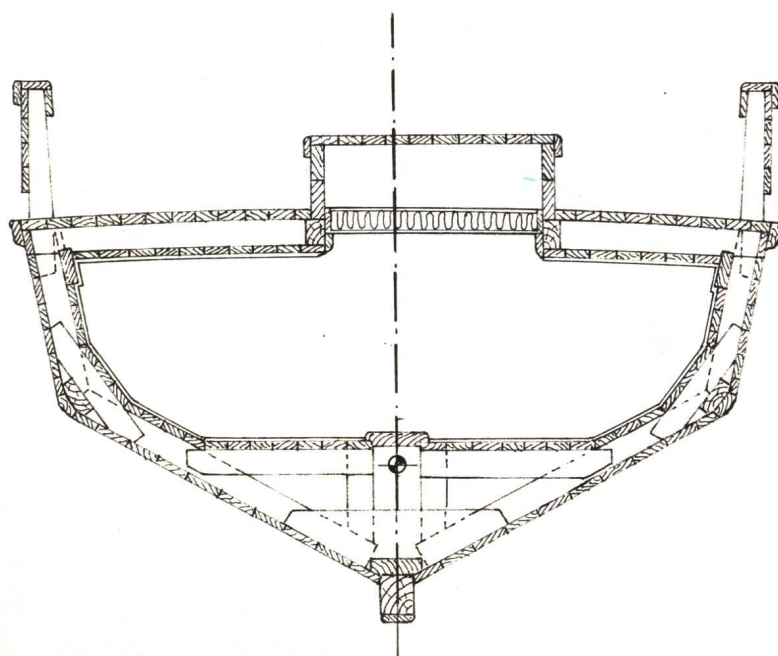
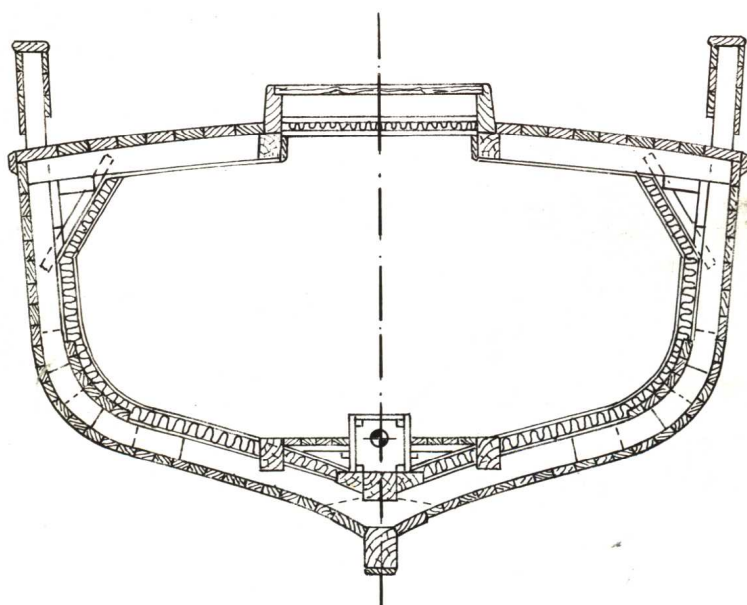


Fishing boat construction: 1 Building a sawn-frame fishing boat

FAO
FISHERIES
TECHNICAL
PAPER

96 Rev. 1



FOOD
AND
AGRICULTURE
ORGANIZATION
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Prepared by

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Fishing Technology Service

FAO Fishery Industries Division

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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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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 surface 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 $30 \text{ ft} + 10 \text{ ft} + 4 \text{ ft} = 44 \text{ ft}$. 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 $1\frac{1}{2}$ inch x $1\frac{1}{2}$ inch or 2 in x $\frac{3}{8}$ inch

For waterlines in plan view:

1 Batten 1 inch x $\frac{3}{8}$ inch
1 Batten $\frac{3}{4}$ inch x $\frac{3}{4}$ inch

For the sections:

1 Batten $\frac{3}{8}$ inch x $\frac{3}{8}$ 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 $\frac{1}{2}$ 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 stern 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,