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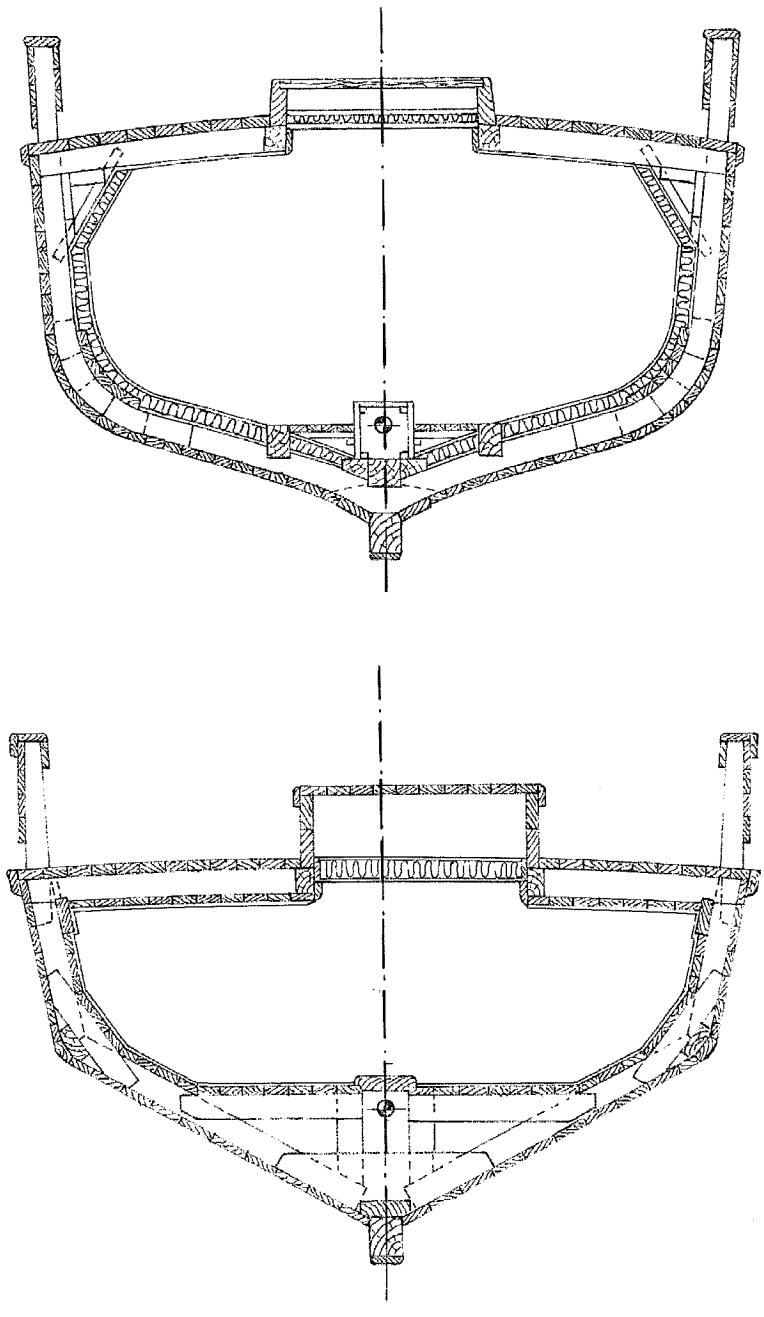

FOOD
AND
AGRICULTURE
ORGANIZATION
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UNITED NATIONS

Fishing boat construction: 1 Building a sawn-frame fishing boat

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This present document is a revision of the 1970 edition by the same author while in the capacity of Senior Fishery Industry Officer in the Fishing Technology Service, for the purpose of establishing a sub-series dealing with boat construction technology within the main series of the FAO Fisheries Technical Papers.

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ABSTRACT

This publication deals with small fishing boat construction. Sections 1 and 2 explain the architect's design drawings and how to draw these out to full size for the making of patterns for the various construction members and is the first step in the building of any boat from plans. Sections 2 to 5 summarise the construction procedures for building wooden craft with sawn frames. Round bottom and V-bottom construction using sawn frames is described.

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PLATES

FIGURES

1. HOW TO READ AND UNDERSTAND BOAT DRAWINGS

Even for someone who is accustomed to reading drawings prepared by engineers or architects, a set of boat plans may appear confusing and difficult to understand. The purpose of this paper is to explain how a designer draws the curved shape of a boat on a flat sheet of paper, what each sheet of a set of drawings shows and where to look for the details of construction and the dimensions necessary to build a boat.

1.1 Drawing conventions

To show all the necessary details and dimensions of a solid object on a flat sheet of paper all constructional drawings use three different views of the object.

In boat plans, the first of these is a view of the boat as it appears to a person standing to one side and seeing only the side of the boat which is facing him. This view, which is known as the profile view, will only show the details of the boat which are visible within the outline of the side which is facing the observer (see Fig. 1). The second or plan view is what a person in a position directly above the boat sees as he looks down at the boat below him (see Fig. 2). The third or section view is perhaps a little more difficult to understand. Imagine that the boat is sawn in two across the hull at a certain point and the two halves separated. Now if a person stands directly in front of the saw cut looking at one of the two halves, he will see everything that has been exposed by the cutting open of the boat in this manner. The designer, in his section view, draws everything that such a person would see and the outside lines of this drawing are the lines that the saw would make on the outside of the boat as it cuts its way through (see Fig. 3).

Certain lines which the designer uses have a special meaning and help to make the drawing clear to the reader. The centreline of a drawing is always shown like this ___ . _____ . ___ so that if you see this line you know that you are looking at the centre of the drawing.

Looking at Fig. 3 again you will see that the imaginary saw as it cuts through the boat would cut some of the wooden pieces in two and the person looking at one of the two halves would see the cut end of these pieces. To make the drawing easily understandable the designer shades these cut ends in a special way. Pieces which have been cut across the length are shown as in Fig. 4, while pieces cut along the length are shown in Fig. 5.

If you look at a number of boat drawings you will see that the boat designer always draws the bow of the boat to the right and in order to tell you the size of the boat the scale will be shown on each sheet. For example, if the designer has drawn his plan to a scale of one to ten you see on the drawing (usually in the right hand lower corner) the figures 1:10. This means that every inch measured on the drawing is equal to ten inches on the full size boat.

1.2 Boat plans and what they show

A complete set of plans for the construction of a fishing boat will include the following drawings:

(a) Profile, deck arrangement, under deck arrangement;
(b) Lines drawing and offset table;
(c) Construction; profile and plan
(d) Construction sections;
(e) Joinery and other details.

1.2.1 Profile, deck arrangement, under deck arrangement (See Plate I)

This drawing is readily understandable to most people. The profile shows the outside of the hull as it looks afloat when seen from the side, while the deck arrangement shows the position of the deckhouse, hatches and various items of deck equipment seen from above. The under deck arrangement shows the position of the various equipment inside the boat. Imagine that the whole deck has been lifted off the boat, then what is shown on this drawing is what would be seen by someone looking down at the resulting open hull from above.

1.2.2 Lines drawing and offset table (See Plate II)

This is the most important drawing of all as it is this drawing which shows the exact space of the hull which the designer wishes to have built.

Look first at the middle drawing of the three shown in Plate II. This is a profile view of the hull and the heavy outside line shows the outside form of the deck, stem, keel and stern. For the moment let us ignore the other lines shown on this drawing and just remember the shape of the boat shown by the heavy outer line.

The lower drawing is the plan view and the heavy outside line on this drawing shows the outer shape of the deck when looked down on from above. In this case only one half of the boat is shown because the other half will be exactly the same. Again let us forget the other lines for the moment.

Finally there is the upper drawing in Plate II which shows the section view. What the designer wishes to show in a section view has already been explained in connection with Fig. 3. This view however, shows not one but a number of sections and to save space and make the drawing more compact these sections have been drawn one inside the other. The first thing to notice is that the designer has drawn only half of each section, as again the other half will be exactly the same. If you find the centreline in this drawing (shown like this ____ . _____ . ___) and then look at the sections drawn to the right of the centreline you will see that they are not the same as those to the left.

The designer chooses a number of fixed positions along the length of the hull at which to draw his sections and these are numbered from 0 to 10. The sections from the middle of the boat (section 5 in Plate II) to the bow are drawn to the right of the centreline from the widest No. 5 (at the centre) to the narrowest No. 10 (near the bow). The sections from No. 4 (near centre) to No. 0 (near the stern) are drawn to the left.

The profile of the outside of the boat, the plan view of the deck and the section views already mentioned are enough to give a general idea of the shape of the boat but these lines are not sufficient to allow the boatbuilder to accurately draw the shape of the boat full size, so that he can make the patterns from which to cut out his wood.

The first requirement is a system of reference lines from which to make measurements. Looking again at the profile view in Plate II you will see a straight line drawn across the paper just under the lowest point of the keel. This is called the baseline and all vertical measurements are made from this line. The position of the baseline is arbitrary.

Along this baseline at equal spacing, are lines perpendicular to the baseline numbered from 0 to 10. These give the positions of the sections which are shown in the section view, and the number below each of these lines is the same as the number on the corresponding section in that view. Therefore by looking at the number on a section and then finding the perpendicular line with the same number in the profile view you can see the exact position along the hull at which each section is drawn. There is also a further set of straight lines in the profile view drawn parallel to the baseline and one above the other at fixed spacing. These lines are called waterlines and they are in ascending order from 1 to 6 with waterline 1 (WL 1 on Plate II) nearest to the baseline. On Fig. 6 you will see these reference lines as they are drawn by the designer before he begins to draw the profile of the boat (shown dotted in Fig. 6). This system of lines is called the grid and all measurements are referred to one or other of these lines.

You will see that the baseline and the waterlines are also drawn with the same spacing in the section view and here also all measurements are referred to these lines.

Now look at the plan view in Plate II; the reference lines here use the centreline as a base and lines showing the positions of the sections are drawn perpendicular to this centreline. Looking up from this view to that of the profile above it, you will see that these section lines have exactly the same spacing and are numbered the same as the section lines in the profile view. The remaining lines on this plan view are a number of curved lines which you will see are numbered the same as the waterlines in the profile view. To understand what these lines show, let us imagine that we make a model corresponding exactly to the shape of the full sized boat but reduced in size. If we draw on the side a straight line representing a waterline as seen by a person looking at the model from the side, what would happen if we took a saw and cut the model in two along this line?

Seen from the side the two pieces would look like the drawing in Fig. 7. If we took away the upper part and looked down on the lower part from above it would look something like Fig. 8. In the figure one half of the boat is drawn with a heavy line and the other half with a dotted line because, as already explained, the designer only draws half of the boat in plan view.

Now looking at the plan view in Plate II you will see that the curved lines shown there are in fact the waterline in the profile view drawn as if the designer had sawn through the waterlines one after the other and then drawn the curved lines which each piece would show if looked down on from

above exactly as in Figs. 7 and 8. We now have three different kinds of line shown in all three views: the outside lines of the boat seen from the side in profile and from above in plan; the sections, which appear as straight lines in the profile and plan view and as curved lines in the section view; and the waterlines, which appear as straight lines in the profile and section view and as curved lines in the plan view. This is sufficient to show the shape of the hull, but to make the drawing of the various curved lines more accurate by providing more reference points, and to aid the designer in his work, two more types of lines are included. Looking down at the plan view in Plate II you will see three straight lines drawn parallel to the centreline and marked I, II and III. If we took our model again and drew one of these straight lines along the deck parallel to the centreline and then sawed along this line to divide the model into two pieces we would have something like the drawing in Fig. 9. If we took away the outside piece shown as a dotted line in Fig. 9 and looked at the remainder from the side we would see a curved line showing the outside of the saw cut and looking like the heavy lines in Figs. 10 and 11. If you look at Plate II again you will see that the line marked I in the profile view does look like this and II and III are similar, each one being drawn at a different distance from the centreline. If the model were turned to be looked at from the stern the saw cut would be seen as a straight line in Fig. 12 and so these lines are drawn in the section view as straight lines perpendicular to the baseline. These lines are called buttocks and they appear as straight lines in the plan and section views and as curved lines in the profile view.

A further set of lines known as diagonals are drawn diagonally to the centreline in the section view (see Fig. 13 and Plate III). Measurements made from the centreline along these lines to the various sections are set out opposite the plan view and curved lines drawn through the points so marked (See Plate III).

All these lines are used to make a complete picture of the shape of the boat which the designer wishes the builder to reproduce. To assist the builder to draw the shape of the boat full size, all measurements necessary to draw the various lines are gathered together in a table called the offset table.

In Plate II the sections are drawn above the profile. In many designs the sections are drawn on top of the profile view using the middle section line No. 5 as a centreline. In Plate II we have shown the sections above the profile to make the explanations easier to read and understand. However one should become accustomed to reading a drawing in which the sections are placed on the profile view and Plate III gives an example of a set of lines drawn in this way.

1.2.3 Construction profile and plan

The next drawing which the designer prepares is the construction profile and plan. This drawing shows the many items which go to make up the construction of the hull of the boat together with indications of the position of such items as engine, winches, power take off, etc.

The upper drawing of Plate V shows a view of the boat like that which you would see if you cut the boat in two vertically down the middle, took the right hand half away and stood at the side looking at the remaining half of the boat. The construction of the keel, stem, and stern are clearly seen and indications of the positions of bolts fastening the different pieces together will usually be given. The frames can be seen running up from the keel to the underside of the deck and their spacing indicated. Across them will be drawn the various longitudinal members, keelson, bilge stringers and clamps, etc. The position of the engine and the wooden bearers to which it is fastened will be shown and the location and construction of the fish hold and its hatches indicated. The deckhouse construction can be seen and details of rudder and steering may also be added.

Below this profile view of the boat will be a plan view. This is drawn in two halves which differ from each other in the position from which they are seen. If you imagine that the construction of the boat has progressed to the stage that the keel, stem, stern, frame and planking have all been completed but the deck beams have not yet been put into place, then someone looking down at the boat from above would see a boat similar to the upper half of the plan view in Plate V. Note that the frames, floors, bilge stringers, clamp, engine bearers and bulkheads are all clearly shown.

If the work continues until all the deck beams and hatch coamings are in place but the deck planking itself is not yet laid, the lower half, B, in Plate V shows how the boat would appear to someone looking down on it as before. This drawing gives the position and spacing of deckbeams and hatches and necessary wooden foundation to which the winch, mast and other deck equipment will be bolted.

1.2.4 Construction sections

This drawing is very important to the builder as it is here that he can read many of the sizes of the various pieces of timber and other items necessary to build the boat. Plates VI and VII show the construction sections. Here the designer has drawn a number of views of the boat as if it had been sawn into sections as described in the discussion on the section view in Plate II. Normally there will be a section at the middle of the boat called the midship section on which all the principal dimensions are shown. In addition the designer will draw sections at various other locations at which he wishes to show special features not seen at the middle of the boat. For example, one section will show the engine, its wooden bearers, position of exhaust piping, and perhaps the location of fuel tanks, etc. Another may show a section through the fish hold giving details of linings, insulation, hatch, etc.

You will note that again only one side of the boat is drawn at each section and an indication will be given as to whether the view shown is that which someone would see if they were looking toward the bow or toward the stern.

In addition to the drawings mentioned already there may also be special details of the construction such as the construction of the deckhouse, various joinery detail, such as window construction, etc., engine room arrangement, piping diagrams showing the layout of plumbing, wiring diagrams for the electrical installation, etc.

2. LOFTING THE LINES TO FULL SIZE

2.1 Introduction

The first step in the building of any boat from plans is the full-size reproduction of the lines drawing described in section 1.2.2. The time spent in careful drawing of the lines full size might at first seem to be unnecessarily long but, in fact, time spent in lofting will be more than made up in time saved in trimming frames by hand and adjusting ill-fitting joints if lofting is not properly done.

2.2 Mold loft floor

The basic requirement for drawing the lines of a boat in full size is a wooden floor with a smooth surfce which is as flat as possible without bumps and ridges. The minimum space necessary is a length at least 6 ft longer than the boat itself with a width equal to the distance from the baseline to the highest point of the sheer plus 6 ft. If a sufficient length of floor is not available to draw the complete lines then the drawing can be made in two parts. In this case the length necessary will be half the length of the boat plus the spacing of two sections on the lines drawing plus a further 4 ft. For a 60 ft boat with a section spacing of 5 ft the required length will be 30 ft + 10 ft + 4 ft = 44 ft. The extra lengths at each end of the drawing area are necessary to allow the battens used for drawing curves to continue on beyond the end of the drawing so that the resulting curves will be fair.

2.3 Battens

Battens to draw the curves should be made from wood with a long straight grain which will bend easily without splitting. The sizes of batten required are as follows:

For the sheer line and other easy curves:

1 Batten of 1½ inch x 1½ inch or 2 in x 3/8 inch

For waterlines in plan view:

1 Batten 1 inch x 3/8 inch
1 Batten 3/4 inch x 3/4 inch

For the sections:

1 Batten 3/8 inch x 3/8 inch

2.4 The grid

The first step is to draw the baseline, the vertical section lines and the horizontal waterlines which form the reference lines from which all the measurements are taken. This is called the grid and it is important to get the perpendicular correctly drawn and dimensions exact as this will influence the accuracy of all later measurements.

The first line to be drawn is the baseline. Two to three feet from the edge, stretch a cord about ½ inch above the floor and running the full length. The straight line so obtained is transferred to the floor by marking directly under the cord at regular intervals and joining the points with a straight edge. About four or five feet from the left hand edge of the floor draw a line perpendicular to the baseline. This will be the after perpendicular (A.P.) of the profile view. The drawing of perpendiculars of this size cannot be conveniently and accurately done with a square and it is usual to draw these with a beam compass. A straight length of wood about three quarters of the length of the longest perpendicular is prepared. Near one end a nail is driven with the point protruding about one inch. Holes are drilled to take a pencil in a tight push fit about half way along the length and near the end opposite to the nail. With a pencil in the middle hole and the nail at the point on the baseline through which the perpendicular is to be drawn, (A in Fig. 14), make two small arcs to cut the baseline at equal distances B and B(1) on either side of A. Place the pencil in the outer hole in the beam and the nail point on B and B(1) in turn. From these points draw two arcs above the baseline. Through the point of intersection C, a straight line is drawn to the baseline at A. CA is then the required perpendicular.

With the after perpendicular drawn on the floor, mark off along the baseline the distance to the first section line. (You will find this dimension marked on the lines drawing). Draw another perpendicular at this point and repeat the process for each section line using the section spacing shown in the lines drawing. Then, measure the distance from the last section to the forward perpendicular (F.P.) and draw this perpendicular in also. Next, find the spacing of the waterlines in the profile view, mark these dimensions on the A.P., F.P. and several of the section lines and draw in the waterlines by connecting the points with a straight edge. If this has been correctly done all these waterlines should then be parallel to the baseline.

To complete the grid a batten is usually nailed along the underside of the baseline so that when dimensions are being measured the end of the ruler can be butted against this batten.

Note that to save space on the floor the lines are not drawn as shown on the designer's plan. The half breadth plan is superimposed on the profile drawing so that the baseline for the profile view becomes the centreline for the half breadth plan view. The middle section line of the profile view becomes the centreline of the section view and the sections are drawn to either side of this line.

2.5 The offset table

As mentioned previously all the dimensions necessary to draw the lines plan are shown in the offset table. The table is laid out in three parts separated by heavy lines (see Plate VIII). Along the top of the table are the numbers of all the sections and the table is divided into columns each of which contains the measurements referring to that particular section.

At the side of the table above the heavy line dividing the first two parts are the words "Height from baseline". This means that all measurements in this part are to be made vertically from the baseline. The table is divided by horizontal lines and against each line is the name of the part of the boat to which the measurements refer.

For example if you wish to draw the line representing the sheer you will find the word sheer against one of the horizontal lines in the part of the table labelled "Height from baseline". Look along the line beside this heading. In each vertical column there will be a dimension which is to be measured along the section line, the number of which is given at the top of the column. The second part of the table is labelled "Half Breadths". Here it is the breadth of the boat which is being measured and as only half the boat is drawn the measurements given are half breadths. Looking at the table you will see that the waterlines, sheer, top of bulwarks, etc., each have a line of figures beside them while the columns for the different sections allow you to choose the section for which you wish to make a measurement.

The third part of the table is marked "Diagonals" and the dimensions given here refer to measurements along the diagonal lines drawn in the section view (see Fig. 13).

With the offset table and lines drawing at hand you are now ready to begin the full size drawing. One word of warning! Dimensions should never be scaled from the blueprint of the lines plan because the blueprint paper often shrinks after printing and measurements made on the print will be incorrect. Always take the dimensions from the offset table or from the measurements marked on the drawing by the designer.

2.6 The profile

The first lines to be drawn are those of the profile of sheer, keel, stem and stern. The dimensions for these are to be measured vertically from the baseline so the upper part of the offset table is used.

First the sheer: dimensions from the offset table are marked on each section line and a nail driven at each point. The sheer batten is then bent until one edge of the batten touches each nail and nails are driven on the other side of the batten to hold it in place. The ends of the batten should run on beyond the last points marked to give a fair curve and you should look along the batten from each end to see if the curve of the batten is smooth without bumps and hollows. If an irregularity is seen at a point the nail should be withdrawn and the batten allowed to spring to a smooth curve. The

same procedure is followed for all of the points and when a smooth curve running as close as possible to the original points has been found the line is drawn on the floor. This same procedure is followed for all the curves which are to be drawn during the lofting.

Next draw the line representing the bottom of the keel, taking the measurements from the offset table. Now for the stem and stern profile. On the lines plan you will see measurements marked from the F.P. along the waterlines to the forward face of the stem. Lay these out on the waterlines on the floor and draw in the stem fairing the curve into the line of the keel with a light batten. The same procedure is followed for the stem and when this is completed the rabbet lines at keel, stem and stern are drawn. The profile is then completed.

2.7 The deckline in plan

This is the next line to be drawn and to save space it is drawn over the profile. In this case the line which served as a baseline for the profile view becomes the centreline for the plan view and the half breadths are measured along the section lines from this centreline. To avoid confusion and make the reading of the various lines easier it is a good idea to draw the separate views in different colours.

In the middle part of the offset table you will find the half breadths of the deckline at each section. These are measured along the section lines and drawn in with a batten in the usual way. The ending of the deckline at the stem and stern however, have first to be found to enable the curve to be completed.

Look at the sheer which you have already drawn in profile. The point at which this line meets the rabbet line of the stem will be the same point at which the deckline touches the stem in plan. Therefore, you measure the distance from the forward perpendicular (F.P.) to the intersection of sheer and rabbet in profile and carry the same measurement along the centreline to find the ending of the deckline in plan. However, in plan the deckline does not run to the centreline but stops at the side of the stem so that the correct point is not on the centreline but one half the breadth of the stem from it. Figure 16 makes this clear.

The same method is used at the stern, the only difference being that, on a boat with a transom stern, the half breadth of the transom at the sheer is found in the offset table and this dimension used to find the position of the point marking the deckline ending.

2.8 Sections

The sections are the next to be drawn, but before beginning this part of the drawing work, measuring sticks should be prepared. As the dimensions of a line in one view must correspond exactly with the same line seen in another view, it will be necessary to transfer measurements from one view to another frequently. Although it is possible to do this by using a ruler each time, the possibility of error is much greater. Therefore two measuring sticks of straight smooth wood are prepared. One, for measuring heights above the baseline, should be a little longer than the highest point on the profile,

while the other, for measuring half breadth should be a little longer than the greatest half breadth in the plan view. The measuring stick for heights is placed on each of the section lines in the profile view in turn, with one end against the batten marking the baseline, and the heights of the keel bottom, the rabbet and the sheer marked off. The same thing is then done with the second batten for the half breadths in the plan view.

The line of the middle section in the profile view (Section No. 5) is used as the centreline for drawing the sections exactly as they are drawn in Plates III and IV. First the half breadth of the keel and stem is measured off and drawn on the right hand side of this centreline. Similarly the half breadth of the keel and stern post are drawn on the left. To draw in a section we must first mark the position of the intersection of the section and the deckline and also the point at which the section line touches the half breadth of the keel (that is to say the rabbet). To do this the measuring sticks are used. First the stick for heights is placed along the half breadth of the keel line and the heights of the keel bottom and rabbet for the section which is to be drawn are marked off. Next the height of the sheer is marked on the floor at about the half breadth of this particular section. The measuring stick for half breadths is then placed parallel to this height with one end against the centreline and the half breadth of the sheer for this section marked on the floor.

Now look in the offset table at the part marked half breadths. Let us say we are drawing Section 5. In the column marked 5 you will see a dimension against the horizontal line for each of the six waterlines. These dimensions are to be measured in the section view from the centreline along each of the numbered waterlines which were drawn in the grid.

Mark out each of these points for Section 5 and you will see the shape which the curved section is to have, marked out by the line of points. However, if you bend a batten around these points you will see that in some places the points are far apart and, as in the lower waterlines the angle between the waterline and the section is acute, it is difficult to fix the position of the point accurately (see Fig. 15). For this reason the designer has provided dimensions for buttocks and diagonals to give more points to help in the drawing of the sections.

To make use of these dimensions we must first draw the reference lines. In the section on the reading of drawings it was explained that the buttock lines seen in section are straight lines perpendicular to the base line. If you look at the lines drawing Plate II you will see the position of these buttock lines together with their spacing from the centreline of the section view. Draw these lines on the floor on either side of the centreline of the section view with the spacing given in Plate II. Similarly draw the diagonal lines shown in the section-view at the spacing indicated. In the part of the offset table marked "Heights from Baseline" you will see dimensions given for each buttock line. Remembering that measurements from this part of the table are to be taken vertically from the baseline, you measure from the baseline up each of the vertical lines just drawn, the dimension given for the Section 5. This will give you three additional points on the section curve. In the third part cf the offset table, marked "Diagonals", you will find dimensions for the diagonals for each section. These dimensions are to be measured along the diagonal lines from the point at which the diagonal crosses the centreline.

Nails are now driven into all these points and a batten bent around them as was done for the sheer line. Similarly any irregular bumps or hollows in the curve are removed and the section line drawn. The same process is repeated for all the sections and the transom.

2.9 Waterlines

With the sections drawn it is necessary to draw the waterlines in plan view to check that the smooth curves drawn in the section view will in fact result in smooth waterlines in the plan view. Some builders are content to draw only the section view, trusting that the waterlines and hence the hull planking which must follow the same curves can be faired up by trimming the frames after erection. This is a time-consuming process and time spent in correctly fairing the lines on the loft floor will be more than compensated for by the saving in time that can be made in reducing the process of trimming frames by hand after erection. The dimensions given by the curves of the sections must be transferred to the plan view and this is best done by use of the measuring sticks.

Let us first look at waterline 1. Place the half breadth measuring stick along WL 1 to the right of the centreline in the section view, with one end of the stick on the centreline. Mark on the stick the distances from the centreline to the points at which each section line crosses the waterline. Reverse the stick and do the same for the distances to the left of the centreline. Note that this waterline does not cut all of the section lines due to the fact that it is low on the hull where the width is much narrower than will be found higher up the hull. These dimensions are then transferred to the sections in the plan view exactly as was done for the deckline in plan. To find the endings of the waterline, look at waterline 1 in the profile view. Where it cuts the rabbet line at the bow will also be the position of the waterline ending in plan. Therefore measure the distance from the F.P. to where WL 1 crosses the rabbet in the profile view, then measure the same distance along the centreline in the plan drawing. Mark this point and then with a square draw a line perpendicular to the centreline with a length equal to the half breadth of the keel. This will be the waterline ending and at the end of this line is the point which the waterline must cross (see Fig. 16). The same process is repeated at the after end and then the batten can be bent around the line of nails to give the curve. Should the line of the batten give a smooth curve when viewed from both ends then all is well and you can continue to the next waterline. If there are bumps or hollows in the line then the nails must be lifted to smooth out the curve. You must remember however that if any changes are made in the waterline the section lines must also be changed so that the dimensions in both views are exactly the same. Therefore as the succeeding waterlines are drawn the fairing consists of altering the two sets of lines in such a way that the result gives curves which are the same as those given in the lines plan and which correspond exactly one to the other. You may ask why, if the designer has drawn his plan carefully, should there by an differences which need correcting. This is because the designer makes his measurements on a small plan on which it is difficult to reach accurately to last 1/8 of an inch so that when the lines are drawn full size small differences will cause bumps and hollows to appear which the builder must correct if he does not want to waste time later fairing the frames by hand.

Two other points should be remembered at this stage. In many designs the sternpost is made thicker than the keel in the area where the stern tube and propeller shaft are located so that when drawing a waterline which ends in this area care must be taken to take the half breadth of the rabbet at this point and not the half breadth of the keel. If the lines being drawn are of a boat with a transom you must draw the waterline endings in this area accordingly.

Look at waterline 5 in the profile view in Plate II. As you can see this waterline ends on the transom. The distance of the waterline ending from the after perpendicular is taken in the same way as the other waterlines but the half breadth of the transom at this waterline must be used instead of the half breadth of the keel or sternpost when marking the position of the waterline ending (see Fig. 16).

2.10 Buttocks

There remains one set of lines to draw. These are the curved buttock lines which can be seen in the profile drawing of Plate II. Again a measuring stick (this time the one for heights) is used to transfer the buttock dimensions from the section view to the profile. Lay the stick along one of the buttock lines to the right of the centreline in the section view with its end against the baseline. Next mark off the points at which the various sections cross the buttock line. Transfer the stick to the buttock line with the same number on the left hand side and mark for the other sections. Returning to the profile view, mark these buttock heights on each section line. Now to find the endings of the buttock line so that we can draw the complete curve. In the section on reading drawings it was explained that the buttock lines seen in plan are straight lines parallel to the centreline (see Fig. 9 and Plate II). The point at which the buttock crosses the deckline in plan gives the dimension which is used to locate the ending in the profile view (see Fig. 17). For the forward ending of the buttock, measure the distance from the F.P. to the point at which the buttock crosses the deckline in plan. Measure this same distance from the forward perpendicular to the sheerline in the profile (see Fig. 17 A). This will be the point at which the buttock touches the sheer.

Additional points on the buttock lines can be found from the intersection of buttocks and waterlines in plan view (see Fig. 17 B). Drawing vertical lines from these intersections to cross the coresponding waterline in the profile view will provide additional points on the buttock lines in profile. When nails have been placed in all these points and a batten bent around them you can see if the resulting curve is fair without bumps or hollows. If corrections must be made then the same corrections must be made to both the waterlines in plan and the sections so that all curves are smooth and without irregularities.

Provided all these curves have been properly faired it is not usually necessary to fair the diagonals in fishing boat construction and so these lines will not be drawn on the floor.

2.11 Transom projection

One more thing remains to be done in the lofting of the lines. This is the projection of the transom if this has not been done by the designer. The line marked T in Plate II is in fact the shape of a vertical section at the transom position. If the transom is vertical this line will give the correct shape of the transom. If the transom is at an angle to the vertical however this will not be the correct shape because the transom will be inclined at an angle to the vertical.

The correct shape can be drawn at the after side of the transom in the profile view if there is room. If not the expansion can be drawn at any convenient place, provided the transom angle is correctly drawn and the waterline spacing properly calculated.

If the expansion is drawn aft of the transom in profile, the centreline of the transom is drawn parallel to the transom line in profile at any convenient distance and the intersections of waterlines and sheer with the transom line in profile are drawn across to cut this centreline at right angles. The rabbet and buttock intersections are also drawn in this way and this gives a grid from which measurements are made to determine the points on the transom curve (see Fig. 18). For a flat transom the spacing of the buttock lines is made exactly as in the section view and the lines drawn parallel to the transom centreline as in Fig. 18.

Perpendiculars are drawn from the baseline to meet the transom at the intersection with the sheer and the waterlines in the profile view. These perpendiculars will cut the deckline and the waterlines in plan (see Fig. 19). The distance from the centreline to these intersections (A, B, C, D, in Fig. 19) are then transferred to the projected transom grid. These points together with the intersections of the vertical and projected buttock lines are then used to draw the shape of the transom using a batten in the same way as the vertical sections are drawn.

2.12 Conclusion

All the essentials of lofting to full size have now been covered, however there are several other points to consider when working on the loft floor.

When fairing the lines, do not forget that a point fixed by the intersection of two lines that cross at right angles, or close to right angles, is much more accurate than that determined by two lines that intersect at an acute angle (see Fig. 15). When one has the choice one should always go by points fixed by the intersection of lines crossing at close to right angles.

In the construction of a round bottomed, sawn frame fishing vessel there are usually many more sawn frames than shown in the sections in the lines plan. To obtain the shape of these frames it is necessary to trace supplementary sections. The position of these along the keel is usually given in the construction profile and to loft them perpendiculars to the base line are set out on the floor. Vertical heights of sheer, deck and rabbet are transferred to a measuring batten from the profile view. Similarly half breadths of the deck line, waterlines and rabbet are taken from the plan view.

The new sections are then drawn in the section view using the measurements taken from the battens to establish the shape of each intermediate section in the same way as was used for the principal sections. If the full sized lofting has been correctly carried out the curves of these new sections should be fair and further modification should not be necessary.

For someone who is not accustomed to reading a loft drawing the large number of lines making up the different views when superimposed one on the other can be confusing and it is suggested to use one colour for the lines of the profile view, for example, another for the plan view and a third for the section view, thus making it easier to identify the different views and avoid errors caused by choosing the wrong line. If the lofting is to be used for the construction of several boats, to avoid the risk of lines being accidentally erased they can be lightly scored into the loft planking using a scriber or a nail driven into a wooden handle. The lofting completed, the next stage is the making of patterns.

3. PATTERN MAKING AND BACKBONE CONSTRUCTION

3.1 Introduction

Some builders make patterns only for the frames, and the backbone structure is drawn directly on the various pieces of timber by scaling from the blueprints. However, if more than one boat is to be built to the same plan it is always advantageous to make patterns of the various members which make up the backbone as time is then saved in marking out and the possibilities of errors resulting in poor fitting joints is minimised.

Before proceeding to the construction of the patterns the shape and position of the various members which make up the backbone are drawn on the loft floor. The outer lines of the stern, keel, sternpost and horntimber have already been drawn in the profile view. From the construction profile dimensions are found for the inner lines of these members together with deadwoods, stem knees and these and the joints between the various members are drawn in.

3.2 Rabbet and bearding lines

During the lofting the outer rabbet line has been drawn but it is also necessary to find the inner rabbet line (called the bearding line) so that the rabbet can be cut before the backbone is set up. This line is the intersection of the inner face of the planking with the keel, stem and stern just as the rabbet line already drawn is the intersection of the outer face of the planking with the same members.

Let us look first at one of the section lines and the keel half breadth from the section view (see Fig. 20). As the section line shows the outside of the planking, if we draw the inside line of the planking thickness the point at which this touches the half breadth line of the keel will be the inner rabbet (or bearding) point for this section. By measuring the distance between inner and outer rabbet lines we can then transfer this point to the profile view at this section. The same thing is done with all the sections

along the keel and sternpost and with a batten these points can be joined to give a line on the profile view. The measurements for the inner rabbet line on the stem are found by referring to the plan view.

At each waterline ending and at the sheer the thickness of the planking is drawn (see Fig. 21). Where the inner face of the planking touches the half breadth of the stem, will be the inner rabbet point at the particular waterline being measured. Finding the distance of these points from the F.P., the distances are then measured along the respective waterlines to give the points, which are connected with a batten, and the bearding line drawn.

3.3 Backbone patterns

Wood for patterns can be any cheap, light wood which works easily, however plywood with its light weight, dimensional stability and resistance to breakage is the best material. The cheapest grade of three-ply 1/4 inch (6 mm) to 3/8 inch (9 mm) depending on the size of pattern is most satisfactory. For large templates the shapes are cut out from the lines on the loft floor, joined by gussets and braced by solid wood battens fastened by clenched nails or screws.

The lines giving the shape of the various members of the backbone can be transferred to the wood in various ways. Where the size of the pattern to be made is not large, nails laid on their sides with their heads on the line at a spacing of about 2 inches will be sufficient. The wood for the pattern is then placed over the nails and the upper side tapped with a mallet to cause the heads of the nails to leave an impression in the wood. The pattern is then lifted off and the marks connected by drawing the shape with a light batten. Another method is to drive light nails into the line on the floor and cut off the heads about 3/8th of an inch above the floor level. The wood is then laid over the nails and tapped as before. This latter method is more satisfactory where the pattern is large as there is no risk of shifting the nails when placing the wood. When the patterns have been cut and planed to the lines, they are assembled on the loft floor to check that joints match up correctly and the shape corresponds exactly to the drawing.

The rabbet and bearding line and the position of sections and waterlines should be drawn on the patterns and transferred to the wood at the time of marking out.

3.4 Backbone construction

The backbone pieces can now be cut, clamped up and holes for bolting drilled according to the indications on the construction profile. The outer ends of bolt holes should be countersunk and when the bolts are in place and tightened up wooden plugs dipped in thick paint or white lead should be driven to cover the heads of the bolts. It is good practice to paint all joint surfaces before assembly with white lead or thick paint and a strand of caulking cotton or oakum dipped in paint twisted round the head of the bolt under the washer before driving.

Stopwaters should be fitted in all joints which cross the rabbet lines. These are round dowels of a soft wood, which swells when in contact with water, about 1/2 inch in diameter and their purpose is to prevent water

leaking along the line of the joint and into the boat. Two stopwaters should be located in each joint one just inside the outer rabbet line and the other just inside the bearding line (see Fig. 21); next the rabbet should be cut. This job is much easier to do before the backbone is set up and much time will be saved if it is cut at this stage. The shape of the rabbet has already been drawn at each section and at the waterlines on the stem (see Fig. 21). You can now make a pattern of the rabbet from light plywood at each of these points (see Fig. 22) using the inner and outer rabbet lines as a guide. A slot about 2 inches wide can be cut in the backbone at each of these points so that the pattern fits into it neatly. It is however wise to leave about 1/8 inch in the back rabbet for final shaping when the frames are in place. When all the slots are cut they will serve as a guide to allow the wood in between them to be cut away leaving a neat rabbet which should be free from bumps and hollows.

3.5 Frame patterns

As we have already seen, the lines drawn in the section view are to the outside of the planking and so we must draw a second line inside the first at a distance equal to the thickness of the planking to give us the outside face of the frame. This is done as follows: a compass is set to the planking thickness and a series of arcs drawn inside the section line (see Fig. 21). A batten is then bent to just touch these arcs and the curve drawn in. This will be the shape of the outer face of the frame. This shape is then transferred to the pattern wood in the same manner as was used for the backbone and the inside edge of the frame drawn in. The pattern is then cut to size, braces added to hold the shape firm and avoid distortion and the pattern replaced on the floor to check for errors. To assist in setting up later, the position of sheer and waterlines should also be marked on the pattern.

3.5.1 Frame bevels

The bevels of each frame and the amount of bevel along its length varies depending on the shape of the hull and these bevels can be calculated on the mold loft floor and marked on the patterns for cutting during frame assembly. Figure 23 shows how these bevels are calculated. First take a piece of smooth plank or plywood two frame spaces long and about 12 inches wide. Along the centre of the board draw a baseline and erect three perpendiculars to this line at distances equal to the spacing of three frames, centre to centre. The centreline of these three is then marked with the number of the frame whose bevels are to be calculated. Now look at the section drawing of this frame on the mold loft floor. First divide up the length of the frame into the number of points at which the bevel is to be calculated. This varies depending on the size of the frame but 8-10 points should be sufficient for the size of boat we are considering. Place a ruler on one of these marks at right angles to the line and measure the distance from this frame line to that of the frames fore and aft of it. These distances are marked a and c in Fig. 24 where A is the frame line forward of B, the frame whose bevels we are measuring, and C is the frame aft of B. At this point look at the frame B to see if it is a frame forward or aft of amidships. Frames forward of the widest section are placed with their after faces on the section line as, due to the narrowing of the hull towards the bow, the bevel must be taken from the forward face. For the frames aft of the widest section the opposite is the

case and the forward face is placed on the section line. If the frame B is in the forward part of the hull the distance is then measured up from the baseline to the intersection on the perpendicular A, and is measured down from the baseline to the intersection on the perpendicular C, and the intersection with perpendicular B is on the baseline. The three points are then joined by a line drawn with a batten. This line may or may not be a straight line. Now draw a line parallel to B and forward of it at a spacing equal to the total thickness of the frame. The portion shown shaded in the figure is the amount of wood which must be cut off to form the bevel at the point for which this line has been drawn. Similar lines must be drawn for the other points chosen along the frame. It is usual to measure the distance and write this on the pattern at the point at which the measurements have been taken. Measuring these distances in from the squared face of the frame will permit the drawing of a curved line with a batten, showing the amount of bevel to be taken off all along the frame. In the case of the frames aft of the widest section the procedure is the same except that the distance to the forward frame is measured in a downward direction on the perpendicular and upward for the after frame. The line for the thickness of the frame is drawn aft of the centreline as in Fig. 25.

A board for the calculation of the bevels must be prepared for each frame and the resulting bevels marked on the patterns.

3.5.2 Transom bevels

The calculation of the bevels for the transom frame varies a little from the procedure outlined due to the rake of the transom. In this case draw the baseline across the board and erect a perpendicular near one end. Lay out the number of points at which the bevels are to be taken on the transom section and measure the distance from the transom to the adjoining section as before. Measure the height of each point from the baseline. Look now at the transom in the profile view. Measure the heights of each point from the baseline. Look now at the transom in the profile view. Measure the heights from the baseline just taken from the section view and mark each of these points on the line of the transom (see Fig. 26). At each of these points in profile measure the distance from the transom to the next section. In Fig. 26 this has been done for two points D and E, distances from the next station are d and e and the heights from the baseline BD and B'E respectively while DS and ES' are the distances from the transom to the next station in profile.

Returning to our bevel board, the distances DS and ES' are measured from the perpendicular along the baseline and the distances d and c measured vertically down from them. The two points thus found are joined to the intersection of the baseline and the perpendicular. The thickness of the transom planking and the transom frame are drawn parallel to the perpendicular and the bevels are found as before. Patterns for all the frames are prepared with the bevels marked and you are then ready to commence frame construction as outlined in Section 4.

4. DOUBLE SAWN FRAME ROUND AND V BOTTOM CONSTRUCTION

4.1 Introduction

Double sawn frames are constructed of two thicknesses of timber fastened together with tree nails, clenched nails or bolts to form the desired total frame thickness.

The older method of frame construction was to cut the frame directly from one thickness of timber and special grown crooks were used in which the line of the grain followed the curve of the crook. Such crooks are now difficult to obtain and in some cases straight grained timber has been used from which the single frames are cut. This type of construction is weak because where the frame is curved a large part of the wood will be cut with the grain running across the frame and if the completed hull takes a heavy blow in the region of cross grain the frames may crack across the grain. If the frames are made double, straight grained timber in one piece of the frame can be placed to reinforce any cross grain in its partner. A further advantage is that the cutting of shorter almost straight grained pieces from the plank will enable the pieces to be cut with less waste than in the case of single frames. Over a period the saving in timber can be quite considerable and should offset the cost of extra labour needed to assemble the frame. The individual pieces making up the frame are called futtocks.

4.2 Futtock and floor layout - Square frames

There are two methods of layout out futtocks and floors, in one of which there are two "long and short" floors and in the other a single floor with arms of equal length. In the first of these, construction consists of two floor timbers which cross the keel but in which the long and short arms are alternated as shown in Fig. 27. If for example the short arm of the first floor is to starboard that of the second floor will be to port. In this way the joints between futtocks are alternated, the joints in one series of futtocks being reinforced by the futtocks of its partners. The frame is completed with bottom futtocks, bilge futtocks and one or more upper futtocks per side, reaching to the deck line. In the second method a single floor crosses the keel and the arms of equal length are completed with a short bottom futtock, bilge futtock and one or more upper futtocks as before. Here the second layer of futtocks consists of a bottom futtock resting against the keel in a notch and which extends just to the middle of the short bottom futtock, together with a series of futtocks so placed that the joints fall in the middle of the series of futtocks on the side of the floor, Fig. 28 makes this clear.

The two series of futtocks are fastened together firmly with special attention to fastenings in the region of the butts so that the final result is a solid rigid frame with far more strength than a single sawn frame in which much cross grain appears.

Of the two methods described the "long and short" floors still require a considerable amount of curvature in any vessel with a reasonable amount of deadrise so that this method is only recommended in craft with very flat bottoms and full sections. With the deadrise usual in most modern fishing vessels the second method will give a stronger construction.

4.3 Layout for half frames

In the case of the half frames the floor does not rest directly on the keel but is placed on the deadwood or horn timber. Here the frame is constructed of two layers of futtocks with staggered butts as before but on one side the futtocks descend to the bearding line while on the other the last futtock rests against a straight floor (often called a strongback) which itself rests on the deadwood or horn timber (see Fig. 29). In this case the keels of the lower futtocks are bolted transversely through the deadwood as shown in the figure.

As the half frames approach the bow the amount of curvature is often small enough to permit the use of single frames instead of double without loss of strength. If joints are required to permit the use of straight timber the two futtocks can be lapped and solidly bolted or they can be butted and cleats used to reinforce the butts.

4.4 Frame assembly

For smaller boats a full sized pattern is made of both sides of the frame. Futtocks and floors are then assembled directly on the pattern, butts are cut in to give a good joint and the two rows of futtocks fastened together. A cross brace is added to hold the head of the frame at the correct opening and the completed frame is removed for marking and cutting of the bevels. Using this method the whole frame must be transported to the band saw for cutting of bevels and beyond a certain size this becomes impracticable. Therefore for larger vessels the pattern is made for a half frame only. Futtocks are assembled on this half frame pattern and the bevels marked and cut. Half frames are then joined by bolting on the floor and fastening a cross brace at the head of the frame.

For correct placing of the floor and to ensure that the resulting whole frame follows the shape of the lines drawn on the loft floor the assembly is carried out either directly on the loft floor or more conveniently on a framing stage erected near the building berth. This stage has a wooden flooring on which the baseline, centreline, waterlines and diagonals are drawn exactly as in the section view. To assemble a frame, measurements to the outside of the frame are taken from the loft floor and marked off on the diagonals and waterlines. Small blocks are fastened to the floor at these points and the half frames moved into position against the blocks. The dimension from the baseline to the bottom of the floor is laid off and the floor placed in position and bolted. A cross brace is fastened while the frame is still in position and then the whole assembly can be moved off the staging for setting up which is discussed in the next section.

4.5 Frames for V Bottom Construction

In V bottom construction framing is somewhat simplified as futtocks can be cut from straight grained timber and double futtocks to reinforce cross grained timber are not necessary.

The frame futtocks are joined at the chine either by halving the two futtocks and securing them by means of a gusset or alternatively by butting them and using gussets on both sides of the futtocks. These gussets are through bolted in heavy construction or screwed and glued in lighter craft.

Gussets should be carefully laid out when lofting to ensure that sufficient length is available to permit a good number of staggered fastenings so that futtocks are firmly held together at this critical point (see Fig. 30).

5. SETTING UP AND GENERAL CONSTRUCTION DETAILS

5.1 Setting up

With the backbone completed and frames under construction setting up can now begin.

The backbone should be marked with the various waterlines taken from the patterns as these will provide useful reference points from which to stretch baselines for measurements inside the hull as construction proceeds. The position of each frame should be marked and squared across the keel. As has already been mentioned frames forward of the widest section should be set up with their after faces on the section line while those aft of this point have their forward face on the line. The designer usually makes provision for this in his drawing when indicating the spacing but if not care should be taken to draw in the spacing correctly.

5.1.1 Foundations

Next a suitable foundation is required on which to set up the backbone. For a straight keel fishing boat such as is shown in the drawings, either posts may be sunk in the ground at suitable intervals or heavy timbers can be placed cross-ways at right angles to a straight line which will represent the centreline of the boat (see Fig. 31). In the first case a horizontal baseline is established by stretching a cord or wire close to the bottoms of the line of posts and then the posts are cut off at the correct height to take the slope of the keel exactly as it was drawn on the loft floor. In the second, a baseline is stretched over the timbers and packing pieces added to give the correct slope. The posts or bearers should be positioned so that they do not interfere with the drilling of bolt holes for the floor timbers later in the construction.

5.1.2 Backbone

The backbone is then raised on the foundation and cleats fastened alongside the posts or across the bearers to hold the keel in position. In the case of larger boats it will not be possible to assemble and raise the backbone in one piece so that stem and horn timbers will be added once the keel is firmly fixed in position. The whole structure is then braced in position after checking with a plumbob that the stem and stern post are truly vertical.

5.1.3 Square frames

Frames can now be set up. It is usual to start with the frame on the midship section and work either forward or aft from this position. This first frame should be carefully erected to be both vertical and exactly at right angles to the keel. As the keel has a slope and the frame is erected vertical to the baseline it will be necessary to bevel the bottom of the floor at the point of contact with the keel. This bevel is calculated from the mold loft and cut before erection of the frame. The frame is then hoisted into position and a plumbob suspended from the centreline of the cross brace. When the plumbob is exactly over the centreline of the frame at the base then the frame is vertical and can be shored in position. Before continuing, the position must be checked to ensure that the frame is exactly at right angles to the keel (see Fig. 32). Cords can be run from the sheer line at each side of the frame to a position on the centreline of the keel at say 6-8 frames spaces distance. The frame is at right angles to the keel when the distances from the fixed point on the keel to the sheer points are exactly equal. When these dimensions are correct and the plumbob shows the frame is vertical, shoring of the frame is completed to hold it rigidly in position. The frames forward and aft of this midship frame can then be erected using spacing sticks to measure the correct distances. It is advisable to plumb and square a further two or three frames as the work proceeds as a check against accumulative errors in spacing. As each frame is positioned a heavy boat nail or drift bolt should be driven through the floor to hold the frame in its position. Care should of course be taken to position these drifts so that they do not interfere with the bolts which will be driven through the keelson, floor and keel after setting up is completed. As soon as a number of square frames are up, the placing of battens (or ribbands) should begin, to hold the frames firmly in place and bring them properly into alignment. If the frames are well built then proper attention to the placing of ribbands will ensure good alignment and greatly reduce the amount of trimming necessary to fair the framing for planking. When the square frames have been completed the keelson is laid and the keel, floor and keelson drilled for the keel bolts. As with bolts in the backbone these should be countersunk into the keel and the holes plugged. It is a wise precaution to place a twisted strand of oakum or caulking cotton soaked in paint under the washer to eliminate possible leaks through the bolt holes. The transom and its frame are next raised, plumbed and fastened in position.

5.1.4 Half frames

At the bow and stem there will be a number of frames which do not cross the keel but have their heels notched into the deadwood or horn timber. These are known as half frames, while the frames which cross the keel are known as square frames. In this case the heels of the frames should be notched into the deadwoods' sternpost and horn timber.

To assist in correct positioning of these frames, curved timbers called harpins giving the shape of the inside of the planking can be fitted. For example at the bow two of these pieces are placed on suitable waterlines extending from the bow to the last square frame and past it for several frames to allow proper fastening. The bow end is notched to fit in the rabbet (see Fig. 33). The position of each frame is marked on the harpins and using these as a guide it is possible to fit the half frames accurately to the

notches. When both half frames are in position the keels are through bolted to the deadwood and a cross brace fastened to the heads of the frames and the ribbanding is completed to hold the alignment of the framing. In smaller vessels it is possible to fasten a straight grained timber called a strongback across the half frames at the correct position and suitably bevelled so that it will rest on the deadwood, stem knee or horn timber as the case may be. A cross brace holds the whole assembly at the head and then the frame is slid down into notches already prepared. In this case harpins can be dispensed with and the frame plumbed as usual. When the frames are all in position stringers and clamp should be fastened in place to hold the whole structure strongly so that the frames are not distorted during planking.

5.1.5 Fitting Chines in V Bottom Construction

Fitting of longitudinals at the chine angle is one of the major differences between sawn frame round bottom and V bottom construction. The fitting of a rabbeted chine log can be awkward if it is not carefully lofted at each frame. Alternative solutions for both light and heavier construction which are simpler to fit are shown in Fig. 34.

5.2 General construction details

In tropical countries the heat generated inside a planked up hull can be very great so that it is recommended that the maximum amount of the interior work be done before planking is commenced. Not only clamps and stringers but shelf, knees, breasthooks, engine stringers and bearers, transverse bulkheads and even certain of the interior joinery can be fitted before planking. The only thing to watch in this latter case is that no obstruction is caused to the placing of the clamps which will be necessary to pull the planking into place, nor to the placing of butt blocks for planking butts if this method of joining planking is used.

5.2.1 Stringers and clamps

Very little comment is needed on the placing of stringers, clamps, etc., as these are straightforward operations. Scarfs for these members can be either edge or flat scarfs (see Fig. 35) but flat scarfs are perhaps stronger as the through fastenings to the frames pass through both parts of the scarf while in edge scarfs the edge bolting is all that holds the two members together. Clamps should be bolted to every frame while stringers can be bolted to every second or third frame and spiked to the intermediates.

Shelves, necessary in larger vessels, are a little more difficult to fit. They are secured to the inside faces of the clamps with the top usually flush with the top edge of the clamp. It is necessary to make these members of several pieces edge-scarfed together. The shape can be picked up from the mold loft floor and care must be taken to bevel the face resting against the clamp so that the shelf is at the correct angle to take the deck beam when it is fitted (see Fig. 36). Shelves are fastened to the clamps by edge bolts between the frames, with sometimes a bolt through the head of each frame as well.

The ends of clamps and stringers should be carried right forward to the stem and aft to the transom and solidly bolted to both with the aid of breasthooks and knees.

5.2.2 Breasthooks and knees

Breasthooks can be fitted on top of a clamp or shelf where the lower member is thick enough to take an edge fastening but the more usual method is to place them between the ends of the clamp or stringer with bolts through clamp, and if possible a frame, as well as a through bolt traversing the stem and breasthook. The head of these bolts in the stem should be countersunk and plugged as already described. Similarly, knees are bolted to clamp or stringer and transom.

These members are important as a solid fastening to stem and transom ensures continuous longitudinal strength throughout the boat.

5.2.3 Deck beams

Deck beams are next made up and fitted. The pattern made up on the loft floor is used to cut the curve of the beams and the length is calculated to just run past the clamp into the frame bay at each beam position. Where no shelf is fitted the beam is notched over the clamp and fastened to it by a bolt running through the beam and edge wise through the clamp. This point has to be watched when fastening clamps to be sure that no bolt in a scarf is likely to interfere with the bolting of the beams. If a shelf is fitted the beam may be bolted to the shelf instead of the clamp. Carlins are now fitted at the deck openings and the half beams cut and fixed in position. To avoid working of the deck and consequent leaks, tie rods should be fixed between clamp and carlin at suitable intervals.

These are galvanised iron or steel bolts made up from rod and threaded both ends. The nuts are taken up tight enough to hold the carlins firmly against the half beams. When a boat is rolling and pitching in waves, forces on the side of the boat tend to try to collapse the boat and a hinging effect occurs at the corner of the deck. For this reason that area must be strongly fastened and to resist these forces vertical brackets of wood called hanging knees are located at intervals along the hull especially around mast position and near deck openings (see Fig. 37). Similarly horizontal brackets or lodging knees are used to prevent horizontal movement due to forces which occur when the boat is pitching. These are located at the ends of major deck openings, at mast beams and winch positions and should be through bolted. Care should be taken to ensure that the grain of the knees runs as shown in Fig. 38.

5.2.4 Planking

Planking a sawn frame boat is no different from planking any boat; however planking widths should not exceed 8-9 inches except perhaps for the garboard while planks around the turn of the bilge will be much narrower. Joints between lengths of plank can be made in several ways. In heavy planking an edge scarf is satisfactory provided the length is adequate (4 times the width) and the nibs of the scarf fall on a frame which reinforces them. Butt joints are more commonly used and are easier to fit and the

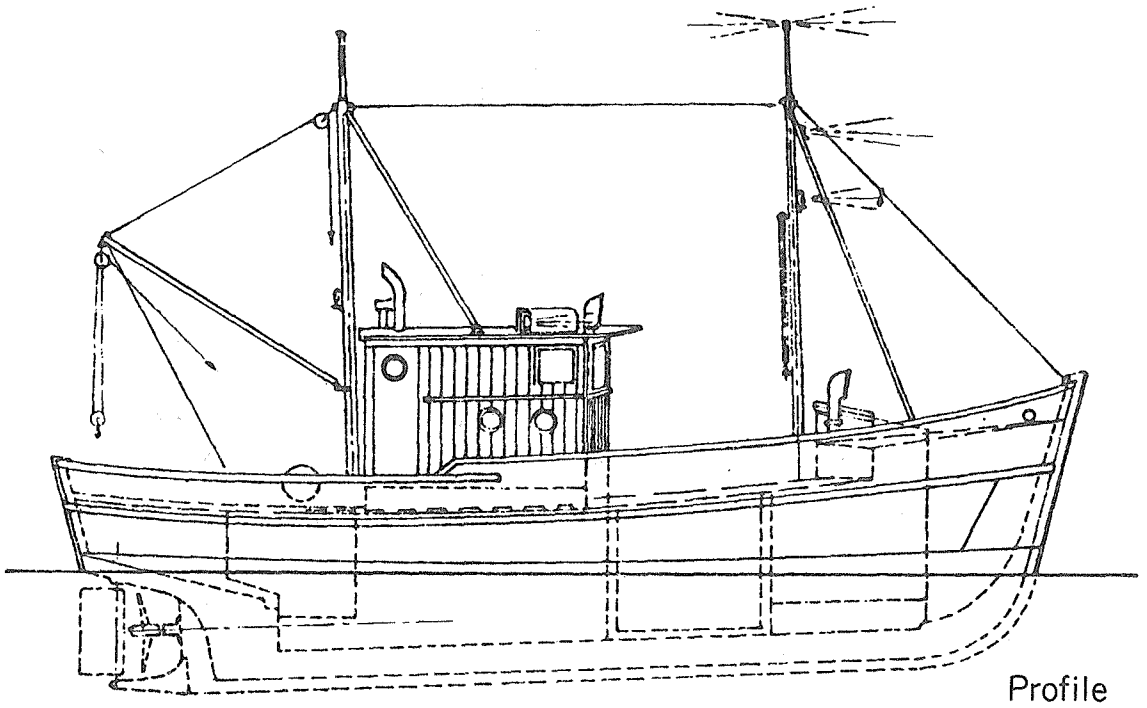
reduction in plank length over the scarf joint can make a price saving over a period. In large craft with a total frame width of 5 inches or more the planks are butted directly on the frames but when the width of frame is less there is not sufficient timber to ensure good fastening and the butts should fall between frames and be reinforced by butt blocks. These should be of the same thickness as the planking and the same length as the frame bay less 1/2 inch at each end to permit drainage. They should lap 1/2 inch or more on to the plank above and below the butt and should be screw fastened in smaller boats and through bolted in larger vessels. The head of the butt block should be bevelled to permit drainage (see Fig. 39).

The spacing of butts is particularly important as butts too close together will allow the hull to work and cause leaks, possibly even starting the fastenings. The rule for this is that butts in adjacent planks should have minimum of three frame spaces between them. Butts in the next plank but one should have two frame spaces between, while butts in the same frame space should have a minimum of three planks between them (see Fig. 40). It is a good plan to make a diagram of the planking and plot out the position of the butts with regard to the planking length available (as in Fig. 40).

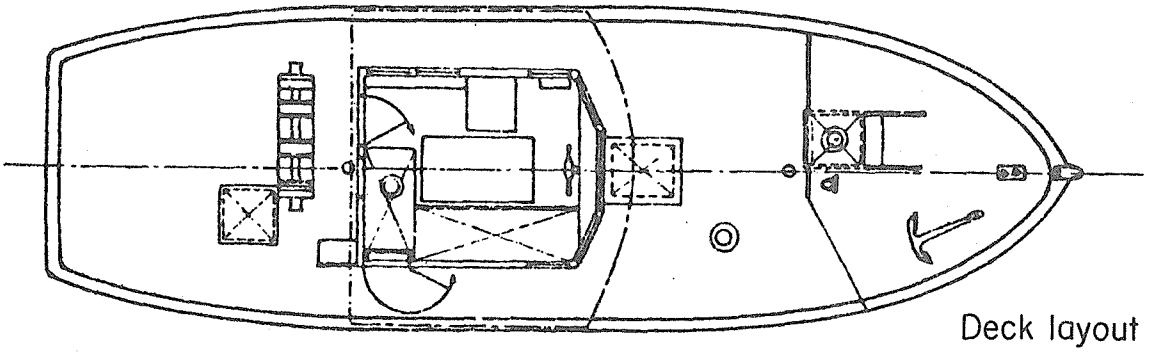
5.2.5 Decking

Deck planking requires little explanation except for the general rule that planking width should be kept to a maximum of 5 inches. Wide planking causes excessive strain on the fastening and will not stay tight due to shrinkage. Fastenings are usually galvanised boat nails and the butts between lengths of plank should be staggered as in hull planking, butts in adjoining planks being at least three deck beam spaces apart. In the type of construction we are considering deck beams are usually of sufficiently large dimension to permit the fastening of the butts on a beam without blocking. Covering boards and waterways can be constructed in several ways. If a caulked ceiling is fitted inside the frames then chocks must be fitted between every second or third frame and a large enough port constructed to permit rapid drainage of water on deck (see Fig. 41). Where a covering board extends outside the frames (as in Fig. 42) it must be pierced to allow the heads of the frames or separate stanchions to run through. This demands careful measurement and accurate fitting. An easier method is to notch the covering board and slide it into place from the inside, the outer ends of the notches being filled with graving pieces when the covering board is in place. The shape of the covering board is lifted from the mold loft floor and it is made up in several scarfed lengths to use the minimum of curvature in each section. Before fastening, the inside edge is marked on the decks and blocks are set in between the deck beams to support the covering board and take the ends of the deck planks which are notched into the covering board where the angle of intersection would leave a sharp pointed end (see Fig. 43). Caulking joints are cut to a depth of 2/3 of the plank thickness and an opening of 1/8 inch.

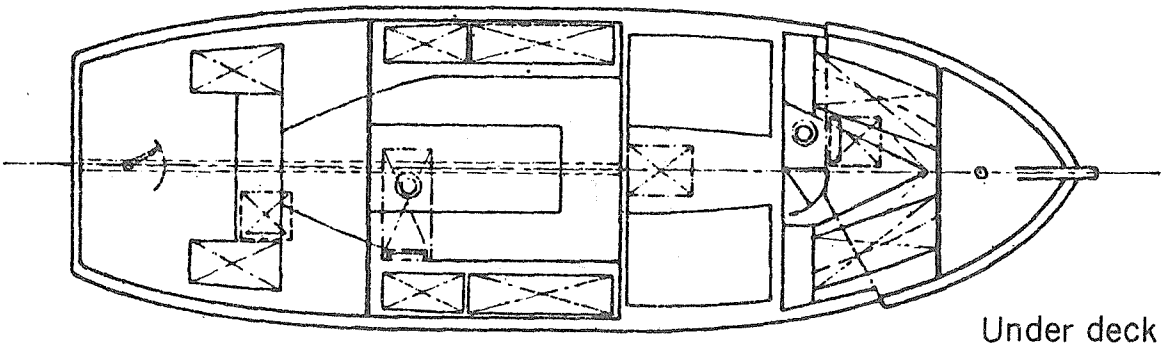
Blockings should be provided between the beams under all deck fittings such as winches, gallows, etc., and these and mast partners will usually be indicated in the plans.



Profile



Deck layout



Under deck

Plate I General arrangement

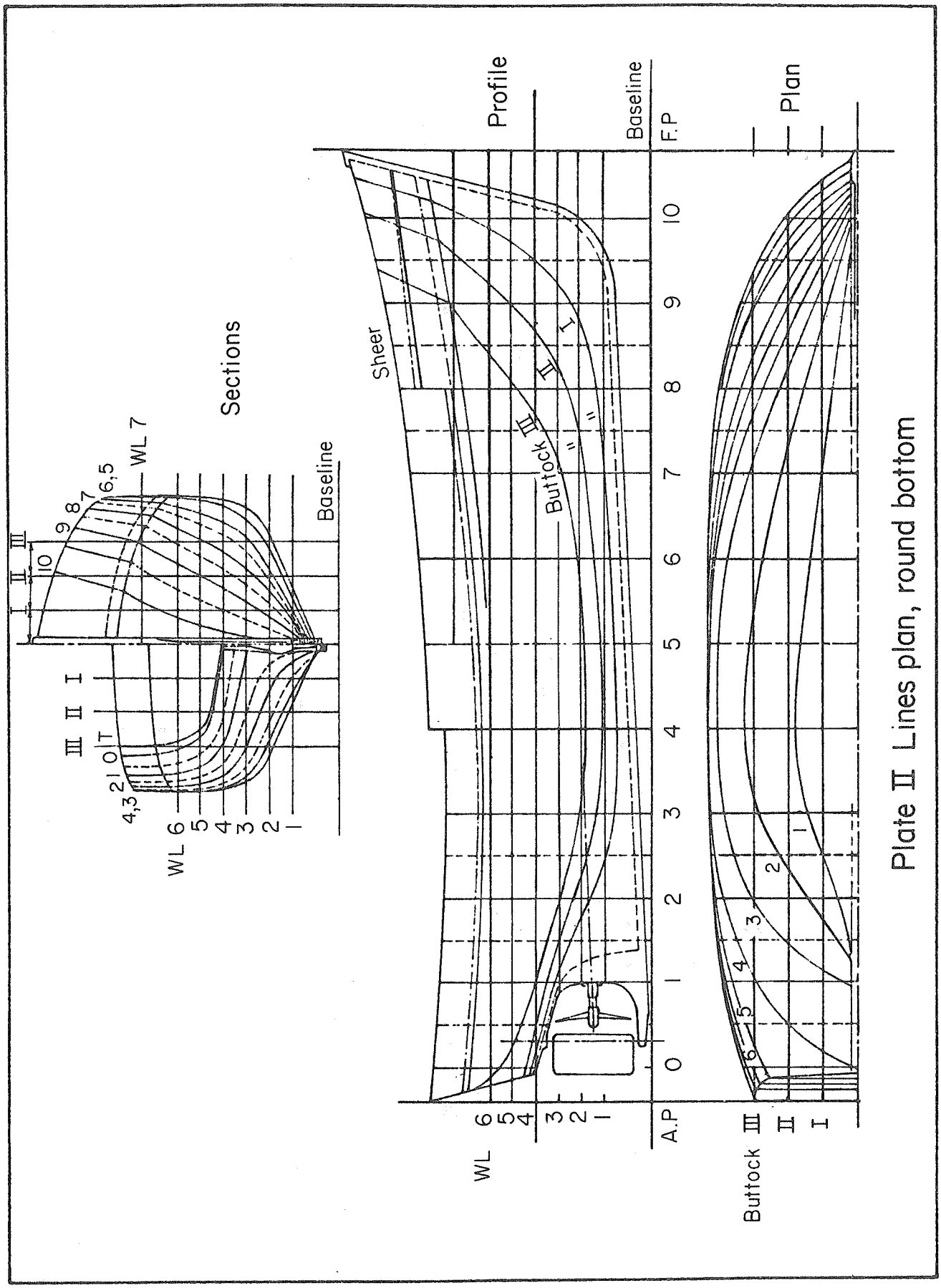


Plate II Lines plan, round bottom

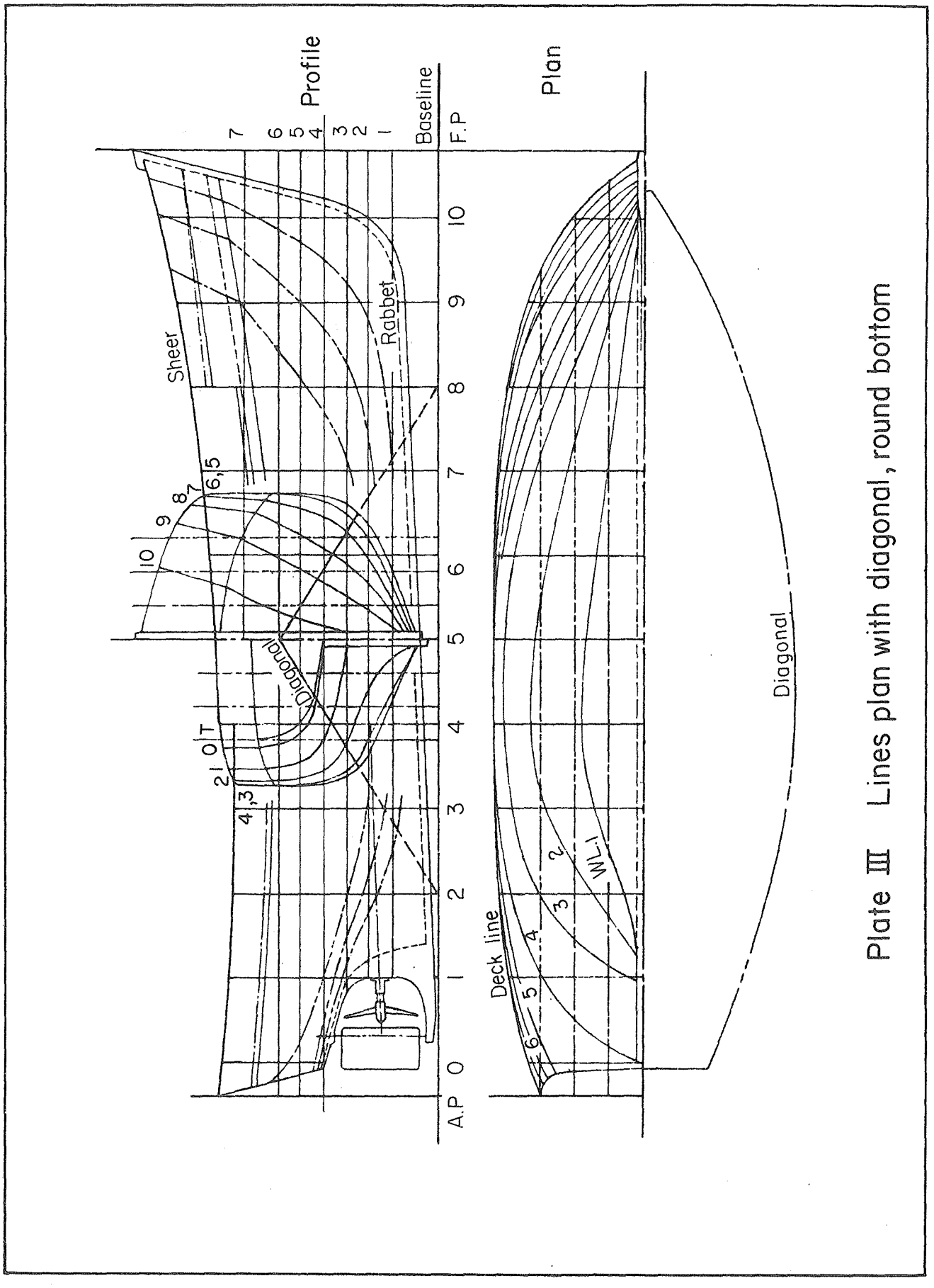


Plate III Lines plan with diagonal, round bottom

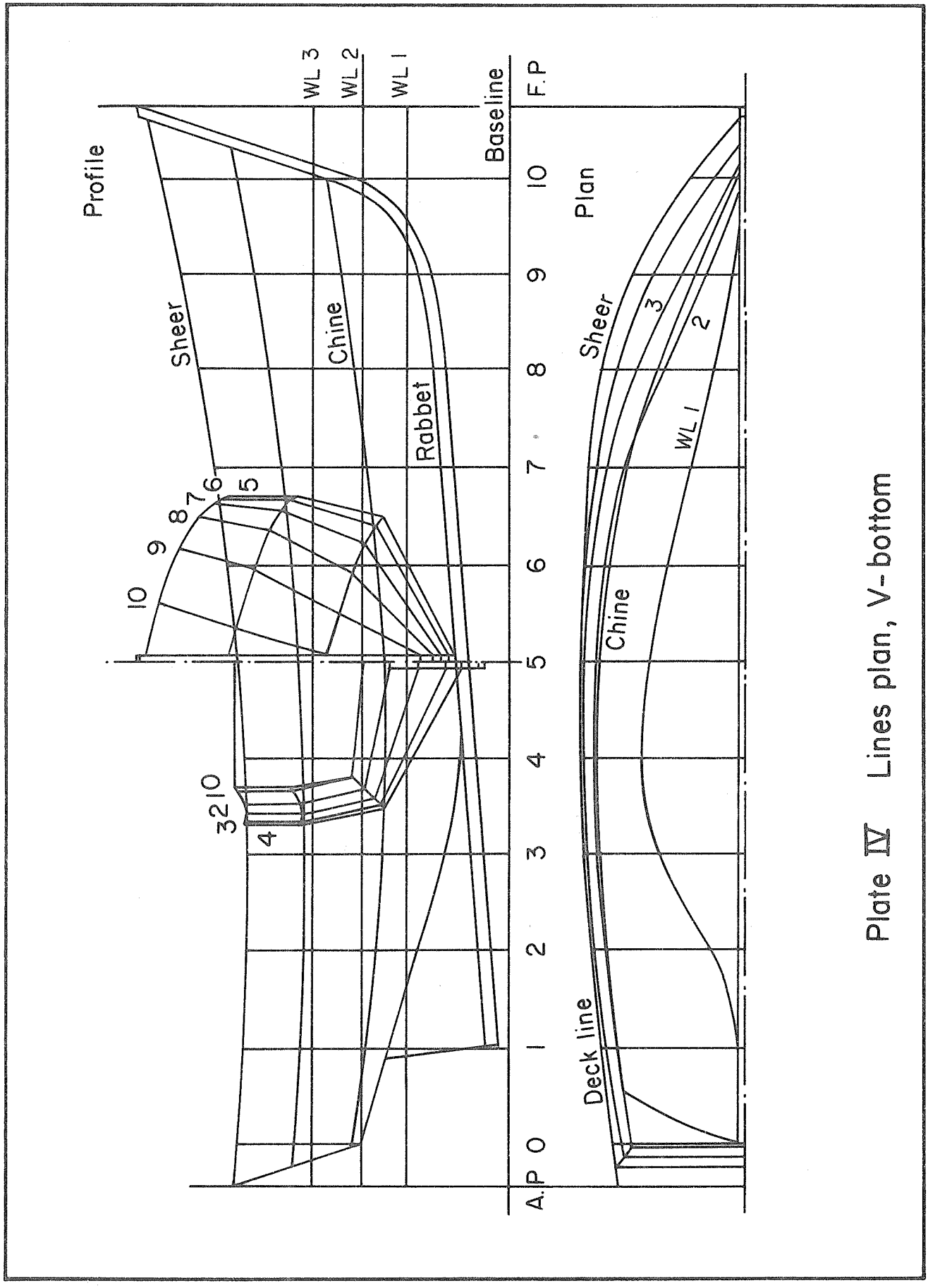


Plate IV Lines plan, V- bottom

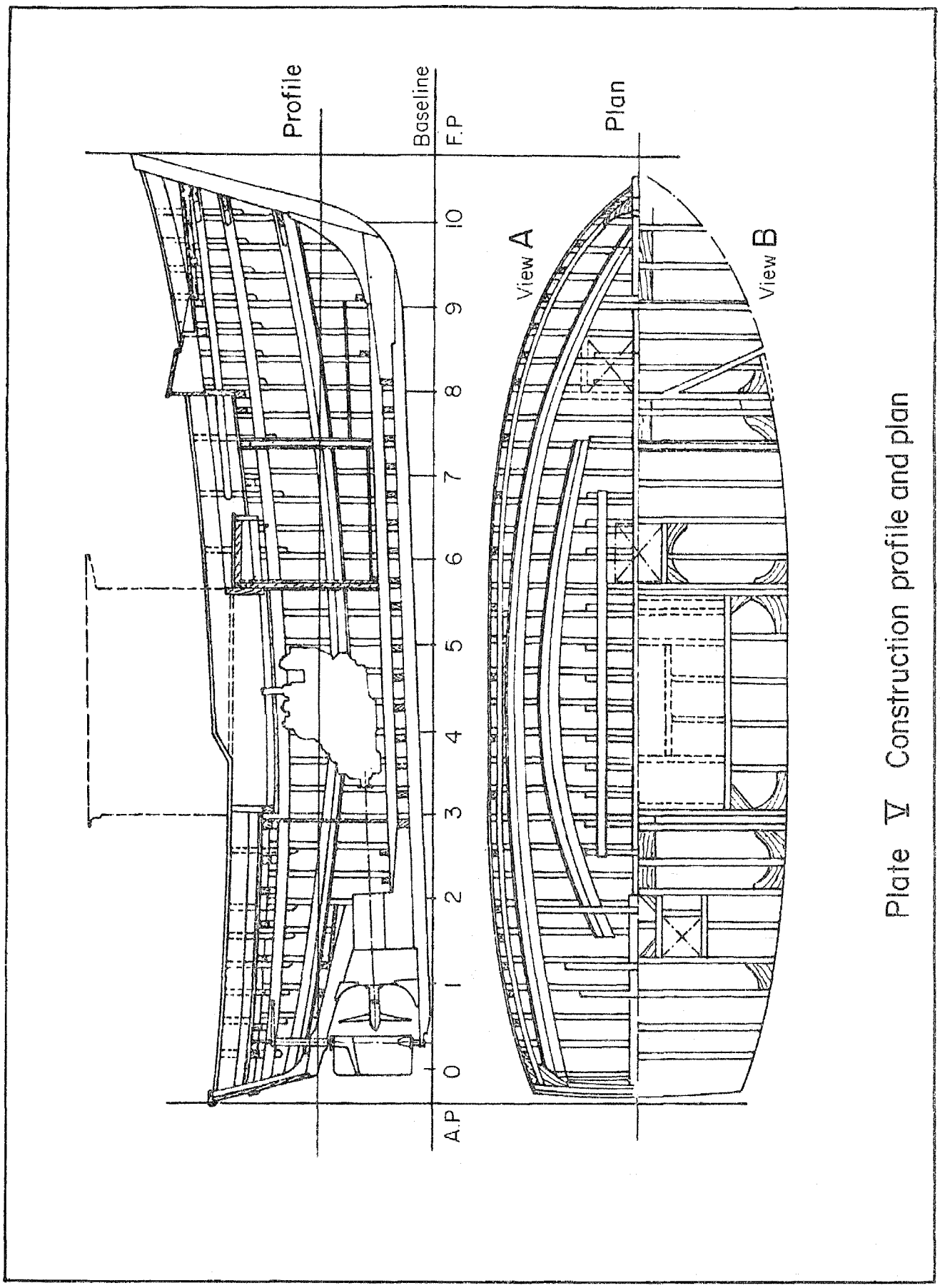


Plate V Construction profile and plan

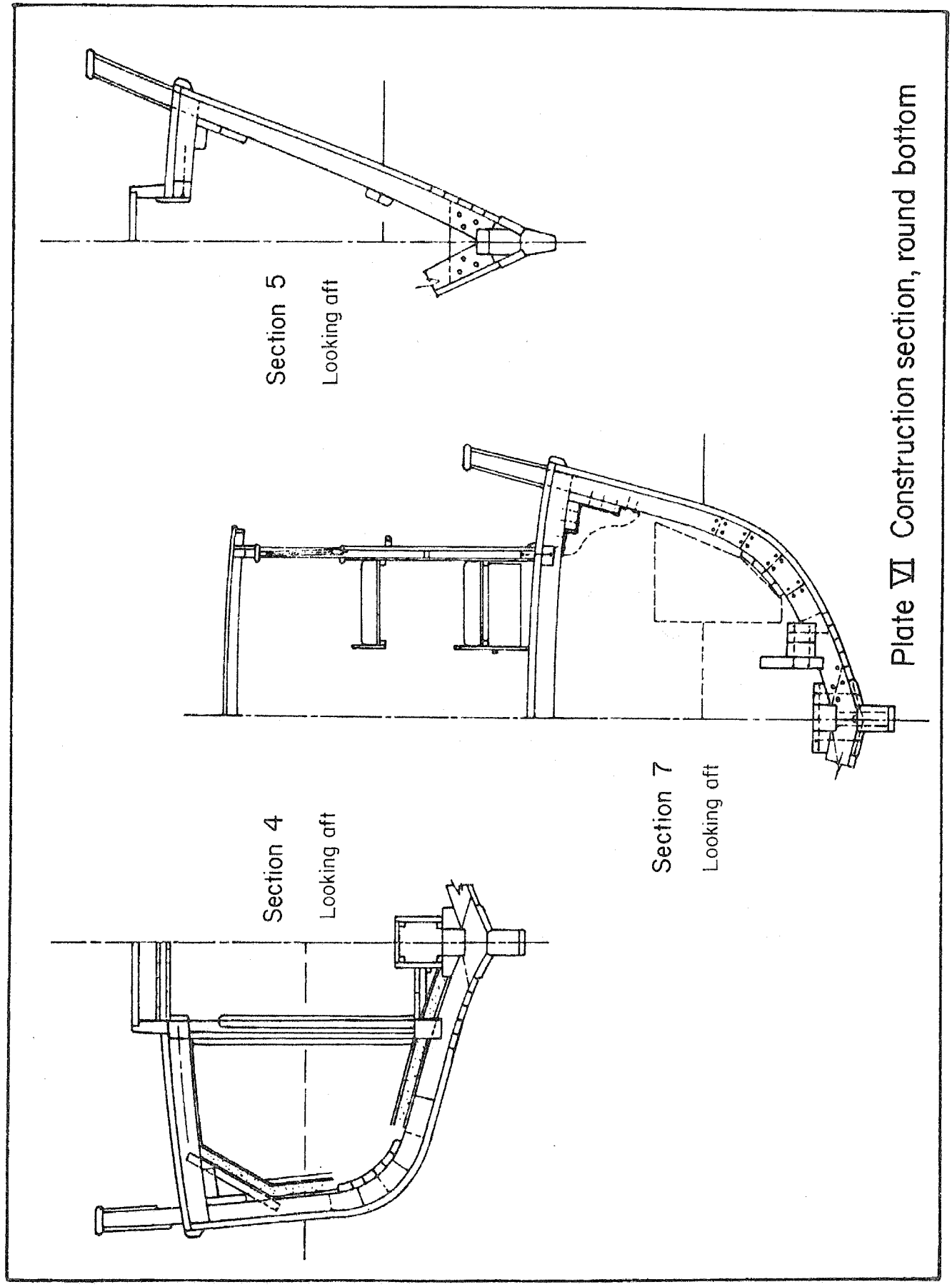


Plate VI Construction section, round bottom

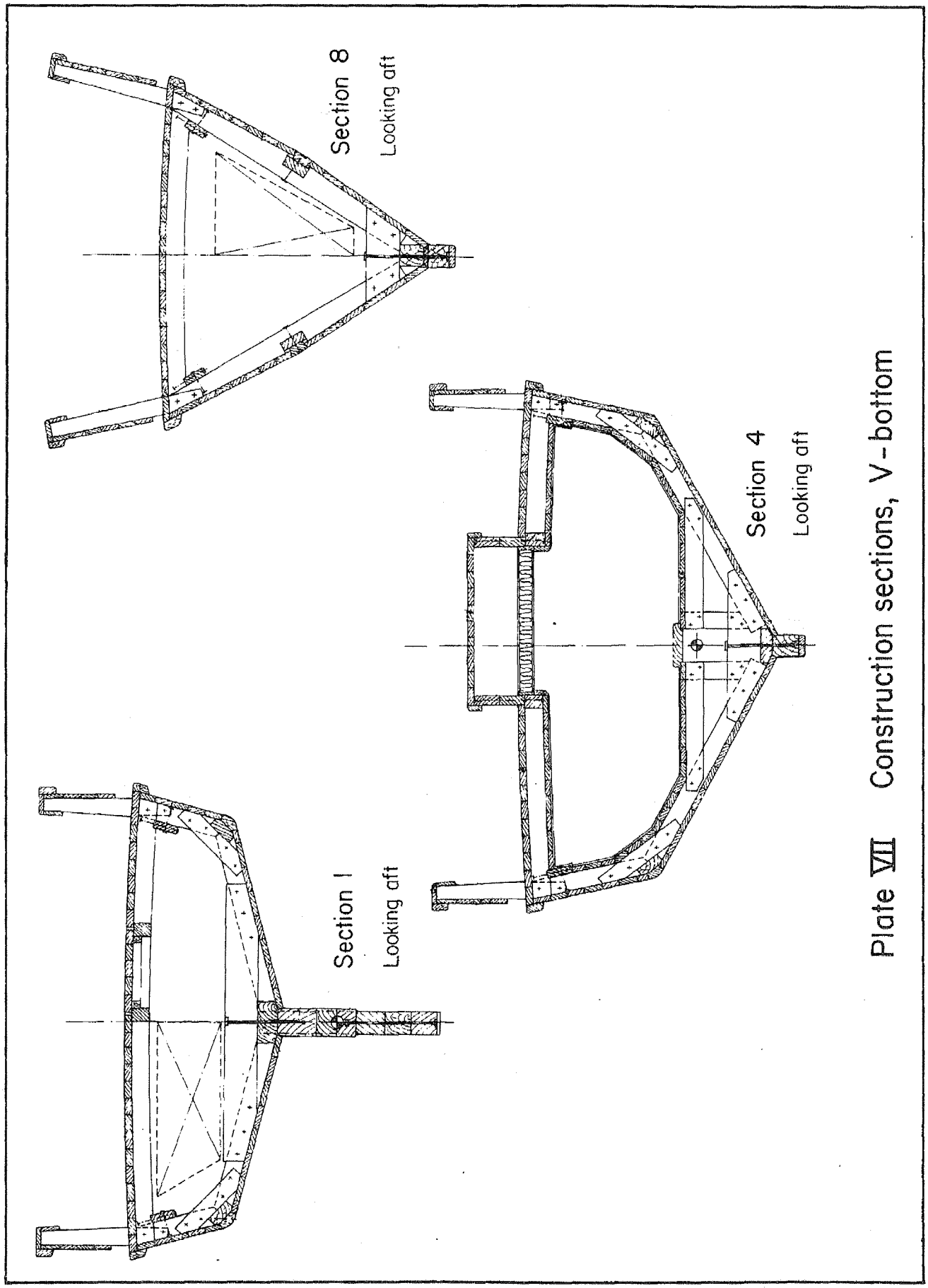


Plate VII Construction sections, V-bottom

	Section	T	0	½	1	1½	2	2½	3	4	5	6	7	7½	8	8½	9	9½	10
Half breadths	WL 1					5·0	10·0	13·0	26·2	32·3	30·0	24·6	18·3	15·2	12·1	8·7	6·1		
	2					10·2	25·7	41·3	51·1	59·3	57·1	50·2	40·0	34·2	28·2	21·4	15·0	8·3	
	3				7·4	38·0	54·6	64·7	70·1	73·6	72·5	67·6	56·2	49·3	40·6	31·7	22·6	13·4	4·1
	4		1·0	35·4	52·4	63·3	70·1	74·1	76·3	77·4	77·0	73·7	64·1	57·5	49·1	39·5	29·1	18·2	6·2
	5	46·0	50·0	58·3	65·3	70·3	74·4	76·5	78·0	78·0	77·5	75·5	68·3	63·0	55·4	46·2	35·2	23·7	9·6
	6	51·5	56·0	63·0	68·6	72·6	75·5	77·1	78·0	78·0	78·0	77·2	72·2	67·4	61·1	52·3	41·6	29·0	13·4
	7										78·0	78·0	75·4	72·7	68·5	62·3	52·5	39·0	21·2
	Sheer (deck)	54·0	58·4	65·0	70·0	73·2	75·7	77·3	78·0	——	——	78·0	75·2	72·4	68·4				
	Raised deck														70·6	65·7	58·4	47·7	32·7
	Knuckle											78·0	75·0	72·1	68·4	62·0	54·0	43·0	27·3
	Top of b'warks	54·0	59·5	65·5	70·0	——	——	as	sheer	——	——	——	77·0	75·1	72·3	67·6	61·4	51·6	38·1
Height from baseline	Keel bottom		0·0	——	——	——	——	straight	line	——	——	——	——	——	14·6	15·5	17·0	21·0	35·0
	Rabbet		60·6	54·5	47·3	6·2	——	straight	line	——	——	——	——	——	18·2	19·1	20·4	25·0	43·4
	Sheer	96·0	94·5	92·4	90·6	89·1	88·1	87·5	87·3	88·1	90·0	93·1	97·5	100·1	103·1	106·3	110·0	113·4	117·7
	Raised deck														119·3	122·0	124·6	127·4	130·6
	Knuckle											87·1	91·5	94·1	97·1	99·3	104·0	107·4	111·7
	Top of b'warks	114·0	112·7	111·1	110·0	108·6	107·7	107·0	106·5	115·7	117·0	119·7	124·2	127·0	130·0	133·6	137·6	142·4	148·0
	Buttock I	63·3	62·3	56·7	50·1	41·0	31·3	24·0	19·5	17·2	18·5	20·7	23·7	25·5	28·0	33·2	40·4	58·4	95·1
	II	66·7	65·5	60·1	54·3	47·1	40·2	33·5	28·7	25·3	26·4	29·1	33·7	37·3	43·3	54·1	73·1	98·1	141·2
	III	96·0	78·5	67·0	61·0	54·1	47·6	41·7	37·2	33·3	34·4	37·7	45·7	53·6	68·6	87·5	104·0		

All measurements in inches and eighths

Plate VIII Offset table

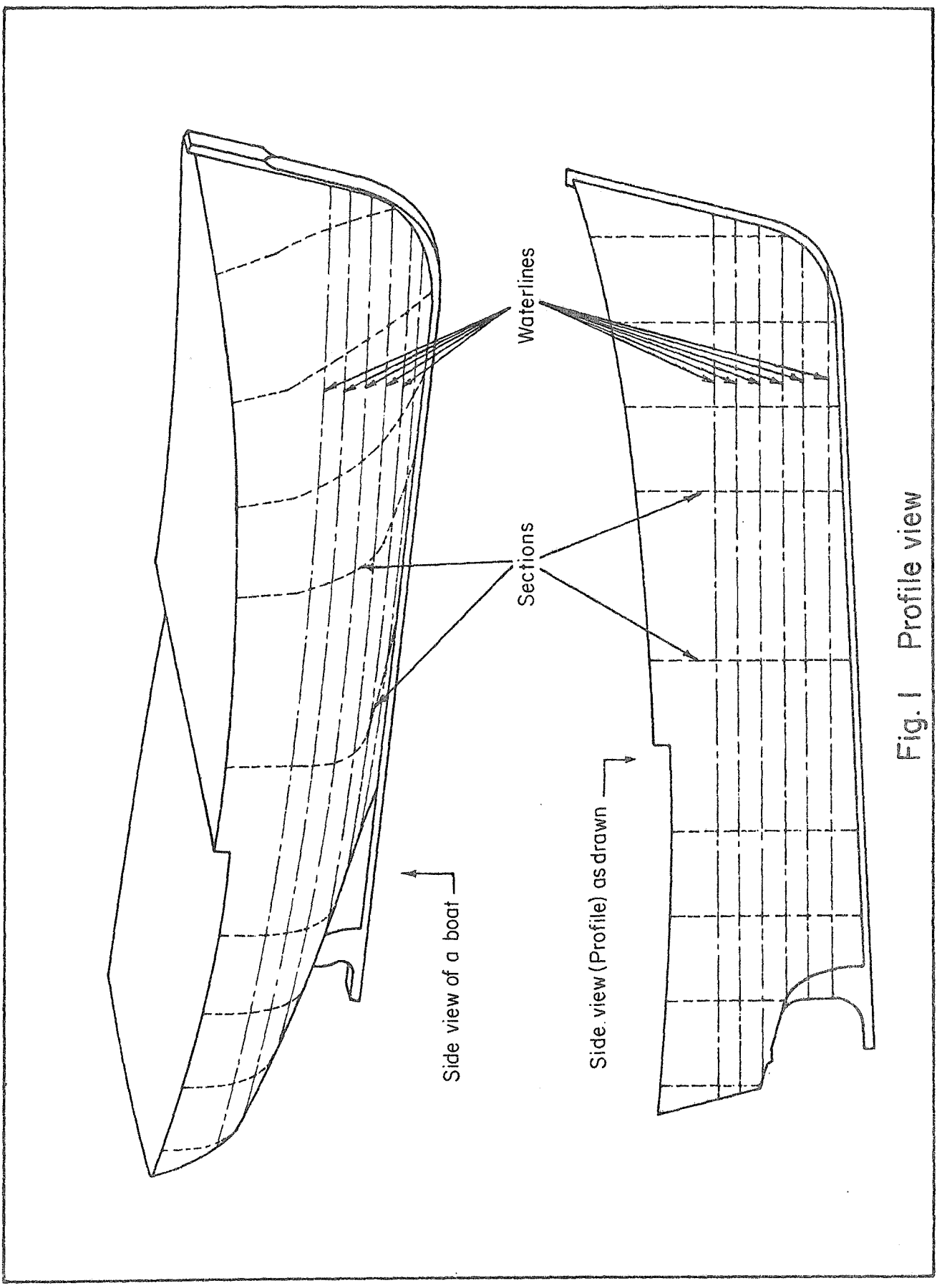


Fig. I Profile view

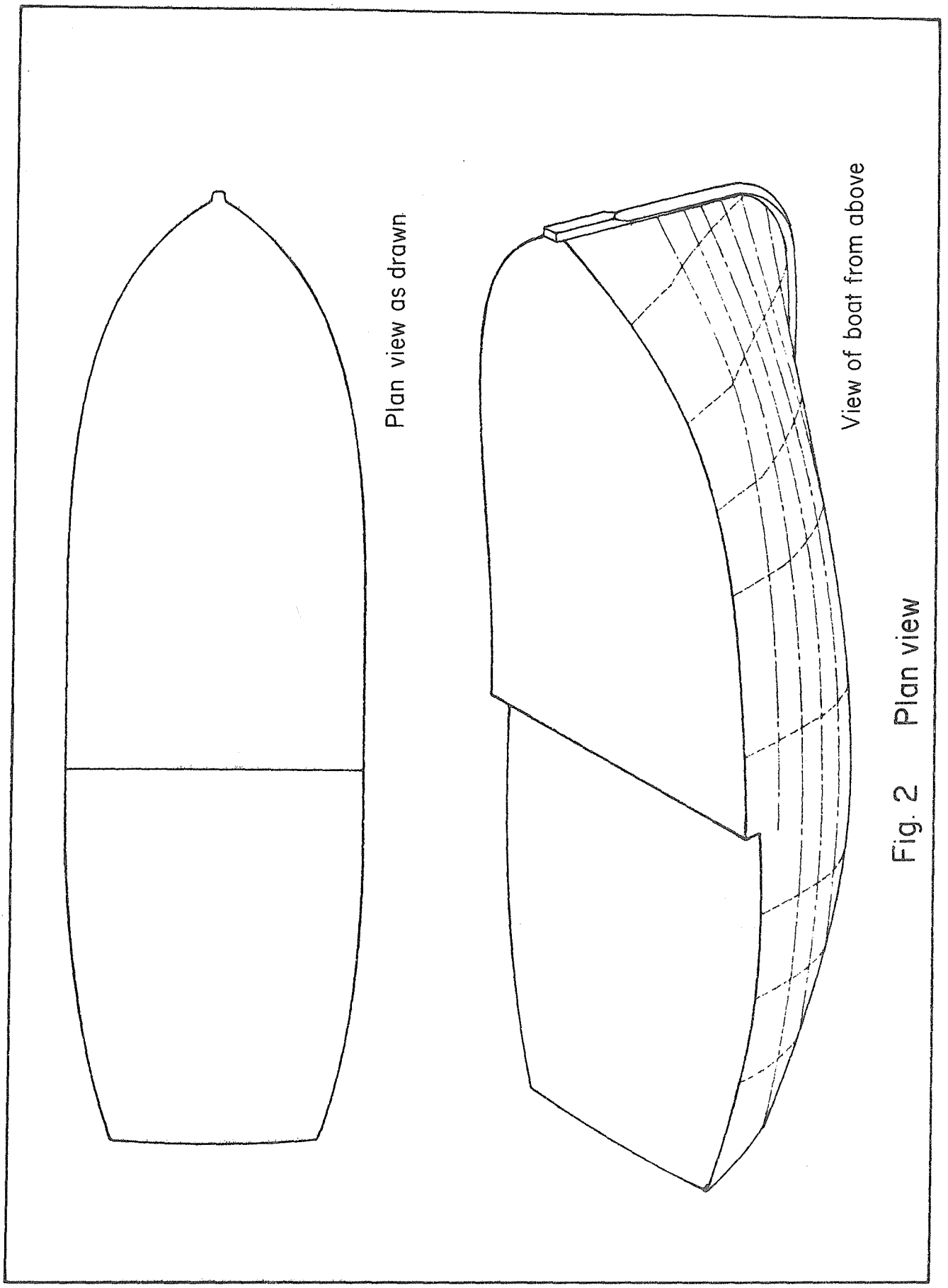


Fig. 2 Plan view

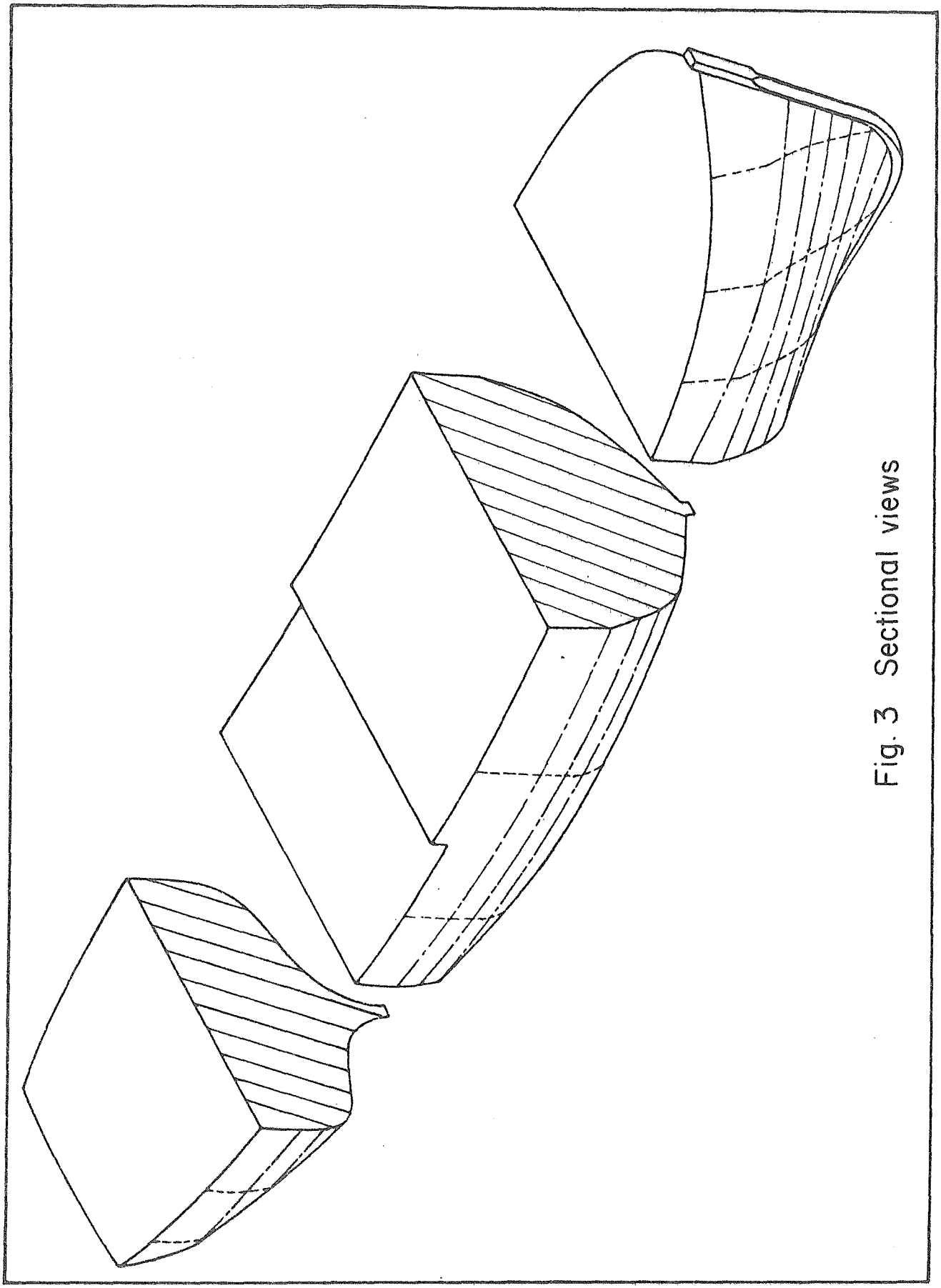
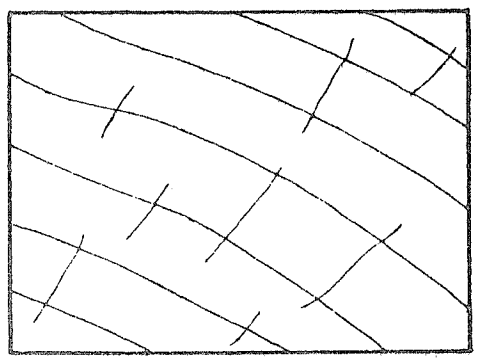


Fig. 3 Sectional views



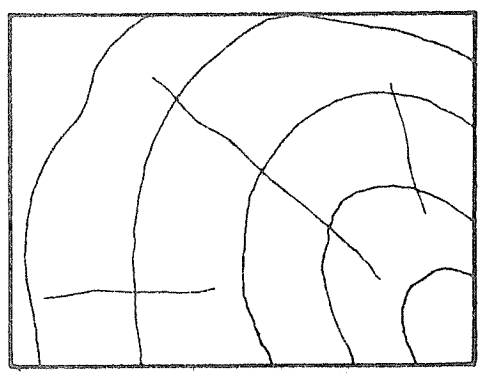
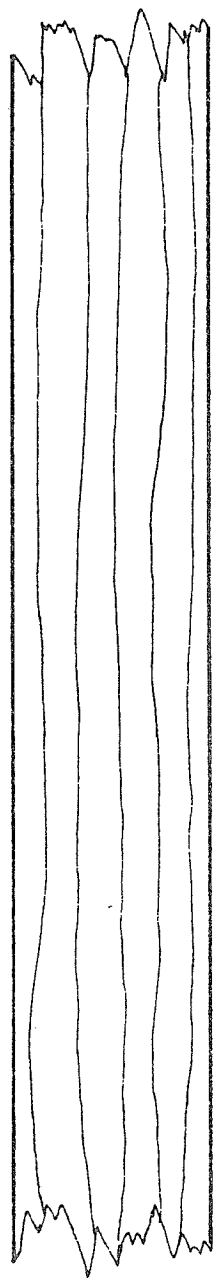


Fig. 4 Sectional graining of wood



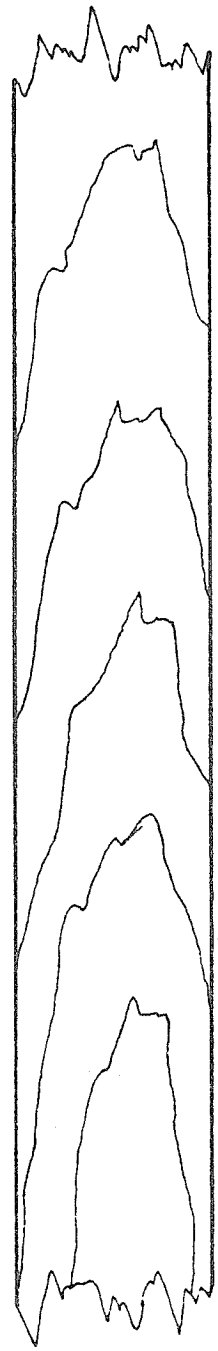


Fig. 5 Longitudinal graining of wood

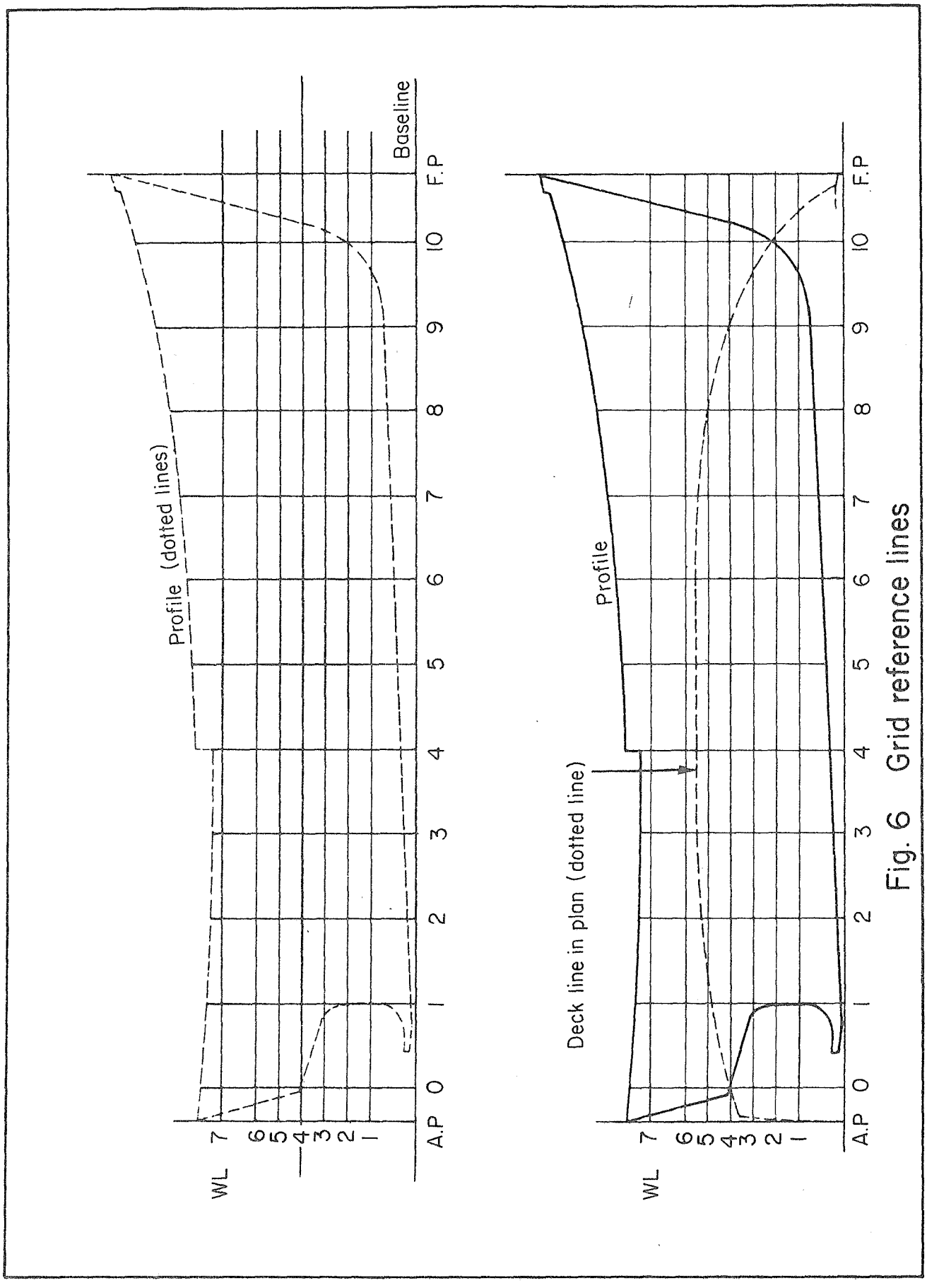


Fig. 6 Grid reference lines

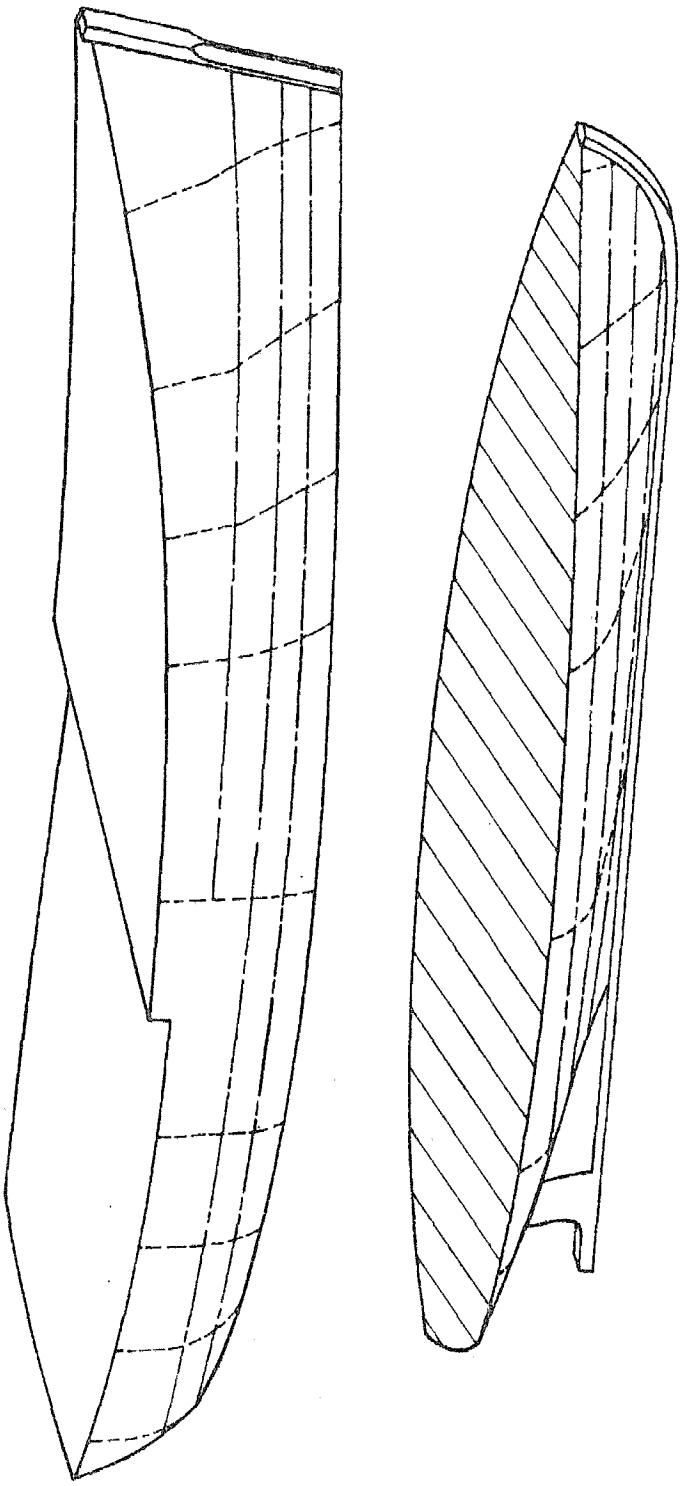


Fig. 7 Two halves of a boat separated at WL 4

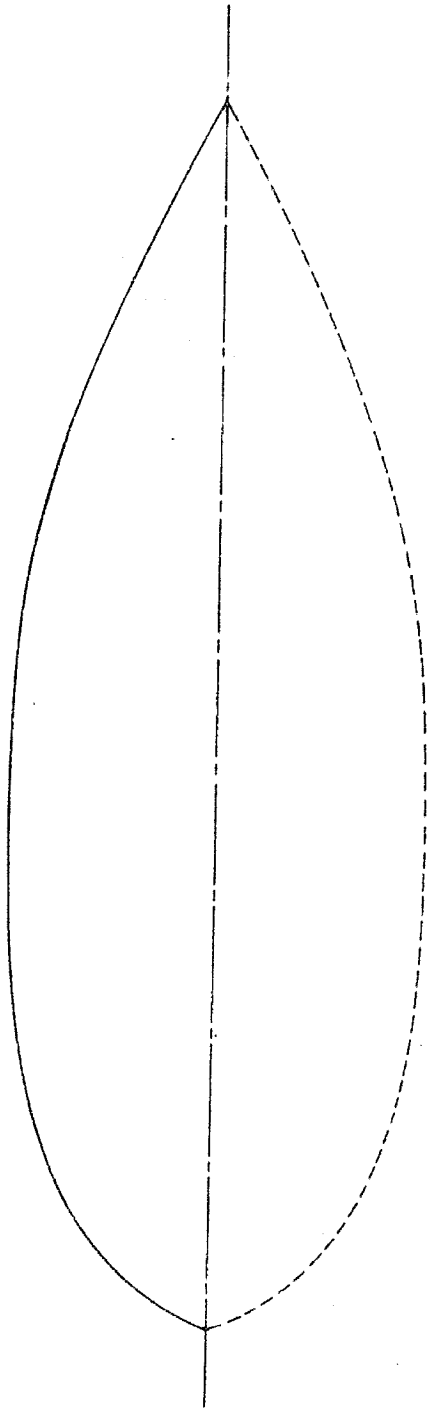


Fig. 8 Plan view of waterline

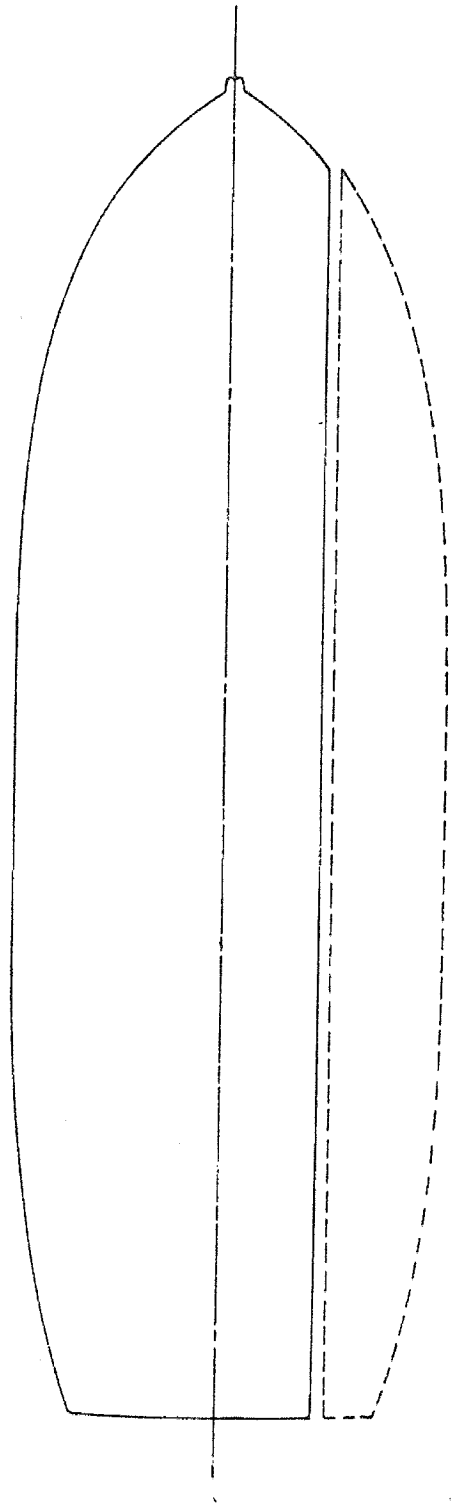


Fig. 9 Plan view of buttock line

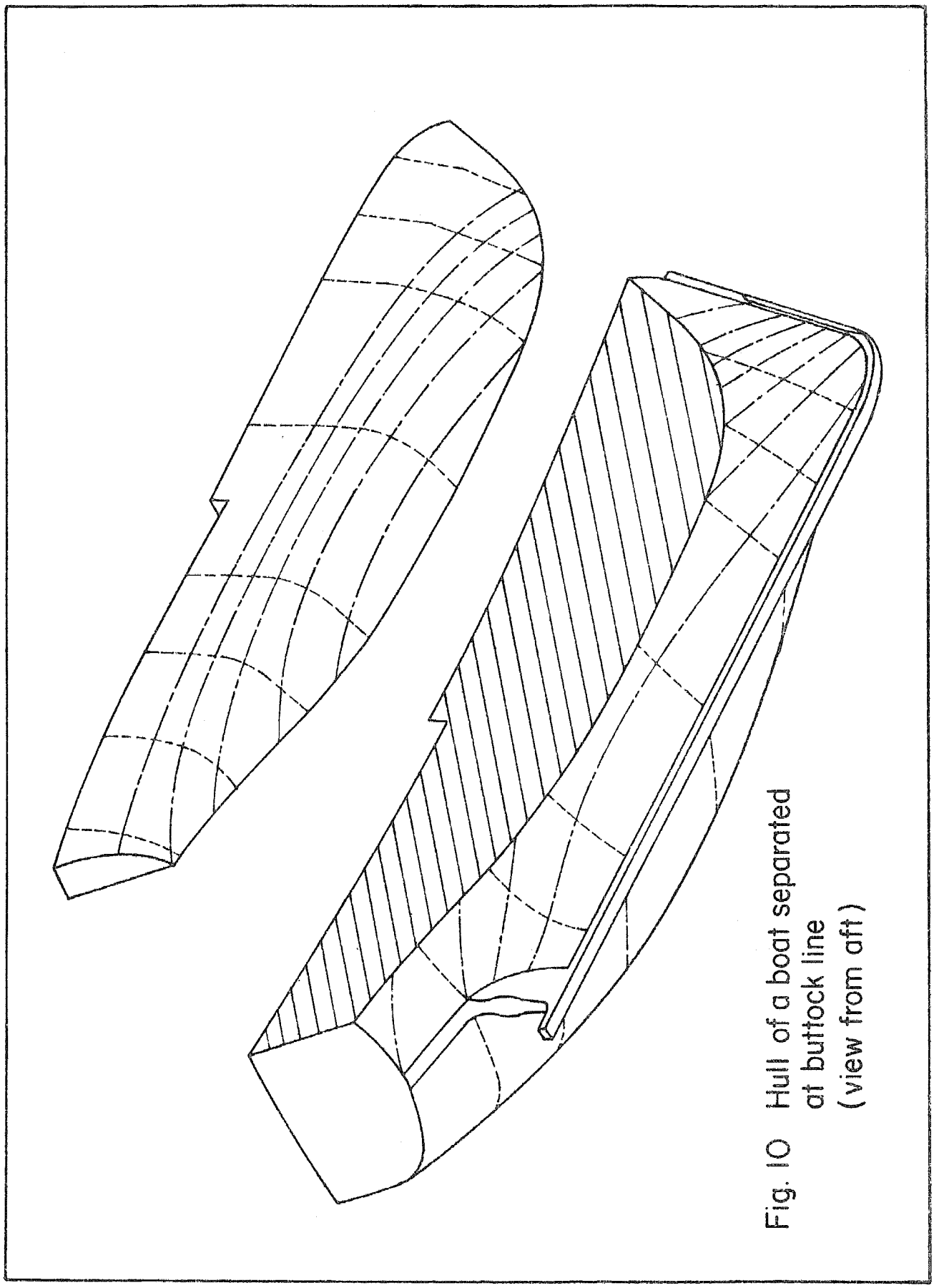


Fig. 10 Hull of a boat separated at buttock line (view from aft)

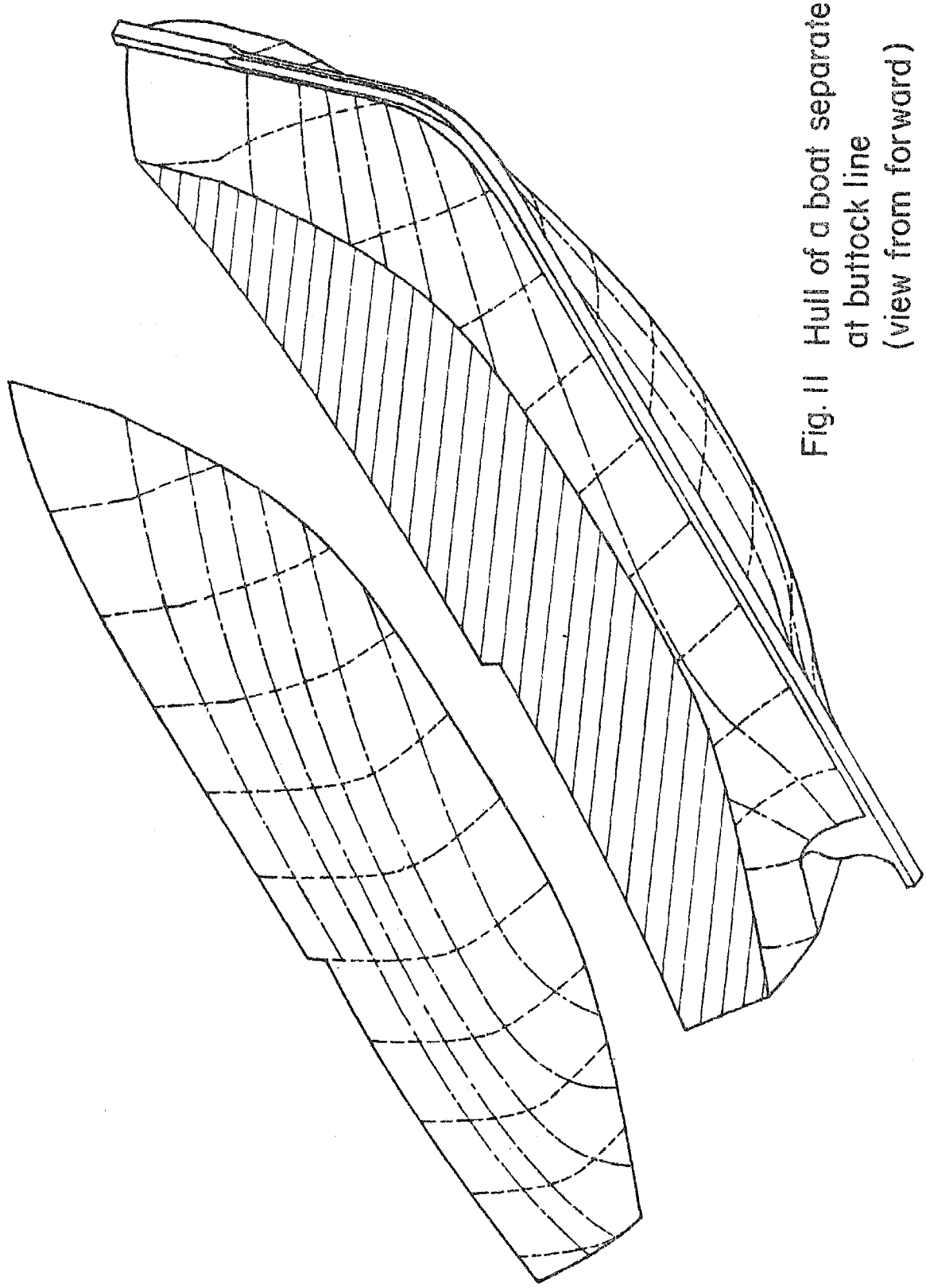


Fig. 11 Hull of a boat separated at buttock line (view from forward)

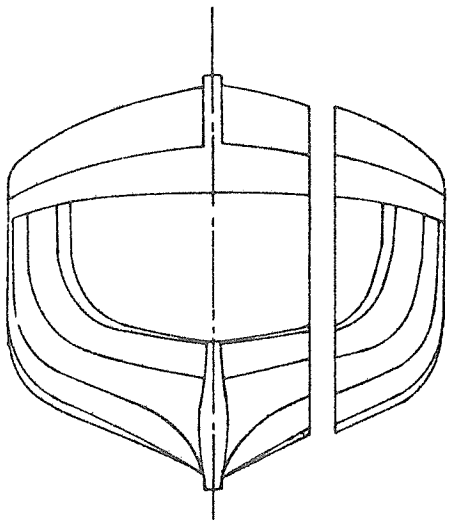


Fig.12 Section view of a buttock line

Fig. 13 Diagonal

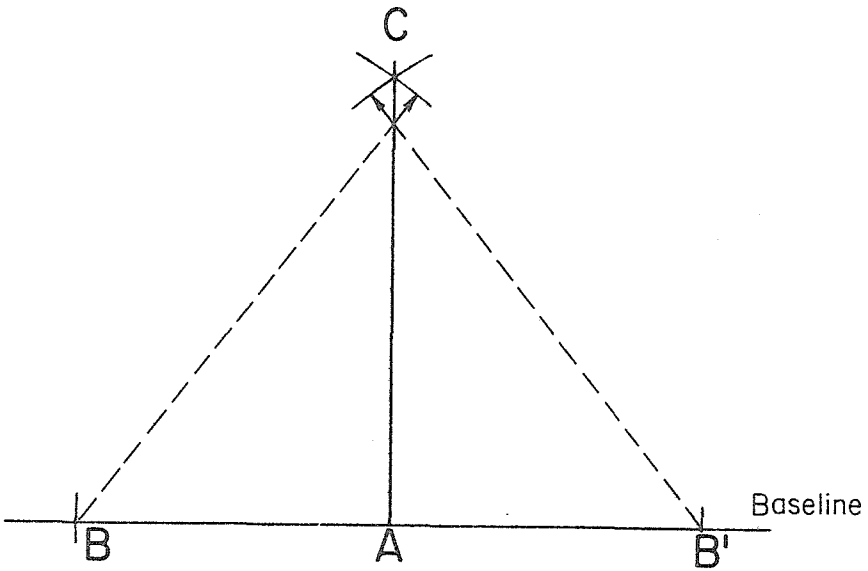


Fig. 14 Erection of perpendicular to a baseline

Fig. 15 Fixing of points by intersection

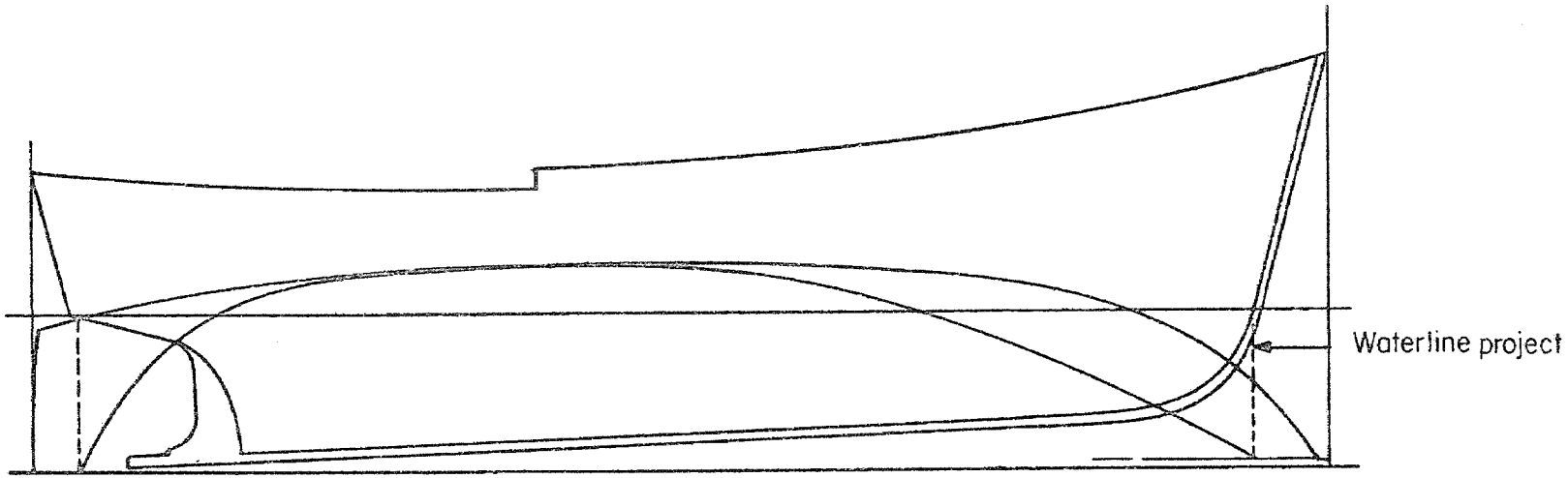


Fig. 16 Waterline endings transferred from profile to plan view

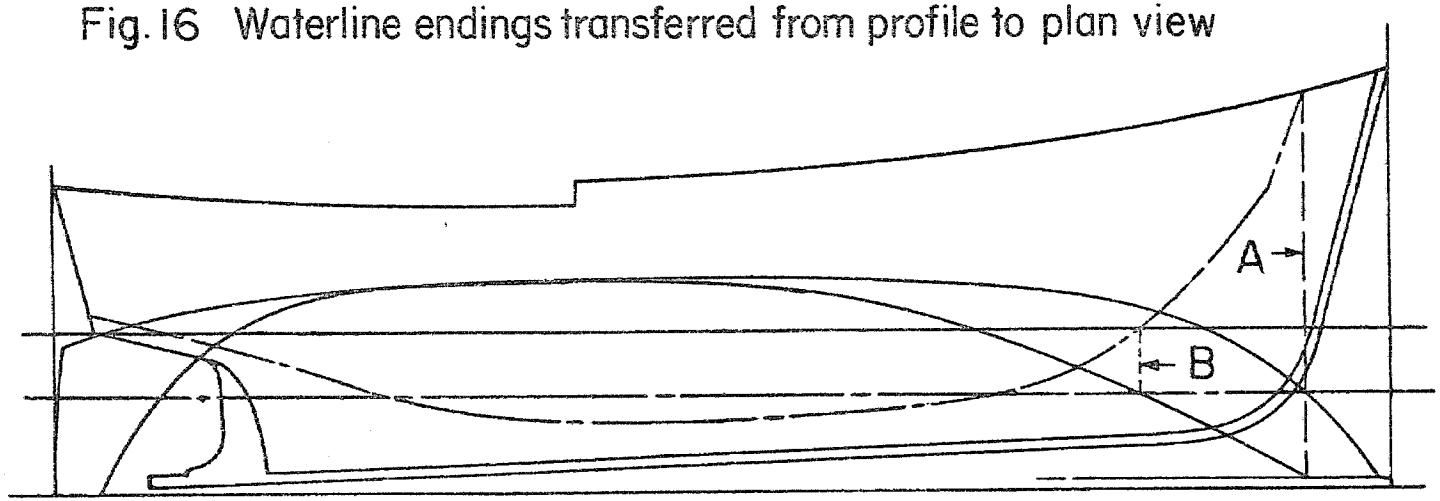


Fig. 17 A. Buttock endings transferred from plan view to profile
B. Intersection of buttock and waterline in plan view transferred to the profile

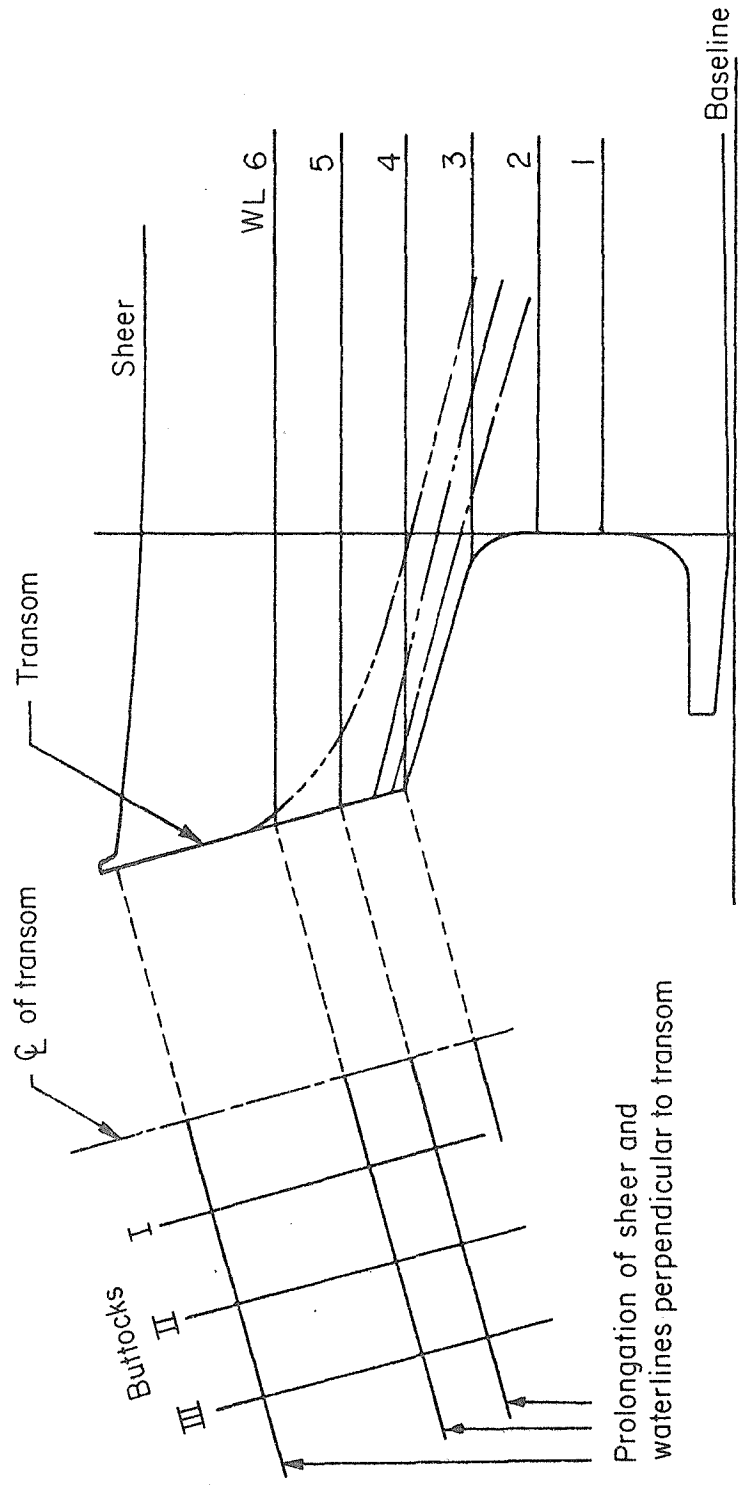


Fig. 18 Preparation of grid for transom expansion

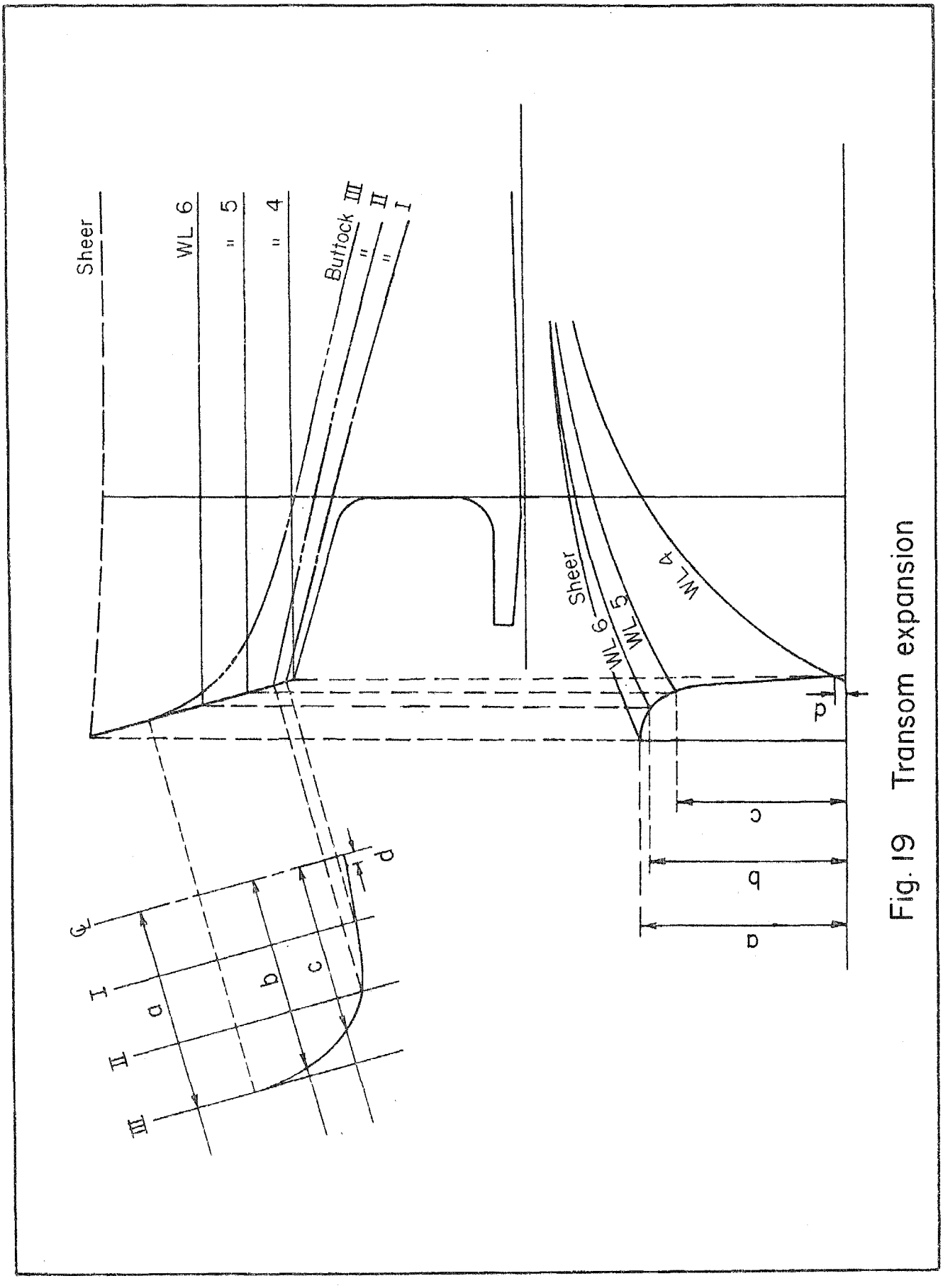


Fig. 19 Transom expansion

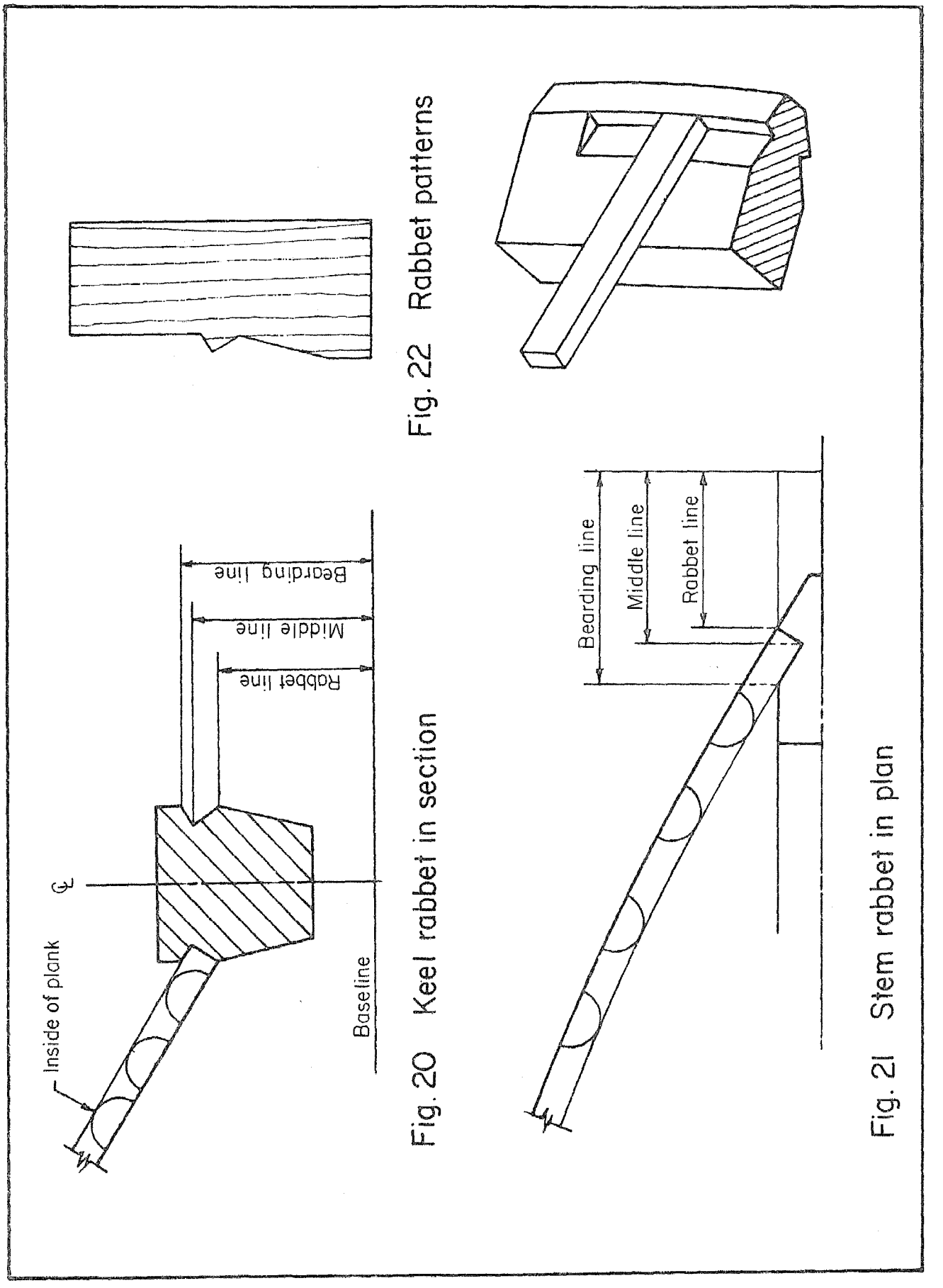


Fig. 20 Keel rabbet in section

Fig. 22 Rabbet patterns

Fig. 21 Stem rabbet in plan

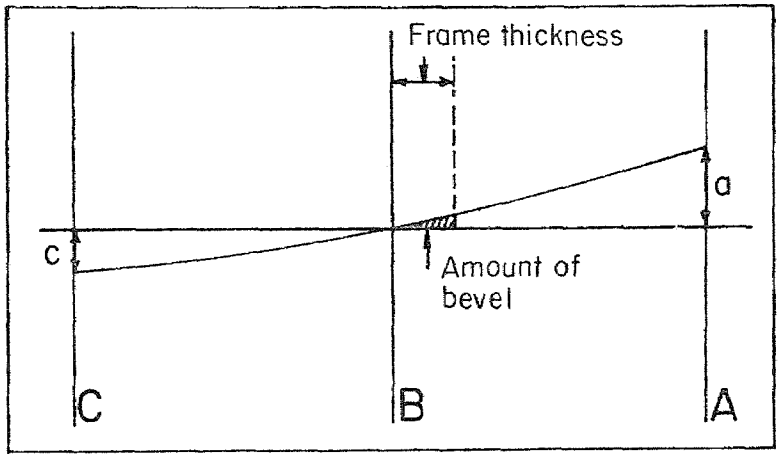


Fig. 23 Calculation of frame bevels (forward sections)

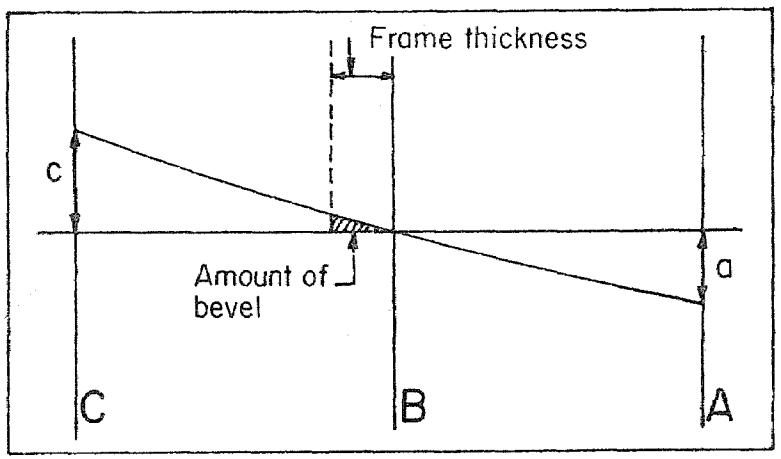


Fig. 25 Calculation of frame bevels (aft section)

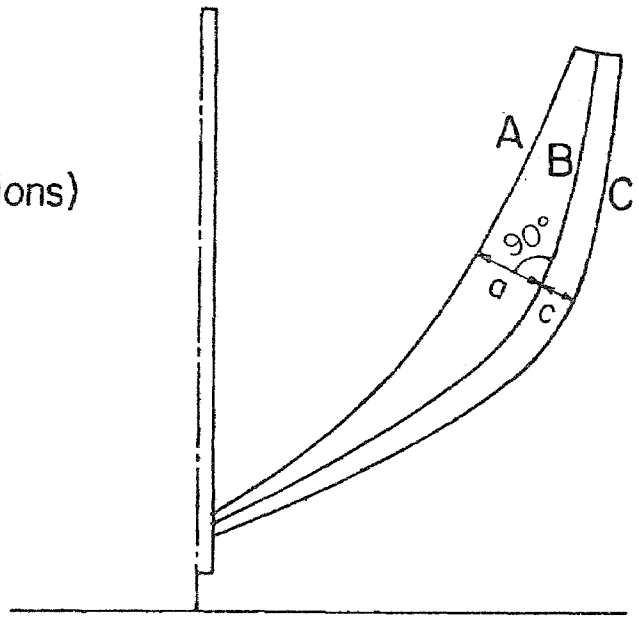


Fig. 24 Plotting frame distances

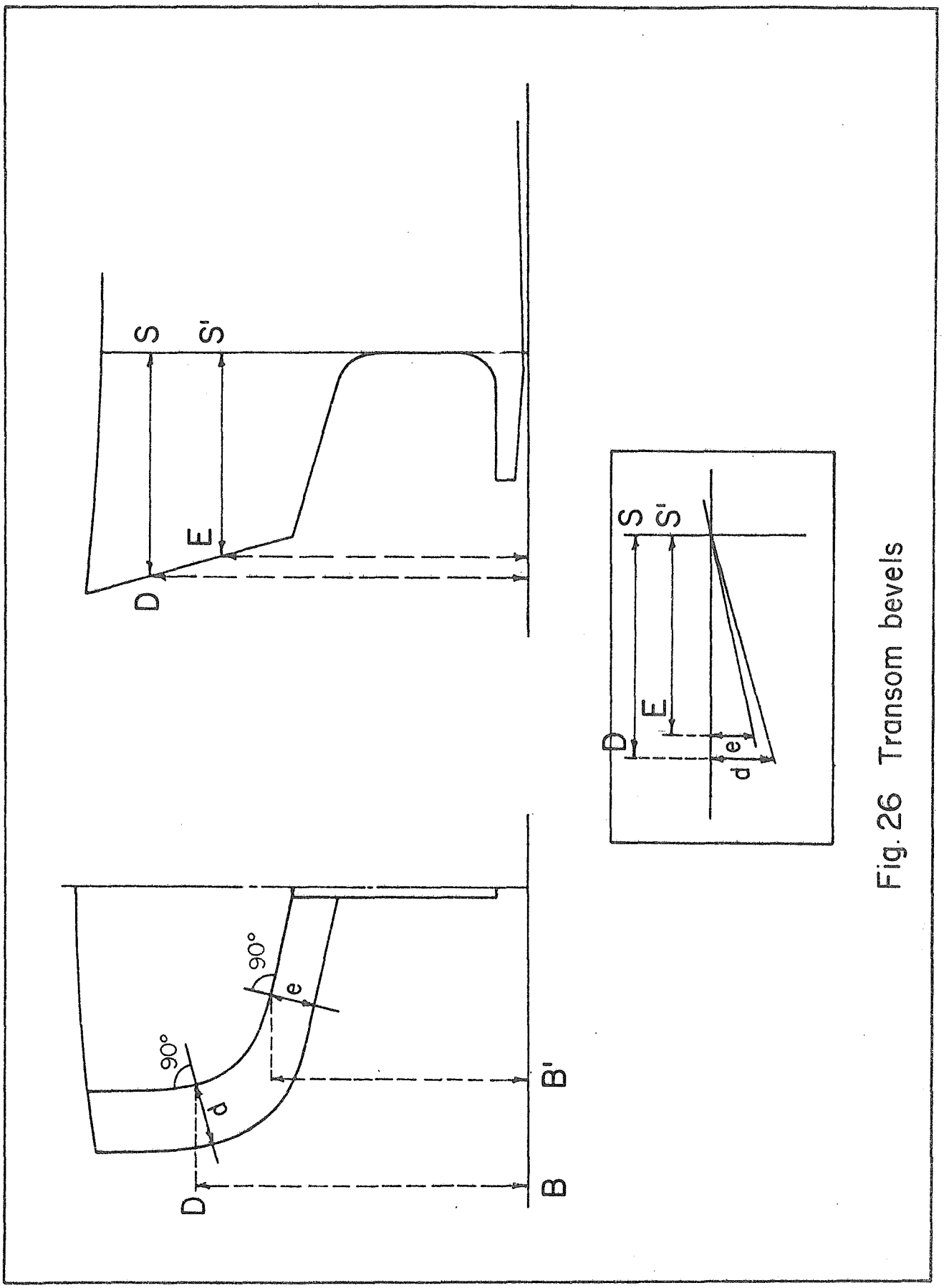


Fig. 26 Transom bevels

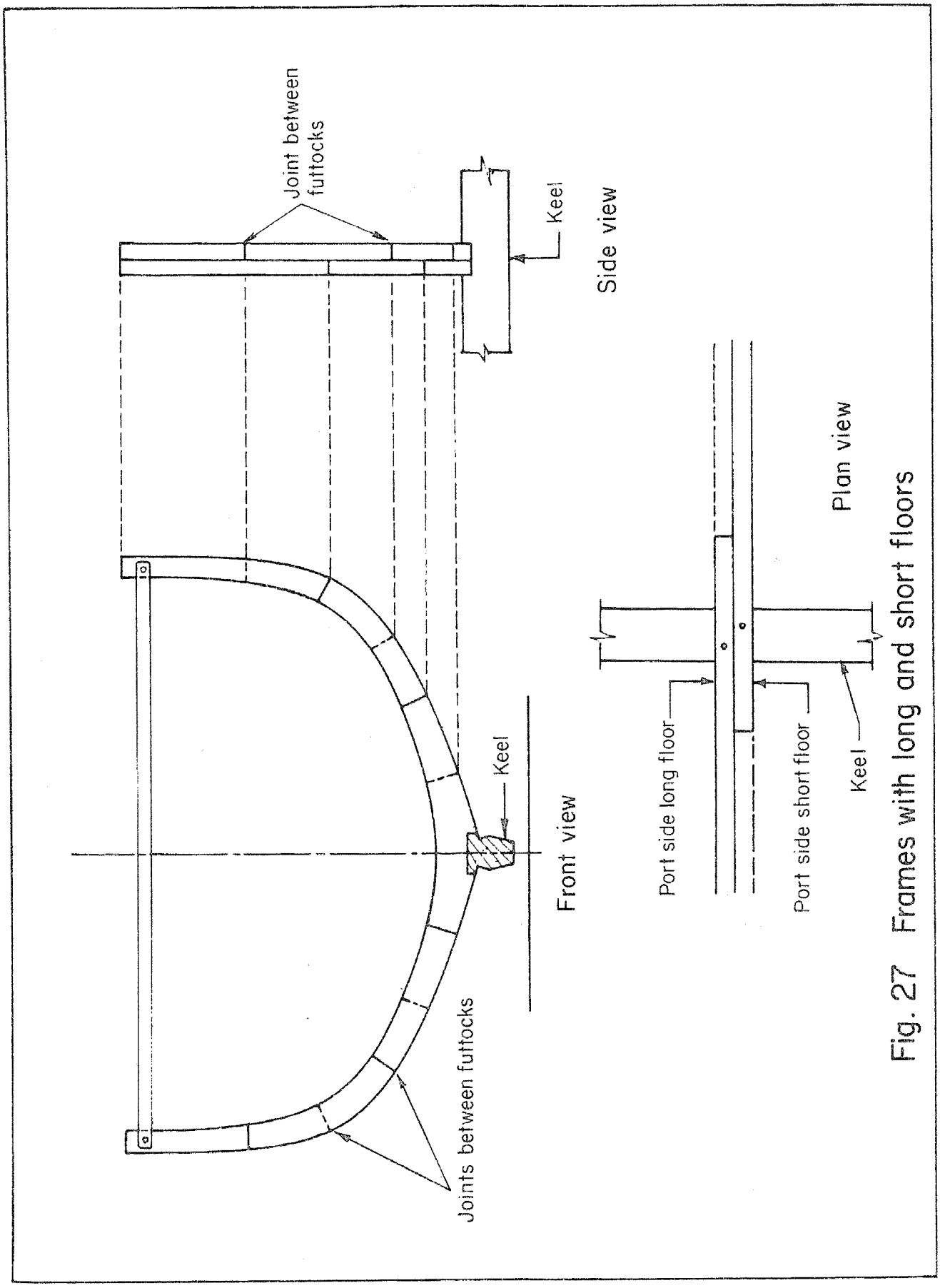


Fig. 27 Frames with long and short floors

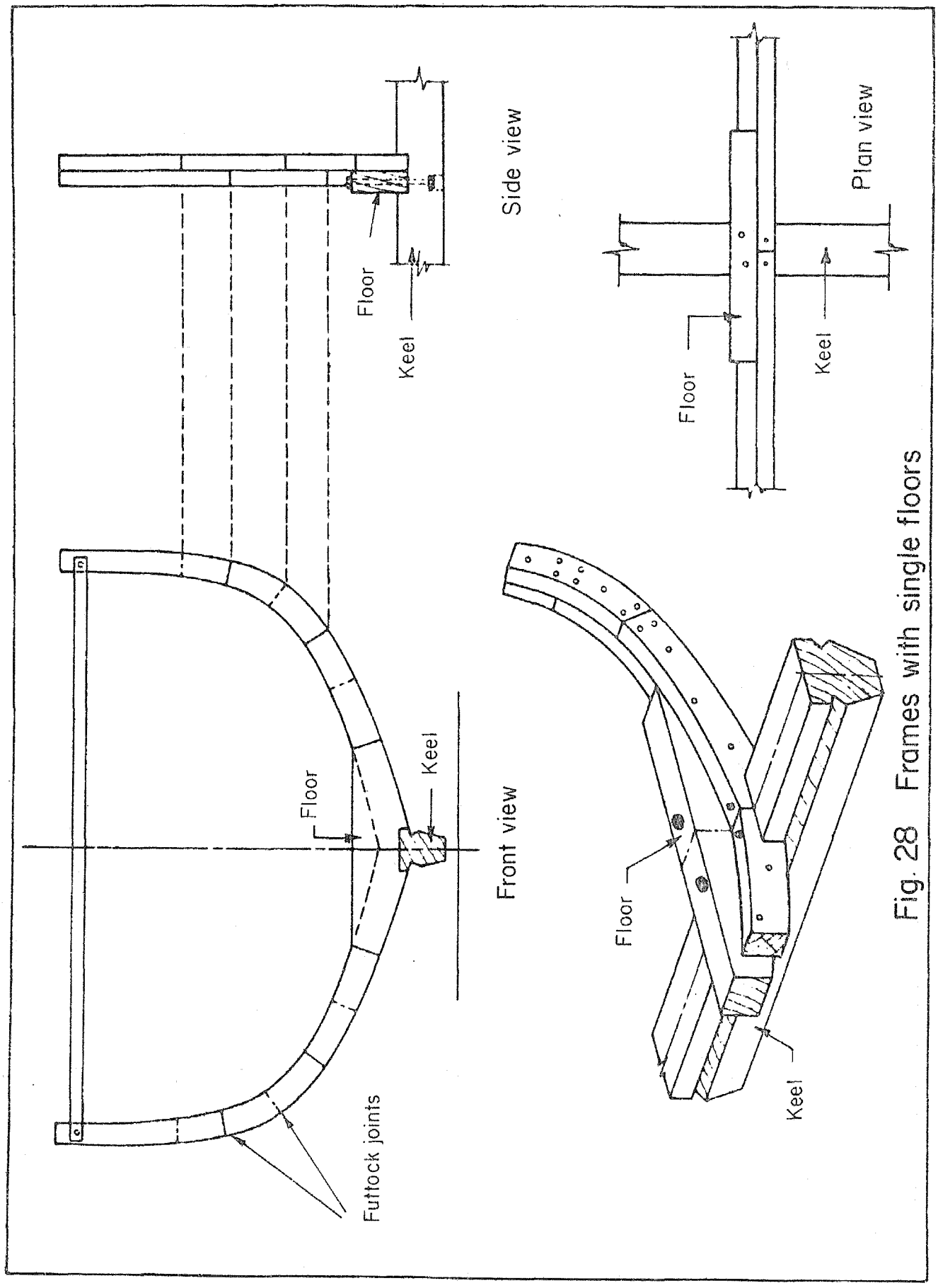


Fig. 28 Frames with single floors

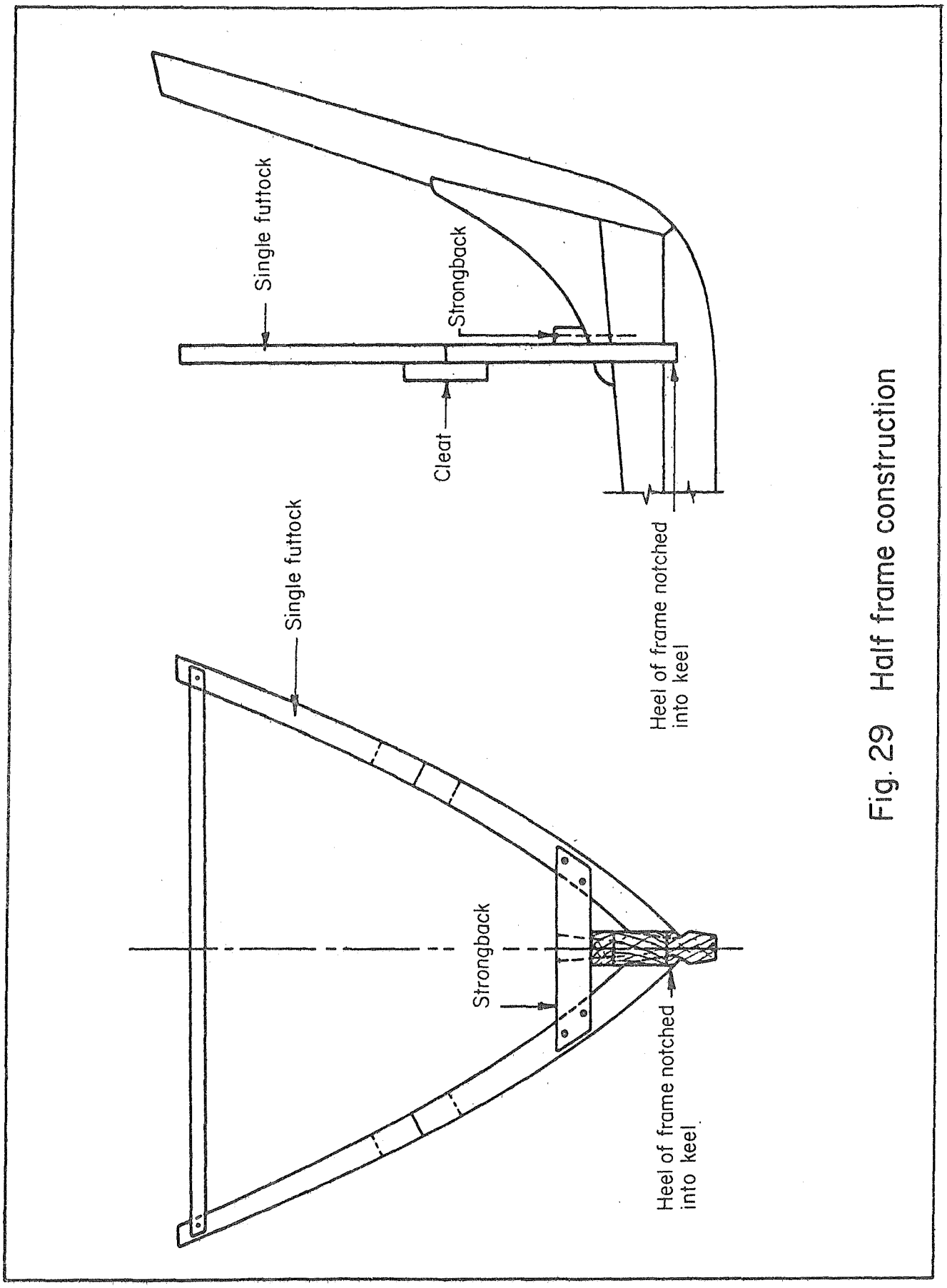
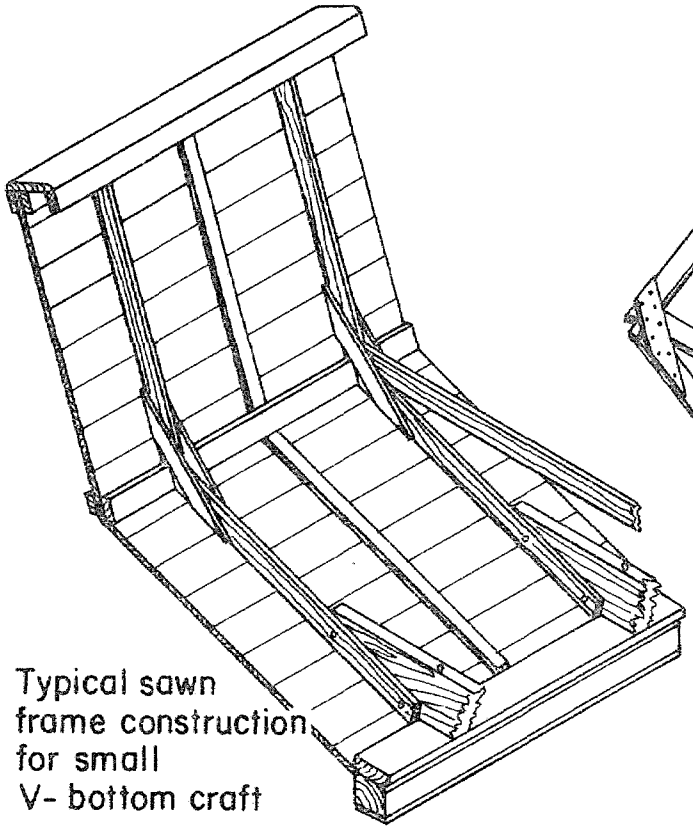
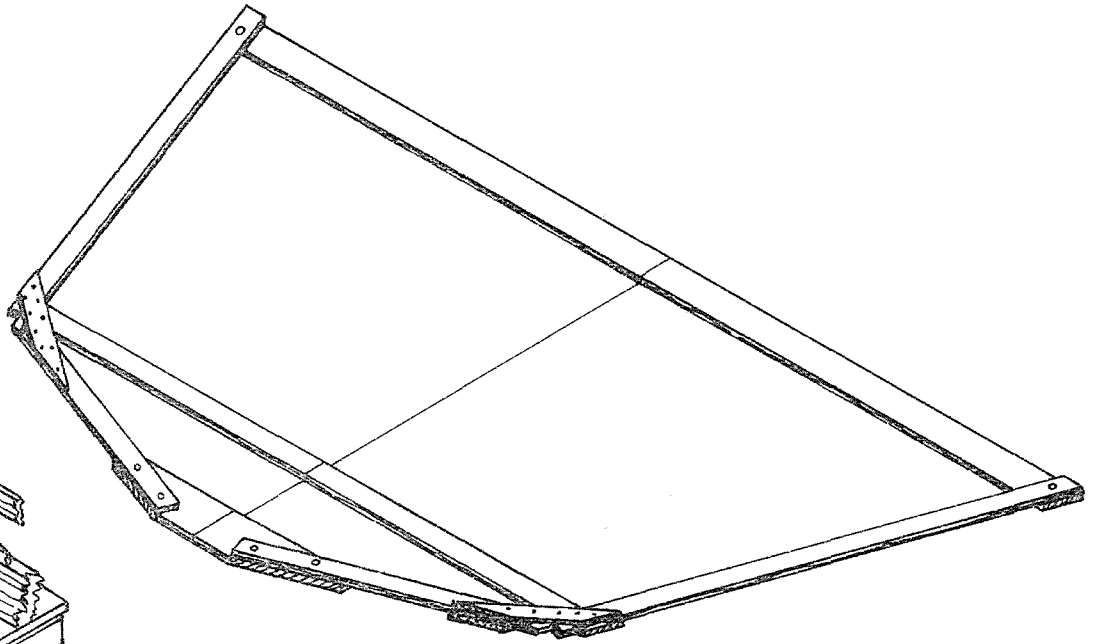


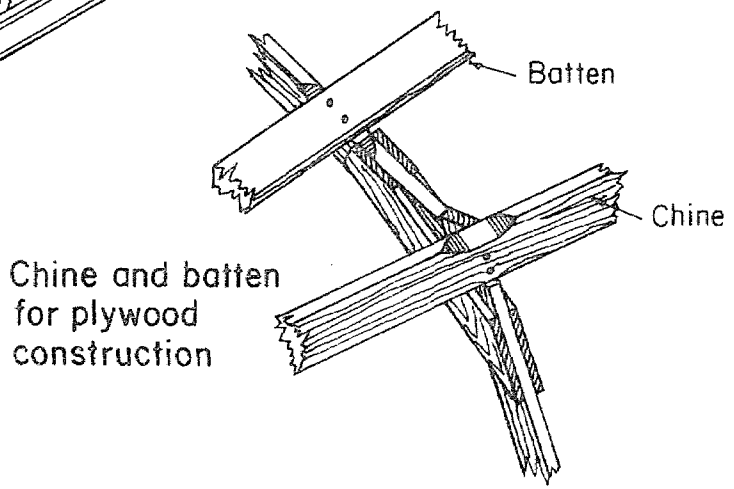
Fig. 29 Half frame construction



Typical sawn frame construction for small V- bottom craft



Assembling a sawn frame



Chine and batten for plywood construction

Fig. 30 Sawn frames for V-bottom construction

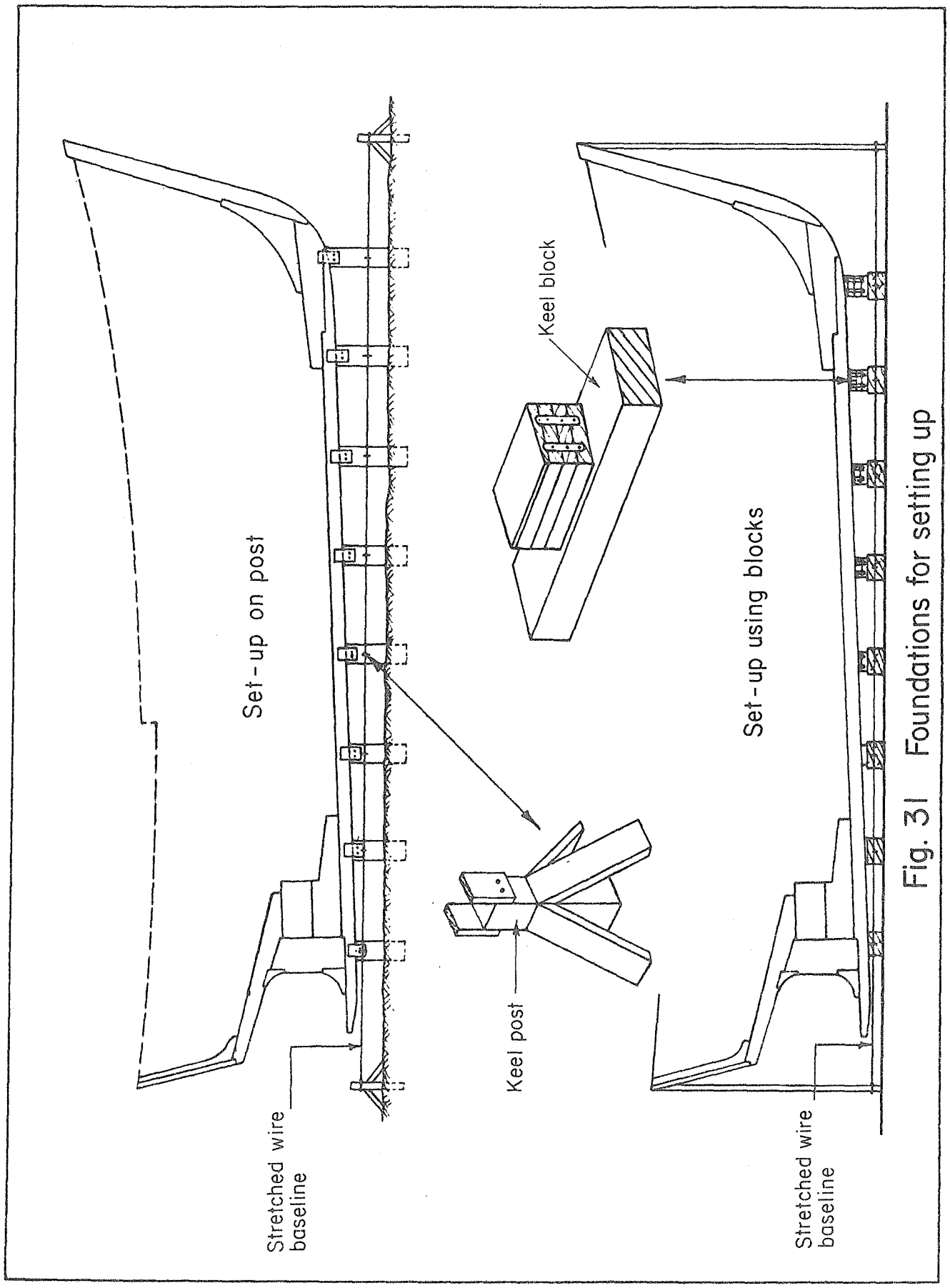


Fig. 31 Foundations for setting up

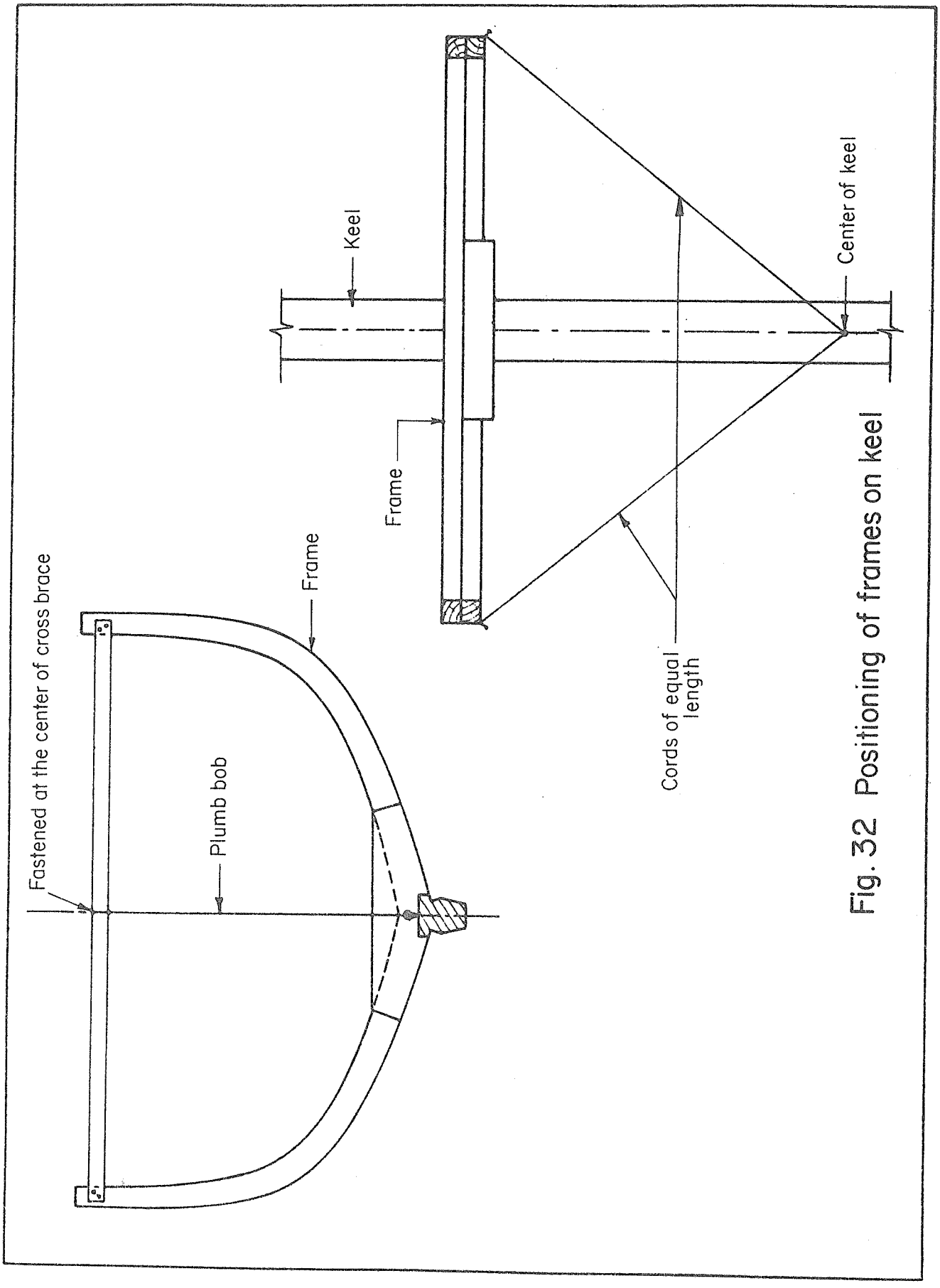


Fig. 32 Positioning of frames on keel

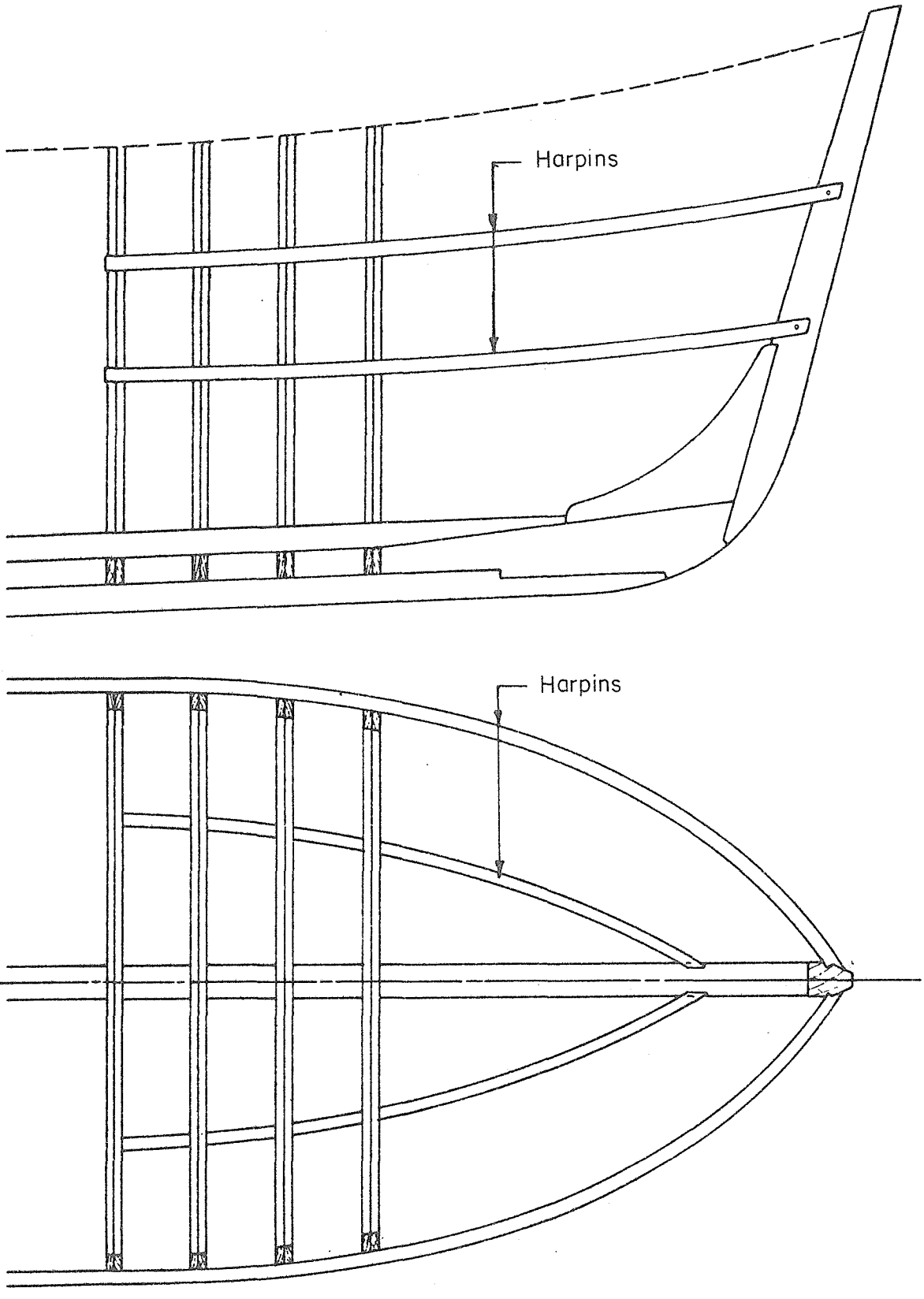


Fig. 33 Harpins for positioning of half frames

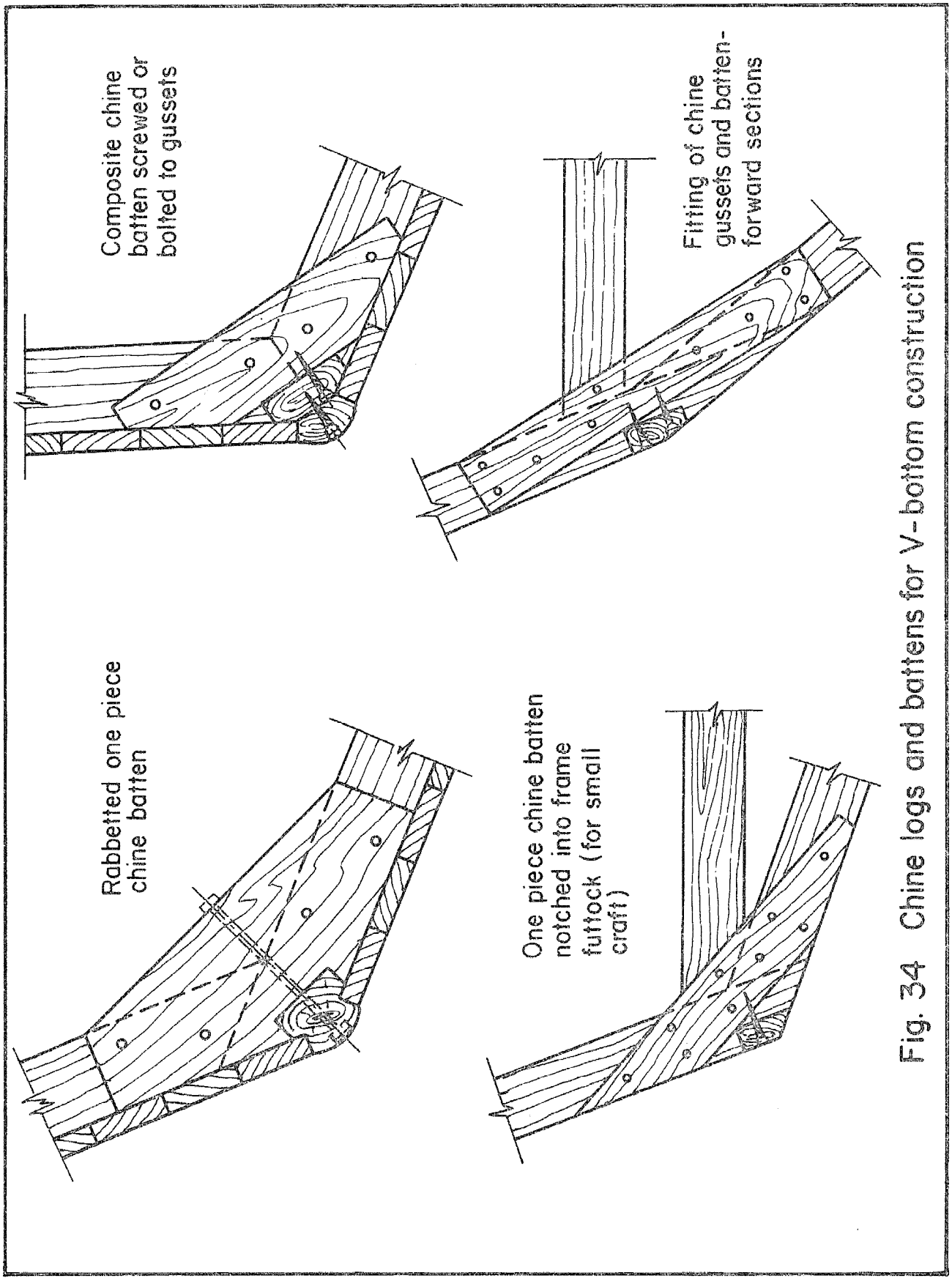
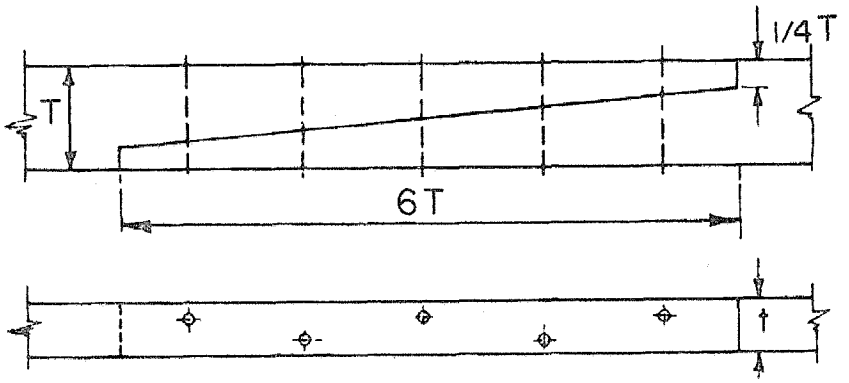
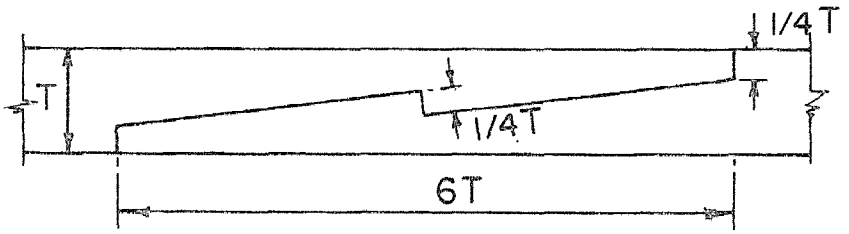


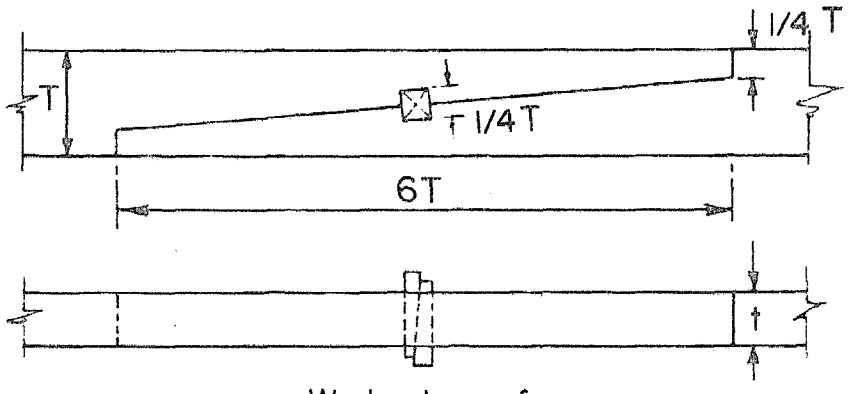
Fig. 34 Chine logs and battens for V-bottom construction



Plain scarf



Hook scarf



Wedged scarf

Fig. 35 Timber scarf

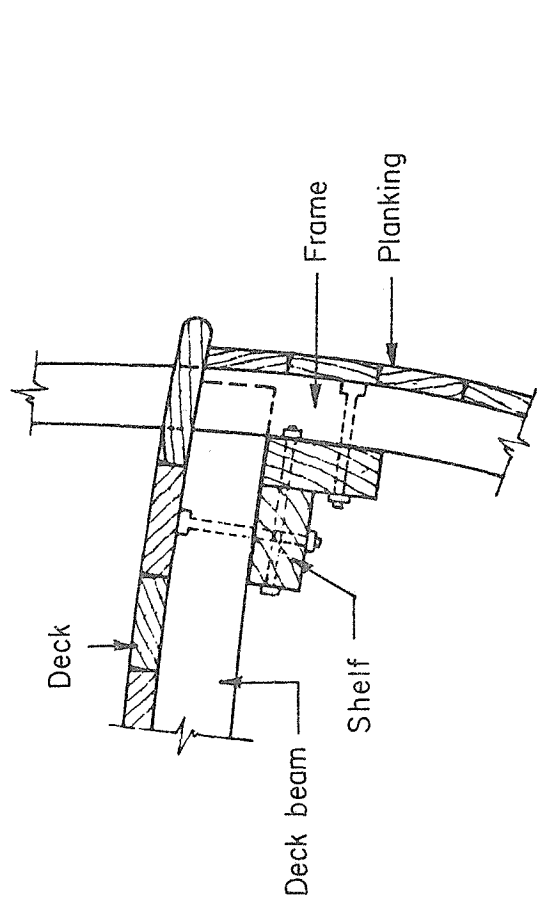
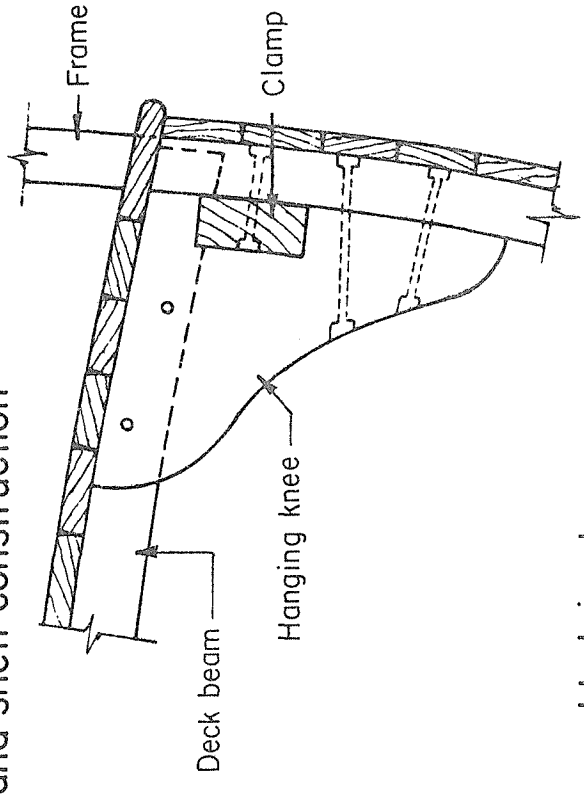


Fig. 36 Clamp and shelf construction



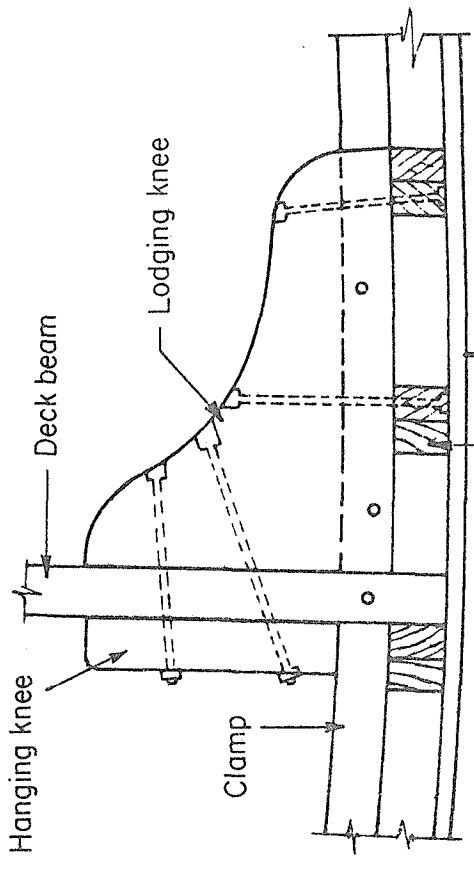


Fig. 37 Hanging and lodging knees

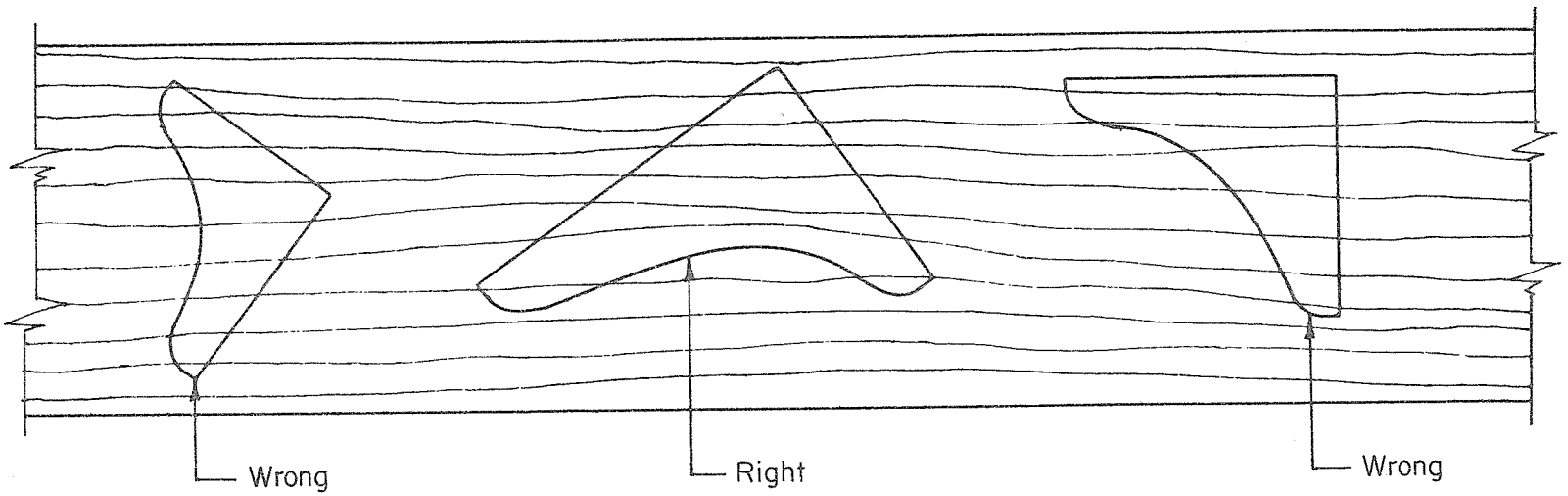


Fig. 38 Direction of grain in the cutting of knees

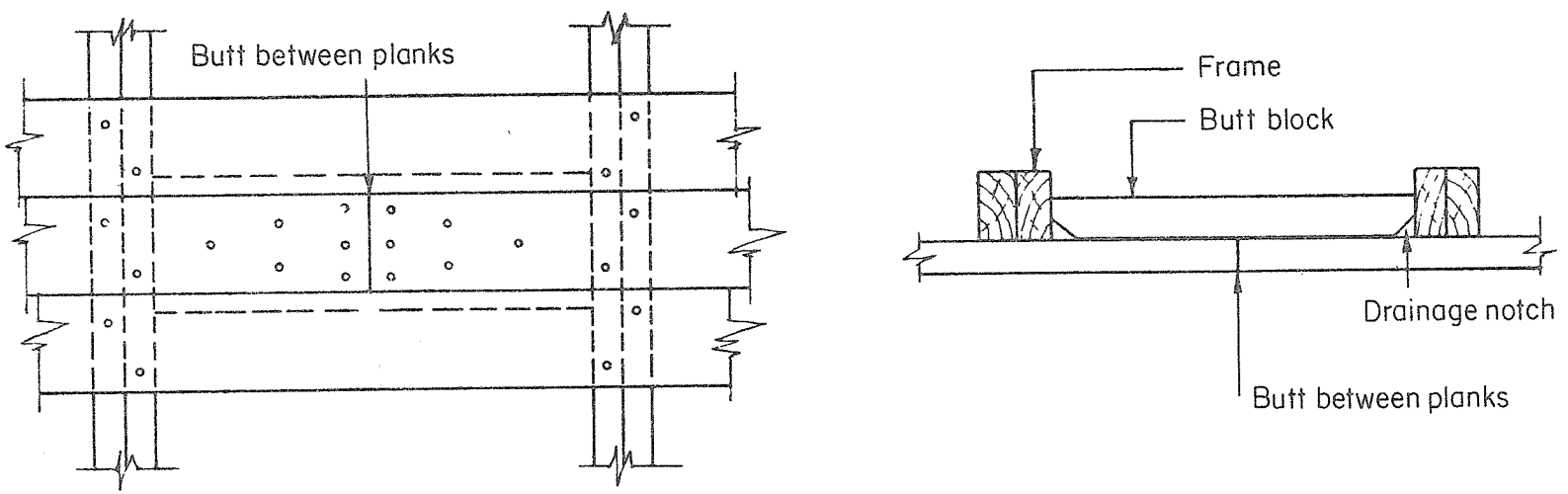


Fig. 39 Butt blocks in planking

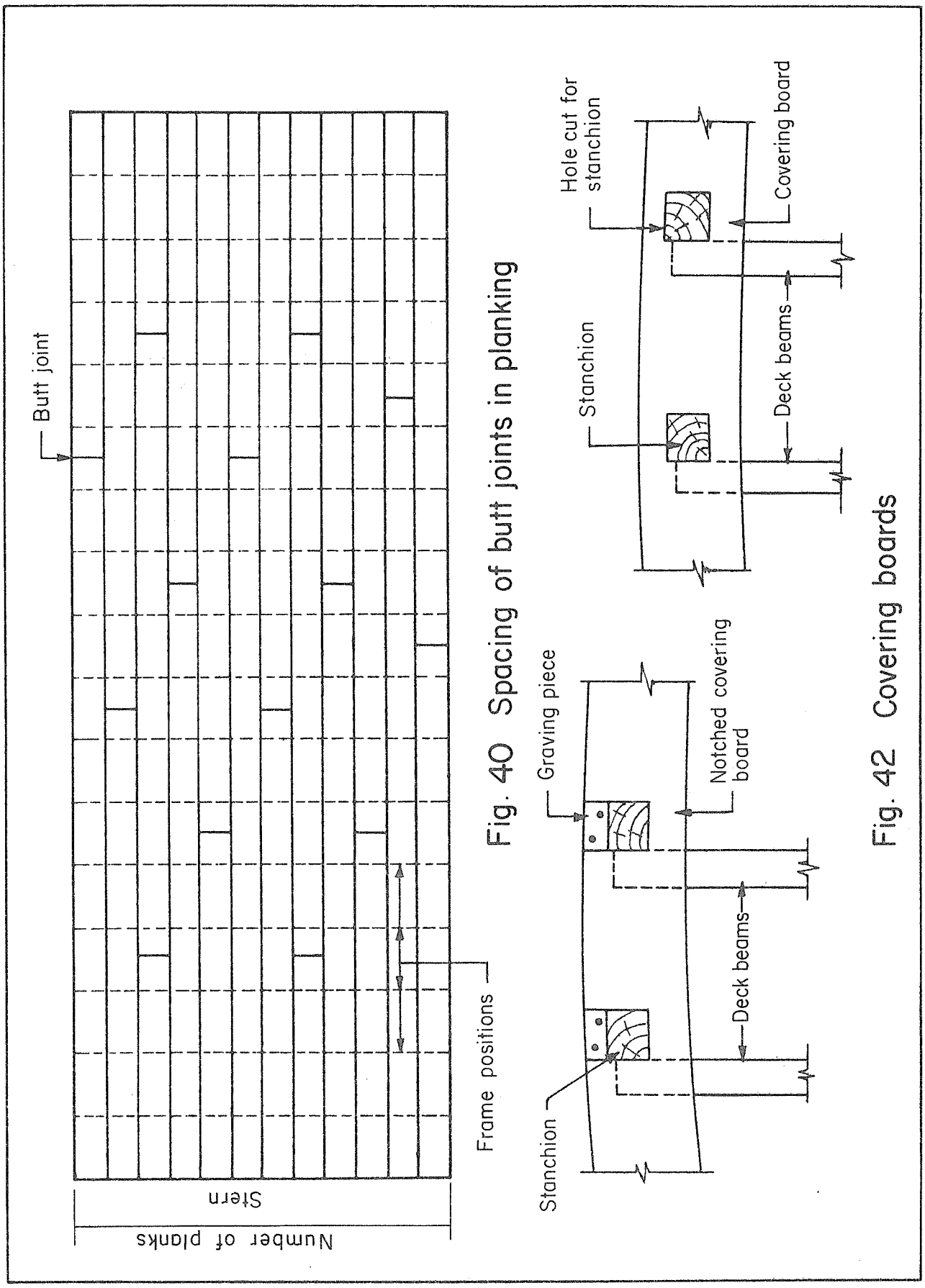


Fig. 40 Spacing of butt joints in planking

Fig. 42 Covering boards

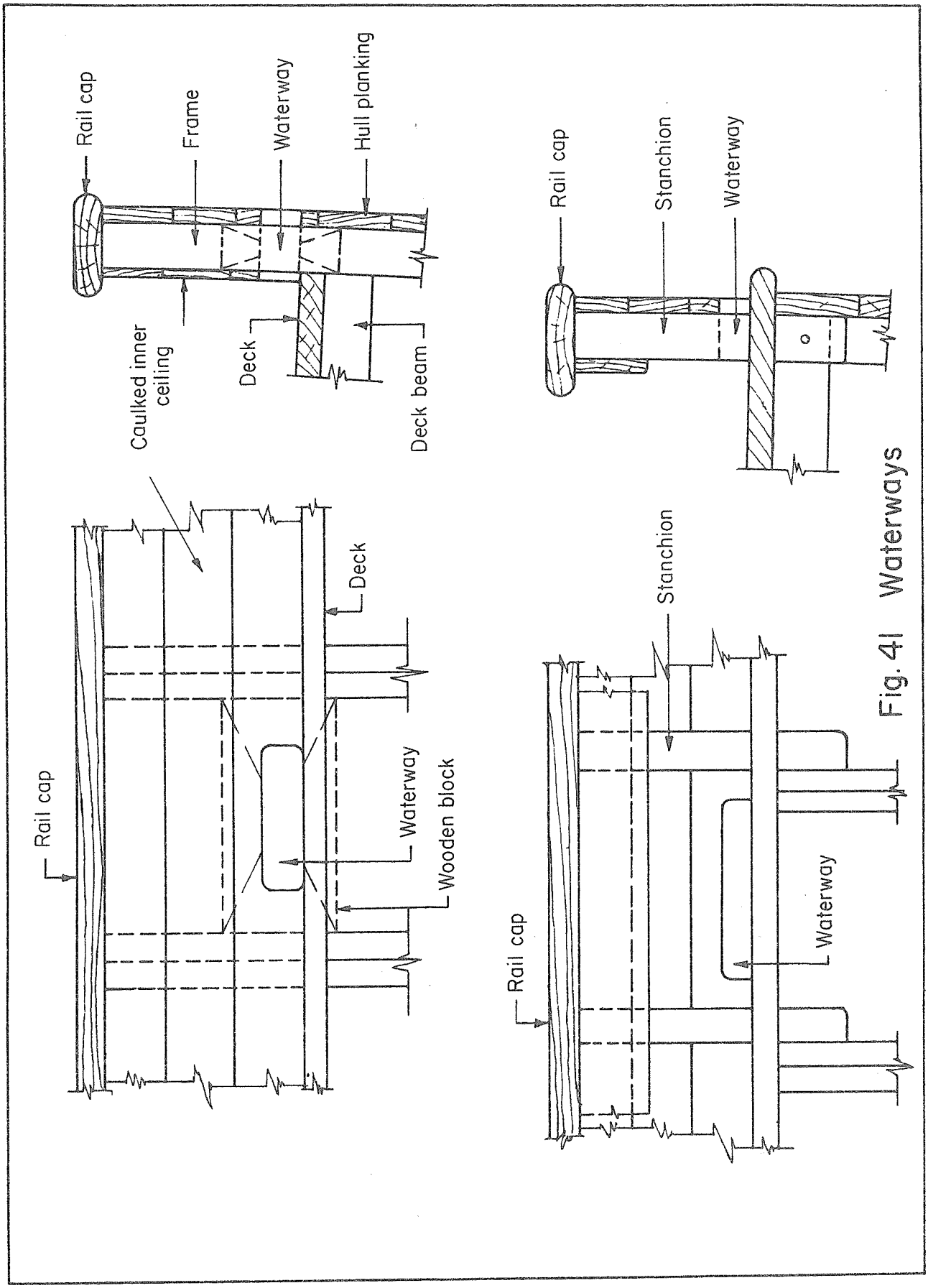


Fig. 41 Waterways

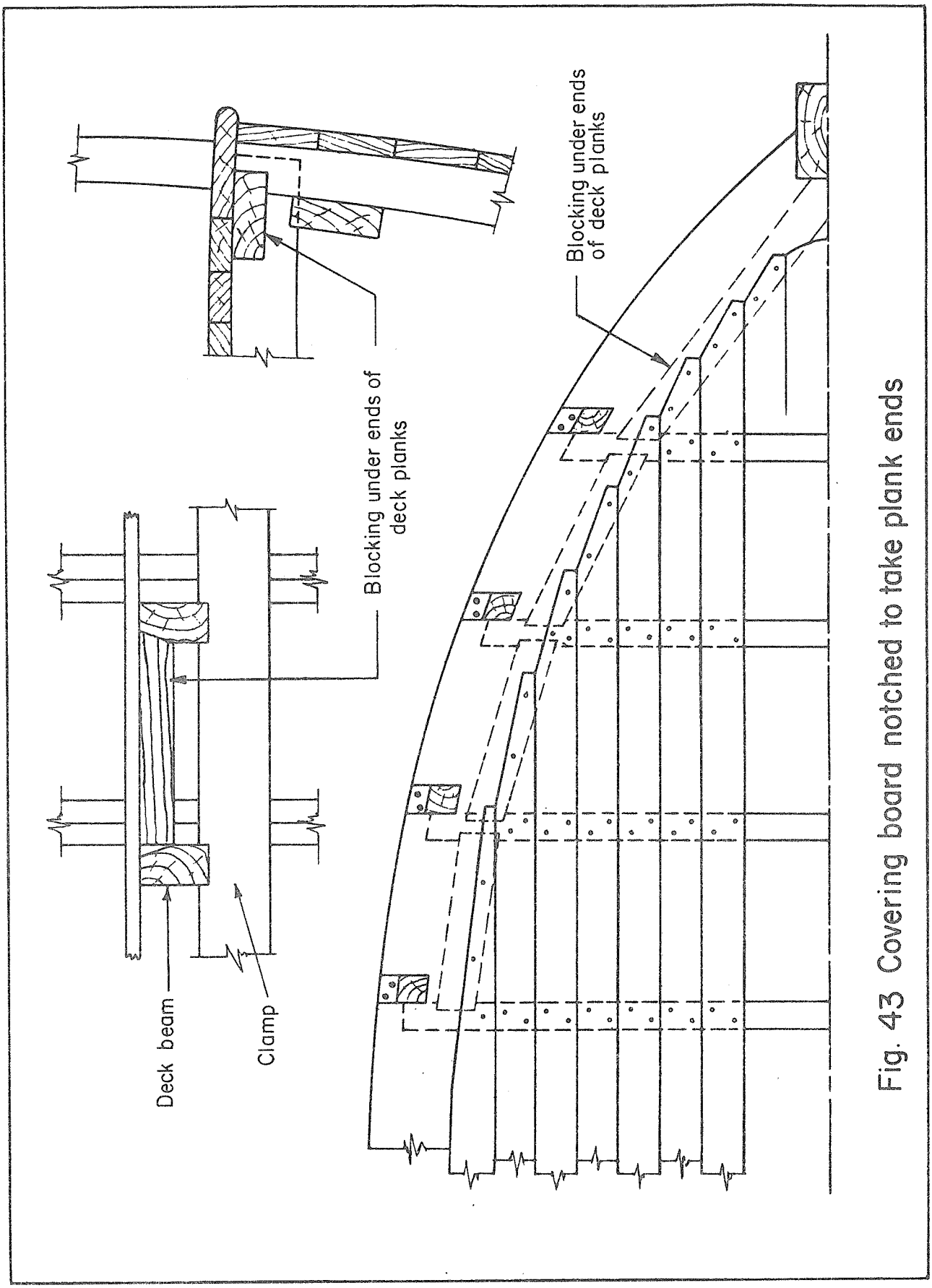


Fig. 43 Covering board notched to take plank ends

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