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DRIFTING SPAR BUOY CURRENT AND TEMPERATURE MEASUREMENTS MADE DURING RRS DISCOVERY CRUISES 145 AND 146

BY

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REPORT NO. 242
1987

NATURAL ENVIRONMENT RESEARCH COUNCIL

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1987

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DOCUMENT DATA SHEET

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PUBLICATION DATE 1987

TITLE
Drifting spar buoy current and temperature measurements made during RRS *Discovery* Cruises 145 and 146.

REFERENCE
Institute of Oceanographic Sciences, Deacon Laboratory, Report, No. 242, 114pp.

ABSTRACT

A free-drifting spar buoy was deployed five times during RRS *Discovery* Cruises 145 and 146 in March and April 1984, for periods from 4 to 6 days. Nine vector averaging current meters were suspended beneath the spar on each occasion, five of them AMF rotor/vane VACMs, the remainder IOS designed electromagnetic VAECMs.

The spar buoy is described, with deployment, recovery and tracking techniques. Current and temperature data from vector averaging instruments suspended beneath the spar at depths from 15m to 230m are presented. After correction, it is believed that temperature differences between VACMs are correct to within 2mK, but errors of up to 5 - 10mK may be present for the VAECMs. Relative currents are correct within about 2cm/s. Sticky compasses affected some VAECMs. Absolute currents have also been calculated over 12-hour periods, with the drift of the spar derived by cubic spline fitting to the Argos and ship(transit satellite and acoustic) fixes of its position.

Deployments were in late winter mixed layers over 250m deep and 150 - 200m deep, and during early spring restratification. Several deployments were near fronts.

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KEYWORDS
CURRENTS
LAGRANGIAN CURRENT MEASUREMENT
MIXED LAYER
DISCOVERY/RRS - CRUISE(1984)(145/146)
SPAR BUOYS
TEMPERATURE
VACM FLOW SENSORS

CONTRACT

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1. INTRODUCTION

A spar buoy for carrying current meters in the upper layers of the ocean was first developed for JASIN 1972 (Pollard, 1973a). It is wellknown that data from instruments beneath surface following floats are contaminated by the induced vertical motions (Pollard, 1973b, Gould & Sambuco, 1975). The spar was developed to minimise surface wave contamination and allow measurements in the mixed layer. In 1972, the spar was tethered to a surface mooring. However, the drag caused by strong currents tilted the spar and reduced its effectiveness. In subsequent experiments, as described here, the spar has therefore been allowed to drift freely. A second problem was encountered in 1972 when it was attempted to measure currents closer to the surface than 15m. To do this, cages were built into the spar to house VACMs (vector averaging current meters), because the spar itself was 10m long. The cages severely affected the calibration of the current meters in them. A limitation in subsequent experiments is thus that measurements cannot be made shallower than 15m.

During the major JASIN experiment, JASIN 1978 (Pollard et al, 1983), the spar was successfully deployed eight times, one of which is described by Pollard (1983). A full description of the spar has not previously been documented, however, and that is the purpose of this report.

While navigation and tracking of a free-drifting spar pose problems, there is one major advantage: a near-Lagrangian experiment can be carried out. Attempts to close heat and momentum budgets in the mixed layer are nearly always plagued by horizontal advection, which is greatly reduced by surveying relative to the spar, whose major drag lies between 0m and 10m deep. Pollard (1983) showed how a SeaSoar survey round a square relative to the spar minimised advection, by plotting the survey track relative to ground and relative to the water. An advection relative to water of about 0.1m/s was induced by windage on the spar in 15m/s winds, and there is of course vertical shear in the water column, but both are measured by the current meters as velocities relative to the spar.

The 1984 spar deployments described here were carried out on two cruises of <u>RRS Discovery</u>, Cruise 145 (Pollard et al, 1984) from 25 February - 24 March, and Cruise 146 (Angel et al,1984) from 27 March - April. The objectives of these cruises were to observe the structure of the upper ocean at the end of winter at two sites with different seasonal characteristics, and to observe the physical and biological changes at the two sites at the start of the heating season. The two sites chosen were in the northeast Atlantic around 40°'N 15°W and 45°45'N 13°40'W where the end of winter mixed layers were around 150-200m deep and 250-300m deep respectively. Further details are given in Section 5.

During the five spar deployments, each lasting from 4 to 6 days, the SeaSoar was used to survey the density structure around the spar buoy and up to 30km away from it. Those data will be presented in a companion data report (in preparation). The heat budget at the spar on the first deployment is described by Thomas (1986).

2. SPAR INSTRUMENTATION

2.1 Surface hardware

The spar buoy (Fig. 1) consists of three sealed sections of aluminium alloy tubing 2.98m long by 0.25m diameter with 0.38m diameter end flanges, bolted together and surmounted by a surface-piercing section (SPS), 2.0m long by 0.13m diameter. The spar, with all instrumentation, is ballasted to float with half (1m) the SPS above the water line in calm water. Thus, about 10m of the spar length out of the total of 11m is subsurface.

The deepest of the three buoyancy tubes has 0.5m diameter aluminium alloy damping plates above and below it. Four alluminium alloy rods run between the damping plates to form a cage around the buoyancy tube. A Fablon fabric sleeve tightly fitted at each damping plate circumference, fits around this cage, secured at each plate by polypropylene line. When the spar enters the water, water floods freely into the space between the sleeve and buoyancy tube through holes in the damping plates, giving added mass which increases the natural period of oscillation of the spar. The sleeve also increases the drag between 7m and 10m deep.

The instrumentation string is attached to the buoy by a three wire suspension attached to the buoy by large dynamo bolts bolted through the lower flange and damping plate. The three wires are terminated at an oval link with a stainless steel snaphook fitted. The snaphook then clips onto an oval link shackled into the instrument line. This enables rapid and reliable connection of the spar to the instrument string.

At the top end of the instrument string, there must be a variable length wire strop. To couple in current meters during deployment, the strop needs to be at least 3m long, which is why the minimum sensor depth for a 2m long VACM is about 15m below the surface in the mean.

2.2 Spar buoyancy and periodicity

Each of the three main tubes displaces about 157kg of water, and the half immersed SPS displaces 13kg water. The total mass from SPS to master link is 230kg, so the net buoyancy, or immersed weight of instruments the spar can support, is 254kg.

The SPS has a net buoyancy of 2.7kg per 25cm length, so that ballasting has to be accurate to 1kg if the spar is to float accurately with the SPS half immersed.

Lead or steel weights preweighed in seawater are available which can be slung beneath the spar to decrease buoyancy or can be bolted to a stainless steel threaded stub at the base of the SPS. This enables them to be added at the last moment if necessary (Section 2.5). Flotation collars of closed cell foam encased in glass reinforced resin with 8.6kg buoyancy are also available, which can be clamped round the spar tubes, preferably inside the sleeve. If necessary, a plastic through-hole float can be attached to the stainless stub at the base of the SPS if buoyancy has to be increased at the last moment, but this is less desirable as it can move and wear. The float gives a buoyancy increase of 8.5kg for 28cm diameter, 3.5kg for 20cm diameter.

The spar is typically deployed supporting five VACMs (73kg in air) and four IOS vector averaging electromagnetic current meters (VAECMs) (25kg in air), so that the mass of the whole system is about 700kg. The SPS displaces 0.081kg of water per cm it is raised. The natural period of oscillation of the spar without the sleeve is thus 18.5 seconds. The sleeve traps a further 450kg of water, increasing the natural period to 24 seconds.

If surface wave amplitudes exceed 1m, however, the uppermost buoyancy tube can become exposed. Having a diameter 2.5 times that of the SPS, the buoyancy period becomes reduced to 10 seconds while the pipe is exposed. The spar therefore sinks rapidly when it is in a wave trough, but rises slowly when it is fully immersed, so tends to ride a meter or two deeper in heavy seas.

2.3 Backup flotation and surface instrumentation

To aid recovery and location, and provide backup buoyancy in case a current meter or conceivably a spar section floods, the spar is tethered by a buoyant line (3 strand polypropylene) from the base of the SPS through twelve 0.28m diameter polo floats to a toroidal float, a converted pitch roll (P/R) buoy (e.g. Fig 2). (Note: The 3-strand polypropylene is now, 1986, replaced with 8 plait multiplait polypropylene rope coated at the terminations with Aliphatic Clear Polyurethane Emulsion (ACPE) to inhibit abrasion.)

A further 15m pickup strop leads from the P/R float to a single float. The line from the spar to the P/R float is 45-50m long. An Argos transmitter and light are on the P/R float. A radio direction finder and light are fastened to the top of the SPS.

2.4 Subsurface instruments

VACMs, VAECMs, and an acoustic transponder were slung beneath the spar buoy in different combinations and at different depth on the five deployments. On all deployments described here, 5 VACMs and 4 VAECMs were used. Details are shown in Table 2 and the five configurations are shown in Figs 2, 8, 14, 20, and 26.

8mm wire straps were used for most deployments, but 7mm diameter 16 plait Kevlar was used to penetrate to 230m on deployment 1462, because the spar had insufficient buoyancy to use wire for the full depth.

The transponder was used for precise ranging (Section 3.2). Acoustic ranges were improved by the surface sound channel caused by the deep mixed layers. The transponder depths were chosen to be optimally located in the sound channel.

2.5 Ballasting, deployment and recovery procedure

Prior to deployment, ballast requirements were calculated as accurately as possible using known weights of all components in sea water.

Deployment off the stern of Discovery was standard, starting with the bottom most instrument. Wire strops of the correct length were attached and seized to the top of each instrument, and the strop was attached to the tail of the payout strop led from a winch to a crane davit. Hauling in lifted the strop and instrument off the deck so the instrument could be swung outboard and attached to the stopped off instrument string.

Once all instruments were deployed and the string stopped off, the entire 11m spar was lifted by the crane on a short strop attached to eyebolts at the base of the SPS. As long as several heaving lines are held in different directions from the spar body, the spar can be keep well under control even in rolling conditions.

This is because the spar is relatively light and so long that the SPS has to be held close to the crane jib and there can be little pendulum effect.

The spar is swung outboard and attached to the instrument string, then lowered into the water slowly, allowing the sleeve to flood. Once the spar is in the water, all weight comes off the crane, and the spar is allowed to drift away from the ship on a long ballasting line, which is paid out rapidly so that it becomes slack. This enables ballasting to be checked. If the spar is not floating close to the mid point of the SPS, it is hauled in again by taking the tether round the capstan, and a weight or float attached to the base of the SPS.

Once ballasted correctly, the spar was hauled in on the capstan and the long tether replaced by the line to the backup flotation. As the spar drifted away from the ship, the flotation line was paid out and finally the P/R float was lifted outboard on the crane and the line slipped.

Recovery is the reverse of deployment, and has few special problems. Note however that the P/R float lies between the spar and the stray line which is initially grappeled. Considerable drag caused strain can thus be transferred across the P/R buoy itself, therefore, both the stray line and the main tether split into Vs to pass round either side of the P/R buoy, as shown in Fig 2, so that the strain bypasses the buoy itself.

Once all backup flotation is inboard, (with the ship manoeuvering towards the spar to reduce strain on the line), the flotation is removed and the line transferred by shackling to the tail line from the winch. The spar can then be eased close to the ship and lifted until the crane hook can be attached to the lifting strap as the base of the SPS. Thereafter, recovery is standard.

3. NAVIGATION

It is easy and undesirable to lose a free drifting system with only a 1m long 10cm diameter tube protruding through the surface and £100,000 of current meters hung beneath it. Several navigation systems are therefore used to locate the spar, and to track its course as accurately as possible without requiring the ship to remain within acoustic range all the time.

3.1 Location aids

The Argos transmitter on the P/R float provides positional information with some restrictions. Fixes are normally received by the Argos computer every few hours. They take a while to process, and must then be obtained by the ship by establishing a communications link (usually by Inmarsat) to the Argos computer. Thus there is a delay of usually 3-6 hours before a fix can be obtained on board ship. If transmitter, computer or communications break down, the delay can be much longer. In any event, fixes are only accurate to about 1km.

We therefore ensure that the ship is never more than a few hours steaming distance away from the drifting spar, and ensure that the ship passes close enough to the spar to obtain an acoustic fix at least once, preferably several times, a day. All position fixes are plotted, so that a track plot is obtained, and can be extrapolated forwards to estimate the most likely position if there is a long time gap between fixes for any reason.

As long as the spar position is known within a few km, it can usually be located acoustically. The 10khz transponder, hung if possible in a sound channel beneath the spar, provides acoustic range accurate to a few metres, though occasionally with a 1500m uncertainty because of the way the signal is read from a mufax recorder showing 1500m per slew across the paper.

The SPS, floats and P/R buoy can usually be seen visually by day at a range of 1-2km, and by night the flashing lights on both the SPS and P/R buoy are similarly visible.

Finally, while the transponder provides range but not bearing, the radio direction finder works within a range of typically 4 to 9n.m. of the 150Mhz transmitter on the SPS. After sea trials in 1986, 4n.m. can be achieved when monitoring the satellite transmitter with a doppler shift RDF detector. Bearings are obtained within ± 20 degrees.

3.2 Accurate navigation

Current meters hung beneath the spar buoy measure only currents relative to the spar, or vertical shear when differenced. Absolute currents can only be obtained to the extent that the velocity of the spar over the ground is known. If good fixes can be obtained every hour or two it is possible to resolve tides and inertial period internal waves (Pollard, 1983) but two factors rendered this not possible during cruises 145 and 146. The first was that there was no Loran in the area, as there had been in the JASIN area (Pollard and Saunders, 1978). The second was that, to resolve mesoscale structure, Discovery had to survey up to tens of km away from the spar, so could only pass close by it to obtain an acoustic fix about three times a day. By comparison Pollard (1983) ran 7km squares which passed the spar every two hours.

Fixes were obtained in two ways, therefore. Argos fixes provided about half of the fixes used, averaging a fix about every four hours. Whenever Discovery passed within acoustic range of the spar, range was measured every two minutes, and afterwards plotted on an expanded scale track plot. The point of intersection of several ranges fixed the spar position to effectively the same accuracy as the track plot (because acoustic ranges are accurate to a few metres, but the ship position is based on transit satellite data only accurate to about 500m). To obtain the ship's track plot, satellite fixes are first edited to remove all dubious ones (duplicates, high or low elevations, more than three iterations, etc.) The ship's 2-component EM log is then used to derive a dead reckoned position at the time of each satellite fix, by integrating forwards from the previous satellite fix position. The DR and second fix positions are reconciled by assuming the ship has been set by a constant current between the two fixes. This current is then used to recalculate the DR.

3.3 Smoothing of track and derivation of spar velocities

The number of spar position fixes available for each of the five deployments is shown in Table 1. Except for deployment 1462 (section 5.4), there was a fix on average every 2-2.5 hours, though occasional long gaps are mentioned in 5.1-5.5. To fit a smooth track to these fixes, cubic splines were least squares fitted independently to the latitudes and longitudes (converted to km north and east of an arbitrary origin), each as functions of time, using subroutines provided by the Numerical Algorithms Group (NAG, 1984). This subroutine forces continuity of the spline function, and also its first and second derivatives, at each knot point (point at which separate cubic curves are matched). The knot points were initially chosen 12 hours apart then increased, decreased and shifted subjectively until a reasonably close fit to the observed fixes was achieved. Knots can obviously be chosen closer together where there are several fixes to constrain the cubic. It was possible to partially resolve long period internal waves (tides and inertial oscillations) for three runs (Table 1) with knots 6.5-7.8 hours apart. In all runs, however, the RMS distance between observed and fitted (fix) positions lay between 0.47 and 0.63km (Table 1) with a mean of 0.57km. This RMS error, 570m, is consistent with known errors in transit satellites fixes, and was indeed the criterion used in choosing knot points, the number of knots being increased to reduce the RMS error until the fitted curves began to exhibit implausible oscillations.

Although the x and y positions were spline fitted separately, the same set of knots was used for each. It is clear from the track plots why a spline fit of y to x is not desirable. While x and y positions behave fairly sinusoidally as function of time, the resultant plot of y against x frequently exhibits cycloid-like cusps.

Spar velocities cannot in general be resolved for periods less than tidal. Twelve-hour averages have therefore been calculated from the spline fitted curve. These have been added to equivalent 12-hour averages of the current meter velocities relative to the spar, to give absolute velocities at all depths. Component plots of the top and bottom current meters are shown in Figs. 6, 12, 18, 24 and 30.

4. CURRENT METER PROCESSING

Two kinds of vector averaging current meters were deployed beneath the spar buoy, standard AMF VACMs and IOS designed VAECMs. VAECMs use electromagnetic means to sense the current. The sensor head consists of a coil of copper wire encased in an toroidal resin ring, with the four electrodes to sense the two horizontal current components protruding towards the centre of the ring. Four stems rise from the toroid, joining to a bar extending from the main electronics housing pressure case. A compass inside the pressure case provides magnetic north reference to orientate the two component sensor head.

4.1 Data reduction

Both VACMs and VAECMs record their data internally on a SeaData Logger cassette tape. Each time the spar was recovered, the cassette tapes were immediately read using a SeaData Decoder interfaced to a Digidata magnetic tape deck. The bit pattern read by the decoder was thus transferred to a computer-compatible 800bpi magnetic tape.

The magnetic tapes were then read on a PDP 11/34 computer by program CPSTAR that converted the SeaData bit pattern into raw data in a standard PSTAR file format (Pollard and Read, 1986). Two calibration programs (PCVACM and PVAECM) then converted the raw VACM and VAECM data into calibrated PSTAR files. These programs applied magnetic deviation (10°W), rotor or two-component speed calibration and temperature calibration. Details are given below. After correcting the time base, truncating start and end transients, completing header records (e.g. adding latitude and longitude) and editing any spikes, the data were plotted and further editing applied as necessary in the light of those plots.

This entire procedure was completed within about a day of recovering the spar. It was thus possible to identify instrumental errors in time for correction or substitution before the instruments were made ready for redeployment. Instrumental problems are described in detail in Sections 4.2, 4.3 and 5.1-5.5.

4.2 Temperature calibration

4.2.1 VACMS

In December 1983, prior to Cruise 145, the VACMs were calibrated.

These calibrations were used for all five deployments. In JASIN (Pollard, 1980), it was found that laboratory calibrations could be up to 10mK in error. This was deduced by comparing temperature records from different instruments in a homogeneous mixed layer. On Cruises 145/6, therefore, we systematically swopped the VACMs and VAECMs to vary their deployment order and depth on each deployment (Table 2). An overplot of all VACM temperature records for 1451 (Fig. 32), in which all instruments were in a deep nearly-homogeneous mixed layer (Thomas, 1986), indicates relative calibration errors possibly as large as 20mK. Corrections to VACM temperatures to improve their relative calibrations were therefore derived as follows.

First, all temperatures were converted to potential temperatures by subtracting 13mK/100m times the depth of each instrument. Then, temperature records from adjacent VACMs were differenced, and plotted as histograms and hourly-averaged listings. Whenever these show the potential temperature increasing with depth, either the salinity must also increase with depth to create a stable or neutral density gradient, or the temperature calibration must be corrected.

Deployment 1451 was particularly useful. Convective mixing at night created an extremely homogeneous mixed layer to over 250m in the vicinity of this spar, and repeated SeaSoar runs round the spar using a NBIS CTD confirmed this homogeneity. The SeaSoar showed greatest vertical homogeneity in the ramp (Thomas, 1986) which the spar crossed between days 69.2-69.4 (compare Fig. 32 and 5, respectively before and after final calibrations). Relative corrections required in the light of this information are shown in Table 3a, line 1.

Instrument pairs from all other deployments were then examined. Some pairs display a stable temperature gradient throughout (Figs. 11, 17, 23, 29) give no constraining information. Overall, to minimise the occurrence of unstable temperature gradients whenever there was no evidence for a compensating salinity gradient (from SeaSoar runs), the corrections shown in the second line of Table 3a were chosen. Assuming the VACM temperature calibrations are stable over the cruises, we conclude that relative errors between all VACMs are no greater than 2mK, once the finally chosen corrections are made.

Post-cruise calibrations, in July 1984, differed from the December 1983 calibrations by the amounts shown in line 3 of Table 3a. Two instruments, 627 and 668 are off from our chosen calibrations by far more than 2mK, namely 15mK and 11mK. If these corrections are used, however, quite implausible temperature inversions result, so we reject them. We conclude:

(a) pre-cruise calibrations for VACMs 673 and 629 were in error, or their calibrations shifted before the first deployment,

(b) neither pre- nor post-cruise calibrations for VCMs 627 and 668 can be correct. Their temperatures were 15-19mK and 9-11mK larger than the laboratory calibrations indicate.

4.2.2 VAECMS

VAECM temperatures were calibrated before and after the cruises using a third order polynomial. The postcruise calibrations are suspect, however, giving implausible shifts, so have been disregarded.

The circuits were also checked before and after each deployment using calibrating resistors in place of thermistors. These checks revealed a drift with battery state, which, for a constant calibration, would give temperatures after each deployment lower by about 8mK than values before the deployment. Batteries were not renewed before 1452 and 1462, so one might also expect to have to add a larger correction for those deployments than for the others.

The actual corrections applied to the precruise calibrations are shown in Table 3b. Differences between adjacent instruments, both VACMs and VAECMs, were calculated, as described above, and the known VACM corrections used to deduce VAECM corrections. No allowance was made for possible calibration drift during a deployment. As before, 1451 provided reliable corrections, and there was no evidence for a change in calibration for 1452. The temperature gradients in 1461 and 1463 provided little help in determining offsets, and only minor changes from 1451 were applied. For 1462, however, instruments 2 and 4 required larger corrections by 10mK and 7mK, consistent with battery state.

In summary, we believe the VAECM temperatures are mostly correct (relative to VACMs) to within 5mK, but offsets as high as 10mK may be present at times when genuine temperature gradients prevented precise intercalibration.

4.3 Velocity calibration

For VACMs, the standard rotor calibrations were used. The VAECM heads were towtank calibrated pre- and post-cruise, all giving linear calibrations ranging from 0.336 to 0.371mm/s per digit. Two heads were broken during the course of the two cruises. The two heads for which before (after) calibrations were possible gave .371(.364) and .348(.350). Calibration errors are thus of order 2%, or 1cm/s in 50cm/s.

During JASIN, Pollard (1983) suspected errors of order 2-3cm/s in VAECM velocities, probably related to sticky compasses. Similar problems affect some of the records presented here. 14635 (ECM3) and 14637 (ECM4) velocities both proved irrecoverable due to partially stuck compasses. A more subtle error is present in 14515 (ECM3). It can be seen from the stick plots (Fig. 4) that 14515 looks anomalous, so the 12-hour mean velocities were used to examine the linearity of the shear for all current meters in the deep homogeneous layer of 1451. From deployment until 699/1200, east velocities appear to be nearly constant, which is consistent with the steady 12m/s east wind which persisted until day 70. The three day (66/1312-69/1200) means of east and north velocities have therefore been computed from the 12 hour absolute velocities (section 3.3) and are shown along with the maximum deviation between any 12-hour mean and the 3-day mean in Table 4. East values are fairly steady, deviating by no more than 1.7cm/s from the 3-day means. North values show increasing deviations with depth, the cause of which has been traced to larger shears by day (1200-2400 hours) than by night (0000-1200 hours), consistent with weak stratification by day with convection dominating by night.

If 14515 is omitted, deviations from a linear velocity gradient from 15-145m are no greater than 1.3cm/s with RMS deviations of only 0.7cm/s for east and north velocity components. The deviations of 14515 from the linear gradient calculated from the other eight records are 2.9 and 2.4cm/s for east and north velocities.

These results give some confidence in the current meter shears, suggesting that 3-day means may have errors of order 1 cm/s. Record 14515 (ECM3) is anomalous, with a 2-3cm/s offset in both components.

4.4 Data Presentation

Six kinds of figure are presented for each of the five deployments.

The spar rig (Figs. 2, 8, 14, 20, 26) complements Table 2.

The spar track and the east and north position components plotted against time are shown in Figs. 3, 9, 15, 21 and 27. Pluses (+) are the fixes finally accepted in the cubic spline fit. Asterisks (*) show the knots between adjacent spline sections. Twelve hourly times are marked (x) and annotated.

Relative velocities are shown as stick plots in Figs. 4, 10, 16, 22 and 28. The vectors are hourly averages of the difference between each of the upper 8 current meters and the bottommost (9th) instrument (which was always a VACM). The vectors are plotted against time (x-axis) and the instrument depth (y-axis).

All 9 temperatures on each deployment are overplotted in Figs. 5, 11, 17, 23 and 29 for 15-minute averages of the final calibrated values. Individual traces cannot easily be isolated on these plots (but compare Figs. 7, 13, 19, 25 and 31). Their function is to show the homogeneity or stratification of the surface layer.

Figs. 6, 12, 18, 24 and 30 show east and north components of 12-hourly averaged absolute velocities (Section 3.3) of the top and bottom current meters. (marked 1 and 9 respectively.)

Figs. 7.1-7.9, 13.1-13.9, 19.1-19.9, 25.1-25.9 and 31.1-31.9 show 15 minute averages of current components relative to the spar buoy and the temperature records of all individual current meters. The scales within each set of plots (for a single deployment) have been kept the same, to allow overlaying and comparison of pairs of records.

5. DESCRIPTION OF EACH DEPLOYMENT

All five spar deployments were in the vicinity of two sites (Pollard et al, 1984; Angel et al, 1984). The southern site, near 40°N, 15°W, was chosen to have a maximum mixed layer depth of 150-200m. It was occupied three times (1452, 1461 and 1463). The northern site, near 45°45'N, 13°30'W was chosen to have a maximum mixed layer depth of nearly 300m, and was occupied twice (1451 and 1462).

5.1 Deployment 1451

The first spar deployment, at the north site, was preceded by a long SeaSoar run from the south site (40°15°W) right up to 47°N 13°W to choose the best position. Mixed layer depths reached 250-300m by 44°N but rapidly decreased from 46°-47°N, so that stratification extended to the surface, and there was a discernible eastward set. Discovery therefore ran south again to escape the frontal zone, and deployed the spar at 45°50'N. In fact, this position was still affected by the front, as the spar set to the east at over 10cm/s, despite winds from the east of 12m/s which persisted until day 70. By day 71 the wind had dropped to 6m/s, but it increased suddenly to 15m/s from the north early on day 72, when the spar was recovered with difficulty. From day 70 the spar track turned southeast and then south, reaching a maximum speed (12 hour average) over 23cm/s.

A triangular SeaSoar survey round the spar was begun as soon as the spar was deployed, and continued until 70/0940. Spar fixes were therefore plentiful until Argos fixes ceased at 68/2126. Inspection after recovering the SeaSoar showed that the pitch roll float had overturned. It was righted using the rubber dinghy but only one further Argos fix was received before the receiver failed because of a flooded battery pack. CTD casts and CTD yoyos were done at varying distances from the spar thereafter, resulting in several long gaps between fixes (largest 12 and 14.5 hours).

Details of the 1451 deployment and recovery are given in Pollard et al (1984). Particular problems were the failure through flooding of the flashing light on the pitch/roll float, and the loss of Argos fixes.

As 1451 was the first spar deployment, we were rather cautious about the instrument depths, so that even the deepest VACM (at 145m) was well within the mixed layer. This proved most useful for intercalibration of the temperature sensors (4.2), but, despite strong winds, a diurnal signal and vertical temperature gradient were discernible at all instruments (Thomas, 1987).

ECM14513 had 4 too many records, so the time base was 15 minutes out by the end. The time base was corrected by reducing the sampling interval from 225 seconds to 224.719 seconds.

Quantization of the VAECM temperatures of about 7.5mK is apparent, particularly for 14517 (Fig. 7.7). Although the sensors have better resolution than this, the data were recorded with too few significant figures, and the ambient temperature noise was so low that averaging has not smoothed the signal.

Mean current shears have been examined in Section 4.3. Record 14515 is anomalous. The remaining 8 records satisfy a linear shear of $7 \times 10^{-4}s^{-1}$ from 15-145m for the first three days (Table 4) with surface shear towards 296° relative to 145m. At the end of this deployment, the wind picked up from the north, and surface shears become south or southwest relative to 145m.

5.2 Deployment 1452

After SeaSoaring back to the southern site, the spar was redeployed with current meters extending from 20m to 195m. As expected from the initial SeaSoar survey, the spar drifted north (Fig. 9.1) at over 15cm/s, with approximately tidal oscillations in its track discernible in the east-west drift.

Mixed layer temperatures of about 13.5°C were 1.5°K higher than at the northern site, and the mixed layer was shallower, varying tidally so that from 0 to 4 instruments were in the thermocline, i.e. from 200 to 130m. The wind strengthened briefly to over 15m/s from the southeast on two occasions, around 78/000 and 79/0800, causing enhanced shear to the north (Fig. 10), followed by apparently inertial oscillations in the shear from day 79.5-81.0

5.3 Deployment 1461

The first spar deployment on Cruise 146 was at the south site, where mean currents were found to be very weak, the spar drifting only 8km in 6 days.
Restratification of the surface layer was such that the top 3-4 current meters (60-80m) were in a stratified layer, with near-zero temperature gradient from 80-

160m. The bottommost current meter (195m) was in the thermocline throughout. Winds reached 10-12m/s on day 91 from 290°. and a response can be seen in the shears at 20 and 40m relative to 195m.

During the deployment, SeaSoar triangles were run round the spar from 89/2000 - 91/0830 and from 94/2000-95/1500. Six 2000m CTD casts were made between 91/0900 and 92/2100, followed by 5 additional shallow casts interspersed with biological net sampling.

An ORE light was taped onto the SPS in addition to that on the P/R float. Both lights worked well, and provided a major safety improvement over the Cruise 145 deployments, allowing the navigating officer to locate the spar at night during SeaSoar tows in plenty of time to take evasive action if necessary. Transponder ranges decreased as surface stratification built up, but were generally excess of 3km.

5.4 Deployment 1462

1462 was the second spar deployment at the northern site. It was short, only 4 days, and spar tracking and SeaSoar surveys were interrupted several times to search for two moorings which had gone astray, resulting in long gaps between fixes.

Spring restratification had taken place in the month since deployment 1451 (days 66-72, mid March) and extended to the surface. Shortly after deployment the wind increased to 30 knots from the east (on day 99) falling off to 20 knots and remaining easterly until the spar was recovered. The Ekman and inertial response is clearly visible in the relative current vectors (Fig. 22). In response to the wind the mixed layer deepened from less than 35m to over 110m (Fig. 23), but mixing could not penetrate the stratification to the depths of over 250m found during 1451 (Thomas, 1986).

5.5 Deployment 1463

After returning to the south site, the spar buoy was deployed for the last time within a triangle formed by three 2000m CTD casts. Winds were light and stratification extended to the surface (Fig. 29). The spar drifted northwest during the six day deployment. Triangular and grid SeaSoar surveys round the spar were carried out.

Currents from two VAECMs (14635 and 14637) were unusable (Section 4.3).

6. ACKNOWLEDGEMENTS

The spar buoy was designed in 1971 by Dr J.C. Swallow and T. Barber. The VAECMs were designed by Dr C.H. Clayson, and checked out by him (Cruise 145) and R. Pascal (Cruise 146). Data were read from SeaData cassette tapes onto computer tapes using interfaces designed by J. Smithers. Shipboard processing was done on a PDP11/34 provided by NERC Research Vessel Servies. R.G. Williams assisted with data reduction on Cruise 145. Dr P.K. Taylor and Dr T.H. Guymer ensured that high quality meteorological observations were made. Dr P.G. Collar and C.A. Hunter ensured that Argos tracking was possible, and G.R.J. Phillips provided, serviced and tracked the transponders.

The ship's masters were S.D. Mayland, M.A. Harding, Chief Officer N.A. Jonas. Particular thanks are due to all officers and crew of RRS *Discovery*, whose expertise facilitated the five deployments and recoveries, sometimes in difficult conditions.

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TABLE 1

Details of spar deployments and navigation

Deployment	1451	1452	1461	1462	1463
Set day/time	66/1312	76/1350	89/1742	98/0734	107/1238
latitude	45° 49.6N	40° 15.5N	39° 31.9N	45° 38.9N	39° 30.6N
longitude	13° 29.8W	15° 01.2W	14° 54.2W	13° 53.8W	14° 57.9W
Haul day/time	72/0858	82/0847	95/1638	102/0848	113/1627
latitude	45° 30.9N	40° 53.0N	39° 35.9N	45° 42.0N	39° 50.0N
longitude	12° 59.9W	14° 57.0W	14° 51.9W	13° 49.1W	15° 05.8W
Duration	5d 20h	5d 19h	5d 23h	4d 1h	6d 4h
Drift north	-34.9km	70.0km	7.5km	5.8km	36.2km
Drift east	38.9km	6.0km	3.3km	6.1km	-11.3km
Mean vel. N	-6.9cm/s	14.0cm/s	1.5cm/s	1.7cm/s	6.8cm/s
Mean vel. E	7.8cm/s	1.2cm.s	0.6cm/s	1.8cm/s	-2.1cm/s
Mean Speed	13.9cm/s	15.2cm/s	4.0cm/s	9.7cm/s	8.4cm/s
Navigation					
No. of fixes	50	68	68	27	62
Argos fixes	22	38	44	11	39
Acoustic fixes	28	30	24	16	23
Ave time between fixes	2.85h	2.09h	2.14h	3.76h	2.43h
Spline Fit					
No. of knots	11	19	23	8	20
Ave time between knots	14.0h	7.8h	6.5h	14.0h	7.8h
RMS dx	.43km	.46km	.36km	.48km	.42km
RMS dy	.45km	.35km	.29km	.27km	.46km
RMS dr	.63km	.58km	.47km	.55km	.63km

TABLE 2

Spar instrumentation

Deployment	1451	1452	1461	1462	1463
Level 1	14511	14521	14611	14621	14631
depth	15m	20m	20m	15m	15m
instrument	VCM627	VCM629	VCM673	VCM668	VCM430
Level 2	14512	14522	14612	14622	14632
depth	25m	48m	40m	35m	25m
instrument	ECM1	ECM2	VCM629	ECM2	ECM1
Level 3	14513	14523	14613	14623	14633
depth	35m	76m	58m	55m	35m
instrument	ECM4	ECM3	ECM4	ECM4	VCM629
Level 4	14514	14524	14614	14624	14634
depth	45m	96m	78m	75m	45m
instrument	VCM668	VCM430	ECM2	VCM627	ECM2
Level 5	14515	14525	14615	14625	14635
depth	65m	115m	98m	95m	55m
instrument	ECM3	ECM4	VCM430	ECM1	ECM3
Level 6	14516	14526	14616	14626	14636
depth	85m	135m	117m	114m	65m
instrument	VCM673	ECM1	ECM3	ECM3	VCM668
Level 7	14517	14527	14617	14627	14637
depth	105m	155m	137m	152m	103m
instrument	ECM2	VCM627	ECM1	VCM629	ECM4
Level 8	14518	14528	14618	14628	14638
depth	125m	175m	157m	190m	142m
instrument	VCM430	VCM673	VCM668	VCM673	VCM627
Level 9	14519	14529	14619	14629	14639
depth	145m	195m	195m	230m	172m
instrument	VCM629	VCM668	VCM627	VCM430	VCM673

TABLE 3

(a) Corrections to VACM temperatures (mK)

VACM	627	668	673	430	629
from 1451	+21	+11	+10	+2	+13
all runs	+19	+9	+8	+1	+13
post-pre cruise	+4	-2	+10	-1	+13

(b) Corrections to VAECM temperatures (mK)

VAECM	1	2	3	4
1451, 1452	+7	+9	-1	+18
1462	+7	+20	-1	+25
1461, 1463	+9	+10	-1	+18

TABLE 4

Mean current components for 1451 from 66/1312-69/1200

Depth (m)	EAST				NORTH			
z	3 day mean cm/s m_e	max deviation of 12 hour means from 3 day mean (cm/s)	LSQ linear gradient (cm/s) l_e	deviation from linear (cm/s) $l_e - m_e$	3 day mean cm/s m_n	max deviation of 12 hour means from 3 day mean (cm/s)	LSQ linear gradient (cm/s) l_n	deviation from linear (cm/s) $l_n - m_n$
15	3.0	0.7	2.4	-0.6	0.8	0.8	0.3	-0.5
25	2.0	1.1	3.1	+1.1	1.0	1.4	0.0	-1.0
35	4.6	0.9	3.8	-0.8	-0.8	0.6	-0.4	+0.4
45	4.4	0.6	4.4	0.0	-2.0	1.3	-0.7	+1.3
65	(8.6)	1.7	5.7	(-2.9)	(0.9)	1.3	-1.3	(-2.4)
85	7.1	1.5	7.0	-0.1	-2.4	2.0	-2.0	+0.4
105	7.1	1.0	8.3	+1.2	-2.1	2.2	-2.6	-0.5
125	10.4	0.7	9.6	-0.8	-3.8	3.8	-3.3	+0.5
145	11.1	0.4	11.0	-0.1	-3.3	4.1	-3.9	-0.6

$l_e = 6.54 \times 10^{-4}(s^{-1})z + 2.8$ (cm/s)
(omitting 65m value, 14515
RMS $(l_e - m_e) = 0.7$ cm/s

$l_n = 3.22 \times 10^{-4}(s^{-1})z + 0.3$ (cm/s)
(omitting 65m value, 14515)
RMS $(l_n - m_n) = 0.7$ cm/s

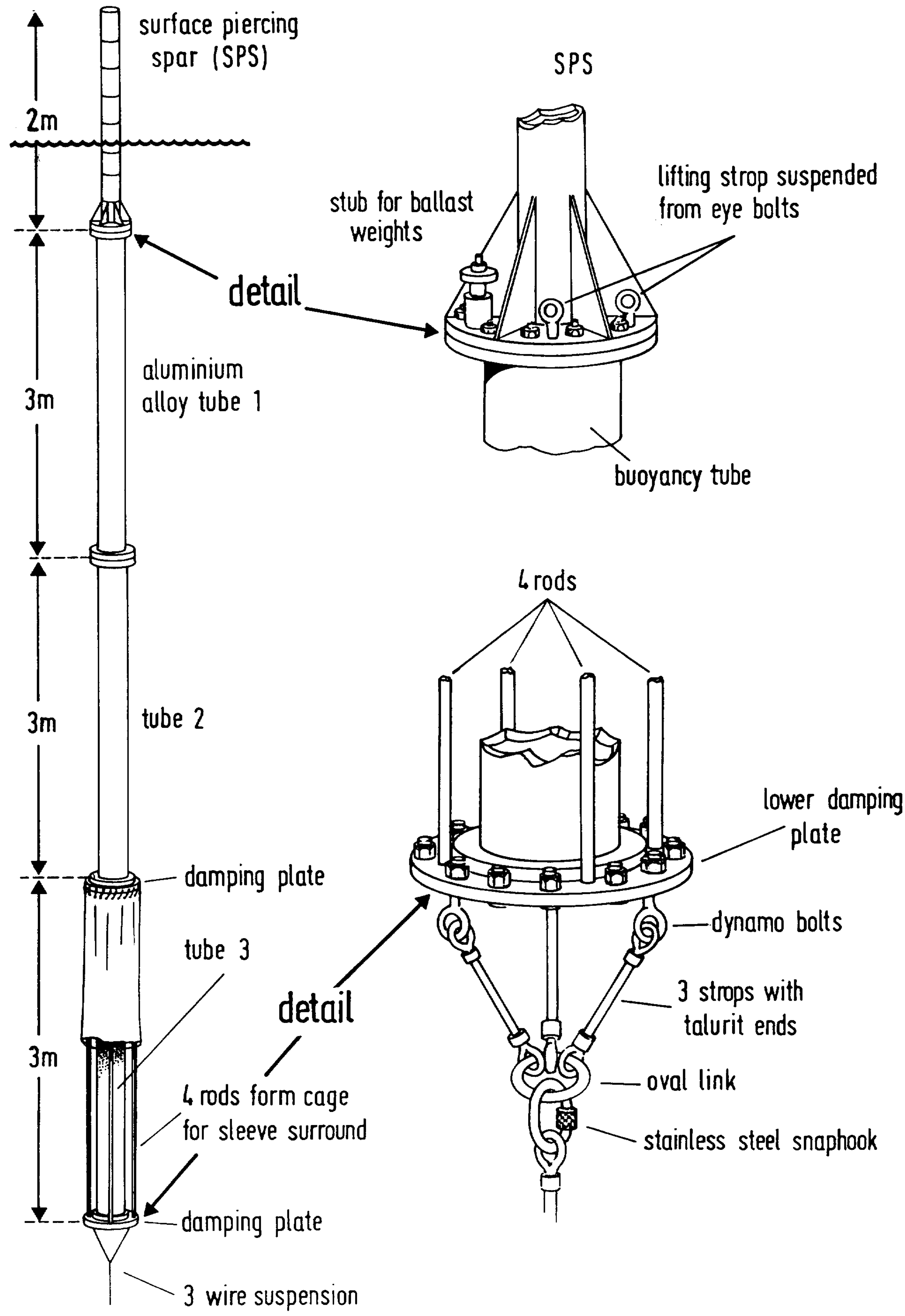


Fig. 1-1:50 scale drawing of spar buoy

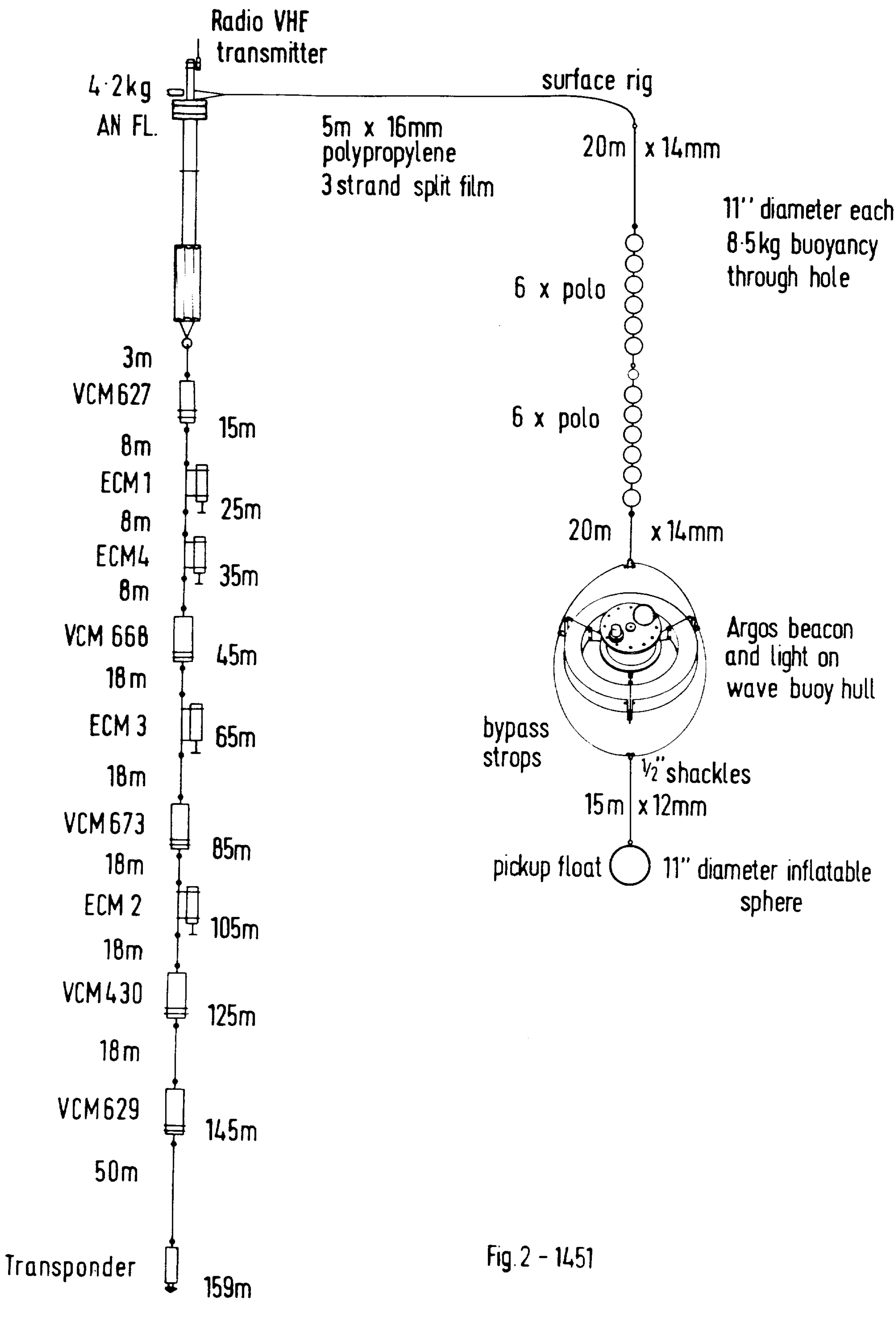

Radio VHF
transmitter
4·2kg
AN FL.
surface rig
5m x 16mm
polypropylene
3strand split film
20m x 14mm
11'' diameter each
8·5kg buoyancy
through hole
6 x polo
6 x polo
20m x 14mm
Argos beacon
and light on
wave buoy hull
bypass
strops
½'' shackles
15m x 12mm
pickup float
11'' diameter inflatable
sphere
3m
VCM627
15m
8m
ECM1
25m
8m
ECM4
35m
8m
VCM 668
45m
18m
ECM 3
65m
18m
VCM673
85m
18m
ECM 2
105m
18m
VCM430
125m
18m
VCM629
145m
50m
Transponder
159m

Fig. 2 - 1451

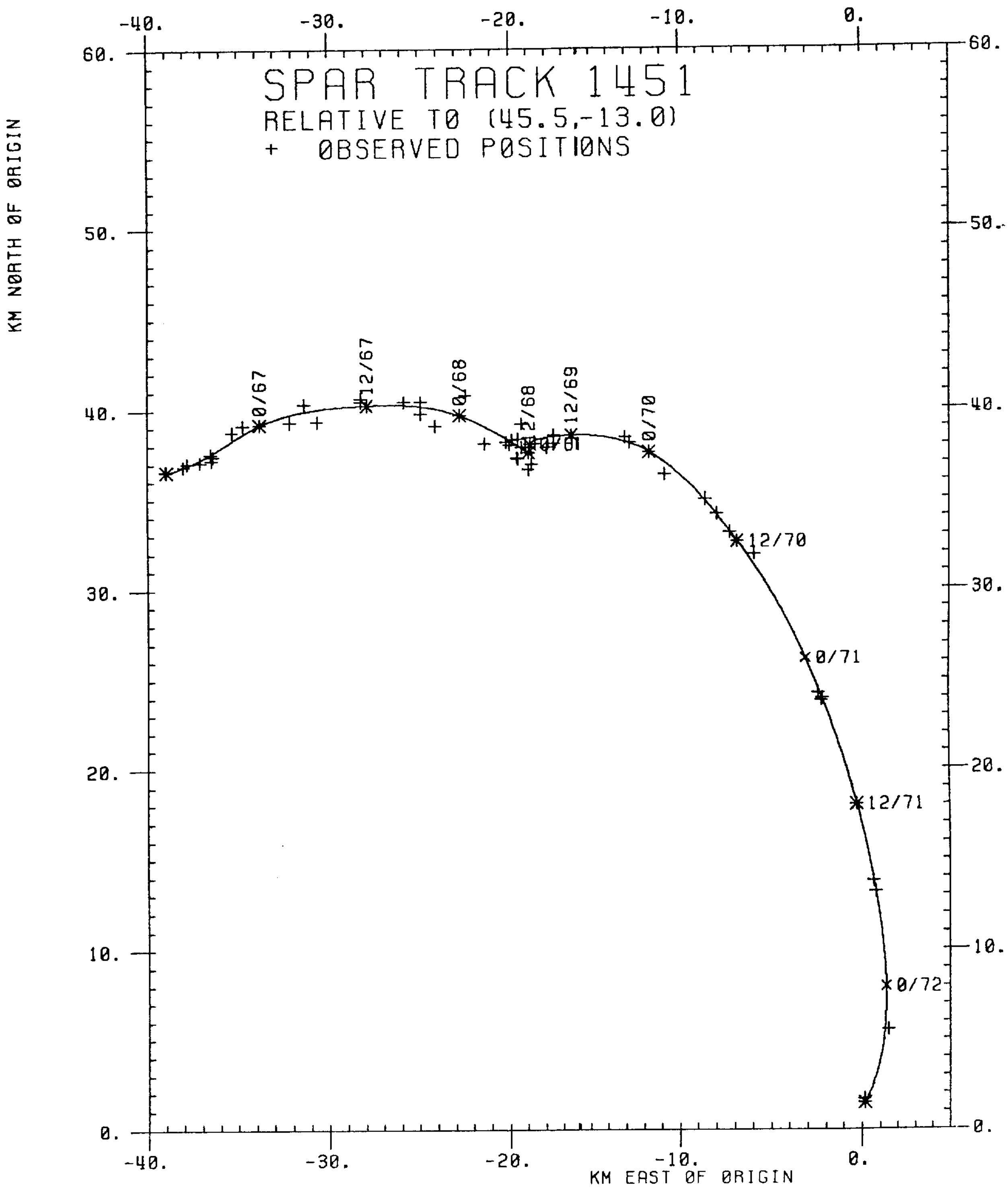

SPAR TRACK 1451
RELATIVE TO (45.5,-13.0)
+ OBSERVED POSITIONS
KM NORTH OF ORIGIN
KM EAST OF ORIGIN
-40.
-30.
-20.
-10.
0.
60.
50.
40.
30.
20.
10.
0.
0/67
12/67
0/68
12/68
12/69
0/70
12/70
0/71
12/71
0/72

Fig. 3.1

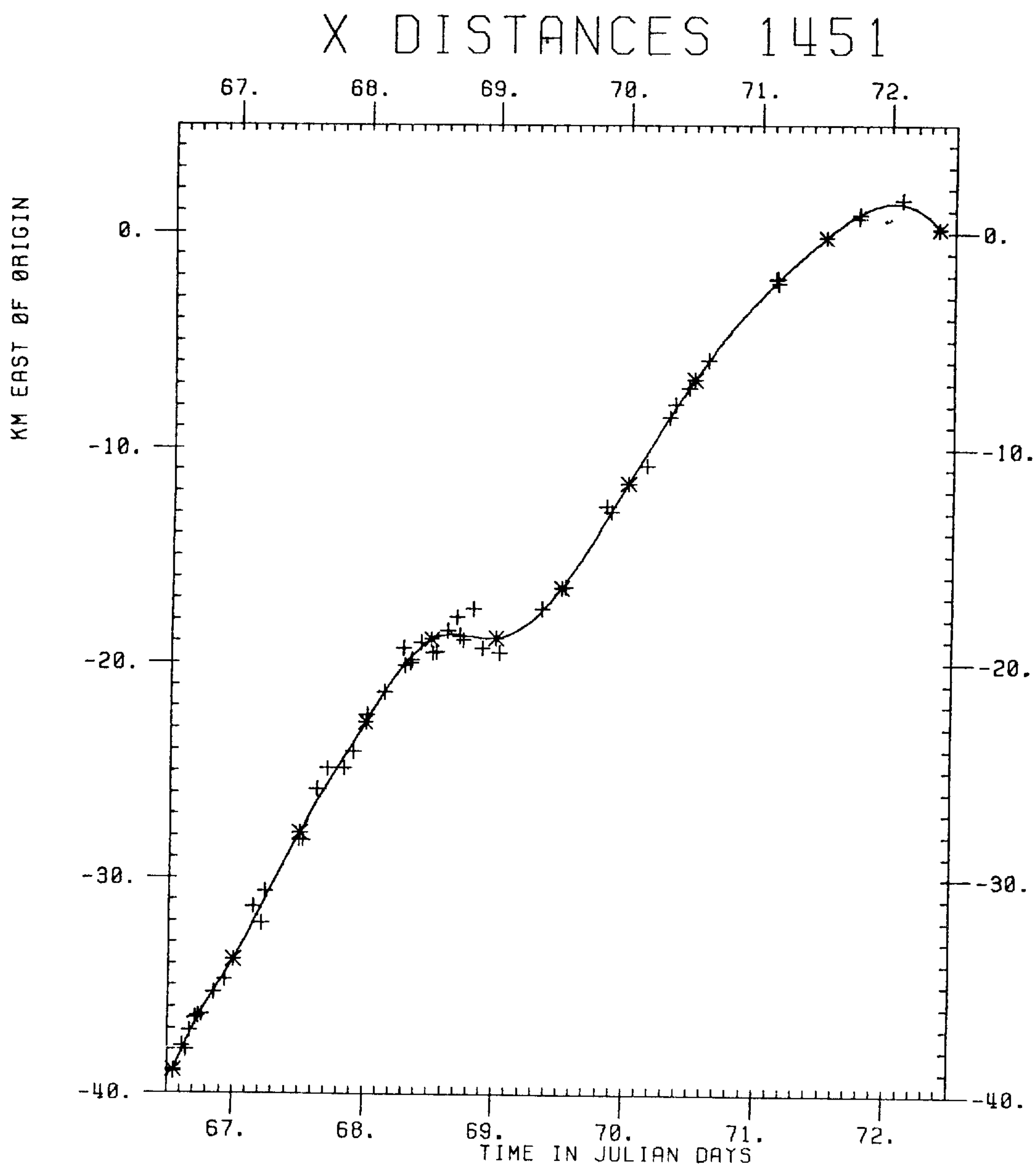

X DISTANCES 1451
67.
68.
69.
70.
71.
72.
KM EAST ØF ØRIGIN
0.
-10.
-20.
-30.
-40.
TIME IN JULIAN DAYS

Fig. 3.2

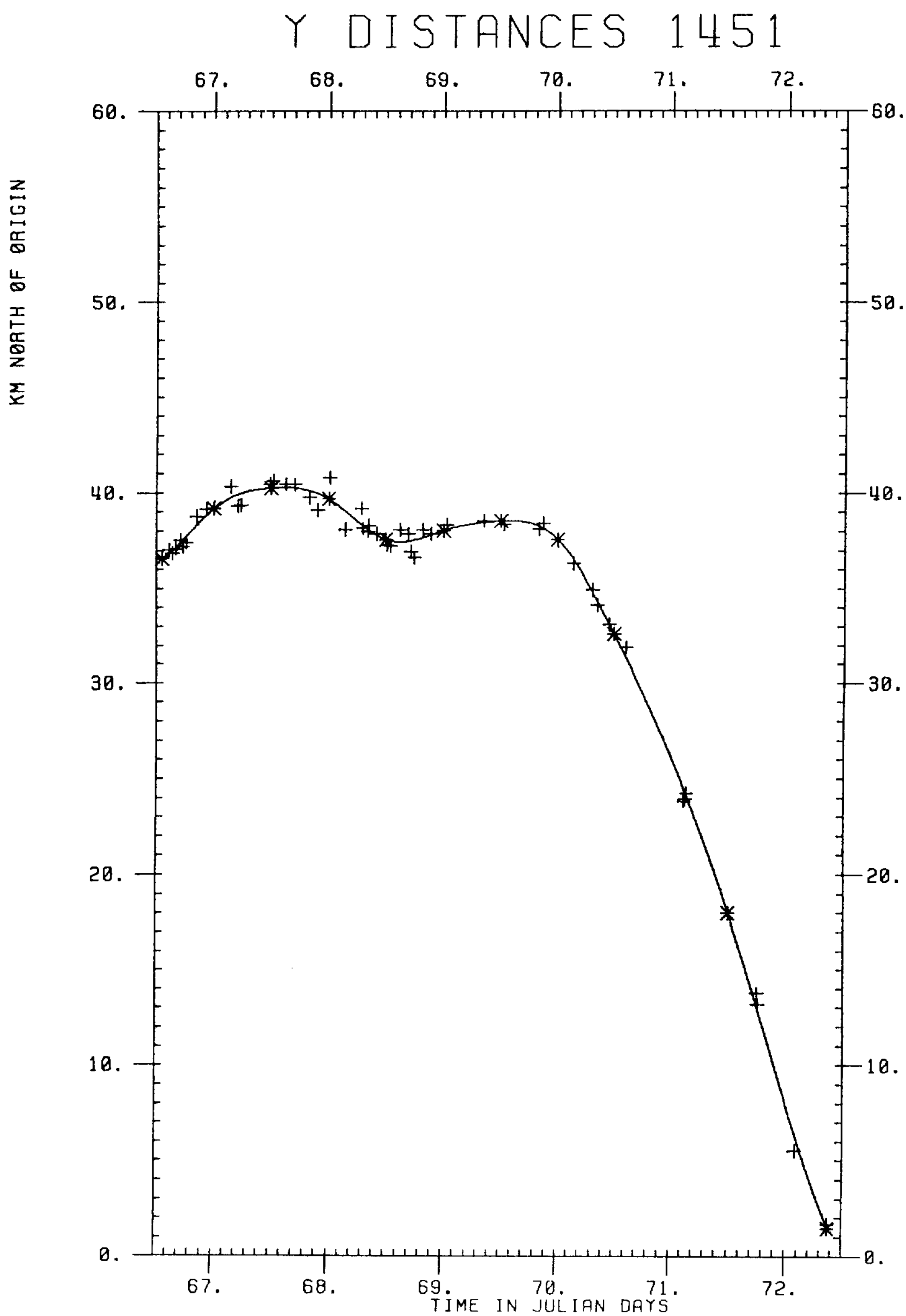
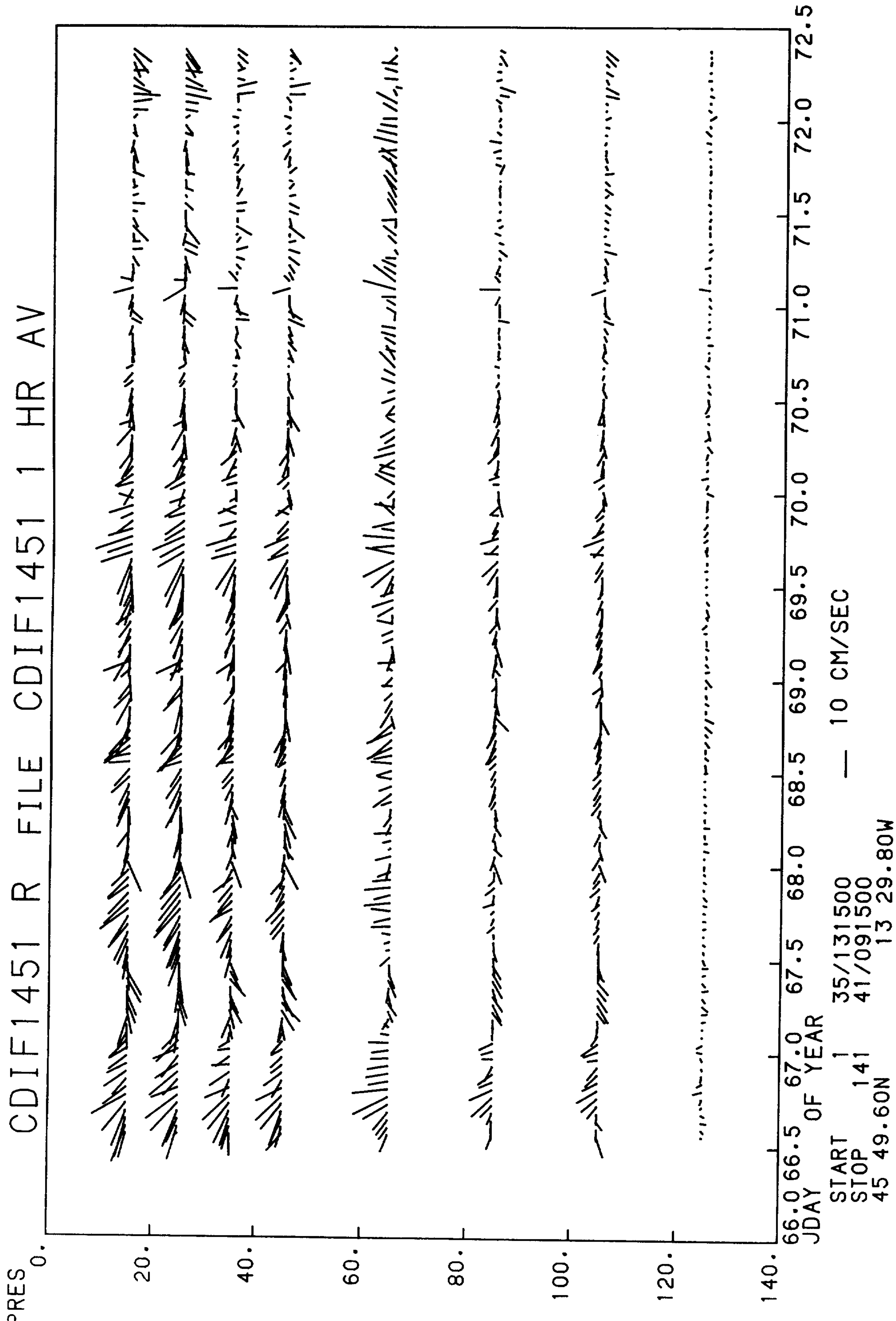

Y DISTANCES 1451
67.
68.
69.
70.
71.
72.
60.
50.
40.
30.
20.
10.
0.
KM NØRTH ØF ØRIGIN
TIME IN JULIAN DAYS

Fig. 3.3


CDIF1451 R FILE CDIF1451 1 HR AV
PRES
0.
20.
40.
60.
80.
100.
120.
140.
66.0 66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
10 CM/SEC
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STOP 141 41/091500
45 49.60N 13 29.80W

Fig. 4

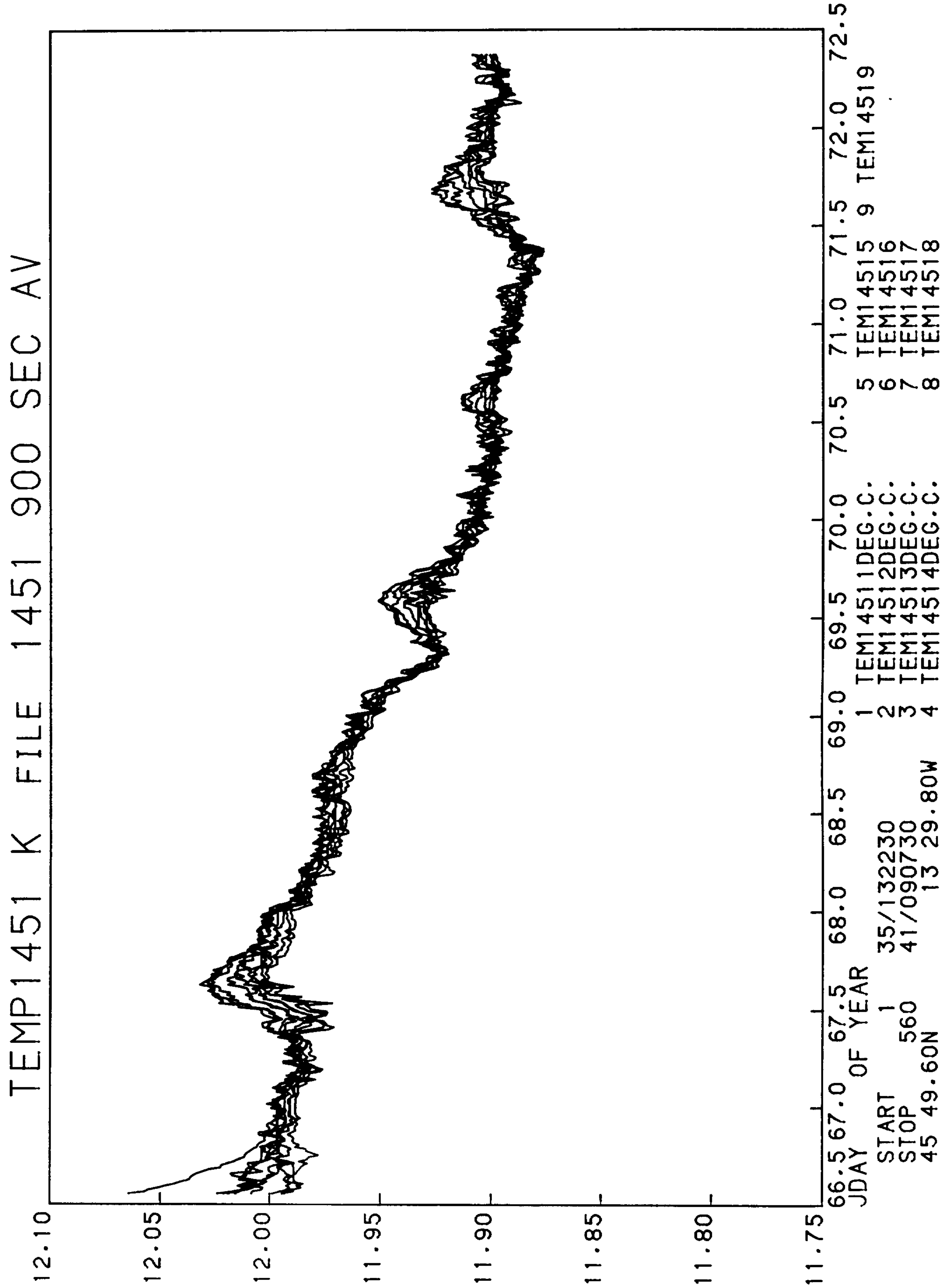
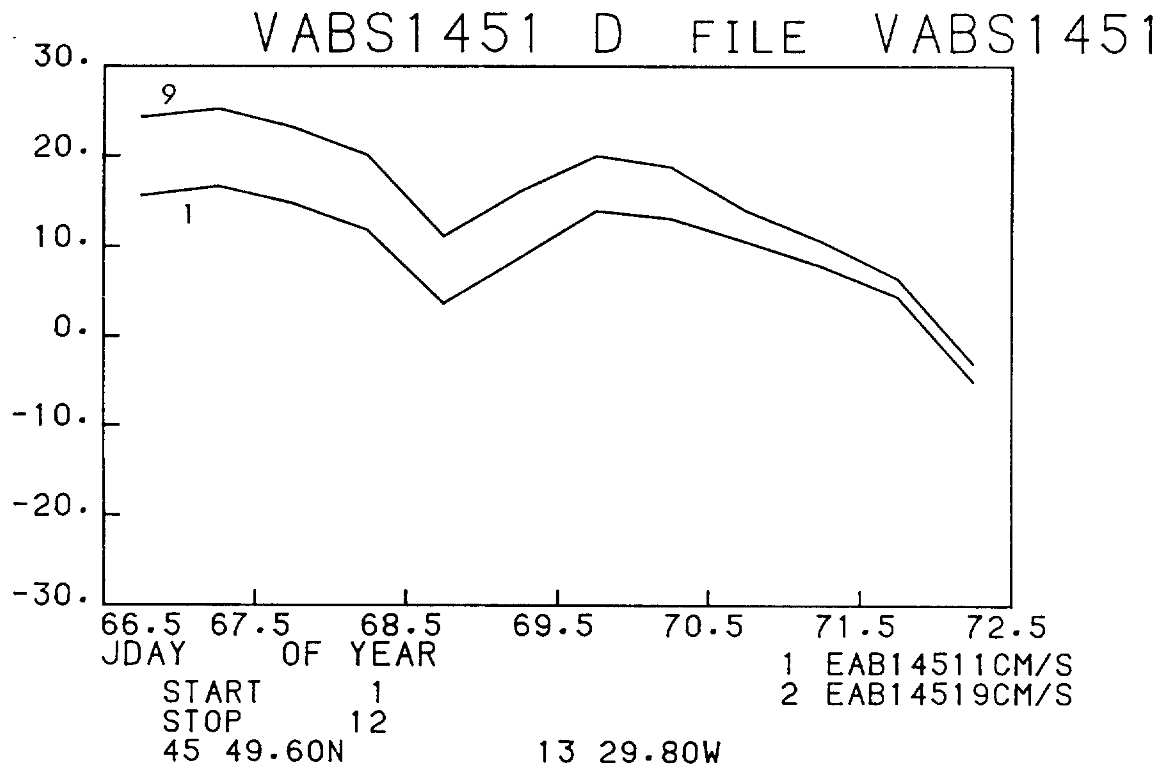

TEMP1451 K FILE 1451 900 SEC AV
12.10
12.05
12.00
11.95
11.90
11.85
11.80
11.75
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 TEM14511DEG.C.
2 TEM14512DEG.C.
3 TEM14513DEG.C.
4 TEM14514DEG.C.
5 TEM14515
6 TEM14516
7 TEM14517
8 TEM14518
9 TEM14519

Fig. 5


VABS1451 D FILE VABS1451
30.
20.
10.
0.
-10.
-20.
-30.
9
1
66.5 67.5 68.5 69.5 70.5 71.5 72.5
JDAY OF YEAR
START 1
STOP 12
45 49.60N 13 29.80W
1 EAB14511CM/S
2 EAB14519CM/S

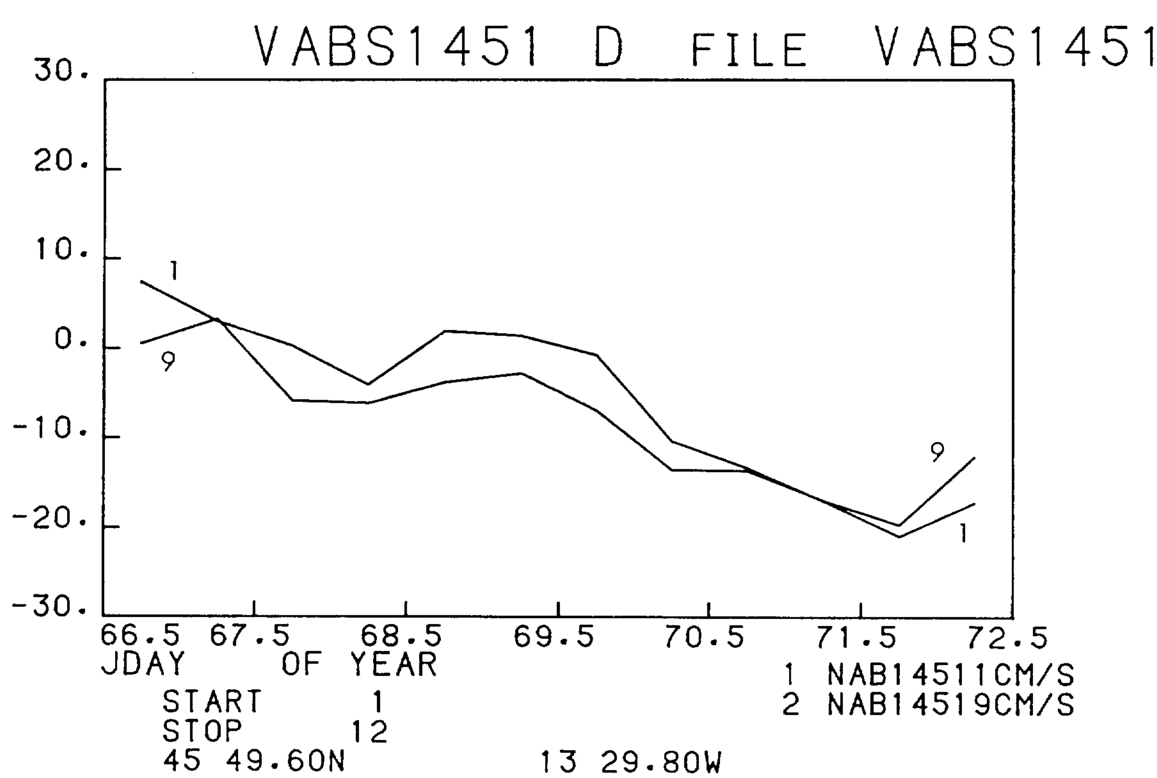

VABS1451 D FILE VABS1451
30.
20.
10.
0.
-10.
-20.
-30.
1
9
9
1
66.5 67.5 68.5 69.5 70.5 71.5 72.5
JDAY OF YEAR
START 1
STOP 12
45 49.60N 13 29.80W
1 NAB14511CM/S
2 NAB14519CM/S

Fig. 6

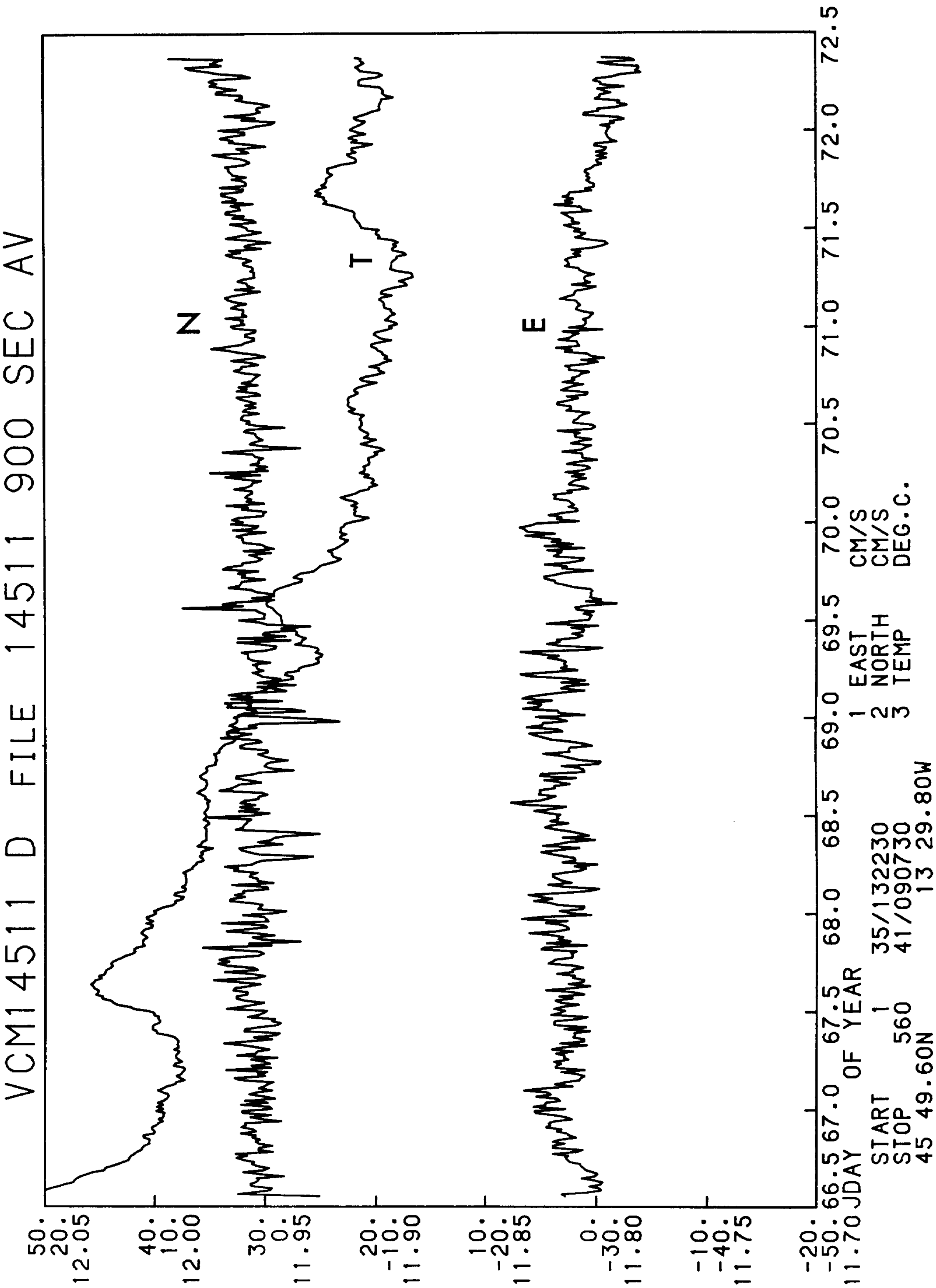
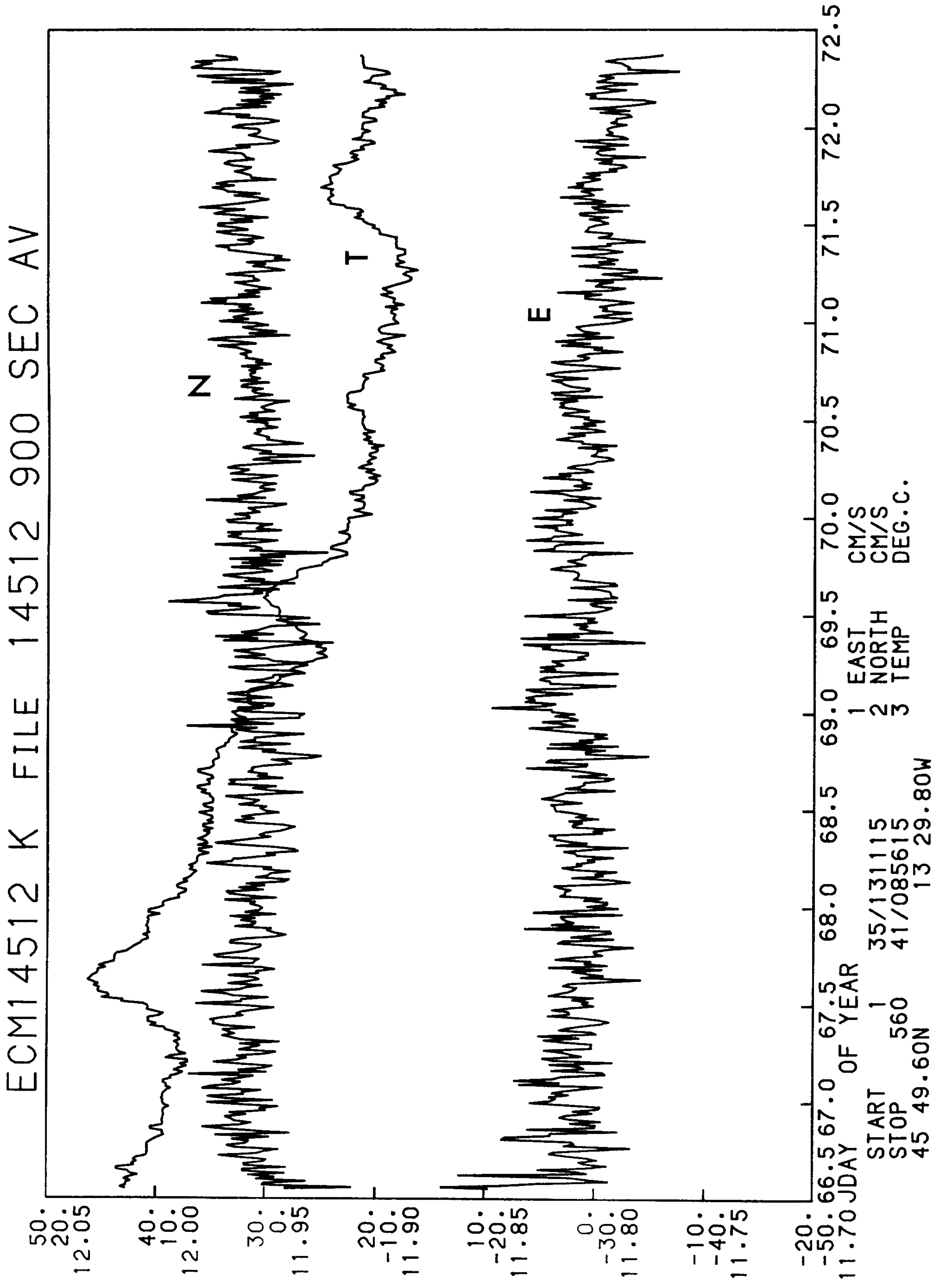
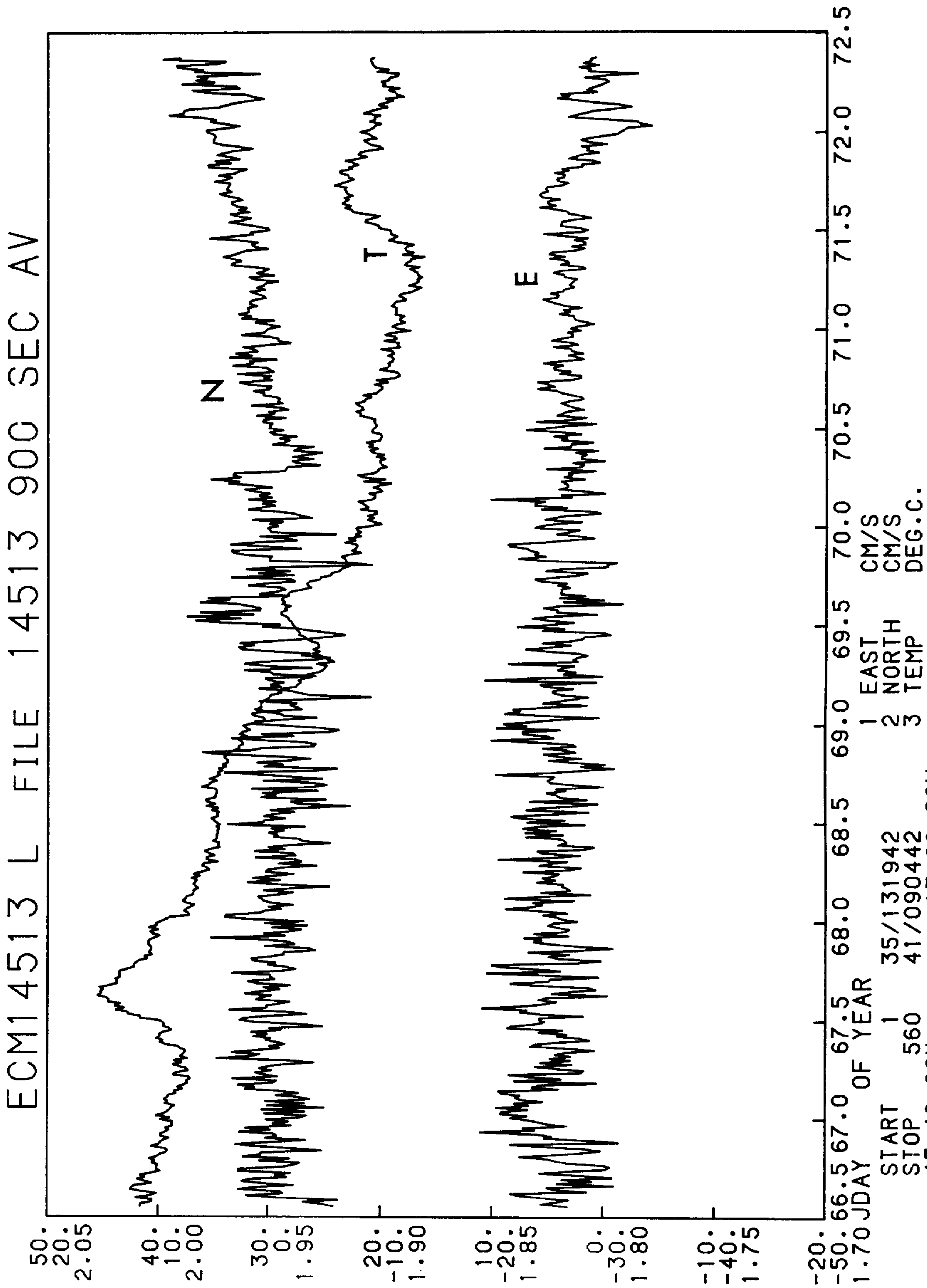

VCM14511 D FILE 14511 900 SEC AV
N
T
E
JDAY OF YEAR
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
50. 20. 12.05
40. 10. 12.00
30. 0. 11.95
20. -10. 11.90
10. -20. 11.85
0. -30. 11.80
-10. -40. 11.75
-20. -50. 11.70

Fig. 7.1



ECM14512 K FILE 14512 900 SEC AV
N
T
E
JDAY OF YEAR
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
START 1 35/131115
STOP 560 41/085615
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 7.2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N
T
E
JDAY OF YEAR
START 1 35/131942
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1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 7.3

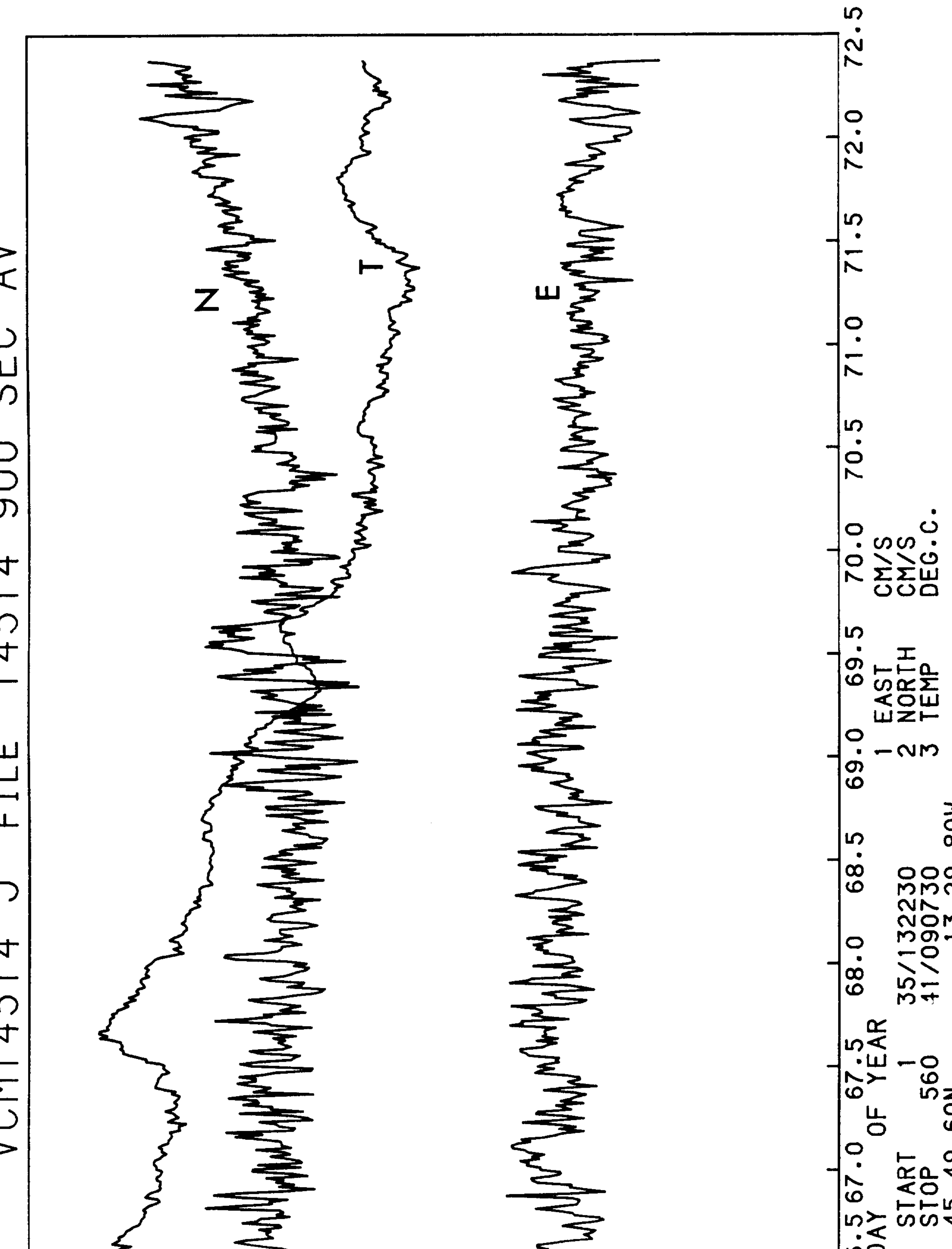
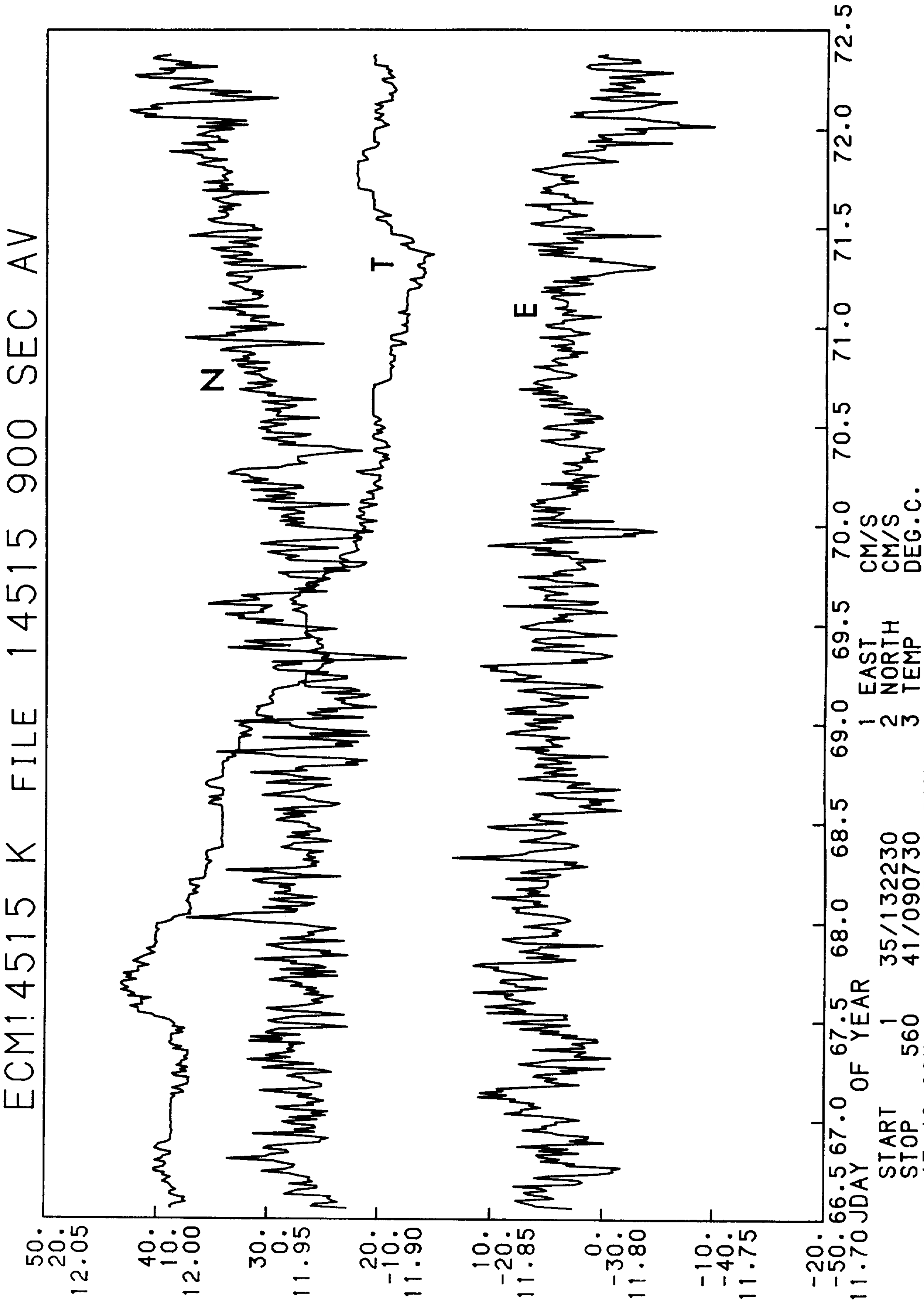

VCM14514 J FILE 14514 900 SEC AV
N
T
E
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
50. 20. 12.05
40. 10. 12.00
30. 0. 11.95
20. -10. 11.90
10. -20. 11.85
0. -30. 11.80
-10. -40. 11.75
-20. -50. 11.70

Fig. 7.4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N
T
E
JDAY OF YEAR
1 EAST CM/S
2 NORTH CM/S
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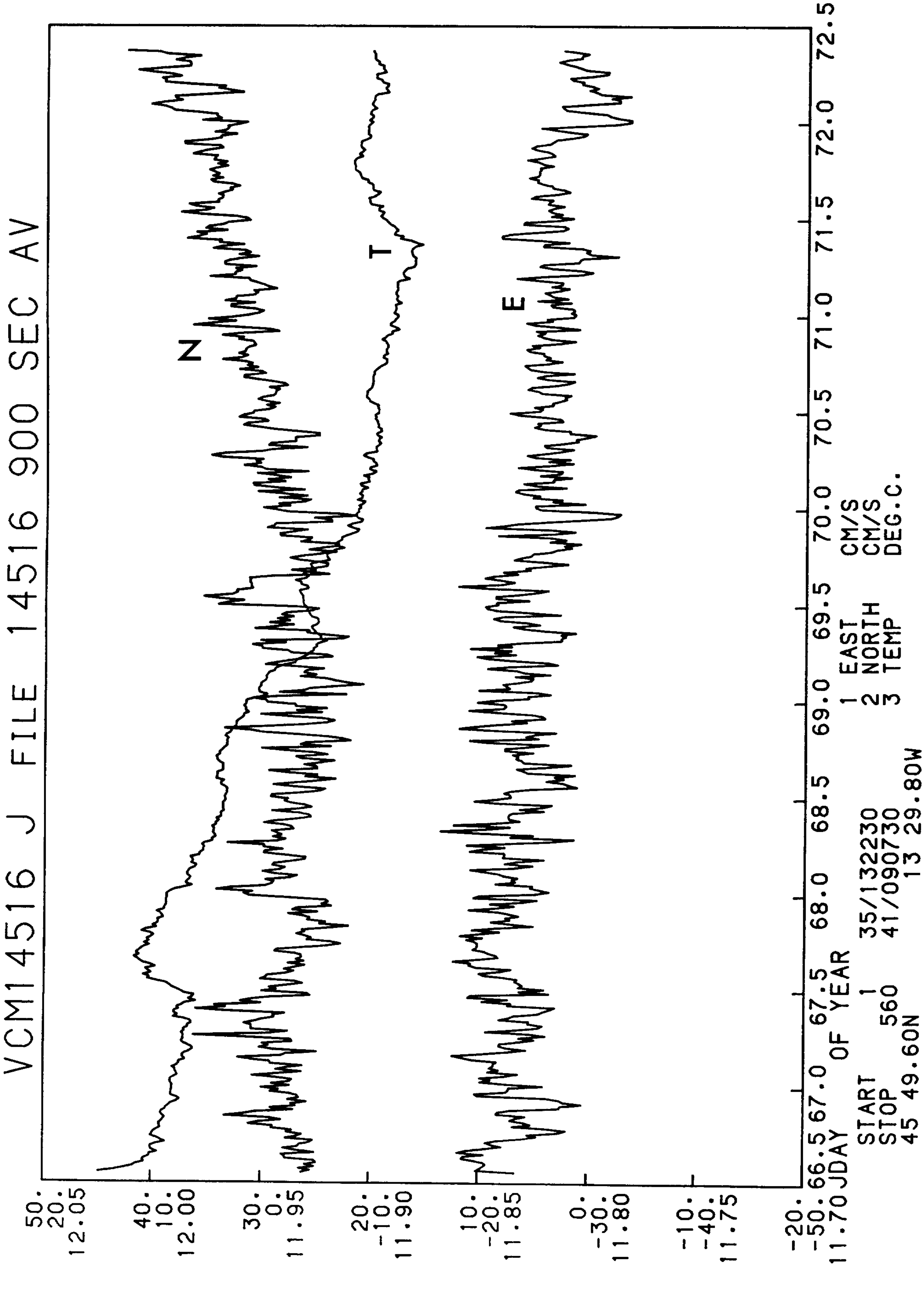
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W

Fig. 7.5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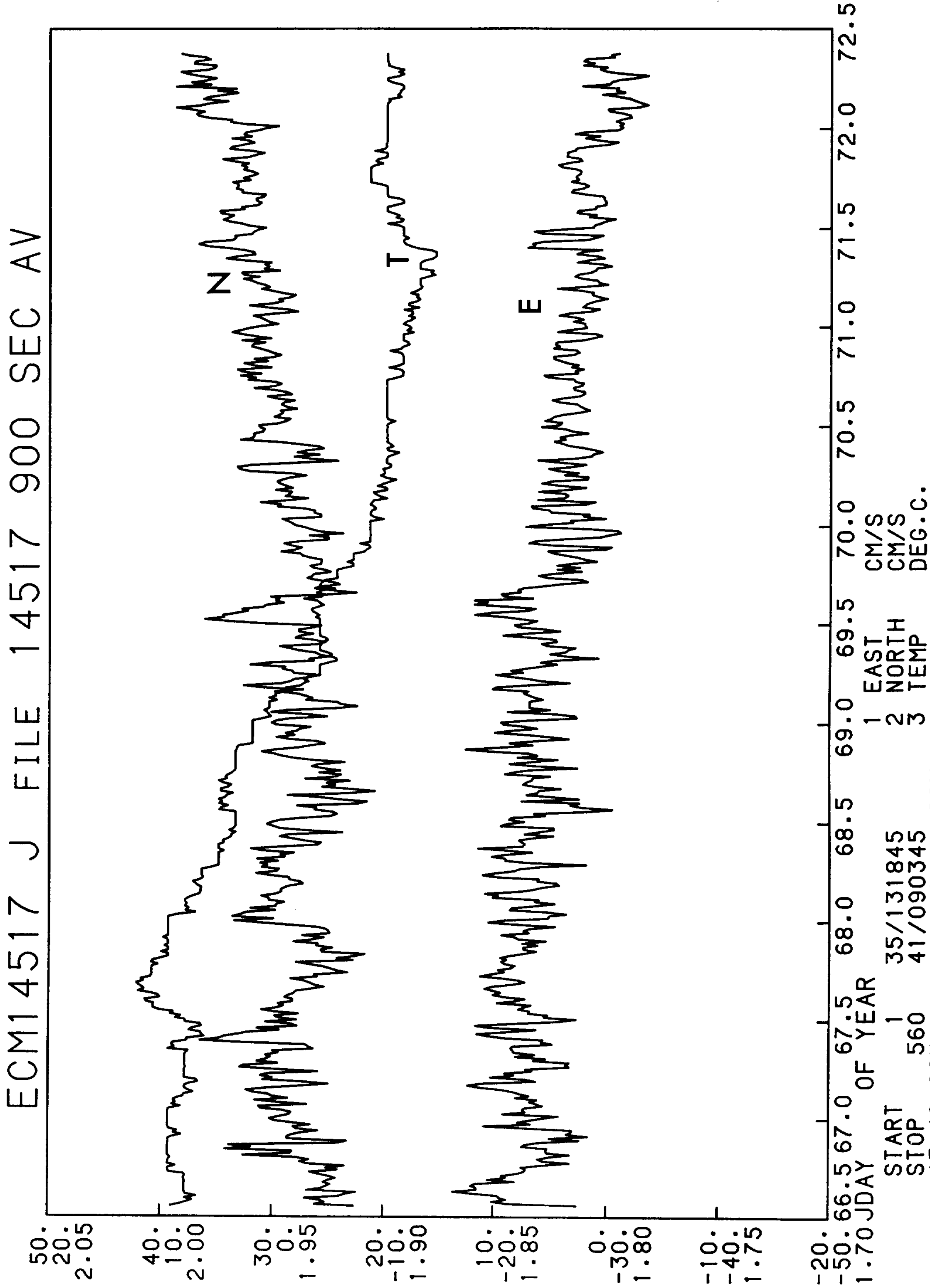
N
T
E
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 7.6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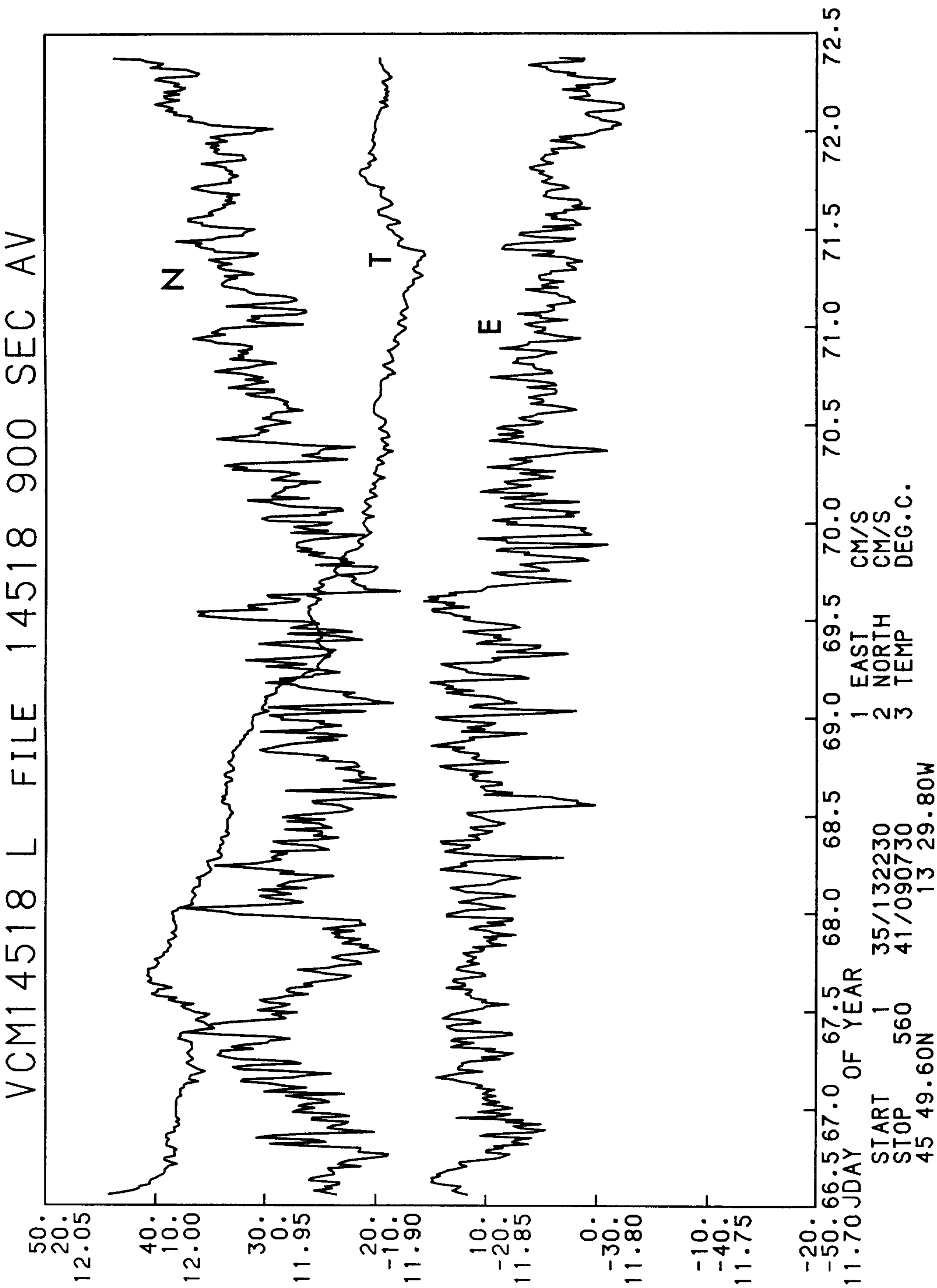
N
T
E
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/131845
STOP 560 41/090345
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
50. 20. 12.05
40. 10. 12.00
30. 0. 11.95
20. -10. 11.90
10. -20. 11.85
0. -30. 11.80
-10. -40. 11.75
-20. -50. 11.70

Fig. 7.7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N
T
E
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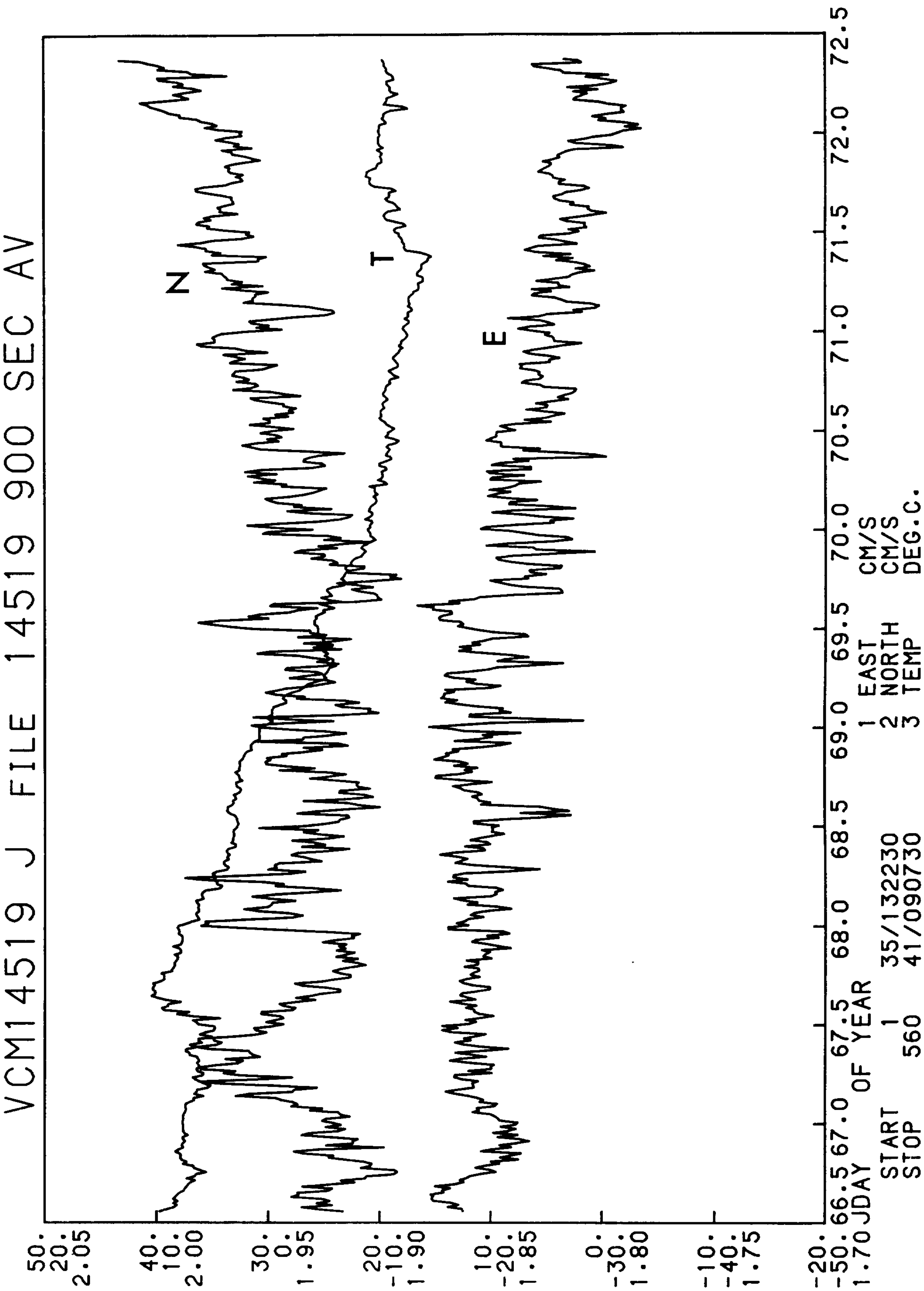
40. 10. 12.00
30. 0. 11.95
20. -10. 11.90
10. -20. 11.85
0. -30. 11.80
-10. -40. 11.75
-20. -50. 11.70
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 7.8



VCM14519 J FILE 14519 900 SEC AV
N
T
E
50. 20. 12.05
40. 10. 12.00
30. 0. 11.95
20. -10. 11.90
10. -20. 11.85
0. -30. 11.80
-10. -40. 11.75
-20. -50. 11.70
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 7.9

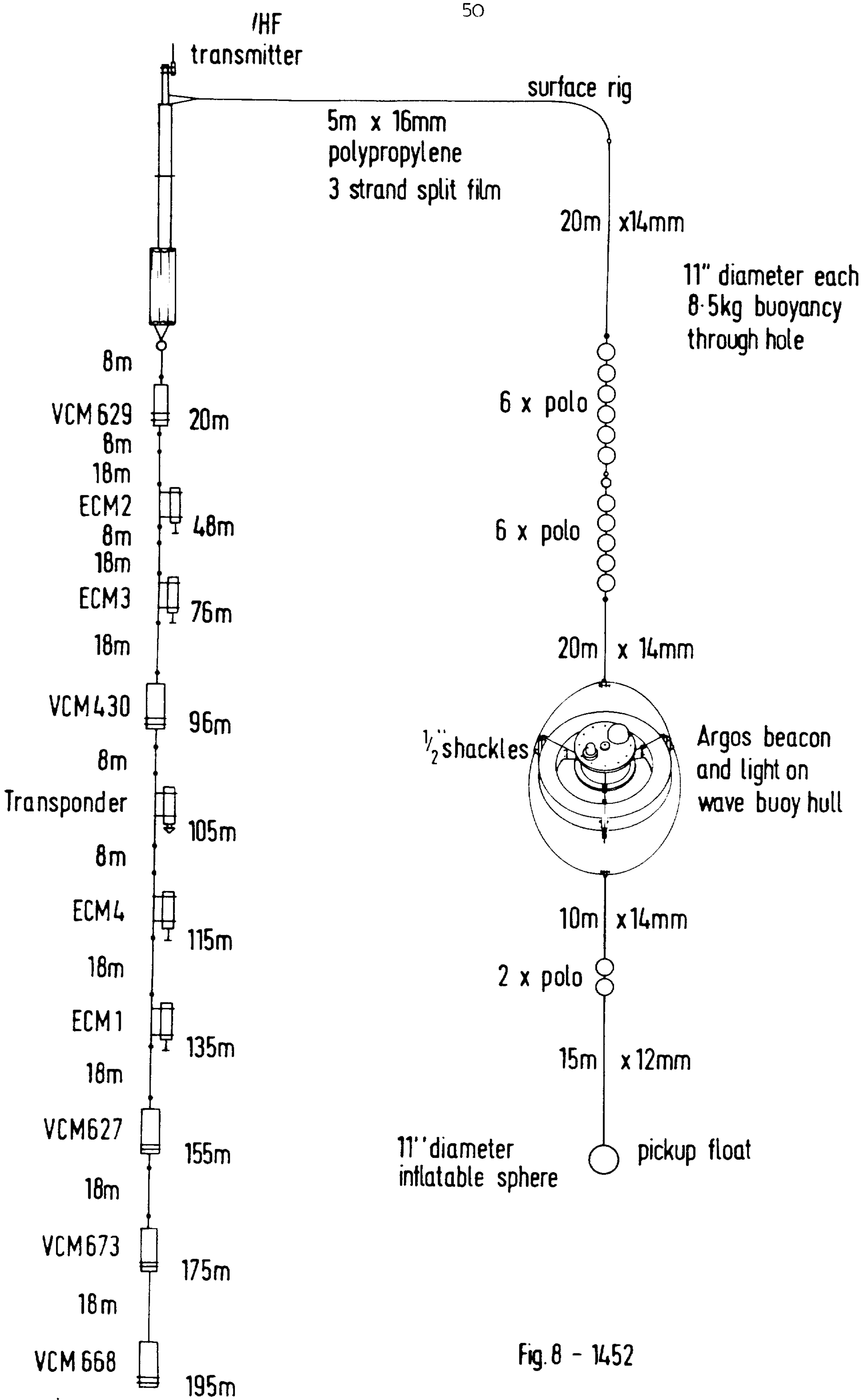

HF transmitter
surface rig
5m x 16mm polypropylene
3 strand split film
20m x14mm
11" diameter each
8·5kg buoyancy
through hole
6 x polo
6 x polo
20m x 14mm
½" shackles
Argos beacon and light on wave buoy hull
10m x14mm
2 x polo
15m x 12mm
11" diameter inflatable sphere
pickup float
8m
VCM 629
20m
8m
18m
ECM2
48m
8m
18m
ECM3
76m
18m
VCM430
96m
8m
Transponder
105m
8m
ECM4
115m
18m
ECM1
135m
18m
VCM627
155m
18m
VCM673
175m
18m
VCM 668
195m

Fig. 8 - 1452

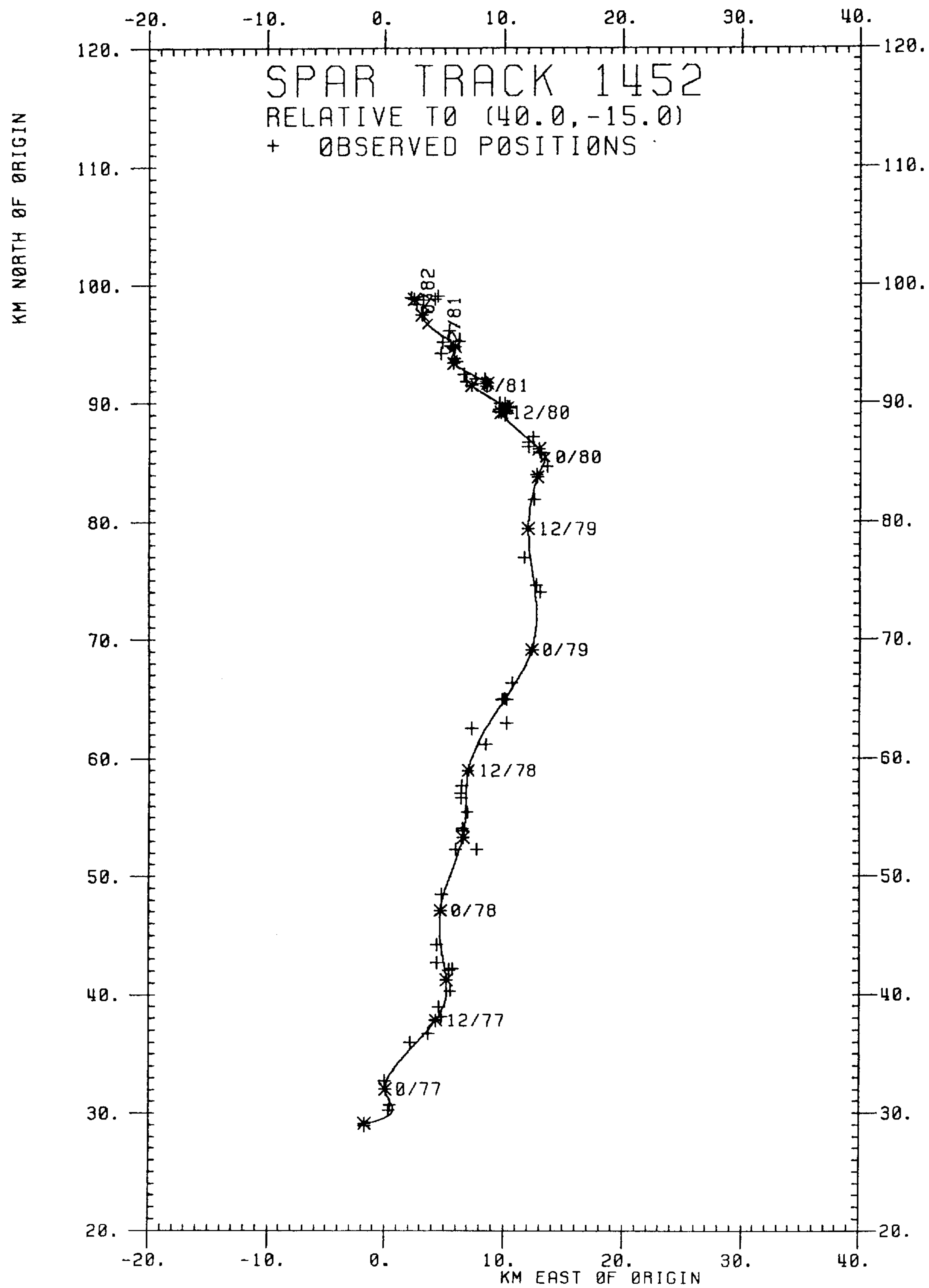

SPAR TRACK 1452
RELATIVE TO (40.0,-15.0)
+ OBSERVED POSITIONS
KM NORTH OF ORIGIN
KM EAST OF ORIGIN
-20.
-10.
0.
10.
20.
30.
40.
120.
110.
100.
90.
80.
70.
60.
50.
40.
30.
20.
0/77
12/77
0/78
12/78
0/79
12/79
0/80
12/80
/81
/81
/82

Fig. 9.1

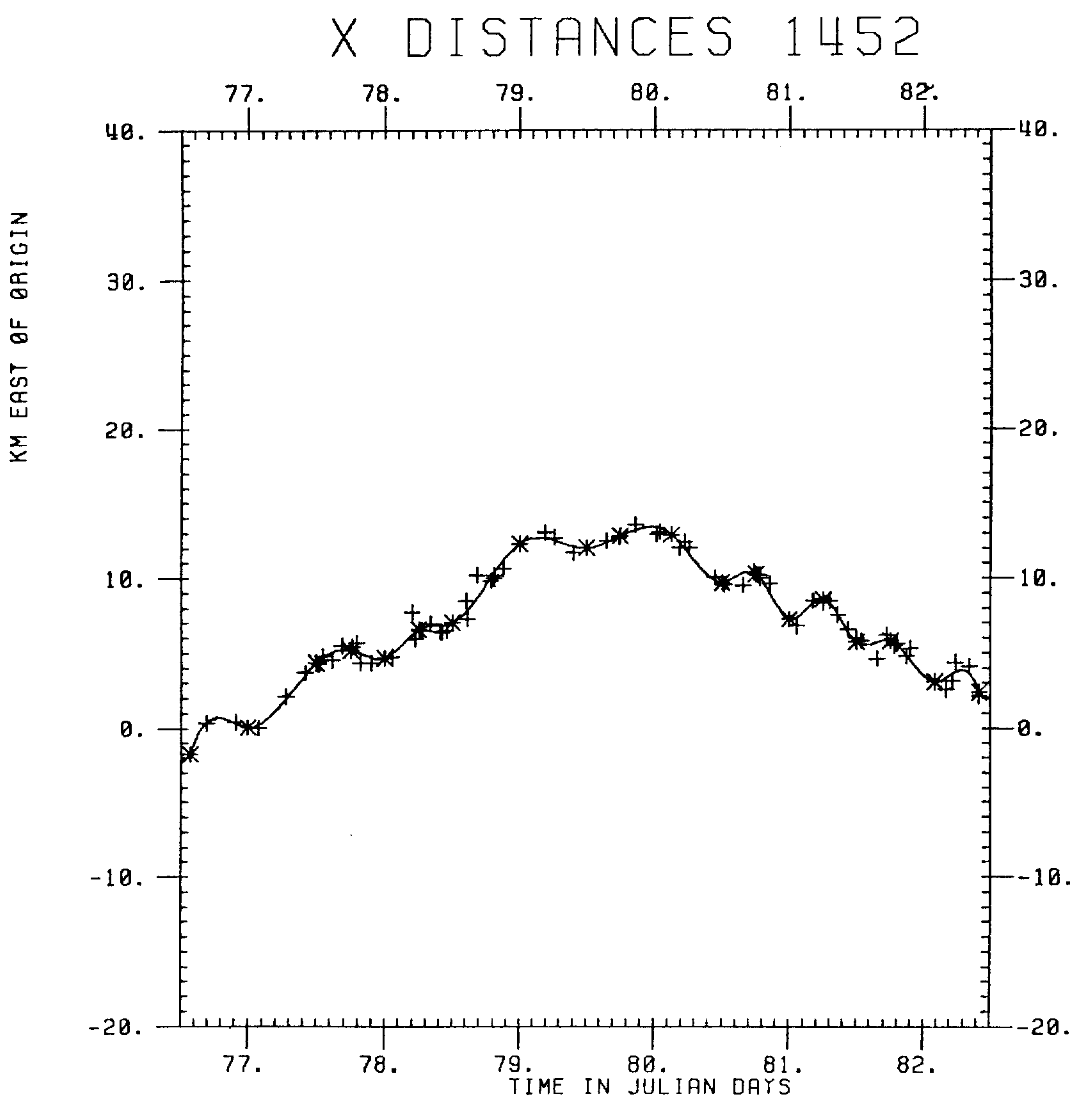

X DISTANCES 1452
77.
78.
79.
80.
81.
82.
40.
30.
20.
10.
0.
-10.
-20.
KM EAST OF ORIGIN
TIME IN JULIAN DAYS

Fig. 9.2

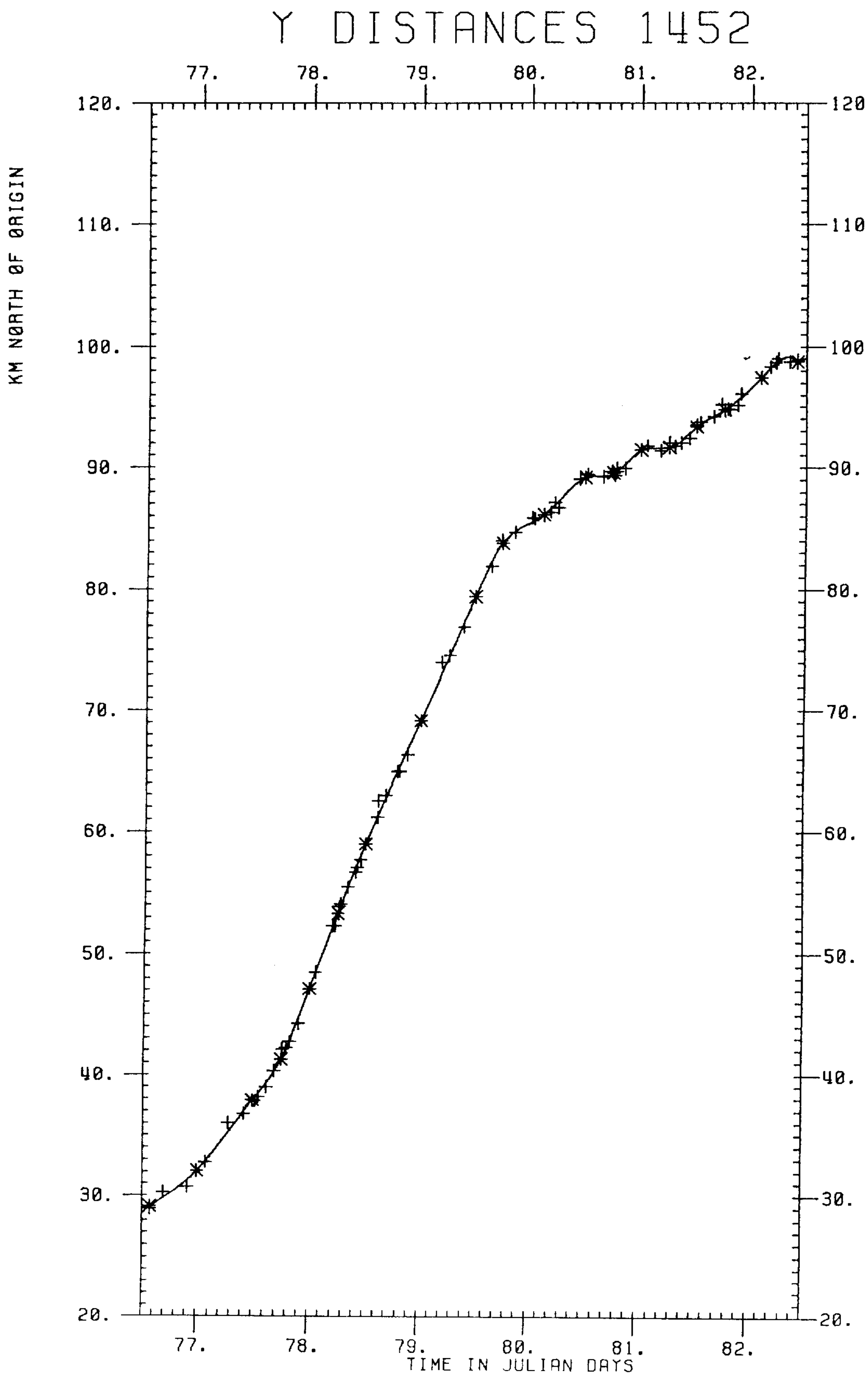

Y DISTANCES 1452
KM NORTH OF ORIGIN
TIME IN JULIAN DAYS
77.
78.
79.
80.
81.
82.
20.
30.
40.
50.
60.
70.
80.
90.
100.
110.
120.

Fig. 9.3

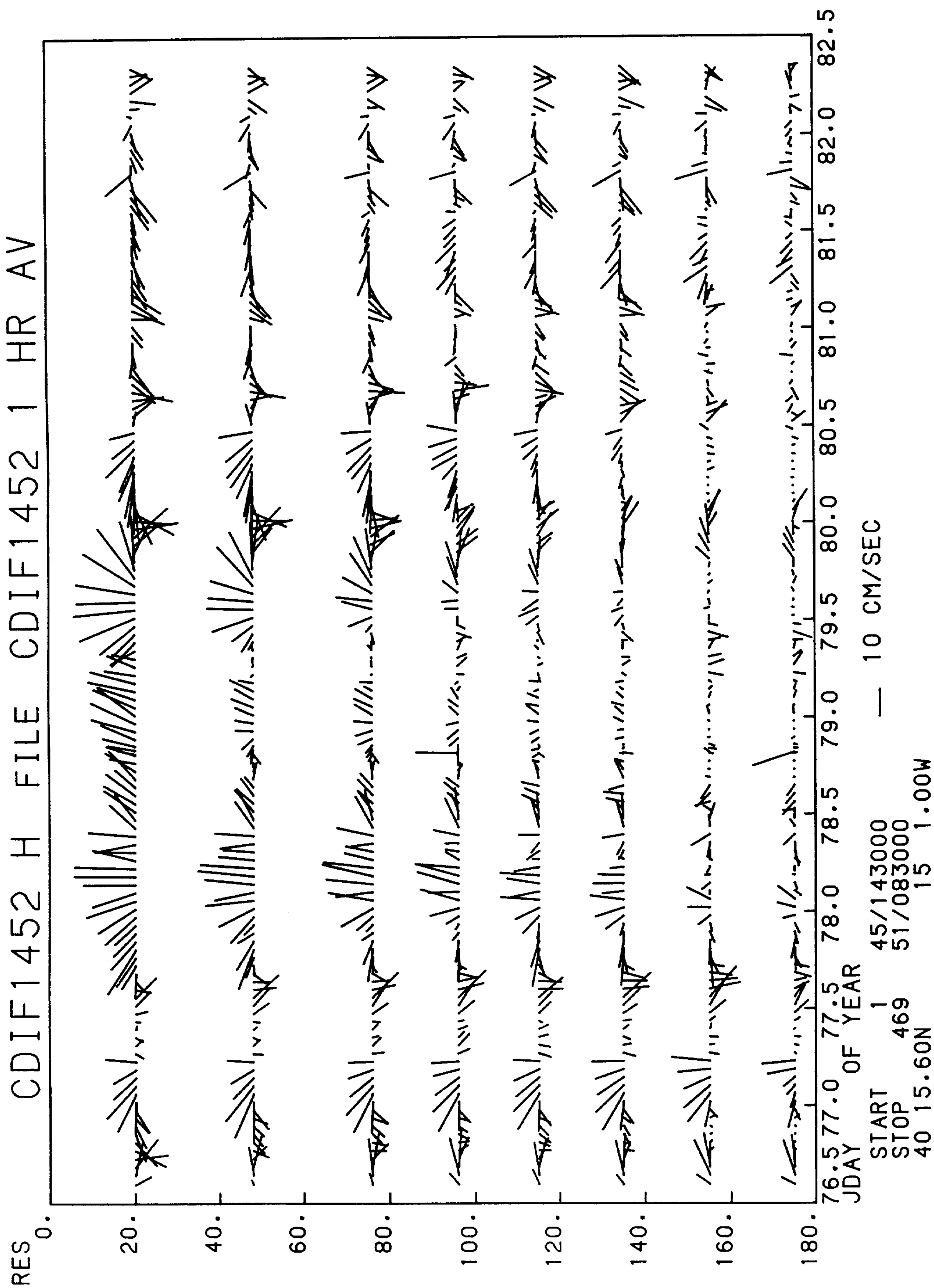

CDIF1452 H FILE CDIF1452 1 HR AV
PRES
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
— 10 CM/SEC
START 1 45/143000
STOP 469 51/083000
40 15.60N 15 1.00W

Fig. 10

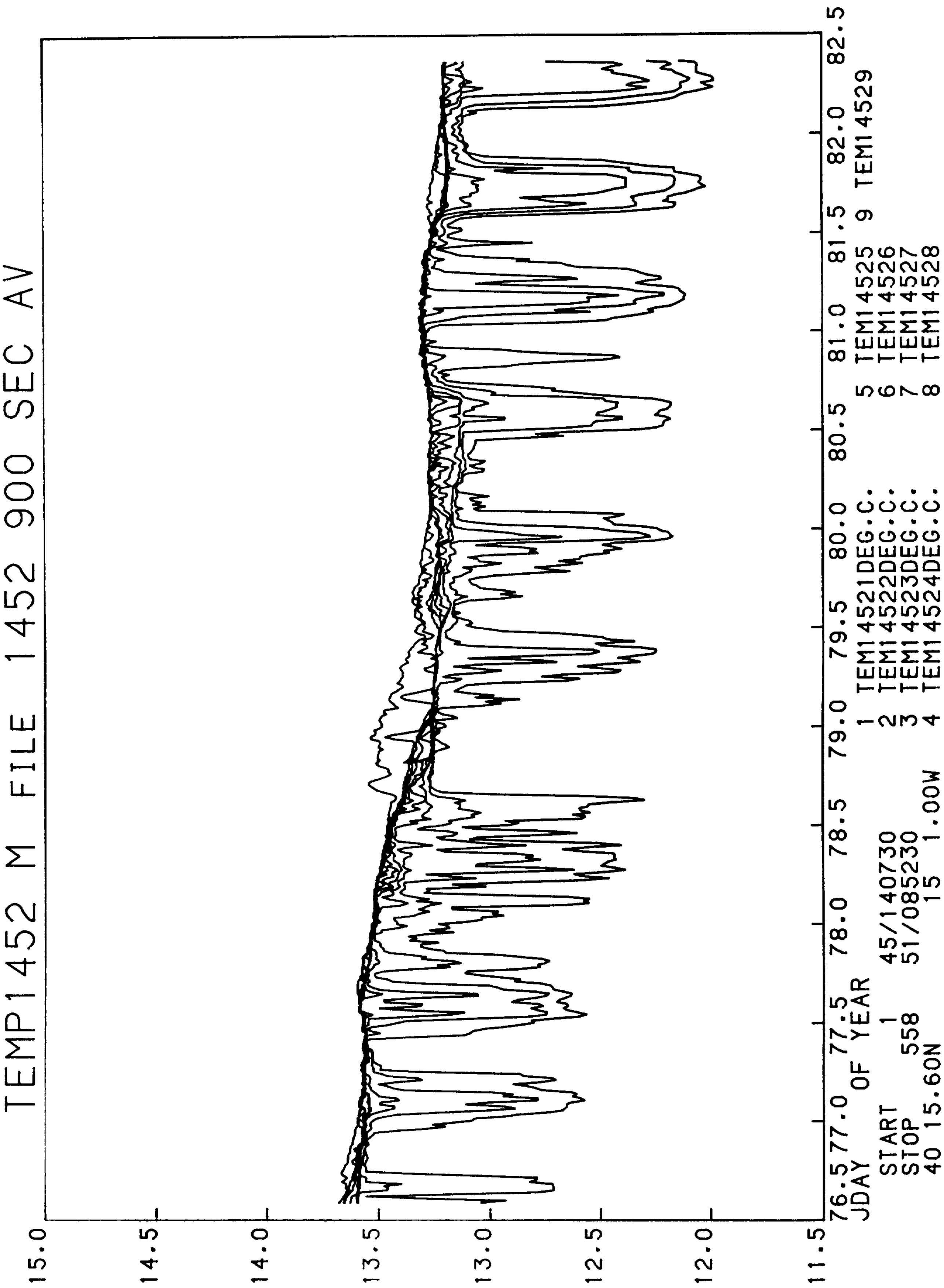
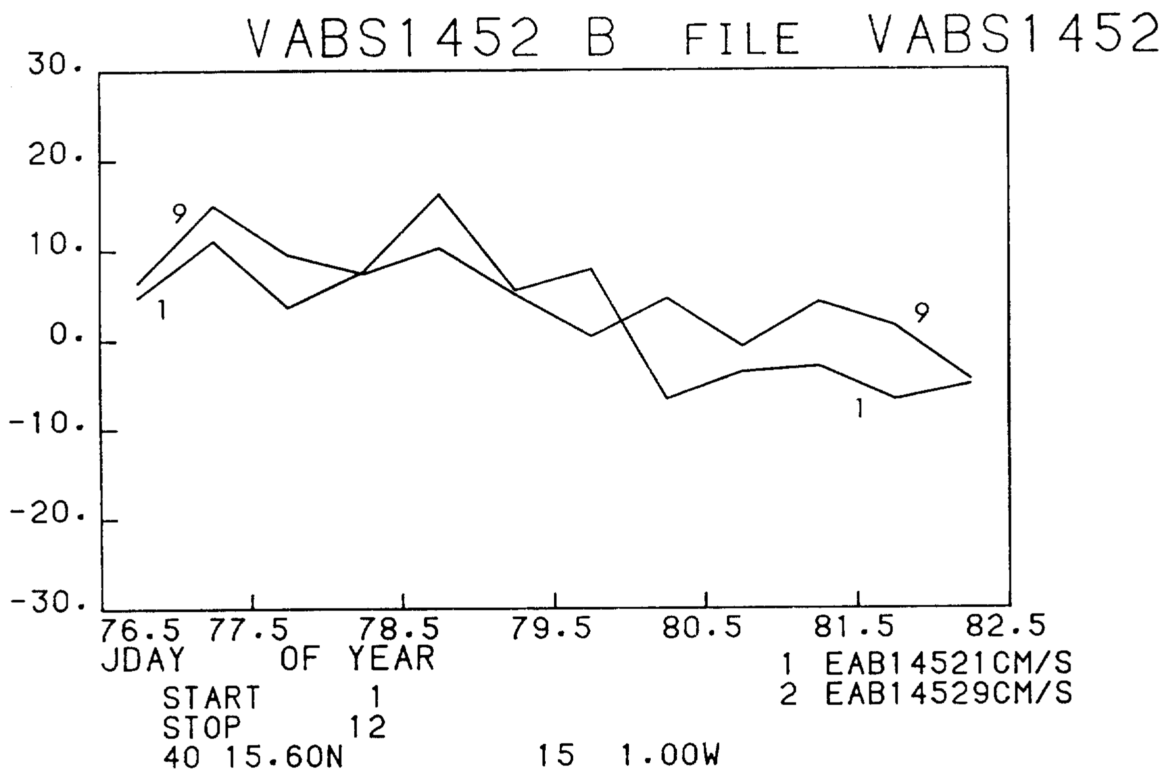

TEMP1452 M FILE 1452 900 SEC AV
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 558 51/085230
40 15.60N 15 1.00W
1 TEM14521DEG.C.
2 TEM14522DEG.C.
3 TEM14523DEG.C.
4 TEM14524DEG.C.
5 TEM14525
6 TEM14526
7 TEM14527
8 TEM14528
9 TEM14529

Fig. 11


VABS1452 B FILE VABS1452
30.
20.
10.
0.
-10.
-20.
-30.
9
1
76.5 77.5 78.5 79.5 80.5 81.5 82.5
JDAY OF YEAR
START 1
STOP 12
40 15.60N 15 1.00W
1 EAB14521CM/S
2 EAB14529CM/S

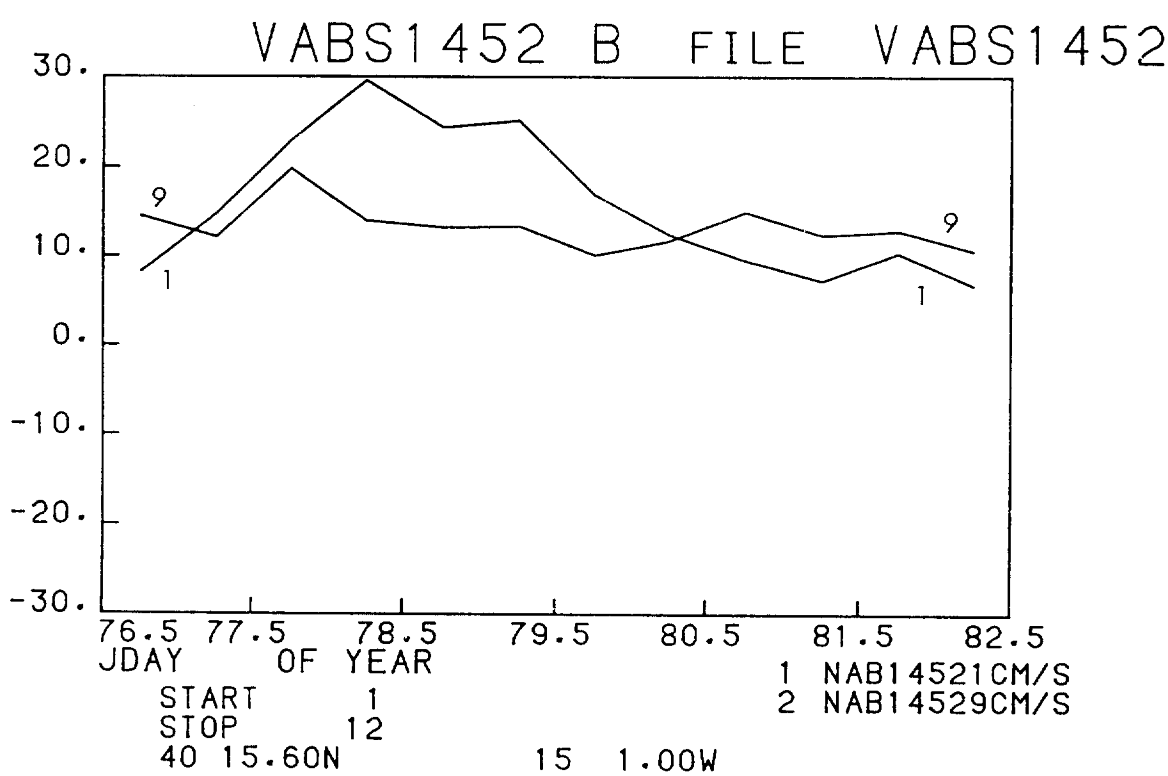

VABS1452 B FILE VABS1452
30.
20.
10.
0.
-10.
-20.
-30.
9
1
76.5 77.5 78.5 79.5 80.5 81.5 82.5
JDAY OF YEAR
START 1
STOP 12
40 15.60N 15 1.00W
1 NAB14521CM/S
2 NAB14529CM/S

Fig. 12

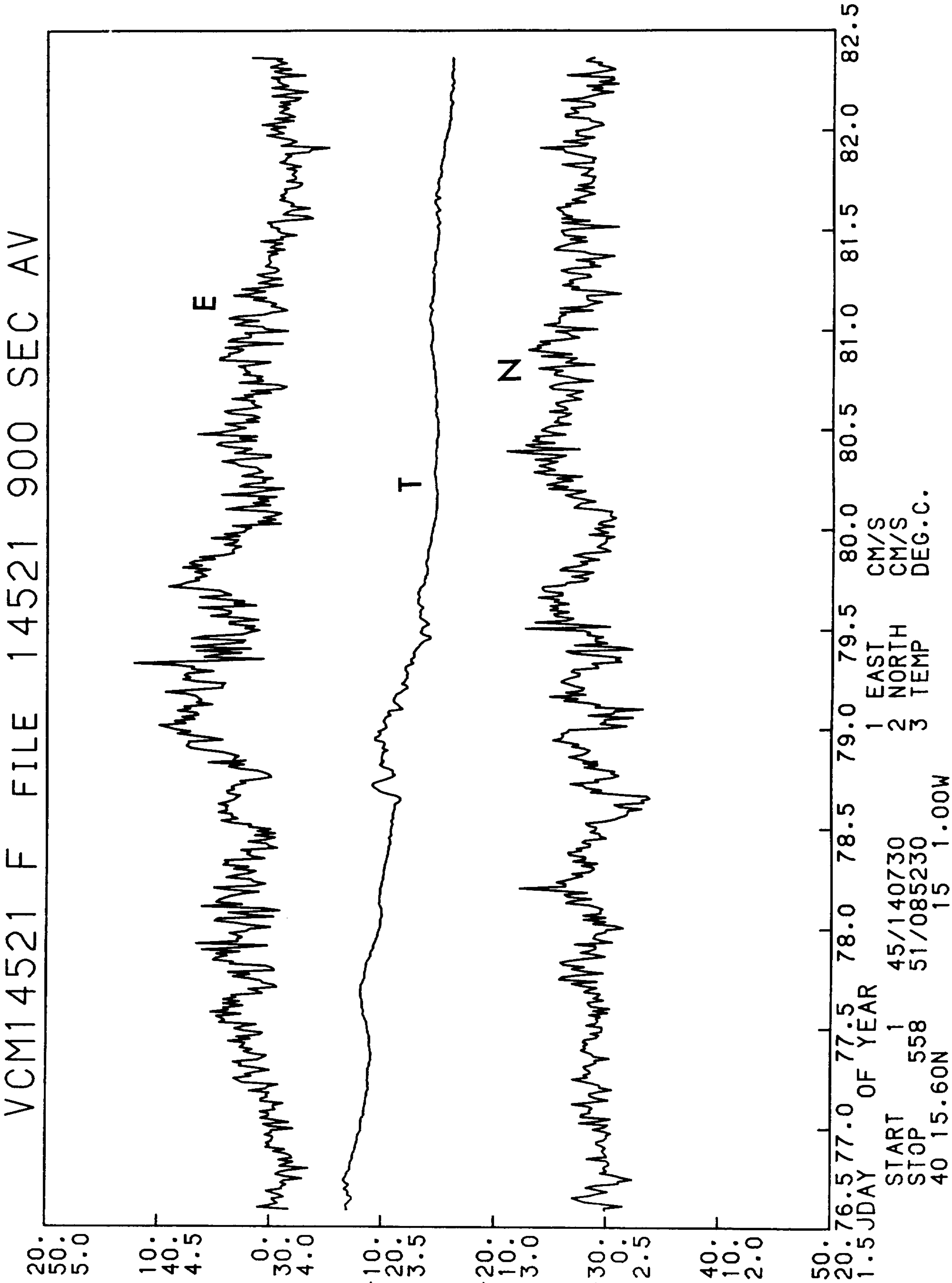

VCM14521 F FILE 14521 900 SEC AV
E
T
N
JDAY OF YEAR
START 1 45/140730
STOP 558 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 13.1

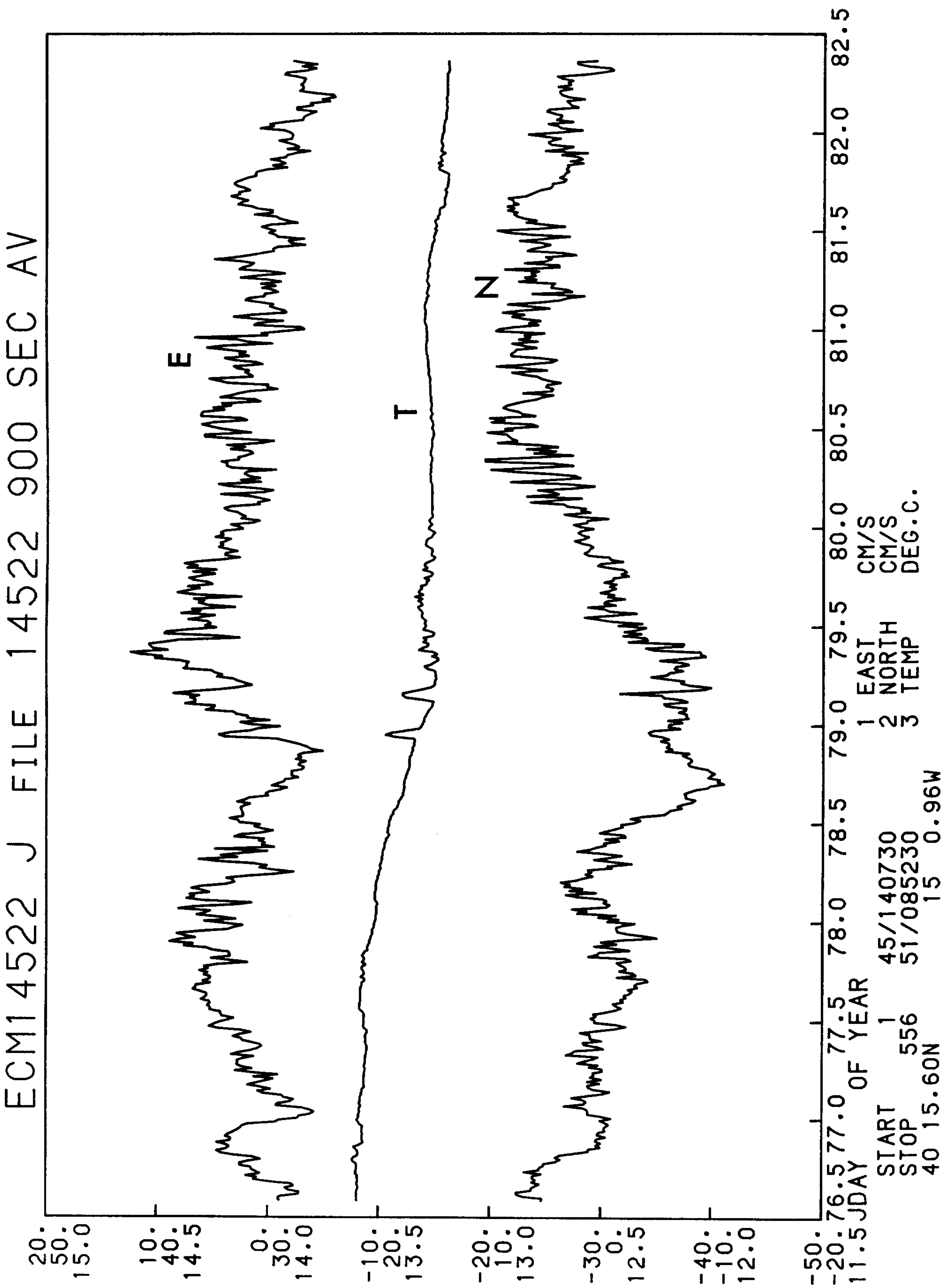

ECM14522 J FILE 14522 900 SEC AV
E
T
N
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 556 51/085230
40 15.60N 15 0.96W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50. 15.0
10. 40. 14.5
0. 30. 14.0
-10. 20. 13.5
-20. 10. 13.0
-30. 0. 12.5
-40. -10. 12.0
-50. -20. 11.5

Fig. 13.2

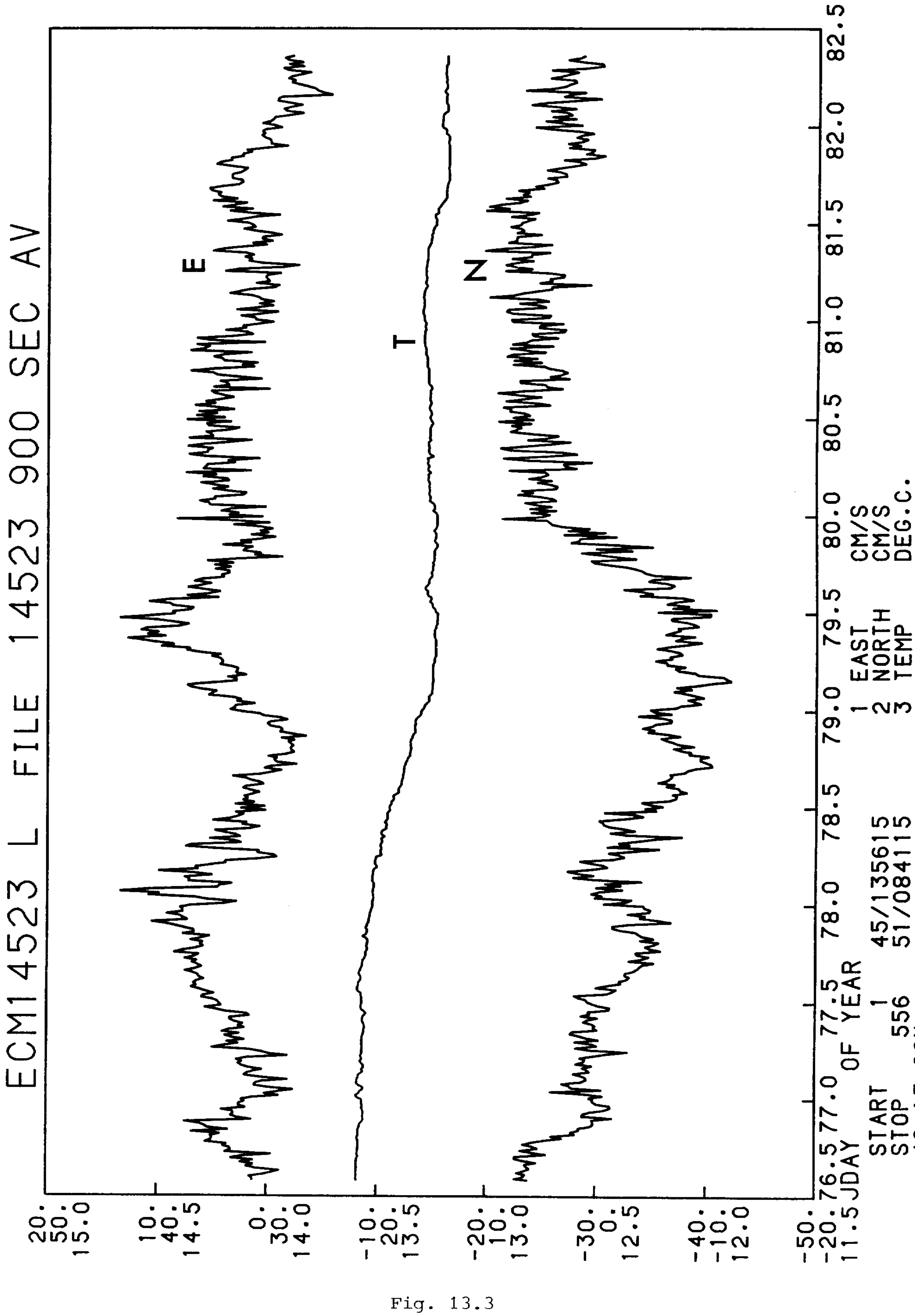

ECM14523 L FILE 14523 900 SEC AV
E
T
N
JDAY OF YEAR
START 1 45/135615
STOP 556 51/084115
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 13.3

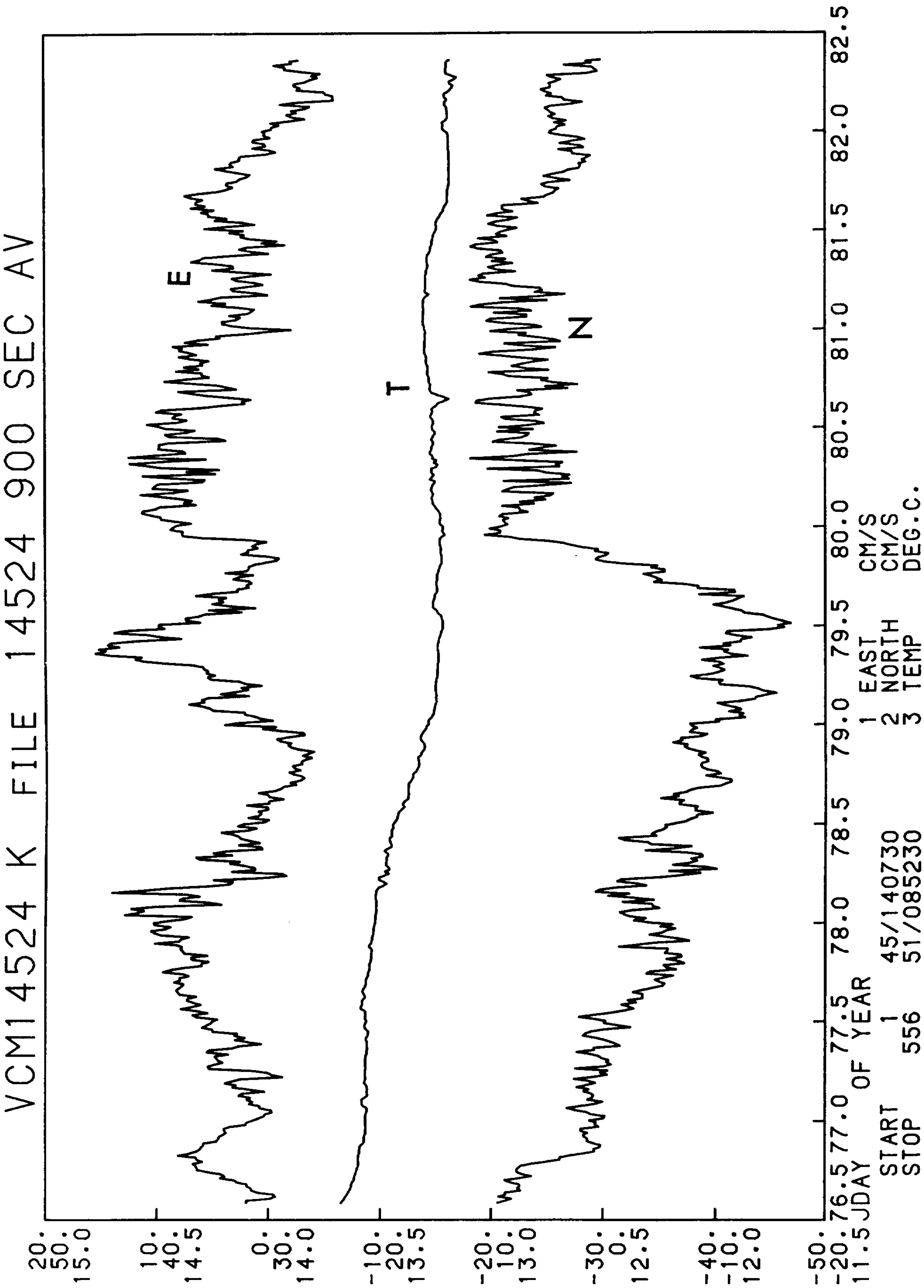

VCM14524 K FILE 14524 900 SEC AV
E
T
N
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 556 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50. 15.0
10. 40. 14.5
0. 30. 14.0
-10. 20. 13.5
-20. 10. 13.0
-30. 0. 12.5
-40. -10. 12.0
-50. -20. 11.5

Fig. 13.4

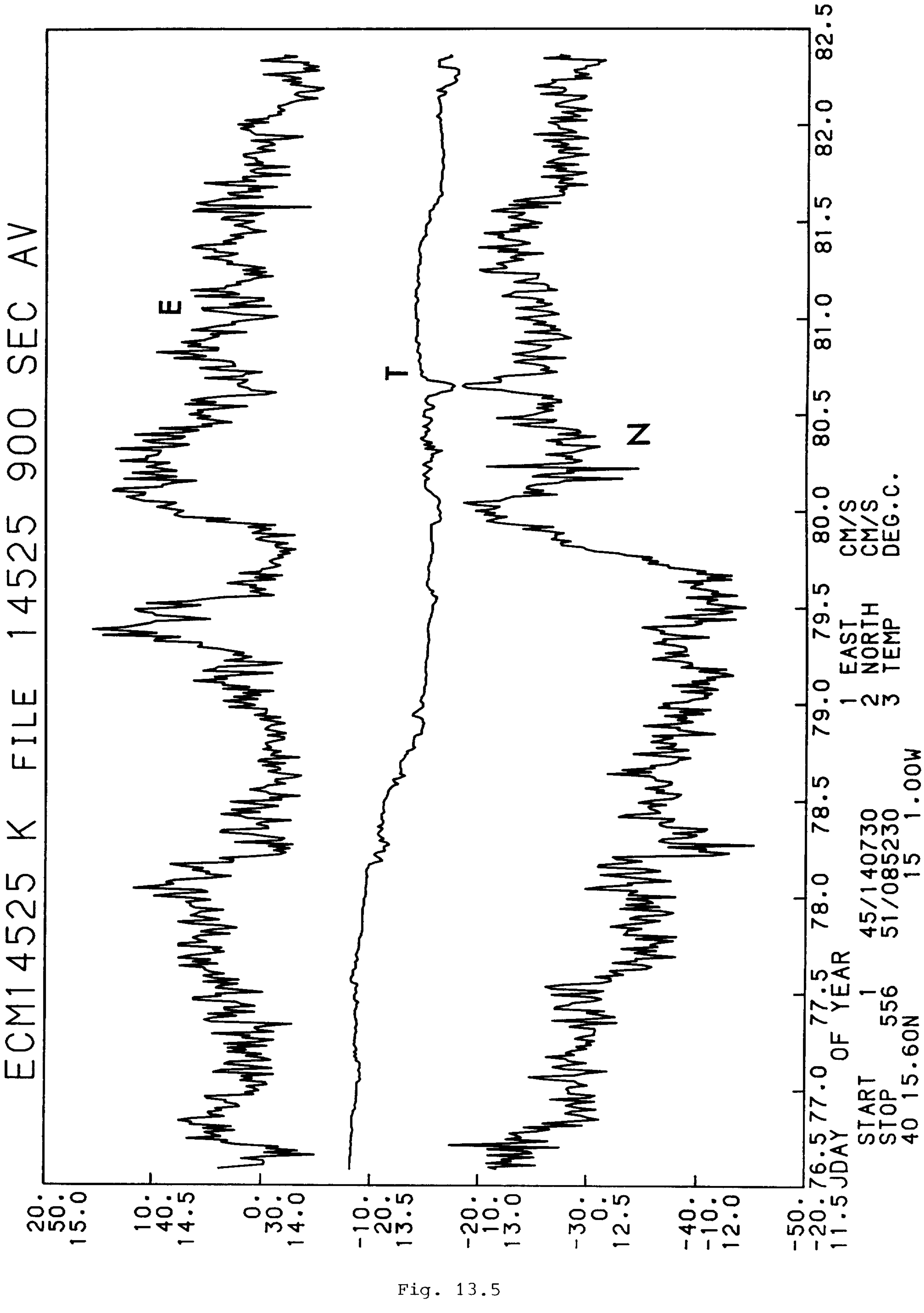

ECM14525 K FILE 14525 900 SEC AV
E
T
N
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
20. 50. 15.0
10. 40. 14.5
0. 30. 14.0
-10. 20. 13.5
-20. 10. 13.0
-30. 0. 12.5
-40. -10. 12.0
-50. -20. 11.5
START 1 45/140730
STOP 556 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 13.5

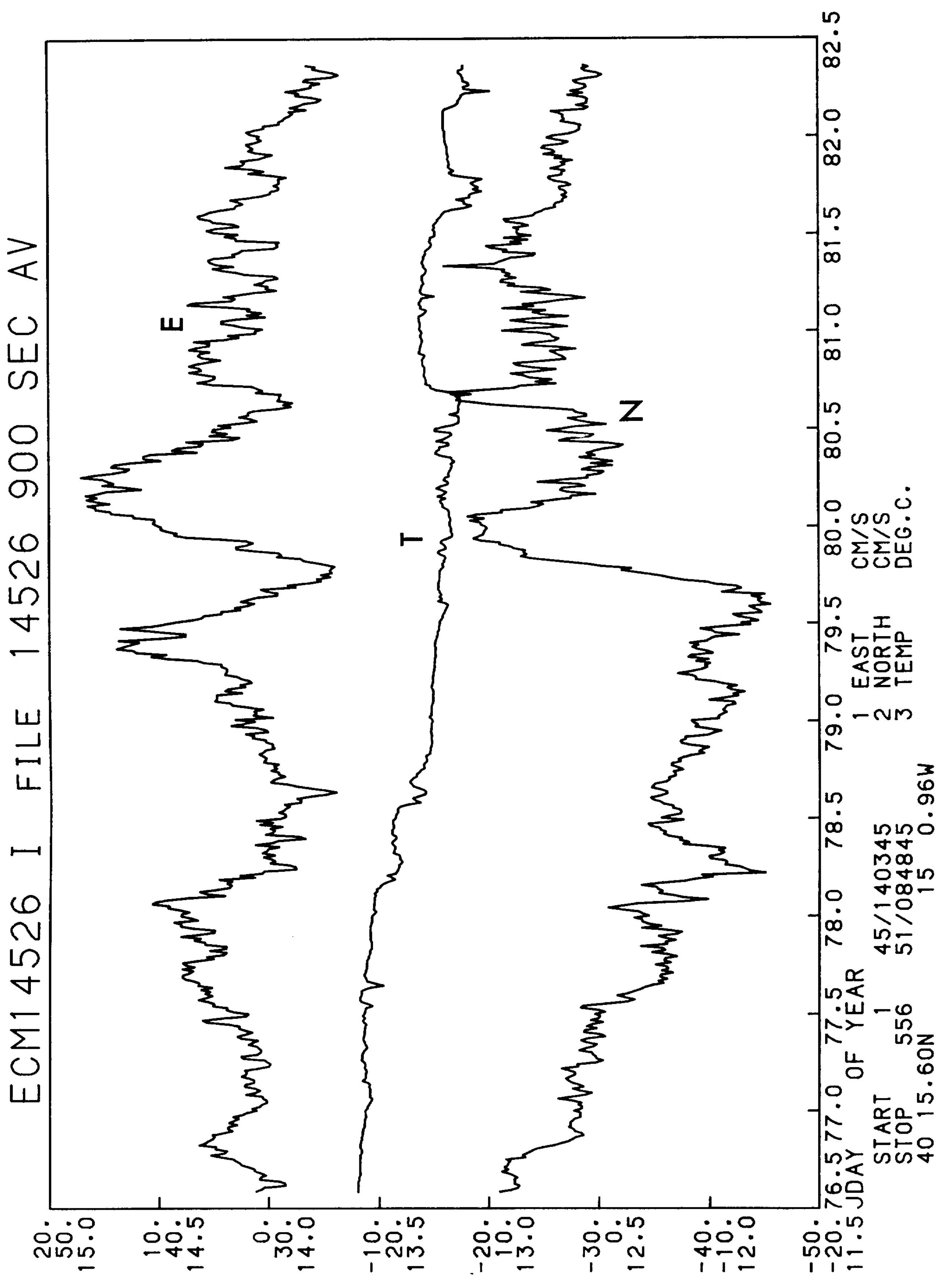

ECM14526 I FILE 14526 900 SEC AV
E
T
N
JDAY OF YEAR
START 1 45/140345
STOP 556 51/084845
40 15.60N 15 0.96W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 13.6

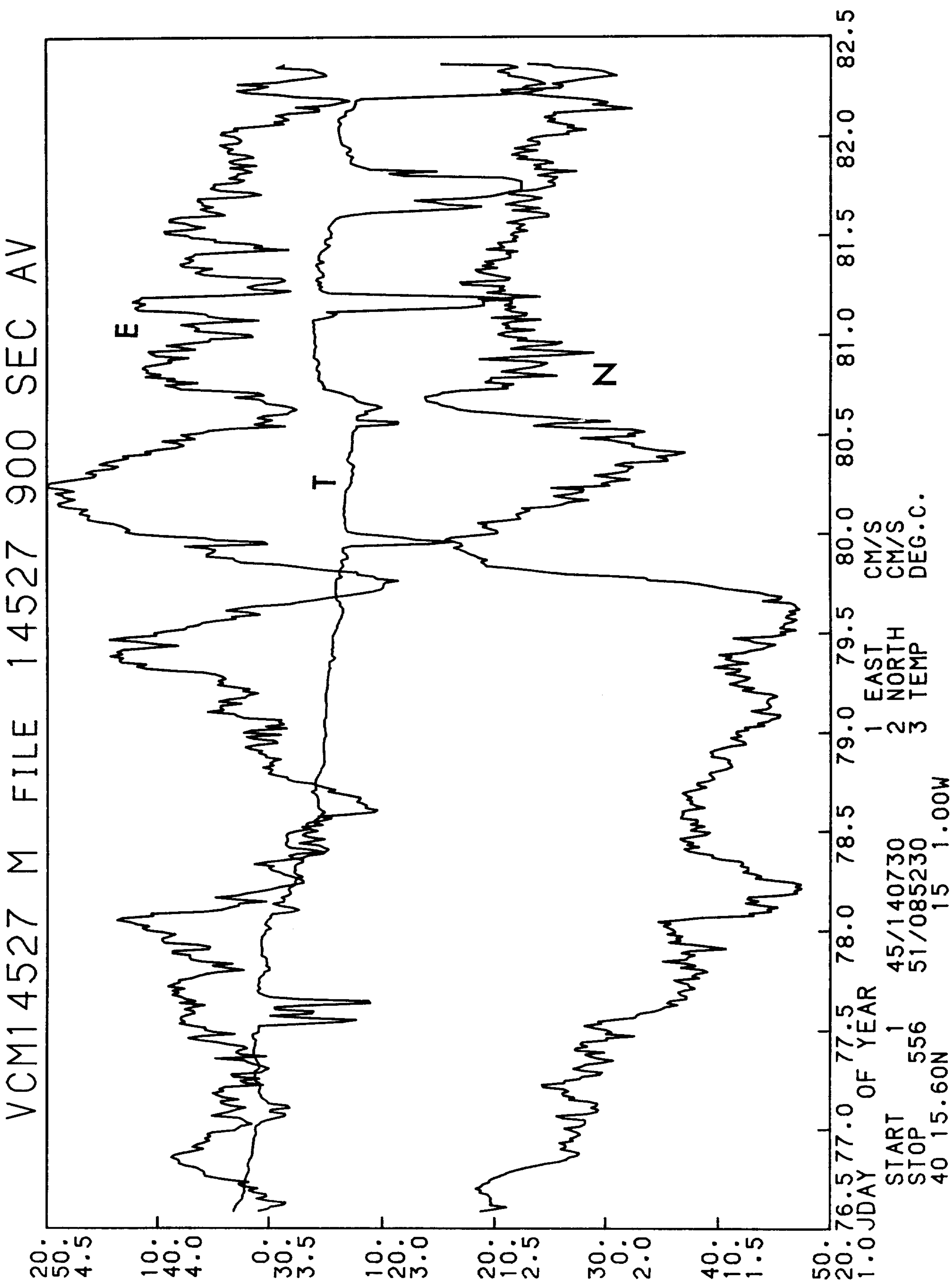

VCM14527 M FILE 14527 900 SEC AV
E
T
N
20. 50. 14.5
10. 40. 14.0
0. 30. 13.5
-10. 20. 13.0
-20. 10. 12.5
-30. 0. 12.0
-40. -10. 11.5
-50. -20. 11.0
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 556 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 13.7

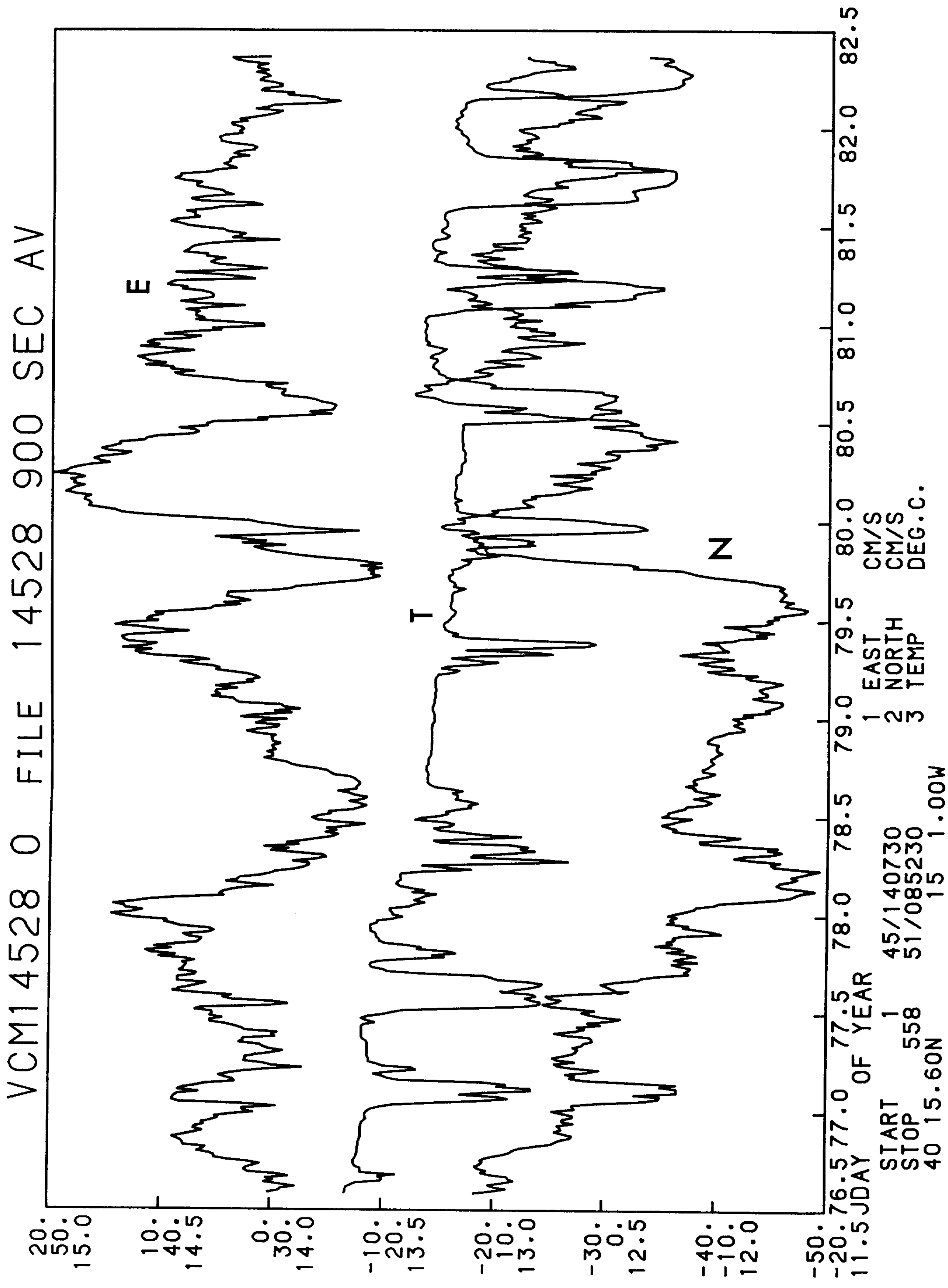

VCM14528 0 FILE 14528 900 SEC AV
E
T
N
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 558 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50. 15.0
10. 40. 14.5
0. 30. 14.0
-10. 20. 13.5
-20. 10. 13.0
-30. 0. 12.5
-40. -10. 12.0
-50. -20. 11.5

Fig. 13.8

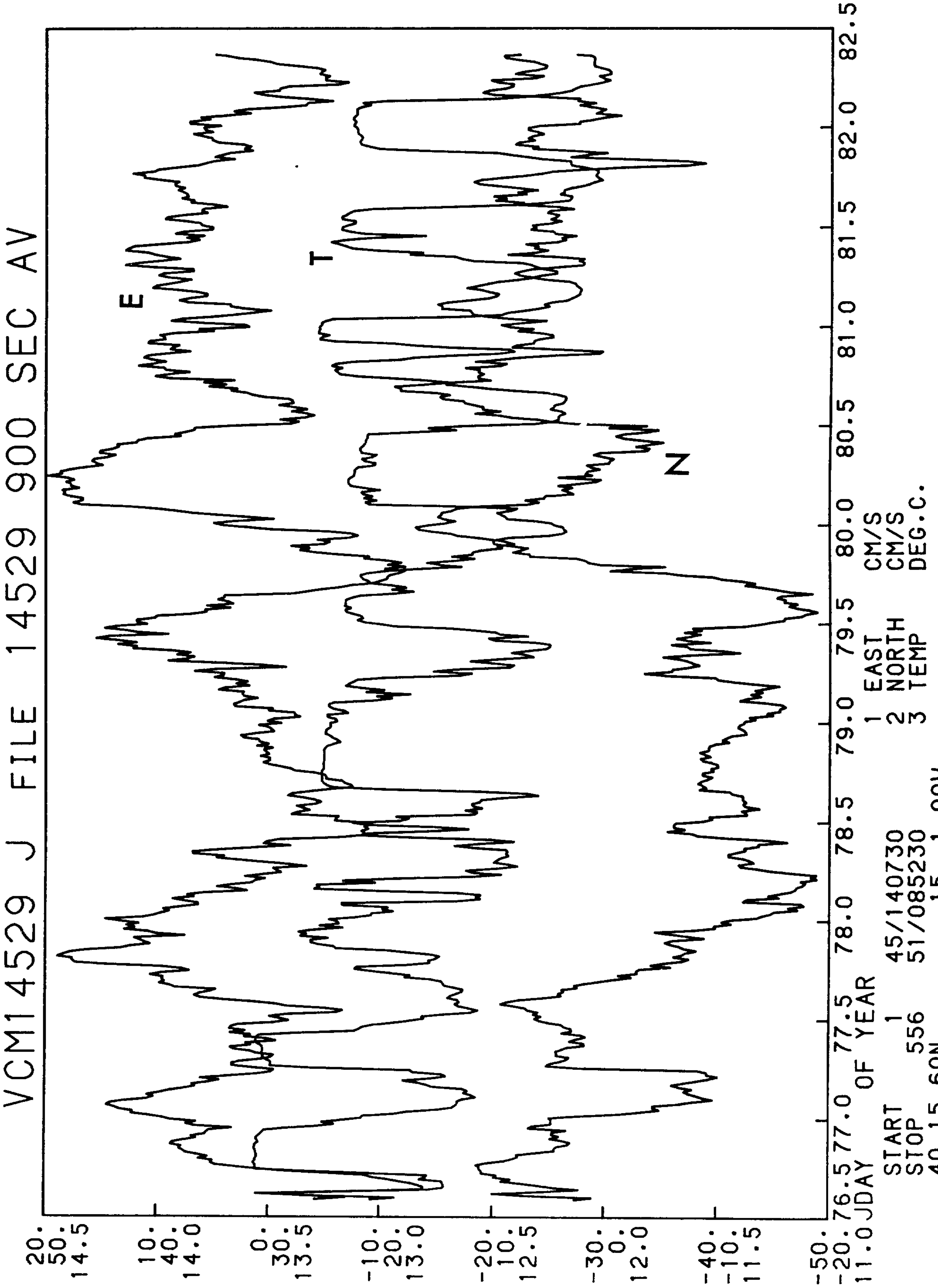

VCM14529 J FILE 14529 900 SEC AV
E
T
N
76.5 77.0 77.5 78.0 78.5 79.0 79.5 80.0 80.5 81.0 81.5 82.0 82.5
JDAY OF YEAR
START 1 45/140730
STOP 556 51/085230
40 15.60N 15 1.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50.5 14.5
10. 40.0 14.0
0. 30.5 13.5
-10. 20.0 13.0
-20. 10.5 12.5
-30. 0. 12.0
-40. -10. 11.5
-50. -20. 11.0

Fig. 13.9

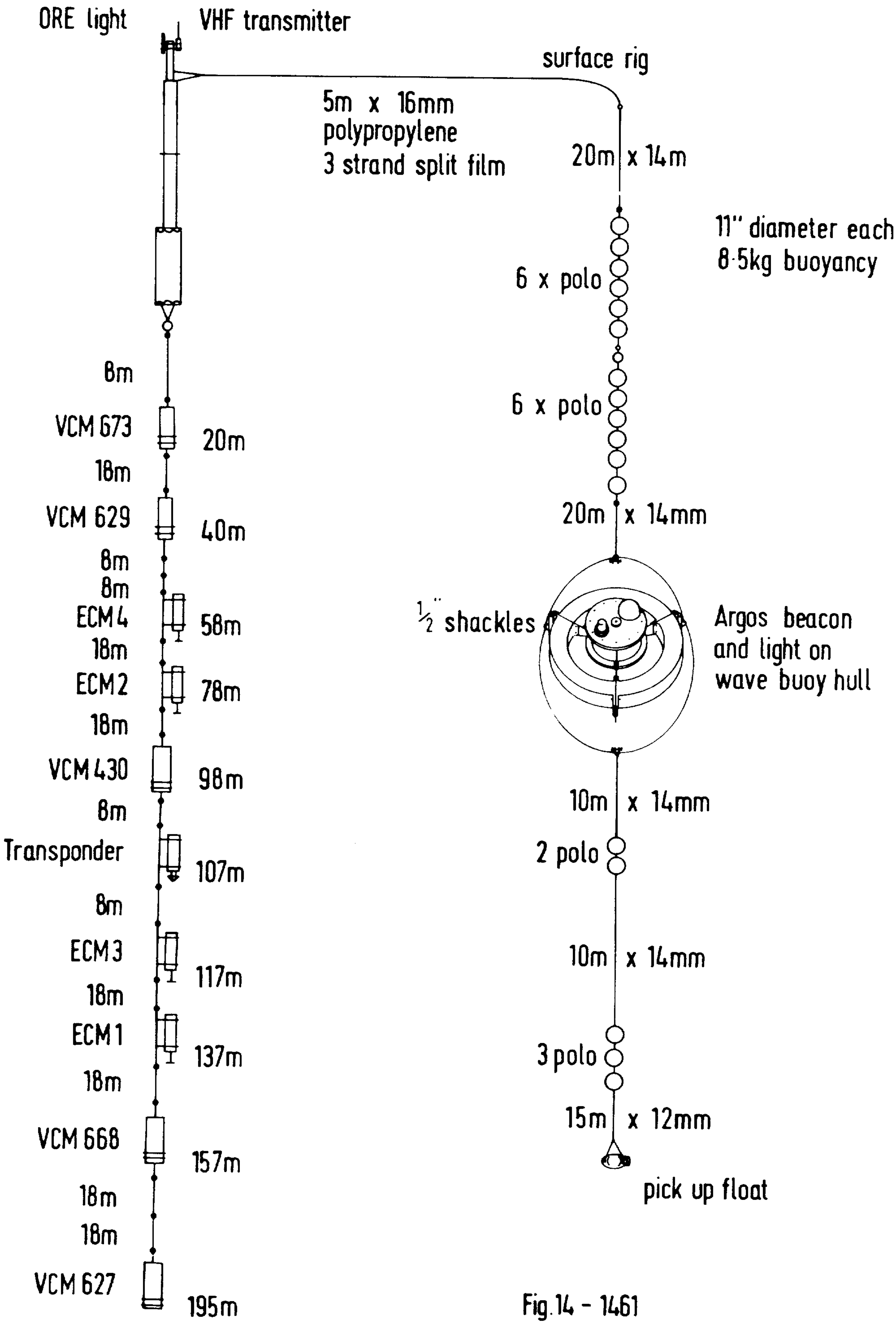

ORE light
VHF transmitter
surface rig
5m x 16mm
polypropylene
3 strand split film
20m x 14m
11" diameter each
8·5kg buoyancy
6 x polo
6 x polo
20m x 14mm
½" shackles
Argos beacon
and light on
wave buoy hull
10m x 14mm
2 polo
10m x 14mm
3 polo
15m x 12mm
pick up float
8m
VCM 673
20m
18m
VCM 629
40m
8m
8m
ECM 4
58m
18m
ECM 2
78m
18m
VCM 430
98m
8m
Transponder
107m
8m
ECM 3
117m
18m
ECM 1
137m
18m
VCM 668
157m
18m
18m
VCM 627
195m

Fig. 14 - 1461

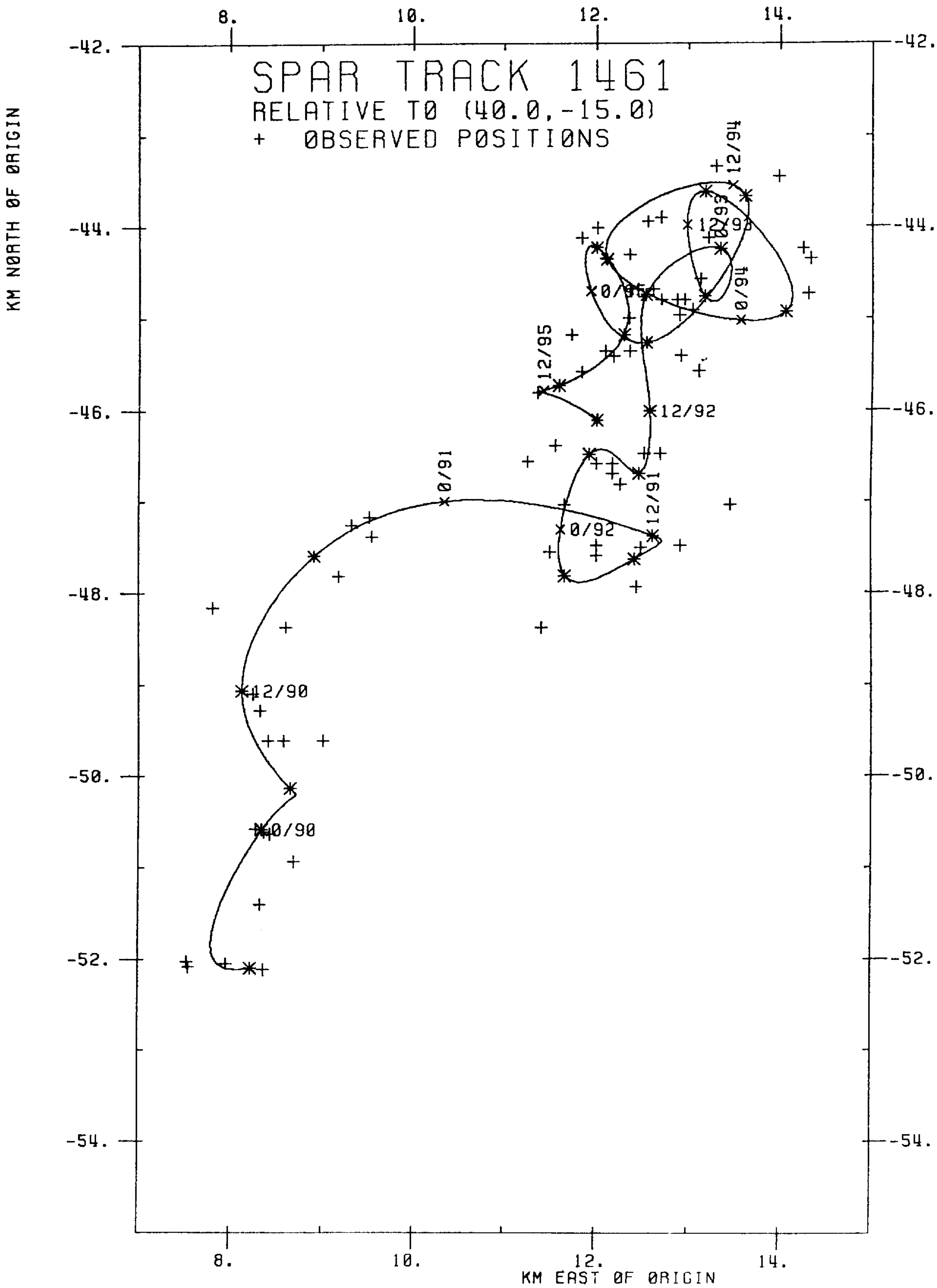

SPAR TRACK 1461
RELATIVE TO (40.0,-15.0)
+ OBSERVED POSITIONS
KM NORTH OF ORIGIN
KM EAST OF ORIGIN
8.
10.
12.
14.
-42.
-44.
-46.
-48.
-50.
-52.
-54.
12/94
12/93
0/93
0/94
0/95
12/95
12/92
0/91
12/91
0/92
12/90
0/90

Fig. 15.1

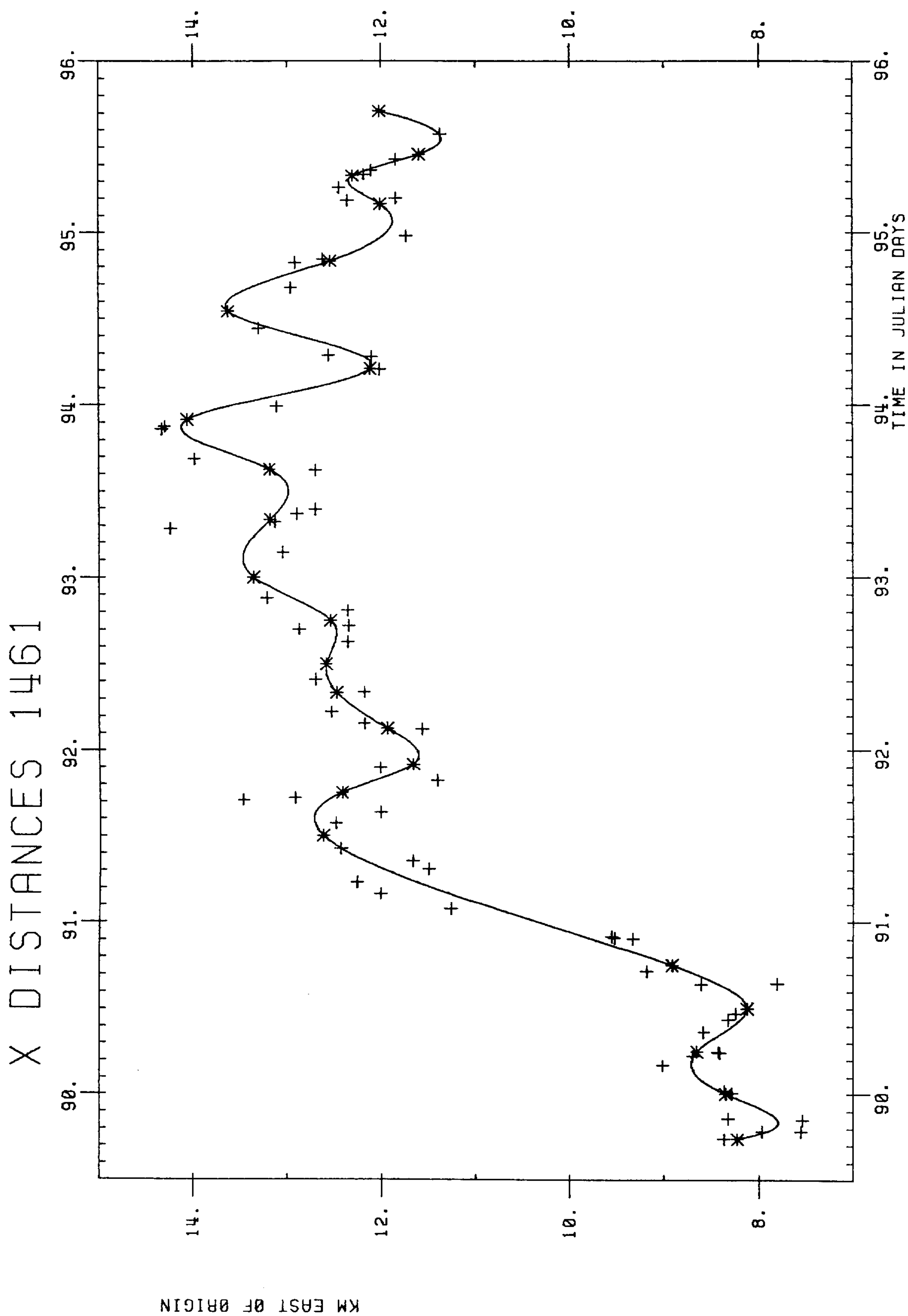

X DISTANCES 1461
TIME IN JULIAN DAYS
KM EAST OF ORIGIN
90.
91.
92.
93.
94.
95.
96.
14.
12.
10.
8.

Fig. 15.2

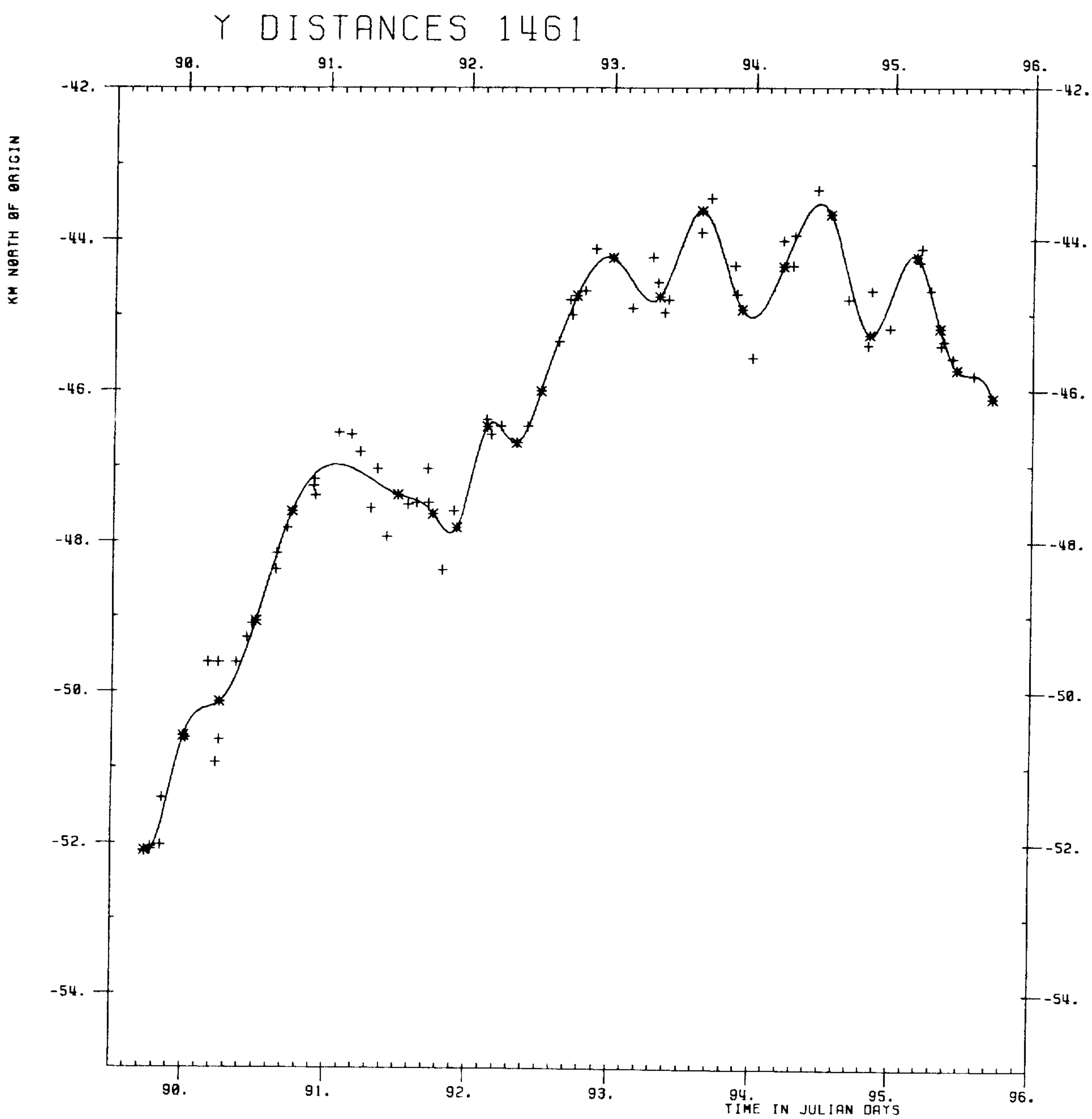

Y DISTANCES 1461
90.
91.
92.
93.
94.
95.
96.
-42.
-44.
-46.
-48.
-50.
-52.
-54.
KM NORTH OF ORIGIN
TIME IN JULIAN DAYS

Fig. 15.3

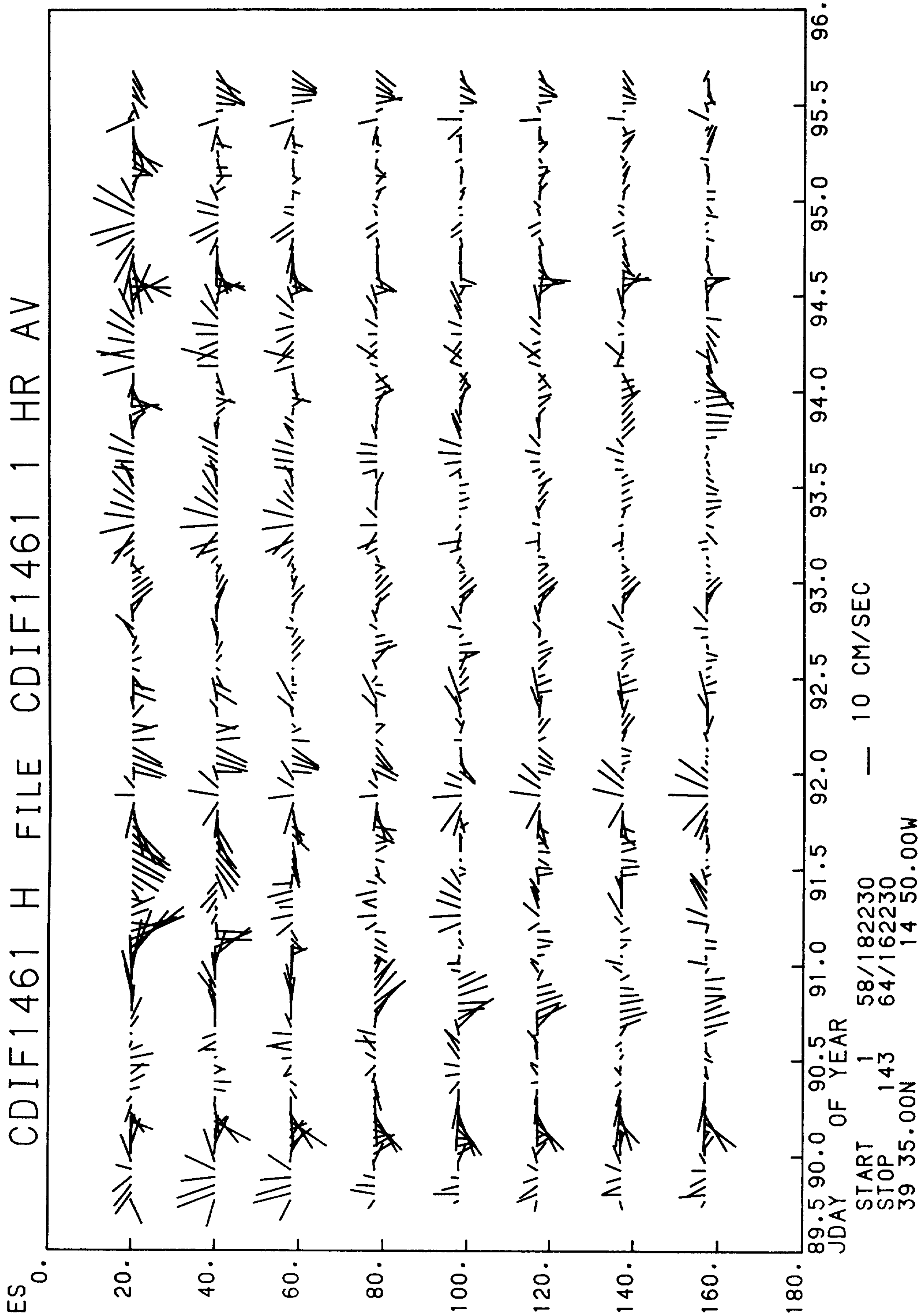

CDIF1461 H FILE CDIF1461 1 HR AV
PRES
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
— 10 CM/SEC
START 1 58/182230
STOP 143 64/162230
39 35.00N 14 50.00W

Fig. 16

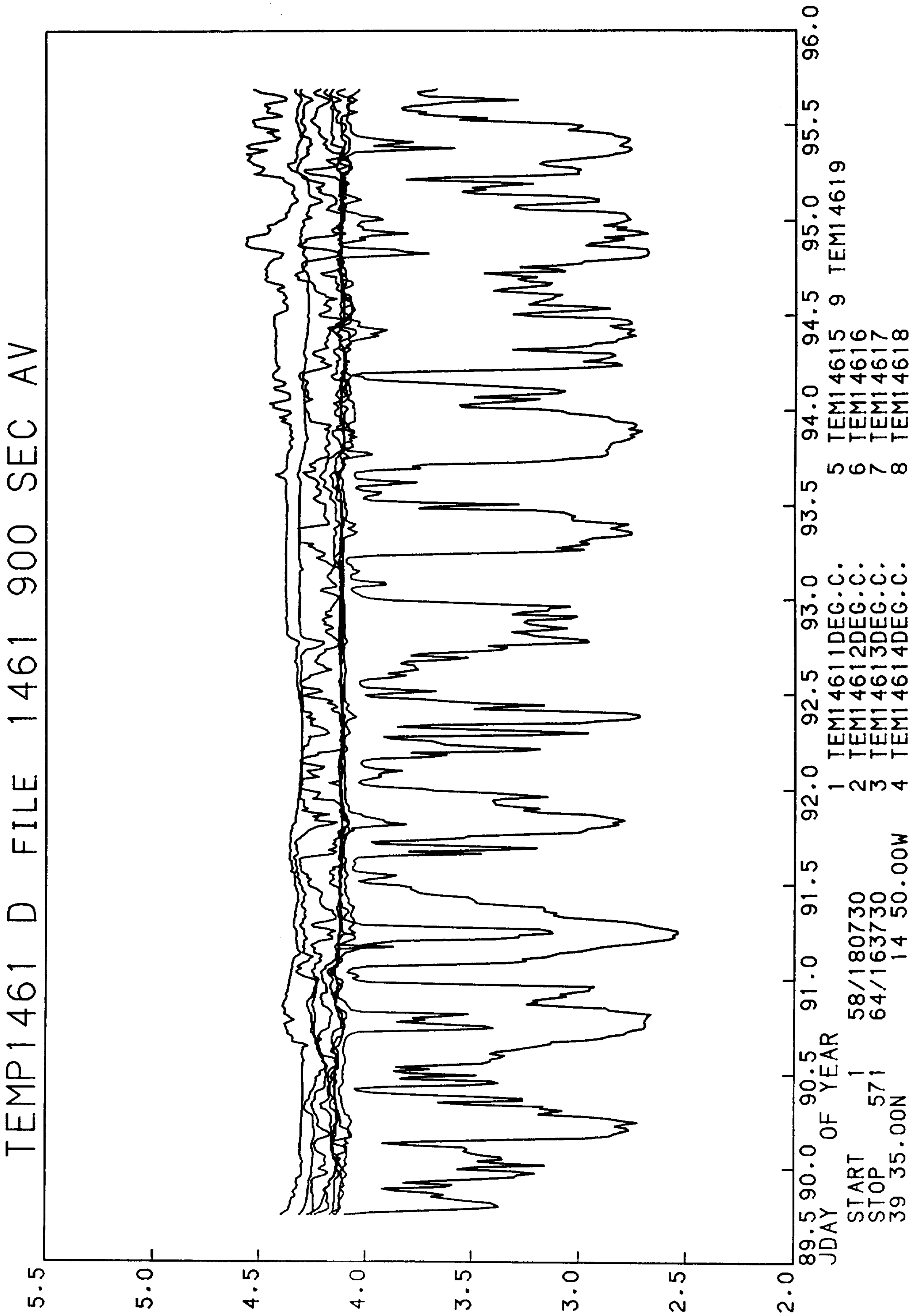
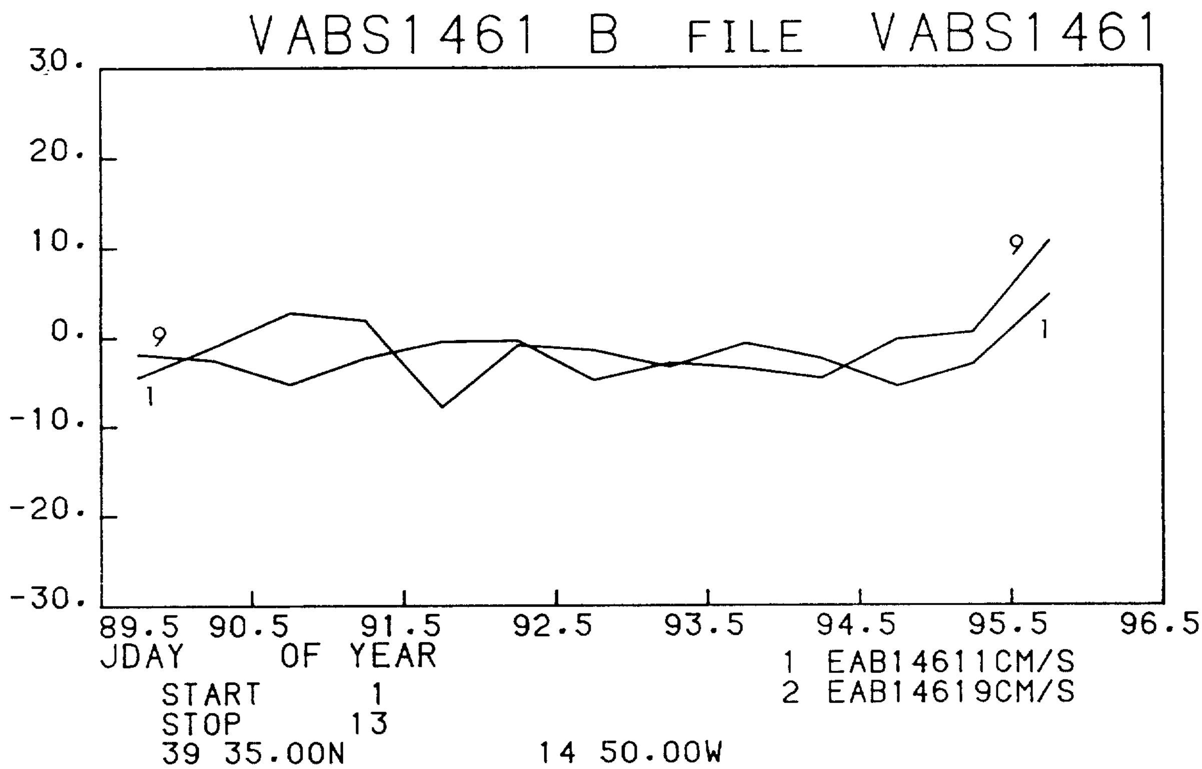

TEMP1461 D FILE 1461 900 SEC AV
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 TEM14611DEG.C.
2 TEM14612DEG.C.
3 TEM14613DEG.C.
4 TEM14614DEG.C.
5 TEM14615
6 TEM14616
7 TEM14617
8 TEM14618
9 TEM14619

Fig. 17


VABS1461 B FILE VABS1461
30.
20.
10.
0.
-10.
-20.
-30.
9
1
89.5 90.5 91.5 92.5 93.5 94.5 95.5 96.5
JDAY OF YEAR
START 1
STOP 13
39 35.00N 14 50.00W
1 EAB14611CM/S
2 EAB14619CM/S

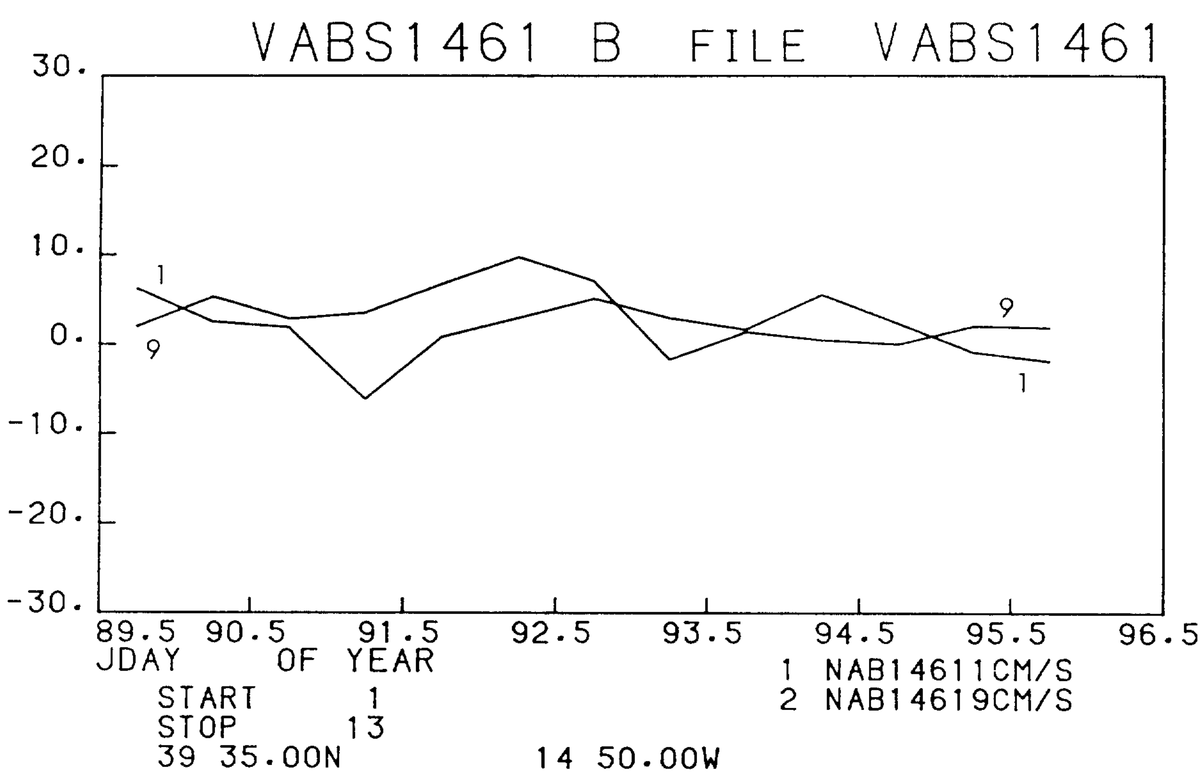

VABS1461 B FILE VABS1461
30.
20.
10.
0.
-10.
-20.
-30.
1
9
89.5 90.5 91.5 92.5 93.5 94.5 95.5 96.5
JDAY OF YEAR
START 1
STOP 13
39 35.00N 14 50.00W
1 NAB14611CM/S
2 NAB14619CM/S

Fig. 18

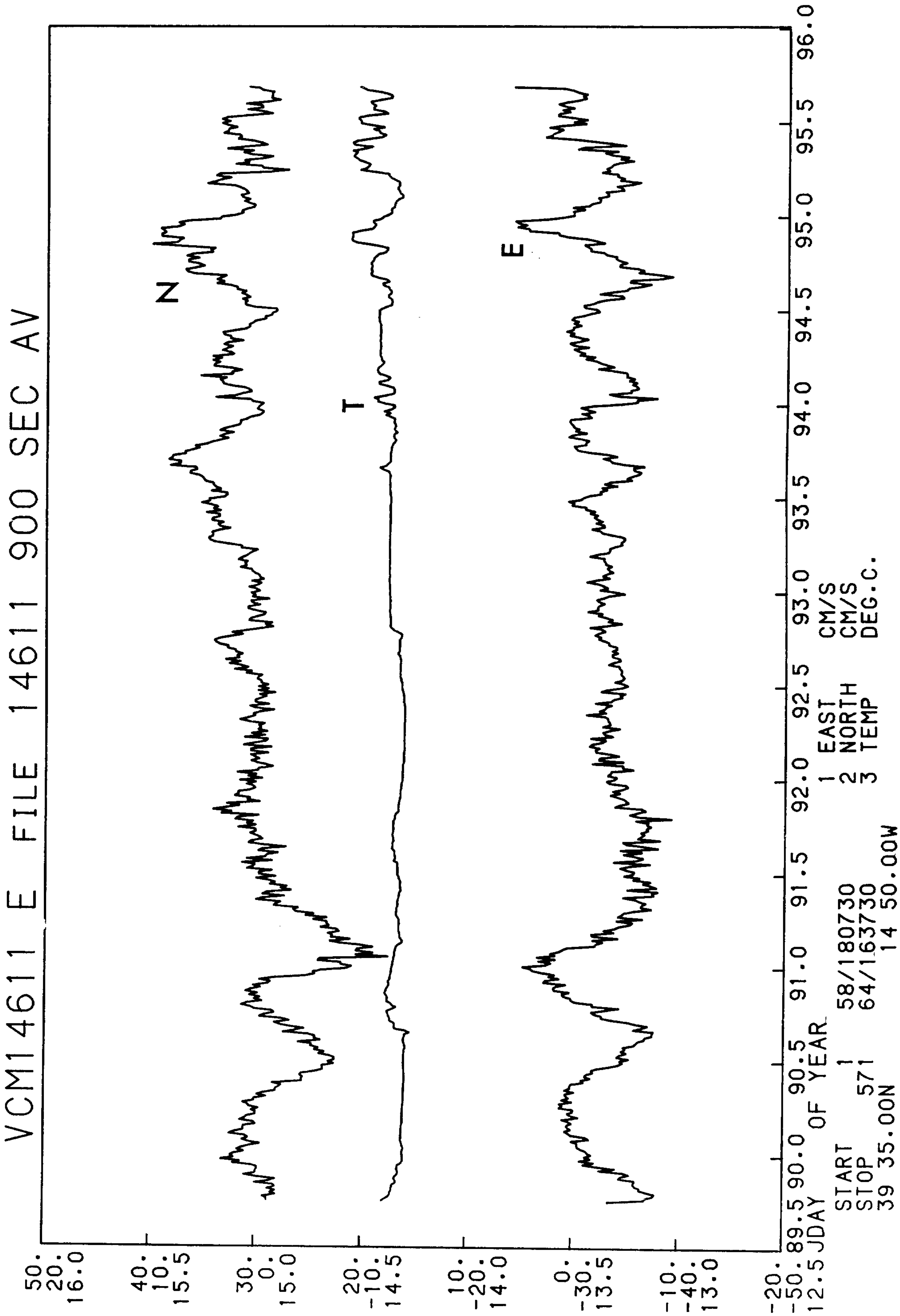

VCM14611 E FILE 14611 900 SEC AV
N
T
E
50. 20. 16.0
40. 10. 15.5
30. 0. 15.0
20. -10. 14.5
10. -20. 14.0
0. -30. 13.5
-10. -40. 13.0
-20. -50. 12.5
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 19.1

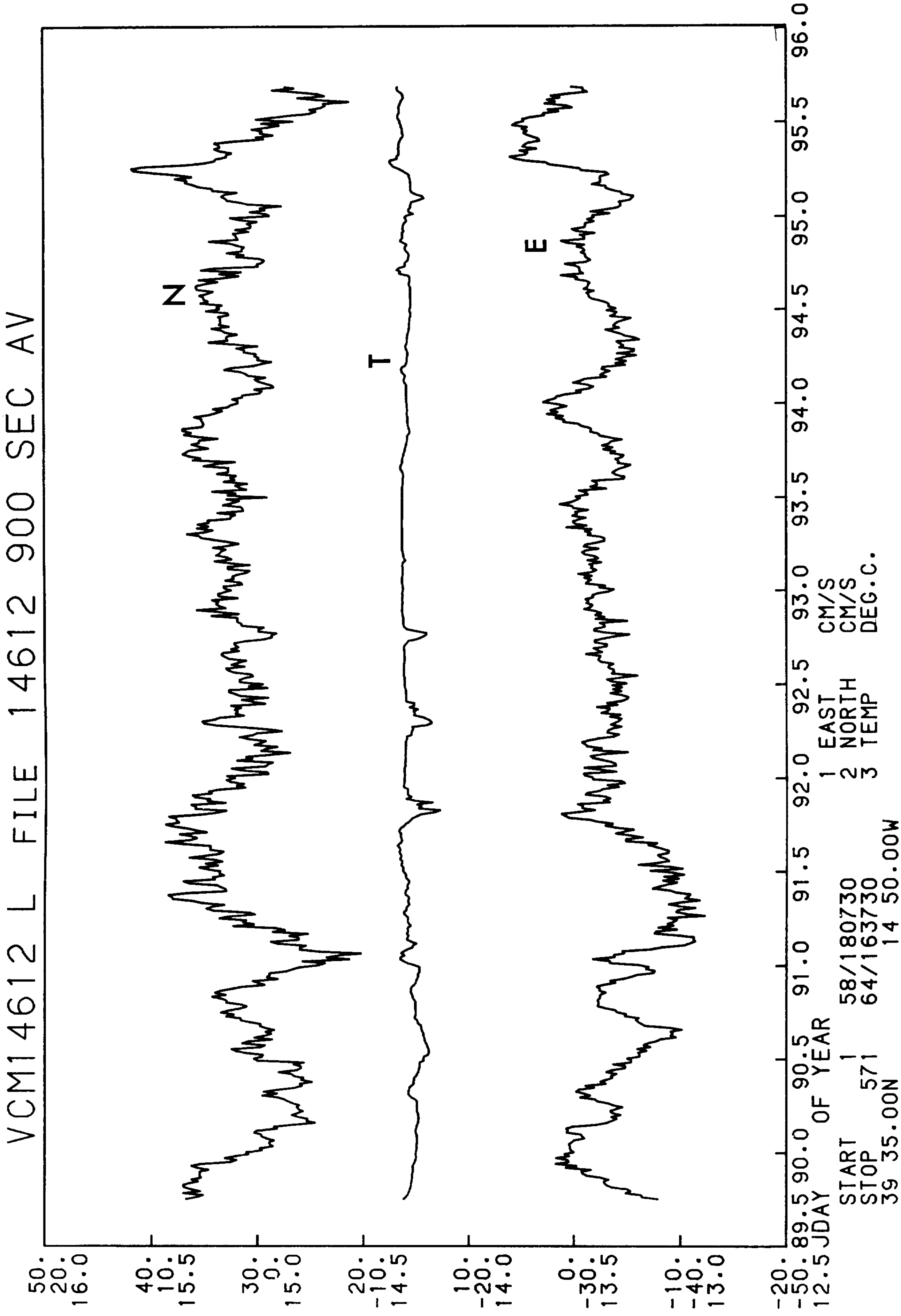
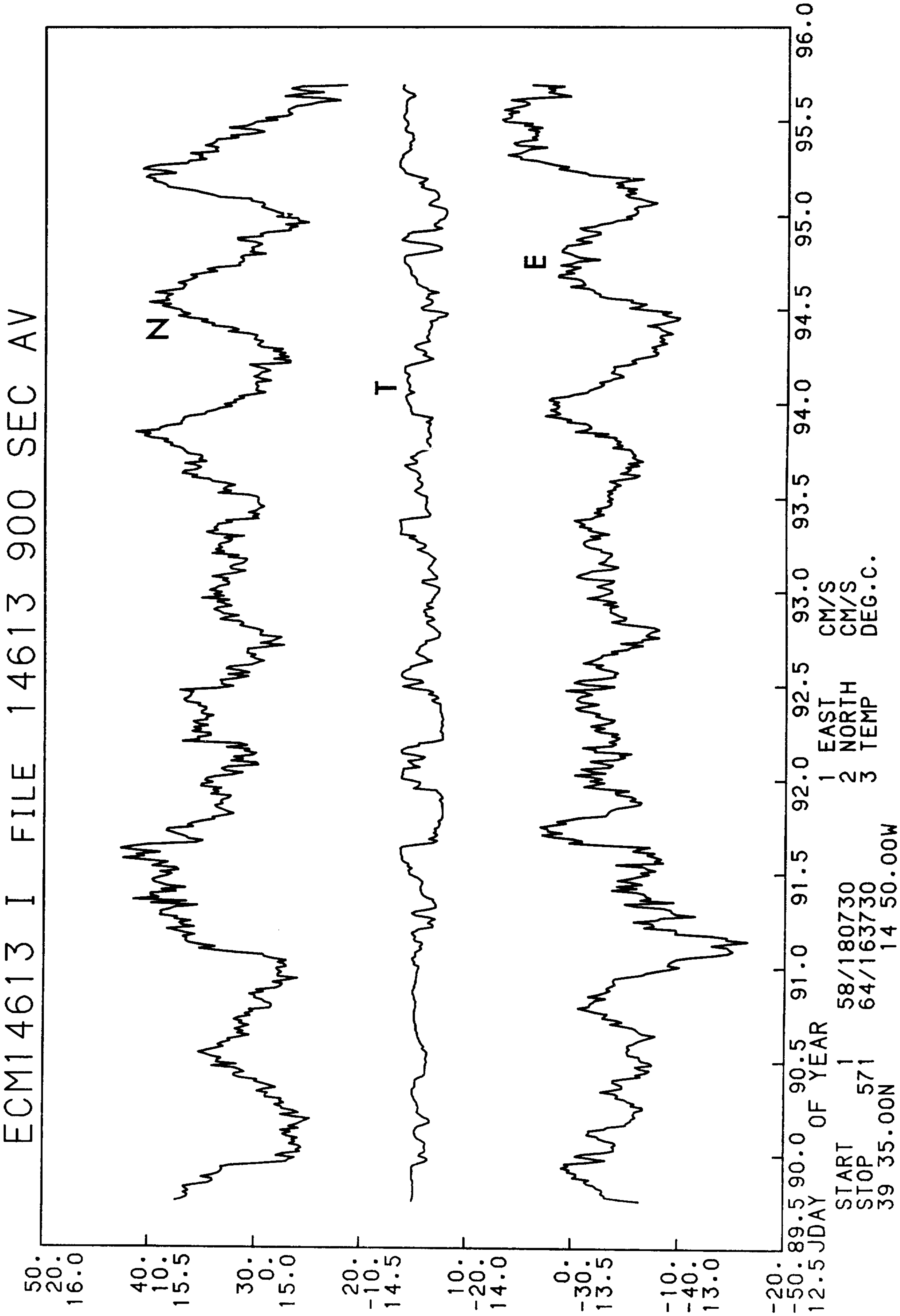
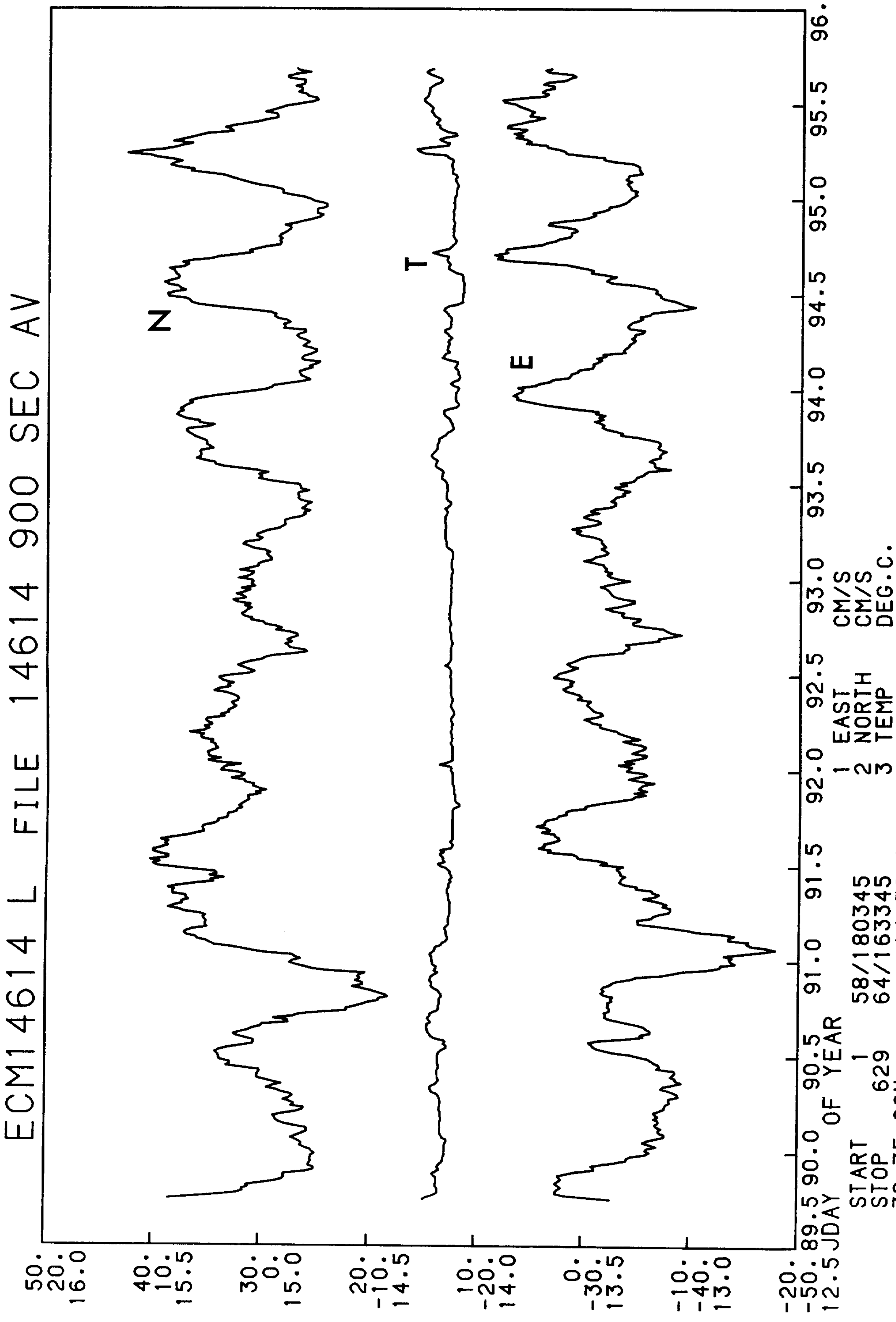

VCM14612 L FILE 14612 900 SEC AV
N
T
E
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
50. 20.0 16.0
40. 10.5 15.5
30. 0. 15.0
20. -10.5 14.5
10. -20.0 14.0
0. -30.5 13.5
-10. -40.0 13.0
-20. -50.5 12.5

Fig. 19.2



ECM14613 I FILE 14613 900 SEC AV
N
T
E
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 19.3



ECM14614 L FILE 14614 900 SEC AV
N
T
E
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180345
STOP 629 64/163345
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
50. 20. 16.0
40. 10. 15.5
30. 0. 15.0
20. -10. 14.5
10. -20. 14.0
0. -30. 13.5
-10. -40. 13.0
-20. -50. 12.5

Fig. 19.4

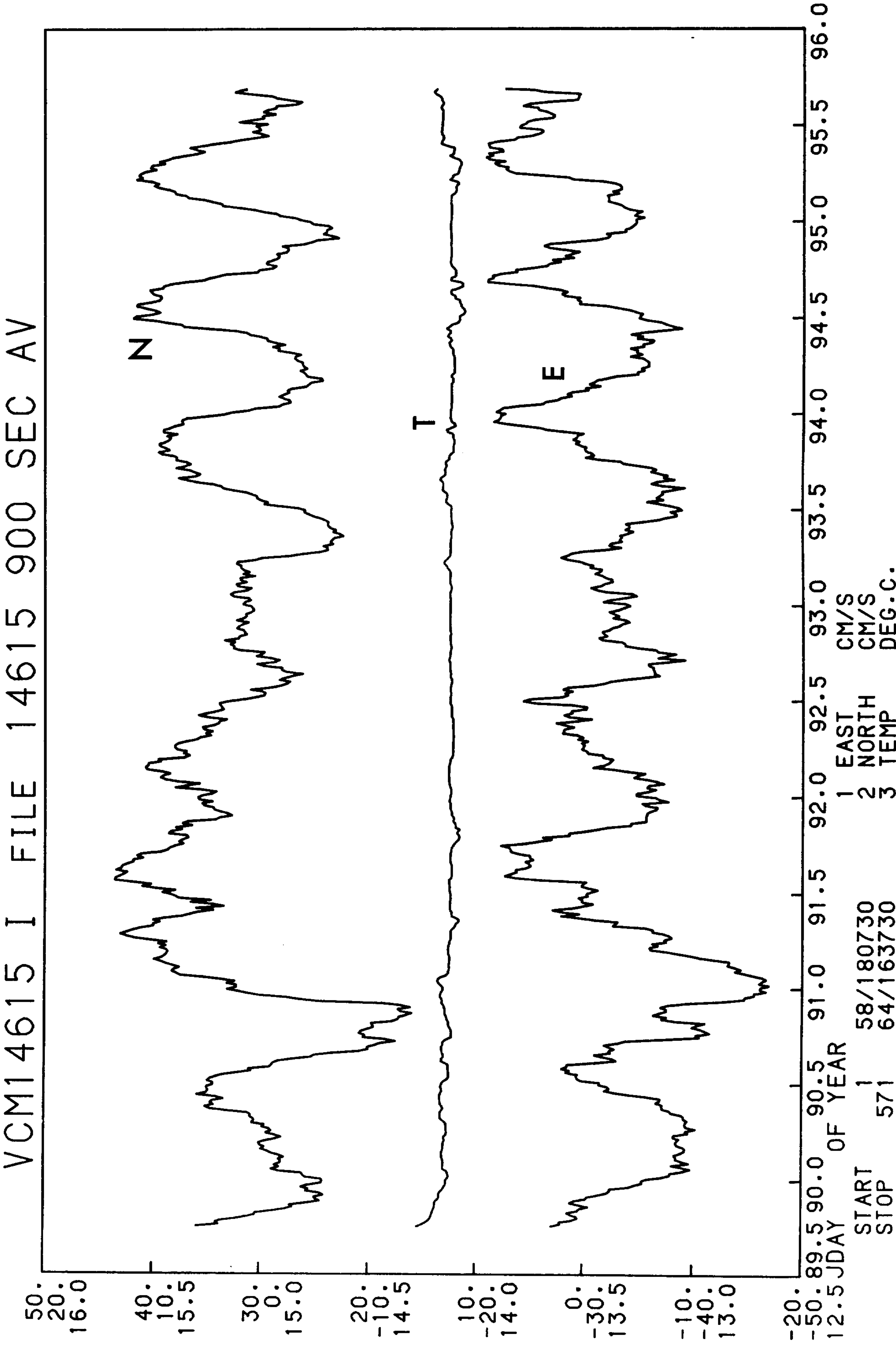

VCM14615 I FILE 14615 900 SEC AV
N
T
E
50. 20. 16.0
40. 10. 15.5
30. 0. 15.0
20. -10. 14.5
10. -20. 14.0
0. -30. 13.5
-10. -40. 13.0
-20. -50. 12.5
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W

Fig. 19.5

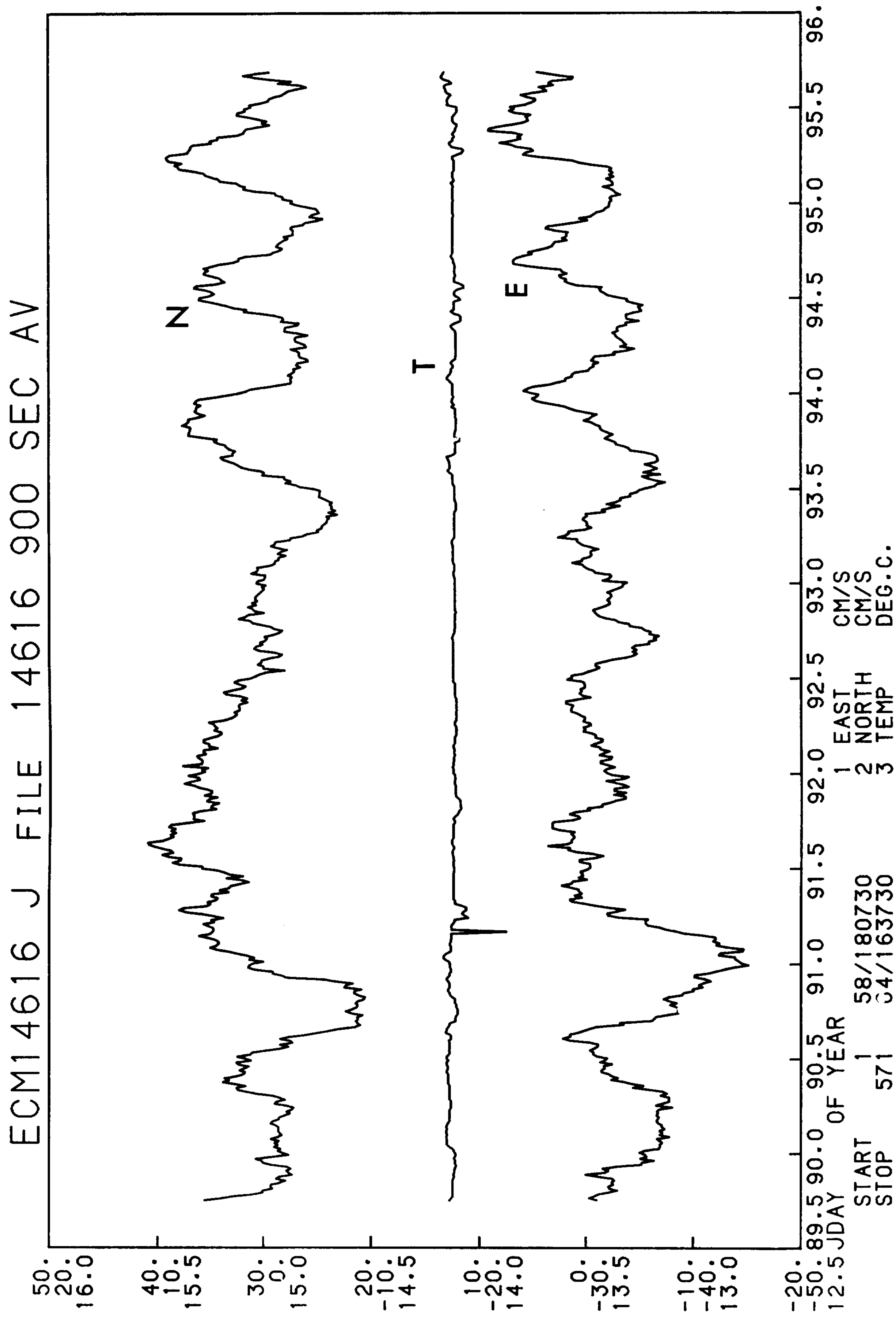

ECM14616 J FILE 14616 900 SEC AV
N
T
E
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
50. 20.0 16.0
40. 10.5 15.5
30. 0. 15.0
20. -10.5 14.5
10. -20.0 14.0
0. -30.5 13.5
-10. -40.0 13.0
-20. -50.5 12.5
START 1 58/180730
STOP 571 04/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 19.6

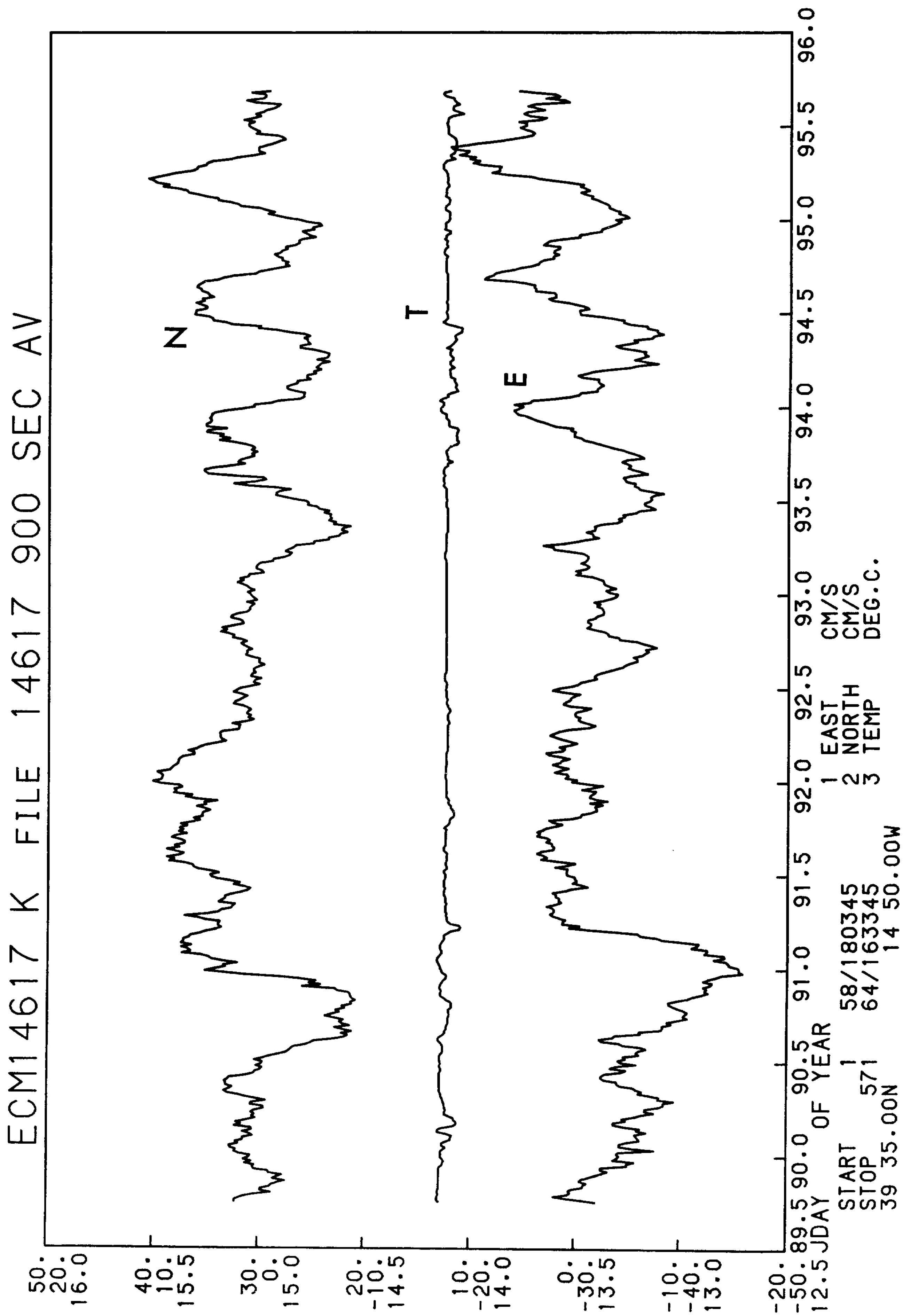

ECM14617 K FILE 14617 900 SEC AV
N
T
E
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180345
STOP 571 64/163345
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
50. 20. 16.0
40. 10. 15.5
30. 0. 15.0
20. -10. 14.5
10. -20. 14.0
0. -30. 13.5
-10. -40. 13.0
-20. -50. 12.5

Fig. 19.7

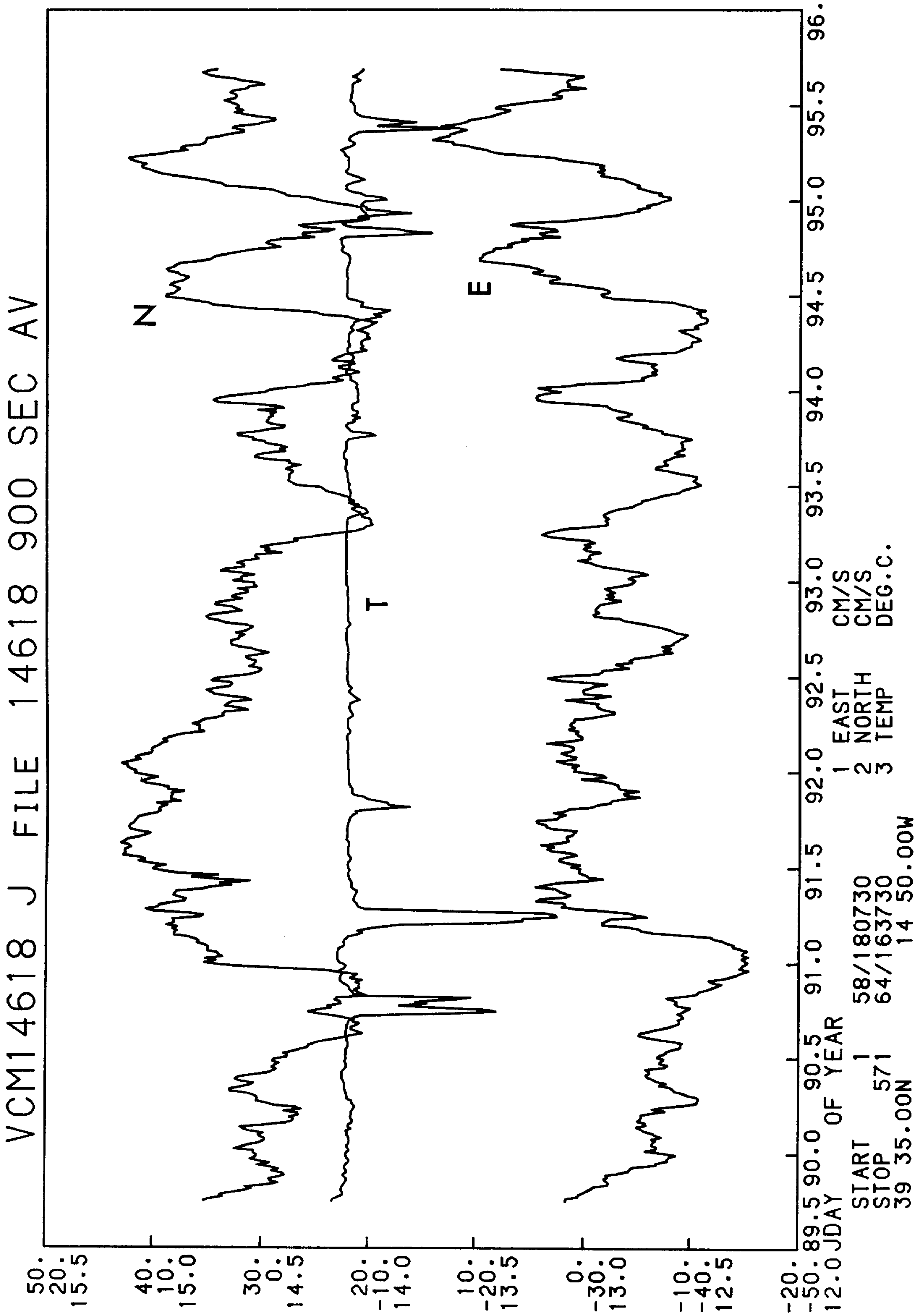

VCM14618 J FILE 14618 900 SEC AV
N
T
E
50. 20.5 15.5
40. 10. 15.0
30. 0. 14.5
20. -10. 14.0
10. -20. 13.5
0. -30. 13.0
-10. -40. 12.5
-20. -50. 12.0
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 19.8

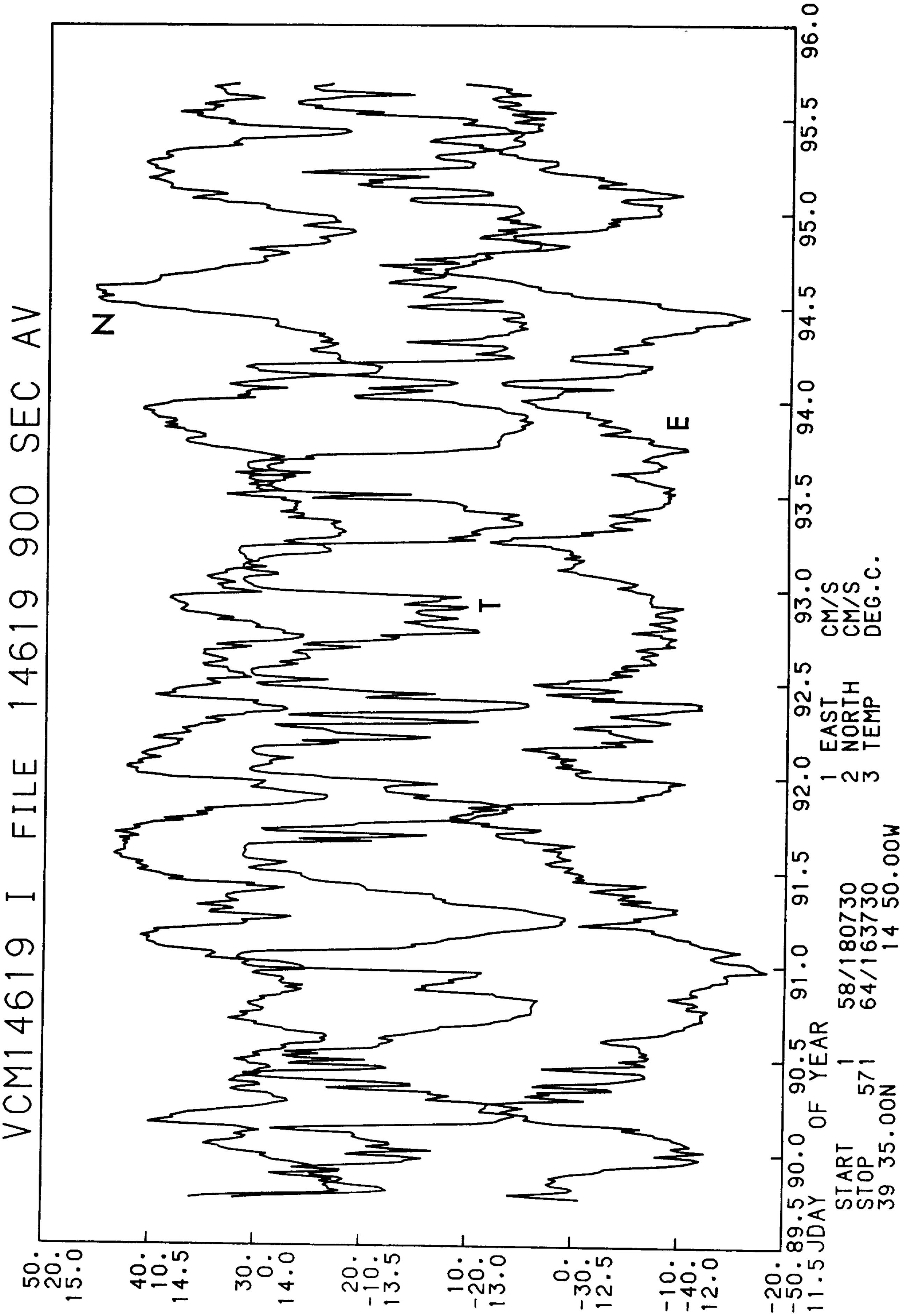

VCM14619 I FILE 14619 900 SEC AV
N
E
T
50. 20. 15.0
40. 10. 14.5
30. 0. 14.0
20. -10. 13.5
10. -20. 13.0
0. -30. 12.5
-10. -40. 12.0
-20. -50. 11.5
89.5 90.0 90.5 91.0 91.5 92.0 92.5 93.0 93.5 94.0 94.5 95.0 95.5 96.0
JDAY OF YEAR
START 1 58/180730
STOP 571 64/163730
39 35.00N 14 50.00W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 19.9

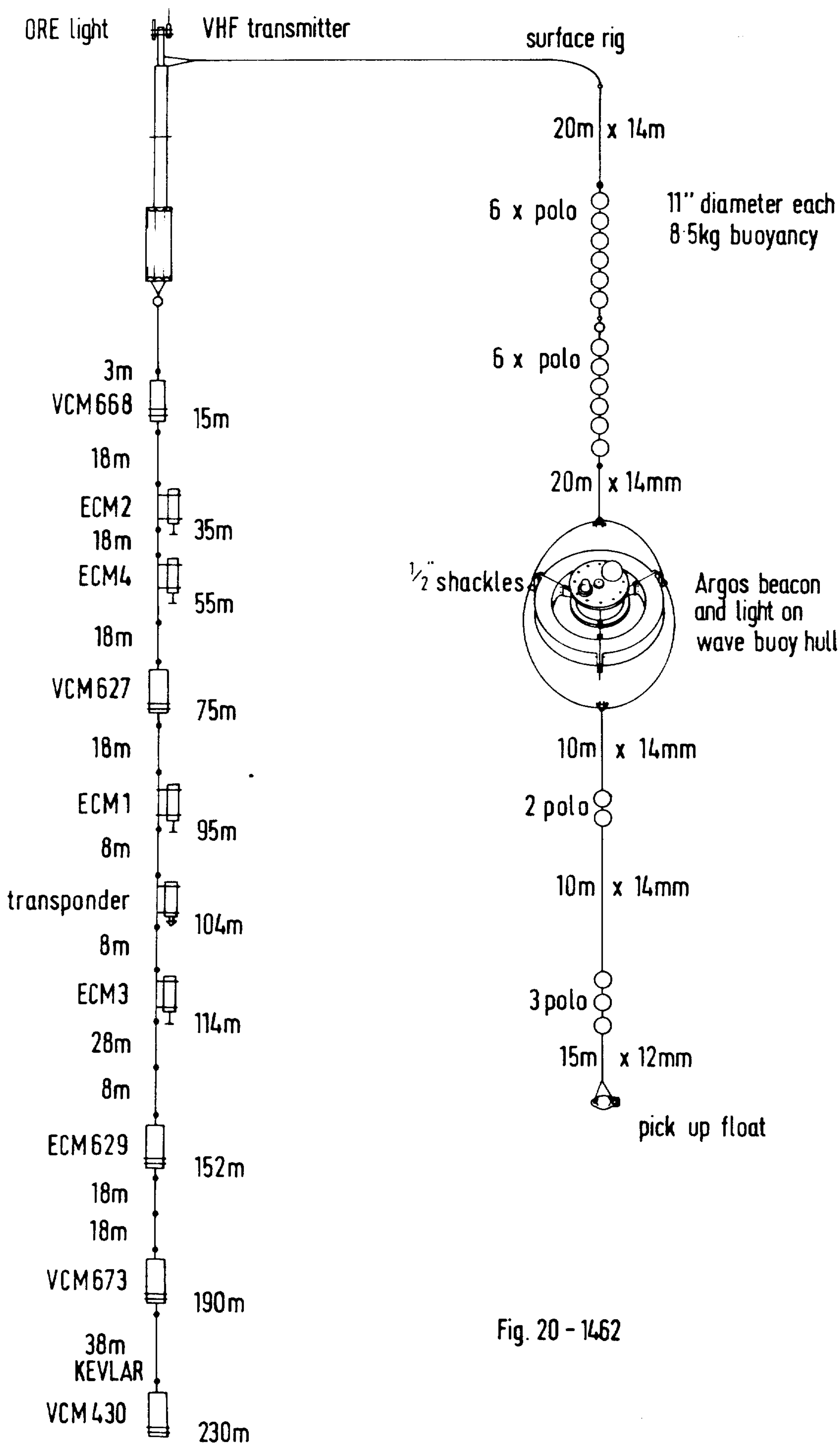
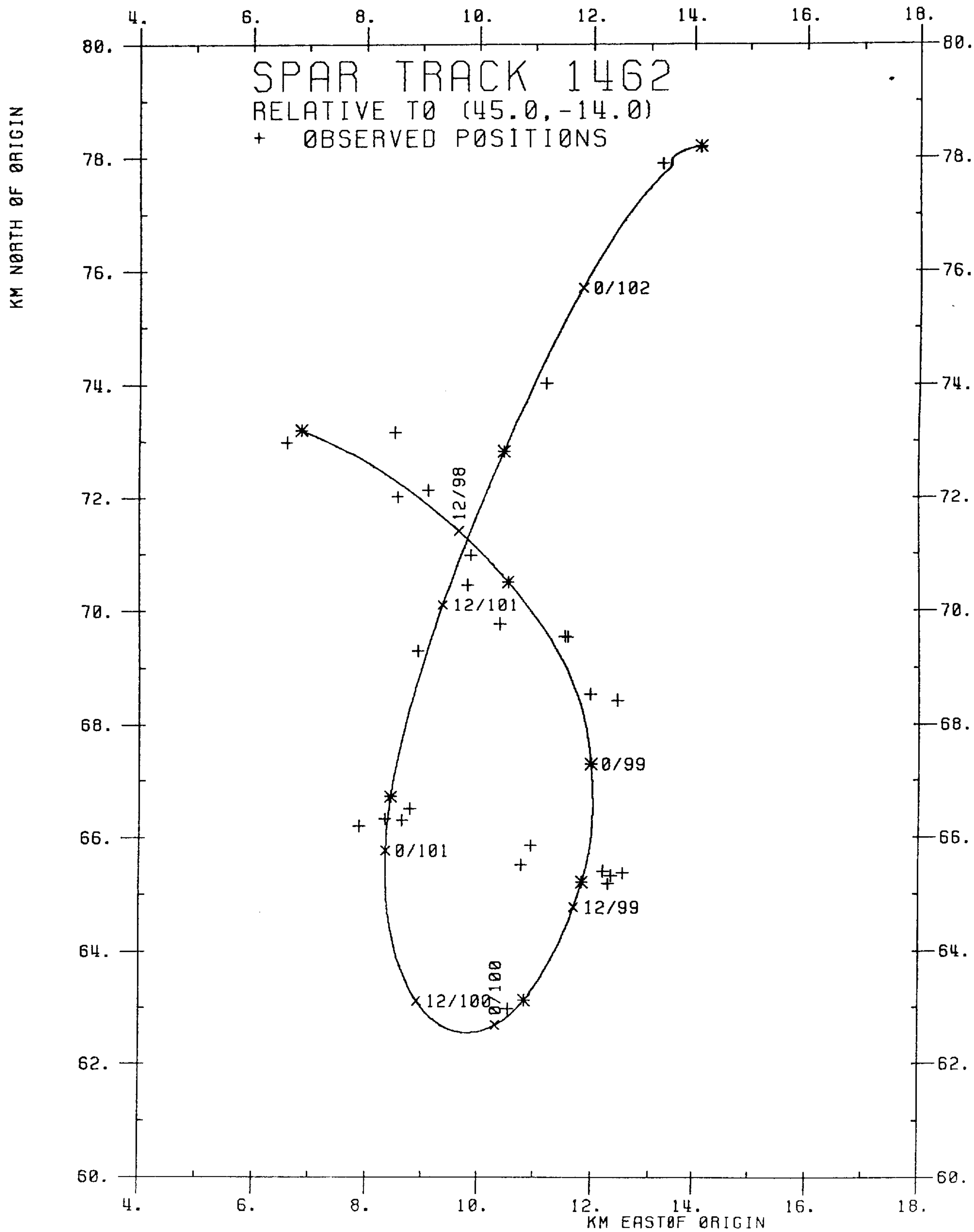

ORE light
VHF transmitter
surface rig
20m x 14m
6 x polo
11" diameter each
8·5kg buoyancy
6 x polo
20m x 14mm
½" shackles
Argos beacon
and light on
wave buoy hull
10m x 14mm
2 polo
10m x 14mm
3 polo
15m x 12mm
pick up float
3m
VCM668
15m
18m
ECM2
35m
18m
ECM4
55m
18m
VCM627
75m
18m
ECM1
95m
8m
transponder
104m
8m
ECM3
114m
28m
8m
ECM629
152m
18m
18m
VCM673
190m
38m
KEVLAR
VCM430
230m

Fig. 20 - 1462



SPAR TRACK 1462
RELATIVE TØ (45.0,-14.0)
+ ØBSERVED PØSITIØNS
KM NØRTH ØF ØRIGIN
KM EASTØF ØRIGIN
0/102
12/98
12/101
0/99
0/101
12/99
12/100
0/100
4.
6.
8.
10.
12.
14.
16.
18.
80.
78.
76.
74.
72.
70.
68.
66.
64.
62.
60.

Fig. 21.1

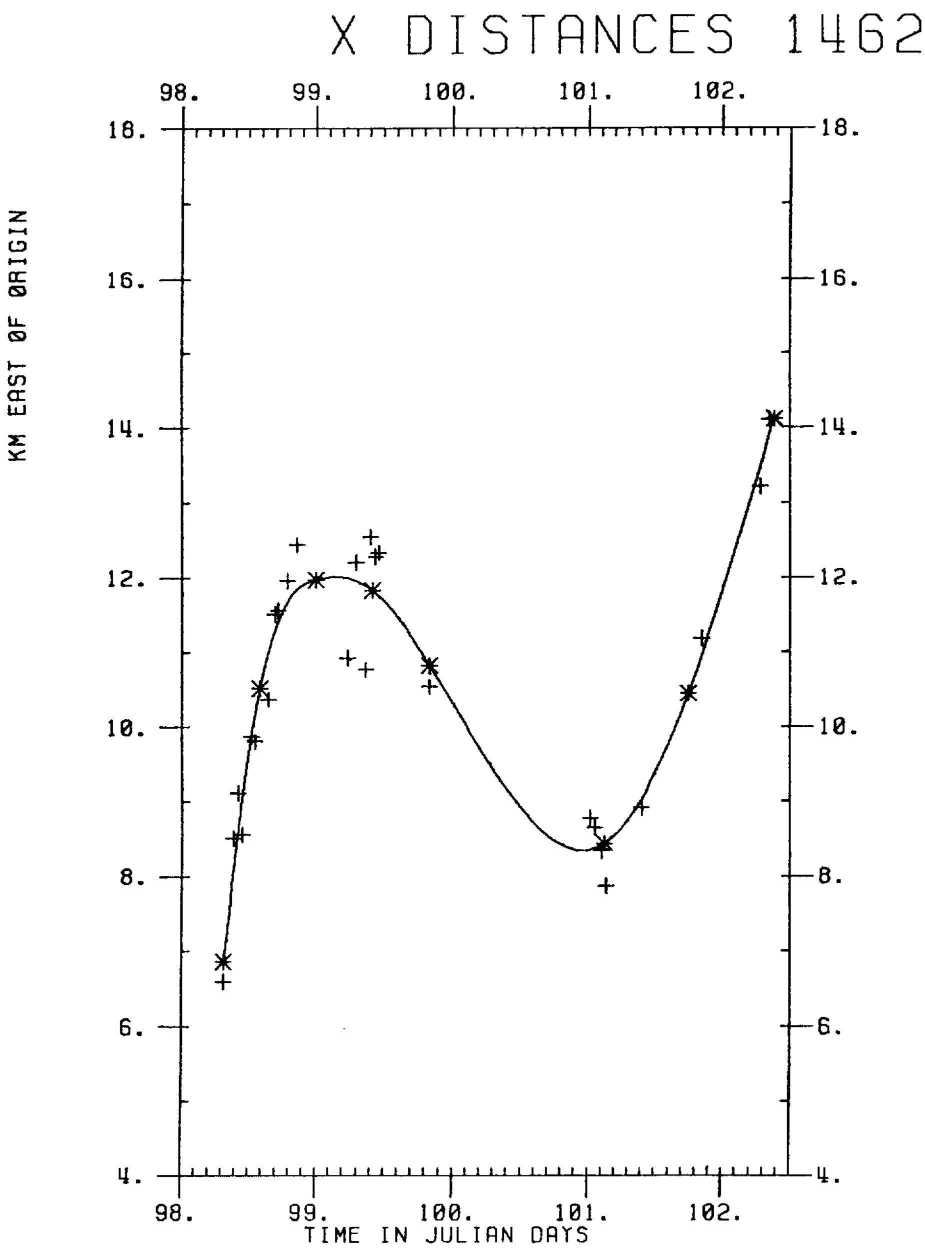

X DISTANCES 1462
98.
99.
100.
101.
102.
18.
16.
14.
12.
10.
8.
6.
4.
KM EAST ØF ØRIGIN
TIME IN JULIAN DAYS

Fig. 21.2

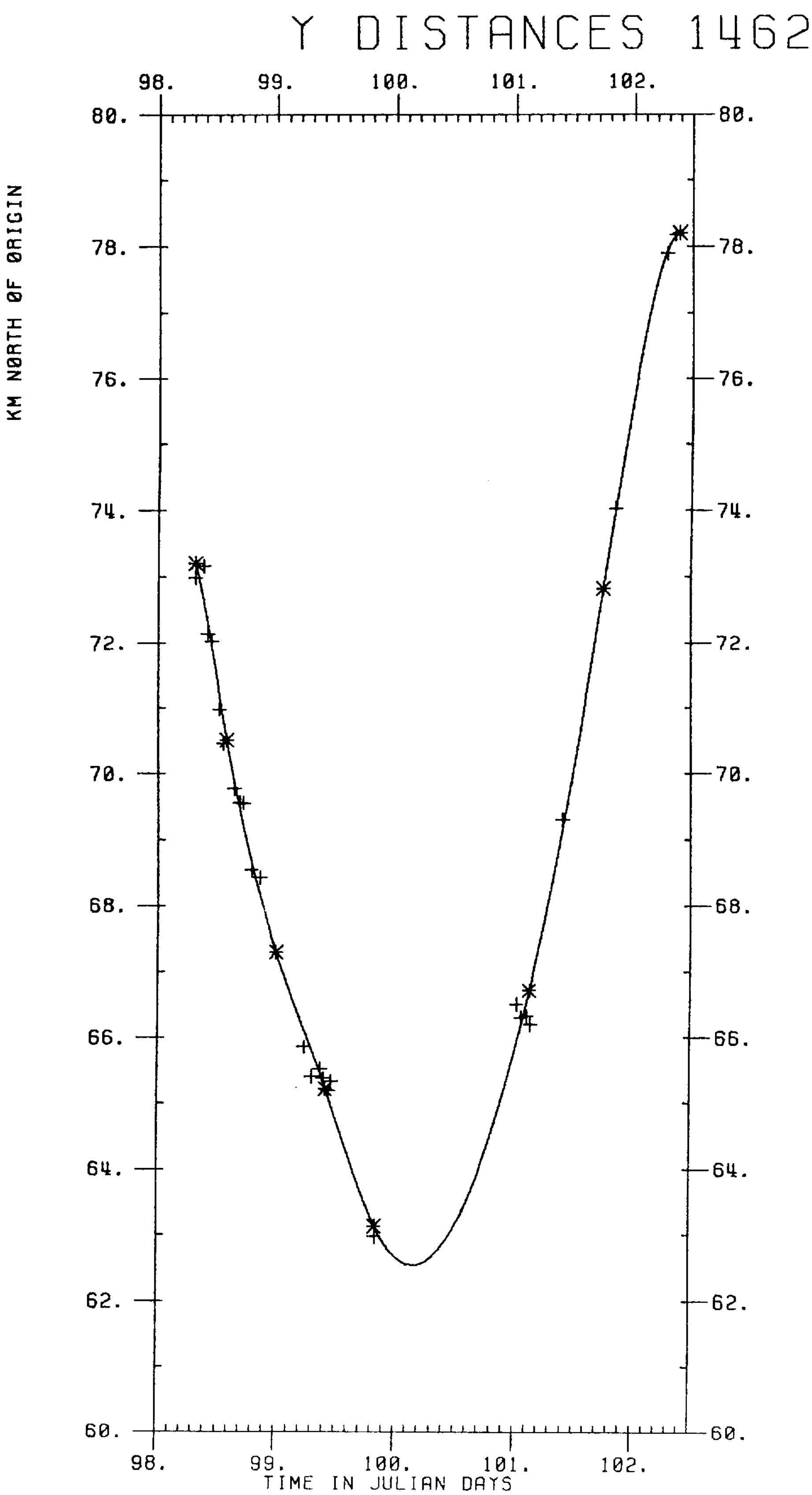

Y DISTANCES 1462
98.
99.
100.
101.
102.
80.
78.
76.
74.
72.
70.
68.
66.
64.
62.
60.
KM NØRTH ØF ØRIGIN
TIME IN JULIAN DAYS

Fig. 21.3

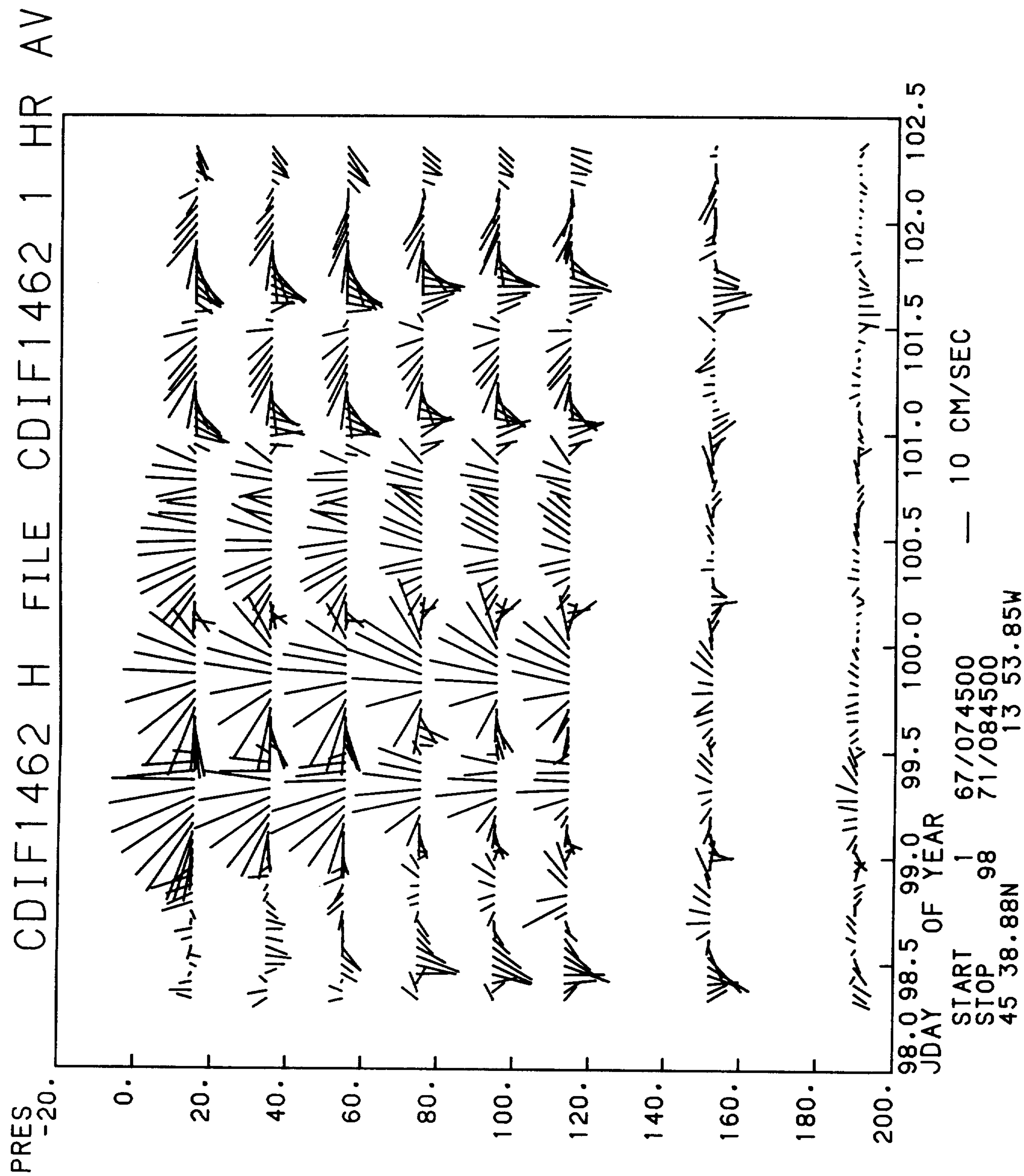

CDIF1462 H FILE CDIF1462 1 HR AV
PRES
-20.
0.
20.
40.
60.
80.
100.
120.
140.
160.
180.
200.
98.0
98.5
99.0
99.5
100.0
100.5
101.0
101.5
102.0
102.5
JDAY OF YEAR
10 CM/SEC
START 1 67/074500
STOP 98 71/084500
45 38.88N 13 53.85W

Fig. 22

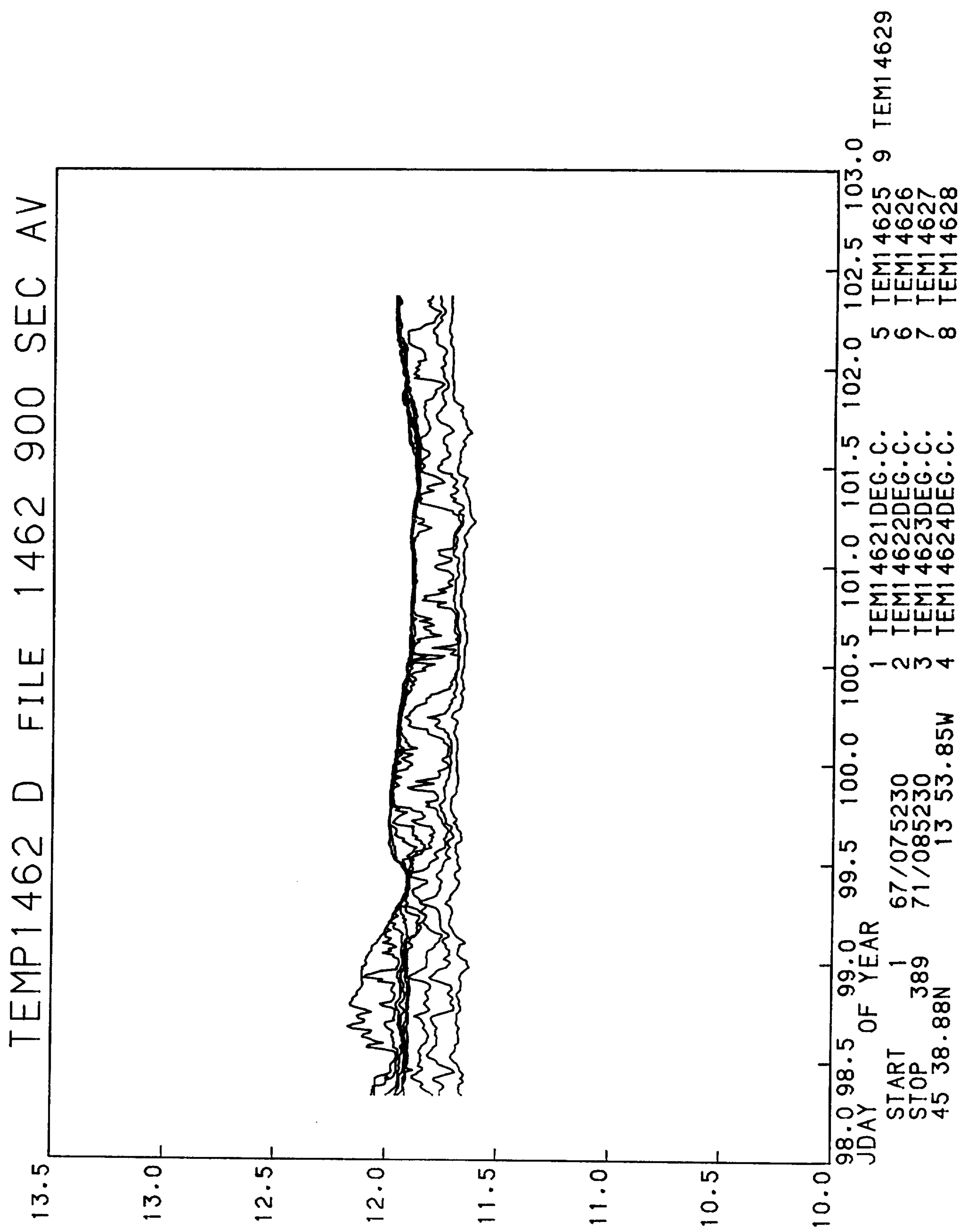
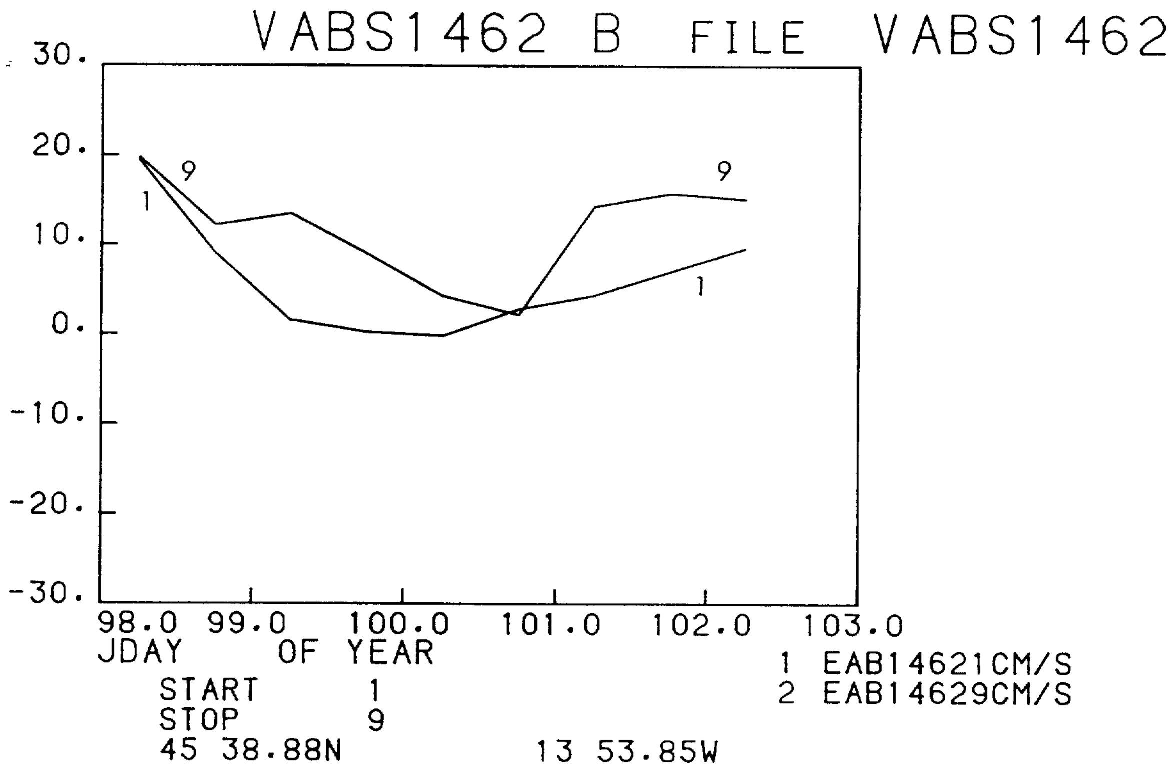

TEMP1462 D FILE 1462 900 SEC AV
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 TEM14621DEG.C.
2 TEM14622DEG.C.
3 TEM14623DEG.C.
4 TEM14624DEG.C.
5 TEM14625
6 TEM14626
7 TEM14627
8 TEM14628
9 TEM14629

Fig. 23


VABS1462 B FILE VABS1462
30.
20.
10.
0.
-10.
-20.
-30.
98.0 99.0 100.0 101.0 102.0 103.0
JDAY OF YEAR
1 EAB14621CM/S
2 EAB14629CM/S
START 1
STOP 9
45 38.88N 13 53.85W

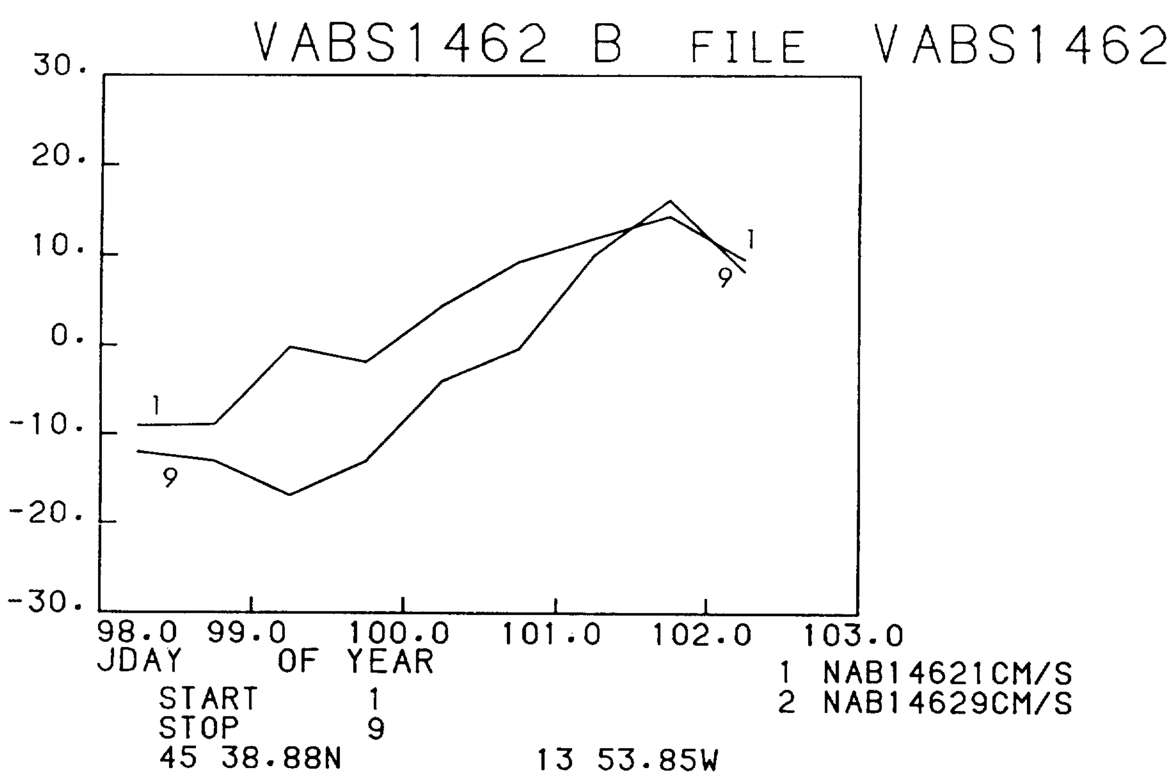

VABS1462 B FILE VABS1462
30.
20.
10.
0.
-10.
-20.
-30.
98.0 99.0 100.0 101.0 102.0 103.0
JDAY OF YEAR
1 NAB14621CM/S
2 NAB14629CM/S
START 1
STOP 9
45 38.88N 13 53.85W

Fig. 24

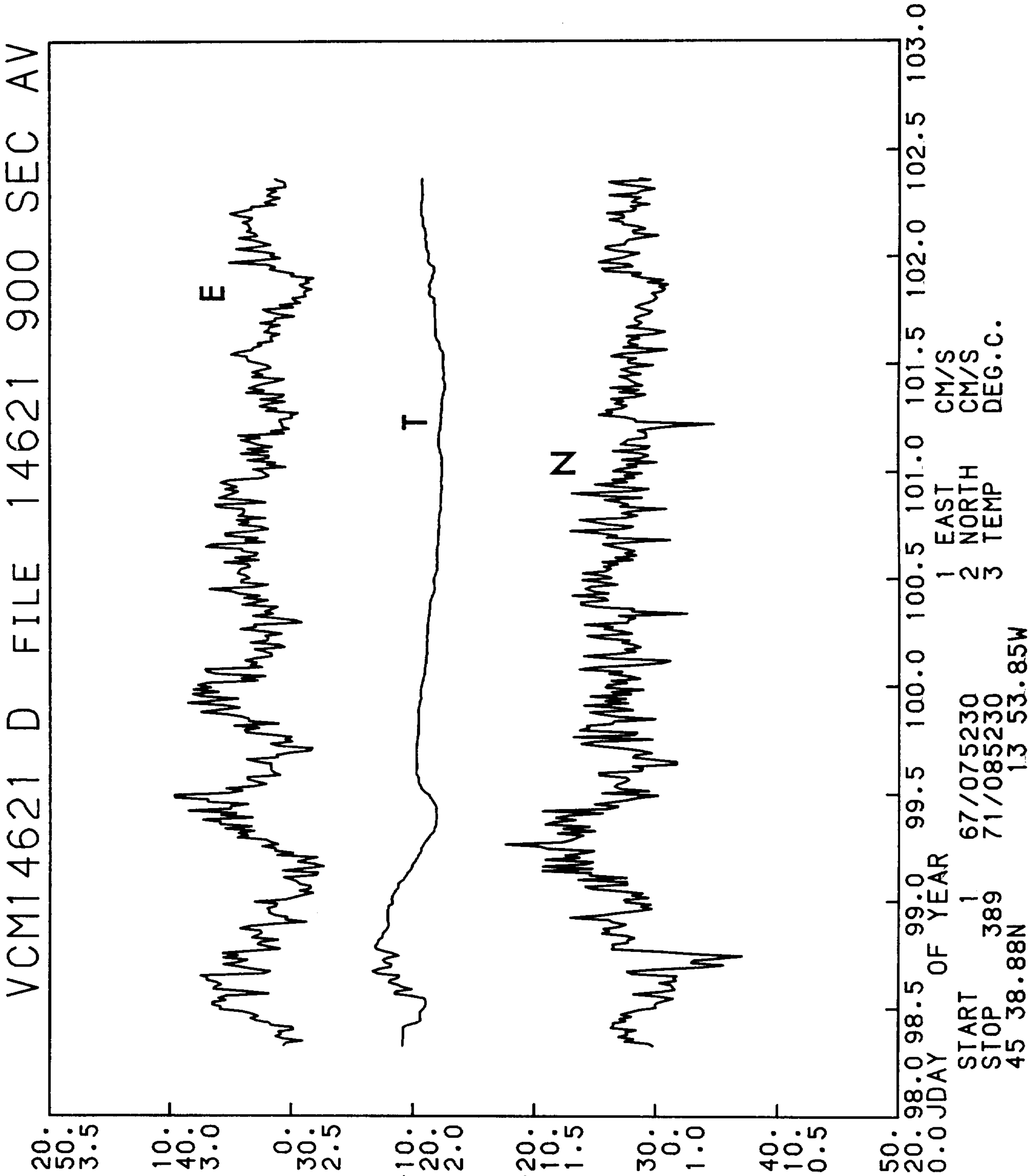

VCM14621 D FILE 14621 900 SEC AV
E
T
N
JDAY OF YEAR
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 25.1

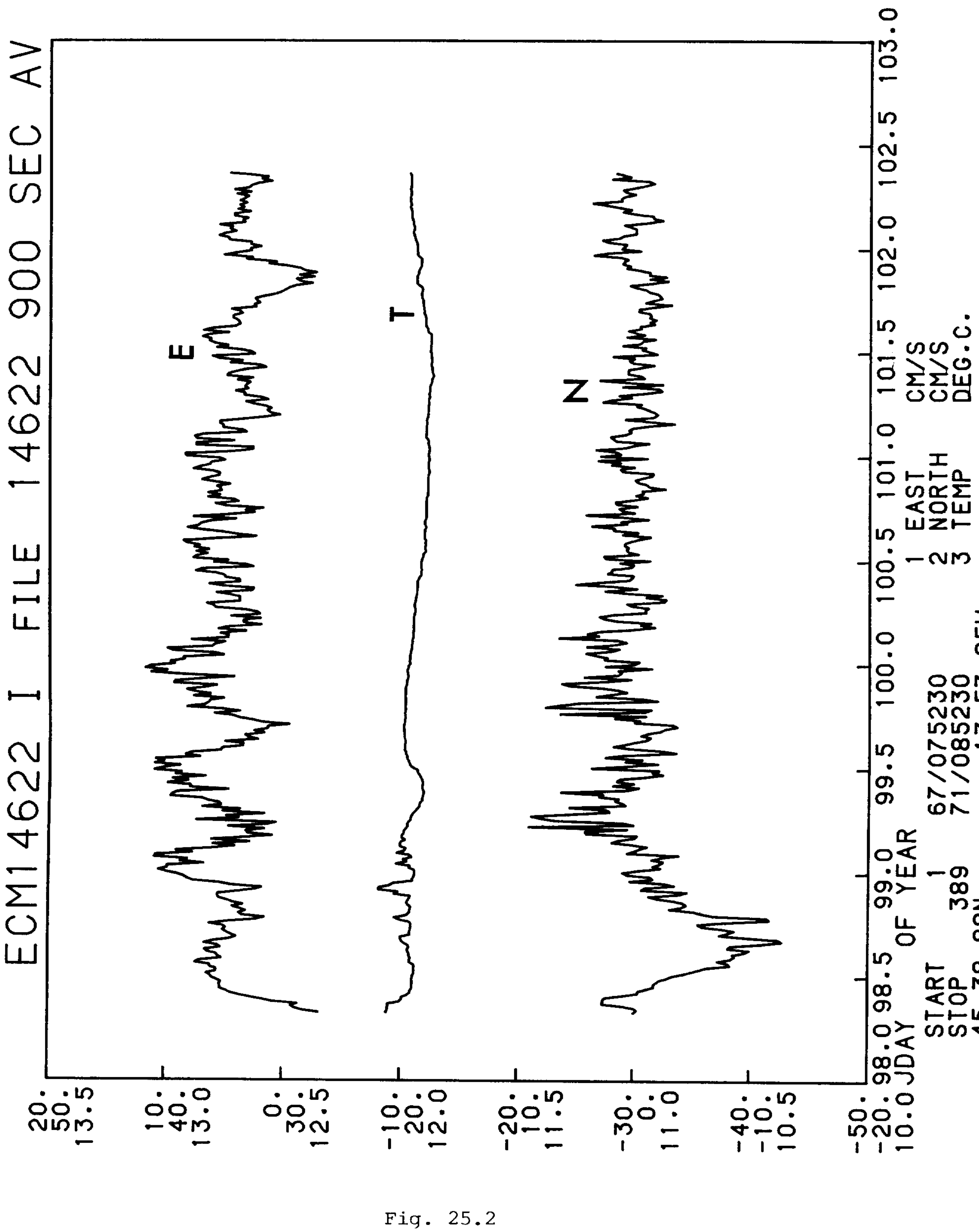

ECM14622 I FILE 14622 900 SEC AV
E
T
N
JDAY OF YEAR
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50. 13.5
10. 40. 13.0
0. 30. 12.5
-10. 20. 12.0
-20. 10. 11.5
-30. 0. 11.0
-40. -10. 10.5
-50. -20. 10.0

Fig. 25.2

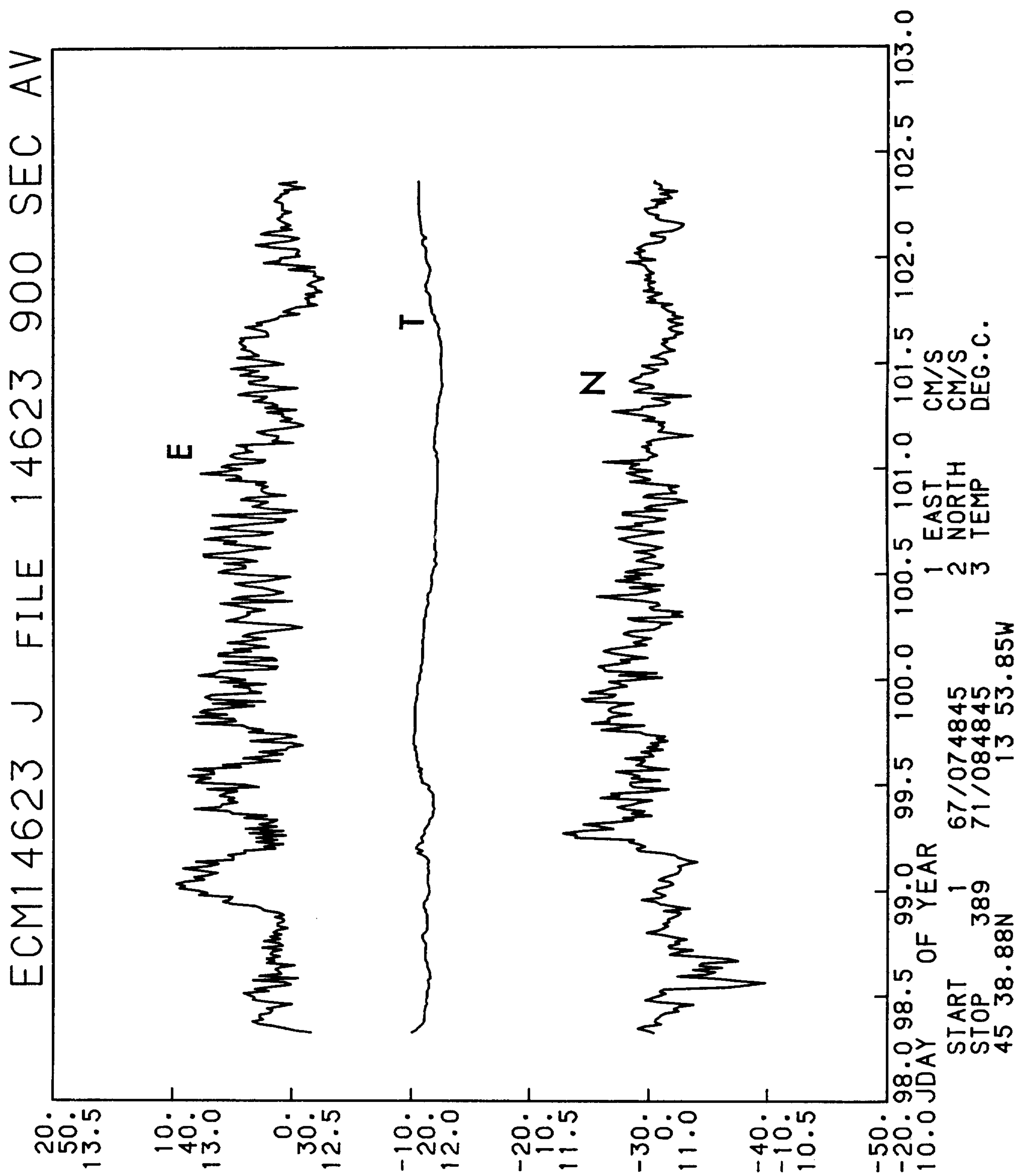

ECM14623 J FILE 14623 900 SEC AV
E
T
N
20. 50.5 13.5
10. 40.0 13.0
0. 30.5 12.5
-10. 20.0 12.0
-20. 10.5 11.5
-30. 0. 11.0
-40. -10.5 10.5
-50. -20.0 10.0
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/074845
STOP 389 71/084845
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 25.3

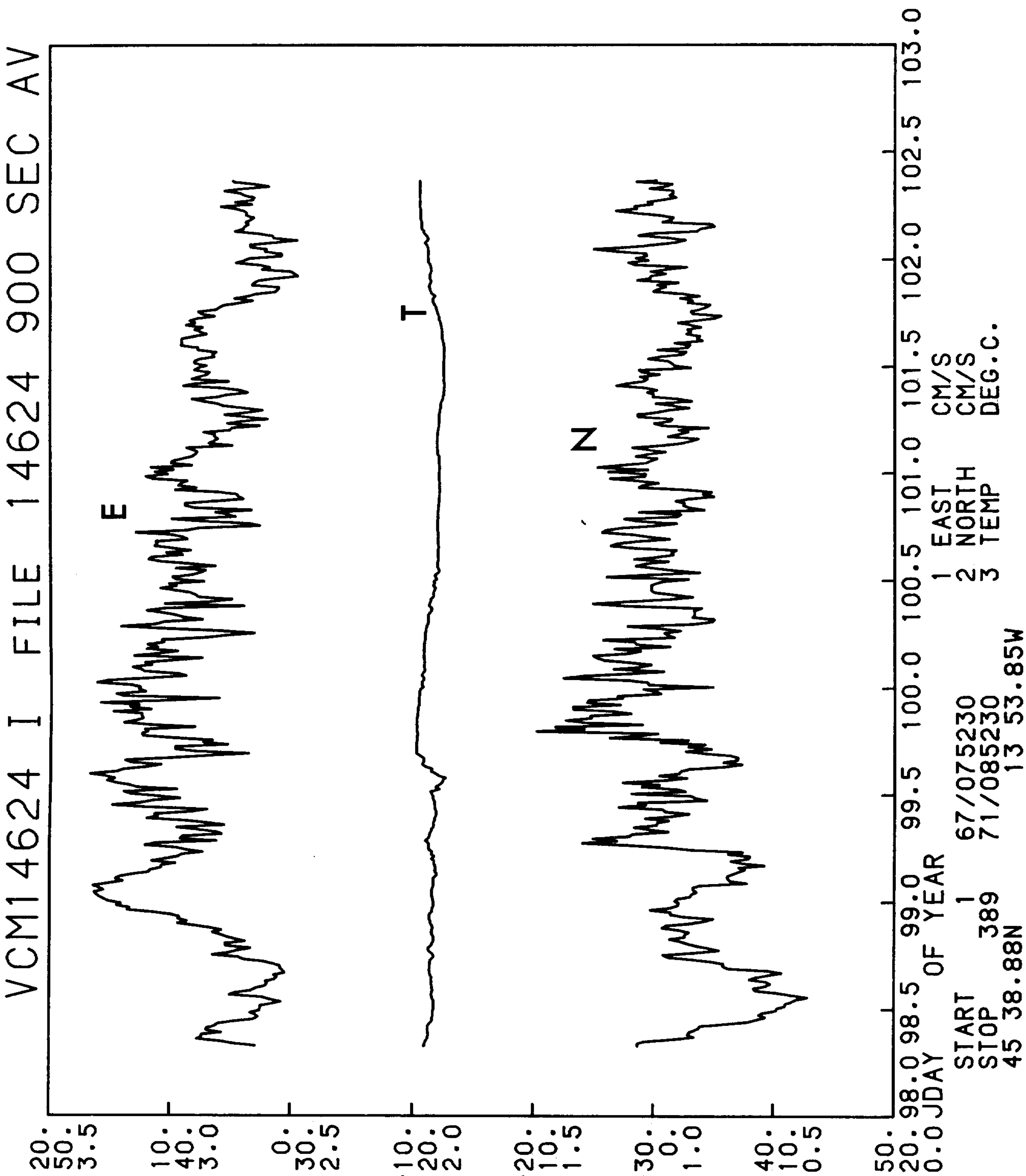

VCM14624 I FILE 14624 900 SEC AV
E
T
N
JDAY OF YEAR
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 25.4

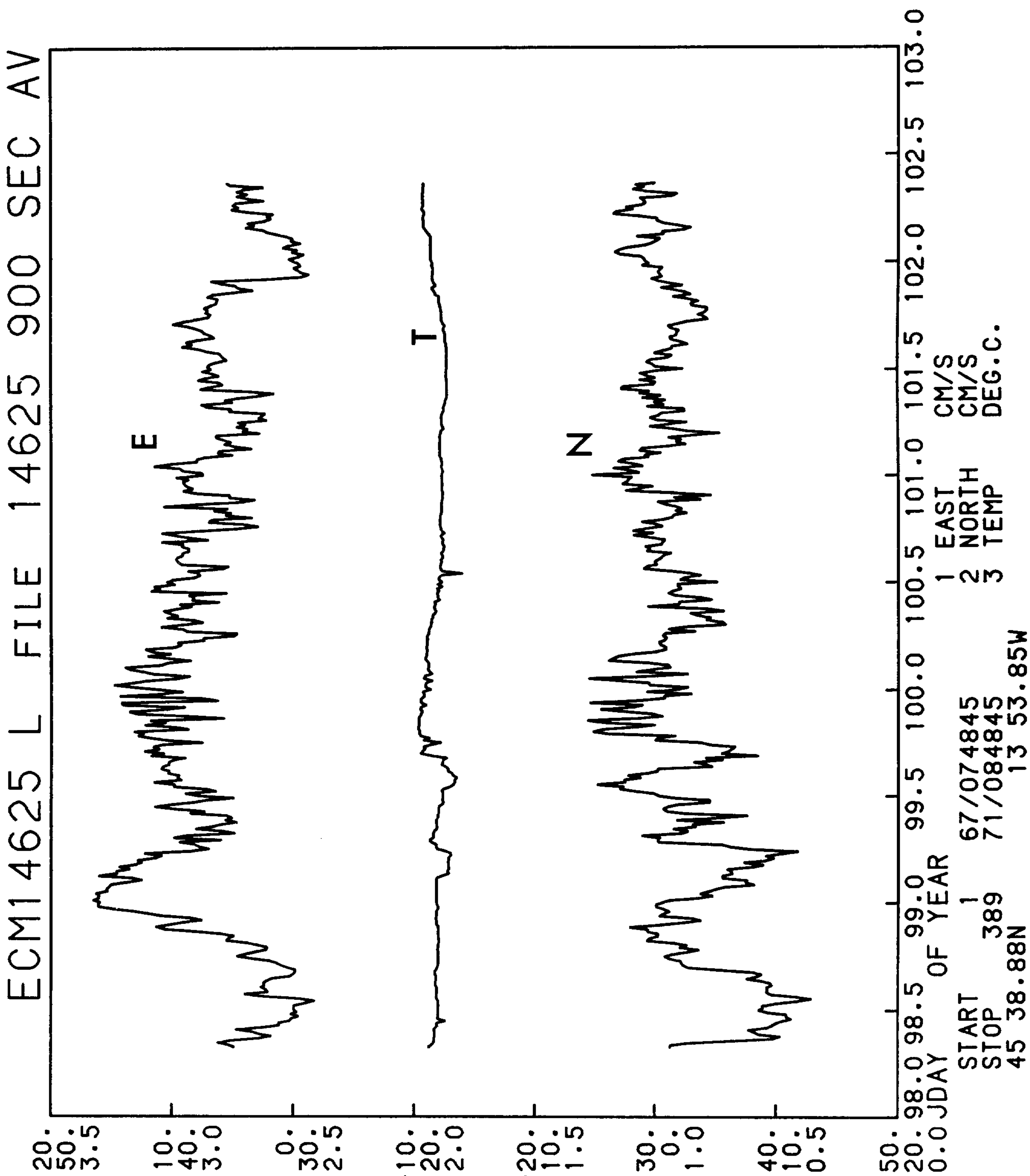

ECM14625 L FILE 14625 900 SEC AV
E
T
N
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/074845
STOP 389 71/084845
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50.5 13.5
10. 40. 13.0
0. 30.5 12.5
-10. 20.0 12.0
-20. 10.5 11.5
-30. 0. 11.0
-40. -10.5 10.5
-50. -20.0 10.0

Fig. 25.5

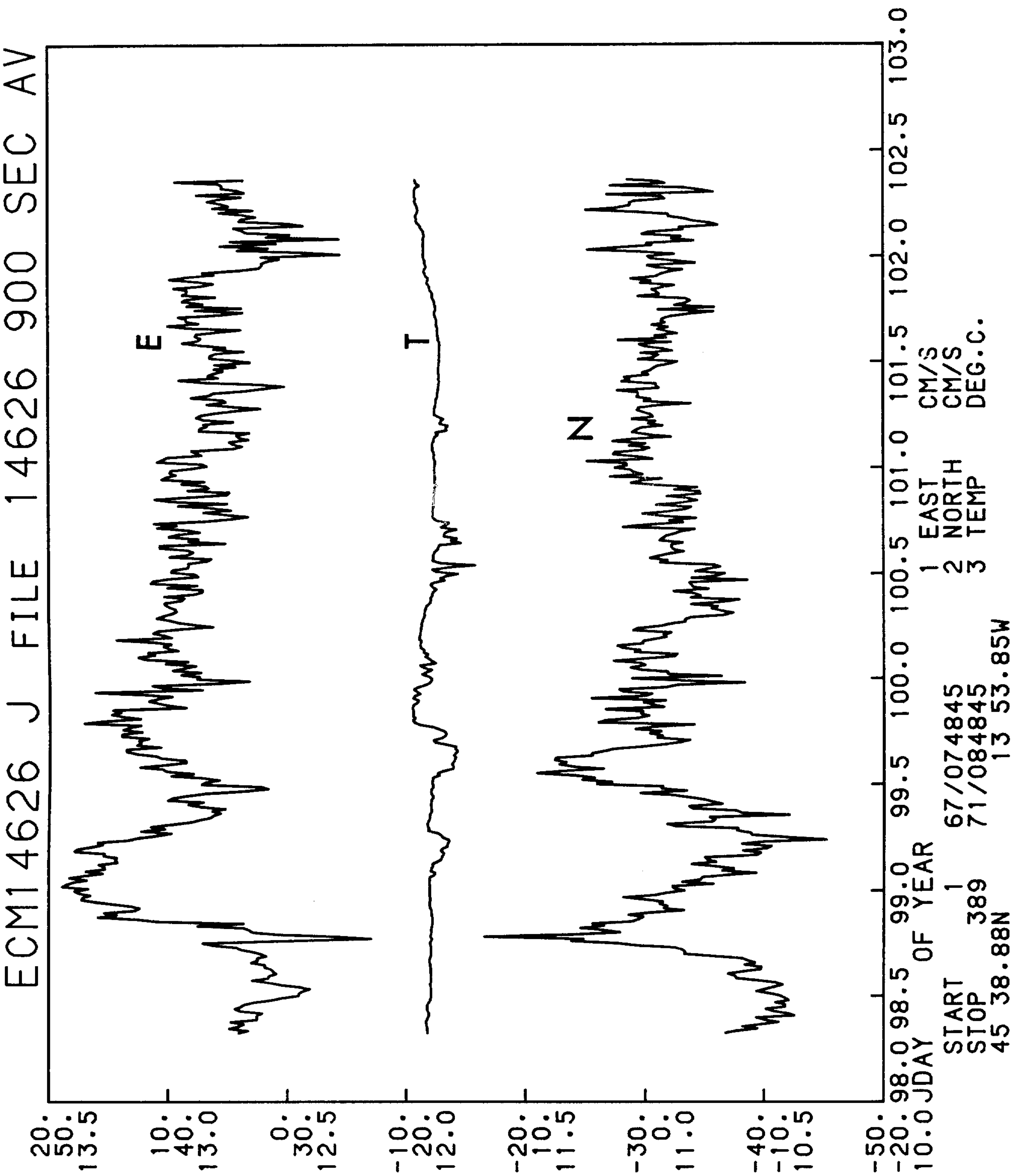

ECM14626 J FILE 14626 900 SEC AV
E
T
N
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/074845
STOP 389 71/084845
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
20. 50.5 13.5
10. 40.0 13.0
0. 30.5 12.5
-10. 20.0 12.0
-20. 10.5 11.5
-30. 0. 11.0
-40. -10.5 10.5
-50. -20.0 10.0

Fig. 25.6

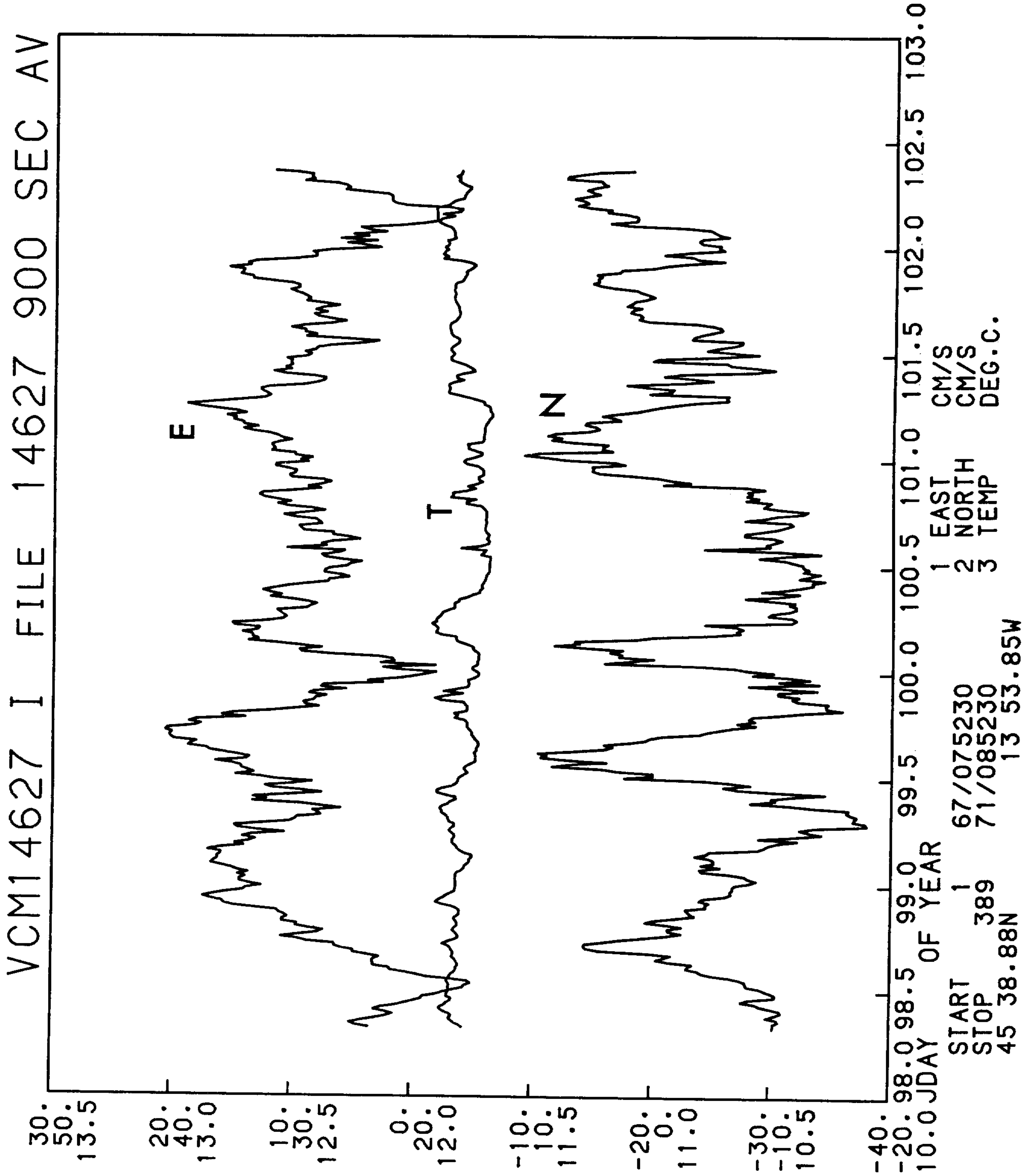

VCM14627 I FILE 14627 900 SEC AV
E
T
N
JDAY OF YEAR
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
30. 50. 13.5
20. 40. 13.0
10. 30. 12.5
0. 20. 12.0
-10. 10. 11.5
-20. 0. 11.0
-30. -10. 10.5
-40. -20. 10.0

Fig. 25.7

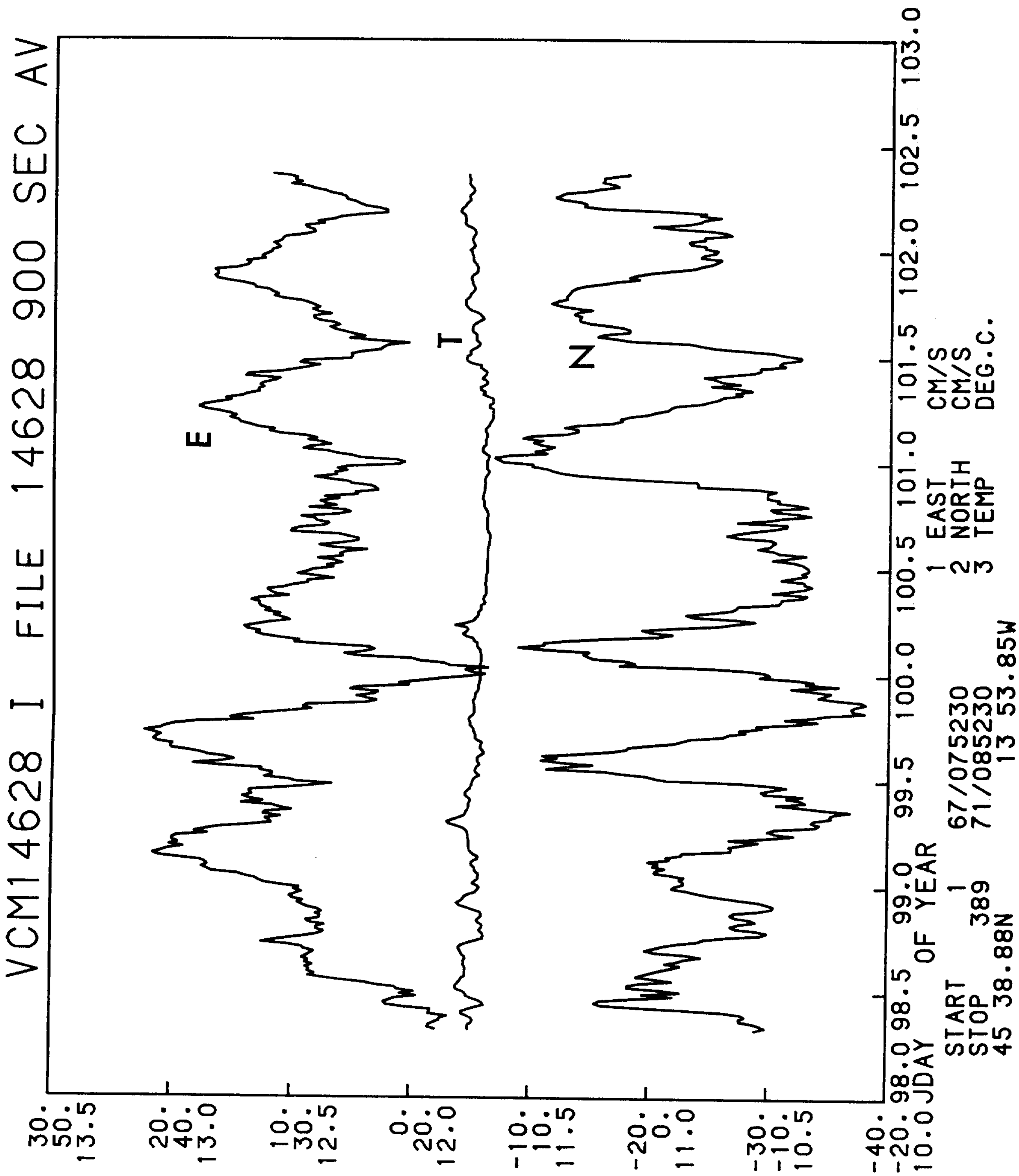

VCM14628 I FILE 14628 900 SEC AV
E
T
N
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/075230
STOP 389 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
30. 50. 13.5
20. 40. 13.0
10. 30. 12.5
0. 20. 12.0
-10. 10. 11.5
-20. 0. 11.0
-30. -10. 10.5
-40. -20. 10.0

Fig. 25.8

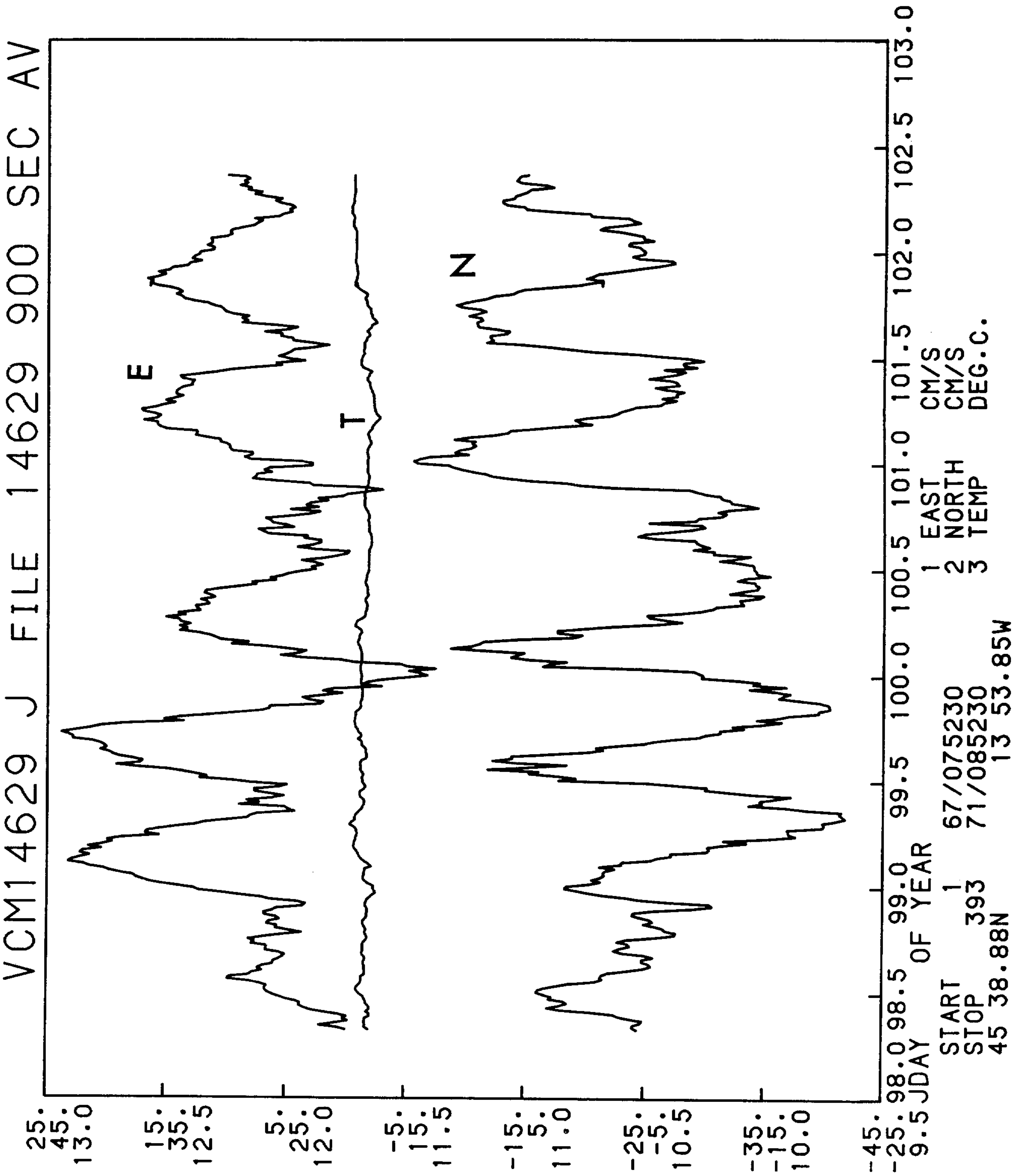

VCM14629 J FILE 14629 900 SEC AV
E
T
N
25. 45. 13.0
15. 35. 12.5
5. 25. 12.0
-5. 15. 11.5
-15. 5. 11.0
-25. -5. 10.5
-35. -15. 10.0
-45. -25. 9.5
98.0 98.5 99.0 99.5 100.0 100.5 101.0 101.5 102.0 102.5 103.0
JDAY OF YEAR
START 1 67/075230
STOP 393 71/085230
45 38.88N 13 53.85W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 25.9

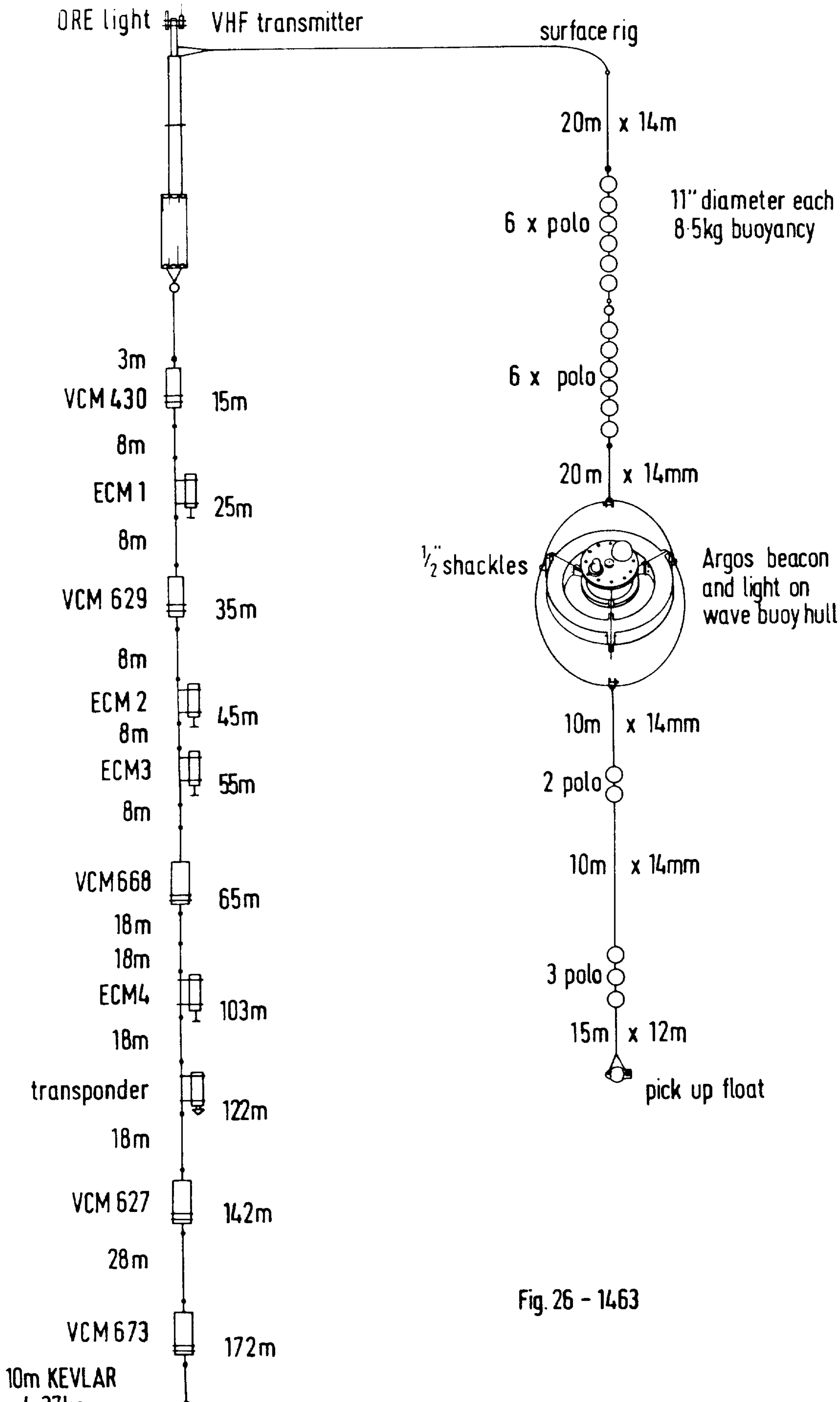

ORE light
VHF transmitter
surface rig
20m x 14m
6 x polo
11" diameter each
8·5kg buoyancy
6 x polo
20 m x 14mm
1/2" shackles
Argos beacon
and light on
wave buoy hull
10m x 14mm
2 polo
10m x 14mm
3 polo
15m x 12m
pick up float
3m
VCM 430
15m
8m
ECM 1
25m
8m
VCM 629
35m
8m
ECM 2
45m
8m
ECM3
55m
8m
VCM668
65m
18m
18m
ECM4
103m
18m
transponder
122m
18m
VCM 627
142m
28m
VCM 673
172m
10m KEVLAR
4·37kg

Fig. 26 - 1463

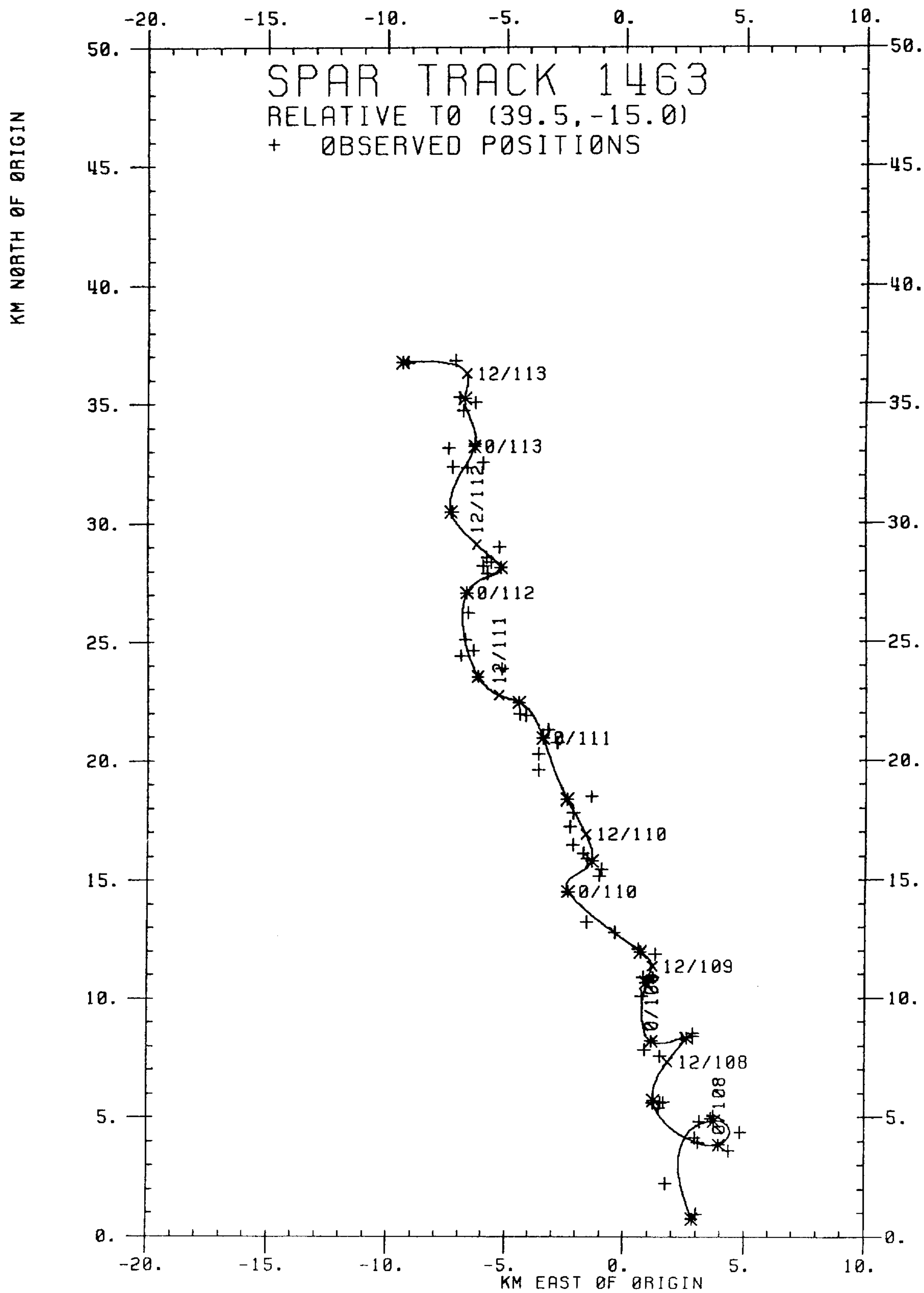

SPAR TRACK 1463
RELATIVE TØ (39.5,-15.0)
+ ØBSERVED PØSITIØNS
KM NØRTH ØF ØRIGIN
KM EAST ØF ØRIGIN
-20. -15. -10. -5. 0. 5. 10.
0. 5. 10. 15. 20. 25. 30. 35. 40. 45. 50.
12/113
0/113
12/112
0/112
12/111
0/111
12/110
0/110
12/109
0/109
12/108
0/108

Fig. 27.1

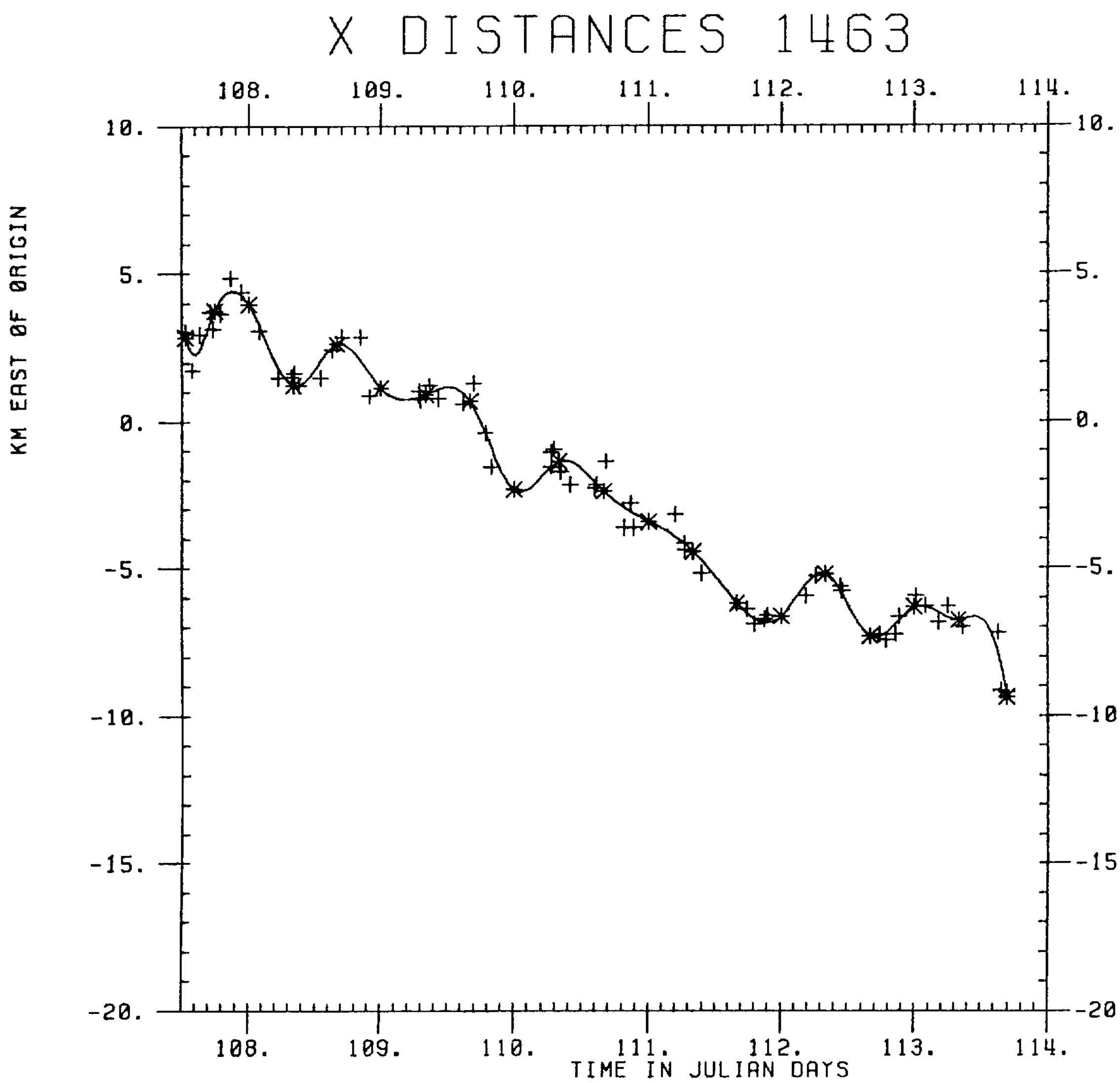

X DISTANCES 1463
108.
109.
110.
111.
112.
113.
114.
10.
5.
0.
-5.
-10.
-15.
-20.
KM EAST ØF ØRIGIN
TIME IN JULIAN DAYS

Fig. 27.2

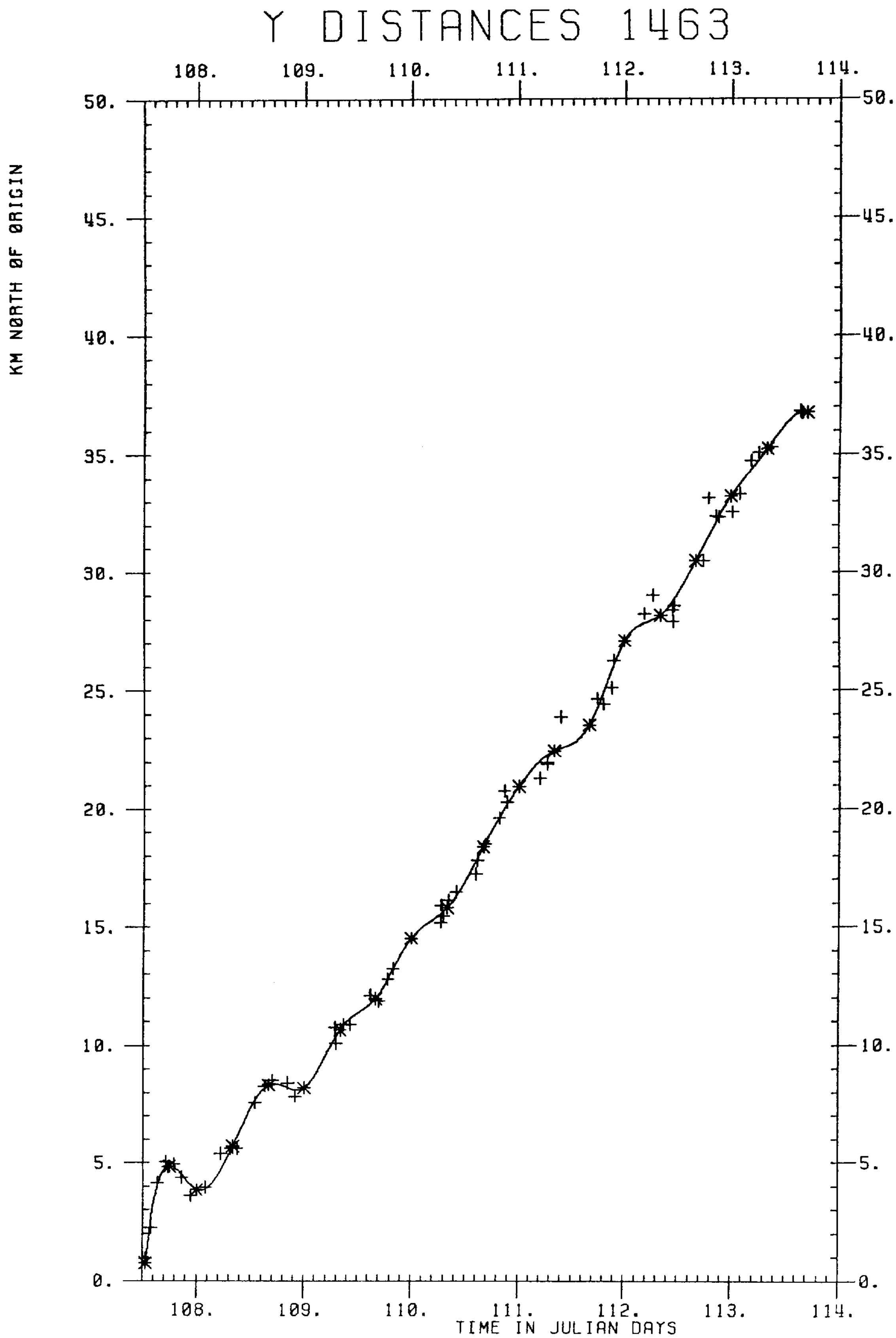

Y DISTANCES 1463
108.
109.
110.
111.
112.
113.
114.
50.
45.
40.
35.
30.
25.
20.
15.
10.
5.
0.
KM NORTH OF ORIGIN
TIME IN JULIAN DAYS

Fig. 27.3

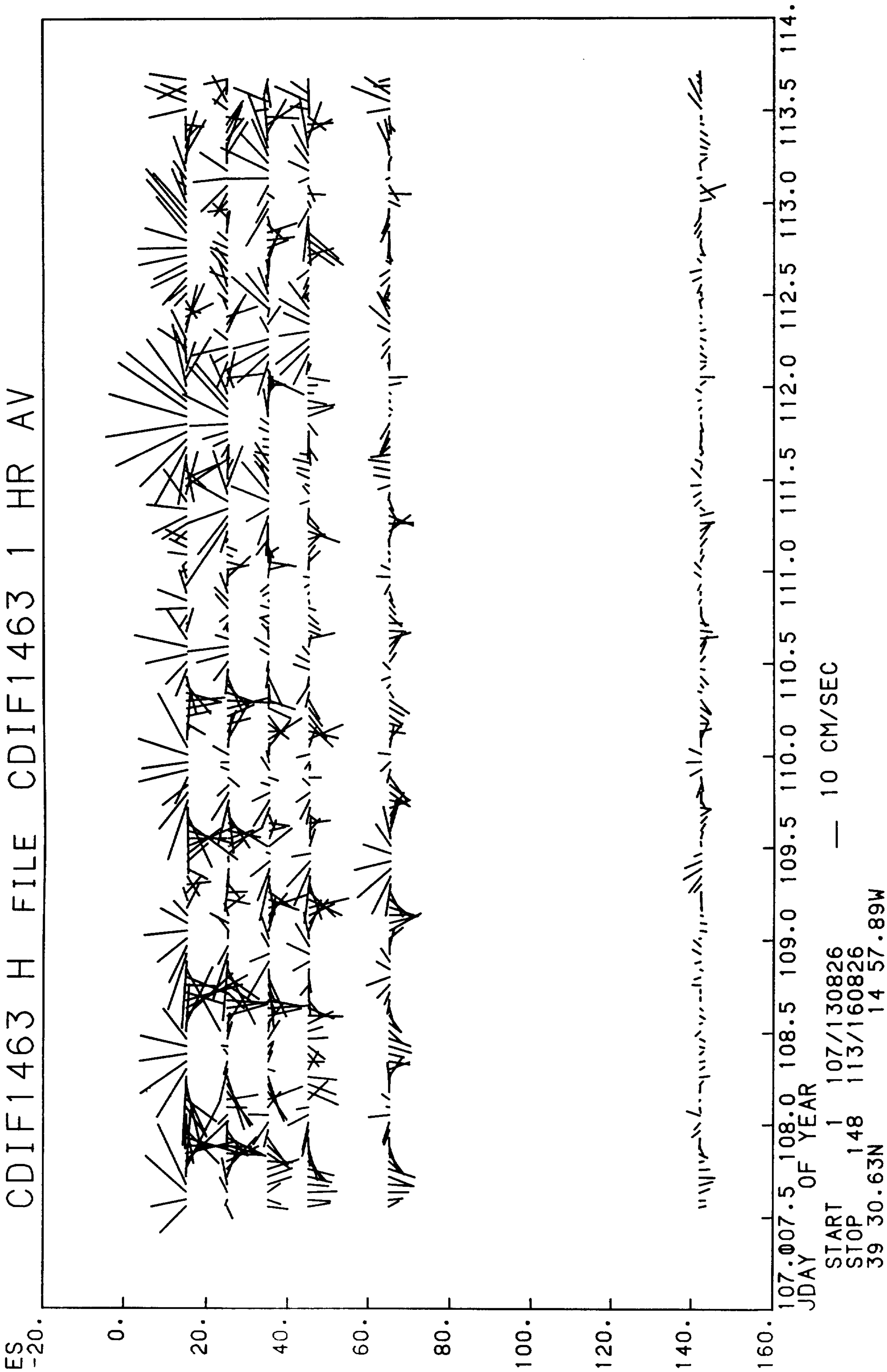

CDIF1463 H FILE CDIF1463 1 HR AV
PRES
-20.
0.
20.
40.
60.
80.
100.
120.
140.
160.
107.0
107.5
108.0
108.5
109.0
109.5
110.0
110.5
111.0
111.5
112.0
112.5
113.0
113.5
114.0
JDAY OF YEAR
— 10 CM/SEC
START 1 107/130826
STOP 148 113/160826
39 30.63N 14 57.89W

Fig. 28

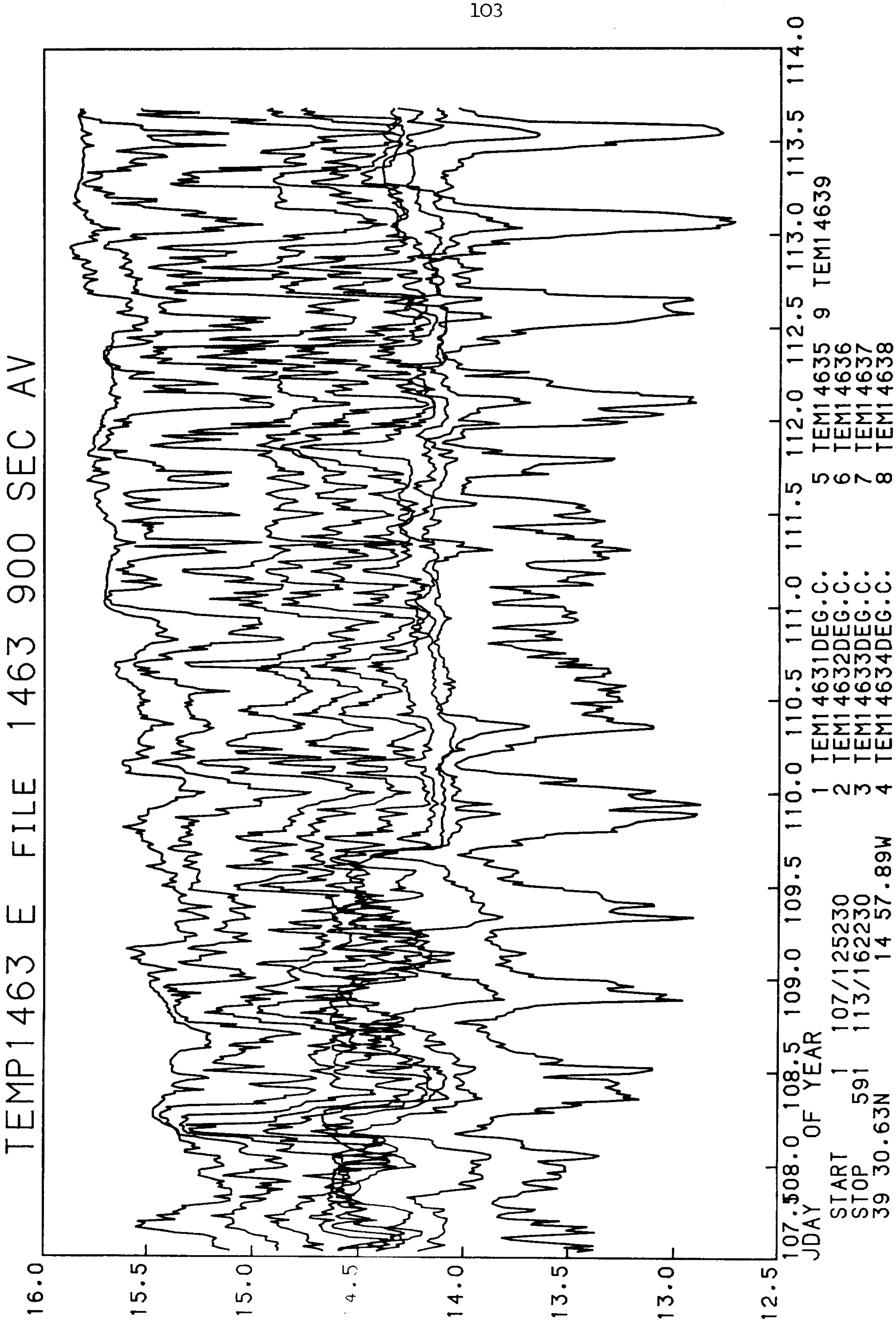
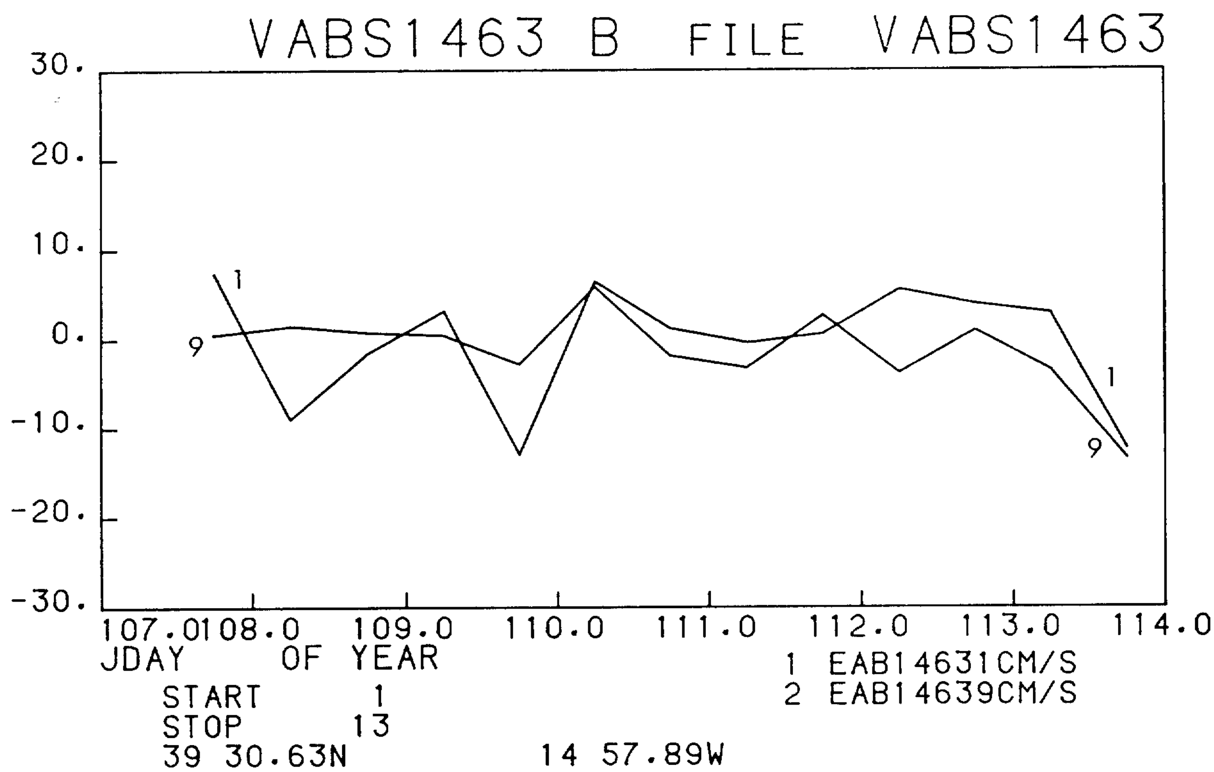

TEMP1463 E FILE 1463 900 SEC AV
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 TEM14631DEG.C.
2 TEM14632DEG.C.
3 TEM14633DEG.C.
4 TEM14634DEG.C.
5 TEM14635
6 TEM14636
7 TEM14637
8 TEM14638
9 TEM14639

Fig. 29


VABS1463 B FILE VABS1463
30.
20.
10.
0.
-10.
-20.
-30.
107.0108.0 109.0 110.0 111.0 112.0 113.0 114.0
JDAY OF YEAR
1 EAB14631CM/S
2 EAB14639CM/S
START 1
STOP 13
39 30.63N 14 57.89W

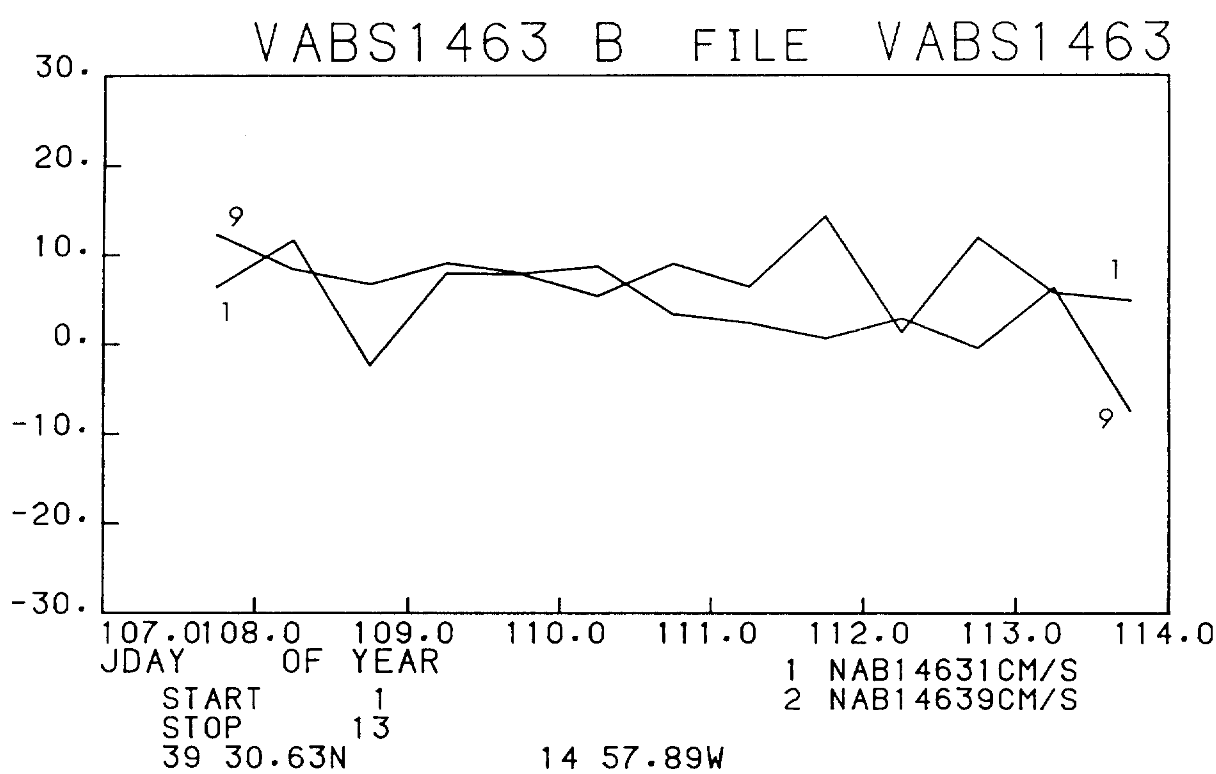

VABS1463 B FILE VABS1463
30.
20.
10.
0.
-10.
-20.
-30.
107.0108.0 109.0 110.0 111.0 112.0 113.0 114.0
JDAY OF YEAR
1 NAB14631CM/S
2 NAB14639CM/S
START 1
STOP 13
39 30.63N 14 57.89W

Fig. 30

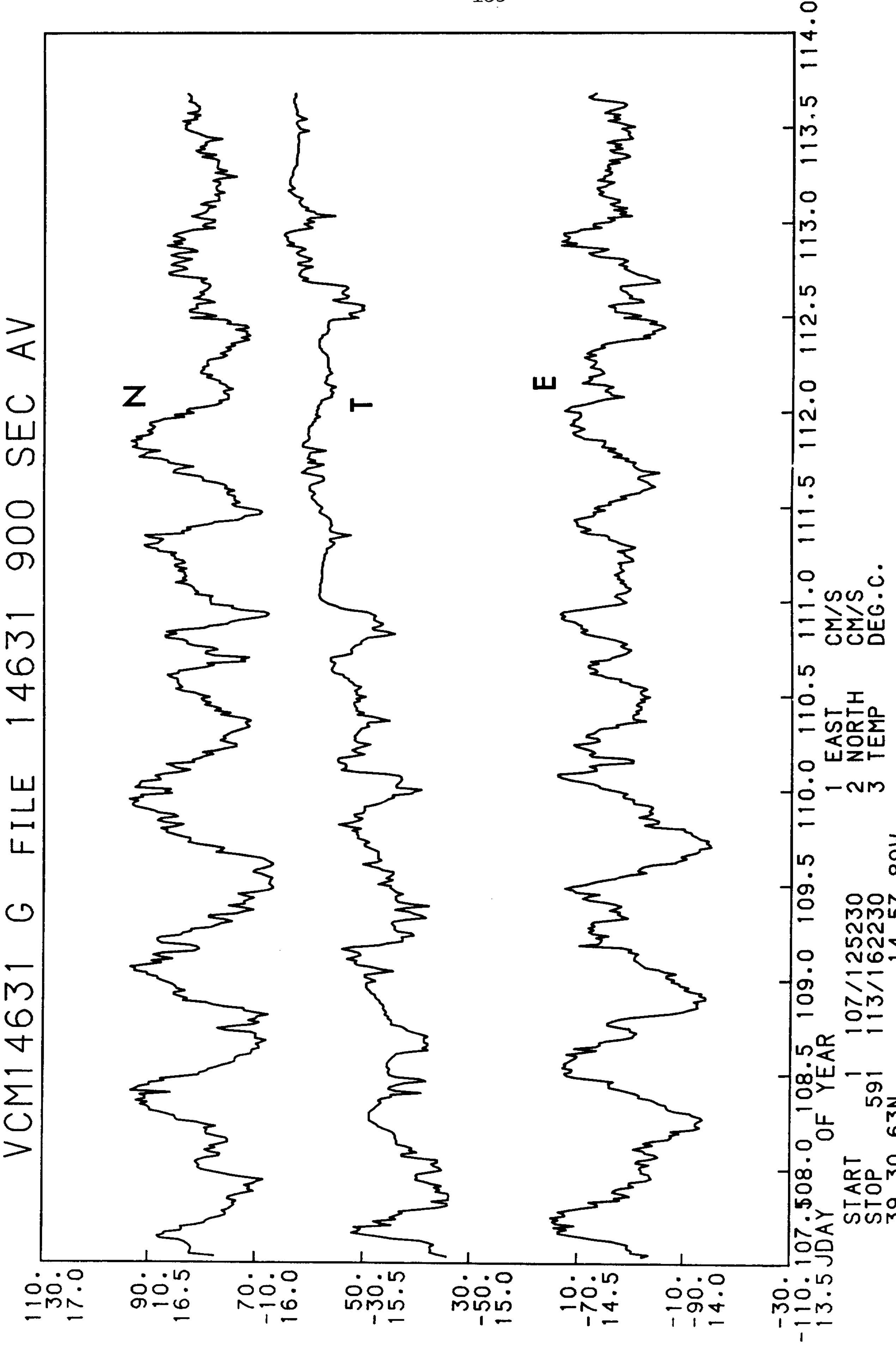

VCM14631 G FILE 14631 900 SEC AV
N
T
E
110. 30. 17.0
90. 10. 16.5
70. -10. 16.0
50. -30. 15.5
30. -50. 15.0
10. -70. 14.5
-10. -90. 14.0
-30. -110. 13.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.1

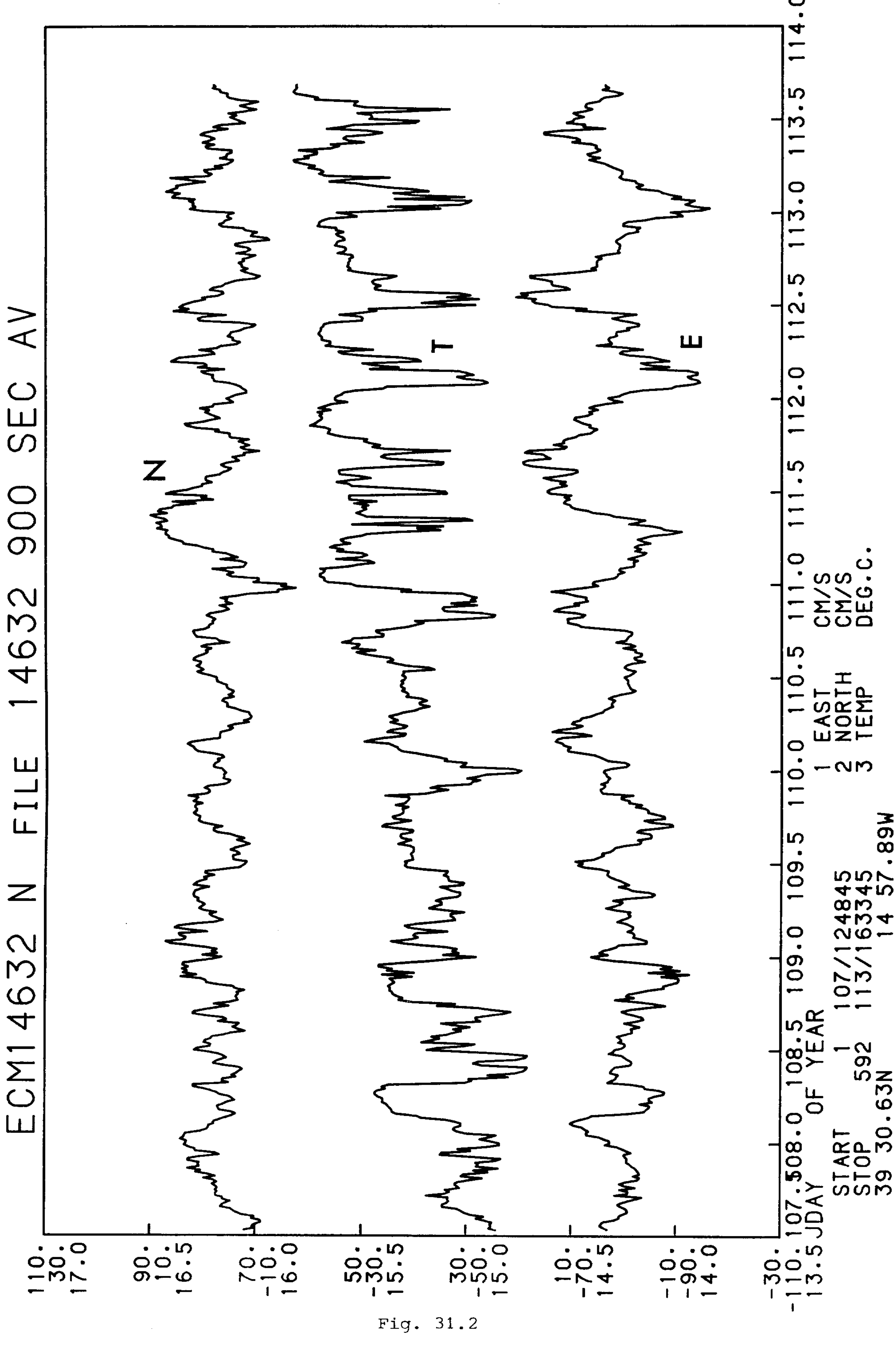

ECM14632 N FILE 14632 900 SEC AV
N
T
E
110. 30. 17.0
90. 10. 16.5
70. -10. 16.0
50. -30. 15.5
30. -50. 15.0
10. -70. 14.5
-10. -90. 14.0
-30. -110. 13.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
START 1 107/124845
STOP 592 113/163345
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.2

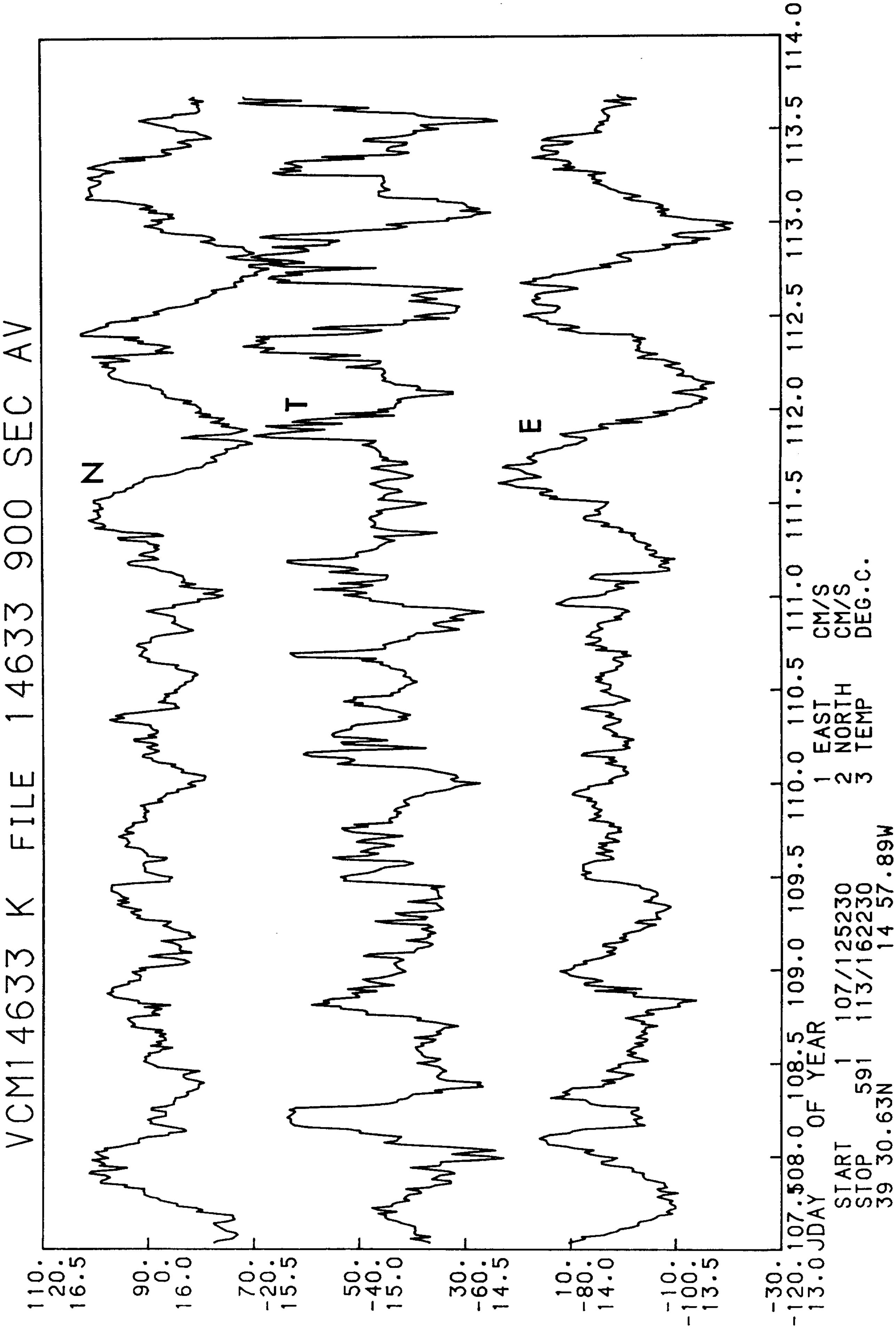

VCM14633 K FILE 14633 900 SEC AV
N
T
E
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
110. 20.5 16.5
90. 0. 16.0
70. -20.5 15.5
50. -40.0 15.0
30. -60.5 14.5
10. -80.0 14.0
-10. -100.5 13.5
-30. -120.0 13.0

Fig. 31.3

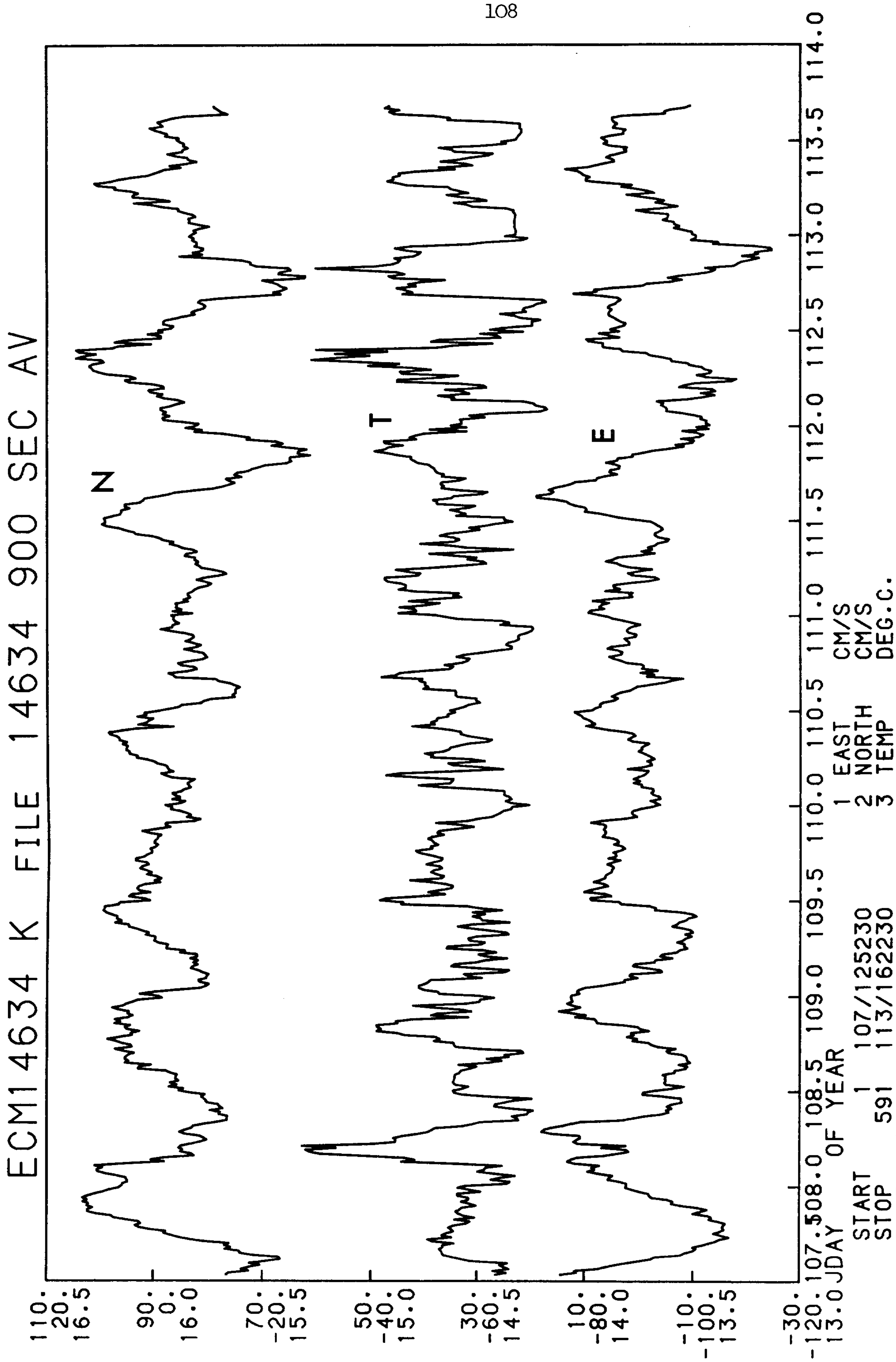

ECM14634 K FILE 14634 900 SEC AV
N
T
E
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.4

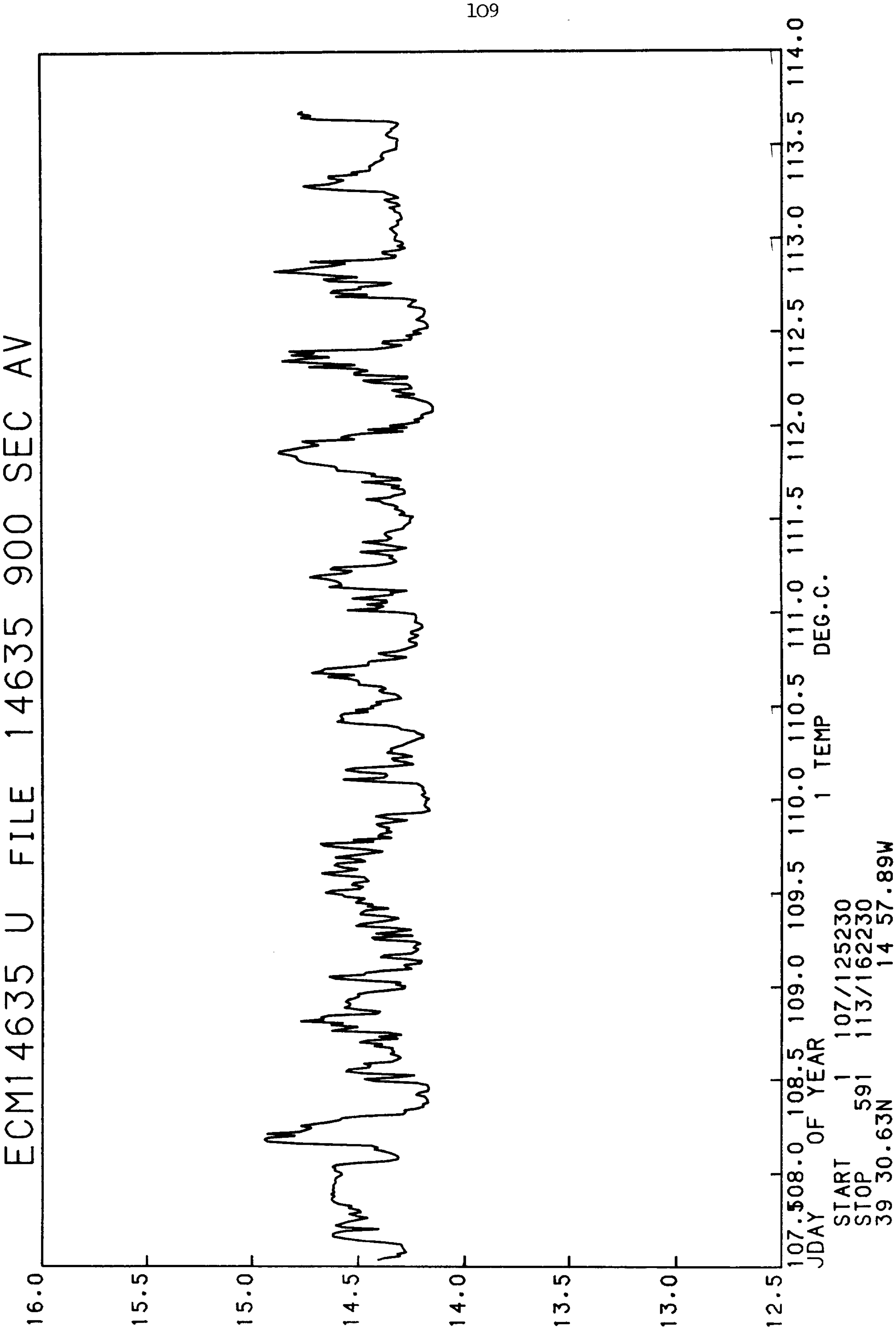

ECM14635 U FILE 14635 900 SEC AV
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
1 TEMP DEG.C.
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W

Fig. 31.5

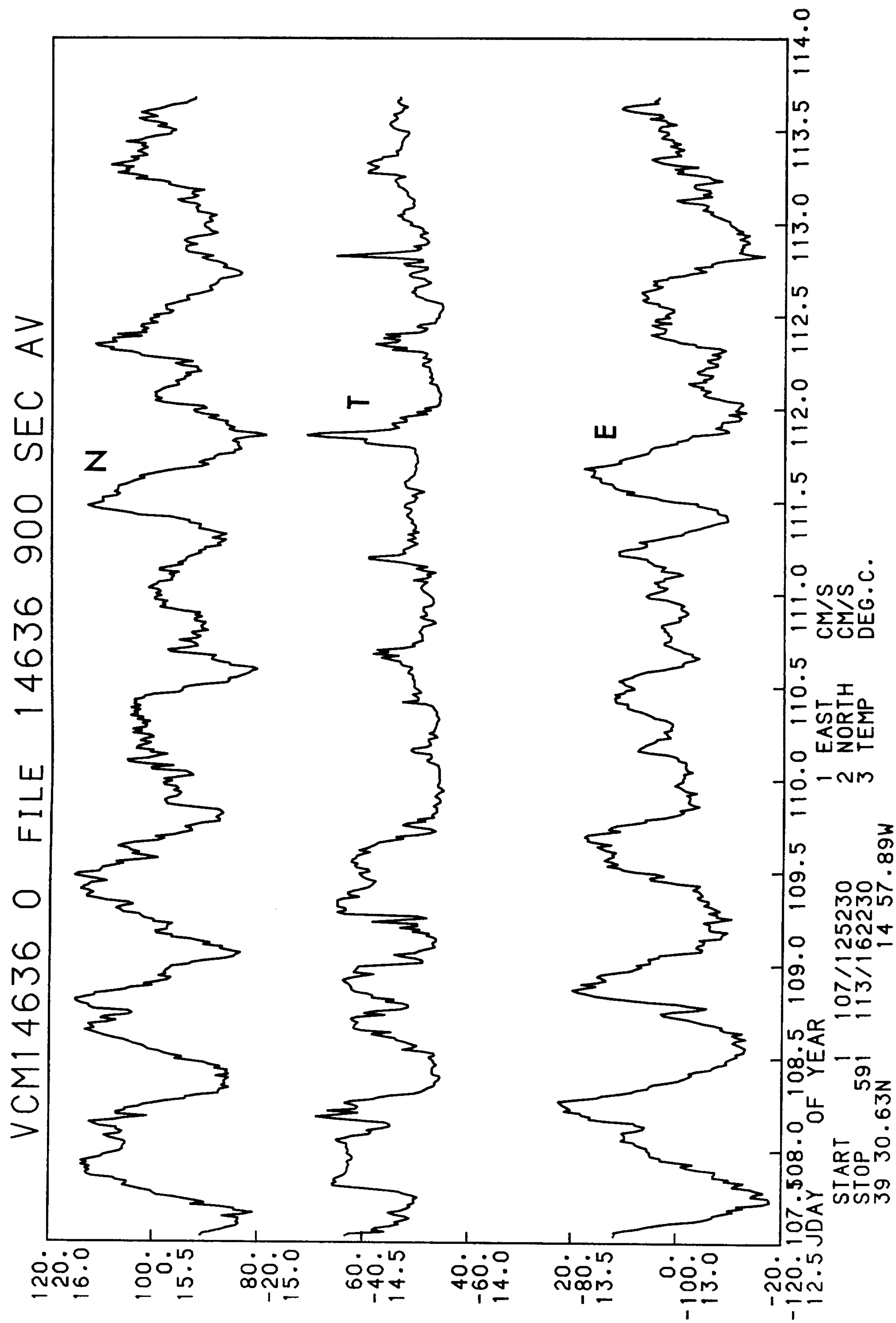

VCM14636 O FILE 14636 900 SEC AV
N
T
E
120. 20. 16.0
100. 0. 15.5
80. -20. 15.0
60. -40. 14.5
40. -60. 14.0
20. -80. 13.5
0. -100. 13.0
-20. -120. 12.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.6

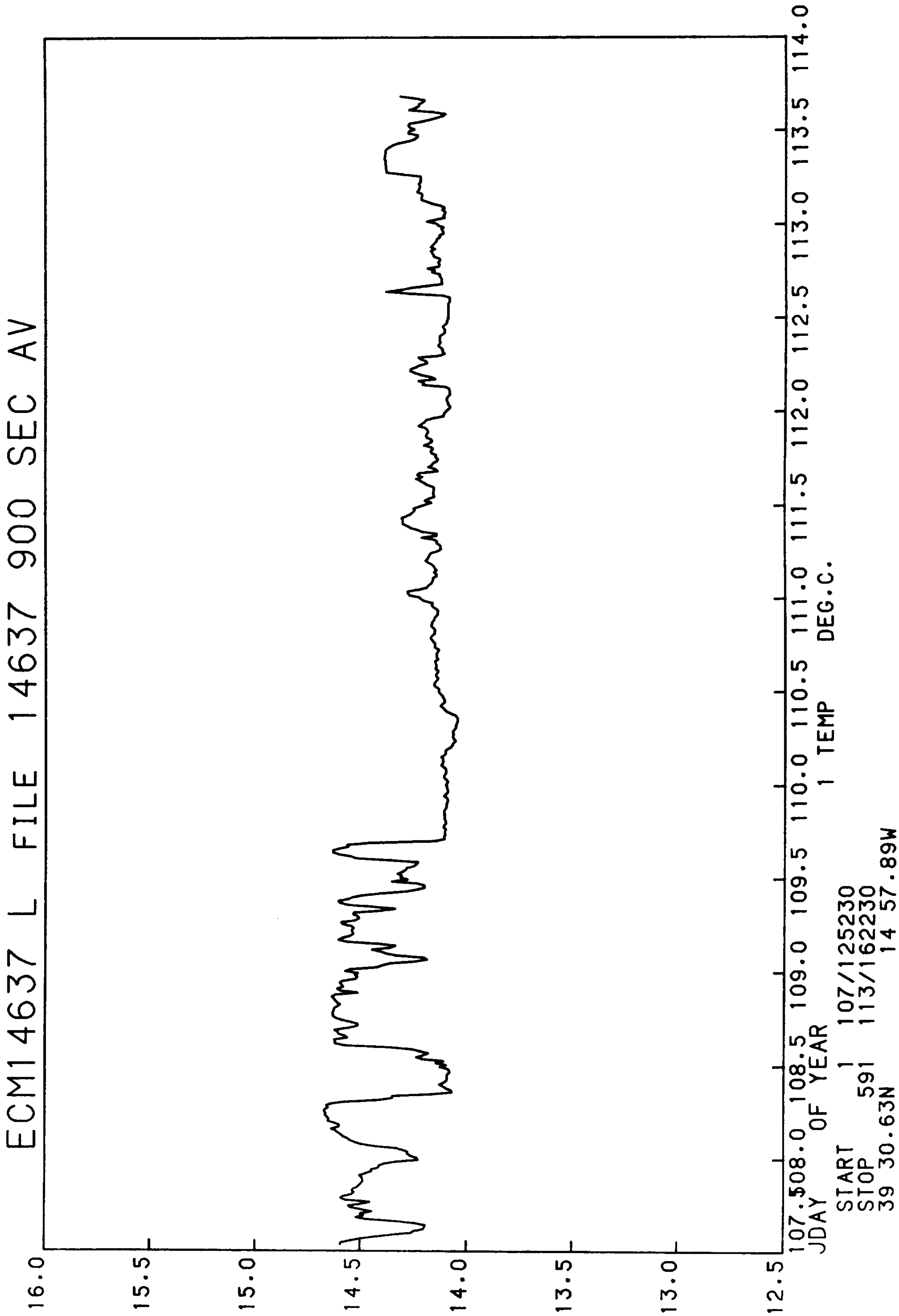

ECM14637 L FILE 14637 900 SEC AV
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
1 TEMP DEG.C.
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W

Fig. 31.7

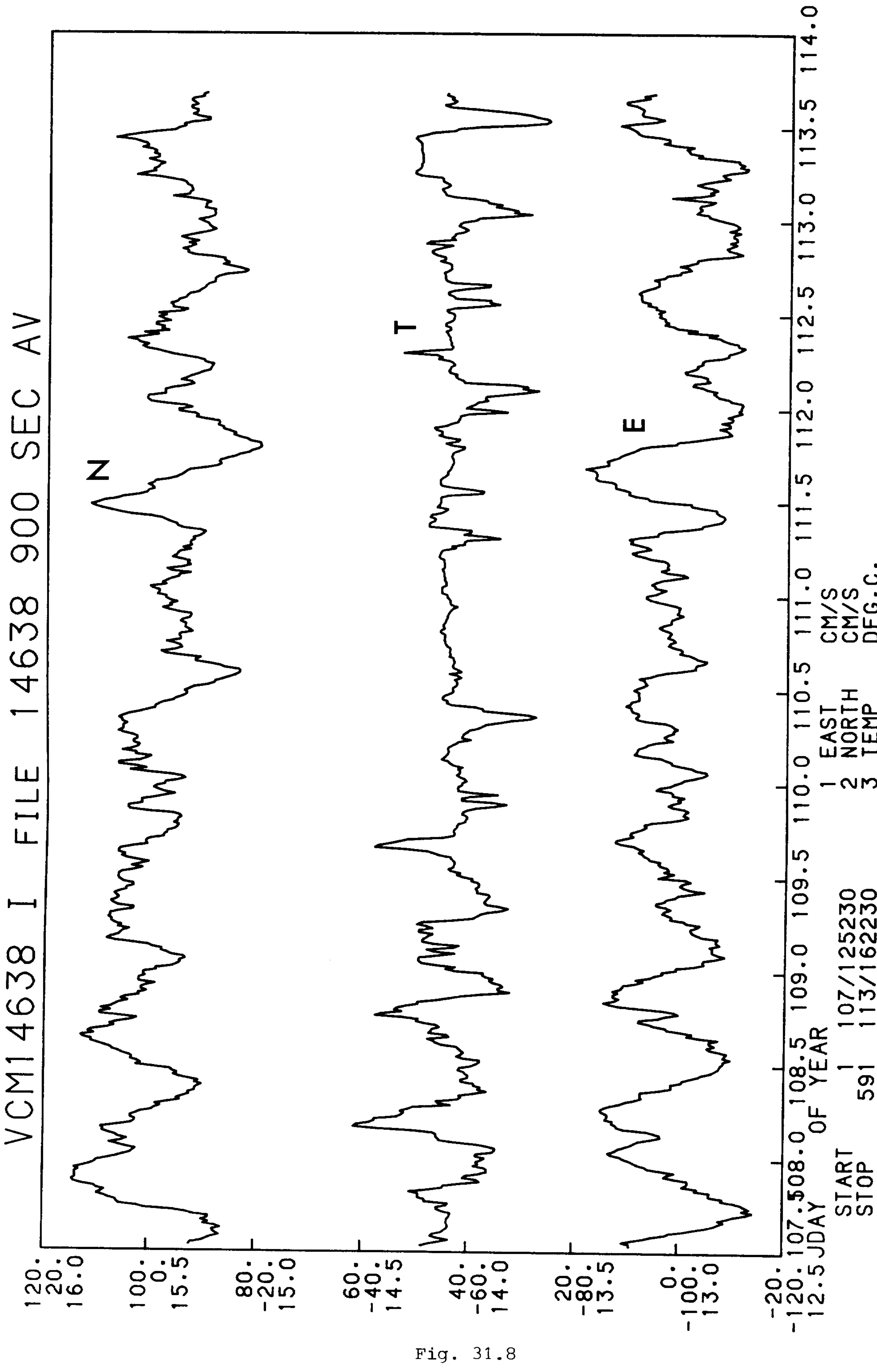

VCM14638 I FILE 14638 900 SEC AV
N
T
E
120. 20. 16.0
100. 0. 15.5
80. -20. 15.0
60. -40. 14.5
40. -60. 14.0
20. -80. 13.5
0. -100. 13.0
-20. -120. 12.5
107.5 108.0 108.5 109.0 109.5 110.0 110.5 111.0 111.5 112.0 112.5 113.0 113.5 114.0
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.8

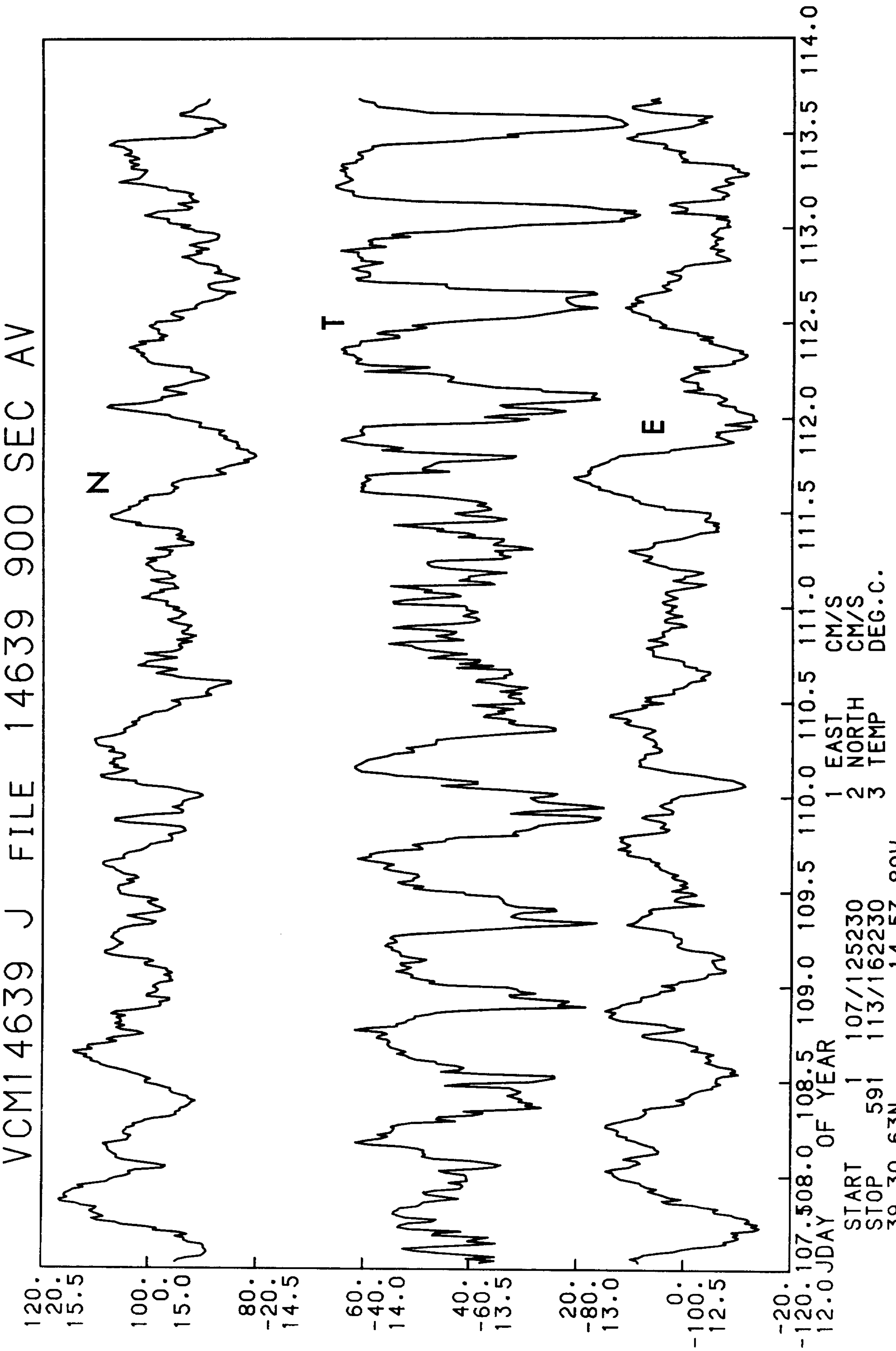

VCM14639 J FILE 14639 900 SEC AV
N
T
E
JDAY OF YEAR
START 1 107/125230
STOP 591 113/162230
39 30.63N 14 57.89W
1 EAST CM/S
2 NORTH CM/S
3 TEMP DEG.C.

Fig. 31.9

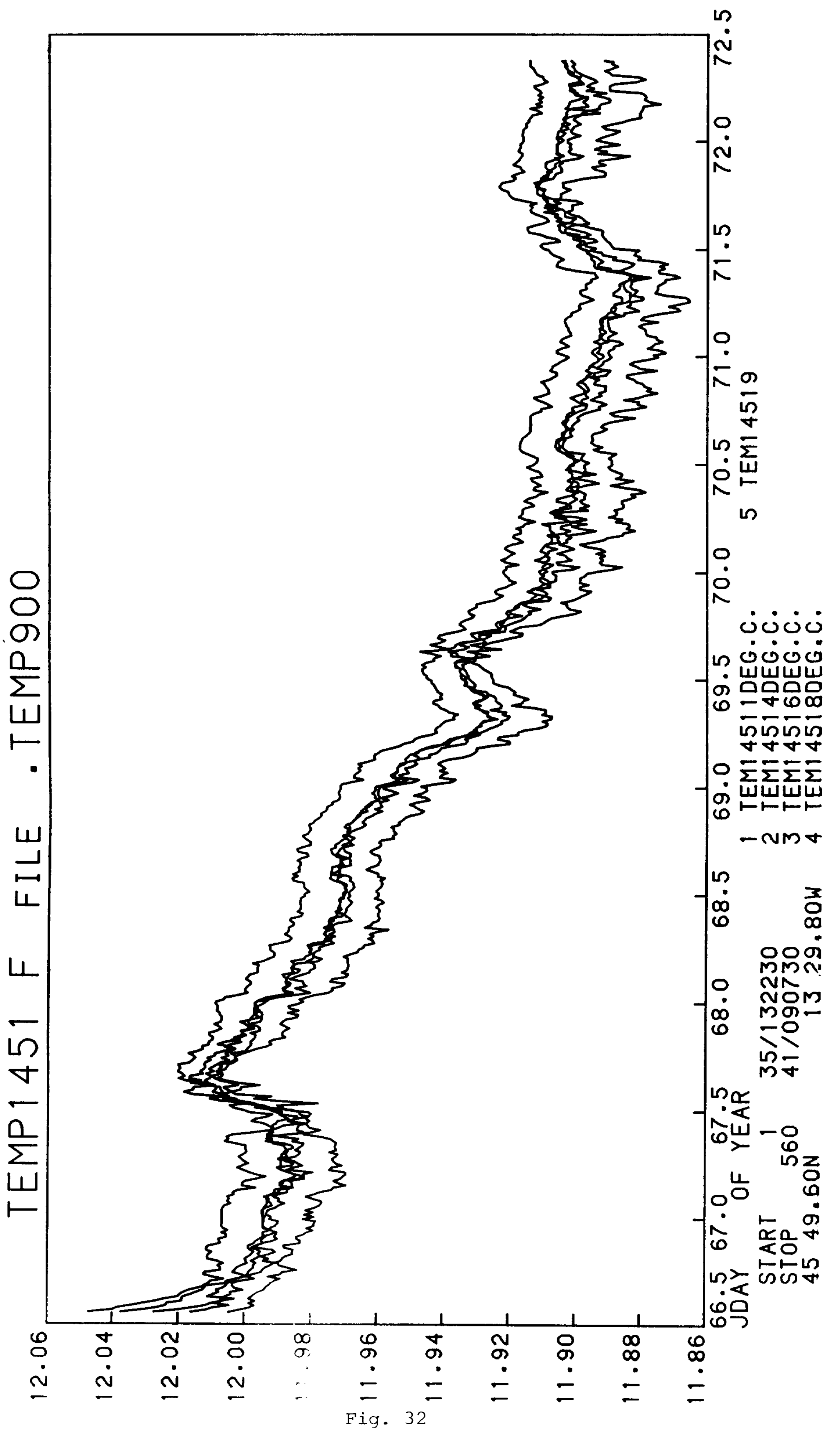

TEMP1451 F FILE .TEMP900
12.06
12.04
12.02
12.00
11.98
11.96
11.94
11.92
11.90
11.88
11.86
66.5 67.0 67.5 68.0 68.5 69.0 69.5 70.0 70.5 71.0 71.5 72.0 72.5
JDAY OF YEAR
START 1 35/132230
STOP 560 41/090730
45 49.60N 13 29.80W
1 TEM14511DEG.C.
2 TEM14514DEG.C.
3 TEM14516DEG.C.
4 TEM14518DEG.C.
5 TEM14519

Fig. 32