INTERNAL DOCUMENT No. 285

IOS

DEACON LABORATORY

The IOSDL Towed Thermistor Spar on MV Sea Searcher in the Iceland Faeroes region April/May 1988

by G J Mohan
A J Hall
A L New

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

Wormley, Godalming,
Surrey, GU8 5UB, U.K.

Telephone: 0428 79 4141
Telex: 858833 OCEANS G
Telefax: 0428 79 3066

DIRECTOR: Dr. C. P. Summerhayes

Natural Environment Research Council

The IOSDL Towed Thermistor Spar on MV Sea Searcher in the Iceland Faeroes region April/May 1988

by G J Mohan
A J Hall
A L New

Institute of Oceanographic Sciences
Deacon Laboratory
Brook Road
Wormley
Godalming
Surrey
GU8 5UB

January 1989

DOCUMENT DATA SHEET

AUTHOR
MOHAN, G.J., HALL, A.J. & NEW, A.L.

PUBLICATION DATE 1989

TITLE
The IOSDL Towed Thermistor Spar on MV "Sea Searcher" in the Iceland-Faeroes region, April/May 1988.

REFERENCE
Institute of Oceanographic Sciences Deacon Laboratory, Internal Document, No.285, 19pp. + 1 fig. & appendices. (Unpublished manuscript)

ABSTRACT

This report describes the performance of the IOSDL towed thermistor spar in the Iceland-Faeroes region during April and May 1988 and provides a summary of the data collected. The quality of the data was significantly higher than had been obtained on previous cruises, and 25-second averages of all the data, together with isotherm plots of frontal crossings, are included in the appendices. The unique nature of the thermistor spar, with a sampling interval of about 0.5m in both the horizontal and the vertical, will allow near surface processes to be studied across the front at a resolution which has never before been possible, and should enable significant new insights to be gained into the frontal structure and variability.

ISSUING ORGANISATION
Institute of Oceanographic Sciences
Deacon Laboratory
Wormley, Godalming
Surrey GU8 5UB. UK.

TELEPHONE 0428 79 4141
TELEX 858833 OCEANS G
TELEFAX 0428 79 3066

KEYWORDS
ICELAND-FAEROES FRONT
ISOTHERMS
NEAR-SURFACE TEMPERATURES
THERMISTOR PROBES
UPPER OCEAN

CONTRACT MOD Upper Ocean Processes

PROJECT

PRICE

Copies of this report are available from:
The Library, Institute of Oceanographic Sciences Deacon Laboratory.

CONTENTS

1. A description of the towed thermistor spar

The thermistor spar (see fig. 1) is designed to measure small scale thermal structures between one and ten metres below the sea surface with a resolution of half a millidegree (mK) and a sampling rate of four Hertz. A catamaran measuring two metres by two metres is towed in undisturbed water ahead of the ship's wake by an armoured conducting cable attached to a point on one of the catamaran's hulls and taken to a point well forward on the towing vessel. A ten metre long, hollow, streamlined spar is suspended between the hulls of the catamaran. An eighty two kilogram mass is attached to the bottom of the spar. The coupling between the spar and the catamaran is via a universal joint and swivel, thus allowing the spar to remain near vertical and pointing into the local flow, decoupled from the angular motions of the catamaran.

Fitted along the spar's leading edge are twelve thermistors, a noise monitoring resistor, a pressure transducer and a forward looking sonar transducer (1 MHz) to detect bubble clouds. Two inclinometers are fitted to the top plate of the spar. Wires from these sensors run internally along the spar and are taken to two pressure cases, each six inches in diameter, containing the electronics mounted in a compartment in each hull. A shipboard sixteen bit ADC (analogue to digital converter) digitises the sixteen channels together with the sonar signal at two fixed range points. The data is the direct output of the ADC and is stored via a Sea Data digital cassette recorder. The decimal output for each channel is in uncalibrated, non-engineering units ('counts') and is in the range zero to sixty five thousand five hundred and thirty six. A real time graphical display and hard copy is produced by a BBC microcomputer for monitoring purposes. Further system details can be found in Appendix 5.

2. Details of the tows

As summarised in table 1 overleaf, four tows were made with the Thermistor Spar on a cruise organised by ARE (called IF88) from the MV Sea Searcher in the Iceland-Faeroes region during April/May 1988. The purpose of the cruise was to investigate the structure and variability of the Iceland-Faeroes front, which is usually found on the Northern side of the Iceland-Faeroes rise, and is associated with cool water to the North and warmer water to the South. The thermistor spar, however, was lost in gale force conditions at the end of the fourth tow, when the towing cable parted. A summary of the ship's meteorological observations is presented in Appendix 6, and further information can be obtained from the thermistor spar log sheets.

The purpose of the first tow was primarily to locate the position of the front. It can be seen in Appendix 1 that a plot of the ship's track resembled a large triangle covering most of the region of interest. The front was located near the North Eastern apex of this triangle, close to the one thousand fathom contour. The second tow consisted of repeated traverses of the front to collect as much data as possible. The third tow was curtailed due to a problem with the towing cable whilst the fourth ended prematurely as described above.

Raw data plots for the ninety Sea Data cassettes, which were recorded, can be found in the appendices, along with isotherm plots which have been produced for cassettes which contain crossings of the frontal region. All times in table 1 are GMT.

Table 1

Tow	Start	Latitude	Longitude	Finish	Latitude	Longitude
1	1500/113	63.09N	11.42W	1800/116	63.12N	9.23W
2	1010/119	64.71N	10.95W	1428/124	63.77N	12.19W
3	1024/133	63.27N	11.27W	1300/135	64.61N	11.55W
4	1010/136	64.10N	10.65W	0728/137	64.14N	10.85W

3. The preparation and performance of the towed thermistor spar

3.1 Spar preparation

3.1.1 IOSDL Wormley

The spar was last deployed on RRS Challenger CR18 in September 1987. On this cruise a number of serious faults arose, mostly concerning the electronics, but also hydrodynamic, such as a capsize in a 5m cross swell, in which, however, no damage appeared to be sustained.

The electronics problems on the above cruise manifested themselves as noise, spikes and offsets. Processing the data at IOSDL threw some light on their causes and despite the poor quality of the data, useful results were obtained (see IOS internal document no.280 "The IOSDL towed thermistor spar on Challenger cruise 18, September 1987 ").

The main improvement attempted prior to the present survey was to rewire the sensors so that each sensor (seventeen in all) on the spar had its own individual connector. These connectors were plugged into an array of fixed bulkhead sockets mounted in the end plate of one of the six inch diameter pressure cases fitted into the hulls of the catamaran. In addition, the towing cable and the power supplies to the sonar system were also plugged into this array. The connectors employed were LEMO precision self latching electrical connectors. These achieved the low contact resistance required and were weatherproof, but not strictly of underwater standard. Thus it was important that the hull compartments were kept reasonably dry. Water ingress had been a continuous problem on all previous cruises, where looms of wire were brought in through the hatch edge seal. On Challenger CR18 one compartment continually flooded with water and may have been a contributory factor in its capsize. Metal plates with an array of glands were mounted in the hatches to seal the nineteen cables. As a further protection, metal weather shields were fitted over these plates to deflect the continuous flow of water experienced whilst towing at four knots. This arrangement was subjected to water tests at IOSDL which showed up very slight leaks. Now that the hatches and the gland plates had become part of the wiring loom, handling became rather more awkward. However, the hatches did seal and had time been available they could have been simplified and the minor leaks rectified. Overall the new arrangement appeared satisfactory, particularly as regards the ease with which individual sensors could be isolated for 'trouble shooting'.

The thermistor bridges were set up for the range three to thirteen degrees Celsius as requested by ARE and the thermistors, complete with their looms, were calibrated before they were fitted to the spar. It was during this process that the source of enhanced noise seen during previous cruises was discovered. The screen/core connection of the thermistor cables in certain cases were reversed. This rendered those thermistors very sensitive to pickup, resulting in a very poor calibration in the laboratory, and, while at sea during a tow those thermistors exhibited enhanced noise.

The Ocean Engineering department obtained a suitable battery powered winch, designed an adaptor and fitted it to the davit handling the spar's bottom weight. The old manual winch was serviced and was to be available as a back up. This worm drive winch was safer than the free wheeling winch used on IF86 and could be operated by one person, but was too slow and required the operator to be underneath the lifting wire and spar weight at times, which was clearly undesirable.

By April 1st equipment had to be packed ready for shipment to Great Yarmouth. Unfortunately many tasks were incomplete. Particularly worrying was the fact that the new end plate containing the LEMO connector array had been delayed by a series of mechanical problems and was not wired at all before the packing date.

3.1.2 Great Yarmouth

An extended mobilisation period enabled the completion of the wiring of the electronics and the rigging of the spar system to be achieved before Sea Searcher sailed. It was the first time the system incorporating the latest modifications had been operated and also the first time that the spar system had been ready to deploy before the ship sailed. As events were to show, this was fortunate, as a period of bad weather lay ahead.

Whilst preparing the instrument it was observed that when the sonar power supply was disconnected a small 'jump' occurred in the output of alternate channels. Whilst this was not understood it did explain a shift seen previously between calibrations made at sea and at IOSDL when the sonar system had been disconnected. This was a direct and useful benefit derived from the new connector arrangements. Had the instrument survived, this observation would have allowed this particular characteristic to be tracked down and eliminated.

During this period the problem which had prevented the use of the 1 MHz sonar on Challenger CR18 recurred and was identified as high frequency oscillations, not mistriggering as had previously been assumed. Appropriate common link changes and extra decoupling capacitors appeared to cure the problem in a reproducible manner and the system was checked by lowering the spare sensor over the side into the river Yar where it produced an excellent image of the river bottom.

An opportunity was taken to test the new electric winch. It was known it could handle the anticipated loads, but there was a thermal cut out switch which would trigger if the winch overheated. Repeated lowerings of an eighty kilogram mass over the ship's side into the river showed no cut out operation in the time period required for deployment or recovery.

Thus when the ship sailed there was some satisfaction that the system had been considerably improved. Excellent results were expected to be obtained from a calibrated system despite the unpromising experience of Challenger CR18.

3.1.3 At sea 12 April to 22 April

Initial deck running of the system indicated much improved stability and reduced noise as judged by the monitoring resistor. A number of simple changes to earths and commons had previously been made and seemed to have been successful.

A force ten gale occurred during the night of 15/16 April with waves breaking over the stern deck (4.5m above sea level) dislodging the spar's pressure sensor from its transit mount. It was found swinging free on the morning of the 16th, but was undamaged. It was known from previous cruises how vulnerable this large system was to rough weather. To this end an eye had been welded to the deck to enable the spar to be lashed down, and this prevented major damage on deck.

On 18th April, problems began to occur, first with the BBC microcomputer programs crashing, much as had happened on Challenger CR18, but not at all at IOSDL. It was then learned that the required temperature range was zero to ten degrees Celsius not three to thirteen.

On 19th April, the catamaran was opened up and the sea unit removed to the laboratory to enable the seven temperature PCBs to have their resistance bridges changed, in order to accommodate the new temperature range. This of course meant that the thermistor calibration, achieved for the first time before a cruise, had to be modified. On returning the sea unit to the catamaran and powering it up, the -24V power supply fuse blew repeatedly. After a fraught investigation, a tantalum capacitor, which had become a short circuit, was found. The system was sealed up and appeared to work normally. This episode was unfortunate in that not only had a calibration been lost, but the conditions in which the nineteen plugs were removed and replaced, high winds, snow flurries and temperatures of minus two degrees Celsius were not ideal for the proper preparation of these plugs which needed to be dry, clean and properly lubricated. This is probably why thermistor T1 later showed faults which disappeared when its LEMO plug was investigated.

3.2 Tow 1 : 22 April to 25 April

Tow 1 started with a poor uncoordinated launch. Considerable trouble was experienced with a GARDLINE quick release hook. Finally, a second type of release, a Peck and Hale 'Release-A-Matic' was used and worked well. The new Rule electric winch worked well with a total of four complete cycles of lowering and hoisting being required for this deployment.

It was immediately apparent that the sonar was experiencing high frequency oscillation problems again and could not be operated. Otherwise, the performance during this tow was the best yet achieved.

The catamaran was recovered after three days. It proved necessary to use the Zodiac to disentangle the recovery line which had been caught around the catamaran the day before, when the ship had broken down for forty five minutes. On recovery the starboard keel was found to be missing. The reason was not obvious. Impact with the spar was a possibility, but there were no marks on the spar. The launch, recovery and the entanglement when the ship broke down were other possibilities for breaking the keel, but since the keel floats it should have been noticed. There were no obvious changes to the catamaran's towing behaviour, and if there had been an impact with some floating object, one might have expected some other signs of damage.

Table 2 lists problems and comments that have emerged from a preliminary examination of the data.

Table 2

Sea Data cassette	Comments	Time/day(Julian)
01	Deployment followed by attempts to run sonar	
02	Attempts to energise sonar have disrupted data	
07	Spiking is an attempt to energise sonar	
17	Engine failure	2000/115
23	Sonar test	1405/116
24	Cassette problem 40 minutes of data lost	
25	System recovered	1820/116

With the exception of the sonar the sensors performed very well during this tow, lasting three days and three hours, the longest yet achieved. The noise and stability as indicated by the monitoring resistor represented an improvement over previous tows and clearly demonstrated that the pre-cruise modifications had been beneficial. An average angle of fourteen degrees to Starboard, as indicated by the inclinometer, and the observation that the catamaran appeared closer to the ship than on previous tows, together with the fact that the starboard keel was lost, indicated a new problem. A small amount of water was found in each hull compartment, whereas on Challenger CR18 they filled in less than nine hours.

Whilst preparing the system for tow 2, it was not possible to reproduce the sonar problem. It was working quite normally immediately after the recovery, but would occasionally develop a short period of high frequency oscillations. Disconnecting the ship's earth from the shipboard sonar's earth link seemed to reduce this effect, but it was not convincing. In port, this very link was the operation which cured this problem. A new keel was constructed from plywood, but was not as robust as its predecessor.

3.3 Tow 2 : 28 April to 3 May

The log book records a "terrible deployment", but the details are not recorded. It was immediately clear that, whilst the sonar was working properly, the lateral inclinometer was not. Events and problems during tow 2 are listed in table 3 below.

Table 3

Sea Data cassette	Comments	Time/day(Julian)
26	Deployment, sonar on	1020/119
29	Radio interference	2015/119
30 to 32	PS inclinometer working, with occasional 'spikes'	
34	Radio interference	1105/120
37 to 38	PS inclinometer working, with occasional 'spikes'	
41	Sonar gain increased by 10db	1028/121
49	Noise monitoring resistor 'spikes'	1102/121 1122/121
51	Noise monitoring resistor 'spike'	1705/121
52	Sonar turned off for 5 mins	2120/121
53	Noise monitoring resistor 'spike'	
55	Calibration shift for T8	0700/122
56	MV Sea Searcher slows to interrogate mooring at Alpha	0935/122
56	Noise monitoring resistor 'spike'	0958/122
57	MV Sea Searcher slows to 2.5 knots	1255/122
58	MV Sea Searcher too fast causing spar instability	1344/122
58	T8 unstable	
59	Noise monitoring resistor 'spikes'	
60	Radio interference	2050/122
60	Noise monitoring resistor 'spikes' caused by towing cable problem	
60	T8 erratic	
62	T8 erratic	
62	Noise monitoring resistor 'spike'	
65	Cable fault induced	1332/123
65	Sonar-electronics 'meddling'	1340/123
65	Towing speed too fast 5 knots	1415/123
65	Calibration shift for T8	
66	Recovery	1450/123

The tow lasted five days and seven hours, and was recovered on schedule. The 1MHz sonar worked well and its audio signal and trigger pulse were recorded on VHS cassettes, using the hi-fi tracks of a VCR, in addition to being digitised (at two fixed ranges) and occasional records being made on an EPC graphic recorder. A problem experienced was the failure of the Port/Starboard inclinometer. However, this occasionally worked, and all seventeen sensors were then functioning properly, a first for the system. Unfortunately, thermistor 8 had a calibration shift at 0700/122 on Sea Data cassette number 55. This continued for the remainder of the tow, and its performance at times was erratic. Spikes are seen in the noise monitoring resistor from cassette 49 onwards. These are very conspicuous on the plots due to the 2mK scale used. They will also be present on the other channels. They have a large divergence from the average and last for less than ten seconds.

The long tows were causing new mechanical problems with the towing cable. The towing point was a snatch block attached to a pair of accumulators, which meant that a length of cable (about 1.5m) was constantly moving backwards and forwards through the snatch block, which, with its radius of sixteen centimetres was too small for the towing cable. Consequently, after towing for a total of eleven days, one of the internal cores was intermittently open circuit, which probably caused the RX 'spikes' noted in table 3, and finally an open circuit as reported on cassette 60. Moving the cable off the block straightened the cable, re-establishing continuity in that core. Only four out of forty cassettes on this tow had more than one 'spike'.

Problems with the BBC microcomputer recurred near the beginning of the tow, so this was replaced by an ARE BBC, and no further difficulties were experienced.

At 0800 on 2nd May the front part of the new keel was seen to be vertical. On recovery only the rear portion was in place, the front portion had snapped, rotated on its screws, and finally, detached itself.

3.4 Tow 3 : 12 May to 14 May

Preparations were made whilst in port in Reykjavik between 5th May and 8th May. Snow and freezing rain hampered spar investigations. Tracing the inclinometer fault back to the sensor revealed that it was an open circuit, but as there was no spare available nothing could be done. The problem with T8 appeared to be a less than perfect edge connector in either the T8 bridge or the multiplexor PCB. A new keel made from quality plywood complete with plastic laminate, and already cut to the right shape was supplied by the Icelandic ship's agent. It was fitted and sealed. This was important as the previous attempt to attach a keel had penetrated into the lower water buoyancy compartment because the only available screws were too long.

The deployment was again poor. A new release, flown out from IOSDL, did not work and the Peck and Hale 'Release-A-Matic' was used in the second attempt. During this attempt the catamaran became caught between the ship's rail and gunwales and the new keel was damaged. The tow started badly. The towing cable fault reappeared and prevented operation at the start, and when this was corrected by moving the section of cable off the snatch block, the sonar was seen to be unstable again. Further comments are summarised in table 4 below.

Table 4

Sea Data cassette	Comments	Time/day(Julian)
67	Deployment	0950/133
67	Cable fault	0950/133
67	Attempt to operate sonar	1040/133
68	Attempt to operate sonar	1238/133
68	Attempt to operate sonar	1320/133
68	Attempt to operate sonar	1330/133
68	Attempt to operate sonar	1340/133
68	Attempt to operate sonar	1350/133
68	Attempt to operate sonar	1355/133
69	T1 fault starting	1600/133
70	T1 fault	1804/133
70	RX 'spikes'	1904/133
70	RX 'spikes'	2055/133
72	RX 'spikes'	
73	T1 fault, RX 'spikes'	
74	T1 fault, RX 'spikes'	
75	T1 fault, RX 'spikes'	
76	T1 fault, RX 'spikes'	
77	T1 fault, RX 'spikes'	
78	RX 'spikes'	
79	RX 'spikes'	
80	RX 'spikes'	
81	T1 fault, RX 'spikes'	
82	T1 fault, RX 'spikes'	
83	RX 'spike' followed by shutdown due to cable fault	

This tow, lasting two days and two hours, was eventually terminated due to a towing cable problem, later identified as two sets of broken cores. The T1 fault was mostly spikes and was not present on every cassette. The cause was unknown but there were indications of a problem with the LEMO connector. The many spikes visible on the RX record have been found to be single record faults. Often what seems to have happened is that the Data Multiplexor frame has slipped on one or more channels. Using RX as an indicator it ought to be a straightforward matter to despike these records and it is likely that they are related to the core failure problem. The problem with the sonar remained a mystery since it was found to be working on deck. It was possible that it had an open circuit in one of the two cores allocated for signal return. The Port/Starboard inclinometer came to life occasionally and showed the usual large Starboard angle. The Starboard keel survived for the first time, but was starting to laminate. Some water was found in the hull compartments, but the amount was too small to cause concern.

3.5 Tow 4 : 15 May to 16 May

The towing cable was reterminated, and a new, larger radius, snatch block was attached to a single accumulator, allowing more movement for given strain. The log describes a 'perfect deployment', with a flat calm sea, and all sensors were functioning at the start. Further comments are indicated in table 5.

Table 5

Sea Data cassette	Comments	Time/day(Julian)
84	Deployment	0945/136
84	Sonar turned on	1002/136
84	PS inclinometer 'spikes'	
86	PS inclinometer 'spikes'	1600/136
87	Radio interference	2018/136
88	PS inclinometer stops working as wind picks up	0012/137
90	Capsize	0525/137
91	Capsize, cable cores damaged	0722/137
91	Capsize, towing cable severed	0732/137

The catamaran sustained three capsizes in heavy seas, culminating in its eventual loss, but during this short tow, lasting twenty three hours, it sampled conditions varying from mirror calm to a force eight gale. The sensors worked well and showed dramatic changes in temperature structure and bubble cloud development associated with the rapid onset of strong winds (see cassette 88).

There were no spikes in the data, and the sonar functioned correctly, confirming the notion that the cable core fractures were responsible for these problems on the previous tows. The instrument continued to function quite normally until the cable was damaged by a capsize. Remarkably the noise monitoring resistor showed nothing unusual, despite the punishment the instrument was taking. The original specification for the system set the highest winds for operation as thirty knots. At the time of loss the wind speeds were forty knots and the prevailing sea conditions meant that the surface water velocity would result in flow reversal around the catamaran. This would result in the catamaran experiencing a flow of ten knots against its direction of motion and a flow of six knots in the direction of motion as a wave passed. This imposed severe strains on the towing cable. After the cable had parted, the catamaran righted itself quickly, and floated in a manner which suggested that it would have ridden out the storm, and had there been some means of locating it, it could in all probability have been recovered intact.

4. Data processing

The processing initially involved transferring the data from the Sea Data cassettes (ninety in total) to nine track magnetic tapes (1600 BPI), using the IOSDL Digidata system and a Sea Data model 12B reader. This process proved to be long and drawn out, mainly due to the temperamental nature of the Digidata system. In general each magnetic tape has three Sea data cassettes stored on it. Some, however, have only one or two. These are cassettes which, because of problems with the Sea Data-Digidata system, initially proved unreadable on the mainframe computer and had to be rewritten to a second magnetic tape.

The following table identifies which Sea Data cassettes are stored on each magnetic tape. The cassettes denoted by an asterisk are those which revealed a crossing of the frontal region and for which isotherm plots have been produced. Also in this table are the 100 point averaged temperatures (Celsius) for the top and bottom thermistors, at the start of each cassette.

Table 6

Sea Data cassette	Tow number	Magnetic tape number	Start time (hour/J.day)	Start temp T1 (°C)	T12
01	1	IF8801	1610/113	4.352	4.286
02	1	IF8801	1918/113	7.299	7.294
03	1	IF8801	2227/113	6.682	6.678
04	1	IF8802	0133/114	7.080	7.077
05	1	IF8802	0439/114	6.753	6.748
06	1	IF8802	0742/114	7.137	7.132
07	1	IF8803	1050/114	7.136	7.125
08	1	IF8803	1358/114	7.038	7.022
09	1	IF8803	1704/114	7.187	7.178
10	1	IF881011	2017/114	6.731	6.728
11	1	IF881011	2330/114	6.998	7.000
12	1	IF8804	0236/115	6.802	6.469
13	1	IF8805	0543/115	6.584	6.577
*14	1	IF8850	0854/115	6.351	6.342
*15	1	IF8805	1200/115	2.818	2.800
16	1	IF8806	1506/115	4.377	4.102
17	1	IF8806	1815/115	3.256	3.245
18	1	IF8806	2124/115	4.130	4.121
19	1	IF8807	0032/116	5.086	5.075
20	1	IF8807	0339/116	5.191	5.147
21	1	IF8807	0647/116	6.232	6.226

Sea Data cassette	Tow number	Magnetic tape number	Start time (hour/J.day)	Start temp T1 (°C)	T12
22	1	IF8808	0958/116	5.440	5.435
23	1	IF8808	1310/116	7.285	7.271
25	1	IF8850	1657/116	6.802	6.498
*26	2	IF8809	0856/119	7.469	7.786
27	2	IF8809	1204/119	6.811	6.344
28	2	IF8810	1514/119	7.195	6.951
*29	2	IF8810	1821/119	7.160	6.809
30	2	IF8810	2130/119	6.981	6.913
31	2	IF8811	0043/120	1.303	1.249
32	2	IF8811	0348/120	6.859	6.857
33	2	IF8811	0655/120	6.853	6.849
34	2	IF8812	1004/120	6.853	6.811
*35	2	IF8812	1313/120	7.125	7.045
*36	2	IF8812	1617/120	1.874	1.021
*37	2	IF8813	1926/120	6.931	6.055
38	2	IF8813	2236/120	6.307	6.280
*39	2	IF8813	0140/121	6.830	6.831
*40	2	IF8814	0450/121	1.952	1.684
41	2	IF8814	0759/121	6.913	6.911
*42	2	IF8814	1108/121	3.714	3.625
43	2	IF8815	1420/121	6.135	6.116
44	2	IF8815	1728/121	6.666	6.665
45	2	IF8815	2038/121	4.831	4.828
46	2	IF8816	2349/121	4.363	4.355
47	2	IF8816	0254/122	3.927	3.923
48	2	IF8816	0601/122	3.608	3.599
49	2	IF884950	0912/122	4.602	4.594
50	2	IF884950	1218/122	6.282	6.282
51	2	IF8817	1530/122	5.781	5.780
52	2	IF8818	1837/122	5.121	5.128
53	2	IF8818	2207/122	6.575	6.572
54	2	IF8818	0114/123	6.315	6.318
55	2	IF8819	0420/123	6.606	6.605
56	2	IF8819	0723/123	6.624	6.624
57	2	IF8819	1034/123	6.314	6.314
58	2	IF8820	1344/123	6.812	6.811
59	2	IF8820	1652/123	6.784	6.781
60	2	IF8860	1958/123	6.786	6.786
*61	2	IF8821	2309/123	6.863	6.864
62	2	IF8821	0215/124	6.413	6.408
63	2	IF8821	0515/124	6.148	6.049
64	2	IF8822	0819/124	6.817	6.781
65	2	IF8822	1134/124	7.062	6.986
66	2	IF8822	1427/124	7.342	7.337
67	3	IF8823	0829/133	8.162	7.715
68	3	IF8823	1139/133	7.451	7.436
69	3	IF8823	1456/133	7.719	7.710
70	3	IF8824	1804/133	7.737	7.693

Sea Data cassette	Tow number	Magnetic tape number	Start time (hour/J.day)	Start temp T1 (°C)	T12
71	3	IF8824	2114/133	7.513	7.501
72	3	IF8824	0026/134	7.633	7.631
73	3	IF8825	0337/134	7.594	7.594
74	3	IF8825	0645/134	7.533	7.514
75	3	IF8825	0958/134	7.494	7.484
76	3	IF8826	1310/134	7.695	7.615
*77	3	IF8826	1608/134	7.520	7.500
78	3	IF8826	1914/134	6.576	6.171
79	3	IF8827	2225/134	6.776	6.773
80	3	IF8827	0136/135	4.476	4.427
81	3	IF8827	0443/135	6.640	6.636
*82	3	IF8828	0749/135	6.428	6.414
*83	3	IF8883	1059/135	2.563	2.363
84	4	IF8828	0850/136	10.794	10.786
*85	4	IF8829	1200/136	8.119	7.328
86	4	IF8829	1508/136	7.869	7.521
87	4	IF8829	1816/136	8.231	7.577
*88	4	IF8830	2127/136	8.005	7.903
89	4	IF8830	0039/137	6.593	6.472
90	4	IF8830	0351/137	7.736	7.724
91	4	IF8850	0700/137	7.571	7.566

For each of the Sea Data cassettes, a data file of the raw data was produced, in which, for each thermistor, each successive hundred points had been averaged together. A plot of this averaged data was then produced showing the general trend of the information on the cassette. These plots are included in the appendices, but strictly the plots are only in 'counts', since temperature calibrations had not been performed at this stage. Nevertheless, a rough temperature scale is indicated in these plots, and they will be loosely termed the 'temperature' plots.

In addition, a plot of the ship's track was produced for each of the four tows showing the path the ship took and its position each hour and at the beginning of each new day. These 'trackplots' can be found at the beginning of the appendices and precede the temperature and isotherm plots for each corresponding tow.

Note that Sea Data cassette number twenty four was found to be running at the wrong speed and for this reason it was terminated after approximately forty minutes and cassette twenty five was begun.

5. A description of the plots

Both the temperature and isotherm plots contained in this report were produced from the the same data set. The data was the raw data from the spar, averaged into twenty five second intervals.

The time scale on the plots is marked on the hour and at each ten minute interval. In addition, the time at the start of each plot is indicated in the lower left hand corner of each figure.

The plots for tows 1 to 4 can be found in appendices 1 to 4 respectively, and isotherm plots for each frontal crossing follow the corresponding 'temperature' plots from which they were produced.

5.1 Temperature plots

These plots contain up to nineteen traces denoted as follows:

T1	**thermistor number one**
T2	**thermistor number two**
T3	**thermistor number three**
T4	**thermistor number four**
T5	**thermistor number five**
T6	**thermistor number six**
T7	**thermistor number seven**
T8	**thermistor number eight**
T9	**thermistor number nine**
T10	**thermistor number ten**
T11	**thermistor number eleven**
T12	**thermistor number twelve**
S1	**sonar number one, range 3.38m**
S2	**sonar number two, range 9.25m**
RX	**noise monitoring resistor**
PX	**pressure transducer (converted to metres to give its own depth)**
FA	**Fore Aft inclinometer**
PS	**Port Starboard inclinometer**
DEP	**depth of pressure transducer calculated from FA and PS**

The plots with less than nineteen traces represent times when various components of the spar were not functioning as they should, notably the sonar traces on the first tow and the Port Starboard inclinometer on the third and fourth. The loss of data from the inclinometer resulted in the loss of the depth calculated from these angles, so where the inclinometer was malfunctioning there is only one measurement of the depth of the pressure transducer.

A one degree (Celsius) scale is indicated for the thermistors, but absolute temperatures are not shown, as the plots were done prior to calibration and are in 'counts' only. There is a two milliKelvin scale for RX, while PX and DEP are measured in metres, and the two inclinometers in degrees, with aft and starboard being taken as positive.

5.2 Isotherm plots

Pre-cruise laboratory calibrations were carried out for the thermistors. The following table of coefficients was produced after the cruise by slightly altering the pre-cruise calibrations to ensure smoothly varying temperature profiles in certain, near-isothermal, regions of the tows, covering the temperature range of interest. Here T is the temperature (Celsius), R is the number of 'counts' and n is the thermistor number in the equation :

$$T_n = a_n * R_n + b_n$$

Table 7

n	a_n	b_n
1	0.000247435	-5.09110
2	0.000248110	-4.98729
3	0.000251060	-5.27068
4	0.000249436	-5.18922
5	0.000249368	-5.20691
6	0.000247532	-5.03567
7	0.000249114	-5.17277
8	0.000255374	-5.32028
9	0.000249516	-5.14494
10	0.000248227	-5.06305
11	0.000247420	-4.97835
12	0.000248992	-5.15253

This calibration was then applied to calculate actual temperatures, typically accurate to about 3mK, from the data stored on the magnetic tapes (in 'counts'), and, using a standard numerical contouring package, isotherm plots were produced for every Sea Data cassette which contained a frontal crossing. In these plots the isotherms are shown and annotated at every half degree (Celsius), and the vertical axis shows thermistor numbers rather than depth in metres.

6. Conclusions

Reviewing the four tows, it was obvious that, despite the difficulties experienced, the system performed better than on IF86, and that all the problems from Challenger CR18 had been corrected or identified correctly. The sonar problem was diagnosed and, from tow four, probably cured.

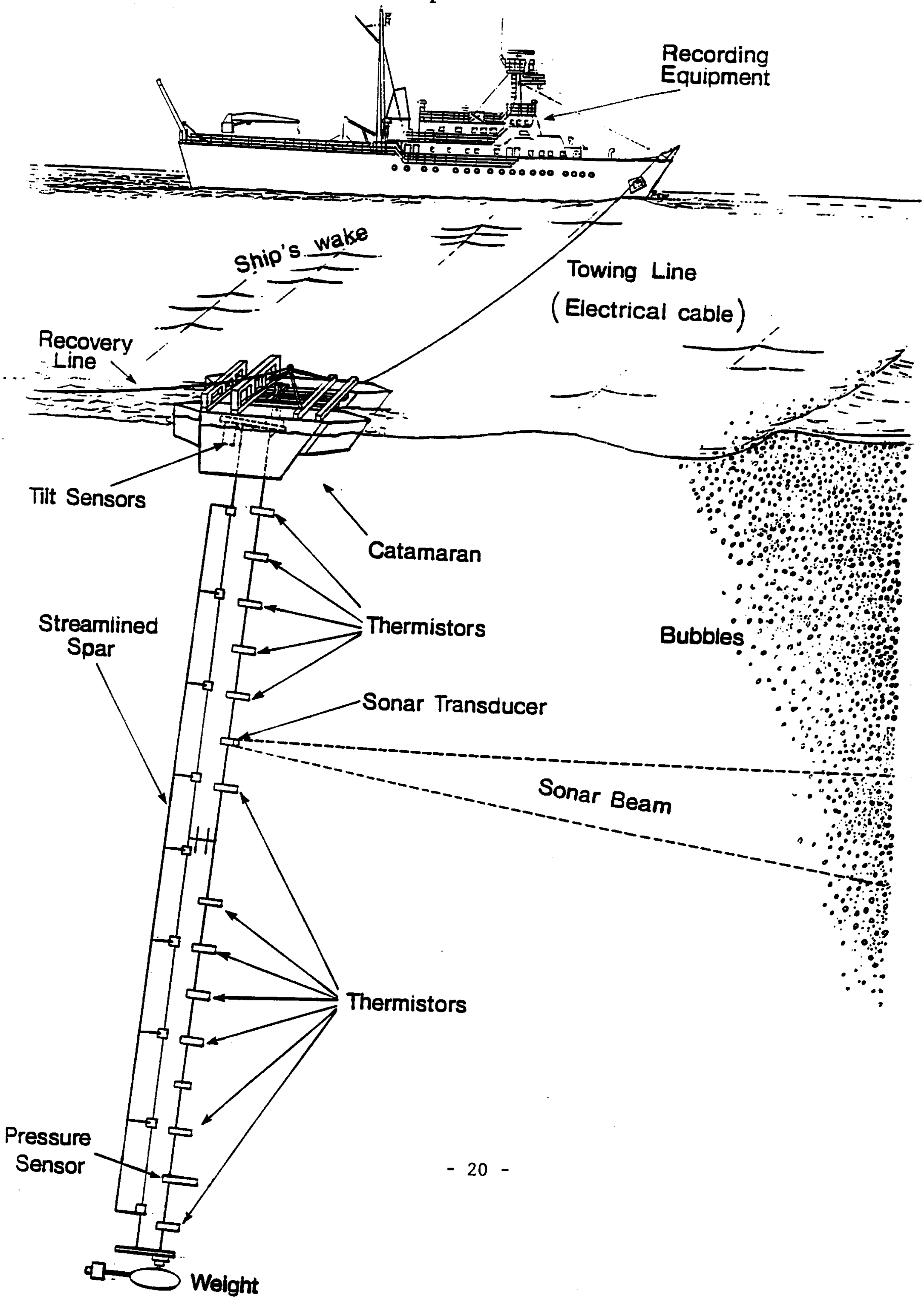
However, a new problem arose, that of the cable failures. This was brought about by the length of the tows achieved, but was understood and readily solvable. Another difficulty was that of the large Starboard angle adopted by the spar. This has been traced back to the capsize on Challenger CR18. The most likely cause was some damage to the universal joint supporting the spar, preventing it from aligning itself fully with the local flow, and consequently developing lift.

Had the instrument survived, it would have progressed significantly up the operational learning curve. However, much useful data was collected and this will allow a more detailed investigation of the Iceland-Faeroes front to be undertaken. The unique nature of the thermistor spar, with a sampling interval of about 0.5m in both the horizontal and the vertical, will allow near surface processes to be studied across the front at a resolution which has, to our knowledge, never before been possible, and should enable significant new insights to be gained into the frontal structure and variability.

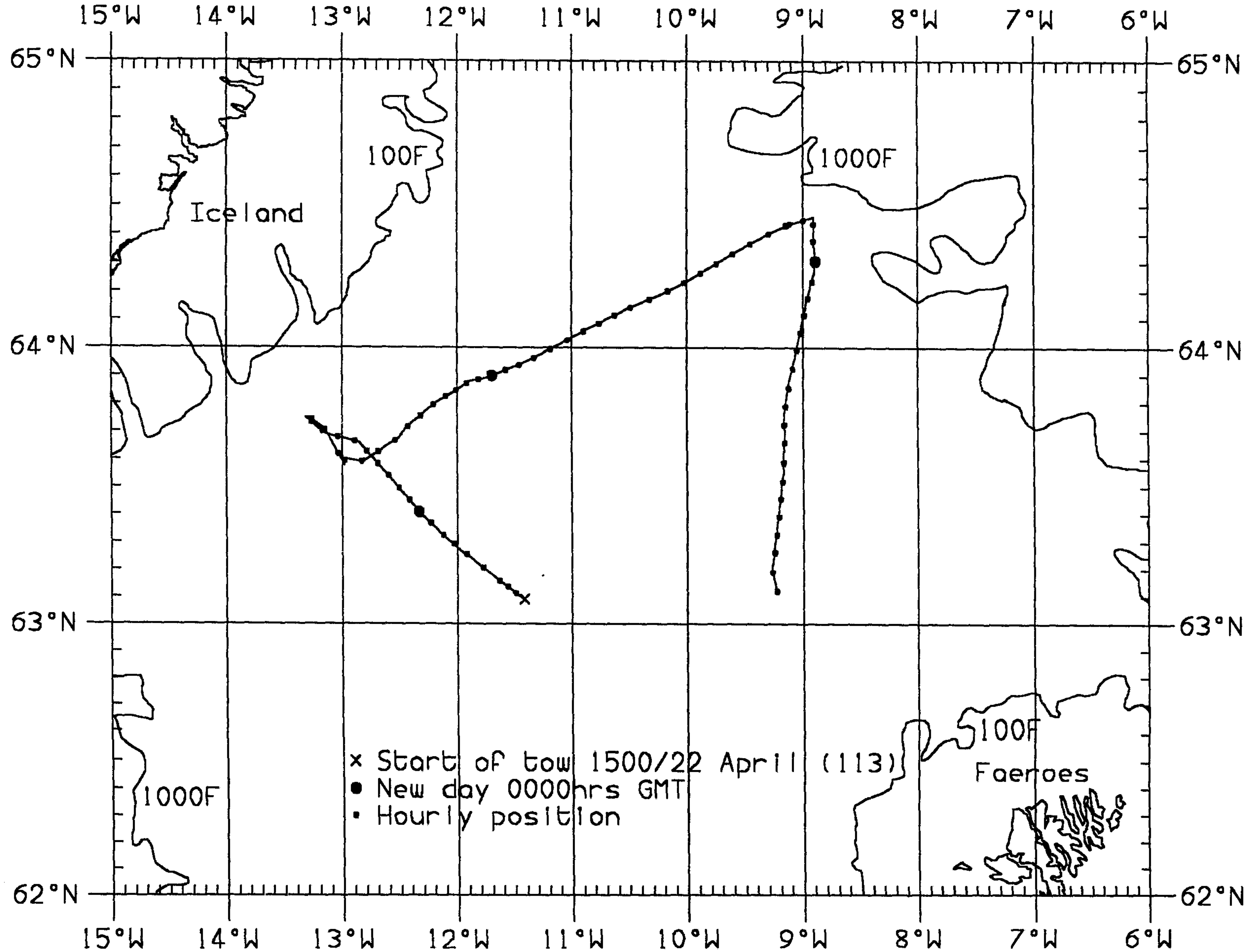
Acknowledgements

This work has been carried out with the support of the Procurement Executive, Ministry of Defence.

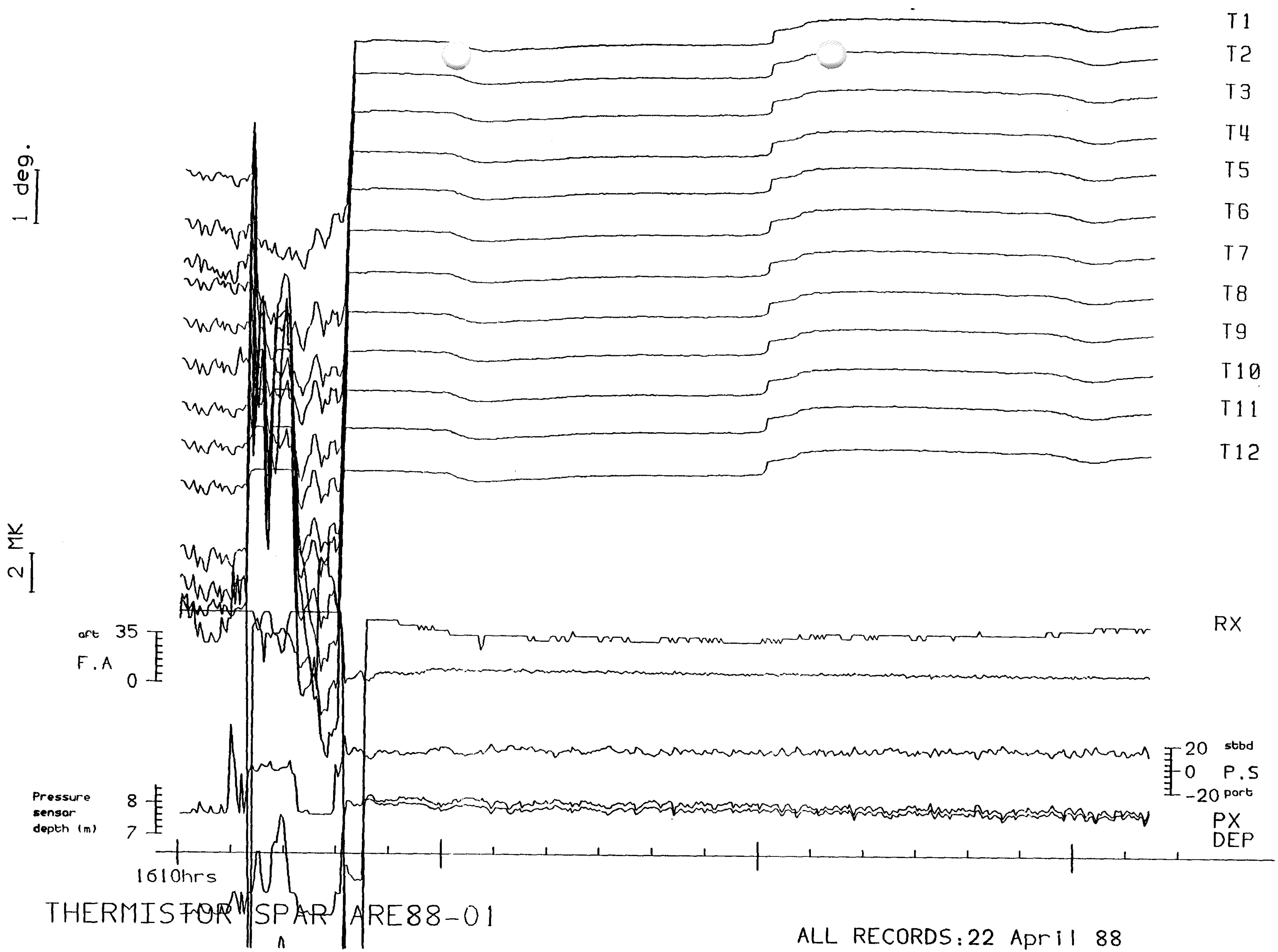
Fig 1 The towed thermistor spar



Appendix 1 : Tow 1

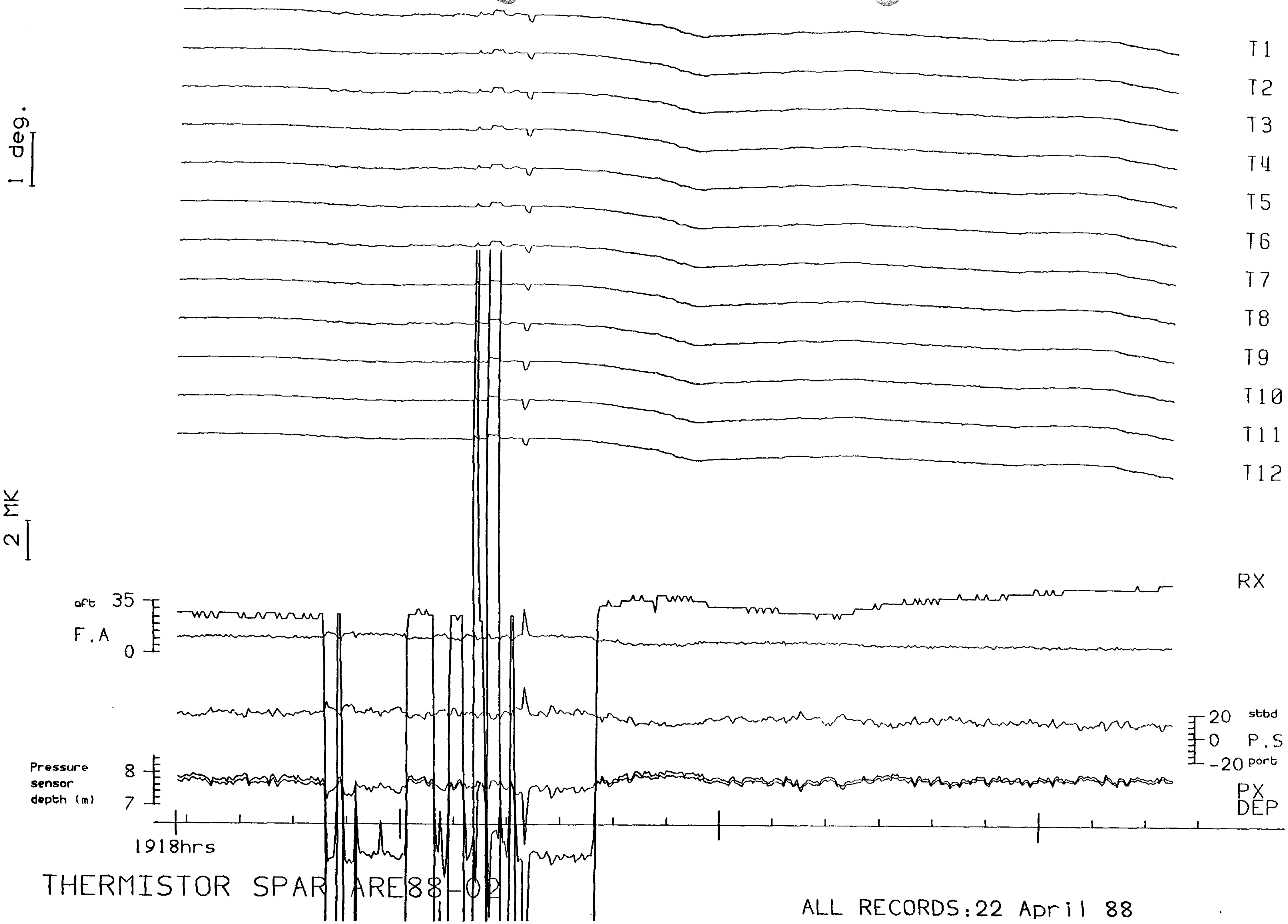


THERMISTOR SPAR TRACKPLOT TOW1 (ARE88-01 to 25)



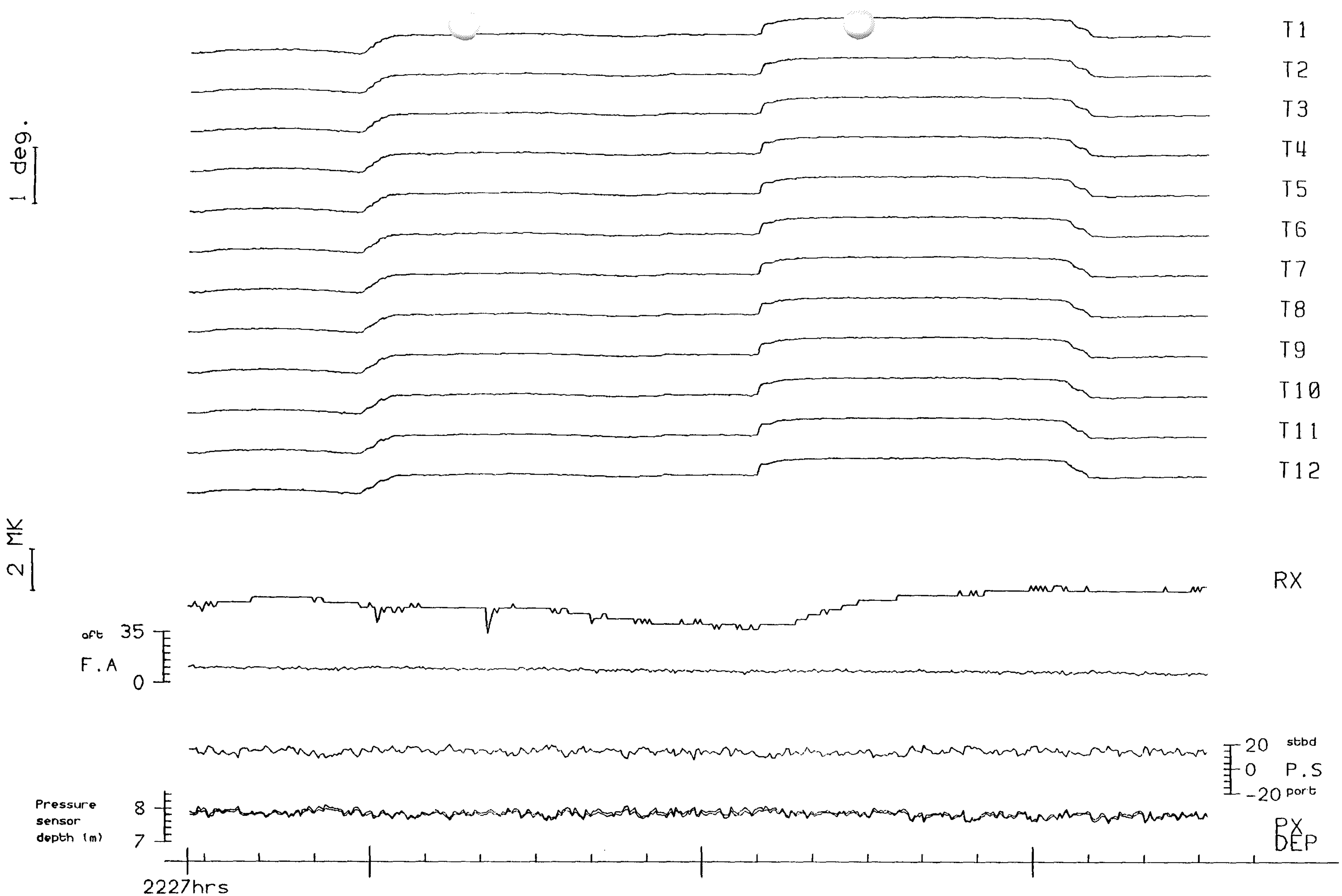
THERMISTOR SPAR ARE88-01

ALL RECORDS: 22 April 88



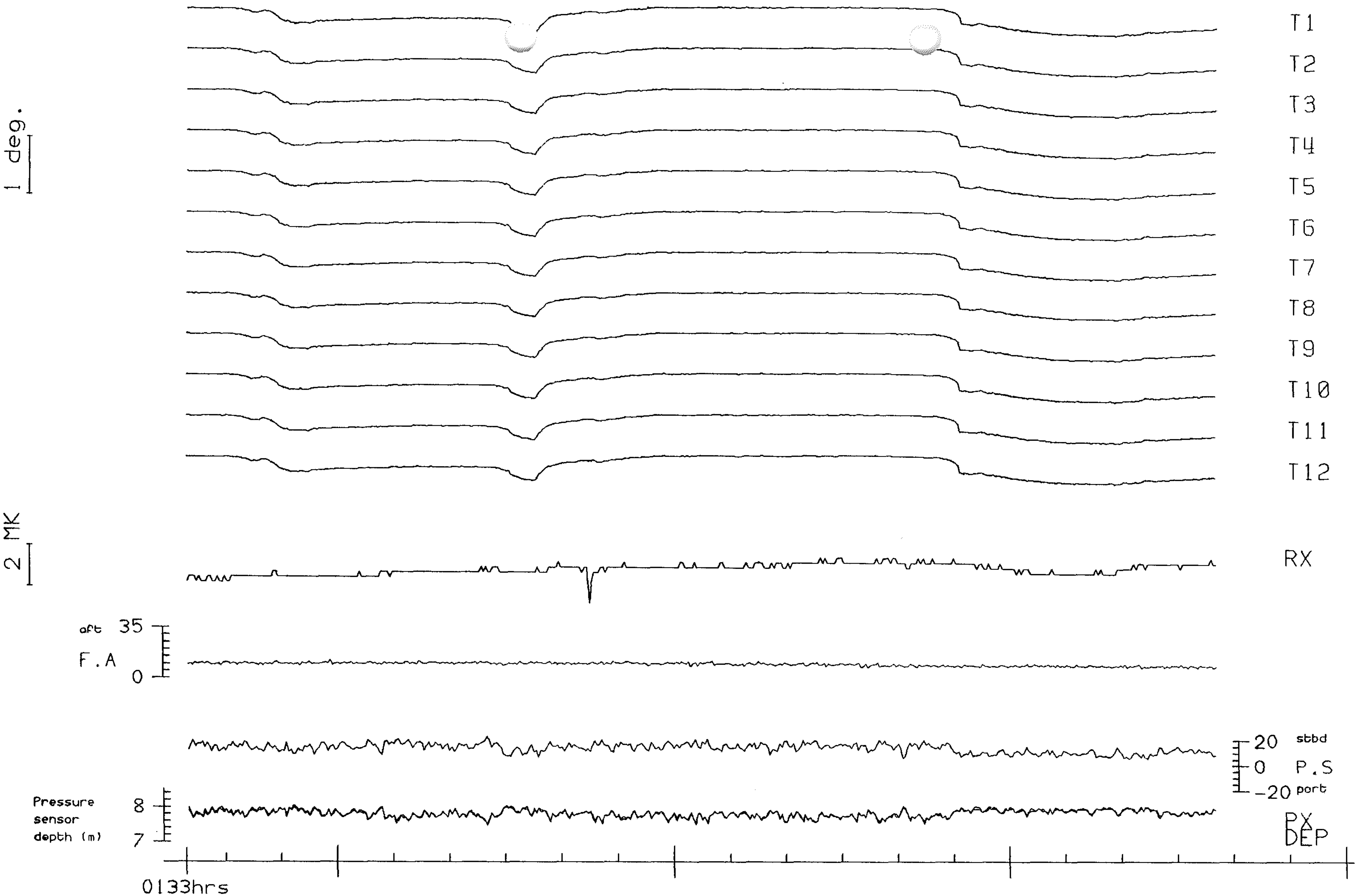
THERMISTOR SPAR ARE88-02

ALL RECORDS: 22 April 88



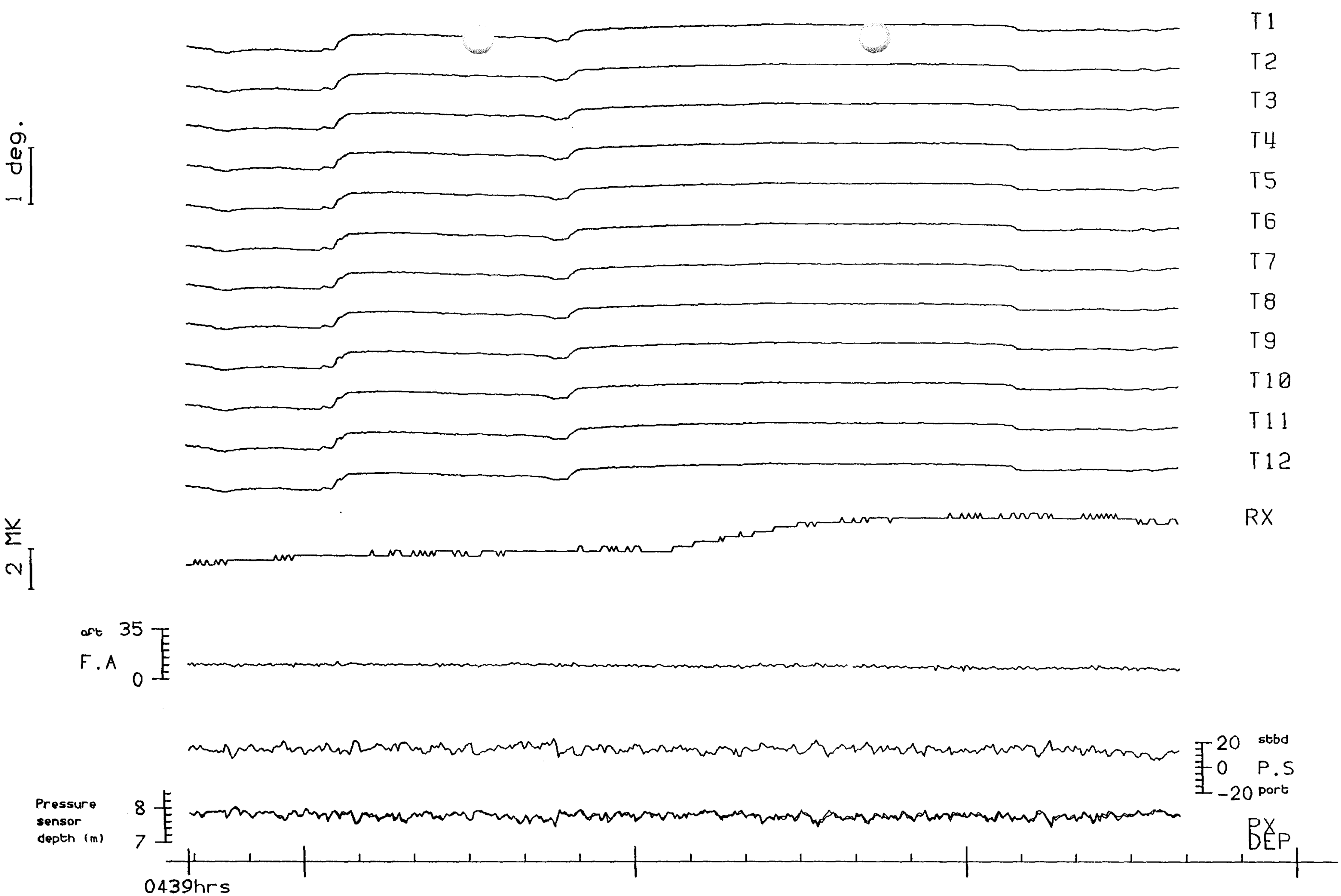
THERMISTOR SPAR ARE88-03

ALL RECORDS:22 Apr11 88



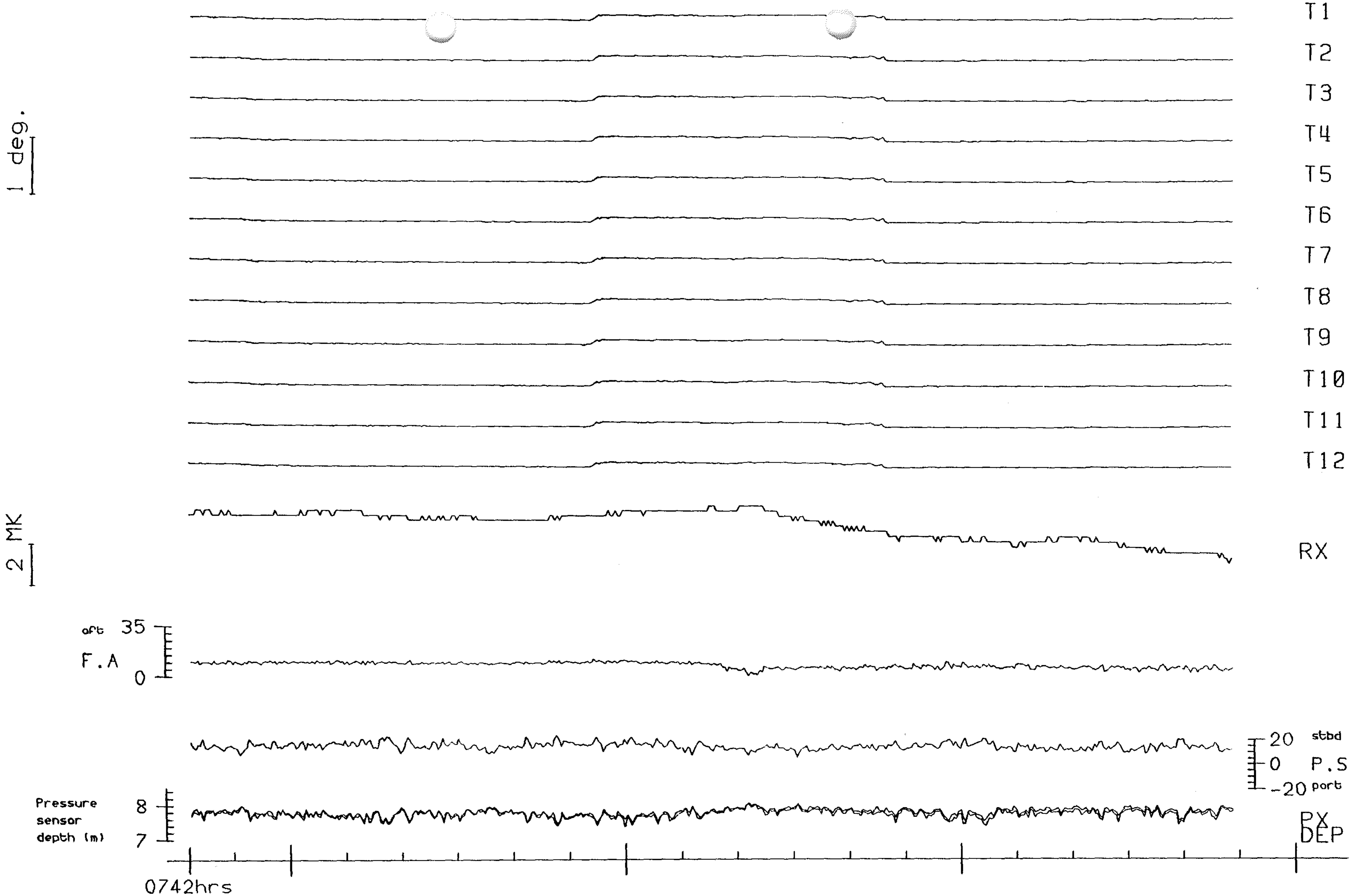
THERMISTOR SPAR ARE88- 4

ALL RECORDS:23 April 88



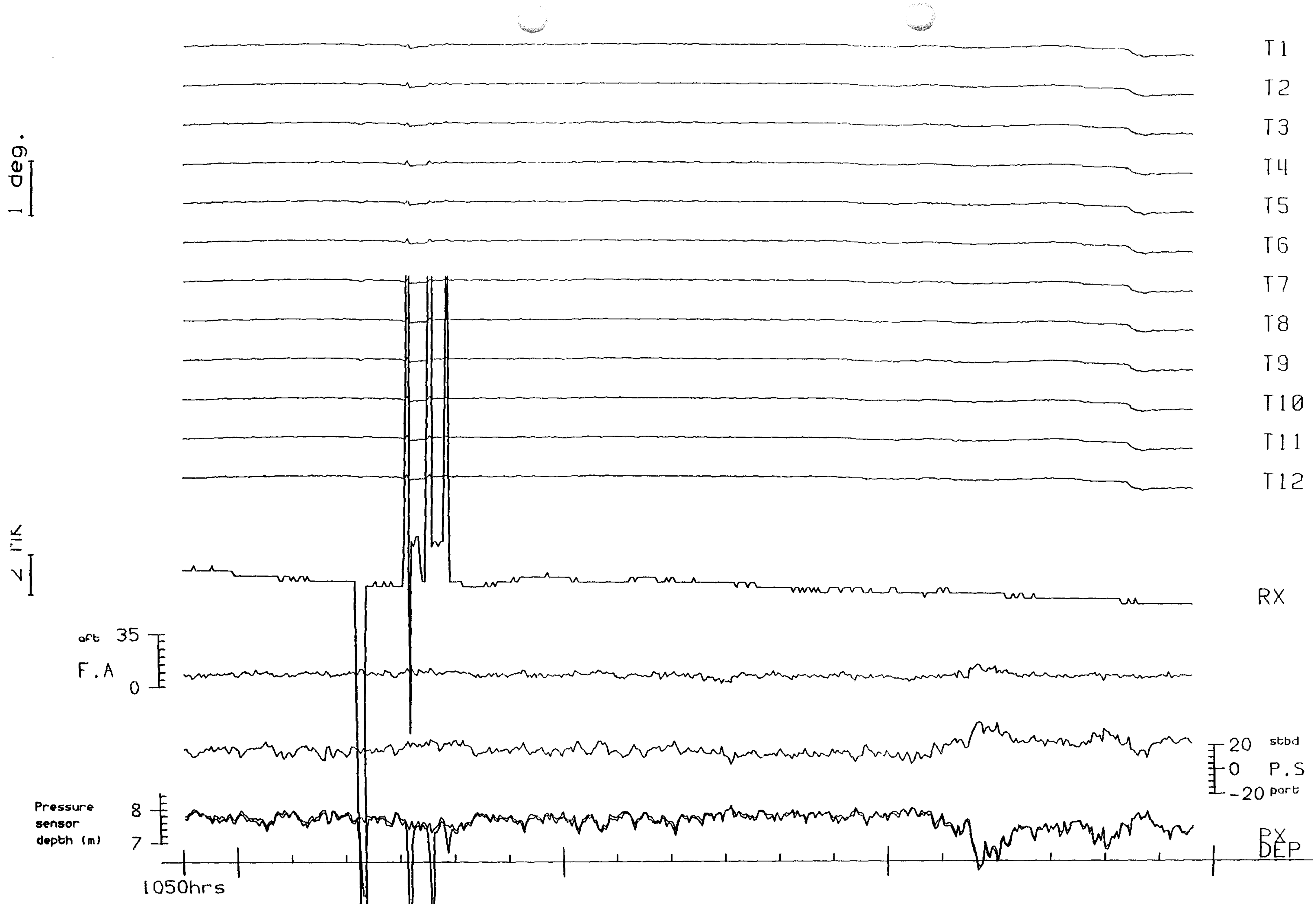
THERMISTOR SPAR ARE88-05

ALL RECORDS:23 April 88



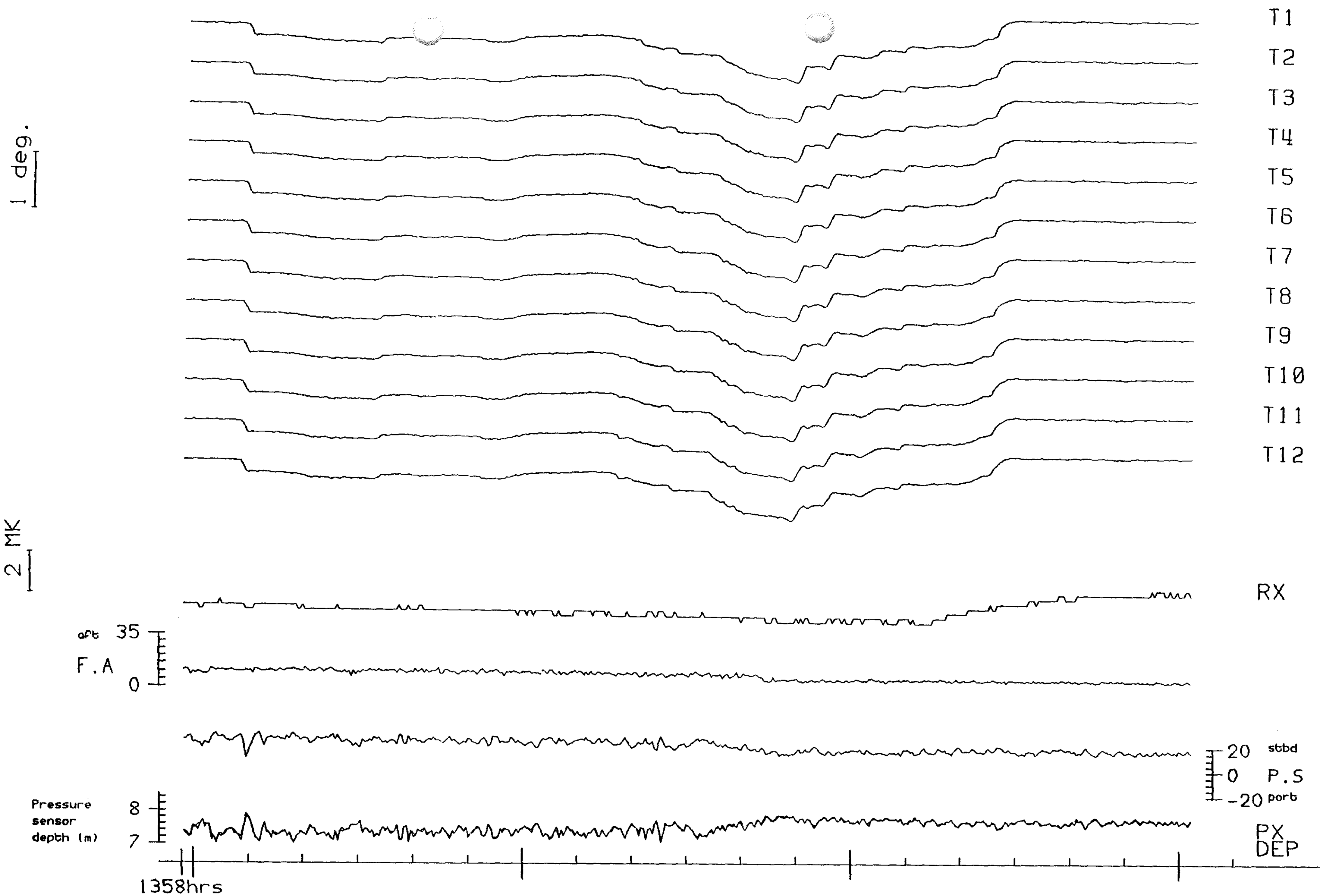
THERMISTOR SPAR ARE88-06

ALL RECORDS: 23 April 88



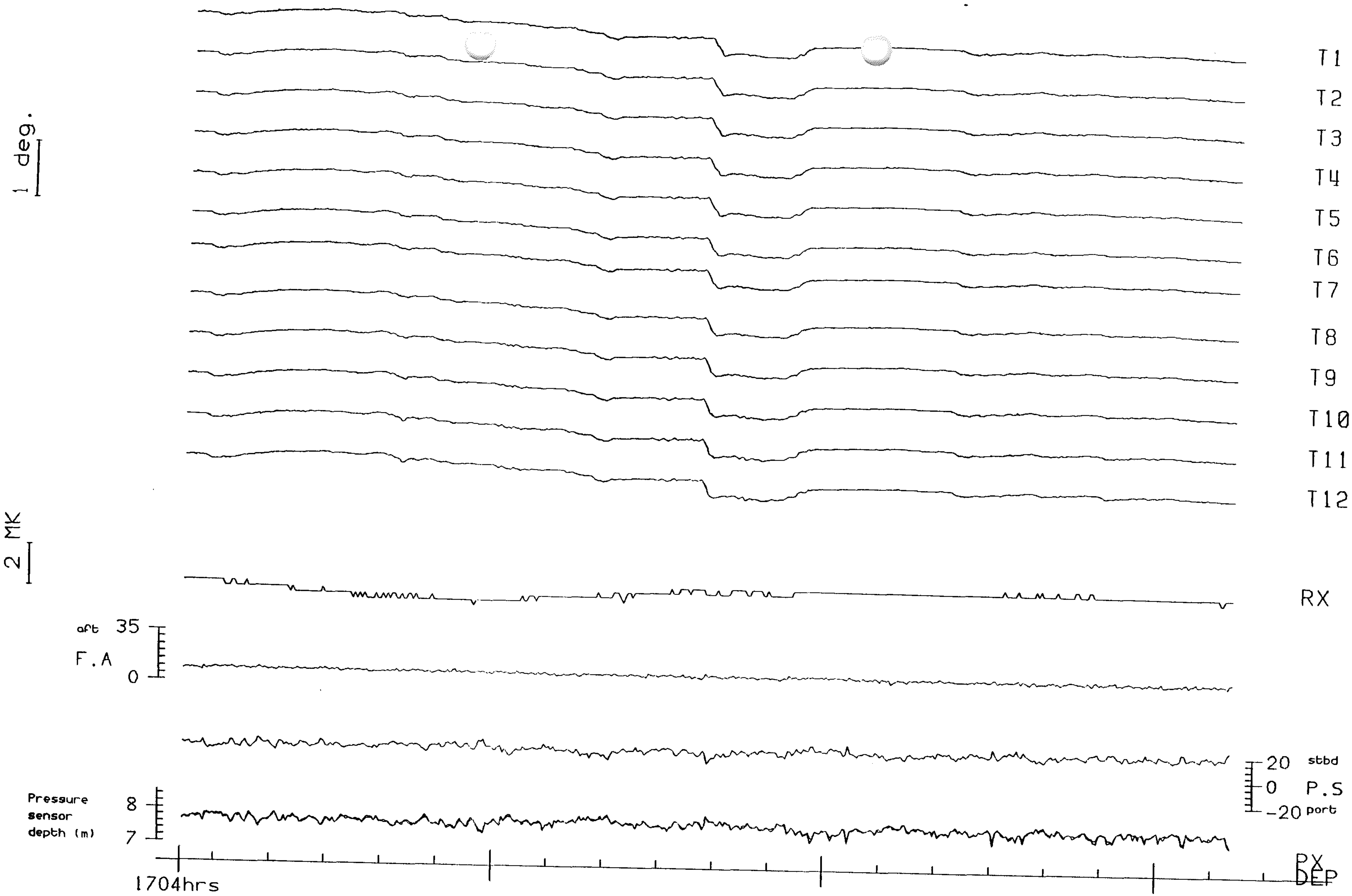
THERMISTOR SPAR ARE88- 7

ALL RECORDS:23 April 88



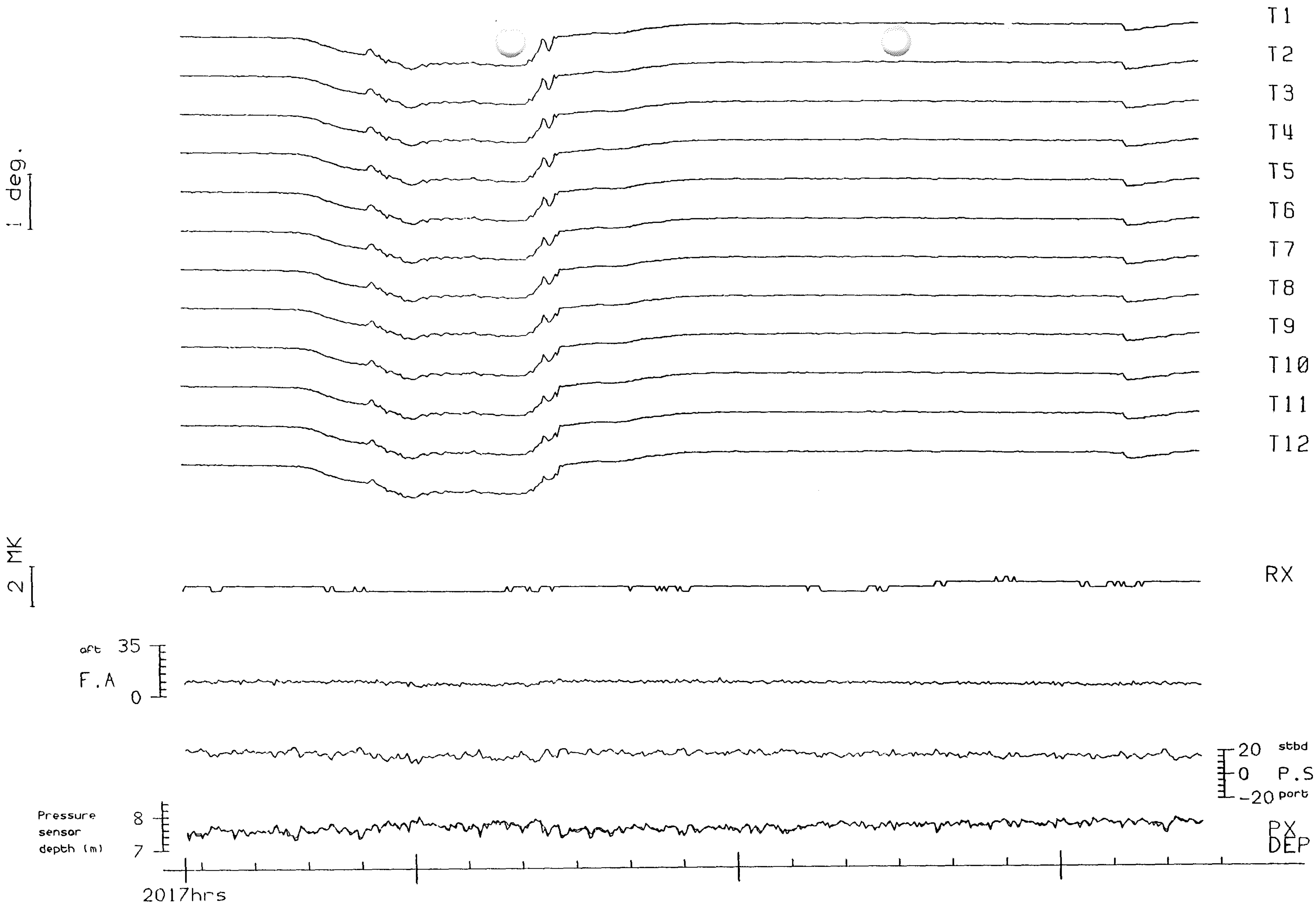
THERMISTOR SPAR ARE88-08

ALL RECORDS: 23 April 88



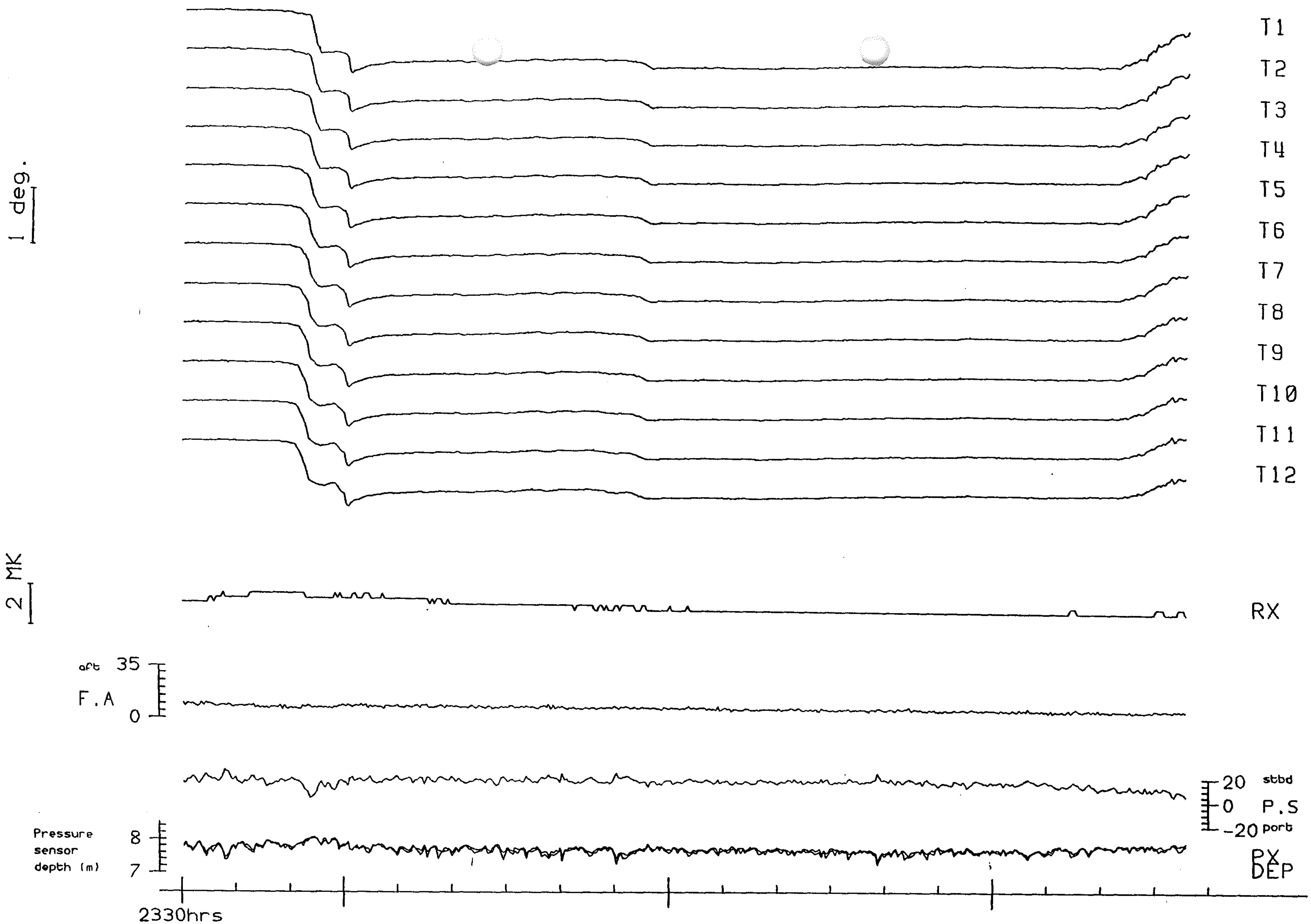
THERMISTOR SPAR ARE88-09

ALL RECORDS: 23 April 88



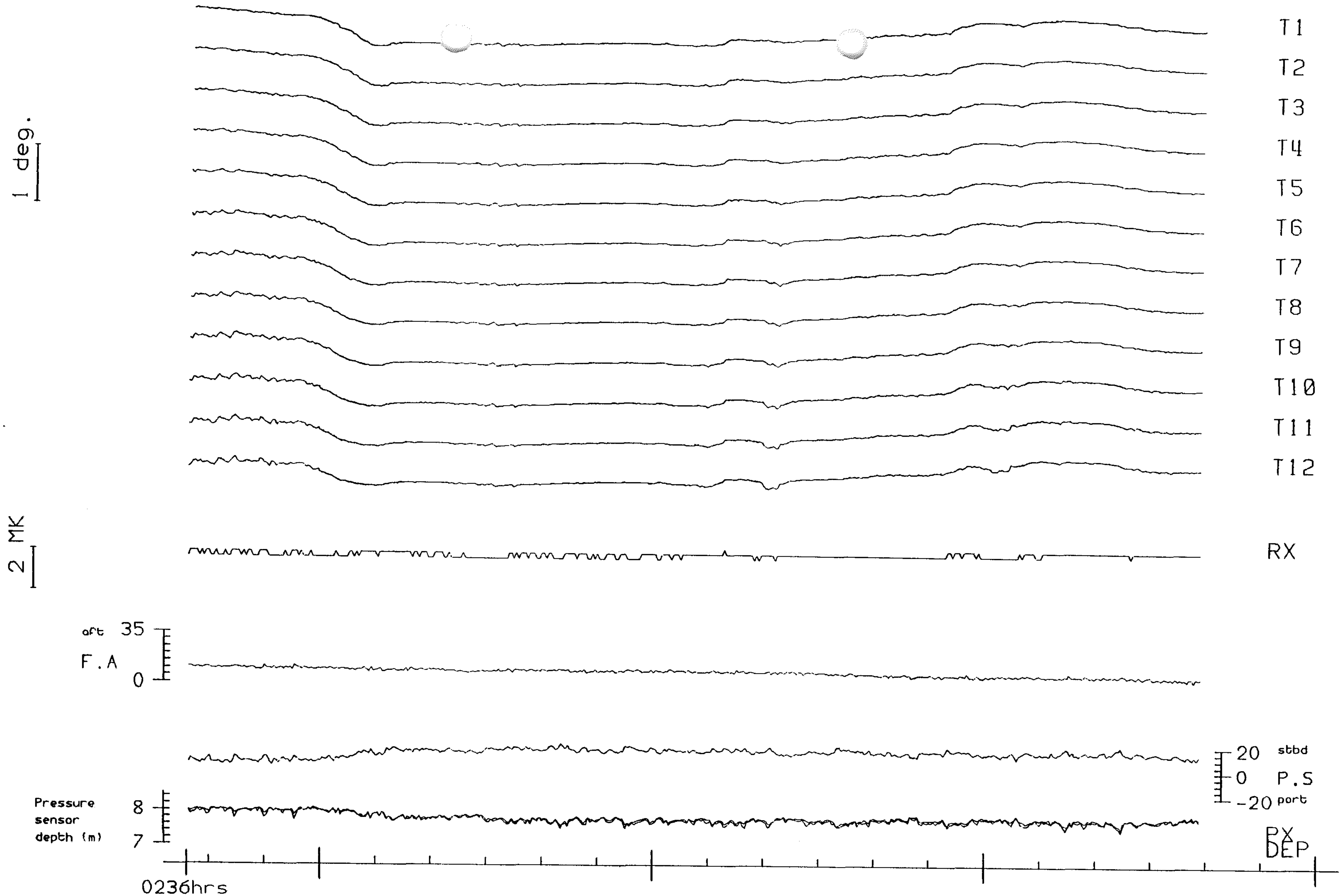
THERMISTOR SPAR ARE88-10

ALL RECORDS:23 April 88



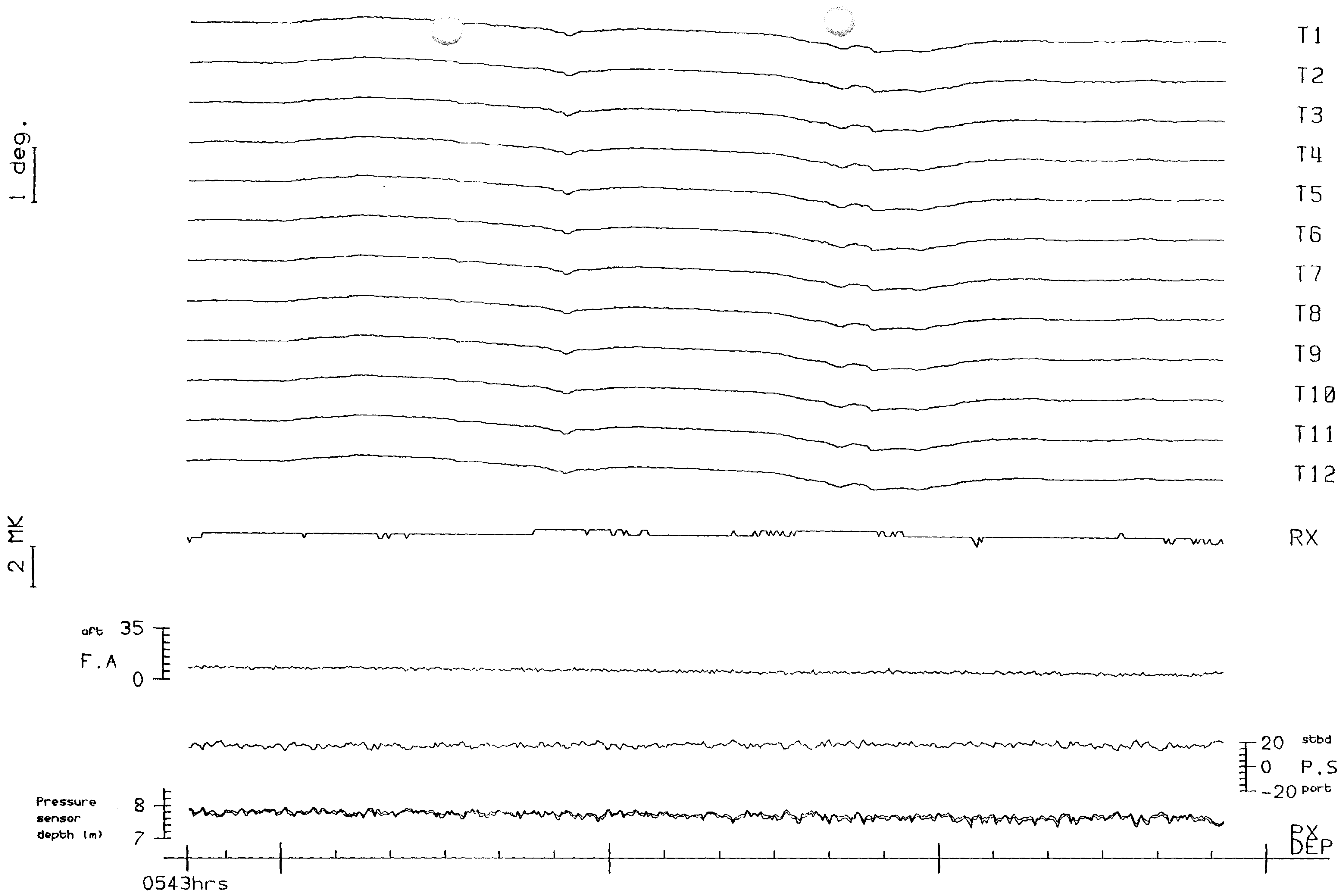
THERMISTOR SPAR ARE88-11

ALL RECORDS;23 April 88



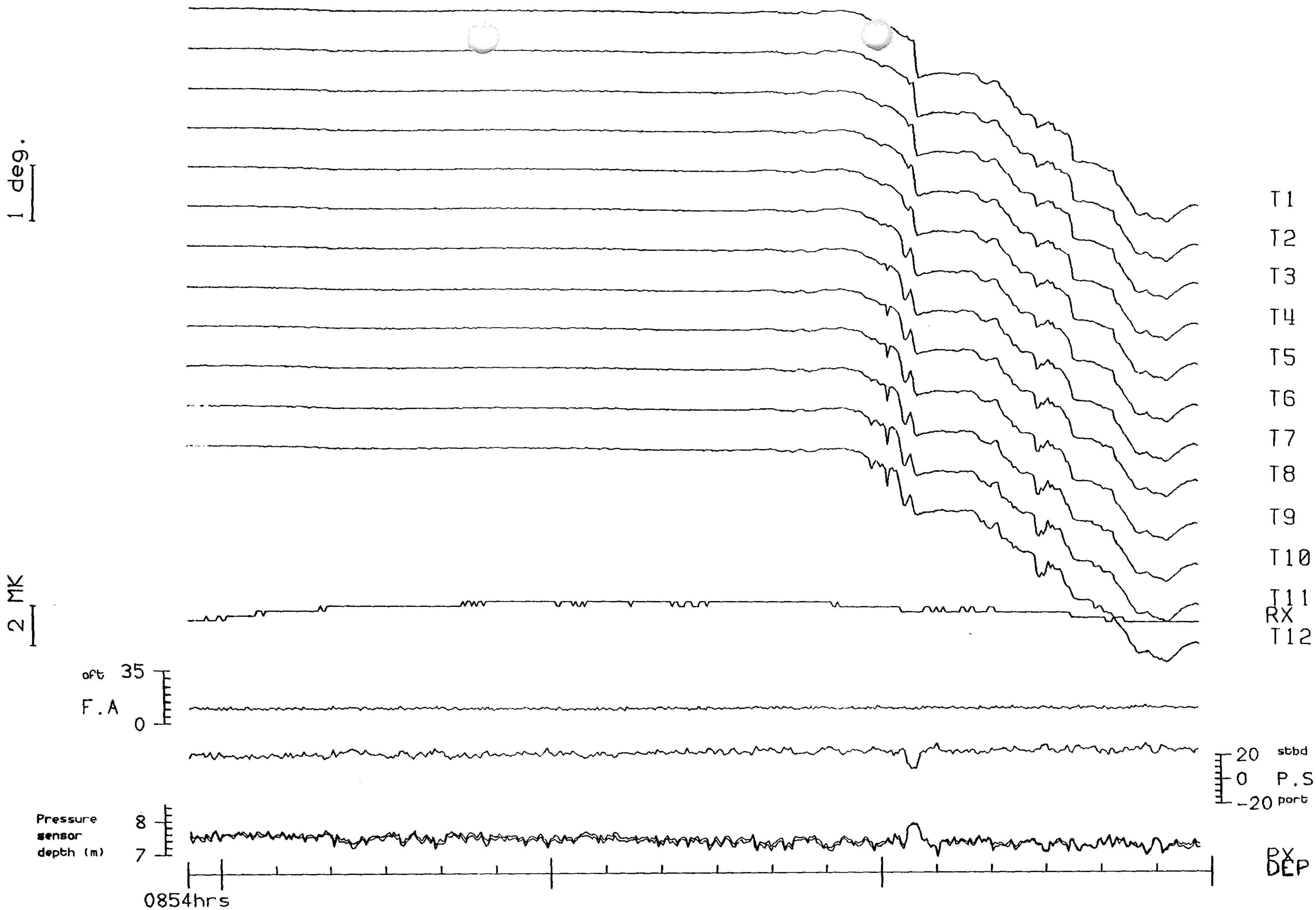
THERMISTOR SPAR ARE88-12

ALL RECORDS: 24 April 88



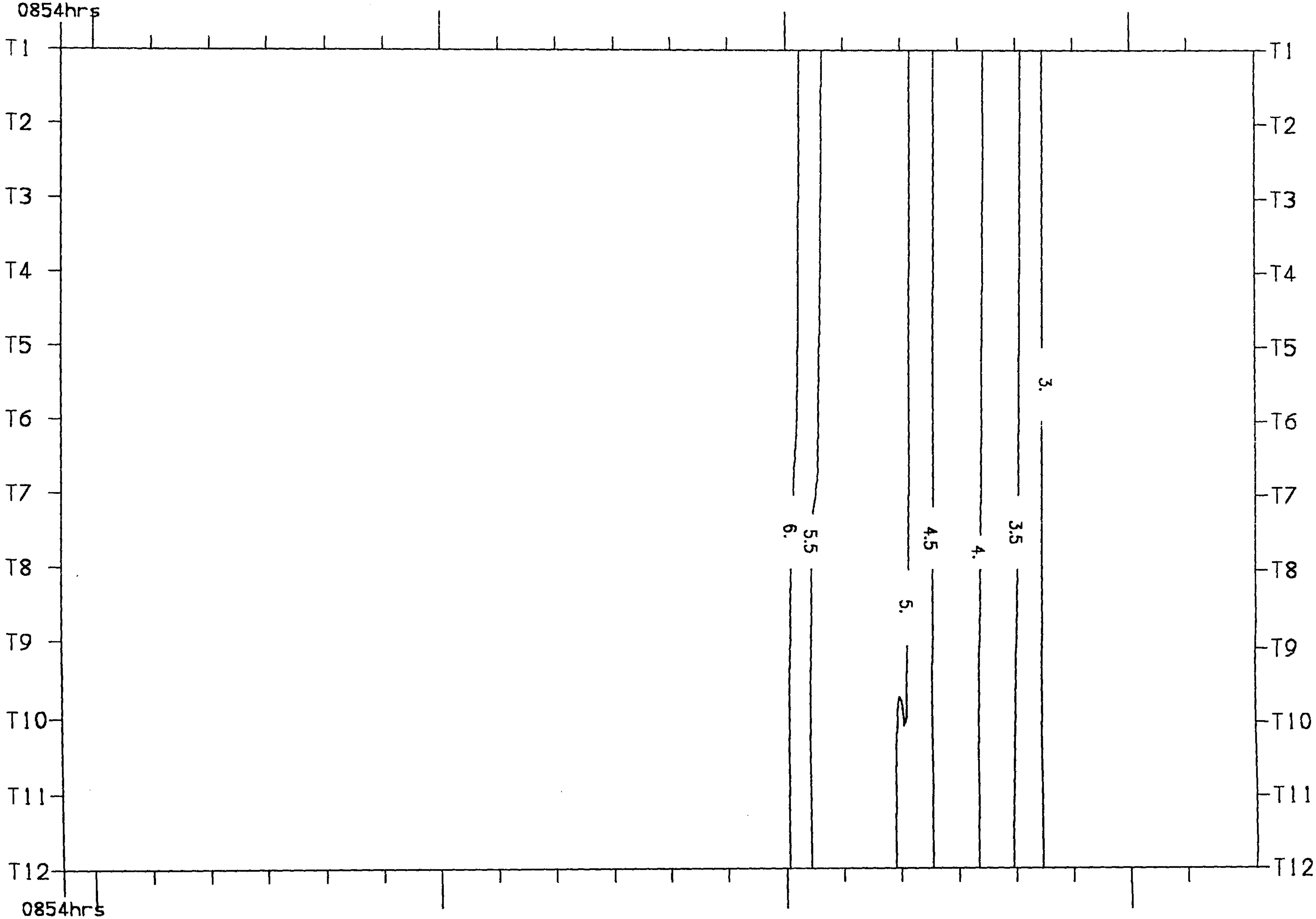
THERMISTOR SPAR ARE88-13

ALL RECORDS: 24 April 88



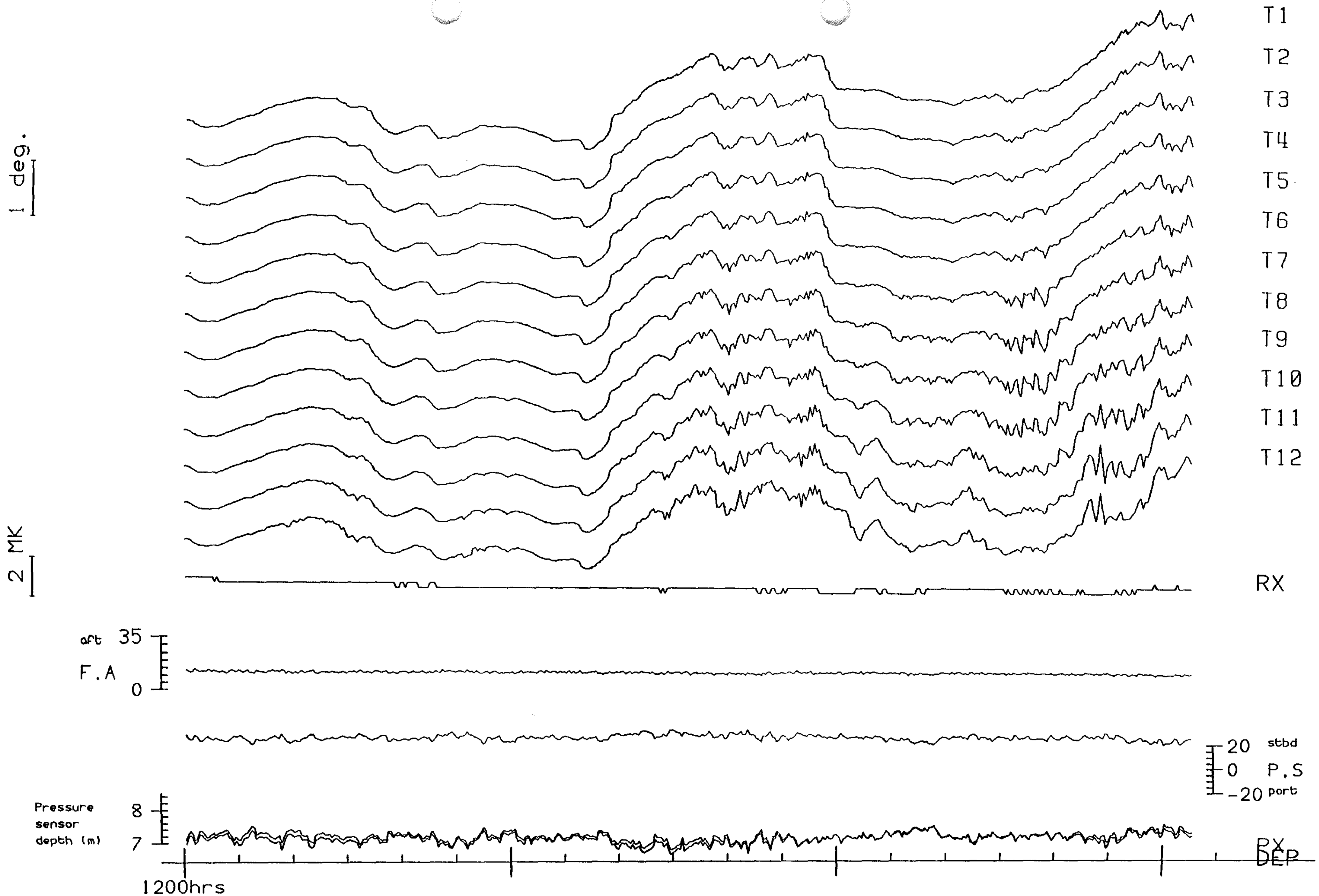
THERMISIOR SPAR ARE88-14

ALL RECORDS:24 April 88



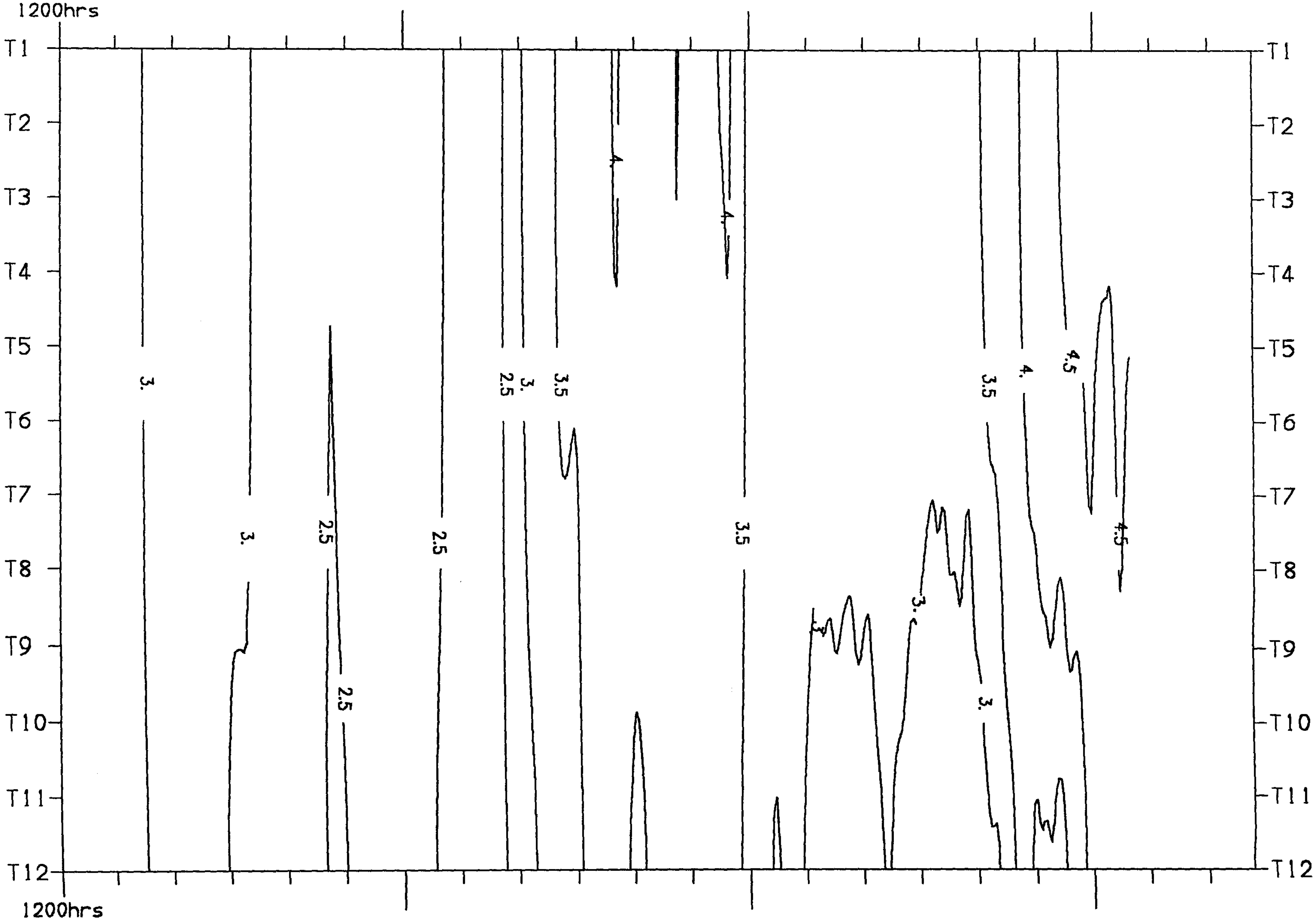
THERMISTOR SPAR ARE88-14

All records 24 April 1988



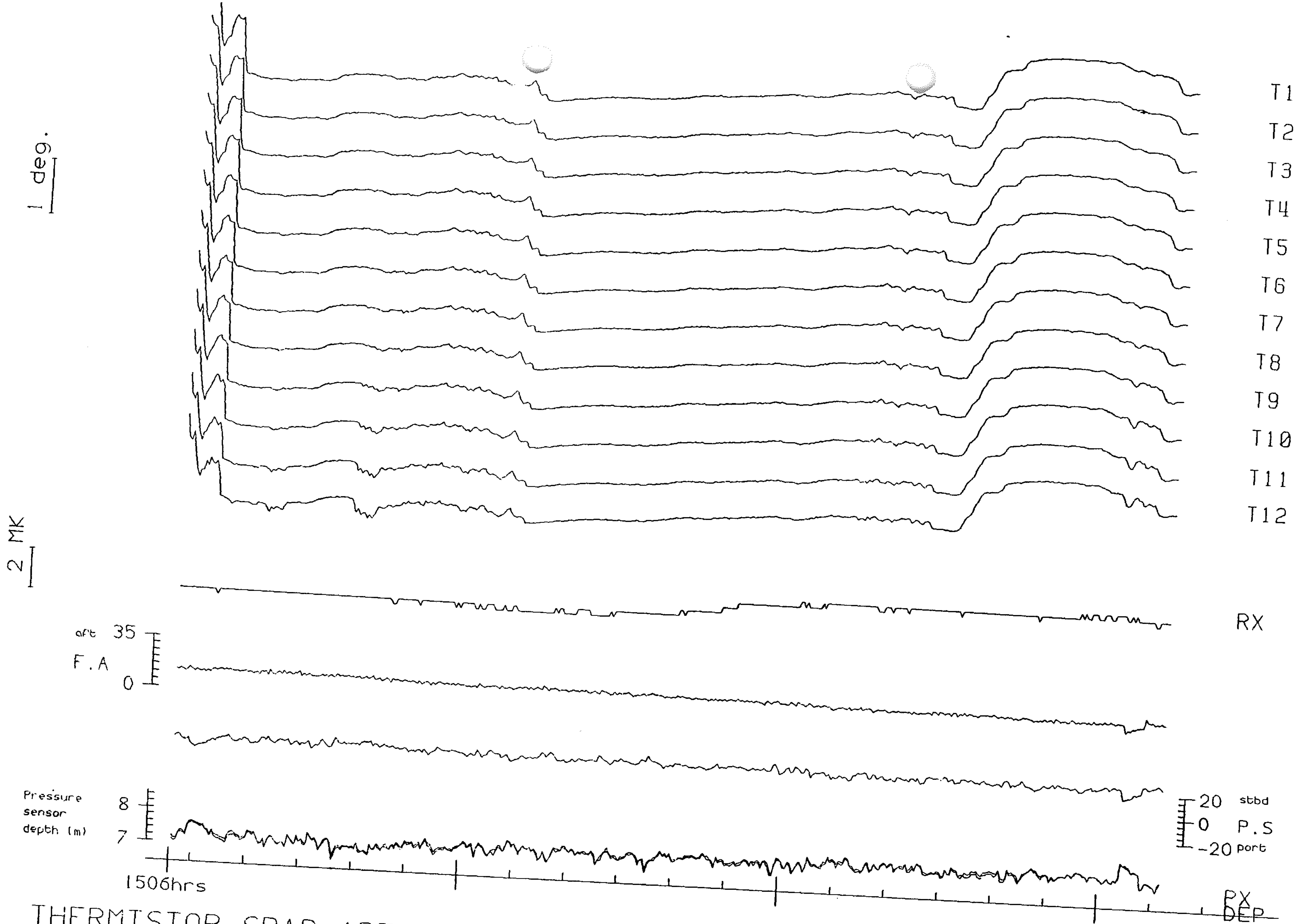
THERMISTOR SPAR ARE88-15

ALL RECORDS: 24 April 88



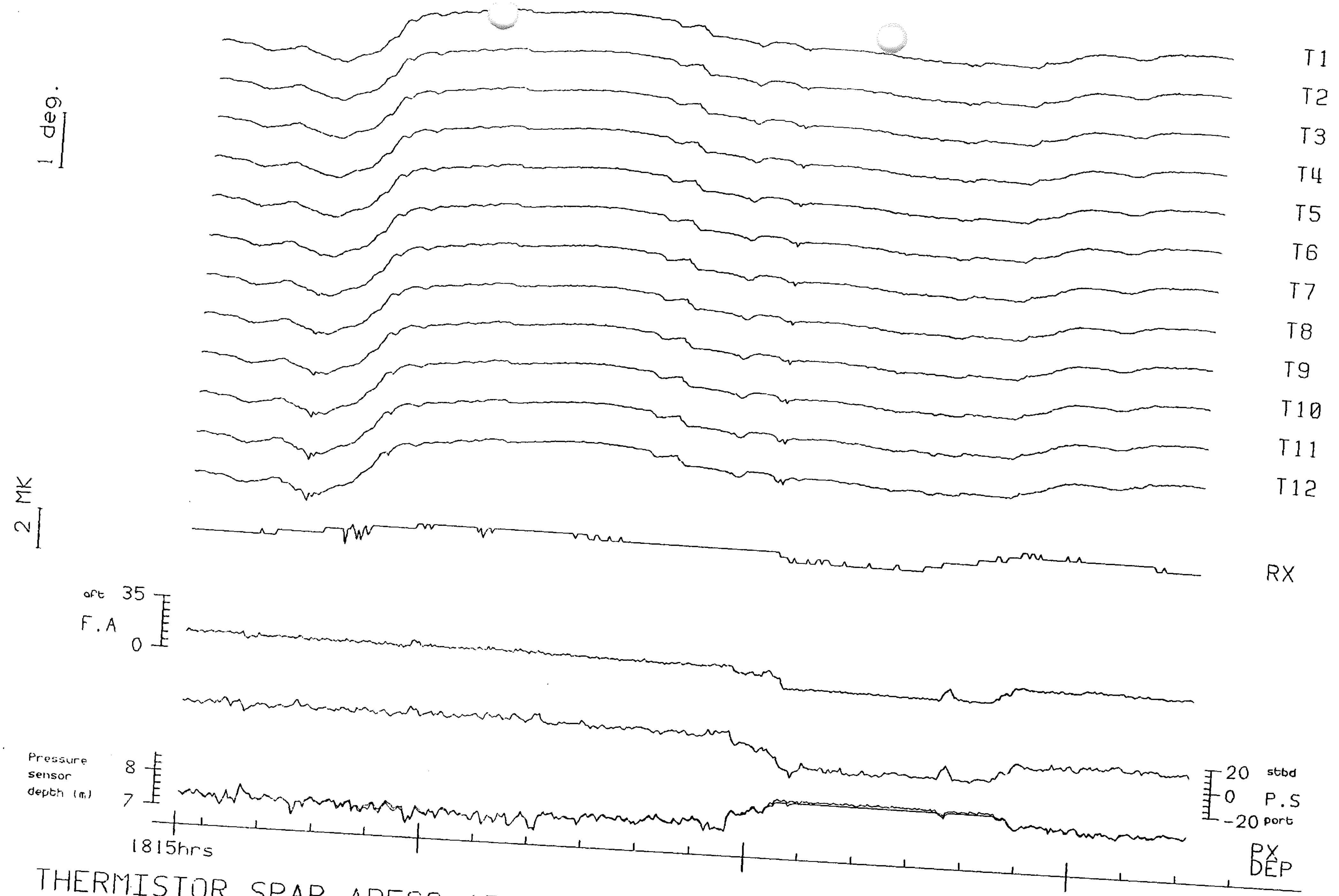
THERMISTOR SPAR ARE88-15

All records 24 April 1988



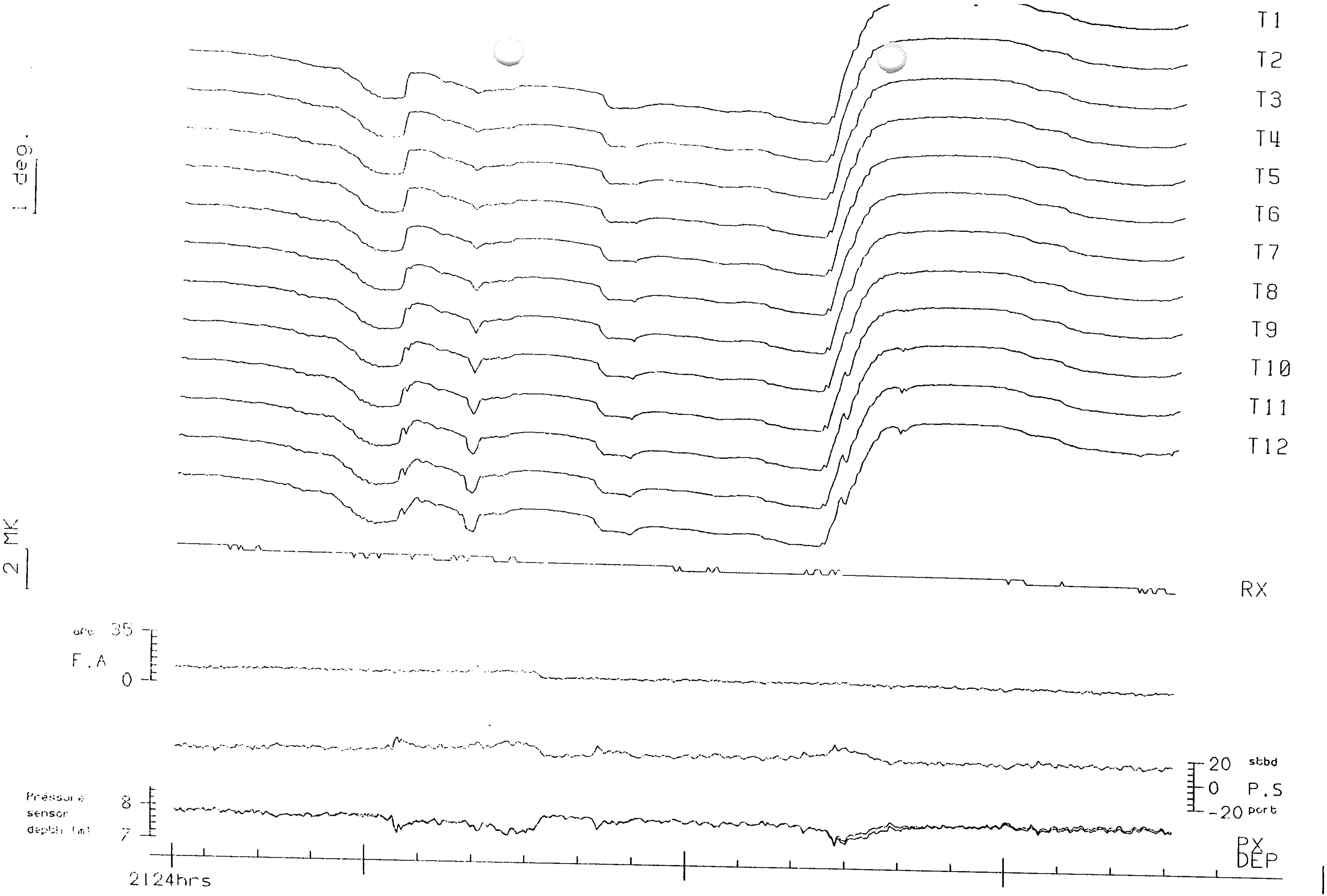
THERMISTOR SPAR ARE88-16

ALL RECORDS: 24 April 88



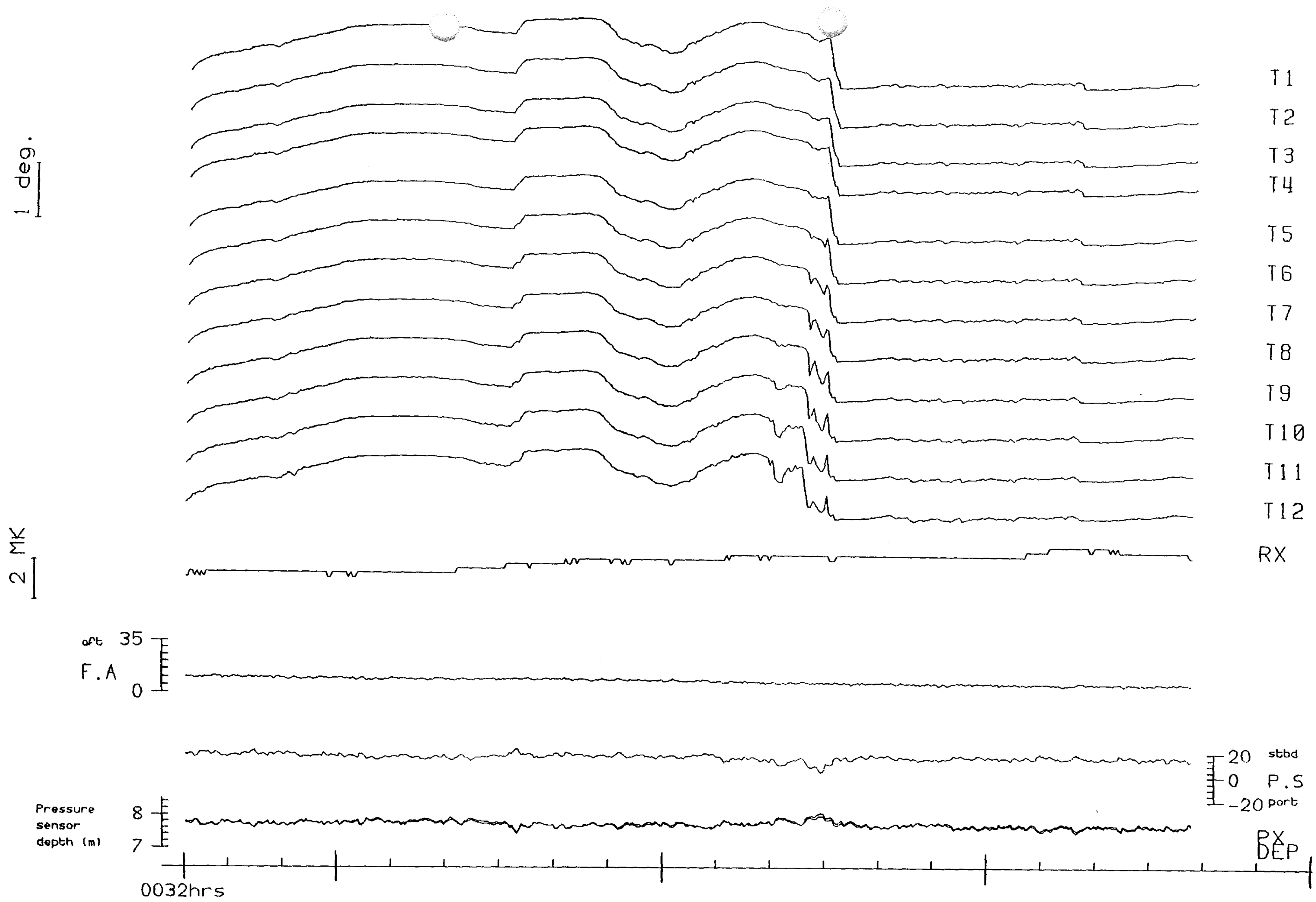
THERMISTOR SPAR ARE88-17

ALL RECORDS: 24 April 88



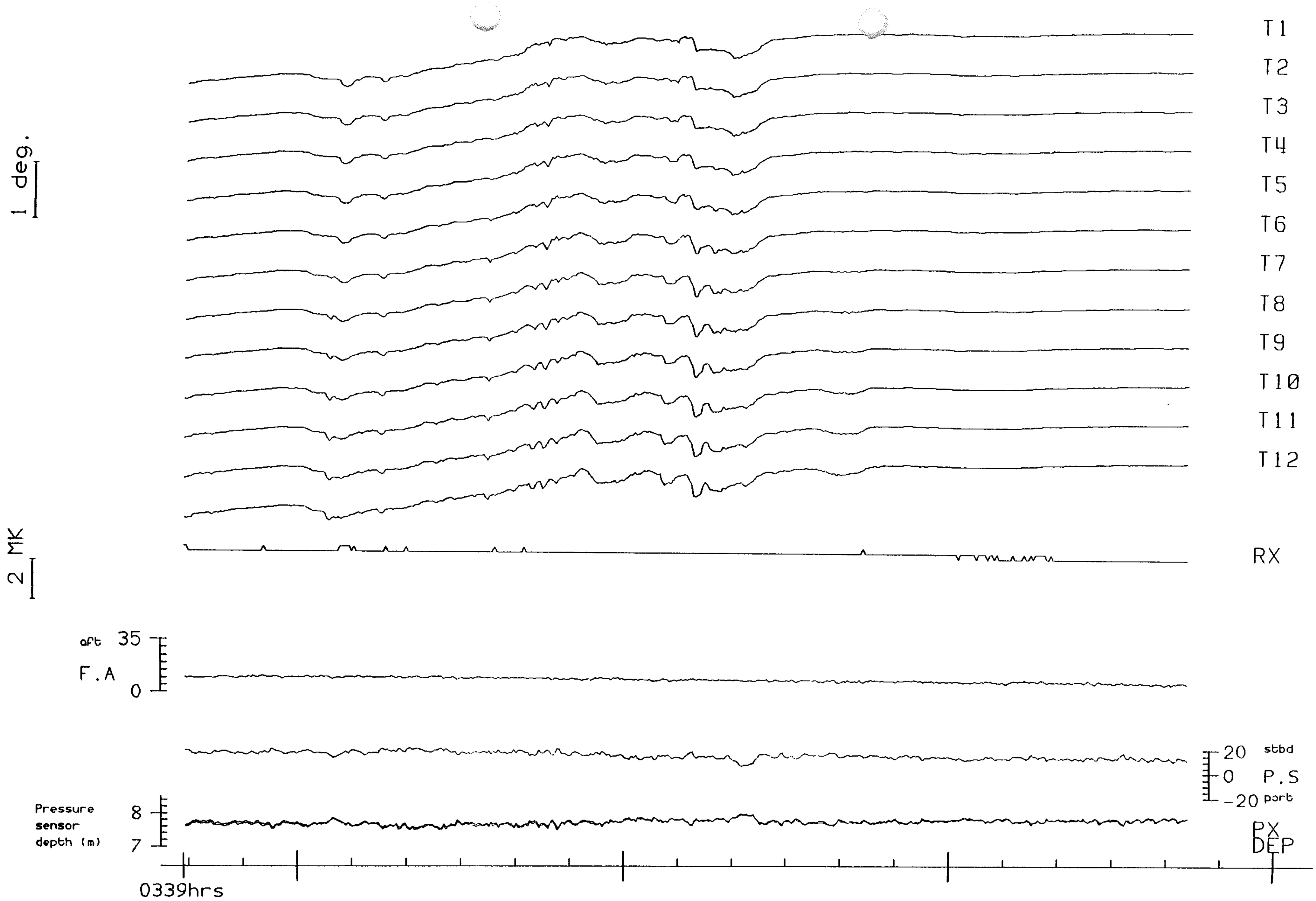
THERMISTOR SPAR ARE88-18

ALL RECORDS:24 April 88



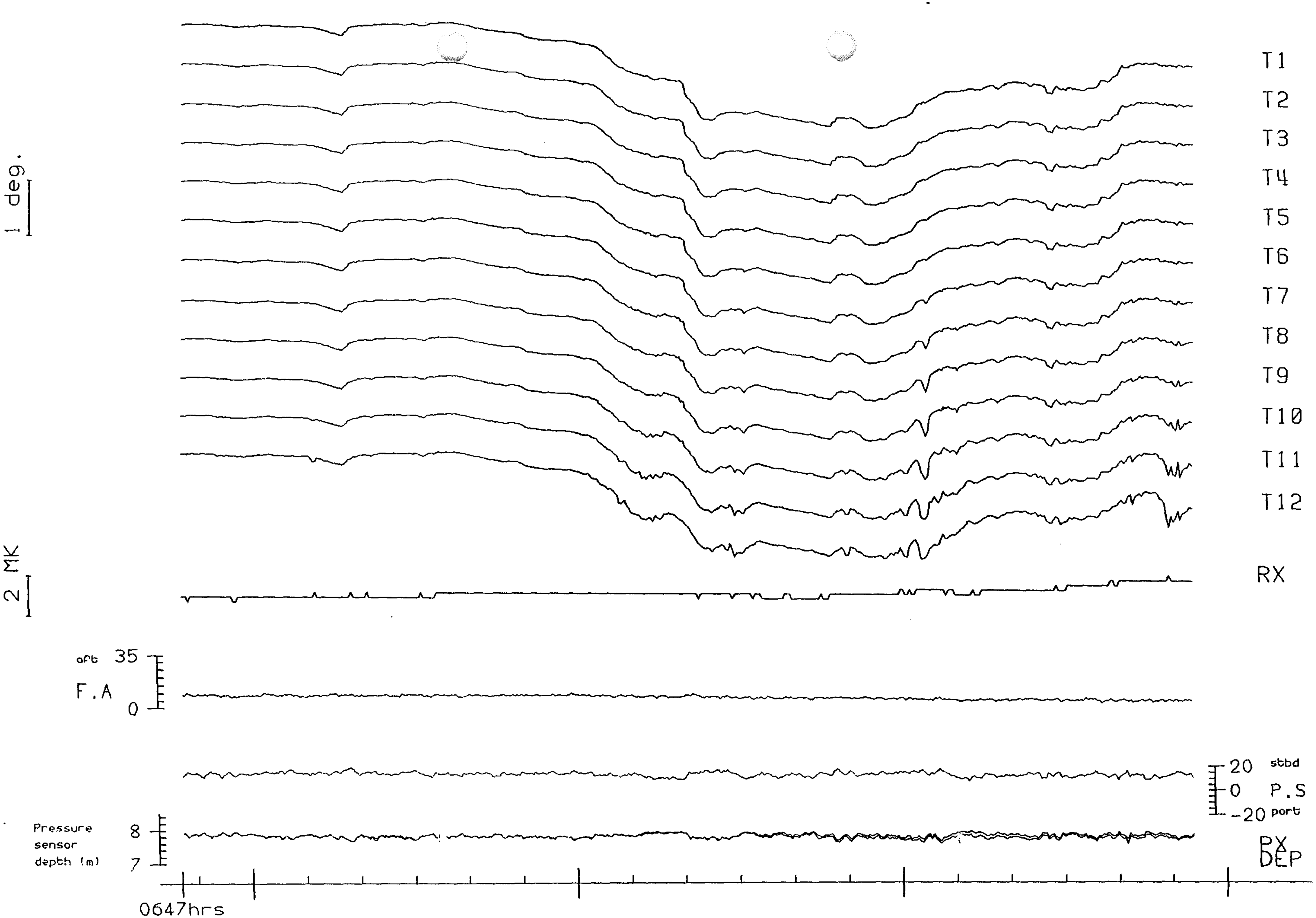
THERMISTOR SPAR ARE88-19

ALL RECORDS: 25 April 88



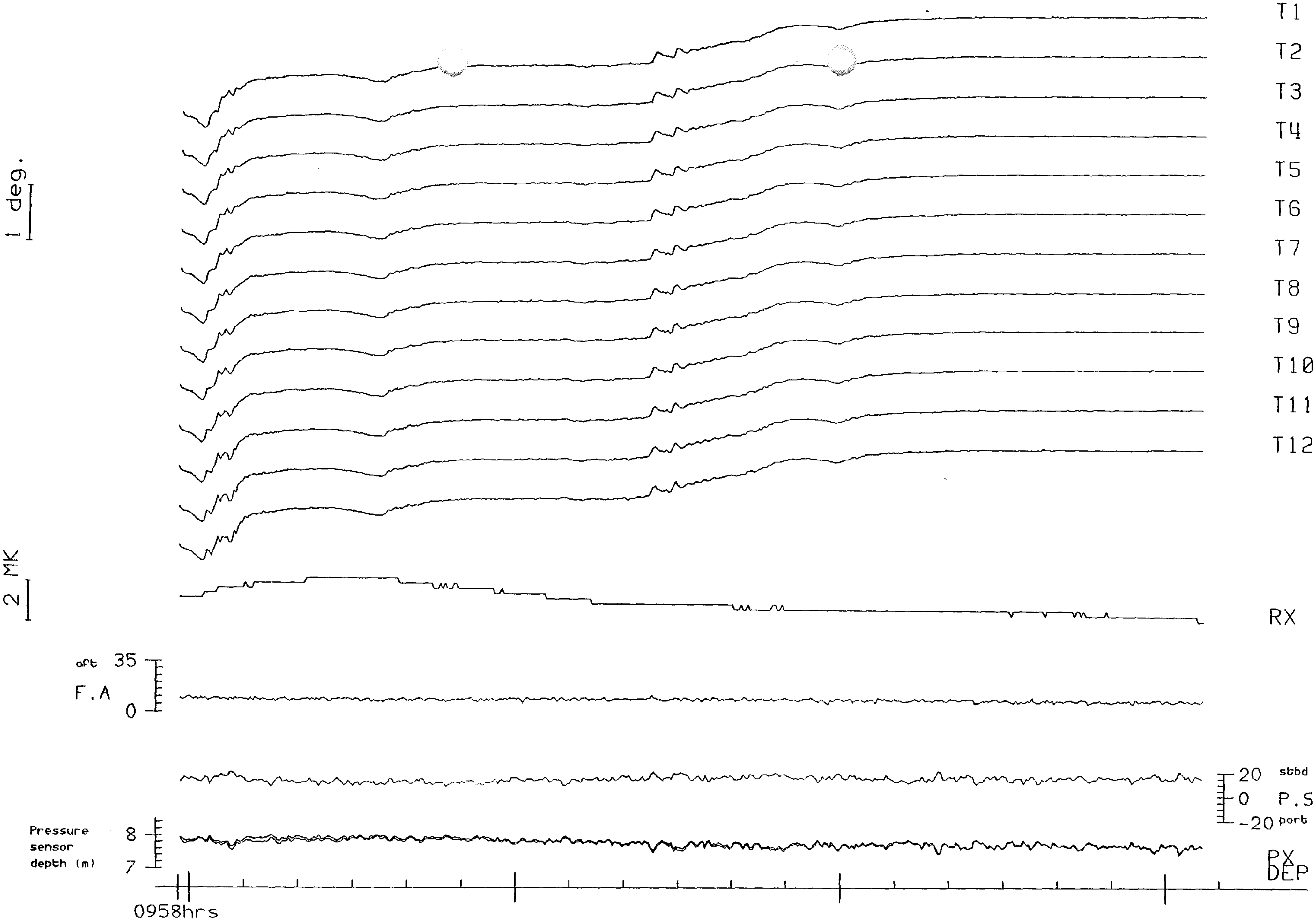
THERMISTOR SPAR ARE88-20

ALL RECORDS: 25 April 88



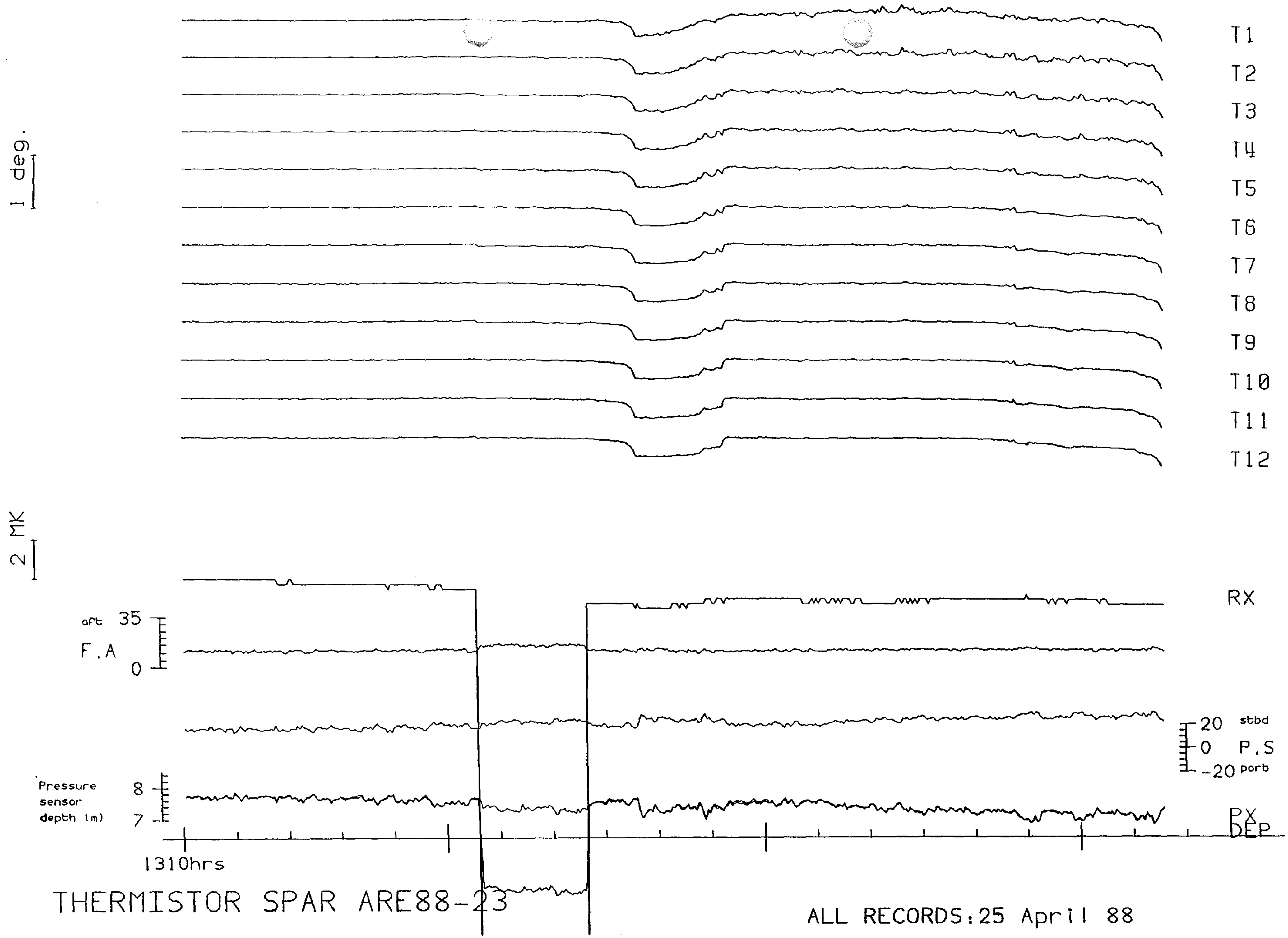
THERMISTOR SPAR ARE88-21

ALL RECORDS: 25 April 88



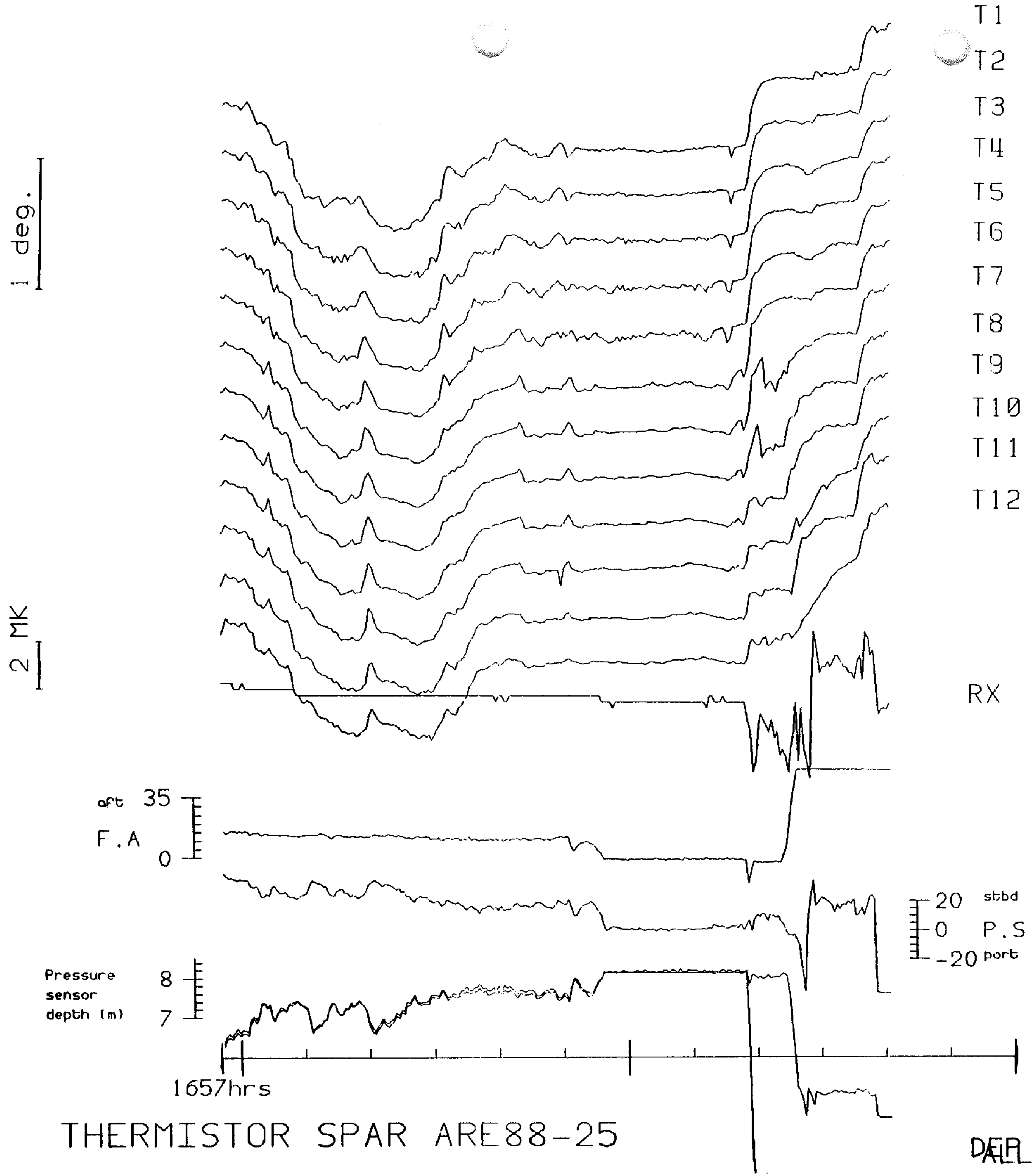
THERMISTOR SPAR ARE88-22

ALL RECORDS: 25 April 88



THERMISTOR SPAR ARE88-23

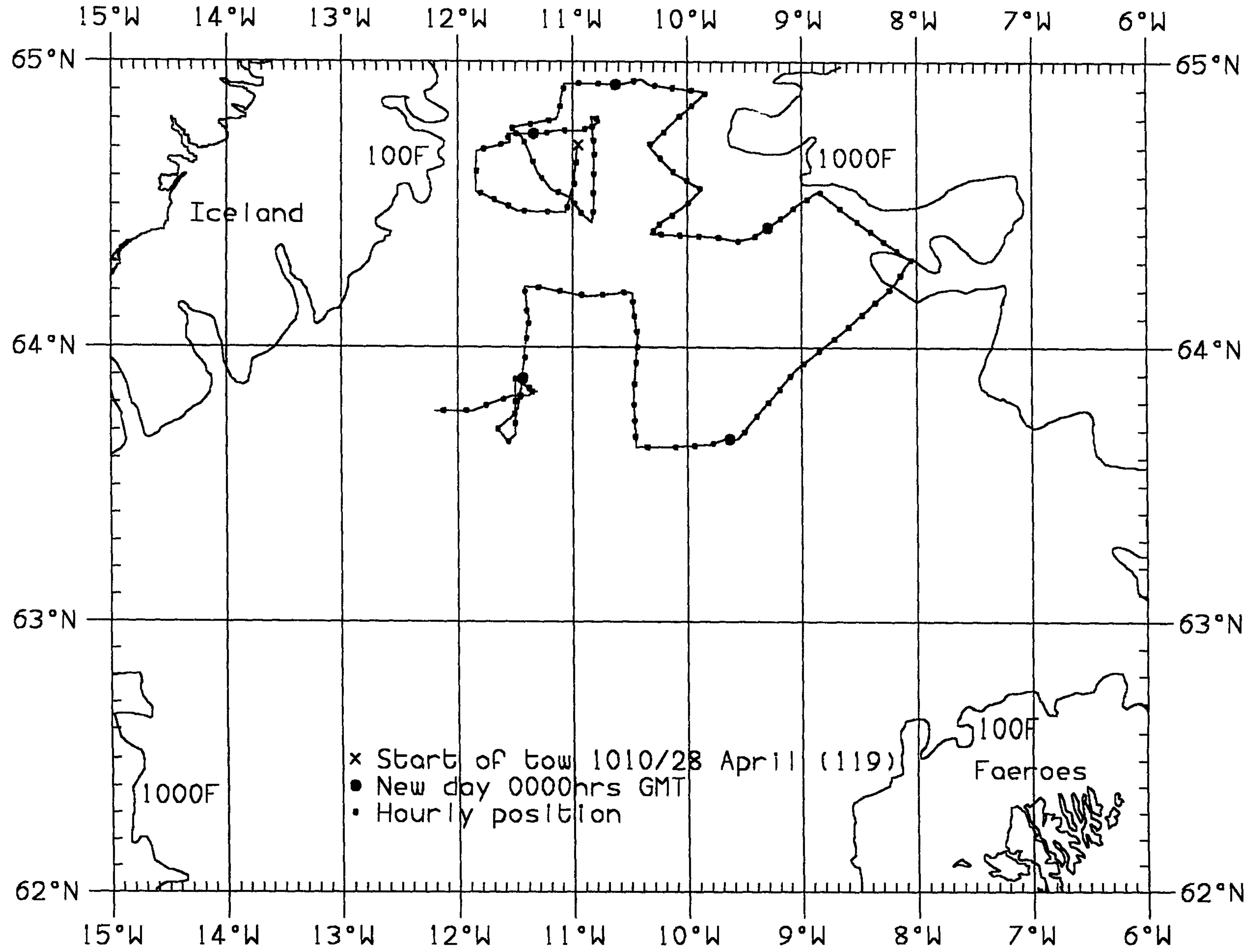
ALL RECORDS:25 April 88



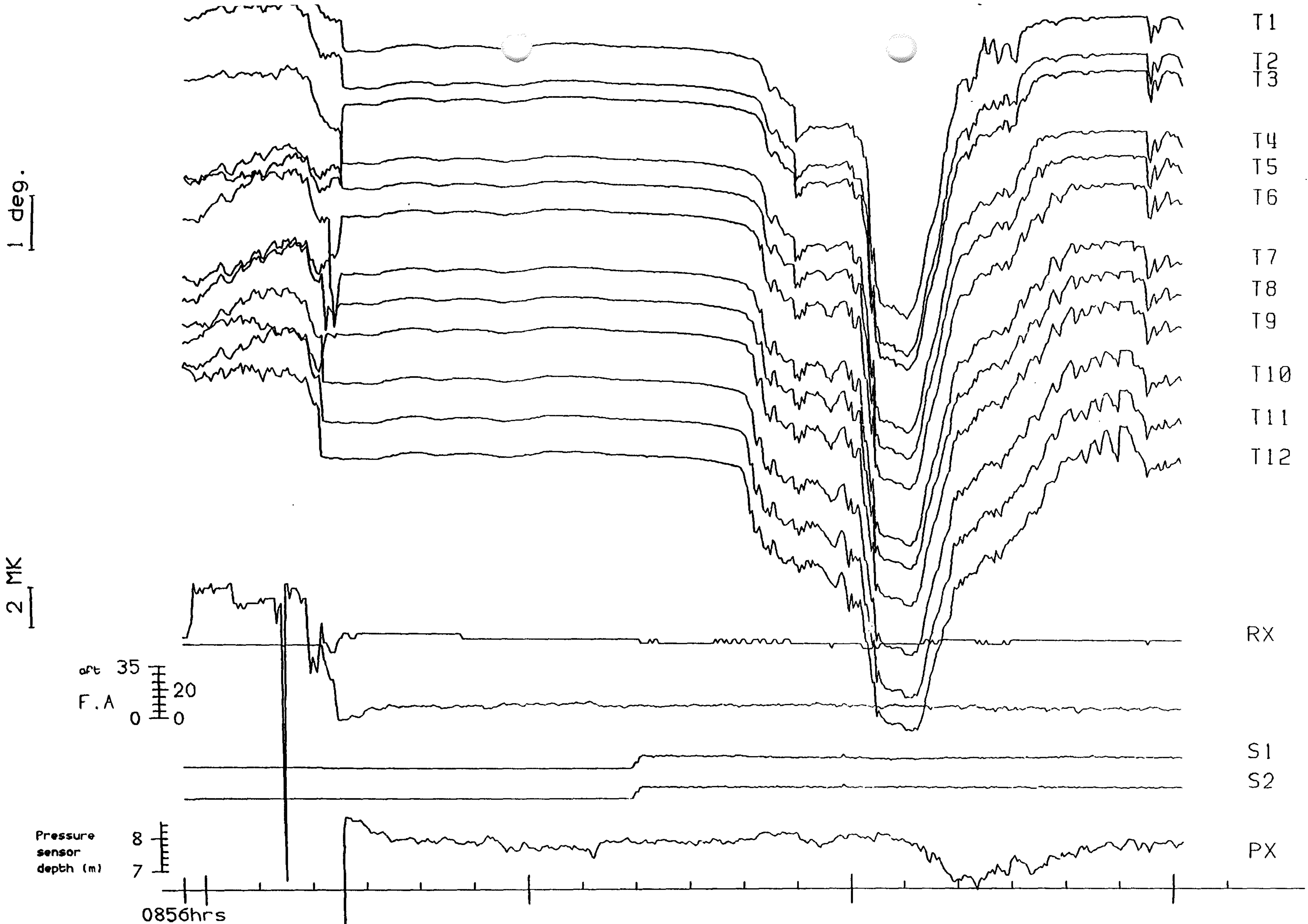
THERMISTOR SPAR ARE88-25

DEP ALL RECORDS: 25 April 88

Appendix 2 : Tow 2

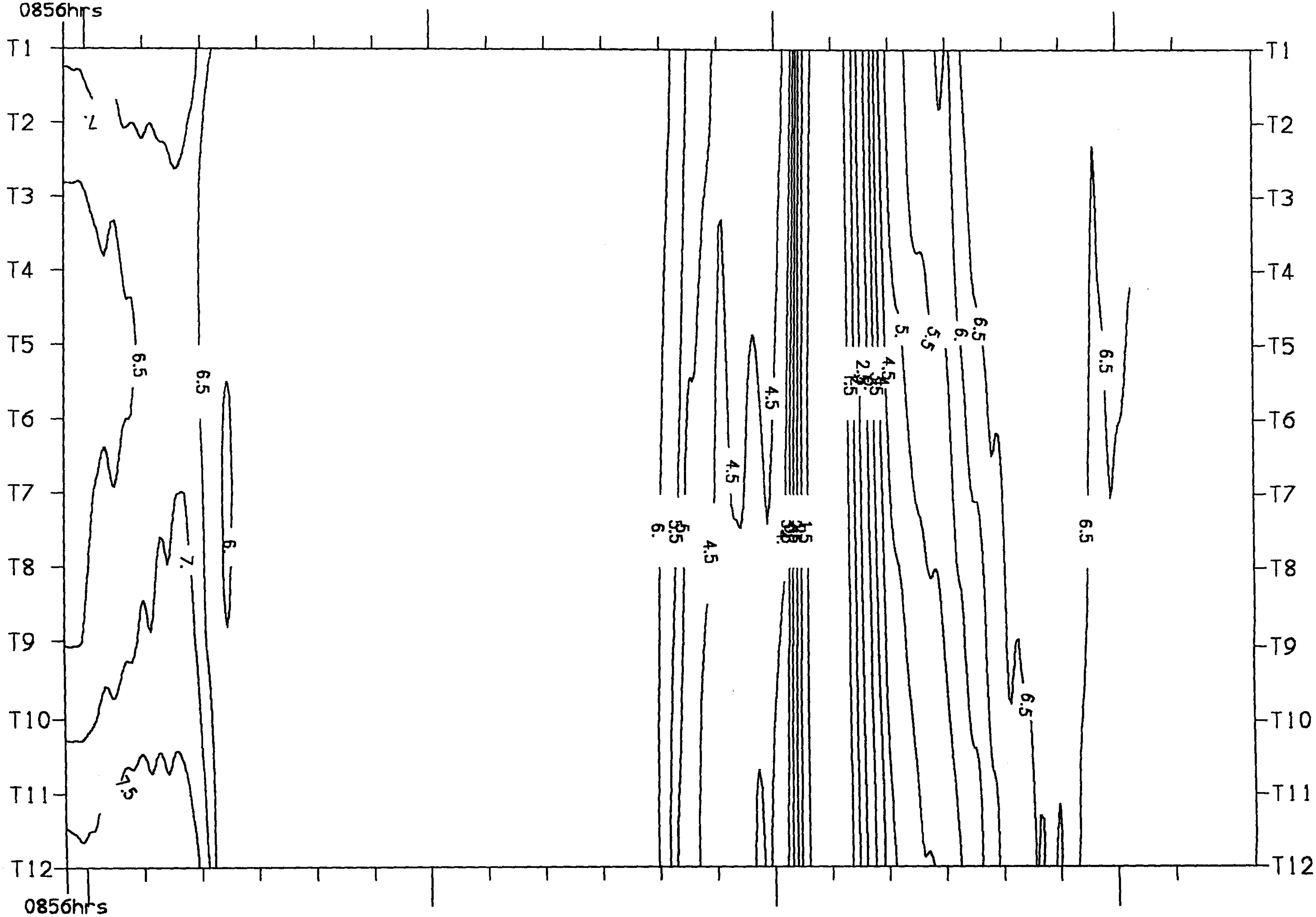


THERMISTOR SPAR TRACKPLOT TOW2 (ARE88-26 to 66)



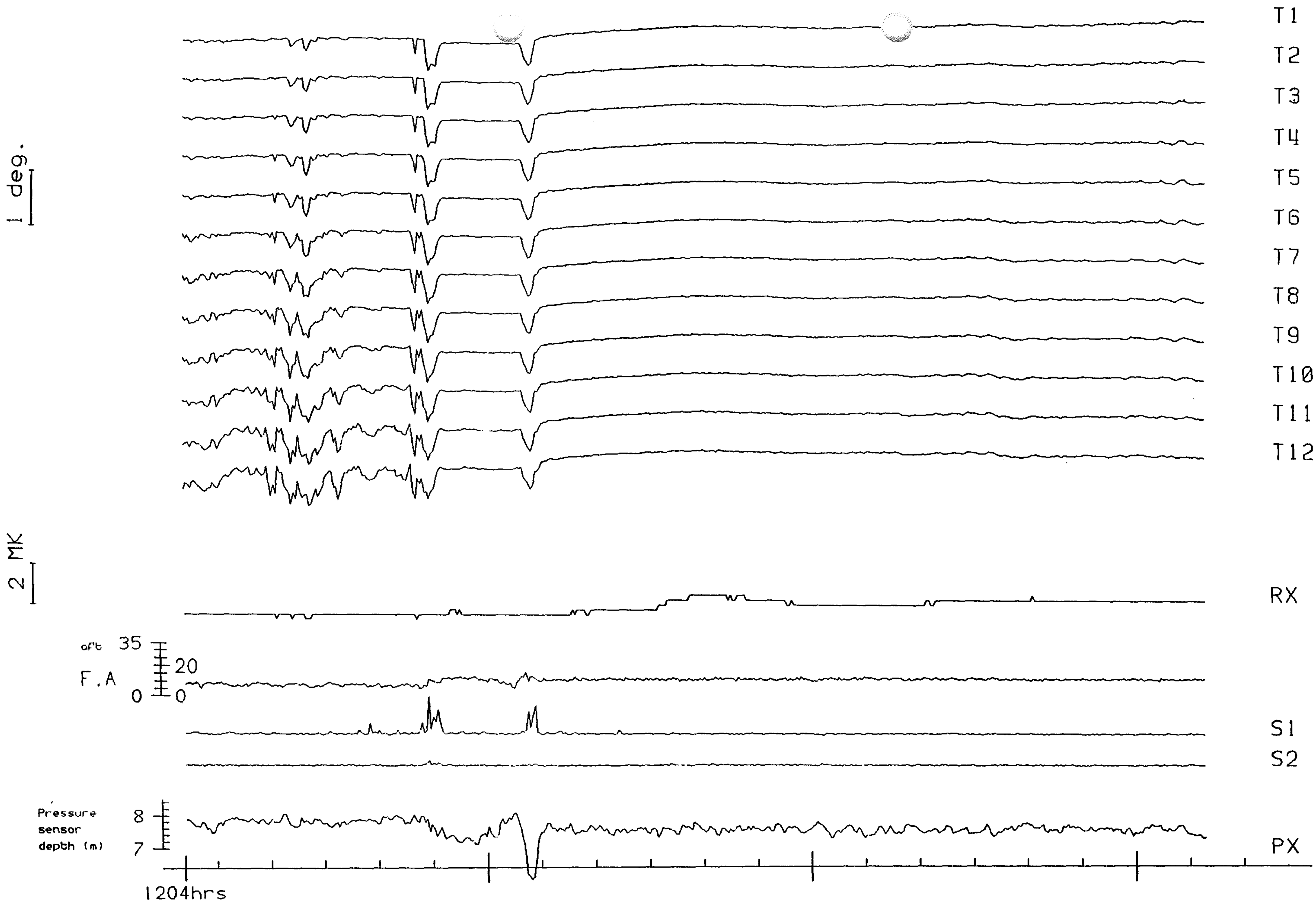
THERMISTOR SPAR ARE88-26

ALL RECORDS: 28 April 88



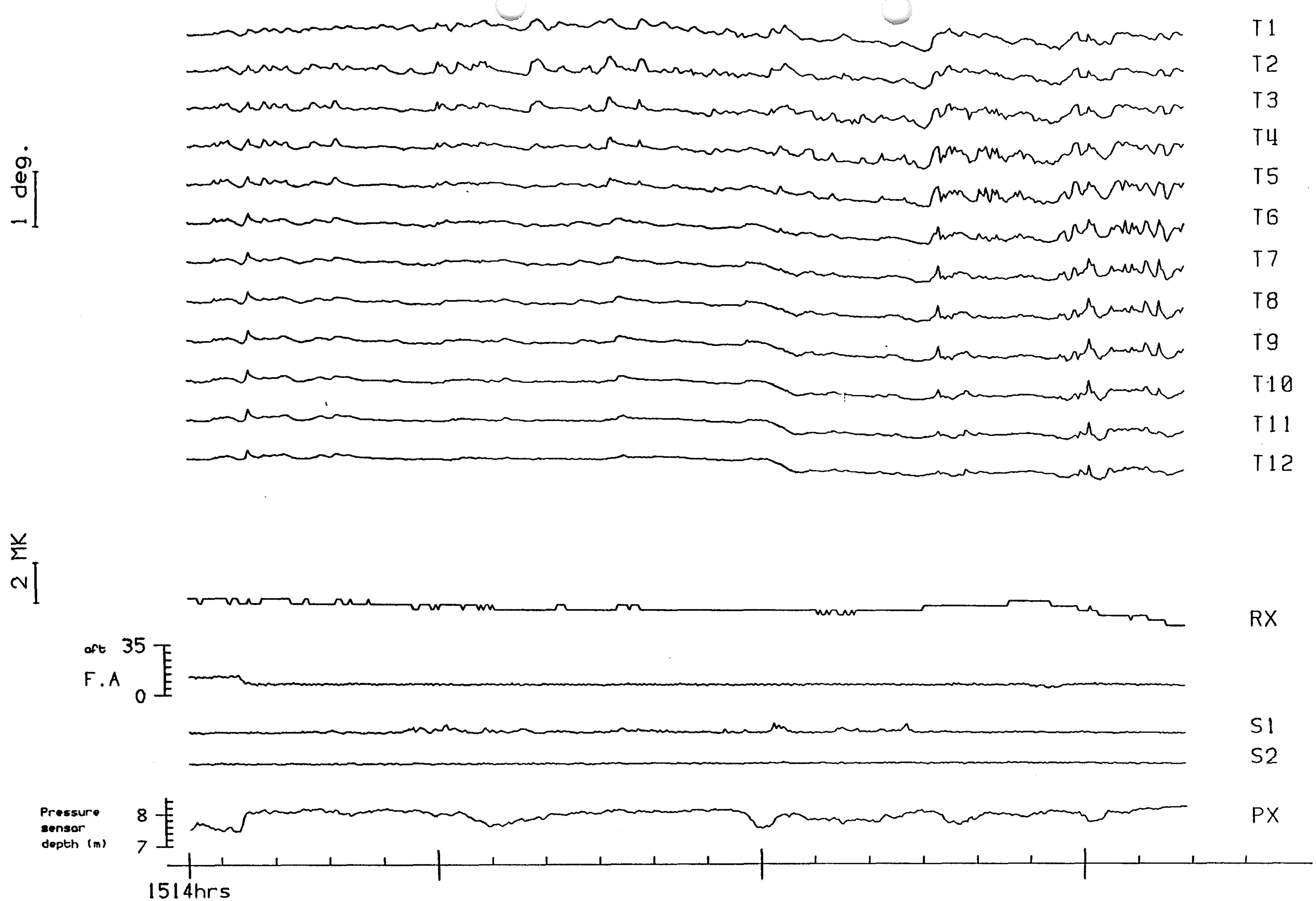
THERMISTOR SPAR ARE88-26

All records 28 April 1988



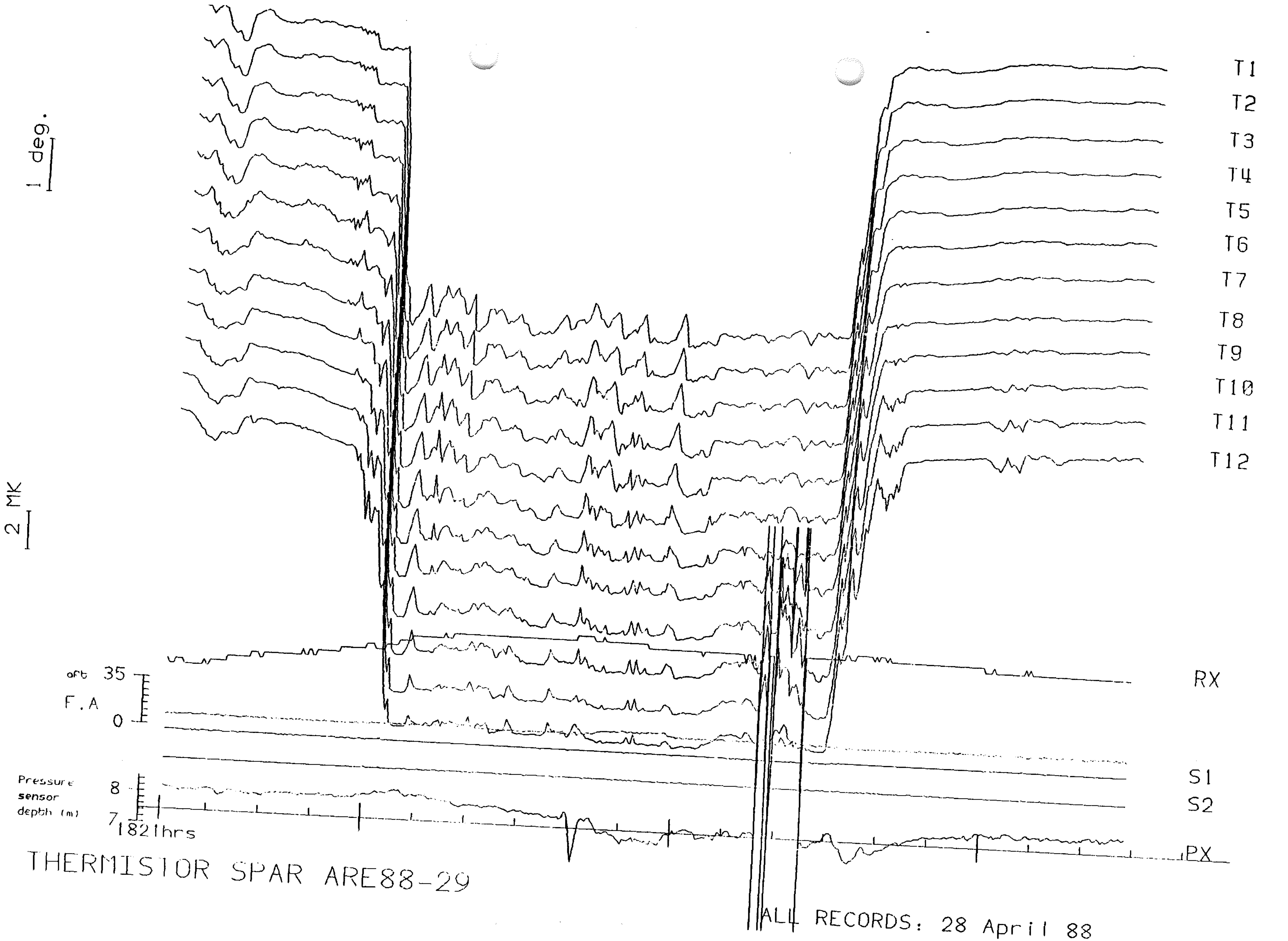
THERMISTOR SPAR ARE88-27

ALL RECORDS:28 April 88



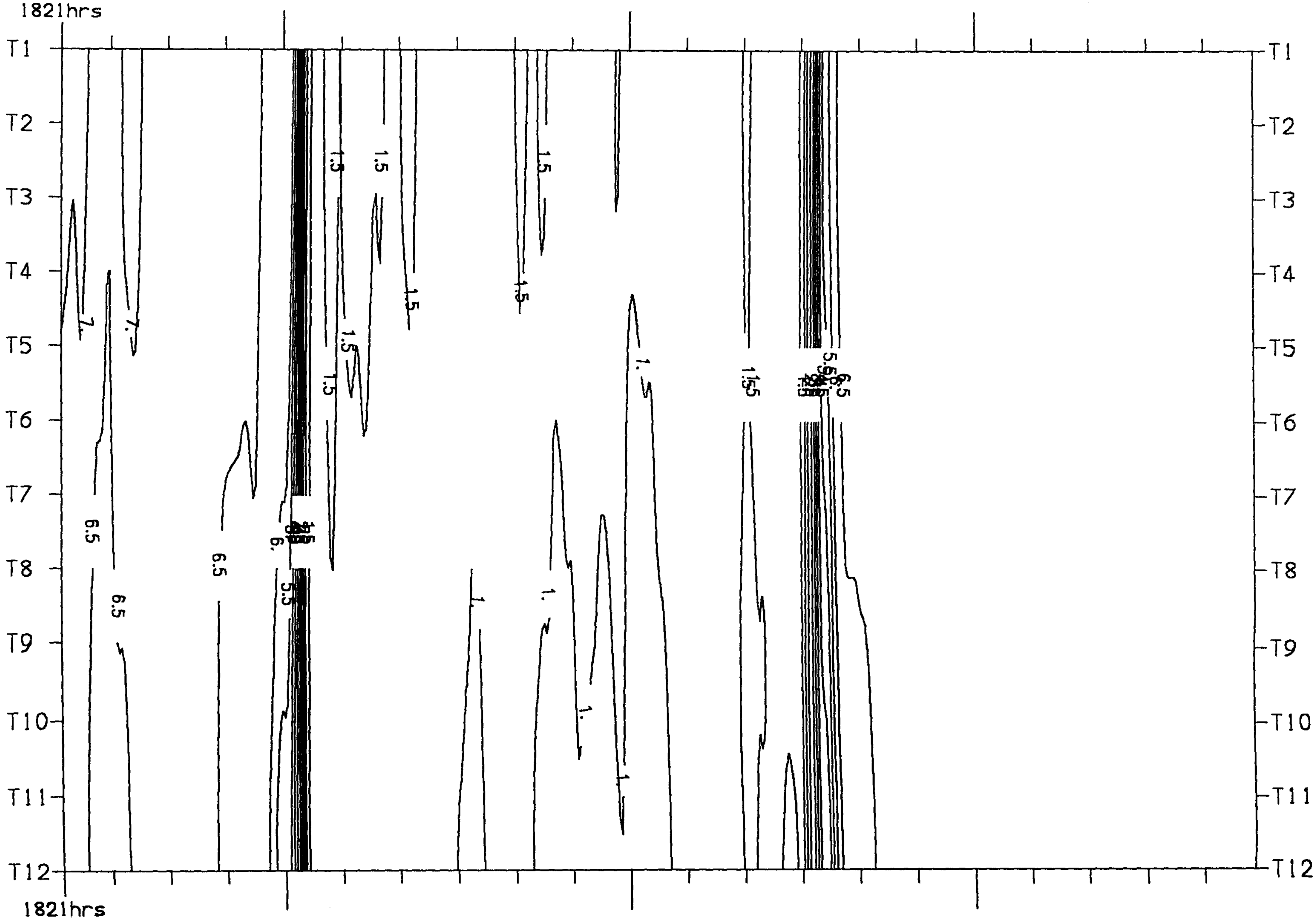
THERMISTOR SPAR ARE88-28

ALL RECORDS: 28 April 88



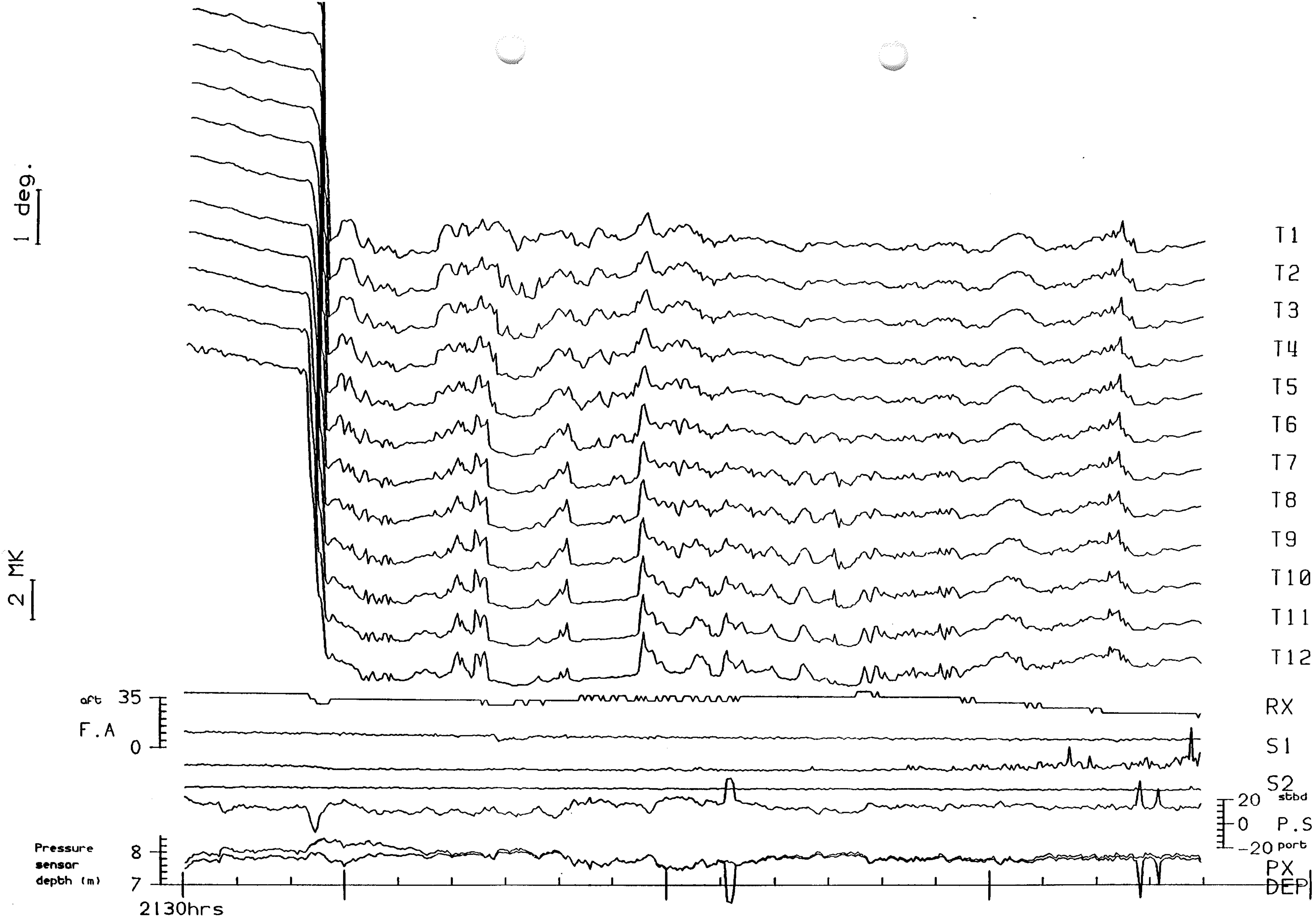
THERMISTOR SPAR ARE88-29

ALL RECORDS: 28 April 88



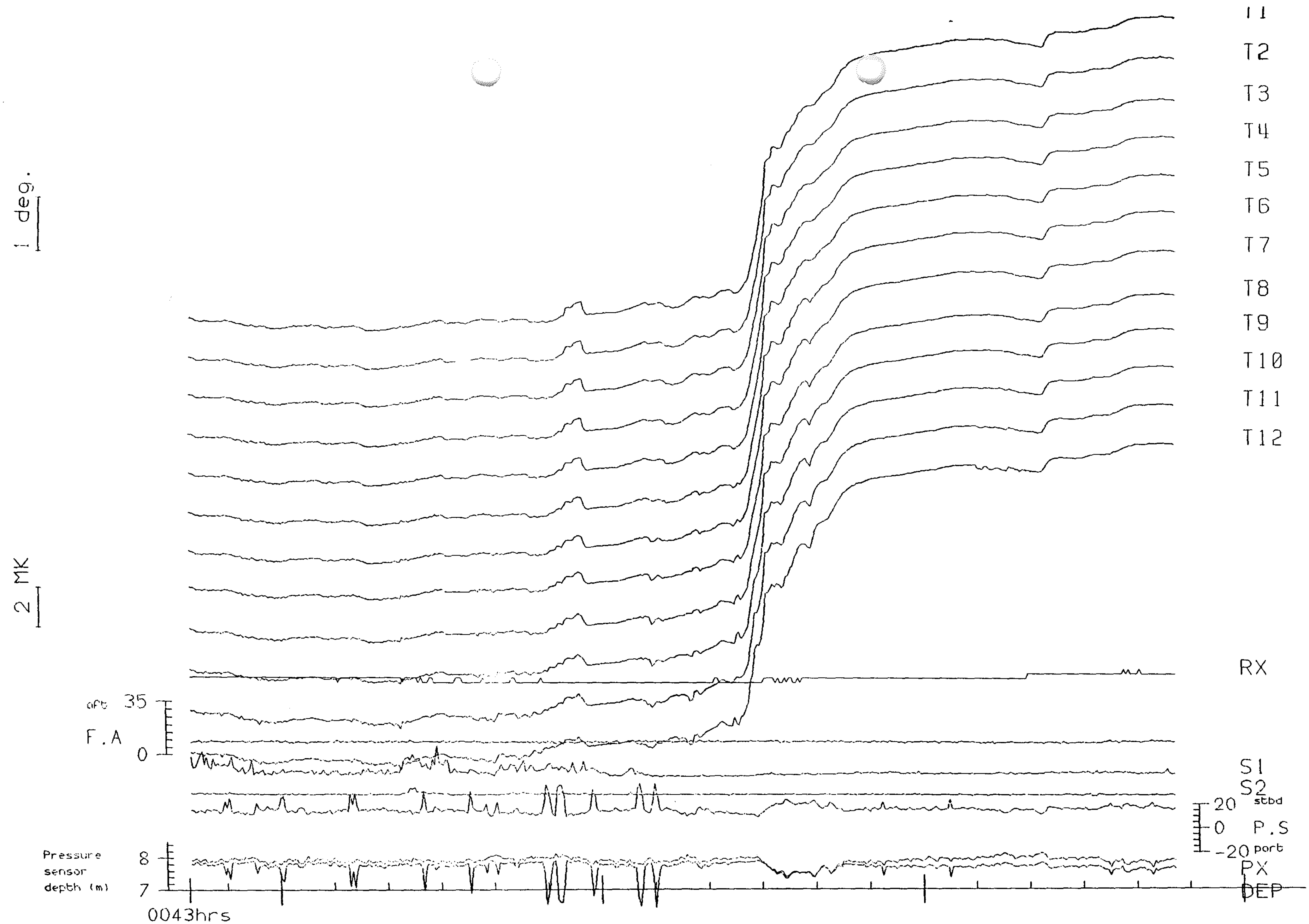
THERMISTOR SPAR ARE88-29

All records 28 April 1988



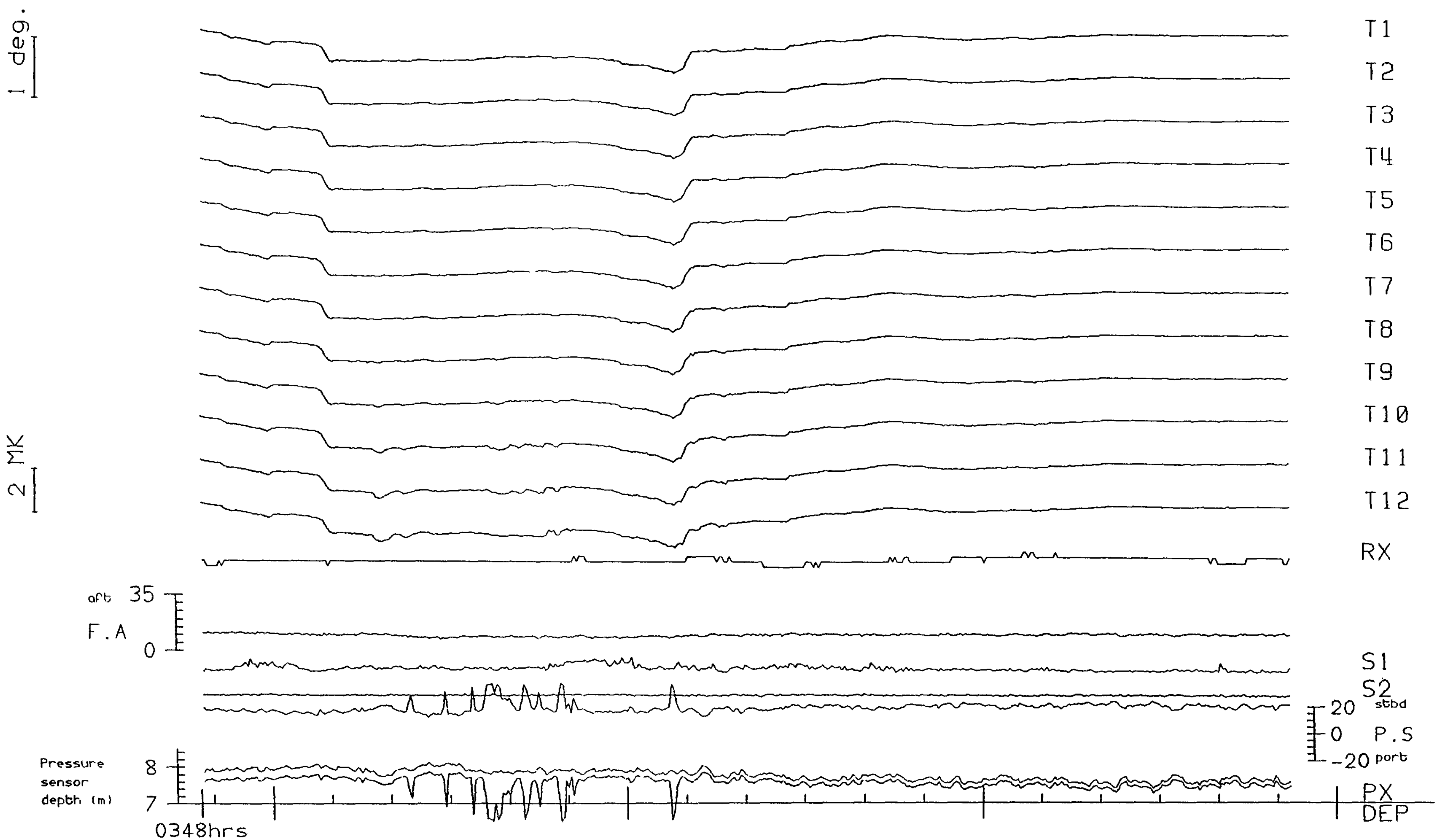
THERMISTOR SPAR ARE88-30

ALL RECORDS:28 April 88



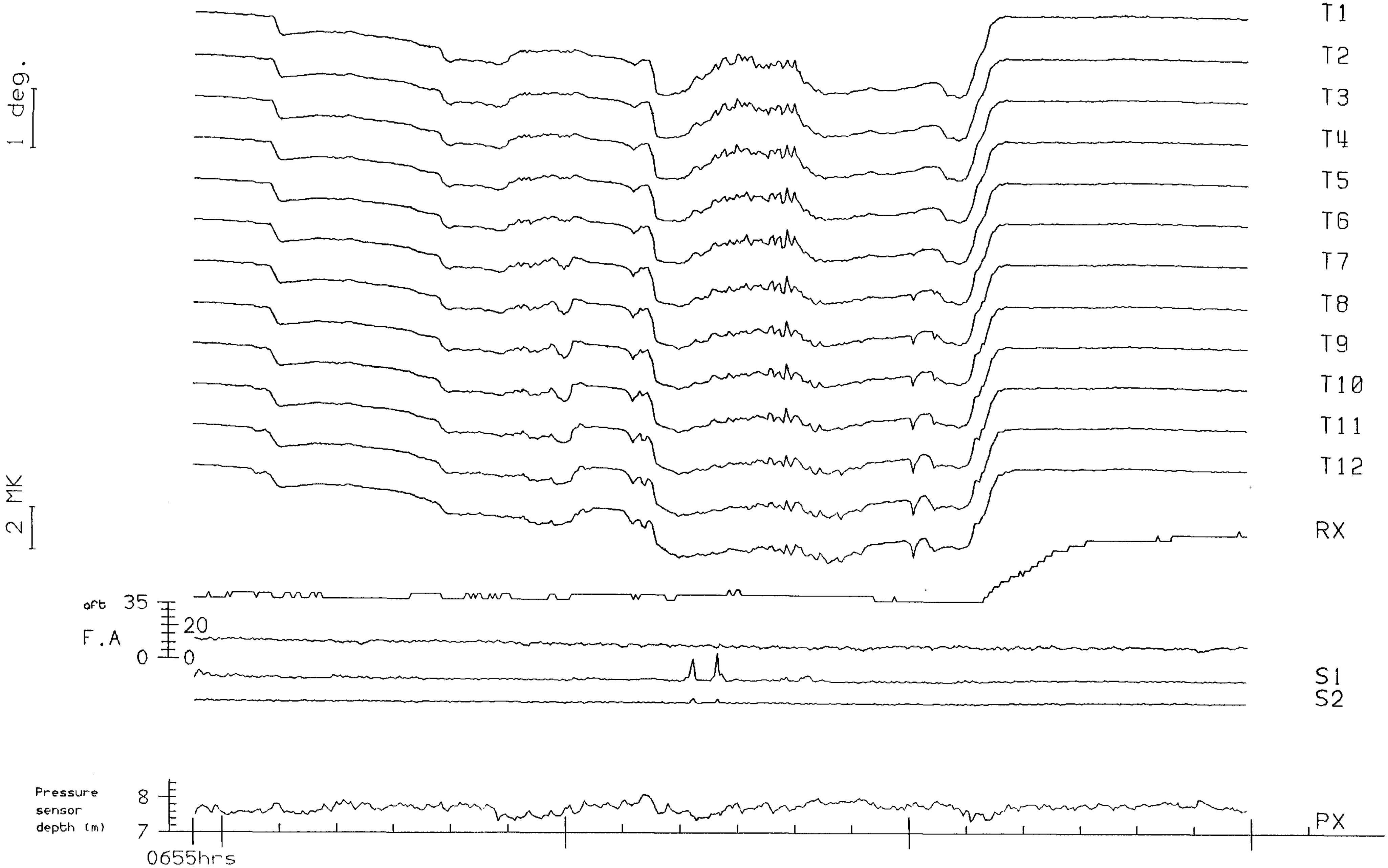
THERMISTOR SPAR ARE88-31

ALL RECORDS:29 April 88



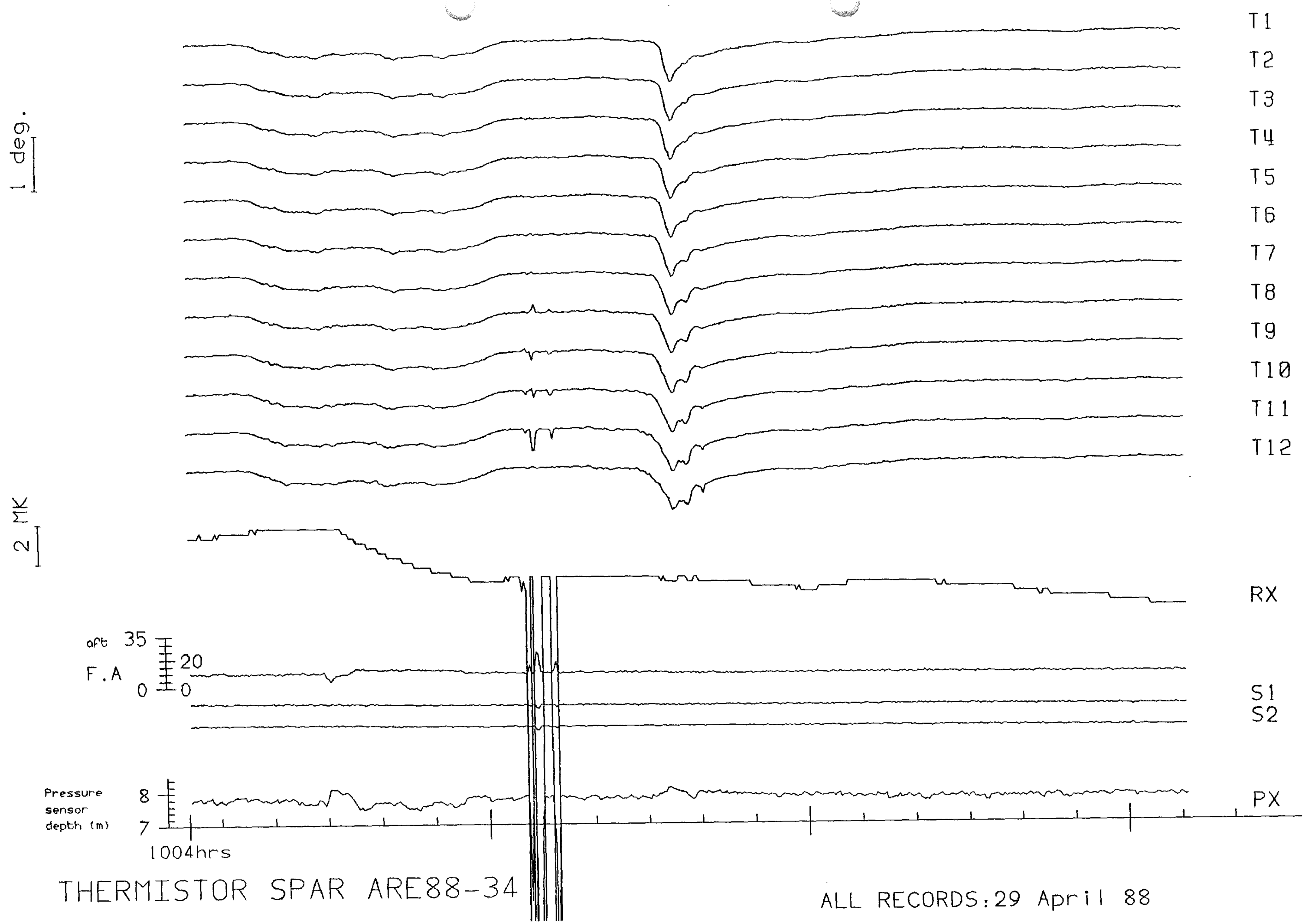
THERMISTOR SPAR ARE88-32

ALL RECORDS:29 April 88



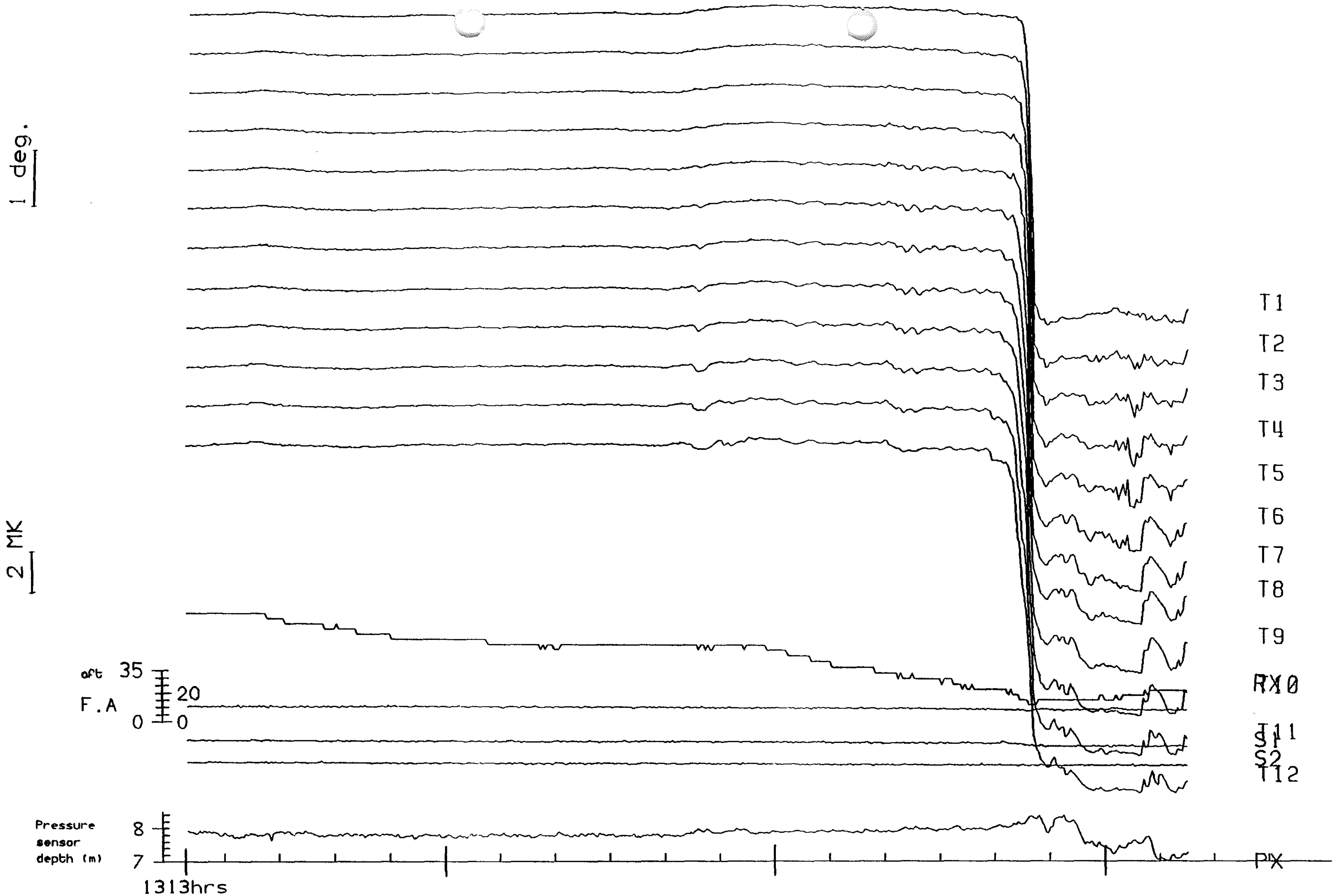
THERMISTOR SPAR ARE88-33

ALL RECORDS: 29 April 88



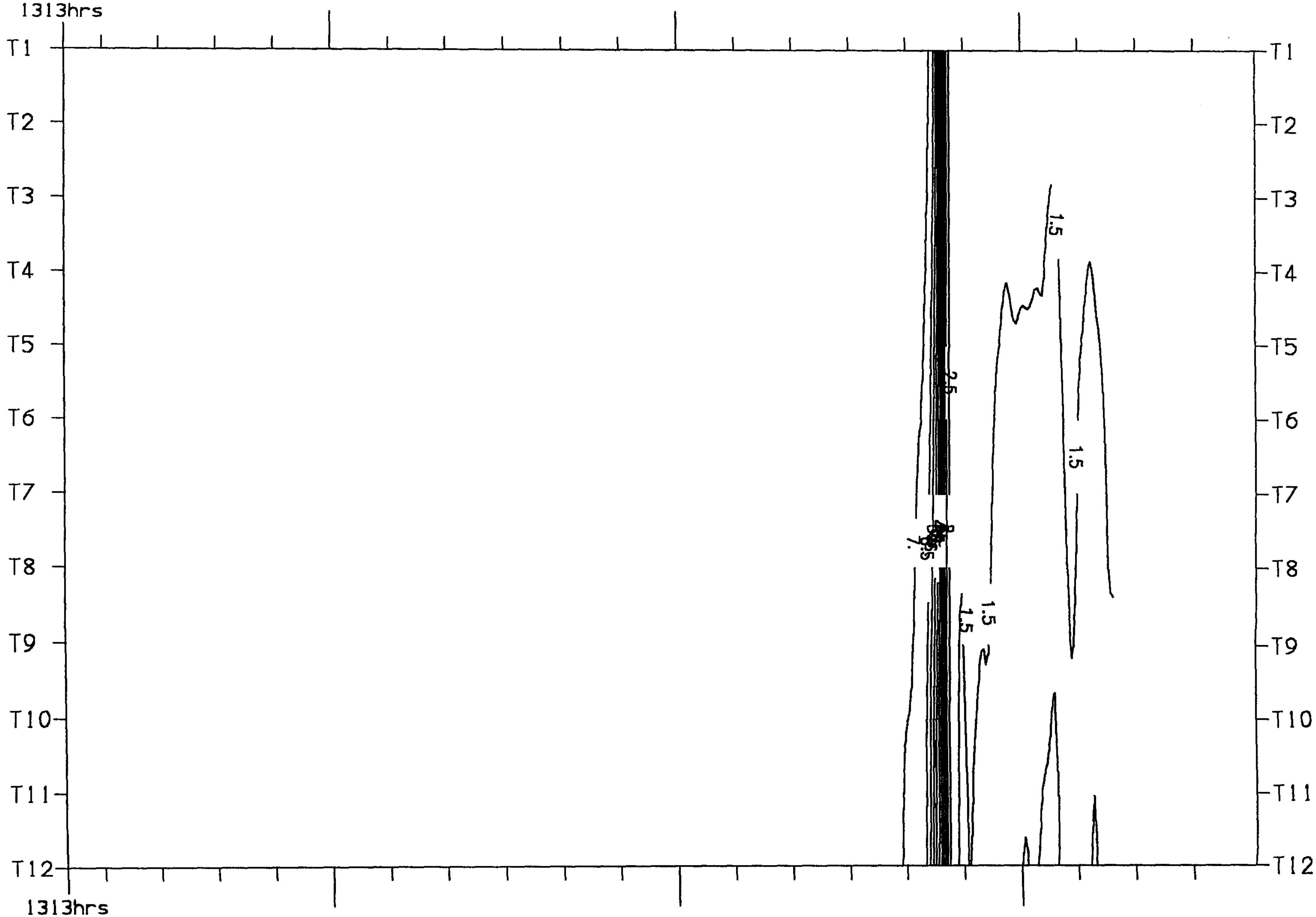
THERMISTOR SPAR ARE88-34

ALL RECORDS:29 April 88



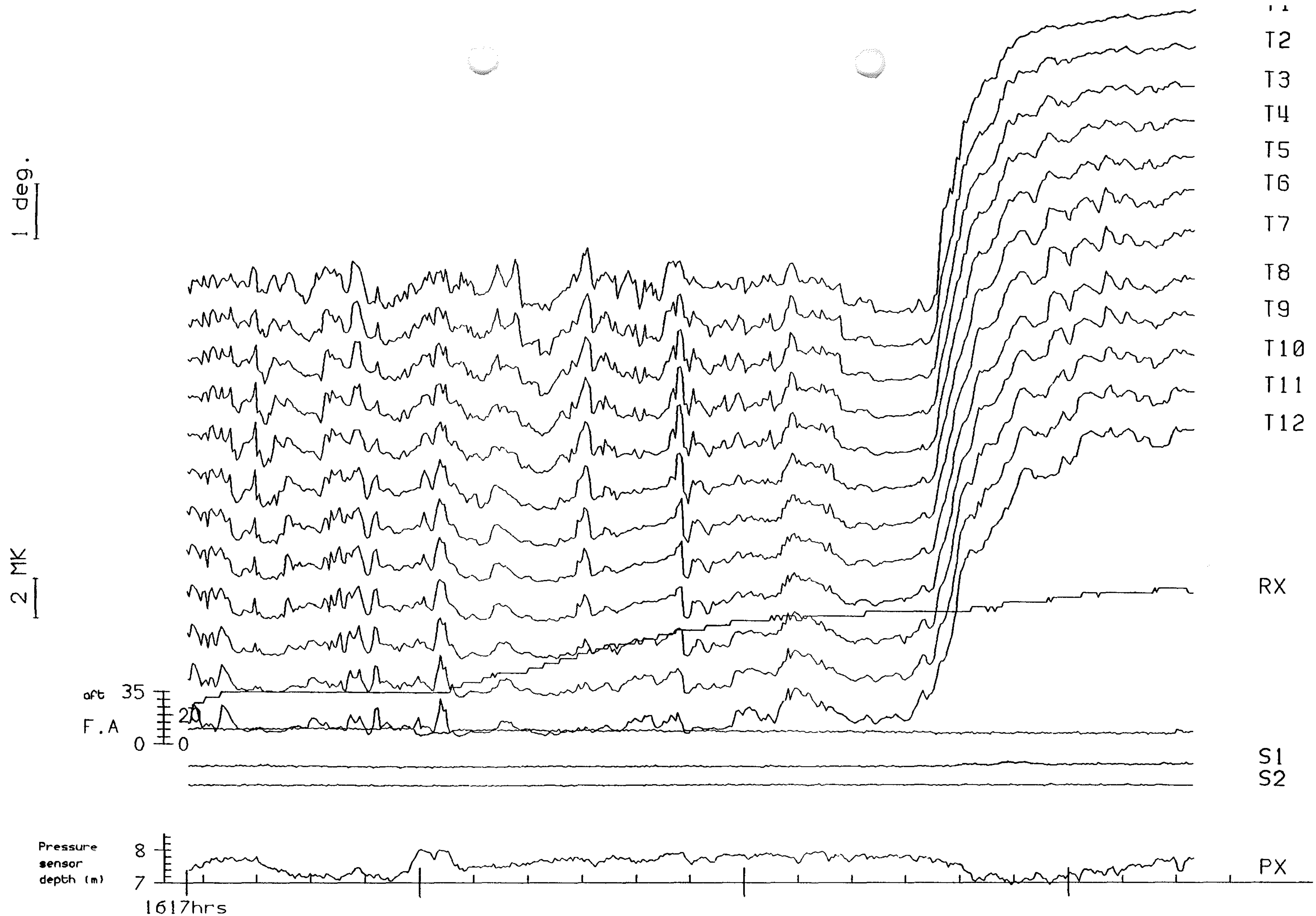
THERMISTOR SPAR ARE88-35

ALL RECORDS: 29 April 88



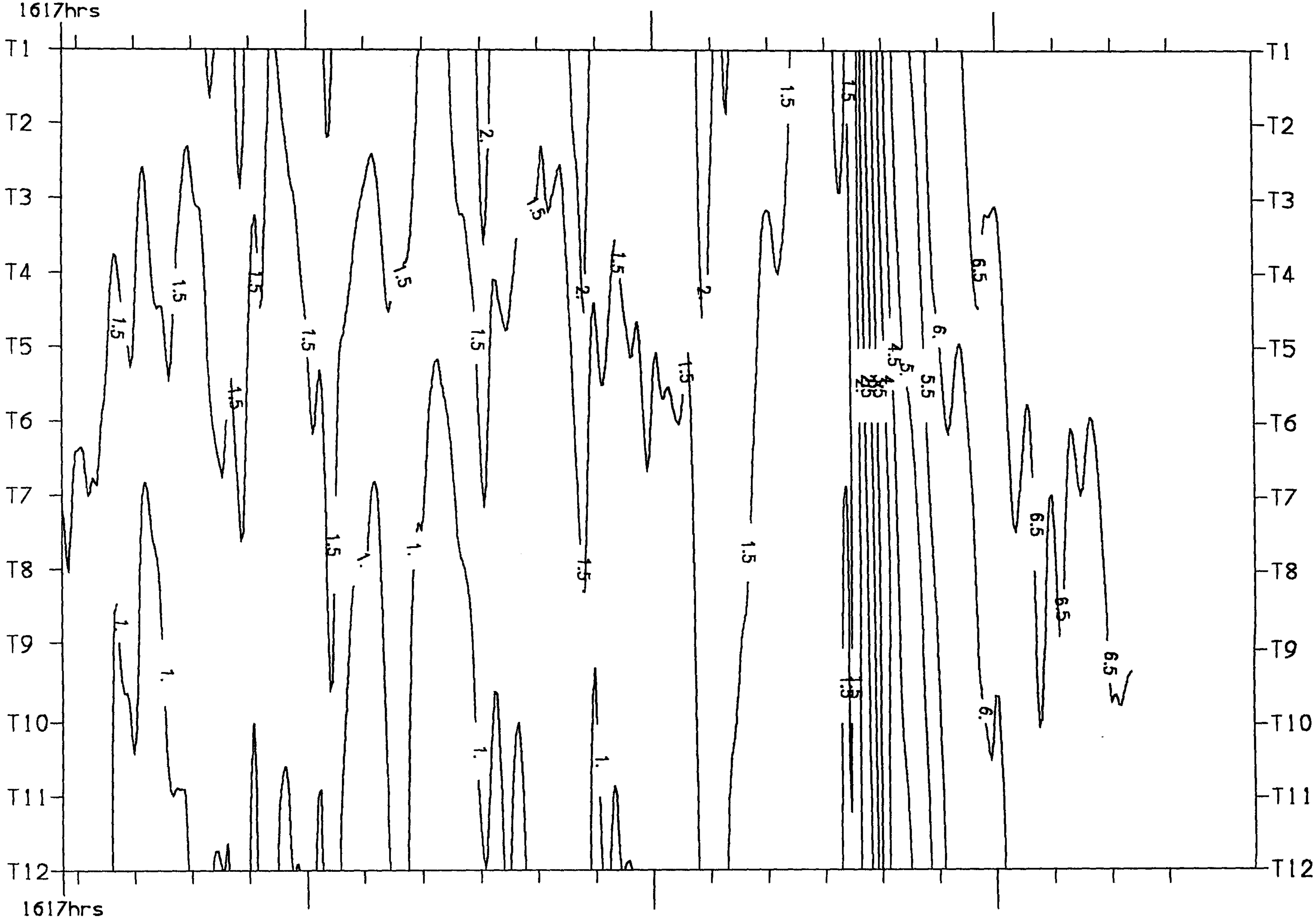
THERMISTOR SPAR ARE88-35

All records 29 April 1988



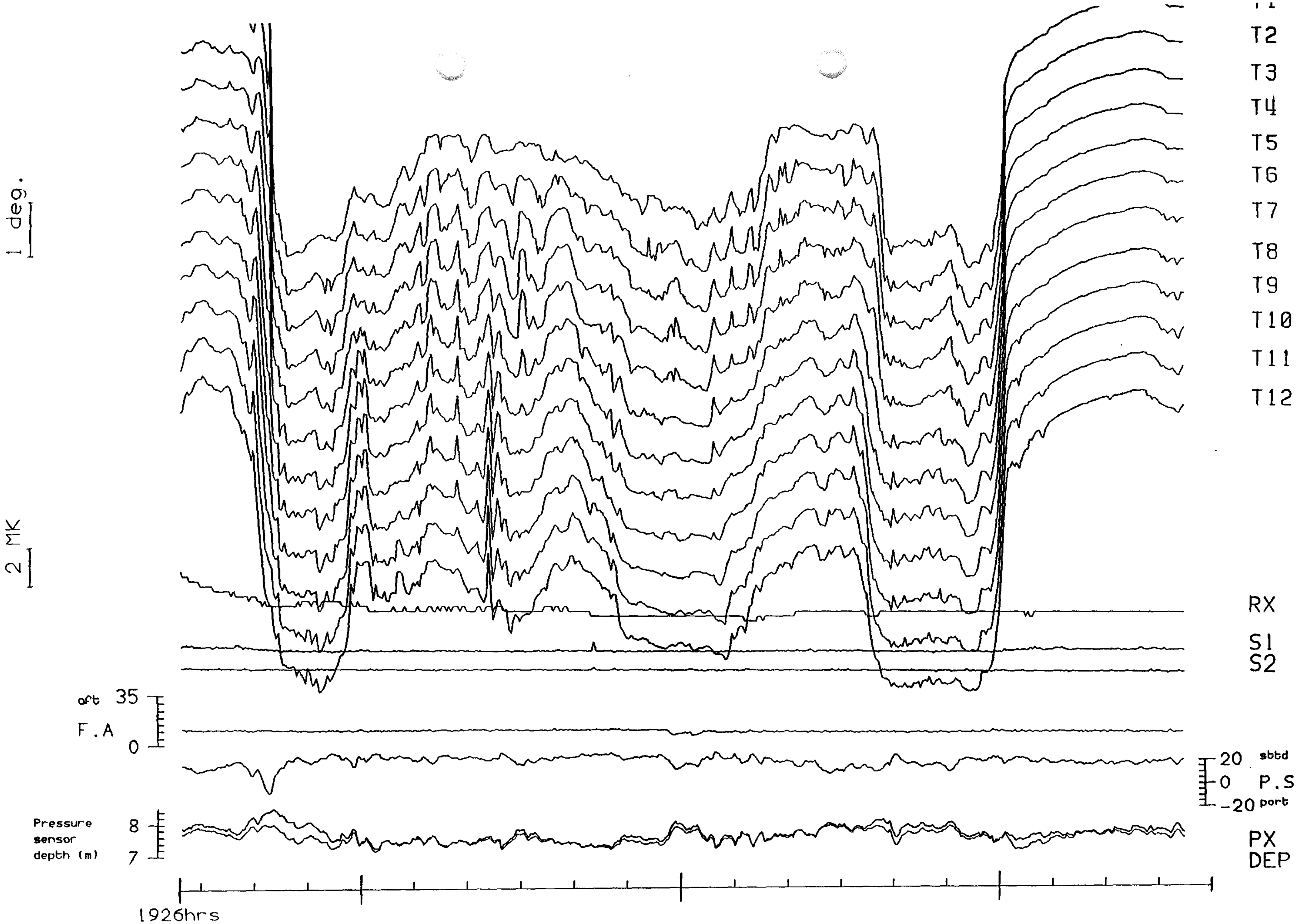
THERMISTOR SPAR ARE88-36

ALL RECORDS: 29 April 88



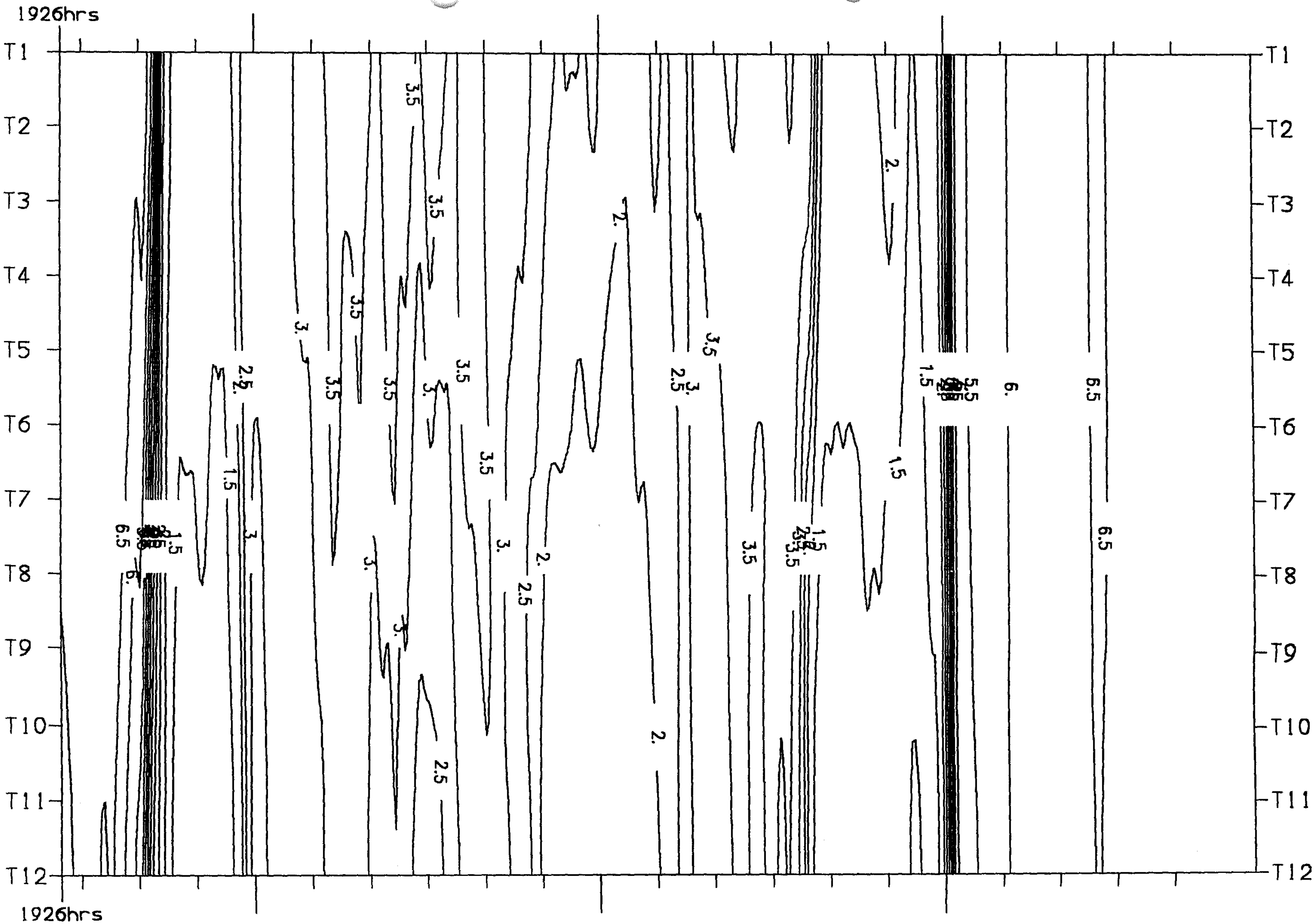
THERMISTOR SPAR ARE88-36

All records 29 April 1988



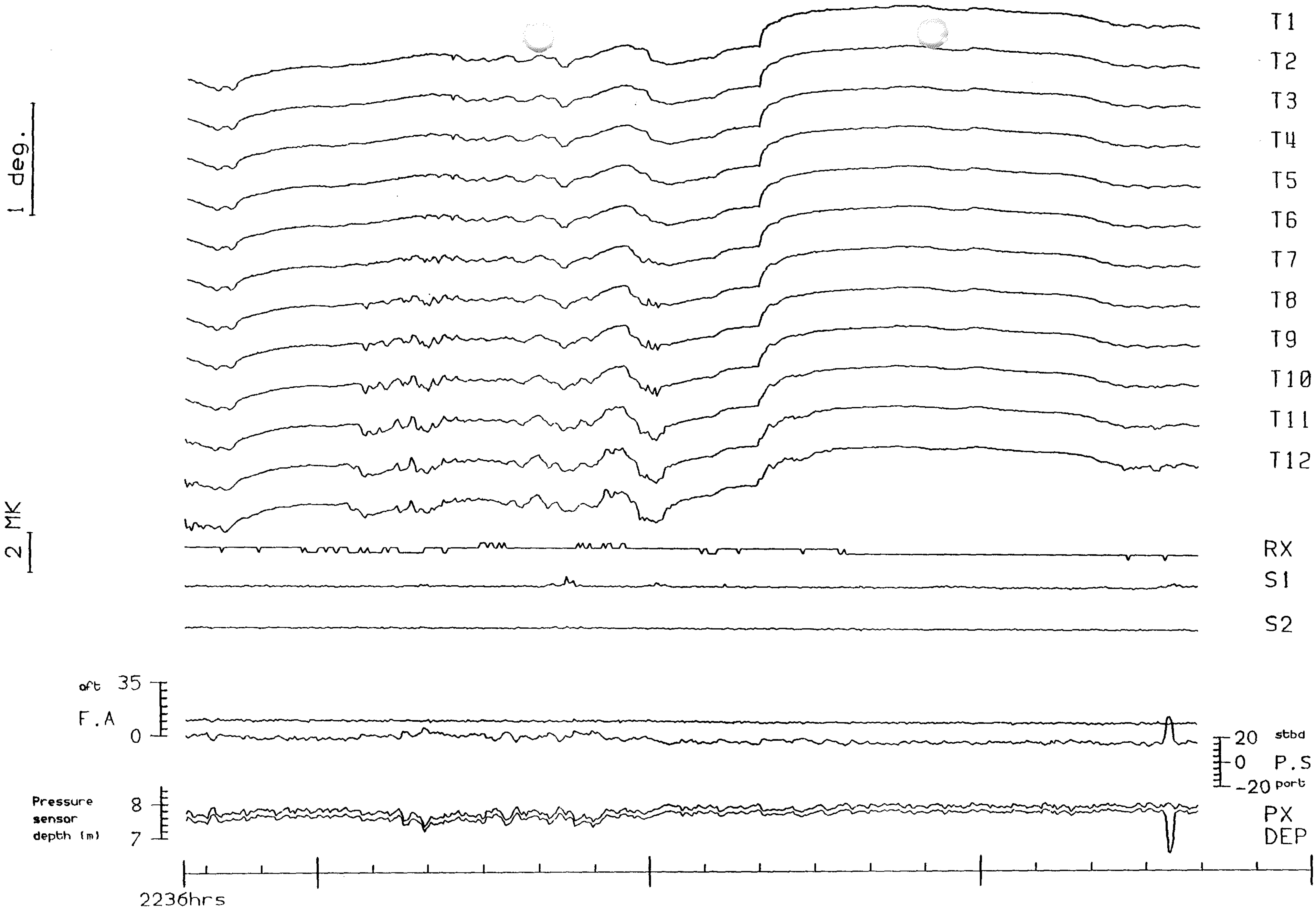
THERMISTOR SPAR ARE88-37

ALL RECORDS: 29 April 88



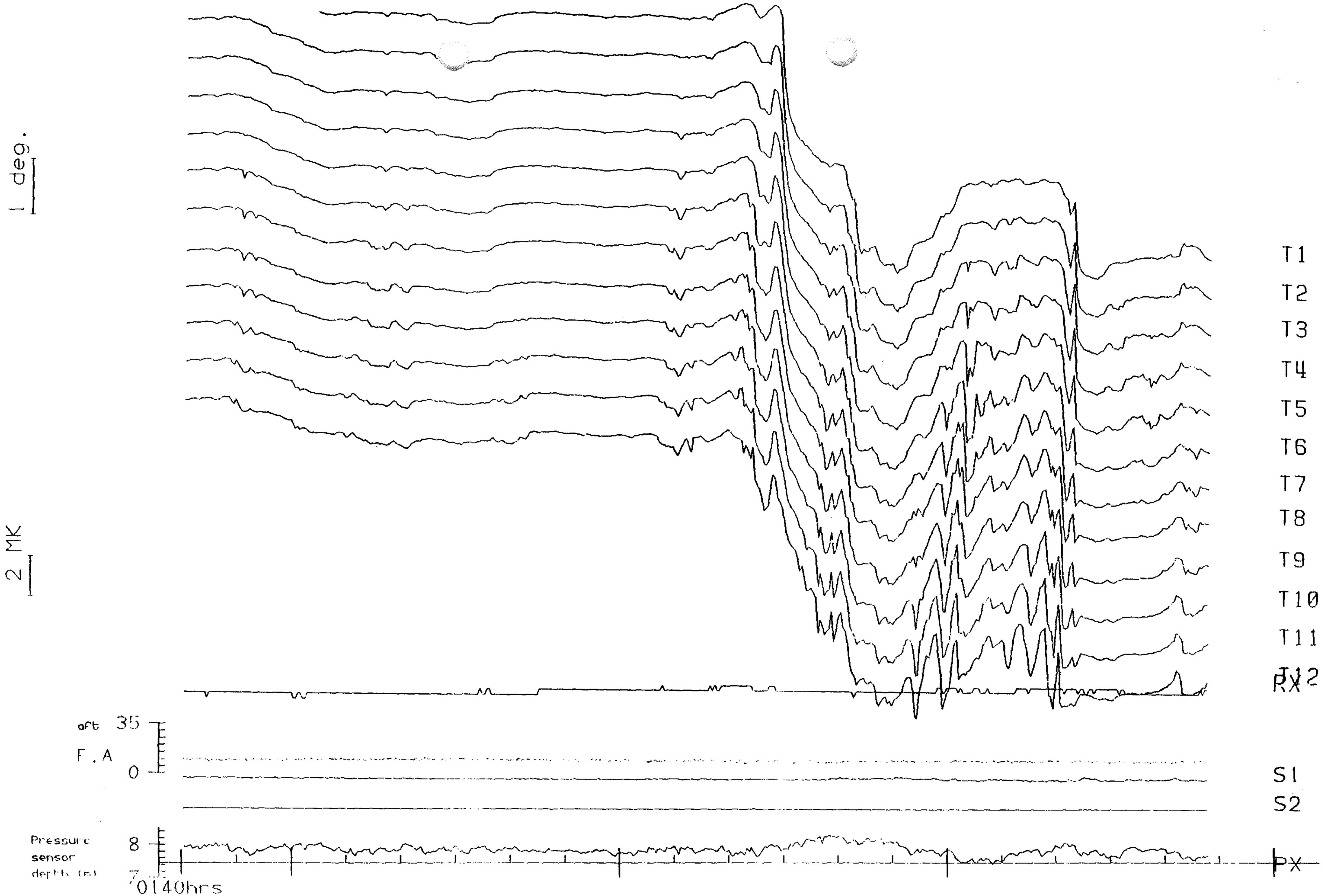
THERMISTOR SPAR ARE88-37

All records 29 April 1988



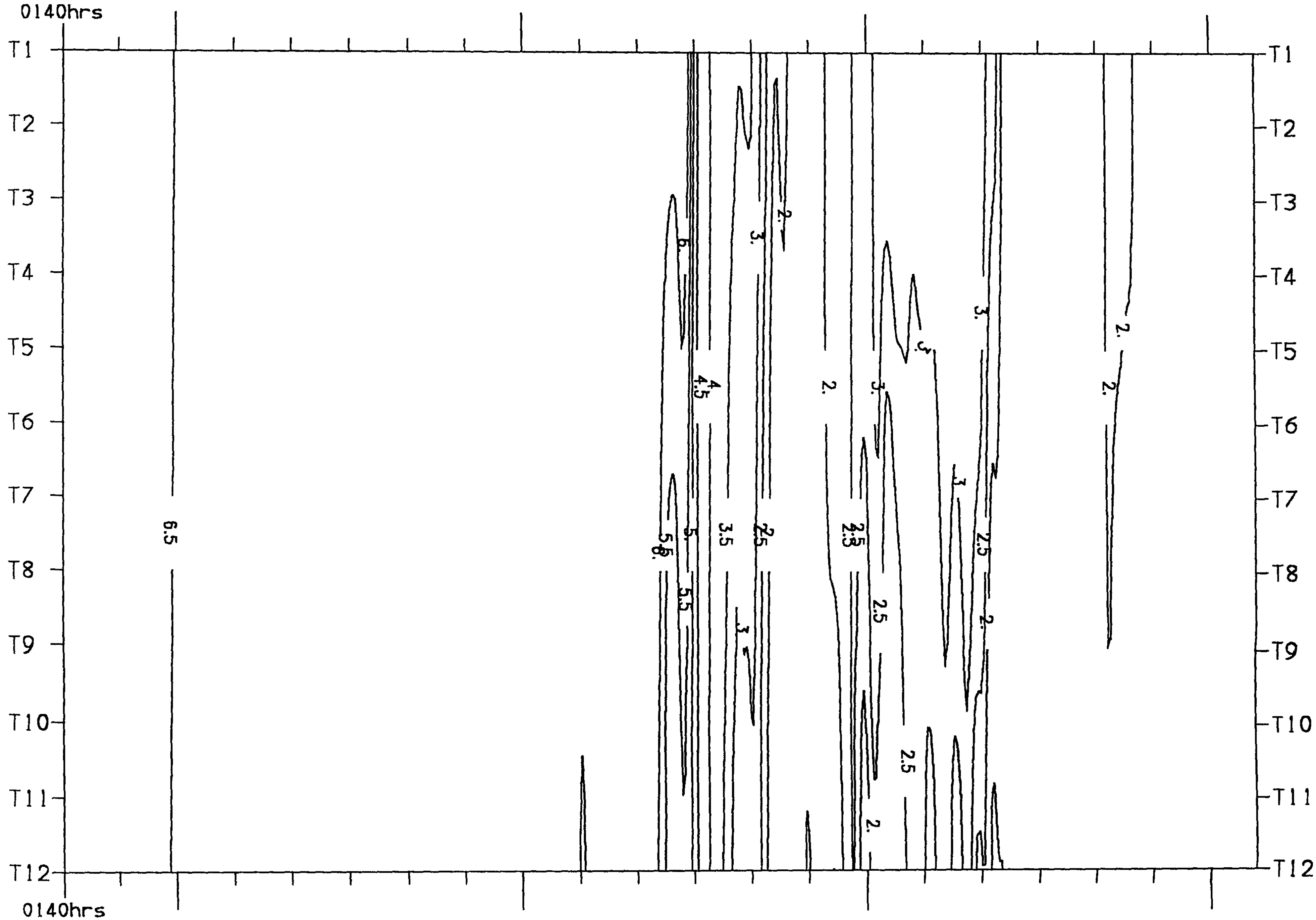
THERMISTOR SPAR ARE88-38

ALL RECORDS: 29 April 88



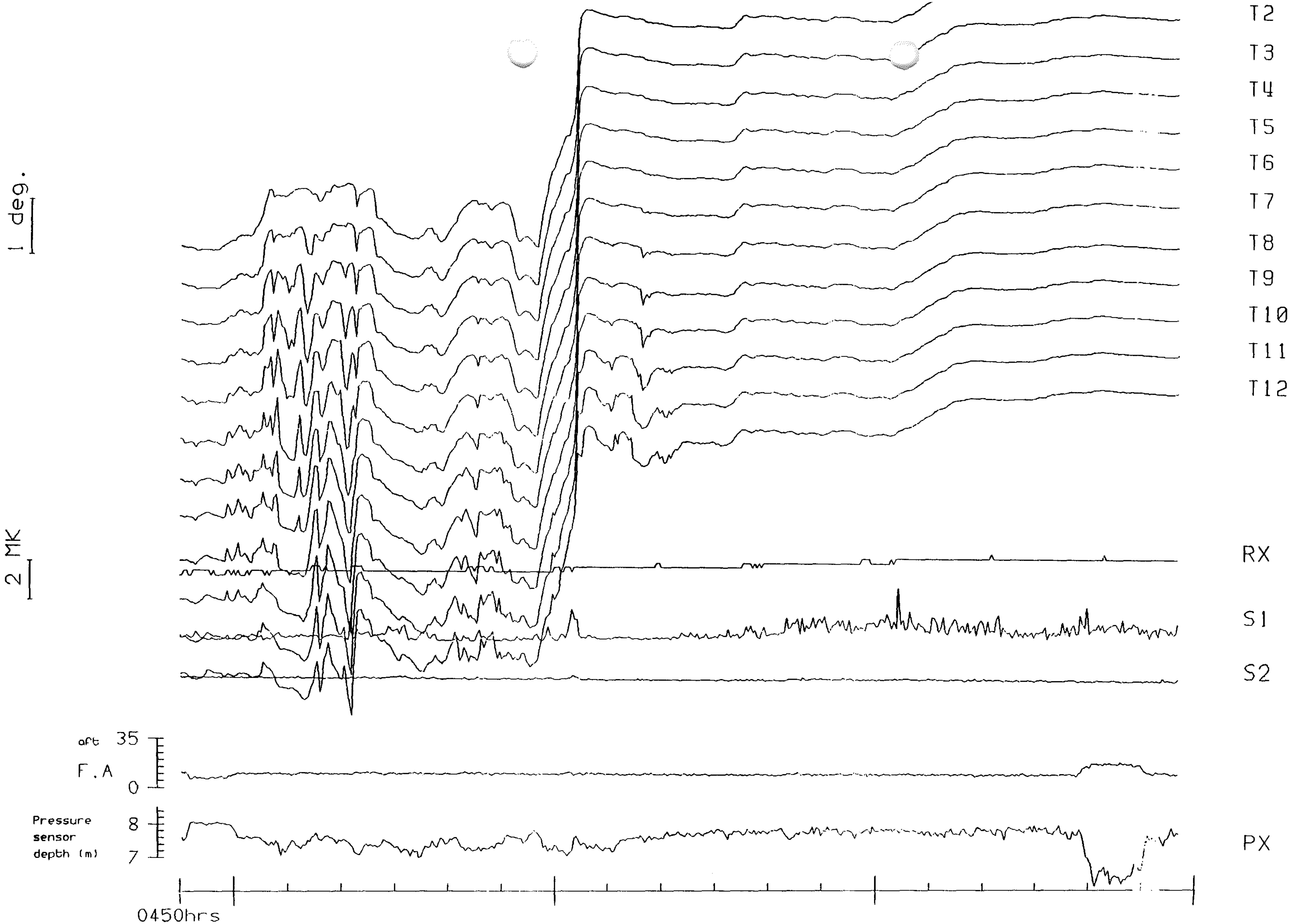
THERMISTOR SPAR ARE88-39

ALL RECORDS: 30 April 88



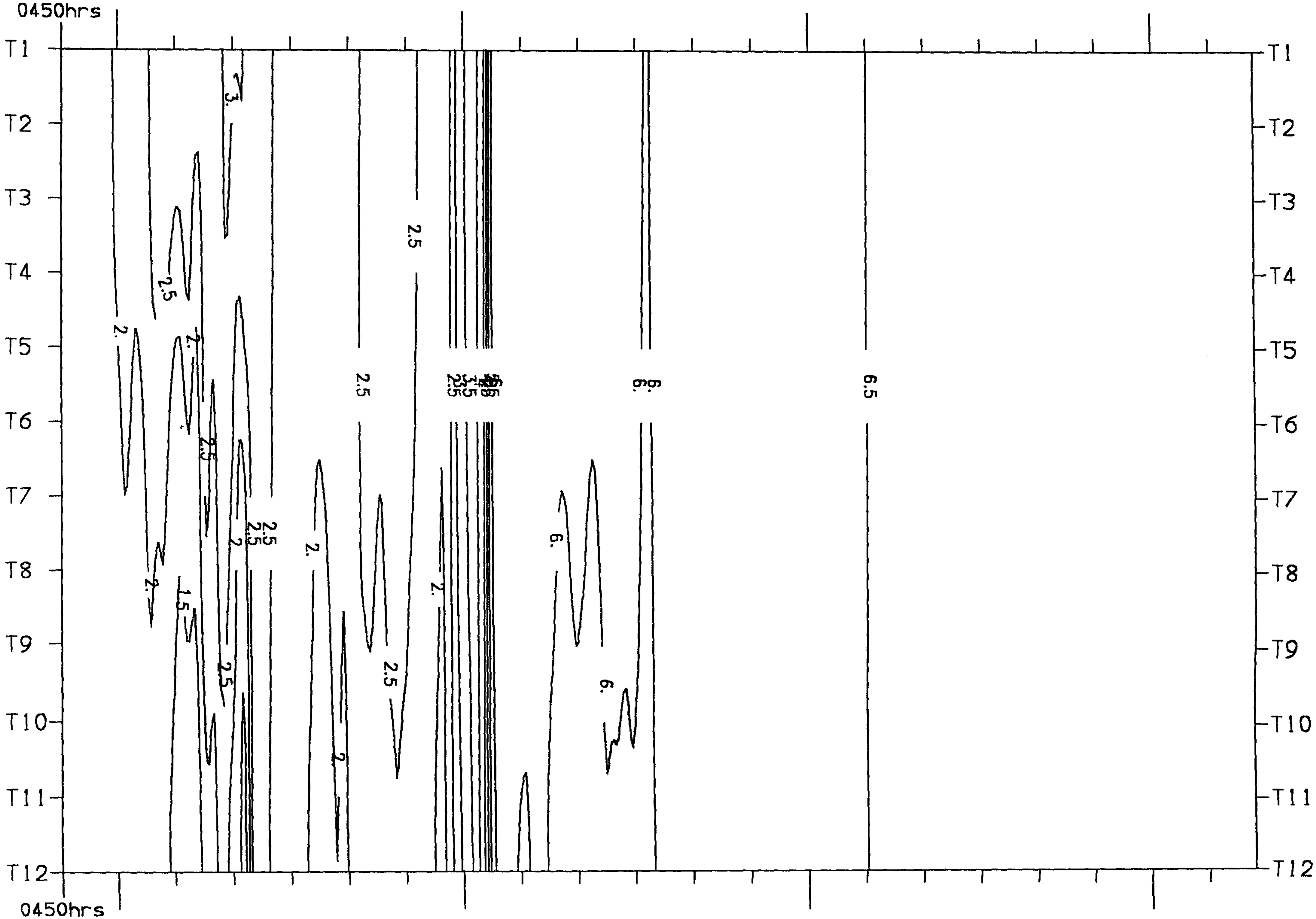
THERMISTOR SPAR ARE88-39

All records 30 April 1988



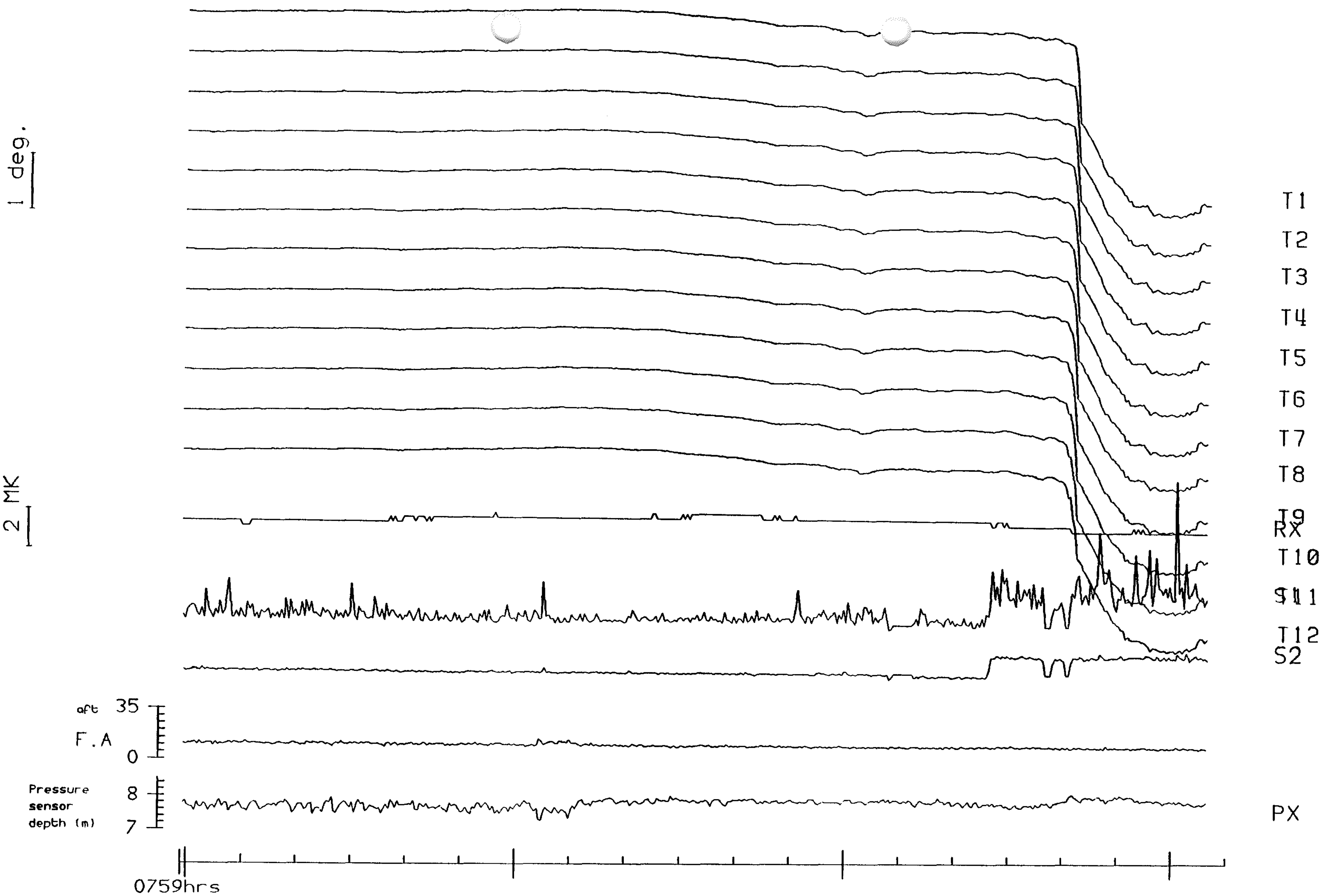
THERMISTOR SPAR ARE88-40

ALL RECORDS: 30 April 88



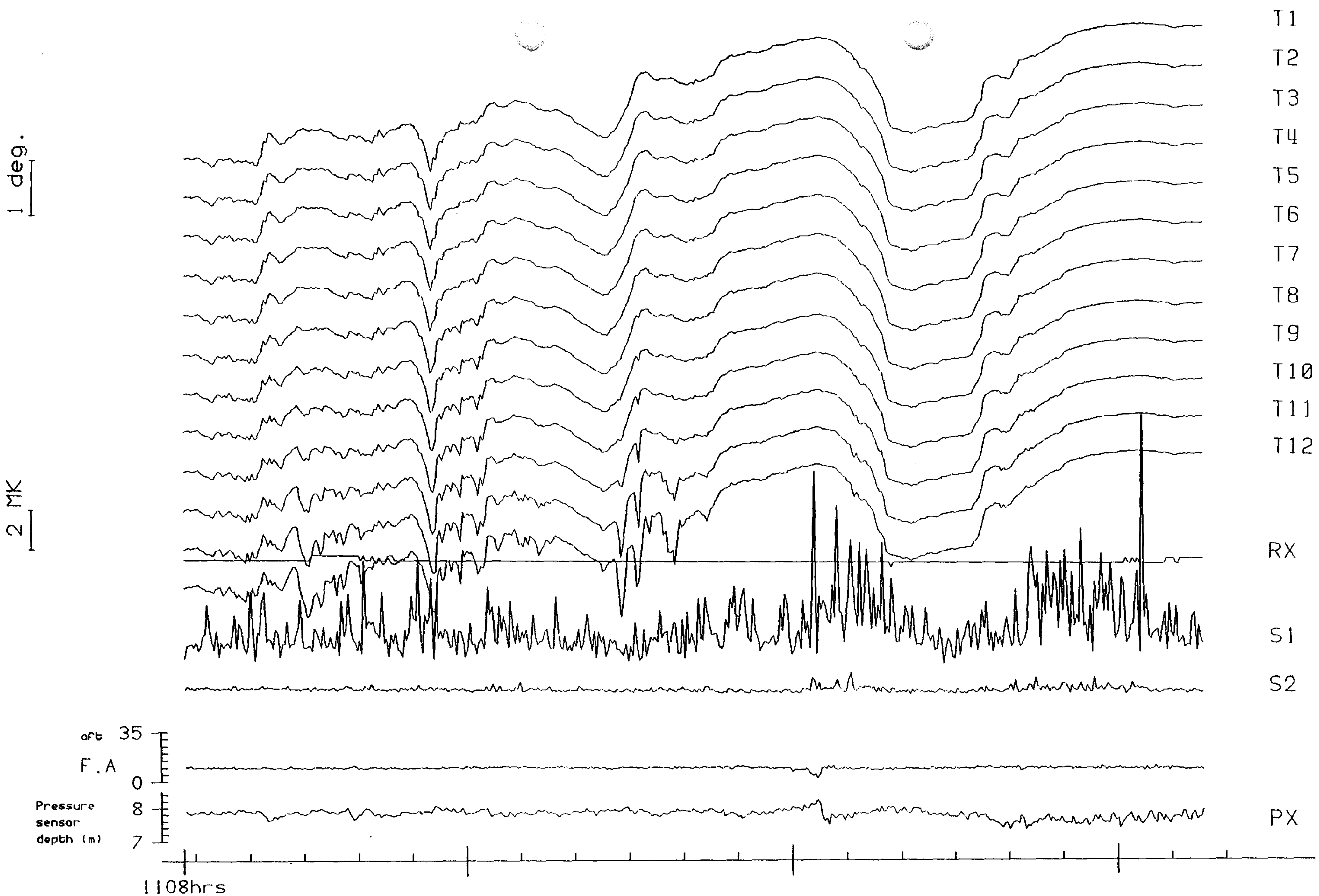
THERMISTOR SPAR ARE88-40

All records 30 April 1988



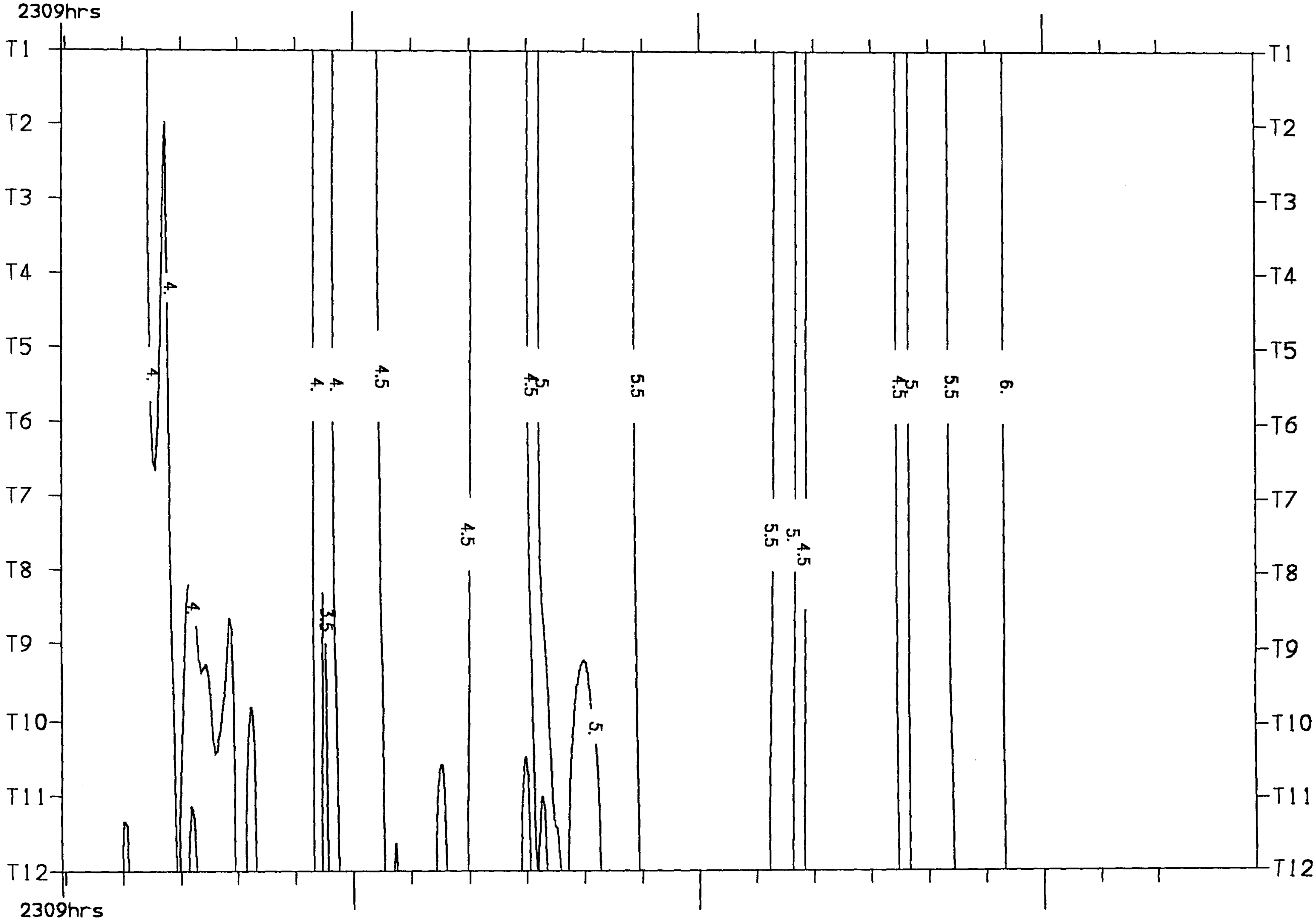
THERMISTOR SPAR ARE88-41

ALL RECORDS: 30 April 88



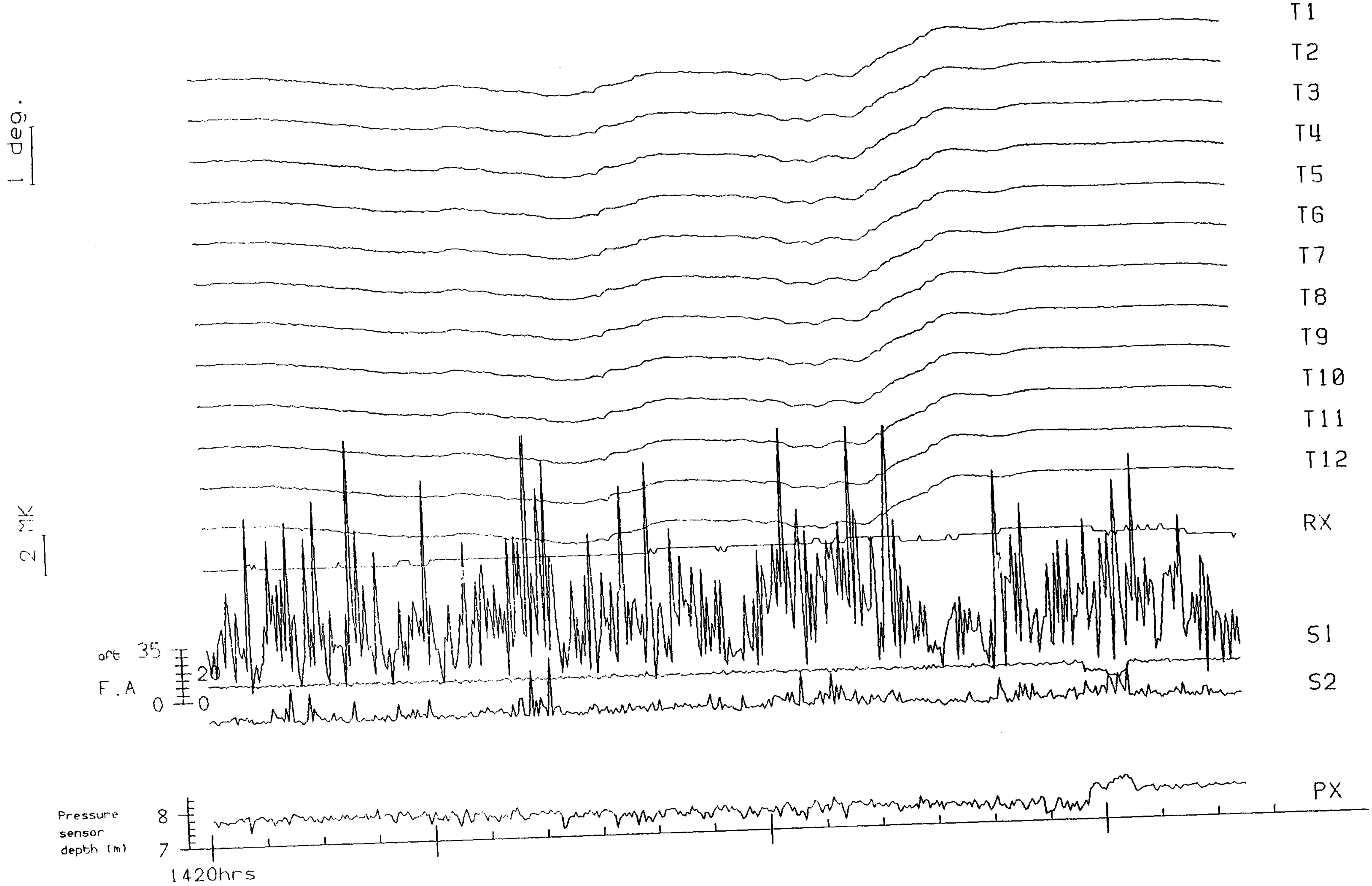
THERMISTOR SPAR ARE88-42

ALL RECORDS: 30 April 88



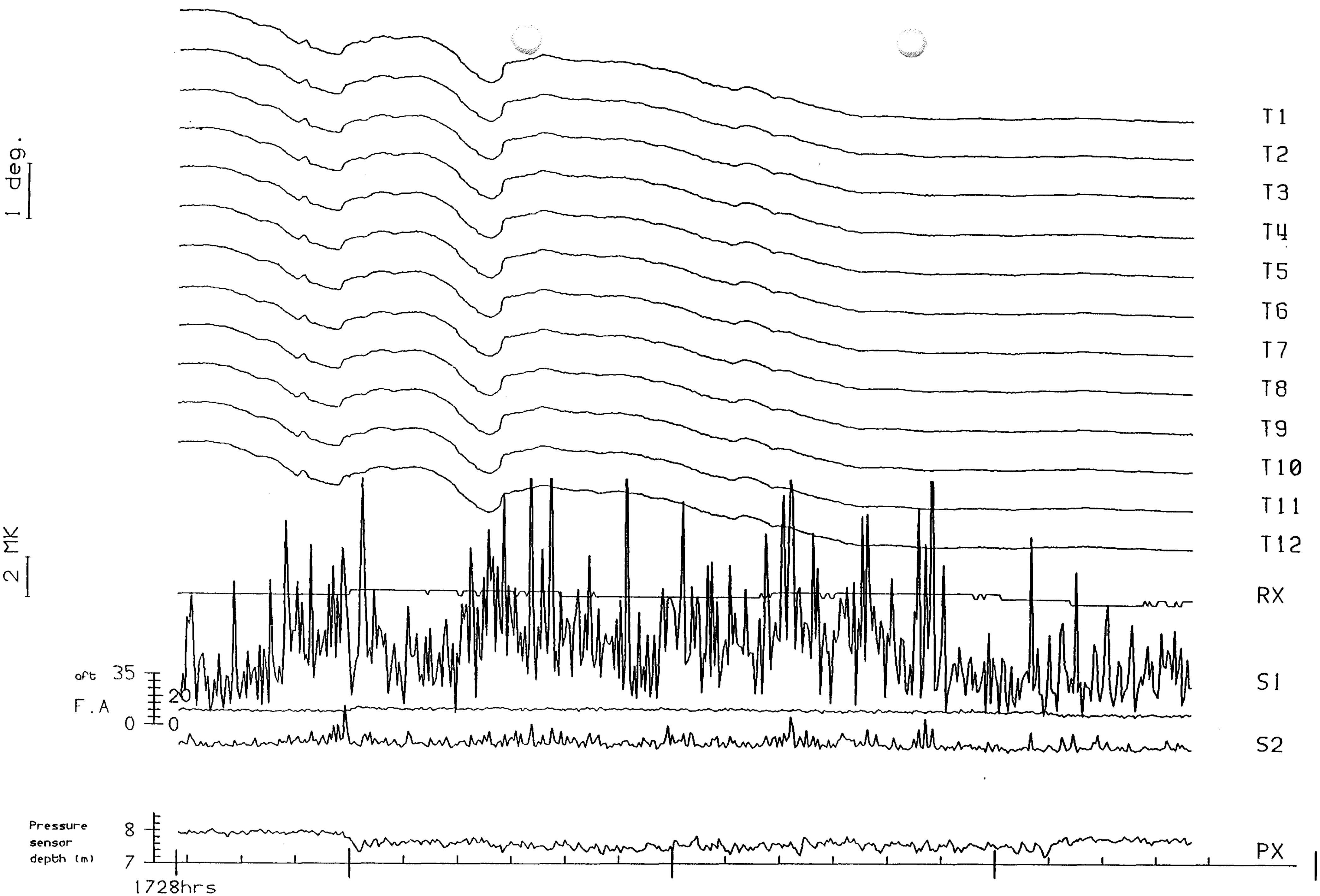
THERMISTOR SPAR ARE88-42

All records 30 April 1988



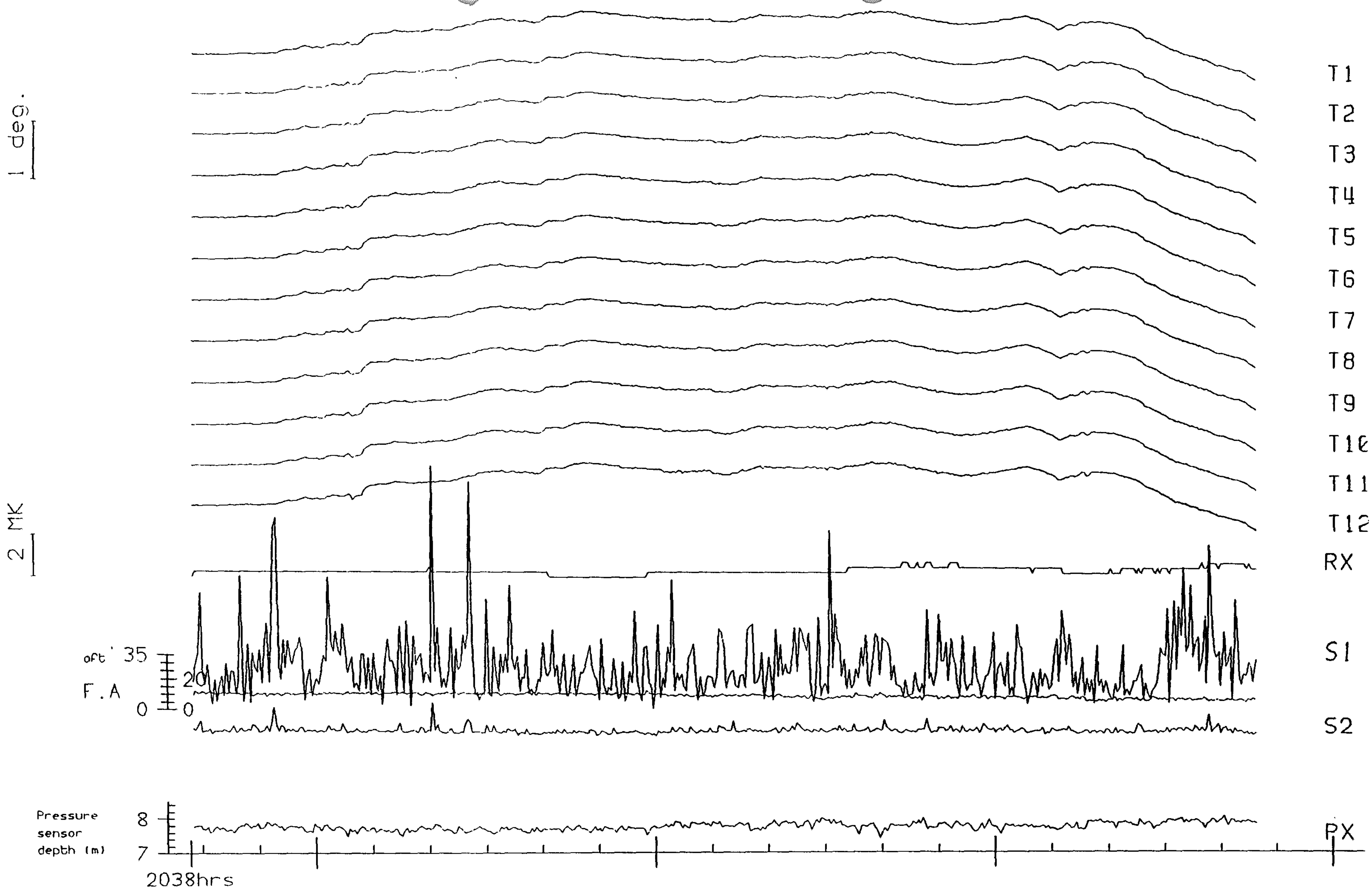
THERMISTOR SPAR ARE88-43

ALL RECORDS:30 April 88



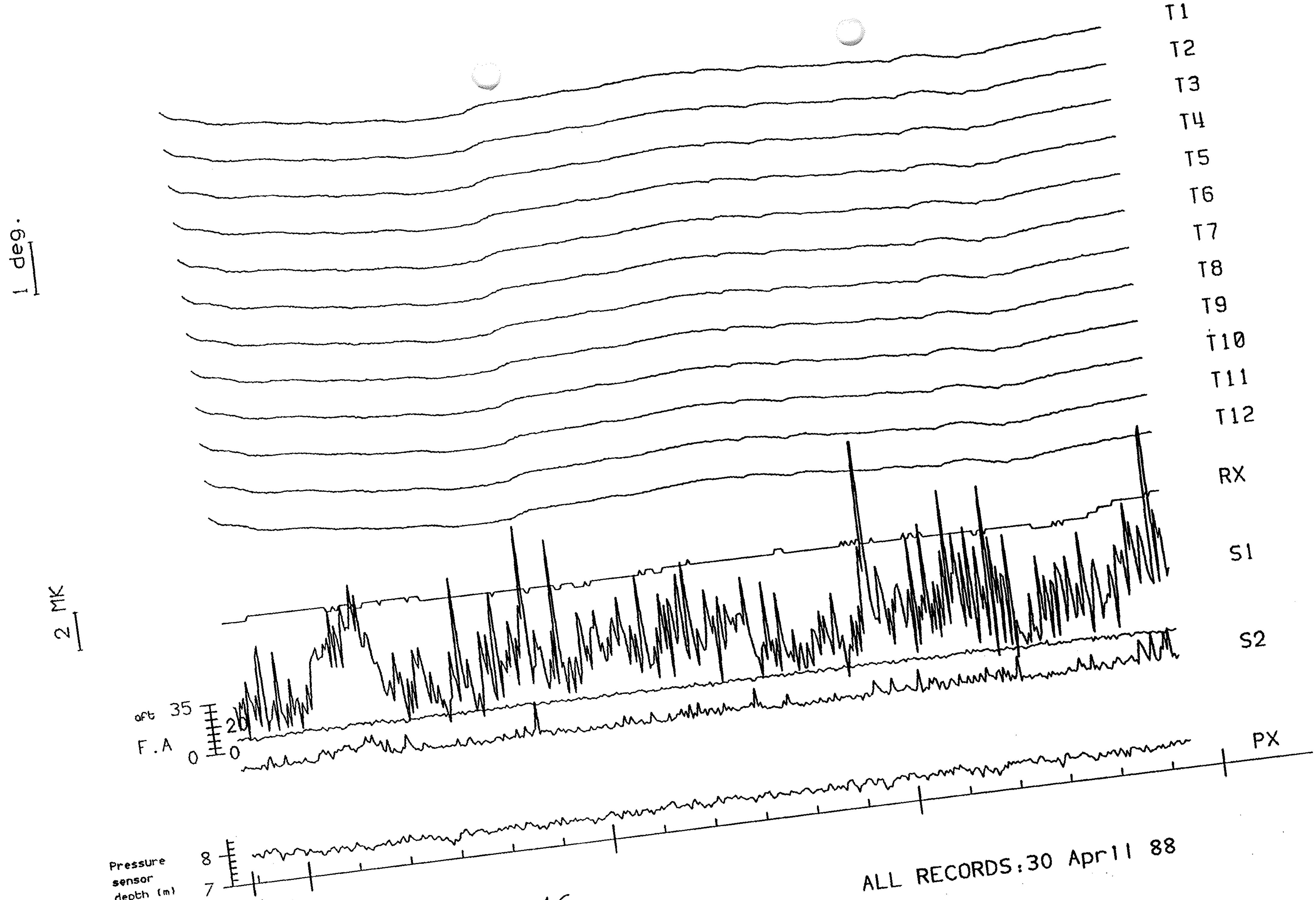
THERMISTOR SPAR ARE88-44

ALL RECORDS:30 April 88

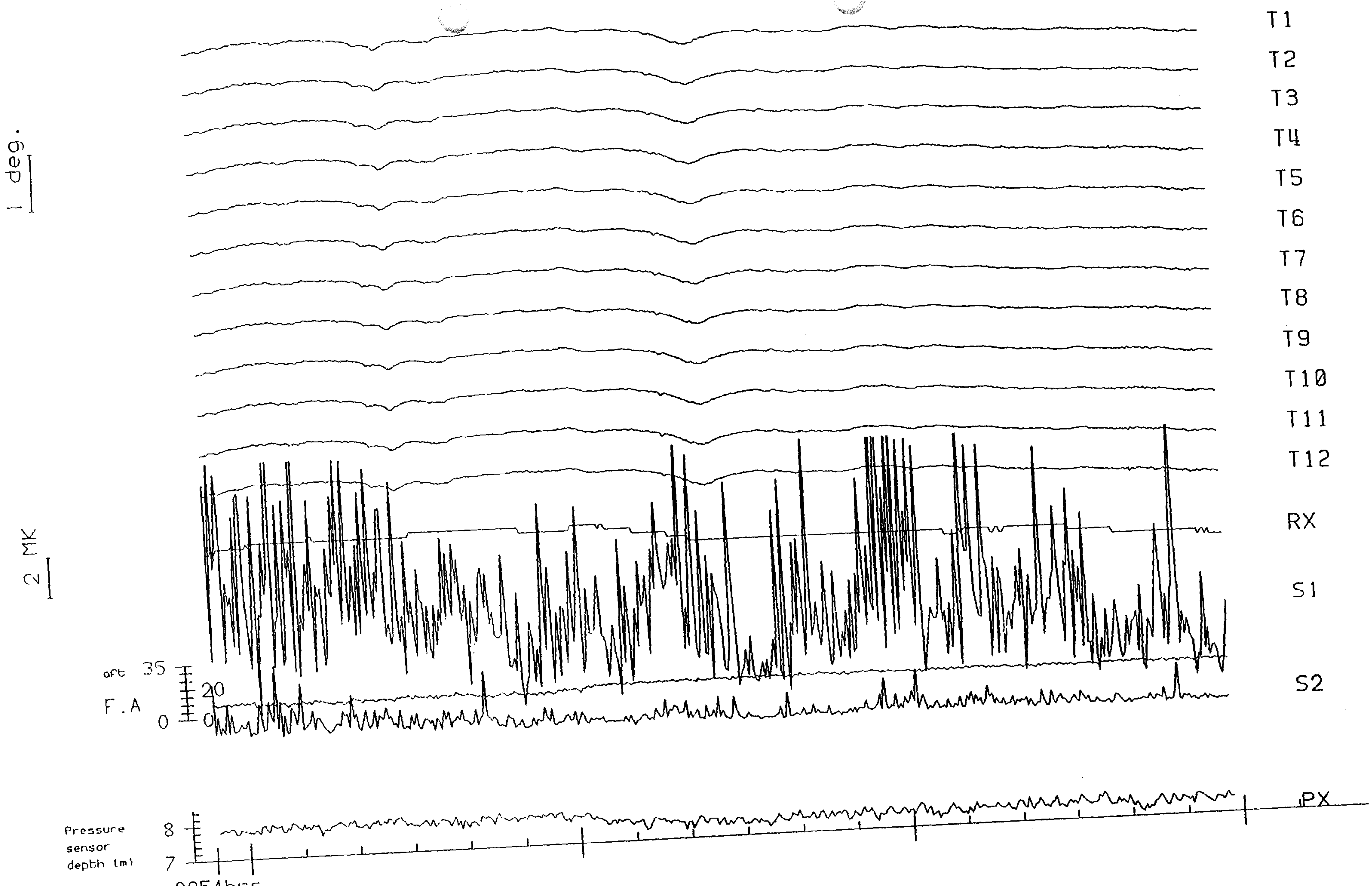


THERMISTOR SPAR ARE88-45

ALL RECORDS: 30 April 88

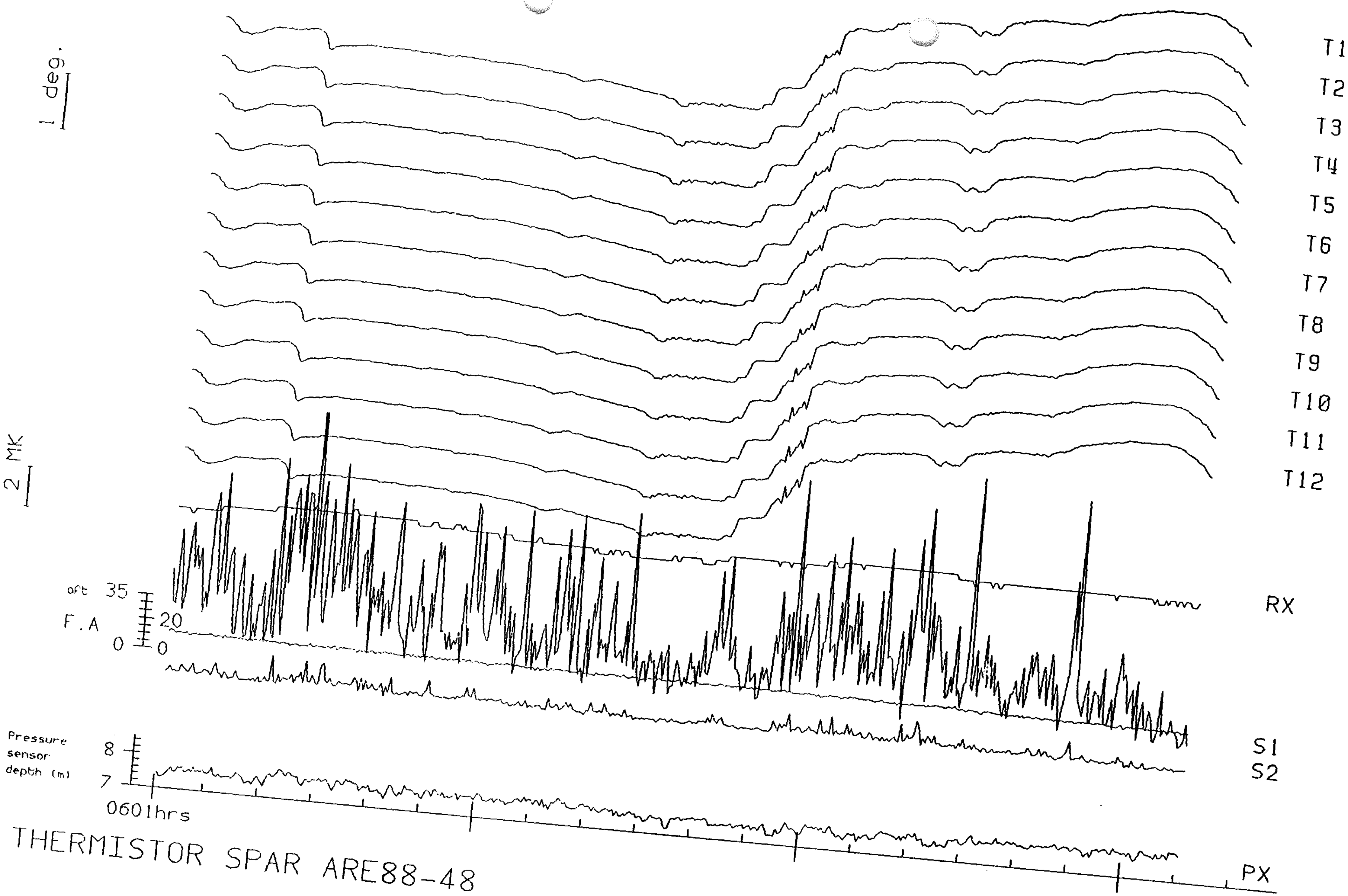


THERMISTOR SPAR ARE88-46



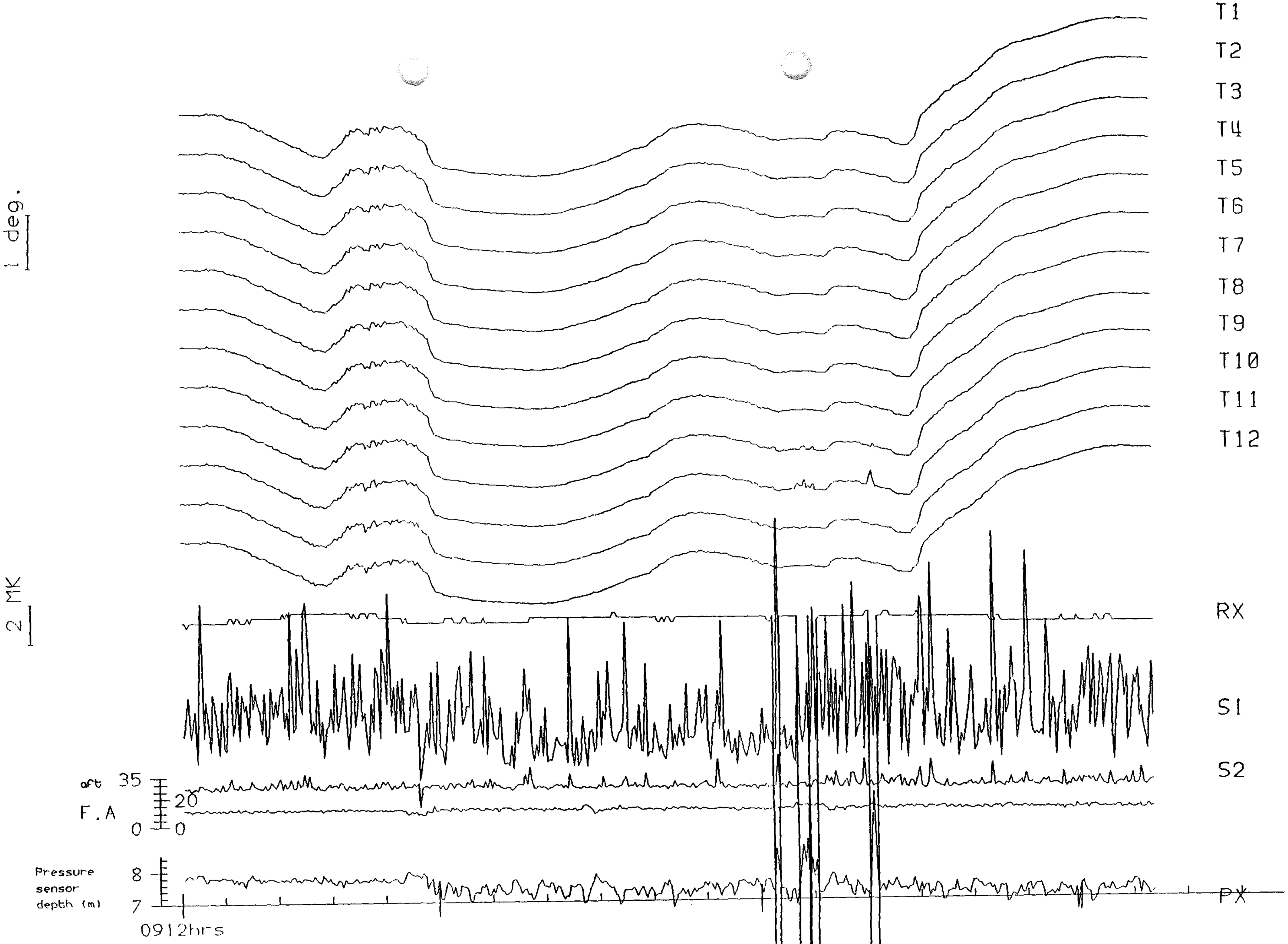
THERMISTOR SPAR ARE88-47

ALL RECORDS: 1 May 88



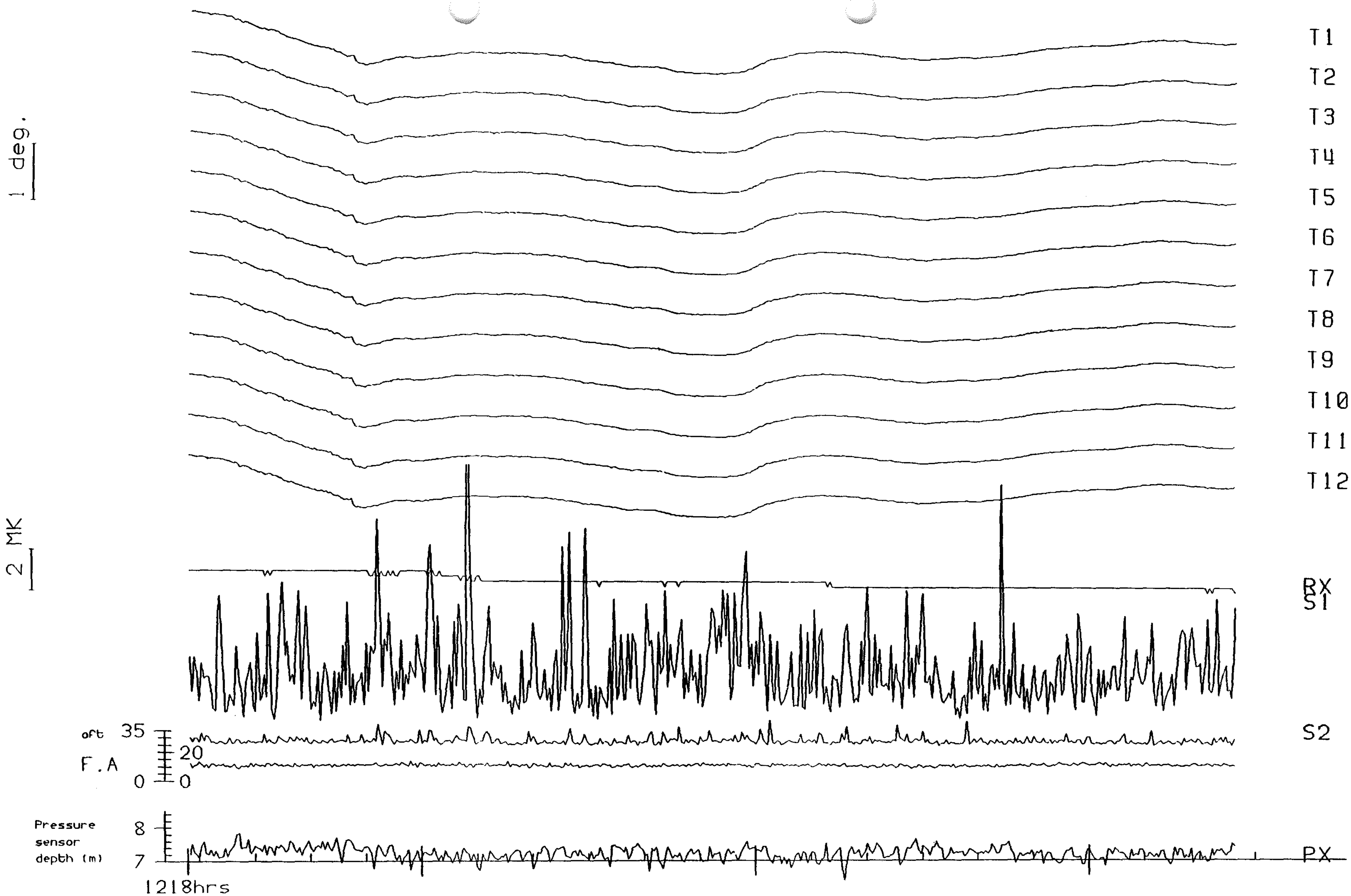
THERMISTOR SPAR ARE88-48

ALL RECORDS: 1 May 88



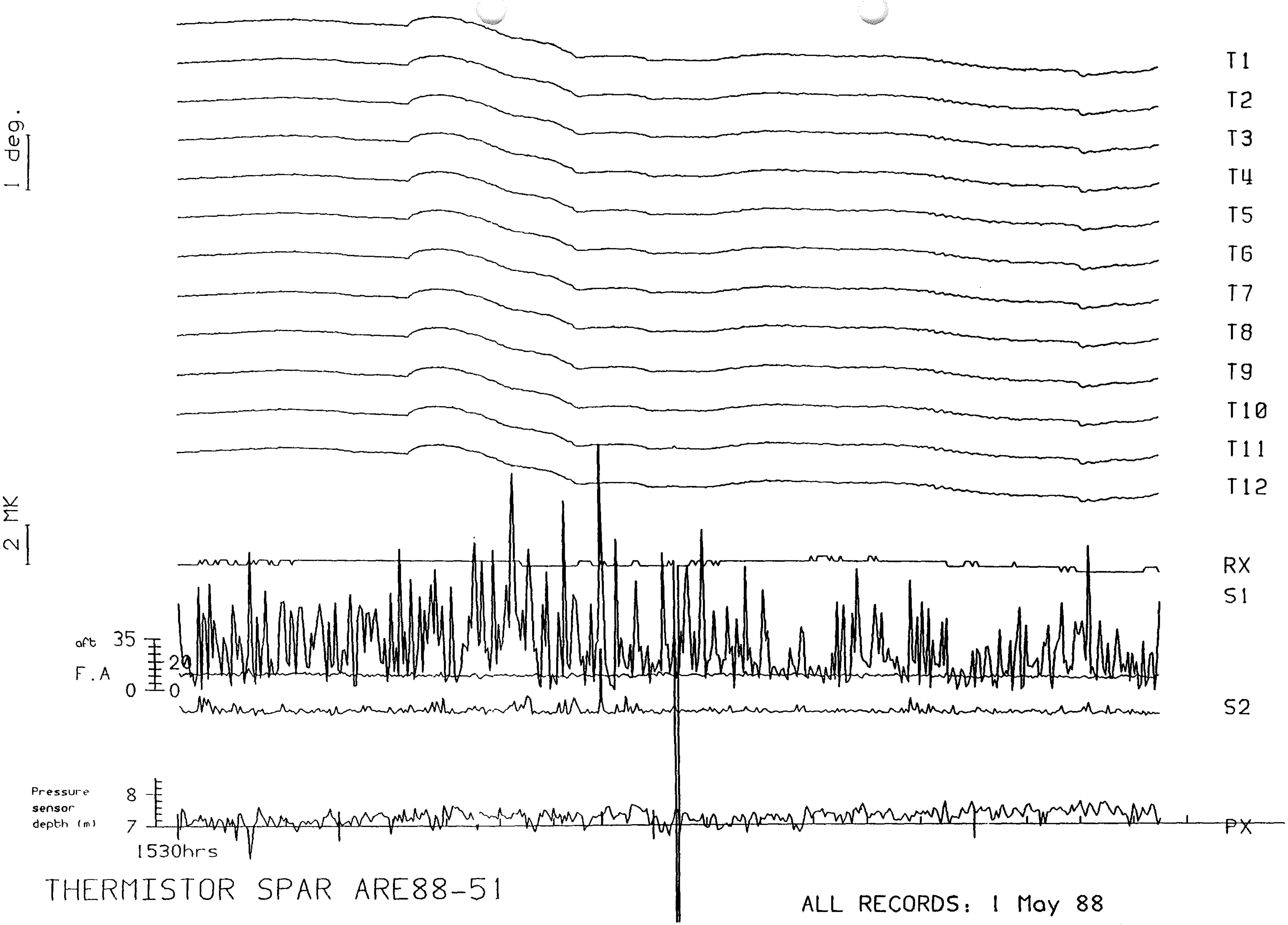
THERMISTOR SPAR ARE88-49

ALL RECORDS: 1 May 88



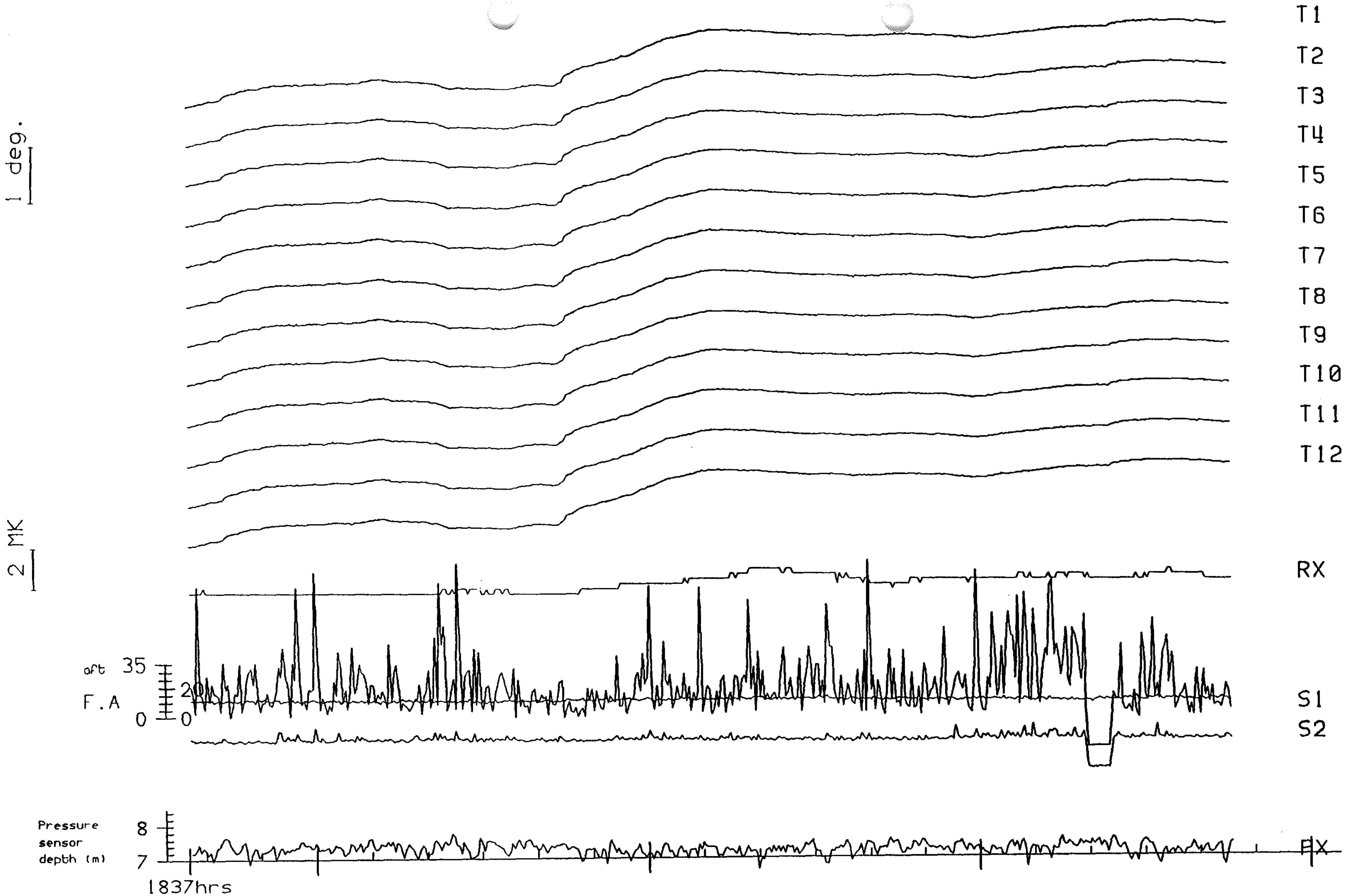
THERMISTOR SPAR ARE88-50

ALL RECORDS: 1 May 88



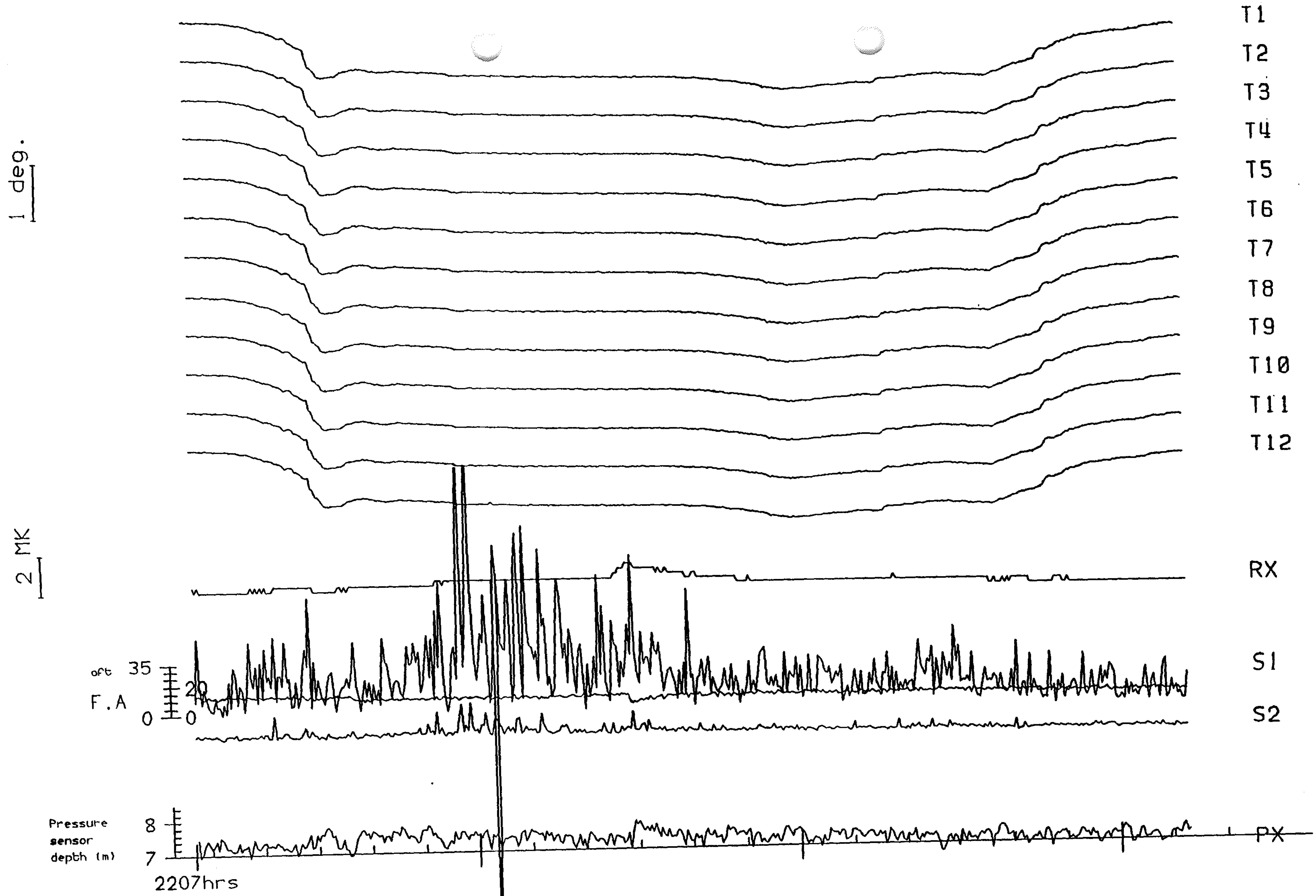
THERMISTOR SPAR ARE88-51

ALL RECORDS: 1 May 88



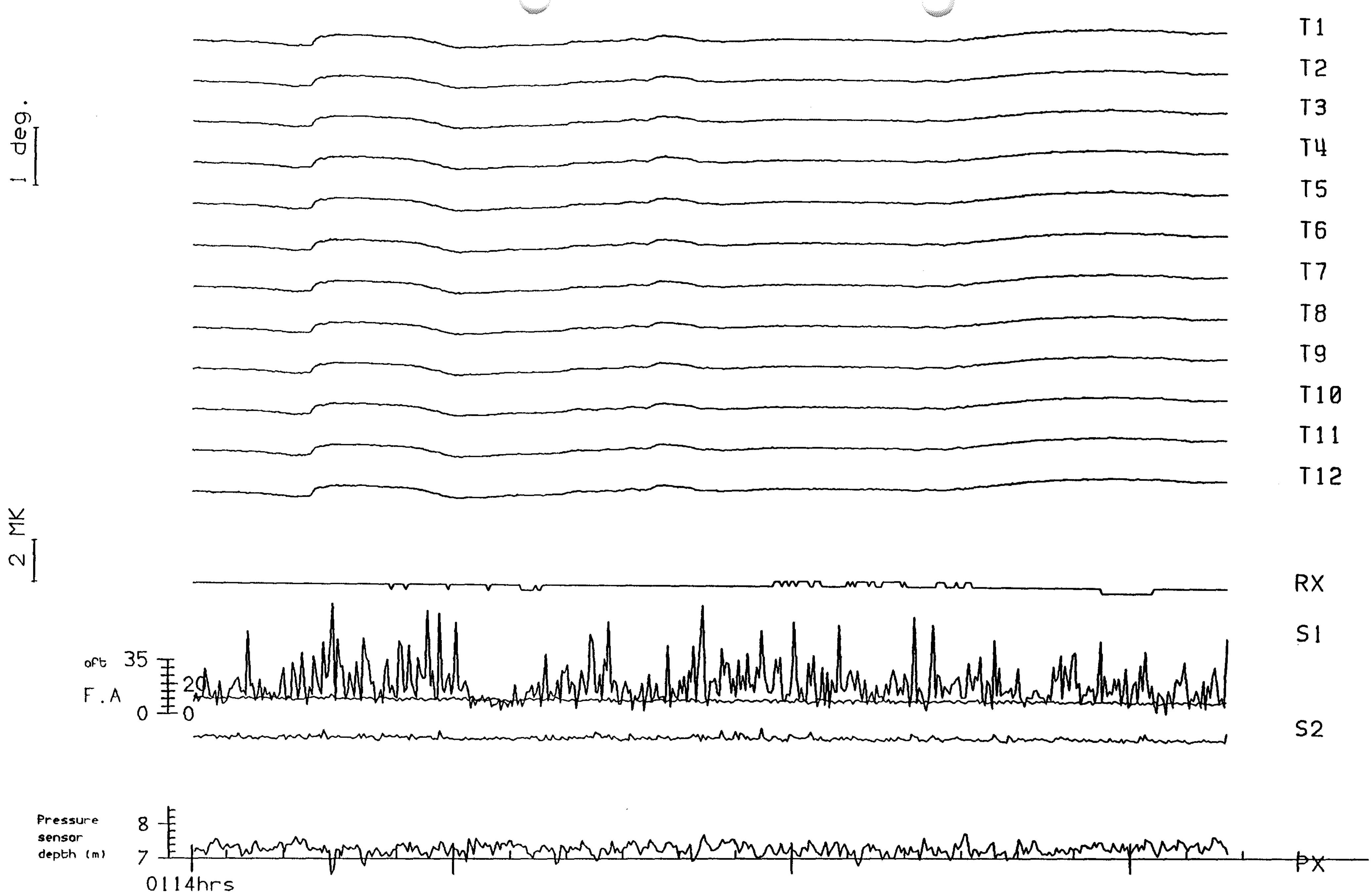
THERMISTOR SPAR ARE88-52

ALL RECORDS: 1 May 88



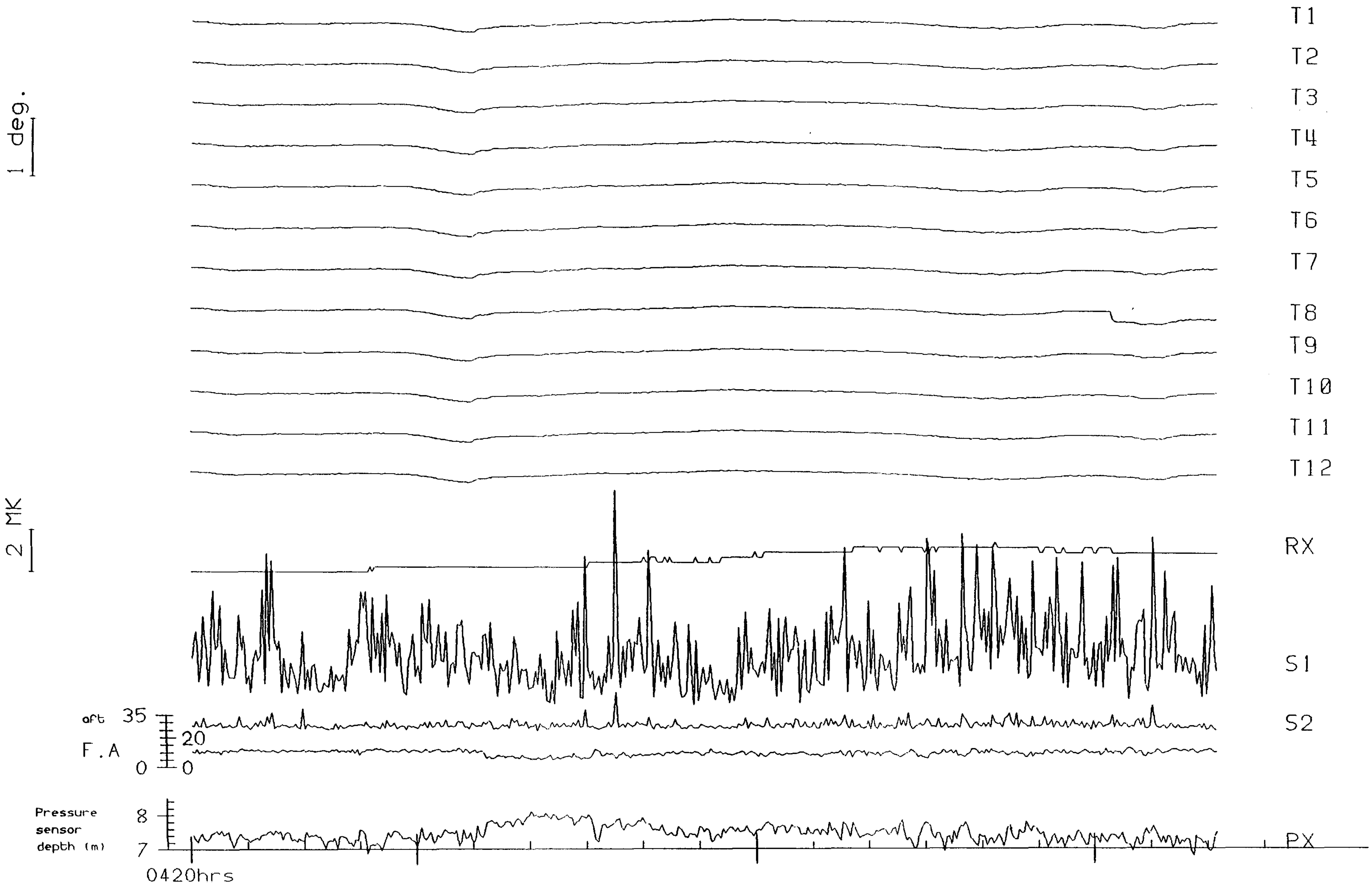
THERMISTOR SPAR ARE88-53

ALL RECORDS: 1 May 88



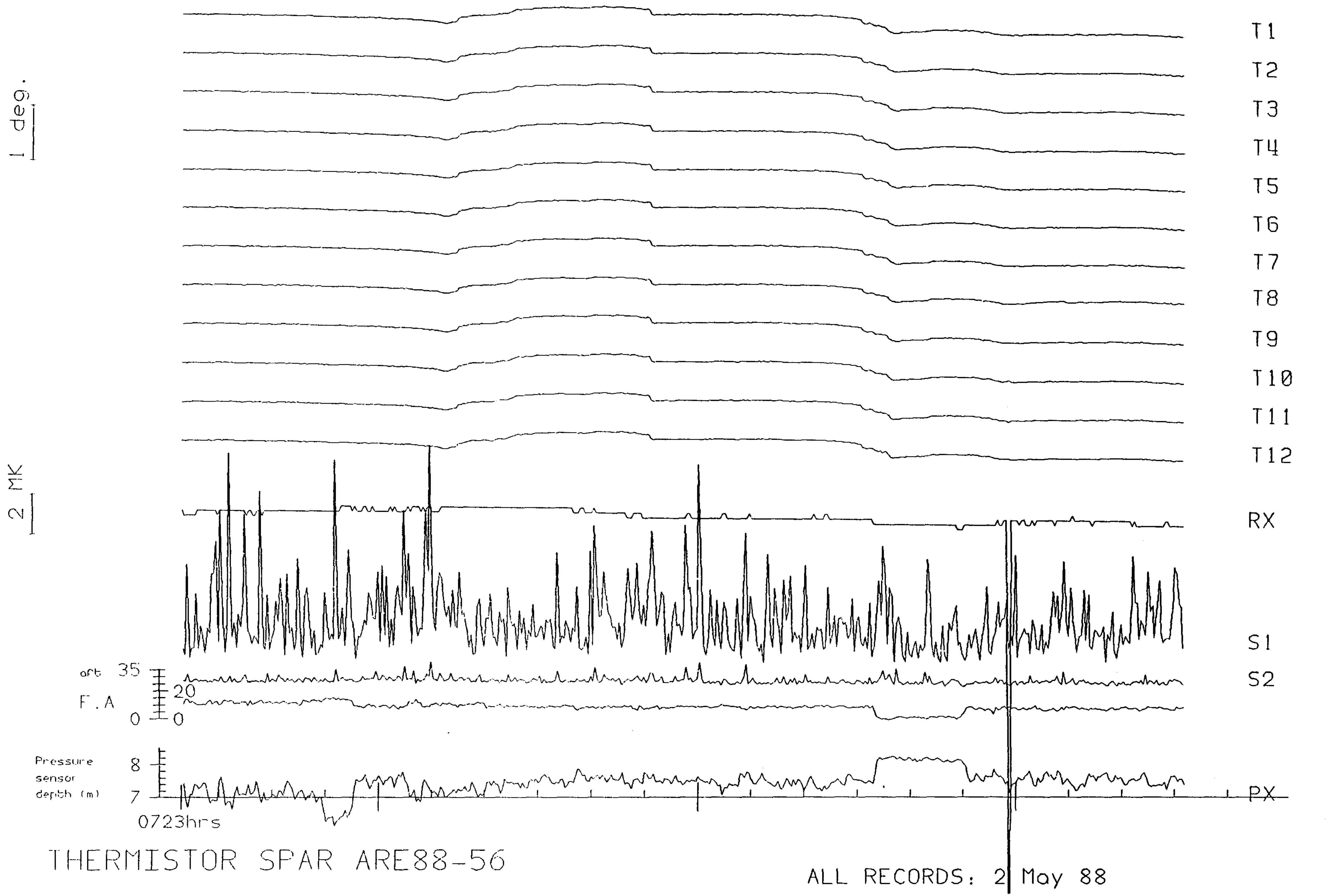
THERMISTOR SPAR ARE88-54

ALL RECORDS: 2 May 88



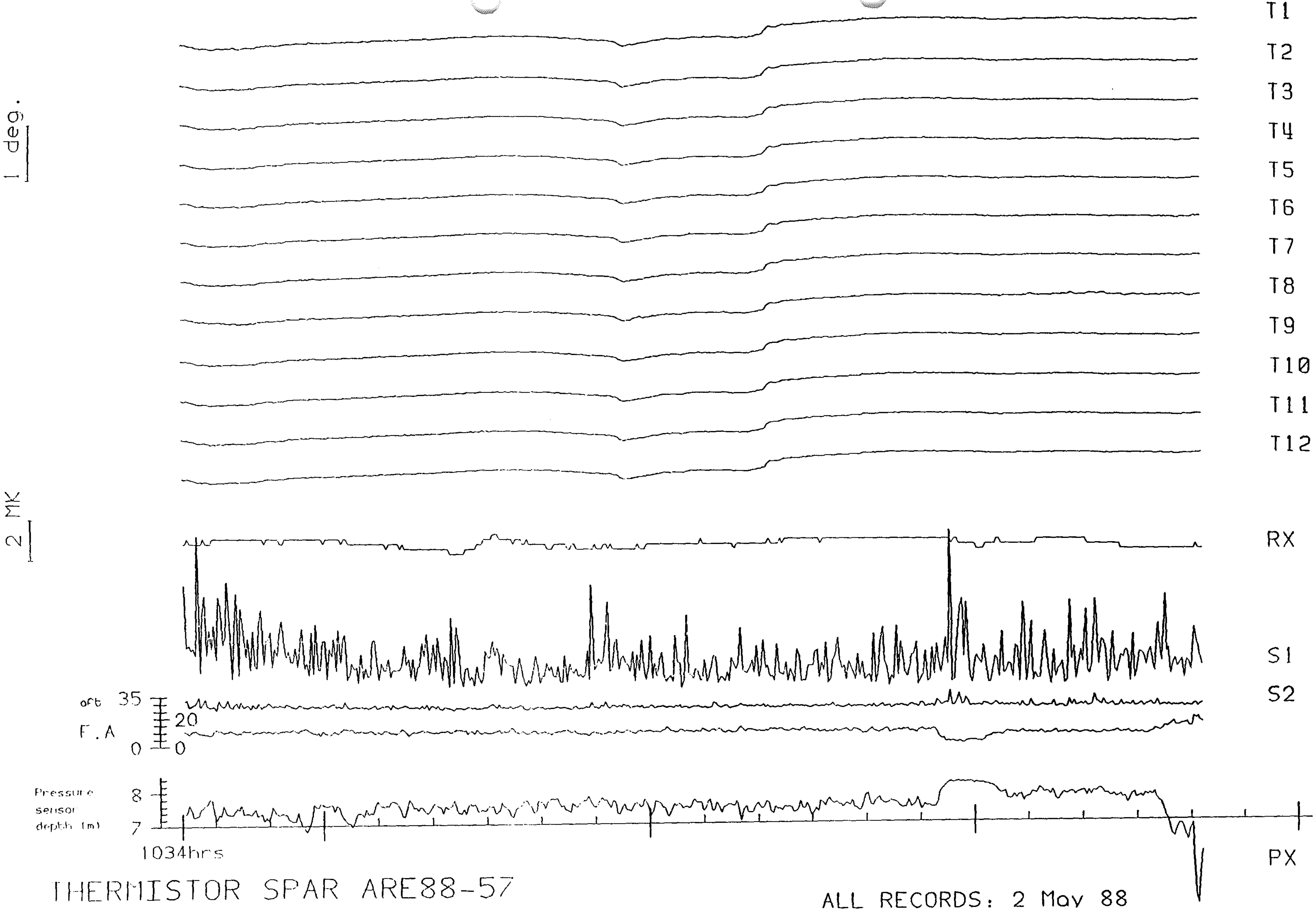
THERMISTOR SPAR ARE88-55

ALL RECORDS: 2 May 88



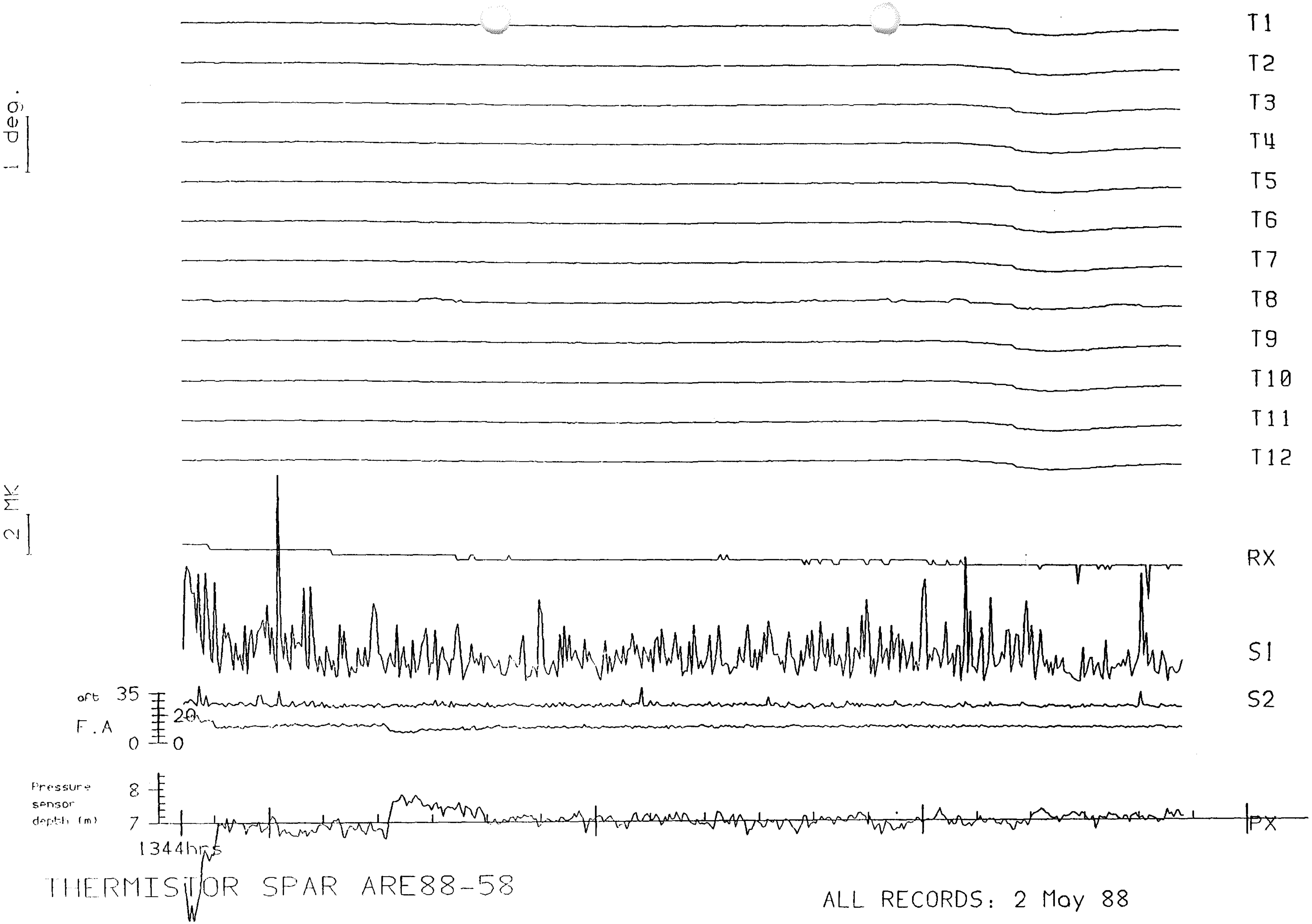
THERMISTOR SPAR ARE88-56

ALL RECORDS: 2 May 88



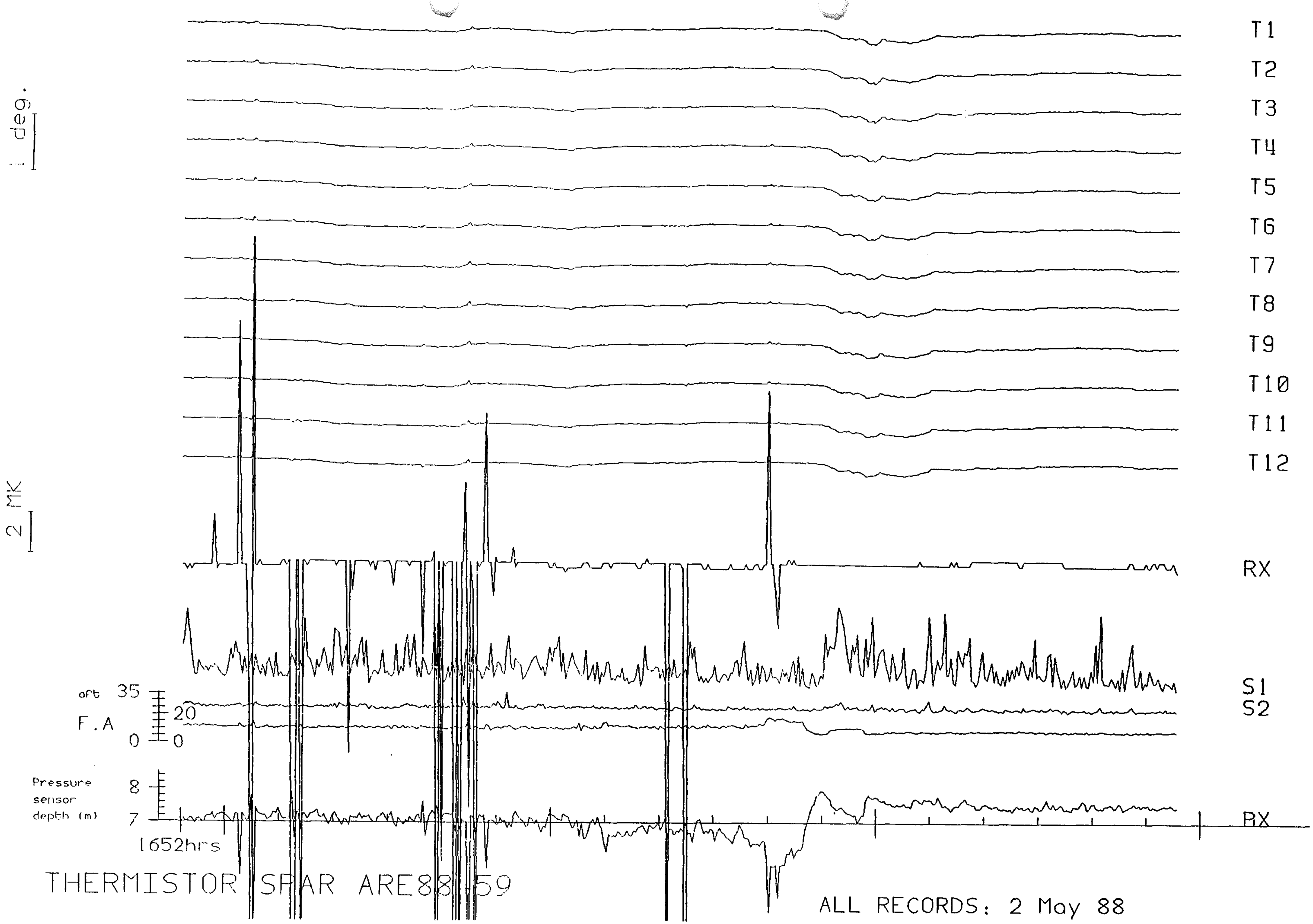
THERMISTOR SPAR ARE88-57

ALL RECORDS: 2 May 88



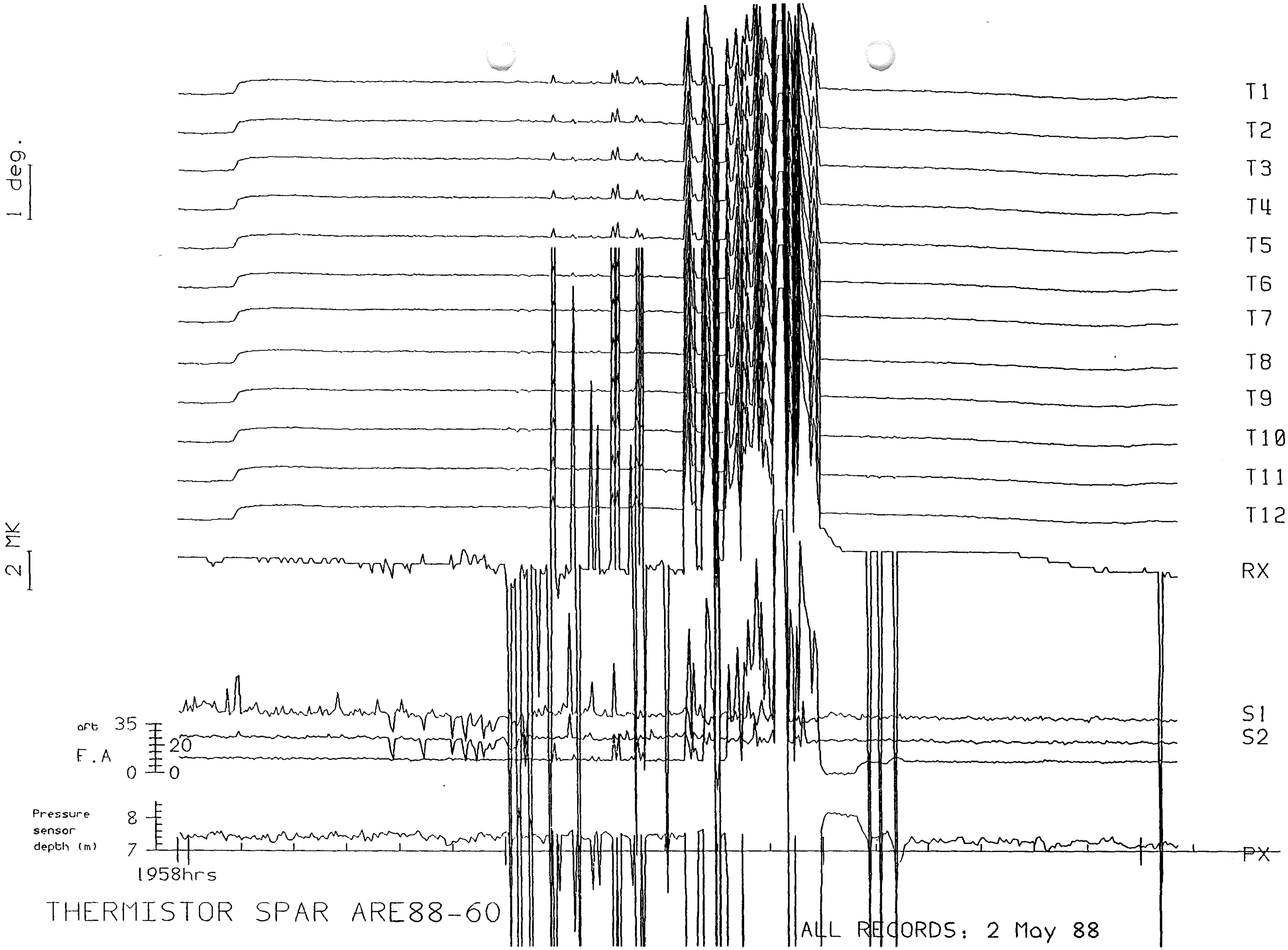
THERMISTOR SPAR ARE88-58

ALL RECORDS: 2 May 88



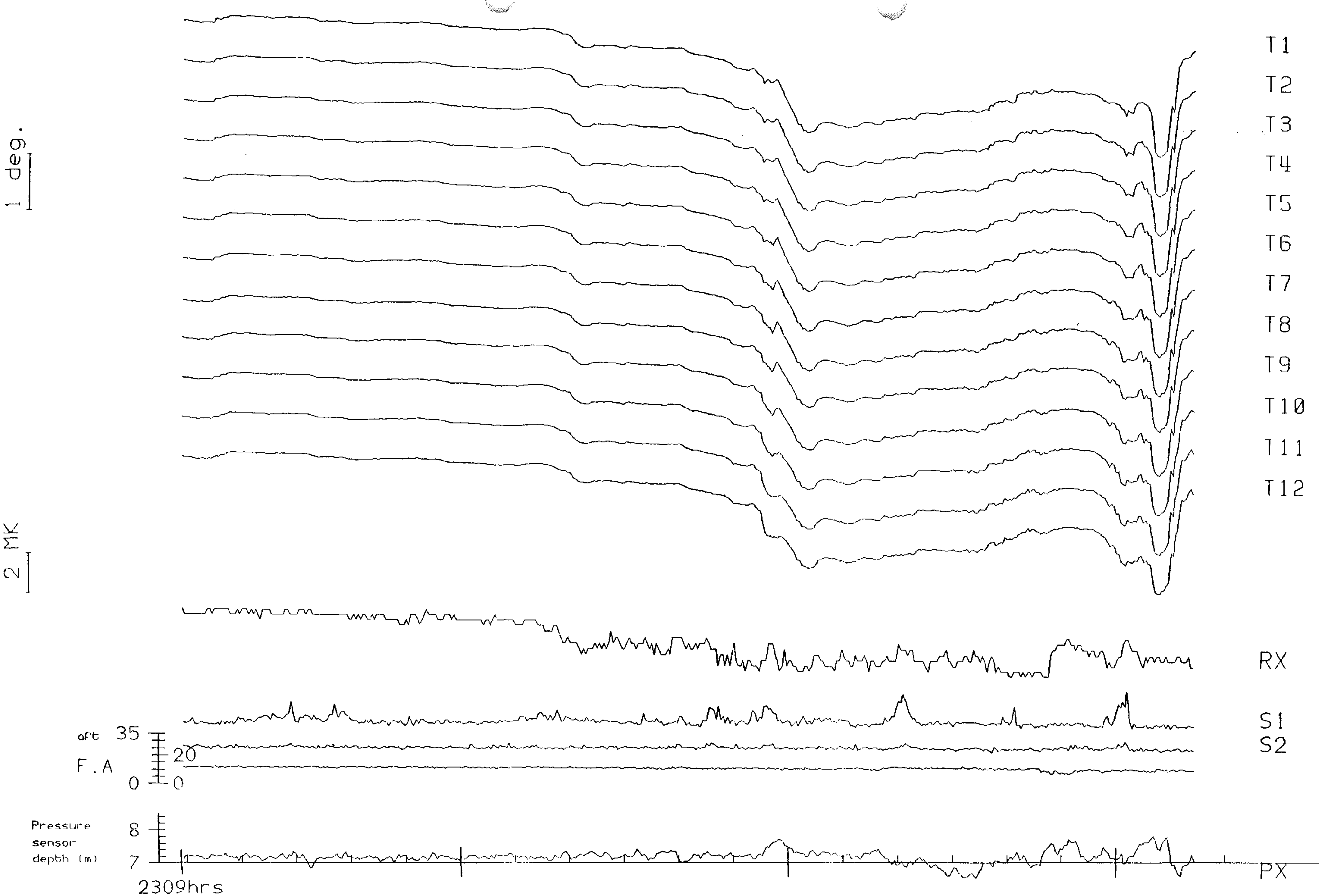
THERMISTOR SPAR ARE88-59

ALL RECORDS: 2 May 88



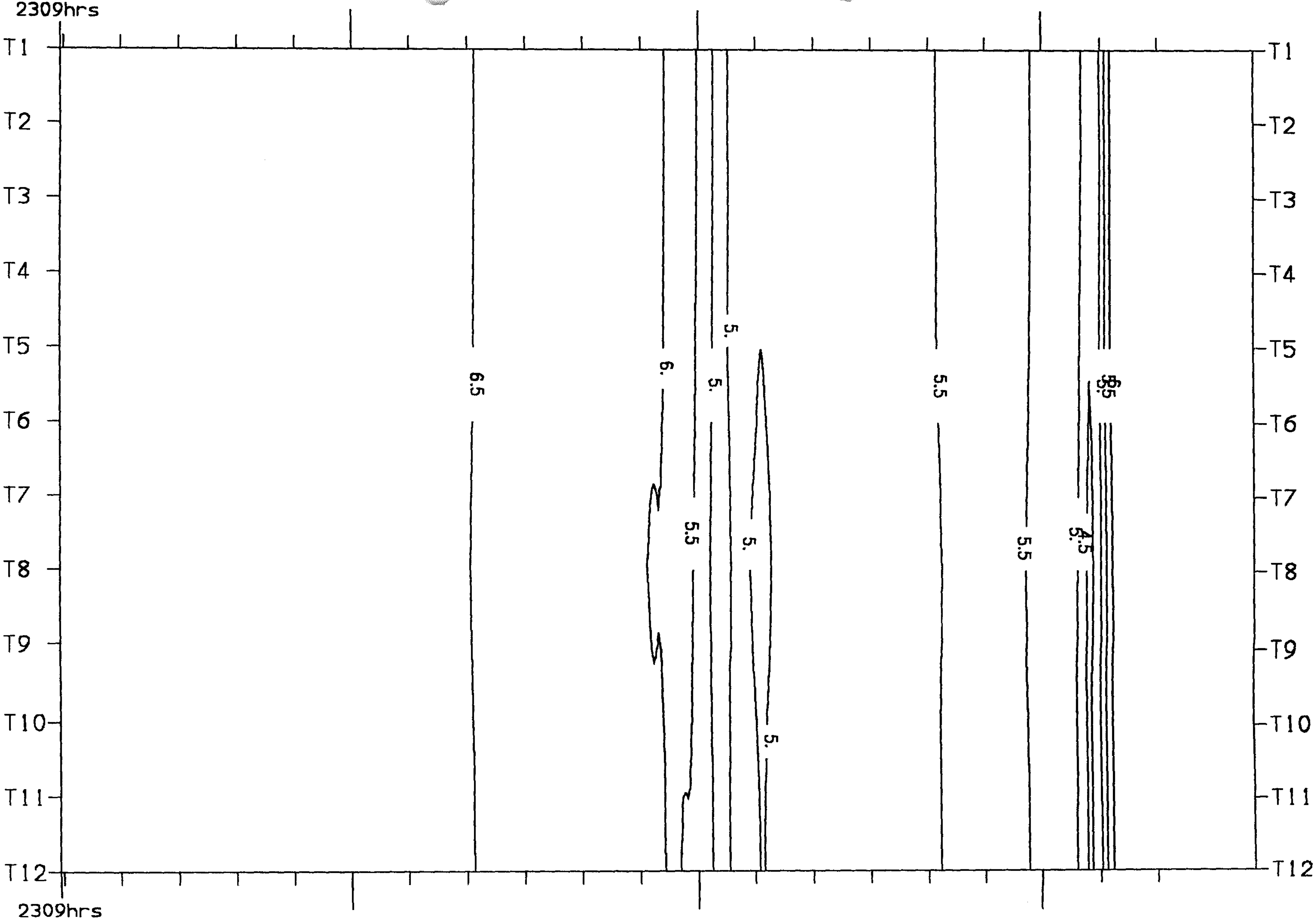
THERMISTOR SPAR ARE88-60

ALL RECORDS: 2 May 88



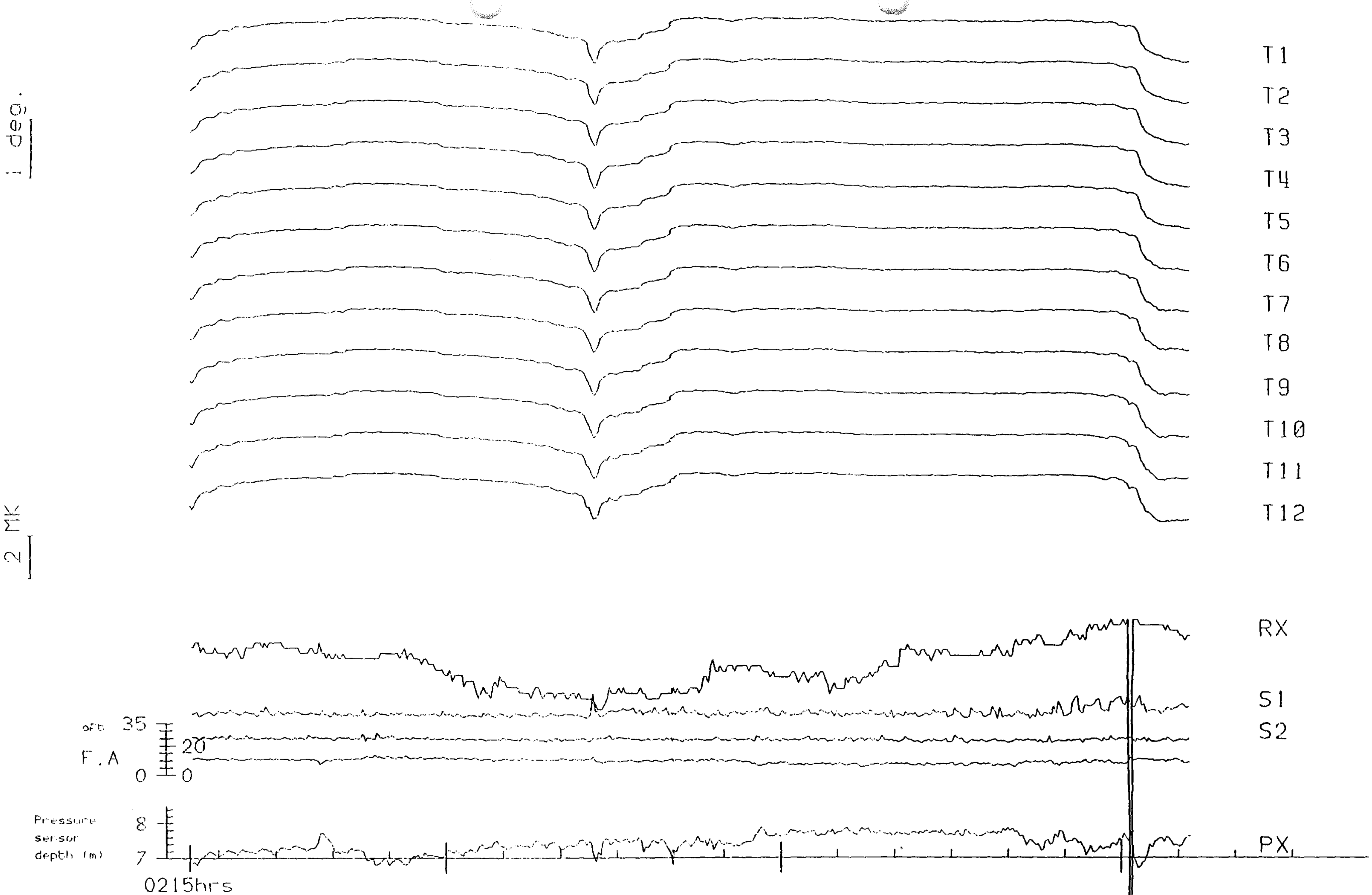
THERMISTOR SPAR ARE88-61

ALL RECORDS: 2 May 88



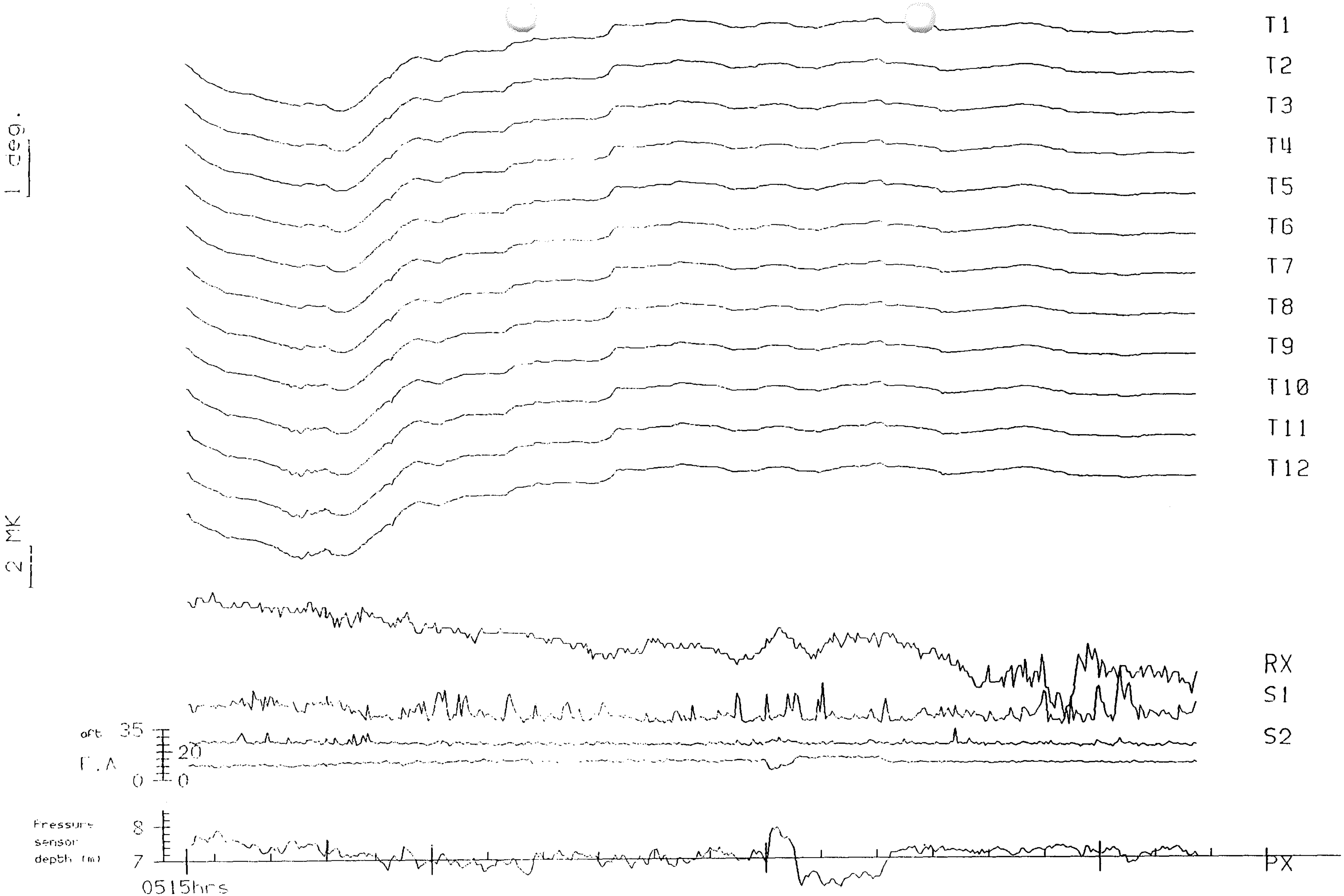
THERMISTOR SPAR ARE88-61

All records 2 May 1988



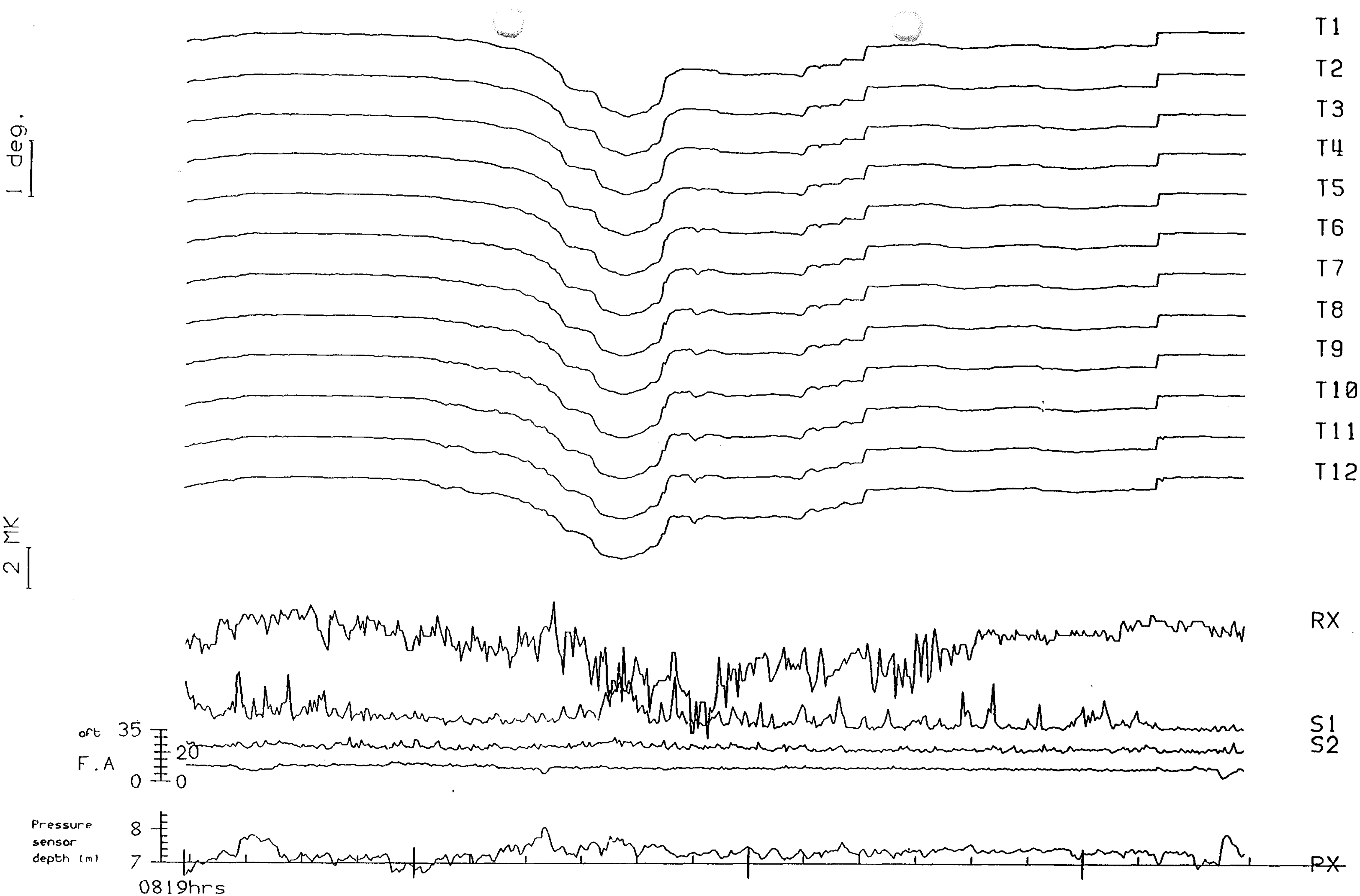
THERMISTOR SPAR ARE88-62

ALL RECORDS: 3 May 88



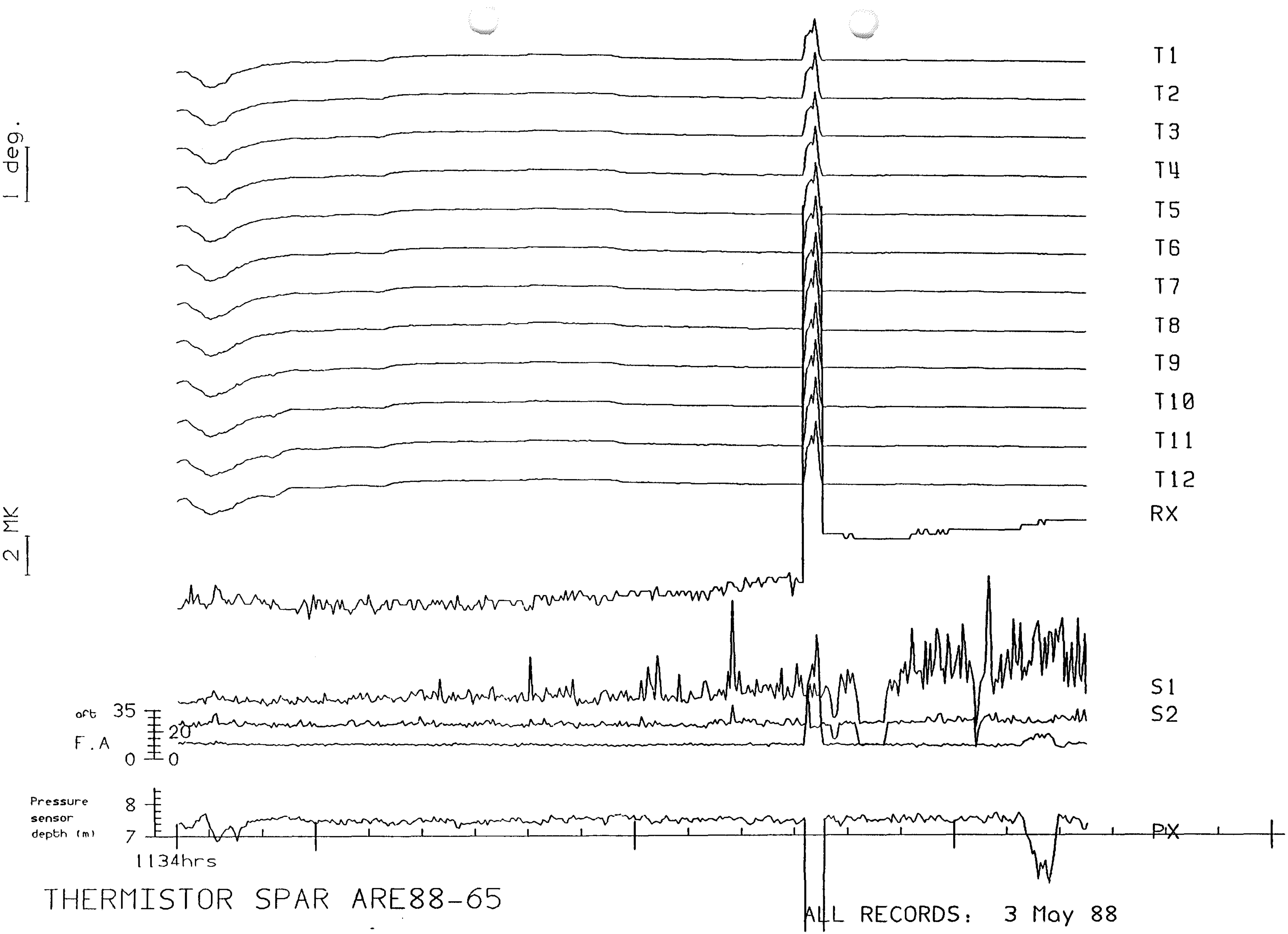
THERMISTOR SPAR ARE88-63

ALL RECORDS: 3 May 88



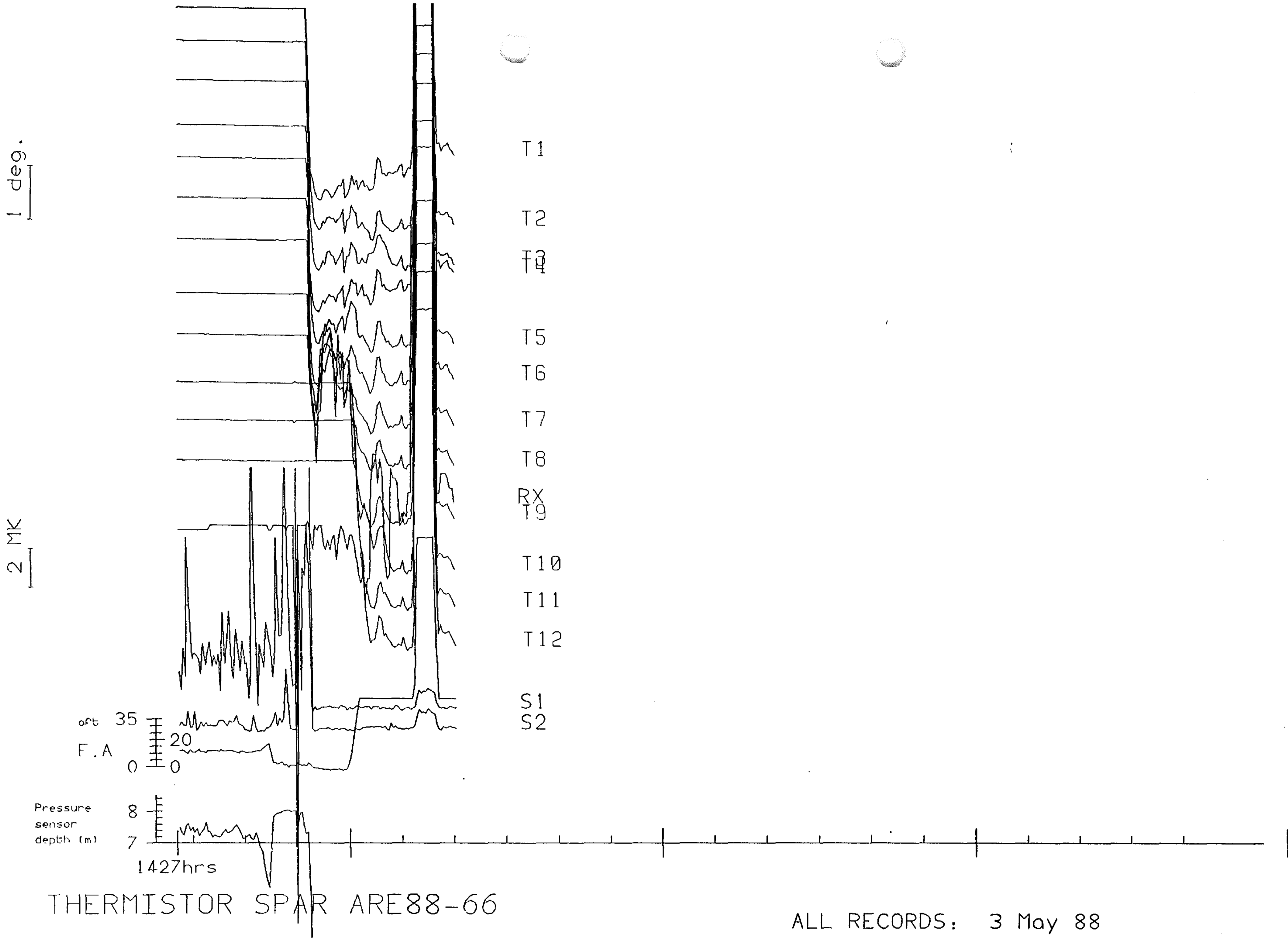
THERMISTOR SPAR ARE88-64

ALL RECORDS: 3 May 88



THERMISTOR SPAR ARE88-65

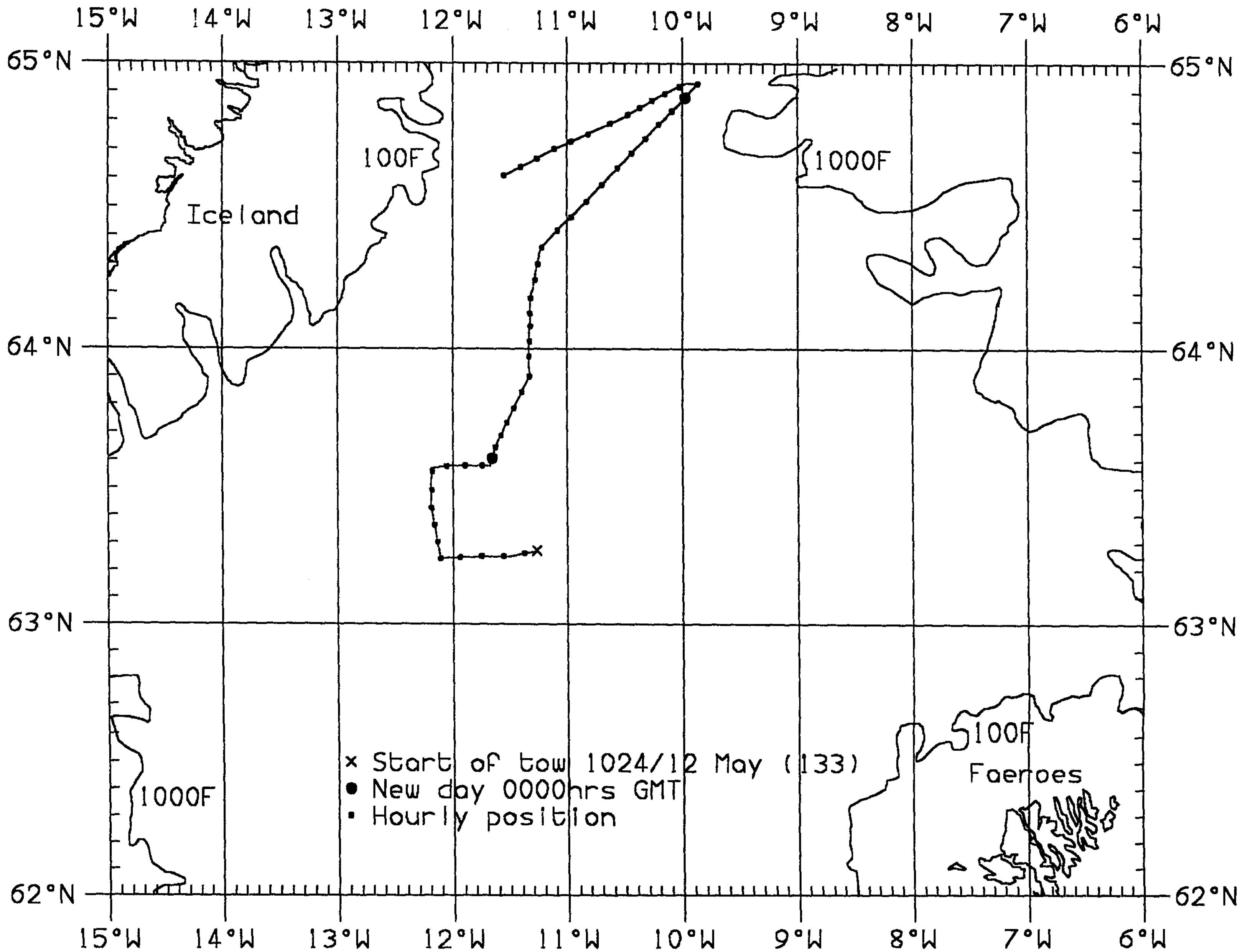
ALL RECORDS: 3 May 88



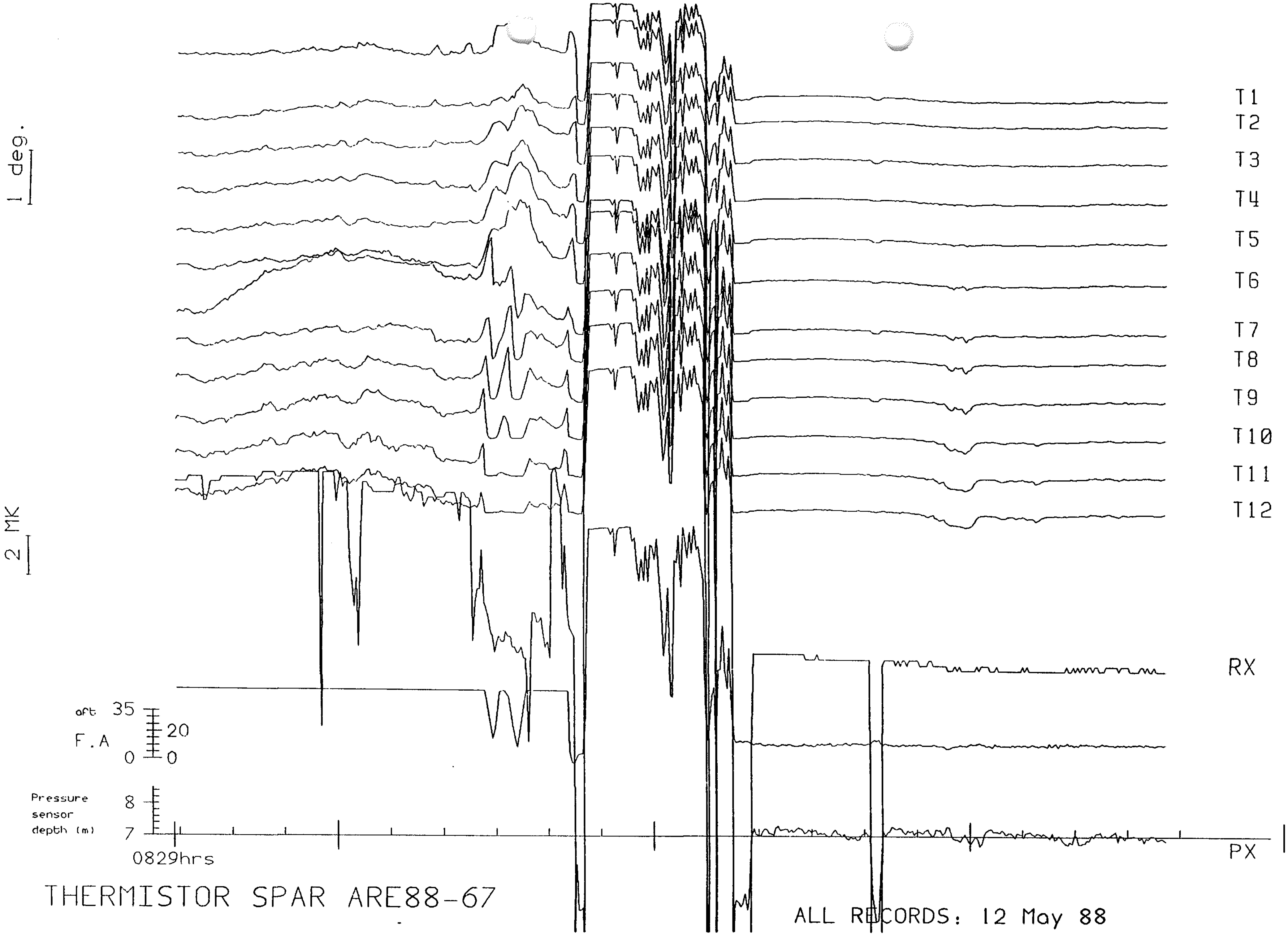
THERMISTOR SPAR ARE88-66

ALL RECORDS: 3 May 88

Appendix 3 : Tow 3

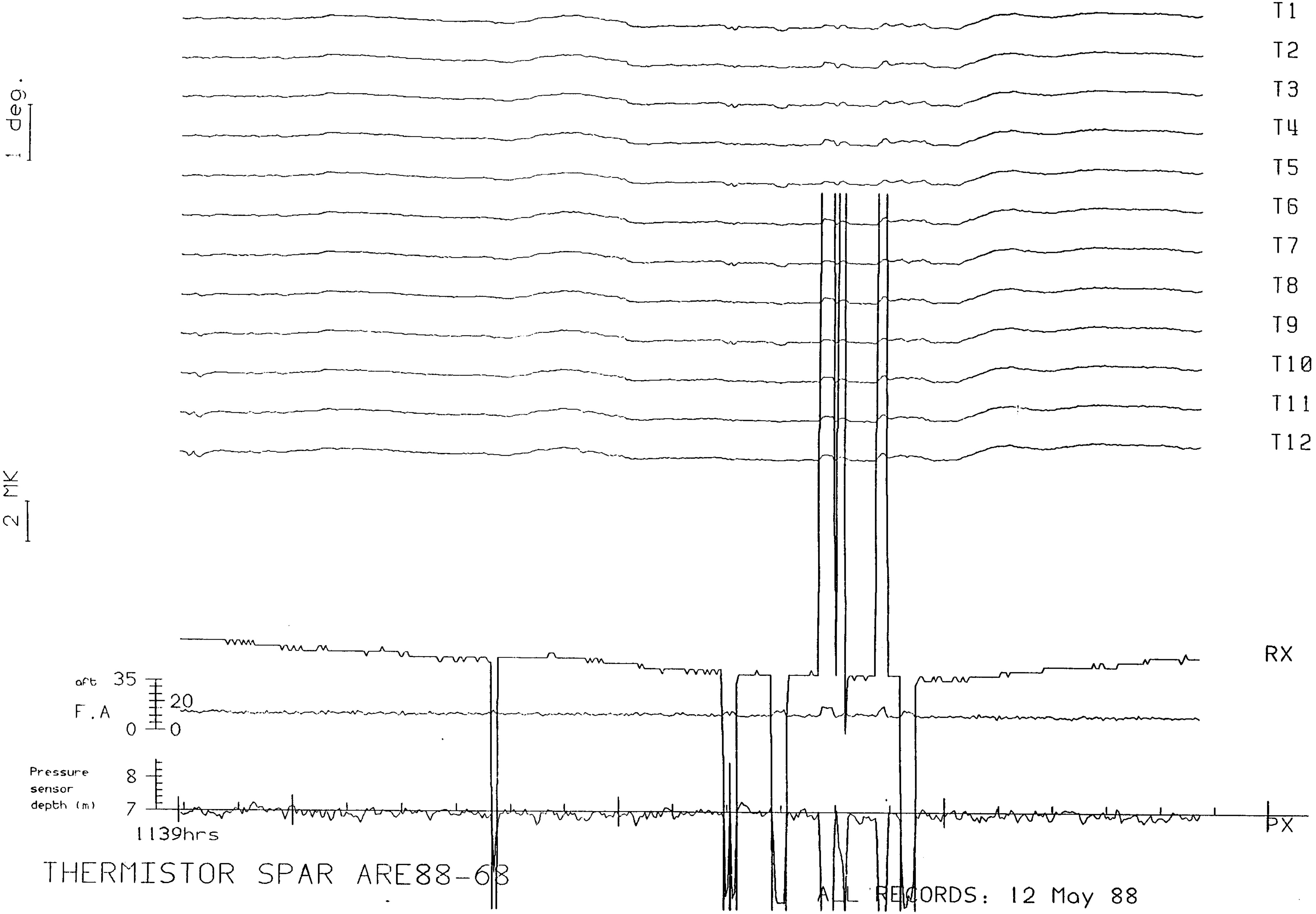


THERMISTOR SPAR TRACKPLOT TOW3 (ARE88-67 to 83)



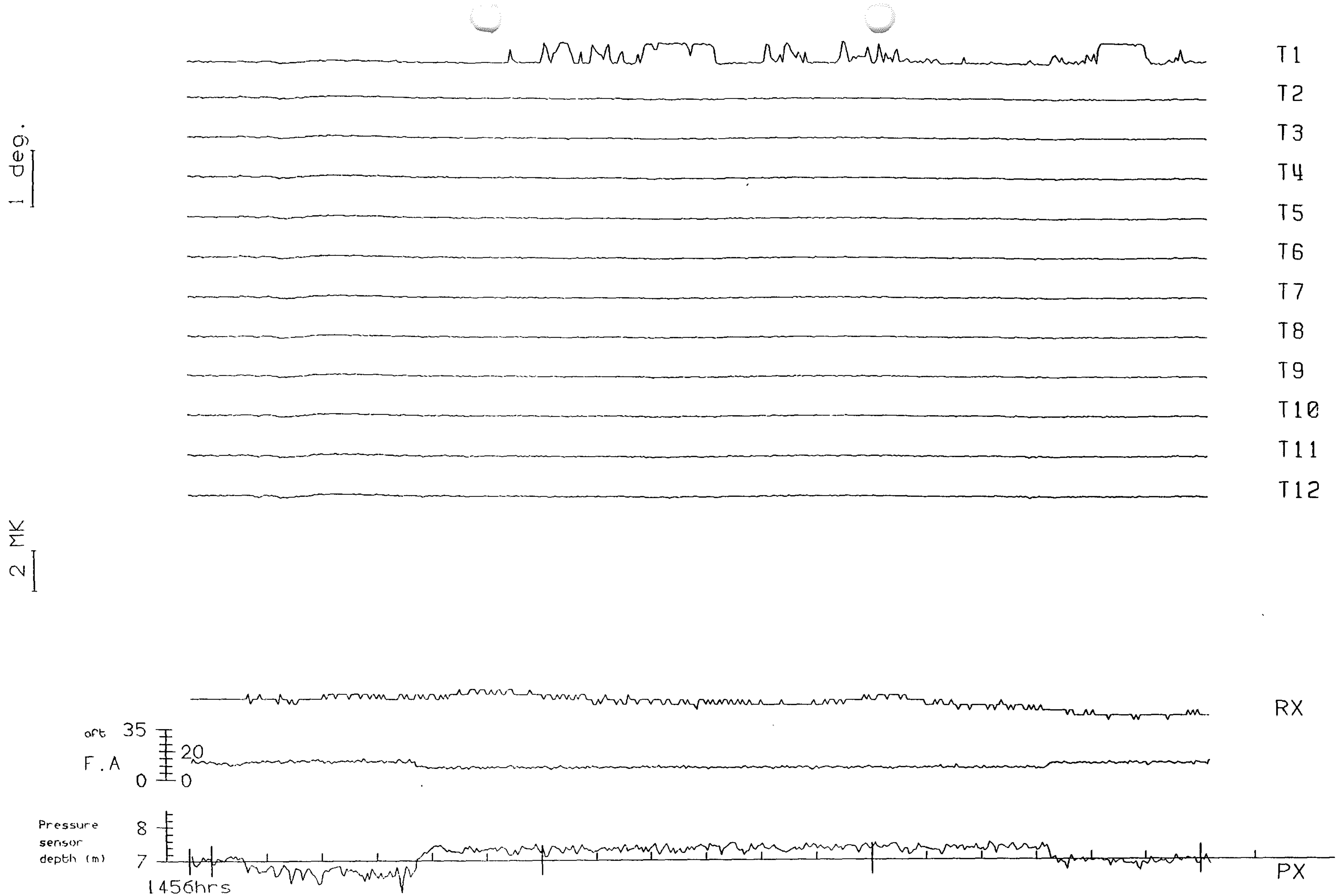
THERMISTOR SPAR ARE88-67

ALL RECORDS: 12 May 88



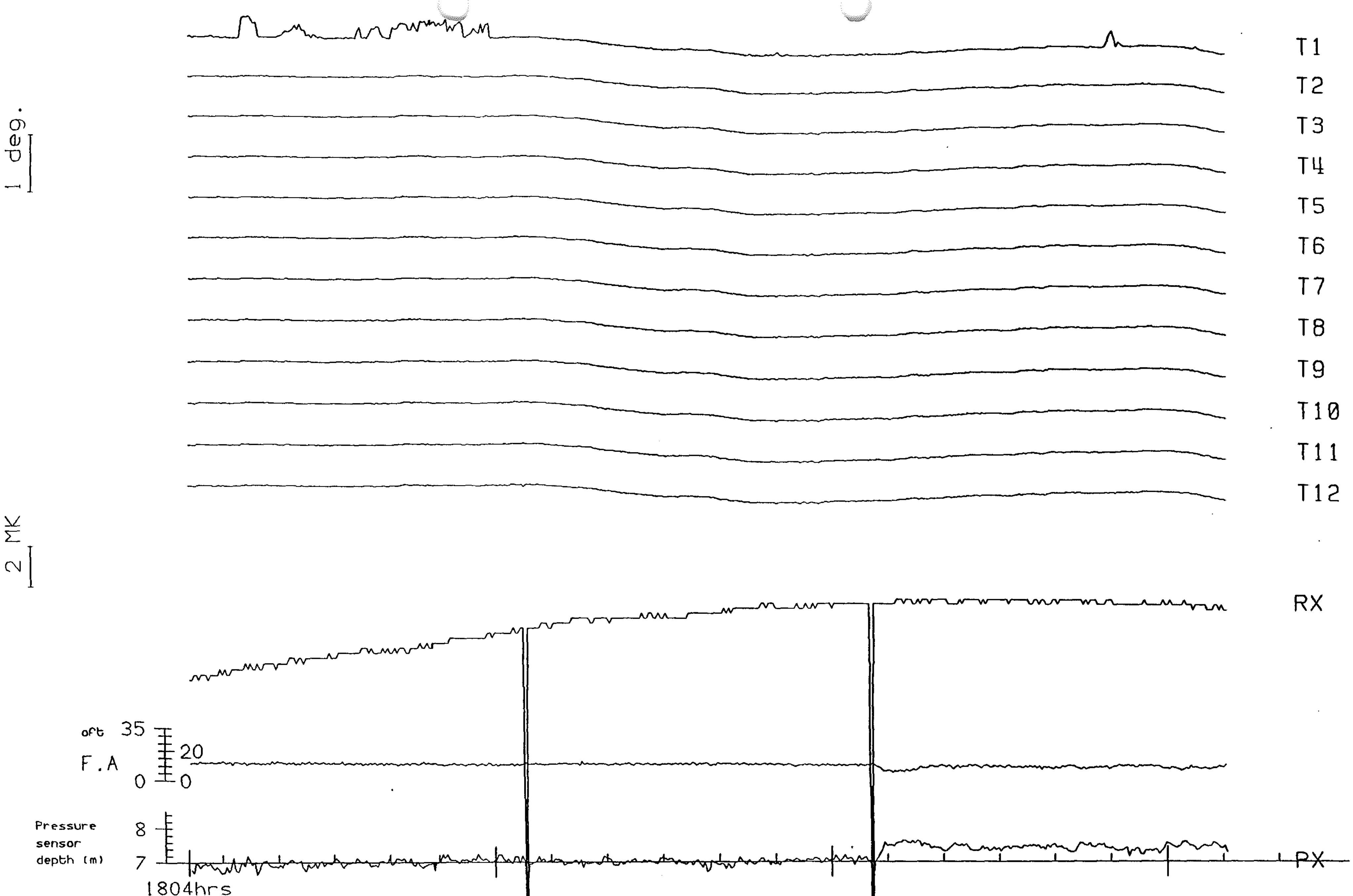
THERMISTOR SPAR ARE88-68

ALL RECORDS: 12 May 88



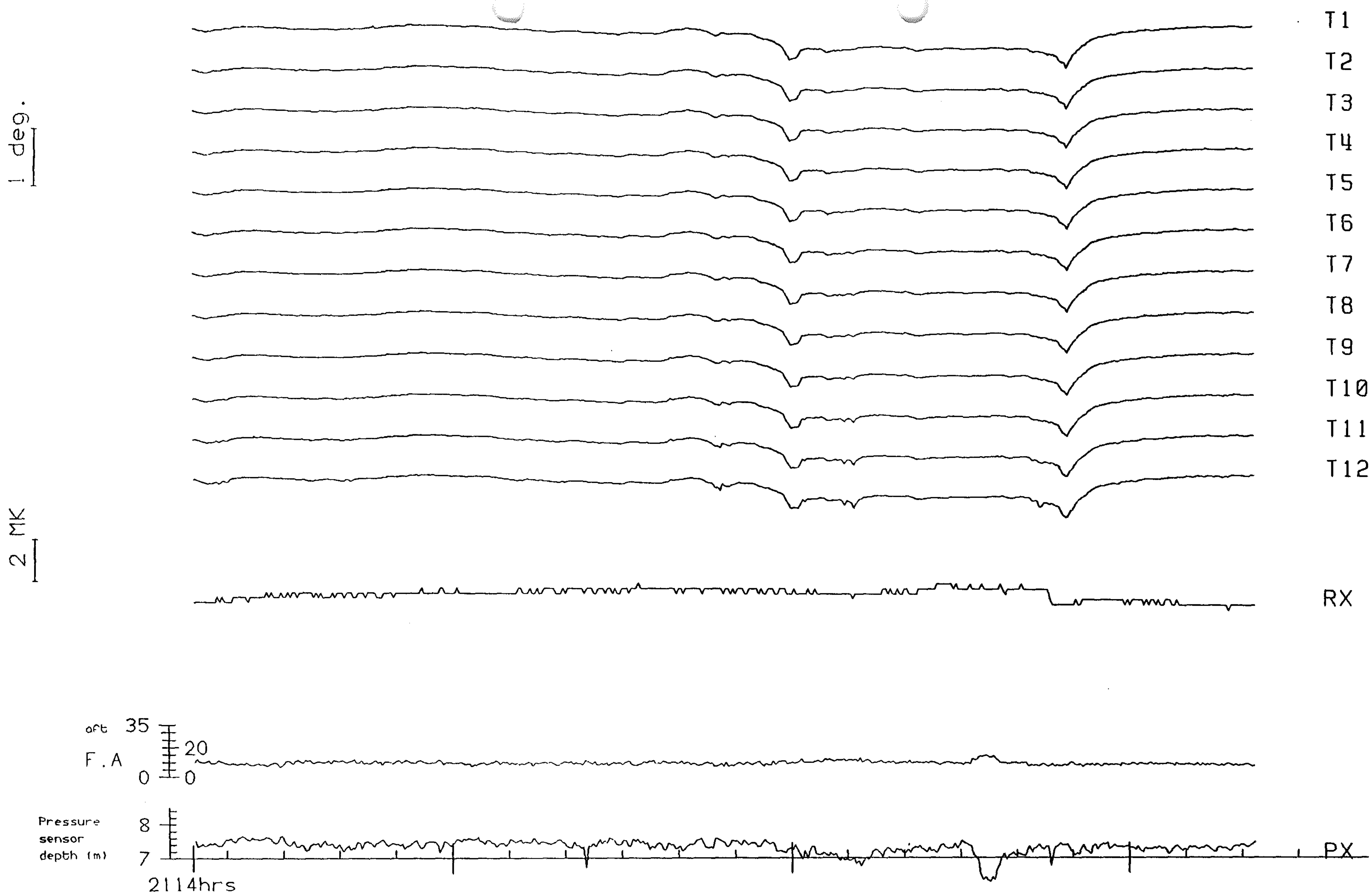
THERMISTOR SPAR ARE88-69

ALL RECORDS: 12 May 88



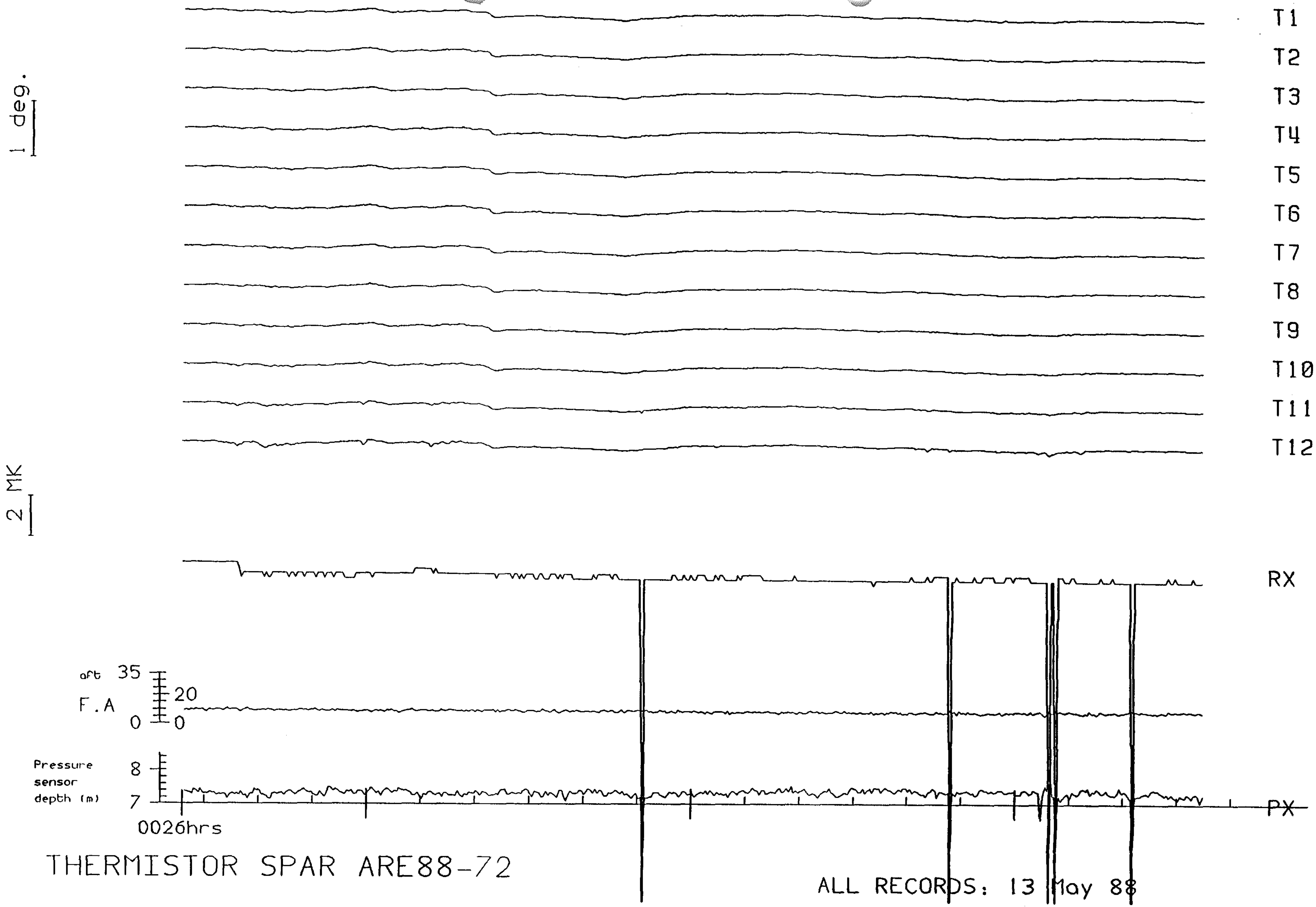
THERMISTOR SPAR ARE88-70

ALL RECORDS: 12 May 88



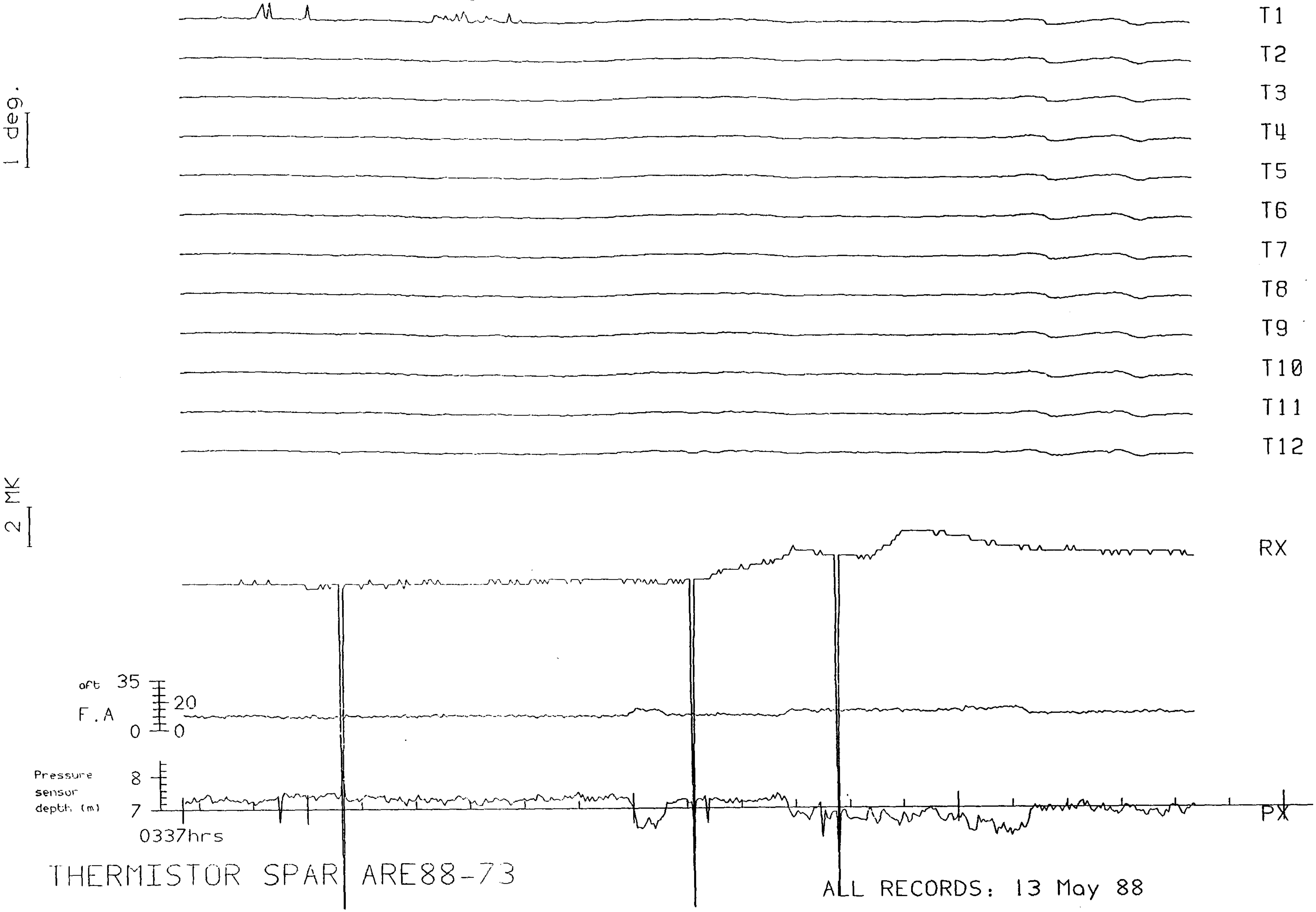
THERMISTOR SPAR ARE88-71

ALL RECORDS: 12 May 88



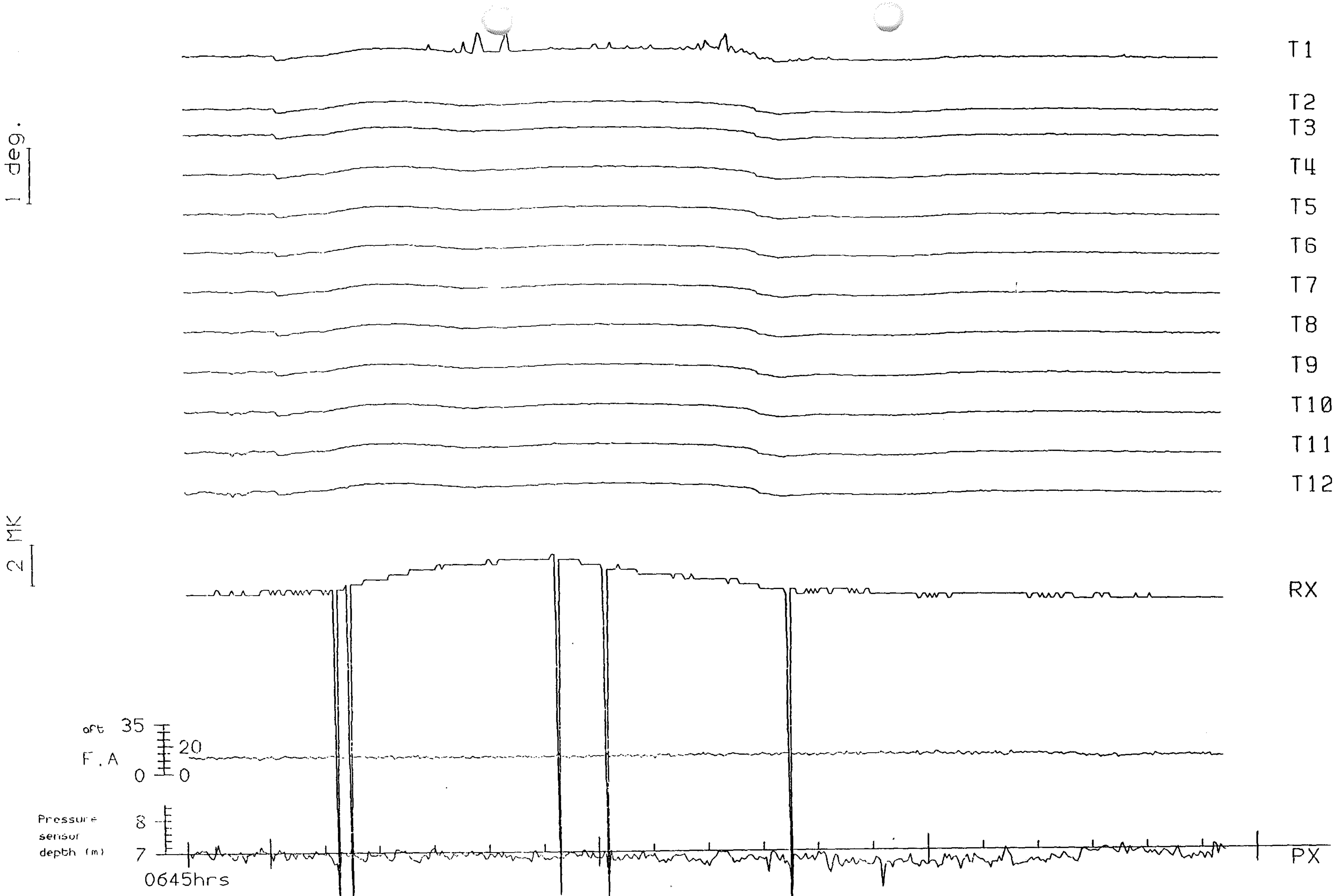
THERMISTOR SPAR ARE88-72

ALL RECORDS: 13 May 88



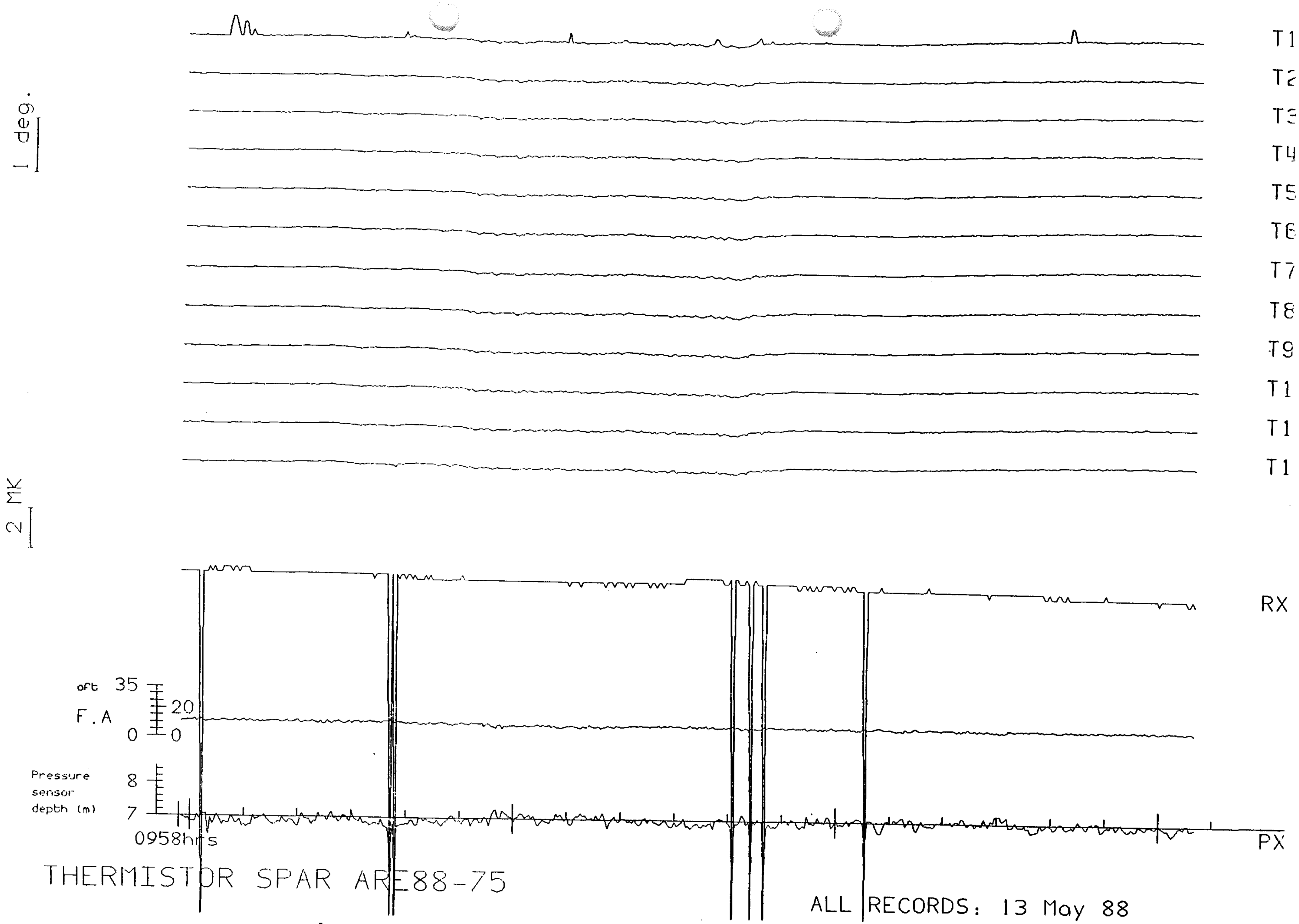
THERMISTOR SPAR ARE88-73

ALL RECORDS: 13 May 88



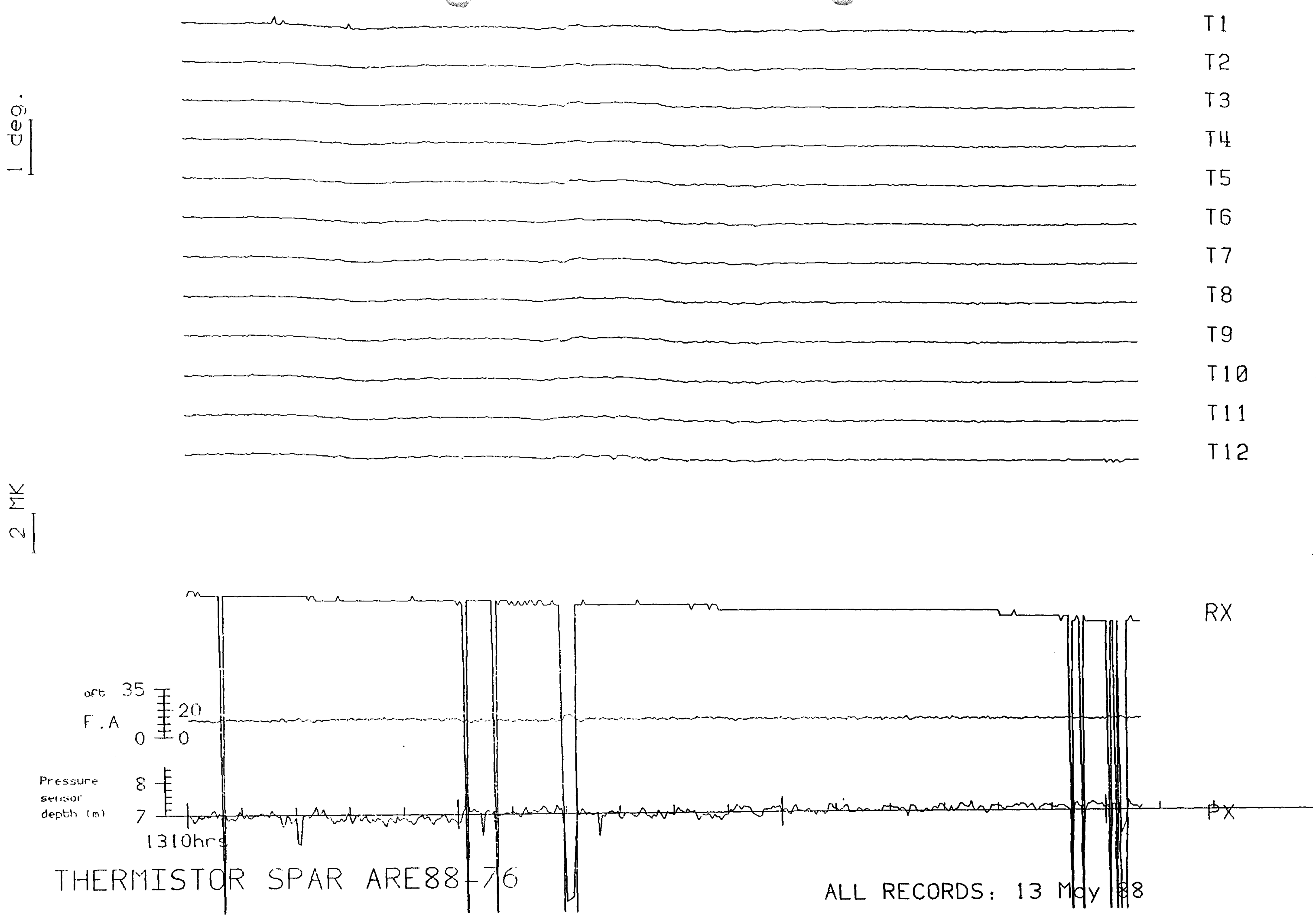
THERMISTOR SPAR ARE88-74

ALL RECORDS: 13 May 88



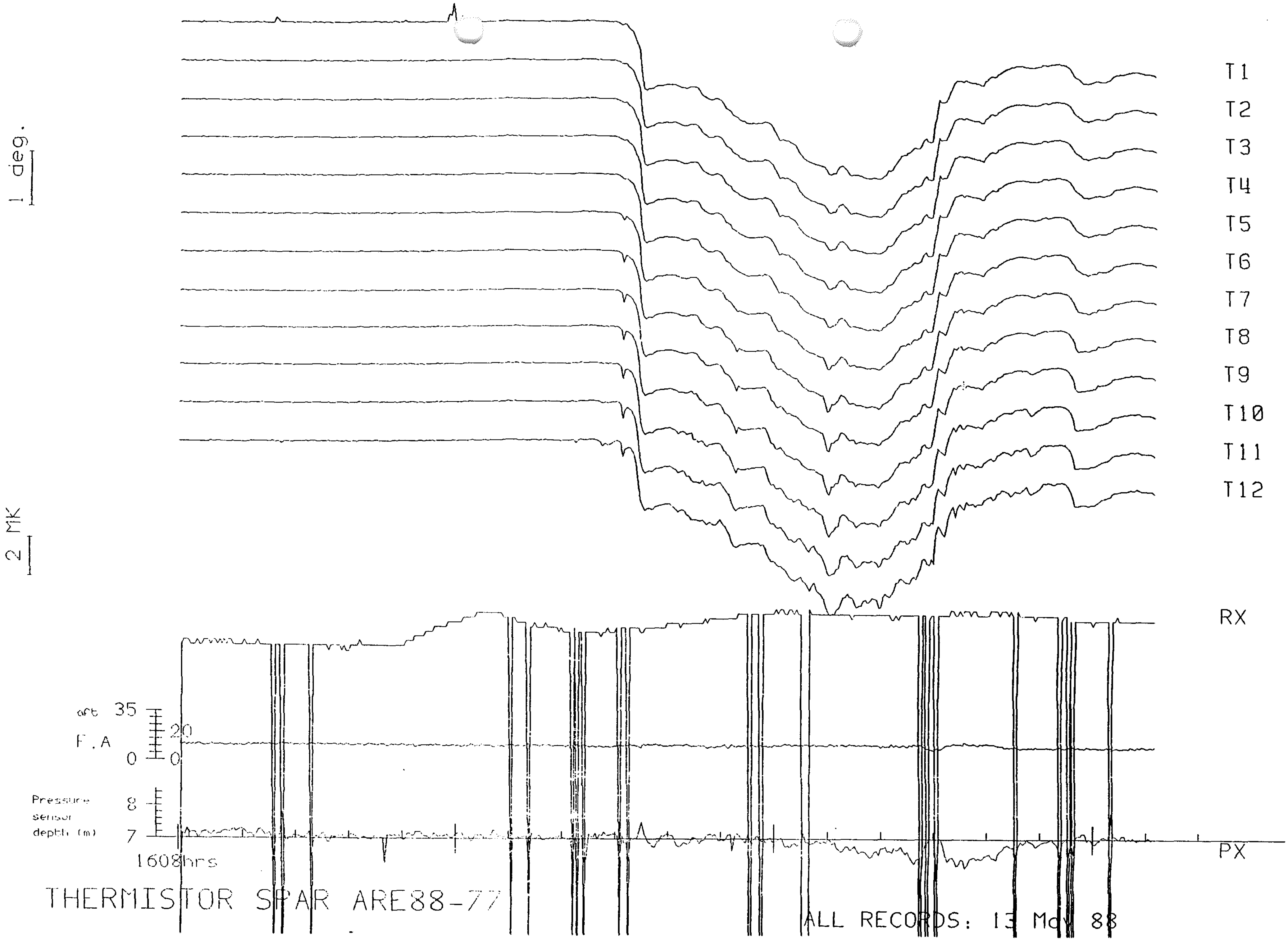
THERMISTOR SPAR ARE88-75

ALL RECORDS: 13 May 88



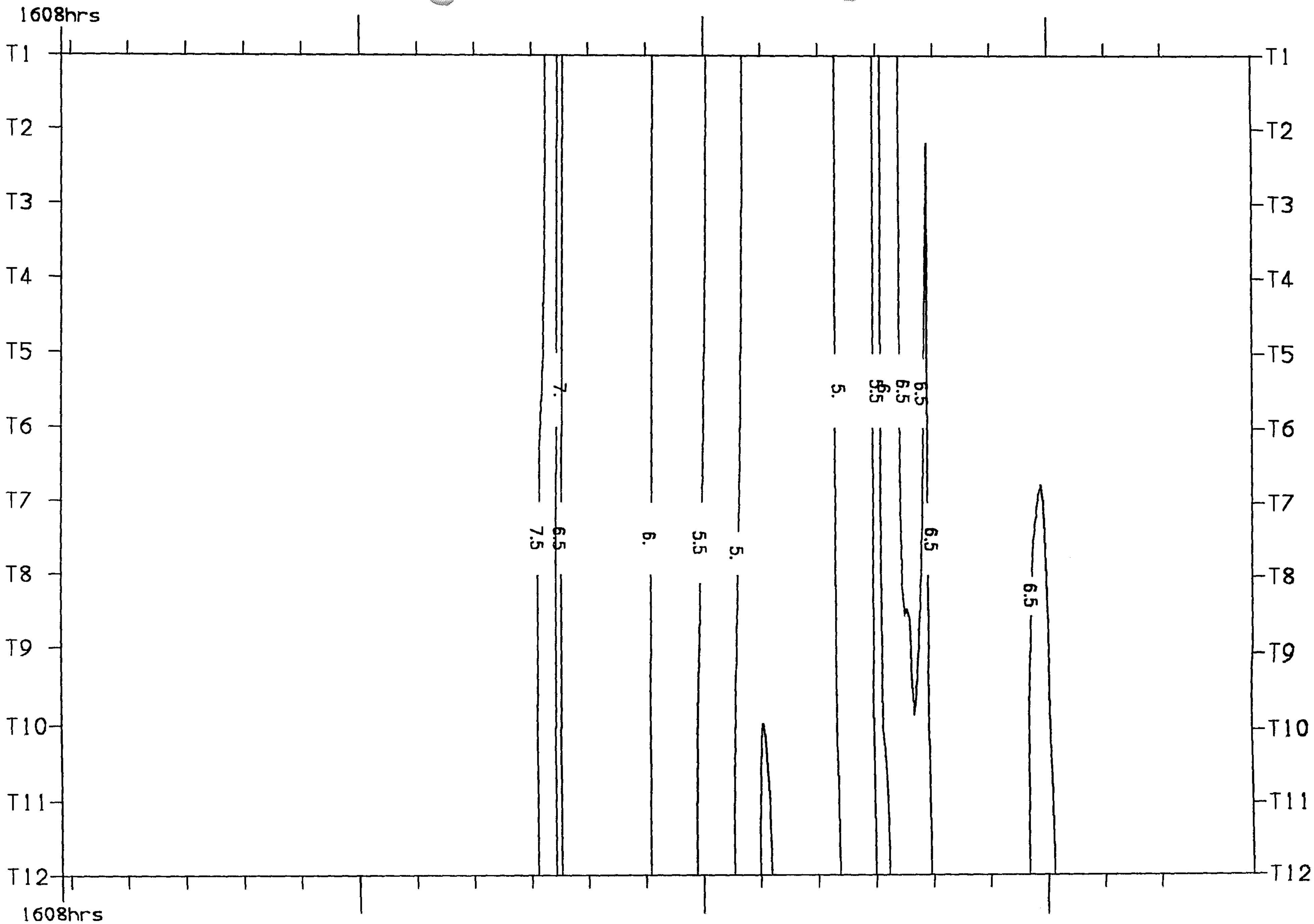
THERMISTOR SPAR ARE88-76

ALL RECORDS: 13 May 88



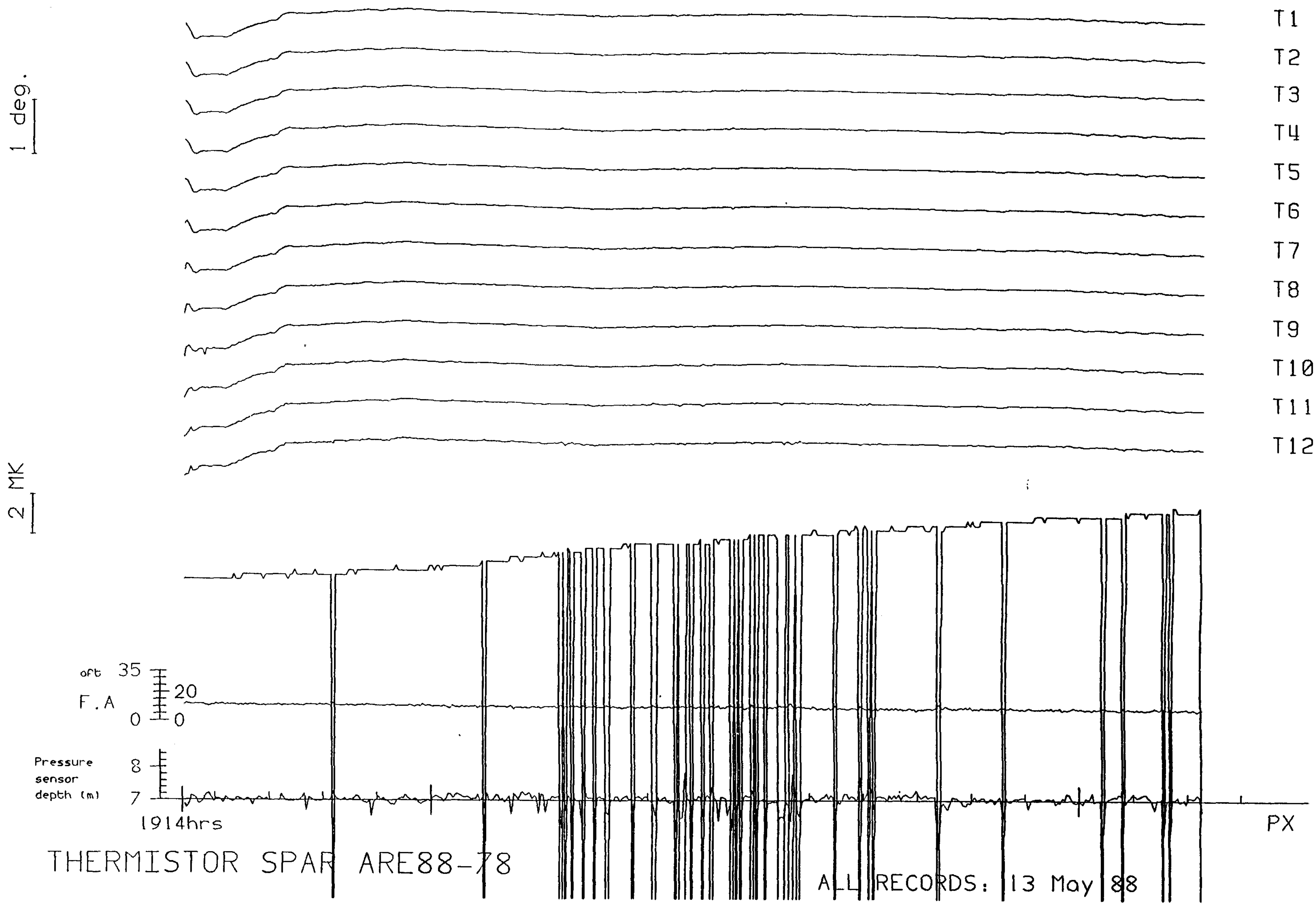
THERMISTOR SPAR ARE88-77

ALL RECORDS: 13 May 88



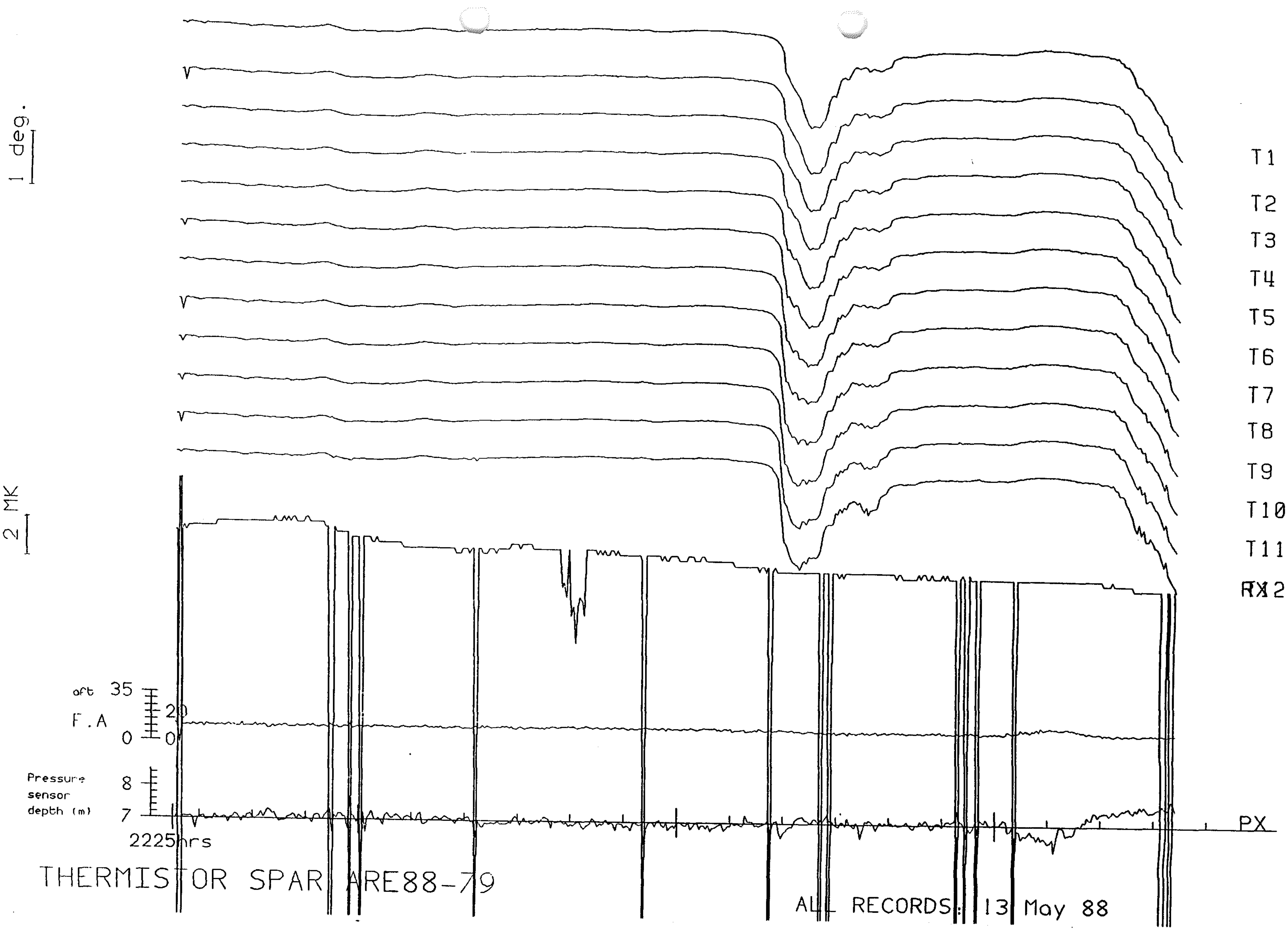
THERMISTOR SPAR ARE88-77

All records 13 May 1988

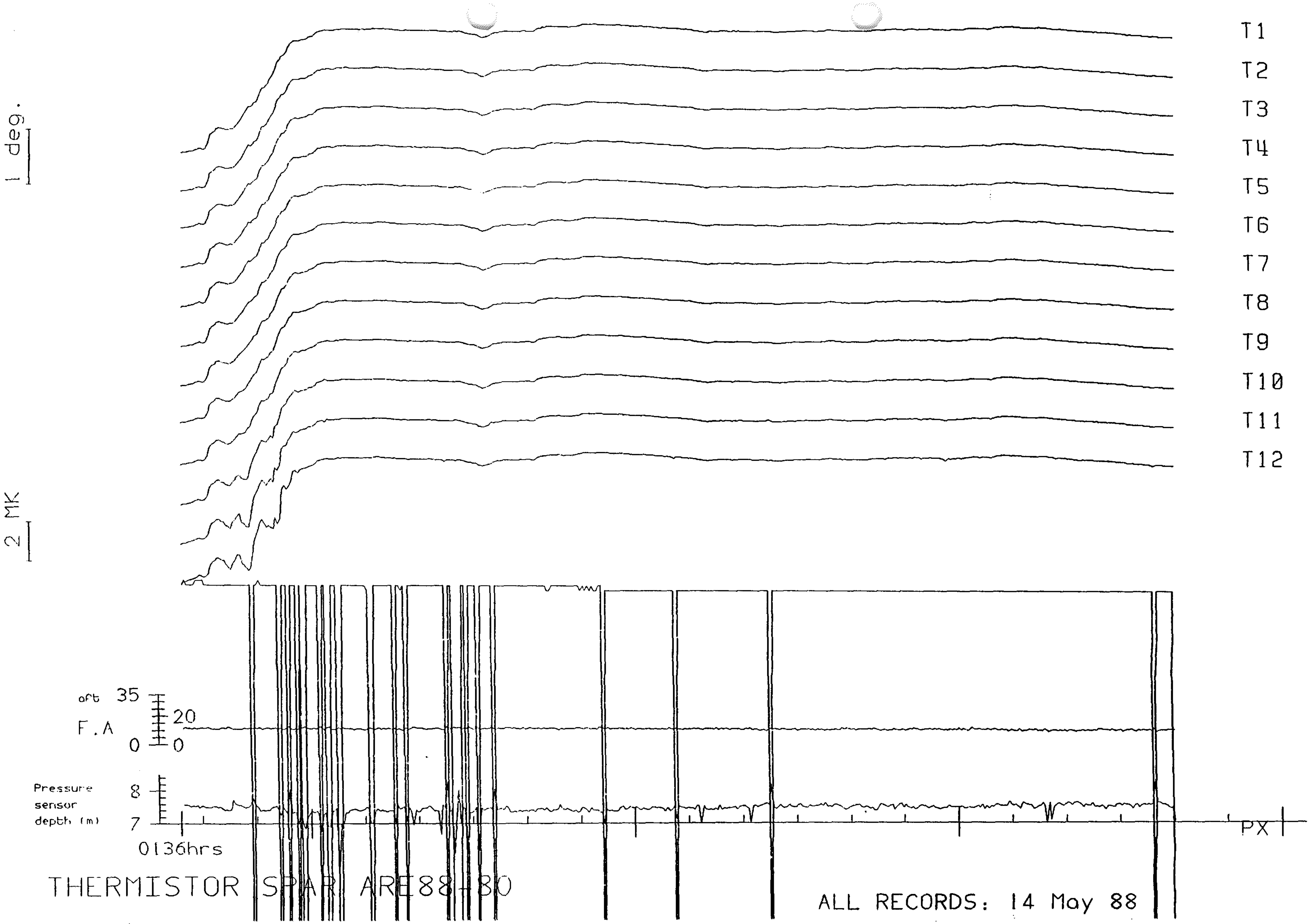


THERMISTOR SPAR ARE88-78

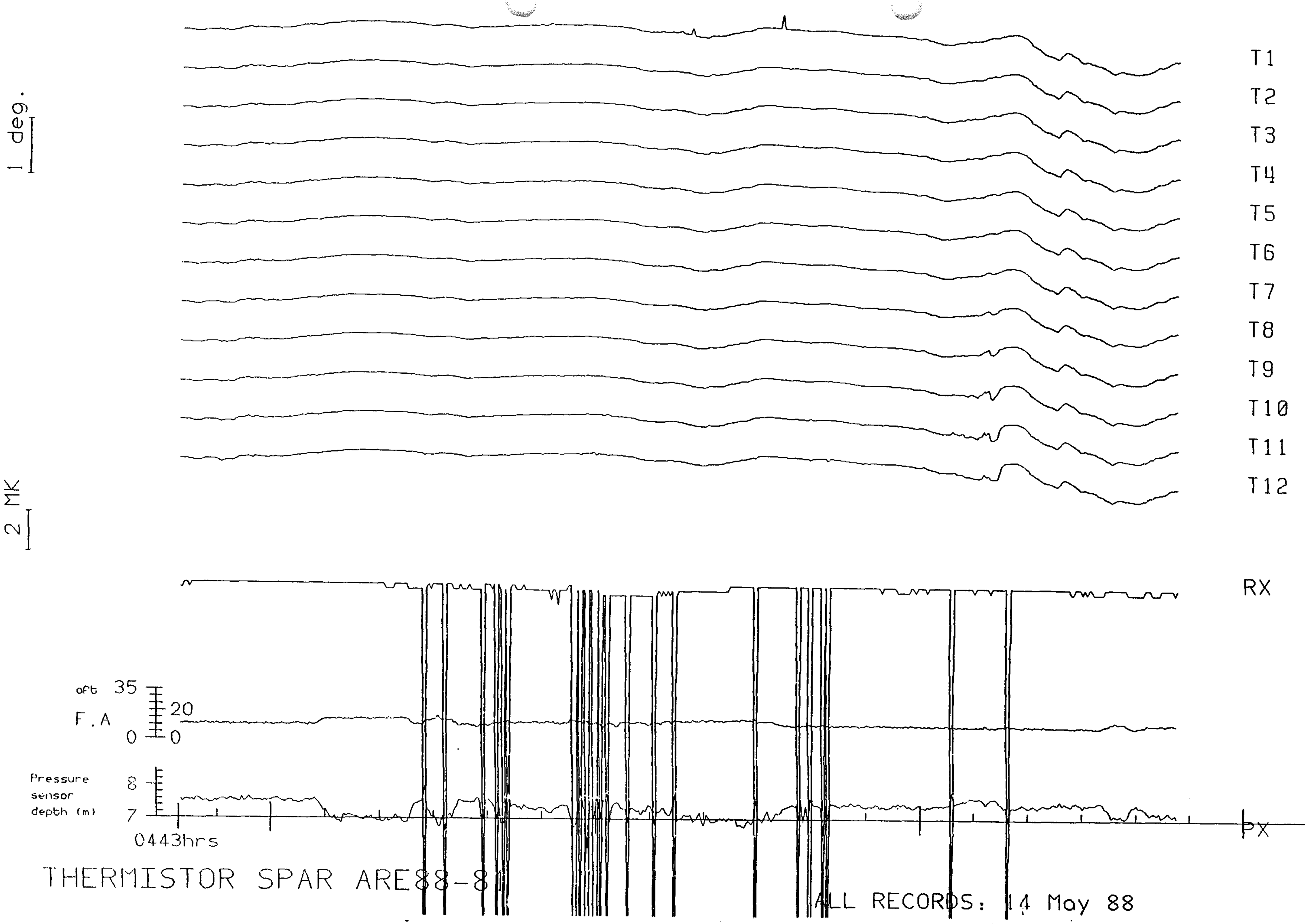
ALL RECORDS: 13 May 88



1 deg.
2 MK
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
RX2
oft 35
F.A
0
20
0
Pressure
sensor
depth (m)
8
7
PX
2225hrs
THERMISTOR SPAR ARE88-79
ALL RECORDS: 13 May 88

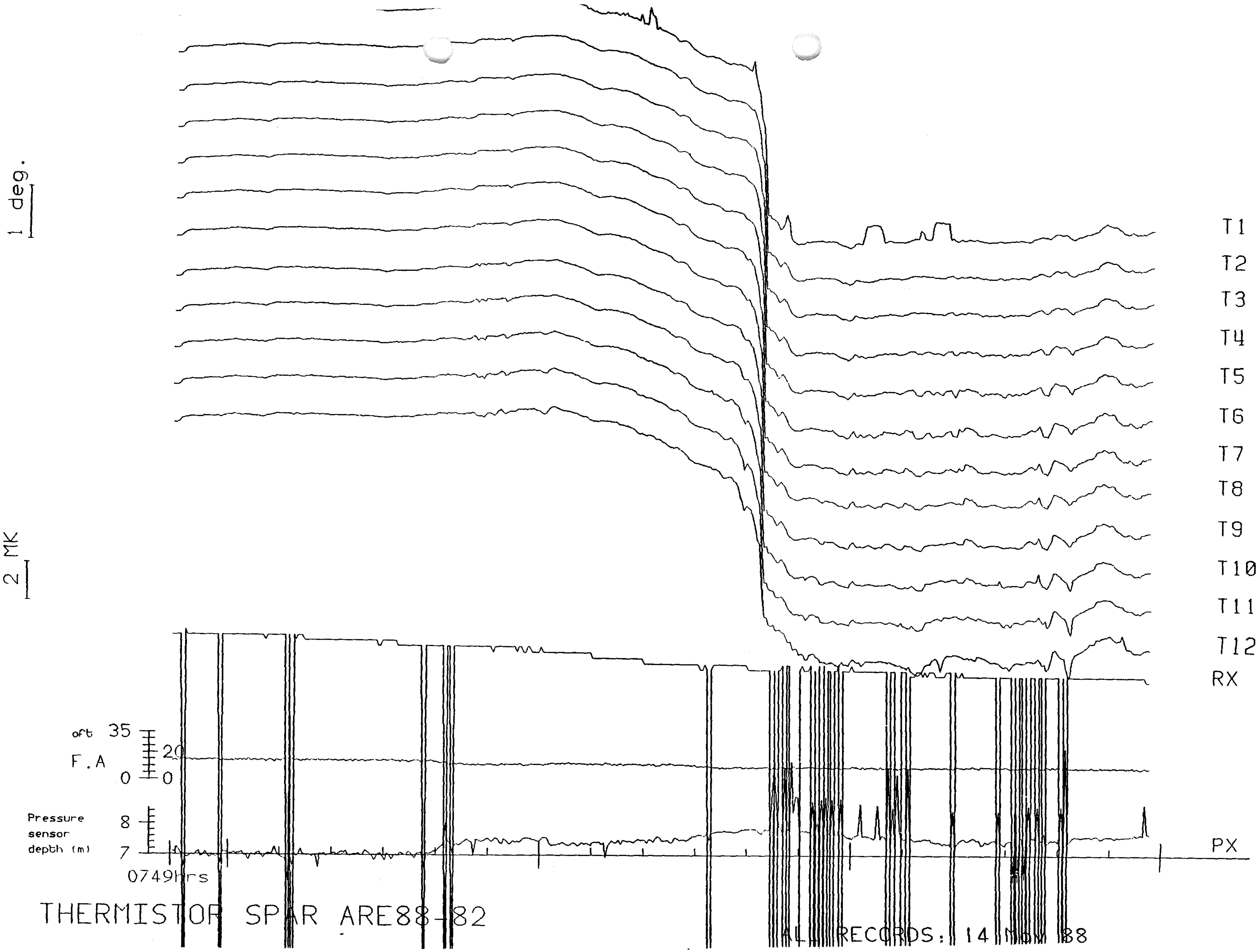


T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
1 deg.
2 MK
oft 35
20
F.A
0
0
Pressure
sensor
depth (m)
8
7
PX
0136hrs
THERMISTOR SPAR ARE88-80
ALL RECORDS: 14 May 88

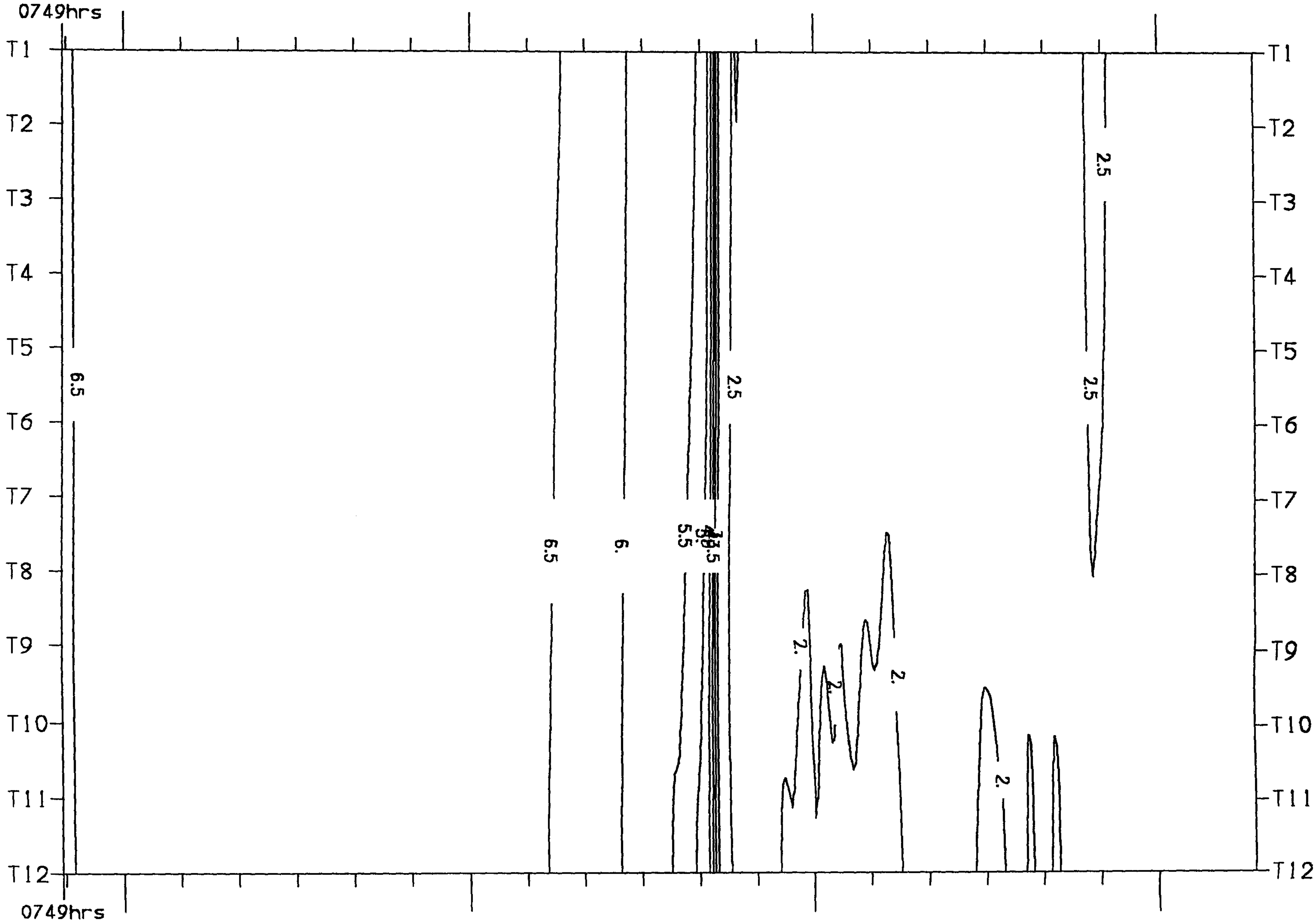


THERMISTOR SPAR ARE88-8

ALL RECORDS: 14 May 88

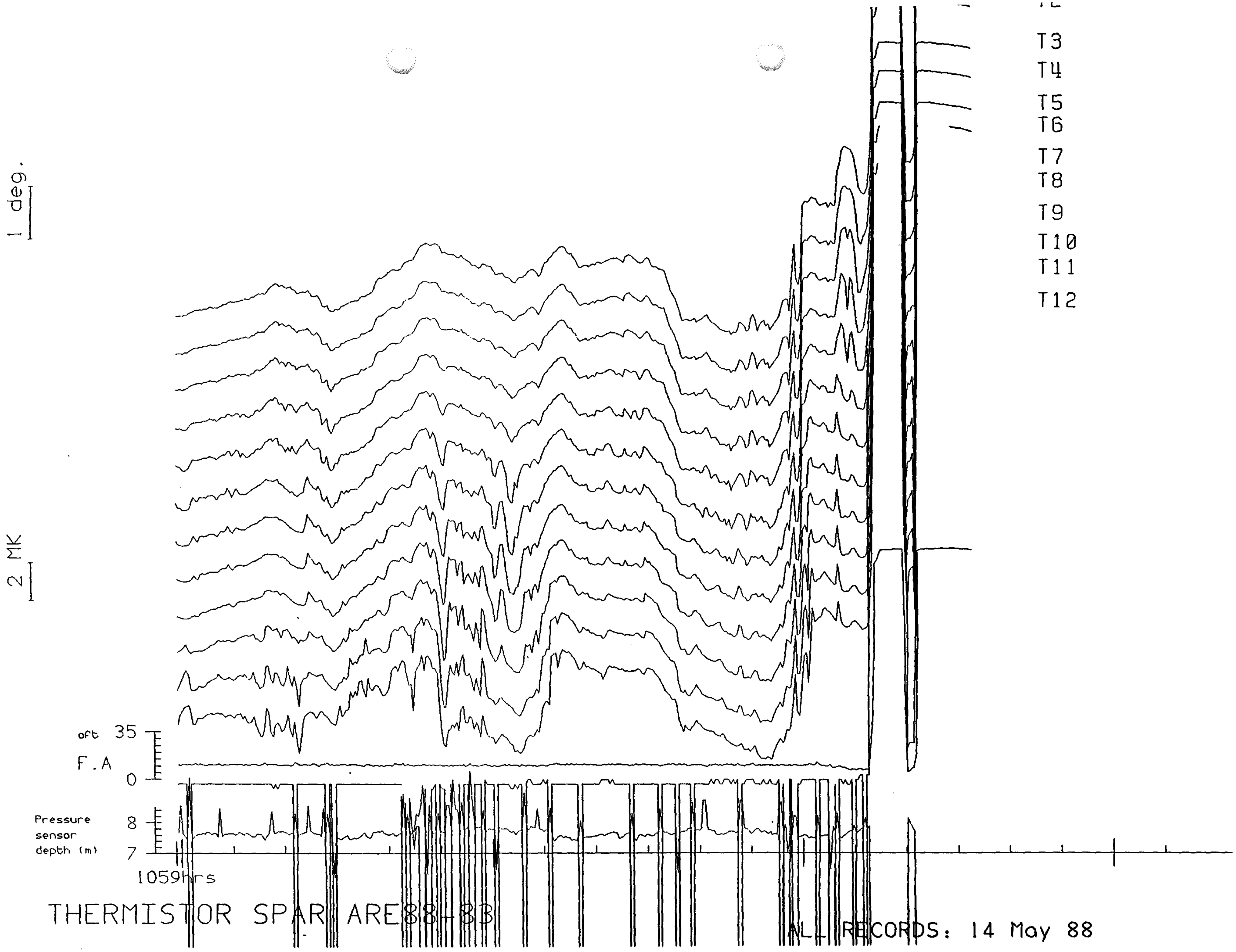


THERMISTOR SPAR ARE88-82



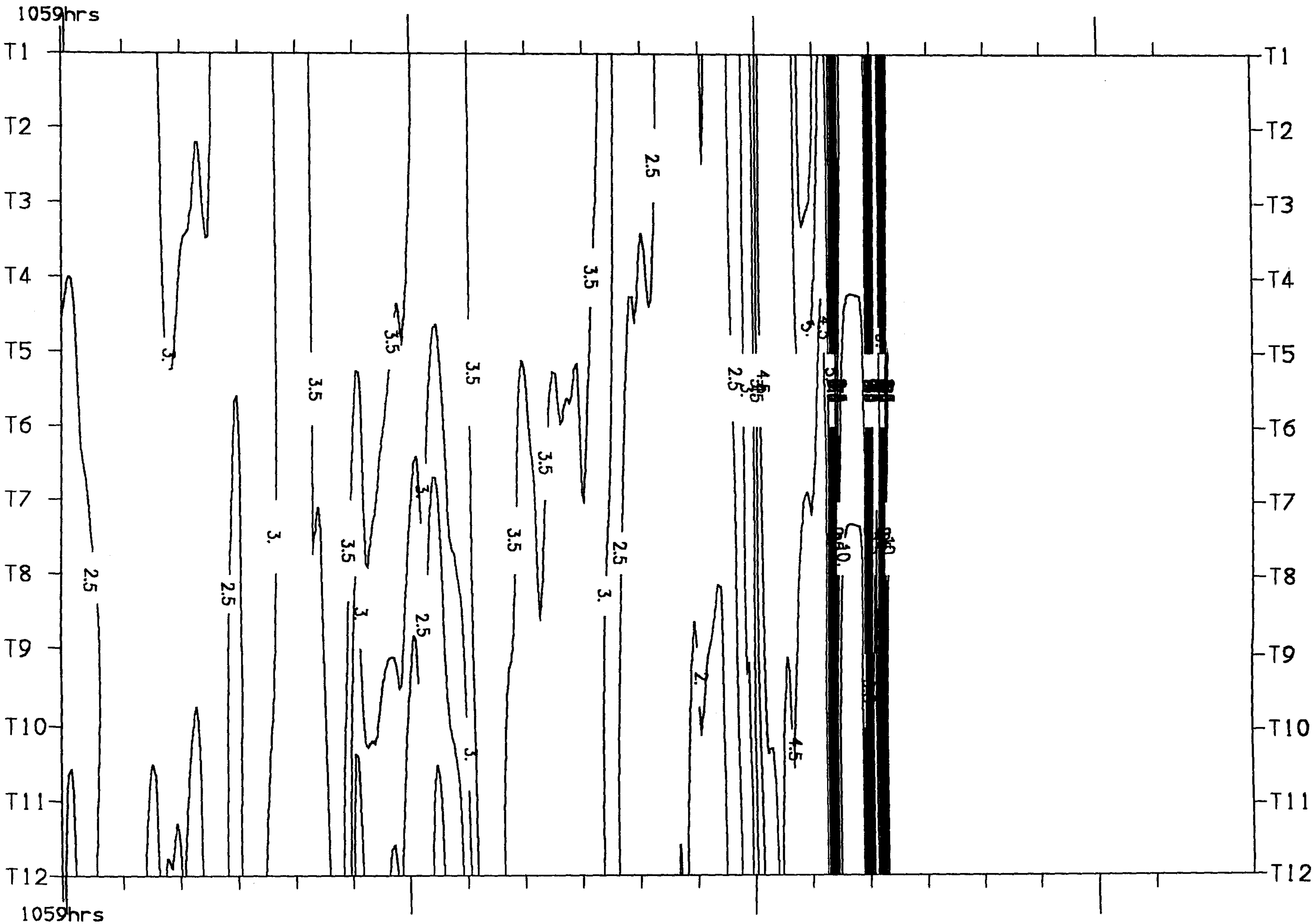
THERMISTOR SPAR ARE88-82

All records 14 May 1988



THERMISTOR SPAR ARE88-83

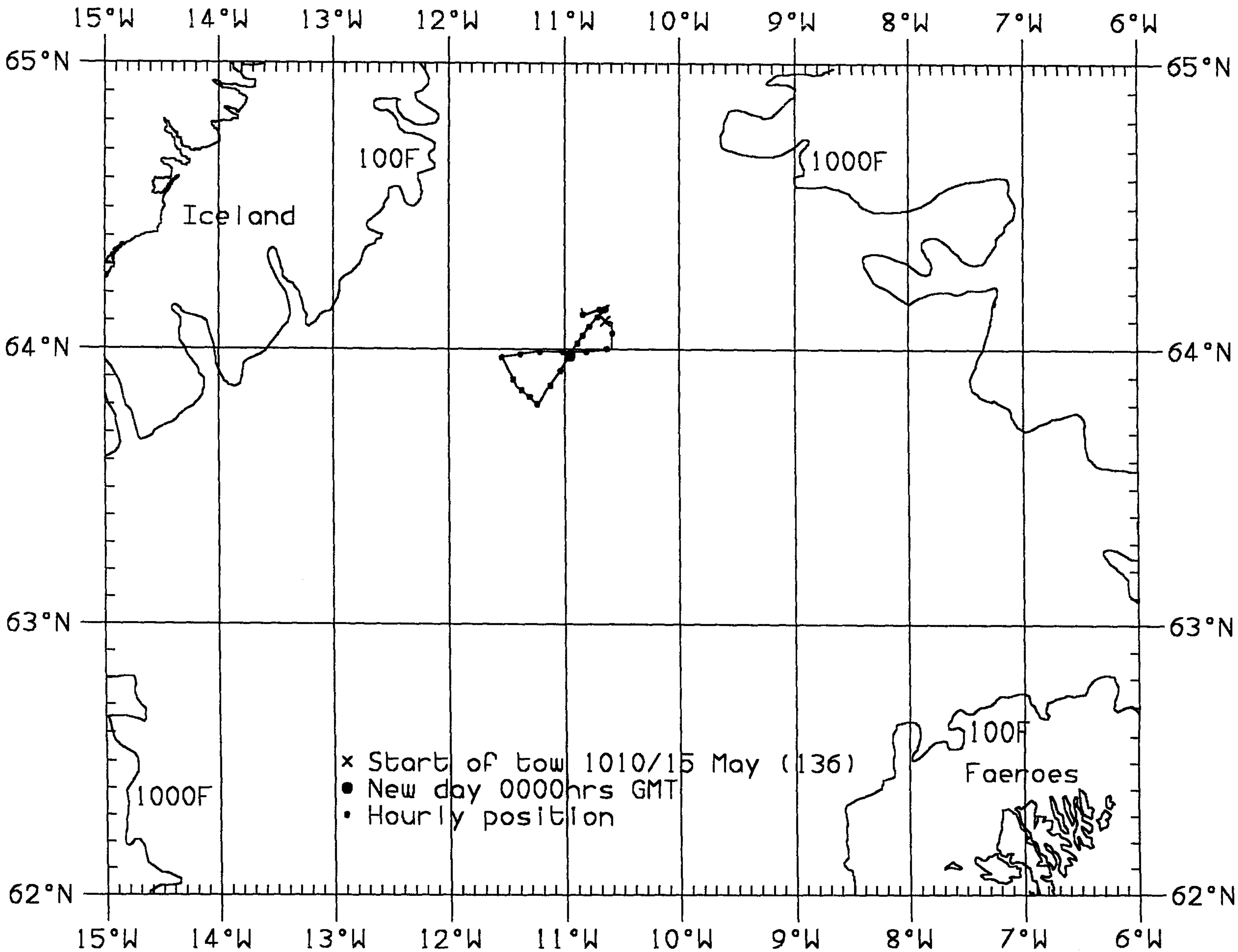
ALL RECORDS: 14 May 88



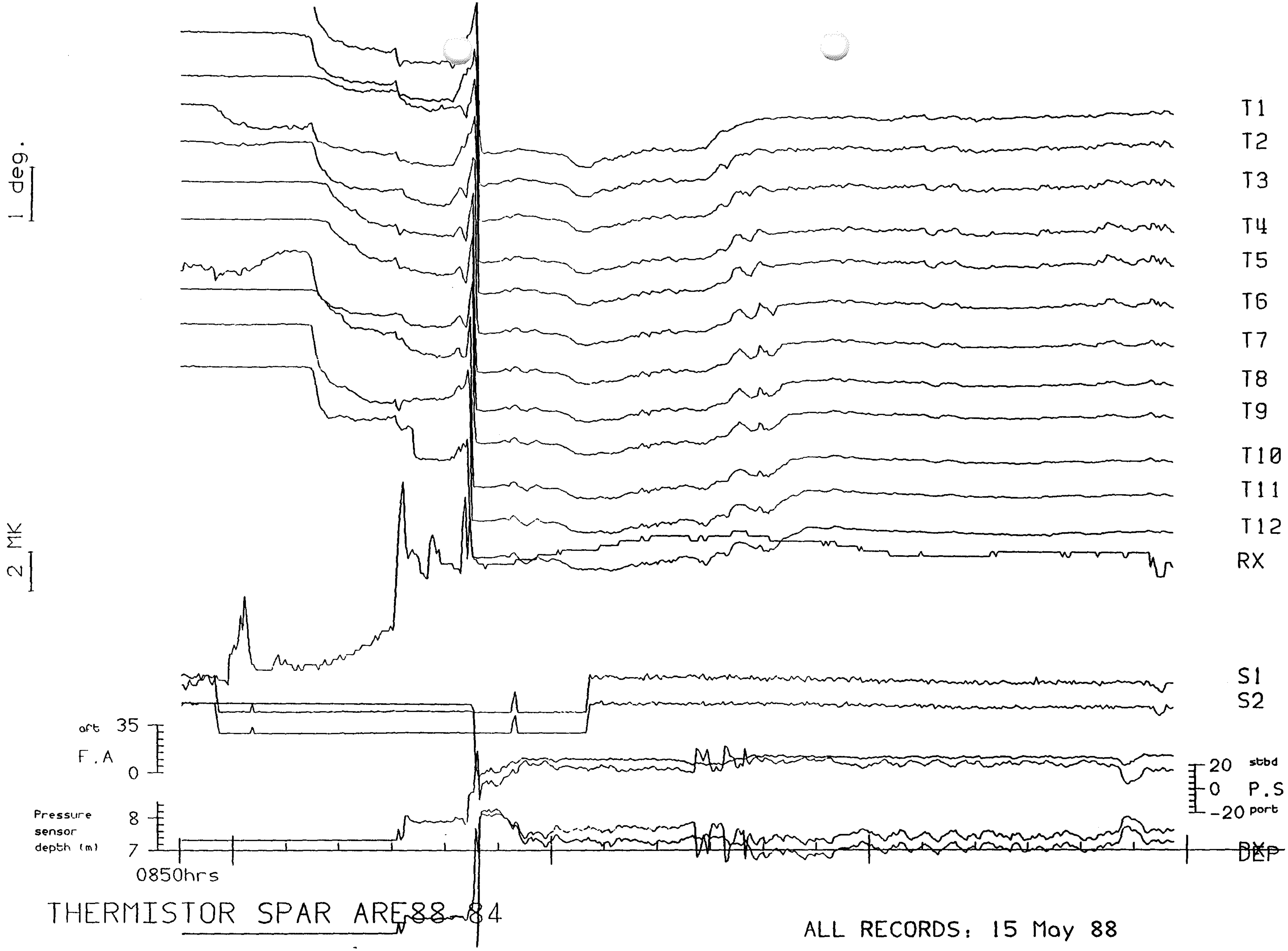
THERMISTOR SPAR ARE88-83

All records 14 May 1988

Appendix 4 : Tow 4

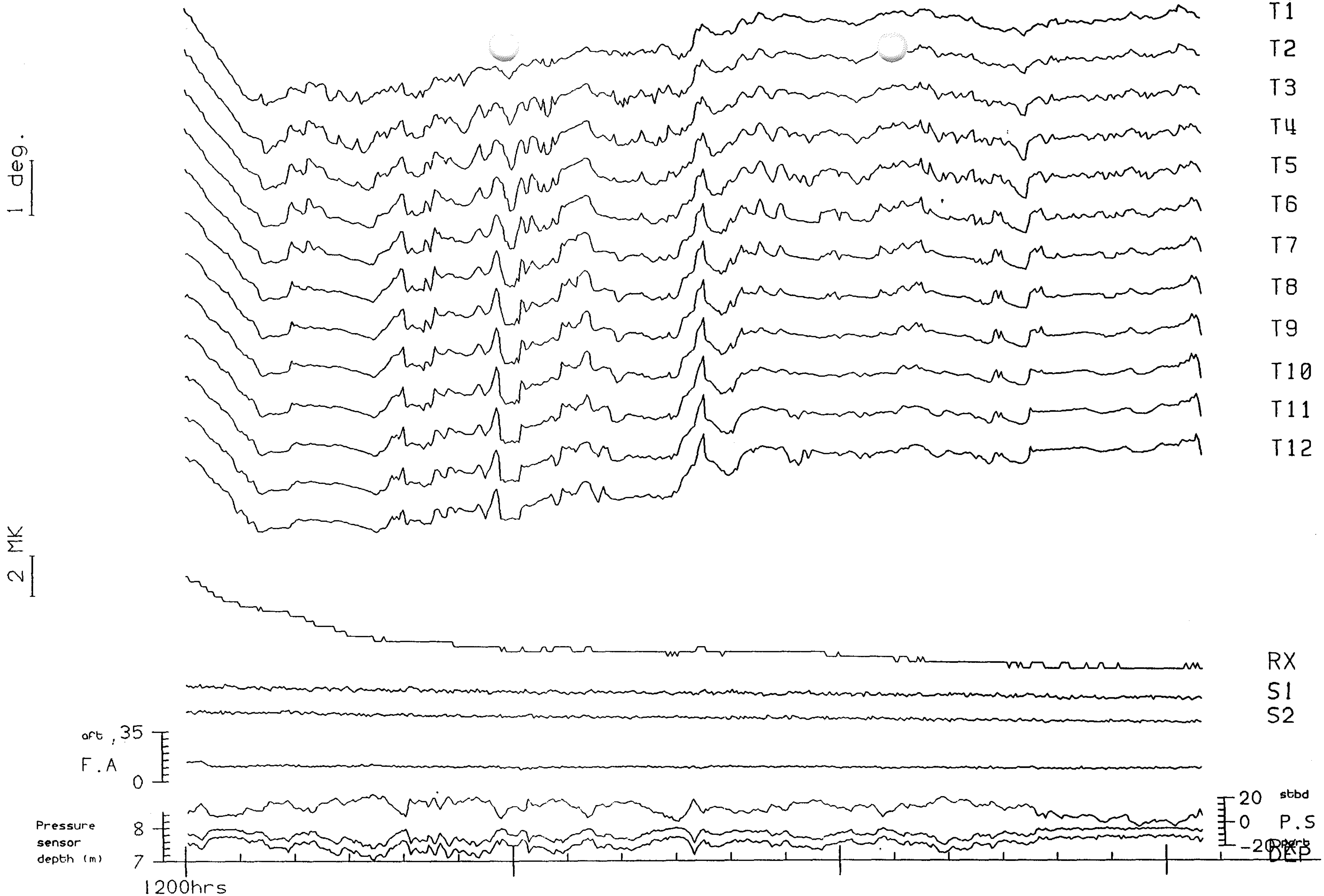


THERMISTOR SPAR TRACKPLOT TOW4 (ARE88-84 to 91)



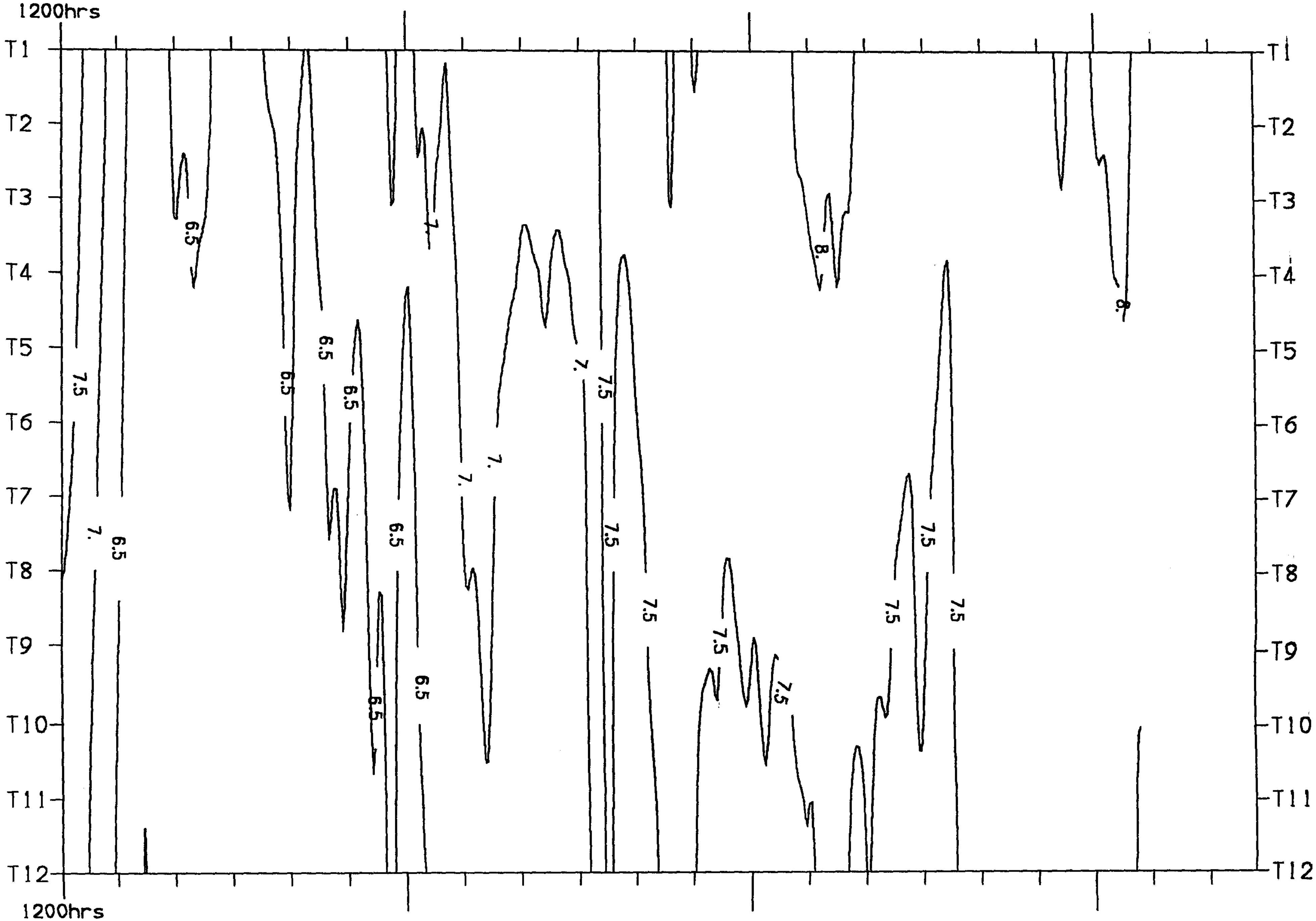
THERMISTOR SPAR ARE88-84

ALL RECORDS: 15 May 88



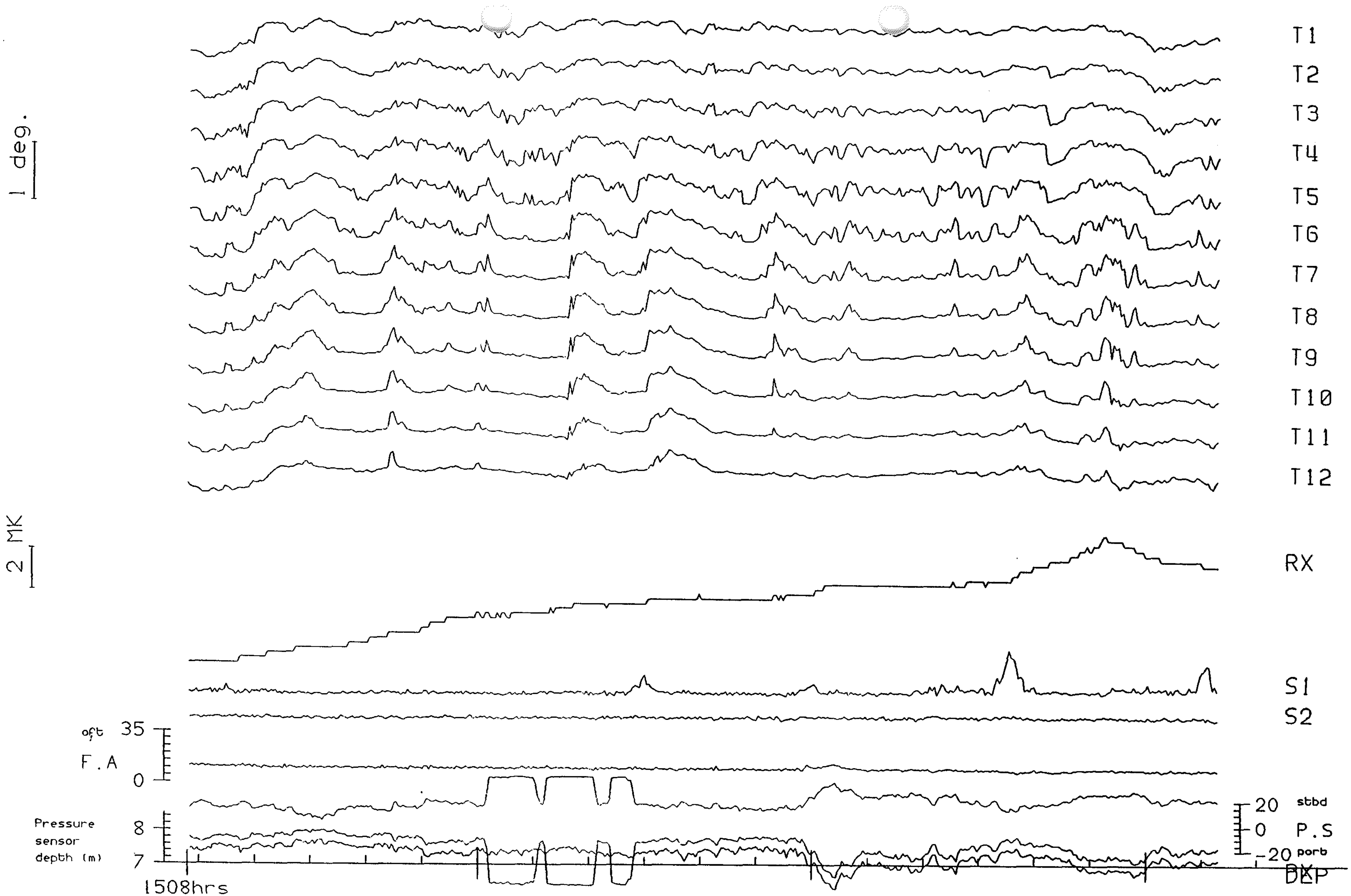
THERMISTOR SPAR ARE88-85

ALL RECORDS: 15 May 88



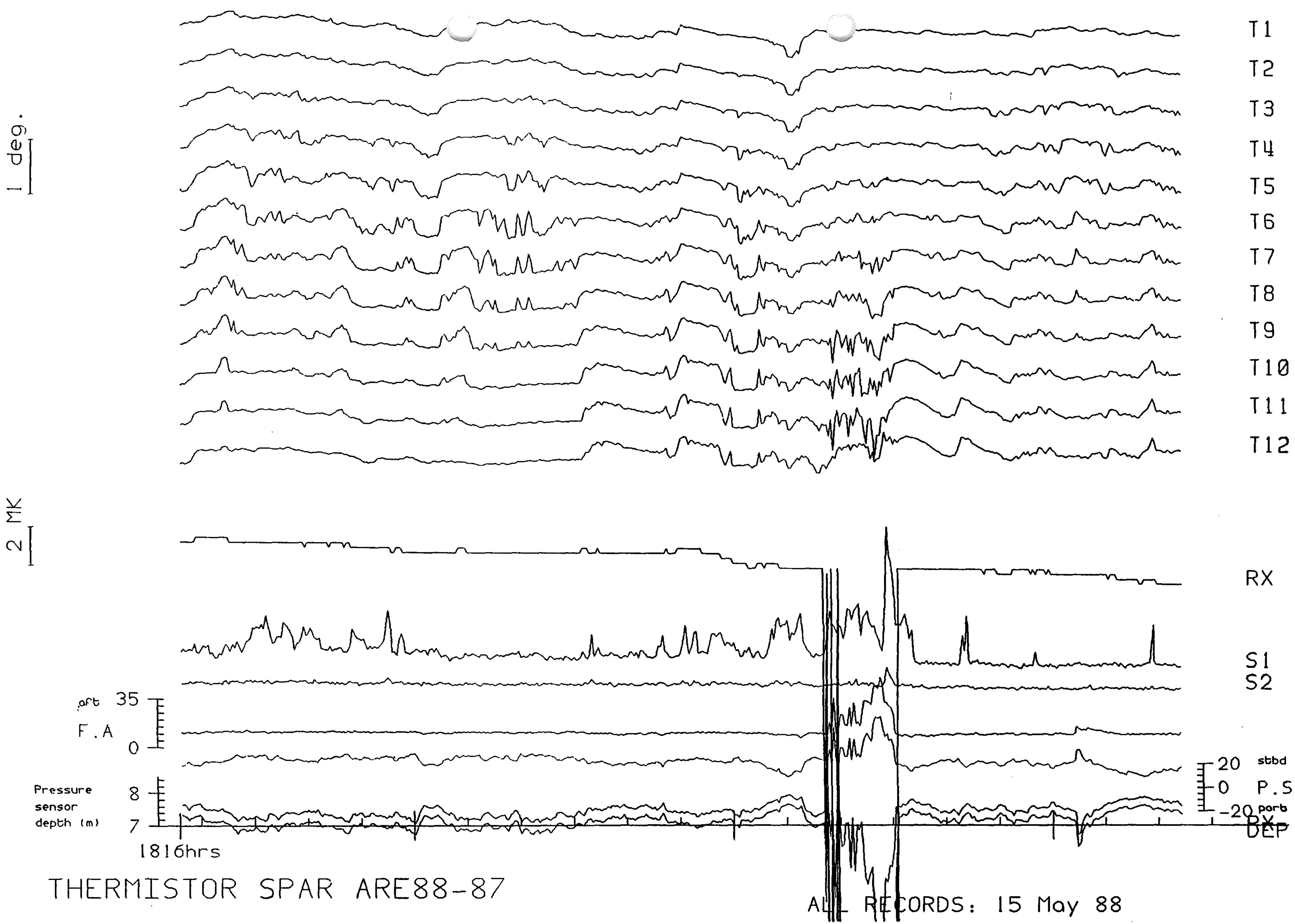
THERMISTOR SPAR ARE88-85

All records 15 May 1988



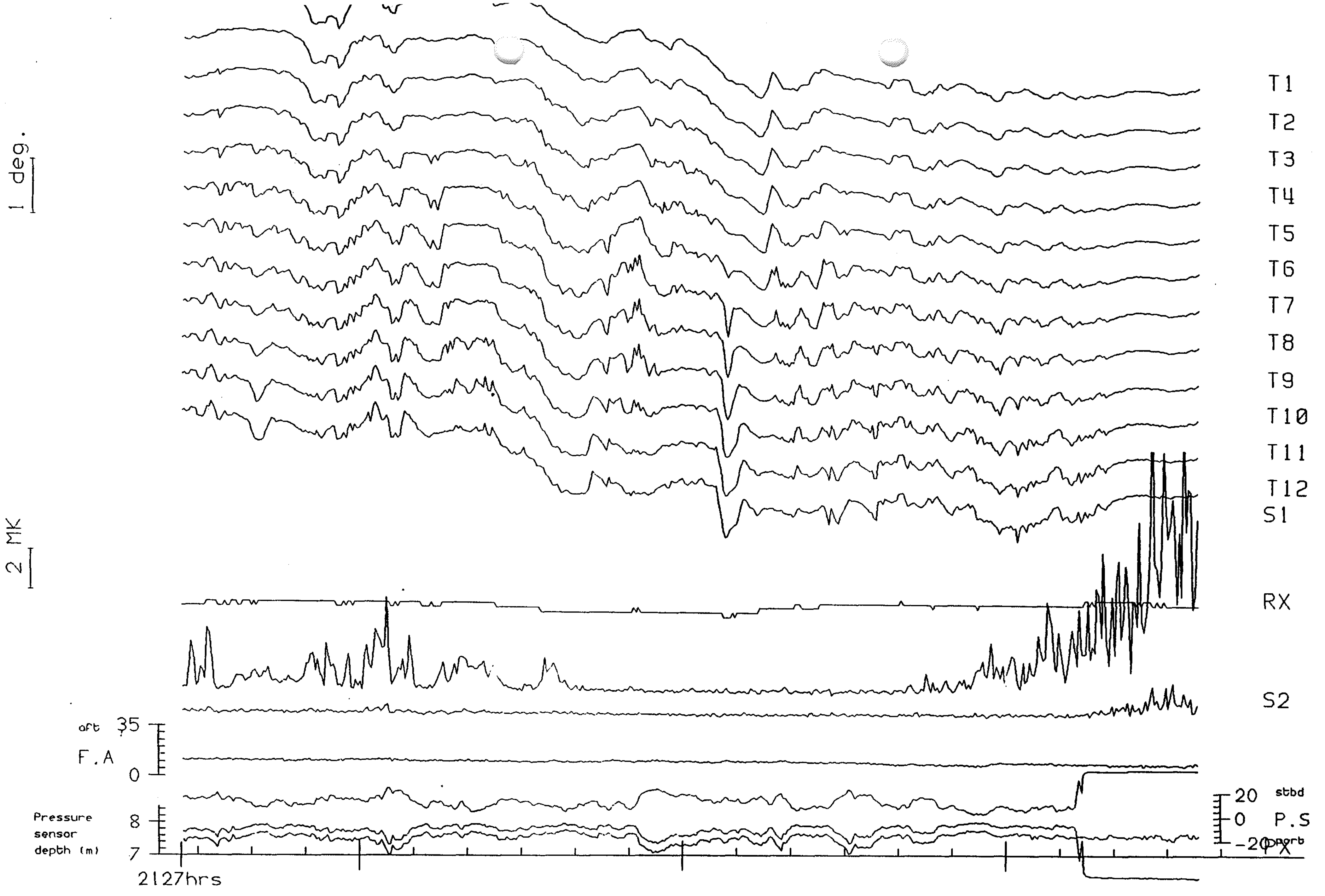
THERMISTOR SPAR ARE88-86

ALL RECORDS: 15 May 88



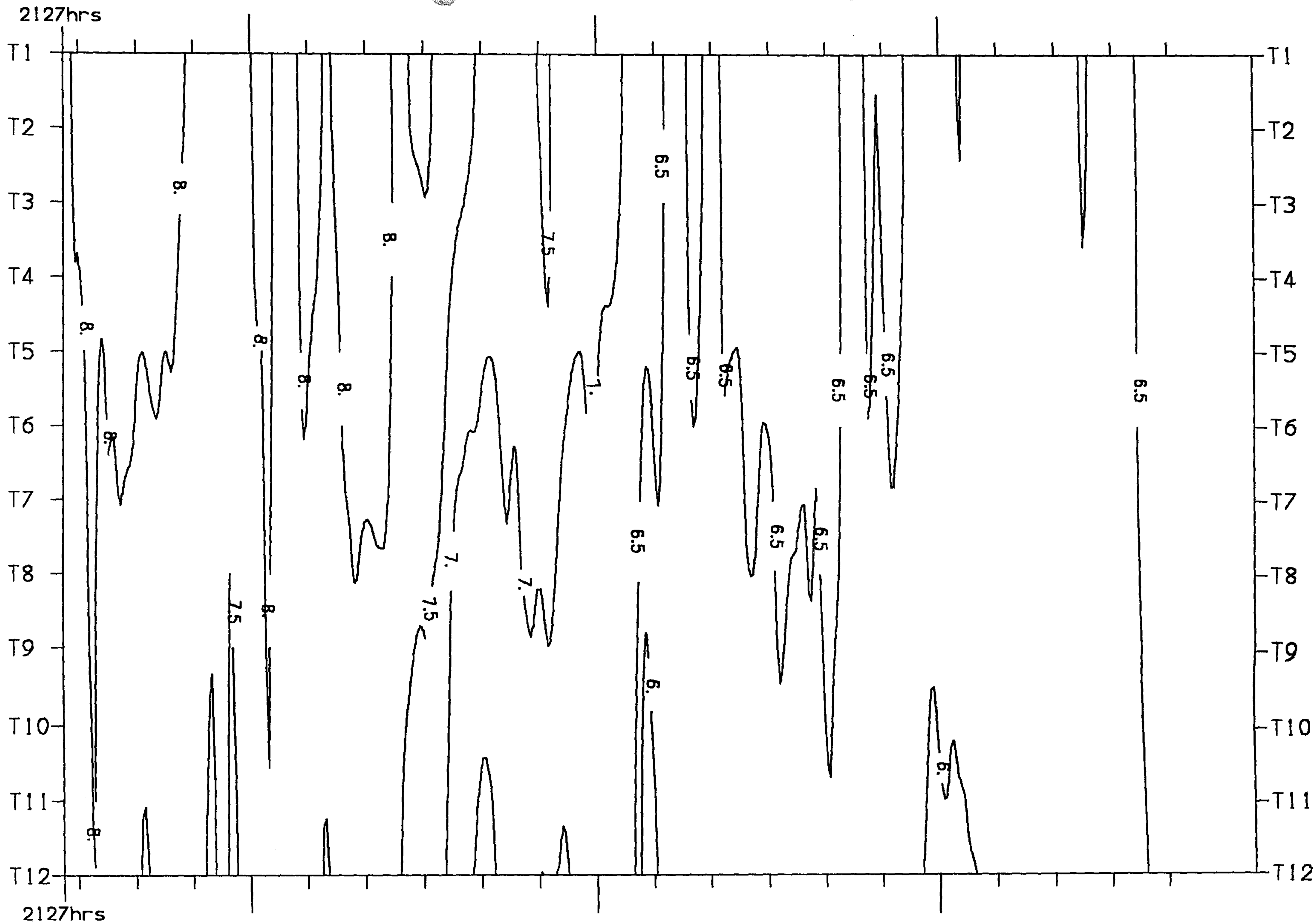
THERMISTOR SPAR ARE88-87

ALL RECORDS: 15 May 88



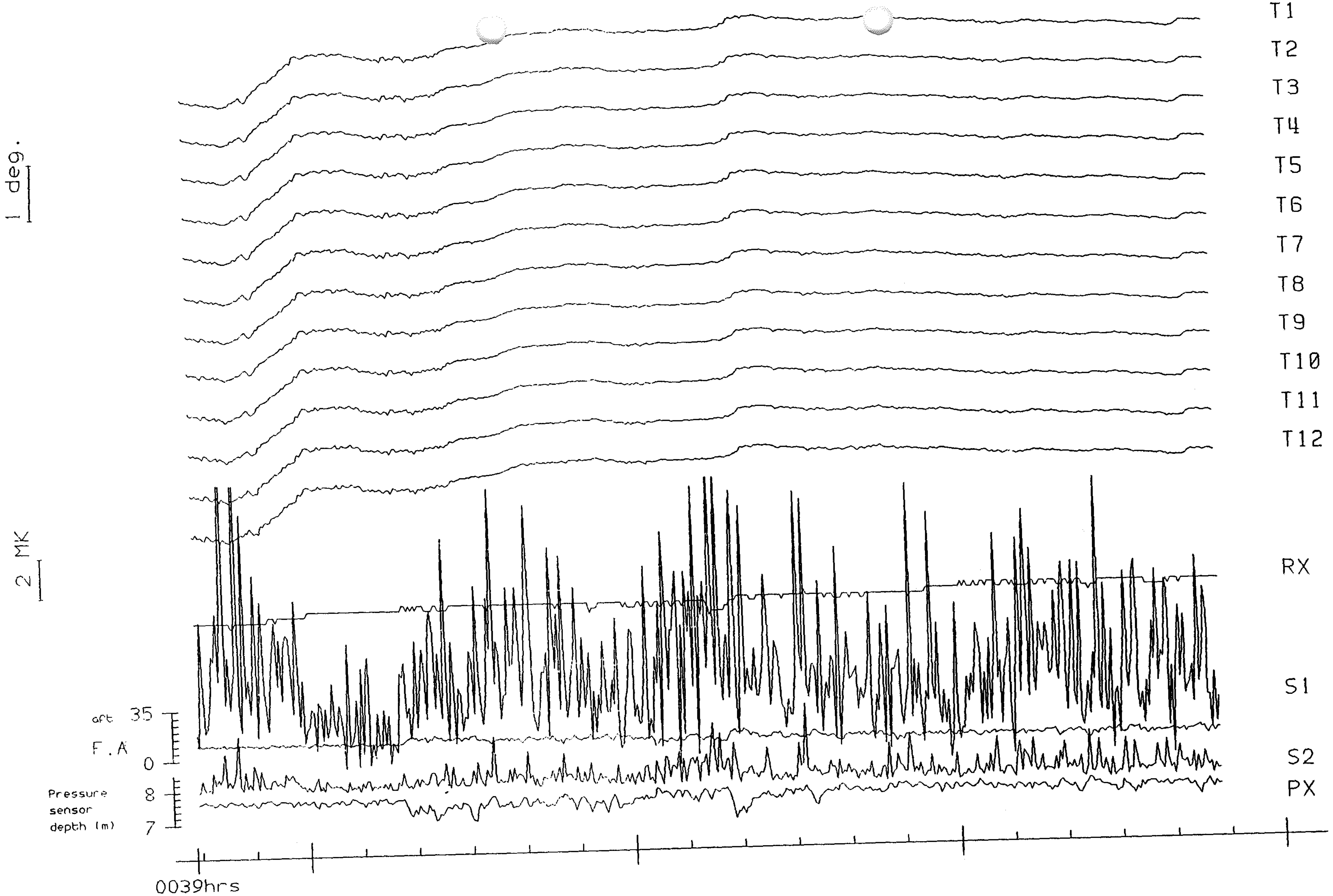
THERMISTOR SPAR ARE88-88

ALL RECORDS: 15 May 88



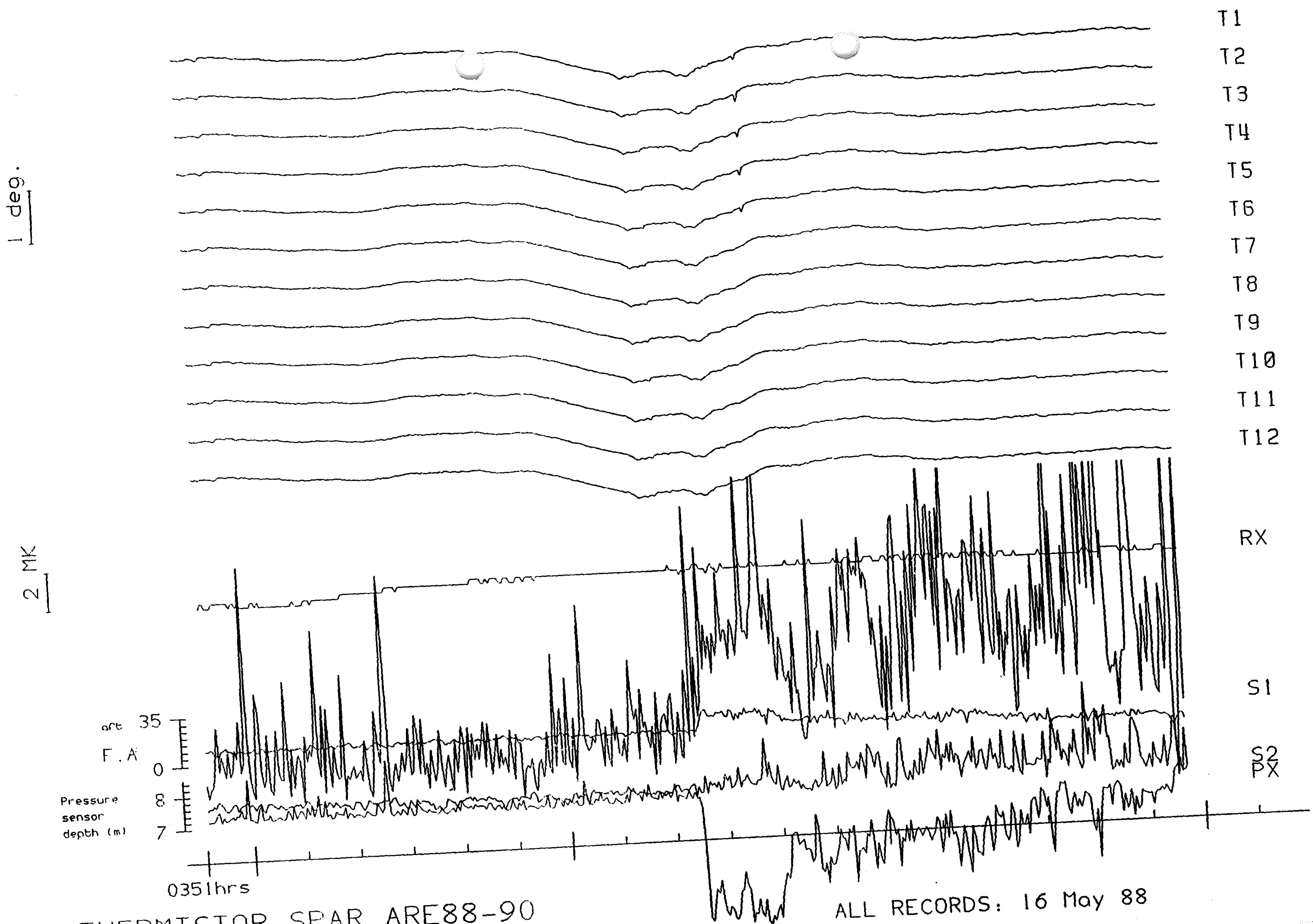
THERMISTOR SPAR ARE88-88

All records 15 May 1988



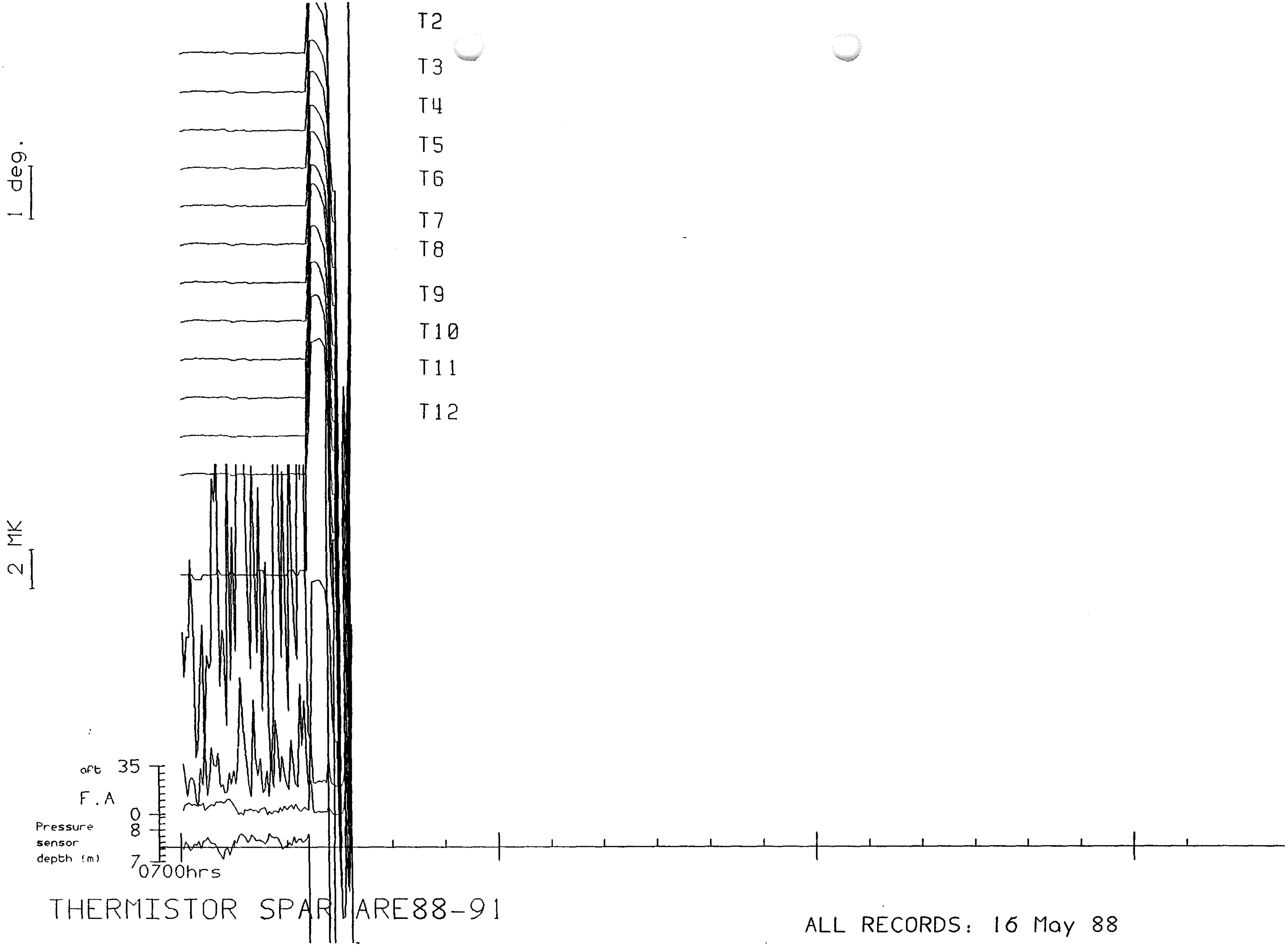
THERMISTOR SPAR ARE88-89

ALL RECORDS: 16 May 88



THERMISTOR SPAR ARE88-90

ALL RECORDS: 16 May 88



THERMISTOR SPAR ARE88-91

ALL RECORDS: 16 May 88

Appendix 5 : System details

1. Digidata system output

Code : Ascii encoded hexadecimal

Density : 1600 BPI

Block length : 12 records = 948 characters

Record : 76 hex characters followed by 3 control characters ending with / to show end of record.

The 76 hex characters consist of 19 sequences of 4 bit hex numbers. One record is shown in the example below :

0030 9FAA 9FA5 B6BF B2DB B30B B40E B402 B43B B3D1 AD66 B0F1
A91E 5F73 B1CA 9DFA 5D15 A635 B4CB AR/

Channel assignments

Channel	Transducer
1	Counter
2	Sonar 1
3	Sonar 2
4	T1
5	T2
6	T3
7	T4
8	T5
9	T6
10	T7
11	T8
12	T9
13	T10
14	Resistor
15	T11
16	FA inclinometer
17	PS inclinometer
18	Pressure transducer
19	T12

The Digidata output was initially translated onto magnetic tapes at 800 BPI. This has now been transferred to 1600 BPI on the IOSDL GEC computer.

2. Sensor depths below mean water level

Sensor	Depth (m)
T1	0.81
T2	1.41
T3	1.91
T4	2.41
T5	2.91
Sonar	3.41
T6	3.91
T7	4.65
T8	5.15
T9	5.65
T10	6.65
RX	7.15
T11	7.65
PX	8.15
T12	8.65

3. Inclinometer calibrations

Fore and Aft angle in degrees is T (from the vertical), where CH16 is channel 16 value, and

$$T = (CH16-31400)/178$$

Similarly Port and Starboard angle L is

$$L = (CH17-31300)/174$$

4. Pressure transducer calibration

There is no pre-cruise dead weight tester data available. We may use an 'in situ' calibration from the situation that exists during a spar recovery, under these conditions the electronics have stabilised. Just prior to recovery the spar is stationary in the water, and consequently nearly vertical (the inclinometer output enables corrections to be made for any non-vertical angles that may occur during the time needed to average out the wave period signal from the pressure transducer). The surface value for the pressure transducer is readily identifiable in the data obtained during the recovery of the spar.

Knowing that the vertical depth of the transducer is 815cm, and that its output is linear, enables a calibration factor for the pressure transducer to be calculated, as follows :

$$\text{Depth (cm)} = (42933-CH18)/1.202$$

Appendix 6 : Meteorological summary

Meteorological Summary (from ship's weather log)

Time (hour/day)	Temperature Air (Celsius)	Sea	Wind Speed (kts)	Direction	Air pressure (mb)	Short period wind wave height (m)
1200/113	3.4	7.0	14	090	1029	0.5
1800/113	5.0	7.0	13	120	1028	0.5
0000/114	5.0	7.2	13	120	1028	0.5
0600/114	6.1	7.3	19	160	1025	0.5
1200/114	6.2	7.5	17	130	1024	0.5
1800/114	6.2	7.3	9	140	1022	0.5
0000/115	6.0	7.3	0	000	1020	0.0
0600/115	4.9	6.8	8	090	1018	0.5
1200/115	4.7	5.7	8	120	1018	0.5
1800/115	4.0	3.9	9	140	1018	0.5
0000/116	5.0	3.6	10	160	1018	0.5
0600/116	5.6	6.3	9	160	1018	0.5
1200/116	6.2	6.5	15	170	1019	0.5
1800/116	7.8	6.6	8	180	1020	0.5
0000/119	6.5	6.4	18	200	1021	1.0
0600/119	6.5	6.6	9	180	1020	0.5
1200/119	7.0	6.4	9	180	1020	0.5
1800/119	7.0	7.4	5	220	1019	0.5
0000/120	6.0	6.8	8	190	1019	0.5
0600/120	6.6	6.9	5	190	1017	0.5
1200/120	8.0	7.2	9	160	1018	0.5
1800/120	6.2	2.6	2	140	1010	0.5
0000/121	5.3	7.0	0	000	1016	0.0
0600/121	2.1	6.3	9	340	1015	0.5
1200/121	0.5	4.4	18	000	1016	0.5
1800/121	0.0	6.1	19	000	1016	0.5
0000/122	-0.9	5.5	13	010	1015	0.5
0600/122	-1.5	3.5	19	020	1014	0.5
1200/122	-0.5	4.8	19	010	1014	1.0
1800/122	-0.3	5.2	13	010	1014	0.5
0000/123	0.1	5.5	13	010	1015	0.5
0600/123	-0.1	6.7	13	010	1014	0.5
1200/123	0.0	6.7	13	010	1014	0.5
1800/123	0.3	6.7	13	350	1014	0.5
0000/124	0.1	6.8	9	030	1014	0.5
0600/124	1.3	6.4	2	050	1012	0.5
1200/124	3.1	7.3	9	200	1011	0.5
1800/124	6.4	7.6	18	250	1008	0.5
0600/133	8.0	7.7	14	150	1017	0.5
1200/133	9.6	7.8	9	080	1020	0.5
1800/133	8.1	7.7	13	070	1021	0.5
0000/134	8.1	7.8	13	070	1024	0.5
0600/134	8.0	7.6	9	040	1025	0.5
1200/134	8.5	7.8	9	050	1026	0.5
1800/134	7.8	5.6	13	070	1028	0.5
0000/135	7.8	7.1	9	090	1030	0.5

Time (hour/day)	Temperature Air (Celsius)	Sea	Wind Speed (kts)	Direction	Air pressure (mb)	Short period wind wave height (m)
0600/135	8.0	6.7	9	110	1031	0.5
1200/135	8.0	3.2	5	140	1033	0.5
1800/135	7.7	7.7	5	090	1033	0.5
0000/136	8.5	8.4	5	100	1033	0.5
0600/136	8.5	7.7	9	150	1032	0.5
1200/136	9.0	8.3	5	150	1032	0.5
1800/136	9.5	8.5	5	180	1029	0.5
0000/137	8.0	7.0	5	310	1029	0.5
0600/137	3.2	7.6	30	350	1029	1.0
1200/137	2.4	7.5	44	350	1029	3.0
1800/137	2.1	6.3	40	350	1029	1.0