I.O.S.

LONG SEASOAR CTD SECTIONS IN THE NORTH EAST ATLANTIC OCEAN COLLECTED DURING RRS DISCOVERY CRUISE 116

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WORMLEY

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ABSTRACT

This report presents CTD data from R.R.S. Discovery Cruise 116 (January 1981) collected in the northeast Atlantic Ocean between 46.7 N, 11.3 W and 36.1 N, 18.5 W. The CTD unit was mounted in a SeaSoar vehicle which undulated between the sea surface and 300m depth about once per km. The data thus comprise a vertical section of the top 300m over 1400 km long, spanning over 10 degrees of latitude, and containing 1340 individual profiles. Methods of data processing and presentation on board ship using a PDP 11/34 computer and on land using G-EXEC and SURFACE II software on the Natural Environment Research Council's Honeywell 66/60 computer are described in detail. Data presentation consists of T/S plots and contoured sections.

INTRODUCTION

During 1980 and 1981 four long SeaSoar sections were obtained in the northeast Atlantic on passage legs of R.R.S. Discovery. The sections, in October 1980 (Cruise 114), January 1981 (Cruise 116), April 1981 (Cruise 119) and July 1981 (Cruise 122) show the seasonal variation of the top 300m of the ocean over about 10 degrees of latitude and over a full annual cycle. The data will be summarized in four IOS Reports, of which this is the first to be produced, although the second in the series.

Initial computer problems on Cruise 114 have slowed the data processing. Cruise 116 was the first cruise on which computer logging worked throughout. It was also the most limited, in that only temperature, conductivity and pressure were sampled. On the other cruises chlorophyll and oxygen were also sampled, requiring further processing before the other data reports can be produced.

Because this is the first report in a series, methods of data collection, reduction and calibration will be described in some detail. Details of program listings are also given, although primarily of interest only to other G-EXEC or SURFACE II users. For those wishing to skip these sections, data presentation begins on page 35 with Notes on Data Presentation.

Cruise 116 was primarily an instrumentation cruise, with Dr. B. S. McCartney as Principal Scientist. It was also a passage cruise from Barry, South Wales to Funchal, Madeira. The intention was to run south towing the SeaSoar to about 42 N to reach deep water and better weather conditions for gear testing. After several days, passage would be resumed to Madiera. In the event, only 16 hours of work at 42 N was done before freshening winds made station work impossible, and the SeaSoar tow was resumed, stopping only when the southernmost planned limit of the SeaSoar section, 200 miles north of Madiera, was reached. The entire section was thus run in 4.5 days. More detail is given in the next section and summarized in the Timetable of Events (page 38).

INSTRUMENTATION AND CTD DATA COLLECTION

The SeaSoar, an IOS development of the Canadian "Batfish" (Dessureault, 1976), is towed behind a ship and undulates between two depths. It is controlled from the attending ship by signals down the cable and may change depth by tilting its wings using hydraulic power from an impellor pump driven by its motion through the water. The minimum tow speed to obtain hyraulic control is about 4 kt (2 m/s). The maximum speed is that at which cable tensions become excessive (about 1500 kg) and ranges from 10 kt (5 m/s) in good conditions to 6 kt (3 m/s) in rough seas. On Cruise 116, the SeaSoar undulated in a symmetrical sawtooth pattern of approximate period 8 minutes between 5-10m and 280-320m while the ship maintained a speed of 8 kt (4 m/s). Thus a complete ascending or descending profile of temperature and conductivity was made every km, the ascent/descent rate being about 1:4. Data are recorded on both ascents ("ups") and descents ("downs").

The SeaSoar contains a Neil Brown Instrument Systems (NBIS) CTD, scanning pressure, temperature and conductivity at a rate of 32 scans per second. This rate is reduced to 16 scans per second if additional instruments are added to the vehicle, but no additions were made on Cruise 116. Electrical power is supplied down the cable and the data are passed back up to the ship, and logged on a PDP 11/34 computer (see next section). As a backup, an IOS-built interface converts the raw data delivered by the NBIS deck unit into ASCII characters, formats the data into 1960 character blocks, adds a keyboard entered header and clock derived timing information in the first 80 characters, and writes the blocks to a 9-track computer compatible tape on a Digidata tape deck.

The SeaSoar is towed on a conducting faired cable of approximate length 550m, and is thus 550m behind the ship when at the surface and approximately 150m behind at a depth of 300m. Some disturbance in the top few metres of the water column results from the passage of the ship before water is sampled by the CTD unit. Previous comparisons with a surface temperature sensor towed alongside the ship out of the wake have shown that, even in the top few metres, features with scales greater than 10m are unchanged by the stirring.

On Cruise 116, the SeaSoar tow continued from 1500(GMT) on the 8th January until 0800 hrs on the 10th when winds had increased to 25-30 knots. The vehicle was relaunched at

0200 hrs on the 11th in worsening conditions and continued profiling until final recovery at 0400 hrs on the 13th, totalling 94 hours of sampling. Near the end of the survey some difficulties were experienced in controlling the SeaSoar as the result of a damaged wing. The Timetable of events (page 38) and Track Plot (page 39) summarize the ship's movements during the SeaSoar survey.

AT SEA DATA REDUCTION AND CALIBRATION

It is highly desirable to do as much data reduction, calibration and analysis at sea as possible, for two reasons. Firstly, at a data rate of 32 hz, over 2.7 million data cycles are collected per day. With continuous sampling continuing for many days, complete analysis on land is a daunting proposition, requiring manyears of work, greatly reducing scientific output and hindering preparation for future cruises. Secondly, it is often desirable to use the data in near real-time to influence the course of the experiment.

A suite of real-time sampling, reduction, calibration, editing and display programs has been developed for a PDP 11/34 computer jointly by the Shipboard Computer Group and Institute of Oceanographic Sciences of the Natural Environment Research Council. The system can sample data from many sources, including the CTD and navigation data, which can be merged in later stages of processing on the common time base. Each program reads data from and writes it back to cyclic disk files in a standard format, setting control variables in COMMON to indicate to what point in a file data have been written, read back and archived to tape. Plotting and listing programs can display data from any disk file. Only the CTD handling programs will be described here.

CTD data pass routinely through six programs for editing and calibration, called CTDSAMP, CTDAVE, CTDCAL, XYPLOT, PRPLOH and FINCTD. CTDSAMP handles the initial data input from the CTD, converting the 16 bit positive integers written by the NBIS deck unit into 32 bit real words, adding time, and writing data cycles at the full 16 or 32 hz data rate to a disk file . These full rate data may be archived to magnetic tape for later use (as may all the standard format disk files) but in general that is not done at IOS because (a) it uses a lot more tape, (b) we regard the NBIS CTD as a finestructure, not a microstructure, instrument (Gregg, 1982), and (c) for SeaSoar tows with profiles on average 1 km apart horizontally it is felt appropriate to match the horizontal sampling with a vertical sampling interval of about 1 m (1 second averages).

CTDAVE reduces the raw data by more than an order of magnitude by averaging over one second, though the averaging period is selectable. An assumption in such averaging is that the calibration procedures to be applied later are linear, so that calibration of a raw averaged value is the same as the average of calibrated raw values. This can be shown to be a good approximation for the short one-second averaging periods used. The rapid sampling rate is necessary to allow the differing time constants of the conductivity cell and temperature probe to be matched for unbiassed estimation of salinities. The necessary information can be retained after averaging as follows. First, it should be remarked that the fast response thermistor available for NBIS CTDs is disabled in the IOS probes, as it has been found to be unsatisfactory. The platinum resistance thermometer used on its own has a very stable calibration and its response is well approximated by a single time constant. The response needs to be speeded up to match that of the conductivity cell. For a single time constant system, we have

$$dTo/dt = \{Tt - To\}/C$$

where To and Tt are the observed and true temperatures, and C is the time constant. Integrating over a period P from t=0 to t=P yields

$$To(t=P) - To(t=0) = P/C * \{\overline{Tt} - \overline{To}\}$$

where the overbar signifies the average over the period, or

$$\overline{Tt} = \overline{To} + C/P * DELTEMP$$

where DELTEMP = To(t=P) - To(t=0). CTDAVE therefore calculates and stores DELTEMP, the temperature difference between start and end of each averaging interval, in addition to the average observed temperature. Subsequently, any time constant C can be applied.

The one-second data are edited and calibrated by CTDCAL. Editing consists of a simple check for single point spikes in conductivity only, this variable having the most noise. The calibration program takes 3 consecutive data points from the averaged data file and compares the absolute difference between the 1st and 2nd (DIFF1) with the absolute difference between the 1st and 3rd (DIFF2). If DIFF1 is greater than a specified limit but DIFF2 is less, point 2 is considered to be a spike and is replaced by an absent data value. The checking continues taking three points with the old point 2 as the new point 1 and so on for all available data. If any of the three points is an absent data value, the checking skips to the next three values. A typical checking limit for conductivity is 0.02 mmho/cm but this may be user defined and is thus variable. More detailed editing is still required after the cruise on the final data set but this check often removes a good proportion of bad data.

CTDCAL calibrates pressure, temperature and conductivity (and chlorophyll, oxygen if present), adjusts the temperature to correct the time constant mismatch, and calculates salinity. Because it is important to use both down and up profiles, the time constant mismatch is found or checked early in a cruise by trial and error adjustment until resulting plots of temperature against salinity show no hysteresis between downs and ups. The method is sensitive in the tight T/S relationship of North Atlantic Central Water (see pages 40 to 45). Throughout the 1980/81 cruises the time constant difference was found by the this method to be 0.23 $\pm$ 0.01 seconds for the CTD in SeaSoar mode (i.e. towed at 4 m/s through the water and 1 m/s vertically). For another CTD used for deep casts from a stationary ship the same method yielded 0.25 $\pm$ 0.01 seconds.

Temperature, pressure and conductivity calibrations are initially obtained from pre-cruise laboratory calibrations, but are checked wherever possible at sea using thermometers, known pressure/depth relationships (Saunders, 1981), and salinity samples. During SeaSoar tows no temperature or pressure calibrations are possible, but samples can be obtained from occasional on-station lowerings, and these are taken together with any post-cruise laboratory calibrations to determine what calibration adjustments are necessary during post-cruise processing on land.

More can and must be done with salinity, as the conductivity cell is prone to sudden biological fouling which occurs on average several times a day, does not always clear, and tends to be cumulative, causing eventual salinity offsets of 0.2 psu (page 12, item D) or more (Pollard, 1980). During Cruise 116 it was at first attempted to use as a comparative standard a Plessey thermosalinograph operated on a pumped non-toxic water supply. This was quickly found to be inadequate, as factors such as range changing, on/off switching, and changing the water flow rate caused recorder pen shifts of order 0.1 psu. An alternative method was perfected during Cruise 116 which allows calibration to an absolute accuracy better than 0.02 psu, relative accuracy 0.01 psu.

Approximate calibration of the conductivity ratio is determined from bottle samples on CTD casts early in a cruise (or the known history of a particular cell), and is used in CTDCAL. CTDCAL is followed by two plotting programs. PLOTXY is a time series plot of temperature, salinity and pressure on a tectronix screen with a hardcopy attachment. PRPLOH is used to produce profile plots of temperature against salinity on a four colour Hewlett Packard 7221 flatbed plotter. The pen colour changes between each down and up trace, and the profiles are offset after every four profiles. Such plots are produced and examined after every two hours of sampling. A sudden fouling of the conductivity cell is immediately apparent as a near constant offset of salinity from the preceding traces on the T/S plots, which are on a scale such that 1 mm corresponds to 0.008 psu. Given a tight T/S relationship (see pages 40 to 45), a constant salinity correction can be measured off the plot to between 0.01 and 0.005 psu. This is a relative correction, i.e. relative to the previous curves. Once the existence of an offset is determined from the T/S profiles, the time at which to apply the correction can be found by looking for the jump on the time series plots. Such a time can be determined within about 30 seconds. A large sudden offset often relaxes to a smaller residual offset in a few tens of seconds, and it is the residual offset that is determined from the T/S curves. Data during the changeover period are left for deletion in subsequent land processing.

Over the relatively small range of salinities and temperatures encountered, a small constant change in conductivity ratio can be approximated by a constant change in salinity to avoid recalculating all salinities. The time at which the offset occurred and the salinity correction to be made are fed back into the computer and used by program FINCTD to recalculate salinity and density.

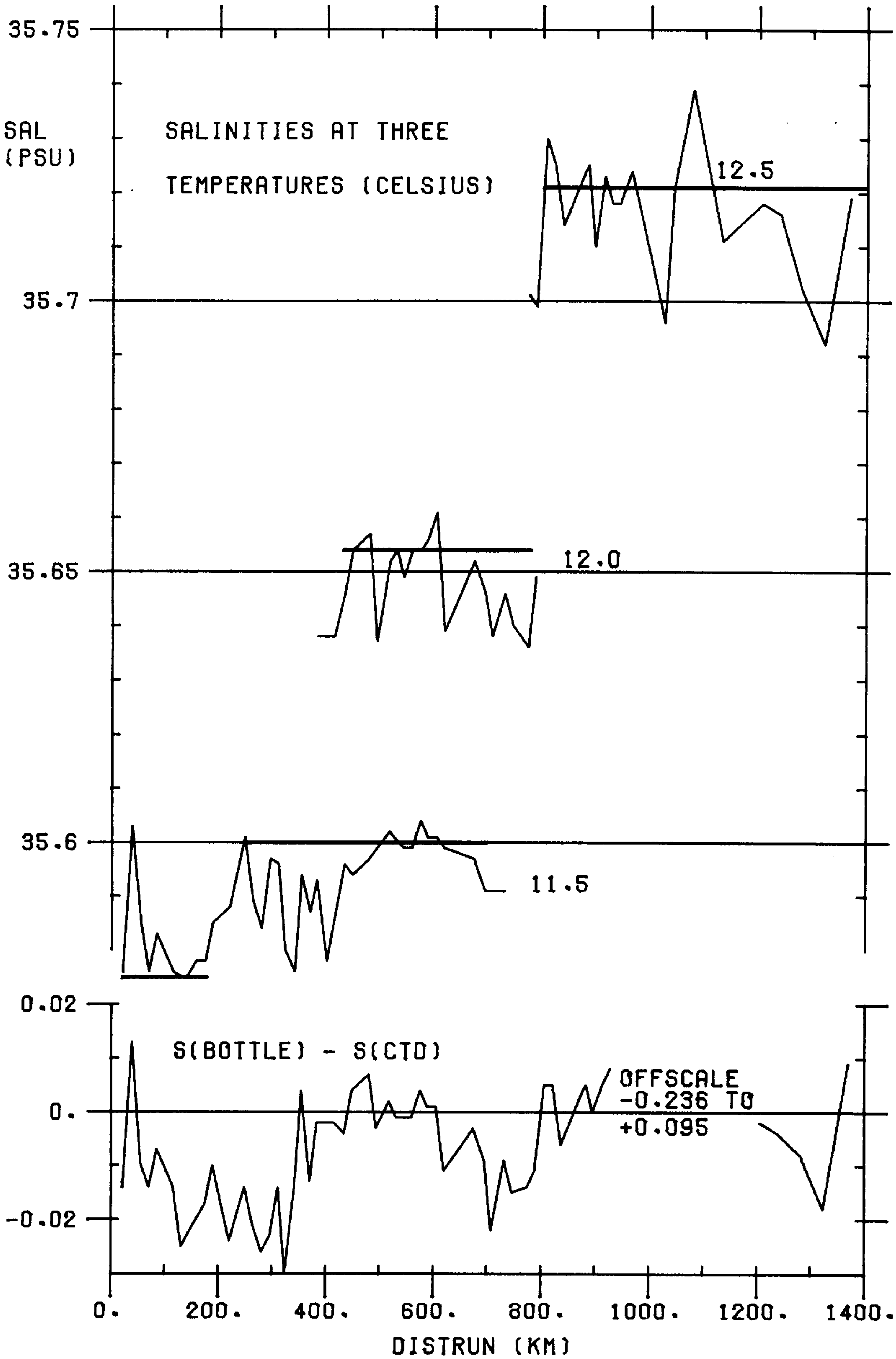
While relative calibration and a tight T/S relation can be obtained in near real-time by the above technique, precise absolute calibration cannot be quickly achieved. During long tows, salinity samples are tapped off the non-toxic supply typically every four hours. By making allowance for the time it takes water to be pumped from the intake to the tap, the speed of the ship, the distance the SeaSoar is behind the ship when it is shallowest, and its known rate of rise, it is possible to time the drawing of samples to correspond approximately to the shallowest CTD reading on a given cycle. Horizontal gradients of surface salinity can be measured from successive cycles and the calibration readings flagged as suspect where large gradients exist.

The salinity samples are analysed on a Guildline salinometer, backed up by an Autolab salinometer, and compared with the CTD salinities obtained from the output of FINCTD.

The FINCTD output file is used for analysis and decision making at sea, using various forms of graphic output, including T/S curves, profiles of parameters, and simple contour plots with pressure or density as the vertical parameter, time as the horizontal.

Problems in putting the above method into practice are shown in Fig. 1. On Cruise 116, FINCTD was not operational and the final corrections were made in subsequent land processing. The absolute T/S curves could still be determined at sea, however. At each calibration point, the salinity difference (bottle - CTD) calculated at the surface

FIG 1 ABSOLUTE SALINITY DETERMINATION



(Fig. 1) was added to salinity on the down trace that immediately followed, and salinities at up to three temperatures in the thermocline read off. The resulting salinities at 11.5, 12.0, and 12.5 degrees C are plotted in Fig. 1.

If there is a precise T/S relationship, the salinity at constant temperature should be constant. In the figure, salinities span rather more than 0.02 psu. It should be noticed, however, that there is a tendency for fluctuations in salinity at constant temperature to match fluctuations in the (bottle - CTD) correction. If the correction had not been applied, the salinities would have been smoother barring fouling events. This 'noise' is particularly large at the southern end of the track (1200 to 1400 km), suggesting that there may be genuine differences of up to 0.02 psu between the surface bottle sample and the CTD value taken perhaps 10 m deeper and several tens of metres horizontally away.

On the other hand, genuine fouling is apparent from the salinity difference plot, with the correction changing from -0.02 to 0.00 at 350 km, drifting to -0.015 at 700 km, and showing large ($\pm$ 0.1) variable errors between 950 and 1200 km. Examination of the salinity traces shows that the offsets are largely removed by the calibration procedure.

We conclude that no variations in the T/S relation in the thermocline are detectable at the 0.01 psu level, and have used Fig 1 to determine points on the T/S curve through hich the data are forced to pass when correcting for fouling. The points, which are lines on the figure, are given by (T,S) = (11.5,35.600), (12.0,35.654) and (12.5,35.721). These are high values rather than means of the calibration curves, as relatively low salinities for a given temperature are indicative of water that has been seasonally heated, so lies off the thermocline T/S line. At the north end of the track (0 to 200 km), an additional point (11.5,35.575) has been used. Examination of the T/S curves suggests that the fresher (by 0.025 psu) value may be seasonally influenced, but at 44 to 47 N the maximum SeaSoar depth is too shallow to be sure of penetrating below the maximum depth of winter convection.

There is one final reservation. The Guildline salinometer, used for all of Fig 1, behaved erratically for many months including Cruise 116, being hard to stabilize on occasion. Thirty samples taken at the end of Cruise 116 were analysed on both Guildline and Autolab salinometers. Differences, excluding four outliers, lay between 0.002 and 0.020 psu, with 18 values in the range 0.011 to 0.018 psu. The Autolab values were all fresher than Guildline values, so it is possible that all our absolute values are up to 0.02 psu too high.

ON LAND DATA PROCESSING AND PRESENTATION

Data from the PDP archived tapes were processed on the NERC Honeywell 66/60 computer using the G-EXEC software system to assist file management and to reduce processing time by a standardized approach. Table 1 shows the various job stages and Tables 2 to 9 list G-EXEC instructions for each job stage. An instruction file is supplied when the G-EXEC controller is run, which converts such instructions to a Fortran program automatically submitted as a batch job.

Graphic output is sometimes more easily manipulated using GRAFIX subroutines outside the G-EXEC system. Tables 10 and 11 are the interactively run programs for producing the track plot and T/S plots in this report.

Another G-EXEC job (Table 12) is necessary to reduce the data for contouring, which is done (Table 13) using the SURFACE II contouring package (Sampson, 1975, 1978).

A description of the processing follows.

(A) Input of data (Table 2)

Data input from magnetic tapes written by the shipboard PDP 11/34 archiving system is efficient and suffers few data transfer problems. The data are transferred to random disk files in a standard format (PSTAR format). Where possible, the data read in are those written by the shipboard program FINCTD (see previous section), which only require slight further absolute recalibration. If FINCTD output is not available, data are taken from earlier files written by CTDCAL or CTDAVE, and extra G-EXEC processing steps are run hich exactly parallel the ship processing already described.

(B) Editing of data (Tables 3 to 5)

Examples of jobs run during editing are shown in Tables 3 to 5. Some or all of these may be required, some more than once. The exact sequence of jobs depends very much on the editing problems of the data set. PSKTCH produces time histograms (Table 3), PCHECK produces histograms, means and standard deviations of each variable and of the first differences of each variable, and flags in a listing any first differences greater than a certain number of standard deviations from the mean. Bad data can then be replaced by absent data values using PRIGHT.

(C) Re-calibration of salinity (Table 6)

The job in Table 6 is used when the relative calibration procedure applied in FINCTD has still left residual errors in time or size of salinity offsets caused by biological fouling. It duplicates FINCTD, and may be run several times until T/S plots are deemed satisfactory. It is also used to make an overall offset to achieve the best absolute calibration.

(D) Calculation of derived variables (Table 7)

Table 7 lists the G-EXEC instructions for calculation of derived oceanographic variables from the finally calibrated data. These calculations use the algorithms for the 1978 Practical Salinity Scale and the 1980 Equation of State. Salinities are thus expressed in practical salinity units (psu). Absent data values are linearly interpolated before calibration.

(E) Merging navigation data (Tables 8 and 9)

Table 8 lists instructions for merging data with navigation. Navigation from satellite fixes and electro-magnetic log is normally recorded on ship. On Cruise 116, however, there was a serious malfunction of the IBM 1800 computer that was in use for navigation data recording. Therefore, satellite fixes listed by the satellite navigator have been culled to reject poor values, and the remainder punched up in card image form and input to a PSTAR file. On the passage legs there are few sudden changes in ship speed or heading, and interpolation between the satellite fixes (on average one to three hours apart) gives an adequate track. Positional inaccuracies are believed less that 1 km, and generally less than 500 m.

A new variable DISTRUN is calculated from successive latitudes and longitudes. DISTRUN is the cumulative distance run, in km, which has been adjusted (Table 9) to have an origin of zero when the SeaSoar was first deployed.

(F) Archiving of data

Output from the job in Table 9 is considered to be the final data set for analysis. It is archived to DEN1600 tape 91293 using the CRUN PEXEC/IOS/PARCH. Files may be restored using the CRUN PEXEC/IOS/PREST. A summary of the contents of a tape may be obtained using the CRUN PEXEC/IOS/PTLOOK.

(G) Track plot and T/S profiles (Tables 10 and 11)

The navigation data from the edited, merged files are plotted by the program in Table 10 on a mercator track plot with land and 1000m depth contours superimposed. The T/S profiles are plotted by programs similar to that in Table 11 acting on the edited, merged files.

(H) Contouring (Tables 12 and 13)

Table 12 lists a G-EXEC instruction file for obtaining a sub-set of the data. Data are averaged to 7.5 decibars in the vertical. In this way a reduced data set is obtained for contouring by the SURFACE II software package. Data are contoured in 100km sections, which restricts the number of input data points to 4500. Table 13 lists the instructions supplied to the SURFACE II contouring package. The data sets must be sequential and sufficient overlap must exist for the entire 100km to be contoured. The typical procedure for creating a sequential file for 100 to 200 km would be

(1) Use the time-sharing program PEXEC/IOS/REFVAL to find the data cycle for distance run of 95km and 205km. An additonal 5 km at each end allows enough data for SURFACE II to calculate a regular data grid for the whole 100km.

(2) Use the time-sharing instruction PEXEC/IOS/PTOSEQ to transfer the data from the 7.5db averaged data set to a sequential file

(3) Use the SURFACE II instruction file in Table 12 with the time sharing instruction PEXEC/IOS/SURFACE2 to submit the contouring job to batch.

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REFERENCES

Dessureault, J.G. (1976) 'Batfish'. A depth controllable towed body for collecting oceanographic data. Ocean Engng. 3 99-111

Gregg, M. C., J. C. Schedvin, W. C. Hess and T. B. Meagher (1982) Dynamic response calibration of the Neil Brown conductivity cell, J. Phys. Oceanog. 12 720-742

Grimm, A. E. (1981) G-EXEC Users Manual (Version 2), NERC Computing Service, Document 23

Institute of Oceanographic Sciences (1981) R.R.S. Discovery Cruise 116, Winch and instrumentation trials with CTD section, Cruise Report No. 109, unpublished manuscript

Pollard, R. T. (1980) Reduction of JASIN Batfish data, JASIN News 17 unpublished manuscript

Sampson, R. J. (1975) The SURFACE II graphics system, in Davis, J. C. and M. J. McCullagh, eds., Display and analysis of spatial data, John Wiley and Sons, London, 244-266

Sampson, R. J. (1978) SURFACE II graphics system, Kansas Geological Survey, 240 pp

Saunders, P. M. (1981) Practical conversion of pressure to depth, J. Phys. Oceanog. 11 573-574

TABLE 1

Summary of job processing steps

The following jobs comprise the total data processing activities for the SeaSoar sections.

Processing of data

Job 1	(Table 2)	Data Input from PDP tapes
Job 2	(Table 3)	Preview of data
Job 3	(Table 4)	Initial editing
Job 4	(Table 5)	Final editing
Job 5	(Table 6)	Re-calibration of salinity
Job 6	(Table 7)	Calculation of derived variables
Job 7	(Table 8)	Merging navigation data
Job 8	(Table 9)	Adjusting Distance Run
Job 9		Archiving of data

Presentation of data

Job 10	(Table 10)	Track plot
Job 11	(Table 11)	Producing T/S profiles
Job 12	(Table 12)	Obtaining sub-sets of the data
Job 13	(Table 13)	Producing contour plots

TABLE 2

Data input from PDP tapes

Typical G-EXEC instruction file, in this case used with CRUN PEXEC/IOS/PPDP,R The following file may be used with the G-EXEC controller in the normal way. At the time of processing, however, tapes could not be handled within G-EXEC. This job transfers raw data from PDP archive format on tape to a standard format (PSTAR) on disk.

```
G-EXEC P61,500,4
SPU,SPU,SPU INPUTING PDIGIN DATA
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PPDPIN
0000001
FILE,3,WBFDI11601BW
TYPE,9
FIND WTAPE92715
MAKE WBFDI11601BW
EXEC GSHFIL
22
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
STOP
```

TABLE 3

Preview of data

Typical G-EXEC instruction file used to produce a time-histogram (THISTO) of data for examination before editing. PSKTCH, as used below, produces a histogram on a single lineprinter line for each 1000 data cycles (GROUP command). The 1000 values are sorted into 36 bins evenly spaced between the minimum and maximum of the variable being processed. The number of values in each bin is then printed across the line.

MESS and DISK are special Bidston G-EXEC statements.

```
G-EXEC P61,200,10
SPU,SPU,SPU PROCESSING DISCOVERY 116 DATA
DISK WBFDI11601BW,SPU/28/DI11601,320
COMM
COMM ************************************
COMM ***** 1ST JOB AFTER PPDPIN CRUN *****
COMM ************************************
COMM
MESS SPU USING IOS28
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PSKTCH
009
GROUP,1000
VARS,PRES,TEMP,SALIN
FIND WBFDI11601BW
EXEC GSHFIL
02
MAKE WSPUHISTORY
STOP
```

TABLE 4

Initial editing

Typical G-EXEC instruction file to perform initial editing on the SeaSoar CTD data. The output from the previous job is studied to establish limits outside of which data values are considered bad. Such values are replaced by absent data values (PEDITA). Spikes are automatically removed from the data (PCHECK/PRIGHT) and information is obtained on remaining troublesome areas using programs PCHECK and PSKTCH (see Table 3) a second time.

```
G-EXEC P61,300,10
SPU,SPU,SPU PROCESSING 116 DATA
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PEDITA
009
LIMIT,SALIN,35.00,37.00
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC PCHECK
019
ERRA,0.00001,8.
VARS,PRES,TEMP,SALIN
FIND WBFDI11601BW
MAKE WSPUEDITFILE
EXEC PRIGHT
019
ENTR,-
FIND WBFDI11601BW
FIND WSPUEDITFILE
MAKE WBFDI11601BW
EXEC PCHECK
019
ERRA,0.00001,8.
VARS,PRES,TEMP,SALIN
FIND WBFDI11601BW
MAKE WSPUEDITFILE
EXEC PSKTCH
009
GROUP,1000
VARS,PRES,TEMP,SALIN
FIND WBFDI11601BW
EXEC GSHFIL
02
MAKE WSPUHISTORY
STOP
```

TABLE 5

Final editing

Typical G-EXEC instruction file to perform final editing of CTD data. The job may be changed to include both editing from an edit file (by specifying entries written by PCHECK) and/or manual editing (by specifying data cycles) with program PRIGHT. This job may be repeated several times. Additionally it has proved useful to run a user-supplied subroutine to remove single spikes with checking limits of 0.2 for temperature and 0.02 for salinity. The method adopted by that subroutine is as described for the ship-board algorithm in the section "At sea data reduction and calibration". This should soon be available as a process program PSPIKE.

Another useful aid has been a time-sharing program run with the command

PEXEC/IOS/THISTO

This provides output similar to that from the GROUP option of process program PSKTCH (Table 3). In time-sharing, this provides an effective means of investigating parts of the data with difficult editing requirements. Data cycles to be replaced by absent data values can be established with little effort. Salinity normally proves to be the most difficult variable to edit.

```
G-EXEC P61,200,10
SPU,SPU,SPU PROCESSING 116 DATA
COMM
COMM ****************************
COMM *****  FINAL EDIT JOB   *****
COMM ****************************
COMM
MESS DSC USING IOS28
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PRIGHT
0090002
VARS,1
REPL,8874,-,8893,9787,-,9803,12089,12090
VARS,2
REPL,84,-,110,156,-,160,173,-,178,9787,-,9814
FIND WBFDI11601BW
```

```
MAKE WBFDI11601BW
EXEC PINTRP
009
LINE,-
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC PCHECK
009
ERRA,0.00001,8.
VARS,SALIN
FIND WBFDI11601BW
EXEC PSKTCH
009
GROUP,1000
VARS,SALIN
FIND WBFDI11601BW
EXEC GSHFIL
02
MAKE WSPUHISTORY
STOP
```

TABLE 6

Re-calibration of salinity

The T/S curves are examined and overlaid to establish places where salinity has shifted. This typically happens as a sudden jump with a gradual drift back to a stable value, not always the original value. There can also be gradual drifts in measured salinity. Both these problems can be identified with the T/S curves although not always easily. The following instruction file makes use of a user-supplied subroutine for adjusting salinity. Some slight editing may be needed at points of change in the correction.

```
G-EXEC P61,200,4
SPU,SPU,SPU AMENDING SALINITY
COMM  ** FINAL CORRECTIONS TO SALINITY **
MESS SPU USING IOS28
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PUSRIO
0
VARS,SALIN
ICON,1,115571,117477,118587,118624,122995,0
FCON,0.0,0.011,-0.005,0.025,-0.005
OVARS,-
SUBS
$$ SELECT(PEXEC/IOS/SALCAL)
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC GSHFIL
22
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
STOP
```

$$ SELECT inserts the subroutine stored in the specified file (PEXEC/IOS/SALCAL), which is listed on the next page:

TABLE 6(cont)

Re-calibration of salinity

Listing of PEXEC/IOS/SALCAL :

```
      SUBROUTINE USERIO (INDISK,IODISK,INPOS,INVARS,
     & IOFLDS,NSTART,NSTOP,ICON,NIC,FCON,NFC,XVAR,TIME,
     & YVAR,SUMMIO,ABSIN,ABSIO,INRECS,
     & IORECS,INRECL,IORECL,NUMWRD,INFLDS,RETREC)
C.....IOS G-EXEC  D S COLLINS  RECALIBRATE SALINITY
C.....ADD FCON(J) TO VARIABLE INPOS(1) CYCLES ICONS(J)
C.....                              TO (ICONS(J+1)-1).
C.....STOP WHEN ICONS(J+1) IS 0
C.....FIND MUST EQUAL MAKE FILE (NO OF FIELDS MUST BE EQUAL)
      DIMENSION INPOS(INVARS),ICON(19),FCON(19),XVAR(NUMWRD),
     & TIME(NUMWRD),YVAR(NUMWRD),SUMMIO(NUMWRD),
     & ABSIN(NUMWRD),ABSIO(NUMWRD),RETREC(NUMWRD)
      COMMON/IO/IOCNSL,IOCSLE,IWKDSK,INTAPE,INCARD,IPRINT,IPUNCH,
     & INBIN,NOBUG,INFLIX,MNINDX,TEPFL,IOTAPE,NHOLD,NDATST
      IORECS=INRECS
      IOFLDS=INFLDS
      NUM=NUMWRD
      DO 300 L=1,20
      NSTART=ICON(L)
      NSTOP=ICON(L+1)
      IF (NSTOP.EQ.0) GO TO 400
      NSTOP=NSTOP-1
      WRITE(IPRINT,10) NSTART,NSTOP,INPOS(1),FCON(L)
   10 FORMAT(/' FOR DATA CYCLE  ',I6,'  TO  ',I6,
     & '   FOR VARIABLE  ',I4,' ADDING  ',F10.3)
      NL=NUM
      DO 200 J=NSTART,NSTOP,NUM
      IF ((J+NUM-1).GT.NSTOP) NL=NSTOP-J+1
      CALL INDATA (INDISK,INPOS(1),J,NL,XVAR,
     & RETREC,NHED,INFLDS,INRECS,INRECL)
      DO 20 N=1,NL
      IF (XVAR(N).EQ.ABSIN(INPOS(1))) GO TO 20
      XVAR(N)=XVAR(N)+FCON(L)
   20 CONTINUE
      CALL OTDATA (IODISK,INPOS(1),J,NL,XVAR
     &,RETREC,NHED,IOFLDS,IORECS,IORECL)
  200 CONTINUE
  300 CONTINUE
  400 CONTINUE
      RETURN
      END
```

TABLE 7

Calculation of derived variables

The following is a typical G-EXEC instruction file for the editing of a few data points remaining after the final salinity corrections and for calculation of derived variables. The program PEOS80 makes use of the Equation of State 1980.

```
G-EXEC P61,900,6
SPU,SPU,DSC PROCESSING DI116 DATA
COMM ** CALCULATING DERIVED VARIABLES **
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PRIGHT
0000002
VARS,3
REPL,95,96,628,668,-,673,1001,-,1007,1351,-,1361
REPL,2024,-,2034,2045,-,2048,2060,2621,-,2624
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC PINTRP
0
COPY,1,2
LINE,3
COPY,4,-,10
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC PEOS80
0
COPY
VARS,1,2,3,4,5,6
PTMP,0.0
VARS,P,2,S,6,T,3
SIGP,0.0
VARS,P,2,S,6,T,3
COPY
VARS,9,10
FIND WBFDI11601BW
MAKE WBFDI11601BW
EXEC GSHFIL
22
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
STOP
```

TABLE 8

Merging navigation data

The following is a typical G-EXEC instruction file for the merging of navigation data with 1-second CTD data. The navigation data consist of selected satellite fixes which have been entered manually. PDSTRN calculates distance run in km, and PCOPYA calculates upper and lower limits and renames the file

```
G-EXEC P61,900,6
SPU,SPU,DSC PROCESSING DI116 DATA
DISK WBFDI11606MG,SPU/28/MRG11606,320
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PMERG1
000
SYNC,TIME
FILE
VARS,-
FILE
VARS,-
FIND WBFDI11606BW
FIND WNVDI11601BW
MAKE WBFDI11606MG
EXEC PDSTRN
009
COPY
VARS,1,2,3
DIST,1,1
VARS,LATITUDE,LNGITUDE
COPY
VARS,5,-,11
FIND WBFDI11606MG
MAKE WBFDI11606MG
EXEC PCOPYA
1000001
VARS,-
COPY,,
FIND WBFDI11606MG
MAKE WBFDI11606MG
EXEC GSHFIL
02
MAKE WSPUHISTORY
STOP
```

TABLE 9

Adjusting distance run

Once navigation and CTD data have been merged, it is useful to add a variable DISTRUN, the distance run along the track in km. DISTRUN is zero where the Sea-Soar is first deployed on a cruise and increments until final recovery. If the data are in several files and there is a gap in recording between files, DISTRUN at the start of the second file is the distance at the end of the first file plus an allowance for the distance travelled during the data gap. DISTRUN is calculated in the previous job. Here the absolute value is adjusted.

```
G-EXEC P61,900,6
SPU,SPU,DSC PROCESSING DI116 DATA
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PCALIB
009
COPY,TIME,TIME
COPY,PRES,PRES
COPY,TEMP,TEMP
LINE,DISTRUN,DISTRUN,1.0,1251.182,KM.
COPY,SALIN,SALIN
COPY,POTEMP,POTEMP
COPY,SIGMO.0,SIGMO.0
COPY,OXYPC,OXYPC
COPY,OXYGEN,OXYGEN
COPY,LATITUDE,LATITUDE
COPY,LNGITUDE,LNGITUDE
FIND WBFDI11607MG
MAKE WBFDI11607MG
EXEC GSHFIL
02
MAKE WSPUHISTORY
STOP
```

TABLE 10

Track plot

The following job plots the mercator track plot, annotating with DISTRUN every 100 km.

```
*#FRN *=(ULIB,NWARN)LIBRARY/GRAFIX,R;LIBRARY/SPI,R
*##PEXEC/2/QLIB,R;OPS/WORMLEY/FLATBED/DSC1"15"
C.....  ************************************
C.....  ** D S COLLINS          18-AUG-82  **
C.....  ************************************
C.....   MERCATOR PLOT OF NORTH ATLANTIC (THE POLLARD SQUARE)
      DIMENSION FILE(10),X(320),Y(320),D(320),IT(3)
      DATA IT/' ','K','M'/
      EXTERNAL SMERC
      CALL SPI
C.....
C.....   A4 SIZE PLOT
      CALL FMTVAR (142.,200.)
      CALL SHIFT2 (0.,-400.)
      CALL DEFFM2 (SMERC,-30.,-5.,30.,55.)
      CALL GRISEL (3,3,1)
      CALL ANNGEO (1,-1)
      CALL AXIMAP (SMERC,1)
      CALL AXIFB2 (SMERC,10.,10,1)
      CALL AXIMAP (SMERC,2)
      CALL AXIFB2 (SMERC,10.,10,2)
C.....
C.....  LABEL MAP
      CALL MOVTO2 (0.,-14.)
      CALL LABEL (0,'TRACK PLOT FOR DISCOVERY CRUISE 116',35)
      CALL MOVTO2 (0.,-18.)
      CALL LABEL (0,'***** **** *** ********* ****** ***',35)
      CALL MOVTO2 (0.,-23.)
      CALL LABEL (0,'MERCATOR PROJECTION WITH COASTLINE',34)
      CALL MOVTO2 (0.,-28.)
      CALL LABEL (0,'          AND 1000M DEPTH CONTOUR',34)
      CALL MOVTO2 (0.,-33.)
      CALL LABEL (0,'TRACK MARKS INDICATE DISTANCE RUN',33)
C.....
C.....   DRAW LAND OUTLINES AND 2 DEPTHS
      CALL WORLDM (SMERC)
      CALL FATHOM (SMERC,1000.)
C.....
C.....   PLOT SHIP TRACK
      CALL MARSEL (0)
      CALL LINSEL (1)
      CALL POIBEG
```

```
      NFIRST=1
      DNEXT=0.0
      CALL CHASEL (1.5)
      DO 10 N=1,5
C.....    ATTACH APPROPIATE DATA FILE
      IF (N.EQ.1) CALL ATTACH (11,'SPU/28/MRG11601;',1,1,ISTAT)
      IF (N.EQ.2) CALL ATTACH (11,'SPU/28/MRG11605;',1,1,ISTAT)
      IF (N.EQ.3) CALL ATTACH (11,'SPU/28/MRG11608;',1,1,ISTAT)
      IF (N.EQ.4) CALL ATTACH (11,'SPU/28/MRG11607;',1,1,ISTAT)
      IF (N.EQ.5) CALL ATTACH (11,'SPU/28/MRG11609;',1,1,ISTAT)
C.....  LOOP TO PLOT TRACK
      CALL QINITI (11)
      CALL QREADD
      CALL QINFIL (FILE,NOFLDS,NORECS)
      NSTART=1
      NSTOP=NORECS
      LEN=320
      DO 20 L=NSTART,NSTOP,320
      IF ((L+LEN-1).GT.NSTOP) LEN=NSTOP-L+1
      CALL QINDAT (7,L,LEN,Y)
      CALL QINDAT (8,L,LEN,X)
      CALL QINDAT (9,L,LEN,D)
      DO 30 K=1,LEN,160
      IF ((Y(K)-LAST).GT.5.) GO TO 33
      CALL POIFA2 (SMERC,X(K),Y(K))
      IF (D(K).LT.DNEXT) GO TO 30
C......  PLOT A SYMBOL EVERY 100KM
      CALL POSSPA (XX,YY,ZZ)
      CALL CENCH (4,1.5)
      CALL MOVBY2 (4.,0.)
      NOW=DNEXT+0.1
      IF (NOW.EQ.700) GO TO 32
      CALL INUMB (NOW,4,2.0,0.0,4,IERR)
      CALL TEXT  (IT,3,2.0,0.0,1)
   32 CALL MOVTO2 (XX,YY)
      DNEXT=DNEXT+100.
C.....    GAP IN TRACK
   33 CALL POIEND
      CALL POIBEG
      CALL POIFA2 (SMERC,X(K),Y(K))
   34 IF (D(K).LT.DNEXT) GO TO 30
      DNEXT=DNEXT+100.
      GO TO 34
   30 LAST=Y(K)
   20 CONTINUE
   10 CALL DETACH (11,ISTAT,)
C.....
C.....    END OF PLOTTING
      CALL POIEND
      CALL GRAEND
      CALL DEVEND
      STOP
      END
```

TABLE 11

Producing T/S profiles

The following is an example of a job to plot the T/S profiles. Only every tenth point is plotted, with the profiles offset by 0.2 p.p.t. after every 40 km of DISTRUN.

```
*#FRN *=(ULIB,NWARN)LIBRARY/GRAFIX,R;LIBRARY/SPI,R
*##PEXEC/2/QLIB,R;OPS/WORMLEY/CC936/RTP6"15";SPU/TSOUT"07"
C.....
C.....  *************************************
C.....  **  D S COLLINS         20 AUG 82     **
C.....  **  MODS BY R T POLLARD 8 NOV 82     **
C.....  *************************************
C.....    STANDARD T/S PLOTS FOR DATA REPORT
C.....
      DIMENSION FILE(10),X(320),Y(320),D(320)
      CALL SPI
      CALL SHIFT2 (20.,20.)
      DBEG=1200
      DSTEP=40.
      DNEXT=DBEG+DSTEP
      DEND=DBEG+280.
      CALL PLTBOX(DBEG,DSTEP)
C.....  ATTACH EACH FILE IN TURN
      XOFF=0.
      XSTEP=0.2
      NFILES=5
      CALL MARSEL (0)
      CALL LINSEL (1)
      CALL POIBEG
      DO 10 JJ=1,NFILES
      IF (JJ.EQ.1) CALL ATTACH (11,'SPU/28/MRG11601;',1,1,ISTAT)
      IF (JJ.EQ.2) CALL ATTACH (11,'SPU/28/MRG11605;',1,1,ISTAT)
      IF (JJ.EQ.3) CALL ATTACH (11,'SPU/28/MRG11608;',1,1,ISTAT)
      IF (JJ.EQ.4) CALL ATTACH (11,'SPU/28/MRG11607;',1,1,ISTAT)
      IF (JJ.EQ.5) CALL ATTACH (11,'SPU/28/MRG11609;',1,1,ISTAT)
      CALL QINITI (11)
      CALL QREADD
      CALL QLSTD (0)
      CALL QINFIL (FILE,NOFLDS,NORECS)
      NSTART=1
      NSTOP=NORECS
      NLEN=320
      DO 20 J=NSTART,NSTOP,320
      IF ((J+NLEN-1).GT.NSTOP) NLEN=NSTOP-J+1
      CALL QINDAT (9,J,NLEN,D)
      IF(D(NLEN).LT.DBEG)GO TO 20
```

```
      CALL QINDAT (4,J,NLEN,X)
      CALL QINDAT (5,J,NLEN,Y)
      DO 30 N=1,NLEN,10
      IF(D(N).LT.DBEG)GO TO 30
      IF (D(N).GT.DEND) GO TO 90
   31 IF (D(N).LE.DNEXT)GO TO 32
      DNEXT=DNEXT+DSTEP
      XOFF=XOFF+XSTEP
      CALL POIEND
      CALL POIBEG
      GO TO 31
   32 CALL POILA2 (X(N)+XOFF,Y(N))
   30 CONTINUE
   20 CONTINUE
      CALL DETACH(11,ISTAT,)
   10 CONTINUE
   90 CALL POIEND
      CALL DEVEND
      STOP
      END
      SUBROUTINE PLTBOX(DBEG,DSTEP)
C.....
C.....   ***************************************
C.....   **  D S COLLINS          20 AUG 82    **
C.....   ***************************************
C.....    PLOT STANDARD BOX FOR T/S CURVES
C.....
      CALL MOVTO2 (0.,0.)
C.....  DRAW A4 BOX
      CALL LINTO2 (297.,0.)
      CALL LINTO2 (297.,210.)
      CALL LINTO2 (0.,210.)
      CALL LINTO2 (0.,0.)
C.....  DRAW DATA BOX
      CALL SHIFT2 (42.,33.)
      CALL MOVTO2 (0.,0.)
      CALL LINTO2 (225.,0.)
      CALL LINTO2 (225.,140.)
      CALL LINTO2 (0.,140.)
      CALL LINTO2 (0.,0.)
C.....  DEFINE AND DRAW AXES
      CALL GRAFIX (225.,140.)
      CALL DEFLA2 (35.5,37.3,10.,17.)
      CALL GRISEL (3,0,2)
      CALL AXILA2 (1)
      CALL AXILA2 (2)
      CALL MOVTO2 (0.,-15.)
      CALL CHASEL (3.0)
      CALL LABEL (0,'POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOV
     &ERY CRUISE 116',62)
      CALL MOVTO2(22.+62.,157.)
      CALL LABEL(0,'DISTANCE ALONG TRACK (KM)',25)
      DO 20 I=1,6
      CALL MOVTO2(22.*I+62.,150.)
```

```
      IA=DBEG+(I-1)*DSTEP+0.2
      IB=DBEG+DSTEP*I+0.2
      CALL INUMB(IA,4,3.,0.,1,IERR)
      CALL LABEL(0,' -',2)
      CALL MOVTO2(22.*I+62.,145.)
      CALL INUMB(IB,4,3.,0.,1,IERR)
 20   CONTINUE
      CALL MOVTO2(0.,200.)
      CALL LABEL(0,'CHANGE PEN TO BLACK BIRO PLEASE',31)
      DO 30 I=1,4
      CALL MOVTO2(0.,200.)
      CALL MOVTO2(250.,200.)
30    CONTINUE
      RETURN
      END
```

TABLE 12

Obtaining subsets of data for contouring

For contouring, a subset of the data is used. The SURFACE II contouring package can only handle 4500 data points easily, which is the limiting factor in choosing the subset. For contour plots each spanning 100km in the variable DISTRUN, the data are averaged by the following job over 7.5 db pressure intervals. The pressure intervals are centred at 3.75 + n*7.5 db (n integer).

```
G-EXEC P61,200,6
SPU,SPU,DSC GENERATING GRID FOR SURFACE2
DISK WBFDI11607GR,SPU/28/GR11607,320
EXEC GSHFIL,,IOSW
11
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
EXEC PAVRGE
0
SCAN,2,0.0,7.5
VARS,2,3,5,6,7,10,4
FIND WBFDI11607MG
MAKE WBFDI11607GR
EXEC GSHFIL
22
MAKE WSPUSUMMARY
MAKE WSPUHISTORY
STOP
```

TABLE 13

Producing contour plots

The following SURFACE II job produces all four contour plots in this report for each 100 km of DISTRUN. The example given is for DISTRUN range 800 to 900 km.

For contour plots with pressure as the vertical coordinate, GRID and EXTR together determine that grid points are 2.0 km apart horizontally and 7.5 db apart vertically, with the pressure grid values (0 + n*7.5 db) lying midway between the averaged input values (Table 12). Values at the grid points are determined by a QUADrant search which seeks up to four points in each of four quadrants about the grid point, with quadrant boundaries parallel to the axes. The points are inversely weighted by their distance (squared) from the grid point. However, points are on average 0.5 to 3.5 units (km) horizontally away from grid points, but 3.75 units (db) vertically away. Consequently, the gridding chooses the points 3.75 db above and below the grid points and up to 4 km away horizontally, with weakly varying weights (0.6 to 1.0).

Gridding therefore averages the data (up to 16 points) over 15 db and 6 to 8 km. The horizontal averaging smooths much of the internal wave noise.

For the last plot, in which density is the vertical coordinate, it has been multiplied by 100 (RTXY) so that the 'radius' of influence search achieves similar averaging to that for pressure.

```
DEVI  4,'DUNCAN',12,10
TITL  DI116 : X=DISTANCE(KM),Y=PRESSURE(DB) : SIGMA.T
IDXY  4500,11,6,6,1,5,,,1,-9.99,'(6F9.4)'
EXTR  800,900,330,0
GRID  1,2.0,7.5,,2,1
QUAD  2,4
CONT  0,1,,0,1
CINT  0,26.6,.02,0,5,0.08,2,1.5,5
BOX   5,4,10,5,,,,,0.1
SIZC  1,7.874,2.5984
PERF
CLEAR
TITL  DI116 : X=DISTANCE(KM),Y=PRESSURE(DB) : SALINITY
IDXY  4500,11,6,6,1,3,,,1,-999.,'(6F9.4)'
EXTR  800,900,330,0
GRID  1,2.0,7.5,,2,1
```

```
QUAD  2,4
CONT  0,1,,0,1
CINT  0,36.0,.02,0,5,0.08,2,1.5,5
BOX   5,4,10,5,,,,,0.1
SIZC  1,7.874,2.5984
PERF
CLEAR
TITL  DI116 : X=DISTANCE(KM),Y=PRESSURE(DB) : POTENTIAL TEMP.
IDXY  4500,11,6,6,1,4,,,1,-9.99,'(6F9.4)'
EXTR  800,900,330,0
GRID  1,2.0,7.5,,2,1
QUAD  2,4
CONT  0,1,,0,1
CINT  0,12.0,.2,0,5,0.08,2,1.5,5
BOX   5,4,10,5,,,,,0.1
SIZC  1,7.874,2.5984
PERF
CLEAR
TITL  DI116 : X=DISTANCE(KM),Y=SIGMA.T*100 : SALINITY
IDXY  4500,11,6,6,5,3,,,1,-999.,'(6F9.4)'
RTXY  0,1.0,100.0
PERF
EXTR  800,900,2750,2650
GRID  1,2.0,2.0,,2,1
QUAD  2,4,8,16
CONT  0,1,,0,1
CINT  0,36.0,.02,0,5,0.08,2,1.5,5
BOX   5,4,5,4,,,,,0.1
SIZC  1,7.874,3.1496
PERF
STOP
```

NOTES ON DATA PRESENTATION

Detailed descriptions of the programs used to produce the following plots are given in previous sections. To avoid back referencing, points of immediate scientific relevance are summarized here.

All data are plotted against DISTRUN, a parameter measuring the distance run (in km) from the point where the SeaSoar was first deployed. Values of DISTRUN are annotated on the track plot (page 39) every 100 km, and contoured sections (page 46 on) are plotted 100 km per page. The latitude, longitude and time of the 100 km points are listed in Table 14 (page 38).

The edited, merged (CTD and navigation) data set consists of 1 second averages of time, pressure, temperature, salinity, potential temperature, sigmatheta, latitude, longitude and distance run along the SeaSoar track. Individual points are thus about 4 m apart horizontally, and 1 m apart vertically. Both down and up traces are used in all plots and there is a profile (down or up) from 10 to 300 m approximately every 1 km.

Every tenth 1 second average has been plotted on the potential temperature against salinity (T/S) plots (page 40 on). The 10 second subsampling causes the plots to be somewhat jerky (obvious straight line sections) in the surface layer where the T/S relation changes rapidly. Data have been overplotted for 40 km (DISTRUN) sections, with an offset of 0.2 psu in salinity between sections. Thus each 40 km plot spans about 3 hours, and consists of about 1000 points ten seconds apart in about 40 vertical profiles. The salinity scale applies to the first plot on a page.

The last 40 km section on each T/S plot is repeated as the first on the following plot so that the along track development of the T/S relation can be followed. North of 44 N (DISTRUN 360-400 km) the tight T/S relation of North Atlantic Central Water (NACW) is confined to temperatures less than 11.5 C. From that point south, the tight T/S relation extends up to 12.5 C. A second major change occurs at about 41.5 N (760 km) where the temperature at 300 db increases from 11.5 to 12.0 C and the tight T/S relation extends to 13.0 C and above. Within some sections, the salinity in the thermocline may vary by less than 0.01 psu at a given temperature, e.g. 400 to 800 km at 12.0 C. The range is generally less than 0.02 psu, e.g. 1000 to 1200 km at 13.0 C (with a data error causing the offset of one down/up profile in the 920 to 960 km section).

The 1 second data have been further averaged over 7.5 db pressure intervals (Table 12) to accommodate the maximum number of points contourable in one run. Yet more averaging is done by the gridding process (Table 13) prior to contouring, so that the gridded values, which are 7.5 db and 2 km apart, are averages over 15 db and 6 to 8 km.

Potential temperature, salinity and sigmatheta are contoured against pressure. The latter plot, which shows baroclinicity, is placed next to a contour plot of salinity with density as the vertical coordinate, which shows haloclinicity (equivalently thermoclinicity). If the T/S relation is constant, lines of constant salinity are horizontal on such a plot.

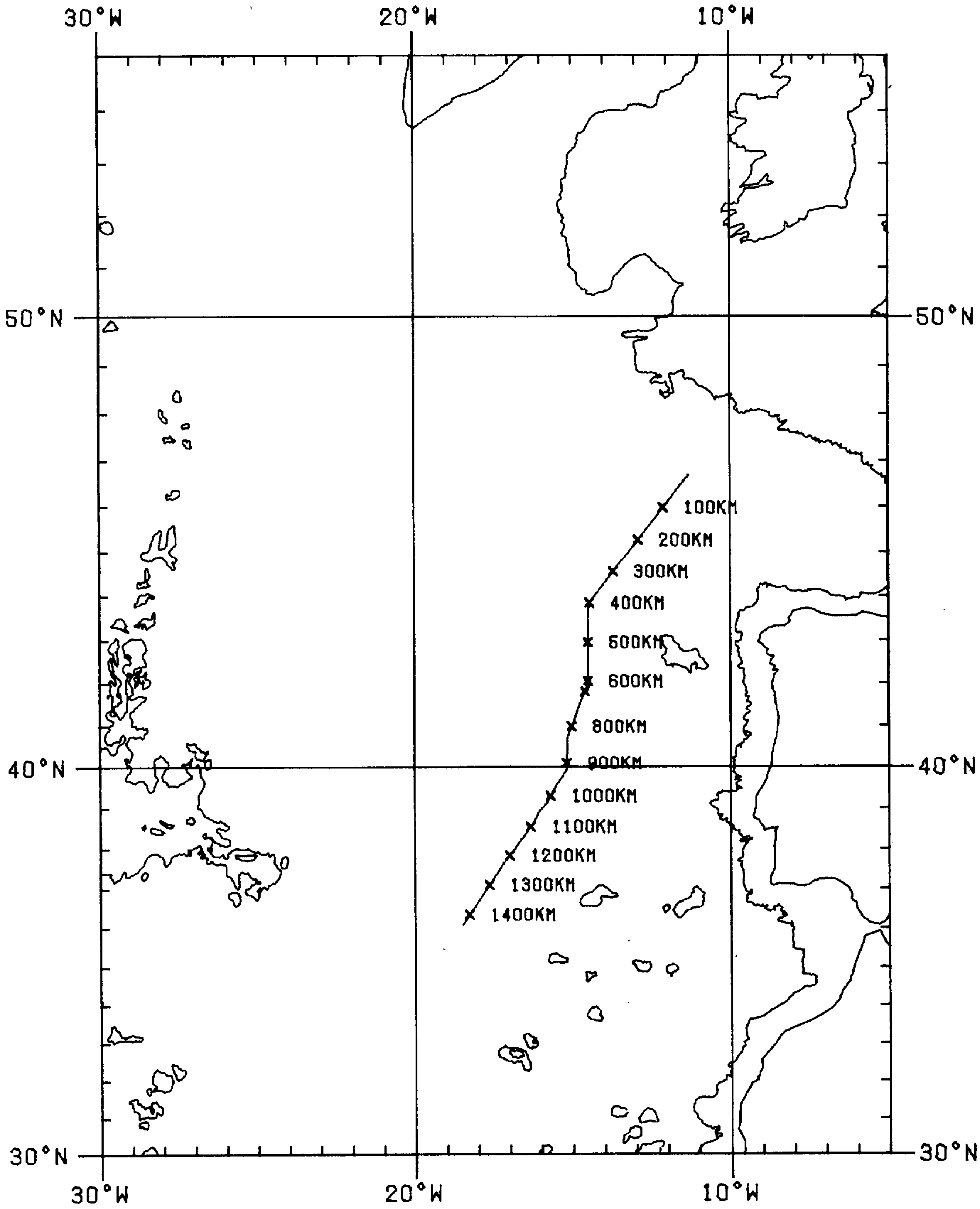
TABLE 14

Timetable of events

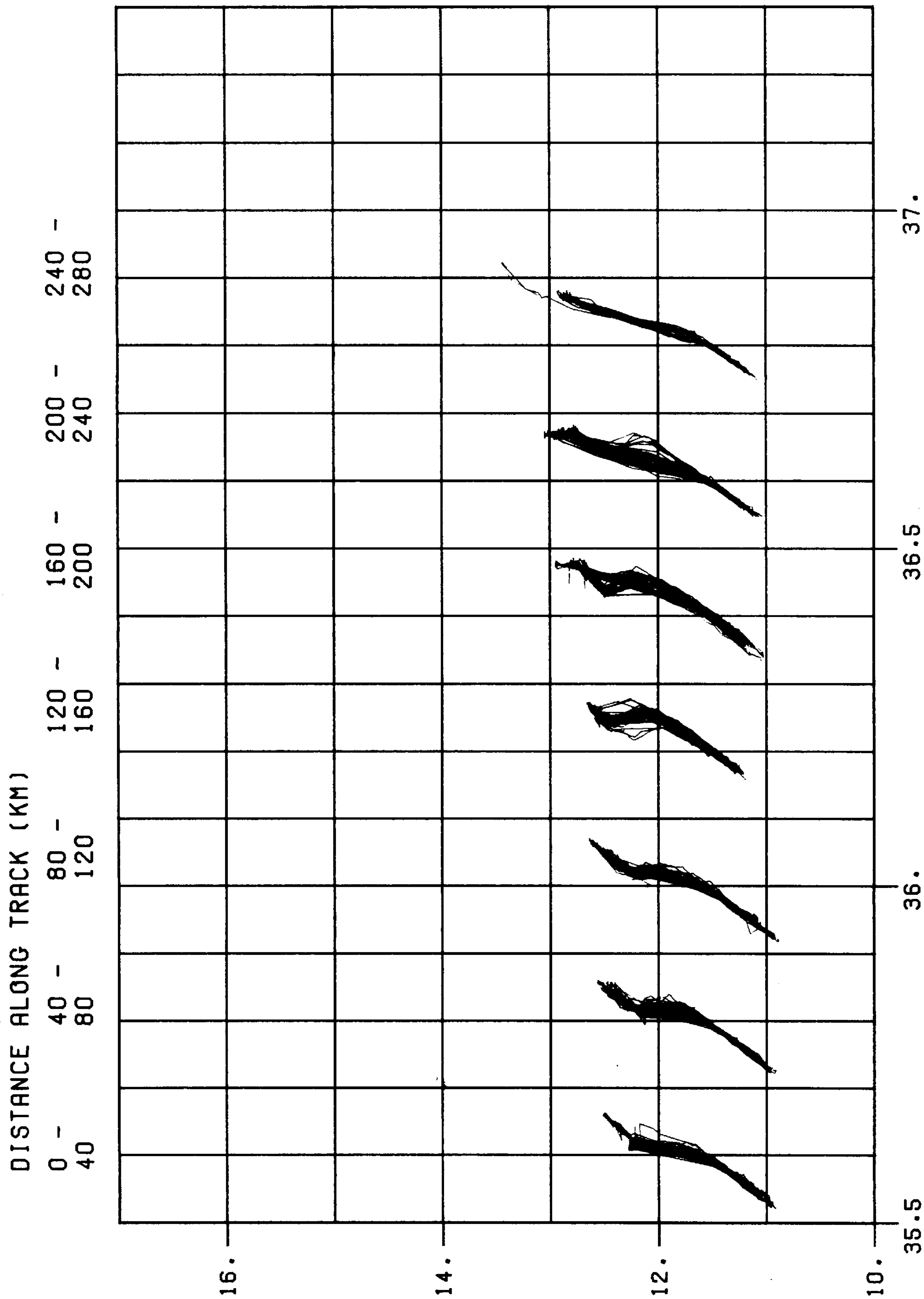
This Table is a summary of events concerned with SeaSoar deployment during Discovery Cruise 116.

Distance run (DISTRUN) is in km, the origin being taken at the start of SeaSoar profiling on the cruise. DISTRUN then continues to increment regardless of whether the SeaSoar is deployed. The 'Date' is of the form YYMMDD where YY=year, MM=month and DD=day (e.g. 780831 is 31st August 1978). Similarly 'Time' is of the form HHMMSS where HH=hour, MM=minute and SS=second (e.g. 140730).

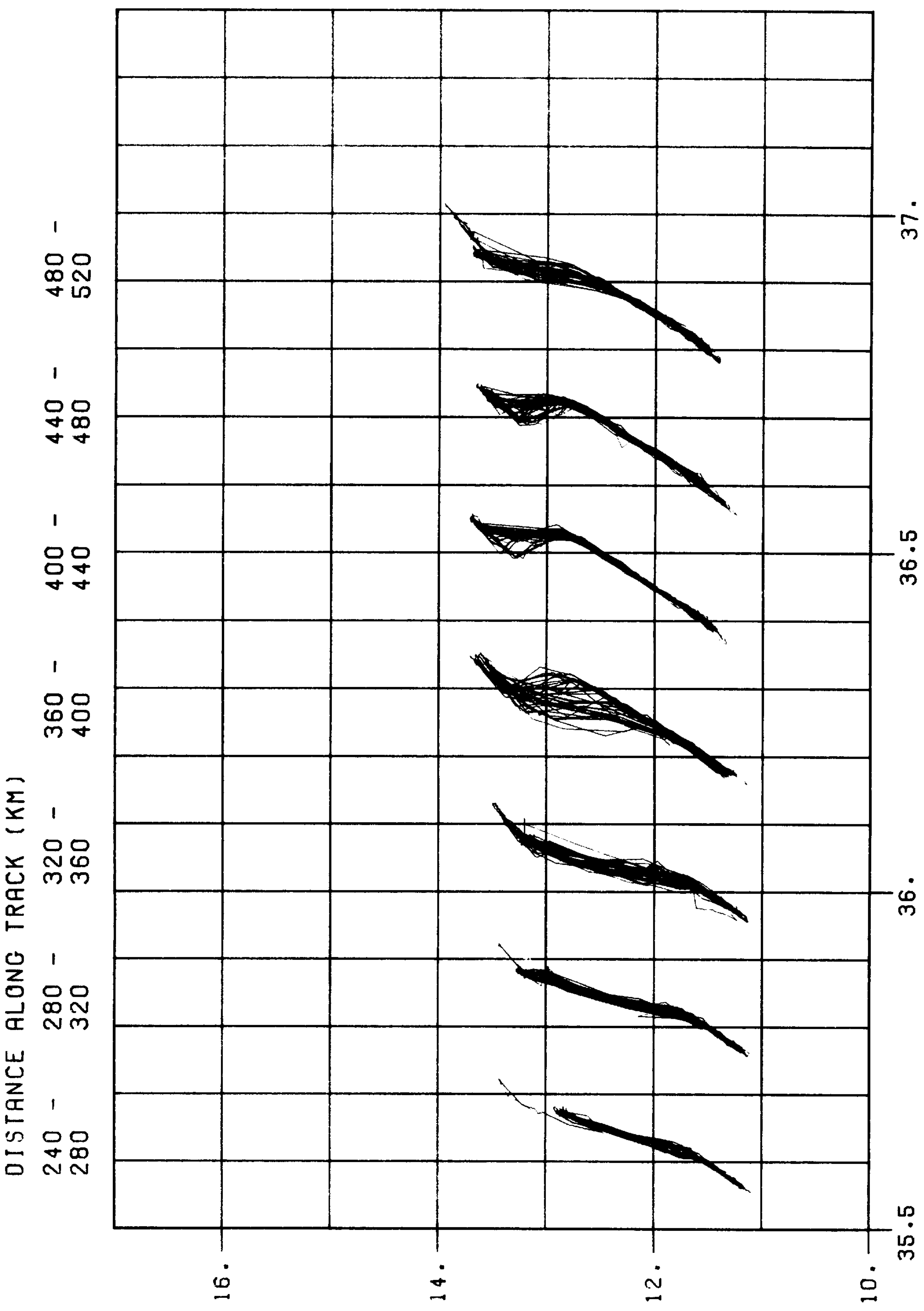
Distance Run (km)	Latitude (degrees)	Longitude (degrees)	Date (YYMMDD)	Time (HHMMSS)	Comments
0.00	46.686	-11.330	810108	151929	First launch
100.00	45.979	-12.132	810108	215810	
200.00	45.268	-12.915	810109	043443	
300.00	44.564	-13.703	810109	111912	
400.00	43.846	-14.453	810109	175317	
500.00	42.951	-14.503	810110	002040	
600.00	42.051	-14.508	810110	062720	
625.16	41.825	-14.506	810110	080152	Recover for station work
659.94	42.130	-14.412	810111	021616	Re-launch
700.00	41.815	-14.607	810111	051102	
800.00	40.974	-15.029	810111	114556	
900.00	40.093	-15.184	810111	180757	
1000.00	39.307	-15.703	810112	002630	
1100.00	38.563	-16.335	810112	064909	
1200.00	37.832	-17.001	810112	131059	
1300.00	37.098	-17.653	810112	194100	
1400.00	36.354	-18.282	810113	020535	
1433.85	36.098	-18.488	810113	041522	End of tow



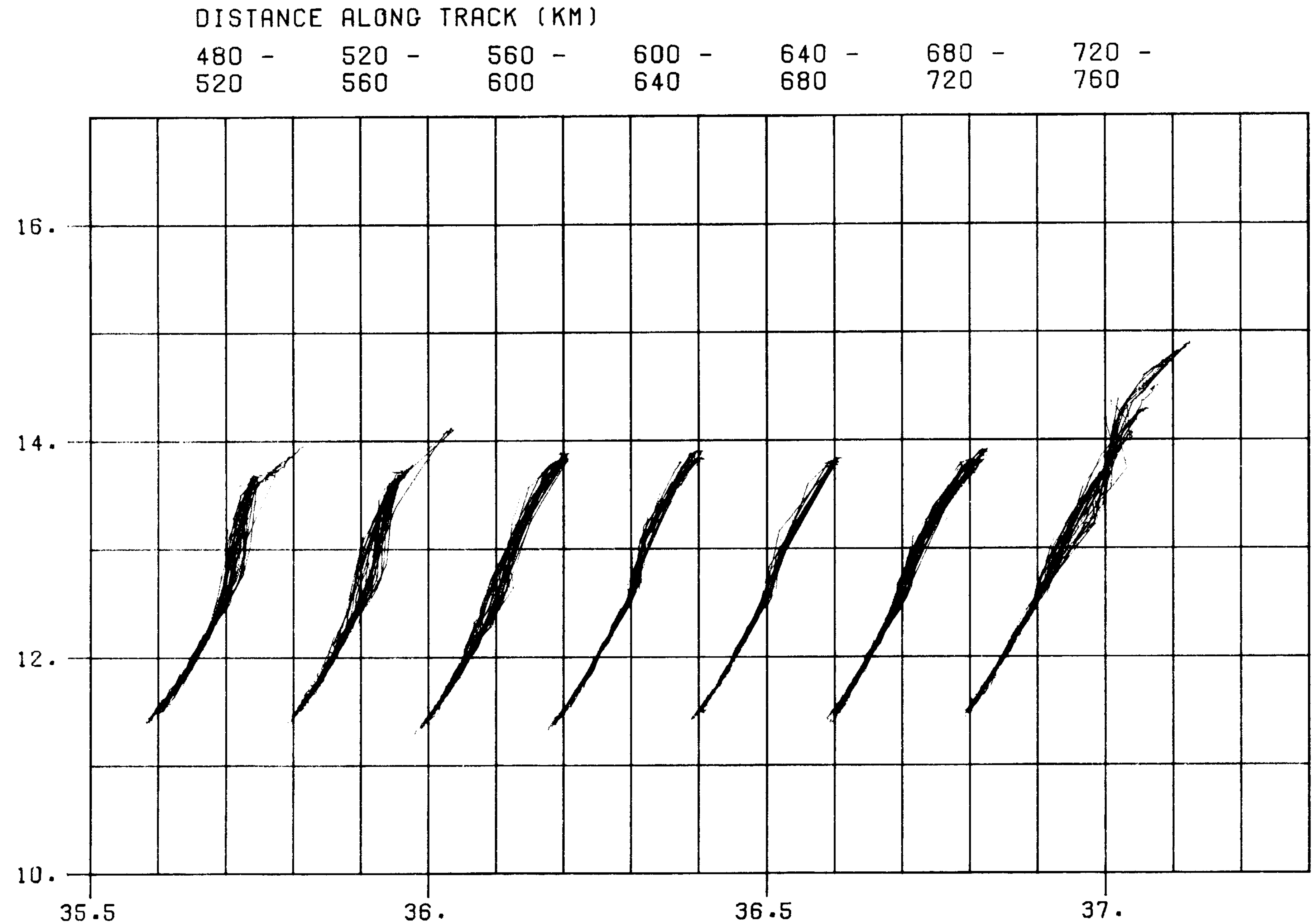
TRACK PLOT FOR DISCOVERY CRUISE 116
***** **** *** ********* ****** ***
MERCATOR PROJECTION WITH COASTLINE
AND 1000M DEPTH CONTOUR
TRACK MARKS INDICATE DISTANCE RUN



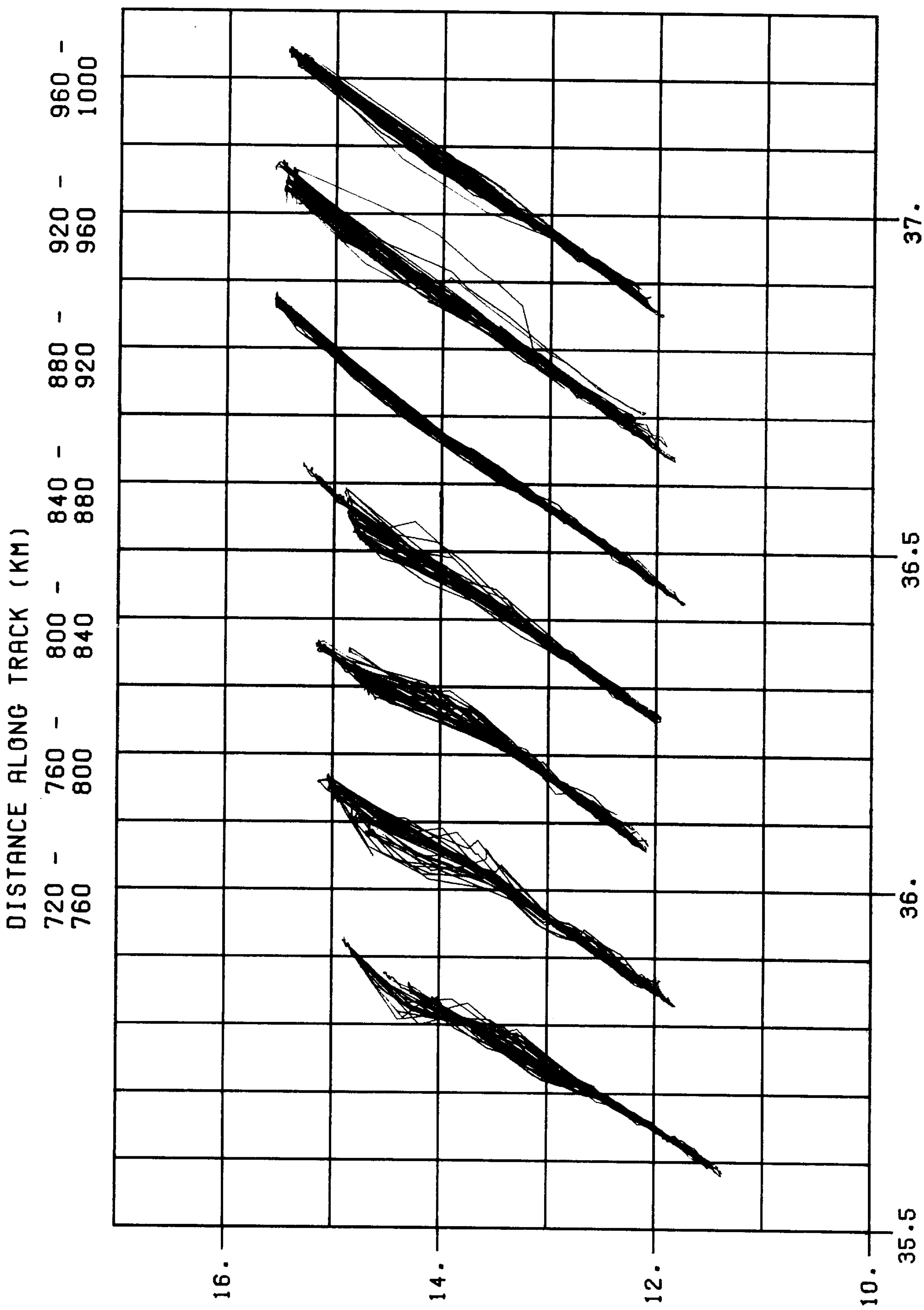
POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116



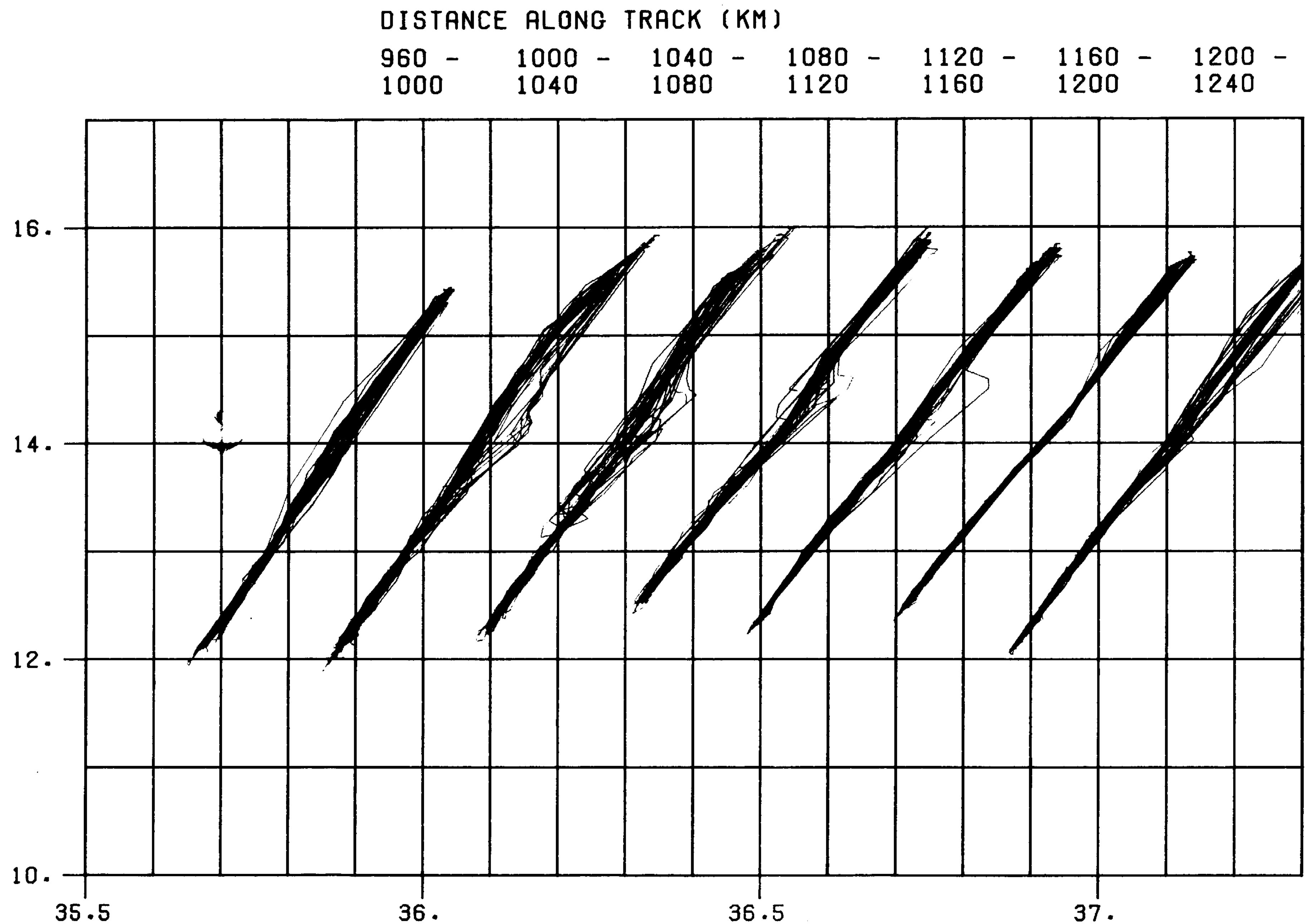
POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116



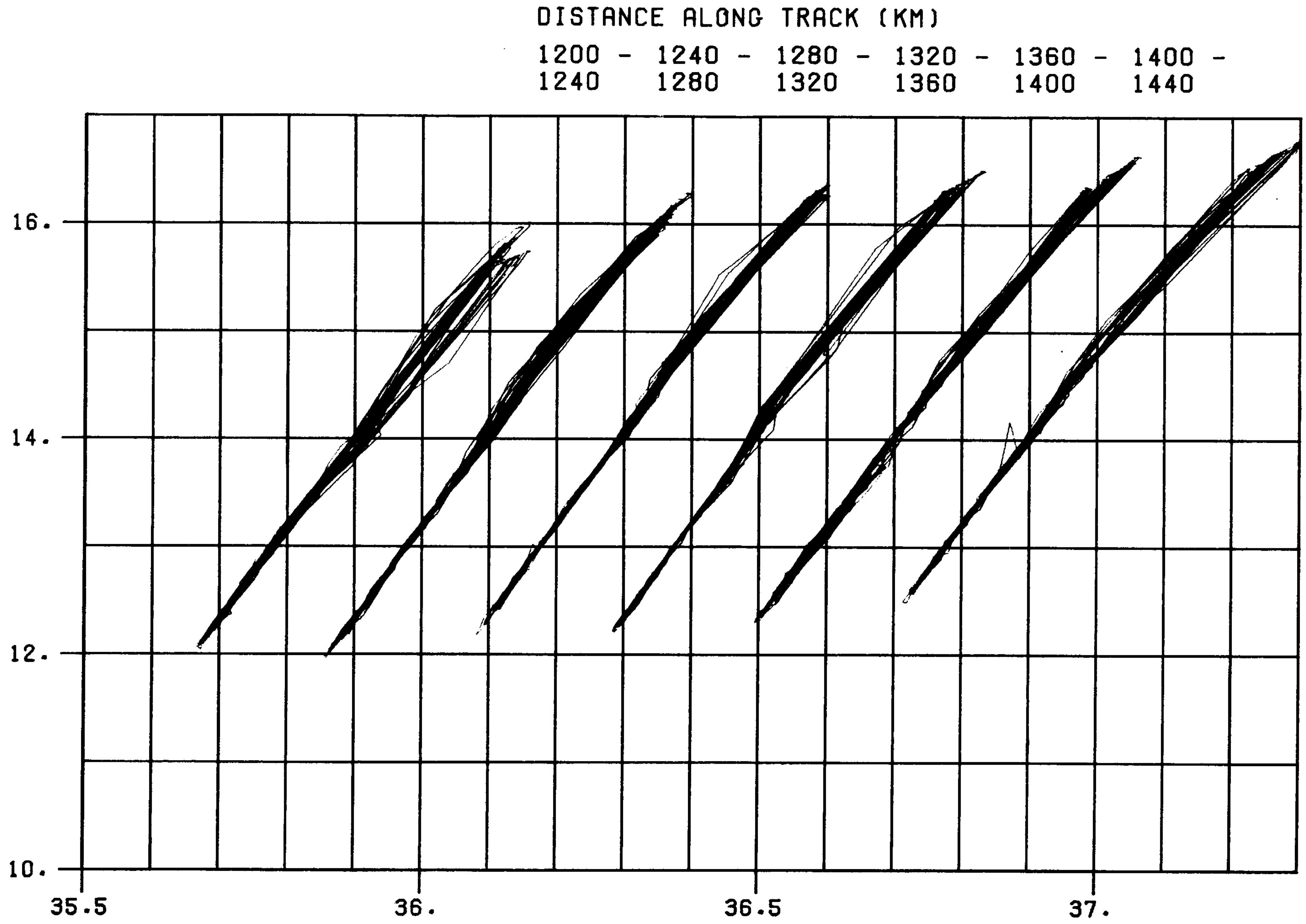
POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116



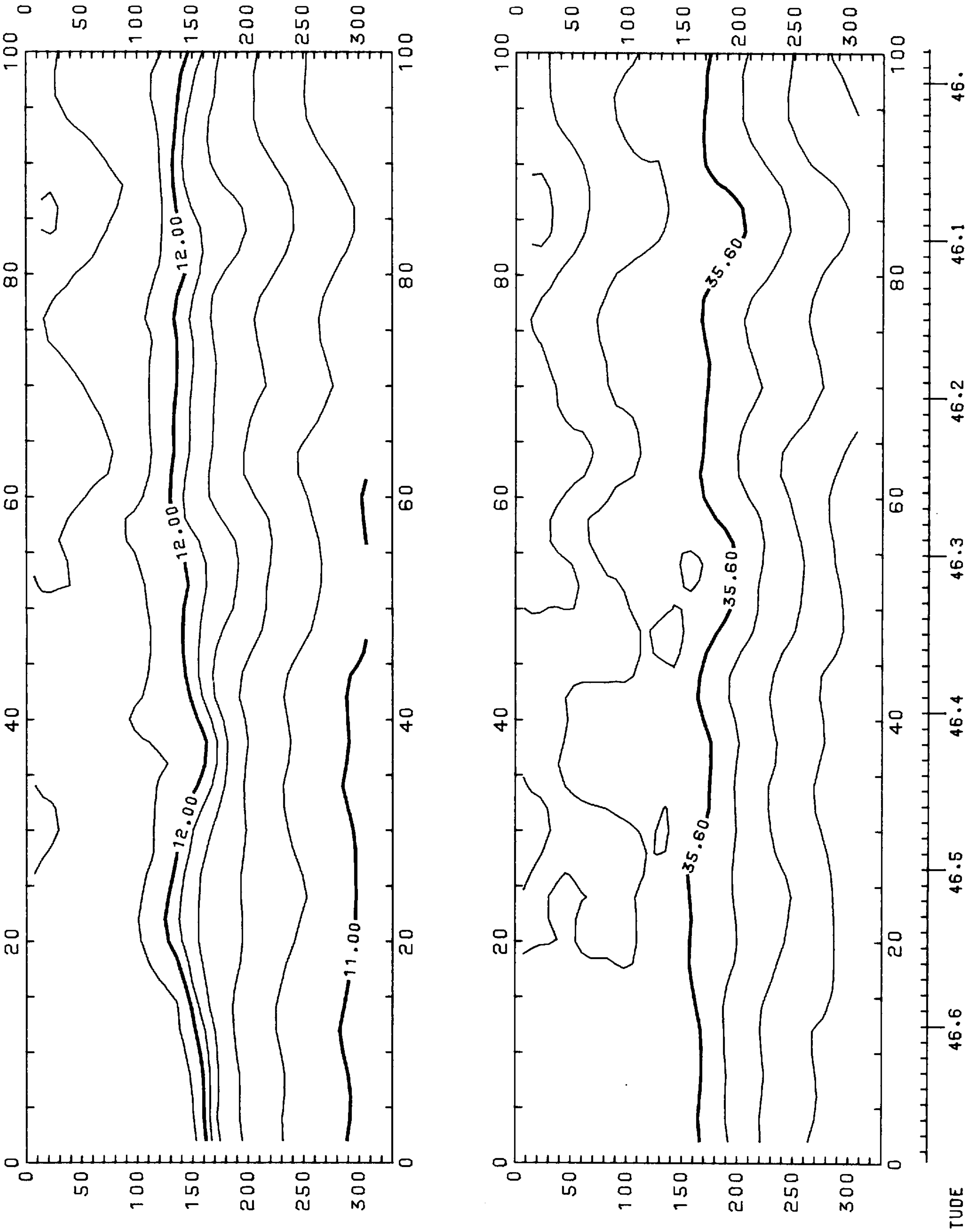
POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116



POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116



POTENTIAL TEMPERATURE/SALINITY CURVES FOR DISCOVERY CRUISE 116

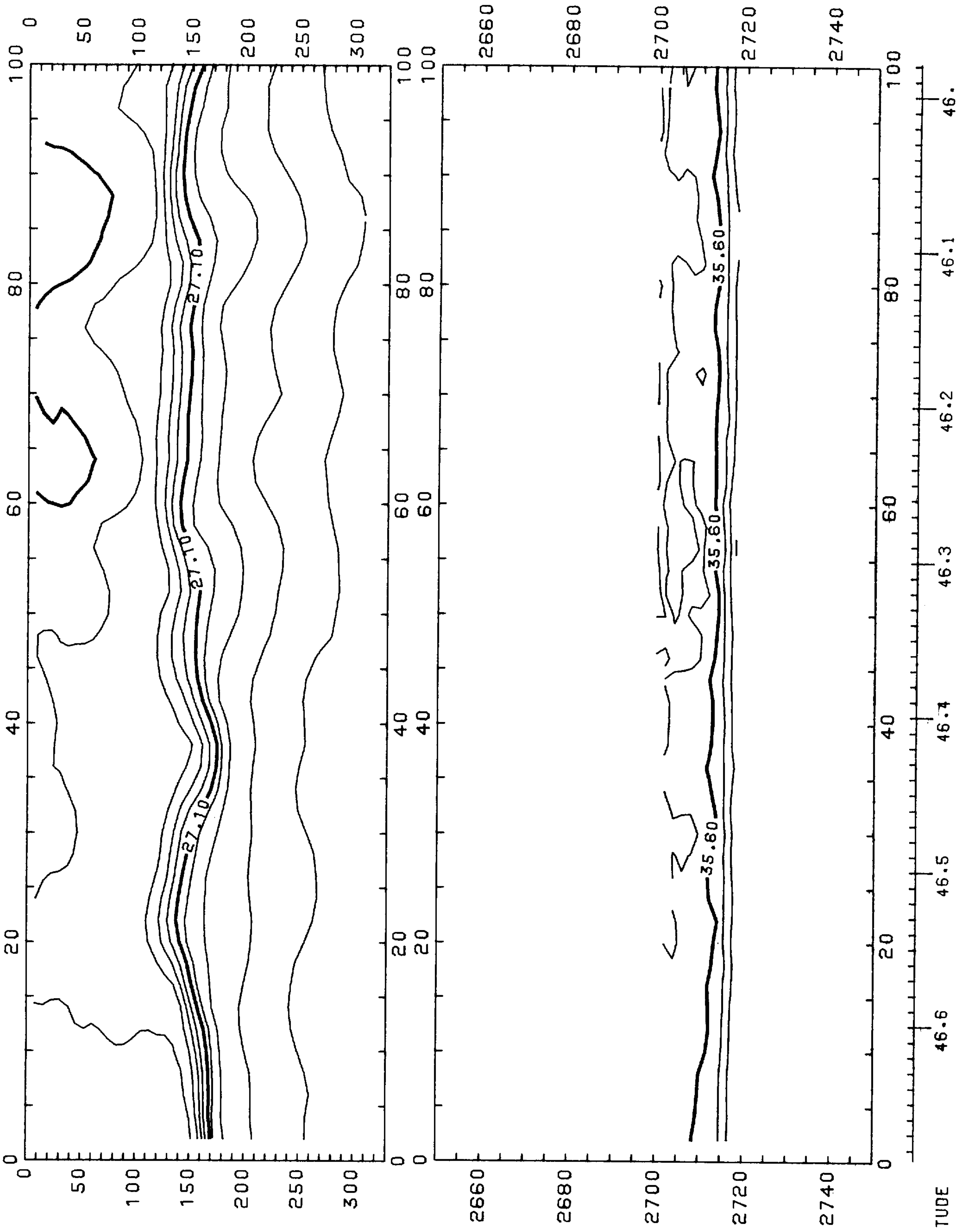


DISCOVERY 116 : JAN 1981 : 0-100 KM

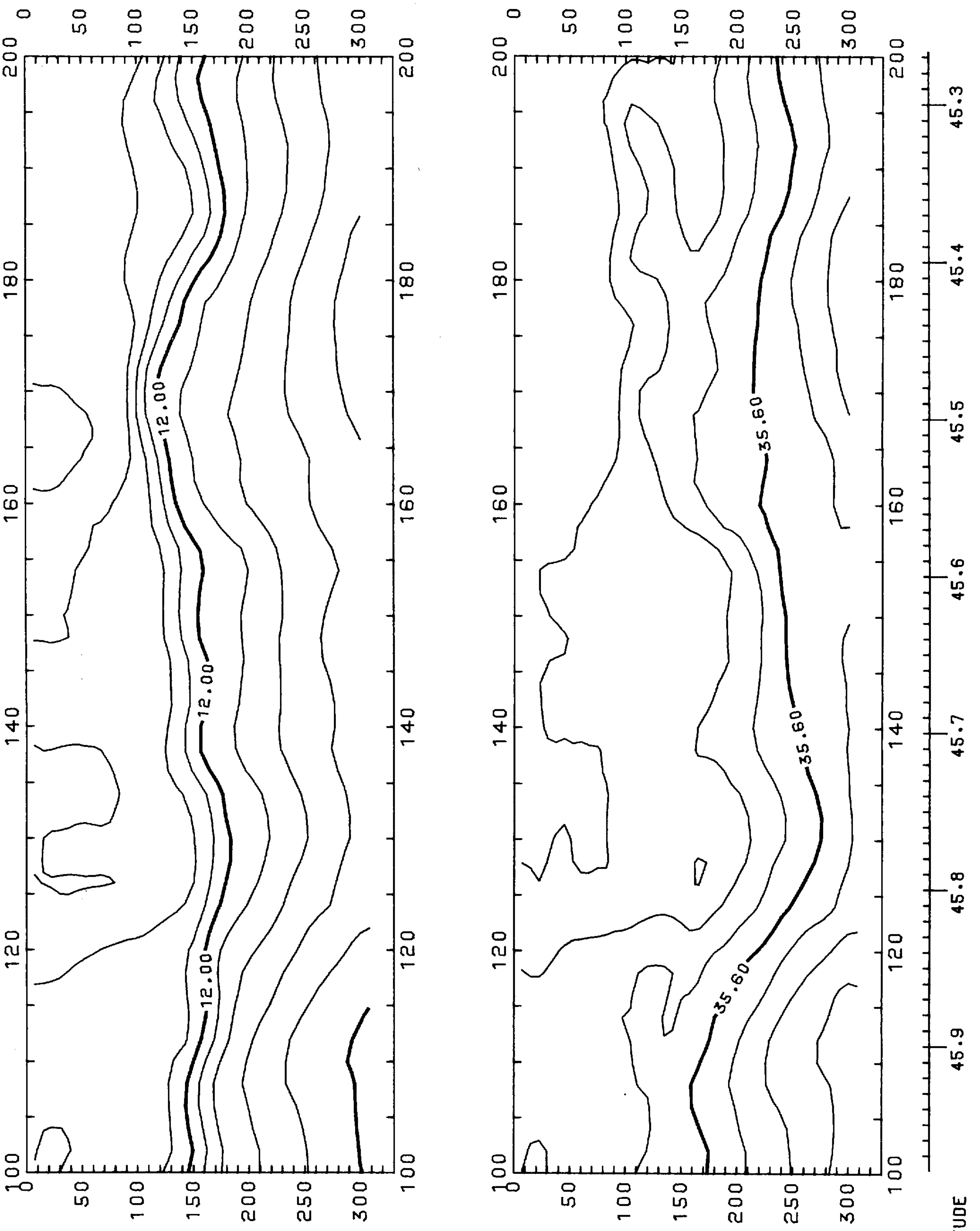
========= === === ==== ==========

CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)

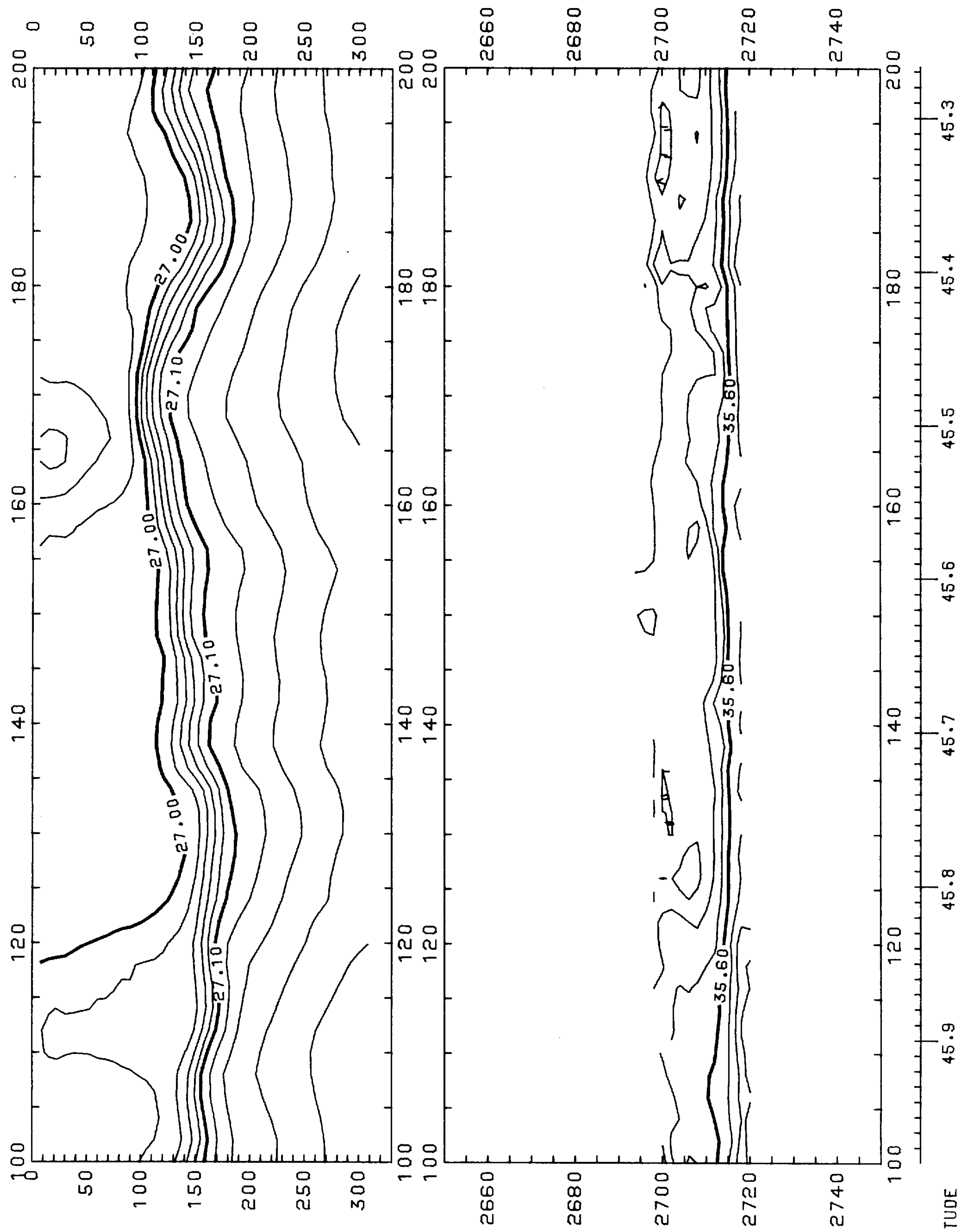
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



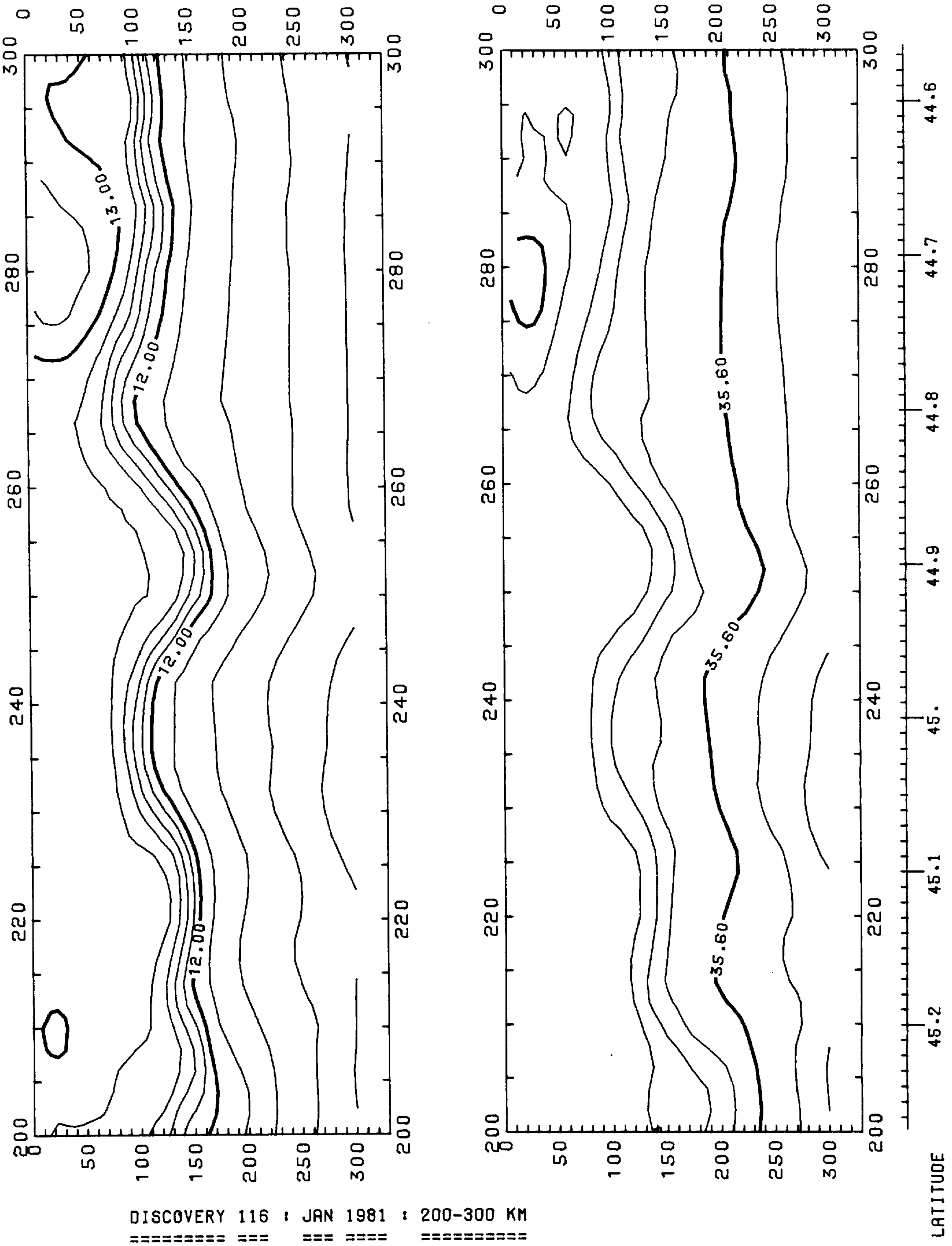
DISCOVERY 116 : JAN 1981 : 0-100 KM
========= === === ==== ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



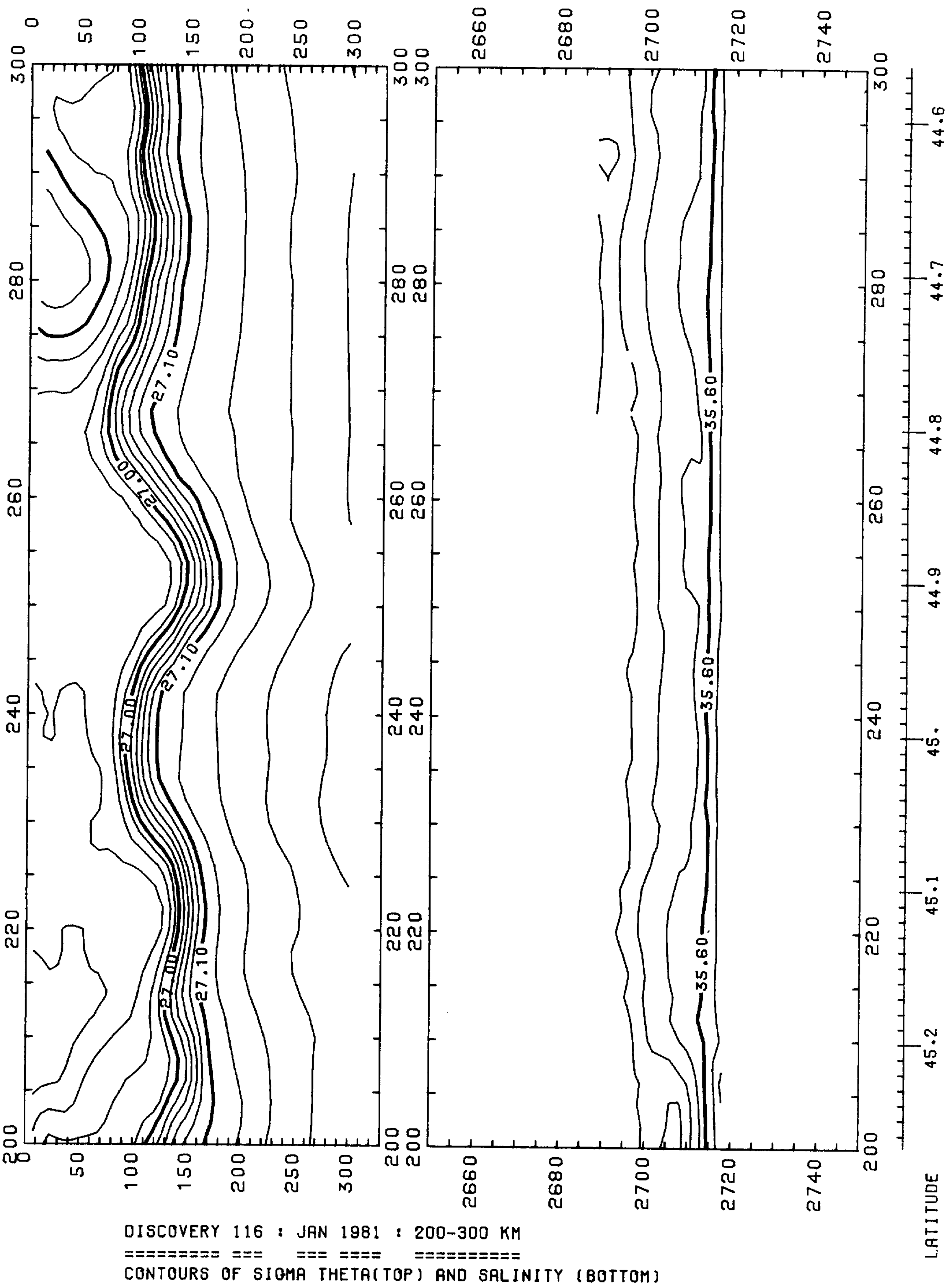
DISCOVERY 116 : JAN 1981 : 100-200 KM
========= === === ==== ==========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



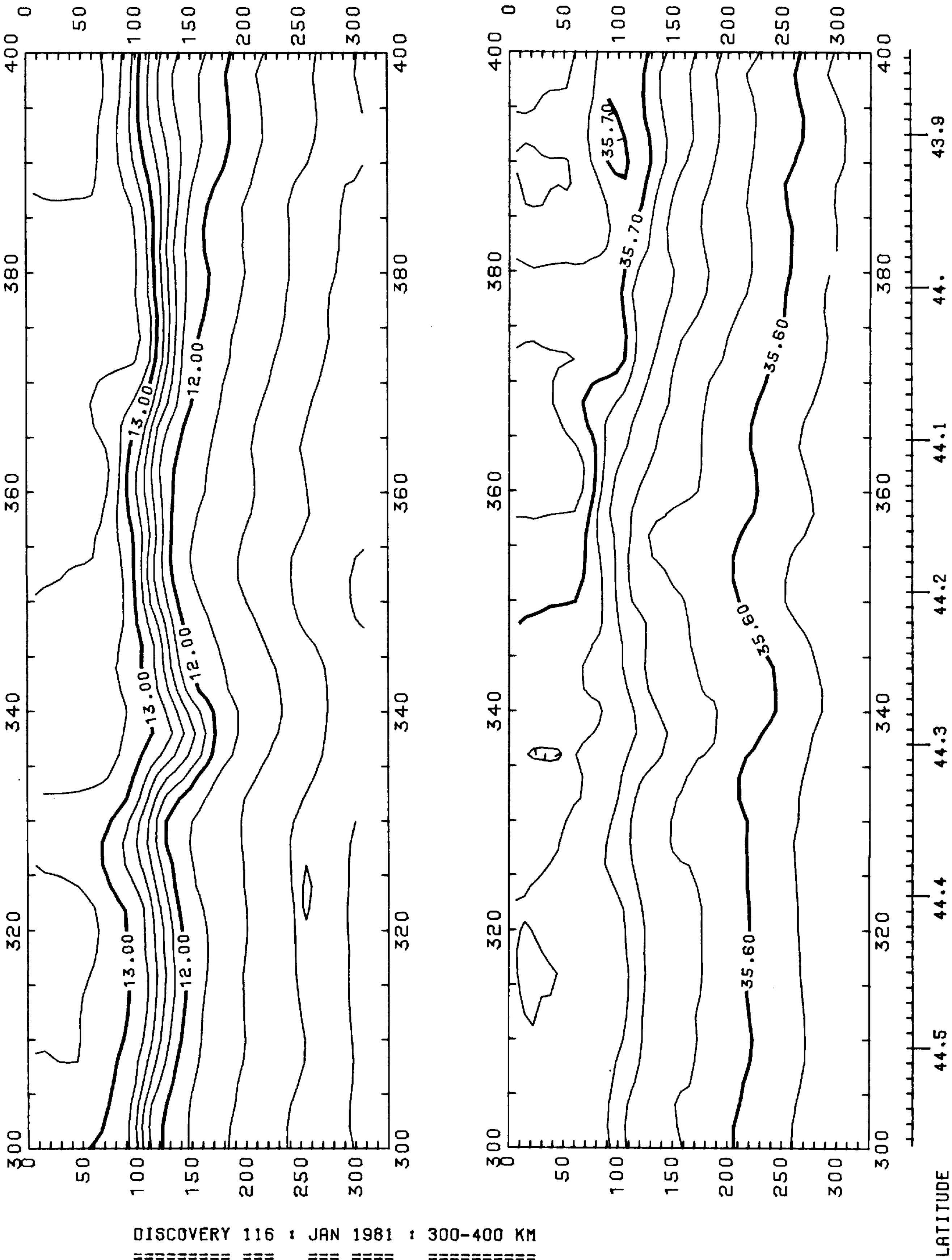
DISCOVERY 116 : JAN 1981 : 100-200 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 200-300 KM
========= ===   === ====   =========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)

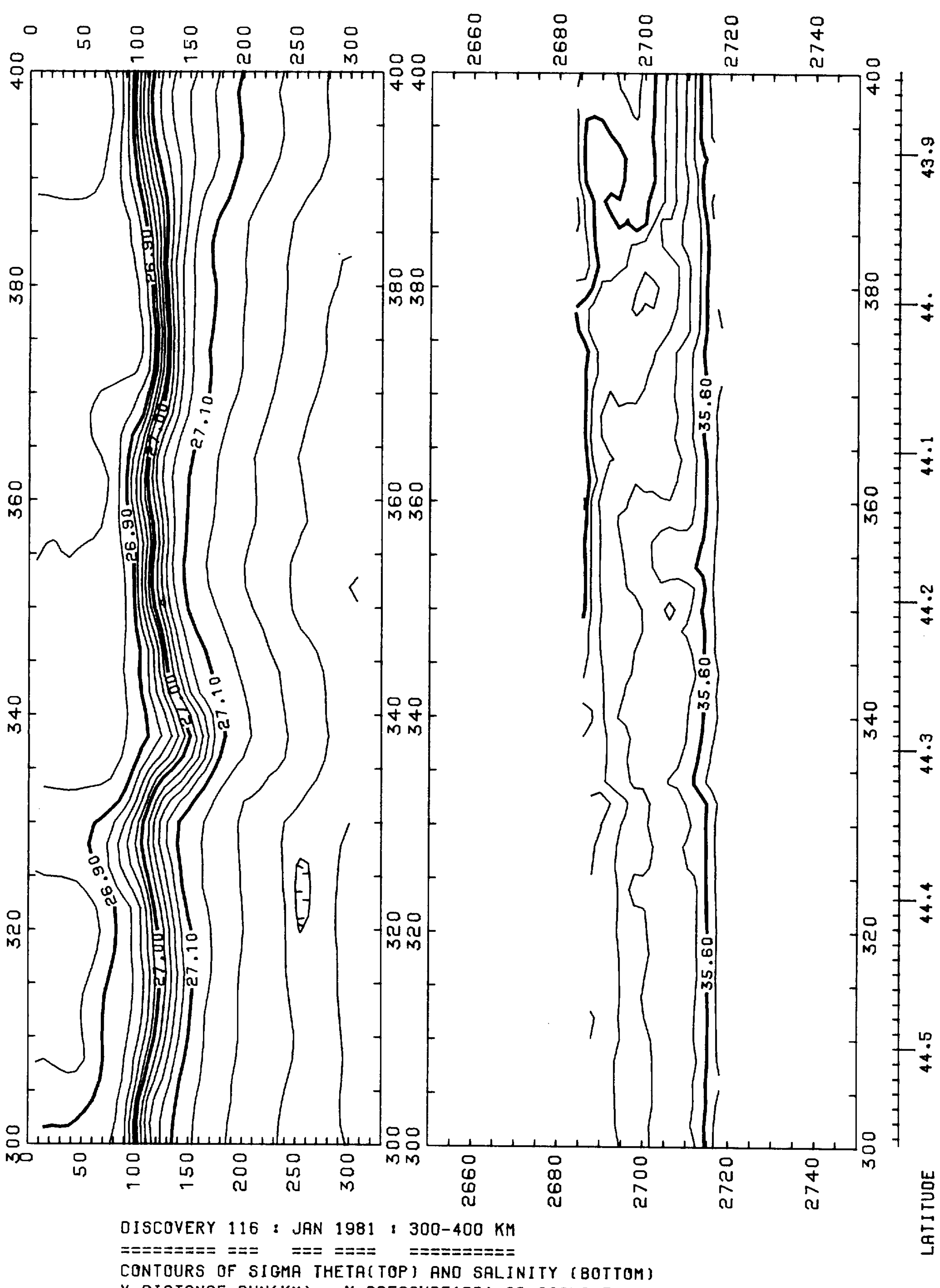


DISCOVERY 116 : JAN 1981 : 200-300 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)

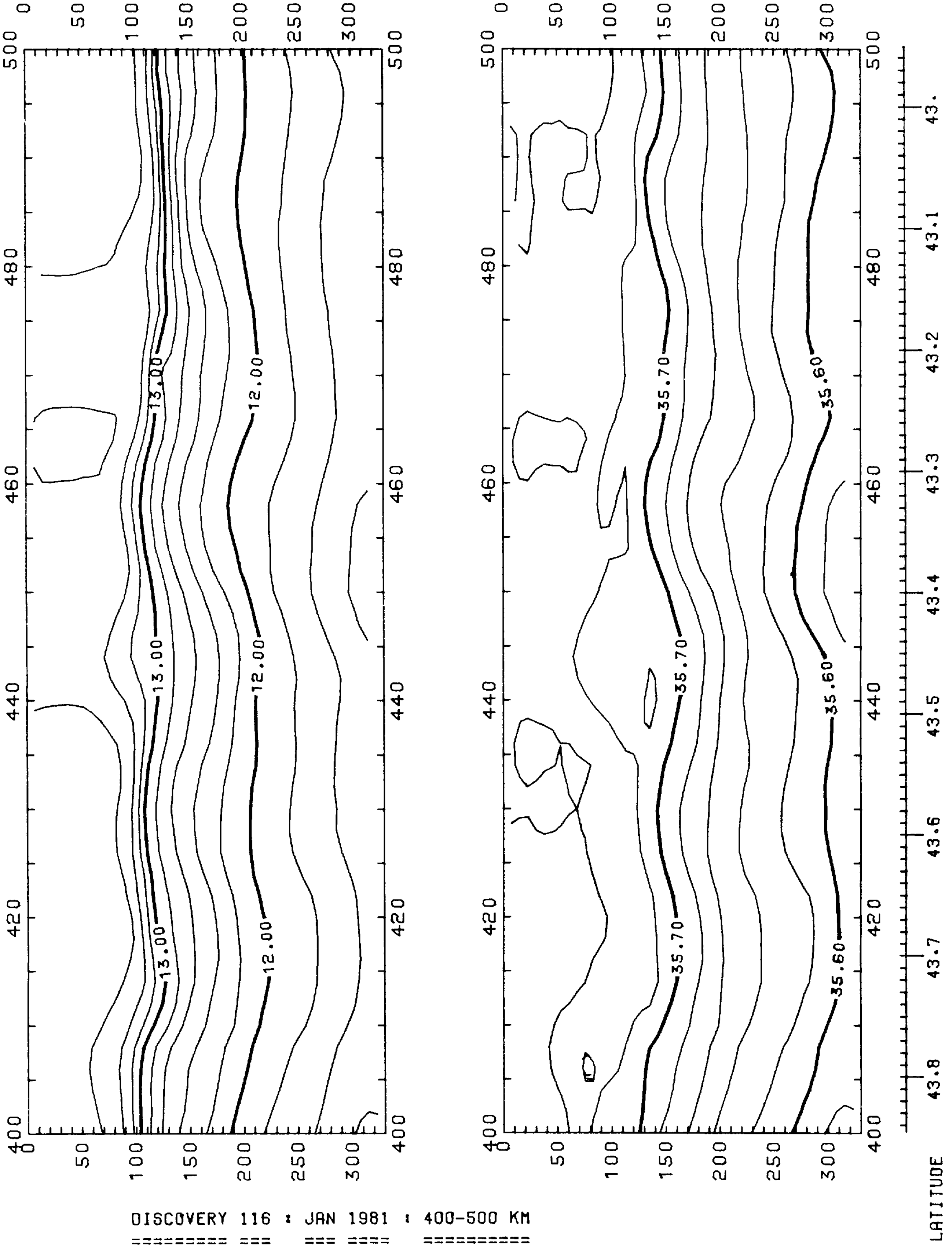


DISCOVERY 116 : JAN 1981 : 300-400 KM

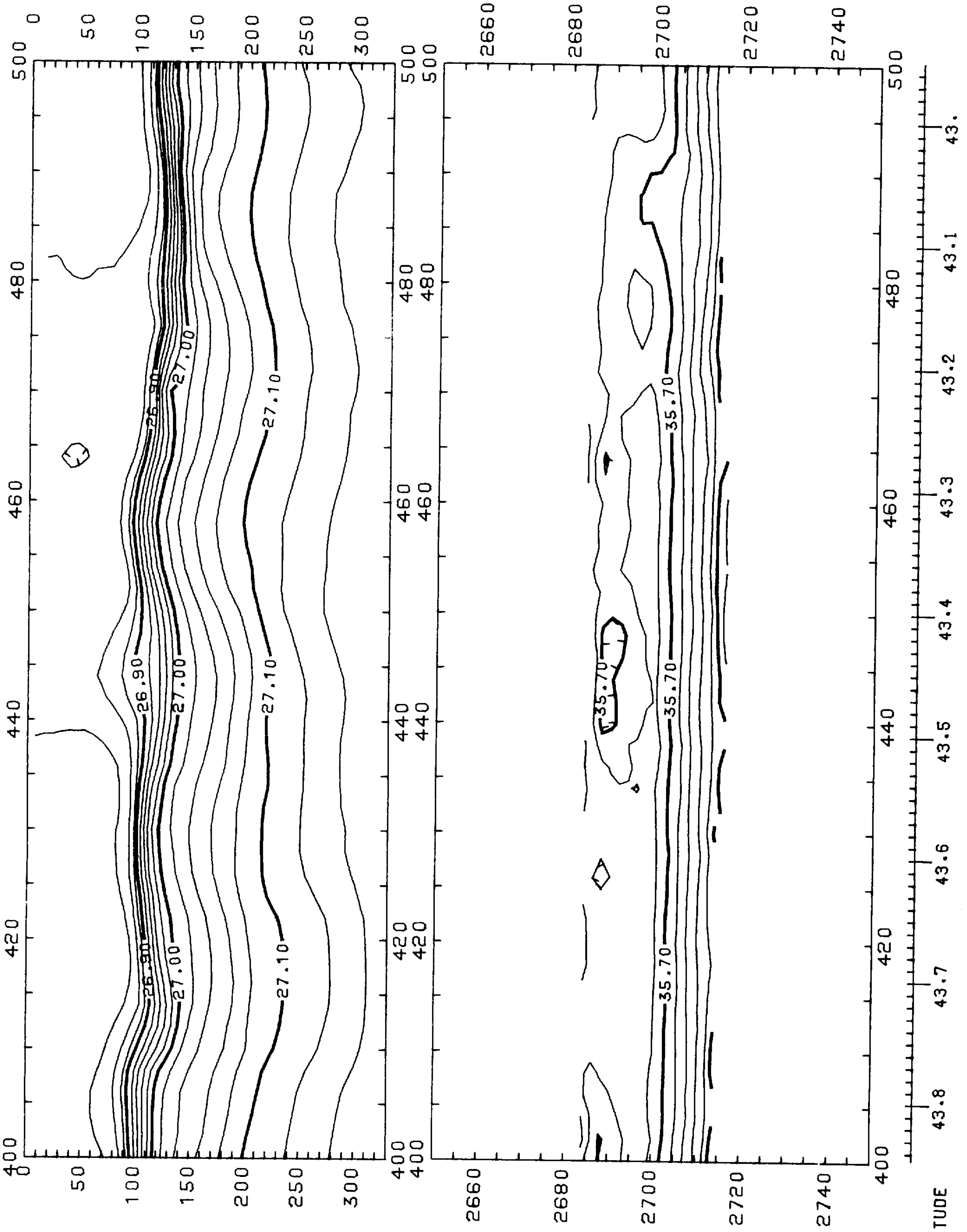
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



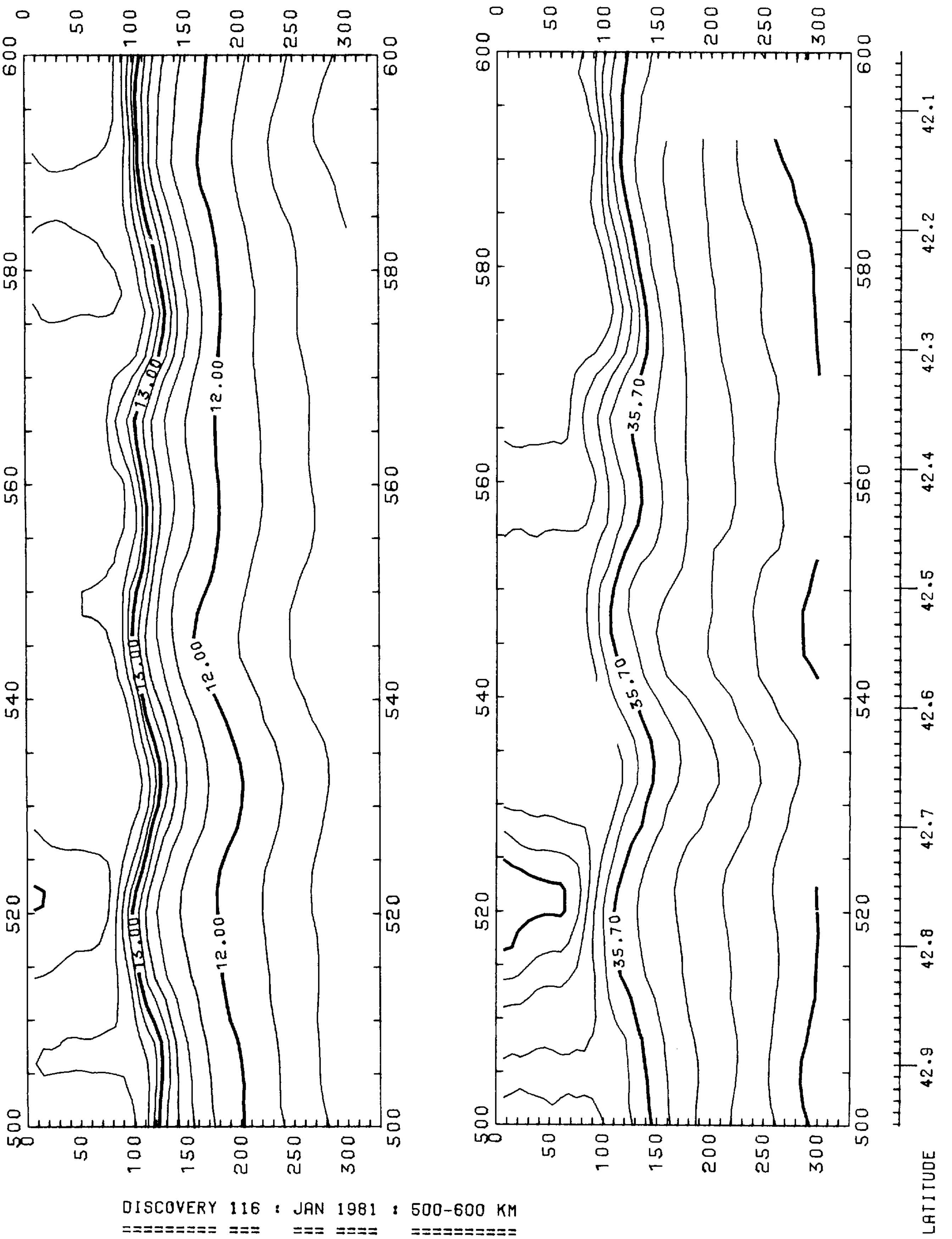
DISCOVERY 116 : JAN 1981 : 300-400 KM
========= === === ==== ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 400-500 KM
========= === === ==== ==========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)

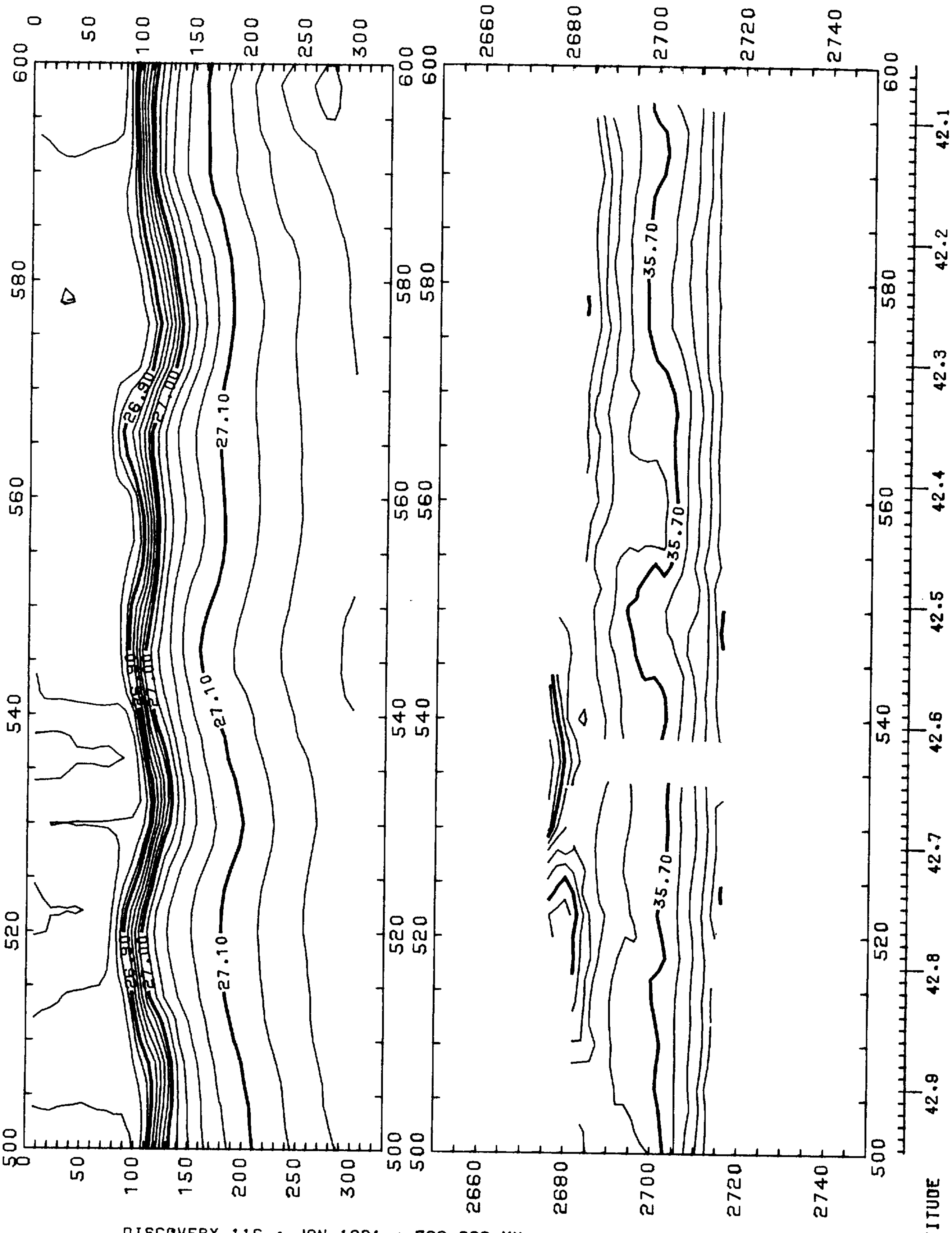


DISCOVERY 116 : JAN 1981 : 400-500 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 500-600 KM

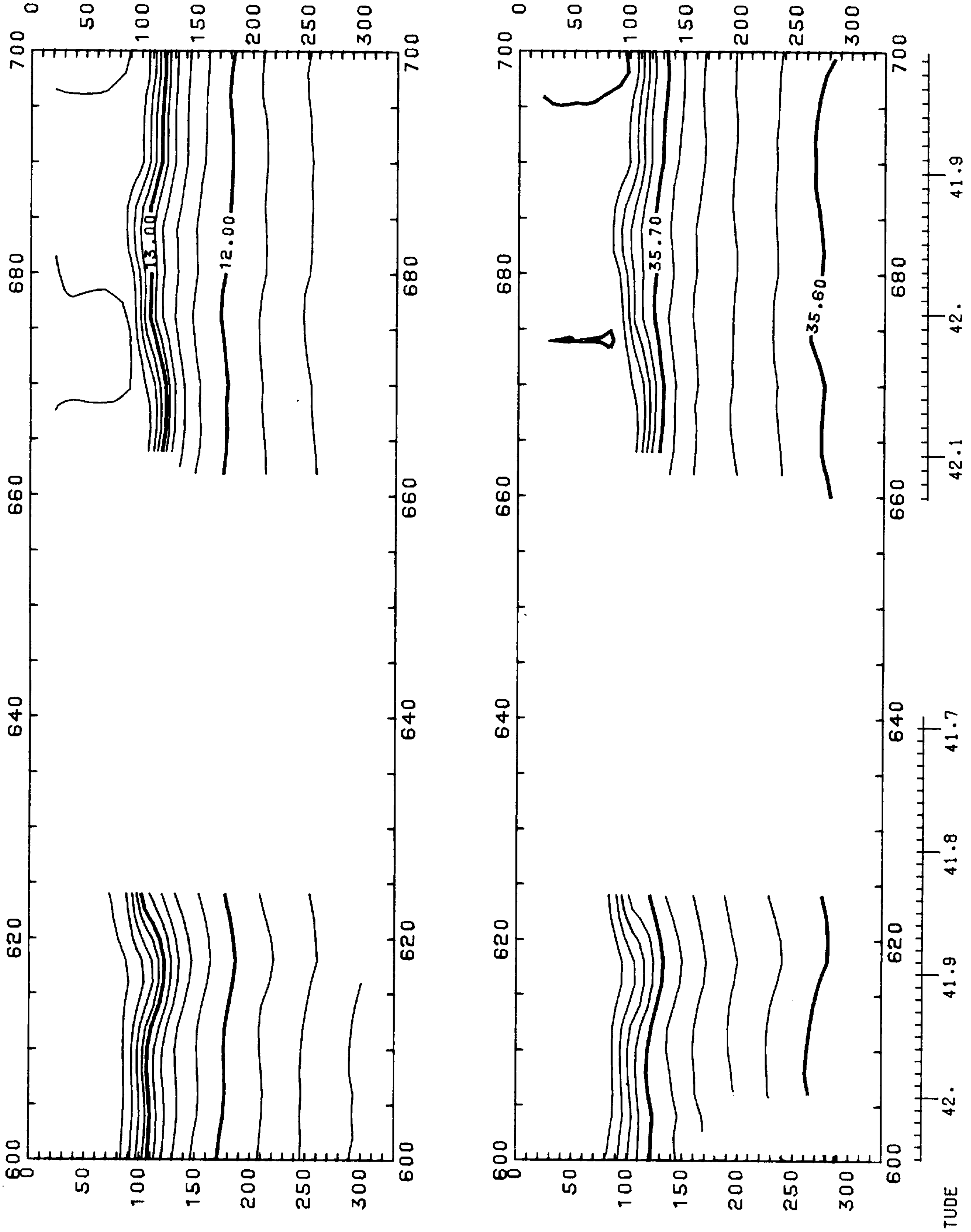
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



DISCOVERY 116 : JAN 1981 : 500-600 KM

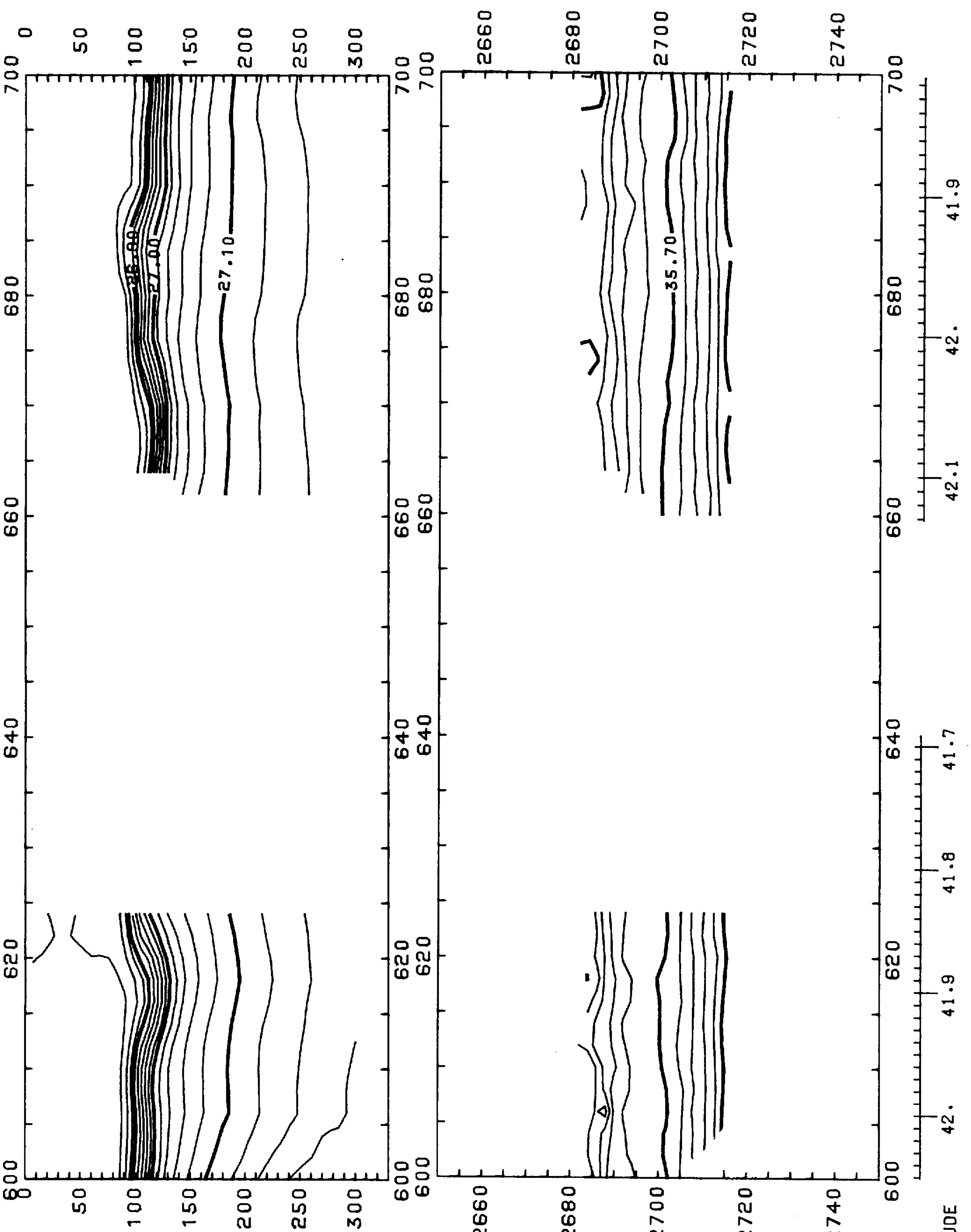
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)

X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



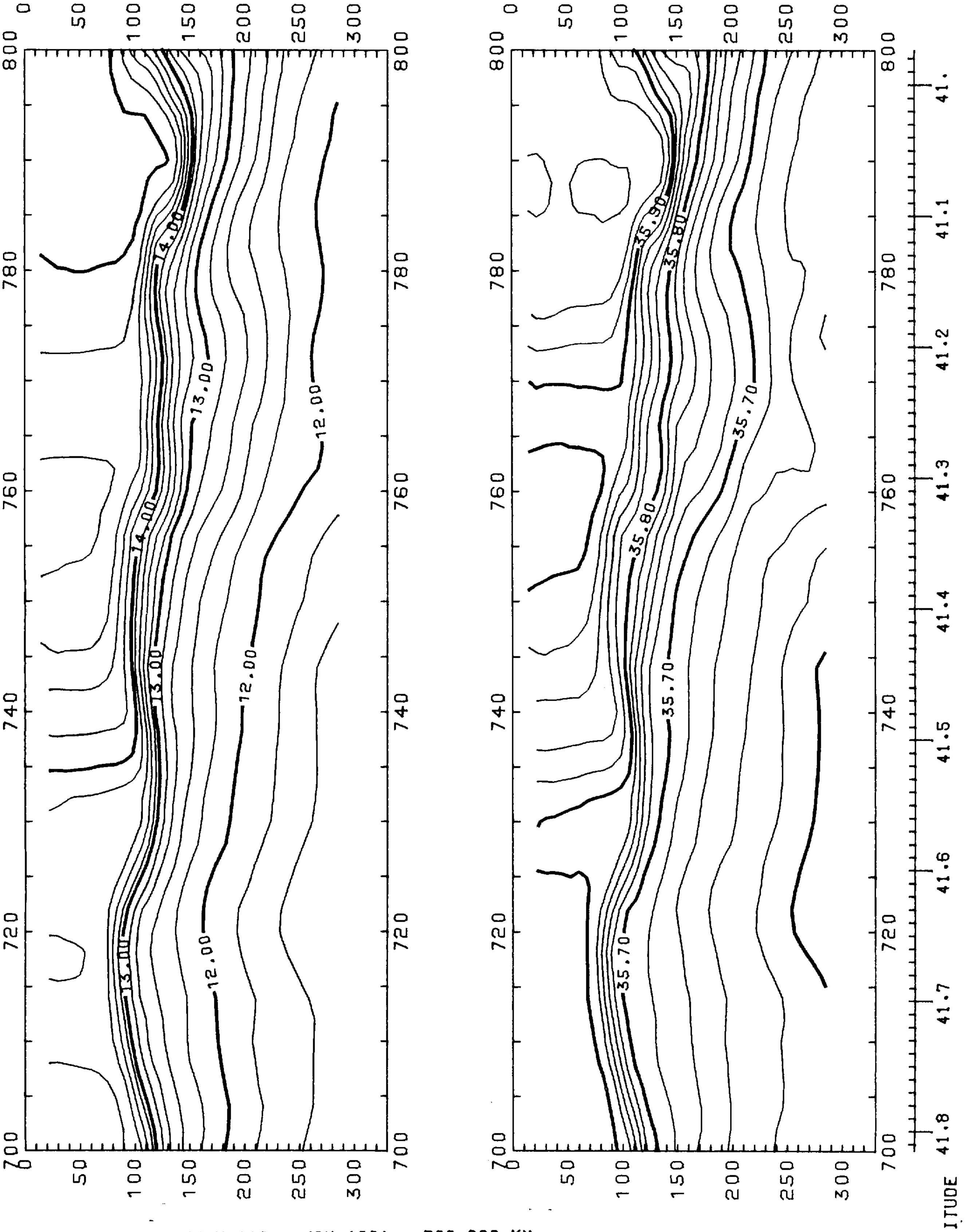
DISCOVERY 116 : JAN 1981 : 600-700 KM

CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)

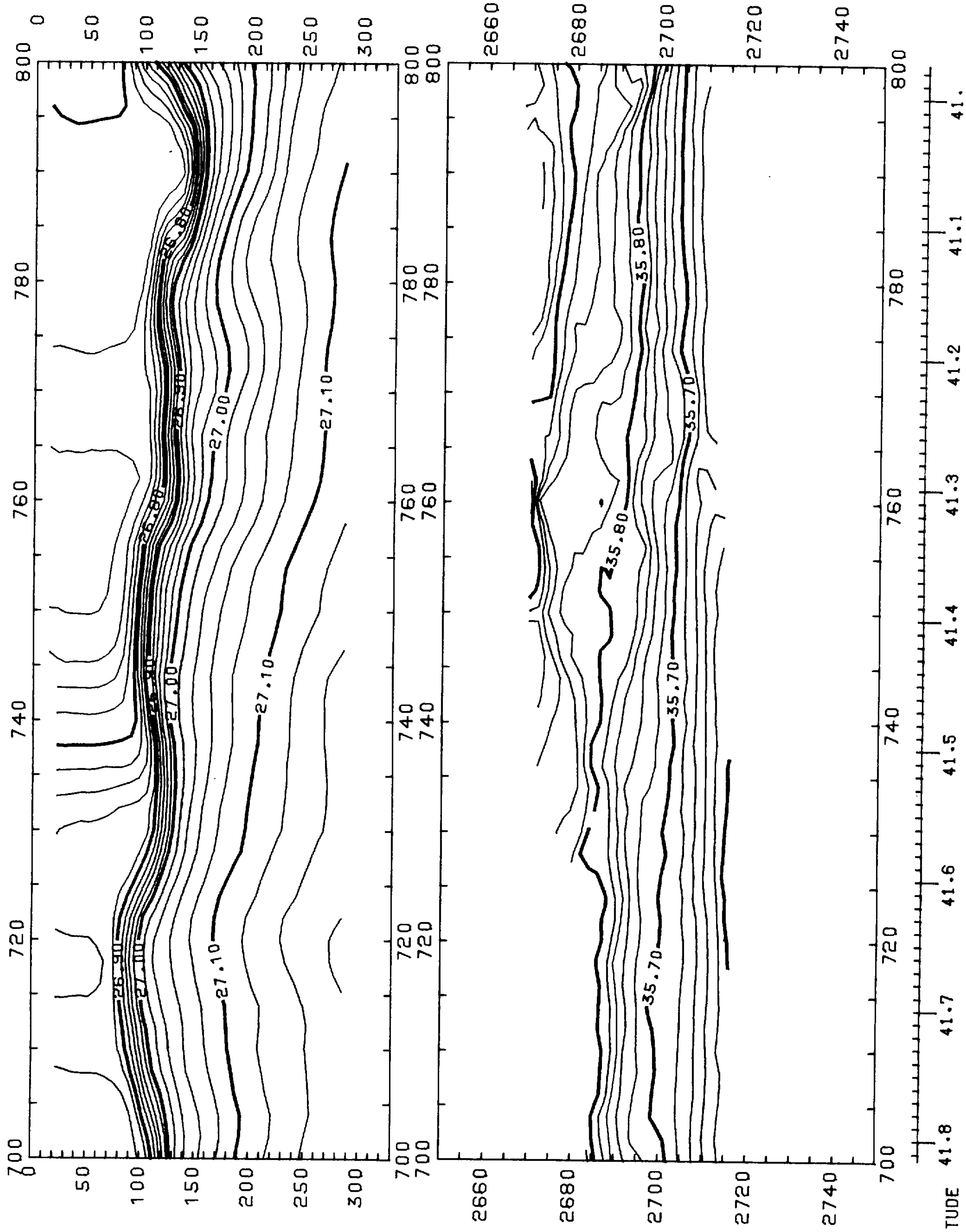


DISCOVERY 116 : JAN 1981 : 600-700 KM
========= ===   === ====   ==========

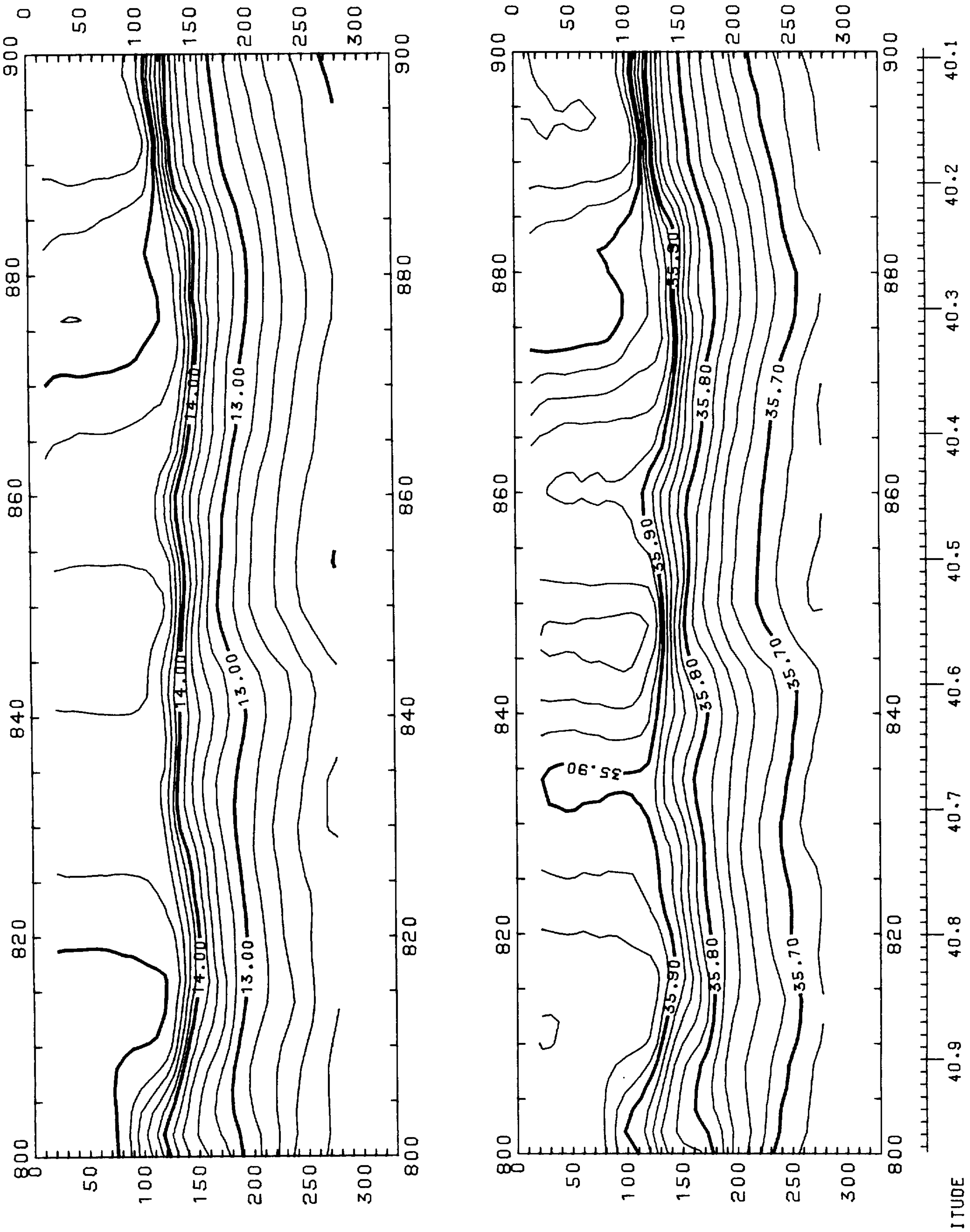
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 700-800 KM
========= ===   === ====   ==========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



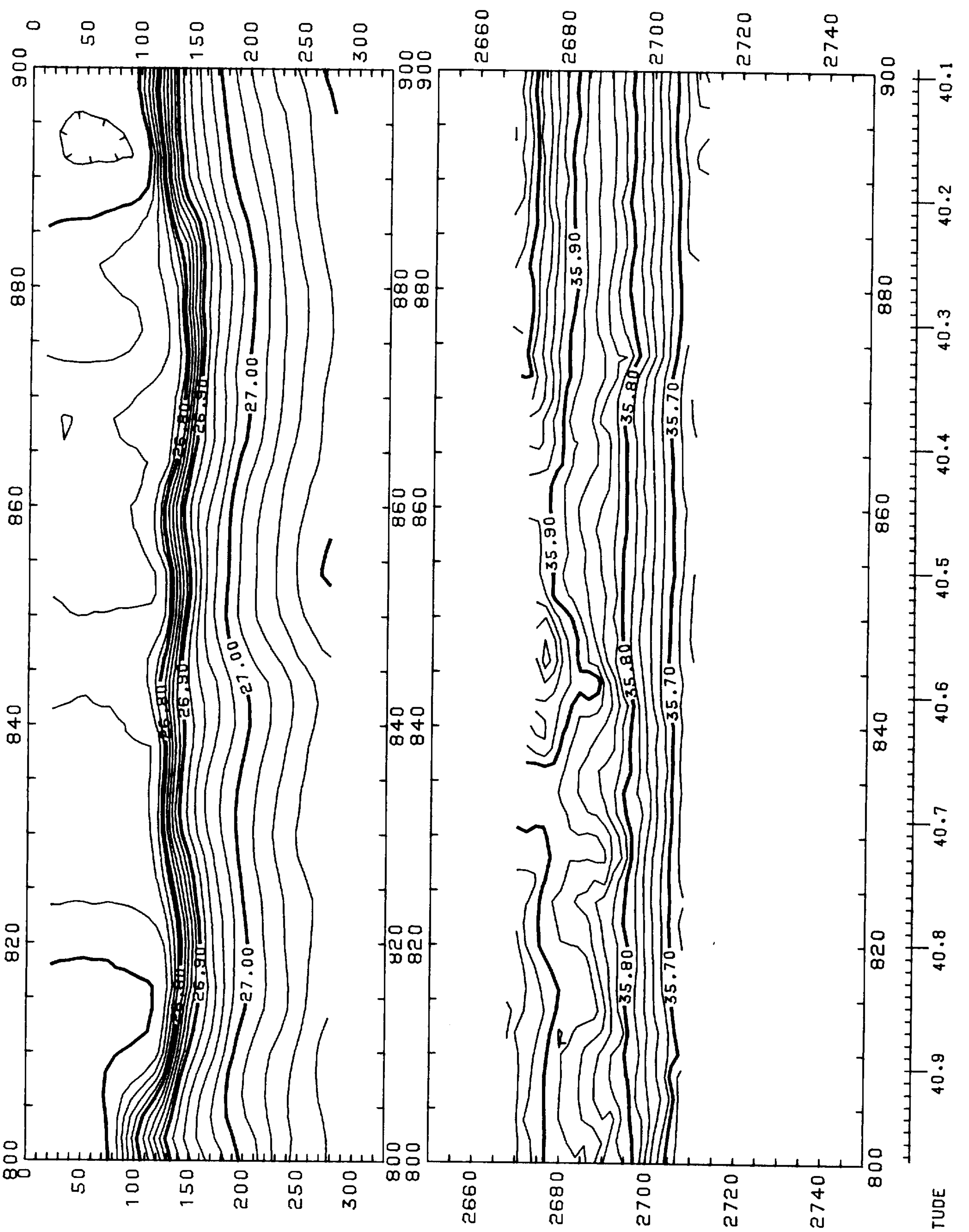
DISCOVERY 116 : JAN 1981 : 700-800 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



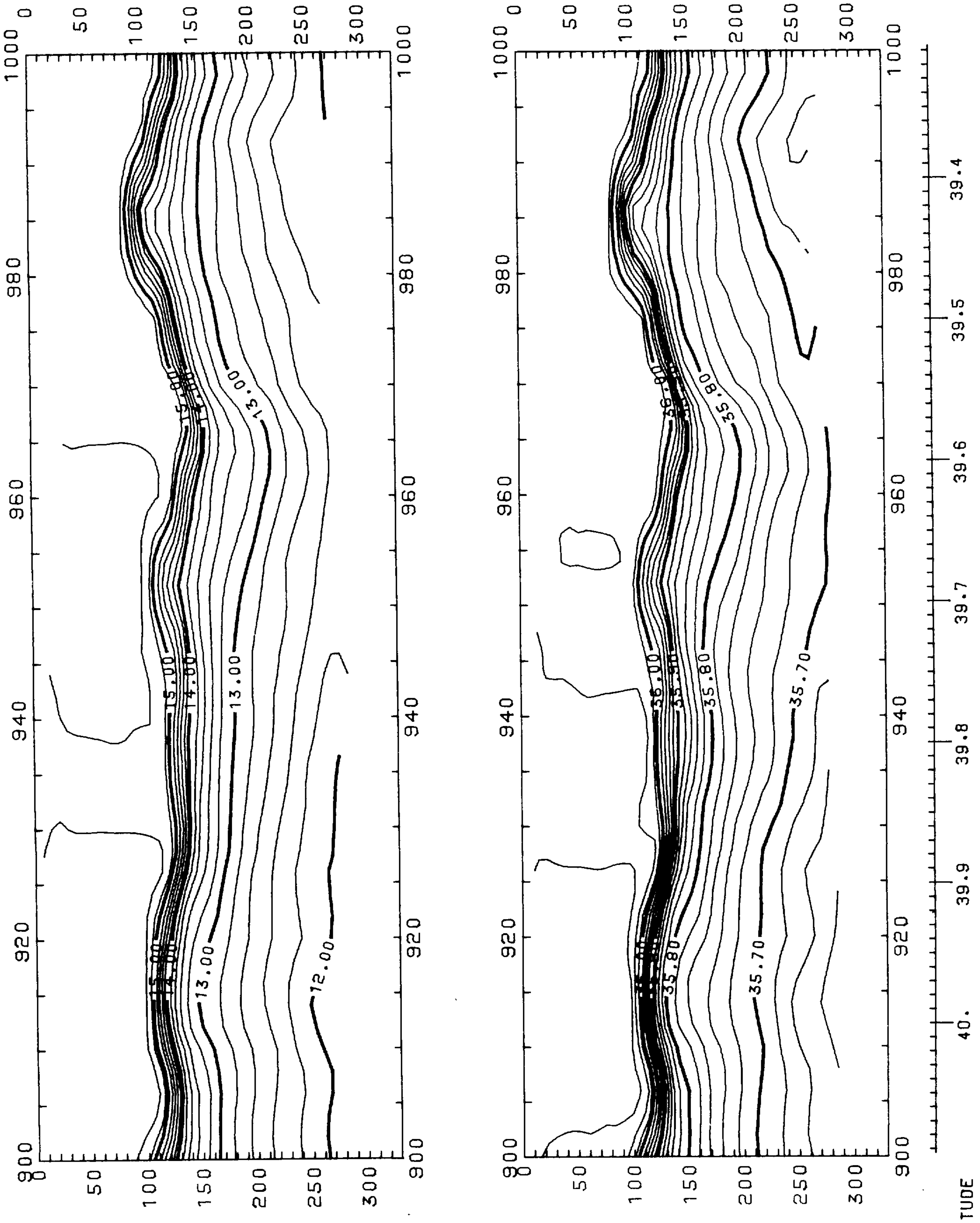
DISCOVERY 116 : JAN 1981 : 800-900 KM
========= === === ==== =========

CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)

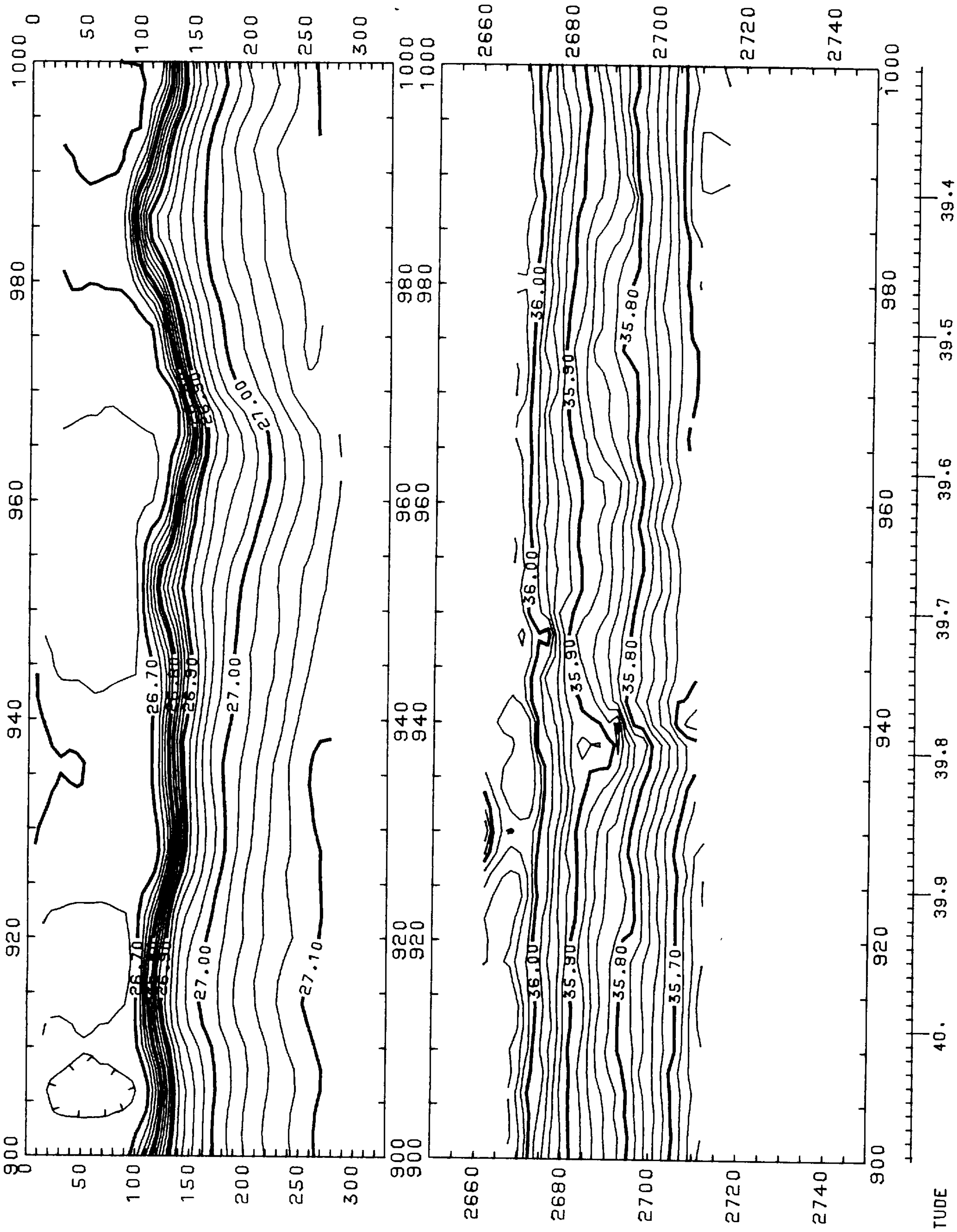
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



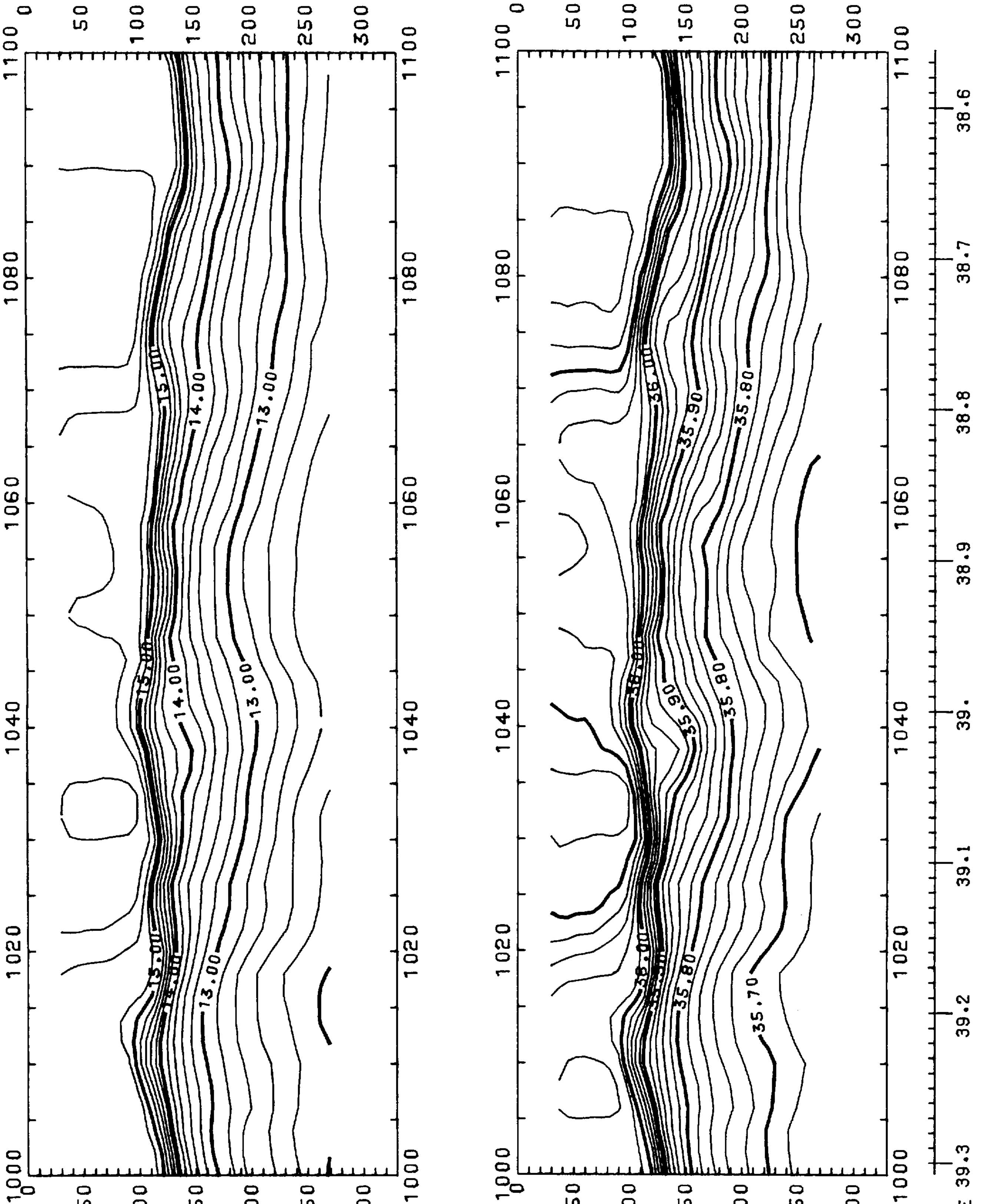
DISCOVERY 116 : JAN 1981 : 800-900 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



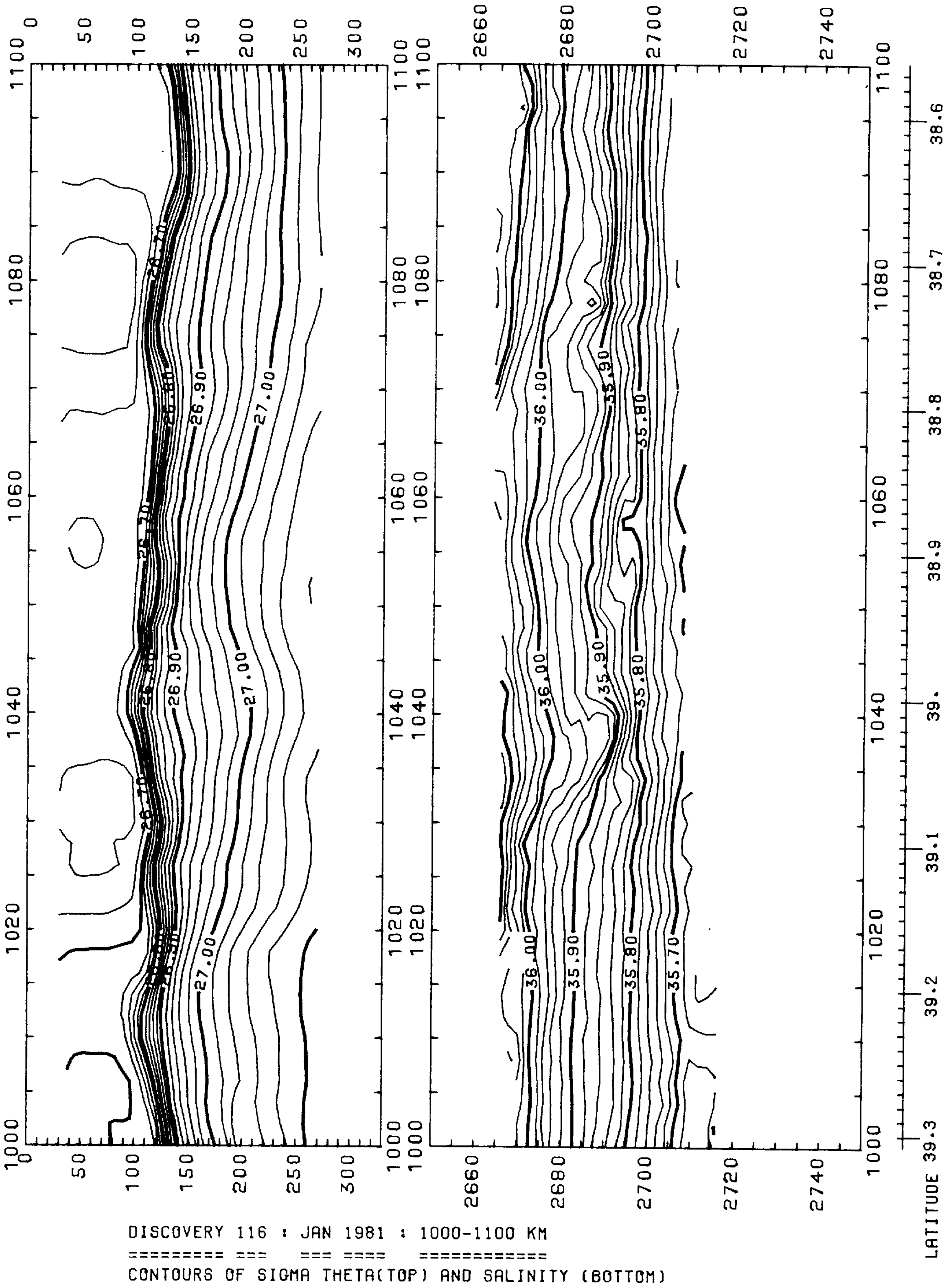
DISCOVERY 116 : JAN 1981 : 900-1000 KM
========= === === ==== ===========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



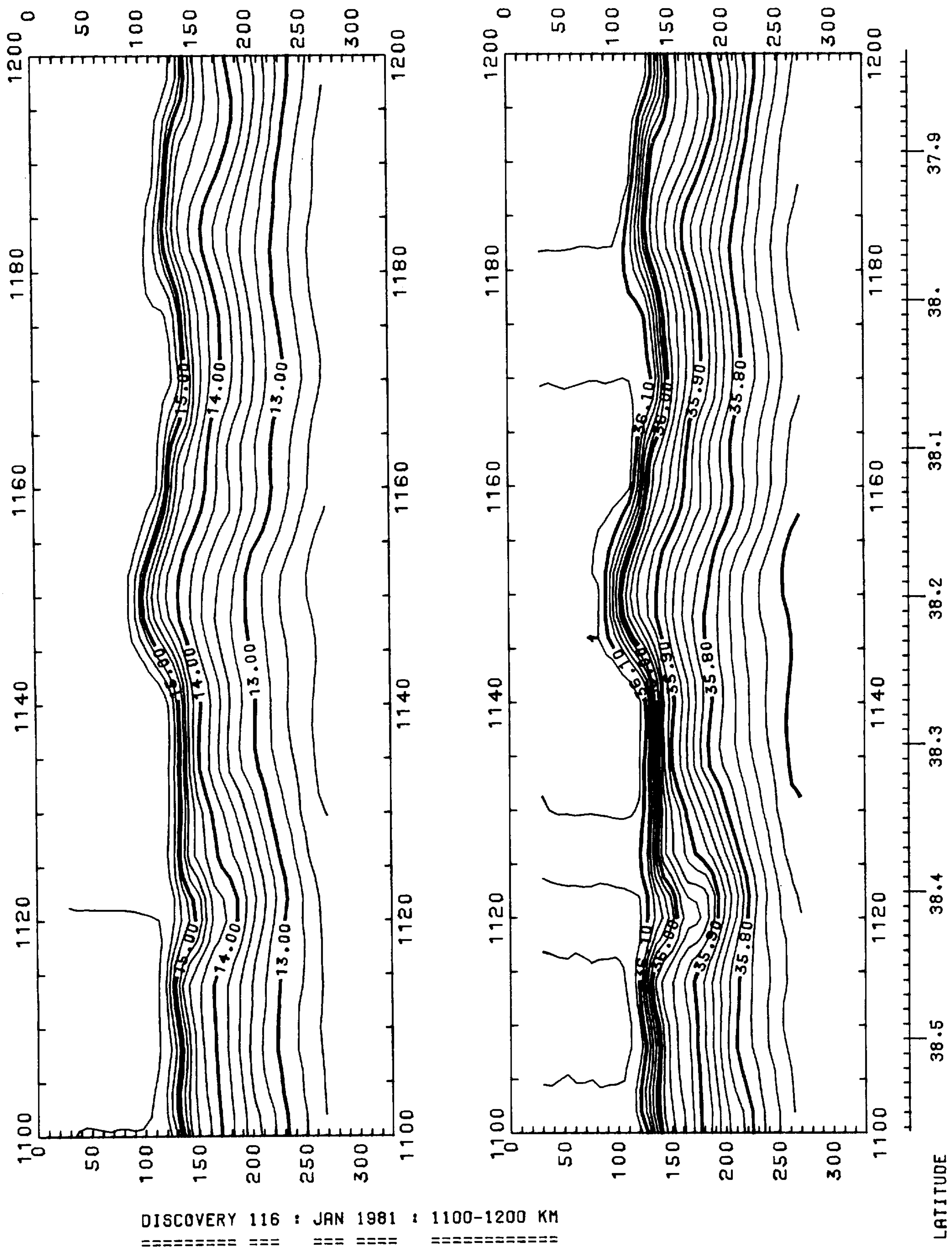
DISCOVERY 116 : JAN 1981 : 900-1000 KM
========= ===   === ====   ==========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



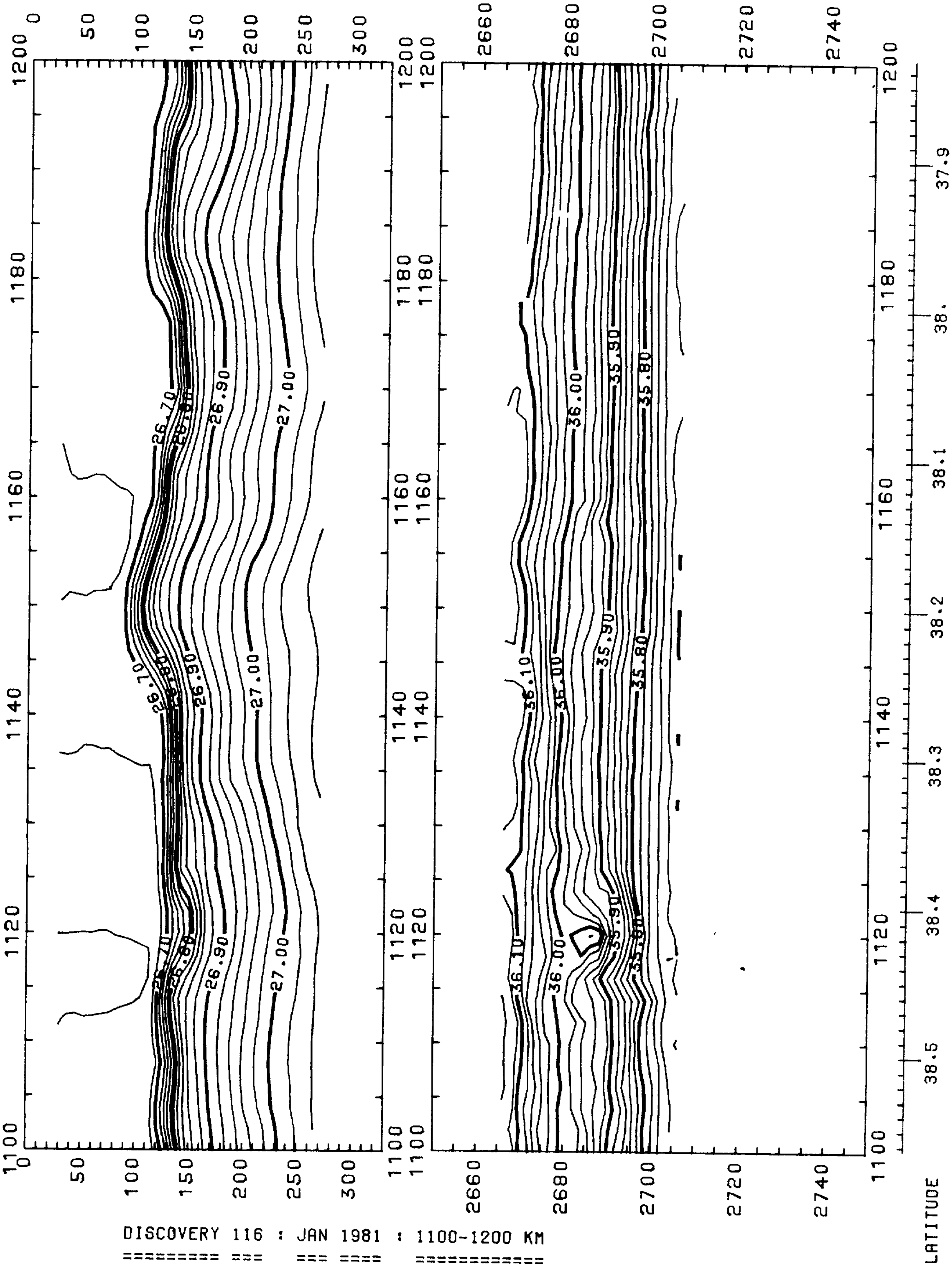
DISCOVERY 116 : JAN 1981 : 1000-1100 KM
========= === === ==== ===========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



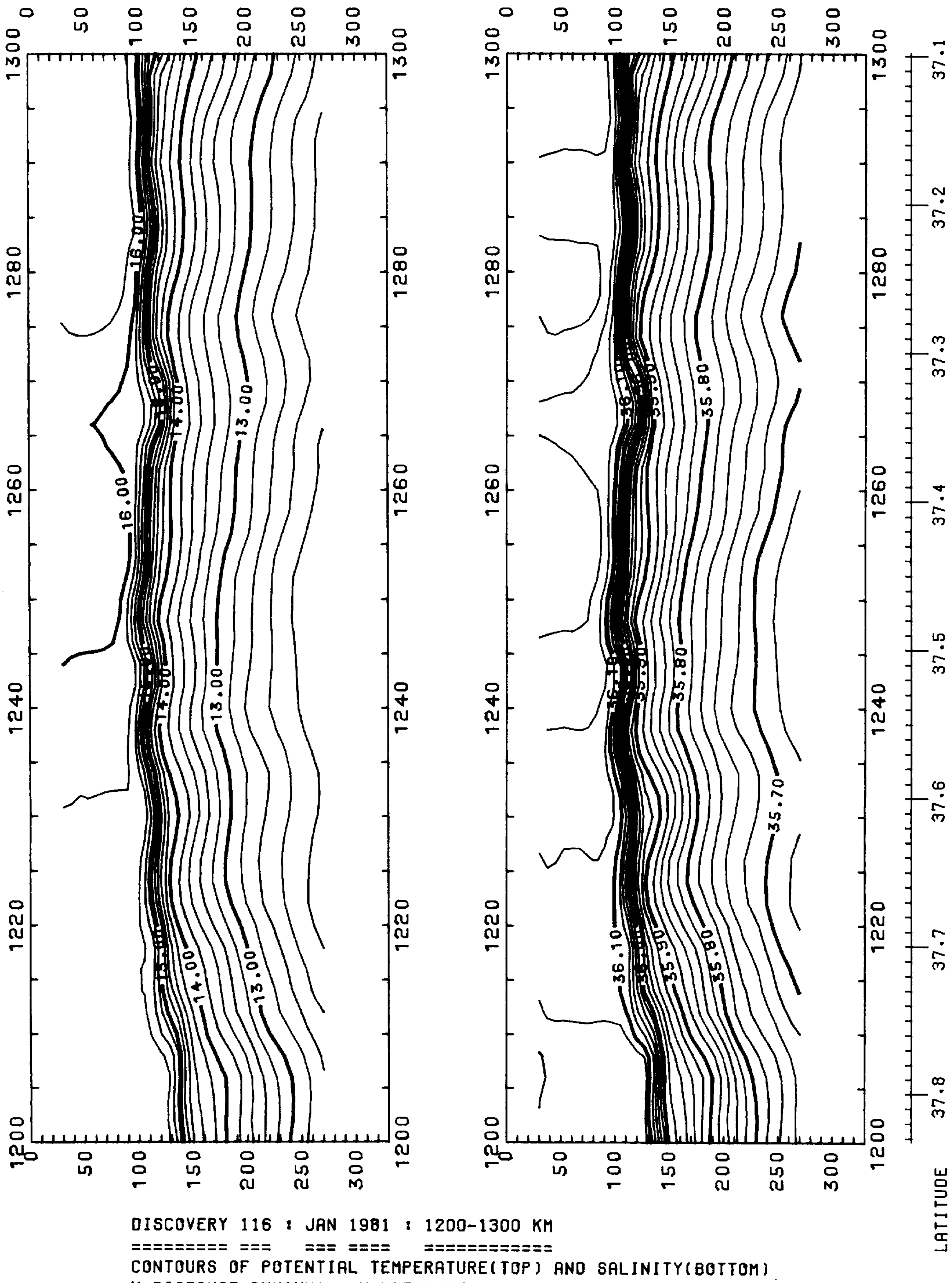
DISCOVERY 116 : JAN 1981 : 1000-1100 KM
========= === === ==== ===========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 1100-1200 KM
========= ===   === ====   ===========
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



DISCOVERY 116 : JAN 1981 : 1100-1200 KM
========= ===   === ====   ===========
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 1200-1300 KM

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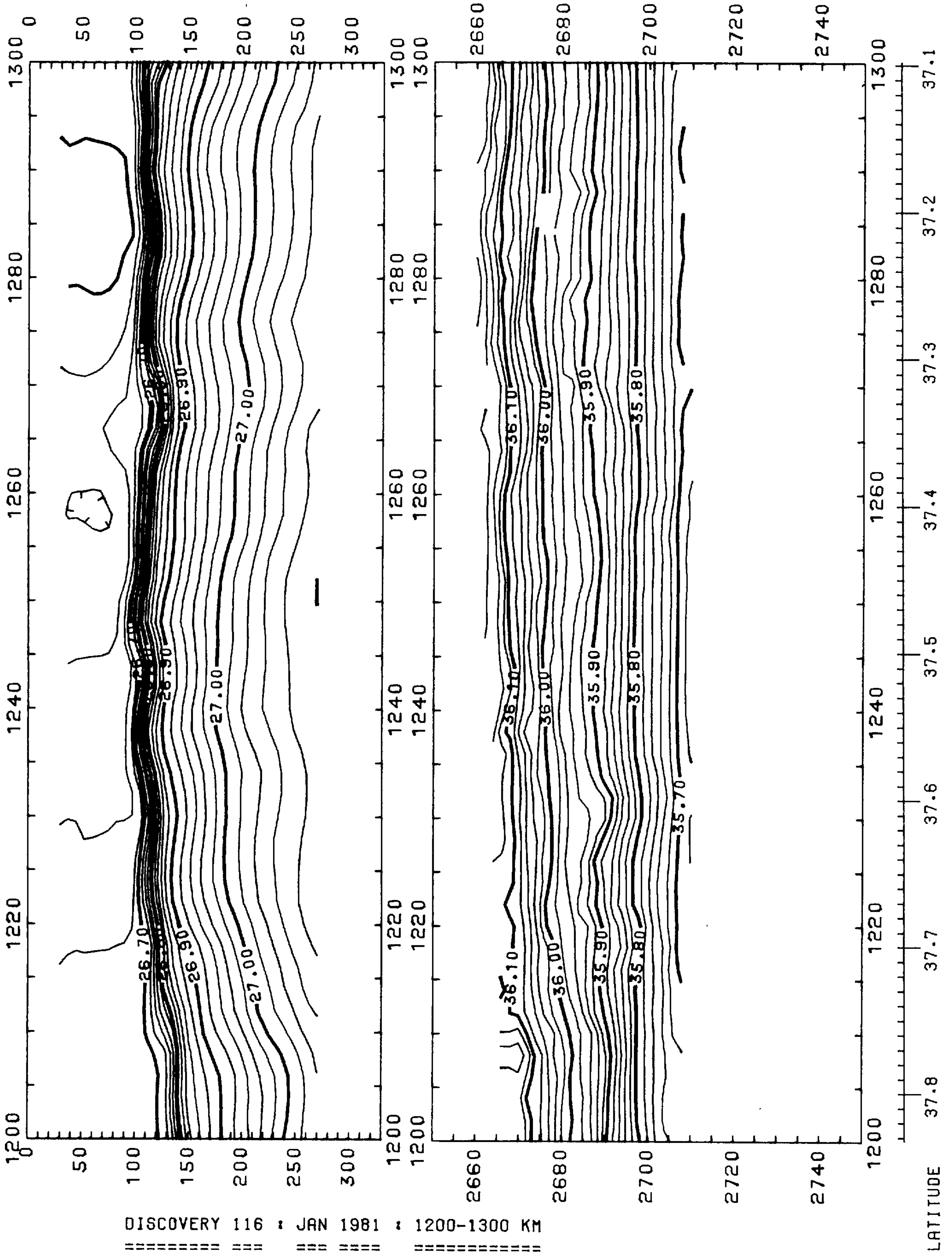
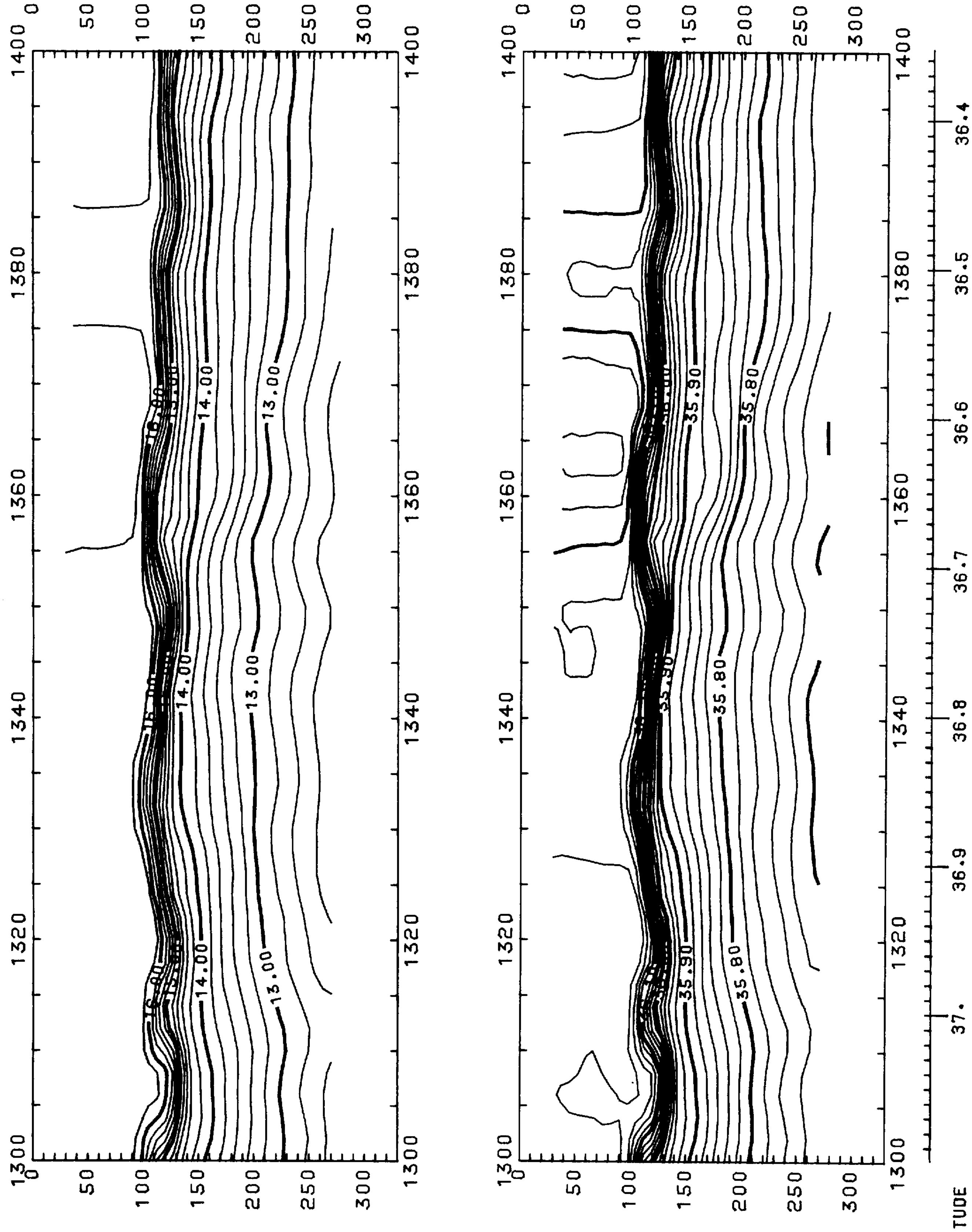
CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)

X=DISTANCE RUN(KM) : Y=PRESSURE(DB)

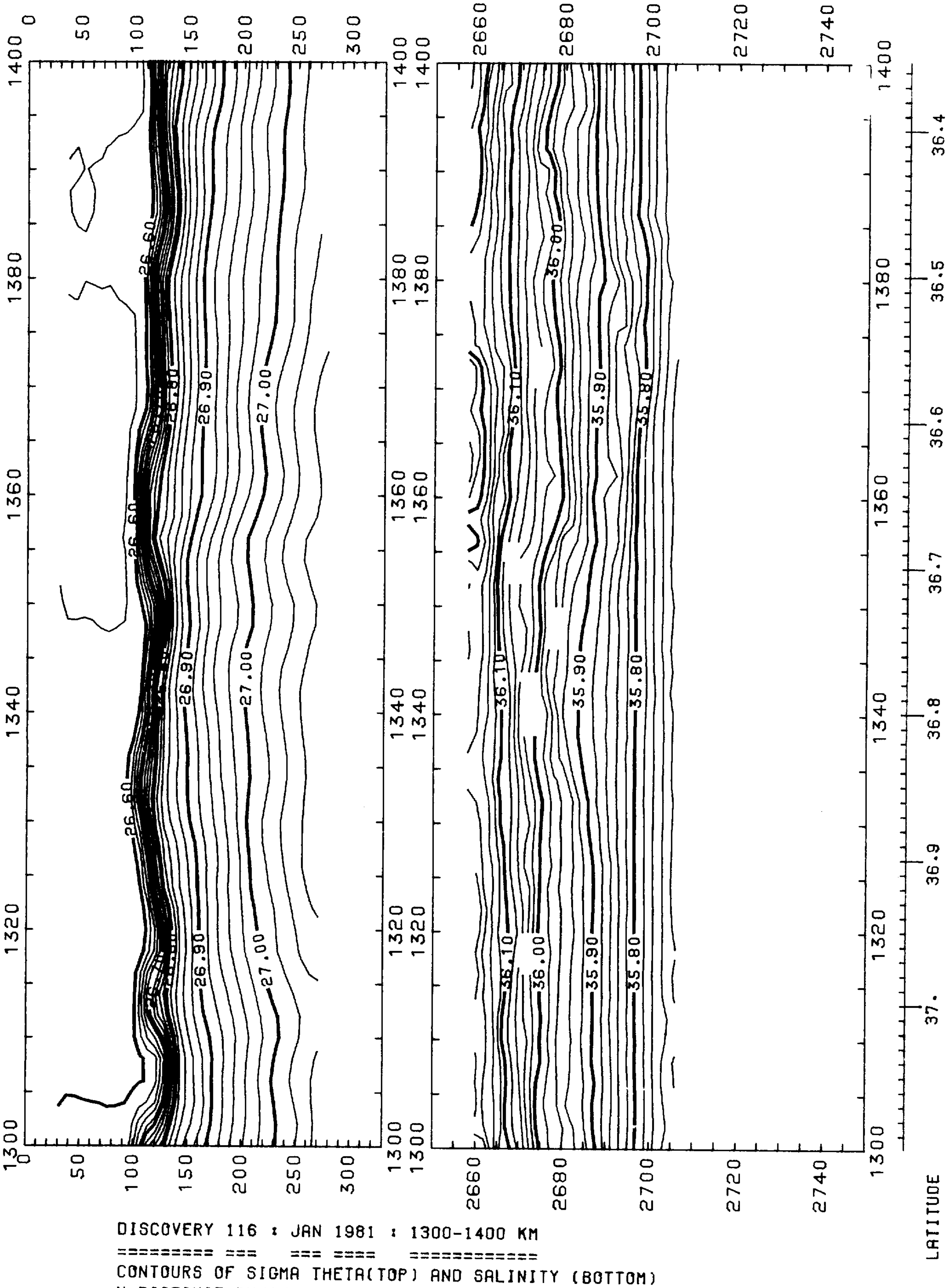


DISCOVERY 116 : JAN 1981 : 1200-1300 KM
========= === === ==== ============
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)

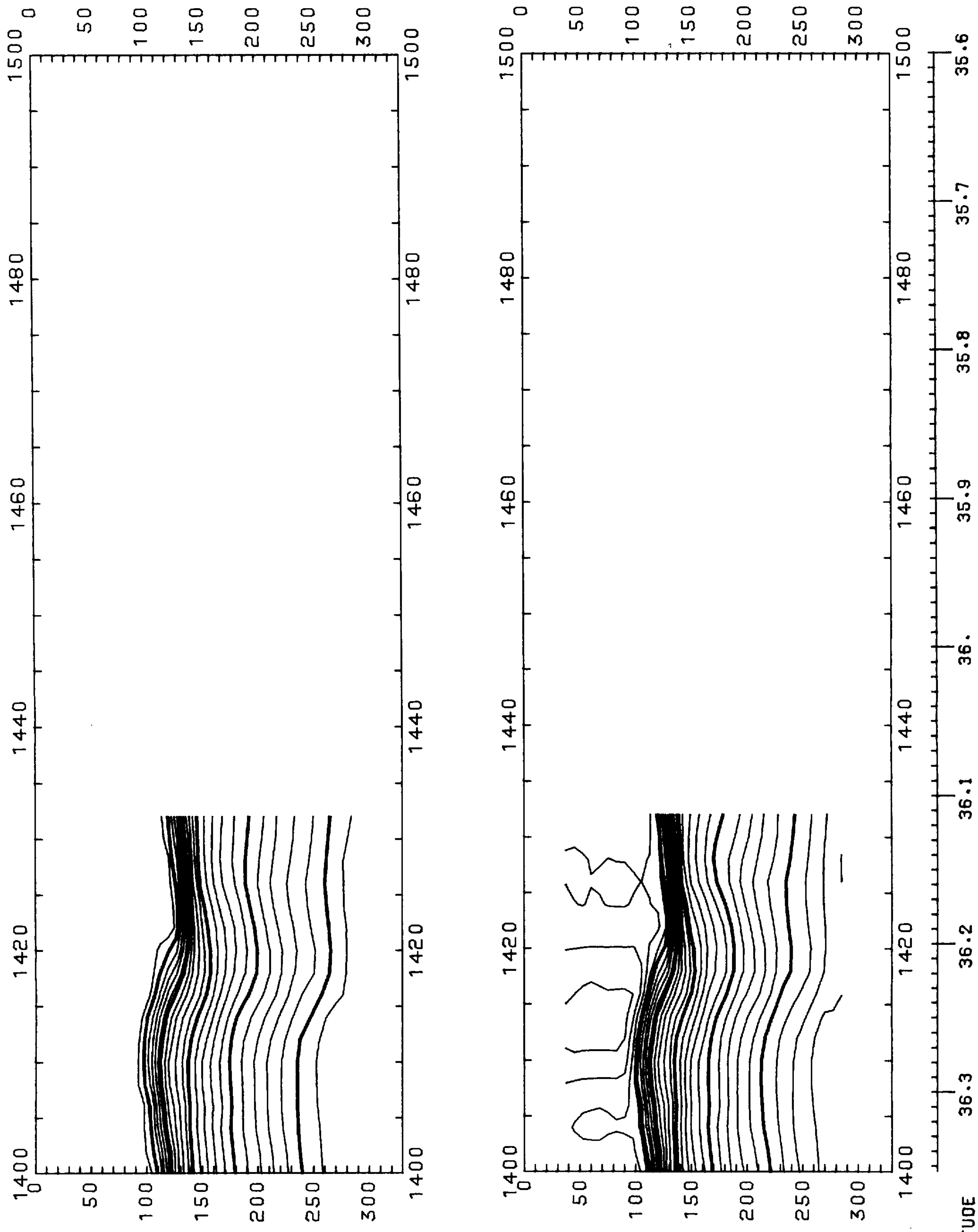


DISCOVERY 116 : JAN 1981 : 1300-1400 KM

CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)

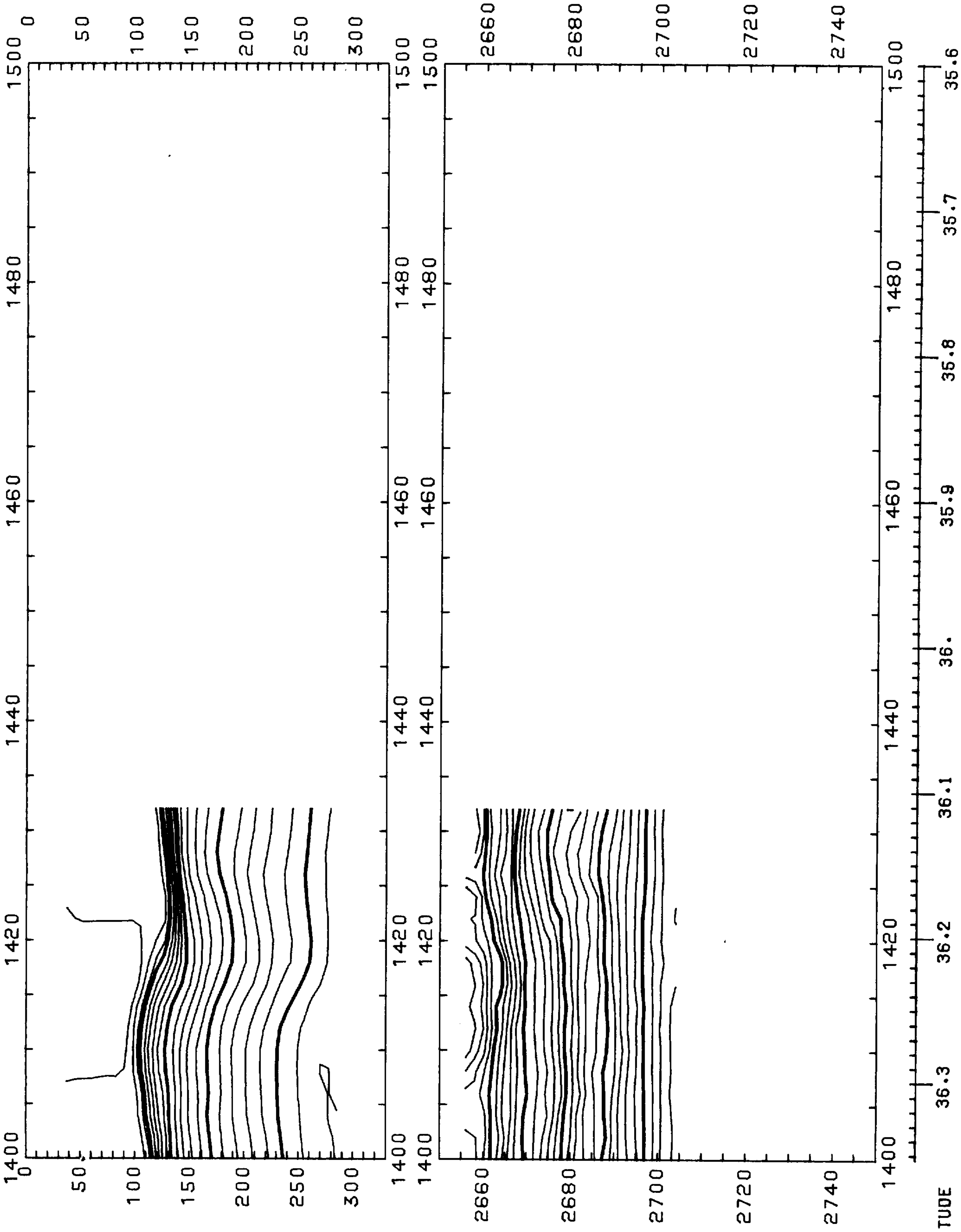


DISCOVERY 116 : JAN 1981 : 1300-1400 KM
========= ===   === ====   ============
CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)



DISCOVERY 116 : JAN 1981 : 1400-1500 KM

CONTOURS OF POTENTIAL TEMPERATURE(TOP) AND SALINITY(BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB)



DISCOVERY 116 : JAN 1981 : 1400-1500 KM

CONTOURS OF SIGMA THETA(TOP) AND SALINITY (BOTTOM)
X=DISTANCE RUN(KM) : Y=PRESSURE(DB) OR SIGMA THETA*100(CGS)