Some results from a joint Swedish-Finnish Sea Ice Experiment, March 1977

Några resultat från ett gemensamt svensk-finskt havsisexperiment, mars 1977

by Anders Omstedt and
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SMHI Rapporter
METEOROLOGI och KLIMATOLOGI
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SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT

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CONTENTS

SUMMARY

A joint Swedish-Finnish sea-ice experiment was performed during March 1977. Measurements in the atmosphere, ice and sea were made during six days onboard the Finnish Research vessel Aranda stationed in the ice field in the Bay of Bothnia. During two days measurements were also carried out from the two Swedish icebreakers Atle and Tor. This report presents the data and some results from the Swedish group.

SAMMANFATTNING

Ett gemensamt svensk-finskt havsisexperiment genomfördes under mars 1977. Mätningar i atmosfären, isen och havet utfördes under sex dagar ombord på det finska forskningsfartyget Aranda som var placerad i isfältet i Bottenviken. Under två dagar utfördes även mätningar från de två svenska isbrytarna Atle och Tor. Denna rapport presenterar data och några resultat från svenska gruppen.

1. INTRODUCTION

Numerical ice models are under development in Sweden and Finland. These models are simulating ice drift and will later simulate freezing and melting. For the theoretical work, field data is needed. During the period 1977-03-25 - 03-31 field measurements on sea ice were carried out in the Bay of Bothnia under the Joint Swedish-Finnish Winter Navigation Research Programme. Participants in the project were the Swedish Meteorological and Hydrological Institute, The Fishery Board of Sweden, the Finnish Institute for Marin Research and University of Helsinki. Base for the measurements was Research vessel Aranda and during two days two Swedish icebreakers, Atle and Tor, participated. The positions for the three ships are shown in figure 1.

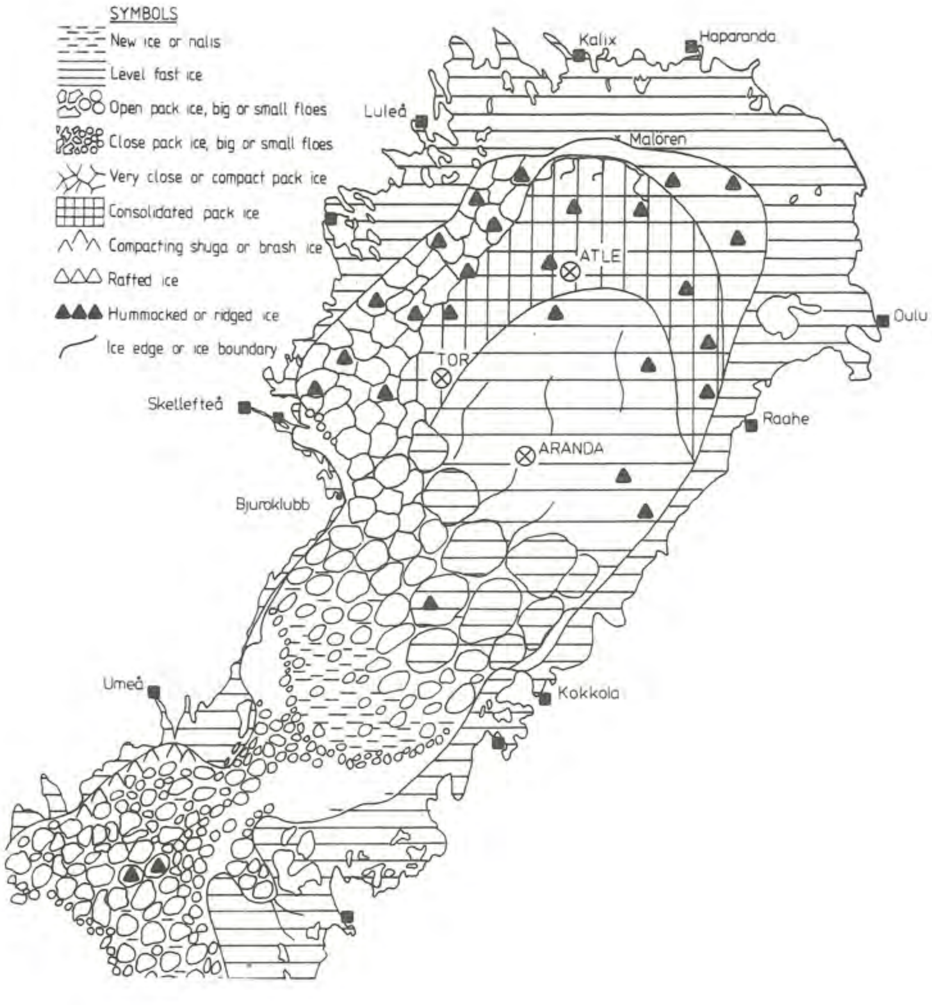


Figure 1.
Ice chart from March 31 with the positions of the three ships.

A photo of Aranda in the ice field is shown in figure 2.

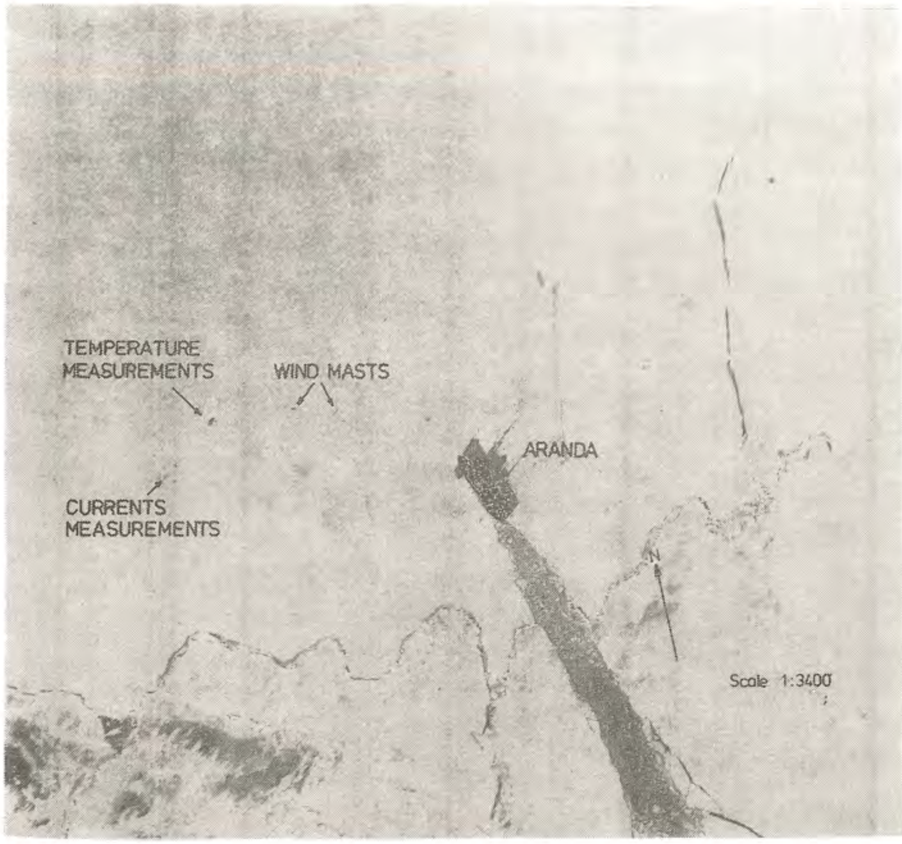


Figure 2.
An air photo of the Finnish research vessel Aranda in the experimental area.

The experiment consisted of three different parts:

- measurements in the atmosphere
- measurements in the ice
- measurements in the sea

It was planned for three weeks, but because of heavy ice pressure due to a southerly storm, the experiment did only last for six days. After the storm the Finnish group continued the measurements in the atmosphere. This report presents data collected by the Swedish group. Measurements of chemical parameters in the sea were also performed by the Fishery Board of Sweden, they are not included in this report.

2. ICE MEASUREMENTS

The Gulf of Bothnia is all or partially ice covered six months during a normal winter. This cause problems for the shipping in the Gulf. For the planning of the icebreaker service and the shipping it is therefore of great interest to predict movements, formation, growing and decay of the ice. In order to study these processes measurements of wind, air temperature, ice drift, ice mass, ice salinity and ice temperature were made.

2.1 Weather and ice situation

In the beginning of the period the weather was dominated by a high pressure ridge with cold and clear weather. The winds were weak and the ice field was slowly moving southward. An intensive low with southerly winds, turned the ice drift to north on March 30. Wind and ice velocity increased, causing heavy ridging in the ice field. The ice situation in the Bay of Bothnia is seen in fig. 1. Typical level ice thickness in the moving ice field was about 50 cm, with a snow cover of about 10 cm.

2.2 Air photo

During two days, March 29 and 31, air photos were taken by the Swedish Air Force. They covered approximately an 11 km wide track of the ice, from Bjuröklubb to Aranda and from Aranda to Luleå. The photos permit studies of ice coverage and ridging density before and after the southerly storm. They are also exposed to permit stereographic interpretation. Figure 3 gives an example of a photo taken of the ice field around Aranda on March 29.

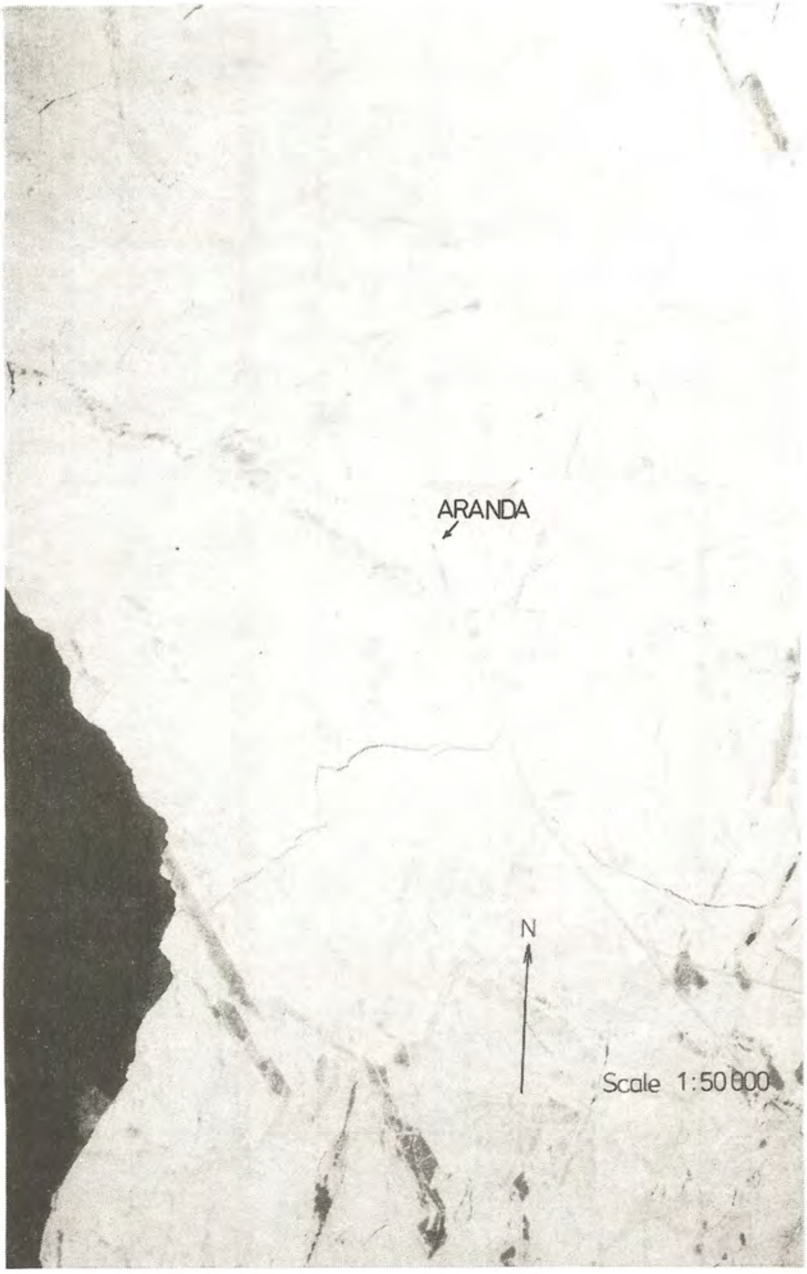


Figure 3.
An airphoto of the ice field around Aranda taken from 6000 m.

2.3 Ice drift

The ice drift was measured with Decca Navigation System during the whole period from Arand and during two days, March 30 and 31, from the icebreakers Atle and Tor. Decca positions were taken every half hour. The wind velocity and direction were measured from a ten meters mast with cup anemometer every 10:th minute at Aranda. From Atle and Tor wind was taken every half hour from the ships ordinary wind meters placed at about 30 and 20 meters respectively

above the sea surface.

The drift of the ships are shown in figure 4.

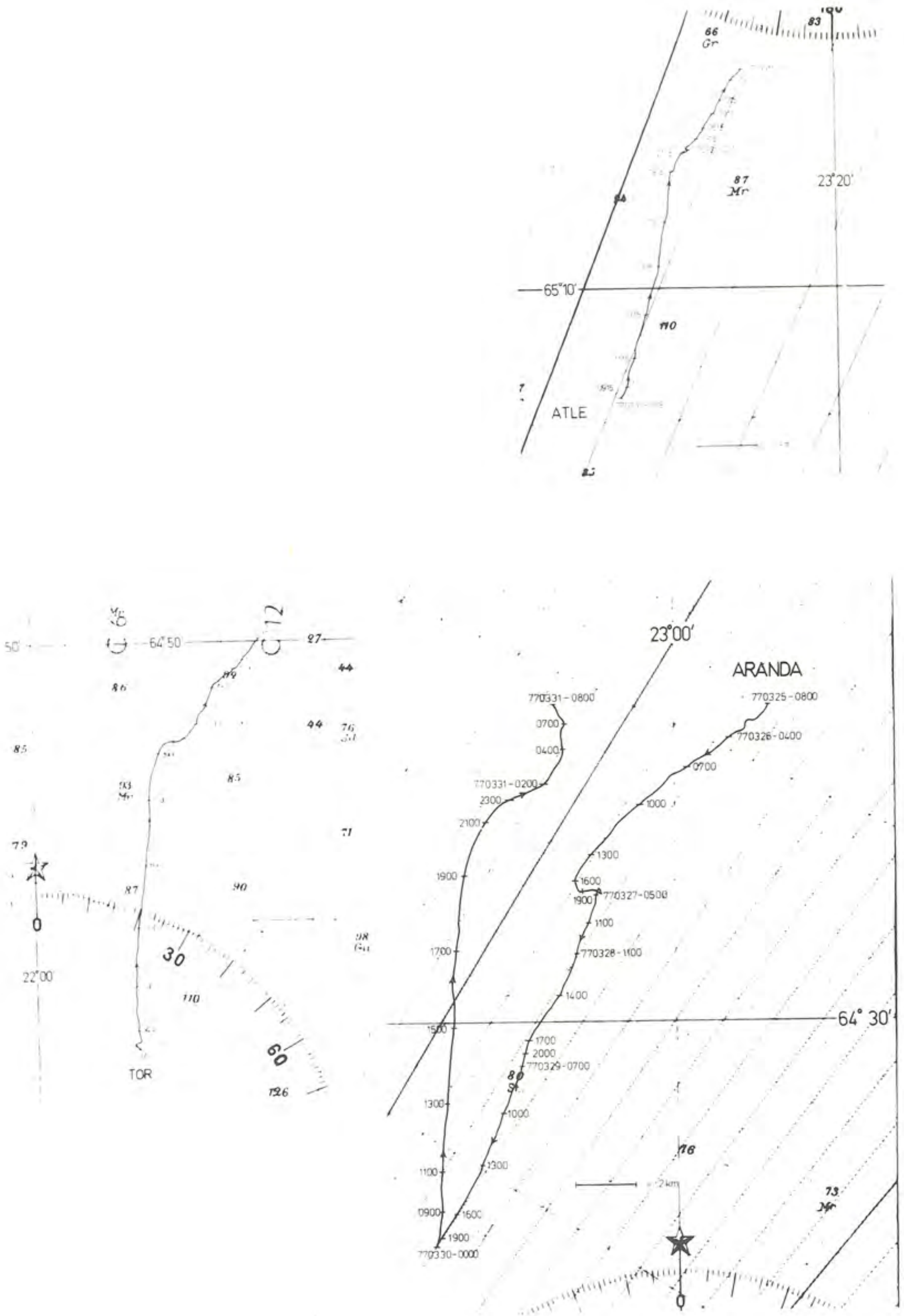


Figure 4.
The ice drift of Aranda, Atle and Tor during the whole experimental period. The numbers at the trajectories indicate date and time.

Hourly meanvalues of ice- and wind velocity are given in attachment 1. Wind direction (θ_a) indicates the direction which the wind is coming from and the ice direction (θ_i) indicates the direction towards which the ice is moving. For a closer examination of the correlation between wind and ice drift figures 5-7 were constructed, see also Udin and Omstedt (1976). The figures show two types of ice velocity fluctuations. One connected with synoptic weather disturbances, that means disturbances on a time scale in the order of days and one on a shorter time scale. These small velocity fluctuations with a period of some hours can be seen for example from Aranda´s drift on March 30 around 12 o´clock. They could be due to the accuracy

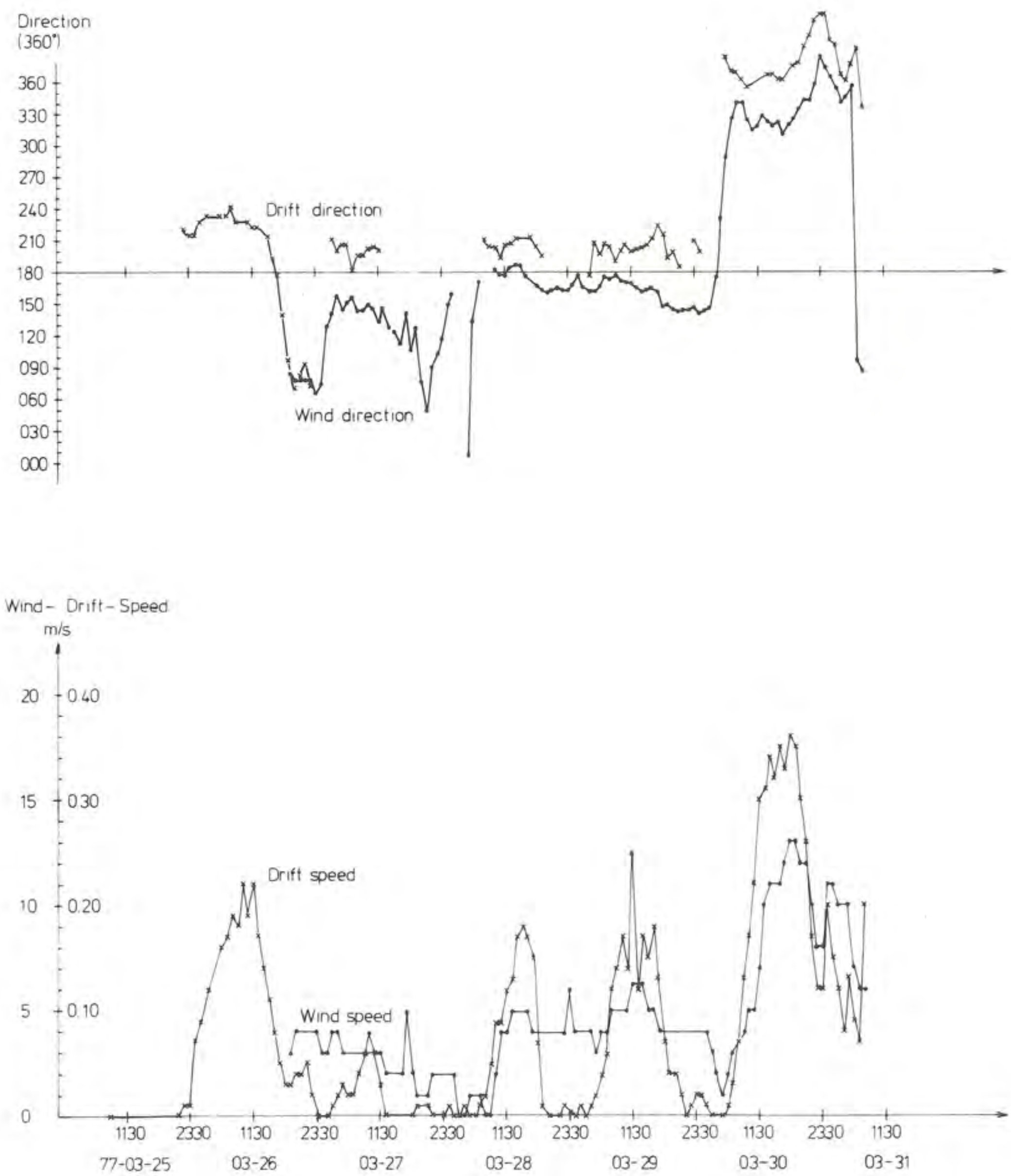
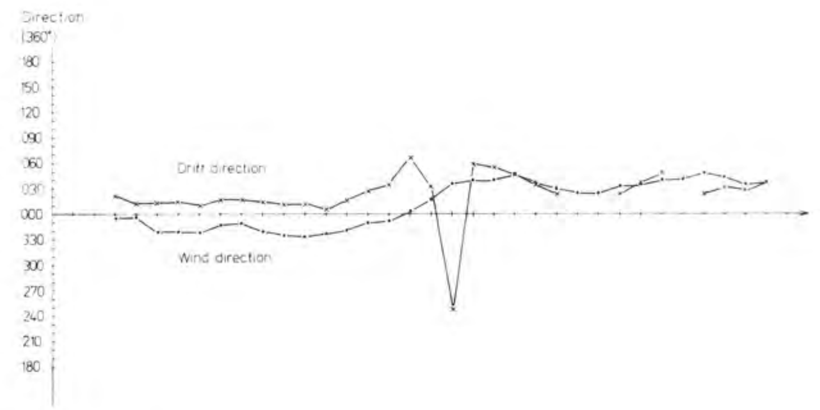


Figure 5.
A comparison between ice drift and wind measured at Aranda.



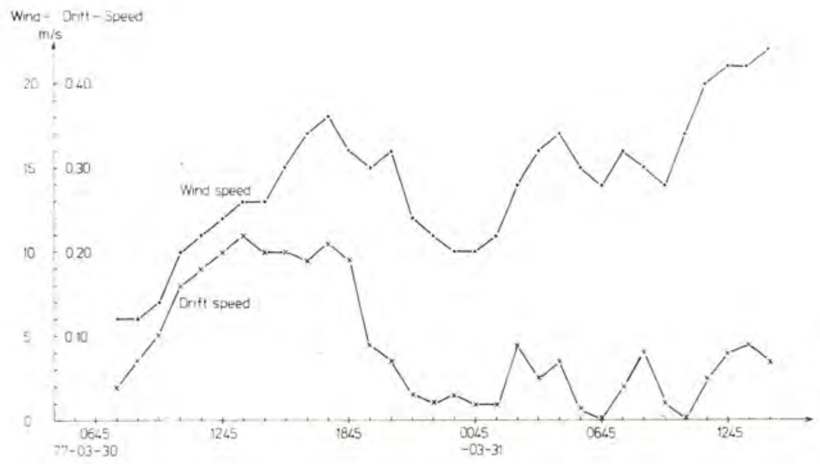
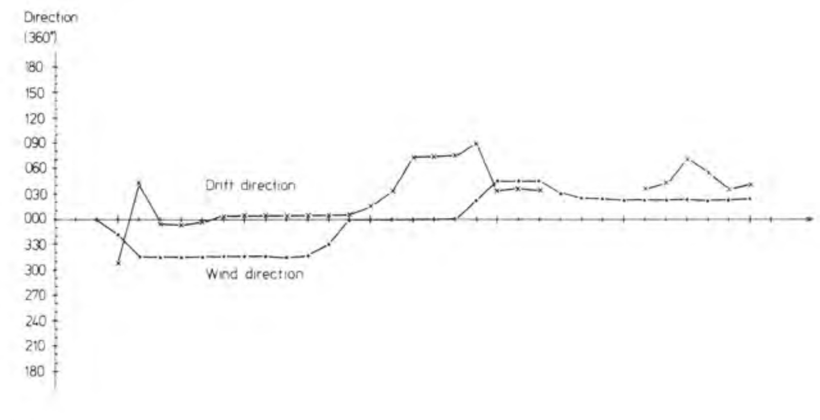


Figure 6.
A comparison between ice drift and wind measured at Atle.



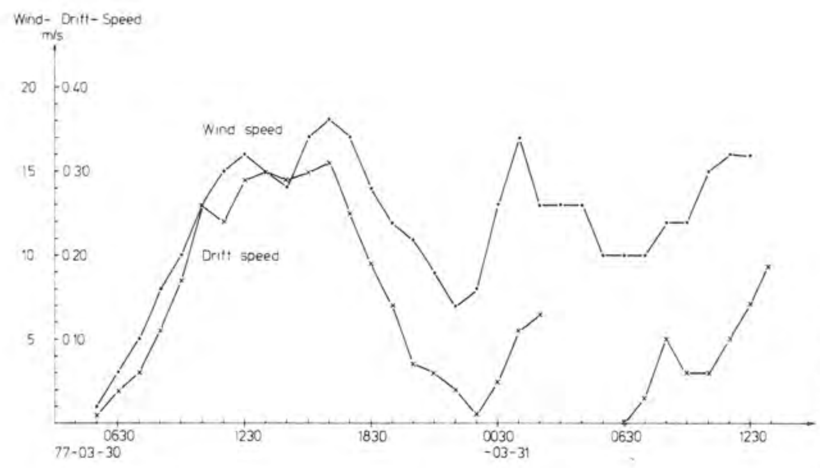


Figure 7.
A comparison between ice drift and wind measured at Tor.

of the Decca Navigation, which under bad conditions has an uncertainty of about 100 meters. Another explanation to these small scale variation may be that ridging and opening of leads cause variable ice velocity.

Attachment 1 shows how the angular difference and the wind factor between ice and wind varies. The large variations in these parameters indicate that no simple rule based on wind information can be used for ice drift prediction. However when the ice is free floating and the wind has been blowing for some hours with the same velocity the ice moves about 30-40 degrees to the right of the wind, with a speed of about 2-3 % of the wind velocity.

The wind factor at Aranda is larger than the wind factors at Atle and Tor. One reason may be the lower wind mast at Aranda, which gives lower wind velocity.

In figure 6 a large change in the drift direction occurs at the evening on March 30. The free floating ice then moves towards the northern fast ice boundary. The ice field is retarding and drift angle changes abruptly. This retarding motion is also seen in figure 5 and 7.

The sea ice deformation was studied on two lenght scales, 10 and 100 km respectively. Four radar reflectors were placed around Aranda approximately in the corners of a 5x5 km area. Rotation and deformation in the ice field on this scale was small, see attachment 2, where the angle and distance to the reflectors from Aranda are given. In the evening on March 28 one of the reflectors was moving away from Aranda. Around 12 o´clock on the 29 it disappeared.

The deformation on the lenght scale of 100 km was acheived by comparing the positions of the three ships at four occasions, see figure 8. The area of the ice field decreased during the northerly drift about 6 %.

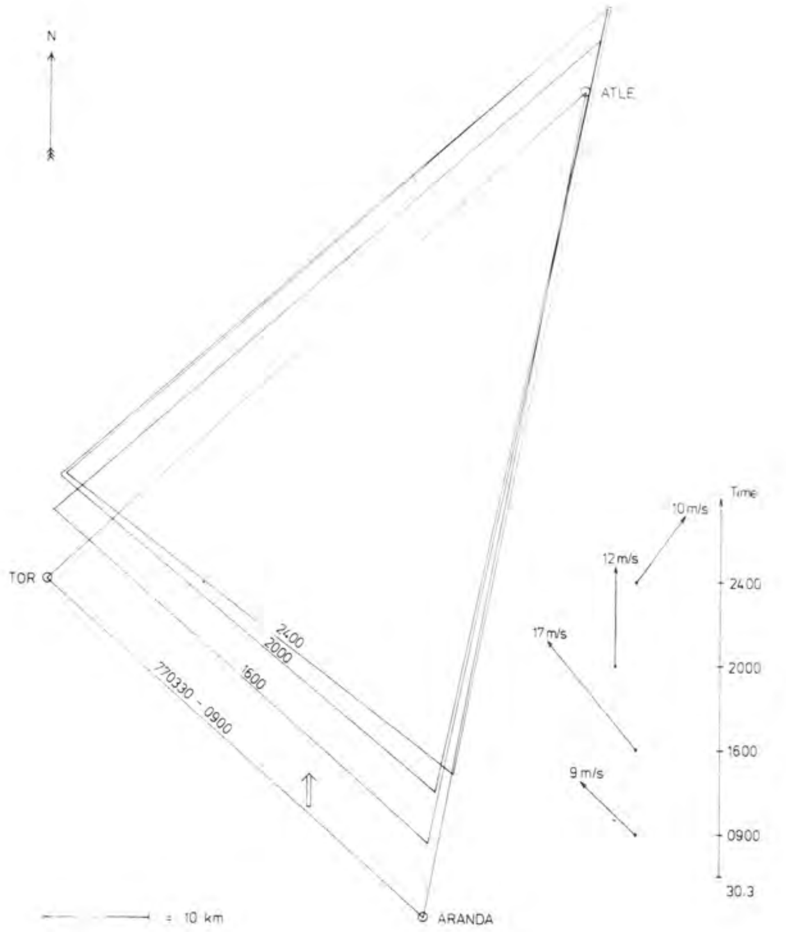


Figure 8.
The deformation of the area between the three ships during the northerly ice drift. The arrows indicate wind measured at Tor.

2.4 Ice temperature and salinity

When studying thermodynamics of sea-ice, the ice temperature and salinity are important physical parameters for the determination of heat fluxes through the ice. Ice temperatures were measured with 9 thermistors placed in two verticals in the ice, see figure 9. The data are presented in figure 10 and attachment 3. The changes in air temperature on a time scale of hours are only detectible in the snow. The

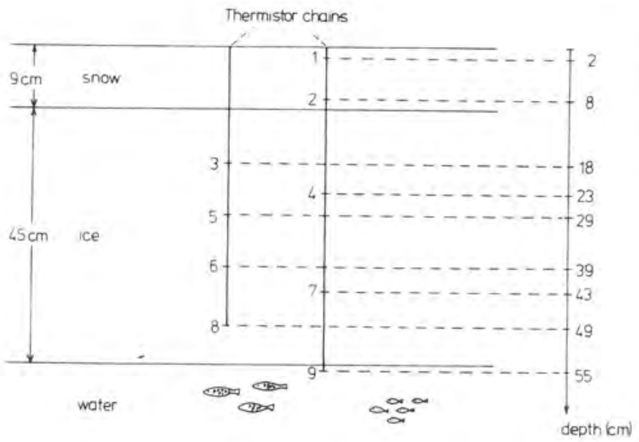


Figure 9.
Principle sketch of how the temperature sensors were placed in the ice.

ice temperature changes are connected with longer time periods.

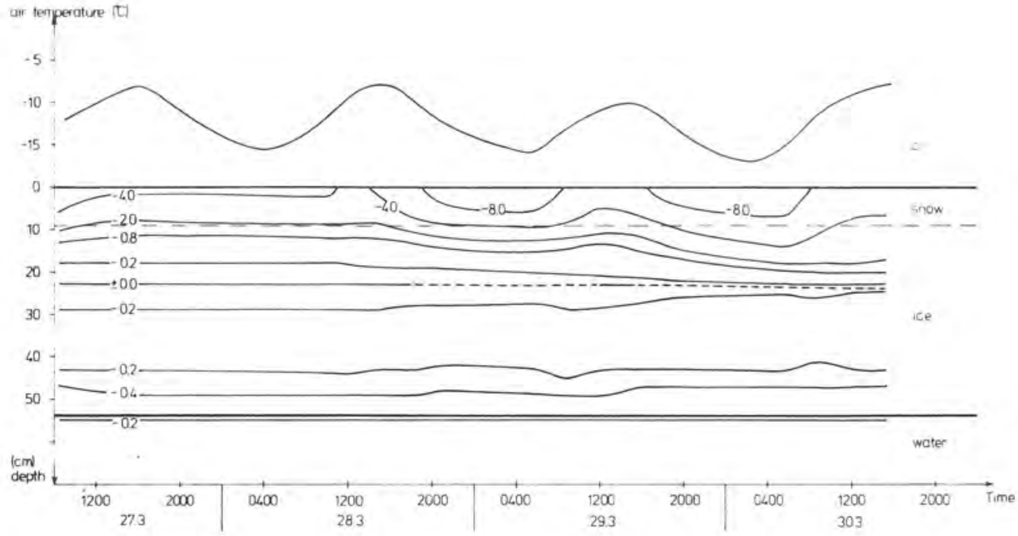


Figure 10.
Analysed temperatures in the air, snow and ice during four days.

The vertical distribution of ice salinity was measured in two places about 1 m apart. Measurements were taken at four different depths on the 50 cm thick ice. The data are presented in figure 11. Earlier measurements, see Sahlberg (1976), have shown that ice salinity varies largely in both horizontal and vertical direction. Due to this proper mean salinity values for different depths are impossible to obtain from two cores.

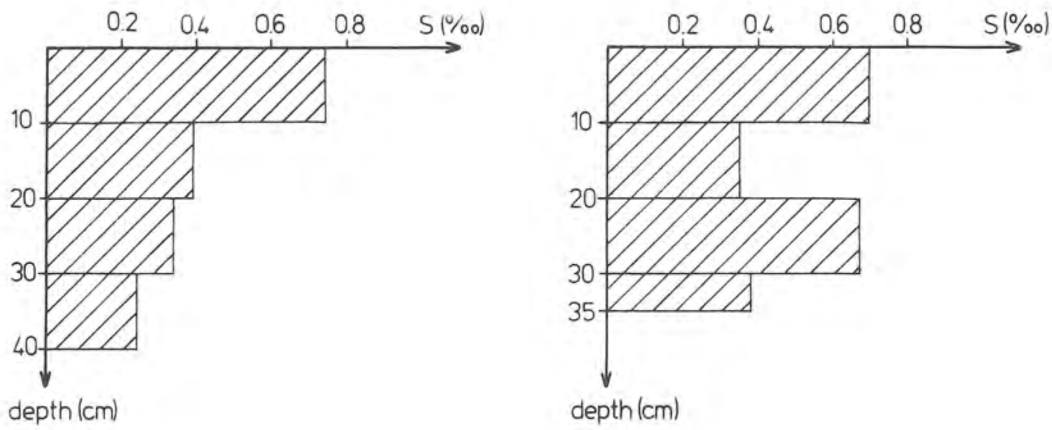


Figure 11.
Ice salinity taken from two cores at Aranda.

3. SEA MEASUREMENTS

The ice cover influences the exchange of different properties between the atmosphere and the sea. The wind drives the ice field which sets up and modifies the currents. It is therefore important when modelling sea ice drift to understand how momentum is transfered from the atmosphere through the ice down to the sea, and how the ice and the wind driven currents in an almost closed basin, like the Gulf of Bothnia, influence the ice drift.

The experiment therefore included measurements of currents, salinity and temperature during the whole period at Aranda and during two days at Atle and Tor.

3.1 Hydrography

Salinity and temperature were determined by taking water samples at different depths. A comparison between the density profiles (σ_t) from the three ships are given in figure 12.

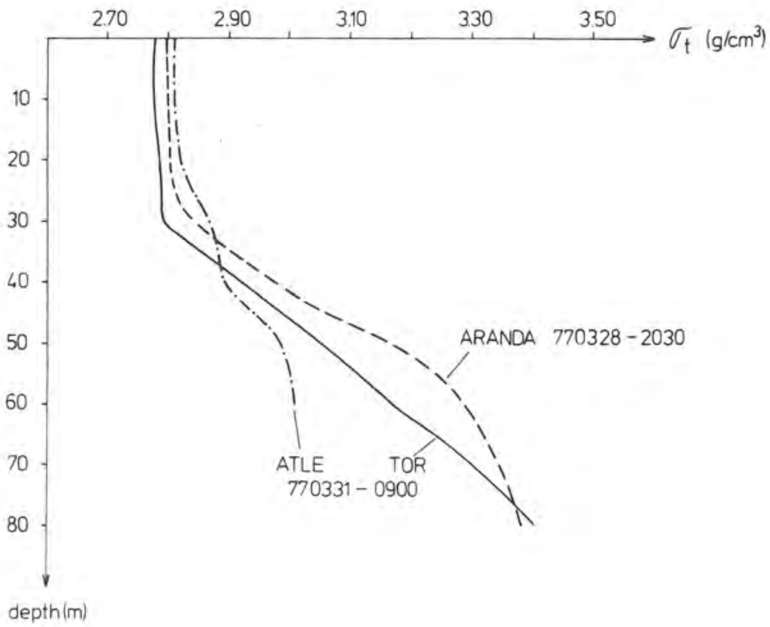


Figure 12.
Sea water density profiles at the three ships.

The water was well mixed down to 30 m. Also the horizontal gradients were small. One important mixing mechanism is probably the moving ice due to the rough ice-water interface. All hydrographic data are presented in attachment 4.

3.2 Currents

Two different kinds of measurements were used for determining the currents under the ice. One registrating current meter, Alexejev (1955) and one manual current meter, gelatine pendelums Haamer (1972). Pendelum measurements were carried out at Aranda, Atle and Tor by hanging the current meters at different depths from the moving ice. The results are presented in attachment 5. Because of heavy ridging during the storm the Alexejev instruments were lost, but later two of them were found by a fisherman. The data from the Alexejev instruments are not included in this report. A comparison between wind, ice and absolute current are given in vectordiagrams, attachment 6. The arrows give speed and direction of the wind ($\mathbb{V}_a$), ice ($\mathbb{V}_i$) and absolute currents at different depths. The numbers at the current arrows indicate depths in meters.

Figures 13 a-c give examples of three vectordiagrams. The ice in figure (a) has been accelerated for five hours, see figure 5. The currents are spread in different directions with rather low velocities except in the bottom water. Between 1230 and 1830 the ice

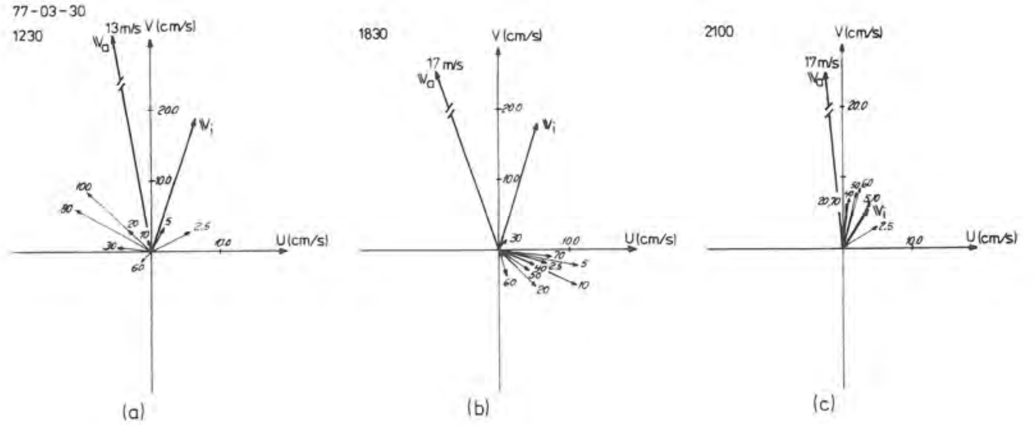


Figure 13.
Vectordiagrams showing wind ($\mathbb{V}_a$), ice ($\mathbb{V}_i$) and water velocities at Atle. The numbers at the current arrows indicate water depths.

drift was rather steady. In figure (b) one can see that the currents are now going to the right of the ice direction with velocities in the order of 5-10 cm/s in the whole water column.

Figure (c) shows a situation when the ice has been retarded. The currents are now in the direction of the ice with velocities a little greater then the ice.

From attachment 6 and earlier measurements, Udin and Omstedt (1976) the current profiles under sea-ice show sharp velocity gradients in the upper meter. They also, in general, show that during steady or nearly steady ice drift the currents are to the right of the ice drift with velocities of the same order in the whole water column.

The currents are not only ice driven. Wind and air pressure on a larger lenght scale cause sea level changes with associated currents. This could be seen in the afternoon on March 29, figure 14. During weak northwesterly winds Aranda was moving southward. Around 16 o'clock the ice retards at the same time as the water level rise in the bay. This rising require a net water transport into the bay with currents in northerly direction. They act therefore as a retarding force on the ice drift.

The currents at the three ships on March 30 are compared in attachment 7. The ice and water moves in northerly direction. This is in agreement with water level recording in the northern part of the Bay.

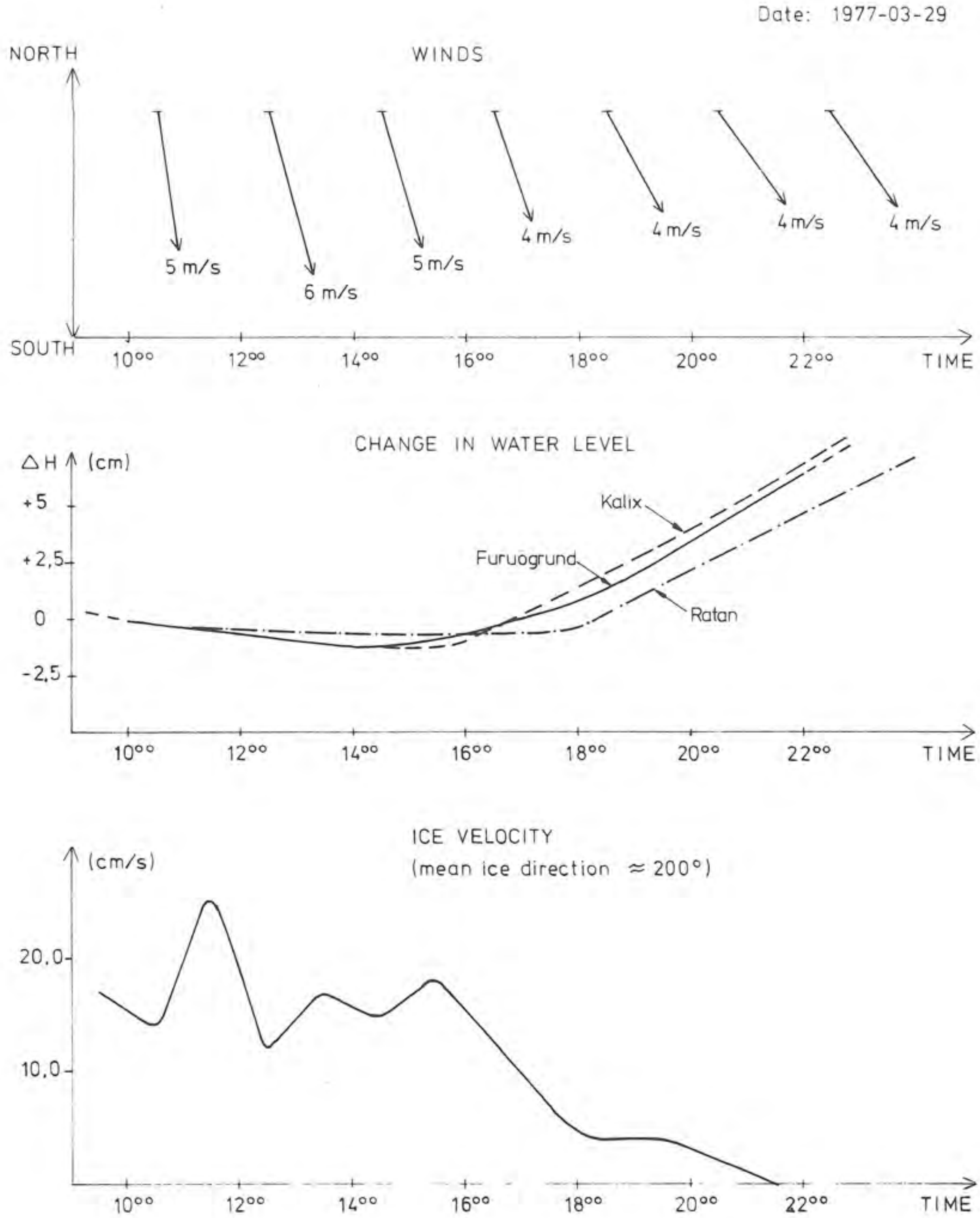


Figure 14.
A comparison between ice and wind velocities and water level changes in the Bay. Ice and wind velocities were measured at Aranda.

3.3 Water level

The vertical movements of the fast ice were measured with a water level recorder. The instrument was placed on 90 cm thick fast ice some km NW Malören. A wire was anchored at 15 m depth and then going over a small wheel on the instrument. The registration was compared with the corresponding registration from Kalix water level station 30 km NW of the fast ice station, see figure 15. The registrations follow each other closely which means that the fast ice follow the sea level fluctuations with the same amplitude and period. The curves deviate however more and more. The most probable explanation to this is that the wire slips over the wheel, and a zero-displacement will enter in the registration. Slipping occurred especially at the occasions associated with large water level changes, 11/4, 19/4 and 25/4.

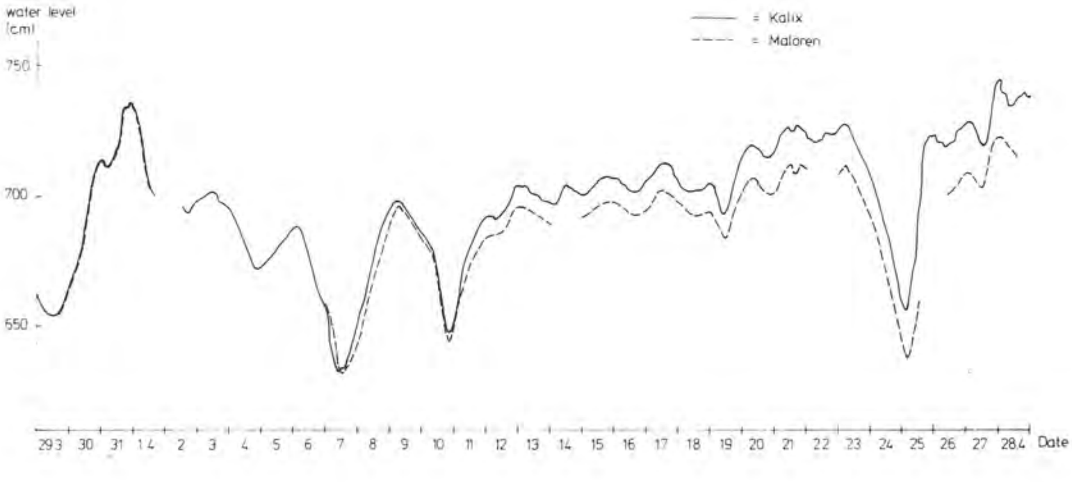


Figure 15.
Water level recordings from Kalix water level station and from the fast ice near Malören.

ACKNOWLEDGEMENT

The authors wish to thank the FIMR for the invitation to perform measurements from R/V Aranda, the captain and crew onboard Aranda. We also want to thank the Swedish Ice Breaking Service, its director and the captains and crew onboard the icebreakers ATLE and TOR for support during the experiment. The thank is extended to the Swedish Air Force for their contribution with air photography of the experimental area. The authors are also indepted to Ingemar Udin at SMHI for managing the experiment and for valuable discussions, suggestions and support.

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Udin I. and Omstedt A. (1976): Dynamical Report. In the Swedish/ Finnish Winter Navigation Research Board, Report No 16:8. Norrköping, Sweden, 1976.

ICE AND WIND MEASUREMENTS

DATE	TIME	WIND VELOCITY SPEED (m/s) $\lvert \mathbb{V}_a \rvert$	WIND VELOCITY DIR (360°) θ_a	ICE VELOCITY SPEED(m/s) $\lvert \mathbb{V}_i \rvert$	ICE VELOCITY DIR (360°) θ_i	ANGULAR DIFF. $\theta_i - (\theta_a \pm 180^\circ)$	WINDFACTOR $\left\lvert \frac{\mathbb{V}_i}{\mathbb{V}_a} \right\rvert \cdot 100$
77-03-25	0830			0.00	-		
	0930			0.00	-		
	1030			0.00	-		
	1130			0.00	-		
	1230			0.00	-		
	1330			0.00	-		
	1430			0.00	-		
	1530			0.00	-		
	1630			0.00	-		
	1730			0.00	-		
	1830			0.00	-		
	1930			0.00	-		
	2030			0.00	-		
	2130			0.00	-		
	2230			0.01	220		
	2330			0.01	213		
77-03-26	0030			0.07	213		
	0130			0.09	228		
	0230						
	0330			0.12*	233*		
	0430						
	0530			0.16	233		
	0630			0.17	232		
	0730			0.19	240		
	0830			0.18	227		
	0930			0.22	228		
	1030			0.19	227		
	1130			0.22	221		
	1230			0.17	222		
	1330			0.14	219		
	1430			0.11	213		
	1530			0.08	192		
	1630			0.05	176		
	1730			0.03	136		
	1830	3	264	0.03	096	012	1.00
	1930	4	258	0.04	070	- 008	1.00
	2030	4	260	0.04	083	003	1.00
	2130	4	259	0.05	093	014	1.25
	2230	4	257	0.02	071	- 006	0.50
	2330	4	246	0.00	-	-	0.00
77-03-27	0030	3	252	0.00	-	-	0.00
	0130	3	309	0.00	-	-	0.00
	0230	4	320	0.01	213	073	0.25
	0330	4	337	0.02	200	043	0.50
	0430	3	325	0.03	205	060	1.00
	0530	3	332	0.02	205	053	0.67
	0630	3	335	0.02	184	029	0.67
	0730	3	323	0.04	195	052	1.33
	0830	3	324	0.06	197	053	2.00
	0930	4	329	0.06	201	052	1.50

* Decca navigation problem, the value is a mean value over three hours.

DATE	TIME	WIND VELOCITY SPEED (m/s) $\lvert V_a \rvert$	WIND VELOCITY Dir (360°) θ_a	ICE VELOCITY SPEED (m/s) $\lvert V_i \rvert$	ICE VELOCITY DIR (360°) θ_i	ANGULAR DIFF. $\theta_i - (\theta_a \pm 180°)$	WINDFACTOR $\left\lvert \frac{V_i}{V_a} \right\rvert \cdot 100$
77-03-27	1030	3	325	0.06	204	059	2,00
	1130	3	312	0.03	200	068	1,00
	1230	2	325	0.00	-	-	0,00
	1330	2	308	0.00	-	-	0,00
	1430	2	305	0.00	-	-	0,00
	1530	2	291	0.00	-	-	0,00
	1630	5	320	0.00	-	-	0,00
	1730	2	286	0.00	-	-	0,00
	1830	1	307	0.01	-	-	1,00
	1930	1	257	0.01	-	-	1,00
	2030	1	230	0.01	-	-	1,00
	2130	2	271	0.00	-	-	0,00
	2230	2	283	0.00	-	-	0,00
	2330	2	299	0.00	-	-	0,00
77-03-28	0030	2	329	0.01	-	-	0,50
	0130	2	339	0.00	-	-	0,00
	0230	0		0.00	-	-	0,00
	0330	0		0.01	-	-	0,00
	0430	1	188	0.00	-	-	0,00
	0530	1	314	0.00	-	-	0,00
	0630	1	350	0.01	-	-	-1,00
	0730	0		0.02	213	-	0,00
	0830	0		0.05	202	-	0,00
	0930	2	002	0.09	203	021	4,50
	1030	4	358	0.09	196	018	2,25
	1130	4	358	0.12	205	027	3,00
	1230	5	005	0.13	209	024	2,60
	1330	5	007	0.17	212	025	3,40
	1430	5	007	0.18	212	025	3,60
	1530	5	356	0.17	212	036	3,40
	1630	4	353	0.15	213	040	3,75
	1730	4	346	0.07	205	039	1,75
	1830	4	344	0.01	197	033	0,25
	1930	4	340	0.00	-	-	0,00
	2030	4	343	0.00	-	-	0,00
	2130	4	345	0.00	-	-	0,00
	2230	4	344	0.01	-	-	0,25
	2330	6	344	0.00	-	-	0,00
77-03-29	0030	4	349	0.00	-	-	0,00
	0130	4	358	0.01	-	-	0,25
	0230	4	345	0.00	-	-	0,00
	0330	4	342	0.01	178	016	0,25
	0430	3	343	0.02	208	045	0,67
	0530	4	347	0.04	198	031	1,00
	0630	4	355	0.06	205	030	1,50
	0730	5	354	0.12	203	029	2,40
	0830	5	356	0.14	192	016	2,80
	0930	5	352	0.17	200	028	3,40
	1030	5	350	0.14	205	035	2,80
	1130	6	350	0.25	200	030	4,17
	1230	6	345	0.12	200	035	2,00

DATE	TIME	WIND VELOCITY SPEED(m/s) $\lvert V_a \rvert$	WIND VELOCITY DIR (360°) θ_a	ICE VELOCITY SPEED (m/s) $\lvert V_i \rvert$	ICE VELOCITY DIR (360°) θ_i	ANGULAR DIFF. $\theta_i - (\theta_a \pm 180^\circ)$	WINDFACTOR $\left\lvert \frac{V_i}{V_a} \right\rvert \cdot 100$
77-03-29	1330	6	341	0.17	204	043	2.83
	1430	5	343	0.15	205	042	3.00
	1530	5	345	0.18	210	045	3.60
	1630	4	341	0.13	224	063	3.25
	1730	4	329	0.07	217	068	1.75
	1830	4	330	0.04	193	043	1.00
	1930	4	324	0.04	198	054	1.00
	2030	4	323	0.02	185	042	0.50
	2130	4	324	0.00	-	-	0.00
	2230	4	325	0.01	-	-	0.25
	2330	4	327	0.02	210	063	0.50
77-03-30	0030	4	320	0.02	199	059	0.50
	0130	4	322	0.01	-	-	0.25
	0230	3	326	0.00	-	-	0.00
	0330	2	356	0.00	-	-	0.00
	0430	1	052	0.00	-	-	0.00
	0530	2	110	0.01	024	094	0.50
	0630	3	148	0.03	010	042	1.00
	0730	3	161	0.07	007	026	2.33
	0830	4	161	0.13	002	021	3.25
	0930	5	145	0.17	356	031	3.40
	1030	5	135	0.22	357	042	4.40
	1130	7	139	0.30	001	042	4.29
	1230	10	147	0.31	005	038	3.10
	1330	11	143	0.34	007	044	3.09
	1430	11	139	0.32	007	048	2.91
	1530	11	141	0.35	004	043	3.18
	1630	12	131	0.33	003	052	2.75
	1730	13	138	0.36	007	049	2.77
	1830	13	145	0.35	015	050	2.69
	1930	12	154	0.30	019	045	2.50
	2030	12	163	0.26	033	050	2.17
	2130	10	164	0.17	044	060	1.70
	2230	8	177	0.12	059	062	1.50
	2330	8	204	0.12	063	039	1.50
77-03-31	0030	11	194	0.20	064	050	1.82
	0130	11	187	0.15	041	034	1.36
	0230	10	174	0.12	036	042	1.20
	0330	10	162	0.08	008	026	0.80
	0430	10	165	0.13	001	016	1.30
	0530	7	178	0.09	018	020	1.29
	0630	6	277	0.07	033	-064	1.17
	0730	6	269	0.20	335	-114	3.33

ICEBREAKER: ATLE

DATE	TIME	WIND VELOCITY SPEED(m/s) $\lvert V_a \rvert$	WIND VELOCITY DIR(360°) θ_a	ICE VELOCITY SPEED(m/s) $\lvert V_i \rvert$	ICE VELOCITY DIR(360°) θ_i	ANGULAR DIFF. $\theta_i - (\theta_a \pm 180^0)$	WINDFACTOR $\left\lvert \frac{V_i}{V_a} \right\rvert \cdot 100$
77-03-30	0745	6	177	0.04	023	026	0.7
	0845	6	177	0.07	014	017	1.2
	0945	7	160	0.10	015	035	1.4
	1045	10	161	0.16	014	033	1.6
	1145	11	159	0.18	013	034	1.6
	1245	12	168	0.20	019	031	1.7
	1345	13	170	0.22	019	029	1.7
	1445	13	160	0.20	016	036	1.5
	1545	15	156	0.20	012	036	1.3
	1645	17	155	0.19	013	038	1.1
	1745	18	157	0.21	006	029	1.2
	1845	16	162	0.19	017	035	1.2
	1945	15	170	0.09	028	038	0.6
	2045	16	173	0.07	035	042	0.4
	2145	12	184	0.03	068	064	0.2
	2245	11	199	0.02	031	012	0.2
	2345	10	216	0.03	250	146	0.3
77-03-31	0045	10	220	0.02	061	021	0.2
	0145	11	221	0.02	057	016	0.2
	0245	14	228	0.09	048	000	0.6
	0345	16	220	0.05	036	-004	0.3
	0445	17	208	0.07	023	-005	0.4
	0545	15	205	0.01	-	-	0.1
	0645	14	202	0.00	-	-	0.0
	0745	16	214	0.04	027	-007	0.2
	0845	15	215	0.08	038	003	0.5
	0945	14	221	0.02	047	006	0.1
	1045	17	222	0.00	-	-	0.0
	1145	20	230	0.05	025	-025	0.2
	1245	21	226	0.08	031	-015	0.4
	1345	21	218	0.09	028	-010	0.4
	1445	22	220	0.07	039	-001	0.3

ICEBREAKER: TOR

DATE	TIME	WIND VELOCITY SPEED(m/s) $\lvert \mathbb{V}_a \rvert$	WIND VELOCITY DIR(360^0) θ_a	ICE VELOCITY SPEED(m/s) $\lvert \mathbb{V}_i \rvert$	ICE VELOCITY DIR(360^0) θ_i	ANGULAR DIFF. $\theta_i - (\theta_a \pm 180^0)$	WINDFACTOR $\left\lvert \frac{\mathbb{V}_i}{\mathbb{V}_a} \right\rvert \cdot 100$
77-03-30	0530	1	180	0.01	-	-	1.0
	0630	3	160	0.04	308	-032	1.3
	0730	5	135	0.06	045	090	1.2
	0830	8	135	0.11	355	040	1.4
	0930	10	135	0.17	354	039	1.7
	1030	13	135	0.26	357	042	2.0
	1130	15	135	0.24	003	048	1.6
	1230	16	135	0.29	004	049	1.8
	1330	15	135	0.30	005	050	2.0
	1430	14	135	0.29	004	049	2.1
	1530	17	135	0.30	004	049	1.8
	1630	18	149	0.31	003	033	1.7
	1730	17	180	0.25	005	005	1.5
	1830	14	180	0.19	014	014	1.4
	1930	12	180	0.14	033	033	1.2
	2030	11	180	0.07	072	072	0.6
	2130	9	180	0.06	075	075	0.7
	2230	7	180	0.04	074	074	0.6
	2330	8	203	0.01	089	066	0.1
77-03-31	0030	13	225	0.05	033	-012	0.4
	0130	17	225	0.11	039	-006	0.6
	0230	13	225	0.13	033	-012	1.0
	0330	13	210				-
	0430	13	202	0.09*	040*	018*	-
	0530	10	202				-
	0630	10	202	0.00	-	-	0.0
	0730	10	202	0.03	037	015	0.3
	0830	12	202	0.10	042	020	0.8
	0930	12	202	0.06	072	050	0.5
	1030	15	202	0.06	053	031	0.4
	1130	16	202	0.10	035	013	0.6
	1230	16	202	0.14	040	018	0.9
	1315			0.19	035		

* Decca navigation problem, the value is a mean value over three hours.

DRIFT OF RADAR REFLECTORS

Date Time	Radar Reflector nr. 1 angle	1 distance (km)	2 angle	2 distance (km)	3 angle	3 distance (km)	4 angle	4 distance (km)
0325-1630	092	4.4	140	6.8	208	6.4	282	3.1
0326-0030	092	4.4	140	6.8	208	6.4	283	3.1
0326-0830	092	4.4	140	6.8	207	6.4	283	3.1
0326-1630	093	4.4	141	6.8	208	6.4	284	3.1
0327-0030	093	4.4	141	6.8	208	6.4	284	3.1
0327-0830	092	4.4	140	6.8	207	6.4	283	3.1
0327-1630	092	4.4	140	6.8	208	6.4	283	3.1
0328-0030	093	4.4	141	6.8	208	6.4	283	3.1
0328-0830	092	4.4	141	6.8	208	6.4	283	3.1
0328-1630	093	4.4	141	6.8	208	6.5	283	3.0
0329-0030	094	4.4	143	6.8	208	8.7	285	3.1
0329-0830	093	4.5	142	6.8	208	11.8	283	3.1
0329-1630	093	4.4	142	6.8	-	-	284	3.0
0330-0030	094	4.4	143	6.8	208	12.3	286	3.0
0330-0830	094	4.4	144	6.8	lost		286	3.0
0330-1630	096	4.5	145	6.8	lost		287	3.1
0331-0030	096	4.5	144	6.8	lost		286	3.1

ICE TEMPERATURE MEASUREMENTS

DATE	TIME	THERMISTOR NUMBER 1 -°C	2 -°C	3 -°C	4 -°C	5 -°C	6 -°C	7 -°C	8 -°C	9 -°C	AIR TEMPERATURE
27/3-77	0830	5.60	3.40	0.20	0.00	0.20	0.20	0.20	0.45	0.25	-12°
	1620	3.65	1.85	0.20	0.00	0.20	0.20	0.20	0.40	0.20	-8°
28/3-77	1000	3.95	2.60	0.20	0.00	0.15	0.20	0.15	0.40	0.20	-12°
	1145	3.25	2.10	0.20	0.00	0.15	0.15	0.15	0.40	0.20	-9°
	1510	3.95	2.15	0.25	0.00	0.20	0.20	0.20	0.40	0.20	-8°
	1800	7.25	3.40	0.25	0.00	0.25	0.25	0.20	0.40	0.25	-9°
	2100	10.00	5.00	0.25	0.05	0.25	0.25	0.20	0.45	0.20	-13°
29/3-77	0550	10.75	5.85	0.30	0.05	0.25	0.25	0.20	0.40	0.25	-16°
	0905	6.15	4.30	0.35	0.05	0.20	0.25	0.15	0.40	0.20	-13°
	1215	5.10	3.05	0.40	0.00	0.15	0.20	0.20	0.40	0.20	-11°
	1525	5.70	3.20	0.50	0.00	0.25	0.25	0.20	0.45	0.20	-10°
	1840	9.85	4.95	0.65	0.10	0.30	0.30	0.20	0.45	0.25	-12°
30/3-77	0600	11.45	6.95	2.05	0.10	0.30	0.30	0.20	0.45	0.20	-15°
	0915	6.55	4.65	2.10	0.10	0.25	0.25	0.15	0.45	0.20	-10°
	1235	5.60	3.65	1.90	0.15	0.30	0.30	0.20	0.50	0.20	-9°
	1520	5.45	3.55	1.80	0.15	0.30	0.30	0.20	0.45	0.20	-8°

HYDROGRAPHIC OBSERVATIONS

DATE TIME	DEPTH (m)	S (°/oo)	T (°C)	$\sigma_t (g/cm^3)$
77-03-28 0830	1	3.54	-0.10	2.78
	10	3.57	-0.10	2.81
	20	3.55	-0.15	2.79
	30	3.56	-0.12	2.80
	40	(3.42)	(0.50)	(2.69)
	50	3.91	1.90	3.16
	60	(3.66)	(2.55)	(2.96)
	70	4.06	2.65	3.28
	75	4.18	2.35	3.38
2030	1	3.56	-0.15	2.80
	10	3.56	-0.15	2.80
	20	3.56	-0.15	2.80
	30	3.60	0.00	2.84
	40	3.72	0.90	2.97
	50	3.91	2.00	3.16
	60	4.07	2.35	3.29
	70	4.15	2.45	3.35
	80	4.18	2.30	3.38
77-03-29 1430	0	3.57		
	10	3.57		
	20	3.57		
	30	3.64		
	40	3.81		
	50	3.98		
	60	4.09		
77-03-30 0825	0	3.59		
	10	3.58		
	20	3.57		
	30	3.62		
	40	3.80		
	50	3.95		
	60	4.07		
	70	4.16		
1430	0	3.57		
	10	3.57		
	20	3.55		
	30	3.61		
	40	3.74		
	50	3.89		
	60	4.02		
	70	4.22		

HYDROGRAPHIC OBSERVATIONS

DATE TIME	DEPTH (m)	S (°/oo)	T (°C)	$\sigma_{t(g/cm^3)}$
77-03-25 1600	1	3.55	-0.25	2.79
	10	3.55	-0.25	2.79
	20	3.56	-0.25	2.80
	30	3.58	-0.25	2.81
	40	3.66	0.85	2.88
	50	3.87	2.15	3.13
	60	4.13	3.20	3.34
	70	4.21	3.00	3.41
77-03-26 0900	1	3.58	-0.10	2.81
	10	3.56	-0.10	2.80
	20	3.55	-0.10	2.79
	30	3.56	-0.10	2.80
	40	3.61	-0.10	2.84
	50	3.90	2.15	3.15
	60	4.08	2.90	3.30
	70	(3.73)	(1.20)	(2.98)
	80	(3.91)	(1.20)	(3.13)
1430	1	3.55	-0.12	2.79
	10	3.56	-0.12	2.80
	20	3.54	-0.12	2.79
	30	3.59	0.00	2.82
	40	3.72	-0.10	2.93
	50	3.98	2.20	3.21
	60	4.09	2.20	3.30
	70	4.15	2.10	3.35
	75	4.18	2.10	3.38
77-03-27 0800	1	3.54	-0.10	2.78
	10	3.55	-0.10	2.79
	20	3.57	-0.10	2.81
	30	3.56	-0.10	2.81
	40	3.72	0.60	2.93
	50	3.81	1.20	3.04
	60	4.08	2.35	3.29
	70	4.15	2.25	3.35
	80	4.17	2.10	3.37
77-03-27 1430	1	3.55	-0.10	2.79
	10	3.55	-0.15	2.79
	20	3.55	-0.15	2.79
	30	3.60	-0.15	2.84
	40	3.75	0.10	2.95
	50	3.89	1.80	3.14
	60	4.08	2.65	3.29
	70	4.16	2.25	3.36
	80	(3.97)	2.25	(3.20)

HYDROGRAPHIC OBSERVATIONS

ICEBREAKER: ATLE

DATE TIME	DEPTH (m)	S (°/oo)	T (°C)	σ_t(g/cm³)
77-03-30 1500	20	3.64	-0.12	2.87
	30	3.68	0.19	2.90
	40	3.72	0.82	2.98
	50	3.73	-	2.98
	60	3.76	1.75	3.03
	70	3.82	1.92	3.08
77-03-31 0930	0	3.58	-0.08	2.81
	10	3.57	-0.02	2.81
	20	3.59	-0.08	2.82
	30	3.64	-	2.87
	40	3.67	0.45	2.89
	50	3.70	1.39	2.99
	60	3.73	1.79	3.01
1400	10	3.57	-0.06	2.81
	20	3.57	-0.10	2.81
	30	3.59	-0.02	2.82
	40	3.67	-0.18	2.89
	50	3.68	0.68	2.94
	60	3.74	1.98	3.01

HYDROGRAPHIC OBSERVATIONS

ICEBREAKER: TOR

DATE TIME	DEPTH (m)	S (°/oo)	T (°C)	σ_t(g/cm³)
77-03-30 0930	0	3.49	-0.05	2.74
	10	3.47	-0.05	2.73
	20	3.55	-	2.79
	30	3.57	0.01	2.81
	40	3.67	0.42	2.89
	50	3.87	2.01	3.13
	60	4.09	1.64	3.30
	70	4.20	1.02	3.36
	80	4.39	0.50	3.47
	100	4.42	0.82	3.50
1500	0	3.48	0.02	2.73
	10	3.48	0.00	2.73
	30	3.55	-0.05	2.79
	40	3.59	0.31	2.82
	50	3.72	1.50	3.00
	60	3.91	2.50	3.17
	70	4.05	2.85	3.27
	80	4.17	3.00	3.38
	90	4.17	1.50	3.37
77-03-31 0900	0	3.53	-	2.78
	10	3.54	0.01	2.78
	20	3.55	-0.03	2.79
	30	3.55	0.00	2.79
	40	3.66	0.84	2.92
	50	3.78	2.13	3.05
	60	3.92	2.87	3.16
	70	4.07	3.18	3.30
	80	4.20	3.38	3.40

CURRENTS MEASUREMENTS

RESEARCH VESSEL: ARANDA

DATE: 1977-03-26 TIME: 0850

ICE VELOCITY*: U = -14.8 Vel. East
V = -13.5 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1.0	5.3	12.4	-9.5	-1.1
2.5	15.0	11.7	0.2	-1.8
5.0	11.5	16.4	-3.3	2.9
7.5	10.6	15.2	-4.2	1.7
10.0	10.7	19.2	-4.1	5.7
15.0	13.5	17.3	-1.3	3.8
30.0	12.9	17.2	-1.9	3.7
40.0	14.6	11.4	-0.2	-2.1
50.0	14.2	17.5	-0.6	4.0
60.0	11.6	12.4	-3.2	-1.1
70.0	15.1	17.4	0.3	3.9
80.0	20.5	10.4	5.7	-3.1

DATE: 1977-03-26 TIME: 1200

ICE VELOCITY: U = -13.1 Vel. East
V = -14.8 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	1.8	12.9	-11.3	-1.9
2.5	0.0	14.0	-13.1	-0.8
5	-	-	-	-
10	5.0	14.7	-8.1	-0.1
15	10.8	13.8	-2.3	-1.0
20	10.2	16.9	-2.9	2.1
25	9.2	17.4	-3.9	2.6
30	13.4	10.5	0.3	-4.3
40	9.5	12.2	-3.6	-2.6
50	9.2	11.8	-3.9	-3.0
60	9.6	11.5	-3.5	-3.3
70	9.4	11.7	-3.7	-3.1
80	8.5	10.5	-4.6	-4.3

* Ice velocity is given in cms^{-1}.

DATE: 1977-03-28 TIME: 0900

ICE VELOCITY: U = -2.0 Vel. East
V = -4.8 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.0	0.0	-2.0	-4.8
2.5	0.0	0.0	-2.0	-4.8
5	0.0	0.0	-2.0	-4.8
7.5	0.0	0.0	-2.0	-4.8
10	0.0	0.0	-2.0	-4.8
12.5	3.5	6.1	1.5	1.3
15	0.6	6.0	-1.4	1.2
20	3.0	6.3	1.0	1.5
25	2.7	3.0	0.7	-1.8
30	0.0	0.0	-2.0	-4.8
40	3.4	3.7	1.4	-1.1
50	2.8	8.6	0.8	3.8
60	2.0	4.6	0.0	-0.2
70	-0.1	4.0	-2.1	-0.8

DATE: 1977-03-28 TIME: 1145

ICE VELOCITY: U = -5.1 Vel. East
V = -10.9 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.6	8.0	-4.5	2.9
2.5	2.3	7.6	-2.8	-3.3
5	1.8	7.8	-3.3	-3.1
7.5	4.0	8.1	-1.1	-2.8
10	5.0	7.5	-0.1	-3.4
12.5	2.5	9.2	-2.6	-1.7
15	6.0	8.0	0.9	-2.9
20	5.8	10.0	0.7	-0.9
25	5.0	6.2	-0.1	-4.7
30	1.2	4.8	-3.9	-6.1
40	0.0	8.0	-5.1	-2.9
50	3.2	13.6	-1.9	2.7
60	3.9	8.7	-1.2	-2.2
70	8.0	4.1	2.9	-6.8
80	1.8	4.7	-3.3	-6.2

DATE: 1977-03-26 TIME: 1520

ICE VELOCITY: U = -1.6 Vel. East
V = -7.4 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
0	0.0	0.0	-1.6	-7.4
1.5	-3.7	7.6	-5.3	0.2
4.0	-2.5	8.6	-4.1	1.2
6.5	-0.9	8.4	-2.5	1.0
9	-0.9	10.5	-2.5	3.1
11.5	0.0	9.0	-1.6	1.6
14	0.0	11.5	-1.6	4.1
19	0.0	8.5	-1.6	1.1
24	0.3	0.9	-1.3	-6.5
29	1.7	2.5	0.1	-4.9
39	1.5	6.3	-0.1	-1.1
49	0.0	0.0	-1.6	-7.4
59	-0.4	3.0	-2.0	-4.4
69	5.4	5.2	3.8	-2.2

DATE: 1977-03-27 TIME: 0900

ICE VELOCITY: U = -1.8 Vel. East
V = -5.7 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
11			-	-
21			-9.3	3.8
31			-10.0	0.0
41			-	-
51			-3.8	-4.0
61			-17.0	-0.9
71			-1.7	5.2
80			-4.0	3.8

DATE: 1977-03-28 TIME: 1330

ICE VELOCITY: U = -8.8 Vel. East
V = -14.1 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.2	9.5	-8.6	-4.6
2.5	1.6	9.4	-7.2	-4.7
5	2.5	9.2	-6.3	-4.9
7.5	3.8	10.3	-5.0	-3.8
10	4.3	11.8	-4.5	-2.3
12.5	4.3	11.8	-4.5	-2.3
15	8.1	10.8	-0.7	-3.3
20	2.4	13.8	-6.4	-0.3
25	2.2	12.3	-6.6	-1.8
30	2.0	9.3	-6.8	-4.8
40	2.8	13.2	-6.0	-0.9
50	9.2	9.9	0.4	-4.2
60	7.0	11.6	-1.8	-2.5
70	7.3	13.1	-1.5	-1.0
80	7.7	12.9	-1.1	-1.2

DATE: 1977-03-28 TIME: 1500

ICE VELOCITY: U = -9.2 Vel. East
V = -14.7 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.6	9.0	-8.6	-5.7
2.5	-0.6	9.0	-9.8	-5.7
5	0.7	9.5	-8.5	-5.2
7.5	0.0	13.5	-9.2	-1.2
10	4.1	11.3	-5.1	-3.4
12.5	5.3	12.4	-3.9	-2.3
15	3.2	13.6	-6.0	-1.1
20	6.2	14.7	-3.0	0.0
25	3.9	15.5	-5.3	0.8
30	4.4	17.5	-4.8	2.8
40	10.8	13.8	1.6	-0.9
50	13.4	11.2	4.2	-3.5
60	9.8	12.6	0.6	-2.1
70	8.6	12.3	-0.6	-2.4
80	3.9	11.9	-5.3	-2.8

CURRENTS MEASUREMENTS

RESEARCH VESSEL: ARANDA

DATE: 1977-03-28 TIME: 1800

ICE VELOCITY: U = -1.7 Vel. East
V = -3.8 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.0	0.0	-1.7	-3.8
2.5	-4.1	3.7	-5.8	-0.1
5	-3.2	2.4	-4.9	-1.4
7.5	-3.3	2.2	-5.0	-1.6
10	-3.1	2.6	-4.8	-1.2
12.5	-1.4	1.4	-3.1	-2.4
15	-1.1	1.7	-2.8	-2.1
20	-0.9	1.8	-2.6	-2.0
25	-1.7	3.6	-3.4	-0.2
30	0.1	2.0	-1.6	-1.8
40	1.2	1.6	0.5	-2.2
50	1.3	1.5	0.4	-2.3
60	1.4	1.4	0.3	-2.4
70	0.0	0.0	-1.7	-3.8
80	0.0	0.0	-1.7	-3.8

DATE: 1977-03-29 TIME: 0900

ICE VELOCITY: U = -4.4 Vel. East
V = -15.5 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.5	6.0	-3.9	-9.5
3.5	0.0	14.0	-4.4	-1.5
6.0	-2.4	14.8	-2.0	-0.7
8.5	0.0	15.0	-4.4	-0.5
11	4.7	16.3	0.3	0.8
13.5	0.0	19.0	-4.4	3.5
18.5	1.3	19.0	-3.1	3.5
23.5	4.9	18.4	0.5	2.9
28.5	-	-	-	-
38.5	5.9	12.1	1.5	-3.4
48.5	1.5	17.4	-2.9	1.9
58.5	1.2	14.0	-3.2	-1.5
68.5	2.2	13.8	-2.2	-1.7

DATE: 1977-03-30 TIME: 0905

ICE VELOCITY: U = -0.4 Vel. West
V = 15.0 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	2.0	-11.3	1.6	3.7
2.5	1.6	-9.4	1.2	5.6
5.0	0.7	-9.5	0.3	5.5
7.5	0.0	-9.5	-0.4	5.5
10	1.6	-9.4	1.2	5.6
20	0.0	-12.5	-0.4	2.5
30	-0.9	-13.5	-1.3	1.5
40	-0.8	-12.0	-1.2	3.0
60	-1.0	-12.0	-1.4	3.0
70	-2.4	-12.3	-2.8	2.7

DATE: 1977-03-30 TIME: 1230

ICE VELOCITY: U = 2.7 Vel. East
V = 31.1 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	11.2	-22.9	13.9	8.2
2.5	6.0	-24.3	8.7	6.8
5.0	13.0	-22.5	15.7	8.6
7.5	1.3	-25.5	4.0	5.6
10	2.8	26.8	5.5	4.3
20	2.9	-27.4	5.6	3.7
30	-3.5	-28.3	-0.8	2.8
40	-5.0	-28.1	-2.3	3.0
60	-5.9	-27.9	-3.2	3.2
70	-5.4	-30.5	-2.7	0.6

DATE: 1977-03-29 TIME: 1205

ICE VELOCITY: U = -6.2 Vel. East
V = -17.0 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	-	-	-	-
2.5	0.4	2.0	-5.8	-15.0
5	-1.9	13.4	-8.1	-3.6
7.5	1.7	13.9	-4.5	-3.1
10	3.4	12.6	-2.8	-4.4
20	1.5	9.4	-4.7	-7.6
30	1.9	8.8	-4.3	-8.2
40	2.8	10.6	-3.4	-6.4
60	2.9	12.7	-3.3	-4.3
70	4.4	16.4	-1.8	-0.6

DATE: 1977-03-29 TIME: 1515

ICE VELOCITY: U = -8.5 Vel. East
V = -15.2 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.3	8.5	-8.2	-6.7
3.5	0.0	8.5	-8.5	-6.7
13.5	6.8	13.9	-1.7	-1.3
23.5	7.2	15.4	-1.3	0.2
33.5	8.8	17.4	0.3	2.2
53.5	7.0	10.4	-1.5	-4.8
63.5	-	-	-	-

DATE: 1977-03-30 TIME: 1510

ICE VELOCITY: U = 3.2 Vel. East
V = 33.7 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	0.8	-23.5	4.0	10.2
2.5	7.0	-24.5	10.2	9.2
5	7.4	-27.5	10.6	6.2
7.5	7.1	-26.6	10.3	7.1
10	12.5	-25.6	15.7	8.1
20	2.0	-28.4	5.2	5.3
30	3.3	-31.8	6.5	1.9
40	-2.2	-30.9	1.0	2.8
60	-1.5	-28.5	1.7	5.2
80	-1.7	-32.0	1.5	1.7

DATE: 1977-03-30 TIME: 1735

ICE VELOCITY: U = 4.4 Vel. East
V = 36.2 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	6.3	-32.4	10.7	3.8
2	6.0	-30.9	10.4	5.3
3	6.3	-32.4	10.7	3.8
4	0.5	-31.0	4.9	5.2
5	3.9	-36.8	8.3	-0.6
6	4.5	-36.7	8.9	-0.5
7	10.8	-35.4	15.2	0.8
8	9.6	-31.6	14.0	4.6
9	6.9	-35.3	11.3	0.9
10	3.9	-37.3	8.3	-1.1

DATE: 1977-03-30 TIME: 1845

ICE VELOCITY: U = 9.3 Vel. East
V = 32.6 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	-2.1	-24.4	7.2	8.2
2.5	-0.9	-25.5	8.4	7.1
5	-4.5	-28.6	4.8	4.0
7.5	-1.6	-30.0	7.7	2.6
10	-1.7	-32.0	7.6	0.6
20	-1.1	-30.5	8.2	2.1
30	-3.1	-29.3	6.2	3.3
40	-4.2	-29.7	5.1	2.9
60	-8.5	27.7	0.8	4.9
80	-1.7	-32.0	7.6	0.6

DATE: 1977-03-30 TIME: 2100

ICE VELOCITY: U = 13.0 Vel. East
V = 17.0 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	-9.0	-16.2	4.0	0.8
2.5	-7.9	-16.2	5.1	0.8
5	-	-	-	-
7.5	-9.2	-18.9	3.8	-1.9
10	-11.1	-17.8	1.9	-0.8
20	-13.2	-17.6	-0.2	-0.6
30	-13.8	-19.7	-0.8	-2.7
40	-20.1	-11.2	-7.1	5.8
60	-13.9	-14.4	-0.9	2.6
80	-13.6	-14.6	-0.6	2.4

CURRENTS MEASUREMENTS

ICEBREAKER: ATLE

DATE: 1977-03-30 TIME: 1230

ICE VELOCITY: U = 6.6 Vel. East
V = 19.1 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
2,5	-0,3	-16,0	6,3	3,1
5	-4,9	-15,2	1,7	3,9
10	-7,1	-17,6	-0,5	1,5
20	-10,1	-16,1	-3,5	3,0
30	-11,7	-18,7	-5,1	0,4
40	-6,8	-18,8	-0,2	0,3
60	-8,2	-20,4	-1,6	-1,3
80	-17,6	-13,2	-11,0	5,9
100	-15,9	-10,4	-9,3	8,7

DATE: 1977-03-30 TIME: 1500

ICE VELOCITY: U = 5,8 Vel. East
V = 19,2 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
2,5	2,5	-15,8	8,3	3,4
5	-1,3	-18,9	4,5	0,3
10	1,1	-16,0	6,9	3,2
20	-7,5	-18,5	-1,7	0,7
30	-1,9	-21,9	3,9	-2,7
40	-4,5	-19,5	1,3	-0,3
60	0,0	-20,0	5,8	-0,8
80	-1,7	-19,9	4,1	-0,7
100	-10,1	-16,1	-4,3	3,1

* Ice velocity is given in cms^{-1}.

DATE: 1977-03-30 TIME: 1830

ICE VELOCITY: U = 5,5 Vel. East
V = 18,1 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
2,5	1,7	-19,9	7,2	-1,8
5	6,1	-20,1	11,6	-2,0
10	6,2	-23,2	11,7	-5,1
20	0,0	-23,0	5,5	-4,9
30	-4,4	-16,4	1,1	1,7
40	-0,4	-20,0	5,1	-1,9
50	-1,1	-21,0	4,4	-2,9
60	-4,6	-21,5	0,9	-3,4
70	2,3	-18,9	7,8	-0,8

DATE: 1977-03-30 TIME: 2100

ICE VELOCITY: U = 4,2 Vel. East
V = 6,0 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
2,5	0,8	-2,9	5,0	3,1
5	0,0	0,0	4,2	6,0
10	0,0	0,0	4,2	6,0
20	-3,9	-1,0	0,3	6,3
30	-	-	-	-
40	-3,3	-5,0	0,9	6,9
50	-2,2	-3,4	2,0	8,0
60	-1,7	-4,7	2,5	8,5
70	-3,9	1,0	0,3	6,3

DATE: 1977-03-31 TIME: 0900

ICE VELOCITY: U = 4,0 Vel. East
V = 5,0 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
1,5	-1,4	-3,7	2,6	1,3
4	-1,6	-4,8	2,4	0,2
9	-1,0	-4,9	3,0	0,1
19	0,0	0,0	4,0	5,0
29	-0,7	-5,0	3,3	0,0
39	-4,6	-10,0	-0,6	-5,0
49	-4,8	-6,4	-0,8	-1,4
69	-3,0	-16,7	1,0	-11,7

DATE: 1977-03-31 TIME: 1230

ICE VELOCITY: U = 4,1 Vel. East
V = 6,9 Vel. North

DEPTH (m)	RELATIVE VELOCITY VEL. EAST (cm/s)	RELATIVE VELOCITY VEL. NORTH (cm/s)	ABSOLUTE VELOCITY VEL. EAST (cm/s)	ABSOLUTE VELOCITY VEL. NORTH (cm/s)
2,5	-3,1	-11,6	1,0	-4,7
5	-4,7	-11,0	-0,6	-4,1
10	-3,9	-11,4	0,2	-4,5
20	-5,1	-10,9	-1,0	-4,0
30	-6,4	-10,2	-2,3	-3,3
40	-3,1	-8,5	1,0	-1,6
50	-9,0	-10,7	-4,9	-3,8
70	-8,0	-11,5	-3,9	-4,6

CURRENTS MEASUREMENTS

ICEBREAKER: TOR

DATE: 1977-03-30 TIME: 0900

ICE VELOCITY: U = -1.3 Vel. East
V = 13.6 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	1.8	-3.6	0.5	10.0
5	1.9	-6.7	0.6	6.9
10	0.4	-11.5	0.9	2.1
20	1.8	-11.4	0.5	2.2
40	4.1	-10.7	2.8	2.9
60	3.1	-12.6	1.8	1.0
100	-1.3	-8.4	-2.6	5.2

DATE: 1977-03-30 TIME: 1230

ICE VELOCITY: U = 2.0 Vel. East
V = 29.2 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	5.8	-9.3	7.8	19.9
5	3.2	-11.0	5.2	18.2
10	7.4	-15.9	9.4	13.3
20	0.9	-25.5	2.9	3.7
40	-2.4	-27.9	-0.4	1.3
60	-8.1	-28.4	-6.1	0.8
100	0.0	-26.5	2.0	2.7

DATE: 1977-03-30 TIME: 1500

ICE VELOCITY: U = 2.0 Vel. East
V = 29.3 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	11.6	-13.8	13.6	15.5
5	5.9	-20.7	7.9	8.6
10	5.8	-23.3	7.8	6.0
20	6.6	-26.7	8.6	2.6
40	-11.4	-19.0	-9.4	10.3
60	-4.7	-24.0	-2.7	5.3
80	1.7	-24.4	3.7	4.9

DATE: 1977-03-30 TIME: 1830

ICE VELOCITY: U = 4.5 Vel. East
V = 18.2 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
1	4.4	-5.4	8.9	12.8
6	2.3	-6.6	6.8	11.6
16	4.1	-8.0	8.6	9.6
36	-7.7	-21.1	-3.2	-2.9
56	-13.6	-14.0	-9.1	4.2
76	-8.8	-20.7	-4.3	-2.5

DATE: 1977-03-30 TIME: 2045

ICE VELOCITY: U = 6.7 Vel. East
V = 2.2 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	0.0	0.0	6.7	2.2
5	0.0	0.0	6.7	2.2
10	-0.2	-5.0	6.5	-2.8
20	-2.1	-7.2	4.6	-5.0
40	6.9	-5.0	13.6	-2.8
60	9.8	-6.1	16.5	-3.9
80	13.0	-5.2	19.7	-3.0

DATE: 1977-03-31 TIME: 0900

ICE VELOCITY: U = 6.4 Vel. East
V = 4.7 Vel. North

DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	0.0	0.0	6.4	4.7
5	0.0	0.0	6.4	4.7
10	0.0	0.0	6.4	4.7
20	-2.5	-0.2	3.9	4.5
40	-5.0	-0.4	1.4	4.3
60	-6.8	5.1	-0.4	9.8
80	-10.8	8.1	-4.4	12.8

ICEBREAKER: TOR

DATE: 1977-03-31 TIME: 1315

ICE VELOCITY: U = 10.7 Vel. East
V = 15.2 Vel. North

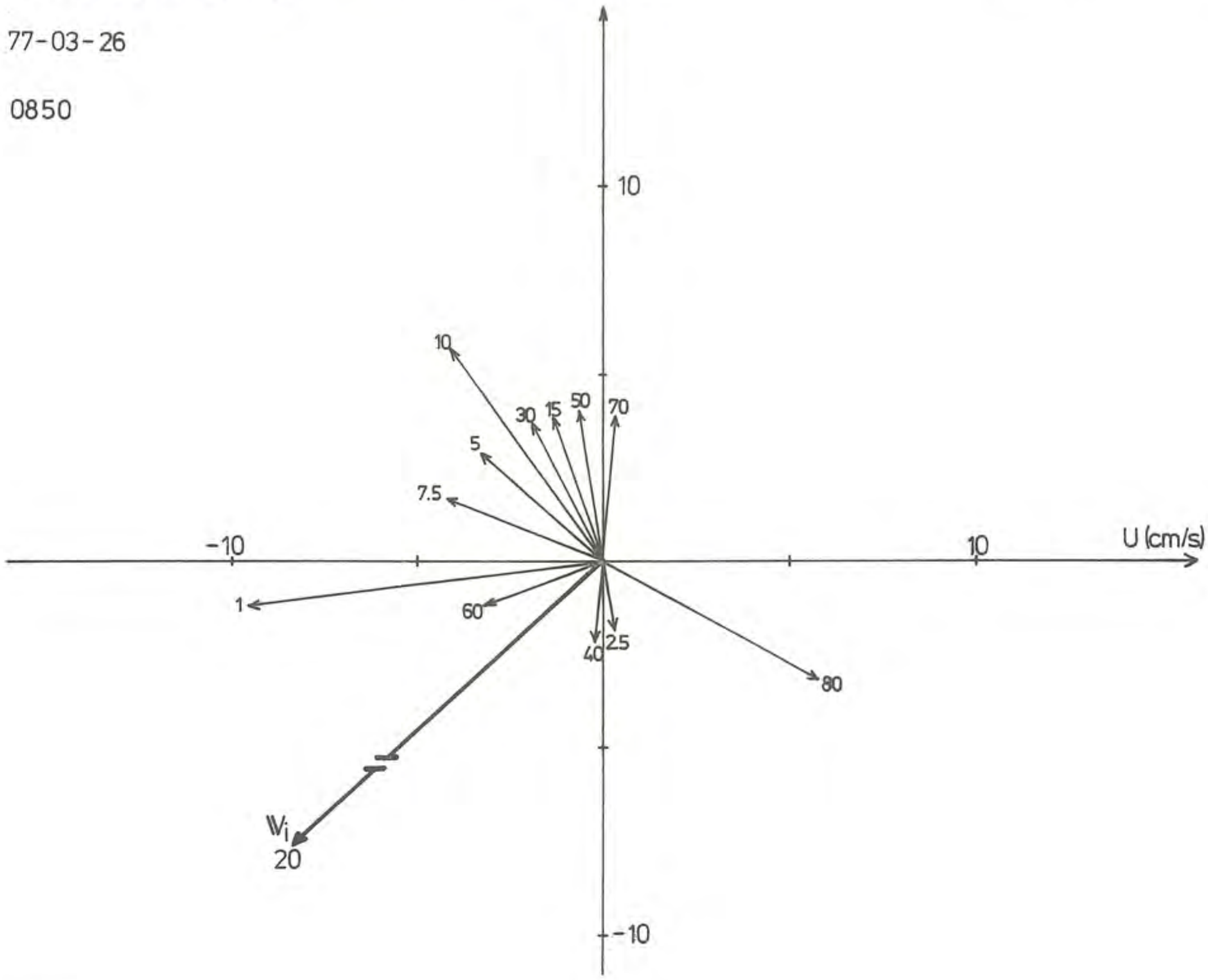
DEPTH (m)	RELATIVE VELOCITY		ABSOLUTE VELOCITY	
	VEL. EAST (cm/s)	VEL. NORTH (cm/s)	VEL. EAST (cm/s)	VEL. NORTH (cm/s)
2.5	-5.8	-9.3	4.9	5.9
5	-11.3	-7.4	-0.6	7.8
10	-13.3	-14.3	-2.6	0.9
20	-15.9	-12.9	-5.2	2.3
30	-20.1	-11.2	-9.4	4.0
40	-16.6	-9.2	-5.9	6.0
60	-12.6	-8.2	-1.9	7.0
70	-15.3	-12.9	-4.6	2.3

CURRENT MEASUREMENTS

Research vessel: ARANDA

77-03-26

0850



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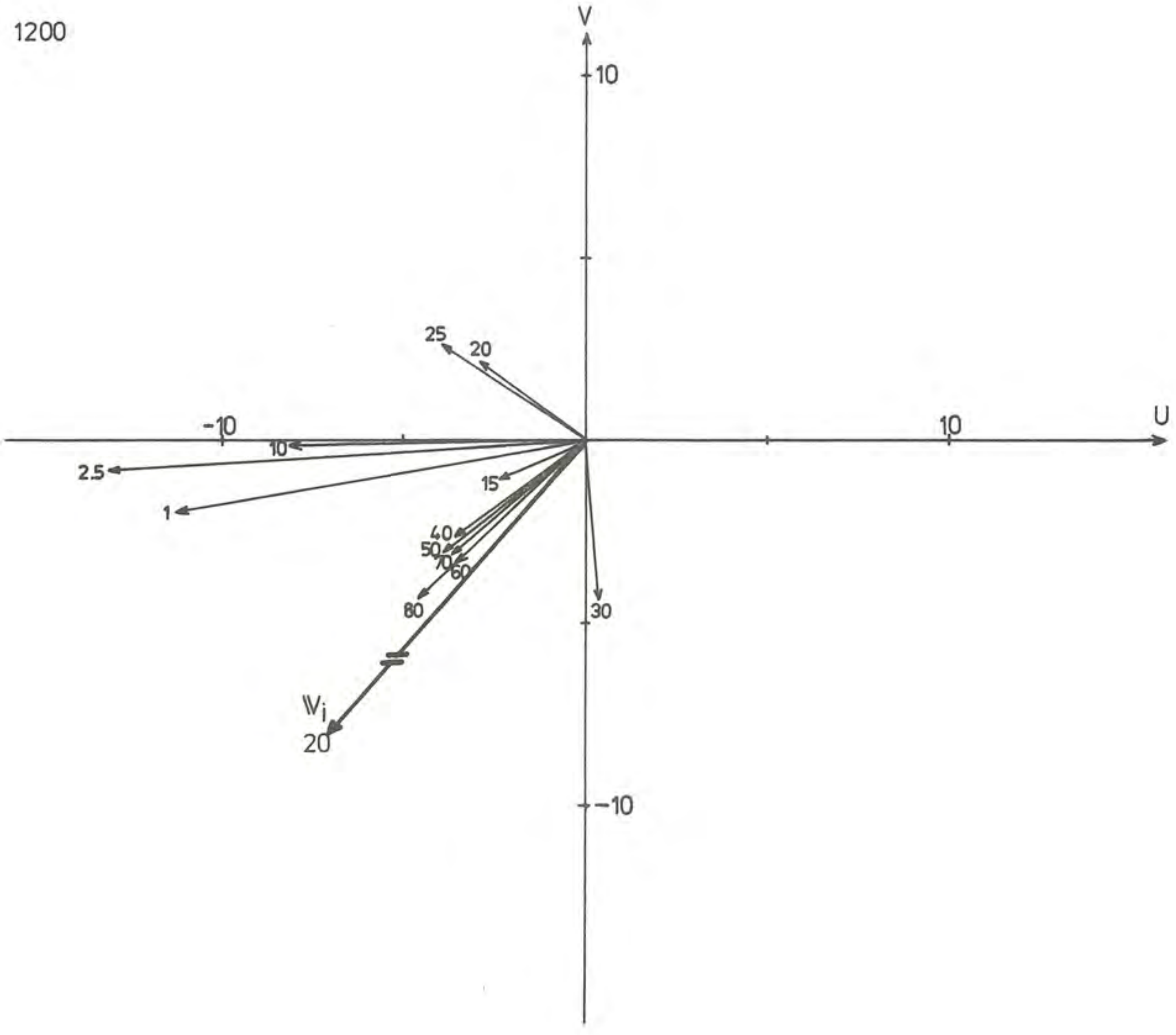

77-03-26

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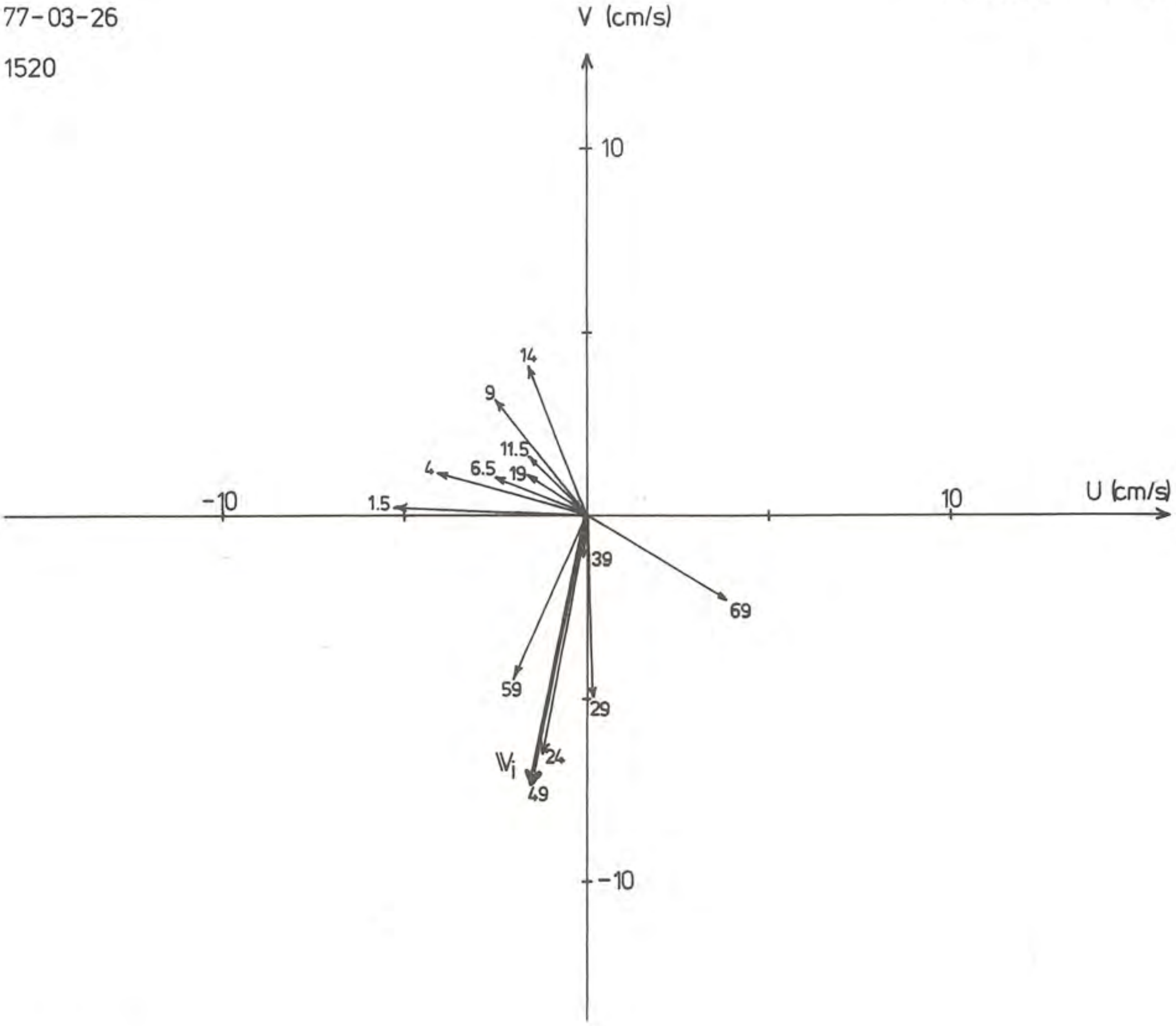

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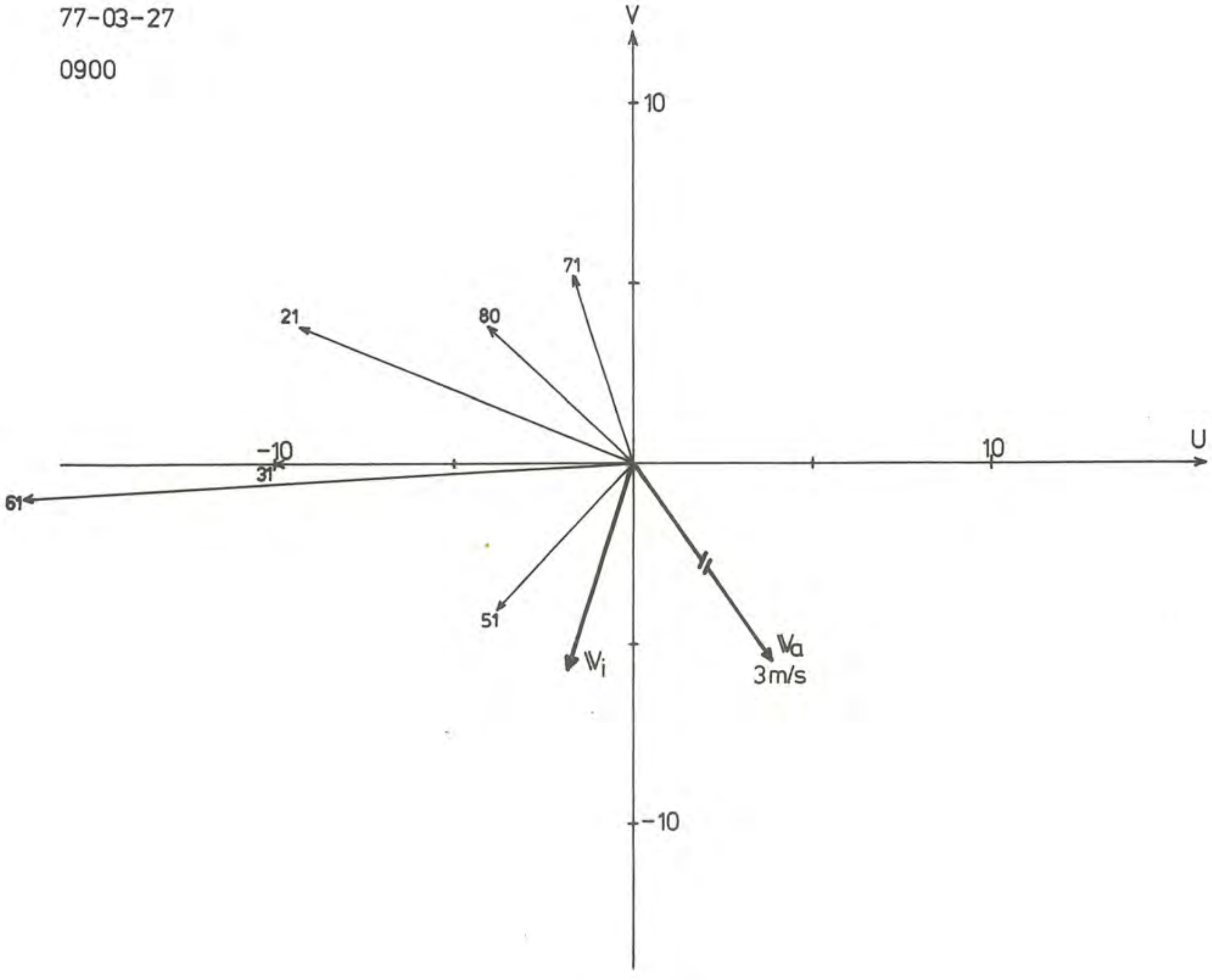
0900



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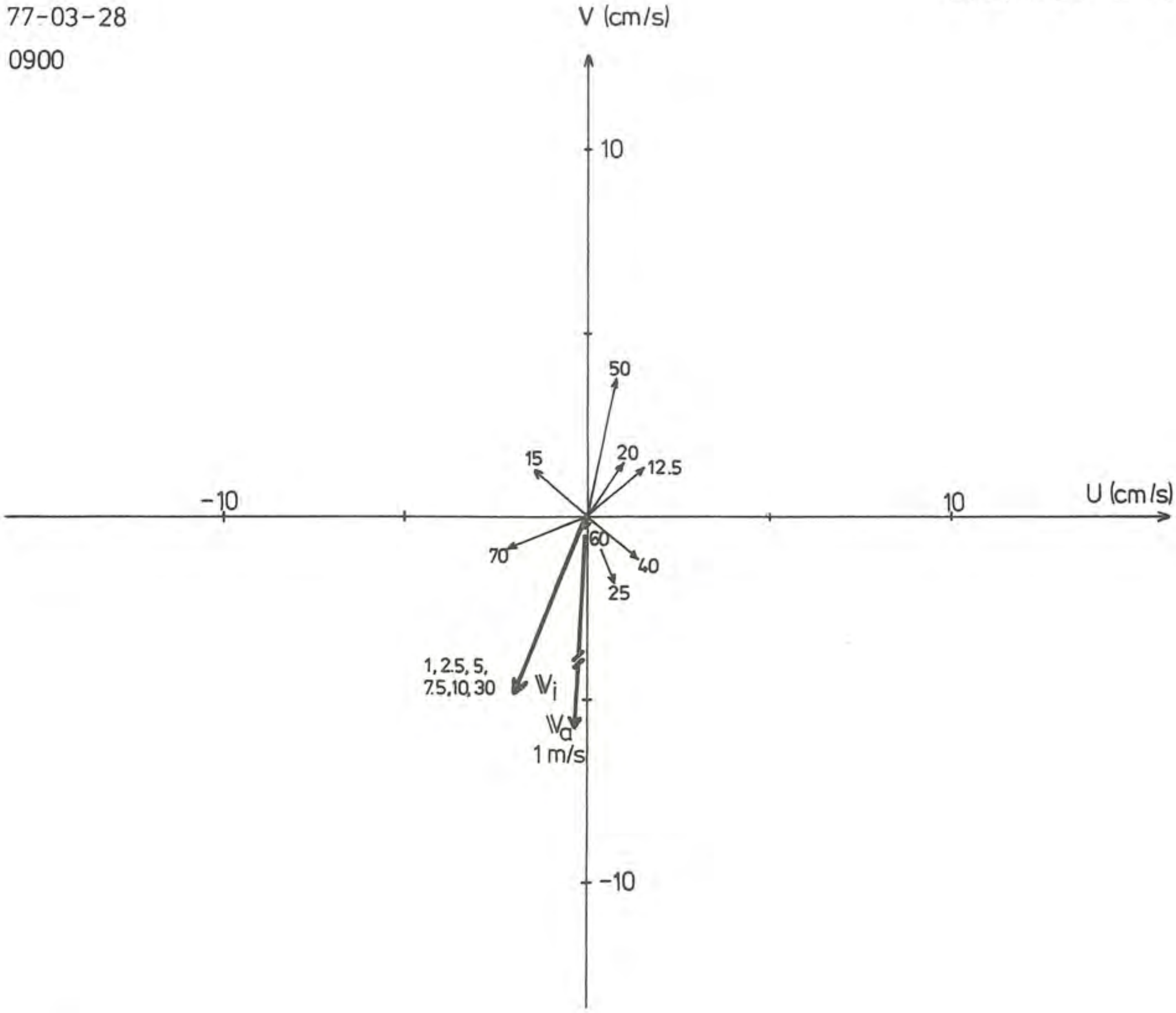
0900



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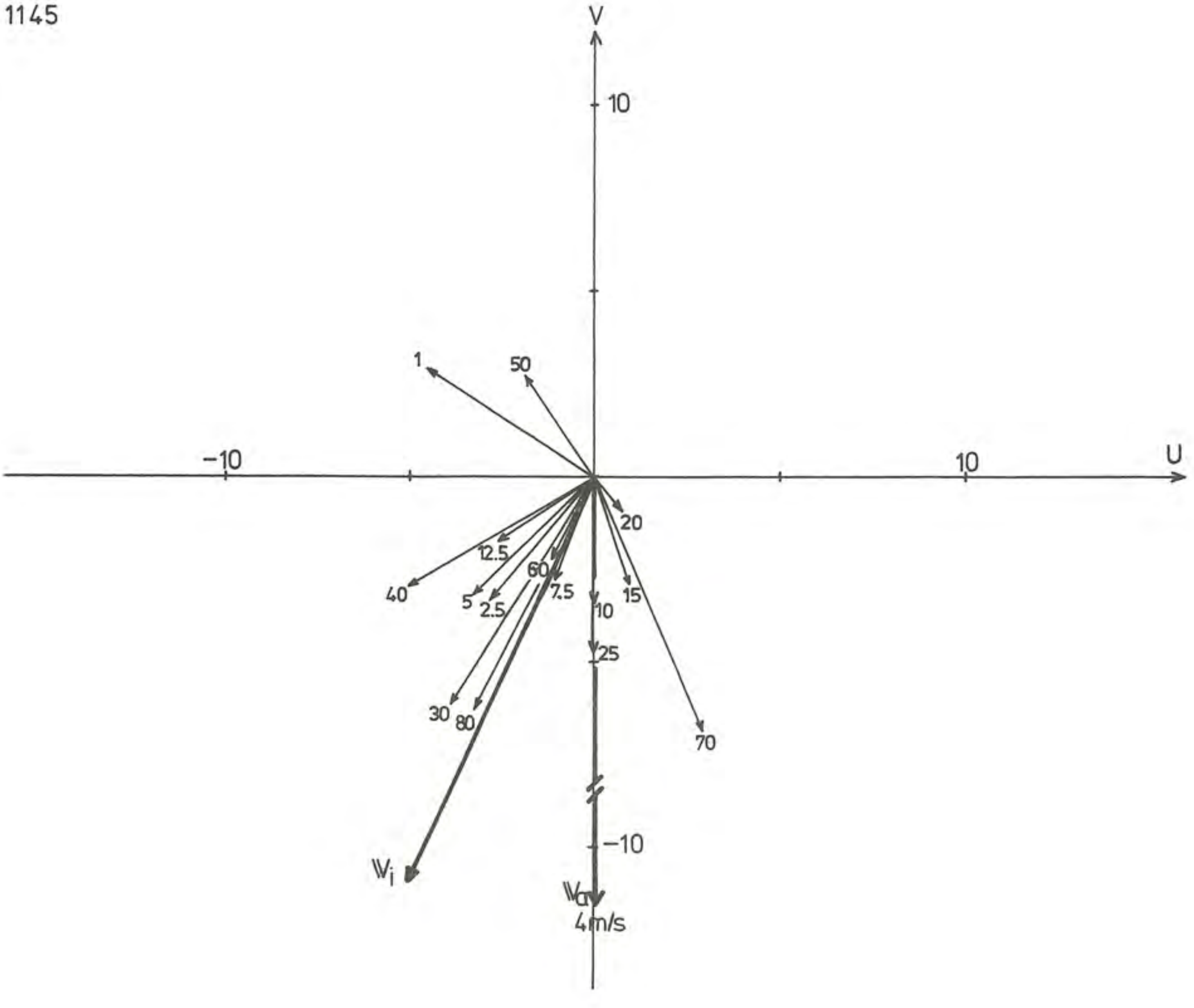

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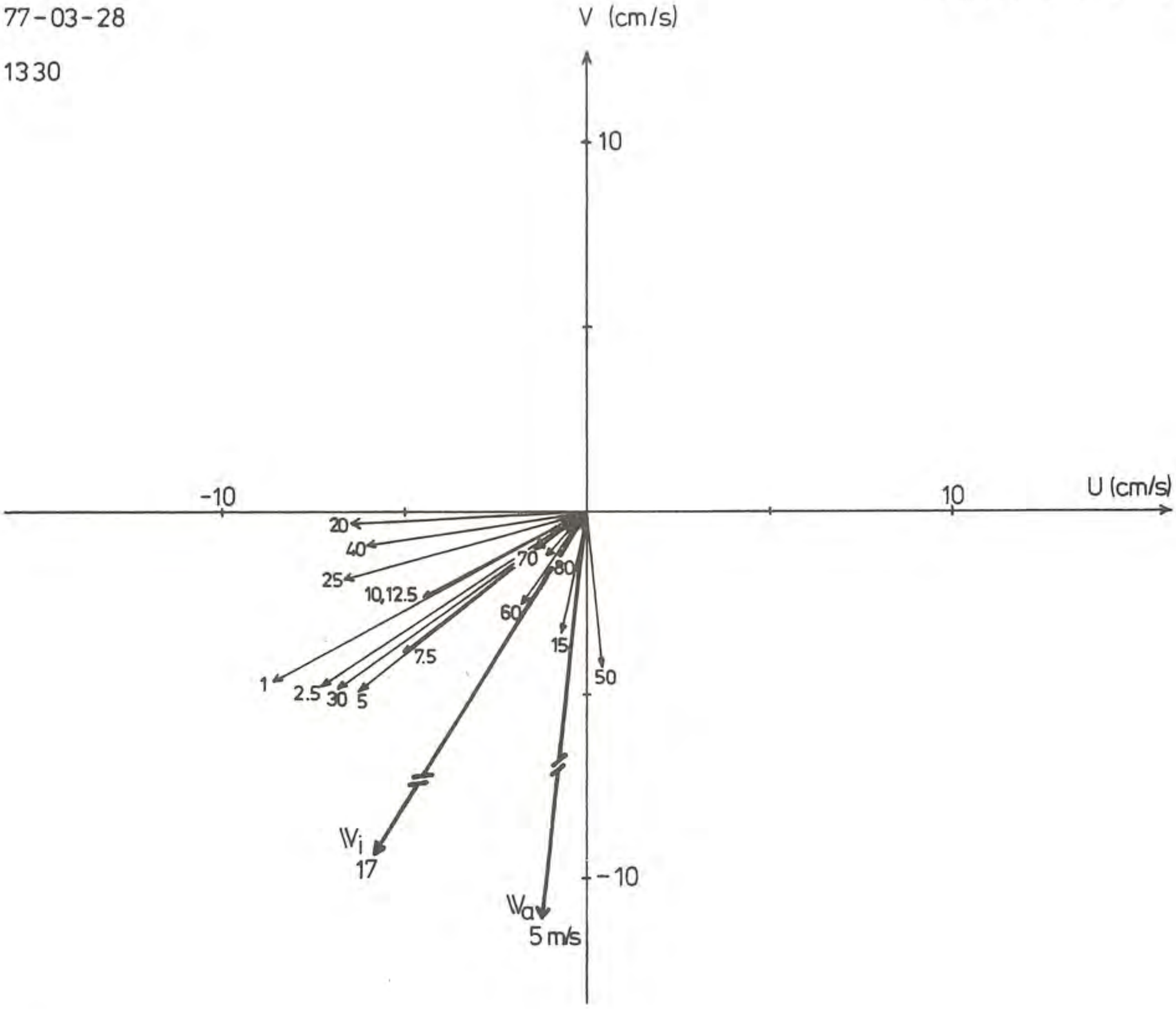

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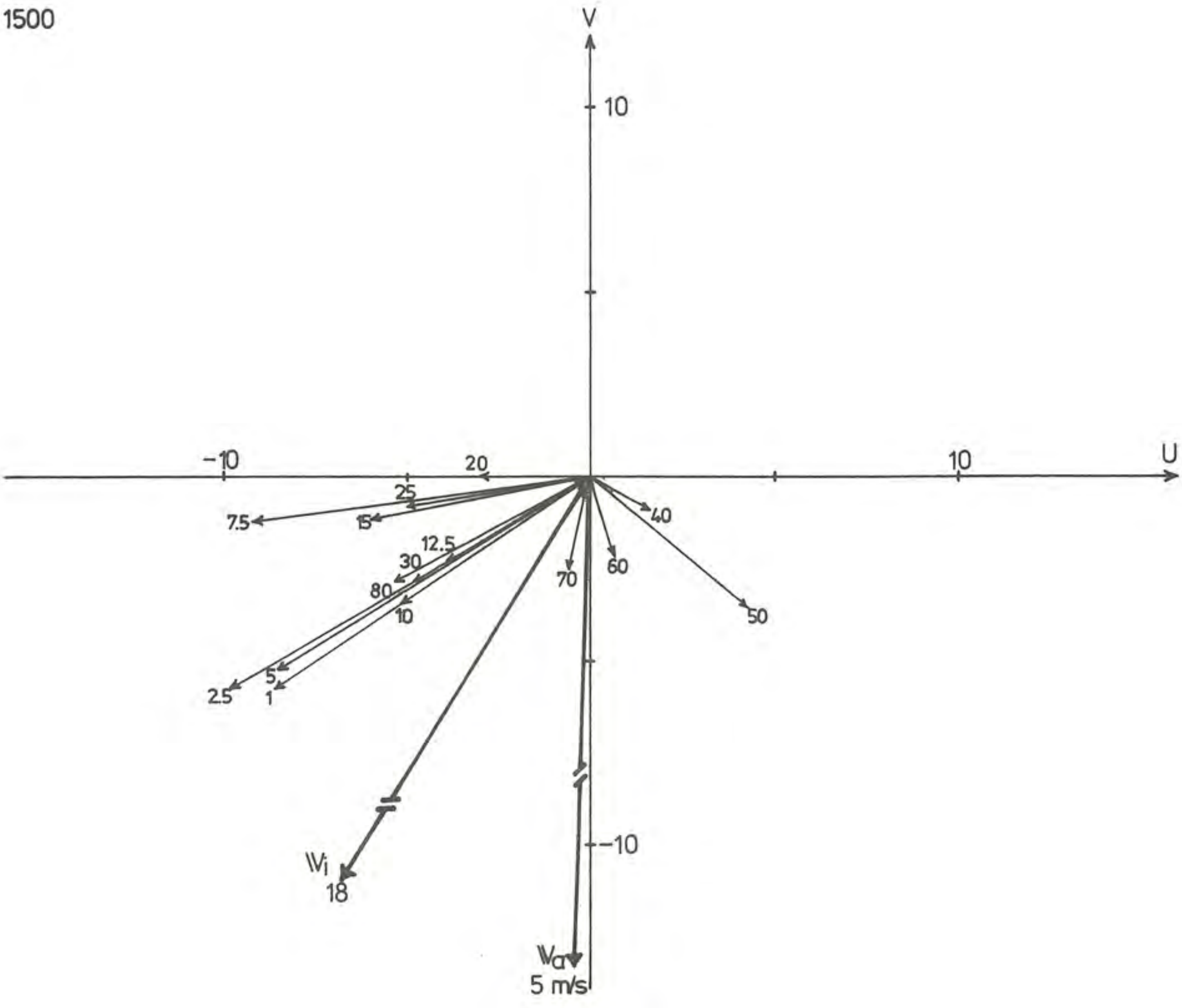

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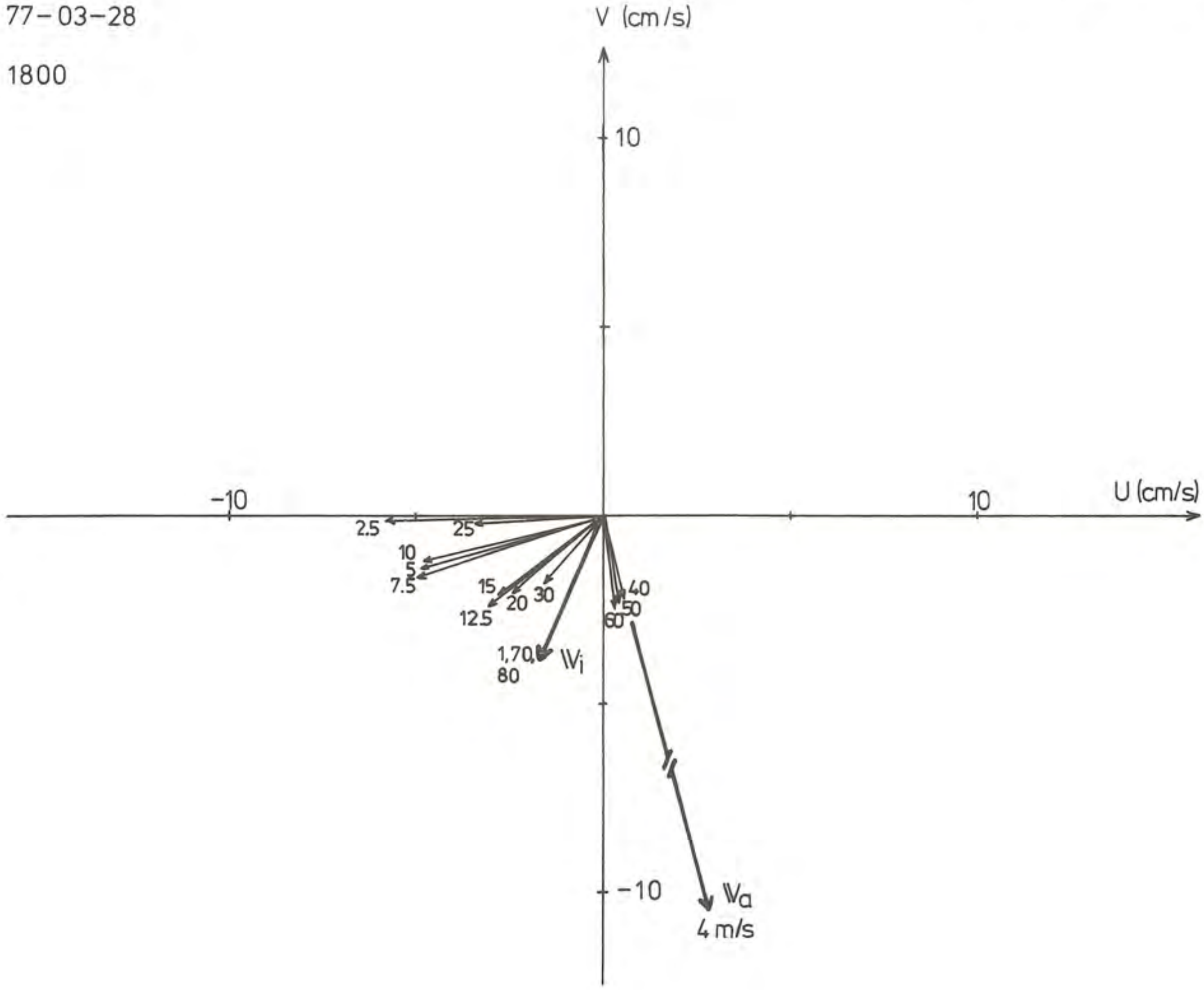

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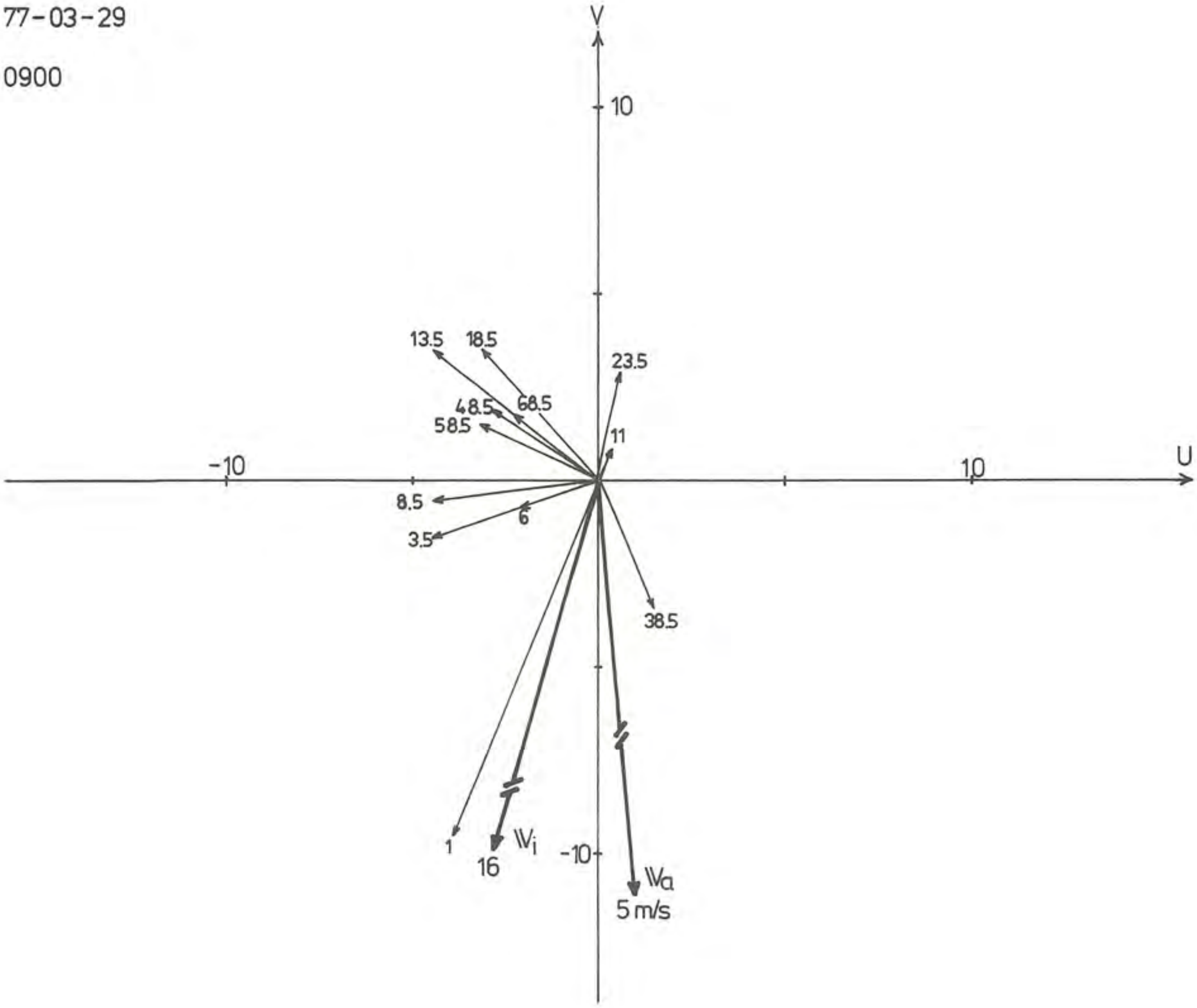

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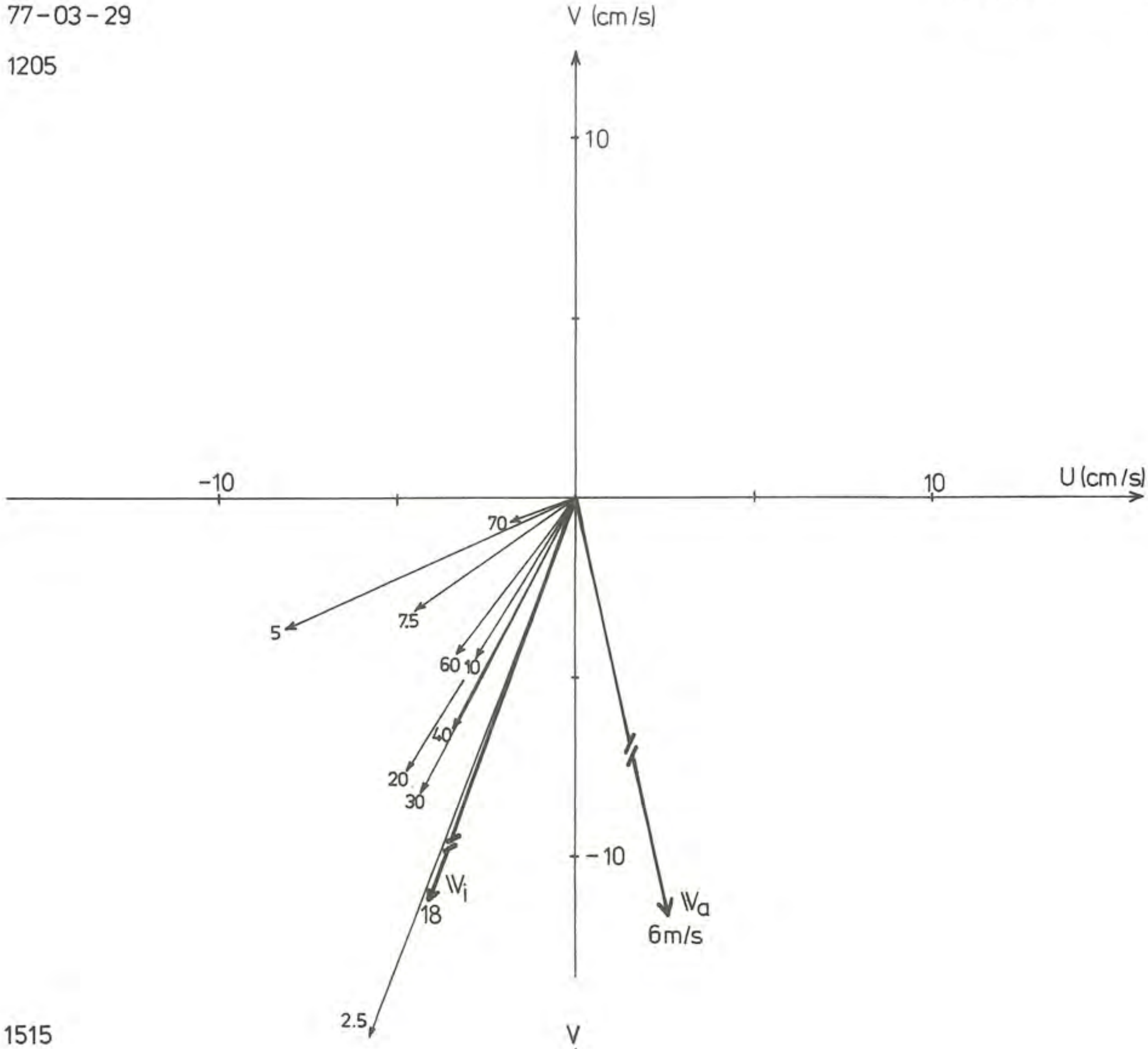

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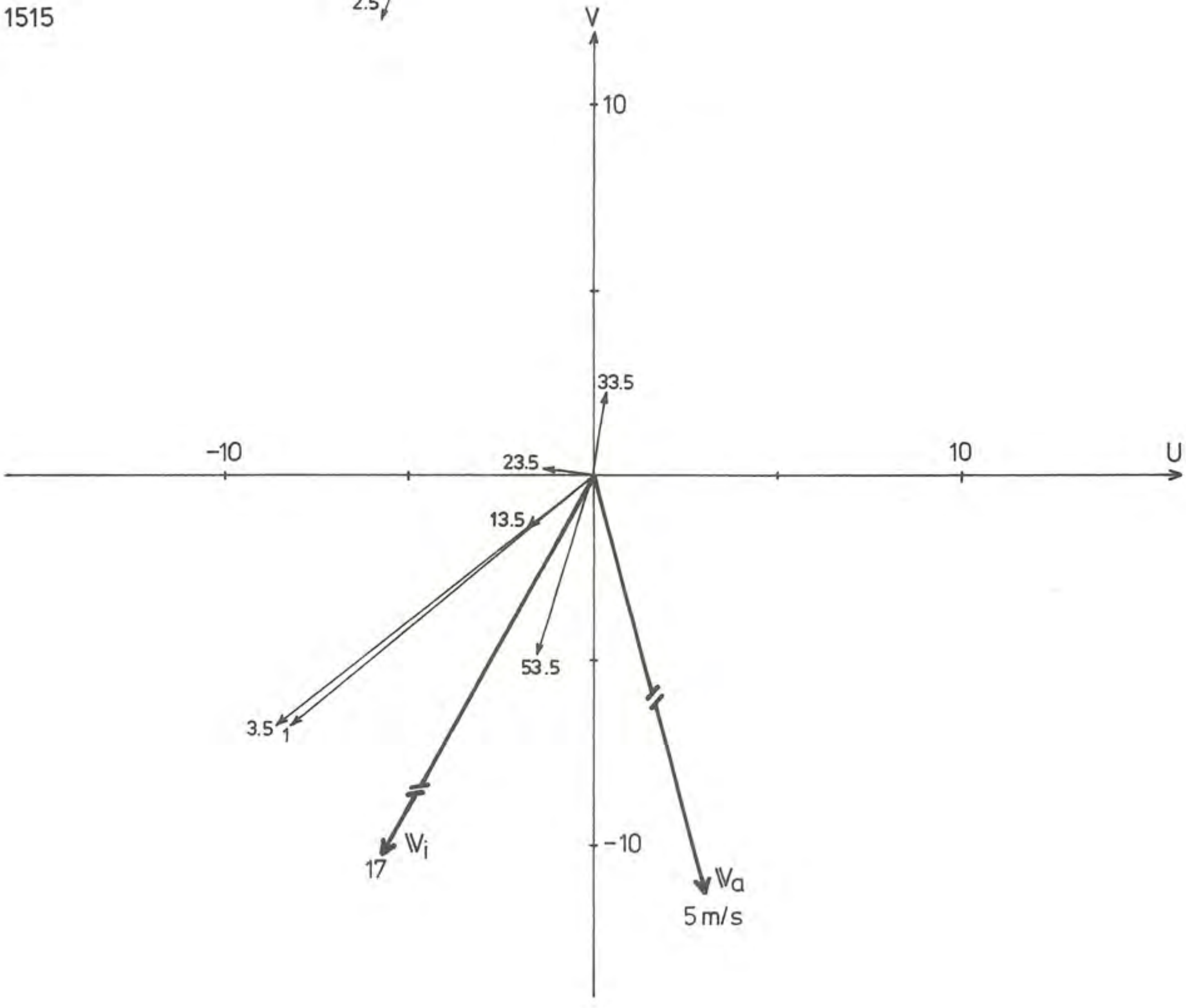

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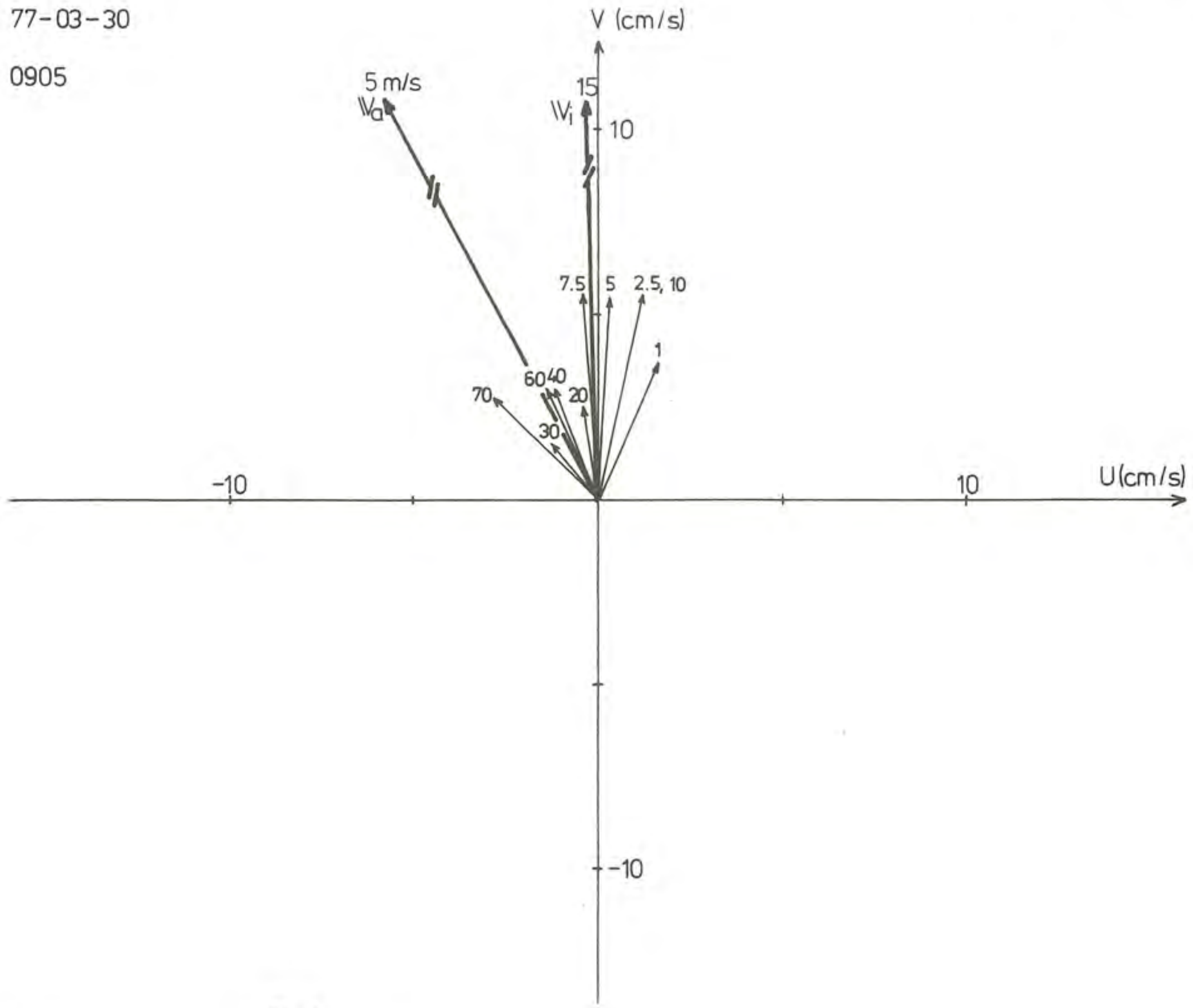

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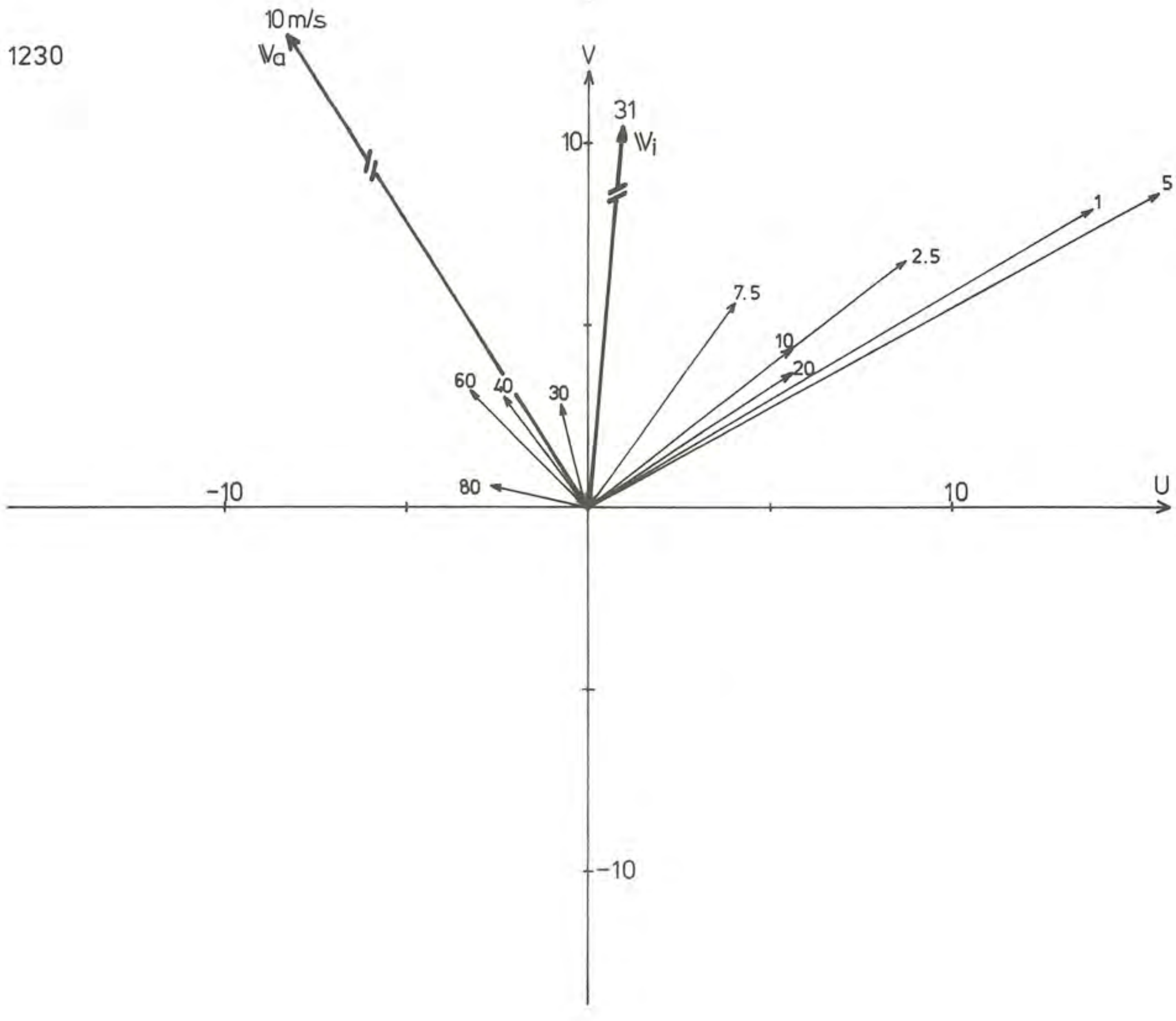

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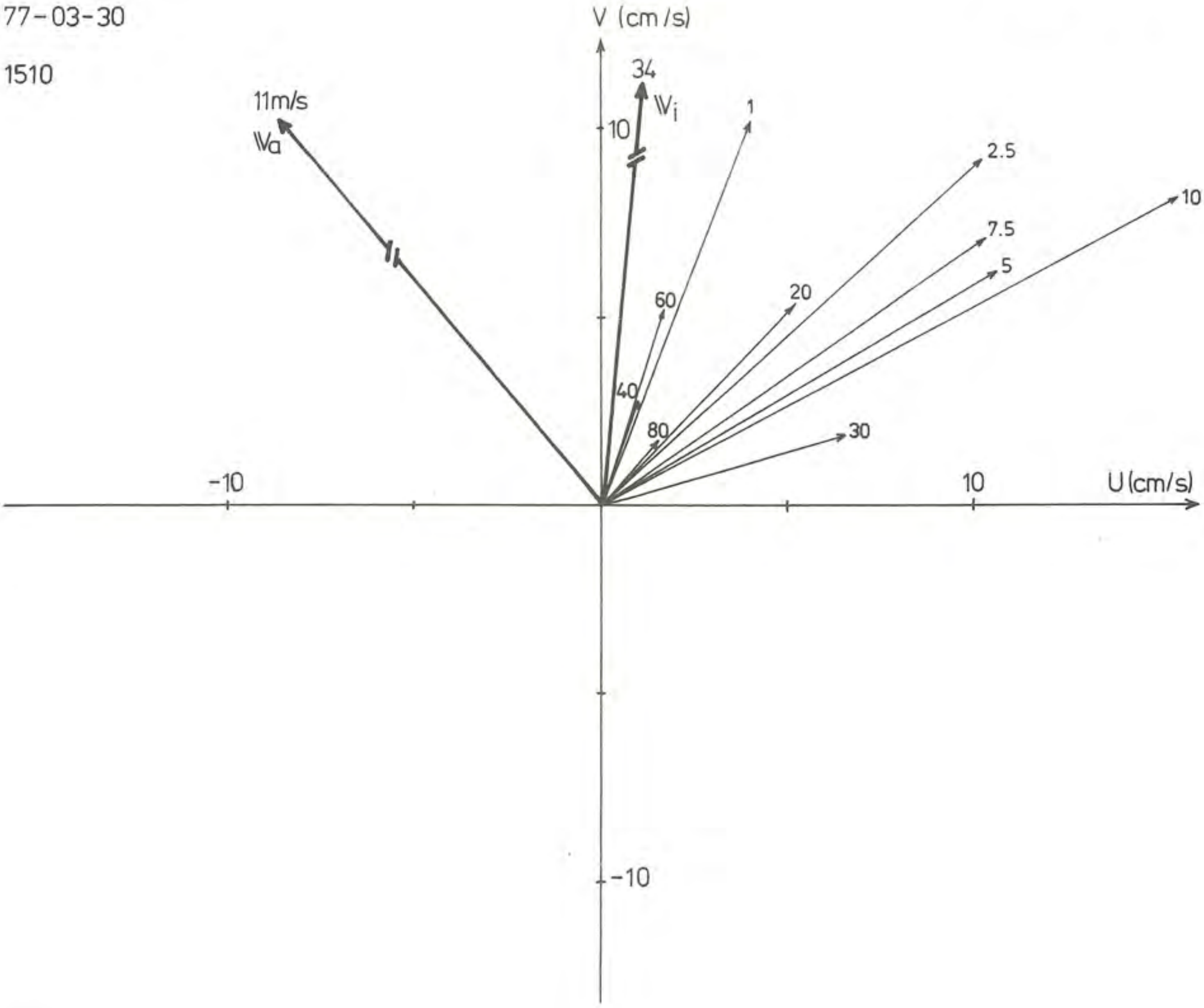

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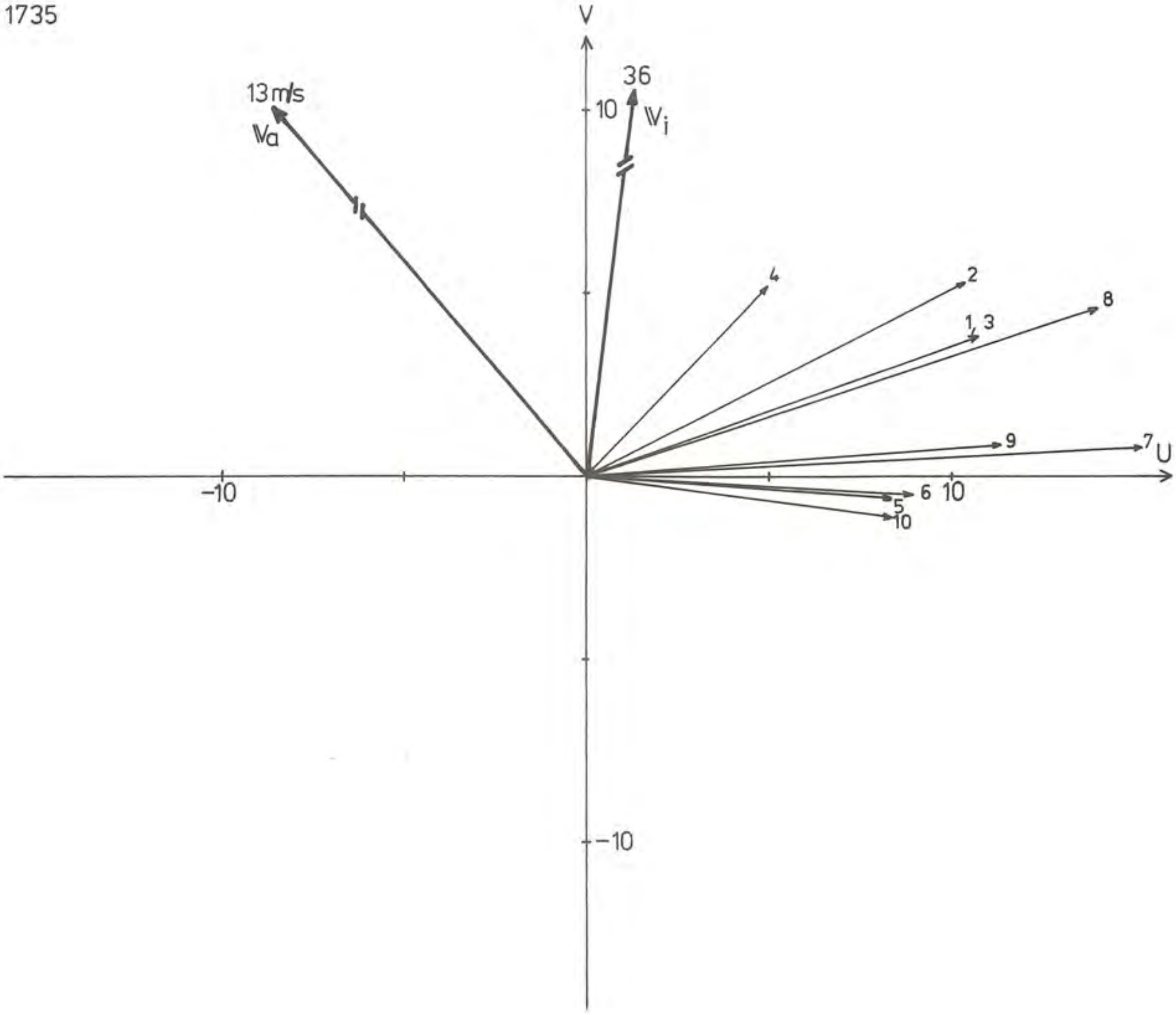

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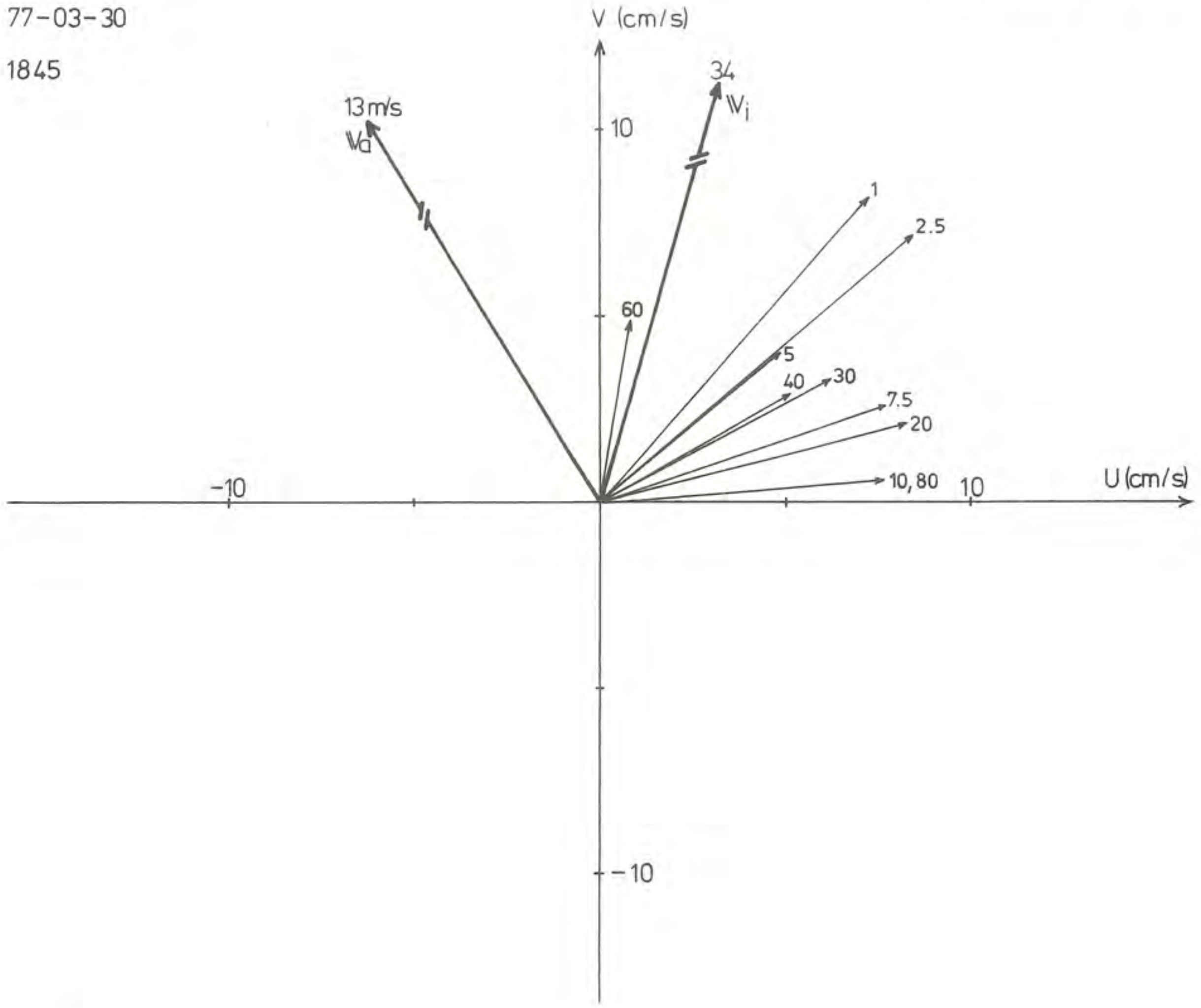

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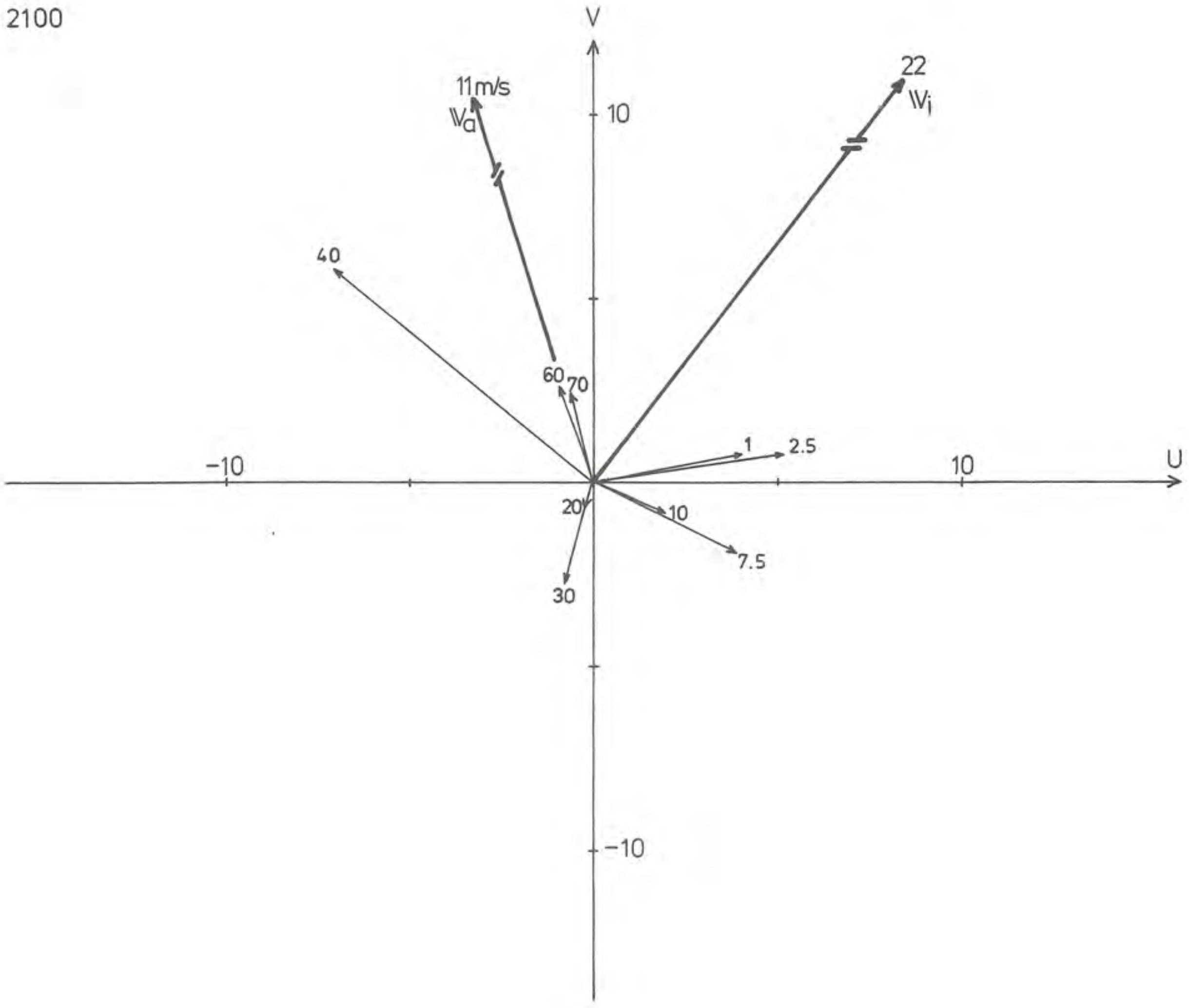
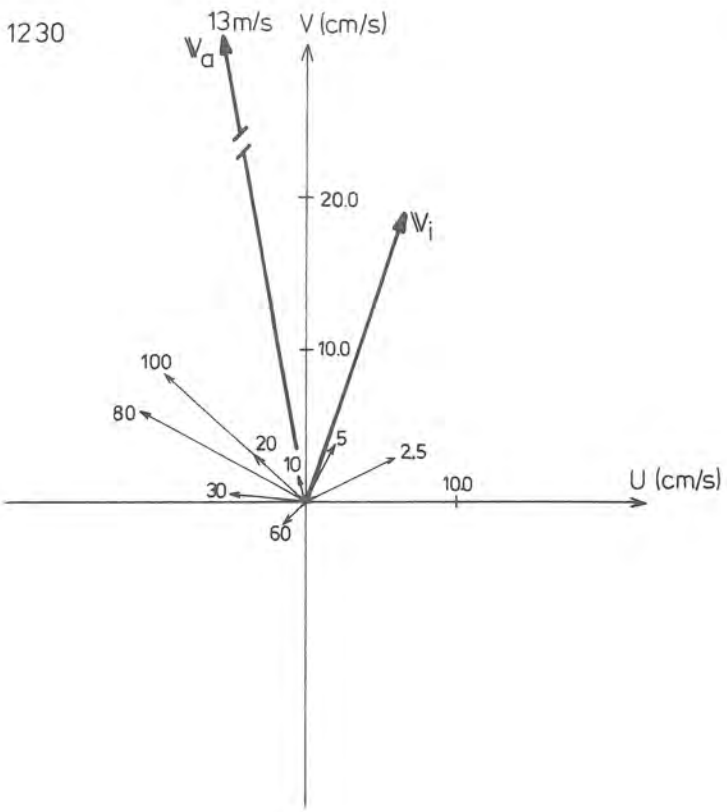


CURRENT MEASUREMENTS

Ice breaker: ATLE

77-03-30

1230



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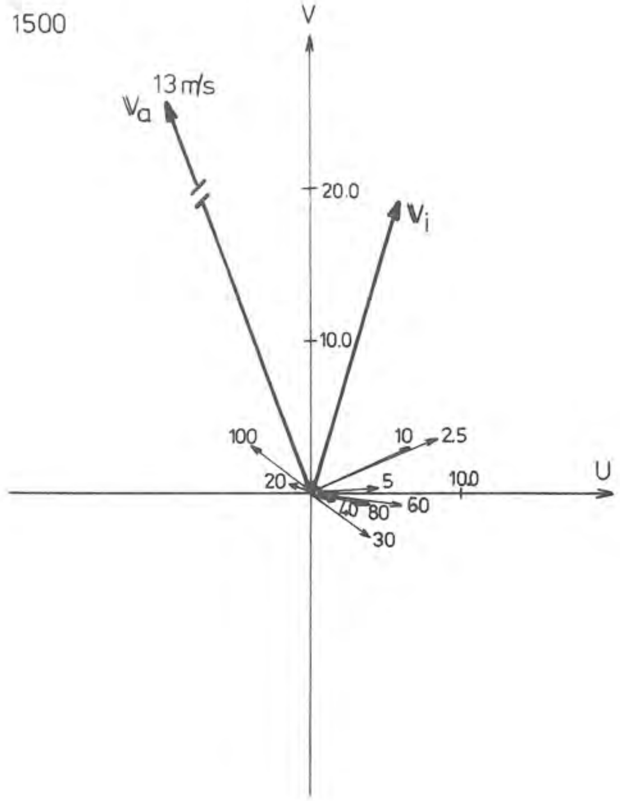

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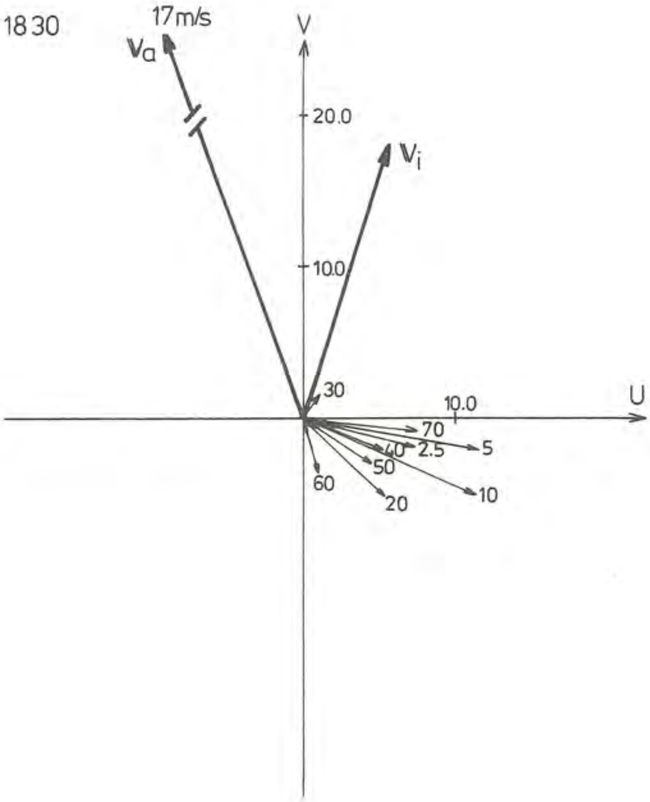

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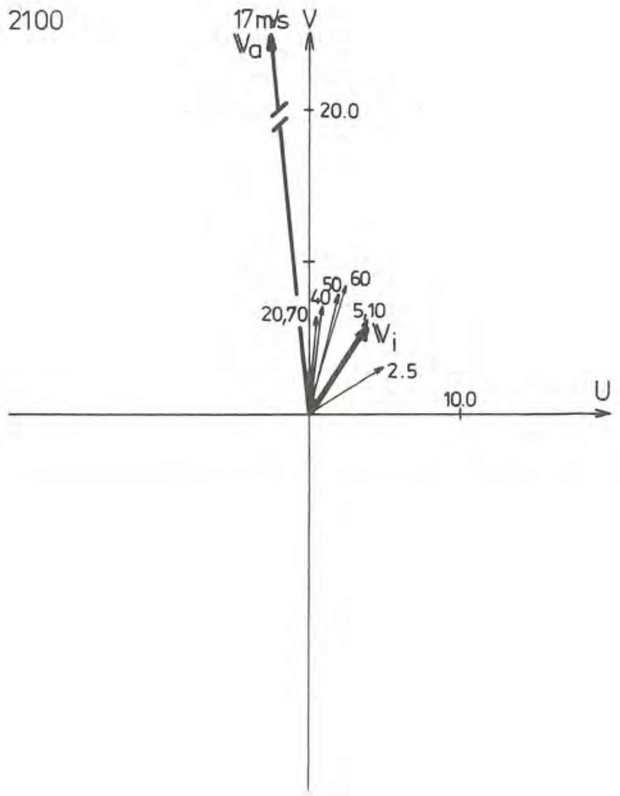

77-03-31

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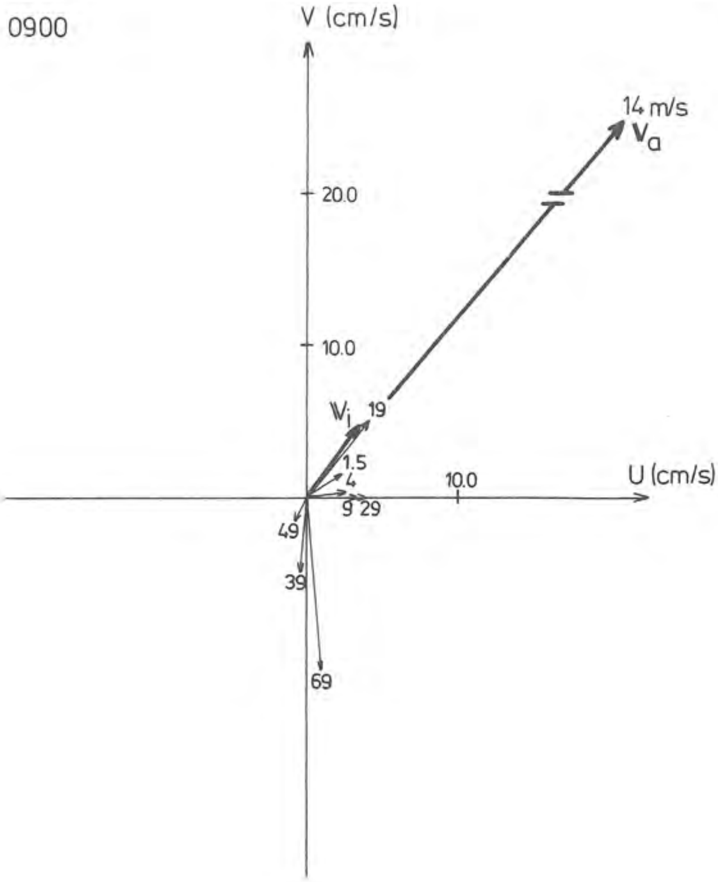

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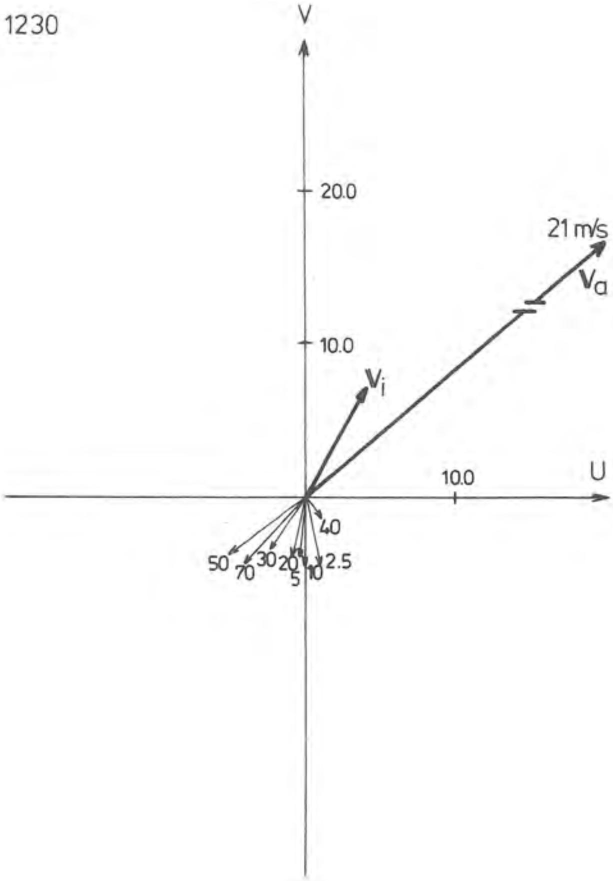
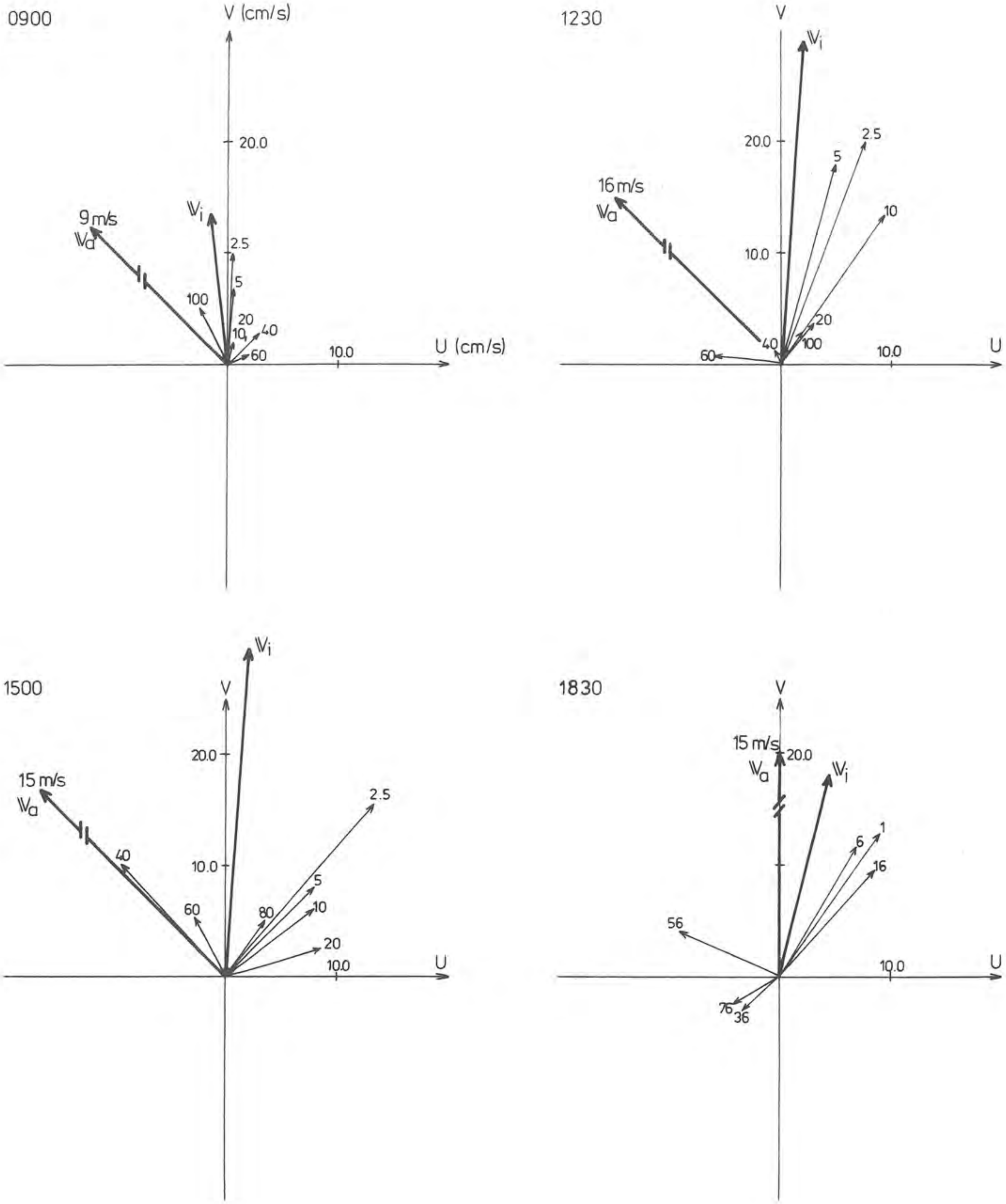


CURRENT MEASUREMENTS

Ice breaker: TOR

77-03-30



77-03-30--31

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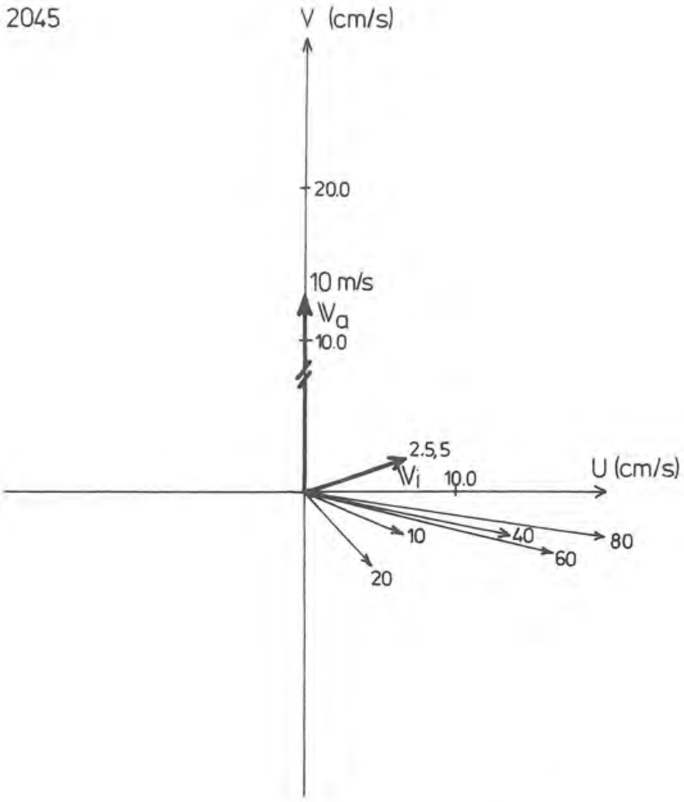

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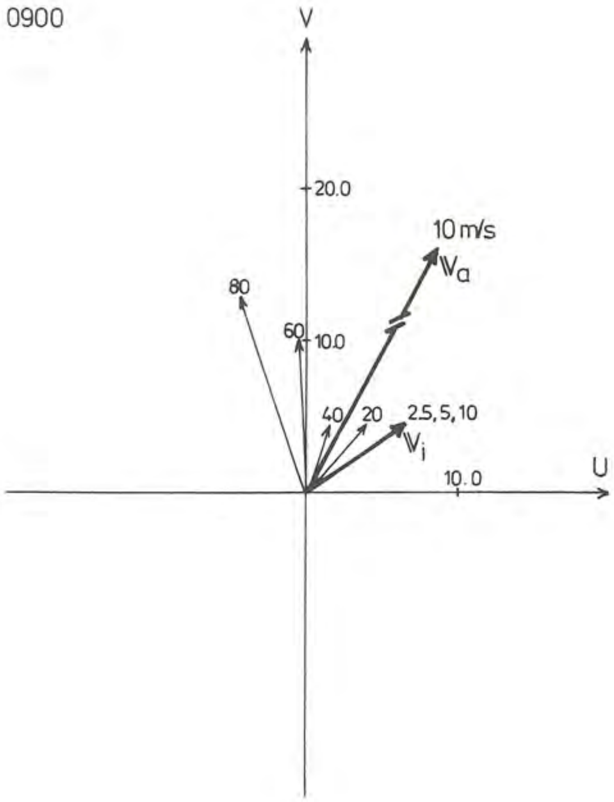

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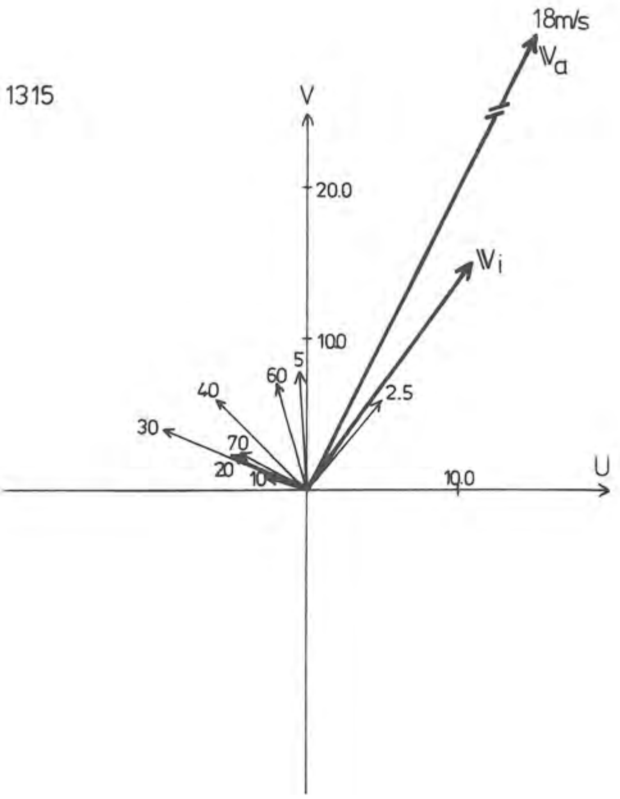
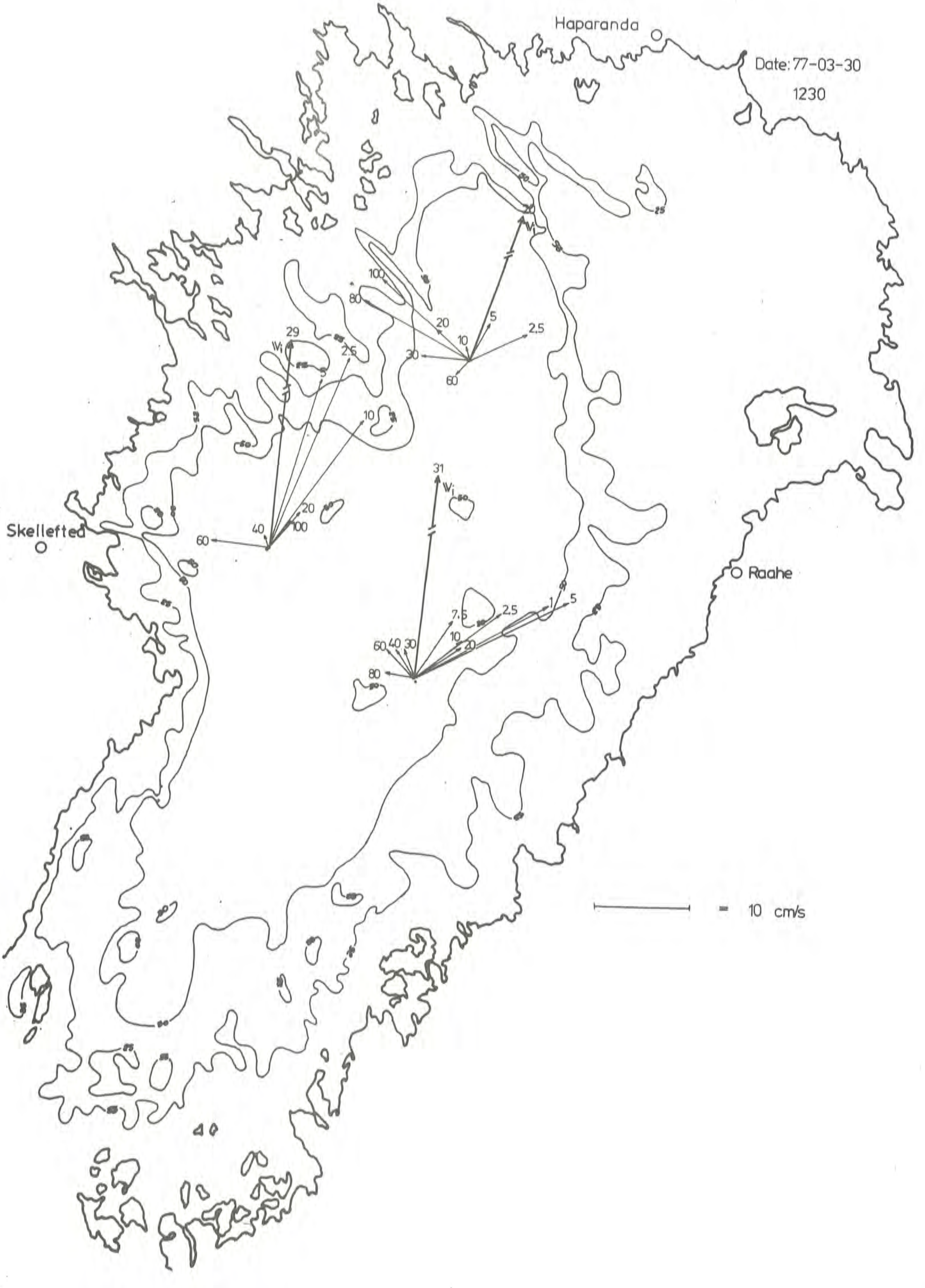


CURRENTS AT THE THREE SHIPS



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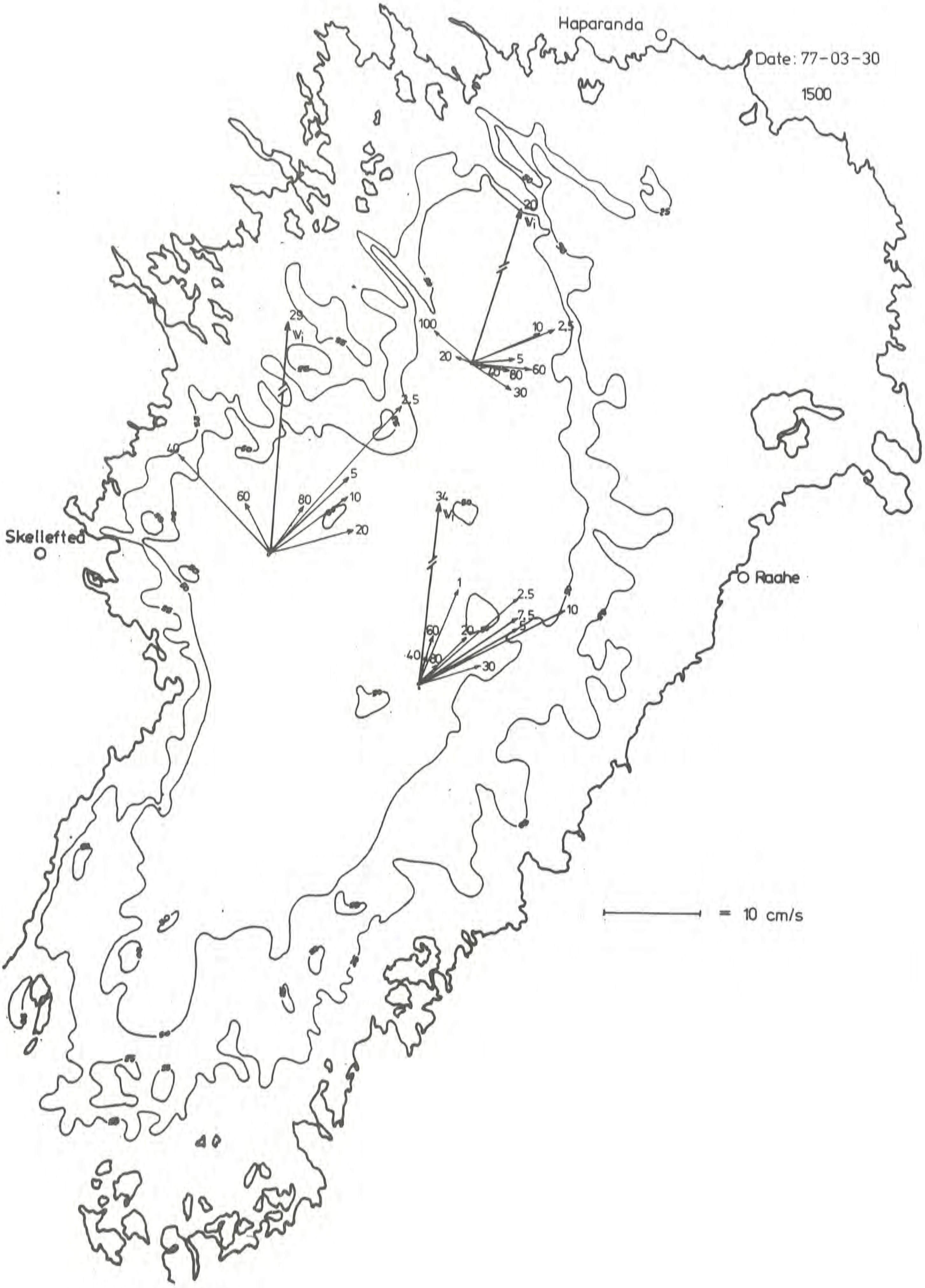

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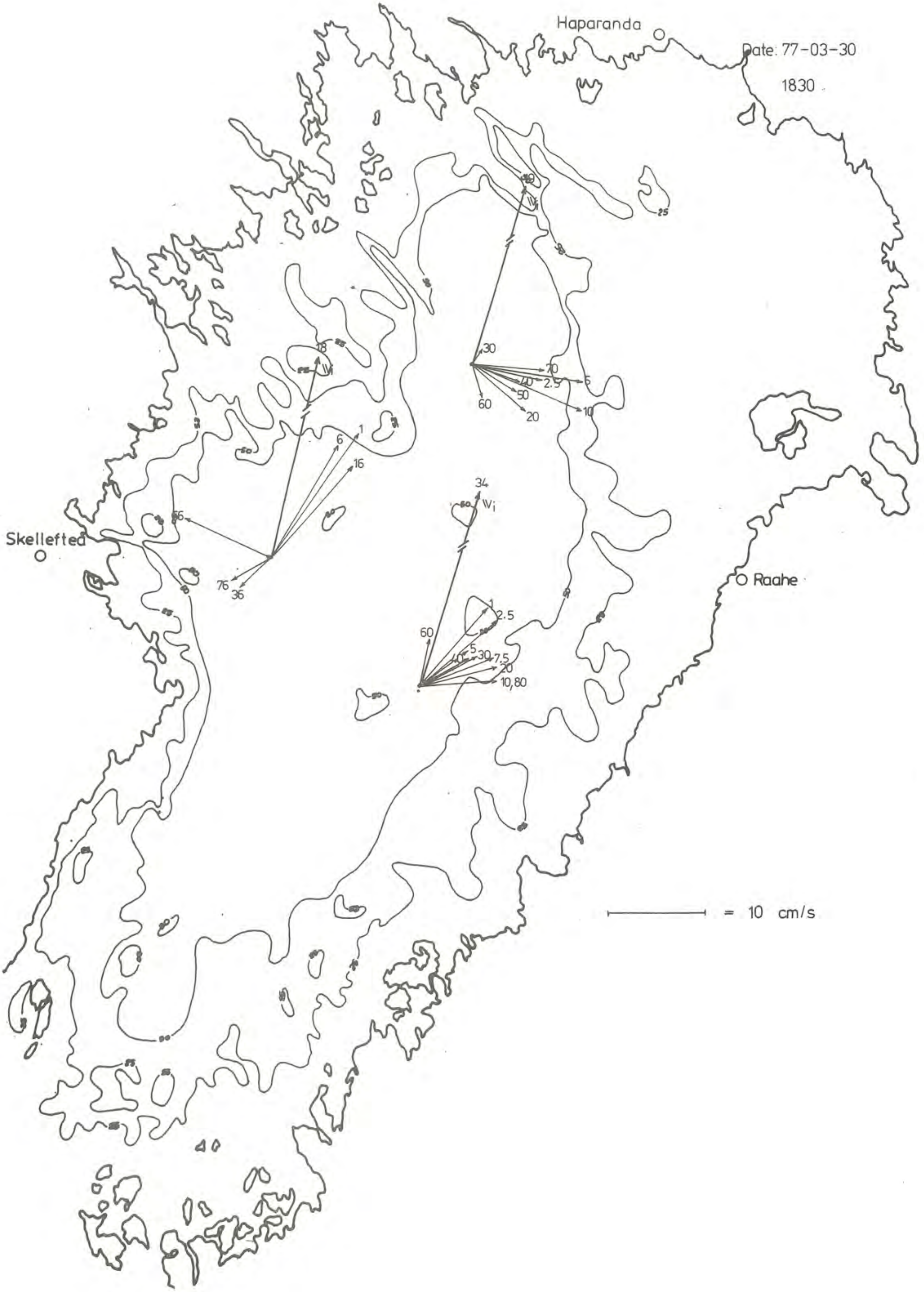

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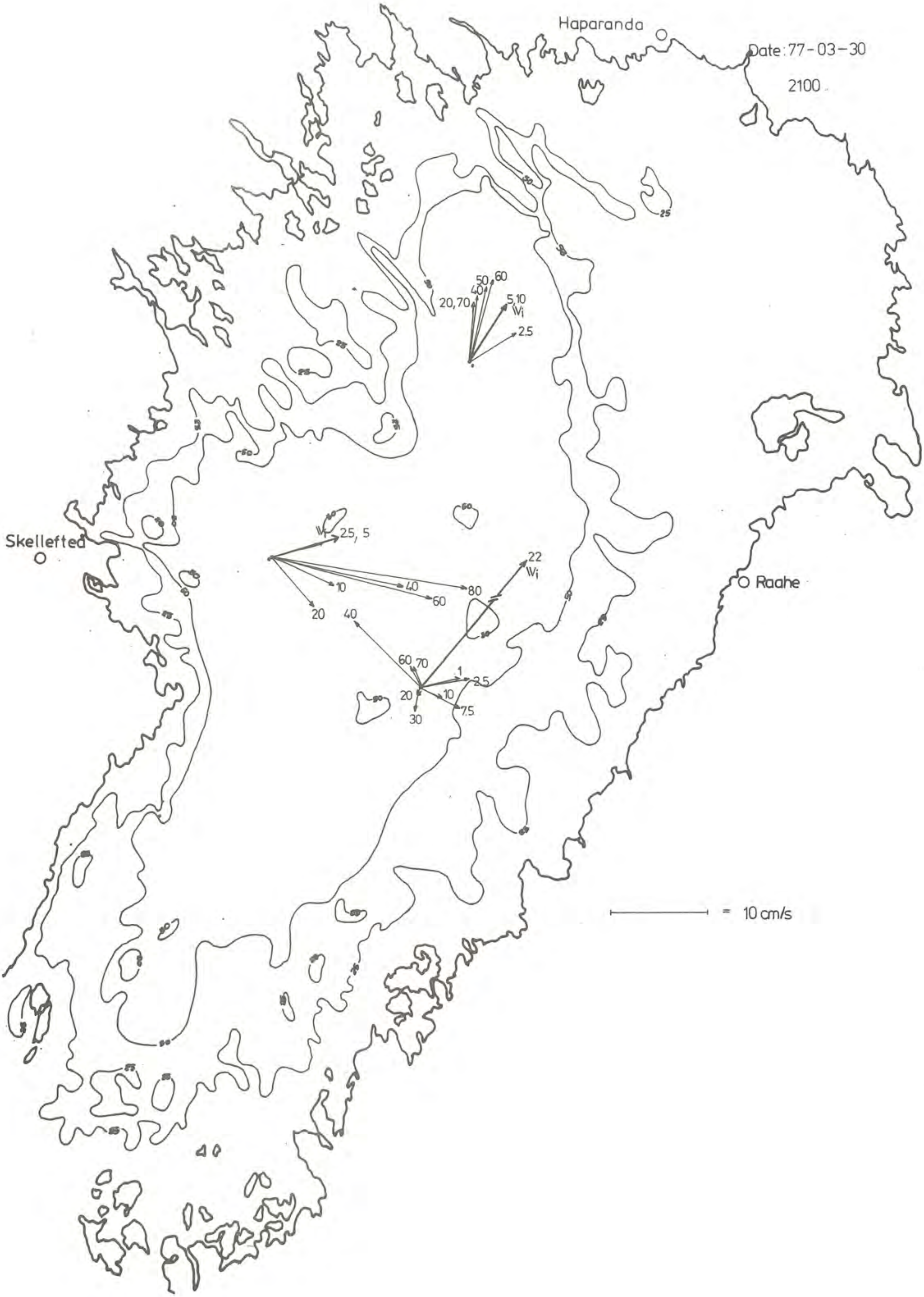

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