INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

C.M. 1985/B : 36
Fish Capture Committee

EXPERIMENTS ON ELECTRICAL STIMULATION OF FLATFISH IN BEAMTRAWLING DURING 1984.

by

J.B. Agricola

Netherlands Institute for Fishery Investigations
P.O. Box 68, 1970 AB IJmuiden
The Netherlands.

International Council for the
Exploration of the Sea

C.M.1985/B:36
Fish Capture Cttee

EXPERIMENTS ON ELECTRICAL STIMULATION OF FLATFISH IN BEAMTRAWLING DURING 1984

J.B. Agricola

1. INTRODUCTION

Research into replacing tickler chains of beam trawls with an array of electrodes stimulating the fish to jump upward in order to reduce the gear drag and consequently the fuel consumption of a fishing boat, has been carried out for a great number of years now.
At the end of 1982, it was felt that a higher voltage was needed for the pulse generator that, at the time, could supply 300 V at the electrodes.
The year 1983 was spend with designing and building a bigger pulser for 600 V at the electrodes using very short pulses.
A comprehensive research programme was set up for 1984 starting with testing the pulser in the laboratory for several weeks, testing it at sea on the FRV "Isis" prior to experiments on a semi commercial basis.
During a total of 22 weeks fishing trials were done on the commercial boat UK 141 "Jacob".

2. CURRENT ACTIVITIES

Features of the new pulser are:

- Frequency variable between 0 and 25 Herz;
- Capacitor-voltage variable from 200 to 2000 V (electrode-voltage 60 à 600 V);
- Circuitry for triggering thyristors previous improved and safer;
- The pulser body has been integrated into the beam, i.e. capacitors, thyristors and electronic circuitry built in;
- Figure 1 depicts the complete system.

Time consuming problems were encountered by oscillations induced by the magnitude of current and voltage variations during loading and unloading of the condensor.
The pulse shape is depicted in Figure 2 for a peak voltage of 500 V and a frequency of 20 Herz.
The trials were split up in short periods, leaving spare time to evaluate intermediate results.

1st Period: 16 January - 3 February 1984

Modified thyristor trigger and safety circuitry was tested with the previous 1000 V pulser in the laboratory and on the FRV "Isis".
The fishing net used is depicted in Figure 3, a conventional net with a catenary shaped footrope. A total of 8 electrodes was applied in the lay-out of Figure 4 to enable comparison with former experiments. It was decided to put the cable winch on the aft deck to enable a smooth operation of cables.

2nd Period: 27 February - 9 March 1984

In this period the new underwater housing, built in the beam (Figure 7) was installed and tested.
Short cut problems arose through leakage of the capacitors and condensated moisture inside the housing. By installing additional bulkheads in the container this problem could be overcome.
Nitrogene was used instead of air to avoid condensation.

3rd Period: 9 April - 19 April 1984

The power generator of "Isis" could not supply enough power for the pulser. A new gear box and fundation proved to be necessary.
Tests with a maximum generator voltage of 500 V were satisfactory.
Trigger circuitry of thyristors were oscillating, a problem that could be solved in the laboratory.

4th Period: 4 June - 29 June 1984

Comprehensive tests were done with the beam trawl lowered from one side of the vessel in IJmuiden harbour. Again lots of difficulties arose with the thyristor circuitry. Voltages higher than 500 V caused the pulser to switch itself off through short cuts.
The safeguard circuit of the thyristors did not function properly.
Finally a peak voltage of 1400 V could be achieved.

5th Period: 2 July - 8 September 1984

On July 2nd the pulser unit and controlsystem was installed on the "Jacob" UK 141. A spone generator was coupled with the ships auxiliary generator. A conventional tickler chain gear was used on the portside (Figure 3) and the electrified beam trawl was fished in the starboardside (Figure 4). Fishing speed varied between 4 and 5 knots, being the normal towing speed for the conventional net.
The aim was to meet or improve the conventional catches with the electrified trawl.
The fishing grounds were grounds commonly used by this boat.
The usual duration of a haul was approximately 2 hours.
Fishing took place from Monday till Friday, day and night.

Parameters varied were voltage and frequency. Alterations in electrode lay-out and the net itself were restricted to collect a suitable number of comparable hauls.
The construction and the material of electrodes was alterated however during the tests to overcome electrolytic corrosion.

A total of 77 hauls was done during the day and 72 during the night, of which respectively 21 and 7 had to be deleted due to equipment failure.

Gear drag measurements were done in the week from 3 - 7 September with a three-wheeler Emsa warp tension meter, type 75-20, results of which will be given in Chapter 4.

6th Period: 10 September - 5 October 1984

It was felt that the stimulation of fish could be improved by changing the array of electrodes from a curved one (Figure 4) into a rectangular one, which meant redesigning of the complete net. Prior to full scale construction, model tests were done in the Flume Tank of Hirtshals in May 1984.
Three different models were observed, all with the objective of creating a square array of electrodes. The idea of having a second beam behind the first one to keep the net open was abandoned for practical reasons, although it served the purpose. The final

result was the square net depicted in Figure 5, which did not need an additional beam and still had a reasonable square section. The drag loads are taken by chains between the shark teeths of the net and a chain between the shoes (Figure 6). The footrope is built with teeth at a distance of 7 m behind the beam.
The parallel electrodes have a length of 4 m each. They are also towed from the front chain and run through to the beam and pulser unit.
The area of stimulation is increased by 30% with this gear.
Being equal in length the electrodes constitute a very symmetrical load for the pulser.
During this period 44 hauls were done during the day and 46 during the night of which respectively 9 and 10 had to be deleted due to equipment failure.
The frequency was kept constant at 20 Herz to enable comparison, the voltage was varied to determine the effect on the catch rate.

This gear performed so well that an extension of two weeks could be organised after the formal period.

3. ELECTRODES; CONSTRUCTION, MATERIALS AND CORROSION (Figure 8)

Positive electrodes deteriorate quickly due to electrolytic corrosion, The material emittes positive ions to the seawater and is practically dissolving. With voltages higher than 800 V this process turned out to be very rapid, especially with a material like copper wire. Of course it applies only to the positive electrodes, a total number of four.
By choosing materials with a high melting point one can retard the process: it can however never be stopped completely.

Three practicle solutions have been investigated during the sea trials:
a. stainless steel wire of 16 mm diameter;
b. copper wire of 45 strands with a cross section of 1 mm^2 each, surrounded by a copper screen and mounted on a 16 mm fibre cord;
c. a composite form having a copper wire in the centre and 4 steel wires surrounding it and kept apart by discs.

Electrodes b. lasted only some ten hauls (i.e. 24 hours).
With c. the centre copper wires lasted also some 24 hours. Catch rates did not drop dramatically as might be expected. Apparently the steel wires, although having a higher electrical resistance, did compensate for the loss of copper wire.
The composite electrode could be used during a full week, although the copper centre wire did not last that long.

With the square net all electrodes, including the negative ones, were replaced with the disc-type, which did not result in changes in the pulse shape.

Conclusively one can state the steel wire electrodes (c.) to last for 1½ week and the stainless steel wires to last for 2 weeks.

4. DISCUSSION OF RESULTS

Catch results of the curved footrope net show a great amount of scatter which make it hard to draw any conclusions (Figure 9).
No explanation could be found for this amount of scatter. The picture is quite similar to that found in earlier years.
The square net shows a distinct correlation between catch rates and stimulation inputs such as frequency and voltage.

The catch rate increases with the voltages. This increase in catch rate seems to reach a maximum and stabilize at approximately 700 V. (figure 10) Scatter is still quite large as may be expected in fisheries.

The length distribution of soles has been compared for both beam trawls over the full range of experiments (figure 10).
Over the full range no significant selection in size was found, contrary to what might be expected, both for day- and night fishery. (figure 11).

The combination of 20 Herz frequency and 600-700 V voltage leads to satisfactory results.
This voltage is low enough to ensure a reliable operation of the pulser unit.

For hauls during the night catch rates increase with voltages over 400 V. 20 Herz and 700 V seemed to work very well in this case.
Problems arose mostly with voltages over 1000 V, which are substantially higher than the optimum values found.
When keeping voltage rather low, around 700, corrosion of electrodes will not be too excessive, enabling to work throughout a week and exchanging electrodes during the weekend.

The place of the cable winches ensured a smooth handling of the cables even with rough weather.

Bycatches of haddock, cod, etc turned out to be smaller for the electrified beam trawl. A possible explanation may be the different flow characteristics of the electrified beam trawl due to the rectangular cross section of the condensor package built in.

Gear drag measurements indicate the electrified trawl to have slightly less drag. Only one load-cell could be used at the time, so only consequentive readings were taken.
An average value of the gear drag of the electrified beam trawl is 2.875 tonnes and of the tickler chain type 3.45 tonnes, a difference of 17% in favour of the electrified net. This can be improved by a better hydrodynamical shape of the beam with pulser.
A weight comparison proved the electrified net to be slightly heavier: 3.49 tonnes in air compared to 3.44 tonnes of the conventional beam trawl, including net and tickler chains.
The total fuel consumption of the boat turned out to be less, indicating a smaller drag value of the electrified net.

5. CONCLUSIONS AND RECOMMENDATIONS

The experiments done in 1984 on a semi-commercial basis on the UK 141 "Jacob" proved the electrified beam trawl to be a feasible concept.
Catch rates of the electrified trawl outnumber those of a conventional tickler chain gear by about 50%.

Further development is needed to come to a reliable fully commercialised system. Endurance of electrodes still needs to be improved.

Experiments should be carried out on a commercial boat with two electrified trawls for a substantial period to enable a technical and economical evaluation.

The effect of the fishing speed on the catch rate is still to be investigated. The energy consumption of the system is a function of voltage, capacity and frequency as follows:

$$P = 0.5 \times C \times V^2 \times f$$

C = capacity (Farad)
V = voltage (V)
f = frequency (Herz)
P = power (Watt)

Consequently, if the optimum speed is lower, the frequency and voltage will be lower and the energy consumption will drop.

German and British research indicate possibilities of lower optimum speeds, a decrease of 1.0 or even 1.5 knots.

Improvements of the net itself are still possible. The additional chains, that take the load of the gear, may be deleted if the electrodes are designed to carry these loads, thus saving weight and drag of the chains.

The capacitors may be built in one of the beam shoes, or possibly in both, leaving the beam to be unchanged from a conventional one and therefore cheaper and resulting in less drag of the system and a better flow around the beam. Fasteners usually cause the centre of the beam to deflect. It is the most vulnerable part and sensible to damage. For this reason a shoe-mounted package may also be favoured.

Corrosion of electrodes is still a problem to be looked after. It is recommended to incorporate institutes specialised in this field and to extend the tests done at RIVO.

Introduction of electrified beam trawling into fisheries requires financial support and the incentive to invest by private companies.

IJmuiden, 7 May 1985

Technical Research Department
Netherlands Institute for
Fishery Investigations

/ML

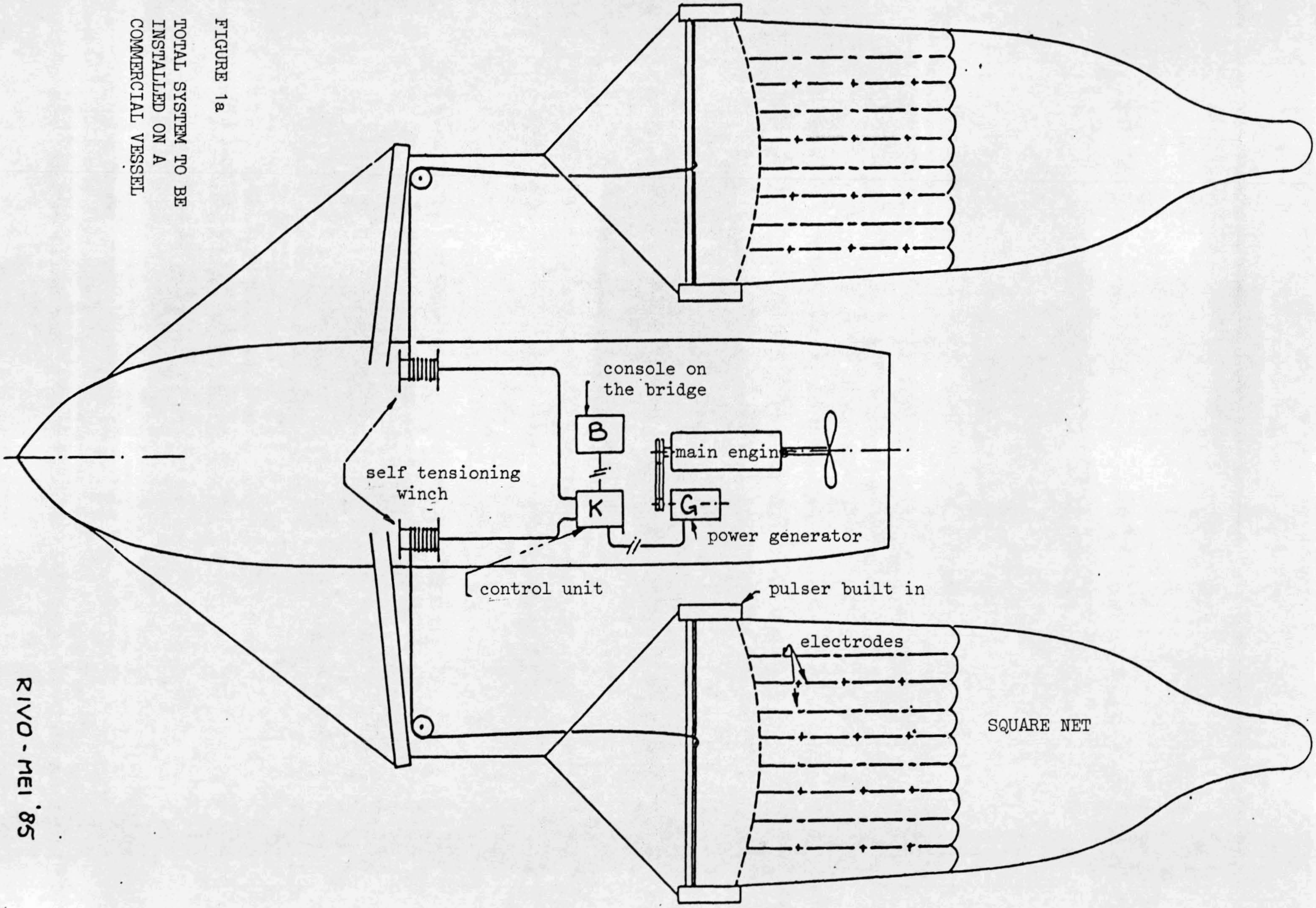
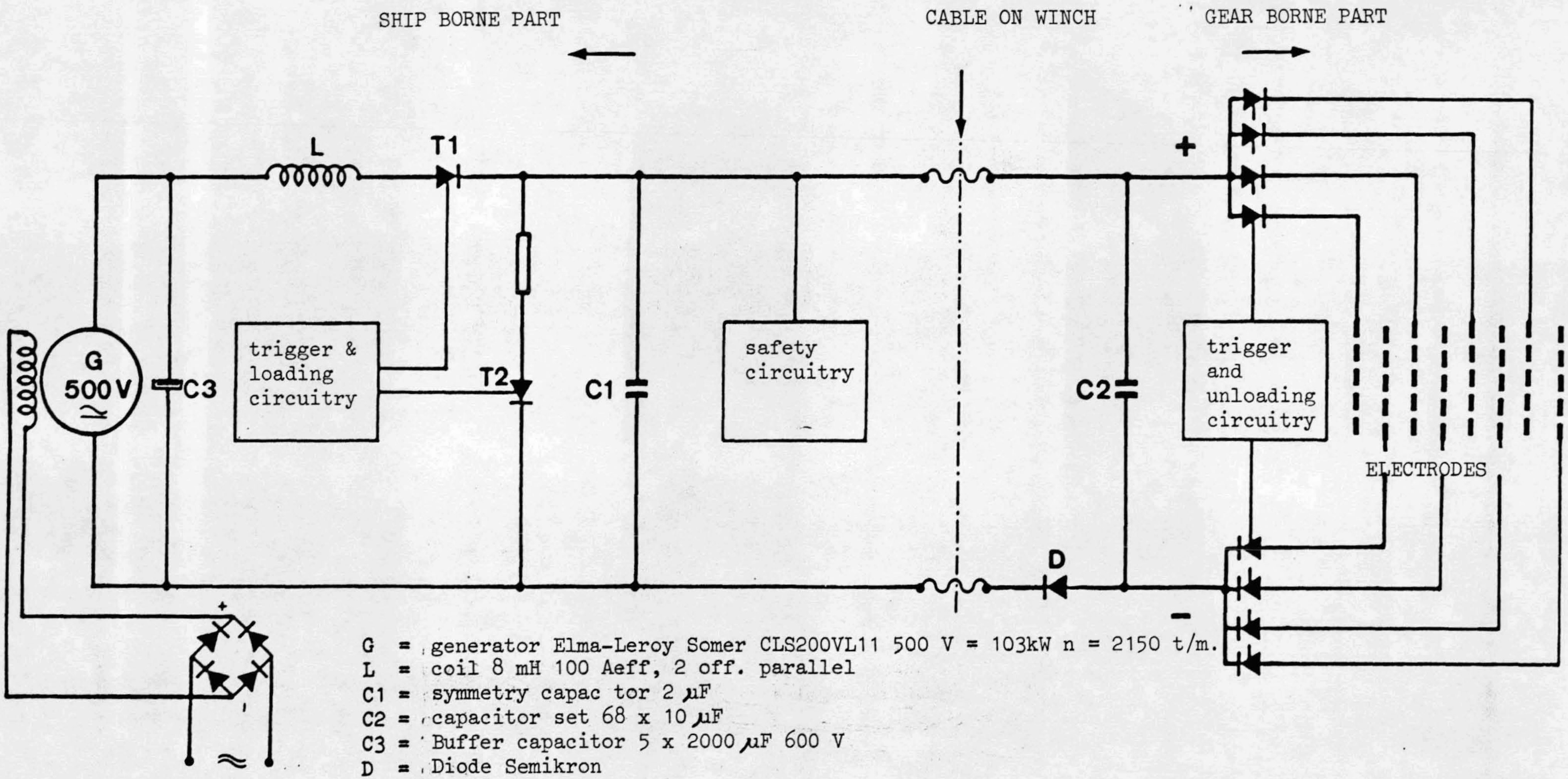


FIGURE 1a.

TOTAL SYSTEM TO BE
INSTALLED ON A
COMMERCIAL VESSEL

RIVO-MEI '85

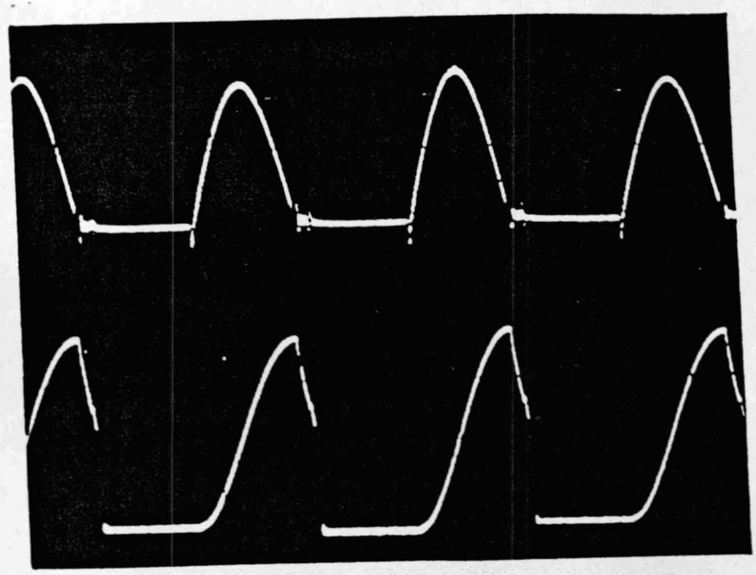
FIGURE 1b: LAY OUT OF THE COMPLETE ELECTRICAL SYSTEM



G = generator Elma-Leroy Somer CLS200VL11 500 V = 103kW n = 2150 t/m.
L = coil 8 mH 100 Aeff, 2 off. parallel
C1 = symmetry capac tor 2 μF
C2 = capacitor set 68 x 10 μF
C3 = Buffer capacitor 5 x 2000 μF 600 V
D = Diode Semikron
T = Thyristor Semikron

CURRENT

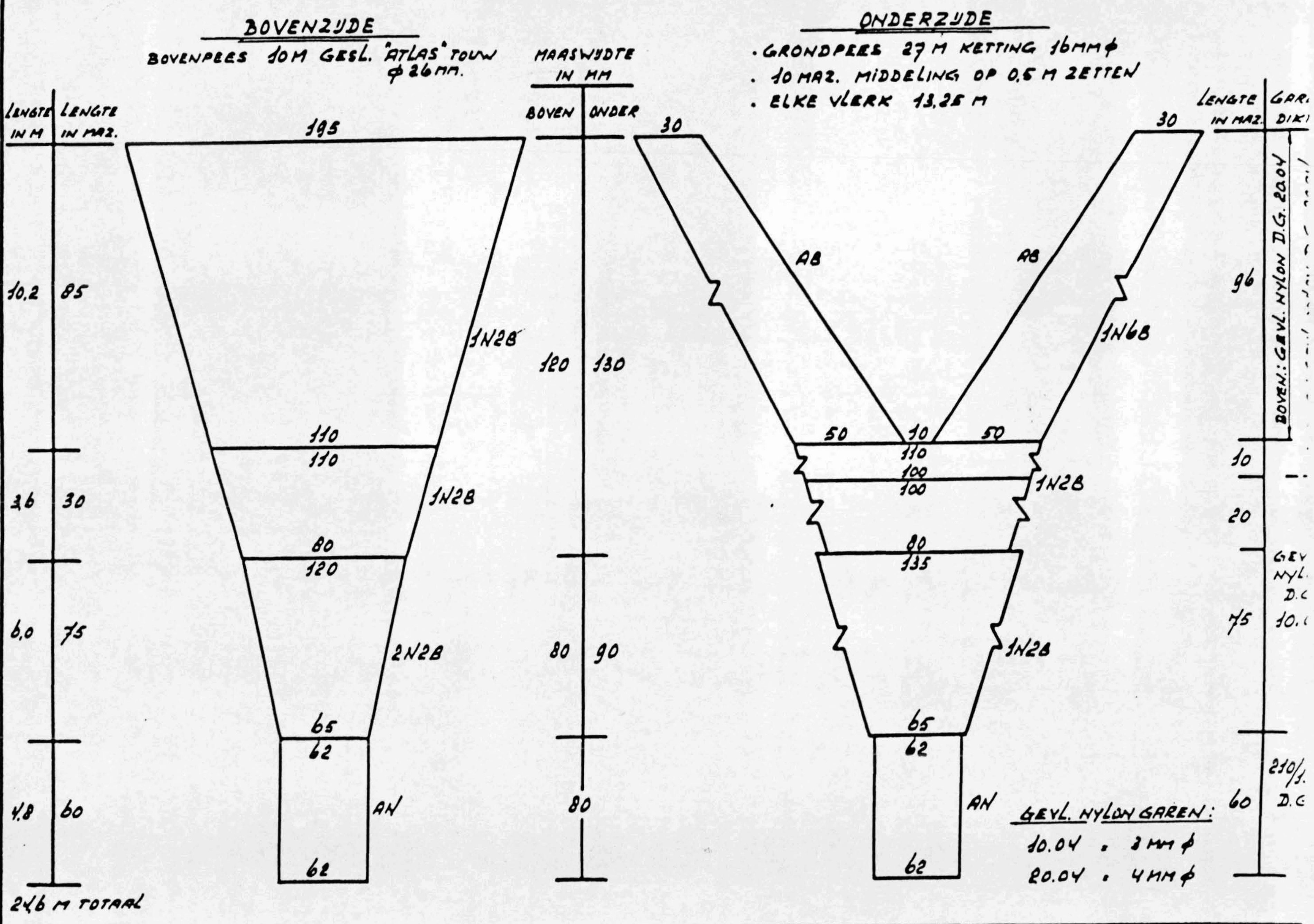
VOLTAGE



Pulse shape

$\hat{u} = 500$ V. $\hat{i} = 35$ A. $f = 20$ Hz.

FIGURE 2



Benaming	BOOMKOR-NET UK-141 (809A)		
RIVO AFD. TECHN. ONDERZOEK	Schaal 1:150	Gecontroleerd	
Auteursrecht voorbehouden volgens de wet	Getekend [signature]	Gezien 17-11-80	

FIGURE 3

CONVENTIONAL NET

BEAM TRAWL FOR ELECTRICAL STIMULATION

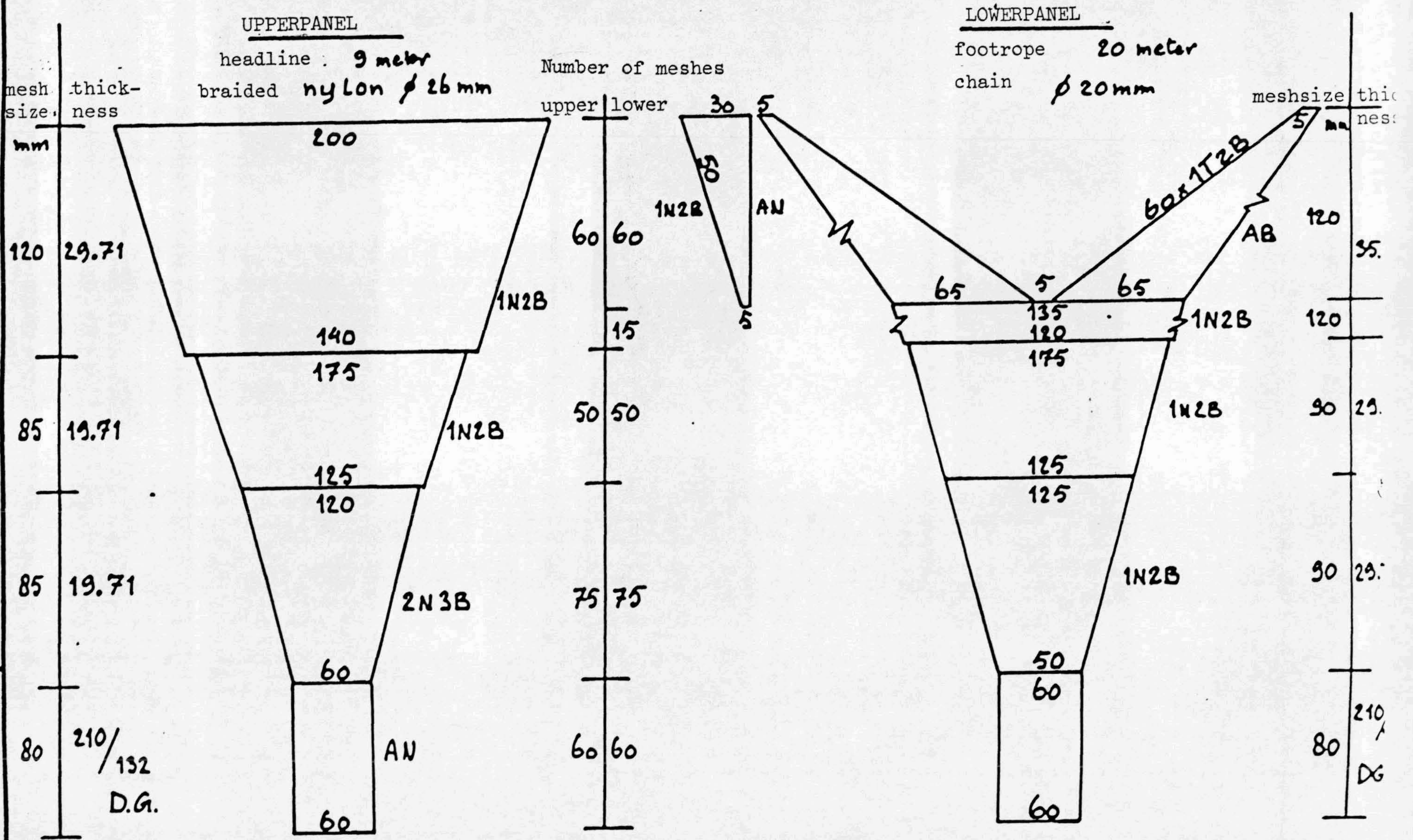


FIGURE 4a
CATENARY ELECTRIC NET

R.I.V.O. afd techn. onderzoek
IJMUIDEN

Benaming BOOMKORNET voor ELEKTRISCHE VISSERIJ

Schaal 1:50
Getekend AK/W.B.
Gecontroleerd
Gezien 22-6'84

ELECTRODE ARRANGEMENT OF CATENARY ELECTRIC NET

Catenary net
Length of headline = 9.00 meter
Length of footrope = 20.00 meter

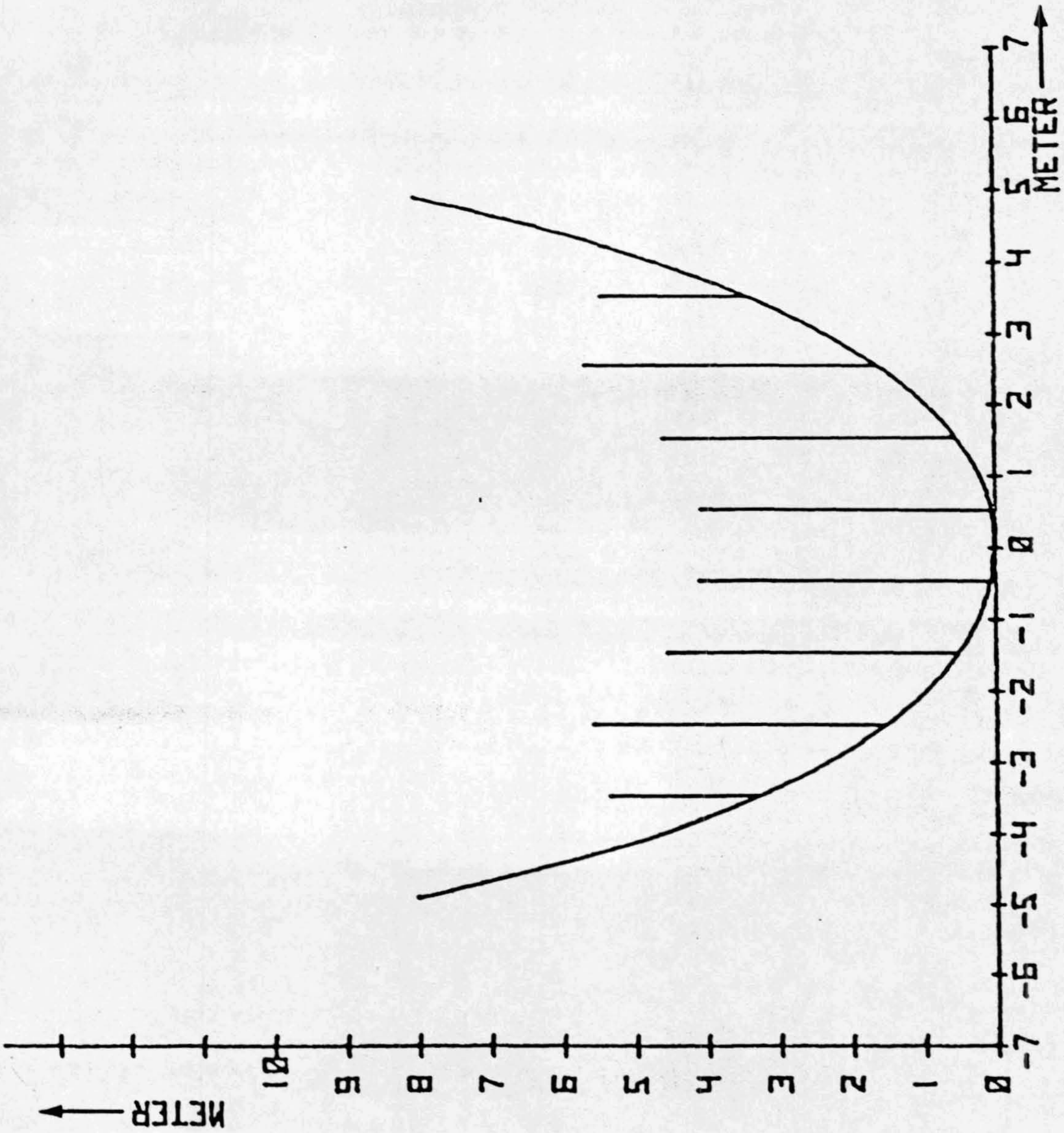


FIGURE 4b

Benaming: HAKTANDENNET I. (809C)
ELEKTRISCHE STIMULERING VAN PLATVIS 1984.

RIVO afd. techn onderzoek
IJMUIDEN - HOLLAND

Schaal 1:200 | Gecontroleerd
Getekend W.Blom | Gezien jan. '85

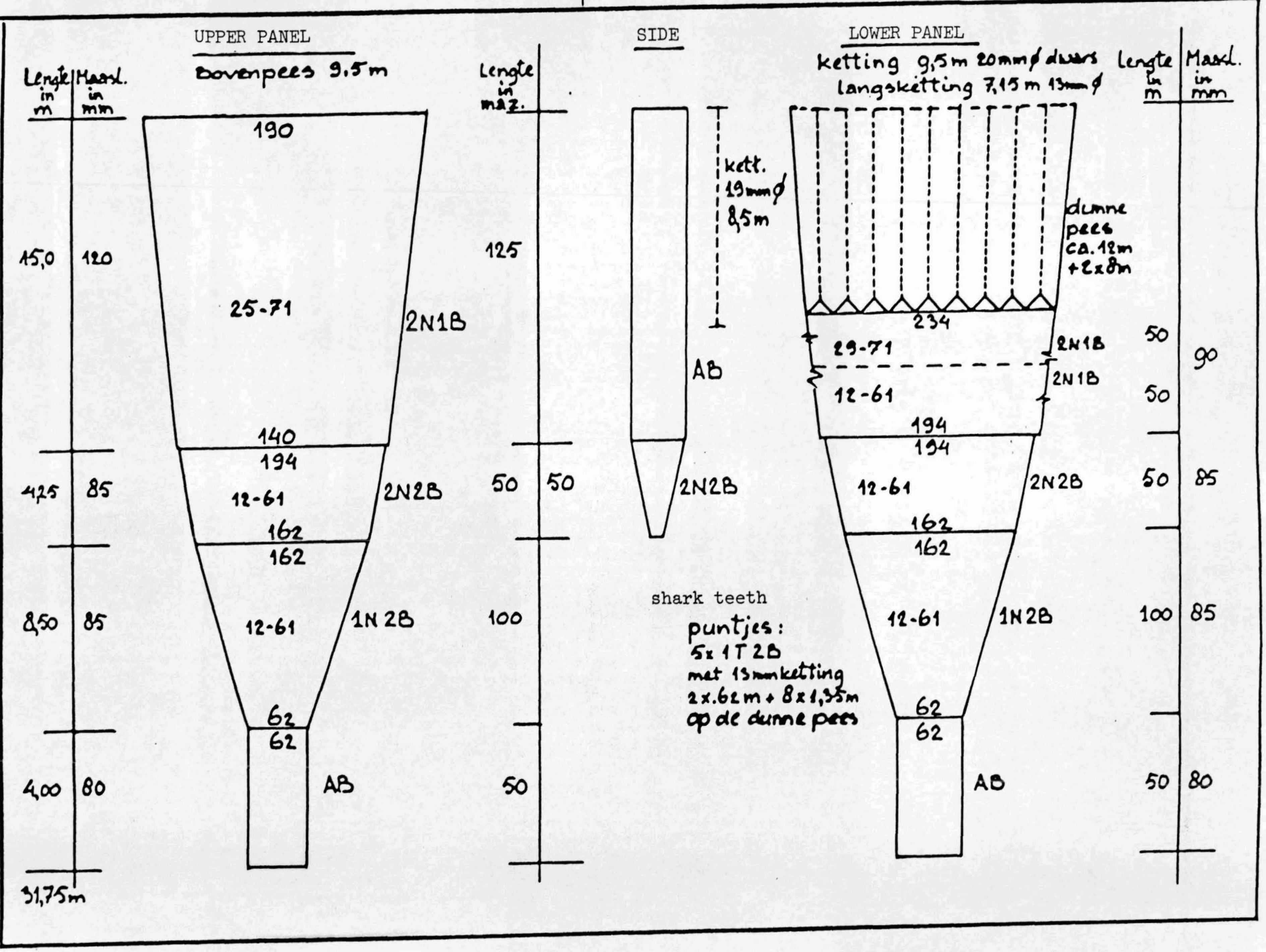


FIGURE 5
SQUARE NET

ELECTRODE LAY OUT SQUARE NET

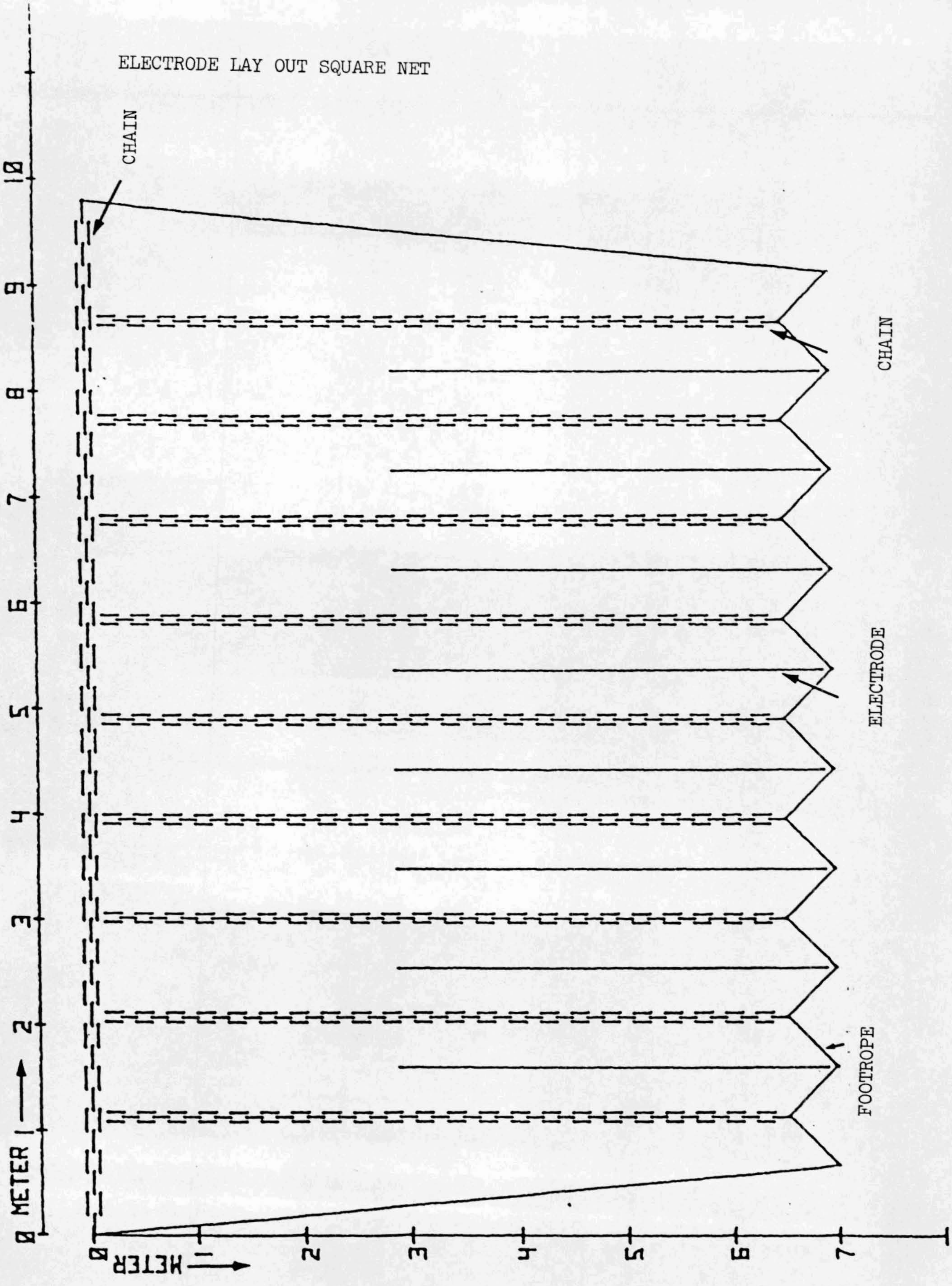


FIGURE 6

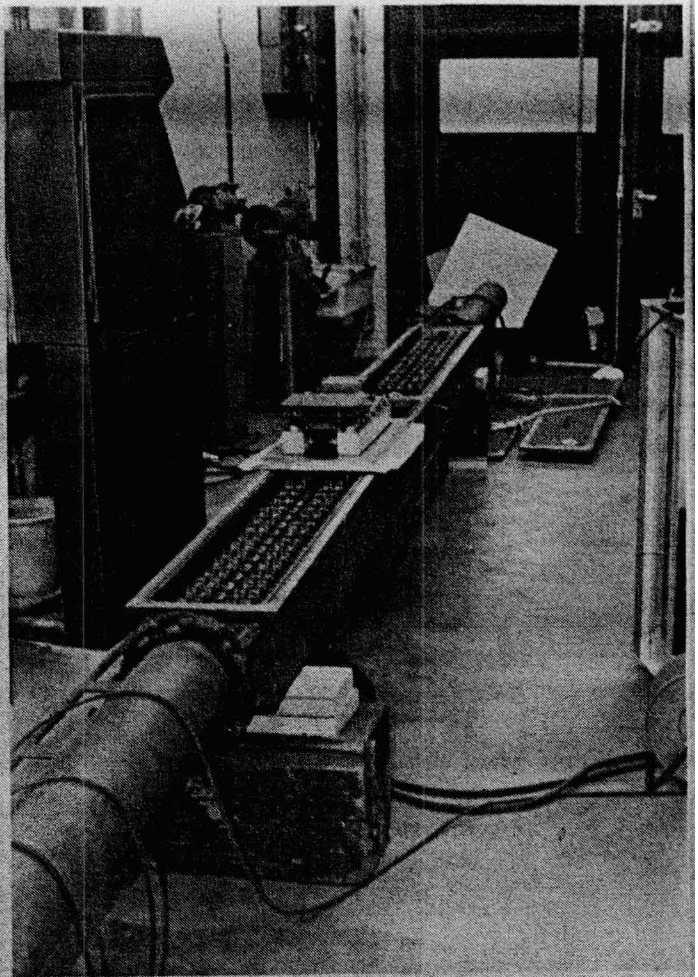


Figure 7a
BUILT IN CAPACITOR SET

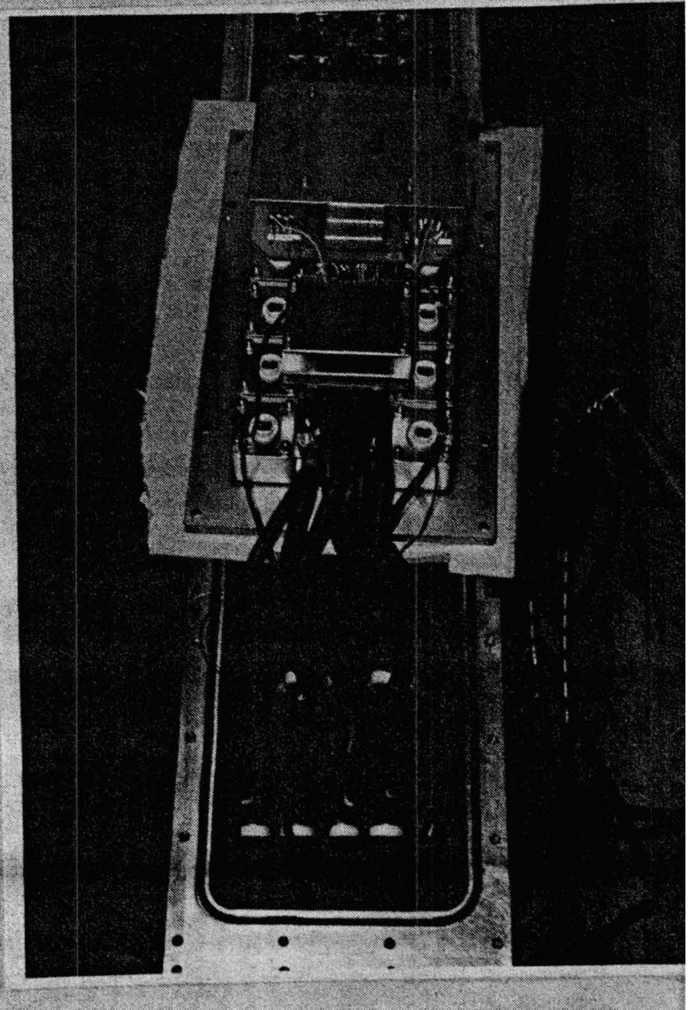


Figure 7b
COOLING PLATE WITH THYRISTORS
TRIGGER AND LOADING CIRCUITRY

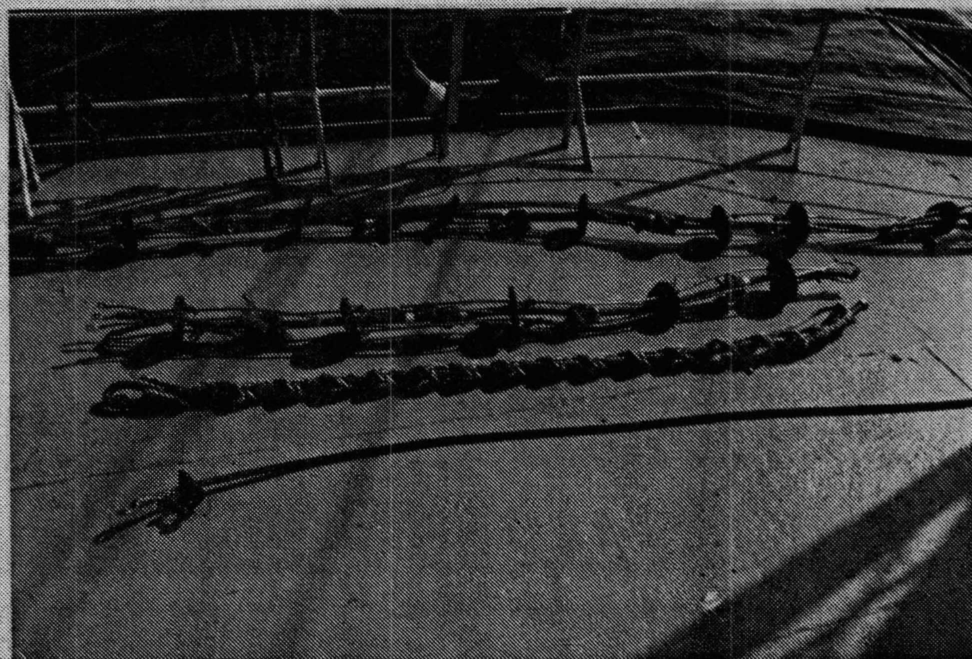


Figure 8a

ELECTRODE TYPES USED

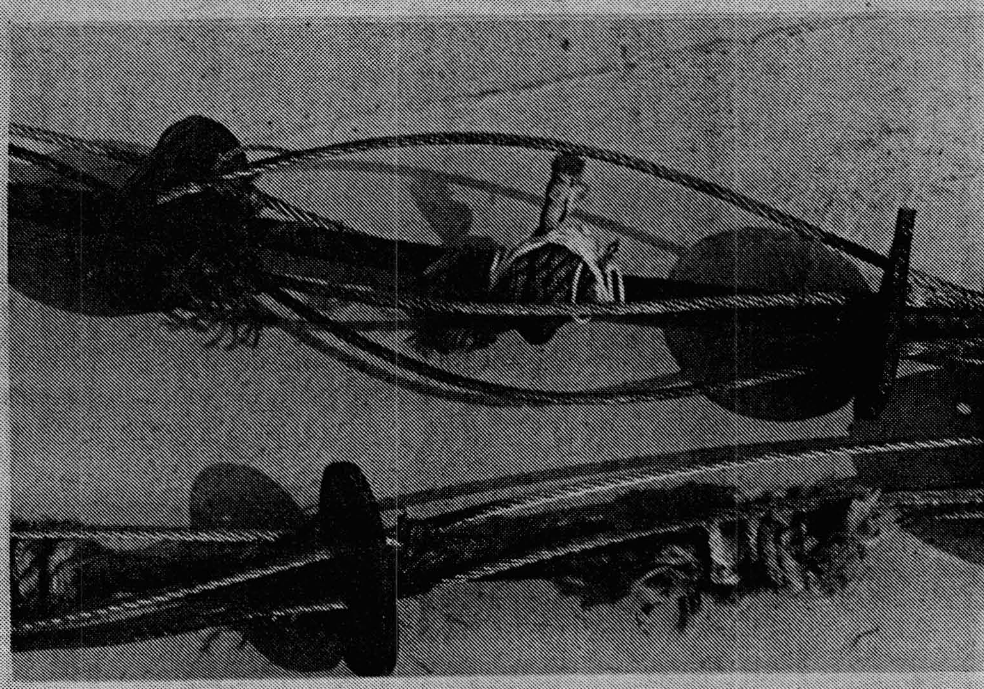


Figure 8b
DISC ELECTRODE AFTER
ONE WEEK OF FISHING

CATCH RATE AS A FUNCTION OF VOLTAGE PER HAUL - DAY FISHERY

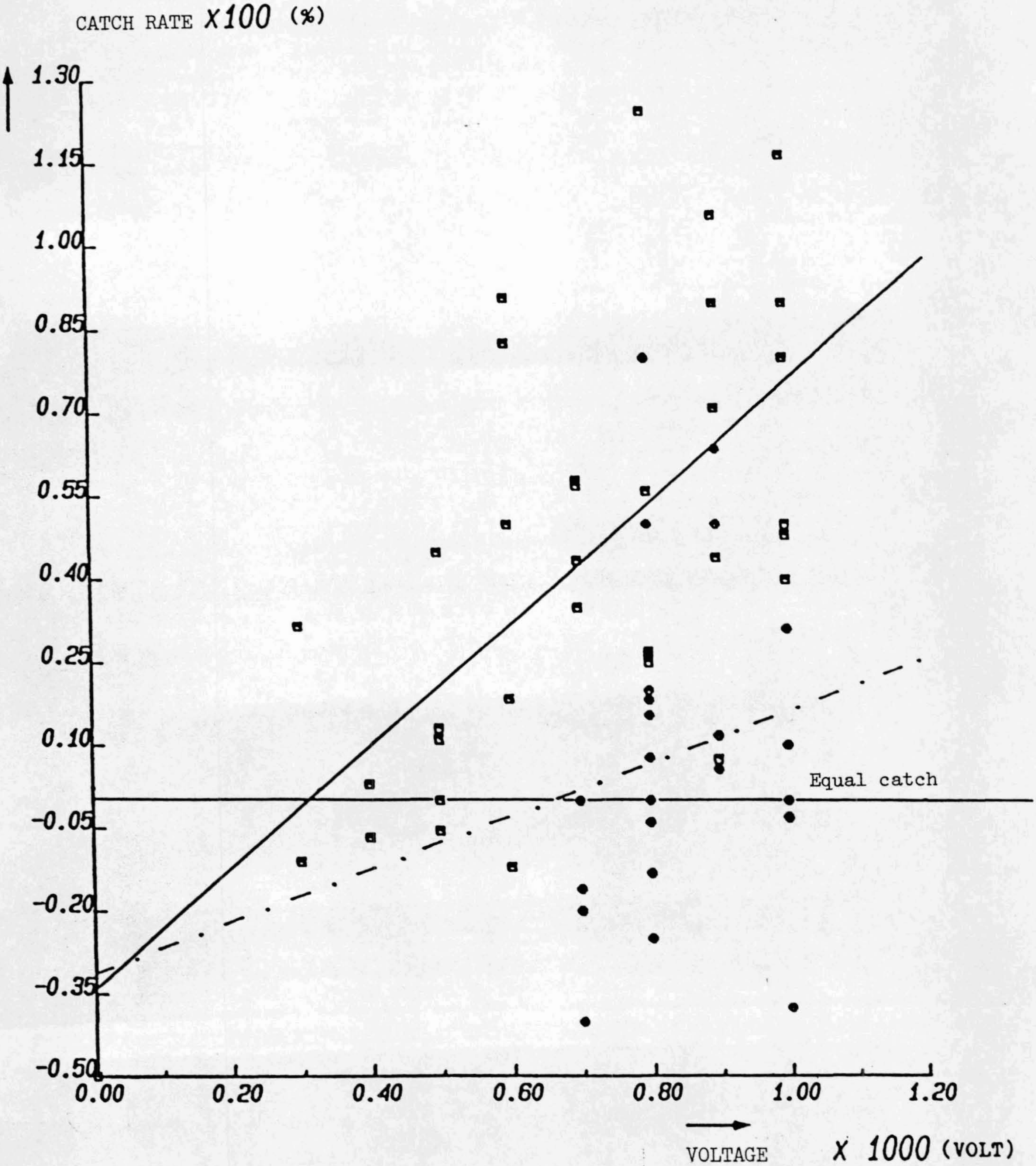


FIGURE 9a

CATCH RATE AS A FUNCTION OF VOLTAGE PER HAUL - NIGHT FISHERY

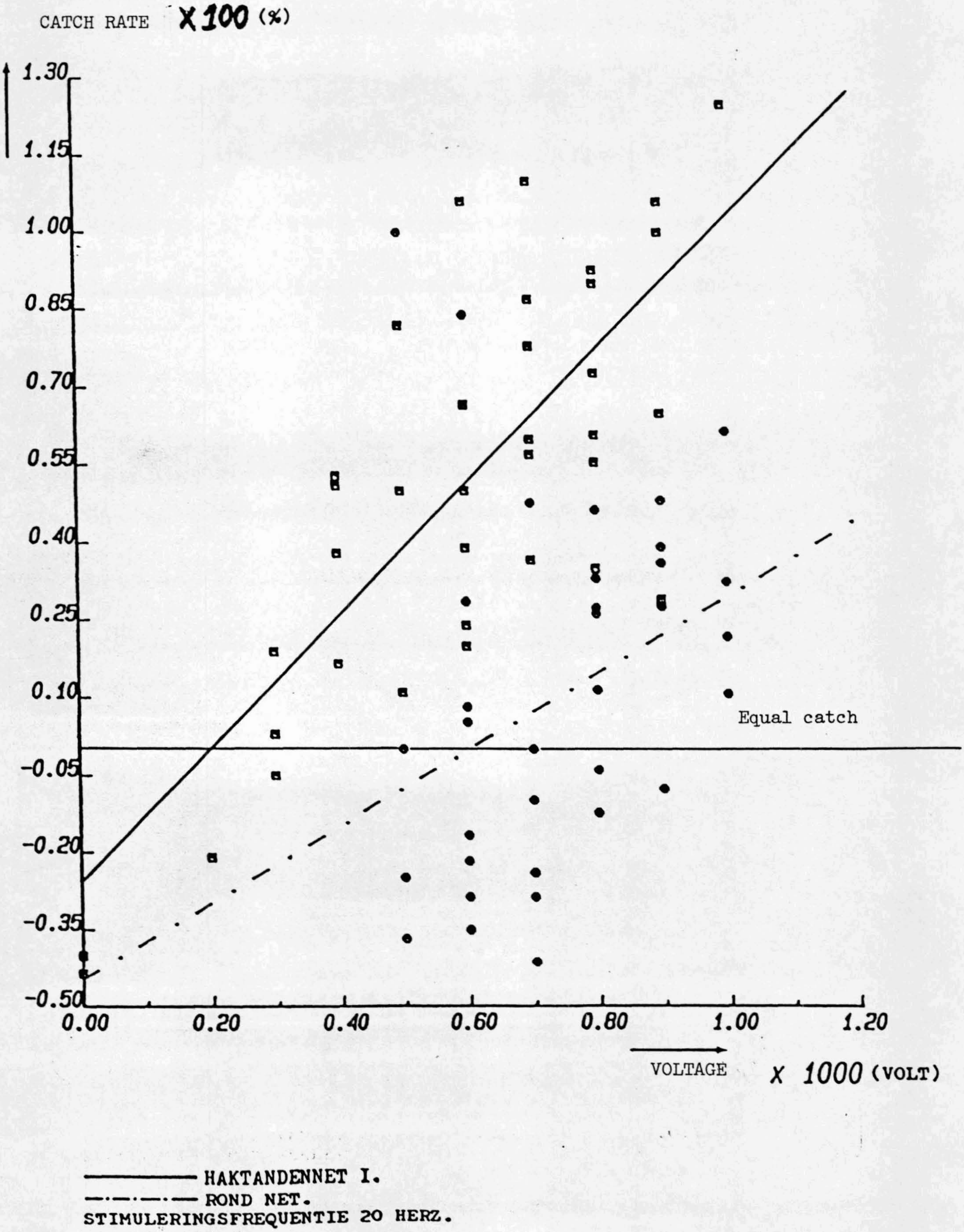
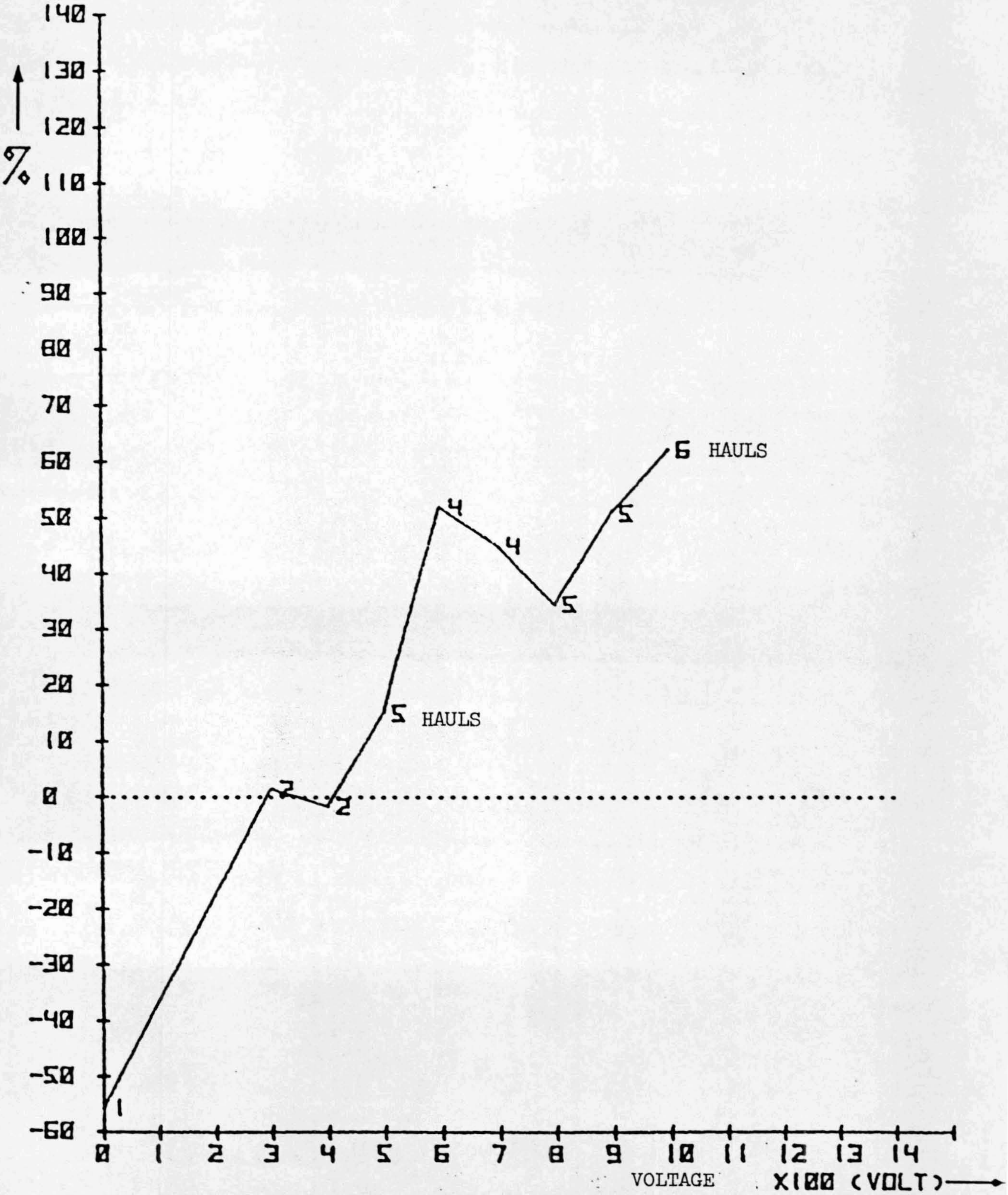


FIGURE 9b

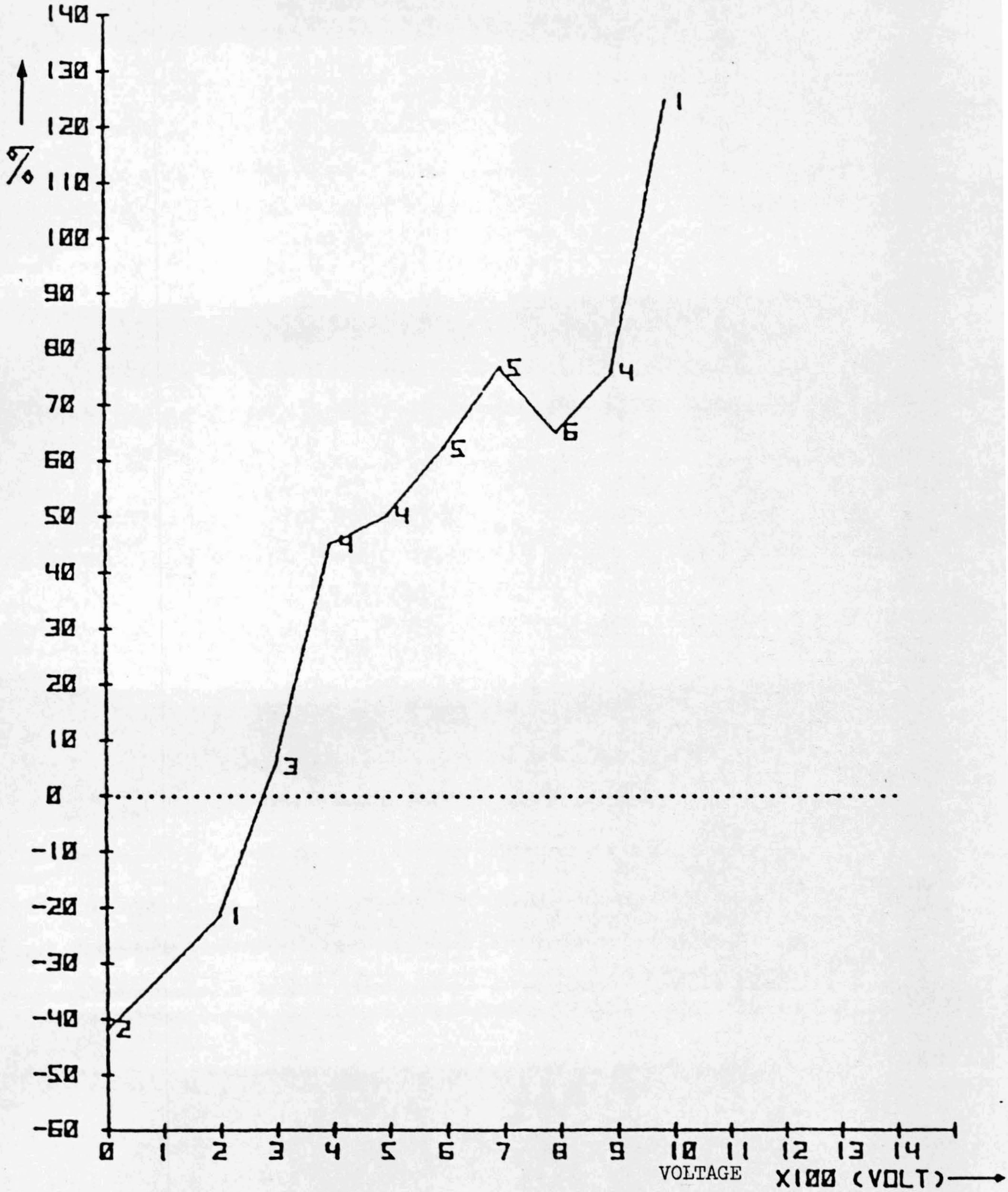
AVERAGE CATCH RATE AS A FUNCTION OF VOLTAGE FOR A GROUP OF HAULS - DAY FISHERY



GEMIDDELDE PROCENTUELE MEERVANGST (KG) ELEKTRISCH
VISTUIG T.O.V. BOOMKORTUIG MET WEKKERS.
STIMULERINGSFREQUENTIE 20 HERZ.
HAKTANDENNET 1. = SQUARE NET
DAGTREKKEN
(AANTAL TREKKEN PER MEETPUNT=GETAL IN GRAFIEK)

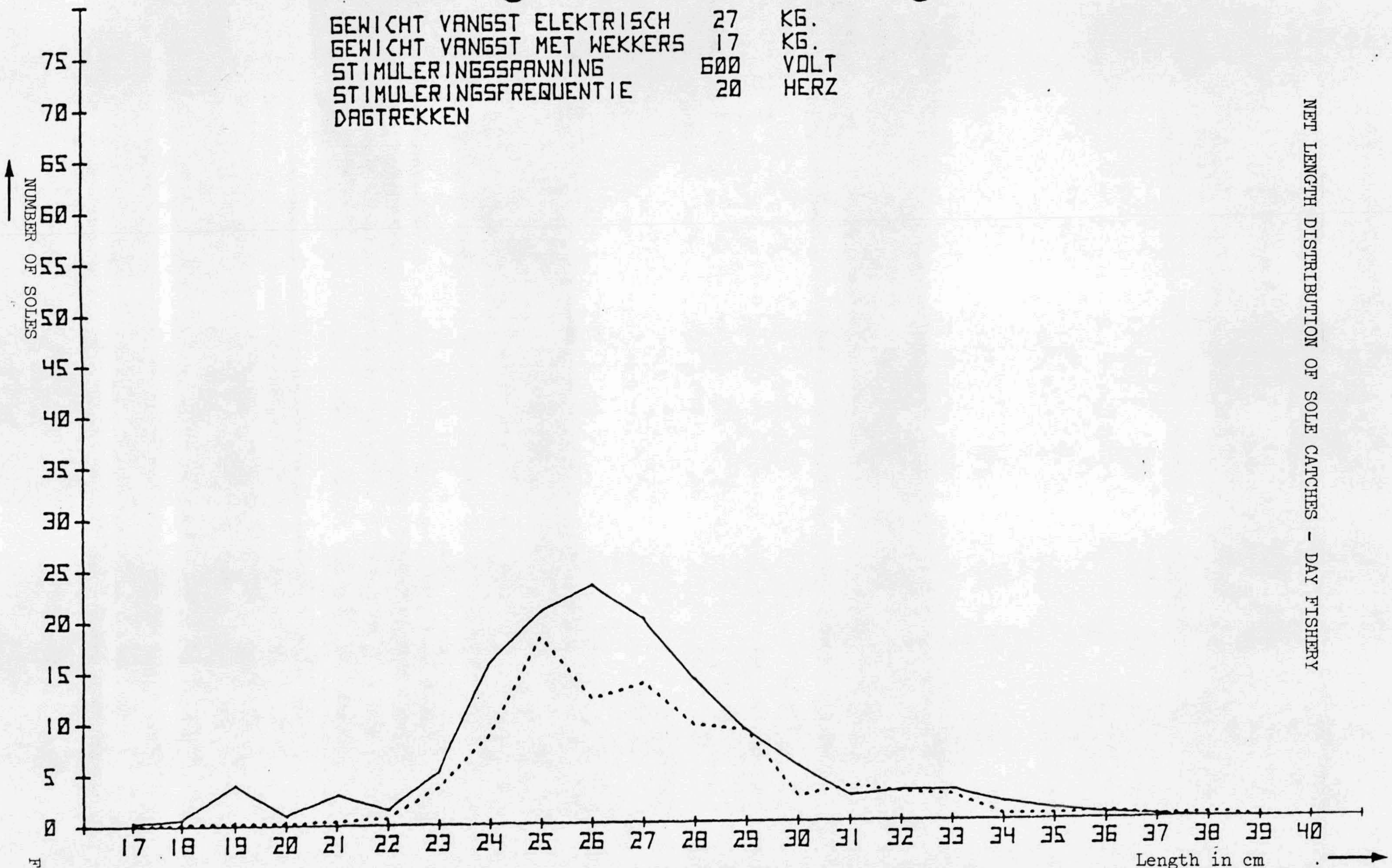
FIGURE 10a

AVERAGE CATCH RATE AS A FUNCTION OF VOLTAGE FOR A GROUP OF HAULS - NIGHT FISHERY



GEMIDDELDE PROCENTUELE MEERVANGST (KG) ELEKTRISCH
VISTUIG T.O.V. BOOMKORTUIG MET WEKKERS.
STIMULERINGSFREQUENTIE 20 HERZ.
HAKTANDENNET 1. = Square net
NACHTTREKKEN.
(AANTAL TREKKEN PER MEETPUNT=GETAL IN GRAFIEK)

FIGURE 10b

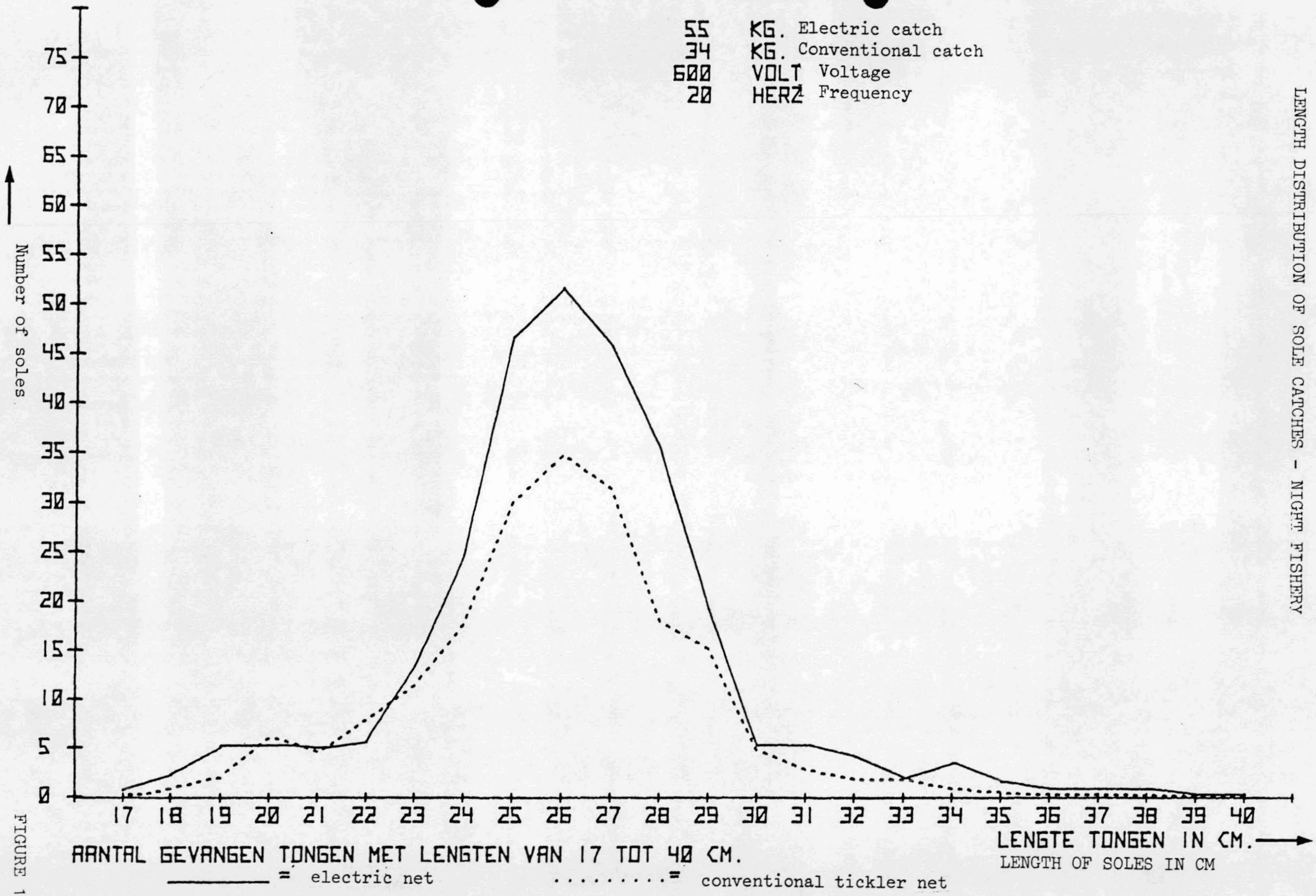


AANTAL GEVANGEN TONGEN MET LENGTEN VAN 17 TOT 40 CM.

———— = electric net .... = conventional tickler net

NET LENGTH DISTRIBUTION OF SOLE CATCHES - DAY FISHERY

FIGURE 11a



LENGTH DISTRIBUTION OF SOLE CATCHES - NIGHT FISHERY

FIGURE 11b