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INSTITUTE OF OCEANOGRAPHIC SCIENCES

RRS SHACKLETON
CRUISE 8/77 LEG 2

5 July – 24 July 1977

Geophysical Studies on the Reykjanes Ridge

CRUISE REPORT NO. 62

1977

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Wormley, Godalming,
Surrey, GU8 5UB.
(0428 - 79 - 4141)

(Director: Professor H. Charnock)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051-653-8633)

(Assistant Director: Dr. D. E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823-86211)

(Assistant Director: M. J. Tucker)

Marine Scientific Equipment Service
Research Vessel Base,
No. 1 Dock.
Barry,
South Glamorgan, CF6 6UZ.
(0446-737451)
(Officer-in-Charge: Dr. L. M. Skinner)

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GEOPHYSICAL STUDIES ON THE REYKJANES RIDGE

Cruise Report No. 62

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Institute of Oceanographic Sciences
Blacknest
Brimpton
Reading
Berks

SHIP'S OFFICERS

G H Selby-Smith	Master
G Long	Chief Officer
D A Pye	2nd Officer
N Jonas	3rd Officer
C S Storrier	Chief Engineer
T Rees	2nd Engineer
F J Richards	3rd Engineer
C Phillips	Extra 3rd Engineer
L Wilson	Electrical Officer
R Overton	Purser/Catering Officer
R Hammerton	Radio Officer

DATES

Depart Aberdeen, Scotland	5 July 1977	Day 186
Arrive Reykjavik, Iceland	24 July 1977	Day 205

SCIENTIFIC PERSONNEL

T J G Francis	Principal Scientist	IOS Blacknest
I T Porter		"
R C Lilwall		"
C A Tew		"
K E Louden		Geodesy & Geophysics, Cambridge
A W H Bunch		"
M Mason		"
A W Claydon		"
B L N Kennett		"
P C Hilary		IOS Barry
C Hazelhurst		"
A R Cumming		"

CRUISE OBJECTIVES

This cruise was a co-operative effort of the Institute of Oceanographic Sciences and the Department of Geodesy and Geophysics, University of Cambridge. The two principal objectives of the cruise were seismological, corresponding to the main interests of the IOS Blacknest and Cambridge teams involved:

1. Observation of microearthquakes on the Reykjanes Ridge with an array of Ocean Bottom Seismographs near $59\frac{1}{2}^{\circ}$N.

2. Determination of the structure of the ridge by means of three long range seismic refraction profiles positioned along the 0, 4 and 9 My isochrons.

In addition to these two main objectives two lesser objectives were included:

3. Projectile experiment. Ten projectiles were dropped to the sea bed to see whether their impacts could be detected by the OBS.

4. Temperature measurement. An IOS temperature-telemetering pinger was towed near the sea floor to look for temperature anomalies in the water which might be associated with geothermal springs.

Last but not least, bathymetric, gravity and magnetic data were acquired continuously throughout the cruise, or when the station work permitted. A detailed bathymetric/magnetic survey was made of the ridge axis in the vicinity of the OBS array.

NARRATIVE (all times GMT)

Shackleton sailed from Aberdeen at 1030/5 July (day 186). Contrary tides through the Pentland Firth obliged us to go round the Orkneys, so that the ship did not settle onto a westerly course past North Ronaldsay until 0240/187. Scientific watches with echo-sounder, gravimeter and magnetometer were begun at 0800/187. The passage out to the Reykjanes Ridge carried us over Rosemary Bank and the northern edges of George Bligh and Hatton banks. Visibility was frequently poor so that the ship was forced to proceed at reduced speed and our arrival at the first station was nearly a day late.

R/T communication was established with Discovery on day 189, shortly after that ship had sailed from Reykjavik. They were able to inform us in some detail about the GLORIA survey in our planned area of operations on the Reykjanes Ridge on their previous leg.

At 0430/191 we reached the position of the first Cambridge refraction line, line Z. Four sonobuoys were laid and explosive charges fired along a north easterly course from 1041 to 1635/191. In spite of some fog patches the ship maintained a good speed of just over 10 knots. This was important because the rather delicate state of Shackleton's stern gland obliged us to get as far away as possible from the bigger charges. Maximum charge weight was 300 lb. Despite thickening fog the last sonobuoy was recovered by 0130/192 after which the ship returned to the north-east to begin a reflection profile along the same line.

At 0930/192 R/T communication was established with Dr Jacoby in the German research vessel Meteor. He informed us of their shooting schedule a few hundred kilometres further north on the Reykjanes Ridge, beginning on day 193 and continuing on and off for a week. This allowed us to plan our remaining refraction programme so as not to interfere with or be troubled by theirs. Two further R/T links were made with Meteor in the following week.

At 2005/192 we stopped to lay the radar transponder buoy, at the centre of the planned array of OBS. During the next two days the five OBS were laid at the corners of a regular pentagon, all between 3 and 5 nm from the transponder. The first four OBS behaved impeccably on launch, all switching off their pingers after four hours - indicating that the programming of the OBS on the bottom was operating correctly. The fifth OBS failed to switch off its pinger, suggesting that the tape recorder in that instrument had failed to unclamp. Overnight and between OBS launchings, short bathymetric/magnetic surveys were run in the vicinity of the array.

From 1621/194 to 0215/195 the 1000 cubic inch airgun was fired along tracks over the array, triggered once a minute by the la' clock, to provide sound ranging and close range refraction data in the vicinity of the OBS. A single disposable sonobuoy was deployed as an extra receiving point. At the conclusion of this experiment we conducted our first sound velocity meter and temperature telemetering pinger station. A dozen more velocity/temperature stations were to follow in the next eight days.

At 1200/195 we began laying sonobuoys some 50 km northeast of the OBS array for Cambridge refraction line X. The first shot on this line was fired just north of the OBS array at 1945/195 and shooting continued on a northeasterly course past the sonobuoys up the ridge axis until 0200/196. The shooting team did well to stick to their schedule despite miserably wet and cold weather. The five sonobuoys were retrieved between 0700 and 1020/196.

By 1730/196 the ship was back over the OBS array to start the projectile experiment. During the next 10 hours a total of ten projectiles were dropped, two near OBS1, five near OBS6 and three near OBS4. The impacts of all were heard on the Precision Echo Sounder and timed against GMT. Depending on water depth they took from 67 to 78 seconds to reach the seabed. Prior to each projectile drop the airgun was fired a few times to provide sound ranges. Since the ship was stopped for this operation only the smallest chamber - 40 cubic inch - could be used for fear of damaging the ship's stern gland.

During the early morning of day 197 the radar transponder became progressively more difficult to see on the radar and finally ceased operating. The buoy was recovered 0830/197 and found to have a flat battery. Throughout the day sound velocity/temperature stations were conducted along the ridge axis.

At 0015/198 we left the OBS area and ran bathymetric tracks towards Cambridge refraction line Y. Five sonobuoys were laid and shooting proceeded, again along a northeasterly track, from 1515 to 2116/198. After recovering the last sonobuoy at 0606/199 the ship returned to the north east end of the line for a seismic reflection profiling run along the shooting track. This was completed by 1900/199 following which the ship set course to return to the OBS array. The remaining 400 lb of explosive were fired on this course between

2100 and 2300/199, with the OBS as receivers at the western end of the line and a disposable sonobuoy at the eastern end. This was labelled refraction line W.

At 0035/200 the radar transponder buoy was relaid with a different transponder and fresh batteries close to the site of the first buoy. Bathymetric/magnetic surveying occupied the night until the first OBS was scheduled to leave the bottom at 0600/200.

In spite of good weather and visibility day 200 proved disastrous. Neither the explosive bolt nor the pinger of OBS1 was heard on the PES and a box search failed to find the instrument on the surface. OBS4 was sighted on the surface at 1249 and brought on board without incident. Then at 1800/200, on schedule, the pinger of OBS6 switched on but no explosive bolt was heard to fire. The instrument remained stuck on the bottom. Although the chances of dredging the instrument up from rough, sediment-free topography seemed small, the shallow depth (1166 metres) and operating pinger on the OBS encouraged us to have a go. In this water depth the ship has to be within about 300 metres horizontal range of the instrument for its pinger to fall within the echo sounder beam and be detected. With the help of Mr Storrier, Chief Engineer, and Mr Rees, Second Engineer, grapnel and barbed chain were welded together - no grapnels suitable for this operation existed on board - and dragging operations were carried out from 2125/200 to 0030/201. 2700 metres of the main warp were paid out - 1500 metres more than the water depth - but nothing was achieved.

By dawn on day 201 the weather had deteriorated. OBS3 was sighted on the surface at 0619 and with the aid of the rubber boat was hooked onto the crane and brought inboard without damage. By 1245/201 when OBS5 was sighted on the surface, it was blowing a gale and visibility was down to about half a mile. The weather was too bad to allow men over the side in the rubber boat and the OBS had to be grappled from the ship's deck. It was only brought inboard after suffering several hard knocks against the ship's side.

Soon after the recovery of OBS3 it became apparent that the transponder buoy was dragging its anchor. This was recovered, 5 miles to the northwest of where it was laid, at 1430/201. The weather remained too bad to attempt a further dragging operation for OBS6 so the remainder of the day were spent on velocity/ temperature stations.

By day 202 the weather had moderated and in the early afternoon another attempt was made to drag for OBS6. The pinger was still operating to act as a guide for this operation. A similar amount of main warp was paid out as on the first occasion, but again without success. At 1805/202 the attempt was abandoned and the ship headed east to the start of a long gravity profile across the ridge. The final velocity/temperature station was carried out in the early hours of day 203 just before starting this profile. The gravity profile then took us on a 120 mile track on course 306°, crossing the ridge axis at 60°N, 29½°W. Unfortunately the weather deteriorated throughout the day until by the early afternoon the wind speed was 45 knots and the barometer had fallen to 977 millibars. The gravimeter remained operational but the heavy weather probably caused some deterioration on the quality of the data. Days 201 and 203 were the only days throughout the cruise in which bad weather hampered operations.

On completion of the gravity traverse of the ridge course was set for Reykjavik. At 0830/204 we stopped to recover the magnetometer and PES fishes and concluded scientific watchkeeping. Our position then was 61°29'N, 29°04'W, just outside the Icelandic 200 mile limit.

PROJECT REPORTS

Ocean Bottom Seismographs

Five OBS were deployed at the corners of a regular pentagon centred approximately at 59°20'N, 30°20'W. The position of the array was chosen to coincide with the northernmost concentration of teleseismic activity reported from the Reykjanes Ridge. The first four OBS behaved correctly at launch, but OBS5 failed to switch its pinger off at the required time, indicating that the tape recorder had not switched on.

In addition to recording earthquakes the OBS acted as receivers for Cambridge refraction lines X and W and for 10 seismic projectiles released near OBS1, 4 and 6.

The expectations of all experiments were to a great extent dashed by the failure of two instruments, OBS1 and 6, to surface and by the failure of OBS5 to run tape. The manner of OBS6 failure was identical to that of OBS2 in August 1975. Its pinger switched on at the correct time but the explosive bolt failed to fire (cf IOS Cruise Report No 34, 1975). As a result of these failures our loss rate is now 3 out of 28 drops in the deep ocean.

Projectile Experiment

Ten projectiles were taken to sea to test the practicability of weight-drop sources for short range seismic experiments on the sea floor. Each projectile consisted essentially of a concrete filled length of steel water pipe with streamlined nose cone and stabilising fins. The weight in air of each projectile was around 120 kg. In the water they reached terminal velocities of about 20 m/sec. Impact on the sea floor caused a glass ball housed immediately behind the nose cone to implode. This provided a high frequency signal which could be detected by the ship's echo sounder.

No difficulties were met with the shipboard aspects of this experiment. The impacts of the projectiles on the sea floor were all heard on the ship's echo-sounder and timed against GMT. Unfortunately the failure of OBS1 and 6 to surface means that a maximum of only three records are available from the OBS. (At the time of writing the OBS tapes have yet to be played back). It is unlikely that these will be sufficient to yield much seismic information and another cruise will be needed to assess the usefulness of these projectiles.

Sound Velocity/Temperature Stations

These stations employed a Plessey sound velocity meter type M031 and the temperature telemetering pinger recently developed by Mr E Darlington of the Applied Physics Group at Wormley. Apart from three stations (2001, 2004, 2017) in which complete profiles of the water column were obtained to provide sound velocity calibrations for the seismic refraction lines, the bulk of this work was devoted to looking at water temperatures close to the bottom. K Crane of Scripps Institution of Oceanography recently claimed to have identified temperature anomalies of geothermal origin in the near bottom water of the Reykjanes Ridge from an analysis of Deep Tow observations (personal communication 1977).

The technique we adopted was to "fly" the pinger 10 to 20 fm above the bottom as the ship drifted. A couple of temperature anomalies were found but it is not yet clear whether these were of geothermal or of physical oceanographic origin.

Seismic Refraction Profiles

Three long range seismic refraction profiles, lines X, Y and Z, were shot parallel to the ridge axis (stations 1999, 2002, 2011). Each line was about 110 km long and consumed approximately 1½ tons of explosive. Four or five Cambridge sonobuoys were deployed near the centre of each line and shooting in each case was from southwest to northeast. Line X was located along the ridge axis, immediately north of the OBS array so that the OBS provided receivers at its southwest end. Line Y was displaced some 35 km off the ridge axis to the east and line Z 90 km off the ridge axis to the east.

In addition to these three principal seismic refraction lines a shorter profile, line W (station 2012), was fired to consume the remaining 400 lb of explosive and effectively connect the OBS array with line Y.

Data Logging and IBM 1130 Computer

Navigation, bathymetric, magnetic and gravity data were continuously logged from 0854/187 to 0830/204 and the tapes processed on board with the IBM 1130 computer housed in a caravan in the hold. Navigation plots and bathymetric/magnetic/gravity profiles were available one or two days after the event and we were able to leave the ship with a merged tape of edited geophysical and navigational data covering the period 0854/187 to 2058/201.

Bathymetric data was digitised for input to the Data Logger by means of an Edo Digitrak. In spite of the shallow water encountered on most of the cruise the Digitrak frequently lost lock and considerable manual editing of the bathymetric data was necessary to remove errors.

In the vicinity of the Reykjanes Ridge Loran C readings were used to interpolate the ship's tracks between satellite fixes, but had to be manually inputed into the computer. Much work could have been avoided if the receiver had been directly interfaced to the data logger. The Loran C receiver (Decca DL91 mark 2) only functioned well for relative positioning in spite of being checked by a Decca engineer in Aberdeen. The Magnavox satellite navigator operated well throughout the cruise.

TABLE 1

TRANSPONDER BUOY POSITIONS

Buoy	Laid	Recovered	Lat N	Long W	Remarks
1	2045/192	0830/197	59°24'4	30°18'3	Transponder ceased operating c 0600/197.
2	0035/200	1430/201	59°24'9	30°19'1	Buoy recovered 5 miles to NW of laying position after dragging its anchor in heavy weather on day 201.

TABLE 2

STATION LIST

Station Number	Type	Equipment Used	Time (Z)/Day No Start	End	Lat.N Long.W	to Lat.N Long.W	Water Depth UCF	CM	Comments
1999	S.Refr.	SB (4) AG1000	0430/191	0130/192	58°56' 29°06'	59°43' 27°52'			Cambridge seismic line Z. 3250 lb of Geophex in 24 charges. Followed by reflection profile along same line.
2000	OBS Deployment	OBS (5) AG1000 DSB	0530/193	0215/195	59°20' 30°20'				Approximate position. See table 3 for positions, depths, recording windows of individual OBS. Airgun tracks over OBS for seismic refraction + sound ranging to improve navigation.
2001	T/V	TTP VM	0315/195	0657/195	59°26' 30°16'		650	1203	Mean position and water depth given.
2002	S.Refr	SB (5) OBS AG1000	1216/195	1020/196	59°30' 30°12'	60°17' 28°58'			Cambridge seismic line X. 3300 lb of Geophex in 33 charges.
2003	Earth Shattering	Projectiles (10) AG40	1730/196	0320/197	59°20' 30°20'				Approx position. Total of 10 acoustic/seismic projectiles released near OBS1, 4 and 6. Impacts recorded from PES against GMT.
2004	T/V	TTP VM	0350/197	0720/197	59°30' 30°19'		751	1391	Mean position and water depth.
2005	T/V	TTP VM	0900/197	1106/197	59°24' 30°19'		613	1134	Mean position and water depth.
2006	T/V	TTP VM	1142/197	1331/197	59°19' 30°20'				Mean position and water depth.

TABLE 2 (Continued)

Station Number	Type	Equipment Used	Time (Z)/Day No Start	Time (Z)/Day No End	Lat.N Long.W	to Lat.N Long.W	Water Depth UCF	Water Depth CM	Comments
2007	T/V	TTP VM	1400/197	1606/197	59°19' 30°27'		565	1045	Mean position and water depth.
2008	T/V	TTP VM	1700/197	1905/197	59°17' 30°33'		628	1162	Mean position and water depth.
2009	T/V	TTP VM	2000/197	2145/197	59°22' 30°28'		685	1268	Mean position and water depth.
2010	T/V	TTP VM	2220/197	0008/198	59°25' 30°23'		778	1441	Mean position and water depth.
2011	S.Refr	SB (5) AG1000	0827/198	0606/199	59°10' 29°54'	59°55' 28°43'			Cambridge seismic line Y. 3300 lb of Geophex in 33 charges. Followed by reflection profile along same line.
2012	S.Refr	OBS DSB	2104/199	2301/199	59°16' 29°46'	59°25' 30°17'			Cambridge seismic line W. 400 lb of Geophex in 7 charges.
2013	T/V	TTP VM	0820/201	1045/201	59°26' 30°19'		630	1166	Mean position and water depth.
2014	T/V	TTP VM	1613/201	1847/201	59°30' 30°12'		684	1266	Mean position and water depth.
2015	T/V	TTP VM	1934/201	2150/201	59°33' 30°05'		600	1110	Mean position and water depth.
2016	T/V	TTP VM	0910/202	1109/202	59°11' 30°38'		617	1142	Mean position and water depth.

TABLE 2 (Continued)

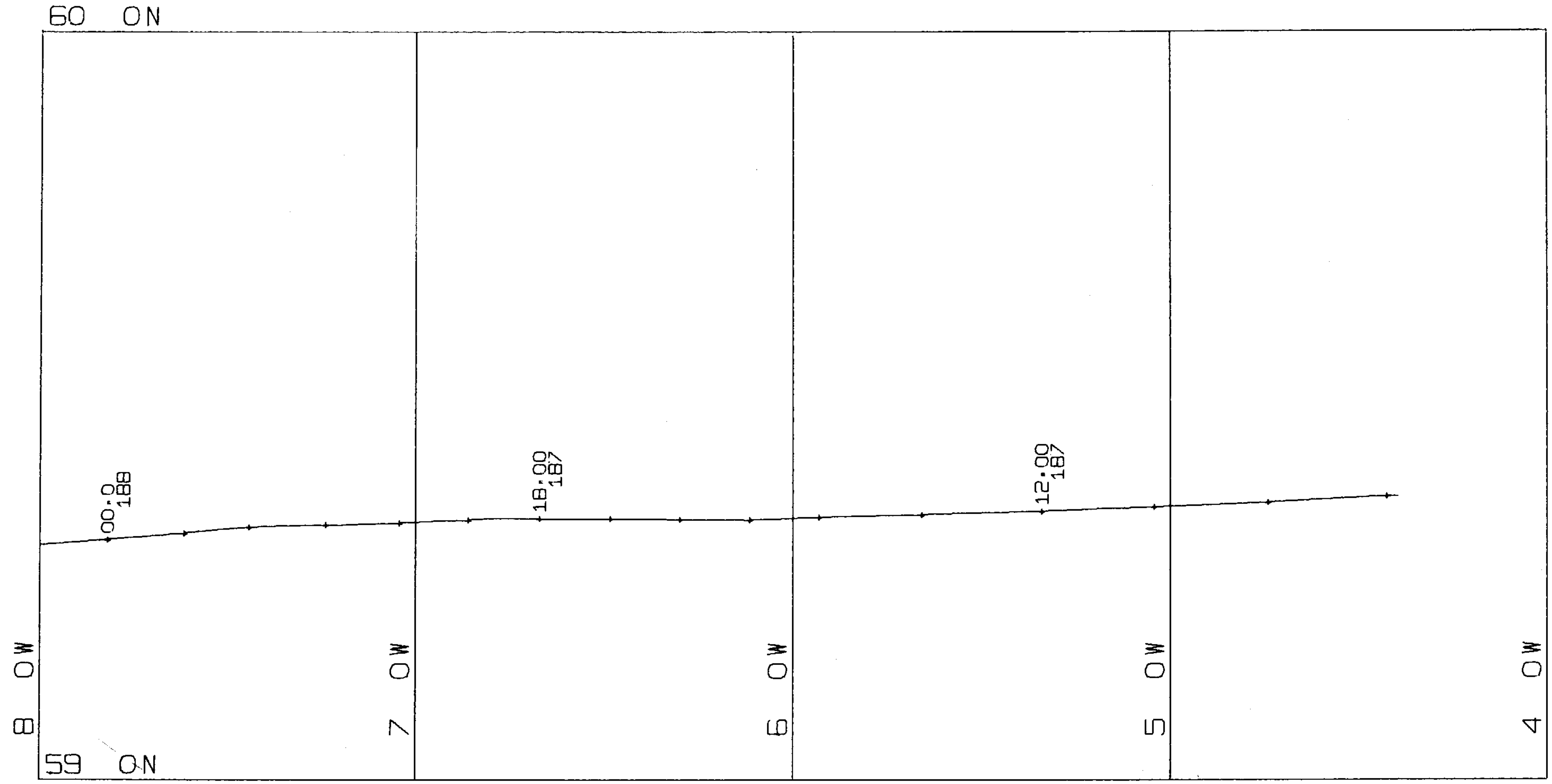
Station Number	Type	Equipment Used	Time (Z)/Day No Start	End	Lat.N Long.W	to Lat.N Long.W	Water Depth UCF	CM	Comments
2017	T/V	TTP VM	0354/203	0635/203	59°24' 27°49'		1136	2108	Mean position and water depth.

SB	Sonobuoy (Cambridge type)
DSB	Disposable Sonobuoy
OBS	Ocean Bottom Seismograph
AG1000	1000 cu in Airgun
AG40	40 cu in Airgun
TTP	Temperature Telemetering Pinger
VM	Velocity Meter
S.Refr	Seismic Refraction
T/V	Temperature and Velocity Station

TABLE 3

OBS PARAMETERS

OBS	Launched	Recovered	Latitude N	Longitude W	Depth	Remarks
1	0643/193	-	59°20'7	30°23'7	1288m	Neither pinger nor explosive bolt heard on PES.
4	1224/193	1350/200	59°28'9	30°23'1	1199	Recorded
6	1840/193	-	59°27.7	30°11'7	1166	Pinger switched on at 1800/200 but bolt failed to fire.
3	0630/194	0650/201	59°22.4	30°13'5	1121	Recorded
5	1238/194	1330/201	59°25'1	30°27'7	1300	Did not run tape. Nearly 1 gallon of water found in instrument sphere on opening.



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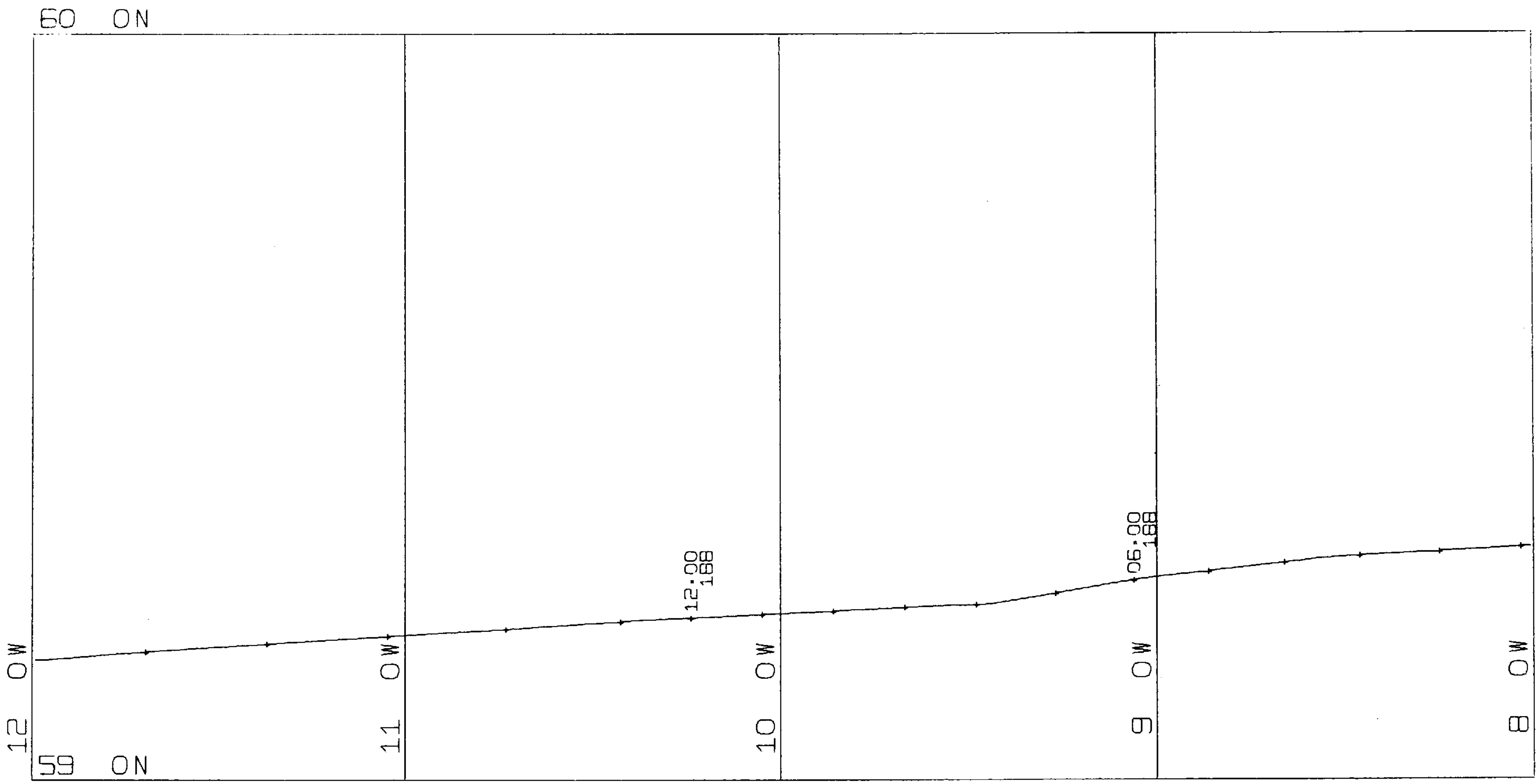
INTERNATIONAL SPHEROID



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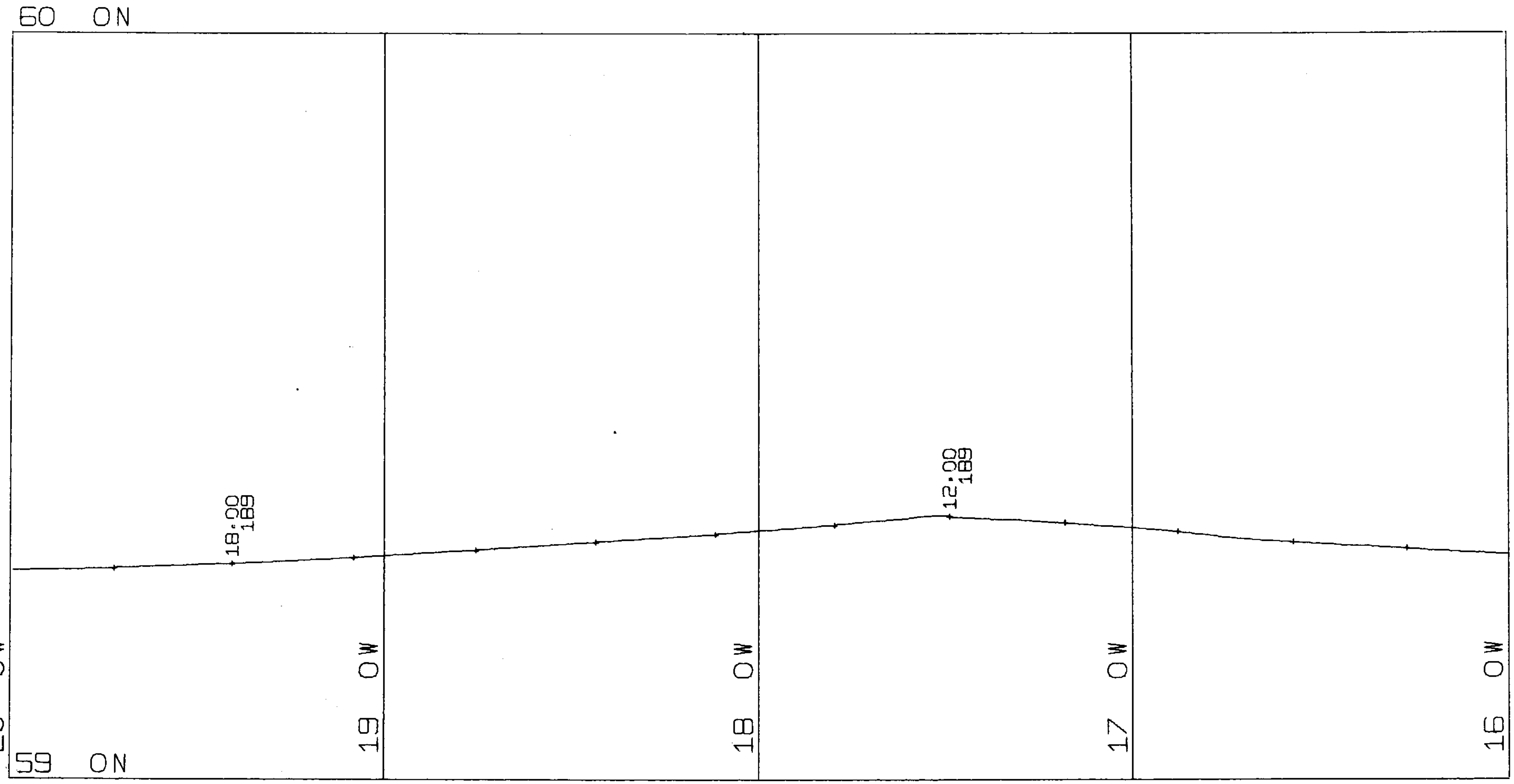

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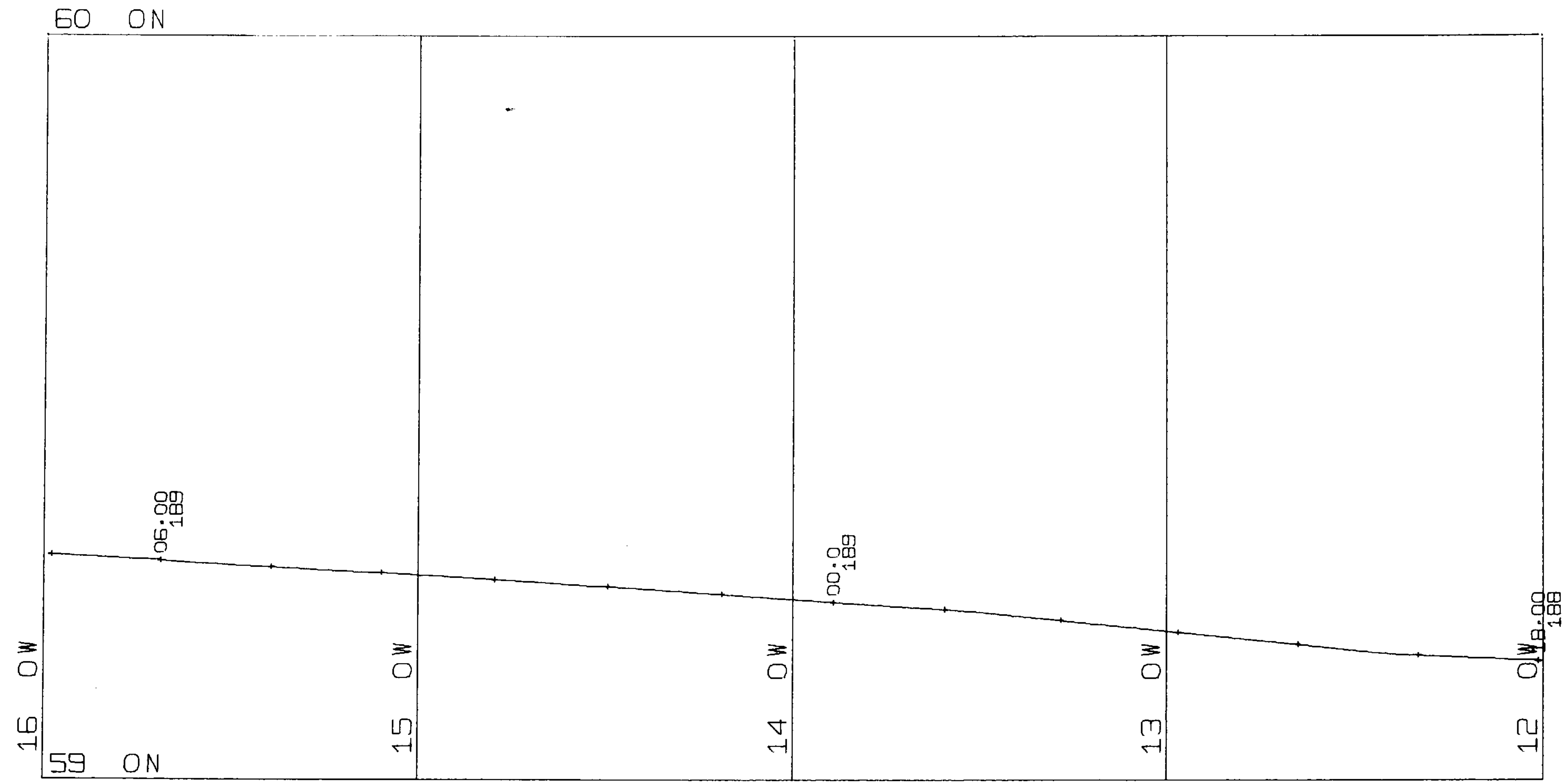

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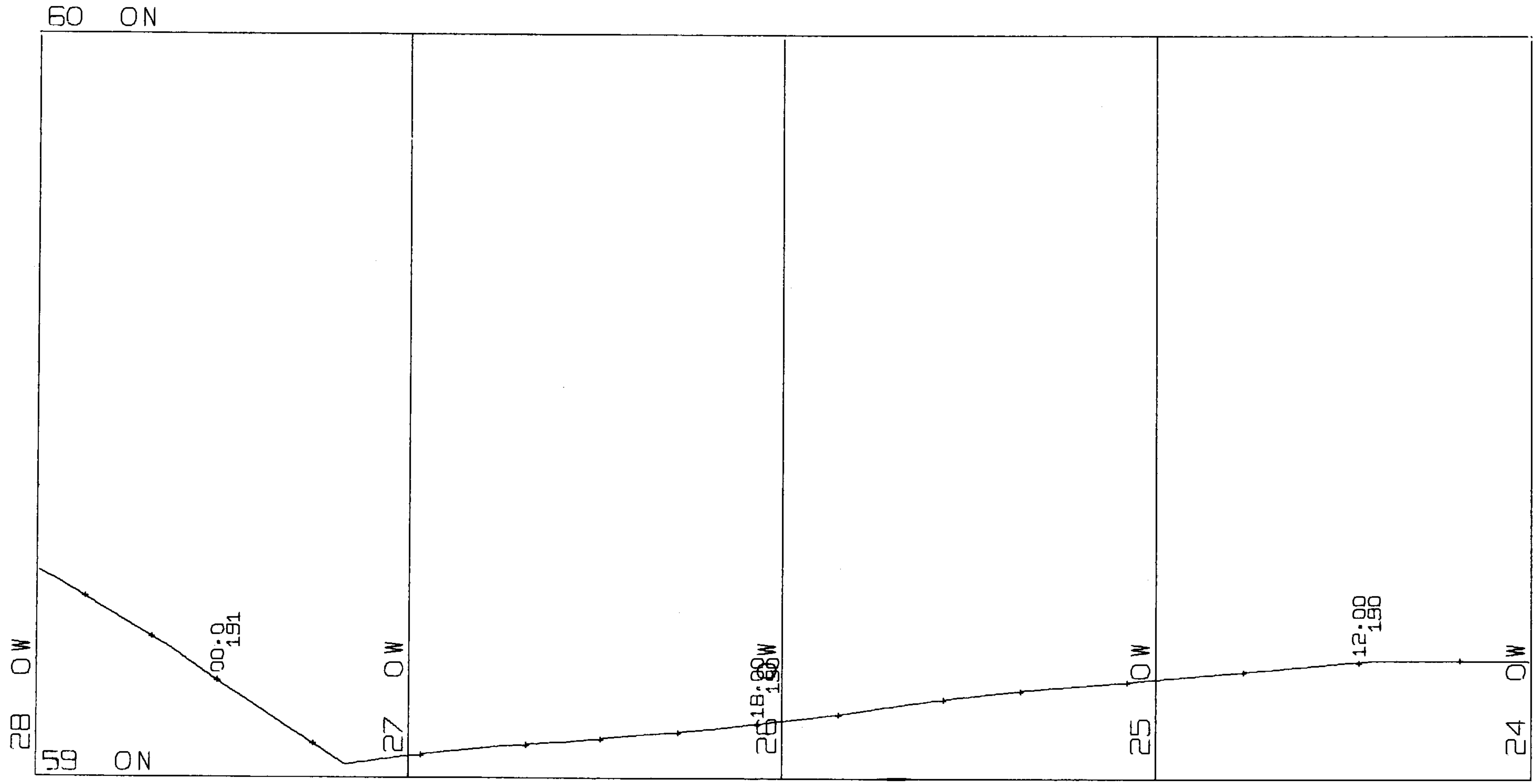

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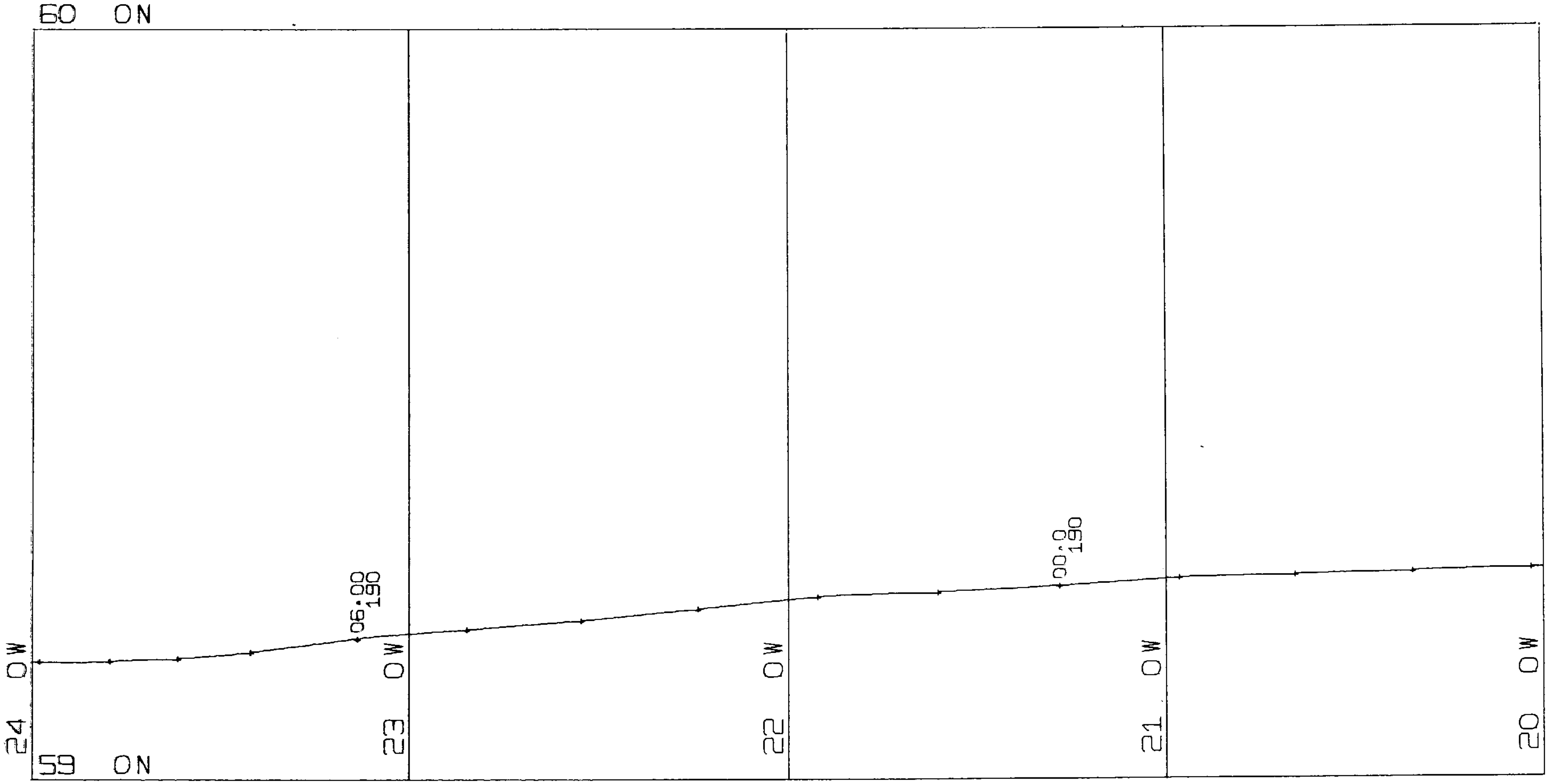

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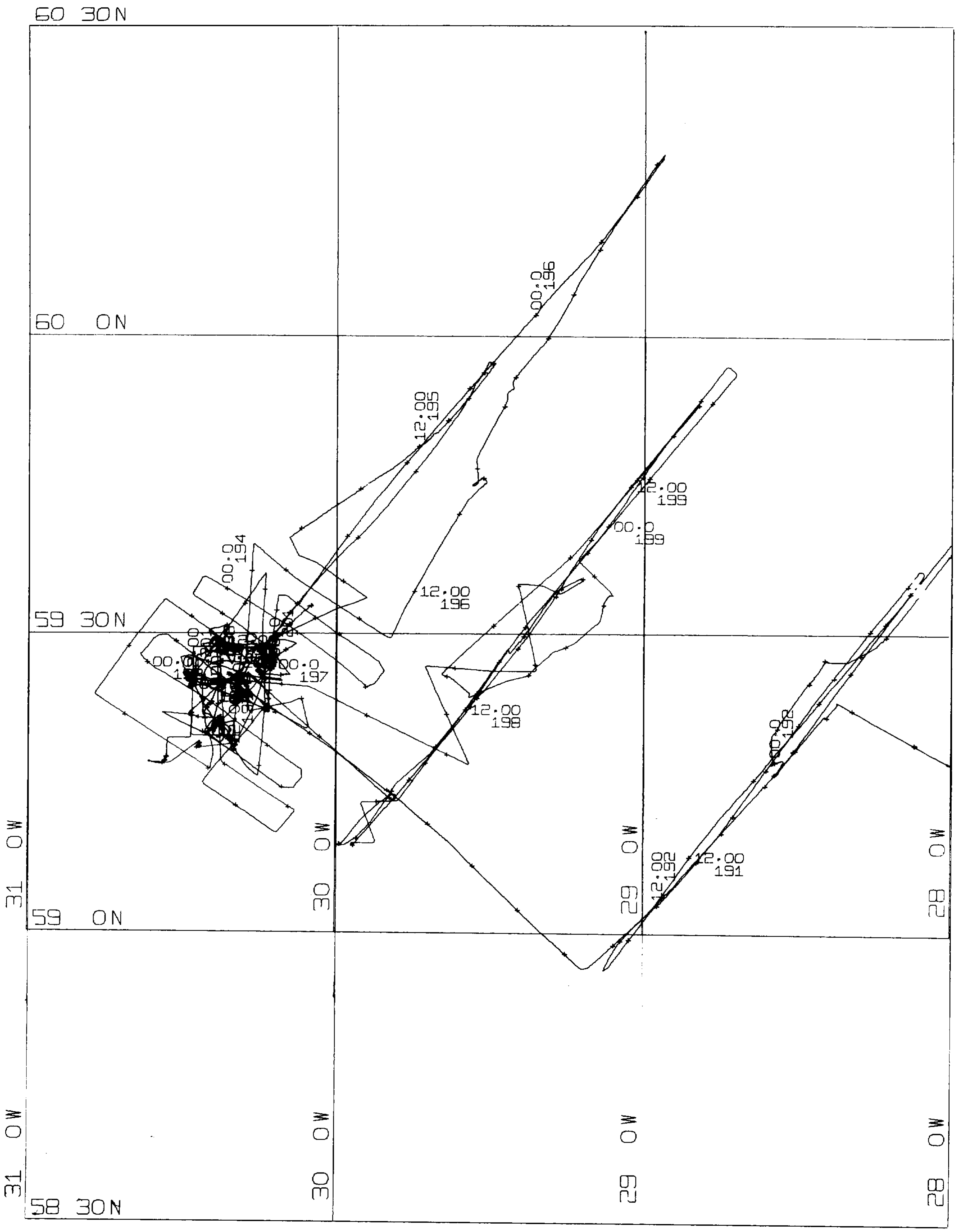

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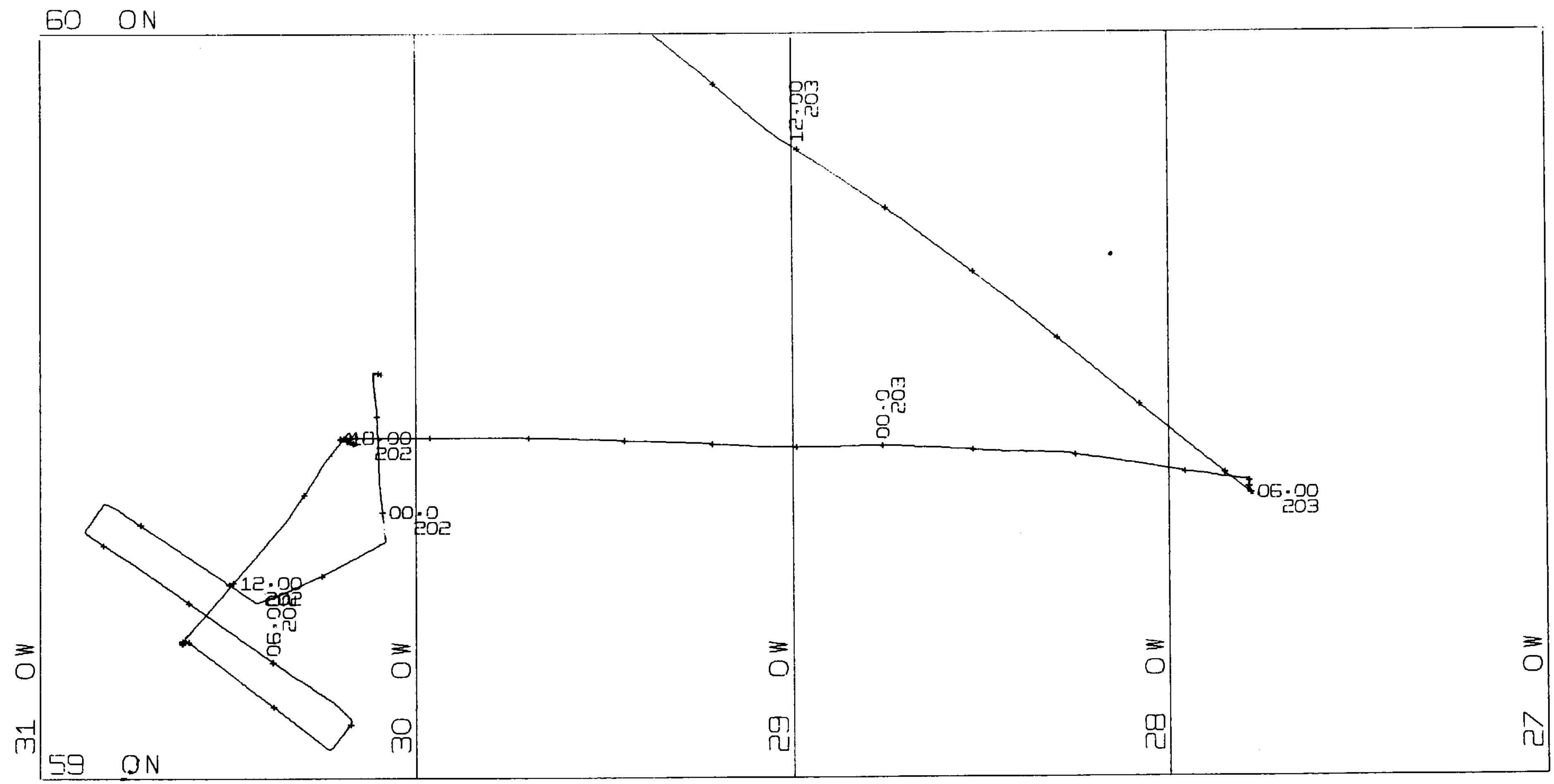

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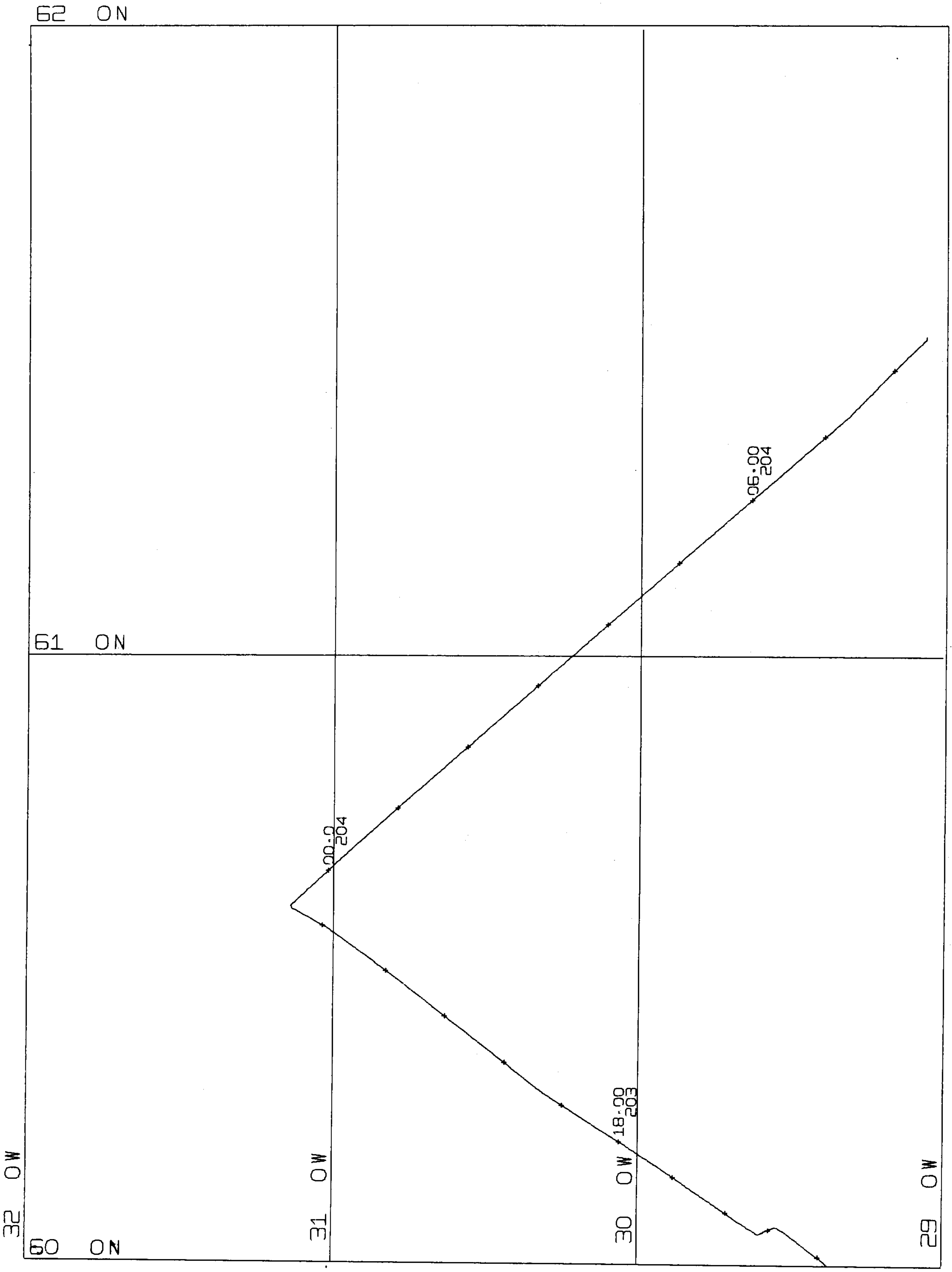

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