Otter Boards and Other Sheer Devices

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Otter boards are gear accessories used for keeping mouth of the trawl net open horizontally and its invention has revolutionized the stern trawling from single boat (Fig. 1). Before the introduction of otter boards the trawl net was kept open by means of a beam. But as the size of the boats and trawls increased it was not possible to use correspondingly longer beams as it created problems of handling on board fishing vessels.

In the beginning the boards were attached directly to the legs (Hoover Rigging) of the trawl. Since the introduction of Vingneron Dahl system long bridles were introduced in between the net and otter boards. In the latter case the sweep lines are connected to the board by a back strop and the net by a bridle or “Dan leno”

The conventional type of otter board consists of a flat or curved surface for developing necessary shear force by diverting the flow of water, a bracket or chain for attaching the trawl warp, rings or back strops rings for attaching the legs or bridles and a heavy shoe to prevent the otter board raising off the ground and to provide stability.

Otter board dynamics

The basic parameters which have a bearing on the performance of the otter boards are.

Angle of attack:
The angle at which the otter board is presented to flow of water.

Heel: The inclination of the plane of the otter board from the vertical. It is termed either “inward” or outward according to whether the inclination is towards or away from the trawl warp (Fig. 1; Table 1).

Tilt: The angle, the bottom of the otter board makes with the horizontal. This is termed as “positive” or “negative” according as the board moves with nose up or nose down (Fig. 1; Table 1).

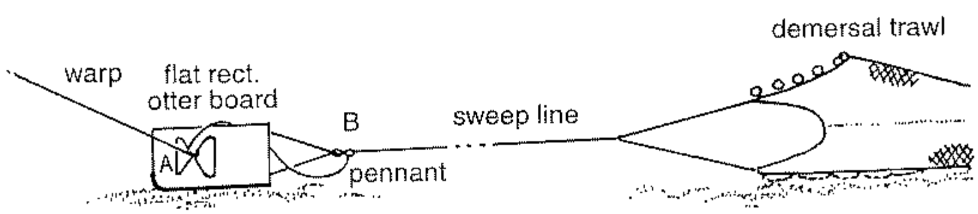

Fig. 1. Rigging of otter boards in trawl system

Aspect ratio: It is the ratio which defines the relationship between the height and length of the otter board.

A = h/I for rectangular boards

A = h/s for elliptical or oval otter boards

Where h = height

I = length

S = area.

Divergence of the warp: The angle between the warps.

Declination of warp: The angle between the warp and horizontal

Both divergence and declination vary throughout the length of the warp as it is affected by the flow of water against the warps.

Table 1: Problems in otter board performance and recommended solutions

	Problem	**Recommended adjustment**
1	Heeling outward	Raise the towing brackets a little if possible
2	Heeling inward	Lower the towing bracket or add weight to the keel
3	Tilting upward	Lengthen the upper backstrop or shorten the lower the lower backstrop
4	Tilting downward	Lengthen the lower backstrop or shorten the upper backstrop

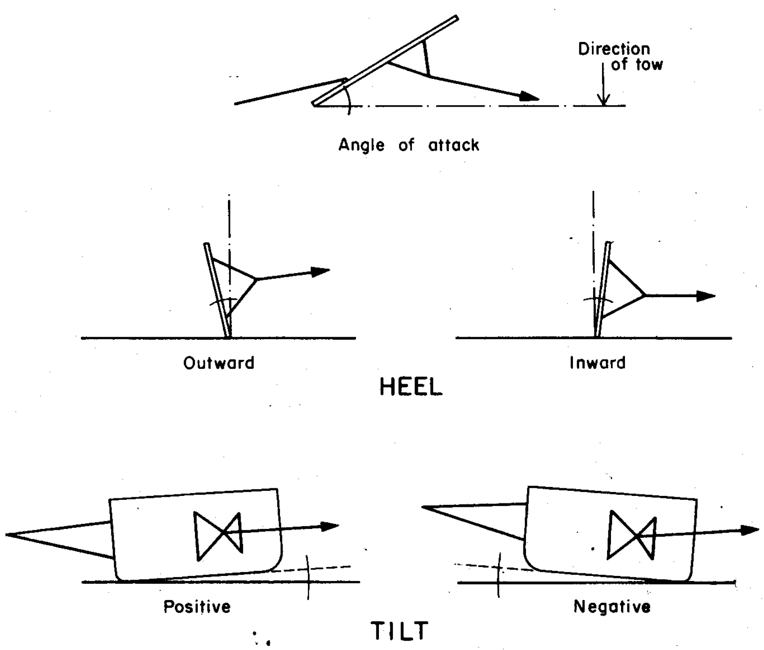

Fig. 2 Definition of otter boar attitude

Neglecting the minor ones, the following four external forces act on the otter board under the influence of which the board is in a state of dynamic equilibrium. They are:-the Towing force or pull on the warp, Drag of the net (resistance), the Hydrodynamic force acting on the board and the weight of the board. Ground reaction form the other internal force which is induced due weight of the board, and its motion against the ground

Towing force:

The towing force or pull of the trawler is transmitted to the otter boards through the warps. There is a vertical component of this force due to the declination of the warp. In addition to these, the tension in the warp has a component of lift and in pull forces. The magnitude and direction of these forces must be taken into consideration when selecting the weight and size of the boards.

Drag of the net:

The drag of the net is the resistance offered by the netting and accessories such as kite, head rope , foot rope, floats, sinkers, bridles etc. to their motion through water. The magnitude of these forces depend on the amount of webbing in the net, sizes of twine sizes of meshes, size and number of floats and so on.

Hydrodynamic forces:

In the towing condition, the water forces act on the otter boards causing them to move apart from each other. The magnitude of these forces is a function of the density of sea water which can be taken as constant for all practical purposes independent of depth, temperature or salinity. There are complexities of forces acting on the otter board due to flow patterns around the board, but these forces will be neglected for purposes of this analysis. The resultant force of all the combined water forces can be taken to action of the board at right angles to its face through its center of pressure.

The angle of attack, angles of heel and tilt also influence the hydrodynamic forces on the otter board (Fig. 3).

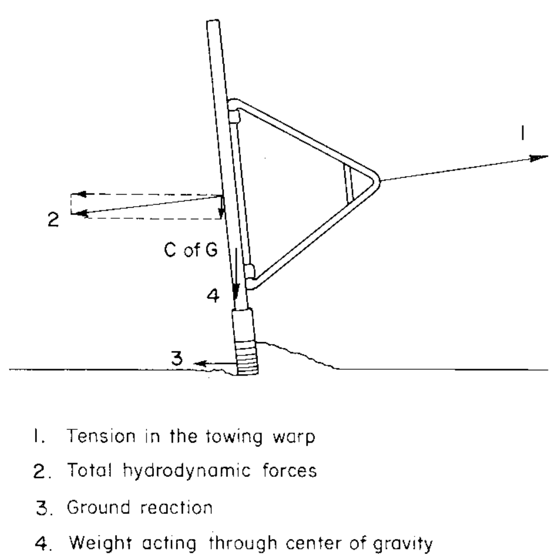

Fig. 3 Forces acting on the otter board

Gravity: The resultant forces of gravity due to the weight of the otter board acts downwards through its center of gravity.

Bottom friction: The force of friction is a reaction caused by the movement of the otter board over the sea bottom. Its magnitude is dependent on the nature of the bottom and width and shape of the shoe weight of the board. This force is however not dependent upon the velocity of motion of the board. Apart from mechanical friction on hard rough grounds, ploughing in softer ground such as sand or mud will also add to the towing resistance, as well as to the spreading force. It is however advisable to reduce contact with the bottom.

Net and forces: The otter board is in dynamic equilibrium under the following horizontal forces. (i.) The pull on the warp (ii.) The hydrodynamic forces applied to the board (iii.) The total frictional forces and (iv.) The drag of the net. Assuming that the equilibrium of the board is upset by an increase in the towing speed, the hydrodynamic force will increase as it increases with speed. That means, the total hydrodynamic force applied to the trawl boards will increase at a greater rate than the drag of the net or total frictional force. The extra force at the front half therefore will upset the equilibrium and will cause the board to turn outwards increasing the angle of attack until a new equilibrium is attained at a wider angle of attack. The board should be so designed, as to give maximum horizontal spread, with least drag and the stable enough during operation while trawling in different types of grounds and sea conditions.

Area and main dimensions: Area of the otter board is determined by using the equation:

$$S = 0.105\,P + 4$$

where S = is the area of the otter board in sq.ft.
and P = installed power of the engine

or by using the equation $S = 0.095\,P$
where S = is the area of otter board in sq.m.

After determining the area the length and height of the otter board are determined by using the simple equation h/1 = A. h & I are length and height respectively of the otter board. A is the aspect ratio. For small trawlers A is taken as ½ which gives I = 2h from this I & h are determined.

Weight of otter board: The weight of the otter board and its distribution along its length and breadth has an important bearing on the stability of the otter board, and the frictional resistance. The weight of the board must be determined according to the dimensions of the net but if optimization has been achieved in the design of the net the weight of the board can be taken to be proportionate to the engine power. For engines below 100 hp which are normally engaged in coastal fishing, the relationship between weight of the board and power of engine is given by

$$W=2.7P$$

where W = weight of the board in lbs and P is the HP of the engine.

As the vertical component of the warp pull exerts a great influence on the behavior of the otter board, Vis-à-vis its weight, it is necessary to increase the weight, if lesser scope ratio is adopted.

Material: Otter board are made of wood, steel or a combination of both. In the case of coastal fishing boats wood is used, for the construction of otter boards, with iron brackets, shoes and rings.

Location and dimensions of attachments: The position of the attachment of the warp and bridles is critical as this determines the angle of attack, tilt and heel angles. The more forward the warp attachment point is located, the more acute will be the angle of attack and visa-versa. If the point of attachment is opposite to the horizontal line dividing the otter board into two halves the board should move with zero tilt, neglecting bottom friction. If this position is moved downwards the board will have an outward tilt, while moving this point upwards will cause an inward tilt. As outward tilt creates a slight additional downward thrust on the otter board which presses it into the sea bottom whereas an inward tilt is accompanied by an upward push on the otter board which tries to lift it away from the ground. A slight outward tilt may be desirable in hard grounds and an inward tilt in soft grounds. While in the case of the rigid brackets the angle of attack cannot be adjusted. It is possible to do so in the case of chain bracket or chain and rod combination brackets. But there is a tendency to foul in the case of chain brackets and its operation is difficult due to high rate of marine corrosion prevalent in our country.

Position of back strops: Back strop rings for attaching the bridles, are fitted at the after end of the board on the outside. The more forward their location, the wider is the angle of attack and visa-versa. On the other hand the more after this position, the stronger is the influence of the changes in the trawl drag on the angle of attack.

Best angle of attack: The shearing power of otter boards in bottom trawling increases with angle of attack up to a point around 25-27° As the angle of attack is increased above this value the shear decreases. But the same board while working as midwater trawl board, will produce a maximum shear at about 37°. The drag increases with angle of attack.

Horizontal spread: The horizontal spread is the distance between a pair of otter board. This increases with increase in speed up to a certain point and then decreases with increased speed. Horizontal spread can be determined by measuring the divergence angle, from which horizontal spread can be calculated approximately. Electronic transducers have also been used to measure the distance between otter boards which is an indication of the horizontal spread.

Efficiency of otter boards

The efficiency of an otter board may be expressed by means of two hydrodynamic forces-namely, outward spreading force (L) which is at right angle to the direction of motion, and the drag force (D), or resistance to motion, which acts backward in opposite direction to motion against the pull of the boat.

It is a fact that forces generated by water flow round a body are proportional to the density of water (ρ), the surface area (S) and the square of speed (V). This may be expressed mathematically for otter board forces by the two equations:

$L = ½\rho\, V^2 S\, C_L$ and

$D = ½\ \rho\, V^2 S\, C_D$

Where C_L and C_D are called the sheer and drag coefficients, which have no dimensions. The forces also vary with angle of attack or attitude and shape.

To calculate the sheer and drag coefficient the following equations can be used

$C_L = L/(½\, \rho\, V^2 S)$

$C_D = D/(½\, \rho\, V^2 S)$

Once the coefficients are calculated it can be plotted against the angles of attack for each board. These curves can be used to compare different designs of otter board.

It is clear from the first equation the larger the sheer coefficient, the larger the spreading force and more efficient the board will be. Similarly the lower the drag coefficient, the smaller the drag (FAO, 1974).

Variation in otter board designs

Rectangular flat otter board

This is the widely used otter board for bottom trawling (Fig. 4). In India the common timbers used for fabrication are any hard wood, which can withstand in sea water. The board is assembled by joining planks and fixing them together with long bolts or mild steel straps. A wide metallic shoe is used to prevent digging into the mud and is rounded off at the leading edge so that it can ride over obstructions. Some times a gap is left in between the planks which is said to prevent turbulence on the other side of the board.

These boards are comparatively cheaper, easy to handle and fabrication is also simple. However these boards are hydrodynamically not very efficient and also not suitable for rough grounds as they can not slide over obstacles.

Rectangular curved otter boards

These boards are hydrodynamically more efficient than flat rectangular boards due to streamlined flow of water (Fig. 5). Boards are fabricated by arranging vertical planks and joining them by iron frames. Main advantage of this board is that greater spread can be achieved at low towing power. These boards work at smaller angle of attack 16-20, which results in a lower towing resistance and may also reduce the tendency of otter board to dig into soft ground.

The main drawback of these boards is its inability to easily right themselves once they fall flat. Bur due to unknown reasons still they have not found wider applications among the trawlers.

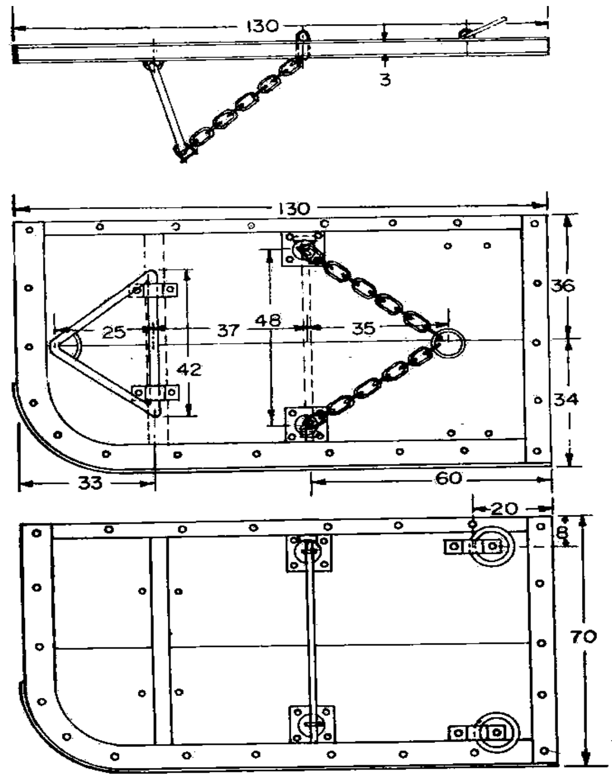

Fig. 4 Flat rectangular otter board

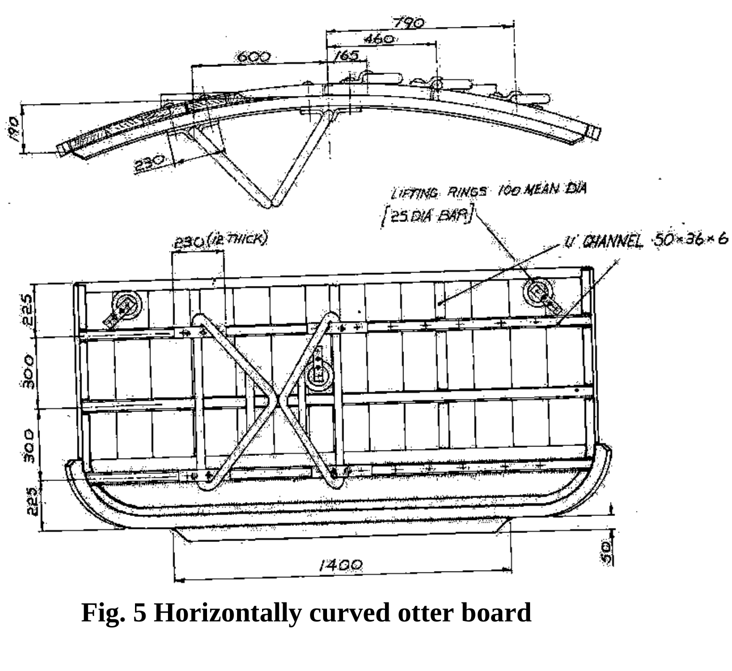

Fig. 5 Horizontally curved otter board

Rectangular vertically curved otter boards (Suberkrub otter board)

These boards are used for one boat midwater trawling and are highly hydrodynamically efficient (Fig. 6). They have the efficiency for opening the net at low drag. The shearing force of otter board for midwater trawls should not be directed slightly downward by horizontally or even slightly upward unlike demersal boards. They have high aspect ratio of approximately 2:1. These boards are normally made of steel.

Oval flat slotted

Also known as Russian type because these boards are very popular in Russia (Fig. 7). These boards are having two sections, the forward and aft sections, with a vertical slot at the joining of the sections. These boards are designed for rough grounds. hydrodynamically it slightly better than rectangular flat boards. The rounded lower edge though adversely affects the spreading performance, improves overall performance on uneven or hard ground because it reduces ground friction and mechanical stress. The vertical slot opening is intended to increase the hydrodynamic efficiency of the board by reducing the turbulence. The main limitation is its lower spreading force on clean ground as compared to cambered board of same area. This board is not suitable for midwater trawling. Hard wood used for the construction.

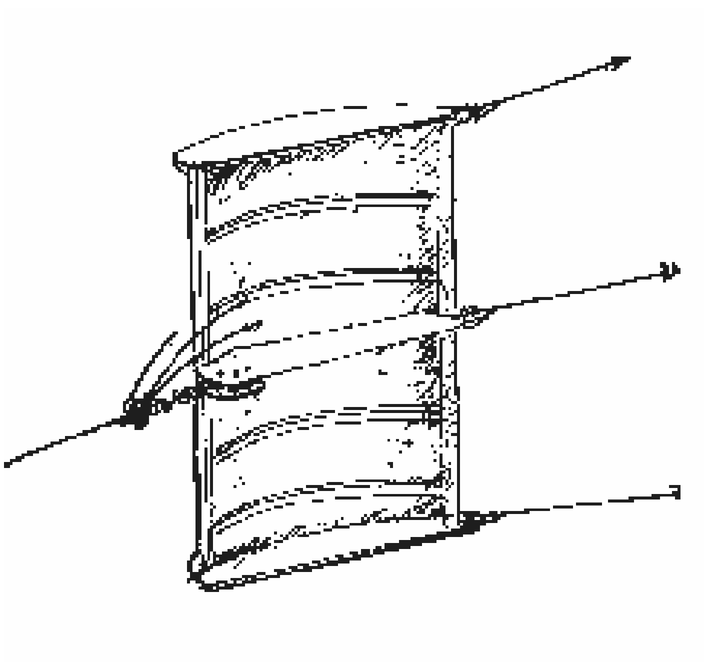

Fig. 6 Suberkrub otter board

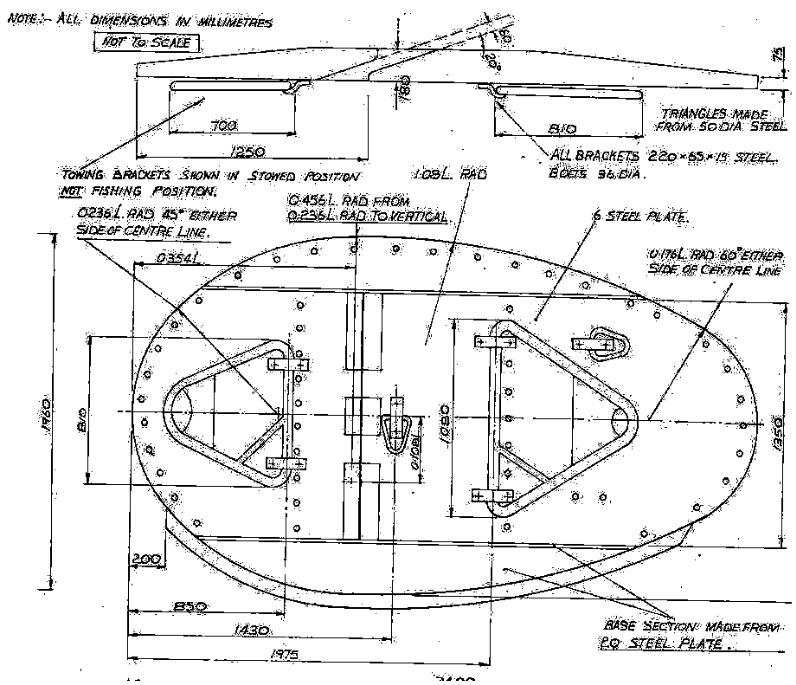

Fig. 7 Oval flat slotted otter board

Oval curved slotted (Polyvalent)

This is a combination of the oval board and curved board, giving the increased spreading efficiency and ability to traverse the hard ground (Fig. 7). They were first introduced in France with full steel body. A slot is cut in the main plate for generating a suitable angle for water flow through the slot. The polyvalent boards are relatively expensive but handling onboard is easy. These boards can be used for bottom and midwater trawling. They are less efficient than Suberkrub boards for midwater trawling. Due to lack of proper ground contact they are also found to be unstable in bottom trawling.

V-form otter board

These boards are simple in construction and relatively inexpensive. They are durable, stable and can fish on uneven ground satisfactorily (Fig. 8). These boards are built completely in steel. The main board is made of 3 pieces of steel sheet and the bottom is lined with a solid shaft. The interchangeability of the towing bracket is an important factor of this board, because spare board can be either way around to make either a port or starboard otter board. The V-form boards are heavier in weight but this is necessary to counter act the upward shear component which comes to play due to the shape of the board. The main disadvantage of the board is its low spreading force, which is less than flat rectangular board, but these can fish in very hard ground.

Diverting Depressor

First introduced in Hong Kong (Fig. 9). The spreading part of the diverter has a slight positive buoyancy due to the horizontal buoyancy chamber, while the complete diverter assembly has a negative buoyancy obtained largely by the attachment of two suspended spherical steel balls. The board is symmetrical about its horizontal axis and the buoyancy tank at the center of the board is filled with material such as polyurethane foam. The foam has the advantage giving some added strength. Though the cost of construction is high these boards can be used on all kinds of ground. like Vee boards, the diverting depressors are interchangeable and can be fished on either side. The diverting depressor is similar in hydro dynamic spreading efficiency to a flat rectangular otter board of the same size, but with the advantage that the spreading force is not affected to the same extent by the ground contact. The board has the ability to perform well over hard ground and can also retain a stable upright position when being used in midwater.

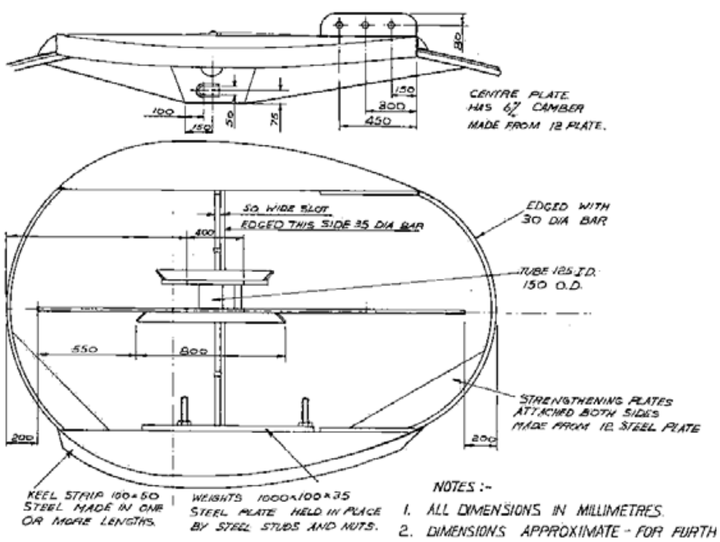

Fig. 7 Oval curved slotted (Polyvalent) otter board

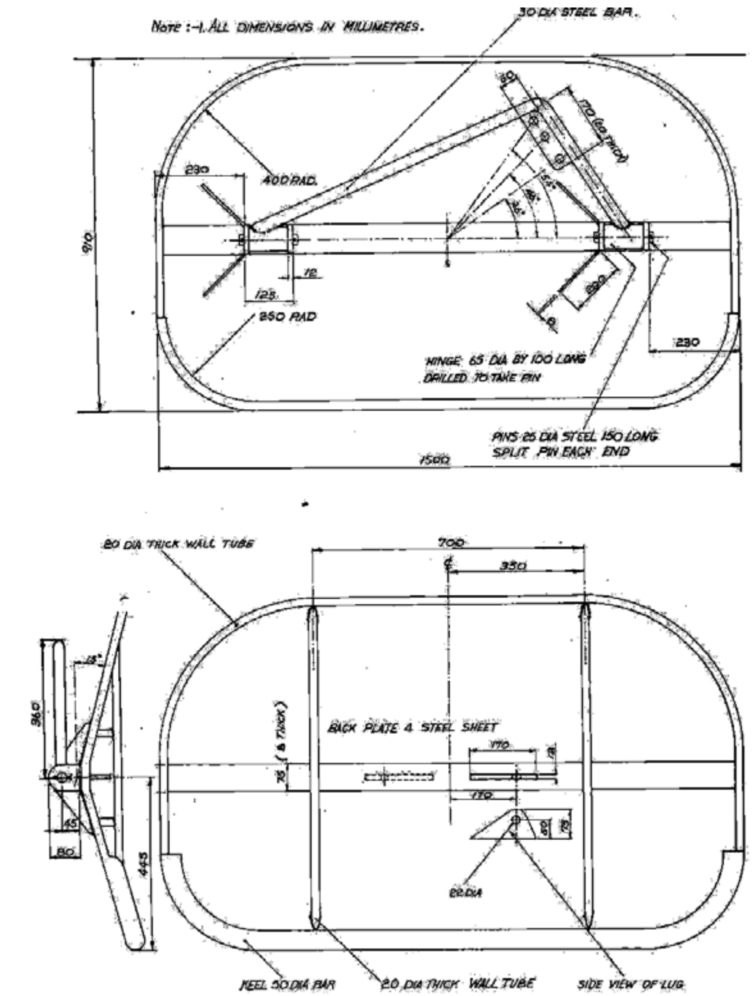

Fig. 8 V-form otter board

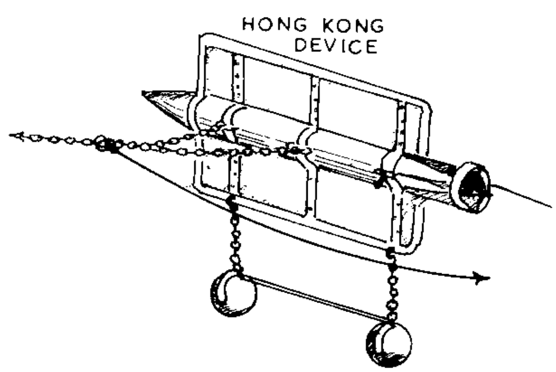

Fig. 9 Diverting Depressor

Rotor door

The rotor doors which was developed for obtaining depth control in midwater trawling. These are made of two boards or wings joined together by a coupling or rotar. Floats are attached to the top and weights are fitted to the bottom to obtain stability. The two wings provide the force required for the horizontal spread while the rotor provides the vertical control by means of an electric motor. An electric cable runs from the boat to the board. This board is complicated, expensive and handling of electric cable also creates problems

Cobb pelagic otter board

These boards made of aluminium alloy with an aerofoil section are hollow inside (Fig. 10). Holes are drilled in the back side of the board for rapid filling and spilling of water during shooting and retrieving. A metal shoe is fitted on the lower side of the board for stabilization. These bards are expensive. But they are very stable and the manipulation of angle of attack by changing bridle chain lengths was quite easy.

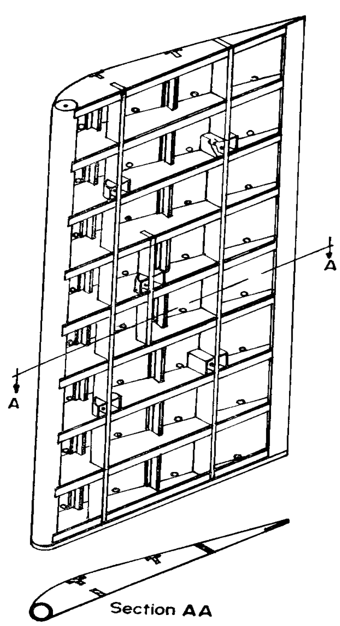

Fig. 10 Cobb pelagic otter board

Other sheer devices

Kite

Generally rectangular in shape, made off wood, attached to the head rope and it is used for having more vertical opening of the trawl net (Fig. 11). It is painted with several coats to prevent water logging. It function as otter boards but it is for the vertical opening. It can be rigged to the head rope of the trawl with or without a false headline.

Sail kite

It is a canvas type sheering device attached to the head rope of trawls to lift the net during operation. South China Sea Fisheries Institute has developed a flexible hydrofoil float for lifting the trawl head rope. CIFT also conducted experiments on using sail kite made of a rectangular thick canvas of 2.7m x 1.35 m size. The outer edge was shaped to follow the catenary of the head line and aluminium eyelets were provided for attaching the kite to the head rope. It was reported that introduction of the sail kite has improved the catching efficiency of the trawl.

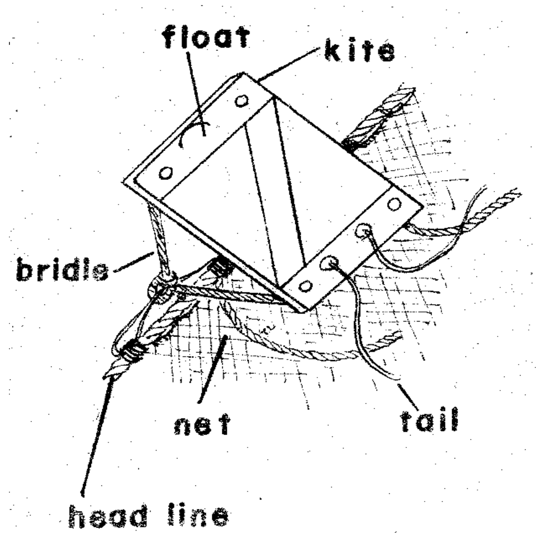

Fig. 11 Rigging of kite on head rope

Conclusion

The otter boards which account for approximately one fourth of the total trawl drag also directly influence the geometry and overall performance of the gear. So selection of right type of otter with correct surface area and weight is very important for achieving the optimum performance of the net and the vessel. From the experience the approximate size and weight of otter boards required to match a trawler of given hp can be calculated. The traditional designs of otter boards has evolved over a long period of trial and error; and now more hydrodynamically efficient otter boards are being produced by advanced technologies.

Although materials like aluminium, fiberglass, laminated wood, glass beads and polystyrene have been tried, at present wood and steel are the two materials used commercially for otter board making. Any advantage in a new type of otter board must outweigh all cost increase associated with the change.

References

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