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Multi-net system

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Flume trials of the near bottom RMT 1 multi-net system

SFIA Flume, Hull 11-13 Dec. 1985

Participants: R.A. Wild, R.G. Aldred, H.S.J. Roe, A.R. Packwood, J.J. Taylor

Introduction

A system of three plankton nets shown in fig. 1 and described below was tested in the Sea Fish Industry Association flume. The nets were opened sequentially and run at a range of water speeds between 1 and 1.75 knots. The objective was to calibrate the net system so that the variation with water speed of the mouth angle of each net could be predicted.

The nets are designed to give a mouth area of $1m^2$ when the mouth angle is 45°. This angle will vary with speed and the amount of weight on the bottom bar. It also depends on which net is open, as the sequentially closing nets increase the drag at the bottom of the rig. This last factor means that all three nets will fish at different angles and an acceptable compromise would be to achieve a condition where the mouth angle of the centre net is 45° at a speed of 2 knots.

Description of the net system

The net system is based on the RMT 1's (Rectangular Midwater Trawls) from the RMT 1+8 multinet, as described by Roe and Shale (1979). Three $1m^2$ mouth area plankton nets are rigged to open and close sequentially, the opening of one net following the closure of the previous one. The nets are opened and closed at the mouth by bars at the bottom and top sliding down side wires. The mouths of the nets are held closed by wire bridles connected from the sliding bars to a four jaw mechanical release. The nets are supported by two fixed, solid steel bars 2m long by 25mm diameter. The total weight is carried by two outer 8mm wires which are attached via bridles to the triangular towing frame. Between the nets and the outer wires two additional wires support a flowmeter on one side and an inclinometer on the other. Circular cast iron weights of 11 or 5.5 kg were added to the lower fixed bar to increase the mouth angle of the net.

Description of the experiments

A diagram of the SFIA flume is shown in fig. 2. The working section of the flume is 5m wide, 2.5m deep and 11m long. The net system was suspended from a moveable overhead gantry on a chain hoist so that the top bar was just in the water when the flume was running. A Braystoke flowmeter was put in the flume upstream of the net to compliment the net flowmeter which was rigged on a separate side wire. The upstream flowmeter was used throughout to give the water speed as the net flowmeter tended to give a higher reading due to it being in a region of accelerated flow between the net and the tunnel wall. The "moving ground" belt was not used because at the higher flow speeds it tended to lift from the bed of the flume. An inclinometer was also mounted on the net on a side wire running parallel with the net wires. However this turned out to be unreliable because the inclinometer took up a different angle to the net side wires in the current.

On each run the flume was run up to speed and the net system positioned so that the weight bar was at least 30-40cm off the bed and the open net was close to the centre of the tank working section. When the net appeared steady the net mouth was photographed in profile through the side windows using flash photography (a single flash gun held against the window). The angle of the net side wire was also measured by eye using a large hand held protractor placed against the glass.

The maximum water speed achievable with the net system in the flume was 1.75 kn. Each net was tested at 3 or 4 speeds between 1 kn and 1.75 kn. The nets were released in sequence using the release gear and the opening and closing mechanism was observed for correct operation and sealing. The fishing behaviour of the open nets and cod ends was also observed.

Three configurations of the weights in the system were examined. As designed the horizontal net opening and closing bars comprise three light aluminium bars (1.3 kg each) and three heavy steel bars (8.5 kg each). These are arranged in sequence so that light bars open the nets and heavy bars close and seal them. In the first two configurations this arrangement was unchanged. The only change between configurations one and two was the number of weights mounted on the weight bar. The weight bar is a solid steel bar weighing 35 kgf in air. in the first configuration four 11 kgf cast iron disc weights were added to the bar outboard of the net side wires. Hence in configuration 1 the total weight of bar plus weights (W) was 79 kgf in air. In the second configuration two 5.5 kgf discs were added to this arrangement increasing W to 90 kgf.

In the third configuration the net bars were rearranged so that the three heavy bars were grouped at the bottom and the light bars at the top of the sequence. Hence the effect of changing to all heavy bars could be assessed. Only the bottom and the middle nets, which were representative of this condition, were tested in this configuration.

Results from the net calibration experiments

The results of the angles measured both using the hand held protractor and from photographs are shown in table 1 for the three configurations. The points are plotted in figures 3, 4 and 5. For each net the points (setting angle θ (degrees) measured to the horizontal and water speed V(kn)) were fitted to a best fit straight line using a least squares fitting procedure. The parameters of the straight lines so obtained and the projected value of θ at the design speed of 2 kn are also given in table 1.

The true relationship between θ, V and W is complex. For the drag of the system undoubtedly is a function of both V^2 and θ. Hence the relationship, balancing drag and weight by taking moments, is probably of the form

$$\theta \propto \tan^{-1} \left\{ \frac{W}{k(\theta)V^2} \right\}$$ where k(θ) is some unknown function of θ.

Graphing the measured points indicates that the curve is nearly linear for the limited range of velocities investigated. Hence in the absence of more information the linear approximation appears as good as any. The results of Roe et al. (1980) for the much larger RMT 8 system also indicate a near linear relationship between setting angle and tow speed in this speed range.

Figures 3 and 4 show the results obtained for the first two configurations. In both cases the weight W was not sufficient to bring θ up to 45° at 2 kn. The increase of 11 kgf increases θ at the middle net by 1.7° at 2 kn. This indicates that W would have to be increased to 112 kgf to achieve the design condition. The projected values of θ at 2 kn for all the nets are plotted against W in fig. 6. Simple extrapolation gives the value of W = 112 kgf for the design condition on the middle net. However the slopes of the lines for the top and bottom nets are rather different. An averaged line equidistant between the top and bottom net lines would give an intercept with the θ = 45° line at W = 105.4 kgf. This would give a spread of angles from bottom to top net of 45° $\pm$ 6° at 2 kn.

The effect of rearranging the net bars is shown in fig. 5. A projected 1.2° increase in bottom net setting angle is achieved on the bottom net but the improvement at the middle net is negligible. Overall the effect of using heavy net bars appears to be small, but these tests could not be said to be conclusive on this point.

Observations of the net behaviour

The trials also gave us the opportunity to observe the net's behaviour as it was operated. The catenary of the net mouth showed up the failings of using separate wires to carry the angle-meter and flow-meter. The drag of the bottom bar caused it to rise thus reducing the distance between the top and bottom bars making the two instrument wires take up a different catenary to the net side wires so the angle-meter reading was not valid. The drag of the eye bolts on the side wire prevented full travels of the net opening bars, a roller system has since been fitted.

The deployment of net and cod end bucket was seen to perform well. Altogether the exercise gave a better feel for what actually happens to a net system when it is out of sight at the end of the warp.

Conclusions

1) The nets appeared to fish well. Improvements could be made in net opening/closing by using rollers instead of eye-bolts at the ends of the net bars and using heavy bars to open the nets.

2) It was disappointing that the speed of 2 kn could not be achieved in the flume for this meant that all results had to be extrapolated, in some cases quite a long way, to reach predictions for the system behaviour.

3) The weights employed in the experiments were not heavy enough to attain the design condition of a 45° setting angle on the middle net at 2 kn. Extrapolations from the limited results available suggest that an all up weight for the weight bar of 105 to 112 kgf (in air) will give the desired setting angle at a tow speed of 2 kn.

4) Rearranging the net bars, so that all heavy bars were at the bottom appeared to have little influence on the setting angle of the middle net but insufficient tests were made to be conclusive.

5) It would be beneficial to repeat some of the tests with the adaptations recommended above at the design operating speed.

Acknowledgements

We would like to thank the staff of the SFIA training centre for their assistance in conducting these trials.

References

Roe, H.S.J. and Shale, D.M. (1979) A new multiple rectangular midwater trawl (RMT 1+8M) and some modifications of the IOS RMT 1+8. Marine Biology 50: 283-288.

Roe, H.S.J. et al. (1980) Behaviour of the IOS RMT: Theoretical aspects and experimental observations. Marine biology 56: 247-259.

Table 1 Net wire angles measured for three configurations

Configuration/ net	Water speed	Hand held protractor	measured from photographs	least squares fitted line $\theta = a + bV$		
	V(kn)	θ(deg)	θ(deg)	a	b	θ at V=2kn (deg)
1 bottom	1.03 1.42 1.57 1.73	66 55 52 -	66, 67 55½ 54 50	91.1	-24.4	42.3
1 middle	1.01 1.44 1.75	66 52 46	65, 66 54½,55 47, 47	91.5	-25.8	39.9
1 top	1.24 1.44 1.57	56 49 45	56½,57 49, 50 46, 46	97.4	-33.1	31.2
2 bottom	1.3 1.46 1.61	60 57 54	61, 62 57 55	88.5	-21.3	46.0
2 middle	1.28 1.46 1.61 1.71	58 54 51 47½	58 54 51 -	87.6	-23.0	41.6
2 top	1.22 1.46 1.57 1.75	55 51 46 41	57, 58 50½,51 47 -	92.5	-29.1	34.4
3 bottom	1.28 1.46 1.61 1.77	61 56 53½ 51	- 57 54½ 52½	83.3	-18.0	47.2
3 middle	1.26 1.46 1.57 1.75	61 57 52 48½	- - - -	94.6	-26.5	41.7

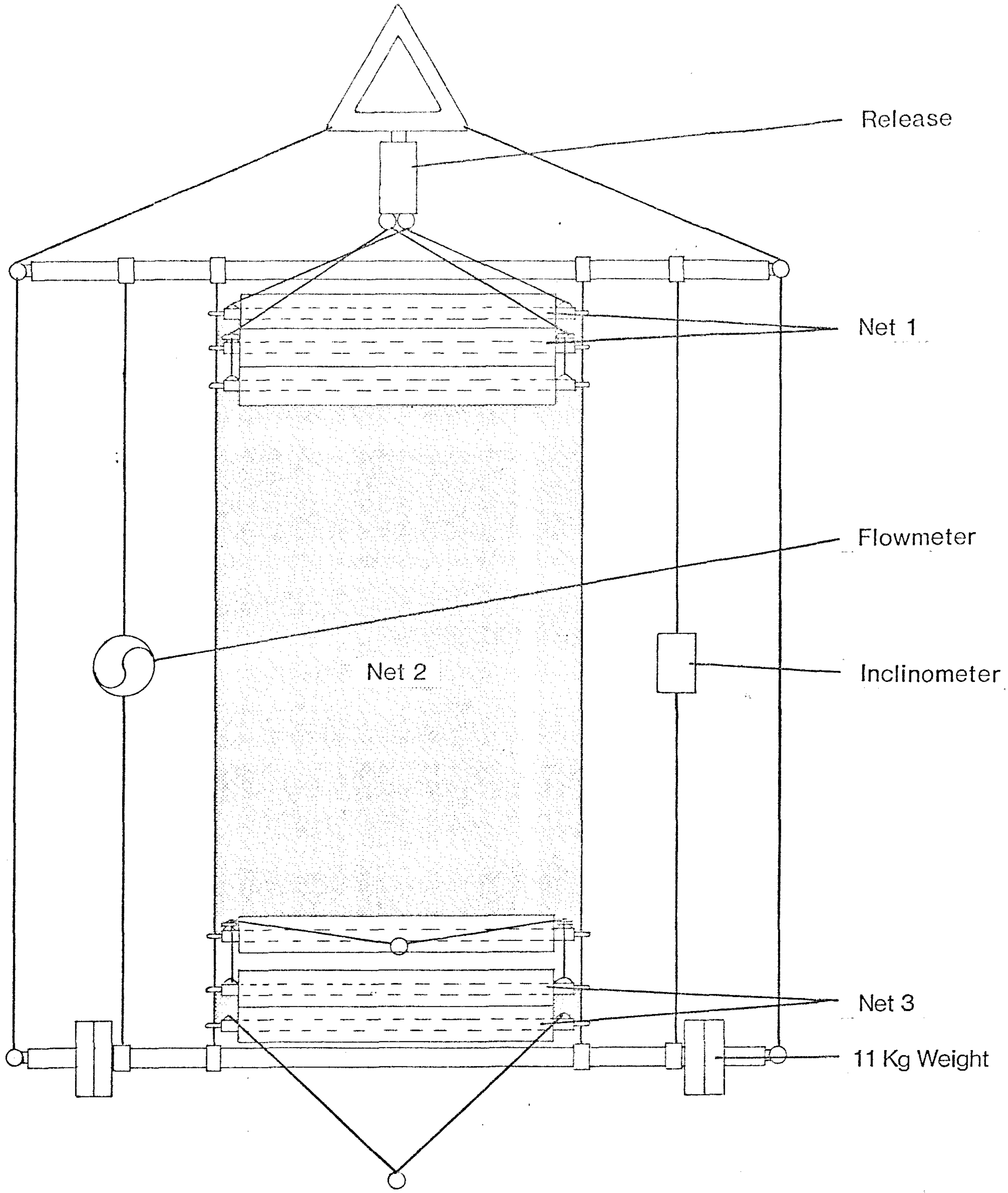
Release
Net 1
Flowmeter
Net 2
Inclinometer
Net 3
11 Kg Weight

Figure I

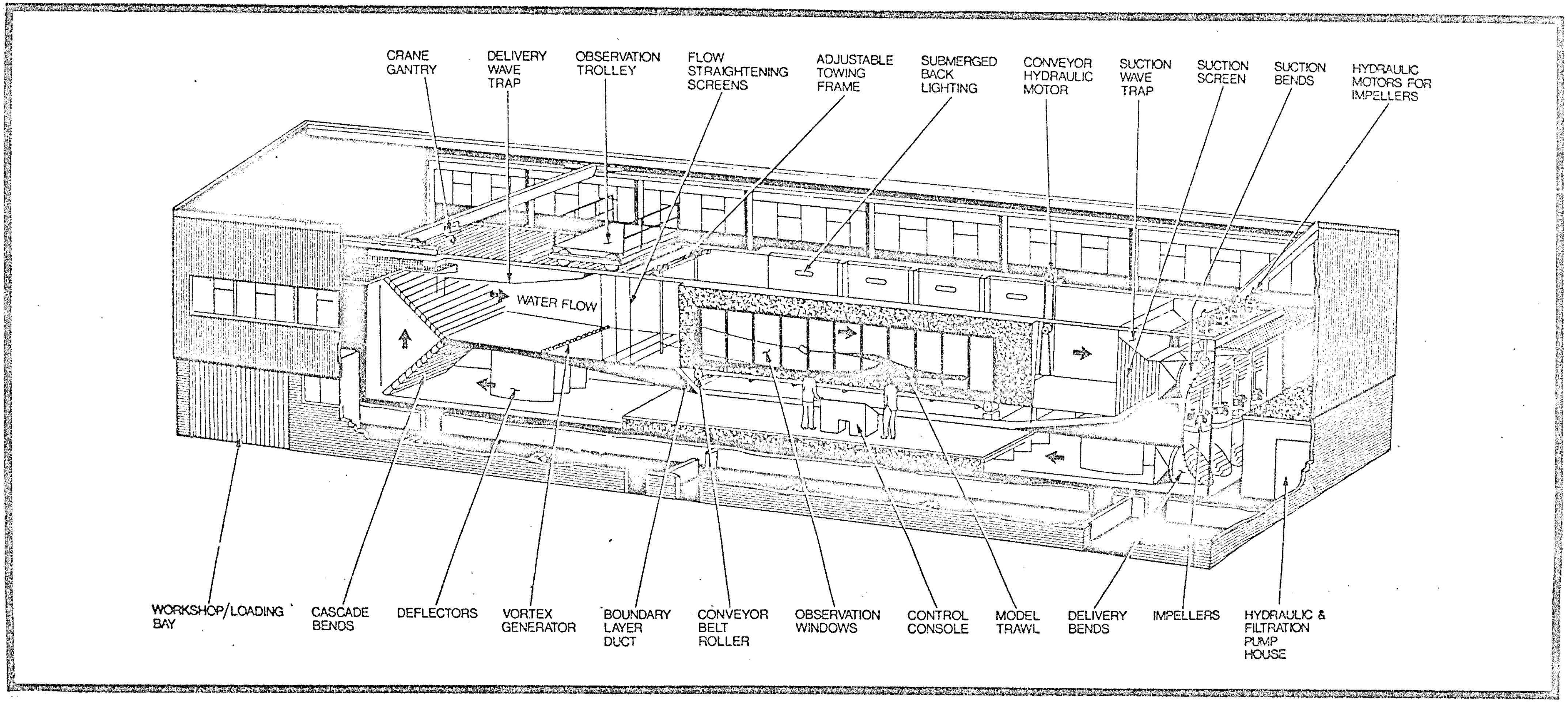

FIG. 2 DIAGRAM OF SEA FISH INDUSTRY ASSOCIATION FLUME.

WORKING SECTION: 5m WIDE
2.5m DEEP
11m LONG

MAX. SPEED: 1 m/s

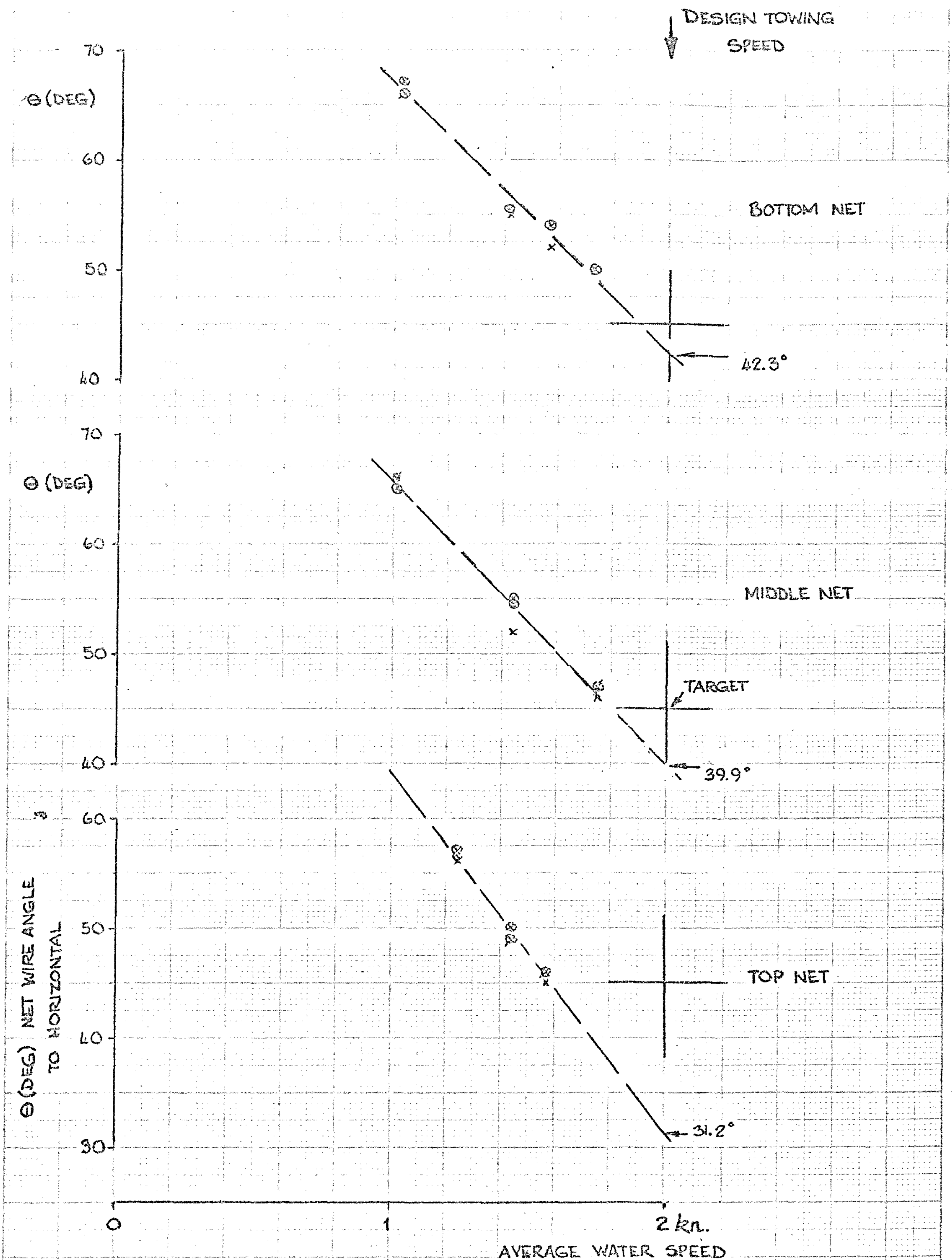

FIG 3 FIRST CONFIGURATION : W= 79 KG
NET SIDE-WIRE ANGLE VS. SPEED

x VISUAL OBSERVATIONS
⊗ MEASUREMENTS FROM PHOTOGRAPHS.

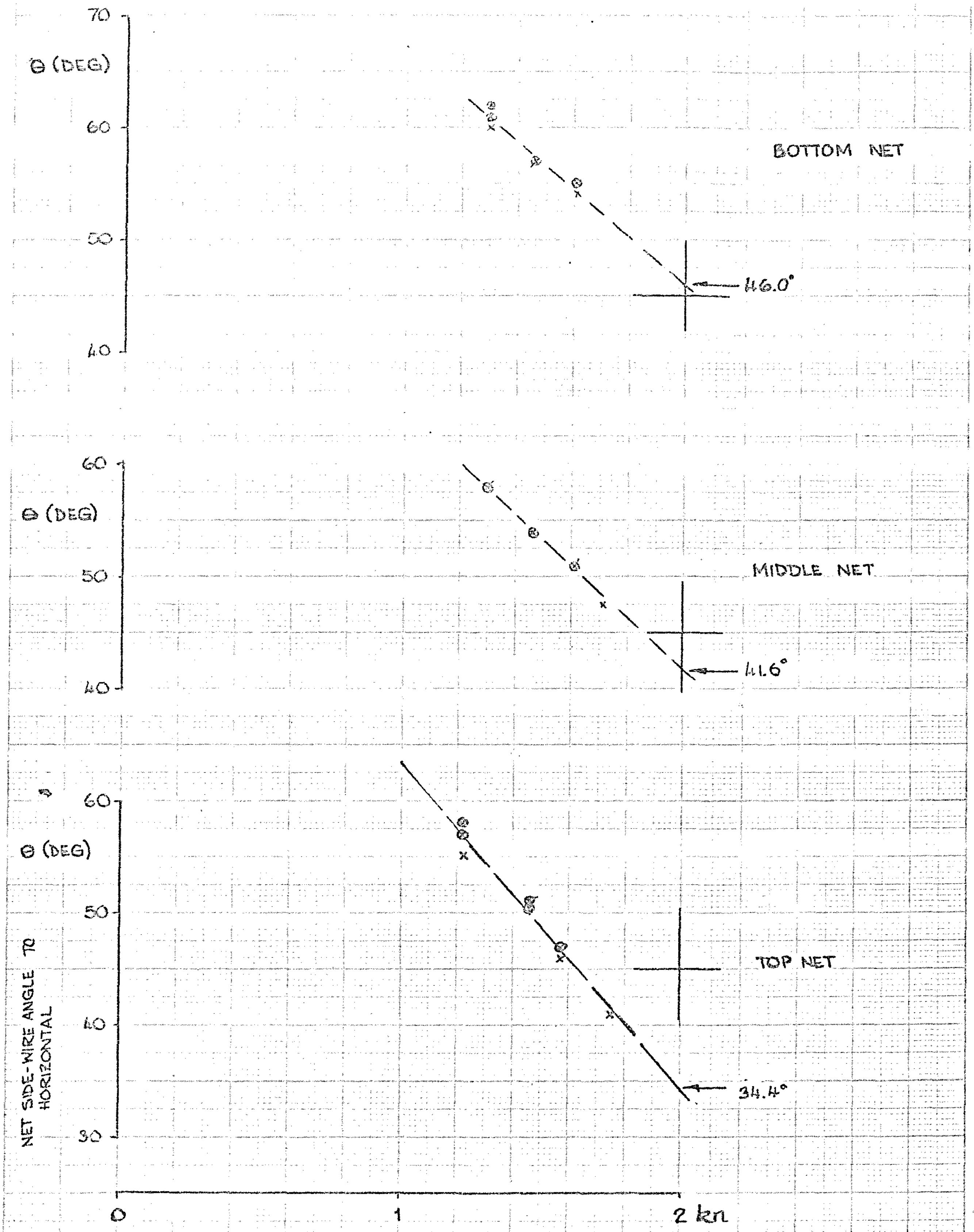

FIG 4. SECOND CONFIGURATION : W = 90KG.
NET SIDE-WIRE ANGLE vs. SPEED

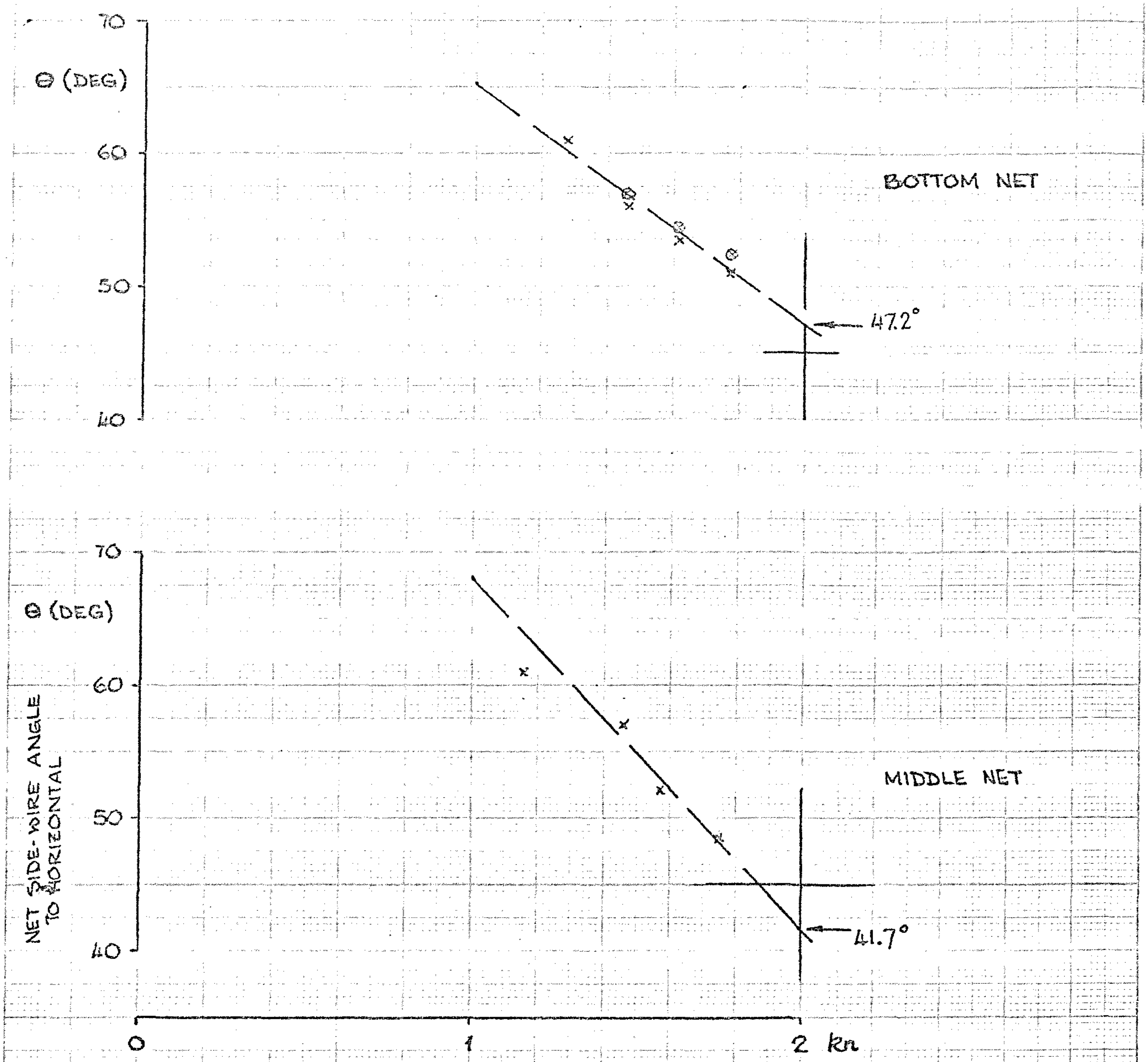

FIG 5 THIRD CONFIGURATION : W= 90KG + HEAVY NET BARS
NET SIDE-WIRE ANGLE VS. SPEED

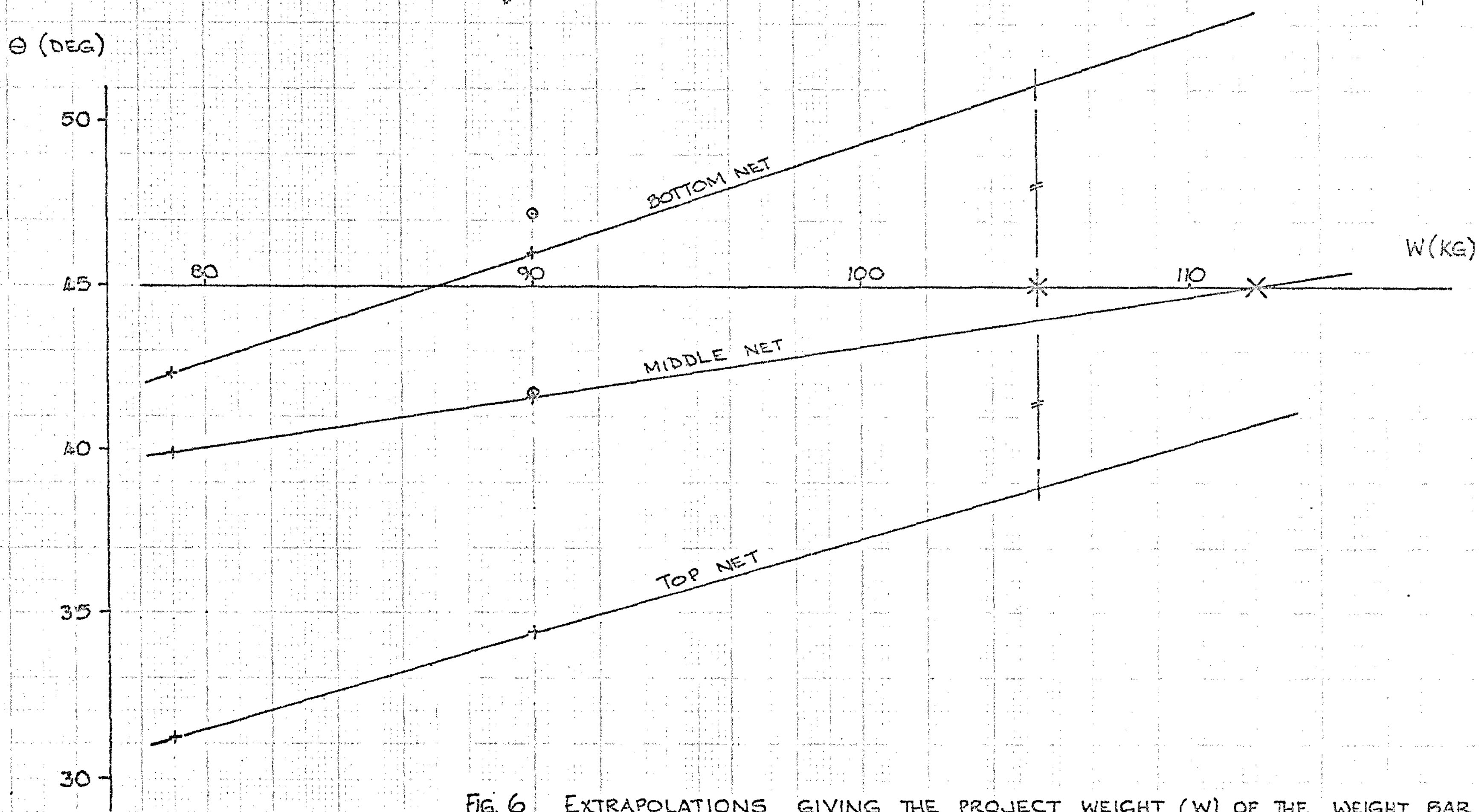

FIG. 6 EXTRAPOLATIONS GIVING THE PROJECT WEIGHT (W) OF THE WEIGHT BAR TO ACHEIVE A 45° SETTING ANGLE ON THE MIDDLE NET AT 2 kn.

⊙ EFFECT OF THE HEAVY NET BARS IN THE 3RD. CONFIGURATION.