DESCRIPTION OF BOAT ECHO-SOUNDING METHODS EMPLOYED BY THE SWEDISH HYDROGRAPHIC OFFICE.

REMARKS.—The abbreviation E-boat, used below, refers to an echo sounding motor-boat. A survey unit consists of one surveyor, two leadsmen, one coxswain and one engineer. When employing an E-boat the two leadsmen alternate as fathometer attendant and recorder. When the course method referred to later is being employed, the complement of the E-boat is increased by one assistant surveyor.

Determination of the general features of the sea bed

Surveyors are urgently requested to comply with the regulations provided for the calibration and periodical checking of the echo sounding gear and checking of the records.

When sounding, one of the following methods should be used :

1.—The course method.
2.—The buoy method.
3.—The check method.

THE COURSE METHOD should be practised in regions of open water, where general depth exceeds 30 m. and implies that an E-boat is running the lines of sounding in conformity with the grid lines at 5 mm. intervals on the field board, hereafter called main lines, which are always directed east-west or north-south.

Where the depth is less than 25 m. interlines have to be run between the main lines. Interlines must also be run in waters with greater depth, if the soundings on the main lines have indicated a considerable irregularity of the sea bed. Within areas which are known in advance to require interlining, the grid lines may be drawn in beforehand, spaced at intervals of 2.5 mm.

The echo-depths are to be read off continually by means of a revolution indicator ; the distance between two adjacent soundings should not exceed the space between the main lines, or between the main lines and the interlines, when interlines are being used.

Fixing of positions should be carried out by means of two simultaneous sextant angles to the survey marks as a rule at every 5th reading. When performing the fixing the surveyor calls out " angle " and when the revolution indicator's bell sounds, the two angles have to be measured at the same time. The surveyor plots the position on the field board also noting the number of the fix. The course should be corrected accordingly. The course corrections

may not exceed 2°—5°. In order to help the coxswain to keep the boat on course, suitable transits should be indicated.

The assistant surveyor should note the number of the fix, the angles measured and the number of the line of sounding in a special position book (fig. 1), in which he also notes down region and course.

One of the crew members should be ordered to enter the number of the fix and the depths obtained into the *sounding book* (fig. 1). The depths should be read off to one tenth of a metre and entered into the book without corrections. If a remarkably diverging depth should be observed between two consecutive readings, this depth must be noted between the ordinary readings in a special column. It is of great importance that the number of the fix coincide on the field board and in the position and sounding books, a matter for which the assistant surveyor is held responsible.

On the front fly-leaf of the sounding book should be noted the region number, dates of beginning and termination of the survey, names of surveyors, instruments employed (sextants and station pointers) and the tide gauge referred to. If the sounding for some reason or other is interrupted or else carried out at intervals, an index should be set up stating the page where the corresponding numbers of main lines can be found. In a special column of the sounding book are entered abbreviations of survey marks employed for fixing. Special observations regarding the surveyed area are also to be noted as well as dates of calibration. The surveyor finally signs the sounding book, which thereafter should be attached to the position book concerned.

If the state of the sea bed (the bottom being too soft for echo-sounding or too shallow) does not permit E-boats to be employed, the sounding has to be carried out by means of *sounding machine* or *hand lead.*

When applying the course method, the sounding machine is used according to the same principles as for echo-sounding previously described, except that the boat has to be stopped at every sounding. Two crew members are ordered to manage the machine, one of them manœuvring the gear, the other one handling the lead and reading the indicator. The engineer should be informed of the number of revolutions required, the coxswain of the course to be kept. When boats with kitchen rudder are used or in case of dense soundings, the speed should be moderated accordingly.

When the revolution indicator's bell is heard the engineer should reverse the engine. Just before the boat has stopped the lead should be released. As soon as the sounding is obtained and the lead is off the bottom, the boat can proceed ahead whilst the lead is being hauled up. When sounding in great depths full speed should not be resumed until only 30 m. of wire remain to be wound in.

When the lower portion of the lead appears at the surface, the indicator's hand shall be controlled to point at zero; if it does not, the wire has slipped, which can be avoided by turning the wire twice round the measuring wheel.

The position of the boat must be ascertained at every fourth sounding.

The engine revolutions should remain constant, when under way between fixes. All entries in the books shall be made by the assistant surveyor.

When sounding by means of hand lead the sinker should be thrown as far forward as possible, striking the bottom before the line comes into the up and down position. The leadsman during this procedure keeps his arm horizontal, thus enabling the assistant surveyor to control the depth. The boat shall be kept at a moderate speed but the speed can be increased if two leadsmen are put into action. All crew members should do their best to detect stones and shoalings visually.

Surveyors are urged to lavish every care on all details of the sounding book and the plotting sheet. The records should be so legible and complete as to permit other surveyors to transfer the details to the fair chart. By signing the surveyor is reminded of the great responsibility involved in his work.

THE BUOY METHOD is resorted to in areas with less depth than 30 m. in general and is employed as follows :

The area to be surveyed is marked off with buoys which are put into position consecutively when running across the main lines of sounding. The correct distance between the buoys i.e. between the main lines, is obtained in a simple way. A buoy is towed on a line of a length equal to the desired space between the main lines. When the towed buoy passes the one previously placed another buoy is put into water, and so on. Positions are ascertained at every second buoy by means of sextant angles and the positions are plotted on the field board. In waters where no currents are prevailing the buoys can be fixed by means of " flying angles " i.e. the first angle is measured at the moment when the buoy is put into position and the other angle is obtained when passing the buoy anew in the opposite direction. The buoys must never be placed wider apart than 400 m. When buoying the area all dangerous shoals are simultaneously indicated by marker buoys.

Where the main lines are cut by the coastline the buoys should be placed so close to the shore as to enable the depth curves to be accurately ascertained. Off-shore where the bottom has a gentle slope the buoys are placed in such a way that an immediate examination of the coast and inshore water can be undertaken.

The survey region is divided into a number of areas, so chosen that after having been transferred to the double scale (1 : 10.000—1 : 5.000 and 1 : 15.000—1 : 7.500) they can be fitted on a *plotting sheet* of normal size, 27 × 16 cm. (fig. 2). The coastline is drawn directly on this sheet with reference to its grid corresponding to the grid of the field board.

On the plotting sheets, which are given consecutive numbers, the positions of the buoys are plotted and depths sounded with hand lead are indicated in red in order to serve as calibration depths. The number of red-coloured depths is left to the surveyors' choice.

When sounding, the E-boat runs along the main lines which are, as described above, marked by buoys. Fixing is consequently unnecessary. The

soundings are read off in the same manner as described for the course method, but are entered directly into the position book by the surveyor. When interlining is considered necessary, the boat is run half-way between the lines of buoys by estimation.

The depth curves are drawn on the plotting sheet in certain colours (see " Indication of the shallowest depth ") and indications are encircled in pencil. The indications are marked out by investigation squares of adequate extension. (See fig. 3 and " Examination ".)

THE CHECK METHOD. In shallow waters it is often better to sound the area by examination. The examination checks are constructed in accordance with rules given under " Examination ". The density of soundings is adjusted with regard to the general character of the waters. When the depth is less than 15 m., main lines, interlines and even " quarterlines " of sounding are run. The sea shore being fairly regular and the depth between 15-25 m., main lines and interlines should be run. When the depth exceeds 25 m. only main lines are run. Should irregularity of the sea bed occur, the density of soundings is increased irrespective of the above rules. When applying this method there is no difficulty in selecting the suitable density of soundings. Furthermore, straight courses can be easily maintained and indications directly examined and verified.

Examination

When the sounding of an area is terminated and the field board completed, the result is thoroughly inspected. The lines of figures should be scrutinized along the main lines as well as in a direction at right angles to them and when questionable even diagonally. Examination of the figures in one direction only might give a false record of the sea bottom. Every depth smaller than the adjacent ones indicates a shoaling. As long as the extent of the shoaling and the least water are unknown, the shoaling must be considered dangerous.

Below are given some examples of the degree of importance which could be attached to a series of soundings.

Very faint indications : 25-22-24 ; 20-18-20.

Faint indications : 29-26-30; 20-17-20; 15-13-16; 8-7-8.

Strong indications : 33-22-30; 20-15-19; 16-12-15; 13-10-13; 7-5-7.

The question whether a shoaling should be investigated or not depends on the importance of the waters with reference to navigation, fishing and other special circumstances. Other matters to be considered are the nature of the sea bottom, depth of water, density of soundings and required accuracy.

Among *important waters* are the sea, inshore waters, approaches, harbours and anchorages. These areas should not be too narrowly limited, bearing in mind the future progress of navigation.

Indications should be investigated on a scale of 1 : 10.000 in accordance with the following rules :

IN IMPORTANT WATERS :

All strong indications (though only exceptionally in depth exceeding 20 m.).

Faint indications in less depth than 15 m.

All channels and sounds with greater depth than 2 m. whether indications have occurred or not.

All indications between the 6- and 3- m. curves.

All irregularities of depth curves.

The strongest indications within the 3- m. curves.

IN LESS IMPORTANT WATERS :

All strong indications.

The above rules need not be too rigidly adhered to, but are given as a method for deciding whether examination should be undertaken or not. The final decision shall be left to the discretion of the officer-in-charge.

Buoying and working out the plotting sheet. When an indication is to be swept, the embracing area must be neither too small nor too large. Extensive shoalings should be divided into strips, and closely situated indications are put together in order to get longish rectangular checks. The extent of the checks should not exceed the ordinary check (having due regard to any special circumstances), which is limited by, at the most, 5 buoys on each side, larger checks being apt to dislocate the work. A large number of shoals within a check tires the surveyor and reduces the accuracy of control. Furthermore, available buoys may not suffice to mark all shoals, and as a large check requires a longer time to be surveyed, the buoys might in the meantime be displaced. Towards the end of the workday it is necessary to lessen the checks, so that the control of the indications is not neglected owing to lack of time.

When searching for, investigating and buoying shoalings, the surveyor should make use of transits, a table of revolutions and compass. Depending on the character of the waters and the types of buoys available, different methods of buoying are practised. Some examples are given below.

Buoys with automatic anchoring gear, navigable water. (Fig. 4 a). When the first buoy A has been dropped, adjusted and fixed in an accurate position, the course and number of revolutions are determined for side A-B. The number of revolutions should be determined for the whole side, and by dividing this number by the number of buoys minus one, the number of revolutions between two buoys is obtained. All buoys on this side having been anchored and the buoy B fixed, the side buoys are dropped. When the buoys C and D have been correctly placed, the remaining side C—D is buoyed. In order to reduce the effect of wind and current, the long sides of the rectangles should always run in the same direction.

When the outlines of the rectangle have been marked the intermediate lines are buoyed. This is performed by crossing the leading lines along the

rectangle and dropping the buoys on the transits. The surveyor then takes position beside the man dropping the buoys and calls out " drop ", when the leading line is crossed. Transits not being available, the buoys are placed with the aid of a revolution indicator, a stop-watch or towed buoy. It must be noted, that all buoying facilitates the echo-sounding, if the buoy lines are made as straight as possible and parallel to each other. It is also of great advantage, if flags of the same colour are attached to all buoys in the same line.

Ordinary buoys, navigable water. (Fig. 4b.) When the buoy A is placed in a correct position, the course and number of revolutions are determined for the side A—E. The second buoy B is dropped in its place, its position is fixed and plotted on the field board. With this buoy as a guide the course and number of revolutions are corrected. The other buoys C, D and E are afterwards anchored in their respective positions, the boat being stopped and the position fixed and plotted on the field board at every operation. The buoys on the line A-E having been placed, the buoying of the short side A-C is executed in a similar way but with the difference that only every second buoy is dropped. Then the buoys on the lines F-K and G-O are dropped starting from the buoys F and G. After this the remaining buoy lines are dropped half-way between the above lines by sight.

Automatic or ordinary buoys, shallow water. (Fig. 4 c.) When examining shallow waters, rocks may be found and prevent arranging rectangles as in figures 4 a and 4 b. The surveyor must then resort to other methods of buoying described below. The first step is to place one buoy in each corner of the check A, B, C and D. The positions of these buoys are fixed. Then one buoy is placed on each side half-way between the corner buoys, this being carried out by means of transits and by sight. (Buoys E, F, G and H). The remaining buoys are put into position by estimation.

If there are dangerous shoals within or close to the rectangle, these are indicated by buoys without flags. When the buoying is completed the buoy positions are plotted on the field board and a plotting sheet is constructed.

The scale of the plotting sheet corresponds to that of the field board as follows :

Field board scale	1 : 10.000	Plotting sheet scale	1 : 2.500
—	1 : 15.000	—	1 : 3.750

The distance between buoys in the same line must not exceed :

On scale 1 : 2.500 — 125 m.

On scale 1 : 3.750 — 185 m.

and the distance between lines must not exceed 50 m. and 75 m. respectively. It is very important that the buoy-positions be carefully transferred from the field board to the plotting sheet by means of proportional dividers, so that the shape of the check corresponds to reality and the right scale is achieved. As the graduating of the proportional dividers is not always reliable, it must be frequently verified.

All buoys should be plotted on the plotting sheet. The depth at every corner of the check is sounded by hand and the figures are inserted in red on the plotting sheet to serve as calibration figures.

The sounding takes place primarily along the *main lines,* secondly along the *interlines* and finally along the *quarterlines.* The lines should not be run further than necessary to get a distinct record of the shoaling. Soundings should be read as densely as necessary for plotting on every 5th mm. on the plotting sheet, i.e. on a scale of 1 : 2.500 for every 12th m. Depths which appear to indicate shoalings should be encircled in pencil.

On the plotting sheet (fig. 5) the surveyor shall note date, time, numbers of region and examination, wind and sea in accordance with the log-book, scale and all other remarks concerning the survey. Reports regarding buoying, sounding and bar-sweeping (described below) shall be signed by the respective surveyor. Height of water expressed in cm. above or below the mean sea level, as read from the tide gauge, should be noted down on the plotting sheet by the cartographer on board who should also confirm the transferring to the field board and the fair chart.

When the field board is completed the plotting sheets are attached to the sounding books of the same region and are furnished with an index chart.

Indication of the shallowest depth

When the sounding is finished the plotting sheet is scrutinized and the 3-, 6-, 10- and 20-metre lines are drawn in blue, red, green and violet, thus indicating the extent of the shoaling. It is of great importance that the outer areas of the check not be neglected.

If the depth is so small that the shallowest spot can be detected directly, the depth is determined by hand lead. The position is fixed with sextant angles, which are noted at the head of the sheet and the position is indicated by a point in pencil on the plotting sheet. The depth is inserted at the head as well as at a convenient place outside the check, and at the same time is noted the abbreviation hl, indicating hand lead. Associated positions and depths are connected by a line in pencil. *The nature of the bottom should always be recorded in its correct position on the plotting sheet.*

The shallowest part not being visible, it is located by drift sweeping, whereby three leadsmen stationed forward, midships and aft are continuously sounding with hand lead. As the boat drifts, the depths are called out continuously in rotation by the leadsmen. When the boat is drifting at a good rate, surveyors and crew have to be very alert. If an E-boat is used for this work, the boat is run for some dense lines of sounding at right angles to the main lines. When the shoal is thus located, its least depth is found out by bar-sweeping.

The bar-sweeping is performed as follows :

The surveyor and one member of the crew attend to one vertical guy each, and another member of the crew operates the two fore-guys.

Fig. 1.

Distrikt n:r 6B76 SW 21

Anmärkning	Vinkel nummer	Djup		Anmärkning	Vinkel nummer	Djup	
Kurs nr 15 W	178	3,7				18,5	
kl. 0620		5,8			183	19	
		9,6				19	
		10					
		10,5					
	179	11		Kurs nr 15½ O	184	18,5	
		11	8,2	kl. 0650		18,5	
		11,5				17,5	
		13				17	
		13,5				17	
		11,8			185	16,5	
	180	12				15	
" "	"	"	"	" " "	"	"	"

Lodningsprotokoll — Standard form for soundings.

8

Distrikt n:r 6B76SW kurs·n:r 15W den 12/5 kl 0620

Komp. kurs	Ortbestämning	Vinkel n:r
265	Ti 56-12 (470) 84-19 kl	178
	" 59-27 " 90-56 "	179
267	" 59-50 " 100-18 "	180
266	" 77-46 Va 63-38 "	181
265	" 76-15 " 82-26 (210)	182
	" 75-42 " 88-53 "	183
. .	Kurs 15½ O kl 0650	
95	Ti 80-11 Va 70-43 (210)	184
96	" 76-29 " 64-52 "	185
	" 72-15 " 54-30 "	186
93	" 68-52 (470) 97-42 kl	187
	" 70-41 " 91-16 "	188
" "	" " " " " "	" "

Vinkelprotokoll — Standard form for angles.

The bar is set at a depth so as to touch the bottom. The boat is run in the direction of wind or stream, whichever is prevalent and the speed must be low (1—3 knots), just tightening the vertical guys. Adequate leading lines make the steering easier for the coxswain and facilitate the fixing, when fouling.

When the bar strikes the bottom it warns the men who attend to the vertical guys. The fore-guys should not be belayed, because the guy-man must be able to slack immediately to prevent the guys from breaking. After a foul the bar is set at a depth 2 dm. less, and the shoal is passed anew. This procedure is repeated until the bar passes clear of the summit. The depth of the bar now indicates the sea depth. On the plotting sheet the swept area is marked by a yellow line and from the spot where fouling occured, a line is drawn to a yellow check outside the surveying check, where the depths of " foul " and " clear " are noted down. The bar sweep should not be used in depths exceeding 10 m. because of its insensitivity at great depths and should only be used under favourable weather conditions as any sea or swell might indicate false strikes.

In depths exceeding 10 m. the density of echo-soundings is increased by crosslining in the area adjacent to the shoal.

Figure 6 represents the least theoretical distances between soundings in different depths, which are necessary for covering an area, when an echo-cone, 30° wide, is used.

The least depth is checked by hand lead. On the plotting sheet yellow lines are used to indicate how densely the sounding has been carried out. Fix and least depth should be inserted in accordance with the above-mentioned rules.

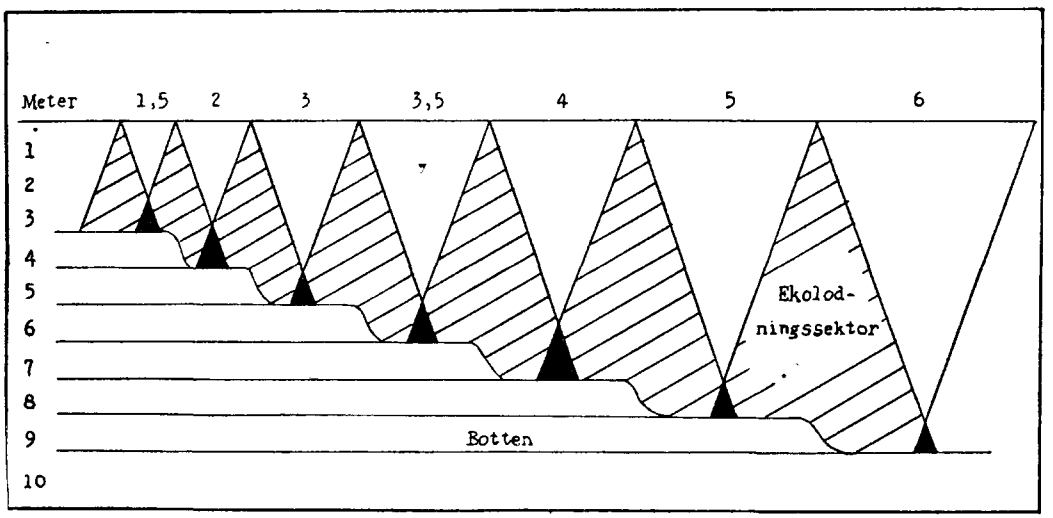


FIG. 6

Sjöm. fartyget *Svensksund* den *19.8* *1948* kl. *15.15* Distr. nr *197* Undersökning nr *V:1*

SV. Bl. nr 22 20000 12 46
Sjökarteverkets tryckeri 1946 · 76

	VÅLAR						VÅLAR					ANMÄRKNING	Djupet på lod	Djupet red.	Botten lag	Vinklar för grundklackarna
A						I	Cp	80-45	Bä	107-05	Sö	Vattenstånd: 0,2 m ö mv	⁘	–	K	Sö 70·30 P 95·42 R
B						K	Sö	69-45	Fyr 2	74-37	R	Vind: SSO				
C	R	64-41	Gry	101-57	Q	L	Bä	84-57	Q	65-41	Sö	Sjöhävning: ingen				
D	Q	68-18	„	23-06	R	M	„	54-40	„	86-45	„	Skala 1: 5000				
E	Sä	88-33	P	79-52	Cp 3	N	Fyr 2	103-33	R	90-25	Q	Övrigt: gynnsamt				
F	„	99-45	„	90-06	„	O	0	73-25	„	79-15	Kvä					
G	Cp 3	114-55	Kvä	74-35	Sö	P	Kvä	83-58	Sö	69-20	Gry	S Bä 101-46 P 87-04 Kvä				
H						R	0	86-51	P	90-25	Kvä	T „ 9·17 „ 79-20 „				

Utvålad av *[signature]* Lodad av *B R* Stångsvept av Införd i mätningskartan av *[signature]*

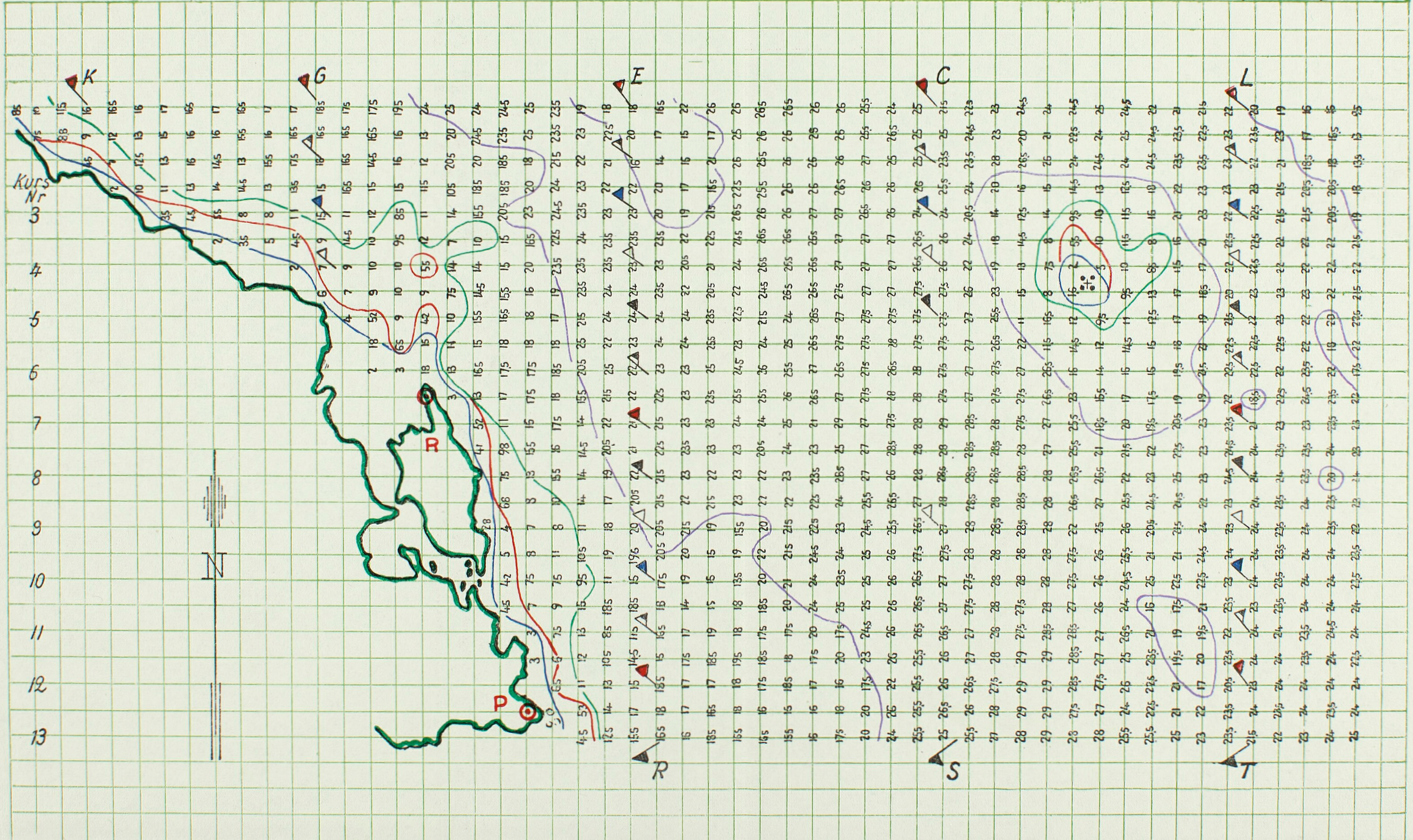
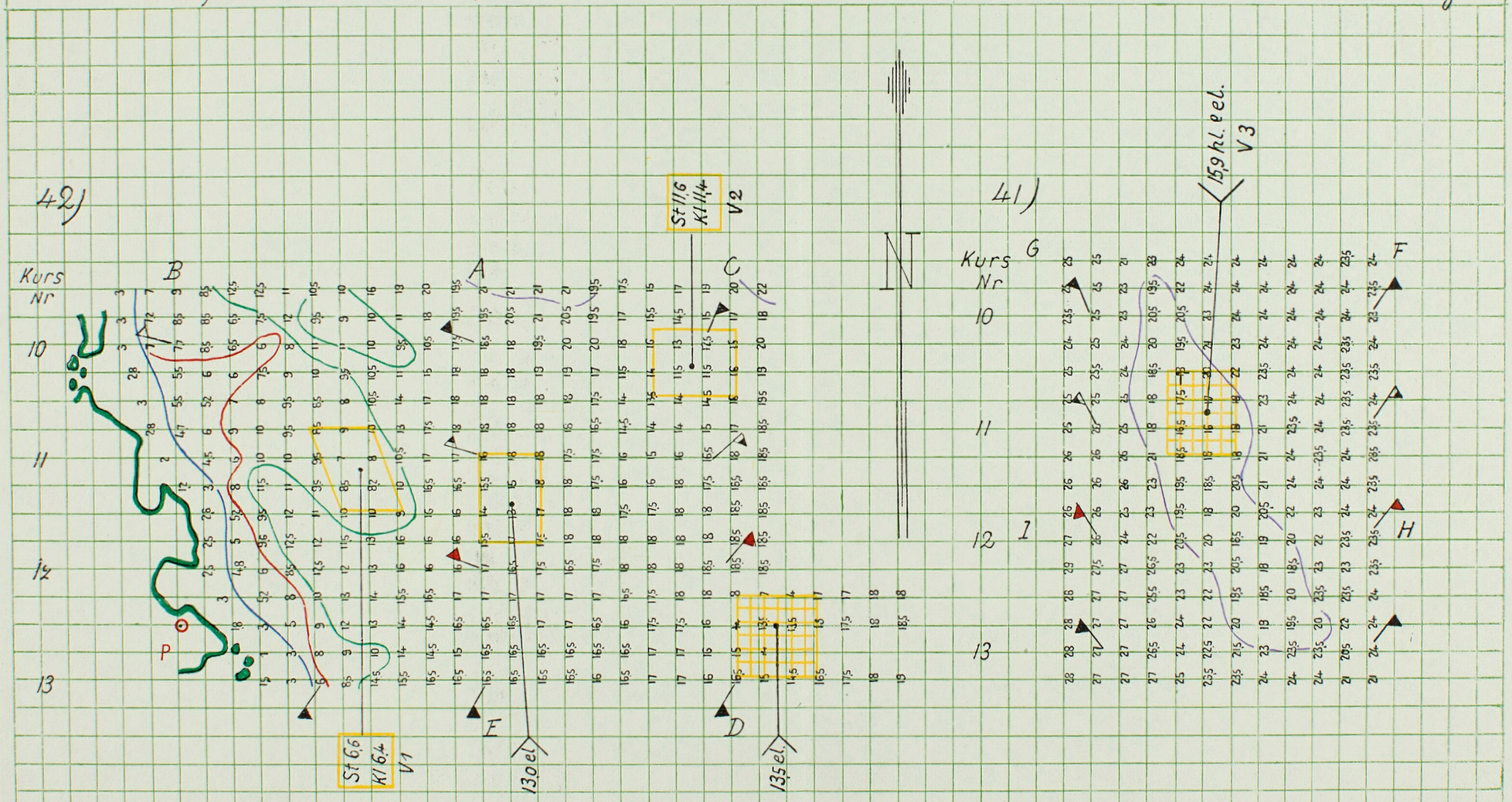


FIG. 2

Sjöm. fartyget Svensksund den 19.8 1948 kl. 715 Distr. nr 197 Undersökning nr 41 o 42

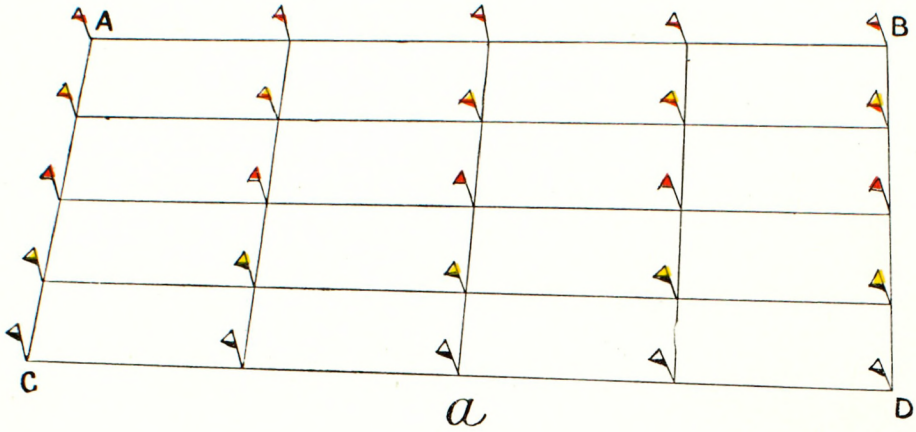
VÅLAR				VÅLAR				ANMÄRKNING	Djupet på lod	Djupet red.	Botten lag	Vinklar för grundklackarna
A	P	83-23	R 105-12 Q	I	R	79-46	Q 84-30 Sö	Vattenstånd: 0,2 m ö. mv	6,4	6,2	K	P 97-33 R 85-41 Q
B	Pä	74-45	Q 94-10 Fyr 1	K				Vind: SW 2	11,4	11,2	K	„ 59-55 „ 102-08 „
C	R	111-47	„ 47-30 Sö	L				Sjöhävning: ingen	15,9	15,7	K	R 88-47 Q 80-07 Sö
D	O	69-	P 94-10 Kvä	M				Skala 1: 2500				
E	Se våle R i V1			N				Övrigt: gynnsamt				
F	R	88-30	Q 85-22 So	O								
G	„	98-10	„ 74-22 „	P								
H	„	87-33	„ 74-35 „	R								

Utvålad av BAE Lodad av BAE Stångsvept av BAE Införd i mätningskartan av HK Wbg

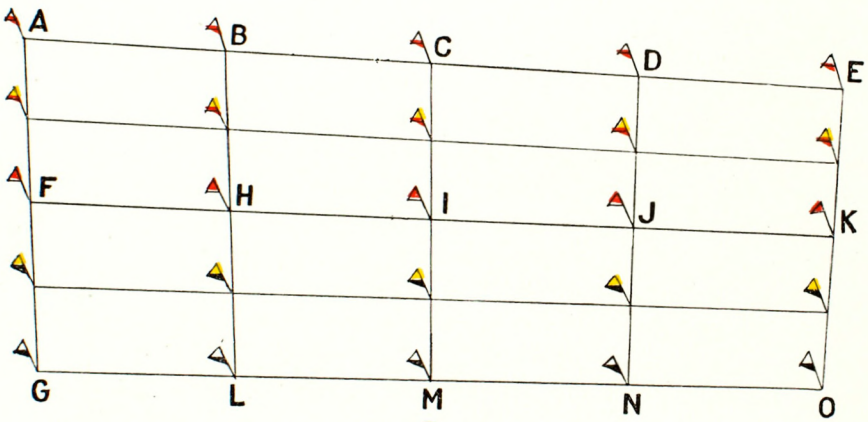


SV. Bl. nr 22 20000 12 46 Sjökartoverkets tryckeri 1946 -76

FIG. 3



a



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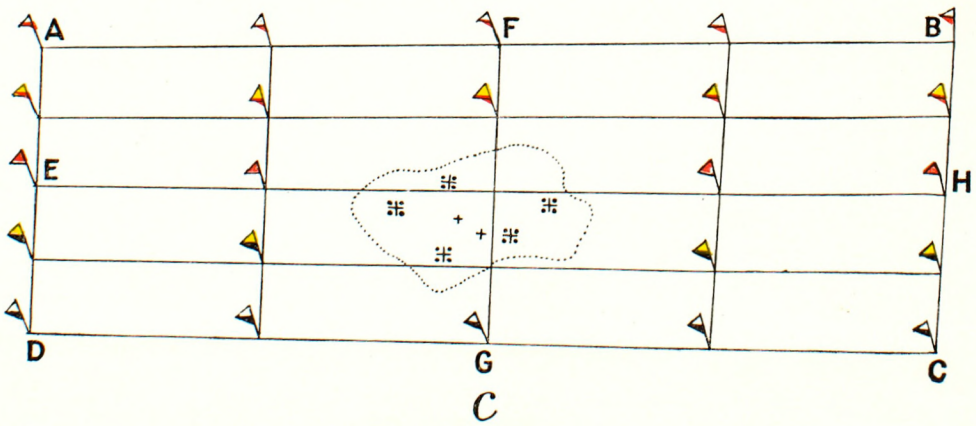

c

FIG. 4

Sjöm. fartyget Svensksund den 7.9 1948 kl. 1400 Distr. nr 197 Undersökning nr 33

VÅLAR		VÅLAR		ANMÄRKNING	Djupet på lod	Djupet red.	Botten lag	Vinklar för grundklackarna
A	O 52-33 Ai 64-05 W	I		Vattenstånd: 0,1 m u.mv	0,5	0,6	K	Bö 88-23 Ai 86-47 AH
B	Ai 69-20 W 85-35 V	K		Vind: syd 1	3,8	3,9	K	„ 100-02 „ 83-08 „
C	se ruta 31	L		Sjöhävning: ingen	5,3	5,4	K	„ 111-52 „ 73-10 „
D		M		Skala 1. 2500	5,2	5,3	K	„ 117-57 „ 63-47 „
E		N		Övrigt: gynnsamt	3,7	3,8	K	AH 56-57 W 104-37 Bö
F		O			9,8	9,9	K	O 61-12 Ai 93-08 V
G		P			55	56	K	„ 55-11 „ 91-16 „
H		R						

Utvålad av BÅE Lodad av COÅ Stångsvept av BR Införd i mätningskartan av KW bg

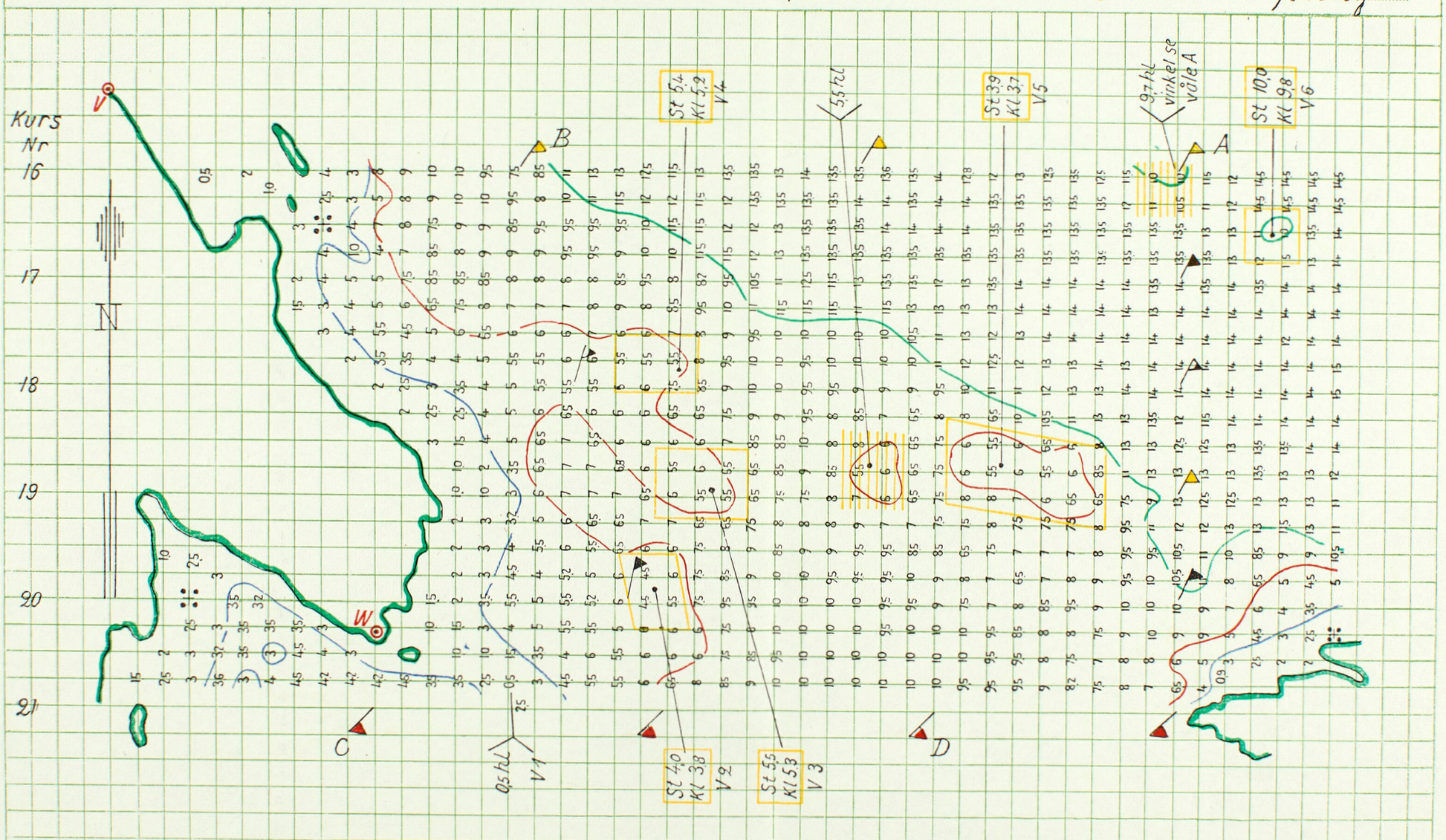

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FIG. 5