MO5S gradients and heat flows

(Surface recording 3-metre outrigger probe with 5 sensors)

Station	Conductivity from	Gradients in Intervals				Average	
	station	L	LM	UM	U	grad.	H.F.
		$(\mathrm{mKm^{-1}})$	$(\mathrm{mKm^{-1}})$	$(\mathrm{mKm^{-1}})$	$(\mathrm{mKm^{-1}})$	$(\mathrm{mKm^{-1}})$	$(\mathrm{mWm^{-2}})$
13	15	189	109	-24	73	87	60
16	15	233	283	72	83	168	116
136	133	48	137	55	67	77	58
145	100	72	169	75	80	99	93

Interval: L-lower, LM-lower middle, UM-upper middle, U-upper

L. Dean Chan. & Fisher Chan.

The next approach is to compare the heat flow from nearby stations, especially clusters or cross channel profiles of stations. The average values are plotted on figures 36 to 38, and the station numbers are indicated on figures 39 to 41. Stations 17-22 in lower Dean Channel form a cluster of high heat flows. However the heat flow at all stations decreases with depth, going to its minimum value of 50 mWm^{-2} for the deepest interval, 4.25 to 6.5 m. The conductivity was measured only in the top metre of sediments, but it could not increase by more than 50% and this increase is unlikely since all of the gradients decreased systematically with depth. Therefore, a warming of the bottom waters is suspected. At stations 25, (23), 30, 31 and 33, also in lower Dean Channel or Fisher Channel, high heat flows were measured which systematically decrease with depth. The heat flow is a maximum of 50 mWm^{-2}.

HEAT FLOW (mW/m²)

BURKE, DEAN and FISHER CHANNELS

Heat flow values are averaged at a station when there is more than one gradient interval.

- ＊ no value, gradients not in equilibrium
- ● calculated using measured conductivities
- · calculated by extrapolating conductivities down to depths covered by gradients

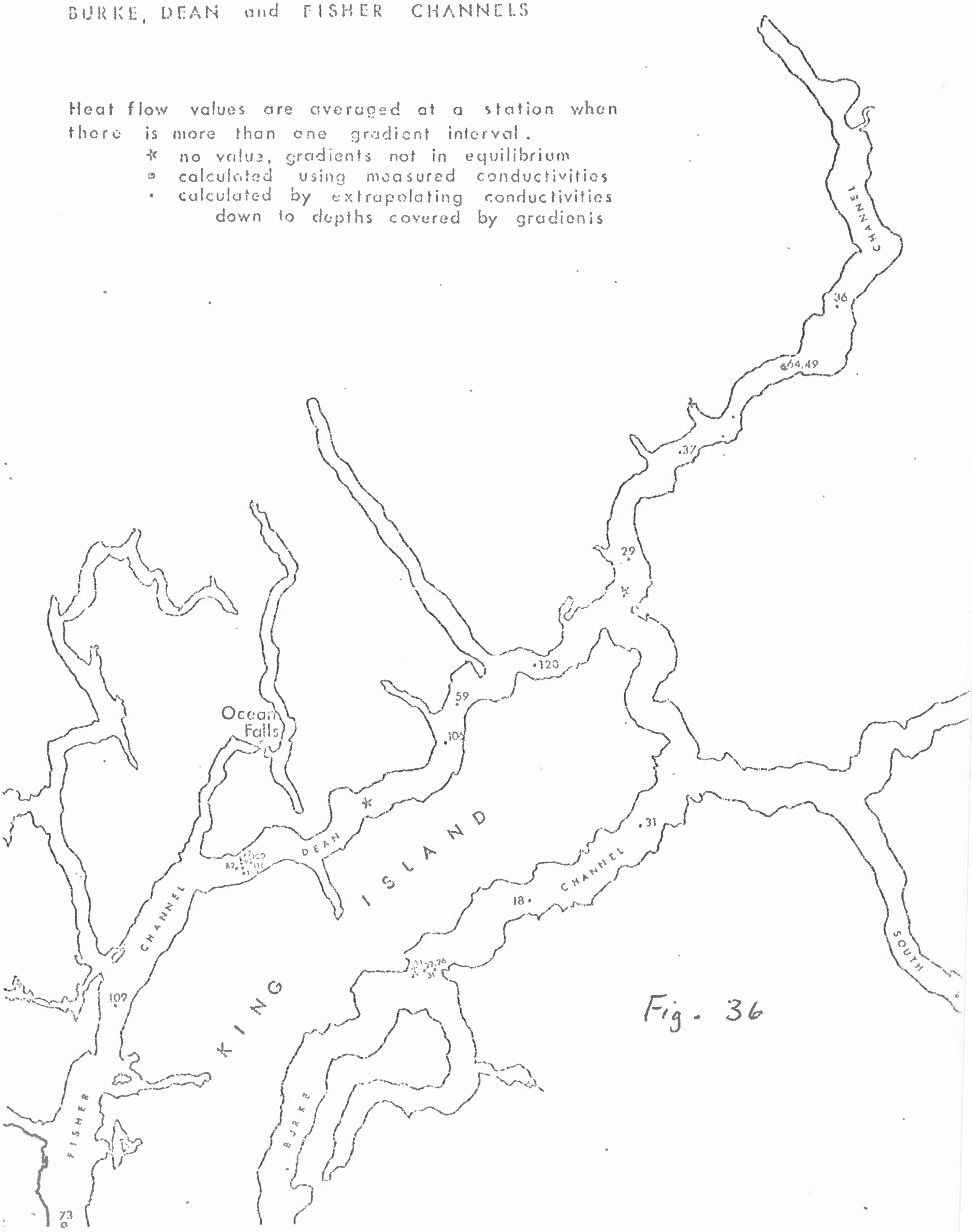


Fig. 36

HEAT FLOW (mW/m²)

BURKE, DEAN and FISHER CHANNELS

Heat flow values are averaged at a station when there is more than one gradient interval.

- ★ no value, gradients not in equilibrium
- ● calculated using measured conductivities
- · calculated by extrapolating conductivities down to depths covered by gradients

Conductivities have been corrected to bottom water temperatures and pressures. No other corrections have been applied to heat flow values.

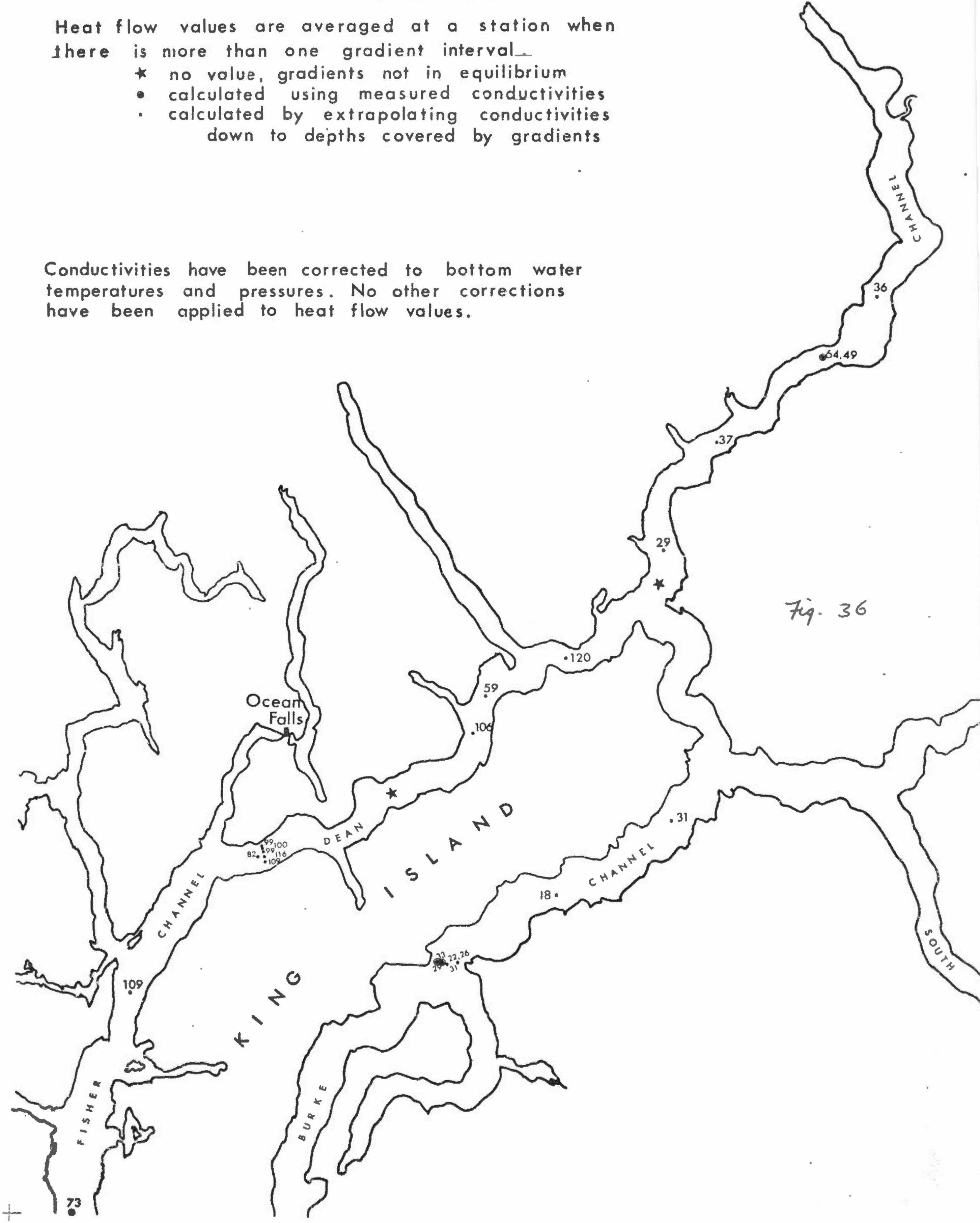


Fig. 36

HEAT FLOW mW/m²

DOUGLAS, SQUALLY and WHALE CHANNELS

Heat flow values are averaged at a station when there is more than one gradient interval.

- ★ no value, gradients not in equilibrium
- ● calculated using measured conductivities
- · calculated by extrapolating conductivities down to depths covered by gradients

Conductivities have been corrected to bottom water temperatures and pressures. No other corrections have been applied to heat flow values.

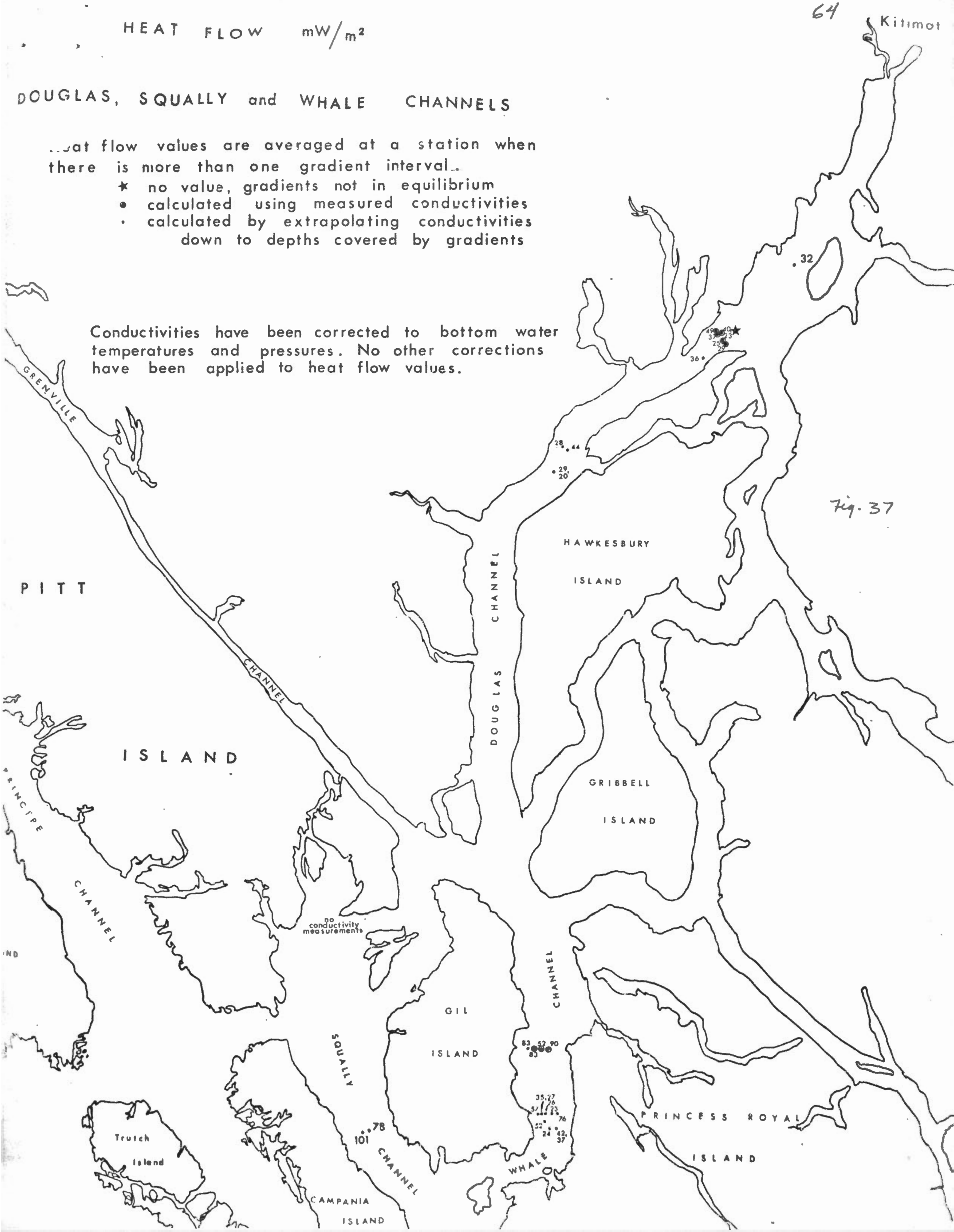


Fig. 37

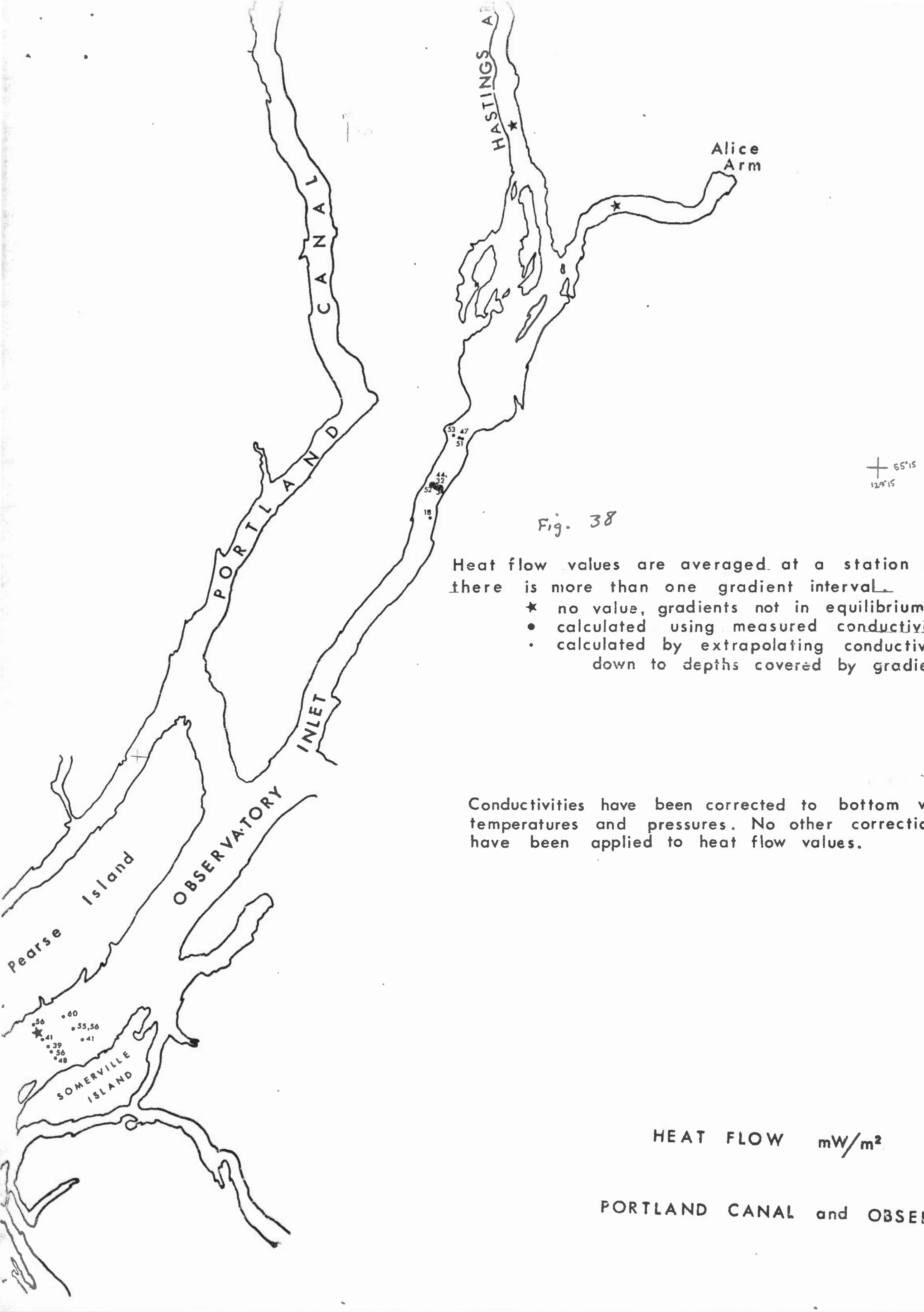


Fig. 38

Heat flow values are averaged at a station when there is more than one gradient interval.

- ★ no value, gradients not in equilibrium
- ● calculated using measured conductivities.
- · calculated by extrapolating conductivities down to depths covered by gradients

Conductivities have been corrected to bottom water temperatures and pressures. No other corrections have been applied to heat flow values.

HEAT FLOW mW/m²

PORTLAND CANAL and OBSERVATORY

HEAT FLOW (mW/m²)

BURKE, DEAN and FISHER CHANNELS

Heat flow values are averaged at a station when there is more than one gradient interval..

- * no value, gradients not in equilibrium
- ● calculated using measured conductivities
- · calculated by extrapolating conductivities down to depths covered by gradients

station nos. on land.

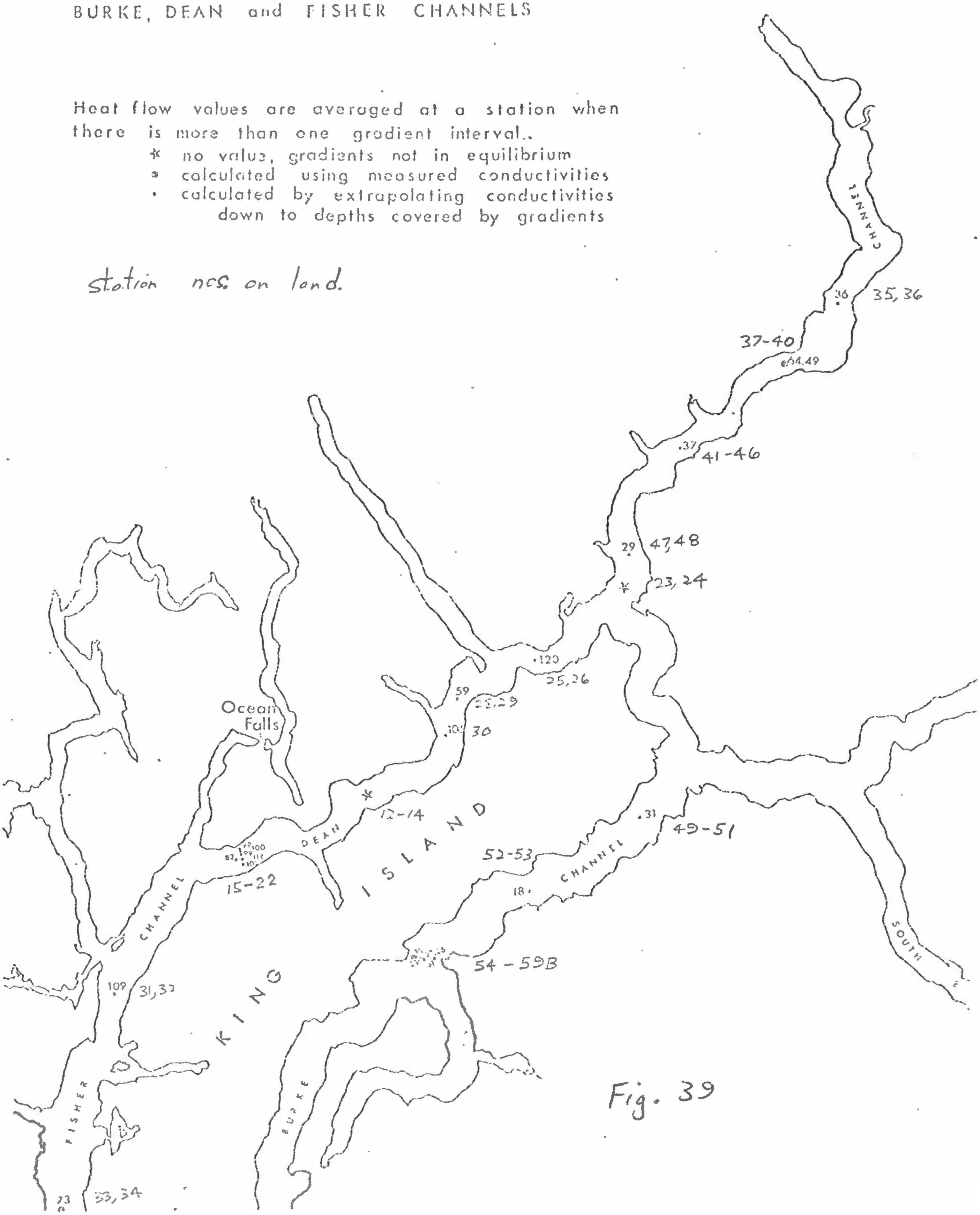
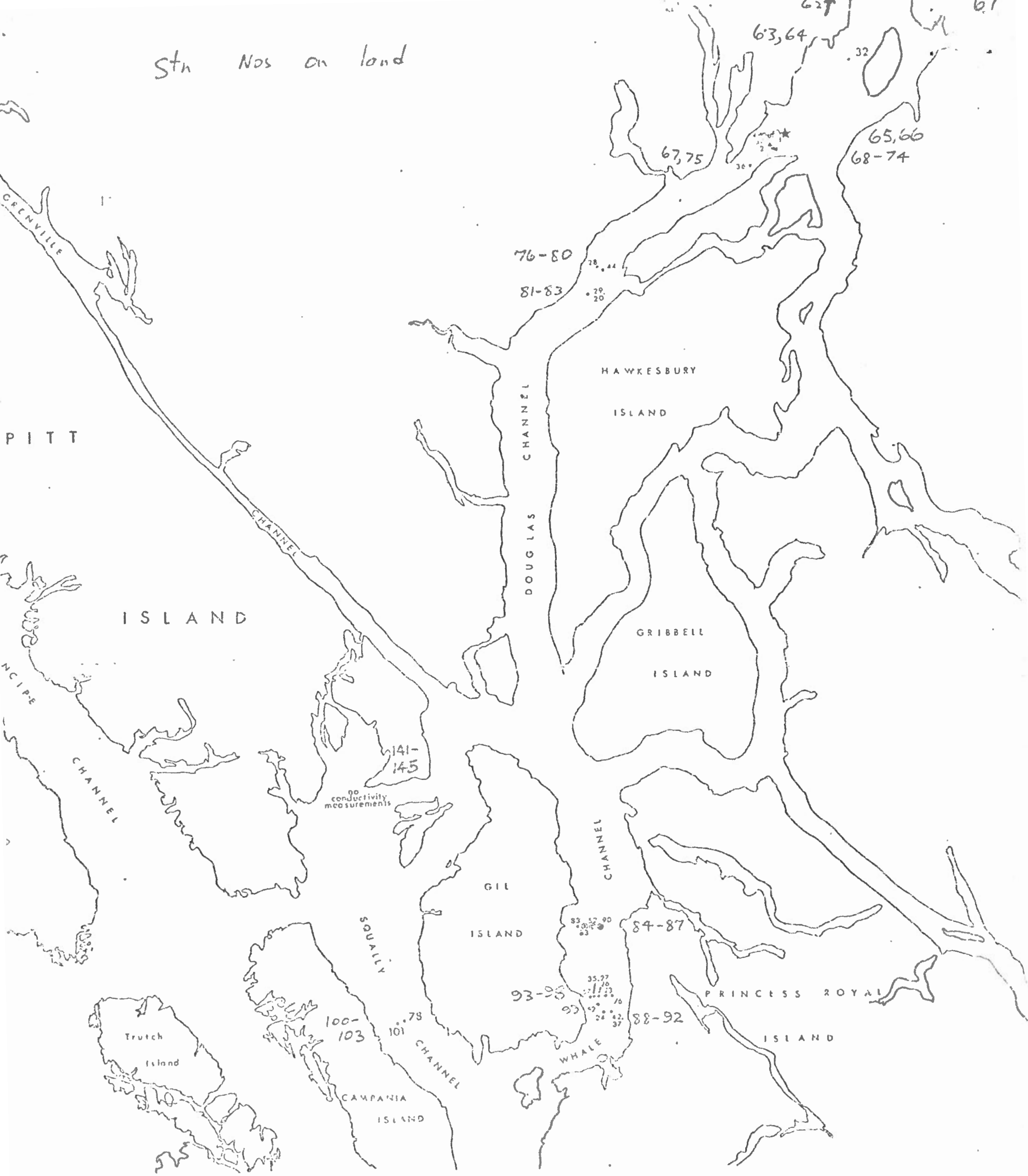


Fig. 39



Stn Nos on land

Fig. 40

Conductivities have been corrected to bottom water temperatures and pressures. No other corrections have been applied to heat flow values.

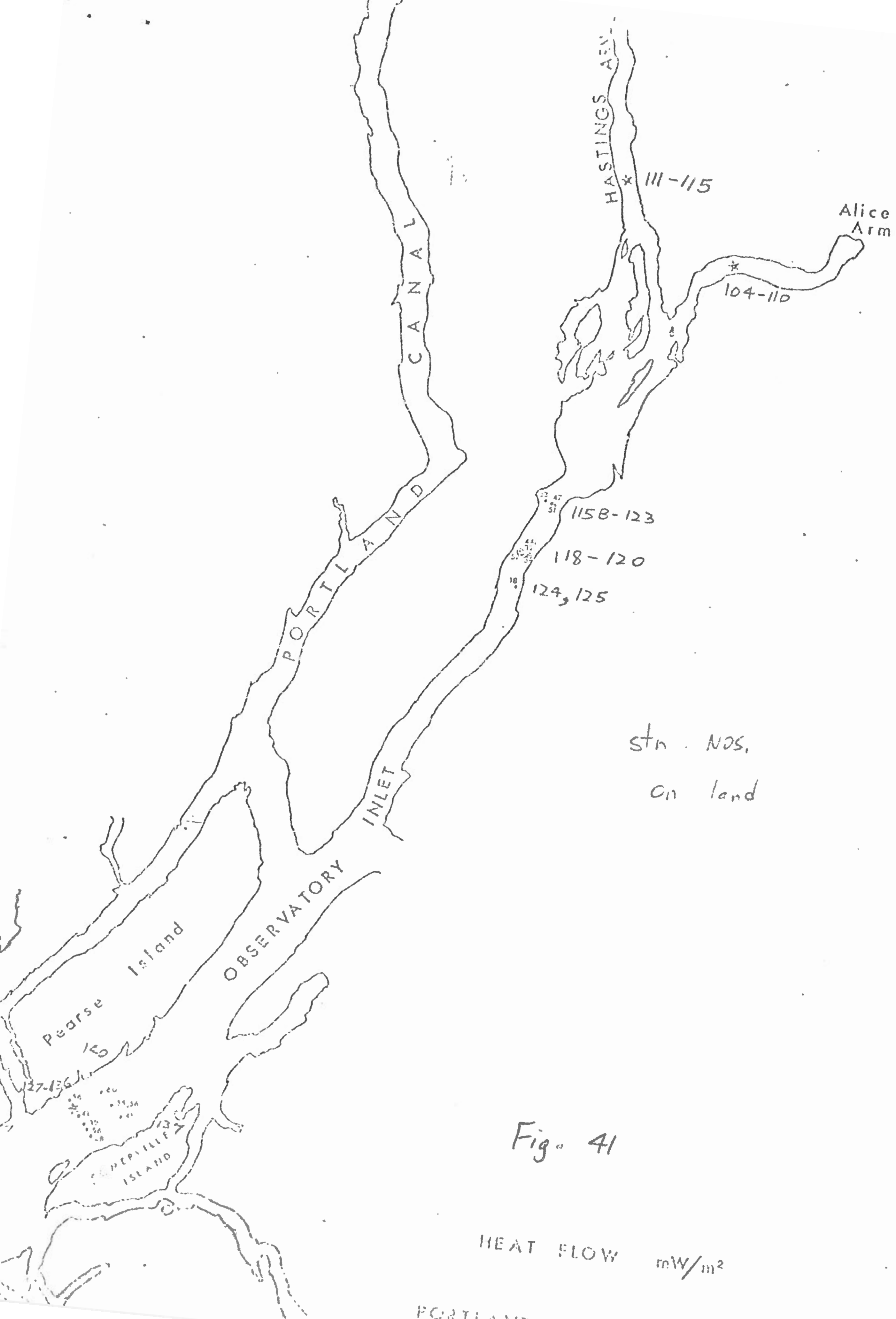


Fig. 41

HEAT FLOW mW/m²

PORTLAND CANAL and OBSERV

Burke Channel

Compared to the results already considered on the west side of King Island, those on the east in Burke Channel are all lower. The eight gradients (stations 51, 53-59) all increase with depth, and ommitting station 51 where the max. heat flow is 48 mWm^{-2}, the heat flow increases to maximum values of 35, 37, 38 and 39 at 4 of 6 stations. Again a recent change in bottom water temperature is suspected and the heat flow is a minimum of 40 mWm^{-2}. Station 51 is the farthest "inland".

Upper Dean Channel

The gradients are quite variable in this area and not too consistent from station to station. The best heat flow value, from station 42, is 37 mWm^{-2}.

Squally Channel

Gradients from stations 141, 143, 144 and 145 seem to be affected by outgassing which was evident in core 143. The gradients from stations 101 and 103 are high, but not too consistent.

Whale Channel

With poor penetration at stations 84-87, shallow, high gradients were obtained. The stations 84-99 to the south seem to be in the midst of local anomalies. Some consistent, low heat flows (21, 23, 24, 26 and 27 mWm^{-2}) were measured, but some shallow, much higher heat flows (76, 57 mWm^{-2}) were measured. If any general trend existed, it was a decrease in heat flow with depth.

Upper Douglas Channel

Twelve of 13 gradients measured in this area had a pronounced minimum in the mid depth interval (approx. 1.5 to 3m depth). Ommitting the one different result (station 78) one high gradient and two low values, the average of the heat flows over the lowest depth interval is 36 mWm^{-2}.

Observatory Inlet

In Hastings Arm and Alice Arm large temperature reversals occurred at shallow depths in the sediments, indicating that the bottom waters had recently warmed. In Alice Arm 4 of 5 gradients showed this reversal, with relatively high heat flows at depth (an average of 70 mWm^{-2}). The heat generation in Alice Arm is quite high.

In Observatory Inlet there were two groupings of stations: 115B to 125 in the upper section and 127 to 140 in the lower section near Pearse Island. At the upper sites the general trend in the top 5 m of sediments is a minimum heat flow in the middle intervals, and a maximum in the deepest interval. The four largest heat flows measured in the deepest intervals of the eight stations are 56, 56, 58 and 62 mWm^{-2}, the deepest interval at station 121 having the largest heat flow.

The heat flows in the lower part of Observatory INlet decrease with depth, average values being 74 mWm^{-2} in the shallow interval, 43 mWm^{-2} and 30 mWm^{-2} in the deepest interval. This probably indicates a recent cooling of bottom water temperatures.

Bottom Water Temperatures

Changes in the temperatures of the bottom waters can be postulated which will account for the variations in geothermal gradient through the sediments for most regions. The necessary changes in temperature are of the order of 0.1 K occurring less than a year before the measurements were made. For example, a single step increase in temperature of 117 mK occurring 1.5 months before the measurements were made in lower Observatory Inlet will remove the systematic variation in the measured gradients.

Heat Production

Shore samples representative of the surrounding plutonic rocks were collected where possible.

Table 10 lists the average results for the eight areas that were collected and appendix B contains individual results. The average density was assumed to be 2.70. These results are mostly comparable to previous ones obtained in the southern Coast Plutonic Complex where the average heat production is 0.8 μWm^{-3} (Lewis, 1976). The rocks of the Coast Plutonic Complex (Roddick and Hutchison, 1974) are similar in the north to the south, but a higher grade of metamorphic core zone occurs in the north (Hutchison, 1970). In the Bella Coola map-area (Baer, 1968; 1973) the granite and quartz monzonite units were not sampled; heat generation in the syenite of Miocene age is low, similar to all of the other rocks sampled in this area. In the Portland Canal Region (Hanson, 1935; Grove, 1971), the "Coast Range Intrusives" of the Alice Arm and Observatory Inlet areas are exceptionally high in heat production, containing an average of 17ppm Thorium.

Table 10 : Heat Production

Samples	Area	(μWm^{-3})
1-5	N.W. of King Is, Dean Channel	1.00
6-10	S. of Engerbrightson Pt., Dean Channel	1.00
11-14	Cathedral Pt., Burke Channel	.92
15-23	Douglas Channel	.53
24-28	Whale Channel	.60
30-37	Alice Arm	2.65
38-41	Observatory Inlet	3.04
42-43, 45-47	Portland Inlet	.86

Conclusions:

1. The thermal conductivity (and the water contents) vary over a large range in the sediments of these inlets.

2. There are large systematic variations in the thermal gradients measured in the sediments.

3. The Heat Production was low near King Island, but the granites were not sampled. The heat generation was high in some parts of the Portland Canal system.

Recommendations:

Procedural

1. A better, complete station list should be kept, with the coordinates for every station. Better communications with the bridge should help this.

2. Graphs and lists of data should be done in black ink onboard so that they will copy easily.

3. Obtain better geological maps, if possible! (Glenn Woodsworth says no modern ones available for the Portland Canal Region.)

Measurements and Technique

4. The 5-m Bullard probe should be tested with a longer measurement time to determine its time constants well.

5. Thermal gradients should be measured as deep as possible in the sediments.

6. Thermal gradients should be measured at sites having low diffusivities.

7. Water temperatures at sites should be re-measured, using the same sensors if possible.

8. Thermal gradients should be re-measured at sites from the first cruise.

9. Conductivities should be measured for each geothermal gradient measurement, in each depth interval.

10. Samples for heat production measurements are still needed, especially from units 13, 14, 14a and 16a near King Island and in the Portland Canal area.

11. Measurements of diffusivity are needed.

12. An air gun should be used to obtain deeper penetration through the sediments in order to map the bedrock interface in the centres of the inlets.

General

13. Other than the Portland Canal, the reconnaissance surveys are complete. More detailed, and repeat measurements are necessary at specific sites.

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Appendix A

Individual measurements and determinations of thermal conductivity

Station	Depth (cm)	Thermal Cond. (W/mK)		Remarks
		measured by needle probe	derived from water content	
9	0	–	.61	
	7.5	.65	.61	
	22.5	.65	.61	
	37.5	.65	.62	
	52.5	.66	.62	
15	0	–	.64	
	7.5	.70	.64	
	16	.67		
	22.5	.66	.63	
	37.5	.68	.64	
	52.5	.67	.65	
	67.5	.66	.66	
	82.5	.67	.65	
26	0	–	.75	
	* 5	.75	.76	
	20	.74	.73	
	50	.76	.76	
	65	.76	.75	
	80	.85	.76	
29	0	–	.70	
	10	.69	.66	
	25	.70	.67	
	40	.70	.67	
	55	.72	.68	
	70	.73	.69	
32	0	–	.61	
	6	.65	.62	

	18	.64	.62
	30	.66	.63
	42	.66	.62
34	0	-	.63
	6	.64	.63
	21	.65	.63
	* 36	.65	.67
	51	.67	.66
	* 66	.66	.67
	81	.68	.66
	96	.68	.68
	111	.68	.67
35	0		
	6	.97	.92
	21	1.03	1.00
	36	1.05	1.00
	51	.96	.96
	66	1.09	1.02
	81	.97	.96
	* 96	.97	.98
37	0	-	.88
	10	.86	
	* 40	.84	.89
	70	.93	.93
	100	.92	.92
	* 130	.89	.90
	* 160	.90	.93
	190	.89	.88
	220	.90	.90
	* 250	.91	.92
	$ 280	.79	.90
	310	.87	.87
	340	.92	.89
	370	.96	.90
41	0	-	.87

	9	.77	.86	
	32	.86	.85	
	55	.90	.89	
	78	.85	.86	
	101	.90	.89	
47	0	–	.68	
	10	.90	.67	
	25	.71	.68	
	40	.74	.68	
49	0	–	.75	
	9	.71	.70	
	25	.70	.70	
	50	.77	.82	
	75	.72	.71	
	100	.71	.71	
	125	.73	.70	
52	0	.69	.66	
	10	.69	.65	
	35	.68	.66	
	60	.73	.69	
	85	.68	.67	
	$ 105	.80	.67	reflector present
57	0	–	.61	
	20	.65	.66	
	50	.65	.66	
	80	.67	.65	
	110	.66	.63	
	140	.66	.63	
	170	.69	.66	
	200	.68	.65	
	230	.69	.65	
	260	.66	.65	
	290	.68	.66	
63	0	–	.76	
	10	.73	.69	
	30	.72	.69	

	50	.76	.69	
	70	.71	.68	
	90	.72	.68	
65	0	–	.66	
	8	.69	.66	
	28	.70	.67	
	48	.71	.67	
	68	.70	.67	
67	0	–	.75	
	9	.80	.80	
	37	.86	.88	
	$ 65	1.08	.95	
	93	1.04	.92	
	121	1.08	1.00	
68	0	–	.87	
	20	.73	.85	
	70	.77	.78	
	120	.75	.73	
	170	.81	.77	
	220	.95	.88	
	270	1.04	.95	(260)
	320	.93	1.16 .87	(304) (310)
	370	.92	.85 1.14	(362) (382)
	420	.89	.88	
	470	.96	.88	
	520	.94	.88	
76	0	–	.65	
	10	.68	.65	
	30	.70	.65	
	50	.69	.66	
	70	.70	.66	
82	0	–	.68	
	10		.69	(5)
	45	.71	.70	
	80	.71	.69	
	115	.71	.68	
	150	.72	.72	

	$ 185	.74	1.30
	220	.83	.80
84	0	–	1.00
	8	1.01	.97
	43	.99	.98
	78	.90	.93
	113	1.05	.99
	148	1.09	
	163	1.07	.98
88	0	–	.63
	10	.66	.63
	30	.66	.64
	50	.68	.65
92	0	–	.61
	10	.65	
	50	.65	.66
	90	.68	.65
	130	.67	.65
	170	.68	.64
	210	.68	
	250	.68	
	290	.68	
	330	.68	
97	0	–	.63
	10	.65	.62
	35	.66	.63
	60	.66	.63
	85	.67	.64
	110	.67	
100	0	–	.96
	10	.96	.88
	32	.89	.84
	54	.93	.88
	76	.91	.86
106	0	–	.78
	20	.95	.90
	70	.95	.92

	170	1.05	1.00
	270	.89	.85
	370	.98	.87
	470	.93	.89
116	0	–	.83
	10	.87	.84
	43	.90	.81
	76	.86	.85
	109	.86	.82
	142	.88	.84
121	0	–	.87
	20	.66	.86
	70	.92	.88
	120	.90	.84
	170	.94	.87
	220	.93	.88
	270	.95	.86
	320	.92	.86
	370	.92	.91
	420	.94	.90
	470	.93	.88
124	0	–	.81
	10	.91	.82
	38	.91	.85
	66	.92	.82
	94	.93	.86
	122	.94	.88
127	0	–	.68
	8	.73	.68
	38	.73	.67
	68	.74	.69
	98	.74	.69
	128	.73	.69
133	0	–	.72
	15	.74	.71
	55	.73	.69

	95	.73	.69
	135	.76	.70
	175	.75	.70
	215	.66	.72
138	0	–	.75
	10	.74	.75
	50	.79	.76
	90	.77	.73
	140	.79	.73
	180	.79	.72
	220	.77	.74
	260	.74	.73

Appendix B : Series 200031 VECTOR Cruise 1977

Gamma-ray spectrometer measurements

Sample	U (ppm)	Th (ppm)	K (%)	HProd/p (hgu/cc)	H. Prod ($\mu W/m^3$)	Th/U	East		North	
1	2.51	5.19	1.35	1.02	1.15	2.1	127°	44'33"	52°	16'15"
2	1.02	3.49	1.18	.56	.63	3.4	"	45'28"	"	14'53"
3*	.65	3.81	1.27	.50	.57	5.9	"	46'39"	"	13'58"
4	2.12	6.66	2.08	1.09	1.23	3.1	"	47'01"	"	13'26"
5	2.34	7.76	2.53	1.24	1.40	3.3	"	49'31"	"	10'53"
6	1.75	5.49	1.85	.91	1.03	3.1	127°	02'59"	52°	38'24"
7	1.84	5.14	2.12	.93	1.05	2.8	"	03'20"	"	38'23"
8	.87	4.18	.90	.54	.61	4.8	"	08'35"	"	34'31"
9	1.65	6.97	1.85	.98	1.11	4.2	"	04'21"	"	38'11"
10	2.31	5.63	2.14	1.07	1.21	2.4	"	04'07"	"	38'12"
11	1.21	3.82	3.45	.82	.93	3.2	127°	28'13"	52°	11'20"
12	1.50	4.47	3.51	.93	1.05	3.0	"	27'53"	"	11'28"
13	.81	2.65	3.80	.68	.77	3.6	"	27'29"	"	11'34"
14	1.28	4.30	4.37	.94	1.06	3.4	"	29'50"	"	12'33"
15	.90	5.06	1.72	.67	.76	5.7	128°	48'42"	53°	51'29"
16	.48	1.29	.47	.23	.26	2.7	"	48'55"	"	51'29"
17	1.02	1.89	.66	.41	.46	1.9	"	49'12"	"	51'49"
18	.84	3.09	1.10	.48	.54	3.7	"	50'48"	"	51'25"
19	.54	1.68	1.36	.35	.40	3.1	"	51'55"	"	50'07"
20	.77	2.40	2.24	.52	.59	3.1	"	52'01"	"	49'06"
21	1.14	3.24	1.89	.63	.71	2.9	"	52'13"	"	48'53"
22	.70	1.73	1.54	40	.45	2.5	"	53'55"	"	48'16"
23							"	53'47"	"	49'13"
24	1.19	2.19	.87	.49	.55	1.8	129°	05'08"	53°	08'06"
25	.51	1.94	.75	.30	.34	3.8	"	05'00"	"	07'53"
26(*)	.93	2.86	.70	.45	.51	3.1	"	05'13"	"	06'51"
27	1.42	3.98	.24	.60	.68	2.8	"	05'13"	"	06'51"
28	1.32	6.00	1.65	.82	.93	4.5	"	05'07"	"	06'06"
29(*)	.24	.96	.22	.14	.16	4.0$				
30	1.50	6.00	2.12	.91	1.03	4.0	129°	37'18"	55°	27'32"
31*	3.08	21.1	3.64	2.35	2.66	6.9	"	35'54"	"	27'32"
32	1.87	6.28	2.12	1.01	1.14	3.4	"	36'32"	"	27'31"
33	1.97	5.38	1.93	.96	1.09	2.7	"	35'28"	"	27'30"

Appendix B : Series 200031 VECTOR Cruise 1977

Gamma-ray spectrometer measurements

(Continued)

Sample	U (ppm)	Th (ppm)	K (%)	HProd/p (hgu/cc)	H. Prod ($\mu W/m^3$)	Th/U	East	North
34	5.88	13.3	2.53	2.41	2.72	2.3	129° 35'05"	55° 26'37"
35	6.07	44.0	2.80	4.41	4.99	7.3	" 35'56"	" 26'42"
36	4.95	29.6	3.54	3.31	3.74	6.0	" 36'35"	" 26'47"
37	8.97	16.5	3.02	3.36	3.80	1.8	" 37'36"	" 26'47"
38	4.03	17.4	4.43	2.40	2.71	4.3	129° 48'31"	55° 15'58"
39	12.6	19.6	3.59	4.45	5.03	1.6	" 49'53"	" 13'58"
40	2.6	13.7	4.12	1.74	1.97	6.1	" 51'03"	" 12'47"
41	4.98	13.0	2.22	2.15	2.43	2.6	" 51'16"	" 11'50"
42	.83	3.65	1.52	.55	.62	4.4	130° 21'25"	54° 44'16"
43	.52	7.86	1.65	.76	.86	15.	" 22'26"	" 43'08"
45	1.02	11.2	2.86	1.19	1.35	11.	" 20'48"	" 44'02"
46	.63	5.20	1.94	.64	.72	8.2	" 20'19"	" 44'22"
47	1.14	1.53	3.37	.65	.73	1.3	" 19'37"	" 44'46"

Appendix C: Station Coordinates

VECTOR CRUISE 1977

Station	Lat. N	Long. W	Water depth (m)	Date Oct.	Time (PDT)	Details	
1	48° 38.1'	123° 30.1'	200	3	1000	Water Temp Profile	
2			196	3	1045	Telemetry Probe	
3			199	3	1230	Ottawa Bullard Probe	
4				3	1325	PGC small D Bullard Probe	
5			201	3	1508	PGC large D Bullard Probe	
6			194	3	1640	PGC Telemetring Probe	
7	50° 05.5'	124° 48.8'	505	5	350	Water Temp Profile	
8	"	"	505	5	0445	5 m. H.F. Probe	
9	"	"	505	5	0631	Benthos Corer	k
10	"	"	505	5	0730	SR3M05S Probe	
11	"	"	505	5	0830	Test of outriggers	
12	52° 18.3'	127° 34.3	264	6	0840	Water Temp Profile	
13	"	"	266	6		SR3M05S	
14	"	"		6	935	Benthos Corer (No core obtained)	
15	52° 15.65'	127° 42.7'	407	6	1431	Benthos Corer	
16	"	"		6		SR3M05S	
*17	52° 15.65	127° 42.92		6	1615	1g gravity corer with outriggers	
18	52° 16.22'	127° 42.83'	395	6	1745	Telemeter Probe	
19	52° 16.08'	127° 42.70'	395	6	1814	"	
20	52° 15.90'	127° 42.58'	402	6	1843	"	
21	52° 15.75'	127° 42.47'	395	6	1913	"	
22	52° 15.59'	127° 42.33'	389	6	1940	"	
*23	52° 27.9'	127° 14.8'	496	6	2356	"	
24	"	"	496	7	0045	" Repeat of 23	
25	52° 24.6	127° 21.1'	483	7	0218	"	
26	"	"	"	7	0300	Benthos Corer	k
27	52° 24.2'	126° 24.0'	526	7	0417	No Pen. 2 attempts Telemetry Probe	
28	52° 22.95'	127° 27.0'	470	7	0536	Telemetry probe	
29	52° 22.95'	127° 27.0'	470	7	0605	Benthos corer	k
30	52° 21.2'	127° 27.9'	510	7	09	Telemetry probe	
31	52° 09.6'	127° 51.8'	570	7	1814	" "	

32	52° 09.6'	127° 51.8'	570	7	1845	Benthos	k
33	52° 00	127° 55.7'	454	7	2044	5 m Bullard	
34	"	"	448	7	2155	Benthos	k
35	52° 40.65'	126° 59.45'	461	8	0834	Benthos	k
36	"	"	450	8	0850	Telemetry Probe	
37	52° 37.9'	127° 03.31	490	8	1115	Outrigger & 20' Corer	k
38	"	"	492	8	1205	Tele. Prob (No trans.)	
39	"	"	492	8	1240	5 m Bullard	
40	"	"	492	8	1300	Water Temp Profile	
41	52° 23.15'	127° 10.9'	460	8	1450	Benthos	k
42	52° 34.15'	127° 10.9'	459	8	1515	5 m Bullard	
43	52° 34.37'	127° 11.06'		8		" no record	
44	52° 34.29'	127° 10.97'		8		" " "	
45	52° 34.04'	127° 10.75'	459	8	1730	" " "	
46	52° 33.96'	127° 10.65'	464	8		" " "	
47	52° 29.3'	127° 14.6'	486	8	2120	Benthos	k
48	"	"	486	8	2215	5 m Bullard	
49	52° 17.55'	127° 13.75'	564	9	0025	Benthos corer	k
50	52° 17.55'	127° 13.75'	564	9	0110	5 m Bullard	
51	52° 17.55'	127° 13.5'	560	9	0210	5 m Bullard	
52	52° 14.1'	127° 22.0'	590	9	0409	Benthos	k
53	52° 14.1'	127° 22.0'	590	9	421	5 m Bullard	
54	52° 11.2'	127° 30.0'	585	9	0717	5 m Bullard	
55	52° 11.2'	127° 29.8'	585	9	0830	5 m Bullard	
56	52° 11.2'	127° 29.6'	585	9	0941	5 m Bullard	
57	52° 11.2'	127° 29.6'	585	9	1031	20' corer & outrigger	k
58	52° 11.12'	127° 29.2'		9	1106	5 m Bullard Probe	
59	52° 11.19'	127° 29.00'	585	9	1300	Bullard Probe	
59b						Water Temp. Profile	
60			126	10	0811	Benthos	Kitimat cores
61	53° 59.02'	128° 41.57'	123	10	0842	Benthos	for
62	53° 56.32'	128° 41.35'	212	10	1120	20' corer	geological studies
63	53° 50.95'	128° 47.40'	323	10	1340	Benthos corer	k
64	"	"	325	10	1426	5 m Bullard	
65	53° 47.6'	128° 52.5	374	10	1606	Benthos	k
66	"	"	374	10	1640	5 m Bullard	
67	53° 46.89'	128° 54.57'	380	10	1810	Benthos	k
68	53° 47.5'	128° 53.7'	383	10	1856	20' corer & outrigger	k

69	53° 47.5'	128° 53.7'	383	10		5 m Bullard Probe	
70	"	"		10	2010	Water Temp Profile	
71	53° 47.6'	128° 54.0'	346	10	2120	5 m Bullard	
72	53° 47.53'	128° 53.85'	352	10	2240	5 m Bullard	
73	53° 47.09'	128° 53.2'	381	10		5 m Bullard	
74	53° 47.23'	128° 53.5'	390	11	0045	5 m Bullard	
75	53° 46.7'	128° 54.6'	380	11	0215	5 m Bullard	
76	53° 41.8'	129° 07.0'	373	11	0615	Benthos	k
77	"	"	385	11	0645	5 m Bullard	
78	53° 41.5'	129° 06.5'		11	0730	5 m Bullard	
79	53° 41.3'	129° 06.3'	390	11	0825	Benthos	
80	"	"	390	11	0835	Water Profile	
81	53° 40.4	129° 07.4	398	11		5 m Bullard	
82	53° 40.4'	129° 07.4'		11	1102	20 ft. corer w/outrigger	k
83	53° 40.4'	129° 07.4'	398	11	1150	5 m Bullard	
84	53° 10.2'	129° 07.9'	565	11	1832	20' gravity core & outriggers	k
85	53° 10.1'	129° 09.0'	562	12	0521	5 m Bullard Probe	
86	53° 10.1'	129° 08.3'	555	12	0604	5 m Bullard	
87	53° 10.1'	129° 07.1'	555	12	0702	5 m Bullard	
88	53° 07.3'	129° 07'	545	12	0910	Benthos	k
89	"	"	545	12	0946	5 m Bullard	
90	53° 07.3'	129° 06.65'	540	12	1032	5 m Bullard	
91	"	"	540	12	1120	Water Temp Profile	
92	53° 07.3'	129° 06.65'	540	12	1251	20' corer & outriggers	k
93	53° 07.9'	129° 07.5'	570	12	1502	5 m Bullard	
94	53° 07.89	129° 07.2	545	12	1630	5 m Bullard	
95	53° 07.9'	129° 06.9'	520	12	1710	5 m Bullard	
96	53° 07.9'	129° 06.6'	508	12	1910	5 m Bullard	
97	53° 07.9	129° 07.4'	549	12	2110	20' corer & outriggers	k
98	"	"	"	12	2205	5 m Bullard	
99	53° 07.86'	129° 07.73'	565	12	2315	5 m Bullard	
100	53° 06.55'	129° 21.8'	663	13	0123	Benthos corer	k
101	"	"	665	13	0220	5 m Bullard	
102	"	"	665	13	0340	Water Temp Profile	
103	53° 06.4'	129° 22.4'	650	13	0417	5 m Bullard	
104	55° 27.15'	129° 37.35'	390	14	1330	Benthos No k	
105	55° 27.15'	129° 37.35'	390	14	1420	5 m Bullard	

106	55° 27.15'	129° 37.35'	390	14	1511	20' core & outriggers	k
107	"	"	390	14	1535	Water Temp profile	
108	55° 27.18'	129° 37.55'	390	14		5 m Bullard	
109	55° 27.06'	129° 37.39'	390	14	1725	5 m Bullard	
110	"	"	390	14	1822	2 m Bullard	
111	55° 30.74'	129° 46.34'	308	14	2135	Water Temp Profile	
112	"	"	308	14	2207	Benthos	
113	"	"	308	14		5 m Bullard	
114	"	"		14	2230	YSI Salinometer	
115	"	"	308	14	2325	2 m Bullard	
115b	55° 16.0'	129° 49.7'	575	15	0330	Water Temp profile	
116	55° 16.0'	129° 49.7'	575	15	0400	Benthos Core	k
117	"	"	575	15	0420	5 m Bullard	
118	55° 13.5'	129° 51.4'	520	15	0620	5 m Bullard	
119	55° 13.5'	129° 51.7'	525	15	0800	5 m Bullard	
120	55° 13.4'	129° 51.2'	515	15	0920	5 m Bullard	
121	55° 13.47'	129° 51.7'	515	15	1035	20' core & outriggers	k
122	55° 15.95'	129° 50.00'		15	1200	5 m Bullard	
123	55° 15.8'	129° 49.52'	580	15	1255	5 m Bullard	
124	55° 11.95'	129° 51.92'	510	15	1450	Benthos	k
125	55° 11.95'	129° 51.92'		15		5 m Bullard	
126	55° 11.93'	129° 52.43'			aborted	5 m Bullard	
127	54° 46.1'	130° 24.9'	504	16	0400	Benthos core	k
128	"	"	"	16	0458	5 m Bullard	
129	"	"	"	16	0530	Water Temp Profile	
130	54° 46.24'	130° 21.13'		16		5 m Bullard	
131	54° 46.41'	130° 21.32'		16	0745	5 m Bullard	
132	54° 46.83'	130° 21.85'		16		5 m Bullard	
133	54° 45.89'	130° 20.66'	499	16	1030	20' core & outriggers	k
134	54° 45.89'	130° 20.66'	498	16	1110	5 m Bullard	
135	54° 45.51'	130° 20.15'	472	16	1245	5 m Bullard	
136	54° 45.68'	130° 20.39'	485	16	1330	SR3MOW5S	
137	59° 46.51'	130° 17.92'		16		5 m Bullard	
138	54° 47.03'	130° 18.79'	490	16	1620	20' core & outrigger	k

[illegible]	54° 47.03'	130° 18.79'	490	16	1720	5 m Bullard
140	54° 47.46'	130° 19.58'		16		5 m Bullard
141	53° 16.77'	129° 25.62'		17	0942	5 m Bullard
142	53° 16.77'	129° 25.62'		17		Water Temp Profile
143	53° 16.77'	129° 25.62'	523	17	1115	20' core & outriggers
144	53° 16.79'	129° 26.14'		17		5 m Bullard
145	53°16.75'	129° 25.11				SR3M05S

k: conductivity measured on core